SEL-700G

Generator and Intertie Protection Relays

SEL-700G0
SEL-700G1
SEL-700GT
SEL-700GW

Instruction Manual

20240329

SCHWEITZER ENGINEERING LABORATORIES

PM700G-01

Table of Contents

Section 6: Settings

SEL-700G Settings Sheets

Section 7: Communications

Section 8: Front-Panel Operations

Section 9: Bay Control

Section 10: Analyzing Events

Section 11: Testing and Troubleshooting

Appendix A: Firmware, ICD, and Manual Versions

Appendix B: Firmware Upgrade Instructions

Appendix C: SEL Communications Processors

Appendix D: DNP3 Communications

Appendix E: Modbus Communications

Appendix F: EtherNet/IP Communications

Appendix G: IEC 61850 Communications

Appendix H: IEC 60870-5-103 Communications

Appendix I: DeviceNet Communications

Appendix J: MIRRORED BITS Communications

Appendix K: Synchrophasors

Appendix L: Relay Word Bits

Appendix M: Analog Quantities

Appendix N: Cybersecurity Features

Glossary

Index

SEL-700G Relay Command Summary

List of Tables

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List of Figures

Preface

Manual Overview

The SEL-700G Relay Instruction Manual describes common aspects of generator and intertie relay application and use. It includes the necessary information to install, set, test, and operate the relay.

An overview of each manual section and topics follows:

Preface. Describes the manual organization, safety information, and conventions used to present information.

Section 1: Introduction and Specifications. Describes the basic features and functions of the SEL-700G; lists the relay specifications.

Section 2: Installation. Describes how to mount and wire the SEL-700G; illustrates wiring connections for various applications.

Section 3: PC Interface. Describes the built-in web server and its features, including settings, meter and monitoring, reports, and firmware upgrading. Also describes the features, installation methods and types of help available with the ACSELERATOR QuickSet® SEL-5030 Software.

Section 4: Protection and Logic Functions. Describes the operating characteristic of each protection element, using logic diagrams and text, and explains how to calculate element settings; describes contact output logic, automation, and report settings.

Section 5: Metering and Monitoring. Describes the operation of each metering function; describes the monitoring functions.

Section 6: Settings. Describes how to view, enter, and record settings for protection, control, communications, logic, and monitoring.

Section 7: Communications. Describes how to connect the SEL-700G to a PC for communication; shows serial port pinouts; lists and defines serial port commands. Describes the communications port interfaces and protocols supported by the relay for serial and Ethernet.

Section 8: Front-Panel Operations. Explains the features and use of the front panel, including front-panel command menu, default displays, and automatic messages. Describes in detail the two-line display (2 x 16 characters) and the touchscreen display (5-inch, color, 800 x 480 pixels).

Section 9: Bay Control. Describes how to configure and design the bay control screens for SEL-700G relays with the touchscreen display (5-inch, color, 800 x 480 pixels).

Section 10: Analyzing Events. Describes event types, messages, event summary data, standard event reports, and Sequential Events Recorder (SER) report.

Section 11: Testing and Troubleshooting. Describes protection element test procedures, relay self-test, and relay troubleshooting.

Appendix A: Firmware, ICD, and Manual Versions. Lists the relay firmware versions and details the differences between versions. Provides a record of changes made to the manual since the initial release.

Appendix B: Firmware Upgrade Instructions. Describes the procedure to update the firmware stored in flash memory.

Appendix C: SEL Communications Processors. Provides examples of how to use the SEL-700G with SEL communications processors for total substation automation solutions.

Appendix D: DNP3 Communications. Describes the DNP3 protocol support provided by the SEL-700G.

Appendix E: Modbus Communications. Describes the Modbus protocol support provided by the SEL-700G.

Appendix F: EtherNet/IP Communications. Describes the EtherNet/IP protocol support provided by the SEL-700G.

Appendix G: IEC 61850 Communications. Describes IEC 61850 implementation in the SEL-700G.

Appendix H: IEC 60870-5-103 Communications. Describes the IEC 60870-5-103 protocol support provided by the SEL-700G.

Appendix I: DeviceNet Communications. Describes the use of DeviceNet (data-link and application protocol) over a Controller Area Network (CAN) (hardware protocol).

Appendix J: MIRRORED BITS Communications. Describes how SEL protective relays and other devices can directly exchange information quickly, securely, and with minimum cost.

Appendix K: Synchrophasors. Describes the phasor measurement and control unit (PMCU), and accessing synchrophasor data via Ethernet port or serial port using ASCII command (**MET PM**) and IEEE C37.118 Protocol.

Appendix L: Relay Word Bits. Lists and describes the Relay Word bits (outputs of protection and control elements).

Appendix M: Analog Quantities. Lists and describes the analog quantities (outputs of analog elements).

Appendix N: Cybersecurity Features. Describes a number of features to help meet cybersecurity design requirements.

SEL-700G Relay Command Summary. Briefly describes the serial port commands that are fully described in *Section 7: Communications*.

Safety Information

⚠CAUTION
To ensure proper safety and operation, the equipment ratings, installation instructions, and operating instructions must be checked before commissioning or maintenance of the equipment. The integrity of any protective conductor connection must be checked before carrying out any other actions. It is the responsibility of the user to ensure that the equipment is installed, operated, and used for its intended function in the manner specified in this manual. If misused, any safety protection provided by the equipment may be impaired.

Dangers, Warnings, and Cautions

This manual uses three kinds of hazard statements, defined as follows:

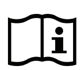
⚠DANGER
Indicates an imminently hazardous situation that, if not avoided, **will** result in death or serious injury.

⚠WARNING
Indicates a potentially hazardous situation that, if not avoided, **could** result in death or serious injury.

⚠CAUTION
Indicates a potentially hazardous situation that, if not avoided, **may** result in minor or moderate injury or equipment damage.

Safety Symbols

The following symbols are often marked on SEL products.

	**⚠CAUTION** Refer to accompanying documents.	**⚠ATTENTION** Se reporter à la documentation.
	Earth (ground)	Terre
	Protective earth (ground)	Terre de protection
	Direct current	Courant continu
	Alternating current	Courant alternatif
	Both direct and alternating current	Courant continu et alternatif
	Instruction manual	Manuel d'instructions

Safety Marks

The following statements apply to this device.

General Safety Marks

⚠CAUTION There is danger of explosion if the battery is incorrectly replaced. Replace only with Panasonic no. BR2330A or equivalent recommended by manufacturer. See Owner's Manual for safety instructions. The battery used in this device may present a fire or chemical burn hazard if mistreated. Do not recharge, disassemble, heat above 100°C or incinerate. Dispose of used batteries according to the manufacturer's instructions. Keep battery out of reach of children.	⚠ATTENTION Une pile remplacée incorrectement pose des risques d'explosion. Remplacez seulement avec un Panasonic no BR2330A ou un produit équivalent recommandé par le fabricant. Voir le guide d'utilisateur pour les instructions de sécurité. La pile utilisée dans cet appareil peut présenter un risque d'incendie ou de brûlure chimique si vous en faites mauvais usage. Ne pas recharger, démonter, chauffer à plus de 100°C ou incinérer. Éliminez les vieilles piles suivant les instructions du fabricant. Gardez la pile hors de la portée des enfants.
For use in Pollution Degree 2 environment.	Pour l'utilisation dans un environnement de Degré de Pollution 2.
Ambient air temperature shall not exceed 50°C (122°F).	La température de l'air ambiant ne doit pas dépasser 50°C (122°F).
For use on a flat surface of a Type 1 enclosure.	Destiné à l'utilisation sur une surface plane d'un boîtier de Type 1.
Terminal Ratings Wire Material Use 75°C (167°F) copper conductors only. Tightening Torque Terminal Block: 0.9–1.4 Nm (8–12 in-lb) Compression Plug: 0.5–1.0 Nm (4.4–8.8 in-lb) Compression Plug Mounting Ear Screw: 0.18–0.25 Nm (1.6–2.2 in-lb)	Spécifications des bornes Type de filage Utiliser seulement conducteurs en cuivre 75°C (167°F). Couple de serrage Bornier : 0,9–1,4 (8–12 livres-pouce) Fiche à compression : 0,5–1,0 Nm (4,4–8,8 livres-pouce) Vis à oreille de montage de la fiche à compression : 0,18–0,25 Nm (1,6–2,2 livres-pouce)

Hazardous Locations Safety Marks

⚠WARNING – EXPLOSION HAZARD Open circuit before removing cover.	⚠AVERTISSEMENT – DANGER D'EXPLOSION Ouvrir le circuit avant de déposer le couvercle.
⚠WARNING – EXPLOSION HAZARD Substitution of components may impair suitability for Class I, Division 2.	⚠AVERTISSEMENT – DANGER D'EXPLOSION La substitution de composants peut détériorer la conformité à Classe I, Division 2.
Ambient air temperature shall not exceed –20°C ≤ Ta ≤ +50°C.	La température de l'air ambiant ne doit pas dépasser –20°C ≤ Ta ≤ +50°C.

Compliance Approvals

Hazardous Locations Approvals

The SEL-700G is UL certified for hazardous locations to U.S. and Canadian standards. In North America, the relay is approved for Hazardous Locations Class I, Division 2, Groups A, B, C, and D, and temperature class T3C in the maximum surrounding air temperature of 50°C.

The SEL-700G shall be installed in an indoor or outdoor (extended) locked enclosure that provides a degree of protection to personnel against access to hazardous parts. In either environment, the relay shall be protected from direct sunlight, precipitation, and full wind pressure.

To comply with the requirements of the European ATEX standard for hazardous location, the SEL-700G shall be installed in an ATEX certified enclosure with a tool removable door or cover that provides a degree of protection not less than IP54, in accordance with EN 60079-0. The enclosure shall be limited to the surrounding air temperature range of –20°C ≤ Ta ≤ +50°C. The enclosure should be certified to these requirements or be tested for compliance as part of the complete assembly. The enclosure must be marked “WARNING – Do not open when a explosive atmosphere is present.”

Other Safety Marks (Sheet 1 of 2)

⚠DANGER Disconnect or de-energize all external connections before opening this device. Contact with hazardous voltages and currents inside this device can cause electrical shock resulting in injury or death.	⚠DANGER Débrancher tous les raccordements externes avant d’ouvrir cet appareil. Tout contact avec des tensions ou courants internes à l’appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.
⚠DANGER Contact with instrument terminals can cause electrical shock that can result in injury or death.	⚠DANGER Tout contact avec les bornes de l’appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.
⚠WARNING Use of this equipment in a manner other than specified in this manual can impair operator safety safeguards provided by this equipment.	⚠AVERTISSEMENT L’utilisation de cet appareil suivant des procédures différentes de celles indiquées dans ce manuel peut désarmer les dispositifs de protection d’opérateur normalement actifs sur cet équipement.
⚠WARNING Have only qualified personnel service this equipment. If you are not qualified to service this equipment, you can injure yourself or others, or cause equipment damage.	⚠AVERTISSEMENT Seules des personnes qualifiées peuvent travailler sur cet appareil. Si vous n’êtes pas qualifiés pour ce travail, vous pourriez vous blesser avec d’autres personnes ou endommager l’équipement.
⚠WARNING Always isolate the relay control circuits before performing any modifications to the relay.	⚠AVERTISSEMENT Il faut toujours isoler les circuits de commande du relais avant d'apporter des modifications au relais.
⚠WARNING Before working on a CT circuit, first apply a short to the secondary winding of the CT.	⚠AVERTISSEMENT Avant de travailler sur un circuit TC, placez d’abord un court-circuit sur l’enroulement secondaire du TC.
⚠WARNING This device is shipped with default passwords. Default passwords should be changed to private passwords at installation. Failure to change each default password to a private password may allow unauthorized access. SEL shall not be responsible for any damage resulting from unauthorized access.	⚠AVERTISSEMENT Cet appareil est expédié avec des mots de passe par défaut. A l’installation, les mots de passe par défaut devront être changés pour des mots de passe confidentiels. Dans le cas contraire, un accès non-autorisé á l’équipement peut être possible. SEL décline toute responsabilité pour tout dommage résultant de cet accès non-autorisé.

Other Safety Marks (Sheet 2 of 2)

⚠WARNING To install an option card, the relay must be de-energized and then re-energized. When re-energized, the relay will reboot. Therefore, de-energize the protected equipment before installing the option card to prevent damage to the protected apparatus.	⚠AVERTISSEMENT Pour installer une carte à option, le relais doit être éteint et ensuite rallumé. Quand il est rallumé, le relais redémarrera. Donc, il faut éteindre l'équipement protégé avant d'installer la carte à option pour empêcher des dégats au moteur.
⚠WARNING Do not perform any procedures or adjustments that this instruction manual does not describe.	⚠AVERTISSEMENT Ne pas appliquer une procédure ou un ajustement qui n'est pas décrit explicitement dans ce manuel d'instruction.
⚠WARNING During installation, maintenance, or testing of the optical ports, use only test equipment qualified for Class 1 laser products.	⚠AVERTISSEMENT Durant l'installation, la maintenance ou le test des ports optiques, utilisez exclusivement des équipements de test homologués comme produits de type laser de Classe 1.
⚠WARNING Overtightening the mounting nuts may permanently damage the relay chassis.	⚠AVERTISSEMENT Une pression excessive sur les écroux de montage peut endommager de façon permanente le chassis du relais.
⚠CAUTION Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.	⚠ATTENTION Les composants de cet équipement sont sensibles aux décharges électrostatiques (DES). Des dommages permanents non-décelables peuvent résulter de l'absence de précautions contre les DES. Raccordez-vous correctement à la terre, ainsi que la surface de travail et l'appareil avant d'en retirer un panneau. Si vous n'êtes pas équipés pour travailler avec ce type de composants, contacter SEL afin de retourner l'appareil pour un service en usine.
⚠CAUTION Looking into optical connections, fiber ends, or bulkhead connections can result in hazardous radiation exposure.	⚠ATTENTION Regarder vers les connecteurs optiques, les extrémités des fibres oules connecteurs de cloison peut entraîner une exposition à des rayonnements dangereux.
⚠CAUTION Use of controls or adjustments, or performance of procedures other than those specified herein, may result in hazardous radiation exposure.	⚠ATTENTION L'utilisation de commandes ou de réglages, ou l'application de tests de fonctionnement différents de ceux décrits ci-après peuvent entraîner l'exposition à des radiations dangereuses.
⚠CAUTION Do not connect power to the relay until you have completed these procedures and receive instruction to apply power. Equipment damage can result otherwise.	⚠ATTENTION Ne pas mettre le relais sous tension avant d'avoir complété ces procédures et d'avoir reçu l'instruction de brancher l'alimentation. Des dommages à l'équipement pourraient survenir autrement.

General Information

Typographic Conventions

There are many ways to communicate with the SEL-700G. The three primary methods are:

- Using a command line interface on a PC terminal emulation window.
- Using the front-panel menus and pushbuttons.
- Using QuickSet.

The instructions in this manual indicate these options with specific font and formatting attributes. The following table lists these conventions.

Example	Description
STATUS	Commands typed at a command line interface on a PC.
<Enter>	Single keystroke on a PC keyboard.
<Ctrl + D>	Multiple/combination keystroke on a PC keyboard.
Start > Settings	PC dialog boxes and menu selections. The > character indicates submenus.
ENABLE	Relay front- or rear-panel labels and pushbuttons.
`Main > Meters`	Relay front-panel LCD menus and relay responses. The > character indicates submenus.

Trademarks

All brand or product names appearing in this document are the trademark or registered trademark of their respective holders. No SEL trademarks may be used without written permission.

SEL trademarks appearing in this manual are shown in the following table.

ACSELERATOR Architect®	SEL-2407®
ACSELERATOR QuickSet®	SELOGIC®
ACSELERATOR Report Server®	SYNCHROWAVE®
Best Choice Ground Directional Element®	MIRRORED BITS®

Examples

This instruction manual uses several example illustrations and instructions to explain how to effectively operate the SEL-700G. These examples are for demonstration purposes only; the firmware identification information or settings values included in these examples may not necessarily match those in the present version of your SEL-700G.

LED Emitter

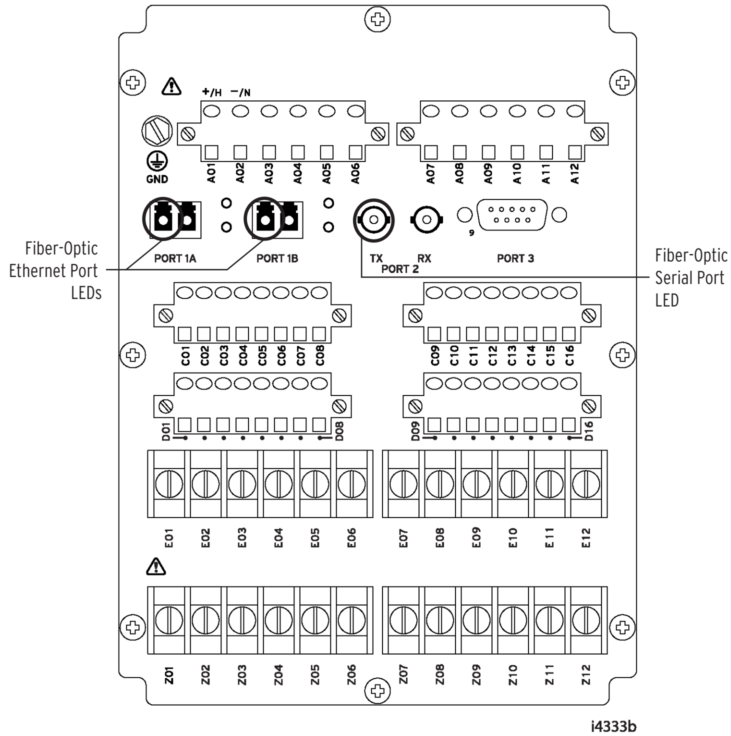
⚠CAUTION
Looking into optical connections, fiber ends, or bulkhead connections can result in hazardous radiation exposure.

⚠CAUTION
Use of controls, adjustments, or performance of procedures other than those specified herein may result in hazardous radiation exposure.

The following table shows LED information specific to the SEL-700G (see *Figure 2.10* for the location of the ports using these LEDs on the relay).

Item	Fiber-Optic Ethernet Port 1 (1A, 1B)	Port 2
Mode	Multimode	Multimode
Wavelength	1300 nm	820 nm
Source	LED	LED
Connector type	LC	ST
Typical Output power	–15.7 dBm	–16 dBm

The following figure shows the LED location specific to the SEL-700G (see *Figure 2.10* for the complete rear-panel drawing).



SEL-700G LED Locations

LED Safety Warnings and Precautions

- ➤ Do not look into the end of an optical cable connected to an optical output.
- ➤ Do not look into the fiber ports/connectors.
- ➤ Do not perform any procedures or adjustments that are not described in this manual.
- ➤ During installation, maintenance, or testing of the optical ports only use test equipment classified as Class 1 laser products.
- ➤ Incorporated components such as transceivers and laser/LED emitters are not user serviceable. Units must be returned to SEL for repair or replacement.

Environmental Conditions and Voltage Information

The following table lists important environmental and voltage information.

Condition	Range/Description
Indoor/outdoor use	Indoor
Altitude[a]	To 2000 m
Temperature	
IEC Performance Rating (per IEC/EN 60068-2-1 and IEC/EN 60068-2-2)	–40° to +85°C
Relative humidity	5% to 95%

Condition	Range/Description
Main supply voltage fluctuations	To ±10% of nominal voltage
Overvoltage	Category II
Pollution	Degree 2
Atmospheric pressure	80 to 110 kPa

[a] Consult the factory for derating specifications for higher altitude applications.

Wire Sizes and Insulation

NOTE: Terminal blocks are best suited to accept 10 AWG wire size. Make sure to select an appropriate lug size that is compatible with the SEL relay terminal block. All SEL qualification testing of terminal blocks is performed with ring or fork terminals for wire sizes as high as 12 AWG.

For standard wiring connections, use 105°C-rated wiring. Wire sizes for grounding (earthing), current, voltage, and contact connections are dictated by the terminal blocks and expected load currents. You can use the following table as a guide in selecting wire sizes. Refer to *SEL Application Note AN2014-08* for wiring and termination guidance. Strip the wires 8 mm (0.31 in) for installation and termination.

Connection Type	Wire Size		Insulation Voltage
	Minimum	Maximum	
Grounding (Earthing)	18 AWG (0.80 mm^2)	14 AWG (2.10 mm^2)	300 V min
Current	16 AWG (1.30 mm^2)	12 AWG (3.30 mm^2)	300 V min
Potential (Voltage)	18 AWG (0.80 mm^2)	14 AWG (2.10 mm^2)	300 V min
Contact I/O	18 AWG (0.80 mm^2)	14 AWG (2.10 mm^2)	300 V min
RTD[a]	28 AWG (0.08 mm^2)	16 AWG (1.30 mm^2)	300 V min
Other	18 AWG (0.80 mm^2)	14 AWG (2.10 mm^2)	300 V min

[a] See Table 2.20: Typical Maximum RTD Lead Lengths.

Instructions for Cleaning and Decontamination

Use a mild soap or detergent solution and a damp cloth to carefully clean the SEL-700G chassis when necessary. Avoid using abrasive materials, polishing compounds, and harsh chemical solvents (such as xylene or acetone) on any surface of the relay.

Copyrighted Software

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Technical Support

We appreciate your interest in SEL products and services. If you have questions or comments, please contact us at:

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Section 1
Introduction and Specifications

Overview

The SEL-700G Relay is designed to provide comprehensive protection, integration and control features in a flexible, compact, and cost-effective package. The SEL-700G0 and SEL-700G1 relays provide basic to full generator protection for small to large machines. The SEL-700GT Relay provides complete intertie and generator protection. The SEL-700GW Relay provides dual feeder protection for a multimachine wind generator network application, including overcurrent protection to feeders, transformers, etc. All relays provide metering, monitoring, control and communications functions. Flexible analog and digital input/output options and RTD based protection are also included.

This manual contains the information necessary to install, set, test, operate, and maintain any SEL-700G. You need not review the entire manual to perform specific tasks.

Features

Protection Features

The SEL-700G protection features depend on the model selected. The models are configured with specific current/voltage input cards. The current/voltage input cards are located in Slot Z and Slot E in the relay.

Slot Z cards are assigned a two-digit code beginning with the number 8 in the SEL-700G Model Options Table (MOT, see *Models on page 1.6*). For example, 81 in the MOT for Slot Z indicates a SELECT 4 ACI /3 AVI card with 3-phase ac current inputs (1 A nominal), neutral ac current input (1 A nominal), and 3-phase ac voltage inputs (300 Vac).

Slot E cards are assigned a two-digit code beginning with the number 7 in the SEL-700G Model Options Table (MOT). For example, 71 in the MOT for Slot E indicates a SELECT 3 ACI /4 AVI card with the 3-phase ac current inputs (1 A nominal), 3-phase ac voltage inputs (300 Vac), and VS (Vsysnc) input (300 Vac).

Slot Z inputs, except for IN, are designated as X-side inputs. Slot E inputs, except for VN and VS, are designated as Y-side inputs. The SEL-700G has between 6 and 14 analog inputs, depending on the model and options selected. *Table 1.1* shows the current and voltage inputs for the different models available. Current inputs are 1 A or 5 A nominal rating and voltage inputs are 300 V continuous rating.

When the VS or VN voltage inputs are unused in the SEL-700G0+, SEL-700G1+, and SEL-700GT+ models and the setting DELTAY_X := DELTA, then one of these voltage inputs could be used to connect an external zero-sequence voltage input. In such an application, the setting EXT3V0_X must also be set accordingly. Refer to *Section 4: Protection and Logic Functions* for more details.

Table 1.1 Current (ACI) and Voltage (AVI) Card Selection for SEL-700G Models

Model	Description	Slot Z Card (MOT Digits)	Slot Z Inputs	Slot E Card (MOT Digits)	Slot E Inputs
700G0	Basic generator protection	4 ACI/3 AVI (81, 82, 85, 86)	IAX, IBX, ICX, IN, VAX, VBX, VCX	(OX)	
700G0+	Basic generator protection plus (see *Table 1.2* for additional protection elements)	4 ACI/3 AVI (81, 82, 85, 86)	IAX, IBX, ICX, IN, VAX, VBX, VCX	2 AVI (74)	VS, VN
700G1	Full generator protection	4 ACI/3 AVI (81, 82, 85, 86)	IAX, IBX, ICX, IN, VAX, VBX, VCX	3 ACIE (73, 77)	IAY, IBY, ICY
700G1+	Full generator protection plus (see *Table 1.2* for additional protection elements)	4 ACI/3 AVI (81, 82, 85, 86)	IAX, IBX, ICX, IN, VAX, VBX, VCX	3 ACI/2 AVI (72, 76)	IAY, IBY, ICY, VS, VN
700GT	Intertie protection	1 ACI (84, 88)	IN	3 ACI/4 AVI (71, 75)	IAY, IBY, ICY, VS, VAY, VBY, VCY
700GT+	Intertie and generator protection	4 ACI/3 AVI (81, 82, 85, 86)	IAX, IBX, ICX, IN, VAX, VBX, VCX	3 ACI/4 AVI (71, 75)	IAY, IBY, ICY, VS, VAY, VBY, VCY
700GW	Basic wind generator protection	3 ACIZ (83, 87)	IAX, IBX, ICX	3 ACIE (73, 77)	IAY, IBY, ICY

The SEL-700G offers an extensive variety of protection features, depending on the model and options selected. *Table 1.2* lists the protection features available in different models. Elements using X-side inputs have an 'X' added to them. For example, phase overcurrent elements using X-side CT inputs are designated as 50PX while phase overcurrent elements using Y-side CT inputs are designated as 50PY.

Table 1.2 SEL-700G Protection Elements (Sheet 1 of 3)

Protection Elements		Basic Generator Protection	Basic With			Intertie Protection	Intertie and Generator Protection	Wind Generator Protection
			21C, 25, 64G, 78	21C, 78, 87	21C, 25, 64G, 78, 87			
		700G0	700G0+	700G1	700G1+	700GT	700GT+	700GW
87	Phase Differential			X	X			
87N	Ground Differential	X	X	X	X		X	
REF	Restricted Earth Fault	X	X	X	X		X	
64G	100% Stator Ground		X		X			
64F	Field Ground	X	X	X	X		X	X
40	Loss of Field	X	X	X	X		X	
49T	Thermal Overload	X	X	X	X		X	
49RTD	RTDs	X	X	X	X	X	X	X
46	Current Unbalance	X	X	X	X		X	
24	Volts/Hz	X	X	X	X		X	
78	Out of Step		X	X	X			
78VS	Vector Shift	X	X	X	X	X	X	
INAD	Inadvertent Energization	X	X	X	X		X	
21C	Compensator Distance		X	X	X			
51C	Voltage-Controlled TOC	X	X	X	X		X	

Table 1.2 SEL-700G Protection Elements (Sheet 2 of 3)

Protection Elements		Basic Generator Protection	Basic With 21C, 25, 64G, 78	Basic With 21C, 78, 87	Basic With 21C, 25, 64G, 78, 87	Intertie Protection	Intertie and Generator Protection	Wind Generator Protection
		700G0	700G0+	700G1	700G1+	700GT	700GT+	700GW
51V	Voltage-Restrained TOC	X	X	X	X		X	
51PX	Phase Time-Overcurrent							X
51PY	Phase Time-Overcurrent					X[a]	X[a]	X
51QX	Neg.-Seq. Time-Overcurrent							X
51QY	Neg.-Seq. Time-Overcurrent					X[a]	X[a]	X
51GX	Ground Time-Overcurrent	X[a]	X[a]	X[a]	X[a]		X[a]	X
51GY	Ground Time-Overcurrent					X[a]	X[a]	X
51N	Neutral Time-Overcurrent	X[a]	X[a]	X[a]	X[a]	X	X[a]	
50PX	Phase Overcurrent	X	X	X	X		X	X
50PY	Phase Overcurrent			X	X	X	X	X
67PY	Directional Phase Overcurrent					X	X	
50QX	Neg.-Seq. Overcurrent	X	X	X	X		X	X
50QY	Neg.-Seq. Overcurrent			X	X	X	X	X
67QY	Directional Neg.-Seq. Overcurrent					X	X	
50GX	Ground Overcurrent	X	X	X	X		X	X
67GX	Directional Ground Overcurrent	X	X	X	X		X	
50GY	Ground Overcurrent			X	X	X	X	X
67GY	Directional Ground Overcurrent					X	X	
50N	Neutral Overcurrent	X[b]	X[b]	X[b]	X[b]	X	X[b]	
67N	Directional Neutral Overcurrent	X	X	X	X		X	
27X	Undervoltage	X	X	X	X		X	
27Y	Undervoltage					X	X	
27S	Synchronism Undervoltage		X		X	X	X	
27I	Inverse-Time Undervoltage[c]	X	X	X	X	X	X	
59X	Overvoltage (P, Q, G)	X	X	X	X		X	
59Y	Overvoltage (P, Q, G)					X	X	
59S	Synchronism Overvoltage		X		X	X	X	
59I	Inverse-Time Overvoltage[d]	X	X	X	X	X	X	
32X	Directional Power	X	X	X	X		X	
32Y	Directional Power					X	X	
81X	Over/Underfrequency	X	X	X	X		X	
81Y	Over/Underfrequency					X	X	
81RX	Rate-of-Change of Frequency	X	X	X	X		X	
81RY	Rate-of-Change of Frequency					X	X	
BFX	Breaker Failure	X	X	X	X		X	X
BFY	Breaker Failure					X	X	X
60LOPX	Loss of Potential	X	X	X	X		X	

Table 1.2 SEL-700G Protection Elements (Sheet 3 of 3)

Protection Elements		Basic Generator Protection	Basic With 21C, 25, 64G, 78	Basic With 21C, 78, 87	Basic With 21C, 25, 64G, 78, 87	Intertie Protection	Intertie and Generator Protection	Wind Generator Protection
		700G0	700G0+	700G1	700G1+	700GT	700GT+	700GW
60LOPY	Loss of Potential					X	X	
25 X	Synchronism Check		X		X		X	
25 Y	Synchronism Check					X	X	
	Autosynchronizer		X		X		X	
	Off-Frequency Accumulators	X	X	X	X		X	

[a] These inverse time-overcurrent elements have directional control.
[b] The 50N element uses the 67NnP and 67NnT Relay Word bits for the SEL-700G0, SEL-700G0+, SEL-700G1, SEL-700G1+, and SEL-700GT+ models.
[c] Two elements are available (select X- and/or Y-side phase, phase-to-phase, positive sequence, or synchronism voltage VS, depending on the part number).
[d] Two elements are available (select X- and/or Y-side phase, phase-to-phase, residual, positive sequence, negative sequence, neutral voltage VN, or synchronism voltage VS, depending on the part number).

Generator Protection Element Selection

The SEL-700G provides protection elements suitable for applications protecting many different generators. Use *Table 1.3* to select the protection elements to enable for specific applications.

Table 1.3 Recommended Protection Elements by Generator Grounding Method (Sheet 1 of 2)

Element/Function	High-Impedance Grounded	Resistance Grounded	Solidly Grounded
21 Backup Element Compensator Distance (DC)	Available[a]	Available[a]	Available[a]
24 Volts/Hertz Element	Recommended	Recommended	Recommended
27 Undervoltage	Optional	Optional	Optional
32 Reverse/Low-Forward Power	Recommended	Recommended	Recommended
40 Loss-of-Field	Recommended	Recommended	Recommended
46 Negative-Sequence Overcurrent	Recommended	Recommended	Recommended
50N/51N Neutral Overcurrent	Suggested[b]	Suggested[b]	Recommended
50P Phase Overcurrent	Not Recommended	Not Recommended	Recommended
51C/51V Voltage-Controlled and Voltage-Restrained Time-Overcurrent	Available[a]	Available[a]	Available[a]
59 Overvoltage	Optional	Optional	Optional
64G 100% Stator Ground Elements	Recommended	Suggested[c]	Not Recommended
78 Out-of-Step	Recommended	Recommended	Recommended
81 Over- and Underfrequency Elements	Recommended	Recommended	Recommended
81 AC Abnormal Frequency Scheme	Available	Available	Available

Table 1.3 Recommended Protection Elements by Generator Grounding Method (Sheet 2 of 2)

Element/Function	High-Impedance Grounded	Resistance Grounded	Solidly Grounded
87 Current Differential Elements	Suggested for Large Machines	Optional	Optional
87N Ground Differential Element	Not Recommended	Suggested[b]	Suggested[b]

[a] Select no more than one of 21DC, 51C, or 51V elements for backup protection.
[b] If neutral CT is available.
[c] If neutral PT is available.

Front-Panel Options

The SEL-700G offers two front-panel HMI layouts that are model and option dependent. *Table 1.4* lists the HMI options for the SEL-700G front panel. For ordering options, refer to the SEL-700G MOT.

Table 1.4 SEL-700G Front-Panel Options

Model/Display Description	Front-Panel Option (MOT String Digit Number 17)	Number of Pushbuttons	LED Type
SEL-700G With Two-Line Display (2 x 16 characters)	0/1	8	Tricolor
SEL-700G With Touchscreen Display (5-inch, color, 800 x 480 pixels)	A/B	8	Tricolor

Monitoring Features

- Event summaries that contain relay ID, date and time, trip cause, and current/voltage magnitudes
- Event reports including filtered and raw analog data
- Sequential Events Recorder (SER)
- Compatibility with SEL-3010 Event Messenger
- A complete suite of accurate metering functions
- Generator operating statistics monitoring
- Breaker wear monitoring
- Load profile report
- Generator automatic synchronization report

Communications and Control Features

- EIA-232, front-panel port
- EIA-232, EIA-485, single or dual, copper or fiber-optic Ethernet, and fiber-optic rear panel EIA-232 ports
- Built-in Web Server
- IRIG-B time-code input
- Modbus RTU slave, Modbus TCP/IP, DNP3 serial, DNP3 LAN/WAN, Ethernet FTP, Telnet, Simple Network Time Protocol (SNTP), IEEE-1588-2008 firmware-based Precision Time Protocol (PTP), MIRRORED BITS, IEC 61850 Edition 2, IEC 60870-5-103, DeviceNet, EtherNet/IP, Synchrophasors with C37.118 Protocol, Parallel Redundancy Protocol (PRP), and Rapid Spanning Tree Protocol (RSTP)
- SEL ASCII, Compressed ASCII, Fast Meter, Fast Operate, Fast SER, and Fast Message Protocols
- Programmable Boolean and math operators, logic functions, and analog compare

Language Support

- The standard relay front-panel overlay is in English; a Spanish overlay is available as an ordering option. Text displayed on the HMI display will correspond to the ENGLISH or SPANISH ordering option.
- All of the ASCII commands can be displayed in multiple languages (English or Spanish). When you set the port setting LANG to either ENGLISH or SPANISH (see *Table 4.83*), the SEL-700G displays the ASCII commands in the corresponding language.

Models, Options, and Accessories

Models

Complete ordering information is not provided in this instruction manual. See the latest SEL-700G Model Option Table at selinc.com/products/, on the SEL-700G product page under Documentation > Ordering Information. Options and accessories are listed below.

SEL-700G Base Unit

- Front panel with large LCD
  - Eight programmable pushbuttons, each with two tricolor LEDs
  - Eight target tricolor LEDs (six programmable)
  - Operator control interface
  - Front EIA-232 port
- Power supply card with two digital inputs and three digital outputs (Slot **A**)
- Processor and communications card (Slot **B**)
  - EIA-232 serial port with IRIG-B time-code input
- Three expansion slots for optional cards (Slots **C**, **D**, **E**)
- Current/Voltage inputs card (Slots **Z** and **E**)
- Protocols
  - Modbus RTU
  - SEL ASCII and Compressed ASCII
  - SEL Fast Meter, Fast Operate, Fast SER, Fast Message
  - Ymodem File Transfer
  - SEL MIRRORED BITS
  - Event Messenger
  - Synchrophasors With C37.118
- Breaker Wear Monitoring

Options

- SEL-700G0, SEL-700G1 for Generator Protection
- SEL-700GT for Intertie and Generator Protection
- SEL-700GW for Wind Generator Protection
- Current/Voltage Input Options (see *Table 1.1*)
- Input/Output (I/O) Options
  - Additional digital I/O (4 DI/4 DO, 4 DI/3 DO, 8 DI, 8 DO, 3 DI/4 DO/1 AO, 14 DI)
  - Additional analog I/O (4 AI/4 AO)
  - 10 RTD inputs

- Front-panel HMI Options (see *Table 1.4*)
- Communications Options (Protocols/Ports)
  - EIA-485/EIA-232/Ethernet ports (single/dual, copper or fiber-optic)
  - Modbus TCP/IP
  - DeviceNet (**Note:** This option has been discontinued and is no longer available as of September 25, 2017.)
  - IEC 61850 Edition 2
  - IEC 60870-5-103
  - DNP3 serial and LAN/WAN
  - SNTP
  - PTP (firmware-based)
  - EtherNet/IP
  - PRP
  - RSTP
- Language Options
  - The relay supports English or Spanish language as an ordering option
- Conformal coating for chemically harsh and/or high-moisture environments

Accessories

Contact your Technical Service Center or the SEL factory for additional detail and ordering information for the following accessories:

- External RTD protection
  - SEL-2600 RTD Module (with ST option only)
  - A simplex 62.5/200 µm fiber-optic cable with ST connector for connecting the external RTD module to the multimode fiber-optic serial port of the SEL-700G
- SEL-2505 Remote I/O Module (with SEL-2812 compatible ST fiber-optic port) for connection to relay fiber-optic serial Port 2, or use SEL-2505 with EIA-232 (DB-9) serial port to connect to EIA-232 Port 3 on the relay
- SEL-2664S Stator Ground Protection Relay
- SEL-2664 Field Ground Module
  - SEL-2664 Field Ground Module on the EIA-232 port using an SEL-2812M or SEL-2814M for ST connectors; SEL-2664 requires the PROTO setting to be set to SEL protocol at a data rate of 9600 bps
  - SEL-2664 Field Ground Module on the EIA-485 port using an SEL-2824 Fiber-Optic Transceiver for ST connectors; SEL-2664 requires the PROTO setting to be set to SEL protocol at a data rate of 9600 bps
  - SEL-2664 Field Ground Module on multimode fiber-optic serial Port 2 for ST connectors; SEL-2664 requires the PROTO setting to be set to SEL protocol at a data rate of 9600 bps
- SEL-700G Configurable Labels

- Rack-Mounting Kits
  - For one relay
  - For two relays
  - For one relay and a test switch
- Wall-Mounting Kits
- Bezels for Retrofit
- Replacement Euro Connector Kit
- Ring Terminal Kit (for all relay connections)
- Dust Protection Kit
- Relay Wire Termination Kits (see *Application Note AN2014-08*)
- IP20 terminal block covers

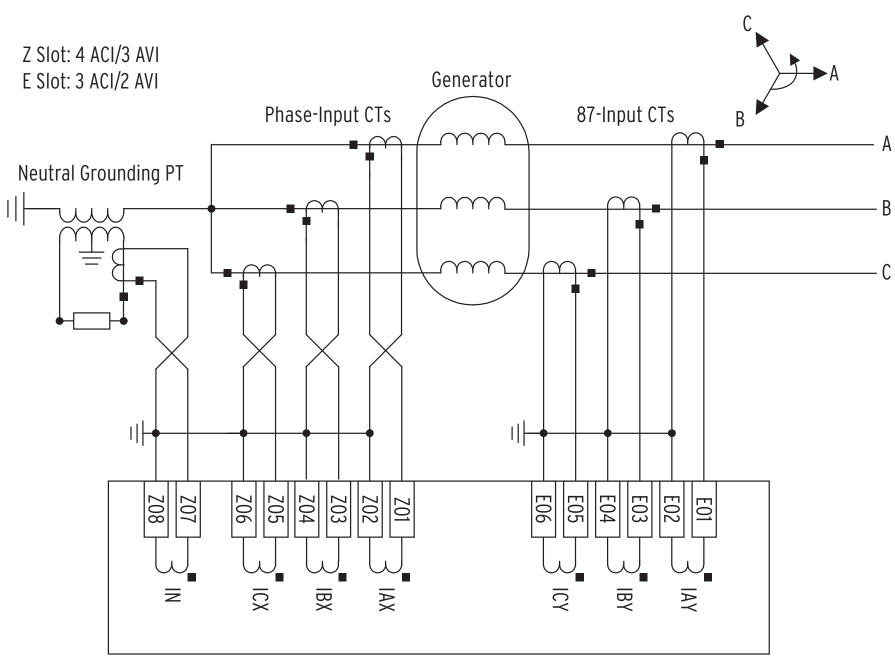
For all SEL-700G mounting accessories for competitor products, including adapter plates, visit selinc.com/app/mounting-selector/.

Applications

Section 2: Installation includes ac and dc connection diagrams for various applications. The following is a list of possible application scenarios:

- Small to large generator protection
- Intertie or intertie and generator protection
- Multiple wind generator feeder protection
- With or without external RTD Module (SEL-2600)
- With or without external Field Ground Module (SEL-2664)

Figure 1.1 shows typical current connections for an SEL-700G1 application. Refer to *Section 2: Installation* for additional applications and the related connection diagrams.



The current transformers and the SEL-700G chassis must be grounded in the relay cabinet.

Figure 1.1 Typical Current Connections

Getting Started

Understanding basic relay operation principles and methods will help you use the SEL-700G effectively. This section presents the fundamental knowledge you need to operate the SEL-700G, organized by task. These tasks help you become familiar with the relay and include the following:

- ➤ *Powering the Relay*
- ➤ *Establishing Communication*
- ➤ *Checking the Relay Status*
- ➤ *Setting the Date and Time*

Perform these tasks to gain a fundamental understanding of the relay operation.

Powering the Relay

Power the SEL-700G with 110–240 Vac, 110–250 Vdc, or 24–48 Vdc, depending on the part number.

- ➤ Observe proper polarity, as indicated by the **+/H** (terminal **A01**) and the **–/N** (terminal **A02**) on the power connections.
- ➤ Connect the ground lead; see *Serial Ports on page 2.22*.
- ➤ Once connected to power, the relay does an internal self-check and the **ENABLED** LED illuminates.

Establishing Communication

The SEL-700G has two EIA-232 serial communications ports. The following steps require PC terminal emulation software and an SEL-C234A Cable (or equivalent) to connect the SEL-700G to the PC. See *Section 7: Communications* for further information on serial communications connections and the necessary cable pinout.

Step 1. Connect the PC and the SEL-700G using the serial communications cable.

Step 2. Apply power to both the PC and the relay.

Step 3. Start the PC terminal emulation program.

Step 4. Set the PC terminal emulation program to the communications port settings listed in the Default Value column of *Table 1.5*. Also, set the terminal program to emulate either VT100 or VT52 terminals.

Step 5. Press the **<Enter>** key on the PC keyboard to check the communications link.

You will see the = prompt at the left side of the computer screen (Column 1).

If you do not see the = prompt, check the cable connections and confirm that the settings in the terminal emulation program are the default values in *Table 1.5*.

Table 1.5 SEL-700G Serial Port Settings

Description	Setting Label	Default Value
SPEED	SPEED	9600
DATA BITS	BITS	8
PARITY	PARITY	N
STOP BITS	STOP	1
PORT TIMEOUT	T_OUT	5
HWDR HANDSHAKING	RTSCTS	N

Step 6. Type **QUIT <Enter>** to view the relay report header.

You will see a computer screen display similar to *Figure 1.2*. If you see jumbled characters, change the terminal emulation type in the PC terminal emulation program.

```
=>QUIT <Enter>

SEL-700GT                    Date: 02/23/2010   Time: 12:01:27.609
INTERTIE RELAY               Time Source: Internal

=
```

Figure 1.2 Response Header

Step 7. Type **ACC <Enter>** and the appropriate password (see *Table 7.41* for factory-default passwords) to go to Access Level 1.

Checking the Relay Status

Use the **STA** serial port command to view the SEL-700G operational status. Analog channel dc offset and monitored component status are listed in the status report depicted in *Figure 1.3*.

```
=>>STA <Enter>

SEL-700GT                                 Date: 02/23/2010   Time: 13:21:15.339
INTERTIE RELAY                            Time Source: Internal

Serial Num = 000000000000000
FID = SEL-700G-X133-V0-Z001001-D20100219                CID = 7170
PART NUM = 0700GT1B0X0X7181063X

Self Tests (W=Warn)
  FPGA  GPSB  HMI   RAM   ROM   CR_RAM  NON_VOL  CLOCK  CID_FILE  +0.9V  +1.2V
  OK    OK    OK    OK    OK    OK      OK       OK     OK        0.90   1.21

  +1.5V  +1.8V  +2.5V  +3.3V  +3.75V  +5.0V  -1.25V  -5.0V   BATT
  1.51   1.82   2.49   3.35   3.75    4.98   -1.25   -5.20   2.96

Option Cards
  CARD_C  CARD_D  CARD_E  CARD_Z
  OK      OK      OK      OK

Offsets (mV) W=Warn
  IAX   IBX   ICX   IAY   IBY   ICY    IN   VAX   VBX   VCX   VAY   VBY   VCY
  12    10    11    3     3     8     -28   -12   -7    -12   -5    -4    -7

   VS
  -2

  Relay Enabled

=>>
```

Figure 1.3 STA Command Response—No Communications Card or EIA-232/EIA-485 Communications Card

If a communications card with the DeviceNet protocol is present, the status report depicted in *Figure 1.4* applies.

```
=>STA <Enter>

SEL-700GT                                 Date: 02/23/2010   Time: 13:20:24.983
INTERTIE RELAY                            Time Source: Internal

Serial Num = 000000000000000
FID = SEL-700G-X133-V0-Z001001-D20100219              CID = 7170
PART NUM = 0700GT1BA30X7181063X

Self Tests (W=Warn)
  FPGA  GPSB  HMI   RAM   ROM   CR_RAM  NON_VOL  CLOCK  CID_FILE  +0.9V  +1.2V
  OK    OK    OK    OK    OK    OK      OK       OK     OK        0.90   1.21

  +1.5V  +1.8V  +2.5V  +3.3V  +3.75V  +5.0V  -1.25V  -5.0V   BATT
  1.51   1.82   2.49   3.35   3.75    4.98   -1.25   -5.21   2.96

Option Cards
  CARD_C  CARD_D  CARD_E  CARD_Z
  OK      OK      OK      OK

DeviceNet
  DN_MAC_ID     ASA       DN_RATE   DN_STATUS
  3          1a0d c1e9h  AUTO      0000 0000

Offsets (mV) W=Warn
  IAX   IBX   ICX   IAY   IBY   ICY    IN   VAX   VBX   VCX   VAY   VBY   VCY
  12    10    11    3     3     8     -28   -12   -7    -12   -5    -4    -7

   VS
  -2

  Relay Enabled

=>>
```

Figure 1.4 STA Command Response—Communications Card/DeviceNet Protocol

Table 7.54 provides the definition of each status report designator. The beginning of the status report printout (see *Figure 1.3*) contains the relay serial number, relay part number, firmware identification (FID) string and checksum (CID) string. These strings uniquely identify the relay and the version of the operating firmware.

Setting the Date and Time

DAT (Date Command)

Viewing the Date

Type **DAT <Enter>** at the prompt to view the date stored in the SEL-700G. If the date stored in the relay is July 29, 2009, and the DATE_F setting is MDY, the relay will reply:

```
7/29/2009
```

If the DATE_F setting is YMD, the relay will reply:

```
2009/7/29
```

If the DATE_F setting is DMY, the relay will reply:

```
29/7/2009
```

Changing the Date

Type **DAT** followed by the correct date at the prompt to change the date stored in the relay. For example, to change the date to May 2, 2009 (DATE_F = MDY), enter the following at the action prompt:

```
DAT 5/2/09
```

You can separate the month, day, and year parameters with spaces, commas, slashes, colons, and semicolons.

TIM (Time Command)

Viewing the Time

Enter **TIM** at the prompt to view the time stored in the SEL-700G. The relay will reply with the stored time. For example

```
13:52:44
```

This time is 1:52 p.m. (and 44 seconds).

Changing the Time

Enter **TIM** followed by the correct time at the action prompt to change the time stored in the relay. For example, to change the time to 6:32 a.m., enter the following at the prompt:

```
TIM 6:32:00
```

You can separate the hours, minutes, and seconds parameters with spaces, commas, slashes, colons, and semicolons.

Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

47 CFR 15B, Class A

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

CE Mark in accordance with the requirements of the European Union

RCM Mark in accordance with the requirements of Australia

UKCA Mark in accordance with the requirements of United Kingdom

Normal Locations

UL Listed to U.S. and Canadian safety standards (File E212775, NRGU, NRGU7)

Hazardous Locations

UL Certified Hazardous Locations to U.S. and Canadian standards CL I, DIV 2; GP A, B, C, D; T3C, maximum surrounding temperature of 50°C (File E470448)

EU

SEL 19 ATEX 0001X
II 3 G
Ex ec nC IIC T3 Gc

EN 60079-0:2012 + A11:2013, EN 60079-7:2015, EN 60079-15:2010, EN 60079-11:2012

Ambient air temperature shall not exceed –20°C ≤ Ta ≤ 50°C

Note: Where so marked, ATEX and UL Hazardous Locations Certification tests are applicable to rated supply specifications only and do not apply to the absolute operating ranges, continuous thermal, or short circuit duration specifications.

General

AC Current Input

Phase and Neutral Currents

I_{NOM} = 1 A or 5 A secondary depending on the model

Measurement Category:	II

I_{NOM} = 5 A

Continuous Rating:	3 • I_{NOM} @ 85°C 4 • I_{NOM} @ 55°C
A/D Measurement Limit:	217 A peak (154 A rms) symmetrical
Saturation Current Rating:	Linear to 96 A symmetrical
1-Second Thermal:	500 A
Burden (per Phase):	<0.1 VA @ 5 A

I_{NOM} = 1 A

Continuous Rating:	3 • I_{NOM} @ 85°C 4 • I_{NOM} @ 55°C
A/D Measurement Limit:	43 A peak (31 A rms) symmetrical
Saturation Current Rating:	Linear to 19.2 A symmetrical
1-Second Thermal:	100 A
Burden (per Phase):	<0.01 VA @ 1 A

AC Voltage Inputs

V_{NOM} (L-L secondary) Range:	20–250 V (if DELTA_Y := DELTA) 20–440 V (if DELTA_Y := WYE)
Rated Continuous Voltage:	300 Vac
10-Second Thermal:	600 Vac
Burden:	<0.1 VA
Input Impedance:	2 MΩ single-ended (phase-to-neutral) 4 MΩ differential (phase-to-phase)

Power Supply

Relay Start-Up Time:	Approximately 5–10 seconds (after power is applied until the **ENABLED** LED turns on)

High-Voltage Supply

Rated Supply Voltage:	110–240 Vac, 50/60 Hz 110–250 Vdc
Input Voltage Range (Design Range):	85–264 Vac 85–275 Vdc
Power Consumption:	<50 VA (ac) <25 W (dc)
Interruptions:	50 ms @ 125 Vac/Vdc 100 ms @ 250 Vac/Vdc

Low-Voltage Supply

Rated Supply Voltage:	24–48 Vdc
Input Voltage Range (Design Range):	19.2–60 Vdc
Power Consumption:	<25 W (dc)
Interruptions:	10 ms @ 24 Vdc 50 ms @ 48 Vdc

Fuse Ratings

LV Power Supply Fuse

Rating:	3.15 A
Maximum Rated Voltage:	300 Vdc, 250 Vac
Breaking Capacity:	1500 A at 250 Vac
Type:	Time-lag T

HV Power Supply Fuse

Rating:	3.15 A
Maximum Rated Voltage:	300 Vdc, 250 Vac
Breaking Capacity:	1500 A at 250 Vac
Type:	Time-lag T

Output Contacts

The relay supports Form A, B, and C outputs.

Dielectric Test Voltage:	2500 Vac
Impulse Withstand Voltage (U_{IMP}):	5000 V
Mechanical Durability:	100,000 no-load operations

Standard Contacts

Pickup/Dropout Time:	≤8 ms (coil energization to contact closure)

DC Output Ratings

Rated Operational Voltage:	250 Vdc
Rated Voltage Range:	19.2–275 Vdc
Rated Insulation Voltage:	300 Vdc
Make:	30 A @ 250 Vdc per IEEE C37.90
Continuous Carry:	6 A @ 70°C 4 A @ 85°C
1-Second Thermal:	50 A
Contact Protection:	360 Vdc, 115 J MOV protection across open contacts

Breaking Capacity (10,000 Operations) per IEC 60255-0-20:1974:

24 Vdc	0.75 A	L/R = 40 ms
48 Vdc	0.50 A	L/R = 40 ms
125 Vdc	0.30 A	L/R = 40 ms
250 Vdc	0.20 A	L/R = 40 ms

Cyclic (2.5 Cycles/Second) per IEC 60255-0-20:1974:

24 Vdc	0.75 A	L/R = 40 ms
48 Vdc	0.50 A	L/R = 40 ms
125 Vdc	0.30 A	L/R = 40 ms
250 Vdc	0.20 A	L/R = 40 ms

AC Output Ratings

Maximum Operational Voltage (U_e) Rating:	240 Vac
Insulation Voltage (U_i) Rating (excluding EN 61010-1):	300 Vac
1-Second Thermal:	50 A
Contact Rating Designation:	B300

B300 (5 A Thermal Current, 300 Vac Max)			
	Maximum Current		Max VA
Voltage	120 Vac	240 Vac	—
Make	30 A	15 A	3600
Break	3 A	1.5 A	360
PF < 0.35, 50–60 Hz			

Utilization Category: AC-15

AC-15		
Operational Voltage (Ue)	120 Vac	240 Vac
Operational Current (Ie)	3 A	1.5 A
Make Current	30 A	15 A
Break Current	3 A	1.5 A
Electromagnetic loads > 72 VA, PF < 0.3, 50–60 Hz		

Voltage Protection Across Open Contacts: 270 Vac, 115 J

Fast Hybrid (High-Speed, High-Current Interrupting)

DC Output Ratings

Rated Operational Voltage:	250 Vdc
Rated Voltage Range:	19.2–275 Vdc
Rated Insulation Voltage:	300 Vdc
Make:	30 A @ 250 Vdc per IEEE C37.90
Continuous Carry:	6 A @ 70°C 4 A @ 85°C
1-Second Thermal:	50 A
Open State Leakage Current:	<500 µA
MOV Protection (Maximum Voltage):	250 Vac/330 Vdc
Pickup Time:	<50 µs, resistive load
Dropout Time:	≤8 ms, resistive load

Break Capacity (10,000 Operations) per IEC 60255-0-20:1974:

48 Vdc	10.0 A	L/R = 40 ms
125 Vdc	10.0 A	L/R = 40 ms
250 Vdc	10.0 A	L/R = 20 ms

Cyclic Capacity (4 Cycles in 1 Second, Followed by 2 Minutes Idle for Thermal Dissipation) per IEC 60255-0-20:1974:

48 Vdc	10.0 A	L/R = 40 ms
125 Vdc	10.0 A	L/R = 40 ms
250 Vdc	10.0 A	L/R = 20 ms

AC Output Ratings

See *AC Output Ratings* for *Standard Contacts*.

Optoisolated Control Inputs

When Used With DC Control Signals

Pickup/Dropout Time:	Depends on the input debounce settings
250 V:	ON for 200–312.5 Vdc OFF below 150 Vdc
220 V:	ON for 176–275 Vdc OFF below 132 Vdc
125 V:	ON for 100–156.2 Vdc OFF below 75 Vdc
110 V:	ON for 88–137.5 Vdc OFF below 66 Vdc
48 V:	ON for 38.4–60 Vdc OFF below 28.8 Vdc
24 V:	ON for 15–30 Vdc OFF for <5 Vdc

When Used With AC Control Signals

Pickup Time:	2 ms
Dropout Time:	16 ms
250 V:	ON for 170.6–312.5 Vac OFF below 106 Vac
220 V:	ON for 150.2–275 Vac OFF below 93.3 Vac
125 V:	ON for 85–156.2 Vac OFF below 53 Vac
110 V:	ON for 75.1–137.5 Vac OFF below 46.6 Vac
48 V:	ON for 32.8–60 Vac OFF below 20.3 Vac
24 V:	ON for 14–30 Vac OFF below 5 Vac
Current Draw at Nominal DC Voltage:	2 mA (at 220–250 V) 4 mA (at 48–125 V) 10 mA (at 24 V)
Rated Impulse Withstand Voltage (U_{imp}):	4000 V

Analog Output (Optional)

	1A0	4A0
Current:	4–20 mA	±20 mA
Voltage:	—	±10 V
Load at 1 mA:	—	0–15 kΩ
Load at 20 mA:	0–300 Ω	0–750 Ω
Load at 10 V:	—	>2000 Ω
Refresh Rate:	100 ms	100 ms
% Error, Full Scale, at 25°C:	<±1%	<±0.55%
Select From:	Analog quantities available in the relay	

Analog Input (Optional)

Maximum Input Range:	±20 mA ±10 V Operational range set by user
Input Impedance:	200 Ω (current mode) >10 kΩ (voltage mode)
Accuracy at 25°C	
With user calibration:	0.050% of full scale (current mode) 0.025% of full scale (voltage mode)
Without user calibration:	Better than 0.5% of full scale at 25°C
Accuracy Variation With Temperature:	±0.015% per °C of full scale (±20 mA or ±10 V)

Frequency and Phase Rotation

System Frequency:	50, 60 Hz
Phase Rotation:	ABC, ACB
Frequency Tracking:	15–70 Hz

Time-Code Input

Format:	Demodulated IRIG-B
On (1) State:	$V_{ih} \geq 2.2$ V
Off (0) State:	$V_{il} \leq 0.8$ V
Input Impedance:	2 kΩ

Synchronization Accuracy

Internal Clock:	±1 µs
Synchrophasor Reports (e.g., MET PM):	±10 µs
All Other Reports:	±5 ms
SNTP Accuracy:	±1 ms (in an ideal network)
PTP Accuracy:	±1 ms
Unsynchronized Clock Drift Relay Powered:	2 minutes per year, typically

Communications Ports

Standard EIA-232 (2 Ports)

Location:	Front Panel Rear Panel
Data Speed:	300–38400 bps

EIA-485 Port (Optional)

Location:	Rear Panel
Data Speed:	300–19200 bps

Ethernet Port (Optional)

Single/Dual 10/100BASE-T copper (RJ45 connector)
Single/Dual 100BASE-FX (LC connector)

Standard Multimode Fiber-Optic Port

Location:	Rear Panel
Data Speed:	300–38400 bps

Fiber-Optic Ports Characteristics

Port 1 (or 1A, 1B) Ethernet

Wavelength:	1300 nm
Optical Connector Type:	LC
Fiber Type:	Multimode
Link Budget:	16.1 dB
Typical TX Power:	–15.7 dBm
RX Min. Sensitivity:	–31.8 dBm
Fiber Size:	62.5/125 µm
Approximate Range:	~6.4 km
Data Rate:	100 Mbps
Typical Fiber Attenuation:	–2 dB/km

Port 2 Serial

Wavelength:	820 nm
Optical Connector Type:	ST
Fiber Type:	Multimode
Link Budget:	8 dB
Typical TX Power:	–16 dBm
RX Min. Sensitivity:	–24 dBm
Fiber Size:	62.5/125 µm
Approximate Range:	~1 km
Data Rate:	5 Mbps
Typical Fiber Attenuation:	–4 dB/km

Optional Communications Cards

Option 1:	EIA-232 or EIA-485 communications card
Option 2:	DeviceNet communications card

Communications Protocols

SEL, Modbus, DNP, FTP, TCP/IP, Telnet, SNTP, IEEE 1588-2008 firmware-based PTP, IEC 61850 Edition 2, IEC 60870-5-103, PRP, IEEE 802.1Q-2014 Rapid Spanning Tree Protocol (RSTP). MIRRORED BITS, EVMSG, EtherNet/IP, C37.118 (synchrophasors), and DeviceNet

Operating Temperature

IEC Performance Rating:	–40° to +85°C (–40° to +185°F) (per IEC/EN 60068-2-1 and 60068-2-2)

NOTE: Not applicable to UL applications
NOTE: The front-panel display is impaired for temperatures below –20°C and above +70°C

DeviceNet Communications Card Rating:	+60°C (140°F) maximum
Optoisolated Control Inputs:	As many as 26 inputs are allowed in ambient temperatures of 85°C or less. As many as 34 inputs are allowed in ambient temperatures of 75°C or less. As many as 44 inputs are allowed in ambient temperatures of 65°C or less.

Operating Environment

Insulation Class:	I
Pollution Degree:	2
Overvoltage Category:	II
Atmospheric Pressure:	80–110 kPa
Relative Humidity:	5%–95%, noncondensing
Maximum Altitude Without Derating (Consult the Factory for Higher Altitude Derating):	2000 m

Dimensions

144.0 mm (5.67 in) x 192.0 mm (7.56 in) x 147.4 mm (5.80 in)

Weight

2.7 kg (6.0 lb)

Relay Mounting Screw (#8–32) Tightening Torque

Minimum:	1.4 Nm (12 in-lb)
Maximum:	1.7 Nm (15 in-lb)

Terminal Connections

Terminal Block

Screw Size:	#6
Ring Terminal Width:	0.310 inch maximum

Terminal Block Tightening Torque

Minimum:	0.9 Nm (8 in-lb)
Maximum:	1.4 Nm (12 in-lb)

Compression Plug Tightening Torque

Minimum:	0.5 Nm (4.4 in-lb)
Maximum:	1.0 Nm (8.8 in-lb)

Compression Plug Mounting Ear Screw Tightening Torque

Minimum:	0.18 Nm (1.6 in-lb)
Maximum:	0.25 Nm (2.2 in-lb)

Product Standards

Electromagnetic Compatibility:	IEC 60255-26:2013 IEC 60255-27:2013 UL 508 CSA C22.2 No. 14-05

Type Tests

Environmental Tests

Enclosure Protection:	IEC 60529:2001 + CRDG:2003 IP65 enclosed in panel (2-line display models) IP54 enclosed in panel (touchscreen display models) IP50 for terminals enclosed in the dust protection assembly (protection against solid foreign objects only) (SEL Part #915900170). The 10°C temperature derating applies to the temperature specifications of the relay. IP10 for terminals and the relay rear panel IP20 for terminals and the relay rear panel with optional terminal block cover
Vibration Resistance:	IEC 60255-21-1:1988 IEC 60255-27:2013, Section 10.6.2.1 Endurance: Class 2 Response: Class 2
Shock Resistance:	IEC 60255-21-2:1988 IEC 60255-27:2013, Section 10.6.2.2 IEC 60255-27:2013, Section 10.6.2.3 Withstand: Class 1 Response: Class 2 Bump: Class 1
Seismic (Quake Response):	IEC 60255-21-3:1993 IEC 60255-27:2013, Section 10.6.2.4 Response: Class 2
Cold:	IEC 60068-2-1:2007 IEC 60255-27:2013, Section 10.6.1.2 IEC 60255-27:2013, Section 10.6.1.4 –40°C, 16 hours
Dry Heat:	IEC 60068-2-2:2007 IEC 60255-27:2013, Section 10.6.1.1 IEC 60255-27:2013, Section 10.6.1.3 85°C, 16 hours
Damp Heat, Steady State:	IEC 60068-2-78:2001 IEC 60255-27:2013, Section 10.6.1.5 40°C, 93% relative humidity, 10 days
Damp Heat, Cyclic:	IEC 60068-2-30:2001 IEC 60255-27:2013, Section 10.6.1.6 25°–55°C, 6 cycles, 95% relative humidity
Change of Temperature:	IEC 60068-2-14:2009 IEC 60255-1:2010, Section 6.12.3.5 –40° to 85°C, ramp rate 1°C/min, 5 cycles

Dielectric Strength and Impulse Tests

Dielectric (HiPot):	IEC 60255-27:2013, Section 10.6.4.3 IEEE C37.90-2005 1.0 kVac on analog outputs, Ethernet ports 2.0 kVac on analog inputs, IRIG 2.5 kVac on contact I/O 3.6 kVdc on power supply, current, and voltage inputs
Impulse:	IEC 60255-27:2013, Section 10.6.4.2 0.5 J, 5 kV on power supply, contact I/O, ac current, and voltage inputs 0.5 J, 530 V on analog outputs IEEE C37.90:2005 0.5 J, 5 kV 0.5 J, 530 V on analog outputs

RFI and Interference Tests

EMC Immunity

Electrostatic Discharge Immunity:	IEC 61000-4-2:2008 IEC 60255-26:2013, Section 7.2.3 IEEE C37.90.3:2001 Severity Level 4 8 kV contact discharge 15 kV air discharge
Radiated RF Immunity:	IEC 61000-4-3:2010 IEC 60255-26:2013, Section 7.2.4 10 V/m IEEE C37.90.2-2004 20 V/m
Fast Transient, Burst Immunity[a]:	IEC 61000-4-4:2012 IEC 60255-26:2013, Section 7.2.5 4 kV @ 5.0 kHz 2 kV @ 5.0 kHz for comm. ports
Surge Immunity[a]:	IEC 61000-4-5:2005 IEC 60255-26:2013, Section 7.2.7 2 kV line-to-line 4 kV line-to-earth
Surge Withstand Capability Immunity[a]:	IEC 61000-4-18:2010 IEC 60255-26:2013, Section 7.2.6 2.5 kV common mode 1.0 kV differential mode 1.0 kV common mode on comm. ports IEEE C37.90.1-2012 2.5 kV oscillatory 4.0 kV fast transient
Conducted RF Immunity:	IEC 61000-4-6:2008 IEC 60255-26:2013, Section 7.2.8 10 Vrms
Magnetic Field Immunity:	IEC 61000-4-8:2009 IEC 60255-26:2013, Section 7.2.10 Severity Level: 1000 A/m for 3 seconds 100 A/m for 1 minute; 50/60 Hz IEC 61000-4-9:2001 Severity Level: 1000 A/m IEC 61000-4-10:2001 Severity Level: 100 A/m (100 kHz and 1 MHz)
Power Supply Immunity:	IEC 61000-4-11:2004 IEC 61000-4-17:1999 IEC 61000-4-29:2000 IEC 60255-26:2013, Section 7.2.11 IEC 60255-26:2013, Section 7.2.12 IEC 60255-26:2013, Section 7.2.13

EMC Emissions

Conducted Emissions:	IEC 60255-26:2013 Class A FCC 47 CFR Part 15.107 Class A Canada ICES-001 (A) / NMB-001 (A) EN 55011:2009 + A1:2010 Class A EN 55022:2010 + AC:2011 Class A EN 55032:2012 + AC:2013 Class A CISPR 11:2009 + A1:2010 Class A CISPR 22:2008 Class A CISPR 32:2015 Class A
Radiated Emissions:	IEC 60255-26:2013 Class A FCC 47 CFR Part 15.109 Class A Canada ICES-001 (A) / NMB-001 (A) EN 55011:2009 + A1:2010 Class A EN 55022:2010 + AC:2011 Class A EN 55032:2012 + AC:2013 Class A CISPR 11:2009 + A1:2010 Class A CISPR 22:2008 Class A CISPR 32:2015 Class A

Processing Specifications and Oscillography

AC Voltage and Current Inputs:	32 samples per power system cycle
Analog Inputs:	4 samples per power system cycle
Frequency Tracking Range:	15–70 Hz
Digital Filtering:	One-cycle cosine after low-pass analog filtering. Net filtering (analog plus digital) rejects dc and all harmonics greater than the fundamental.
Protection and Control Processing:	Processing interval is 4 times per power system cycle (except for math variables and analog quantities, which are processed every 25 ms). The protection elements 40, 51, and 78 are processed twice per cycle. Analog quantities for rms data are determined through use of data averaged over the previous 8 cycles.

Oscillography

Length:	15, 64, 180 cycles
Sampling Rate:	32 samples per cycle unfiltered 4 samples per cycle filtered
Trigger:	Programmable with Boolean expression
Format:	ASCII and Compressed ASCII Binary COMTRADE (32 samples per cycle unfiltered)
Time-Stamp Resolution:	1 ms
Time-Stamp Accuracy:	±5 ms

Sequential Events Recorder

Time-Stamp Resolution:	1 ms
Time-Stamp Accuracy (With Respect to Time Source) for all RWBs except those corresponding to digital inputs (IN*xxx*):	±5 ms
Time-Stamp Accuracy (With Respect to Time Source) for RWBs corresponding to digital inputs (IN*xxx*):	1 ms

Relay Elements

Instantaneous/Definite Time-Overcurrent (50P, 50G, 50N, 50Q)

Pickup Setting Range, A secondary	
5 A models:	0.50–96.00 A, 0.01 A steps
1 A models:	0.10–19.20 A, 0.01 A steps
Accuracy:	±5% of setting plus ±0.02 • I_{NOM} A secondary (steady-state pickup)
Time Delay:	0.00–400.00 seconds, 0.01 seconds steps, ±0.5% plus ±0.25 cycle 0.10–400.00 seconds, 0.01 seconds steps, ±0.5% plus ±0.25 cycle for 50Q
Pickup/Dropout Time:	<1.5 cycle

Inverse-Time Overcurrent (51P, 51G, 51N, 51Q)

Pickup Setting Range, A secondary	
5 A models:	0.50–16.00 A, 0.01 A steps
1 A models:	0.10–3.20 A, 0.01 A steps
Accuracy:	±5% of setting plus ±0.02 • I_{NOM} A secondary (steady-state pickup)
Time Dial	
US:	0.50–15.00, 0.01 steps
IEC:	0.05–1.00, 0.01 steps
Accuracy:	±1.5 cycles plus ±4% between 2 and 30 multiples of pickup (within rated range of current)

Differential (87)

Unrestrained Pickup Range:	1.0–20.0 in per unit of TAP
Restrained Pickup Range:	0.10–1.00 in per unit of TAP
Pickup Accuracy (A secondary)	
5 A Model:	±5% plus ±0.10 A
1 A Model:	±5% plus ±0.02 A
TAP Range (A secondary)	
5 A Model:	0.5–31.0 A
1 A Model:	0.1–6.2 A

Unrestrained Element

Pickup Time:	0.8/1.0/1.9 cycles (Min/Typ/Max)

Restrained Element (With Harmonic Blocking)

Pickup Time:	1.5/1.6/2.2 cycles (Min/Typ/Max)

Restrained Element (With Harmonic Restraint)

Pickup Time:	2.62/2.72/2.86 cycles (Min/Typ/Max)

Harmonics

Pickup Range (% of fundamental):	5%–100%
Pickup Accuracy (A secondary)	
5 A Model:	±5% plus ±0.10 A of harmonic current
1 A Model:	±5% plus ±0.02 A of harmonic current
Time Delay Accuracy:	±0.5% plus ±0.25 cycle

Restricted Earth Fault (REF)

Pickup Range (per unit of I_{NOM} of neutral current input, IN):	0.05–3.00 per unit, 0.01 per-unit steps
Pickup Accuracy (A secondary)	
5 A Model:	±5% plus ±0.10 A
1 A Model:	±5% plus ±0.02 A
Timing Accuracy	
Directional Output Maximum Pickup/Dropout Time:	1.75 cycles

ANSI Extremely Inverse TOC Curve (U4 With 0.5 Time Dial):	±5 cycles plus ±5% between 2 and 30 multiples of pickup (within rated range of current)

Undervoltage (27P, 27PP, 27V1, 27S)

Pickup Range:	Off, 2.0–300.0 V (2.0–520.0 V for phase-to-phase wye connected; 2.0–170.0 V positive-sequence, delta connected)
Accuracy:	±5% of setting plus ±2 V
Pickup/Dropout Time:	<1.5 cycle
Time Delay:	0.00–120.00 seconds, 0.01 second steps
Accuracy:	±0.5% plus ±0.25 cycle

Overvoltage (59P, 59PP, 59V1, 59S, 59Q, 59G)

Pickup Range:	Off, 2.0–300.0 V (2.0–520.0 V for phase-to-phase wye connected; 2.0–170.0 V positive sequence, delta connected)
Pickup Range (59G, 59Q):	Off, 2.0–200.0 V
Accuracy:	±5% of setting plus ±2 V
Pickup/Dropout Time:	<1.5 cycle
Time Delay:	0.00–120.00 seconds, 0.01 second steps
Accuracy:	±0.5% plus ±0.25 cycle

Inverse-Time Undervoltage (27I)

Setting Range:	OFF, 2.00–300.00 V (Phase elements, positive-sequence elements, phase-to-phase elements with delta inputs or synchronism voltage input) OFF, 2.00–520.00 V (Phase-to-phase elements with wye inputs)
Accuracy:	±1% of setting plus ±0.5 V
Time Dial:	0.00–16.00 s
Accuracy:	±1.5 cyc plus ±4% between 0.95 and 0.1 multiples of pickup

Inverse-Time Overvoltage (59I)

Setting Range:	OFF, 2.00–300.00 V (Phase elements, sequence elements, or phase-to-phase elements with delta inputs, neutral voltage input, or synchronism voltage input) OFF, 2.00–520.00 V (Phase-to-phase elements with wye inputs)
Accuracy:	±1% of setting plus ±0.5 V
Time Dial:	0.00–16.00 s
Accuracy:	±1.5 cyc plus ±4% between 1.05 and 5.5 multiples of pickup

Volts/Hertz (24)

Definite-Time Element

Pickup Range:	100%–200%
Steady-State Pickup Accuracy:	±1% of set point
Pickup Time:	25 ms @ 60 Hz (Max)
Time-Delay Range:	0.04–400.00 s
Time-Delay Accuracy:	±0.1% plus ±4.2 ms @ 60 Hz
Reset Time Range:	0.00–400.00 s

Inverse-Time Element

Pickup Range:	100%–200%
Steady-State Pickup Accuracy:	±1% of set point
Pickup Time:	25 ms @ 60 Hz (Max)
Curve:	0.5, 1.0, or 2.0
Factor:	0.1–10.0 s
Timing Accuracy:	±4% plus ±25 ms @ 60 Hz, for V/Hz above 1.2 multiple of pickup setting, and for operating times >4 s
Reset Time Range:	0.00–400.00 s

Composite-Time Element

Combination of Definite-Time and Inverse-Time specifications

User-Definable Curve Element

Pickup Range:	100%–200%
Steady-State Pickup Accuracy:	±1% of set point
Pickup Time:	25 ms @ 60 Hz (Max)
Reset Time Range:	0.00–400.00 s

Vector Shift (78VS)

Pickup Setting Range:	2.0°–30.0°, 0.1° increment
Accuracy:	±10% of the pickup setting, ±1 degree
Voltage Supervision Threshold:	20.0%–100.0% • VNOM
Pickup Time:	<3 cycles

Directional Power (32)

Instantaneous/Definite Time, 3 Phase Elements

Type:	+W, –W, +VAR, –VAR
Pickup Settings Range, VA secondary	
5 A Model:	1.0–6500.0 VA, 0.1 VA steps
1 A Model:	0.2–1300.0 VA, 0.1 VA steps
Accuracy:	±0.10 A • (L-L voltage secondary) and ±5% of setting at unity power factor for power elements and zero power factor for reactive power element (5 A nominal) ±0.02 A • (L-L voltage secondary) and ±5% of setting at unity power factor for power elements and zero power factor for reactive power element (1 A nominal)
Pickup/Dropout Time:	<10 cycles
Time Delay:	0.00–240.00 seconds, 0.01 second steps
Accuracy:	±0.5% plus ±0.25 cycle

Frequency (81)

Setting Range:	Off, 15.00–70.00 Hz
Accuracy:	±0.01 Hz (V1 > 60 V)
Pickup/Dropout Time:	<4 cycles
Time Delay:	0.00–400.00 seconds, 0.01 second steps
Accuracy:	±0.5% plus ±0.25 cycle

RTD Protection

Setting Range:	Off, 1°–250°C
Accuracy:	±2°C
RTD Open-Circuit Detection:	>250°C
RTD Short-Circuit Detection:	<–50°C
RTD Types:	PT100, NI100, NI120, CU10
RTD Lead Resistance:	25 ohm max. per lead
Update Rate:	<3 s
Noise Immunity on RTD Inputs:	To 1.4 Vac (peak) at 50 Hz or greater frequency
RTD Fault/Alarm/Trip Time Delay:	Approx. 12 s

Distance Element (21)

Two zones of compensator distance elements with load encroachment block

Reach Pickup Range:	5 A model: 0.1–100.0 ohms 1 A model: 0.5–500.0 ohms
Offset Range:	5 A model: 0.0–10.0 ohms 1 A model: 0.0–50.0 ohms
Steady-State Impedance Accuracy:	5 A model: ±5% plus ±0.1 ohm 1 A mode: ±5% plus ±0.5 ohm
Pickup Time:	33 ms at 60 Hz (Max)
Definite-Time Delay:	0.00–400.00 s
Accuracy:	±0.1% plus ±0.25 cycle
Minimum Phase Current:	5 A model: 0.5 A 1 A model: 0.1 A
Maximum Torque Angle Range:	90°–45°, 1° step

Loss-of-Field Element (40)

Two Mho Zones

Zone 1 Offset:	5 A model: –50.0 to 0.0 ohms 1 A model: –250.0 to 0.0 ohms
Zone 2 Offset:	5 A model: –50.0 to 50.0 ohms 1 A model: –250.0 to 250.0 ohms
Zone 1 and Zone 2 Diameter:	5 A model: 0.1–100.0 ohms 1 A model: 0.5–500.0 ohms
Steady-State Impedance Accuracy:	5 A model: ± 0.1 ohm plus ±5% of (offset + diameter) 1 A model: ±0.5 ohm plus ±5% of (offset + diameter)
Minimum Pos.-Seq. Signals:	5 A model: 0.25 V (V1), 0.25 A (I1) 1 A model: 0.25 V (V1), 0.05 A (I1)
Directional Element Angle:	–20.0° to 0.0°
Pickup Time:	3 cycles (Max)
Zone 1 and Zone 2 Definite-Time Delays:	0.00–400.00 s
Accuracy:	±0.1% plus ±1/2 cycle

Voltage-Restrained Phase Time-Overcurrent Element (51V)

Phase Pickup (A secondary):	5 A Model: 2.0–16.0 A 1 A Model: 0.4–3.2 A
Steady-State Pickup Accuracy:	5 A Model: ±5% plus ±0.10 A 1 A Model: ±5% plus ±0.02 A
Time Dials:	US: 0.50–15.00, 0.01 steps IEC: 0.05–1.00, 0.01 steps
Accuracy:	±4% plus ±1.5 cycles for current between 2 and 20 multiples of pickup (within rated range of current)
Linear Voltage Restraint Range:	0.125–1.000 per unit of VNOM

Voltage-Controlled Phase Time-Overcurrent Element (51C)

Phase Pickup (A secondary):	5 A Model: 0.5–16.0 A 1 A Model: 0.1–3.2 A
Steady State Pickup Accuracy:	5 A Model: ±5% plus ±0.10 A 1 A Model: ±5% plus ±0.02 A
Time Dials:	US: 0.50–15.00, 0.01 steps IEC: 0.05–1.00, 0.01 steps
Accuracy:	±4% plus ±1.5 cycles for current between 2 and 20 multiples of pickup (within rated range of current)

100 Percent Stator Ground Protection (64G)

Neutral Fundamental Overvoltage (64G1):	OFF, 0.1–150.0 V
Steady-State Pickup Accuracy:	±5% plus ±0.1 V
Pickup Time:	1.5 cycles (Max)
Definite-Time Delay:	0.00–400.00 s
Accuracy:	±0.1% plus ±0.25 cycle
Third-Harmonic Voltage Differential or Third-Harmonic Neutral Undervoltage Pickup 64G2:	0.1–20.0 V
Steady-State Pickup Accuracy:	±5% plus ±0.1 V
Third-Harmonic Voltage Differential Ratio Setting Range:	0.0 to 5.0
Pickup Time:	3 cycles (Max)
Definite-Time Delay:	0.00–400.00 s
Accuracy:	±0.1% plus ±0.25 cycle

Field Ground Protection (64F) (Requires SEL-2664 Field Ground Module)

Field Ground Protection Element:	0.5–200.0 kilohms, 0.1 kilohm step
Pickup Accuracy:	±5% plus ±500 ohms for 48 < VF < 825 Vdc
	±5% plus ±20 kilohms for 825 < VF < 1500 Vdc
	(VF is the generator field winding excitation dc voltage)
Pickup Time:	2 s if the injection frequency in the SEL-2664 is selected at 1 Hz
	8 s if the injection frequency in the SEL-2664 is selected at 0.25 Hz
Definite-Time Delay:	0.0–99.0 s
Maximum Definite-Time Delay Accuracy:	±0.5% plus ±5 ms

Out-of-Step Element (78)

Forward Reach:	5 A model: 0.1–100.0 ohms 1 A model: 0.5–500.0 ohms
Reverse Reach:	5 A model: 0.1–100.0 ohms 1 A model: 0.5–500.0 ohms

Single Blinder

Right Blinder:	5 A model: 0.1–50.0 ohms 1 A model: 0.5–250.0 ohms
Left Blinder:	5 A model: 0.1–50.0 ohms 1 A model: 0.5–250.0 ohms

Double Blinder

Outer Resistance Blinder:	5 A model: 0.2–100.0 ohms 1 A model: 1.0–500.0 ohms
Inner Resistance Blinder:	5 A model: 0.1–50.0 ohms 1 A model: 0.5–250.0 ohms
Steady-State Impedance Accuracy:	5 A model: ±0.1 ohm plus ±5% of diameter 1 A model: ±0.5 ohm plus ±5% of diameter
Pos.-Seq. Current Supervision:	5 A model: 0.25–30.00 A 1 A model: 0.05–6.00 A
Pickup Time:	3 cycles (Max)
Definite Time Delay:	0.00–1.00 s, 0.01 s step
Trip Delay Range:	0.00–1.00 s, 0.01 s step
Trip Duration Range:	0.00–5.00 s, 0.01 s step
Definite-Time Timers:	±0.1% plus ±1/2 cycle

Ground Differential Elements (87N)

Ground Differential Pickup:	5 A Model: 0.10*CTR/CTRN – 15.00 A 1 A Model: 0.02*CTR/CTRN – 3.00 A (Ratio CTR/CTRN must be within 1.0–40.0)
Steady-State Pickup Accuracy:	5 A Model: ±5% plus ±0.10 A 1 A Model: ±5% plus ±0.02 A
Pickup Time:	1.5 cycles (Max)
Time Delay Range:	0.00–5.00 s
Time Delay Accuracy:	±0.5% plus ±1/4 cycle

Negative-Sequence Overcurrent Elements (46)

Definite-Time and Inverse-Time Neg.-Seq. I^2 Pickup:	2%–100% of generator rated secondary current
Generator Rated Secondary Current:	5 A Model: 1.0–10.0 A secondary 1 A Model: 0.2–2.0 A secondary
Steady-State Pickup Accuracy:	5 A Model: ±0.025 A plus ±3% 1 A Model: ±0.005 A plus ±3%
Pickup Time:	50 ms at 60 Hz (Max)
Definite-Time Delay Setting Range:	0.02–999.90 s
Maximum Definite-Time Delay Accuracy:	±0.1% plus ±4.2 ms at 60 Hz
Inverse-Time Element Time Dial:	K = 1 to 100 s
Linear Reset Time:	240 s fixed
Inverse-Time Timing Accuracy:	±4% plus ±50 ms at 60 Hz for $\mid I_2 \mid$ above 1.05 multiples of pickup

Rate-of-Change of Frequency (81R)

Pickup Setting Range:	Off, 0.10–15.00 Hz/s
Accuracy:	±100 mHz/s plus ±3.33% of pickup
Trend Setting:	INC, DEC, ABS
Pickup/Dropout Time:	3–30 cycles, depending on pickup setting
Pickup/ Dropout Delay Range:	0.10–60.00/0.00–60.00 s, 01 s increments
Voltage Supervision (Positive Sequence) Pickup Range:	Off, 12.5–300.0 V, 0.1 V increments

Synchronism Check (25Y) for Tie Breaker

Synchronism-Check Voltage Source:	VAY, VBY, VCY, VABY, VBCY, VCAY or angle from VAY or VABY
Voltage Window High Setting Range:	0.00–300.00 V
Voltage Window Low Setting Range:	0.00–300.00 V
Steady-State Voltage Accuracy:	±5% plus ±2.0 V (over the range of 12.5–300 V)
Maximum Percentage Voltage Difference:	1.0–15.0%
Maximum Slip Frequency:	–0.05 Hz to 0.50 Hz
Steady-State Slip Accuracy:	±0.02 Hz
Close Acceptance Angle 1, 2:	0°–80°
Breaker Close Delay:	0.001–1.000 s
Steady-State Angle Accuracy:	±2°

Synchronism Check (25X) for Generator Breaker

Synchronism-Check Voltage Source:	VAX, VBX, VCX, VABX, VBCX, VCAX or angle from VAX or VABX
Voltage Window High Setting Range:	0.00–300.00 V
Voltage Window Low Setting Range:	0.00–300.00 V
Steady-State Voltage Accuracy:	±5% plus ±2.0 V (over the range of 12.5–300 V)
Maximum Percentage Voltage Difference:	1.0–15.0%
Minimum Slip Frequency:	–1.00 Hz to 0.99 Hz
Maximum Slip Frequency:	–0.99 Hz to 1.00 Hz
Steady-State Slip Accuracy:	±0.02 Hz
Close Acceptance Angle 1, 2:	0°–80°
Target Close Angle:	–15° to 15°
Breaker Close Delay:	0.001–1.000 s
Close Failure Angle:	3°–120°
Steady-State Angle Accuracy:	±2°

Generator Thermal Model (49T)

Thermal Overload Trip Pickup Level:	30–250% of full load current (full load current I_{NOM} range: 0.2–2.0 • I_{NOM}, where I_{NOM} = 1 A or 5 A)
TCU Alarm Pickup Level:	50–99% Thermal Capacity Used
Time-Constant Range (2):	1–1000 minutes
Time Accuracy Pickup/ Dropout Time:	±(5% + 25 ms) at multiple-of-pickup ≥2, 50/60 Hz (pre-load = 0)

Autosynchronizing

Frequency Matching

Speed (Frequency) Control Outputs:

Raise:	Digital output, adjustable pulse duration and interval
Lower:	Digital output, adjustable pulse duration and interval
Frequency Synchronism Timer:	5–3600 s, 1 s increments
Frequency Adjustment Rate:	0.01–10.00 Hz/s, 0.01 Hz/s increment

Frequency Pulse Interval:	1–120 s, 1 s increment
Frequency Pulse Minimum:	0.10–60.00 s, 0.01 s increment
Frequency Pulse Maximum:	0.10–60.00 s, 0.01 s increment
Kick Pulse Interval:	1–120 s, 1 s increments
Kick Pulse Minimum:	0.02–2.00 s, 0.01 s increments
Kick Pulse Maximum:	0.02–2.00 s, 0.01 s increments

Voltage Matching

Voltage Control Outputs:	
Raise:	Digital Output, adjustable pulse duration and interval
Lower:	Digital Output, adjustable pulse duration and interval
Voltage Synchronized Timer:	5–3600 s, 1 s increments
Voltage Adjustment Rate (Control System):	0.01–30.00 V/s, 0.01 V/s increment
Voltage Pulse Interval:	1–120 s, 1 s increment
Voltage Control Pulse Minimum:	0.10–60.00 s, 0.01 s increment
Voltage Control Pulse Maximum:	0.10–60.00 s, 0.01 s increment
Timing Accuracy:	±0.5% plus ±1/4 cycle

Inadvertent Energization

Generator De-Energization Setting Range:	0.00–100.00 s, 0.01 s increment
Inadvertent Energization Setting Range:	0.00–10.00 s, 0.01 s increment
Accuracy:	±0.5% of settings plus ±0.25 cycle

Metering Accuracy

Accuracies are specified at 20°C, nominal frequency, ac currents within (0.2–20.0) • I_{NOM} A secondary, and ac voltages within 50–250 V secondary unless otherwise noted.

Phase Currents:	±1% of reading, ±1° (±2.5° at 0.2–0.5 A for relays with I_{NOM} = 1 A)
3-Phase Average Current:	±1% of reading
Differential Quantities:	±5% of reading plus ±0.1 A (5 A nominal), ±0.02 A (1 A nominal)
Current Harmonics:	±5% of reading plus ±0.1 A (5 A nominal), ±0.02 A (1 A nominal)
IG (Residual Current):	±2% of reading, ±2° (±5.0° at 0.2–0.5 A for relays with I_{NOM} = 1 A)
IN (Neutral Current):	±1% of reading, ±1° (±2.5° at 0.2–0.5 A for relays with I_{NOM} = 1 A)
3I2 Negative-Sequence Current:	±2% of reading
System Frequency:	±0.01 Hz of reading for frequencies within 20–70 Hz (V1 > 60 V)
Line-to-Line Voltages:	±1% of reading, ±1° for voltages within 24–264 V
3-Phase Average Line-to-Line Voltage:	±1% of reading for voltages within 24–264 V
Line-to-Ground Voltages:	±1% of reading, ±1° for voltages within 24–264 V
3-Phase Average Line-to-Ground Voltages:	±1% of reading for voltages within 24–264 V
Voltage Harmonics:	±5% of reading plus ±0.5 V
3V2 Negative-Sequence Voltage:	±2% of reading for voltages within 24–264 V
Real 3-Phase Power (kW):	±3% of reading for 0.10 < pf < 1.00
Reactive 3-Phase Power (kVAR):	±3% of reading for 0.00 < pf < 0.90
Apparent 3-Phase Power (kVA):	±3% of reading
Power Factor:	±2% of reading
RTD Temperatures:	±2°C

Synchrophasor Accuracy

Maximum Message Rate

Nominal 60 Hz System:	60 messages per second
Nominal 50 Hz System:	50 messages per second

Accuracy for Voltages

Level 1 compliant as specified in IEEE C37.118 under the following conditions for the specified range.

Conditions

- At maximum message rate
- When phasor has the same frequency as the positive-sequence tracking quantity (see *Table K.10*)
- Frequency-based phasor compensation is enabled (PHCOMP := Y)
- The narrow bandwidth filter is selected (PMAPP := N)

Range

Frequency:	±5.0 Hz of nominal (50 or 60 Hz)
Magnitude:	30 V–250 V
Phase Angle:	–179.99° to 180°
Out-of-Band Interfering Frequency (Fs):	10 Hz ≤ Fs ≤ (2 • FNOM)

Accuracy for Currents

Level 1 compliant as specified in IEEE C37.118 under the following conditions for the specified range.

Conditions

- At maximum message rate
- When phasor has the same frequency as the positive-sequence tracking quantity (see *Table K.10*)
- Frequency-based phasor compensation is enabled (PHCOMP := Y)
- The narrow bandwidth filter is selected (PMAPP := N)

Range

Frequency:	±5.0 Hz of nominal (50 or 60 Hz)
Magnitude:	(0.4–2) • I_{NOM} (I_{NOM} = 1 A or 5 A)
Phase Angle:	–179.99° to 180°
Out-of-Band Interfering Frequency (Fs):	10 Hz ≤ Fs ≤ (2 • FNOM)

[a] Front port serial cable (non-fiber) lengths assumed to be <3 m.

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Section 2
Installation

Overview

The first steps in applying the SEL-700G Relay are installing and connecting the relay. This section describes common installation features and requirements.

To install and connect the relay safely and effectively, you must be familiar with relay configuration features and options. Carefully plan relay placement, cable connections, and relay communication.

This section contains drawings of typical ac and dc connections to the SEL-700G. Use these drawings as a starting point for planning your particular relay application.

The instructions for using the versatile front-panel custom label option are available on the SEL-700G product page on the SEL website. This allows you to use SELOGIC control equations and slide-in configurable front-panel labels to change the function and identification of target LEDs.

Relay Placement

Proper placement of the SEL-700G helps to ensure years of trouble-free protection. Use the following guidelines for proper physical installation of the SEL-700G.

Physical Location

The SEL-700G is EN 61010-1 certified at Installation/Overvoltage Category II and Pollution Degree 2. This allows mounting of the relay in a sheltered indoor environment that does not exceed the temperature and humidity ratings for the relay. The SEL-700G is required to be mounted in an indoor or outdoor (extended) locked enclosure that provides a degree of protection to personnel against access to hazardous parts. In either environment, the relay shall be protected from direct sunlight, precipitation, and full wind pressure.

You can place the relay in extreme temperature and humidity locations. (See *Operating Temperature* and *Operating Environment on page 1.15*.) For EN 61010-1 certification, the SEL-700G rating is 2000 m (6562 ft) above mean sea level.

To comply with the requirements of the European ATEX standard for hazardous locations, the SEL-700G shall be installed in an ATEX-certified enclosure with a tool-removable door or cover that provides a degree of protection not less than IP54, in accordance with EN 60079-0. The enclosure shall be limited to the surrounding temperature range of –20°C ≤ Ta ≤ +50°C. The enclosure should be certified to these requirements or be tested for compliance as part of the complete assembly. The enclosure must be marked "WARNING—Do not open when an explosive atmosphere is present." In North America, the relay is approved for Hazardous Locations Class I, Division 2, Groups A, B, C, and D, and temperature class T3C with a maximum surrounding air temperature of 50°C.

Relay Mounting

To flush mount the SEL-700G in a panel, cut a rectangular hole with the dimensions shown in *Figure 2.1*. Use the supplied front-panel gasket for protection against dust and water ingress into the panel. The relay is rated IP65 when the two-line display model is enclosed in a panel and rated IP54 when the touchscreen display model is enclosed in a panel.

For extremely dusty environments, use the optional IP50-rated terminal dust-protection assembly (protection against solid foreign objects only) (SEL Part #915900170). The 10°C-temperature derating applies to the temperature specifications of the relay.

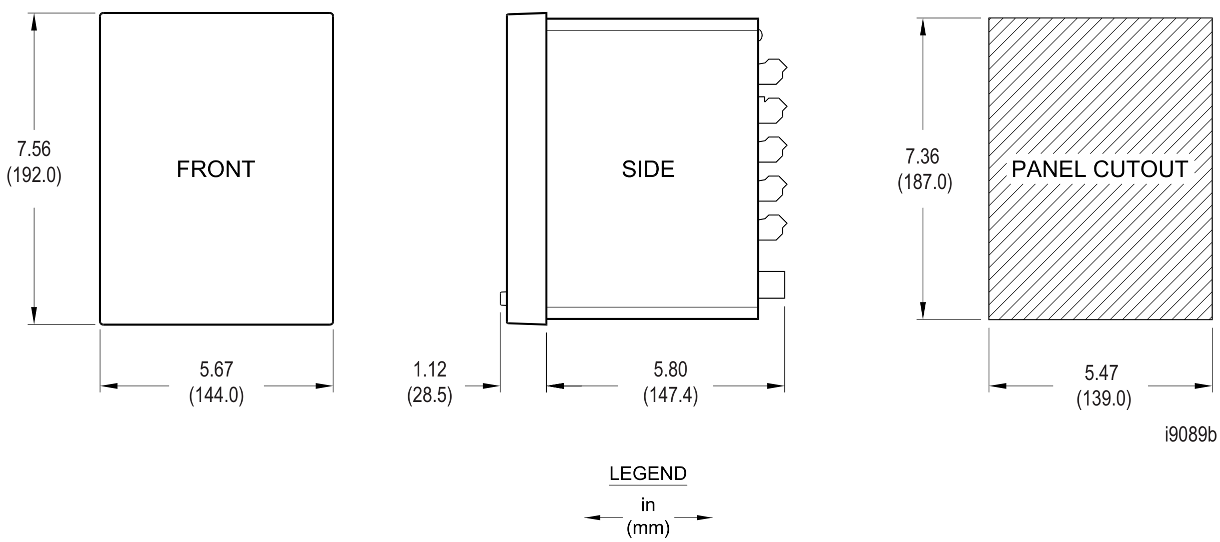


Figure 2.1 Relay Panel-Mount Dimensions

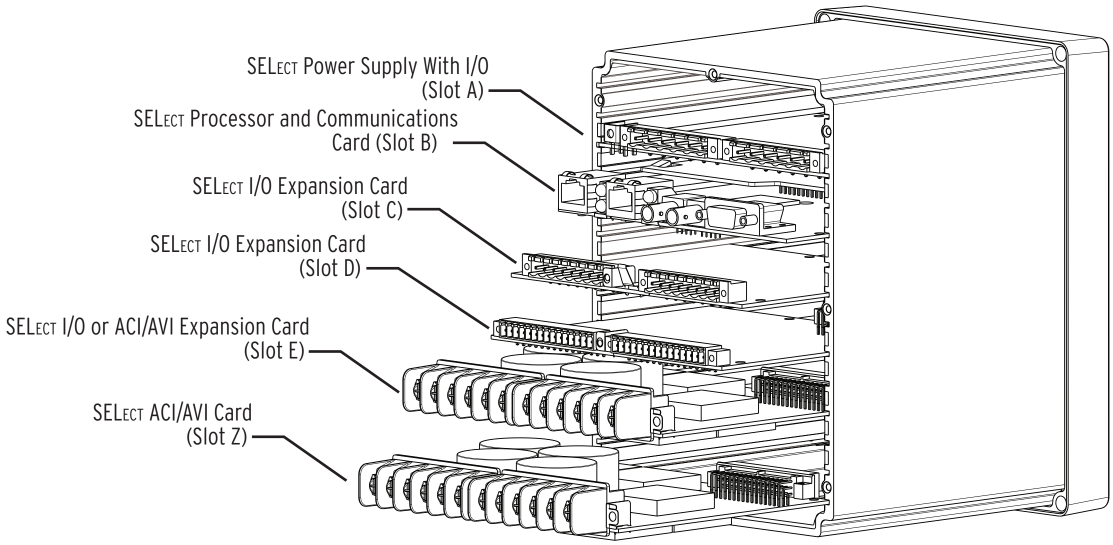
Refer to *Section 1: Introduction and Specifications*, *Models, Options, and Accessories* for information on mounting accessories.

I/O Configuration

Your SEL-700G offers flexibility in tailoring I/O to your specific application. In total, the SEL-700G has six rear-panel slots, labeled as Slots **A**, **B**, **C**, **D**, **E**, and **Z**. Slots **A**, **B**, and **Z** are base unit slots, each associated with a specific function. Optional digital/analog I/O, communications, RTD, and current/voltage cards are available for the SEL-700G. *Figure 2.2* shows the slot allocations for the cards.

The SEL-700G comes with an orange Euro connector on the Slot A card for the 24–48 Vdc low-voltage power supply and C, D, or E slots with the 24–48 Vdc/Vac digital input option. Relays manufactured after May 18, 2022 will be provided with an orange Euro connector for the low-voltage power supply and digital inputs. Refer *Figure 2.12* and *Figure 2.13* for orange Euro connector examples.

Because installations differ substantially, the SEL-700G offers a variety of card configurations to provide options for the many diverse applications. Choose the combination of option cards most suited for your application from the following selection.



	Rear-Panel Slot					
	A	B	C	D	E	Z
Software Reference	1 (e.g., OUT101)		3 (e.g., IN301)	4 (e.g., OUT401)	5 (e.g., AI501)	
Description	Power supply and I/O card[a]	CPU/comm. card[b]	Comm. or input/output[c] card	Input/output[c] or RTD card	Input/output[c] or current/voltage card	Current/voltage card
Card Type						
SELECT EIA-232/485			●			
SELECT DeviceNet			●			
SELECT 3 DI/4 DO/1 AO (one card per relay)			●	●	●	
SELECT 4 DI/4 DO			●	●	●	
SELECT 8 DI			●	●	●	
SELECT 14 DI			●	●	●	
SELECT 8 DO			●	●	●	
SELECT 4 AI/4 AO (one card per relay)			●	●	●	
SELECT 4 DI/3 DO (2 Form C, 1 Form B)			●	●	●	
SELECT 10 RTD				●		
SELECT 3 ACI (1A)/4 AVI (MOT… x71x…)					●	
SELECT 3 ACI (1A)/2 AVI (MOT … x72x…)					●	
SELECT 3 ACIE (1A) (MOT … x73x…)					●	
SELECT 2 AVI (MOT … x74x…)					●	
SELECT 3 ACI (5 A)/4 AVI (MOT…x75x…)					●	
SELECT 3 ACI (5 A)/2 AVI (MOT…x76x…)					●	
SELECT 3 ACIE (5 A) (MOT…x77x…)					●	
SELECT 4 ACI (1A ph, 1A neut)/3 AVI (MOT…x81x…)						●
SELECT 4 ACI (1A ph, 5 A neut)/3 AVI (MOT…x82x…)						●
SELECT 3 ACIZ (1A ph) (MOT…x83x…)						●
SELECT 1 ACI (1A neut) (MOT…x84x…)						●
SELECT 4 ACI (5 A ph, 5 A neut)/3 AVI (MOT…x85x…)						●
SELECT 4 ACI (5 A ph, 1A neut)/3 AVI (MOT…x86x…)						●

	Rear-Panel Slot					
	A	B	C	D	E	Z
Software Reference	1 (e.g., OUT101)		3 (e.g., IN301)	4 (e.g., OUT401)	5 (e.g., AI501)	
Description	Power supply and I/O card[a]	CPU/comm. card[b]	Comm. or input/output[c] card	Input/output[c] or RTD card	Input/output[c] or current/voltage card	Current/voltage card
Card Type						
SELECT 3 ACIZ (5 A ph) (MOT…x87x…)						●
SELECT 1 ACI (5 A neut) (MOT…x88x…)						●

[a] Power supply, two inputs, and three outputs.
[b] IRIG-B, EIA-232/485, fiber-optic serial and/or Ethernet ports. The IRIG-B input option is available on terminals B01, B02 for all models except models with fiber-optic Ethernet port (P1) and dual copper Ethernet port (P1). IRIG-B is also supported via fiber-optic serial port (Port 2) and rear-panel EIA-232 serial port (Port 3). You can use only one input at a time.
[c] Digital or analog.

Figure 2.2 Slot Allocations for Different Cards

Power Supply Card PSIO/2 DI/3 DO (Slot A)

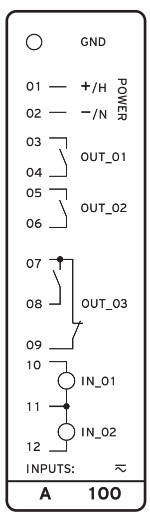
Select appropriate power supply option for the application:

- High Voltage: 110–250 Vdc, 110–240 Vac, 50/60 Hz
- Low Voltage: 24–48 Vdc

Select appropriate digital input voltage option: 125 Vdc/Vac, 24 Vdc/Vac, 48 Vdc/Vac, 110 Vdc/Vac, 220 Vdc/Vac, or 250 Vdc/Vac.

This card is supported in Slot A of the SEL-700G Relay. It has two digital inputs and three digital outputs (two normally open Form A contact outputs and one Form C output). *Table 2.1* shows the terminal designation for the PSIO/2 DI/3 DO card.

Table 2.1 Power Supply Inputs (PSIO/2 DI/3 DO) Card Terminal Designations

Side-Panel Connections Label	Terminal Number	Description
	⏚	Ground connection
	A01, A02	Power supply input terminals
	A03, A04	OUT101, driven by OUT101 SELOGIC control equation
	A05, A06	OUT102, driven by OUT102 SELOGIC control equation
	A07, A08, A09	OUT103, driven by OUT103 SELOGIC control equation
	A10, A11	IN101, drives IN101 element
	A12, A11	IN102, drives IN102 element

Communications Ports (Slot B)

Select the communications ports necessary for your application from the options shown in *Table 2.2*.

Table 2.2 Communications Ports

Port	Location	Feature	Description
F	Front Panel	Standard	Nonisolated EIA-232 serial port
1	Rear Panel	Optional	(Single/Dual) Isolated 10/100BASE-T Ethernet copper port or 100BASE-FX Ethernet fiber-optic port
2	Rear Panel	Standard	Isolated multimode fiber-optic serial port with ST connectors (with IRIG-B)
3	Rear Panel	Standard	Either nonisolated EIA-232 (with IRIG-B) or isolated EIA-485 serial port

Port F supports the following protocols:

- SELBOOT
- Modbus RTU Slave
- SEL ASCII and Compressed ASCII
- SEL Settings File Transfer
- Event Messenger
- C37.118 (Synchrophasor Data)

Port 1 (Ethernet) supports the following protocols:

- Modbus TCP/IP
- DNP3 LAN/WAN
- IEC 61850
- FTP
- EtherNet/IP
- Parallel Redundancy Protocol (PRP)
- Rapid Spanning Tree Protocol (RSTP)
- Telnet
- IEEE C37.118 (Synchrophasor Data)
- Simple Network Time Protocol (SNTP)
- Precision Time Protocol (PTP)

Port 2 and **Port 3** support the following protocols:

- Modbus RTU Slave
- SEL ASCII and Compressed ASCII
- SEL Fast Meter
- SEL Fast Operate
- SEL Fast SER
- SEL Fast Message Unsolicited Write
- SEL Settings File Transfer
- SEL MIRRORED BITS (MBA, MBB, MB8A, MB8B, MBTB, MBTA)
- Event Messenger

- DNP3 Level 2 Outstation
- C37.118 (Synchrophasor Data)
- IEC 60870-5-103

Communications Card (Slot C)

NOTE: After any change, be sure to thoroughly test the settings.

Either the DeviceNet (see *Appendix I: DeviceNet Communications*) or the EIA-232/EIA-485 communications card is supported in Slot **C**. The EIA-232/EIA-485 card provides one serial port with one of the following two serial port interfaces:

- **Port 4A**, an isolated EIA-485 serial port interface
- **Port 4C**, nonisolated EIA-232 serial port interface, supporting the +5 Vdc interface

Select either EIA-232 or EIA-485 functionality using the **Port 4** Setting COMM Interface. *Table 2.3* shows the port number, interface, and type of connector for the two protocols.

Table 2.3 Communications Card Interfaces and Connectors

Port	Interface	Connectors
4A	EIA-485	5 pin-Euro
4C	EIA-232	D-sub

The communications card supports the following protocols:

- Modbus RTU Slave
- SEL ASCII and Compressed ASCII
- SEL Fast Meter
- SEL Fast Operate
- SEL Fast SER
- SEL Fast Message Unsolicited Write
- SEL Settings File Transfer
- SEL Mirrored Bits (MBA, MBB, MB8A, MB8B, MBTB, MBTA)
- Event Messenger
- DNP3 Level 2 Outstation
- C37.118 (Synchrophasor Data)
- IEC 60870-5-103

Current/Voltage Card (3 ACI/4 AVI)

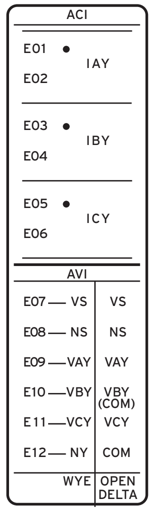
⚠WARNING
Before working on a CT circuit, first apply a short to the secondary winding of the CT.

NOTE: When the **VS-NS** voltage input is unused in the SEL-700GT+ model and the setting DELTAY_X := DELTA, then the voltage input could be used to connect an external zero-sequence voltage. In such an application, the setting EXT3V0_X must also be set accordingly.

MOT...x71x...(1 A phase CTs) or ...x75x...(5 A phase CTs). This card is only supported in Slot **E** of the SEL-700GT model (refer to *Table 1.1* and *Figure 2.2*). It supports Y-side current inputs for three-phase CTs and Y-side voltage inputs for three-phase (wye or delta) PTs. It also supports a synchronism-check voltage input.

⚠**WARNING**
Voltage measurement circuits have high input impedance and will respond to stray signals when left open (disconnected). Always isolate the relay control circuit before opening the voltage input test switches or performing work on the voltage circuit.

Table 2.4 Current/Voltage Inputs (3 ACI/4 AVI) Card Terminal Designations



Side-Panel Connections Label	Terminal Number	Description
(see label above)	E01, E02	IAY, Y-side A-phase current input
	E03, E04	IBY, Y-side B-phase current input
	E05, E06	ICY, Y-side C-phase current input
	E07	VS, synchronism-check voltage input
	E08	NS, common connection for synchronism-check voltage input
	E09	VAY, Y-side A-phase voltage input
	E10	VBY, Y-side B-phase voltage input
	E11	VCY, Y-side C-phase voltage input
	E12	NY, common connection for VAY, VBY, VCY

Current/Voltage Card (3 ACI/2 AVI)

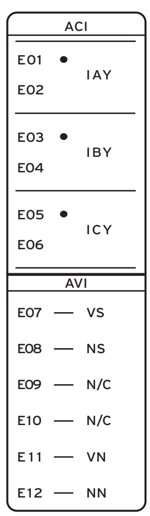
⚠**WARNING**
Before working on a CT circuit, first apply a short to the secondary winding of the CT.

NOTE: When the **VS-NS** voltage input is unused in the SEL-700GT+ model and the setting DELTAY_X := DELTA, then the voltage input could be used to connect an external zero-sequence voltage. In such an application, the setting EXT3V0_X must also be set accordingly.

⚠**WARNING**
Voltage measurement circuits have high input impedance and will respond to stray signals when left open (disconnected). Always isolate the relay control circuit before opening the voltage input test switches or performing work on the voltage circuit.

MOT...x72x... (1 A phase CTs) or ...x76x...(5 A phase CTs). This card is only supported in Slot **E** of the SEL-700G1+ model (refer to *Table 1.1* and *Figure 2.2*). It supports Y-side current inputs for three-phase CTs. It also supports a synchronism-check voltage input VS and neutral voltage input VN.

Table 2.5 Current/Voltage Inputs (3 ACI/2 AVI) Card Terminal Designations



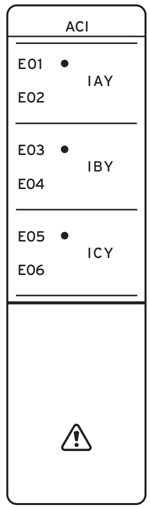
Side-Panel Connections Label	Terminal Number	Description
(see label above)	E01, E02	IAY, Y-side A-phase current input
	E03, E04	IBY, Y-side B-phase current input
	E05, E06	ICY, Y-side C-phase current input
	E07	VS, synchronism-check voltage input
	E08	NS, common connection for synchronism-check voltage input
	E11	VN, neutral voltage input
	E12	NN, common connection for neutral voltage input

Current Card (3 ACI)

⚠WARNING
Before working on a CT circuit, first apply a short to the secondary winding of the CT.

MOT...x73x... (1 A phase CTs) or ...x77x...(5 A phase CTs). This card is only supported in Slot **E** of the SEL-700G1 base model (refer to *Table 1.1* and *Figure 2.2*). It supports Y-side current inputs for three-phase CTs.

Table 2.6 Currents Inputs (3 ACIE) Card Terminal Designations

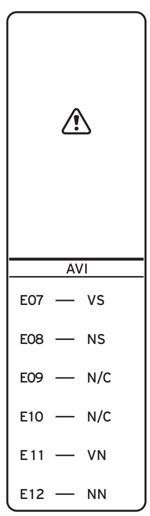
Side-Panel Connections Label	Terminal Number	Description
	E01, E02	IAY, Y-side A-phase current input
	E03, E04	IBY, Y-side B-phase current input
	E05, E06	ICY, Y-side C-phase current input

Voltage Card (2 AVI)

⚠WARNING
Voltage measurement circuits have high input impedance and will respond to stray signals when left open (disconnected). Always isolate the relay control circuit before opening the voltage input test switches or performing work on the voltage circuit.

MOT...x74x.... This card is only supported in Slot **E** of the SEL-700G0+ model (refer to *Table 1.1* and *Figure 2.2*). It supports a synchronism-check voltage input VS and neutral voltage input VN.

Table 2.7 Voltage Inputs (2 AVI) Card Terminal Designations

Side-Panel Connections Label	Terminal Number	Description
	E07	VS, synchronism-check voltage input
	E08	NS, common connection for synchronism-check voltage input
	E11	VN, neutral voltage input
	E12	NN, common connection for neutral voltage input

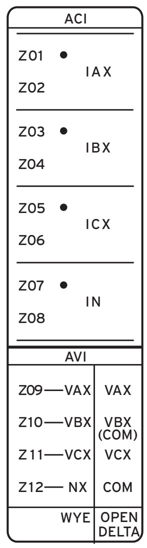
Current/Voltage Card (4 ACI/3 AVI)

⚠WARNING
Before working on a CT circuit, first apply a short to the secondary winding of the CT.

⚠WARNING
Voltage measurement circuits have high input impedance and will respond to stray signals when left open (disconnected). Always isolate the relay control circuit before opening the voltage input test switches or performing work on the voltage circuit.

MOT...x81x... (1 A phase, 1 A neutral CTs); or ...x85x... (5 A phase, 5 A neutral CTs); or ...x82x... (1 A phase, 5 A neutral CTs); or ...x86x... (5 A phase, 1 A neutral CTs). This card is supported in Slot Z of the SEL-700G0, SEL-700G1, and the SEL-700GT+ models (refer to *Table 1.1* and *Figure 2.2*). It supports X-side current inputs for three-phase CTs, neutral current CTs, and X-side voltage inputs for three-phase (wye or delta) PTs.

Table 2.8 Current/Voltage Inputs (4 ACI/3 AVI) Card Terminal Designations

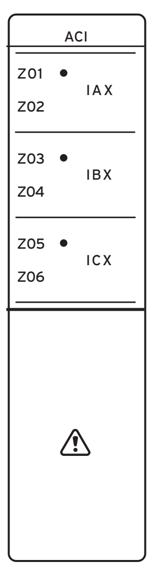
Side-Panel Connections Label	Terminal Number	Description
	Z01, Z02	IAX, X-side A-phase current input
	Z03, Z04	IBX, X-side B-phase current input
	Z05, Z06	ICX, X-side C-phase current input
	Z07, Z08	IN, neutral current input
	Z09	VAX, X-side A-phase voltage input
	Z10	VBX, X-side B-phase voltage input
	Z11	VCX, X-side C-phase voltage input
	Z12	NX, common connection for VAX, VBX, VCX

Current Card (3 ACIZ)

⚠WARNING
Before working on a CT circuit, first apply a short to the secondary winding of the CT.

MOT...x83x... (1 A phase CTs), or ...x87x...(5 A phase CTs). This card is supported in Slot Z of the SEL-700GW model only. It supports X-side current inputs for three-phase CTs.

Table 2.9 Current Inputs (3 ACIZ) Card Terminal Designations

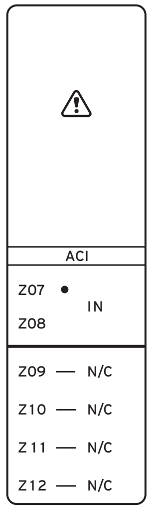
Side-Panel Connections Label	Terminal Number	Description
	Z01, Z02	IAX, X-side A-phase current input
	Z03, Z04	IBX, X-side B-phase current input
	Z05, Z06	ICX, X-side C-phase current input

Current Card (1 ACI)

⚠ **WARNING**
Before working on a CT circuit, first apply a short to the secondary winding of the CT.

MOT...x84x... (1 A neutral CT) or ...x88x...(5 A neutral CT). This card is supported in Slot Z of the SEL-700GT model only. It supports the neutral current input.

Table 2.10 Current Input (1 ACI) Card Terminal Designation

Side-Panel Connections Label	Terminal Number	Description
	Z07, Z08	IN, neutral current input

Analog Inputs/Outputs Card (4 AI/4 AO)

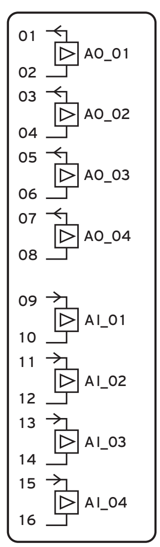
Supported in only one of the nonbase unit Slots C, D, or E, this card has four analog inputs and four analog outputs. *Table 2.11* shows the terminal designations.

NOTE: Analog inputs cannot provide loop power. Each analog output is self powered and has an isolated power supply.

NOTE: Analog outputs are isolated from each other.

NOTE: Analog inputs and outputs with connection lengths less than 10 meters meet the requirements of IEC 60255-26 and IEC 60255-27.

Table 2.11 Four Analog Inputs/Four Analog Outputs (4 AI/4 AO) Card Terminal Designations

Side-Panel Connections Label	Terminal Number	Software Reference, Description[a]
	01, 02	AO*x*01, Analog Output *x*01
	03, 04	AO*x*02, Analog Output *x*02
	05, 06	AO*x*03, Analog Output *x*03
	07, 08	AO*x*04, Analog Output *x*04
	09, 10	AI*x*01, Transducer Input *x*01
	11, 12	AI*x*02, Transducer Input *x*02
	13, 14	AI*x*03, Transducer Input *x*03
	15, 16	AI*x*04, Transducer Input *x*04

[a] x = 3, 4, or 5, if the card was installed in Slot C, D, or E, respectively.

Input/Output Card (3 DI/4 DO/1 AO)

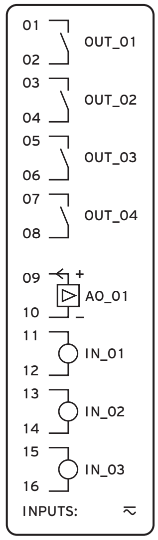
NOTE: Analog output is self powered and has an isolated power supply.

NOTE: All digital inputs and digital outputs (including high-current, high-speed hybrid) connections are polarity neutral.

NOTE: Analog inputs and outputs with connection lengths less than 10 meters meet the requirements of IEC 60255-26 and IEC 60255-27.

Supported in only one of the nonbase unit Slots **C**, **D**, or **E**, this card has three digital inputs, four digital outputs (normally open), and one analog output. *Table 2.12* shows the terminal designations.

Table 2.12 Three Digital Inputs/Four Digital Outputs/One Analog Output (3 DI/4 DO/1 AO) Card Terminal Designations



Side-Panel Connections Label	Terminal Number	Software Reference, Description[a]
	01, 02	OUT*x*01, driven by OUT*x*01 SELOGIC control equation
	03, 04	OUT*x*02, driven by OUT*x*02 SELOGIC control equation
	05, 06	OUT*x*03, driven by OUT*x*03 SELOGIC control equation
	07, 08	OUT*x*04, driven by OUT*x*04 SELOGIC control equation
	09, 10	AO*x*01, Analog Output Number 1
	11, 12	IN*x*01, drives IN*x*01 element
	13, 14	IN*x*02, drives IN*x*02 element
	15, 16	IN*x*03, drives IN*x*03 element

[a] x=3, 4, or 5, if the card was installed in Slot C, D, or E, respectively.

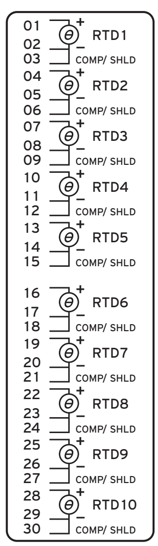
RTD Card (10 RTD)

NOTE: All comp/shield terminals are internally connected to relay chassis.

NOTE: Use passive resistors to simulate temperatures. Note that using RTD simulators to test RTD inputs can damage the relay.

Supported in Slot **D** only, this card has 10 three-wire RTD inputs. *Table 2.13* shows the terminal designations.

Table 2.13 RTD (10 RTD) Card Terminal Designations

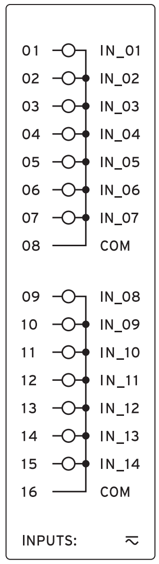


Side-Panel Connections Label	Terminal Number	Description
	01	RTD01 (+)
	02	RTD01 (–)
	03	RTD01 Comp/Shield
	04	RTD02 (+)
	05	RTD02 (–)
	06	RTD02 Comp/Shield
	07	RTD03 (+)
	08	RTD03 (–)
	09	RTD03 Comp/Shield
	•	•
	•	•
	•	•
	28	RTD10 (+)
	29	RTD10 (–)
	30	RTD10 Comp/Shield

Input Card (14 DI)

Supported in nonbase unit Slots **C**, **D**, and **E**, this card has fourteen digital inputs. *Table 2.14* shows the terminal designations.

Table 2.14 Fourteen Digital Inputs (14 DI) Card Terminal Designations



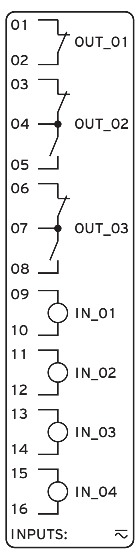
Side-Panel Connections Label	Terminal Number	Description[a]
(see diagram above)	01	IN*x*01, drives IN*x*01 element
	02	IN*x*02, drives IN*x*02 element
	03	IN*x*03, drives IN*x*03 element
	04	IN*x*04, drives IN*x*04 element
	05	IN*x*05, drives IN*x*05 element
	06	IN*x*06, drives IN*x*06 element
	07	IN*x*07, drives IN*x*07 element
	08	COM
	09	IN*x*08, drives IN*x*08 element
	10	IN*x*09, drives IN*x*09 element
	11	IN*x*10, drives IN*x*10 element
	12	IN*x*11, drives IN*x*11 element
	13	IN*x*12, drives IN*x*12 element
	14	IN*x*13, drives IN*x*13 element
	15	IN*x*14, drives IN*x*14 element
	16	COM

[a] x = 3, 4, or 5, if the card was installed in Slot C, D, or E, respectively.

Input/Output Card (4 DI/3 DO)

Supported in nonbase unit Slots **C**, **D**, and **E**, this card has four digital inputs, one Form B digital output (normally closed) and two Form C digital output contacts. *Table 2.15* shows the terminal designations.

Table 2.15 Four Digital Inputs/Three Digital Outputs (4 DI/3 DO) Card Terminal Designations



Side-Panel Connections Label	Terminal Number	Description[a]
(see diagram above)	01, 02	OUT*x*01, driven by OUT*x*01 SELOGIC control equation
	03, 04, 05	OUT*x*02, driven by OUT*x*02 SELOGIC control equation
	06, 07, 08	OUT*x*03, driven by OUT*x*03 SELOGIC control equation
	09, 10	IN*x*01, drives IN*x*01 element
	11, 12	IN*x*02, drives IN*x*02 element
	13, 14	IN*x*03, drives IN*x*03 element
	15, 16	IN*x*04, drives IN*x*04 element

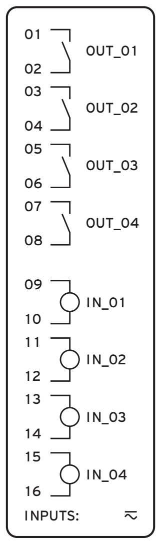
[a] x = 3, 4, or 5, if the card was installed in Slot C, D, or E, respectively.

Input/Output Card (4 DI/4 DO)

Supported in nonbase unit Slots **C**, **D**, and **E**, this card has four digital inputs and four digital outputs (all normally open). Optionally, the outputs can be fast hybrid (high-speed, high-current interrupting) outputs. *Table 2.16* shows the terminal designations.

NOTE: All digital inputs and digital outputs (including high-current, high-speed hybrid) connections are polarity neutral.

Table 2.16 Four Digital Inputs/Four Digital Outputs (4 DI/4 DO) Card Terminal Designations



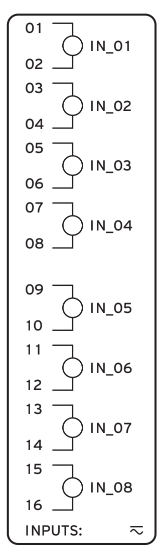
Side-Panel Connections Label	Terminal Number	Software Reference, Description[a]
	01, 02	OUT*x*01, driven by OUT*x*01 SELOGIC control equation
	03, 04	OUT*x*02, driven by OUT*x*02 SELOGIC control equation
	05, 06	OUT*x*03, driven by OUT*x*03 SELOGIC control equation
	07, 08	OUT*x*04, driven by OUT*x*04 SELOGIC control equation
	09, 10	IN*x*01, drives IN*x*01 element
	11, 12	IN*x*02, drives IN*x*02 element
	13, 14	IN*x*03, drives IN*x*03 element
	15, 16	IN*x*04, drives IN*x*04 element

[a] x=3, 4, or 5, if the card was installed in Slot C, D, or E, respectively.

Input Card (8 DI)

Supported in nonbase unit Slots **C**, **D**, and **E**, this card has eight digital inputs. *Table 2.17* shows the terminal designations.

Table 2.17 Eight Digital Inputs (8 DI) Card Terminal Designations



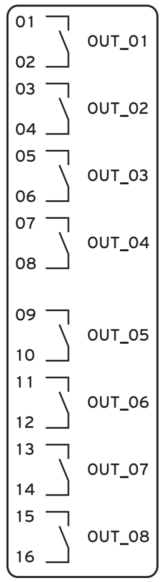
Side-Panel Connections Label	Terminal Number	Description[a]
	01, 02	IN*x*01, drives IN*x*01 element
	03, 04	IN*x*02, drives IN*x*02 element
	05, 06	IN*x*03, drives IN*x*03 element
	07, 08	IN*x*04, drives IN*x*04 element
	09, 10	IN*x*05, drives IN*x*05 element
	11, 12	IN*x*06, drives IN*x*06 element
	13, 14	IN*x*07, drives IN*x*07 element
	15, 16	IN*x*08, drives IN*x*08 element

[a] x=3, 4, or 5, if the card was installed in Slot C, D, or E, respectively.

Output Card (8 DO)

Supported in nonbase unit Slots **C**, **D**, and **E**, this card has eight digital outputs (all normally open). *Table 2.18* shows the terminal designations.

Table 2.18 Eight Digital Outputs (8 DO) Card Terminal Designations

Side-Panel Connections Label	Terminal Number	Description[a]
	01, 02	OUT*x*01, driven by OUTx01 SELOGIC control equation
	03, 04	OUT*x*02, driven by OUTx02 SELOGIC control equation
	05, 06	OUT*x*03, driven by OUTx03 SELOGIC control equation
	07, 08	OUT*x*04, driven by OUTx04 SELOGIC control equation
	09, 10	OUT*x*05, driven by OUTx05 SELOGIC control equation
	11, 12	OUT*x*06, driven by OUTx06 SELOGIC control equation
	13, 14	OUT*x*07, driven by OUTx07 SELOGIC control equation
	15, 16	OUT*x*08, driven by OUTx08 SELOGIC control equation

[a] x=3, 4, or 5, if the card was installed in Slot C, D, or E, respectively.

Card Configuration Procedure

Changing card positions, or expanding on the initial number of cards requires no card programming; the relay detects the new hardware and updates the software accordingly (you still have to use the **SET** command to program the I/O settings).

The SEL-700G offers flexibility in tailoring I/O to your specific application. The SEL-700G has six rear-panel slots, labeled as Slots **A**, **B**, **C**, **D**, **E**, and **Z**. Slots **A**, **B**, and **Z** are base unit slots, each associated with a specific function. Optional digital/analog I/O are available for the SEL-700G in Slots **C**, **D**, and **E**. Optional communications cards are available only for Slot C, an RTD card is available only for Slot **D**, and 1 A/5 A CT combinations for voltage/current cards are available only on Slots **E** and **Z**. *Figure 2.2* shows the slot allocations for the cards. Because installations differ substantially, the SEL-700G offers a variety of card configurations that provide options for an array of applications. Choose the combination of option cards most suited for your application.

Swapping Optional I/O Cards

When an I/O card is moved from one slot to a different slot, the associated settings for the slot the card is moved from are lost. For example, if a 4 DI/4 DO card is installed in Slot **D**, the SELOGIC control equation settings OUT401–OUT404 are available. If OUT401 = IN101 AND 51PYT, and the card is moved to a different slot, then the OUT401 setting is lost. This is true for all the digital and analog I/O cards.

Adding Cards to Slots C, D, E, and Z

The SEL-700G Relay can be upgraded by adding as many as three cards.

Installation

Perform the following steps to install cards into Slots **C**, **D**, **E**, or **Z** of the base unit.

Step 1. Save the settings and event report data before installing the new card in the relay.

⚠DANGER
Disconnect or de-energize all external connections before opening this device. Contact with hazardous voltages and currents inside this device can cause electrical shock resulting in injury or death.

NOTE: To replace the communications card in Slot C with a standard I/O card, remove the white stick-on label on the back plate to see the correct slots for the selected I/O card.

Step 2. Remove the power supply voltage from terminals **A01+** and **A02–** and remove the ground wire from the green ground screw.

Step 3. Disconnect all the connection plugs.

Step 4. Remove the eight screws on the rear and remove the rear cover.

Step 5. Remove the plastic filler plate covering the slot associated with the card being installed.

Step 6. Insert the card in the correct slot.

Make sure the contact fingers on the printed circuit board are bent at an approximate 130-degree angle relative to the board for proper electromagnetic interference protection.

Step 7. Before reattaching the rear cover, check for and remove any foreign material that may remain inside the SEL-700G case.

Step 8. Carefully reattach the rear cover.

Step 9. Reinstall the eight screws that secure the rear cover to the case.

Step 10. Apply power supply voltage to terminals **A01+** and **A02–**, and reconnect the ground wire to the green ground screw.

If you have a two-line display front panel, perform *Step 11* through *Step 19*; if you have a touchscreen display front panel, proceed to *Step 20*.

Step 11. If the card is in the proper slot, the front panel displays the following:

```
STATUS FAIL
X Card Failure
```

If you *do not* see this message and the **ENABLED** LED is turned on, the card was inserted into the wrong slot. Begin again at *Step 2*.

Step 12. Press the **ESC** pushbutton.

Step 13. Press the **Down Arrow** pushbutton until `STATUS` is highlighted.

Step 14. Press the **ENT** pushbutton.

The front panel displays the following:

```
STATUS
Relay Status
```

Step 15. Press the **ENT** pushbutton.

The front panel displays the following:

```
Serial Num
000000000000000000000000
```

Step 16. Press the **ENT** pushbutton.

The front panel displays the following:

```
Confirm Hardware
Config (Enter)
```

Step 17. Press the **ENT** pushbutton.

The front panel displays the following:

```
Accept New Config?
No Yes
```

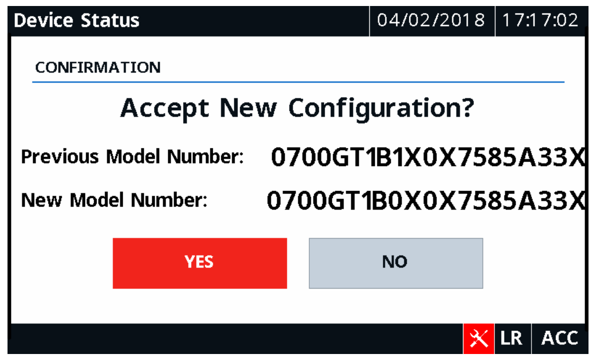
Step 18. Select **Yes** and press the **ENT** pushbutton.

The front panel displays the following:

```
Config Accepted
Enter to Reboot
```

Step 19. Press the **ENT** pushbutton and proceed to *Step 22*.

Step 20. Wait for the Device Status screen to appear, and then verify the new part number and tap Yes to confirm the new configuration.



Step 21. Tap **OK** on the notification screen to reboot the relay.

Step 22. Use the **PARTNO** command from Access Level C to enter the exact part number of the relay after the relay restarts and the **ENABLED** LED is turned on to indicate the card was installed correctly.

After reconfiguration, the relay updates the part number, except for the following indicated digits. These digits remain unchanged, i.e., these digits retain the same character as before the reconfiguration. Also, a communications card installed in Slot **C** will be reflected as an empty slot in the part number. A regular 4 DI/4 DO card and a hybrid 4 DI/4 DO card have the same device ID. When interchanging these two cards, the part number for the respective slots should be updated manually. Use the **STATUS** command to view the part number.

```
PART NUM = 0700G11ACA1D7281020X
```

Step 23. Update the side-panel drawing with the drawing sticker provided in the option card kit. If necessary, replace the rear panel with the one applicable for the option card and attach the terminal-marking label provided with the card to the rear-panel cover. Also, contact SEL for an updated product serial number label with the updated part number.

Step 24. Reconnect all connection plugs and add any additional wiring/ connectors required by the new card.

Slot B CPU Card Replacement

When replacing the Slot **B** card, do the following:

1. Ensure that the card has the latest firmware from the factory.
2. Review the firmware revision history for the changes that were made; note that new settings added, if any, might affect existing settings in the relay or its application.
3. Save all settings and event reports before replacing the card.
4. If the IEC 61850 protocol option was used previously, verify that the IEC 61850 protocol is still operational after the replacement. If not, reenable it. Refer to *Protocol Verification for Relays With IEC 61850 Option* in *Appendix B: Firmware Upgrade Instructions*.

Perform the following steps to replace the existing CPU board with a new board:

Step 1. Turn off the power to the relay.

Step 2. Use a ground strap between yourself and the relay.

Step 3. Disconnect the terminal blocks and CT/PT wires.

Step 4. Remove the rear panel.

Step 5. Remove the main board from its slot and insert the new board.

Step 6. Attach the rear panel (new, if applicable) and reconnect the terminal blocks and CT/PT wires.

Step 7. Apply new side stickers to the relay.

Step 8. Turn on the relay and log in via terminal emulation software.

Step 9. Issue the **STA** command and accept the new configuration.

Step 10. From Access Level 2, type **CAL** to enter Access Level C level.

Do not modify any settings other than those listed in this procedure.

The default password for Access Level C is CLARKE.

Step 11. From Access Level C, issue the **SET C** command.

Step 12. Update the serial number and part number to the appropriate values, then type **END** and save the settings.

Step 13. Issue the **STA C** command to reboot the relay.

Step 14. Issue the **STA** command to verify that the serial number and part number of your relay are correct.

Slot A Power Supply Card

If you are replacing the power supply card, change the part number accordingly using the **PARTNO** command from Access Level C. Install new side stickers on the side of the relay.

Analog Input (AI) Voltage/Current Jumper Selection

Figure 2.3 shows the circuit board of an analog I/O board. Jumper *x* (*x* = 5–8) determines the nature of Channel *x*. For a current channel, insert Jumper *x* in position 1–2; for a voltage channel, insert Jumper *x* in position 2–3.

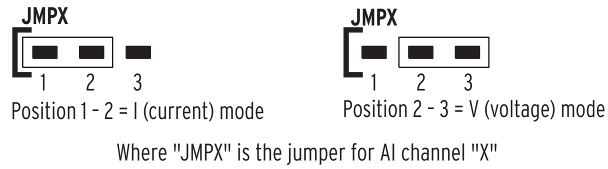


Figure 2.3 Circuit Board of Analog I/O Board, Showing Jumper Selection

Analog Output (AO) Voltage/Current Jumper Selection

NOTE: Analog inputs cannot provide loop power. Each analog output is self powered and has an isolated power supply.

Figure 2.4 shows the locations of JMP1 through JMP4 on an analog output board. You can select each of the four analog output channels as either a current analog output or a voltage analog output.

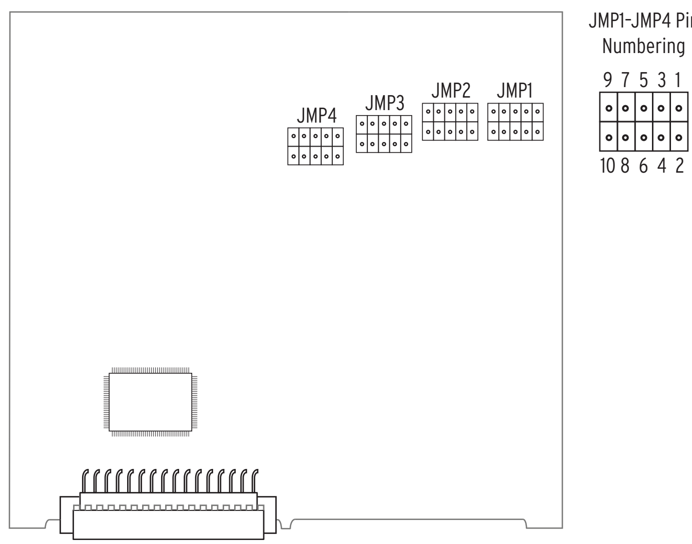


Figure 2.4 JMP1 Through JMP4 Locations on 4 AI/4 AO Board

NOTE: There is no jumper between Pins 5 and 6 for a voltage analog output selection.

You need to insert three jumpers for a current analog output selection and two jumpers for a voltage analog output selection. For a current analog output selection, insert a jumper between Pins 1 and 2, Pins 5 and 6, and Pins 9 and 10. For a voltage analog output selection, insert a jumper between Pins 3 and 4, and Pins 7 and 8. *Figure 2.5* shows JMP4 selected as a current analog output. The current analog output selection is the default setting for JMP1 through JMP4. *Figure 2.6* shows JMP1 selected as a voltage analog output.

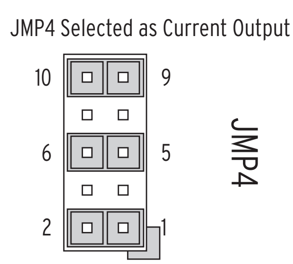


Figure 2.5 Current Output Jumpers

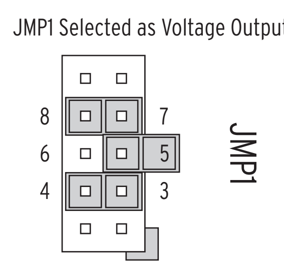


Figure 2.6 Voltage Output Jumpers

Password, Breaker Control, and SELBOOT Jumper Selection

Figure 2.7 shows the major components of the B-slot card in the base unit. Notice the three sets of pins labeled A, B, and C.

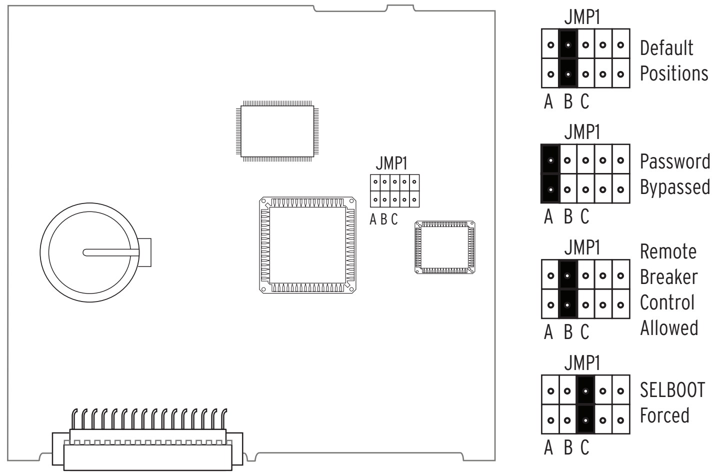


Figure 2.7 Pins for Password, Breaker Control, and SELBOOT Jumper

Pins labeled A bypass the password requirement, pins labeled B enable breaker control, and pins labeled C force the relay to the SEL operating system called SELBOOT. In the unlikely event that the SEL-700G experiences an internal failure, communications with the relay can be compromised. Forcing the relay to SELBOOT provides a means of downloading new firmware. To force the relay to SELBOOT, position the jumper in Position C, as shown in *Figure 2.7* (SELBOOT forced). Once the relay is forced to SELBOOT, you can communicate with the relay only through the front-panel port.

To gain access to Level 1, Level 2, and Level C command levels without passwords, position the jumper in Position A, as shown in *Figure 2.7* (password bypassed). Note that you can only access command levels without passwords to the access level set for the MAXACC setting for the port through which you are communicating. Although you gain access to Level 2 and Level C without a password, the alarm contact still closes momentarily when you access Level 2 and Level C. *Table 2.19* tabulates the functions of the three sets of pins and jumper default positions.

Table 2.19 Jumper Functions and Default Positions

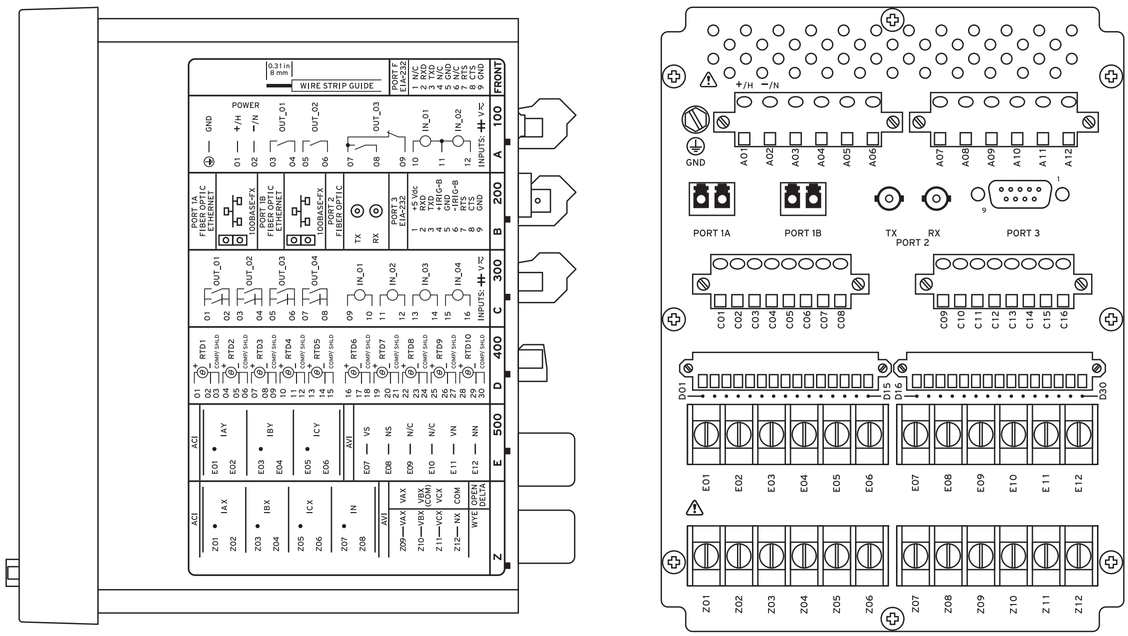
Pins	Jumper Default Position	Description
A	Not bypassed (requires password)	Password bypass
B	On (breaker control enabled)	Enable breaker control[a,b]
C	Not bypassed (not forced SELBOOT)	Forced SELBOOT

[a] Enable/disable serial port, front panel, and Fast Operate commands for the breaker control. The jumper position affects the breaker control using the OPEN or CLOSE commands and output contact control using the PULSE command via the serial port, the front-panel menu-driven user interface, or the communications protocols. The jumper position does not affect the operation of the local bits, the remote bits, or the front-panel programmable pushbuttons.
[b] Units shipped prior to December 3, 2019 do not have the breaker control jumper installed by default.

Relay Connections

Side-Panel and Rear-Panel Diagrams

The physical layout of the connectors on the rear-panel and side-panel diagrams of three sample configurations of the SEL-700G are shown in *Figure 2.8* through *Figure 2.11*.

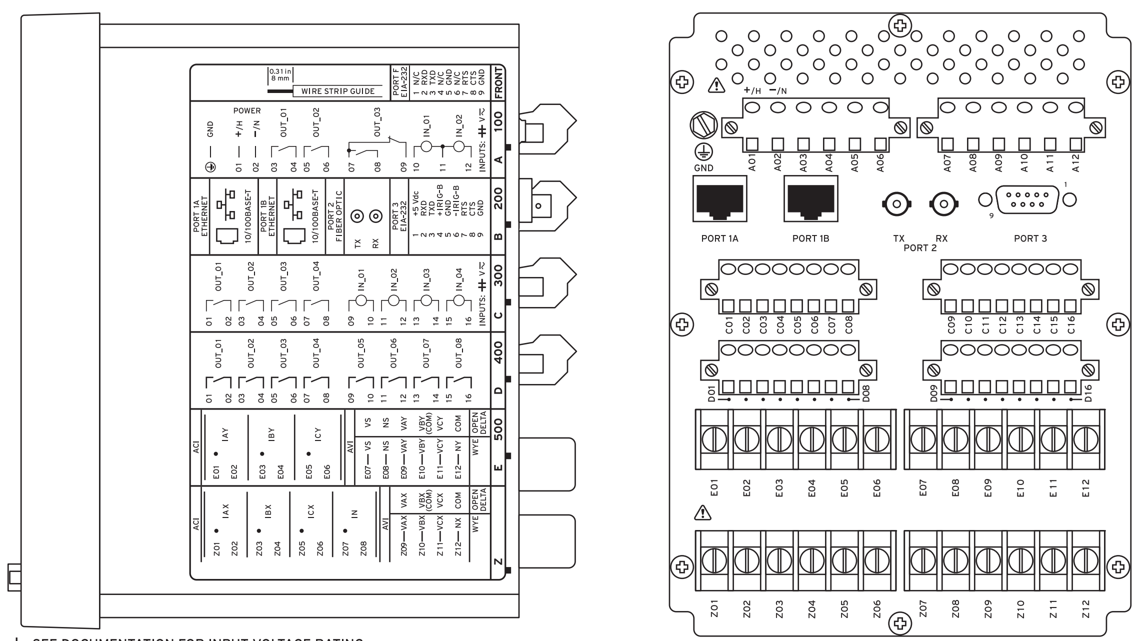


‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(a) Side-Panel View

(b) Rear-Panel View

Figure 2.8 SEL-700G1+ With Dual-Fiber Ethernet, Fast Hybrid 4 DI/4 DO, 10 RTDs, 3 ACI/2 AVI, 4 ACI/3 AVI (Relay MOT 0700G11ACA9X76850830)

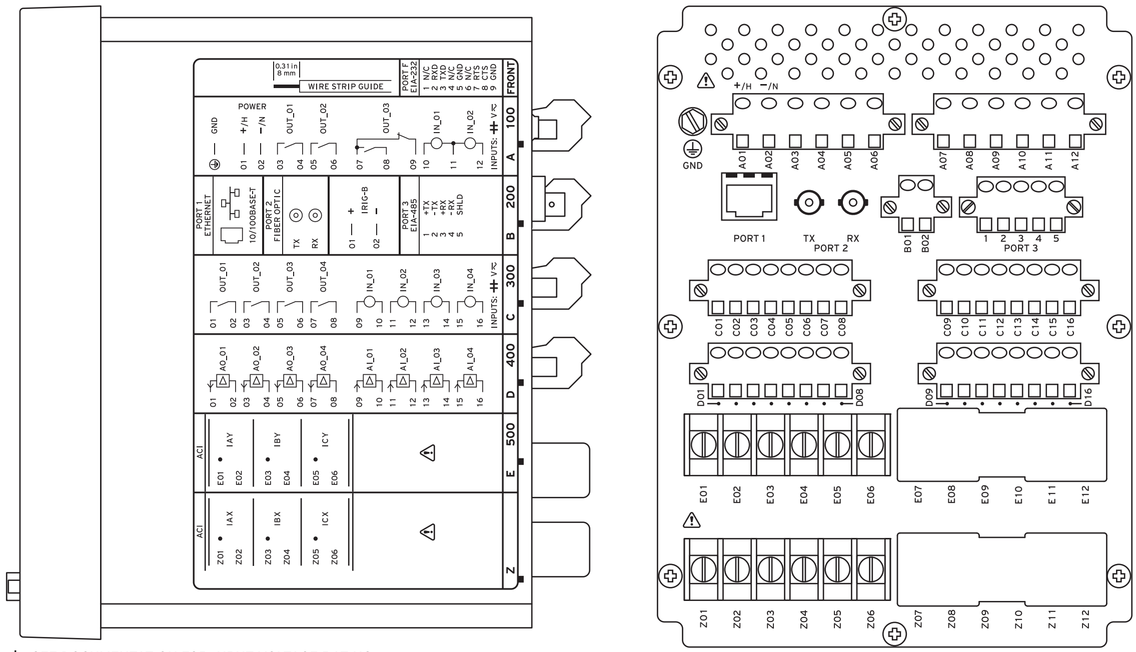


‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(a) Side-Panel View

(b) Rear-Panel View

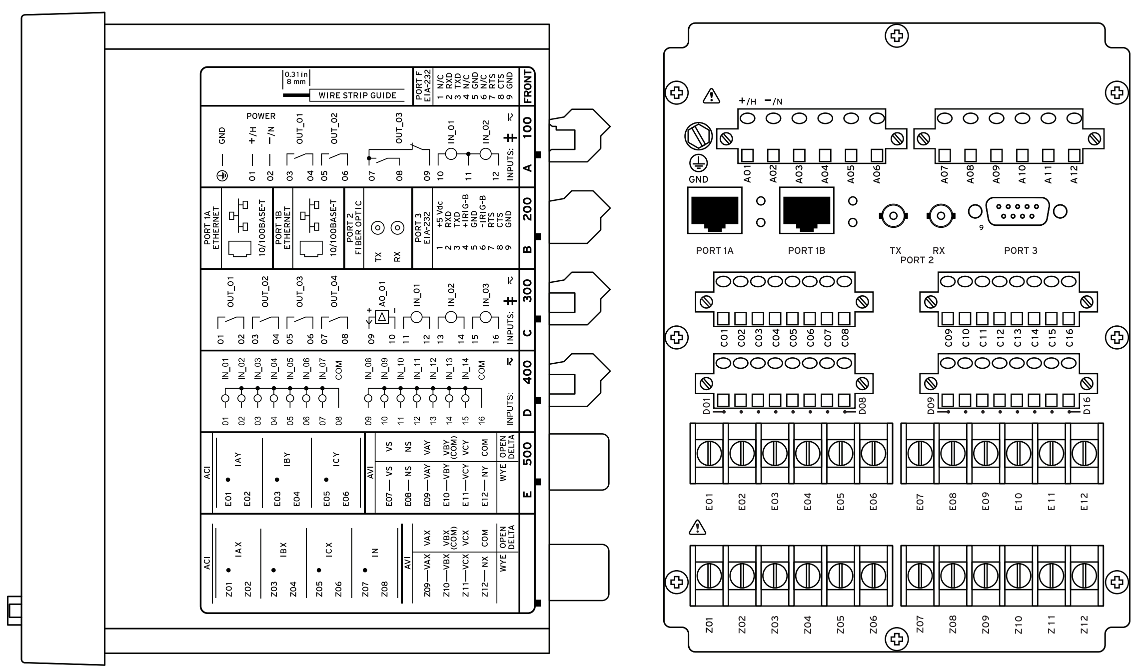
Figure 2.9 SEL-700GT+ With Dual Copper Ethernet, 4 DI/4 DO, 8 DO, 3 ACI/4 AVI, 4 ACI/3 AVI (Relay MOT 0700GT1A1A2X75850630)



‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(a) Side-Panel View (b) Rear-Panel View

Figure 2.10 SEL-700GW With Copper Ethernet, 4 DI/4 DO, 4 AI/4 AO, 3 ACIE, 3 ACIZ (Relay MOT 0700GW1A1A6X77870310)



‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(a) Side-Panel View (b) Rear-Panel View

Figure 2.11 SEL-700GT+ With Dual Copper Ethernet, 3 DI/4 DO/1 AO, 14 DI, 3 ACI/4 AVI on Slot E, 4 ACI/3 AVI on Slot Z (Relay MOT 0700GT1ABA4A7585A670)

Power Connections

⚠DANGER
Contact with instrument terminals can cause electrical shock that can result in injury or death.

⚠CAUTION
Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.

The **POWER** terminals on the rear panel, **A01 (+/H)** and **A02 (—/N),** must connect to 110–240 Vac, 110–250 Vdc, or 24–48 Vdc (see *Power Supply on page 1.13* for complete power input specifications). The **POWER** terminals are isolated from chassis ground. Use 14 AWG (2.1 mm^2) to 16 AWG (1.3 mm^2) size wire to connect to the **POWER** terminals.

The SEL-700G comes with an orange Euro connector on the Slot A card for the 24–48 Vdc low-voltage power supply options. *Figure 2.12* shows the orange Euro connector with 24–48 Vdc power supply rating.

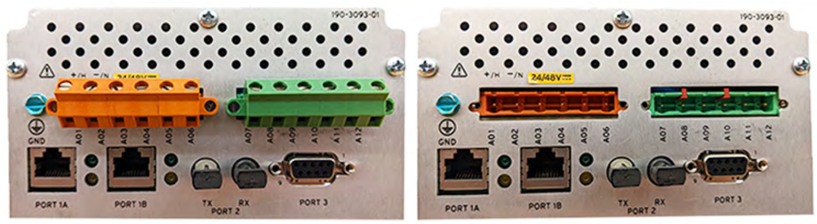


Figure 2.12 Slot A Euro Connector

For compliance with IEC 60947-1 and IEC 60947-3, place a suitable external switch or circuit breaker in the power leads for the SEL-700G; this device should interrupt both the hot **(+/H)** and neutral **(-/N)** power leads. The maximum rating for the power disconnect circuit breaker or optional overcurrent device (fuse) should be 20 A, 300 V.

Operational power is internally fused by a power supply fuse. See *Field Serviceability on page 2.39* for details. Be sure to use fuses that comply with IEC 60127-2.

Serial Ports

Because all ports (**F**, **2**, **3**, and **4**) are independent, you can communicate to any combination simultaneously. Although serial **PORT 4** on the optional communications card consists of an EIA-485 (**4A**) and an EIA-232 (**4C**) port, only one port is available at a time. Use the **PORT 4** communications interface COMMINF setting to select between EIA-485 and EIA-232.

The serial port EIA-485 plug-in connector accepts wire size 26 AWG through 14 AWG. Strip the wires 8 mm (0.31 in) and install with a small slotted-tip screwdriver. All EIA-232 ports accept 9-pin D-subminiature male connectors.

For connecting devices at distances over 100 ft, where metallic cable is not appropriate, SEL offers fiber-optic transceivers or the SEL-2812 compatible ST fiber-optic port. The SEL-2800 family of transceivers provides fiber-optic links between devices for electrical isolation and long-distance signal transmission. Contact SEL for further information on these products.

IRIG-B Time-Code Input

The SEL-700G accepts a demodulated IRIG-B time signal to synchronize the internal clock with an external source. Three options for IRIG-B signal input are given, but only one should be used at a time. You can use the IRIG-B (**B01** and **B02**) inputs, an SEL communications processor via EIA-232 serial **PORT 3**, or fiber-optic serial **PORT 2**. The available communications processors are the SEL-2032, SEL-2030, SEL-2020, and the SEL-2100 Logic Processor. You can also use the SEL-3530 Real-Time Automation Controller (RTAC) to provide IRIG-B input.

The models with fiber-optic Ethernet and dual copper Ethernet do not have the terminals **B01** and **B02** for IRIG-B but have IRIG-B input via EIA-232 **PORT 3**. The third option for IRIG-B is via fiber-optic serial **PORT 2**. Use an

SEL-2812MT Transceiver to connect to the SEL-2030 or SEL-2032 and bring the IRIG-B signal with the EIA-232 input. Use a fiber-optic cable pair with ST connectors (C805, C807, or C808) to connect to **PORT 2** on the SEL-700G. Refer to *Section 7: Communications* for IRIG-B connection examples and for details about using an SEL-2401/2407/2404 as a time source.

Ethernet Port

The SEL-700G can be ordered with an optional single/dual 10/100BASE-T or 100BASE-FX Ethernet port. Connect to **PORT 1** of the device by using a standard RJ45 connector for the copper port and an LC connector for the fiber-optic port.

Fiber-Optic Serial Port

The optional fiber-optic serial port is compatible with the SEL-2812 (with IRIG-B) or the SEL-2814 Fiber-Optic Transceivers, SEL-2664 Field Ground Module, and the SEL-2600 RTD Module.

I/O Connections

When the relay is ordered with the 24 Vdc/Vac or 48 Vdc/Vac input voltage option, the digital inputs come with the orange Euro connector on the slot. *Figure 2.13* shows the orange Euro connector for the 3 DI/4 DO/1 AO digital inputs option on Slot C.

Figure 2.13 Slot C Euro Connector

I/O Diagram

A more functional representation of two of the control (I/O) connections is shown in *Figure 2.14* and *Figure 2.15*.

NOTE: All digital inputs and digital outputs (including high-current, high-speed hybrid) connections are polarity neutral.

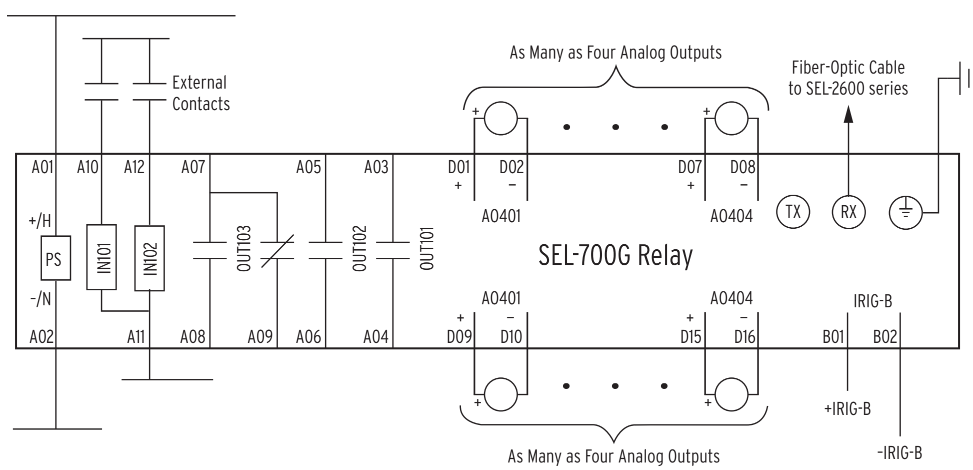
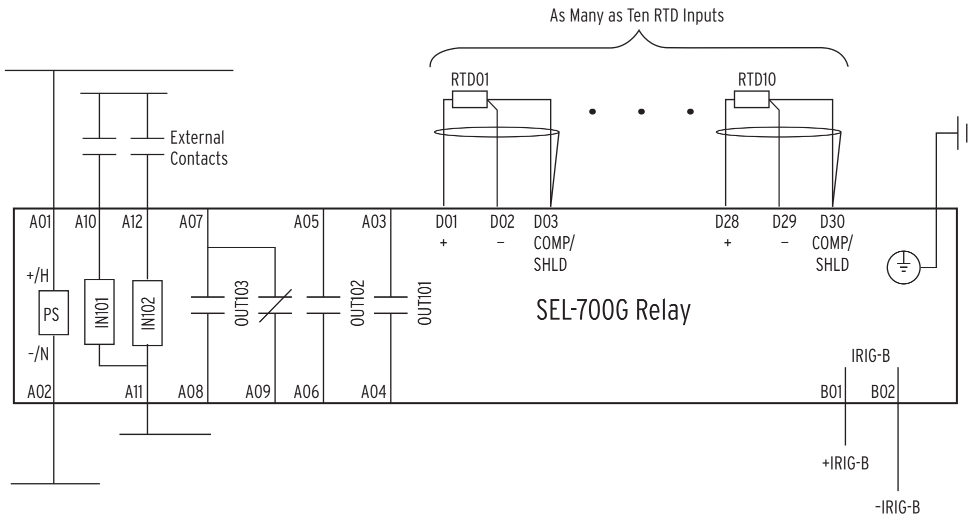


Figure 2.14 Control I/O Connections—4 AI/4 AO Option in Slot D

NOTE: All RTD comp/shield terminals are connected internally to the relay chassis.



- The chassis ground connector located on the rear-panel card Slot A must always be connected to the local ground mat.
- Power supply rating (110-240 Vac, 110-250 Vdc, or 24–48 Vdc) depends on the relay part number.
- Optoisolated Inputs IN101 and IN102 are standard and are located on the card in Slot A.
- All optoisolated inputs are single-rated: 24, 48, 110, 125, 220, or 250 Vac/Vdc. Standard Inputs IN101 and IN102 can have a different rating than the optional IN401/402/403/404 (not shown).
- Output Contacts OUT101, OUT102, and OUT103 are standard and are located on the card in Slot A.
- The analog (transducer) outputs shown are located on the optional I/O expansion card in Slot D.
- The fiber-optic serial port is located on the card in Slot B. A Simplex 62.5/200 µm fiber-optic cable is necessary to connect the SEL-700G with an SEL-2600 RTD Module. This fiber-optic cable should be 1000 meters or shorter.

Figure 2.15 Control I/O Connections—Internal RTD Option

RTD Wiring

NOTE: RTD inputs are not internally protected for electrical surges. External protection is recommended if surge protection is necessary.

Table 2.20 shows the maximum cable lengths for the RTD connections that satisfy the 25-ohm limit required for connecting to SEL devices.

Table 2.20 Typical Maximum RTD Lead Length

RTD Lead AWG	Maximum Length (meters)
28	116 m
26	184 m
24	290 m
22	455 m
20	730 m
18	1155 m
16	1848 m

Refer to application guide *AG2017-09: Applying Various Types of RTDs With SEL Devices*. This application guide specifies the correct connection of two-wire, three-wire, and four-wire RTDs to three-terminal SEL measurement devices.

RTD wiring recommendations:

1. Use shielded, twisted-pair cables for RTD wiring.
2. Connect the RTD_CAL wire to the RTD CAL/SHIELD Terminal on the SEL device. This will eliminate any wiring resistance error.
3. Make sure the RTD mounting ear screws are snug and secure.

Use relay wire termination kits—see *Application Note AN2014-08*—and avoid fitting multiple wires into a single terminal, the bird caging effect of stranded wire, and bulky wire bundles.

Analog Output Wiring

NOTE: Connection of dc voltage to the analog output terminals could result in damage to the relay.

Connect the two terminals of the analog output as shown in *Figure 2.16*. Also connect the analog output cable shield to ground at the relay chassis ground, programmable logic controller (PLC), or meter location. Do not connect the shield to ground at both locations.

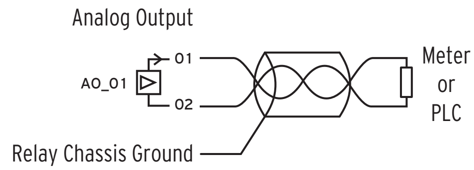


Figure 2.16 Analog Output Wiring Example

AC/DC Control Connection Diagrams

This section describes fail-safe versus nonfail-safe tripping, describes voltage connections, and provides the ac and dc wiring diagrams.

Fail-Safe/Nonfail-Safe Tripping

NOTE: Fast hybrid contacts are designed for fast closing (50 µs) only. Fail-safe mode operating time (time to open the contacts) for fast hybrid contacts is <8 ms (the same time as for a normal output contact).

Figure 2.17 shows the output **OUT103** relay coil and Form C contact. When the relay coil is de-energized, the contact between **A07** and **A08** is open while the contact between **A07** and **A09** is closed.

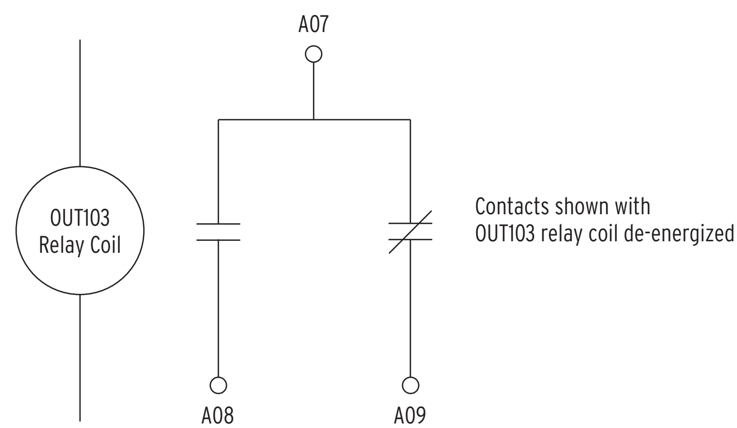


Figure 2.17 Output OUT103 Relay Output Contact Configuration

The SEL-700G provides fail-safe and nonfail-safe trip modes (setting selectable) for all output contacts. The following occurs in fail-safe mode:

- The relay coil is energized continuously if the SEL-700G is powered and operational.
- When the SEL-700G generates a trip signal, the relay coil is de-energized.
- The relay coil is also de-energized if the SEL-700G power supply voltage is removed or if the SEL-700G fails (self-test status is FAIL).

Figure 2.18 shows fail-safe and nonfail-safe wiring methods to control breakers.

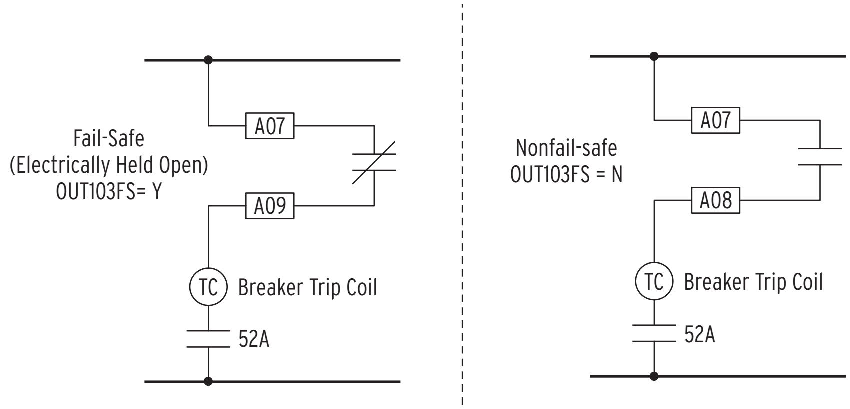


Figure 2.18 Breaker Trip Coil Connections With OUT103FS := Y and OUT103FS := N

High-Speed, High-Current Interrupting DC Tripping Outputs

High-speed outputs are optimized for direct tripping of power circuit breakers. They operate in less than 50 µs, work with dc trip coil circuits, are polarity insensitive and capable of making 30 A, and can interrupt 10 A with an 8 ms dropout time. High-speed outputs are implemented as hybrid circuits, each of which consists of the parallel combination of a high-current, solid-state switch and an electromechanical bypass relay.

Avoid using high-speed outputs to drive highly sensitive, high-input-resistance electronic inputs (e.g., <2 mA electronic circuits) unless such inputs are connected in parallel with a low-resistance load (e.g., a breaker trip coil). Avoid connecting multiple high-speed outputs in parallel when driving highly sensitive electronic inputs. Keep wiring short and use fiber-based MIRRORED BITS communications to bridge longer distances.

Voltage Connections

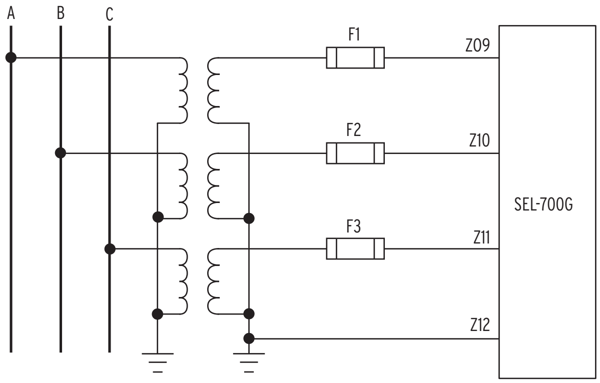
NOTE: Current limiting fuses in direct-connected voltage applications are recommended to limit short circuit arc-flash incident energy.

With the voltage inputs option, the three-phase voltages can be connected either 3-wire (delta) or 4-wire (wye). *Figure 2.19 (a–d)* shows typical methods for connecting three-phase voltages. The relay also allows you to connect external zero-sequence voltage (3V0) to **VS-NS** or **VN-NN** inputs, as shown in *Figure 2.19 (e)* and *Figure 2.19 (f)*, respectively, when the terminal PTs are delta connected. Refer to *SEL-700G1+ Generator Relay Application Example 2*, *Illustrating the 67N Element* and *Section 4: Protection and Logic Functions* for more details.

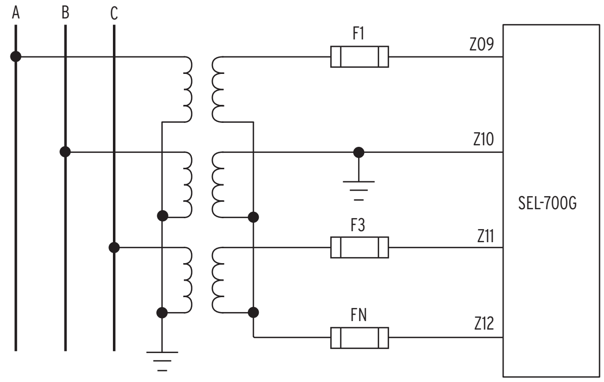
Notes:

1. Voltage circuit should be grounded in the relay cabinet.
2. Slot Z connections are shown; Slot E connections are similar.

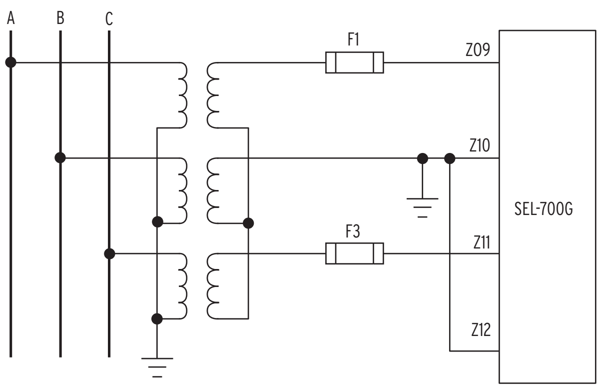
(a) Wye-Wye VT 4-Wire Connection (Set DELTAY_X := Wye)



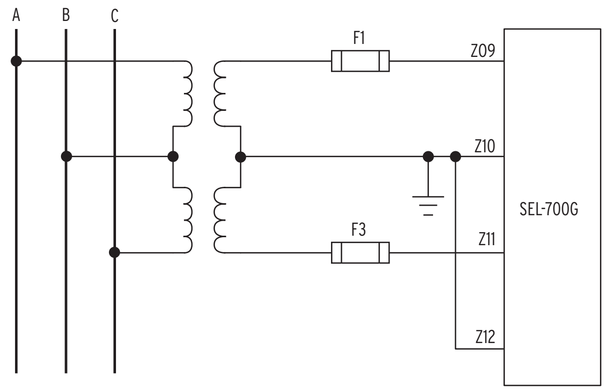
(b) Wye-Wye VT 4-Wire Connection (Set DELTAY_X := Wye)



(c) Wye-Wye VT 3-Wire Connection (Set DELTAY_X := Delta)



(d) Open-Delta VT 3-Wire Connection (Set DELTAY_X := Delta)



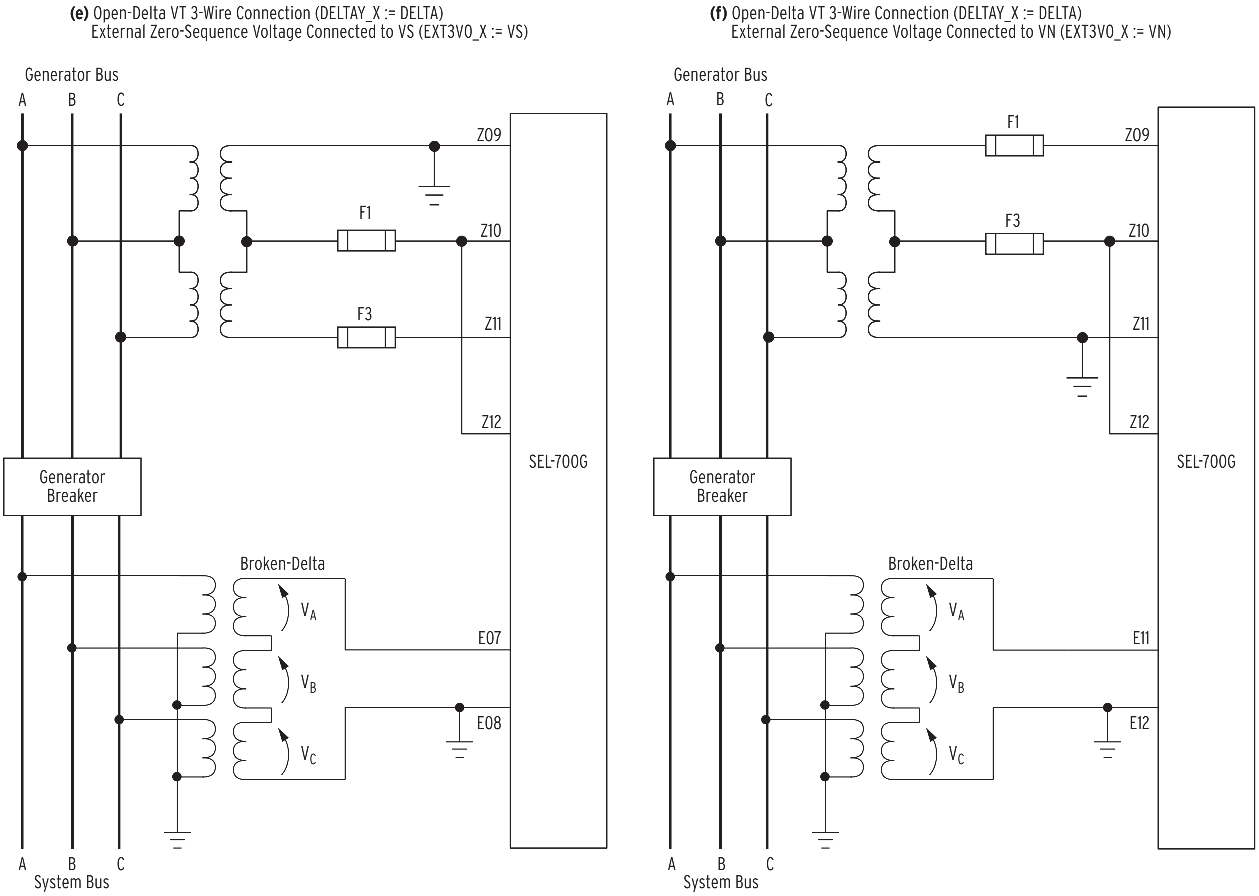


Figure 2.19 Voltage Connections

AC/DC Connections and Applications

NOTE: When the **VS-NS** or **VN-NN** voltage inputs are unused in the SEL-700G1+ model and the setting DELTAY_X := DELTA, then one of these voltage inputs could be used to connect an external zero-sequence voltage. In such an application, the setting EXT3V0_X must also be set accordingly. Refer to *Section 4: Protection and Logic Functions* for more details.

Figure 2.20 through *Figure 2.25* show ac and dc connection diagrams and applications for the SEL-700G0, SEL-700G1, SEL-700GT, and SEL-700GW relays.

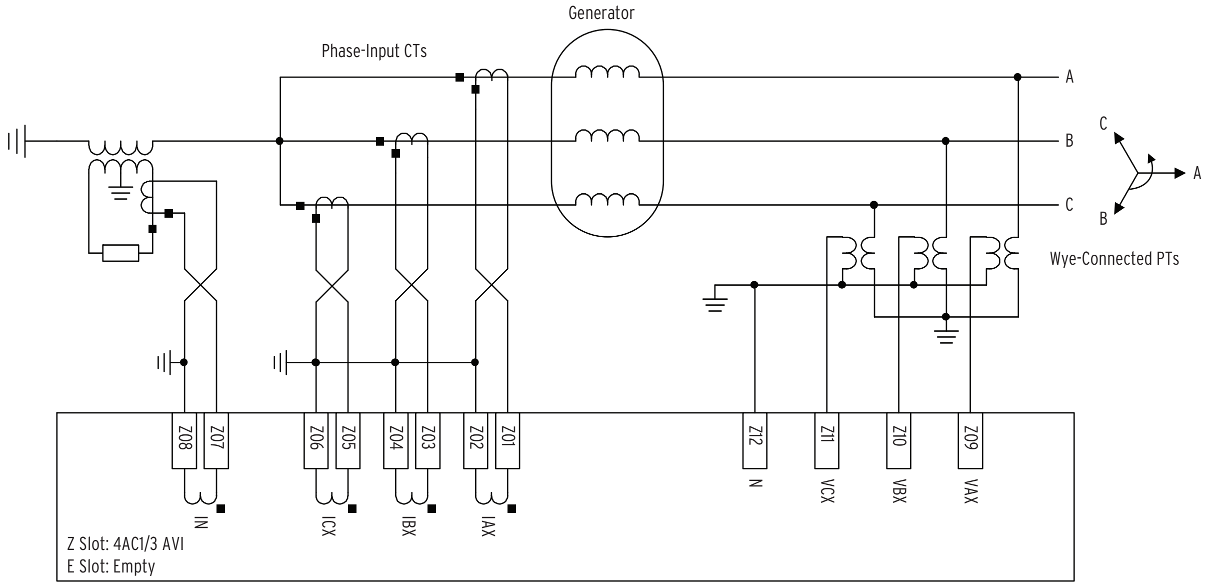


Figure 2.20 SEL-700G0 Relay AC Connection Example—High-Impedance Grounded Generator Without Current Differential Protection

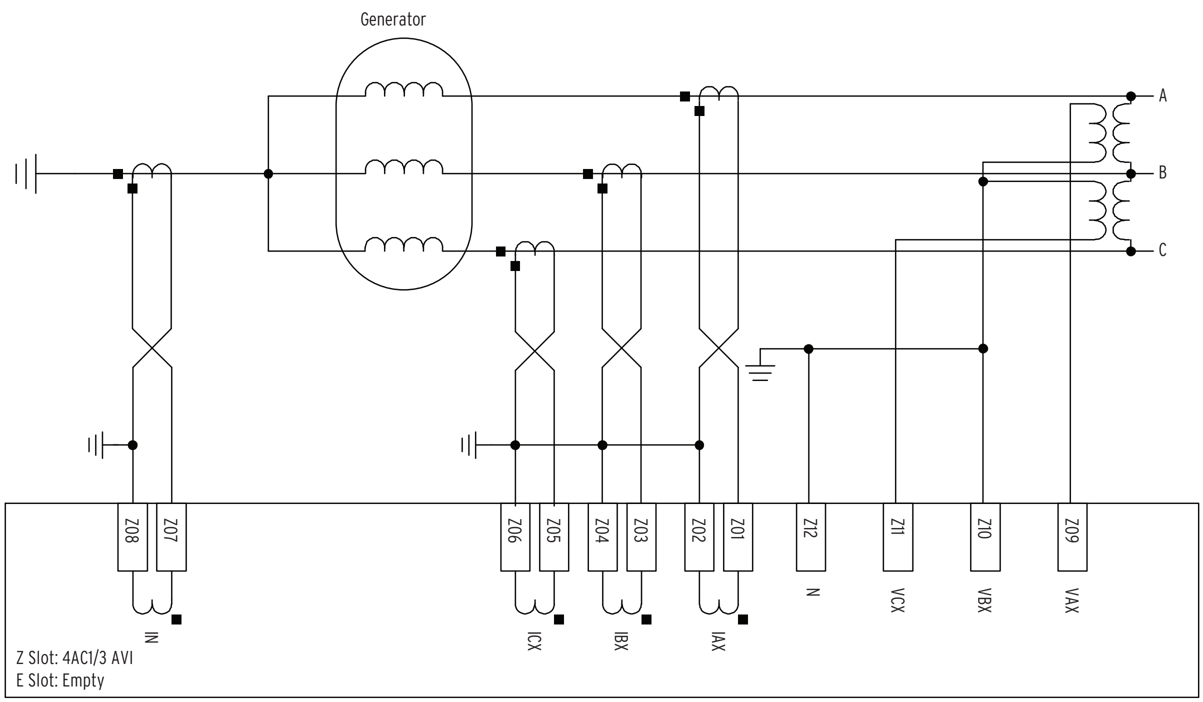


Figure 2.21 SEL-700G0 Relay AC Connection Example—Solidly Grounded Generator With Ground Differential Protection (87N)

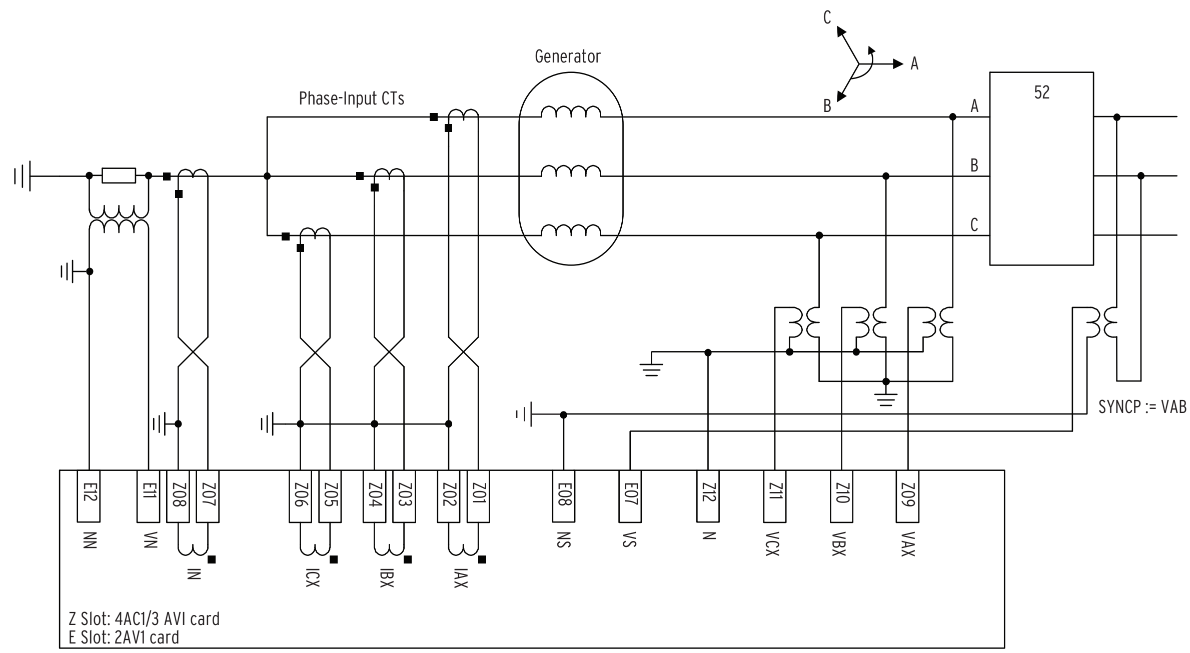


Figure 2.22 SEL-700G0+ Relay High-Impedance Grounded Generator With Synchronism Check and Without Current Differential Protection

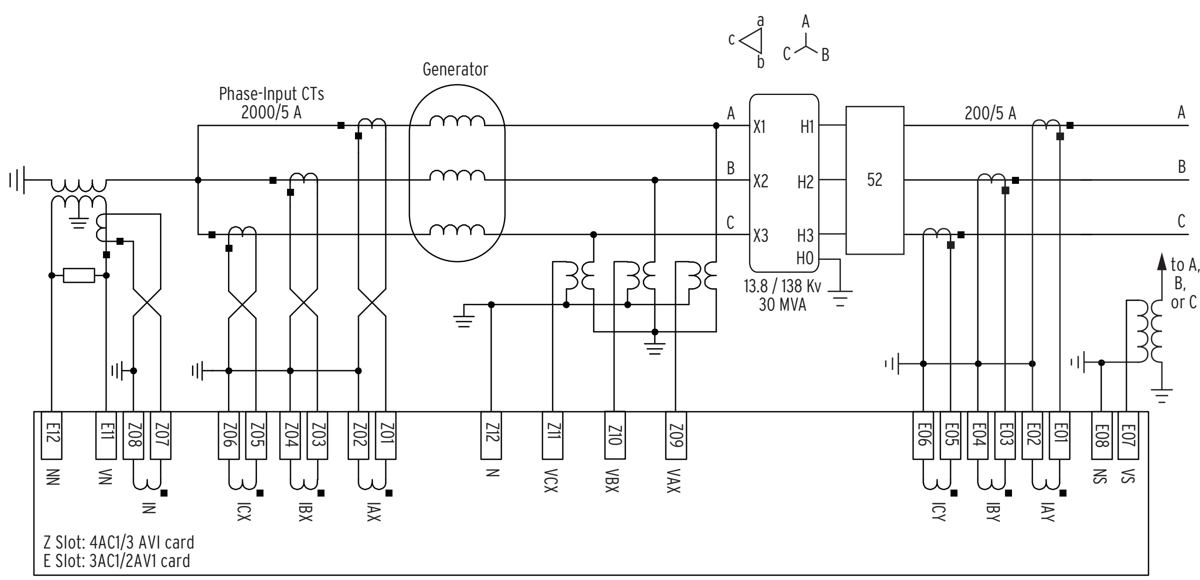


Figure 2.23 SEL-700G1+ Relay AC Connection Example—High-Impedance Grounded Generator With Step-Up Transformer Included in Differential Zone (With Synchronism Check and 100% Stator Ground Protection)

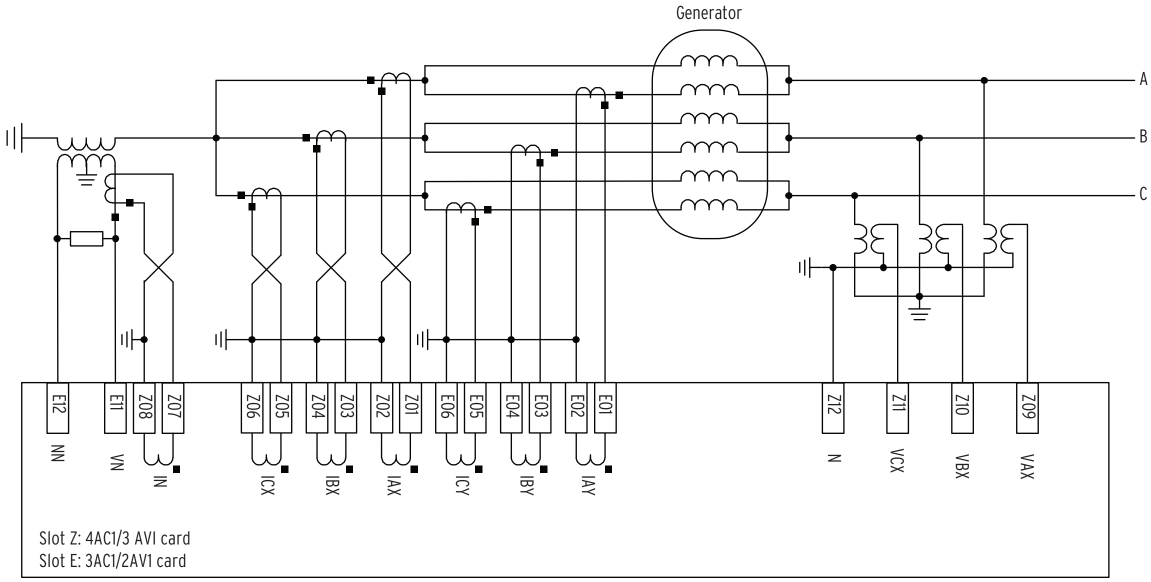


Figure 2.24 SEL-700G1+ Relay AC Connection Example—High-Impedance Grounded Generator With Split-Phase Current Differential Protection

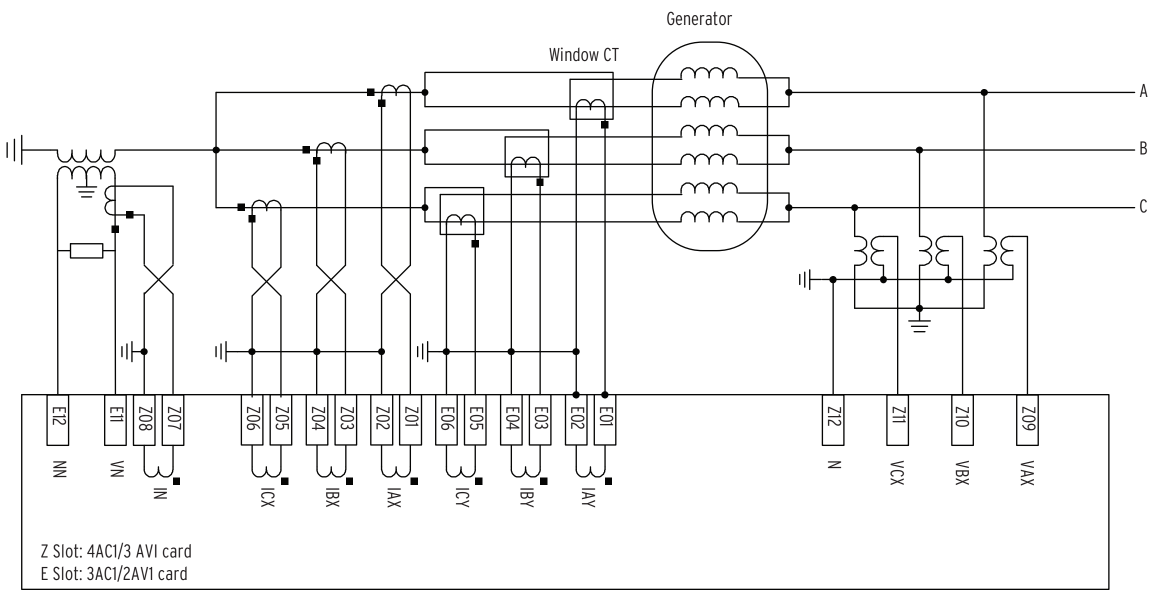


Figure 2.25 SEL-700G1+ Relay High-Impedance Grounded Generator With Split-Phase, Self-Balancing Differential Protection

SEL-700G1+ Generator Relay Application Example 1

Example 1 shows an SEL-700G1+ Relay application with full generator protection including:

- ➤ Phase differential element (87)
- ➤ Field ground element (64F) requires SEL-2664 Field Ground Module
- ➤ 100% stator ground protection (64G elements)
- ➤ RTD inputs—requires SEL-2600 RTD Module or RTD input card in Slot D
- ➤ Synchronism-check (25X) and autosynchronism functions

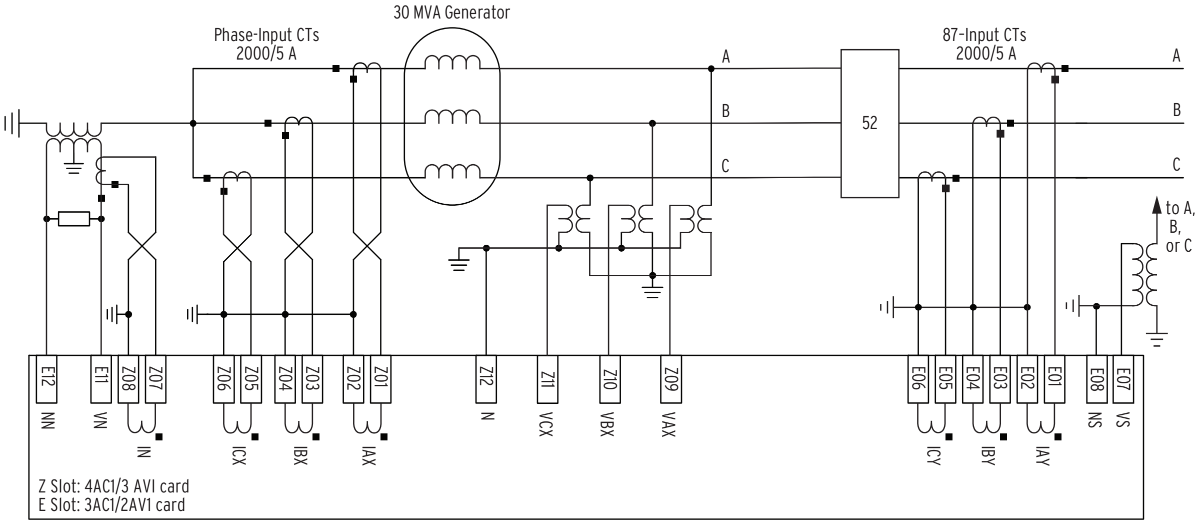
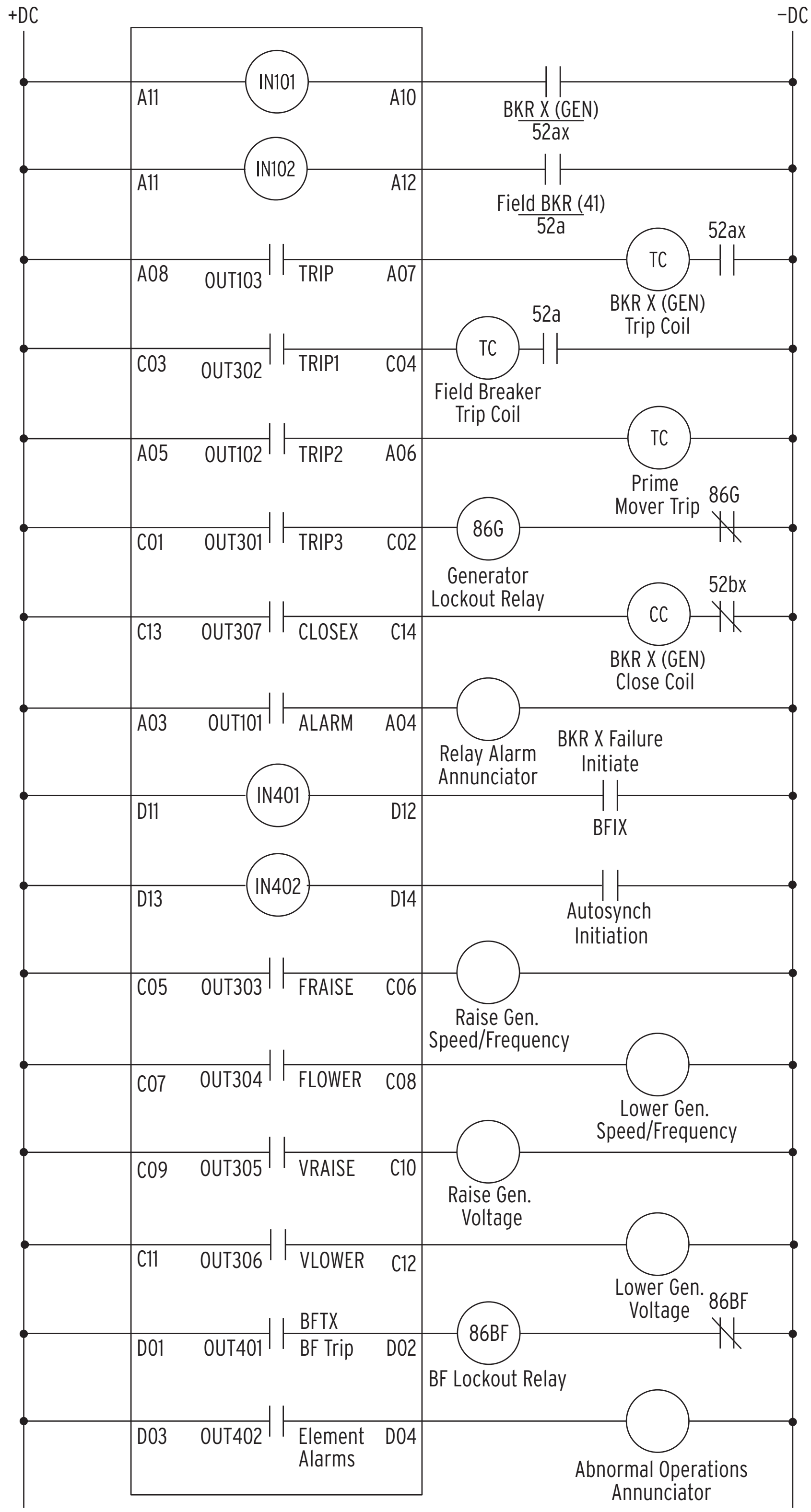


Figure 2.26 SEL-700G1+ Relay Typical AC Current and Four-Wire Wye Voltage Connection With MOT SEL-0700G11A2XBA76850231



Notes:

- IN101–102 and OUT 101–103 are in the "base"relay—Slot A Power Supply card.
- Slot C—Select 8DO card OUT301–OUT308.
- Slot D—Select 3DI/4DO/1AO IN401–IN403 OUT401–OUT404 AO401.
- Spares IN403, OUT403–404, AO401, OUT308.
- Use Ethernet Port 1 for Synchrophasors, Modbus, DNP or IEC 61850.
- Use Port 2 for SEL-2600 RTD Module.
- Use Port 3 for SEL-2664 Field Ground Module (with an SEL-2812MR or SEL-2812MT and an SEL-C805, SEL-C807, or SEL-C808 fiber-optic cable).
- Settings changes required are not shown.
- Additional I/O and relay logic may be necessary for a specific application.

Figure 2.27 SEL-700G1+ Typical DC External Connections

SEL-700G1+ Generator Relay Application Example 2

Illustrating the 67N Element

This example shows an SEL-700G1+ Relay application with full generator protection. The application involves several high-impedance grounded generators connected to the same bus. This application calls for a sensitive neutral directional overcurrent element (67N) looking into the generator. A core-balance CT is installed to achieve greater sensitivity. The output of the core-balance CT is connected to the **IN** input on the relay. The terminal PTs in this application are connected in open-delta, but the 67N element requires zero-sequence voltage (3V0) for polarization. In this application, by setting EXT3V0_X := VS, connect external 3V0 to **VS-NS** input for use with 67N element. When external 3V0 is connected to the **VS-NS** input, the relay disables the synchronism-check (25X) and autosynchronism functions. Likewise, external 3V0 can also be connected to the **VN-NN** input (set EXT3V0_X := VN) for use with the 67N element, in which case the relay disables the 64G function.

The generator protection for this application includes the following elements:

- ➤ Phase differential element (87)
- ➤ Field ground element (64F)—requires SEL-2664 Field Ground Module
- ➤ 100% stator ground protection (64G elements)
- ➤ RTD inputs—requires SEL-2600 RTD Module or RTD input card in Slot D
- ➤ Zero-sequence voltage-polarized directional element for high-impedance grounded system (67N)

When the voltage inputs **VS-NS** or **VN-NN** are unused in the corresponding models (SEL-700G0+, SEL-700G1+ or SEL-700GT+) and the setting DELTAY_X := DELTA, then you can use one of the available voltage inputs to connect an external zero-sequence voltage. In such an application, the setting EXT3V0_X must also be set accordingly. External 3V0 is neither required nor allowed if the terminal PTs are wye connected (DELTAY_X := WYE). You can use the external 3V0 with the following elements. Refer to *Section 4: Protection and Logic Functions* for more details.

- ➤ 100% Stator Ground Protection Elements (64G1, 64G2; refer to *Section 4: Protection and Logic Functions*, *100% Stator Ground Protection Elements*)
- ➤ Ground Overvoltage Elements (59GX1, 59GX2; refer to *Section 4: Protection and Logic Functions*, *Over- and Undervoltage Elements*)
- ➤ Zero-Sequence Voltage-Polarized Directional Element With IG as Operate Quantity (67G; refer to *Section 4: Protection and Logic Functions*, *Overcurrent Elements on page 4.90* and *Directional Elements on page 4.105*)
- ➤ Zero-Sequence Voltage-Polarized Directional Element With IN as Operate Quantity (67N; refer to *Section 4: Protection and Logic Functions*, *Overcurrent Elements on page 4.90* and *Directional Elements on page 4.105*)

Note that the 67G element listed previously could be achieved by setting the 50G element with the appropriate directional control setting. Similarly, the 67N element listed previously could be achieved by setting the 50N element with the appropriate directional control setting. Refer to *Section 4: Protection and Logic Functions*, *Overcurrent Elements on page 4.90* and *Directional Elements on page 4.105* for more information.

SEL recommends that the external 3V0 connected to **VS-NS** or **VN-NN** inputs for use with the previous elements should be an equivalent of that calculated by the relay at the generator terminals, given wye-connected PTs (i.e., when a DELTAY_X := WYE relay calculated 3V0 = VAX + VBX + VCX).

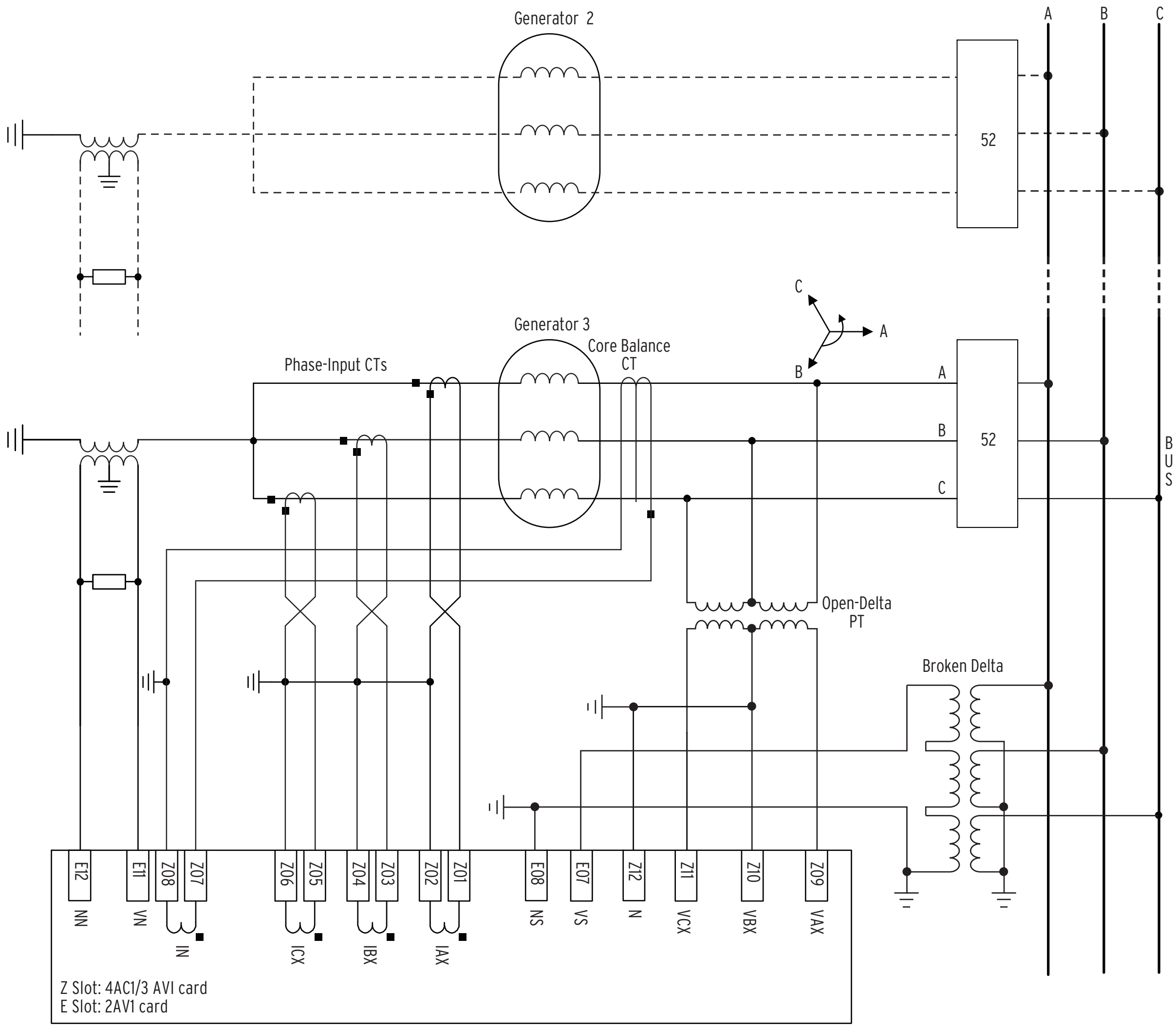


Figure 2.28 SEL-700G1+ Relay AC Connection Example, Multiple High-Impedance Grounded Generators Connected to a Common Bus, With 67N and Other Protection

SEL-700GT+ Intertie Relay Application

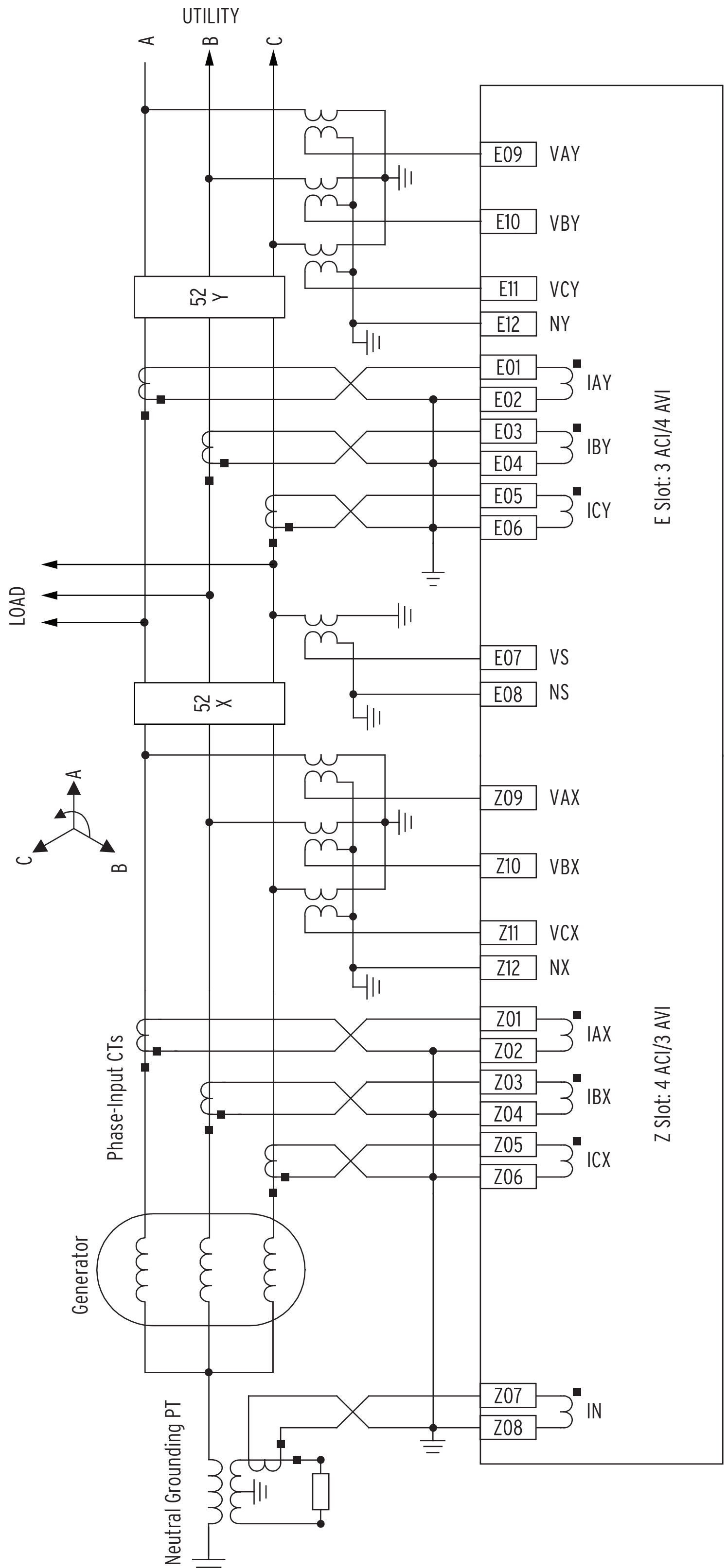


Figure 2.29 SEL-700GT+ Relay Typical AC Current and Four-Wire Wye Voltage Connection

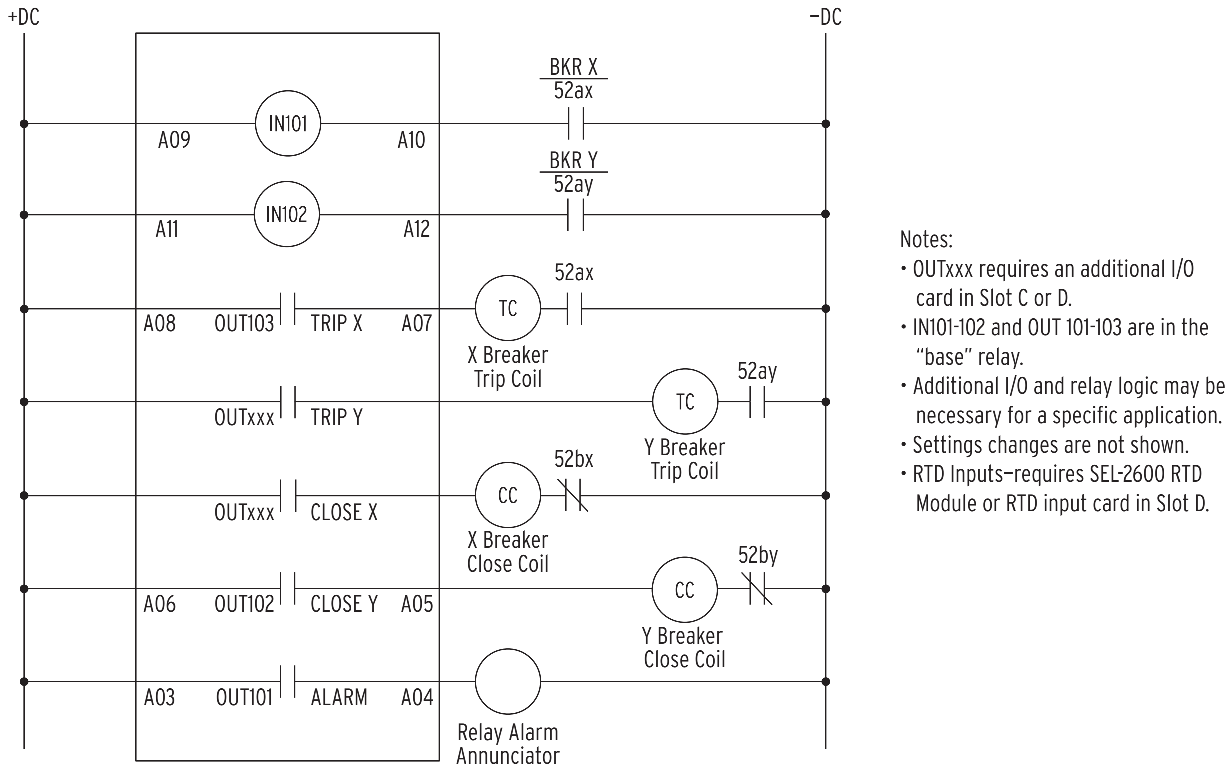


Figure 2.30 SEL-700GT+ Typical DC External Connections

SEL-700GW Wind Generator Relay Application

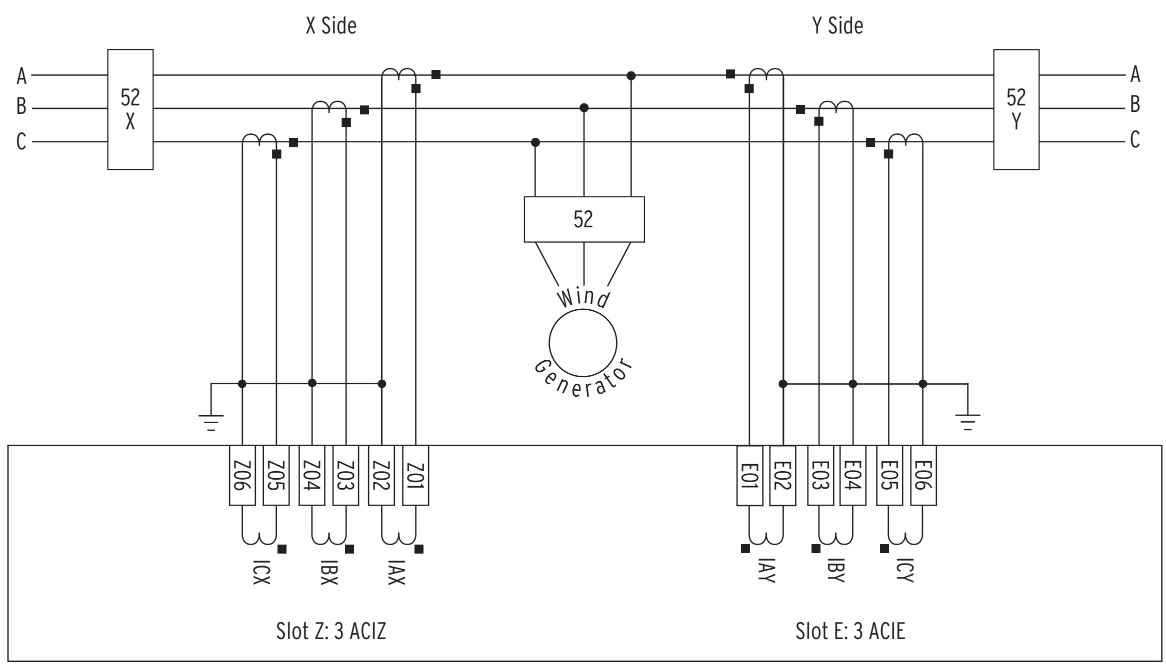
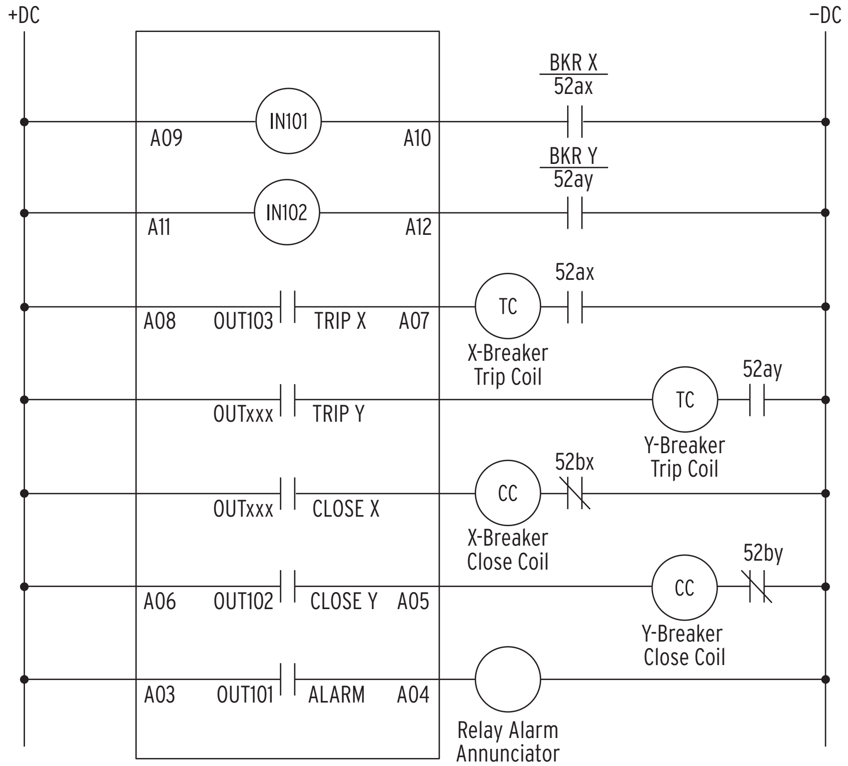


Figure 2.31 SEL-700GW Dual Feeder AC Current Connections



Notes:
- OUTxxx requires an additional I/O card in Slot C or D.
- IN101-102 and OUT 101-103 are in the "base" relay.
- Additional I/O and relay logic may be necessary for a specific application.
- Settings changes are not shown.
- Field ground element (64F) requires SEL-2664 Field Ground Module.
- RTD Inputs—requires SEL-2600 RTD Module or RTD input card in Slot D.

Figure 2.32 SEL-700GW Typical DC External Connections

Thermal Protection of Generator and Prime Mover

Figure 2.33 shows an application example of an SEL-700G Relay and an SEL-2600 RTD Module connected to the multimode fiber-optic serial Port 2 of the relay providing thermal protection for the generator and prime mover.

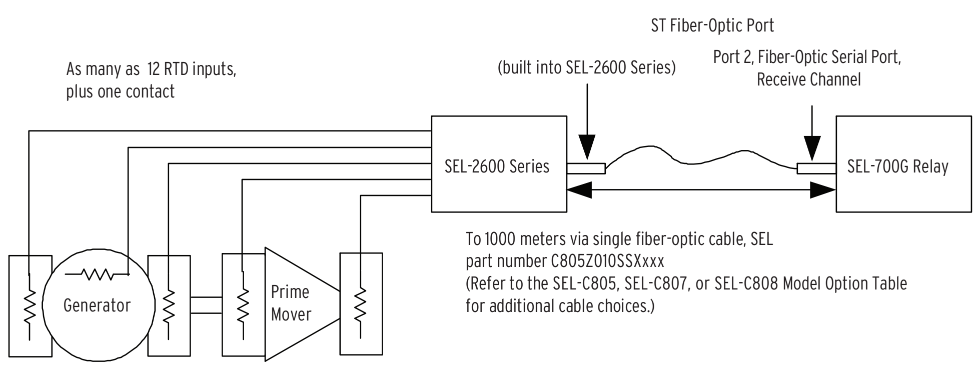


Figure 2.33 Generator Thermal Protection With an SEL-2600 RTD Module and an SEL-700G

Field Ground Protection of Generator

The SEL-700G Relay works with the SEL-2664 Field Ground Module to provide field ground protection for the generator field winding. Two different pickup levels of the insulation resistance are available for configuration. The field ground protection elements (64F) Relay Word bits can be programmed into an output contact for alarm or into the trip equation for tripping. The protection covers a range of high-resistance as well as low-resistance ground faults (from 0.5 to 200 kilohms).

The SEL-700G supports an SEL-2664 Field Ground Module on the EIA-232 port using an SEL-2812M or SEL-2814M for ST connectors. The SEL-700G supports an SEL-2664 Field Ground Module on the EIA-485 port using an SEL-2824 Fiber-Optic Transceiver for ST connectors. The SEL-700G also supports an SEL-2664 on multimode fiber-optic serial Port 2 for ST connectors. The SEL-2664 requires the setting PROTO to be set to SEL protocol at a data rate of 9600 bps.

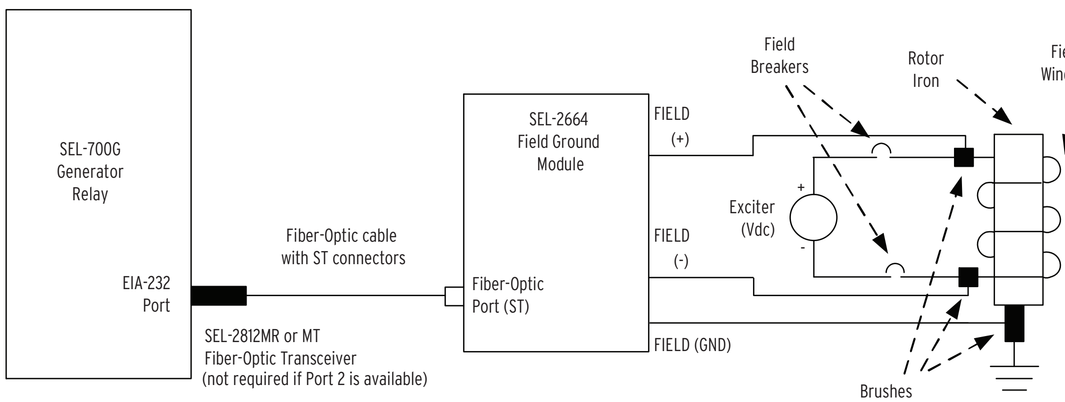


Figure 2.34 Field Ground Protection With an SEL-700G Relay

Field Serviceability

⚠CAUTION
Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.

The SEL-700G firmware can be upgraded in the field; refer to *Appendix B: Firmware Upgrade Instructions* for firmware upgrade instructions. You detect when a self-test failure has occurred by configuring an output contact to create a diagnostic alarm as explained in *Section 4: Protection and Logic Functions*. By using the metering functions, you determine if the analog front end (not monitored by relay self-test) is functional. Refer to *Section 11: Testing and Troubleshooting* for detailed testing and troubleshooting information.

The only two components that can be replaced in the field are the power supply fuse and the real-time clock battery. A lithium battery powers the clock (date and time) if the external power source is lost or removed. The battery is a 3 V lithium coin cell, Panasonic no. BR2330A or equivalent. At room temperature (25°C), the battery operates nominally for 10 years at rated load. When the relay is powered from an external source, the battery experiences a low self-discharge rate. Thus, battery life can extend well beyond 10 years. The battery cannot be recharged.

Fuse Replacement

To replace the power supply fuse, perform the following steps:

Step 1. De-energize the relay.

Step 2. Remove the four rear-panel screws and the relay rear panel.

Step 3. Remove the Slot **A** printed circuit board.

⚠DANGER
Disconnect or de-energize all external connections before opening this device. Contact with hazardous voltages and currents inside this device can cause electrical shock resulting in injury or death.

Step 4. Locate the fuse on the board.

Step 5. Remove the fuse from the fuse holder.

Step 6. Replace the fuse with a BUSS S505 3.15 A (ceramic), Schurter T 3.15 A H 250V, or equivalent.

Step 7. Insert the printed circuit board into Slot **A**.

Step 8. Replace the relay rear panel and energize the relay.

Real-Time Clock Battery Replacement

⚠CAUTION
There is danger of explosion if the battery is incorrectly replaced. Replace only with Panasonic no. BR2330A or equivalent recommended by manufacturer. See Owner's Manual for safety instructions. The battery used in this device may present a fire or chemical burn hazard if mistreated. Do not recharge, disassemble, heat above 100°C or incinerate. Dispose of used batteries according to the manufacturer's instructions. Keep battery out of reach of children.

To replace the real-time clock battery, perform the following steps:

Step 1. De-energize the relay.

Step 2. Remove the four rear-panel screws and the relay rear panel.

Step 3. Remove the Slot **B** printed circuit board.

Step 4. Locate the battery clip (holder) on the board.

Step 5. Carefully remove the battery from beneath the clip.

Properly dispose of the old battery.

Step 6. Install the new battery with the positive (**+**) side facing up.

Step 7. Insert the printed circuit board into Slot **B**.

Step 8. Replace the relay rear panel and energize the relay.

Step 9. Set the relay date and time.

Section 3

PC Interface

Overview

NOTE: We have tested the web server for correct operation and formatting with the following browsers: Internet Explorer 8, Firefox 14, and Chrome 5.

There are a wide variety of browsers available. While most browsers have the same functionality, we cannot guarantee the correct operation and formatting for all of them.

The SEL-700G Relay can communicate with your computer in three different ways.

- ➤ The web server requires a web browser (Microsoft Internet Explorer, Mozilla FireFox, Google Chrome, etc.) and an Ethernet cable. The relay must have the Ethernet port option. See *Web Server* for functional details and capabilities.
- ➤ The SEL software solution requires downloading QuickSet (via Compass) to your computer. Communication to the relay is accomplished through a serial or Ethernet port. Refer to *QuickSet Software* for functional details and capabilities.
- ➤ The ASCII command line requires PC-based terminal emulation software (HyperTerminal, Tera Term, etc.), a serial or Ethernet port, and a serial or Ethernet cable to connect to the relay. Refer to *Section 7: Communications* for details on ASCII commands and functions supported.

Web Server

Connection and Login to Web Server

The web server provides a graphical user interface to the relay without loading any software on your PC. The user interface is contained in the relay firmware. To connect to the web server of the SEL-700G, the relay and your PC must be connected to the same Ethernet network. The network can be of any size, from a company-wide network to a direct-connect from your PC to the relay. The connection from the relay is through the Ethernet port of the relay (Port 1). To start communicating with the relay, you must enter a valid IP address (SET P 1 IPADDR) and valid default router (SET P 1 DEFRTR) via the serial port of the relay. Be sure to obtain the IP address and default router from your IT resource to avoid network conflicts with duplicate IP addresses.

The SEL-700G comes pre-loaded with settings that enable you to communicate with the relay over a simple network. The network consists of connecting the SEL-700G (via Port 1) directly to the Ethernet port of your computer. Use a standard RJ45 connector for the copper port and an LC connector for the fiber-optic port to connect to Ethernet Port 1 of the relay. This connection requires that the computer not be connected to any other network (see *Figure 3.1*).

NOTE: For relays with the fiber-optic Ethernet ports, use a commercially available 100BASE-FX-to-100BASE-TX media converter to interface with a PC RJ45 port. Use SEL-C808 62.5/125 µm Multimode Fiber-Optic Cable to connect to Port 1 on the relay.

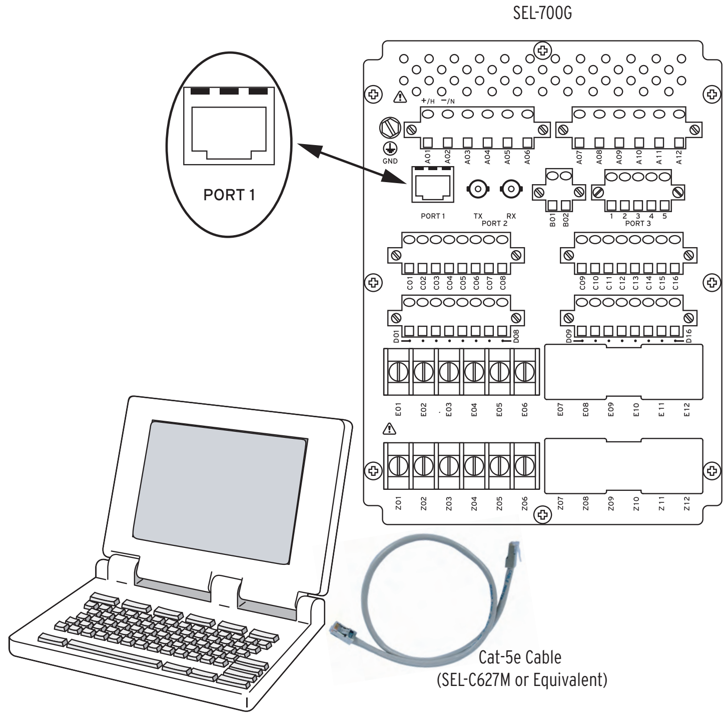


Figure 3.1 Direct Connection of SEL-700G to a Computer

The default IP address is 192.168.1.2 and the default router is 192.168.1.1. Once the network is configured, as shown in *Figure 3.1*, you can connect to the web server in the relay by entering 192.168.1.2 in the address bar of your web browser (as shown in *Figure 3.2*).

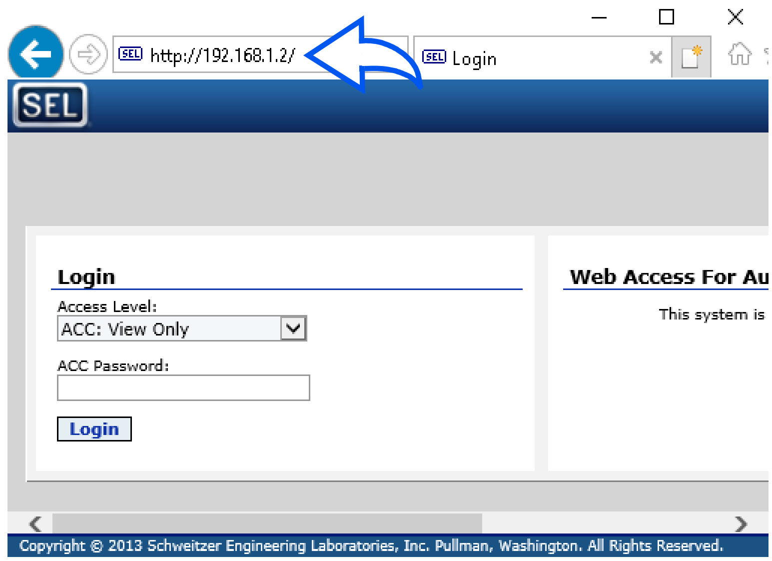


Figure 3.2 Login Page of Web Server for SEL-700G

The Login page of the web server allows you to access either the ACC or 2AC level. The menu item you select under Access Level determines the access level at which you enter the web server (see *Figure 3.3*). For factory-default passwords, refer to *Table 7.41*. **Meter**, **Reports**, **Communications**, **Relay Status**, and **Settings** (Show Only) require Access Level 1 or 2. **System/File Management** requires Access Level 2.

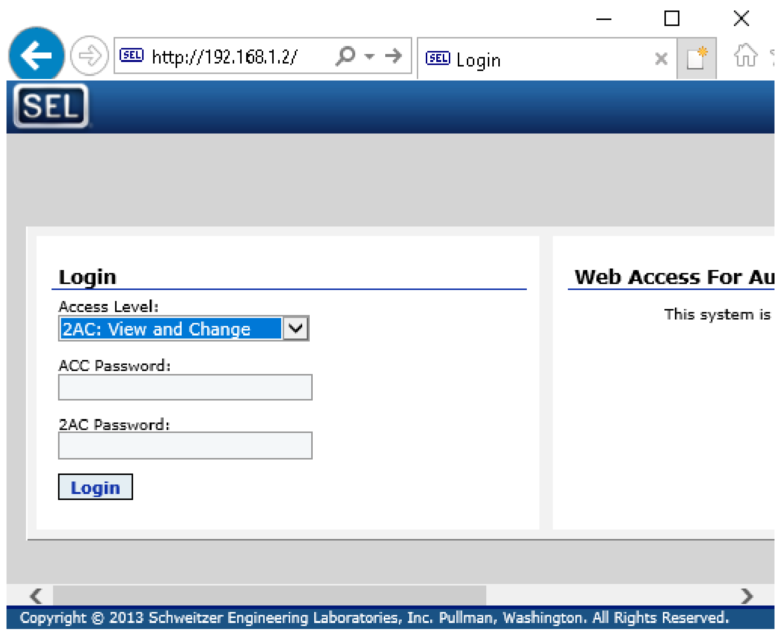


Figure 3.3 Selecting Access Level 2 From Web Server Login

Meter

NOTE: All meter reports will automatically update. To disable updates, select the **Disable Page Refresh** button at the bottom of the display windc

The web server offers a convenient method for displaying all metering reports stored in the relay. Located on the navigation pane, the **Meter** menu contains categories for each of the meter reports. When you select a category from the **Meter** menu, its corresponding meter report is displayed (see *Figure 3.4*).

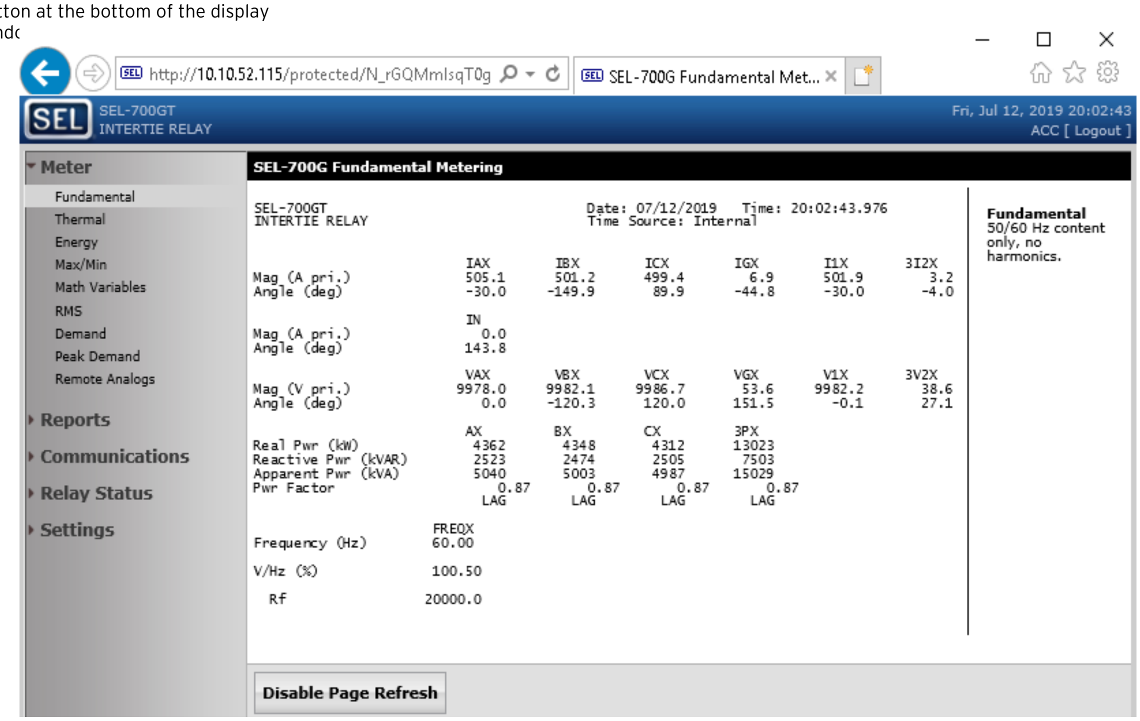


Figure 3.4 Fundamental Meter Report

Reports

In addition to data on metering, the SEL-700G collects and stores a variety of data and statistics from the power system. These data are stored and reported through a series of reports. Located on the navigation pane, the **Report** menu contains categories for each of the reports stored in the relay (Event Reports, Sequential Events Recorder, Load Profile, etc.). When you select a category from the **Reports** menu, its corresponding report is displayed.

Event Reports

Event reports stored in the SEL-700G can be exported in three different formats (Binary COMTRADE, Raw CEV, or Filtered CEV format). When you select **Event Reports**, a list of all the event reports presently stored in the relay is shown (see *Figure 3.5*).

After selecting the event format to be used, select the event report to export by clicking on the event you need. When prompted, you can then open or save the event.

In addition to retrieving events, the **Event Reports** page allows you to clear all events stored in the relay or to trigger events. Clear Event Report History erases the events from the nonvolatile memory of the relay. Trigger Event Report commands the relay to do an event capture of the present voltages and currents detected by the relay (see *Figure 3.5*).

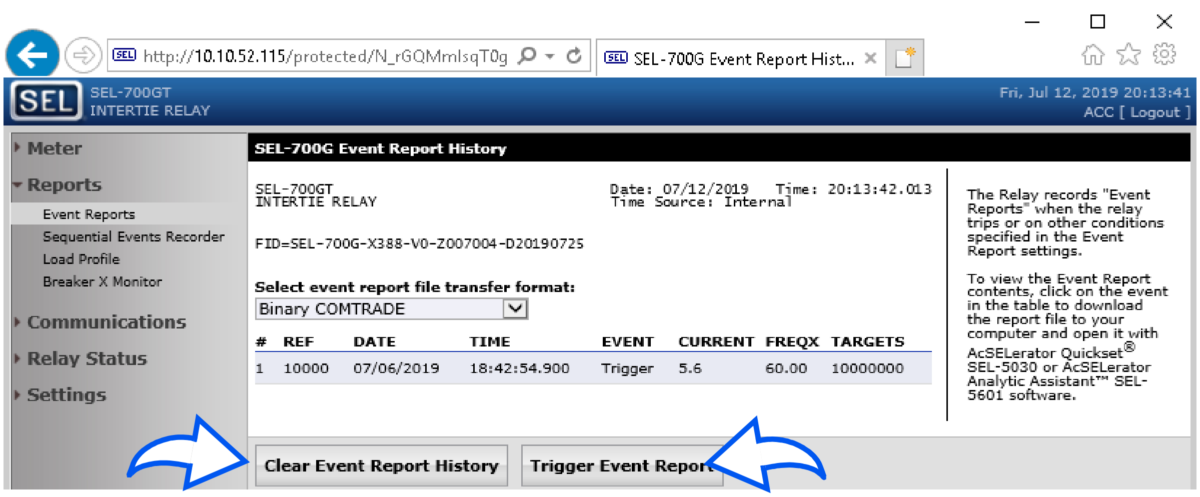


Figure 3.5 Event Report Webpage

Sequential Events Recorder

In addition to event reports, the SEL-700G collects and stores time-stamped data for assertion and deassertion of Relay Word bits. These data are captured in the Sequential Events Recorder (SER) and can be exported through the web server.

When you select **Sequential Events Recorder**, a list of all SER reports presently stored in the relay displays (see *Figure 3.6*). SER reports stored in the SEL-700G can be downloaded or cleared by clicking the appropriate button at the bottom of the webpage.

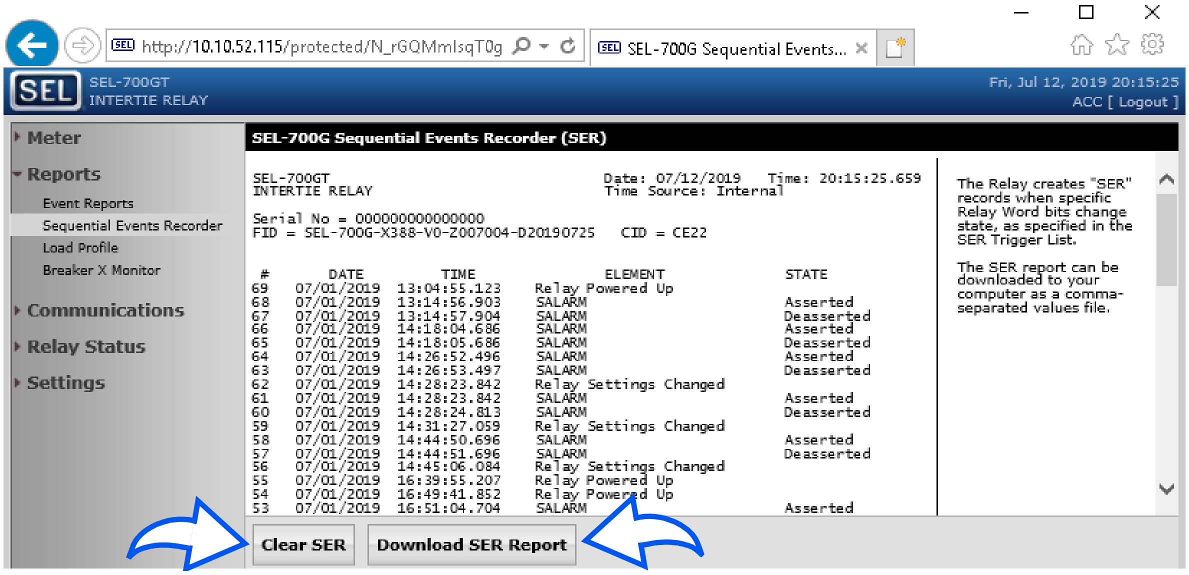


Figure 3.6 Sequential Events Recorder Report

Load Profile

The SEL-700G collects and stores time-stamped data of analog quantities. These data are reported in the load-profile report.

When you select the **Load Profile** menu item, a list of all the load-profile reports presently stored in the relay displays (see *Figure 3.7*). Using the two buttons at the bottom of the display window, you can export or clear the load-profile reports stored in the SEL-700G.

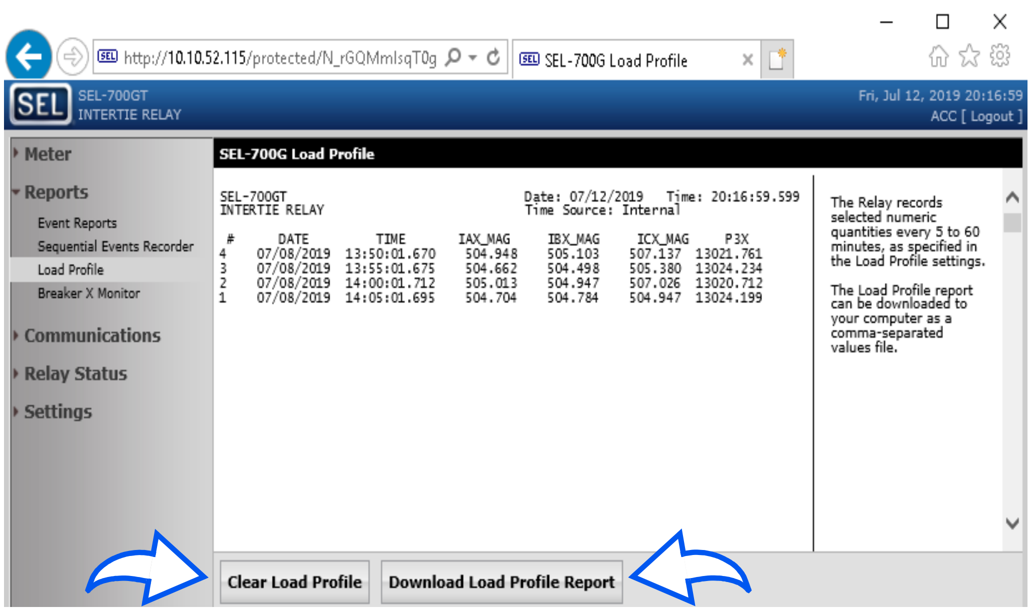


Figure 3.7 Load-Profile Webpage

Breaker Monitor Report

The breaker monitor in the SEL-700G helps in scheduling circuit breaker maintenance (see *Breaker Monitor on page 5.16*). When you select **Breaker**

Monitor Report, the breaker monitor report presently stored in the relay displays (see *Figure 3.8*). You can use the Download Breaker Monitor Report button at the bottom of the screen to download the breaker monitor report stored in the SEL-700G.

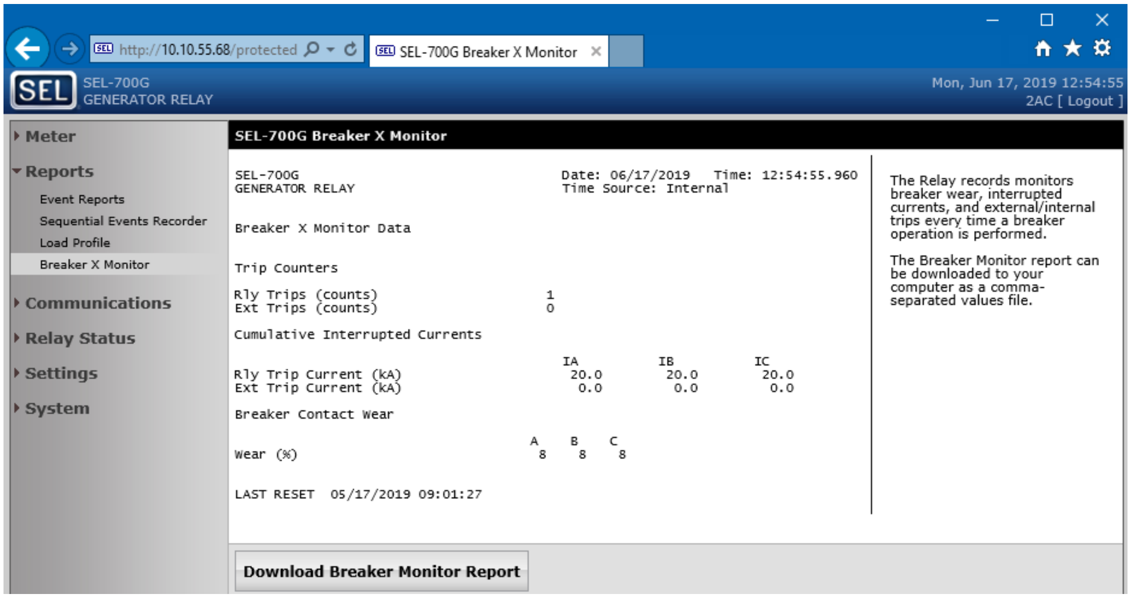


Figure 3.8 Breaker Monitor Report

Communications

You can view the Ethernet port configuration details including the MAC address of the relay by clicking **Communications > Ethernet** (see *Figure 3.9*). Use the Clear Ethernet Statistics button to clear PACKETS, BYTES, and ERRORS data. Refer to *Section 7: Communications* for further details on the Ethernet command.

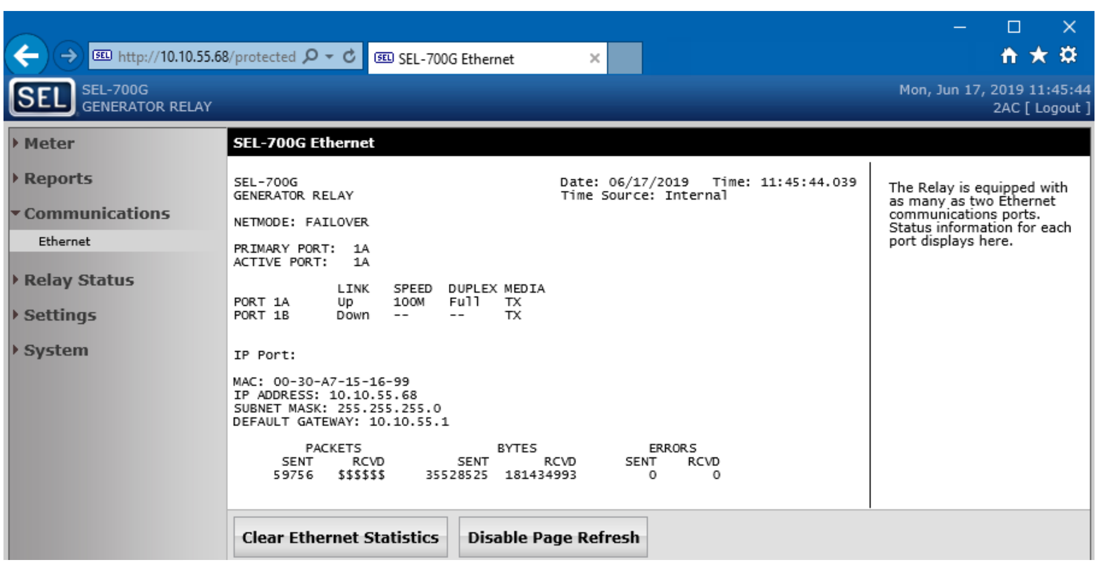


Figure 3.9 MAC Address

Relay Status

The **Relay Status** menu lists the status report pages available through the web server (Self-Tests, Relay Word Bits, and SELOGIC Counters). When you select a status report from the **Relay Status** menu, the corresponding status report appears.

Self-Tests

The SEL-700G has continual diagnostics that verify the status of the relay hardware. The results of these diagnostics can be viewed by selecting **Relay Status** > **Self-Tests** in the navigation pane. **Relay Status** contains categories for each of the status pages in the web server (Self-Tests, Relay Word Bits, and SELOGIC Counters). When you select the category from the **Relay Status** menu, the corresponding report appears.

When you select **Relay Status** > **Self-Tests**, the status of the relay, including the serial number, part number, and self-tests results, is displayed (see *Figure 3.10*).

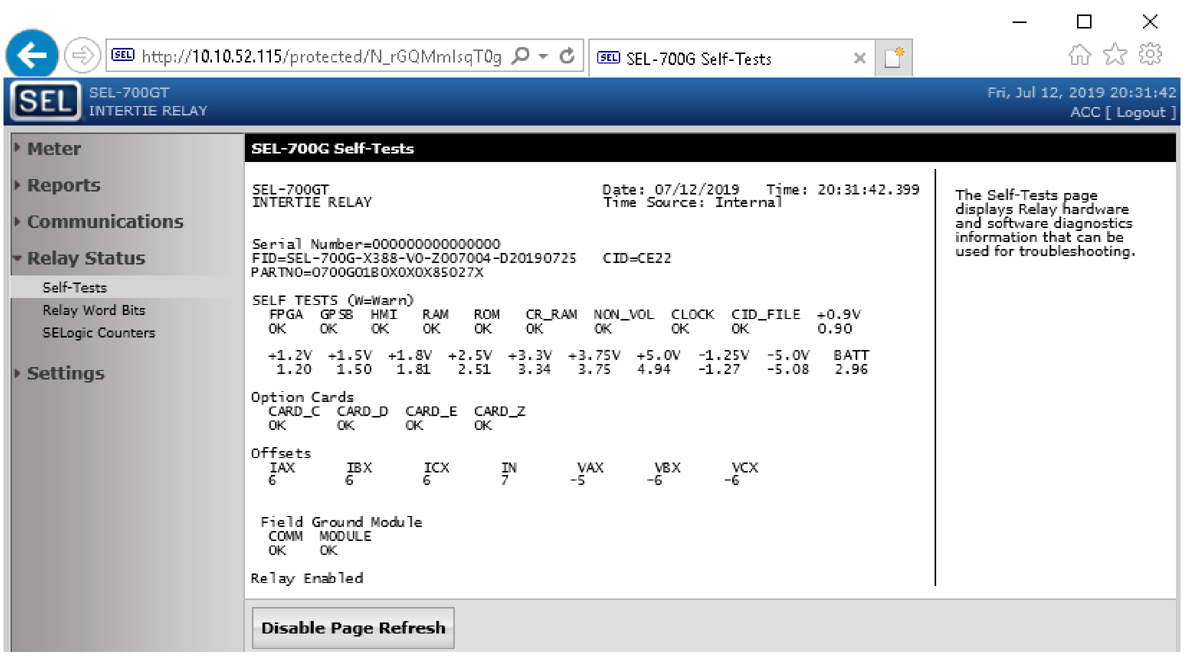
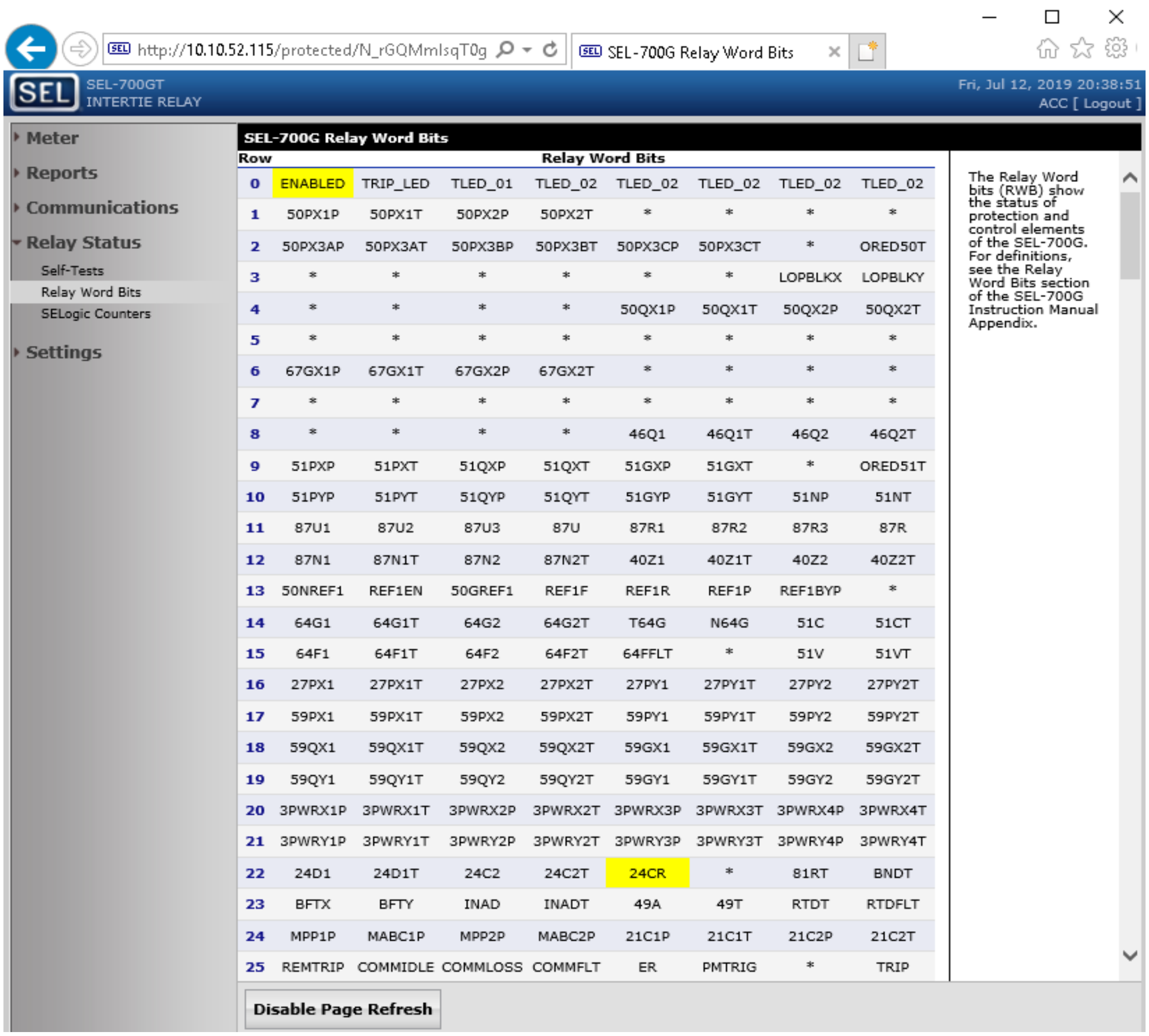


Figure 3.10 Self-Tests Webpage

Relay Word Bits

The web server can display the present state of the Relay Word bits of the relay. Located on the navigation pane, **Relay Status** contains categories for each of the status pages in the web server (Self-Tests, Relay Word Bits, and SELOGIC Counters). When you select a category from **Relay Status**, the corresponding report appears.

Selecting **Relay Word Bits** displays the state of all the Relay Word bits (see *Figure 3.11*). Note that Relay Word bits shown in yellow are asserted. This webpage updates automatically; you can disable the automatic updates by clicking Disable Page Refresh. Scroll up or down to view the remaining Relay Word bits not visible on the screen.



Row	Relay Word Bits							
0	ENABLED	TRIP_LED	TLED_01	TLED_02	TLED_02	TLED_02	TLED_02	TLED_02
1	50PX1P	50PX1T	50PX2P	50PX2T	*	*	*	*
2	50PX3AP	50PX3AT	50PX3BP	50PX3BT	50PX3CP	50PX3CT	*	ORED50T
3	*	*	*	*	*	*	LOPBLKX	LOPBLKY
4	*	*	*	*	50QX1P	50QX1T	50QX2P	50QX2T
5	*	*	*	*	*	*	*	*
6	67GX1P	67GX1T	67GX2P	67GX2T	*	*	*	*
7	*	*	*	*	*	*	*	*
8	*	*	*	*	46Q1	46Q1T	46Q2	46Q2T
9	51PXP	51PXT	51QXP	51QXT	51GXP	51GXT	*	ORED51T
10	51PYP	51PYT	51QYP	51QYT	51GYP	51GYT	51NP	51NT
11	87U1	87U2	87U3	87U	87R1	87R2	87R3	87R
12	87N1	87N1T	87N2	87N2T	40Z1	40Z1T	40Z2	40Z2T
13	50NREF1	REF1EN	50GREF1	REF1F	REF1R	REF1P	REF1BYP	*
14	64G1	64G1T	64G2	64G2T	T64G	N64G	51C	51CT
15	64F1	64F1T	64F2	64F2T	64FFLT	*	51V	51VT
16	27PX1	27PX1T	27PX2	27PX2T	27PY1	27PY1T	27PY2	27PY2T
17	59PX1	59PX1T	59PX2	59PX2T	59PY1	59PY1T	59PY2	59PY2T
18	59QX1	59QX1T	59QX2	59QX2T	59GX1	59GX1T	59GX2	59GX2T
19	59QY1	59QY1T	59QY2	59QY2T	59GY1	59GY1T	59GY2	59GY2T
20	3PWRX1P	3PWRX1T	3PWRX2P	3PWRX2T	3PWRX3P	3PWRX3T	3PWRX4P	3PWRX4T
21	3PWRY1P	3PWRY1T	3PWRY2P	3PWRY2T	3PWRY3P	3PWRY3T	3PWRY4P	3PWRY4T
22	24D1	24D1T	24C2	24C2T	24CR	*	81RT	BNDT
23	BFTX	BFTY	INAD	INADT	49A	49T	RTDT	RTDFLT
24	MPP1P	MABC1P	MPP2P	MABC2P	21C1P	21C1T	21C2P	21C2T
25	REMTRIP	COMMIDLE	COMMLOSS	COMMFLT	ER	PMTRIG	*	TRIP

Figure 3.11 Relay Word Bits Webpage

SELogic Counters

When you select **Relay Status > SELogic Counters**, the count of each of the enabled SELogic counters appears (see *Figure 3.12*). A counter is only displayed when it is enabled.

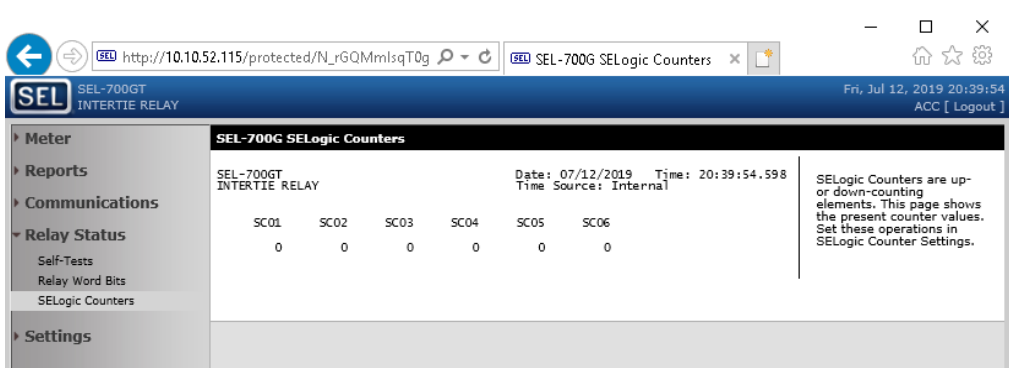


Figure 3.12 SELogic Counters Webpage

Settings

When you select Settings on the navigation pane, a list of all the available settings classes in the SEL-700G appears. Select a class of settings to view each of the settings in that class (Group, Logic, Global, Report, etc.). *Figure 3.13* shows the Group 1 settings category.

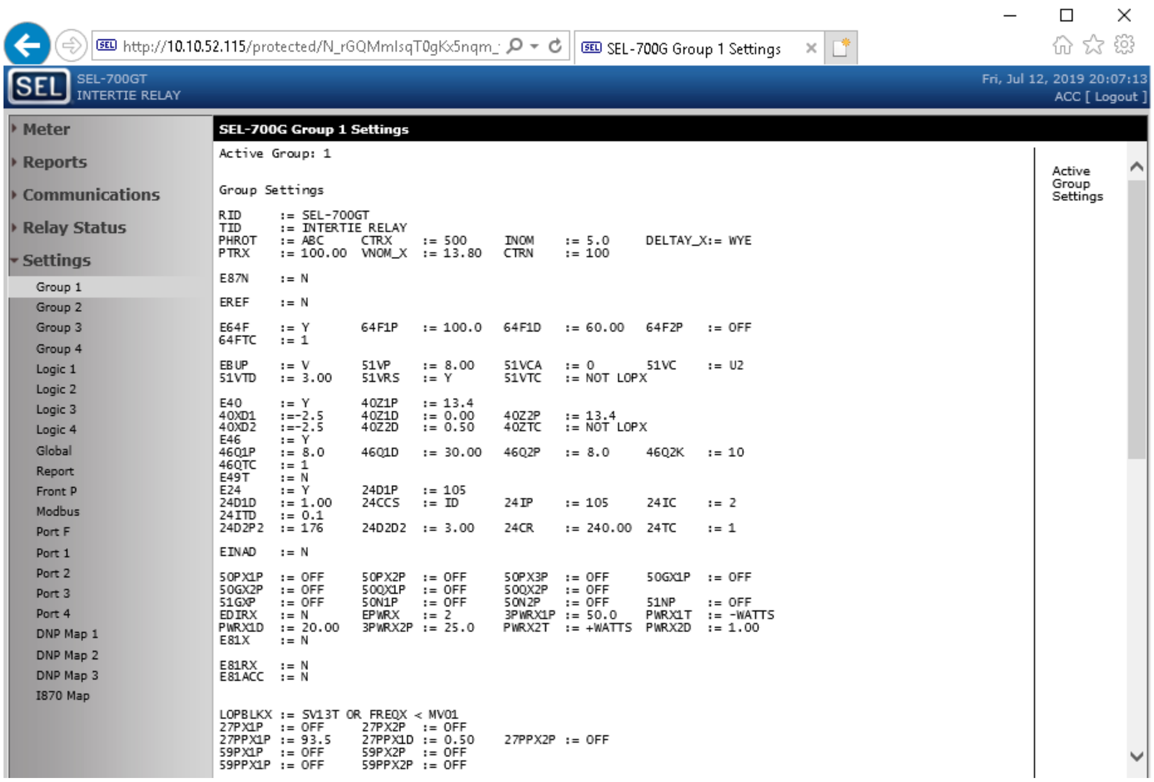


Figure 3.13 Group 1 Settings Webpage

System

File Management (Firmware Upgrade)

The web server offers a convenient method for upgrading relay firmware. Select **System** > **File Management** (on the navigation pane) to upgrade your relay firmware (see *Figure 3.14*).

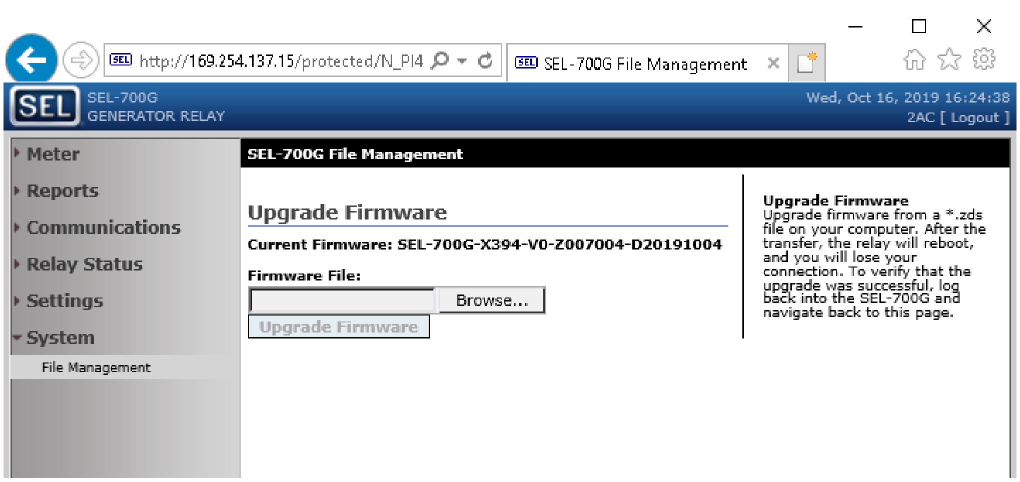


Figure 3.14 Upgrade Relay Firmware From the File Management Webpage

When preparing to upgrade relay firmware, you must first have the new relay firmware. The firmware is designated with a .zds extension. Use the **Browse** button to select the firmware you want sent to the relay, then click **Upgrade Firmware** to start the upgrade process (see *Figure 3.14*). See *Appendix B: Firmware Upgrade Instructions* for complete details on the firmware upgrade procedure.

Language Support

The web server reports can be displayed in English or Spanish by setting the Ethernet port 1 setting LANG to either ENGLISH or SPANISH.

QuickSet Software

This section describes how to get started with the SEL-700G and QuickSet. SEL provides many PC software solutions (applications) to support the SEL-700G Relay and other SEL devices. *Table 3.1* lists SEL-700G software solutions.

Table 3.1 SEL Software Solutions

Part Number	Product Name	Description
SEL-5030	ACSELERATOR QuickSet SEL-5030 Software	See *Table 3.2*
SEL-5032	ACSELERATOR Architect SEL-5032 Software	Configures IEC 61850 communications
SEL-5036	ACSELERATOR Bay Screen Builder SEL-5036 Software	Designs and manages bay screens in conjunction with SEL-5030 for the SEL-700G with the color touchscreen display
SEL-5040	ACSELERATOR Report Server SEL-5040 Software	Automatically retrieves, files, and summarizes reports
SEL-5601-2	SEL-5601-2 SYNCHROWAVE Event Software	Plots COMTRADE and SEL ASCII format event report oscillography; performs custom calculations on analog, digital, and complex quantities; and analyzes the Impedance Plane for distance element (mho) operation, the Alpha Plane for differential element (78L) operation, and the Bewley Lattice for traveling-wave data
SEL-5702	SEL-5702 Synchrowave Operations	Supports a variety of power system operations and analytics applications with high-resolution time-series data, real-time analytics, and GIS location information to improve operator situational awareness.
SEL-5703	SEL-5703 Synchrowave Monitoring	Provides power system situational awareness by translating data into visual information; displays and analyzes time-synchronized synchrophasor data and relay event reports
SEL-5801	SEL-5801 Cable Selector	Selects the proper SEL cables for your application
SEL-5806	SEL-5806 Curve Designer Software	Designs user-defined, volts/Hz inverse-time characteristic curve to match any transformer characteristic (refer to *Section 4: Protection and Logic Functions*)

QuickSet is a powerful setting, event analysis, and measurement tool that aids in setting, applying, and using the SEL-700G. *Table 3.2* shows the suite of QuickSet applications provided for the SEL-700G.

Table 3.2 QuickSet Applications

Application	Description
Rules-Based Settings Editor	Provides online or offline device settings that include interdependency checks. Use this feature to create and manage settings for multiple devices in a database.
HMI	Provides a summary view of device operation. Use this feature to simplify commissioning testing.
Design Templates[a]	Allows you to customize relay settings to particular applications and to store those settings in design templates. You can lock settings to match your standards or lock and hide settings that are not used.
Event Analysis	Provides oscillography and other event analysis tools.
Bay Control	Allows you to design new bay screens and edit existing bay screens by launching the Bay Screen Builder software for SEL-700G relays with the color touchscreen display.
Settings Database Management	QuickSet uses a database to manage the settings of multiple devices.
Terminal	Provides a direct connection to the SEL device. Use this feature to ensure proper communications and to directly interface with the device.
Help	Provides general QuickSet and device-specific QuickSet context.

[a] Available only in licensed versions of QuickSet.

Setup

Follow the steps outlined in *Section 2: Installation* to prepare the SEL-700G for use. Perform the following steps to initiate communications:

Step 1. Connect the appropriate communications cable between the SEL-700G and your PC.

Step 2. Apply power to the SEL-700G.

Step 3. Start QuickSet.

Communications

QuickSet uses relay communications **Port 1** through **Port 4**, or **Port F** (front panel) to communicate with the SEL-700G. Perform the following steps to configure QuickSet to communicate with the relay.

Step 1. Select **Communications** from the QuickSet main menu bar, as shown in *Figure 3.15*.

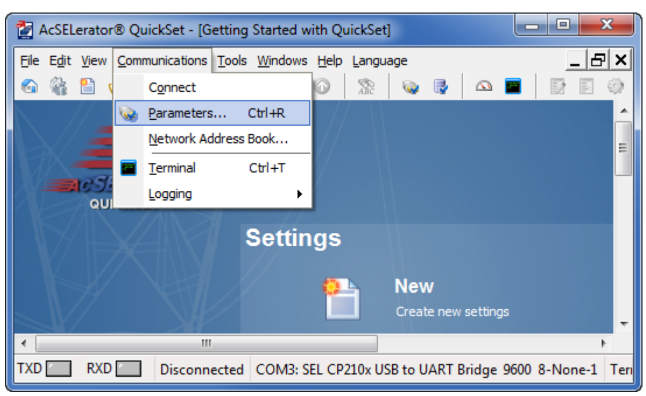


Figure 3.15 Communications Parameter Menu Selection

Step 2. Select the **Parameters** submenu to display the screen shown in *Figure 3.16*.

Step 3. Configure the PC port to match the relay communications settings.

Step 4. Configure QuickSet to match the SEL-700G default settings by entering the Access Level 1 and Access Level 2 passwords in the respective text boxes.

Step 5. For network communications, select **Network** from the **Active Connection Type** drop-down menu and enter the network parameters as shown in *Figure 3.17*.

For the SEL-700G, always select FTP as the file transfer option.

Step 6. Exit the menu by clicking **OK** when finished.

NOTE: Factory-default passwords for Access Level 1 and 2 are OTTER and TAIL, respectively.

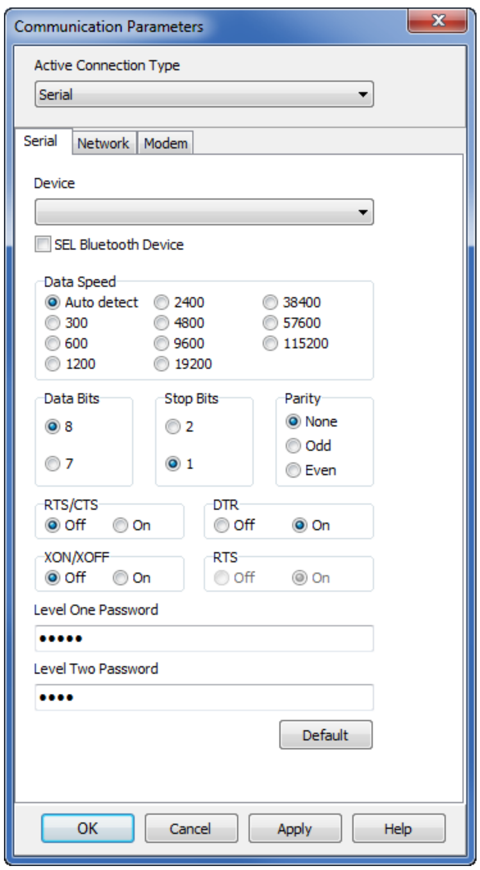


Figure 3.16 Serial Port Communication Parameters Dialog Box

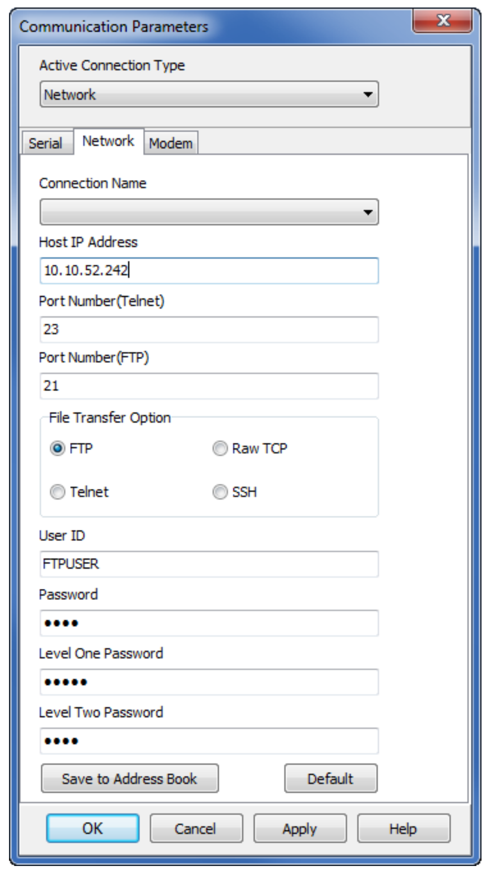


Figure 3.17 Network Communication Parameters Dialog Box

Terminal

Terminal Window

Select **Communications > Terminal** on the main menu bar (see *Figure 3.18*) to open the terminal window.

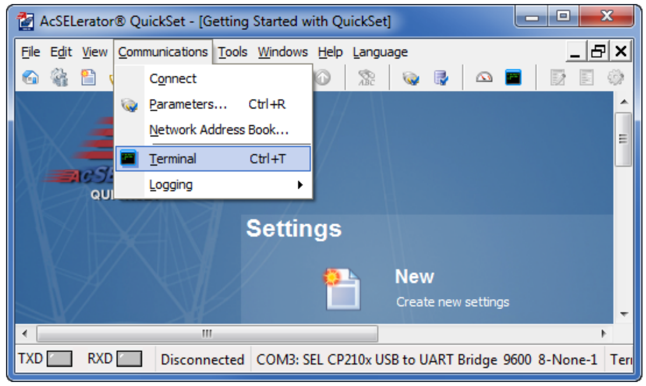


Figure 3.18 Communications Terminal Menu Selection

The terminal window is an ASCII interface with the relay. This is a basic terminal emulator. Many third-party terminal emulation programs are available with file transfer encoding schemes. Open the terminal window by either clicking **Communications > Terminal** or pressing **<Ctrl+T>**. Verify proper communications with the relay by opening a terminal window, pressing **<Enter>** a few times, and verifying that a prompt is received. If a prompt is not received, verify proper setup.

Terminal Logging

To create a file that contains all terminal communications with the relay, select **Terminal Logging** in the **Communications > Logging** menu, and specify a file at the prompt. QuickSet records communications events and errors in this file. Click **Communications > Logging > Connection Log** to view the log. Clear the log by selecting **Communications > Logging > Clear Connection Log**.

Driver and Part Number

After clicking **Communications > Terminal**, access the relay at Access Level 1. Issue the **ID** command to receive an identification report, as shown in *Figure 3.19*.

NOTE: The SEL display package and customer display package versions are only displayed in the touchscreen display model.

```
=>ID <Enter>
"FID=SEL-700G-X349-V0-Z006003-D20180412","08FA"
"BFID=BOOTLDR-R501-V0-Z000000-D20140224","0947"
"CID=66D2","025F"
"DEVID=SEL-700GT","045C"
"DEVCODE=74","0312"
"PARTNO=0700GT1B1X0X7585A67X","0746"
"CONFIG=111122000","041B"
"SEL DISPLAY PACKAGE=1.0.40700.3470","0887"
"CUSTOMER DISPLAY PACKAGE=1.574871567","09A2"
"iedName=SEL_700G_1","0611"
"type=SEL_700G","0490"
"configVersion=ICD-700G-X303-V0-Z200006-D20180403","0D64"
"LIB61850ID=3DB89FD6","04FF"
=>
```

Figure 3.19 Relay Response to the ID Command

Locate and record the Z-number (Z006003) in the FID string. The first portion of the Z-number (Z006…) determines the settings driver version when you are creating or editing relay settings files in QuickSet. The use of the driver version is discussed in more detail in *Settings Editor on page 3.18*. Compare the part number (PARTNO=700G0XXXXXXXXXXXXXX) with the Model Option Table (MOT) to ensure the correct relay configuration. The SEL display package version can be found in *Table A.5*. The customer display (CDP) version has a unique ID code based on the total number of seconds from 1/1/2000 to the time stamp of when the CDP was created and downloaded to the relay via QuickSet.

Settings Database Management and Driver

QuickSet uses a database to save the relay settings. QuickSet contains sets of all settings files for each relay specified in the database manager. Choose appropriate backup storage methods and a secure location for storing the database files.

Database Manager

Select **File > Database Manager** on the main menu bar to create new databases and manage records within existing databases.

Settings Database

Step 1. Open the database manager to access the database. Click **File > Database Manager**. A dialog box appears.

The default database file already configured in QuickSet is Relay.rdb. This database contains example settings files for the SEL products with which you can use QuickSet.

Step 2. Enter a description for the database in the **Database Description** text box.

Step 3. Enter special operating characteristics that describe the relay settings in the **Settings Description** text box. These can include the protection scheme settings and communications settings.

Step 4. Highlight a relay or settings file listed in **Settings** and click the **Copy** button to create a new set of settings.

QuickSet prompts for a new name. Be sure to enter a new description in **Settings Description**.

Copy/Move Settings Between Databases

Copy creates an identical device or settings file that appears in both databases. **Move** removes the device or settings file from one database and places the device or settings file in another database. To copy/move settings between settings databases, perform the following steps.

Step 1. Select the **Copy/Move Settings Between Settings Databases** tab to create multiple databases with the database manager; these databases are useful for grouping similar protection schemes or geographic areas.

Step 2. Click the **Settings Database B** button to open a relay database.

Step 3. Type a filename and click **Open**.

a. Highlight a device or settings file in **Settings Database A**.

b. Click **Copy** or **Move**, and click the **>** button to create a new device or settings file in **Settings Database B**.

Step 4. Reverse this process to move or copy a device or settings file from **Settings Database B** to **Settings Database A**.

Create a New Database, Copy an Existing Database

To create a new database:

Step 1. Click **File > Database Manager**, and then click **New**. QuickSet prompts you for a file name.

Step 2. Type the new database name (and select a new location if the new location differs from the existing one), and click **Save**. QuickSet displays the message `Settings [path and filename] was successfully created`.

Step 3. Click **OK**.

To copy an existing database of devices to a new database:

Step 1. Click **File > Database Manager**, and select the **Copy/Move Settings Between Settings Databases** tab.

QuickSet opens the last active database and assigns it as **Settings Database A**.

Step 2. Click the **Settings Database B** button; QuickSet prompts you for a file location.

Step 3. Type a new database name and click **Open**. Click **Yes**; the program creates a new empty database. Load devices or settings files into the new database as in *Copy/Move Settings Between Databases on page 3.14*.

Settings

QuickSet has the capability of creating settings for one or more SEL-700G relays. Store existing relay settings downloaded from SEL-700G relays with QuickSet. Create a library of relay settings, then modify and upload these settings from the settings library to an SEL-700G. QuickSet makes setting the relay easy and efficient. However, you do not have to use QuickSet to configure the SEL-700G; you can use an ASCII terminal or a computer running terminal emulation software. QuickSet provides the advantages of rules-based settings checks, SELOGIC control equation Expression Builder, operator control and metering HMI, event analysis, and help.

The QuickSet settings editor shows the relay settings in easy-to-understand categories. Settings are grouped logically, and relay elements that are not used in the selected protection scheme are not accessible. For example, if there is only one analog card installed in the relay, you can access settings for this one card only. Settings for the other slots are dimmed (grayed) in the QuickSet menu. QuickSet shows all of the settings categories in the settings tree view. The settings tree view remains constant whether settings categories are enabled or disabled.

Settings Menu

QuickSet uses a database to store and manage SEL relay settings. Each unique relay has its own settings records. Use the **File** menu to **Open** an existing record, create and open a **New** record, or **Read** relay settings from a connected SEL-700G and then create and open a new record. Click **Tools** > **Settings** > **Convert** to convert and open an existing record in the settings editor.

Table 3.3 File/Tools Menus

Menus	Description
<<, >>	Use these navigation menu buttons to move from one category to the next
New	Open a new record
Open	Open an existing record
Read	Read device settings and then create and open a new record
Convert	Convert and open an existing record

File > New

To make SEL-700G settings with the settings editor, click **File** > **New** on the main menu bar and select the SEL-700G and the latest driver version (00*X*) on the **Settings Editor Selection** screen, as shown in *Figure 3.20*.

QuickSet makes the new settings file using the driver that you specify in the **Settings Editor Selection** screen. QuickSet uses the Z-number in the FID string to create a particular settings file.

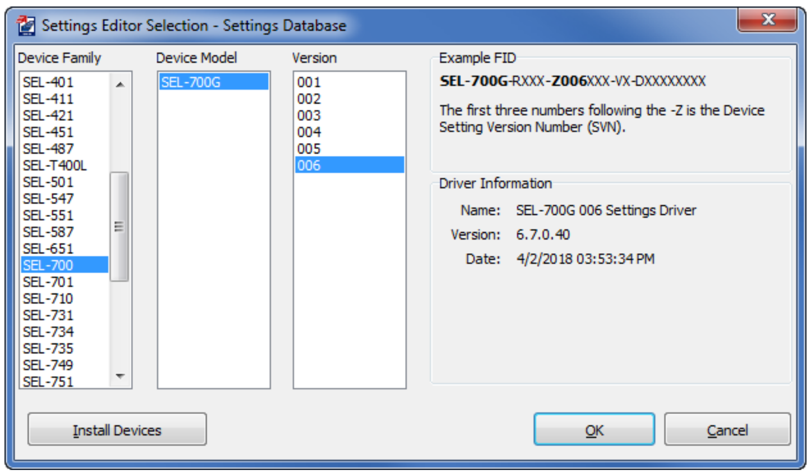


Figure 3.20 Driver Selection

After the relay model and settings driver selection, QuickSet presents the **Device Part Number** dialog box. Use this dialog box to configure the settings editor to produce settings for a relay with options determined by the part number, as shown in *Figure 3.21*. Click **OK** when finished.

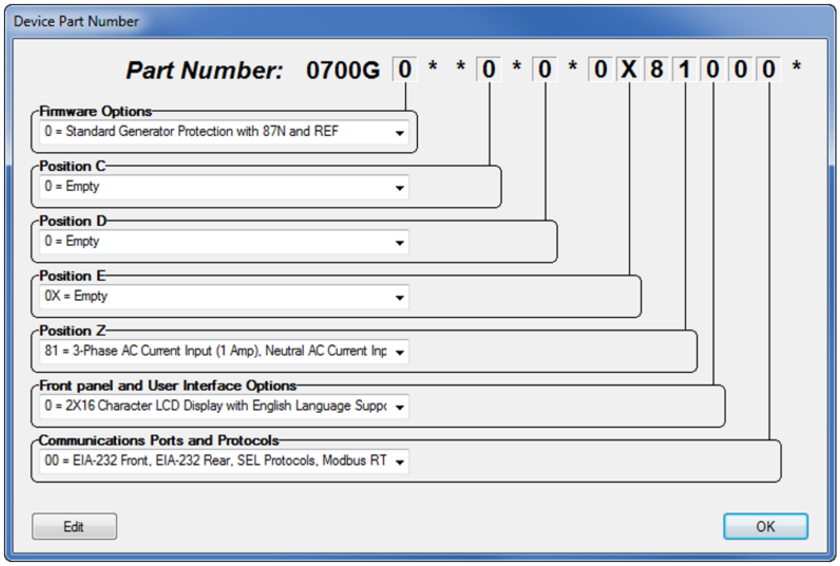


Figure 3.21 Update Part Number

Figure 3.22 shows the Settings Editor screen. Check the driver version number in the title bar of the Settings Editor screen. Compare the QuickSet settings driver number and the first portion of the Z-number in the FID string (select **Tools > HMI > HMI > Status**). These numbers must match. QuickSet uses this first portion of the Z-number to determine the correct settings editor to display.

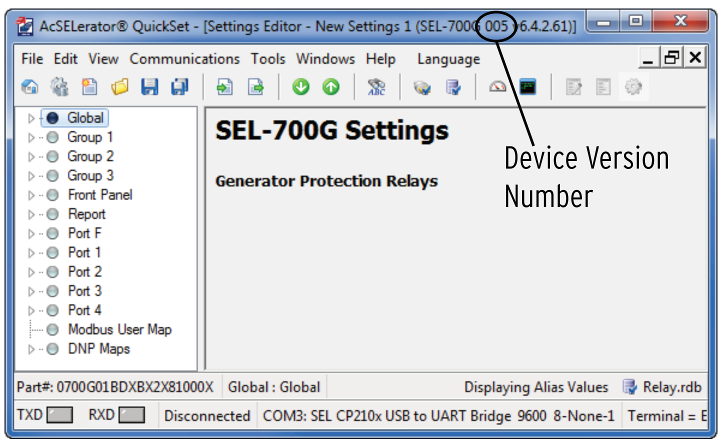


Figure 3.22 New Settings Editor Screen

File > Open

The **Open** menu item opens an existing device from the active database folder. QuickSet prompts for a device to load into the settings editor.

File > Read

When the **Read** menu item is selected, QuickSet uses serial protocols to read the device settings from the connected device. As QuickSet reads the device, a Transfer Status dialog box appears.

Tools > Settings > Convert

Use the **Convert** menu item (**Tools** > **Settings**) to convert from one settings version to another. Typically, this utility is used to upgrade an existing settings file to a newer version because devices are using a newer version number. QuickSet provides a Convert Settings report that shows missed, changed, and invalid settings created as a result of the conversion. Review this report to determine whether changes are necessary.

Settings Editor

Use the settings editor to enter settings. The settings editor includes the settings driver version (the first three digits of the Z-number) in the Settings Editor title bar.

Enter Settings

NOTE: Setting changes made during the edit session are not read by the relay unless they are transferred to the relay with the **Send** menu item.

Step 1. Click the ▷ drop-downs and the buttons in the settings tree view to expand and select the settings you want to change.

Step 2. Use **Tab** to navigate through the settings, or click a settings text box.

Step 3. To restore the previous value for a setting, right-click on the setting text box and select **Previous Value**.

Step 4. To restore the factory-default setting value, right-click on the setting text box and select **Default Value**.

Step 5. If you enter a setting that is out of range or has an error, QuickSet shows the error at the bottom of the settings editor. Double-click the error listing to go to the setting and enter a valid input.

Expression Builder

NOTE: Be sure to enable the functions you need (**Logic Settings** > **SELogic Enable**) before using Expression Builder.

SELOGIC control equations are a powerful means for customizing device performance. QuickSet simplifies this process with Expression Builder, a rules-based editor for programming SELOGIC control equations. Expression Builder organizes device elements, analog quantities, and SELOGIC control equation variables.

Access Expression Builder. Click the ellipsis button [...] that follows the settings text boxes in the settings editor to create an expression, as shown in *Figure 3.23*.

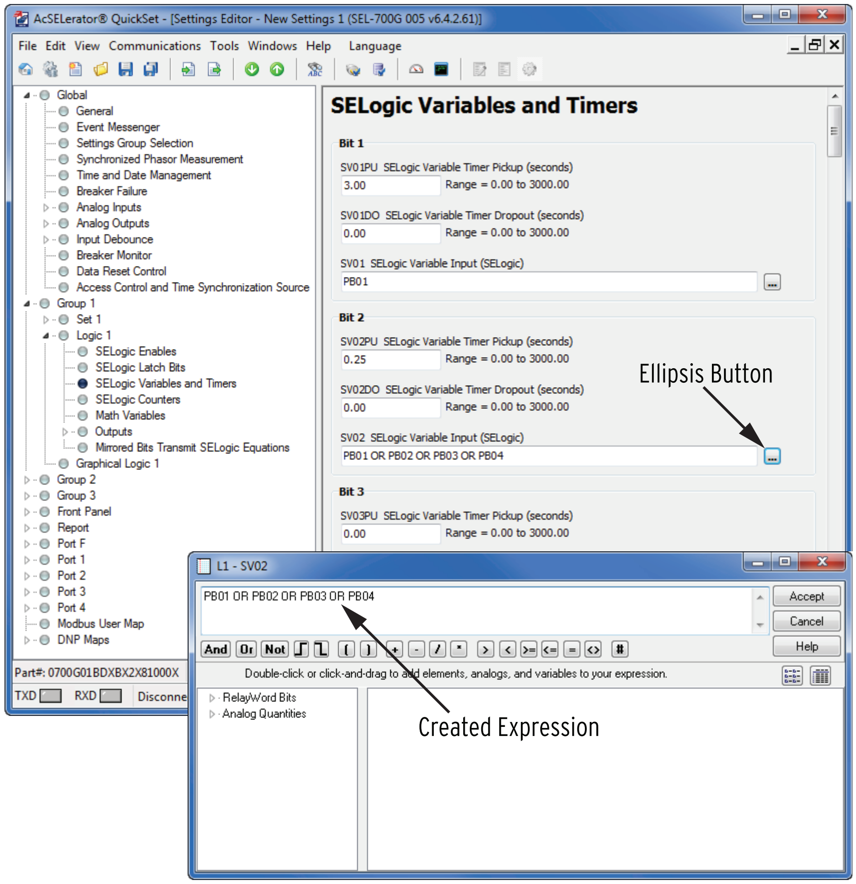


Figure 3.23 Expression Created With Expression Builder

Using Expression Builder. The expression builder screen is organized into three main parts: the expression builder text box, the left side column (which contains broad categories of device elements, analog quantities, counters, timers, latches, and logic variables), and the right side column (which displays category operands for use in the expression). Directly underneath the expression builder text box is a row of operators that you can include in your expression. The operators include basic logic, rising- and falling-edge triggers, expression compares, and comments.

Touchscreen Settings and Bay Screen Builder

The touchscreen settings are available when the touchscreen display option is selected as part of the front-panel options. This option provides you with the ability to design bay screen one-line diagrams with the help of Bay Screen Builder SEL-5036 Software. For more information, refer to *Bay Screens Design Using QuickSet and Bay Screen Builder on page 9.10*.

File > Save

Select the **Save** menu item from the **File** menu once settings are entered into QuickSet to ensure that the settings are not lost.

File > Send

To transfer the edits made in the QuickSet edit session, you must send the settings to the relay by selecting **Send** from the **File** menu. In the dialog box that opens, select the settings section(s) that you want to transfer to the relay by checking the appropriate box and click **OK**.

Edit > Part Number

Use the **Part Number** menu item to change the part number.

Text Files

Select **Tools > Settings > Import** or **Tools > Settings > Export** on the main menu bar to import or export settings from or to a text file. Use this feature to create a small file that can be easily stored or sent electronically.

Event Analysis

QuickSet has integrated analysis tools that help you retrieve information about relay operations quickly and easily. Use the event information that the SEL-700G stores to evaluate the performance of a system (select **Tools > Events > Get Event Files**). *Figure 3.24* shows the event retrieval screen.

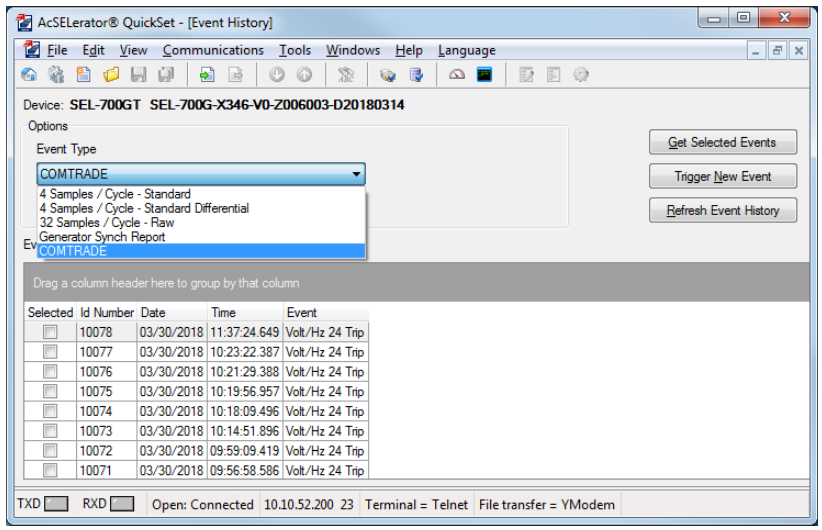


Figure 3.24 Retrieve Events Screen

You can retrieve event files stored in the relay and transfer these files to a computer. For information on the types of event files and data capture, see *Section 10: Analyzing Events*. To download event files from the device, click **Tools > Events > Get Event Files**. The Event History dialog box appears, as shown in *Figure 3.24*.

View Event History

The SEL-700G is capable of capturing two types of events (4-samples/cycle filtered and 32-samples/cycle raw). These two types of events can be captured in either Compressed ASCII (.cev) or COMTRADE format. QuickSet allows you to download both .cev and COMTRADE events. Use the **Event Type** drop-down menu shown in *Figure 3.24* to select the 32-samples/cycle unfiltered (raw) or COMTRADE format event data (the default is 4-samples/cycle filtered data). For information on other methods of retrieving COMTRADE events from the relay, see *Section 10: Analyzing Events, Retrieving COMTRADE Event Files*.

In addition to event reports, the SEL-700G can also store generator synchronism reports. These reports can be triggered to capture data during a generator synchronism procedure. Graph the captured generator synchronism report with SYNCHROWAVE Event in a manner similar to event reports.

To view the generator synchronism report history, click **Tools > Events > Get Event Files** and then select **Generator Synch Report** in the **Event Type** drop-down menu, as shown in *Figure 3.25*.

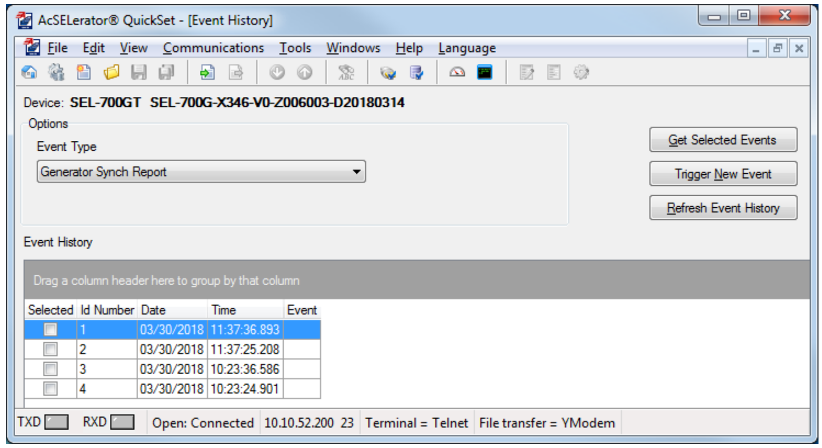


Figure 3.25 Generator Synchronism Report

Get Event

Highlight the event you want to view (e.g., Event 3 in *Figure 3.24*), select the event type from the **Event Type** drop-down menu (4 samples, 32 samples, or generator synchronism report), and click **Get Selected Event**. When the download is complete, QuickSet queries whether to save the file on your computer, as shown in *Figure 3.26*.

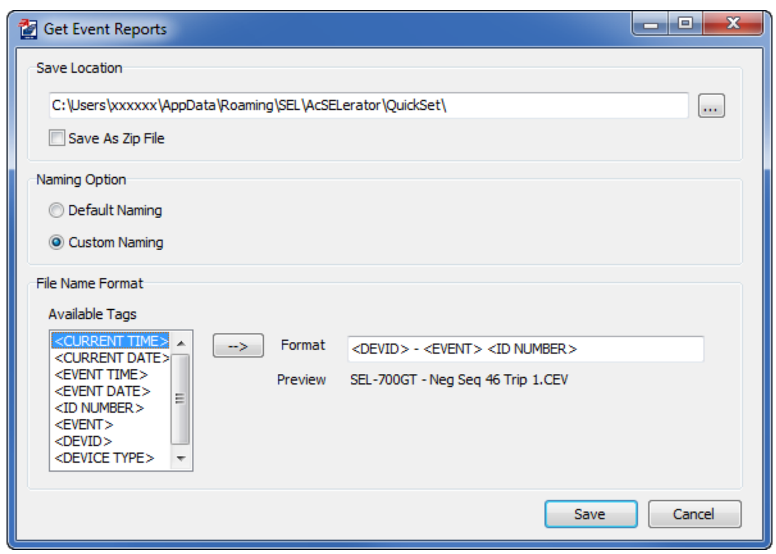


Figure 3.26 Save the Retrieved Event

When saving an event report, select a save location and a file name for your report. Select either **Default Naming** or **Custom Naming**. Default naming has predefined tags and organization, which appear in the Format text box when default naming is selected. You can use **Custom Naming** to create file names specific to your application by selecting and organizing your own tags (listed in Available Tags).

View Event Files

Click **Tools > Events** to view an event with SYNCHROWAVE Event. You can view multiple events by clicking on **Load Event** > **Add New Event** in the SYNCHROWAVE Event.

Meter and Control

Click on **Tools > HMI > HMI** to display a screen similar to the one shown in *Figure 3.27*. The HMI tree view shows all the functions available in the HMI. Unlike the self-configuration of the device settings tree, the HMI tree remains the same regardless of the type of cards installed. For example, if no analog input card is installed, the analog input function is still available, but the relay responds as follows:

```
No Analog Input Card Present.
```

Device Overview

The Device Overview screen provides an overview of the device. The contact I/O portion of the screen displays the status of the two inputs and three outputs of the power supply board. You cannot change these assignments.

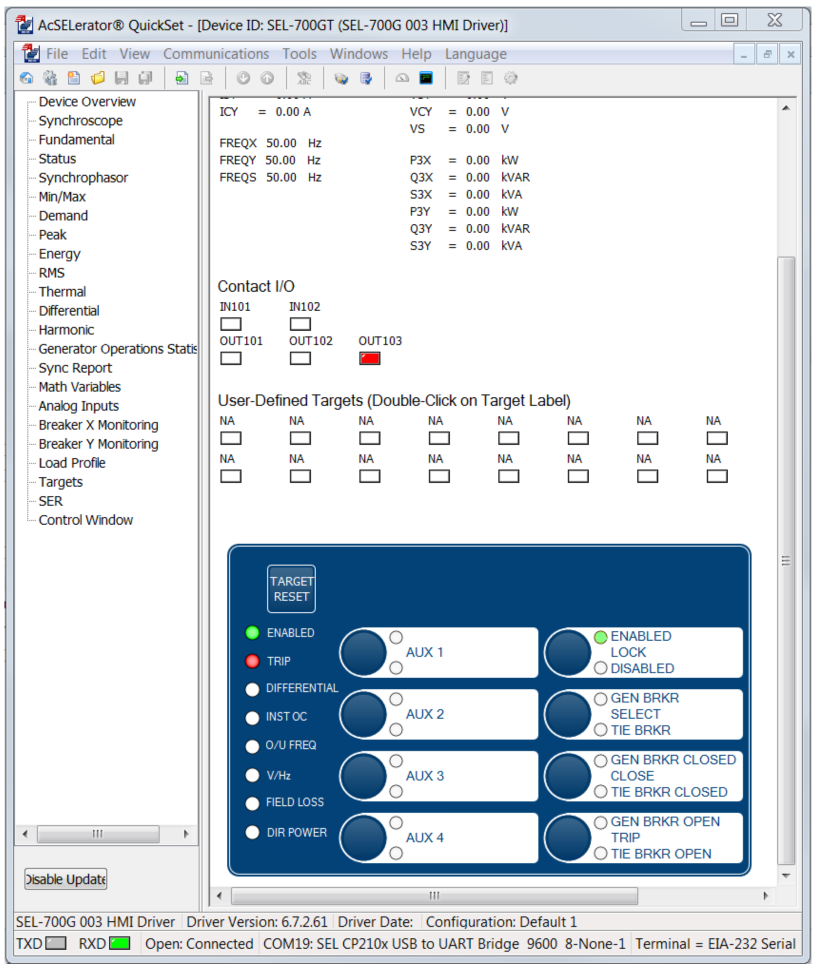


Figure 3.27 Device Overview Screen

You can assign any Relay Word bit to the 16 user-defined target LEDs. To change the present assignment, double-click on the text above the square you want to change. After double-clicking on the text, a box with available Relay Word bits appears in the lower left corner of the screen. Select the appropriate

Relay Word bit, and click **Update** to assign the Relay Word bit to the LED. To change the color of the LED, click in the square and make your selection from the color palette.

The front-panel LED representation shown in QuickSet (see *Figure 3.27*) displays the status of the 16 front-panel LEDs. Use the front-panel settings to change the front-panel LED assignments. The Fundamental, Min/Max, Energy, etc., screens display the corresponding values.

Click on **Targets** in the tree view to see the status of all the Relay Word bits. When a Relay Word bit has a value of 1 (e.g., RB02 = 1), the Relay Word bit is asserted. When a Relay Word bit has a value of 0 (e.g., RB02 = 0), the Relay Word bit is deasserted.

The Status and SER screens display the same information as the ASCII **STA** and **SER** commands.

Figure 3.28 shows the control screen. From here, you can reset metering data; clear the event history, SER, MIRRORED BITS report, or LDP; trigger events; or view generator operating statistics. You can also reset the targets, synchronize with IRIG, or set the time and date.

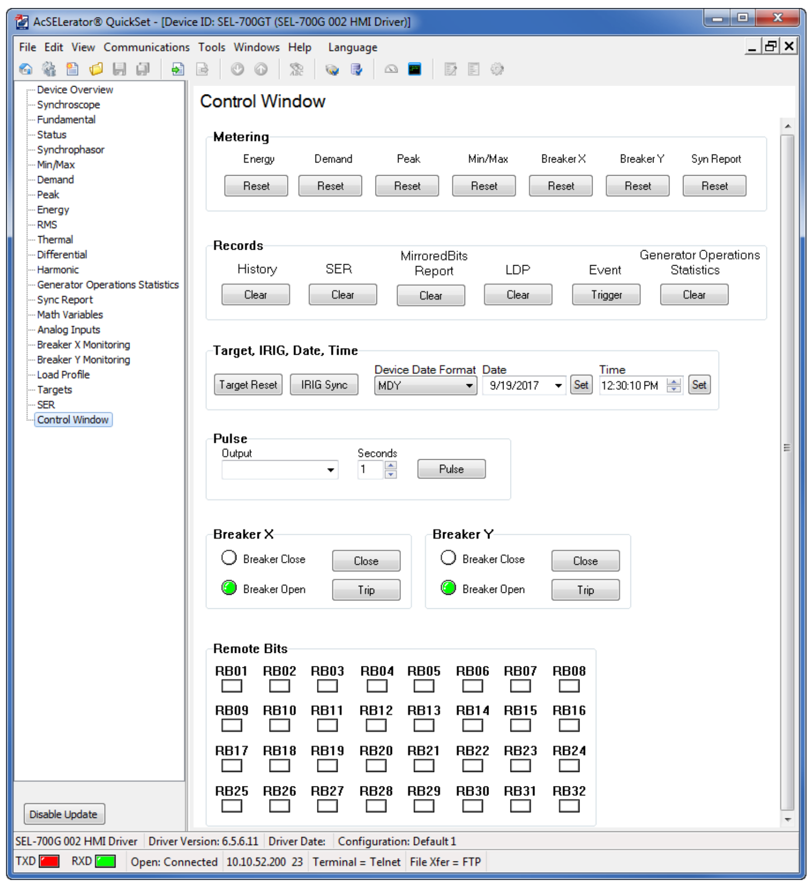


Figure 3.28 Control Screen

To control the remote bits, click on the appropriate square (RB01–RB32), then select the operation from the Remote Bits prompt, as shown in *Figure 3.29*.

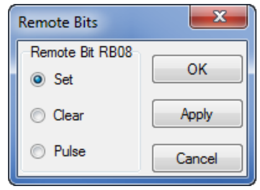


Figure 3.29 Remote Bit Operation Selection

Synchroscope

When the optional synchronism-check function is added to the SEL-700G, the synchroscope is available in QuickSet. This option displays a graphical representation of the phasors and the difference between the bus (voltage and frequency) and the generator (voltage and frequency).

Start the autosynchronizer from the HMI screen by clicking the **Start** button. This commands the SEL-700G to begin the synchronism process. Throughout the process, you can see the phasor difference between the bus and the generator. *Figure 3.30* shows an example of the SEL-700G synchroscope.

IMPORTANT: The synchroscope display in QuickSet is only intended for visualization and is not recommended for the use of closing the breaker manually for synchronization while looking at the graphical scope. The display has no significance if the breaker status is "Close".

The synchroscope also shows the breaker status (Relay Word bit 52AX) as well as the status of the Relay Word bits FRAISE, FLOWER, VRAISE, and VLOWER. These indicators correspond to the outputs of the SEL-700G to the governor and exciter controllers of a generator.

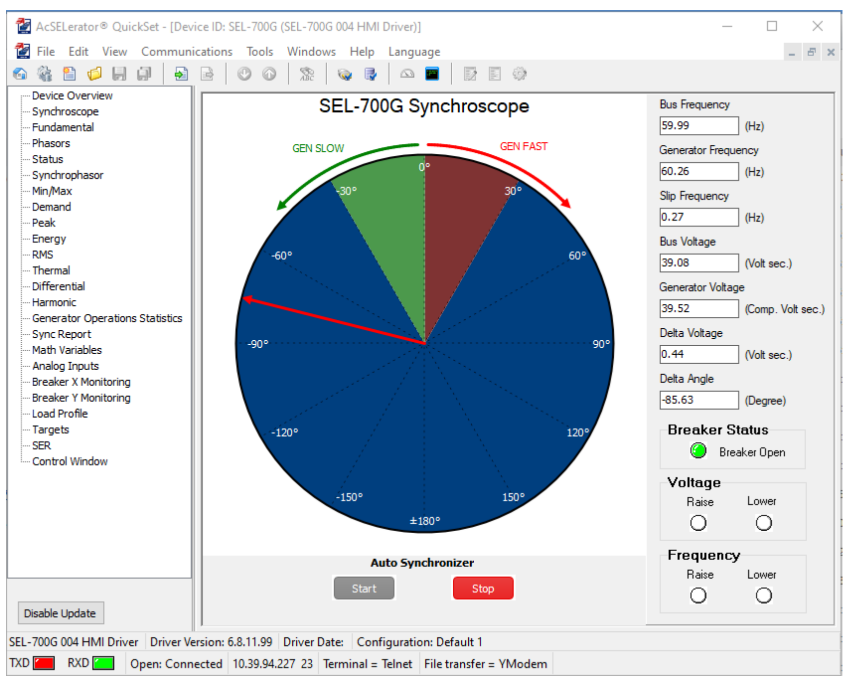


Figure 3.30 Synchroscope

Language Support

QuickSet has multi-language support. Click on the **Language** menu to choose from English, Spanish, French, Portuguese, Russian, Turkish, or Chinese, as seen in *Figure 3.31*. Selecting any of these choices converts the menu items in QuickSet to the selected language.

NOTE: If the SEL-700G is connected to any SEL communications processor (SEL-203x or RTAC), the corresponding LANG port setting must be set to ENGLISH.

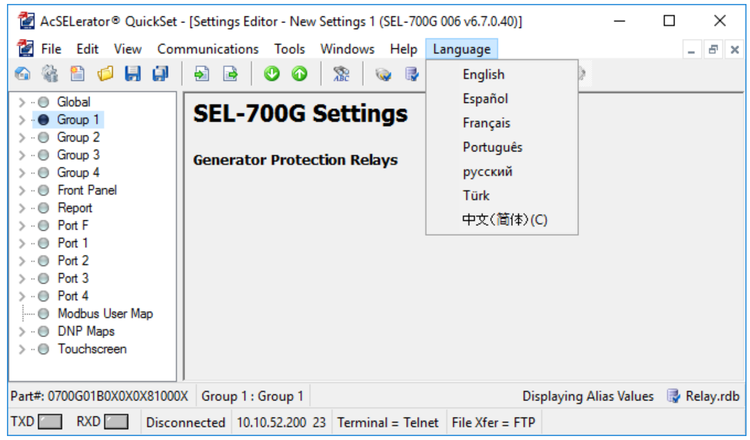


Figure 3.31 Language Support Options

Additionally, if Spanish or English is selected from the **Language** menu, the relay settings displayed by QuickSet are converted into the corresponding language as shown in *Figure 3.32*.

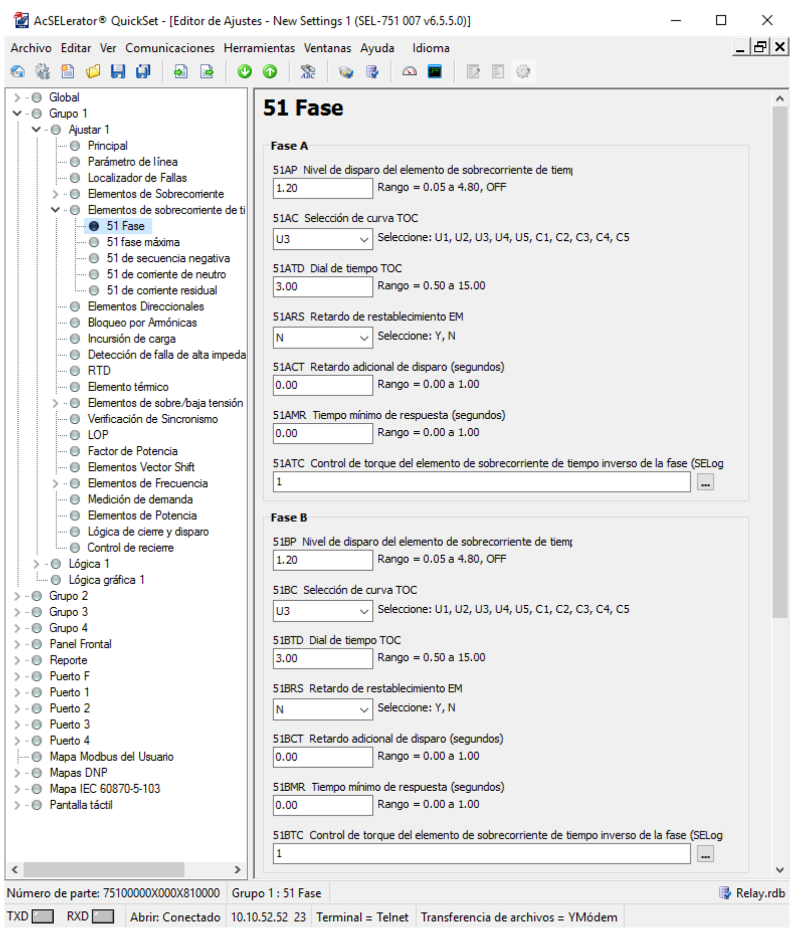


Figure 3.32 Spanish Settings QuickSet Display

NOTE: Once the HMI screen is displayed in QuickSet, the LANG setting does not affect the displayed HMI. To change the language of the HMI, close the HMI, change the LANG setting, and then reopen the HMI.

Each communications port (serial or Ethernet) on the SEL-700G can be independently set to display either English or Spanish. Changing the port setting LANG to SPANISH or ENGLISH results in the QuickSet HMI and all of its available functions displaying in the corresponding language. For example, if the **Control Window** is selected in the HMI while the setting LANG := SPANISH, QuickSet displays the Control Window (Ventana de Control) in *Figure 3.33*.

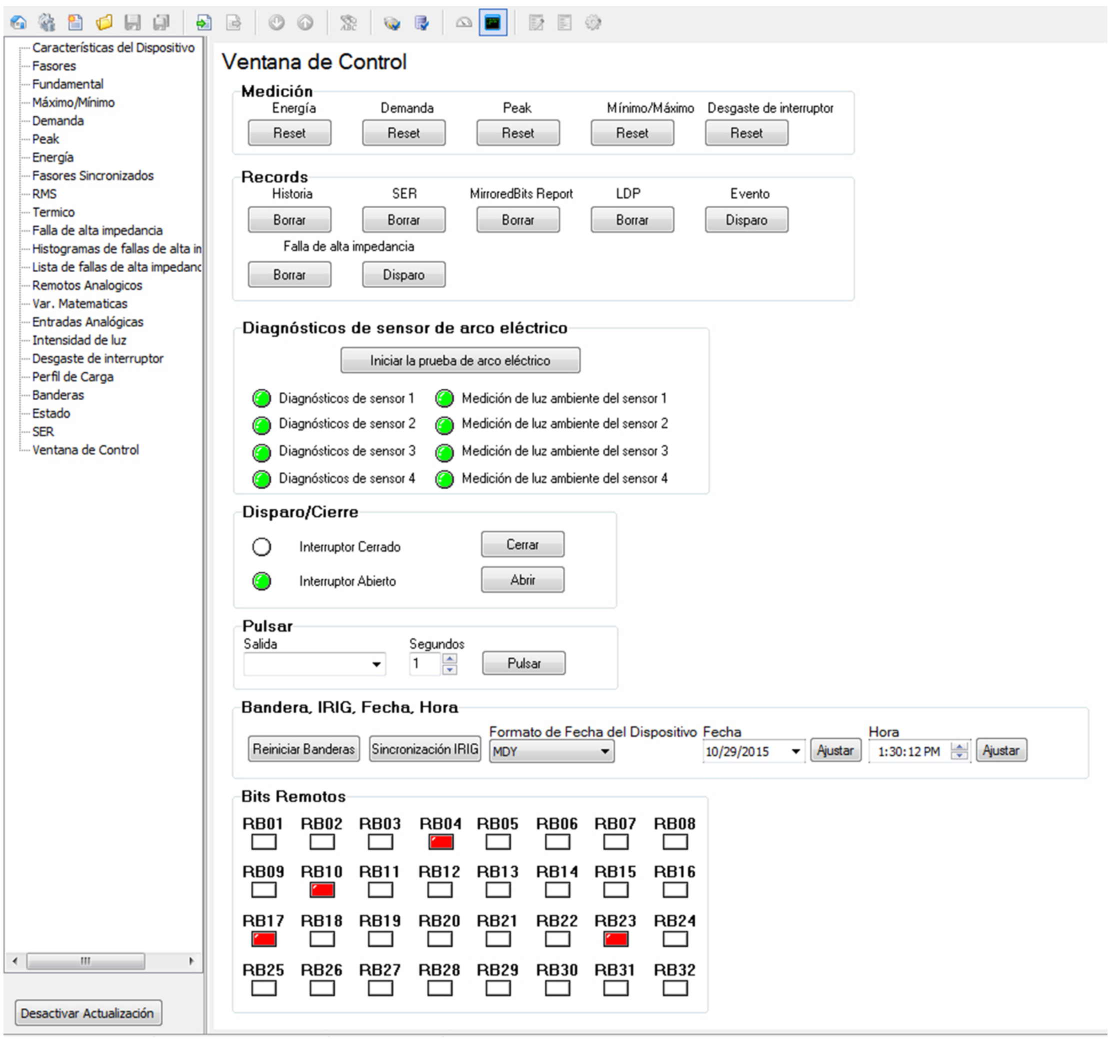


Figure 3.33 Spanish Control Window (Ventana de Control) Display

QuickSet Help

Various forms of QuickSet help are available, as shown in *Table 3.4*. Press **<F1>** to open a context-sensitive help file with the appropriate topic as the default.

Table 3.4 QuickSet Help

Help	Description
General QuickSet	Select **Help** from the main menu bar.
SEL-700G Settings	Select **Settings Help** from the **Help** menu bar while the settings editor is open.

Section 4

Protection and Logic Functions

Overview

NOTE: Each SEL-700G is shipped with default factory settings. Calculate the settings for your application to ensure secure and dependable protection. Document and enter the settings (see Section 6: Settings).

This section describes the SEL-700G Relay settings, including the protection elements and basic functions, control I/O logic, as well as the settings that control the communications ports and front-panel displays. Depending on the relay model number, some of the settings do not apply. Refer to *Table 1.1* and *Table 1.2* in *Section 1: Introduction and Specifications* for the applicable features in various relay models.

This section includes the following:

Application Data. Lists information that you need to know about the protected equipment before you calculate the relay settings.

Group Settings (SET Command). Lists the settings that configure the relay inputs to accurately measure and interpret the ac current and voltage input signals.

ID Settings and Configuration Settings. Lists the ID settings and the settings that configure the relay inputs to accurately measure and interpret the ac current and voltage input signals.

Generator Protection. Lists the settings for the following elements available in SEL-700G0, SEL-700G1, and SEL-700GT relays for generator protection and abnormal operating conditions. See Intertie and Feeder Protection for additional generator protection elements that are also applicable to intertie protection.

- ➤ *Phase Differential Element* and *Ground Differential Element*
- ➤ *Restricted Earth Fault Element*
- ➤ *100% Stator Ground Protection Elements*
- ➤ *Directional Elements*
- ➤ *Field Ground Protection Elements*
- ➤ *System Backup Protection*: *Distance Elements*, *Voltage-Controlled/Restrained Time-Overcurrent Elements*
- ➤ *Loss-of-Field Element*
- ➤ *Current Unbalance Elements*
- ➤ *Thermal Overload Elements*
- ➤ *Volts-Per-Hertz Elements*
- ➤ *Off-Frequency Accumulators*
- ➤ *Out-of-Step Element*
- ➤ *Inadvertent Energization*

Intertie and Feeder Protection. Describes elements primarily associated with intertie protection but which are also applicable to generator and feeder protection.

- *Overcurrent Elements*
- *Directional Elements*
- *Load-Encroachment Logic*

Power Elements. Lists the settings associated with power elements.

Frequency Measurement and Tracking. Identifies the signals the relay uses for frequency measurement and tracking across different models.

Over- and Underfrequency Protection. Lists the settings and describes the logic associated with over- and underfrequency elements.

Rate-of-Change-of-Frequency Protection. Lists the settings and describes the logic associated with rate-of-change-of-frequency elements.

Over- and Undervoltage Elements. Lists the settings associated with under- and overvoltage elements.

Inverse-Time Undervoltage Protection. Lists the settings and inverse-time undervoltage curves and describes the logic associated with the elements.

Inverse-Time Overvoltage Protection. Lists the settings and inverse-time overvoltage curves and describes the logic associated with the elements.

RTD-Based Protection. Lists the settings associated with RTD inputs. You can skip this subsection if your application does not include RTD inputs.

Synchronism Elements. Lists the settings for the optional synchronism-checking and autosynchronizing features available in the SEL-700G and SEL-700GT relays.

Loss-of-Potential (LOP) Protection. Describes the LOP features available in SEL-700G and SEL-700GT relays.

Vector Shift Element. Lists the settings associated with vector shift logic.

Other Settings. Lists the settings for *Demand Metering*, *Pole Open Logic*, and *Trip/Close Logic Settings*.

Logic Settings. Lists the settings associated with latches, timers, and output contacts.

Global Settings (SET G Command). Lists the settings that allow you to configure the relay to your power system, date format, analog inputs/outputs, and logic equations of global nature.

General Settings. Lists the global system settings like phase rotation, nominal frequency, date format, etc.

Event Messenger Points. Describes configuration of event messenger points.

Multiple Settings Groups. Lists settings for active group selection and describes configuration of active group selection via SELOGIC control equations.

Synchrophasor Measurement. Describes Phasor Measurement Unit (PMU) settings for C37.118 Protocol.

Time and Date Management Settings. Lists settings for time and date management and describes configuration of these settings. Covers supported time protocols.

Breaker Failure Setting. Lists the settings and describes the logic for the flexible breaker failure function.

Analog Inputs. Describes analog input functionality, lists the settings, and gives an example.

Analog Outputs. Describes analog output functionality, lists the settings, and gives an example.

Breaker Monitor. Lists the settings and describes the breaker monitor function that is used for scheduling circuit breaker maintenance.

Digital Input Debounce. Provides the settings for digital input dc debounce or ac debounce mode of operation.

Data Reset. Lists the data reset SELOGIC settings for resetting targets, energy metering, max/min metering, demand metering, and peak demand metering.

Access Control. Describes the SELOGIC setting used for disabling the settings changes from the relay front panel.

Time Synchronization Source. Describes the setting used for choosing IRIG1 or IRIG2 as the time-synchronization source.

Disconnect Control Settings. Describes the settings and logic associated with the disconnects.

Local/Remote Control. Describes the local/remote breaker control function.

Port Settings (SET P Command). Lists the settings that configure the relay front- and rear-panel serial ports.

Front-Panel Settings (SET F Command). Lists the settings for the front-panel display, pushbuttons, and LED control.

Report Settings (SET R Command). Lists the settings for the sequential event reports, event, generator autosynchronism, and load profile reports.

DNP Map Settings (SET D Command). Shows the DNP user map register settings.

Modbus Map Settings (SET M Command). Shows the Modbus user map register settings.

EtherNet/IP Assembly Map Settings (SET E Command). Shows the EtherNet/IP assembly map settings.

Touchscreen Settings. The touchscreen settings apply to relays that support the color touchscreen display. (The settings are supported in QuickSet only.)

When you calculate the protection element settings, proceed through the subsections listed earlier. Skip those settings that do not apply to your specific relay model or installation.

See *Section 6: Settings* for a list of all settings (*SEL-700G Settings Sheets*) and the various methods of accessing them. All current and voltage settings in the SEL-700G are in secondary (except nominal system and transformer winding voltages).

NOTE: The DeviceNet port parameters can only be set at the rear of the relay on the DeviceNet card (see Figure I.1).

You can enter the settings by using the front-panel `SET RELAY` function (see *Section 8: Front-Panel Operations*), the serial port (see *Section 7: Communications*), or the Ethernet port (see *Section 7: Communications*).

Application Data

It is faster and easier for you to calculate the settings for the SEL-700G if you collect the following information before you begin:

- Highest expected load current
- Generator/Transformer data (if applicable)
- Current transformer primary and secondary ratings and connections
- System phase rotation and nominal frequency
- Voltage transformer ratios and connections, if used
- Type and location of resistance temperature devices (RTDs), if used
- Expected fault current magnitudes for ground and three-phase faults

Group Settings (SET Command)

ID Settings

All models of the SEL-700G have the identifier settings shown in *Table 4.1*.

Table 4.1 Identifier Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
UNIT ID LINE 1	16 Characters	RID := SEL-700G RID := SEL-700GT RID := SEL-700GW
UNIT ID LINE 2	16 Characters	TID := GENERATOR RELAY TID := INTERTIE RELAY TID := WIND GEN RELAY

The SEL-700G prints the relay and terminal identifier strings at the top of the responses to serial port commands to identify messages from individual relays.

Enter as many as 16 characters, including letters A–Z (not case sensitive), numbers 0–9, periods (.), dashes (-), and spaces. Suggested identifiers include the location or number of the protected equipment.

Configuration Settings

Table 4.2 Configuration Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
PHASE ROTATION	ABC, ACB	PHROT := ABC
X CUR INPUT FROM	NEUT, TERM	X_CUR_IN := NEUT
X PH CT RATIO	1–10000[a]	CTRX := 500
NOMINAL CURRENT	1.0–10.0 A[b]	INOM := 5.0 A[b]
X SIDE PT CONN	DELTA, WYE	DELTAY_X := WYE
X PT RATIO	1.00–10000.00	PTRX := 100.00
X SIDE VNOM	0.02–1000 kV	VNOM_X := 13.80 kV
EXT ZERO SQ VOLT	NONE, VS, VN	EXT3V0_X := NONE

Table 4.2 Configuration Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
Y PH CT CONN	DELTA, WYE	CTCONY := WYE
Y PH CT RATIO	1–10000[a]	CTRY := 500[c]
Y SIDE PT CONN	DELTA, WYE	DELTAY_Y := WYE
Y PT RATIO	1.00–10000.00	PTRY := 1000.00
Y SIDE VNOM	0.02–1000 kV	VNOM_Y := 138.00 kV
SYNCV PT RATIO	1.00–10000.00	PTRS := 100.00
NEUT CT RATIO	1–10000[a]	CTRN := 100
NEUT PT RATIO	1.00–10000.00	PTRN := 100.00

[a] Range settings shown are for relay models with 5 A rated current input. Multiply by 5 for the 1 A rated input.
[b] Range and default setting shown are for relay models with 5 A rated current input. Divide by 5 for the 1 A rated input.
[c] Default setting may be different, depending on the relay part number.

The phase rotation setting tells the relay your phase labeling standard. Set PHROT equal to ABC when B-phase current lags A-phase current by 120 degrees. Set PHROT equal to ACB when B-phase current leads A-phase current by 120 degrees. You have great application flexibility (use the SEL-700G in pumped storage applications, for example) by being able to set any phase rotation you want in each setting group.

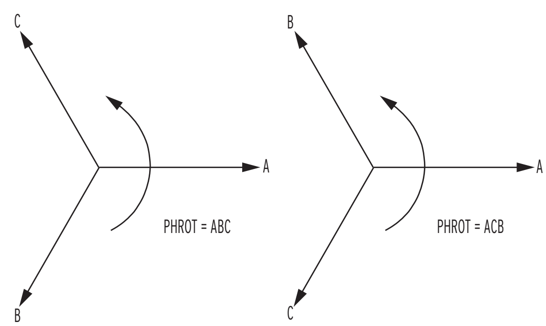


Figure 4.1 Phase Rotation Setting

The X_CUR_IN setting is available only in SEL-700G1 relays. For most applications where neutral side CTs are connected to the X-input of the relay (see *Figure 2.26*), set X_CUR_IN := NEUT. However, if the CTs are connected on the terminal side of the generator, set the X_CUR_IN to TERM. The SEL-700G0 and SEL-700GT+ relays use X_CUR_IN := TERM automatically and cannot be changed. The relays use this setting to configure Ground Differential (see *Figure 4.16*) and Restricted Earth Fault (see *Figure 4.17*) elements for proper operations.

The CT ratio settings configure the relay to accurately scale measured values and report the primary quantities. Calculate the phase and neutral CT ratios by dividing the primary rating by the secondary rating.

EXAMPLE 4.1 Phase CT Ratio Setting Calculation

Consider an application where the phase CT rating is 100:5 A.

Set CTR := 100/5 := 20.

Set the INOM setting to nominal machine current by using the following equation:

$$\text{INOM} = \frac{\left[\dfrac{\text{MVA} \bullet 1000}{1.73 \bullet \text{kV}}\right]}{\text{CTRX}}\ \text{A}$$

where:

MVA = the generator-rated output
kV = generator-rated phase-to-phase voltage
CTRX = the phase current transformer ratio to one

The relay negative-sequence overcurrent and differential elements use the INOM setting.

The X-side phase CTs must always be connected in WYE. The CTCONY setting (Y-side phase CT connection) is used to appropriately configure differential protection. This setting is available only in the SEL-700G1 relays.

Set the DELTAY_X setting to define whether relay ac potentials are supplied by three-wire (for example, open-delta) or four-wire wye connected generator voltage transformers. Similarly, set the DELTAY_Y for the Y side. See *Figure 2.19* for the voltage connection examples and appropriate setting.

The PTRX, PTRY, PTRS, and PTRN settings configure the relay voltage inputs to measure and scale the voltage signals correctly. Set the PTRs equal to their respective VT ratio. The synchronism check and neutral voltage inputs (VS and VN) are optional single-phase voltage inputs. See *Example 4.2* for sample calculations to set the PTRX setting.

EXAMPLE 4.2 Phase VT Ratio Setting Calculations

Consider a 13.8 kV Generator application where 14400:120 V rated voltage transformers (connected in open delta) are used.

Set PTRX := 14400/120 := 120, VNOM_X := 13.8, and DELTAY_X := DELTA.

The relay performs a range check for the VNOM_X and VNOM_Y settings that depends upon the respective PT connection setting (DELTAY). When setting DELTAY is DELTA, then the allowed range of the VNOM is 20–250 V (L-L secondary). When setting DELTAY is WYE, then the allowed range of VNOM is 20–440 V (L-L secondary).

Note that the VNOM_X and VNOM_Y settings are always in line-to-line primary kV, even when set for a wye configuration. Be careful to use a solidly grounded wye system for VNOM inputs greater than 250 V (L-L secondary) to avoid a 1.73 increase in terminal voltages from a line-to-ground fault.

When DELTAY_X : = DELTA, the relay allows you to connect external zero-sequence voltage (3V0) by setting EXT3V0_X. Set EXT3V0_X to VS or VN to connect external 3V0 to **VS-NS** or **VN-NN** voltage inputs, respectively, for use with different elements. Refer to *Figure 2.19* for the voltage connection and *Figure 2.28* for an application example.

Generator Protection

Phase Differential Element

Protect your apparatus with dual-slope percentage differential protection. Percentage differential protection provides more sensitive and secure protection than traditional differential protection; the dual-slope characteristic compensates for steady-state, proportional, and transient differential errors within the zone of protection. Steady-state errors are those that do not vary with loading through the differential zone. These include transformer magnetizing current and unmonitored loads. Proportional errors are those that vary with loading. These include relay measuring error, CT ratio errors, and errors because of tap changing. Transient errors are those that occur temporarily due to transients such as CT saturation.

The relay allows you to choose harmonic blocking, harmonic restraint, or both, providing stability during transformer inrush conditions. Even-numbered harmonics (second and fourth) provide security during transformer energization, while fifth-harmonic blocking provides security for overexcitation conditions.

Operating Characteristic

The SEL-700G1 has three differential elements (87R-1, 87R-2, and 87R-3). These elements employ Operate (IOP) and Restraint (IRT) quantities that the relay calculates from the winding input current. *Figure 4.2* shows the relay characteristic. You can set the characteristic as either a single-slope, percentage differential characteristic or as a dual-slope, variable-percentage differential characteristic. Tripping occurs if the Operate quantity is greater than the curve value for the particular restraint quantity. A minimum pickup level for the Operate quantity must also be satisfied.

The four settings that define the characteristic are:

O87P = minimum IOP level required for operation

SLP1 = initial slope, beginning at the origin and intersecting O87P at IRT = O87P • 100/SLP1

IRS1 = limit of IRT for SLP1 operation; intersection where SLP2 begins

SLP2 = second slope must be greater than or equal to SLP1

By careful selection of these settings, you can duplicate closely the characteristics of existing differential relays that have been in use for many years.

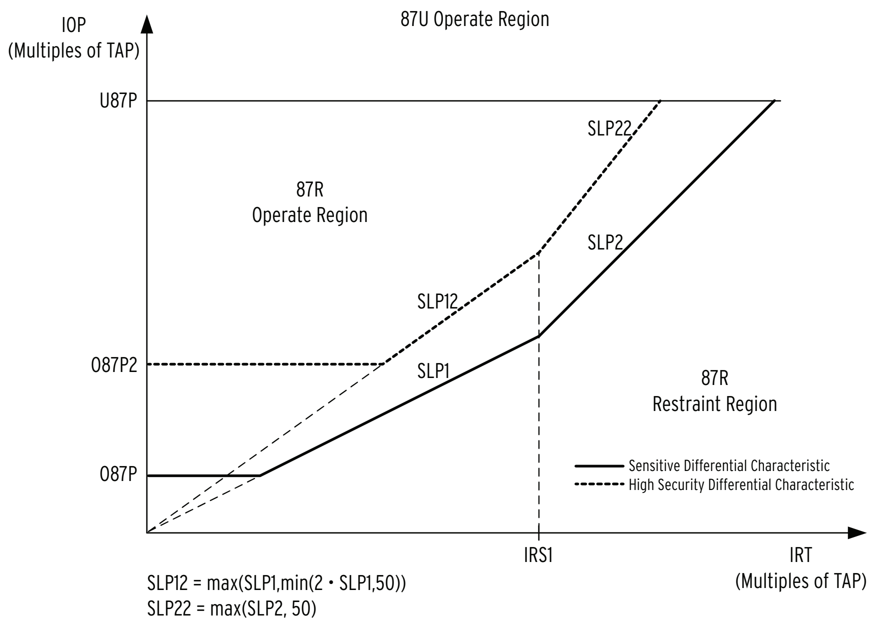


Figure 4.2 Percentage Restraint Differential Characteristic

Figure 4.3 to *Figure 4.7* illustrate how input currents are acquired and used in the unrestrained and restrained differential elements. Data acquisition, filtering, tap scaling, and transformer and CT connection compensation for Winding X are shown in *Figure 4.3*.

Four digital filters extract the fundamental, second, fourth, and fifth harmonics of the input currents.

Using the transformer MVA rating as a common reference point, TAP scaling converts all secondary currents entering the relay from the two windings to per-unit values, thus changing the ampere values into dimensionless multiples of TAP. Throughout the text, the term "TAP" refers to both windings, whereas "TAP*n*" refers to the ampere value of a particular winding; TAPmin and TAPmax refer to the least and greatest of the two TAP*n* values. This method ensure that, for full-load through-current conditions, all incoming current multiples of tap sum to 1.0 and all outgoing current multiples of tap sum to –1.0, with a reference direction into the transformer windings.

Transformer and CT connection compensation adjusts the sets of three-phase currents for the phase angle and phase interaction effects introduced by the winding connection of the transformer and CTs. Settings CTCX and CTCY determine the mathematical corrections to the three-phase currents for Winding X and Winding Y, respectively. CTCX is shown in *Figure 4.3* as the phase angle and sequence quantity adjustment for Winding X.

I1XC1, I2XC1, and I3XC1 are the fundamental frequency A-phase, B-phase, and C-phase compensated currents for Winding X. Similarly, I1XC2, I2XC2, and I3XC2 are the second-harmonic compensated currents for Winding X. The fourth-harmonic and fifth-harmonic compensated currents use similar names. The I1-compensated currents are used with differential element 87-1, I2 with element 87-2, and I3 with element 87-3.

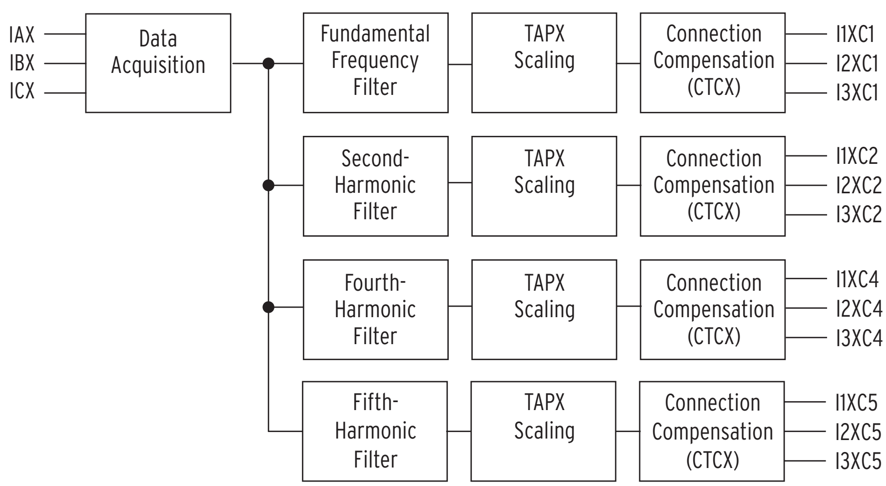


Figure 4.3 Winding X Compensated Currents

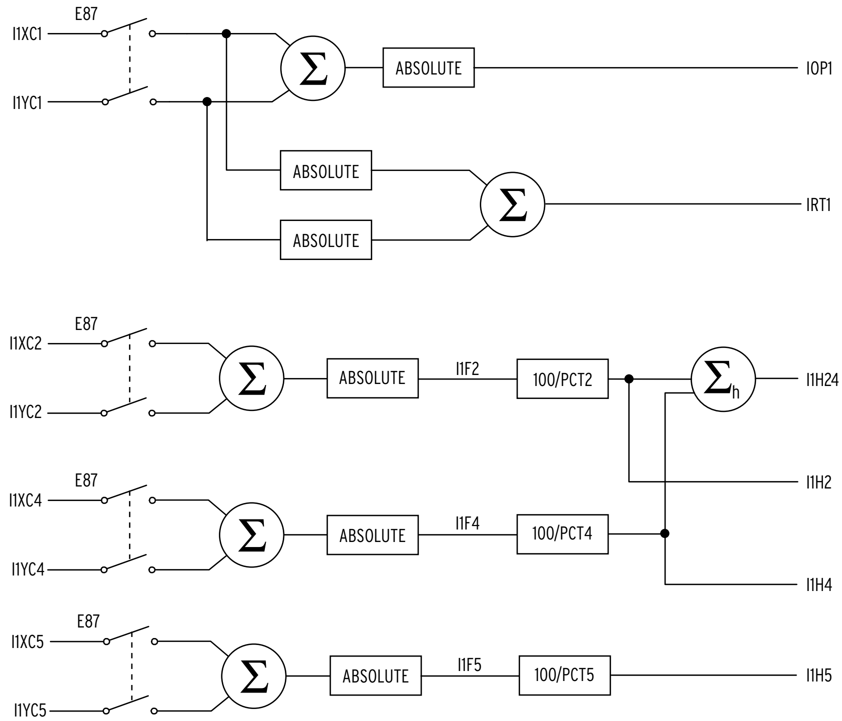


Figure 4.4 Differential Element (87-1) Quantities

NOTE: The SEL-700G restraint quantity IRTn calculation differs from the SEL-587 and SEL-387 by a factor of 2.

Figure 4.4 illustrated how the IOP1 (operate), IRT1 (restraint), I1H24 (harmonic restraint), I1H2 (second harmonic), I1H4 (fourth harmonic), and I1H5 (fifth harmonic) quantities are calculated for the 87-1 element. IOP1 is generated by summing the winding currents in a phasor addition. IRT1 is generated by summing the magnitudes of the winding currents in a simple scalar addition. The 87-2 and 87-3 quantities are calculated in a similar manner.

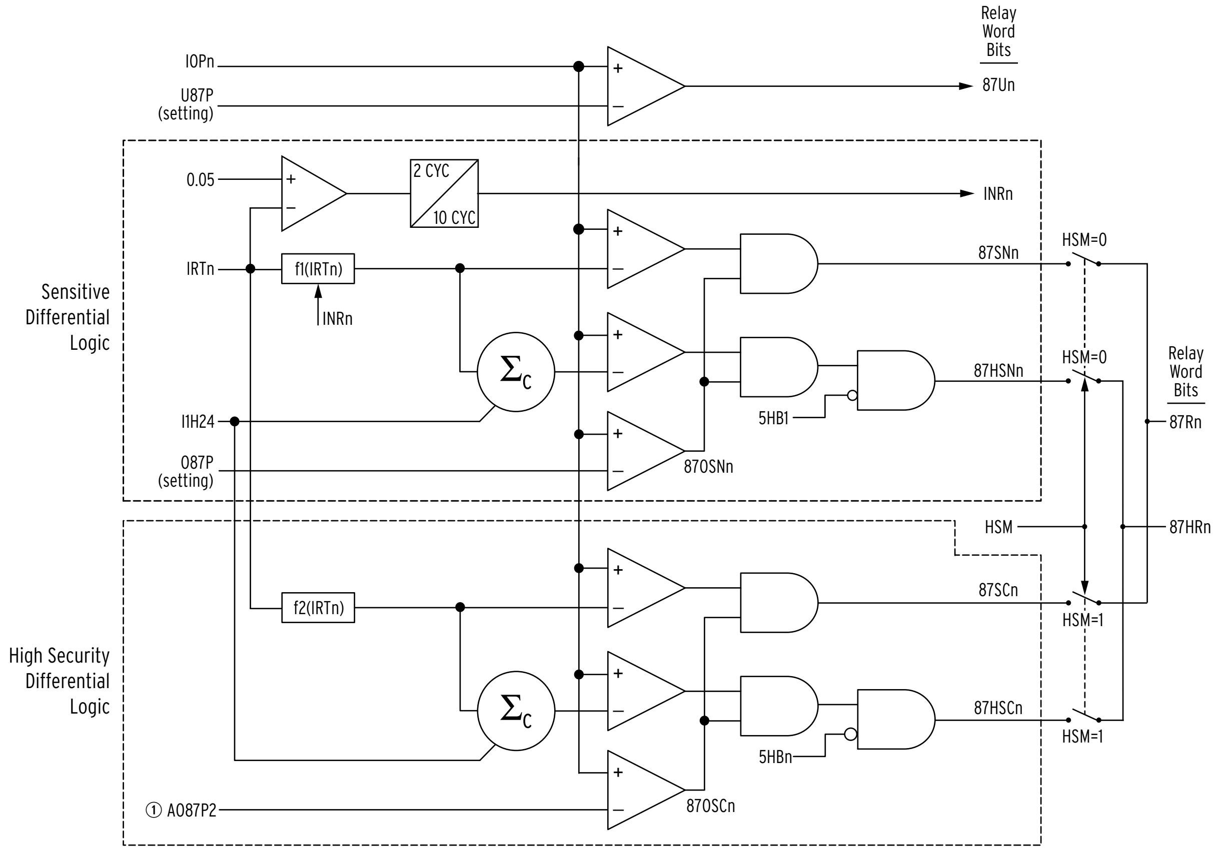
For each restraint element (87R-1, 87R-2, 87R-3), the quantities are summed as phasors and the magnitude becomes the operate quantity (IOP*n*). For a through-current condition, IOP*n* should calculate to about 1 + (–1) = 0, at rated load. Calculation of the restraint quantity (IRT*n*) occurs through a summation of all current magnitudes. For a through-current condition, this will calculate to about (| 1 | + | –1 |) = 2, at rated load.

Figure 4.5 shows how the differential element quantities are used to generate the unrestrained 87U*n* (87U1, 87U2, 87U3) and restrained 87R*n*/87HR*n* (87R1, 87R2, 87R3, 87HR1, 87HR2, 87HR3) elements.

Unrestrained elements (87U1, 87U2, and 87U3) compare the IOP quantity to a setting value (U87P), typically about 10 times TAP, and trip if this level is exceeded. Elements 87U1, 87U2, and 87U3 are combined to form element 87U, as shown in *Figure 4.7*. Harmonic blocking or restraint is not performed on the unrestrained elements. Use these elements to protect your transformer bushings and end windings while maintaining security for inrush and through-fault conditions.

Restrained elements (87R1, 87R2, and 87R3) determine whether the IOP quantity is greater than the restraint quantity by using the differential characteristic shown in *Figure 4.2*. This characteristic is modified by increasing the restraint current threshold as a function of the second- and fourth-harmonic content in the input currents for the harmonic restraint elements (87HR1, 87HR2, and 87HR3). Set HRSTR = Y to activate the harmonic restraint element 87HR.

In element 87R*n*, for example, the IOP*n* and IRT*n* quantities determine whether the relay trips. The logic enclosed within the dotted lines, sensitive differential and high security differential logic, of *Figure 4.5* implements the respective sensitive differential and high security differential characteristics shown in *Figure 4.2*. The differential element calculates a threshold as a function of IRT*n* (f1(IRT*n*) or f2(IRT*n*)) as shown in *Figure 4.5*. IOP*n* must exceed this threshold to assert 87R*n*. The function, f1(IRT*n*), uses SLP1, SLP2, and IRS1 settings, along with IRT*n*, to calculate the IOP value. The function uses SLP2 in place of SLP1 when the Relay Word bit INR*n* is asserted. This feature provides a high security mode of operation for 10 cycles when the transformer is energized. The function, f2(IRT*n*), uses the IRS1 setting, along with the SLP12, SLP22, and IRT*n*, to calculate the IOP value. The high security mode Relay Word bit, HSM, determines which characteristic to use. If HSM = 0, the element uses the sensitive differential logic and 87R*n* is driven by 87SN*n*. If HSM = 1, the element uses the high security differential logic and 87R*n* is driven by 87SC*n*. More information on HSM is covered later in this section (see *High Security Mode Settings HSM, O87P2, and HSMDOT*). If E87 = GEN, 87R*n* will produce a trip. If E87 = TRANS, the relay still needs the results of the harmonic blocking and/or harmonic restraint decision logic (see *Harmonic Restraint* and *Harmonic Blocking* for more information). Note that the operating current elements 87OSN*n* (87OSN1, 87OSN2, 87OSN3) and 87OSC*n* (87OSC1, 87OSC2, 87OSC3) are not available as Relay Word bits.



Conditions	f1(IRTn) Output
If INR*n* = 1	IRT*n* • SLP2
If INR*n* = 0 and O87P < IRT*n* <IRS1	IRT*n* • SLP1
If INR*n* = 0 and IRT*n* > IRS1	IRT*n* • SLP2 + IRS1 • (SLP1–SLP2)
Conditions	**f2(IRTn) Output**
If AO87P2 < IRT*n* < IRS1	IRT*n* • SLP12
If IRT*n* > IRS1	IRT*n* • SLP22 + IRS1 • (SLP12–SLP22)

① From Figure 4.12.
NOTE: n = 1, 2, or 3; SLP12 = max(SLP1,min(2 • SLP1,50)); SLP22 = max(SLP2, 50).

Figure 4.5 Differential Element Logic

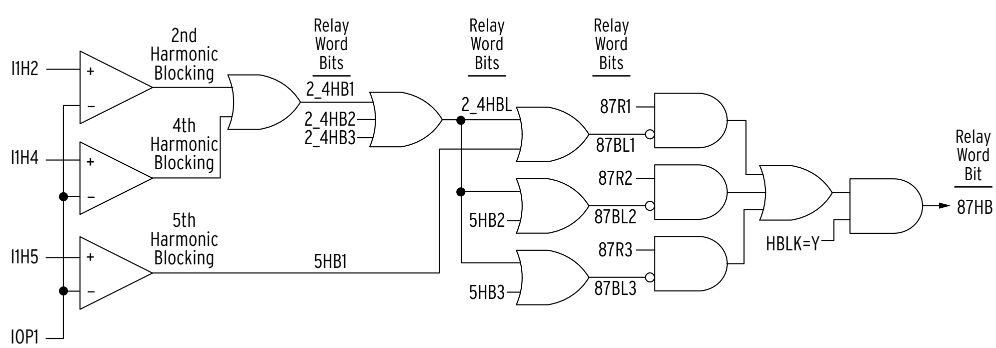


Figure 4.6 Differential Element Harmonic Blocking Logic

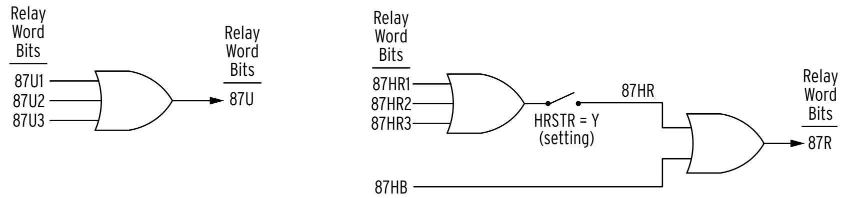


Figure 4.7 Differential Element Output Logic

Harmonic Restraint. Consider the harmonic restraint feature (HRSTR = Y) if your practices require independent harmonic restraint. Blocking features are discussed in more detail later in this section.

For harmonic blocking, the harmonic content of the differential current must exceed the individual (PCT2 or PCT4) threshold values, i.e., the thresholds are treated as independent measurements of each harmonic value. For harmonic restraint, the values of the second- and fourth-harmonic currents are summed, and that value is used in the relay characteristic. Consider, for example, the simple case of Slope 1, i.e., a straight line through the origin. The general equation for a line is:

y = m • x + c

More specifically, in the SEL-700G:

IOP = SLP1 • IRT + c (for sensitive differential logic)

IOP = SLP12 • IRT + c (for high-security differential logic)

Because the line starts at the origin, the value of *c* is normally zero. The sum of the second- and fourth-harmonic currents, I1H24 in *Figure 4.5*, now forms the constant *c* in the equation, raising the relay characteristic proportionally to the harmonic values. Based on the status of the HSM Relay Word bit, 87HR*n* is driven by either 87HSN*n* (HSM = 0) or 87HSC*n* (HSM = 1), indicating operation of the harmonic restrained differential element, *n*, and tripping can take place.

Harmonic Blocking. Set HRBLK = Y to enable the harmonic blocking feature. While the restrained differential elements are making decisions, a parallel blocking decision process occurs regarding the magnitudes of specifics harmonics in the IOP quantities.

Figure 4.6 shows how blocking elements (87BL1, 87BL2, and 87BL3) supervise the restrained differential elements if the second-, fourth-, or fifth-harmonic operating current is above its set threshold. The blocking prevents improper tripping during transformer inrush or allowable overexcitation conditions. The SEL-700G1 uses common (cross-phase) blocking. Common blocking prevents all restrained elements (87R*n*) from tripping if any blocking element is picked up.

However, an independent blocking is used for the fifth-harmonic current. In this logic, an individual element will only disable tripping of that element. Tripping can take place if 87R*n* is asserted and the corresponding blocking elements are deasserted.

An additional alarm function for fifth harmonic to warn of overexcitation (not shown in *Figure 4.6*) employs a separate threshold (TH5P) and an adjustable timer (TH5D).

Differential Element Output Logic. Relay Word bits 87R and 87U, shown in *Figure 4.7*, are high-speed elements that must trip all breakers. The assigns 87R and 87U (along with other protection elements) to assert four Relay Word bits (TRIPX, TRIP1, TRIP2, and TRIP3) to shut down the generator.

Table 4.3 Differential Element Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PHASE DIFF EN	GEN, TRANS, NONE	E87 := GEN
MAX XFMR CAP	OFF, 0.2-5000.0 MVA	MVA := OFF
DEFINE CT COMP	Y, N	ICOM := N
X SIDE CT COMP	0, 12	CTCX := 0
Y SIDE CT COMP	0, 1, 5, 6, 7, 11, 12	CTCY := 0
WDG-X L-L VOLTS	0.20-1000.00 kV	VWDGX := 13.80 kV
WDG-Y L-L VOLTS	0.20-1000.00 kV	VWDGY := 138.00 kV
X SIDE CURR TAP	0.50–31.00 A[a]	TAPX := 2.09
Y SIDE CURR TAP	0.50–31.00 A[a]	TAPY := 2.09
OPERATE CURR LVL	0.10–1.00 TAP	O87P := 0.30
UNRES CURR LVL	1.0–20.0 TAP	U87P := 10.0
DIFF CURR AL LVL	OFF, 0.05–1.00 TAP	87AP := 0.15
DIFF CURR AL DLY	1.00–120.00 s	87AD := 5.00
RESTRAINT SLOPE1	5–90 %	SLP1 := 25
RESTRAINT SLOPE2	5–90 %	SLP2 := 70[b]
RES SLOPE1 LIMIT	1.0–20.0 TAP	IRS1 := 6.0
2ND HARM BLOCK	OFF, 5–100 %	PCT2 := OFF
4TH HARM BLOCK	OFF, 5–100 %	PCT4 := OFF
5TH HARM BLOCK	OFF, 5–100 %	PCT5 := OFF
5TH HARM AL LVL	OFF, 0.02–3.20 TAP	TH5P := OFF
5TH HARM AL DLY	0.00–120.00 s	TH5D := 1.00
HARMONIC RESTRNT	Y, N	HRSTR := N
HARMONIC BLOCK	Y, N	HBLK := Y
HI SECURITY MODE	SELOGIC	HSM := 0
HI SECURITY PU	AUTO, O87P–2.00	O87P2 := 1.25
EXT FLT DET DO	1.00–30.00 s	HSMDOT := 10.00

[a] Range shown is for I_{NOM} = 5 A; range for I_{NOM} = 1 A is 0.1–6.20 A.
[b] The SLP2 setting is automatically set to 70 and hidden if E87 := GEN.

Select GEN or TRANS for E87 to configure the differential element for generator or transformer protection, respectively.

When E87 := TRANS, use the highest expected transformer rating, such as the forced oil and air cooled (FOA) rating or a higher emergency rating, when setting the maximum transformer capacity (MVA). When a value is entered in the MVA setting (that is, MVA is not set to OFF), the relay uses the MVA, winding voltage, CT ratio, and CT connection settings (see *Table 4.2*) you have entered and calculates the TAPX and TAPT values automatically. You can also directly enter tap values when MVA := OFF. The ratio of maximum ($TAPn/I_{NOMn}$) to the minimum ($TAPn/I_{NOMn}$) must be less than or equal to 7.5, where I_{NOMn} (n = X, Y) is the nominal rating of the CT, 5 A or 1 A.

The ICOM setting defines whether the input currents need any correction, either to accommodate phase shifts in the transformer or CTs, or to remove zero-sequence components from the secondary currents. If this setting is Y, the relay permits you, in the next group of settings, to define the amount of shift necessary to align the secondary currents properly for the differential calculation.

Settings CTCX and CTCY for Winding X and Y, respectively, define the amount of compensation to each set of the winding currents. The relay automatically sets CTCX to 0 when ICOM := N. These settings account for phase shifts in transformer winding connections and also in CT connections. For example, this correction is necessary if all the CTs are connected in wye in a delta-wye step-up transformer application. The effect of the compensation is to create phase shift and removal of zero-sequence current components.

Set the operating current level O87P at a minimum for increased sensitivity (0.2 to 0.3 for transformers and around 1.0 for buses), but high enough to avoid operation because of unmonitored loads and transformer excitation current. O87P must be greater than or equal to the minimum of $0.1 \cdot I_{NOMn}/TAPn$, where n = X, Y.

The SEL-700G1 includes a differential current alarm feature. Set the 87AP level above the highest expected differential current under normal operations (typically lower than O87P) setting) and a security delay 87AD. See *Figure 4.8* for the logic diagram of this feature. Assertion of Relay Word bit 87AT indicates a problem in the differential current circuit (e.g., open CT). You must program the 87AT bit to take appropriate action (alarm, display message, SER, etc.) as desired.

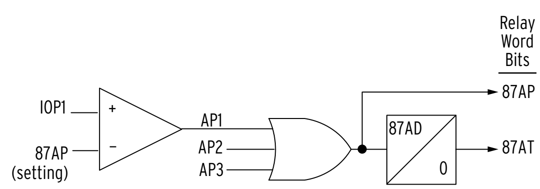


Figure 4.8 Differential Current Alarm Logic Diagram

Use the restraint slope percentage settings to discriminate between internal and external faults. Set SLP1 to accommodate current differences from steady-state and proportional errors such as power transformer tap-changer, CT errors, and relay error. Set SLP2 to accommodate transient error caused by CT saturation.

A two-slope, or variable-percentage differential application, improves sensitivity in the region where CT error is less and increases security in the high-current region where CT error is greater. We must define both slopes, as well as the Slope 1 limit or point IRS1, where SLP1 and SLP2 intersect. If you want a single slope characteristic, set both SLOPE1 and SLOPE2 to the desired slope value.

The purpose of the instantaneous unrestrained current element is to react quickly to very heavy current levels that clearly indicate an internal fault. Set the pickup level U87P to 8 to 10 times tap. The unrestrained differential element only responds to the fundamental frequency component of the differential operating current. It is unaffected by the SLP1, SLP2, IRS1, PCT2, or PCT5 settings. Thus, you must set the element pickup level high enough so as not to react to large inrush currents.

Energization of a transformer causes a temporary large flow of magnetizing inrush current into one terminal of a transformer, without the other terminal seeing this current. Thus, it appears as a differential current that could cause improper relay operation. Magnetizing inrush currents contain greater amounts of even-harmonic current than do fault currents. This even-harmonic current can be used to identify the inrush phenomenon and to prevent relay misoperation. The SEL-700G1 measures the amount of second-harmonic and fourth-harmonic currents flowing in the transformer. You can set the relay to block the percentage restrained differential element if the ratio of the second-harmonic and/or fourth-harmonic current to fundamental current (IF2/IF1, IF4/IF1) is greater than the PCT2 or PCT4 setting, respectively. The differential element automatically goes into high security mode when the transformer is de-energized and IRN*n* asserts. The relay will stay in this mode for 10 cycles after energization is detected. See *Figure 4.5* and the associated description.

According to industry standards (ANSI/IEEE C37.91, C37.102), overexcitation occurs when the ratio of the voltage to frequency (V/Hz) applied to the transformer terminals exceeds 1.05 per unit at full load or 1.1 per unit at no load. Transformer voltage and generator frequency may vary somewhat during startup, overexciting the transformers. Transformer overexcitation produces odd-order harmonics that can appear as differential current to a transformer differential relay. The SEL-700G1 measures the amount of fifth-harmonic current flowing in the transformer. You can set the relay to block the percentage restrained differential element if the ratio of fifth-harmonic current to fundamental current (IF5/IF1) is greater than the PCT5 setting. Unit-generator step-up transformers at power plants are the primary users of fifth-harmonic blocking.

Fifth-harmonic alarm level and delay settings (TH5P and TH5D) use the presence of fifth-harmonic differential current to assert a Relay Word bit TH5T. This bit indicates that the rated transformer excitation current is exceeded. You may consider triggering an alarm and/or event report if fifth-harmonic current exceeds the fifth-harmonic threshold that you set.

The SEL-700G1 includes common harmonic blocking (cross-phase blocking) and harmonic restraint logic; you can select either one or both of them. The combination of both logic functions provides optimum differential element operating speed and security. Use the HRSTR := Y setting to enable the harmonic restraint logic and the HBLK := Y setting to enable the harmonic blocking logic.

Common harmonic blocking provides superior security against tripping on magnetizing inrush during transformer energization, yet allows faster differential element tripping for an energized transformer fault. Differential tripping through the harmonic restraint logic is slightly slower, but provides a dependable tripping function when energizing a faulted transformer that might otherwise have the differential tripping element blocked by common harmonic blocking logic.

High Security Mode Settings HSM, O87P2, and HSMDOT. Uneven CT saturation during external events, such as faults or transformer energization, can lead to differential operation in some installations. While the preferred method to avoid these unwanted operations is to properly size and match the

CTs, the high security mode SELOGIC control equation, HSM, can be programmed to force the element into high security mode during these external events. The HSM SELOGIC control equation can be programmed to assert based on the external event detector Relay Word bits as follows:

HSM = (DRDOPT OR HRT) AND NOT RHSM

When HSM = 1, the element switches to the high security characteristic (O87P2 pickup, slopes SLP12 and SLP22) shown in *Figure 4.2*. Refer to *Figure 4.9*, *Figure 4.10*, and *Figure 4.11* for the logic associated with the Relay Word bits DRDOPT, HRT, and RHSM, respectively. The HSMDOT default dropout time of 10 seconds will maintain the external event detector DRDOPT bit assertion longer than the duration of most inrush events. Program HSMDOT to meet the needs of your application.

Similarly, the O87P2 default setting of 1.25 should avoid an undesired operation under severe CT mismatch conditions while maintaining adequate sensitivity for internal faults. To achieve a balance between security and sensitivity, set O87P2 = AUTO. O87P2 can only be set to AUTO when E87 = GEN. AO87P2 is used as a pickup for the high security differential element shown in *Figure 4.5*. *Figure 4.12* shows how AO87P2 is computed. KCLI is the phasor sum of the six normalized compensated currents. In the case of tightly matched CTs and with even CT saturation or no CT saturation, we can expect the output of KCLI to be zero and AO87P2 to equal the O87P setting. Any uneven saturation will result in an increase in KCLI and pickup of AO87P2, thus increasing the security of the element. As the CTs recover from uneven saturation, KCLI and AO87P2 decrease, thus increasing the sensitivity of the element for evolving internal faults.

All previous settings can be optimized based on worst case inrush currents expected or monitored in a specific application. For more information, refer to the Western Protective Relay Conference paper *Generator Protection Overcomes Current Transformer Limitations*, available at selinc.com, or contact your SEL customer service representative.

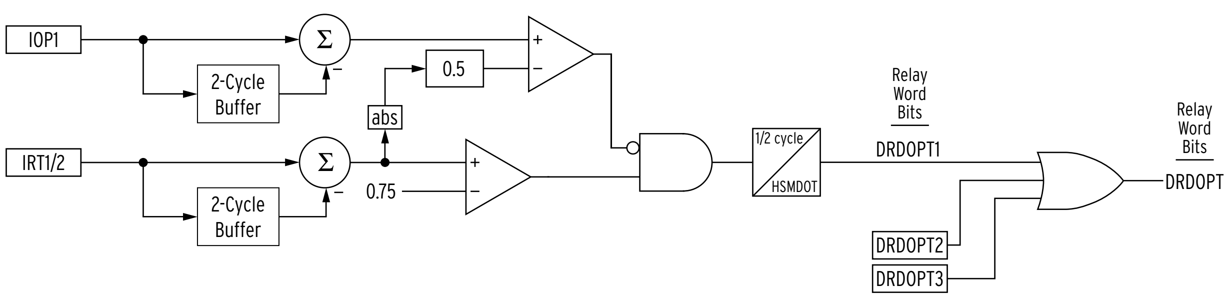


Figure 4.9 Delta IRTn and Delta IOPn External Event Detector Logic

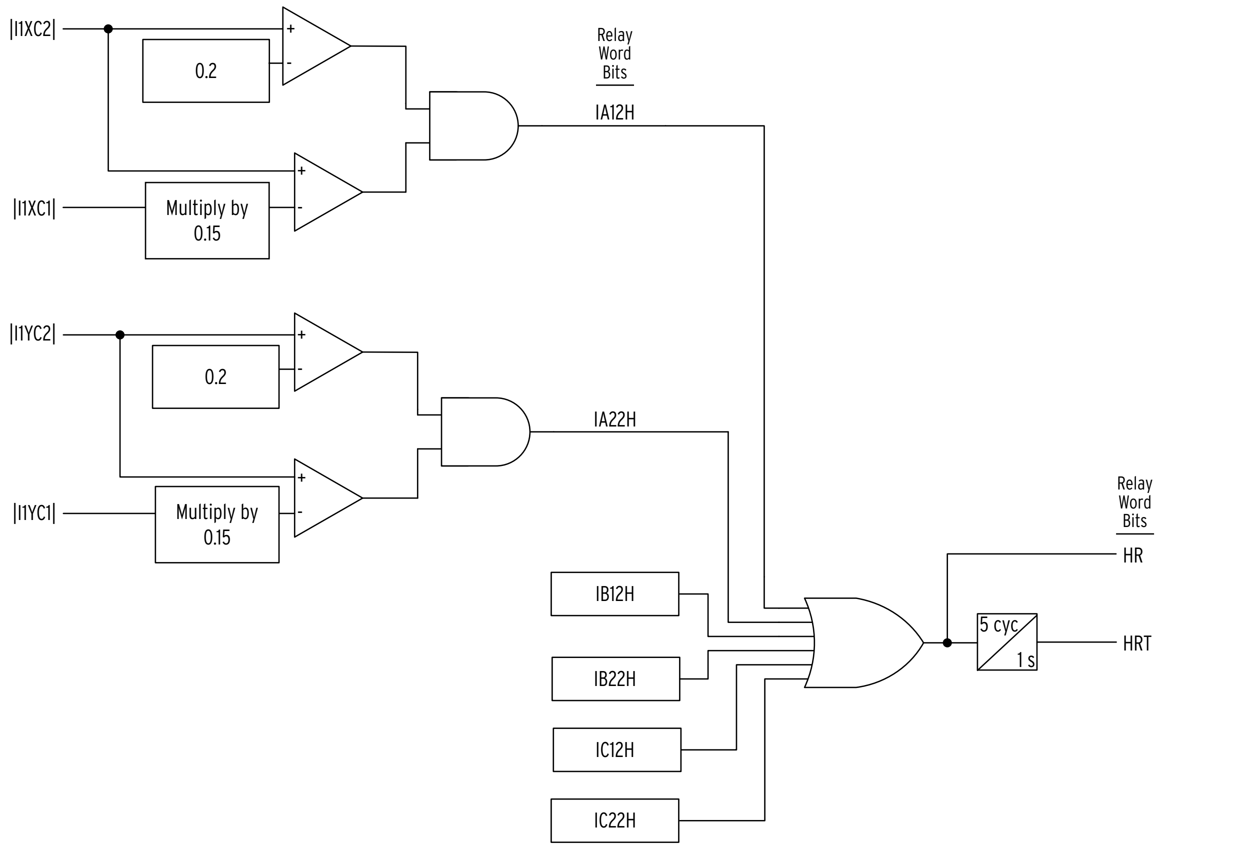


Figure 4.10 Second-Harmonic External Event Detector Logic

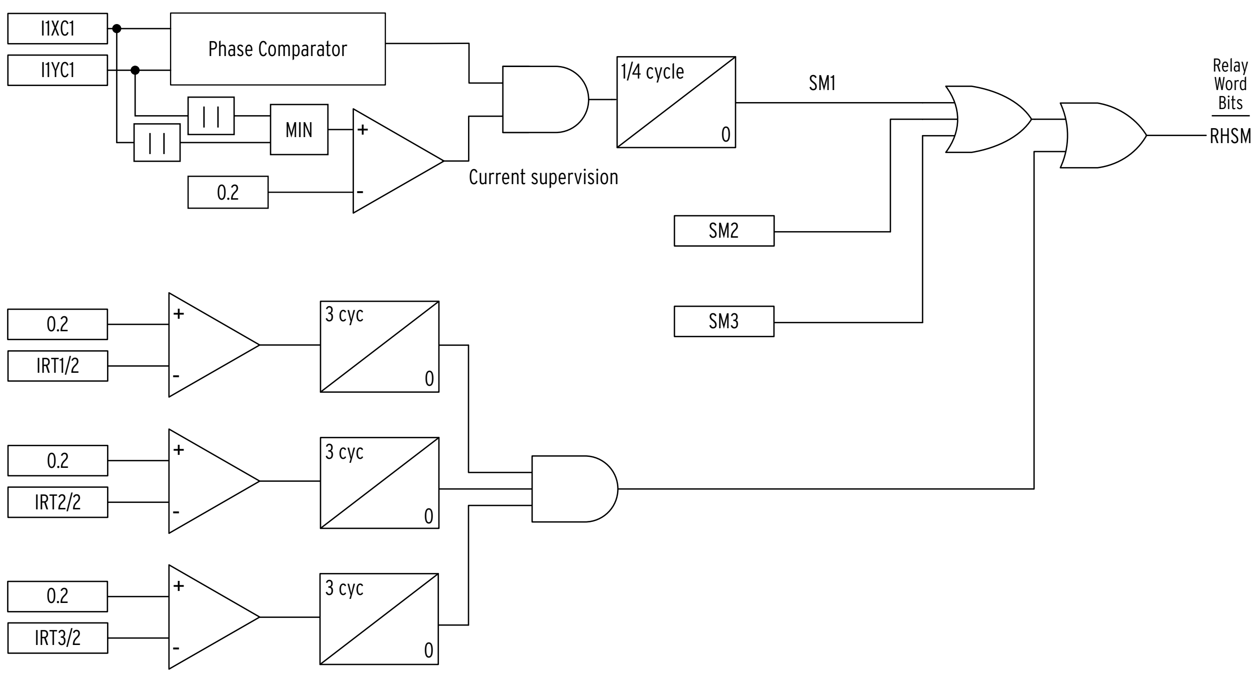
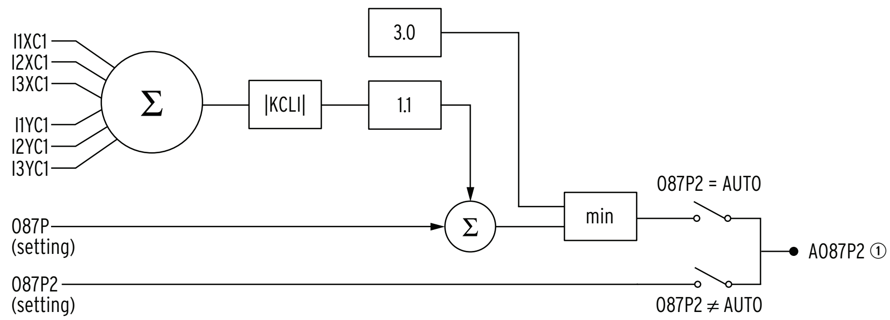


Figure 4.11 High Security Mode RESET Logic



① To Figure 4.5.

Figure 4.12 AO87P2 Logic

Differential Element Settings in SEL-700G1, SEL-300G, SEL-387, and SEL-587. The SEL-700G1 restraint quantity IRT*n* calculation differs from the SEL-300G, SEL-587, and SEL-387 by a factor of 2. To achieve the same characteristics for the differential elements in the SEL-700G1, SEL-300G, SEL-387, and SEL-587, you must account for this factor of 2. Following are the settings relationships among the four products.

Convert the SEL-300G, SEL-387, and SEL-587 Relay Settings to the SEL-700G1 Relay

$O87P_{700G1} = O87P_{300G/387/587}$

$SLP1_{700G1} = 1/2 \bullet SLP1_{300G/387/587}$

$SLP2_{700G1} = 1/2 \bullet SLP2_{300G/387/587}$

$IRS1_{700G1} = 2 \bullet IRS1_{300G/387/587}$

$U87P_{700G1} = U87P_{300G/387/587}$

Convert the SEL-700G1 Relay Settings to the SEL-300G, SEL-387, and SEL-587 Relays

$O87P_{300G/387/587} = O87P_{700G1}$

$SLP1_{300G/387/587} = 2 \bullet SLP1_{700G1}$

$SLP2_{300G/387/587} = 2 \bullet SLP2_{700G1}$

$IRS1_{300G/387/587} = 1/2 \bullet IRS1_{700G1}$

$U87P_{300G/387/587} = U87P_{700G1}$

Setting Calculation

General Discussion of Connection Compensation. The general expression for current compensation is as follows:

$$\begin{bmatrix} I1nC \\ I2nC \\ I3nC \end{bmatrix} = [CTC(m)] \bullet \begin{bmatrix} IAn \\ IBn \\ ICn \end{bmatrix}$$

where IA*n*, etc., are the three-phase currents entering terminal "*n*" of the relay; I1*n*C, etc., are the corresponding phase currents after compensation; and [CTC(*m*)] is the three-by-three compensation matrix.

Setting CTC*n* = *m* specifies which [CTC(*m*)] matrix the relay is to use. For CTCY the setting values can be 0, 1, 5, 6, 7, 11, or 12. These are discrete values "*m*" can assume in [CTC(*m*)]; the values physically represent the "*m*" number of increments of 30 degrees that a balanced set of currents with ABC phase sequence will be rotated in a counterclockwise direction when multiplied by [CTC(*m*)].

If a balanced set of currents with ACB phase rotation undergoes the same exercise, the rotations by the [CTC(*m*)] matrices are in the clockwise direction. This is because the compensation matrices, when performing phasor addition or subtraction involving B or C phases, will produce “mirror image” shifts relative to A-phase, when ACB phase rotation is used instead of ABC. In ACB phase rotation the three phases still rotate in a counterclockwise direction, but C-phase is in the 120-degree lagging position and B-phase leads by 120 degrees, relative to A-phase.

The discussions below assume ABC phase rotation, unless mentioned otherwise.

The “0” setting value is intended to create no changes at all in the currents and merely multiplies them by an identity matrix. Thus, for CTC*n* = 0,

$$[CTC(0)] = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

that is,

I1*n*C = IA*n*
I2*n*C = IB*n*
I3*n*C = IC*n*

The “1” setting performs a 30-degree compensation in the counterclockwise direction, as would a delta CT connection of type DAB (30-degree leading). The name for this connection comes from the fact that the polarity end of the A phase CT connects to the nonpolarity end of the B phase CT, and so on, in forming the delta. Thus, for CTC*n* = 1, the relay uses the following [CTC(*m*)] matrix:

$$[CTC(1)] = \frac{1}{\sqrt{3}} \bullet \begin{bmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ -1 & 0 & 1 \end{bmatrix}$$

that is,

$$I1nC = \frac{(IAn - IBn)}{\sqrt{3}}$$

$$I2nC = \frac{(IBn - ICn)}{\sqrt{3}}$$

$$I3nC = \frac{(ICn - IAn)}{\sqrt{3}}$$

The “11” setting performs a 330-degree compensation (11 • 30) in the counterclockwise direction, or a 30-degree compensation in the clockwise direction, as would a delta CT connection of type DAC (30-degree lagging). The name for this connection comes from the fact that the polarity end of the A phase CT connects to the nonpolarity end of the C phase CT, and so on, in forming the delta. Thus, for CTC*n* = 11, the relay uses the following [CTC(*m*)] matrix:

$$[\mathrm{CTC}(11)] = \frac{1}{\sqrt{3}} \bullet \begin{bmatrix} 1 & 0 & -1 \\ -1 & 1 & 0 \\ 0 & -1 & 1 \end{bmatrix}$$

that is,

$$\mathrm{I1}n\mathrm{C} = \frac{(\mathrm{IA}n - \mathrm{IC}n)}{\sqrt{3}}$$

$$\mathrm{I2}n\mathrm{C} = \frac{(\mathrm{IB}n - \mathrm{IA}n)}{\sqrt{3}}$$

$$\mathrm{I3}n\mathrm{C} = \frac{(\mathrm{IC}n - \mathrm{IB}n)}{\sqrt{3}}$$

The effect of each compensation on balanced three-phase currents is to rotate them $m \bullet 30°$ without a magnitude change.

The compensation matrix [CTC(12)] is similar to [CTC(0)], in that it produces no phase shift (or, more correctly, 360 degrees of shift) in a balanced set of phasors separated by 120 degrees. However, it removes zero-sequence components from the winding current, as do all of the matrices having nonzero values of *m*.

$$[\mathrm{CTC}(12)] = \frac{1}{3} \bullet \begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}$$

that is,

$$\mathrm{I1}n\mathrm{C} = \frac{(+2 \bullet \mathrm{IA}n - \mathrm{IB}n - \mathrm{IC}n)}{3}$$

$$\mathrm{I2}n\mathrm{C} = \frac{(-\mathrm{IA}n + 2 \bullet \mathrm{IB}n - \mathrm{IC}n)}{3}$$

$$\mathrm{I3}n\mathrm{C} = \frac{(-\mathrm{IA}n - \mathrm{IB}n + 2 \bullet \mathrm{IC}n)}{3}$$

We could use this type of compensation in applications having wye-connected transformer windings (no phase shift) with wye CT connections for each winding. Using CTC*n* = 12 for each winding removes zero-sequence components, just as connection of the CTs in delta would do, but without producing a phase shift. (One might also use CTC*n* = 1 or 11 for this same application, yielding compensation similar to that from connection of the CTs on both sides in DAB or DAC.)

$$\mathrm{I1}n\mathrm{C} = \frac{(+2 \bullet \mathrm{IA}n - \mathrm{IB}n - \mathrm{IC}n)}{3}$$

$$\mathrm{I2}n\mathrm{C} = \frac{(-\mathrm{IA}n + 2 \bullet \mathrm{IB}n - \mathrm{IC}n)}{3}$$

$$\mathrm{I3}n\mathrm{C} = \frac{(-\mathrm{IA}n - \mathrm{IB}n + 2 \bullet \mathrm{IC}n)}{3}$$

The Complete List of Compensation Matrices (m = 1 to 12).

$$[CTC(1)] = \frac{1}{\sqrt{3}} \bullet \begin{bmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ -1 & 0 & 1 \end{bmatrix} \qquad [CTC(2)] = \frac{1}{3} \bullet \begin{bmatrix} 1 & -2 & 1 \\ 1 & 1 & -2 \\ -2 & 1 & 1 \end{bmatrix}$$

$$[CTC(3)] = \frac{1}{\sqrt{3}} \bullet \begin{bmatrix} 0 & -1 & 1 \\ 1 & 0 & -1 \\ -1 & 1 & 0 \end{bmatrix} \qquad [CTC(4)] = \frac{1}{3} \bullet \begin{bmatrix} -1 & -1 & 2 \\ 2 & -1 & -1 \\ -1 & 2 & -1 \end{bmatrix}$$

$$[CTC(5)] = \frac{1}{\sqrt{3}} \bullet \begin{bmatrix} -1 & 0 & 1 \\ 1 & -1 & 0 \\ 0 & 1 & -1 \end{bmatrix} \qquad [CTC(6)] = \frac{1}{3} \bullet \begin{bmatrix} -2 & 1 & 1 \\ 1 & -2 & 1 \\ 1 & 1 & -2 \end{bmatrix}$$

$$[CTC(7)] = \frac{1}{\sqrt{3}} \bullet \begin{bmatrix} -1 & 1 & 0 \\ 0 & -1 & 1 \\ 1 & 0 & -1 \end{bmatrix} \qquad [CTC(8)] = \frac{1}{3} \bullet \begin{bmatrix} -1 & 2 & -1 \\ -1 & -1 & 2 \\ 2 & -1 & -1 \end{bmatrix}$$

$$[CTC(9)] = \frac{1}{\sqrt{3}} \bullet \begin{bmatrix} 0 & 1 & -1 \\ -1 & 0 & 1 \\ 1 & -1 & 0 \end{bmatrix} \qquad [CTC(10)] = \frac{1}{3} \bullet \begin{bmatrix} 1 & 1 & -2 \\ -2 & 1 & 1 \\ 1 & -2 & 1 \end{bmatrix}$$

$$[CTC(11)] = \frac{1}{\sqrt{3}} \bullet \begin{bmatrix} 1 & 0 & -1 \\ -1 & 1 & 0 \\ 0 & -1 & 1 \end{bmatrix} \qquad [CTC(12)] = \frac{1}{3} \bullet \begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}$$

The matrices for odd values of *m* (1, 3, 5, 7, 9, 11) are similarly constructed, as are the matrices for even values of *m* (2, 4, 6, 8, 10, 12). Also, [CTC(*m*)] equals the minus of [CTC(*m*±6)], because these matrices represent shifts separated by exactly 180 degrees.

Selecting the Correct Values of CTCn for Each Winding. The process of choosing the correct CTC*n* setting value for each winding involves a complete knowledge of the transformer winding connections, phase relationships, and CT connections. The following review discusses the nature of the various connections, their phase shifts, and the reference motion for CTC*n* selection based on system phase rotation.

Winding Connection Review. *Figure 4.13* shows the three basic winding connections, consisting of a wye connection and the two possible delta connections.

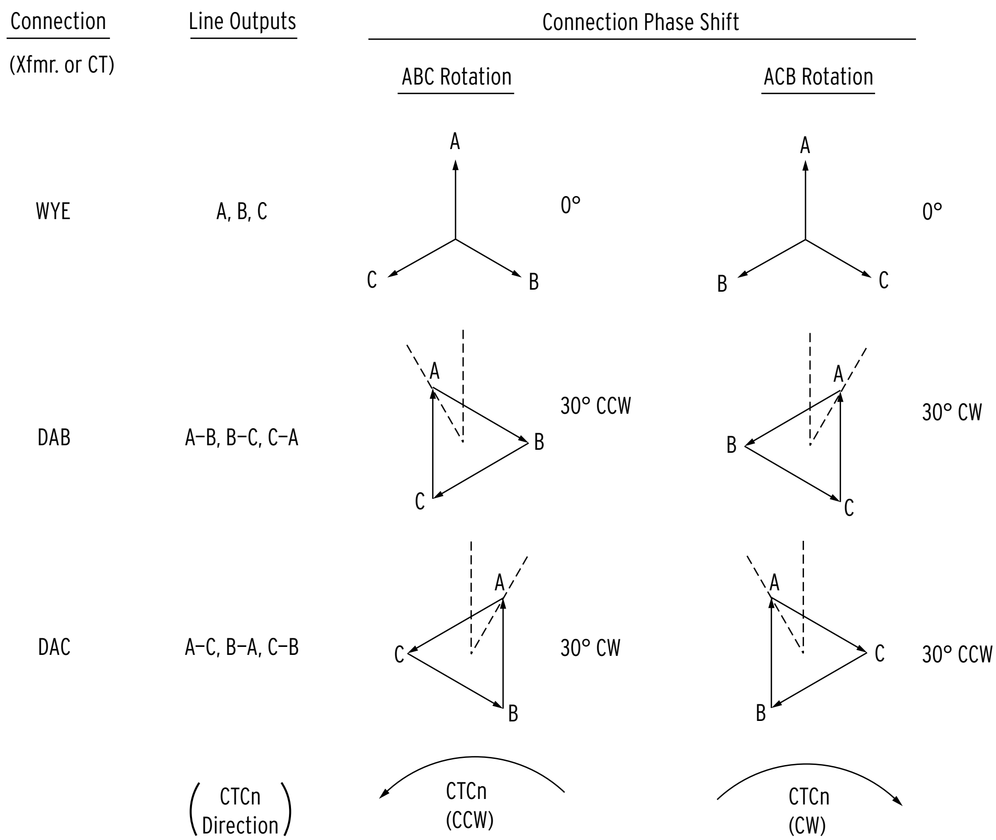


Figure 4.13 Winding Connections, Phase Shifts, and Compensation Direction

The wye connection consists of connecting one end of each winding to a common or neutral point, leaving the other ends of each winding for the line terminals. Because the windings do not interconnect at the line ends, the line current equals the respective winding current, A, B, or C, and no phase shift occurs in the line currents with respect to the winding currents. The neutral point, if it is grounded, permits flow of zero-sequence current components in the windings and line outputs.

There are two possible delta connections. In determining CTC*n*, it is essential to know not only that the CTs or transformer windings are connected in delta but in which delta. In this manual we call these delta connections DAB and DAC. In the DAB connection the polarity end of the A winding connects to the nonpolarity end of the B winding, and so on, to produce the delta. In the DAC connection the polarity end of the A winding connects to the nonpolarity end of the C winding, and so on, to produce the delta. In *Figure 4.13*, an arrowhead indicates the polarity end of each winding.

These arrangements involve a connection point between two windings at each line terminal; the line currents are not the same as the winding currents, but are in fact the phasor difference between the associated winding currents. Therefore, the line currents will shift in phase by some amount with respect to the winding currents. In the DAB connection the line currents from the A, B, and C line terminals are, respectively, A-B, B-C, and C-A in terms of the winding currents. In the DAC connection the line currents from the A, B, and C line terminals are, respectively, A-C, B-A, and C-B in terms of the winding currents. The phase shift produced by each physical type of delta depends on the system phase sequence.

NOTE: The terms "lead" and "lag" refer to the assumed counterclockwise (CCW) rotation of the phasors for both ABC and ACB phase rotation. "Lead" implies movement in the CCW direction; "lag" is movement in the clockwise (CW) direction.

In the ABC phase sequence B lags A by 120 degrees and C leads A by 120 degrees. The DAB connection line current at terminal A is A-B, which in this case is a phasor that leads A winding current by 30 degrees. For this reason, DAB is often referred to as the "leading connection." However, DAB is the leading connection only for ABC phase sequence. In the ACB phase sequence C lags A by 120 degrees, and B leads A by 120 degrees. Terminal A line current is still A-B, but current now lags A winding current by 30 degrees.

The DAC connection produces opposite shifts to DAB. In the ABC phase sequence line current from terminal A is A-C, which lags A winding current by 30 degrees. In the ACB phase sequence line current A is still A-C, but this result leads A winding current by 30 degrees.

Five-Step Compensation Process. The process of determining CTC*n* for each winding involves the following five basic steps. Two examples illustrate important points about the five steps. For an additional resource, see the "Winding Compensation Settings Worksheet" (SEL_WCTC_R1_0.xls, available on the SEL-700G Product Literature CD).

Step 1. Establish the phase direction for the terminal-A line voltage for each three-phase winding of the transformer. (This step requires transformer nameplate drawings and/or internal connection diagrams.)

Step 2. Adjust the terminal-A line voltage direction for each set of input currents by the phase shift (if any) of the current transformer connection. (Reference *Figure 4.13* for this step.)

Step 3. Select any one of the adjusted terminal-A directions from *Step 2*, to serve as the reference direction. (The relay compensates all other windings to line up with this reference.)

Step 4. Choose a setting for CTC*n* for each set of winding input currents. This setting is the number of 30-degree increments needed to adjust each nonreference winding to line it up with the reference. This number will range from 0 to 12 increments.

For ABC phase sequence, begin at the winding direction and proceed in a CCW direction until reaching the reference. For ACB phase sequence, begin at the winding direction and proceed in a CW direction until reaching the reference. *Figure 4.13* shows these compensation directions.

Step 5. If any winding needs no phase correction (zero degrees), but is a grounded-wye winding having wye-connected CTs, choose CTC*n* = 12 for that winding, rather than CTC*n* = 0. This setting will remove zero-sequence current components from the relay currents to prevent false differential tripping on external ground faults. (All non-zero values of CTC*n* remove zero-sequence current.)

Example for CTCn Selection. *Figure 4.14* illustrates the first example. This is a two-winding transformer with a DAB delta primary and secondary connected in grounded wye. The secondary winding has DAB delta-connected CTs. We assume ABC phase rotation. Using the "hour of the clock" convention for specifying transformer connections, the transformer is a "Dy1" connection. This means the transformer has a high-voltage delta whose reference is "noon" and a wye secondary winding whose direction is at "one o'clock" with respect to the direction of the delta. The CT currents go to relay winding inputs 1 and 2 from left to right as *Figure 4.14* illustrates.

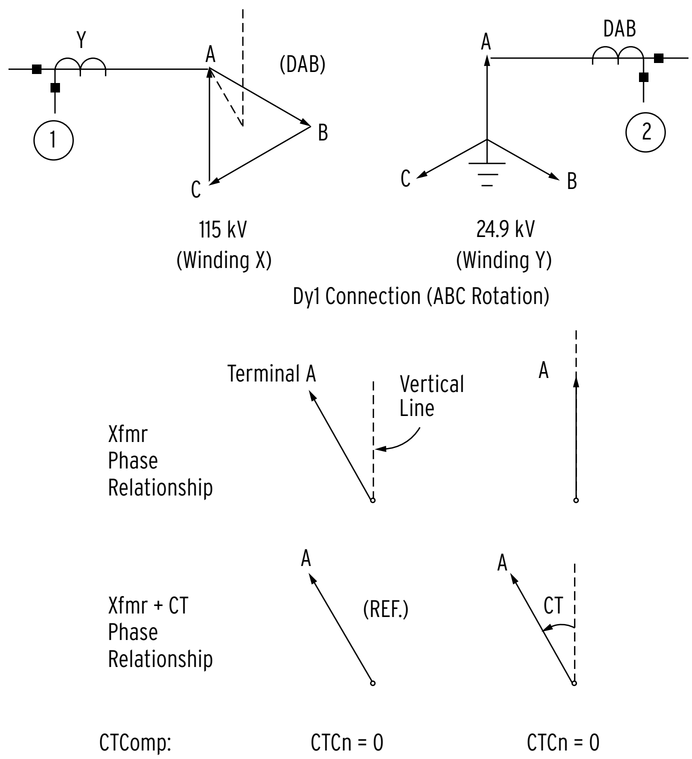


Figure 4.14 Example 1 for WnCTC Selection

The 115 kV delta primary and the 24.9 kV grounded-wye secondary represent a traditional "DABY" two-winding application. This application has wye CTs on the delta side and delta CTs on the wye side, using the same CT delta connection as the primary of the transformer. Perform the following simple steps to handle these traditional connections.

Step 1. Establish the line terminal directions.

Refer to the Xfmr Phase Relationship in *Figure 4.14* and note that Terminal A of Winding X is 30 degrees CCW from the vertical line, as we would expect for a DAB connection with ABC phase rotation. Terminal A of Winding Y is in phase with the vertical line.

Step 2. Adjust the CT connections.

In this case, the primary winding with wye CTs need no adjustment. The 24.9 kV winding, with DAB CTs, needs a 30-degree correction in the CCW direction. *Figure 4.14* shows this adjustment under Xfmr + CT Phase Relationship.

Step 3. Select a reference direction for the transformer.

You can use either one of the two winding directions as the reference, but this need not be the case. You could establish any of the 12 possible directions, separated by 30 degrees around with complete circle of 360 degrees, as the reference. Both windings would then receive adjustments to correlate them with this reference. As *Figure 4.14* illustrates, Winding X direction serves as reference in this example.

Step 4. Choose the CTC*n* settings for the windings.

Because Winding X is the reference, we need no adjustment; the setting is CTCX = 0. Note that the adjusted Winding Y inputs coincide exactly with the reference direction; we need make no adjustment for the 24.9 kV winding either. Therefore, the setting is CTCY = 0. As mentioned earlier, these two windings represent a classical DABY application. We can see this from the fact that the CTC*n* setting is zero for both windings. The CT connections themselves perform exactly the right correction without additional help from the relay. The process is nearly complete.

Step 5. As a final step, ensure that no wye-connected winding having wye-connected CTs is set at CTC*n* = 0 (uncompensated).

Were this the case, zero-sequence currents could appear in these relay inputs but in no others, and a possible false trip could occur for external ground faults. Any non-zero value of CTC*n* will eliminate the zero-sequence. In this example there is no wye-connected winding with wye-connected CTs. The selection is complete. Set ICOM := N (forces the CTC*n* := 0) because no compensation is necessary from the relay.

Winding Line-to-Line Voltages. Enter the nominal line-to-line transformer terminal voltages. If a load tap changer is included in the transformer differential zone, assume that it is in the neutral position. The setting units are kilovolts.

Current TAP. The relay uses a standard equation to set TAP*n*, based on settings entered for the particular winding (*n* denotes the winding number.)

$$\text{TAPn} = \frac{\text{MVA} \bullet 1000}{\sqrt{3} \bullet \text{VWDG}n \bullet \text{CTR}n} \bullet \text{C}$$

where:

C = 1 if CTCON*n* setting = Y (wye-connected CTs)
C = $\sqrt{3}$ if CTCON*n* setting = D (delta-connected CTs)
MVA = maximum power transformer capacity setting (must be the same for all TAP*n* calculations)
VWDG*n* = winding line-to-line voltage setting, in kV
CTR*n* = current transformer ratio setting

The relay calculates TAP*n* with the following limitations:

- The tap settings are within the range $0.1 \bullet I_{NOMn}$ and $6.2 \bullet I_{NOMn}$
- The ratio of the highest ($TAPn/I_{NOMn}$) to the lowest ($TAPn/I_{NOMn}$) is less than or equal to 7.5, where *n* = X, Y

Restrained Element Operating Current Pickup. The O87P setting range is 0.1 to 1.0; we suggest an O87P setting of 0.2 to 0.3. The setting must be at a minimum for increased sensitivity but high enough to avoid operation because of steady-state errors such as unmonitored station service loads, transformer excitation current, and relay measuring error at very low current levels. The setting must also yield an operating current greater than or equal to a minimum of $0.1 \bullet I_{NOMn}/TAPn$, where *n* = X, Y. This restriction applies to each winding side (irrespective of TAP magnitudes) when 1 A and 5 A nominal CTs are used in the same relay.

Restraint Slope Percentage. The purpose of the percentage restraint characteristic is to allow the relay to differentiate between differential current from an internal fault versus differential current during normal or external fault conditions. You must select slope characteristic settings that balance security and dependability. To do this, it is helpful to determine what slope ratio is characteristic of normal conditions (slope must exceed that for security) and what slope ratio is characteristic of an internal fault (the slope must be below that for dependability). In the case of the SEL-700G1 Relay, the slope ratio for a bolted internal fault is 100%.

The sources of differential current for external faults fall into three categories:

- Differential current that is not proportional to the current flow through the zone (steady state).
- Differential current that is proportional to current flow through the zone (proportional).
- Differential current that is transient in nature (transient).

SLP1 should be set above normal steady-state and proportional errors. SLP2 is used to accommodate transient errors. The following is a list of typical sources of error that must be considered.

- Excitation current (typically 1 to 4%)
- CT accuracy (typically less than 3% in the nominal range)
- No-Load Tap Changer (NLTC) (typically ±5%)
- Load Tap-Changer (LTC) (typically ±10%)
- Relay accuracy (±5% or ±0.02 • I_{NOM}, whichever is largest.)

We recognize that the excitation current of the transformer is not proportional to load flow. However, a conservative approach would include it as a proportional error.

CTs create both steady-state and transient errors, which can result in false differential current. IEEE Standard Requirements for Instrument Transformers, IEEE Standard C57.13-1993 specifies that a relay-accuracy CT must be 3 percent accurate at rated current and 10 percent accurate at 20 times rated current when ZB is the standard burden. It is important to note that the rated current specified in the standard is a symmetrical sinusoidal waveform (it does not have a transient DC component). Because the burden is usually designed to be much smaller than the standard burden, the error current will likely be much less than 3 percent for current flow at low multiples of the nominal rating of the CTs.

The errors can be added to determine the amount of error that the SLP1 characteristic must accommodate for normal system conditions. At that point, use the following equation and add margin to determine SLP1 and determine the minimum limit of the allowable slope ratio.

$$SLP1_{MIN}\% = \left(\frac{Err\%}{(200 - Err\%) \bullet k}\right) \bullet 100$$

where:

$SLP1_{MIN}$ = slope ratio that will just accommodate Err with no margin
Err = amount of error expected in normal operation
k = AVERAGE restraint scaling factor (1 for the SEL-700G)

The variable restraint characteristic provided by SLP2 at high multiples of TAP for a through fault accommodates transient CT error. SLP2 can be set fairly high without jeopardizing sensitivity for low-grade partial winding faults. The CTs should be evaluated for the likelihood of going into saturation for a through fault, and SLP2 should be adjusted accordingly. Another consideration for selecting the SLP2 setting is that the effectiveness of the variable percentage depends on SLP1 and IRS1, which determine the starting point of SLP2. If SLP1 is set very low, a higher SLP2 may be warranted.

Unrestrained Element Current Pickup. The instantaneous unrestrained current element is intended to react quickly to very heavy current levels that clearly indicate an internal fault. Set the pickup level (U87P) to approximately 8 to 10 times TAP. The unrestrained differential element only responds to the fundamental frequency component of the differential operating current. It is not affected by the SLP1, SLP2, IRS1, PCT2, or PCT5 settings. Thus, it must be set high enough so as not to react to large inrush currents.

Note that the U87P must be set lower than the minimum of $31 \cdot I_{NOMn}/TAPn$, where n = X, Y.

Second-Harmonic Blocking. Transformer simulations show that magnetizing inrush current usually yields more than 30 percent of IF2/IF1 in the first cycle of the inrush. A setting of 15 percent usually provides a margin for security. However, some types of transformers, or the presence within the differential zone of equipment that draws a fundamental current of its own, may require setting the threshold as low as 7 percent. For example, the additional fundamental frequency charging current of a long cable run on the transformer secondary terminals could “dilute” the level of second harmonic seen at the primary to less than 15 percent.

Fourth-Harmonic Blocking. Transformer magnetizing inrush currents are generated during transformer energization when the current contains a dc offset due to point-on-wave switching. Inrush conditions typically are detected using even harmonics and are used to prevent misoperations due to inrush. The largest even-harmonic current component is usually second harmonic followed by fourth harmonic. Use fourth-harmonic blocking to provide additional security against inrush conditions; set PCT4 less than PCT2.

Fifth-Harmonic Blocking. Fourier analysis of transformer currents during overexcitation indicates that a 35 percent fifth-harmonic setting is adequate to block the percentage differential element. To disable fifth-harmonic blocking, set PCT5 to OFF.

You may use the presence of fifth-harmonic differential current to assert an alarm output during startup. This alarm indicates that the rated transformer excitation current is exceeded. At full load, a TH5P setting of 0.1 corresponds to 10 percent of the fundamental current. A delay, TH5D, that you can set prevents the relay from indicating transient presence of fifth-harmonic currents.

You may consider triggering an event report if transformer excitation current exceeds the fifth-harmonic threshold.

There are two criteria for setting TH5P:

$$TH5P \geq \text{minimum } (0.05 \cdot I_{NOMn}/TAPn)$$

where:

n = X, Y

I_{NOMn} = nominal current of the corresponding CT

Example of Setting the SEL-700G Relay (Unit Differential). The example represents a typical unit differential application and demonstrates the use of CT compensation settings and tap calculations.

Figure 2.23 illustrates the application. The transformer is a 138 kV to 13.8 kV. The transformer has a maximum rating of 30 MVA. Both windings have wye-connected current transformers, with ratios of 200/5 A at 138 kV, and 2000/5 A at 13.8 kV. We have connected the transformer per IEEE standards, with the low voltage delta lagging the high-voltage wye by 30 degrees.

Step 1. Enable the differential settings as follows:

E87 := TRANS

Step 2. Select settings for the current transformer connection and ratio for each winding. All CTs connect in wye. The ratios are equal to primary current divided by secondary current. The settings are as follows:

13.8 kV	138 kV
CTCONX = WYE (hidden)	CTCONY = WYE
CTRX = 400	CTRY = 40

Step 3. Set the transformer maximum rating. We use this rating for all windings in the later tap calculation:

MVA := 30

Step 4. Decide whether to use internal CT compensation and determine compensation settings.

Because there are both wye and delta transformer windings but only wye CTs, we must adjust for the phase angle shift. In the "traditional" differential relay connection the wye transformer windings would have their CTs connected in delta to produce a shift in the same direction as that produced in the transformer. In this case a "DAC" or "30-degree lagging" connection would have been used. This would not only shift the currents, but it would remove the zero-sequence current component by physically subtracting the appropriate phase currents via the delta connection. We achieve the same effect within the relay by using the selected compensation. The settings are:

ICOM := Y (choose to define the CT compensation)

CTCX := 0 CTCY = 11

NOTE: Setting CTCX is not available for changing. It is hidden and set automatically by the relay.

The relay will multiply the wye CT currents from the wye transformer windings by the matrix [CTC(11)] to give the same results as the physical DAC CT connection.

Step 5. Enter winding line-to-line voltages. The relay needs these voltages for the tap calculation. Voltages are in units of kV. For this example we enter the following values:

VWDGX = 13.80 VWDGY = 138.00

The relay now calculates each tap current, using the formula stated previously:

$$\text{TAP}n = \frac{\text{MVA} \bullet 1000}{\sqrt{3} \bullet \text{VWDG}n \bullet \text{CTR}n} \bullet \text{C}$$

where

$\text{C} = 1$ for wye CTs

Thus, we have the following:

$$\text{TAPX} = \frac{30\ \text{MVA} \bullet 1000}{\sqrt{3} \bullet 13.8\ \text{kV} \bullet 400}$$

$$\text{TAPX} = 3.14$$

$$\text{TAPY} = \frac{30\ \text{MVA} \bullet 1000}{\sqrt{3} \bullet 138\ \text{kV} \bullet 40}$$

$$\text{TAPY} = 3.14$$

The relay calculates these taps automatically if MVA is given. If MVA is set to OFF, you must calculate the taps and enter them individually. The relay will check to see if a violation of the maximum tap ratio has occurred, and it will notify you of any violation.

Step 6. Set the differential element characteristic. Select the settings according to our suggestions in the earlier setting descriptions.

For this example, we have selected a two slope, variable-percentage differential characteristic for maximum sensitivity at low currents and greater tolerance for CT saturation on external high-current faults. The high security mode settings are left at default; with HSM := 0, this mode is disabled.

The minimum error for selecting SLP1 for this application is determined as follows:

- ➢ Excitation current (4%)
- ➢ CT accuracy (3%)
- ➢ No-Load Tap Changer (NLTC) (5%)
- ➢ Load Tap-Changer (LTC) (0%)
- ➢ Relay accuracy (±5% or ±0.02 • INOM, whichever is largest) (5%)

$$\text{SLP1}_{\text{MIN}}\% = \left(\frac{17}{(200 - 17)}\right) \bullet 100 = 9.3\%$$

The CTs have been evaluated for maximum through fault and found to be unlikely to saturate severely. So, SLP2 does not have to be set higher than normal.

The settings are as follows:

O87P =	0.3 (Operate current pickup in multiple of tap)
SLP1 =	15 (15 percent initial slope)
SLP2 =	50 (50 percent second slope)
IRS1 =	6.0 (limit of Slope 1, Restraint current in multiple of tap)

U87P = 10 (unrestrained differential Operate current level, multiple of tap)
PCT4 = 15 (block operation if fourth harmonic is above 15 percent)
PCT5 = 35 (block operation if fifth harmonic is above 35 percent)
TH5P = OFF (no fifth-harmonic alarm)
HRSTR = Y (harmonic restraint enabled)
HBLK = Y (harmonic blocking enabled)
HSM = 0 (high security mode disabled)
O87P2 = 1.25
HSMDOT = 10.00

Remember that the O87P setting must yield an operating current value of at least a minimum of 0.1 • INOM*n*/TAP*n*, where *n* = X, Y. In this case, O87P = minimum ((0.1 • INOM*n*)/TAP*n*) = 0.5/3.14 = 0.159. Therefore, the O87P setting of 0.3 is valid.

The differential unit settings are complete for this specific application. At this point you can also choose to set backup overcurrent elements which we discuss at the end of this section.

Example of Setting the SEL-700G Relay (Generator Differential):

This example describes the generator differential element, which does not include a step-up transformer in its protection zone.

Figure 2.26 illustrates an application that uses a 13.8 kV generator with a rating of 30 MVA and current transformer ratios of 2000/5 A.

Step 1. Select/calculate the configuration settings for the current transformer connections, ratios, and generator nominal current. The ratios are equal to primary current divided by secondary current. The configuration settings are as follows:

CTRX and CTRY := 2000/5 = 400
INOM = (30 • 1000)/(1.732 • 13.8 • 400) = 3.1
CTCONY = WYE

Step 2. Enable the differential settings: E87 = GEN.

Step 3. The relay will automatically calculate and set settings TAPX and TAPY based on the INOM. You cannot change the TAP settings:

TAPX = INOM = 3.10
TAPY = (INOM • CTRX)/CTRY = 3.10

Step 4. Set the differential element characteristic.

When E87 = GEN the SEL-700G uses the dual-slope percentage- restraint differential characteristic without harmonic restraint or blocking. Also, the relay automatically sets SLP2 = 70 percent and IRS1 = 6, and hides these settings. In some installations where uneven CT saturation during external events, such as faults or transformer energization, can lead to differential operation, consider programming the SELOGIC high security mode equation, HSM. Set HSMDOT longer than the duration of expected inrush. Similarly, set O87P2 to avoid an undesired operation when under severe CT saturation conditions. You can set and edit the remaining settings according to the suggestions in the previous setting descriptions.

O87P =	0.3 (Operate current pickup in multiple of tap)
SLP1 =	25 (25 percent initial slope)
SLP2 =	70 (70 percent second slope, fixed)
IRS1 =	6.0 (limit of slope 1 restraint current in multiple of tap, fixed)
U87P =	10 (unrestrained differential operate current level, multiple of tap)
HSM =	(DRDOPT OR HRT) AND NOT RHSM (high security mode enabled)
O87P2 =	1.25 (high security mode operate current pickup in multiple of TAP)
HSMDOT =	5.00 (high security mode dropout time in seconds)

Remember that the O87P setting must yield an operating current value of at least 0.1 • INOM. In this case, O87 must be greater than or equal to (0.1 • INOM*n*)/TAP*n* = 0.5/3.1 = 0.16.

Therefore, the O87P setting of 0.3 is valid.

The differential unit settings are complete for this specific application. At this point, you can also choose to set backup overcurrent elements. More discussion of these elements is at the end of this section.

Application Guidelines

It is vital that you select adequate current transformers for the differential application. Use the following procedure, based on ANSI/IEEE Standard C37.110-1996, *IEEE Guide for the Application of Current Transformers Used for Protective Relaying Purposes*.

CT Arrangements

Use separate relay restraint circuits for each power source to the relay. In the SEL-700G1 you may apply two restraint inputs to the relay. You may connect CT secondary windings in parallel only if both circuits meet the following criteria:

- ➤ They are connected at the same voltage level.
- ➤ Both have CTs that are matched in ratio and C voltage ratings.
- ➤ Both circuits are radial (no fault current contributions).

CT Sizing

Sizing a CT to avoid saturation for the maximum asymmetrical fault current is ideal but not always possible. Such sizing requires CTs with C voltage ratings greater than (1 + X/R) times the burden voltage for the maximum symmetrical fault current, where X/R is the reactance-to-resistance ratio of the primary system.

As a rule of thumb, CT performance will be satisfactory if the CT secondary maximum symmetrical external fault current multiplied by the total secondary burden in ohms is less than half of the C voltage rating of the CT. The following CT selection procedure uses this second guideline.

CT Ratio Selection

Step 1. Determine the secondary side burdens in ohms for all current transformers connected to the relay.

Step 2. Select the CT ratio, considering the maximum continuous secondary current, I_{HS}, based on the highest MVA rating of the transformer.

For wye-connected CTs, the relay current, I_{REL}, equals I_{HS}. For delta-connected CTs, I_{REL} equals $\sqrt{3} \cdot I_{HS}$. Select the nearest standard ratio such that I_{REL} is between $0.1 \cdot I_{NOM}$ and $1.0 \cdot I_{NOM}$ A secondary, where I_{NOM} is the relay nominal secondary current, 1 A or 5 A.

Step 3. Select the remaining CT ratios (e.g., CTR2) by considering the maximum continuous secondary current, I_{LS}.

As before, for wye-connected CTs I_{REL} equals I_{LS}. For delta-connected CTs I_{REL} equals $\sqrt{3} \cdot I_{LS}$. Select the nearest standard ratio such that I_{REL} is between $0.1 \cdot I_{NOM}$ and $1.0 \cdot I_{NOM}$ A secondary.

The SEL-700G calculates settings TAP1 and TAP2 if the ratio of maximum ($TAPn/I_{NOMn}$) to minimum ($TAPn/I_{NOMn}$) is less than or equal to 7.5. When the relay calculates the tap settings, it reduces CT mismatch to less than 1 percent. Allowable tap settings are in the range $(0.1\text{-}6.2) \cdot I_{NOM}$.

If the ratio of maximum ($TAPn/I_{NOMn}$) to minimum ($TAPn/I_{NOMn}$) is greater than 7.5, select a different CT ratio to meet the previous conditions. You can often do this by selecting a higher CT ratio for the smallest rated winding, but you may need to apply auxiliary CTs to achieve the required ratio. In this case, repeat *Step 2* and *Step 3*.

Step 4. Calculate the maximum symmetrical fault current for an external fault, and verify that the CT secondary currents do not exceed your utility standard maximum allowed CT current, typically $20 \cdot I_{NOM}$. If necessary, reselect the CT ratios and repeat *Step 2* through *Step 4*.

Step 5. For each CT, multiply the burdens calculated in *Step 1* by the magnitude, in secondary amperes, of the expected maximum symmetrical fault current for an external fault. Select a nominal accuracy class voltage for each CT that is greater than twice the calculated voltage.

If necessary, select a higher CT ratio to meet this requirement, then repeat *Step 2* through *Step 5*. This selection criterion helps reduce the likelihood of CT saturation for a fully offset fault current signal.

Please note that the effective C voltage rating of a CT is lower than the nameplate rating if a tap other than the maximum is used. Derate the CT C voltage rating by a factor of ratio used/ratio max.

Ground Differential Element

Basic generator protection in SEL-700G relays includes the ground differential element (87N) that operates based on the difference between the measured neutral current and the sum of the three-phase current inputs. The 87N element provides sensitive ground fault detection on resistance-grounded and solidly grounded generators, particularly where multiple generators are connected directly to a load bus. This element should not be applied to protect high-impedance grounded generators.

NOTE: You must locate phase CTs (either X or Y-side) on the terminal side of the generator for the 87N elements to be effective (see Figure 2.21 and Figure 2.26 for examples of CT location). Also, do not attempt to use this element with high-impedance grounded generators, because the primary residual current they supply during a ground fault is too low for secure, dependable protection.

The relay provides two definite-time delayed ground current differential elements designed to detect ground faults on resistance grounded and solidly grounded generators. Because these elements are current-based, they cannot provide ground fault coverage for 100 percent of the stator windings. They do, however, offer selective ground fault protection because they do not respond to ground faults beyond the generator phase current transformers. This quality makes the element ideal for protecting generators connected to multiple-unit buses or generators connected to a load bus, such as might be found in an industrial installation.

The relay uses the neutral CT connected to the relay **IN** input to measure the generator neutral current. It then calculates the residual current, which is the sum of the three-phase current inputs (from CTs located at generator terminals). The relay adjusts the residual current by the ratio of the CTR and CTRN settings to scale the residual current in terms of the secondary neutral current. It then calculates the difference. Normally, under balanced load or external ground fault conditions, the difference current should be zero. In the event of an internal ground fault, the difference current is nonzero. If the difference current magnitude is greater than the element pickup setting, the element picks up and begins to operate the definite time-delay. If the difference current remains above the pickup setting for the duration of the definite time-delay, the time-delayed element Relay Word bit asserts.

The relay configures the 87N element to use the appropriate residual current (IG) automatically based on the X_CUR_IN setting, as shown in *Figure 4.15* and *Figure 4.16*.

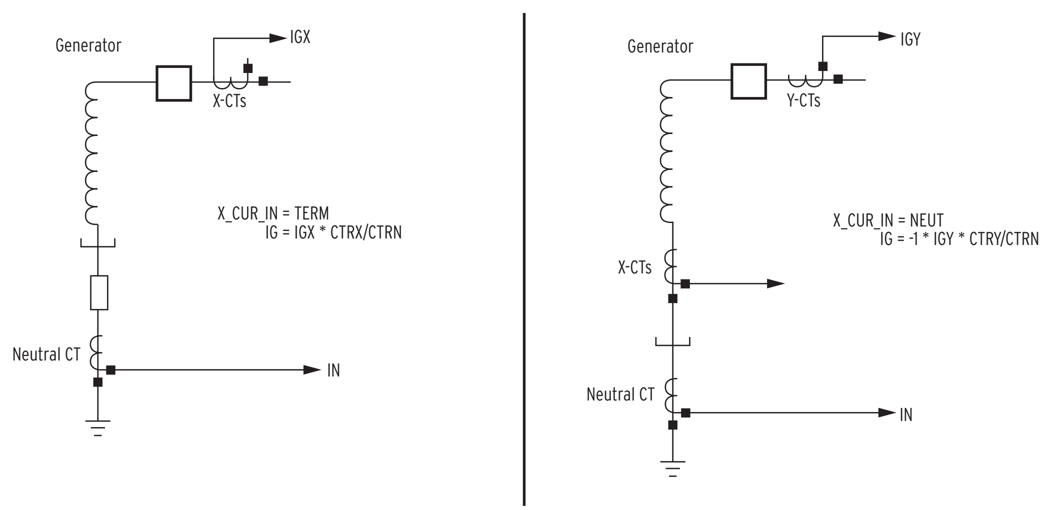


Figure 4.15 Effect of X_CUR_IN Setting on Residual Current (IG)

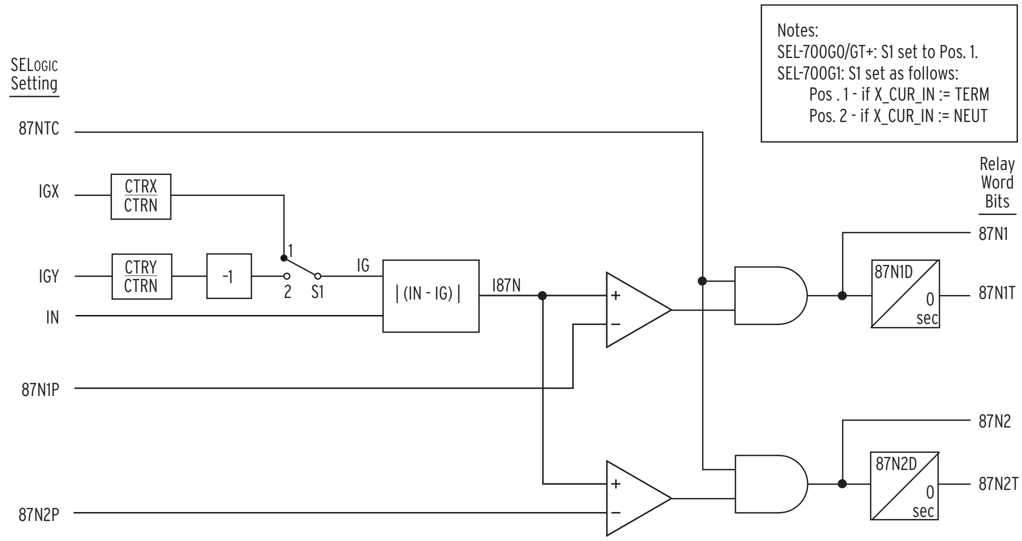


Figure 4.16 87N Element Logic Diagram

Table 4.4 Ground Differential Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
GND DIFF EN	Y, N	E87N := N
LVL1 GND DIFF PU	(0.10 • CTR/CTRN - 15.00) A[a]	87N1P := 2.5 A
LVL1 GND DIFF DLY	0.00-400.00 s	87N1D := 0.10
LVL2 GND DIFF PU	OFF, (0.10 • CTR/CTRN - 15.00) A[a]	87N2P := OFF
LVL2 GND DIFF DLY	0.00-400.00 s	87N2D := 0.00
87N TRQCTRL	SELOGIC	87NTC := 1

[a] Ranges and/or default settings shown are for relay models with 5 A rated neutral current input. Divide by 5 for the 1 A rated input. CTR = ratio of phase CTs located at generator terminals.

Set E87N := Y to enable the ground differential elements.

Set the 87N1P element sensitively, considerably lower than 50 percent of the maximum ground differential current and disregarding the system contribution (Idiff), to detect the highest number of faults. With this high sensitivity, there is some risk of element pickup resulting from phase current transformer saturation during external three-phase faults close to the generator. To help ensure that this pickup does not cause a misoperation, set the 87N1D time delay longer than the longest clearing time for a severe, external fault.

Idiff = Ignd / CTRN

where:

Ignd = Maximum generator contribution to ground faults

CTRN = Neutral CT ratio setting

Set the 87N2P element less sensitively to detect severe ground faults high in the generator windings or on the generator bushings. When the protected generator is connected to a bus that can source ground fault current, set 87N2P equal to the Idiff calculated in the previous equation. The higher pickup setting allows a shorter or zero time delay.

Alternatively, the 87NTC can be used to enhance security during external events like transformer energization and phase faults. During these events, the terminal CTs can saturate and generate false residual current. Depending on 87N pickup and time delay, the resulting false non-zero difference current can cause the 87N element to operate. Consider setting 87NTC to one or both of the following approaches to enhance the security of the element during external events:

- ➤ The neutral CT is typically unaffected during these external events. Set 50N1P to less than 87N pickup value (about 50 percent of 87N pickup) to prevent the 87N element from operating when little to no neutral current is detected. Set 50N1D := OFF and 87NTC := 67N1P.
- ➤ Block the element during high-security mode. Set 87NTC := NOT HSM. For more information on the HSM setting, please refer to *High Security Mode Settings HSM, O87P2, and HSMDOT*.

Because the ground differential elements detect generator faults, tripping generally is applied to the generator shutdown. Refer to *Trip/Close Logic Settings* for more detail and examples of tripping SELOGIC control equations.

Restricted Earth Fault Element

Use the Restricted Earth Fault (REF) element to provide sensitive protection against ground faults in your wye-connected generator winding. The element is “restricted” in the sense that protection is restricted to ground faults within a zone defined by the neutral and terminal CT placement. The REF is a basic generator protection element available in the SEL-700G and SEL-700GT relays. The REF element is intended for resistance and solidly grounded generators, particularly where multiple generators are connected directly to a load bus. It can also be used to protect wye-connected transformer windings. This element should not be applied to protect high-impedance grounded generators or transformers.

REF protection employs a neutral CT at one end of the winding and the normal set of three CTs at the terminal end of the winding; thus, REF protection can detect only ground faults within that particular wye-connected winding. For REF to function, the terminal-end CTs must also be connected in wye, because the technique uses comparison of zero-sequence currents. Delta-connected CTs cancel out all zero-sequence components of the currents, eliminating one of the quantities the REF element needs for comparison.

The REF implementation in the SEL-700G uses a directional element (REF1F) that compares the direction of a polarizing current derived from the terminal CTs with the operating current obtained from the neutral CT. A zero-sequence current threshold supervises tripping.

Figure 4.17 shows the REF simplified enable and bypass logic. The logic determines whether to enable the REF directional element by assertion of the REF1EN Relay Word bit. Also, the logic detects the bypass condition of substantial neutral current and no terminal-end current flow (Relay Word bit REF1BYP), the situation of an internal wye-winding fault with the terminal-end breaker open, when REF52BYP := YES. This bit is used to bypass the main algorithm and initiate assertion of Relay Word bit REF1F (see *Figure 4.17*). REF1BYP could be blocked, if intended for the previous fault, by setting REF52BYP := NO.

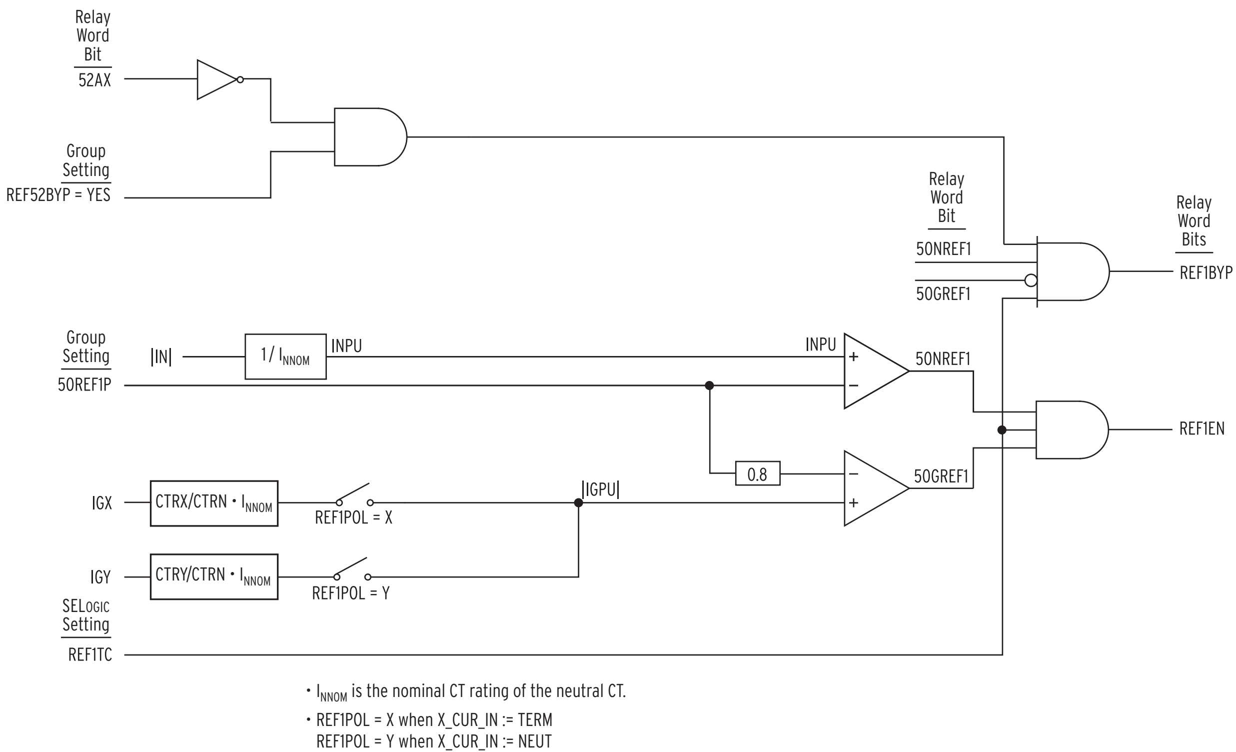


Figure 4.17 REF Enable Logic

Figure 4.18 illustrates the logic of the REF directional element, REF1F. It is at this stage that the element decides whether to operate.

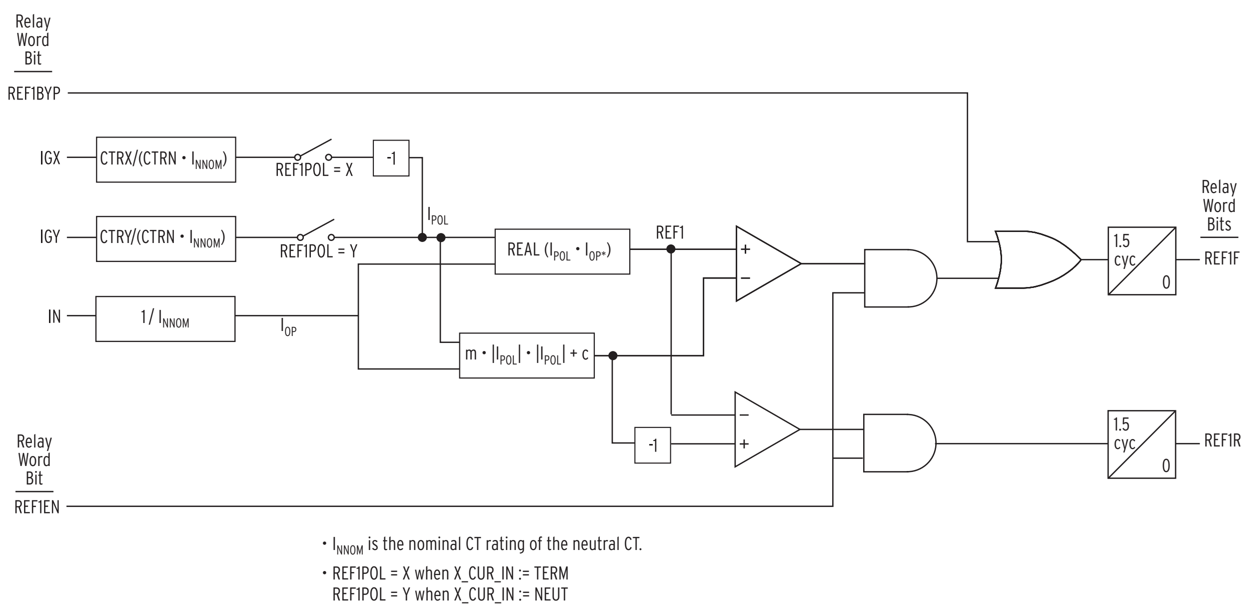


Figure 4.18 REF Directional Element

The directional element compares the polarizing current to the operating current and indicates forward (internal) fault location or reverse (external) fault location. The internal/forward indication occurs when the fault is within the protected winding, between the terminal-end CTs and the neutral CT. The relay converts appropriate terminal current to secondary in per unit of nominal CT rating to form polarizing current, IPOL.

The operating current, IOP, is simply the neutral CT current divided by nominal rating of the neutral CT, I_{NNOM}. The REF1 element calculates the real part of IPOL times IOP* (IOP complex conjugate). This equates to |IPOL| times |IOP| times the cosine of the angle between them. The result is positive if the angle is within ±90 degrees, indicating a forward or internal fault. The result is negative if the angle is greater than +90 or less than –90 degrees, indicating a reverse or external fault. The relay compares the output of the REF1 element to positive and negative thresholds, to ensure security for very small currents or for an angle very near +90 or –90 degrees. If the REF1 output exceeds the threshold test, it then must persist for at least 1.5 cycles before the Relay Word bit REF1F (forward) or REF1R (reverse) asserts. Assertion of REF1F constitutes a decision to trip by the REF1 function.

You can perform tripping directly by inclusion of the Relay Word bit REF1F into one or more of the trip variables (TRX, TR1, TR2, TR3), as appropriate. If you want additional security, the relay is programmed to use REF1F to torque control an inverse-time curve for delayed tripping, as discussed in the following text. *Figure 4.19* shows the output of the REF1 protection function. Timing is on an extremely inverse time-overcurrent curve (Curve U4) at the time-dial setting (0.5) and with 50REF1P as the pickup setting.

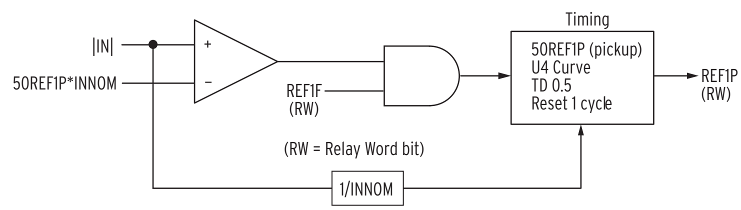


Figure 4.19 REF Protection Output (Extremely Inverse-Time O/C)

Relay Word bit REF1F (forward fault) torque controls the timing curve, and IN operates the timing function. The curve resets in one cycle if current drops below pickup or if REF1F deasserts. When the curve times out, Relay Word bit REF1P asserts. The default trip logic uses REF1P to shut down the generator.

Table 4.5 Restricted Earth Fault Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
REF ENABLE	Y, N	EREF := N
REF1 CURR LEVEL	0.05–3.00 pu	50REF1P := 0.25
REF1 TRQCTRL	SELOGIC	REF1TC := 1
52AX BYPASS EN	Y, N	REF52BYP := Y

When REF protection is enabled (EREF := Y), the relay automatically configures the protection to use the appropriate phase CT based on X_CUR_IN setting for SEL-700G1 relays. For other relay models, locate the phase CTs on the terminal side of the generator for the REF elements to be effective (as shown in *Figure 2.21*).

The setting REF1TC is a SELOGIC control equation setting that defines the conditions under which the relay enables REF1.

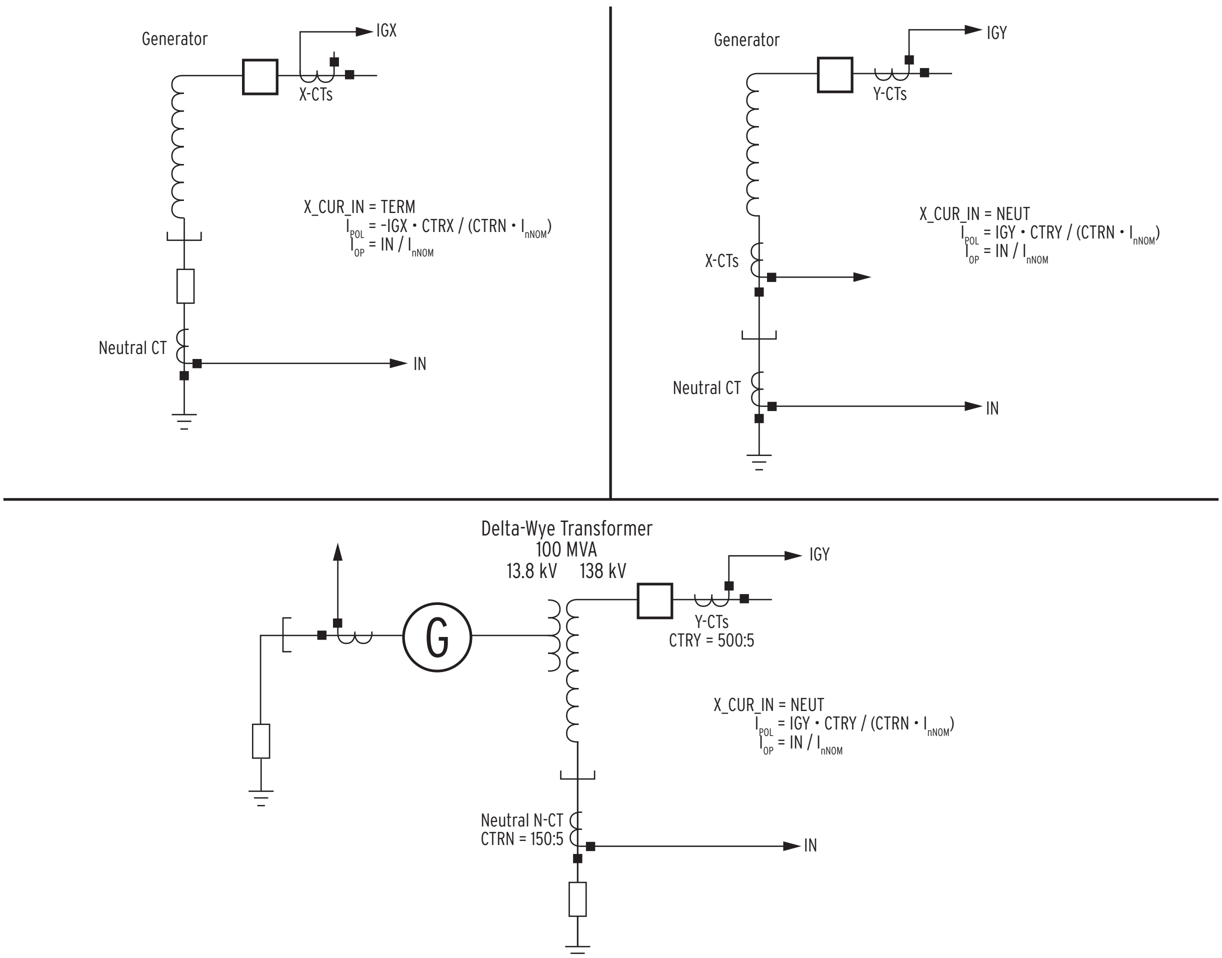
You can set the neutral current sensitivity threshold, 50REF1P, to as low as 0.05 times nominal current for a 1 A CT (0.25 A for a 5 A nominal CT current). However, the minimum acceptable value of 50REF1P must meet the following two criteria.

1. 50REF1P must be greater than any natural residual current imbalance caused by load conditions.
2. 50REF1P must be greater than a minimum value determined by the relationship of the CTR*n* (where *n* is N, X, or Y) values used in the REF function.

You must set the threshold setting, 50REF1P, at the greater of the two criteria values. See sample calculations in *REF Current Pickup Level*.

Polarizing Quantity

Figure 4.20 shows the effect of the X_CUR_IN setting on the polarizing quantity.



(I_{nNOM} = Nominal Current of n CTs, n = X, Y, N)

Figure 4.20 Effect of X_CUR_IN Setting on Polarizing Current

Calculation of the residual current for X and Y CTs is as follows:

$$IGn = IAn + IBn + ICn \quad (n = X, Y)$$

REF Current Pickup Level

The minimum acceptable REF element pickup value, 50REF1P, must meet the following criteria and be set at the greater of the two criteria values.

1. 50REF1P must be greater than any natural residual current imbalance caused by load conditions.
2. 50REF1P must be greater than a minimum value determined by the relationship of the CTR*n* (where *n* = N, X, or Y) values used in the REF function.

Calculate the pickup for the application shown in *Figure 4.20*, where the REF1 element is applied to the step-up transformer. To determine the pickup value per the first criteria, use 10% of full load as the highest expected unbalance. This can be calculated as

$$\text{10\% Full Load Current (Primary Amps)} = \frac{100\ \text{MVA}}{(\sqrt{3} \bullet 138\ \text{kV})} \bullet 10\% = 41.84\ \text{A}$$

$$\text{10\% Full Load Current (Secondary Amps)} = \frac{41.84\ \text{A}}{\text{CTRN}} = \frac{41.84\ \text{A}}{30} = 1.39\ \text{A}$$

$$\text{10\% Full Load Current (per unit)} = \frac{1.39\ \text{A}}{\text{INOM}} = \frac{1.39\ \text{A}}{5\ \text{A}} = 0.28\ \text{pu}$$

The resulting pickup using criterion one is 0.28 pu.

Now apply criterion two. The second criterion of 50REF1P is related to the relative sensitivity of the phase CTs compared to the neutral CT. Based on the X_CUR_IN setting, use the corresponding phase CT ratio (CTRX if X_CUR_IN = TERM, CTRY if X_CUR_IN = NEUT). Because X_CUR_IN = NEUT in this application, use CTRY to determine the pickup value.

$$\text{50REF1P} \geq 0.05 \bullet [(\text{CTRY} \bullet \text{INOMY})/(\text{CTRN} \bullet \text{INOM})]$$

$$\text{50REF1P} \geq 0.05 \bullet [(100 \bullet 5)/(30 \bullet 5)]$$

$$\text{50REF1P} \geq 0.17$$

The resulting setting per criterion two is 0.17 pu. Because 50REF1P must be set at the greater of the two criteria values, you would select a setting of 0.28 pu.

100% Stator Ground Protection Elements

The SEL-700G provides a two-zone function designed to detect stator winding ground faults on resistance and high-impedance grounded generators. The Zone 1 element, 64G1, uses a fundamental-frequency neutral overvoltage element that is sensitive to faults in the middle and upper portions of the winding. The Zone 2 element, 64G2, uses a third-harmonic voltage differential function to detect faults in the upper and lower portions of the winding. By using the two zones together, the relay provides 100 percent stator ground fault coverage.

NOTE: Most generators produce enough third-harmonic voltage for proper application of the 64G2 element; however, some generators (for example, those with 2/3 pitch winding) may not. In those cases, the element based on the third-harmonic voltage, such as the 64G2, cannot be used for 100 percent Stator Ground Protection.

When a ground fault occurs high in the winding of a resistance or high-impedance grounded generator, a voltage appears at the generator neutral. The neutral voltage magnitude during the fault is proportional to the fault location within the winding. For instance, if a fault occurs 85 percent up the winding from the neutral point, the neutral voltage is 85 percent of the generator rated line-neutral voltage. The SEL-700G asserts the 64G1 Relay Word bit when neutral voltage is greater than the 64G1P setting.

Typically the 64G1P is set to detect stator ground faults in all but the bottom 5 percent of the generator winding. In this area close to the generator neutral, the neutral voltage does not increase significantly during a generator ground fault. The SEL-700G uses the third-harmonic voltage differential element to detect faults in this area.

NOTE: The 64G third-harmonic filters are cosine filters.

The 64G2 third-harmonic voltage differential element measures the third-harmonic voltage magnitudes at the generator terminals and neutral point, then evaluates the equation:

$$||VP3| \bullet 64RAT - |VN3|| > 64G2P$$

where:

VP3 = measured generator terminal third-harmonic voltage magnitude

64RAT = third-harmonic voltage ratio setting

VN3 = measured generator neutral third-harmonic voltage magnitude

64G2P = differential sensitivity setting

If the difference between the measured third-harmonic voltage magnitudes is greater than the 64G2P setting, the relay asserts the 64G2 Relay Word bit.

Figure 4.21 illustrates the 64G1 and 64G2 element operating characteristics. Notice that while the 64G2 element detects faults near the neutral and generator terminals, it has a deadband near the middle of the winding. The width of this deadband is governed by the 64G2P setting and the amount of third-harmonic voltage that the generator produces. The 64G1 element detects generator winding faults in the 64G2 element deadband and vice versa.

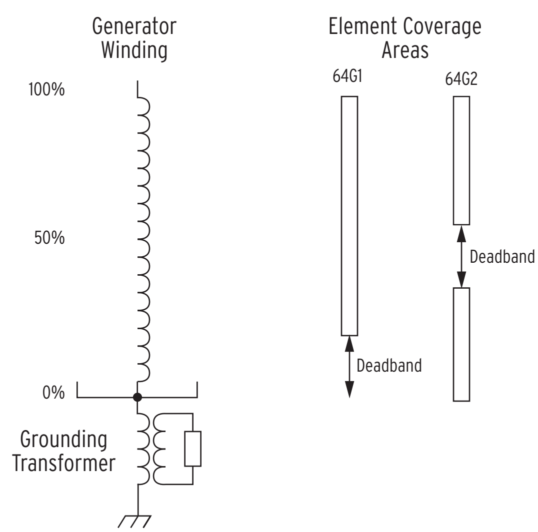


Figure 4.21 64G Element Operating Characteristic

Typical generators produce varying amounts of third-harmonic voltage, depending on machine construction and loading. The magnitudes of terminal and neutral third-harmonic voltage may not be equal, and their rates of increase with increasing load may be different as well. Note also that the third-harmonic characteristics of generators have been observed to change over time, perhaps because of modifications to auxiliary equipment connected to the generator bus. After such modifications, repeat the commissioning procedure and adjust the settings of the element.

The 64RAT setting is calculated to balance the voltage differential element performance over the range of machine loading. To properly set this element for an individual generator, operate the generator at full load and no load outputs, use the relay **METER** command to record the measured third-harmonic voltages, then calculate the settings. Details of this procedure are provided in the following text. More elaborate procedures using the third harmonic measurements at several load outputs and varying power factors can be found in the SEL Application Guide AG2005-08, *Setting 100% Stator Ground Fault Detection Elements in the SEL-300G Relay*, available on the SEL website. This guide is written for the SEL-300G, but it can be adapted for the SEL-700G.

You can apply the Zone 2 stator ground element as a neutral third-harmonic undervoltage element. When you set 64RAT := 0.0, the relay disables the third-harmonic voltage differential function. Setting 64G2 acts as a neutral third-harmonic undervoltage element (27N3) with voltage pickup defined by 64G2P.

When open-delta generator PTs are applied (DELTAY_X := DELTA) and an external zero-sequence voltage (3V0) is connected to the VS input (EXT3V0_X := VS), the relay allows you to program 64G2 as a third-harmonic voltage differential element or a neutral third-harmonic undervoltage element. On the other hand, when open-delta generator PTs are applied and no external 3V0 is brought in (EXT3V0_X := NONE), the relay allows you to program 64G2 only as neutral third-harmonic undervoltage protection.

Note: If EXT3V0_X := VN, then the 64G element is disabled.

The 64G1P setting defines the sensitivity of the relay fundamental frequency neutral overvoltage element used to detect stator ground faults in the middle and upper areas of the generator winding. The 64G1D setting defines the Zone 1 element time delay.

The 64G2P setting defines the sensitivity of the relay third-harmonic voltage differential function used to detect stator ground faults in the lower and upper areas of the generator winding. The 64RAT setting defines a balancing ratio used to provide consistent element performance over the range of machine operation. The 64G2D setting defines the Zone 2 element time delay.

Setting 64RAT is hidden and set to 0.0 when setting DELTAY_X := DELTA and EXT3V0_X := NONE.

The 64G1TC torque-control setting disables Zone 1 when its result is logical 0 and enables Zone 1 when its result is logical 1. Setting 64G2TC works similarly for Zone 2.

Table 4.6 Stator Ground Protection Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
64G PROT EN	Y, N	E64G := Y
NEUTRAL O/V LVL	OFF, 0.1–150.0 V	64G1P := 5
ZONE 1 TIMER	0.00–400.00 s	64G1D := 0.75
64G1 TRQCTRL	SELOGIC	64G1TC := 1
DIFF VOLT LVL	OFF, 0.1–20.0 V	64G2P := 2.5
ZONE 2 RATIO	0.0–5.0	64RAT := 1.0
ZONE 2 TIMER	0.00–400.00 s	64G2D := 0.08
64G2 TRQCTRL	SELOGIC	64G2TC := 1

Loss-of-Potential and Other Supervision

When 64G2 is configured as a third-harmonic voltage differential element, the relay must have information about the level of third-harmonic voltage at the generator terminal. If the potential transformers are lost, the 64G2 element operates and causes an unnecessary trip unless the SEL-700G Relay loss-of-potential detection logic (by setting 64G2TC := NOT LOPX AND 52AX, for example) supervises the element.

Note that LOPX is associated with the terminal PTs wired on the X-side. When external 3V0 is connected to the VS input (DELTAY_X := DELTA and EXT3V0_X := VS), LOPX should not be used for supervising 64G2.

In hydro-generator applications, where overspeed after load rejection events is possible, consider using an overfrequency element to disable the third-harmonic elements. The change in generator frequency during overspeed can cause unexpected operation of the third-harmonic elements. Other supervision, such as for breaker position (52AX) or voltage (27PPX1), may be necessary in some applications, for example, by setting 64G2TC := NOT LOPX AND NOT 27PPX1.

When a generator is out of service, you can use indicators such as low terminal voltage, an open field circuit breaker, or no phase current to supervise the operation of the 64G element by using the 64G torque-control settings (e.g., to detect low terminal voltage, set 64G*n*TC := NOT 27V1X1 and the pickup setting 27V1X1P to as low as 2.0 V as necessary for your application to supervise the 64G element).

100% Stator Ground Protection Setting Calculation

Collect the following information before setting the 100% Stator Ground Protection.

- Generator nominal voltage, VNOM_X
- Generator neutral transformer ratio
- Neutral auxiliary transformer ratio (if the relay is connected via an auxiliary transformer)
- Generator neutral voltage during system ground fault (Capacitive coupling in the generator step-up transformer causes this voltage). If this voltage is unknown, you can perform this coordination on a time basis.)
- Relay settings PTRX, DELTAY_X, EXT3V0_X, and PTRN

Third-Harmonic Voltage Differential Setting Recommendations (Use With Four-Wire Potentials or With Open-Delta Potentials and External 3V0). This setting procedure assists you in calculating 64G element settings that offer secure, sensitive detection of stator winding faults. As described, the 64G2 element characteristic has a midwinding deadband whose width is governed by the 64G2P setting. The 64G1 neutral overvoltage element provides sensitive detection of stator faults in the deadband when you select its settings according to the following procedure.

The following procedure assumes WYE connected PTs (DELTAY_X := WYE) at the terminals. If DELTAY_X := DELTA and EXT3V0_X := VS, then replace PTRX by PTRS in the following procedure.

NOTE: Perform the procedure when the relay is first installed, but after the generator being protected is connected to its step-up transformer or bus. Remove the 64G2T Relay Word bit from the relay tripping SELOGIC control equations. Use 64G1P := 5 V during the test. Set the balance of tripping functions according to the requirements of the particular generator. Leave these tripping functions in service to protect the generator in the event that a fault occurs during the test sequence.

To simplify the following calculations, you can use the Microsoft Excel spreadsheet, *64G Element Setting Worksheet*, which is available on the SEL product webpage at selinc.com or by contacting the factory.

Step 1. Operate the generator at near no load (less than 10 percent of the load rating). Use the SEL-700G **METER** command and record the values of terminal and neutral third-harmonic voltage.

VP3_NL := VPX3/PTRX := ______ Third-harmonic terminal voltage, no load, V secondary

VN3_NL := VN3/PTRN := ______Third-harmonic neutral voltage, no load, V secondary

V3_NL := VN3 + VPX3/3 := ______ V primary

Step 2. Increase the generator loading to above 90 percent of the rating. Record the values of terminal and neutral third-harmonic voltage. Shut down the generator; the rest of this procedure does not require that the generator be in service.

VP3_FL := VPX3/PTRX := _____Third-harmonic terminal voltage, full load, V secondary

VN3_FL := VN3/PTRN := _____Third-harmonic neutral voltage, full load, V secondary

V3_FL := VN3 + VPX3/3 := ______ V primary

V3min := MIN(V3_NL, V3_FL) := ______ V primary

V3avg := (V3_NL + V3_FL)/2 := ______ V primary

NOTE: A more elaborate procedure using the third-harmonic measurements at several load outputs can be found in the SEL Application Guide AG2005-08, Setting 100% Stator Ground Fault Detection Elements in the SEL-300G Relay. This guide is written for the SEL-300G, but it can be easily adapted for the SEL-700G. The steps in this manual are the minimum required to set the element. Using additional load and third-harmonic data, as discussed in the application guide, results in a more secure setting and is recommended.

Step 3. Calculate the 64RAT setting by using the following equation:

$$64RAT = \frac{(VN3\_FL + VN3\_NL)}{(VP3\_FL + VP3\_NL)}$$

$$64RAT = \underline{\hspace{6cm}}$$

Step 4. Calculate the minimum secure 64G2P setting by using the following equation:

$$64G2P_{Min} = 1.1 \bullet (0.1 + |64RAT \bullet VP3x - VN3x|) \text{ volts}$$

$$64G2P_{Min} = \underline{\hspace{6cm}} \text{ volts}$$

Step 5. Calculate 64G2Pmin for each load point that third harmonic voltage data are available, where:

- VP3x := third harmonic terminal voltage, VPX3, for the given load point
- VN3x := third harmonic neutral voltage, VN3, for the given load point

Step 6. Select the largest of the calculated values as $64G2P_{Min}$.

Step 7. Set the pickup setting 64G2P equal to the Optimum 64G2P, calculated through the following equation, or to $64G2P_{Min}$ from *Step 6*, whichever is higher.

$$\text{Optimum 64G2P} = \frac{64RAT \bullet 3 \bullet V3min \bullet (1 - X)}{PTR} - \frac{V3min \bullet X}{PTRN}$$

where:

X = Low-winding coverage. Use a 15%–25% range (e.g., 20% as an optimized coverage). (Avoid X > 25% unless Relay Word bit T64G is used for alarm only. See *100% Stator Ground Fault Tripping* for additional details).

Use *Step 8* and *Step 9* to calculate the actual overlap between the 64G1 and 64G2 elements.

Step 8. Use the following equation to calculate the low-winding coverage ($64G2_{Min}$) these settings offer when you operate the machine at a specific load (e.g., no load):

$$64G2_{Min} = \frac{64RAT \bullet 3 \bullet V3\_NL - 64G2P \bullet PTR}{64RAT \bullet 3 \bullet V3\_NL + V3\_NL \bullet (PTR/PTRN)}$$

$$64G2_{Min} = \underline{\hspace{3em}}\%$$

Typically, this value should be 15 percent or greater for the most dependable stator ground protection.

The referenced spreadsheet performs these calculations automatically for the worst case load among the third-harmonic measurements entered.

NOTE: Although the minimum low-winding coverage usually occurs at no load, this is not always the case. Verify coverage at all loads for which VP3 and VN3 are available.

Step 9. Use the following equation to select the 64G1P setting to detect faults in the top 95–98 percent of the generator winding:

$$64G1P = \left(1 - \frac{95\%}{100\%}\right) \bullet \left(\frac{kV \bullet 1000}{1.73 \bullet PTRN}\right) \text{ V secondary,}$$

assuming 95 percent coverage

where:

kV = nominal machine line-to-line voltage, kV primary

PTRN = Ngt • Nat

Ngt = generator neutral transformer ratio

Nat = neutral auxiliary transformer ratio if the relay is connected via an auxiliary transformer (use Nat = 1 if the relay is connected directly to the grounding transformer secondary winding)

The 64G1P setting must be greater than 0.5 V secondary. Zero-sequence voltage can appear across the grounding transformer secondary during a system ground fault resulting from capacitive coupling between the windings of the unit transformer. If 64G1P is less than the zero-sequence voltage, then the 64G1D setting must be longer than system ground fault clearing time to provide security.

Ensuring $64G2_{Min}$:= 15 percent, and selecting 64G1P for at least 95 percent winding coverage, gives an overlap of 10 percent or greater between the elements.

Step 10. Select the 64G2D delay setting, keeping in mind that detection of a single stator ground fault by this element may not require immediate tripping. The element is only used on generators where high grounding impedance limits the ground-fault current. At minimum, the 64G2D setting must be greater than the time necessary to clear faults on the transmission system. Faults and other disturbances can affect the measured harmonic voltages.

Third-Harmonic Neutral Undervoltage Setting Recommendations (Use With Open-delta Potentials and EXT3V0_X := NONE.). The vast majority of generator protection applications benefit from the improved ground fault sensitivity that the previously described third-harmonic voltage differential protection scheme offers. In the event that your protection standards require third-harmonic neutral undervoltage protection, use the following setting procedure to define the protection settings.

NOTE: Perform the procedure when the relay is first installed, but after the generator being protected is connected to its step-up transformer or bus. Remove the 64G2T Relay Word bit from the relay tripping SELOGIC control equation. Use 64G1P := 5 V during the test. Set the balance of tripping functions according to the requirements of the particular generator. Leave these tripping functions in service to protect the generator in the event that a fault occurs during the test sequence.

Typically, the minimum neutral third-harmonic voltage occurs at no-load conditions. However, some cases have been observed where the minimum voltage occurs with the machine partially loaded. Therefore, we recommend measuring the neutral third-harmonic voltage at various real and reactive load conditions to find the minimum voltage.

Step 1. Operate the generator at various loads. Use the SEL-700G **METER** command and record the values of neutral third-harmonic voltage.

VN3_min := VN3/PTRN = ______Minimum third harmonic neutral voltage V secondary

Step 2. Set the 64RAT setting equal to 0.0 to disable third-harmonic voltage differential protection and enable third-harmonic neutral undervoltage protection. The relay does this automatically and hides the 64RAT setting if DELTAY_X := D.

64RAT := 0.0

Step 3. Set the 64G2P setting approximately 50 percent of the generator minimum third-harmonic neutral voltage:

$$64G2P = 0.5 \bullet VN3\_min \text{ V secondary}$$

$$64G2P = \underline{\hspace{5cm}} \text{ V secondary}$$

It is not possible to calculate the low-winding coverage this setting offers, because the third-harmonic terminal voltages are unavailable.

Step 4. Use the following equation to select the 64G1P setting to detect faults in the top 95–98 percent of the generator winding:

$$64G1P = \left(1 - \frac{95\%}{100\%}\right) \bullet \left(\frac{kV \bullet 1000}{1.73 \bullet PTRN}\right) \text{ V secondary,}$$

assuming 95 percent coverage

where:

kV = nominal machine line-to-line voltage, kV primary

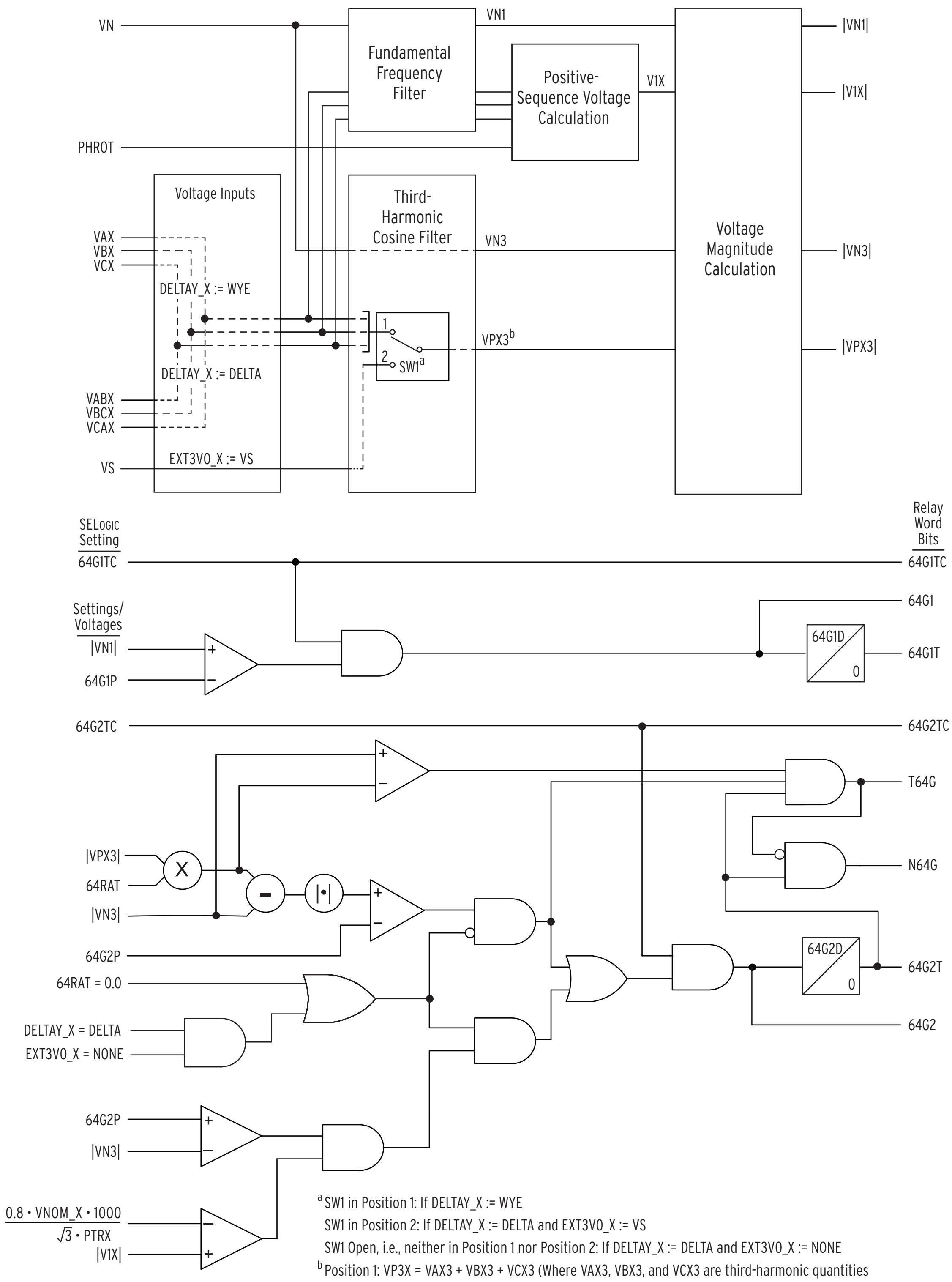
PTRN = Ngt • Nat

Ngt = generator neutral transformer ratio

Nat = neutral auxiliary transformer ratio if the relay is connected via an auxiliary transformer (use Nat = 1 if the relay is connected directly to the grounding transformer secondary winding)

The 64G1P setting must be greater than 0.5 V secondary. Zero-sequence voltage can appear across the grounding transformer secondary during a system ground fault resulting from capacitive coupling between the windings of the unit transformer. If the 64G1P setting is less than the zero-sequence voltage, then the 64G1D setting must be longer than system ground fault clearing time to provide security.

100% Stator Ground Fault Tripping. If your company practice is to trip for stator ground fault, use the 100 percent stator ground fault elements to trip the generator main breaker, the field breaker, the prime mover, and the generator lockout relay (generator shutdown). If your company practice is to alarm only for stator ground fault, use the 64G1T, 64G2T, N64G, and/or T64G Relay Word bits to control outputs for alarming to an operator. Relay Word bit N64G indicates the location of a ground fault close to Neutral, and Relay Word bit T64G indicates the location of a ground fault close to the terminals of the generator. N64G is the essential bit for providing 100 percent coverage. The default trip configuration (see *Trip/Close Logic Settings*) includes both N64G and T64G bits. However, you can change the default settings to use N64G for tripping and T64G for alarming, if security of T64G is a concern.



[a] SW1 in Position 1: If DELTAY_X := WYE
SW1 in Position 2: If DELTAY_X := DELTA and EXT3V0_X := VS
SW1 Open, i.e., neither in Position 1 nor Position 2: If DELTAY_X := DELTA and EXT3V0_X := NONE

[b] Position 1: VP3X = VAX3 + VBX3 + VCX3 (Where VAX3, VBX3, and VCX3 are third-harmonic quantities filtered out on corresponding phases)
Position 2: VP3X = VS3 (Where VS3 is the third-harmonic component filtered out on VS channel)

Figure 4.22 64G Logic Diagram

Field Ground Protection Elements

The SEL-700G works with the SEL-2664 Field Ground Module to protect the generator field winding. Connect the SEL-2664 directly to two ends of the generator field winding and the rotor ground brush. When the SEL-2664 calculates the insulation resistance value between the field winding and ground, it uses a fiber-optic cable with ST connectors and a transceiver (SEL-2812MR or MT) to transmit the insulation resistance value to the SEL-700G. Consult the SEL-2664 Instruction Manual for detailed instructions on setting up the SEL-2664.

Set the EIA-232 port in the SEL-700G to SEL protocol and change the port settings to 9600 bps, 8 data bits, no parity, and 1 stop bit to start receiving the insulation resistance value from the SEL-2664.

The SEL-700G compares the insulation resistance value to the pickup settings (64F1P and 64F2P) of the field ground protection elements (64F1T and 64F2T, see *Figure 4.23*). Set two different pickup levels to alarm and/or trip when the insulation resistance value causes the elements (64F1T or 64F2T) to assert.

If there is no insulation deterioration, there is no leakage path between the field winding to ground; the insulation resistance value is extremely high. In this situation, however, because of sensitivity limits, the SEL-2664 calculates a very large insulation resistance value of 20 megohms. As soon as the field winding insulation develops a breakdown to the rotor iron (assuming that the generator rotor iron is connected to ground through a grounding brush), the SEL-2664 detects a sharp drop in insulation resistance.

The **MET** command response includes the value of the insulation resistance Rf in kilohms when the element is enabled and functional. The **STA** command response includes the status of the field ground module and the associated communications link.

The technology the SEL-2664 uses does not discriminate between one point of insulation breakdown and multiple points of insulation breakdown. A single point of insulation breakdown does not harm the generator. Multiple points of insulation breakdown could lead to serious generator damages because the distribution of magnetic flux in the rotor is substantially altered. When a different device (such as a generator vibration detector) is used to detect multiple points of insulation breakdown, SEL recommends using the SEL-2664 to generate an alarm only and using the other device under supervision of the SEL-2664 to trip. If you do not use an additional device, it is a good idea to alarm and trip with the SEL-2664.

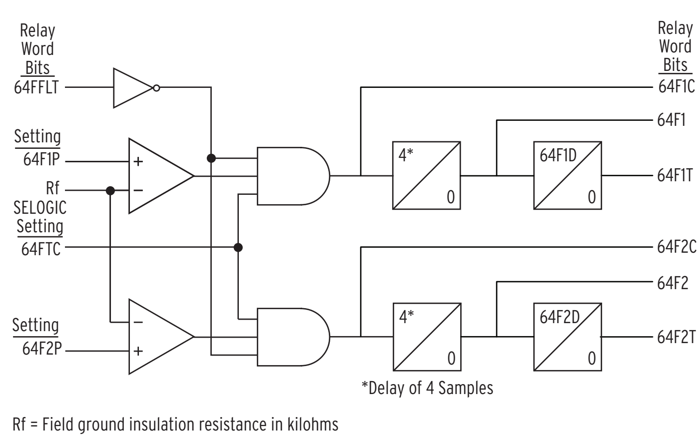


Figure 4.23 Field Ground Protection (64F) Elements Logic

If 64FFLT := 1, indicating a non-functional SEL-2664 or fiber-optic connection, then the 64F elements are not calculated, the 64F1, 64F1T, 64F2, and 64F2T Relay Word bits are set to zero (0), and all accumulated timer values are reset to zero (0). *Table 4.7* lists the setting prompt, range, and factory-default name for the field ground protection element settings.

Table 4.7 Field Ground Protection Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
64F PROT EN	Y, N	E64F := N
64F LVL 1 PICKUP	OFF, 0.5-200.0 kilohm	64F1P := 100.0
64F LVL 1 DELAY	0.00-99.00 s	64F1D := 60.00
64F LVL 2 PICKUP	OFF, 0.5-200.0 kilohm	64F2P := OFF
64F LVL 2 DELAY	0.00-99.00 s	64F2D := 60.00
64F TRQCTRL	SELOGIC	64FTC := 1

NOTE: The Relay Word bit 64F2T is configured to shut down the generator in the factory-default logic. See Trip/Close Logic Settings for details. Change the setting if your application requires a different action.

When the SEL-2664 module is not in use, set the E64F setting equal to N. When the SEL-2664 is connected to the generator field winding and the SEL-700G, set the 64F Input Option setting equal to Y.

Set the 64F element torque control equation (64FTC) to enable or disable the 64F elements. When the 64FTC SELOGIC control equation calculates to zero (0), the 64F1, 64F1T, 64F2, and 64F2T Relay Word bits are set to zero (0), and all accumulated timer values are reset to zero (0).

System Backup Protection

The SEL-700G Relay offers three choices for system backup protection. Use EBUP setting (see *Table 4.8*) to select one or more of the available elements, Distance (DC), Voltage Restraint (V), or Voltage Controlled (C) Overcurrent elements. By setting EBUP := DC_V, both Distance and Voltage Restraint Overcurrent (DC_V) elements can be enabled. By setting EBUP := DC_C, both Distance and Voltage Controlled Overcurrent (DC_C) elements can be enabled.

Distance Elements

The SEL-700G provides a two-zone distance element designed for backup distance protection for system phase-to-phase and three-phase faults. Each zone is equipped with independently settable forward reach, reverse offset, maximum torque angle, and definite-time delay. The relay uses compensator distance elements consisting of phase-to-phase and three-phase elements.

In a typical application, you might set the Zone 1 element to reach into the generator step-up transformer and, with little or no time delay, protect the phase-to-phase and three-phase faults external to the generator differential zone to as far as the transformer delta winding. You can then set the Zone 2 element to reach through the step-up transformer into the system and use a longer time delay. Alternatively, you can set the Zone 1 element to provide backup protection for faults on the high-side bus with a coordinating time delay and set the Zone 2 element with a long reach and long time delay for breaker failure backup protection. You can use the load encroachment feature to prevent misoperation of the distance elements resulting from heavy load conditions.

The relay includes a user-settable SELOGIC control equation to disable the distance elements, as well as the supervision by the LOPX loss-of-potential logic and the load-encroachment function, to provide three-phase element security under maximum generator loading conditions.

Table 4.8 Compensator Distance Protection Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
System Backup		
BACKUP PROT EN	N, DC, V, C, DC_V, DC_C	EBUP := DC
Compensator Distance		
Z1 COMP REACH	OFF, 0.1-100.0 ohms[a]	Z1C := 8.0[a]
Z1 COMP OFFSET	0.0-10.0 ohms[a]	Z1CO := 0.0
Z1 COMP TIME DLY	0.00-400.00 s	Z1CD := 0.00
Z1 CURRENT FD	0.50-170 A	50PP1 := 0.50
Z1 POS-SEQ ANGLE	45-90 Deg	Z1ANG := 88
Z2 COMP REACH	OFF, 0.1-100.0 ohms[a]	Z2C := 16.0[a]
Z2 COMP OFFSET	0.0-10.0 ohms[a]	Z2CO := 0.0
Z2 COMP TIME DLY	0.00-400.00 s	Z2CD := 0.00
Z2 CURRENT FD	0.50-170 A[b]	50PP2 := 0.50[b]
Z2 POS-SEQ ANGLE	45-90 Deg	Z2ANG := 88
21C ELE TRQCTRL	SELOGIC	21CTC := NOT 3POX

[a] Ranges and default settings shown are for 5 A CT. Multiply by 5 for 1 A rated CTs.
[b] Range and default setting shown are for 5 A CT. Divide by 5 for 1 A rated CTs.

Set Z1C to define the forward (toward the system) phase distance reach defined in secondary ohms. For distance element security under heavy load, set the load-encroachment element (see *Table 4.37*). This eliminates load impedance concerns when selecting the Z1C reach setting.

The Z1CO setting defines the element offset for the three-phase faults. When the relay has current transformers located at the terminals of the generator, as shown in *Figure 2.21*, you can apply an offset equal to the generator impedance as backup protection for three-phase faults in the generator stator. When the element is used to protect for a phase fault external to the generator differential zone, apply a small offset to include the origin (zero-voltage fault) in the tripping zone.

The Z1CD setting defines the Zone 1 element definite-time delay.

Set 50PP1 to its minimum value, unless a special condition requires a higher value.

Set Z1ANG equal to the angle of the transformer plus system impedance defined by the Zone 1 reach setting. The relay places the distance element maximum reach along a line at the angle defined by the Z1ANG setting.

Set Z2C to define the forward (toward the system) phase distance reach, in secondary ohms. For distance element security under heavy load, set the load-encroachment element (see *Table 4.37*). This eliminates load impedance concerns when you select the Z2C reach setting.

The Z2CO setting defines the element offset for the three-phase faults. You can apply an offset, typically equal to the generator impedance, to provide generator phase backup protection.

The Z2CD setting defines the Zone 2 element definite-time delay.

Set 50PP2 to its minimum value, unless a special condition requires a higher value.

NOTE: Loss-of-potential (LOPX) supervision is built into the element logic, so it does not need to be added to the 21CTC SELOGIC control equation setting.

Set Z2ANG equal to the angle of the transformer plus system impedance defined by the Zone 2 reach setting. The relay places the distance element maximum reach along a line at the angle defined by the Z2ANG setting.

The phase distance elements are enabled when the result of 21CTC equals logical 1. The elements are blocked when the 21CTC SELOGIC control equation result equals logical 0. Typically, the 21CTC SELOGIC control equation should be set so that the elements are enabled when the generator main circuit breaker is closed (NOT 3POX). You can add other supervisory conditions if necessary for your application.

Settings Calculation. Collect the following information before setting the compensator distance.

- Zone 1 and Zone 2 reach apparent impedance magnitude and angle
- Generator step-up transformer connection (only necessary if Zone 1 or Zone 2 mho element is used and set to reach through the transformer)
- Zone 1 and Zone 2 coordination time delay
- Generator rated minimum power factor and maximum emergency loading

Recommendations. The compensator distance elements provide backup phase fault protection for the system, step-up transformer, and generator. Zone 2 is typically set to reach far out onto the system. Usually, a fault study is necessary to determine the magnitude and angle of the apparent impedance seen by the generator relay during a system fault. Set the reach (Z*n*C) equal to the apparent positive-sequence impedance calculated by fault study for a three-phase fault at the targeted reach limit point on the system. All distance element reaches and offsets are set in secondary ohms.

After determining the minimum reach setting necessary to obtain the sensitivity you want with all system breakers closed, you can determine the element sensitivity when one or more local bus circuit breakers are open. This operating contingency review shows with which relays the Zone 2 element time delay must coordinate. Zone 1 is usually set shorter than Zone 2, with a corresponding shorter time delay.

The distance element offset necessary for each zone depends on the location of the relay current transformers. If current transformers are connected near the generator neutral, as in *Figure 2.20* or *Figure 2.22*, and the element is used to protect for a zero-voltage three-phase fault external to the generator differential zone, set the distance element offsets equal to 10 percent of the generator X'd. If current transformers are located at the terminals of the generator, as in *Figure 2.21*, set the distance element offsets equal to the generator X'd. Offsets for Zone 1 and Zone 2 should be set equal, unless some special performance characteristic is necessary.

The Relay Word bits 21C1T and 21C2T are configured to shut down the generator in the factory-default logic. See *Trip/Close Logic Settings* for details. You must change the setting if a different action is necessary for your application.

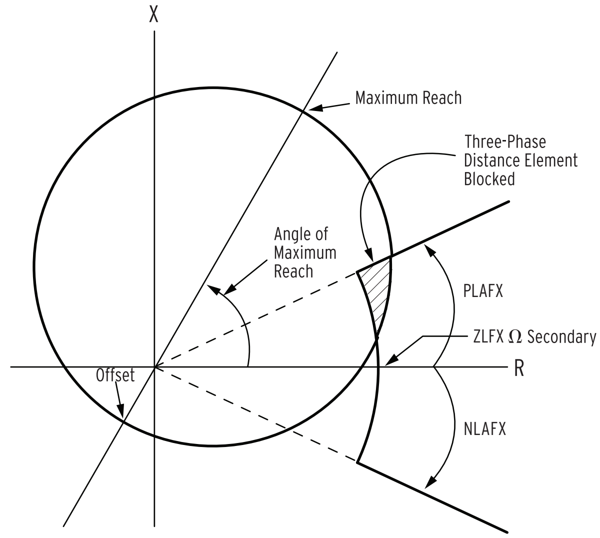


Figure 4.24 Three-Phase Distance Element Operating Characteristics

NOTE: The three-phase distance element operates for ABC faults. It is normal for it to operate for AB faults depending on the 50PPn pickup setting. The phase-to-phase element operates for AB, BC, and CA faults.

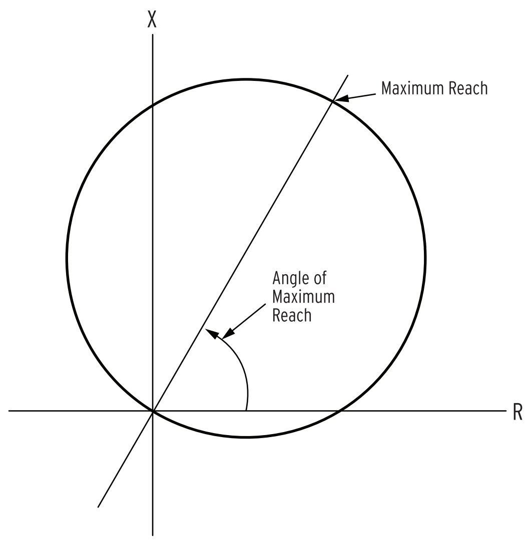


Figure 4.25 Phase-to-Phase Distance Element Operating Characteristics

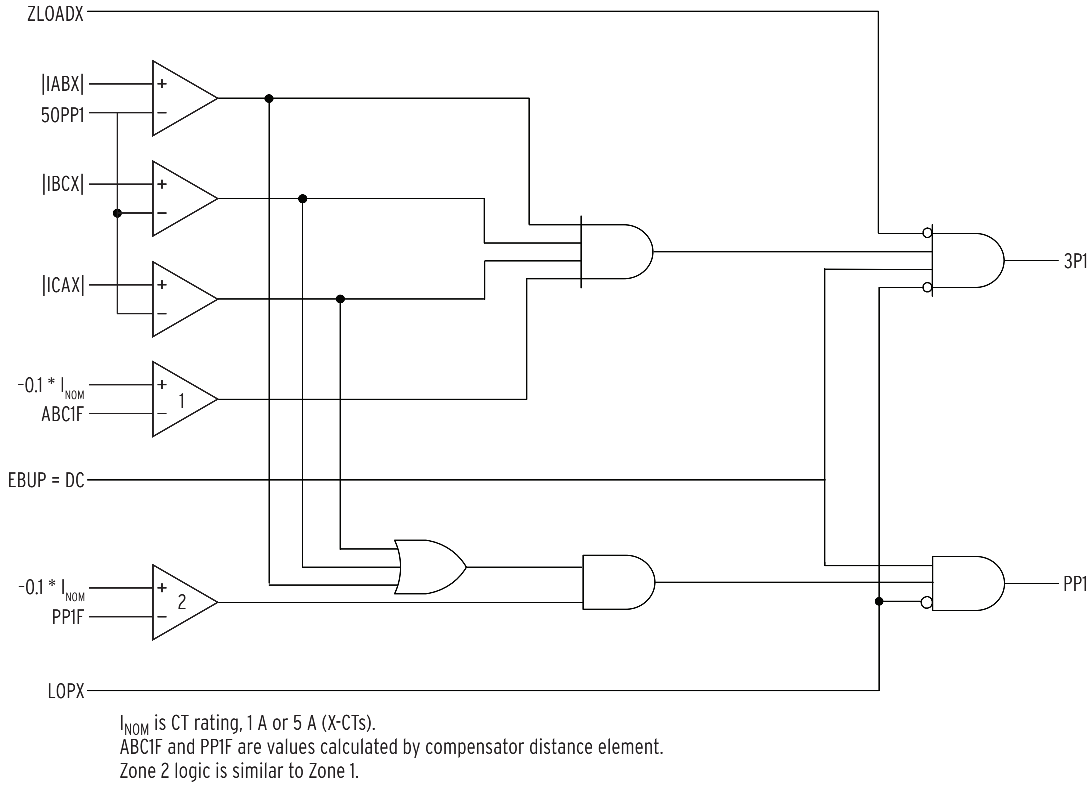


Figure 4.26 Zone 1 Compensator Element Logic

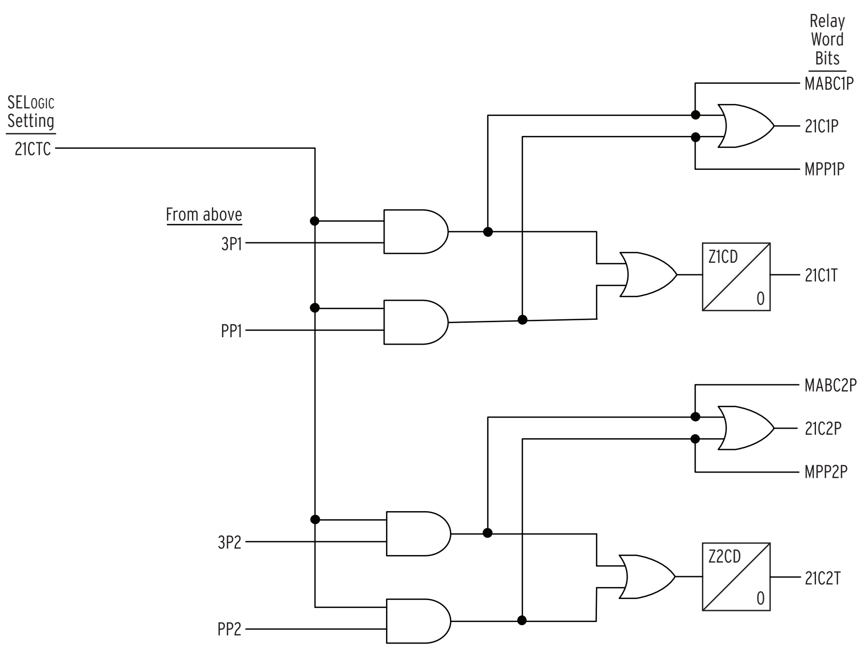


Figure 4.27 Compensator Distance Element Logic

Voltage-Controlled/Restrained Time-Overcurrent Elements

The SEL-700G provides a voltage-restrained phase time-overcurrent element and a voltage-controlled phase time-overcurrent element. One of these elements is typically used for system phase fault backup protection to trip the generator in the event of an uncleared phase fault on the system side of the step-up transformer.

The voltage-controlled phase time-overcurrent element, 51C, operates when its torque-control setting, 51CTC, is equal to logical 1. Typically, the torque-control setting should include the Relay Word bit for an undervoltage element, such as 27PPX1. This way, the 51C element operates only when generator terminal voltage is less than 27PPX1P setting. This element works properly whether or not a step-up transformer is present and regardless of the connection of the step-up transformer—delta/wye, wye/wye, etc.

The 51V element in the SEL-700G Relay is intended for applications in which the generator is directly connected to a bus, to the delta side of a delta-wye transformer, or to a wye-wye or delta-delta transformer. The voltage-restrained phase time-overcurrent element, 51V, also includes a torque-control setting, 51VTC. However, the 51V element operation is fundamentally different in that the element pickup setting is reduced automatically as the generator phase-to-phase voltage decreases during a fault. When the generator voltage is 100 percent of the VNOM_X setting, the 51V element operates based on 100 percent of its pickup setting, 51VP. As the generator phase-to-phase voltage drops, the relay decreases the element pickup by a like amount, down to 12.5 percent of nominal phase-to-phase voltage. For voltages below 12.5 percent, the relay uses a pickup that is 12.5 percent of the 51VP setting. The element automatically determines fault type and appropriate phase-to-phase restrain voltage based on the compensation angle setting 51VCA; it will not operate if the relay cannot determine the fault type. The 51V element is designed to operate when there is a multi-phase fault. It will not operate for a single phase-to-ground fault. It will operate for AB, ABG, BC, BCG, CA, CAG, ABC, OR ABCG faults. Use other elements (for example, neutral/residual overcurrent 50N, 51N, 50GX, 51GX) for the ground overcurrent protection.

When a step-up transformer is present, the generator phase-to-phase voltage is compensated for the phase shift across the transformer. There is no compensation for the voltage drop across the step-up transformer.

Table 4.9 Voltage Controlled/Restraint Time OC Protection Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Voltage-Controlled TOC (EBUP := C or DC_C)		
V-CTRL TOC LVL	OFF, 0.50-16.00 A[a]	51CP := 3.00[a]
V-CTRL TOC CURVE	U1–U5, C1–C5	51CC := U2
V-CTRL TOC TDIAL	0.50-15.00[b]	51CTD := 3.20
V-CTRL TOC EM RST	Y, N	51CRS := Y
51C TOC TRQCTRL	SELOGIC	51CTC := 27PPX1 AND NOT LOPX
Voltage-Restraint TOC (EBUP := V or DC_V)		
V-RESTR TOC LVL	OFF, 2.00–16.00 A[a]	51VP := 8.00[a]
COMPEN ANGLE	0, -30, 30	51VCA := 0
V-RESTR TOC CURV	U1–U5, C–C5	51VC := U2
V-RES TOC TDIAL	0.50–15.00[b]	51VTD := 3.00
V-RES TOC EM RST	Y, N	51VRS := Y
51V TOC TRQCTRL	SELOGIC	51VTC := NOT LOPX

[a] Ranges and default settings shown are for 5 A CT. Divide by 5 for 1 A rated CTs.
[b] Setting Range shown is for US Curves. Range is 0.05-1.00 for the IEC Curves.

Use the 51VCA setting to compensate the voltage-restrained overcurrent element for the presence of a delta-wye generator step-up transformer between the generator and system. When the element is not set to reach through the step-up transformer, set 51VCA := 0. When the element is set to respond to phase faults on the high side of a delta-wye transformer, and the system phase-to-neutral voltage phase angle leads the generator phase-to-neutral voltage phase angle by 30°, set 51VCA := –30°. When the system phase-to-neutral voltage phase angle lags the generator phase-to-neutral voltage phase angle by 30°, set 51VCA := 30.

For system backup protection, the SEL-700G provides a choice of voltage-controlled or voltage-restrained phase inverse time-overcurrent elements or phase distance elements (discussed earlier in this section). The overcurrent elements include a settable pickup, curve shape, and time-dial. Ten curve shapes are available. Curves U1–U5 emulate the popular North American induction disk relays. Curves C1–C5 emulate popular European analog time-overcurrent relays. Operating characteristics of the available curves are shown in *Figure 4.62* through *Figure 4.71*.

When you set 51*n*RS := Y to enable electromechanical reset emulation, the relay provides a slow reset that is dependent on the amount of current measured, similar to an induction disk relay reset. When you select N, the relay fully resets the time-overcurrent element one cycle after current drops below the pickup setting, similar to analog and many microprocessor-based time-overcurrent relays. Select Y or N to match the operating characteristic of other time-overcurrent protection protecting the system near this generator.

Each of the elements is also equipped with a torque-control setting. When the equation result is logical 1, the element can operate. When the result is logical 0, the element cannot operate. Use other protection elements, logic conditions, or control inputs to supervise these elements if necessary.

Voltage-Controlled and Voltage-Restrained Time-Overcurrent Setting Calculation

Gather the following information to calculate the voltage-controlled and voltage-restrained time-overcurrent settings.

- Generator nominal voltage, VNOM_X
- Generator current for long duration system phase fault, If, A primary
- Generator voltage for system phase fault, Vf, V primary
- Generator voltage and current transformer ratios to 1, PTR and CTR

Choose either the voltage-controlled or voltage-restrained time-overcurrent element for system phase fault backup protection when overcurrent relays are used for primary system protection.

Generally, the voltage-controlled element provides adequate backup protection and consistent performance. Use the voltage-restrained element if your protection standards or preferences require it.

Voltage-Controlled Time-Overcurrent Settings. Set the 51CP pickup setting less than the generator fault duty, which you can calculate by using the generator steady-state reactance, X_d (you can use transient reactance X'_d if the generator excitation system supports higher fault voltage and current). This value may safely be below maximum load, because the element is only enabled during low-voltage fault conditions. Divide the generator fault duty by the phase current transformer ratio, CTRX, to find the element pickup current in secondary amps.

$$51CP \le \frac{IP}{CTRX}$$

Select a curve shape and time-dial that allow this element to coordinate with the system primary protection.

$$51CC = U2$$
$$51CTD = 3.00$$

Apply electromechanical reset emulation if the system phase overcurrent relays are induction disk relays; otherwise, electromechanical reset emulation is not necessary.

$$51CRS = N$$

By definition, this element should be torque controlled by an undervoltage element. To prevent misoperation if a potential transformer fuse blows, the element is also torque controlled by the NOT LOPX Relay Word bit.

$$51CTC := 27PPX1 \text{ AND NOT LOPX}$$

To enable and set the undervoltage element, set

$$27PPX1P = 0.8 \bullet V_{nom} \text{ volts}$$

where:

V_{nom}= VNOM_X • 1000/PTRX

With the previous settings, the 51C element is enabled whenever the generator voltage is less than 80 percent of nominal, as long as there is no simultaneous loss-of-potential condition. You can choose to use a different undervoltage element pickup setting.

Voltage-Restrained Time-Overcurrent Settings. When using the 51V element, set the 51VP pickup setting greater than the maximum generator phase current expected under full voltage, nonfault conditions. Divide this current by the phase current transformer ratio, CTRX, to find the element pickup current in secondary amps.

$$51VP > \frac{\text{max load current}}{CTRX} \text{ amps}$$

Select a curve shape and time-dial that allow this element to coordinate with the system primary protection.

$$51VC = U2$$
$$51VTD = 3.00$$

Apply electromechanical reset emulation if the system phase overcurrent relays are induction disk relays; otherwise, electromechanical reset emulation is not necessary.

$$51VRS = N$$

Because this element reduces its pickup setting automatically as generator voltage decreases, the element should not be permitted to operate if there is a blown potential transformer fuse condition. To prevent misoperation if a potential transformer fuse blows, the element is torque controlled by the NOT LOPX Relay Word bit.

51VTC := NOT LOPX

With the previous settings, the 51V element is enabled as long as there is no loss-of-potential condition.

The Relay Word bits 51CT and 51VT are configured to shut down the generator in the factory-default logic (see *Trip/Close Logic Settings* for details). You must change the setting if your application requires a different action.

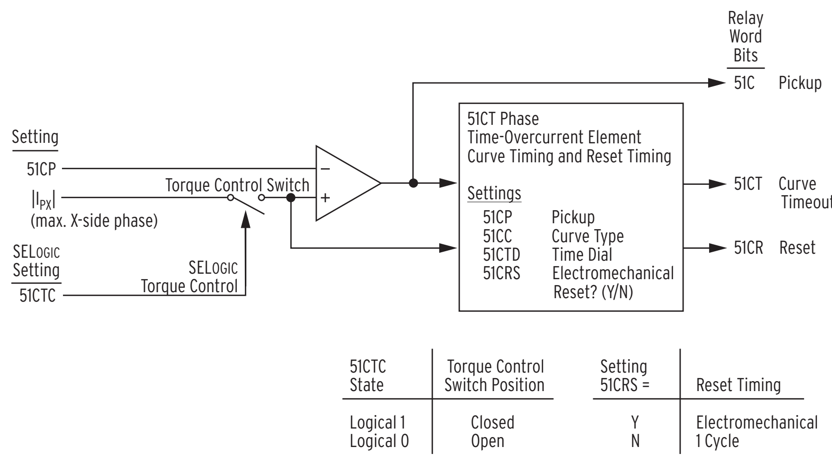


Figure 4.28 Voltage-Controlled Phase Time-Overcurrent Element 51CT

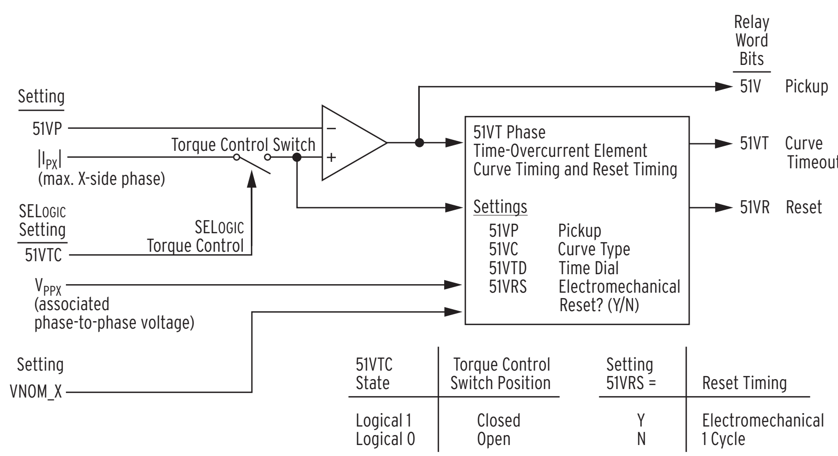


Figure 4.29 Voltage-Restrained Phase Time-Overcurrent Element 51VT

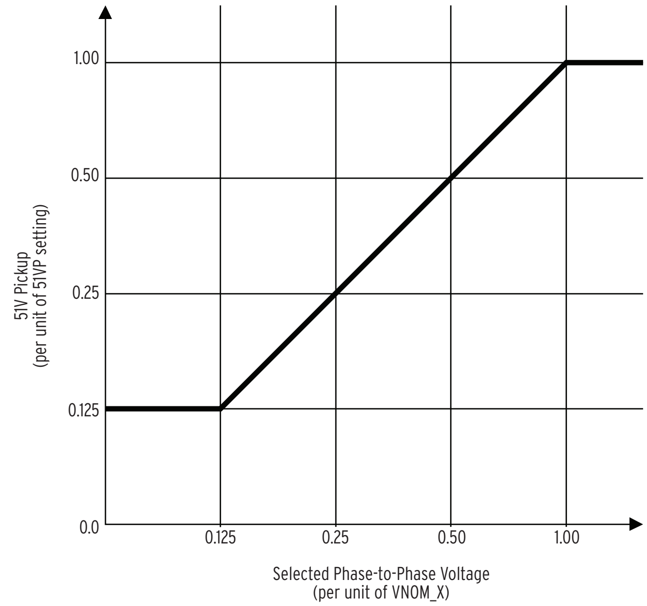


Figure 4.30 51V Element Voltage Restraint Characteristic

Loss-of-Field Element

Loss-of-field current causes the synchronous generator to act as an induction generator. The rotor speed increases, active power output decreases, and the generator pulls vars from the system. High currents are induced in the rotor, and stator current as high as 2.0 per unit is possible. These high currents cause dangerous overheating in a very short time.

The SEL-700G uses a pair of offset mho circles to detect loss-of-field. Because loss-of-field affects all three phases, the condition is a balanced one. The SEL-700G uses measured positive-sequence impedance to form the mho circles.

Typically, Zone 1 and Zone 2 are offset from the impedance plane origin by a value equal to half of the machine transient reactance, as shown in *Figure 4.32*. Zone 1 is intended to operate with little time delay in the event of a loss-of-field under full load conditions. Zone 2 reaches farther and operates with a longer time delay. Zone 2 is intended to trip for loss-of-field conditions that occur under light load conditions.

For compatibility with some existing electromechanical loss-of-field relays, the SEL-700G Zone 2 element can be set with a positive offset, as shown in *Figure 4.33*. When Zone 2 is used in this manner, the relay provides a directional element with a settable angle characteristic. The Zone 2 element is used together with an undervoltage element to provide faster tripping when the system voltage is depressed during the loss-of-field condition.

The loss-of-field elements are supervised by the 40ZTC torque-control setting.

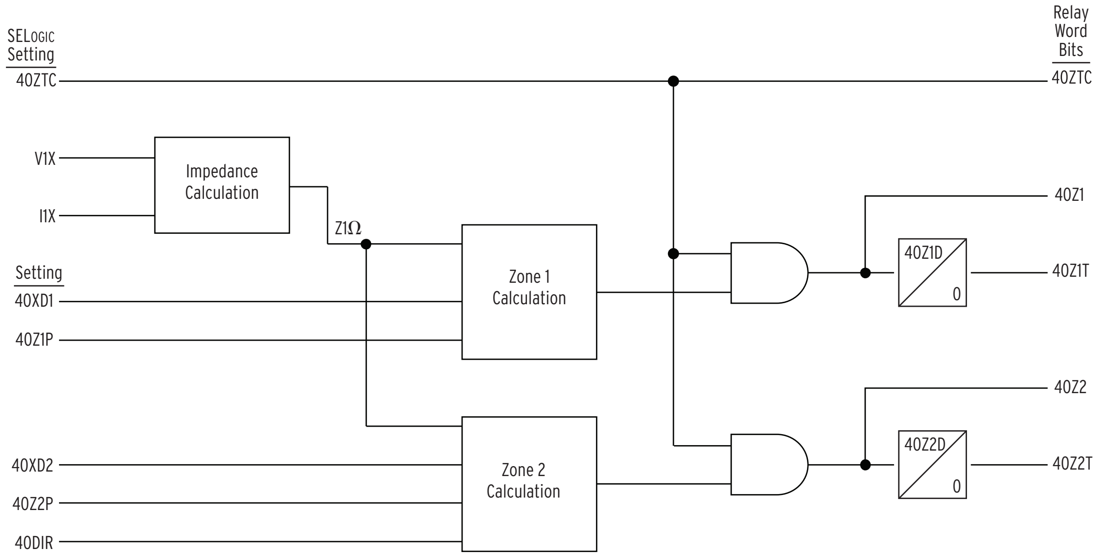


Figure 4.31 Loss-of-Field Logic Diagram

Table 4.10 Loss-of-Field Protection Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
LOSS OF FIELD EN	Y, N	E40 := Y
Z1 MHO DIAMETER	OFF, 0.1–100 ohm[a]	40Z1P := 13.4[a]
Z1 OFFSET	–50.0 to 0.0 ohm[a]	40XD1 := –2.5[a]
Z1 TIME DELAY	0.00–400.00 s	40Z1D := 0.00
Z2 MHO DIAMETER	OFF, 0.1–100 ohm[a]	40Z2P := 13.4[a]
Z2 OFFSET	–50.0 to 50.0 ohm[a]	40XD2 := –2.5[a]
Z2 TIME DELAY	0.00–400.00 s	40Z2D := 0.50
Z2 DIR ANGLE	–20.0 to 0.0 deg	40DIR := –10
40Z TRQCTRL	SELogic	40ZTC := NOT LOPX

[a] Ranges and default settings shown are for 5 A CT. Multiply by 5 for 1 A rated CTs.

Set E40 := Y to enable loss-of-field protection elements. If loss-of-field protection is not necessary, set E40 := N.

The Zone 1 element typically is applied as a tripping function. Zone 1 diameter and offset setting guidelines are described below. Set the Zone 1 offset equal to half the generator transient reactance, X'_d, in secondary ohms. Zone 1 loss-of-field tripping is typically performed with short or zero time delay. Use the 40Z1D setting to add any necessary delay.

The 40Z1 Relay Word bit asserts without time delay when the measured positive-sequence impedance falls within the Zone 1 mho circle defined by the offset and diameter settings.

The 40Z1T Relay Word bit asserts 40Z1D seconds after 40Z1 asserts.

The Zone 2 element typically is applied as a time-delayed tripping function. Zone 2 diameter and offset setting guidelines are described below.

Zone 2 loss-of-field tripping typically is performed with a time delay of 0.5 to 0.6 seconds. Set 40Z2D equal to the necessary delay.

The 40DIR setting is hidden when 40XD2 < 0.

The 40Z2 Relay Word bit asserts without time delay when the measured positive-sequence impedance falls within the Zone 2 mho circle defined by the offset and diameter settings, and below the directional supervision line (if used). The 40Z2T Relay Word bit asserts 40Z2D seconds after 40Z2 asserts.

NOTE: The loss-of-field elements require at least 0.25 volts of positive-sequence voltage and 0.25 amps of positive-sequence current to operate.

The loss-of-field elements are disabled when the 40ZTC SELOGIC control equation equals logical 0. The relay allows these elements to operate when the 40ZTC SELOGIC control equation equals logical 1. With the example setting, the loss-of-field elements operate when the relay detects no loss-of-potential condition.

Setting Calculation

Collect the following information to set loss-of-field.

- Generator direct axis reactance, X_d, in secondary ohms
- Generator transient reactance, X'_d, in secondary ohms
- Generator-rated line-to-line voltage, in secondary volts (V_{nom} = 1000 • VNOM_X/PTRX)
- Generator-rated phase current, in secondary amps (INOM setting)
- When a positive Zone 2 offset is necessary, you also need:
  - Step-up transformer reactance XT, and system reactance Xsys, in secondary ohms
  - Generator-rated power factor

Recommendations

Two methods are available for loss-of-field protection: negative offset Zone 2 and positive offset Zone 2. Recommendations for both setting methods are provided.

Loss-of-Field Protection Using a Negative Offset Zone 2. When setting Zone 2 with a negative offset, set the Zone 1 diameter equal to 1.0 per unit impedance.

$$40Z1P = \frac{V_{nom}}{1.73 \bullet INOM}\ \Omega$$

NOTE: Typically, the X_d is greater than 1 per unit impedance. However, if X_d is less than or equal to 1 per unit impedance, set the 40Z1P shorter so that the worst-case stable power system swing does not enter the Zone 1 characteristic.

Set the Zone 1 offset equal to half the generator transient reactance, X'_d, in secondary ohms.

$$40XD1 = \frac{-X'_d}{2}\ \Omega$$

Zone 1 loss-of-field tripping is typically performed with short or zero time delay.

$$40Z1D = 0.0 \text{ seconds}$$

Set the Zone 2 diameter equal to the machine direct axis reactance, X_d, in secondary ohms.

$$40Z2P = X_d\Omega$$

Set the Zone 2 offset equal to the Zone 1 offset.

$$40XD2 = \frac{-X'_d}{2}\ \Omega$$

Set the Zone 2 time delay long enough to avoid an incorrect operation during a worst-case stable power system swing condition, typically 0.5 to 0.6 seconds or according to the recommendations of the generator manufacturer.

$$40Z2D = 0.5 \text{ seconds}$$

In this case, the 40DIR setting is hidden.

The Relay Word bits 40Z1T and 40Z2T are configured to trip the field breaker and the generator breaker in the factory-default logic (see *Trip/Close Logic Settings* for details). You must change the setting if your application requires a different action.

Loss-of-Field Protection Using a Positive Offset Zone 2. When setting Zone 2 with a positive offset, set the Zone 1 diameter:

$$40Z1P = 1.1 \bullet X_d + \frac{-X'_d}{2}\ \Omega$$

Set the Zone 1 offset equal to half the generator transient reactance, X'_d, in secondary ohms.

$$40XD1 = \frac{-X'_d}{2}\ \Omega$$

Traditionally, the Zone 1 delay for this type of scheme is 0.25 seconds.

$$40Z1D = 0.25 \text{ seconds}$$

Use the direct axis reactance and XS, the sum of the step-up transformer reactance XT and system reactance Xsys, to set the Zone 2 diameter.

$$40Z2P = 1.1 \bullet X_d + XS\ \Omega$$

where

$$XS = XT + Xsys$$

Use the total reactance of XS to set the Zone 2 offset.

$$40XD2 = XS\ \Omega$$

Traditionally, the Zone 2 delay for this type of scheme is approximately 60 seconds (it is advisable to conduct system studies to determine the best time delay when using the positive offset method).

$$40Z2D = 60.0 \text{ seconds}$$

The relay applies a shorter delay if the Zone 2 element picks up at the same time that the relay detects an undervoltage condition. This logic is discussed in the following text. In this case, the 40DIR setting is necessary. Set 40DIR equal to -20 degrees or the arc cosine of the minimum rated power factor, whichever is smaller.

When applying loss-of-field protection with a positive Zone 2 offset, you can use the time-delayed Zone 1 Relay Word bit, 40Z1T, and the long-time-delayed Zone 2 Relay Word bit, 40Z2T, directly in the generator breaker and field breaker tripping SELOGIC control equations.

The traditional application of this scheme provides accelerated (0.25 second) Zone 2 tripping in the event of an undervoltage condition occurring during the loss-of-field. To achieve this accelerated tripping, it is necessary to use a SELOGIC control equation variable and a positive-sequence undervoltage element, 27V1X1. The undervoltage element is generally set to 80 percent of the nominal voltage for single-machine buses and 87 percent for multimachine buses.

$$\text{Set 27V1X1P} = \frac{0.8 * \text{VNOM\_X} * 1000}{1.732 * \text{PTRX}}$$

Use any SELOGIC control equation variable to define a tripping condition for Zone 2 with undervoltage:

SV15 := 27V1X1 AND 40Z2

SV15PU := 0.25 seconds

SV15DO := 0.00 seconds

The Relay Word bit, SV15T, should be added to the SV08 SELOGIC control equation, along with the Zone 1 and Zone 2 conditions discussed previously, to cause generator breaker and field breaker tripping (see *Trip/Close Logic Settings* for details).

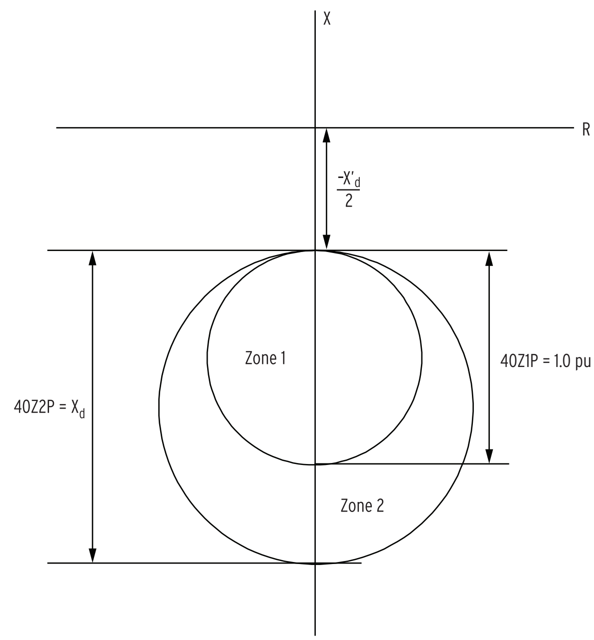


Figure 4.32 Loss-of-Field Element Operating Characteristic, Negative Zone 2 Offset

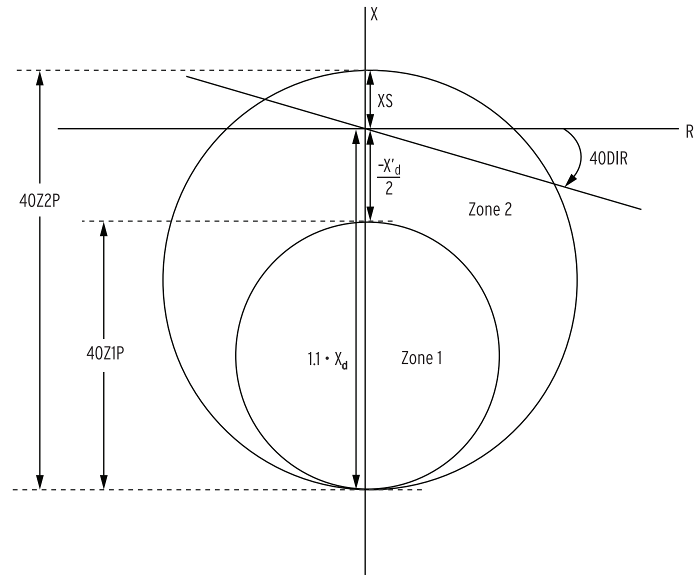


Figure 4.33 Loss-of-Field Element Operating Characteristic, Positive Zone 2 Offset

Current Unbalance Elements

Generator unbalance current causes high rotor heating. IEEE Standard C50.13-1977 defined the ability of generators to withstand unbalance current in terms of negative-sequence current. The standard defines a continuous withstand capability as well as a short-time capability, expressed in terms of I_2^2t.

The SEL-700G provides a negative-sequence definite time-overcurrent element suitable for unbalance alarm application and an I_2^2t time-overcurrent element for unbalance current tripping. The negative-sequence overcurrent elements are supervised by the 46QTC torque-control setting.

Table 4.11 Current Unbalance Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
NEG-SEQ OC ENBL	Y, N	E46 := Y
LVL1 NEG-SEQ O/C	OFF, 2.0–100.0 %	46Q1P := 8.0
LVL1 TIME DELAY	0.02–999.90 s	46Q1D := 30
LVL2 NEG-SEQ O/C	OFF, 2.0–100.0 %	46Q2P := 8.0
LVL1 TIME DIAL	1–100	46Q2K := 10
46Q TRQCTRL	SELOGIC	46QTC := 1

Set E46 := Y to enable negative-sequence overcurrent elements. If negative-sequence overcurrent protection is not necessary, set E46 := N. The Level 1 element is typically applied as an unbalance alarm. The pickup is defined in percent of machine nominal phase current, INOM. Use the 46Q1D setting to add any necessary delay. Disable the element by setting 46Q1P := OFF.

When the measured negative-sequence current is greater than 46Q1P percent of INOM, the current must persist for the duration of the security timer before Relay Word bit 46Q1 asserts. The 46Q1T Relay Word bit asserts 46Q1D seconds after 46Q1 asserts if the unbalance condition continues.

The negative-sequence time-overcurrent element operates with an I_2^2t time characteristic. Set the pickup value equal to the minimum percent of nominal current to which the element must respond. Set the 46Q2K setting equal to the generator-rated I_2^2t short time-current capability rating defined by the generator manufacturer.

When the measured negative-sequence current is greater than 46Q2P percent of INOM, the current must persist for the duration of the security timer before Relay Word bit 46Q2 asserts. The 46Q2T Relay Word bit asserts in a time defined by the time-overcurrent element operating characteristic.

NOTE: The reset of 46Q2 element is independent of the 46QTC setting.

The negative-sequence time-overcurrent element resets after a fixed linear time of 240 seconds. The 46Q2R Relay Word bit asserts when the element is fully reset.

The negative-sequence overcurrent elements are disabled (except the linear reset described previously) when the 46QTC SELOGIC control equation equals logical 0. The elements are allowed to operate when the 46QTC SELOGIC control equation equals logical 1. With the example setting, the elements are always allowed to operate.

Setting Calculation

Gather the following information to calculate the negative-sequence overcurrent setting.

- Generator continuous current unbalance withstand capability, percent of rated current
- Generator negative-sequence current short-time withstand capability, seconds

Recommendations

Set the 46Q1P equal to or less than the generator continuous unbalance current capability.

46Q1P := 8.0–12.0%

Set the 46Q1D time delay greater than the maximum time of normal unbalance current periods, including system phase-fault clearing time. This delay setting prevents unwanted unbalance current alarms.

46Q1D := 30 seconds

Set the 46Q2P setting equal to or less than the generator continuous unbalance current capability.

46Q2P := 8.0–12.0%

Set the 46Q2K setting equal to or less than the generator short-time negative-sequence current capability.

46Q2K = 10

You can define conditions that prevent negative-sequence overcurrent element operation in the 46QTC torque-control setting. Normally, the negative-sequence overcurrent elements should be enabled all the time.

46QTC = 1

Generally, negative-sequence overcurrent tripping is applied to the generator main breaker only. This permits rapid resynchronization after the system unbalance condition clears. The Relay Word bit 46Q2T is configured to trip the generator breaker in the factory-default logic (see *Trip/Close Logic Settings* for details). You must change the setting if your application requires a different action.

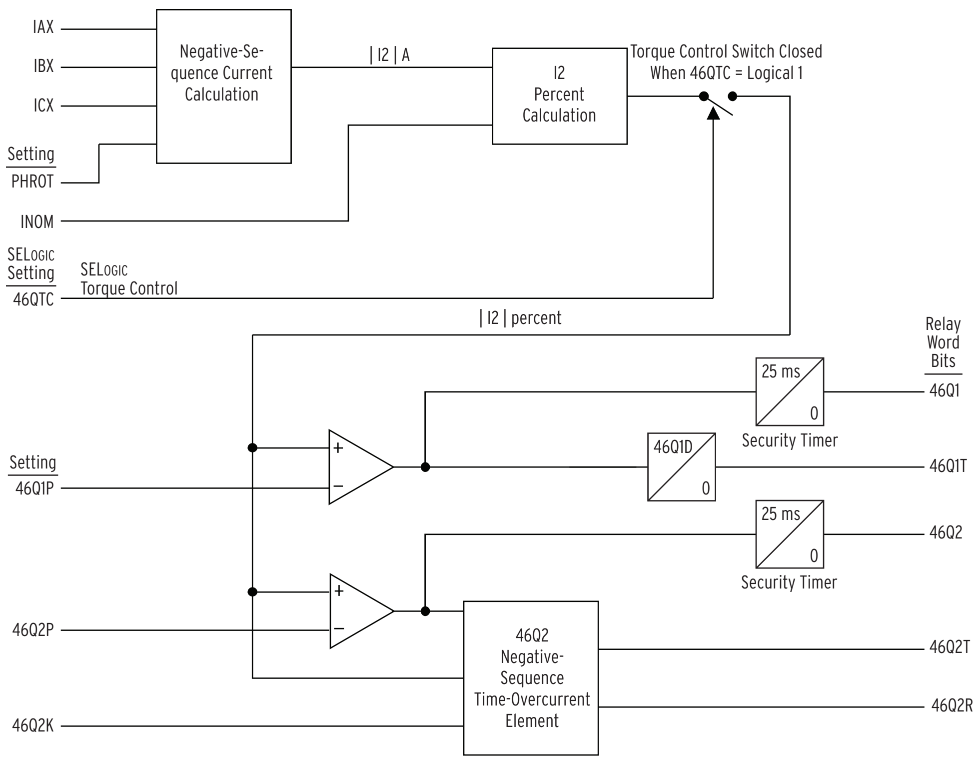
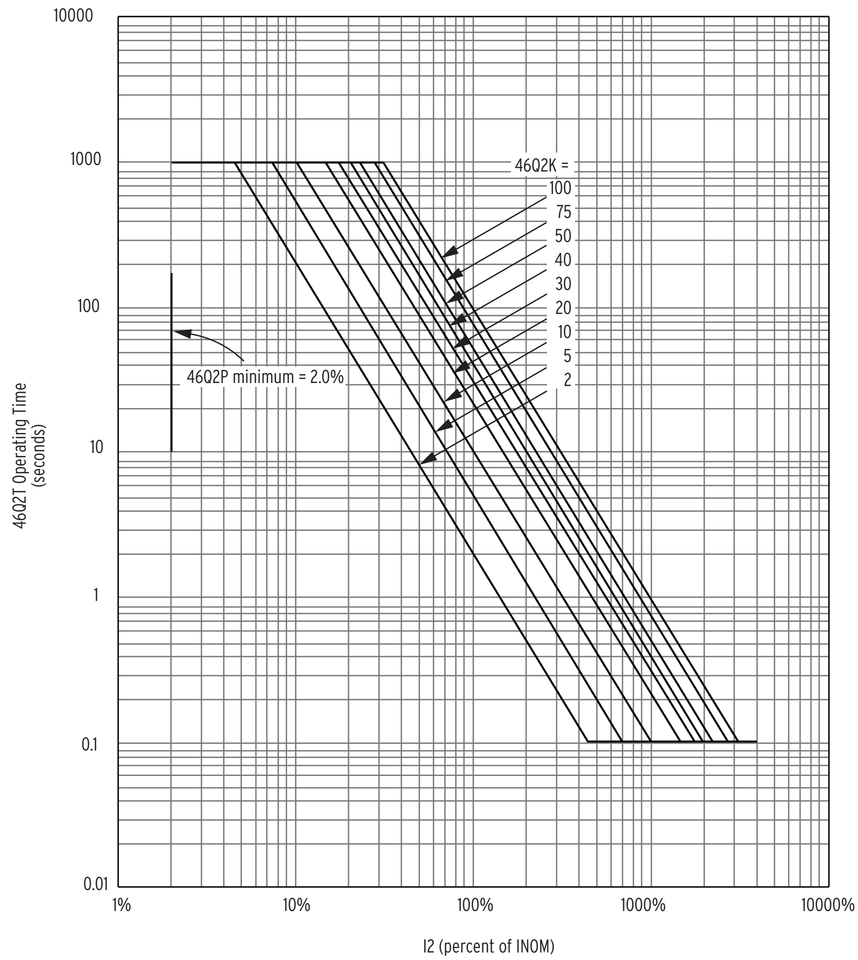


Figure 4.34 Negative-Sequence Overcurrent Element Logic Diagram



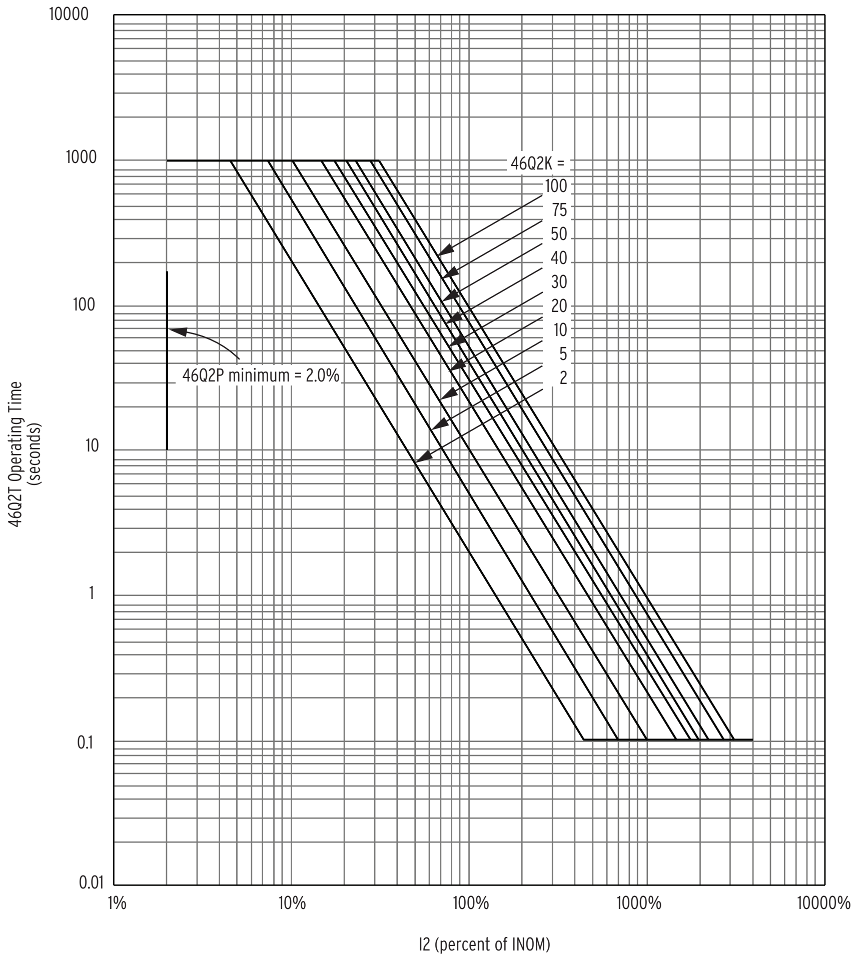
$$t_{op} = \frac{46Q2K}{\left(\frac{I2}{INOM}\right)^2} \text{ seconds}$$

Figure 4.35 Negative-Sequence Time-Overcurrent Operating Characteristic

Thermal Overload Elements

The SEL-700G thermal element provides generator overload protection based on the thermal model described in IEC standard 60255-8. If you have the RTD option, you can bias the model by ambient temperature.

The relay operates a thermal model with a trip value defined by the relay settings and a present heat estimate that varies with time and changing generator current. *Figure 4.36* and *Table 4.12* show a simplified model and available settings, respectively. The relay expresses the present generator thermal estimate as a % Thermal Capacity Used (TCU). The thermal element asserts bit 49A when TCU reaches alarm level setting 49TAP and asserts bit 49T when the TCU reaches 100 percent. The relay uses the dropout level for bit 49A as 90 percent of the pickup to prevent chattering. You can see the present thermal capacity values by using the relay front-panel Meter > Thermal function or the serial port **METER T** command.



$$t_{op} = \frac{46Q2K}{\left(\frac{I2}{INOM}\right)^2} \text{ seconds}$$

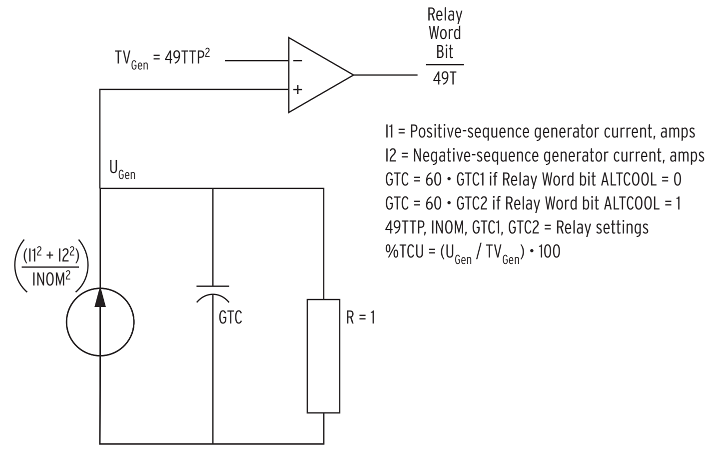


Figure 4.36 Simplified Thermal Model, Generator

Table 4.12 Thermal Overload Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
THERM OVERLD EN	Y, N	E49T := N
THERM OL TRIP PU	0.30–2.50 pu	49TTP := 1.10
TIME CONSTANT1	1–1000 min	GTC1 := 10
TIME CONSTANT2	OFF, 1–1000 min	GTC2 := OFF
ALT COOLING MODE	SELOGIC	ALTCOOL := 0
TCU ALARM PU	OFF, 50–99 %	49TAP := 85
OL RTD BIASING?	Y, N	ETHMBIAS := N

If the thermal model is turned off (E49T := N), the thermal model is disabled, the output of the thermal model is blocked, and the relay reports the % Thermal Capacity as 0, as noted in *Section 5: Metering and Monitoring*.

When you enable overload protection, the relay requires information about the protected generator. Obtain the time constant information from the generator specifications; all other settings are based on the protection practices of the individual user. Set thermal overload level 1 to the necessary overload pickup in per unit of INOM (see *Table 4.2*) and set thermal overload level 2 to the necessary thermal capacity to trigger alarm/indication prior to an overload trip.

Use the Alternate Cooling Mode SELOGIC control equation to dynamically change the time constant for the generator cooling status. For example, ALTCOOL := IN303 switches the time constant a system uses from GTC1 to GTC2 when IN303 asserts, indicating a cooling system failure.

When the relay is monitoring one or more RTDs in the generator windings and an ambient temperature RTD, you can bias the thermal model by ambient temperature when ETHMBIAS := Y. The relay uses the ambient temperature above 40°C and the winding RTD trip temperature setting to calculate the overload RTD bias.

Figure 4.37 shows the generator overload curve for specified settings and preload current. Use the following equation to calculate trip time or to plot the curve for any settings you want.

$$\text{TripTime} = \text{GTC} \bullet \text{LN}\left[\frac{I^2 - Io^2}{I^2 - 49TTP^2}\right] \text{seconds}$$

where

GTC = Generator Time Constant in seconds

I = Generator current in per unit, assuming no negative-sequence current

Io = Generator preload current in per unit, assuming no negative-sequence current

49TTP = Overload level setting in per unit

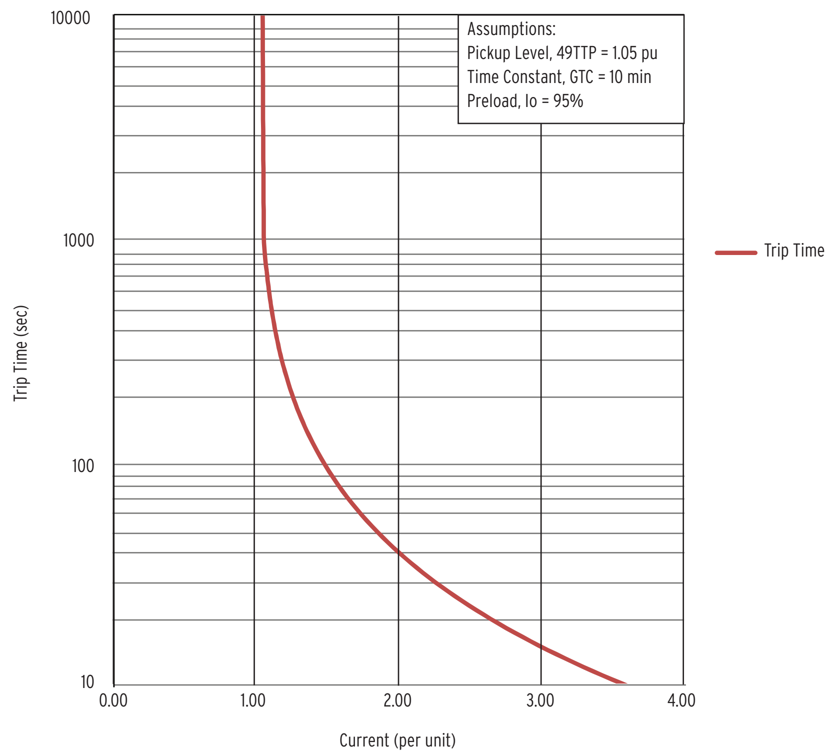


Figure 4.37 Generator Overload Curve

Volts-Per-Hertz Elements

Overexcitation occurs when a generator or transformer magnetic core becomes saturated. When this happens, stray flux is induced in nonlaminated components, causing overheating. In the SEL-700G Relay, a volts/hertz element detects overexcitation. The SEL-700G has a sensitive definite-time volts/hertz element, plus a tripping element with a composite operating time. The relay calculates the present machine volts/hertz as a percentage of nominal, based on the present and nominal voltages and frequencies. The VNOM_X, PTRX, and FNOM settings define the nominal machine voltage and frequency.

Figure 4.38 shows the logic diagram of the volts/hertz elements. If the torque-control 24TC SELogic control equation is true and the volts/hertz value exceeds the 24D1P setting, the relay asserts the 24D1 Relay Word bit and starts the 24D1D timer. If the condition remains for 24D1D seconds, the relay asserts the 24D1T Relay Word bit. Typically, you should apply this element as an overexcitation alarm.

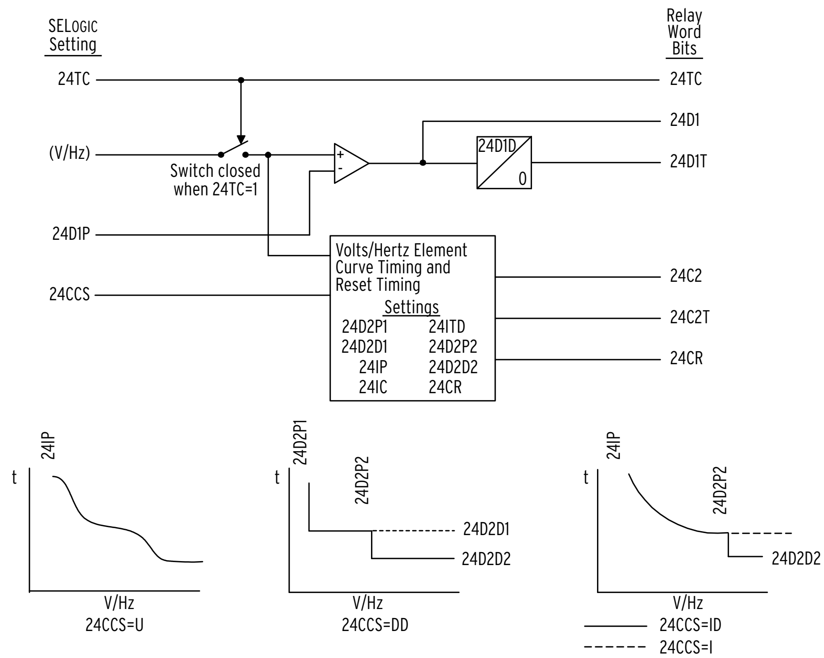


Figure 4.38 Volts/Hertz Element Logic

For volts/hertz tripping, the relay uses a time-integrating element with a settable operating characteristic. You can set the element to operate as an inverse-time element; a user-defined curve element (using the SEL-5806 PC Software); a composite element with an inverse-time characteristic and a definite-time characteristic; or as a dual-level, definite-time element. In any case, the element provides a linear reset characteristic with a settable reset time. The 24TC torque-control setting supervises this element.

The volts/hertz tripping element has a percent-travel operating characteristic similar to that employed by an induction-disk time-overcurrent element. This characteristic coincides well with the heating effect that overexcitation has on generator components.

The element compares the three-phase voltages and uses the highest of the values for the volts/hertz magnitude calculations. The relay asserts the 24C2 Relay Word bit without time delay when the machine volts/hertz value exceeds the element pickup setting, and asserts the 24C2T Relay Word bit after a delay determined by the characteristic setting. The relay tracks the frequency over the range 15 to 70 Hz.

The Relay Word bit 24C2T is configured to trip the field breaker and the generator breaker in the factory-default logic (see *Trip/Close Logic Settings* for details). You must change the setting if your application requires a different action. Volts/hertz logic is discussed in the following section.

Figure 4.39 and *Figure 4.40* are similar to *IEEE C37.102-2006, Guide for AC Generator Protection, Figure 4.5.4-1 and Figure 4.5.4-2*.

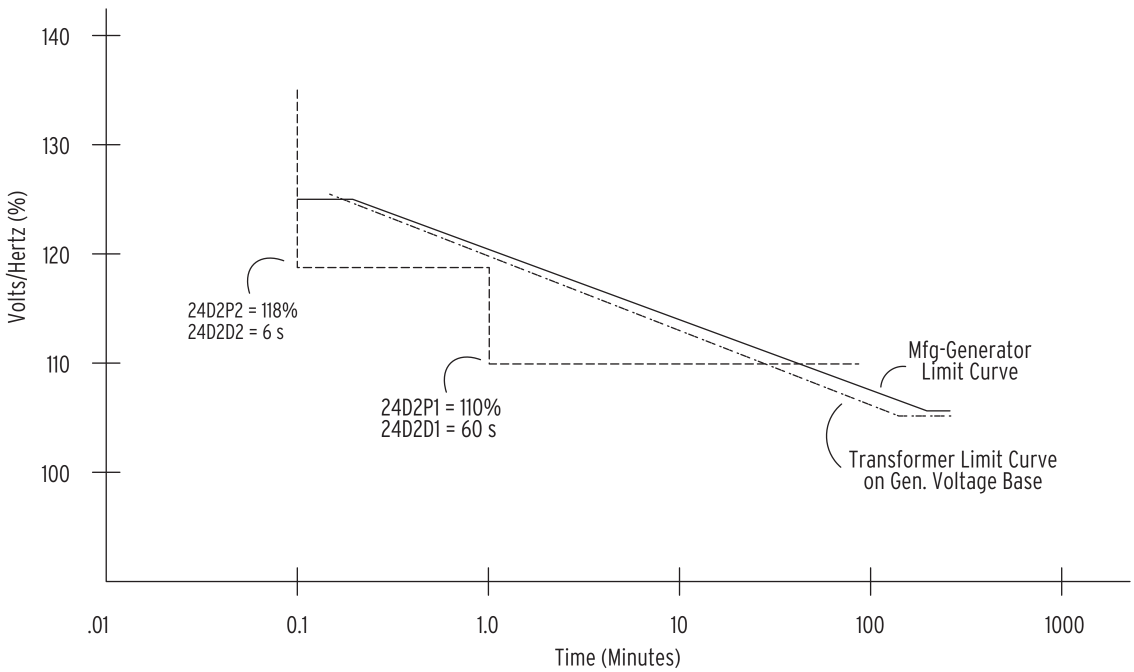


Figure 4.39 Dual-Level Volts/Hertz Time-Delay Characteristic 24CCS = DD

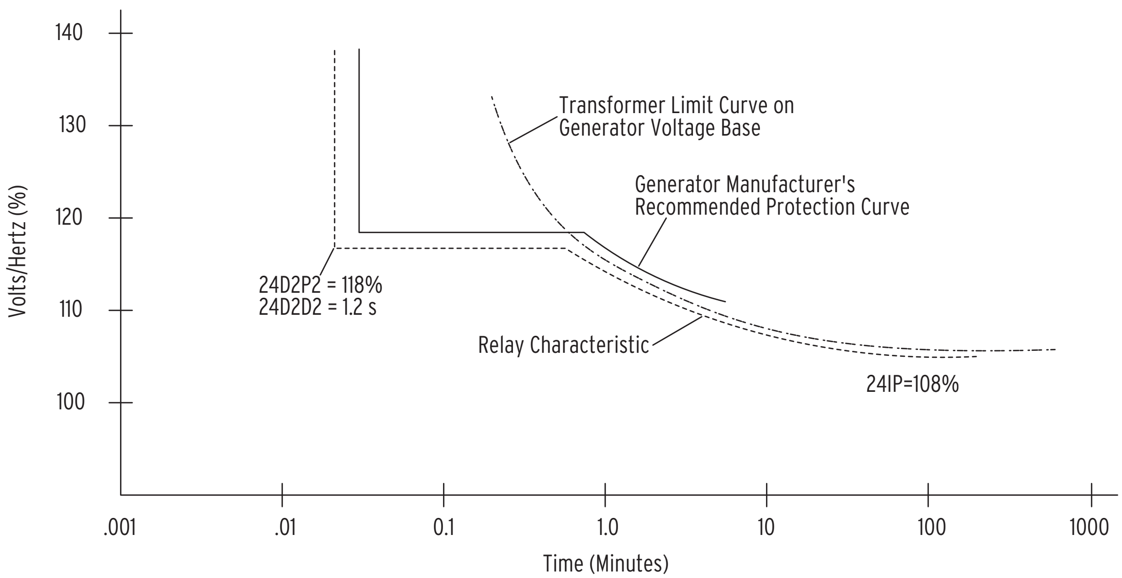


Figure 4.40 Composite Inverse/Definite-Time Overexcitation Characteristic, 24CCS = ID

Table 4.13 Volts-Per-Hertz Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE V/HZ PROT	Y, N	E24 := Y
LVL1 V/HZ PICKUP	100–200 %	24D1P := 105
LVL1 TIME DLY	0.04–400.00 s	24D1D := 1.00
LVL2 CURVE SHAPE	OFF, DD, ID, I, U	24CCS := ID
LVL2 INV-TM PU	100–200 %	24IP := 105
LVL2 INV-TM CURV	0.5, 1, 1.0, 2, 2.0	24IC := 2
LVL2 INV-TM FCTR	0.1–10.0 s	24ITD := 0.1
LVL2 PICKUP 1	100–200 %	24D2P1 := 175
LVL2 TIME DLY 1	0.04–400.00 s	24D2D1 := 3.00
LVL2 PICKUP 2	101–200 %	24D2P2 := 176
LVL2 TIME DLY 2	0.04–400.00 s	24D2D2 := 3.00
LVL2 RESET TIME	0.00–400.00 s	24CR := 240.00
24 ELEM TRQ-CNTRL	SELOGIC	24TC := 1

Collect the following information before calculating the volts/hertz element settings:

- The generator manufacturer's overexcitation limit curve
- The step-up transformer manufacturer's overexcitation limit curve on generator voltage base (if you want transformer overexcitation protection)

Set E24 := Y to enable volts/hertz protection elements. If you do not need volts/hertz protection, set E24 := N. When E24 := N, the 24TC, 24D1, 24D1T, 24C2, 24C2T, and 24CR Relay Word bits are inactive. The relay hides the corresponding settings; you do not need to enter these settings.

The relay uses X-side frequency and the highest phase-to-phase voltage to calculate the actual V/Hz level.

Use the Level 1 volts/hertz element as an overexcitation alarm. Set 24D1P equal to or greater than 105 percent, but less than the minimum pickup of the Level 2 element. Use a 24D1D time delay of 1.0 second to allow time for correction of an overexcitation condition prior to an alarm.

The 24CCS setting defines the overexcitation tripping element time-delay characteristic as shown in *Figure 4.38*. Set 24CCS := OFF if you do not require Level 2 volts/hertz protection. When 24CCS := OFF, the other Level 2 settings are hidden and do not need to be entered.

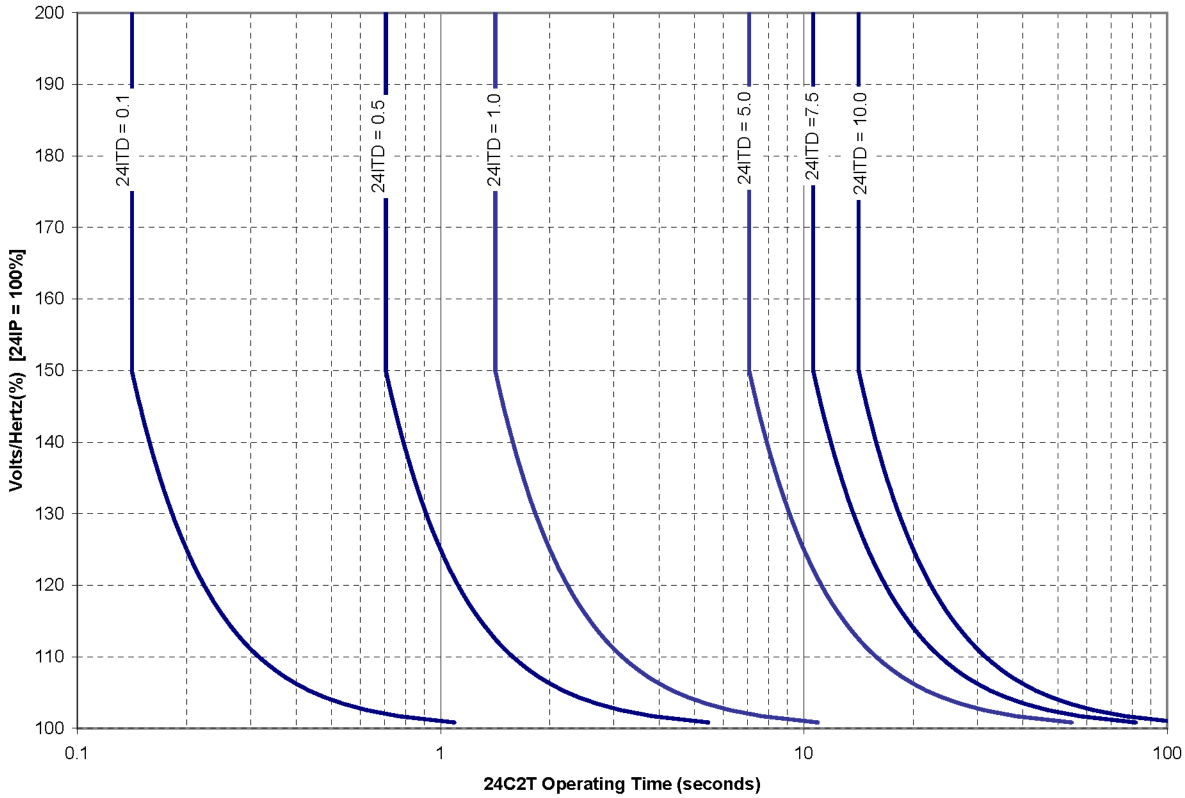
- When 24CCS := DD, the element operates with a dual-level definite-time characteristic with pickup and delay of 24D2P*n* and 24D2D*n* (*n* = 1 or 2).
- When 24CCS := ID, the element operates with a composite inverse-time and definite-time characteristic with pickup of 24IP (inverse-time) and 24D2P2 (definite-time). The 24IC and 24ITD settings define the inverse-time curve shape (see *Figure 4.41* through *Figure 4.43*).

- When 24CCS := I, the element operates with a simple inverse-time characteristic, defined by the 24IP, 24IC and 24ITD settings described previously.
- When 24CCS := U, the element operates with a user-defined inverse-time characteristic with a pickup of 24IP. The user curve should be set with SEL-5806 Curve Designer Software. This program handles individual mapping of points to make a curve that matches any transformer characteristic. It also handles all relay communication by either uploading the current curve or programming a new curve.

NOTE: If 24CCS := U and no user curve is uploaded to the relay, the relay uses the curve corresponding to 24IC := 2.

The 24CR setting defines the composite element reset time. When the element times out to trip, it fully resets 24CR seconds after the applied volts/hertz drops below the element pickup setting. The reset characteristic is linear, so if the element times 60 percent toward a trip, it fully resets (0.6 • 24CR) seconds after the applied volts/hertz drops below the element pickup setting. When the element is reset, the relay asserts the 24CR Relay Word bit.

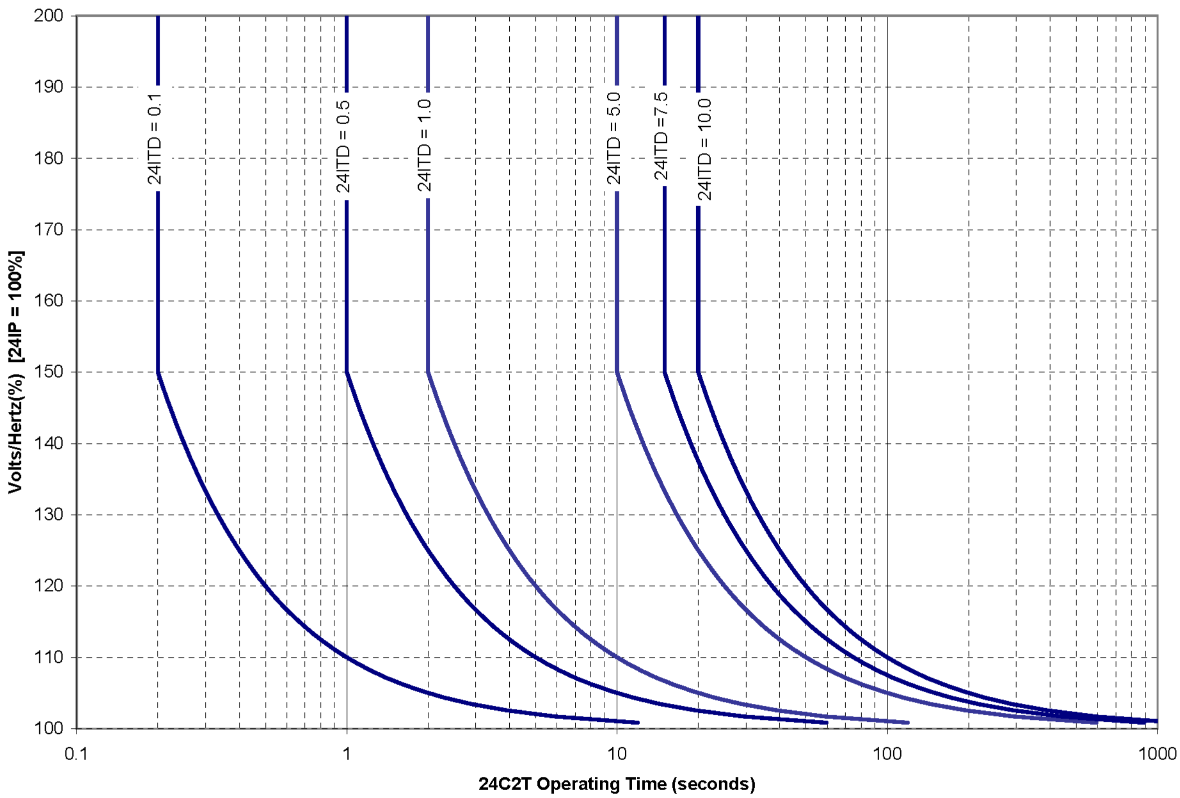
Both volts/hertz elements are disabled when the 24TC SELOGIC control equation equals logical 0. The elements are allowed to operate when the 24TC SELOGIC control equation equals logical 1, the default setting. You can add other supervisory conditions if you need these for your application.



$$t_p = \frac{24ITD}{\left(\left(\frac{\frac{VPP \bullet PTRX}{freq} \bullet \frac{FNOM}{VNOM\_X \bullet 10^3}}{\frac{24IP}{100}}\right) - 1\right)^{0.5}} \text{ seconds} \qquad \text{if V/Hz} \le 1.5 \bullet 24IP$$

$$t_p = 1.414 \bullet 24ITD \text{ seconds} \qquad \text{if V/Hz} > 1.5 \bullet 24IP$$

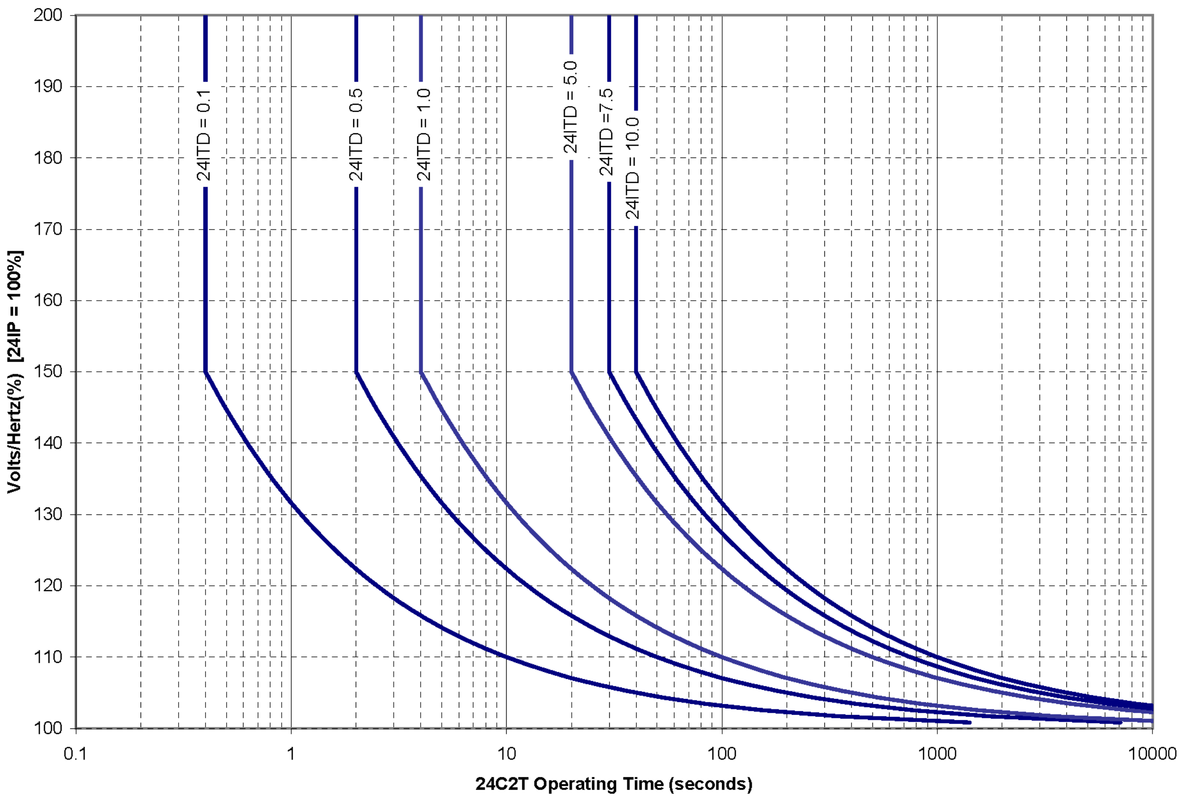
Figure 4.41 Volts/Hertz Inverse-Time Characteristic, 24IC = 0.5



$$t_p = \frac{24ITD}{\left(\left(\frac{\frac{VPP \bullet PTRX}{freq} \bullet \frac{FNOM}{VNOM\_X \bullet 10^3}}{\frac{24IP}{100}}\right) - 1\right)^{1.0}} \text{ seconds} \qquad \text{if } V/Hz \leq 1.5 \bullet 24IP$$

$$t_p = 2.0 \bullet 24ITD \text{ seconds} \qquad \text{if } V/Hz > 1.5 \bullet 24IP$$

Figure 4.42 Volts/Hertz Inverse-Time Characteristic, 24IC = 1



$$t_p = \frac{24ITD}{\left(\left(\frac{\frac{VPP \bullet PTRX}{freq} \bullet \frac{FNOM}{VNOM\_X \bullet 10^3}}{\frac{24IP}{100}}\right) - 1\right)^{2.0}} \text{ seconds} \qquad \text{if } V/Hz \le 1.5 \bullet 24IP$$

$$t_p = 4.0 \bullet 24ITD \text{ seconds} \qquad \text{if } V/Hz > 1.5 \bullet 24IP$$

Figure 4.43 Volts/Hertz Inverse-Time Characteristic, 24IC = 2

Off-Frequency Accumulators

When steam turbine prime movers operate at other than design speed, vibration can cause cumulative metal fatigue in the turbine blades. Eventually, this fatigue can lead to premature and catastrophic turbine blade failure. For steam turbine prime mover applications, the SEL-700G records the total time of operation of the generator at off-nominal frequencies in as many as six frequency bands. This function satisfies the requirements of the IEEE C37.106-2003, Guide For Abnormal Frequency Protection for Power Generating Plants.

If the frequency is within a time-accumulator band, the relay asserts an alarm bit and starts the 62ACC timer for that band. If the frequency remains within the band for greater than 62ACC seconds, the relay begins adding time to that accumulator band timer. If the total time of operation within a particular accumulator band exceeds the limit setting for that band, the relay asserts a Relay Word bit (for example, BND1T), which you can use for alarm and/or trip as necessary.

The accumulator values are nonvolatile and are retained through relay power-off cycles. You can use the relay serial port **GENERATOR** command to view or reset the accumulator values.

Table 4.14 Frequency Accumulation Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE FREQ ACC	N, 1–6	E81ACC := N
FREQ ACC DELAY	00.00–400.00 s	62ACC := 0.16
BAND1 UPPER LIMIT	15.0–70.0 Hz	UBND1 := 59.5
BAND1 LOWER LIMIT	15.0–70.0 Hz	LBND1 := 58.8
BAND1 ACC TIME	0.01–6000.00 s	TBND1 := 3000.00
BAND2 LOWER LIMIT	15.0–70.0 Hz	LBND2 := 58.0
BAND2 ACC TIME	0.01–6000.00 s	TBND2 := 540.00
BAND3 LOWER LIMIT	15.0–70.0 Hz	LBND3 := 57.5
BAND3 ACC TIME	0.01–6000.00 s	TBND3 := 100.00
BAND4 LOWER LIMIT	15.0–70.0 Hz	LBND4 := 57.0
BAND4 ACC TIME	0.01–6000.00 s	TBND4 := 14.00
BAND5 LOWER LIMIT	15.0–70.0 Hz	LBND5 := 56.5
BAND5 ACC TIME	0.01–6000.00 s	TBND5 := 2.40
BAND6 LOWER LIMIT	15.0–70.0 Hz	LBND6 := 40.0
BAND6 ACC TIME	0.01–6000.00 s	TBND6 := 1.00
FREQ ACC TRQCTRL	SELOGIC	81ACCTC := 1

Set 62ACC delay long enough for the system frequency to stabilize within a band before time accumulation starts. Ten cycles or 0.16 seconds is the recommended setting.

Use the torque control setting 81ACCTC to disable the element for conditions during which you do not want to accumulate time. For example, 81ACCTC := NOT 3POX blocks the element until the generator is synchronized and on-line. Relay Word bit FREQTRKX inherently blocks the element if the relay cannot accurately measure the frequency (see *Figure 4.45*).

Abnormal Frequency Protection Setting Calculation

Consult the turbine manufacturer's abnormal operating frequency protection information before calculating the setting.

Recommendations

Steam turbine manufacturers can provide documentation showing turbine operating time limitations during abnormal frequency. This documentation should show continuous operation at nominal frequency, an area of restricted time of operation, and an area of prohibited time of operation. Define accumulator frequency bands and assign times to those bands that prevent the generator from operating in the restricted area. *Figure 4.44* shows an example, with settings shown.

Abnormal Frequency Tripping

Consult the generator and prime mover manufacturers to determine the need to trip the generator when it reaches the set time accumulation.

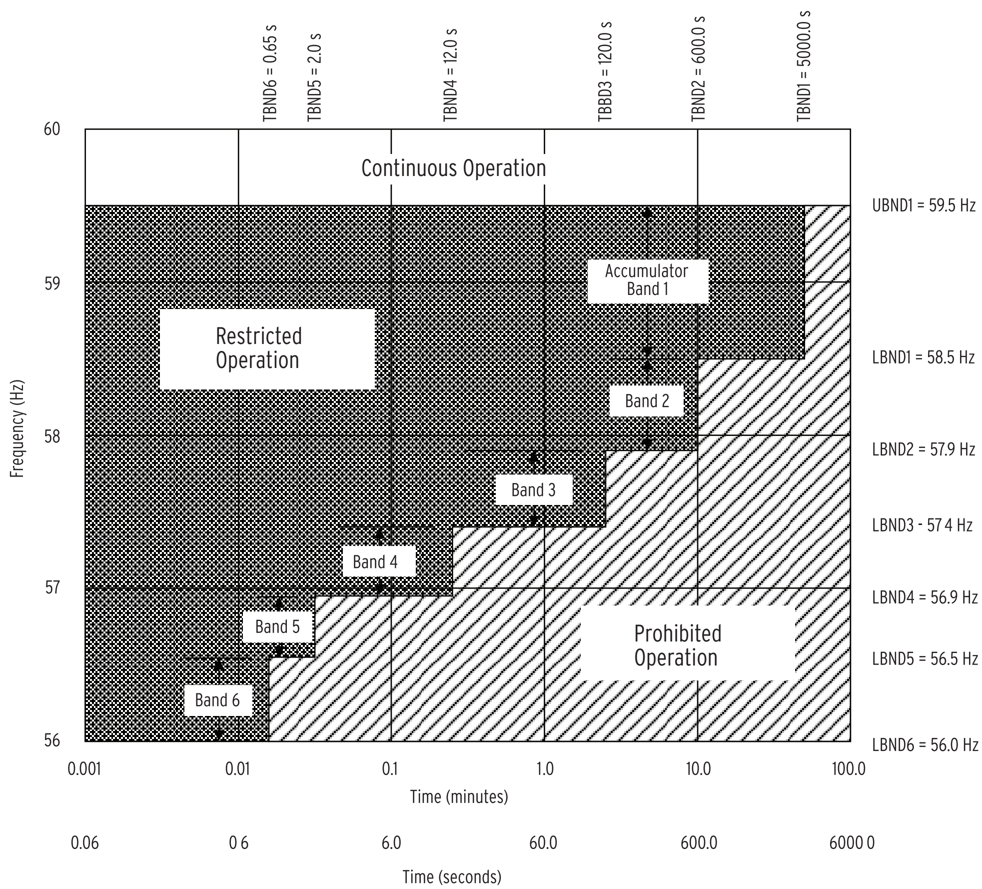


Figure 4.44 Example Turbine Operating Limitations During Abnormal Frequency

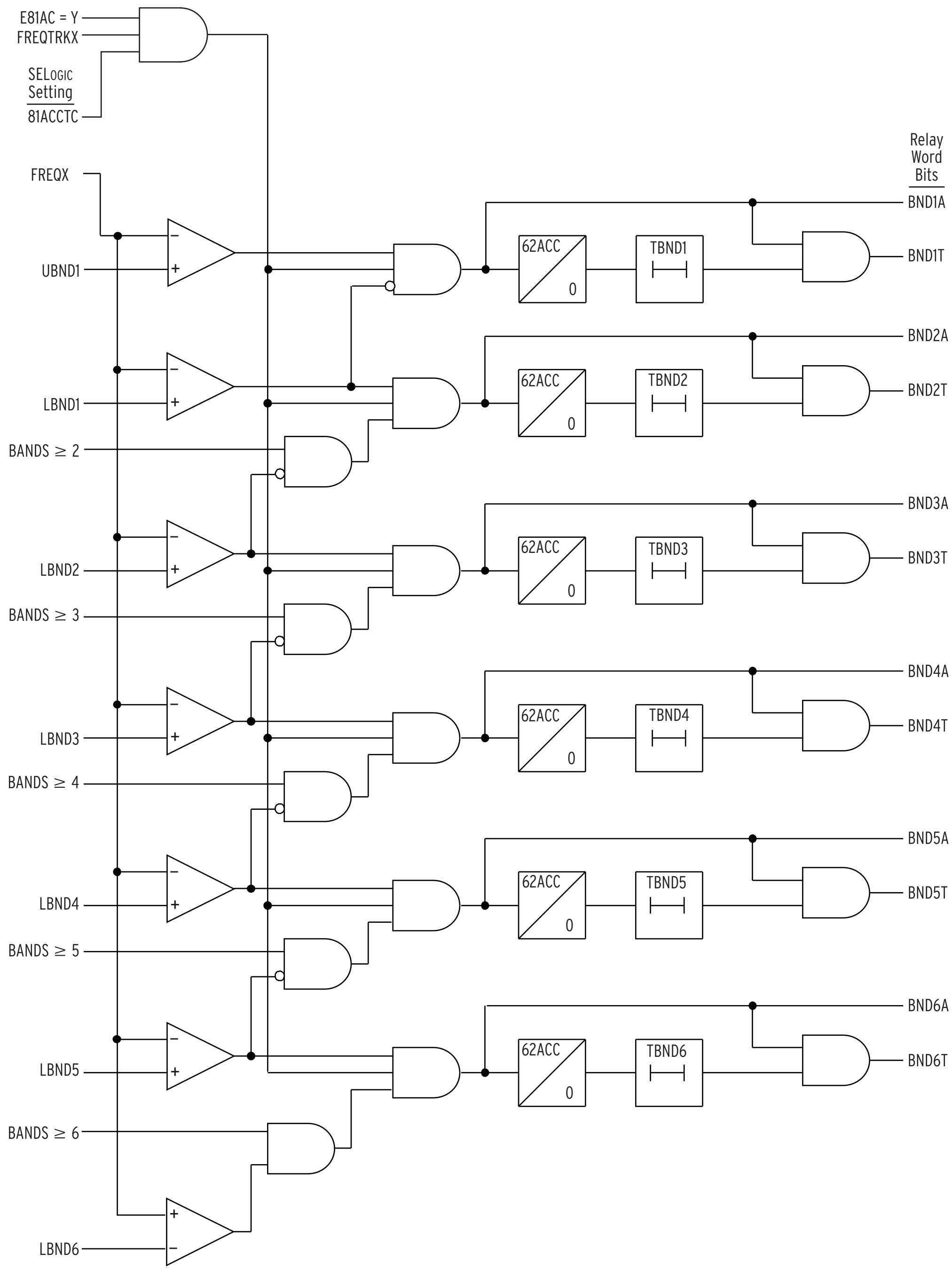


Figure 4.45 Abnormal Frequency Protection Logic Diagram

Out-of-Step Element

The SEL-700G contains an out-of-step element to detect out-of-step conditions between two electrical sources. Two interconnected systems can experience an out-of-step condition for several reasons. For example, loss of excitation can cause a generator to lose synchronism with the rest of the system. Similarly, delayed tripping of a generator breaker to isolate a fault can cause the generator to go out of step with the rest of the system.

Detecting and isolating an out-of-step condition as early as possible is imperative, because the resulting high peak currents, winding stresses, and high shaft torques can be very damaging to the generator and the associated generator step-up transformer.

The SEL-700G implements two out-of-step tripping schemes: single blinder and double blinder. Users can select whichever scheme suits their application, or they can disable out-of-step protection.

Table 4.15 Out-of-Step Protection Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
OUT-OF-STEP PROT	N, 1B, 2B	E78 := 1B
FORWARD REACH	0.1–100.0 ohms[a]	78FWD := 8[a]
REVERSE REACH	0.1–100.0 ohms[a]	78REV := 8[a]
RIGHT BLINDER[b]	0.1–50.0 ohms[a]	78R1 := 6[a]
LEFT BLINDER[b]	0.1–50.0 ohms[a]	78R2 := 6[a]
OUTER BLINDER[c]	0.2–100.0 ohms[a]	78R1 := 6[a]
INNER BLINDER[c]	0.1–50.0 ohms[a]	78R2 := 6[a]
OOS DELAY[c]	0.00–1.00 s	78D := 0.05
OOS TRIP DELAY	0.00–1.00 s	78TD := 0
OOS TRIP DUR	0.00–5.00 s	78TDURD := 0
POS-SEQ CURRENT	0.25-30.00 A[d]	50ABC := 0.25[d]
OOS TRQCTRL	SELOGIC	OOSTC := 1

[a] Ranges and default settings shown are for 5 A CT. Multiply by 5 for 1 A rated CTs.
[b] Right/Left Blinder settings apply to single-blinder scheme (1B) only.
[c] Outer/Inner Blinder and OOS Delay settings apply to double-blinder scheme (2B) only.
[d] Range and default setting shown are for 5 A CT. Divide by 5 for 1 A rated CTs.

Set E78 := 1B or 2B to enable out-of-step protection elements. If out-of-step protection is not necessary, set E78 := N.

Single-Blinder Scheme

The single-blinder scheme, shown in *Figure 4.46*, consists of mho element 78Z1, right blinder 78R1, and left blinder 78R2.

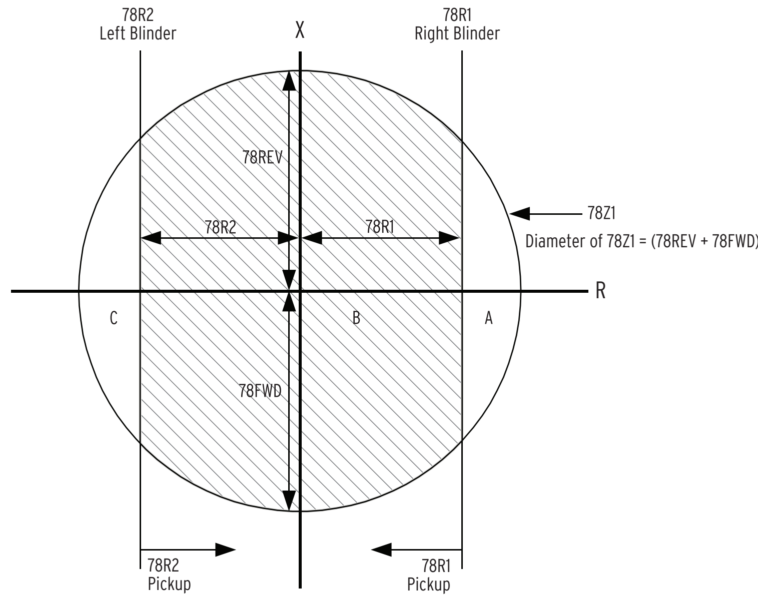


Figure 4.46 Single-Blinder Scheme Operating Characteristics

This scheme detects an out-of-step condition by tracking the path of positive-sequence impedance trajectories that pass through the protection zone. If the relay detects an out-of-step condition, it asserts the following Relay Word bits:

- Relay Word bit SWING picks up when the positive-sequence impedance moves from the load region into Area A (left blinder 78R2 and mho element 78Z1 assert).
- Relay Word bit OOS picks up when the impedance trajectory advances to Area B between the two blinders (right blinder 78R1, left blinder 78R2, and mho element 78Z1 assert).
- At the time the impedance trajectory exits the mho circle via Area C, the rising-edge triggered timer with 78TD pickup delay and 78TDURD dropout-delay starts timing. Relay Word bit OOST remains picked up for 78TDURD seconds after the pickup delay time 78TD expires.
- The previous description is only for trajectories traveling from right to left. Out-of-step trajectories traveling from left to right traverse the protection zone in the reverse sequence (that is, from Area C to B to A). The Relay Word bits assert in the same way, whether trajectories travel from right to left or from left to right.

The single-blinder scheme distinguishes between short-circuit faults and out-of-step conditions by tracking the path of the impedance trajectory. During short-circuit faults, the impedance moves from the load region to inside the mho element and between the two blinders almost instantaneously, preventing the out-of-step function from picking up.

Figure 4.47 shows the logic diagram for the single-blinder scheme. In the figure, the states of 78R1 and 78R2 are latched on the rising edge of SWING to determine if the swing has entered the 78Z1 mho circle from the right or the left. (For an OOST to occur, the swing must exit the 78Z1 mho circle in the opposite direction from which it entered.) The latched states of 78R1 and 78R2 are retained until the next time SWING asserts, which is the next time a power system swing occurs.

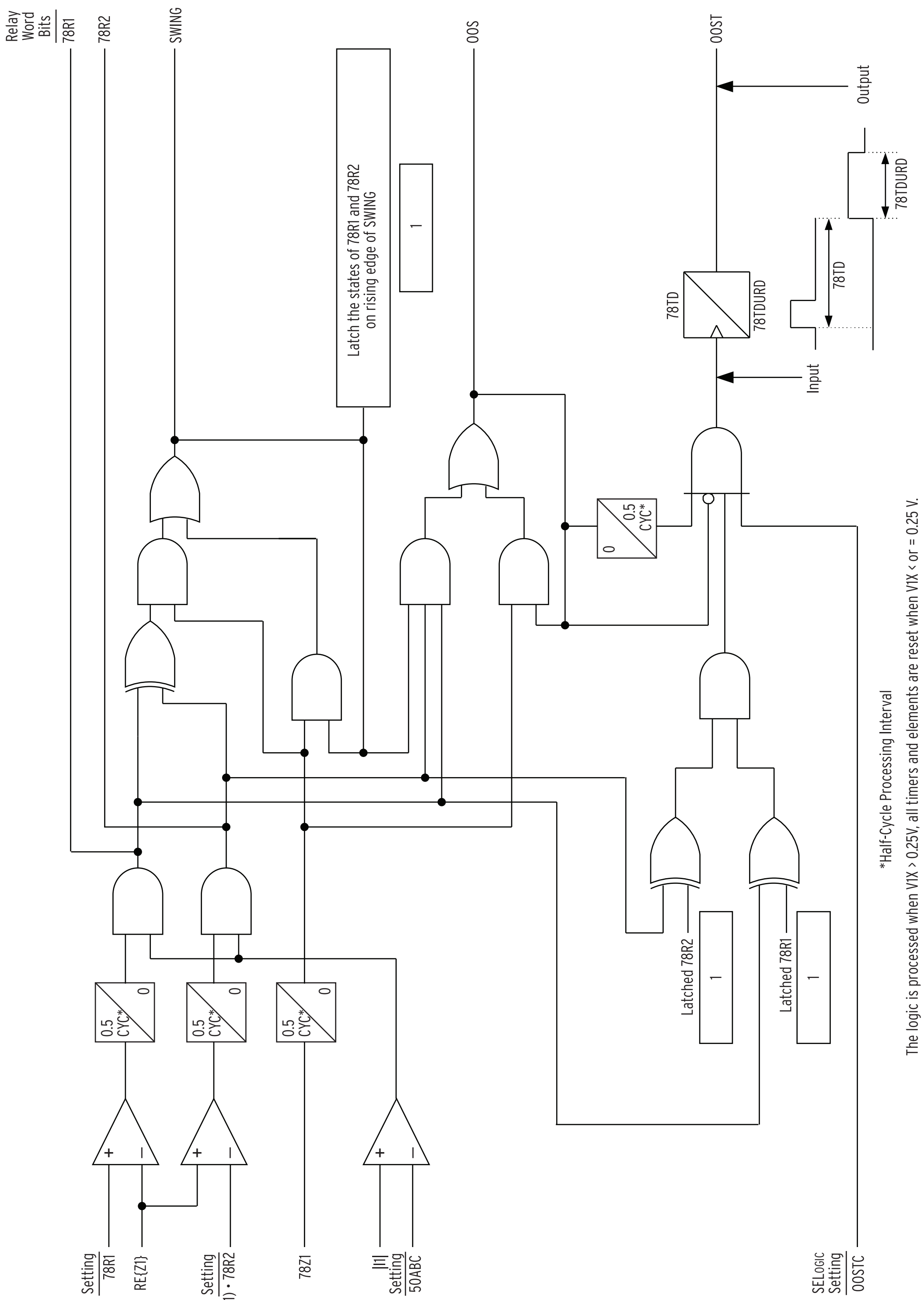


Figure 4.47 Single-Blinder Scheme Logic Diagram

The sum of the forward and reverse reaches (the diameter of the mho circle) has to be 100 ohms or less for a 5 A relay and 500 ohms or less for a 1 A relay.

The blinder settings must be greater than or equal to five percent of either the forward or the reverse reach, whichever is greater.

The 78 element torque control SELOGIC control equation OOSTC has a default setting of one. If this value is left at one, the out-of-step element is not controlled by any other conditions external to the element. However, users can block the operation of the 78 element for certain conditions, such as the presence of excessive negative-sequence currents, by setting OOSTC to NOT 46Q1. Refer to *Logic Settings (SET L Command) on page 4.208* for a detailed discussion of SELOGIC control equations.

The trip delay timer also has an adjustable dropout delay 78TDURD (Trip Duration). The 78TDURD should be set appropriately if the Relay Word bit OOST is configured to operate an output contact directly. The default setting for 78TDURD is zero because the Relay Word bit OOST is configured to trip the generator breaker with default trip logic TRX (which includes an identical timer TDURD). You must change the settings (trip logic and/or 78TDURD) if your application requires a different action.

The scheme includes positive-sequence current supervision setting 50ABC, which has a setting range of 0.25–30.00 A for 5 A relays and 0.05–6.00 A for 1 A relays. Normally, a setting of 0.25 A for 5 A relays is adequate for most applications; however, a higher setting can be applied based on minimum expected swing currents. Note that the positive-sequence current levels below the 50ABC setting block the out-of-step function.

Both 78R1 and 78R2 must be within the mho circle.

Settings Calculation. Collect the following information to calculate the out-of-step protection settings.

- Generator transient reactance, X'_d, in secondary ohms
- Generator step-up transformer impedance in secondary ohms
- Impedance of line or lines beyond the generator step-up transformers, if necessary

Convert all impedances to generator base kV.

Recommendations. *Figure 4.48* shows the elements set according to the following recommendations.

A transient stability study normally provides adequate data for setting the elements and timers properly. The out-of-step protection zone, which is limited by mho element 78Z1, should extend from the generator neutral to the high-side bushings of the generator step-up transformer. Normally, set forward reach 78FWD at 2–3 times the generator transient reactance, X'_d, and set reverse reach 78REV at 1.5–2.0 times the transformer reactance, XT, to provide adequate coverage with a margin of error.

Set the left and right blinders to detect all out-of-step conditions. To do this, the right and left blinders are set so that the equivalent machine angles α and β are approximately 120 degrees, as shown in *Figure 4.48*. Separation angles of 120 degrees or greater between the two sources usually results in loss of synchronism.

Make sure that the mho element and the blinders do not include the maximum possible generator load, to avoid assertion of 78Z1, 78R1, and 78R2 under normal system operation.

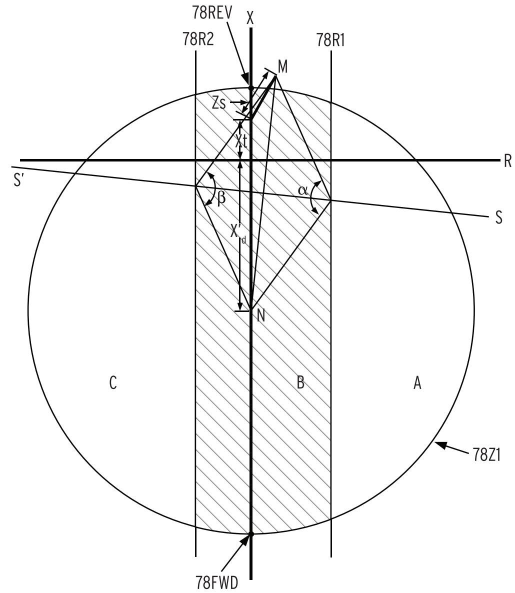


Figure 4.48 Single-Blinder Typical Settings

Double-Blinder Scheme

The double-blinder scheme, shown in *Figure 4.49*, consists of mho element 78Z1 and two blinder pairs: outer resistance blinder 78R1 and inner resistance blinder 78R2. This scheme uses timer 78D as part of its logic to detect out-of-step conditions. The scheme declares an out-of-step condition if the positive-sequence impedance stays between the two blinders for more than 78D seconds and advances farther inside the inner blinder. The logic issues an out-of-step trip once an out-of-step condition is established and the positive-sequence impedance exits the mho circle.

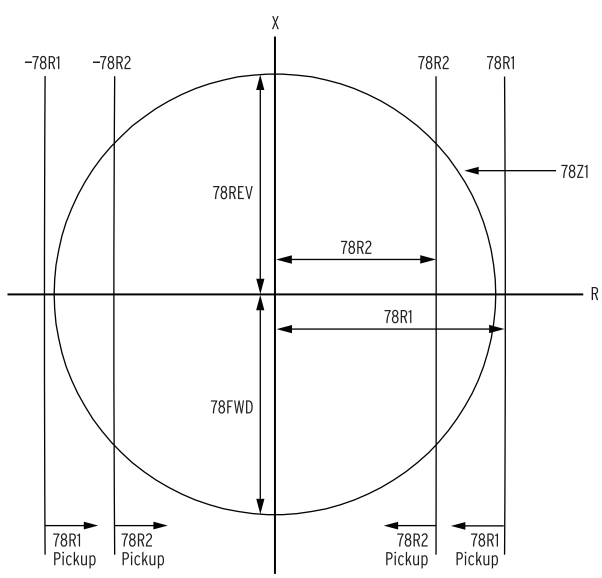


Figure 4.49 Double-Blinder Scheme Operating Characteristics

If the relay detects an out-of-step condition, it asserts the following Relay Word bits:

- Relay Word bit SWING picks up when the positive-sequence impedance stays between the outer and inner blinders for more than 78D seconds (78R1 asserts, mho element 78Z1 may or may not assert).
- Relay Word bit OOS picks up when the impedance trajectory advances farther inside the inner blinder (78R1, 78R2, and mho element 78Z1 assert).
- At the time the impedance trajectory exits the mho circle, the rising-edge triggered timer with 78TD pickup delay and 78TDURD dropout delay starts timing. Relay Word bit OOST remains picked up for 78TDURD seconds after pickup delay time 78TD expires.

The double-blinder scheme distinguishes between short-circuit faults and out-of-step conditions by monitoring the length of time that the impedance trajectory stays between the two blinders. During short-circuit faults, the impedance either moves inside the inner blinder or goes through the two blinders almost instantaneously so that the 78D does not time out. Either case prevents the out-of-step element from picking up. *Figure 4.50* shows the logic diagram for the double-blinder scheme.

The sum of the forward and reverse reaches (the diameter of the mho circle) has to be 100 ohms or less for a 5 A relay and 500 ohms or less for a 1 A relay.

Set the inner blinder (78R2) so that its setting is greater than or equal to five percent of either the forward or the reverse reach, whichever is greater.

The 78 element torque control SELOGIC control equation OOSTC has a default setting of one. If this value is left at one, the out-of-step element is not controlled by any other conditions external to the element. However, users can block operation of the 78 element for certain conditions, such as the presence of excessive negative-sequence currents, by setting OOSTC to NOT 46Q1. Refer to Logic Settings (SET L Command) for a detailed discussion of SELOGIC control equations.

The scheme includes positive-sequence current supervision setting 50ABC, which has a setting range of 0.25–30.00 A for 5 A relays and 0.05–6.00 A for 1 A relays. Normally, a setting of 0.25 A for 5 A relays is adequate for most applications. However, a higher setting can be applied based on minimum expected swing currents. Note that the positive-sequence current levels below the 50ABC setting block the out-of-step function.

The trip delay timer also has an adjustable dropout delay 78TDURD (Trip Duration). The 78TDURD should be set appropriately if the Relay Word bit OOST is configured to operate an output contact directly. The default setting for the 78TDURD is zero because the Relay Word bit OOST is configured to trip the generator breaker with default trip logic TRX (which includes an identical timer TDURD). You must change the settings (trip logic and/or 78TDURD) if your application requires a different action.

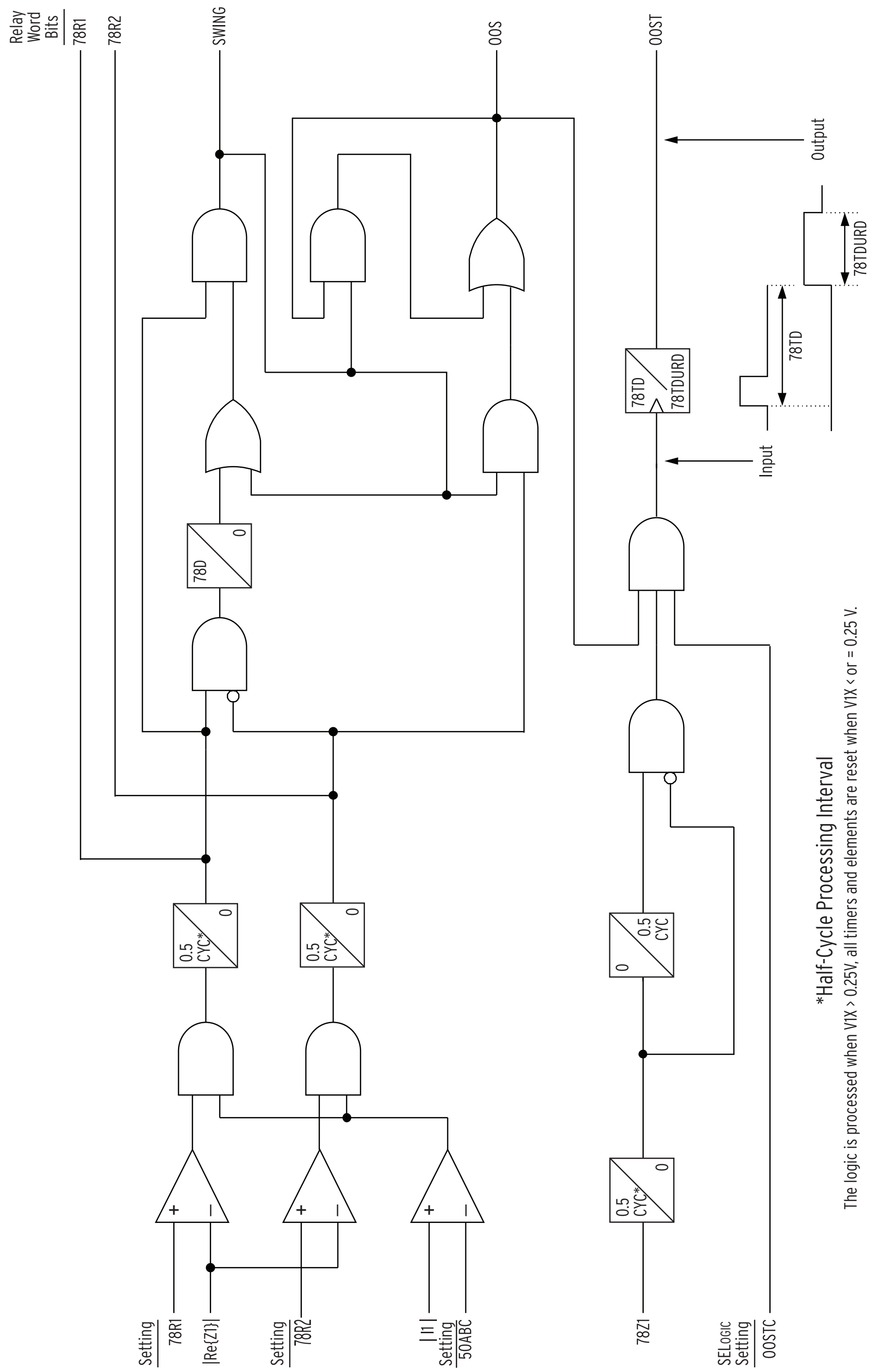


Figure 4.50 Double-Blinder Scheme Logic Diagram

The inner resistance blinder must be inside the mho circle while the outer resistance blinder should be outside the mho circle for the logic to operate correctly.

Settings Calculation. Collect the following information to calculate the out-of-step protection settings.

- Generator transient reactance, X'_d in secondary ohms.
- Generator step-up transformer impedance in secondary ohms.
- Impedance of line or lines beyond the generator step-up transformers, if necessary.

Convert all impedances to generator base kV.

Recommendations. *Figure 4.51* shows the elements set according to the following recommendations.

The out-of-step protection zone, which is limited by mho element 78Z1, should extend from the generator neutral to the high-side bushings of the generator step-up transformer. Normally, the forward reach 78FWD of the mho element is set at 2–3 times the generator transient reactance X'_d and its reverse reach 78REV at 1.5–2 times the transformer reactance, XT. These settings for the forward and the reverse reach provide adequate coverage plus some margin. Refer to *Figure 4.51* for details.

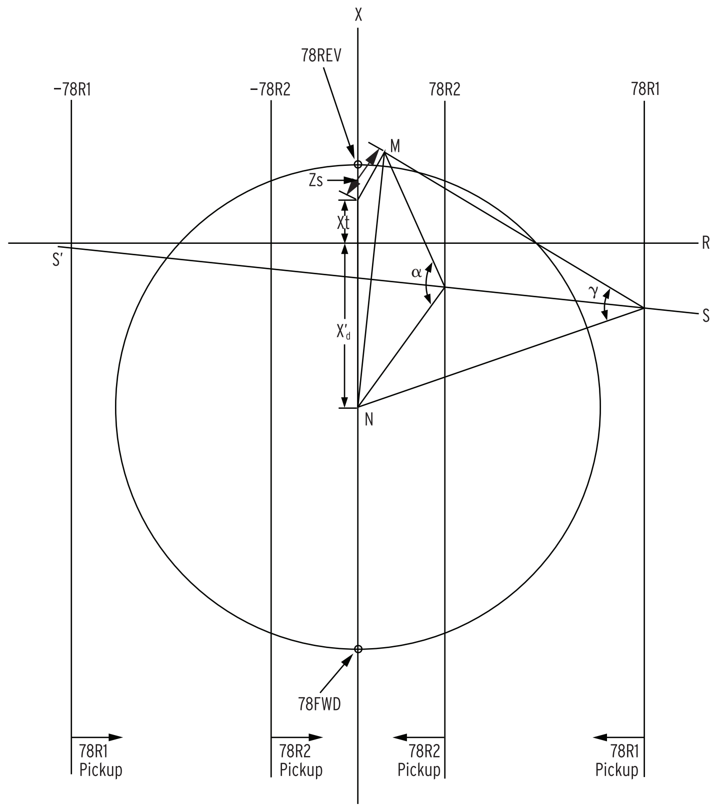
Set the inner blinder 78R2 to detect all out-of-step conditions. To do this, set the inner blinder so that the equivalent machine angle, shown in *Figure 4.51*, is approximately 120 degrees. A separation angle of 120 degrees or greater between two sources generally results in loss of synchronism.

The outer blinder 78R1 and out-of-step timer 78D should be set to satisfy the following:

- The outer blinder should not assert on maximum load.
- The outer blinder should lie outside the mho circle, to satisfy the relay logic.
- The outer blinder should separate from the inner blinder far enough to ensure that the 78D timer accurately times the out-of-step slip cycle.

The SEL-700G processes the out-of-step logic every half cycle of the system frequency. To ensure that the relay times the out-of-step slip frequency accurately, the outer and inner blinders must be separated appropriately. For example, assume that the highest out-of-step frequency encountered is five slip cycles per second, which translates to 30 degrees per cycle (60 Hz). Set the blinders with a 70-degree separation. This separation translates to a positive-sequence impedance travel time of 2.3 cycles between the two blinders, which should provide adequate timing accuracy. Set the 78D timer at approximately 0.034 seconds (two cycles), which ensures that 78D will pickup for swings traveling at 30 degrees per cycle or less.

The out-of-step slip frequency is a system-specific value. A transient stability study normally determines this variable and, therefore, the double-blinder settings.



78FWD: Forward Reach
78REV: Reverse Reach
X'_d: Generator Transient Reactance
XT: Transformer Reactance
ZS: System Impedance
M-N: Total Impedance Between Generator and System
S-S': Perpendicular Bisector of M-N
α: Angle of Separation Between Generator and System Measured at 78R2
γ: Angle of Separation Between Generator and System Measured at 78R1

Figure 4.51 Double-Blinder Typical Settings

Inadvertent Energization

Inadvertent energization occurs when the generator main circuit breaker or auxiliary transformer circuit breaker is incorrectly closed to energize the generator while the generator is out of service. When this occurs, the generator can act as an induction motor, drawing as much as four to six times rated stator current from the system. These high stator currents induce high currents in the rotor, quickly damaging the rotor.

The SEL-700G INADT element is intended to provide an inadvertent energization protection. Two accepted approaches are voltage-supervised overcurrent relays and auxiliary contact-supervised overcurrent relays. The INADT element supports both.

The objective of inadvertent energization protection is to detect that the generator has been re-energized suddenly after being removed from service. *Table 4.16* shows the settings associated with the element.

Table 4.16 Inadvertent Energization Protection Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
INADV ENRG EN	Y, N	EINAD := N
GEN DE-ENRG PU	0.00-100.00 s	GENDEPU := 2
GEN DE-ENRG DO	0.00-100.00 s	GENDEDO := 1
INADV ENRG PU	0.00-10.00 s	INADPU := 0.25
INADV ENRG DO	0.00-10.00 s	INADDO := 0.13
INADV TRQCTRL	SELOGIC	INADTC := 3POX

Some indicators that the generator is removed from service include:

- Low terminal voltage
- Field circuit breaker is open
- No phase current

Set 27V1X1P pickup (see *Table 4.43* for the undervoltage element settings) to a low value to ensure that there is no voltage at the generator terminals. Use the SELOGIC control equation INADTC to indicate open generator breaker and/or field breaker. The SEL-700G uses Relay Word bit 50LX as a generator current detector. See *Pole Open Logic on page 4.200* for details.

Settings GENDEPU and GENDEDO provide time-delay pickup and dropout to the logic. The time-delay pickup adds an arming delay to prevent the scheme from arming prematurely when the generator is removed from service. The dropout time ensures that the scheme trips when the relay detects current during an inadvertent energization.

See *Figure 4.52* for the logic diagram of the scheme. The Relay Word bit INADT is configured to shut down the generator in the factory-default logic. Refer to *Trip/Close Logic Settings on page 4.201* for details. You must change the setting if your application requires a different action.

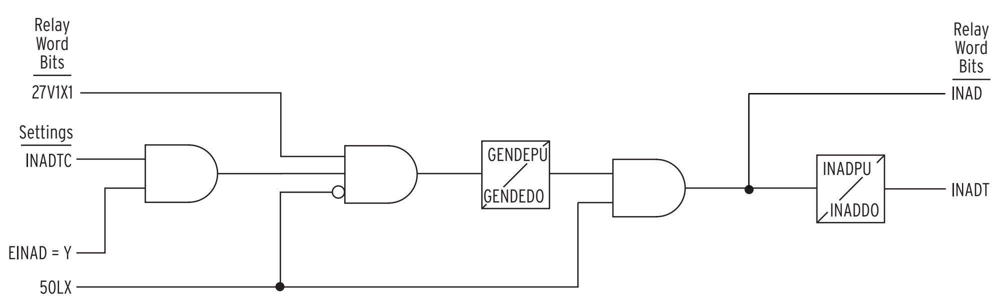


Figure 4.52 Inadvertent Energization Logic Diagram

NOTE: Because this protection scheme is disabled when generator terminal voltage returns to near normal, it does not provide protection for generator energization that results from breaker flashover prior to synchronizing.

Following are some setting guidelines for the inadvertent energization logic:

- Set 50LXP (see *Table 4.60*) equal to 0.25 A secondary, for most applications, to provide maximum current sensitivity. A higher pickup setting may be necessary in special cases (static start of a gas turbine, for example) to prevent assertion of Relay Word 50LX by the starting current.
- The default for the torque control setting INADTC is 3POX. The Relay Word bit 3POX logic includes generator current and main breaker auxiliary contact input (see *Figure 4.132*). If necessary, change the setting INADTC to suit your application.

➤ The GENDEDO setting ensures that inadvertent energization protection remain armed for 1 second after the 27V1X1 element deasserts to allow for reapplication of the generator field. If you can parallel the generator within 1 second of reenergizing the field, shorten the GENDEDO setting.

➤ INADPU must be set less than GENDEDO.

Intertie and Feeder Protection

This section describes elements associated primarily with intertie protection, but which may also be applied to generator and feeder protection. Refer to *Table 1.2* for the list of elements included in various relay models.

Overcurrent Elements

Three levels of instantaneous/definite-time elements are available for phase and two levels of neutral, residual, and negative-sequence overcurrent, as shown in *Table 4.17* through *Table 4.20* and in *Figure 4.53*, *Figure 4.54* and *Figure 4.56*. Refer to *Table 1.2* for the available elements in specific relay models.

Each element can be torque controlled through the use of appropriate SELOGIC control equations (for example, when 50PY1TC := IN401, the 50PY1 element operates only if IN401 is asserted). Also, the level 1 and level 2 elements can be controlled by directional elements according to the relay model number (refer to *Table 1.2* and *Table 4.34*). Directional elements are described later in this section. Level 3 elements (phase overcurrent) are always non-directional.

Table 4.17 Phase Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default[a]
PHASE IOC LEVEL	OFF, 0.50–96.00 A[b]	50P*m*1P := OFF
PHASE IOC DELAY	OFF, 0.00–400.00 s	50P*m*1D := 0.00
PH IOC TRQCTRL	SELOGIC	50P*m*1TC := 1
PHASE IOC LEVEL	OFF, 0.50–96.00 A[b]	50P*m*2P := OFF
PHASE IOC DELAY	OFF, 0.00–400.00 s	50P*m*2D := 0.00
PH IOC TRQCTRL	SELOGIC	50P*m*2TC := 1
PHASE IOC LEVEL	OFF, 0.50–96.00 A[b]	50P*m*3P := OFF
PHASE IOC DELAY	OFF, 0.00–400.00 s	50P*m*3D := 0.00
PH IOC TRQCTRL	SELOGIC	50P*m*3TC := 1

[a] m = X or Y.
[b] Setting ranges shown are for 5 A nominal CT rating. Divide by 5 for 1 A CTs.

NOTE: The cosine filter provides excellent performance in removing dc offset and harmonics. However, the bipolar peak detector has the best performance in situations of severe CT saturation when the cosine-filter magnitude estimation is significantly degraded. Combining the two methods provides an elegant solution for ensuring dependable short-circuit overcurrent element operation.

Normally, the phase instantaneous overcurrent elements (50Pm1 through 50Pm3) use the output of the one-cycle cosine-filtered phase current to operate (see *Figure 4.53*). During severe CT saturation, a distorted secondary waveform can substantially reduce the cosine-filtered phase magnitude. Relying solely on the output of the cosine-filtered secondary current can jeopardize the operation of the high-set instantaneous overcurrent element. In the SEL-700G Relay, for any phase instantaneous overcurrent element set above eight times the relay current input rating (40 A in a 5 A relay), the overcurrent element also uses the output of a bipolar peak detector when the current waveform is highly distorted. This ensures fast operation of the 50P*mn* phase overcurrent elements even with severe CT saturation.

When the harmonic distortion index exceeds the fixed threshold, which indicates severe CT saturation, the phase overcurrent elements operate on the output of the peak detector. When the harmonic distortion index is below the fixed threshold, the phase overcurrent elements operate on the output of the cosine filter.

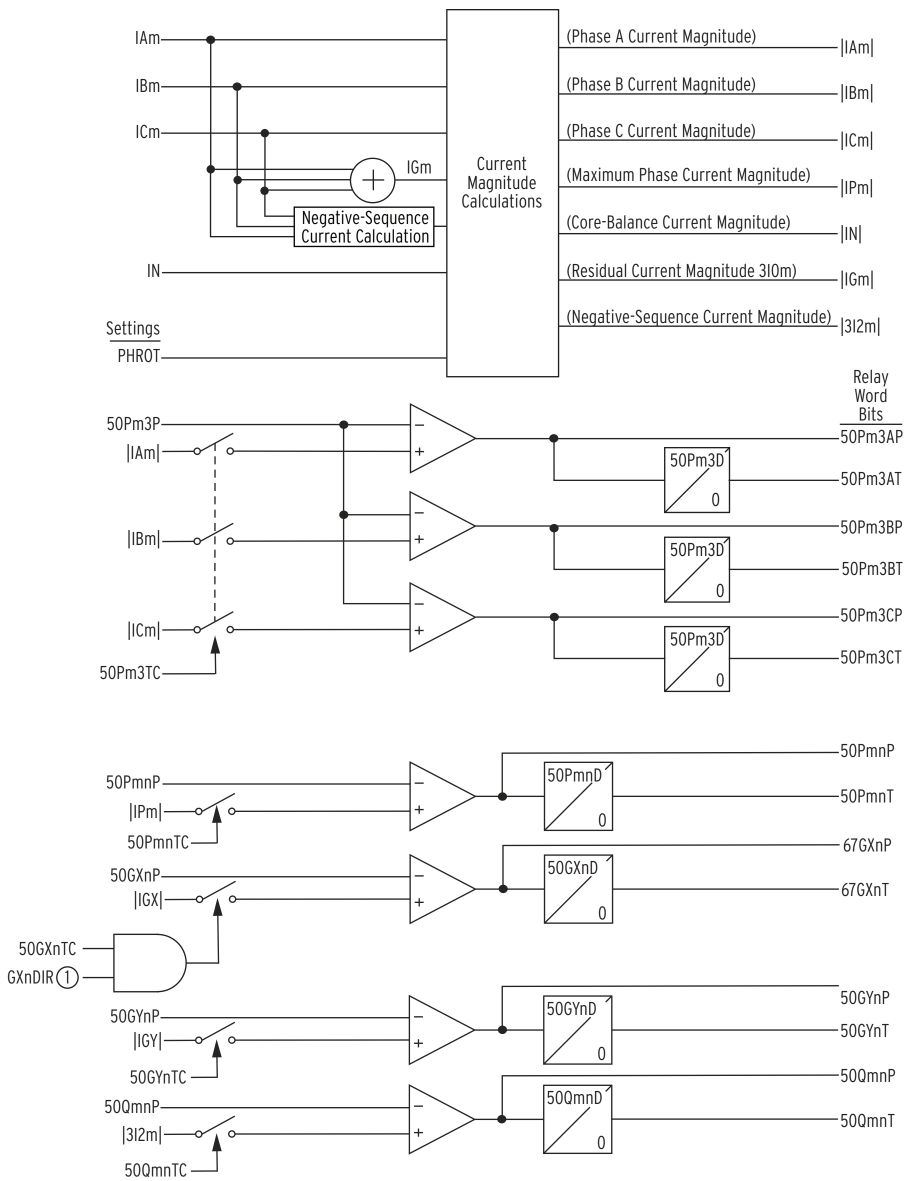
The 50P*m*3 individual phase overcurrent elements are three single-phase overcurrent elements with common pickup and delay settings. *Figure 2.25* shows a typical application using window CTs for differential protection of split-phase winding. The individual phase elements facilitate identification of the faulted phase. If you want individual pickup setting per phase, use SELOGIC timers and analog quantities (for example, IAY_MAG, IBY_MAG, and ICY_MAG) to create the necessary elements. See *Logic Settings (SET L Command) on page 4.208* and *Table M.1*.

Table 4.18 Neutral Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
NEUT IOC LEVEL	OFF, 0.50–96.00 A[a]	50N1P := OFF
NEUT IOC DELAY	OFF, 0.00–400.00 s	50N1D := 0.50
NEUT IOC TRQCTRL	SELOGIC	50N1TC := 1
NEUT IOC LEVEL	OFF, 0.50–96.00 A[a]	50N2P := OFF
NEUT IOC DELAY	OFF, 0.00–400.00 s	50N2D := 0.50
NEUT IOC TRQCTRL	SELOGIC	50N2TC := 1

[a] Setting ranges shown are for 5 A nominal CT rating. Divide by 5 for 1 A CT.

The relay offers two types of ground fault-detecting overcurrent elements. The neutral overcurrent elements (50N1T and 50N2T) operate with current measured by the input IN. The residual (RES) overcurrent elements operate with the current derived from each winding phase currents (see *Figure 4.53*).

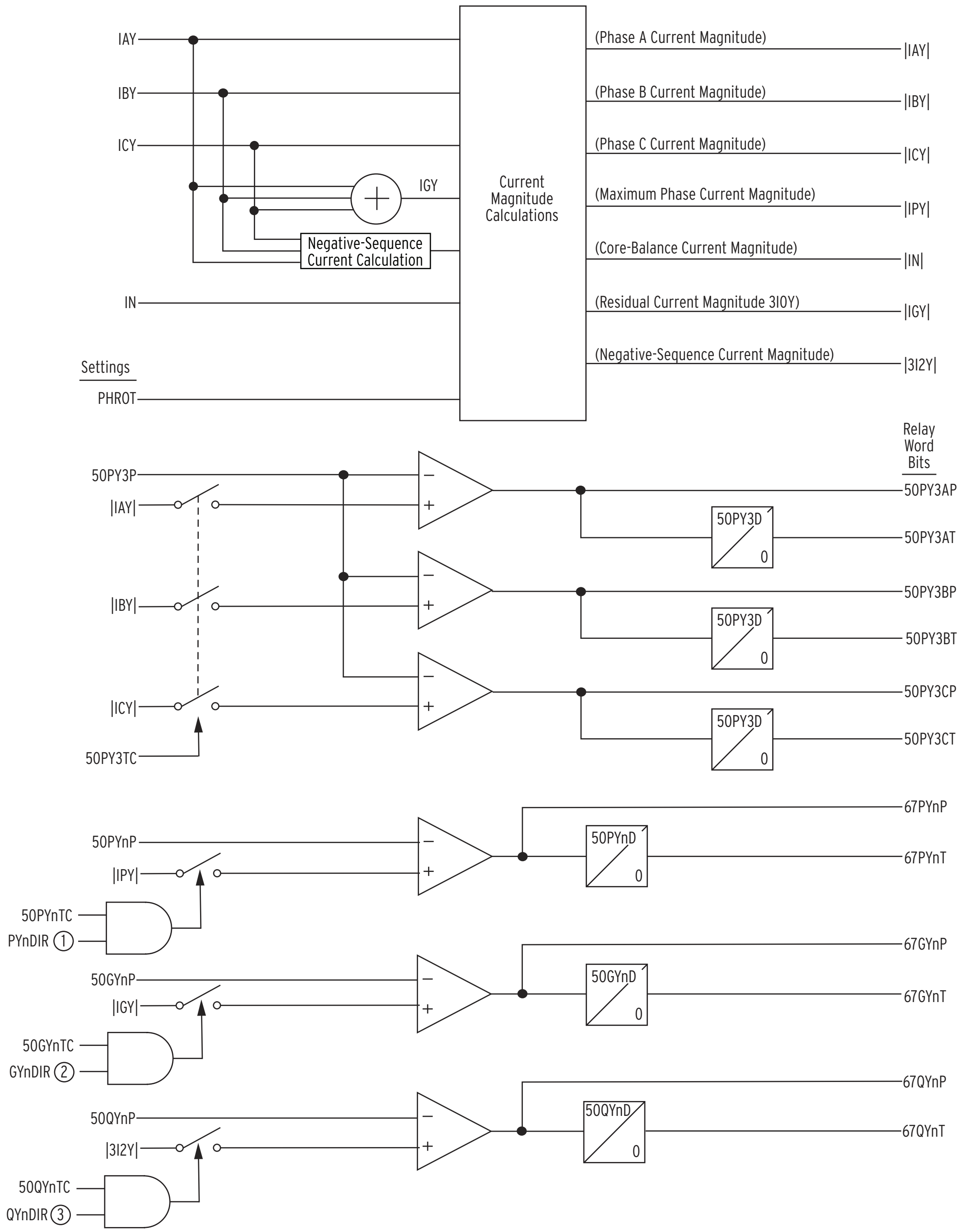


① Figure 4.83
m = X or Y (Y-side elements apply to SEL-700G1 only).
n = 1, 2, or 3 (for phase overcurrent elements only).

Torque Control switch position = Closed when the corresponding control bit is asserted (e.g., 50PY3TC = 1); open when it is deasserted.

Not shown in the figure, Relay Word bit ORED50T is asserted if any of the 50Pm3AT, 50Pm3BT, 50Pm3CT, 50PmnT, 67PYnT, 50QmnT, 50GmnT, 67GmnT, 50NnT, or 67NnT Relay Word bits are asserted.

Figure 4.53 SEL-700G0, SEL-700G1, SEL-700G1+ Instantaneous Overcurrent Element Logic (Generator Protection)



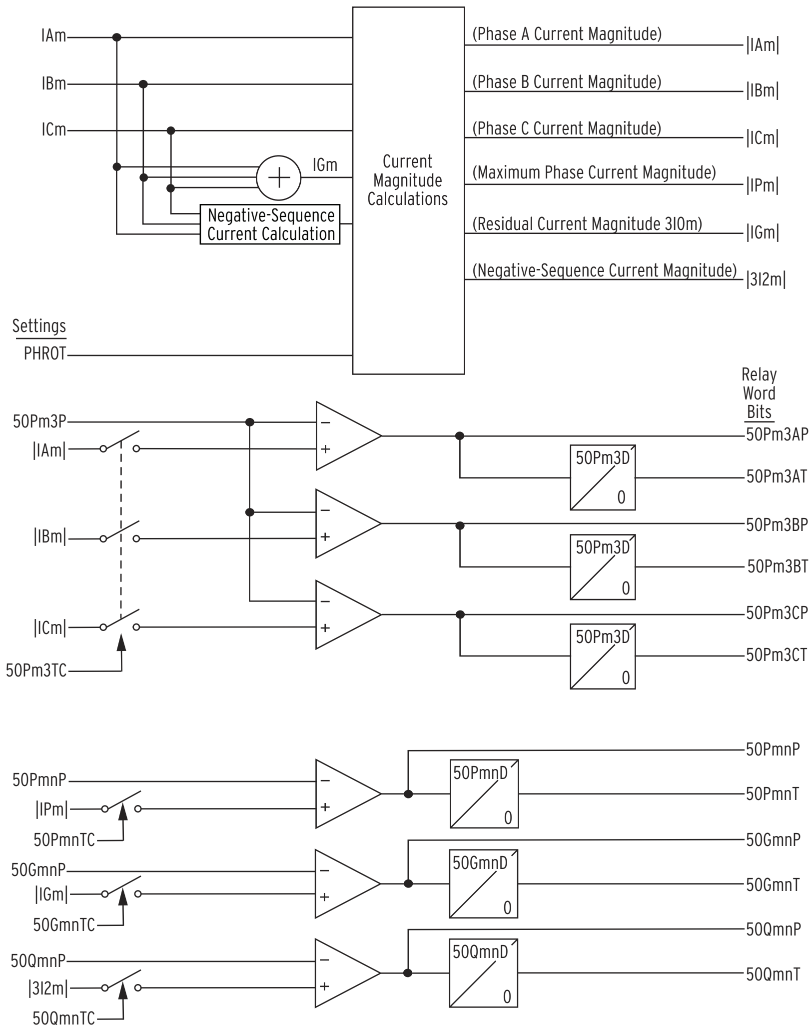
① From Figure 4.90 ② From Figure 4.83 ③ From Figure 4.89

n = 1, 2, or 3 (for phase overcurrent elements only).

Torque Control switch position = Closed when corresponding control bit is asserted (e.g., 50PY3TC = 1); open when it is deasserted.

Not shown in the figure, Relay Word bit ORED50T is asserted if any of the 50Pm3AT, 50Pm3BT, 50Pm3CT, 50PmnT, 67PYnT, 50QmnT, 50GmnT, 67GmnT, 50NnT or 67NnT Relay Word bits are asserted.

Figure 4.54 SEL-700GT+ Instantaneous Overcurrent Element Logic (Intertie Protection)

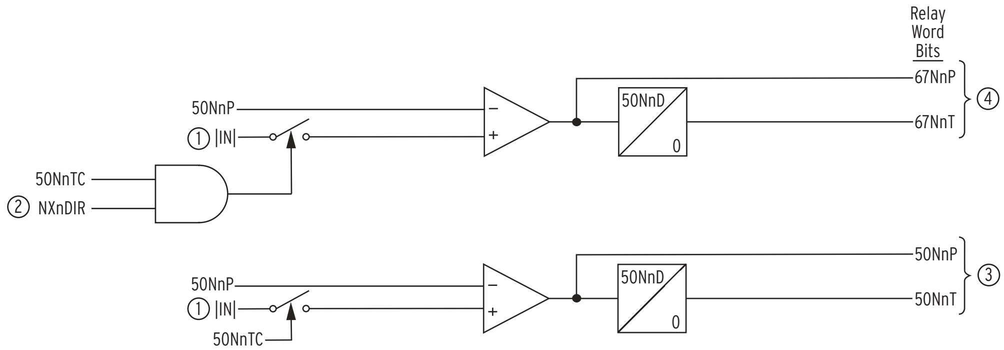


m = X or Y; n = 1, 2, or 3 (for phase overcurrent elements only).

Torque Control switch position = Closed when corresponding control bit is asserted (e.g., 50PY3TC = 1); open when it is deasserted.

Not shown in the figure, Relay Word bit ORED50T is asserted if any of the 50Pm3AT, 50Pm3BT, 50Pm3CT, 50PmnT, 67PYnT, 50QmnT, 50GmnT, 67GmnT, or 50NnT Relay Word bits are asserted.

Figure 4.55 Instantaneous Overcurrent Element Logic (Feeder Protection, SEL-700GW)



① From Figure 4.53 ② From Figure 4.84 ③ Only applicable to SEL-700GT
④ Applicable to SEL-700G0, SEL-700G0+, SEL-700G1, SEL-700G1+, SEL-700GT+

n = 1 or 2.

Torque Control switch position = Closed when corresponding control bit is asserted (e.g., 50N1TC = 1); open when it is deasserted.

Not shown in the figure, Relay Word bit ORED50T is asserted if any of the 50Pm3AT, 50Pm3BT, 50Pm3CT, 50PmnT, 67PYnT, 50QmnT, 50GmnT, 67GmnT, 50NnT, or 67NnT Relay Word bits are asserted.

Figure 4.56 SEL-700G0, SEL-700G1, SEL-700GGT Instantaneous Neutral-Ground Overcurrent Element Logic (Generator Protection)

When a core-balance CT is connected to the relay IN input, as in *Figure 4.56*, use the neutral overcurrent element to detect the ground faults. Calculate the trip level settings based on the available ground fault current and the core-balance CT ratio.

EXAMPLE 4.3 Ground Fault Core-Balance CT Application

A resistance-grounded power system limits the ground fault currents. The resistor is sized to limit the current to 10 A primary. The three feeder leads are passed through the window of a 10:1 core-balance CT. The CT secondary is connected to the SEL-700G IN current input (terminals Z07, Z08), as shown in Figure 4.57. Setting the Neutral OC CT Ratio (CTRN) equal to 10 and Neutral Trip Lvl (50N1P) equal to 0.5 A or lower with 0.10-second time delay ensures that the element quickly detects and trips for feeder ground faults.

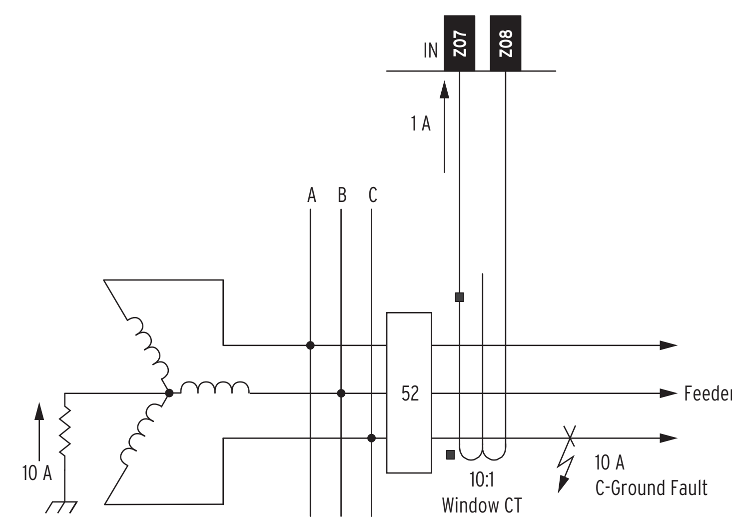


Figure 4.57 Ground Fault Protection Using Core-Balance CT

NOTE: Phase CT ratios are typically higher than core-balance (CB) CT ratios. For this reason, the relay sensitivity to ground faults is less when the residual overcurrent element is used instead of the CB element. A separate ground fault detection method should be used if a CB CT is not available in applications where resistance grounding reduces the available ground fault current.

Table 4.19 Residual Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default[a]
RES IOC LEVEL	OFF, 0.50–96.00 A[b]	50G*m*1P := OFF
RES IOC DELAY	OFF, 0.00–400.00 s	50G*m*1D := 0.50
RES IOC TRQCTRL	SELOGIC	50G*m*1TC := 1
RES IOC LEVEL	OFF, 0.50–96.00 A[b]	50G*m*2P := OFF
RES IOC DELAY	OFF, 0.00–400.00 s	50G*m*2D := 0.50
RES IOC TRQCTRL	SELOGIC	50G*m*2TC := 1

[a] m = X or Y.
[b] Setting ranges shown are for 5 A nominal CT rating. Divide by 5 for 1 A CTs.

When a core-balance CT is not available, use the 50G residual overcurrent elements.

Table 4.20 Negative-Sequence Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default[a]
NSEQ IOC LEVEL	OFF, 0.50–96.00 A[b]	50Q*m*1P := OFF
NSEQ IOC DELAY	OFF, 0.00–400.00 s	50Q*m*1D := 0.50
NSEQ IOC TRQCTRL	SELOGIC	50Q*m*1TC := 1
NSEQ IOC LEVEL	OFF, 0.50–96.00 A[b]	50Q*m*2P := OFF
NSEQ IOC DELAY	OFF, 0.00–400.00 s	50Q*m*2D := 0.50
NSEQ IOC TRQCTRL	SELOGIC	50Q*m*2TC := 1

[a] m = X or Y.
[b] Settings ranges shown are for 5 A nominal CT rating. Divide by 5 for 1 A CTs.

The relay offers two negative-sequence overcurrent elements per winding to detect phase-to-phase faults, phase reversal, single phasing, and unbalance load.

Time-Overcurrent Elements

One level of inverse time elements is available for maximum phase, negative-sequence, residual, and neutral overcurrent. Refer to *Table 1.1* and *Table 1.2* for the elements available in specific relay models. *Table 4.21* through *Table 4.24* show the settings associated with the time-overcurrent elements.

You can select from five U.S. and five IEC inverse characteristics. *Table 4.25* and *Table 4.26* show the equations for the curves, and *Figure 4.62* through *Figure 4.71* show the curves. The curves and equations shown do not account for constant time adder and minimum response time (settings 51_CT and 51_MR respectively, each assumed equal to zero). Use the 51_CT if you want to raise the curves by a constant time. Also, you can use the 51_MR if you want to ensure that the curve times no faster than a minimum response time.

You can use appropriate SELOGIC control equations (for example, when 51NTC := IN401, the 51N element operates only if IN401 is asserted) to torque control each element. You can also control the elements by directional elements depending on the relay model number (refer to *Table 1.2*). Directional elements are described later in this section.

Table 4.21 Maximum Phase Time-Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default[a]
PHASE TOC LEVEL	OFF, 0.50–16.00 A[b]	51P*m*P := OFF
PHASE TOC CURVE	U1–U5, C1–C5	51P*m*C := U3
PHASE TOC TDIAL	0.50–15.00[c], 0.05–1.00[d]	51P*m*TD := 3.00
EM RESET DELAY	Y, N	51P*m*RS := N
CONST TIME ADDER	0.00–1.00 s	51P*m*CT := 0.00
MIN RESPONSE TIM	0.00–1.00 s	51P*m*MR := 0.00
PH TOC TRQCTRL	SELOGIC	51P*m*TC := 1

[a] m = X or Y.
[b] Setting range shown is for 5 A nominal CT rating. Divide by 5 for 1 A CTs.
[c] Setting range shown is for 51_C := U_.
[d] Setting range shown is for 51_C := C_.

The maximum phase time-overcurrent element, 51P*m*T, responds to the highest of the A-, B-, and C-phase currents, as shown in *Figure 4.58*.

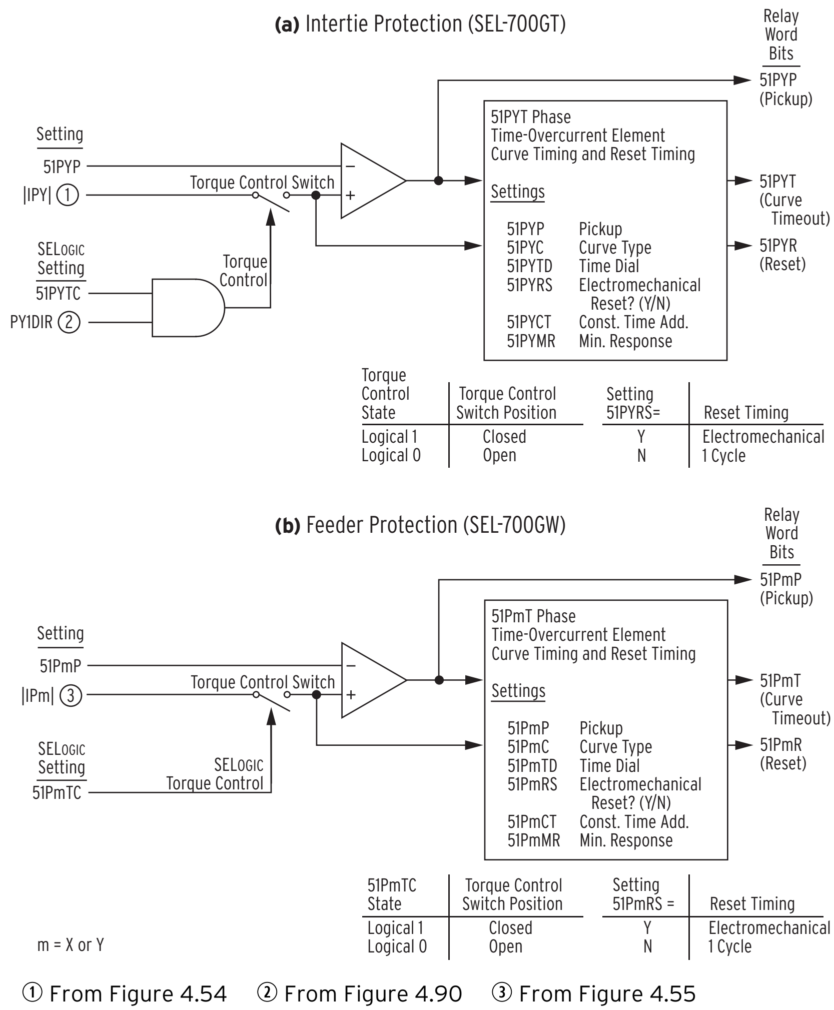


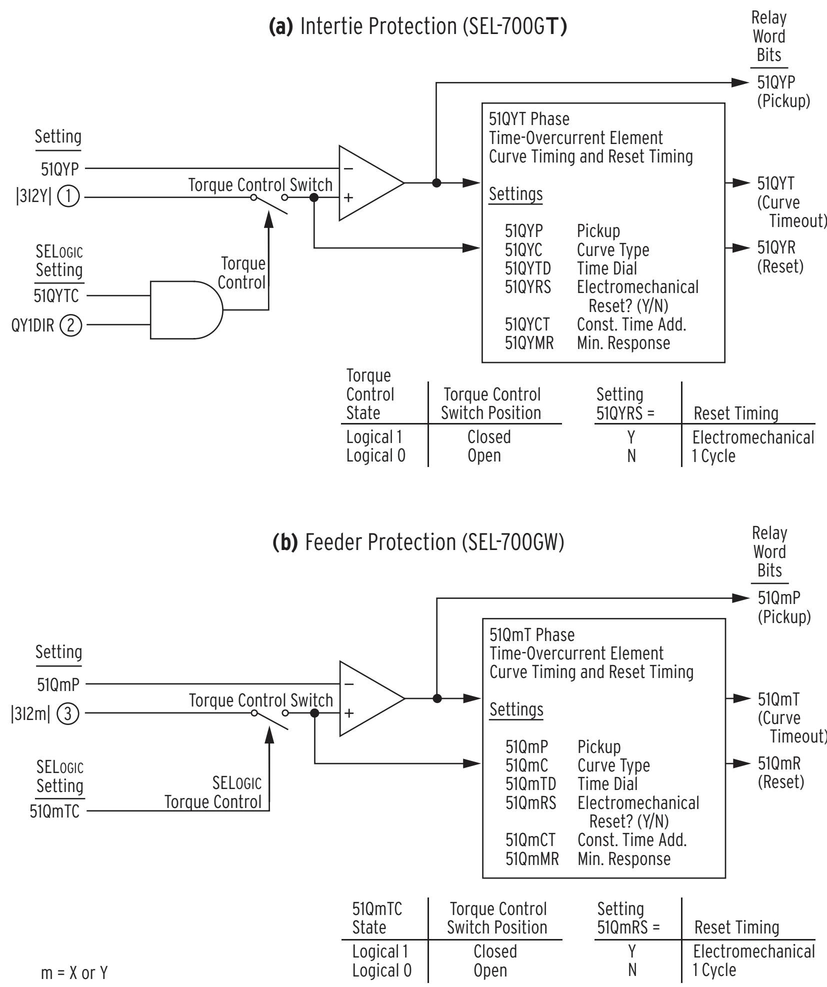
Figure 4.58 Maximum Phase Time-Overcurrent Elements

Table 4.22 Negative-Sequence Time-Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default[a]
NSEQ TOC LEVEL	OFF, 0.50–16.00 A[b]	51Q*m*P :=OFF
NSEQ TOC CURVE	U1–U5, C1–C5	51Q*m*C := U3
NSEQ TOC TDIAL	0.50–15.00[c], 0.05–1.00[d]	51Q*m*TD := 3.00
EM RESET DELAY	Y, N	51Q*m*RS := N
CONST TIME ADDER	0.00–1.00 s	51Q*m*CT := 0.00
MIN RESPONSE TIM	0.00–1.00 s	51Q*m*MR := 0.00
NSEQ TOC TRQCTRL	SELOGIC	51Q*m*TC := 1

[a] m = X or Y.
[b] Setting range shown is for 5 A nominal CT rating. Divide by 5 for 1 A CTs.
[c] Setting range shown is for 51_C := U_.
[d] Setting range shown is for 51_C := C_.

The negative-sequence time-overcurrent element 51Q*m*T responds to the 3I2*m* current as shown in *Figure 4.59*.



① From Figure 4.54 ② From Figure 4.89 ③ From Figure 4.55

Figure 4.59 Negative-Sequence Time-Overcurrent Elements

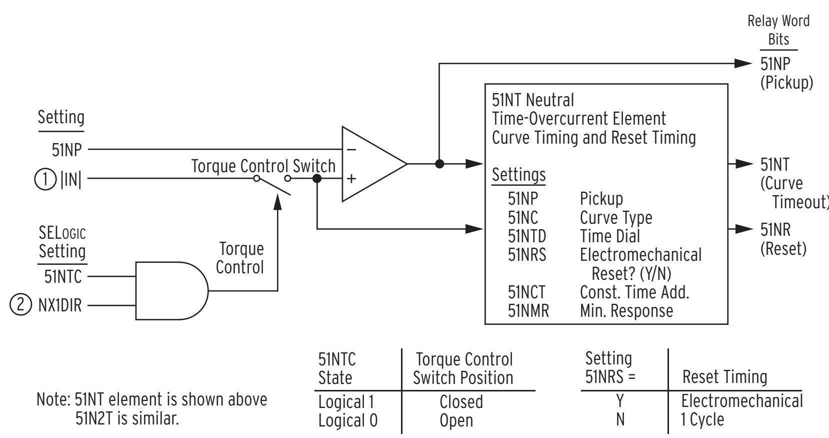
False negative-sequence current can appear transiently when a circuit breaker is closed and a balanced load current suddenly appears. To avoid tripping for this transient condition, do not use a time-dial setting that results in curve times below three cycles.

Table 4.23 Neutral Time-Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
NEUT TOC LEVEL	OFF, 0.50–16.00 A[a]	51NP := OFF
NEUT TOC CURVE	U1–U5, C1–C5	51NC := U3
NEUT TOC TDIAL	0.50–15.00[b] 0.05–1.00[c]	51NTD := 3.00
EM RESET DELAY	Y, N	51NRS := N
CONST TIME ADDER	0.00–1.00 s	51NCT := 0.00
MIN RESPONSE TIM	0.00–1.00 s	51NMR := 0.00
NSEQ TOC TRQCTRL	SELOGIC	51NTC := 1

[a] Setting range shown is for 5 A nominal CT rating. Divide by 5 for 1 A CTs.
[b] Setting range shown is for 51_C := U_.
[c] Setting range shown is for 51_C := C_.

The neutral time-overcurrent element, 51NT, responds to neutral channel current IN, as shown in *Figure 4.60*.



① From Figure 4.53 or Figure 4.54 ② From Figure 4.84

Figure 4.60 Neutral Time-Overcurrent Element 51NT

Table 4.24 Residual Time-Overcurrent Settings (Sheet 1 of 2)

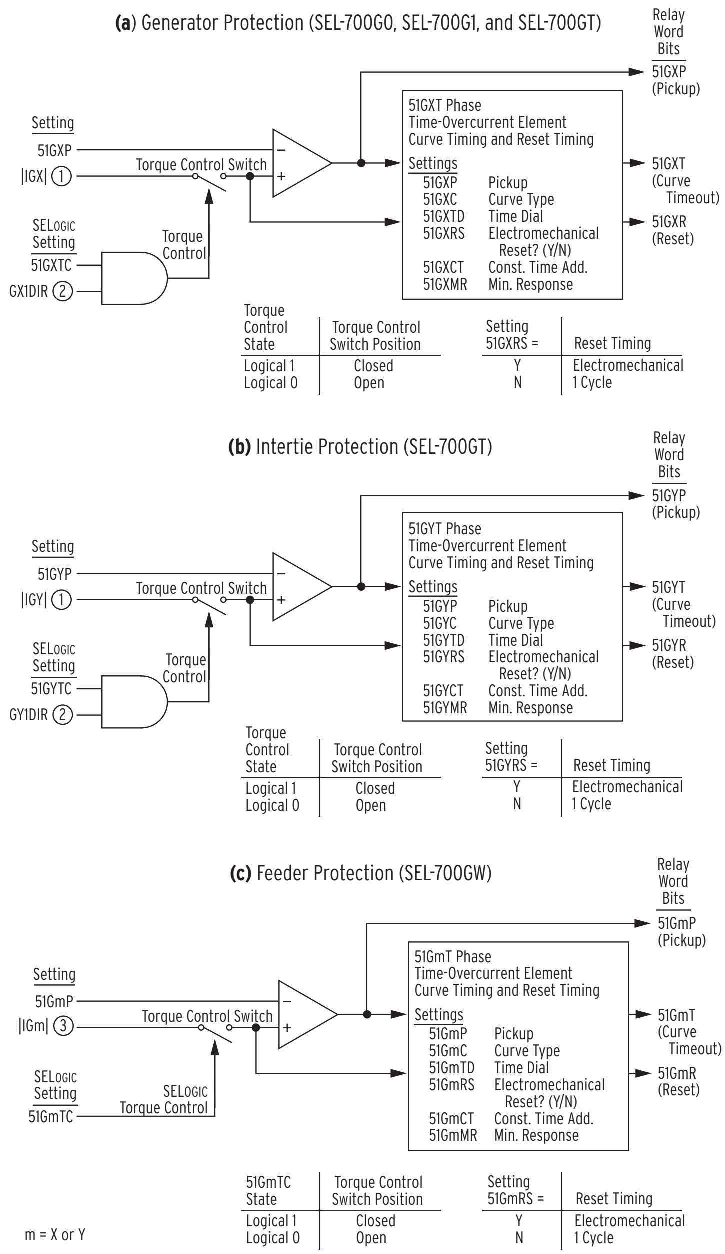
Setting Prompt	Setting Range	Setting Name := Factory Default[a]
RES TOC LEVEL	OFF, 0.50–16.00 A[b]	51G*m*P := OFF
RES TOC CURVE	U1–U5, C1–C5	51G*m*C := U3
RES TOC TDIAL	0.50–15.00[c] 0.05–1.00[d]	51G*m*TD := 1.50
EM RESET DELAY	Y, N	51G*m*RS := G*m*
CONST TIME ADDER	0.00–1.00 s	51G*m*CT := 0.00

Table 4.24 Residual Time-Overcurrent Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default[a]
MIN RESPONSE TIM	0.00–1.00 s	51G*m*MR := 0.00
TOC TRQ CONTROL	SELOGIC	51G*m*TC := 1

[a] m = X or Y.
[b] Setting range shown is for 5 A nominal CT rating. Divide by 5 for 1 A CTs.
[c] Setting range shown is for 51_C := U_.
[d] Setting range shown is for 51_C := C_.

The residual time-overcurrent elements, 51GXT and 51GYT, respond to residual current IG*m*, as shown in *Figure 4.61*.



① From Figure 4.54 or Figure 4.55 ② From Figure 4.83 ③ From Figure 4.55

Figure 4.61 Residual Time-Overcurrent Elements

Time-Overcurrent Curves

The following information describes the curve timing for the curve and time dial settings made for the time-overcurrent elements (see *Figure 4.58–Figure 4.61*). The U.S. and IEC time-overcurrent relay curves are shown in *Figure 4.62–Figure 4.71*. Curves U1, U2, and U3 (*Figure 4.62–Figure 4.64*) conform to IEEE C37.112-1996, Standard Inverse-Time Characteristic Equations for Overcurrent Relays.

Relay Word Bit ORED51T

Relay Word bit ORED51T is asserted if any of the Relay Word bits 51PXT, 51QXT, 51GXT, 51PYT, 51QYT, 51GYT, OR 51NT are asserted.

Table 4.25 Equations Associated With U.S. Curves

Curve Type	Operating Time	Reset Time	Figure
U1 (Moderately Inverse)	$t_p = TD \bullet \left(0.0226 + \frac{0.0104}{M^{0.02} - 1}\right)$	$t_r = TD \bullet \left(\frac{1.08}{1 - M^2}\right)$	*Figure 4.62*
U2 (Inverse)	$t_p = TD \bullet \left(0.180 + \frac{5.95}{M^2 - 1}\right)$	$t_r = TD \bullet \left(\frac{5.95}{1 - M^2}\right)$	*Figure 4.63*
U3 (Very Inverse)	$t_p = TD \bullet \left(0.0963 + \frac{3.88}{M^2 - 1}\right)$	$t_r = TD \bullet \left(\frac{3.88}{1 - M^2}\right)$	*Figure 4.64*
U4 (Extremely Inverse)	$t_p = TD \bullet \left(0.0352 + \frac{5.67}{M^2 - 1}\right)$	$t_r = TD \bullet \left(\frac{5.67}{1 - M^2}\right)$	*Figure 4.65*
U5 (Short-Time Inverse)	$t_p = TD \bullet \left(0.00262 + \frac{0.00342}{M^{0.02} - 1}\right)$	$t_r = TD \bullet \left(\frac{0.323}{1 - M^2}\right)$	*Figure 4.66*

where:

t_p = operating time in seconds
t_r = electromechanical induction-disk emulation reset time in seconds (if you select electromechanical reset setting)
TD = time-dial setting
M = applied multiples of pickup current [for operating time (t_p), M>1; for reset time (t_r), M≤1]

Table 4.26 Equations Associated With IEC Curves

Curve Type	Operating Time	Reset Time	Figure
C1 (Standard Inverse)	$t_p = TD \bullet \left(\frac{0.14}{M^{0.02} - 1}\right)$	$t_r = TD \bullet \left(\frac{13.5}{1 - M^2}\right)$	*Figure 4.67*
C2 (Very Inverse)	$t_p = TD \bullet \left(\frac{13.5}{M - 1}\right)$	$t_r = TD \bullet \left(\frac{47.3}{1 - M^2}\right)$	*Figure 4.68*
C3 (Extremely Inverse)	$t_p = TD \bullet \left(\frac{80}{M^2 - 1}\right)$	$t_r = TD \bullet \left(\frac{80}{1 - M^2}\right)$	*Figure 4.69*
C4 (Long-Time Inverse)	$t_p = TD \bullet \left(\frac{120}{M - 1}\right)$	$t_r = TD \bullet \left(\frac{120}{1 - M}\right)$	*Figure 4.70*
C5 (Short-Time Inverse)	$t_p = TD \bullet \left(\frac{0.05}{M^{0.04} - 1}\right)$	$t_r = TD \bullet \left(\frac{4.85}{1 - M^2}\right)$	*Figure 4.71*

where:

t_p = operating time in seconds
t_r = electromechanical induction-disk emulation reset time in seconds (if you select electromechanical reset setting)
TD = time-dial setting
M = applied multiples of pickup current [for operating time (t_p), M>1; for reset time (t_r), M≤1]

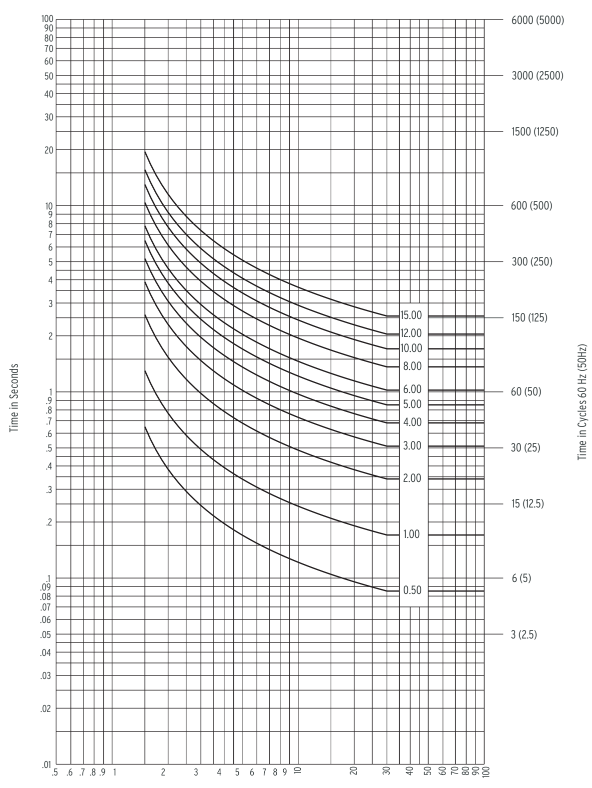


Figure 4.62 U.S. Moderately Inverse Curve: U1

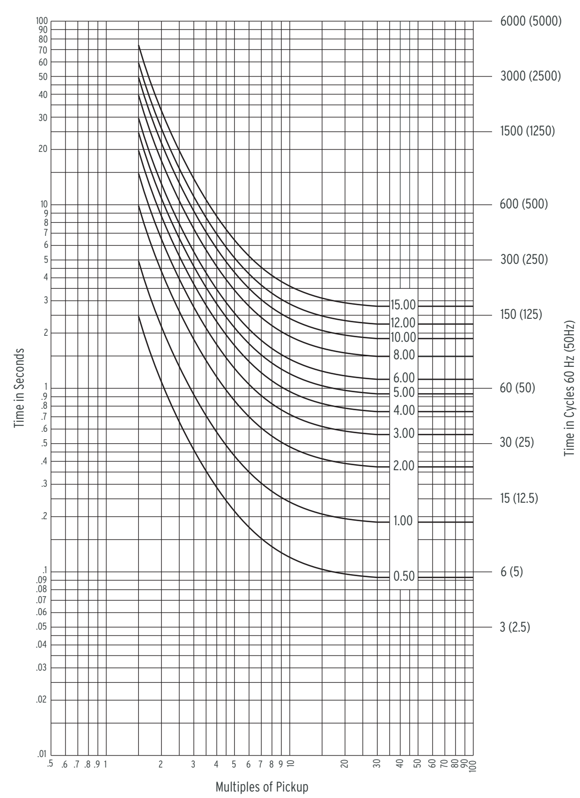


Figure 4.63 U.S. Inverse Curve: U2

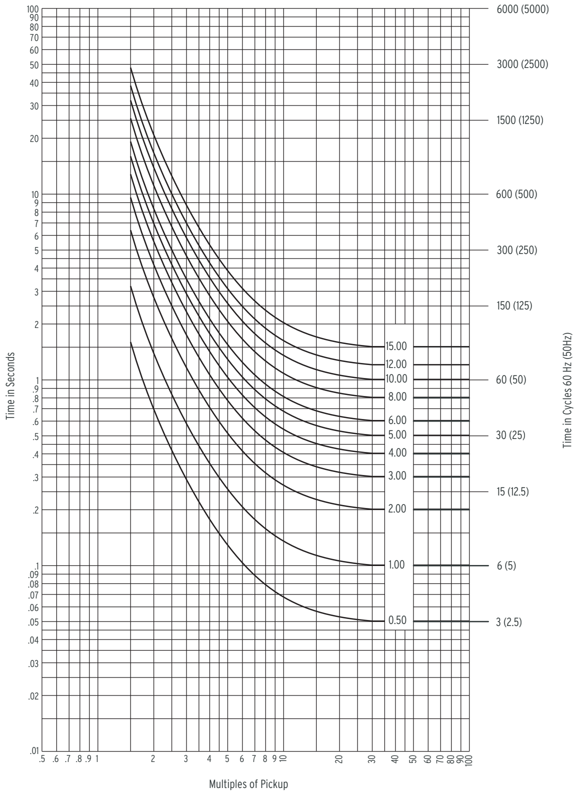


Figure 4.64 U.S. Very Inverse Curve: U3

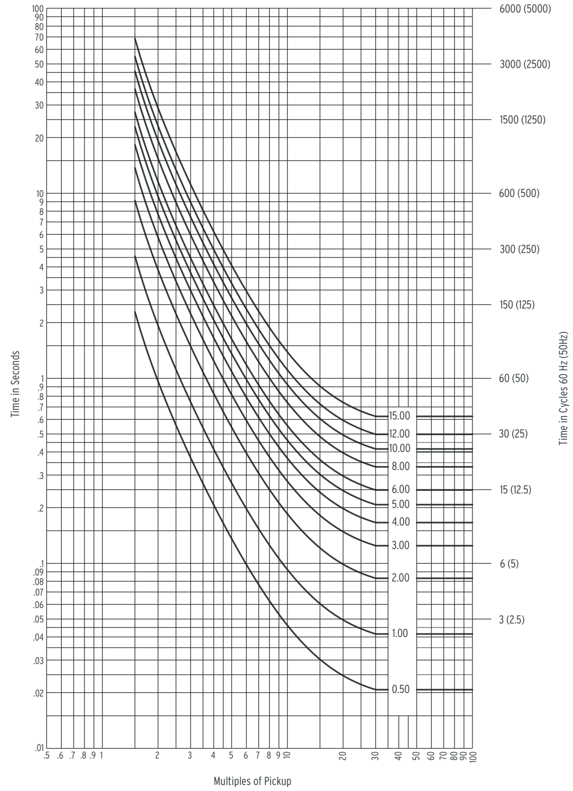


Figure 4.65 U.S. Extremely Inverse Curve: U4

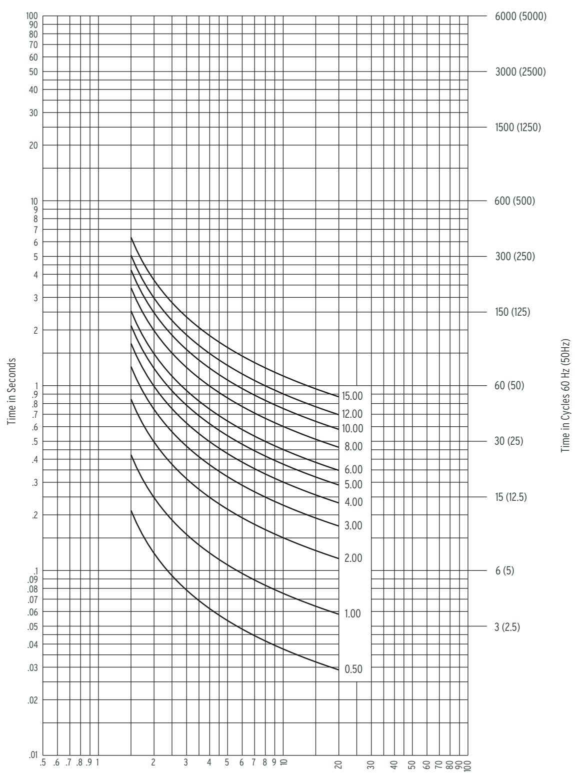


Figure 4.66 U.S. Short-Time Inverse Curve: U5

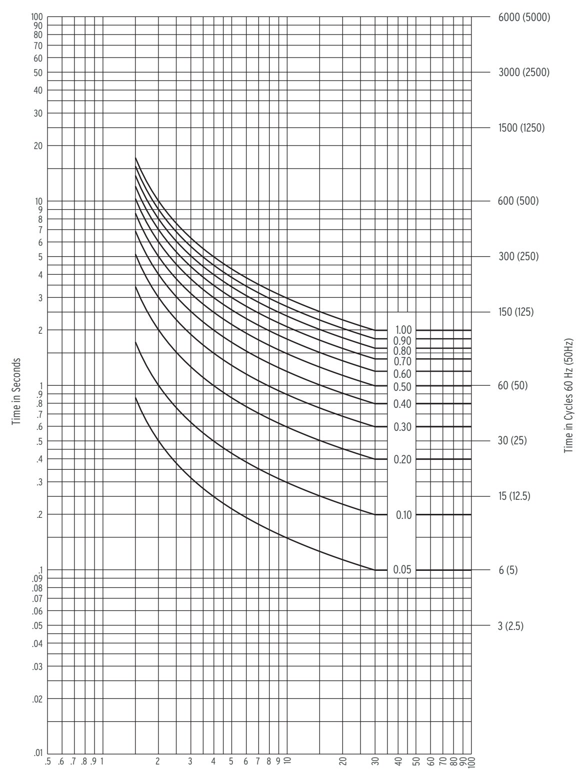


Figure 4.67 IEC Class A Curve (Standard Inverse): C1

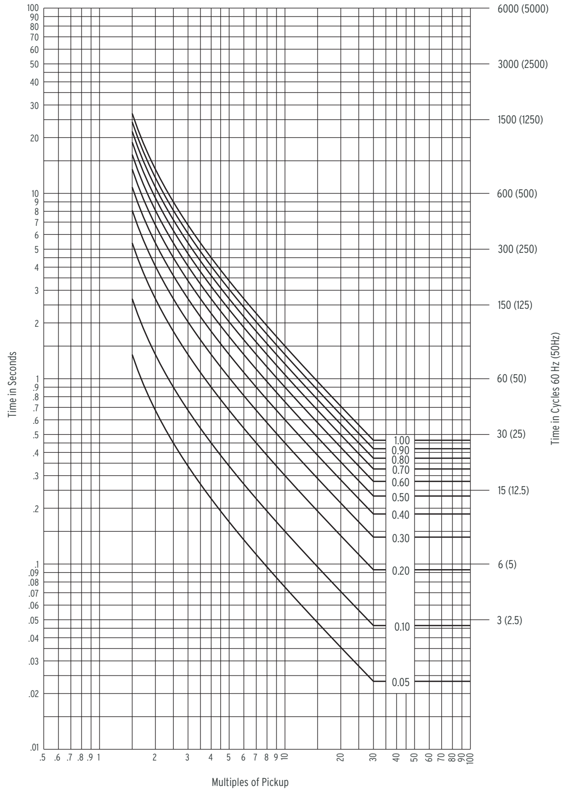


Figure 4.68 IEC Class B Curve (Very Inverse): C2

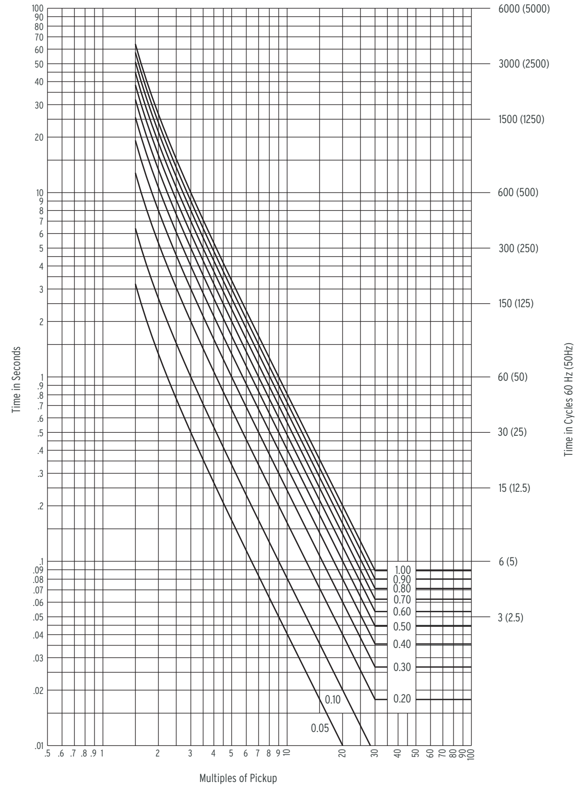


Figure 4.69 IEC Class C Curve (Extremely Inverse): C3

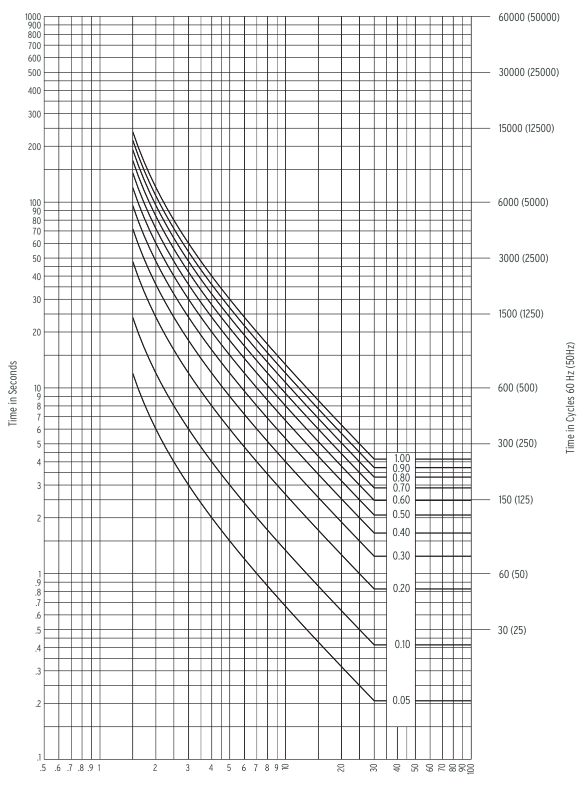


Figure 4.70 IEC Long-Time Inverse Curve: C4

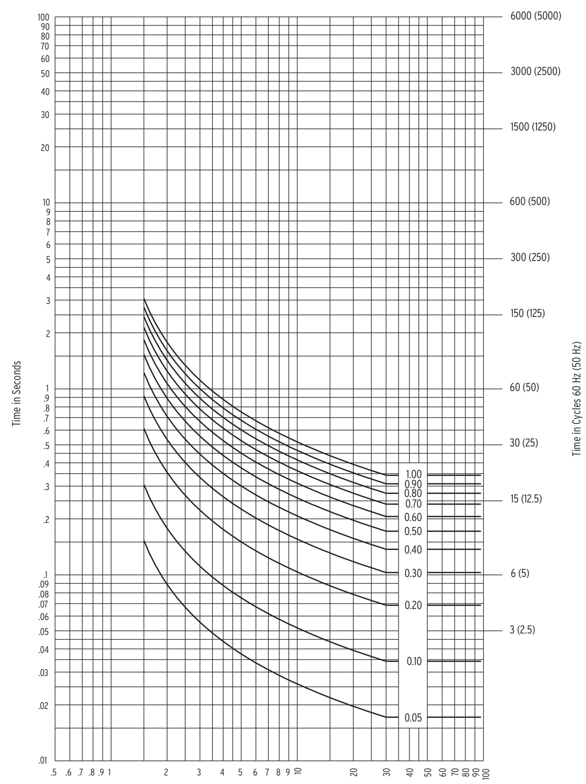


Figure 4.71 IEC Short-Time Inverse Curve: C5

Directional Elements

The directional control for overcurrent elements is enabled by making directional control enable setting EDIRX and EDIRY for X and Y sides, respectively. For simplicity, the following descriptions do not necessarily show X and Y in various settings, Relay Word bits, and figures. X and Y sides are explicitly shown in the Relay Word bits and figures wherever necessary. Setting EDIR and other directional control settings are described in *Directional Control Settings on page 4.124*.

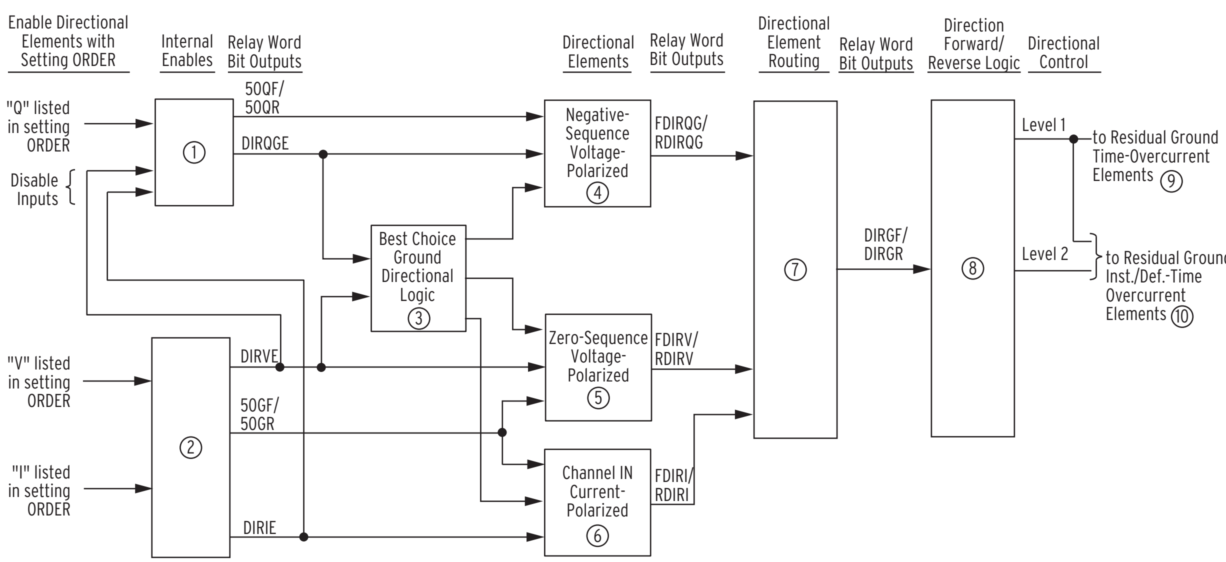
Directional Control for Residual and Neutral Overcurrent Elements

Three directional elements (items 1, 2 and 3 listed below) are available to control the residual-ground overcurrent elements and one directional element (item 4 listed below) to control the neutral-ground overcurrent (IN) elements. Not all are available simultaneously. These four directional elements are:

1. Negative-sequence voltage-polarized directional element
2. Zero-sequence voltage-polarized directional element (with IG as operate quantity)
3. Channel **IN** current-polarized directional element
4. Zero-sequence voltage-polarized directional element (with **IN** as operate quantity)

See *Figure 4.72* and *Figure 4.73* for an overview of how these directional elements are enabled and routed to control the residual-ground overcurrent elements and neutral-ground overcurrent elements respectively. Note in *Figure 4.72* and *Figure 4.73* that the ORDER setting enables the directional elements. ORDER can be set with the elements listed and defined in *Table 4.27*.

The order in which these directional elements are listed in setting ORDER determines the priority in which they operate to provide Best Choice Ground Directional Element logic control. See the discussion on setting ORDER in the *Directional Control Settings on page 4.124*.



① Figure 4.74 ② Figure 4.75 ③ Table 4.27 and Table 4.28 ④ Figure 4.77 ⑤ Figure 4.78
⑥ Figure 4.79 ⑦ Figure 4.81 ⑧ Figure 4.83 ⑨ Figure 4.61 ⑩ Figure 4.53 and Figure 4.54

Figure 4.72 General Logic Flow of Directional Control for Residual Ground Overcurrent Elements

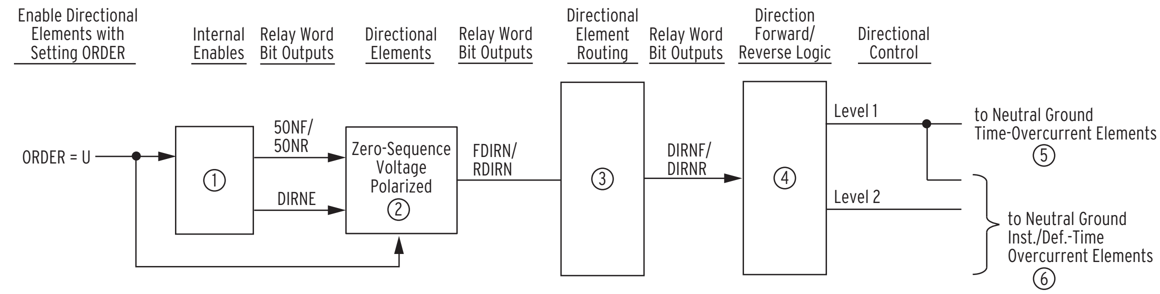


Figure 4.73 General Logic Flow of Directional Control for Neutral-Ground Overcurrent Elements

Table 4.27 Available Ground Directional Elements

ORDER Setting Choices	Corresponding Ground Directional Element (and System Grounding)	Corresponding Internal Enables (and System Grounding)	Corresponding Figures	Availability
Q	Negative-sequence voltage-polarized	DIRQGE	*Figure 4.74*, *Figure 4.77*	All models, except SEL-700GW
V	Zero-sequence voltage-polarized (with IG as operate quantity)	DIRVE	*Figure 4.75*, *Figure 4.78*	
I	Channel **IN** current polarized	DIRIE	*Figure 2.21*, *Figure 4.76*, *Figure 4.79*	Models with a 1 A or 5 A nominal neutral channel (**IN**)
U[a]	Zero-sequence voltage-polarized (with IN as operate quantity)	DIRNE	*Figure 2.21*, *Figure 4.76*, *Figure 4.80*	SEL-700G0, SEL-700G0+, SEL-700G1, SEL-700G1+, SEL-700GT+

[a] U cannot be listed together with other choices in the ORDER setting. ORDER = U can only be set on the X side.

Table 4.28 Best Choice Ground Directional Element Logic

ORDER Setting Combinations	Resultant Ground Directional Element Preference (indicated below with corresponding internal enables; run element that corresponds to highest choice internal enable that is asserted; system grounding in parentheses)			ORDER Setting Combination Availability
	1st Choice	2nd Choice	3rd Choice	
OFF	No ground directional elements enabled			All models, except SEL-700GW
Q	DIRQGE			
QV	DIRQGE	DIRVE		
V	DIRVE			
VQ	DIRVE	DIRQGE		
I	DIRIE			
IQ	DIRIE	DIRQGE		
IQV	DIRIE	DIRQGE	DIRVE	
IV	DIRIE	DIRVE		
IVQ	DIRIE	DIRVE	DIRQGE	
QI	DIRQGE	DIRIE		
QIV	DIRQGE	DIRIE	DIRVE	
QVI	DIRQGE	DIRVE	DIRIE	
VI	DIRVE	DIRIE		
VIQ	DIRVE	DIRIE	DIRQGE	
VQI	DIRVE	DIRQGE	DIRIE	
U[a]	DIRNE			SEL-700G0 SEL-700G0+ SEL-700G1 SEL-700G1+ SEL-700GT+

[a] U cannot be listed together with other choices in the ORDER setting. ORDER = U can only be set on the X side.

Table 4.29 and *Table 4.30* show the availability of the ground directional elements for the voltage transformer settings DELTAY_X and DELTAY_Y. Note that on the X side, even when the generator terminal PTs are connected in DELTA (DELTAY_X := DELTA), the relay allows you to set ORDER to contain V or U. This is only possible if an external zero-sequence voltage (3V0) is available and is connected to VS or VN inputs for polarization (EXT3V0_X := VS or VN). Refer to *Figure 2.19* and *Figure 2.28*.

Table 4.29 Ground Directional Element Availability by Voltage Transformer Connections On X Side

Element Designation in ORDER Setting for X Side	DELTAY_X := WYE	DELTAY_X := DELTA and	
		EXT3V0_X := NONE	EXT3V0_X := VS or VN
Q	Yes	Yes	Yes
V	Yes	No	Yes
I	Yes	Yes	Yes
U	Yes	No	Yes

Table 4.30 Ground Directional Element Availability by Voltage Transformer Connections On Y Side

Element Designation in ORDER Setting for Y Side	DELTAY_Y := WYE	DELTAY_Y := DELTA
Q	Yes	Yes
V	Yes	No
I	Yes	Yes

Zero-Sequence Voltage Sources. The directional elements that rely on zero-sequence voltage 3V0 (ORDER setting choices V and U, shown in *Figure 4.78* and *Figure 4.80*) may use either a calculated 3V0 from the wye-connected voltages VA, VB, and VC, or a measured 3V0 from the VS or VN inputs, which are typically connected to a broken-delta PT secondary (refer to *Figure 2.19*). The possible zero-sequence voltages the relay could use on the X side and Y side for the directional elements are presented below.

- **For both X side and Y side**, if DELTAY_*m* := WYE (m = X or Y), the relay always uses zero-sequence voltage calculated from the wye-connected voltages VA*m*, VB*m*, and VC*m*.
- **On the Y side**, if DELTAY_Y := DELTA, then no source of zero-sequence voltage is available and choice V in the ORDER setting is unavailable.
- **On the X side**, if DELTAY_X := DELTA, then the relay gives you the option to connect external 3V0 to VS or VN inputs with the help of the global setting EXT3V0_X := VS or VN, respectively. If EXT3V0_X := NONE, then no source of zero-sequence voltage is available and choices V and U in the ORDER setting are unavailable.
  - When EXT3V0_X := VS, the measured voltage on terminals VS-NS is scaled by the ratio of Group settings PTRS/PTR to convert it to the same voltage base as the VAX, VBX, and VCX at terminals, and the resulting signal is applied to the directional element 3V0 inputs.
  - When EXT3V0_X := VN, the measured voltage on terminals VN-NN is scaled by the ratio of Group settings PTRN/PTR to convert it to the same voltage base as the VAX, VBX, and VCX at terminals, and the resulting signal is applied to the directional element 3V0 inputs.

NOTE: When Group setting ORDERX := U, EDIR cannot be set to AUTO.

When testing the relay, it is important to note that the **METER** command 3V0 quantity is only available for wye-connected PT inputs. The **METER** command VS and VN quantities are always the measured values from the VS-NS and VN-NN terminals, respectively. Refer to *Figure 2.19* for various voltage connections.

Internal Enables. Refer to *Figure 4.74*, *Figure 4.75*, and *Figure 4.76*. *Table 4.27* lists the internal enables and their correspondence to the ground directional elements.

Note that *Figure 4.74* has extra internal enable DIRQE, which is used in the directional element logic that controls negative-sequence and phase overcurrent elements (see *Figure 4.85*).

Additionally, note that under a loss-of-potential condition some or all of the voltage-based directional elements are disabled. Refer to *Loss-of-Potential on page 4.109* for more information on how different ground directional elements are disabled under a loss-of-potential condition.

The settings involved with the internal enables (for example, settings a2, k2, a0, and a0N) are explained in *Directional Control Settings on page 4.124*.

Best Choice Ground Directional Element Logic. The Best Choice Ground Directional Element logic determines which directional element should be enabled to operate. The residual-ground overcurrent elements set for directional control are then controlled by this enabled directional element.

Table 4.28 is the embodiment of the Best Choice Ground Directional logic (refer to *Figure 4.72*, *Figure 4.73*, *Figure 4.78*, *Figure 4.79*, and *Figure 4.80*). Setting choice U can only be listed by itself (ORDER = U), so Best Choice Ground Directional Element logic is irrelevant in this case, just as it is also irrelevant when Q, V, or I are listed by themselves in setting ORDER.

Directional Element Routing. Refer to *Figure 4.72* and *Figure 4.81* for routing of directional elements to residual-ground overcurrent elements and *Figure 4.73* and *Figure 4.82* for routing of directional elements to neutral-ground overcurrent elements.

The directional element outputs are routed to the forward (Relay Word bits DIRGF and DIRNF) and reverse (Relay Word bits DIRGR and DIRNR) logic points and then on to the direction forward/reverse logic in *Figure 4.83* and *Figure 4.84*.

Loss-of-Potential. Refer to *Figure 4.127* and the accompanying text for more information on loss-of-potential. Some or all of the voltage-based directional elements are disabled during a loss-of-potential condition. Thus, the overcurrent elements controlled by these voltage-based directional elements are also disabled. However, this disable condition is overridden for these overcurrent elements set direction forward if setting EFWDLOP := Y.

The effect of LOP on the internal enables associated with the voltage-based directional elements is described below (refer to *Figure 4.74*, *Figure 4.75*, and *Figure 4.76*).

- If DELTAY_ := WYE and an LOP condition occur (Relay Word bit LOP asserts), the internal enables associated with the voltage-based directional elements, DIRVE, DIRQE, DIRQGE and DIRNEX get disabled.
- If DELTAY_ := DELTA, EXT3V0_X := NONE (Note that EXT3V0_X is only available on the X side), and an LOP condition occurs, the internal enables associated with the voltage-based directional elements DIRQE and DIRQGE get disabled (DIRVE and DIRNEX are not applicable under this condition).
- If DELTAY_ := DELTA, EXT3V0_X := VS or VN, and an LOP condition occur, the internal enables associated with the voltage-based directional elements DIRQE, DIRQGE get disabled. DIRVEX and DIRNEX are enabled under this condition. (DIRVEY is not applicable under this condition)

The internal enable associated with channel IN current polarized directional element, DIRIE, does not use voltage in making directional decisions, thus an LOP condition does not disable the element.

The effect of LOP on the residual-ground directional logic is described below (refer to *Figure 4.81*).

➤ If DELTAY_ := WYE, EFWDLOP := Y, internal enable DIRIE is not asserted, and an LOP condition occurs, then the forward logic point (Relay Word bit DIRGF) asserts to logical 1, thus enabling the residual-ground (*Figure 4.83*) overcurrent elements that are set direction forward (with settings DIR1 = F, DIR2 = F, etc.). These direction forward overcurrent elements effectively become non-directional and provide overcurrent protection during an LOP condition. With the rest of the settings remaining the same, if the internal enable DIRIE is asserted and an LOP condition occurs, then the output of the forward/reverse logic points (Relay Word bits DIRGF and DIRGR) is dictated by the Channel IN current-polarized directional element (Relay Word bits FDIRI and RDIRI, respectively).

➤ The previous is also true for DELTAY_ := DELTA, EFWDLOP := Y, EXT3V0_X := NONE.

➤ If DELTAY_ := DELTA, EFWDLOP := Y, EXT3V0_X := VS or VN, internal enable DIRVE is asserted, and internal enable DIRIE is not asserted, then the LOP condition will not cause the forward directional outputs to assert as shown in *Figure 4.81*. In this situation, the directional element enabled by DIRVE is still able to operate reliably during an LOP condition, so there is no need to force the forward outputs to assert. However, when DIRVE is not asserted, a standing LOP condition will force the forward outputs to assert continuously. Consider this when determining residual-ground overcurrent element pickup settings and time delay settings, so that load conditions do not cause a forward-set ground directional overcurrent element to pickup and start timing.

The effect of LOP on the neutral-ground directional logic is described below (refer to *Figure 4.82*).

➤ If DELTAY_ := WYE, EFWDLOP := Y, and an LOP condition occurs, then the forward logic point (Relay Word bit DIRNF) asserts to logical 1, thus enabling the neutral-ground (*Figure 4.84*) overcurrent elements that are set direction forward (with settings DIR1 = F, DIR2 = F, etc.). These direction forward overcurrent elements effectively become non-directional and provide overcurrent protection during an LOP condition.

➤ If DELTAY_ := DELTA, EFWDLOP := Y, EXT3V0_X := VS or VN, and internal enable DIRVE is asserted, then the LOP condition will not cause the forward directional outputs to assert as shown in *Figure 4.82*. In this situation, the directional element enabled by DIRNE is still able to operate reliably during an LOP condition, so there is no need to force the forward outputs to assert. However, when DIRNE is not asserted, a standing LOP condition will force the forward outputs to assert continuously. Consider this when determining neutral-ground overcurrent element pickup settings and time delay settings, so that load conditions do not cause a forward-set ground directional overcurrent element to pickup and start timing.

Direction Forward/Reverse Logic. Refer to *Figure 4.72*, *Figure 4.73*, *Figure 4.83* and *Figure 4.84*.

With the forward Relay Word bits, DIRGF and DIRNF and the reverse Relay Word bits, DIRGR and DIRNR, in *Figure 4.83* and *Figure 4.84*, respectively, logic points are routed to the different levels of overcurrent protection by the level direction settings DIR1 and DIR2.

Table 4.33 shows the overcurrent elements that are controlled by each level direction setting. Note in *Table 4.33* that all the time-overcurrent elements (51_T elements) are controlled by the DIR1 level direction setting.

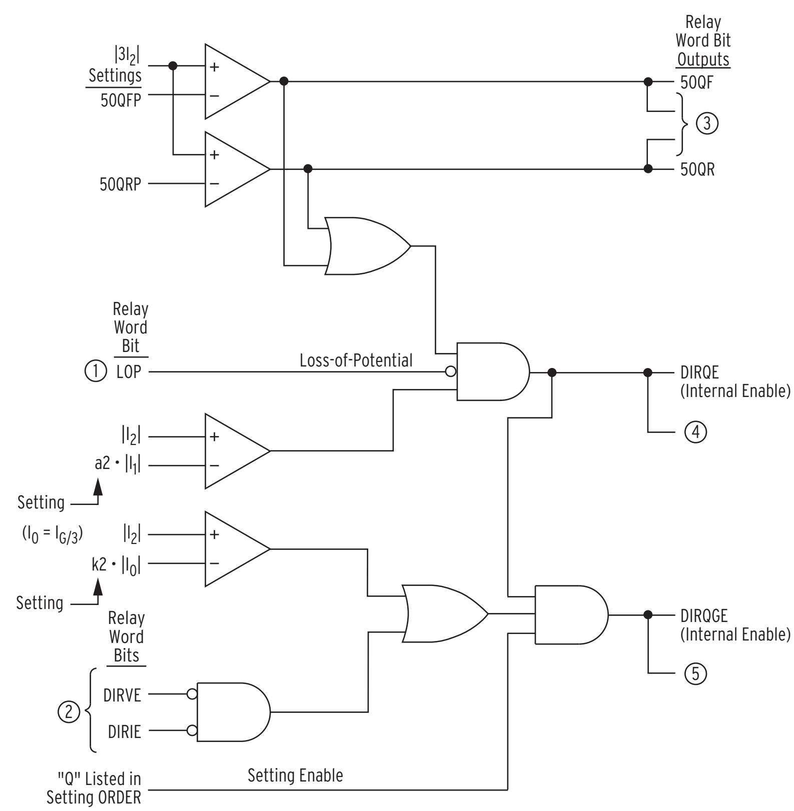
If a level direction setting (for example, DIR1) is set as follows,

DIR1 := **N** (nondirectional)

then the corresponding Level 1 directional control outputs in *Figure 4.83* and *Figure 4.84* assert to logical 1. The referenced Level 1 overcurrent elements in *Figure 4.83* and *Figure 4.84* are then not controlled by the directional control logic.

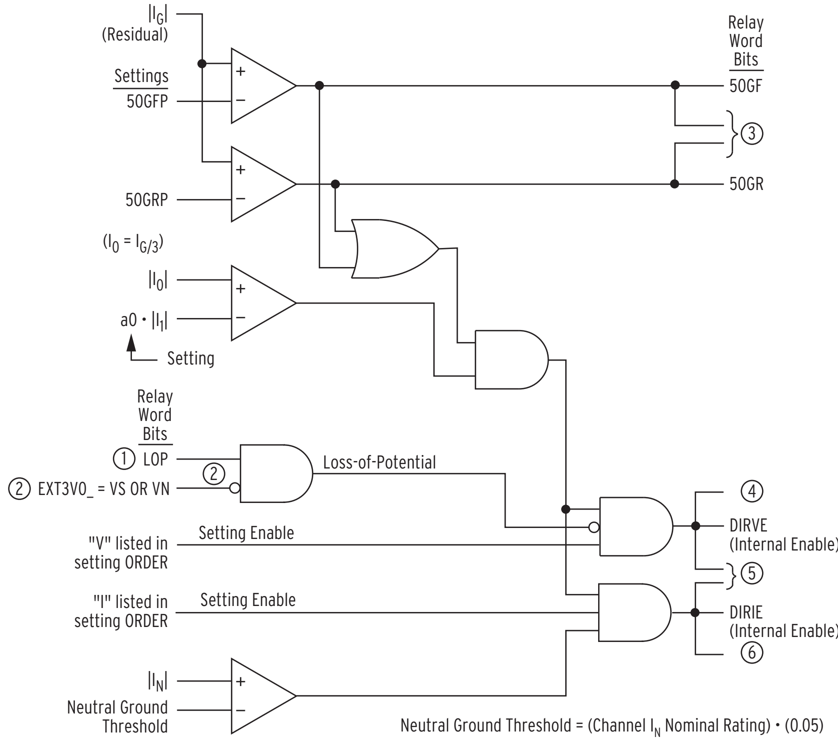
See the beginning of *Directional Control Settings on page 4.124* for a discussion on the operation of level direction settings DIR1 and DIR2 when the directional control enable setting EDIR is set to EDIR := N.

In some applications, level direction settings DIR1 and DIR2 are not flexible enough in assigning the necessary direction for certain overcurrent elements. *Directional Control Provided by Torque Control Settings on page 4.136* describes how to avoid this limitation for special cases.



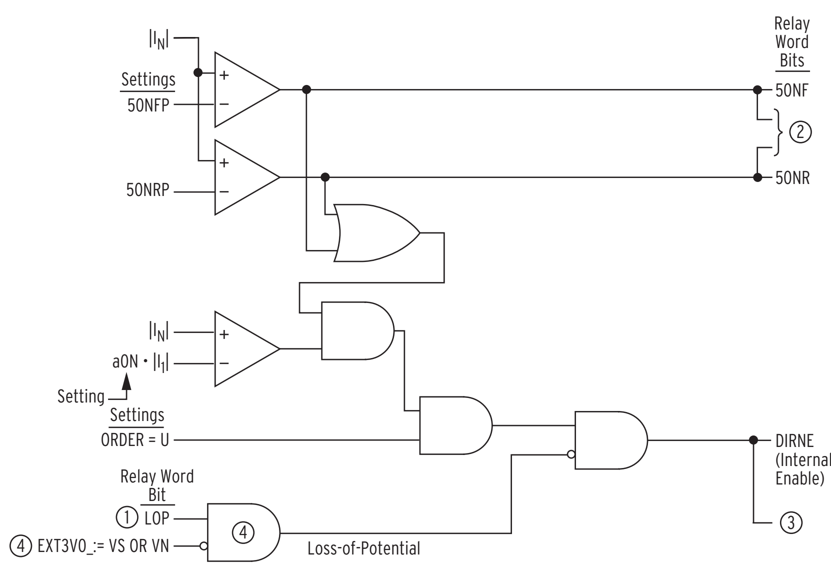
① From Figure 4.127 ② From Figure 4.75 ③ To Figure 4.77 and Figure 4.86
④ To Figure 4.86 ⑤ To Figure 4.77, Table 4.27 and Table 4.28

Figure 4.74 Internal Enables (DIRQE and DIRQGE) Logic for Negative-Sequence Voltage-Polarized Directional Elements



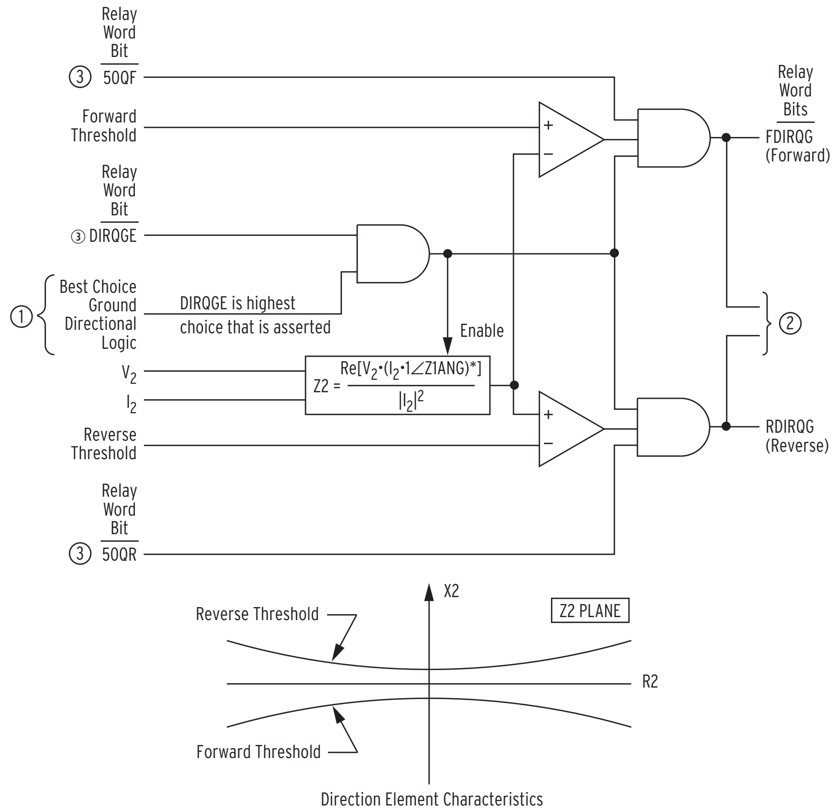
① From Figure 4.127
② EXT3V0_ and the AND gate are applicable to the X side only. For the Y side, Loss-of-Potential = LOP.
③ To Figure 4.78 and Figure 4.79
④ To Figure 4.78 and Figure 4.81
⑤ To Figure 4.74, Table 4.27, and Table 4.28
⑥ To Figure 4.79 and Figure 4.81

Figure 4.75 Internal Enables (DIRVE and DIRIE) Logic for Zero-Sequence Voltage-Polarized Directional Element With IG as Operate Quantity and Channel IN Current-Polarized Directional Element



① From Figure 4.127 ② To Figure 4.80
③ To Figure 4.80, Figure 4.82, Table 4.27, and Table 4.28
④ EXT3V0_ and the AND gate are applicable to the X side only. They are not applicable to the Y side.

Figure 4.76 Internal Enables (DIRNE) Logic for Zero-Sequence Voltage-Polarized Directional Element With IN as Operate Quantity



Forward Threshold:

If Z2F Setting ≤ 0, Forward Threshold = $0.75 \cdot Z2F - 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

If Z2F Setting > 0, Forward Threshold = $1.25 \cdot Z2F - 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

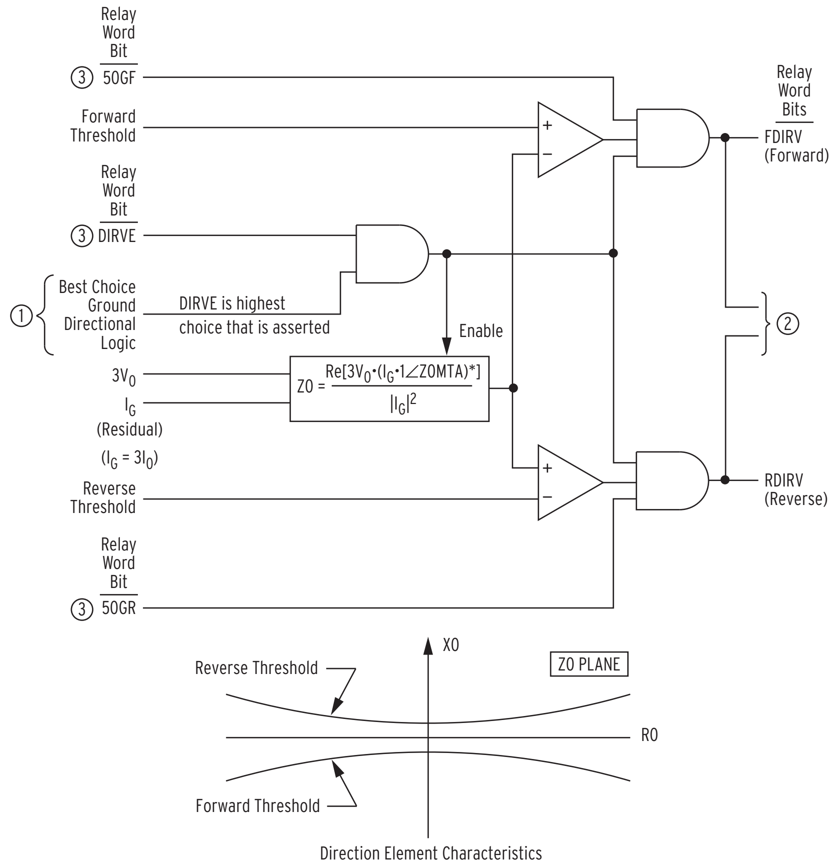
Reverse Threshold:

If Z2R Setting ≥ 0, Reverse Threshold = $0.75 \cdot Z2R + 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

If Z2R Setting < 0, Reverse Threshold = $1.25 \cdot Z2R + 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

① From Table 4.28 ② To Figure 4.81 ③ From Figure 4.74

Figure 4.77 Negative-Sequence Voltage-Polarized Directional Element for Residual-Ground Overcurrent Elements



<u>Forward Threshold:</u>

If Z0F Setting ≤ 0, Forward Threshold $= 0.75 \cdot Z0F - 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

If Z0F Setting > 0, Forward Threshold $= 1.25 \cdot Z0F - 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

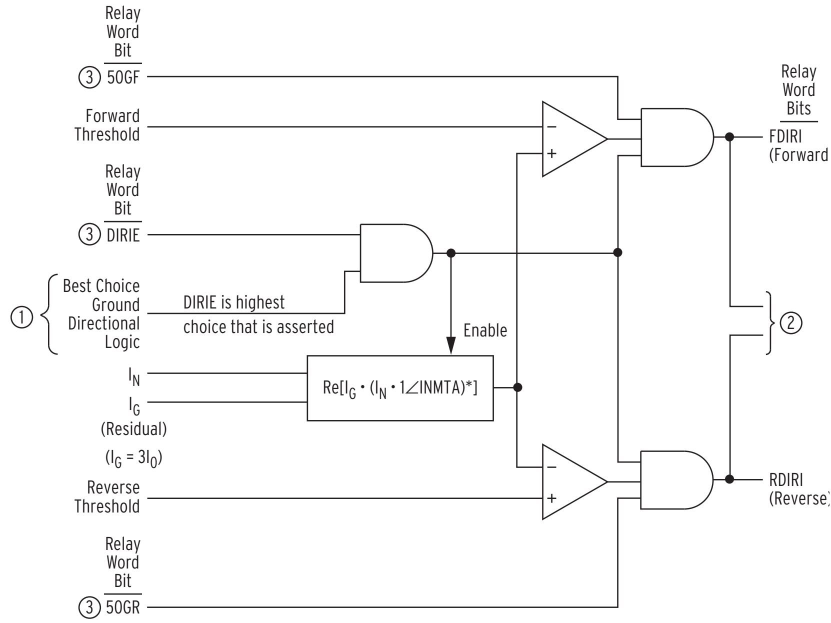
<u>Reverse Threshold:</u>

If Z0R Setting ≥ 0, Reverse Threshold $= 0.75 \cdot Z0R + 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

If Z0R Setting < 0, Reverse Threshold $= 1.25 \cdot Z0R + 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

① From Table 4.28 ② To Figure 4.81 ③ From Figure 4.75

Figure 4.78 Zero-Sequence Voltage-Polarized Directional Element for Residual-Ground Overcurrent Elements



Forward Threshold:

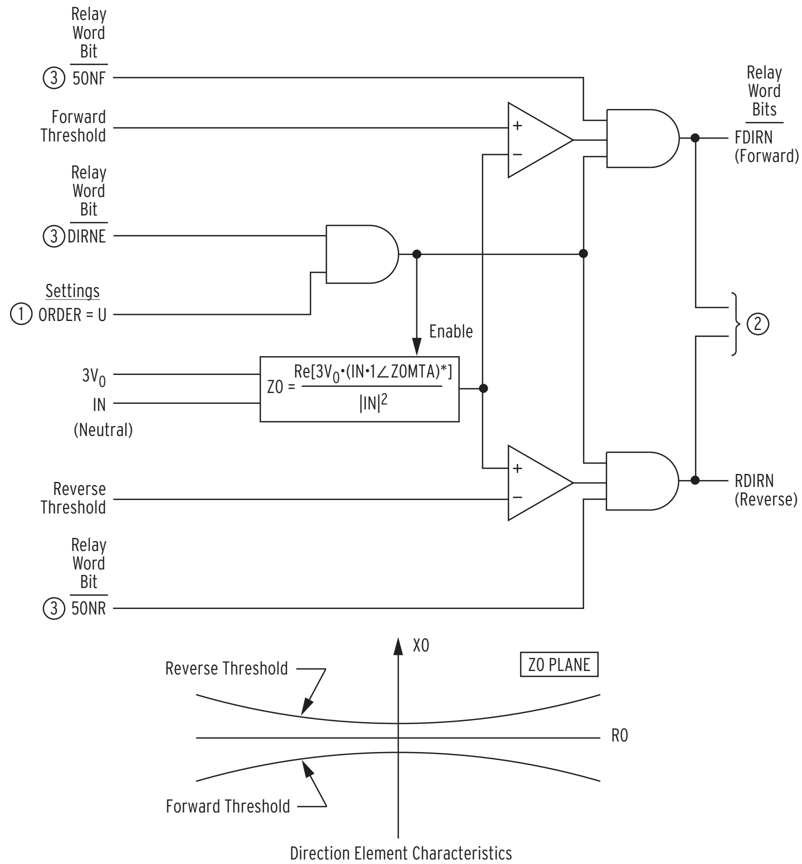
Forward Threshold = (Channel I_N Nominal Rating) • (Phase Channels Nominal Rating) • $(0.05)^2$

Reverse Threshold:

Reverse Threshold = −(Channel I_N Nominal Rating) • (Phase Channels Nominal Rating) • $(0.05)^2$

① From Table 4.4 ② To Figure 4.81 ③ From Figure 4.75

Figure 4.79 Channel IN Current-Polarized Directional Element



Forward Threshold: Z0F = −0.10 ohm secondary

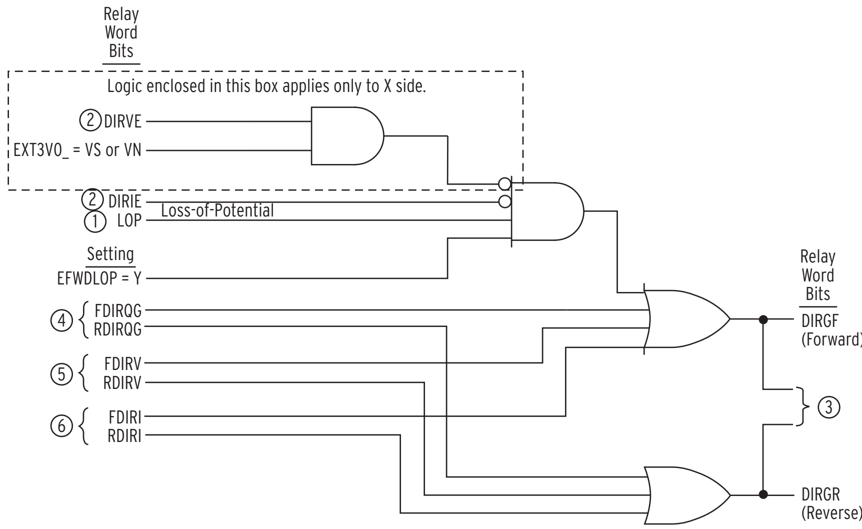
$$\text{Forward Threshold} = 0.75 \cdot Z0F - 0.25 \cdot \left| \frac{3V_0}{IN} \right|$$

Reverse Threshold: Z0R = 0.10 ohm secondary

$$\text{Reverse Threshold} = 0.75 \cdot Z0R + 0.25 \cdot \left| \frac{3V_0}{IN} \right|$$

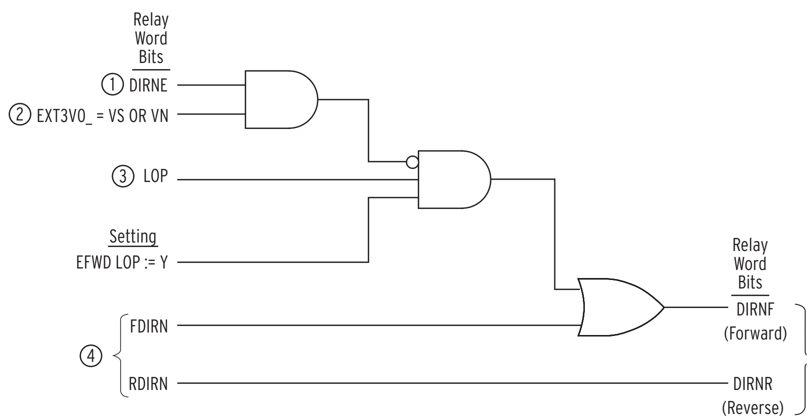
① From Table 4.28 ② To Figure 4.82 ③ From Figure 4.76

Figure 4.80 Zero-Sequence Voltage-Polarized Directional Element for Neutral-Ground Overcurrent Elements



① From Figure 4.127 ② From Figure 4.75 ③ From Figure 4.83
④ From Figure 4.77 ⑤ From Figure 4.78 ⑥ To Figure 4.79

Figure 4.81 Routing of Directional Elements to Residual-Ground Overcurrent Elements



① From Figure 4.76 ② EXT3V0_ and the AND gate are applicable to X side only. It is not applicable to Y side.
③ From Figure 4.127 ④ From Figure 4.80 ⑤ From Figure 4.84

Figure 4.82 Routing of Neutral Directional Element to Neutral-Ground Overcurrent Elements

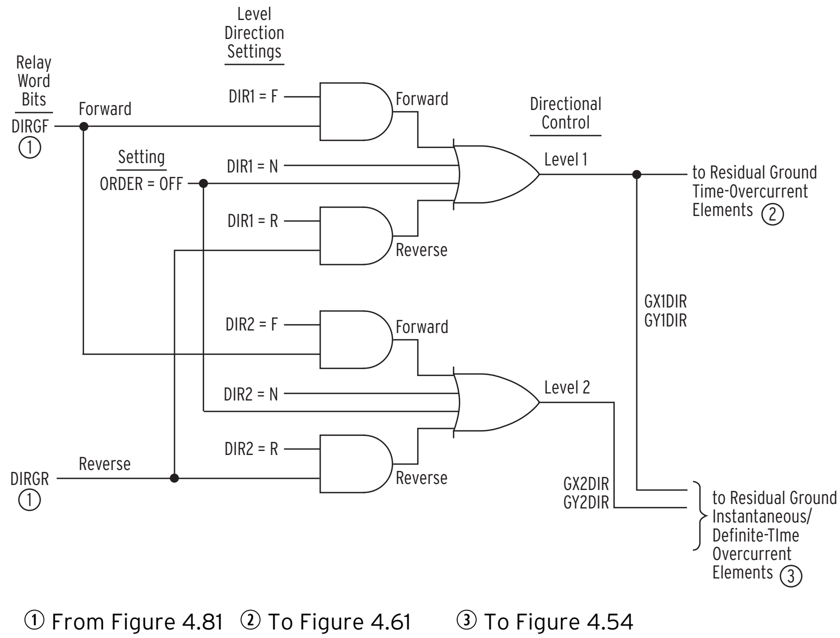


Figure 4.83 Direction Forward/Reverse Logic for Residual-Ground Overcurrent Elements

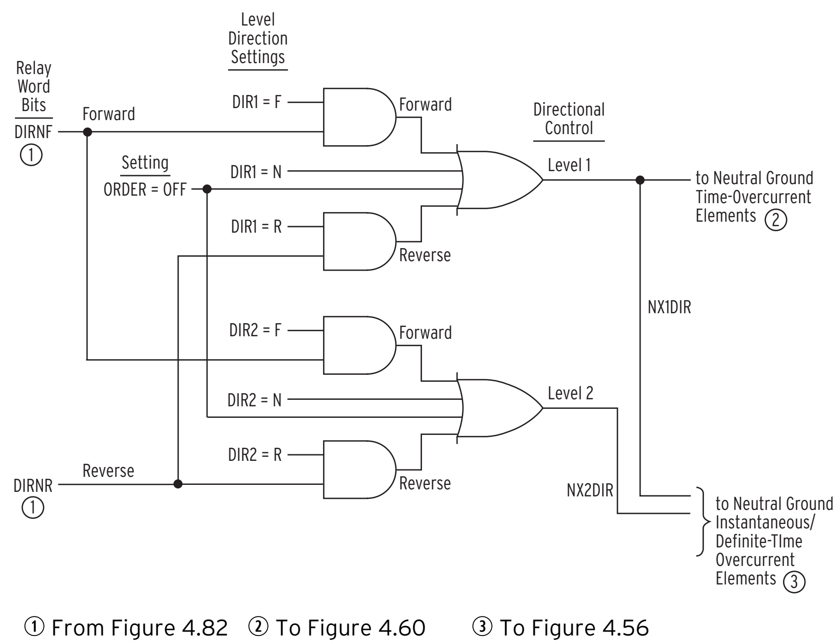
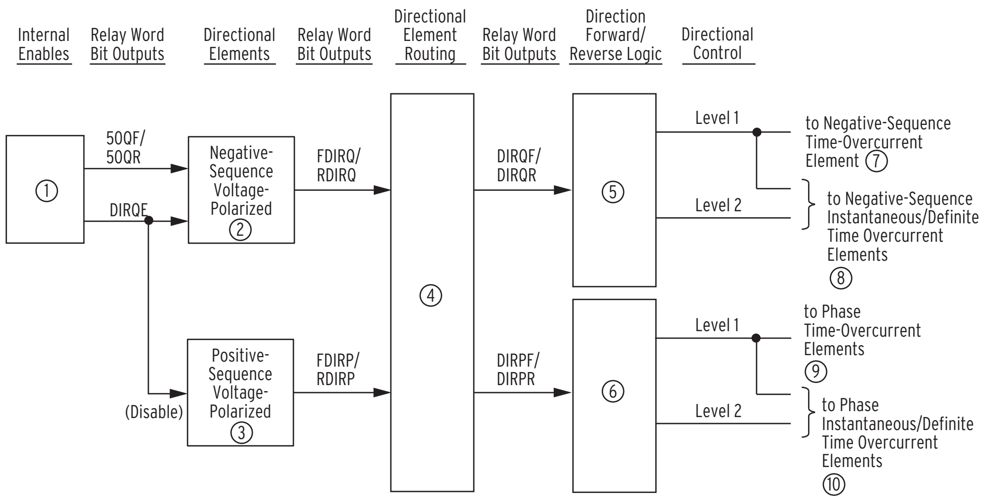


Figure 4.84 Direction Forward/Reverse Logic for Neutral-Ground Overcurrent Elements

Directional Control for Negative-Sequence and Phase Overcurrent Elements. The directional control for overcurrent elements is enabled by making directional control enable setting EDIR. Setting EDIR and other directional control settings are described in *Directional Control Settings on page 4.124*.

The negative-sequence voltage-polarized directional element controls the negative-sequence overcurrent elements. Negative-sequence voltage-polarized and positive-sequence voltage-polarized directional elements control the phase overcurrent elements. *Figure 4.85* gives an overview of how the negative-sequence voltage-polarized and positive-sequence voltage-polarized directional elements are enabled and routed to control the negative-sequence and phase overcurrent elements.



① Figure 4.74 ② Figure 4.86 ③ Figure 4.87 ④ Figure 4.88 ⑤ Figure 4.89
⑥ Figure 4.90 ⑦ Figure 4.59 ⑧ Figure 4.54 ⑨ Figure 4.58 ⑩ Figure 4.54

Figure 4.85 General Logic Flow of Directional Control for Negative-Sequence and Phase Overcurrent Elements (Apply Only to the Y Side of the SEL-700GT and SEL-700GT+ Relays)

The directional control for negative-sequence and phase overcurrent elements is intended to control overcurrent elements with pickup settings above load current to detect faults. In some applications, it may be necessary to set a sensitive overcurrent element to detect currents in one direction (reverse, for example) and a less sensitive overcurrent element for the other direction (forward). In such applications, with default relay logic, a reverse overcurrent element with pickup setting below forward load may operate for some remote, unbalanced, reverse faults. If possible, overcurrent element pickup settings should be set above the current expected for load in either direction. If this is not possible, refer to the technical paper, *Use of Directional Elements at the Utility-Industrial Interface*, by Dave Costello, Greg Bow, and Martin Moon, which is available on the SEL website, or by contacting SEL for assistance.

Internal Enables

Refer to *Figure 4.74* and *Figure 4.85*. The internal enable DIRQE corresponds to the negative-sequence voltage-polarized directional element.

Note that *Figure 4.74* has extra internal enable DIRQGE, which is used in the directional element logic that controls the neutral-ground and residual-ground overcurrent elements (see *Figure 4.72*).

The settings involved with internal enable DIRQE in *Figure 4.74* (for example, settings a2, k2) are explained in *Directional Control Settings on page 4.124*.

Directional Elements

Refer to *Figure 4.85*, *Figure 4.89*, and *Figure 4.87*. If a loss-of-potential condition occurs (Relay Word bit LOP asserts), the negative-sequence voltage-polarized and positive-sequence voltage-polarized directional elements are disabled (see *Figure 4.74* and *Figure 4.87*).

Refer to *Figure 4.127* and the accompanying text for more information on loss-of-potential.

Note in *Figure 4.85* and *Figure 4.87* that the assertion of internal enable DIRQE (for the negative-sequence voltage-polarized directional element) disables the positive-sequence voltage-polarized directional element. The negative-sequence voltage-polarized directional element has priority over the positive-sequence voltage-polarized directional element in controlling the phase overcurrent elements. The negative-sequence voltage-polarized directional element operates for unbalanced faults, while the positive-sequence voltage-polarized directional element operates for three-phase faults.

Note also in *Figure 4.87* that the assertion of ZLOAD disables the positive-sequence voltage-polarized directional element. ZLOAD asserts when the relay is operating in a user-defined load region (see *Figure 4.94*).

Directional Element Routing

Refer to *Figure 4.85* and *Figure 4.88*. The directional element outputs are routed to the forward (Relay Word bits DIRQF and DIRPF) and reverse (Relay Word bits DIRQR and DIRPR) logic points and then on to the direction forward/reverse logic in *Figure 4.89* and *Figure 4.90*.

Loss-of-Potential

If a loss-of-potential condition occurs (Relay Word bit LOP asserts), then the forward logic points (Relay Word bits DIRQF and DIRPF) assert to logical 1, thus enabling the negative-sequence and phase overcurrent elements that are set direction forward (with settings DIR1 = F, DIR2 = F). These direction forward overcurrent elements effectively become nondirectional and provide overcurrent protection during a loss-of-potential condition.

As detailed previously (in *Figure 4.74* and *Figure 4.87*), voltage-based directional elements are disabled during a loss-of-potential condition. Thus, the overcurrent elements controlled by these voltage-based directional elements are also disabled. But this disable condition is overridden for the overcurrent elements set direction forward if setting EFWDLOP := Y.

Refer to *Figure 4.127* and the accompanying text for more information on loss-of-potential.

Direction Forward/Reverse Logic

Refer to *Figure 4.85*, *Figure 4.89*, and *Figure 4.90*. The forward (Relay Word bits DIRQF and DIRPF) and reverse (Relay Word bits DIRQR and DIRPR) logic points are routed to the different levels of overcurrent protection by the level direction settings DIR1 and DIR2.

Table 4.33 shows the overcurrent elements that are controlled by each level direction setting. Note in *Table 4.33* that all the time-overcurrent elements (51_T elements) are controlled by the DIR1 level direction setting.

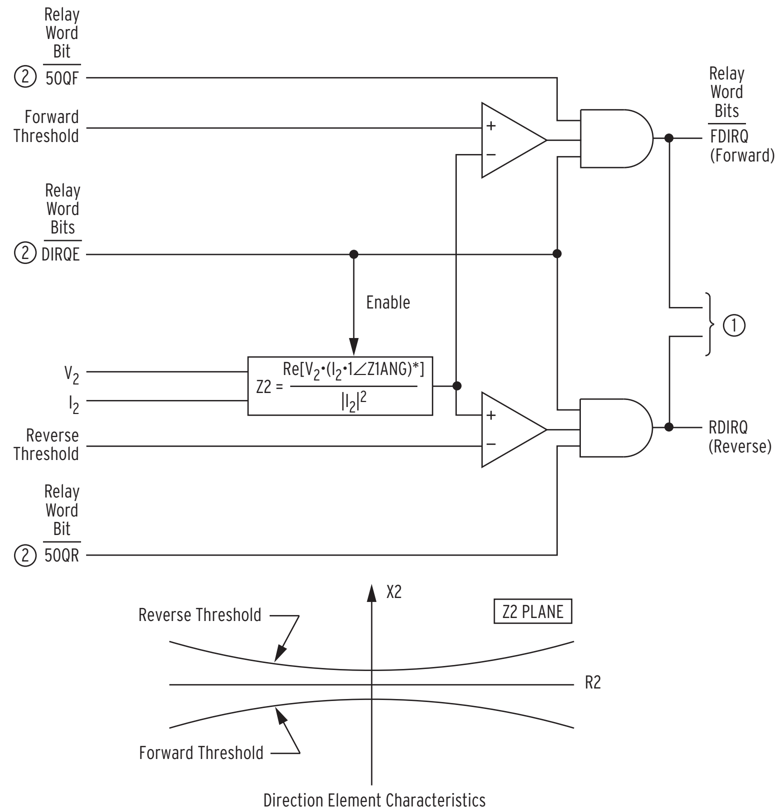
If a level direction setting (for example, DIR1) is set:

DIR1 := **N** (nondirectional)

then the corresponding Level 1 directional control outputs in *Figure 4.89* and *Figure 4.90* assert to logical 1. The referenced Level 1 overcurrent elements in *Figure 4.89* and *Figure 4.90* are not controlled by the directional control logic.

See *Directional Control Settings on page 4.124* for a discussion of the operation of level direction settings DIR1 and DIR2 when the directional control enable setting EDIR is set to EDIR := N.

In some applications, level direction settings DIR1 and DIR2 are not flexible enough in assigning the necessary direction for certain overcurrent elements. *Directional Control Provided by Torque Control Settings on page 4.136* describes how to avoid this limitation for special cases.



Forward Threshold:

If Z2F Setting ≤ 0, Forward Threshold = $0.75 \cdot Z2F - 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

If Z2F Setting > 0, Forward Threshold = $1.25 \cdot Z2F - 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

Reverse Threshold:

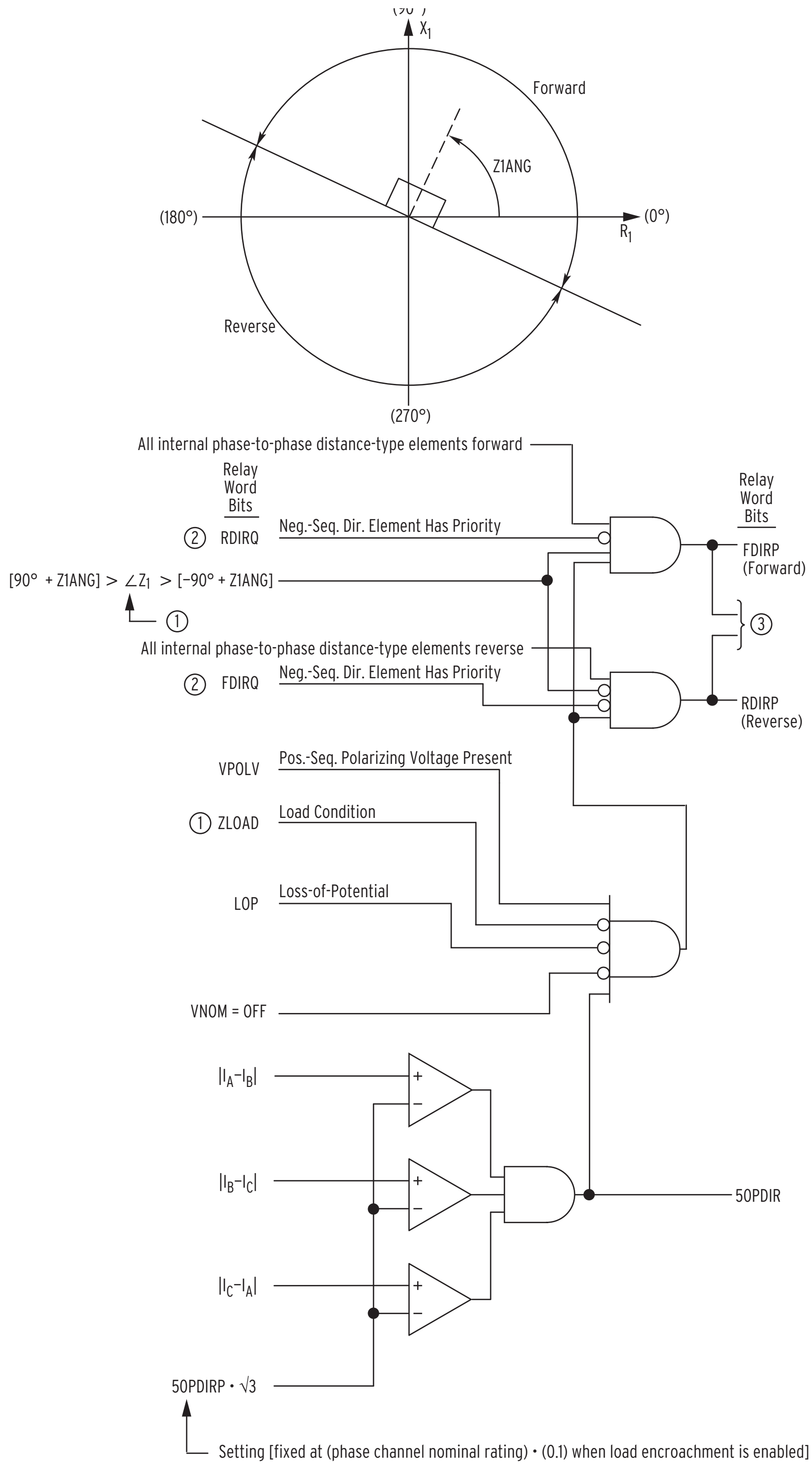
If Z2R Setting ≥ 0, Reverse Threshold = $0.75 \cdot Z2R + 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

If Z2R Setting < 0, Reverse Threshold = $1.25 \cdot Z2R + 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

① To Figure 4.88 ② From Figure 4.74

Figure 4.86 Negative-Sequence Voltage-Polarized Directional Element for Negative-Sequence and Phase Overcurrent Elements (Apply Only to the Y Side of the SEL-700GT and SEL-700GT+ Relays)

NOTE: This element uses positive-sequence memory voltage as the polarization voltage.



① To Figure 4.94 ② From Figure 4.74 ③ To Figure 4.88

Figure 4.87 Positive-Sequence Voltage-Polarized Directional Element for Phase Overcurrent Elements (Apply Only to the Y Side of the SEL-700GT and SEL-700GT+ Relays)

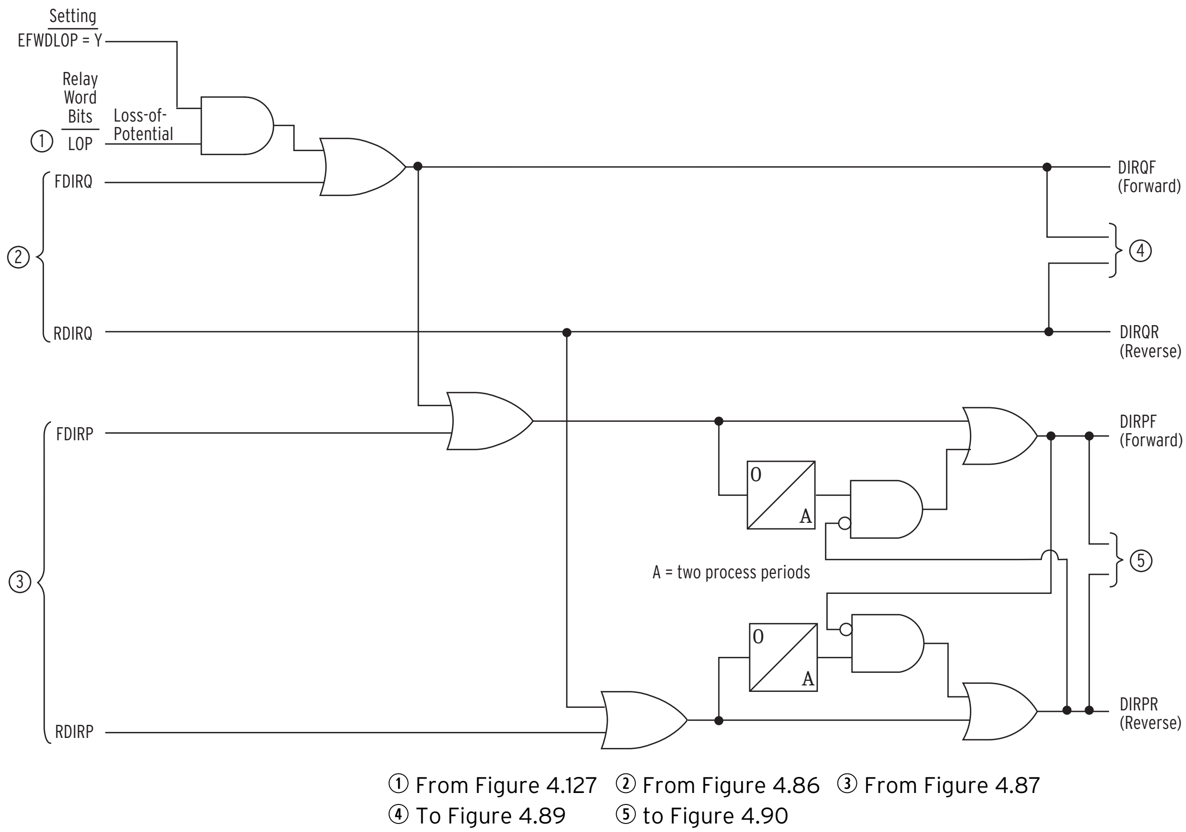


Figure 4.88 Routing of Directional Elements to Negative-Sequence and Phase Overcurrent Elements (Apply Only to the Y Side of the SEL-700GT and SEL-700GT+ Relays)

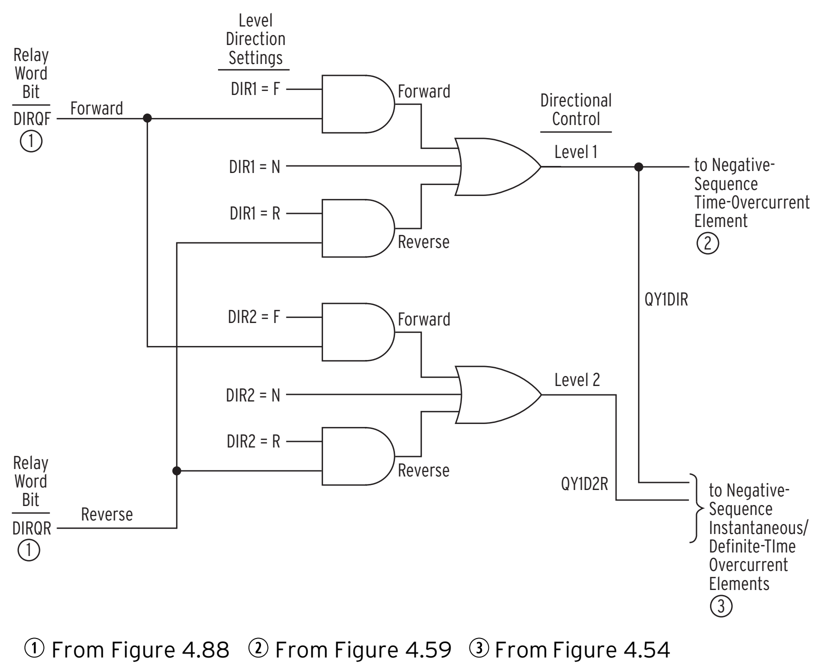
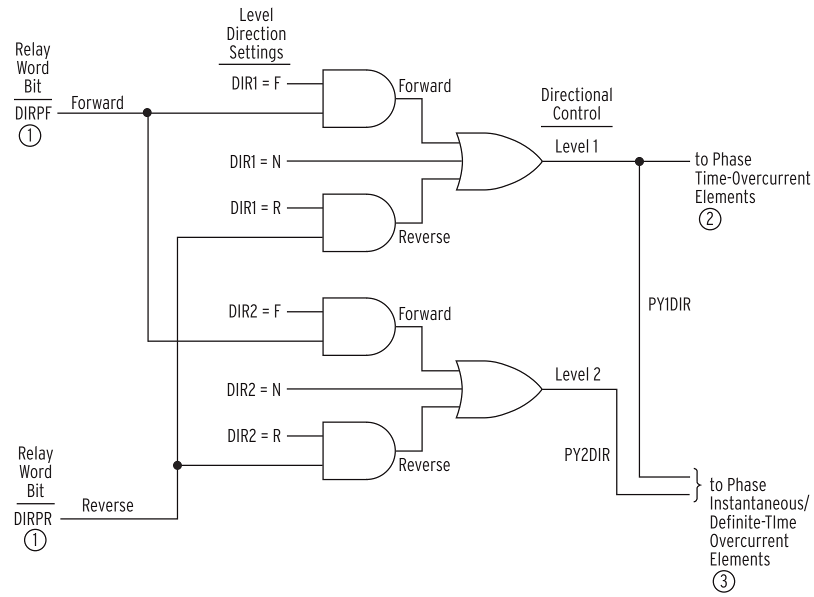


Figure 4.89 Direction Forward/Reverse Logic for Negative-Sequence Overcurrent Elements (Apply Only to the Y Side of the SEL-700GT and SEL-700GT+ Relays)



① From Figure 4.88 ② Figure 4.58 ③ Figure 4.54

Figure 4.90 Direction Forward/Reverse Logic for Phase Overcurrent Elements (Apply Only to the Y Side of the SEL-700GT and SEL-700GT+ Relays)

Directional Control Settings

The directional control for overcurrent elements is enabled by making directional control enable setting EDIR. Setting EDIR has setting choices:

Y	Enable directional control
N	Disable directional control
AUTO	Enable directional control and set many of the directional element settings automatically

If directional control enable setting EDIR := N, directional control is disabled and no directional control settings are made. All level direction settings are set internally as:

DIR1 := N	(no directional control for Level 1 overcurrent elements)
DIR2 := N	(no directional control for Level 2 overcurrent elements)

With these settings, the directional control outputs in *Figure 4.83*, *Figure 4.84*, *Figure 4.89*, and *Figure 4.90* assert to logical 1. The overcurrent elements referenced in *Figure 4.83*, *Figure 4.84*, *Figure 4.89*, and *Figure 4.90* are then not controlled by the directional control logic.

Table 4.31 Directional Element Settings for X Side and Y Side (Sheet 1 of 3)

Setting Prompt	Setting Range	Setting Name := Factory Default
X Side		
DIR CONTROL ENBL	Y, AUTO[a], N	EDIRX := N
FWD DIR ON LOP	Y, N	EFWDLOPX := Y
POS SQ LN Z MAG	0.10–510.00 ohm[b]	Z1MAGX := 2.14

Table 4.31 Directional Element Settings for X Side and Y Side (Sheet 2 of 3)

Setting Prompt	Setting Range	Setting Name := Factory Default
POS SQ LN Z ANG	50.00–90.00 deg	Z1ANGX := 68.86
ZERO SQ LN Z MAG	0.10–510.00 ohm[b]	Z0MAGX := 6.38[b]
ZERO SQ LN Z ANG	50.00–90.00 deg	Z0ANGX := 72.47
DIR CONTROL LVL1	F, R, N	DIR1X := N
DIR CONTROL LVL2	F, R, N	DIR2X := N
GND DIR PRIORITY	Q, V[c], I, U[a, c], OFF	ORDERX := OFF[a, c]
FWD DIR Z2 LVL	–128.00 to 128.00 ohm[b]	Z2FX := –0.06[b]
REV DIR Z2 LVL	–128.00 to 128.00 ohm[b]	Z2RX := 0.06[b]
FWD DIR NSEQ LVL	0.25–5.00 A[d]	50QFPX := 0.50[d]
REV DIR NSEQ LVL	0.25–5.00 A[d]	50QRPX := 0.25[d]
I1 RST FAC I2/I1	0.02–0.50	a2X := 0.10
I0 RST FAC I2/I0	0.10–1.20	k2X := 0.20
FWD DIR RES LVL	0.05–5.00 A[d]	50GFPX := 0.50[d]
REV DIR RES LVL	0.05–5.00 A[d]	50GRPX := 0.25[d]
I1 RST FAC I0/I1	0.02–0.50	a0X := 0.10
FWD DIR Z0 LVL	–128.00 to 128.00 ohm[b]	Z0FX := –0.06[b, e]
REV DIR Z0 LVL	–128.00 to 128.00 ohm[b]	Z0RX := 0.06[b, e]
ZRO SQ MX TQ ANG	–90.00 to 90.00 deg	Z0MTAX := 72.47
FWD DIR IN LVL	0.25-5.00 A [d, e]	50NFP :=0.5 [d, e]
REV DIR IN LVL	0.25-5.00 A [d, e]	50NRP :=0.25 [d, e]
POS SQ RESTR FAC	0.001-0.500[e]	a0N := 0.001 [e]
Y Side		
DIR CONTROL ENBL	Y, AUTO, N	EDIRY := N
FWD DIR ON LOP	Y, N	EFWDLOPY := Y
POS SQ LN Z MAG	0.10–510.00 ohm[b]	Z1MAGY := 2.14[b]
POS SQ LN Z ANG	50.00–90.00 deg	Z1ANGY := 68.86
ZERO SQ LN Z MAG	0.10–510.00 ohm[b]	Z0MAGY := 6.38[b]
ZERO SQ LN Z ANG	50.00–90.00 deg	Z0ANGY := 72.47
DIR CONTROL LVL1	F, R, N	DIR1Y := N
DIR CONTROL LVL2	F, R, N	DIR2Y := N
GND DIR PRIORITY	Q, V[c], I, OFF	ORDERY := OFF[c]
FWD DIR Z2 LVL	–128.00 to 128.00 ohm[b]	Z2FY := –0.06[b]
REV DIR Z2 LVL	–128.00 to 128.00 ohm[b]	Z2RY := 0.06[b]
FWD DIR NSEQ LVL	0.25–5.00 A[d]	50QFPY := 0.50[d]

Table 4.31 Directional Element Settings for X Side and Y Side (Sheet 3 of 3)

Setting Prompt	Setting Range	Setting Name := Factory Default
REV DIR NSEQ LVL	0.25–5.00 A[d]	50QRPY := 0.25[d]
I1 RST FAC I2/I1	0.02–0.50	a2Y := 0.10
I0 RST FAC I2/I0	0.10–1.20	k2Y := 0.20
FWD DIR RES LVL	0.05–5.00 A[d]	50GFPY := 0.50[d]
REV DIR RES LVL	0.05–5.00 A[d]	50GRPY := 0.25[d]
I1 RST FAC I0/I1	0.02–0.50	a0Y := 0.10
FWD DIR Z0 LVL	–128.00 to 128.00 ohm[b]	Z0FY := –0.06[b]
REV DIR Z0 LVL	–128.00 to 128.00 ohm[b]	Z0RY := 0.06[b]
ZRO SQ MX TQ ANG	–90.00 to 90.00 deg	Z0MTAY := 72.47

[a] EDIRX cannot be set to AUTO when ORDERX := U.
[b] Setting ranges and default ohm values shown are for 5 A nominal CT rating. Multiply by 5 for 1 A CTs.
[c] On the X side, choice V and U are available when DELTAY_X := WYE or when DELTAY_X := DELTA and EXT3V0_X = VS or VN; On the Y side, choice V is available when DELTAY_Y := WYE. All combinations of available Q, V, and I are allowed on both sides. Option U, only available on the X side, cannot be combined with other options—Q, V or I.
[d] Setting ranges and default Amp values shown are for 5 A nominal CT rating. Divide by 5 for 1 A CTs.
[e] 50NFP, 50NRP and a0N are only available when ORDER := U. When ORDER := U, Z0FX and Z0RX are hidden and forced to -0.10 and 0.10 ohms secondary, respectively, irrespective of the nominal rating of the CT.

Settings Made Automatically

If the directional control enable setting EDIR is set:

EDIR := **AUTO**

then the following directional control settings are calculated and set automatically:

Z2F, Z2R, 50QFP, 50QRP, a2, k2, 50GFP, 50GRP, a0, Z0F, Z0R, and Z0MTA

If EDIR := AUTO, then Z0MTA is set equal to Z0ANG and Z0MTA is hidden. Note that EDIR cannot be set to AUTO if ORDER := U and vice-versa. Moreover, if ORDER := U, Z0FX and Z0RX are hidden and forced to -0.10 and 0.10 ohms secondary respectively, irrespective of the nominal rating of the CT.

Once these settings are calculated automatically, they can only be modified if you go back and change the directional control enable setting to EDIR := Y.

The remaining directional control settings are *not* set automatically if setting EDIR := AUTO. You must set these whether you are setting EDIR := AUTO or Y. These settings are:

DIR1, DIR2, ORDER, and 50PDIRP

All these settings are explained in detail in the remainder of this subsection.

Not all of these directional control settings (set automatically or by you) are used in every application. Following are directional control settings that are hidden/not made for particular conditions.

Table 4.32 Directional Control Settings Not Made for Particular Conditions

Settings hidden/not made:	for condition:
50PDIRP	Always hidden (X side), ELOADY := Y (Y side).
50GFP, 50GRP, a0	setting ORDER does not contain V or I
Z0F, Z0R, Z0MTA	setting ORDER does not contain V or I
ORDERX := U	setting EDIRX := AUTO
Z0FX := -0.10, Z0RX := 0.10	setting ORDERX := U

Settings

DIR1 and DIR2 Overcurrent Element Direction Settings. *Table 4.33* shows the overcurrent elements that are controlled by each level direction setting. *Table 4.34* shows the Relay Word bits associated with all the X-side and Y-side overcurrent elements with and without directional control across the different SEL-700G models. Note in *Table 4.33* that all the time-overcurrent elements (51_T elements) are controlled by the DIR1 level direction setting. *Figure 4.83*, *Table 4.84*, *Figure 4.89*, and *Figure 4.90* show the logic implementation of the control listed in *Table 4.33*.

Table 4.33 Overcurrent Elements Controlled by Level Direction Settings DIR1X, DIR2X, DIR1Y, and DIR2Y[a][b]

Level Direction Settings	Phase	Residual-Ground	Negative-Sequence	Neutral-Ground
DIR1*m*	67PY1P (*Figure 4.54*) 67PY1T (*Figure 4.54*) 51PYP(*Figure 4.58*) 51PYT (*Figure 4.58*)	67G*m*1P (*Figure 4.53* and *Figure 4.54*) 67G*m*1T (*Figure 4.53* and *Figure 4.54*) 51G*m*P (*Figure 4.61*) 51G*m*T (*Figure 4.61*)	67QY1 (*Figure 4.54*) 67QY1T (*Figure 4.54*) 51QYP (*Figure 4.59*) 51QYT (*Figure 4.59*)	67N1P (*Figure 4.56*) 67N1T (*Figure 4.56*) 51NP (*Figure 4.60*) 51NT (*Figure 4.60*)
DIR2*m*	67PY2P (*Figure 4.54*) 67PY2T (*Figure 4.54*)	67G*m*2P (*Figure 4.53* and *Figure 4.54*) 67G*m*2T (*Figure 4.53* and *Figure 4.54*)	67QY2P (*Figure 4.54*) 67QY2T (*Figure 4.54*)	67N2P (*Figure 4.56*) 67N2T (*Figure 4.56*)

[a] Corresponding overcurrent element figure numbers are in parentheses.
[b] m = X or Y.

Table 4.34 Relay Word Bits Associated With X-Side and Y-Side Overcurrent Elements With and Without Directional Control Across Different SEL-700G Models (Sheet 1 of 2)

Elements	Models						
	700G0	700G0+	700G1	700G1+	700GT	700GT+	700GW
50P*m*1P	X	X	X and Y	X and Y		X	X and Y
50P*m*1T	X	X	X and Y	X and Y		X	X and Y
50P*m*2P	X	X	X and Y	X and Y		X	X and Y
50P*m*2T	X	X	X and Y	X and Y		X	X and Y
50P*m*3AP	X	X	X and Y	X and Y		X	X and Y
50P*m*3AT	X	X	X and Y	X and Y		X	X and Y
50P*m*3BP	X	X	X and Y	X and Y		X	X and Y
50P*m*3BT	X	X	X and Y	X and Y		X	X and Y
50P*m*3CP	X	X	X and Y	X and Y		X	X and Y
50P*m*3CT	X	X	X and Y	X and Y		X	X and Y

Table 4.34 Relay Word Bits Associated With X-Side and Y-Side Overcurrent Elements With and Without Directional Control Across Different SEL-700G Models (Sheet 2 of 2)

Elements	Models						
	700G0	**700G0+**	**700G1**	**700G1+**	**700GT**	**700GT+**	**700GW**
67PY1P					Y	Y	
67PY1T					Y	Y	
67PY2P					Y	Y	
67PY2T					Y	Y	
50Q*m*1P	X	X	X and Y	X and Y		X	X and Y
50Q*m*1T	X	X	X and Y	X and Y		X	X and Y
50Q*m*2P	X	X	X and Y	X and Y		X	X and Y
50Q*m*2T	X	X	X and Y	X and Y		X	X and Y
67QY1P					Y	Y	
67QY1T					Y	Y	
67QY2P					Y	Y	
67QY2T					Y	Y	
50GY1P			Y	Y			Y
50GY1T			Y	Y			Y
50GY2P			Y	Y			Y
50GY2T			Y	Y			Y
67G*m*1P	X	X	X	X	Y	X and Y	X
67G*m*1T	X	X	X	X	Y	X and Y	X
67G*m*2P	X	X	X	X	Y	X and Y	X
67G*m*2T	X	X	X	X	Y	X and Y	X
50N1P					X		
50N1T					X		
50N2P					X		
50N2T					X		
67N1P	X[a]	X[a]	X[a]	X[a]		X[a]	
67N1T	X[a]	X[a]	X[a]	X[a]		X[a]	
67N2P	X[a]	X[a]	X[a]	X[a]		X[a]	
67N2T	X[a]	X[a]	X[a]	X[a]		X[a]	
51PNP					Y[b]	Y[b]	X and Y
51PNT					Y[b]	Y[b]	X and Y
51Q*m*P					Y[b]	Y[b]	X and Y
51Q*m*T					Y[b]	Y[b]	X and Y
51G*m*P	X[b]	X[b]	X[b]	X[b]	Y[b]	X[b] and Y[b]	X and Y
51G*m*T	X[b]	X[b]	X[b]	X[b]	Y[b]	X[b] and Y[b]	X and Y
51NP	X[a]	X[a]	X[a]	X[a]	X	X[a]	
51NT	X[a]	X[a]	X[a]	X[a]	X	X[a]	

[a] These time-overcurrent elements have directional control. X-side zero-sequence voltage is used for polarization.
[b] These time-overcurrent elements have directional control. The corresponding side sequence quantity is used for polarization.

In some applications, the level direction settings DIR1 and DIR2 are not flexible enough in assigning the necessary direction for certain overcurrent elements. *Directional Control Provided by Torque Control Settings on page 4.136* describes how to avoid this limitation for special cases.

ORDER—Ground Directional Element Priority Setting. Setting **ORDER** can be set with the elements listed and defined in *Table 4.27*, subject to the setting combination constraints in *Table 4.28* and *Table 4.29*. *Table 4.29* lists the ground directional element availability resulting from the voltage transformer connections.

The *order* in which the directional elements are listed in setting ORDER determines the priority in which these elements operate to provide Best Choice Ground Directional Element logic control.

For example, if setting:

ORDERY := **QV**

then the first listed directional element (Q = negative-sequence voltage-polarized directional element; see *Figure 4.77*) is the first priority directional element to provide directional control for the residual-ground overcurrent elements.

If the negative-sequence voltage-polarized directional element is not operable (that is, it does not have sufficient operating quantity as indicated by its internal enable, DIRQGE, not being asserted; see *Figure 4.74*), then the second listed directional element (V = zero-sequence voltage-polarized directional element; see *Figure 4.78*) provides directional control for the residual-ground overcurrent elements.

If the zero-sequence voltage-polarized directional element is not operable (that is, it does not have sufficient operating quantity as indicated by its internal enable, DIRVE, not being asserted (see *Figure 4.72*), then no directional control is available. The residual-ground overcurrent elements do not operate, even though these elements are designated with the DIR*n* (*n* = 1, 2) settings to be directionally controlled (see *Figure 4.83*).

Another example, if setting:

ORDERX := **V**

then the zero-sequence voltage-polarized directional element (see *Figure 4.78*) provides directional control for the residual-ground overcurrent elements at all times (assuming it has sufficient operating quantity). If there is not sufficient operating quantity during an event (that is, internal enable DIRVE is not asserted; see *Figure 4.75*), then no directional control is available. The residual-ground overcurrent elements do not operate, even though these elements are designated with the DIR*n* (*n* = 1, 2) settings to be directionally controlled (see *Figure 4.83*).

Another example, if setting:

ORDERX := **U**

then the zero-sequence voltage-polarized directional element (see *Figure 4.80*) provides directional control for the neutral-ground overcurrent elements at all times (assuming it has sufficient operating quantity). Note that choice U cannot be combined with the rest, V, Q, or I. If there is not sufficient operating quantity during an event (that is, internal enable DIRNE is not asserted; see *Figure 4.76*), then no directional control is available. The neutral-ground overcurrent elements do not operate, even though these elements are designated with the DIRn (n = 1, 2) settings to be directionally controlled (see *Figure 4.84*). Note that ORDERX cannot be set to U if EDIR is set to AUTO.

If setting:

ORDER*m* := **OFF**

then all of the ground directional elements are inoperable. Note in *Figure 4.83* and *Figure 4.84* that setting ORDER := OFF effectively makes the residual-ground and neutral-ground overcurrent elements nondirectional (the directional control outputs of *Figure 4.83* and *Figure 4.84*, respectively, are continuously asserted to logical 1).

50PDIRPY—Phase Directional Element Three-Phase Current Pickup. The 50PDIRPY setting is set to pick up for all three-phase faults that need to be covered by the phase overcurrent elements. It supervises the positive-sequence voltage-polarized directional elements FDIRP and RDIRP (see *Figure 4.87*).

If the load-encroachment logic is enabled (enable setting ELOADY := Y), then setting 50PDIRPY is not made or displayed, but is fixed internally at:

0.5 A secondary (5 A nominal phase current inputs, **IAY**, **IBY**, **ICY**)

0.1 A secondary (1 A nominal phase current inputs, **IAY**, **IBY**, **ICY**)

Z2F/Z2R—Forward/Reverse Directional Z2 Thresholds. Z2F and Z2R are used to calculate the Forward and Reverse Thresholds, respectively, for the negative-sequence voltage-polarized directional elements (see *Figure 4.77* and *Figure 4.89*).

If enable setting EDIR := Y, you calculate and enter the settings Z2F and Z2R (negative-sequence impedance values), but setting Z2R must be greater in value than setting Z2F by 0.1 Ω secondary.

If enable setting EDIR := AUTO, the relay uses the positive-sequence line impedance magnitude setting Z1MAG as follows to calculate the settings Z2F and Z2R (negative-sequence impedance values) automatically:

Z2F := **Z1MAG/2** (Ω secondary)

Z2R := **Z1MAG/2 +** *z* (Ω secondary; *z* listed in *Table 4.35* below)

NOTE: If the calculation of Z2F or Z2R exceeds the setting range, the quantity is set to the upper limit of the setting range.

Table 4.35 z Constant for Z2R Setting

Relay Configuration	z (Ω Secondary)
5 A nominal current	0.2
1 A nominal current	1.0

Figure 4.91 and *Figure 4.92* and supporting text concern the zero-sequence impedance network, the relay polarity, and the derivation of settings Z0F and Z0R. The same general approach outlined for deriving settings Z0F and Z0R can also be applied to deriving settings Z2F and Z2R in the negative-sequence impedance network, although the preceding method of automatically making the settings Z2F and Z2R usually suffices.

50QFP/50QRP—Forward/Reverse Directional Negative-Sequence Current Pickup. The 50QFP setting ($3I_2$ current value) is the pickup for the forward fault detector 50QF of the negative-sequence voltage-polarized directional elements (see *Figure 4.74*). Ideally, the setting is above normal load unbalance and below the lowest expected negative-sequence current magnitude for unbalanced forward faults.

The 50QRP setting ($3I_2$ current value) is the pickup for the reverse fault detector 50QR of the negative-sequence voltage-polarized directional elements (see *Figure 4.74*). Ideally, the setting is above normal load unbalance and below the lowest expected negative-sequence current magnitude for unbalanced reverse faults.

If enable setting EDIR := AUTO, the settings 50QFP and 50QRP are set automatically at:

50QFP = 0.50 A secondary (5 A nominal phase current inputs, **IA**, **IB**, **IC**)

50QRP = 0.25 A secondary (5 A nominal phase current inputs, **IA**, **IB**, **IC**)

50QFP = 0.10 A secondary (1 A nominal phase current inputs, **IA**, **IB**, **IC**)

50QRP = 0.05 A secondary (1 A nominal phase current inputs, **IA**, **IB**, **IC**)

a2—Positive-Sequence Current Restraint Factor, I_2/I_1. The a2 factor (refer to *Figure 4.74*) increases the security of the negative-sequence voltage-polarized directional elements. It keeps the elements from operating for negative-sequence current (system unbalance), which circulates as a result of line asymmetries, CT saturation during three-phase faults, etc.

If enable setting EDIR := AUTO, setting a2 is set automatically at:

a2 = **0.1**

For setting a2 = 0.1, the negative-sequence current (I_2) magnitude has to be greater than 1/10 of the positive-sequence current (I_1) magnitude in order for the negative-sequence voltage-polarized directional elements to be enabled ($|I_2| > 0.1 \cdot |I_1|$).

k2—Zero-Sequence Current Restraint Factor, I_2/I_0. Note the internal enable logic outputs in *Figure 4.74*:

DIRQE — internal enable for the negative-sequence voltage-polarized directional element that controls the negative-sequence and phase overcurrent elements

DIRQGE — internal enable for the negative-sequence voltage-polarized directional element that controls the residual-ground overcurrent elements

The k2 factor is applied to internal enable DIRQGE. The negative-sequence current (I_2) magnitude has to be greater than the zero-sequence current (I_0) magnitude multiplied by k2 in order for the DIRQGE internal enable (and following negative-sequence voltage-polarized directional element in *Figure 4.77*) to be enabled:

$$|I_2| > k2 \cdot |I_0|$$

This check ensures that the relay uses the most robust analog quantities in making directional decisions for the neutral-ground and residual-ground overcurrent elements.

The zero-sequence current (I_0), referred to in the previous application of the k2 factor, is from the residual current (I_G), which is derived from phase currents I_A, I_B, and I_C:

$$I_0 = I_G/3 \qquad 3I_0 = I_G = I_A + I_B + I_C$$

If both of the internal enables:

DIRVE internal enable for the zero-sequence voltage-polarized directional element that controls the neutral-ground and residual-ground overcurrent elements

DIRIE internal enable for the channel IN current-polarized directional element that controls the neutral-ground and residual-ground overcurrent elements

are deasserted, then factor k2 is ignored as a logic enable for the DIRQGE internal enable. This effectively puts less restrictions on the operation of the negative-sequence voltage-polarized directional element.

If enable setting EDIR := AUTO, setting k2 is set automatically at:

k2 := **0.2**

For setting k2 = 0.2, the negative-sequence current (I_2) magnitude has to be greater than 1/5 of the zero-sequence current (I_0) magnitude in order for the negative-sequence voltage-polarized directional elements to be enabled ($|I_2| > 0.2 \cdot |I_0|$). Again, this presumes that at least one of the internal enables DIRVE or DIRIE is asserted.

50GFP/50GRP—Forward/Reverse Directional Residual-Ground Current Pickup. If setting ORDER does not contain V or I (no zero-sequence voltage-polarized or channel IN current-polarized directional elements are enabled), then settings 50GFP and 50GRP are not made or displayed.

The 50GFP setting ($3I_0$ current value) is the pickup for the forward fault detector 50GF of the zero-sequence voltage-polarized and channel IN current-polarized directional elements (see *Figure 4.75*). Ideally, this setting is above normal load unbalance and below the lowest expected zero-sequence current magnitude for unbalanced forward faults.

The 50GRP setting ($3I_0$ current value) is the pickup for the reverse fault detector 50GR of the zero-sequence voltage-polarized and channel IN current-polarized directional elements (see *Figure 4.75*). Ideally, this setting is above normal load unbalance and below the lowest expected zero-sequence current magnitude for unbalanced reverse faults.

If enable setting EDIR := AUTO, the settings 50GFP and 50GRP are set automatically at:

50GFP = 0.50 A secondary (5 A nominal phase current inputs, IA, IB, IC)

50GRP = 0.25 A secondary (5 A nominal phase current inputs, IA, IB, IC)

50GFP = 0.10 A secondary (1 A nominal phase current inputs, IA, IB, IC)

50GRP = 0.05 A secondary (1 A nominal phase current inputs, IA, IB, IC)

a0—Positive-Sequence Current Restraint Factor, I_0/I_1. If setting ORDER does not contain V or I (no zero-sequence voltage-polarized or channel IN current-polarized directional elements are enabled), then setting a0 is not made or displayed.

Refer to *Figure 4.75*. The a0 factor increases the security of the zero-sequence voltage-polarized and channel IN current-polarized directional elements. This factor keeps the elements from operating for zero-sequence current (system unbalance), which circulates as a result of line asymmetries, CT saturation during three-phase faults, etc.

The zero-sequence current (I_0), referred to in the application of the a0 factor, is from the residual current (I_G), which is derived from phase currents I_A, I_B, and I_C:

$$I_0 = I_G/3 \qquad 3I_0 = I_G = I_A + I_B + I_C$$

If enable setting EDIR = AUTO, setting a0 is set automatically at:

a0 := **0.1**

For setting a0 := 0.1, the zero-sequence current (I_0) magnitude has to be greater than 1/10 of the positive-sequence current (I_1) magnitude in order for the zero-sequence voltage-polarized and channel **IN** current-polarized directional elements to be enabled ($|I_0| > 0.1 \cdot |I_1|$).

Z0F/Z0R—Forward/Reverse Directional Z0 Threshold. Z0F and Z0R are used to calculate the forward and reverse thresholds, respectively, for the zero-sequence voltage-polarized directional elements (see *Figure 4.78* and *Figure 4.80*). If the setting ORDER does not contain V (no zero-sequence voltage-polarized directional element is enabled), then there is no need to make the settings Z0F and Z0R. The relay also does not display these settings. If the setting ORDERX is set to U, then Z0FX and Z0RX are hidden and forced to -0.10 and 0.10, respectively, (refer to *Figure 4.80*) for use with the zero-sequence voltage-polarized directional element with IN as operate quantity.

When ORDER is set to contain V and if the enable setting EDIR := Y, you calculate and enter settings Z0F and Z0R (zero-sequence impedance values), but setting Z0R must be greater in value than setting Z0F by 0.1 Ω secondary. If enable setting EDIR = AUTO, the relay calculates the settings Z0F and Z0R (zero-sequence impedance values) automatically, using the zero-sequence line impedance magnitude setting Z0MAG as follows:

NOTE: If Z0F or Z0R exceeds the setting range, the quantity is set to the upper limit of the setting range.

NOTE: Z0F and Z0R (Ω secondary) are set in reference to the phase current channels **IA**, **IB**, and **IC**, as are settings Z2F and Z2R.

Z0F = **Z0MAG/2** (Ω Secondary)

Z0R = **Z0MAG/2 +** *z* (Ω Secondary; *z* listed in *Table 4.36*)

Table 4.36 z Constant for Z0R Setting

Relay Configuration	z (Ω Secondary)
5 A nominal current	0.2
1 A nominal current	1.0

Deriving Z0F and Z0R Settings. *Figure 4.91* shows the voltage and current polarity for an SEL-700G in a zero-sequence impedance network (the same approach can be instructive for negative-sequence impedance analysis, too). For a forward fault, the SEL-700G effectively sees the sequence impedance behind it as:

$$Z_M = V_0/(-I_0) = -(V_0/I_0)$$

$V_0/I_0 = -Z_M$ (what the relay sees for a forward fault)

For a reverse fault, the SEL-700G effectively sees the sequence impedance in front of it:

$$Z_N = V_0/I_0$$

$V_0/I_0 = Z_N$ (what the relay sees for a reverse fault)

If the system in *Figure 4.91* is a solidly-grounded system (mostly inductive; presume uniform system angle) with load-connected line to neutral, the impedance plot (in the R + jX plane) would appear as in *Figure 4.92a*, with resultant Z0F and Z0R settings as in *Figure 4.92b*. The zero-sequence line angle noted in *Figure 4.92a* (∠Z0MTA) is the same angle found in *Figure 4.78* and *Figure 4.80* (in the equation box with the Enable line). Note that the Z0MTA shown in *Figure 4.78* and *Figure 4.80* should be set (calculated) accordingly taking into account the system grounding (solidly grounded, low or high impedance).

The preceding method of automatically making settings Z0F and Z0R (where both Z0F and Z0R are positive values and Z0R > Z0F) usually suffices for mostly inductive systems—*Figure 4.91* and *Figure 4.92* just provide a theoretical background.

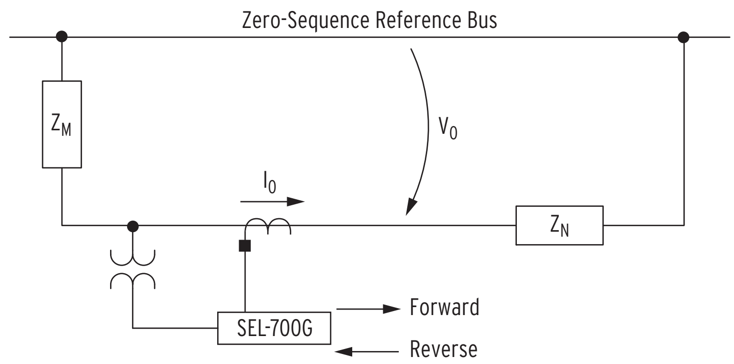


Figure 4.91 Zero-Sequence Impedance Network and Relay Polarity

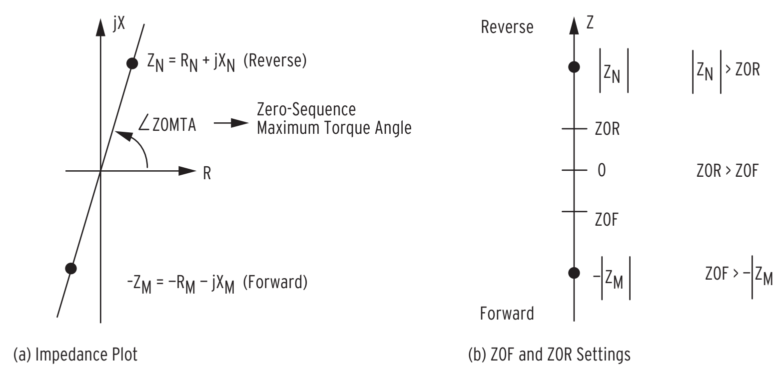


Figure 4.92 Zero-Sequence Impedance Plot for Solidly-Grounded, Mostly Inductive System

Z0MTA—Zero-Sequence Maximum Torque Angle. If enable setting EDIR := AUTO, then Z0MTA is set equal to Z0ANG and Z0MTA is hidden. Note that ORDERX := U cannot be set when EDIRX := AUTO and vice-versa. If enable setting EDIR := Y and ORDER contains a V or U setting, Z0MTA should be set.

If the protected line belongs to a hybrid power system, such as shown in *Figure 4.93*, then for proper directional decision, Z0ANG does not equal Z0MTA. Z0MTA must be set to compensate for the neutral-ground resistor and is used in the Ground Directional Logic to make proper forward and reverse fault determination.

Figure 2.28 shows a specific application where multiple high-impedance grounded generators are connected to a common bus. The grounding resistance value in the secondary of the grounding transformer is typically selected to allow a ground fault current through the resistor equal to or somewhat more than the capacitive charging current of the system. To detect a ground fault internal to the generator, which is forward looking from the core-balance CT into the generator, a Z0MTAX value of -45 degrees should suffice. To determine a more accurate value of Z0MTAX, a system study is recommended.

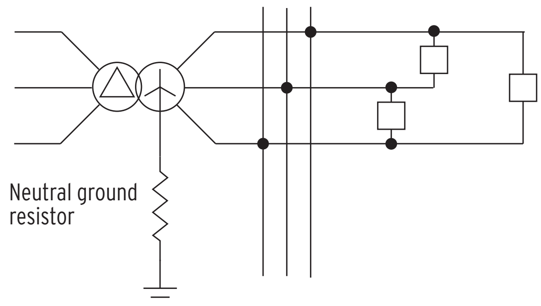


Figure 4.93 Hybrid Power System With Neutral-Ground Resistor

50NFP/50NRP—Forward/Reverse Directional Neutral-Ground Current Pickup. Note that 50NFP and 50NRP settings are tied into X-side settings of the relay. If setting ORDERX does not contain U, then settings 50NFP and 50NRP are not made or displayed.

The 50NFP setting (IN current value) is the pickup for the forward fault detector 50NF of the zero-sequence voltage-polarized directional element with IN as operate quantity (see *Figure 4.76*). Ideally, this setting is above normal load unbalance and below the lowest expected zero-sequence current magnitude for unbalanced forward faults.

The 50NRP setting (IN current value) is the pickup for the reverse fault detector 50NR of the zero-sequence voltage-polarized directional element with IN as operate quantity (see *Figure 4.76*). Ideally, this setting is above normal load unbalance and below the lowest expected zero-sequence current magnitude for unbalanced reverse faults.

a0N—Positive-Sequence Current Restraint Factor, IN/I1. If setting ORDER does not contain U, then setting a0N is not made or displayed (refer to *Figure 4.76*). The following comparison is made as part of internal enable DIRNE:

$$|IN| > a0N \bullet |I1|$$

IN is the secondary current measured by neutral channel IN. I1 is the positive-sequence secondary current derived from the phase current channels IA, IB, and IC. Presumably, channel IN is connected in such a manner that it sees the system zero-sequence current (e.g., channel IN is connected to a core-balance CT through which the three-phase conductors pass; in such a connection, channel IN sees 3I0 zero- sequence current, IN = 3I0; see *Figure 2.28*). If a core-balance current transformer is connected to neutral channel IN, it most likely has a different ratio, compared to the current transformers connected to the phase current channels IA, IB, and IC (CT ratio settings CTRN and CTRX, respectively).

From a primary system study, load profile values, or metering values, derive a0N as follows:

$$a0N = (3I0\ pri./I1\ pri.) \bullet (CTRX/CTRN)$$

3I0 pri. = standing system unbalance current (zero-sequence; A primary)

I1 pri. = maximum load current (positive-sequence; A primary)

Adjust the final setting value of a0N from the above derived value of a0N, depending on your security philosophy, etc. The a0N factor increases the security of the zero-sequence voltage-polarized directional element. It keeps the elements from operating for zero-sequence current as a result of any system unbalance.

High-Impedance Grounded System Considerations for Phase-to-Phase or Three-Phase Faults

On high-impedance grounded systems (when setting ORDERX := U), phase-to-phase or unbalanced three-phase faults can cause the high-impedance grounded element to operate on false quantities. To prevent this situation, consider 67N element for example, use the SELOGIC torque control equation 50N1TC as follows:

50N1TC := 59V1X1 AND NOT DIRQEX

The positive-sequence over-voltage element in the above torque-control equation is set to 75% of nominal voltage considering DELTAY_X := WYE, PTRX := 100, VNOM_X := 11.6 kV (line-line).

59V1X1P := 50.23 V (75%*11.6kV/(1.732*PTRX)

The 59V1X1 Relay Word bit deasserts during a three-phase fault, and the DIRQE Relay Word bit asserts during a phase-to-phase fault. If either one of these occur, the 50N1TC setting evaluates to logical 0, and the high-impedance grounded directional element is blocked.

Directional Control Provided by Torque Control Settings

For most applications, the level direction settings DIR1 and DIR2 are used to set overcurrent elements direction forward, reverse, or nondirectional. *Table 4.33* shows the overcurrent elements that are controlled by each level direction setting. Note in *Table 4.33* that all the time-overcurrent elements (51_T elements) are controlled by the DIR1 level direction setting. See *Figure 4.83*, *Figure 4.84*, *Figure 4.89*, and *Figure 4.90*.

Suppose that you need to set the Level 1 overcurrent elements as follows:

67PY1T	direction forward
67GY1T	direction forward
51PYT	direction reverse
51GYT	nondirectional

To accomplish this, the DIR1 setting is “turned off”, and the corresponding SELOGIC control equation torque control settings for the previous overcurrent elements are used to make the elements directional (forward or reverse) or nondirectional. The necessary settings are as follows:

DIR1Y := **N** (“turned off”; see *Figure 4.83*, *Figure 4.89*, and *Figure 4.90*)
50PY1TC := **DIRPFY** (direction forward)
50GY1TC := **DIRGFY** (direction forward)
51PYTC := **DIRPRY** (direction reverse)
51GYTC := **1** (nondirectional)

This is just one example of using SELOGIC control equation torque control settings to make overcurrent elements directional (forward or reverse) or nondirectional. This example shows only Level 1 overcurrent elements (controlled by level direction setting DIR1). The same setting principles apply to the other levels as well. Many variations are possible.

Load-Encroachment Logic

The load-encroachment feature allows certain elements (system backup, phase directional, etc.) to be set without regard for load levels. For example, to obtain necessary system backup sensitivity, it may be necessary to set the impedance element reach very long. Because of the long reach setting, the phase distance element would pick up during heavy load. The SEL-700G distance and phase directional elements are supervised by a load-encroachment function that prevents element misoperation under heavy load. You must set load impedance magnitude and angles to the necessary values to enable load-encroachment supervision. The relay uses these settings to define a region in the impedance plane where operation of the three-phase elements is prevented. This allows you to make the phase protection element reach the settings without concern for misoperation under heavy load.

Table 4.37 Load-Encroachment Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
FWD LD IMPEDANCE	OFF, 0.10–128.00 ohm[a]	ZLFX := 6.50[a]
POS-FWD LD ANGLE	–90.00 to 90.00 deg	PLAFX := 30.00
NEG-FWD LD ANGLE	–90.00 to 90.00 deg	NLAFX := -30.00
LOAD ENCROACH EN	Y, N	ELOADY := N
FWD LD IMPEDANCE	0.10–128.00 ohm[a]	ZLFY := 6.50[a]
POS-FWD LD ANGLE	–90.00 to 90.00 deg	PLAFY := 30.00
NEG-FWD LD ANGLE	–90.00 to 90.00 deg	NLAFY := –30.00
REV LD IMPEDANCE	0.10–128.00 ohm[a]	ZLRY := 6.50[a]
POS-REV LD ANGLE	90.00–270.00 deg	PLARY := 150
NEG-REV LD ANGLE	90.00–270.00 deg	NLARY := 210.00

[a] Setting ranges and default ohm values shown are for 5 A nominal CT rating. Multiply by 5 for 1 A CTs.

Note that a positive-sequence impedance calculation (Z_1) is made in the load-encroachment logic in *Figure 4.94* and *Figure 4.95*. Load is largely a balanced condition, so apparent positive-sequence impedance is a good load measure. The load-encroachment logic operates only if the positive-sequence current (I_1) is greater than the Positive-Sequence Threshold defined in *Figure 4.94* and *Figure 4.95*. For a balanced load condition, I_1 = phase current magnitude.

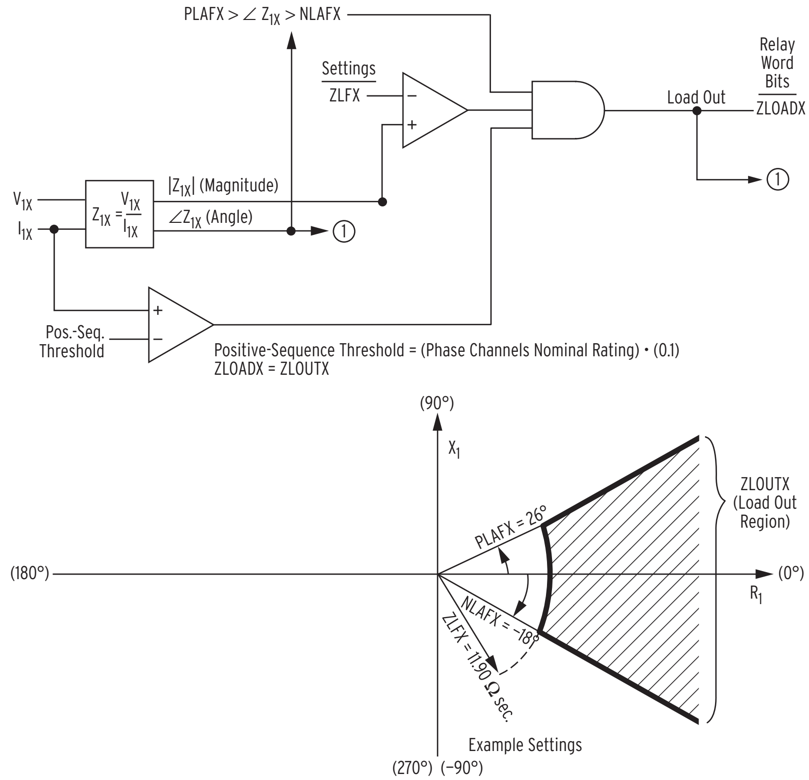
Forward load (load flowing out) lies within the hatched region labeled ZLOUT. Relay Word bit ZLOUT asserts to logical 1 when the load lies within this hatched region.

Reverse load (load flowing in) lies within the hatched region labeled ZLIN. Relay Word bit ZLIN asserts to logical 1 when the load lies within this hatched region. The reverse load feature applies to Y side only, because the generator protection applications (X side) do not require load encroachment for the ZLIN condition.

Relay Word bit ZLOAD is the OR-combination of ZLOUT and ZLIN:

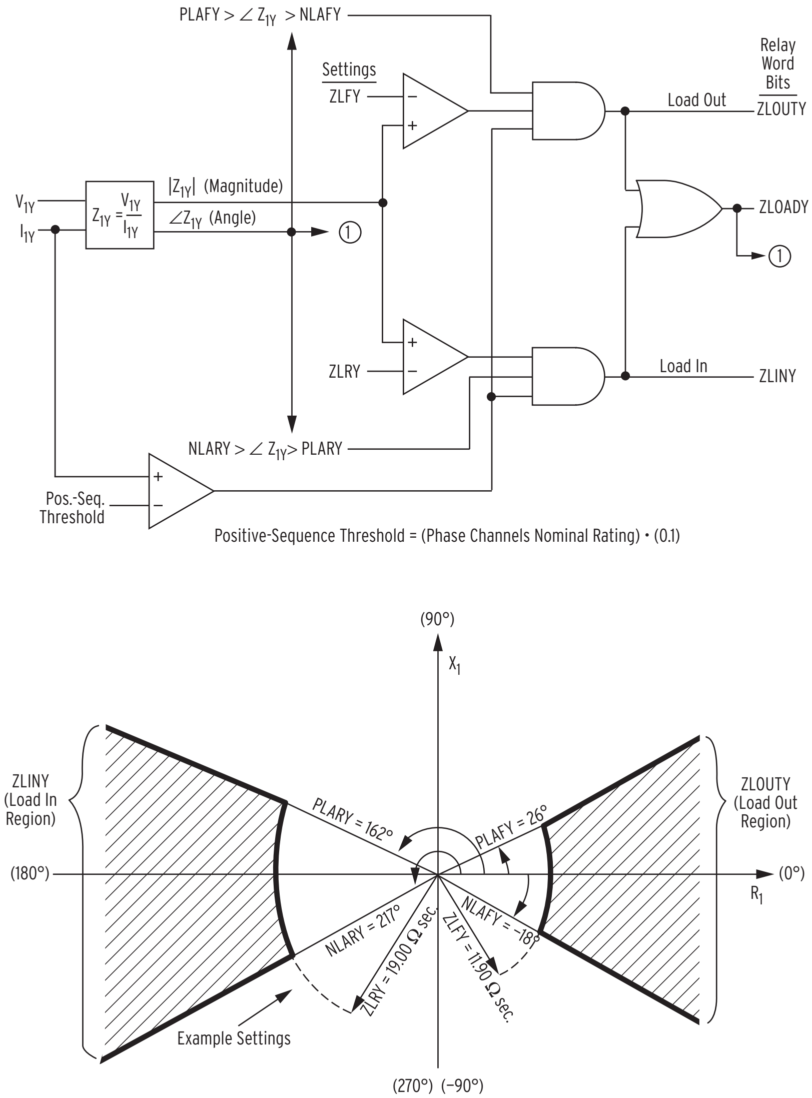
ZLOADY := ZLOUTY OR ZLINY

ZLOADX := ZLOUTX



① To Figure 4.87

Figure 4.94 Load-Encroachment Logic for X Side



① To Figure 4.87

Figure 4.95 Load-Encroachment Logic for Y Side

Load-Encroachment Setting Example

Example system conditions:

Nominal Line-Line Voltage:	230 kV
Maximum Forward Load:	800 MVA
Maximum Reverse Load:	500 MVA
Power Factor (Forward Load):	0.90 lag to 0.95 lead
Power Factor (Reverse Load):	0.80 lag to 0.95 lead
CT ratio:	2000/5 = 400
PT ratio:	134000/67 = 2000

The PTs are connected line-to-neutral.

Convert Maximum Loads to Equivalent Secondary Impedances. Start with maximum forward load:

800 MVA • (1/3)	267 MVA per phase
230 kV • (1/√ 3) =	132.8 kV line-to-neutral
267 MVA • (1/132.8 kV) • (1000kV/MV) =	2010 A primary
2010 A primary • (1/CT ratio) =	2010 A primary • (1 A secondary/400 A primary)
=	5.03 A secondary
132.8 kV • (1000 V/kV) =	132800 V primary
132800 V primary • (1/PT ratio) =	132800 V primary • (1 V secondary/2000 V primary)
=	66.4 V secondary

Now, calculate the equivalent secondary impedance:

$$\frac{66.4\ \text{V secondary}}{5.03\ \text{A secondary}} = 13.2\ \Omega\ \text{secondary}$$

This secondary value can be calculated more expediently with the following equation:

$$\frac{(\text{line-line voltage in kV})^2 \bullet\ \text{CT ratio}}{\text{3-phase load in MVA} \bullet\ \text{PT ratio}}$$

Again, for the maximum forward load:

$$\frac{230^2 \bullet\ 400}{800 \bullet\ 2000} = 13.2\ \Omega\ \text{secondary}$$

To provide a margin for setting ZLF, multiply by a factor of 0.9:

$$\begin{aligned} \text{ZLF} &= 13.2\ \Omega\ \text{secondary} \bullet\ 0.9 \\ &= 11.90\ \Omega\ \text{secondary} \end{aligned}$$

For the maximum reverse load:

$$\frac{230^2 \bullet\ 400}{500 \bullet\ 2000} = 21.1\ \Omega\ \text{secondary}$$

Again, to provide a margin for setting ZLR:

$$\begin{aligned} \text{ZLR} &= 21.1\ \text{secondary} \bullet\ 0.9 \\ &= 19.00\ \Omega\ \text{secondary} \end{aligned}$$

Convert Power Factors to Equivalent Load Angles. The power factor (forward load) can vary from 0.90 lag to 0.95 lead.

Setting PLAF := $\cos^{-1}(0.90) = 26°$

Setting NLAF := $\cos^{-1}(0.95) = -18°$

The power factor (reverse load) can vary from 0.80 lag to 0.95 lead.

Setting PLAR := $180° - \cos^{-1}(0.95) = 180° - 18° = 162°$

Setting NLAR := $180° + \cos^{-1}(0.80) = 180° + 37° = 217°$

Use the SEL-321 Relay Application Guide for the SEL-700G Relay

The load-encroachment logic and the settings in the SEL-700G are the same as those in the SEL-321. Refer to SEL Application Guide AG93-10, SEL-321 Relay Load-Encroachment Function Setting Guidelines, for applying the load-encroachment logic in the SEL-700G. Note that Application Guide AG93-10 discusses applying the load-encroachment feature to phase distance elements in the SEL-321. The principles and the settings example are applicable to the SEL-700G.

Power Elements

You can enable as many as four independent three-phase power elements in the SEL-700G Relay. Each enabled element can be set to detect real power or reactive power. When voltage inputs to the relay are from delta-connected PTs, the relay cannot account for unbalance in the voltages in calculating the power. Take this into consideration in applying the power elements.

With SELOGIC control equations, the power elements provide a wide variety of protection and control applications. Typical applications are:

- Overpower and/or underpower protection/control
- Reverse and/or low-forward power for generator antimotoring protection
- VAR control for capacitor banks
- Supervision of the third-harmonic neutral undervoltage element
- Detection of power export in DG applications

Generator motoring occurs when prime mover input power to the generator is cut off while the generator is connected to the system. When this happens, the generator acts as a synchronous motor to drive the prime mover shaft. In steam turbine prime mover applications, generator motoring can quickly damage the turbine by causing overheating. In applications of other prime movers, motoring can cause mechanical damage and/or unsafe operating conditions.

Table 4.38 Power Element Settings (Sheet 1 of 2)

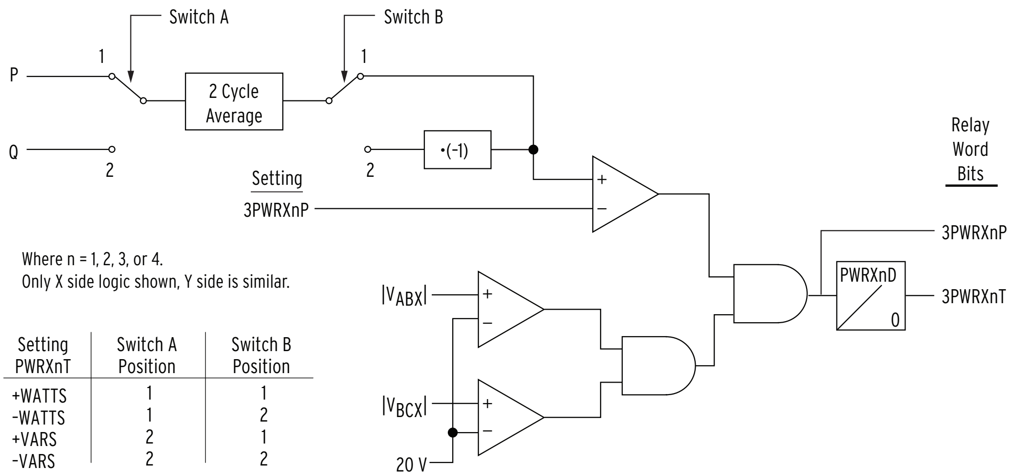
Setting Prompt	Setting Range	Setting Name := Factory Default[a]
ENABLE PWR ELEM	N, 1–4 N, 1–4	EPWRX := 2 EPWRY := N
3PH PWR ELEM PU	OFF, 1.0–6500.0 VA (secondary VA)[b]	3PWR*m*1P := 50
PWR ELEM TYPE	+WATTS, –WATTS, +VARS, –VARS	PWR*m*1T := -WATTS
PWR ELEM DELAY	0.00–240.00 s	PWR*m*1D := 20.00
3PH PWR ELEM PU	OFF, 1.0–6500.0 VA (secondary VA)[b]	3PWR*m*2P := 25.0
PWR ELEM TYPE	+WATTS, –WATTS, +VARS, –VARS	PWR*m*2T := +WATTS
PWR ELEM DELAY	0.00–240.00 s	PWR*m*2D := 1.00
3PH PWR ELEM PU	OFF, 1.0–6500.0 VA (secondary VA)[b]	3PWR*m*3P := OFF
PWR ELEM TYPE	+WATTS, –WATTS, +VARS, –VARS	PWR*m*3T := +VARS

Table 4.38 Power Element Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default[a]
PWR ELEM DELAY	0.00–240.00 s	PWR*m*3D := 0.00
3PH PWR ELEM PU	OFF, 1.0–6500.0 VA (secondary VA)[b]	3PWR*m*4P := OFF
PWR ELEM TYPE	+WATTS, –WATTS, +VARS, –VARS	PWR*m*4T := +VARS
PWR ELEM DELAY	0.00–240.00 s	PWR*m*4D := 0.00

[a] m = X or Y.
[b] The ranges and default settings shown are for 5 A input. Divide by 5 for 1 A input.

Set EPWR to N (None) or as many as four power elements, as necessary for your application. Set the element pickup, 3PH PWR ELEM PU to the values you want. *Figure 4.96* shows the power element logic diagram, and *Figure 4.97* shows the operation in the real/reactive power plane.



Setting PWRXnT	Switch A Position	Switch B Position
+WATTS	1	1
–WATTS	1	2
+VARS	2	1
–VARS	2	2

Figure 4.96 Three-Phase Power Elements Logic

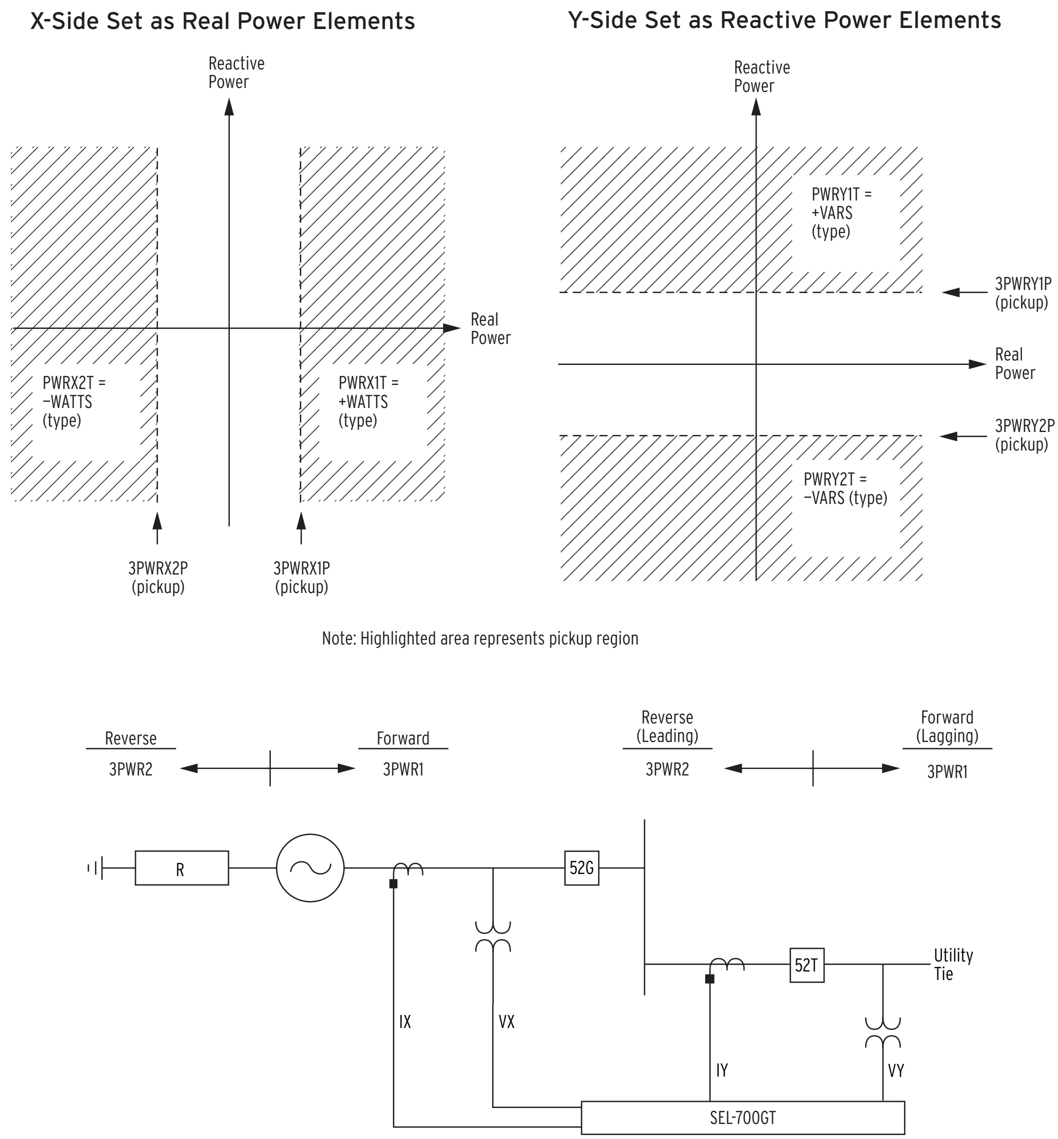


Figure 4.97 Power Elements Operation in the Real/Reactive Power Plane

The power element type settings are made in reference to the load convention:

- +WATTS: positive or forward real power
- –WATTS: negative or reverse real power
- +VARS: positive or forward reactive power
- –VARS: negative or reverse reactive power

The four power element time delay settings ((PWRm1D–PWRm4D)) can be set to have no intentional delay for testing purposes. For protection applications involving the power element Relay Word bits, SEL recommends a minimum time delay setting of 0.1 second for general applications. The classical power calculation is a product of voltage and current, to determine the real and reactive power quantities. During a system disturbance, because of the high sensitivity of the power elements, the changing system phase angles and/or frequency shifts may cause transient errors in the power calculation.

For antimotoring protection of the generator, calculate the prime mover rated motoring power. To ensure that the element securely detects this level of power, set the element pickup lower than this level to account for measuring errors in the relay, voltage transformers, and current transformers. For sequential tripping of the generator, you might want low-forward power. The default settings of the Level 2 power element and associated trip logic is set up for such an application. The scheme is only permitted to cause a generator breaker trip after the prime mover trip by the sequential tripping scheme. The SELOGIC control equations used to implement sequential generator tripping are shown in *Trip/Close Logic Settings* later in this section.

The power elements are not supervised by any relay elements other than the minimum voltage check shown in *Figure 4.96*. If the protection application requires overcurrent protection in addition to the power elements, there may be a race condition, during a fault, between the overcurrent element(s) and the power element(s) if the power element(s) are still receiving sufficient operating quantities. Use the power element time delay setting to avoid such race conditions.

Frequency Measurement and Tracking

The SEL-700G Relay uses two different algorithms, phase rate-of-change (ROC) and zero-crossing (ZC), to measure the frequency of the X and Y side signals and the synchronism-check voltage input (VS). While the relay measures the frequency of multiple signals, it uses only one signal for frequency tracking. *Table 4.39* shows the signals that are used to measure frequency and the priority in determining the appropriate signal for frequency tracking in a specific model of the SEL-700G.

NOTE: When the relay switches the signal used for frequency measurement/tracking, it is normal for filtered analog quantities (e.g., voltage and currents) to be depressed for approximately five cycles. This may cause some elements (e.g., 27) to pickup. An appropriate delay should be used to override this transient behavior.

Table 4.39 Signals Used for Frequency Measurement and Tracking[a]

Relay Model	Signals Used for Frequency Measurements	Signals Used for Frequency Tracking and Their Priority
SEL-700G0+ and SEL-700G1+	V1X, VAX, VS	1. V1X, 2. VAX
SEL-700G0 and SEL-700G1	V1X, VAX	1. V1X, 2. VAX
SEL-700GT	V1Y, VAY, VS	1. V1Y, 2. VAY
SEL-700GT+	V1X, VAX, V1Y, VAY, VS	(If FRQTRK = X) 1. V1X, 2. V1Y, 3. VAX, 4. VAY (If FRQTRK = Y) 1. V1Y, 2. V1X, 3. VAX, 4. VAY
SEL-700GW	I1X and I1Y	1. I1X 2. I1Y

[a] Frequency measured on the phase voltages (VAX, VAY) is via the ZC method, while frequency measured on the positive-sequence quantities is via the phase ROC method. Frequency measured on the synchronization-voltage (VS) is through both methods.

The relay initially tracks at nominal frequency (FNOM). As soon as the voltages (or currents) are applied, the relay starts measuring the voltage/current phasors, from which the positive-sequence quantities (V1, I1) are calculated. These quantities are then used for frequency measurement and tracking.

The ZC method uses VAX, VAY, and VS signals to measure the frequencies. The frequency measured by the ZC method is used when the associated signal (positive-sequence) shown in *Table 4.39* is too low or when the frequency measured by the ZC algorithm is outside a window of ± 0.3 Hz from the tracking frequency. The relay uses the VAX signal to measure the X-side frequency with the ZC method in all the models except the SEL-700GT and SEL-700GW. The relay uses the VAY signal to measure the Y-side frequency with the ZC method in the models SEL-700GT and SEL-700GT+. The relay uses the VS signal to measure the VS channel frequency in the models SEL-700G0+, SEL-700G1+, SEL-700GT, and SEL-700GT+.

Each method requires minimum signal level of 10 V or 0.1*(Nominal CT Rating). The measured frequency is set to nominal frequency setting (FNOM) if the signal is below the minimum level.

Over- and Underfrequency Protection

The SEL-700G provides six trip over- or underfrequency elements with independent level and time-delay settings. When an element level setting is less than the nominal frequency setting, the element operates as an underfrequency element. When the level setting is greater than the nominal frequency setting, the element operates as an overfrequency element.

Table 4.40 Frequency Settings

Setting Prompt	Setting Range	Setting Name := Factory Default[a]
ENABLE 81*m*	N, 1–6	E81*m* := N
FREQ*m* TRIP1 LVL	OFF, 15.00–70.00 Hz	81*m*1TP := OFF
FREQ*m* TRIP1 DLY[b]	0.00–400.00 s	81*m*1TD := 1.00
FREQ*m* TRIP2 LVL	OFF, 15.00–70.00 Hz	81*m*2TP := OFF
FREQ*m* TRIP2 DLY[b]	0.00–400.00 s	81*m*2TD := 1.00
FREQ*m* TRIP3 LVL	OFF, 15.00–70.00 Hz	81*m*3TP := OFF
FREQ*m* TRIP3 DLY[b]	0.00–400.00 s	81*m*3TD := 1.00
FREQ*m* TRIP4 LVL	OFF, 15.00–70.00 Hz	81*m*4TP := OFF
FREQ*m* TRIP4 DLY[b]	0.00–400.00 s	81*m*4TD := 1.00
FREQ*m* TRIP5 LVL	OFF, 15.00–70.00 Hz	81*m*5TP := OFF
FREQ*m* TRIP5 DLY[b]	0.00–400.00 s	81*m*5TD := 1.00
FREQ*m* TRIP6 LVL	OFF, 15.00–70.00 Hz	81*m*6TP := OFF
FREQ*m* TRIP6 DLY[b]	0.00–400.00 s	81*m*6TD := 1.00
FREQ*m* TRQCTRL	SELOGIC	81*m*TC := 1

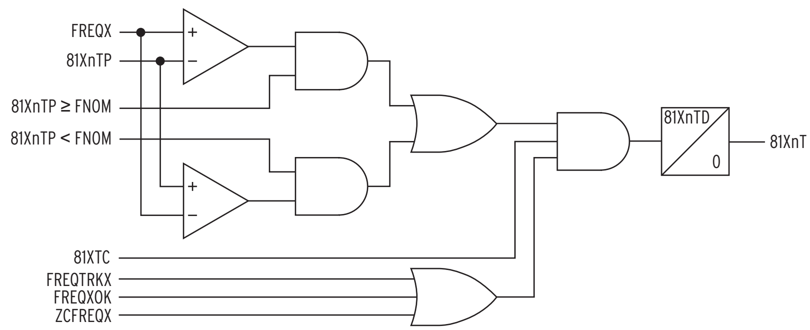
[a] m = X or Y.
[b] The frequency element time delays are best set for at least three cycles at the lowest 81 pickup setting. The relay requires at least three cycles to measure frequency.

Figure 4.98 and *Figure 4.99* show the logic diagrams for the X and Y-side frequency elements. Additionally SEL-700G asserts Relay Word bits 81XT, 81YT, and 81T through the use of the following logic equations:

81XT = 81X1T OR 81X2T OR…OR 81X6T

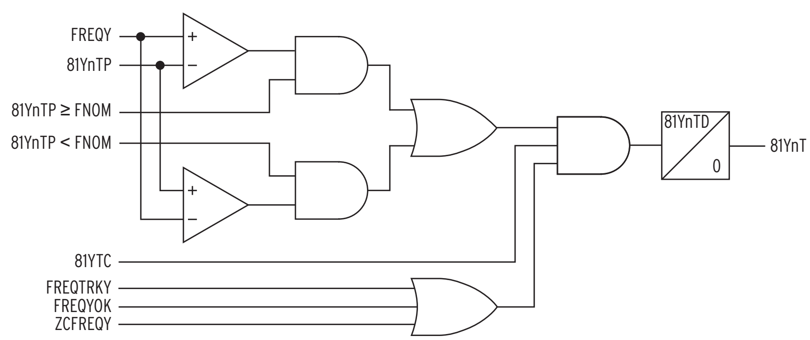
81YT = 81Y1T OR 81Y2T OR…OR 81Y6T

81T = 81XT OR 81YT



n = Frequency Elements 1–6
FREQX = Measured Frequency
81XnTP = Frequency Pickup Setting
FNOM = Nominal Frequency Setting
81XnTD = Over- and Underfrequency Element Pickup Time Delay
81XnT = Definite-Time Delayed Over- and Underfrequency Element Relay Word Bit
FREQTRKX = Set to 1 if the relay is tracking frequency on the X-side voltages or currents
FREQXOK = Set to 1 if the frequency on the X side is being measured by the phase rate of change algorithm
ZCFREQX = Set to 1 if the frequency on the X-side is being measured using the zero crossing algorithm
81XTC = Over- and Underfrequency Element Torque Control Bit

Figure 4.98 X-Side Over- and Underfrequency Element Logic



n = Frequency Elements 1–6
FREQY = Measured Frequency
81YnTP = Frequency Pickup Setting
FNOM = Nominal Frequency Setting
81YnTD = Over- and Underfrequency Element Pickup Time Delay
81YnT = Definite-Time Delayed Over- and Underfrequency Element Relay Word Bit
FREQTRKY = Set to 1 if the relay is tracking frequency on the Y-side voltages or currents
FREQYOK = Set to 1 if the frequency on the Y-side is being measured by the phase rate of change algorithm
ZCFREQY = Set to 1 if the frequency on the Y-side is being measured using the zero crossing algorithm
81YTC = Over- and Underfrequency Element Torque Control

Figure 4.99 Y-Side Over- and Underfrequency Element Logic

Rate-of-Change-of-Frequency Protection

Frequency changes occur in power systems when there is an unbalance between load and active power generated. Typically, generator control action adjusts the generated active power and restores the frequency to nominal value. Failure of such control action may lead to system instability unless there is some remedial action, such as load shedding. You can use the rate-of-change-of-frequency element to detect and initiate a remedial action. The SEL-700G provides four rate-of-change-of-frequency elements. *Table 4.41* shows the settings for this element.

Table 4.41 Rate-of-Change-of-Frequency Settings

Setting Prompt	Setting Range	Setting Name := Factory Default[a]
ENABLE 81R*m*	N, 1–4	E81R*m* := N
FREQ*m* ROC LEVEL	OFF, 0.10–15.00 Hz/s	81R*m*1TP := OFF
FREQ*m* ROC TREND	INC, DEC, ABS	81R*m*1TRN := ABS
FREQ*m* ROC PU DLY	0.10–60.00 s	81R*m*1TD := 1.00
FREQ*m* ROC DO DLY	0.00–60.00 s	81R*m*1DO := 0.00
FREQ*m* ROC LEVEL	OFF, 0.10–15.00 Hz/s	81R*m*2TP := OFF
FREQ*m* ROC TREND	INC, DEC, ABS	81R*m*2TRN := ABS
FREQ*m* ROC PU DLY	0.10–60.00 s	81R*m*2TD := 1.00
FREQ*m* ROC DO DLY	0.00–60.00 s	81R*m*2DO := 0.00
FREQ*m* ROC LEVEL	OFF, 0.10–15.00 Hz/s	81R*m*3TP := OFF
FREQ*m* ROC TREND	INC, DEC, ABS	81R*m*3TRN := ABS
FREQ*m* ROC PU DLY	0.10–60.00 s	81R*m*3TD := 1.00
FREQ*m* ROC DO DLY	0.00–60.00 s	81R*m*3DO := 0.00
FREQ*m* ROC LEVEL	OFF, 0.10–15.00 Hz/s	81R*m*4TP := OFF
FREQ*m* ROC TREND	INC, DEC, ABS	81R*m*4TRN := ABS
FREQ*m* ROC PU DLY	0.10–60.00 s	81R*m*4TD := 1.00
FREQ*m* ROC DO DLY	0.00–60.00 s	81R*m*4DO := 0.00
FREQ*m* ROC VSUPER	OFF, 12.5–300.0 V	81R*m*VSUP := OFF
FREQ*m* ROC TRQCTRL	SELOGIC	81R*m*TC := 1

[a] m = X or Y.

Use the E81R setting to enable the number of elements you want. *Figure 4.100* shows the general element logic that applies to both X and Y sides. The SEL-700G measures frequency (MF1) and second frequency (MF2) after a time window (dt) determined by Trip Level setting (81R*mn*TP) to compute rate-of-change of frequency. The frequency measurement used by the X-side 81R element is available in the COMTRADE event report as FREQ_81R. The element uses an hysteresis (dropout/pickup ratio of 95 percent) to prevent chattering. *Table 4.42* shows the time windows for different trip level settings.

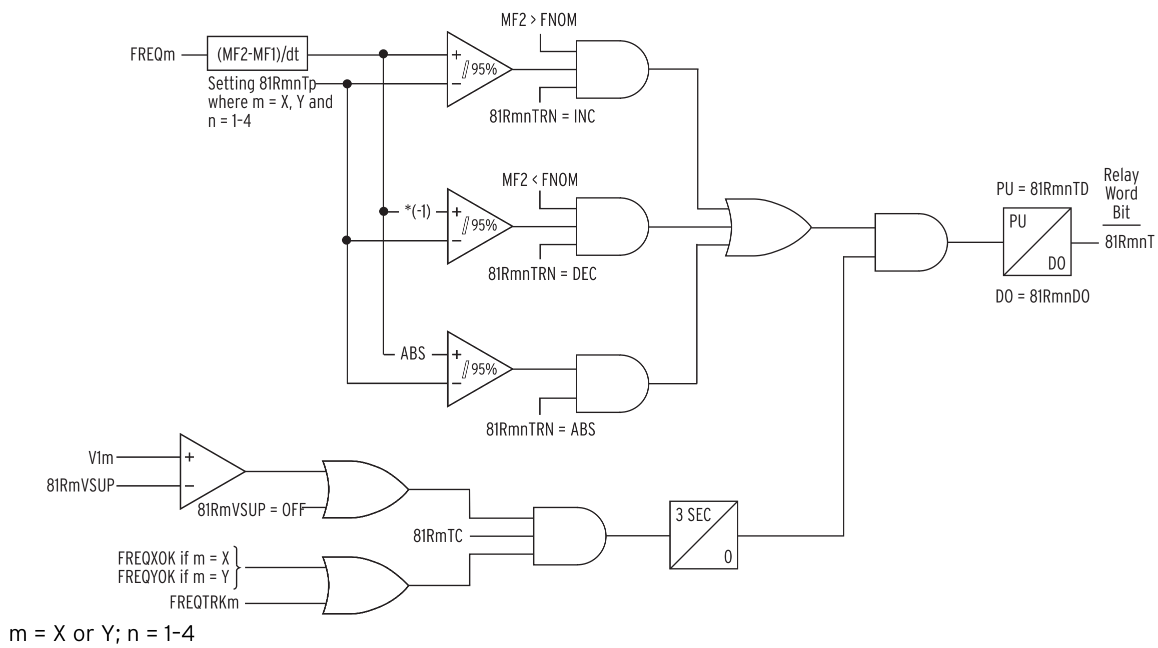


Figure 4.100 81R Frequency Rate-of-Change Scheme Logic

Table 4.42 Time Window Versus 81RmnTP Setting[a]

81RmnTP Setting (Hz/s)	Time-Window (Cycles)
15.00–2.33	3
2.32–1.17	6
1.16–0.78	9
0.77–0.58	12
0.57–0.47	15
0.46–0.38	18
0.37–0.33	21
0.32–0.29	24
0.28–0.26	27
< 0.25	30

[a] (m = X or Y; n = 1–4).

Set 81R*mn*TRN Trend to INC or DEC to limit the operation of the element to increasing or decreasing frequency, respectively. Also, when set to INC or DEC, the element is supervised by nominal frequency, FNOM. Set the trend to ABS if you want the element to disregard the frequency trend.

Voltage supervision: A minimum positive-sequence voltage is necessary for the operation of the 81R element when the 81R*m*VSUP setting specifies the level. Set 81R*m*VSUP := OFF if no voltage supervision is necessary. In any case, the element is also supervised by Relay Word FREQTRK*m*, which ensures that the relay is tracking and measuring the system frequency.

Use the Relay Word bits 81RX*n*T and 81RY*n*T to operate output contacts that open the appropriate breaker(s) necessary for your load-shedding scheme.

Over- and Undervoltage Elements

The SEL-700G Relay provides two levels of phase-to-phase overvoltage and undervoltage elements irrespective of the delta or wye VT connections. Six levels of positive-sequence overvoltage and undervoltage elements are also provided to comply with NERC standard PRC-024-1.

When you connect the SEL-700G voltage inputs to phase-to-neutral connected VTs, as in *Figure 2.19*, the relay provides two levels of phase-to-neutral overvoltage and undervoltage elements. When a synchronism voltage input is present (for example, VS input shown in *Figure 2.26*), the SEL-700G provides two levels of VS under- and overvoltage elements.

When an open-delta PT is connected to the SEL-700G voltage inputs, the relay allows you to connect external zero-sequence voltage to VS-NS or VN-NN inputs (EXT3V0_X := VS or VN), as in *Figure 2.19 (e)* and *(f),* respectively. In either case, when EXT3V0_X := VS or VN, the relay routs the external 3V0 to 3V0X for use with X-side residual-ground overvoltage elements (59GX1 and 59GX2), as shown in *Figure 4.103*. Note that when EXT3V0_X := VS, the two levels of VS undervoltage and overvoltage are not available for setting. The voltage magnitude calculation block in *Figure 4.102 (a)* calculates the zero-sequence voltage (3V0m) as follows for different PT configurations and the EXT3V0_X setting.

- If DELTAY_*m* := WYE, then 3V0*m* = VA*m* + VB*m* + VC*m* (Applies to both X and Y sides, *m* = X or Y)
- If DELTAY_X := DELTA, EXT3V0_X = VS, then 3V0X := VS (Applies to X side only)
- If DELTAY_X := DELTA, EXT3V0_X = VN, then 3V0X := VN (Applies to X side only).

You can use these elements for protection and/or control actions, as necessary.

Each of the elements, except the three-phase under- and overvoltage elements, 3P27 and 3P59, has an associated time delay. You can use these elements as you choose for tripping, warning, and control. *Figure 4.101* to *Figure 4.104* show the logic diagram for the undervoltage and overvoltage elements, respectively. To disable any of these elements, set the level settings equal to OFF.

Table 4.43 Undervoltage Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default[a]
PHASE UV LEVEL	OFF, 2.0–300.0 V	27P*m*1P := OFF
PHASE UV DELAY	00.00–120.00 s	27P*m*1D := 0.50
PHASE UV LEVEL	OFF, 2.0–300.0 V	27P*m*2P := OFF
PHASE UV DELAY	00.00–120.00 s	27P*m*2D := 5.00
PH-PH UV LEVEL	OFF, 2.0–300.0 V[b]	27PP*m*1P := 93.5
PH-PH UV LEVEL	OFF, 2.0–520.0 V[c]	27PP*m*1P := 93.5
PH-PH UV DELAY	00.00–120.00 s	27PP*m*1D := 0.50
PH-PH UV LEVEL	OFF, 2.0–300.0 V[b]	27PP*m*2P := OFF
PH-PH UV LEVEL	OFF, 2.0–520.0 V[c]	27PP*m*2P := OFF
PH-PH UV DELAY	00.00–120.00 s	27PP*m*2D := 0.50
ENABLE P-SEQ UV	N, 1–6	E27V1X := 1

Table 4.43 Undervoltage Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default[a]
POS SEQ UV LEVEL	OFF, 2.0–170.0 V[b]	27V1X*n*P := 5.0
POS SEQ UV LEVEL	OFF, 2.0–300.0 V[c]	27V1X*n*P := 5.0
POS SEQ UV DELAY	00.00–120.00 s	27V1X*n*D := 0.50
SYNC PH UV LEVEL	OFF, 2.0–300.0 V	27S1P := OFF
SYNC PH UV DELAY	00.00–120.00 s	27S1D := 0.50
SYNC PH UV LEVEL	OFF, 2.0–300.0 V	27S2P := OFF
SYNC PH UV DELAY	00.00–120.00 s	27S2D := 0.50

[a] m = X or Y; n = 1–6.
[b] Setting range shown is for DELTAY_m := DELTA.
[c] Setting range shown is for DELTAY_m := WYE.

Table 4.44 Overvoltage Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default[a]
PHASE OV LEVEL	OFF, 2.0–300.0 V	59P*m*1P := OFF
PHASE OV DELAY	00.00–120.00 s	59P*m*1D := 0.50
PHASE OV LEVEL	OFF, 2.0–300.0 V	59P*m*2P := OFF
PHASE OV DELAY	00.00–120.00 s	59P*m*2D := 5.00
PH-PH OV LEVEL	OFF, 2.0–300.0 V[b]	59PP*m*1P := OFF
PH-PH OV LEVEL	OFF, 2.0–520.0 V[c]	59PP*m*1P := OFF
PH-PH OV DELAY	00.00–120.00 s	59PP*m*1D := 0.50
PH-PH OV LEVEL	OFF, 2.0–300.0 V[b]	59PP*m*2P := OFF
PH-PH OV LEVEL	OFF, 2.0–520.0 V[c]	59PP*m*2P := OFF
PH-PH OV DELAY	00.00–120.00 s	59PP*m*2D := 0.50
ENABLE P-SEQ OV	N, 1–6	E59V1X := N
POS SEQ OV LEVEL	OFF, 2.0–170.0 V[b]	59V1X*n*P := OFF
POS SEQ OV LEVEL	OFF, 2.0–300.0 V[c]	59V1X*n*P := OFF
POS SEQ OV DELAY	00.00–120.00 s	59V1X*n*D := 0.00
NSEQ OV LEVEL	OFF, 2.0–200.0 V	59Q*m*1P := OFF
NSEQ OV DELAY	00.00–120.00 s	59Q*m*1D := 0.50
NSEQ OV LEVEL	OFF, 2.0–200.0 V	59Q*m*2P := OFF
NSEQ OV DELAY	00.00–120.00 s	59Q*m*2D := 5.00
GND OV LEVEL	OFF, 2.0–200.0 V	59G*m*1P := OFF
GND OV DELAY	00.00–120.00 s	59G*m*1D := 0.50
GND OV LEVEL	OFF, 2.0–200.0 V	59G*m*2P := OFF
GND OV DELAY	00.00–120.00 s	59G*m*2D := 5.00

Table 4.44 Overvoltage Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default[a]
SYNC PH OV LEVEL	OFF, 2.0–300.0 V	59S1P := OFF
SYNC PH OV DELAY	00.00–120.00 s	59S1D := 5.00
SYNC PH OV LEVEL	OFF, 2.0–300.0 V	59S2P := OFF
SYNC PH OV DELAY	00.00–120.00 s	59S2D := 5.00

[a] m = X or Y; n = 1–6.
[b] Setting range shown is for DELTAY_m := DELTA.
[c] Setting range shown is for DELTAY_m := WYE.

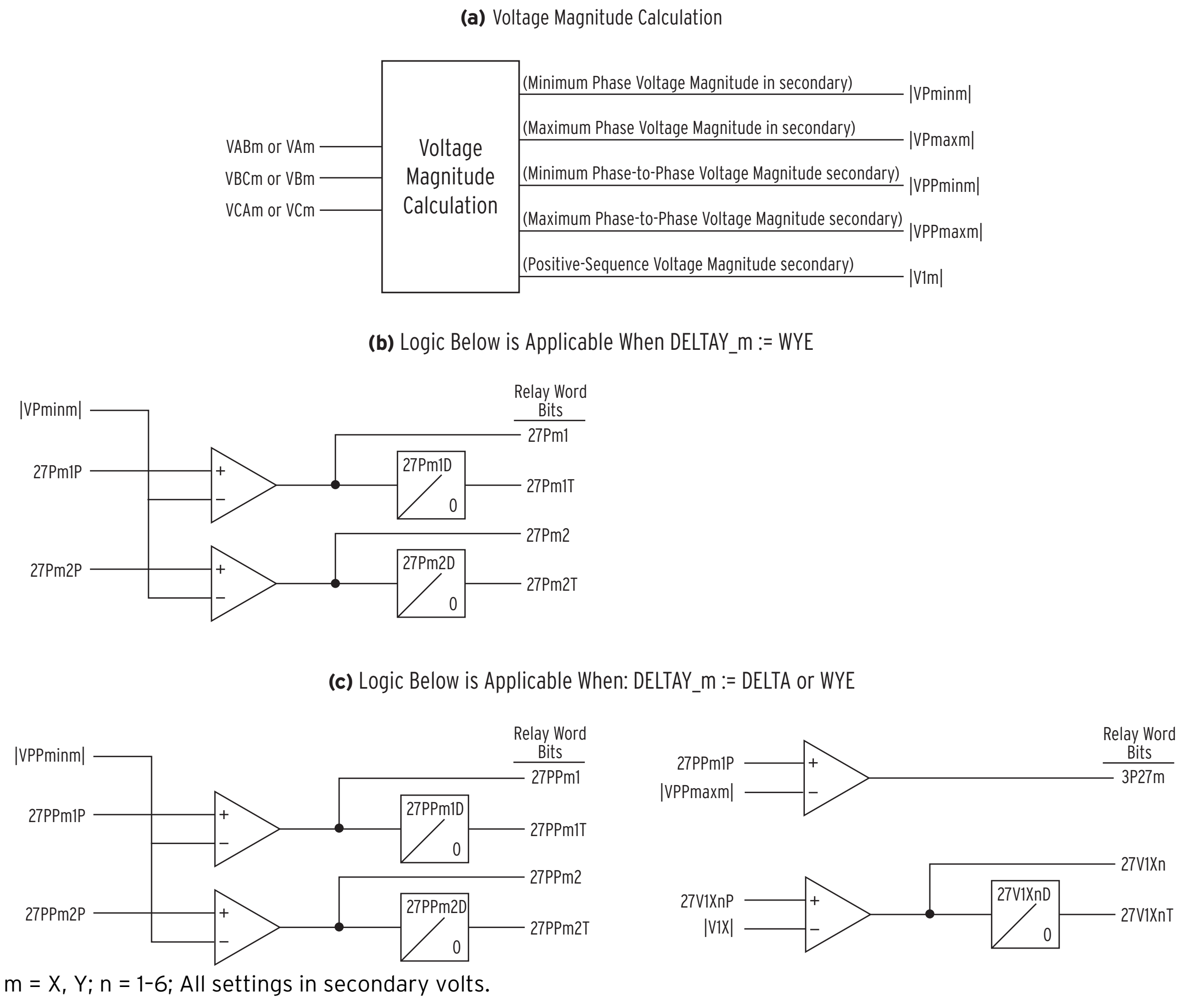
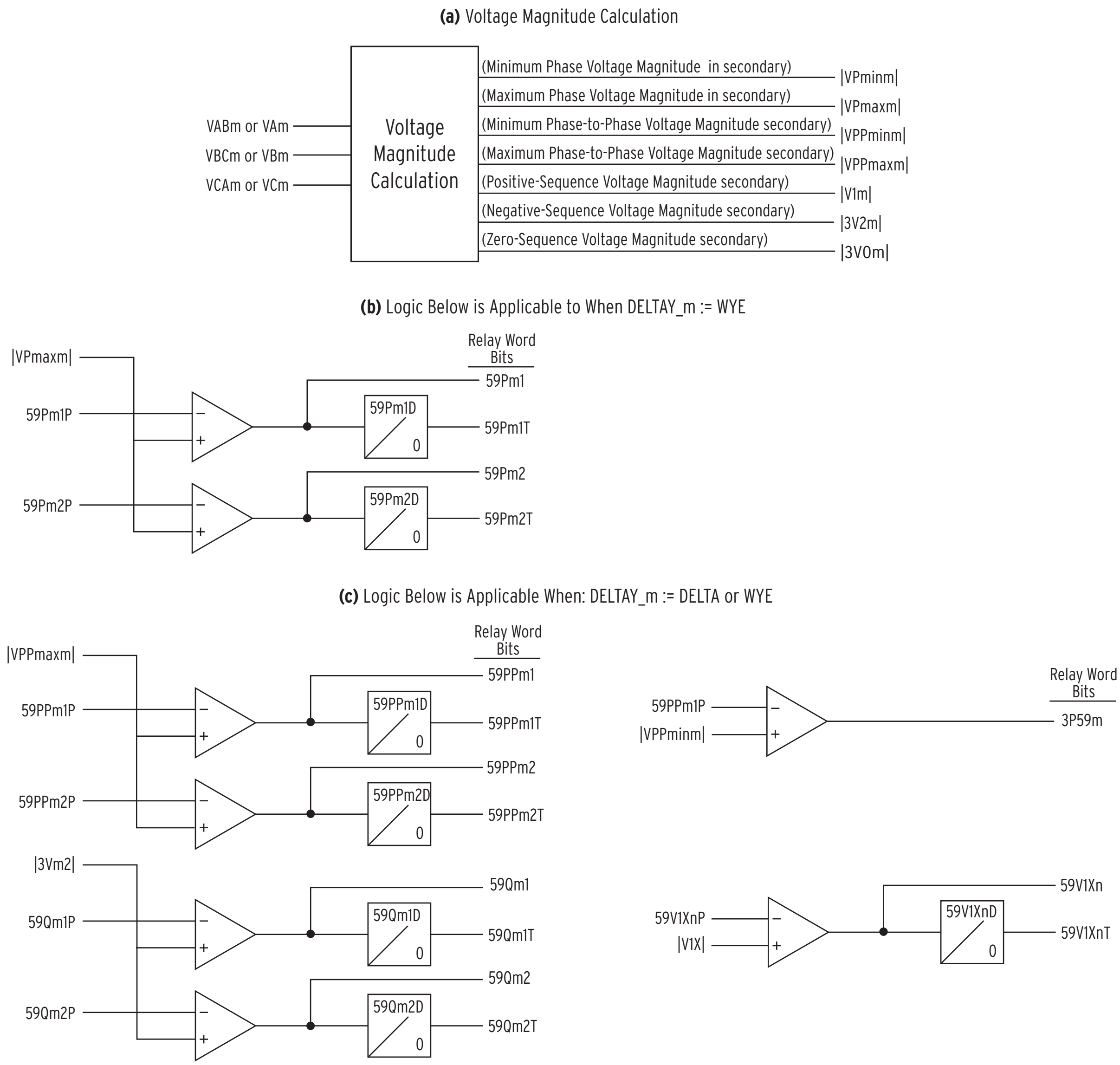
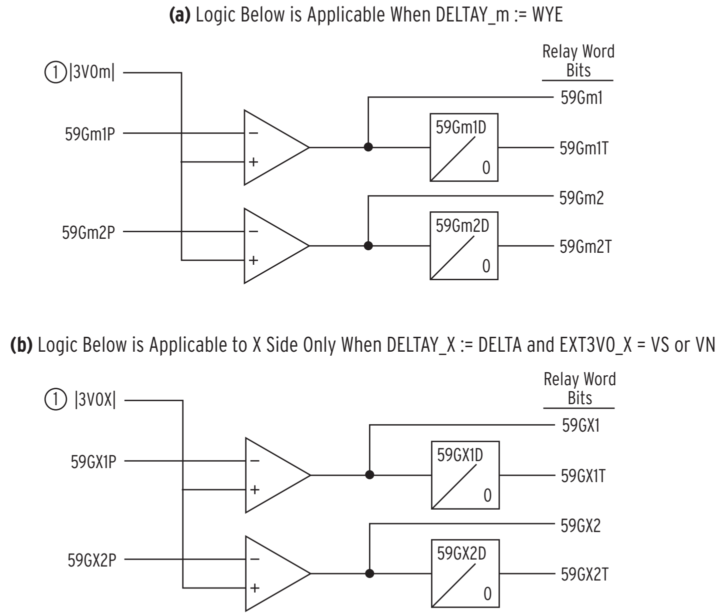


Figure 4.101 Undervoltage Element Logic



m = X or Y; n = 1–6; All settings in secondary volts.

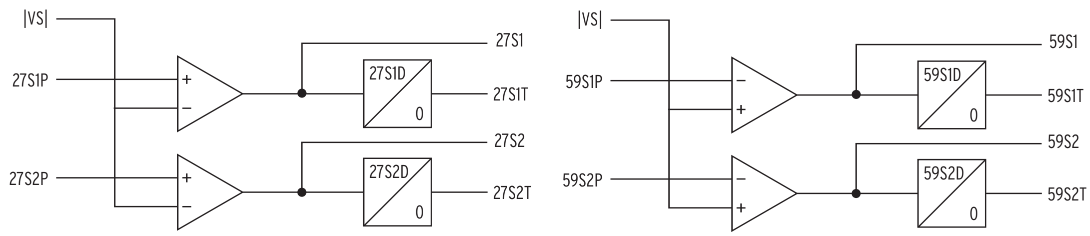
Figure 4.102 Overvoltage Element Logic



m = X or Y; All settings in secondary volts

① Figure 4.102 (a)

Figure 4.103 Zero-Sequence Overvoltage Elements (59G)



27Sn and 59Sn are disabled if EXT3V0_X := VS
n = 1–2; All settings in secondary volts

Figure 4.104 Channel VS Voltage Elements (27S, 59S)

Inverse-Time Undervoltage Protection

The SEL-700G provides two inverse-time undervoltage protection elements (27I1 and 27I2). Based on relay hardware options and settings, the 27I element offers the flexibility of using various analog quantities as operating quantities. The availability of these analog quantities is contingent on the settings DELTAY_*m*, as indicated in *Table 4.45*.

Table 4.45 Operating Quantities for the 27I Element

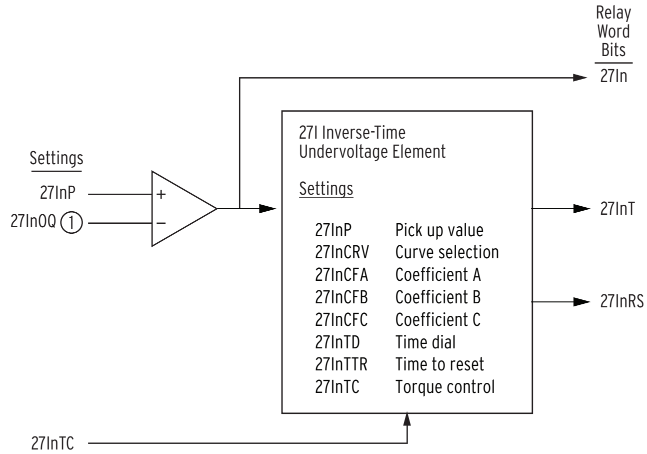
Settings	Operating Quantities Available in 27InOQ Range[a]									
DELTAY_m	**VABm**	**VBCm**	**VCAm**	**VAm**	**VBm**	**VCm**	**VS**	**V1m**	**MINLLm**	**MINLNm**
DELTA	#	#	#	—	—	—	#	#	#	—
WYE	$	$	$	#	#	#	#	#	$	#

= 2.00–300.00 V $ = 2.00–520.00 V — Operating quantity is not available
The "#" and "$" signs indicate the setting range for 27InP (n = 1 or 2). m = X or Y depending on the part number.

[a] The physical meanings of the operating quantities are described as follows:

VABm: Magnitude of A-to-B line voltage
VBCm: Magnitude of B-to-C line voltage
VCAm: Magnitude of C-to-A line voltage
VAm: Magnitude of A-phasengle voltage
VBm: Magnitude of B-phase voltage
VCm: Magnitude of C-phase voltage
VS: Magnitude of Vsync voltage
V1m: Magnitude of positive-sequence voltage
MINLLm: Magnitude of the minimum phase-to-phase voltage
MINLNm: Magnitude of the minimum phase-to-neutral voltage

Figure 4.105 shows the inputs, settings, and outputs of the inverse-time undervoltage element.



n = 1 or 2. ① Refer to Table 4.45.

Figure 4.105 Logic Diagram of the Inverse-Time Undervoltage Element

When the fundamental frequency component of the operating quantity falls below the pickup setting (27I*n*P), Relay Word bit 27I*n* asserts. The timer does not start to integrate unless the operating quantity falls below 0.975 • 27I*n*P. The inverse-time undervoltage protection element has the characteristic defined by *Equation 4.1*.

$$TTT_n = 27InTD \bullet \left(27InCFB + \frac{27InCFA}{\left(1 - \frac{27InOQ}{27InP}\right)^{27InCFC}} \right)$$

Equation 4.1

The settings used are listed in *Table 4.46*.

Table 4.46 Inverse-Time Undervoltage Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
27I ENABLE	Y, N	E27I*n* := N
OPERATING QTY	Refer to *Table 4.45*	27I*n*OQ := VAB
PICKUP LVL	Refer to *Table 4.45*	27I*n*P := 120.00
CURVE	CURVEA, CURVEB, COEF	27I*n*CRV := CURVEA
COEFF A	0.00–3.00	27I*n*CFA := 1
COEFF B	0.00–3.00	27I*n*CFB := 0
COEFF C	0.01–3.00	27I*n*CFC := 1
TIME DIAL	0.00–16.00	27I*n*TD := 1.00
RESET TIME	0.00–1.00 sec	27I*n*TTR := 0.01
TRQ CONTROL	SELOGIC	27I*n*TC := 1

The SEL-700G provides three curve options for each of the 27I elements, settable via the 27I*n*CRV setting—CURVEA, CURVEB, and COEF (user programmable curve). CURVEA is compliant with IEC 60255-127 and is the

IEC standard curve as shown in *Figure 4.106*. CURVEB is a non-standard curve as shown in *Figure 4.106*. The curve option COEF is the user programmable curve. Set the coefficient related settings 27I*n*CFA, 27I*n*CFB and 27I*n*CFC to realize the curve that meets your application needs. *Table 4.47* shows the parameters of the three curves. Note that when 27I*n*CRV is set to CURVEA or CURVEB the coefficient related settings 27I*n*CFA, 27I*n*CFB and 27I*n*CFC are forced to the values shown in *Table 4.47* and hidden.

Table 4.47 Specification of Inverse-Time Undervoltage Protection Element

Curve Description	Curve Defining Constants		
	27InCFA	27InCFB	27InCFC
Curve A	1	0	1
Curve B	0.98	1.28	2.171
Programmable Curve	0.00–3.00	0.00–3.00	0.01–3.00

n = 1 or 2.

When the operating quantity exceeds the pickup level, 27I*n*P, then the output remains deasserted. If the operating quantity exceeds the pickup level for the reset time setting, 27I*n*TTR, then the time integrator resets to 0.

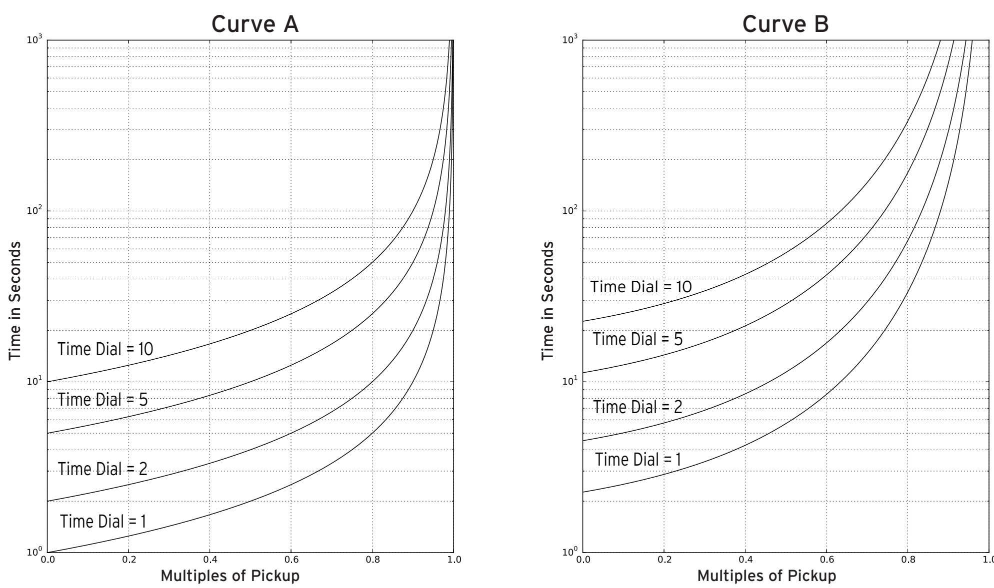


Figure 4.106 Inverse-Time Undervoltage Element Curves

Inverse-Time Overvoltage Protection

There are four inverse-time overvoltage elements (59I) available. Based on relay hardware options and settings, the 59I element offers the flexibility of using various analog quantities as operating quantities. The availability of these analog quantities is contingent on the settings DELTAY_*m*, as indicated in *Table 4.48*.

Table 4.48 Operating Quantities for the 59I Element

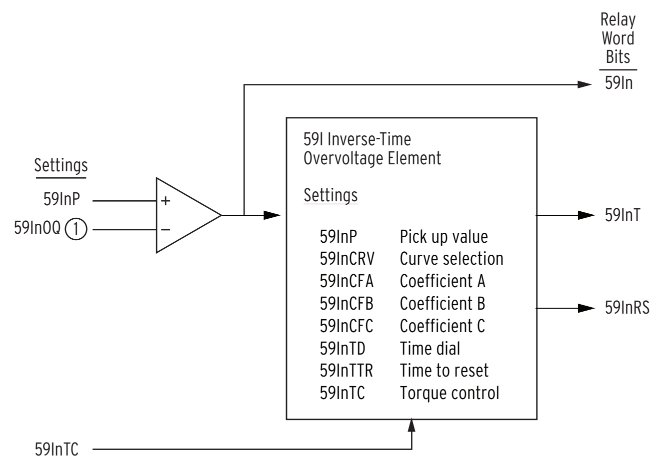
Settings	Operating Quantities Available in 59InOQ Setting Range[a]												
DELTAY_m	**VABm**	**VBCm**	**VCAm**	**VN**	**VAm**	**VBm**	**VCm**	**VS**	**VGm**	**V1m**	**3V2m**	**MAXLLm**	**MAXLNm**
DELTA	#	#	#	#	—	—	—	#	—	#	#	#	—
WYE	$	$	$	#	#	#	#	#	#	#	#	$	#

= 2.00–300.00 V $ = 2.00–520.00 V — Operating quantity is not available
The "#" and "$" signs indicate the setting range for 59InP (n = 1, 2, 3, or 4). m = X or Y depending on the part number.

[a] The physical meanings of the operating quantities are described as follows:

VABm: Magnitude of A-to-B line voltage
VBCm: Magnitude of B-to-C line voltage
VCAm: Magnitude of C-to-A line voltage
VN: Neutral voltage
VAm: Magnitude of A-phasengle voltage
VBm: Magnitude of B-phase voltage
VCm: Magnitude of C-phase voltage
VS: Magnitude of Vsync voltage
VGm: Magnitude of zero-sequence voltage
V1m: Magnitude of positive-sequence voltage
3V2m: Magnitude of negative-sequence voltage
MAXLL: Magnitude of the maximum phase-to-phase voltage
MAXLN: Magnitude of the maximum phase-to-neutral voltage

Figure 4.107 shows the inputs, settings, and outputs of the inverse-time overvoltage element.



n = 1, 2, 3, or 4. ① Refer to Table 4.48.

Figure 4.107 Logic Diagram of the Inverse-Time Overvoltage Element

When the fundamental frequency component of the operating quantity exceeds the pickup setting, 59I*n*P, Relay Word bit 59I*n* asserts. The timer will not start to integrate unless the operating quantity exceeds 1.025 • 59I*n*P. The inverse-time overvoltage protection element has the characteristic defined by *Equation 4.2*.

$$TTT_n = 59InTD \bullet \left(59InCFB + \frac{59InCFA}{\left(\frac{59InOQ}{59InP}\right)^{59InCFC} - 1} \right)$$

Equation 4.2

The settings used are listed in *Table 4.49*.

Table 4.49 Inverse-Time Overvoltage Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
59I ENABLE	Y, N	E59I*n* := N
OPERATING QTY	Refer to *Table 4.48*	59I*n*OQ := VAB

Table 4.49 Inverse-Time Overvoltage Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
PICKUP LVL	Refer to *Table 4.48*	59I*n*P := 120.00
CURVE	CURVEA, CURVEB, CURVEC, COEF	59I*n*CRV := CURVEA
COEFF A	0.00–6.00	59I*n*CFA := 3.88
COEFF B	0.00–3.00	59I*n*CFB := 0.96
COEFF C	0.01–3.00	59I*n*CFC := 2.00
TIME DIAL	0.00–16.00	59I*n*TD := 1.00
RESET TIME	0.00–1.00 sec	59I*n*TTR := 0.01
TRQ CONTROL	SELOGIC	59I*n*TC := 1

The SEL-700G provides four curve options for each of the 59I elements, settable via the 59I*n*CRV setting—CURVEA, CURVEB, CURVEC, and COEF (user-programmable curve). The characteristics of Curve A, Curve B, and Curve C are shown in *Figure 4.108*.

The curve option COEF is the user-programmable curve. Set the coefficient related settings 59I*n*CFA, 59I*n*CFB, and 59I*n*CFC to realize the curve that meets your application needs. *Table 4.50* shows the parameters of the three curves. Note that when 59I*n*CRV is set to CURVEA, CURVEB, or CURVEC the coefficient related settings 59I*n*CFA, 59I*n*CFB, and 59I*n*CFC are forced to the values shown in *Table 4.50* and hidden.

Table 4.50 Specification of Inverse-Time Overvoltage Protection Element

Curve Description	Curve Defining Constants		
	59InCFA	59InCFB	59InCFC
Curve A	3.88	0.96	2
Curve B	5.64	0.24	2
Curve C	0.14	0	0.02
Programmable Curve	0.00–6.00	0.00–3.00	0.01–3.00

n = 1, 2, 3, or 4.

When the operating quantity remains lower than the pickup level, 59I*n*P, then the output remains deasserted. If the operating quantity gets lower than the pickup level for the reset time setting, 59I*n*TTR, then the time integrator resets to 0.

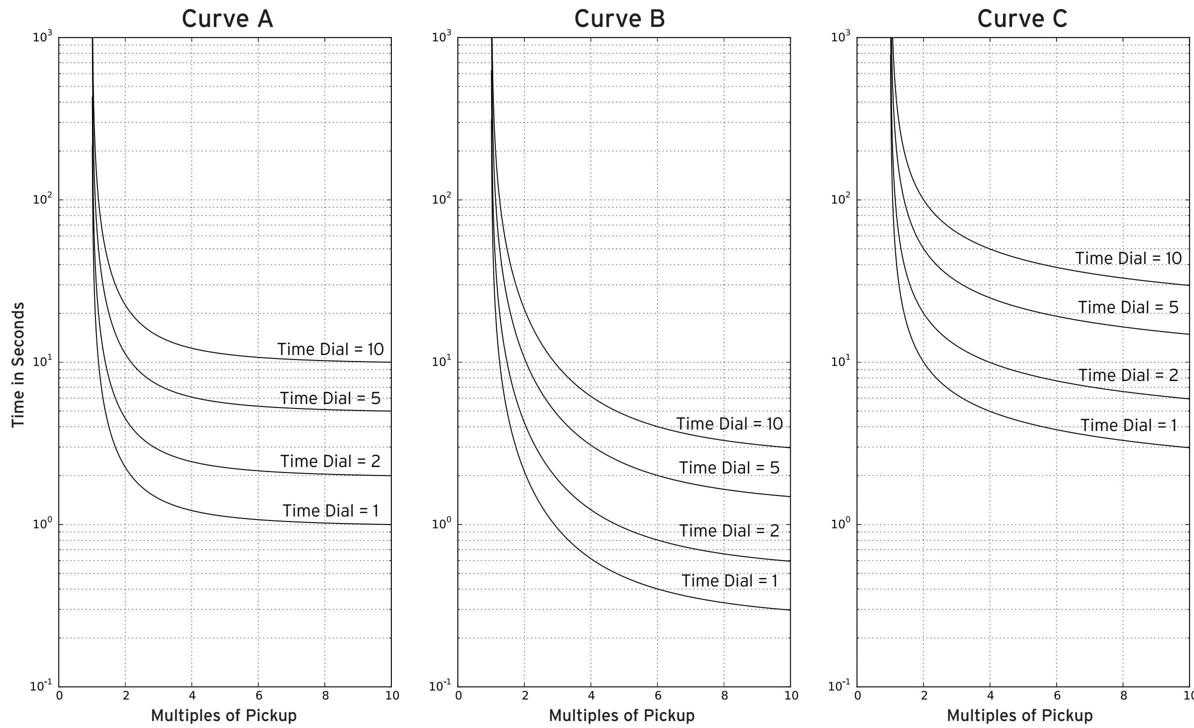


Figure 4.108 Inverse-Time Overvoltage Element Curves

RTD-Based Protection

When you connect an SEL-2600 RTD Module (set E49RTD := EXT) or order the internal RTD card (set E49RTD := INT) option, the SEL-700G offers several protection and monitoring functions, the settings for which are described in *Table 4.51*. See *Figure 2.14* for the RTD module fiber-optic cable connections. If the relay has no internal or external RTD inputs, set E49RTD := NONE.

NOTE: The SEL-700G can monitor as many as 10 RTDs connected to an internal RTD card or as many as 12 RTDs connected to an external SEL-2600 RTD Module. Table 4.51 shows the location, type, and trip/warn level settings for RTD1; settings for RTD2–RTD12 are similar.

NOTE: RTD curves in SEL products are based on the DIN/IEC 60751 standard.

Table 4.51 RTD Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
RTD ENABLE	INT, EXT, NONE	E49RTD := NONE
RTD1 LOCATION	OFF, WDG, BRG, AMB, OTH	RTD1LOC := OFF
RTD1 IDENTIFIER[a]	To 10 Characters	RTD1NAM :=
RTD1 TYPE	PT100, NI100, NI120, CU10	RTD1TY := PT100
RTD1 TRIP LEVEL	OFF, 1–250 degC	TRTMP1 := OFF
RTD1 WARN LEVEL	OFF, 1–250 degC	ALTMP1 := OFF
• • •	• • •	• • •
WIND TRIP VOTING	Y, N	EWDGV := N
BEAR TRIP VOTING	Y, N	EBRGV := N

[a] The RTD Identifier setting is available only when associated RTD Location is set to OTH.

RTD Location

The relay allows you to independently define the location of each monitored RTD by using the RTD location settings. Define the RTD location settings through use of the following suggestions:

- ➤ If an RTD is not connected to an input or has failed in place and will not be replaced, set the RTD location for that input equal to OFF.
- ➤ For RTDs embedded in generator stator windings, set the RTD location equal to WDG.
- ➤ For inputs connected to RTDs measuring bearing race temperature, set the RTD location equal to BRG.
- ➤ For the input connected to an RTD measuring ambient motor cooling air temperature, set the RTD location equal to AMB. Only one ambient temperature RTD is allowed.
- ➤ For inputs connected to monitor temperatures of apparatus, such as transformer oil and winding temperature, set the RTD location equal to OTH. Use the RTD identifier setting to assign an appropriate name to the RTD. For example, set RTD1NAM := XFRMR1 OIL.

If an RTD location setting is equal to OFF, the relay does not request that an RTD type setting be entered for that input.

RTD Type

The four available RTD types are:

- ➤ 100-ohm platinum (PT100)
- ➤ 100-ohm nickel (NI100)
- ➤ 120-ohm nickel (NI120)
- ➤ 10-ohm copper (CU10)

RTD Trip/Warning Levels

NOTE: To improve the security, RTD FAULT, ALARM, and TRIP indicators are delayed by approximately 12 seconds.

The SEL-700G provides temperature warnings and trips through use of the RTD temperature measurements and the warning and trip temperature settings, shown in *Table 4.51*.

The relay issues a winding temperature warning if any of the healthy winding RTDs (RTD location setting equals WDG) indicate a temperature greater than the relay RTD warning temperature setting. The relay issues a winding temperature trip if one or two of the healthy winding RTDs indicate a temperature greater than their RTD trip temperature settings. Two winding RTDs must indicate excessive temperature when the winding trip voting setting equals Y. Only one excessive temperature indication is necessary if winding trip voting is not enabled. Bearing trip voting works similarly.

The warning and trip temperature settings for bearing, ambient, and other RTD types function similarly, except that trip voting is not available for ambient and other RTDs.

To disable any of the temperature warning or trip functions, set the appropriate temperature setting to OFF.

Only healthy RTDs can contribute temperatures to the warning and trip functions. The relay includes specific logic to indicate if RTD leads are shorted or open. Refer to SEL Application Guide *AG2016-10: How to Identify* *a Faulty RTD Connected to an SEL-700 Series Relay* to determine if the RTD connected to an SEL-700 series relay is faulty. *Table 4.52* lists the RTD resistance versus temperature for the four supported RTD types.

NOTE: An open condition for an RTD is detected if the temperature is greater than 250°C and a short condition is detected if the temperature is less than –50°C.

Table 4.52 RTD Resistance Versus Temperature

Temp (°F)	Temp (°C)	100 Platinum	120 Nickel	100 Nickel	10 Copper
–58	–50.00	80.31	86.17	74.30	7.10
–40	–40.00	84.27	92.76	79.10	7.49
–22	–30.00	88.22	99.41	84.20	7.88
–4	–20.00	92.16	106.15	89.30	8.26
14	–10.00	96.09	113.00	94.60	8.65
32	0.00	100.00	120.00	100.00	9.04
50	10.00	103.90	127.17	105.60	9.42
68	20.00	107.79	134.52	111.20	9.81
86	30.00	111.67	142.06	117.10	10.19
104	40.00	115.54	149.79	123.00	10.58
122	50.00	119.39	157.74	129.10	10.97
140	60.00	123.24	165.90	135.30	11.35
158	70.00	127.07	174.25	141.70	11.74
176	80.00	130.89	182.84	148.30	12.12
194	90.00	134.70	191.64	154.90	12.51
212	100.00	138.50	200.64	161.80	12.90
230	110.00	142.29	209.85	168.80	13.28
248	120.00	146.06	219.29	176.00	13.67
266	130.00	149.83	228.96	183.30	14.06
284	140.00	153.58	238.85	190.90	14.44
302	150.00	157.32	248.95	198.70	14.83
320	160.00	161.05	259.30	206.60	15.22
338	170.00	164.77	269.91	214.80	15.61
356	180.00	168.47	280.77	223.20	16.00
374	190.00	172.17	291.96	231.80	16.39
392	200.00	175.85	303.46	240.70	16.78
410	210.00	179.15	315.31	249.80	17.17
428	220.00	183.17	327.54	259.20	17.56
446	230.00	186.82	340.14	268.90	17.95
464	240.00	190.45	353.14	278.90	18.34
482	250.00	194.08	366.53	289.10	18.73

Synchronism Elements

Synchronism-Check Elements (Generator Breaker, X-Side)

A synchronism-check relay verifies that the generator frequency, voltage magnitude, and phase angle match the system frequency, voltage magnitude, and phase angle before allowing the generator breaker to be closed. The SEL-700G offers a built-in synchronism-check function that you can operate manually or automatically with the autosynchronizer function described later. The relay uses the VS voltage input to measure system voltage. Connect this input to the secondary of a phase-to-ground or phase-to-phase connected VT on the system or bus side of the generator circuit breaker. See *Section 2: Installation* for connection examples.

NOTE: If EXT3V0_X is set to VS to connect an external zero-sequence voltage to the **VS-NS** input on the relay, synchronism-check and autosynchronizing functions are disabled.

The relay uses the X-side positive-sequence voltage to measure the generator frequency. Other generator voltage conditions use the voltage selected by the SYNCP setting, set to match the VS input connection. If the slip frequency (frequency difference between the generator and system) is within settable bounds, both voltage magnitudes are within settable bounds, and the phase-angle difference is within limits, the relay synchronism-check function permits the SEL-700G to issue a CLOSE signal or close an output contact to supervise an external close condition. The relay takes into account the breaker closing time and the present slip frequency to issue a close signal timed to have the system and generator at a settable angle difference when the breaker closes.

If a generator step-up transformer is connected between the generator terminals and the open generator breaker, the SEL-700G can account for the phase shift the transformer connections introduce without using auxiliary voltage transformers.

In the event that the generator breaker is slow to close, the generator and system voltages might drift to a phase angle that is unsafe for closing before the breaker closes. In this event, the relay detects that the phase angle between the generator and system voltages exceeds a safe closing angle and can issue a breaker close failure signal to perform breaker failure tripping and protect the generator.

Table 4.53 X-Side Synchronism-Check Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
SYNC CHECK EN	Y, N	E25X := N
V-WINDOW LOW	0.00–300.00 V	25VLOX := 58.3
V-WINDOW HIGH	0.00–300.00 V	25VHIX := 69.7
MAX VOLTAGE DIFF	OFF, 1.0–15.0 %	25VDIFX := 3.3
VOLT RATIO CORR	0.500–2.000	25RCFX := 1.000
GEN-VOLTAGE HI	Y, N	GENV+ := Y
MIN SLIP FREQ	–1.00 to 0.99 Hz	25SLO := 0.05
MAX SLIP FREQ	–0.99 to 1.00 Hz	25SHI := 0.10
MAX ANGLE 1	0–80 deg	25ANG1X := 5
MAX ANGLE 2	0–80 deg	25ANG2X := 15
TARGET CLOSE ANG	–15 to 15 deg	CANGLE := -3
SYNC PHASE	VAX, VBX, VCX, VABX, VBCX, VCAX, 0, 30, 60, …, 330 deg[a]	SYNCPX := VAX[a]

Table 4.53 X-Side Synchronism-Check Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
SYNC PHASE	VABX, VBCX, VCAX, 0, 30, 60, …, 330 deg[b]	SYNCPX := VABX[b]
BRKR CLOSE TIME	OFF, 1–1000 ms	TCLOSDX := 150
CLOSE FAIL INIT	SELOGIC	CFI := CLOSEX
CLOSE FAIL ANGLE	OFF, 3–120 deg	CFANGLE := 30
BLK SYNC CHECK	SELOGIC	BSYNCHX := NOT 3POX

[a] Setting range and default values shown are for DELTAY_X := WYE.
[b] Setting range and default values shown are for DELTAY_X := DELTA.

Set E25X := Y to enable synchronism-check elements. When E25X := N, the 59VPX, 59VSX, GENVHI, GENVLO, GENFHI, GENFLO, VDIFX, 25AX1, 25AX2, 25C, CFA, and BKRCF Relay Word bits are inactive and both synchronism-check and autosynchronizing functions are disabled.

Set SYNCPX to select a phase voltage input (generator terminals) that is in phase with the synchronizing voltage (VS). The VS can be derived from phase-to-ground or phase-to-phase connected VT, regardless of whether open-delta or four-wire wye VTs are used on the generator.

For the applications requiring VS to be at a constant phase angle difference from any of the possible phase voltages (VAX, VBX, VCX; or VABX, VBCX, VCAX depending on DELTAY_X := WYE or DELTA), set the SYNCPX to an angle by which VS lags VAX or VABX. If SYNCPX is set to an angle, then VP equals either VAX∠angle (if DELTAY_X = WYE) or VABX∠angle (if DELTAY_X = DELTA).

The 25VLOX and 25VHIX settings define the acceptable system (VS) voltage magnitude window prior to closing the generator breaker. 25VHIX must be a higher voltage value than 25VLOX. The system and generator voltages must both be greater than 25VLOX and less than 25VHIX for the synchronism-check outputs to operate. The 25VDIFX setting defines the maximum acceptable percentage magnitude difference between the system and generator voltages prior to closing the generator breaker. When used with the autosynchronism voltage matching element (see *Figure 4.122*, *Figure 4.123*, and *Figure 4.124*), the relay applies a correction deadband 20 percent inside of the 25VDIFX setting to reduce the possibility of the generator voltage remaining at the edge of the 25VDIFX setting. VDIFX asserts when the voltage difference is within the 25VDIFX setting. 25VCDB asserts when the voltage difference is within the deadband. See *Figure 4.109*, *Figure 4.110*, *Figure 4.123*, and *Figure 4.124* for more detail.

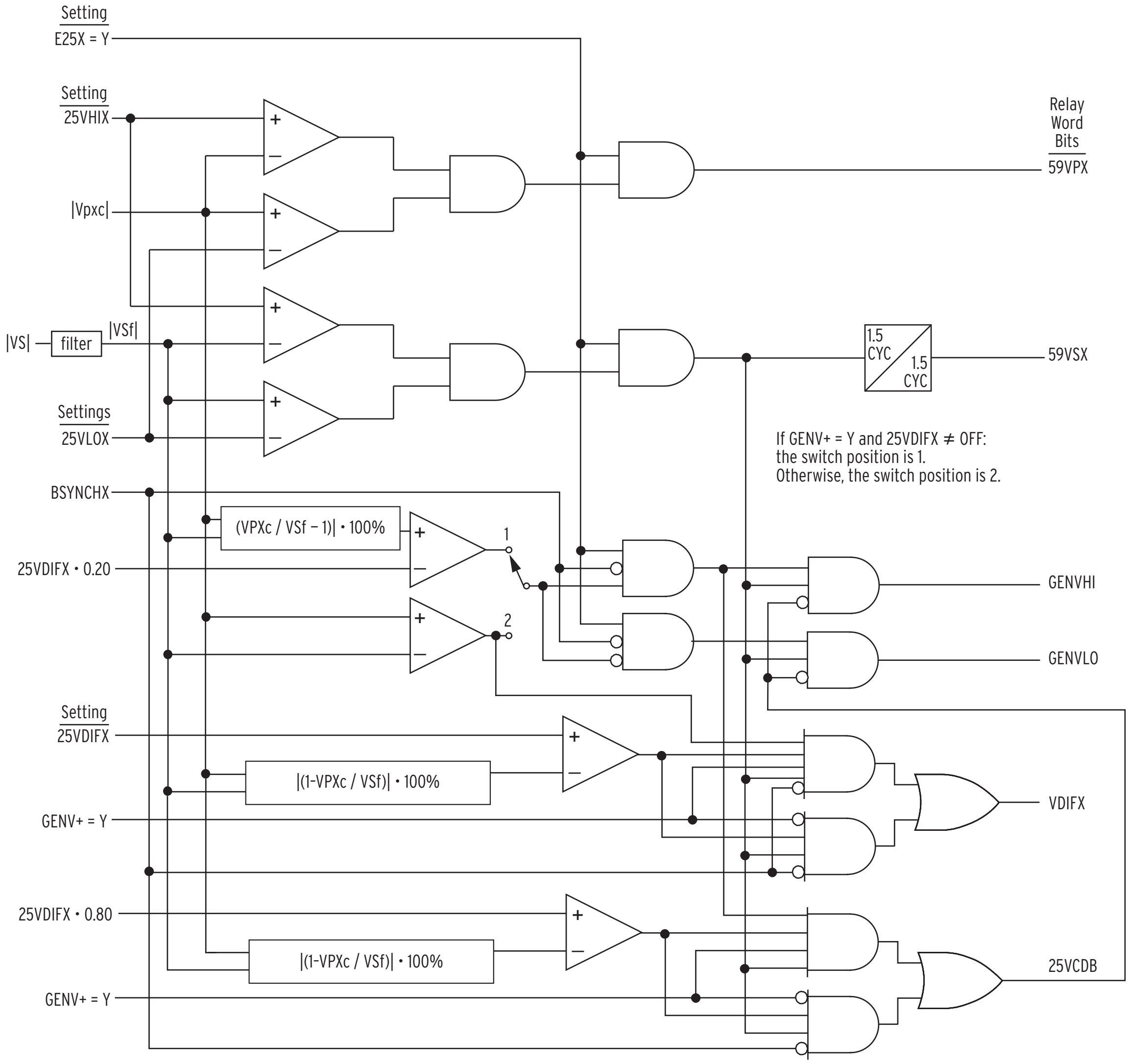


Figure 4.109 Synchronism-Check Function Voltage Elements

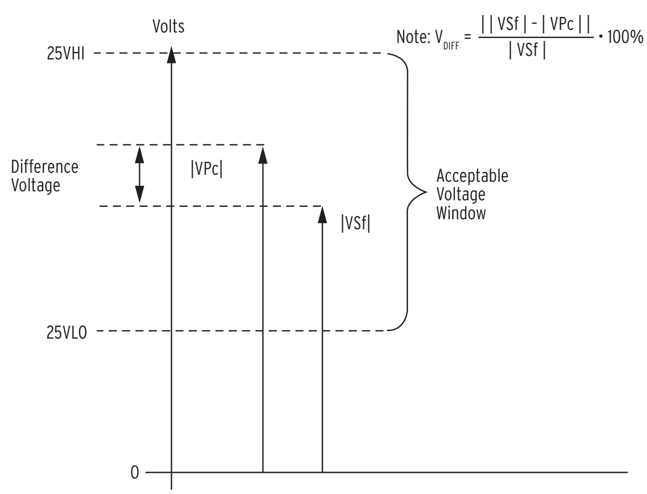


Figure 4.110 Synchronism-Check Function Voltage Element Characteristic

If your synchronization practice requires that the generator voltage be higher than the system voltage prior to closing the generator breaker, set GENV+ = Y. If not, set GENV+ = N. When GENV+ = Y, 25VCDB asserts when the voltage difference is within the deadband and the generator voltage magnitude is 0.002 • 25VDIFX • |VSf| higher than the system voltage. See *Figure 4.124*.

Use the voltage ratio correction factor setting 25RCFX to compensate nominal magnitude of the phase voltage (selected by the SYNCPX setting) to match the nominal magnitude of the synchronism-check voltage VS. In *Figure 4.109*, Vpxc = 25RCFX • VP, where VP can have the following values based on the value of setting SYNCPX:

Table 4.54 Determination of VP Based on SYNCPX and PT Connection Setting Values

DELTA_X = WYE		DELTA_X = DELTA	
SYNCPX	VP	SYNCPX	VP
VAX	VAX	VABX	VABX
VBX	VBX	VBCX	VBCX
VCX	VCX	VCAX	VCAX
Angle	VAX ∠Angle	Angle	VABX ∠Angle
VABX	VABX		
VBCX	VBCX		
VCAX	VCAX		

Many applications require 25RCFX := 1.000, but some applications may need a different setting. *Figure 4.111* shows four out of several possible configurations and their associated settings and calculations. Evaluate your configuration to determine the appropriate settings for your specific application.

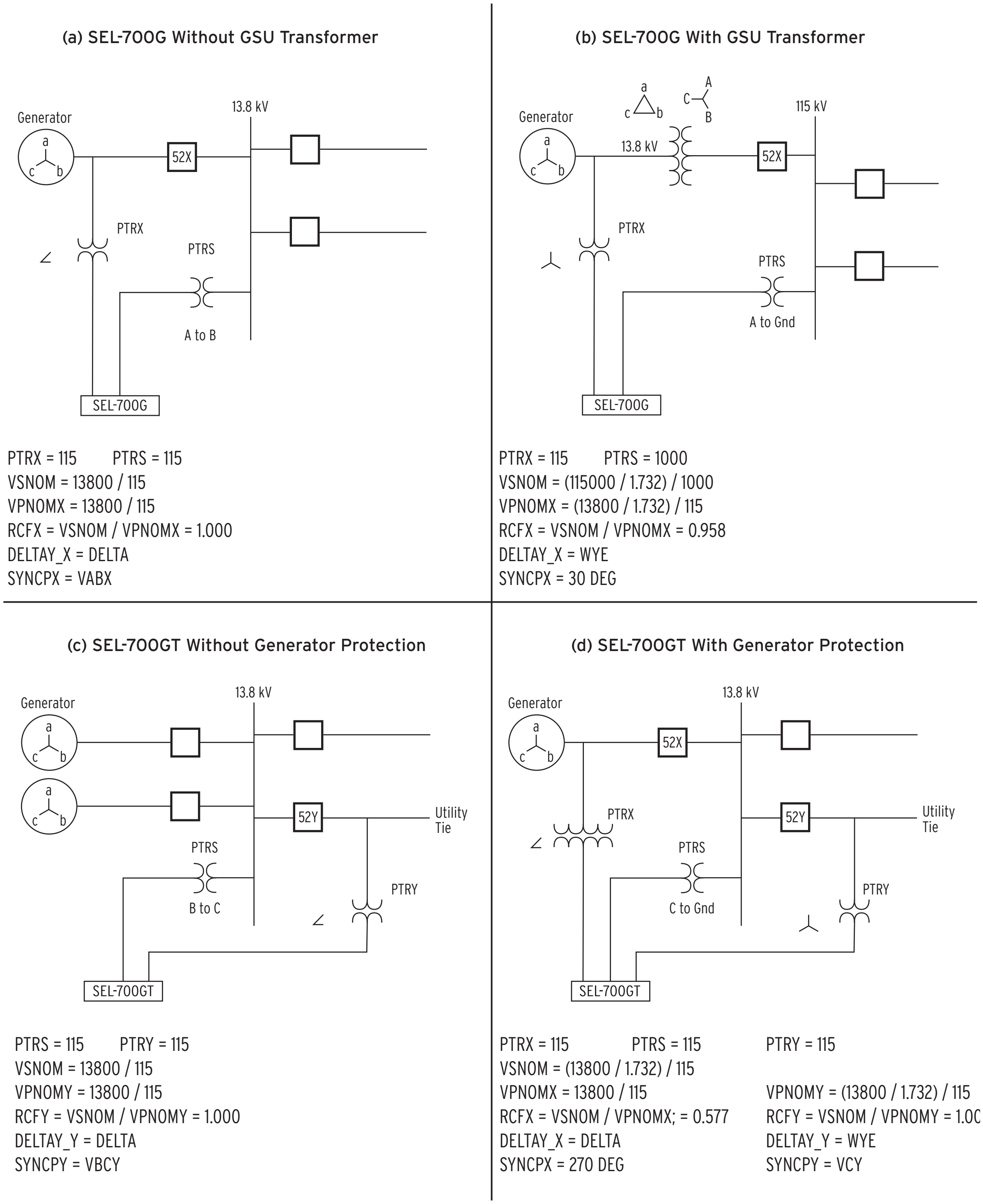


Figure 4.111 Synchronism-Check Function 25RCFX and SYNCPX/SYNCPY Setting Examples

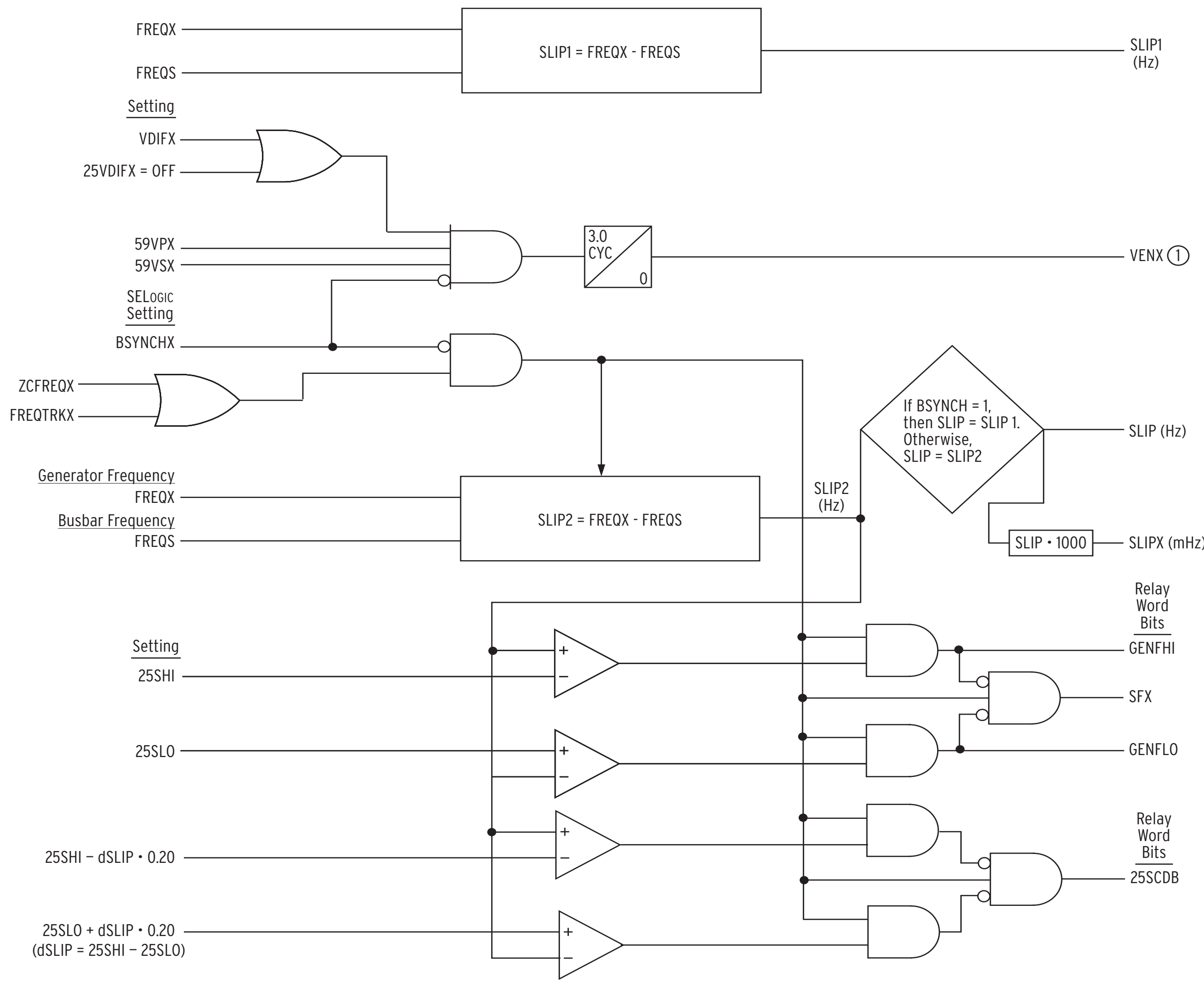
The 25SLO and 25SHI settings define the acceptable slip frequency between the system and the generator prior to closing the generator breaker. 25SHI must be greater than 25SLO. The SEL-700G defines the slip frequency as positive when the generator frequency is higher than the system frequency. When used with the autosynchronism frequency matching element (see *Figure 4.120* and *Figure 4.121*), the relay applies a correction deadband 20 percent inside the difference of the 25SHI and 25SLO settings to reduce the possibility of the generator frequency remaining at the edge of the 25SHI and 25SLO settings. SFX asserts when the slip frequency is within the25SHI and 25SLO settings. Setting 25SCDB asserts when the slip frequency is within the deadband. See *Figure 4.112* for details.

The 25ANG1X setting defines an acceptable generator breaker closing angle. The relay asserts the 25AX1 Relay Word bit when the generator voltage is within 25ANG1X degrees of the system voltage if the other supervisory conditions also are met. When the breaker close time setting, TCLOSDX, is nonzero, the relay accounts for the breaker time and present slip frequency to adjust the phase angles where 25AX1 is asserted.

The 25ANG2X setting also defines an acceptable generator breaker closing angle. The relay asserts the 25AX2 Relay Word bit when the generator voltage is within 25ANG2X degrees of the system voltage if the other supervisory conditions also are met. The relay does not account for the breaker time or present slip frequency to adjust the phase angles where 25AX2 is asserted; it is an absolute phase angle comparison.

The CFI SELOGIC control setting can be used to program breaker close fail-initiate conditions. By default it is programmed to the CLOSEX Relay Word bit and can be programmed to other similar conditions to initiate a close fail.

The CANGLE setting defines a target closing angle (positive angle indicates VS lagging SYNCP voltage). When the balance of the supervisory conditions are satisfied (slip, voltage window, voltage difference) the synchronism-check function accounts for the present slip and the set TCLOSDX time (if not equal to zero). The relay asserts the 25C Relay Word bit for 1/4 cycle to initiate a close. The relay asserts the 25C Relay Word bit to initiate a close when the compensated angle difference equals the CANGLE setting. 25C assertion is timed so that, if the slip remains constant and the breaker closes in TCLOSDX ms, the breaker main contacts close the instant the angle different is equal to CANGLE. See *Figure 4.112*, *Figure 4.113*, *Figure 4.114*, and *Figure 4.115* for additional detail.



① Figure 4.113

Figure 4.112 Synchronism-Check Function Slip Elements

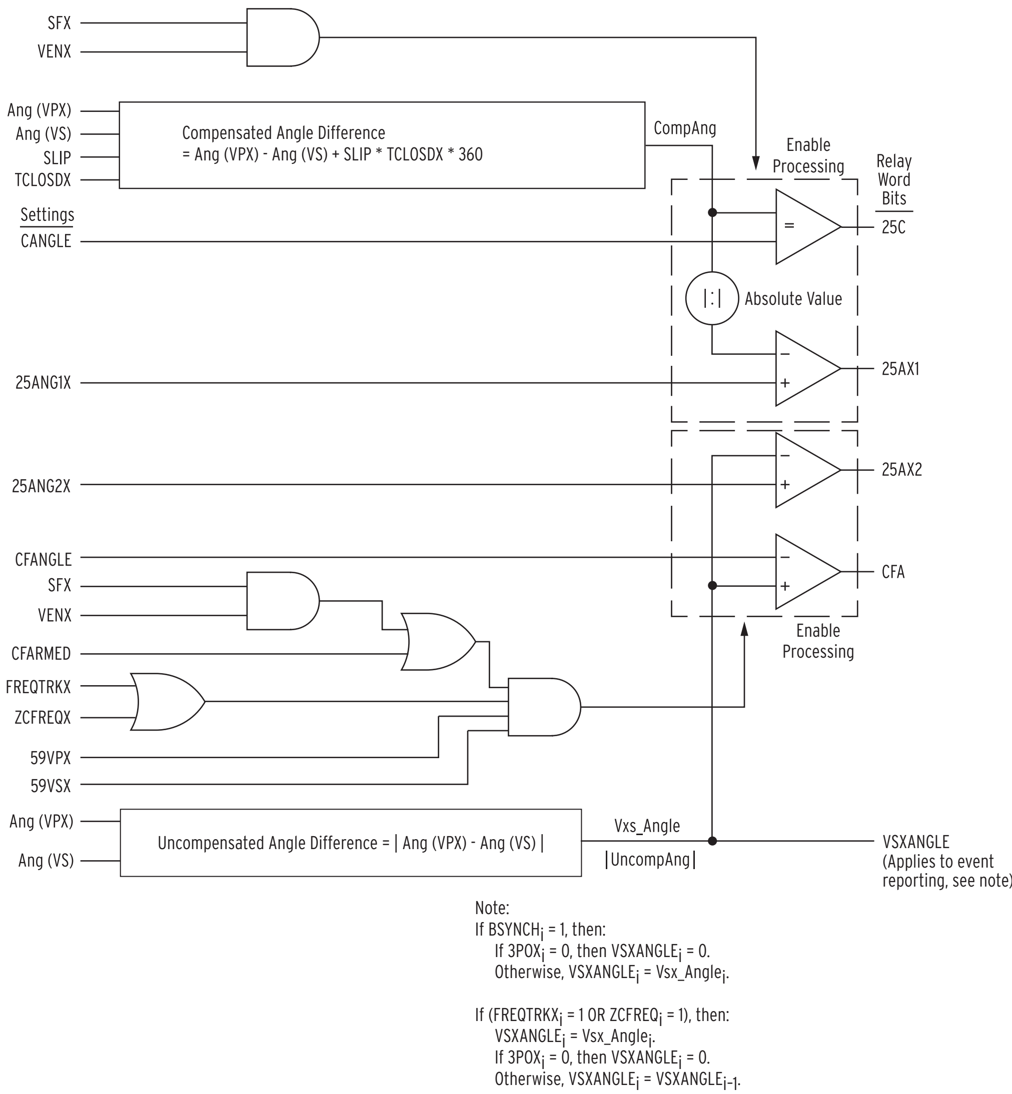


Figure 4.113 Synchronism-Check Function Angle Elements

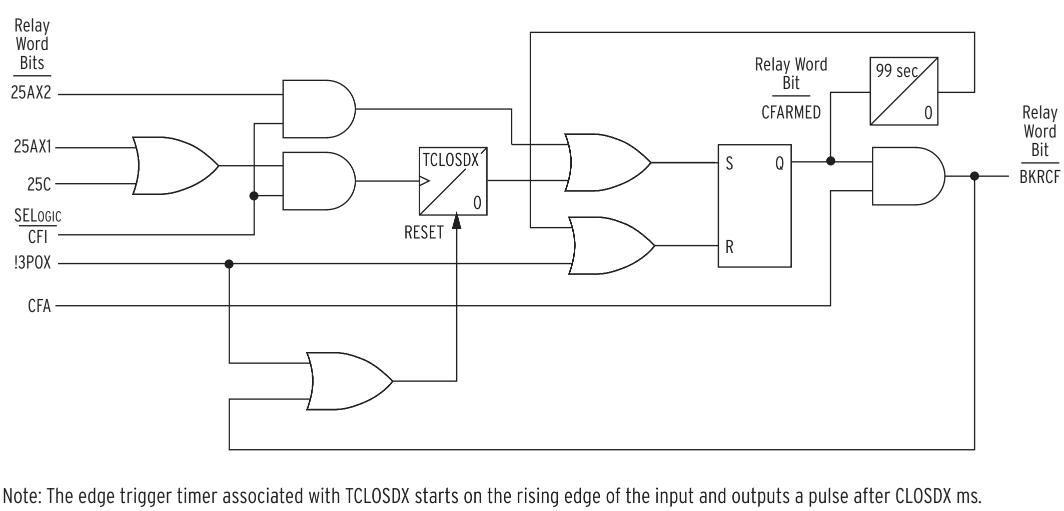


Figure 4.114 Breaker Close Failure Logic Diagram

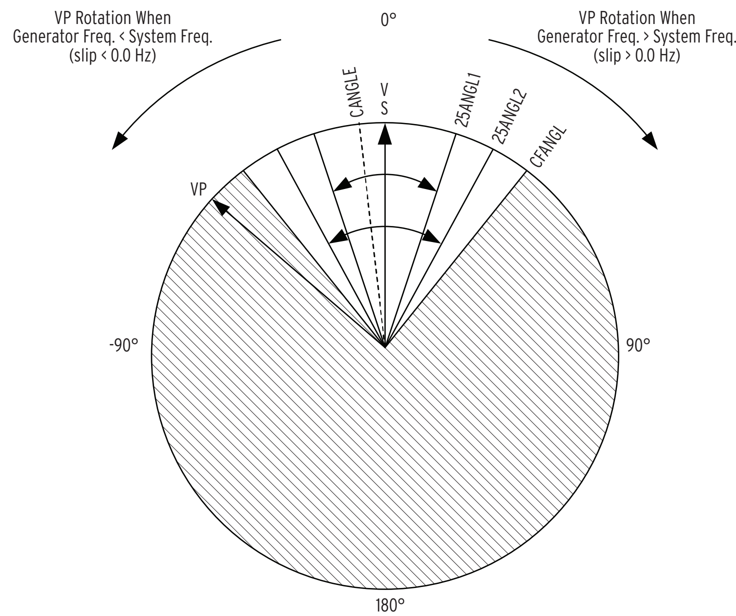


Figure 4.115 Synchronism-Check Function Angle Characteristics

The TCLOSDX setting predicts the time that it will take for the generator main breaker to close, from the instant the SEL-700G Relay Word bit CLOSEX asserts, to the instant the breaker main contacts close. Enter a value that is as accurate as possible, to obtain the best performance of the 25C close-initiating Relay Word bit.

If the relay uses the 25C Relay Word bit to initiate a closure, and the breaker has not closed when the phase angle difference between the generator and system reaches the CFANGLE setting, the relay asserts the BKRCF breaker close failure Relay Word bit. This Relay Word bit typically would be used to close a relay output contact to energize the bus lockout relay. The bus lockout relay would trip all breakers connected to the bus, protecting the generator from the out-of-synchronism close.

The synchronism-check function is blocked when the BSYNCHX SELOGIC control equation result equals logical 1. The function is allowed to operate when the BSYNCHX SELOGIC control equation result equals logical 0. Typically, the BSYNCHX SELOGIC control equation should be set so that the function is blocked when the generator main circuit breaker is closed (NOT 3POX). You can add other supervisory conditions if necessary for your application.

⚠CAUTION
Synchronism-check requirements and practices vary widely for different prime mover types. Be sure to consult your prime mover manufacturer's synchronism-check guidelines as you prepare these settings or severe equipment damage or loss of equipment life may result.

Collect the following information to calculate the synchronism-check settings.

- Prime Mover Manufacturer Synchronization Guidelines
- Synchronism-Check VT Connection and Transformer Ratio
- Generator VT Connection and Transformer Ratio
- Generator Breaker Closing Time
- Generator Step-Up Transformer Winding Turns Ratio and Connection (only necessary if the transformer is connected between the generator VTs and the synchronism-checked VT)

Recommendations

Set SYNCPX to select the phase voltage input (generator terminals) that is in phase with the synchronism-checked voltage (VS).

Sometimes the VS voltage cannot be in phase with any one of the voltage inputs. This happens in applications where voltage input VS is connected

- ➤ Phase-to-neutral when DELTAY_X := DELTA
- ➤ Beyond a delta-wye transformer

For such applications requiring VS to be at a constant phase angle difference from any of the possible synchronizing voltages (VAX, VBX, VCX; or VABX, VBCX, VCAX), an angle setting is made with the SYNCPX setting. The SEL-700G allows additional setting selections of VABX, VBCX, or VCAX for SYNCPX if VS is connected phase-to-phase when DELTAY_X := WYE.

The angle setting choices (0, 30, …, 300, or 330 degrees) for setting SYNCPX are referenced to VAX or VABX (for DELTAY_X := WYE or DELTA respectively), and they indicate how many degrees VS constantly lags the reference. Use the angle setting in situations where VS cannot be in phase with one of the voltage inputs.

NOTE: The settings SYNCPX := 0 and SYNCPX := VAX or VABX (reference voltage) are effectively the same (voltage VS is directly synchronism checked with the reference; VS does not lag the reference).

See *Figure 4.111* for a few examples of setting SYNCPX. *Figure 4.111 (d)* shows a relay wired with delta-connected phase PTs, and a C-phase-to-ground connected VS input. With ABC rotation, the correct SYNCPX setting for this example is 270 degrees, the amount that VS (C to Gnd.) lags VABX. See SEL Application Guide AG2002-02, Compensate for Constant Phase Angle Difference in Synchronism Check with the SEL-351 Relay Family, for more information on setting SYNCP with an angle setting. This application guide was written for the SEL-351, but it is generally applicable to the SEL-700G.

Use the 25VLOX, 25VHIX, 25VDIFX, and GENV+ settings to define the voltage conditions under which the generator breaker can be closed safely. The 25VLOX and 25VHIX settings define an acceptable voltage magnitude window. A close is permitted only if the generator and system voltages are within this window.

Make the 25VLOX and 25VHIX settings based on the secondary magnitude of VS. For instance, if a close is acceptable while the system voltage ranges from 90 percent to 105 percent of nominal, if the synchronism-check PT is connected phase-to-neutral and the nominal line-to-neutral voltage is 67 V secondary, then

25VLOX := 0.9 • 67 V secondary = 60.3 V secondary
25VHIX := 1.05 • 67 V secondary = 70.4 V secondary

When a phase-to-phase connected synchronism-check VT is used, the nominal phase-to-phase voltage would probably be approximately 120 V secondary, leading to

25VLOX := 0.9 • 120 V secondary = 108 V secondary
25VHIX := 1.05 • 120 V secondary = 126 V secondary

The 25VDIFX setting defines a maximum acceptable percentage difference between the generator and system voltages. GENV+ defines whether the generator voltage must be greater than the system voltage. Setting 25VDIFX := OFF disables this supervision and permits a close when both voltages are within the voltage window described earlier.

For instance, the generator and prime mover manufacturer may recommend that the generator voltage be between 0 percent and +3 percent of the system voltage when the generator breaker is closed. In that case, set 25VDIFX := 3% and GENV+ := Y. If a close is permitted when the generator voltage is within ±5 percent of the system voltage, set 25VDIFX := 5% and GENV+ := N.

The 25RCFX setting compensates magnitude differences between the synchronism-check voltage and the generator voltage. Unmatched voltage transformer or step-up transformer ratios can introduce magnitude differences.

Use the following equation to set 25RCFX:

$$25RCFX := \frac{VSNOM}{VPNOMX}$$

where:

VSNOM = Nominal magnitude of VS input, secondary volts
VPNOMX = Nominal magnitude of VAX input, secondary volts (if DELTAY_X := WYE)
VPNOMX = Nominal magnitude of VABX input, secondary volts (if DELTAY_X := DELTA)

After the relay has been placed in service and the generator breaker closed, you may want to refine the 25RCFX setting to account for transformer ratio errors. Use the procedure in the *Manually Refine the 25RCFX Setting While the Generator Is in Service on page 4.173* to refine the 25RCFX setting manually.

The 25SLO and 25SHI settings define the minimum and maximum acceptable slip frequency for a generator breaker close. 25SLO must be set less than 25SHI. The SEL-700G defines the slip frequency as positive when the generator frequency is higher than the system frequency.

Some large steam turbine generators require that a low, positive slip be present when the generator breaker is closed (e.g., IEEE Std. C50.12). Setting 25SLO = 0.02 Hz and 25SHI = 0.06 Hz could satisfy that requirement.

The SEL-700G synchronism-check function provides three methods to supervise internal and external close signals. Relay Word bits 25AX1, 25AX2, and 25C assert for different generator and system voltage phase angles, but all are supervised by the voltage magnitude and difference and slip frequency limits.

The relay uses two phase-angle calculations to control the 25AX1, 25AX2, and 25C Relay Word bits.

The first phase-angle calculation is the absolute phase-angle difference between the generator and system voltages. The next phase-angle calculation adjusts the absolute phase-angle difference by an angle value that is the phase angle the system will travel through in TCLOSDX ms, assuming that the present slip frequency remains constant. This slip-compensated phase angle predicts the phase-angle difference when the breaker closes, if a close were issued at this instant and if the breaker closed in TCLOSDX ms.

The 25AX2 Relay Word bit asserts when the absolute phase-angle difference is less than the 25ANG2X setting.

Relay Word bit 25AX1 asserts when the absolute value of the slip-compensated phase-angle difference is less than the 25ANG1X setting.

The 25C Relay Word bit asserts when the slip-compensated phase-angle difference is equal to the CANGLE setting. When you would like to initiate a generator breaker close, timed so that the phase angle difference equals the CANGLE setting, supervise the CLOSEX initiation with the 25C Relay Word bit.

The settings for 25ANG1X, 25ANG2X, and CANGLE depend on the requirements of the application.

Set TCLOSDX equal to the circuit breaker closing time in milliseconds. The relay uses this value to calculate the slip-compensated phase-angle difference between the generator and system voltages, as described previously. If there are interposing relays between the SEL-700G CLOSEX output and the circuit breaker close coil, add the operating time of these components to the breaker's own closing time to calculate the TCLOSDX setting.

Large generators can sustain serious damage if the generator circuit breaker closes while there is a large phase-angle difference between the generator voltage and the system voltage. Synchronism-check relays help prevent this occurrence. However, if the circuit breaker is slow to close, the generator slip frequency can cause the generator voltage to rotate away from the system voltage, increasing the phase-angle difference to dangerous levels. At this point it is not possible to trip the slowly closing breaker; but if the breaker does close eventually, it could badly damage the generator or reduce its life. To prevent this, you can use a breaker failure lockout signal to clear the generator bus. This removes system voltage from the outboard side of the circuit breaker so that if the breaker does close, it only energizes a dead bus.

The SEL-700G synchronism-check function includes breaker slow close detection logic. The breaker close failure logic is armed when CFI is asserted along with 25C or 25AX1 or 25AX2 bits (see *Figure 4.114*). If the breaker closes, the 3POX Relay Word bit deasserts and the logic is disarmed. If the breaker does not close and the generator voltage rotates to greater than the close failure angle, CFANGLE, the relay asserts the BKRCF circuit breaker close failure Relay Word bit. This Relay Word bit would be applied to trip the bus lockout relay. If some type of control failure occurs that prevents the generator breaker from closing, the breaker close failure logic is disarmed automatically after 99 seconds, as long as the generator voltage does not enter the close failure region.

If breaker close failure protection is not necessary, set CFANGLE := Off. If breaker close failure protection is necessary, first determine the phase angle difference at which generator or prime mover damage can occur.

Damage Angle = ________°

Next, calculate the phase angle through which the generator rotates while the generator bus is being cleared if a close failure occurs at maximum slip. Use the following equation:

Angle Rotation = Bus clearing time • 25S*xx* • 360 degrees

where

Bus clearing time = time in seconds for all breakers connected to the generator bus to open in the event of a breaker failure lockout relay operation

25S*xx* = maximum acceptable slip frequency. This value will be equal to the absolute value of 25SHI or 25SLO, whichever is larger.

Angle Rotation = _______°

Set CFANGLE less than or equal to:

CFANGLE = Damage Angle° – Angle Rotation°

CFANGLE := _______°

The BSYNCHX SELOGIC control equation should be set to block the synchronism-check function whenever the generator circuit breaker is closed and during other conditions that you select.

Manually Refine the 25RCFX Setting While the Generator Is in Service. Once the generator is in service and the generator breaker is closed, you may want to refine the 25RCFX setting. The refinement removes the effect of differences between the actual voltage transformer ratios and the nameplate markings. These differences should be small, but they may be additive and therefore significant. To refine the 25RCFX setting, take the following steps:

Step 1. Use the front-panel interface or a PC connected to a relay serial port to review the relay settings. Note the values of the following settings:

PTRX := _________

PTRS := _________

SYNCPX := _________

25RCFX := _________

DELTAY_X := _________

Step 2. With the generator running and the generator main circuit breaker closed, reduce the generator load current to as low as possible. This is particularly important when a step-up transformer is connected between the generator VTs and the synchronism-check VT, as in *Figure 4.111 (b)*.

Step 3. Using the front-panel or serial port **METER** command, determine the magnitude of VS:

VS = __________ V primary

Step 4. Depending on the SYNCPX and DELTAY_X settings, note the appropriate generator voltage, as follows:

When DELTAY_X := WYE, record the phase voltage named by the SYNCPX setting VAX, VBX, VCX, VABX, VBCX, or VCAX (use VAX if the setting is a numeric value):

V__ = _________ V primary

When DELTAY_X := DELTA, record the phase-to-phase voltage named by the SYNCPX setting VABX, VBCX, or VCAX (use VABX if the setting is a numeric value):

V__ = _________ V primary

Step 5. Calculate the secondary magnitude of VS by dividing the primary value noted in *Step 3* by the PTRS setting:

VSs = VS/PTRS = __________ V secondary

Step 6. Calculate the secondary magnitude of the generator voltage noted in *Step 4* by dividing that magnitude by the PTRX setting:

VP = V_ (from *Step 4*)/PTRX = _________ V secondary

Step 7. Calculate a refined 25RCFX setting by dividing VSs by VP:

25RCFX = VSs/VP = __________

Step 8. If the 25RCFX value calculated in *Step 7* varies from the 25RCFX setting noted in *Step 1*, enter the value as a new 25RCFX setting to improve the accuracy of the synchronism-check voltage acceptance logic.

Synchronism-Checked Supervised Closing. The 25C, 25AX1, and 25AX2 Relay Word bits are available to supervise the internal Close Logic or external devices. The most convenient method to apply the synchronism-check function is to use one of the resulting Relay Word bits in the CLX SELOGIC control equation, see *Figure 4.138* and *Figure 4.139* for additional detail.

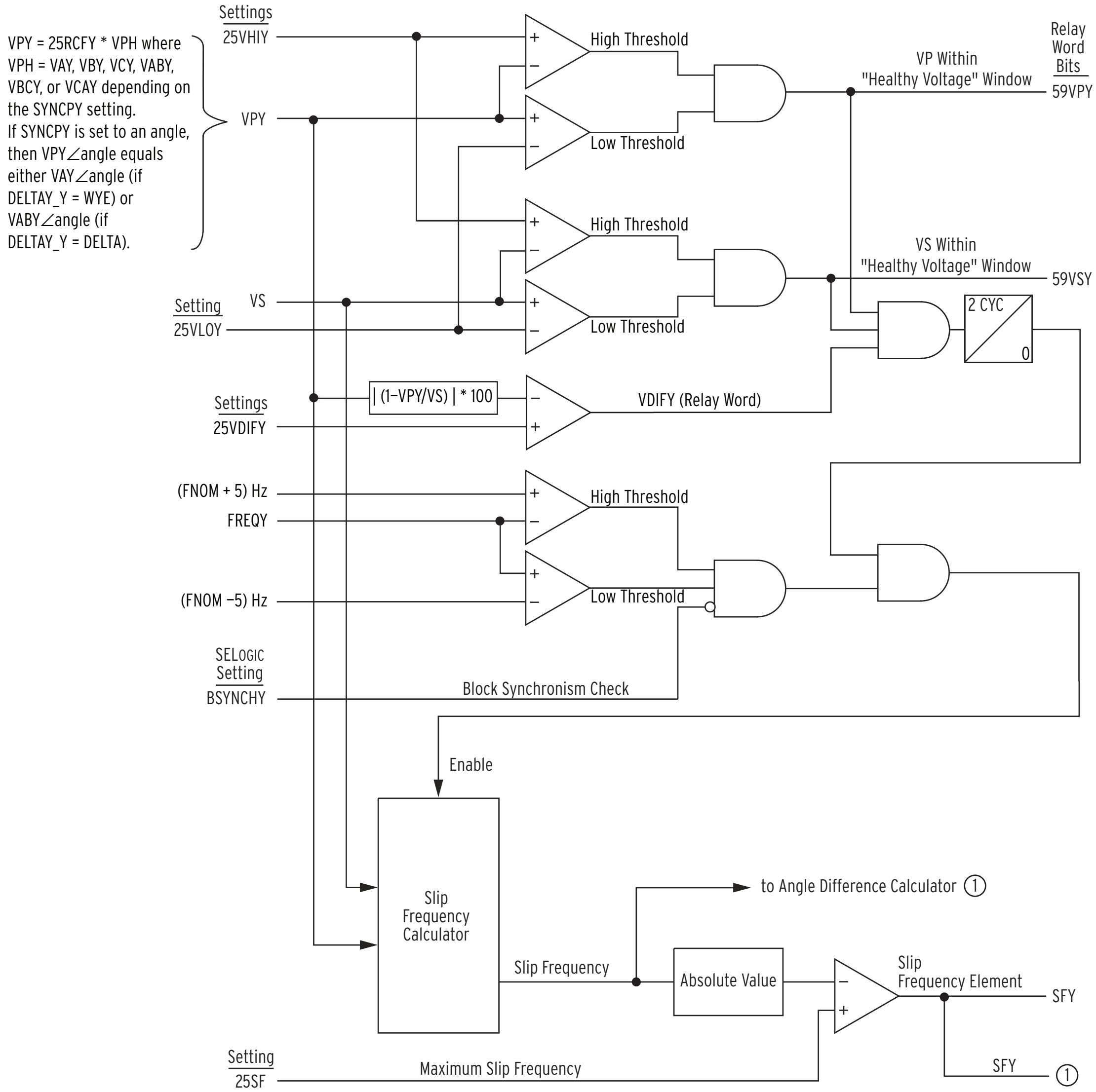
Synchronism-Check Elements (Tie Breaker, Y-Side)

Figure 2.29 shows an example of where synchronism check can be applied. Synchronism-check voltage input **VS** is connected to one side of the circuit breaker, on any necessary phase. The other synchronizing phase (**VA**, **VB**, or **VC** voltage inputs) on the other side of the circuit breaker is setting selected.

The two synchronism-check elements (25A1Y and 25A2Y) use the same voltage window (to ensure healthy voltage), frequency window (FNOM +/- 5 Hz), and slip frequency settings (see *Figure 4.116* and *Figure 4.117*). They have separate angle settings.

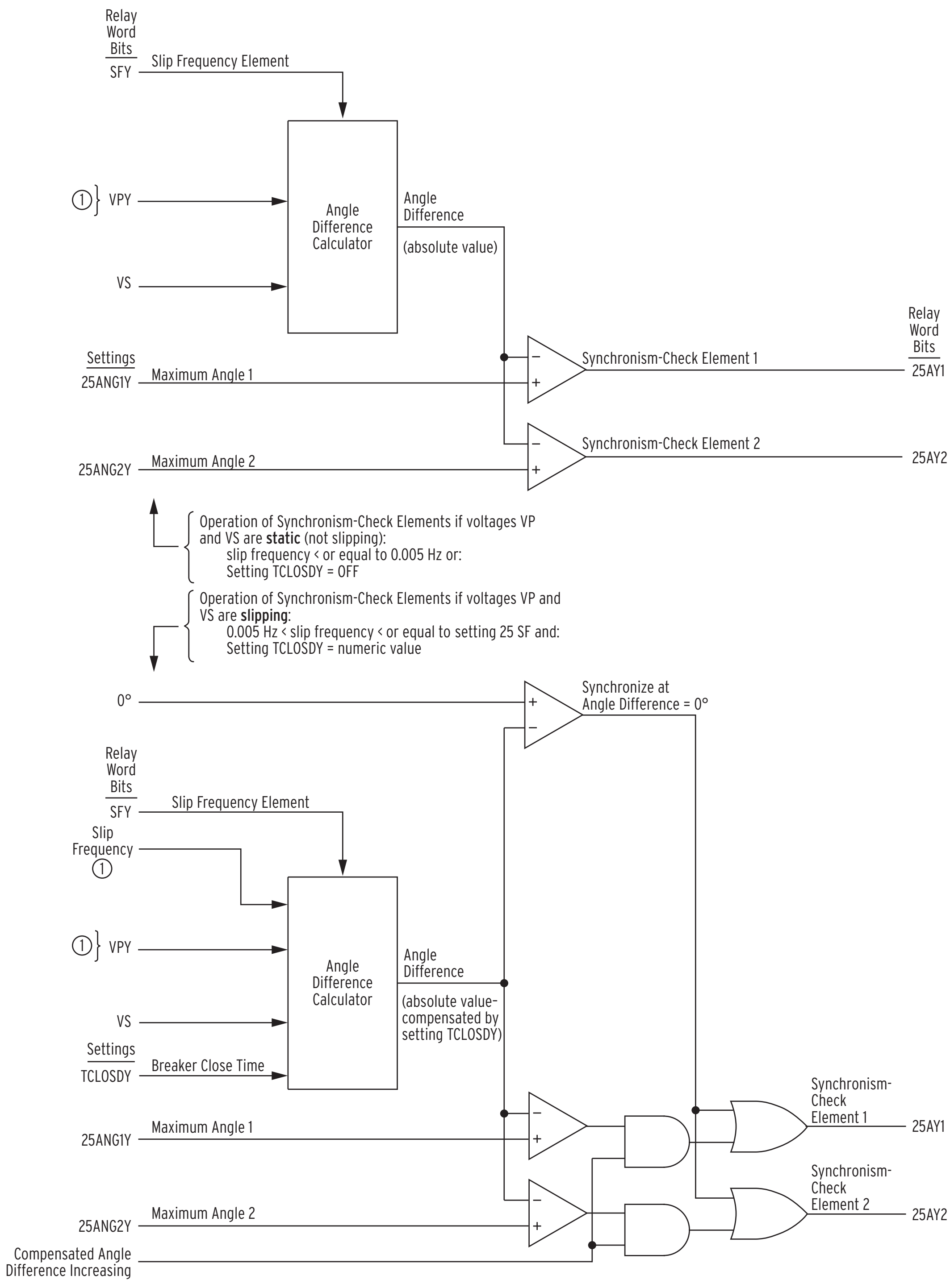
If the voltages are static (voltages not slipping with respect to one another) or setting TCLOSDY := OFF, the two synchronism-check elements operate as shown in the top of *Figure 4.117*. The relay checks these angle settings for synchronism-check closing.

If the voltages are not static (voltages slipping with respect to one another), the two synchronism-check elements operate as shown in the bottom of *Figure 4.117*. The angle difference is compensated by breaker close time, and the breaker is ideally closed at a zero-degree phase angle difference, to minimize system shock.



① Figure 4.117

Figure 4.116 Synchronism-Check Voltage Window and Slip Frequency Elements



① From Figure 4.116

Figure 4.117 Synchronism-Check Elements

The synchronism-check elements are explained in detail in the following text.

Voltage Input VS Connected Phase-to-Phase or Beyond Delta-Wye Transformer

Sometimes synchronism-check voltage **VS** cannot be in phase with voltage VA, VB, or VC (wye-connected PTs); or VAB, VBC, or VCA (delta-connected PTs). This happens in applications where voltage input **VS** is connected

- ➤ Phase-to-neutral when using a delta-connected relay
- ➤ Beyond a delta-wye transformer

For such applications requiring VS to be at a constant phase angle difference from any of the possible synchronizing voltages (VA, VB, or VC; VAB, VBC, or VCA), an angle setting is made with the SYNCPY setting (see *Table 4.55* and *Setting SYNCPY*). The SEL-700G allows additional setting selections of VABY, VBCY, or VCAY for SYNCPY if VS is connected phase-to-phase when DELTAY_Y := WYE.

Table 4.55 Synchronism-Check Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
SYNC CHECK EN	Y, N	E25Y := N
V-WINDOW LOW	0.00–300.00 V	25VLOY := 58.30
V-WINDOW HIGH	0.00–300.00 V	25VHIY := 69.70
MAX VOLTAGE DIFF	OFF, 1.0–15 %	25VDIFY := 3.3
VOLT RATIO CORR	0.5000–2.000	25RCFY := 1.000
MAX SLIP FREQ	0.05–0.50 Hz	25SF := 0.20
MAX ANGLE 1	0–80 deg	25ANG1Y := 25
MAX ANGLE 2	0–80 deg	25ANG2Y := 40
SYNC PHASE	VAY, VBY, VCY, VABY, VBCY, VCAY or 0, 30, 60, 90, 120, 150, 180, 210, 240, 270, 300, 330 deg lag VAY[a]	SYNCPY := VAY
SYNC PHASE	VABY, VBCY, VCAY, or 0, 30, 60, 90, 120, 150, 180, 210, 240, 270, 300, 330 deg lag VABY[b]	SYNCPY := VABY
BRKR CLOSE TIME	OFF, 1–1000 ms	TCLOSDY := 50
BLK SYNCH CHECK	SV	BSYNCHY := NOT 3POY

[a] Range shown for DELTAY_Y := WYE.
[b] Range shown for DELTAY_Y := DELTA.

Setting SYNCPY

Enable the two single-phase synchronism-check elements by setting E25Y := Y.

NOTE: Settings SYNCPY := 0 and SYNCPY := VAY are effectively the same (voltage VS is directly synchronism checked with voltage VAY; VS does not lag VAY). The relay displays the setting entered (SYNCPY := VAY or SYNCPY := 0).

Wye-Connected Voltages. The angle setting choices (0, 30, …, 300, or 330 degrees) for setting SYNCPY are referenced to VAY, and they indicate how many degrees VS constantly lags VAY. In this case, voltage input **VAY-N** has to be connected and has to meet the “healthy voltage” criteria (settings 25VHIY and 25VLOY—see *Figure 4.116*). For situations where VS cannot be in phase with VAY, VBY, VCY, VABY, VBCY, or VCAY the angle setting choices (0, 30, …, 300, or 330 degrees) are referenced to VAY.

NOTE: Settings SYNCPY := 0 and SYNCPY := VABY are effectively the same (voltage VS is directly synchronism checked with voltage VABY; VS does not lag VABY). The relay displays the setting entered (SYNCPY := VABY or SYNCPY := 0).

Delta-Connected Voltages. The angle setting choices (0, 30, …, 300, or 330 degrees) for setting SYNCPY are referenced to VABY, and they indicate how many degrees VS constantly lags VABY. In this application, voltage input VAY-VBY has to be connected and has to meet the "healthy voltage" criteria (settings 25VHIY and 25VLOY—see *Figure 4.116*). For situations where VS cannot be in phase with VABY, VBCY, or VCAY, the angle setting choices (0, 30, …, 300, or 330 degrees) are referenced to VABY.

See *Figure 4.111* for examples of wye and delta-connected voltages and associated SYNCP and 25RCF for both X and Y sides.

Synchronism-Check Elements Voltage Inputs

The two synchronism-check elements are single-phase elements, with single-phase voltage inputs VPY and VS used for both elements:

- ➤ VPY Phase input voltage (VAY, VBY, VCY, VABY, VBCY, or VCAY • 25RCFY for DELTAY_Y := WYE; VABY, VBCY, or VCAY • 25RCFY for DELTAY_Y:= DELTA), designated by setting SYNCPY (If SYNCPY is set to one of the angle settings, then VPY = VAY • 25RCFY or VABY • 25RCFY, depending on the DELTAY_Y setting.)
- ➤ VS Synchronism-check voltage, from SEL-700G rear-panel voltage input VS

For example, if the rear-panel voltage input VS-NS is connected to BC phase-to-phase, then set SYNCPY := VBCY. The voltage across terminals VBY-VCY is synchronism checked with the voltage across terminals VS-NS (see *Figure 4.111 (c)*.

System Frequencies Determined From Voltages V1Y and VS. To determine slip frequency, first determine the system frequencies on both sides of the circuit breaker. Voltage VS determines the frequency on one side. Voltage V1Y (positive-sequence utility tie voltage) determines the frequency on the other side.

Synchronism-Check Elements Operation

Refer to *Figure 4.116* and *Figure 4.117*.

Voltage Window. Refer to *Figure 4.116*. Single-phase voltage inputs VPY and VS are compared to a voltage window, to verify that the voltages are "healthy" and lie within settable voltage limits 25VLOY and 25VHIY. If both voltages are within the voltage window, the following Relay Word bits assert:

59VPY indicates that voltage VPY is within voltage window setting limits 25VLOY and 25VHIY

59VSY indicates that voltage VS is within voltage window setting limits 25VLOY and 25VHIY

Other Uses for Voltage Window Elements. If voltage limits 25VLOY and 25VHIY are applicable to other control schemes, you can use Relay Word bits 59VPY and 59VSY in other logic at the same time you use them in the synchronism-check logic.

If synchronism check is not being used, Relay Word bits 59VPY and 59VSY can still be used in other logic, with the voltage limit settings 25VLOY and 25VHIY set as necessary. Enable the synchronism-check logic (setting E25Y := Y) and make settings 25VLOY, 25VHIY, and 25RCFY. Use SELOGIC control equations to apply Relay Word bits 59VPY and 59VSY to your logic scheme. Even though synchronism-check logic is enabled, the synchronism-check logic outputs (Relay Word bits SFY, 25AY1, and 25AY2) do not need to be used.

Block Synchronism-Check Conditions. Refer to *Figure 4.116*. The synchronism-check element slip frequency calculator runs if both voltages VPY and VS are healthy (59VPY and 59VSY asserted to logical 1) and the SELOGIC control equation setting BSYNCHY (Block Synchronism Check) is deasserted (= logical 0). Setting BSYNCHY is most commonly set to block synchronism-check operation when the circuit breaker is closed (synchronism check is only necessary when the circuit breaker is open):

BSYNCHY := **NOT 3POY** (see *Figure 4.133*)

In addition, synchronism-check operation can be blocked when the relay is tripping:

BSYNCHY := **... OR TRIPY**

Slip Frequency Calculator. Refer to *Figure 4.116*. The synchronism-check element Slip Frequency Calculator in *Figure 4.116* runs if voltages VPY and VS are healthy (59VPY and 59VSY asserted to logical 1) and the SELOGIC control equation setting BSYNCHY (Block Synchronism Check) is deasserted (= logical 0). The Slip Frequency Calculator output is:

Slip Frequency = fPY – fS (in units of Hz = slip cycles/second)

fPY = frequency of voltage VPY (in units of Hz = cycles/second)

fS = frequency of voltage VS (in units of Hz = cycles/second)

A complete slip cycle is one single 360-degree revolution of one voltage (for example, VS) by another voltage (for example, VPY). Both voltages are thought of as revolving phasor-wise, so the “slipping” of VS past VPY is the relative revolving of VS past VPY.

For example, in *Figure 4.116*, if voltage VPY has a frequency of 59.95 Hz and voltage VS has a frequency of 60.05 Hz, the difference between them is the slip frequency:

Slip Frequency = 59.95 Hz – 60.05 Hz = –0.10 Hz = –0.10 slip cycles/second

The slip frequency in this example is negative, indicating that voltage VS is not “slipping” behind voltage VPY, but in fact “slipping” ahead of voltage VPY. In a period of one second, the angular distance between voltage VPY and voltage VS changes by 0.10 slip cycles, which translates into:

0.10 slip cycles/second • (360°/slip cycle) • 1 second = 36°

Thus, in a period of one second, the angular distance between voltage VPY and voltage VS changes by 36 degrees.

The SEL-700G runs the absolute value of the slip frequency output through a comparator. If the slip frequency is less than the maximum slip frequency setting, 25SF, Relay Word bit SFY asserts to logical 1.

Angle Difference Calculator. The synchronism-check element angle difference calculator in *Figure 4.117* runs if the slip frequency is less than the maximum slip frequency setting 25SF (Relay Word bit SFY is asserted).

Voltages VPY and VS Are “Static”. Refer to the top of *Figure 4.117*. If the slip frequency is less than or equal to 0.005 Hz, the angle difference calculator does *not* take into account breaker close time—it presumes voltages VPY and VS are “static” (not “slipping” with respect to one another). This would usually be the case for an open breaker with voltages VPY and VS, which are paralleled via some other electric path in the power system. The angle difference calculator calculates the angle difference between voltages VPY and VS:

Angle Difference = |(∠VPY – ∠VS)|

For example, if SYNCPY := 90 (indicating VS constantly lags VPY = VAY by 90 degrees), but VS actually lags VAY by 100 angular degrees on the power system at a given instant, the angle difference calculator automatically accounts for the 90 degrees and:

Angle Difference = |(∠ VPY – ∠ VS)| = 10°

Also, if breaker close time setting TCLOSDY := OFF, the angle difference calculator does not take into account breaker close time, even if the voltages VPY and VS are "slipping" with respect to one another. Thus, synchronism-check elements 25AY1 or 25AY2 assert to logical 1 if the absolute angle difference is less than corresponding maximum angle setting 25ANG1Y or 25ANG2Y.

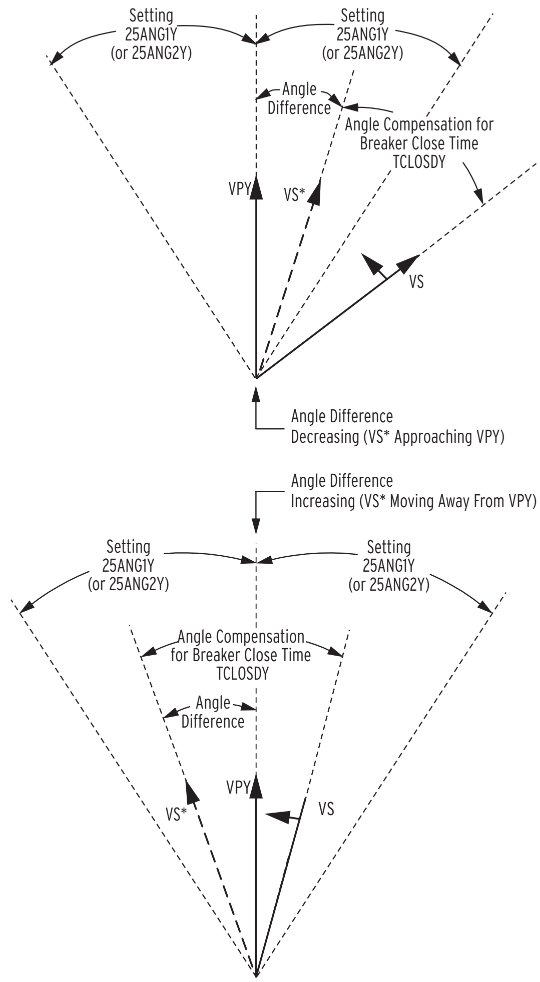


Figure 4.118 Angle Difference Between VPY and VS Compensated by Breaker Close Time (fPY < fS and VPY Shown as Reference in This Example)

Voltages VPY and VS Are "Slipping". Refer to the bottom of *Figure 4.117*. If the slip frequency is greater than 0.005 Hz, and breaker close time setting TCLOSDY ≠ OFF, the angle difference calculator takes the breaker close time into account with breaker close time setting TCLOSDY (set in ms; see *Figure 4.118*). The angle difference calculator calculates the angle difference between voltages VPY and VS, compensated with the breaker close time:

Angle Difference = |(∠VPY – ∠VS) + [(fPY – fS) • TCLOSDY • (1 / 1000) • (360°/slip cycle)]|

Angle Difference Example (Voltages VPY and VS Are "Slipping"). Refer to the bottom of *Figure 4.117*. For example, if the breaker close time is 100 ms, set TCLOSDY := 100. Presume that the slip frequency is the example slip frequency calculated previously. The angle difference calculator calculates the angle difference between voltages VPY and VS, compensated with the breaker close time:

Angle Difference = |(∠VPY – ∠VS) + [(fPY – fS) • TCLOSDY • (1 / 1000) • (360°/slip cycle)]|

Intermediate calculations:

(fPY – fS) = (59.95 Hz – 60.05 Hz) = –0.10 Hz = –0.10 slip cycles/second
TCLOSDY • (1 / 1000) = 0.1 second

Resulting in:

Angle Difference

= |(∠VPY – ∠VS) + [(fPY – fS) • TCLOSDY • (1 / 1000) • (360°/slip cycle)]|
= |(∠VPY – ∠VS) + [–0.10 • 0.1 • 360°]|
= |(∠VPY – ∠VS) – 3.6°|

NOTE: The angle compensation in Figure 4.118 appears much greater than 3.6 degrees. Figure 4.118 is for general illustrative purposes only.

During the breaker close time (TCLOSDY), the voltage angle difference between voltages VPY and VS changes by 3.6 degrees. This angle compensation is applied to voltage VS, resulting in derived voltage VS*, as shown in *Figure 4.118*.

The top of *Figure 4.118* shows the angle difference *decreasing*—VS* is approaching VPY. Ideally, circuit breaker closing is initiated when VS* is in phase with VPY (Angle Difference = 0 degrees). Then, when the circuit breaker main contacts finally close, VS is in phase with VPY, minimizing system shock.

The bottom of *Figure 4.118* shows the angle difference *increasing*—VS* is moving away from VPY. Ideally, circuit breaker closing is initiated when VS* is in phase with VPY (Angle Difference = 0 degrees). Then, when the circuit breaker main contacts finally close, VS is in phase with VPY. But in this case, VS* has already moved past VPY. To initiate circuit breaker closing when VS* is in phase with VPY (Angle Difference = 0 degrees), VS* has to slip around another revolution, relative to VPY.

Synchronism-Check Element Outputs. Synchronism-check element outputs (Relay Word bits 25AY1 and 25AY2 in *Figure 4.117*) assert to logical 1 for the conditions explained in the following text.

Voltages VPY and VS Are "Static" or Setting TCLOSDY := OFF. To implement a simple fixed-angle synchronism-check scheme, set TCLOSDY := OFF and 25SF = 0.50. With these settings, the synchronism check is performed as described in the top of *Figure 4.117*.

If there is the possibility of a high slip frequency, exercise caution if synchronism-check elements 25AY1 or 25AY2 are used to close a circuit breaker. A high slip frequency and a slow breaker close could result in closing the breaker outside the synchronism-check window. Max Slip Frequency (25SF) should be set appropriately to avoid such an unwanted breaker closing.

Voltages VPY and VS Are “Slipping” and Setting TCLOSDY ≠ OFF.

Refer to the bottom of *Figure 4.117*. If VPY and VS are “slipping” with respect to one another and breaker close time setting TCLOSDY ≠ OFF, the angle difference (compensated by breaker close time TCLOSDY) changes through time. Synchronism-check element 25AY1 or 25AY2 asserts to logical 1 for either one of the following scenarios.

1. The top of *Figure 4.118* shows the angle difference *decreasing*—VS* is approaching VPY. When VS* is in phase with VPY (Angle Difference = 0 degrees), synchronism-check elements 25AY1 and 25AY2 assert to logical 1.
2. The bottom of *Figure 4.118* shows the angle difference *increasing*—VS* is moving away from VPY. VS* was in phase with VPY (Angle Difference = 0 degrees), but it has now moved past VPY. If the angle difference is *increasing*, but the angle difference is still less than maximum angle settings 25ANG1Y or 25ANG2Y, then corresponding synchronism-check elements 25AY1 or 25AY2 assert to logical 1.

   In this scenario of the angle difference increasing, but where it is still less than maximum angle settings 25ANG1Y or 25ANG2Y, the operation of corresponding synchronism-check elements 25AY1 and 25AY2 becomes *less restrictive*. Synchronism-check breaker closing does not have to wait for voltage VS* to slip around again in phase with VPY (Angle Difference = 0 degrees). There might not be enough time to wait for this to happen. Thus, the “Angle Difference = 0 degrees” restriction is eased for this scenario.

Synchronism-Check Applications for Manual Closing

Refer to *Figure 4.138* for additional detail.

SEL-700GT can be applied for synchronism-check supervised closing of breaker 52Y.

EXAMPLE 4.4 For Manual Closing by Input IN302 Set

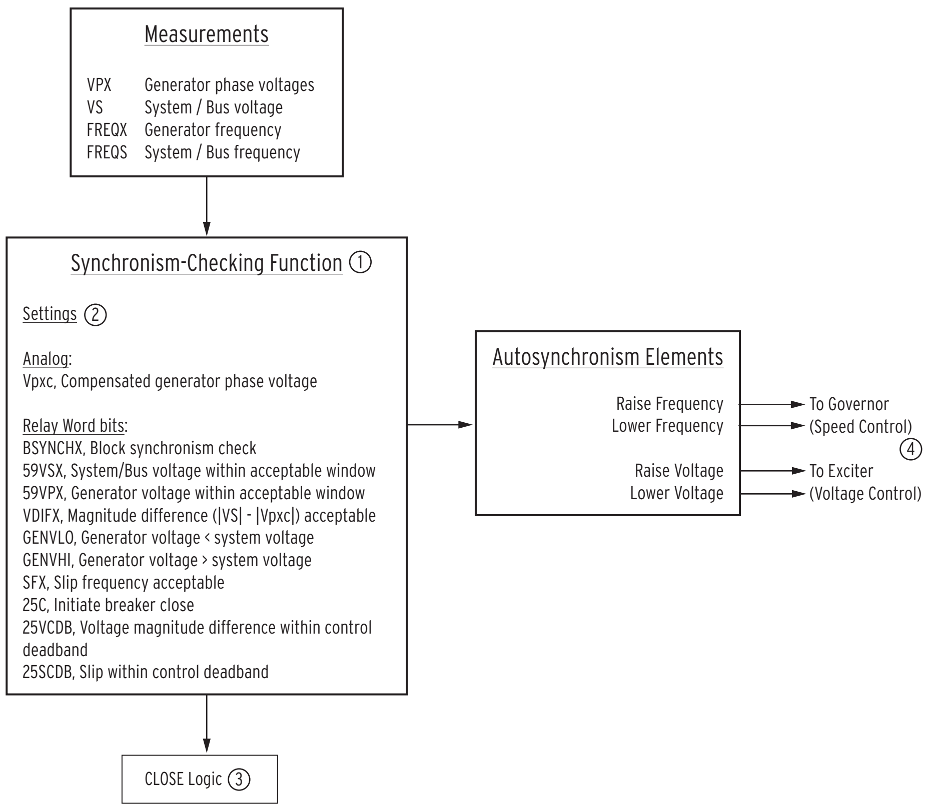
CLY := … OR SV12T AND 25AY1
SV12 := R_TRIG IN302
SV12PU := 0.00
SV12DO := as necessary

The SV12DO defines a time window for the supervising Relay Word bit (25A1Y) to assert for a successful closing.

Autosynchronism

The autosynchronizer is used to match the frequency, phase, and voltage of an incoming generator to the frequency, phase, and voltage of the bus before allowing the generator breaker to be closed. The SEL-700G Relay offers built-in autosynchronism. See *Figure 4.119* for an overall block diagram. The relay uses system and compensated generator phase voltages (VS and Vpxc, respectively) and provides an autosynchronism function that:

- Controls generator frequency so that the slip frequency difference between VS and Vpxc is within an acceptable frequency window.
- Controls generator frequency so that the compensated angle difference between Vpxc and VS is within an acceptable window.
- Controls generator voltage, Vpxc, so that Vpxc is within an acceptable magnitude window.



① See Synchronism Elements ② See Table 4.53 ③ See Figure 4.138, Figure 4.139, and Figure 2.27
④ See Figure 2.27

Figure 4.119 Overall Functional Block Diagram

The autosynchronism feature works in conjunction with the X-side synchronism-check function. You must first enable 25X elements (see *Table 4.53* for detail) and then set EAUTO := DIG to enable the autosynchronism elements. *Figure 4.119* shows the Relay Word bits (and other information) from synchronism check that are also used by the autosynchronism elements.

Table 4.56 Autosynchronism Settings

Setting Prompt	Setting Range	Setting Name := Factory Default	Description
AUTO SYNC EN	NONE, DIG	EAUTO := NONE	Autosynchronism enable
FREQ SYNC TIMER	5–3600 sec	FSYNCT := 100	Frequency matching Timer
FREQ ADJ RATE	0.01–10.00 Hz/s	FADJRATE := 0.10	Frequency adjustment rate (Governor)
FREQ PULS INTRVL	1–120 s	FPULSEI := 5	Frequency pulse interval
FREQ PULS MIN	0.02–60 sec	FPLSMIND := 0.10	Frequency pulse minimum duration
FREQ PULS MAX	0.10–60 sec	FPLSMAXD := 1.00	Frequency pulse maximum duration
KICK PULS INTRVL	1–120 sec	KPULSEI := 5	Kick pulse interval
KICK PULS MIN	0.02–2.00 sec	KPLSMIND := 0.02	Kick pulse minimum duration
KICK PULS MAX	0.02–2.00 sec	KPLSMAXD := 0.04	Kick pulse maximum duration
FMATCH START	SELOGIC	FSYNCST := 0	Frequency matching start SELOGIC
VOLT SYNC TIMER	5–3600 sec	VSYNCT := 100	Voltage matching timer
VOLT ADJ RATE	0.01–30.00 V/s	VADJRATE := 1.00	Voltage adjustment rate (Exciter/Voltage Regulator)
VOLT PULS INTRVL	1–120 sec	VPULSEI := 5	Voltage pulse interval
VOLT PULS MIN	0.02–60.00 sec	VPLSMIND := 0.10	Voltage pulse minimum duration
VOLT PULS MAX	0.10–60.00 sec	VPLSMAXD := 1.00	Voltage pulse maximum duration
VMATCH START	SELOGIC	VSYNCST := 0	Voltage matching start SELOGIC

Set FSYNCST and VSYNCST to individually initiate automatic frequency and voltage matching, respectively. For example, FSYNCST := IN301 activates frequency matching when IN301 momentarily asserts. You can also use the ASCII command **AST** to activate both frequency and voltage matching simultaneously. Use the ASCII command **ASP** to stop the autosynchronizer function; see *AST Command (Start Autosynchronizer)* and *ASP Command (Stop Autosynchronizer)* in *Section 7: Communications*. Relay Word bits FSYNCACT and VSYNCACT indicate that frequency and voltage matching logic, respectively, are active. Set the maximum active time allowed for the frequency and the voltage matching logic by setting FSYNCT and VSYNCT as necessary. The frequency, phase angle, and voltage matching features are described in the following text.

Frequency Matching

Refer to *Figure 4.120* for the functional block diagram of the frequency matching function and *Figure 4.121* for the frequency correction characteristics.

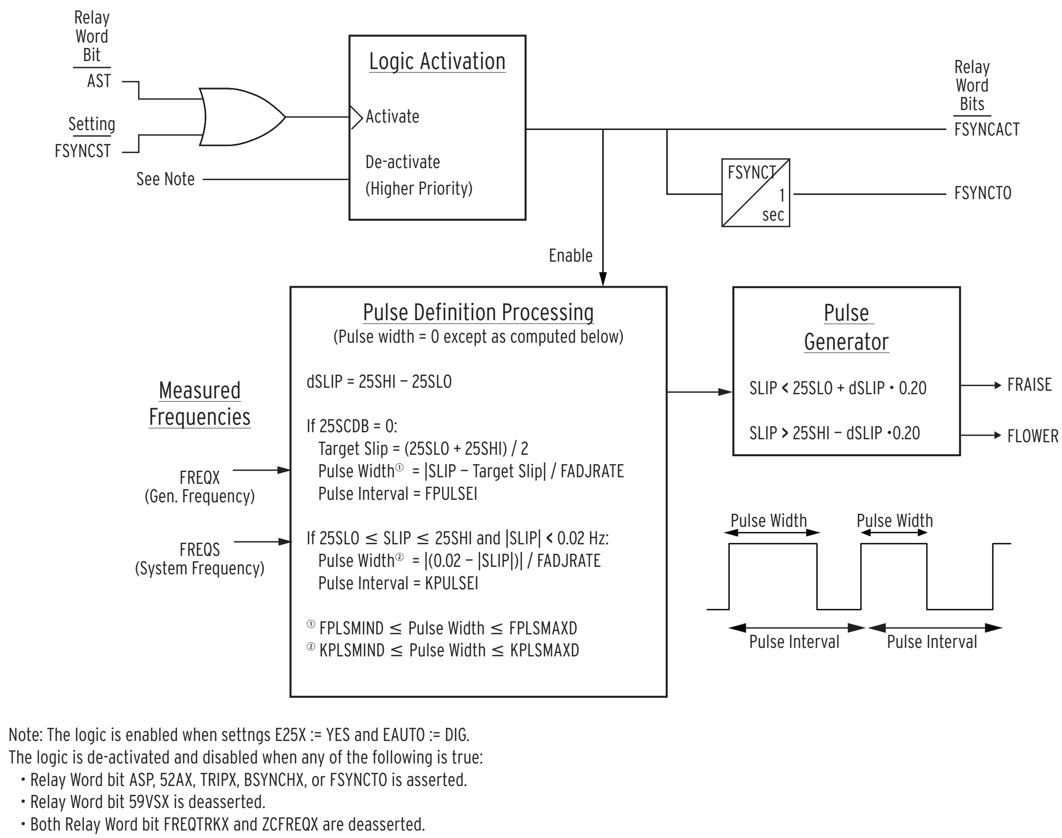


Figure 4.120 Simplified Block Diagram, Frequency and Phase Matching Elements

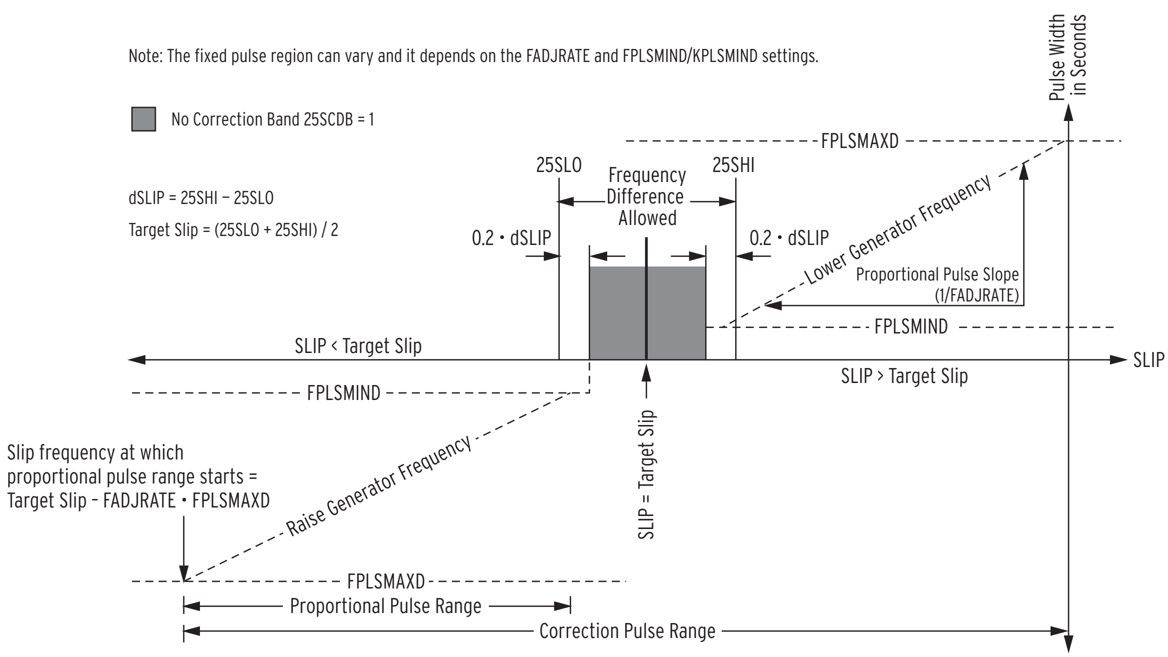


Figure 4.121 Frequency Correction Characteristics

SEL-700G autosynchronism adjusts the generator frequency to match the frequency of the system. While 25SCDB is deasserted, the relay compares generator frequency (FREQX) to that of the system/bus (FREQS) and asserts Relay Word bit FRAISE or FLOWER accordingly.

The FRAISE and FLOWER bits provide correction pulses to facilitate frequency matching. You must assign these bits to the necessary outputs (for example, OUT301 etc., see *Table 4.70* for detail) connected to the governor to control the generator speed/frequency.

As shown in *Figure 4.120* and *Figure 4.121*, the relay computes the width of each correction pulse, which is proportional to how far the slip is from the target slip frequency. Set FADJRATE equal to the governor's rate of response to the control pulses. Also set FPLSMIND and FPLSMAXD to define the minimum and maximum limits of the computed pulse widths.

Set FPULSEI to define an interval for the FRAISE and FLOWER pulses. Make sure that the interval setting is greater than the time necessary for the generator frequency to stabilize after a control pulse is applied. This prevents a premature application of the next control pulse from overshooting the target slip. Refer to the governor data sheet for the information to properly set the FADJRATE, FPLSMIND, FPLSMAXD, and FPULSEI settings.

As the slip frequency gets closer to the target slip, the correction pulses get shorter to prevent hunting and stop when the slip frequency is within an acceptable window, as shown in *Figure 4.120* and *Figure 4.121*. Typically, this creates an acceptable slip condition that allows the synchronism-check function to assert Relay Word bit 25C and initiate generator breaker closing.

Phase Matching

NOTE: The SEL-700G accurately measures the "phase angle difference" when the slip is within +/- 1.00 Hz. If the slip is outside this window, the measured angle difference has no significance.

In some cases (that is, either 25SLO or 25SHI is set within +/- 0.02 Hz), the correction pulses described previously in *Frequency Matching* are likely to stop when the slip is very close to zero. This prevents the synchronism-check function from asserting the bit 25C if the phase angle difference between Vpxc and VS is not acceptable and is nearly static. The SEL-700G includes a phase angle matching logic to automatically detect this condition and produce kick pulses to raise or lower the slip, as shown in *Figure 4.120*. Set KPLSMIND, KPLSMAXD, and KPULSEI to define minimum / maximum kick pulse width and interval. Refer to the governor data sheet for relevant information.

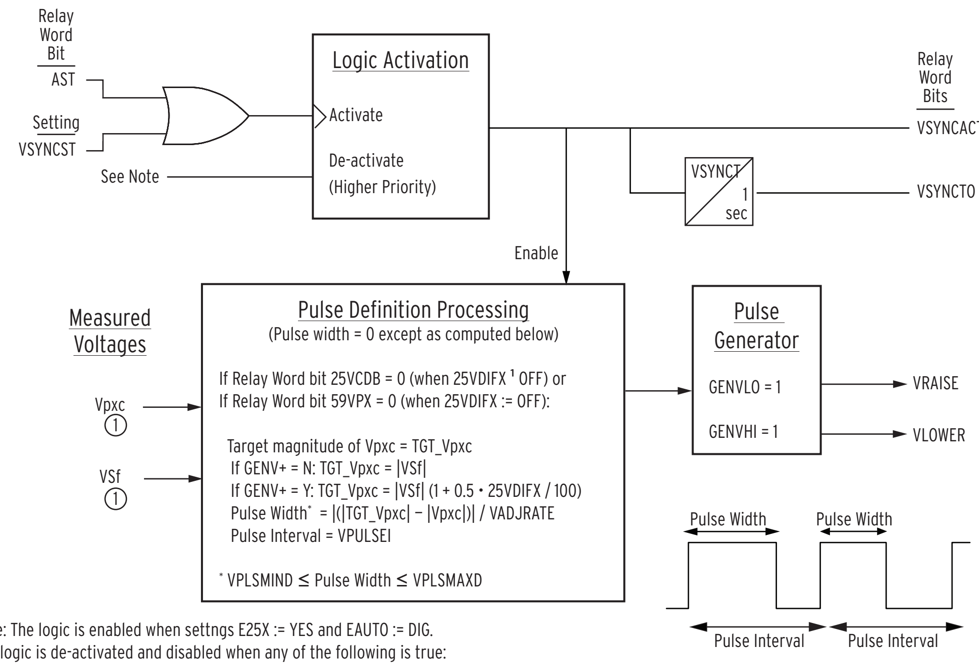
Voltage Matching

Refer to *Figure 4.122* for a functional block diagram of the voltage matching function. Refer to *Figure 4.123* and *Figure 4.124* for voltage correction characteristics when GENV+ = N and GENV+ = Y, respectively.

The SEL-700G autosynchronism adjusts the generator voltage to match the system voltage. While 25VCDB is deasserted, the relay compares generator voltage magnitude (Vpxc) to that of the system/bus (VSf) and asserts Relay Word bit VRAISE or VLOWER accordingly.

The VRAISE and VLOWER bits provide correction pulses to facilitate voltage matching. You must assign these bits to the necessary outputs (for example, OUT303 etc., see *Table 4.70* for detail) connected to the exciter/voltage regulator to control the generator voltage.

The relay computes the width of each correction pulse, as shown in *Figure 4.122*, *Figure 4.123*, and *Figure 4.124*. This width is proportional to how far the magnitude is from the target magnitude. Set VADJRATE equal to the exciter/voltage regulator's rate of response to the control pulses. Also, set VPLSMIND and VPLSMAXD to define the minimum and maximum limits of the computed pulse widths.



Note: The logic is enabled when settngs E25X := YES and EAUTO := DIG.
The logic is de-activated and disabled when any of the following is true:
- Relay Word bit ASP, 52AX, TRIPX, BSYNCHX, or VSYNCTO is asserted.
- Relay Word bit 59VSX is deasserted.
- Both Relay Word bit FREQTRKX and ZCFREQX are deasserted.

① See Figure 4.109

Figure 4.122 Simplified Block Diagram, Voltage Matching Elements

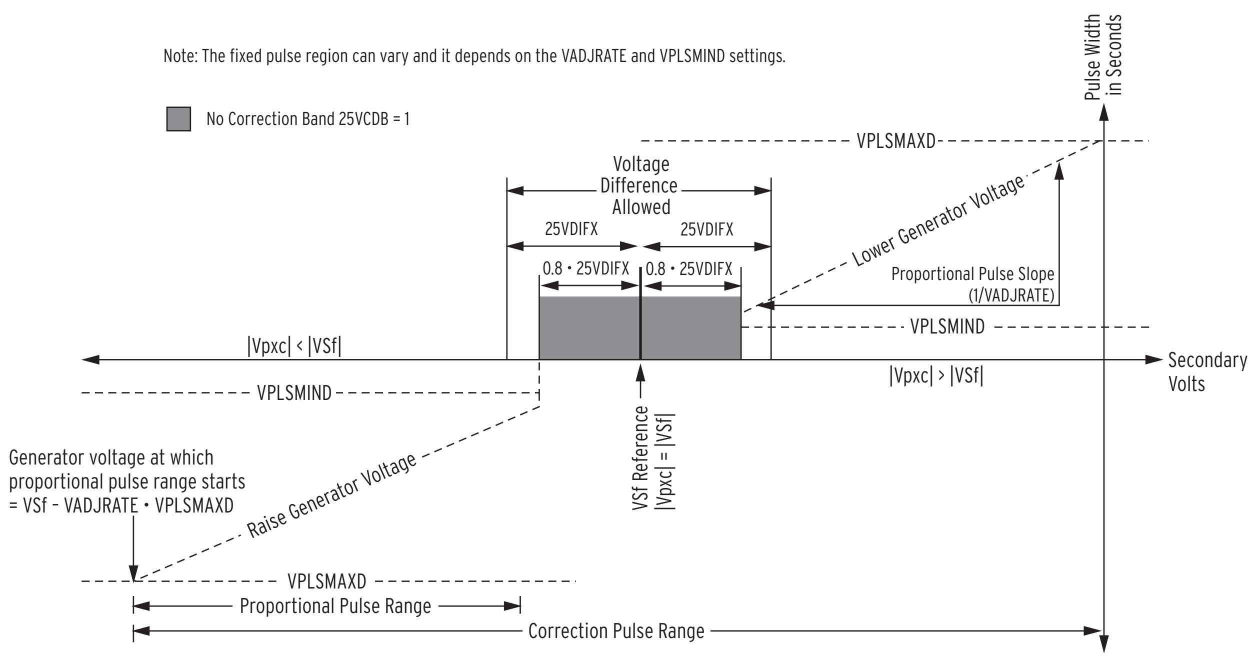


Figure 4.123 Voltage Connection Characteristics When GENV+ = N

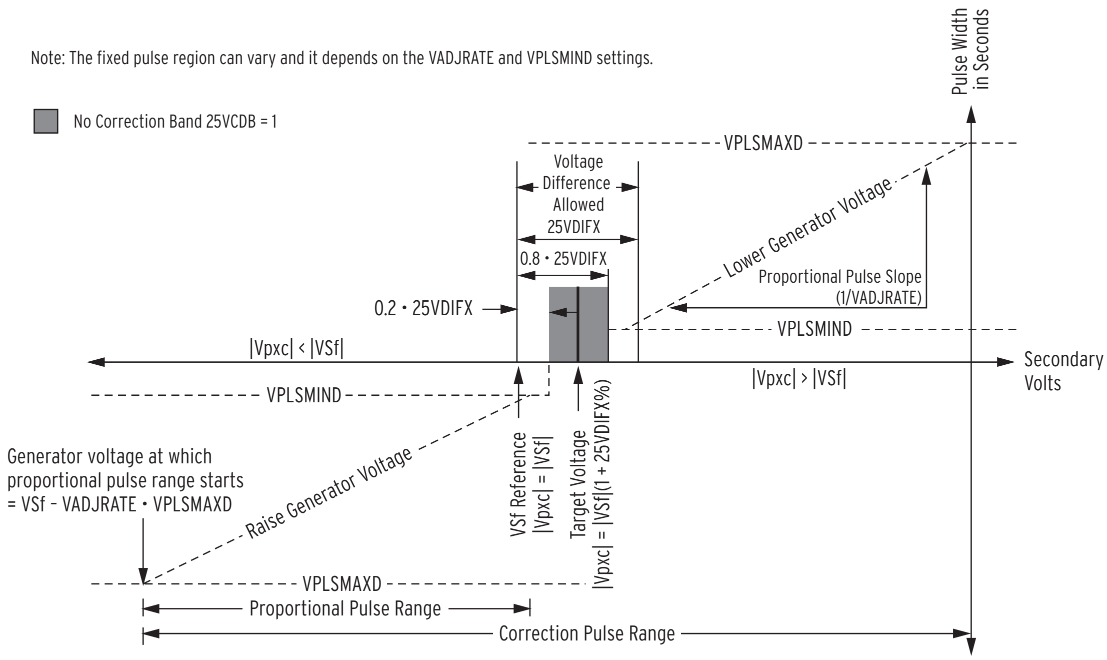


Figure 4.124 Voltage Connection Characteristics When GENV+ = Y

Set VPULSEI to define an interval for the VRAISE and VLOWER pulses. Make sure that the interval setting is greater than the time necessary for the generator voltage to stabilize after a control pulse is applied. This prevents the relay from overshooting the target magnitude by prematurely applying the next control pulse. Refer to the exciter/voltage regulator data sheet for information to properly set the VADJRATE, VPLSMIND, VPLSMAXD, and VPULSEI settings.

As the generator voltage magnitude gets closer to the target magnitude, the correction pulses get shorter to prevent hunting and stop when voltage magnitude is within an acceptable window. Typically, this creates an acceptable voltage magnitude condition for the synchronism-check function to assert Relay Word bit 25C and initiate generator breaker closing.

Synchroscope

QuickSet provides a synchroscope display when connected to an SEL-700G Relay. Refer to *Synchroscope* in *Section 3: PC Interface* for more information on this screen.

In models with the touchscreen option, the Synchroscope application provides a graphical representation of the phasor difference between the bus and the generator or the tie. See *Monitor on page 8.24* for more information on the Synchroscope application. You can also use the Auto Synchronizer application to synchronize your generator to your system. See *Control on page 8.28* for more information on the Auto Synchronizer application. *Figure 4.125* shows an Auto Synchronizer screen.

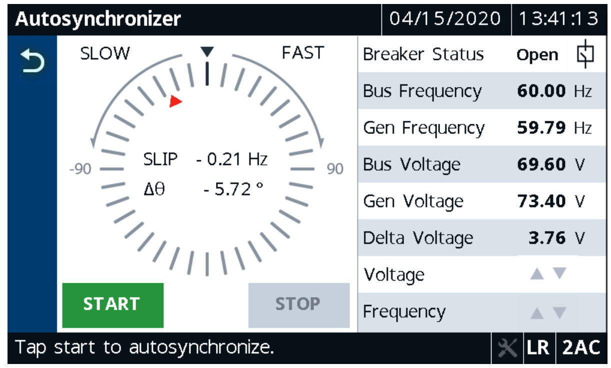


Figure 4.125 Auto Synchronizer Before Synchronization

Autosynchronism and Synchronism-Check Reports

The SEL-700G Relay triggers and saves the generator autosynchronism report on the rising edge of Relay Word bit GSRTRG. Refer to *Table 4.106* for the GRSTRG SELOGIC control equation setting and the rest of the settings associated with the autosynchronism report. You may also use the ASCII command **GST** (at Access Level 1 or higher) to trigger the generator autosynchronism report data acquisition (see *Section 7: Communications*, *GST Command (Trigger GSR) on page 7.52*). See *Figure 4.126* for a sample graphical display of the autosynchronism report.

This report can be viewed using the compressed ASCII command **CGSR**. The list of all the available autosynchronism reports can be viewed using the command **GSH**. Refer to *Section 7: Communications*, *CGSR Command (Generator Autosynchronism Report) on page 7.36* and *GSH Command on page 7.51* for more information on the commands **CGSR** and **GSH**. For more information on the CGSR report, refer to *Section 10: Analyzing Events*, *Generator Autosynchronism Report (CGSR Command)*.

The SEL-700G Relay also triggers and saves synchronism-check reports on the X-side each time the relay initiates a synchronism-check supervised generator breaker close. The report contains information about the system and generator at the time the close is performed and can be viewed using the **SYN** command. Refer to *Section 10: Analyzing Events*, *Synchronism-Check Report* for more information on the SYN report.

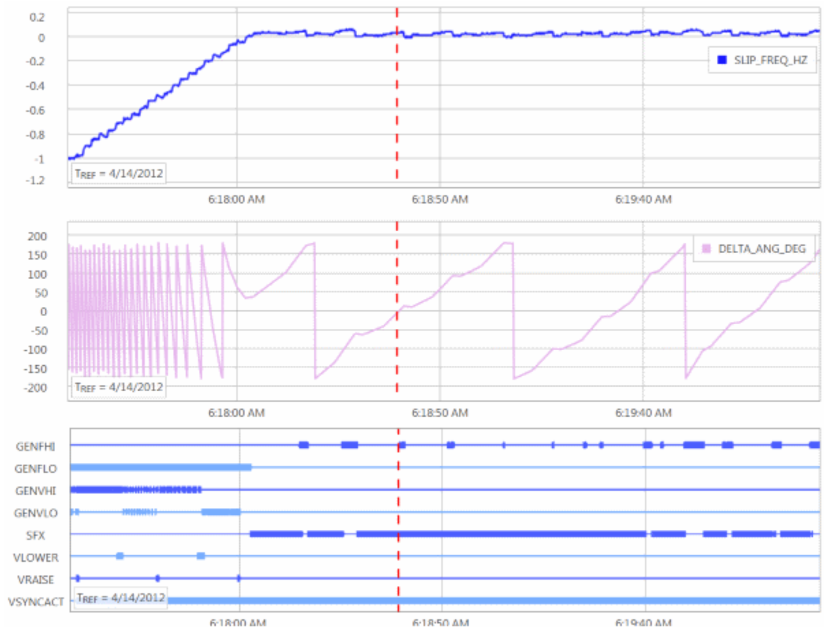


Figure 4.126 Graphical Display of Generator Autosynchronism Report

Loss-of-Potential (LOP) Protection

The SEL-700G sets Relay Word bit LOPX or LOPY (loss-of-potential) when it detects a loss of either the X or Y-side relay ac voltage input, such as that caused by blown potential fuses or by the operation of molded-case circuit breakers. Because accurate relaying potentials are necessary for certain protection elements (undervoltage 27 elements, for example), you can use the LOP function to supervise these protection elements.

NOTE: **(Applies to X Side Only)**. When the global setting EXT3V0_X := VS or VN, the ground-directional elements that rely on external zero-sequence voltage quantities (ORDERX settings V and U) are not affected by a loss-of-potential condition on relay voltage inputs VA, VB, and VC. For more information on the impact of LOP on different ground-directional elements refer to Loss-of-Potential on page 4.109.

Refer to *Figure 4.127* for the generic LOP logic. The logic is applicable to both X and Y sides. The Relay Word bit LOPX is determined using the measurements and settings from the X side, and Relay Word bit LOPY is determined using the measurements and settings from the Y side. The relay declares an LOP and seals it when there is more than a 20 percent drop in the measured positive-sequence voltage (V1) and the additional conditions shown in *Figure 4.127* are satisfied. If this condition persists for 1 second, then the relay latches the LOP Relay Word bit at logical 1. The relay resets the LOP Relay Word bit when the conditions of the RESET input of the latch are met, as shown in *Figure 4.128*.

The LOP element is disabled when the positive-sequence voltage, V1, is below 10.5 V. This threshold is to coordinate with the frequency tracking threshold of 10.0 V. For example, the LOP will be disabled before the frequency tracking on a decreasing voltage condition typically seen during a generator shutdown.

Settings

The LOPX and LOPY functions, when available in a given SEL-700G model, are always active unless blocked by the corresponding SELOGIC control equations LOPBLKX and LOPBLKY, respectively (see *Table 4.57* for the settings and *Figure 4.127* for the logic). You must incorporate the LOP function into a SELOGIC control equation to supervise relay protection elements (see *Example 4.5*).

Table 4.57 Loss of Potential (LOP) Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
LOPX BLOCK	SELOGIC	LOPBLKX := 0
LOPY BLOCK	SELOGIC	LOPBLKY := 0

LOP Impact on Other Protection Elements

Several elements (for example, 64G2, 51C, 51V, 21C, 40Z, 67, 27, 32, etc.) require accurate relaying potentials for correct operation. It is critical that the relay detects an LOP condition and prevents operation of these elements. For example, when dropping a wrench on the phase-voltage input fuse holders, the relay LOP logic accurately determines that this loss of input voltages is an LOP condition and does not trip (if the LOP Relay Word bit supervises selected tripping elements, see *Example 4.5*). If you are using voltage-determined relay elements for tripping decisions, then blocking these elements is crucial when the voltage component is no longer valid.

EXAMPLE 4.5 Supervising Protection Elements by LOP

See Figure 4.75 and Figure 4.77 for examples of Relay Word bit LOPY automatically supervising elements.

The factory-default settings also supervise protection elements, as in, for example, the following torque control settings.

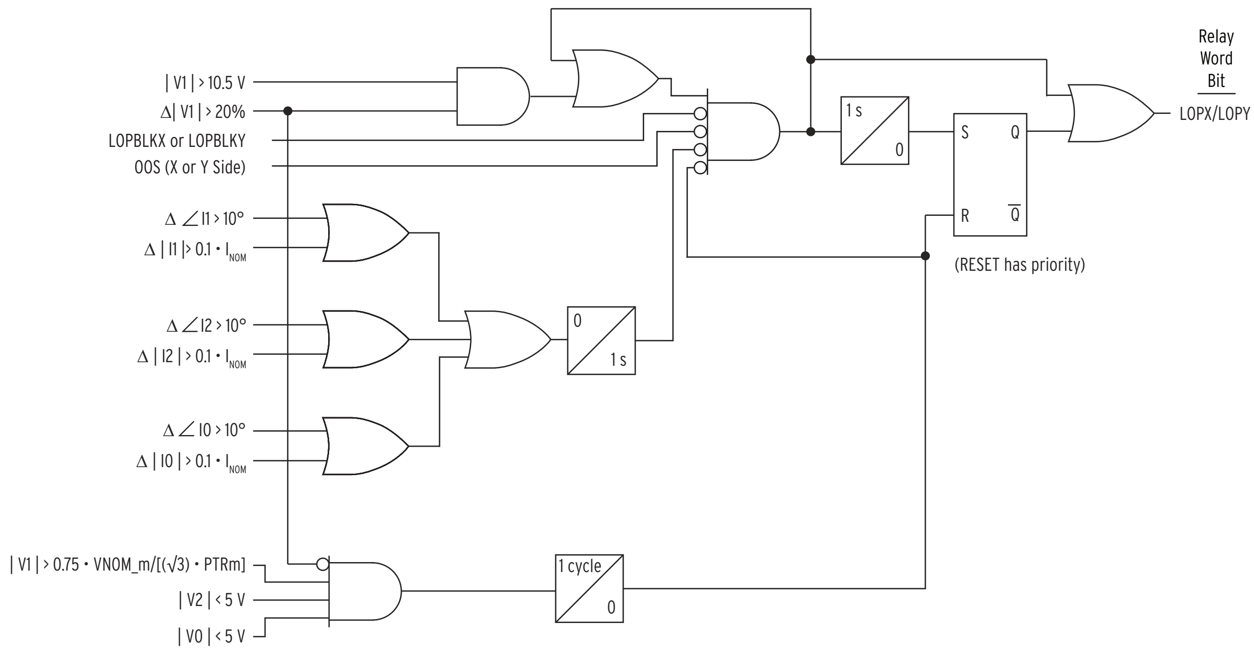
51CTC := 27PPX1 AND NOT LOPX

51VTC := NOT LOPX

40ZTC := NOT LOPX

LOP Monitoring and Alarms

Take steps to immediately correct an LOP problem so that normal protection is rapidly restored. Include the LOP Relay Word bit in an output contact alarm to notify operation personnel of abnormal voltage input conditions and failures that can be detrimental to the protection system performance if not quickly corrected.



Notes:

I_{NOM} is 1 A or 5 A, depending on the part number.
I_{NOM} is the phase secondary input rating.

LOPX is determined using measurements and settings from the X side and LOPY is determined using measurements and settings from the Y side.

When DELTAY_X := DELTA and EXT3V0_X := VS/VN, the V0 input to the logic is not taken into account.

VNOM_m and PTRm, where m = X or Y, are X-side and Y-side line-to-line nominal voltage and PT ratio settings.

Figure 4.127 Loss-of-Potential Generic Logic (Applies to both X and Y Sides)

Vector Shift Element

Use the vector shift element to detect islanding conditions of distributed generators (DGs) or loss of mains, and disconnect these DGs from the utility network under these conditions. Failure to trip islanded generators can lead to problems relating to out-of-synchronism reclosing, equipment damage, unstable operation, and degradation of power quality and personnel safety.

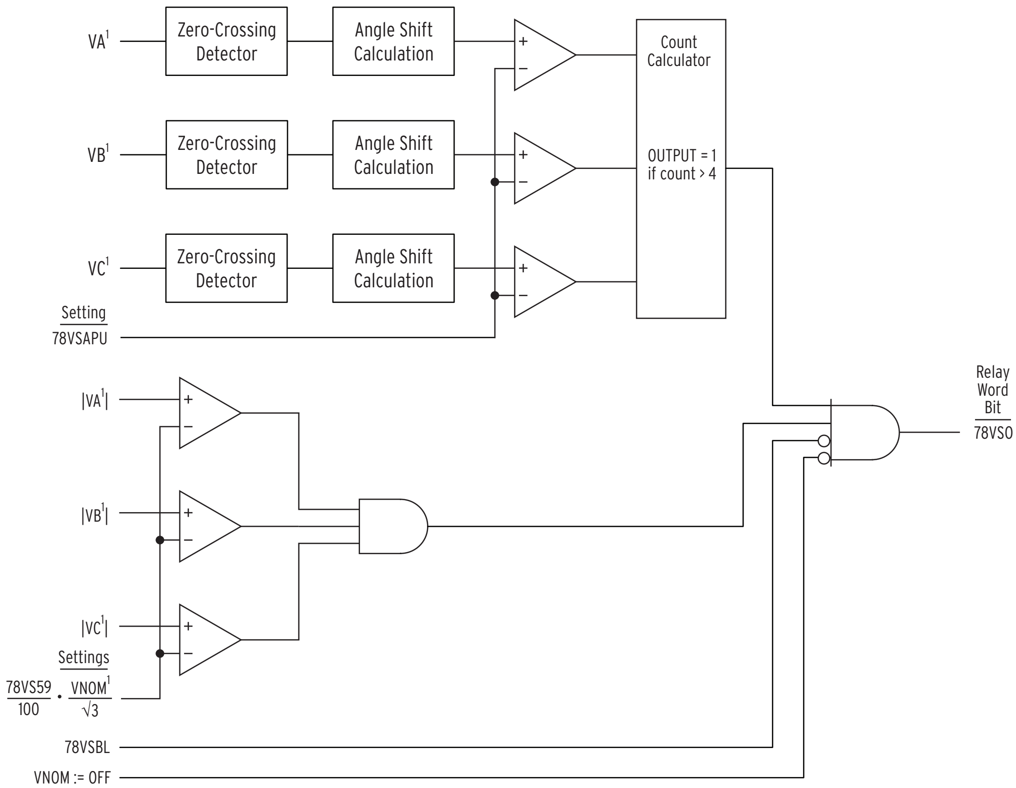
The vector shift element in the SEL-700G is designed for applications where a DG is connected to either the utility or other main generators that require fast disconnection upon detection of an islanding condition. To provide fast and reliable islanding protection, the vector shift element operates within three cycles; this operating time is fast enough to prevent out-of-synchronism reclosing of the network feeders that can cause generator damage and other adverse effects.

Islanding can occur on all three phases of the voltage signals; therefore, vector shift monitoring is performed on all of the three phases of the voltage signals. Detection of an islanding condition follows the occurrence of sudden phase variations on all three phases of the voltage signals. At the moment of islanding, the sudden change in load current causes a sudden change in the periods of the voltage signals. This element measures the difference between the present period duration and a reference period (see *Vector Shift Element Logic*). This difference is then converted to degrees and compared against the user-defined setting 78VSAPU.

Vector Shift Element Logic

The following steps that are performed for islanding condition detection are represented in *Figure 4.128*.

- Zero-crossing-based period estimation
- Angle shift calculation and angle shift threshold check
- Angle shift count calculator
- Blocking conditions



[1]The logic diagram shown applies when DELTA_Y := WYE.
When DELTA_Y := DELTA, the quantities VA, VB, and VC are replaced by VAB, VBC, and VCA, respectively. In addition, VNOM is not divided by √3.
The element is disabled when E78VS := OFF. The logic uses either X-side or Y-side voltages and VNOM based on the SEL-700G model and/or the setting E78VS (see Table 4.57 for details).

Figure 4.128 Logic Diagram of the Vector Shift Element

The element performs period calculations on each of the voltage inputs, **VA**, **VB**, and **VC**. Zero-crossing detection logic is used to perform the period calculations. The time stamps of two consecutive positive-going zero-crossings or two consecutive negative-going zero-crossings are used in determining the period. The relay establishes a reference period for each phase using the previous 32 period measurements. The initialization period for this element requires at least 16 cycles of voltage signal to establish an accurate reference period. During the initialization period, this element will not detect an islanding condition.

In each quarter-cycle, the relay calculates the difference between the present period on each phase with the corresponding reference period. This difference is expressed in degrees to determine the angle shift and the angle shift is compared to the angle shift threshold setting, 78VSAPU. If the calculated angle shift is greater than the angle shift threshold of the 78VSAPU setting, the comparator output for the corresponding phase is one, and this output is fed to the angle shift count calculator logic.

The count calculator receives angle shift detection information from all three phases and records the number of times that the angle shift threshold of all phases has been exceeded in two consecutive quarter-cycles. If the angle shift count exceeds four and no blocking conditions exist, 78VSO is asserted, indicating an islanding or loss of mains condition.

Power system short-circuit conditions can also cause the voltage angle change to exceed the angle shift setting threshold. To prevent possible false tripping, the vector shift element is blocked for undervoltage conditions. If any of the phase voltages fall below the voltage supervision threshold of the 78VS59 setting, the output of the vector shift element is blocked. You can program the 78VSBL SELOGIC control equation to provide additional blocking conditions as required by your application.

Depending on the DG loading conditions, a vector shift occurs when an islanding event happens, causing a change in two consecutive period measurements, after which the voltage stabilizes. For this reason, a delayed operation of the element is not applicable. Although the vector shift element allows for fast and reliable detection of DG islanding conditions, the limitation of this element needs to be realized. This element is based on the sudden phase change in the voltage waveform. If there is no load current change between the DG and the utility at the point of common coupling, there is no vector shift and this element does not detect the islanding condition. For this element to operate properly, the load change must be at least 20 percent of the rated power of the DG.

The vector shift element (78VS) or the rate-of-change-of-frequency element (81R) can be used to detect islanding conditions. The vector shift element is designed to detect islanding conditions the moment that the islanding condition occurs and the element typically responds within 1.5–3.0 cycles after the islanding condition occurs. The 81R element is designed to detect islanding conditions during and after the occurrence of the voltage shift. Because the 78VS and 81R operate on different principles and sensitivities, you can set both elements to provide more dependable protection.

Vector Shift Element Settings

When you set E78VS := VX (or VY), the relay uses X-side (or Y-side) voltages for the vector shift element. Note that, depending on the relay model, only VX (SEL-700G), VY (SEL-700GT), or both VX and VY (SEL-700GT+), are available.

Set the vector shift angle pickup threshold setting, 78VSAPU, to the desired angle to detect a vector shift condition. The factory-default value of this setting is 10 degrees. Determine this setting based on the generator impedance and your studies. See *Table 4.58* for the range and default settings for the vector shift element.

The vector shift voltage supervision threshold setting, 78VS59, defines the minimum voltage magnitude required for this element in percentage of the nominal voltage setting, VNOM. The factory-default threshold is 80 percent of the VNOM setting. If VNOM := OFF, then the vector shift element is turned off.

The vector shift SELOGIC control equation, 78VSBL, allows you to define additional blocking conditions of the vector shift element. For example, you can block the element for a few cycles when the DG breaker is closed to keep the element from operating under this condition.

Table 4.58 Vector Shift Element Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
EN VECTOR SHIFT	OFF, VX, VY	E78VS := OFF
VS ANGLE PU THR	2.0–30.0 deg	78VSAPU := 10.0
VS VOLT SUPV THR	20.0%–100.0%	78VS59 := 80.0
VS BLOCK	SELOGIC	78VSBL := 1

Other Settings

Demand Metering

The SEL-700G provides demand and peak demand metering, selectable between thermal and rolling demand types, for the following values:

- IAX, IBX, ICX, IAY, IBY, ICY phase currents (A primary)
- IGX, IGY residual-ground current (A primary; IG = 3I0 = IA + IB + IC)
- 3I2X, 3I2Y negative-sequence current (A primary)

Table 4.59 shows the demand metering settings. Also refer to *Section 5: Metering and Monitoring* and *Section 7: Communications* for other related information for the demand meter.

Table 4.59 Demand Meter Settings

Setting Prompt	Setting Range	Setting Name := Factory Default[a]
ENABLE DEM MTR	THM, ROL	EDEM := ROL
DEM TIME CONSTNT	5, 10, 15, 30, 60 min	DMTC := 15
PH CURR DEM LVL	OFF, 0.50-16.00 A[b] OFF. 0.10-3.20 A[c]	PHDEMP*m* := OFF PHDEMP*m* := OFF
RES CURR DEM LVL	OFF, 0.50-16.00 A[b] OFF, 0.10-3.20 A[c]	GNDEMP*m* := OFF GNDEMP*m* := OFF
3I2 CURR DEM LVL	OFF, 0.50-16.00 A[b] OFF, 0.10-3.20 A[c]	3I2DEMP*m* := OFF 3I2DEMP*m* := OFF

[a] m = X or Y.
[b] For I_{NOM} = 5 A.
[c] For I_{NOM} = 1 A.

The demand current level settings are applied to demand current meter outputs, as shown in *Figure 4.129*. For example, when residual-ground demand current IGD goes above the corresponding demand pickup GNDEMP, Relay Word bit GNDEM asserts to logical 1. Use these demand current logic outputs (PHDEM, GNDEM, and 3I2DEM) to alarm for high loading or unbalance conditions.

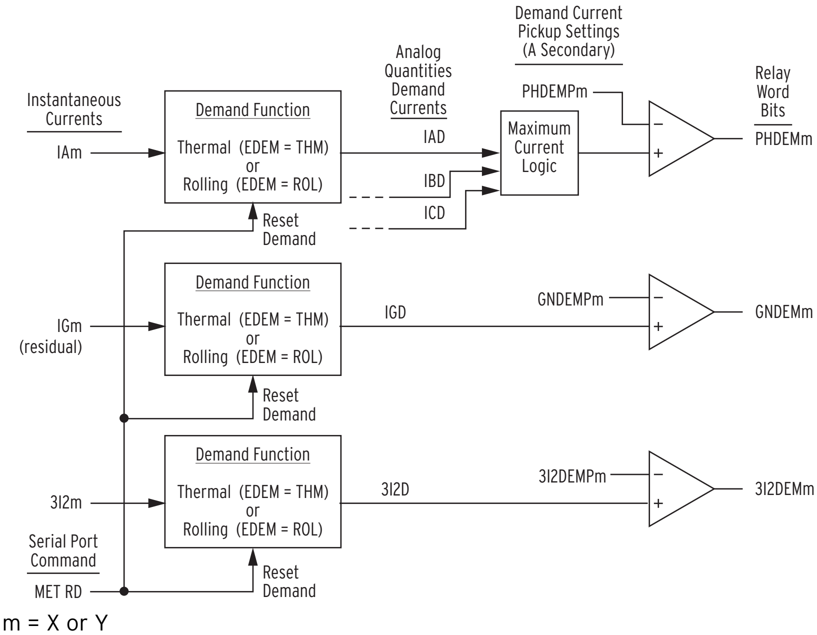


Figure 4.129 Demand Current Logic Outputs

The demand values are updated approximately once a second. The relay stores peak demand values to nonvolatile storage every six hours (it overwrites the previous stored value if it is exceeded). Should the relay lose control power, it restores the peak demand values saved by the relay.

Demand metering peak recording is momentarily suspended when SELOGIC control equation setting FAULT is asserted (= logical 1).

The differences between thermal and rolling demand metering are explained in the following discussion.

The example in *Figure 4.130* shows the response of thermal and rolling demand meters to a step current input. The current input is at a magnitude of zero and then suddenly goes to an instantaneous level of 1.0 per unit (a "step").

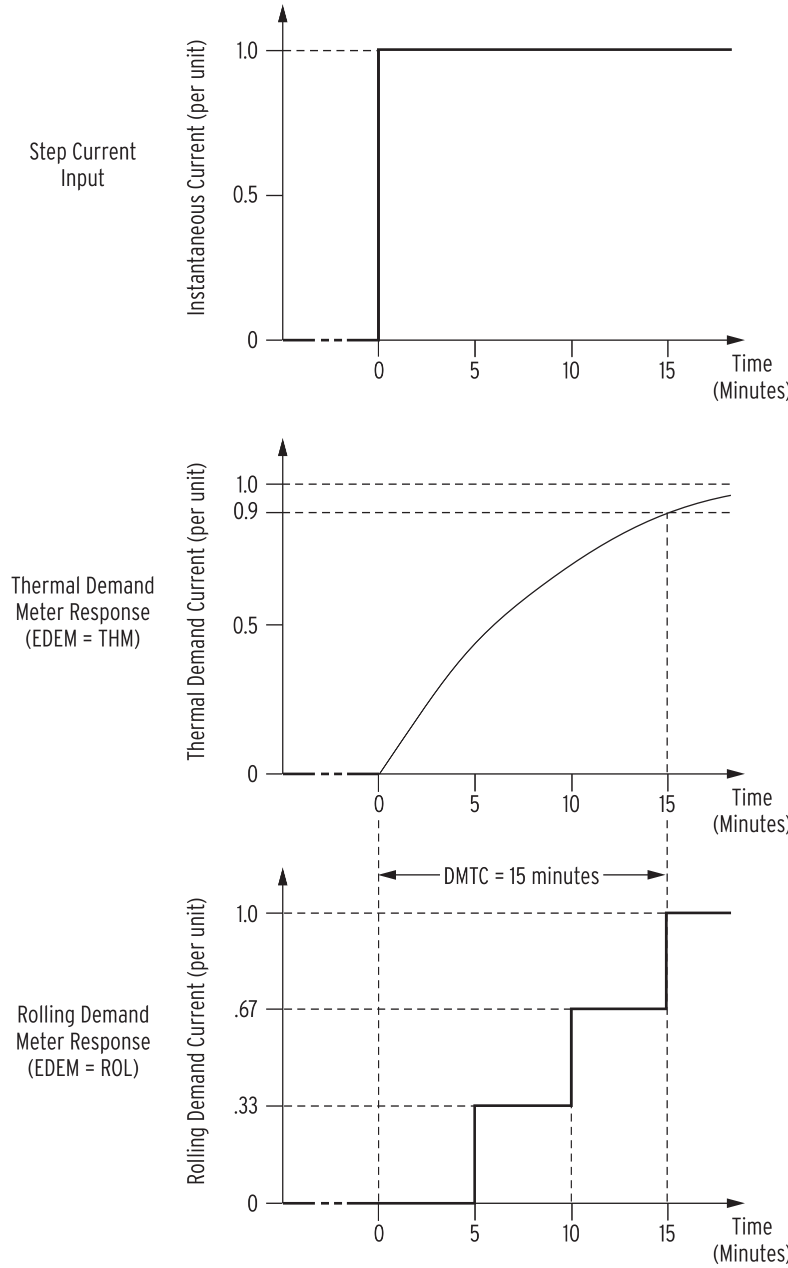


Figure 4.130 Response of Thermal and Rolling Demand Meters to a Step Input (Setting DMTC = 15 minutes)

Thermal Demand Meter Response

The response of the thermal demand meter in *Figure 4.130* (middle) to the step current input (top) is analogous to the series RC circuit in *Figure 4.131*.

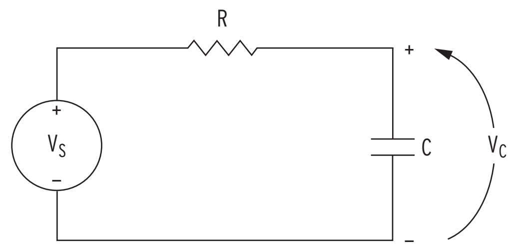


Figure 4.131 Voltage V_S Applied to Series RC Circuit

In the analogy:

- Voltage V_S in *Figure 4.131* corresponds to the step current input in *Figure 4.130* (top).
- Voltage V_C across the capacitor in *Figure 4.131* corresponds to the response of the thermal demand meter in *Figure 4.130* (middle).

If voltage V_S in *Figure 4.131* has been at zero (V_S = 0.0 per unit) for some time, voltage V_C across the capacitor in *Figure 4.131* is also at zero (V_C = 0.0 per unit). If voltage V_S is suddenly stepped up to some constant value (V_S = 1.0 per unit), voltage V_C across the capacitor starts to rise toward the 1.0 per-unit value. This voltage rise across the capacitor is analogous to the response of the thermal demand meter in *Figure 4.129* (middle) to the step current input (top).

In general, as voltage V_C across the capacitor in *Figure 4.131* cannot change instantaneously, the thermal demand meter response is not immediate either for the increasing or decreasing applied instantaneous current. The thermal demand meter response time is based on the demand meter time constant setting DMTC (see *Table 4.59*). Note in *Figure 4.130* that the thermal demand meter response (middle) is at 90 percent (0.9 per unit) of full applied value (1.0 per unit) after a time period equal to setting DMTC = 15 minutes, referenced to when the step current input is first applied. The SEL-700G updates thermal demand values approximately every second.

Rolling Demand Meter Response

The response of the rolling demand meter in *Figure 4.130* (bottom) to the step current input (top) is calculated with a sliding time-window arithmetic average calculation. The width of the sliding time-window is equal to the demand meter time constant setting DMTC (see *Table 4.59*). Note in *Figure 4.130* that the rolling demand meter response (bottom) is at 100 percent (1.0 per unit) of full applied value (1.0 per unit) after a time period equal to setting DMTC = 15 minutes, referenced to when the step current input is first applied.

The rolling demand meter integrates the applied signal (for example, step current) input in five-minute intervals. The integration is performed approximately every second. The average value for an integrated five-minute interval is derived and stored as a five-minute total. The rolling demand meter then averages a number of the five-minute totals to produce the rolling demand meter response. In the *Figure 4.130* example, the rolling demand meter averages the three latest five-minute totals because setting

DMTC = 15 (15/5 = 3). The rolling demand meter response is updated every five minutes, after a new five-minute total is calculated.

The following is a step-by-step calculation of the rolling demand response example in *Figure 4.130* (bottom).

Time = 0 Minutes

Presume that the instantaneous current has been at zero for quite some time before “Time = 0 minutes” (or the demand meters were reset). The three five-minute intervals in the sliding time-window at “Time = 0 minutes” each integrate into the following five-minute totals.

Five-Minute Totals	Corresponding Five-Minute Interval
0.0 per unit	–15 to –10 minutes
0.0 per unit	–10 to –5 minutes
0.0 per unit	–5 to 0 minutes
0.0 per unit	

Rolling demand meter response at “Time = 0 minutes” = 0.0/3 = 0.0 per unit.

Time = 5 Minutes

The three five-minute intervals in the sliding time-window at “Time = 5 minutes” each integrate into the following five-minute totals.

Five-Minute Totals	Corresponding Five-Minute Interval
0.0 per unit	–10 to –5 minutes
0.0 per unit	–5 to 0 minutes
1.0 per unit	0 to 5 minutes
1.0 per unit	

Rolling demand meter response at “Time = 5 minutes” = 1.0/3 = 0.33 per unit.

Time = 10 Minutes

The three five-minute intervals in the sliding time-window at “Time = 10 minutes” each integrate into the following five-minute totals.

Five-Minute Totals	Corresponding Five-Minute Interval
0.0 per unit	–5 to 0 minutes
1.0 per unit	0 to 5 minutes
1.0 per unit	5 to 10 minutes
2.0 per unit	

Rolling demand meter response at “Time = 10 minutes” = 2.0/3 = 0.67 per unit.

Time = 15 Minutes

The three five-minute intervals in the sliding time-window at "Time = 15 minutes" each integrate into the following 5-minute totals.

Five-Minute Totals	Corresponding Five-Minute Interval
1.0 per unit	0 to 5 minutes
1.0 per unit	5 to 10 minutes
1.0 per unit	10 to 15 minutes
3.0 per unit	

Rolling demand meter response at "Time = 15 minutes" = 3.0/3 = 1.0 per unit.

Pole Open Logic

The SEL-700G includes pole open logic for breaker 52X and/or 52Y, depending on the model number. Relay Word bit outputs of the logic are useful in event triggering, SER triggering, and other indication and control applications.

Table 4.60 Pole Open Logic Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
LOAD DETECTION	OFF, 0.25–96.00 A[a]	50LXP := 0.25[a]
3POLE OPEN DELAY	0.00–1.00 s	3POXD := 0.00
LOAD DETECTION	OFF, 0.25–96.00 A[a]	50LYP := 0.25[a]
3POLE OPEN DELAY	0.00–1.00 s	3POYD := 0.00

[a] Ranges and default settings shown are for relay models with 5 A rated current input. Divide by 5 for the 1 A rated input.

If 50LXP or 50LYP is set to OFF, there is no current supervision for the pole open logic and the corresponding Relay Word bits 50LX and 50LY are 0.

Figure 4.132 and *Figure 4.133* show the logic diagrams for breaker 52X and 52Y, respectively.

NOTE: The generator is considered running if Relay Word bit 3POX = 0.

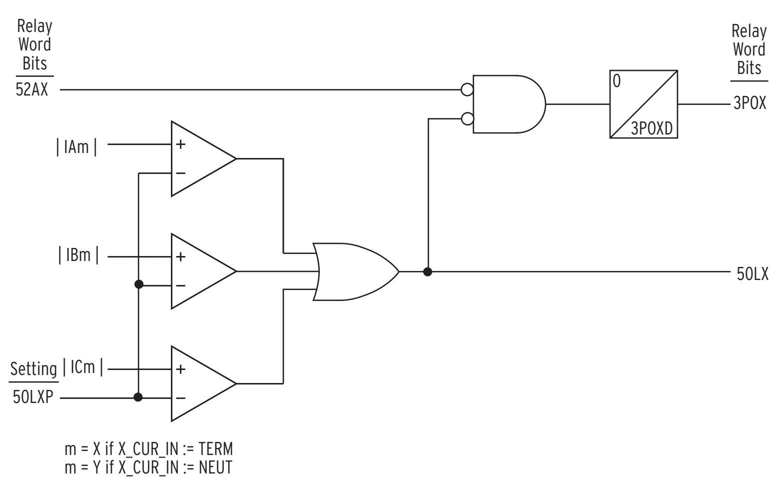


Figure 4.132 Pole Open Logic Diagram, Breaker 52X

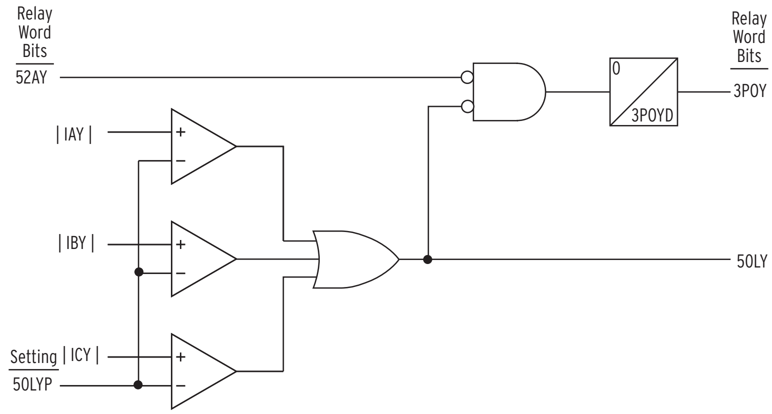


Figure 4.133 Pole Open Logic Diagram, Breaker 52Y

Set 50L*m*P (*m* = X or Y) to its minimum value. When the breaker current is extremely low, the relay relies on the 52A*m* input status to indicate breaker position. Set 3PO*m*D := 0 cycles, unless your application requires a specific time-delayed dropout.

Trip/Close Logic Settings

The trip logic and close logic for the SEL-700G operate in a similar manner. Each has a SELOGIC control equation setting to set or latch the logic and another SELOGIC control equation setting to reset or unlatch the logic. Each also has other elements or functions that unlatch the logic. The output of each logic is a Relay Word bit that can be assigned to operate output contacts or to operate in any other manner for which you can use a Relay Word bit. The specifics of each type of logic are discussed below.

NOTE: The factory-default assignment of the Relay Word bit TRIP is the output **OUT103**. See Table 4.70 for the output contacts settings.

Table 4.61 Trip/Close Logic Settings[a] (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
MIN TRIP TIME	0.0–400.0 sec	TDURD := 0.5
CLOSE m FAIL DLY	0.0–400.0 sec	CFD*m* := 0.5
X-SIDE BRKR TRIP EQN	SV	TRX := SV06 OR SV07 OR SV08 OR 46Q2T OR 81X1T OR 81X2T OR 81RX1T OR 81RX2T OR OOST OR SV04T OR OCX[b]
X-SIDE BRKR TRIP EQN	SV	TRX := SV06 OR SV07 OR SV08 OR 46Q2T OR 81X1T OR 81X2T OR 81RX1T OR 81RX2T OR NOT LT02 AND SV04T OR OCX[c]
X-SIDE BRKR TRIP EQN	SV	TRX := SV06 OR SV07 OR NOT LT02 AND SV04T OR OCX[d]
GEN FIELD BRKR TRIP EQN	SV	TR1 := SV06 OR SV07 OR SV08[bc]
PRIME MOVER TRIP EQN	SV	TR2 := SV06 OR SV07 OR LT06 [b,c]
GEN LOCKOUT TRIP EQN	SV	TR3 := SV06 OR SV07[b,c]
Y-SIDE BRKR TRIP EQN	SV	TRY := SV09 OR SV10 OR LT02 AND SV04T OR OCY[c]
REMOTE TRIP EQN	SV	REMTRIP := 0
UNLATCH *m*-SIDE TRIP	SV	ULTR*m* := 3POm
UNLATCH TRIP 1	SV	ULTR1 := NOT TR1[b,c]
UNLATCH TRIP 2	SV	ULTR2 := NOT TR2[b,c]

Table 4.61 Trip/Close Logic Settings[a] (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
UNLATCH TRIP 3	SV	ULTR3 := NOT TR3[b,c]
BREAKER *m* STATUS	SV	52A*m* := 0
CLOSE X EQUATION	SV	CLX := SV03T OR CCX OR SV11T AND 25C[b]
CLOSE X EQUATION	SV	CLX := SV03T AND NOT LT02 OR CCX[f]
CLOSE X EQUATION	SV	CLX := SV03T AND NOT LT02 OR CCX OR SV11T AND 25C[f]
CLOSE Y EQUATION	SV	CLY := SV03T AND LT02 OR CCY[d]
CLOSE Y EQUATION	SV	CLY := SV03T AND LT02 OR CCY OR SV12T AND 25AY1[f]
UNLATCH CLOSE *m*	SV	ULCL*m* := TRIP*m*

[a] m = X or Y.
[b] Default settings shown are for the SEL-700G0 and the SEL-700G1.
[c] Default settings shown are for the SEL-700GT with optional generator protection.
[d] Default settings shown are for the SEL-700GW.
[e] Default settings shown are for the SEL-700GT and the SEL-700GW.
[f] Default settings shown are for the SEL-700GT.

TDURD Minimum Trip Time

This timer establishes the minimum time duration for which the TRIP Relay Word bit asserts. This is a rising-edge initiated timer.

Trips initiated by the TR Relay Word bit (includes **OPEN** command from front-panel and serial ports) are maintained for at least the duration of the minimum trip duration time (TDURD) setting.

TR Trip Conditions SELOGIC Control Equation

There are five trip logic equations within the SEL-700G. These equations are designed to operate when the SELOGIC control equation trip variable setting TR*m* is asserted (*m* = X, 1, 2, 3, or Y), and to unlatch when the SELOGIC control equation setting ULTR*m* is asserted.

The TR*m* equations and associated Relay Word bits TRIP*m* of the trip logic (see *Figure 4.134*) are intended for applications as listed below:

- TRX, TRIPX—Trip breaker 52X
- TR1, TRIP1—Trip field breaker 41
- TR2, TRIP2—Trip prime mover
- TR3, TRIP3—Trip generator lockout
- TRY, TRIPY—Trip breaker 52Y

NOTE: The outputs in the SEL-700G are not designed to interrupt the trip coil current. An auxiliary contact with adequate current interrupting capacity must clear the trip coil current before the output of the SEL-700G opens. Failure to observe this safeguard could result in damage to the output contacts of the SEL-700G. Avoid programming Relay Word bit TR*m* in the output equation to directly trip the breaker. Instead, use Relay Word bit TRIP*m*, which stays asserted for at least the duration of the TDURD setting or until TRIPm is unlatched, whichever is longer.

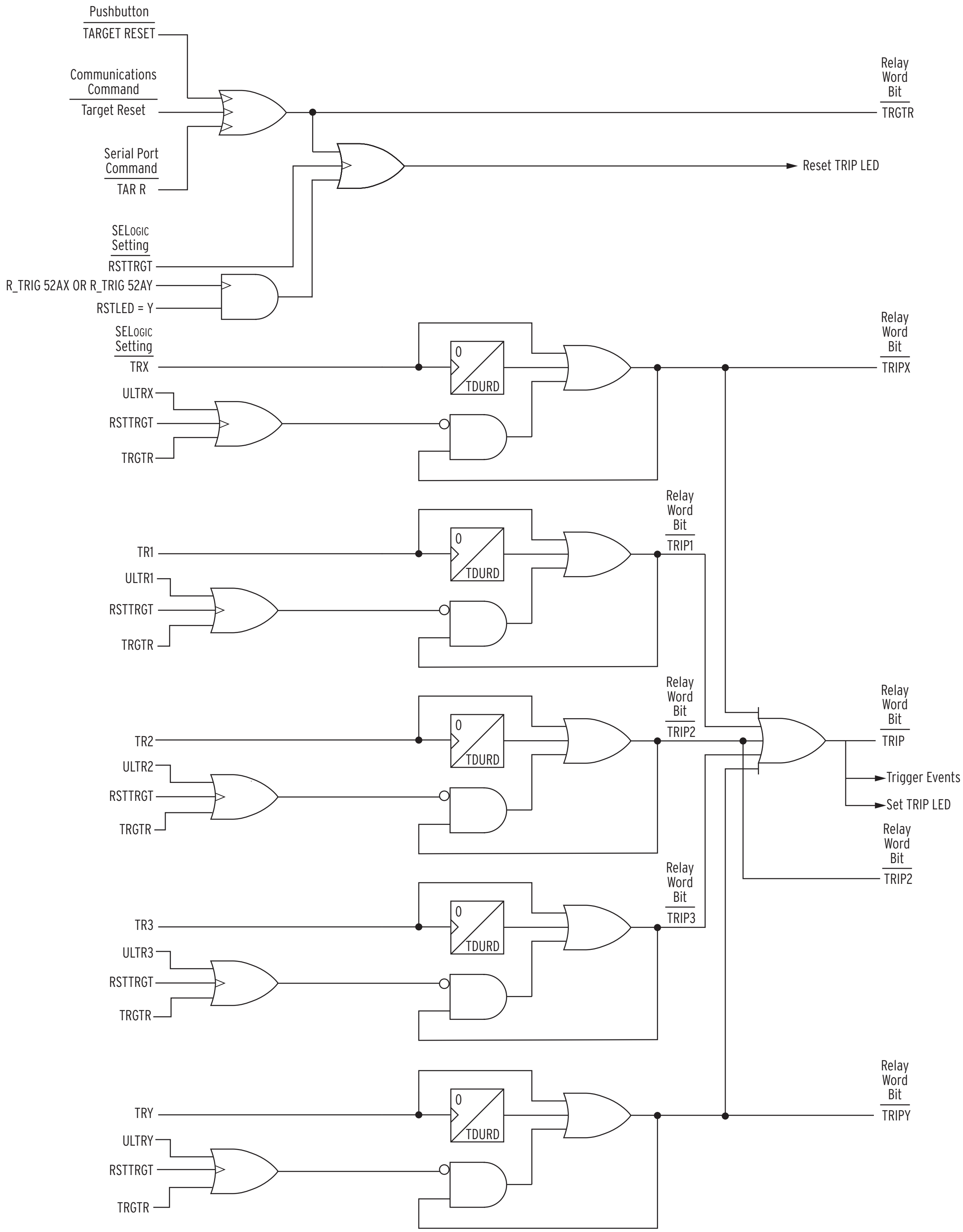


Figure 4.134 Trip Logic

Figure 4.135 through *Figure 4.137* show typical TR logic for the generator, intertie, and feeder trip applications (SEL-700G, SEL-700GT, and SEL-700GW). Review the default TR*m* equations, and edit them to suit your application.

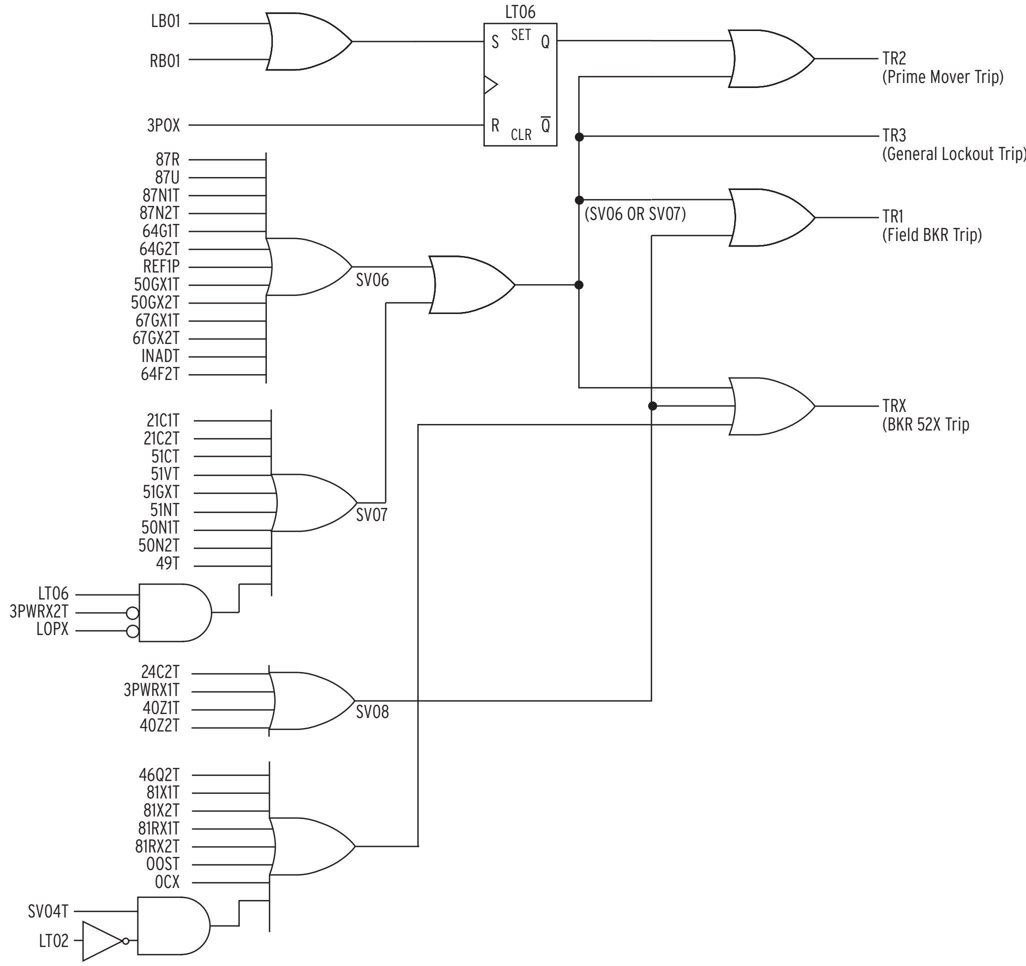


Figure 4.135 Typical Generator Trip TR Logic (SEL-700G0, SEL-700G1, SEL-700GT)

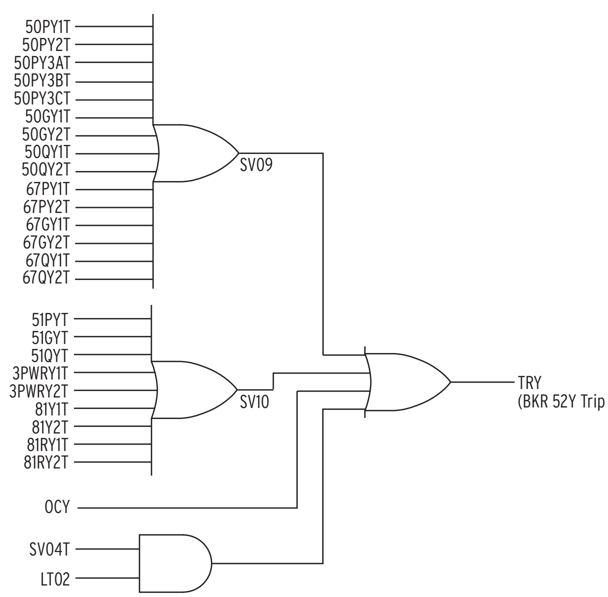


Figure 4.136 Typical Intertie Trip TR Logic (SEL-700GT)

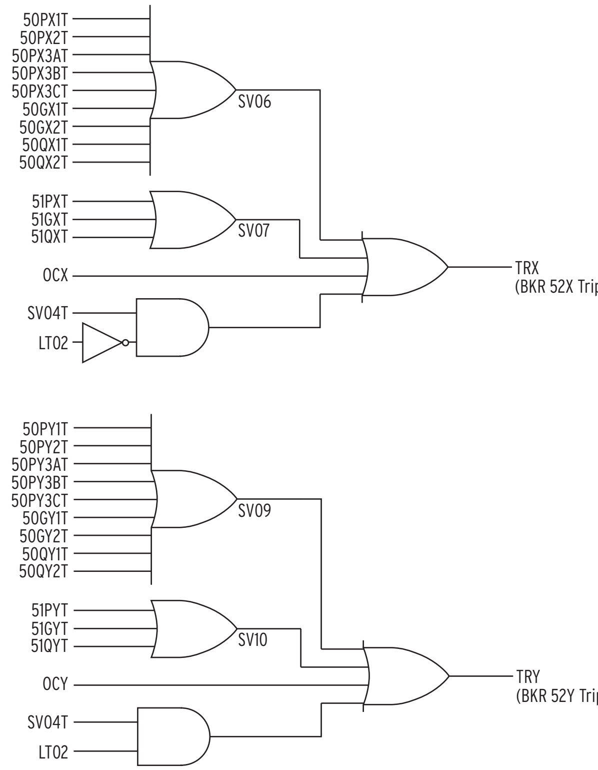


Figure 4.137 Typical Feeder Trip TR Logic (SEL-700GW)

The relay controls the tripping output contacts when the Relay Word bit TRIP*m* appears in an output contact SELOGIC control equation. You must assign the Relay Word bits TRIP*m* to the outputs appropriate for your application. See *Table 4.70* for the output contacts settings. *Figure 2.27*, *Figure 2.30*, and *Figure 2.32* show the typical dc external connections for the SEL-700G, SEL-700GT, and SEL-700GW relays, respectively.

Set the TR*m* SELOGIC control equations to include an OR combination of all the Relay Word bits for which you want the associated trip bits to assert. The factory-default setting already includes all commonly used Relay Word bits.

REMTRIP SELOGIC Control Equation

The REMTRIP SELOGIC control equation is intended to define a remote trip condition. For example, the following settings will trip the breaker by input IN303 via REMTRIP.

REMTRIP := IN303

TRX := … OR REMTRIP

The HMI will display `Remote Trip` to indicate the trip by remote trip logic.

Unlatch Trip Logic

Each of the five trip logic equations has an associated unlatch trip SELOGIC control equation. Following a fault, the trip signal is maintained until all of the following conditions are true:

- Minimum trip duration time (TDURD) passes.
- The TR*m* (*m* = X, 1, 2, 3, or Y) SELOGIC control equation result deasserts to logical 0.
- One of the following occurs:
  - Unlatch Trip SELOGIC control equation setting ULTRIP asserts to logical 1.
  - Target Reset SELOGIC control equation setting RSTTRGT asserts to logical 1.
  - Target Reset Relay Word TRGTR asserts. The TRGTR is asserted when the front-panel **TARGET RESET** pushbutton is pressed or a target reset serial port command is executed (ASCII, Modbus, or DeviceNet).

52A and 52B Breaker Status Conditions SELOGIC Control Equations

NOTE: For disconnect settings and logic, refer to Disconnect Control Settings. For the touchscreen relay option, refer to Table 9.5 for typical disconnect symbols. For the settings related to bay control disconnects, refer to Table 9.7 and the corresponding descriptions.

Use the SELOGIC settings 52A*m* and 52B*m* (*m* = X or Y) to map the respective breaker auxiliary contacts to the relay. Because the 52B*m* contact is not always available, and to reduce the number of I/O required, the breaker status logic does not include the 52B*m* contact. The relay uses the 52A*m* Relay Word bit as the status of the breaker in conjunction with the protection elements and the trip and close logic. The default 52B*m* setting is NOT 52A*m*. The factory-default setting assumes no auxiliary contact connection (i.e., 52AX := 0 and 52AY := 0).

If you connect the breaker auxiliary contacts to digital inputs, you must change the factory-default logic equations for 52A*m* and 52B*m*. For example, set 52AX := IN101 and 52BX := IN102 if you connect the 52a and 52b contacts to Inputs **IN101** and **IN102**, respectively.

NOTE: For the settings related to the local/remote breaker control function, refer to Local/Remote Control on page 9.7. For breaker control via the front-panel pushbuttons, refer to Front-Panel Operator Control Pushbuttons on page 8.15. For breaker control via the two-line display, refer to Control Menu on page 8.8. For breaker control via the touchscreen, refer to Breaker/Disconnect Control Via the Touchscreen on page 9.8.

The SEL-700G Relay with the touchscreen display option also provides you with the ability to design detailed single-line diagrams and to display the breaker and disconnect statuses. Refer to *Table 9.1* for typical circuit breaker symbols available for display on the bay screens. For settings related to bay control breaker symbols, refer to *Table 9.7* and the corresponding description.

Figure 4.138 shows a close logic diagram of breaker 52AX; the logic of breaker 52AY is similar.

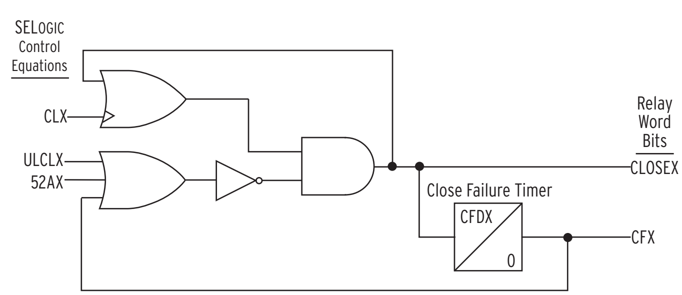


Figure 4.138 Close Logic

CL Close SELOGIC Control Equation

There are two close logic equations within the SEL-700G. These equations are designed to operate when the SELOGIC control equation close variable setting CL*m* is asserted (*m* = X or Y) and to unlatch when the SELOGIC control equation setting ULCL*m* is asserted. The output of the logic is the Relay Word bit CLOSE*m*.

The relay controls the closing output contact(s) when the Relay Word bit CLOSE*m* appears in an output contact SELOGIC control equation. Assign the CLOSE bits to the output relays you need for your application. See *Figure 2.23* for a typical close circuit connection.

Set the CL SELOGIC control equation to include an OR combination of all Relay Word bits for which you want to cause the relay to close the breaker. The factory-default setting already includes all commonly used Relay Word bits. See *Figure 4.139* for a typical generator or intertie close logic for the SEL-700G or SEL-700GT and *Figure 4.140* for a typical feeder close logic for the SEL-700GW. Review the default CL*m* equation, and edit it to suit your application.

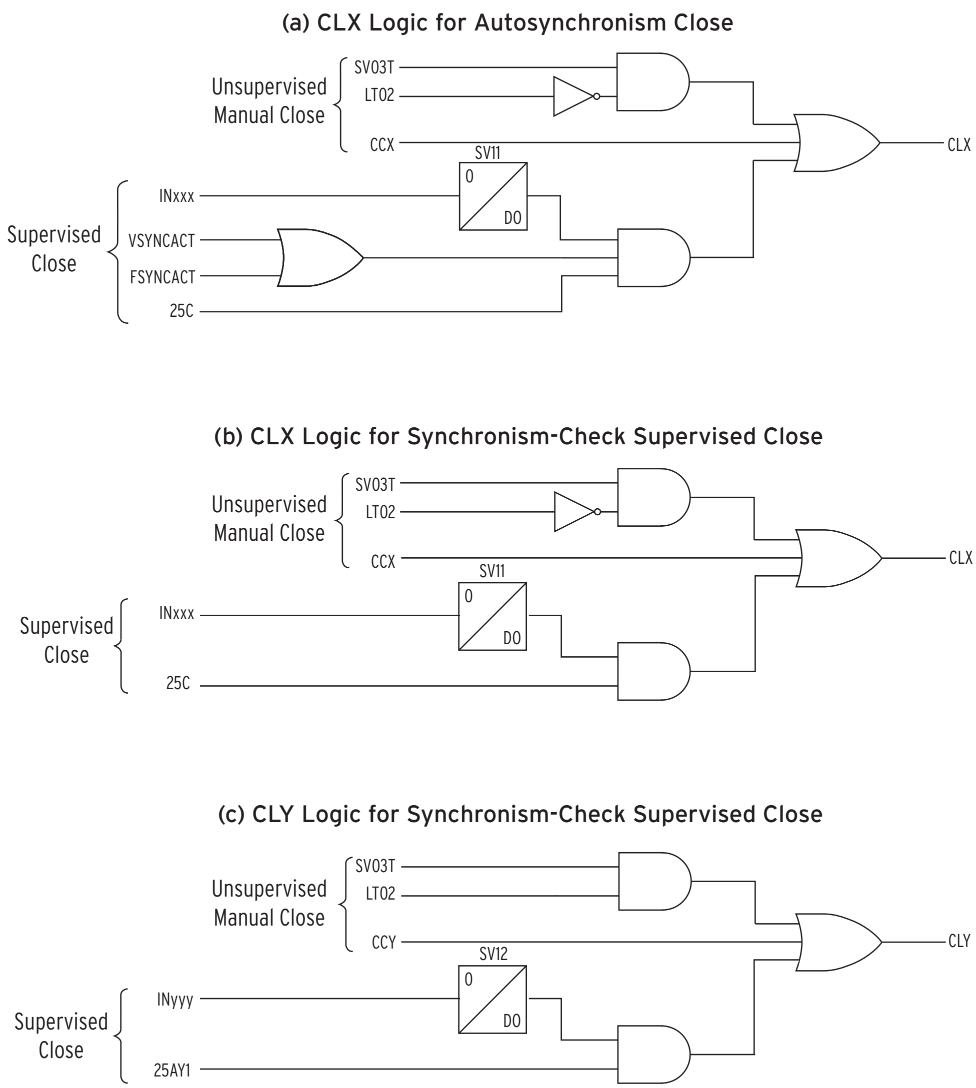


Figure 4.139 Typical Generator or Intertie Close CL Logic (SEL-700G or GT)

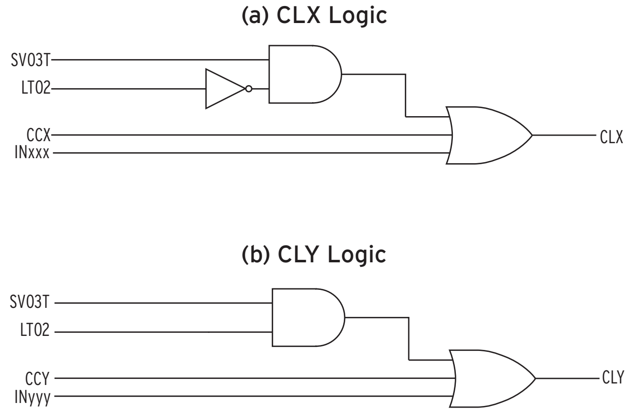


Figure 4.140 Typical Feeder Close CL Logic (SEL-700GW)

Unlatch Close Logic

Each of the two close logic equations has an associated unlatch close SELOGIC control equation. Once the CLOSE bit is asserted, it is sealed-in until any of the following conditions are true:

- Unlatch Close SELOGIC control equation setting ULCLX (or ULCLY) asserts to logical 1.
- Relay Word bit 52AX (or 52AY) asserts to logical 1.
- Close failure Relay Word bit asserts to logical 1.

Close Failure Logic

Each of the two close logic equations includes a close failure detection with an associated delay setting CFDX and CFDY. Set the close failure delay (setting CFD) equal to the highest breaker close time plus a safety margin. If the breaker fails to close, the Relay Word CFX (or CFY) asserts for 1/4 cycle. Use the CF bit as necessary.

Logic Settings (SET L Command)

The settings associated with latches, timers, counters, math variables, and output contacts are listed below. Note that SELOGIC control equations are processed every quarter cycle, while math variable equations and analog quantities are updated every 25 ms.

SELOGIC Enables

IMPORTANT: Upon relay initial turn on, Port 1 setting changes, or Logic setting changes, you may have to wait as long as two minutes before an additional settings change can occur. Note that the relay is functional with protection enabled as soon as the ENABLED LED comes on (approximately 5–10 seconds from turn on).

Table 4.62 shows the enable settings for latch bits (ELAT), SELOGIC control equations (including timers) (ESV), Counters (ESC), and math variable equations (EMV). This helps limit the number of settings that you need to make. For example, if you need six timers, only enable six timers.

Table 4.62 Enable Settings

Setting Prompt	Setting Range	Setting Name := Default Setting
SELOGIC LATCHES	N, 1–32	ELAT := 6
SV/TIMERS	N, 1–32	ESV := 15
SELOGIC COUNTERS	N, 1–32	ESC := N
MATH VARIABLES[a]	N, 1–32	EMV := 1

[a] If a math variable is set equal to NA (e.g., MV01 := NA), it is treated as 0.

Latch Bits

Latch control switches (latch bits are the outputs of these switches) replace traditional latching devices. Traditional latching devices maintain output contact state. The SEL-700G latch control switch also retains state even when power to the device is lost. If the latch control switch is set to a programmable output contact and power to the device is lost, the state of the latch control switch is stored in nonvolatile memory, but the device de-energizes the output contact. When power to the device is restored, the programmable output contact goes back to the state of the latch control switch after device initialization. Traditional latching device output contact states are changed by pulsing the latching device inputs (see *Figure 4.141*). Pulse the set input to close (set) the latching device output contact. Pulse the reset input to open (reset) the latching device output contact. The external contacts wired to the latching device inputs are often from remote control equipment (for example, SCADA, RTU).

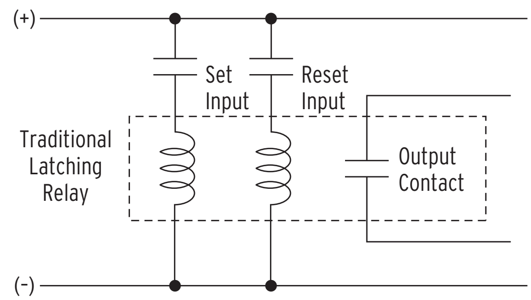


Figure 4.141 Schematic Diagram of a Traditional Latching Device

Thirty-two latch control switches in the SEL-700G provide latching device functionality. *Figure 4.142* shows the logic diagram of a latch switch. The output of the latch control switch is the Relay Word bit LT*n* (*n* = 01–32) called a latch bit.

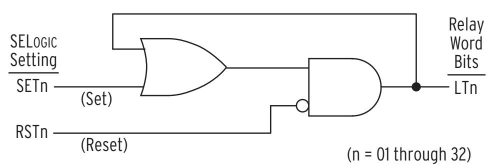


Figure 4.142 Logic Diagram of a Latch Switch

If the setting SET*n* asserts to logical 1, the latch bit LT*n* asserts to logical 1. If the setting RST*n* asserts to logical 1, the latch bit LT*n* deasserts to logical 0. If both settings SET*n* and RST*n* assert to logical 1, setting RST*n* has priority and latch bit LT*n* deasserts to logical 0. You can use these latch bits in SELOGIC control equations to create custom logic for your application.

The SEL-700G includes 32 latches. *Table 4.63* shows SET, RESET, and latches LT01–LT06. The factory-default settings for these should address most applications. Review the default settings and make any changes necessary to suit your application. The remaining latches are not enabled (see *Table 4.62*), but are available for any special needs.

Table 4.63 Latch Bits Equation Settings

Settings Prompt	Setting Range	Setting Name := Factory Default	Description
SET01	SELOGIC	SET01 := R_TRIG SV01T AND NOT LT01	Disables front-panel control LOCK.
RST01	SELOGIC	RST01 := R_TRIG SV01T AND LT01	Enables front-panel control LOCK.
SET02	SELOGIC	SET02 := R_TRIG SV02T AND NOT LT02 AND PB02	Selects breaker Y for front-panel control (SEL-700GT and GW).
SET02	SELOGIC	SET02 := 0	Not used in SEL-700G0 and G1.
RST02	SELOGIC	RST02 := R_TRIG SV02T AND LT02 AND PB02	Selects breaker X for front-panel control (SEL-700GT and GW).
RST02	SELOGIC	RST02 := 0	Not used in SEL-700G0 and G1.
SET03	SELOGIC	SET03 := (PB03 AND R_TRIG SV02T) AND LT01 AND NOT (52AX AND NOT LT02 OR 52AY AND LT02)	Latch set by front-panel CLOSE control (SEL-700GT and GW)
SET03	SELOGIC	SET03 := PB03 AND R_TRIG SV02T AND LT01 AND NOT 52AX	Latch set by front-panel CLOSE control (SEL-700G0 and G1)
RST03	SELOGIC	RST03 := (R_TRIG SV02T OR SV03T) AND LT03	Latch reset by close output signal.
SET04	SELOGIC	SET04 := (PB04 AND R_TRIG SV02T) AND (52AX AND NOT LT02 OR 52AY AND LT02)	Latch set by front-panel TRIP control (SEL-700GT and GW)
SET04	SELOGIC	SET04 := PB04 AND R_TRIG SV02T AND 52AX	Latch set by front-panel TRIP control (SEL-700G0 and G1)
RST04	SELOGIC	RST04 := (R_TRIG SV02T OR SV04T) AND LT04	Latch reset by trip output signal.
SET05	SELOGIC	SET05 := NA	
RST05	SELOGIC	RST05 := NA	
SET06	SELOGIC	SET06 := LB01 OR RB01	Latch set by manual prime mover trip (SEL-700G0, G1, and GT with generator protection).
SET06	SELOGIC	SET06 := 0	Not used in SEL-700GW and GT without generator protection.
RST06	SELOGIC	RST06 := 3POX	Latch reset by 3-pole open (SEL-700G0, G1, and GT with generator protection).
RST06	SELOGIC	RST06 := 0	Not used in SEL-700GW and GT without generator protection.
• • •	• • •	• • •	
SET32	SELOGIC	SET32 := NA	
RST32	SELOGIC	RST32 := NA	

Latch Bits: Nonvolatile State

Power Loss

The states of the latch bits (LT01–LT32) are retained if power to the device is lost and then restored. If a latch bit is asserted (for example, LT02 := logical 1) when power is lost, it is asserted (LT02 := logical 1) when power is restored. If a latch bit is deasserted (for example, LT03 := logical 0) when power is lost, it is deasserted (LT03 := logical 0) when power is restored.

Settings Change

If individual settings are changed, the states of the latch bits (Relay Word bits LT01 through LT32) are retained, as in the preceding *Power Loss on page 4.210* explanation. If the individual settings change causes a change in the SELOGIC control equation settings SET*n* or RST*n* (*n* = 1 through 32), the retained states of the latch bits can be changed, subject to the newly enabled settings SET*n* or RST*n*.

Make Latch Control Switch Settings With Care

The latch bit states are stored in nonvolatile memory, so that they can be retained during power loss or settings change. The nonvolatile memory is rated for a finite number of writes for all cumulative latch bit state changes. Exceeding the limit can result in a flash self-test failure. *An average of 5000 cumulative latch bit state changes per day can be made for a 25-year device service life.*

The settings SET*n* and RST*n* cannot result in continuous cyclical operation of the latch bit LT*n*. Use timers to qualify the conditions set in settings SET*n* and RST*n*. If you use any optoisolated inputs in settings SET*n* and RST*n*, the inputs each have a separate debounce timer that can help in providing the necessary time qualification.

SELOGIC Control Equation Variables/Timers

Enable the number of SELOGIC control equations necessary for your application. Only the enabled SELOGIC control equations appear for the settings. Each SELOGIC control equation variable/timer has a SELOGIC control equation setting input and variable/timer outputs, as shown in *Figure 4.143*. Timers SV01T through SV32T in *Figure 4.143* have a setting range of 0.00–3000.00 seconds. This timer setting range applies to both pickup and dropout times (SV*n*PU and SV*n*DO, *n* = 1 through 32).

NOTE: Any SELOGIC control equation that contains a Relay Word bit/analog quantity that gets hidden due to a setting change or a configuration change will show up as a `BAD SELOGIC EQUATION`.

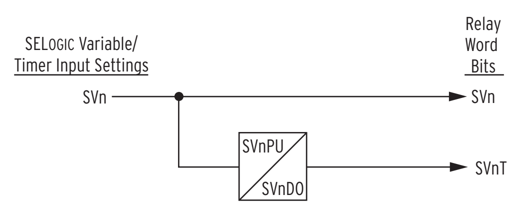


Figure 4.143 SELOGIC Control Equation Variable/Timers SV01/SV01T–SV32T

You can enter as many as 15 elements for each SELOGIC control equation, including a total of 14 elements in parentheses (see *Table 4.65* for more information).

SELOGIC Control Equation Operators

Use the Boolean operators to combine values with a resulting Boolean value. Edge trigger operators provide a pulse output. Combine the operators and operands to form statements that evaluate complex logic. SELOGIC control equations are either Boolean type or math type. Because the equals sign (=) is already used as an equality comparison, both Boolean type and math type SELOGIC control equation settings begin with an “assignment” operator (:=) instead of with an equals sign.

Boolean SELOGIC control equation settings use logic similar to Boolean algebra logic, combining Relay Word bits together with one or more of the Boolean operators listed in *Table 4.65*. Math SELOGIC control equation settings operate on numerical values, using one or more of the mathematical operators listed in *Table 4.65*. These numerical values can be mathematical variables or real numbers.

The relay converts variables from decimal to integer before performing math operations (through multiplication by 128 followed by rounding). After the math operations, the relay converts the result back from integer to decimal by scaling the value down by 128 before reporting the results. This effectively means that math calculations are rounded. See *Example 4.6* for an explanation on improving the accuracy of the math operations by managing the processing order.

EXAMPLE 4.6 Improving the Accuracy of Math Operations

If MV01 := (60/4160) • 100,000, the relay performs the 60/4160 calculation and scales it by 128, then rounds this up to 2. The relay then multiplies it by 100,000 and stores it as 200,000. When the number is reported, the relay divides out the scale factor (128) and reports 1562.5.

Alternatively, if MV01 := (60 • 100,000)/4160, the relay multiplies (60 • 100,000), then scales by 128, and then divides by 4160. This result is then rounded and stored as 184,615. The relay then divides 184,615 by 128 and reports 1442.3.

Example 4.6 illustrates the importance of avoiding calculations where a small number is divided by a large number followed by multiplication. Such calculations amplify any error significantly.

NOTE: Math variables are reset to zero if the relay loses power because the math variables are stored in volatile memory.

The executed result of a math SELOGIC control equation is stored in a math variable. The storage format of the math variable is a 32-bit fixed point signed integer; 24 bits represent the integer portion, 7 bits represent the fractional portion, and one bit represents the sign. The smallest and largest values a math variable can represent are –16777215.99 and +16777215.99, respectively. If the executed result exceeds these limits, it will be clipped at the limit value. For example, when the MV01 := executed result is –16777219.00, MV01 will be –16777215.99. Similarly, when the MV02 := executed result is +16777238.00, MV02 will be +16777215.99. Since there are only 7 bits available for the fractional portion, the result of multiplication and division with decimals will have lower accuracy than one would expect with a floating point processor. As illustrated by the results in *Table 4.64*, the results vary from 20 percent at the smallest end of the fractional values to 0.2 percent at the largest. Using scaling factors where possible is recommended to avoid the error introduced by the fixed point processor when multiplying and dividing fractional numbers.

Table 4.64 Math Variable Fractional Multiplication Results

MV01 := 0.01 • 10	Result = 0.08	Error = 20%
MV01 := 0.05 • 10	Result = 0.47	Error = 6.0%
MV01 := 0.10 • 10	Result = 1.02	Error = 2.0%
MV01 := 0.50 • 10	Result = 5.00	Error = 0.0%
MV01 := 0.99 • 10	Result = 9.92	Error = 0.2%

Comments can be added to both Boolean and math SELOGIC control equations by inserting a # symbol. Everything following the # symbol in a SELOGIC control equation is treated as a comment. See *Table 4.66* for this and other Boolean and math operators and values.

Operator Precedence

When you combine several operators and operands within a single expression, the SEL-700G evaluates the operators from left to right, starting with the highest precedence operators and working down to the lowest precedence. This means that if you write an equation with three AND operators, for example SV01 AND SV02 AND SV03, each AND is evaluated from left to right. If you substitute NOT SV04 for SV03 to make SV01 AND SV02 AND NOT SV04, the device evaluates the NOT operation of SV04 first and uses the result in subsequent evaluation of the expression.

Table 4.65 SELOGIC Control Equation Operators (Listed in Operator Precedence)

Operator	Function	Function Type (Boolean and/or Mathematical)
( )	parentheses	Boolean and Mathematical (highest precedence)
–	negation	Mathematical
NOT	NOT	Boolean
R_TRIG	rising-edge trigger/detect	Boolean
F_TRIG	falling-edge trigger/detect	Boolean
* /	multiply divide	Mathematical
+ -	add subtract	Mathematical
<, >, <=, >=	comparison	Boolean
= <>	equality inequality	Boolean
AND	AND	Boolean
OR	OR	Boolean (lowest precedence)

Parentheses Operator ( )

You can use more than one set of parentheses in a SELOGIC control equation setting. For example, the following Boolean SELOGIC control equation setting has two sets of parentheses:

SV04 := **(SV04 OR IN102) AND (PB01_LED OR RB01)** In the previous example, the logic within the parentheses is processed first and then the two parentheses resultants are ANDed together. Use as many as 14 sets of parentheses in a single SELOGIC control equation setting. You can "nest" parentheses within parentheses.

Math Negation Operator (–)

The negation operator – changes the sign of a numerical value. For example:

MV01 := **RB01** When Remote bit RB01 asserts, Math variable MV01 has a value of 1, that is, MV01 := 1. We can change the sign on MV01 with the following expression:

MV01 := **-1 * RB01** Now, when Remote bit RB01 asserts, Math variable MV01 has a value of –1, that is, MV01 := –1.

Boolean NOT Operator (NOT)

Apply the NOT operator to a single Relay Word bit and to multiple elements (within parentheses).

An example of a single Relay Word bit is as follows:

SV01 := **NOT RB01** When Remote bit RB01 asserts from logical 0 to logical 1, the Boolean NOT operator, in turn, changes the logical 1 to a logical 0. In this example, SV01 deasserts when RB01 asserts.

Following is an example of the NOT operator applied to multiple elements within parentheses.

The Boolean SELOGIC control equation OUT101 setting could be set as follows:

OUT101 := **NOT(RB01 OR SV02)** If both RB01 and SV02 are deasserted (= logical 0), output contact OUT101 asserts. That is, OUT101 := NOT (logical 0 OR logical 0) := NOT (logical 0) := logical 1.

In a Math SELOGIC control equation, use the NOT operator with any Relay Word bits. This allows a simple if/else type equation, as shown in the following example.

MV01 := **12 * IN101 + (MV01 + 1) * NOT IN101** The previous equation sets MV01 to 12 whenever IN101 asserts. Otherwise, it increments MV01 by 1 each time the equation is executed.

Boolean Rising-Edge Operator (R_TRIG)

Apply the rising-edge operator, R_TRIG, to individual Relay Word bits only; you cannot apply R_TRIG to groups of elements within parentheses. When any Relay Word bit asserts (going from logical 0 to logical 1), R_TRIG interprets this logical 0 to logical 1 transition as a “rising edge” and asserts to logical 1 for one processing interval.

For example, the Boolean SELOGIC control equation event report generation setting uses rising-edge operators:

ER := **R_TRIG IN101 OR R_TRIG IN102** The rising-edge operators detect a logical 0 to logical 1 transition each time either IN101 or IN102 asserts. Using these settings, the device triggers a new event report each time IN101 or IN102 asserts anew, if the device is not already recording an event report. You can use the rising-edge operator with the NOT operator as long as the NOT operator precedes the R_TRIG operator. The NOT R_TRIG combination produces a logical 0 for one processing interval when it detects a rising edge on the specified element.

Boolean Falling-Edge Operator (F_TRIG)

Apply the falling-edge operator, F_TRIG, to individual Relay Word bits only; you cannot apply F_TRIG to groups of elements within parentheses. The falling-edge operator, F_TRIG, operates similarly to the rising-edge operator, but it operates on Relay Word bit deassertion (elements going from logical 1 to logical 0) instead of Relay Word bit assertion. When the Relay Word bit deasserts, F_TRIG interprets this logical 1 to logical 0 transition as a “falling edge” and asserts to logical 1 for one processing interval, as shown in *Figure 4.144*.

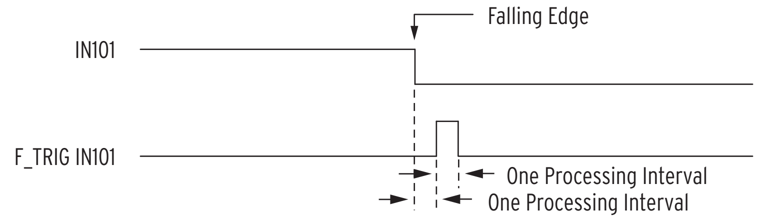


Figure 4.144 Result of Falling-Edge Operator on a Deasserting Input

You can use the falling-edge operator with the NOT operator as long as the NOT operator precedes the F_TRIG operator. The NOT F_TRIG combination produces a logical 0 for one processing interval when it detects a falling edge on the specified element.

Math Arithmetic Operators (*, /, +, and –)

If Relay Word bits (which are effectively Boolean resultants, equal to logical 1 or logical 0) are used in mathematical operations, they are treated as numerical values 0 and 1, depending on if the Relay Word bit is equal to logical 0 or logical 1, respectively.

Boolean Comparison Operators (<, >, <=, and >=)

Comparisons are mathematical operations that compare two numerical values, with the result being a logical 0 (if the comparison is not true) or logical 1 (if the comparison is true). Thus, what starts out as a mathematical comparison ends up as a Boolean resultant. For example, if the output of a math variable is above a certain value, an output contact is asserted:

OUT103 := **MV01 > 8** If the math variable (MV01) is greater than 8, output contact OUT103 asserts (OUT103 := logical 1). If the math variable (MV01) is less than or equal to 8, output contact OUT103 deasserts (OUT103 := logical 0).

Boolean Equality (=) and Inequality (<>) Operators

Equality and inequality operators operate similarly to the comparison operators. These are mathematical operations that compare two numerical values, with the result being a logical 0 (if the comparison is not true), or logical 1 (if the comparison is true). Thus what starts out as a mathematical comparison ends up as a Boolean resultant. For example, if the output of a math variable is not equal to a certain value, an output contact asserts:

OUT102 := **MV01 <> 45** If the math variable (MV01) is not equal to 45, output contact OUT102 asserts (effectively OUT102 := logical 1). If the math variable (MV01) is equal to 45, output contact OUT102 deasserts (effectively OUT102 := logical 0). *Table 4.66* shows other operators and values that you can use in writing SELOGIC control equations.

Table 4.66 Other SELOGIC Control Equation Operators/Values

Operator/ Value	Function	Function Type (Boolean and/or Mathematical)
0	Set SELOGIC control equation directly to logical 0 (XXX := 0)	Boolean
1	Set SELOGIC control equation directly to logical 1 (XXX := 1)	Boolean
#	Characters entered after the # operator are not processed and are deemed as comments	Boolean and Mathematical
\	Indicates that the preceding logic should be continued on the next line ("\" is entered only at the end of a line)	Boolean and Mathematical

Timers Reset When Power Lost or Settings Changed

If the device loses power or the settings change, the SELOGIC control equation variables/timers reset. Relay Word bits SV*n* and SV*n*T (*n* = 01–32) reset to logical 0 after power restoration or a settings change. *Figure 4.145* shows an effective seal-in logic circuit, created by the use of Relay Word bit SV07 (SELOGIC control equation variable SV07) in SELOGIC control equation SV07:

SV07 := **(SV07 OR OUT101) AND (OUT102 OR OUT401)**

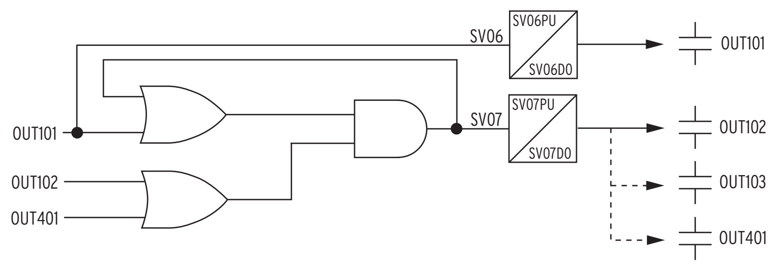


Figure 4.145 Example Use of SELOGIC Variables/Timers

SV/Timers Settings

The SEL-700G includes 32 SELOGIC variables. *Table 4.67* shows the pickup, dropout, equation settings, and brief descriptions for SV01–SV12. The factory-default settings for these variables should address most applications. Review the default settings and make any changes necessary to suit your application. The remaining SELOGIC variables are not enabled (see *Table 4.62*), but they are available for any special needs.

Table 4.67 SELOGIC Variable Settings (Sheet 1 of 4)

Setting Prompt	Setting Range	Default Settings	Description
SV TIMER PICKUP	0.00–3000.00	SV01PU := 3.00	LOCK button pickup time
SV TIMER DROPOUT	0.00–3000.00	SV01DO := 0.00	LOCK button dropout time
SV INPUT	SELOGIC	SV01 := PB01	Assigned to LOCK button.
SV TIMER PICKUP	0.00–3000.00	SV02PU := 0.25	De-bounce time for all buttons.
SV TIMER DROPOUT	0.00–3000.00	SV02DO := 0.00	
SV INPUT	SELOGIC	SV02 := PB01 OR PB02 OR PB03 OR PB04 OR PB05	Assigned to all buttons.

Table 4.67 SELOGIC Variable Settings (Sheet 2 of 4)

Setting Prompt	Setting Range	Default Settings	Description
SV TIMER PICKUP	0.00–3000.00	SV03PU := 0.00	CLOSE button delay.
SV TIMER DROPOUT	0.00–3000.00	SV03DO := 0.00	
SV INPUT	SELOGIC	SV03 := LT03	Assigned to close signal.
SV TIMER PICKUP	0.00–3000.00	SV04PU := 0.00	TRIP button delay.
SV TIMER DROPOUT	0.00–3000.00	SV04DO := 0.00	
SV INPUT	SELOGIC	SV04 := LT04	Assigned to trip signal.
SV TIMER PICKUP	0.00–3000.00	SV05PU := 0.25	Flashing LED ON time.
SV TIMER DROPOUT	0.00–3000.00	SV05DO := 0.25	Flashing LED OFF time.
SV INPUT	SELOGIC	SV05 := (PB01 OR PB02 OR LT03 OR LT04) AND NOT SV05T	Initiate flashing LED.
SV TIMER PICKUP	0.00–3000.00	SV06PU := 0.00	
SV TIMER DROPOUT	0.00–3000.00	SV06DO := 0.00	
SV INPUT	SELOGIC	SV06 := 87N1T OR 87N2T OR REF1P OR 67GX1T OR 67GX2T OR INADT OR 64F2T	Assigned to generator faults and inadvertent energization for SEL-700G0 and SEL-700GT+ models.
		SV06 := 87N1T OR 87N2T OR 64G1T OR 64G2T OR REF1P OR 67GX1T OR 67GX2T OR INADT OR 64F2T	Assigned to generator faults and inadvertent energization for SEL-700G0+ model.
		SV06 := 87R OR 87U OR 87N1T OR 87N2T OR REF1P OR 67GX1T OR 67GX2T OR INADT OR 64F2T	Assigned to generator faults and inadvertent energization for SEL-700G1 model.
		SV06 := 87R OR 87U OR 87N1T OR 87N2T OR 64G1T OR 64G2T OR REF1P OR 67GX1T OR 67GX2T OR INADT OR 64F2T	Assigned to generator faults and inadvertent energization for SEL-700G1+ model.
		SV06 := 0	Not used in SEL-700GT model.
		SV06 := 50PX1T OR 50PX2T OR 50PX3AT OR 50PX3BT OR 50PX3CT OR 50GX1T OR 50GX2T OR 50QX1T OR 50QX2	Assigned to X-side instantaneous overcurrent elements for SEL-700GW model.
SV TIMER PICKUP	0.00–3000.00	SV07PU := 0.00	
SV TIMER DROPOUT	0.00–3000.00	SV07DO := 0.00	
SV INPUT	SELOGIC	SV07 := 51CT OR 51VT OR 51GXT OR 51NT OR 67N1T OR 67N2T OR 49T OR LT06 AND NOT 3PWRX2T AND NOT LOPX	Assigned to prolonged system faults, overload, and neutral overcurrent trips for SEL-700G0 and SEL-700GT+ models.
		SV07 := 21C1T OR 21C2T OR 51CT OR 51VT OR 51GXT OR 51NT OR 67N1T OR 67N2T OR 49T OR LT06 AND NOT 3PWRX2T AND NOT LOPX	Assigned to prolonged system faults, overload, and neutral overcurrent trips for SEL-700G0+, SEL-700G1, and SEL-700G1+ models.
		SV07 := 51NT OR 50N1T OR 50N2T	Assigned to X-side neutral overcurrent trips for SEL-700GT model.
		SV07 := 51PXT OR 51GXT OR 51QXT	Assigned to X-side overcurrent trips for SEL-700GW model.

Table 4.67 SELOGIC Variable Settings (Sheet 3 of 4)

Setting Prompt	Setting Range	Default Settings	Description
SV TIMER PICKUP	0.00–3000.00	SV08PU := 0.00	
SV TIMER DROPOUT	0.00–3000.00	SV08DO := 0.00	
SV INPUT	SELOGIC	SV08 := 24C2T OR 3PWRX1T OR 40Z1T OR 40Z2T	Assigned to generator abnormal operating conditions for all SEL-700G0, G1, and GT models.
		SV08 := 0	Not used in SEL-700GW model
SV TIMER PICKUP	0.00–3000.00	SV09PU := 0.00	
SV TIMER DROPOUT	0.00–3000.00	SV09DO := 0.00	
SV INPUT	SELOGIC	SV09 := 50PY3AT OR 50PY3BT OR 50PY3CT OR 67PY1T OR 67PY2T OR 67GY1T OR 67GY2T OR 67QY1T OR 67QY2T	Assigned to Y-side instantaneous overcurrent trips for all SEL-700GT and SEL-700GT+ models.
		SV09 := 50PY1T OR 50PY2T OR 50PY3AT OR 50PY3BT OR 50PY3CT OR 50GY1T OR 50GY2T OR 50QY1T OR 50QY2T	Assigned to Y-side instantaneous overcurrent trips for SEL-700GW.
		SV09 := 0	Not used in SEL-700G0, SEL-700G0+, SEL-700G1, and SEL-700G1+ models.
SV TIMER PICKUP	0.00–3000.00	SV10PU := 0.00	
SV TIMER DROPOUT	0.00–3000.00	SV10DO := 0.00	
SV INPUT	SELOGIC	SV10 := 51PYT OR 51GYT OR 51QYT OR 3PWRY1T OR 3PWRY2T OR 81Y1T OR 81Y2T OR 81RY1T OR 81RY2T	Assigned to Y-side time-overcurrent trips for all SEL-700GT+ models.
		SV10 := 51PYT OR 51GYT OR 51QYT	Assigned to Y-side time-overcurrent trips for SEL-700GW.
		SV10 := 0	Not used in SEL-700G0 and SEL-700G1 models.
SV TIMER PICKUP	0.00–3000.00	SV11PU := 0.00	
SV TIMER DROPOUT	0.00–3000.00	SV11DO := 2.00	Reserved for synchronism-check supervised close of breaker 52X.
SV INPUT	SELOGIC	SV11 := 0	
SV TIMER PICKUP	0.00–3000.00	SV12PU := 0.00	
SV TIMER DROPOUT	0.00–3000.00	SV12DO := 2.00	Reserved for synchronism-check supervised close of breaker 52Y.
SV INPUT	SELOGIC	SV12 := 0	
SV TIMER PICKUP	0.00–3000.00	SV13PU := 0.00	
SV TIMER DROPOUT	0.00–3000.00	SV13DO := 0.20	
SV INPUT	SELOGIC	SV13 := R_TRIG ZCFREQX OR F_TRIG ZCFREQX OR F_TRIG ASYNSDC	Assigned to enhance security during asynchronous sampling data conversion for SEL-700GT+ models.
		SV13 := O	Not used in SEL-700G0, SEL-700G0+, SEL700G1, SEL-700G1+, SEL-700GT, and SEL-700GW models.
SV TIMER PICKUP	0.00–3000.00	SV14PU := 0.00	
SV TIMER DROPOUT	0.00–3000.00	SV14DO := 0.00	

Table 4.67 SELOGIC Variable Settings (Sheet 4 of 4)

Setting Prompt	Setting Range	Default Settings	Description
SV INPUT	SELOGIC	SV14 := FREQX > 16.00	Assigned to enhance security during asynchronous sampling data conversion for SEL-700GT+ models.
		SV14 := 0	Not used in SEL-700G0, SEL-700G0+, SEL700G1, SEL-700G1+, SEL-700GT, and SEL-700GW models.
SV TIMER PICKUP	0.00–3000.00	SV15PU := 0.00	
SV TIMER DROPOUT	0.00–3000.00	SV15DO := 0.00	
SV INPUT	SELOGIC	SV15 := NA	
• • •	• • •		
SV TIMER PICKUP	0.00–3000.00	SV32PU := 0.00	
SV TIMER DROPOUT	0.00–3000.00	SV32DO := 0.00	
SV INPUT	SELOGIC	SV32 := NA	

Counter Variables

NOTE: These counter elements conform to the standard counter function block #3 in IEC 1131-3 First Edition 1993-03 International Standard for Programmable controllers—Part 3: Programming languages.

NOTE: The SEL-700G tracks the frequency using either voltage or current. When tracking the frequency, the processing interval varies with the frequency.

NOTE: If setting SCnnCD is set to NA, the entire counter nn is disabled.

NOTE: If setting SCnnCU is set to NA, the counter counts only downward.

NOTE: SELOGIC counters are reset to zero if the relay loses power because the counters are stored in volatile memory.

SELOGIC counters are up- or down-counting elements, updated every processing interval.

Each counter element consists of one count setting, four control inputs, two digital outputs, and one analog output. *Figure 4.146* shows Counter 01, the first of 32 counters available in the device.

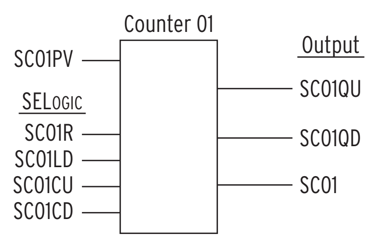


Figure 4.146 Counter 01

Digital output SC01QD asserts when the counter is at position zero, and Digital output SC01QU asserts when the counter reaches the programmable count value. Use the reset input (SC01R) to force the count to zero, and the analog output (SC*nn*) with analog comparison operators. *Table 4.68* describes the counter inputs and outputs, and *Table 4.69* shows the order of precedence of the control inputs.

Table 4.68 Counter Input/Output Description (Sheet 1 of 2)

Name	Type	Description
SC*nn*LD	Active High Input	Load counter with the preset value to assert the output (SC*n*QU) (follows SELOGIC setting).
SC*nn*PV	Input Value	This Preset Value is loaded when SC*n*LD pulsed. This Preset Value is the number of counts before the output (SC*n*QU) asserts (follows SELOGIC setting).
SC*nn*CU	Rising-Edge Input	Count Up increments the counter (follows SELOGIC setting).

Table 4.68 Counter Input/Output Description (Sheet 2 of 2)

Name	Type	Description
SC*nn*CD	Rising-Edge Input	Count Down decrements the counter (follows SELOGIC setting).
SC*nn*R	Active High Input	Reset counter to zero (follows SELOGIC setting)
SC*nn*QU	Active High Output	This Q Up output asserts when the Preset Value (maximum count) is reached (SC*n* = SC*n*PV, *n* = 01 to 32).
SC*nn*QD	Active High Output	This Q Down output asserts when the counter is equal to zero (SC*n* = 0, *n* = 01 to 32).
SC*nn*	Output Value	This counter output is an analog value that may be used with analog comparison operators in a SELOGIC control equation and viewed using the **COU** command.

Table 4.69 Order of Precedence of the Control Inputs

Order	Input
1	SC*nn*R
2	SC*nn*LD
3	SC*nn*CU
4	SC*nn*CD

SC01CU first being seen as a rising edge and the resultant outputs. This indicates that there is no intentional lag between the control input asserting and the count value changing. Most of the pulses in the diagram are on every second processing interval. The "one processing interval" valley is an example where the CD and CU pulses are only separated by one processing interval.

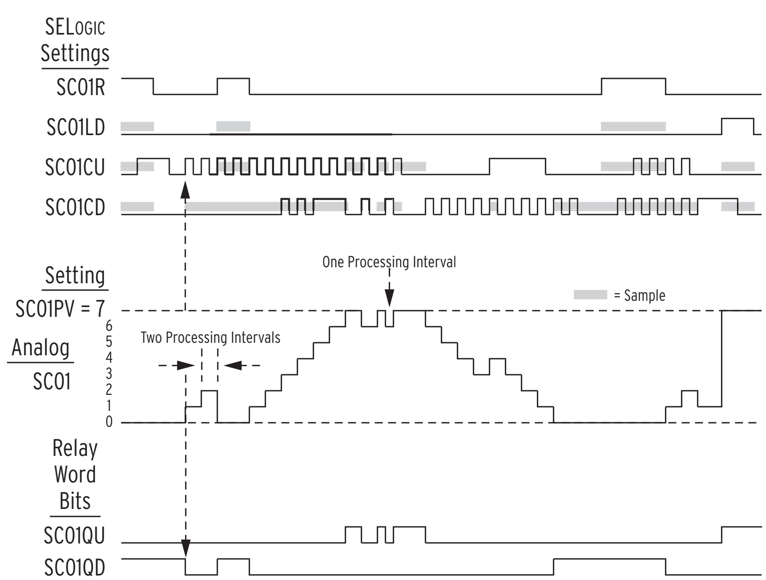


Figure 4.147 Example of the Effects of the Input Precedence

The shaded areas illustrate the precedence of the inputs:

- ➤ When SC01R is asserted, the SC01LD input is ignored.
- ➤ When SC01R or SC01LD is asserted, rising edges on the SC01CU or SC01CD inputs are ignored.
- ➤ When input SC01CU has a rising edge, a rising edge on SC01CD is ignored (unless SC01 is already at the maximum value SC01PV (= 7), in which case SC01CU is ignored, and the SC01CD is processed). An example of this exception appears in the previous diagram, just before the "one processing interval" notation.

A maintained logical 1 state on the SC01CU or SC01CD inputs is ignored (after the rising edge is processed). A rising edge received on the SC01CU or SC01CD inputs is ignored when the SC01R or SC01LD inputs are asserted.

A maintained logical 1 on the SC01CU or SC01CD inputs does not get treated as a rising edge when the SC01R or SC01LD input deasserts.

The same operating principles apply for all of the counters: SC01–SC*mm*, where *mm* = the number of enabled counters.

Output Contacts

The SEL-700G provides the ability to use SELOGIC control equations to map protection (trip and warning) and general-purpose control elements to the outputs. In addition, you can enable fail-safe output contact operation for relay contacts on an individual basis.

NOTE: When an output contact is not used for a specific function, you must set the associated SELOGIC control equation to either 0 or 1.

NOTE: Fast hybrid contacts are designed for fast closing (50 µs) only. Fail-safe mode operating time (time to open the contacts) for fast hybrid contacts is <8 ms (the same time as for a normal output contact).

NOTE: Four digital outputs in Slot **D** are shown. The outputs in Slots **C** and **E** have similar settings.

Table 4.70 Control Output Equations and Contact Behavior Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
OUT101 FAIL-SAFE	Y, N	OUT101FS := Y
OUT101	SELOGIC	OUT101 := HALARM OR SALARM
OUT102 FAIL-SAFE	Y, N	OUT102FS := N
OUT102	SELOGIC	OUT102 := 0
OUT103 FAIL-SAFE	Y, N	OUT103FS := N
OUT103	SELOGIC	OUT103 := TRIPX[a] OUT103 := 0[b]
• • •	• • •	• • •
OUT401 FAIL-SAFE	Y, N	OUT401FS := N
OUT401	SELOGIC	OUT401 := 0
OUT402 FAIL-SAFE	Y, N	OUT402FS := N
OUT402	SELOGIC	OUT402 := 0
OUT403 FAIL-SAFE	Y, N	OUT403FS := N
OUT403	SELOGIC	OUT403 := 0
OUT404 FAIL-SAFE	Y, N	OUT404FS := N
OUT404	SELOGIC	OUT404 := 0
• • •	• • •	• • •

Table 4.70 Control Output Equations and Contact Behavior Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
OUT408 FAIL-SAFE	Y, N	OUT408FS := N
OUT408	SELOGIC	OUT408 := 0

[a] Default setting shown applies to all models except basic SEL-700GT.
[b] Default setting shown applies to basic SEL-700GT models.

If the contact fail-safe is enabled, the relay output is held in its energized position when relay control power is applied. The output falls to its de-energized position when control power is removed. Contact positions with de-energized output relays are indicated on the relay chassis and in *Figure 2.14* and *Figure 2.15*.

When TRIP output fail-safe is enabled and the **TRIP** contact is appropriately connected (see *Figure 2.18*), the breaker is automatically tripped when relay control power fails.

MIRRORED BITS Transmit SELOGIC Control Equations

See *Appendix J: MIRRORED BITS Communications* and SEL-700G Settings Sheets for details.

Global Settings (SET G Command)

General Settings

Set the FNOM setting equal to your system nominal frequency.

The FRQTRK setting determines priority (X- or Y-side) for the frequency tracking in SEL-700GT+ models. It is automatically set and hidden for all other SEL-700G models (see *Table 4.39* for additional details). Set FRQTRK := Y in the SEL-700GT+ Relay if used in an inverter-based intertie application (solar farms, wind farms, storage battery, etc.). When FRQTRK = Y the relay tracks Y-side frequency and switches to tracking the X-side only if the Y-side is out of service. Set FRQTRK := X for the intertie applications using conventional generators.

The DATE_F setting allows you to change the relay date presentation format to the North American standard (Month/Day/Year), the engineering standard (Year/Month/Day), or the European standard (Day/Month/Year).

The METHRES setting governs how various metering functions behave when the metered value is smaller than a fixed threshold. Refer to *Small Signal Cutoff for Metering on page 5.14* for more details.

Set the SELOGIC control equation FAULT to temporarily block *Maximum and Minimum Metering*, *Energy Metering*, and *Demand Metering*.

Table 4.71 General Global Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default	Description
RATED FREQ	50, 60 Hz	FNOM := 60	
PRIORITY FRQ TRK	X, Y	FRQTRK := X	For SEL-700GT+ model.
DATE FORMAT	MDY, DMY, DMY	DATE_F := MDY	
MET CUTOFF THRES	Y, N	METHRES := Y	

Table 4.71 General Global Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default	Description
FAULT CONDITION	SELogic	FAULT := 51V OR 51C OR 50PX1P OR 46Q2 OR 67N1P OR TRIP	For SEL-700G0 model.
		FAULT := 51V OR 51C OR 50PX1P OR 46Q2 OR 21C1P OR 21C2P OR 67N1P OR TRIP	For SEL-700G0+ model.
		FAULT := 51V OR 51C OR 50PX1P OR 46Q2 OR 21C1P OR 21C2P OR 50PY1P OR 50QY1P OR 50GY1P OR 67N1P OR 51PYP OR 51QYP OR 51GYP OR TRIP	For SEL-700G1 and SEL-700G1+ models.
		FAULT := 67PY1P OR 67QY1P OR 67GY1P OR 50N1P OR 51PYP OR 51QYP OR 51GYP OR TRIP	For SEL-700GT model.
		FAULT := 51V OR 51C OR 50PX1P OR 46Q2 OR 67PY1P OR 67QY1P OR 67GY1P OR 67N1P OR 51PYP OR 51QYP OR 51GYP OR TRIP	For SEL-700GT+ model.
		FAULT := 50PX1P OR 50PY1P OE 50QY1P OR 50GY1P OR 51PYP OR 51QYP OR 51GYP OR TRIP	For SEL-700GW model.

Event Messenger Points

You can configure the SEL-700G to automatically send an ASCII message on a communications port when a trigger condition is satisfied. Use the **SET P** command to set PROTO := EVMSG on the port you want to select. This feature is designed to send messages to the SEL-3010 Event Messenger, but you can use any device capable of receiving ASCII messages.

Table 4.72 Event Messenger Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
EVE MSG PTS ENABL	N, 1–32	EMP := N
MESSENGER POINT MP01 TRIGGER	Off, 1 Relay Word bit	MPTR01 := OFF
MESSENGER POINT MP01 AQ	None, 1 analog quantity	MPAQ01 := NONE
MESSENGER POINT MP01 TEXT	148 characters	MPTX01 :=
• • •	• • •	• • •
MESSENGER POINT MP32 TRIGGER	Off, 1 Relay Word bit	MPTR32 := OFF
MESSENGER POINT MP32 AQ	None, 1 analog quantity	MPAQ32 := NONE
MESSENGER POINT MP32 TEXT	148 characters	MPTX32 :=

Set EMP to enable the number of message points that you want.

Set each of MPTR*xx* (*xx* := 01–32) to the necessary Relay Word bits, the rising edges of which define the trigger condition.

MPAQ*xx* is an optional setting and you can use it to specify an Analog Quantity to be formatted into a single message, as the following text describes.

Use MPTX*xx* to construct your message. Note that, by default, any analog quantity you specify is added at the end of the message and is rounded to the nearest integer value (see *Example 4.7*).

EXAMPLE 4.7 Setting MPTXxx Using the Default Location of Analog Quantity

MPTX01 := THE LOAD CURRENT IS

MPAQ01 value := 157.44

Formatted message out when triggered: THE LOAD CURRENT IS 157

The location and resolution of the analog quantity value within the message can be specified by using "%.pf", where,

% defines location of the value

p defines number of digits (as many as 6, defaults to 6 if omitted)

f indicates floating point value (use %d for the nearest whole number)

EXAMPLE 4.8 Setting MPTXxx With a Specified Location of Analog Quantity

MPTX01 := THE LOAD CURRENT IS %.2f AMPERES

MPAQ01 value := 157.44

Formatted message out when triggered: THE LOAD CURRENT IS 157.44 AMPERES

MPTX01 := THE LOAD CURRENT IS %d AMPERES

MPAQ01 value := 157.44

Formatted message out when triggered: THE LOAD CURRENT IS 157 AMPERES

Multiple Settings Groups

SEL-700G relays have four independent settings groups. Each settings group has complete relay settings and protection SELOGIC settings. The active settings group can be:

- Viewed on the front-panel two-line LCD using the **MAIN** > **Set/Show** > **Active Group** menus, as shown in *Figure 8.21*.
- Viewed using the SEL ASCII serial port **GROUP** command, as described in *Table 7.30*.
- Selected using the SEL ASCII serial port **GROUP *n*** command described in *Table 7.30*.
- Selected using SELOGIC control equation settings SS1 through SS4, as shown in *Table 4.73*.

If SELOGIC control equations SS1–SS4 are defined and evaluate to logical 1, they have priority over the **GROUP *n*** command to select the active settings group. If SELOGIC control equations are defined but evaluate to logical 0, or if they are not defined, the **GROUP *n*** command can be used to select the active settings group.

Active Settings Group Indication

Only one settings group can be active at a time. Relay Word bits SG1 through SG4 indicate the active settings group. For example, if settings Group 3 is the active settings group, Relay Word bit SG3 is asserted to logical 1 and Relay Word bits SG1, SG2, and SG4 are deasserted to logical 0.

Active Settings Group Selection Via SELOGIC Control Equations

The Global settings class contains the SELOGIC control equation settings SS1 through SS4, as shown in *Table 4.73*.

Table 4.73 Setting Group Selection

Setting Prompt	Setting Range	Setting Name := Factory Default
GRP CHG DELAY	0–400 s	TGR := 3
SELECT GROUP1	SELOGIC	SS1 := 1
SELECT GROUP2	SELOGIC	SS2 := 0
SELECT GROUP3	SELOGIC	SS3 := 0
SELECT GROUP4	SELOGIC	SS4 := 0

As an example of how these settings operate, assume that the active settings group is settings Group 3. The corresponding Relay Word bit, SG3, is asserted to logical 1 to indicate that settings Group 3 is the active settings group.

When settings Group 3 is the active settings group, setting SS3 has priority. If setting SS3 is asserted to logical 1, settings Group 3 remains the active settings group, regardless of the activity of settings SS1, SS2, or SS4. If settings SS1 through SS4 all deassert to logical 0, settings Group 3 remains the active settings group.

If the active settings Group 3 SELOGIC control equation SS3 deasserts to logical 0 and one of the other settings (e.g., SS1) asserts to logical 1, the relay switches the active settings group from settings Group 3 to one of the other settings groups (e.g., settings Group 1) after the qualifying time setting TGR (Global setting).

In this example, if multiple SS*n* assert after SS3 deasserts to logical 0, the order of switching follows the first SS*n* that is set in a priority order of 1 through 4.

Active Settings Group Changes

The relay is disabled for less than one second while it processes the active settings group change. Relay elements, timers, and logic are reset, unless otherwise indicated in the specific logic description. For example, local bit (LB01–LB32), remote bit (RB01–RB32), and latch bit (LT01–LT32) states are retained during an active settings group change. The output contacts do not change state until the relay enables in the new settings group and the SELOGIC control equations are processed to determine the output contact status for the new group. After a group change, an automatic message is shown on the front panel and sent to any serial port that has setting AUTO := Y.

Active Setting: Nonvolatile State

Power Loss

The active settings group is retained if power to the relay is lost and then restored. If a settings group is active (e.g., settings Group 3) when power is lost, the same settings group is active when power is restored.

Settings Change

If individual settings are changed for the active settings group or one of the other settings groups, the active settings group is retained, much like in the preceding explanation. If individual settings are changed for a settings group other than the active settings group, there is no interruption of the active settings group, so the relay is not momentarily disabled. If the individual settings change causes a change in one or more SELOGIC control equation settings SS1–SS4, the active settings group can be changed, subject to the newly enabled SS1–SS4 settings.

Synchrophasor Measurement

The SEL-700G Relay provides Phasor Measurement Control Unit (PMCU) capabilities when connected to an IRIG-B time source. See *Appendix K: Synchrophasors* for description and *Table K.1* for the settings.

Time and Date Management Settings

The SEL-700G supports several methods of updating the relay time and date. For IRIG-B and phasor measurement unit (PMU) synchrophasor applications, refer to *Appendix K: Synchrophasors* for the description and *Table K.1* for the settings. For SNTP applications, refer to *Simple Network Time Protocol (SNTP) on page 7.16*. For PTP applications, refer to *Precision Time Protocol (PTP) on page 7.19*. For time update from a DNP Master, see *Time Synchronization on page D.9*.

Table 4.74 shows the time and date management settings that are available in the Global settings.

Table 4.74 Time and Date Management Settings

Setting Description	Setting Range	Setting Name := Factory Default
IRIG-B CONTROL BITS DEFINITION	NONE, C37.118	IRIGC := NONE
OFFSET FROM UTC	–24.00 to 24.00 hours, rounds up to nearest 0.25 hour	UTC_OFF := 0.00
MONTH TO BEGIN DST	OFF, 1–12	DST_BEGM := OFF
WEEK OF THE MONTH TO BEGIN DST	1–3, L	DST_BEGW := 2
DAY OF THE WEEK TO BEGIN DST	SUN, MON, TUE, WED, THU, FRI, SAT, SUN	DST_BEGD := SUN
LOCAL HOUR TO BEGIN DST	0–23	DST_BEGH := 2
MONTH TO END DST	1–12	DST_ENDM := 11
WEEK OF THE MONTH TO END DST	1–3, L	DST_ENDW := 1
DAY OF THE WEEK TO END DST	SUN, MON, TUE, WED, THU, FRI, SAT, SUN	DST_ENDD := SUN
LOCAL HOUR TO END DST	0–23	DST_ENDH := 2

IRIGC

IRIGC defines whether IEEE C37.118 control bit extensions are in use. Control bit extensions contain information such as Leap Second, UTC, Daylight Saving Time, and Time Quality. When your satellite-synchronized clock provides these extensions, your relay adjusts the synchrophasor time stamp accordingly.

- IRIGC := NONE will ignore bit extensions
- IRIGC := C37.118 will extract bit extensions and correct synchrophasor time accordingly

Coordinated Universal Time (UTC) Offset Setting

The SEL-700G has a Global setting UTC_OFF, settable from –24.00 to 24.00 hours, in 0.25 hour increments. The relay uses the UTC_OFF setting to calculate local (relay) time from the UTC source when configured for Simple Network Time Protocol (SNTP) updating via Ethernet. When a time source other than SNTP is updating the relay time, the UTC_OFF setting is not considered because the other time sources are defined as local time.

Automatic Daylight-Saving Time Settings

The SEL-700G can automatically switch to and from daylight-saving time, as specified by the eight Global settings DST_BEGM through DST_ENDH. The first four settings control the month, week, day, and time that daylight-saving time shall commence, while the last four settings control the month, week, day, and time that daylight-saving time shall cease.

Once configured, the SEL-700G will change to and from daylight-saving time every year at the specified time. Device Word bit DST asserts when daylight-saving time is active.

The SEL-700G interprets the week number settings DST_BEGW and DST_ENDW (1–3, L = Last) as follows:

- The first seven days of the month are considered to be in week 1.
- The second seven days of the month are considered to be in week 2.
- The third seven days of the month are considered to be in week 3.
- The last seven days of the month are considered to be in week “L”.

This method of counting of the weeks allows easy programming of statements like “the first Sunday”, “the second Saturday”, or “the last Tuesday” of a month.

As an example, consider the following settings:

DST_BEGM = 3

DST_BEGW = L

DST_BEGD = SUN

DST_BEGH = 2

DST_ENDM = 10

DST_ENDW = 3

DST_ENDD = WED

DST_ENDH = 3

With these example settings, the relay will enter daylight-saving time on the last Sunday in March at 0200 h, and leave daylight-saving time on the third Wednesday in October at 0300 h. The relay asserts Relay Word bit DST when DST is active.

When an IRIG-B time source is being used, the relay time follows the IRIG-B time, including daylight-saving time start and end, as commanded by the time source. If there is a discrepancy between the daylight-saving time settings and the received IRIG-B signal, the relay follows the IRIG-B signal.

When using IEEE C37.118 compliant IRIG-B signals (e.g., Global setting IRIGC = C37.118), the relay automatically populates the DST Relay Word bit, regardless of the daylight-saving time settings.

When using regular IRIG-B signals (e.g., Global setting IRIGC = NONE), the relay only populates the DST Relay Word bit of the daylight-saving time settings are properly configured.

Simple Network Time Protocol (SNTP)

The SEL-700G Port 1 (Ethernet Port) supports the SNTP Client protocol. See *Section 7: Communications*, *Simple Network Time Protocol (SNTP) on page 7.16* for a description and *Table 7.5* for the settings.

Precision Time Protocol (PTP)

The SEL-700G Port 1 (Ethernet Port) supports PTP. See *Precision Time Protocol (PTP) on page 7.19* for a description and *Table 7.7* for the settings.

PTP Timekeeping

When using PTP, the SEL-700G can only be synchronized by a grandmaster (GM) clock on the PTP timescale, not one on an arbitrary (ARB) timescale. For a relay on the ARB timescale, the epoch is set by an administrative procedure and can change at any time during normal operation. The PTP timescale uses the PTP epoch of January 1, 1970 00:00:00 International Atomic Time (TAI), which corresponds to December 31, 1969 23:59:51.999918 UTC. The unit of time for the PTP timescale is the SI second and accounts for leap seconds. As of June 2016, TAI is 37 seconds ahead of UTC.

When the SEL-700G is synchronized to a PTP master and the UTC offset information from the PTP master is valid, the PTP master instructs the SEL-700G when to go into Daylight Savings Time and when to exit Daylight Savings Time. The PTP master also provides the UTC offset at this time. Otherwise, the SEL-700G uses the internal values for Daylight Savings Time and UTC Offset.

The offset between TAI and UTC is included in the PTP Announce message, along with a flag that indicates whether the offset is valid. The SEL-700G uses the offset sent by the GM clock to determine UTC regardless of validity. Because of this, all SEL devices and other slave devices that share this behavior and are synchronized with the GM will retain relational accuracy with each other even if the GM may be incorrect in relation to UTC.

The Announce message may also include the current TAI to Local offset value (required in the Power, C37.238 profile). In accordance with IEEE 1588-2008 16.3.3.4, this value must include the TAI to UTC offset to reflect local time at the node, or slave device. If the SEL-700G receives a TAI to Local offset value that does not include the TAI to UTC offset, it may incorrectly calculate UTC and local time. Also, if the Announce message does not include the TAI to Local offset value, the SEL-700G uses its configured Time and Date Management Settings (UTC_OFF and DST_BEGM) to calculate local time. This is one reason that the SEL-700G Time and Date Management Settings must match the settings in the GM clock, or devices that are synchronized may have issues with time alignment.

SEL-700G relays only synchronize to clocks that serve TAI and they do not support PTP in SWITCHED NETMODE. Additionally, the maximum synchronization interval that SEL-700G relays can support is 16 seconds.

If you want to use PTP, PTP must be enabled in the Port 1 settings (EPTP := Y). The SEL-700G must be connected to a network containing an appropriate PTP master and all intervening switches must be IEEE 1588-aware. For SEL-700G relays, PTP is only available on Ethernet Ports 1A and 1B. See *Precision Time Protocol (PTP) on page 7.19* for more information on configuring the relay and the Ethernet network for PTP.

PTP Over PRP Networks

In SEL-700G relays, PTP over PRP is based on a first-come, first-served method. While the SEL-700G Relay monitors incoming traffic on both Port 1A and Port 1B, it synchronizes to the first port on which it receives its first PTP message. If incoming PTP messages stop on that synchronized port, the relay waits 70 seconds and if no PTP messages appear within those 70 seconds, it switches to the other port.

Breaker Failure Setting

The SEL-700G provides flexible breaker failure logic for as many as two breakers (see *Figure 4.148*). In the default breaker failure logic, the assertion of the Relay Word bit TRIP*m* (*m* = X, Y) starts the associated BFD timer if the sum of positive-sequence and negative-sequence currents is above 0.02 • I_{NOM}, where I_{NOM} is nominal CT rating 1 or 5 A. If the current remains above the threshold for the BFD delay setting, the Relay Word bit BFT*m* asserts. Use BFT*m* to operate an output relay to trip appropriate backup breakers.

NOTE: Breaker failure logic requires that either X or Y-side CTs meter the breaker currents. Do not use this element if the appropriate current inputs are not available in your application. For example, Figure 2.20 connections do not provide breaker currents to the relay.

Table 4.75 Breaker Failure Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
52A INTERLOCK	Y, N	52ABF := N
BRKRX FAIL DELAY	0.00–2.00 sec	BFDX := 0.50
BRKRX FAIL INIT	SELOGIC	BFIX := R_TRIG TRIPX
BRKRY FAIL DELAY	0.00–2.00 sec	BFDY := 0.50
BRKRY FAIL INIT	SELOGIC	BFIY := R_TRIG TRIPY

Changing the BFI*m* and/or 52ABF settings can modify the default breaker failure logic (52ABF is a common setting that applies to both logic schemes).

- Set BFIX := R_TRIG TRIPX AND NOT IN102 if input **IN102** is manual trip only and you do not want breaker failure initiation when the tripping is caused by this input.
- Set 52ABF := Y if you want the breaker failure logic to detect a failure of the breaker/contactor auxiliary contact to operate during the trip operation, as defined by the BFI*m* setting.

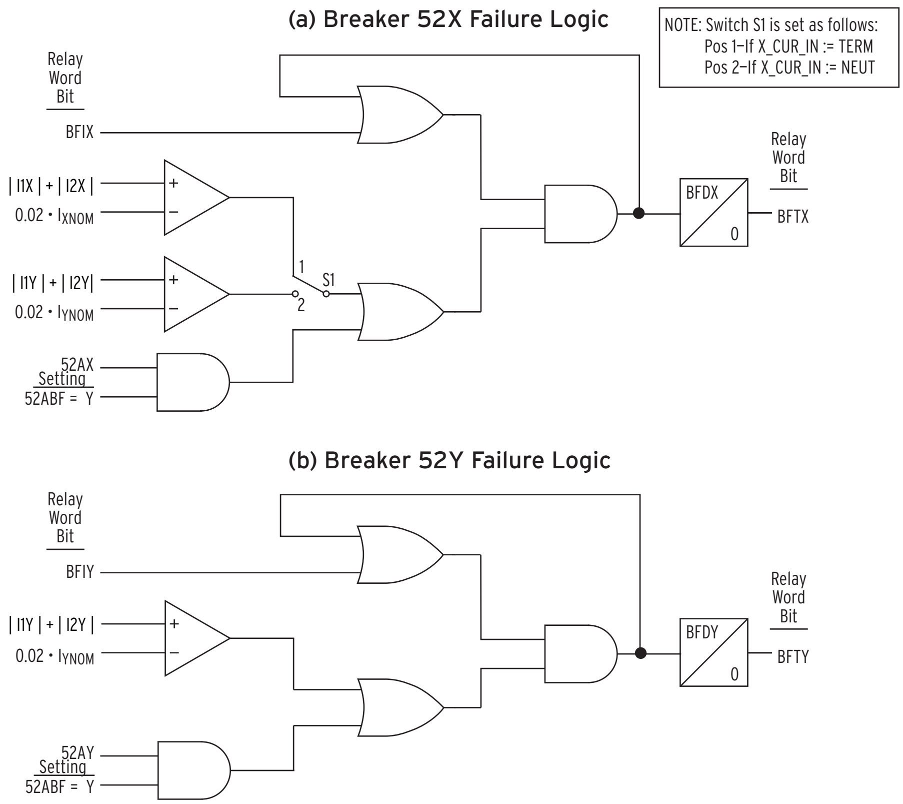


Figure 4.148 Breaker Failure Logic

Analog Inputs

The SEL-700G tracks the power system frequency and samples the analog inputs four times per power system cycle. For analog inputs, set the following parameters for each input:

- Analog type
- High and low input levels
- Engineering units

You can install different cards in the rear-panel slots of the SEL-700G relays. The relay setting prompt adapts to the *x* and *y* variables shown in *Figure 4.149*. Variable *x* displays the slot position (**3** through **5**), and variable *y* displays the transducer (analog) input number (1 through 4).

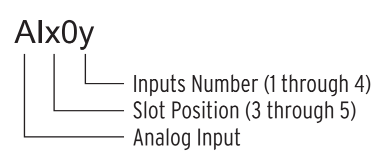


Figure 4.149 Analog Input Card Adaptive Name

Analog Input Calibration Process

In the analog input circuit, the dominant error is signal offset. To minimize the signal offset, we adjust each of the device analog input channels by a compensation factor. These compensation factors correct the signal offset errors to within ±1 µA or ±1 mV.

The signal offset compensation factor calculation procedure is as follows:

1. Turn the SEL-700G on and allow it to warm up for a few minutes.
2. Set the analog inputs for each analog channel to the necessary range, by using the AI*xxx*TYP, AI*xxx*L, AI*xxx*H, AI*xxx*EL, and AI*xxx*EH settings (for example, ±1 mA).
3. Short each analog input in turn at the device terminals using short, low resistance leads with solid connections.
4. Issue the command **MET AI 10** to obtain 10 measurements for each channel.
5. Record these 10 measurements, then calculate the average of the 10 measurements by adding the 10 values algebraically and dividing the sum by 10. This is the average offset error in engineering units at zero input (for example, –0.014 mA).
6. Negate this value (flip the sign) and add the result to each of the AI*xxx*EL and AI*xxx*EH quantities. For this example, the new AI*xxx*EL and AI*xxx*EH values are –0.986 mA and 1.014 mA.

Analog Input Setting Example

Assume that we installed an analog card in Slot **3**. On Input 1 of this analog card, we connect a 4–20 mA transducer driven from a device that measures temperature on a transformer load tap changer mechanism. For this temperature transducer, 4 mA corresponds to –50°C, and 20 mA corresponds to 150°C. You have already installed the correct hardware jumper (see *Figure 2.3* for more information) for Input 1 to operate as a current input. At power up, allow approximately five seconds for the SEL-700G to boot up, perform self-diagnostics, and detect installed cards. *Table 4.76* summarizes the steps and describes the settings we carry out in this example.

Table 4.76 Summary of Steps (Sheet 1 of 2)

	Step	Activity	Terse Description
General	1	SET G AI301NAM	Access settings for INPUT 1
	2	TX_TEMP	Enter a Tag name
	3	I	Select type of analog input; “I” for current
Transducer High/Low Output	4	4	Enter transducer low output (LOW IN VAL)
	5	20	Enter transducer high output (HI IN VAL)
Level	6	Degrees C	Enter Engineering unit
	7	–50	Enter Engineering unit value LOW
	8	150	Enter Engineering unit value HIGH
Low Warning/ Alarm	9	OFF	Enter LOW WARNING 1 value
	10	OFF	Enter LOW WARNING 2 value
	11	OFF	Enter LOW ALARM value

Table 4.76 Summary of Steps (Sheet 2 of 2)

	Step	Activity	Terse Description
High Warning/ Alarm	12	65	Enter HIGH WARNING 1 value
	13	95	Enter HIGH WARNING 2 value
	14	105	Enter HIGH ALARM value

NOTE: The AIx0yNAM setting cannot accept the following and will issue the Invalid Element message:
Analog Quantities
Duplicate Names
Other AI Names

Because the analog card is in Slot **3**, type **SET G AI301NAM <Enter>** to go directly to the setting for Slot **3**, Input 1. Although the device accepts alphanumeric characters, the name for the AI*x*0*y*NAM setting must begin with an alpha character (A through Z) and not a number. The device displays the following prompt:

```
AI301 TAG NAME (8 Characters)   AI301NAM:= AI301 ?
```

Use the Instrument Tag Name to give the analog quantity a more descriptive name. This tag name, instead of the default name of AI301, appears in reports (EVENT, METER, and SUMMARY). SELOGIC control equations, signal profiles, and Fast Message Read use the default names. Use as many as eight valid tag name characters to name the analog quantity. Valid tag name characters are: 0–9, A–Z, and the underscore (_). For this example, we assign TX_TEMP as the tag name.

Because this is a 4–20 mA transducer, enter **I <Enter>** (for a current-driven device) at AI301TYP, the next prompt (enter **V** if this is a voltage-driven device). The next two settings define the lower level (AI301L) and the upper level (AI301H) of the transducer. In this example, the low level is 4 mA and the high level is 20 mA.

```
AI301 TYPE (I,V)                AI301TYP:= I ?
```

NOTE: Because the SEL-700G accepts current values ranging from –20.48 to 20.48 mA, be sure to enter the correct range values.

The next three settings define the applicable engineering unit (AI301EU), the lower level in engineering units (AI301EL) and the upper level in engineering units (AI301EH). Engineering units refer to actual measured quantities (temperature, pressure, etc.). Use the 16 available characters to assign descriptive names for engineering units. Because we measure temperature in this example, enter “degrees C” (without quotation marks) as engineering units. Enter **–50 <Enter>** for the lower level and **150 <Enter>** for the upper level.

With the levels defined, the next six settings provide two warning settings and one alarm setting for low temperature values, as well as two warning settings and one alarm setting for high temperature values. State the values in engineering units, not the setting range of the transducer. Note the difference between low warnings and alarm functions and high warnings and alarm functions: low warnings and alarm functions assert when the measured value falls below the setting; high warnings and alarm functions assert when the measured values rise above the setting.

In this example, we measure the oil temperature of a power transformer, and we want the following three actions to take place at three different temperature values:

- At 65°C, start the cooling fans
- At 95°C, send an alarm
- At 105°C, trip the transformer

Because we are only interested in cases when the temperature values exceed their respective temperature settings (high warnings and alarm functions), we do not use the low warnings and alarm functions. Therefore, set the lower values (AI301LW1, AI301LW2, AI301LAL) to OFF, and set the three higher values as shown in *Figure 4.150*. Set inputs connected to voltage-driven transducers in a similar way.

```
=>>SET G AI301NAM TERSE <Enter>

Global
AI 301 Settings
AI301 TAG NAME (8 characters)
AI301NAM:= AI301
? TX_TEMP <Enter>
AI301 TYPE (I,V)                              AI301TYP:= I       ? <Enter>
AI301 LOW IN VAL (-20.480 to 20.480 mA)       AI301L  := 4.000   ? <Enter>
AI301 HI IN VAL (-20.480 to 20.480 mA)        AI301H  := 20.000  ? <Enter>
AI301 ENG UNITS (16 characters)
AI301EU := mA
? degrees C <Enter>
AI301 EU LOW (-99999.000 to 99999.000)        AI301EL := 4.000   ? -50 <Enter>
AI301 EU HI (-99999.000 to 99999.000)         AI301EH := 20.000  ? 150 <Enter>
AI301 LO WARN L1 (OFF,-99999.000 to 99999.000) AI301LW1:= OFF    ? <Enter>
AI301 LO WARN L2 (OFF,-99999.000 to 99999.000) AI301LW2:= OFF    ? <Enter>
AI301 LO ALARM (OFF,-99999.000 to 99999.000)  AI301LAL:= OFF     ? <Enter>
AI301 HI WARN L1 (OFF,-99999.000 to 99999.000) AI301HW1:= OFF    ? 65 <Enter>
AI301 HI WARN L2 (OFF,-99999.000 to 99999.000) AI301HW2:= OFF    ? 95 <Enter>
AI301 HI ALARM (OFF,-99999.000 to 99999.000)  AI301HAL:= OFF     ? 115 <Enter>
AI 302 Settings
AI302 TAG NAME (8 characters)
AI302NAM:= AI302
? END  <Enter>

Save changes (Y,N)? Y <Enter>
Settings Saved
=>>
```

Figure 4.150 Settings to Configure Input 1 as a 4–20 mA Transducer Measuring Temperatures Between –50°C and 150°C

Analog (DC Transducer) Input Board

Table 4.77 shows the setting prompt, setting range, and factory-default settings for an analog input card in Slot **3**. For the name setting (AI301NAM, for example), enter only alphanumeric and underscore characters. Characters are not case sensitive, but the device converts all lowercase characters to uppercase. Although the device accepts alphanumeric characters, the name for the AI301NAM setting must begin with an alpha character (A–Z) and not a number.

Table 4.77 Analog Input Card in Slot 3 (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
AI301 TAG NAME	8 characters 0–9, A–Z, _	AI301NAM := AI301
AI301 TYPE	I, V	AI301TYP := I
AI301 LOW IN VAL	–20.480 to +20.480 mA	AI301L := 4.000
AI301 HI IN VAL	–20.480 to +20.480 mA	AI301H := 20.000
AI301 LOW IN VAL	–10.240 to +10.240 V	AI301L := 0.000[a]
AI301 HI IN VAL	–10.240 to +10.240 V	AI301H := 10.000[a]
AI301 ENG UNITS	16 characters	AI301EU := mA
AI301 EU LOW	–99999.000 to +99999.000	AI301EL := 4.000
AI301 EU HI	–99999.000 to +99999.000	AI301EH := 20.000
AI301 LO WARN 1	OFF, –99999.000 to +99999.000	AI301LW1 := OFF
AI301 LO WARN 2	OFF, –99999.000 to +99999.000	AI301LW1 := OFF
AI301 LO ALARM	OFF, –99999.000 to +99999.000	AI301LAL := OFF
AI301 HI WARN 1	OFF, –99999.000 to +99999.000	AI301HW1 := OFF

Table 4.77 Analog Input Card in Slot 3 (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
AI301 HI WARN 2	OFF, –99999.000 to +99999.000	AI301HW2 := OFF
AI301 HI ALARM	OFF, –99999.000 to +99999.000	AI301HAL := OFF

[a] Voltage setting range for a voltage transducer (when AI301TYP := V).

Analog Outputs

If an SEL-700G configuration includes the four analog inputs and four analog outputs (4 AI/4 AO) card, the analog outputs are allocated to output numbers 1-4. *Figure 4.151* shows the *x* and *y* variable allocation for the analog output card.

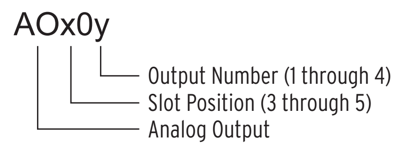


Figure 4.151 Analog Output Number Allocation

For an analog input/output card in Slot **3**, setting AO301AQ identifies the analog quantity we assign to Analog Output 1 (when set to OFF, the device hides all associated AO*x*0*y* settings and no value appears on the output). You can assign any of the analog quantities listed in *Appendix M: Analog Quantities*.

Table 4.78 shows the setting prompt, setting range, and factory-default settings for an analog card in Slot **3**.

NOTE: The SEL-700G hides the following settings with default values when you use a 3 DI/4 DO/1 AO card:
AOxx1TYP := I
AOxx1L := 4.000
AOxx1H := 20.000

Table 4.78 Output Setting for a Card in Slot 3

Setting Prompt	Setting Range	Setting Name := Factory Default
AO301 ANALOG QTY	Off, 1 analog quantity	AO301AQ := OFF
AO301 TYPE	I, V	AO301TYP := I
AO301 AQTY LO	–2147483647.000 to +2147483647.000	AO301AQL := 4.000
AO301 AQTY HI	–2147483647.000 to +2147483647.000	AO301AQH := 20.000
AO301 LO OUT VAL	–20.480 to +20.480 mA	AO301L := 4.000
AO301 HI OUT VAL	–20.480 to +20.480 mA	AO301H := 20.000
AO301 LO OUT VAL	–10.240 to +10.240 V	AO301L := 0.000[a]
AO301 HI OUT VAL	–10.240 to +10.240 V	AO301H := 10.000[a]

[a] Voltage setting range for a voltage transducer (when AO301TYP := V).

Example

In this example, assume we want to display in the control room the analog quantity (refer to *Appendix M: Analog Quantities*) IAX_MAG, Phase Angle current magnitude in primary amperes (0 to 3000 A range) using a –20 to +20 mA analog output channel. We install an analog input/output card in Slot **C** (SELECT 4 AI/4 AO) and set the card channel AO301, as shown in *Figure 4.152*. Note that the AO301 channel has to be configured as a “current analog output” channel (refer to *Figure 2.4* through *Figure 2.6*). The display instrument expects –20 mA when the IAX_MAG current is 0 amperes primary and +20 mA when it is 3000 amperes primary.

```
=>>SET G AO301AQ TERSE <Enter>

Global
AO 301 Settings
AO301 ANALOG QTY (OFF, 1 analog quantity)
AO301AQ := OFF
? IAX_MAG <Enter>
AO301 TYPE (I,V)                              AO301TYP:= I        ? <Enter>
AO301 AQTY LO (-2147483647.000 to 2147483647.000)
                                              AO301AQL:= 4.000    ? 0 <Enter>
AO301 AQTY HI (-2147483647.000 to 2147483647.000)
                                              AO301AQH:= 20.000   ? 3000 <Enter>
AO301 LO OUT VAL (-20.480 to 20.480 mA)       AO301L  := 4.000    ? –20 <Enter>
AO301 HI OUT VAL (-20.480 to 20.480 mA)       AO301H  := 20.000   ? 20 <Enter>
AO 302 Settings
AO302 ANALOG QTY (OFF, 1 analog quantity)
AO302AQ := OFF

? END <Enter>

Save changes (Y,N)? Y <Enter>

Settings Saved

=>>
```

Figure 4.152 Analog Output Settings

Breaker Monitor

The breaker monitor in the SEL-700G helps in scheduling circuit breaker maintenance. Refer to *Breaker Monitor on page 5.16* for a detailed description and see *Table 5.10* for the settings.

Digital Input Debounce

To comply with different control voltages, the SEL-700G offers dc and ac debounce modes. Therefore, if the control voltage is dc, select the dc mode of operation, and if the control voltage is ac, select the ac mode of operation. In general, debounce refers to a qualifying time delay before processing the change of state of a digital input. Normally, this delay applies to both the processing of the debounced input when used in device logic, and to time stamping in the SER. Following is a description of the two modes.

DC Mode Processing (DC Control Voltage)

Figure 4.153 shows the logic for the dc debounce mode of operation. To select the dc mode of debounce, set IN101D to any number between 0 and 65000 ms. In the figure, Input IN101 becomes IN101R (internal variable), after analog-to-digital conversion. On assertion, IN101R starts the debounce timer, and the logic produces Relay Word bit IN101 after the debounce time delay. The debounce timer is a pickup/dropout combination timer, with debounce setting IN101D applying to both pickup (pu) and dropout (do) timers; you cannot set any timer individually. For example, a setting of IN101D := 20 ms delays processing of the input signal by 20 ms (pu) and maintains the output of the timer (do) for 20 ms. Relay Word bit IN101 is the output of the debounce timer. If you do not want to debounce a particular input, you can still use Relay Word bit IN101 in logic programming, but you must set the debounce time delay to 0 (IN101D := 0).

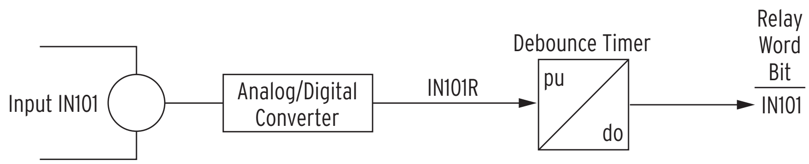


Figure 4.153 DC Mode Processing

AC Mode Processing (AC Control Voltage)

Figure 4.154 shows IN101R from Input IN101 applied to a pickup/dropout timer. As opposed to the dc mode, there are no time settings for the debounce timer in the ac mode: the pickup time delay is fixed at 2 ms, and the dropout time is fixed at 16 ms. Relay Word bit IN101 is the output of the debounce timer. To select the ac mode of debounce, set IN101D := AC.

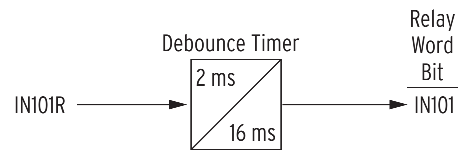


Figure 4.154 AC Mode Processing

Figure 4.155 shows a timing diagram for the ac mode of operation. On the rising edge of IN101R, the pickup timer starts timing (points marked 1 in *Figure 4.155*). If IN101R deasserts (points marked 2 in *Figure 4.155*) before expiration of the pickup time setting, Relay Word bit IN101 does not assert, but remains at logical 0. If, however, IN101R remains asserted for a period longer than the pickup timer setting, then Relay Word bit IN101 asserts to a logical 1.

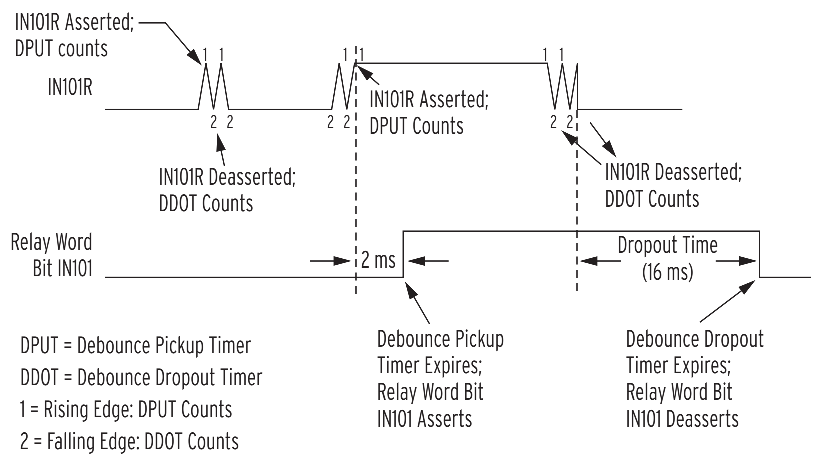


Figure 4.155 Timing Diagram for Debounce Timer Operation When Operating in AC Mode

Deassertion follows the same logic. On the falling edge of IN101R, the dropout timer starts timing. If IN101R remains deasserted for a period longer than the dropout timer setting, then Relay Word bit IN101 deasserts to a logical 0.

Table 4.79 shows the settings prompt, the setting range, and the factory-default settings for an 8 DI card in Slot **C**. See the *SEL-700G Settings Sheets* for a complete list of the input debounce settings.

Table 4.79 Slot C Input Debounce Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
IN301 DEBOUNCE	AC, 0–65000 ms	IN301D := 10
IN302 DEBOUNCE	AC, 0–65000 ms	IN302D := 10
IN303 DEBOUNCE	AC, 0–65000 ms	IN303D := 10
IN304 DEBOUNCE	AC, 0–65000 ms	IN304D := 10
IN305 DEBOUNCE	AC, 0–65000 ms	IN305D := 10
IN306 DEBOUNCE	AC, 0–65000 ms	IN306D := 10
IN307 DEBOUNCE	AC, 0–65000 ms	IN307D := 10
IN308 DEBOUNCE	AC, 0–65000 ms	IN308D := 10

Data Reset

The RSTTRGT setting resets the trip output and front-panel **TRIP** LED, provided that there is no trip condition present. See *Figure 4.131* for more details. The RSTENRGY and RSTMXMN settings reset the Energy and Max/Min Metering values, respectively. Assign a contact input (for example, RSTTRGT := IN401) to each of these settings if you want remote reset. The RSTDEM and RSTPKDEM settings reset demand and peak-demand. See *Figure 4.129* for the demand current logic diagram.

Table 4.80 Data Reset Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
RESET TARGETS	SELOGIC	RSTTRGT := 0
RESET ENERGY	SELOGIC	RSTENRGY := 0
RESET MAX/MIN	SELOGIC	RSTMXMN := 0
RESET DEMAND	SELOGIC	RSTDEM := 0
RESET PK DEMAND	SELOGIC	RSTPKDEM := 0

Access Control

NOTE: DSABLSET does not disable the setting changes from the serial or Ethernet ports.

NOTE: Do not set the maximum access level setting MAXACC := ACC on all ports at the same time when you are using the DSABLSET setting. This locks you out from editing settings.

The DSABLSET setting defines conditions for disabling all setting changes from the front-panel interface. To disable setting changes from the front-panel interface, assign, for example, a contact input (for example, DSABLSET := IN402) to the DSABLSET setting. When Relay Word bit DSABLSET asserts, you can view the device settings from the front-panel interface, but you can only change the settings by using serial port commands. *Table 4.81* shows the settings prompt, the setting range, and the factory-default settings.

Table 4.81 Setting Change Disable Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
DISABLE SETTINGS	SELOGIC	DSABLSET := 0

Time Synchronization Source

The SEL-700G accepts a demodulated IRIG-B time signal. *Table 4.82* shows the setting to identify the input for the signal. Set TIME_SRC := IRIG1 when you use relay terminals B01/B02 or EIA-232 serial Port 3 for the time signal input. When you use fiber-optic Port 2 for the signal, set the TIME_SRC := IRIG2. Refer to *IRIG-B Time-Code Input on page 2.22* and *IRIG-B on page 7.8* for additional information.

Table 4.82 Time Synchronization Source Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
IRIG TIME SOURCE	IRIG1, IRIG2	TIME_SRC := IRIG1

Disconnect Control Settings

The SEL-700G supports as many as eight two-position and two three-position disconnects. For the disconnect settings and logic, refer to *Disconnect Control Settings on page 9.2*. The SEL-700G Relay with the touchscreen display also provides you with the ability to design detailed single-line diagrams and to display the breaker and disconnect statuses. Refer to *Table 9.5* for typical disconnect symbols available for display on the bay screens. For the settings related to bay control disconnect symbols, refer to *Table 9.7* and the corresponding description.

Local/Remote Control

The SEL-700G supports local/remote control of the breakers and disconnects. For the settings related to the local/remote control function, refer to *Local/ Remote Control on page 9.7*. For breaker control via the front-panel pushbuttons, refer to *Front-Panel Operator Control Pushbuttons on page 8.15*. For breaker control via the two-line display, refer to *Control Menu on page 8.8*. The touchscreen allows you to control the breaker through two applications, **Bay Screens** and **Breaker Control**. For breaker control via the touchscreen display, refer to *Breaker/Disconnect Control Via the Touchscreen on page 9.8*.

Port Settings (SET P Command)

The SEL-700G provides the settings that allow you to configure the parameters for the communications ports. See *Section 2: Installation* for a detailed description of port connections. On the base unit, Port F (front panel) is an EIA-232 port; Port 1 is an optional Ethernet port(s); Port 2 is a fiber-optic serial port; and Port 3 (rear) is either an optional EIA-232 or EIA-485 port. On the optional communications card, you can select Port 4 as either EIA-485 or EIA-232 (not both) with the COMMINF setting. See *Table 4.83* through *Table 4.88* for the port settings. See the appropriate appendix for additional information on the protocols (DNP3, Modbus, EtherNet/IP, IEC 61850, IEC 60870-5-103, DeviceNet, MIRRORED BITS, and Synchrophasors) of interest.

The EPORT and MAXACC settings provide you with access controls for the corresponding port. Setting EPORT to N disables the port and hides the remaining port settings. The MAXACC setting selects the highest access level for the port.

PORT F

Table 4.83 Front-Panel Serial Port Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PORT	Y, N	EPORT := Y
PROTOCOL	SEL, MOD, EVMSG[a], PMU	PROTO := SEL
MAXIMUM ACCESS LEVEL	1, 2, C	MAXACC := 2
SPEED	300–38400 bps	SPEED := 9600
DATA BITS	7, 8 bits	BITS := 8

Table 4.83 Front-Panel Serial Port Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
PARITY	O, E, N	PARITY := N
STOP BITS	1, 2 bits	STOP := 1
PORT TIME-OUT	0–30 min	T_OUT := 5
HDWR HANDSHAKING	Y, N	RTSCTS := N
LANGUAGE	ENGLISH, SPANISH	LANG := ENGLISH
SEND AUTOMESSAGE	Y, N	AUTO := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

[a] When PROTO := EVMSG, the relay uses the settings BITS = 8, PARITY = N, and STOP = 1, regardless of any user-entered settings.

PORT 1

Table 4.84 Ethernet Port Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PORT	Y, N	EPORT := Y
ENABLE ETHERNET FIRMWARE UPGRADE	Y, N	EETHFWU := N
IP ADDRESS	zzz.yyy.xxx.www	IPADDR := 192.168.1.2
SUBNET MASK	15 characters	SUBNETM := 255.255.255.0
DEFAULT ROUTER	15 characters	DEFRTR := 192.168.1.1
ENABLE TCP KEEP-ALIVE	Y, N	ETCPKA := Y
TCP KEEP-ALIVE IDLE RANGE	1–20 sec	KAIDLE := 10
TCP KEEP-ALIVE INTERVAL RANGE	1–20 sec	KAINTV := 1
TCP KEEP-ALIVE COUNT RANGE	1–20	KACNT := 6
OPERATING MODE	FIXED, FAILOVER, SWITCHED, PRP	NETMODE := FAILOVER
FAILOVER TIMEOUT	OFF, 0.10–65.00 sec	FTIME := 1.00
PRIMARY NETPORT	A, B	NETPORT := A
PRP ENTRY TIMEOUT	400–10000 msec	PRPTOUT := 500
PRP DESTINATION ADDR LSB	0–255	PRPADDR := 0
PRP SUPERVISION TX INTERVAL	1–10 sec	PRPINTV := 2
NETWRK PORTA SPD	AUTO, 10, 100 Mbps	NETASPD := AUTO
NETWRK PORTB SPD	AUTO, 10, 100 Mbps	NETBSPD := AUTO
ENABLE TELNET	Y, N	ETELNET := Y
MAXIMUM ACCESS LEVEL	1, 2, C	MAXACC := 2
LANGUAGE	ENGLISH, SPANISH	LANG := ENGLISH
TELNET PORT	23, 1025–65534	TPORT := 23
TELNET CONNECT BANNER	254 characters	TCBAN := TERMINAL SERVER
TELNET TIME OUT	1–30 min	TIDLE := 15
FAST OP MESSAGES	Y, N	FASTOP := N

IMPORTANT: Upon relay initial turn on, Port 1 setting changes, or Logic setting changes, you may have to wait as long as two minutes before an additional settings change can occur. Note that the relay is functional with protection enabled as soon as the ENABLED LED comes on (about 5–10 seconds from turn on).

NOTE: The Telnet LANG setting also applies to the web server interface.

NOTE: The FAST OP MESSAGES setting only functions when using SEL Fast Operate protocol to operate/set/pulse breaker bits and remote bits. This setting has no effect on other protocols.

Table 4.84 Ethernet Port Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE FTP	Y, N	EFTPSERV := Y
FTP MAXIMUM ACCESS LEVEL	1, 2, C	FTPACC := 2
FTP USER NAME	20 characters	FTPUSER := FTPUSER
FTP CONNECT BANNER	254 characters	FTPBAN := FTP
ENABLE IEC 61850 PROTOCOL	Y, N	E61850 := N
ENABLE IEC 61850 GSE	Y, N	EGSE := N
ENABLE MMS FILE SERVICES	Y, N	EMMSFS := N
ENABLE 61850 MODE/ BEHAVIOR CONTROL	Y, N	E850MBC := N
ENABLE GOOSE TX IN OFF MODE	Y, N	EOFFMTX := N
ENABLE MODBUS SESSIONS	0–2	EMOD := 0
MODBUS MASTER IP ADDRESS	zzz.yyy.xxx.www[a]	MODIP1 := 0.0.0.0
MODBUS MASTER IP ADDRESS	zzz.yyy.xxx.www[a]	MODIP2 := 0.0.0.0
MODBUS TCP PORT 1	1–65534	MODNUM1 := 502
MODBUS TCP PORT 2	1–65534	MODNUM2 := 502
MODBUS TIMEOUT 1	15–900 sec	MTIMEO1 := 15
MODBUS TIMEOUT 2	15–900 sec	MTIMEO2 := 15
ENABLE HTTP SERVER	Y, N	EHTTP := Y
HTTP MAXIMUM ACCESS LEVEL	1, 2, C	HTTPACC := 2
TCP/IP PORT	1–65535	HTTPPORT := 80
HTTP CONNECT BANNER	254 ASCII printable characters	HTTPBAN := This system is for the use of authorized personnel only.
HTTP WEB SERVER TIMEOUT	1–60 min	HTTPIDLE := 10
ENABLE RSTP	Y, N	ERSTP := N
BRIDGE PRIORITY[b]	0–61440	BRDGPRI := 49152
PORTA PRIORITY[b]	0–240	PORTAPRI := 128
PORTB PRIORITY[b]	0–240	PORTBPRI := 128
ENABLE PMU PROCESSING[c]	0–2	EPMIP := 0
ENABLE DNP SESSIONS[d]	0–5	EDNP := 0
ENABLE SNTP CLIENT[e]	OFF, UNICAST, MANYCAST, BROADCAST	ESNTP := OFF
ENABLE PTP[f]	Y, N	EPTP := N
ENABLE ETHERNET/IP[g]	Y, N	EEIP := N

[a] MODIP1 and MODIP2 cannot share an address and must be unique (except when 0.0.0.0, which effectively disables security and allows any master to communicate).
[b] The bridge priority and port priority settings should be in increments of 4096 and 16, respectively.
[c] See Appendix K: Synchrophasors for a complete list of synchrophasor settings and their descriptions.
[d] See Table D.7 for a complete list of the DNP3 session settings.
[e] See Table 7.5 for a complete list of SNTP settings and the corresponding descriptions.
[f] See *Table 7.7* for a complete list of PTP settings and their descriptions.
[g] See *Table F.1* for a complete list of EtherNet/IP settings and their descriptions.

Port Number Settings Must be Unique

When you make the SEL-700G Port 1 settings, you cannot use port number settings for more than one protocol. The relay checks all of the settings shown in *Table 4.85* before saving changes. If a port number is used more than once, or if it matches any of the fixed port numbers (20, 21, 23, 102, 502), the relay displays an error message and returns to the first setting that is in error or contains a duplicate value.

Table 4.85 Port Number Settings That Must be Unique

Setting	Name	Setting Required When
TPORT	Telnet Port	Always
MODNUM1[a]	Modbus TCP Port 1	EMOD > 0
MODNUM2[a]	Modbus TCP Port 2	EMOD > 1
PMOTCP1	PMU Output 1 TCP/IP (Local) Port Number	PMOTS1 = TCP, UDP_T, or UDP_U
PMOTCP2	PMU Output 2 TCP/IP (Local) Port Number	PMOTS2 = TCP, UDP_T, or UDP_U
DNPNUM	DNPTCP and UDP Port	EDNP > 0
SNTPPORT	SNTPIP (Local) Port Number	ESNTP ≠ OFF
EPTP	Enable PTP	PTPPRO = DEFAULT and PTPTR = UDP (Ports 319 and 320 are reserved)
EEIP	Enable EtherNet/IP	EEIP ≠ N (Ports 2222/44818 are reserved)

[a] MODNUM1 and MODNUM2 can have the same port number. The relay displays an error message if this number matches with the port numbers of the other protocols.

PORT 2

NOTE: For additional settings when PROTO := MBxx, see Table J.5 as well as MIRRORED BITS Transmit SELOGIC Control Equations on page SET.38.

For additional settings when PROTO := DNP, see Table D.7 for a complete list of the DNP3 session settings.

Refer to Appendix H: IEC 60870-5-103 Communications for more information on IEC 60870-5-103.

Table 4.86 Fiber-Optic Serial Port Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PORT	Y, N	EPORT := Y
PROTOCOL	SEL, DNP, MOD, EVMSG[a], PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB, 103	PROTO := SEL
MAXIMUM ACCESS LEVEL	1, 2, C	MAXACC := 2
SPEED	300–38400 bps	SPEED := 9600
DATA BITS	7, 8 bits	BITS := 8
PARITY	O, E, N	PARITY := N
STOP BITS	1, 2 bits	STOP := 1
PORT TIME-OUT	0–30 min	T_OUT := 5
LANGUAGE	ENGLISH, SPANISH	LANG := ENGLISH
SEND AUTOMESSAGE	Y, N	AUTO := N
FAST OP MESSAGES	Y, N	FASTOP := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

[a] When PROTO := EVMSG, the relay uses the settings BITS = 8, PARITY = N, and STOP = 1, regardless of any user-entered settings.

PORT 3

Table 4.87 Rear-Panel Serial Port (EIA-232) Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PORT	Y, N	EPORT := Y
PROTOCOL	SEL, DNP, MOD, EVMSG[a], PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB, 103	PROTO := SEL
MAXIMUM ACCESS LEVEL	1, 2, C	MAXACC := 2
SPEED	300–38400 bps	SPEED := 9600
DATA BITS	7, 8 bits	BITS := 8
PARITY	O, E, N	PARITY := N
STOP BITS	1, 2 bits	STOP := 1
PORT TIMEOUT	0–30 min	T_OUT := 5
HDWR HANDSHAKING	Y, N	RTSCTS := N
LANGUAGE	ENGLISH, SPANISH	LANG := ENGLISH
SEND AUTOMESSAGE	Y, N	AUTO := N
FAST OP MESSAGES	Y, N	FASTOP := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

[a] When PROTO := EVMSG, the relay uses the settings BITS = 8, PARITY = N, and STOP = 1, regardless of any user-entered settings.

NOTE: For additional settings when PROTO := MBxx, see Table J.5 as well as MIRRORED BITS Transmit SELOGIC Control Equations on page SET.38.

For additional settings when PROTO := DNP, see Table D.7 for a complete list of the DNP3 session settings.

Refer to Appendix H: IEC 60870-5-103 Communications for more information on IEC 60870-5-103.

PORT 4

Table 4.88 Rear-Panel Serial Port (EIA-232/EIA-485) Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PORT	Y, N	EPORT := Y
PROTOCOL	SEL, MOD, DNET, DNP, EVMSG[a], PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB, 103	PROTO := SEL
MAXIMUM ACCESS LEVEL	1, 2, C	MAXACC := 2
COMM INTERFACE	232, 485	COMMINF := 232
SPEED	300–38400 bps	SPEED := 9600
DATA BITS	7, 8 bits	BITS := 8
PARITY	O, E, N	PARITY := N
STOP BITS	1, 2 bits	STOP := 1
PORT TIMEOUT	0–30 min	T_OUT := 5
HDWR HANDSHAKING	Y, N	RTSCTS := N
LANGUAGE	ENGLISH, SPANISH	LANG := ENGLISH
SEND AUTOMESSAGE	Y, N	AUTO := N
FAST OP MESSAGES	Y, N	FASTOP := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

[a] When PROTO := EVMSG, the relay uses the settings BITS = 8, PARITY = N, and STOP = 1, regardless of any user-entered settings.

NOTE: For additional settings when PROTO := MBxx, see Table J.5 as well as MIRRORED BITS Transmit SELOGIC Control Equations on page SET.38.

For additional settings when PROTO := DNP, see Table D.7 for a complete list of the DNP3 session settings.

Refer to Appendix H: IEC 60870-5-103 Communications for more information on IEC 60870-5-103.

Set the speed, data bits, parity, and stop bits settings to match the serial port configuration of the equipment that is communicating with the serial port.

After port timeout minutes of inactivity on a serial port at Access Level 2, the port automatically returns to Access Level 0. This security feature helps prevent unauthorized access to the relay settings if the relay is accidentally left in Access Level 2. If you do not want the port to time out, set Port Timeout equal to 0 minutes.

For detailed information on communications protocols, refer to *Appendix C: SEL Communications Processors*, *Appendix D: DNP3 Communications*, *Appendix E: Modbus Communications*, *Appendix F: EtherNet/IP Communications*, *Appendix G: IEC 61850 Communications*, *Appendix H: IEC 60870-5-103 Communications*, *Appendix I: DeviceNet Communications*, *Appendix J: MIRRORED BITS Communications*, and *Appendix K: Synchrophasors*.

Use the MBT option if you are using a Pulsar MBT9600 Four Wire Modem (see *Appendix J: MIRRORED BITS Communications* for more information). With this option set, the relay transmits a message every second processing interval, and the device deasserts the RTS signal on the EIA-232 connector. Also, the device monitors the CTS signal on the EIA-232 connector, which the modem deasserts if the channel has too many errors. The modem uses the device RTS signal to determine whether the MB or MB8 MIRRORED BITS protocol is in use.

The relay EIA-232 serial ports support software (XON/XOFF) flow control. To enable support for hardware (RTS/CTS) flow control, set the RTSCTS setting equal to Y.

On Ports F, 2, 3, and 4, when PROTO := SEL, use the LANG setting to communicate with the relay in English or Spanish. On Port 1, when ETELNET := Y, use the LANG setting to communicate with the relay in English or Spanish. Refer to the *SEL-700G Relay Command Summary* for commands in both languages.

Set the AUTO := Y to allow automatic messages at a serial port.

Set FASTOP := Y to enable binary Fast Operate messages at the serial port. Set FASTOP := N to block binary Fast Operate messages. Refer to *Appendix C: SEL Communications Processors* for the description of the SEL-700G Fast Operate commands.

Set PROTO := DNET to establish communications when the DeviceNet card is used. *Table 4.89* shows the additional settings, which can be set only at the rear on the DeviceNet card. Once the relay detects the DeviceNet card, all **Port 4** settings are hidden. Refer to *Appendix I: DeviceNet Communications* for details on DeviceNet.

Table 4.89 Rear-Panel DeviceNet Port Settings

Setting Name	Setting Range
MAC_ID	0–63
ASA	8 Hex characters assigned by factory
DN_Rate	125, 250, 500 kbps

Front-Panel Settings (SET F Command)

The SEL-700G supports various front-panel options (see *Table 1.4*). This section covers all of the front-panel related settings, except the touchscreen display settings. Refer to *Table 9.7* for the touchscreen display settings. The touchscreen display settings are not settable via the **SET F** command.

General Settings

Local bits provide control from the front panel (local bits), and display points show selected information on the LCD. However, you need to first enable the appropriate number of local bits and display points necessary for your application. When your SEL-700G arrives, two display points are already enabled, but no local bits are enabled. If more display points are necessary for your application, use the EDP setting to enable as many as 32 display points. Use the ELB setting to enable as many as 32 local bits. The EDP setting and the corresponding display point settings are not available for the touchscreen display model. The touchscreen display model provides you with the ability to configure bay screens with analog and digital labels, similar to the display point functionality in the two-line display model. Refer to *Section 9: Bay Control* for the procedure to create configurable bay screens.

Table 4.90 Display Point and Local Bit Default Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
DISPLAY PTS ENABL	N, 1–32	EDP := 2
LOCAL BITS ENABL	N, 1–32	ELB := N

To optimize the time you spend on setting the device, only the number of enabled display points and enabled local bits become available for use. Use the front-panel LCD timeout setting FP_TO as a security measure. If the display is within an Access Level 2 function when a timeout occurs, such as the device setting entry, the function is automatically terminated (without saving changes) after inactivity for this length of time. After terminating the function, the front-panel display returns to the default display. The FP_TO setting is not available in the touchscreen display model. Refer to *Section 9: Bay Control* for the touchscreen display settings. If you prefer to disable the front-panel timeout function during device testing, set the LCD timeout equal to OFF.

Use the front-panel LCD contrast setting FP_CONT to adjust the contrast of the LCD. The FP_CONT setting is not available in the touchscreen display model.

Use the front-panel automessage setting FP_AUTO to define the display of Trip/Warning messages. Set FP_AUTO either to OVERRIDE or ROTATING for when the relay triggers a Trip/Warning message. Choosing OVERRIDE will have the Trip/Warning message override the rotating display, while choosing ROTATING will add the Trip/Warning message to the rotating display. Refer to *Table 9.7* for the equivalent touchscreen display settings. Note that the FP_AUTO setting is not available in the touchscreen display model. The touchscreen display provides settings that allow you to choose from a wide range of screens, including custom screens, to display as part of the rotating display. The touchscreen automatically flashes a screen that overrides the rotating display in the case of trip or diagnostic failures. Refer to *Section 8: Front-Panel Operations* for more information on trip and diagnostic messages.

Set RSTLED := Y to automatically reset the latched LEDs when the breaker or contactor closes.

The MAXACC setting (under *Front-Panel Settings (SET F Command)*) selects the highest access level for the front-panel HMI. If MAXACC is set to 1, the front-panel HMI only allows metering and read access to the settings. If MAXACC is set to 2, the front-panel HMI allows breaker control and read/write access to the settings.

NOTE: All target LED settings can be found in Table 4.99.

Table 4.91 LCD Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
LCD TIMEOUT[a]	OFF, 1–30 min	FP_TO := 15
LCD CONTRAST[a]	1–8	FP_CONT := 5
FP AUTOMESSAGES[a]	OVERRIDE, ROTATING	FP_AUTO := OVERRIDE
CLOSE RESET LEDS	Y, N	RSTLED := Y
MAXIMUM ACCESS LEVEL[a]	1, 2, C	MAXACC := 2

[a] These settings are not supported in the touchscreen display model.

Display Points

NOTE: The rotating display is updated approximately every two seconds.

Use display points to view either the state of internal relay elements (Boolean information) or analog information on the LCD. Although the LCD displays a maximum of 16 characters at a time, you can enter as many as 60 valid characters. Valid characters are 0–9, A–Z, -, /, ", {, }, space. For text exceeding 16 characters, the LCD displays the first 16 characters. It then scrolls through the remaining text not initially displayed on the screen.

Table 4.92 Front-Panel Display Point Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
DISPLAY POINT DP01	60 characters	DP01 := RID
DISPLAY POINT DP02	60 characters	DP02 := TID
DISPLAY POINT DP03	60 characters	DP03 :=
•	•	•
•	•	•
•	•	•
DISPLAY POINT DP32	60 characters	DP32 :=

Boolean Display Point Entry Composition

Boolean information is the status of Relay Word bits (see *Appendix L: Relay Word Bits*). In general, the legal syntax for Boolean display points consists of the following four fields or strings, separated by commas:

Relay Word bit Name, “Alias,” “Set String,” “Clear String.”

where:

Name = Relay Word bit name (IN101, for example). All binary quantities occupy one line on the front-panel display (all analog quantities occupy two lines).

Alias = A more descriptive name for the Relay Word bit (such as TRANSFORMER 3), or the analog quantity (such as TEMPERATURE).

Set String = State what should be displayed on the LCD when the Relay Word bit is asserted (CLOSED, for example)

Clear String = State what should be displayed on the LCD when the Relay Word bit is deasserted (OPEN, for example)

Any or all of Alias, Set String, or Clear String can be empty. Although the relay accepts an empty setting Name as valid, a display point with an empty Name setting is always hidden (see below). Commas are significant in identifying and separating the four strings. Use quotation marks only if the text you enter for Alias, Set String, or Clear String contains commas or spaces. For example, DP01 := Name, Text is valid, but Name, Alias 3 is not valid (contains a space). Correct the Alias name by using the quotation marks: Name, “Text 3”. You can customize the data display format by entering data in selected strings only. *Table 4.93* shows the various display appearances resulting from entering data in selected strings.

Hidden (No Display)

A display point is hidden when the settings are entered (DP*n* := XX, where *n* = 01 through 32 and XX = any valid setting), but nothing shows on the front-panel display. *Table 4.93* shows examples of the settings that always, never, or conditionally hide a display point.

Table 4.93 Settings That Always, Never, or Conditionally Hide a Display Point

Programmable Automation Controller Setting	Name	Alias	Set String	Clear String	Comment
DP01 := IN101,TRFR1,CLOSED,OPEN	IN101	TRFR1	CLOSED	OPEN	Never hidden
DP01 := IN101,TRFR1	IN101	TRFR1	—	—	Never hidden
DP01 := NA	—	—	—	—	Always hidden
DP01 := IN101,,,	IN101	—	—	—	Always hidden
DP01 := IN101,TRFR1,,	IN101	TRFR1	—	—	Always hidden
DP01 := IN101,TRFR1,CLOSED,	IN101	TRFR1	CLOSED	—	Hidden when IN101 is deasserted
DP01 := IN101,"TRFR 1",,OPEN	IN101	TRFR 1	—	OPEN	Hidden when IN101 is asserted
DP01 := 1,{}	1	{}	—	—	Displays empty line
DP01 := 1,"Fixed Text"	1	Fixed Text	—	—	Displays the fixed text
DP01 := 0	0	—	—	—	Hides the display point

Following are examples of selected display point settings, showing the resulting front-panel displays. For example, at a certain station we want to display the status of both HV and LV circuit breakers of Transformer 1. When the HV circuit breaker is open, we want the LCD to show: `TRFR 1 HV BRKR: OPEN`. When the HV circuit breaker is closed, we want the display to show: `TRFR 1 HV BRKR: CLOSED`. We also want similar displays for the LV breaker.

After connecting a form a (normally open) auxiliary contact from the HV circuit breaker to Input **IN101** and a similar contact from the LV circuit breaker to Input **IN102** of the SEL-700G, we are ready to program the display points, using the following information for the HV breaker (LV breaker is similar):

- Relay Word bit—IN101
- Alias—TRFR 1 HV BRKR:

- Set String—CLOSED (the form a [normally open] contact asserts or sets Relay Word bit IN101 when the circuit breaker is closed)
- Clear String—OPEN (the form a [normally open] contact deasserts or clears Relay Word bit IN101 when the circuit breaker is open)

Name, Alias, Set String, and Clear String

When all four strings have entries, the relay reports all states.

Table 4.94 Entries for the Four Strings

Name	Alias	Set String	Clear String
IN101	TRFR 1 HV BRKR	CLOSED	OPEN

Figure 4.156 shows the settings for the example, when you use the **SET F** command. Use the **>** character to move to the next settings category.

```
=>>SET F TERSE <Enter>
Front Panel
General Settings
DISPLY PTS ENABL (N,1-32)                      EDP     := 4         ? > <Enter>
Target LED Set
TRIP LATCH T_LED (Y,N)                         T01LEDL := Y         ? > <Enter>
Display Point Settings (maximum 60 characters):
(Boolean): Relay Word Bit Name, "Alias", "Set String", "Clear String"
(Analog) : Analog Quantity Name, "User Text and Formatting"
DISPLAY POINT DP01 (60 characters)
DP01    := RID,"{16}"
? IN101,"TRFR 1 HV BRKR:",CLOSED,OPEN <Enter>
DISPLAY POINT DP02 (60 characters)
DP02    := TID,"{16}"
? IN102,"TRFR 1 LV BRKR:",CLOSED,OPEN <Enter>
DISPLAY POINT DP03 (60 characters)
DP03    := IAV, "I MOTOR {6} A"
? END <Enter>
Save changes (Y,N)? Y <Enter>
Settings Saved
=>>
```

Figure 4.156 Display Point Settings

Figure 4.157 shows the display when both HV and LV breakers are open (both IN101 and IN102 deasserted). *Figure 4.158* shows the display when the HV breaker is closed, and the LV breaker is open (IN101 asserted, but IN102 still deasserted).

Figure 4.157 Front-Panel Display—Both HV and LV Breakers Open

Figure 4.158 Front-Panel Display—HV Breaker Closed, LV Breaker Open

Name String, Alias String, and Either Set String or Clear String Only

The following discusses omission of the Clear String; omission of the Set String gives similar results. Omitting the Clear String causes the relay to only show display points in the set state, when you use the **SET F** command, as follows:

```
DP01    := RID, "{16}"
 ? IN101,"TRFR 1 HV BRKR:",CLOSED <Enter>
```

When the Relay Word bit IN101 deasserts, the relay removes the complete line with the omitted Clear String (TRFR 1 HV BRKR). When both breakers are closed, the relay has the set state information for both HV and LV breakers, and the relay displays the information as shown in *Figure 4.159*. When the HV breaker opens (LV breaker is still closed), the relay removes the line containing the HV breaker information because the Clear String information was omitted. Because the line containing the HV breaker information is removed, the relay now displays the LV breaker information on the top line, as shown in *Figure 4.160*.

Figure 4.159 Front-Panel Display—Both HV and LV Breakers Closed

Figure 4.160 Front-Panel Display—LV Breaker Closed

If you want the relay to display a blank state when IN101 deasserts instead of removing the line altogether, use the curly brackets {} for the Clear String, as follows:

```
DP01    := RID, "{16}"
 ? IN101,"TRFR 1 HV BRKR:",CLOSED,{} <Enter>
```

When Input IN101 now deasserts, the relay still displays the line with the HV breaker information, but the state is left blank, as shown in *Figure 4.161*.

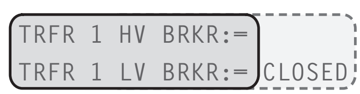


Figure 4.161 Front-Panel Display—HV Breaker Open, LV Breaker Closed

Name Only

Table 4.95 shows an entry in the Name String only (leaving the Alias string, Set String, and Clear String void), when you use the **SET F** command, as follows:

```
DP01    := RID, "{16}"
 ? IN101 <Enter>
```

Table 4.95 Binary Entry in the Name String Only

Name	Alias	Set String	Clear String
IN101	—	—	—

Figure 4.162 shows the front-panel display for the entry in *Table 4.95*. Input IN101 is deasserted in this display (IN101=0), but the display changes to IN101=1 when Input IN101 asserts.

```
IN101=0
```

Figure 4.162 Front-Panel Display for a Binary Entry in the Name String Only

Analog Display Point Entry Composition

In general, the legal syntax for analog display points consists of the following two fields or strings:

Name, "User Text and Formatting."

where:

Name = Analog quantity name (AI301 for example). All analog quantities occupy two lines on the front-panel display (all binary quantities occupy one line on the display).

User text and numerical formatting = Display the user text, replacing the numerical formatting {width.dec, scale} with the value of Name, scaled by "scale" formatted with total width "width" and "dec" decimal places. Name can be either an analog quantity or a Relay Word bit. The width value includes the decimal point and sign character, if applicable. The "scale" value is optional; if omitted, the scale factor is 1. If the numeric value is smaller than the string size requested, the string is padded with spaces to the left of the number. If the numeric value does not fit within the string width given, the string grows (to the left of the decimal point) to accommodate the number.

Unlike binary quantities, the relay displays analog quantities on both display lines. *Table 4.96* shows an entry in the Name string only (leaving the User Text and Formatting string void) with the following syntax:

Table 4.96 Analog Entry in the Name String Only

Name	Alias	Set String	Clear String
AI301	—	—	—

Figure 4.163 shows the front-panel display for the entry in *Table 4.96*, when you use the **SET F** command, as follows:

```
P01    := RID, "{16}"
? AI301 <Enter>
```

```
AI301
             5.36 mA
```

Figure 4.163 Front-Panel Display for an Analog Entry in the Name String Only

For a more descriptive name of the Relay Word bit, enter the Relay Word bit in the Name String and an alias name in the User Text and Formatting String. *Table 4.97* shows a Boolean entry in the Name and Alias Strings (DP01) and an entry in the Name and User Text and Formatting Strings (DP02), when you use the **SET F** command, as follows:

```
DP01    := RID, “{16}”
 ? IN101,"INPUT IN101:" <Enter>
DP02    := TID, “{16}”
 ? AI301,TEMPERATURE: <Enter>
```

Table 4.97 Entry in the Name String and the Alias Strings

Name	Alias	Set String	Clear String
IN101	INPUT IN101	—	—
AI301	TEMPERATURE	—	—

Figure 4.164 shows the front-panel display for the entry in *Table 4.97*. Input IN101 is deasserted in this display (0), and the display changes to `INPUT IN101=1` when Input IN101 asserts.

Figure 4.164 Front-Panel Display for an Entry in (a) Boolean Name and Alias Strings and (b) Analog Name and User Text and Formatting Strings

If the engineering units are set, then the front-panel display shows the engineering units. For example, in the Group setting example, we set AI301EU to degrees C. With this setting, the front-panel display looks similar to *Figure 4.165*.

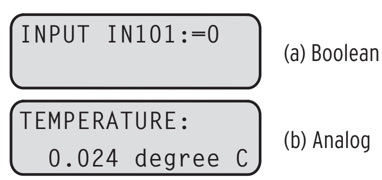


Figure 4.165 Front-Panel Display for an Entry in (a) Boolean Name and Alias Strings and (b) Analog Name, User Text and Formatting Strings, and Engineering Units

For fixed text, enter a 1 in the Name String, then enter the fixed text as the alias text. For example, to display the word DEFAULT and SETTINGS on two different lines, use a display point for each word (DP01 = 1,“DEFAULT” and DP02 = 1,“SETTINGS,” for example). *Table 4.98* shows other options and front-panel displays for the User Text and Formatting settings.

Table 4.98 Example Settings and Displays

Example Display Point Setting Value	Example Display
AI301,"TEMP {4}deg C"	TEMP 1234 deg C
AI301,"TEMP := {4.1}"	TEMP = xx.x
AI301,"TEMP := {5}"	TEMP = 1230
AI301,"TEMP = {4.2, 0.001} C"	TEMP = 1.23 C
AI301,"TEMP HV HS1 = {4, 1000}"	TEMP HV HS1 = 1234
1,{}	Empty line
1,"Fixed Text"	Fixed Text
0	Hides the display point

Following is an example of an application of the analog settings. Assume that we also want to know the hot-spot temperature, oil temperature, and winding temperature of the transformer at a certain installation. To measure these temperatures, we install an analog card in relay Slot **C**, and we connect 4–20 mA transducers inputs to analog inputs AI301 (hot-spot temperature), AI302 (oil temperature), and AI303 (winding temperature).

First, enable enough display points for the analog measurements (e.g., EDP = 5). *Figure 4.166* shows the settings to add the three transducer measurements. (Use the > character to move to the next settings category.)

```
=>>SET F TERSE <Enter>
Front Panel
General Settings
DISPLY PTS ENABL (N,1-32)                     EDP     := 4         ? 5 <Enter>
LOCAL BITS ENABL (N,1-32)                     ELB     := 1         ? > <Enter>
Target LED Set
TRIP LATCH T_LED (Y,N)                        T01LEDL := Y         ?> <Enter>
Display Point Settings (maximum 60 characters):
(Boolean): Relay Word Bit Name, "Alias", "Set String", "Clear String"
(Analog) : Analog Quantity Name, "User Text and Formatting"
DISPLAY POINT DP01 (60 characters)
DP01    := IN101,"TRFR 1 HV BRKR:",CLOSED,OPEN
? <Enter>
DISPLAY POINT DP02 (60 characters)
DP02    := IN102,"TRFR 1 LV BRKR:",CLOSED,OPEN
? <Enter>
DISPLAY POINT DP03 (60 characters)
DP03    := IAV, "I MOTOR {6} A"
? AI301,"HOT SPOT TEMP" <Enter>
DISPLAY POINT DP04 (60 characters)
DP04    := TCUSTR, "Stator TCU {3} %"
? AI302,"OIL TEMPERATURE" <Enter>
DISPLAY POINT DP05 (60 characters)
DP05    := IA_MAG, "IA {7.1} A pri"
? AI303,"WINDING TEMP" <Enter>
Save changes (Y,N)? Y <Enter>
Settings Saved
=>>
```

Figure 4.166 Adding Temperature Measurement Display Points

Rotating Display

With more than two display points enabled, the relay scrolls through all enabled display points, thereby forming a rotating display, such as that shown in *Figure 4.167*.

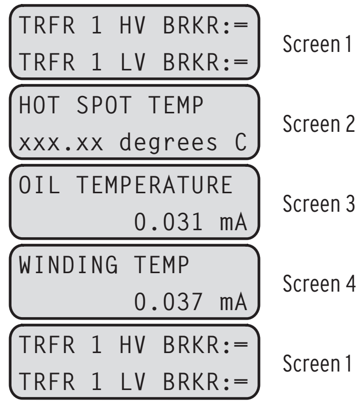


Figure 4.167 Rotating Display

To change the temperature units to more descriptive engineering units, enter your units with the AI*xxx*EU (for example, AI302EU) setting.

Local Bits

Local bits are variables (LB*nn*, where *nn* means 01 through 32) that are controlled from front-panel pushbuttons. Use local bits to replace traditional panel switches. The states of the local bits are stored in nonvolatile memory every second. When power to the device is restored, the local bits will go back to their states after the device initialization. Each local bit requires three of the following four settings, using a maximum of 14 valid characters for the NLB*nn* setting and a maximum of seven valid characters (0–9, A–Z, -, /, ., space) for the remainder:

- NLB*nn*: Names the switch (normally the function that the switch performs, such as SUPERV SW) that appears on the LCD.
- CLB*nn*: Clears local bit. Enter the text that describes the intended operation of the switch (this text appears on the display) when LB*nn* deasserts (OPEN, for example).
- SLB*nn*: Sets local bit. Enter the text that describes the intended operation of the switch (this text appears on the display) when LB*nn* asserts (CLOSE, for example).
- PLB*nn*: Pulses local bit. When selecting the pulse operation, LB*nn* asserts for only one processing interval before deasserting again. Enter the text that describes the intended operation when LB*nn* asserts (START, for example).
- Omit either SLB*nn* or PLB*nn* (never CLB*nn*) by setting the omitted setting to NA.

For the transformer in our example, configure two local bits: one to replace a supervisory switch, and the other to start a fan motor. Local bit 1 replaces a supervisory switch (SUPERV SW), and we use the clear/set combination. Local bit 2 starts a fan motor (START) that only needs a short pulse to seal itself in, and we use the clear/pulse combination. *Figure 4.168* shows the settings to program the two local bits.

```
=>>SET F TERSE <Enter>
Front Panel
General Settings
DISPLY PTS ENABL (N,1-32)                      EDP     := 5        ? <Enter>
LOCAL BITS ENABL (N,1-32)                      ELB     := N        ? 2 <Enter>
LCD TIMEOUT (OFF,1-30 min)                     FP_TO   := 15       ? > <Enter>
Target LED Set
TRIP LATCH T_LED (Y,N)                         T01LEDL := Y        ? > <Enter>
Display Point Settings (maximum 60 characters):
(Boolean): Relay Word Bit Name, "Alias", "Set String", "Clear String"
(Analog) : Analog Quantity Name, "User Text and Formatting"
DISPLAY POINT DP01 (60 characters)
DP01    := IN101,"TRFR 1 HV BRKR:",CLOSED,OPEN
? > <Enter>
Local Bits Labels:
LB_ NAME (14 characters; Enter NA to null)
NLB01   :=
? SPERV SW <Enter>
CLEAR LB_ LABEL (7 characters; Enter NA to null)
CLB01   :=
? OPEN <Enter>
SET LB_ LABEL (7 characters; Enter NA to null)
SLB01   :=
? CLOSE <Enter>
PULSE LB_ LABEL (7 characters; Enter NA to null)
PLB01   :=
? NA <Enter>
LB_ NAME (14 characters; Enter NA to null)
NLB02   :=
? FAN START <Enter>
CLEAR LB_ LABEL (7 characters; Enter NA to null)
CLB02   :=
? OFF <Enter>
SET LB_ LABEL (7 characters; Enter NA to null)
SLB02   :=
? NA <Enter>

PULSE LB_ LABEL (7 characters; Enter NA to null)
PLB02   :=
? START <Enter>
Save changes (Y,N)? Y <Enter>
Settings Saved
=>>
```

Figure 4.168 Adding Two Local Bits

Target LED Settings

The SEL-700G offers the following two types of LEDs. See *Figure 8.2* and *Figure 8.28* for the programmable LED locations:

- ➤ One **ENABLED** and one **TRIP** tricolored target LED
- ➤ Six tricolored programmable target LEDs
- ➤ Sixteen tricolored programmable pushbutton LEDs

You can program all 22 LEDs using SELOGIC control equations, the only difference being that the target LEDs also include a latch function.

Target LEDs

The **ENABLED** and **TRIP** LEDs are not programmable. Except for choosing the LED illuminated color (LEDENAC or LEDTRPC), they are fixed-function LEDs. The **ENABLED** LED illuminates when the SEL-700G is powered correctly, is functional, and has no self-test failures. The **TRIP** LED illuminates and latches in at the rising-edge of any trip that comes from the trip logic. The LEDENAC setting is not supported in the touchscreen display models. For touchscreen display relays, the illuminated color of the **ENABLED** LED is fixed at green.

The settings T*n*_LEDL (*n* = 01 through 06) and T*n*_LED (*n* = 01 through 06) control the six front-panel LEDs. If setting T*n*_LEDL is set to Y, the LED will assert if a trip condition occurs and the T0*n*_LED equation is asserted within 1.5 cycles of the trip assertion. At this point, the LED is latched. To reset these

NOTE: If the LED latch setting (TnLEDL) is set to Y, and TRIP asserts, the LED latches to the state at TRIP assertion. The latched LED targets can be reset using TARGET RESET if the target conditions are absent.

latched LEDs, the TRIP condition should no longer exist and one of the following takes place:

- Pressing **TARGET RESET** on the front panel.
- Issuing the serial port command **TAR R**.
- The assertion of the SELOGIC control equation RSTTRGT.

With the T*n*LEDL settings set to N, the LEDs do not latch and directly follow the state of the associated SELOGIC control equation setting.

Enter any of the Relay Word bits (or combinations of Relay Word bits) as conditions in the T*n*_LED SELOGIC control equation settings. When these Relay Word bits assert, the corresponding LED also asserts.

Table 4.99 shows the target LED settings. The factory-default settings shown match the as-shipped front-panel overlay (see *Figure 8.2*). You can change the settings to suit your application. See *Section 8: Front-Panel Operations* for slide-in labels for custom LED designations.

Table 4.99 Target LED Settings (Sheet 1 of 2)

Setting Prompt	Setting Range[a]	Setting Name := Factory Default
ENA_LED COLOR[b]	R, G, A	LEDENAC := G
TRIP_LED COLOR	R, G, A	LEDTRPC := R
TRIP LATCH T_LED	Y, N	T01LEDL := Y
TARGET T_LED ASSERTED COLOR[c]	R, G, A	T01LEDC := R
LED1 EQUATION	SELOGIC	T01_LED := 87U OR 87R OR 87N1T OR 87N2T[d,e] T01_LED := 50PX1T OR 50PX2T OR 50PX3AT OR 50PX3BT OR 50PX3CT OR 51PXT[f]
TRIP LATCH T_LED	Y, N	T02LEDL := Y
TARGET T_LED ASSERTED COLOR[c]	R, G, A	T02LEDC := R
LED2 EQUATION	SELOGIC	T02_LED := ORED50T OR ORED51T OR 46Q1T OR 46Q2T OR 51VT OR 51CT[d,e] T02_LED := 50GX1T OR 50GX2T OR 51GXT[f]
TRIP LATCH T_LED	Y, N	T03LEDL := Y
TARGET T_LED ASSERTED COLOR[c]	R, G, A	T03LEDC := R
LED3 EQUATION	SELOGIC	T03_LED := 81T OR 81RT OR BNDT[d,e] T03_LED := 50QX1T OR 50QX2T OR 51QXT[f]
TRIP LATCH T_LED	Y, N	T04LEDL := Y
TARGET T_LED ASSERTED COLOR[c]	R, G, A	T04LEDC := R
LED4 EQUATION	SELOGIC	T04_LED := 24D1T OR 24C2T[d,e] T04_LED := 50PY1T OR 50PY2T OR 50PY3AT OR 50PY3BT OR 50PY3CT OR 51PYT[f]
TRIP LATCH T_LED	Y, N	T05LEDL := Y
TARGET T_LED ASSERTED COLOR[c]	R, G, A	T05LEDC := R

Table 4.99 Target LED Settings (Sheet 2 of 2)

Setting Prompt	Setting Range[a]	Setting Name := Factory Default
LED5 EQUATION	SELOGIC	T05_LED := 40Z1T OR 40Z2T[d,e] T05_LED := 50GY1T OR 50GY2T OR 51GYT[f]
TRIP LATCH T_LED	Y, N	T06LEDL := Y
TARGET T_LED ASSERTED COLOR[c]	R, G, A	T06LEDC := R
LED6 EQUATION	SELOGIC	T06_LED := 64G1T OR 64G2T OR 64F1T OR 64F2T[d] T06_LED := 3PWRX1T OR 3PWRX2T OR 3PWRX3T OR 3PWRX4T OR 3PWRY1T OR 3PWRY2T OR 3PWRY3T OR 3PWRY4T[e] T06_LED := 50QY1T OR 50QY2T OR 51QYT[f]

[a] R = Red, G = Green, and A = Amber
[b] The setting LEDENAC is not supported in the touchscreen display model.
[c] Hidden and forced to R if the Relay Word bit TRICOLOR is deasserted.
[d] Default settings shown apply to SEL-700G0 and G1.
[e] Default settings shown apply to SEL-700GT.
[f] Default settings shown apply to SEL-700GW.

Pushbutton LEDs

Enter any of the Relay Word bits (or combinations of Relay Word bits) as conditions in the PB*p*_LED (*p* = 1A, 1B, …, 8A, 8B) SELOGIC control equation settings. When these Relay Word bits assert, the corresponding LED also asserts.

Table 4.100 shows the setting prompts, the settings ranges, and the default settings for the LEDs. The factory-default settings shown match the as-shipped front-panel overlay (see *Figure 8.2*). You can change the settings to suit your application. See *Section 8: Front-Panel Operations* for slide-in labels for custom LED designations.

Table 4.100 Pushbutton LED Settings[a] (Sheet 1 of 3)

Setting Prompt	Setting Range[b]	Setting Name := Factory Default
PB_LED ASSERTED/ DEASSERTED COLORS[c]	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB1ALEDC := AO
PB1A_LED EQUATION	SELOGIC	PB1A_LED := NOT LT01 OR SV01 AND NOT SV01T AND SV05T
PB_LED ASSERTED/ DEASSERTED COLORS[c]	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB1BLEDC := AO
PB1B_LED EQUATION	SELOGIC	PB1B_LED := LT01 OR SV01 AND NOT SV01T AND SV05T
PB_LED ASSERTED/ DEASSERTED COLORS[c]	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB2ALEDC := AO
PB2A_LED EQUATION	SELOGIC	PB2A_LED := 0[d] PB2A_LED := NOT LT02 OR SV02 AND NOT SV02T AND SV05T AND PB02[e,f]

Table 4.100 Pushbutton LED Settings[a] (Sheet 2 of 3)

Setting Prompt	Setting Range[b]	Setting Name := Factory Default
PB_LED ASSERTED/ DEASSERTED COLORS[c]	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB2BLEDC := AO
PB2B_LED EQUATION	SELOGIC	PB2B_LED := 0[d] PB2B_LED := LT02 OR SV02 AND NOT SV02T AND SV05T AND PB02[e,f]
PB_LED ASSERTED/ DEASSERTED COLORS[c]	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB3ALEDC := AO
PB3A_LED EQUATION	SELOGIC	PB3A_LED := 52AX OR (SV03 AND SV05T AND NOT SV03T)[d] PB3A_LED := 52AX OR (SV03 AND SV05T AND NOT SV03T AND NOT LT02)[e f]
PB_LED ASSERTED/ DEASSERTED COLORS[c]	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB3BLEDC := AO
PB3B_LED EQUATION	SELOGIC	PB3B_LED := NOT LT01 AND NOT 52AX[d] PB3B_LED := 52AY OR (SV03 AND SV05T AND NOT SV03T AND LT02)[e,f]
PB_LED ASSERTED/ DEASSERTED COLORS[c]	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB4ALEDC := AO
PB4A_LED EQUATION	SELOGIC	PB4A_LED := NOT 52AX OR (SV04 AND SV05T AND NOT SV04T)[d] PB4A_LED := NOT 52AX OR (SV04 AND SV05T AND NOT SV04T AND NOT LT02)[e,f]
PB_LED ASSERTED/ DEASSERTED COLORS[c]	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB4BLEDC := AO
PB4B_LED EQUATION	SELOGIC	PB4B_LED := 0[d] PB4B_LED := NOT 52AY OR (SV04 AND SV05T AND NOT SV04T AND LT02)[e,f]
PB_LED ASSERTED/ DEASSERTED COLORS[c]	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB5ALEDC := AO
PB5A_LED EQUATION	SELOGIC	PB5A_LED := 0
PB_LED ASSERTED/ DEASSERTED COLORS[c]	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB5BLEDC := AO
PB5B_LED EQUATION	SELOGIC	PB5B_LED := 0
PB_LED ASSERTED/ DEASSERTED COLORS[c]	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB6ALEDC := AO
PB6A_LED EQUATION	SELOGIC	PB6A_LED := 0
PB_LED ASSERTED/ DEASSERTED COLORS[c]	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB6BLEDC := AO
PB6B_LED EQUATION	SELOGIC	PB6B_LED := 0

Table 4.100 Pushbutton LED Settings[a] (Sheet 3 of 3)

Setting Prompt	Setting Range[b]	Setting Name := Factory Default
PB_LED ASSERTED/ DEASSERTED COLORS[c]	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB7ALEDC := AO
PB7A_LED EQUATION	SELOGIC	PB7A_LED := 0
PB_LED ASSERTED/ DEASSERTED COLORS[c]	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB7BLEDC := AO
PB7B_LED EQUATION	SELOGIC	PB7B_LED := 0
PB_LED ASSERTED/ DEASSERTED COLORS[c]	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB8ALEDC := AO
PB8A_LED EQUATION	SELOGIC	PB8A_LED := 0
PB_LED ASSERTED/ DEASSERTED COLORS[c]	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB8BLEDC := AO
PB8B_LED EQUATION	SELOGIC	PB8B_LED := 0

[a] The pushbutton LED settings, PB5A/PB5B–PB8A/PB8B, are hidden if the Relay Word bit TRICOLOR is deasserted.
[b] Hidden and forced to AO if the Relay Word bit TRICOLOR is deasserted.
[c] Setting is a two-letter combination of the letters R, G, A, and O, where asserted/deasserted color choices: R = Red, G = Green, A = Amber, and O = OFF.
[d] Default settings shown apply to SEL-700G0 and G1.
[e] Default settings shown apply to SEL-700GT.
[f] Default settings shown apply to SEL-700GW.

Report Settings (SET R Command)

The report settings use Relay Word bits for the SER trigger, as shown in *Table 4.102* (see *Appendix L: Relay Word Bits* for more information).

SER Chatter Criteria

The SER includes an automatic deletion and reinsertion function to prevent overfilling of the SER buffer with chattering information. Each processing interval, the relay checks the Relay Word bits in the four SER reports for any changes of state (except the Relay Word bits corresponding to the digital inputs that have 1/16 of the power system cycle SER-accurate timestamps). When detecting a change of state, the relay adds a record to the SER report that contains the Relay Word bit(s), new state, time stamp, and checksum (see *Section 10: Analyzing Events* for more information).

When detecting oscillating SER items, the relay automatically deletes these oscillating items from SER recording. *Table 4.101* shows the auto-removal settings.

Table 4.101 Auto-Removal Settings

Settings Prompt	Setting Range	Setting Name := Factory Default
Auto-Removal Enable	Y, N	ESERDEL := N
Number of Counts	2–20 counts	SRDLCNT := 5
Removal Time	0.1–90.0 seconds	SRDLTIM := 1.0

To use the automatic deletion and reinsertion function, proceed with the following steps:

Step 1. Set Report setting ESERDEL (Enable SER Delete) to Y to enable this function.

Step 2. Select values for the setting SRDLCNT (SER Delete Count) and the setting SRDLTIM (SER Delete Time) that mask the chattering SER element.

Setting SRDLTIM declares a time interval during which the relay qualifies an input by comparing the changes of state of each input against the SRDLCNT setting. When an item changes state more than SRDLCNT times in an SRDLTIM interval, the relay automatically removes these Relay Word bits from SER recording. Once the relay deletes these bits from the recording, the relay ignores the item(s) for the next nine intervals. At the ninth interval, the chatter criteria is again checked and, if the point does not exceed the criteria, it is automatically reinserted into recording at the starting of the tenth interval. You can enable or disable the auto-deletion function via the SER settings. Any auto-deletion notice entry is lost during changes of the settings. The deleted items can be viewed in the SER Delete Report (command **SER D**—refer to *Section 7: Communications* for additional information).

SER Trigger Lists

To capture element state changes in the SER report, enter the Relay Word bit into one of the four SER (SER1 through SER4) trigger equations. Each of the four programmable trigger equations allows entry of as many as 24 Relay Word bits separated by spaces or commas; the SER report accepts a total of 96 Relay Word bits. *Table 4.102* shows the settings prompt and the default settings for the four SER trigger equations.

Table 4.102 SER[a] Trigger Settings

Setting Prompt	Setting Name := Factory Default
SER1	SER1 := IN101 IN102 PB01 PB02 PB03 PB04 52AX 52AY TRIPX TRIPY TRIP1 TRIP2 TRIP3
SER2	SER2 := ORED51T ORED50T 87U 87R OOST 21C1T 21C2T 3PWRX1T 3PWRX2T 3PWRY1T 3PWRY2T REF1F REF1R 24D1T 24C2T RTDT
SER3	SER3 := 64G1T 64G2T 64F1T 64F2T 46Q1T 46Q2T LOPX LOPY 81X1T 81X2T 81Y1T 81Y2T
SER4	SER4 := SALARM 49T 40Z1T 40Z2T

[a] Use as many as 24 Relay Word elements separated by spaces or commas for each setting.

Relay Word Bit Aliases

To simplify your review of the information displayed in the SER record, the relay provides the Alias setting function. Using the Alias settings, you can change the way relay elements listed previously in the SER settings are displayed in the SER report. In addition, the Alias settings allow you to change the text displayed when a particular element is asserted and deasserted. The relay permits as many as 32 unique aliases, as defined by the Enable Alias Settings (EALIAS) setting. Factory-default alias settings are shown in *Table 4.104*.

Table 4.103 Enable Alias Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Enable ALIAS Settings (N, 1–32)	N, 1–32	EALIAS := 4

Define the Enabled ALIAS settings by entering the Relay Word bit name, a space, your alias, a space, the text to display when the condition asserts, a space, and the text to display when the condition deasserts.

```
ALIAS1 = PB01 FP_AUX1 PICKUP DROPOUT
```

See *Table L.1* for the complete list of Relay Word bits. Use as many as 15 characters to define the alias, asserted text, and deasserted text strings. You can use capital letters (A–Z), numbers (0–9), and the underscore character (_) within each string. Do not attempt to use a space within a string, because the relay interprets a space as the break between two strings. To clear a string, simply type **NA**.

Table 4.104 SET R SER Alias Settings

Setting Prompt	Relay Word Bit	Alias	Asserted Text	Deasserted Text
ALIAS1 :=	PB01	FP_LOCK	PICKUP	DROPOUT
ALIAS2 :=	PB02	FP_BRKR_SELECT	PICKUP	DROPOUT
ALIAS3 :=	PB03	FP_CLOSE	PICKUP	DROPOUT
ALIAS4 :=	PB04	FP_TRIP	PICKUP	DROPOUT
ALIAS5 –ALIAS32	NA			

Event Report Settings

The programmable SELOGIC control equation setting ER is set to trigger event reports for conditions other than trip conditions. When setting ER sees a logical 0 to logical 1 transition, it generates an event report (if the SEL-700G is not already generating a report that encompasses the new transition). For example, ER := R_TRIG 64G1 OR R_TRIG SWING OR R_TRIG 52AX triggers an event report when either 64G1 or SWING asserts or when the breaker is closed, even if the event does not result in a trip.

NOTE: Event report data stored in the relay will be lost when you change the LER setting. You must save the data before changing the setting.

Table 4.105 Event Report Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
EVENT TRIGGER	SELOGIC	ER := 0
EVENT LENGTH	15, 64, 180 cyc	LER := 15
PREFAULT LENGTH	1–175 cyc[a]	PRE := 5

[a] The range shown is for LER := 180. The generalized range is 1 - (LER-5) cyc.

Event reports can be 15, 64, or 180 cycles in length, as determined by the LER setting. The prefault length, PRE, can be set up to (LER-5) cycles. The relay can hold at least 8, 21, or 44 event reports, depending on the LER setting of 180, 64, and 15 cycles, respectively.

Generator Autosynchronism Report

SEL-700G relays that are equipped with generator synchronism check trigger the generator autosynchronism report when the SELOGIC control equation GSRTRG transitions from 0 to 1. The report contains 4800 samples of data, each containing the analog and digital information shown in *Table 4.107*. The resolution and number of pre-trigger data samples are defined by the settings GSRR and PRESYNC and can be set as necessary.

Table 4.106 Generator Autosynchronism Report Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
GEN SYNC TRG	SELOGIC	GSRTRG := CLOSEX AND (25C OR 25AX1 OR 25AX2)
GEN SYNC RPT RES	0.25, 1, 5 cyc	GSRR := 0.25
PRE SYNC LEN	1–4799 samples	PRESYNC := 4790

The relay stores the four latest reports in nonvolatile relay memory. Use the **CGSR** command to retrieve the report data. See *Figure 4.126* for a sample graphical display of the report using QuickSet. You can also trigger the report with the **GST** command. See *Section 7: Communications* for more detail on ASCII commands.

Table 4.107 Generator Autosynchronism Report Data

Data	Description	Remarks
Analog Data: DELTA_VOLT VS SLIP_FREQ FREQS DELTA_ANGLE	(From *Figure 4.109*) Vpxc_Mag–Vs_Mag Vs_Mag * PTRS FREQX–FREQS FREQS Vxs_Angle	See *Appendix M: Analog Quantities* for additional descriptions (FREQS is the frequency of synchronism-check voltage input, and PTRS is the setting).
Digital Data: 59VPX, 59VSX, GENVHI, GENVLO VDIFX, GENFHI, GENFLO, SFX, 25AX1, 25AX2, 25C, CFA, BKRCF, FSYNCST, VSYNCST, 52AX, VSYNCTO, FSYNCTO, ASP, AST, VRAISE, VLOWER, FRAISE, FLOWER, VSYNCACT, FSYNCACT, SV27T, SV28T, SV29T, SV30T, SV31T, SV32T	Relay Word bits	See *Appendix L: Relay Word Bits* for descriptions. Use unassigned variables SV27–SV32 to enhance the report as necessary (see *Table 4.66*).

Load Profile Settings

Use the LDLIST setting to declare the analog quantities you want included in the Load Profile Report. Enter as many as 17 analog quantities, separated by spaces or commas, into the LDLIST setting. See *Appendix M: Analog Quantities* for a list of the available analog quantities. Also set the LDAR to the acquisition rate you want for the report.

IMPORTANT: All stored load data are lost when you change the LDLIST setting.

Table 4.108 Load Profile Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
LDP LIST	0, as many as 17 Analog Quantities	LDLIST := 0
LDP ACQ RATE	5, 10, 15, 30, 60 min	LDAR := 15

DNP Map Settings (SET D Command)

Table 4.109 shows the available settings. See *Appendix D: DNP3 Communications* for additional details.

Table 4.109 DNP Map Settings[a]

Setting Prompt	Setting Range	Setting Name := Factory Default
DNP Binary Input Label Name	10 characters	BI_00 := ENABLED
DNP Binary Input Label Name	10 characters	BI_01 := TRIP
DNP Binary Input Label Name	10 characters	BI_02 := TRIPX
DNP Binary Input Label Name	10 characters	BI_03 := STFAIL
DNP Binary Input Label Name	10 characters	BI_04 := STSET
DNP Binary Input Label Name	10 characters	BI_05 := IN101
DNP Binary Input Label Name	10 characters	BI_06 := IN102
. . .		
DNP Binary Input Label Name	10 characters	BI_99 := NA
DNP Binary Output Label Name	10 characters	BO_00 := RB01
. . .		
DNP Binary Output Label Name	10 characters	BO_31 := RB32
DNP Analog Input Label Name	24 characters	AI_00 := IAX_MAG
DNP Analog Input Label Name	24 characters	AI_01 := IBX_MAG
. . .		
DNP Analog Input Label Name	24 characters	AI_99 := NA
DNP Analog Output Label Name	6 characters	AO_00 := NA
. . .		
DNP Analog Output Label Name	6 characters	AO_31 := NA
DNP Counter Label Name	11 characters	CO_00 := NA
. . .		
DNP Counter Label Name	11 characters	CO_31 := NA

[a] See Appendix D: DNP3 Communications for a complete list of the DNP Map Labels and factory-default settings.

Modbus Map Settings (SET M Command)

Table 4.110 shows the available settings. See *Appendix E: Modbus Communications* for additional details.

Table 4.110 User Map Register Settings[a]

Setting Prompt	Setting Range	Setting Name := Factory Default
USER REG#1	NA, 1 Modbus Register Label	MOD_001 :=
•	•	•
•	•	•
•	•	•
USER REG#125	NA, 1 Modbus Register Label	MOD_125 :=

[a] See Appendix E: Modbus Communications for Modbus Register Labels and factory-default settings.

EtherNet/IP Assembly Map Settings (SET E Command)

Table 4.111 shows the available assembly map settings. See *Appendix F: EtherNet/IP Communications* for additional details.

Table 4.111 EtherNet/IP Assembly Map (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
Input Assembly (IA) Binary		
EIP Input Assembly Binary Label Name	10 characters	IAB_00 := NA
•	•	•
•	•	•
•	•	•
EIP Input Assembly Binary Label Name	10 characters	IAB_99 := NA
Input Assembly (IA) Analog		
EIP Input Assembly Analog Label Name	10 characters	IAA_00 := NOOP IAA_01 : = NA
•	•	•
•	•	•
•	•	•
EIP Input Assembly Analog Label Name	10 characters	IAA_99 := NA

Table 4.111 EtherNet/IP Assembly Map (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
Output Assembly (OA) Binary		
EIP Output Assembly Binary Label Name	10 characters	OAB_00 := NA
•	•	•
•	•	•
•	•	•
EIP Output Assembly Binary Label Name	10 characters	OAB_31 := NA
Output Assembly (OA) Analog		
EIP Output Assembly Analog Label Name	10 characters	OAA_00 := NOOP OAA_01 := NA
•	•	•
•	•	•
•	•	•
EIP Output Assembly Analog Label Name	10 characters	OAA_31 := NA

Touchscreen Settings

The touchscreen settings apply to relays that support the color touchscreen display and are discussed in *Section 9: Bay Control* (see *Table 9.7*).

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Section 5
Metering and Monitoring

Overview

The SEL-700G Generator and Intertie Protection Relay includes metering functions to display the present values of current, voltage (if included), analog inputs (if included), field insulation resistance (with external SEL-2664 Field Ground Module), and RTD measurements (with the external SEL-2600 RTD Module or an internal RTD card). The relay provides the following methods to read the present meter values:

- Front-panel rotating display
- Front-panel menu
- Web server via Ethernet port
- EIA-232 serial ports (using SEL ASCII text commands or QuickSet)
- Telnet via Ethernet port
- Modbus via EIA-232 port or EIA-485 port
- Modbus TCP via Ethernet port
- DNP3 serial via EIA-232 port or EIA-485 port
- DNP3 LAN/WAN via Ethernet port
- DeviceNet port
- Analog outputs
- IEC 61850 Edition 2 via Ethernet port
- IEC 60870-5-103 via EIA-232 or EIA-485 port
- C37.118 Synchrophasor Protocol via serial port or Ethernet port
- EtherNet/IP via Ethernet Port

Load monitoring and trending are possible through use of the Load Profile function. The relay automatically configures itself to save as many as 17 quantities (selected from the Analog Quantities) every 5, 10, 15, 30, or 60 minutes. The data are stored in nonvolatile memory. As many as 9800 time samples are stored.

The Breaker Monitor feature is available in all SEL-700G relays. Refer to *Breaker Monitor on page 5.16* for description and application details.

Power Measurement Conventions

The SEL-700G uses the IEEE convention for power measurement. The implications of this convention are depicted in *Figure 5.1*.

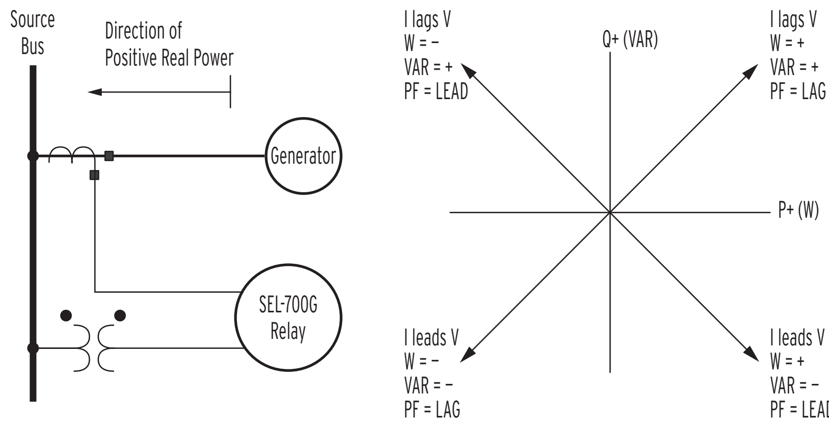

Figure 5.1 Complex Power Measurement Conventions

Delta-Connected CTs

The relay displays currents, voltages, and power in primary values as part of most metering and monitoring reports. If the winding phase CTs are wye connected, the relay can accurately derive the primary currents from the secondary values through multiplying them by the corresponding CT ratio.

Delta-connected CTs, in general, remove zero-sequence current and introduce a phase shift. They also increase magnitude by $\sqrt{3}$ under balanced system conditions and as high as two times under unbalanced conditions. As a result, the relay cannot derive the primary currents/quantities accurately. The relay performs the following under all system conditions in the case of delta-connected CTs. The primary currents displayed are derived from the secondary values through multiplying them by the corresponding CT ratio and dividing them by $\sqrt{3}$. The phase angles are not compensated and reflect the same values as measured on the secondary.

Metering

The SEL-700G meter data fall into the following categories:

- *Fundamental Metering*
- *Thermal Metering*: RTD metering (with the external SEL-2600 RTD Module or an internal RTD option) and generator thermal capacity
- *Energy Metering*
- *Maximum and Minimum Metering*
- *Math Variable Metering*
- *RMS Metering*
- *Analog Input Metering*

- ➤ *Demand Metering*
- ➤ *Synchrophasor Metering*
- ➤ *Remote Analog Metering*
- ➤ *Differential Metering*
- ➤ *Harmonic Metering*

Fundamental Metering

Table 5.1 details each of the fundamental meter data types in the SEL-700G. *Section 8: Front-Panel Operations* and *Section 7: Communications* describe how to access the various types of meter data by using the relay front panel and communications ports.

NOTE: Calculated phase-to-phase voltages for wye-connected PTs are available in the analog quantities and can be selected as display points. See Appendix M: Analog Quantities.

If the winding phase CTs are delta connected, the primary currents displayed are derived from the secondary values by multiplying them with CTR (CT ratio) and dividing them by $\sqrt{3}$. The phase angles shown are the same as the secondary values. If the CT connection type is known (DAB or DAC), the phase angles could be corrected by the user. The MET response is meant to show steady-state primary values. During unbalanced conditions it is not possible to reproduce the primary line currents accurately because the delta-connected CTs filter out the zero-sequence component of the line current. Wye connected CTs do not have any such issue.

Table 5.1 Measured Fundamental Meter Values (Sheet 1 of 2)

Relay Option	Fundamental Meter Values
X-Side Quantities (model dependent)	➤ Input currents IAX, IBX, and ICX magnitudes (A primary) and phase angles (degrees) ➤ Calculated currents IGX (IGX = 3I0 = IAX + IBX + ICX), positive-sequence current I1X, and negative-sequence current 3I2X magnitudes (A primary) and phase angles (degrees) ➤ Wye-connected input voltages (with respect to neutral): ➢ VAX, VBX, and VCX magnitudes (V primary) and phase angles (degrees) ➢ Calculated voltages VGX (VGX = 3V0 = VAX + VBX + VCX), positive-sequence voltage V1X and negative-sequence voltage 3V2X magnitudes (V primary) and phase angles (degrees) ➤ Delta-connected input voltages: ➢ VABX, VBCX, and VCAX magnitudes (V primary) and phase angles (degrees) ➢ Calculated positive-sequence voltage V1X and negative-sequence voltage 3V2X magnitudes (V primary) and phase angles (degrees) ➤ Power and Power Factor (single phase quantities for wye-connected PTs only): ➢ Single-phase (PAX, PBX, PCX) and three-phase (P3X) real power (kW) ➢ Single-phase (QAX, QBX, QCX) and three-phase (Q3X) reactive power (kVAR) ➢ Single-phase (SAX, SBX, SCX) and three-phase (S3X) apparent power (kVA) ➢ Single-phase (PFAX, PFBX, PFCX) and three-phase (PF3X) power factor (lead/lag) ➤ Frequency (FREQX) in Hz ➤ Volts/Hertz in %
Y-Side Quantities (model dependent)	➤ Input currents IAY, IBY, and ICY magnitudes (A primary) and phase angles (degrees) ➤ Calculated currents IGY (IGY = 3I0 = IAY + IBY + ICY), positive-sequence current I1Y, and negative-sequence current 3I2Y magnitudes (A primary) and phase angles (degrees) ➤ Wye-connected input voltages (with respect to neutral): ➢ VAY, VBY, and VCY magnitudes (V primary) and phase angles (degrees) ➢ Calculated voltages VGY (VGY = 3V0 = VAY + VBY + VCY), positive-sequence voltage V1Y and negative-sequence voltage 3V2Y magnitudes (V primary) and phase angles (degrees) ➤ Delta-connected input voltages: ➢ VABY, VBCY, and VCAY magnitudes (V primary) and phase angles (degrees) ➢ Calculated positive-sequence voltage V1Y and negative-sequence voltage 3V2Y magnitudes (V primary) and phase angles (degrees)

Table 5.1 Measured Fundamental Meter Values (Sheet 2 of 2)

Relay Option	Fundamental Meter Values
	➤ Power and Power Factor (single phase quantities for WYE connected PTs only): ➢ Single-phase (PAY, PBY, PCY) and three-phase (P3Y) real power (kW) ➢ Single-phase (QAY, QBY, QCY) and three-phase (Q3Y) reactive power (kVAR) ➢ Single-phase (SAY, SBY, SCY) and three-phase (S3Y) apparent power (kVA) ➢ Single-phase (PFAY, PFBY, PFCY) and three-phase (PF3Y) power factor (lead/lag) ➤ Frequency (FREQY) in Hz
Other Quantities (model dependent)	➤ Synchronism-check voltage input (VS) magnitude (V primary) and phase angle (degrees) and frequency (FREQS) in Hz ➤ Neutral voltage input (VN) magnitude (V primary) and phase angle (degrees) ➤ Third harmonic voltages for stator ground element 64G (Wye-connected X-side PTS only): Third harmonic voltages VPX3 (VPX3 = VAX3 + VBX3 + VCX3) and VN3 (V primary); Field ground insulation resistance Rf in kilohms[a] (requires SEL-2664 Field Ground Module)

[a] Field ground insulation resistance, Rf, will read FAIL when E64F = Y and the data are invalid.

All angles are displayed between –180 and +180 degrees. The angles are referenced to VAB*n*, VAN*n* (for delta- or wye-connected PT, respectively), or IA*n* (*n* = X or Y). If the voltage channels are not supported, if VAB*n* < 13 V (for delta-connected PT), or if VAN*n* < 13 V (for wye-connected PT), the angles are referenced to IA*n* current. If the relay includes both X and Y-side quantities, the angles are referenced to the X-side quantity. *Figure 5.2* shows an example of the METER command report.

```
=>MET <Enter>

SEL-700G                                  Date: 02/24/2010   Time: 11:43:44.875
GENERATOR RELAY                           Time Source: Internal

                IAX      IBX      ICX      IGX      I1X     3I2X
Mag (A pri.)    505.1    501.2    499.4      6.9    501.9      3.2
Angle (deg)     -30.0   -149.9     89.9    -44.8    -30.0     -4.0

                IAY      IBY      ICY      IGY      I1Y     3I2Y
Mag (A pri.)    500.7    502.5    500.1      9.2    501.1      4.9
Angle (deg)     150.0     30.6    -89.1     40.7    150.5     83.8

                IN
Mag (A pri.)      0.0
Angle (deg)     143.8

                VAX      VBX      VCX      VGX      V1X     3V2X
Mag (V pri.)   9978.0   9982.1   9986.7     53.6   9982.2     38.6
Angle (deg)       0.0   -120.3    120.0    151.5     -0.1     27.1

                VS       VN
Mag (V pri.)      0.0     0.00
Angle (deg)    -102.7    16.9

                VN3     VPX3
Mag (V pri.)     0.66     3.94

                          AX             BX             CX             3PX
Real Pwr (kW)              4362           4348           4312           13023
Reactive Pwr (kVAR)        2523           2474           2505            7503
Apparent Pwr (kVA)         5040           5003           4987           15029
Pwr Factor                    0.87           0.87           0.87            0.87
                             LAG            LAG            LAG             LAG

                FREQX  FREQS
Frequency (Hz)  60.00  60.00

V/Hz (%)                   100.5
Field Resistance (kOhm)   19276.6

=>
```

Figure 5.2 METER Command Report for SEL-700G1 With Synchronism Check and Neutral Voltage Inputs

Thermal Metering

The thermal metering function reports the RTD meter values (see *Table 5.2* for details) and also reports the state of connected RTDs, if any have failed (see *Table 5.3* for details). The report also displays % generator thermal capacity used and % RTD-based thermal capacity used quantities for selected models with thermal model element.

Table 5.2 Thermal Meter Values

Relay Option	Thermal Values
With External SEL-2600 RTD Module or Internal RTD Option	All RTD Temperatures
Models With Thermal Model Element Enabled	% Generator Thermal Capacity Used % RTD-based Thermal Capacity Used

Table 5.3 RTD Input Status Messages

Message	Status
Open	RTD leads open
Short	RTD leads shorted
Comm Fail	Fiber-optic communications to SEL-2600 RTD Module have failed
Stat Fail	SEL-2600 RTD Module self-test status failure

Figure 5.3 provides an example of the METER T command report.

```
=>MET T <Enter>
SEL-700G                                  Date: 02/24/2010   Time: 15:09:23.117
GENERATOR RELAY                           Time Source: Internal
Max Winding RTD    96 C
Max Bearing RTD    72 C
Ambient RTD        35 C
Max Other RTD     168 C
 RTD1 WDG      91 C
 RTD2 WDG      94 C
 RTD3 WDG      96 C
 RTD4 BRG      24 C
 RTD5 BRG      48 C
 RTD6 BRG      72 C
 RTD7 AMB      35 C
 RTD8 OTH 1   120 C
 RTD9 OTH 2   144 C
RTD10 OTH 3   168 C
Generator TCU (%)   76.2
RTD TCU (%)         72
=>
```

Figure 5.3 MET T Report for SEL-700GO Model

Energy Metering

The SEL-700G with the voltage option includes energy metering. Use this form of metering to quantify real and reactive energy supplied by the transformer. Refer to *Figure 5.4* for the definitions of positive real power, negative real power, positive reactive power, and negative reactive power. Below are the energy meter values:

- MWhPn (*n* = X or Y)—Positive real 3-phase energy
- MWhNn—Negative real 3-phase energy
- MVARhPn—Positive reactive 3-phase energy
- MVARhNn—Negative reactive 3-phase energy
- Last date and time energy meter quantities were reset

NOTE: Energy values rollover after 999,999 MVAh and reset to 0.

Figure 5.4 shows the device response to the **METER E** command.

```
=>>MET E <Enter>

SEL-700G                                  Date: 03/05/2010   Time: 10:56:59.234
GENERATOR RELAY                           Time Source: Internal

X Side Energy
Positive MWHX (MWh)      999998.500
Negative MWHX (MWh)       67543.037
Positive MVARHX (MVArh)  123454.765
Negative MVARHX (MVArh)    4523.386

LAST RESET = 03/04/2010 13:07:54
=>>
```

Figure 5.4 Device Response to the METER E Command

To reset energy meter values, issue the **METER RE** command as shown in *Figure 5.5*.

```
=>>MET RE <Enter>
Reset Metering Quantities (Y,N)? Y <Enter>
Reset Complete
=>>
```

Figure 5.5 Device Response to the METER RE Command

The **MET WE** command from Access Level 2 allows you to preload data for the energy meter report. See *Figure 5.6* for the device response to the **MET WE** command.

```
=>>MET WE <Enter>

X Side 3-Phase Energy Data Preload

Positive real energy (0 - 999999.000)     MWHPX   = 123456.789 ? 123456.789
Negative real energy (0 - 999999.000)     MWHNX   = 123456.789 ? 123456.789
Positive reactive energy (0 - 999999.000) MVARHPX = 123456.789 ? 123456.789
Negative reactive energy (0 - 999999.000) MVARHNX =      0.000 ? 123456.789

Y Side 3-Phase Energy Data Preload

Positive real energy (0 - 999999.000)     MWHPY   =  12345.123 ? 123456.789
Negative real energy (0 - 999999.000)     MWHNY   =    123.123 ? 123456.789
Positive reactive energy (0 - 999999.000) MVARHPY =      0.345 ? 123456.789
Negative reactive energy (0 - 999999.000) MVARHNY =    123.000 ? 123456.789


Last Reset                                Date    = 03/10/2010 ? 3/11/2010
                                          Time    = 08:10:10   ? 16:01:02

Save changes (Y,N)? Y <Enter>
New Energy Data Saved

=>>
```

Figure 5.6 Device Response to the METER WE Command

Energy metering values are stored to nonvolatile memory four times a day and within one minute of the energy metering values being reset.

Maximum and Minimum Metering

Maximum and minimum metering allows you to determine maximum and minimum operating quantities such as currents, voltages, power, analog input quantities, RTD quantities, and frequency. *Table 5.4* lists the max/min metering quantities.

Table 5.4 Maximum/Minimum Meter Values

Relay Option	Maximum/Minimum Meter Values
X-Side Maximum/ Minimum Quantities (model dependent)	➤ Input currents IAX, IBX, and ICX magnitudes (A primary) ➤ Calculated currents IGX (IGX = 3I0 = IAX + IBX + ICX) (A primary) ➤ Wye-connected input voltages (with respect to neutral): VAX, VBX, and VCX magnitudes (V primary); Calculated voltages VGX (VGX = 3V0 = VAX + VBX + VCX) (V primary) ➤ Delta-connected input voltages: VABX, VBCX, and VCAX magnitudes (V primary) ➤ Three-phase (P3X) real power (kW) ➤ Three-phase (Q3X) reactive power (kVAR) ➤ Three-phase (S3X) apparent power (kVA) ➤ Frequency (FREQX) in Hz.
Y-Side Maximum/ Minimum Quantities (model dependent)	➤ Input currents IAY, IBY, and ICY magnitudes (A primary) ➤ Calculated currents IGY (IGY = 3I0 = IAY + IBY + ICY) (A primary) ➤ Wye-connected input voltages (with respect to neutral): VAY, VBY, and VCY magnitudes (V primary); Calculated voltages VGY (VGY = 3V0 = VAY + VBY + VCY) (V primary) ➤ Delta-connected input voltages: VABY, VBCY, and VCAY magnitudes (V primary) ➤ Three-phase (P3Y) real power (kW) ➤ Three-phase (Q3Y) reactive power (kVAR) ➤ Three-phase (S3Y) apparent power (kVA) ➤ Frequency (FREQY) in Hz.
Other Maximum/ Minimum Quantities (model dependent)	➤ Synchronism-check voltage input (VS) magnitude (V primary) ➤ Neutral voltage input (VN) magnitude (V primary) ➤ Third harmonic voltages for stator ground element 64G (Wye-connected X-side PTS only): ➤ Third harmonic voltages VPX3 (VPX3 = VAX3 + VBX3 + VCX3) and VN3 (V primary). ➤ RTD1-RTD12 temperatures (°C) ➤ Analog input values (±20mA, ±10V) in engineering units

All maximum and minimum metering values include the date and time that these values occurred. The analog quantities from *Table 5.4* are checked approximately every 0.5 seconds and, if a new maximum or minimum value occurs, this value is saved along with the date and time that the maximum or minimum value occurred. Maximum and minimum values are only checked if relay element FAULT is deasserted (no fault condition exists) for at least one second.

Additionally, the following minimum thresholds must also be met (*n* = X or Y for X or Y-side quantities):

➤ Current values I_An, I_Bn, I_Cn, and I_N: 3% of the nominal CT rating.

➤ Current values I_Gn: I_An, I_Bn, and I_Cn all must be above their thresholds.

➤ Voltage values (phase, phase-to-phase, synchronism check, neutral): 7.5 V • PTR*n,* 13 V • PTR*n*, 7.5 V • PTRS, and 7.5 V • PTRN, respectively.

➤ Power values (real, reactive, and apparent): All three currents (I_An, I_Bn, I_Cn) and all three voltages (V_An, V_Bn, V_Cn, or $V_{AB}n$, $V_{BC}n$, $V_{CA}n$) must be above their thresholds.

Figure 5.7 shows an example device response to the **METER M** command.

```
=>>MET M <Enter>

SEL-700G                                  Date: 02/24/2010   Time: 15:13:20.377
GENERATOR RELAY                           Time Source: Internal

                  MAX       DATE       TIME       MIN       DATE       TIME
IAX (A)            505.2  02/24/2010  15:03:38     504.2  02/24/2010  11:29:14
IBX (A)            502.7  02/24/2010  11:29:28     501.1  02/24/2010  14:58:14
ICX (A)            500.0  02/24/2010  15:01:15     498.1  02/24/2010  11:28:33
IGX (A)             11.7  02/24/2010  11:30:07       4.0  02/24/2010  15:12:28
IAY (A)            501.2  02/24/2010  15:03:38     500.6  02/24/2010  11:29:14
IBY (A)            503.5  02/24/2010  11:29:28     502.3  02/24/2010  14:58:14
ICY (A)            500.1  02/24/2010  15:01:15     499.6  02/24/2010  11:28:33
IGY (A)             10.1  02/24/2010  15:03:14       9.0  02/24/2010  14:59:16
IN (A)              11.1  02/24/2010  15:05:12       9.6  02/24/2010  14:54:15
VAX (V)           9980.8  02/24/2010  15:07:16    9974.7  02/24/2010  15:11:21
VBX (V)           9983.4  02/24/2010  11:29:07    9979.7  02/24/2010  14:51:00
VCX (V)           9987.4  02/24/2010  11:29:45    9983.5  02/24/2010  15:07:59
VS (V)            9985.8  02/24/2010  15:05:13    9975.7  02/24/2010  14:11:24
VN (V)              15.8  02/24/2010  15:03:12       5.7  02/24/2010  14:12:25
VN3 (V)              5.8  02/24/2010  14:05:23       2.7  02/24/2010  14:15:44
VP3X (V)            17.9  02/24/2010  15:05:13       9.7  02/24/2010  12:11:54
kW3X (kW)        13026    02/24/2010  14:54:52   12702    02/24/2010  11:27:49
kVAR3X (kVAR)     8031.6  02/24/2010  11:29:01    7494.6  02/24/2010  14:50:34
kVA3X (kVA)      15033    02/24/2010  15:06:53   15023    02/24/2010  11:29:57
FREQX (Hz)         60.00 02/24/2010  11:22:50       59.98  02/24/2010  15:02:24
RTD1 (C)           91     02/24/2010  15:06:19     -48    02/24/2010  14:50:23
RTD2 (C)           94     02/24/2010  15:06:23     -24    02/24/2010  14:50:23
RTD3 (C)           96     02/24/2010  15:06:27       0    02/24/2010  14:50:23
RTD4 (C)           24     02/24/2010  14:50:22      24    02/24/2010  14:50:23
RTD5 (C)           48     02/24/2010  14:50:22      48    02/24/2010  14:50:23
RTD6 (C)           72     02/24/2010  14:50:22      72    02/24/2010  14:50:23
RTD7 (C)           96     02/24/2010  14:50:22      23    02/24/2010  15:02:59
RTD8 (C)          120     02/24/2010  14:50:22     120    02/24/2010  14:50:23
RTD9 (C)          144     02/24/2010  14:50:22     144    02/24/2010  14:50:23
RTD10 (C)         168     02/24/2010  14:50:22     168    02/24/2010  14:50:23

LAST RESET = 02/24/2010 11:22:49

=>>
```

Figure 5.7 Device Response to the METER M Command

To reset maximum/minimum meter values, issue the **METER RM** command as shown in *Figure 5.8*. The max/min meter values can be reset from the serial port, Modbus, the front panel, or assertion of the RSTMXMN relay element. The date and time of the reset are preserved and shown in the max/min meter report.

```
=>>MET RM <Enter>

Reset Metering Quantities (Y,N)? Y <Enter>
Reset Complete

=>>
```

Figure 5.8 Device Response to the METER RM Command

All maximum and minimum metering values are stored to nonvolatile memory four times per day and within one minute of the maximum and minimum metering values being reset.

Math Variable Metering

The SEL-700G includes 32 math variables. When you receive your SEL-700G, no math variables are enabled. To use math variables, enable the number of math variables (between 1 and 32) you require, using the EMV setting in the Logic setting category. *Figure 5.9* shows the device response to the **METER MV** command with 8 of the 32 math variables enabled.

```
=>>MET MV <Enter>

SEL-700G                                  Date: 02/24/2010   Time: 15:26:40.866
GENERATOR RELAY                           Time Source: Internal

MV01          1.00
MV02     -32767.00
MV03         -1.00
MV04          0.00
MV05       1000.59
MV06      -1000.61
MV07       2411.01
MV08       2410.99

=>>
```

Figure 5.9 Device Response to the METER MV Command

RMS Metering

The SEL-700G includes root-mean-squared (rms) metering. Use rms metering to measure the entire signal (including harmonics). You can measure the rms quantities shown in *Table 5.5*.

Table 5.5 RMS Meter Values

Relay Option	RMS Meter Values
X-Side RMS Quantities (model dependent)	➤ Input currents IAX, IBX, and ICX magnitudes (A primary) ➤ Wye-connected input voltages (with respect to neutral): VAX, VBX, and VCX magnitudes (V primary) ➤ Delta-connected input voltages: VABX, VBCX, and VCAX magnitudes (V primary)
Y-Side RMS Quantities (model dependent)	➤ Input currents IAY, IBY, and ICY magnitudes (A primary) ➤ Wye-connected input voltages (with respect to neutral): VAY, VBY, and VCY magnitudes (V primary) ➤ Delta-connected input voltages: VABY, VBCY, and VCAY magnitudes (V primary)
Other RMS Quantities (model dependent)	➤ Synchronism-check voltage input (VS) magnitude (V primary) ➤ Neutral current input (IN) magnitude (A primary)

RMS quantities contain the total signal energy including harmonics. This differs from the fundamental meter (**METER** command) in that the fundamental meter quantities only contain the fundamental frequency (60 Hz for a 60 Hz system). *Figure 5.10* shows the METER RMS command report.

```
=>MET RMS <Enter>
SEL-700G                                             Date: 02/24/2010   Time: 15:28:59.635
GENERATOR RELAY                                      Time Source: Internal
                IAX      IBX      ICX
RMS (A pri.)    505.1    501.7    498.6
                IAY      IBY      ICY
RMS (A pri.)    500.6    502.7    499.8
                VAX      VBX      VCX
RMS (V pri.)     9977     9980     9984
                IN
RMS (A pri.)      1.1
                VS
RMS (V pri.)     9972

=>
```

Figure 5.10 Device Response to the METER RMS Command

Analog Input Metering

The SEL-700G can monitor analog (transducer) quantities that it measures if it is equipped with optional analog inputs. Analog input metering shows transducer values from standard voltage and current transducers. You can use these values for automation and control applications within an industrial plant.

Through the use of global settings, you can set each type of analog input to the type of transducer that drives that analog input. You also set the range of the transducer output. Analog inputs can accept both current and voltage transducer outputs. Ranges for the current transducers are ±20 mA, and ranges for the voltage transducers are ±10 V. You also set the corresponding output of the analog inputs in engineering units. See *Section 4: Protection and Logic Functions* for an explanation of how to set up analog inputs for reading transducers. *Figure 5.11* shows an example of analog input metering.

```
=>MET AI <Enter>

SEL-700G                                                Date: 02/24/2010 Time: 16:22:22
GENERATOR RELAY                                         Time Source: Internal

Input Card 4
AI401 (psi)         99.97
AI402 (mA)           2.013
AI403 (Volts)       -0.0027
AI404 (ft-lbs)     993

=>
```

Figure 5.11 Device Response to the METER AI Command

Demand Metering

The SEL-700G offers the choice between two types of demand metering, settable with the enable setting:

EDEM = THM (Thermal Demand Metering)

or

EDEM = ROL (Rolling Demand Metering)

The relay provides demand (**METER DE** command) and peak demand (**METER PE** command) metering. *Table 5.6* shows the values reported. *Figure 5.12* is an example of the **METER DE** (Demand) command report, and *Figure 5.13* is an example of the **METER PE** (Peak Demand) command report. Refer to *Demand Metering on page 4.195* for detailed descriptions and settings selection.

Table 5.6 Demand Values

Relay Option	Demand/Peak Demand Values
X-Side Demand/Peak Demand Quantities (model dependent)	➤ Demand/peak demand values of input currents IAX, IBX, and ICX magnitudes (A primary) ➤ Demand/peak demand value of calculated current IGX (IGX = 3I0 = IAX + IBX + ICX) magnitude (A primary) ➤ Demand/peak demand value of calculated negative-sequence current (3I2X) magnitude (A primary)
Y-Side Demand/Peak Demand Quantities (model dependent)	➤ Demand/peak demand values of input currents IAY, IBY, and ICY magnitudes (A primary) ➤ Demand/peak demand value of calculated current IGY (IGY = 3I0 = IAY + IBY + ICY) magnitude (A primary) ➤ Demand/peak demand value of calculated negative-sequence current (3I2Y) magnitude (A primary)

```
=>>MET DE <Enter>

SEL-700GT                                 Date: 02/24/2010   Time: 18:13:20.751
INTERTIE RELAY                            Time Source: Internal

                   IAX      IBX      ICX      IGX     3I2X
DEMAND (A pri.)   3036.7   3023.3   3004.1     36.6     21.0

                   IAY      IBY      ICY      IGY     3I2Y
DEMAND (A pri.)   3016.4   3026.5   3011.3     35.5     31.3

LAST RESET = 02/24/2010 17:20:51

=>>
```

Figure 5.12 Device Response to the MET DE Command

```
=>>MET PE <Enter>

SEL-700GT                                 Date: 02/24/2010   Time: 18:13:59.993
INTERTIE RELAY                            Time Source: Internal

                        IAX      IBX      ICX      IGX     3I2X
PEAK DEMAND (A pri.)   3036.8   3023.3   3004.8     36.9     21.0

                        IAY      IBY      ICY      IGY     3I2Y
PEAK DEMAND (A pri.)   3016.5   3026.9   3011.3     35.8     31.5

LAST RESET = 02/24/2010 17:20:51

=>>
```

Figure 5.13 Device Response to the MET PE Command

Peak demand metering values are stored to nonvolatile memory four times a day and within one minute of the peak demand metering values being reset. Demand metering is stored in volatile memory only and the data will be lost when power to the relay is removed.

Synchrophasor Metering

The **METER PM** serial port ASCII command is used to view SEL-700G synchrophasor measurements. There are multiple ways to use the **METER PM** command:

- ➤ As a test tool, to verify connections, phase rotation, and scaling
- ➤ As an analytical tool, to capture synchrophasor data at an exact time, so that this information can be compared with similar data captured in other phasor measurement unit(s) at the same time.
- ➤ As a method of periodically gathering synchrophasor data through a communications processor.

The **METER PM** command displays the same set of analog synchrophasor information, regardless of the global settings PHDATAV, PHDATAI, and PHCURR. The **METER PM** command can function even when no serial ports are sending synchrophasor data.

NOTE: To have the MET PM xx:yy:zzz response transmitted from a serial port, the corresponding port must have the AUTO setting set to Y (YES).

The **METER PM** command only operates when the SEL-700G is in the IRIG timekeeping mode, as indicated by Relay Word bit TSOK = logical 1. *Table 5.7* below, shows the measured values for the **METER PM** Command. *Figure K.7* in *Appendix K: Synchrophasors* shows a sample **METER PM** command response. You can use the **METER PM** *xx:yy:zzz* command to direct the SEL-700G to display the synchrophasor for an exact specified time, in 24-hour format. For example, entering the command **METER PM** 14:14:12 results in a response similar to *Figure K.7*, occurring just after 14:14:12, with the time stamp 14:14:12.000. Refer to *Appendix K: Synchrophasors*, for further details on synchrophasor measurements, settings, C37.118 Protocol, etc.

Table 5.7 Synchrophasor Measured Values

Relay Option	Fundamental Meter Values
X-Side Quantities (model dependent)	➤ Fundamental current phasors IAX, IBX, and ICX and positive-sequence current I1X ➤ Wye-connected input voltages (with respect to neutral): Fundamental voltage phasors VAX, VBX, and VCX and positive-sequence voltage V1X ➤ Delta-connected input voltages: Fundamental voltage phasors VABX, VBCX, and VCAX and positive-sequence voltage V1X ➤ Frequency (FREQX) in Hz ➤ df/dt in Hz/s
Y-Side Quantities (model dependent)	➤ Fundamental current phasors IAY, IBY, and ICY and positive-sequence current I1Y ➤ Wye-connected input voltages (with respect to neutral): Fundamental voltage phasors VAY, VBY, and VCY and positive-sequence voltage V1Y ➤ Delta-connected input voltages: Fundamental voltage phasors VABY, VBCY, and VCAY and positive-sequence voltage V1Y ➤ Frequency (FREQY) in Hz ➤ df/dt in Hz/s
Digitals	TSOK and SV17–SV32 Relay Word bit status
Other Analog (model dependent)	➤ Synchronism-check voltage input (VS) magnitude ➤ Neutral current input (IN) magnitude ➤ MV29–MV32 Math Variables[a]

[a] These data are calculated every 100 ms. Only the data that occur at the top of the second are used for METER PM responses.

Remote Analog Metering

Use remote analog metering to verify the values received from an external device. The SEL-700G includes 128 remote analog variables. In *Appendix C: SEL Communications Processors*, we show how to enter remote analog settings in an SEL communications processor and the SEL-700G. *Figure 5.21* shows an example of the METER RA command report for the settings in *Appendix C: SEL Communications Processors*.

```
=>>MET RA <Enter>
SEL-700G Date: 02/11/2011 Time: 13:42:23
GENERATOR RELAY Time Source: External
RA01 1.00
RA02 -32767.00
RA03 -1.00
RA04 0.00
RA05 1000.59
RA06 -1000.61
RA07 2411.01
RA08 2410.99
RA09 98303.00
RA10 -98303.00
RA11 -38400.00
RA12 -65536.00
RA13 0.00
RA14 0.00
RA15 0.00
. .
. .
. .
RA126 0.00
RA127 0.00
RA128 0.00
=>>
```

Figure 5.14 MET RA Command Report

Differential Metering

The differential metering function in the SEL-700G1 model reports the fundamental frequency operate and restraint currents for each differential element (87) in multiples of TAP. *Table 5.8* shows the value reported. *Figure 5.15* shows an example of the METER DIF (differential) command report.

Table 5.8 Measured Differential Meter

Relay Option	Differential Values
SEL-700G1	Operate currents IOP1, IOP2, IOP3 in pu of TAP value for elements 87-1, 87-2, and 87-3, respectively Restraint currents IRT1, IRT2, IRT3 in pu of TAP value for elements 87-1, 87-2, and 87-3, respectively IOP1F2, IOP2F2, and IOP3F2 are 2nd harmonic currents as a percentage of IOP1, IOP2, and IOP3, respectively. IOP1F4, IOP2F4, IOP3F4 are 4th harmonic currents as a percentage of IOP1, IOP2, and IOP3, respectively. IOP1F5, IOP2F5, and IOP3F5 are 5th harmonic currents as a percentage of IOP1, IOP2, and IOP3, respectively.

```
=>>MET DIF <Enter>

SEL-700G                                  Date: 02/24/2010   Time: 15:49:20.763
GENERATOR RELAY                           Time Source: Internal

                    IOP1    IOP2    IOP3
Operate      (pu)    0.01    0.01    0.02

                    IRT1    IRT2    IRT3
Restraint    (pu)    2.01    2.01    1.99

                  IOP1F2  IOP2F2  IOP3F2
2nd Harmonic (%)    0.00    0.00    0.00

                  IOP1F4  IOP2F4  IOP3F4
4th Harmonic (%)    0.00    0.00    0.00

                  IOP1F5  IOP2F5  IOP3F5
5th Harmonic (%)    0.00    0.00    0.00

=>>
```

Figure 5.15 METER DIF (Differential) Command Report

Harmonic Metering

The harmonic metering function in the SEL-700G1 reports the current harmonics through the fifth harmonic and the total harmonic distortion percentage (THD %). *Table 5.9* shows the harmonic values reported. This command is only available in the SEL-700G1 model with the differential element. *Figure 5.16* provides an example of the **METER H** (harmonic) command report.

Table 5.9 Measured Harmonic Meter Values

Relay Option	Harmonic Values
SEL-700G1 Only	Fundamental and 2nd-, 3rd-, 4th-, 5th-harmonic values magnitude (secondary A) and THD % of line currents IAX, IBX, ICX, IAY, IBY, and ICY

```
=>>MET H <Enter>

SEL-700G                                  Date: 02/24/2010   Time: 15:53:02.780
GENERATOR RELAY                           Time Source: Internal

                IAX     IBX     ICX     IAY     IBY     ICY
Fund (A sec.)    5.05    5.01    5.00    5.01    5.02    5.00
2nd (A sec.)     0.01    0.00    0.00    0.00    0.00    0.00
3rd (A sec.)     0.00    0.01    0.01    0.00    0.00    0.01
4th (A sec.)     0.00    0.00    0.00    0.00    0.00    0.00
5th (A sec.)     0.00    0.01    0.01    0.00    0.00    0.00
THD (%)          0.18    0.29    0.24    0.14    0.15    0.19

=>>
```

Figure 5.16 METER H (Harmonic) Command Report

Small Signal Cutoff for Metering

The relay applies a threshold to the voltage and current magnitude metering quantities to force a reading to zero when the measurement is near zero. The threshold for fundamental metering current values is $0.01 \cdot I_{NOM}$ A (secondary) and for voltage values is 0.1 V (secondary). The threshold for rms metering current values is $0.03 \cdot I_{NOM}$ A (secondary) and for voltage values is 0.3 V (secondary).

The Global setting METHRES (as shown in *Table 4.71*) controls how these metering functions work when the metered value is smaller than the previously stated thresholds.

METHRES := Y

Set METHRES := Y to force the fundamental and rms metering values of currents and voltages to zero when the corresponding applied signals fall below the previously stated thresholds.

METHRES := N

Set METHRES := N to bypass the meter threshold checks and disable the metering cutoff.

Load Profiling

The SEL-700G includes a load profiling function. The relay automatically records selected quantities into nonvolatile memory every 5, 10, 15, 30, or 60 minutes, depending on the LDAR load profile report setting (see *Load Profile Settings on page 4.260*). Choose which analog quantities you want to monitor from the analog quantities listed in *Appendix M: Analog Quantities*. Set these quantities into the LDLIST load profile list report setting.

The relay memory can hold data for 9800 time-stamped entries. For example, if you choose to monitor 10 values at a rate of every 15 minutes, you could store approximately as many as 102 days worth of data.

Download the load rate profile data by using the serial port **LDP** command described in *LDP Command (Load Profile Report) on page 7.57*. *Figure 5.17* shows an example **LDP** serial port command response.

```
=>LDP <Enter>

SEL-700G                                     Date: 02/24/2010   Time: 16:54:04.464
GENERATOR RELAY                              Time Source: Internal

#      DATE         TIME        IAX_MAG    VAX_MAG      P3X       PF3X       FREQX
10  02/24/2010  16:05:01.651    504.948   9978.167   13021.76      0.866      59.989
9   02/24/2010  16:10:01.706    504.662   9978.728   13024.23      0.866      59.988
8   02/24/2010  16:15:01.673    505.013   9978.229   13020.71      0.867      59.988
7   02/24/2010  16:20:01.681    504.784   9978.532   13022.14      0.867      59.988
6   02/24/2010  16:25:01.694    504.498   9975.058   13024.19      0.867      59.988
5   02/24/2010  16:30:01.298    504.677   9977.791   13025.01      0.867      59.988
4   02/24/2010  16:35:01.448    504.947   9978.691   13020.72      0.866      59.988
3   02/24/2010  16:40:01.248    707.137   9999.430   18255.97      0.867      59.989
2   02/24/2010  16:45:01.369    705.380   9973.406   18257.78      0.867      59.989
1   02/24/2010  16:50:01.661    707.026   9979.489   18257.22      0.867      59.989

=>
```

Figure 5.17 LDP Command Response

LDP data are also available as a read-only file that can be retrieved using Ethernet FTP or MMS. MMS is only available in models that support IEC 61850 and only when IEC 61850 and MMS file transfer are enabled (E61850 := Y, EMMSFS := Y). See *File Transfer Protocol (FTP) and MMS File Transfer on page 7.15*, *Virtual File Interface on page 7.77*, and *MMS on page G.5* for additional information.

Breaker Monitor

The breaker monitor in the SEL-700G helps in scheduling circuit breaker maintenance. The breaker monitor (one for each breaker), can be enabled independently with the corresponding enable setting:

EBMON*n* = **Y**, where *n* = X or Y

The breaker monitor settings in *Table 5.11* are available via the **SET G** commands (see *Table 6.3*). Also refer to *BRE n Command (Monitor Breaker Data, Where n = X or Y) on page 7.35* and *BRE n W or R Command (Preload/ Reset Breaker Wear, Where n = X or Y) on page 7.35*.

The breaker monitor is set with breaker maintenance information provided by circuit breaker manufacturers. This breaker maintenance information lists the number of close/open operations that are permitted for a given current interruption level. The following is an example of breaker maintenance information for a 25 kV circuit breaker. The breaker maintenance information in *Table 5.10* is plotted in *Figure 5.18*.

Table 5.10 Breaker Maintenance Information for a 25 kV Circuit Breaker

Current Interruption Level (kA)	Permissible Number of Close/Open Operations[a]
0.00–1.20	10,000
2.00	3,700
3.00	1,500
5.00	400
8.00	150
10.00	85
20.00	12

[a] The action of a circuit breaker closing and then later opening is counted as one close/open operation.

Connect the plotted points in *Figure 5.18* for a breaker maintenance curve. To estimate this breaker maintenance curve in the SEL-700G breaker monitor, three set points are entered for Breaker *n*, where *n* = X or Y:

Set Point 1 COSP1*n*	**maximum** number of close/open operations with corresponding current interruption level.
Set Point 2 COSP2*n*	number of close/open operations that correspond to some **midpoint** current interruption level.
Set Point 3 COSP3*n*	number of close/open operations that correspond to the **maximum** current interruption level.

These three points are entered with the settings in *Table 5.11*.

Table 5.11 Breaker Monitor Settings[a]

Setting Prompt	Setting Range	Setting Name := Factory Default
Breaker *n* Monitor	Y, N	EBMON*n* := Y
*n*CL/OPN OPS SETPT 1	0–65000	COSP1*n* := 10000[b]
*n*CL/OPN OPS SETPT 2	0–65000	COSP2*n* := 150[c d]
*n*CL/OPN OPS SETPT 3	0–65000	COSP2*n* := 12
*n*kA PRI INTERRPTD 1	0.10–999.00 kA	KASP1*n* := 1.20[e]
*n*kA PRI INTERRPTD 2	0.10–999.00 kA	KASP2*n* := 8.00
*n*kA PRI INTERRPTD 3	0.10–999.00 kA	KASP3*n* := 20.00[f]
BRKR*n* MON CONTROL	SELOGIC	BKMON*n* := TRIP

[a] n = X or Y.
[b] COSP1n must be set greater than COSP2n.
[c] COSP2n must be set greater than or equal to COSP3n.
[d] If COSP2n is set the same as COSP3n, then KASP2 must be set the same as KASP3n.
[e] KASP1n must be set less than KASP2n.
[f] KASP3n must be set at least five times (but no more than 100 times) the KASP1n setting value.

The following settings are made from the breaker maintenance information in *Table 5.10* and *Figure 5.18*. *Figure 5.19* shows the resultant breaker maintenance curve.

COSP1*n* = **10000**	KASP1*n* = **1.20**
COSP2*n* = **150**	KASP2*n* = **8.00**
COSP3*n* = **12**	KASP3*n* = **20.00**

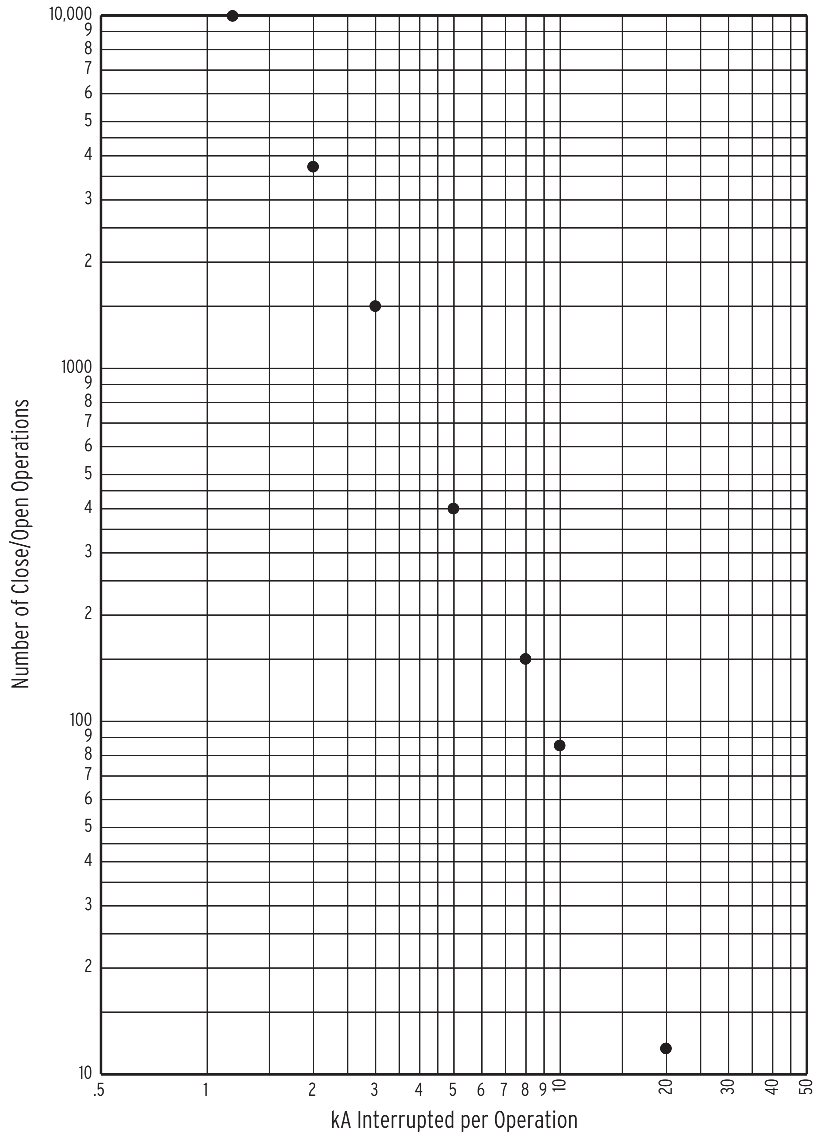

Figure 5.18 Plotted Breaker Maintenance Points for a 25 kV Circuit Breaker

Breaker Maintenance Curve Details

In *Figure 5.19*, note that set points KASP1*n*, COSP1*n* and KASP3*n*, COSP3*n* are set with breaker maintenance information from the two extremes in *Table 5.10* and *Figure 5.18*.

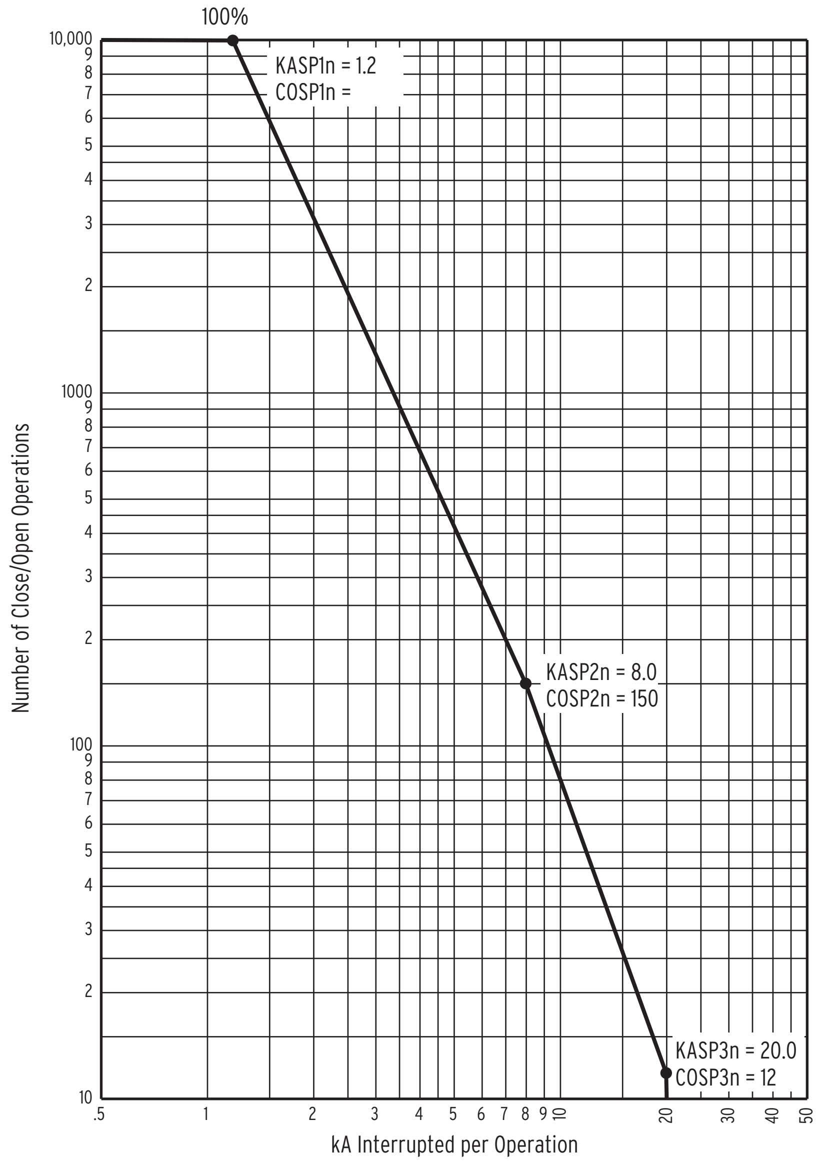

Figure 5.19 SEL-700G Breaker Maintenance Curve for a 25 kV Circuit Breaker

In this example, set point KASP2*n*, COSP2*n* happens to be from an in-between breaker maintenance point in the breaker maintenance information in *Table 5.10* and *Figure 5.18*, but it does not have to be. Set point KASP2*n*, COSP2*n* should be set to provide the best "curve-fit" with the plotted breaker maintenance points in *Figure 5.18*.

Each phase (A, B, and C) has its own breaker maintenance curve (like that in *Figure 5.20*), because the separate circuit breaker interrupting contacts for phases A, B, and C do not necessarily interrupt the same magnitude current (depending on fault type and loading).

In *Figure 5.20*, note that the breaker maintenance curve levels off horizontally above set point KASP1*n*, COSP1*n*. This is the close/open operation limit of the circuit breaker (COSP1*n* = 10000), regardless of interrupted current value.

Also, note that the breaker maintenance curve falls vertically below set point KASP3*n*, COSP3*n*. This is the maximum interrupted current limit of the circuit breaker (KASP3*n* = 20.0 kA). If the interrupted current is greater than setting KASP3*n*, the interrupted current is accumulated as a current value equal to setting KASP3*n*.

Operation of SELOGIC Control Equation Breaker Monitor Initiation Setting BKMON

The SELOGIC control equation breaker monitor initiation setting BKMON*n* in *Table 5.11* determines when the breaker monitor reads in current values (Phases A, B, and C) for the breaker maintenance curve (see *Figure 5.20*) and the breaker monitor accumulated currents/trips (see *BRE n Command (Monitor Breaker Data, Where n = X or Y) on page 7.35*).

The BKMON*n* setting looks for a rising edge (logical 0 to logical 1 transition) as the indication to read in current values. The acquired current values are then applied to the breaker maintenance curve and the breaker monitor accumulated currents/trips (see references in previous paragraph).

In the factory-default settings, the SELOGIC control equation breaker monitor initiation setting is set:

BKMON*n* = **TRIP***n* (**TRIP***n* is the logic output of *Figure 4.36*)

Refer to *Figure 5.20*. When BKMON*n* asserts (Relay Word bit TRIP*n* goes from logical 0 to logical 1), the breaker monitor reads in the current values and applies these values to the breaker monitor maintenance curve and the breaker monitor accumulated currents/trips.

As detailed in *Figure 5.20*, the breaker monitor actually reads in the current values 1.5 cycles after the assertion of BKMON*n*. This helps especially if an instantaneous trip occurs. The instantaneous element trips when the fault current reaches its pickup setting level. The fault current may still be "climbing" to its full value, at which it levels off. The 1.5-cycle delay on reading in the current values allows time for the fault current to level off.

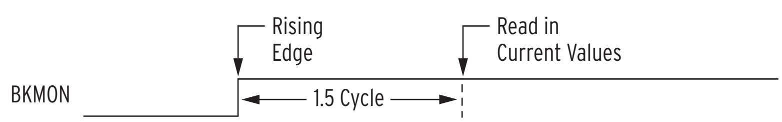

Figure 5.20 Operation of SELOGIC Control Equation Breaker Monitor Initiation Setting

See *Figure 5.25* and accompanying text for more information on setting BKMON*n*. The operation of the breaker monitor maintenance curve, when new current values are read in, is explained in the following example.

Breaker Monitor Operation Example

As stated earlier, each phase (A, B, and C) has its own breaker maintenance curve. For this example, presume that the interrupted current values occur on a single phase in *Figure 5.21* through *Figure 5.24*. Also, presume that the circuit breaker interrupting contacts have no wear at first (brand new or recent maintenance performed).

Note in *Figure 5.21* through *Figure 5.24* that the interrupted current in a given figure is the same magnitude for all interruptions (for example, in *Figure 5.22*, 2.5 kA is interrupted 290 times). This is not realistic, but it demonstrates the operation of the breaker maintenance curve and how it integrates for varying current levels.

0 Percent to 10 Percent Breaker Wear

Refer to *Figure 5.21*. 7.0 kA is interrupted 20 times (20 close/open operations = 20 – 0), pushing the breaker maintenance curve from the 0 percent wear level to the 10 percent wear level.

Compare the 100 percent and 10 percent curves. Note that for a given current value, the 10 percent curve has only 1/10 of the close/open operations of the 100 percent curve.

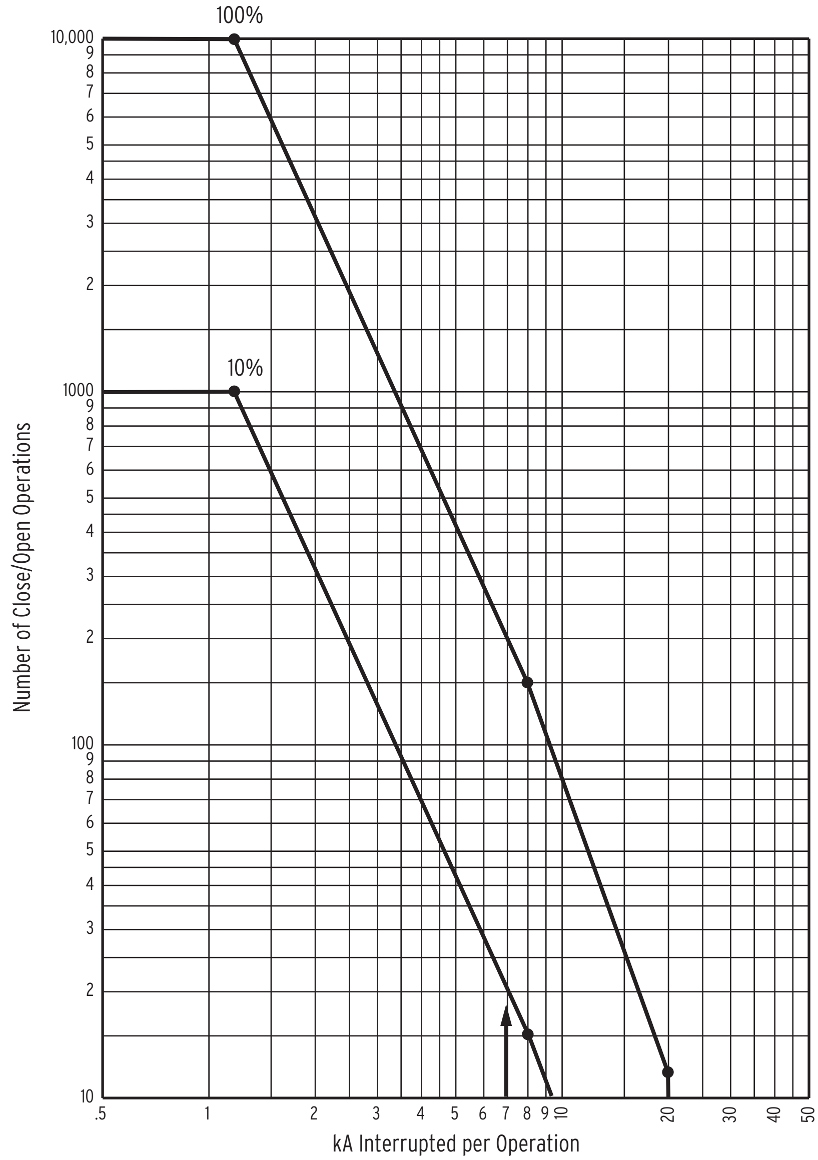

Figure 5.21 Breaker Monitor Accumulates 10 Percent Wear

10 Percent to 25 Percent Breaker Wear

Refer to *Figure 5.22*. The current value changes from 7.0 kA to 2.5 kA. 2.5 kA is interrupted 290 times (290 close/open operations = 480 – 190), pushing the breaker maintenance curve from the 10 percent wear level to the 25 percent wear level.

Compare the 100 percent and 25 percent curves. Note that for a given current value, the 25 percent curve has only 1/4 of the close/open operations of the 100 percent curve.

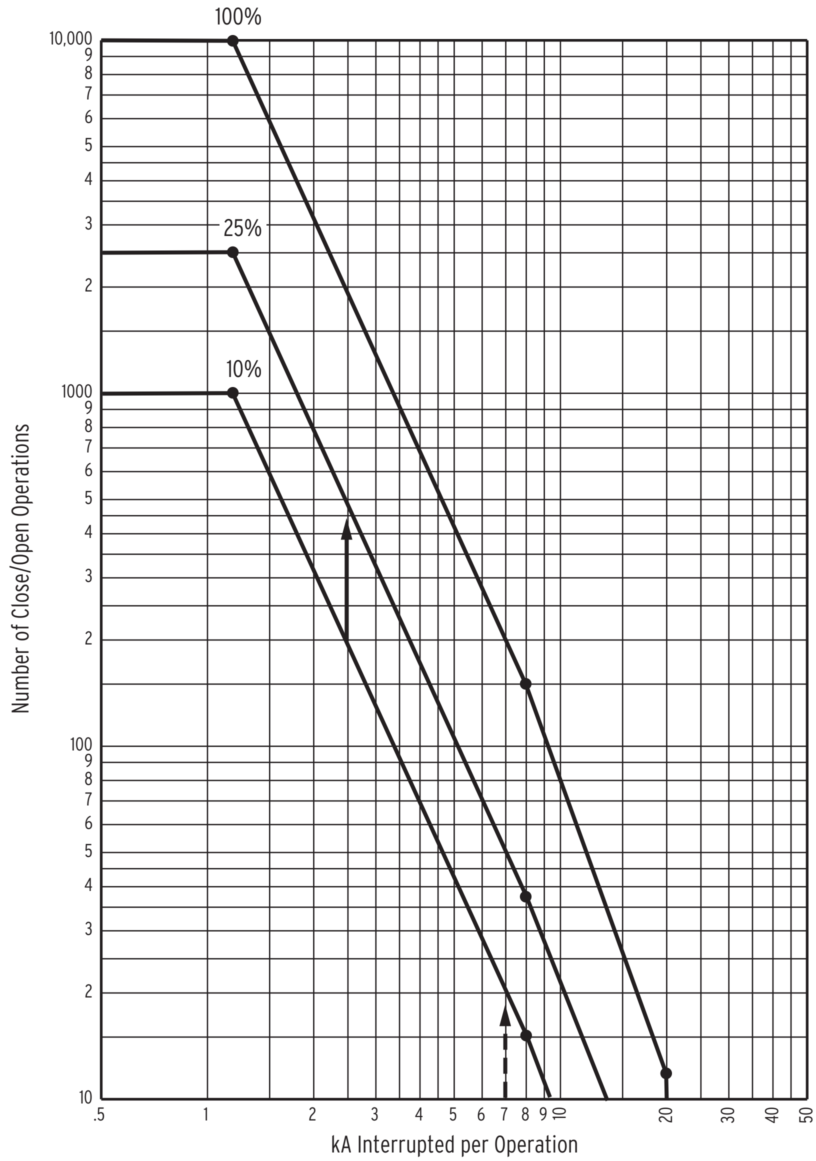

Figure 5.22 Breaker Monitor Accumulates 25 Percent Wear

25 Percent to 50 Percent Breaker Wear

Refer to *Figure 5.23*. The current value changes from 2.5 kA to 12.0 kA. 12.0 kA is interrupted 11 times (11 close/open operations = 24 – 13), pushing the breaker maintenance curve from the 25 percent wear level to the 50 percent wear level.

Compare the 100 percent and 50 percent curves. Note that for a given current value, the 50 percent curve has only 1/2 of the close/open operations of the 100 percent curve.

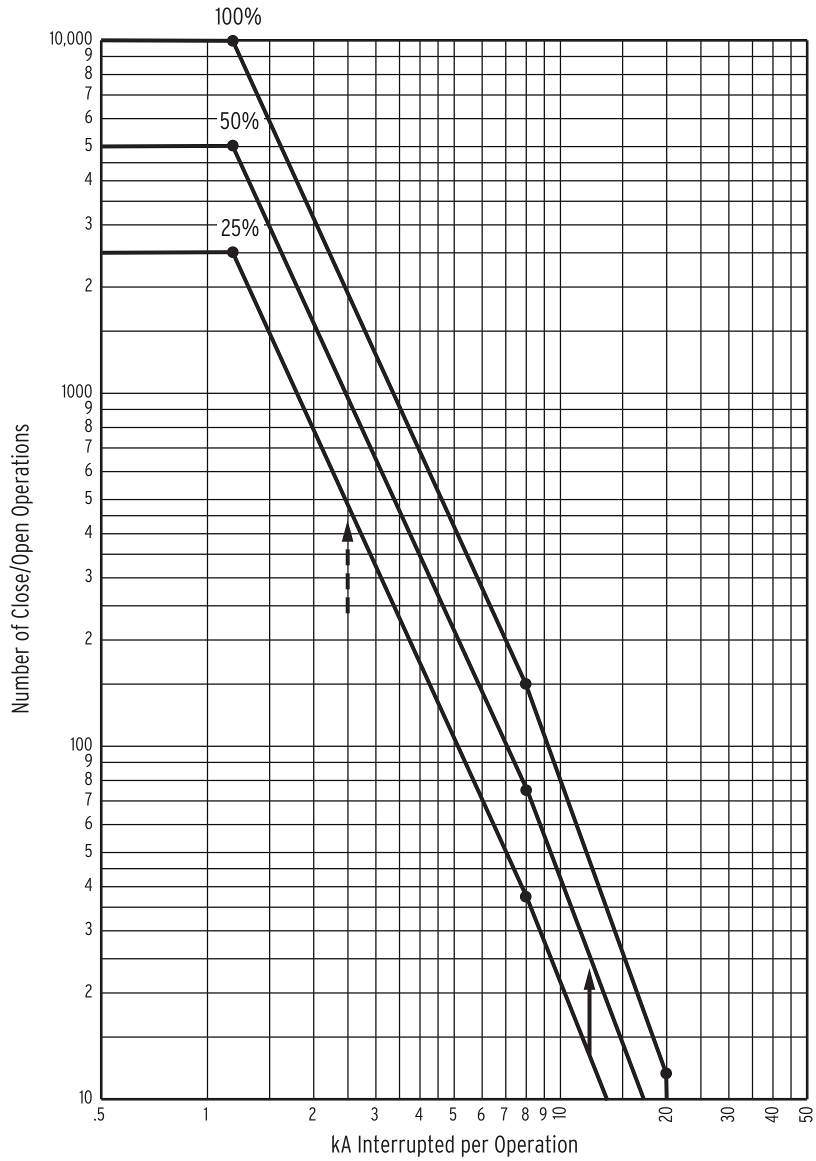

Figure 5.23 Breaker Monitor Accumulates 50 Percent Wear

50 Percent to 100 Percent Breaker Wear

Refer to *Figure 5.24*. The current value changes from 12.0 kA to 1.5 kA. 1.5 kA is interrupted 3000 times (3000 close/open operations = 6000 – 3000), pushing the breaker maintenance curve from the 50 percent wear level to the 100 percent wear level.

When the breaker maintenance curve reaches 100 percent for a particular phase, the percentage wear remains at 100 percent (even if additional current is interrupted), until reset by the **BRE** *n* **R** command (see *View or Reset Breaker Monitor Information on page 5.25*). But the current and trip counts continue to accumulate, until the **BRE** *n* **R** command resets these counts.

Additionally, logic outputs assert for alarm or other control applications—see the following discussion.

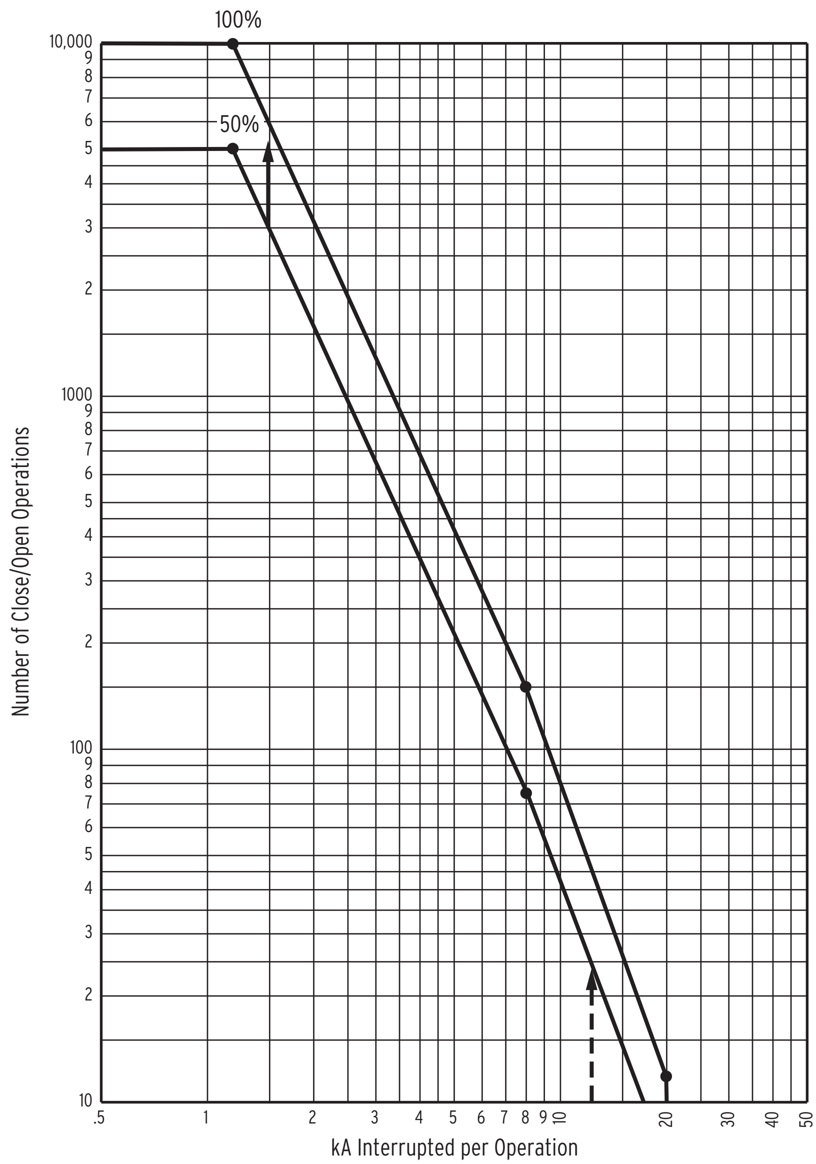

Figure 5.24 Breaker Monitor Accumulates 100 Percent Wear

Breaker Monitor Output

When the breaker maintenance curve for a particular phase (A, B, or C) reaches the 100 percent wear level (see *Table 5.12*), a corresponding Relay Word bit (BCWA*n*, BCWB*n*, or BCWC*n*) asserts.

Table 5.12 Breaker Monitor Output

Relay Word Bits	Definition
BCWA*n*	A-phasengle Breaker *n* contact wear has reached the 100 percent wear level
BCWB*n*	B-phase Breaker *n* contact wear has reached the 100 percent wear level
BCWC*n*	C-phase Breaker *n* contact wear has reached the 100 percent wear level
BCW*n*	BCWA*n* or BCWB*n* or BCWC*n*
where *n* is X for X-side and Y for Y-side breakers	

EXAMPLE 5.1 Example Applications

You can use these logic outputs to alarm:

OUT*xxx* = **BCW***n*

View or Reset Breaker Monitor Information

Accumulated breaker wear/operations data are retained if the relay loses power or if the breaker monitor is disabled (setting EBMON*n* := N). The accumulated data can only be reset if the **BRE** *n* **R** command is executed (see the following discussion on the **BRE** *n* **R** command).

Via Serial Port

See *Section 7: Communications*. The **BRE** *n* command displays the following information:

- ➤ Accumulated number of relay-initiated trips
- ➤ Accumulated interrupted current from relay-initiated trips
- ➤ Accumulated number of externally initiated trips
- ➤ Accumulated interrupted current from externally initiated trips
- ➤ Percent circuit breaker contact wear for each phase
- ➤ Date when the preceding items were last reset (via the **BRE** *n* **R** command)

See *Section 7: Communications*. The **BRE** *n* **W** command allows the trip counters, accumulated values, and percent breaker wear to be preloaded for each individual phase.

The **BRE** *n* **R** command resets the accumulated values and the percent wear for all three phases. For example, if breaker contact wear has reached the 100 percent wear level for A-phasengle, the corresponding Relay Word bit BCWA asserts (BCWA*n* = logical 1). Execution of the **BRE** *n* **R** command resets the wear levels for all three phases back to 0 percent and consequently causes Relay Word bit BCWA to deassert (BCWA*n* = logical 0).

Via Front Panel

The information and reset functions available via the previously discussed serial port commands **BRE** *n* and **BRE** *n* **R** are also available via the front panel. See *Section 8: Front-Panel Operations* for details.

Breaker wear data are also available as a read-only file that can be retrieved using Ethernet FTP or MMS. MMS is only available in models that support IEC 61850 and only when IEC 61850 and MMS file transfer are enabled (E61850 := Y, EMMSFS := Y). See *File Transfer Protocol (FTP) and MMS File Transfer on page 7.15*, *Virtual File Interface on page 7.77*, and *MMS on page G.5* for additional information.

Determination of Relay-Initiated Trips and Externally Initiated Trips

See *Section 7: Communications*. Note in the **BRE** *n* command response that the accumulated number of trips and accumulated interrupted current are separated into two groups of data: those generated by relay-initiated trips (Rly Trips), and those generated by externally initiated trips (Ext Trips). The categorization of these data is determined by the status of the TRIP*n* Relay Word bit when the SELOGIC control equation breaker monitor initiation setting BKMON*n* operates.

Refer to *Figure 5.20* and accompanying explanation. If BKMON*n* newly asserts (logical 0 to logical 1 transition), the relay reads in the current values (Phases A, B, and C). Now, the relay must determine whether to accumulate this current and trip count information under relay-initiated trips or externally initiated trips.

To make this determination, the relay checks the status of the TRIP*n* Relay Word bit at the instant BKMON*n* newly asserts (TRIP*n* is the logic output of *Figure 4.36 on page 4.68*). If TRIP*n* is asserted (TRIP*n* = logical 1), the current and trip count information is accumulated under relay-initiated trips (Rly Trips). If TRIP*n* is deasserted (TRIP*n* = logical 0), the current and trip count information is accumulated under externally initiated trips (Ext Trips).

Regardless of whether the current and trip count information is accumulated under relay-initiated trips or externally initiated trips, this same information is routed to the breaker maintenance curve for continued breaker wear integration (see *Figure 5.20–Figure 5.24*).

Relay-initiated trips (Rly Trips) are also referred to as internally initiated trips (Int Trips) in the course of this manual; the terms are interchangeable.

EXAMPLE 5.2 Factory-Default Setting Example

As discussed previously, the SELOGIC control equation breaker monitor initiation factory-default setting is:

BKMON*n* = **TRIP***n*

Thus, any new assertion of BKMON*n* is deemed a relay trip, and the current and trip count information is accumulated under relay-initiated trips (Rly Trips).

EXAMPLE 5.3 Additional Example

Refer to *Figure 5.25*. Output contact **OUTxxx** is set to provide tripping:

OUT*xxxn* = **TRIP***n*

Note that optoisolated input **INxxx** monitors the trip bus. If the trip bus is energized by output contact **OUTxxx**, an external control switch, or some other external trip, then **INxxx** is asserted.

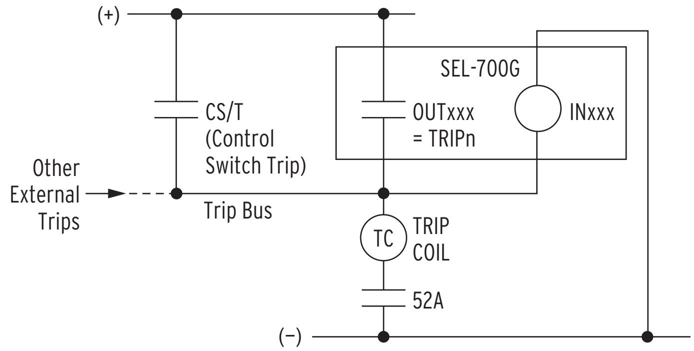

Figure 5.25 Input INxxx Connected to Trip Bus for Breaker Monitor Initiation

If the SELOGIC control equation breaker monitor initiation setting is set:

BKMON*n* = **IN*xxx***

then the SEL-700G breaker monitor sees all trips.

If output contact **OUTxxx** asserts, energizing the trip bus, the breaker monitor deems it a relay-initiated trip. This is because, when BKMON*n* is newly asserted (input **INxxx** energized), the TRIP*n* Relay Word bit is asserted. Thus, the current and trip count information is accumulated under relay-initiated trips (Rly Trips).

If the control switch trip (or some other external trip) asserts, energizing the trip bus, the breaker monitor deems it an externally initiated trip. This is because, when BKMON*n* is newly asserted (input **INxxx** energized), the TRIP*n* Relay Word bit is deasserted. Thus, the current and trip count information is accumulated under externally initiated trips (Ext Trips).

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Section 6

Settings

Overview

IMPORTANT: Upon relay initial turn on, Port 1 settings changes, or Logic settings changes, you may have to wait as long as two minutes before an additional settings change can occur. Note that the relay is functional with protection enabled as soon as the **ENABLED** LED comes on (about 5–10 seconds from turn on).

The SEL-700G Relay stores the settings you enter in nonvolatile memory. Settings are divided into the following 11 setting classes:

1. Group *n* (where *n* = 1, 2, 3, or 4)
2. Logic Group *n* (where *n* = 1, 2, 3, or 4)
3. Global
4. Port *p* (where *p* = F, 1 [Ethernet], 2, 3, or 4)
5. Front Panel
6. Report
7. Modbus
8. EtherNet/IP
9. DNP3
10. IEC 60870-5-103
11. Touchscreen (this setting class is only available for models with the color touchscreen display)

Some setting classes have multiple instances. In the previous list, there are five port setting instances, one for each port. You can view or set settings in several ways, as shown in *Table 6.1*.

Table 6.1 Methods of Accessing Settings[a]

	Web Server[b]	Serial Port Commands[c]	Front-Panel HMI Set/ Show Menu[d]	ACSELERATOR QuickSet SEL-5030 Software[b]
Display Settings	All settings	All settings (**SHO** command)	Global, Group, and Port settings	All settings
Change Settings	Not available	All settings (**SET** command)	Global, Group, and Port settings	All settings

[a] These settings access methods do not apply to the touchscreen settings.
[b] Refer to Section 3: PC Interface for detailed information.
[c] Refer to Section 7: Communications for detailed information on set up and use of the serial communications port and Ethernet port.
[d] Refer to Section 8: Front-Panel Operations for detailed information on the front-panel layout, menus and screens, and operator control pushbuttons.

Setting entry error messages, together with corrective actions, are also presented in this section to assist in correct settings entry.

The *SEL-700G Settings Sheets* at the end of this section list all SEL-700G settings, the setting definitions, and input ranges. Refer to *Section 4:*

Protection and Logic Functions for detailed information on individual elements and settings.

Touchscreen settings are only available through QuickSet for models with the color touchscreen display. These settings are not available via ASCII terminal, unlike the other relay settings. Refer to *Section 9: Bay Control* for detailed information on individual settings.

View/Change Settings With the Two-Line Front Panel

You can use the pushbuttons on the front panel to view/change settings. See *Section 8: Front-Panel Operations* for the operating details of the front panel.

Enter the front-panel menu by pushing the **ESC** pushbutton. It will display the following message:

```
MAIN
Meter
```

Scroll down the menu by using the **Down Arrow** pushbutton until the display shows the following message:

```
Control
Set/Show
```

The cursor (underline) should be on the `Set/Show` command. Enter the `Set/Show` command by pushing the **ENT** pushbutton. The display shows the following message:

```
SET/SHOW
Global
```

Enter the underlined relay message with the **ENT** pushbutton, and the relay presents you with the relay settings as listed in the *SEL-700G Settings Sheets*. Use the **Up Arrow**, **Down Arrow**, **Left Arrow**, and **Right Arrow** pushbuttons to scroll through the relay settings. View and change the settings according to your needs by selecting and editing them. After viewing or changing the relay settings, press the **ESC** pushbutton until the following message appears:

```
Save Changes?
Yes   No
```

NOTE: Each SEL-700G is shipped with default factory settings. Calculate the settings for your application to ensure secure and dependable protection. Document the settings on the SEL-700G Settings Sheets at the end of this section before entering new settings in the relay.

Select and enter the appropriate command by pushing the **ENT** pushbutton. Select `Yes` to save the settings changes and `No` to discard the changes.

Figure 6.1 shows a front-panel menu navigation example for the relay to enter the INOM setting for CTRX (X-side phase CT ratio).

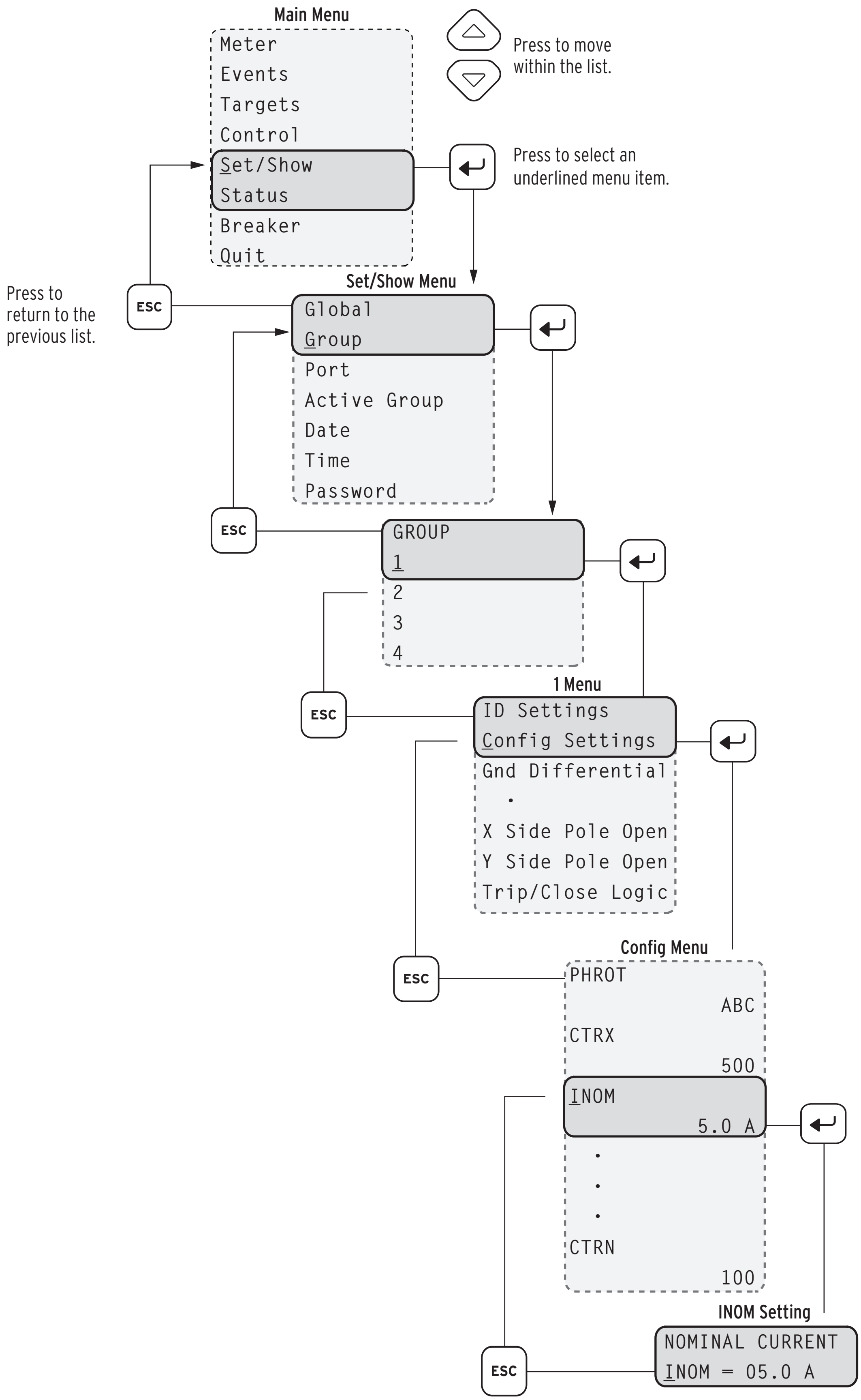

Figure 6.1 Front-Panel Setting Entry Example for the SEL-700GT Relay

View/Change Settings With the Touchscreen Front Panel

You can view or change Port, Global, Group, Date and Time, and Touchscreen settings using the touchscreen display. Tap the **Settings** folder on the Home screen to navigate to the Settings screen, through which you can view or change settings. Refer to *Touchscreen Display Front Panel on page 8.17* for detailed information on how to view or change settings using the touchscreen display.

View/Change Settings Over Communications Port

Refer to *Section 7: Communications* for information on how to set up and access the relay serial or Ethernet port with a personal computer and how to use ASCII commands to communicate with the relay.

View Settings

Use the **SHOW** command to view relay settings. The **SHOW** command is available from Access Level 1 and Access Level 2. *Table 6.2* lists the **SHOW** command options.

Table 6.2 SHOW Command Options

Command	Description
SHO *n*	Show group settings: *n* specifies the settings group (1, 2, 3, or 4); *n* defaults to the active settings group if not listed.
SHO L *n*	Show logic settings: *n* specifies the settings group (1, 2, 3, or 4); *n* defaults to the active settings group if not listed.
SHO G	Show global configuration settings.
SHO P *n*	Show serial port settings for Port *n* (*n* = F, 1, 2, 3, or 4).
SHO F	Show front-panel display and LED settings.
SHO E	Show EtherNet/IP assembly map settings
SHO R	Show Sequential Events Recorder (SER) and event report settings.
SHO M	Show Modbus map settings.
SHO D	Show DNP3 map settings.
SHO I	Show IEC 60870-5-103 map settings.

You can append a setting name to each of the commands to specify the first setting to display (for example, **SHO 50PX1P** displays the relay settings starting with setting **50PX1P**). The default is the first setting. The **SHOW** command displays only the enabled settings.

Enter Settings

The **SET** command (available from Access Level 2) allows you to view or change settings. *Table 6.3* lists the **SET** command options.

Table 6.3 SET Command Options

Command	Settings Type	Description
SET *n*	Group	Protection elements, timers, etc., for settings Group *n* (1, 2, 3, or 4).
SET L *n*	Logic	SELOGIC control equations for settings Group *n* (1, 2, 3, or 4).
SET G	Global	Global configuration settings, including Event Messenger, optoisolated input debounce timers, etc.
SET P *n*	Port	Serial port settings for serial Port *n* (1, 2, 3, 4, or F).
SET F	Front Panel	Front-panel display and LED settings.
SET E	EtherNet/IP	EtherNet/IP assembly map settings.
SET R	Report	SER and event report settings.
SET M	Modbus	Modbus map settings.
SET D	DNP3	DNP3 map settings.
SET I	IEC 60870-5-103	IEC 60870-5-103 map settings.

You can append a setting name to each of the commands to specify the first setting to display (for example, **SET 50PX1P** displays the relay settings starting with setting 50PX1P). The default is the first setting.

When you issue the **SET** command, the relay presents a list of settings one at a time. Enter a new setting, or press **<Enter>** to accept the existing setting. Editing keystrokes are listed in *Table 6.4*.

Table 6.4 SET Command Editing Keystrokes

Press Key(s)	Results
<Enter>	Retains the setting and moves to the next setting.
^ <Enter>	Returns to the previous setting.
< <Enter>	Returns to the previous setting category.
> <Enter>	Moves to the next setting category.
END <Enter>	Exits the editing session, then prompts you to save the settings.
<Ctrl+X>	Aborts the editing session without saving changes.

The relay checks each entry to ensure that the entry is within the setting range. If it is not in range, an `Out of Range` message is generated, and the relay prompts you for the setting again.

When all the settings are entered, the relay displays the new settings and prompts you for approval to enable them. Press **Y <Enter>** to enable the new settings. The relay is disabled for as long as five seconds while it saves the new settings. The SALARM Relay Word bit is set momentarily, and in the two-line display model, the **ENABLED** LED extinguishes while the relay is disabled. In the touchscreen display model, the **ENABLED** LED stays illuminated while the relay saves the settings.

To change a specific setting, enter the command shown in *Table 6.5*.

Table 6.5 SET Command Format

SET n m s TERSE	
where:	
n	is left blank or is D, G, L, F, R, M, or P to identify the class of settings.
m	is 1, 2, 3, or 4 when *n* = G or L for group settings; *n* defaults to 1 if the parameter is left blank. is F, 1, 2, 3, or 4 when *n* = P for port settings; *n* defaults to the active port if the parameter is left blank.
s	is the name of the specific setting you want to jump to and begin setting. If *s* is not entered, the relay starts at the first setting (e.g., enter 50PX1P to start at the phase overcurrent trip level setting).
TERSE	instructs the relay to skip the settings display after the last setting. Use this parameter to speed up the **SET** command. If you want to review the settings before saving, do not use the **TERSE** option.

Setting Entry Error Messages

As you enter relay settings, the relay checks the setting entered against the range for the setting as published on the relay setting sheet. If any setting entered falls outside the corresponding range for that setting, the relay immediately responds `Out of Range` and prompts you to reenter the setting.

In addition to the immediate range check, several of the settings have interdependency checks with other settings. The relay checks setting interdependencies after you answer `Y` to the `Saves Settings?` prompt, but before the settings are stored. If any of these checks fail, the relay issues a self-explanatory error message and returns you to the settings list for a correction. *Table 6.6* shows the settings interdependency error messages that require some additional explanation and guidance.

Table 6.6 Setting Interdependency Error Messages

Error Message	Setting/Function	Correct the Condition
`CTRm, TAPm setting combination out of range` (*m* = X or Y)	Group settings, differential element autocalculation of TAPX and TAPY	Check: 0.1 * I*m*NOM < TAP*m* <6.2 * I*m*NOM (I*m*NOM = 5 or 1 for 5 A and 1 A phase CT based on PARTNO). Should either TAP*m* value violate this requirement, adjust the affected TAP*m* and /or CTR*m* to satisfy the check. (*m* = X or Y).
`Maximum to minimum per unit tap-ratio must be < or = 7.5`	Group settings, differential element autocalculation of TAPX and TAPY	Check: [MAX (TAPX/IXNOM, TAPY/IYNOM) / MIN (TAPX/IXNOM, TAPY/IYNOM)] < or = 7.5. Adjust TAPX or TAPY setting until the check is satisfied.

View Settings Using the Web Server

Refer to *Section 3: PC Interface* for information on how to set up communication and how to access the relay on an Ethernet port with a personal computer.

View Settings

Once communication with the relay is established through the web server, the home page screen appears in your browser window. Click on **Settings** from the navigation pane to view all the available settings classes, as shown in *Figure 6.2*. Access Level 1 and Access Level 2 are view only. Click on a settings class to view its settings.

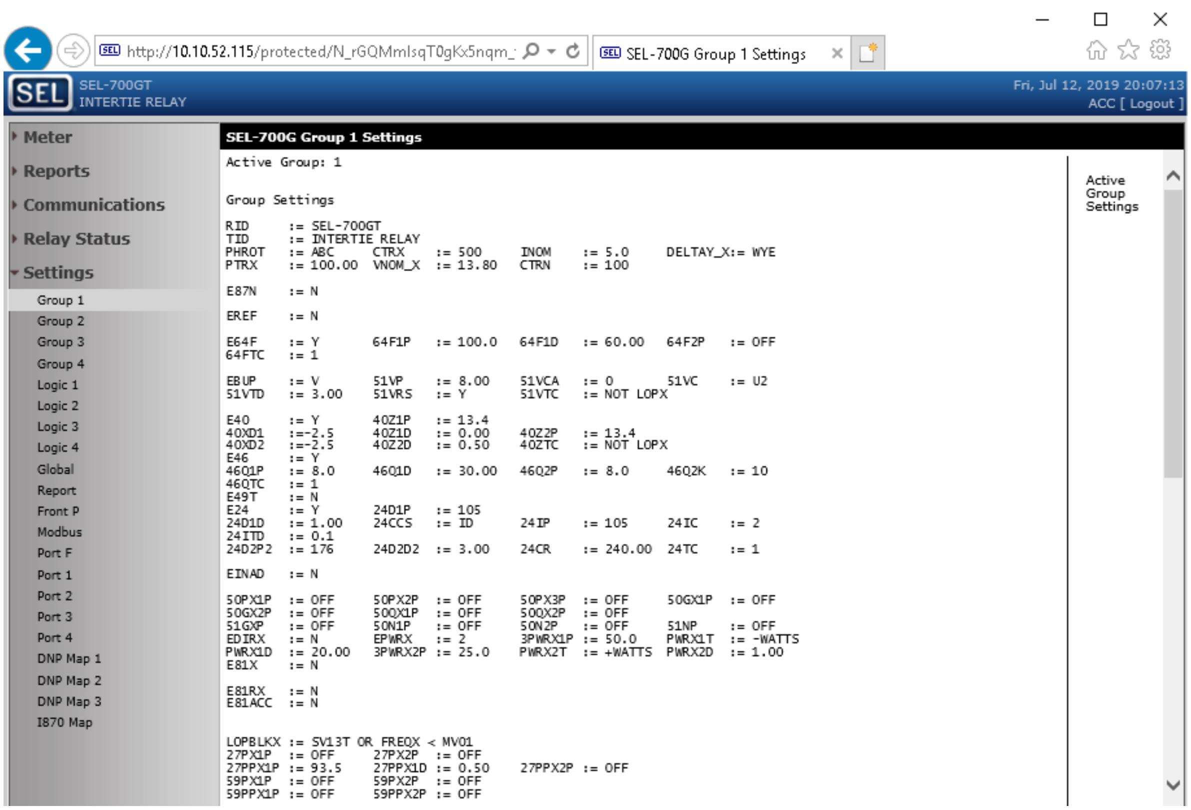

Figure 6.2 Web Server Settings Screen

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SEL-700G Settings Sheets

These settings sheets include the definition and input range for each setting in the relay. You can access the settings from the relay front panel and the communications ports. See *Section 4: Protection and Logic Functions* in the instruction manual for detailed descriptions of the settings.

- Some settings require an optional module. Refer to the SEL-700G Model Option Table, *Table 1.1*, and the notes to the settings below for details on which settings are available in a specific model. QuickSet, which shows and hides settings depending on the MOT part number selected, is the best way to view settings available in a specific model. Some of the settings ranges may be more restrictive than shown because of settings interdependency checks performed when new settings are saved (see *Setting Entry Error Messages on page 6.6* of the instruction manual)
- The settings are not case sensitive.

Group Settings (SET Command)

Identifier

UNIT ID LINE 1 (16 Characters) **RID :=**________________

UNIT ID LINE 2 (16 Characters) **TID :=**________________

Configuration

PHASE ROTATION (ABC, ACB) **PHROT :=**________

X-side

X CUR INPUT FROM (NEUT, TERM) (Shown if Slot E = 72/76, or Slot E = 73/77 and Slot Z = 81/85/82/86, else hidden and auto-set to TERM) **X_CUR_IN :=**________

X PH CT RATIO (1–10000 [5 A I_{XNOM}]; 1–50000 [1 A I_{XNOM}]) (Hidden if Slot Z = 84/88) **CTRX :=**________

NOMINAL CURRENT (1.0–10.0 A [5 A I_{XNOM}]; 0.2–2.0 A [1 A I_{XNOM}]) (Hidden if Slot Z = 84/88/83/87) **INOM :=**________

X SIDE PT CONN (DELTA, WYE) (Hidden if Slot Z = 84/88/83/87) **DELTAY_X :=**________

X PH PT RATIO (1.00–10000.00) (Hidden if Slot Z = 84/88/83/87) **PTRX :=**________

X SIDE VNOM (0.02–1000.00 kV) (Hidden if Slot Z = 84/88/83/87) **VNOM_X :=**________

EXT ZERO SEQ VOLT (NONE, VS, VN) (Hidden if Slot Z = 84/88 or Slot Z = 83/87. VS is hidden from the range if Slot E = 73/77 or empty. VN is hidden from the range if Slot E = 73/77, 71/75, or empty.) **EXT3V0_X:=**________

Y-side

Y PH CT CONN (DELTA, WYE) (Hidden if Slot Z = 84/88/83/87 or if Slot E = empty/74/71/75) **CTCONY :=**________

Y PH CT RATIO (1–10000 [5 A I_{YNOM}] 1–50000 [1 A I_{YNOM}]) (Hidden if Slot E = empty/74) **CTRY :=**________

Y SIDE PT CONN (DELTA, WYE) (Shown if Slot E = 71/75. If hidden, auto-set to WYE) **DELTAY_Y :=**________

Y PH PT RATIO (1.00–10000.00) (Shown if Slot E = 71/75) **PTRY :=**________

Y SIDE VNOM (0.02–1000.00 kV) (Shown if Slot E = 71/75) **VNOM_Y :=**________

Other

SYNCV PT RATIO (1.00–10000.00) (Hidden if Slot **E** = Empty/73/77)	**PTRS :=**_______________
NEUT CT RATIO (1–10000 [5 A I_{NNOM}], 1–50000 [1 A I_{NNOM}]) (Hidden if Slot **Z** = 83/87)	**CTRN :=**_______________
NEUT PT RATIO (1.00–10000.00) (Shown if Slot **E** = 74/72/76)	**PTRN :=**_______________

Generator Differential (Hidden if Slot E = Empty/74/71/75 or if Slot Z = 83/84/87/88)

PHASE DIFF EN (GEN, TRANS, NONE)	**E87 :=**_______________
Note: (All Differential settings are hidden if E87 := NONE.)	
MAX XFMR CAP (OFF, 0.2–5000.0 MVA) (Hidden and auto-set to OFF if E87 := GEN)	**MVA :=**_______________
DEFINE CT COMP (Y, N) (Hidden and auto-set to N if E87 := GEN)	**ICOM :=**_______________
X SIDE CT COMP (0, 12) (Hidden and automatically set to 0 if ICOM := N)	**CTCX :=**_______________
Y SIDE CT COMP (0, 1, 5, 6, 7, 11, 12) (Hidden and auto-set to 0 if ICOM := N)	**CTCY :=**_______________
WDG-X L-L VOLTS (0.2–1000.0 kV) (Hidden if MVA := OFF)	**VWDGX :=**_______________
WDG-Y L-L VOLTS (0.2–1000.0 kV) (Hidden if MVA := OFF)	**VWDGY :=**_______________
X SIDE CURR TAP (0.5–31.0 A [5 A I_{XNOM}]; 0.1-6.2 A [1 A I_{XNOM}]) (Auto-set if MVA setting is not OFF)	**TAPX :=**_______________
Y SIDE CURR TAP (0.5–31.0 A [5 A I_{YNOM}]; 0.1-6.2 A [1 A I_{YNOM}]) (Auto-set if MVA setting is not OFF)	**TAPY :=**_______________
OPERATE CURR LVL (0.10–1.00 TAP)	**O87P :=**_______________
UNRES CURR LVL (1.0–20.0 TAP)	**U87P :=**_______________
DIFF CURR AL LVL (OFF, 0.05–1.00 TAP)	**87AP :=**_______________
DIFF CURR AL DLY (1.00–120.00 s) (Hidden if O87P := OFF)	**87AD :=**_______________
RESTRAINT SLOPE1 (5–70 %)	**SLP1 :=**_______________
RESTRAINT SLOPE2 (5–90 %) (Hidden and auto-set to 70 if E87 := GEN)	**SLP2 :=**_______________
RES SLOPE1 LIMIT (1.0–20.0 TAP) (Hidden and auto-set to 6.0 if E87 := GEN)	**IRS1 :=**_______________
2ND HARM BLOCK (OFF, 5–100 %) (Hidden and auto-set to OFF if E87 := GEN)	**PCT2 :=**_______________
4TH HARM BLOCK (OFF, 5–100 %) (Hidden and auto-set to OFF if E87 := GEN)	**PCT4 :=**_______________
5TH HARM BLOCK (OFF, 5–100 %) (Hidden and auto-set to OFF if E87 := GEN)	**PCT5 :=**_______________
5TH HARM AL LVL (OFF, 0.02–3.20 TAP) (Hidden and auto-set to OFF if E87 := GEN)	**TH5P :=**_______________
5TH HARM AL DLY (0.00–120.00 s) (Hidden if TH5P := OFF)	**TH5D :=**_______________
HARMONIC RESTRNT (Y, N) (Hidden and auto-set to N if E87 := GEN)	**HRSTR :=**_______________
HARMONIC BLOCK (Y, N) (Hidden and auto-set to Y if E87 := GEN)	**HBLK :=**_______________
HI SECURITY MODE (SELOGIC)	**HSM :=**_______________
HI SECURITY PU (AUTO, O87P–2.00) (AUTO in the setting range is hidden if E87 := GEN. The value of O87P2 must be greater than or equal to O87P.)	**O87P2 :=**_______________
EXT FLT DET DO (1.00–30.00 s)	**HSMDOT :=**_______________

Ground Differential (Hidden if Slot Z = 83/84/87/88)

GND DIFF EN (Y, N) (Hidden and auto-set to N if CTCONY := DELTA)	**E87N :=**________________
LVL1 GND DIFF PU (0.1 • CTR*m*/CTRN – 15.0 A [5 A I_{NNOM}], 0.02 • CTR*m*/CTRN – 3.0 A [1 A I_{NNOM}]) (m = X or Y when X_CUR_IN := TERM or NEUT, respectively) (Hidden if E87N := N)	**87N1P :=**________________
LVL1 GND DIFF DLY (0.00–400.00 s) (Hidden if E87N := N)	**87N1D :=**________________
LVL2 GND DIFF PU (OFF, 0.1 • CTR*m*/CTRN – 15.0 A [5 A I_{NNOM}], 0.02 • CTR*m*/CTRN – 3.0 A [1 A I_{NNOM}]) (Hidden if E87N := N or if 87N2P := OFF)	**87N2P :=**________________
LVL2 GND DIFF DLY (0.00–400.00 s) (Hidden if E87N := N)	**87N2D :=**________________
87N TRQCTRL (SELOGIC) (Hidden if 87N := N)	**87NTC :=**________________

Restricted Earth Fault (REF) (Hidden if Slot Z = 83/84/87/88)

REF ENABLE (Y, N) (Hidden and auto-set to N if CTCONY := DELTA)	**EREF :=**________________
REF1 CURR LEVEL (0.05–3.00 pu) (Hidden if EREF := N)	**50REF1P :=**________________
REF1 TRQCTRL (SELOGIC) (Hidden if EREF := N)	**REF1TC :=**________________
52AX BYPASS ENABL (Y, N) ((Hidden if EREF := N)	**REF52BYP :=**________________

Stator Ground (64G) (Shown if Slot E = 72/74/76)

64G PROT EN (Y, N)	**E64G :=**________________

(All Stator Ground settings are hidden if E64G := N. If EXT3V0_X = VN, then E64G is hidden and forced to N.)

NEUTRAL O/V LVL (OFF, 0.1–150.0 V)	**64G1P :=**________________
ZONE 1 TIMER (0.00–400.00 s) (Hidden if 64G1P := OFF)	**64G1D :=**________________
64G1 TRQCTRL (SELOGIC)	**64G1TC :=**________________
DIFF VOLT LVL (OFF, 0.1–20.0 V)	**64G2P :=**________________
ZONE 2 RATIO (0.0–5.0) (Hidden if 64G2P := OFF or hidden and autoset to 0.0 when DELTAY_X := DELTA and EXT3V0_X := NONE)	**64RAT :=**________________
ZONE 2 TIMER (0.00–400.00 s) (Hidden if 64G2P := OFF)	**64G2D :=**________________
64G2 TRQCTRL (SELOGIC)	**64G2TC :=**________________

Rotor Ground (64F) (Hidden if Slot Z = 84/88)

64F PROT EN (Y, N)	**E64F :=**________________

(All Field Ground settings are hidden if E64F := N)

64F LVL 1 PICKUP (OFF, 0.5–200.0 kOhms)	**64F1P :=**________________
64F LVL 1 DELAY (0.00–99.00 s) (Hidden if 64F1P := OFF)	**64F1D :=**________________
64F LVL 2 PICKUP (OFF, 0.5–200.0 kOhms)	**64F2P :=**________________
64F LVL 2 DELAY (0.00–99.00 s) (Hidden if 64F2P := OFF)	**64F2D :=**________________
64F TRQCTRL (SELOGIC)	**64FTC :=**________________

System Backup (Hidden if Slot Z = 83/84/87/88)

BACKUP PROT EN (N, V, C) (Hidden if Slot E = 74/73/77/72/76) **EBUP :=**________________

BACKUP PROT EN (N, V, C, DC, DC_V, or DC_C) (Shown if Slot E = 74/73/77/72/76) **EBUP :=**________________

Compensator Distance (Hidden if EBUP := N, V, or C)

Z1 COMP REACH (OFF, 0.1–100.0 ohm [5 A I_{XNOM}], 0.5-500.0 ohm [1 A I_{XNOM}]) **Z1C :=**________________

Z1 COMP OFFSET (0.0–10.0 ohm [5 A I_{XNOM}], 0.0-50.0 ohm [1 A I_{XNOM}]) (Hidden if Z1C := OFF) **Z1CO :=**________________

Z1 COMP TIME DLY (0.00–400.00 s) (Hidden if Z1C := OFF) **Z1CD :=**________________

Z1 CURRENT FD (0.50–170.00 A [5 A I_{XNOM}], 0.10–34.00 A [1 A I_{XNOM}]) (Hidden if Z1C := OFF) **50PP1 :=**________________

Z1 POS-SEQ ANGLE (45–90°) (Hidden if Z1C := OFF) **Z1ANG :=**________________

Z2 COMP REACH (OFF, 0.1–100.0 ohm [5 A I_{XNOM}], 0.5–500.0 ohm [1 A I_{XNOM}]) **Z2C :=**________________

Z2 COMP OFFSET (0.0–10.0 ohm [5 A I_{XNOM}], 0.0–50.0 ohm [1 A I_{XNOM}]) (Hidden if Z2C := OFF) **Z2CO :=**________________

Z2 COMP TIME DLY (0.00–400.00 s) (Hidden if Z2C := OFF) **Z2CD :=**________________

Z2 CURRENT FD (0.50–170.00 A [5 A I_{XNOM}], 0.10–34.00 A [1 A I_{XNOM}]) (Hidden if Z2C := OFF) **50PP2 :=**________________

Z2 POS-SEQ ANGLE (45–90°) (Hidden if Z2C := OFF) **Z2ANG :=**________________

21C ELE TRQCTRL (SELOGIC) **21CTC :=**________________

Volt-Control TOC (Hidden if EBUP := N, V, DC, or DC_V)

V-CTRL TOC LVL (OFF, 0.50–16.00 A [5 A I_{XNOM}], 0.10-3.20 A [1 A I_{XNOM}]) **51CP :=**________________

V-CTRL TOC CURVE (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) (Hidden if 51CP := OFF) **51CC :=**________________

V-CTRL TOC TDIAL (0.50–15.00 [if 51CC := U_], 0.05–1.00 [if 51CC := C_]) (Hidden if 51CP := OFF) **51CTD :=**________________

V-CTR TOC EM RST (Y, N) (Hidden if 51CP := OFF) **51CRS :=**________________

51C TOC TRQCTRL (SELOGIC) (Hidden if 51CP := OFF) **51CTC :=**________________

Volt-Restrained TOC (Hidden if EBUP := N, C, DC, or DC_C)

V-RESTR TOC LVL (OFF, 2.00–16.00 A [5 A I_{XNOM}], 0.40–3.20 A [1 A I_{XNOM}]) **51VP :=**________________

COMPEN ANGLE (0, –30, 30°) (Hidden if 51VP := OFF) **51VCA:=**________________

V-RESTR TOC CURV (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) (Hidden if 51VP := OFF) **51VC :=**________________

V-RESTR TOC TDIAL (0.50–15.00 [if 51CC := U_], 0.05–1.00 [if 51CC := C_]) (Hidden if 51VP := OFF) **51VTD :=**________________

V-RES TOC EM RST (Y, N) (Hidden if 51VP := OFF) **51VRS :=**________________

51V TOC TRQCTRL (SELOGIC) (Hidden if 51VP := OFF) **51VTC :=**________________

Loss of Field (Hidden if Slot Z = 83/84/87/88)

LOSS OF FIELD EN (Y, N)	**E40** := ________________
(All Loss of Field settings are hidden if E40 := N)	
Z1 MHO DIAMETER (OFF, 0.1–100.0 ohm [5 A I_{XNOM}], 0.5–500.0 ohm [1 A I_{XNOM}])	**40Z1P** := ________________
Z1 OFFSET (–50.0 to 0.0 ohm [5 A I_{XNOM}], –250.0 to 0.0 ohm [1 A I_{XNOM}]) (Hidden if 40Z1P := OFF)	**40XD1** := ________________
Z1 TIME DELAY (0.00–400.00 s) (Hidden if 40Z1P := OFF)	**40Z1D** := ________________
Z2 MHO DIAMETER (OFF, 0.1–100.0 ohm [5 A I_{XNOM}], 0.5–500.0 ohm [1 A I_{XNOM}]	**40Z2P** := ________________
Z2 OFFSET (–50.0 to 50.0 ohm [5 A I_{XNOM}], –250.0 to 250.0 ohm [1 A I_{XNOM}]) (Hidden if 40Z2P := OFF)	**40XD2** := ________________
Z2 TIME DELAY (0.00–400.00 s) (Hidden if 40Z2P := OFF)	**40Z2D** := ________________
Z2 DIR ANGLE (–20.0 to 0.0°) (Hidden if 40Z2P := OFF or 40XD2 < 0)	**40DIR** := ________________
40Z TRQCTRL (SELOGIC)	**40ZTC** := ________________

Current Unbalance (Shown if Slot Z = 81/82/85/86)

NEG-SEQ OC ENBL (Y, N)	**E46** := ________________
(All Current Unbalance settings are hidden if E46 := N)	
LVL1 NEQ-SEQ O/C (OFF, 2.0–100.0 %)	**46Q1P** := ________________
LVL1 TIME DELAY (0.02–999.90 s) (Hidden if 46Q1P := OFF)	**46Q1D** := ________________
LVL2 NEQ-SEQ O/C (OFF, 2.0–100.0 %)	**46Q2P** := ________________
LVL2 TIME DIAL (1–100 s) (Hidden if 46Q2P := OFF)	**46Q2K** := ________________
46Q TRQCTRL (SELOGIC)	**46QTC** := ________________

Thermal Overload (Hidden if Slot Z = 83/84/87/88)

THERM OVERLD EN (Y, N)	**E49T** := ________________
(All Thermal Overload settings are hidden if E49T := N)	
THERM OL TRIP PU (0.30–2.50 pu of setting INOM)	**49TTP** := ________________
TIME CONSTANT1 (1–1000 min)	**GTC1** := ________________
TIME CONSTANT2 (OFF, 1–1000 min)	**GTC2** := ________________
ALT COOLING MODE (SELOGIC) (Hidden if GTC2 := OFF)	**ALTCOOL** := ________________

TCU ALARM PU (OFF, 50–99 %TCU)	**49TAP** := ________________
OL RTD BIASING? (Y, N) (Hidden if E49RTD := NONE)	**ETHMBIAS** := ________________

Volts Per Hertz (Hidden if Slot Z = 83/84/87/88)

ENABLE V/HZ PROT (Y, N)	**E24** := ________________
(All Volts-Per-Hertz settings are hidden if E24 := N)	
LVL1 V/HZ PICKUP (100–200 %)	**24D1P** := ________________
LVL1 TIME DLY (0.04–400.00 s)	**24D1D** := ________________
LVL2 CURVE SHAPE (OFF, DD, ID, I, U)	**24CCS** := ________________
LVL2 INV-TM PU (100–200 %) (Hidden if 24CCS := OFF or DD)	**24IP** := ________________

LVL2 INV-TM CURV (0.5, 1, 1.0, 2, 2.0) (Hidden if 24CCS := OFF, DD, or U)	**24IC :=**_______________
LVL2 INV-TM FCTR (0.1–10.0 s) (Hidden if 24CCS := OFF, DD, or U)	**24ITD :=**_______________
LVL2 PICKUP 1 (100–200 %) (Hidden if 24CCS := OFF, ID, I, or U)	**24D2P1 :=**_______________
LVL2 TIME DLY 1 (0.04–400.00 s) (Hidden if 24CCS := OFF, ID, I, or U)	**24D2D1 :=**_______________
LVL2 PICKUP 2 (101–200 %) (Hidden if 24CCS := OFF, I, or U)	**24D2P2 :=**_______________
LVL2 TIME DLY 2 (0.04–400.00 s) (Hidden if 24CCS := OFF, I, or U)	**24D2D2 :=**_______________
LVL2 RESET TIME (0.00–400.00 s) (Hidden if 24CCS := OFF)	**24CR :=**_______________
24 ELEM TRQCTRL (SELOGIC)	**24TC :=**_______________

Out of Step Element (Hidden if Slot E = Empty/71/75 or Slot Z = 83/87)

OUT-OF-STEP PROT (N, 1B, 2B)	**E78 :=**_______________

(All Out of Step settings are hidden if E78 := N is selected)

FORWARD REACH (0.1–100.0 ohm [5 A I_{XNOM}], 0.5–500.0 ohm [1 A I_{XNOM}])	**78FWD :=**_______________
REVERSE REACH (0.1–100.0 ohm [5 A I_{XNOM}], 0.5–500.0 ohm [1 A I_{XNOM}])	**78REV :=**_______________
RIGHT BLINDER (0.1–50.0 ohm [5 A I_{XNOM}], 0.5–250.0 ohm [1 A I_{XNOM}]) (Hidden if E78 := 2B)	**78R1 :=**_______________
LEFT BLINDER (0.1–50.0 ohm [5 A I_{XNOM}], 0.5–250.0 ohm [1 A I_{XNOM}]) (Hidden if E78 := 2B)	**78R2 :=**_______________
OUTER BLINDER (0.2–100.0 ohm [5 A I_{XNOM}], 1.0–500.0 ohm [1 A I_{XNOM}]) (Hidden if E78 := 1B)	**78R1 :=**_______________
INNER BLINDER (0.1–50.0 ohm [5 A I_{XNOM}], 0.5–250.0 ohm [1 A I_{XNOM}]) (Hidden if E78 := 1B)	**78R2 :=**_______________
OOS DELAY (0.00–1.00 s) (Hidden if E78 := 1B)	**78D :=**_______________
OOS TRIP DELAY (0.00–1.00 s)	**78TD :=**_______________
OOS TRIP DUR (0.00–5.00 s)	**78TDURD :=**_______________
POS-SEQ CURRENT (0.25–30.00 A [5 A I_{XNOM}], 0.05–6.00 A [1 A I_{XNOM}])	**50ABC :=**_______________
OOS TRQCTRL (SELOGIC)	**OOSTC :=**_______________

Inadvertent Energization (Shown if Slot Z = 81/82/85/86)

INADV ENRG EN (Y, N)	**EINAD :=**_______________

(All Inadvertent Energization settings are hidden if EINAD := N)

GEN DE-ENRG PU (0.00–100.00 s)	**GENDEPU :=**_______________
GEN DE-ENRG DO (0.00–100.00 s) (GENDEDO > INADPU)	**GENDEDO :=**_______________
INADV ENRG PU (0.00–10.00 s) (GENDEDO > INADPU)	**INADPU :=**_______________
INADV ENRG DO (0.00–10.00 s)	**INADDO :=**_______________
INADV TRQCTRL (SELOGIC)	**INADTC :=**_______________

X-Side Phase Overcurrent (Hidden if Slot Z = 84/88)

PHASE IOC LEVEL (OFF, 0.50–96.00 A [5 A I_{XNOM}], 0.10–19.20 A [1 A I_{XNOM}]) **50PX1P :=**________________
PHASE IOC DELAY (OFF, 0.00–400.00 s) (Hidden if 50PX1P := OFF) **50PX1D :=**________________
PH IOC TRQCTRL (SELOGIC) (Hidden if 50PX1P := OFF) **50PX1TC :=**________________

PHASE IOC LEVEL (OFF, 0.50–96.00 A [5 A I_{XNOM}], 0.10–19.20 A [1 A I_{XNOM}]) **50PX2P :=**________________
PHASE IOC DELAY (OFF, 0.00–400.00 s) (Hidden if 50PX2P := OFF) **50PX2D :=**________________
PH IOC TRQCTRL (SELOGIC) (Hidden if 50PX2P := OFF) **50PX2TC :=**________________

PHASE IOC LEVEL (OFF, 0.50–96.00 A (5 A I_{XNOM}], 0.10–19.20 A [1 A I_{XNOM}]) **50PX3P :=**________________
PHASE IOC DELAY (OFF, 0.00–400.00 s) (Hidden if 50PX3P := OFF) **50PX3D :=**________________
PH IOC TRQCTRL (SELOGIC) (Hidden if 50PX3P := OFF) **50PX3TC :=**________________

X-Side Residual Overcurrent (Hidden if Slot Z = 84/88)

RES IOC LEVEL (OFF, 0.50–96.00 A [5 A I_{XNOM}], 0.10–19.20 A [1 A I_{XNOM}]) **50GX1P :=**________________
RES IOC DELAY (OFF, 0.00–400.00 s) (Hidden if 50GX1P := OFF) **50GX1D :=**________________
RES IOC TRQCTRL (SELOGIC) (Hidden if 50GX1P := OFF) **50GX1TC :=**________________

RES IOC LEVEL (OFF, 0.50–96.00 A [5 A I_{XNOM}], 0.10–19.20 A [1 A I_{XNOM}]) **50GX2P :=**________________
RES IOC DELAY (OFF, 0.00–400.00 s) (Hidden if 50GX2P := OFF) **50GX2D :=**________________
RES IOC TRQCTRL (SELOGIC) (Hidden if 50GX2P := OFF) **50GX2TC :=**________________

X-Side Negative-Sequence Overcurrent (Hidden if Slot Z = 84/88)

NSEQ IOC LEVEL (OFF, 0.50–96.00 A [5 A I_{XNOM}], 0.10–19.20 A [1 A I_{XNOM}]) **50QX1P :=**________________
NSEQ IOC DELAY (OFF, 0.10–400.00 s) (Hidden if 50QX1P := OFF) **50QX1D :=**________________
NSEQ IOC TRQCTRL (SELOGIC) (Hidden if 50QX1P := OFF) **50QX1TC :=**________________

NSEQ IOC LEVEL (OFF, 0.50–96.00 A [5 A I_{XNOM}], 0.10–19.20 A [1 A I_{XNOM}]) **50QX2P :=**________________
NSEQ IOC DELAY (OFF, 0.10–400.00 s) (Hidden if 50QX2P := OFF) **50QX2D :=**________________
NSEQ IOC TRQCTRL (SELOGIC) (Hidden if 50QX2P := OFF) **50QX2TC :=**________________

Y-Side Phase Overcurrent (Hidden if Slot E = Empty/74)

PHASE IOC LEVEL (OFF, 0.50–96.00 A [5 A I_{YNOM}], 0.10–19.20 A [1 A I_{YNOM}]) **50PY1P :=**________________
PHASE IOC DELAY (OFF, 0.00–400.00 s) (Hidden if 50PY1P := OFF) **50PY1D :=**________________

PH IOC TRQCTRL (SELOGIC) (Hidden if 50PY1P := OFF) **50PY1TC :=**_______________

PHASE IOC LEVEL (OFF, 0.50–96.00 A [5 A I_{YNOM}], 0.10–19.20 A [1 A I_{YNOM}]) **50PY2P :=**_______________
PHASE IOC DELAY (OFF, 0.00–400.00 s) (Hidden if 50PY2P := OFF) **50PY2D :=**_______________
PH IOC TRQCTRL (SELOGIC) (Hidden if 50PY2P := OFF) **50PY2TC :=**_______________

PHASE IOC LEVEL (OFF, 0.50–96.00 A [5 A I_{YNOM}], 0.10–19.20 A [1 A I_{YNOM}]) **50PY3P :=**_______________
PHASE IOC DELAY (OFF, 0.00–400.00 s) (Hidden if 50PY3P := OFF) **50PY3D :=**_______________
PH IOC TRQCTRL (SELOGIC) (Hidden if 50PY3P := OFF) **50PY3TC :=**_______________

Y-Side Residual Overcurrent (Hidden if Slot E = Empty/74 or CTCONY := Delta)

RES IOC LEVEL (OFF, 0.50–96.00 A [5 A I_{YNOM}], 0.10–19.20 A [1 A I_{YNOM}]) **50GY1P :=**_______________
RES IOC DELAY (OFF, 0.00–400.00 s) (Hidden if 50GY1P := OFF) **50GY1D :=**_______________
RES IOC TRQCTRL (SELOGIC) (Hidden if 50GY1P := OFF) **50GY1TC :=**_______________

RES IOC LEVEL (OFF, 0.50–96.00 A [5 A I_{YNOM}], 0.10–19.20 A [1 A I_{YNOM}]) **50GY2P :=**_______________
RES IOC DELAY (OFF, 0.00–400.00 s) (Hidden if 50GY2P := OFF) **50GY2D :=**_______________
RES IOC TRQCTRL (SELOGIC) (Hidden if 50GY2P := OFF) **50GY2TC :=**_______________

Y-Side Negative-Sequence Overcurrent (Hidden if Slot E = Empty/74)

NSEQ IOC LEVEL (OFF, 0.50–96.00 A [5 A I_{YNOM}], 0.10–19.20 A [1 A I_{YNOM}]) **50QY1P :=**_______________
NSEQ IOC DELAY (OFF, 0.10–400.00 s) (Hidden if 50QY1P := OFF) **50QY1D :=**_______________
NSEQ IOC TRQCTRL (SELOGIC) (Hidden if 50QY1P := OFF) **50QY1TC :=**_______________

NSEQ IOC LEVEL (OFF, 0.50–96.00 A [5 A I_{YNOM}], 0.10–19.20 A [1 A I_{YNOM}]) **50QY2P :=**_______________
NSEQ IOC DELAY (OFF, 0.10–400.00 s) (Hidden if 50QY2P := OFF) **50QY2D :=**_______________
NSEQ IOC TRQCTRL (SELOGIC) (Hidden if 50QY2P := OFF) **50QY2TC :=**_______________

Neutral Overcurrent (Hidden if Slot Z = 83/87)

NEUT IOC LEVEL (OFF, 0.50–96.00 A [5 A I_{NNOM}], 0.10–19.20 A [1 A I_{NNOM}]) **50N1P :=**_______________
NEUT IOC DELAY (OFF, 0.00–400.00 s) (Hidden if 50N1P := OFF) **50N1D :=**_______________
NEUT IOC TRQCTRL (SELOGIC) (Hidden if 50N1P := OFF) **50N1TC :=**_______________

NEUT IOC LEVEL (OFF, 0.50–96.00 A [5 A I_{NNOM}], 0.10–19.20 A [1 A I_{NNOM}]) **50N2P :=**_______________
NEUT IOC DELAY (OFF, 0.00–400.00 s) (Hidden if 50N2P := OFF) **50N2D :=**_______________
NEUT IOC TRQCTRL (SELOGIC) (Hidden if 50N2P := OFF) **50N2TC :=**_______________

X-Side Phase Time-Overcurrent (Shown if Slot Z = 83/87 [SEL-700GW])

PHASE TOC LEVEL (OFF, 0.50–16.00 A [5 A I_{XNOM}], 0.10–3.20 A [1 A I_{XNOM}])	**51PXP :=**________________
PHASE TOC CURVE (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) (Hidden if 51PXP := OFF)	**51PXC :=**________________
PHASE TOC TDIAL (0.50–15.00 [if 51P_C := U_], 0.05–1.00 [if 51P_C := C_]) (Hidden if 51PXP := OFF)	**51PXTD :=**________________
EM RESET DELAY (Y, N) (Hidden if 51PXP := OFF)	**51PXRS :=**________________
CONST TIME ADDER (0.00–1.00 s) (Hidden if 51PXP := OFF)	**51PXCT :=**________________
MIN RESPONSE TIM (0.00–1.00 s) (Hidden if 51PXP := OFF)	**51PXMR :=**________________
PH TOC TRQCTRL (SELOGIC) (Hidden if 51PXP := OFF)	**51PXTC :=**________________

X-Side Residual Time-Overcurrent (Hidden if Slot Z = 84/88 or CTCONX := Delta)

RES TOC LEVEL (OFF, 0.50–16.00 A [5 A I_{XNOM}], 0.10–3.20 A [1 A I_{XNOM}])	**51GXP :=**________________
RES TOC CURVE (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) (Hidden if 51GXP := OFF)	**51GXC :=**________________
RES TOC TDIAL (0.50–15.00 [if 51G_C := U_], 0.05–1.00 [if 51G_C := C_]) (Hidden if 51GXP := OFF)	**51GXTD :=**________________
EM RESET DELAY (Y, N) (Hidden if 51GXP := OFF)	**51GXRS :=**________________
CONST TIME ADDER (0.00–1.00 s) (Hidden if 51GXP := OFF)	**51GXCT :=**________________
MIN RESPONSE TIM (0.00–1.00 s) (Hidden if 51GXP := OFF)	**51GXMR :=**________________
RES TOC TRQCTRL (SELOGIC) (Hidden if 51GXP := OFF)	**51GXTC :=**________________

X-Side Negative-Sequence Time-Overcurrent (Shown if Slot Z = 83/87 [700GW])

NSEQ TOC LEVEL (OFF, 0.50–16.00 A [5 A I_{XNOM}], 0.10–3.20 A [1 A I_{XNOM}])	**51QXP :=**________________
NSEQ TOC CURVE (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) (Hidden if 51QXP := OFF)	**51QXC :=**________________
NSEQ TOC TDIAL (0.50–15.00 [if 51Q_C := U_], 0.05–1.00 [if 51Q_C := C_]) (Hidden if 51QXP := OFF)	**51QXTD :=**________________
EM RESET DELAY (Y, N) (Hidden if 51QXP := OFF)	**51QXRS :=**________________
CONST TIME ADDER (0.00–1.00 s) (Hidden if 51QXP := OFF)	**51QXCT :=**________________
MIN RESPONSE TIM (0.00–1.00 s) (Hidden if 51QXP := OFF)	**51QXMR :=**________________
NSEQ TOC TRQCTRL (SELOGIC) (Hidden if 51QXP := OFF)	**51QXTC :=**________________

Y-Side Phase Time-Overcurrent (Shown if Slot E = 71/73/75/77 [700GT, 700GW])

PHASE TOC LEVEL (OFF, 0.50–16.00 A [5 A I_{YNOM}], 0.10–3.20 A [1 A I_{YNOM}])	**51PYP :=**________________
PHASE TOC CURVE (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) (Hidden if 51PYP := OFF)	**51PYC :=**________________
PHASE TOC TDIAL (0.50–15.00 [if 51P_C := U_], 0.05–1.00 [if 51P_C := C_]) (Hidden if 51PYP := OFF)	**51PYTD :=**________________
EM RESET DELAY (Y, N) (Hidden if 51PYP := OFF)	**51PYRS :=**________________
CONST TIME ADDER (0.00–1.00 s) (Hidden if 51PYP := OFF)	**51PYCT :=**________________
MIN RESPONSE TIM (0.00–1.00 s) (Hidden if 51PYP := OFF)	**51PYMR :=**________________
PH TOC TRQCTRL (SELOGIC) (Hidden if 51PYP := OFF)	**51PYTC :=**________________

Y-Side Residual Time-Overcurrent (Shown if Slot E = 71/75 or Slot Z = 83/87 [700GT, 700GW]) (Hidden if CTCONY := Delta)

RES TOC LEVEL (OFF, 0.50–16.00 A [5 A I_{YNOM}], 0.10–3.20 A [1 A I_{YNOM}])	**51GYP :=**_______________
RES TOC CURVE (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) (Hidden if 51GYP := OFF)	**51GYC :=**_______________
RES TOC TDIAL (0.50–15.00 [if 51G_C := U_], 0.05–1.00 [if 51G_C := C_]) (Hidden if 51GYP := OFF)	**51GYTD :=**_______________
EM RESET DELAY (Y, N) (Hidden if 51GYP := OFF)	**51GYRS :=**_______________
CONST TIME ADDER (0.00–1.00 s) (Hidden if 51GYP := OFF)	**51GYCT :=**_______________
MIN RESPONSE TIM (0.00–1.00 s) (Hidden if 51GYP := OFF)	**51GYMR :=**_______________
RES TOC TRQCTRL (SELOGIC) (Hidden if 51GYP := OFF)	**51GYTC :=**_______________

Y-Side Negative-Sequence Time-Overcurrent (Shown if Slot E = 71/73/75/77 [700GT, 700GW])

NSEQ TOC LEVEL (OFF, 0.50 to 16.00 A [5 A I_{YNOM}], 0.10 to 3.20 A [1 A I_{YNOM}])	**51QYP :=**_______________
NSEQ TOC CURVE (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) (Hidden if 51QYP := OFF)	**51QYC :=**_______________
NSEQ TOC TDIAL (0.50 to 15.00 [if 51Q_C := U_], 0.05 to 1.00 [if 51Q_C := C_]) (Hidden if 51QYP := OFF)	**51QYTD :=**_______________
EM RESET DELAY (Y, N) (Hidden if 51QYP := OFF)	**51QYRS :=**_______________
CONST TIME ADDER (0.00 to 1.00 s) (Hidden if 51QYP := OFF)	**51QYCT :=**_______________
MIN RESPONSE TIM (0.00 to 1.00 s) (Hidden if 51QYP := OFF)	**51QYMR :=**_______________
NSEQ TOC TRQCTRL (SELOGIC) (Hidden if 51QYP := OFF)	**51QYTC :=**_______________

Neutral Time-Overcurrent (Hidden if Slot Z = 83/87 [700GW])

NEUT TOC LEVEL (OFF, 0.50–16.00 A [5 A I_{NNOM}], 0.10–3.20 A [1 A I_{NNOM}])	**51NP :=**_______________
NEUT TOC CURVE (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) (Hidden if 51NP := OFF)	**51NC :=**_______________
NEUT TOC TDIAL (0.50–15.00 [if 51N_C := U_], 0.05–1.00 [if 51N_C := C_]) (Hidden if 51NP := OFF)	**51NTD :=**_______________
EM RESET DELAY (Y, N) (Hidden if 51NP := OFF)	**51NRS :=**_______________
CONST TIME ADDER (0.00–1.00 s) (Hidden if 51NP := OFF)	**51NCT :=**_______________
MIN RESPONSE TIM (0.00–1.00 s) (Hidden if 51NP := OFF)	**51NMR :=**_______________
NEUT TOC TRQCTRL (SELOGIC) (Hidden if 51NP := OFF)	**51NTC :=**_______________

X-Side Directional Elements (Hidden if Slot Z = 83/84/87/88)

DIR CONTROL ENBL (Y, AUTO, N)	**EDIRX :=**_______________

(All X-Side Directional Elements settings are hidden if EDIRX := N)

FWD DIR ON LOP (Y, N)	**EFWDLOPX:=**_______________
POS SQ LN Z MAG (0.10–510.00 ohm [5 A I_{XNOM}], 0.50–2550.00 ohm [1 A I_{XNOM}])	**Z1MAGX :=**_______________
POS SQ LN Z ANG (50.00–90.00°)	**Z1ANGX :=**_______________

ZERO SQ LN Z MAG (0.10–510.00 ohm [5 A I_{XNOM}], 0.50–2550.00 ohm [1 A I_{XNOM}])	**Z0MAGX :=**_______________
ZERO SQ LN Z ANG (50.00–90.00°)	**Z0ANGX :=**_______________
DIR CONTROL LVL1 (F, R, N)	**DIR1X :=**_______________
DIR CONTROL LVL2 (F, R, N)	**DIR2X :=**_______________
GND DIR PRIORITY (I, V, Q, IV, VI, QV, VQ, IQ, QI, IVQ, IQV, VQI, VIQ, QIV, QVI, U, OFF) (V and U are hidden if DELTAY_X := DELTA and EXT3V0_X := NONE). (U is hidden when EDIRX := AUTO.)	**ORDERX :=**_______________
FWD DIR Z2 LVL (–128.00 to 128.00 ohm [5 A I_{XNOM}], –640.00 to 640.00 ohm [1 A I_{XNOM}]) (Hidden if EDIRX:=AUTO)	**Z2FX :=**_______________
REV DIR Z2 LVL (–128.00 to 128.00 ohm [5 A I_{XNOM}], –640.00 to 640.00 ohm [1 A I_{XNOM}]) (Hidden if EDIRX:=AUTO)	**Z2RX :=**_______________
FWD DIR NSEQ LVL (0.25–5.00 A [5 A I_{XNOM}], 0.05–1.00 A [1 A I_{XNOM}]) (Hidden if EDIRX:=AUTO)	**50QFPX :=**_______________
REV DIR NSEQ LVL (0.25–5.00 A [5 A I_{XNOM}], 0.05–1.00 A [1 A I_{XNOM}]) (Hidden if EDIRX:=AUTO)	**50QRPX :=**_______________
I1 RST FAC I2/I1 (0.02–0.50) (Hidden if EDIRX:=AUTO)	**a2X :=**_______________
I0 RST FAC I2/I0 (0.10–1.20) (Hidden if EDIRX:=AUTO)	**k2X :=**_______________
FWD DIR RES LVL (0.05–5.00 A [5 A I_{XNOM}], 0.01–1.00 A [1 A I_{XNOM}]) (Hidden if EDIRX:=AUTO or ORDERX does not contain V or I when EDIRX:=Y)	**50GFPX :=**_______________
REV DIR RES LVL (0.05–5.00 A [5 A I_{XNOM}], 0.01–1.00 A [1 A I_{XNOM}]) (Hidden if EDIRX:=AUTO or ORDERX does not contain V or I when EDIRX:=Y)	**50GRPX :=**_______________
I1 RST FAC I0/I1 (0.02–0.50) (Hidden if EDIRX:=AUTO or ORDERX does not contain V or I when EDIRX:=Y)	**a0X :=**_______________
FWD DIR Z0 LVL (–128.00 to 128.00 ohm [5 A I_{XNOM}], –640.00 to 640.00 ohm [1 A I_{XNOM}]) (Hidden if EDIRX:=AUTO or ORDERX does not contain V when EDIRX:=Y)	**Z0FX :=**_______________
REV DIR Z0 LVL (–128.00 to 128.00 ohm [5 A I_{XNOM}], –640.00 to 640.00 ohm [1 A I_{XNOM}]) (Hidden if EDIRX:=AUTO or ORDERX does not contain V when EDIRX:=Y)	**Z0RX :=**_______________
ZRO SQ MX TQ ANG (–90.00 to 90.00°) (Hidden if EDIRX := AUTO or ORDERX does not contain V or U when EDIRX := Y)	**Z0MTAX :=**_______________
FWD DIR IN LVL (0.25 to 5.00 A [5 A I_{NNOM}], 0.05 to 1.00 A [1 A I_{NNOM}]) (Displayed if EDIRX := Y and ORDERX := U, else hidden)	**50NFP :=**_______________
REV DIR IN LVL (0.25 to 5.00 A [5 A I_{NNOM}], 0.05 to 1.00 A [1 A I_{NNOM}]) (Displayed if EDIRX := Y and ORDERX := U, else hidden)	**50NRP :=**_______________
POS SQ RESTR FAC (0.001 to 0.500) (Displayed if EDIRX := Y and ORDERX := U, else hidden)	**a0N :=**_______________

Y-Side Directional Elements (Hidden if Slot E = Empty/72/73/74/76/77)

DIR CONTROL ENBL (Y, AUTO, N)	**EDIRY :=**_______________

(All Y-Side Directional Elements settings are hidden if EDIRY := N)

FWD DIR ON LOP (Y, N)	**EFWDLOPY:=**_______________
POS SQ LN Z MAG (0.10–510.00 ohm [5 A I_{YNOM}], 0.50–2550.00 ohm [1 A I_{YNOM}])	**Z1MAGY :=**_______________
POS SQ LN Z ANG (50.00–90.00°)	**Z1ANGY :=**_______________
ZERO SQ LN Z MAG (0.10–510.00 ohm [5 A I_{YNOM}], 0.50–2550.00 ohm [1 A I_{YNOM}])	**Z0MAGY :=**_______________
ZERO SQ LN Z ANG (50.00–90.00°)	**Z0ANGY :=**_______________
DIR CONTROL LVL1 (F, R, N)	**DIR1Y :=**_______________
DIR CONTROL LVL2 (F, R, N)	**DIR2Y :=**_______________

GND DIR PRIORITY (I, V, Q, IV, VI, QV, VQ, IQ, QI, IVQ, IQV, VQI, VIQ, QIV, QVI, OFF) (V is hidden if DELTAY_Y := DELTA)	**ORDERY :=**_______________
PH DIR 3PH LVL (0.50–10.00 A [5 A I_{YNOM}], 0.10–2.00 A [1 A I_{YNOM}]) (Hidden if ELOADY:=Y)	**50PDIRPY :=**_______________
FWD DIR Z2 LVL (–128.00 to 128.00 ohm [5 A I_{YNOM}], –640.00 to 640.00 ohm [1 A I_{YNOM}]) (Hidden if EDIRY := AUTO)	**Z2FY :=**_______________
REV DIR Z2 LVL (–128.00 to 128.00 ohm [5 A I_{YNOM}], –640.00 to 640.00 ohm [1 A I_{YNOM}]) (Hidden if EDIRY := AUTO)	**Z2RY :=**_______________
FWD DIR NSEQ LVL (0.25–5.00 A [5 A I_{YNOM}], 0.05–1.00 A [1 A I_{YNOM}]) (Hidden if EDIRY := AUTO)	**50QFPY :=**_______________
REV DIR NSEQ LVL (0.25–5.00 A [5 A I_{YNOM}], 0.05–1.00 A [1 A I_{YNOM}]) (Hidden if EDIRY := AUTO)	**50QRPY :=**_______________
I1 RST FAC I2/I1 (0.02–0.50) (Hidden if EDIRY := AUTO)	**a2Y :=**_______________
I0 RST FAC I2/I0 (0.10–1.20) (Hidden if EDIRY := AUTO)	**k2Y :=**_______________
FWD DIR RES LVL (0.05–5.00 A [5 A I_{YNOM}], 0.01–1.00 A [1 A I_{YNOM}]) (Hidden if EDIRY := AUTO or ORDERY does not contain V or I when EDIRY := Y)	**50GFPY :=**_______________
REV DIR RES LVL (0.05–5.00 A [5 A I_{YNOM}], 0.01–1.00 A [1 A I_{YNOM}]) (Hidden if EDIRY := AUTO or ORDERY does not contain V or I when EDIRY := Y)	**50GRPY :=**_______________
I1 RST FAC I0/I1 (0.02–0.50) (Hidden if EDIRY := AUTO or ORDERY does not contain V or I when EDIRY := Y)	**a0Y :=**_______________
FWD DIR Z0 LVL (–128.00 to 128.00 ohm [5 A I_{YNOM}], –640.00 to 640.00 ohm [1 A I_{YNOM}]) (Hidden if EDIRY := AUTO or ORDERY does not contain V when EDIRY := Y)	**Z0FY :=**_______________
REV DIR Z0 LVL (–128.00 to 128.00 ohm [5 A I_{YNOM}], –640.00 to 640.00 ohm [1 A I_{YNOM}]) (Hidden if EDIRY := AUTO or ORDERY does not contain V when EDIRY := Y)	**Z0RY :=**_______________
ZRO SQ MX TQ ANG (–90.00 to 90.00°) (Hidden if EDIRY := AUTO or ORDERY does not contain V when EDIRY := Y)	**Z0MTAY :=**_______________

X-Side Load Encroachment (Hidden if Slot Z = 83/87 or Slot E = Empty/71/75)

FWD LD IMPEDANCE (OFF, 0.10–128.00 ohm [5 A I_{XNOM}], 0.50–640.00 ohm [1 A I_{XNOM}])	**ZLFX :=**_______________
POS-FWD LD ANGLE (–90.00 to +90.00°) (Hidden if ZLFX:=OFF) (PLAFX must be greater than or equal to NLAFX)	**PLAFX :=**_______________
NEG-FWD LD ANGLE (–90.00 to +90.00°) (Hidden if ZLFX:=OFF) (PLAFX must be greater than or equal to NLAFX)	**NLAFX :=**_______________

Y-Side Load Encroachment (Shown if Slot E = 71/75)

LOAD ENCROACH EN (Y, N)	**ELOADY :=**_______________

(All Y-Side Load-Encroachment settings are hidden if ELOADY := N)

FWD LD IMPEDANCE (0.10–128.00 ohm [5 A I_{YNOM}], 0.50–640.00 ohm [1 A I_{YNOM}])	**ZLFY :=**_______________
POS-FWD LD ANGLE (–90.00 to +90.00°) (PLAFY must be greater than or equal to NLAFY)	**PLAFY :=**_______________
NEG-FWD LD ANGLE (–90.00 to +90.00°) (PLAFY must be greater than or equal to NLAFY)	**NLAFY :=**_______________
REV LD IMPEDANCE (0.10–128.00 ohm [5 A I_{YNOM}], 0.50–640.00 ohm [1 A I_{YNOM}])	**ZLRY :=**_______________

POS-REV LD ANGLE (90.00–270.00°) (PLARY must be less than or equal to NLARY)	**PLARY :=**________________
NEG-REV LD ANGLE (90.00–270.00°) (PLARY must be less than or equal to NLARY)	**NLARY :=**________________

X-Side Power Elements (Hidden if Slot Z = 83/84/87/88)

ENABLE PWR ELEM (N, 1–4)	**EPWRX :=**________________

(All X-Side Power element settings are hidden if EPWRX := N)

3PH PWR ELEM PU (OFF, 0.2–1300.0 VA [5 A 1 A I_{XNOM}], 1.0–6500.0 VA[1 A I_{XNOM}])	**3PWRX1P :=**________________
PWR ELEM TYPE (+WATTS, -WATTS, +VARS, -VARS) (Hidden if 3PWRX1P := OFF)	**PWRX1T :=**________________
PWR ELEM DELAY (0.00–240.00 s) (Hidden if 3PWRX1P := OFF)	**PWRX1D :=**________________
3PH PWR ELEM PU (OFF, 0.2–1300.0 VA [5 A I_{XNOM}], 1.0–6500.0 VA[1 A I_{XNOM}]) (Hidden if EPWRX < 2)	**3PWRX2P :=**________________
PWR ELEM TYPE (+WATTS, -WATTS, +VARS, -VARS) (Hidden if 3PWRX2P := OFF)	**PWRX2T :=**________________
PWR ELEM DELAY (0.00–240.00 s) (Hidden if 3PWRX2P := OFF)	**PWRX2D :=**________________
3PH PWR ELEM PU (OFF, 0.2–1300.0 VA [1 A 1 A I_{XNOM}], 1.0–6500.0 VA[1 A I_{XNOM}]) (Hidden if EPWRX < 3)	**3PWRX3P :=**________________
PWR ELEM TYPE (+WATTS, -WATTS, +VARS, -VARS) (Hidden if 3PWRX3P := OFF)	**PWRX3T :=**________________
PWR ELEM DELAY (0.00–240.00 s) (Hidden if 3PWRX3P := OFF)	**PWRX3D :=**________________
3PH PWR ELEM PU (OFF, 0.2–1300.0 VA [5 A I_{XNOM}], 1.0–6500.0 VA[1 A I_{XNOM}]) (Hidden if EPWRX < 4)	**3PWRX4P :=**________________
PWR ELEM TYPE (+WATTS, -WATTS, +VARS, -VARS) (Hidden if 3PWRX4P := OFF)	**PWRX4T :=**________________
PWR ELEM DELAY (0.00–240.00 s) (Hidden if 3PWRX4P := OFF)	**PWRX4D :=**________________

Y-Side Power Elements (Hidden if Slot Z = 83/87 or Slot E = Empty/72/73/74/76/77)

ENABLE PWR ELEM (N, 1–4)	**EPWRY :=**________________

(All Y-Side Power Elements settings are hidden if EPWRY := N)

3PH PWR ELEM PU (OFF, 0.2–1300.0 VA [5 A I_{YNOM}], 1.0–6500.0 VA[5 A I_{YNOM}])	**3PWRY1P :=**________________
PWR ELEM TYPE (+WATTS, -WATTS, +VARS, -VARS) (Hidden if 3PWRY1P := OFF)	**PWRY1T :=**________________
PWR ELEM DELAY (0.00–240.00 s) (Hidden if 3PWRY1P := OFF)	**PWRY1D :=**________________
3PH PWR ELEM PU (OFF, 0.2–1300.0 VA [5 A I_{YNOM}], 1.0–6500.0 VA[5 A I_{YNOM}]) (Hidden if EPWRY < 2)	**3PWRY2P :=**________________
PWR ELEM TYPE (+WATTS, -WATTS, +VARS, -VARS) (Hidden if 3PWRY2P := OFF)	**PWRY2T :=**________________
PWR ELEM DELAY (0.00–240.00 s) (Hidden if 3PWRY2P := OFF)	**PWRY2D :=**________________
3PH PWR ELEM PU (OFF, 0.2–1300.0 VA [5 A I_{YNOM}], 1.0–6500.0 VA[5 A I_{YNOM}]) (Hidden if EPWRY < 3)	**3PWRY3P :=**________________
PWR ELEM TYPE (+WATTS, -WATTS, +VARS, -VARS) (Hidden if 3PWRY3P := OFF)	**PWRY3T :=**________________
PWR ELEM DELAY (0.00–240.00 s) (Hidden if 3PWRY3P := OFF)	**PWRY3D :=**________________
3PH PWR ELEM PU (OFF, 0.2–1300.0 VA [5 A I_{YNOM}], 1.0–6500.0 VA[5 A I_{YNOM}]) (Hidden if EPWRY < 4)	**3PWRY4P :=**________________
PWR ELEM TYPE (+WATTS, -WATTS, +VARS, -VARS) (Hidden if 3PWRY4P := OFF)	**PWRY4T :=**________________
PWR ELEM DELAY (0.00–240.00 s) (Hidden if 3PWRY4P := OFF)	**PWRY4D :=**________________

X-Side Frequency Elements (Hidden if Slot Z = 84/88/83/87)

ENABLE 81X (N, 1–6)	**E81X:=**________________

(All X-Side Frequency Elements settings are hidden if E81X := N)

FREQX TRIP1 LVL (OFF, 15.00–70.00 Hz)	**81X1TP :=**________________
FREQX TRIP1 DLY (0.00–400.00 s) (Hidden if 81X1TP := OFF)	**81X1TD :=**________________
FREQX TRIP2 LVL (OFF, 15.00–70.00 Hz) (Hidden if E81X < 2)	**81X2TP :=**________________
FREQX TRIP2 DLY (0.00–400.00 s) (Hidden if 81X2TP := OFF)	**81X2TD :=**________________
FREQX TRIP3 LVL (OFF, 15.00–70.00 Hz) (Hidden if E81X < 3)	**81X3TP :=**________________
FREQX TRIP3 DLY (0.00–400.00 s) (Hidden if 81X3TP := OFF)	**81X3TD :=**________________
FREQX TRIP4 LVL (OFF, 15.00–70.00 Hz) (Hidden if E81X < 4)	**81X4TP :=**________________
FREQX TRIP4 DLY (0.00–400.00 s) (Hidden if 81X4TP := OFF)	**81X4TD :=**________________
FREQX TRIP5 LVL (OFF, 15.00–70.00 Hz) (Hidden if E81X < 5)	**81X5TP :=**________________
FREQX TRIP5 DLY (0.00–400.00 s) (Hidden if 81X5TP := OFF)	**81X5TD :=**________________
FREQX TRIP6 LVL (OFF, 15.00–70.00 Hz) (Hidden if E81X < 6)	**81X6TP :=**________________
FREQX TRIP6 DLY (0.00–400.00 s) (Hidden if 81X6TP := OFF)	**81X6TD :=**________________
FREQX TRQCTL (SELOGIC)	**81XTC :=**________________

Y-Side Frequency Elements (Shown if Slot E = 71/75)

ENABLE 81Y (N, 1—6)	**E81Y:=**________________

(All Y-Side Frequency Elements settings are hidden if E81Y := N)

FREQY TRIP1 LVL (OFF, 15.00–70.00 Hz)	**81Y1TP :=**________________
FREQY TRIP1 DLY (0.00–400.00 s) (Hidden if 81Y1TP := OFF)	**81Y1TD :=**________________
FREQY TRIP2 LVL (OFF, 15.00–70.00 Hz) (Hidden if E81Y < 2)	**81Y2TP :=**________________
FREQY TRIP2 DLY (0.00–400.00 s) (Hidden if 81Y2TP := OFF)	**81Y2TD :=**________________
FREQY TRIP3 LVL (OFF, 15.00–70.00 Hz) (Hidden if E81Y < 3)	**81Y3TP :=**________________
FREQY TRIP3 DLY (0.00–400.00 s) (Hidden if 81Y3TP := OFF)	**81Y3TD :=**________________
FREQY TRIP4 LVL (OFF, 15.00–70.00 Hz) (Hidden if E81Y < 4)	**81Y4TP :=**________________
FREQY TRIP4 DLY (0.00–400.00 s) (Hidden if 81Y4TP := OFF)	**81Y4TD :=**________________
FREQY TRIP5 LVL (OFF, 15.00–70.00 Hz) (Hidden if E81Y < 5)	**81Y5TP :=**________________
FREQY TRIP5 DLY (0.00–400.00 s) (Hidden if 81Y5TP := OFF)	**81Y5TD :=**________________
FREQY TRIP6 LVL (OFF, 15.00–70.00 Hz) (Hidden if E81Y < 6)	**81Y6TP :=**________________
FREQY TRIP6 DLY (0.00–400.00 s) (Hidden if 81Y6TP := OFF)	**81Y6TD :=**________________
FREQY TRQCTL (SELOGIC)	**81YTC :=**________________

X-Side Rate-of-Change-of-Frequency Elements (Hidden if Slot Z = 83/84/87/88)

ENABLE 81RX (N, 1–4)	**E81RX :=**________________

(All X-Side Rate-of-Change-of-Frequency Elements settings are hidden if E81RX := N)

FREQX ROC LEVEL (OFF, 0.10–15.00 Hz/s)	**81RX1TP :=**________________
FREQX ROC TREND (INC, DEC, ABS) (Hidden if 81RX1TP := OFF)	**81RX1TRN :=**________________

FREQX ROC PU DLY (0.10–60.00 s) (Hidden if 81RX1TP := OFF) **81RX1TD :=**________________
FREQX ROC DO DLY (0.00–60.00 s) (Hidden if 81RX1TP := OFF) **81RX1DO :=**________________
FREQX ROC LEVEL (OFF, 0.10–15.00 Hz/s) (Hidden if E81RX < 2) **81RX2TP :=**________________
FREQX ROC TREND (INC, DEC, ABS) (Hidden if 81RX2TP := OFF) **81RX2TRN :=**________________
FREQX ROC PU DLY (0.10–60.00 s) (Hidden if 81RX2TP := OFF) **81RX2TD :=**________________
FREQX ROC DO DLY (0.00–60.00 s) (Hidden if 81RX2TP := OFF) **81RX2DO :=**________________
FREQX ROC LEVEL (OFF, 0.10–15.00 Hz/s) (Hidden if E81RX < 3) **81RX3TP :=**________________
FREQX ROC TREND (INC, DEC, ABS) (Hidden if 81RX3TP := OFF) **81RX3TRN :=**________________
FREQX ROC PU DLY (0.10–60.00 s) (Hidden if 81RX3TP := OFF) **81RX3TD :=**________________
FREQX ROC DO DLY (0.00–60.00 s) (Hidden if 81RX3TP := OFF) **81RX3DO :=**________________
FREQX ROC LEVEL (OFF, 0.10–15.00 Hz/s) (Hidden if E81RX < 4) **81RX4TP :=**________________
FREQX ROC TREND (INC, DEC, ABS) (Hidden if 81RX4TP := OFF) **81RX4TRN :=**________________
FREQX ROC PU DLY (0.10–60.00 s) (Hidden if 81RX4TP := OFF) **81RX4TD :=**________________
FREQX ROC DO DLY (0.00–60.00 s) (Hidden if 81RX4TP := OFF) **81RX4DO :=**________________
FREQX ROC VSUPER (OFF, 12.5–300.0 V) **81RXVSUP :=**________________
FREQX ROC TRQCTRL (SELOGIC) **81RXTC :=**________________

Y-Side Rate-of-Change-of-Frequency Elements (Shown if Slot E = 71/75)

ENABLE 81RY (N, 1–4) **E81RY :=**________________

(All Y-Side Rate-of-Change-of-Frequency settings are hidden if E81RY := N)

FREQY ROC LEVEL (OFF, 0.10–15.00 Hz/s) **81RY1TP :=**________________
FREQY ROC TREND (INC, DEC, ABS) (Hidden if 81RY1TP := OFF) **81RY1TRN :=**________________
FREQY ROC PU DLY (0.10–60.00 s) (Hidden if 81RY1TP := OFF) **81RY1TD :=**________________
FREQY ROC DO DLY (0.00–60.00 s) (Hidden if 81RY1TP := OFF) **81RY1DO :=**________________
FREQY ROC LEVEL (OFF, 0.10–15.00 Hz/s) (Hidden if E81RY < 2) **81RY2TP :=**________________
FREQY ROC TREND (INC, DEC, ABS) (Hidden if 81RY2TP := OFF) **81RY2TRN :=**________________
FREQY ROC PU DLY (0.10–60.00 s) (Hidden if 81RY2TP := OFF) **81RY2TD :=**________________
FREQY ROC DO DLY (0.00–60.00 s) (Hidden if 81RY2TP := OFF) **81RY2DO :=**________________
FREQY ROC LEVEL (OFF, 0.10–15.00 Hz/s) (Hidden if E81RY < 3) **81RY3TP :=**________________
FREQY ROC TREND (INC, DEC, ABS) (Hidden if 81RY3TP := OFF) **81RY3TRN :=**________________
FREQY ROC PU DLY (0.10–60.00 s) (Hidden if 81RY3TP := OFF) **81RY3TD :=**________________
FREQY ROC DO DLY (0.00–60.00 s) (Hidden if 81RY3TP := OFF) **81RY3DO :=**________________
FREQY ROC LEVEL (OFF, 0.10–15.00 Hz/s) (Hidden if E81RY < 4) **81RY4TP :=**________________
FREQY ROC TREND (INC, DEC, ABS) (Hidden if 81RY4TP := OFF) **81RY4TRN :=**________________
FREQY ROC PU DLY (0.10–60.00 s) (Hidden if 81RY4TP := OFF) **81RY4TD :=**________________
FREQY ROC DO DLY (0.00–60.00 s) (Hidden if 81RY4TP := OFF) **81RY4DO :=**________________
FREQY ROC VSUPER (OFF, 12.5–300.0 V) **81RYVSUP :=**________________
FREQY ROC TRQCTRL (SELOGIC) **81RYTC :=**________________

X-Side Frequency Accumulators (Hidden if Slot Z = 83/84/87/88)

ENABLE FREQ ACC (N, 1–6) **E81ACC :=**_______________

(All Frequency Accumulators settings are hidden if E81ACC := N)

FREQ ACC DELAY (0.00–400.00 s) **62ACC :=**_______________

BAND1 UPPER LIMIT (15.00–70.00 Hz) **UBND1 :=**_______________

BAND1 LOWER LIMIT (15.00–70.00 Hz) (UBND1 must be greater than LBND1) **LBND1 :=**_______________

BAND1 ACC TIME (0.01–6000.00 s) **TBND1 :=**_______________

BAND2 LOWER LIMIT (15.00–70.00 Hz) (LBND1 must be greater than LBND2) (Hidden if E81ACC < 2) **LBND2 :=**_______________

BAND2 ACC TIME (0.01–6000.00 s) (Hidden if E81ACC < 2) **TBND2 :=**_______________

BAND3 LOWER LIMIT (15.00–70.00 Hz) (LBND2 must be greater than LBND3) (Hidden if E81ACC < 3) **LBND3 :=**_______________

BAND3 ACC TIME (0.01–6000.00 s) (Hidden if E81ACC < 3) **TBND3 :=**_______________

BAND4 LOWER LIMIT (15.00–70.00 Hz) (LBND3 must be greater than LBND4) (Hidden if E81ACC < 4) **LBND4 :=**_______________

BAND4 ACC TIME (0.01–6000.00 s) (Hidden if E81ACC < 4) **TBND4 :=**_______________

BAND5 LOWER LIMIT (15.00–70.00 Hz) (LBND4 must be greater than LBND5) (Hidden if E81ACC < 5) **LBND5 :=**_______________

BAND5 ACC TIME (0.01–6000.00 s) (Hidden if E81ACC < 5) **TBND5 :=**_______________

BAND6 LOWER LIMIT (15.00–70.00 Hz) (LBND5 must be greater than LBND6) (Hidden if E81ACC < 6) **LBND6 :=**_______________

BAND6 ACC TIME (0.01–6000.00 s) (Hidden if E81ACC < 6) **TBND6 :=**_______________

FREQ ACC TRQCTRL (SELOGIC) **81ACCTC :=**_______________

Loss of Potential

LOPX BLOCK (SELOGIC) (Hidden if Slot Z = 83/84/87/88) **LOPBLKX :=**_______________

LOPY BLOCK (SELOGIC) (Shown if Slot E = 71/75) **LOPBLKY :=**_______________

X-Side Phase Undervoltage Elements (Shown only when Slot Z = 81/82/85/86)

PHASE UV LEVEL (OFF, 2.0–300.0 V) (Hidden if DELTAY_X = DELTA) **27PX1P :=**_______________

PHASE UV DELAY (0.00–120.00 s) (Hidden if 27PX1P := OFF) (Hidden if DELTAY_X = DELTA) **27PX1D :=**_______________

PHASE UV LEVEL (OFF, 2.0–300.0 V) (Hidden if DELTAY_X = DELTA) **27PX2P :=**_______________

PHASE UV DELAY (0.00–120.00 s) (Hidden if 27PX2P := OFF) (Hidden if DELTAY_X = DELTA) **27PX2D :=**_______________

PH_PH UV LEVEL (OFF, 2.0–300.0 V [DELTAY_X = DELTA] or 2.0–520.0 V [DELTAY_X = WYE]) **27PPX1P :=**_______________

PH_PH UV DELAY (0.00–120.00 s) (Hidden if 27PPX1P := OFF) **27PPX1D :=**_______________

PH_PH UV LEVEL (OFF, 2.0–300.0 V [DELTAY_X = DELTA] or 2.0–520.0 V [DELTAY_X = WYE]) **27PPX2P :=**_______________

PH_PH UV DELAY (0.00–120.00 s) (Hidden if 27PPX2P := OFF) **27PPX2D :=**_______________

X-Side Phase Overvoltage Elements (Shown only when Slot Z = 81/82/85/86)

PHASE OV LEVEL (OFF, 2.0–300.0 V) (Hidden if DELTAY_X = DELTA)	**59PX1P :=**_______________
PHASE OV DELAY (0.00–120.00 s) (Hidden if 59PX1P := OFF) (Hidden if DELTAY_X = DELTA)	**59PX1D :=**_______________
PHASE OV LEVEL (OFF, 2.0–300.0 V) (Hidden if DELTAY_X = DELTA)	**59PX2P :=**_______________
PHASE OV DELAY (0.00–120.00 s) (Hidden if 59PX2P := OFF) (Hidden if DELTAY_X = DELTA)	**59PX2D :=**_______________
PH_PH OV LEVEL (OFF, 2.0–300.0 V [DELTAY_X = DELTA]; 2.0–520.0 V [DELTAY_X = WYE])	**59PPX1P :=**_______________
PH_PH OV DELAY (0.00–120.00 s) (Hidden if 59PPX1P := OFF)	**59PPX1D :=**_______________
PH_PH OV LEVEL (OFF, 2.0–300.0 V [DELTAY_X = DELTA]; 2.0–520.0 V [DELTAY_X = WYE])	**59PPX2P :=**_______________
PH_PH OV DELAY (0.00–120.00 s) (Hidden if 59PPX2P := OFF)	**59PPX2D :=**_______________

X-Side Positive-Sequence Under/Overvoltage Elements (Shown only when Slot Z = 81/82/85/86)

ENABLE P-SEQ UV (N, 1–6)	**E27V1X :=**_______________

(All P-SEQ UV settings are hidden if E27V1X := N)

POS SEQ UV LEVEL (OFF, 2.0–300.0 V [DELTAY_X = WYE]; 2.0–170.0 V [DELTAY_X = DELTA])	**27V1X1P :=**_______________
POS SEQ UV DELAY (0.00–120.00 s) (Hidden if 27V1X1P := OFF)	**27V1X1D :=**_______________
POS SEQ UV LEVEL (OFF, 2.0–300.0 V [DELTAY_X = WYE]; 2.0–170.0 V [DELTAY_X = DELTA]) (Hidden if E27V1X <2)	**27V1X2P :=**_______________
POS SEQ UV DELAY (0.00–120.00 s) (Hidden if 27V1X2P := OFF) (Hidden if E27V1X <2)	**27V1X2D :=**_______________
POS SEQ UV LEVEL (OFF, 2.0–300.0 V [DELTAY_X = WYE]; 2.0–170.0 V [DELTAY_X = DELTA]) (Hidden if E27V1X <3)	**27V1X3P :=**_______________
POS SEQ UV DELAY (0.00–120.00 s) (Hidden if 27V1X3P := OFF) (Hidden if E27V1X <3)	**27V1X3D :=**_______________
POS SEQ UV LEVEL (OFF, 2.0–300.0 V [DELTAY_X = WYE]; 2.0–170.0 V [DELTAY_X = DELTA]) (Hidden if E27V1X <4)	**27V1X4P :=**_______________
POS SEQ UV DELAY (0.00–120.00 s) (Hidden if 27V1X4P := OFF) (Hidden if E27V1X <4)	**27V1X4D :=**_______________
POS SEQ UV LEVEL (OFF, 2.0–300.0 V [DELTAY_X = WYE]; 2.0–170.0 V [DELTAY_X = DELTA]) (Hidden if E27V1X <5)	**27V1X5P :=**_______________
POS SEQ UV DELAY (0.00–120.00 s) (Hidden if 27V1X5P := OFF) (Hidden if E27V1X <5)	**27V1X5D :=**_______________
POS SEQ UV LEVEL (OFF, 2.0–300.0 V [DELTAY_X = WYE]; 2.0–170.0 V [DELTAY_X = DELTA]) (Hidden if E27V1X <6)	**27V1X6P :=**_______________
POS SEQ UV DELAY (0.00–120.00 s) (Hidden if 27V1X6P := OFF) (Hidden if E27V1X <6)	**27V1X6D :=**_______________
ENABLE P-SEQ OV (N, 1–6)	**E59V1X :=**_______________

(All P-SEQ OV settings are hidden if E59V1X := N)

POS SEQ OV LEVEL (OFF, 2.0–300.0 V [DELTAY_X = WYE]; 2.0–170.0 V [DELTAY_X = DELTA])	**59V1X1P :=**_______________
POS SEQ OV DELAY (0.00–120.00 s) (Hidden if 59V1X1P := OFF)	**59V1X1D :=**_______________
POS SEQ OV LEVEL (OFF, 2.0–300.0 V [DELTAY_X = WYE]; 2.0–170.0 V [DELTAY_X = DELTA]) (Hidden if E59V1X <2)	**59V1X2P :=**_______________

POS SEQ OV DELAY (0.00–120.00 s) (Hidden if 59V1X2P := OFF) (Hidden if E59V1X <2)	**59V1X2D :=**_______________
POS SEQ OV LEVEL (OFF, 2.0–300.0 V [DELTAY_X = WYE]; 2.0–170.0 V [DELTAY_X = DELTA]) (Hidden if E59V1X <3)	**59V1X3P :=**_______________
POS SEQ OV DELAY (0.00–120.00 s) (Hidden if 59V1X3P := OFF) (Hidden if E59V1X <3)	**59V1X3D :=**_______________
POS SEQ OV LEVEL (OFF, 2.0–300.0 V [DELTAY_X = WYE]; 2.0–170.0 V [DELTAY_X = DELTA]) (Hidden if E59V1X <4)	**59V1X4P :=**_______________
POS SEQ OV DELAY (0.00–120.00 s) (Hidden if 59V1X4P := OFF) (Hidden if E59V1X <4)	**59V1X4D :=**_______________
POS SEQ OV LEVEL (OFF, 2.0–300.0 V [DELTAY_X = WYE]; 2.0–170.0 V [DELTAY_X = DELTA]) (Hidden if E59V1X <5)	**59V1X5P :=**_______________
POS SEQ OV DELAY (0.00–120.00 s) (Hidden if 59V1X5P := OFF) (Hidden if E59V1X <5)	**59V1X5D :=**_______________
POS SEQ OV LEVEL (OFF, 2.0–300.0 V [DELTAY_X = WYE]; 2.0–170.0 V [DELTAY_X = DELTA]) (Hidden if E59V1X <6)	**59V1X6P :=**_______________
POS SEQ OV DELAY (0.00–120.00 s) (Hidden if 59V1X6P := OFF) (Hidden if E59V1X <6)	**59V1X6D :=**_______________

X-Side Negative-Sequence Overvoltage Elements (Shown only when Slot Z = 81/82/85/86)

NSEQ OV LEVEL (OFF, 2.0–200.0 V)	**59QX1P :=**_______________
NSEQ OV DELAY (0.00–120.00 s) (Hidden if 59QX1P := OFF)	**59QX1D :=**_______________
NSEQ OV LEVEL (OFF, 2.0–200.0 V)	**59QX2P :=**_______________
NSEQ OV DELAY (0.00–120.00 s) (Hidden if 59QX2P := OFF)	**59QX2D :=**_______________

X-Side Zero-Sequence Overvoltage Elements (Shown only when Slot Z = 81/82/85/86; hidden if DELTAY_X=DELTA and EXT3V0_X := NONE)

GND OV LEVEL (OFF, 2.0–200.0 V)	**59GX1P :=**_______________
GND OV DELAY (0.00–120.00 s) (Hidden if 59GX1P := OFF)	**59GX1D :=**_______________
GND OV LEVEL (OFF, 2.0–200.0 V)	**59GX2P :=**_______________
GND OV DELAY (0.00–120.00 s) (Hidden if 59GX2P := OFF)	**59GX2D :=**_______________

Y-Side Phase Undervoltage Elements (Shown only when Slot E = 71/75)

PHASE UV LEVEL (OFF, 2.0–300.0 V) (Hidden if DELTAY_Y = DELTA)	**27PY1P :=**_______________
PHASE UV DELAY (0.00–120.00 s) (Hidden if 27PY1P := OFF) (Hidden if DELTAY_Y = DELTA)	**27PY1D :=**_______________
PHASE UV LEVEL (OFF, 2.0–300.0 V) (Hidden if DELTAY_Y = DELTA)	**27PY2P :=**_______________
PHASE UV DELAY (0.00–120.00 s) (Hidden if 27PY2P := OFF) (Hidden if DELTAY_Y = DELTA)	**27PY2D :=**_______________
PH_PH UV LEVEL (OFF, 2.0–300.0 V [DELTAY_Y = DELTA] or 2.0–520.0 V [DELTAY_Y = WYE])	**27PPY1P :=**_______________
PH_PH UV DELAY (0.00–120.00 s) (Hidden if 27PPY1P := OFF)	**27PPY1D :=**_______________
PH_PH UV LEVEL (OFF, 2.0–300.0 V [DELTAY_Y = DELTA] or 2.0–520.0 V [DELTAY_Y = WYE])	**27PPY2P :=**_______________
PH_PH UV DELAY (0.00–120.00 s) (Hidden if 27PPY2P := OFF)	**27PPY2D :=**_______________

Y-Side Phase Overvoltage Elements (Shown only when Slot E = 71/75)

PHASE OV LEVEL (OFF, 2.0–300.0 V)	**59PY1P :=**_______________
PHASE OV DELAY (0.00–120.00 s) (Hidden if 59PY1P := OFF)	**59PY1D :=**_______________
PHASE OV LEVEL (OFF, 2.0–300.0 V)	**59PY2P :=**_______________
PHASE OV DELAY (0.00–120.00 s) (Hidden if 59PY2P := OFF)	**59PY2D :=**_______________
PH_PH OV LEVEL (OFF, 2.0–300.0 V [DELTAY_Y = DELTA] or 2.0–520.0 V [DELTAY_Y = WYE])	**59PPY1P :=**_______________
PH_PH OV DELAY (0.00–120.00 s) (Hidden if 59PPY1P := OFF)	**59PPY1D :=**_______________
PH_PH OV LEVEL (OFF, 2.0–300.0 V [DELTAY_Y = DELTA] or 2.0–520.0 V [DELTAY_Y = WYE])	**59PPY2P :=**_______________
PH_PH OV DELAY (0.00–120.00 s) (Hidden if 59PPY2P := OFF)	**59PPY2D :=**_______________

Y-Side Negative-Sequence Overvoltage Elements (Shown only when Slot E = 71/75)

NSEQ OV LEVEL (OFF, 2.0–200.0 V)	**59QY1P :=**_______________
NSEQ OV DELAY (0.00–120.00 s) (Hidden if 59QY1P := OFF)	**59QY1D :=**_______________
NSEQ OV LEVEL (OFF, 2.0–200.0 V)	**59QY2P :=**_______________
NSEQ OV DELAY (0.00–120.00 s) (Hidden if 59QY2P := OFF)	**59QY2D :=**_______________

Y-Side Zero-Sequence Overvoltage Elements

(Shown only when Slot E = 71/75; hidden if DELTAY_Y = DELTA)

GND OV LEVEL (OFF, 2.0–200.0 V)	**59GY1P :=**_______________
GND OV DELAY (0.00–120.00 s) (Hidden if 59GY1P := OFF)	**59GY1D :=**_______________
GND OV LEVEL (OFF, 2.0–200.0 V)	**59GY2P :=**_______________
GND OV DELAY (0.00–120.00 s) (Hidden if 59GY2P := OFF)	**59GY2D :=**_______________

Synchronism Over- and Undervoltage Elements

(Shown only when Slot E = 71/72/74/75/76; hidden if EXT3V0_X := VS)

SYNC PH UV LEVEL (OFF, 2.0–300.0 V)	**27S1P :=**_______________
SYNC PH UV DELAY (0.00–120.00 s) (Hidden if 27S1P := OFF)	**27S1D :=**_______________
SYNC PH UV LEVEL (OFF, 2.0–300.0 V)	**27S2P :=**_______________
SYNC PH UV DELAY (0.00–120.00 s) (Hidden if 27S2P := OFF)	**27S2D :=**_______________
SYNC PH OV LEVEL (OFF, 2.0–300.0 V)	**59S1P :=**_______________
SYNC PH OV DELAY (0.00–120.00 s) (Hidden if 59S1P := OFF)	**59S1D :=**_______________
SYNC PH OV LEVEL (OFF, 2.0–300.0 V)	**59S2P :=**_______________
SYNC PH OV DELAY (0.00–120.00 s) (Hidden if 59S2P := OFF)	**59S2D :=**_______________

27 Inverse-Time Undervoltage (Hidden if Slot Z = Ax)

27I ENABLE (Y, N)	**E27I1 :=**_______________
(The following 27I1 inverse-time undervoltage settings are hidden if E27I1 := N)	
OPERATING QTY (*VS option is hidden if Slot E ≠ 70 or L0*) *See Table SET.1 for range dependencies.*	**27I1OQ :=**_______________

Table SET.1 Range Dependencies for 27I Operating Quantities

Settings	Operating Quantities Available in 27InOQ Range									
DELTAY_m	VABm	VBCm	VCAm	VAm	VBm	VCm	VS	V1m	MINLLm	MINLNm
DELTA	#	#	#	—	—	—	#	#	#	—
WYE	$	$	$	#	#	#	#	#	$	#

= 2.00–300.00 V $ = 2.00–520.00 V — Operating quantity is not available

The "#" and "$" signs indicate the setting range for 27InP (n = 1 or 2). m = X and/or Y depending on the part number.

PICKUP LVL (2.00–300.00 V or 2.00–520.00 V from *Table SET.1*) **27I1P :=**________________

CURVE (CURVEA, CURVEB, COEF) **27I1CRV :=**________________

COEFF A (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **27I1CFA :=**________________

COEFF B (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **27I1CFB :=**________________

COEFF C (0.01–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **27I1CFC :=**________________

TIME DIAL (0.00–16.00) **27I1TD :=**________________

RESET TIME (0.00–1.00 s) **27I1TTR :=**________________

TRQ CONTROL (SELOGIC) **27I1TC :=**________________

27I ENABLE (Y, N) **E27I2 :=**________________

(The following 27I2 settings are hidden if E27I2 := N)

OPERATING QTY (*VS option is hidden if Slot E ≠ 70 or L0*)
See Table SET.1 for range dependencies. **27I2OQ :=**________________

PICKUP LVL (2.00–300.00 V or 2.00–520.00 V from *Table SET.1*) **27I2P :=**________________

CURVE (CURVEA, CURVEB, COEF) **27I2CRV :=**________________

COEFF A (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **27I2CFA :=**________________

COEFF B (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **27I2CFB :=**________________

COEFF C (0.01–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **27I2CFC :=**________________

TIME DIAL (0.00–16.00) **27I2TD :=**________________

RESET TIME (0.00–1.00 s) **27I2TTR :=**________________

TRQ CONTROL (SELOGIC) **27I2TC :=**________________

59 Inverse-Time Overvoltage (Hidden if Slot Z = Ax)

59I ENABLE (Y, N) **E59I1 :=**________________

(The following 59I1 inverse-time overvoltage settings are hidden if E59I1 := N)

OPERATING QTY (*VS option is hidden if Slot E ≠ 70 or L0*)
See Table SET.2 for range dependencies. **59I1OQ :=**________________

Table SET.2 Range Dependencies for 59I Operating Quantities

Settings	Operating Quantities Available in 59InOQ Setting Range												
DELTAY_m	VABm	VBCm	VCAm	VN	VAm	VBm	VCm	VS	VGm	V1m	3V2m	MAXLLm	MAXLNm
DELTA	#	#	#	#	—	—	—	#	—	#	#	#	—
WYE	$	$	$	#	#	#	#	#	#	#	#	$	#

= 2.00–300.00 V $ = 2.00–520.00 V — Operating quantity is not available

The "#" and "$" signs indicate the setting range for 59InP (n = 1, 2, 3, or 4). m = X and/or Y depending on the part number.

PICKUP LVL (2.00–300.00 V or 2.00–520.00 V from *Table SET.2*)	**59I1P :=**_______________
CURVE (CURVEA, CURVEB, COEF)	**59I1CR :=**_______________
COEFF A (0.00–6.00) *(Hidden if CURVE is set to CURVEA or CURVEB)*	**59I1CFA :=**_______________
COEFF B (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)*	**59I1CFB :=**_______________
COEFF C (0.01–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)*	**59I1CFC :=**_______________
TIME DIAL (0.00–16.00)	**59I1TD :=**_______________
RESET TIME (0.00–1.00 s)	**59I1TTR :=**_______________
TRQ CONTROL (SELOGIC)	**59I1TC :=**_______________
59I ENABLE (Y, N)	**E59I2 :=**_______________
(The following 59I2 settings are hidden if E59I2 := N)	
OPERATING QTY (*VS option is hidden if Slot E ≠ 70 or L0*) *See Table SET.2 for range dependencies.*	**59I2OQ :=**_______________
PICKUP LVL (2.00–300.00 V or 2.00–520.00 V from *Table SET.2*)	**59I2P :=**_______________
CURVE (CURVEA, CURVEB, COEF)	**59I2CRV :=**_______________
COEFF A (0.00–6.00) *(Hidden if CURVE is set to CURVEA or CURVEB)*	**59I2CFA :=**_______________
COEFF B (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)*	**59I2CFB :=**_______________
COEFF C (0.01–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)*	**59I2CFC :=**_______________
TIME DIAL (0.00–16.00)	**59I2TD :=**_______________
RESET TIME (0.00–1.00 s)	**59I2TTR :=**_______________
TRQ CONTROL (SELOGIC)	**59I2TC :=**_______________
59I ENABLE (Y, N)	**E59I3 :=**_______________
(The following 59I3 settings are hidden if E59I3 := N)	
OPERATING QTY (*VS option is hidden if Slot E ≠ 70 or L0*) *See Table SET.2 for range dependencies.*	**59I3OQ :=**_______________
PICKUP LVL (2.00–300.00 V or 2.00–520.00 V from *Table SET.2*)	**59I3P :=**_______________
CURVE (CURVEA, CURVEB, COEF)	**59I3CRV :=**_______________
COEFF A (0.00–6.00) *(Hidden if CURVE is set to CURVEA or CURVEB)*	**59I3CFA :=**_______________
COEFF B (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)*	**59I3CFB :=**_______________
COEFF C (0.01–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)*	**59I3CFC :=**_______________
TIME DIAL (0.00–16.00)	**59I3TD :=**_______________
RESET TIME (0.00–1.00 s)	**59I3TTR :=**_______________
TRQ CONTROL	**59I3TC :=**_______________
59I ENABLE (Y, N)	**E59I4 :=**_______________
(The following 59I4 settings are hidden if E59I4 := N)	
OPERATING QTY (*VS option is hidden if Slot E ≠ 70 or L0*) *See Table SET.2 for range dependencies.*	**59I4OQ :=**_______________
PICKUP LVL (2.00–300.00 V or 2.00–520.00 V from *Table SET.2*)	**59I4P :=**_______________
CURVE (CURVEA, CURVEB, COEF)	**59I4CRV :=**_______________
COEFF A (0.00–6.00) *(Hidden if CURVE is set to CURVEA or CURVEB)*	**59I4CFA :=**_______________
COEFF B (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)*	**59I4CFB :=**_______________
COEFF C (0.01–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)*	**59I4CFC :=**_______________
TIME DIAL (0.00–16.00)	**59I4TD :=**_______________

RESET TIME (0.00–1.00 s)	**59I4TTR :=**________________
TRQ CONTROL (SELOGIC)	**59I4TC :=**________________

RTD Settings

RTD ENABLE (INT, EXT, NONE)	**E49RTD :=**________________

(All RTD settings are hidden if E49RTD := NONE)

RTD1 LOCATION (OFF, WDG, BRG, AMB, OTH)	**RTD1LOC :=**________________
RTD1 IDENTIFIER (10 Characters) (Hidden unless RTD1LOC:= OTH)	**RTD1NAM :=**________________
RTD1 TYPE (PT100, NI100, NI120, CU10) (Hidden if RTD1LOC := OFF)	**RTD1TY :=**________________
RTD1 TRIP LEVEL (OFF, 1–250°C) (Hidden if RTD1LOC := OFF)	**TRTMP1 :=**________________
RTD1 WARN LEVEL (OFF, 1–250°C) (Hidden if RTD1LOC := OFF)	**ALTMP1 :=**________________
RTD2 LOCATION (OFF, WDG, BRG, AMB, OTH)	**RTD2LOC :=**________________
RTD2 IDENTIFIER (10 Characters) (Hidden unless RTD2LOC:= OTH)	**RTD2NAM :=**________________
RTD2 TYPE (PT100, NI100, NI120, CU10) (Hidden if RTD2LOC := OFF)	**RTD2TY :=**________________
RTD2 TRIP LEVEL (OFF, 1–250°C) (Hidden if RTD2LOC := OFF)	**TRTMP2 :=**________________
RTD2 WARN LEVEL (OFF, 1–250°C) (Hidden if RTD2LOC := OFF)	**ALTMP2 :=**________________
RTD3 LOCATION (OFF, WDG, BRG, AMB, OTH)	**RTD3LOC :=**________________
RTD3 IDENTIFIER (10 Characters) (Hidden unless RTD3LOC := OTH)	**RTD3NAM :=**________________
RTD3 TYPE (PT100, NI100, NI120, CU10) (Hidden if RTD3LOC := OFF)	**RTD3TY :=**________________
RTD3 TRIP LEVEL (OFF, 1–250°C) (Hidden if RTD3LOC := OFF)	**TRTMP3 :=**________________
RTD3 WARN LEVEL (OFF, 1–250°C) (Hidden if RTD3LOC := OFF)	**ALTMP3 :=**________________
RTD4 LOCATION (OFF, WDG, BRG, AMB, OTH)	**RTD4LOC :=**________________
RTD4 IDENTIFIER (10 Characters) (Hidden unless RTD4LOC:= OTH)	**RTD4NAM :=**________________
RTD4 TYPE (PT100, NI100, NI120, CU10) (Hidden if RTD4LOC := OFF)	**RTD4TY :=**________________
RTD4 TRIP LEVEL (OFF, 1–250°C) (Hidden if RTD4LOC := OFF)	**TRTMP4 :=**________________
RTD4 WARN LEVEL (OFF, 1–250°C) (Hidden if RTD4LOC := OFF)	**ALTMP4 :=**________________
RTD5 LOCATION (OFF, WDG, BRG, AMB, OTH)	**RTD5LOC :=**________________
RTD5 IDENTIFIER (10 Characters) (Hidden unless RTD5LOC:= OTH)	**RTD5NAM :=**________________
RTD5 TYPE (PT100, NI100, NI120, CU10) (Hidden if RTD5LOC := OFF)	**RTD5TY :=**________________
RTD5 TRIP LEVEL (OFF, 1–250°C) (Hidden if RTD5LOC := OFF)	**TRTMP5 :=**________________
RTD5 WARN LEVEL (OFF, 1–250°C) (Hidden if RTD5LOC := OFF)	**ALTMP5 :=**________________
RTD6 LOCATION (OFF, WDG, BRG, AMB, OTH)	**RTD6LOC :=**________________
RTD6 IDENTIFIER (10 Characters) (Hidden unless RTD6LOC:= OTH)	**RTD6NAM :=**________________
RTD6 TYPE (PT100, NI100, NI120, CU10) (Hidden if RTD6LOC := OFF)	**RTD6TY :=**________________
RTD6 TRIP LEVEL (OFF, 1–250°C) (Hidden if RTD6LOC := OFF)	**TRTMP6 :=**________________
RTD6 WARN LEVEL (OFF, 1–250°C) (Hidden if RTD6LOC := OFF)	**ALTMP6 :=**________________
RTD7 LOCATION (OFF, WDG, BRG, AMB, OTH)	**RTD7LOC :=**________________
RTD7 IDENTIFIER (10 Characters) (Hidden unless RTD7LOC := OTH)	**RTD7NAM :=**________________
RTD7 TYPE (PT100, NI100, NI120, CU10) (Hidden if RTD7LOC := OFF)	**RTD7TY :=**________________
RTD7 TRIP LEVEL (OFF, 1–250°C) (Hidden if RTD7LOC := OFF)	**TRTMP7 :=**________________
RTD7 WARN LEVEL (OFF, 1–250°C) (Hidden if RTD7LOC := OFF)	**ALTMP7 :=**________________

RTD8 LOCATION (OFF, WDG, BRG, AMB, OTH)	**RTD8LOC :=**________________
RTD8 IDENTIFIER (10 Characters) (Hidden unless RTD8LOC := OTH)	**RTD8NAM :=**________________
RTD8 TYPE (PT100, NI100, NI120, CU10) (Hidden if RTD8LOC := OFF)	**RTD8TY :=**________________
RTD8 TRIP LEVEL (OFF, 1–250°C) (Hidden if RTD8LOC := OFF)	**TRTMP8 :=**________________
RTD8 WARN LEVEL (OFF, 1–250°C) (Hidden if RTD8LOC := OFF)	**ALTMP8 :=**________________
RTD9 LOCATION (OFF, WDG, BRG, AMB, OTH)	**RTD9LOC :=**________________
RTD9 IDENTIFIER (10 Characters) (Hidden unless RTD9LOC := OTH)	**RTD9NAM :=**________________
RTD9 TYPE (PT100, NI100, NI120, CU10) (Hidden if RTD9LOC := OFF)	**RTD9TY :=**________________
RTD9 TRIP LEVEL (OFF, 1–250°C) (Hidden if RTD9LOC := OFF)	**TRTMP9 :=**________________
RTD9 WARN LEVEL (OFF, 1–250°C) (Hidden if RTD9LOC := OFF)	**ALTMP9 :=**________________
RTD10 LOCATION (OFF, WDG, BRG, AMB, OTH)	**RTD10LOC :=**________________
RTD10 IDENTIFIER (10 Characters) (Hidden unless RTD10LOC := OTH)	**RTD10NAM :=**________________
RTD10 TYPE (PT100, NI100, NI120, CU10) (Hidden if RTD10LOC := OFF)	**RTD10TY :=**________________
RTD10 TRIP LEVEL (OFF, 1–250°C) (Hidden if RTD10LOC := OFF)	**TRTMP10 :=**________________
RTD10 WARN LEVEL (OFF, 1–250°C) (Hidden if RTD10LOC := OFF)	**ALTMP10 :=**________________
RTD11 LOCATION (OFF, WDG, BRG, AMB, OTH) (Hidden if E49RTD := INT)	**RTD11LOC :=**________________
RTD11 IDENTIFIER (10 Characters) (Hidden unless RTD11LOC:= OTH)	**RTD11NAM :=**________________
RTD11 TYPE (PT100, NI100, NI120, CU10) (Hidden if RTD11LOC := OFF or E49RTD := INT)	**RTD11TY :=**________________
RTD11 TRIP LEVE (OFF, 1–250°C) (Hidden if RTD11LOC := OFF or E49RTD := INT)	**TRTMP11 :=**________________
RTD11 WARN LEVEL (OFF, 1–250°C) (Hidden if RTD11LOC := OFF or E49RTD := INT)	**ALTMP11 :=**________________
RTD12 LOCATION (OFF, WDG, BRG, AMB, OTH) (Hidden if E49RTD := INT)	**RTD12LOC :=**________________
RTD12 IDENTIFIER (10 Characters) (Hidden unless RTD12LOC:= OTH)	**RTD12NAM :=**________________
RTD12 TYPE (PT100, NI100, NI120, CU10) (Hidden if RTD12LOC := OFF or E49RTD := INT)	**RTD12TY :=**________________
RTD12 TRIP LEVEL (OFF, 1–250°C) (Hidden if RTD12LOC := OFF or E49RTD := INT)	**TRTMP12 :=**________________
RTD12 WARN LEVEL (OFF, 1–250°C) (Hidden if RTD12LOC := OFF or E49RTD := INT)	**ALTMP12 :=**________________
WIND TRIP VOTING (Y, N) (Hidden if less than 2 locations are WDG)	**EWDGV :=**________________
BEAR TRIP VOTING (Y, N) (Hidden if less than 2 locations are BRG)	**EBRGV :=**________________
TMP RTD BIASING? (Y, N) (Hidden unless one AMB and one WDG RTD enabled)	**ERTDBIAS :=**________________

Vector Shift (Hidden if Slot Z = 83/87)

EN VECTOR SHIFT (OFF, VX, VY) (VY is hidden from the range if Slot E ≠ 71/75; VX is hidden from the range if Slot E = 71/75 and Slot Z = 84/88)	**E78VS :=**________________

The following vector shift element settings are hidden if E78VS := OFF.

VS ANGLE PU THR (2.0–30.0 deg)	**78VSAPU :=**________________
VS VOLT SUPV THR (20.0–100.0%)	**78VS59 :=**________________
VS BLOCK (SELOGIC)	**78VSBL :=**________________

X-Side Synchronism-Check Elements (Hidden if Slot E = Empty/73/77 or if Slot Z = 84/88)

SYNC CHECK EN (Y, N)	**E25X :=**________________
(All X-Side Synchronism-Check Elements settings are hidden if E25X := N)	
V-WINDOW LOW (0.00–300.00 V) (25VHIX must be greater than 25VLOX)	**25VLOX :=**________________
V-WINDOW HIGH (0.00–300.00 V) (25VHIX must be greater than 25VLOX)	**25VHIX :=**________________
MAX VOLTAGE DIFF (OFF, 1.0–15.0 %)	**25VDIFX :=**________________
VOLT RATIO CORR (0.500–2.000)	**25RCFX :=**________________
GEN-VOLTAGE HIGH (Y, N)	**GENV+ :=**________________
MIN SLIP FREQ (–1.00 to +0.99 Hz)	**25SLO :=**________________
MAX SLIP FREQ (–0.99 to +1.00 Hz)	**25SHI :=**________________
MAX ANGLE 1 (0–80°)	**25ANG1X :=**________________
MAX ANGLE 2 (0–80°)	**25ANG2X :=**________________
TARGET CLOSE ANG (–15 to +15°)	**CANGLE :=**________________
SYNCP PHASE (VAX, VBX, VCX, VABX, VBCX, VCAX, 0, 30, 60, 90, 120, 150, 180, 210, 240, 270, 300, 330° lag VAX) (Hidden if DELTAY_X := DELTA)	**SYNCPX :=**________________
SYNCP PHASE (VABX, VBCX, VCAX, 0, 30, 60, 90, 120, 150, 180, 210, 240, 270, 300, 330° lag VABX) (Hidden if DELTAY_X := WYE)	**SYNCPX :=**________________
BRKR CLOSE TIME (OFF, 1–1000 ms)	**TCLOSDX :=**________________
CLOSE FAIL INIT (SELOGIC)	**CFI :=**________________
CLOSE FAIL ANGLE (OFF, 3–120°)	**CFANGLE :=**________________
BLK SYNC CHECK (SELOGIC)	**BSYNCHX :=**________________

Y-Side Synchronism-Check Elements (Shown if Slot E = 71/75)

SYNC CHECK EN (Y, N)	**E25Y :=**________________
(All Y-Side Synchronism-Check Elements settings are hidden if E25Y := N.)	
V-WINDOW LOW (0.00–300.00 V)	**25VLOY :=**________________
V-WINDOW HIGH (0.00–300.00 V)	**25VHIY :=**________________
MAX VOLTAGE DIFF (OFF, 1.0–15.0 %)	**25VDIFY :=**________________
VOLT RATIO CORR (0.500–2.000)	**25RCFY :=**________________
MAX SLIP FREQ (0.05–0.5 Hz)	**25SF :=**________________
MAX ANGLE 1 (0–80°)	**25ANG1Y :=**________________
MAX ANGLE 2 (0–80°)	**25ANG2Y :=**________________
SYNCP PHASE (VAY, VBY, VCY, VABY, VBCY, VCAY, 0, 30, 60, 90, 120, 150, 180, 210, 240, 270, 300, 330° lag VAY) (Hidden if DELTAY_Y := DELTA)	**SYNCPY :=**________________
SYNCP PHASE (VABY, VBCY, VCAY, 0, 30, 60, 90, 120, 150, 180, 210, 240, 270, 300, 330° lag VABY) (Hidden if DELTAY_Y := WYE)	**SYNCPY :=**________________
BRKR CLOSE TIME (OFF, 1–1000 ms)	**TCLOSDY :=**________________
BLK SYNC CHECK (SELOGIC)	**BSYNCHY :=**________________

Autosynchronism (Hidden if Slot E = Empty/73/77, Slot Z = 84/88, or E25X := N)

AUTO SYNC EN (NONE, DIG)	**EAUTO :=**________________

(All Autosynchronism settings are hidden if EAUTO := NONE)

FREQ SYNC TIMER (5–3600 s)	**FSYNCT :=**_______________
FREQ ADJ RATE (0.01–10.00 Hz/s)	**FADJRATE :=**_______________
FREQ PULS INTRVL (1–120 s)	**FPULSEI :=**_______________
FREQ PULS MIN (0.02–60.00 s)	**FPLSMIND :=**_______________
FREQ PULS MAX (0.10–60.00 s)	**FPLSMAXD :=**_______________
KICK PULS INTRVL (1–120 s)	**KPULSEI :=**_______________
KICK PULS MIN (0.02–2.00 s)	**KPLSMIND :=**_______________
KICK PULS MAX (0.02–2.00 s)	**KPLSMAXD :=**_______________
FMATCH START (SELOGIC)	**FSYNCST :=**_______________

VOLT SYNC TIMER (5–3600 s)	**VSYNCT :=**_______________
VOLT ADJ RATE (0.01–30.00 V/s)	**VADJRATE :=**_______________
VOLT PULS INTRVL (1–120 s)	**VPULSEI :=**_______________
VOLT PULS MIN (0.02–60.00 s)	**VPLSMIND :=**_______________
VOLT PULS MAX (0.10–60.00 s)	**VPLSMAXD :=**_______________
VMATCH START (SELOGIC)	**VSYNCST :=**_______________

Demand Metering

ENABLE DEM MTR (THM, ROL)	**EDEM :=**_______________
DEM TIME CONSTNT (5, 10, 15, 30, 60 min)	**DMTC :=**_______________

X-Side Demand Metering (Hidden if Slot Z = 84/88)

PH CURR DEM LVL (OFF, 0.50–16.00 A [5 A I_{XNOM}], 0.10–3.20 A [1 A I_{XNOM}])	**PHDEMPX :=**_______________
RES CURR DEM LVL (OFF, 0.50–16.00 A [5 A I_{XNOM}], 0.10–3.20 A [1 A I_{XNOM}])	**GNDEMPX :=**_______________
3I2 CURR DEM LVL (OFF, 0.50–16.00 A [5 A I_{XNOM}], 0.10–3.20 A [1 A I_{XNOM}])	**3I2DEMPX :=**_______________

Y-Side Demand Metering (Shown if Slot E = 71/75 or Slot Z = 83/87)

PH CURR DEM LVL (OFF, 0.50–16.00 A [5 A I_{YNOM}], 0.10–3.20 A [1 A I_{YNOM}])	**PHDEMPY :=**_______________
RES CURR DEM LVL (OFF, 0.50–16.00 A [5 A I_{YNOM}], 0.10–3.20 A [1 A I_{YNOM}])	**GNDEMPY :=**_______________
3I2 CURR DEM LVL (OFF, 0.50–16.00 A [5 A I_{YNOM}], 0.10–3.20 A [1 A I_{YNOM}]}	**3I2DEMPY :=**_______________

X-Side Pole Open Element (Hidden if Slot Z = 84/88)

LOAD DETECTION (OFF, 0.25–96.00 A [5 A I_{XNOM}], 0.05–19.20 A [1 A I_{XNOM}])	**50LXP :=**_______________
3POLE OPEN DELAY (0.00–1.00 s)	**3POXD :=**_______________

Y-Side Pole Open Element (Shown if Slot E = 71/75 or if Slot Z = 83/87)

LOAD DETECTION (OFF, 0.25–96.00 A [5 A I_{YNOM}], 0.05–19.20 A [1 A I_{YNOM}])	**50LYP :=**_______________
3POLE OPEN DELAY (0.00–1.00 s)	**3POYD :=**_______________

Trip/Close Logic

MIN TRIP TIME (0.00–400.00 s)	**TDURD :=**_______________
CLOSE X FAIL DLY (0.00–400.00 s) (Hidden if Slot Z = 84/88)	**CFDX :=**_______________

CLOSE Y FAIL DLY (0.00–400.00 s) (Shown if Slot Z = 83/87 or Slot E = 71/75) **CFDY :=**________________

X-SIDE BRKR TRIP EQN (SELOGIC) **TRX :=**________________

GEN FIELD BRKR TRIP EQN (SELOGIC) (Hidden if Slot Z = 83/84/87/88) **TR1 :=**________________

PRIME MOVER TRIP EQN (SELOGIC) (Hidden if Slot Z = 83/84/87/88) **TR2 :=**________________

GEN LOCKOUT TRIP EQN (SELOGIC) (Hidden if Slot Z = 83/84/87/88) **TR3 :=**________________

Y-SIDE BRKR TRIP EQN (SELOGIC) **TRY :=**________________

REMOTE TRIP EQN (SELOGIC) **REMTRIP :=**________________

UNLATCH X-SIDE TRIP (SELOGIC) **ULTRX :=**________________

UNLATCH TRIP1 (SELOGIC) (Hidden if Slot Z = 83/84/87/88) **ULTR1 :=**________________

UNLATCH TRIP2 (SELOGIC) (Hidden if Slot Z = 83/84/87/88) **ULTR2 :=**________________

UNLATCH TRIP3 (SELOGIC) (Hidden if Slot Z = 83/84/87/88) **ULTR3 :=**________________

UNLATCH Y-SIDE TRIP (SELOGIC) **ULTRY :=**________________

BREAKER X N/O CONT (SELOGIC) **52AX :=**________________

BREAKER X N/C CONT (SELOGIC) **52BX :=**________________

CLOSE X EQUATION (SELOGIC) **CLX :=**________________

UNLATCH CLOSE X (SELOGIC) **ULCLX :=**________________

BREAKER Y N/O CONT (SELOGIC) **52AY :=**________________

BREAKER Y N/C CONT (SELOGIC) **52BY :=**________________

CLOSE Y EQUATION (SELOGIC) (Shown if Slot Z = 83/87 or Slot E = 71/75) **CLY :=**________________

UNLATCH CLOSE Y (SELOGIC) **ULCLY :=**________________

Logic Settings (SET L Command)

SELOGIC Enables

SELOGIC LATCHES (N, 1–32)	**ELAT :=**________________
SV/TIMERS (N, 1–32)	**ESV :=**________________
SELOGIC COUNTERS (N, 1–32)	**ESC :=**________________
MATH VARIABLES (N, 1–32)	**EMV :=**________________

Latch Bits Equations

SET01 :=________________

RST01 :=________________

SET02 :=________________

RST02 :=________________

SET03 :=________________

RST03 :=________________

SET04 :=________________

RST04 :=________________

SET05 :=________________

RST05 :=________________

SET06 :=________________

RST06 :=________________

SET07 :=________________

RST07 :=________________

SET08 :=________________

RST08 :=________________

SET09 :=________________

RST09 :=________________

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SET11 :=________________

RST11 :=________________

SET12 :=________________

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SET13 :=________________

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RST14 :=________________

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SET16 :=________________

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SET26 :=____________________
RST26 :=____________________
SET27 :=____________________
RST27 :=____________________
SET28 :=____________________
RST28 :=____________________
SET29 :=____________________
RST29 :=____________________
SET30 :=____________________
RST30 :=____________________
SET31 :=____________________
RST31 :=____________________
SET32 :=____________________
RST32 :=____________________

SV/Timers

SV TIMER PICKUP (0.00–3000.00 s)	**SV01PU :=**________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV01DO :=**________
SV INPUT (SELOGIC)	**SV01 :=**________

____

SV TIMER PICKUP (0.00–3000.00 s)	**SV02PU :=**________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV02DO :=**________

SV INPUT (SELOGIC)	**SV02 :=**_______________
SV TIMER PICKUP (0.00–3000.00 s)	**SV03PU :=**_______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV03DO :=**_______________
SV INPUT (SELOGIC)	**SV03 :=**_______________
SV TIMER PICKUP (0.00–3000.00 s)	**SV04PU :=**_______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV04DO :=**_______________
SV INPUT (SELOGIC)	**SV04 :=**_______________
SV TIMER PICKUP (0.00–3000.00 s)	**SV05PU :=**_______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV05DO :=**_______________
SV INPUT (SELOGIC)	**SV05 :=**_______________
SV TIMER PICKUP (0.00–3000.00 s)	**SV06PU :=**_______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV06DO :=**_______________
SV INPUT (SELOGIC)	**SV06 :=**_______________
SV TIMER PICKUP (0.00–3000.00 s)	**SV07PU :=**_______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV07DO :=**_______________
SV INPUT (SELOGIC)	**SV07 :=**_______________
SV TIMER PICKUP (0.00–3000.00 s)	**SV08PU :=**_______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV08DO :=**_______________
SV INPUT (SELOGIC)	**SV08 :=**_______________
SV TIMER PICKUP (0.00–3000.00 s)	**SV09PU :=**_______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV09DO :=**_______________
SV INPUT (SELOGIC)	**SV09 :=**_______________
SV TIMER PICKUP (0.00–3000.00 s)	**SV10PU :=**_______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV10DO :=**_______________
SV INPUT (SELOGIC)	**SV10 :=**_______________
SV TIMER PICKUP (0.00–3000.00 s)	**SV11PU :=**_______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV11DO :=**_______________
SV INPUT (SELOGIC)	**SV11 :=**_______________
SV TIMER PICKUP (0.00–3000.00 s)	**SV12PU :=**_______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV12DO :=**_______________

SV INPUT (SELOGIC) **SV12 :=**________________

SV TIMER PICKUP (0.00–3000.00 s) **SV13PU :=**________________
SV TIMER DROPOUT (0.00–3000.00 s) **SV13DO :=**________________
SV INPUT (SELOGIC) **SV13 :=**________________

SV TIMER PICKUP (0.00–3000.00 s) **SV14PU :=**________________
SV TIMER DROPOUT (0.00–3000.00 s) **SV14DO :=**________________
SV INPUT (SELOGIC) **SV14 :=**________________

SV TIMER PICKUP (0.00–3000.00 s) **SV15PU :=**________________
SV TIMER DROPOUT (0.00–3000.00 s) **SV15DO :=**________________
SV INPUT (SELOGIC) **SV15 :=**________________

SV TIMER PICKUP (0.00–3000.00 s) **SV16PU :=**________________
SV TIMER DROPOUT (0.00–3000.00 s) **SV16DO :=**________________
SV INPUT (SELOGIC) **SV16 :=**________________

SV TIMER PICKUP (0.00–3000.00 s) **SV17PU :=**________________
SV TIMER DROPOUT (0.00–3000.00 s) **SV17DO :=**________________
SV INPUT (SELOGIC) **SV17 :=**________________

SV TIMER PICKUP (0.00–3000.00 s) **SV18PU :=**________________
SV TIMER DROPOUT (0.00–3000.00 s) **SV18DO :=**________________
SV INPUT (SELOGIC) **SV18 :=**________________

SV TIMER PICKUP (0.00–3000.00 s) **SV19PU :=**________________
SV TIMER DROPOUT (0.00–3000.00 s) **SV19DO :=**________________
SV INPUT (SELOGIC) **SV19 :=**________________

SV TIMER PICKUP (0.00–3000.00 s) **SV20PU :=**________________
SV TIMER DROPOUT (0.00–3000.00 s) **SV20DO :=**________________
SV INPUT (SELOGIC) **SV20 :=**________________

SV TIMER PICKUP (0.00–3000.00 s) **SV21PU :=**________________
SV TIMER DROPOUT (0.00–3000.00 s) **SV21DO :=**________________
SV INPUT (SELOGIC) **SV21 :=**________________

SV TIMER PICKUP (0.00–3000.00 s) **SV22PU :=**________________
SV TIMER DROPOUT (0.00–3000.00 s) **SV22DO :=**________________

SV INPUT (SELOGIC) **SV22 :=**________________

SV TIMER PICKUP (0.00–3000.00 s) **SV23PU :=**________________
SV TIMER DROPOUT (0.00–3000.00 s) **SV23DO :=**________________
SV INPUT (SELOGIC) **SV23 :=**________________

SV TIMER PICKUP (0.00–3000.00 s) **SV24PU :=**________________
SV TIMER DROPOUT (0.00–3000.00 s) **SV24DO :=**________________
SV INPUT (SELOGIC) **SV24 :=**________________

SV TIMER PICKUP (0.00–3000.00 s) **SV25PU :=**________________
SV TIMER DROPOUT (0.00–3000.00 s) **SV25DO :=**________________
SV INPUT (SELOGIC) **SV25 :=**________________

SV TIMER PICKUP (0.00–3000.00 s) **SV26PU :=**________________
SV TIMER DROPOUT (0.00–3000.00 s) **SV26DO :=**________________
SV INPUT (SELOGIC) **SV26 :=**________________

SV TIMER PICKUP (0.00–3000.00 s) **SV27PU :=**________________
SV TIMER DROPOUT (0.00–3000.00 s) **SV27DO :=**________________
SV INPUT (SELOGIC) **SV27 :=**________________

SV TIMER PICKUP (0.00–3000.00 s) **SV28PU :=**________________
SV TIMER DROPOUT (0.00–3000.00 s) **SV28DO :=**________________
SV INPUT (SELOGIC) **SV28 :=**________________

SV TIMER PICKUP (0.00–3000.00 s) **SV29PU :=**________________
SV TIMER DROPOUT (0.00–3000.00 s) **SV29DO :=**________________
SV INPUT (SELOGIC) **SV29 :=**________________

SV TIMER PICKUP (0.00–3000.00 s) **SV30PU :=**________________
SV TIMER DROPOUT (0.00–3000.00 s) **SV30DO :=**________________
SV INPUT (SELOGIC) **SV30 :=**________________

SV TIMER PICKUP (0.00–3000.00 s) **SV31PU :=**________________
SV TIMER DROPOUT (0.00–3000.00 s) **SV31DO :=**________________
SV INPU (SELOGIC) **SV31 :=**________________

SV TIMER PICKUP (0.00–3000.00 s)	**SV32PU :=**________________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV32DO :=**________________
SV INPUT (SELOGIC)	**SV32 :=**________________

Counters Equations

SC PRESET VALUE (1–65000)	**SC01PV :=**
SC RESET INPUT (SELOGIC)	**SC01R :=**
SC LOAD PV INPUT (SELOGIC)	**SC01LD :=**
SC CNT UP INPUT (SELOGIC)	**SC01CU :=**
SC CNT DN INPUT (SELOGIC)	**SC01CD :=**
SC PRESET VALUE (1–65000)	**SC02PV :=**
SC RESET INPUT (SELOGIC)	**SC02R :=**
SC LOAD PV INPUT (SELOGIC)	**SC02LD :=**
SC CNT UP INPUT (SELOGIC)	**SC02CU :=**
SC CNT DN INPUT (SELOGIC)	**SC02CD :=**
SC PRESET VALUE (1–65000)	**SC03PV :=**
SC RESET INPUT (SELOGIC)	**SC03R :=**
SC LOAD PV INPUT (SELOGIC)	**SC03LD :=**
SC CNT UP INPUT (SELOGIC)	**SC03CU :=**
SC CNT DN INPUT (SELOGIC)	**SC03CD :=**
SC PRESET VALUE (1–65000)	**SC04PV :=**
SC RESET INPUT (SELOGIC)	**SC04R :=**
SC LOAD PV INPUT (SELOGIC)	**SC04LD :=**
SC CNT UP INPUT (SELOGIC)	**SC04CU :=**
SC CNT DN INPUT (SELOGIC)	**SC04CD :=**
SC PRESET VALUE (1–65000)	**SC05PV :=**
SC RESET INPUT (SELOGIC)	**SC05R :=**
SC LOAD PV INPUT (SELOGIC)	**SC05LD :=**
SC CNT UP INPUT (SELOGIC)	**SC05CU :=**
SC CNT DN INPUT (SELOGIC)	**SC05CD :=**
SC PRESET VALUE (1–65000)	**SC06PV :=**
SC RESET INPUT (SELOGIC)	**SC06R :=**
SC LOAD PV INPUT (SELOGIC)	**SC06LD :=**
SC CNT UP INPUT (SELOGIC)	**SC06CU :=**
SC CNT DN INPUT (SELOGIC)	**SC06CD :=**
SC PRESET VALUE (1–65000)	**SC07PV :=**
SC RESET INPUT (SELOGIC)	**SC07R :=**
SC LOAD PV INPUT (SELOGIC)	**SC07LD :=**
SC CNT UP INPUT (SELOGIC)	**SC07CU :=**

SC CNT DN INPUT (SELOGIC) **SC07CD :=**____

SC PRESET VALUE (1–65000) **SC08PV :=**____

SC RESET INPUT (SELOGIC) **SC08R :=**____

SC LOAD PV INPUT (SELOGIC) **SC08LD :=**____

SC CNT UP INPUT (SELOGIC) **SC08CU :=**____

SC CNT DN INPUT (SELOGIC) **SC08CD :=**____

SC PRESET VALUE (1–65000) **SC09PV :=**____

SC RESET INPUT (SELOGIC) **SC09R :=**____

SC LOAD PV INPUT (SELOGIC) **SC09LD :=**____

SC CNT UP INPUT (SELOGIC) **SC09CU :=**____

SC CNT DN INPUT (SELOGIC) **SC09CD :=**____

SC PRESET VALUE (1–65000) **SC10PV :=**____

SC RESET INPUT (SELOGIC) **SC10R :=**____

SC LOAD PV INPUT (SELOGIC) **SC10LD :=**____

SC CNT UP INPUT (SELOGIC) **SC10CU :=**____

SC CNT DN INPUT (SELOGIC) **SC10CD :=**____

SC PRESET VALUE (1–65000) **SC11PV :=**____

SC RESET INPUT (SELOGIC) **SC11R :=**____

SC LOAD PV INPUT (SELOGIC) **SC11LD :=**____

SC CNT UP INPUT (SELOGIC) **SC11CU :=**____

SC CNT DN INPUT (SELOGIC) **SC11CD :=**____

SC PRESET VALUE (1–65000) **SC12PV :=**____

SC RESET INPUT (SELOGIC) **SC12R :=**____

SC LOAD PV INPUT (SELOGIC) **SC12LD :=**____

SC CNT UP INPUT (SELOGIC) **SC12CU :=**____

SC CNT DN INPUT (SELOGIC) **SC12CD :=**____

SC PRESET VALUE (1–65000) **SC13PV :=**____

SC RESET INPUT (SELOGIC) **SC13R :=**____

SC LOAD PV INPUT (SELOGIC) **SC13LD :=**____

SC CNT UP INPUT (SELOGIC) **SC13CU :=**____

SC CNT DN INPUT (SELOGIC) **SC13CD :=**____

SC PRESET VALUE (1–65000) **SC14PV :=**____

SC RESET INPUT (SELOGIC) **SC14R :=**____

SC LOAD PV INPUT (SELOGIC) **SC14LD :=**____

SC CNT UP INPUT (SELOGIC) **SC14CU :=**____

SC CNT DN INPUT (SELOGIC) **SC14CD :=**____

SC PRESET VALUE (1–65000) **SC15PV :=**____

SC RESET INPUT (SELOGIC) **SC15R :=**____

SC LOAD PV INPUT (SELOGIC) **SC15LD :=**____

SC CNT UP INPUT (SELOGIC) **SC15CU :=**____

SC CNT DN INPUT (SELOGIC)	**SC15CD :=**	
SC PRESET VALUE (1–65000)	**SC16PV :=**	
SC RESET INPUT (SELOGIC)	**SC16R :=**	
SC LOAD PV INPUT (SELOGIC)	**SC16LD :=**	
SC CNT UP INPUT (SELOGIC)	**SC16CU :=**	
SC CNT DN INPUT (SELOGIC)	**SC16CD :=**	
SC PRESET VALUE (1–65000)	**SC17PV :=**	
SC RESET INPUT (SELOGIC)	**SC17R :=**	
SC LOAD PV INPUT (SELOGIC)	**SC17LD :=**	
SC CNT UP INPUT (SELOGIC)	**SC17CU :=**	
SC CNT DN INPUT (SELOGIC)	**SC17CD :=**	
SC PRESET VALUE (1–65000)	**SC18PV :=**	
SC RESET INPUT (SELOGIC)	**SC18R :=**	
SC LOAD PV INPUT (SELOGIC)	**SC18LD :=**	
SC CNT UP INPUT (SELOGIC)	**SC18CU :=**	
SC CNT DN INPUT (SELOGIC)	**SC18CD :=**	
SC PRESET VALUE (1–65000)	**SC19PV :=**	
SC RESET INPUT (SELOGIC)	**SC19R :=**	
SC LOAD PV INPUT (SELOGIC)	**SC19LD :=**	
SC CNT UP INPUT (SELOGIC)	**SC19CU :=**	
SC CNT DN INPUT (SELOGIC)	**SC19CD :=**	
SC PRESET VALUE (1–65000)	**SC20PV :=**	
SC RESET INPUT (SELOGIC)	**SC20R :=**	
SC LOAD PV INPUT (SELOGIC)	**SC20LD :=**	
SC CNT UP INPUT (SELOGIC)	**SC20CU :=**	
SC CNT DN INPUT (SELOGIC)	**SC20CD :=**	
SC PRESET VALUE (1–65000)	**SC21PV :=**	
SC RESET INPUT (SELOGIC)	**SC21R :=**	
SC LOAD PV INPUT (SELOGIC)	**SC21LD :=**	
SC CNT UP INPUT (SELOGIC)	**SC21CU :=**	
SC CNT DN INPUT (SELOGIC)	**SC21CD :=**	
SC PRESET VALUE (1–65000)	**SC22PV :=**	
SC RESET INPUT (SELOGIC)	**SC22R :=**	
SC LOAD PV INPUT (SELOGIC)	**SC22LD :=**	
SC CNT UP INPUT (SELOGIC)	**SC22CU :=**	
SC CNT DN INPUT (SELOGIC)	**SC22CD :=**	

SC PRESET VALUE (1–65000)	**SC23PV :=**__________
SC RESET INPUT (SELOGIC)	**SC23R :=**__________
SC LOAD PV INPUT (SELOGIC)	**SC23LD :=**__________
SC CNT UP INPUT (SELOGIC)	**SC23CU :=**__________
SC CNT DN INPUT (SELOGIC)	**SC23CD :=**__________
SC PRESET VALUE (1–65000)	**SC24PV :=**__________
SC RESET INPUT (SELOGIC)	**SC24R :=**__________
SC LOAD PV INPUT (SELOGIC)	**SC24LD :=**__________
SC CNT UP INPUT (SELOGIC)	**SC24CU :=**__________
SC CNT DN INPUT (SELOGIC)	**SC24CD :=**__________
SC PRESET VALUE (1–65000)	**SC25PV :=**__________
SC RESET INPUT (SELOGIC)	**SC25R :=**__________
SC LOAD PV INPUT (SELOGIC)	**SC25LD :=**__________
SC CNT UP INPUT (SELOGIC)	**SC25CU :=**__________
SC CNT DN INPUT (SELOGIC)	**SC25CD :=**__________
SC PRESET VALUE (1–65000)	**SC26PV :=**__________
SC RESET INPUT (SELOGIC)	**SC26R :=**__________
SC LOAD PV INPUT (SELOGIC)	**SC26LD :=**__________
SC CNT UP INPUT (SELOGIC)	**SC26CU :=**__________
SC CNT DN INPUT (SELOGIC)	**SC26CD :=**__________
SC PRESET VALUE (1–65000)	**SC27PV :=**__________
SC RESET INPUT (SELOGIC)	**SC27R :=**__________
SC LOAD PV INPUT (SELOGIC)	**SC27LD :=**__________
SC CNT UP INPUT (SELOGIC)	**SC27CU :=**__________
SC CNT DN INPUT (SELOGIC)	**SC27CD :=**__________
SC PRESET VALUE (1–65000)	**SC28PV :=**__________
SC RESET INPUT (SELOGIC)	**SC28R :=**__________
SC LOAD PV INPUT (SELOGIC)	**SC28LD :=**__________
SC CNT UP INPUT (SELOGIC)	**SC28CU :=**__________
SC CNT DN INPUT (SELOGIC)	**SC28CD :=**__________
SC PRESET VALUE (1–65000)	**SC29PV :=**__________
SC RESET INPUT (SELOGIC)	**SC29R :=**__________
SC LOAD PV INPUT (SELOGIC)	**SC29LD :=**__________
SC CNT UP INPUT (SELOGIC)	**SC29CU :=**__________
SC CNT DN INPUT (SELOGIC)	**SC29CD :=**__________
SC PRESET VALUE (1–65000)	**SC30PV :=**__________
SC RESET INPUT (SELOGIC)	**SC30R :=**__________
SC LOAD PV INPUT (SELOGIC)	**SC30LD :=**__________
SC CNT UP INPUT (SELOGIC)	**SC30CU :=**__________
SC CNT DN INPUT (SELOGIC)	**SC30CD :=**__________

SC PRESET VALUE (1–65000) **SC31PV :=**______________________

SC RESET INPUT (SELOGIC) **SC31R :=**______________________

SC LOAD PV INPUT (SELOGIC) **SC31LD :=**______________________

SC CNT UP INPUT (SELOGIC) **SC31CU :=**______________________

SC CNT DN INPUT (SELOGIC) **SC31CD :=**______________________

SC PRESET VALUE (1–65000) **SC32PV :=**______________________

SC RESET INPUT (SELOGIC) **SC32R :=**______________________

SC LOAD PV INPUT (SELOGIC) **SC32LD :=**______________________

SC CNT UP INPUT (SELOGIC) **SC32CU :=**______________________

SC CNT DN INPUT (SELOGIC) **SC32CD :=**______________________

Math Variables

MV01 :=______________________

MV02 :=______________________

MV03 :=______________________

MV04 :=______________________

MV05 :=______________________

MV06 :=______________________

MV07 :=______________________

MV08 :=______________________

MV09 :=______________________

MV10 :=______________________

MV11 :=______________________

MV12 :=______________________

MV13 :=______________________

MV14 :=______________________

MV15 :=______________________

MV16 :=______________________

MV17 :=______________________

MV18 :=______________________

MV19 :=______________________

MV20 :=______________________

MV21 :=______________________

MV22 :=______________________

MV23 :=______________________

MV24 :=______________________

MV25 :=______________________

MV26 :=______________________

MV27 :=______________________

MV28 :=______________________

MV29 :=____

MV30 :=____

MV31 :=____

MV32 :=____

Base Output

OUT101 FAIL-SAFE (Y, N) **OUT101FS :=**________________

OUT101 :=____

OUT102 FAIL-SAFE (Y, N) **OUT102FS :=**________________

OUT102 :=____

OUT103 FAIL-SAFE (Y, N) **OUT103FS :=**________________

OUT103 :=____

Slot C Output (Hidden if output option not included; OUT305–OUT308 only available with 8 DO card)

OUT301 FAIL-SAFE (Y, N) **OUT301FS :=**________________

OUT301 :=____

OUT302 FAIL-SAFE (Y, N) **OUT302FS :=**________________

OUT302 :=____

OUT303 FAIL-SAFE (Y, N) **OUT303FS :=**________________

OUT303 :=____

OUT304 FAIL-SAFE (Y, N) **OUT304FS :=**________________

OUT304 :=____

OUT305 FAIL-SAFE (Y, N) **OUT305FS :=**________________

OUT305 :=____

OUT306 FAIL-SAFE (Y, N) **OUT306FS :=**________________

OUT306 :=____

OUT307 FAIL-SAFE (Y, N) **OUT307FS :=**________________

OUT307 :=____

OUT308 FAIL-SAFE (Y, N) **OUT308FS :=**________________

OUT308 :=____

Slot D Output (Hidden if output option not included; OUT405–OUT408 only available with 8 DO card)

OUT401 FAIL-SAFE (Y, N) **OUT401FS :=**________________

OUT401 :=____

OUT402 FAIL-SAFE (Y, N) **OUT402FS :=**________________

OUT402 :=____

OUT403 FAIL-SAFE (Y, N) **OUT403FS :=**________________

OUT403 :=____

OUT404 FAIL-SAFE (Y, N) **OUT404FS :=**________________

OUT404 :=____

Slot D Output (Hidden if output option not included; OUT405–OUT408 only available with 8 DO card)

OUT405 FAIL-SAFE (Y, N) **OUT405FS :=**______________

OUT405 :=______________

OUT406 FAIL-SAFE (Y, N) **OUT406FS :=**______________

OUT406 :=______________

OUT407 FAIL-SAFE (Y, N) **OUT407FS :=**______________

OUT407 :=______________

OUT408 FAIL-SAFE (Y, N) **OUT408FS :=**______________

OUT408 :=______________

Slot E Output (Hidden if output option not included; OUT505–OUT508 only available with 8 DO card)

OUT501 FAIL-SAFE (Y, N) **OUT501FS :=**______________

OUT501 :=______________

OUT502 FAIL-SAFE (Y, N) **OUT502FS :=**______________

OUT502 :=______________

OUT503 FAIL-SAFE (Y, N) **OUT503FS :=**______________

OUT503 :=______________

OUT504 FAIL-SAFE (Y, N) **OUT504FS :=**______________

OUT504 :=______________

OUT505 FAIL-SAFE (Y, N) **OUT505FS :=**______________

OUT505 :=______________

OUT506 FAIL-SAFE (Y, N) **OUT506FS :=**______________

OUT506 :=______________

OUT507 FAIL-SAFE (Y, N) **OUT507FS :=**______________

OUT507 :=______________

OUT508 FAIL-SAFE (Y, N) **OUT508FS :=**______________

OUT508 :=______________

MIRRORED BITS Transmit SELOGIC Control Equations

(Hidden if PROTO is not MBxx on any of the communications ports)

TMB1A :=______________

TMB2A :=______________

TMB3A :=______________

TMB4A :=______________

TMB5A :=______________

TMB6A :=______________

TMB7A :=______________

TMB8A :=______________

TMB1B :=______________

TMB2B :=______________

TMB3B :=______________

TMB4B :=____

TMB5B :=____

TMB6B :=____

TMB7B :=____

TMB8B :=____

Global Settings (SET G Command)

General

RATED FREQ. (50, 60 Hz)	**FNOM :=**_______________
PRIORITY FRQ TRK (X, Y)	**FRQTRK :=**_______________
DATE FORMAT (MDY, YMD, DMY)	**DATE_F :=**_______________
MET CUTOFF THRES (Y, N)	**METHRES :=**_______________
FAULT CONDITION (SELOGIC)	**FAULT :=**_______________

Event Messenger Points

EVE MSG PTS ENABL (N, 1–32)	**EMP :=**_______________

(Only the points enabled by EMP are visible)

MESSENGER POINT MP01 TRIGGER (Off, 1 Relay Word bit)	**MPTR01 :=**_______________
MESSENGER POINT MP01 AQ (None, 1 analog quantity)	**MPAQ01 :=**_______________
MESSENGER POINT MP01 TEXT (148 characters)	**MPTX01 :=**_______________
MESSENGER POINT MP02 TRIGGER (Off, 1 Relay Word bit)	**MPTR02 :=**_______________
MESSENGER POINT MP02 AQ (None, 1 analog quantity)	**MPAQ02 :=**_______________
MESSENGER POINT MP02 TEXT (148 characters)	**MPTX02 :=**_______________
MESSENGER POINT MP03 TRIGGER (Off, 1 Relay Word bit)	**MPTR03 :=**_______________
MESSENGER POINT MP03 AQ (None, 1 analog quantity)	**MPAQ03 :=**_______________
MESSENGER POINT MP03 TEXT (148 characters)	**MPTX03 :=**_______________
MESSENGER POINT MP04 TRIGGER (Off, 1 Relay Word bit)	**MPTR04 :=**_______________
MESSENGER POINT MP04 AQ (None, 1 analog quantity)	**MPAQ04 :=**_______________
MESSENGER POINT MP04 TEXT (148 characters)	**MPTX04 :=**_______________
MESSENGER POINT MP05 TRIGGER (Off, 1 Relay Word bit)	**MPTR05 :=**_______________
MESSENGER POINT MP05 AQ (None, 1 analog quantity)	**MPAQ05 :=**_______________
MESSENGER POINT MP05 TEXT (148 characters)	**MPTX05 :=**_______________
MESSENGER POINT MP06 TRIGGER (Off, 1 Relay Word bit)	**MPTR06 :=**_______________
MESSENGER POINT MP06 AQ (None, 1 analog quantity)	**MPAQ06 :=**_______________
MESSENGER POINT MP06 TEXT (148 characters)	**MPTX06 :=**_______________
MESSENGER POINT MP07 TRIGGER (Off, 1 Relay Word bit)	**MPTR07 :=**_______________
MESSENGER POINT MP07 AQ (None, 1 analog quantity)	**MPAQ07 :=**_______________
MESSENGER POINT MP07 TEXT (148 characters)	**MPTX07 :=**_______________

MESSENGER POINT MP08 TRIGGER (Off, 1 Relay Word bit)	**MPTR08 :=**________________
MESSENGER POINT MP08 AQ (None, 1 analog quantity)	**MPAQ08 :=**________________
MESSENGER POINT MP08 TEXT (148 characters)	**MPTX08 :=**________________
MESSENGER POINT MP09 TRIGGER (Off, 1 Relay Word bit)	**MPTR09 :=**________________
MESSENGER POINT MP09 AQ (None, 1 analog quantity)	**MPAQ09 :=**________________
MESSENGER POINT MP09 TEXT (148 characters)	**MPTX09 :=**________________
MESSENGER POINT MP10 TRIGGER (Off, 1 Relay Word bit)	**MPTR10 :=**________________
MESSENGER POINT MP10 AQ (None, 1 analog quantity)	**MPAQ10 :=**________________
MESSENGER POINT MP10 TEXT (148 characters)	**MPTX10 :=**________________
MESSENGER POINT MP11 TRIGGER (Off, 1 Relay Word bit)	**MPTR11 :=**________________
MESSENGER POINT MP11 AQ (None, 1 analog quantity)	**MPAQ11 :=**________________
MESSENGER POINT MP11 TEXT (148 characters)	**MPTX11 :=**________________
MESSENGER POINT MP12 TRIGGER (Off, 1 Relay Word bit)	**MPTR12 :=**________________
MESSENGER POINT MP12 AQ (None, 1 analog quantity)	**MPAQ12 :=**________________
MESSENGER POINT MP12 TEXT (148 characters)	**MPTX12 :=**________________
MESSENGER POINT MP13 TRIGGER (Off, 1 Relay Word bit)	**MPTR13 :=**________________
MESSENGER POINT MP13 AQ (None, 1 analog quantity)	**MPAQ13 :=**________________
MESSENGER POINT MP13 TEXT (148 characters)	**MPTX13 :=**________________
MESSENGER POINT MP14 TRIGGER (Off, 1 Relay Word bit)	**MPTR14 :=**________________
MESSENGER POINT MP14 AQ (None, 1 analog quantity)	**MPAQ14 :=**________________
MESSENGER POINT MP14 TEXT (148 characters)	**MPTX14 :=**________________
MESSENGER POINT MP15 TRIGGER (Off, 1 Relay Word bit)	**MPTR15 :=**________________
MESSENGER POINT MP15 AQ (None, 1 analog quantity)	**MPAQ15 :=**________________
MESSENGER POINT MP15 TEXT (148 characters)	**MPTX15 :=**________________
MESSENGER POINT MP16 TRIGGER (Off, 1 Relay Word bit)	**MPTR16 :=**________________
MESSENGER POINT MP16 AQ (None, 1 analog quantity)	**MPAQ16 :=**________________
MESSENGER POINT MP16 TEXT (148 characters)	**MPTX16 :=**________________
MESSENGER POINT MP17 TRIGGER (Off, 1 Relay Word bit)	**MPTR17 :=**________________
MESSENGER POINT MP17 AQ (None, 1 analog quantity)	**MPAQ17 :=**________________
MESSENGER POINT MP17 TEXT (148 characters)	**MPTX17 :=**________________

MESSENGER POINT MP18 TRIGGER (Off, 1 Relay Word bit)	**MPTR18 :=**________________
MESSENGER POINT MP18 AQ (None, 1 analog quantity)	**MPAQ18 :=**________________
MESSENGER POINT MP18 TEXT (148 characters)	**MPTX18 :=**________________
MESSENGER POINT MP19 TRIGGER (Off, 1 Relay Word bit)	**MPTR19 :=**________________
MESSENGER POINT MP19 AQ (None, 1 analog quantity)	**MPAQ19 :=**________________
MESSENGER POINT MP19 TEXT (148 characters)	**MPTX19 :=**________________
MESSENGER POINT MP20 TRIGGER (Off, 1 Relay Word bit)	**MPTR20 :=**________________
MESSENGER POINT MP20 AQ (None, 1 analog quantity)	**MPAQ20 :=**________________
MESSENGER POINT MP20 TEXT (148 characters)	**MPTX20 :=**________________
MESSENGER POINT MP21 TRIGGER (Off, 1 Relay Word bit)	**MPTR21 :=**________________
MESSENGER POINT MP21 AQ (None, 1 analog quantity)	**MPAQ21 :=**________________
MESSENGER POINT MP21 TEXT (148 characters)	**MPTX21 :=**________________
MESSENGER POINT MP22 TRIGGER (Off, 1 Relay Word bit)	**MPTR22 :=**________________
MESSENGER POINT MP22 AQ (None, 1 analog quantity)	**MPAQ22 :=**________________
MESSENGER POINT MP22 TEXT (148 characters)	**MPTX22 :=**________________
MESSENGER POINT MP23 TRIGGER (Off, 1 Relay Word bit)	**MPTR23 :=**________________
MESSENGER POINT MP23 AQ (None, 1 analog quantity)	**MPAQ23 :=**________________
MESSENGER POINT MP23 TEXT (148 characters)	**MPTX23 :=**________________
MESSENGER POINT MP24 TRIGGER (Off, 1 Relay Word bit)	**MPTR24 :=**________________
MESSENGER POINT MP24 AQ (None, 1 analog quantity)	**MPAQ24 :=**________________
MESSENGER POINT MP24 TEXT (148 characters)	**MPTX24 :=**________________
MESSENGER POINT MP25 TRIGGER (Off, 1 Relay Word bit)	**MPTR25 :=**________________
MESSENGER POINT MP25 AQ (None, 1 analog quantity)	**MPAQ25 :=**________________
MESSENGER POINT MP25 TEXT (148 characters)	**MPTX25 :=**________________
MESSENGER POINT MP26 TRIGGER (Off, 1 Relay Word bit)	**MPTR26 :=**________________
MESSENGER POINT MP26 AQ (None, 1 analog quantity)	**MPAQ26 :=**________________
MESSENGER POINT MP26 TEXT (148 characters)	**MPTX26 :=**________________
MESSENGER POINT MP27 TRIGGER (Off, 1 Relay Word bit)	**MPTR27 :=**________________
MESSENGER POINT MP27 AQ (None, 1 analog quantity)	**MPAQ27 :=**________________
MESSENGER POINT MP27 TEXT (148 characters)	**MPTX27 :=**________________

MESSENGER POINT MP28 TRIGGER (Off, 1 Relay Word bit)	**MPTR28 :=**_______________
MESSENGER POINT MP28 AQ (None, 1 analog quantity)	**MPAQ28 :=**_______________
MESSENGER POINT MP28 TEXT (148 characters)	**MPTX28 :=**_______________
MESSENGER POINT MP29 TRIGGER (Off, 1 Relay Word bit)	**MPTR29 :=**_______________
MESSENGER POINT MP29 AQ (None, 1 analog quantity)	**MPAQ29 :=**_______________
MESSENGER POINT MP29 TEXT (148 characters)	**MPTX29 :=**_______________
MESSENGER POINT MP30 TRIGGER (Off, 1 Relay Word bit)	**MPTR30 :=**_______________
MESSENGER POINT MP30 AQ (None, 1 analog quantity)	**MPAQ30 :=**_______________
MESSENGER POINT MP30 TEXT (148 characters)	**MPTX30 :=**_______________
MESSENGER POINT MP31 TRIGGER (Off, 1 Relay Word bit)	**MPTR31 :=**_______________
MESSENGER POINT MP31 AQ (None, 1 analog quantity)	**MPAQ31 :=**_______________
MESSENGER POINT MP31 TEXT (148 characters)	**MPTX31 :=**_______________
MESSENGER POINT MP32 TRIGGER (Off, 1 Relay Word bit)	**MPTR32 :=**_______________
MESSENGER POINT MP32 AQ (None, 1 analog quantity)	**MPAQ32 :=**_______________
MESSENGER POINT MP32 TEXT (148 characters)	**MPTX32 :=**_______________

Group Selection

GRP CHG DELAY (0–400 s)	**TGR :=**_______________
SELECT GROUP1 (SELOGIC)	**SS1 :=**_______________
SELECT GROUP2 (SELOGIC)	**SS2 :=**_______________
SELECT GROUP3 (SELOGIC)	**SS3 :=**_______________
SELECT GROUP4 (SELOGIC)	**SS4 :=**_______________

Phasor Measurement (PMU)

EN SYNCHRO PHSOR (Y, N)	**EPMU :=**_______________

(All Phasor Measurement settings are hidden if EPMU := N)

MESSAGES PER SEC (1, 2, 5, 10, 12, 15, 20, 30, 60 for FNOM := 60 Hz; 1, 2, 5, 10, 25, 50 for FNOM := 50 Hz)	**MRATE :=**_______________
PMU APPLICATION (FAST, NARROW)	**PMAPP :=**_______________
FREQ BASED COMP (Y, N)	**PHCOMP :=**_______________
STATION NAME (16 characters)	**PMSTN :=**_______________
PMU HARDWARE ID (1–65534)	**PMID :=**_______________
VOLTAGE DATA SET (V1, ALL, NA) (Hidden when Slot Z = 83/87)	**PHDATAV :=**_______________

VOLTAGE SOURCE (VX, VY, BOTH)	**PHVOLT :=**________________
VX COMP ANGLE (–179.99 to 180.00°) (Shown for Slot Z = 81/82/85/86)	**VXCOMP :=**________________
VY COMP ANGLE (–179.99 to 180.00°) (Shown for Slot E = 71/75)	**VYCOMP :=**________________
VS COMP ANGLE (–179.99 to 180.00°) (Shown for Slot E = 71/75/72/76/74)	**VSCOMP :=**________________
CURRENT DATA SET (I1, ALL, NA)	**PHDATAI :=**________________
CURRENT SOURCE (IX, IY, BOTH)	**PHCURR :=**________________
IX COMP ANGLE (–179.99 to 180.00°) (Hidden if PHCURR = IY or PHDATAI = NA.)	**IXCOMP :=**________________
IY COMP ANGLE (–179.99 to 180.00°) (Hidden if PHCURR = IX or PHDATAI = NA.)	**IYCOMP :=**________________
NUM ANALOGS (0–4)	**NUMANA :=**________________
NUM 16BIT DIGTAL (0, 1)	**NUMDSW :=**________________
TRIG REASON BIT 1 (SELOGIC)	**TREA1 :=**________________
TRIG REASON BIT 2 (SELOGIC)	**TREA2 :=**________________
TRIG REASON BIT 3 (SELOGIC)	**TREA3 :=**________________
TRIG REASON BIT 4 (SELOGIC)	**TREA4 :=**________________
TRIGGER (SELOGIC)	**PMTRIG :=**________________

Time and Date Management

CTRL BITS DEFN (NONE, C37.118)	**IRIGC :=**________________
OFFSET FROM UTC (–24.00 to 24.00) rounded up to quarter	**UTC_OFF :=**________________
MONTH TO BEGIN DST (OFF, 1–12)	**DST_BEGM :=**________________
WEEK OF THE MONTH TO BEGIN DST (1–3, L) L = Last week of the month (Hidden if DST_BEGM := OFF)	**DST_BEGW :=**________________
DAY OF THE WEEK TO BEGIN DST (SUN, MON, TUE, WED, THU, FRI, SAT) (Hidden if DST_BEGM := OFF)	**DST_BEGD :=**________________
LOCAL HOUR TO BEGIN DST (0–23) (Hidden if DST_BEGM := OFF)	**DST_BEGH :=**________________
MONTH TO END DST (1–12) (Hidden if DST_BEGM := OFF)	**DST_ENDM :=**________________
WEEK OF THE MONTH TO END DST (1–3, L) L = Last week of the month (Hidden if DST_BEGM := OFF)	**DST_ENDW :=**________________
DAY OF THE WEEK TO END DST (SUN, MON, TUE, WED, THU, FRI, SAT) (Hidden if DST_BEGM := OFF)	**DST_ENDD :=**________________
LOCAL HOUR TO END DST (0–23) (Hidden if DST_BEGM := OFF)	**DST_ENDH :=**________________

Breaker Failure

52A INTERLOCK (Y, N)	**52ABF :=**________________
BRKRX FAIL DELAY (0.00–2.00 s) (Hidden if Slot Z = 84/88)	**BFDX :=**________________
BRKRX FAIL INIT (SELOGIC) (Hidden if Slot Z = 84/88)	**BFIX :=**________________

BRKRY FAIL DELAY (0.00–2.00 s) (Hidden if not available)	**BFDY :=**________________
BRKRY FAIL INIT (SELOGIC) (Hidden if not available)	**BFIY :=**________________

Analog Inputs/Outputs

For the Analog Inputs/Outputs settings, x is the card position (3, 4, or 5 in Slot C, D, and E, respectively) (Settings are hidden if Analog I/O are not included.)

AIx01

AI*x*01 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*01NAM :=**________________
AI*x*01 TYPE (I, V)	**AI*x*01TYP :=**________________

If AIx01TYP = I

AI*x*01 LOW IN VAL (–20.480 to +20.480 mA)	**AI*x*01L :=**________________
AI*x*01 HI IN VAL (–20.480 to +20.480 mA)	**AI*x*01H :=**________________

If AIx01TYP = V

AI*x*01 LOW IN VAL (–10.240 to +10.240 V)	**AI*x*01L :=**________________
AI*x*01 HI IN VAL (–10.240 to +10.240 V)	**AI*x*01H :=**________________

Note: Set Warn and Alarm to a value between Engr Low and Engr High settings.

AI*x*01 ENG UNITS (16 characters)	**AI*x*01EU :=**________________
AI*x*01 EU LOW (–99999.000 to +99999.000)	**AI*x*01EL :=**________________
AI*x*01 EU HI (–99999.000 to +99999.000)	**AI*x*01EH :=**________________
AI*x*01 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*01LW1 :=**________________
AI*x*01 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*01LW2 :=**________________
AI*x*01 LO ALARM (OFF, –99999.000 to +99999.000)	**AI*x*01LAL :=**________________
AI*x*01 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*01HW1 :=**________________
AI*x*01 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AIx01HW2 :=**________________
AI*x*01 HI ALARM (OFF, –99999.000 to +99999.000)	**AIx01HAL :=**________________

AIx02

AI*x*02 TAG NAME (8 characters 0–9, A–Z, _)	**AIx02NAM :=**________________
AI*x*02 TYPE (I, V)	**AIx02TYP :=**________________

If AIx02TYP = I

AI*x*02 LOW IN VAL (–20.480 to +20.480 mA)	**AIx02L :=**________________
AI*x*02 HI IN VAL (–20.480 to +20.480 mA)	**AIx02H :=**________________

If AIx02TYP = V

AI*x*02 LOW IN VAL (–10.240 to +10.240 V)	**AIx02L :=**________________
AI*x*02 HI IN VAL (–10.240 to +10.240 V)	**AIx02H :=**________________
AI*x*02 ENG UNITS (16 characters)	**AIx02EU :=**________________
AI*x*02 EU LOW (–99999.000 to +99999.000)	**AIx02EL :=**________________
AI*x*02 EU HI (–99999.000 to +99999.000)	**AIx02EH :=**________________
AI*x*02 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AIx02LW1 :=**________________
AI*x*02 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AIx02LW2 :=**________________

AIx02 LO ALARM (OFF, –99999.000 to +99999.000)	**AIx02LAL :=**_______________
AIx02 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AIx02HW1 :=**_______________
AIx02 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AIx02HW2 :=**_______________
AIx02 HI ALARM (OFF, –99999.000 to +99999.000)	**AIx02HAL :=**_______________

AIx03

AIx03 TAG NAME (8 characters 0–9, A–Z, _)	**AIx03NAM :=**_______________
AIx03 TYPE (I, V)	**AIx03TYP :=**_______________

If AIx03TYP = I

AIx03 LOW IN VAL (–20.480 to +20.480 mA)	**AIx03L :=**_______________
AIx03 HI IN VAL (–20.480 to +20.480 mA)	**AIx03H :=**_______________

If AIx03TYP = V

AIx03 LOW IN VAL (–10.240 to +10.240 V)	**AIx03L :=**_______________
AIx03 HI IN VAL (–10.240 to +10.240 V)	**AIx03H :=**_______________
AIx03 ENG UNITS (16 characters)	**AIx03EU :=**_______________
AIx03 EU LOW (–99999.000 to +99999.000)	**AIx03EL :=**_______________
AIx03 EU HI (–99999.000 to +99999.000)	**AIx03EH :=**_______________
AIx03 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AIx03LW1 :=**_______________
AIx03 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AIx03LW2 :=**_______________
AIx03 LO ALARM (OFF, –99999.000 to +99999.000)	**AIx03LAL :=**_______________
AIx03 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AIx03HW1 :=**_______________
AIx03 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AIx03HW2 :=**_______________
AIx03 HI ALARM (OFF, –99999.000 to +99999.000)	**AIx03HAL :=**_______________

AIx04

AIx04 TAG NAME (8 characters 0–9, A–Z, _)	**AIx04NAM :=**_______________
AIx04 TYPE (I, V)	**AIx04TYP :=**_______________

If AIx04TYP = I

AIx04 LOW IN VAL (–20.480 to +20.480 mA)	**AIx04L :=**_______________
AIx04 HI IN VAL (–20.480 to +20.480 mA)	**AIx04H :=**_______________

If AIx04TYP = V

AIx04 LOW IN VAL (–10.240 to +10.240 V)	**AIx04L :=**_______________
AIx04 HI IN VAL (–10.240 to +10.240 V)	**AIx04H :=**_______________
AIx04 ENG UNITS (16 characters)	**AIx04EU :=**_______________
AIx04 EU LOW (–99999.000 to +99999.000)	**AIx04EL :=**_______________
AIx04 EU HI (–99999.000 to +99999.000)	**AIx04EH :=**_______________
AIx04 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AIx04LW1 :=**_______________
AIx04 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AIx04LW2 :=**_______________
AIx04 LO ALARM (OFF, –99999.000 to +99999.000)	**AIx04LAL :=**_______________
AIx04 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AIx04HW1 :=**_______________

AI*x*04 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*04HW2 :=**________________
AI*x*04 HI ALARM (OFF, –99999.000 to +99999.000)	**AI*x*04HAL :=**________________

AOx01

AO*x*01 ANALOG QTY (Off, 1 analog quantity)	**AO*x*01AQ :=**________________
AO*x*01 TYPE (I, V)	**AO*x*01TYP :=**________________
AO*x*01 AQTY LOW (–2147483647 to +2147483647)	**AO*x*01AQL :=**________________
AO*x*01 AQTY HI (–2147483647 to +2147483647)	**AO*x*01AQH :=**________________

If AOx01TYP = I

AO*x*01 LO OUT VAL (–20.480 to +20.480 mA)	**AO*x*01L :=**________________
AO*x*01 HI OUT VAL (–20.480 to +20.480 mA)	**AO*x*01H :=**________________

If AOx01TYP = V

AO*x*01 LO OUT VAL (–10.240 to +10.240 V)	**AO*x*01L :=**________________
AO*x*01 HI OUT VAL (–10.240 to +10.240 V)	**AO*x*01H :=**________________

AOx02

AO*x*02 ANALOG QTY (Off, 1 analog quantity)	**AO*x*02AQ :=**________________
AO*x*02 TYPE (I, V)	**AO*x*02TYP :=**________________
AO*x*02 AQTY LOW (–2147483647 to +2147483647)	**AO*x*02AQL :=**________________
AO*x*02 AQTY HI (–2147483647 to +2147483647)	**AO*x*02AQH :=**________________

If AOx02TYP = I

AO*x*02 LO OUT VAL (–20.480 to +20.480 mA)	**AO*x*02L :=**________________
AO*x*02 HI OUT VAL (–20.480 to +20.480 mA)	**AO*x*02H :=**________________

If AOx02TYP = V

AO*x*02 LO OUT VAL (–10.240 to +10.240 V)	**AO*x*02L :=**________________
AO*x*02 HI OUT VAL (–10.240 to +10.240 V)	**AO*x*02H :=**________________

AOx03

AO*x*03 ANALOG QTY (Off, 1 analog quantity)	**AO*x*03AQ :=**________________
AO*x*03 TYPE (I, V)	**AO*x*03TYP :=**________________
AO*x*03 AQTY LOW (–2147483647 to +2147483647)	**AO*x*03AQL :=**________________
AO*x*03 AQTY HI (–2147483647 to +2147483647)	**AO*x*03AQH :=**________________

If AOx03TYP = I

AO*x*03 LO OUT VAL (–20.480 to +20.480 mA)	**AO*x*03L :=**________________
AO*x*03 HI OUT VAL (–20.480 to +20.480 mA)	**AO*x*03H :=**________________

If AOx03TYP = V

AO*x*03 LO OUT VAL (–10.240 to +10.240 V)	**AO*x*03L :=**________________
AO*x*03 HI OUT VAL (–10.240 to +10.240 V)	**AO*x*03H :=**________________

AOx04

AO*x*04 ANALOG QTY (Off, 1 analog quantity)	**AO*x*04AQ :=**________________
AO*x*04 TYPE (I, V)	**AO*x*04TYP :=**________________

AO*x*04 AQTY LOW (–2147483647 to +2147483647)	**AO*x*04AQL :=**________________
AO*x*04 AQTY HI (–2147483647 to +2147483647)	**AO*x*04AQH :=**________________

If AOx04TYP = I

AO*x*04 LO OUT VAL (–20.480 to +20.480 mA)	**AO*x*04L :=**________________
AO*x*04 HI OUT VAL (–20.480 to +20.480 mA)	**AO*x*04H :=**________________

If AOx04TYP = V

AO*x*04 LO OUT VAL (–10.240 to +10.240 V)	**AO*x*04L :=**________________
AO*x*04 HI OUT VAL (–10.240 to +10.240 V)	**AO*x*04H :=**________________

Input Debounce Settings (Base Unit)

IN101 Debounce (AC, 0–65000 ms)	**IN101D :=**________________
IN102 Debounce (AC, 0–65000 ms)	**IN102D :=**________________

Input Debounce Settings (Slot C) (Hidden if input option not included)

IN301 Debounce (AC, 0–65000 ms)	**IN301D :=**________________
IN302 Debounce (AC, 0–65000 ms)	**IN302D :=**________________
IN303 Debounce (AC, 0–65000 ms)	**IN303D :=**________________
IN304 Debounce (AC, 0–65000 ms)	**IN304D :=**________________
IN305 Debounce (AC, 0–65000 ms)	**IN305D :=**________________
IN306 Debounce (AC, 0–65000 ms)	**IN306D :=**________________
IN307 Debounce (AC, 0–65000 ms)	**IN307D :=**________________
IN308 Debounce (AC, 0–65000 ms)	**IN308D :=**________________
IN309 Debounce (AC, 0–65000 ms)	**IN309D :=**________________
IN310 Debounce (AC, 0–65000 ms)	**IN310D :=**________________
IN311 Debounce (AC, 0–65000 ms)	**IN311D :=**________________
IN312 Debounce (AC, 0–65000 ms)	**IN312D :=**________________
IN313 Debounce (AC, 0–65000 ms)	**IN313D :=**________________
IN314 Debounce (AC, 0–65000 ms)	**IN314D :=**________________

Input Debounce Settings (Slot D) (Hidden if input option not included)

IN401 Debounce (AC, 0–65000 ms)	**IN401D :=**________________
IN402 Debounce (AC, 0–65000 ms)	**IN402D :=**________________
IN403 Debounce (AC, 0–65000 ms)	**IN403D :=**________________
IN404 Debounce (AC, 0–65000 ms)	**IN404D :=**________________
IN405 Debounce (AC, 0–65000 ms)	**IN405D :=**________________
IN406 Debounce (AC, 0–65000 ms)	**IN406D :=**________________
IN407 Debounce (AC, 0–65000 ms)	**IN407D :=**________________
IN408 Debounce (AC, 0–65000 ms)	**IN408D :=**________________
IN409 Debounce (AC, 0–65000 ms)	**IN409D :=**________________
IN410 Debounce (AC, 0–65000 ms)	**IN410D :=**________________
IN411 Debounce (AC, 0–65000 ms)	**IN411D :=**________________
IN412 Debounce (AC, 0–65000 ms)	**IN412D :=**________________
IN413 Debounce (AC, 0–65000 ms)	**IN413D :=**________________
IN414 Debounce (AC, 0–65000 ms)	**IN414D :=**________________

Input Debounce Settings (Slot E) (Hidden if input option not included)

IN501 Debounce (AC, 0–65000 ms) **IN501D :=**________________
IN502 Debounce (AC, 0–65000 ms) **IN502D :=**________________
IN503 Debounce (AC, 0–65000 ms) **IN503D :=**________________
IN504 Debounce (AC, 0–65000 ms) **IN504D :=**________________
IN505 Debounce (AC, 0–65000 ms) **IN505D :=**________________
IN506 Debounce (AC, 0–65000 ms) **IN506D :=**________________
IN507 Debounce (AC, 0–65000 ms) **IN507D :=**________________
IN508 Debounce (AC, 0–65000 ms) **IN508D :=**________________
IN509 Debounce (AC, 0–65000 ms) **IN509D :=**________________
IN510 Debounce (AC, 0–65000 ms) **IN510D :=**________________
IN511 Debounce (AC, 0–65000 ms) **IN511D :=**________________
IN512 Debounce (AC, 0–65000 ms) **IN512D :=**________________
IN513 Debounce (AC, 0–65000 ms) **IN513D :=**________________
IN514 Debounce (AC, 0–65000 ms) **IN514D :=**________________

Breaker Monitor Settings (Hidden if not available)

BRK X MONITOR (Y, N) **EBMONX :=**________________

(All X Breaker Monitor settings are hidden if EBMONX := N)

X CL/OPN OP SET1 (0–65000) **COSP1X :=**________________
X CL/OPN OP SET2 (0–65000) **COSP2X :=**________________
X CL/OPN OP SET3 (0–65000) **COSP3X :=**________________
X kA PRI INTRPT1 (0.00–999.00) **KASP1X :=**________________
X kA PRI INTRPT2 (0.00–999.00) **KASP2X :=**________________
X kA PRI INTRPT3 (0.00–999.00) **KASP3X :=**________________
BRK X MON CTRL (SELOGIC) **BKMONX :=**________________

____

BRK Y MONITOR (Y, N) **EBMONY :=**________________

(All Y Breaker Monitor settings are hidden if EBMONY := N)

Y CL/OPN OP SET1 (0–65000) **COSP1Y :=**________________
Y CL/OPN OP SET2 (0–65000) **COSP2Y :=**________________
Y CL/OPN OP SET3 (0–65000) **COSP3Y :=**________________
Y kA PRI INTRPT1 (0.00–999.00) **KASP1Y :=**________________
Y kA PRI INTRPT2 (0.00–999.00) **KASP2Y :=**________________
Y kA PRI INTRPT3 (0.00–999.00) **KASP3Y :=**________________
BRK Y MON CTRL (SELOGIC) **BKMONY :=**________________

____

Data Reset

RESET TARGETS (SELOGIC) **RSTTRGT :=**________________

____

RESET ENERGY (SELOGIC) **RSTENRGY :=**________________

____

RESET MAX/MIN (SELOGIC)	RSTMXMN :=
RESET DEMAND (SELOGIC)	RSTDEM :=
RESET PK DEMAND (SELOGIC)	RSTPKDEM :=

Access Control

DISABLE SETTINGS (SELOGIC)	DSABLSET :=

Time-Synchronization Source

IRIG TIME SOURCE (IRIG1, IRIG2)	TIME_SRC :=

Two-Position Disconnect

EN 2P DISC (N, 1–8)	89EN2P :=
2P DISC 1 NAME (16 characters)	89NM2P1 :=
DISC 1 N/O CONT (SELOGIC)	89A2P1 :=
DISC 1 N/C CONT (SELOGIC)	89B2P1 :=
DISC 1 ALM PU (0.00–300.00 sec)	89A2P1D :=
DISC 1 SEALIN (0.00–300.00 sec)	89S2P1D :=
DISC 1 IMMOBI (0.00–300.00 sec)	89I2P1D :=
DISC 1 CL CONT (SELOGIC)	89RC2P1 :=
DISC 1 CL BLK (SELOGIC)	89CB2P1 :=
DISC 1 CL RST (SELOGIC)	89CR2P1 :=
DISC 1 CL IM RS (SELOGIC)	89CT2P1 :=
DISC 1 OP CONT (SELOGIC)	89RO2P1 :=
DISC 1 OP BLK (SELOGIC)	89OB2P1 :=
DISC 1 OP RST (SELOGIC)	89OR2P1 :=
DISC 1 OP IM RS (SELOGIC)	89OT2P1 :=
2P DISC 2 NAME (16 characters)	89NM2P2 :=
DISC 2 N/O CONT (SELOGIC)	89A2P2 :=
DISC 2 N/C CONT (SELOGIC)	89B2P2 :=
DISC 2 ALM PU (0.00–300.00 sec)	89A2P2D :=
DISC 2 SEALIN (0.00–300.00 sec)	89S2P2D :=
DISC 2 IMMOBI (0.00–300.00 sec)	89I2P2D :=
DISC 2 CL CONT (SELOGIC)	89RC2P2 :=
DISC 2 CL BLK (SELOGIC)	89CB2P2 :=
DISC 2 CL RST (SELOGIC)	89CR2P2 :=
DISC 2 CL IM RS (SELOGIC)	89CT2P2 :=
DISC 2 OP CONT (SELOGIC)	89RO2P2 :=

DISC 2 OP BLK (SELOGIC)	**89OB2P2 :=**________________
DISC 2 OP RST (SELOGIC)	**89OR2P2 :=**________________
DISC 2 OP IM RS (SELOGIC)	**89OT2P2 :=**________________
2P DISC 3 NAME (16 characters)	**89NM2P3 :=**________________
DISC 3 N/O CONT (SELOGIC)	**89A2P3 :=**________________
DISC 3 N/C CONT (SELOGIC)	**89B2P3 :=**________________
DISC 3 ALM PU (0.00–300.00 sec)	**89A2P3D :=**________________
DISC 3 SEALIN (0.00–300.00 sec)	**89S2P3D :=**________________
DISC 3 IMMOBI (0.00–300.00 sec)	**89I2P3D :=**________________
DISC 3 CL CONT (SELOGIC)	**89RC2P3 :=**________________
DISC 3 CL BLK (SELOGIC)	**89CB2P3 :=**________________
DISC 3 CL RST (SELOGIC)	**89CR2P3 :=**________________
DISC 3 CL IM RS (SELOGIC)	**89CT2P3 :=**________________
DISC 3 OP CONT (SELOGIC)	**89RO2P3 :=**________________
DISC 3 OP BLK (SELOGIC)	**89OB2P3 :=**________________
DISC 3 OP RST (SELOGIC)	**89OR2P3 :=**________________
DISC 3 OP IM RS (SELOGIC)	**89OT2P3 :=**________________
2P DISC 4 NAME (16 characters)	**89NM2P4 :=**________________
DISC 4 N/O CONT (SELOGIC)	**89A2P4 :=**________________
DISC 4 N/C CONT (SELOGIC)	**89B2P4 :=**________________
DISC 4 ALM PU (0.00–300.00 sec)	**89A2P4D :=**________________
DISC 4 SEALIN (0.00–300.00 sec)	**89S2P4D :=**________________
DISC 4 IMMOBI (0.00–300.00 sec)	**89I2P4D :=**________________
DISC 4 CL CONT (SELOGIC)	**89RC2P4 :=**________________
DISC 4 CL BLK (SELOGIC)	**89CB2P4 :=**________________
DISC 4 CL RST (SELOGIC)	**89CR2P4 :=**________________
DISC 4 CL IM RS (SELOGIC)	**89CT2P4 :=**________________
DISC 4 OP CONT (SELOGIC)	**89RO2P4 :=**________________
DISC 4 OP BLK (SELOGIC)	**89OB2P4 :=**________________
DISC 4 OP RST (SELOGIC)	**89OR2P4 :=**________________
DISC 4 OP IM RS (SELOGIC)	**89OT2P4 :=**________________
2P DISC 5 NAME (16 characters)	**89NM2P5 :=**________________
DISC 5 N/O CONT (SELOGIC)	**89A2P5 :=**________________
DISC 5 N/C CONT (SELOGIC)	**89B2P5 :=**________________
DISC 5 ALM PU (0.00–300.00 sec)	**89A2P5D :=**________________
DISC 5 SEALIN (0.00–300.00 sec)	**89S2P5D :=**________________
DISC 5 IMMOBI (0.00–300.00 sec)	**89I2P5D :=**________________
DISC 5 CL CONT (SELOGIC)	**89RC2P5 :=**________________
DISC 5 CL BLK (SELOGIC)	**89CB2P5 :=**________________
DISC 5 CL RST (SELOGIC)	**89CR2P5 :=**________________

DISC 5 CL IM RS (SELOGIC)	**89CT2P5 :=**________________
DISC 5 OP CONT (SELOGIC)	**89RO2P5 :=**________________
DISC 5 OP BLK (SELOGIC)	**89OB2P5 :=**________________
DISC 5 OP RST (SELOGIC)	**89OR2P5 :=**________________
DISC 5 OP IM RS (SELOGIC)	**89OT2P5 :=**________________
2P DISC 6 NAME (16 characters)	**89NM2P6 :=**________________
DISC 6 N/O CONT (SELOGIC)	**89A2P6 :=**________________
DISC 6 N/C CONT (SELOGIC)	**89B2P6 :=**________________
DISC 6 ALM PU (0.00–300.00 sec)	**89A2P6D :=**________________
DISC 6 SEALIN (0.00–300.00 sec)	**89S2P6D :=**________________
DISC 6 IMMOBI (0.00–300.00 sec)	**89I2P6D :=**________________
DISC 6 CL CONT (SELOGIC)	**89RC2P6 :=**________________
DISC 6 CL BLK (SELOGIC)	**89CB2P6 :=**________________
DISC 6 CL RST (SELOGIC)	**89CR2P6 :=**________________
DISC 6 CL IM RS (SELOGIC)	**89CT2P6 :=**________________
DISC 6 OP CONT (SELOGIC)	**89RO2P6 :=**________________
DISC 6 OP BLK (SELOGIC)	**89OB2P6 :=**________________
DISC 6 OP RST (SELOGIC)	**89OR2P6 :=**________________
DISC 6 OP IM RS (SELOGIC)	**89OT2P6 :=**________________
2P DISC 7 NAME (16 characters)	**89NM2P7 :=**________________
DISC 7 N/O CONT (SELOGIC)	**89A2P7 :=**________________
DISC 7 N/C CONT (SELOGIC)	**89B2P7 :=**________________
DISC 7 ALM PU (0.00–300.00 sec)	**89A2P7D :=**________________
DISC 7 SEALIN (0.00–300.00 sec)	**89S2P7D :=**________________
DISC 7 IMMOBI (0.00–300.00 sec)	**89I2P7D :=**________________
DISC 7 CL CONT (SELOGIC)	**89RC2P7 :=**________________
DISC 7 CL BLK (SELOGIC)	**89CB2P7 :=**________________
DISC 7 CL RST (SELOGIC)	**89CR2P7 :=**________________
DISC 7 CL IM RS (SELOGIC)	**89CT2P7 :=**________________
DISC 7 OP CONT (SELOGIC)	**89RO2P7 :=**________________
DISC 7 OP BLK (SELOGIC)	**89OB2P7 :=**________________
DISC 7 OP RST (SELOGIC)	**89OR2P7 :=**________________
DISC 7 OP IM RS (SELOGIC)	**89OT2P7 :=**________________
2P DISC 8 NAME (16 characters)	**89NM2P8 :=**________________
DISC 8 N/O CONT (SELOGIC)	**89A2P8 :=**________________
DISC 8 N/C CONT (SELOGIC)	**89B2P58 :=**________________
DISC 8 ALM PU (0.00–300.00 sec)	**89A2P8D :=**________________
DISC 8 SEALIN (0.00–300.00 sec)	**89S2P8D :=**________________
DISC 8 IMMOBI (0.00–300.00 sec)	**89I2P8D :=**________________
DISC 8 CL CONT (SELOGIC)	**89RC2P8 :=**________________

DISC 8 CL BLK (SELOGIC)	**89CB2P8 :=**________________
DISC 8 CL RST (SELOGIC)	**89CR2P8 :=**________________
DISC 8 CL IM RS (SELOGIC)	**89CT2P8 :=**________________
DISC 8 OP CONT (SELOGIC)	**89RO2P8 :=**________________
DISC 8 OP BLK (SELOGIC)	**89OB2P8 :=**________________
DISC 8 OP RST (SELOGIC)	**89OR2P8 :=**________________
DISC 8 OP IM RS (SELOGIC)	**89OT2P8 :=**________________

Three-Position Disconnect

EN 3P DISC (N, 1–2)	**89EN3P :=**________________
3P DISC 1 NAME (16 characters)	**89NM3P1 :=**________________
LDISC 1 N/O CONT (SELOGIC)	**89A3PL1 :=**________________
LDISC 1 N/C CONT (SELOGIC)	**89B3PL1 :=**________________
LDISC 1 ALM PU CONT (0.00–300.00 sec)	**89A3PL1D :=**________________
LDISC 1 SEALIN (0.00–300.00 sec)	**89S3PL1D :=**________________
LDISC 1 IMMOBI (0.00–300.00 sec)	**89I3PL1D :=**________________
LDISC 1 CL CONT (SELOGIC)	**89RC3PL1 :=**________________
LDISC 1 CL BLK (SELOGIC)	**89CB3PL1 :=**________________
LDISC 1 CL RST (SELOGIC)	**89CR3PL1 :=**________________
LDISC 1 CL IM RS (SELOGIC)	**89CT3PL1 :=**________________
LDISC 1 OP CONT (SELOGIC)	**89RO3PL1 :=**________________
LDISC 1 OP BLK (SELOGIC)	**89OB3PL1 :=**________________
LDISC 1 OP RST (SELOGIC)	**89OR3PL1 :=**________________
LDISC 1 OP IM RS (SELOGIC)	**89OT3PL1 :=**________________
EDISC 1 N/O CONT (SELOGIC)	**89A3PE1 :=**________________
EDISC 1 N/C CONT (SELOGIC)	**89B3PE1 :=**________________
EDISC 1 ALM PU CONT (0.00–300.00 sec)	**89A3PE1D :=**________________
EDISC 1 SEALIN (0.00–300.00 sec)	**89S3PE1D :=**________________
EDISC 1 IMMOBI (0.00–300.00 sec)	**89I3PE1D :=**________________
EDISC 1 CL CONT (SELOGIC)	**89RC3PE1 :=**________________
EDISC 1 CL BLK (SELOGIC)	**89CB3PE1 :=**________________
EDISC 1 CL RST (SELOGIC)	**89CR3PE1 :=**________________
EDISC 1 CL IM RS (SELOGIC)	**89CT3PE1 :=**________________
EDISC 1 OP CONT (SELOGIC)	**89RO3PE1 :=**________________
EDISC 1 OP BLK (SELOGIC)	**89OB3PE1 :=**________________
EDISC 1 OP RST (SELOGIC)	**89OR3PE1 :=**________________
EDISC 1 OP IM RS (SELOGIC)	**89OT3PE1 :=**________________
3P DISC 2 NAME (16 characters)	**89NM3P2 :=**________________
LDISC 2 N/O CONT (SELOGIC)	**89A3PL2 :=**________________
LDISC 2 N/C CONT (SELOGIC)	**89B3PL2 :=**________________
LDISC 2 ALM PU CONT (0.00–300.00 sec)	**89A3PL2D :=**________________

LDISC 2 SEALIN (0.00–300.00 sec)	**89S3PL2D :=**________________
LDISC 2 IMMOBI (0.00–300.00 sec)	**89I3PL2D :=**________________
LDISC 2 CL CONT (SELOGIC)	**89RC3PL2 :=**________________
LDISC 2 CL BLK (SELOGIC)	**89CB3PL2 :=**________________
LDISC 2 CL RST (SELOGIC)	**89CR3PL2 :=**________________
LDISC 2 CL IM RS (SELOGIC)	**89CT3PL2 :=**________________
LDISC 2 OP CONT (SELOGIC)	**89RO3PL2 :=**________________
LDISC 2 OP BLK (SELOGIC)	**89OB3PL2 :=**________________
LDISC 2 OP RST (SELOGIC)	**89OR3PL2 :=**________________
LDISC 2 OP IM RS (SELOGIC)	**89OT3PL2 :=**________________
EDISC 2 N/O CONT (SELOGIC)	**89A3PE2 :=**________________
EDISC 2 N/C CONT (SELOGIC)	**89B3PE2 :=**________________
EDISC 2 ALM PU CONT (0.00–300.00 sec)	**89A3PE2D :=**________________
EDISC 2 SEALIN (0.00–300.00 sec)	**89S3PE2D :=**________________
EDISC 2 IMMOBI (0.00–300.00 sec)	**89I3PE2D :=**________________
EDISC 2 CL CONT (SELOGIC)	**89RC3PE2 :=**________________
EDISC 2 CL BLK (SELOGIC)	**89CB3PE2 :=**________________
EDISC 2 CL RST (SELOGIC)	**89CR3PE2 :=**________________
EDISC 2 CL IM RS (SELOGIC)	**89CT3PE2 :=**________________
EDISC 2 OP CONT (SELOGIC)	**89RO3PE2 :=**________________
EDISC 2 OP BLK (SELOGIC)	**89OB3PE2 :=**________________
EDISC 2 OP RST (SELOGIC)	**89OR3PE2 :=**________________
EDISC 2 OP IM RS (SELOGIC)	**89OT3PE2 :=**________________

Control Configuration

ENABLE LOC REM CON (Y, N)	**EN_LRC :=**________________
LOCAL CONTROL (SELOGIC)	**LOCAL :=**________________

61850 Mode Control (Hidden when IEC 61850 is not supported)

CONTROL FOR IEC 61850 BLOCKED MODE (SELOGIC)	**SC850BM :=**________________
CONTROL FOR IEC 61850 TEST MODE (SELOGIC)	**SC850TM :=**________________

61850 Simulation Mode (Hidden when IEC 61850 is not supported)

SELOGIC CONTROL FOR IEC 61850 SIMULATION MODE (SELOGIC)	**SC850SM :=**________________

61850 Local Remote (Hidden when IEC 61850 is not supported)

SELOGIC CONTROL FOR CONTROL AUTHORITY AT STATION LEVEL (SELOGIC)	**SC850LS :=**________________
SELOGIC CONTROL FOR CONTROL AUTHORITY AT LOCAL/BAY LEVEL (SELOGIC)	**LOC :=**________________
SELOGIC CONTROL FOR MULTILEVEL MODE OF CONTROL AUTHORITY (SELOGIC)	**MLTLEV :=**________________

SET PORT p (p = F, 1, 2, 3, or 4) Command

Port F

ENABLE PORT (Y, N) **EPORT** := ____________

PROTOCOL (SEL, MOD, EVMSG, PMU) **PROTO** := ____________

MAXIMUM ACCESS LEVEL (1, 2, C) **MAXACC** := ____________

Communications

SPEED (300, 1200, 2400, 4800, 9600, 19200, 38400 bps) **SPEED** := ____________

DATA BITS (7, 8 bits) **BITS** := ____________
(Hidden if PROTO := MOD, EVMSG, or PMU)

PARITY (O, E, N) **PARITY** := ____________
(Hidden if PROTO := EVMSG or PMU)

STOP BITS (1, 2 bits) **STOP** := ____________
(Hidden if PROTO := MOD or EVMSG)

PORT TIME-OUT (0–30 min) **T_OUT** := ____________
(Hidden and forced to 0 if PROTO := MOD, EVMSG, or PMU)

HDWR HANDSHAKING (Y, N) **RTSCTS** := ____________
(Hidden if PROTO := MOD or EVMSG)

SEL Protocol

LANGUAGE (ENGLISH, SPANISH) **LANG** := ____________

SEND AUTOMESSAGE (Y, N) **AUTO** := ____________
(Hidden and forced to N if PROTO := MOD, EVMSG, or PMU)

Modbus Protocol

MODBUS SLAVE ID (1–247) **SLAVEID** := ____________
(Hidden if PROTO := SEL, EVMSG, or PMU)

Port 1

(Ethernet Port in Slot B; all Ethernet settings are hidden if an Ethernet option is not available; IP addresses are entered using zzz = 1–126, 128–223; yyy = 0–255; xxx = 0–255; www = 0–255)

ENABLE PORT (Y, N) **EPORT** := ____________

ENABLE ETHERNET FIRMWARE UPGRADE (Y, N) **EETHFWU** := ____________

IP ADDRESS (zzz.yyy.xxx.www) (15 characters) **IPADDR** := ____________

SUBNET MASK (zzz.yyy.xxx.www) (15 characters) **SUBNETM** := ____________

DEFAULT ROUTER (zzz.yyy.xxx.www) (15 characters) **DEFRTR** := ____________
(NOTE: Settings DEFRTR := 0.0.0.0 disables the default router)

Enable TCP Keep-Alive (Y, N) **ETCPKA** := ____________

TCP Keep-Alive Idle Range (1–20 sec) **KAIDLE** := ____________
(Hidden if ETCPKA := N; KAIDLE ≥ KAINTV)

TCP Keep-Alive Interval Range (1–20 sec) **KAINTV** := ____________
(Hidden if ETCPKA := N; KAIDLE ≥ KAINTV)

TCP Keep-Alive Count Range (1–20) **KACNT** := ____________
(Hidden if ETCPKA := N)

OPERATING MODE (FIXED, FAILOVER, SWITCHED, PRP) **NETMODE** := ____________
(Hidden when the dual redundant Ethernet port option is not included)

FAILOVER TIMEOUT (OFF, 0.10–65.00 sec) **FTIME** := ____________
(Hidden when the dual redundant Ethernet port option is not included or if NETMODE ≠ FAILOVER)

PRIMARY NETPORT (A, B) **NETPORT** := ____________
(Hidden when the dual redundant Ethernet port option is not included)

PRP ENTRY TIMEOUT (400–10000 ms) *(Hidden when the dual redundant Ethernet port option is not included or if NETMODE ≠ PRP)*	**PRPTOUT** := ______
PRP DESTINATION ADDR LSB (0–255) *(Hidden when the dual redundant Ethernet port option is not included or if NETMODE ≠ PRP)*	**PRPADDR** := ______
PRP SUPERVISION TX INTERVAL (1–10 sec) *(Hidden when the dual redundant Ethernet port option is not included or if NETMODE ≠ PRP)*	**PRPINTV** := ______
NETWRK PORTA SPD (AUTO, 10, 100 Mbps) *(Hidden when the dual redundant Ethernet port option is not included)*	**NETASPD** := ______
NETWRK PORTB SPD (AUTO, 10, 100 Mbps) *(Hidden when the dual redundant Ethernet port option is not included)*	**NETBSPD** := ______
ENABLE TELNET (Y, N)	**ETELNET** := ______
MAXIMUM ACCESS LEVEL (1, 2, C)	**MAXACC** := ______
LANGUAGE (ENGLISH, SPANISH)	**LANG** := ______
TELNET PORT (23, 1025–65534) *(NOTE: See Table SET.3 and the note at the end of Port 1 settings)*	**TPORT** := ______
TELNET CONNECT BANNER (254 characters)	**TCBAN** := ______
TELNET TIME-OUT (1–30 min)	**TIDLE** := ______
FAST OP MESSAGES (Y, N) *Note: The FAST OP MESSAGES setting only functions when using SEL Fast Operate protocol to operate/set/pulse breaker bits and remote bits. This setting has no effect on other protocols.*	**FASTOP** := ______
ENABLE FTP (Y, N)	**EFTPSERV** := ______
FTP MAXIMUM ACCESS LEVEL (1, 2 C)	**FTPACC** := ______
FTP USER NAME (20 Characters)	**FTPUSER** := ______
FTP CONNECT BANNER (254 characters)	**FTPCBAN** := ______
FTP IDLE TIME-OUT (5–255 min)	**FTPIDLE** := ______
Enable IEC 61850 Protocol (Y, N) *(Hidden when IEC 61850 is not supported)*	**E61850** := ______
Enable IEC 61850 GSE (Y, N) *(Hidden and forced to N if E61850 := N)*	**EGSE** := ______
ENABLE MMS FILE SERVICES (Y, N)	**EMMSFS** := ______
ENABLE 61850 MODE/BEHAVIOR CONTROL (Y, N)	**E850MBC** := ______
ENABLE GOOSE Tx IN OFF MODE (Y, N)	**EOFFMTX** := ______
Enable Modbus Sessions (0–2)	**EMOD** := ______
MODBUS MASTER IP ADDRESS (zzz.yyy.xxx.www) *(Hidden if EMOD := 0)*	**MODIP1** := ______
MODBUS MASTER IP ADDRESS (zzz.yyy.xxx.www) *(Hidden if EMOD := 0 or 1)*	**MODIP2** := ______

NOTE: MODIP1 and MODIP2 cannot share an address and must be unique (except when 0.0.0.0, which effectively disables security and allows any master to communicate).

Modbus TCP Port1 (1–65534)* *(Hidden if EMOD := 0)* *(NOTE: See Table SET.3 and the note at the end of Port 1 settings)*	**MODNUM1** := ______
Modbus TCP Port2 (1–65534)* *(Hidden if EMOD := 0 or 1)* *(NOTE: See Table SET.3 and the note at the end of Port 1 settings)*	**MODNUM2** := ______
Modbus Timeout 1 (15–900 sec) *(Hidden if EMOD := 0)*	**MTIMEO1** := ______

Modbus Timeout 2 (15–900 sec) **MTIMEO2** := ____________
(Hidden if EMOD := 0 or 1)

ENABLE HTTP SERVER (Y, N) **EHTTP** := ____________

HTTP MAXIMUM ACCESS LEVEL (1, 2, C) **HTTPACC** := ____________
(Hidden when EHTTP := N)

HTTP SERVER TCP/IP PORT NUMBER (1–65534) **HTTPPORT** := ____________
(Hidden when EHTTP := N)
(NOTE: See Table SET.3 and the note at the end of Port 1 settings)

HTTP CONNECT BANNER (254 ASCII printable characters **HTTPBAN** := ____________
(Hidden when EHTTP := N)

HTTP WEB SERVER TIMEOUT (1–60 min) **HTTPIDLE** := ____________
(Hidden when EHTTP := N)

ENABLE RSTP (Y, N) **ERSTP** := ____________
(Hidden when the dual redundant Ethernet port option is not included or if NETMODE ≠ SWITCHED)

BRIDGE PRIORITY (0–61440) **BRDGPRI** := ____________
(Hidden if ERSTP := N; the input must be set in increments of 4096)

PORTA PRIORITY (0–240) **PORTAPRI** := ____________
(Hidden if ERSTP := N; the input must be set in increments of 16)

PORTB PRIORITY (0–240) **PORTBPRI** := ____________
(Hidden if ERSTP := N; the input must be set in increments of 16)

SEL Synchrophasor Protocol Settings

(The following synchrophasor protocol settings are hidden if the Global setting EPMU := N)

Enable PMU Processing (0–2) **EPMIP** := ____________

PMU Output 1 Transport Scheme (OFF, TCP, UDP_S, UDP_T, UDP_U) **PMOTS1** := ____________
(Hidden if EPMIP := 0)

PMU Output 1 Client IP Address [zzz.yyy.xxx.www] (15 characters) **PMOIPA1** := ____________
(Hidden if PMOTS1 := OFF) (PMOIPA1 cannot be set to the same address as IPADDR. IP address from 224.0.0.1 through 239.255.255.255 are also valid when PMOTS1 = UDP_S. IP address 255.255.255.255 is also valid when PMOTS1 = UDP_S or TCP.)

PMU Output 1 TCP/IP Port Number (1–65534) **PMOTCP1** := ____________
(Shown only when EPMIP is not equal to 0 and PMOTS1 is not equal to UDP_S; PMOTCP1 cannot be set to the same number as PMOTCP2)
(See Table SET.3 and the note at the end of Port 1 settings.)

PMU Output 1 UDP/IP Data Port Number (1–65534) **PMOUDP1** := ____________
(Shown only when EPMIP is not equal to 0 and PMOTS1 is not equal to TCP)

PMU Output 2 Transport Scheme (OFF, TCP, UDP_S, UDP_T, UDP_U) **PMOTS2** := ____________
(Hidden if EPMIP := 0 or 1)

PMU Output 2 Client IP Address (zzz.yyy.xxx.www) (15 characters) **PMOIPA2** := ____________
(Hidden if PMOTS2 := OFF) (PMOIPA2 cannot be set to the same address as IPADDR. IP addresses from 224.0.0.1 through 239.255.255.255 are also valid when PMOTS2 = UDP_S. IP address 255.255.255.255 is also valid when PMOTS2 = UDP_S or TCP.)

PMU Output 2 TCP/IP Port Number (1–65534) **PMOTCP2** := ____________
(Shown only when EPMIP := 2 and PMOTS2 is not equal to UDP_S; PMOTCP2 cannot be set to the same number as PMOTCP1)
(See Table SET.3 and the note at the end of Port 1 settings.)

PMU Output 2 UDP/IP Data Port Number (1–65534) **PMOUDP2** := ____________
(Shown only when EPMIP = 2 and PMOTS2 is not equal to TCP)

DNP3 Protocol

(The following DNP3 settings are hidden if DNP3 is not an option)

Enable DNP3 Sessions (0–5)	**EDNP** := ________
(The following DNP3 settings are hidden if EDNP := 0)	
DNP TCP and UDP Port (1–65534)	**DNPNUM** := ________
(NOTE: See Table SET.3 and the note at the end of Port 1 settings)	
DNP Address (0–65519)	**DNPADR** := ________

Session 1

(NOTE: The DNP IP address of each session (DNPIP1, DNPIP2, etc.) must be unique.)

DNP Master IP Address {zzz.yyy.xxx.www} (15 Characters)	**DNPIP1** := ________
Transport Protocol (UDP, TCP)	**DNPTR1** := ________
UDP Response Port (REQ, 1–65534)	**DNPUDP1** := ________
DNP Address to Report to (0–65519)	**REPADR1** := ________
DNP Map (1–3)	**DNPMAP1** := ________
Analog Input Default Variation (1–6) *(Only applies to objects 30 and 32)*	**DVARAI1** := ________
Class for Binary Event Data (0–3)	**ECLASSB1** := ________
Class for Counter Event Data (0–3)	**ECLASSC1** := ________
Class for Analog Event Data (0–3)	**ECLASSA1** := ________
Currents Scaling Decimal Places (0–3)	**DECPLA1** := ________
Voltages Scaling Decimal Places (0–3)	**DECPLV1** := ________
Misc Data Scaling Decimal Places (0–3)	**DECPLM1** := ________
Amps Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBA1** := ________
Volts Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBV1** := ________
Misc Data Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0 and ECLASSC1 := 0)*	**ANADBM1** := ________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ1** := ________
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO1** := ________
Seconds to send Data Link Heartbeat (0–7200) *(Hidden if DNPTR1 := UDP)*	**DNPINA1** := ________
Event Message Confirm Time-Out (1–50 sec)	**ETIMEO1** := ________
Enable Unsolicited Reporting (Y, N) *(Hidden and forced to N if ECLASSA1 := 0, ECLASSB1 := 0, and ECLASSC1 := 0)* *(All subsequent settings are hidden and forced to N if UNSOL1 := N)*	**UNSOL1** := ________
Enable Unsolicited Reporting at Power-Up (Y, N)	**PUNSOL1** := ________
Number of Events to Transmit On (1–200)	**NUMEVE1** := ________
Oldest Event to Tx On (0.0–99999.0 sec)	**AGEEVE1** := ________
Unsolicited Message Max Retry Attempts (2–10)	**URETRY1** := ________
Unsolicited Message Offline Time-Out (1–5000 sec)	**UTIMEO1** := ________

Session 2

(All Session 2 settings are hidden if EDNP < 2)

DNP Master IP Address {zzz.yyy.xxx.www} (15 Characters)	**DNPIP2** := ________
Transport Protocol (UDP, TCP)	**DNPTR2** := ________
UDP Response Port (REQ, 1–65534)	**DNPUDP2** := ________

DNP Address to Report to (0–65519)	**REPADR2** := ____________
DNP Map (1–3)	**DNPMAP2** := ____________
Analog Input Default Variation (1–6)	**DVARAI2** := ____________
Class for Binary Event Data (0–3)	**ECLASSB2** := ____________
Class for Counter Event Data (0–3)	**ECLASSC2** := ____________
Class for Analog Even Data (0–3)	**ECLASSA2** := ____________
Currents Scaling Decimal Places (0–3)	**DECPLA2** := ____________
Voltages Scaling Decimal Places (0–3)	**DECPLV2** := ____________
Misc Data Scaling Decimal Places (0–3)	**DECPLM2** := ____________
Amps Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA2 := 0)*	**ANADBA2** := ____________
Volts Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA2 := 0)*	**ANADBV2** := ____________
Misc Data Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA2 := 0 and ECLASSC2 := 0)*	**ANADBM2** := ____________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ2** := ____________
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO2** := ____________
Seconds to send Data Link Heartbeat (0–7200) *(Hidden if DNPTR2 := UDP)*	**DNPINA2** := ____________
Event Message Confirm Time-Out (1–50 sec)	**ETIMEO2** := ____________
Enable Unsolicited Reporting (Y, N) *(Hidden and forced to N if ECLASSA2 := 0, ECLASSB2 := 0, ECLASSC2 := 0, and ECLASSV2 := 0)* *(All subsequent settings are hidden and forced to N if UNSOL2 := N)*	**UNSOL2** := ____________
Enable Unsolicited Reporting at Power-Up (Y, N)	**PUNSOL2** := ____________
Number of Event to Transmit On (1–200)	**NUMEVE2** := ____________
Oldest Even to Tx On (0.0–99999.0 sec)	**AGEEVE2** := ____________
Unsolicited Message Max Retry Attempts (2–10)	**URETRY2** := ____________
Unsolicited Message Offline Time-Out (1–5000 sec)	**UTIMEO2** := ____________

Session 3

(All Session 3 settings are hidden if EDNP < 3)

DNP Master IP Address {zzz.yyy.xxx.www} (15 Characters)	**DNPIP3** := ____________
Transport Protocol (UDP, TCP)	**DNPTR3** := ____________
UDP Response Port (REQ, 1–65534)	**DNPUDP3** := ____________
DNP Address to Report to (0–65519)	**REPADR3** := ____________
DNP Map (1–3)	**DNPMAP3** := ____________
Analog Input Default Variation (1–6)	**DVARAI3** := ____________
Class for Binary Event Data (0–3)	**ECLASSB3** := ____________
Class for Counter Event Data (0–3)	**ECLASSC3** := ____________
Class for Analog Even Data (0–3)	**ECLASSA3** := ____________
Currents Scaling Decimal Places (0–3)	**DECPLA3** := ____________
Voltages Scaling Decimal Places (0–3)	**DECPLV3** := ____________
Misc Data Scaling Decimal Places (0–3)	**DECPLM3** := ____________
Amps Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA3 := 0)*	**ANADBA3** := ____________

Volts Reporting Deadband Counts (0–32767) **ANADBV3** := ________
(Hidden if ECLASSA3 := 0)

Misc Data Reporting Deadband Counts (0–32767) **ANADBM3** := ________
(Hidden if ECLASSA3 := 0 and ECLASSC3 := 0)

Minutes for Request Interval (I, M, 1–32767) **TIMERQ3** := ________

Seconds to Select/Operate Time-Out (0.0–30.0) **STIMEO3** := ________

Seconds to Send Data Link Heartbeat (0–7200) **DNPINA3** := ________
(Hidden if DNPTR3 := UDP)

Event Message Confirm Time-Out (1–50 sec) **ETIMEO3** := ________

Enable Unsolicited Reporting (Y, N) **UNSOL3** := ________
(Hidden and forced to N if ECLASSA3 := 0, ECLASSB3 := 0, ECLASSC3 := 0, and ECLASSV3 := 0)
(All subsequent settings are hidden and forced to N if UNSOL3 := N)

Enable Unsolicited Reporting at Power-Up (Y, N) **PUNSOL3** := ________

Number of Event to Transmit On (1–200) **NUMEVE3** := ________

Oldest Event to Tx On (0.0–99999.0 sec) **AGEEVE3** := ________

Unsolicited Message Max Retry Attempts (2–10) **URETRY3** := ________

Unsolicited Message Offline Time-Out (1–5000 sec) **UTIMEO3** := ________

Session 4

(All Session 4 settings are hidden if EDNP < 4)

DNP Master IP Address {zzz.yyy.xxx.www} (15 Characters) **DNPIP4** := ________

Transport Protocol (UDP, TCP) **DNPTR4** := ________

UDP Response Port (REQ, 1–65534) **DNPUDP4** := ________

DNP Address to Report to (0–65519) **REPADR4** := ________

DNP Map (1–3) **DNPMAP4** := ________

Analog Input Default Variation (1–6) **DVARAI4** := ________

Class for Binary Event Data (0–3) **ECLASSB4** := ________

Class for Counter Event Data (0–3) **ECLASSC4** := ________

Class for Analog Even Data (0–3) **ECLASSA4** := ________

Currents Scaling Decimal Places (0–3) **DECPLA4** := ________

Voltages Scaling Decimal Places (0–3) **DECPLV4** := ________

Misc Data Scaling Decimal Places (0–3) **DECPLM4** := ________

Amps Reporting Deadband Counts (0–32767) **ANADBA4** := ________
(Hidden if ECLASSA4 := 0)

Volts Reporting Deadband Counts (0–32767) **ANADBV4** := ________
(Hidden if ECLASSA4 := 0)

Misc Data Reporting Deadband Counts (0–32767) **ANADBM4** := ________
(Hidden if ECLASSA4 := 0 and ECLASSC4 := 0)

Minutes for Request Interval (I, M, 1–32767) **TIMERQ4** := ________

Seconds to Select/Operate Time-Out (0.0–30.0) **STIMEO4** := ________

Seconds to Send Data Link Heartbeat (0–7200) **DNPINA4** := ________
(Hidden if DNPTR4 := UDP)

Event Message Confirm Time-Out (1–50 sec) **ETIMEO4** := ________

Enable Unsolicited Reporting (Y, N) **UNSOL4** := ________
(Hidden and forced to N if ECLASSA4 := 0, ECLASSB4 := 0, ECLASSC4 := 0, and ECLASSV4 := 0)
(All subsequent settings are hidden and forced to N if UNSOL4 := N)

Enable Unsolicited Reporting at Power-Up (Y, N) **PUNSOL4** := ________

Number of Event to Transmit On (1–200)	**NUMEVE4** := ______
Oldest Event to Tx On (0.0–99999.0 sec)	**AGEEVE4** := ______
Unsolicited Message Max Retry Attempts (2–10)	**URETRY4** := ______
Unsolicited Message Offline Time-Out (1–5000 sec)	**UTIMEO4** := ______

Session 5

(All Session 5 settings are hidden if EDNP < 5)

DNP Master IP Address {zzz.yyy.xxx.www} (15 Characters)	**DNPIP5** := ______
Transport Protocol (UDP, TCP)	**DNPTR5** := ______
UDP Response Port (REQ, 1–65534)	**DNPUDP5** := ______
DNP Address to Report to (0–65519)	**REPADR5** := ______
DNP Map (1–3)	**DNPMAP5** := ______
Analog Input Default Variation (1–6)	**DVARAI5** := ______
Class for Binary Event Data (0–3)	**ECLASSB5** := ______
Class for Counter Event Data (0–3)	**ECLASSC5** := ______
Class for Analog Even Data (0–3)	**ECLASSA5** := ______
Currents Scaling Decimal Places (0–3)	**DECPLA5** := ______
Voltages Scaling Decimal Places (0–3)	**DECPLV5** := ______
Misc Data Scaling Decimal Places (0–3)	**DECPLM5** := ______
Amps Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA5 := 0)*	**ANADBA5** := ______
Volts Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA5 := 0)*	**ANADBV5** := ______
Misc Data Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA5 := 0 and ECLASSC5 := 0)*	**ANADBM5** := ______
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ5** := ______
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO5** := ______
Seconds to Send Data Link Heartbeat (0–7200) *(Hidden if DNPTR5 := UDP)*	**DNPINA5** := ______
Event Message Confirm Time-Out (1–50 sec)	**ETIMEO5** := ______
Enable Unsolicited Reporting (Y, N) *(Hidden and forced to N if ECLASSA5 := 0, ECLASSB5 := 0, ECLASSC5 := 0, and ECLASSV5 := 0)* *(All subsequent settings are hidden and forced to N if UNSOL5 := N)*	**UNSOL5** := ______
Enable Unsolicited Reporting at Power-Up (Y, N)	**PUNSOL5** := ______
Number of Event to Transmit On (1–200)	**NUMEVE5** := ______
Oldest Event to Tx On (0.0–99999.0 sec)	**AGEEVE5** := ______
Unsolicited Message Max Retry Attempts (2–10)	**URETRY5** := ______
Unsolicited Message Offline Time-Out (1–5000 sec)	**UTIMEO5** := ______

SNTP Client Protocol Settings

Enable SNTP Client (OFF, UNICAST, MANYCAST, BROADCAST) *(All subsequent category settings are hidden if ESNTP := OFF)*	**ESNTP** := ______

Make the following settings when ESNTP ≠ MANYCAST

Primary Server IP Address (zzz.yyy.xxx.www) *(NOTE: To accept updates from any server when ESNTP := BROADCAST, set SNTPPSIP to 0.0.0.0. NOTE: Only IP addresses in the range 224.0.0.1 through 239.255.255.255 are valid when ESNTP = MANYCAST.)*	**SNTPPSIP** := ______
Make the following setting when ESNTP := UNICAST	
Backup Server IP Address (zzz.yyy.xxx.www) *(Hidden if ESNTP ≠ UNICAST)*	**SNTPBSIP** := ______
SNTP IP (Local) Port Number (1–65534) *(NOTE: See Table SET.3 and the note at the end of Port 1 settings.)*	**SNTPPORT** := ______
SNTP Update Rate (15–3600 sec)	**SNTPRATE** := ______
Make the following setting when ESNTP := UNICAST or MANYCAST	
SNTP Timeout (5–20 sec) *(Hidden and forced to 5 if ESNTP := BROADCAST NOTE: SNTPTO must be less than setting SNTPRATE.)*	**SNTPTO** := ______

PTP Settings

Enable PTP (Y, N) *(All subsequent category settings are hidden if EPTP := N) (Hidden and forced to N if NETMODE := SWITCHED)*	**EPTP** := ______
PTP Profile (DEFAULT, C37.238) *(Hidden and forced to C37.238 if NETMODE := PRP)*	**PTPPRO** := ______
PTP Transport Mechanism (UDP, LAYER2) *(Hidden and forced to LAYER2 if PTPPRO := C37.238 or if NETMODE := PRP)*	**PTPTR** := ______
PTP Domain Number (0–255)	**DOMNUM** := ______
PTP Path Delay Mechanism (P2P, E2E, OFF) *(Hidden and forced to P2P if PTPPRO := C37.238 or if NETMODE := PRP)*	**PTHDLY** := ______
Peer Delay Request Interval (1, 2, 4, 8, 16, 32, 64 seconds) *(Hidden if PTHDLY ≠ P2P, PTPPRO ≠ C37.238, and NETMODE ≠ PRP)*	**PDINT** := ______
PTP Number of Acceptable Masters, (OFF, 1–5)	**AMNUM** := ______
PTP Acceptable Master *n* IP (zzz.yyy.xxx.www) *(Hidden if n > AMNUM or if AMNUM := OFF or if PTPTR := LAYER2 or if NETMODE := PRP or if PTPPRO := C37.238)*	**AMIP*n*** := ______
PTP Acceptable Master *n* MAC (xx:xx:xx:xx:xx:xx) *(Hidden if AMNUM := OFF or if NETMODE ≠ PRP and if PTPTR ≠ LAYER2 and if PTPPRO ≠ C37.238)*	**AMMAC*n*** := ______
PTP Alternative Priority1 for Master *n* (0–255) *(Hidden if n > AMNUM or if AMNUM := OFF)*	**ALTPRI*n*** := ______
PTP VLAN Identifier (1–4094) *(Hidden if NETMODE ≠ PRP and PTPPRO ≠ C37.238)*	**PVLAN** := ______
PTP VLAN Priority (0–7) *(Hidden if NETMODE ≠ PRP and PTPPRO ≠ C37.238)*	**PVLANPR** := ______

EtherNet/IP Settings

ENABLE ETHERNET IP (Y, N)	**EEIP** := ______
Configuration ID (0–255)	**CONFIGID** := ______
Major EDS Revision (1–255)	**MAJOREDS** := ______
Minor EDS Revision (1–255)	**MINOREDS** := ______
Number of IP Addresses for EIP Scanner (OFF, 1–8) *(OFF allows anonymous clients)*	**NUMIP** := ______

IP Address (zzz.yyy.xxx.www) **EIPIP*n*** :=________________
(Hidden if NUMIP := OFF, or if n > NUMIP
NOTE: EIPIPn settings shall not be equal to the value of the IPADDR setting. EIPIP1 through EIPIP8 must be unique)

Number of IO Connections (1–6) **NUMCONN** :=________________

Application Type (EXCLUSIVE_OWNER, INPUT_ONLY) **APPTYP*n*** :=________________
(NOTE: At most, three EXCLUSIVE_OWNER types are allowed)

Input Assembly (IA1, IA2, IA3, OA1, OA2, OA3) **INASSM*n*** :=________________

Output Assembly (OA1, OA2, OA3) **OUTASSM*n*** :=________________
(Hidden if APPTYPn := INPUT_ONLY)

Port Number Settings Must be Unique

When making the SEL-700G Port 1 settings, port number settings cannot be used for more than one protocol. The relay checks all of the settings shown in *Table SET.3* before saving changes. If a port number is used more than once, or if it matches any of the fixed port numbers (20, 21, 23, 102, 502), the relay displays an error message and returns to the first setting that is in error or contains a duplicate value.

Table SET.3 Port Number Settings That Must be Unique

Setting	Name	Setting Required When
TPORT	Telnet Port	Always
MODNUM1[a]	Modbus TCP Port 1	EMOD > 0
MODNUM2[a]	Modbus TCP Port 2	EMOD > 1
PMOTCP1	PMU Output 1 TCP/IP (Local) Port Number	PMOTS1 = TCP, UDP_T, or UDP_U
PMOTCP2	PMU Output 2 TCP/IP (Local) Port Number	PMOTS2 = TCP, UDP_T, or UDP_U
DNPNUM	DNPTCP and UDP Port	EDNP > 0
SNTPPORT	SNTPIP (Local) Port Number	ESNTP ≠ OFF
EPTP	Enable PTP	PTPPRO = DEFAULT and PTPTR = UDP (Ports 319 and 320 are reserved)
EEIP	Enable EtherNet/IP	EEIP ≠ N (Ports 2222/44818 are reserved)

[a] MODNUM1 and MODNUM2 can have the same port number. The relay displays an error message if this number matches with the port numbers of the other protocols.

Port 2

(Fiber-optic serial port in Slot B; the following settings are autoset and hidden if E49RTD := EXT)

ENABLE PORT (Y, N) **EPORT** :=________________

PROTOCOL (SEL, DNP, MOD, EVMSG, PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB, 103) **PROTO** :=________________

MAXIMUM ACCESS LEVEL (1, 2, C) **MAXACC** :=________________

Communications

SPEED (300, 1200, 2400, 4800, 9600, 19200, 38400 bps) **SPEED** :=________________

DATA BITS (7, 8 bits) **BITS** :=________________
(Hidden if PROTO := MOD, DNP, PMU, EVMSG, 103, or MB_)

PARITY (O, E, N) **PARITY** :=________________
(Hidden if PROTO := EVMSG, PMU, or MB_)

STOP BITS (1, 2 bits) **STOP** :=________________
(Hidden if PROTO := MOD, EVMSG, or MB_)

PORT TIME-OUT (0–30 min) **T_OUT** :=________________
(Hidden and forced to 0 if PROTO := MOD, EVMSG, PMU, 103, or MB_)

HDWR HANDSHAKING (Y, N) **RTSCTS** :=________________
(Hidden and forced to N if PROTO := MOD, EVMSG, DNP, SEL, or MB_)

LANGUAGE (ENGLISH, SPANISH)	**LANG** := ________
SEND AUTOMESSAGE (Y, N) *(Hidden and forced to N if PROTO := MOD, DNP, PMU, EVMSG, 103, or MB_)*	**AUTO** := ________
FAST OP MESSAGES (Y, N) *(Hidden if PROTO := MOD, EVMSG, DNP, PMU, 103, or MB_)*	**FASTOP** := ________

Modbus

MODBUS SLAVE ID (1–247) *(Hidden if PROTO := SEL, EVMSG, MB_, 103, or DNP)*	**SLAVEID** := ________

DNP3 Protocol

(Hidden if PROTO := SEL, EVMSG, MB, PMU, 103, or MOD)

DNP Address (0–65519)	**DNPADR** := ________
DNP Address to Report to (0–65519)	**REPADR1** := ________
DNP Map (1–3)	**DNPMAP1** := ________
Analog Input Default Variation (1–6)	**DVARAI1** := ________
Class for Binary Event Data (0–3)	**ECLASSB1** := ________
Class for Counter Event Data (0–3)	**ECLASSC1** := ________
Class for Analog Event Data (0–3)	**ECLASSA1** := ________
Current Scaling Decimal Places (0–3)	**DECPLA1** := ________
Voltages Scaling Decimal Places (0–3)	**DECPLV1** := ________
Misc Data Scaling Decimal Places (0–3)	**DECPLM1** := ________
Amps Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBA1** := ________
Volts Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBV1** := ________
Misc Data Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0 and ECLASSC1 := 0*	**ANADBM1** := ________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ1** := ________
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO1** := ________
Data Link Retries (0–51)	**DRETRY1** := ________
Seconds to Data Link Time-Out (0–5 sec) *(Hidden if DRETRY1 := 0)*	**DTIMEO1** := ________
Event Message Confirm Time-Out (1–50 sec)	**ETIMEO1** := ________
Enable Unsolicited Reporting (Y, N) *(Hidden and forced to N if ECLASSA1 := 0, ECLASSB1 := 0, and ECLASSC1 := 0)* *(All subsequent settings are hidden and forced to N if UNSOL1 := N)*	**UNSOL1** := ________
Enable Unsolicited Reporting at Power-Up (Y, N)	**PUNSOL1** := ________
Number of Events to Transmit On (1–200)	**NUMEVE1** := ________
Oldest Event to Tx On (0.0–99999.0 sec)	**AGEEVE1** := ________
Unsolicited Message Max Retry Attempts (2–10)	**URETRY1** := ________
Unsolicited Message Offline Time-Out (1–5000 sec)	**UTIMEO1** := ________

MIRRORED BITS Protocol

(All subsequent settings are hidden if PROTO := SEL, DNP, PMU, EVMSG, 103, or MOD)

MB Transmit Identifier (1–4)	**TXID** := ________
MB Receive Identifier (1–4)	**RXID** := ________
MB RX Bad Pickup Time (0–10000 sec)	**RBADPU** := ________

MB Channel Bad Pickup (1–10000 ppm)	**CBADPU** := ____________
MB Receive Default State (8 Characters)	**RXDFLT** := ____________
RMB1 Pickup Debounce Messages (1–8)	**RMB1PU** := ____________
RMB1 Dropout Debounce Messages (1–8)	**RMB1DO** := ____________
RMB2 Pickup Debounce Messages (1–8)	**RMB2PU** := ____________
RMB2 Dropout Debounce Messages (1–8)	**RMB2DO** := ____________
RMB3 Pickup Debounce Messages (1–8)	**RMB3PU** := ____________
RMB3 Dropout Debounce Messages (1–8)	**RMB3DO** := ____________
RMB4 Pickup Debounce Messages (1–8)	**RMB4PU** := ____________
RMB4 Dropout Debounce Messages (1–8)	**RMB4DO** := ____________
RMB5 Pickup Debounce Messages (1–8)	**RMB5PU** := ____________
RMB5 Dropout Debounce Messages (1–8)	**RMB5DO** := ____________
RMB6 Pickup Debounce Messages (1–8)	**RMB6PU** := ____________
RMB6 Dropout Debounce Messages (1–8)	**RMB6DO** := ____________
RMB7 Pickup Debounce Messages (1–8)	**RMB7PU** := ____________
RMB7 Dropout Debounce Messages (1–8)	**RMB7DO** := ____________
RMB8 Pickup Debounce Messages (1–8)	**RMB8PU** := ____________
RMB8 Dropout Debounce Messages (1–8)	**RMB8DO** := ____________

IEC 60870-5-103 Protocol

(Hidden unless serial port with PROTO := 103)

103 DEVICE ADDRESS (0–254)	**103ADDR** := ____________
CYCLIC DATA REPORTING PERIOD (1–3600 sec)	**103CYC** := ____________
ACCUMULATOR REPORTING PERIOD (OFF, 1–3600 sec)	**103ACYC** := ____________
ACCUMULATOR REPORTING TRIGGER (1 Relay Word Bit)	**103ATRI** := ____________
ENABLE TIME SYNCHRONIZATION (Y, N)	**103TIME** := ____________

Port 3

(EIA-232 or EIA-485 Port in Slot B)

ENABLE PORT (Y, N)	**EPORT** := ____________
PROTOCOL (SEL, DNP, MOD, EVMSG, PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB, 103)	**PROTO** := ____________
MAXIMUM ACCESS LEVEL (1, 2, C)	**MAXACC** := ____________

Communications

SPEED (300, 1200, 2400, 4800, 9600, 19200, 38400 bps)	**SPEED** := ____________
DATA BITS (7, 8 bits) *(Hidden if PROTO := MOD, DNP, PMU, EVMSG, 103, or MB_)*	**BITS** := ____________
PARITY (O, E, N) *(Hidden if PROTO := EVMSG, PMU, or MB_)*	**PARITY** := ____________
STOP BITS (1, 2 bits) *(Hidden if PROTO := MOD, EVMSG, or MB_)*	**STOP** := ____________
PORT TIME-OUT (0–30 min) *(Hidden and forced to 0 if PROTO := MOD, PMU, EVMSG, 103, or MB_)*	**T_OUT** := ____________
HDWR HANDSHAKING (Y, N) *(Hidden and forced to N if EIA-485 Port or PROTO := MOD, DNP, EVMSG, or MB_)*	**RTSCTS** := ____________
LANGUAGE (ENGLISH, SPANISH)	**LANG** := ____________

SEND AUTOMESSAGE (Y, N) *(Hidden and forced to N if PROTO := MOD, DNP, PMU, EVMSG, 103, or MB_)*	**AUTO** := ________
FAST OP MESSAGES (Y, N) *(Hidden if PROTO := MOD, DNP, PMU, EVMSG, 103, or MB_)*	**FASTOP** := ________
MINIMUM SECONDS FROM DCD TO TX (0.00–1.00 sec) *(Hidden if PROTO ≠ DNP)*	**MINDLY** := ________
MAXIMUM SECONDS FROM DCD TO TX (0.0–1.00 sec) *(Hidden if PROTO ≠ DNP)*	**MAXDLY** := ________
SETTLE TIME FROM RTS ON TO TX (OFF, 0.00–30.00 sec) *(Hidden if PROTO ≠ DNP or 103)*	**PREDLY** := ________
SETTLE TIME FROM TX TO RTD OFF (0.00–30.00 sec) *(Hidden if PROTO ≠ DNP or 103)*	**PSTDLY** := ________

Modbus

MODBUS SLAVE ID (1–247) *(Hidden if PROTO := SEL, EVMSG, 103, DNP, or MB_)*	**SLAVEID** := ________

DNP3 Protocol

(Hidden if PROTO := SEL, EVMSG, MB, PMU, 103, or MOD)

DNP Address (0–65519)	**DNPADR** := ________
DNP Address to Report to (0–65519)	**REPADR1** := ________
DNP Map (1–3)	**DNPMAP1** := ________
Analog Input Default Variation (1–6)	**DVARAI1** := ________
Class for Binary Event Data (0–3)	**ECLASSB1** := ________
Class for Counter Event Data (0–3)	**ECLASSC1** := ________
Class for Analog Event Data (0–3)	**ECLASSA1** := ________
Current Scaling Decimal Places (0–3)	**DECPLA1** := ________
Voltages Scaling Decimal Places (0–3)	**DECPLV1** := ________
Misc Data Scaling Decimal Places (0–3)	**DECPLM1** := ________
Amps Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0*	**ANADBA1** := ________
Volts Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBV1** := ________
Misc Data Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0 and ECLASSC1 := 0)*	**ANADBM1** := ________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ1** := ________
Seconds to Select/Operate Time-Out (0.0–30.0 sec)	**STIMEO1** := ________
Data Link Retries (0–15)	**DRETRY1** := ________
Seconds to Data Link Time-Out (0–5 sec) *(Hidden if DRETRY1 := 0)*	**DTIMEO1** := ________
Event Message Confirm Time-Out (1–50 sec)	**ETIMEO1** := ________
Enable Unsolicited Reporting (Y, N) *(Hidden and forced to N if ECLASSA1 := 0, ECLASSB1 := 0, and ECLASSC1 := 0)* *(All subsequent settings are hidden and forced to N when UNSOL1 := N)*	**UNSOL1** := ________
Enable Unsolicited Reporting at Power-Up (Y, N)	**PUNSOL1** := ________
Number of Events to Transmit On (1–200)	**NUMEVE1** := ________
Oldest Event to Tx On (0.0–99999.0 sec)	**AGEEVE1** := ________
Unsolicited Message Max Retry Attempts (2–10)	**URETRY1** := ________
Unsolicited Message Offline Time-Out (1–5000 sec)	**UTIMEO1** := ________

Modem Protocol

(For DNP3 session and EIA-232 port only)

Modem Connected to Port (Y, N)	**MODEM** :=	____________
Modem Startup String (30 Characters)	**MSTR** :=	____________
Phone Number for Dial-Out (30 Characters)	**PH_NUM1** :=	____________
Phone Number for Dial-Out (30 Characters)	**PH_NUM2** :=	____________
Retry Attempts for Phone 1 Dial-Out (1–20)	**RETRY1** :=	____________
Retry Attempts for Phone 2 Dial-Out (1–20)	**RETRY2** :=	____________
Time to Attempt Dial (5–300 sec)	**MDTIME** :=	____________
Time Between Dial-Out Attempts (5–3600 sec)	**MDRET** :=	____________

MIRRORED BITS Protocol

(Hidden if PROTO := SEL, DNP, PMU, EVMSG, 103, or MOD)

MB Transmit Identifier (1–4)	**TXID** :=	____________
MB Receive Identifier (1–4)	**RXID** :=	____________
MB RX Bad Pickup Time (0–10000 sec)	**RBADPU** :=	____________
MB Channel Bad Pickup (1–10000 ppm)	**CBADPU** :=	____________
MB Receive Default State (8 Characters)	**RXDFLT** :=	____________
RMB1 Pickup Debounce Messages (1–8)	**RMB1PU** :=	____________
RMB1 Dropout Debounce Messages (1–8)	**RMB1DO** :=	____________
RMB2 Pickup Debounce Messages (1–8)	**RMB2PU** :=	____________
RMB2 Dropout Debounce Messages (1–8)	**RMB2DO** :=	____________
RMB3 Pickup Debounce Messages (1–8)	**RMB3PU** :=	____________
RMB3 Dropout Debounce Messages (1–8)	**RMB3DO** :=	____________
RMB4 Pickup Debounce Messages (1–8)	**RMB4PU** :=	____________
RMB4 Dropout Debounce Messages (1–8)	**RMB4DO** :=	____________
RMB5 Pickup Debounce Messages (1–8)	**RMB5PU** :=	____________
RMB5 Dropout Debounce Messages (1–8)	**RMB5DO** :=	____________
RMB6 Pickup Debounce Messages (1–8)	**RMB6PU** :=	____________
RMB6 Dropout Debounce Messages (1–8)	**RMB6DO** :=	____________
RMB7 Pickup Debounce Messages (1–8)	**RMB7PU** :=	____________
RMB7 Dropout Debounce Messages (1–8)	**RMB7DO** :=	____________
RMB8 Pickup Debounce Messages (1–8)	**RMB8PU** :=	____________
RMB8 Dropout Debounce Messages (1–8)	**RMB8DO** :=	____________

IEC 60870-5-103

(Hidden unless serial port with PROTO := 103)

103 DEVICE ADDRESS (0–254)	**103ADDR** :=	____________
CYCLIC DATA REPORTING PERIOD (1–3600 sec)	**103CYC** :=	____________
ACCUMULATOR REPORTING PERIOD (OFF, 1–3600 sec)	**103ACYC**	____________
ACCUMULATOR REPORTING TRIGGER (1 Relay Word Bit)	**103ATRI**	____________
ENABLE TIME SYNCHRONIZATION (Y, N)	**103TIME**	____________

Port 4

(EIA-232/485 port or DeviceNet port in Slot C)

ENABLE PORT (Y, N)	**EPORT** := ________
PROTOCOL (SEL, DNP, MOD, DNET, EVMSG, PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB, 103)	**PROTO** := ________
MAXIMUM ACCESS LEVEL (1, 2, C)	**MAXACC** := ________

Interface Select

(Hidden if PROTO := DNET)

COMM INTERFACE (232, 485)	**COMMINF** := ________

Communications

SPEED (300, 1200, 2400, 4800, 9600, 19200, 38400 bps) *(Hidden if PROTO := DNET)*	**SPEED** := ________
DATA BITS (7, 8 bits) *(Hidden if PROTO := DNP, MOD, PMU, EVMSG, MB_, 103, or DNET)*	**BITS** := ________
PARITY (O, E, N) *(Hidden and forced to 0 if PROTO := DNET, EVMSG, PMU, or MB_)*	**PARITY** := ________
STOP BITS (1, 2 bits) *(Hidden if PROTO := MOD, EVMSG, MB_, or DNET)*	**STOP** := ________
PORT TIME-OUT (0–30 min) *(Hidden if PROTO := MOD, EVMSG, MB_, PMU, 103, or DNET)*	**T_OUT** := ________
HDWR HANDSHAKING (Y, N) *(Hidden and forced to N if COMMINF := 485 or PROTO := MOD, DNP, EVMSG, MB_, or DNET)*	**RTSCTS** := ________
LANGUAGE (ENGLISH, SPANISH)	**LANG** := ________
SEND AUTOMESSAGE (Y, N) *(Hidden and forced to N if PROTO := DNP, MOD, EVMSG, MB_, PMU, 103, or DNET)*	**AUTO** := ________
FAST OP MESSAGES (Y, N) *(Hidden if PROTO := DNP, MOD, EVMSG, MB_, PMU, 103, or DNET)*	**FASTOP** := ________
MINIMUM SECONDS FROM DCD TO TX (0.00–1.00) *(Hidden if PROTO ≠ DNP)*	**MINDLY** := ________
MAXIMUM SECONDS FROM DCD TO TX (0.0–1.00) *(Hidden if PROTO ≠ DNP)*	**MAXDLY** := ________
SETTLE TIME FROM RTD ON TO TX (OFF, 0.00–30.00 sec) *(Hidden if PROTO ≠ DNP or 103)*	**PREDLY** := ________
SETTLE TIME FROM TX TO RTS OFF (0.00–30.00 sec) *(Hidden if PROTO ≠ DNP or 103)*	**PSTDLY** := ________

Modbus

MODBUS SLAVE ID (1–247) *(Hidden if PROTO := SEL, EVMSG, MB_, 103, or DNET)*	**SLAVEID** := ________

DNP3

(Hidden if PROTO := SEL, EVMSG, MB, PMU, DNET, 103, or MOD)

DNP Address (0–65519)	**DNPADR** := ________
DNP Address to Report to (0–65519)	**REPADR1** := ________
DNP Map (1–3)	**DNPMAP1** := ________
Analog Input Default Variation (1–6)	**DVARAI1** := ________
Class for Binary Event Data (0–3)	**ECLASSB1** := ________
Class for Counter Event Data (0–3)	**ECLASSC1** := ________
Class for Analog Event Data (0–3)	**ECLASSA1** := ________
Current Scaling Decimal Places (0–3)	**DECPLA1** := ________
Voltages Scaling Decimal Places (0–3)	**DECPLV1** := ________

Misc Data Scaling Decimal Places (0–3)	**DECPLM1** := ______
Amps Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBA1** := ______
Volts Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBV1** := ______
Misc Data Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0 and ECLASSC1 := 0)*	**ANADBM1** := ______
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ1** := ______
Seconds to Select/Operate Time-Out (0.0–30.0 sec)	**STIMEO1** := ______
Data Link Retries (0–15)	**DRETRY1** := ______
Seconds to Data Link Time-Out (0–5 sec) *(Hidden if DRETRY := 0)*	**DTIMEO1** := ______
Event Message Confirm Time-Out (1–50 sec)	**ETIMEO1** := ______
Enable Unsolicited Reporting (Y, N) *(Hidden and forced to N if ECLASSA1 := 0, ECLASSB1 := 0, ECLASSC1 := 0, and ECLASSV1 := 0)* *(All subsequent settings are hidden and forced to N when UNSOL1 := N)*	**UNSOL1** := ______
Enable Unsolicited Reporting at Power-Up (Y, N)	**PUNSOL1** := ______
Number of Event to Transmit On (1–200)	**NUMEVE1** := ______
Oldest Event on Tx On (0.0–99999.0 sec)	**AGEEVE1** := ______
Unsolicited Message Max Retry Attempts (2–10)	**URETRY1** := ______
Unsolicited Message Offline Time-Out (1–5000 sec) *(Hidden if UNSOL1 := N)*	**UTIMEO1** := ______

Modem Protocol

(For DNP3 session and EIA-232 port only)

Modem Connected to Port (Y, N)	**MODEM** := ______
Modem Startup String (30 Characters)	**MSTR** := ______
Phone Number for Dial-Out (30 Characters)	**PH_NUM1** := ______
Phone Number for Dial-Out (30 Characters)	**PH_NUM2** := ______
Retry Attempts for Phone 1 Dial-Out (1–20)	**RETRY1** := ______
Retry Attempts for Phone 2 Dial-Out (1–20)	**RETRY2** := ______
Time to Attempt Dial (5–300 sec)	**MDTIME** := ______
Time Between Dial-Out Attempts (5–3600 sec)	**MDRET** := ______

Mirrored Bits Protocol

(Hidden if PROTO := SEL, EVMSG, DNP, PMU, DNET, 103, or MOD)

MB Transmit Identifier (1–4)	**TXID** := ______
MB Receive Identifier (1–4)	**RXID** := ______
MB RX Bad Pickup Time (0–10000 sec)	**RBADPU** := ______
MB Channel Bad Pickup (1–10000 ppm)	**CBADPU** := ______
MB Receive Default State (8 Characters)	**RXDFLT** := ______
RMB1 Pickup Debounce Messages (1–8)	**RMB1PU** := ______
RMB1 Dropout Debounce Messages (1–8)	**RMB1DO** := ______
RMB2 Pickup Debounce Messages (1–8)	**RMB2PU** := ______
RMB2 Dropout Debounce Messages (1–8)	**RMB2DO** := ______
RMB3 Pickup Debounce Messages (1–8)	**RMB3PU** := ______
RMB3 Dropout Debounce Messages (1–8)	**RMB3DO** := ______

RMB4 Pickup Debounce Messages (1–8)	**RMB4PU** := ____________
RMB4 Dropout Debounce Messages (1–8)	**RMB4DO** := ____________
RMB5 Pickup Debounce Messages (1–8)	**RMB5PU** := ____________
RMB5 Dropout Debounce Messages (1–8)	**RMB5DO** := ____________
RMB6 Pickup Debounce Messages (1–8)	**RMB6PU** := ____________
RMB6 Dropout Debounce Messages (1–8)	**RMB6DO** := ____________
RMB7 Pickup Debounce Messages (1–8)	**RMB7PU** := ____________
RMB7 Dropout Debounce Messages (1–8)	**RMB7DO** := ____________
RMB8 Pickup Debounce Messages (1–8)	**RMB8PU** := ____________
RMB8 Dropout Debounce Messages (1–8)	**RMB8DO** := ____________

IEC 60870-5-103 Protocol

(Hidden unless serial port with PROTO := 103)

103 DEVICE ADDRESS (0–254)	**103ADDR** := ____________
CYCLIC DATA REPORTING PERIOD (1–3600 sec)	**103CYC** := ____________
ACCUMULATOR REPORTING PERIOD (OFF, 1–3600 sec)	**103ACYC** := ____________
ACCUMULATOR REPORTING TRIGGER (1 Relay Word Bit)	**103ATRI** := ____________
ENABLE TIME SYNCHRONIZATION (Y, N)	**103TIME** := ____________

Front-Panel Settings (SET F Command)

General

DISPLY PTS ENABL (N, 1–32) (Hidden and forced to N if the front-panel MOT option is A/B)	**EDP** := ____________
LOCAL BITS ENABL (N, 1–32)	**ELB** := ____________
LCD TIMEOUT (OFF, 1–30 min) (Hidden and forced to OFF if the front-panel MOT option is A/B)	**FP_TO** := ____________
LCD CONTRAST (1–8)	**FP_CONT** := ____________
FP AUTOMESSAGES (OVERRIDE, ROTATING) (Hidden if the front-panel MOT option is A/B)	**FP_AUTO** := ____________
CLOSE RESET LEDS (Y, N)	**RSTLED** := ____________
ENA_LED COLOR (R = Red, G= Green, A = Amber) (Shown if the front-panel MOT option is 0/1 and if Relay Word bit TRICOLOR is asserted)	**LEDENAC** := ____________
TRIP_COLOR LED (R = Red, G = Green, A = Amber) (Hidden if Relay Word bit TRICOLOR is deasserted)	**LEDTRPC** := ____________
MAXIMUM ACCESS LEVEL (1, 2) (Hidden if the front-panel MOT option is A/B)	**MAXACC** := ____________

Target LED

(R = Red, G = Green, A = Amber)

TRIP LATCH T_LED (Y, N)	**T01LEDL** := ____________
TARGET T_LED ASSERTED COLOR (R, G, A) (Hidden and forced to R if Relay Word bit TRICOLOR is deasserted)	**T01LEDC** := ____________
LED1 EQUATION (SELOGIC)	**T01_LED** := ____________
TRIP LATCH T_LED (Y, N)	**T02LEDL** := ____________
TARGET T_LED ASSERTED COLOR (R, G, A) (Hidden and forced to R if Relay Word bit TRICOLOR is deasserted)	**T02LEDC** := ____________

LED2 EQUATION (SELOGIC)	**T02_LED** := ________
TRIP LATCH T_LED (Y, N)	**T03LEDL** := ________
TARGET T_LED ASSERTED COLOR (R, G, A) (Hidden and forced to R if Relay Word bit TRICOLOR is deasserted)	**T03LEDC** := ________
LED3 EQUATION (SELOGIC)	**T03_LED** := ________
TRIP LATCH T_LED (Y, N)	**T04LEDL** := ________
TARGET T_LED ASSERTED COLOR (R, G, A) (Hidden and forced to R if Relay Word bit TRICOLOR is deasserted)	**T04LEDC** := ________
LED4 EQUATION (SELOGIC)	**T04_LED** := ________
TRIP LATCH T_LED (Y, N)	**T05LEDL** := ________
TARGET T_LED ASSERTED COLOR (R, G, A) (Hidden and forced to R if Relay Word bit TRICOLOR is deasserted)	**T05LEDC** := ________
LED5 EQUATION (SELOGIC)	**T05_LED** := ________
TRIP LATCH T_LED (Y, N)	**T06LEDL** := ________
TARGET T_LED ASSERTED COLOR (R, G, A) (Hidden and forced to R if Relay Word bit TRICOLOR is deasserted)	**T06LEDC** := ________
LED6 EQUATION (SELOGIC)	**T06_LED** := ________

Operator Control LED

(Asserted/deasserted color choices: R = Red, G = Green, A = Amber, O = Off. Asserted and deasserted colors must be different)

PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO) (Hidden and forced to AO if Relay Word bit TRICOLOR is deasserted)	**PB1ALEDC** := ________
PB1A_LED EQUATION (SELOGIC)	**PB1A_LED** := ________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO) (Hidden and forced to AO if Relay Word bit TRICOLOR is deasserted)	**PB1BLEDC** := ________
PB1B_LED EQUATION (SELOGIC)	**PB1B_LED** := ________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO) (Hidden and forced to AO if Relay Word bit TRICOLOR is deasserted)	**PB2ALEDC** := ________
PB2A_LED EQUATION (SELOGIC)	**PB2A_LED** := ________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO) (Hidden and forced to AO if Relay Word bit TRICOLOR is deasserted)	**PB2BLEDC** := ________
PB2B_LED EQUATION (SELOGIC)	**PB2B_LED** := ________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO) (Hidden and forced to AO if Relay Word bit TRICOLOR is deasserted)	**PB3ALEDC** := ________
PB3A_LED EQUATION (SELOGIC)	**PB3A_LED** := ________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO) (Hidden and forced to AO if Relay Word bit TRICOLOR is deasserted)	**PB3BLEDC** := ________
PB3B_LED EQUATION (SELOGIC)	**PB3B_LED** := ________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO) (Hidden and forced to AO if Relay Word bit TRICOLOR is deasserted)	**PB4ALEDC** := ________

PB4A_LED EQUATION (SELOGIC) **PB4A_LED :=**_______________

PB_LED ASSERTED/DEASSERTED COLORS **PB4BLEDC :=**_______________
(AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)
(Hidden and forced to AO if Relay Word bit TRICOLOR is deasserted)

PB4B_LED EQUATION (SELOGIC) **PB4B_LED :=**_______________

(The following operator control LED settings are hidden if the Relay Word bit TRICOLOR is deasserted)

PB_LED ASSERTED/DEASSERTED COLORS **PB5ALEDC :=**_______________
(AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)

PB5A_LED EQUATION (SELOGIC) **PB5A_LED :=**_______________

PB_LED ASSERTED/DEASSERTED COLORS **PB5BLEDC :=**_______________
(AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)

PB5B_LED EQUATION (SELOGIC) **PB5B_LED :=**_______________

PB_LED ASSERTED/DEASSERTED COLORS **PB6ALEDC :=**_______________
(AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)

PB6A_LED EQUATION (SELOGIC) **PB6A_LED :=**_______________

PB_LED ASSERTED/DEASSERTED COLORS **PB6BLEDC :=**_______________
(AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)

PB6B_LED EQUATION (SELOGIC) **PB6B_LED :=**_______________

PB_LED ASSERTED/DEASSERTED COLORS **PB7ALEDC :=**_______________
(AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)

PB7A_LED EQUATION (SELOGIC) **PB7A_LED :=**_______________

PB_LED ASSERTED/DEASSERTED COLORS **PB7BLEDC :=**_______________
(AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)

PB7B_LED EQUATION (SELOGIC) **PB7B_LED :=**_______________

PB_LED ASSERTED/DEASSERTED COLORS **PB8ALEDC :=**_______________
(AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)

PB8A_LED EQUATION (SELOGIC) **PB8A_LED :=**_______________

PB_LED ASSERTED/DEASSERTED COLORS **PB8BLEDC :=**_______________
(AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)

PB8B_LED EQUATION (SELOGIC) **PB8B_LED :=**_______________

Display Points

(The following display point settings are hidden if the front-panel MOT option is A/B)
Display Point Settings (maximum 60 characters):
(Boolean): Relay Word bit Name, “Alias”, “Set String”, “Clear String”
(Analog): Analog Quantity Name, “User Text and Formatting”

DISPLAY POINT DP01 (60 characters) **DP01 :=**_______________

DISPLAY POINT DP02 (60 characters) **DP02 :=**_______________

DISPLAY POINT DP03 (60 characters) **DP03 :=**_______________

DISPLAY POINT DP04 (60 characters) **DP04 :=**_______________

DISPLAY POINT DP05 (60 characters) **DP05 :=**_______________

DISPLAY POINT DP06 (60 characters) **DP06 :=**_______________

DISPLAY POINT DP07 (60 characters)	**DP07 :=**
DISPLAY POINT DP08 (60 characters)	**DP08 :=**
DISPLAY POINT DP09 (60 characters)	**DP09 :=**
DISPLAY POINT DP10 (60 characters)	**DP10 :=**
DISPLAY POINT DP11 (60 characters)	**DP11 :=**
DISPLAY POINT DP12 (60 characters)	**DP12 :=**
DISPLAY POINT DP13 (60 characters)	**DP13 :=**
DISPLAY POINT DP14 (60 characters)	**DP14 :=**
DISPLAY POINT DP15 (60 characters)	**DP15 :=**
DISPLAY POINT DP16 (60 characters)	**DP16 :=**
DISPLAY POINT DP17 (60 characters)	**DP17 :=**
DISPLAY POINT DP18 (60 characters)	**DP18 :=**
DISPLAY POINT DP19 (60 characters)	**DP19 :=**
DISPLAY POINT DP20 (60 characters)	**DP20 :=**
DISPLAY POINT DP21 (60 characters)	**DP21 :=**
DISPLAY POINT DP22 (60 characters)	**DP22 :=**
DISPLAY POINT DP23 (60 characters)	**DP23 :=**
DISPLAY POINT DP24 (60 characters)	**DP24 :=**
DISPLAY POINT DP25 (60 characters)	**DP25 :=**
DISPLAY POINT DP26 (60 characters)	**DP26 :=**

DISPLAY POINT DP27 (60 characters)	**DP27 :=**
DISPLAY POINT DP28 (60 characters)	**DP28 :=**
DISPLAY POINT DP29 (60 characters)	**DP29 :=**
DISPLAY POINT DP30 (60 characters)	**DP30 :=**
DISPLAY POINT DP31 (60 characters)	**DP31 :=**
DISPLAY POINT DP32 (60 characters)	**DP32 :=**

Local Bits Labels

LB_NAME (14 characters)	**NLB01 :=**
CLEAR LB_ LABEL (7 characters)	**CLB01 :=**
SET LB_ LABEL (7 characters)	**SLB01 :=**
PULSE LB_ LABEL (7 characters)	**PLB01 :=**
LB_NAME (14 characters)	**NLB02 :=**
CLEAR LB_ LABEL (7 characters)	**CLB02 :=**
SET LB_ LABEL (7 characters)	**SLB02 :=**
PULSE LB_ LABEL (7 characters)	**PLB02 :=**
LB_NAME (14 characters)	**NLB03 :=**
CLEAR LB_ LABEL (7 characters)	**CLB03 :=**
SET LB_ LABEL (7 characters)	**SLB03 :=**
PULSE LB_ LABEL (7 characters)	**PLB03 :=**
LB_NAME (14 characters)	**NLB04 :=**
CLEAR LB_ LABEL (7 characters)	**CLB04 :=**
SET LB_ LABEL (7 characters)	**SLB04 :=**
PULSE LB_ LABEL (7 characters)	**PLB04 :=**
LB_NAME (14 characters)	**NLB05 :=**
CLEAR LB_ LABEL (7 characters)	**CLB05 :=**
SET LB_ LABEL (7 characters)	**SLB05 :=**
PULSE LB_ LABEL (7 characters)	**PLB05 :=**
LB_NAME (14 characters)	**NLB06 :=**
CLEAR LB_ LABEL (7 characters)	**CLB06 :=**
SET LB_ LABEL (7 characters)	**SLB06 :=**
PULSE LB_ LABEL (7 characters)	**PLB06 :=**
LB_NAME (14 characters)	**NLB07 :=**

CLEAR LB_ LABEL (7 characters)	**CLB07 :=**________________________
SET LB_ LABEL (7 characters)	**SLB07 :=**________________________
PULSE LB_ LABEL (7 characters)	**PLB07 :=**________________________
LB_NAME (14 characters)	**NLB08 :=**________________________
CLEAR LB_ LABEL (7 characters)	**CLB08 :=**________________________
SET LB_ LABEL (7 characters)	**SLB08 :=**________________________
PULSE LB_ LABEL (7 characters)	**PLB08 :=**________________________
LB_NAME (14 characters)	**NLB09 :=**________________________
CLEAR LB_ LABEL (7 characters)	**CLB09 :=**________________________
SET LB_ LABEL (7 characters)	**SLB09 :=**________________________
PULSE LB_ LABEL (7 characters)	**PLB09 :=**________________________
LB_NAME (14 characters)	**NLB10 :=**________________________
CLEAR LB_ LABEL (7 characters)	**CLB10 :=**________________________
SET LB_ LABEL (7 characters)	**SLB10 :=**________________________
PULSE LB_ LABEL (7 characters)	**PLB10 :=**________________________
LB_NAME (14 characters)	**NLB11 :=**________________________
CLEAR LB_ LABEL (7 characters)	**CLB11 :=**________________________
SET LB_ LABEL (7 characters)	**SLB11 :=**________________________
PULSE LB_ LABEL (7 characters)	**PLB11 :=**________________________
LB_NAME (14 characters)	**NLB12 :=**________________________
CLEAR LB_ LABEL (7 characters)	**CLB12 :=**________________________
SET LB_ LABEL (7 characters)	**SLB12 :=**________________________
PULSE LB_ LABEL (7 characters)	**PLB12 :=**________________________
LB_NAME (14 characters)	**NLB13 :=**________________________
CLEAR LB_ LABEL (7 characters)	**CLB13 :=**________________________
SET LB_ LABEL (7 characters)	**SLB13 :=**________________________
PULSE LB_ LABEL (7 characters)	**PLB13 :=**________________________
LB_NAME (14 characters)	**NLB14 :=**________________________
CLEAR LB_ LABEL (7 characters)	**CLB14 :=**________________________
SET LB_ LABEL (7 characters)	**SLB14 :=**________________________
PULSE LB_ LABEL (7 characters)	**PLB14 :=**________________________
LB_NAME (14 characters)	**NLB15 :=**________________________
CLEAR LB_ LABEL (7 characters)	**CLB15 :=**________________________
SET LB_ LABEL (7 characters)	**SLB15 :=**________________________
PULSE LB_ LABEL (7 characters)	**PLB15 :=**________________________
LB_NAME (14 characters)	**NLB16 :=**________________________
CLEAR LB_ LABEL (7 characters)	**CLB16 :=**________________________
SET LB_ LABEL (7 characters)	**SLB16 :=**________________________
PULSE LB_ LABEL (7 characters)	**PLB16 :=**________________________
LB_NAME (14 characters)	**NLB17 :=**________________________

CLEAR LB_ LABEL (7 characters)	**CLB17 :=**________
SET LB_ LABEL (7 characters)	**SLB17 :=**________
PULSE LB_ LABEL (7 characters)	**PLB17 :=**________
LB_NAME (14 characters)	**NLB18 :=**________
CLEAR LB_ LABEL (7 characters)	**CLB18 :=**________
SET LB_ LABEL (7 characters)	**SLB18 :=**________
PULSE LB_ LABEL (7 characters)	**PLB18 :=**________
LB_NAME (14 characters)	**NLB19 :=**________
CLEAR LB_ LABEL (7 characters)	**CLB19 :=**________
SET LB_ LABEL (7 characters)	**SLB19 :=**________
PULSE LB_ LABEL (7 characters)	**PLB19 :=**________
LB_NAME (14 characters)	**NLB20 :=**________
CLEAR LB_ LABEL (7 characters)	**CLB20 :=**________
SET LB_ LABEL (7 characters)	**SLB20 :=**________
PULSE LB_ LABEL (7 characters)	**PLB20 :=**________
LB_NAME (14 characters)	**NLB21 :=**________
CLEAR LB_ LABEL (7 characters)	**CLB21 :=**________
SET LB_ LABEL (7 characters)	**SLB21 :=**________
PULSE LB_ LABEL (7 characters)	**PLB21 :=**________
LB_NAME (14 characters)	**NLB22 :=**________
CLEAR LB_ LABEL (7 characters)	**CLB22 :=**________
SET LB_ LABEL (7 characters)	**SLB22 :=**________
PULSE LB_ LABEL (7 characters)	**PLB22 :=**________
LB_NAME (14 characters)	**NLB23 :=**________
CLEAR LB_ LABEL (7 characters)	**CLB23 :=**________
SET LB_ LABEL (7 characters)	**SLB23 :=**________
PULSE LB_ LABEL (7 characters)	**PLB23 :=**________
LB_NAME (14 characters)	**NLB24 :=**________
CLEAR LB_ LABEL (7 characters)	**CLB24 :=**________
SET LB_ LABEL (7 characters)	**SLB24 :=**________
PULSE LB_ LABEL (7 characters)	**PLB24 :=**________
LB_NAME (14 characters)	**NLB25 :=**________
CLEAR LB_ LABEL (7 characters)	**CLB25 :=**________
SET LB_ LABEL (7 characters)	**SLB25 :=**________
PULSE LB_ LABEL (7 characters)	**PLB25 :=**________
LB_NAME (14 characters)	**NLB26 :=**________
CLEAR LB_ LABEL (7 characters)	**CLB26 :=**________
SET LB_ LABEL (7 characters)	**SLB26 :=**________
PULSE LB_ LABEL (7 characters)	**PLB26 :=**________
LB_NAME (14 characters)	**NLB27 :=**________

CLEAR LB_ LABEL (7 characters)	**CLB27 :=**____________________
SET LB_ LABEL (7 characters)	**SLB27 :=**____________________
PULSE LB_ LABEL (7 characters)	**PLB27 :=**____________________
LB_NAME (14 characters)	**NLB28 :=**____________________
CLEAR LB_ LABEL (7 characters)	**CLB28 :=**____________________
SET LB_ LABEL (7 characters)	**SLB28 :=**____________________
PULSE LB_ LABEL (7 characters)	**PLB28 :=**____________________
LB_NAME (14 characters)	**NLB29 :=**____________________
CLEAR LB_ LABEL (7 characters)	**CLB29 :=**____________________
SET LB_ LABEL (7 characters)	**SLB29 :=**____________________
PULSE LB_ LABEL (7 characters)	**PLB29 :=**____________________
LB_NAME (14 characters)	**NLB30 :=**____________________
CLEAR LB_ LABEL (7 characters)	**CLB30 :=**____________________
SET LB_ LABEL (7 characters)	**SLB30 :=**____________________
PULSE LB_ LABEL (7 characters)	**PLB30 :=**____________________
LB_NAME (14 characters)	**NLB31 :=**____________________
CLEAR LB_ LABEL (7 characters)	**CLB31 :=**____________________
SET LB_ LABEL (7 characters)	**SLB31 :=**____________________
PULSE LB_ LABEL (7 characters)	**PLB31 :=**____________________
LB_NAME (14 characters)	**NLB32 :=**____________________
CLEAR LB_ LABEL (7 characters)	**CLB32 :=**____________________
SET LB_ LABEL (7 characters)	**SLB32 :=**____________________
PULSE LB_ LABEL (7 characters)	**PLB32 :=**____________________

Touchscreen Settings

(Shown if the front-panel MOT option is A/B)

(Note: The touchscreen settings category is only available in QuickSet, with the exception of the settings FPTO, FPDUR, and FPBAB, which are also available to set via the touchscreen display.)

Touchscreen Configuration

DISPLAY HOME SCREEN (Refer to *Table 8.18* for setting range)	**FPHOME :=**________________
DISPLAY TIME-OUT (1–30 min)	**FPTO :=**________________
ROTATING DISPLAY TRANSITION TIME (3–15 sec)	**FPDUR :=**________________
BACKLIGHT ACTIVE BRIGHTNESS (1–10)	**FPBAB :=**________________

Rotating Display

(Refer to *Table 8.18* for the setting range)

ROTATING DISPLAY 01	**FPRD01 :=**________________
ROTATING DISPLAY 02	**FPRD02 :=**________________
ROTATING DISPLAY 03	**FPRD03 :=**________________
ROTATING DISPLAY 04	**FPRD04 :=**________________
ROTATING DISPLAY 05	**FPRD05 :=**________________

ROTATING DISPLAY 06	**FPRD06** := ________
ROTATING DISPLAY 07	**FPRD07** := ________
ROTATING DISPLAY 08	**FPRD08** := ________
ROTATING DISPLAY 09	**FPRD09** := ________
ROTATING DISPLAY 10	**FPRD10** := ________
ROTATING DISPLAY 11	**FPRD11** := ________
ROTATING DISPLAY 12	**FPRD12** := ________
ROTATING DISPLAY 13	**FPRD13** := ________
ROTATING DISPLAY 14	**FPRD14** := ________
ROTATING DISPLAY 15	**FPRD15** := ________
ROTATING DISPLAY 16	**FPRD16** := ________

Pushbuttons

(OFF, refer to *Table 8.18* for the setting range)

PUSHBUTTON 01 HMI SCREEN	**FPPB01** := ________
PUSHBUTTON 02 HMI SCREEN	**FPPB02** := ________
PUSHBUTTON 03 HMI SCREEN	**FPPB03** := ________
PUSHBUTTON 04 HMI SCREEN	**FPPB04** := ________
PUSHBUTTON 05 HMI SCREEN	**FPPB05** := ________
PUSHBUTTON 06 HMI SCREEN	**FPPB06** := ________
PUSHBUTTON 07 HMI SCREEN	**FPPB07** := ________
PUSHBUTTON 08 HMI SCREEN	**FPPB08** := ________

Bay Control Breaker

BREAKER TRIP TYPE (3)	**BK01TTY** := ________
BREAKER MODE (CONTROL, MONITOR)	**BK01MOD** := ________
BREAKER CLOSE STATUS (Relay Word bit)	**BK01CS** := ________
BREAKER OPEN STATUS (Relay Word bit)	**BK01OS** := ________
BREAKER ALARM STATUS (Relay Word bit)	**BK01AS** := ________
BREAKER HMI CLOSE COMMAND (Relay Word bit)	**BK01CLC** := ________
BREAKER HMI OPEN COMMAND (Relay Word bit)	**BK01OPC** := ________
BREAKER TRIP TYPE (3)	**BK02TTY** := ________
BREAKER MODE (CONTROL, MONITOR)	**BK02MOD** := ________
BREAKER CLOSE STATUS (Relay Word bit)	**BK02CS** := ________
BREAKER OPEN STATUS (Relay Word bit)	**BK02OS** := ________
BREAKER ALARM STATUS (Relay Word bit)	**BK02AS** := ________
BREAKER HMI CLOSE COMMAND (Relay Word bit)	**BK02CLC** := ________
BREAKER HMI OPEN COMMAND (Relay Word bit)	**BK02OPC** := ________

Bay Control Two-Position Disconnect

TWO-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**2D01MOD** := ________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS01CS** := ________

TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS01OS** := __________
TWO-POSITION DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**2DS01IS** := __________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS01AS** := __________
TWO-POSITION DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**2DS01CL** := __________
TWO-POSITION DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**2DS01OP** := __________
TWO-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**2D02MOD** := __________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS02CS** := __________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS02OS** := __________
TWO-POSITION DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**2DS02IS** := __________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS02AS** := __________
TWO-POSITION DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**2DS02CL** := __________
TWO-POSITION DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**2DS02OP** := __________
TWO-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**2D03MOD** := __________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS03CS** := __________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS03OS** := __________
TWO-POSITION DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**2DS03IS** := __________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS03AS** := __________
TWO-POSITION DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**2DS03CL** := __________
TWO-POSITION DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**2DS03OP** := __________
TWO-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**2D04MOD** := __________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS04CS** := __________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS04OS** := __________
TWO-POSITION DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**2DS04IS** := __________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS04AS** := __________
TWO-POSITION DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**2DS04CL** := __________
TWO-POSITION DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**2DS04OP** := __________
TWO-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**2D05MOD** := __________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS05CS** := __________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS05OS** := __________
TWO-POSITION DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**2DS05IS** := __________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS05AS** := __________
TWO-POSITION DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**2DS05CL** := __________
TWO-POSITION DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**2DS05OP** := __________
TWO-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**2D06MOD** := __________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS06CS** := __________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS06OS** := __________
TWO-POSITION DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**2DS06IS** := __________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS06AS** := __________
TWO-POSITION DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**2DS06CL** := __________
TWO-POSITION DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**2DS06OP** := __________

TWO-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**2D07MOD** :=
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS07CS** :=
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS07OS** :=
TWO-POSITION DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**2DS07IS** :=
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS07AS** :=
TWO-POSITION DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**2DS07CL** :=
TWO-POSITION DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**2DS07OP** :=
TWO-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**2D08MOD** :=
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS08CS** :=
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS08OS** :=
TWO-POSITION DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**2DS08IS** :=
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS08AS** :=
TWO-POSITION DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**2DS08CL** :=
TWO-POSITION DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**2DS08OP** :=

Bay Control Three-Position Disconnect

THREE-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**3D01MOD** :=
THREE-POSITION IN-LINE DISCONNECT CLOSE STATUS (Relay Word bit)	**3ID01CS** :=
THREE-POSITION IN-LINE DISCONNECT OPEN STATUS (Relay Word bit)	**3ID01OS** :=
THREE-POSITION IN-LINE DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**3ID01IS** :=
THREE-POSITION IN-LINE DISCONNECT ALARM STATUS (Relay Word bit)	**3ID01AS** :=
THREE-POSITION IN-LINE DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**3ID01CL** :=
THREE-POSITION IN-LINE DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**3ID01OP** :=
THREE-POSITION EARTHING DISCONNECT CLOSE STATUS (Relay Word bit)	**3ED01CS** :=
THREE-POSITION EARTHING DISCONNECT OPEN STATUS (Relay Word bit)	**3ED01OS** :=
THREE-POSITION EARTHING DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**3ED01IS** :=
THREE-POSITION EARTHING DISCONNECT ALARM STATUS (Relay Word bit)	**3ED01AS** :=
THREE-POSITION EARTHING DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**3ED01CL** :=
THREE-POSITION EARTHING DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**3ED01OP** :=
THREE-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**3D02MOD** :=
THREE-POSITION IN-LINE DISCONNECT CLOSE STATUS (Relay Word bit)	**3ID02CS** :=
THREE-POSITION IN-LINE DISCONNECT OPEN STATUS (Relay Word bit)	**3ID02OS** :=
THREE-POSITION IN-LINE DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**3ID02IS** :=
THREE-POSITION IN-LINE DISCONNECT ALARM STATUS (Relay Word bit)	**3ID02AS** :=
THREE-POSITION IN-LINE DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**3ID02CL** :=

THREE-POSITION IN-LINE DISCONNECT HMI OPEN COMMAND
(Relay Word bit) **3ID02OP** := ____________

THREE-POSITION EARTHING DISCONNECT CLOSE STATUS
(Relay Word bit) **3ED02CS** := ____________

THREE-POSITION EARTHING DISCONNECT OPEN STATUS
(Relay Word bit) **3ED02OS** := ____________

THREE-POSITION EARTHING DISCONNECT IN-PROGRESS STATUS
(Relay Word bit) **3ED02IS** := ____________

THREE-POSITION EARTHING DISCONNECT ALARM STATUS
(Relay Word bit) **3ED02AS** := ____________

THREE-POSITION EARTHING DISCONNECT HMI CLOSE COMMAND
(Relay Word bit) **3ED02CL** := ____________

THREE-POSITION EARTHING DISCONNECT HMI OPEN COMMAND
(Relay Word bit) **3ED02OP** := ____________

Analog Label

ANALOG QUANTITY **ALAB01** := ____________

ANALOG QUANTITY **ALAB02** := ____________

ANALOG QUANTITY **ALAB03** := ____________

ANALOG QUANTITY **ALAB04** := ____________

ANALOG QUANTITY **ALAB05** := ____________

ANALOG QUANTITY **ALAB06** := ____________

ANALOG QUANTITY **ALAB07** := ____________

ANALOG QUANTITY **ALAB08** := ____________

ANALOG QUANTITY **ALAB09** := ____________

ANALOG QUANTITY **ALAB10** := ____________

ANALOG QUANTITY **ALAB11** := ____________

ANALOG QUANTITY **ALAB12** := ____________

ANALOG QUANTITY **ALAB13** := ____________

ANALOG QUANTITY **ALAB14** := ____________

ANALOG QUANTITY **ALAB15** := ____________

ANALOG QUANTITY **ALAB16** := ____________

ANALOG QUANTITY **ALAB17** := ____________

ANALOG QUANTITY **ALAB18** := ____________

ANALOG QUANTITY **ALAB19** := ____________

ANALOG QUANTITY **ALAB20** := ____________

ANALOG QUANTITY **ALAB21** := ____________

ANALOG QUANTITY **ALAB22** := ____________

ANALOG QUANTITY **ALAB23** := ____________

ANALOG QUANTITY **ALAB24** := ____________

ANALOG QUANTITY **ALAB25** := ____________

ANALOG QUANTITY **ALAB26** := ____________

ANALOG QUANTITY **ALAB27** := ____________

ANALOG QUANTITY **ALAB28** := ____________

ANALOG QUANTITY	**ALAB29** :=
ANALOG QUANTITY	**ALAB30** :=
ANALOG QUANTITY	**ALAB31** :=
ANALOG QUANTITY	**ALAB32** :=

Digital Label

RELAY WORD BIT	**DLAB01** :=
RELAY WORD BIT	**DLAB02** :=
RELAY WORD BIT	**DLAB03** :=
RELAY WORD BIT	**DLAB04** :=
RELAY WORD BIT	**DLAB05** :=
RELAY WORD BIT	**DLAB06** :=
RELAY WORD BIT	**DLAB07** :=
RELAY WORD BIT	**DLAB08** :=
RELAY WORD BIT	**DLAB09** :=
RELAY WORD BIT	**DLAB10** :=
RELAY WORD BIT	**DLAB11** :=
RELAY WORD BIT	**DLAB12** :=
RELAY WORD BIT	**DLAB13** :=
RELAY WORD BIT	**DLAB14** :=
RELAY WORD BIT	**DLAB15** :=
RELAY WORD BIT	**DLAB16** :=
RELAY WORD BIT	**DLAB17** :=
RELAY WORD BIT	**DLAB18** :=
RELAY WORD BIT	**DLAB19** :=
RELAY WORD BIT	**DLAB20** :=
RELAY WORD BIT	**DLAB21** :=
RELAY WORD BIT	**DLAB22** :=
RELAY WORD BIT	**DLAB23** :=
RELAY WORD BIT	**DLAB24** :=
RELAY WORD BIT	**DLAB25** :=
RELAY WORD BIT	**DLAB26** :=
RELAY WORD BIT	**DLAB27** :=
RELAY WORD BIT	**DLAB28** :=
RELAY WORD BIT	**DLAB29** :=
RELAY WORD BIT	**DLAB30** :=
RELAY WORD BIT	**DLAB31** :=
RELAY WORD BIT	**DLAB32** :=

Report Settings (SET R Command)

SER Chatter Criteria

Auto-Removal Enable (Y, N) **ESERDEL :=**_______________

Number of Counts (2–20 counts) **SRDLCNT :=**_______________

Removal Time (0.1–90.0 s) **SRDLTIM :=**_______________

SER Trigger Lists

SER*n* = As many as 24 Relay Word elements separated by spaces or commas. Use NA to disable setting.

SER1 :=______________________________

SER2 :=______________________________

SER3 :=______________________________

SER4 :=______________________________

Relay Word Bit Aliases

ALIAS*n*= "RW Bit" (space) "Alias" (space) "Asserted Text" (space) "Deasserted Text". Alias, Asserted, and Deasserted text strings can be as long as 15 characters. Use NA to disable setting.

Enable ALIAS (N, 1–32)

(All subsequent ALIAS settings are hidden and forced to NA if EALIAS := N)

EALIAS :=_______________

ALIAS1 :=_______________

ALIAS2 :=_______________

ALIAS3 :=_______________

ALIAS4 :=_______________

ALIAS5 :=_______________

ALIAS6 :=_______________

ALIAS7 :=_______________

ALIAS8 :=_______________

ALIAS9 :=_______________

ALIAS10 :=_______________

ALIAS11 :=_______________

ALIAS12 :=_______________

ALIAS13 :=_______________

ALIAS14 :=_______________

ALIAS15 :=_______________

ALIAS16 :=_______________

ALIAS17 :=_______________

ALIAS18 :=_______________

ALIAS19 :=_______________

ALIAS20 :=_______________

ALIAS21 :=_______________

ALIAS22 :=_______________

ALIAS23 :=_______________

ALIAS24 :=_______________

ALIAS25 :=_______________

ALIAS26 :=_______________

ALIAS27 :=_______________

ALIAS28 :=_______________

ALIAS29 :=_______________

ALIAS30 :=_______________

ALIAS31 :=_______________

ALIAS32 :=_______________

Event Report

EVENT TRIGGER (SELOGIC) **ER :=**_______________

____

EVENT LENGTH (15, 64, 180 cyc) **LER :=**_______________

PREFAULT LENGTH (1–10 cyc [if LER := 15], 1–59 cyc [if LER := 64], 1-175 cyc [if LER := 180]) **PRE :=**_______________

Fast Message Read Settings

FMRnNAM = Any valid string. (No spaces allowed; should be different from other FMRxNAM)
FMRn = As many as 24 analog quantities separated by spaces or commas. (Analog quantities listed here will be included in the Fast Message read request)
Use NA to disable setting.

FMR1 Name (9 characters) **FMR1NAM :=**________________

Fast Message Read FMR1 (24 analog quantities) **FMR1 :=**________________

FMR2 Name (9 characters) **FMR2NAM :=**________________

Fast Message Read FMR2 (24 analog quantities) **FMR2 :=**________________

FMR3 Name (9 characters) **FMR3NAM :=**________________

Fast Message Read FMR3 (24 analog quantities) **FMR3 :=**________________

FMR4 Name (9 characters) **FMR4NAM :=**________________

Fast Message Read FMR4 (24 analog quantities) **FMR4 :=**________________

Fast Message Remote Analog Settings

Remote Analog Value Type (I, F, L), I = Integer, F = Float, L = Long

RA01TYPE :=________________

RA02TYPE :=________________

RA03TYPE :=________________

RA04TYPE :=________________

RA05TYPE :=________________

RA06TYPE :=________________

RA07TYPE :=________________

RA08TYPE :=________________

RA09TYPE :=________________

RA10TYPE :=________________

RA11TYPE :=________________

RA12TYPE :=________________

RA13TYPE :=________________

RA14TYPE :=________________

RA15TYPE :=________________

RA16TYPE :=________________

RA17TYPE :=________________

RA18TYPE :=________________

RA19TYPE :=________________

RA20TYPE :=________________

RA21TYPE :=________________

RA22TYPE :=________________

RA23TYPE :=________________

RA24TYPE :=________________

RA25TYPE :=________________

RA26TYPE :=________________

RA27TYPE :=________________

RA28TYPE :=________________

RA29TYPE :=________________

RA30TYPE :=________________

RA31TYPE :=________________

RA32TYPE :=________________

Generator Autosynchronism Report

(Settings shown if Slot E = 71/72/74/75/76 and if Slot Z = 81/82/85/86)

GEN SYNC TRG (SELOGIC) **GSRTRG :=**________________

____

GEN SYNC RPT RES (0.25, 1, 5 cyc) **GSRR :=**________________

PRE SYNC LEN (1–4799 samples) **PRESYNC :=**________________

Load Profile

LDP LIST (NA, As many as 17 Analog Quantities) **LDLIST :=**________________

LDP ACQ RATE (5, 10, 15, 30, 60 min.) **LDAR :=**________________

Modbus Map Settings (SET M Command)

Modbus User Map

User Map Register Label Name (8 characters)

(See *Appendix E: Modbus Communications* for additional details)

MOD_001 :=________________
MOD_002 :=________________
MOD_003 :=________________
MOD_004 :=________________
MOD_005 :=________________
MOD_006 :=________________
MOD_007 :=________________
MOD_008 :=________________
MOD_009 :=________________
MOD_010 :=________________
MOD_011 :=________________
MOD_012 :=________________
MOD_013 :=________________
MOD_014 :=________________
MOD_015 :=________________
MOD_016 :=________________
MOD_017 :=________________
MOD_018 :=________________
MOD_019 :=________________
MOD_020 :=________________
MOD_021 :=________________
MOD_022 :=________________
MOD_023 :=________________
MOD_024 :=________________
MOD_025 :=________________
MOD_026 :=________________
MOD_027 :=________________
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MOD_051 :=__________
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MOD_058 :=__________
MOD_059 :=__________
MOD_060 :=__________
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MOD_063 :=__________
MOD_064 :=__________
MOD_065 :=__________
MOD_066 :=__________
MOD_067 :=__________
MOD_068 :=__________
MOD_069 :=__________
MOD_070 :=__________
MOD_071 :=__________
MOD_072 :=__________
MOD_073 :=__________
MOD_074 :=__________
MOD_075 :=__________
MOD_076 :=__________
MOD_077 :=__________
MOD_078 :=__________
MOD_079 :=__________
MOD_080 :=__________
MOD_081 :=__________
MOD_082 :=__________
MOD_083 :=__________
MOD_084 :=__________
MOD_085 :=__________
MOD_086 :=__________
MOD_087 :=__________
MOD_088 :=__________
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MOD_102 :=__________
MOD_103 :=__________
MOD_104 :=__________
MOD_105 :=__________
MOD_106 :=__________
MOD_107 :=__________
MOD_108 :=__________
MOD_109 :=__________
MOD_110 :=__________
MOD_111 :=__________
MOD_112 :=__________
MOD_113 :=__________
MOD_114 :=__________
MOD_115 :=__________
MOD_116 :=__________
MOD_117 :=__________
MOD_118 :=__________
MOD_119 :=__________
MOD_120 :=__________
MOD_121 :=__________
MOD_122 :=__________
MOD_123 :=__________
MOD_124 :=__________
MOD_125 :=__________

DNP3 Map Settings (SET DNP n Command)

(Hidden if DNP Option Not Included)

Use SET DNP *n* command with *n* = 1, 2, or 3 to create as many as three DNP User Maps. Refer to *Appendix D: DNP3 Communications* for details. This is DNP Map 1 (DNP Map 2 and DNP Map 3 tables are identical to DNP Map 1 table).

Binary Input Map

DNP Binary Input Label Name (10 characters)

BI_00 :=____________________
BI_01 :=____________________
BI_02 :=____________________
BI_03 :=____________________
BI_04 :=____________________
BI_05 :=____________________
BI_06 :=____________________
BI_07 :=____________________
BI_08 :=____________________
BI_09 :=____________________
BI_10 :=____________________
BI_11 :=____________________
BI_12 :=____________________
BI_13 :=____________________
BI_14 :=____________________
BI_15 :=____________________
BI_16 :=____________________
BI_17 :=____________________
BI_18 :=____________________
BI_19 :=____________________
BI_20 :=____________________
BI_21 :=____________________
BI_22 :=____________________
BI_23 :=____________________
BI_24 :=____________________
BI_25 :=____________________
BI_26 :=____________________
BI_27 :=____________________
BI_28 :=____________________
BI_29 :=____________________
BI_30 :=____________________
BI_31 :=____________________
BI_32 :=____________________
BI_33 :=____________________
BI_34 :=____________________
BI_35 :=____________________
BI_36 :=____________________
BI_37 :=____________________
BI_38 :=____________________
BI_39 :=____________________
BI_40 :=____________________
BI_41 :=____________________
BI_42 :=____________________
BI_43 :=____________________
BI_44 :=____________________
BI_45 :=____________________
BI_46 :=____________________
BI_47 :=____________________
BI_48 :=____________________
BI_49 :=____________________
BI_50 :=____________________
BI_51 :=____________________
BI_52 :=____________________
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BI_54 :=____________________
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BI_56 :=____________________
BI_57 :=____________________
BI_58 :=____________________
BI_59 :=____________________
BI_60 :=____________________
BI_61 :=____________________
BI_62 :=____________________
BI_63 :=____________________
BI_64 :=____________________
BI_65 :=____________________
BI_66 :=____________________
BI_67 :=____________________

BI_68 :=____

BI_69 :=____

BI_70 :=____

BI_71 :=____

BI_72 :=____

BI_73 :=____

BI_74 :=____

BI_75 :=____

BI_76 :=____

BI_77 :=____

BI_78 :=____

BI_79 :=____

BI_80 :=____

BI_81 :=____

BI_82 :=____

BI_83 :=____

BI_84 :=____

BI_85 :=____

BI_86 :=____

BI_87 :=____

BI_88 :=____

BI_89 :=____

BI_90 :=____

BI_91 :=____

BI_92 :=____

BI_93 :=____

BI_94 :=____

BI_95 :=____

BI_96 :=____

BI_97 :=____

BI_98 :=____

BI_99 :=____

Binary Output Map

DNP Binary Output Label Name (10 characters)

BO_00 :=____

BO_01 :=____

BO_02 :=____

BO_03 :=____

BO_04 :=____

BO_05 :=____

BO_06 :=____

BO_07 :=____

BO_08 :=____

BO_09 :=____

BO_ 10 :=____

BO_ 11 :=____

BO_ 12 :=____

BO_ 13 :=____

BO_ 14 :=____

BO_ 15 :=____

BO_ 16 :=____

BO_ 17 :=____

BO_ 18 :=____

BO_ 19 :=____

BO_ 20 :=____

BO_ 21 :=____

BO_ 22 :=____

BO_ 23 :=____

BO_ 24 :=____

BO_ 25 :=____

BO_ 26 :=____

BO_ 27 :=____

BO_ 28 :=____

BO_ 29 :=____

BO_ 30 :=____

BO_ 31 :=____

Analog Input Map

DNP Analog Input Label Name (24 characters)

AI_00 :=________________
AI_01 :=________________
AI_02 :=________________
AI_03 :=________________
AI_04 :=________________
AI_05 :=________________
AI_06 :=________________
AI_07 :=________________
AI_08 :=________________
AI_09 :=________________
AI_10 :=________________
AI_11 :=________________
AI_12 :=________________
AI_13 :=________________
AI_14 :=________________
AI_15 :=________________
AI_16 :=________________
AI_17 :=________________
AI_18 :=________________
AI_19 :=________________
AI_20 :=________________
AI_21 :=________________
AI_22 :=________________
AI_23 :=________________
AI_24 :=________________
AI_25 :=________________
AI_26 :=________________
AI_27 :=________________
AI_28 :=________________
AI_29 :=________________
AI_30 :=________________
AI_31 :=________________
AI_32 :=________________
AI_33 :=________________
AI_34 :=________________
AI_35 :=________________
AI_36 :=________________
AI_37 :=________________
AI_38 :=________________
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AI_40 :=________________
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AI_85 :=______________________________

AI_86 :=______________________________

AI_87 :=______________________________

AI_88 :=______________________________

AI_89 :=______________________________

AI_90 :=______________________________

AI_91 :=______________________________

AI_92 :=______________________________

AI_93 :=______________________________

AI_94 :=______________________________

AI_95 :=______________________________

AI_96 :=______________________________

AI_97 :=______________________________

AI_98 :=______________________________

AI_99 :=______________________________

Analog Output Map

DNP Analog Output Label Name (6 characters)

AO_00 :=______________________________

AO_01 :=______________________________

AO_02 :=______________________________

AO_03 :=______________________________

AO_04 :=______________________________

AO_05 :=______________________________

AO_06 :=______________________________

AO_07 :=______________________________

AO_08 :=______________________________

AO_09 :=______________________________

AO_10 :=______________________________

AO_11 :=______________________________

AO_12 :=______________________________

AO_13 :=______________________________

AO_14 :=______________________________

AO_15 :=______________________________

AO_16 :=______________________________

AO_17 :=______________________________

AO_18 :=______________________________

AO_19 :=______________________________

AO_20 :=______________________________

AO_21 :=______________________________

AO_22 :=______________________________

AO_23 :=______________________________

AO_24 :=______________________________

AO_25 :=______________________________

AO_26 :=______________________________

AO_27 :=______________________________

AO_28 :=______________________________

AO_29 :=______________________________

AO_30 :=______________________________

AO_31 :=______________________________

Counter Map

DNP Counter Label Name (11 characters)

CO_00 :=________________

CO_01 :=________________

CO_02 :=________________

CO_03 :=________________

CO_04 :=________________

CO_05 :=________________

CO_06 :=________________

CO_07 :=________________

CO_08 :=________________

CO_09 :=________________

CO_10 :=________________

CO_11 :=________________

CO_12 :=________________

CO_13 :=________________

CO_14 :=________________

CO_15 :=________________

CO_16 :=________________

CO_17 :=________________

CO_18 :=________________

CO_19 :=________________

CO_20 :=________________

CO_21 :=________________

CO_22 :=________________

CO_23 :=________________

CO_24 :=________________

CO_25 :=________________

CO_26 :=________________

CO_27 :=________________

CO_28 :=________________

CO_29 :=________________

CO_30 :=________________

CO_31 :=________________

IEC 60870-5-103 Map Settings (SET I Command)

(Hidden if the IEC 60870-5-103 option is not included)
Use the SET I command to input the map required for the IEC 60870-5-103 protocol.

Binary Input Map

103BI00 :=________________

103BI01 :=________________

103BI02 :=________________

103BI03 :=________________

103BI04 :=________________

103BI05 :=________________

103BI06 :=________________

103BI07 :=________________

103BI08 :=________________

103BI09 :=________________

103BI10 :=________________

103BI11 :=________________

103BI12 :=________________

103BI13 :=________________

103BI14 :=________________

103BI15 :=________________

103BI16 :=________________

103BI17 :=________________

103BI18 :=________________

103BI19 :=________________

103BI20 :=________________

103BI21 :=________________

103BI22 :=________________

103BI23 :=________________

103BI24 :=________________

103BI25 :=________________

103BI26 :=________________

103BI27 :=________________

103BI28 :=________________

103BI29 :=________________

103BI30 :=________________

103BI31 :=________________

103BI32 := ____________________
103BI33 := ____________________
103BI34 := ____________________
103BI35 := ____________________
103BI36 := ____________________
103BI37 := ____________________
103BI38 := ____________________
103BI39 := ____________________
103BI40 := ____________________
103BI41 := ____________________
103BI42 := ____________________
103BI43 := ____________________
103BI44 := ____________________
103BI45 := ____________________
103BI46 := ____________________
103BI47 := ____________________
103BI48 := ____________________
103BI49 := ____________________
103BI50 := ____________________
103BI51 := ____________________
103BI52 := ____________________
103BI53 := ____________________
103BI54 := ____________________
103BI55 := ____________________
103BI56 := ____________________
103BI57 := ____________________
103BI58 := ____________________
103BI59 := ____________________
103BI60 := ____________________
103BI61 := ____________________
103BI62 := ____________________
103BI63 := ____________________
103BI64 := ____________________
103BI65 := ____________________
103BI66 := ____________________
103BI67 := ____________________
103BI68 := ____________________
103BI69 := ____________________
103BI70 := ____________________
103BI71 := ____________________
103BI72 := ____________________
103BI73 := ____________________
103BI74 := ____________________
103BI75 := ____________________
103BI76 := ____________________
103BI77 := ____________________
103BI78 := ____________________
103BI79 := ____________________
103BI80 := ____________________
103BI81 := ____________________
103BI82 := ____________________
103BI83 := ____________________
103BI84 := ____________________
103BI85 := ____________________
103BI86 := ____________________
103BI87 := ____________________
103BI85 := ____________________
103BI88 := ____________________
103BI89 := ____________________
103BI90 := ____________________
103BI91 := ____________________
103BI92 := ____________________
103BI93 := ____________________
103BI94 := ____________________
103BI95 := ____________________
103BI96 := ____________________
103BI97 := ____________________
103BI98 := ____________________
103BI99 := ____________________

Binary Target Map

103BT00 := ____________________
103BT01 := ____________________
103BT02 := ____________________
103BT03 := ____________________
103BT04 := ____________________
103BT05 := ____________________
103BT06 := ____________________
103BT07 := ____________________

Fault Analog Map

103FA00 := ____________________
103FA01 := ____________________
103FA02 := ____________________
103FA03 := ____________________
103FA04 := ____________________
103FA05 := ____________________
103FA06 := ____________________
103FA07 := ____________________
103FA08 := ____________________
103FA09 := ____________________
103FA10 := ____________________
103FA11 := ____________________
103FA12 := ____________________
103FA13 := ____________________
103FA14 := ____________________
103FA15 := ____________________
103FA16 := ____________________
103FA17 := ____________________
103FA18 := ____________________
103FA19 := ____________________
103FA20 := ____________________
103FA21 := ____________________
103FA22 := ____________________
103FA23 := ____________________
103FA24 := ____________________
103FA25 := ____________________
103FA26 := ____________________
103FA27 := ____________________
103FA28 := ____________________
103FA29 := ____________________
103FA30 := ____________________
103FA31 := ____________________

Binary Control Map

103BO00 := ____________________
103BO01 := ____________________
103BO02 := ____________________
103BO03 := ____________________
103BO04 := ____________________
103BO05 := ____________________
103BO06 := ____________________
103BO07 := ____________________
103BO08 := ____________________
103BO09 := ____________________
103BO10 := ____________________
103BO11 := ____________________
103BO12 := ____________________
103BO13 := ____________________
103BO14 := ____________________
103BO15 := ____________________
103BO16 := ____________________
103BO17 := ____________________
103BO18 := ____________________
103BO19 := ____________________
103BO20 := ____________________
103BO21 := ____________________
103BO22 := ____________________
103BO23 := ____________________
103BO24 := ____________________
103BO25 := ____________________

103BO26 := ________________

103BO27 := ________________

103BO28 := ________________

103BO29 := ________________

103BO30 := ________________

103BO31 := ________________

Measurand Map

3MLB000 := ________________

3MLB001 := ________________

3MLB002 := ________________

3MLB003 := ________________

3MLB004 := ________________

3MLB005 := ________________

3MLB006 := ________________

3MLB007 := ________________

3MLB008 := ________________

3MLB009 := ________________

3MLB010 := ________________

3MLB011 := ________________

3MLB012 := ________________

3MLB013 := ________________

3MLB014 := ________________

3MLB015 := ________________

3MLB016 := ________________

3MLB017 := ________________

3MLB018 := ________________

3MLB019 := ________________

3MLB020 := ________________

3MLB021 := ________________

3MLB022 := ________________

3MLB023 := ________________

3MLB024 := ________________

3MLB025 := ________________

3MLB026 := ________________

3MLB027 := ________________

3MLB028 := ________________

3MLB029 := ________________

3MLB030 := ________________

3MLB031 := ________________

3MLB032 := ________________

3MLB033 := ________________

3MLB034 := ________________

3MLB035 := ________________

3MLB036 := ________________

3MLB037 := ________________

3MLB038 := ________________

3MLB039 := ________________

3MLB040 := ________________

3MLB041 := ________________

3MLB042 := ________________

3MLB043 := ________________

3MLB044 := ________________

3MLB045 := ________________

3MLB046 := ________________

3MLB047 := ________________

3MLB048 := ________________

3MLB049 := ________________

3MLB050 := ________________

EtherNet/IP Assembly Map Settings (SET E Command)

EtherNet/IP Assembly Map

(See Appendix F: EtherNet/IP Communications for additional details)
(EtherNet/IP Assembly Map settings are hidden if EtherNet/IP is not included)
(Use SET E n command where n = 1, 2, or 3 to create as many as three EtherNet/IP Assembly Maps)
(This is EtherNet/IP Assembly Map 1 (EtherNet/IP Assembly Map 2 and EtherNet/IP Assembly Map 3 are identical to EtherNet/IP Assembly Map 1))

Input Assembly (IA) Binary

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_00** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_01** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_02** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_03** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_04** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_05** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_06** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_07** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_08** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_09** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_10** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_11** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_12** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_13** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_14** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_15** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_16** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_17** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_18** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_19** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_20** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_21** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_22** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_23** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_24** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_25** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_26** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_27** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_28** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_29** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_30** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_31** := ________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_32** := ________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_33** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_34** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_35** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_36** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_37** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_38** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_39** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_40** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_41** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_42** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_43** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_44** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_45** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_46** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_47** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_48** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_49** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_50** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_51** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_52** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_53** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_54** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_55** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_56** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_57** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_58** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_59** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_60** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_61** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_62** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_63** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_64** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_65** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_66** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_67** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_68** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_69** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_70** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_71** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_72** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_73** := ______
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_74** := ______

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_75** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_76** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_77** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_78** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_79** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_80** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_81** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_82** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_83** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_84** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_85** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_86** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_87** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_88** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_89** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_90** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_91** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_92** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_93** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_94** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_95** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_96** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_97** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_98** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_99** := ______________

Input Assembly (IA) Analog

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_00** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_01** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_02** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_03** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_04** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_05** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_06** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_07** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_08** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_09** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_10** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_11** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_12** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_13** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_14** := ______________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_15** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_16** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_17** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_18** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_19** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_20** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_21** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_22** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_23** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_24** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_25** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_26** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_27** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_28** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_29** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_30** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_31** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_32** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_33** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_34** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_35** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_36** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_37** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_38** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_39** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_40** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_41** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_42** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_43** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_44** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_45** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_46** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_47** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_48** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_49** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_50** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_51** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_52** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_53** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_54** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_55** := ______________
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_56** := ______________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_57** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_58** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_59** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_60** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_61** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_62** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_63** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_64** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_65** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_66** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_67** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_68** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_69** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_70** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_71** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_72** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_73** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_74** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_75** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_76** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_77** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_78** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_79** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_80** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_81** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_82** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_83** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_84** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_85** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_86** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_87** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_88** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_89** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_90** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_91** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_92** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_93** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_94** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_95** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_96** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_97** := ______
EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_98** := ______

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_99** := ____________

Output Assembly (OA) Binary

EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_00** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_01** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_02** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_03** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_04** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_05** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_06** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_07** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_08** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_09** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_10** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_11** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_12** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_13** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_14** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_15** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_16** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_17** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_18** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_19** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_20** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_21** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_22** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_23** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_24** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_25** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_26** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_27** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_28** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_29** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_30** := ____________
EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_31** := ____________

Output Assembly (OA) Analog

EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **OAA_00** := ____________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **OAA_01** := ____________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **OAA_02** := ____________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **OAA_03** := ____________

EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_04** := ________________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_05** := ________________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_06** := ________________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_07** := ________________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_08** := ________________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_09** := ________________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_10** := ________________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_11** := ________________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_12** := ________________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_13** := ________________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_14** := ________________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_15** := ________________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_16** := ________________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_17** := ________________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_18** := ________________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_19** := ________________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_20** := ________________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_21** := ________________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_22** := ________________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_23** := ________________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_24** := ________________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_25** := ________________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_26** := ________________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_27** := ________________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_28** := ________________
EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_29** := ________________

EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **OAA_30** := ______________________

EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **OAA_31** := ______________________

Section 7
Communications

Overview

A communications interface and protocol are necessary for communicating with an SEL-700G Relay. A communications interface is the physical connection on a device. Once you have established a physical connection, you must use a communications protocol to interact with the relay.

The first part of this section describes communications interfaces and protocols available with the relay, including communications interface connections. The remainder of the section describes the ASCII commands you can use to communicate with the relay to obtain information, reports, and data to perform control functions.

Communications Interfaces

The SEL-700G physical interfaces are shown in *Table 7.1*. Several optional SEL devices are available to provide alternative physical interfaces. These include EIA-485, EIA-232, fiber-optic serial port, and copper or fiber Ethernet port (which can be either single or dual redundant).

Table 7.1 SEL-700G Communications Port Interfaces

	Communications Port Interfaces	Location	Feature
PORT F	EIA-232	Front	Standard
PORT 1	Option 1: 10/100BASE-T Ethernet (RJ45 connector) Option 2: Dual, redundant 10/100 BASE-T Ethernet (Port 1A, Port 1B) Option 3: 100BASE-FX Ethernet (LC connector) Option 4: Dual, redundant 100BASE-FX Ethernet (Port 1A, Port 1B)	Rear	Ordering Option
PORT 2[a]	Multimode Fiber-Optic Serial (ST connector)	Rear	Standard
PORT 3[b]	Option 1: EIA-232 Option 2: EIA-485	Rear	Ordering Option
PORT 4	Option 1: EIA-232 or EIA-485 Serial Communications Card Option 2: DeviceNet Communications Card[c]	Rear	Ordering Option

[a] This port can receive the RTD measurement information OR the field ground insulation resistance measurement from an optional external SEL-2600 RTD Module or SEL-2664 Field Ground Module. Refer to the SEL-2600 RTD Module or SEL-2664 Field Ground Module Instruction Manual for information on the fiber-optic interface. The SEL-2600 RTD Module requires the PROTO setting to be set to SEL protocol at a data rate of 2400 bps, and the SEL-2664 Field Ground Module requires the PROTO setting to be set to SEL protocol at a data rate of 9600 bps.
[b] Connect the SEL-2664 Field Ground Module on the EIA-232 port using an SEL-2812M or SEL-2814M for ST connectors; or connect the SEL-2664 Field Ground Module on the EIA-485 port using an SEL-2824 Fiber-Optic Transceiver for ST connectors. In either case, the SEL-2664 requires the PROTO setting to be set to SEL Protocol at a data rate of 9600 bps.
[c] Refer to Appendix I: DeviceNet Communications for information on the DeviceNet communications card.

Be sure to evaluate the installation and communications necessary to integrate with existing devices before ordering your SEL-700G. For example, consider the fiber-optic interface in noisy installations or for large communications distances. Following is general information on possible applications of the different interfaces.

Serial (EIA-232 and EIA-485) Port

Use the EIA-232 port for communications distances of as far as 15 m (49 ft) in low noise environments. Use the optional EIA-485 port for communications distances as far as 1200 m (3937 ft) maximum distance (to achieve this performance, ensure proper line termination at the receiver).

To connect a PC serial port to the relay front-panel serial port and enter relay commands, you need the following:

- ➤ A personal computer equipped with one available EIA-232 serial port
- ➤ A communications cable to connect the computer serial port to the relay serial ports
- ➤ Terminal emulation software to control the computer serial port
- ➤ An SEL-700G Relay

Some of the SEL devices available for integration or communication system robustness are included in the following list:

- ➤ SEL communications processors (SEL-2032, SEL-2030, SEL-2020), SEL-3530 Real-Time Automation Controller (RTAC)
- ➤ SEL-2800 series fiber-optic transceivers
- ➤ SEL-2890 Ethernet Transceiver
- ➤ SEL-3010 Event Messenger
- ➤ SEL-2505 Remote I/O Module (with SEL-2812 compatible ST fiber-optic port) for connection to relay fiber-optic serial Port 2, or use SEL-2505 with EIA-232 (DB-9) serial port to connect to EIA-232 Port 3 on the relay

A variety of terminal emulation programs on personal computers can communicate with the relay. For the best display, use VT-100 terminal emulation or the closest variation.

The default settings for all EIA-232 serial ports are listed below:

Data Rate = 9600
Data Bits = 8
Parity = N
Stop Bits = 1

To change the port settings, use the **SET P** command (see *Section 6: Settings*) or the front panel. *Section 8: Front-Panel Operations* provides details on making settings with the front panel.

Hardware Flow Control

All EIA-232 serial ports support RTS/CTS hardware handshaking (hardware flow control). To enable hardware handshaking, use the **SET P** command or front-panel PORT submenu to set RTSCTS = Y. Disable hardware handshaking by setting RTSCTS := N.

- ➤ If RTSCTS := N, the relay permanently asserts the RTS line.
- ➤ If RTSCTS := Y, the relay deasserts RTS when it is unable to receive characters.
- ➤ If RTSCTS := Y, the relay does not send characters until the CTS input is asserted.

Fiber-Optic Serial Port

Use the optional fiber-optic port (Port 2) for safety and communications distances as far as 1 km. Communications distances as far as 4 km can be achieved by using an SEL-2812 transceiver on Port 3. While Port 2 and the SEL-2812 are compatible, Port 2 is less sensitive than the SEL-2812, which limits the distance to 1 km. This port can receive the RTD measurement information from the optional external SEL-2600 RTD module.

Telnet or the Web Server

Factory-default settings for the Ethernet ports disable all Ethernet protocols except for Telnet, HTTP, and PING. Command **SET P 1** accesses settings for both Ethernet ports on the SEL-700G: Port 1A and Port 1B. See the Ethernet port settings in *Table 4.84* for a sample of the **SET P 1** command with factory-default settings.

Set the listed settings to the following using the **SET P 1** command:

NOTE: Telnet and the web server work with other NETMODE settings as well, but NETMODE = SWITCHED is the easiest to begin communication. The relay hides setting NETMODE when it is equipped with a single Ethernet port.

- ➤ IPADDR := IP address assigned by the network administrator
- ➤ DEFRTR := Default router IP address assigned by the network administrator
- ➤ NETMODE := SWITCHED (available with dual Ethernet ports)
- ➤ ETELNET := Y
- ➤ EHTTP := Y

Leave all other settings at their default values.

Connect an Ethernet cable between your PC or a network switch and any Ethernet port on the relay. Verify that the amber **Link** LED illuminates on the connected relay port. Many computers and most Ethernet switches support autocrossover, so nearly any Cat 5 Ethernet cable with RJ45 connectors, such as an SEL-C627 cable, will work. If the computer does not support autocrossover, use a crossover cable, such as an SEL-C628 cable. If your relay is equipped with dual Ethernet ports, connect to either port. Use a Telnet application of QuickSet on the host PC to communicate with the relay. To terminate a Telnet session, use the command **EXI** from any access level.

In addition, you can communicate with the relay through your web browser. Launch a web browser and go to http://IPADDR or https://IPADDR for nonsecure or secure HTTP communication, respectively, where IPADDR is the Port 1 IPADDR setting.

To terminate the session, close the web browser (see *Section 3: PC Interface* for more details).

Ethernet Port

Use the Ethernet port for interfacing with an Ethernet network environment. SEL-700G Ethernet port choices include single or dual copper or fiber-optic configurations. With dual Ethernet ports, the unit has an unmanaged Ethernet switch. Redundant configurations support automatic failover switching from primary to backup network if the relay detects a failure in the primary network. The basic concept in the Parallel Redundancy Protocol (PRP) mode of operation is that the Ethernet network and all traffic are fully duplicated, with the two copies operating in parallel. The purpose of the protocol is to provide seamless recovery from any single Ethernet network failure. In addition to failover and PRP modes, the unit can operate in a "fixed connection (to netport) mode" or in a "switched mode" (as an unmanaged switch).

Carefully design your Ethernet network to maximize reliability, minimize system administrator efforts, and provide adequate security. SEL recommends that you work with a networking profession to design your substation Ethernet network.

Several settings control how the relay with the optional Ethernet card operates on an Ethernet network. These settings include IP addressing information, network port failover options, and network speed.

Use the network configuration settings shown in *Table 4.84* to configure the relay for operation on an IP network and to set other parameters affecting the physical Ethernet network interface operation.

Figure 7.1 shows an example of a Simple Ethernet Network Configuration, *Figure 7.2* shows an example of an Ethernet Network Configuration with Dual Redundant Connections, and *Figure 7.3* shows an example of an Ethernet Network Configuration with Ring Structure.

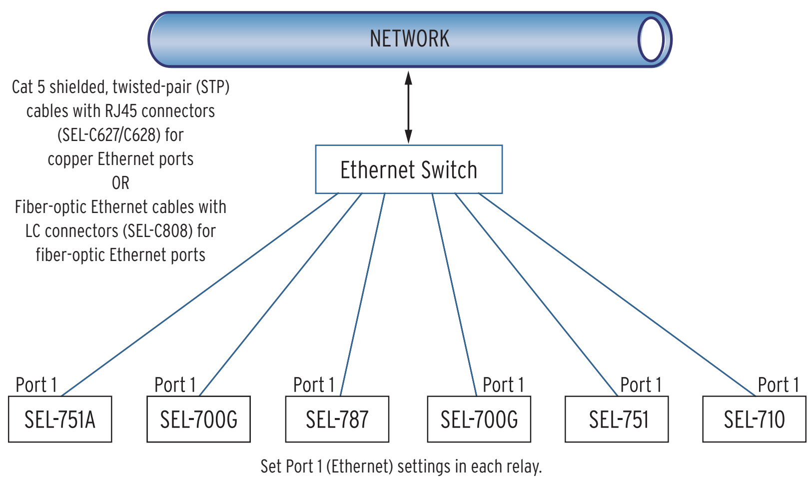


Figure 7.1 Simple Ethernet Network Configuration

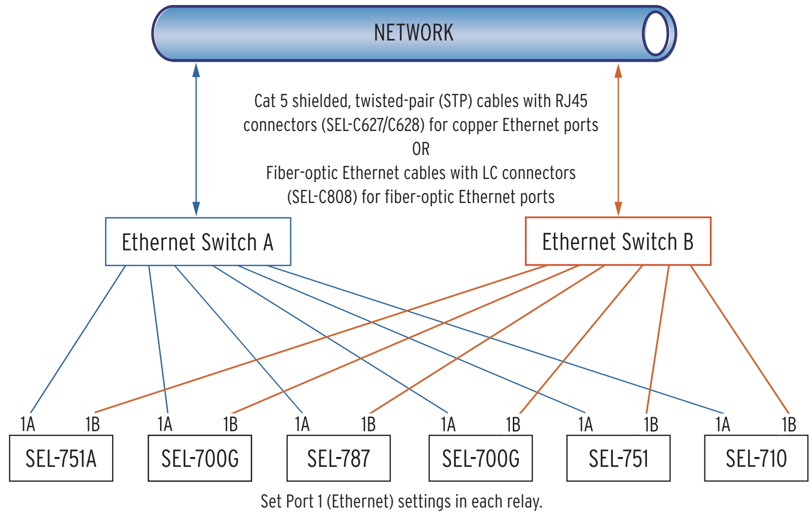


Figure 7.2 Ethernet Network Configuration With Dual Redundant Connections (Failover Mode)

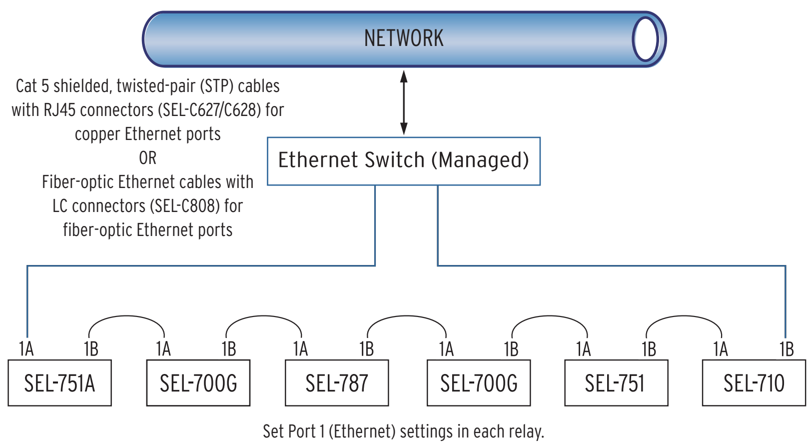


Figure 7.3 Ethernet Network Configuration With Ring Structure (Switched Mode)

Dual Network Port Operation

The SEL-700G dual Ethernet port option has two network ports. Network port failover mode enables the dual Ethernet port to operate as a single network adapter with a primary and standby physical interface. You can connect the two network ports to the same network or to different networks, depending on your specific Ethernet network architecture.

Failover Mode

In the failover mode operation, the relay determines the active port. To use failover mode, proceed with the following steps.

NOTE: If you change settings for the host port in the relay and the standby network port is active, the relay resets and returns to operation on the primary port.

Step 1. Set NETMODE to FAILOVER.

Step 2. Set FTIME to the desired network port failover time (0.10–65.00 s or OFF).

Step 3. Set NETPORT to the network interface you want.

On startup, the relay communicates via NETPORT (primary port) selected. If the SEL-700G detects a link failure on the primary port, it activates the standby port after the failover time, FTIME, elapses. If the link status on the primary link returns to normal before the failover time expires, the failover timer resets and uninterrupted operation continues on the primary network port.

Setting FTIME = OFF allows fast port switching (with no intentional delay). Fast port switching can occur within one processing interval (typically 4 ms to 5 ms) and can help with IEC 61850 GOOSE performance.

After failover, while communicating via the standby port, the SEL-700G checks the primary link periodically and continues checking until it detects a normal link status. The relay continues to communicate via the standby port even after the primary port returns to normal. The relay reevaluates the port of choice for communication upon a change of settings, a failure of the standby port, or a reboot. The relay returns to operation on the primary link under those conditions if it detects a normal link status. When the active and backup links both fail, the relay alternately checks the link status of the primary and standby ports.

Switched Mode

If you have a network configuration where you want to use the relay as an unmanaged or managed switch, set NETMODE to SWITCHED. Set ERSTP := to use it as a managed switch. In SWITCHED mode, both links are enabled. The relay responds to the messages it receives on either port. All the messages received on one network port that are not addressed to the relay are transmitted out of the other port without any modifications. In this mode, the relay ignores the NETPORT setting.

SWITCHED mode is often used to connect several relays to each other, creating a network of relays, then connecting at least two relays to a managed switch for redundancy. This configuration is popular because it reduces cost and reduces the number of devices in a network without sacrificing redundancy. Basically, each relay has a redundant path to the network. Refer to *Figure 7.3*.

There are compromises to be made in this configuration, however. When connecting cables between multiple switches in an Ethernet network, physical loops (rings) may occur that cause traffic storms, total bandwidth consumption, and other improper functioning. As a result, a subset of the relays in this configuration can seem unresponsive for extended periods of time.

For example, in *Figure 7.3*, imagine that a DNP master is receiving DNP UDP unsolicited messages from the relays. When a link is broken, it can sometimes take as long as 5 minutes for communications to be restored. For a similar network involving IEC 61850 GOOSE and a broken link, the restoration time can be greater than 5 seconds. The relay offers Rapid Spanning Tree Protocol (RSTP) mode to improve restoration times in such configurations. With RSTP enabled, the expected restoration time of the before-mentioned GOOSE network is around 100 ms.

RSTP protocol controls active paths in an Ethernet network to avoid loops and enable a level of redundancy. All Port 1 protocols are supported when RSTP is enabled. Refer to *Rapid Spanning Tree Protocol (RSTP) on page 7.22* for additional details.

Fixed Connection Mode

If you have a single network and want to use only one network port, or if you have both ports connected but want to force usage of only one port for various reasons, set NETMODE to FIXED and set NETPORT to the port you want to use. Only the selected network port operates, and the other port is disabled.

PRP Connection Mode

Parallel Redundancy Protocol (PRP) is part of an IEC standard for high-availability automation networks (IEC 62439-3). The purpose of the protocol is to provide seamless recovery from any single Ethernet network failure.

The basic concept is that the Ethernet network and all traffic are fully duplicated with the two copies operating in parallel.

Make the following settings for Port 1 to configure the relay for PRP mode.

- ➤ NETMODE = PRP
- ➤ PRPTOUT = desired timeout for PRP frame entry
- ➤ PRPADDR = PRP destination MAC address LSB (least significant byte of "01-15-4E-00-01-*XX*," converted to decimal and entered as 0–255)
- ➤ PRPINTV = desired supervision frame transmit interval

When NETMODE is not set to PRP, the settings shown in *Table 7.2* are hidden.

Table 7.2 PRP Settings

Setting Prompt	Setting Description	Setting Range	Setting Name := Factory Default
PRP ENTRY TIMEOUT	PRP Entry Timeout	400–10000 ms	PRPTOUT := 500
PRP DESTINATION ADDR LSB	The multicast MAC address of PRP supervision frames is 01-15-4E-00-01-*XX* where *XX* is specified by this setting in decimal notation as 0–255	0–255	PRPADDR := 0
PRP SUPERVISION TX INTERVAL	PRP Supervision TX Interval	1–10 s	PRPINTV := 2

Autonegotiation, Speed, and Duplex Mode

Single or dual copper Ethernet ports autonegotiate to determine the link speed and duplex mode. Accomplish this by setting the NETASPD and NETBSPD (network speed) to AUTO. You can apply single or dual copper ports in networks with older switch devices by setting these ports to specific speeds. However, the relay ignores speed settings for fiber Ethernet ports. The relay hardware fixes the single and dual fiber Ethernet ports to work at 100 Mbps and full duplex mode.

NETPORT Selection

The NETPORT setting gives you the option to select the primary port of communication in failover or fixed communications modes.

TCP Keep Alive

NOTE: The ETCPKA setting applies to all TCP traffic on Ethernet ports, including Telnet, FTP, IEC 61850, MMS, and C37.118 (PMU). TCP Keep Alive is enabled with default KAIDLE, KAINTV, and KACNT settings for C37.118 (PMU) sessions even when ETCPKA = N.

The ETCPKA setting, along with the KAIDLE, KAINTV, and KACNT settings, can be used to verify that the computer at the remote end of a TCP connection is still available. If ETCPKA is enabled and the relay does not transmit any TCP data within the interval specified by the KAIDLE setting, the relay sends a keep-alive packet to the remote computer. If the relay does not receive a response from the remote computer within the time specified by KAINTV, the keep-alive packet is re-transmitted as many as KACNT times. After this count is reached, the relay considers the remote device no longer available, so the relay terminates the connection without waiting for the idle timer (TIDLE or FTPIDLE) to expire.

The relay monitors MMS inactivity to identify and disconnect MMS clients that have stopped communicating. You can set it from 0 to 4,200,000 seconds via the IED Properties MMS Settings in ACSELERATOR Architect® SEL-5032 Software. The MMS inactivity default value is either 120 seconds or 900 seconds, depending on the relay firmware version. Setting this value to 0 disables the MMS inactivity timer. If enabled, the relay starts a timer for an MMS session after it receives an MMS request from the client on that session. It resets the timer whenever it receives a new MMS request from that client. When the timer runs out, the relay disconnects the MMS session, making it available for other MMS clients.

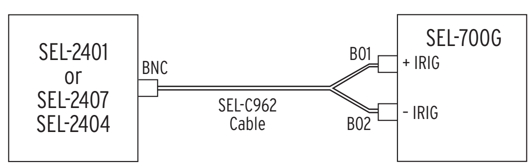
This feature was implemented in addition to the TCP keep-alive timer to specifically handle MMS clients that do not disconnect properly. As there are a limited number of MMS sessions available, this ensures that misbehaving MMS clients do not take up multiple MMS sessions. Note that the MMS inactivity time-out can still disconnect an MMS session even if the relay receives TCP keep-alive messages from that MMS client.

IRIG-B

The SEL-700G has three different physical interfaces, depending on the model options, to provide demodulated IRIG-B time-code input for time synchronization. If the relay has multiple options for IRIG-B input, you can use only one input at a time. Connection diagrams for IRIG-B and settings selection are in *Figure 7.4* through *Figure 7.8* in this section.

Option 1: Terminals B01 and B02

This input is available on all models except models with dual Ethernet Port or Fiber-Optic Ethernet port. Refer to *Figure 7.4* for a connection diagram.



B01–B02 IRIG-B input is available on all models except those with fiber-optic Ethernet or dual-copper Ethernet.

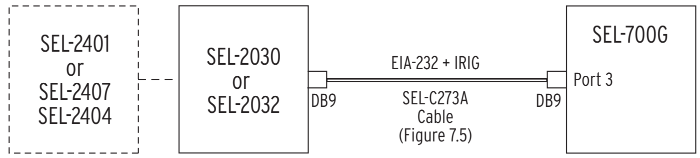
If you use a **B01–B02** input, you cannot bring IRIG-B via Port 2 or 3.

Set Global setting IRIG TIME SOURCE to TIME_SRC := IRIG1.

Figure 7.4 IRIG-B Input (Relay Terminals B01–B02)

Option 2: Port 3 (EIA-232 Option Only)

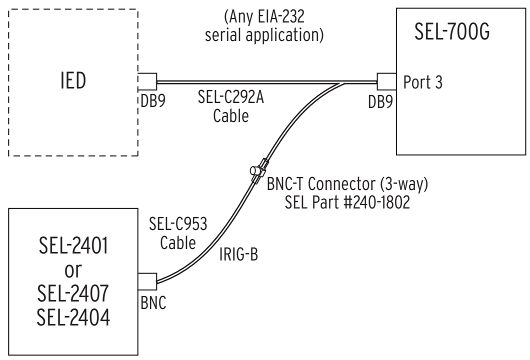
Connect to an SEL communications processor with SEL-C273A Cable to bring IRIG-B input with the EIA-232 Port. Refer to *Figure 7.5* for a connection diagram. Refer to *Figure 7.6* on how to connect an SEL Time Source (SEL-2401, SEL-2404, SEL-2407) for IRIG-B Input to Port 3.



If you use Port 3, you cannot use **B01–B02** input or Port 2.

Set Global setting IRIG TIME SOURCE to TIME_SRC := IRIG1.

Figure 7.5 IRIG-B Input Via EIA-232 Port 3 (SEL Communications Processor as Source)



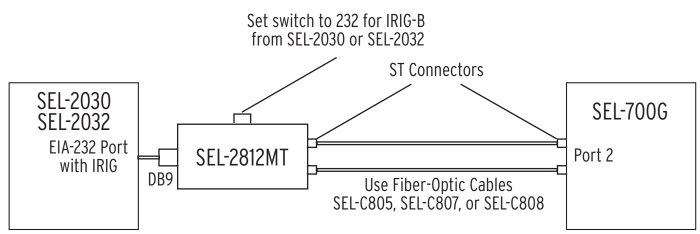
If you use Port 3, you cannot use a **B01–B02** input or Port 2.

Set Global setting IRIG TIME SOURCE to TIME_SRC := IRIG1.

Figure 7.6 IRIG-B Input Via EIA-232 Port 3 (SEL-2401/2404/2407 Time Source)

Option 3: Port 2 (Fiber-Optic Serial Port)

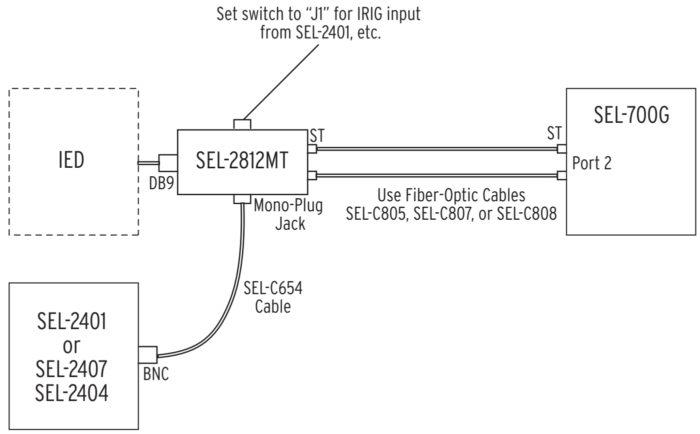
You can use Fiber-Optic Serial Port 2 to bring IRIG-B Input to the relay as shown in *Figure 7.7* and *Figure 7.8*.



If you use Port 2 for IRIG-B input, you cannot use **B01–B02** input or Port 3 input.

Set Global setting IRIG TIME SOURCE to TIME_SRC := IRIG2.

Figure 7.7 IRIG-B Input Via Fiber-Optic EIA-232 Port 2 (SEL-2030/2032 Time Source)



If you use Port 2 for the IRIG-B input, you cannot use a B01–B02 input or Port 3 input.
Set Global setting IRIG TIME SOURCE to TIME_SRC := IRIG2.

Figure 7.8 IRIG-B Input Via Fiber-Optic EIA-232 Port 2 (SEL-2401/2404/2407 Time Source)

+5 Vdc Power Supply

Serial port power can provide as much as 0.25 A total from all of the +5 Vdc pins. Some SEL communications devices require the +5 Vdc power supply. This +5 Vdc is available on Pin 1 only on EIA-232 Port 3 and EIA-232 Port 4 (if available).

Connect Your PC to the Relay

The front port of the SEL-700G is a standard female 9-pin connector with pin numbering shown in *Figure 7.9*. The pinout assignments for this port are shown in *Table 7.3*. You can connect to a standard 9-pin computer port with an SEL-C234A Cable; wiring for this cable is shown in *Figure 7.10*. The SEL-C234A Cable and other cables are available from SEL. Use the SEL-5801 Cable Selector Software to select an appropriate cable for another application. This software is available for free download from the SEL website at selinc.com.

For best performance, the SEL-C234A Cable should be no more than 15 m (49 ft) long. For long-distance communications and for electrical isolation of communications ports, use the SEL family of fiber-optic transceivers. Contact SEL for more details on these devices.

Port Connector and Communications Cables

Figure 7.9 shows the front-panel EIA-232 serial port (PORT F) DB-9 connector pinout for the SEL-700G.

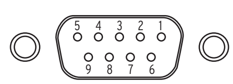


Figure 7.9 EIA-232 DB-9 Connector Pin Numbers

Table 7.3 shows the pin functions for the EIA-232 and EIA-485 serial ports.

Table 7.3 EIA-232/EIA-485 Serial Port Pin Functions

Pin[a]	PORT 3 EIA-232	PORT 3 EIA-485[a]	PORT 4C EIA-232	PORT 4A EIA-485[a]	PORT F EIA-232
1	+5 Vdc	+TX	+5 Vdc	+TX	N/C
2	RXD	–TX	RXD	–TX	RXD
3	TXD	+RX	TXD	+RX	TXD
4	IRIG+	–RX	N/C	–RX	N/C
5	GND	Shield	GND	Shield	GND
6	IRIG –		N/C		N/C
7	RTS		RTS		RTS
8	CTS		CTS		CTS
9	GND		GND		GND

[a] For EIA-485, the pin numbers represent relay terminals _01 through _05.

NOTE: Serial communications cables that are used in the SEL-700G relays for the MIRRORED BITS protocol should have the **R** designation at the end of the SEL cable number instead of an **A**. For example, use C234**R** instead of C234**A**. The SEL-C234**R** cable is double shielded and provides better data integrity than the SEL-C234**A**.

The following cable diagrams show several types of EIA-232 serial communications cables that connect the SEL-700G to other devices. These and other cables are available from SEL. Contact the factory for more information.

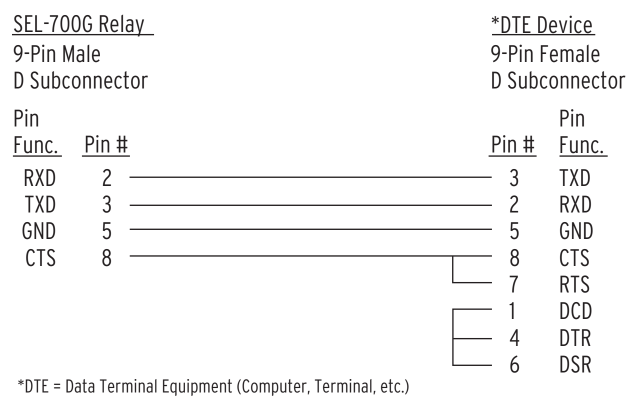


Figure 7.10 SEL-C234A Cable—SEL-700G to DTE Device

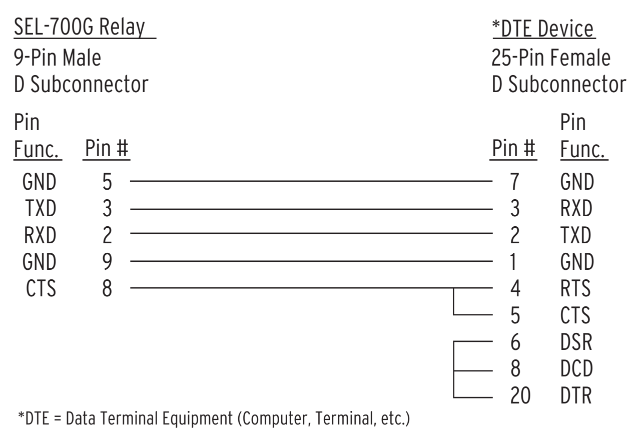


Figure 7.11 SEL-C227A Cable—SEL-700G to DTE Device

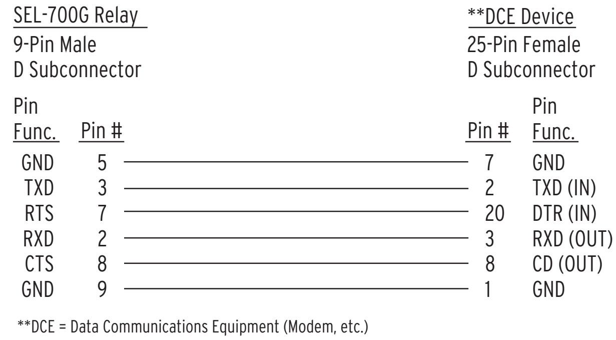


Figure 7.12 SEL-C222 Cable—SEL-700G to Modem

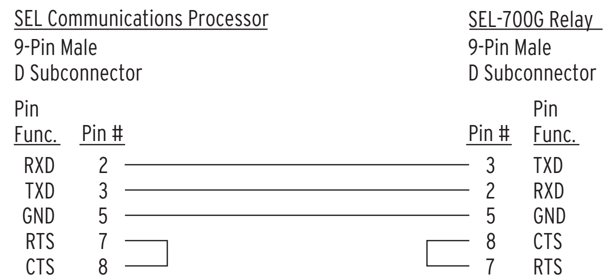


Figure 7.13 SEL-C272A Cable—SEL-700G to SEL Communications Processor (Without IRIG-B Signal)

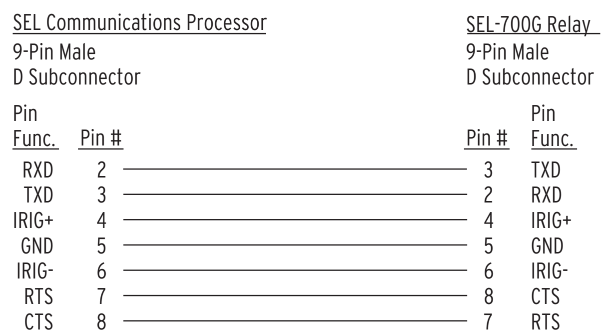


Figure 7.14 SEL-C273A Cable—SEL-700G to SEL Communications Processor (With IRIG-B Signal)

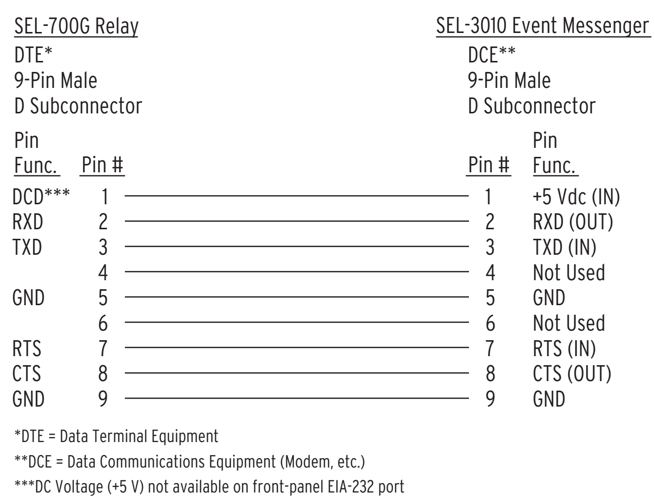


Figure 7.15 SEL-C387 Cable—SEL-700G to SEL-3010

Communications Protocols

Protocols

Although the SEL-700G supports a wide range of protocols, not all protocols are available on all ports. In addition, not all hardware options support all protocols.

Be sure to select the correct hardware to support a particular protocol. For example, if Modbus TCP is necessary for your application, be sure to order the Ethernet option for **Port 1**. *Table 7.4* shows the ports and the protocols available on each port.

NOTE: FTP, Modbus, and DeviceNet protocols ignore the hide rules of the settings.

Table 7.4 Protocols Supported on the Various Ports

PORT	Supported Protocol
PORT F	SEL ASCII and Compressed ASCII Protocols, SELBOOT, File Transfer Protocol, Modbus RTU Slave, C37.118 Protocol (synchrophasor data), and Event Messenger
PORT 1[a]	Modbus TCP/IP, FTP, TCP/IP, IEC 61850, SNTP, PTP, DNP3 LAN/WAN, and Telnet TCP/IP (SEL ASCII, Compressed ASCII), SEL Fast Meter, SEL Fast Operate, SEL Fast SER, C37.118 Protocol (synchrophasor data), web server (HTTP), PRP, and RSTP
PORT 2	SEL ASCII and Compressed ASCII Protocols, SEL Fast Meter, SEL Fast Operate, SEL Fast SER, SEL Settings File Transfer, SEL MIRRORED BITS, DNP3, IEC 60870-5-103, Modbus RTU Slave, C37.118 Protocol (synchrophasor data), and Event Messenger
PORT 3	All the protocols supported by **Port 2**
PORT 4	All the protocols supported by **Port 2** or DeviceNet

[a] PORT 1 concurrently supports two Modbus, five DNP3 LAN/WAN, two FTP, two Telnet, two C37.118 Protocol, one SNTP, one PTP, and seven IEC 61850 sessions, as well as two EIP I/O connections and six EIP message connections.

SEL Communications Protocols

SEL ASCII

This protocol is described in *SEL ASCII Protocol and Commands on page 7.25*.

SEL Compressed ASCII

This protocol provides compressed versions of some of the ASCII commands. The compressed commands are described in *SEL ASCII Protocol and Commands*, and the protocol is described in *Appendix C: SEL Communications Processors*.

SEL Fast Meter

This protocol supports binary messages to transfer metering and digital element messages. Compressed ASCII commands that support Fast Meter are described in *SEL ASCII Protocol and Commands*, and the protocol is described in *Appendix C: SEL Communications Processors*.

SEL Fast Operate

This protocol supports binary messages to transfer operation messages. The protocol is described in *Appendix C: SEL Communications Processors*.

SEL Fast Message

This protocol uses binary messages to receive/transmit data from/to an SEL communications processor. The protocol is described in *Appendix C: SEL Communications Processors*.

SEL Fast SER

This protocol is used to receive binary Sequential Events Record unsolicited responses. The protocol is described in *Appendix C: SEL Communications Processors*.

SEL Event Messenger

This is an SEL ASCII protocol with 8 Data bits, No Parity, and 1 Stop bit for transmitting data to SEL-3010 Event Messenger. You can change only the Communications Speed to match the settings in the SEL-3010.

Other Support Protocols

MIRRORED BITS Protocol

The SEL-700G supports two MIRRORED BITS communications channels, designated A and B. Within each MIRRORED BITS communications message for a given channel (A or B), there are eight logical data channels (1–8). You can, for example, set MBA on Port 3 of the base unit and MBB on Port 4A of the optional communications card. Attempting to set the PROTO setting to MBA, MB8A, or MBTA when channel A is already assigned to another port (or MBB, MB8B, or MBTB when channel B is already assigned on another port) results in the following error message: `This Mirrored Bits channel is assigned to another port`. After displaying the error message, the device returns to the PROTO setting for reentry. The MIRRORED BITS protocol is described in *Appendix J: MIRRORED BITS Communications*.

C37.118 Protocol

The SEL-700G provides C37.118 protocol (synchrophasor data) support at serial Ports **F**, **2**, **3**, or **4**. Additionally, Port **1** allows for two C37.118 protocol sessions. The C37.118 protocol is described in *Appendix K: Synchrophasors*.

Modbus RTU Protocol

The SEL-700G provides Modbus RTU support. Modbus is an optional protocol described in *Appendix E: Modbus Communications*.

Distributed Network Protocol (DNP3)

The SEL-700G provides DNP3 protocol support if the option is selected. The DNP3 protocol is described in *Appendix D: DNP3 Communications*.

DeviceNet Protocol

The SEL-700G provides DeviceNet Support. DeviceNet is an optional protocol described in *Appendix I: DeviceNet Communications*.

IEC 60870-5-103 Protocol

The SEL-700G provides IEC 60870-5-103 protocol support if the option is selected. The protocol is available on Ports 2, 3, and 4. All ports operate using the same map settings. The IEC 60870-5-103 protocol is described in *Appendix H: IEC 60870-5-103 Communications*.

Ethernet Protocols

As with other communications interfaces, you must choose a data exchange protocol that operates over the Ethernet network link to exchange data. The relay supports FTP, Telnet, Ping, Modbus/TCP, HTTP, DNP3 LAN/WAN, C37.118 Protocol (synchrophasor data), and IEC 61850 protocols.

Carefully design your Ethernet network to maximize reliability, minimize system administration effort, and provide adequate security. Work with a networking professional to design your substation Ethernet network.

File Transfer Protocol (FTP) and MMS File Transfer

FTP is a standard protocol for exchanging files between computers over a TCP/IP network. The SEL-700G operates as an FTP server, presenting files to FTP clients. To create an FTP session, you need the FTP username and password. The default username and password are FTPUSER and TAIL, respectively. The SEL-700G supports two FTP sessions at a time. Requests to establish additional FTP sessions are denied.

Manufacturing Messaging Specification (MMS) is used in IEC 61850 applications and provides services for the transfer of real-time data, including files, within a substation LAN.

File Structure

The file structure is organized as a directory and subdirectory tree similar to that used by Windows and other common operating systems. See *Virtual File Interface on page 7.77* for information on available files.

File dates within the last 12 months are displayed with month, day, hour, and minutes. Dates older than twelve months have the year, month, and day. The times are UTC.

Access Control

To log in to the FTP server, enter the value of the Port 1 setting FTPUSER as the user name in your FTP application. Enter the Port 1 setting FTPACC level password as the password in your FTP application. Note that FTP does not encrypt passwords before sending them to the server.

MMS is enabled when the Port 1 setting E61850 is set to Y. No authentication is required. MMS File Transfer is enabled when setting EMMSFS is set to Y. If MMS Authentication is enabled via the CID file, then an authenticated connection must be established via MMS for MMS file transfer to take place.

Using FTP and MMS

A free FTP application is included with most web browser software and PC operating systems. You can also obtain free or inexpensive FTP applications from the Internet. Once you have retrieved the necessary files, be sure to close the FTP connection using the disconnect function of your FTP application or completely closing the application. Failure to do so can cause the FTP connection to remain open, which blocks subsequent connection attempts until FTPIDLE time expires. See *Appendix G: IEC 61850 Communications* for information about using MMS.

Telnet Server

Use the Telnet session (TPORT default setting is Port 23) to connect to the relay to use the protocols, which are described in more detail below:

- SEL ASCII
- Compressed ASCII
- Fast Meter
- Fast Operate
- Fast SER

NOTE: Use the **QUIT** command prior to closing the Telnet-to-Host session to set the relay to Access Level 0. Otherwise, the relay remains at an elevated access level until TIDLE expires.

Telnet is a terminal connection across a TCP/IP network that operates in a manner very similar to a direct serial port connection to one of the relay ports. As with FTP, Telnet is a part of TCP/IP. A free Telnet application is included with most computer operating systems, or you can obtain low-cost or free Telnet applications on the Internet.

Ping Server

Ping is an application based on ICMP over an IP network. A free Ping application is included with most computer operating systems. Use a Ping client with the relay Ping server to verify that your network configuration is correct.

C37.118

The SEL-700G provides two streams of C37.118 protocol (synchrophasor data) support at the Ethernet ports. The C37.118 protocol is described in *Appendix K: Synchrophasors*.

IEC 61850

Use as many as 7 sessions of MMS over a TCP network to exchange data with the relay. Use GOOSE to do real-time data exchange with as many as 64 incoming messages and 8 outgoing messages. For more details on the IEC 61850 protocol, see *Appendix G: IEC 61850 Communications*.

Simple Network Time Protocol (SNTP)

When Port 1 (Ethernet port) setting ESNTP is not OFF, the internal clock of the relay conditionally synchronizes to the time of day served by a Network Time Protocol (NTP) server. The relay uses a simplified version of NTP called the Simple Network Time Protocol (SNTP). SNTP is not as accurate as IRIG-B. The relay can use SNTP as a less accurate primary time source, or as a backup to the higher accuracy IRIG-B time source.

SNTP as Primary or Backup Time Source

If an IRIG-B time source is connected and either Relay Word bit TSOK or Relay Word bit IRIGOK asserts, then the relay synchronizes the internal time-of-day clock to the incoming IRIB-G time code signal, even if SNTP is configured in the relay and an NTP server is available. If the IRIG-B source is disconnected (if both TSOK and IRIGOK deassert) then the relay synchronizes the internal time-of-day clock to the NTP server, if available. In this way, an NTP server acts either as the primary time source or as a backup time source to the more accurate IRIG-B time source.

Creating an NTP Server

Three SEL application notes, available from the SEL website, describe how to create an NTP server.

- *AN2009-10: Using an SEL-2401, SEL-2404, or SEL-2407 to Serve NTP Via the SEL-3530 RTAC*
- *AN2009-38: Using SEL Satellite-Synchronized Clocks With the SEL-3332 or SEL-3354 to Output NTP*
- *AN2010-03: Using an SEL-2401, SEL-2404, or SEL-2407 to Create a Stratum 1 Linux NTP Server*

Configuring SNTP Client in the Relay

To enable SNTP in the relay, make Port 1 setting ESNTP = UNICAST, MANYCAST, or BROADCAST. *Table 7.5* shows each setting associated with SNTP.

Table 7.5 Settings Associated With SNTP

Setting Name	Range	Description	Factory-Default Settings
ESNTP	UNICAST, MANYCAST, BROADCAST	Selects the mode of operation of SNTP. See descriptions in *SNTP Operation Modes*.	OFF
SNTPPSIP	Valid IP Address	Selects primary NTP server when ESNTP = UNICAST, or broadcast address when ESNTP = MANYCAST or BROADCAST.	192.168.1.1
SNTPPSIB	Valid IP Address	Selects backup NTP server when ESNTP = UNICAST.	192.168.1.1
SNTPPORT	1–65534	Ethernet port used by SNTP. Leave at default value unless otherwise necessary.	123
SNTPRATE	15–3600 seconds	Determines the rate at which the relay asks for updated time from the NTP server when ESNTP = UNICAST or MANYCAST. Determines the time the relay will wait for an NTP broadcast when ESNTP = BROADCAST.	60
SNTPTO	5–20 seconds	Determines the time the relay will wait for the NTP master to respond when ESNTP = UNICAST or MANYCAST.	5

SNTP Operation Modes

The following sections explain the setting associated with each SNTP operation mode (UNICAST, MANYCAST, and BROADCAST).

ESNTP = UNICAST. In unicast mode of operation, the SNTP client in the relay requests time updates from the primary (IP address setting SNTPPSIP) or backup (IP address setting SNTPBSIP) NTP server at a rate defined by setting SNTPRATE. If the NTP server does not respond with the period defined by setting SNTPTO, then the relay tries the other SNTP server. When the relay successfully synchronizes to the primary NTP time server, Relay Word bit TSNTPP asserts. When the relay successfully synchronizes to the backup NTP time server, Relay Word bit TSNTPB asserts.

ESNTP = MANYCAST. In the manycast mode of operation, the relay initially sends an NTP request to the broadcast address contained in setting SNTPPSIP. The relay continues to broadcast requests at a rate defined by setting SNTPRATE. When a server replies, the relay considers that server to be the primary NTP server, and switches to UNICAST mode, asserts Relay Word bit TSNTPP, and thereafter requests updates from the primary server. If the NTP server stops responding for time SNTPTO, the relay deasserts

TSNTPP and begins to broadcast requests again until the original or another server responds.

ESNTP = BROADCAST. If setting SNTPPSIP = 0.0.0.0 while setting ESNTP = BROADCAST, the relay will listen for and synchronize to any broadcasting NTP server. If setting SNTPPSIP is set to a specific IP address while setting ESNTP = BROADCAST, then the relay will listen for and synchronize to only NTP server broadcasts from that address. When synchronized, the relay asserts Relay Word bit TSNTPP. Relay Word bit TNSTPP deasserts if the relay does not receive a valid broadcast within five seconds after the period defined by setting SNTPRATE.

SNTP Accuracy Considerations

The accuracy of the SNTP server and the networking environment limit SNTP time-synchronization accuracy. You can achieve the highest degree of SNTP time synchronization by minimizing the number of switches and routers between the SNTP server and the SEL-700G. You can also use network monitoring software to ensure that average and worst-case network bandwidth use is moderate.

When installed on a network configured with one Ethernet switch between the SEL-700G and the SNTP server, and when using ESNTP = UNICAST or MANYCAST, the relay time-synchronization error with the SNTP server is typically less than ±1 millisecond.

Embedded Web Server (HTTP)

When Port 1 setting EHTTP := Y, the relay serves webpages displaying settings, metering, status reports, event files, etc. The relay-embedded web server has been optimized and tested to work with the most popular web browsers, but should work with any standard web browser. As many as three users can access the embedded web server simultaneously. To begin using the embedded read-only web server, launch your web browser and browse to http://IPADDR, where IPADDR is the Port 1 setting IPADDR (e.g., http://192.168.1.2).

Login using your username and password to view or export various reports, view settings, monitor communications or relay status, or upgrade firmware (Access Level 2 only).

To log out of the web server, either close the web browser window or click on **Logout** in the banner bar near the top of the webpage. For more information on the web server, see *Section 3: PC Interface*.

Table 7.6 lists the HTTP settings that are available for configuring the web server.

Table 7.6 HTTP Server Configuration Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE HTTP SERVER	Y, N	EHTTP := Y
HTTP MAXIMUM ACCESS LEVEL	1, 2	HTTPACC := 2
TCP/IP PORT	1–65535	HTTPPORT := 80

Table 7.6 HTTP Server Configuration Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
HTTP CONNECT BANNER	254 ASCII printable characters	HTTPBAN := This system is for the use of authorized personnel only.
HTTP WEB SERVER TIMEOUT	1–60 min	HTTPIDLE := 10

Precision Time Protocol (PTP)

Configuring PTP in the Relay

PTP implementation in the SEL-700G is firmware-based only. If the EPTP setting is available and set to Y, the SEL-700G supports PTP Version 2 (PTPv2) as a slave-only clock as defined by IEEE 1588-2008 on Port 1A and Port 1B. *Table 7.7* shows the settings associated with PTP.

Table 7.7 Settings Associated With PTP

Setting Name	Range	Description	Factory-Default Setting
EPTP	Y, N	When set to Y, the device becomes a slave PTP clock	N
PTPPRO	DEFAULT, C37.238	Sets the PTP profile	DEFAULT
PTPTR	UDP, LAYER2	Transport mechanism for PTP messages	UDP
DOMNUM	0–255	PTP domain number of the clock	0
PTHDLY	P2P, E2E, OFF	Path delay measurement method to be used on the PTP network	E2E
PDINT	1, 2, 4, 8, 16, 32, 64 sec	Duration of time between transmissions of peer delay request messages	1
AMNUM	1–5, OFF	Number of acceptable PTP masters	OFF
AMIP[n][a]	*zzz.yyy.xxx.www* zzz: 1–126, 127–223 yyy: 0–255 xxx: 0–255 www: 0–255	Acceptable master IP addresses	192.168.1.12*n*[a]
AMMAC[n][a]		Acceptable master MAC addresses	00-30-A7-00-0*m*[b]
ALTPRI[n][a]	0–255	If the Acceptable Table Master option is enabled and this setting value is not zero, the Priority 1 value received in the Announce message from the specified master will be replaced by this value and used in the Best Master Clock Algorithm (BMCA)	0
PVLAN	1–4094	VLAN ID for a C37.238 Ethernet frame	1
PVLANPR	0–7	VLAN priority for a C37.238 Ethernet frame	4

[a] n = 1–5.
[b] m = A–E.

To achieve the best accuracy (< 1 ms), it is necessary to have one or more PTP master clocks and for all intervening equipment (e.g., Ethernet switches) to be IEEE 1588-aware (i.e., all intervening network devices need to be transparent or boundary clocks).

In PTP, a clock that provides time to other devices, typically based on GPS input, is a master clock. The intervening switches are transparent clocks. You can use boundary clocks to connect networks together and pass time from one network to another. Transparent and boundary clocks are important because they provide time correction in the PTP messages that pass through them, whereas devices that are not IEEE 1588-aware do not provide this correction. Because it is possible for a network to have multiple master clocks, PTP clocks implement algorithms to select the best available clock. The one selected for use by an end device is the grandmaster clock. You can learn more about configuring a PTP network in the following application notes:

- L. Thoma, "Using the SEL-2488 to Provide IEEE 1588 Version 2 Grandmaster Functionality in a Redundant Network Topology," SEL Application Note (AN2015-07), 2015. Available: selinc.com
- L. Thoma, "Using the SEL-2488 to Provide IEEE 1588 Version 2 Grandmaster Functionality to Isolated Ethernet Networks," SEL Application Note (AN2015-06), 2015. Available: selinc.com.

To configure PTP, update the Port 1 PTP settings as described in *Table 7.7*. By default, PTP is disabled in the SEL-700G. Set EPTP to **Y** to enable PTP and to make the other PTP settings available.

PTP implementation in the SEL-700G supports both one-step and two-step clocks. A one-step clock uses a single event message to provide time information. A two-step clock uses the combination of an event message and a subsequent general message to provide time information.

Within PTP, there are multiple clock profiles available. A profile defines the set of PTP features available in a specific application domain. SEL-700G relays support two profiles: Default and Power (C37.238-2011).

The Default profile has many optional features and is intended to address common applications. The Default profile supports both UDP or Layer 2 (802.3) Ethernet transport and can use either the end-to-end (E2E) or the peer-to-peer (P2P) delay mechanism. Grandmaster clocks can send Announce, Sync, and Delay request messages over a wide range of intervals. A Default profile network can consist of boundary clocks or transparent clocks anywhere between the grandmaster and the end devices. The only performance requirement for the Default profile is that a master clock must maintain frequency accuracy to within 0.01 percent.

The Power profile has minimal optional features to facilitate interoperability and performance predictability. The Power profile is only supported on Layer 2 networks and exclusively uses the peer-to-peer delay mechanism. All messages must be sent at 1-second intervals, have 802.1Q VLAN tags, and include grandmaster ID and (maximum) inaccuracy fields in the Announce message. Transparent clocks are mandatory in a Power profile network, while boundary clocks are not allowed. Use the PTPPRO setting to select the profile.

PTP defines a logical grouping of clocks in a network as a clock domain. This provides a logical separation among clocks that participate in different application domains, allowing these clocks to coexist on the same network. Domains are identified by domain numbers. The DOMNUM setting determines the domain number for the SEL-700G. Set DOMNUM to match the domain number configured in the master clocks to which the SEL-700G should synchronize.

The SEL-700G supports transport of PTP messages over UDP or Layer 2 (Ethernet). Use the PTPTR setting to select the PTP transport mechanism. This needs to match the transport mechanism used in the master clocks. Only Layer 2 is available with the Power profile. If you are operating in a UDP network, PTP will operate on Ports 319 or 320. Except for peer delay messages, the SEL-700G sets the time allowed to live (TTL) value in the UDP/IP header of PTP messages to 64. This allows you to use routers across a WAN to synchronize the SEL-700G PTP master. High-accuracy synchronization may not be achievable across the WAN, so it is left to you to determine if the accuracy meets the needs of your application.

When using the Power profile, use the VLAN identifier and priority settings, PVLAN and PVLANPR, to set the VLAN ID and priority, respectively, of the Ethernet frames. Be sure to set PVLAN unique from other VLANs used within the SEL-700G Relay.

PTP defines two methods for calculating and correcting the communications path delay between the SEL-700G and the master clock: end-to-end (Delay Request Response) and peer-to-peer (Peer Delay Request Response). The end-to-end mechanism calculates the total path delay between the SEL-700G and the master clock.

The peer-to-peer mechanism calculates the total path delay in a piecemeal fashion between each device in the path. Peer-to-peer is the more accurate method and SEL recommends its use in the SEL-700G. Only the peer-to-peer mechanism is available for the Power profile. The SEL-700G periodically initiates path delay calculations. Use the PTHDLY and PDINT settings to configure the path delay method and the path delay request rate. If PTHDLY is set to OFF, the SEL-700G neither calculates nor corrects for path delay.

By default, the SEL-700G synchronizes to any clock on the network that it evaluates to be the best clock based on the BMCA. Use the settings to specify a list of master (grandmaster or boundary) clocks to which the SEL-700G may synchronize. The SEL-700G will not synchronize to any master clock that is not in the list. Use this feature for additional security. The AMNUM setting selects the number of master clocks you list. The default value is OFF, which means the SEL-700G synchronizes to any master clock on the network. If AMNUM is set to a value other than OFF, the number of allowable masters must be identified in accordance with the PTP transport chosen, i.e., MAC address for 802.3 or IP address for UDP transport.

If the PTP transport (PTPTR) is set to UDP, use the AMIP*n* settings to specify the IP addresses of the clocks to which the SEL-700G may synchronize. If PTP transport is set to Layer 2, use the AMMAC*n* settings to specify the MAC addresses of the clocks to which the SEL-700G may synchronize.

If ALTPRI*n* (Alternate Priority1 for Master *n*) is positive, this value replaces the Priority1 value in received Announce messages (from the corresponding master clock) before the relay applies the BMCA. The ALTPRI*n* values reprioritize the master clocks locally.

EtherNet/Industrial Protocol (IP)

EtherNet/IP is an industrial protocol that uses standard Ethernet and TCP/IP technology to transport Common Industrial Protocol (CIP) packets. You can enable EtherNet/IP on Port 1 for a maximum of eight simultaneous CIP connections. Of these eight simultaneous connections, you can have as many as two Class 1 (I/O) connections and as many as six combined Class 3 messages and Unconnected Message Manager (UCMM) messages.

When configuring EIP on Port 1, you can create as many as six Class 1 (I/O) connection configurations. Of these six, only two can be used simultaneously. Of the remaining six available connection configurations, as many as three can be Exclusive Owner connection configurations. The remaining number of connection configurations must be Input Only connection configurations.

EtherNet/IP is described in detail in *Appendix F: EtherNet/IP Communications*.

Rapid Spanning Tree Protocol (RSTP)

RSTP is a protocol and is a distributed algorithm that is defined in the IEEE 802.1Q-2014 standard. Devices communicate RSTP through packets called Bridge Protocol Data Units (BPDUs) that travel between adjacent RSTP-enabled devices. These frames allow the devices to determine the root bridge in the network, as well as defines the state and role of each port of devices connected in the RSTP network.

Table 7.8 and *Table 7.9* provide the various roles and states supported by the SEL-700G. Use the **RSTP** command to view the assigned state and role of a port. The relay keeps a log of the states and roles in the Sequential Events Recorder (SER) report.

Table 7.8 RSTP Roles Supported in the SEL-700G

Roles	Definition
Root Port	A port with the shortest path[a] to the root bridge. All STP and RSTP capable bridges must have exactly one except the root bridge, which cannot have any.
Designated Port	The port that connects a LAN to its designated bridge.
Alternate Port	Represents the best alternative path to the root bridge. This path is different than using the root port. The alternative port moves to the forwarding state if there is a failure on the designated port for the segment.
Backup Port	Represents a redundant path to a segment where another port on the bridge already connects.
Disabled	The port is disabled during the role initialization or it is disabled due to a link or hardware failure.

[a] This is not always the shortest path. The settings in the network define the path costs, so the root port is the one with the smallest path costs to the root switch. There may be a physically shorter path, but because of the path costs of the other devices, a longer path to the root may be used.

Table 7.9 RSTP States Supported in the SEL-700G

States	Definition
Forwarding	A port receiving and transmitting message frames and BPDUs.
Learning	A port receiving and transmitting BPDUs; this port does not receive or transmit message frames.
Discarding	A port receiving BPDUs; this port does not receive or transmit message frames.

NOTE: Exercise caution when disabling RSTP (ERSTP := N) in a relay connected in a switched network because doing so could introduce network loops.

There are three RSTP settings available to set on Port 1 after RSTP is enabled. They include the bridge priority (BRDGPRI), which is used to help determine the root bridge in the network, and the port priorities (PORTAPRI and PORTBPRI) for Ports 1A and 1B, which are used to help determine the root port of the device. See *Table 7.46* for more information regarding these settings.

Example of a Simple Topology

The simplest example of a loop is a network of devices connected in a ring (*Figure 7.16*). Devices connected in a ring topology allow traffic to go from one port on one device to another port on another device in either direction around the ring, as the two green lines show in *Figure 7.16* between Devices 1 and 6.

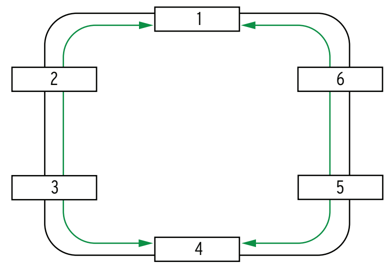


Figure 7.16 Physical Ring Without Loop Mitigation

Disabling the link between Devices 3 and 4 forces traffic to follow a single path across the network (as the green line in *Figure 7.17* shows). The process of disabling links to logically remove loops from the network is called convergence because the devices use RSTP to converge the network into a stable configuration without any loops.

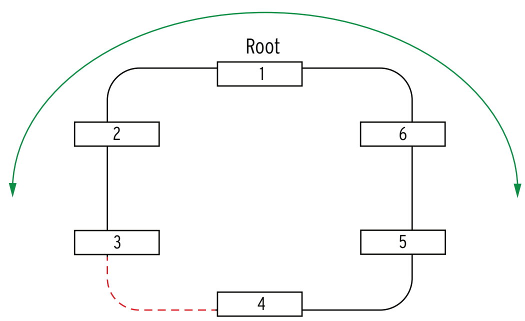


Figure 7.17 Network Convergence With Logically Disabled Link

The logically disabled connections remain physically present and can be quickly enabled by RSTP to provide an alternative path for the network traffic in the event of a physical network failure. For example, if the link between Devices 2 and 3 were to fail, traffic would be disrupted on the network, as indicated by the dashed green line in *Figure 7.18*. Devices 2 and 3 would respond by using RSTP and BPDUs to inform the other devices in the network that an event occurred. The rapid spanning tree algorithm (RSTA) in each network device would then use BPDUs over RSTP to communicate with their respective connected devices, in turn, and eventually the logically disabled link between Devices 3 and 4 would be re-enabled, as shown in *Figure 7.19*.

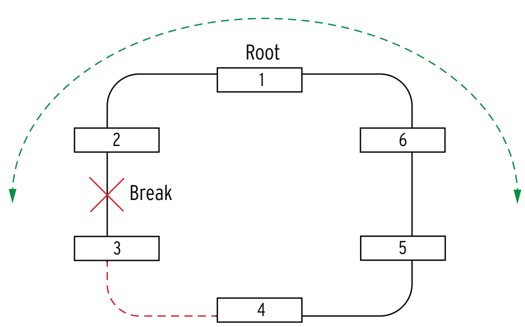


Figure 7.18 Physical Link Failure Between Devices

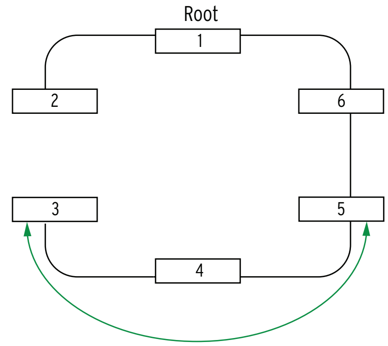


Figure 7.19 Network Convergence

As the green line in *Figure 7.19* shows, traffic can still flow between Devices 3 and 5 but now it is through a different path. The process of re-enabling disabled links to allow traffic to flow and heal the network is called reconvergence. During this change in the network, traffic is temporarily disrupted. *Figure 7.3* is a typical network diagram that uses the SEL-700G in a switched network with ERSTP := Y. Refer to SEL application guides “Understanding RSTP and Choosing the Best Network Topology” (AG2017-21) and “Maintaining Switched-Mode Relay Responsiveness in an RSTP Network” (AG2019-15) at selinc.com for additional information on RSTP.

RSTP Performance Measurement

Figure 7.20 shows a convergence example involving a ring network where both SEL-2730M switches and all seven SEL-700 series relays are configured with default RSTP settings. In this example, there is a transmitting device connected to the North SEL-2730M switch and a receiving device connected to the South SEL-2730M switch.

As a result of the devices being configured with default RSTP settings, the network converges to break the loop at Relay 14. This configuration results in the port for Relay 14 to be in discarding state (indicated by “D”). In this state, traffic flows from the North SEL-2730M switch to the South SEL-2730M switch by passing through Link L1.

For this example, consider a link-down event occurring at Link L1. A link-down event is when the cable that connects two devices is physically broken (indicated by the slash). After this link-down event, the network takes approximately 150 ms to reconverge such that the discarding port on Relay 14 transitions into a forwarding state. This allows traffic to flow from the North SEL-2730M switch to the South SEL-2730M switch by passing through all seven relays.

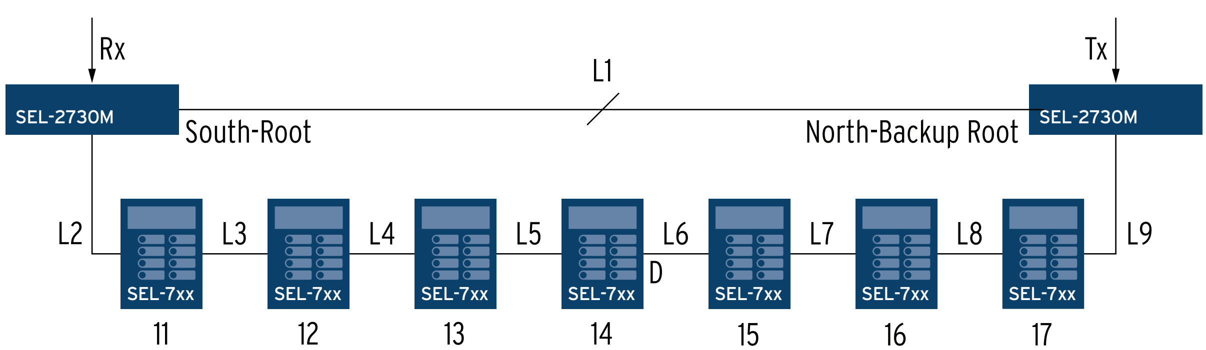


Figure 7.20 Link-Down Event at Link L1

If additional relays are added to this example network, the reconvergence time increases by approximately 20 ms per additional relay.

SEL-700 series relays are configured with a Max Age value of 40. This means that a network with SEL-700 series RSTP devices should be created with the understanding that the maximum number of hops from the root in the network should not exceed 40.

To understand the importance of enabling RSTP in an SEL-700 series relay ring network in comparison to leaving it disabled, refer to the SEL application guide “Maintaining Switched-Mode Relay Responsiveness in an RSTP Network” (AG2019-15).

SEL ASCII Protocol and Commands

Message Format

SEL ASCII protocol is designed for manual and automatic communication. All commands the relay receives must be of the following form:

```
<command><CR>  or  <command><CRLF>
```

NOTE: The **<Enter>** key on most keyboards is configured to send the ASCII character 13 (**<Ctrl+M>**) for a carriage return. This manual instructs you to press the **<Enter>** key after commands to send the proper ASCII code to the SEL-700G.

A command transmitted to the relay consists of the command followed by either a CR (carriage return) or a CRLF (carriage return and line feed). You can truncate commands to the first three characters. For example, **EVENT 1 <Enter>** becomes **EVE 1 <Enter>**. Use upper- and lowercase characters without distinction, except in passwords.

The relay transmits all messages in the following format:

```
<STX><MESSAGE LINE 1><CRLF>
<MESSAGE LINE 2><CRLF>
.
.
.
<LAST MESSAGE LINE><CRLF><ETX>
```

Each message begins with the start-of-transmission character (ASCII 02) and ends with the end-of-transmission character (ASCII 03). Each line of the message ends with a carriage return and line feed.

Software Flow Control

The relay implements XON/XOFF flow control. You can use the XON/XOFF protocol to control the relay during data transmission. When the relay receives XOFF during transmission, it pauses until it receives an XON character. If there is no message in progress when the relay receives XOFF, it blocks transmission of any message presented to the relay input buffer. Messages are accepted after the relay receives XON.

The relay transmits XON (ASCII hex 11) and asserts the RTS output (if hardware handshaking is enabled) when the relay input buffer drops below 25 percent full.

The relay transmits XOFF (ASCII hex 13) when the buffer is more than 75 percent full. If hardware handshaking is enabled, the relay deasserts the RTS output when the buffer is approximately 95 percent full. Automatic transmission sources should monitor for the XOFF character to avoid overwriting the buffer. Transmission terminates at the end of the message in progress when XOFF is received, and it resumes when the relay sends XON.

The CAN character (ASCII hex 18) aborts a pending transmission. This is useful for terminating an unwanted transmission. You can send control characters from most keyboards with the following keystrokes:

- XOFF**: <Ctrl+S>** (hold down the **<Ctrl>** key and press **S**)
- XON: **<Ctrl+Q>** (hold down the **<Ctrl>** key and press **Q**)
- CAN: **<Ctrl+X>** (hold down the **<Ctrl>** key and press **X**)

Automatic Messages

When the serial port AUTO setting is Y, the relay sends automatic messages to indicate specific conditions. *Table 7.10* lists these messages.

Table 7.10 Serial Port Automatic Messages

Condition	Description
Power Up	The relay sends a message containing the present date and time, Relay and Terminal Identifiers, and the Access Level 0 prompt when the relay is turned on.
Event Trigger	The relay sends an event summary each time an event report is triggered. See *Section 10: Analyzing Events*.
Self-Test Warning or Failure	The SEL-700G sends a status report each time it detects a self-test warning or failure condition. See *STATUS Command (Relay Self-Test Status) on page 7.70*.

Access Levels

You can issue commands to the SEL-700G via the serial port or Telnet session to view metering values, change relay settings, etc. The available serial port commands are listed in the *SEL-700G Relay Command Summary* at the end of this manual. These commands can be accessed only from the corresponding access level, as shown in the *SEL-700G Relay Command Summary*. The access levels are:

- Access Level 0 (the lowest access level)
- Access Level 1
- Access Level 2 (the highest access level)
- Access Level C (restricted access level, should be used under direction of SEL only)

The EPORT and MAXACC settings provide you with access controls for the corresponding port. Setting EPORT to N disables the port and hides the remaining port settings. The MAXACC setting selects the highest access level for the port.

Access Level 0

Once serial port communication is established with the SEL-700G, the relay sends the following prompt:

```
=
```

This is referred to as Access Level 0. Only a few commands are available at Access Level 0. One is the **ACC** command. See the *SEL-700G Relay Command Summary* at the end of this manual. Enter the **ACC** command at the Access Level 0 prompt:

```
=ACC <Enter>
```

The **ACC** command takes the SEL-700G to Access Level 1. See *Access Commands (ACCESS, 2ACCESS, and CAL) on page 7.31* for more detail.

Access Level 1

When the SEL-700G is in Access Level 1, the relay sends the following prompt:

```
=>
```

See the *SEL-700G Relay Command Summary* at the end of this manual for the commands available from Access Level 1. The relay can go to Access Level 2 from this level.

The **2AC** command places the relay in Access Level 2. See *Access Commands (ACCESS, 2ACCESS, and CAL)* for more detail. Enter the **2AC** command at the Access Level 1 prompt:

```
=>2AC <Enter>
```

Access Level 2

When the relay is in Access Level 2, the SEL-700G sends the prompt:

```
=>>
```

See the *SEL-700G Relay Command Summary* at the end of this manual for the commands available from Access Level 2. Any of the Access Level 1 commands are also available in Access Level 2.

Access Level C

Access Level C is intended for use by the SEL factory, and for use by SEL field service personnel to help diagnose troublesome installations. Do not enter Access Level C except as directed by SEL.

The **CAL** command allows the relay to go to Access Level C. Enter the **CAL** command at the Access Level 2 prompt:

```
=>>CAL <Enter>
```

Command Summary

The *SEL-700G Relay Command Summary* at the end of this manual lists the serial port commands alphabetically. Much of the information available from the serial port commands is also available via the front-panel pushbuttons.

Access Level Functions

The serial port commands at the different access levels offer varying levels of control:

- The Access Level 0 commands provide the first layer of security. In addition, Access Level 0 supports several commands necessary for SEL communications processors.
- The Access Level 1 commands are primarily for reviewing information only (settings, metering, etc.), not changing it.

- ➤ The Access Level 2 commands are primarily for changing relay settings.
- ➤ Access Level C (restricted access level, should be used under direction of SEL only)

The SEL-700G responds with `Invalid Access Level` when a command is entered from an access level lower than the specified access level for the command. The relay responds with `Invalid Command` to commands that are not available or are entered incorrectly.

Header

Many of the command responses display the following header at the beginning:

```
[RID Setting]                                    Date: mm/dd/yyyy  Time: hh:mm:ss.sss
[TID Setting]                                    Time Source: external
```

Table 7.11 lists the header items and their definitions.

Table 7.11 Command Response Header Definitions

Item	Definition
[RID Setting]:	This is the RID (Relay Identifier) setting. The relay ships with the default setting RID = 700G; see *ID Settings on page 4.4*.
[TID Setting]:	This is the TID (Terminal Identifier) setting. The relay ships with the default setting TID = GENERATOR RELAY; see *ID Settings on page 4.4*.
Date:	This is the date when the command response was given, except for relay response to the **EVE** command (Event), when it is the date the event occurred. You can modify the date display format (Month/Day/Year, Year/Month/Day, or Day/Month/Year) by changing the DATE_F relay setting.
Time:	This is the time when the command response was given, except for relay response to the **EVE** command, when it is the time the event occurred.
Time Source:	This is internal if no time-code input is attached, and this is external if an input is attached.

Command Explanations

This section lists ASCII commands alphabetically. Commands, command options, and command variables to enter are shown in bold. Lowercase italic letters and words in a command represent command variables that are determined based on the application. For example, time ***t*** = 1 to 30 seconds, remote bit number ***n*** = 01 to 32, and ***level***.

Command options appear with brief explanations about the command function. Refer to the references listed with the commands for more information on the control function corresponding to the command or examples of the control response to the command.

You can simplify the task of entering commands by shortening any ASCII command to the first three characters; for example, **ACCESS** becomes **ACC**. Always send a carriage return **<CR>** character or a carriage return character followed by a line feed character **<CR><LF>** to command the control to process the ASCII command. Usually, most terminals and terminal programs interpret the Enter key as a **<CR>**. For example, to send the **ACCESS** command, type **ACC <Enter>**.

Tables in this section show the access level(s) where the command or command option is active. Access levels in this device are Access Level 0, Access Level 1, and Access Level 2.

89CLOSE Command (Close Disconnect)

The **89C** command (see *Table 7.12* for the command description and the format) is used to close a two-position disconnect, or the respective in-line or earthing disconnect for a three-position disconnect. The **89C *m*** command asserts Relay Word Bit 89CC2P*m* for a quarter-cycle when executed, while the **89C *n m*** command asserts Relay Word bit 89CC3P*nm* for a quarter-cycle when executed. See *Figure 9.2* for how the disconnect close control logic uses these Relay Word bits.

Table 7.12 89CLOSE Command

Command	Description	Access Level
89C *m*	Closes Two-Position Disconnect *m*	2
89C *n m*	Closes Three-position Disconnect *m*, where *n* signals for an in-line or earthing disconnect	2
Parameters		
m	Specifies which two-position disconnect (*m* = 1–8) or three-position disconnect (*m* = 1–2) to close.	
n	L or E, to signal an in-line or earthing disconnect, respectively.	

To issue the **89C 1** command, enter the following:

```
=>>89C 1 <Enter>
Close 2P1 (Y,N)? Y <Enter>
Are you sure (Y,N)? Y <Enter>
Operation In Progress...
Disconnect Closed
=>>
```

Typing **N <Enter>** after either of the prompts will abort the command.

Following successful issue of the command, the relay displays `Operation In Progress....` While 89IP2P*m* or 89IP3P*nm* is asserted and the respective Relay Word bits 89OP2P*m*/89OP3P*nm*, 89CL2P*m*/89CL3P*nm*, and 89AL2P*m*/89AL3P*nm* are deasserted, a dot (.) is appended to the above message every half-second to show progress. While the operation is in progress, communications are unavailable on the port where the **89C** command was executed. If none of the Relay Word bits asserts within 60 seconds, the relay exits the **89C** Command. Following the in-progress state, the Relay Word bit that asserts determines the subsequent status message displayed in the terminal: `Disconnect Open` if 89OP2P*m* or 89OP3P*nm* is asserted, `Disconnect Closed` if 89CL2P*m* or 89CL3P*nm* is asserted, or `Status Undetermined—Check Wiring` if 89AL2P*m* or 89AL3P*nm* is asserted. See *Disconnect Control Settings on page 9.2*.

The **89C** command is supervised by the main board breaker control jumper (see *Table 2.19*). If the breaker control jumper is not in place (breaker control jumper = OFF), the relay does not execute the **89C** command and responds with the following:

```
=>>89C L 1 <Enter>

Command Aborted: No Breaker Jumper

=>>
```

When you set EN_LRC := Y (see *Table 9.6*), the Relay Word bit LOCAL supervises the **89C** command. If the LOCAL bit is asserted (LOCAL = 1), the relay does not execute the **89C** command and responds with the following:

```
=>>89C L 1 <Enter>

Command Aborted: Device in Local Control

=>>
```

The Relay Word bit LOCAL is determined by the LOCAL SELOGIC control equation (see *Table 9.6*).

89OPEN Command (Open Disconnect)

Use the **89O** command (see *Table 7.13* for the command description and the format) to open a two-position disconnect, or the respective in-line or earthing disconnect for a three-position disconnect. The **89O *m*** command asserts Relay Word Bit 89OC2P*m* for a quarter-cycle when executed, while the **89O *n m*** command asserts Relay Word bit 89OC3P*nm* for a quarter-cycle when executed. See *Figure 9.3* for how the disconnect open control logic uses these Relay Word bits.

Table 7.13 89OPEN Command

Command	Description	Access Level
89O *m*	Opens Two-position Disconnect *m*	2
89O *n m*	Opens Three-position Disconnect *m*, where *n* signals for an in-line or earthing disconnect	2
Parameters		
m	Specifies which two-position disconnect (*m* = 1–8) or three-position disconnect (*m* = 1–2) to open.	
n	L or E, to signal an in-line or earthing disconnect, respectively.	

To issue the **89O 1** command, enter the following:

```
=>>89O 1 <Enter>

Open 2P1 (Y,N)? Y <Enter>

Are you sure (Y,N)? Y <Enter>

Operation In Progress...

Disconnect Open

=>>
```

Typing **N <Enter>** after either of the prompts aborts the command.

Following successful issue of the command, the relay displays `Operation In Progress....` While 89IP2P*m* or 89IP3P*nm* is asserted and the respective Relay Word bits 89OP2P*m*/89OP3P*nm*, 89CL2P*m*/89CL3P*nm*, and 89AL2P*m*/89AL3P*nm* are deasserted, a dot (.) is appended to the above message every half-second to show progress. While the operation is in progress, communications are unavailable on the port where the **89O** command was executed. If none of the Relay Word bits assert within 60 seconds, the relay exits the **89O** Command. Following the in-progress state, the Relay Word bit that asserts will determine the subsequent status message displayed in the terminal: `Disconnect Open` if 89OP2P*m* or 89OP3P*nm* is asserted, `Disconnect Closed` if 89CL2P*m* or 89CL3P*nm* is asserted, or `Status Undetermined—Check Wiring` if 89AL2P*m* or 89AL3P*nm* is asserted. See *Disconnect Control Settings on page 9.2*.

The main board breaker control jumper (see *Table 2.19*) supervises the **89O** command. If the breaker control jumper is not in place (breaker control jumper = OFF), the relay does not execute the **89O** command and responds with the following:

```
=>>89O L 1 <Enter>

Command Aborted: No Breaker Jumper

=>>
```

When setting EN_LRC := Y (see *Table 9.6*), the Relay Word bit LOCAL supervises the **89O** command. If the LOCAL bit is asserted (LOCAL = 1), the relay does not execute the **89O** command and responds with the following:

```
=>>89O L 1 <Enter>

Command Aborted: Device in Local Control

=>>
```

The LOCAL SELOGIC control equation (see *Table 9.6*) determines the Relay Word bit LOCAL.

Access Commands (ACCESS, 2ACCESS, and CAL)

The **ACC, 2AC,** and **CAL** commands (see *Table 7.14*) provide entry to the multiple access levels. Different commands are available at the different access levels, as shown in the *SEL-700G Relay Command Summary* at the end of this manual. Commands **ACC** and **2AC** are explained together because they operate similarly. See *Access Levels on page 7.26* for a discussion of placing the relay in an access level.

Table 7.14 Access Commands

Command	Description	Access Level
ACC	Moves from Access Level 0 to Access Level 1.	0
2AC	Moves from Access Level 1 to Access Level 2.	1
CAL	Moves from Access Level 2 to Access Level C	2

Password Requirements

Passwords are necessary unless they are disabled. See *PASSWORD Command (Change Passwords) on page 7.61* for the list of default passwords and for more information on changing and disabling passwords.

Access Level Attempt (Password Required). Assume the following conditions:

- Access Level 1 password is not disabled.
- Access Level is 0.

At the Access Level 0 prompt, enter the **ACC** command:

```
=ACC <Enter>
```

Because the password is not disabled, the relay prompts you for the Access Level 1 password:

```
Password: ?
```

The relay is shipped with the default Access Level 1 password shown in *PASSWORD Command (Change Passwords) on page 7.61*. At the prompt, enter the default password and press the <Enter> key. The relay responds with the following:

```
[RID Setting]                              Date: mm/dd/yyyy  Time: hh:mm:ss
[TID Setting]                              Time Source: external

Level 1
=>
```

The => prompt indicates the relay is now in Access Level 1.

If the entered password is incorrect, the relay prompts you for the password again (`Password: ?`). The relay prompts for the password as many as three times. If the requested password is incorrectly entered three times, the relay pulses the SALARM Relay Word bit for one second and remains at Access Level 0 (= prompt).

Access Level Attempt (Password Not Required). Assume the following conditions:

- Access Level 1 password is disabled.
- Access Level is 0.

At the Access Level 0 prompt, enter the **ACC** command:

```
=ACC <Enter>
```

Because the password is disabled, the relay does not prompt you for a password and goes directly to Access Level 1. The relay responds with the following:

```
[RID Setting]                                    Date: mm/dd/yyyy  Time: hh:mm:ss.sss
[TID Setting]                                    Time Source: external
Level 1
=>
```

The => prompt indicates that the relay is now in Access Level 1.

The two previous examples demonstrate going from Access Level 0 to Access Level 1. The procedure to go from Access Level 1 to Access Level 2 with the **2AC** command entered at the access level screen prompt is similar. The relay pulses the SALARM Relay Word bit for one second after a successful Level 2 or Level C access, or if access is denied.

ANALOG Command

Use the **ANA** command to test an analog output by temporarily assigning a value to an analog output channel (see *Table 7.15* for the command description and the format). After entering the **ANA** command, the device suspends normal operation of the analog output channel and scales the output to a percentage of full scale. After assigning the specified value for the specified time, the device returns to normal operation. Entering any character (including pressing the space key) ends the command before it reaches the specified interval completion. You can test the analog output in one of the following two modes:

- Fixed percentage: Outputs a fixed percentage of the signal for a specified duration
- Ramp: Ramps the output from minimum to maximum of full scale over the time specified

Table 7.15 ANALOG Command

Command	Description	Access Level
ANA *c p t*	Temporarily assigns a value to an analog output channel.	2
Parameters		
c	The analog channel (either the channel name, for example, A0301, or the channel number, for example, 301).	
p	A percentage of full scale, or either the letter “R” or “r” to indicate ramp mode.	
t	Duration (in decimal minutes) of the test.	

NOTE: 0% = low span, 100% = high span. For a scaled output from 4–20 mA, 0 percent is 4 mA and 100 percent is 20 mA.

When parameter *p* is a percentage, the relay displays the following message during the test:

```
Outputting xx.xx [units] to Analog Output Port for y.y minutes. Press any key to end
    test
```

where:

`xx.xx` is the calculation of percent of full scale
`[units]` is either mA or V, depending on the channel type setting
`y.y` is the time in minutes

When parameter *p* is a ramp function, the device displays the following message during the test:

```
Ramping Analog Output at xx.xx [units]/min; full scale in y.y minutes. Press any key
    to end test
```

where:

`xx.xx` is the calculation based upon range/time *t*
`[units]` is either mA or V, depending on the channel type setting
`y.y` is the time in minutes

For either mode of operation (percentage or ramp), when the time expires, or upon pressing a key, the analog output port returns to normal operation and the device displays the following message:

```
Analog Output Port Test Complete
```

Example 1

The following is an example of the device response to the **ANA** command in the percentage mode. For this example, we assume that the analog output signal type is 4–20 mA, and we want to test the analog output at 75 percent of rating for 5.5 minutes. To check the device output, calculate the expected mA output as follows:

$$\text{Output} = \left[(20.00\text{ mA} - 4.00\text{ mA}) \bullet \frac{75}{100}\right] + 4.00\text{ mA} = 16.00\text{ mA}$$

To start the test, enter **ANA A0301 75 5.5** at the Access Level 2 prompt:

```
=>>ANA AO301 75 5.5 <Enter>
Outputting 16.00 mA to Analog Output Port for 5.5 minutes.
Press any key to end test
```

Example 2

The following is an example of the ramp mode when the analog output signal type is 4–20 mA for a 9.0 minute test.

To check the device output, calculate the current/time (mA/min) output as follows:

$$\text{Output} = \left[\frac{20.00\text{ mA} - 4.00\text{ mA}}{9.0\text{ min}}\right] = 1.78\text{ mA/min}$$

To start the test, enter **ANA AO301 R 9.0** at the Access Level 2 prompt:

```
=>>ANA AO301 R 9.0 <Enter>
Ramping Analog Output at 1.78 mA/min; full scale in 9.0 minutes.
Press any key to end test
```

AST Command (Start Autosynchronizer)

The **AST** command (Access Level 2) is available in SEL-700G models with autosynchronizer function. It allows the ASCII serial port to control the AST Relay Word bit, which when asserted starts and runs the autosynchronizer, provided that all the necessary conditions are met. The relay responds automatically with a message if conditions are not met, giving a specific explanation. See *Autosynchronism on page 4.183* for further details.

ASP Command (Stop Autosynchronizer)

The **ASP** command (Access Level 2) allows ASCII serial port control of the ASP Relay Word bit, which when asserted stops the autosynchronizer function. See *Autosynchronism on page 4.183* for further details.

BRE n Command (Monitor Breaker Data, Where n = X or Y)

Use the **BRE *n*** command to view the breaker monitor report. See *Breaker Monitor on page 5.16* for further details on the breaker monitor.

```
=>BRE X <Enter>

SEL-700GT                                   Date: 02/25/2010   Time: 15:58:07.216
INTERTIE RELAY                              Time Source: Internal


Breaker X Monitor Data

Trip Counters

Rly Trips (counts)          15
Ext Trips (counts)           2

Cumulative Interrupted Currents

                               IA          IB          IC
Rly Trip Current (kA)           55.5        76.5        65.5
Ext Trip Current (kA)            7.3         5.6         4.2

Breaker Contact Wear

                               A    B    C
Wear (%)                      21   34   26

LAST RESET  02/24/2010 17:02:36

=>
```

Figure 7.21 BRE X Command Response

BRE n W or R Command (Preload/Reset Breaker Wear, Where n = X or Y)

Use the **BRE *n* W** command to preload breaker wear data. The **BRE *n* W** command saves only new data after the `Save Changes (Y/N)?` message. If you make a data entry error using the **BRE *n* W** command, the values echoed after the `Invalid format, changes not saved` message are the previous breaker wear values, unchanged by the aborted **BRE *n* W** attempt.

```
=>>BRE X W <Enter>

Breaker X Wear Preload

Relay (or Internal) Trip Counter (0-65000)    =    2       ? 11

Internal Current (0.0-999999 kA)      IA      =   5.5      ? 34
                                      IB      =   6.5      ? 43
                                      IC      =   5.5      ? 51

External Trip Counter (0-65000)               =    0       ? 4

External Current (0.0-999999 kA)      IA      =   0.0      ? 31
                                      IB      =   0.0      ? 37
                                      IC      =   0.0      ? 41

Percent Wear (0-100)                  A-phase =  0         ? 23
                                      B-phase =  0         ? 31
                                      C-phase =  0         ? 26

Last Reset                            Date    = 02/24/2010 ?

                                      Time    = 17:02:36   ?
Save Changes (Y/N)?y
New Breaker Wear Data Saved.

=>>
```

Figure 7.22 BRE X W Command Response

Use the **BRE *n* R** command to reset the breaker monitor.

```
=>>BRE X R <Enter>

Reset Breaker Monitor Data (Y/N)?Y
Clearing Complete

=>>
```

Figure 7.23 BRE X R Command Response

CEV Command

The SEL-700G provides Compressed ASCII event reports to facilitate event report storage and display. SEL communications processors and SEL-5601-2 SYNCHROWAVE Event Software take advantage of the Compressed ASCII format. Use the **CHIS** command to display Compressed ASCII event history information. Use the **CSUM** command to display Compressed ASCII event summary information. Use the **CEVENT *n*** (**CEV *n***) command to display Compressed ASCII event reports. Parameter *n* indicates the event number. The events can be accessed by the event record number or by their unique reference number. The most recent event report is record number one (1), the next most recent report is record number two (2), and so on. Reference numbers start at 10000 and increment by 1 with each event. When the event report list is cleared, the reference number resets to 10000. See *Table C.2* for further information. Compressed ASCII Event Reports contain all of the Relay Word bits. The **CEV *n* R** command shows the raw Compressed ASCII event report.

CGSR Command (Generator Autosynchronism Report)

The **CGSR** command is available in SEL-700G models with the generator autosynchronizer function. It generates the requested generator autosynchronism report in Compressed ASCII format to facilitate report storage and display. SEL communications processors and SYNCHROWAVE Event take advantage of the Compressed ASCII format. Refer to *Section 10: Analyzing Events* for more details on the generator autosynchronism report.

CLOSE n Command (Close Breaker n, Where n = X or Y)

The **CLO *n*** (**CLOSE *n***) command asserts Relay Word bit CC *n* for 1/4 cycle when it is executed. Relay Word bit CC*n* can then be programmed into the CL *n* SELOGIC control equation to assert the CLOSE ***n*** Relay Word bit, which in turn asserts an output contact (e.g., OUT*xxx* = CLOSE ***n***) to close Circuit Breaker *n* (see *Table 4.62* and *Figure 4.138* through *Figure 4.140* for factory-default setting CL *n* and the close logic).

To issue the **CLO X** command, enter the following.

```
=>>CLO X <Enter>

Close Breaker X(Y,N)? Y <Enter>

=>>
```

Typing **N <Enter>** after the previous prompt aborts the command.

The **CLO *n*** command is supervised by the main board breaker control jumper (see *Table 2.19*). If the breaker jumper is not in place (breaker control jumper = OFF), the relay does not execute the **CLO *n*** command and responds with the following.

```
=>>CLO X <Enter>

Command Aborted: No BRKR Jumper

=>>
```

When setting EN_LRC := Y (see *Table 9.6*), the Relay Word bit LOCAL supervises the **CLO *n*** command. If the LOCAL bit is asserted (LOCAL = 1), the relay does not execute the **CLO *n*** command and responds with the following:

```
=>>CLO X <Enter>

Command Aborted: Device in Local Control

=>>
```

The Relay Word bit LOCAL is determined by the LOCAL SELOGIC control equation (see *Table 9.6*).

COM PTP Command

The **COM PTP** command provides a report of the PTP data sets maintained by the device as well as statistics for the measured time offsets with the parent (master) clock. The PTP data sets contain information about the state, identity, and configuration of the local, parent, and grandmaster clocks in addition to properties of the time being distributed by the grandmaster clock.

Table 7.16 COM PTP Command

Command	Description	Access Level
COM PTP	Displays the PTP data sets and offset statistics for the active PTP slave port or the last active PTP slave port before all PTP slave ports went down.	1
COM PTP C or **R**	Clears or resets the PTP offset statistics for all ports.	1

If the EPTP setting is set to NO, and the **COM PTP** command (with or without any parameters) is sent to the relay, the relay responds with:

```
=>COM PTP <Enter>

PTP not enabled
```

If a temporary resource shortage exists, a settings change is in progress, or the PTP component is not yet initialized, and the **COM PTP** command is sent to the relay, the relay responds with:

```
=>COM PTP <Enter>

Command is not available
```

If EPTP is enabled and the **COM PTP C** or **R** command is sent to the SEL-700G, the SEL-700G responds with:

```
=>COM PTP C <Enter>

Clear PTP offset statistics?
Are you sure? Y N
```

If you select **Y**, the relay responds with: `Clearing Complete`. If you select **N**, the relay responds with: `Command Canceled`. If you select anything else, the relay responds with: `Command Canceled`.

If a **COM PTP C** or **R** command is sent to the SEL-700G and the PTP component is enabled but not yet initialized, the SEL-700G responds with:

```
=>COM PTP R <Enter>

Command is not available
```

The SEL-700G Relay saves the date and time when the PTP offset statistics are cleared. The format of the offset clearing data matches the DATE_F Global Setting. The statistic clearing date and time is the time of the last user reset through an ASCII command, the last Port 1 settings change, or the last power up. The time stamp of the most recent event is displayed.

An example response to the **COM PTP** command when PTP is available is shown in *Figure 7.24*.

```
=>>COM PTP <Enter>

SEL-700GT                                   Date: 05/13/2019   Time: 10:01:41.976
INTERTIE RELAY                              Time Source: External


PTP offset statistics previously cleared on 05/09/2019 09:32:18 (UTC)


Settings Data Set
  PTP Profile : Default
  Transport Mechanism : UDP
  Path Delay : P2P


Default Data Set
  Two Step : true
  Clock Identity : 00 30 A7 FF FE 12 32 22
  Number of Ports : 1
  Clock Quality
    Clock Class : 255
    Clock Accuracy : 254
    Offset Log Variance : 0
  Priority1 : 255
  Priority2 : 255
  Domain Number : 0
  Slave Only : true


Current Data Set
  Steps Removed : 1


Parent Data Set
  Parent Port Identity
  Clock Identity : 00 30 A7 FF FE 0B 29 91
    Port Number : 1
  Grandmaster Clock Identity : 00 30 A7 FF FE 0B 29 91
  Grandmaster Clock Quality
    Clock Class : Synchronized with PTP timescale 6
    Clock Accuracy : Within 100 ns
    Offset Log Variance : 18887
  Grandmaster Priority1 : 128
  Grandmaster Priority2 : 128


Time Properties Data Set
  Current UTC Offset : 37
  Current UTC Offset Valid : true
  Leap59 : false
  Leap61 : false
  Time Traceable : true
  Frequency Traceable : true
  PTP Timescale : true
  Time Source : GPS
  Local Time Offset
    Offset Valid : true
    Name : UTC-07:00
    Current Offset : -25237 s
    Jump Seconds : -3600 s
    Time of Next Jump : 1572771637 s


Port Data Set
  Port Identity
    Clock Identity : 00 30 A7 FF FE 12 32 22
    Port Number : 1
  Port State : SLAVE
  Log Pdelay Request Interval : 0
  Peer Mean Path Delay : 0 ns
  Announce Receipt Timeout : 4 intervals
  Path Delay Mechanism : P2P
  Failed to Receive Response : true
  Received Multiple Pdelay Responses : false
  Reason for Non-synchronization :
  Port status : A, ACTIVE

=>>
```

Figure 7.24 COM PTP Command Response When PTP Is Available

A description of each PTP data set displayed in *Figure 7.24* is given in *Table 7.17*.

Table 7.17 PTP Data Set Descriptions (Sheet 1 of 5)

Type of Data Set	Information Field	Description
Settings	PTP Profile	This value is the same as PTPPRO.
	Transport Mechanism	This value is the same as PTPTR.
	Path Delay	This value is the same as PTHDLY.
Default	Two Step	For the default data set, this is set to TRUE. A two-step clock uses the combination of an event message and a subsequent general message to provide time information. A one-step clock uses a single event message to provide time information.
	Clock Identity	This is an 8-octet number that uniquely identifies the clock on the network. It is derived from the Ethernet MAC address.
	Number of Ports	This is the number of Ethernet ports used to communicate PTP messages. It is always 1 for SEL-700G relays.
	Clock Quantity	This contains information about clock class, accuracy, and variance of the SEL-700G Relay.
	Priority1	This is the first priority for the SEL-700G Relay used in the default BMCA. It is always set to 255.
	Priority2	This is the second priority for the SEL-700G Relay used in the default BMCA. It is always set to 255.
	Domain Number	This value is the same as DOMNUM. It is the PTP domain number to which the clock belongs.
	Slave Only	This value is always TRUE for SEL-700G relays.
Current	Steps Removed	This is the number of communication paths between the SEL-700G Relay and the grandmaster clock. A communication path is the link between a master and a slave port. Hence, links to transparent clocks do not count as separate paths. The values range from 1 to 65535.
Parent	Parent Port Identity	This contains the clock identity and port number of the adjacent clock to which the SEL-700G clock is synchronized. The port number identifies the specific port on the adjacent clock from which the SEL-700G clock is receiving PTP messages.
	Grandmaster Clock Identity	This is the clock identity of the grandmaster clock to which the SEL-700G is synchronized.
	Grandmaster Clock Quality	This contains the class, accuracy, and variance of the grandmaster clock.

Table 7.17 PTP Data Set Descriptions (Sheet 2 of 5)

Type of Data Set	Information Field	Description
	Grandmaster Clock Class	This field displays an ASCII message based on the received clock class code as described in the following table.

Code (decimal)	Message
68–122, 133–170, 216–232	Profile specific value
6	Synchronized with PTP timescale
7	Holdover with PTP timescale
13	Synchronized with ARB timescale
14	Holdover with ARB timescale
52	Holdover degrade A with PTP timescale
58	Holdover degrade A with ARB timescale
187	Holdover degrade B with PTP timescale
193	Holdover degrade B with ARB timescale
248	Default
255	Slave only
All other codes	Reserved with decimal code value (xxx)

Table 7.17 PTP Data Set Descriptions (Sheet 3 of 5)

Type of Data Set	Information Field	Description
	Grandmaster Clock Accuracy	This field displays an ASCII message based on the received clock accuracy enumeration value as described in the following table.

Value (Hex)	Message
20	Within 25 ns
21	Within 100 ns
22	Within 250 ns
23	Within 1 µs
24	Within 2.5 µs
25	Within 10 µs
26	Within 25 µs
27	Within 100 µs
28	Within 250 µs
29	Within 1 ms
2A	Within 2.5 ms
2B	Within 10 ms
2C	Within 25 ms
2D	Within 100 ms
2E	Within 250 ms
2F	Within 1 s
30	Within 10 s
31	Greater than 10 s
80–FD	Profile specific value (0xyy)
FE	Unknown
All other values	Reserved (0xyy)

Type of Data Set	Information Field	Description
	Grandmaster Priority1	This is the priority1 value set in the grandmaster clock. If the setting ALTPRI*n* > 0, its value is used as the reported priority1 value for grandmaster *n*. The expected value is between 0 to 255.
	Grandmaster Priority 2	This is the priority2 value set in the grandmaster clock. The expected value is between 0 to 255.
	C37.238 TLV Information	This is the C37.238 TLV information received. It is valid only in the Power profile. In the case of Default profile, this section is hidden.
Time Properties	Current UTC Offset	This is the current number of leap seconds between TAI and UTC.
	Current UTC Offset Valid	This attribute is TRUE if the Current UTC Offset is valid and should be used. It is FALSE otherwise.
	Leap59	This is set to TRUE if there is an impending leap second removal, i.e., the last minute of the current day contains 59 seconds.
	Leap61	This is set to TRUE if there is an impending leap second insertion, i.e., the last minute of the current day contains 61 seconds.
	Time Traceable	This indicates if the time being served is traceable to UTC reference time.
	Frequency Traceable	This indicates if the frequency being distributed is traceable to a primary source.
	PTP Timescale	This is TRUE if the time being served uses the PTP/UTC timescale. Otherwise, it is FALSE.

Table 7.17 PTP Data Set Descriptions (Sheet 4 of 5)

Type of Data Set	Information Field	Description
	Time Source	This shows the source of the time being distributed based on the value of the time source enumeration as shown in the following table. **Code (decimal)** — **Message** 10 — ATOMIC_CLOCK 20 — GPS 30 — TERRESTRIAL_RADIO 40 — PTP 50 — NTP 60 — HAND_SET 90 — OTHER A0 — INTERNAL_OSCILLATOR F0–FE — PROFILE SPECIFIC VALUE (0xyy) All other values — RESERVED (0xyy)
	Local Time Offset	This is the offset of local time from UTC and information about impending change in the offset.
Port	Port Identity	This contains the clock ID and port number of the SEL-700G Relay on the PTP network.
	Port State	This is the synchronization state of the SEL-700G Relay: LISTENING, SLAVE, UNCALIBRATED, or FAULTY. The relay is synchronized if the state is SLAVE.
	Log Delay Request Interval	If the end-to-end delay mechanism is enabled, then this is the logarithm to base 2 of the delay request intervals (in seconds) received from the master clock. If the peer-to-peer (P2P) delay mechanism is enabled, these data are hidden. Also, these data are hidden when delay mechanism is set to OFF.
	Log Pdelay Request Interval	If the peer-to-peer (P2P) delay mechanism is enabled, this is the logarithm to base 2 of the configured peer delay request intervals (PDINT). If the end-to-end delay mechanism is enabled, these data are hidden. Also, these data are hidden when delay mechanism is set to OFF.
	Peer Mean Path Delay	If the peer-to-peer (P2P) delay mechanism is enabled, this is the measured mean peer delay on the SEL-700G Relay. If the peer-to-peer (P2P) delay mechanism is not selected (PTHDLY := P2P), these data are hidden.
	Announce Receipt Timeout	This value is always 4 announce intervals.
	Path Delay Mechanism	This is the same value as PTHDLY.
	Failed to Receive Response	The value is TRUE if no response is received after 5 consecutive Delay or Pdelay Requests from the port. Otherwise, the value is FALSE. These data are hidden if PTHDLY := OFF.
	Received Multiple Pdelay Responses	This is set to TRUE if a response is received from more than one clock to a Pdelay request from the SEL-700G. The port state will transition to faulty when this happens. The value is reset to FALSE, when only one clock responds to Pdelay requests from the SEL-700G. These data are hidden if PTHDLY := P2P.

Table 7.17 PTP Data Set Descriptions (Sheet 5 of 5)

<table>
<tr><th>Type of Data Set</th><th>Information Field</th><th>Description</th></tr>
<tr><td></td><td>Reason for Non-synchronization</td><td>If the SEL-700G Relay is failing to synchronize, this provides one of the following reasons for the failure: incorrect domain number, clock not in the acceptable master table, or missing TLV in Announce messages. Otherwise, the string is empty. See the following table.
<table>
<tr><th>Number</th><th>Reason for Non-synchronization Display Strings</th></tr>
<tr><td>1</td><td>Received Announce message for a different domain:
<domain number></td></tr>
<tr><td>2</td><td>Received Announce message from an unacceptable master:
<MAC or IP address></td></tr>
<tr><td>3</td><td>Required TLV is missing or incorrectly formatted by clock:
<clock ID></td></tr>
</table></td></tr>
<tr><td></td><td>Port Status</td><td>This displays the Port 1A or 1B time-synchronization status. If the port is not synchronized to a PTP master, NA is displayed. If a port is in the SLAVE state and it is chosen as master, ACTIVE is displayed.
Additional port status indications are available via Relay Word bits PTPA, PTPB, PASEL, and PBSEL. When Ethernet Port 1A is active, PASEL asserts. Similarly, when Ethernet Port 1B is active, PBSEL asserts. If the operating mode on Port 1 of the relay is PRP, PTP is enabled and the relay is receiving PTP messages on Port 1A, PTPA asserts. Similarly, in PTP mode, if PTP is enabled and the relay is receiving PTP messages on Port 1B, PTPB asserts.</td></tr>
</table>

COMMUNICATIONS Command

The **COM *x*** command (see *Table 7.18*) displays communications statistics for the MIRRORED BITS communications channels. For more information on MIRRORED BITS communications, see *Appendix J: MIRRORED BITS Communications*.

The summary report includes information on the failure of ROKA or ROKB. The `Last Failure` field displays the reason for the most recent channel error, even if the channel was already failed. We define failure reasons as one of the following error types:

- Device disabled
- Framing error
- Parity error
- Overrun
- Re-sync
- Data error
- Loopback
- Underrun

Table 7.18 COM Command (Sheet 1 of 2)

Command	Description	Access Level
COM S A or **COM S B**	Returns a summary report of the last 255 records in the communications buffer for either MIRRORED BITS communications Channel A or Channel B when only one channel is enabled.	1
COM A	Returns a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.	1
COM B	Returns a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.	1
COM L A	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.	1

Table 7.18 COM Command (Sheet 2 of 2)

Command	Description	Access Level
COM L B	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.	1
COM C	Clears all communications records. If both MIRRORED BITS channels are enabled, omitting the channel specifier (A or B) clears both channels.	1
COM C A	Clears all communications records for Channel A.	1
COM C B	Clears all communications records for Channel B.	1

CONTROL Command (Control Remote Bit)

Use the **CON** command (see *Table 7.19*) to control remote bits (Relay Word bits RB01–RB32). You can also use the **CON** function from the front panel HMI to pulse the output contacts. Remote bits are device variables that you set via serial port communication only; you cannot navigate remote bits via the front-panel HMI. You can select the control operation from three states: set, clear, or pulse, as described in *Table 7.19*.

Table 7.19 CONTROL Command

Command	Description	Access Level
CON RB*nn k*	Set a remote bit to set, clear, or pulse.	2
Subcommand		
S	Set remote bit (ON position)	2
C	Clear remote bit (OFF position)	2
P	Pulse remote bit for 1/4 cycle (MOMENTARY position)	2
Parameters		
nn	A number from 01 to 32, representing RB01 through RB32.	
k	S, C, or P.	

For example, use the following command to set Remote Bit RB05:

```
=>>CON RB05 S <Enter>
```

COPY Command

Use the **COPY *j k*** command (see *Table 7.20*) to copy the settings of Group *j* to the settings of Group *k*. The settings of Group *j* effectively overwrite the settings of Group *k*. Parameters *j* and *k* can be any available settings group number 1 through 4.

Table 7.20 COPY Command

Command	Description	Access Level
COPY *j k*	Copy settings values from Group *j* to Group *k*.	2
Parameters		
j	1, 2, 3 or 4.	
k	1, 2, 3 or 4.	

For example, when you enter the **COPY 1 3** command, the relay responds, `Are you sure (Y/N)?` Answer **Y <Enter>** (for yes) to complete copying. The settings in Group 3 are overwritten by the settings in Group 1.

COUNTER Command (Counter Values)

The device generates the values of the 32 counters in response to the **COU** command (see *Table 7.21*).

Table 7.21 COUNTER Command

Command	Description	Access Level
COU *n*	Display current state of device counters *n* times, with a 1/2-second delay between each display	1

DATE Command (View/Change Date)

Use the **DATE** command (see *Table 7.22*) to view and set the relay date.

Table 7.22 Date Command

Command	Description	Access Level
DATE	Display the internal clock date.	1
DATE *mm/dd/yyyy*, ***yyyy/mm/dd***, or ***dd/mm/yyyy***	Set the internal clock date (DATE_F set to MDY, YMD, or DMY).	1

The relay can overwrite the date you enter by using other time sources, such as IRIG. Enter the **DATE** command with a date to set the internal clock date.

Separate the month, day, and year parameters with spaces, commas, slashes, colons, and semicolons. Set the year in 4-digit form (for dates 2000–2099). Global setting DATE_F sets the date format.

ETH Command

The **ETH** command (Access Level 1) can be used to display the Ethernet port (**Port 1**) status as shown in *Figure 7.25* for the redundant fiber-optic (FX) Ethernet **Port 1A** and **Port 1B** configuration. The copper Ethernet port is labeled as TX. The response is similar for relays with the single Ethernet port option.

Different Ethernet configurations and different NETMODE settings result in slightly different information being displayed, as shown in the following figures.

```
=>>ETH <Enter>

SEL-700G                                   Date: 07/10/2015   Time: 20:16:05.914
FEEDER RELAY                              Time Source: External

NETMODE: PRP

             LINK   SPEED  DUPLEX MEDIA
PORT 1A      Up     100M   Full   TX
PORT 1B      Up     100M   Full   TX

IP Port:

MAC: 00-30-A7-01-02-04
IP ADDRESS: 10.10.52.221
SUBNET MASK: 255.255.255.0
DEFAULT GATEWAY: 10.10.52.1

         PACKETS                BYTES              ERRORS
      SENT     RCVD         SENT       RCVD      SENT    RCVD
      5098     1000       645526      88876         0       0

=>>
```

Figure 7.25 Ethernet Port (PORT 1) Status Report When NETMODE := PRP

```
=>>ETH <Enter>

SEL-700G                                   Date: 07/10/2015   Time: 20:18:11.791
FEEDER RELAY                              Time Source: External

NETMODE: FIXED

 PRIMARY PORT:  PORT 1A
 ACTIVE PORT:   PORT 1A

             LINK   SPEED  DUPLEX MEDIA
PORT 1A      Up     100M   Full   TX

IP Port:

MAC: 00-30-A7-01-02-04
IP ADDRESS: 10.10.52.221
SUBNET MASK: 255.255.255.0
DEFAULT GATEWAY: 10.10.52.1

         PACKETS                BYTES              ERRORS
      SENT     RCVD         SENT       RCVD      SENT    RCVD
       143      107        14652       7861         0       0

=>>
```

Figure 7.26 Ethernet Port (PORT 1) Status Report When NETMODE := FIXED

NOTE: Relays with older CPU cards can be upgraded to firmware versions R200 or higher, but the relay will not have the GOOSE performance improvements (i.e., a GOOSE port with a dedicated MAC address).

```
=>>ETH <Enter>

SEL-700G                                    Date: 10/25/2016   Time: 10:59:25.558
FEEDER RELAY                                Time Source: Internal

NETMODE: FAILOVER

PRIMARY PORT:  1A
ACTIVE PORT:   1A

             LINK   SPEED  DUPLEX MEDIA
PORT 1A      Up     100M   Full   TX
PORT 1B      Down   --     --     TX


IP Port:

MAC: 00-30-A7-67-32-10
IP ADDRESS: 10.10.52.244
SUBNET MASK: 255.255.255.0
DEFAULT GATEWAY: 10.10.52.1

         PACKETS                BYTES              ERRORS
      SENT     RCVD         SENT       RCVD      SENT    RCVD
        36       72         2660       5081         0       0

GOOSE Port:

MAC: 00-30-A7-78-10-20

         PACKETS                BYTES              ERRORS
      SENT     RCVD         SENT       RCVD      SENT    RCVD
         0        0            0          0         0       0

=>>
```

Figure 7.27 Ethernet Port (PORT 1) Status Report When NETMODE := FAILOVER, E61850 := Y, and EGSE := Y

```
=>>ETH <Enter>

SEL-700G                                     Date: 07/10/2015   Time: 20:21:34.698
FEEDER RELAY                                Time Source: External

NETMODE: SWITCHED

             LINK   SPEED  DUPLEX MEDIA
PORT 1A      Up     100M   Full   TX
PORT 1B      Up     100M   Full   TX

IP Port:

MAC: 00-30-A7-01-02-04
IP ADDRESS: 10.10.52.221
SUBNET MASK: 255.255.255.0
DEFAULT GATEWAY: 10.10.52.1

         PACKETS                BYTES              ERRORS
      SENT     RCVD         SENT       RCVD      SENT    RCVD
        93       74         8537       5096         0       0

=>>
```

Figure 7.28 Ethernet Port (PORT 1) Status Report When NETMODE := SWITCHED

The command response for the single Ethernet port option is as shown in *Figure 7.29*.

```
==>>ETH <Enter>

SEL-700G                                  Date: 06/05/2010   Time: 10:41:44
FEEDER RELAY                              Time Source: Internal

 MAC: 00-30-A7-00-75-6A
 IP ADDRESS: 192.168.1.2
 SUBNET MASK: 255.255.255.0
 DEFAULT GATEWAY: 192.168.1.1

             LINK   SPEED  DUPLEX   MEDIA
PORT 1A      Up     100M    Full      TX

=>>
```

Figure 7.29 Ethernet Port (PORT 1) Status Report for the Single Ethernet Port Option

EVENT Command (Event Reports)

Use the **EVE** command (see *Table 7.23*) to view event reports. See *Section 10: Analyzing Events* for further details on retrieving and analyzing event reports. See the *HISTORY Command on page 7.56* for details on clearing event reports.

Table 7.23 EVENT Command (Event Reports)

Command	Description	Access Level
EVE *n m*	Return the *n* event report with 4-samples/cycle data.	1
EVE *n* R *m* or **EVE R *n m***	Return the *n* event report with raw (unfiltered) 32-samples/cycle analog data and 4 samples/cycle digital data.	1
EVE D *n m*	Return the *n* digital data event report with 4-samples/cycle data.	1
EVE D *n* R *m*	Return the *n* digital data event report with 32-samples/cycle data.	1
EVE DIF1 *n*	Return the *n* differential element 1 event report, with 4-samples/cycle data.	1
EVE DIF2 *n*	Return the *n* differential element 2 event report, with 4-samples/cycle data.	1
EVE DIF3 *n*	Return the *n* differential element 3 event report, with 4-samples/cycle data.	1
EVE GND *n*	Return the *n* ground event report (64G element) with 4-samples/cycle data.	1
Parameters		
n	Indicates a record or event reference number. The most recent event has a record number of 1 and increments by 1 with each event, whereas the event reference number is a unique number that starts at 10000 and increments by 1 with each event (see *Event Reference Number on page 10.4* for details). If n is not specified, the relay displays the latest event report by default.	
m	X for X-side voltages and currents or digital data and Y for Y-side currents and voltages or digital data. If *m* is not specified, the relay defaults to *m* = X.	

FILE Command

The **FIL** command (see *Table 7.24*) is a safe and efficient means of transferring files between intelligent electronic devices (IEDs) and external support software (ESS). The **FIL** command ignores the hide rules and transfers visible as well as hidden settings, except for the settings hidden by a part number. The **FIL** command is supported if you connect over the serial or Ethernet ports.

Table 7.24 FILE Command

Command	Description	Access Level
FIL DIR	Returns a list of files.	1
FIL READ *filename*	Transfers settings file *filename* from the relay to the PC.	1
FIL WRITE *filename*	Transfers settings file *filename* from the PC to the relay.	2
FIL SHOW *filename*	Displays contents of the file *filename*.	1

GEN Command (Generator Operating Statistics Report)

The **GEN** command and associated report are available in SEL-700G models that protect a generator.

Table 7.25 GEN Command Variants

Command Variant	Description	Access Level
GEN	Displays the generator operating profile information.	1
GEN R	Resets the generator operating profile information.	2

The **GEN** command displays the generator operation profile, which includes:

- ➤ Accumulated time in 81AC off-frequency time accumulators, if enabled
- ➤ Total generator running hours, stopped hours, full load hours, and percent running time
- ➤ Accumulated I_2^2t
- ➤ Three-phase power output averages

To view the generator operation profile, enter the command:

```
=>GEN <Enter>
```

The output from an SEL-700G is shown:

```
=>GEN <Enter>

SEL-700GT                                   Date: 02/26/2010   Time: 17:33:20.453
INTERTIE RELAY                              Time Source: Internal

81AC Off-Frequency Time Accumulators                Since: 02/24/2010     17:02:36
Frequency Band 1,  59.5 to  58.8:     23.4s or    0.8% of  3000.00
Frequency Band 2,  58.8 to  58.0:    422.5s or   78.2% of   540.00

Operating History, elapsed time in ddd:hh:mm:ss  Since: 02/24/2010     17:02:36
Running hours:                 0:01:31:03
Stopped hours:>                1:19:55:43
Full load hours:               0:01:48:57
Time running:                3  %
Accumulated I2*I2*t (A*A*s): 20.9

Average power                                       Since: 02/24/2010     17:02:36
MW out:                      63.94
MVAR out:                    36.83
MVAR in:                     0.00
power factor:                0.87 LAG


=>
```

Figure 7.30 GEN Command Response

The GEN report is also available as a read-only file that can be retrieved using Ethernet FTP or MMS. MMS is only available in models that support IEC 61850 and only when IEC 61850 and MMS file transfer are enabled (E61850 := Y, EMMSFS := Y). See *File Transfer Protocol (FTP) and MMS File Transfer on page 7.15*, *Virtual File Interface on page 7.77*, and *MMS on page G.5* for additional information.

GSH Command

The **GSH** command (see *Table 7.26*) displays the requested generator autosynchronism report (CGSR or GSR) history. This report lists all of the time stamps for the generator autosynchronism reports (see *Figure 7.31*).

Table 7.26 GSH Command Variants

Command Variant	Description	Access Level
GSH	Displays the generator autosynchronism report history.	1
GSH C or **R**	Clears the generator autosynchronism report history.	2

```
=>GSH <Enter>

SEL-700GT                                   Date: 02/26/2010   Time: 17:44:48.585
INTERTIE RELAY                              Time Source: Internal

FID=SEL-700G-X133-V0-Z001001-D20100219

#      DATE         TIME
1   02/26/2010  17:44:14.819
2   02/26/2010  17:42:46.686
3   02/26/2010  17:42:43.356
4   02/26/2010  17:42:03.777

=>
```

Figure 7.31 GSH Command Response

The GSH report is also available as a read-only file that can be retrieved using Ethernet FTP or MMS. MMS is only available in models that support

IEC 61850 and only when IEC 61850 and MMS file transfer are enabled (E61850 := Y, EMMSFS := Y). See *File Transfer Protocol (FTP) and MMS File Transfer on page 7.15*, *Virtual File Interface on page 7.77*, and *MMS on page G.5* for additional information.

GST Command (Trigger GSR)

The **GST** (level 1) command triggers the generator autosynchronism report data acquisition.

GOOSE Command

Use the **GOOSE** command to display transmit and receive GOOSE messaging information, which you can use for troubleshooting. The **GOOSE** command variants and options are shown in *Table 7.27*.

Table 7.27 GOOSE Command Variants

Command Variant	Description	Access Level
GOOSE	Displays GOOSE information.	1
GOOSE *k*	Displays GOOSE information *k* times.	1
GOOSE S	Displays a list of GOOSE subscriptions with their ID.	1
GOOSE S *n*	Displays GOOSE statistics for subscription ID *n*.	1
GOOSE S ALL	Displays GOOSE statistics for all subscriptions.	1
GOOSE S *n* L	Displays GOOSE statistics for subscription ID *n* including error history.	1
GOOSE S ALL L	Displays GOOSE statistics for all subscriptions including error history.	1
GOOSE S *n* C	Clears GOOSE statistics for subscription ID *n*.	1
GOOSE S ALL C	Clears GOOSE statistics for all subscriptions.	1

The information displayed for each GOOSE IED is described in *Table 7.28*.

Table 7.28 GOOSE IED Description (Sheet 1 of 2)

Information Field	Description
`Transmit` `GOOSE Control Reference`	This field represents the GOOSE control reference information that includes the IED name, ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and GSEControl name (GSE Control Block Name) (e.g., SEL_351S_1CFG/LLN0GOGooseDSet13).
`Receive` `GOOSE Control Reference`	This field represents the goCbRef (GOOSE Control Block Reference) information that includes the iedName (IED name), ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and cbName (GSE Control Block Name) (e.g., SEL_351S_1CFG/LLN0GOGooseDSet13).
`MultiCastAddr` (Multicast Address)	This hexadecimal field represents the GOOSE multicast address.
`Ptag`	This three-bit decimal field represents the priority tag value, where spaces are used if the priority tag is unknown.
`Vlan`	This 12-bit decimal field represents the virtual LAN (Local Area Network) value, where spaces are used if the virtual LAN is unknown.
`StNum` (State Number)	This hexadecimal field represents the state number that increments with each state change.
`SqNum` (Sequence Number)	This hexadecimal field represents the sequence number that increments with each retransmitted GOOSE message sent.
`TTL` (Time to Live)	This field contains the time (in ms) before the next message is expected.

Table 7.28 GOOSE IED Description (Sheet 2 of 2)

Information Field	Description
Code	When appropriate, this text field contains warning or error condition text that is abbreviated as follows: **Code Abbreviation** — **Explanation** OUT OF SEQUENC — Out of sequence error CONF REV MISMA — Configuration Revision mismatch NEED COMMISSIO — Needs Commissioning TEST MODE — Test Mode MSG CORRUPTED — Message Corrupted TTL EXPIRED — Time to live expired
Transmit Data Set Reference	This field represents the DataSetReference (Data Set Reference) that includes the IED name, LN0 lnClass (Logical Node Class), and GSEControl datSet (Data Set Name) (e.g., SEL_351S_1CFG/LLN0$DSet13).
Receive Data Set Reference	This field represents the datSetRef (Data Set Reference) that includes the iedName (IED name), ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and datSet (Data Set Name) (e.g., SEL_351S_1CFG/LLN0$DSet13).
Ctrl Ref/ ControlBlockReference	This is the GOOSE control block reference. It is a concatenation of the logical device name, LLN0 (logical node containing the control block), GO (functional constraint), and the GSEControl name. (e.g. SEL_351S_1CFG/LLN0GOGooseDSet13)
AppID	This is the application identifier as a decimal number.
From	This is the date and time the current statistics collection started.
To	This is the date and time the GOOSE statistics command was executed.
Accumulated downtime duration	This represents the total amount of time a subscription was in an error state. The duration is displayed in the format: hhhh:mm:ss.zzz.
Maximum downtime duration	This represents the maximum amount of time a subscription was continuously in error state. The duration is displayed in the format: hhhh:mm:ss.zzz.
Date & time maximum downtime began	This is the date and time the recorded maximum downtime started.
Number of messages received out-of-sequence (OOS)	This represents the total number of messages received with either the state number and/or sequence number out-of-sequence. This includes cases where more than one instance of a message is received within a single relay processing interval. In this case, the most recent message is processed and the others are discarded.
Number of time-to-live (TTL) violations detected	This represents the total number of times a message was not received within the expected period/interval.
Number of messages incorrectly encoded or corrupted	This represents the total number of messages that were identified with this subscription but were either incorrectly encoded or encoded with a wrong dataset.
Number of messages lost due to receive overflow	This represents the total number of messages that were not processed because memory resources were exhausted. This includes cases where more than one instance of a message is received within a single relay processing interval. In this case, the most recent message is processed and the others are discarded.
Calculated max. sequential messages lost due to OOS	This represents the maximum estimated number of messages that were missed after receiving a message with a higher state or sequence number than expected.
Calculated number of messages lost due to OOS	This represents the total of all estimated number of messages lost due to state or sequence number skip in received messages.

Table 7.29 Warning and Error Codes for GOOSE Subscriptions

Code	Enumeration[a]	Definition	Error/Warning
–	0	No errors present.	–
HOST DISABLED	1	Optional code for when the subscribing device is disabled or becomes unresponsive after the **GOOSE** command has been issued.	Error
CONF REV MISMA	2	Configuration revision mismatch. Displayed when the value of the configuration revision number in the received GOOSE message does not match with the value of the configuration revision number present in the CID file.	Error
NEED COMMISSIO	3	Needs commissioning. Displayed when the received GOOSE message has NdsCom = true.	Error
MSG CORRUPTED	4	Message corrupted. Displayed when a received GOOSE message does not meet the proper format or is corrupted.	Error
TTL EXPIRED	5	Time-to-live expired.	Error
OUT OF SEQUENC	6	Out-of-sequence (OOS) error. This error is present when the StNum or SqNum value between received GOOSE messages is not sequential.	Warning
INVALID QUAL	7	Invalid date quality received.	Warning

[a] Enumerations are used to communicate GOOSE error codes in the LGOS logical node.

An example response to the **GOOSE** commands is shown in *Figure 7.32*.

```
=>GOOSE <Enter>

GOOSE Transmit Status

 MultiCastAddr   Ptag:Vlan AppID  StNum      SqNum      TTL    Code
-----------------------------------------------------------------------------
SEL_700G_1CFG/LLN0$GO$GPub01
 01-0C-CD-01-00-0A 4:1     4106   1          5608       322
 Data Set: SEL_700G_1CFG/LLN0$GPDSet01

SEL_700G_1CFG/LLN0$GO$NewGOOSEMessage
 01-0C-CD-01-00-05 4:3     5      1          5608       323
 Data Set: SEL_700G_1CFG/LLN0$NewDataset


GOOSE Receive Status

 MultiCastAddr   Ptag:Vlan AppID  StNum      SqNum      TTL    Code
-----------------------------------------------------------------------------
```

Figure 7.32 GOOSE Command Response

```
SEL_710d5_1CFG/LLN0$GO$NewGOOSEMessage
 01-0C-CD-01-00-04 4:3     4      11208      3          2000
 Data Set: SEL_710d5_1CFG/LLN0$NewDataset

SEL_787d4_1CFG/LLN0$GO$NewGOOSEMessage
 01-0C-CD-01-00-03 4:3     3      1          5567       2000
 Data Set: SEL_787d4_1CFG/LLN0$NewDataset


=>GOO S 1 L

 SubsID 1
-----------------------------------------------------------------------------
 Ctrl Ref: SEL_710d5_1CFG/LLN0$GO$NewGOOSEMessage
 AppID   : 4
 From    : 04/20/2018 12:38:00.635  To: 04/20/2018 14:14:29.287

 Accumulated downtime duration                      : 0000:00:07.980
 Maximum downtime duration                          : 0000:00:07.825
 Date & time maximum downtime began                 : 04/20/2018 12:40:22.255
 Number of messages received out-of-sequence(OOS)   : 1
 Number of time-to-live(TTL) violations detected    : 2
 Number of messages incorrectly encoded or corrupted: 0
 Number of messages lost due to receive overflow    : 0
 Calculated max. sequential messages lost due to OOS: 0
 Calculated number of messages lost due to OOS      : 0


 #    Date        Time          Duration        Failure
 1    04/20/2018  12:40:30.076  0000:00:00.004  OUT OF SEQUENCE
 2    04/20/2018  12:40:22.255  0000:00:07.820  TTL EXPIRED
 3    04/20/2018  12:40:16.054  0000:00:00.155  TTL EXPIRED

=>
```

Figure 7.32 GOOSE Command Response (Continued)

GROUP Command

Use the **GROUP** command (see *Table 7.30*) to display the active settings group or try to force an active settings group change (SS*n* SELOGIC control equations have priority over the **GROUP** command).

Table 7.30 GROUP Command

Command	Description	Access Level
GROUP	Display the active settings group.	1
GROUP *n*	Change the active group to Group *n*.	2
Parameter		
n	Indicates group numbers 1–4.	

When you change the active group, the relay responds with a confirmation prompt: `Are you sure (Y/N)?` Answer **Y <Enter>** to change the active group. The relay asserts the Relay Word bit SALARM for one second when you change the active group.

If any of the SELOGIC control equations SS1–SS4 are set when you issue the **GROUP *n*** command, the group change will fail. The relay responds: `Command Unavailable: Active setting group SELogic equations have priority over the GROUP command`.

HELP Command

The **HELP** command (see *Table 7.31*) gives a list of commands available at the present access level. You can also get a description of any particular command; type **HELP** followed by the name of the command for help on each command.

Table 7.31 HELP Command

Command	Description	Access Level
HELP	Displays a list of each command available at the present access level with a one-line description.	1
HELP *command*	Displays information on the command *command*.	1

HISTORY Command

Use the **HIS** command (see *Table 7.32*) to view a list of one-line descriptions of relay events or clear the list (and corresponding event reports) from nonvolatile memory. For more information on event reports, see *Section 10: Analyzing Events*.

Table 7.32 HISTORY Command

Command	Description	Access Level
HIS	Returns event histories with the oldest at the bottom of the list and the most recent at the top of the list.	1
HIS *n*	Returns event histories with the oldest at the bottom of the list and the most recent at the top of the list, beginning at event *n*.	1
HIS C or **R**	Clears/resets the event history and all corresponding event reports from nonvolatile memory.	1
HIS CA or **RA**	Clears/resets the event history and all corresponding event reports from nonvolatile memory and resets the unique reference number to 10000.	1

ID Command

Use the **ID** command (see *Table 7.33*) to extract device identification codes, as shown in *Figure 7.33*. You can use the information in the SPECIAL field in the **ID** command response to determine the hardware and firmware compatibility of the relay. Contact SEL technical support before you downgrade the relay firmware.

Table 7.33 ID Command

Command	Description	Access Level
ID	Returns a list of device identification codes.	0

```
=ID <Enter>

"FID=SEL-700G-R301-V4-Z007004-D20220225","08EB"
"BFID=SLBT7XX-R601-V0-Z000000-D20211116","094D"
"CID=0D77","025F"
"DEVID=SEL-700G","0408"
"DEVCODE=74","0312"
"PARTNO=0700G01B0X0X0X85027X","0728"
"CONFIG=111122010","041C"
"SPECIAL=0","02DE"
"iedName=SEL_700G_2","0612"
"type=SEL_700G","0490"
"configVersion=ICD-700G-R302-V0-Z301006-D20210723","0D5E"
"LIB61850ID=39236F6A","04D9"
```

Figure 7.33 ID Command Response

IRIG Command

Use the **IRIG** command to direct the relay to read the demodulated IRIG-B time code at the serial port or IRIG-B input (see *Table 7.34*).

Table 7.34 IRIG Command

Command	Description	Access Level
IRIG	Forces synchronization of internal control clock to IRIG-B time-code input.	1

To force the relay to synchronize to IRIG-B, enter the following command:

```
=>IRI <Enter>
```

If the relay successfully synchronizes to IRIG-B, it sends the following header and access level prompt:

```
SEL-700G                      Date: 02/27/2010 Time: 08:56:03.190
GENERATOR RELAY               Time Source: external
=>
```

If no IRIG-B code is present at the serial port input or if the code cannot be read successfully, the relay responds with `IRIG-B DATA ERROR`.

If an IRIG-B signal is present, the relay synchronizes its internal clock with IRIG-B. It is not necessary to issue the **IRIG** command to synchronize the relay clock with IRIG-B. Use the **IRIG** command to determine if the relay is properly reading the IRIG-B signal.

L_D Command (Load Firmware)

Use the **L_D** command (see *Table 7.35*) to load firmware. See *Appendix A: Firmware, ICD, and Manual Versions* for information on changes to the firmware and instruction manual. See *Appendix B: Firmware Upgrade Instructions* for further details on downloading firmware. Only download firmware to the front port.

Table 7.35 L_D Command (Load Firmware)

Command	Description	Access Level
L_D	Loads new firmware.	2

LDP Command (Load Profile Report)

Use the **LDP** commands (see *Table 7.36*) to view and manage the load profile report (see *Figure 5.16*). If there are no stored data and an **LDP** command is issued, the relay responds with `No data available`.

Table 7.36 LDP Commands

Command	Description	Access Level
LDP ***row1 row2*** **LDP** ***date1 date2***	Displays a numeric progression of all of the load profile report rows. Use the **LDP** command with parameters to display a numeric or reverse numeric subset of the load profile rows.	1
LDP C	Clears the load profile report from nonvolatile memory.	1
Parameters		
row1 row2	Append *row1* to return a chronological progression of the first *row1* rows. Append *row1* and *row2* to return all rows between *row1* and *row2*, beginning with *row1* and ending with *row2*. Enter the smaller number first to display a numeric progression of rows through the report. Enter the larger number first to display a reverse numeric progression of rows.	
date1 date2	Append *date1* to return all rows with this date. Append *date1* and *date2* to return all rows between *date1* and date beginning with *date1* and ending with *date2*. Enter the oldest date first to display a chronological progression through the report. Enter the newest date first to display a reverse chronological progression. Date entries are dependent on the date format setting DATE_F.	

LOOPBACK Command

The **LOO** command (see *Table 7.37*) is used for testing the MIRRORED BITS communications channel for proper communication. For more information on MIRRORED BITS, see *Appendix J: MIRRORED BITS Communications*. With the transmitter of the communications channel physically looped back to the receiver, the MIRRORED BITS addressing will be wrong and ROK will be deasserted. The **LOO** command tells the MIRRORED BITS software to temporarily expect to see its own data looped back as its input. In this mode, LBOK asserts if error-free data are received. The **LOO** command, with just the channel specifier, enables the loopback mode on that channel for five minutes, while the inputs are forced to the default values.

Table 7.37 LOO Command

Command	Description	Access Level
LOO	Enables loopback testing of MIRRORED BITS channels.	2
LOO A	Enables loopback on MIRRORED BITS Channel A for the next 5 minutes.	2
LOO B	Enables loopback on MIRRORED BITS Channel B for the next 5 minutes.	2
LOO R	Cancels the loopback test.	2

```
=>>LOO A <Enter>
Loopback will be enabled on Mirrored Bits channel A for the next 5 minutes.
The RMB values will be forced to default values while loopback is enabled.
Are you sure (Y/N)?
=>>
```

If only one MIRRORED BITS port is enabled, the channel specifier (A or B) can be omitted. To enable loopback mode for other than the 5-minute default, enter the number of minutes (1–5000) that you want as a command parameter. To allow the loopback data to modify the RMB values, include the DATA parameter.

```
=>>LOO 10 DATA <Enter>
Loopback will be enabled on Mirrored Bits channel A for the next 10 minutes.
The RMB values will be allowed to change while loopback is enabled.
Are you sure (Y/N)? N <Enter>
Canceled.
=>>
```

To disable loopback mode before the selected number of minutes, re-issue the **LOO** command with the R parameter. The R parameter returns the device to normal operation. If both MIRRORED BITS channels are enabled, omitting the channel specifier in the disable command causes both channels to be disabled.

```
=>>LOO R <Enter>
Loopback is disabled on both channels.
=>>
```

MAC Command

Use the **MAC** command to display the MAC addresses of **PORT 1**, as in the following:

NOTE: Relays with older CPU cards can be upgraded to firmware versions R200 or higher, but the relay will not have the GOOSE performance improvements (i.e., a GOOSE port with a dedicated MAC address).

```
=>>MAC <Enter>

Port 1 (IP) MAC Address: 00-30-A7-67-32-10
Port 1 (GOOSE) MAC Address: 00-30-A7-78-10-20

=>>
```

MET Command (Metering Data)

The **MET** command (see *Table 7.38* and *Table 7.39*) provides access to the relay metering data.

Table 7.38 METER Command

Command	Description	Access Level
MET *c n*	Displays the metering data.	1
MET *c* R	Resets the metering data.	2
Parameters		
c	Identifies the meter class. If c is not specified, the relay displays the fundamental meter report.	
n	Specifies the number of times (1–32767) to repeat the meter response.	

Table 7.39 Meter Class (Sheet 1 of 2)

c	Meter Class
F	Fundamental Metering
E[a]	Energy Metering
M[a]	Maximum/Minimum Metering
RMS	RMS Metering
T	Thermal and RTD Metering
AI	Analog Input (Transducer) Metering
DIF	Differential Metering
H	Harmonic Metering for Differential Currents
DE[a]	Demand Metering

Table 7.39 Meter Class (Sheet 2 of 2)

c	Meter Class
PE[a]	Peak Demand Metering
PM	Synchrophasor Metering
MV	SELOGIC Math Variable Metering
RA	Remote Analog Metering

[a] Reset command available.

For more information on metering and example responses for each meter class, see *Section 5: Metering and Monitoring*.

On issuing the **MET *c* R** command for resetting metering quantities in class *c*, the relay responds: `Reset Metering Quantities (Y,N)?` Upon confirming (pressing **Y**), the metering quantities are reset and the relay responds with `Reset Complete`.

OPEN n Command (Open Breaker n, Where n = X or Y)

The **OPE *n*** (OPEN) command asserts the Relay Word bit OC*n* for 1/4 cycle when it is executed. Relay Word bit OC*n* can then be programmed into the TR*n* SELOGIC control equation to assert the TRIP*n* Relay Word bit, which in turn asserts an output contact (for example, OUT301 = TRIP*n*) to open a Circuit Breaker *n* (see *Table 4.61* and *Figure 4.135* through *Figure 4.137* for factory-default setting TR*n* and the trip logic).

To issue the **OPE X** command, enter the following.

```
=>>OPE X <Enter>

Open Breaker X (Y,N)? Y <Enter>

=>>
```

Typing **N <Enter>** after the previous prompt aborts the command.

The **OPE *n*** command is supervised by the main board breaker control jumper (see *Table 2.19*). If the breaker control jumper is not in place (breaker control jumper = OFF), the relay does not execute the **OPE *n*** command and responds with the following.

```
=>>OPE X <Enter>

Command Aborted: No BRKR Jumper

=>>
```

When setting EN_LRC := Y (see *Table 9.6*), the Relay Word bit LOCAL supervises the **OPE *n*** command. If the LOCAL bit is asserted (LOCAL = 1), the relay does not execute the **OPE *n*** command and responds with the following:

```
=>>OPE X <Enter>

Command Aborted: Device in Local Control

=>>
```

The Relay Word bit LOCAL is determined by the LOCAL SELOGIC control equation (see *Table 9.6*).

PASSWORD Command (Change Passwords)

Use the **PAS** command (see *Table 7.40*) to change existing passwords.

Table 7.40 PASSWORD Command

Command	Description	Access Level
PAS *level*	Change password for Access Level *level*.	2
Parameters		
level	Represents the relay Access Levels 1, 2 or C.	

⚠**WARNING**
The device is shipped with default passwords. Default passwords should be changed to private passwords at installation. Failure to change each default password to a private password may allow unauthorized access. SEL shall not be responsible for any damage resulting from unauthorized access.

The factory-default passwords are as shown in *Table 7.41*.

Table 7.41 Factory-Default Passwords for Access Levels 1, 2, and C

Access Level	Factory-Default Password
1	OTTER
2	TAIL
C	CLARKE

To change the password for Access Level 1 to #Ot3579!ijd7, enter the following command sequence:

```
=>>PAS 1 <Enter>
New PW: ? *********** <Enter>
Confirm PW: ? *********** <Enter>
Password Changed
=>>
```

Figure 7.34 Command Sequence to Change Password

Similarly, use **PAS 2** to change the Access Level 2 password and **PAS C** to change the Access Level C password.

Table 7.42 Valid Password Characters

Alpha	A B C D E F G H I J K L M N O P Q R S T U V W X Y Z a b c d e f g h i j k l m n o p q r s t u v w x y z
Numeric	0 1 2 3 4 5 6 7 8 9
Special	! " # $ % & ' ( ) * + , - . / : ; < = > ? @ [\ ] ^ _ ` { | } ~

Passwords can contain as many as 12 characters. Upper- and lowercase letters are treated as different characters. Strong passwords consist of 12 characters, with at least one special character or digit and mixed-case sensitivity, but do not form a name, date, acronym, or word. Passwords formed in this manner are less susceptible to password guessing and automated attacks.

Examples of valid, distinct, and strong passwords are as follows:

- #0t3579!ijd7
- (Ih2dcs)36dn
- $A24.68&,mvj
- *4u-Iwg+?lf-

PING Command

When you are setting up or testing substation networks, it is helpful to determine if the network is connected properly and if the other devices are powered up and configured properly. The **PING** command (Access Level 1) allows you to determine if a host is reachable across an IP network and/or if the Ethernet port (Port 1) is functioning and configured correctly. A typical **PING** command response is shown in *Figure 7.35*.

The command structure is:

PING *x.x.x.x t*

where:

x.x.x.x is the Host IP address and

t is the PING interval in seconds, with a 2 to 255 second range

The default PING interval is one second when *t* is not specified. The relay sends ping messages to the remote node until you stop the PING test by pressing the **Q** key.

```
=>PING 10.201.7.52 <Enter>

Press the Q key to end the ping test.

Pinging 10.201.7.52 every 1 second(s):

Reply from 10.201.7.52
Reply from 10.201.7.52
Reply from 10.201.7.52
Reply from 10.201.7.52
Reply from 10.201.7.52
Reply from 10.201.7.52
Ping test stopped.

Ping Statistics for 10.201.7.52
   Packets: Sent = 7, Received = 6, Lost = 1
   Duplicated = 0

=>
```

Figure 7.35 PING Command Response

PULSE Command

NOTE: The **PULSE** command is available when the breaker control jumper on the main board is in the ENABLED position.

Use the **PULSE** command (see *Table 7.43*) to pulse any of the relay outputs for a specified time. This function aids you in relay testing and commissioning. When a **PUL** command is issued, the selected contact will close or open depending on the output contact type (a or b). The **PUL** command energizes the coil and does not have any effect if the coil is already energized. The outputs are OUT*nnn*, where *nnn* represents 101–103 (standard), 301–308 (optional), 401–408 (optional), or 501–508 (optional). For example, OUTPUT 301 refers to Output 01 in Slot **C**.

Table 7.43 PUL OUTnnn Command

Command	Description	Access Level
PUL OUT*nnn*	Pulses output OUT*nnn* for 1 second.	2
PUL OUT*nnn s*	Pulses output OUT*nnn* for *s* seconds.	2
Parameters		
nnn	Output number.	
s	Time in seconds, with a range of 1–30.	

QUIT Command

Use the **QUIT** command (see *Table 7.44*) to revert to Access Level 0.

Table 7.44 QUIT Command

Command	Description	Access Level
QUIT	Go to Access Level 0.	0

Access Level 0 is the lowest access level; the SEL-700G performs no password check to descend to this level (or to remain at this level).

RSTP Command

Use the **RSTP** command (see *Table 7.45*) to display the RSTP statistics and the present RSTP configuration when RSTP is enabled.

Table 7.45 RSTP Command

Command	Description	Access Level
RSTP	Displays the RSTP statistics and the present RSTP configuration.	1

Table 7.46 describes the information displayed in the output of the **RSTP** command.

Table 7.46 RSTP Command Definitions (Sheet 1 of 2)

Information Field	Description
ROOT BRIDGE	Reveals the role of the relay in the RSTP configuration. It will either display YES or NO.
BRIDGE ID	Displays the Bridge ID of the relay, which consists of the bridge priority (in decimal format) and the MAC address of the relay.
ROOT BRIDGE ID	Displays the Bridge ID of the root bridge, which consists of the bridge priority (in decimal format) and the MAC address of the root bridge.
ROOT PORT	Displays the port number (i.e., Port 1A or Port 1B) that is forwarding towards the root bridge when the relay is a designated bridge. If the relay is the root bridge, this displays NA.
TIME SINCE TOPOLOGY CHANGE	Displays the number of seconds since the last topology change occurred.
BRIDGE PRIORITY	Determines the root bridge. The bridge with the lowest value becomes the root bridge. It can be set under the Port 1 settings.
HELLO TIME	Interval in which the relay sends BPDUs. It is fixed at 2 seconds.
MAX AGE	Maximum number of hops before a BPDU is discarded. It is fixed at 40.
FORWARD DELAY	The time that the relay must spend in the listening and learning states before transitioning to forwarding. It is fixed at 21 seconds. This is only used when the relay is in STP compatibility mode.
PORT 1A PROTOCOL	Displays either STP or RSTP.
PORT 1B PROTOCOL	Displays either STP or RSTP.
PORT 1A STATE	The state of Port 1A.
PORT 1B STATE	The state of Port 1B.
PORT 1A ROLE	The role of Port 1A.
PORT 1B ROLE	The role of Port 1B.
PORT 1A PRIORITY	Determines which port the device selects as a root port when there is a tie between two ports. The port with the lower value becomes the root port. It can be set under the Port 1 settings.

Table 7.46 RSTP Command Definitions (Sheet 2 of 2)

Information Field	Description
PORT 1B PRIORITY	Determines which port the device selects as a root port when there is a tie between two ports. The port with the lower value becomes the root port. It can be set under the Port 1 settings.
PORT 1A PATH COST	Helps determine which path the device selects to a root bridge. The device selects paths with the lowest overall cost first. It is fixed at 200000.
PORT 1B PATH COST	Helps determine which path the device selects to a root bridge. The device selects paths with the lowest overall cost first. It is fixed at 200000.
PORT 1A EDGE PORT	If YES, Port 1A is an edge port. If NO, it is not.
PORT 1B EDGE PORT	If YES, Port 1B is an edge port. If NO, it is not.
PORT 1A BPDU COUNT	Displays the number of BPDUs received on Port 1A.
PORT 1B BPDU COUNT	Displays the number of BPDUs received on Port 1B.

Figure 7.36 shows an example response to the **RSTP** command.

```
=>RSTP <Enter>

SEL-700G                                  Date: 08/26/2022   Time: 10:37:34.788
GENERATOR RELAY                           Time Source: External

RSTP Communication Statistics:

Root Bridge: NO
Bridge Id: 36864-0030A7169000
Root Bridge Id: 12288-0030A70B64F9
Root Port: 1A
Time Since Topology Change: 76601 sec
Bridge Priority: 36864;   Hello Time:  2 sec
Max Age: 40;   Forward Delay:  21 sec

PORT PROTOCOL  STATE       ROLE    PRIORITY  PATHCOST EDGE #BPDU-RCVD
 1A   RSTP   Forwarding   Rootport    128    200000   False     39608
 1B   RSTP   Discarding   Disabled    128    200000   False      1077

=>
```

Figure 7.36 RSTP Command Response

R_S Command (Restore Factory Defaults)

Use the **R_S** command (see *Table 7.47*) to restore the factory-default settings.

Table 7.47 R_S Command (Restore Factory Defaults)

Command	Description	Access Level
R_S	Restores the factory-default settings and passwords and reboots the system.[a]	2

[a] Only available after a settings or critical RAM failure.

SER Command (Sequential Events Recorder Report)

Use the **SER** commands (see *Table 7.48*) to view and manage the Sequential Events Recorder report. If there is no SER report row stored, the relay responds with `No data available`. See *Section 10: Analyzing Events* for further details on SER reports.

Table 7.48 SER Command (Sequential Events Recorder Report)

Command	Description	Access Level
SER	Use the **SER** command to display a chronological progression of all available SER rows (as many as 1024 rows). Row 1 is the most recently triggered row, and row 1024 is the oldest.	1
SER C or **R**	Use this command to clear/reset the SER records.	1
Parameters		
row1	Append *row1* to return a chronological progression of the first *row1* rows. For example, use **SER 5** to return the first five rows.	
row1 row2	Append *row1* and *row2* to return all rows between *row1* and *row2*, beginning with row1 and ending with *row2*. Enter the smaller number first to display a numeric progression of rows through the report. Enter the larger number first to display a reverse numeric progression of rows. For example, use **SER 1 10** to return the first 10 rows in numeric order or **SER 10 1** to return these same items in reverse numeric order.	
date1	Append *date1* to return all rows with this date. For example, use **SER 1/1/2003** to return all records for January 1, 2003.	
date1 date2	Append *date1* and *date2* to return all rows between date1 and date beginning with *date1* and ending with *date2*. Enter the oldest date first to display a chronological progression through the report. Enter the newest date first to display a reverse chronological progression. Date entries are dependent on the date format setting DATE_F. For example, use **SER 1/5/2003 1/7/2003** to return all records for January 5, 6, and 7, 2003.	

SER D Command

The **SER D** command shows a list of SER items that the relay has automatically removed. These are “chattering” elements. You can automatically remove chattering SER elements in the SER Chatter Criteria category of the Report settings; the enable setting is ESERDEL. See *Section 4: Protection and Logic Functions*, *Report Settings (SET R Command) on page 4.257* for more information on SER automatic deletion and reinsertion.

Table 7.49 SER D Command

Command	Description	Access Level
SER D	Lists chattering SER elements that the relay is removing from the SER records.	1

If you issue the **SER D** command and you have not enabled automatic removal of chattering SER elements (Report setting ESERDEL), the relay responds, `Automatic removal of chattering SER elements not enabled`.

SET Command (Change Settings)

The **SET** command is for viewing or changing the relay settings (see *Table 7.50*).

Table 7.50 SET Command (Change Settings)

Command	Description	Access Level
SET *n s* TERSE	Sets the group settings, beginning at the first setting for Group *n*.	2
SET L *n s* TERSE	Sets the general logic settings for Group *n*.	2
SET G *s* TERSE	Sets the global settings.	2
SET P *k s* TERSE	Sets the serial port settings. *k* specifies the port; *k* defaults to the active port if not listed.	2
SET R *s* TERSE	Sets the report settings such as Sequential Events Recorder (SER) and Event Report (ER) settings.	2
SET E TERSE	Sets the EtherNet/IP settings.	2
SET F *s* TERSE	Sets the front-panel settings.	2
SET I TERSE	Sets the IEC 60870-5-103 settings.	2
SET M *s* TERSE	Sets the Modbus user map settings.	2
SET DNP *m s* TERSE	Sets the DNP Map *m* settings.	2
Parameters		
k	Indicates the port number 1, 2, 3, 4, or F.	
m	Indicates the DNP map number 1, 2, or 3.	
n	Indicates the group number 1, 2, 3 or 4.	
s	Append *s*, the name of the specific setting you want to view, and jump to this setting. If ***s*** is not entered, the relay starts at the first setting.	
TERSE	Append TERSE or TE to skip the settings display after the last setting. Use this parameter to speed up the **SET** command. If you want to review the settings before saving, do not use the TERSE option.	

When you issue the **SET** command, the relay presents a list of settings one at a time. Enter a new setting or press **<Enter>** to accept the existing setting. Editing keystrokes are shown in *Table 7.51*.

Table 7.51 SET Command Editing Keystrokes

Press Key(s)	Results
<Enter>	Retains the setting and moves to the next setting.
^ <Enter>	Returns to the previous setting.
< <Enter>	Returns to the previous setting category.
> <Enter>	Moves to the next setting category.
END <Enter>	Exits the editing session, then prompts you to save the settings.
<Ctrl+X>	Aborts the editing session without saving changes.

The relay checks each setting to ensure that it is within the allowed range. If the setting is not within the allowed range, the relay generates an `Out of Range` message and prompts you for the setting again.

When all the settings are entered, the relay displays the new settings and prompts you for approval to enable them. Answer **Y <Enter>** to enable the new settings. The relay is disabled for as long as one second while it saves the new settings. The SALARM Relay Word bit is set momentarily, and the **ENABLED** LED extinguishes while the relay is disabled.

SHOW Command (Show/View Settings)

When showing settings, the relay displays the settings label and the present value from nonvolatile memory for each setting class. See *Table 7.52* for the **SHOW** command settings and the command format.

Table 7.52 SHOW Command (Show/View Settings)

Command	Description	Access Level
SHO *n s*	Shows the group settings for Group *n*.	1
SHO L *n s*	Shows the general logic settings for Group *n*.	1
SHO G *s*	Shows the global settings.	1
SHO P *k s*	Shows the serial port settings. *k* specifies the port; *k* defaults to the active port if not listed.	1
SHO R *s*	Shows the report settings such as Sequential Events Recorder (SER) and Event Report (ER) settings.	1
SHO E	Shows the EtherNet/IP assembly map settings.	1
SHO F *s*	Shows the front-panel settings.	1
SHO I	Shows the IEC 60870-5-103 settings.	1
SHO M *s*	Shows the Modbus user map settings.	1
SHO DNP *m s*	Shows the DNP Map *m* settings.	1
Parameters		
k	Indicates the port number 1, 2, 3, 4, or F.	
m	Indicates the DNP map number 1, 2, or 3.	
n	Indicates the group number 1, 2, 3, or 4.	
s	Append *s*, the name of the specific settings you want to view, and jump to this setting. If *s* is not entered, the relay starts at the first setting.	

```
=>SHO <Enter>

Group 1
Relay Settings

ID Settings
RID      := SEL-700GT+
TID      := INTERTIE RELAY

Config Settings
PHROT    := ABC           CTRX     := 500           INOM     := 1.0
DELTAY_X := WYE           PTRX     := 100.00        VNOM_X   := 13.80
CTRY     := 500           DELTAY_Y := WYE           PTRY     := 1000.00
VNOM_Y   := 138.00        PTRS     := 100.00        CTRN     := 100

Gnd Differential
E87N     := N

Res Earth Fault
EREF     := N

Rotor Ground
E64F     := N

System Backup
EBUP     := V
```

Figure 7.37 SHOW Command Example

```
Volt-Restr TOC
51VP     := 1.60          51VCA    := 0             51VC     := U2
51VTD    := 3.00          51VRS    := Y
51VTC    := NOT LOPX

Loss of Field
E40      := Y             40Z1P    := 67.0          40XD1    := -12.5
40Z1D    := 0.00          40Z2P    := 67.0          40XD2    := -12.5
40Z2D    := 0.50
40ZTC    := NOT LOPX

Curr Unbalance
E46      := Y             46Q1P    := 8.0           46Q1D    := 30.00
46Q2P    := 8.0           46Q2K    := 10
46QTC    := 1

Thermal Overload
E49T     := N

Volts per Hertz
E24      := Y             24D1P    := 105           24D1D    := 1.00
24CCS    := ID            24IP     := 105           24IC     := 2
24ITD    := 0.1           24D2P2   := 176           24D2D2   := 3.00
24CR     := 240.00
24TC     := 1

Inadv Enrgzation
EINAD    := N

X Side Phase IOC
50PX1P   := OFF           50PX2P   := OFF           50PX3P   := OFF

X Side Res IOC
50GX1P   := OFF           50GX2P   := OFF

XSide NegSeq IOC
50QX1P   := OFF           50QX2P   := OFF

X Side Res TOC
51GXP    := OFF

Y Side Phase IOC
50PY1P   := OFF           50PY2P   := OFF           50PY3P   := OFF

Y Side Res IOC
50GY1P   := OFF           50GY2P   := OFF

YSide NegSeq IOC
50QY1P   := OFF           50QY2P   := OFF

Y Side Phase TOC
51PYP    := OFF

Y Side Res TOC
51GYP    := OFF


YSide NegSeq TOC
51QYP    := OFF

Neutral IOC
50N1P    := OFF           50N2P    := OFF

Neutral TOC
51NP     := OFF

X Side Dir Elem
EDIRX    := N

Y Side Dir Elem
EDIRY    := N

Y Side Ld Encrch
ELOADY   := N

X Side Pwr Elem
EPWRX    := 2             3PWRX1P  := 10.0          PWRX1T   := -WATTS
PWRX1D   := 20.00         3PWRX2P  := 5.0           PWRX2T   := +WATTS
PWRX2D   := 1.00
```

Figure 7.37 SHOW Command Example (Continued)

```
Y Side Pwr Elem
EPWRY    := N

X Side Frequency
E81X     := N

Y Side Frequency
E81Y     := N

X Side ROC Freq
E81RX    := N

Y Side ROC Freq
E81RY    := N

Freq Accumulator
E81ACC   := N

LOP Setting
LOPBLKX  := SV13T OR FREQX < MV01
LOPBLKY  := SV13T OR FREQX < MV01

X Ph Undervolt
27PX1P   := OFF          27PX2P   := OFF          27PPX1P  := 93.5
27PPX1D  := 0.50         27PPX2P  := OFF

Y Ph Undervolt
27PY1P   := OFF          27PY2P   := OFF          27PPY1P  := 93.5
27PPY1D  := 0.50         27PPY2P  := OFF

X Ph Overvolt
59PX1P   := OFF          59PX2P   := OFF          59PPX1P  := OFF
59PPX2P  := OFF

Y Ph Overvolt
59PY1P   := OFF          59PY2P   := OFF          59PPY1P  := OFF
59PPY2P  := OFF

X P-Seq U/O Volt
E27V1X   := 1            27V1X1P  := 5.0          27V1X1D  := 0.50
E59V1X   := N

X N-Seq Overvolt
59QX1P   := OFF          59QX2P   := OFF

Y N-Seq Overvolt
59QY1P   := OFF          59QY2P   := OFF

X Z-Seq Overvolt
59GX1P   := OFF          59GX2P   := OFF

Y N-Seq Overvolt
59GY1P   := OFF          59GY2P   := OFF

Sync U/Ovr Volt
27S1P    := OFF          27S2P    := OFF          59S1P    := OFF
59S2P    := OFF


27 Inverse Time
E27I1    := N            E27I2    := N

59 Inverse Time
E59I1    := N            E59I2    := N            E59I3    := N
E59I4    := N

RTD Settings
E49RTD   := NONE

Vector Shift Set
E78VS    := OFF

X Side SyncCheck
E25X     := N

Y Side SyncCheck
E25Y     := N
```

Figure 7.37 SHOW Command Example (Continued)

```
Demand Mtr Set
EDEM     := ROL          DMTC     := 15          PHDEMPX  := OFF
GNDEMPX  := OFF          3I2DEMPX := OFF         PHDEMPY  := OFF
GNDEMPY  := OFF          3I2DEMPY := OFF

X Side Pole Open
50LXP    := 0.05         3POXD    := 0.00

Y Side Pole Open
50LYP    := 0.05         3POYD    := 0.00

Trip/Close Logic
TDURD    := 0.50         CFDX     := 0.50        CFDY     := 0.50
TRX      := SV06 OR SV07 OR SV08 OR 46Q2T OR 81X1T OR 81X2T OR 81RX1T OR 81RX2T
            OR NOT LT02 AND SV04T OR OCX
TR1      := SV06 OR SV07 OR SV08
TR2      := SV06 OR SV07 OR LT06
TR3      := SV06 OR SV07
TRY      := SV09 OR SV10 OR LT02 AND SV04T OR OCY
REMTRIP  := 0
ULTRX    := 3POX
ULTR1    := NOT TR1
ULTR2    := NOT TR2
ULTR3    := NOT TR3
ULTRY    := 3POY
52AX     := 0
52BX     := NOT 52AX
CLX      := SV03T AND NOT LT02 OR CCX OR SV11T AND 25C
ULCLX    := TRIPX
52AY     := 0
52BY     := NOT 52AY
CLY      := SV03T AND LT02 OR CCY OR SV12T AND 25AY1
ULCLY    := TRIPY

=>
```

Figure 7.37 SHOW Command Example (Continued)

STATUS Command (Relay Self-Test Status)

The **STA** command (see *Table 7.53*) displays the status report.

Table 7.53 STATUS Command (Relay Self-Test Status)

Command	Description	Access Level
STA *n*	Displays the relay self-test information *n* times.	1
STA S	Displays the memory and execution utilization for the SELOGIC control equations.	1
STA C or **R**	Reboots the relay and clears the self-test warning and failure status results.	2
Parameters		
n	*n* = 1–32767. Defaults to 1 if *n* is not specified.	

Refer to *Section 11: Testing and Troubleshooting* for self-test thresholds and corrective actions, as well as hardware configuration conflict resolution. *Table 7.54* shows the status report definitions and message formats for each test. Refer to *Figure 1.3* and *Figure 1.4* for STATUS command response outputs.

Table 7.54 STATUS Command Report and Definitions (Sheet 1 of 2)

STATUS Report Designator	Definition	Message Format
Serial Num	Serial number	Number
FID	Firmware identifier string	Text Data
CID	Firmware checksum identifier	Hex
PART NUM	Part number	Text Data

Table 7.54 STATUS Command Report and Definitions (Sheet 2 of 2)

STATUS Report Designator	Definition	Message Format
FPGA	FPGA programming unsuccessful, or FPGA failed	OK/FAIL
GPSB	General Purpose Serial Bus	OK/FAIL
HMI	Front-panel FPGA programming unsuccessful, or front-panel FPGA failed	OK/WARN
RAM	Volatile memory integrity	OK/FAIL
ROM	Firmware integrity	OK/FAIL
CR_RAM	Integrity of settings in RAM and code that runs in RAM	OK/FAIL
Non_Vol	Integrity of data stored in nonvolatile memory	OK/FAIL
Clock	Clock functionality	OK/WARN
RTD	Integrity of RTD module/ communications	OK/FAIL
CID_FILE	Configured IED description file	OK/FAIL
x.x V	Power supply status	Voltage/FAIL
BATT	Clock battery voltage	Voltage/WARN
CARD_C	Integrity of Card C	OK/FAIL
CARD_D	Integrity of Card D	OK/FAIL
CARD_E	Integrity of Card E	OK/FAIL
CARD_Z	Integrity of Card Z	OK/FAIL
DN_MAC_ID	Specific DeviceNet card identification	Text Data
ASA	Manufacturers identifier for DeviceNet	Text Data
DN_Rate	DeviceNet card network communications data rate ___kbps	Text Data
DN_Status	DeviceNet connection and fault status 000b bbbb	Text Data
Current Offset (IA*n*, IB*n*, IC*n*, IN)	Measurement of dc offset in hardware circuits of current channels, *n* = X or Y	Measurement of dc offset/WARN
Voltage Offset (VA*n*, VB*n*, VC*n*, VS, VN)	Measurement of dc offset in hardware circuits of voltage channels, *n* = X or Y	Measurement of dc offset/WARN
Field Ground Module—COMM	SEL-2664 to SEL-700G communication status	OK/FAIL
Field Ground Module—MODULE	SEL-2664 FGM self-test status	OK/FAIL/NA

Figure 7.38 shows the typical relay output for the **STATUS S** command, showing available SELOGIC control equation capability.

NOTE: The STA S report gives the available SELOGIC capacity of the relay. For example, Execution 90% means that 90% of the execution capacity is still available.

```
=>STA S <Enter>

SEL-700GT                                Date: 03/02/2010   Time: 10:29:01.041
INTERTIE RELAY                           Time Source: Internal

Part Number = 0700GT1B1X0X7585063X

SELogic Equation Available Capacity

Global (%)   74
FP (%)       50
Report (%)   95

               GROUP 1  GROUP 2  GROUP 3  GROUP 4
Execution (%)   79       79       79       79
Group (%)       83       83       83       83
Logic (%)       87       87       87       87

=>
```

Figure 7.38 Typical Relay Output for STATUS S Command

SUMMARY Command

The **SUM** command (see *Table 7.55*) displays an event summary in human-readable format.

Table 7.55 SUMMARY Command

Command	Description	Access Level
SUM *n*	The command without arguments displays the latest event summary. Use *n* to display particular event summary.	1
SUM R or **C**	Use this command to clear the archive.	1
Parameters		
n	Either the event record number or the reference number.	

Each event summary report shows the date, time, current and voltage magnitudes (primary values), LED targets, frequency, and hottest RTD values (if RTDs are enabled). The relay reports the voltage and current when the largest current occurs during the event. The event summary report also shows the event type (type of trip).

SYN Command (Synchronism-Check Report)

The **SYN** command is available in an SEL-700G with the generator synchronism-check function. The **SYN** command displays the latest of three reports stored by the relay synchronism-check function in nonvolatile memory. For more information on **SYN** reports, see *Section 10: Analyzing Events*.

Table 7.56 SYN Command

Command	Description	Access Level
SYN *n*	Displays the *n* generator synchronism-check report.	1
SYN R	Resets the breaker close time average and breaker close operations counter.	2
Parameters		
n	*n* = 1, 2, or 3. Defaults to 1 if *n* is not specified.	

TARGET Command (Display Relay Word Bit Status)

The **TAR** command (see *Table 7.57*) displays the status of front-panel target LEDs or Relay Word bits, whether these LEDs or Relay Word bits are asserted or deasserted.

Table 7.57 TARGET Command (Display Relay Word Bit Status)

Command	Description	Access Level
TAR *name k* TAR *n* TAR *n k*	Use **TAR** without parameters to display Relay Word Row 0 or the last displayed target row.	1
TAR R	Clears the front-panel tripping targets. Unlatches the trip logic for testing purposes (see *Figure 8.2*). Shows Relay Word Row 0.	1
Parameters		
name	Displays the Relay Word row with the Relay Word bit name.	
n	Shows Relay Word row number *n*.	
k	Repeats *k* times (1–32767).	

NOTE: The **TARGET R** command cannot reset the latched targets if a TRIP condition is present.

The elements are represented as Relay Word bits and are listed in rows of eight, called Relay Word rows. The first four rows, representing the front-panel operation and target LEDs, correspond to *Table 7.58*. All of the Relay Word rows are described in *Table L.1* and *Table L.3*.

Relay Word bits are used in SELOGIC control equations. See *Appendix L: Relay Word Bits*.

The **TAR** command does not remap the front-panel target LEDs, as is done in some previous SEL relays.

Table 7.58 Front-Panel LEDs and the TAR 0 Command

LEDs	7	6	5	4	3	2	1	0
TAR 0	ENABLED	TRIP_LED	TLED_01	TLED_02	TLED_03	TLED_04	TLED_05	TLED_06

TEST DB Command

Use the **TEST DB** command to temporarily force the relay to send fixed analog and/or digital values over communications interfaces for protocol testing.

If the relay is enabled to control 61850 Mode/Behavior, then the **TEST DB** command can only be used when the relay is in On mode. The **TEST DB** command cannot be used in any other mode.

If the **TEST DB** command is active while the relay is in On mode, a change of mode will deactivate the **TEST DB** command.

Table 7.59 TEST DB Commands (Sheet 1 of 2)

Command	Description	Access Level
TEST DB	Displays the present status of digital and analog overrides.	2
TEST DB A *name value*	Forces the protocol analog element *name* to override *value*.	2
TEST DB D *name value*	Forces the protocol digital element *name* to override *value*.	2

Table 7.59 TEST DB Commands (Sheet 2 of 2)

Command	Description	Access Level
TEST DB *name* OFF	Clears (analog or digital) override for element *name*.	2
TEST DB A OFF	Clears all analog overrides.	2
TEST DB D OFF	Clears all digital overrides.	2
TEST DB OFF	Clears all analog and digital overrides.	2

⚠WARNING
To reduce the chance of a false operating decision when using the **TEST DB** command, ensure that protocol master device(s) flag the data as "forced or test data". One possible method is to monitor the TESTDB Relay Word bit.

NOTE: The **TEST DB** command does not support digital points in the case of SEL Fast Message Protocol.

The **TEST DB** command provides a method to override Relay Word bits or analog values to aid testing and commissioning of communications interfaces only and should not be used on an energized system. The command overrides values in the communications interfaces (ASCII, SEL Fast Message, DNP, Modbus, EtherNet/IP, IEC 60870-5-103, and IEC 61850) only. The actual values the relay uses for protection and control are not changed. However, remote devices may use these analog and digital signals to make control decisions. Before using the **TEST DB** command, ensure that remote devices are properly configured to receive the overridden data.

R1*xx* firmware versions use a previous version of the **TEST DB** command that aids testing and commissioning of IEC 61850 protocol only. Note that the **TEST DB** command supported by R1*xx* firmware versions provides a method to override Relay Word bits only and should not be used on an energized system. If used on an energized system, the command can lead to unwanted operations, including a potential trip.

NOTE: When using the **TEST DB** command to generate values for Fast Meter testing, you may need to override all current and voltage angles (IAX_ANG, VAX_ANG, etc.) to ensure the expected phase relationship.

NOTE: When using the **TEST DB** command, specifying a negative value may yield an unexpected display in some instances.

To override analog data in a communications interface, enter the following from Access Level 2 or higher:

```
=>>TEST DB A name value <Enter>
```

where *value* is a numerical value and *name* is an analog label from *Table M.1*, with an "x" in the DNP, Modbus, EtherNet/IP, Fast Meter, IEC 60870-5-103, or IEC 61850 column. For example, the **TEST DB** command can be used to force the value of the A-phase current magnitude transmitted to a remote device to 100 amperes:

```
=>>TEST DB A IAX_MAG 100 <Enter>
```

To override digital data in an SEL ASCII, Modbus, EtherNet/IP, DNP, IEC 60870-5-103, or IEC 61850 communications interface, enter the following from Access Level 2 or higher:

```
=>>TEST DB D name value <Enter>
```

where *name* is a Relay Word bit (see *Table L.1*) and *value* is 1 or 0. For example, if Relay Word bit 51PXT := logical 0, the **TEST DB** command can be used effectively to test the communications interface by forcing the communicated status of this Relay Word bit to logical 1:

```
=>>TEST DB D 51PXT 1 <Enter>
```

Values listed in the SER triggers SER1, SER2, SER3, and SER4 cannot be overridden.

When the relay is not in Test Mode, the relay responds to either the digital or analog override request with the following message:

```
WARNING:  TEST MODE is not a regular operation.
Communication outputs of the device will be overridden by simulated values.

Are you sure (Y/N)? Y <Enter>
```

The relay responds:

```
Test Mode Active.  Use Test DB OFF command to exit Test Mode.
Override Added
```

Relay Word bit TESTDB will also assert to indicate that Test Mode is active. If the relay is already in the test mode (overrides are already active), the relay responds:

```
Override Added
```

The **TEST DB** command alone displays the present status of digital and analog overrides. An example **TEST DB** response after two analogs follows:

```
=>>TEST DB <Enter>

SEL-700G                          Date: 02/02/09    Time: 16:24:38.764
FEEDER RELAY                     Time Source: Internal

NAME          OVERRIDE VALUE
IAX_MAG             100.0000
FREQX               60.0000

=>>
```

Individual overrides are cleared using the **TEST DB** command with the OFF parameter:

```
=>>TEST DB D name OFF <Enter>
```

Entering **TEST DB A OFF** clears all analog overrides and **TEST DB D OFF** clears all digital overrides. Entering **TEST DB OFF** without any parameters clears all overrides. When there are no overrides, the relay automatically exits the Test Mode and clears all of the overrides if no **TEST DB** commands are entered for 30 minutes.

TIME Command (View/Change Time)

The **TIME** command (see *Table 7.60*) returns information about the SEL-700G internal clock. You can also set the clock if you specify hours and minutes (seconds data are optional). Separate the hours, minutes, and seconds with colons, semicolons, spaces, commas, or slashes.

Table 7.60 TIME Command (View/Change Time)

Command	Description	Access Level
TIME	Displays the present internal clock time.	1
TIME *hh*	Sets the internal clock to *hh*.	1
TIME *hh:mm*	Sets the internal clock to *hh:mm*.	1
TIME *hh:mm:ss*	Sets the internal clock to *hh:mm:ss*.	1

Use the **TIME *hh***, **TIME *hh:mm***, and **TIME *hh:mm:ss*** commands to set the internal clock time. The value *hh* is for hours from 0–23; the value *mm* is for minutes from 0–59; the value *ss* is for seconds from 0–59. If you enter a valid time, the relay updates and saves the time in the nonvolatile clock, and displays the time you just entered. If you enter an invalid time, the SEL-700G responds with `Invalid Time`.

TRIGGER Command (Trigger Event Report)

Use the **TRI** command (see *Table 7.61*) to trigger the SEL-700G to record data for the high-resolution oscillography and event reports.

Table 7.61 TRIGGER Command (Trigger Event Report)

Command	Description	Access Level
TRI	Triggers an event report data capture.	1

When you issue the **TRI** command, the SEL-700G responds with `Triggered`. If the event does not trigger within one second, the relay responds with `Did not trigger`. See *Section 10: Analyzing Events* for further details on event reports.

VEC Command (Show Diagnostic Information)

Issue the **VEC** command under the direction of SEL. The information contained in a vector report is formatted for SEL in-house use only. Your SEL application engineer or the factory may request a **VEC** command capture to help diagnose a relay or system problem.

Table 7.62 VEC Command

Command	Description	Access Level
VEC D	Displays the standard vector report.	2
VEC E	Displays the extended vector report.	2

Language Support

All of the ASCII commands can be displayed in multiple languages (English or Spanish). When you set the port setting LANG (see *Table 4.83*) to either ENGLISH or SPANISH, the SEL-700G displays the ASCII commands in the corresponding language. See the *SEL-700G Relay Command Summary* for a list of the commands.

Virtual File Interface

You can retrieve and send data as files through the relay virtual file interface. Devices with embedded computers can also use the virtual file interface. When using serial ports with SEL ASCII protocol or the Ethernet port with Telnet, use the **FILE DIR** command to access the file interface. When using the Ethernet port, the FTP and MMS protocols supported by the Ethernet port present the file structure and send and receive files.

Send and receive files using the following three protocols.

Protocol	Port Availability
File Transfer Protocol	Ethernet only
Manufacturing Message Specification	Ethernet only
Ymodem	Serial and Ethernet

FTP and MMS File Structure

FTP and the IEC 61850 MMS have a two-level file structure. Files are available at the root level and in subdirectories. *Table 7.63* shows the directories and their contents.

Table 7.63 FTP and MMS Virtual File Structure

Directory	Contents
/ (Root)	CFG.TXT file, CFG.XML file, ERR.TXT file and SET_61850.CID and the SETTINGS, REPORTS, EVENTS, COMTRADE[a], and HMI[b] directories
/SETTINGS	Relay settings
/REPORTS	SER, LDP, BRE, GSH, GSR, SYN, GEN, and HIS reports
/EVENTS	CEV, COMTRADE, Stator GND, and HIS reports
/COMTRADE[a]	COMTRADE events
/HMI[b]	Touchscreen settings (SET_HMI.zds and CDP.zds) and diagnostics (HMI_ALL.zip)

[a] The COMTRADE directory is only available in the MMS file structure.
[b] Available only in the SEL-700G touchscreen display model. HMI_ALL.ZIP is not available in the MMS file structure.

Root Directory

The root directory (/) contains files and subdirectories as shown in *Table 7.63*.

CFG.TXT File (Read-Only)

The CFG.TXT file contains general configuration information about the relay and each settings class. External support software retrieves the CFG.TXT file to interact automatically with the relay. Calibration settings are included only when the file is read at Access Level C.

```
[INFO]
RELAYTYPE=SEL-700G
FID=SEL-700G-X335-V0-Z006003-D20171204
BFID=BOOTLDR-R500-V0-Z000000-D20090925
PARTNO=0700GT1B3X0X7584066X
[FRONTPANEL]
BDP=1.0.50700G.2000
[CLASSES]
PF,"Port F"
P2,"Port 2"
P3,"Port 3"
P1,"Port 1"
G,"Global"
1,"Group 1"
2,"Group 2"
3,"Group 3"
4,"Group 4"
L1,"Logic 1"
L2,"Logic 2"
L3,"Logic 3"
L4,"Logic 4"
M,"Modbus User Map"
R,"Report"
F,"Front Panel"
D1,"DNP Map 1 Settings"
D2,"DNP Map 2 Settings"
D3,"DNP Map 3 Settings"
I,"IEC 60870-5-103 Map"
E1,"EtherNet/IP Assembly Map 1 Settings"
E2,"EtherNet/IP Assembly Map 2 Settings"
E3,"EtherNet/IP Assembly Map 3 Settings"
```

Figure 7.39 CFG.TXT File

CFG.XML File (Read-Only)

Present only in units with the Ethernet option, the CFG.XML file is supplementary to the CFG.TXT file. The CFG.XML file describes the IED configuration and any options such as the Ethernet port, and includes firmware identification, settings class names, and configuration file information.

ERR.TXT (Read-Only) and SET_61850.CID File

Present if ordered with the IEC 61850 protocol option. The ERR.TXT file contents is based on the most recent SET_61850.CID file written to the relay. If there were no errors, the file is empty. If errors occurred, the relay logs these errors in the ERR.TXT file. The SET_61850.CID file contains the IEC 61850 configured IED description in XML. ACSELERATOR Architect SEL-5032 Software generates and then downloads this file to the relay. See *Appendix G: IEC 61850 Communications* for more information.

Settings Directory (Available for FTP and MMS)

You can access the relay settings through files in the SETTINGS directory. It is recommended that you use support software to access the settings files, rather than directly accessing them via other means. External settings support software reads settings from all of these files to perform its functions. The relay only allows you to write to the individual SET_*cn* files, where *c* is the settings class code and *n* is the settings instance. Except for the SET_61850 CID file, changing settings with external support software involves the following steps:

Step 1. The PC software reads the CFG.TXT and SET_ALL.TXT files from the relay.

Step 2. You modify the settings at the PC. For each settings class that you modify, the software sends a SET_*cn*.TXT file to the relay.

Step 3. The PC software reads the ERR.TXT file. If it is not empty, the relay detects errors in the SET_*cn*.TXT file.

Step 4. For any detected errors, modify the settings and send the settings until the relay accepts your settings.

Step 5. Repeat *Step 2–Step 4* for each settings class that you want to modify.

Step 6. After all setting changes are complete, test and commission the relay.

SET_ALL.TXT File (Read-Only)

The SET_ALL.TXT file contains the settings for all of the settings classes in the relay. Calibration settings are included only when the file is read at Access Level C.

SET_cn.TXT Files (Read and Write)

There is a file for each instance of each setting class. *Table 7.64* summarizes the settings files. The settings class is designated by *c*, and the settings instance number is designated by *n*.

ERR.TXT (Read-Only)

The ERR.TXT file contents are based on the most recent SET_*cn*.TXT file written to the relay. If there were no errors, the file is empty. If errors occurred, the relay logs these errors in the ERR.TXT file.

Table 7.64 Settings Directory Files

File Name	Settings Description
SET_*n*.TXT	Group; *n* in range 1–4
SET_D*n*.TXT	DNP3 Map; *n* in range 1–3
SET_E*n*.TXT	EtherNet/IP Assembly Map; *n* in range 1–3
SET_F.TXT	Front panel
SET_G.TXT	Global
SET_I.TXT	IEC 60870 Map
SET_L*n*.TXT	Logic; *n* in range 1–4
SET_M.TXT	Modbus Map
SET_P*n*.TXT	Port; *n* in range 1, 2, 3, 4, F
SET_R.TXT	Report
SET_ALL.TXT	All instances of all settings classes
ERR.TXT	Error log for most recently written settings file

Reports Directory (Read-Only) (Available for FTP and MMS)

Use the REPORTS directory to retrieve files that contain the reports shown in *Table 7.65*. Note that the relay provides a report file that contains the latest information each time you request the file. Each time you request a report, the relay stores its corresponding command response in the designated text file.

Table 7.65 Reports Directory Files

File Name	Description	Equivalent Command Response
BRE_X.TXT	Breaker X Report	BRE_X
BRE_Y.TXT	Breaker Y Report	BRE_Y
CHISTORY.TXT	Compressed ASCII History Report	CHI
HISTORY.TXT	History Report	HIS
CLDP.TXT	Compressed Load Profile Data	CLDP
LDP.TXT	Load Profile Data	LDP
CSER. TXT	Compressed Sequence of Events	CSER
SER. TXT	Sequence of Events	SER
GEN	Generator Operating Statistics	GEN
GSH.TXT	Generator Synchronism Check Report	GSH
CGSR_*nnnnn*.CEV	Generator Start Report	CGSR *nnnnn*
SYN.TXT	Synchronism Check Report	SYN

Events Directory (Read-Only) (Available for FTP and MMS)

The relay provides history, event reports, and oscillography files in the EVENTS directory as shown in *Table 7.66*.

Event reports are available in the following formats:

- SEL Compressed ASCII
- Binary COMTRADE format (IEEE C37.111-1999)

The size of each event report file is determined by the LER setting in effect at the time the event is triggered.

Compressed SEL ASCII event report files are generated, when requested, by storing the appropriate command response shown in *Table 7.66*.

Oscillography files are generated at the time the event is triggered (see *Event Reporting on page 10.2*). Higher resolution oscillography is available with SEL Compressed ASCII 32-sample/cycle raw event reports and binary COMTRADE files.

COMTRADE event files are available to read as a batch. See *Batch File Access on page 7.83*.

Table 7.66 Event Directory Files (Sheet 1 of 2)

File Name	Description	Equivalent Command Response
CHISTORY.TXT[a]	Compressed ASCII History Report	CHI
HISTORY. TXT[a]	History Report	HIS
C4_*nnnnn*.CEV	Compressed 4-samples/cycle ASCII filtered event report; event ID number = *nnnnn*	CEV *nnnnn*
CR_*nnnnn*.CEV	Compressed 32-samples/cycle ASCII raw event report; event ID number = *nnnnn*	CEV R *nnnnn*

Table 7.66 Event Directory Files (Sheet 2 of 2)

File Name	Description	Equivalent Command Response
CD1_*nnnnn*.CEV	Compressed 4-samples/cycle ASCII filtered differential event report for 87 element 1; event ID number = *nnnnn*	CEV D *nnnnn* 1
CD2_*nnnnn*.CEV	Compressed 4-samples/cycle ASCII filtered differential event report for 87 element 2; event ID number = *nnnnn*	CEV D *nnnnn* 2
CD3_*nnnnn*.CEV	Compressed 4-samples/cycle ASCII filtered differential event report for 87 element 3; event ID number = *nnnnn*	CEV D *nnnnn* 3
HR_*nnnnn*.CFG[b]	COMTRADE configuration file; event ID number = *nnnnn*	N/A
HR_*nnnnn*.DAT[b]	COMTRADE binary data file; event ID number = *nnnnn*	N/A
HR_*nnnnn*.HDR[b]	COMTRADE header file; event ID number = *nnnnn*	N/A

[a] Also available in the Reports directory for convenience.
[b] Also available in the COMTRADE directory for MMS only.

HR_nnnnn.* (Read-Only)

The three files HR_*nnnnn*.CFG, HR_*nnnnn*.DAT, and HR_*nnnnn*.HDR shown in *Table 7.66* are used to create an event report that conforms to the COMTRADE standard. The event is an unfiltered (raw) 32-samples/cycle event. The field, *nnnnn*, corresponds to the unique event identification number displayed by the **HIS** command. For details on event reports see *Section 10: Analyzing Events*.

COMTRADE Directory (Available Only for MMS)

When using MMS file transfer, conveniently retrieve all of the COMTRADE files from the COMTRADE directory. Note that the COMTRADE files are also available in the EVENTS directory. Refer to *Table 7.66* for all the files available in the COMTRADE directory.

HMI Directory (Read and Write)

Use the HMI directory to retrieve the diagnostic information and the setting files that apply to the touchscreen. Refer to *Table 7.63* for all the files available in the HMI directory.

Ymodem File Structure

All the files available (see *Table 7.67*) for Ymodem protocol are in the root directory. See *FILE Command on page 7.50* for a response to the **FIL DIR** command.

Table 7.67 Files Available for Ymodem Protocol (Sheet 1 of 3)

File Name	Description	Read Access Level	Write Access Level
CFG.TXT	See *Root Directory on page 7.77*	1, 2, C	N/A
ERR.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.78*	1, 2, C	N/A
SET_ALL.TXT[a]	See *Settings Directory (Available for FTP and MMS) on page 7.78*	1, 2, C	N/A
SET_*n*.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.78*	1, 2, C	2, C

Table 7.67 Files Available for Ymodem Protocol (Sheet 2 of 3)

File Name	Description	Read Access Level	Write Access Level
SET_C.TXT[a]	See *Settings Directory (Available for FTP and MMS) on page 7.78*	C	C
SET_D*n*.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.78*	1, 2, C	2, C
SET_F.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.78*	1, 2, C	2, C
SET_G.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.78*	1, 2, C	2, C
SET_I.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.78*	1, 2, C	2, C
SET_L*n*.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.78*	1, 2, C	2, C
SET_M.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.78*	1, 2, C	2, C
SET_P*n*.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.78*	1, 2, C	2, C
SET_R.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.78*	1, 2, C	2, C
C4_*nnnnn*.CEV	See *Events Directory (Read-Only) (Available for FTP and MMS) on page 7.80*	1, 2, C	N/A
CD_*nnnnn*.CEV	See *Events Directory (Read-Only) (Available for FTP and MMS) on page 7.80*	1, 2, C	N/A
CR_*nnnnn*.CEV	See *Events Directory (Read-Only) (Available for FTP and MMS) on page 7.80*	1, 2, C	N/A
CD1_*nnnnn*.CEV	See *Events Directory (Read-Only) (Available for FTP and MMS) on page 7.80*	1, 2, C	N/A
CD2_*nnnnn*.CEV	See *Events Directory (Read-Only) (Available for FTP and MMS) on page 7.80*	1, 2, C	N/A
CD3_*nnnnn*.CEV	See *Events Directory (Read-Only) (Available for FTP and MMS) on page 7.80*	1, 2, C	N/A
HR_*nnnnn*.CFG	See *Events Directory (Read-Only) (Available for FTP and MMS) on page 7.80*	1, 2, C	N/A
HR_*nnnnn*.DAT	See *Events Directory (Read-Only) (Available for FTP and MMS) on page 7.80*	1, 2, C	N/A
HR_*nnnnn*.HDR	See *Events Directory (Read-Only) (Available for FTP and MMS) on page 7.80*	1, 2, C	N/A
EG_*nnnnn*.TXT	See *Events Directory (Read-Only) (Available for FTP and MMS) on page 7.80*	1, 2, C	N/A
BRE_X.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.79*	1, 2, C	N/A
BRE_Y.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.79*	1, 2, C	N/A
CHISTORY.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.79*	1, 2, C	N/A
HISTORY.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.79*	1, 2, C	N/A
CLDP.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.79*	1, 2, C	N/A
LDP.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.79*	1, 2, C	N/A
CSER.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.79*	1, 2, C	N/A
SER.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.79*	1, 2, C	N/A
SET_HMI.zds	See *HMI Directory (Read and Write) on page 7.81*	1, 2, C	2, C

Table 7.67 Files Available for Ymodem Protocol (Sheet 3 of 3)

File Name	Description	Read Access Level	Write Access Level
GSH.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.79*	1, 2, C	N/A
GEN.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.79*	1, 2, C	N/A
SYN.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.79*	1, 2, C	N/A
CGSR_*nnnnn*.CEV	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.79*	1, 2, C	N/A
CDP.zds	See *HMI Directory (Read and Write) on page 7.81*	1, 2, C	2, C
HMI_ALL.zip	See *HMI Directory (Read and Write) on page 7.81*	1, 2, C	N/A

[a] Calibration settings are included only when accessed at Access Level C.

Batch File Access

Files can be accessed as a batch by using the supported wildcard character, *.

FTP and MMS Wildcard Usage

Table 7.68 shows examples using supported wildcards. Note that these wildcards may be appended to a directory path (e.g., /specified_directory/ *.txt).

Table 7.68 FTP and MMS Wildcard Usage Examples

Usage	Description	Example	Note
*xyz	Lists all files and/or subdirectories in a specified directory whose name (including extension) ends with xyz.	/*.TXT	List all files with the .TXT extension.
abc*	Lists all files and/or subdirectories in a specified directory whose name begins with abc.	/SETTINGS/SET*	List all settings files that start with SET.
mno	Lists all files and/or subdirectories in a specified directory whose name contains mno.	/EVENTS/*_100*	List all events that contain _100 in the ID number.

Ymodem Wildcard Usage

NOTE: Ymodem protocol does not support wildcards for settings files.

Event, report, and diagnostic files can also be accessed as a batch using wildcards.

Table 7.69 Ymodem Wildcard Usage Examples

Usage	Description	Example	Note
*xyz	Lists all files that end with xyz.	FILE DIR HIS*.TXT	Lists all of the metering files (HISTORY.TXT)
abc*	Lists all files whose name begins with abc.	FILE READ HR_10007*	Retrieves all of the three files for the COMTRADE event 10007 (HR_10007.CFG, HR_10007.DAT, and HR_10007.HDR)

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Section 8

Front-Panel Operations

Overview

The SEL-700G Relay front panel makes generator and intertie data collection and control quick and efficient. You can order all of the SEL-700G model relays with either the two-line LCD or the 5-inch, color, 800 x 480-pixel touchscreen display, as shown in *Table 1.4* and *Figure 8.1*. Each display option comes with eight front-panel pushbuttons. Use either front panel to analyze operating information, view and change relay settings, and perform control functions. You can use the front panel to accomplish the following activities:

- Read metering
- Inspect targets
- Access settings
- Control relay operations
- View diagnostics

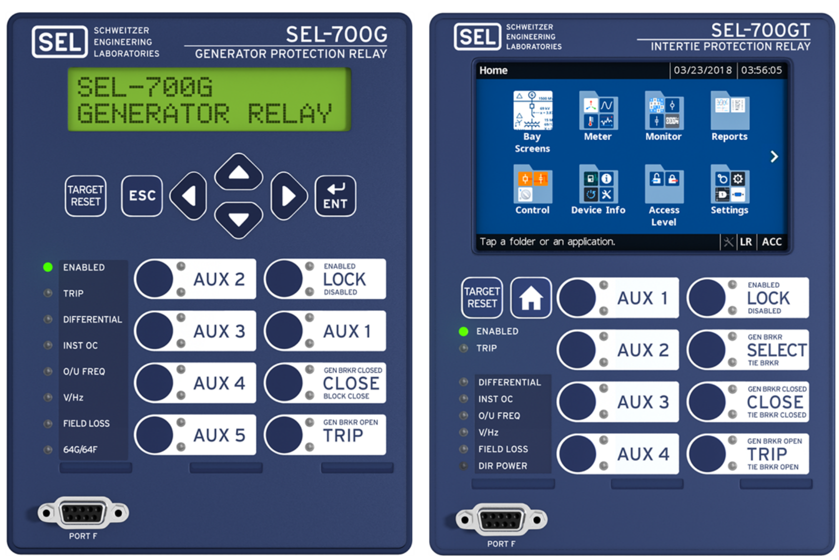


Figure 8.1 SEL-700G Front-Panel Options

The two-line display and the touchscreen display front-panel models are similar in all aspects except the display and navigation scheme. The touchscreen display model offers additional features with respect to monitoring, control, and device status that are discussed in *Touchscreen Display Front Panel*. The function of operation and target LEDs and the **TARGET RESET** and control pushbuttons are similar in both front-panel variations.

This section includes the following:

- *Two-Line Display Front Panel on page 8.2*. Discusses the navigation scheme in the two-line display models, the operation of target LEDs, and programming of the control pushbuttons.
- *Touchscreen Display Front Panel on page 8.17*. Discusses the navigation scheme and the display screens in the touchscreen display model.

Two-Line Display Front Panel

Front-Panel Layout

NOTE: Refer to Figure 8.28 for the pushbutton and LED numbering conventions.

NOTE: If the relay part number specifies the Spanish language option, all of the front-panel pushbuttons and LED labels will be in Spanish.

Figure 8.2 shows and identifies the following regions:

- HMI
- **TARGET RESET** and navigation pushbuttons
- Operation and target LEDs
- Operator control pushbuttons and pushbutton LEDs
- EIA-232 serial port (**PORT F**). See *Section 7: Communications* for details on the serial port.

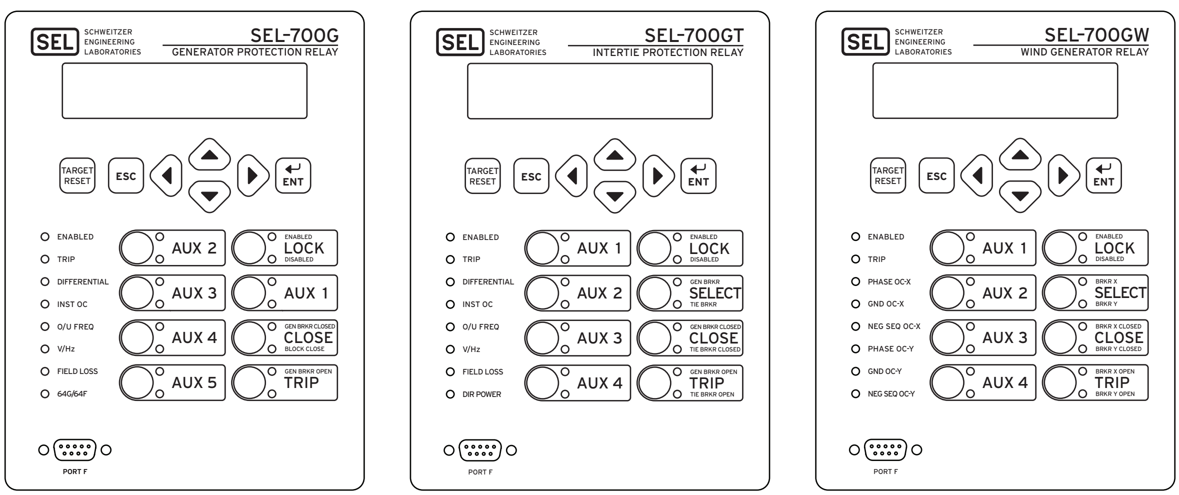


Figure 8.2 Front-Panel Overview

NOTE: SEL-700G relays manufactured before September 15, 2018 have only four pushbuttons.

You can use the following features of the versatile front panel to customize it to your needs:

- Rotating display on the HMI
- Programmable target LEDs
- Programmable pushbutton LEDs
- Slide-in configurable front-panel labels to change the identification of target LEDs, pushbuttons, pushbutton LEDs and their operation.

Two-Line Display HMI

Contrast

NOTE: See the Preface for an explanation of typographic conventions used to describe menus, the front-panel display, and the front-panel pushbuttons.

NOTE: The two-line display updates every second.

You can adjust the LCD screen contrast to suit your viewing angle and lighting conditions. To change screen contrast, press and hold the **ESC** pushbutton for two seconds. The SEL-700G displays a contrast adjustment box. Pressing the **Right Arrow** pushbutton increases the contrast. Pressing the **Left Arrow** pushbutton decreases the screen contrast. When you are finished adjusting the screen contrast, press the **ENT** pushbutton; this process is a shortcut for changing the LCD contrast setting FP_CONT in the front-panel settings.

Front-Panel Automatic Messages

The relay displays automatic messages that override the rotating display under the conditions described in *Table 8.1*. Relay failure has the highest priority, followed by trip and alarm when the front-panel setting FP_AUTO := OVERRIDE.

If the front-panel setting FP_AUTO := ROTATING, then the rotating display messages continue and any TRIP or ALARM message is added to the rotation. Relay failure still overrides the rotating display.

Table 8.1 Front-Panel Automatic Messages (FP_AUTO := OVERRIDE)

Condition	Front-Panel Message
Relay detecting any failure	Displays the type of latest failure (see *Section 11: Testing and Troubleshooting*).
Relay trip has occurred	Displays the type or cause of the latest trip. Refer to *Table 10.1* for a list of trip display messages.
Relay alarm condition has occurred	Displays the type of alarm. The **TRIP** LED is also flashing during an alarm condition. See *Table 8.3* for a list of the alarm conditions.

Front-Panel Security

Front-Panel Access Levels

The SEL-700G front panel typically operates at Access Level 1 and provides viewing of relay measurements and settings. Some activities, such as editing settings and controlling output contacts, are restricted to those operators who know the Access Level 2 passwords.

In the figures that follow, restricted activities are indicated by the padlock symbol.

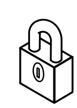


Figure 8.3 Access Level Security Padlock Symbol

Before you can perform a front-panel menu activity that is marked with the padlock symbol, you must enter the correct Access Level 2 password. After you have correctly entered the password, you can perform other Access Level 2 activities without reentering the password.

Access Level 2 Password Entry

When you try to perform an Access Level 2 activity, the relay determines whether you have entered the correct Access Level 2 password since the front-panel inactivity timer expired. If you have not, the relay displays the screen shown in *Figure 8.4* for you to enter the password. See *PASSWORD Command (Change Passwords) on page 7.61* for the list of default passwords and for more information on changing passwords.

```
Password=
Del Clr Accept
A B C D E F G H
I J K L M N O P
Q R S T U V W X
Y Z . . . . . .
a b c d e f g h
i j k l m n o p
q r s t u v w x
y z . . . . . .
0 1 2 3 4 5 6 7
8 9 . . . . . .
! " # $ % & ' (
) * + , - . / :
; < = > ? @ [ \
] ^ _ ` { | } ~
```

Figure 8.4 Password Entry Screen

Front-Panel Timeout

To help prevent unauthorized access to password-protected functions, the SEL-700G has a front-panel timeout, setting FP_TO. A timer resets every time you press a front-panel pushbutton. Once the timeout period expires, the access level resets to Access Level 1. Manually reset the access level by selecting `Quit` from the `MAIN` menu.

Front-Panel Menus and Screens

Navigating the Menus

The SEL-700G front panel gives you access to most of the information that the relay measures and stores. You can also use front-panel controls to view or modify relay settings.

All of the front-panel functions are accessible through use of the six-button keypad and LCD. Use the keypad (shown in *Figure 8.5*) to maneuver within the front-panel menu structure, described in detail throughout the remainder of this section. *Table 8.2* describes the function of each front-panel pushbutton.

NOTE: Front-panel menus and screens are model dependent; consequently, specific models may not have some of the features presented in this section.

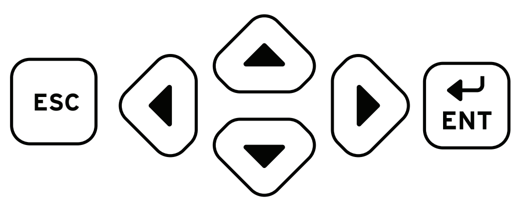


Figure 8.5 Front-Panel Pushbuttons

Table 8.2 Front-Panel Pushbutton Functions

Pushbutton	Function
Up Arrow	Move up within a menu or data list. While editing a setting value, increase the value of the underlined digit.
Down Arrow	Move down within a menu or data list. While editing a setting value, decrease the value of the underlined digit.
Left Arrow	Move the cursor to the left.
Right Arrow	Move the cursor to the right.
ESC	Escape from the current menu or display. Displays additional information if lockout condition exists. Hold for two seconds to display contrast adjustment screen.
ENT	Move from the rotating display to the `MAIN` menu. Select the menu item at the cursor. Select the displayed setting to edit that setting.

The SEL-700G automatically scrolls information that requires more space than provided by a 16-character LCD line. Use the **Left Arrow** and **Right Arrow** pushbuttons to suspend automatic scrolling and enable manual scrolling of this information.

MAIN Menu

Figure 8.6 shows the `MAIN` menu screen. Using the **Up Arrow** or **Down Arrow** and **ENT** pushbuttons, you can navigate to specific menu items in the `MAIN` menu. Each menu item is explained in detail in the following paragraphs.

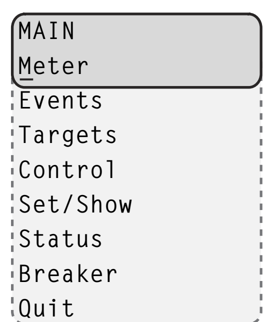


Figure 8.6 MAIN Menu

Meter Menu. Select the `Meter` menu item from the `MAIN` menu as shown in *Figure 8.7* to view metering data. The `METER` menu has menu items for viewing different types of metering data like Fundamental, rms, Thermal, etc. Select the type of metering and view the data by using the **Up Arrow** or **Down Arrow** pushbuttons. See *Metering on page 5.2* for a description of the available data fields.

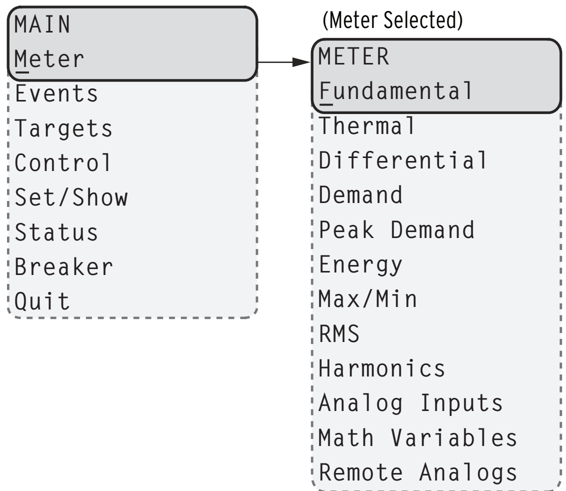


Figure 8.7 MAIN Menu and METER Submenu

For viewing `Energy` (or `Max/Min`) metering data, select the `Energy` (or `Max/Min`) menu item from the `METER` menu and select the `Display` menu item as shown in *Figure 8.8*.

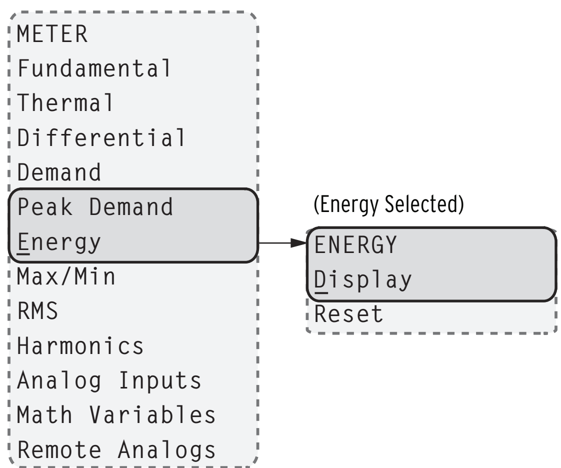


Figure 8.8 METER Menu and ENERGY Submenu

`Energy` (or `Max/Min`, `Demand`, `Peak Demand`) metering data can be reset from the front-panel HMI by selecting the `Reset` menu item in the `Energy` (or `Max/Min`, `Demand`, `Peak Demand`) menu. After selecting `Reset` and confirming the reset, the relay displays as shown in *Figure 8.9*.

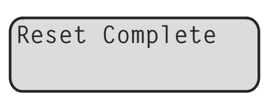


Figure 8.9 Relay Response When Energy (or Max/Min, Demand, Peak Demand) Metering Is Reset

Assume that the relay configuration contains no analog input cards. In response to a request for analog data (selecting Analog Inputs), the device displays the message as shown in *Figure 8.10*.

Figure 8.10 Relay Response When No Analog Cards Are Installed

Assume that the math variables are not enabled. In response to a request for math variable data (selecting Math Variables), the device displays the message as shown in *Figure 8.11*.

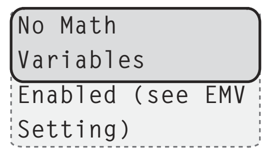


Figure 8.11 Relay Response When No Math Variables Enabled

Events Menu. Select the Events menu item from the MAIN menu as shown in *Figure 8.12*. EVENTS menu has Display and Clear as menu items. Select Display to view events and Clear to delete all events data.

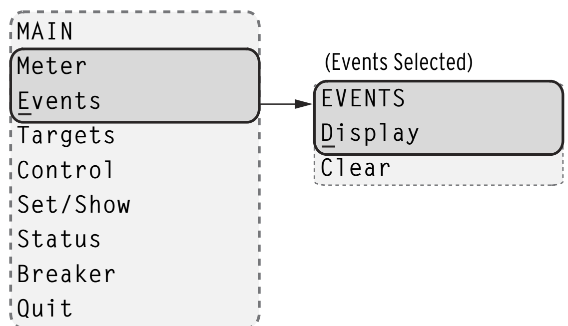


Figure 8.12 MAIN Menu and EVENTS Submenu

Figure 8.13 shows the DISPLAY menu when Display is selected from the EVENTS menu with events in the order of occurrence starting with the most recent. You can select an event from the DISPLAY menu and navigate through the event data.

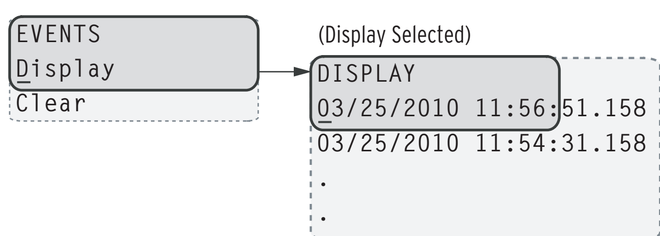


Figure 8.13 EVENTS Menu and DISPLAY Submenu

When you select Display and no event data are available, the relay displays as shown in *Figure 8.14*.

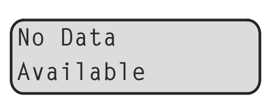


Figure 8.14 Relay Response When No Event Data Available

When you select `Clear` from the `EVENTS` menu and confirm the selection, the relay displays as shown in *Figure 8.15* after it clears the events data.

Figure 8.15 Relay Response When Events Are Cleared

Targets Menu. Select the `Targets` menu item on the `MAIN` menu as shown in *Figure 8.16* to view the binary state of the target rows. Each target row has eight Relay Word bits as shown in *Table L.1*.

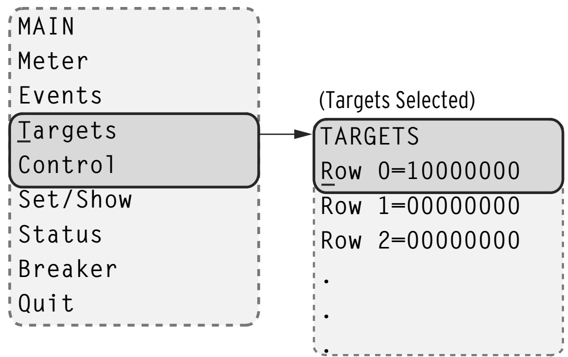


Figure 8.16 MAIN Menu and TARGETS Submenu

Select the target row to display two consecutive Relay Word bits with name and binary state as shown in *Figure 8.17*.

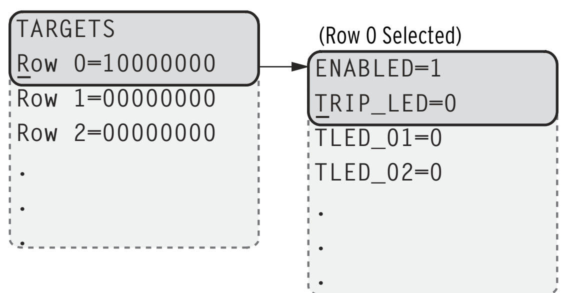


Figure 8.17 TARGETS Menu Navigation

Control Menu. Select the `Control` menu item on the `MAIN` menu as shown in *Figure 8.18* to go to the `CONTROL` menu.

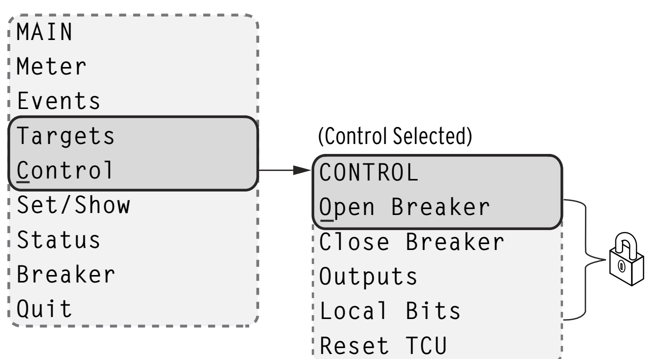


Figure 8.18 MAIN Menu and CONTROL Submenu

The CONTROL menu has Open Breaker, Close Breaker, Outputs, Local Bits, and Reset TCU as menu items.

Select the Open Breaker menu item, and then select breaker X or Y to assert Relay Word bit OCX or OCY, which opens breaker X or Y via the TRX or TRY SELOGIC control equations (see *Table 4.61* for the TRX or TRY equations and *Table L.3* for the definition of the OCX or OCY bits). Note that this requires Level 2 access.

Select the Close Breaker menu item, and then select breaker X or Y to assert Relay Word bit CCX or CCY, which closes breaker X or Y via the CLX or CLY SELOGIC control equation (see *Table 4.61* and *Figure 4.134*). Note that this requires Level 2 access.

Breaker control through the front panel is supervised by the position of the breaker jumper (refer to *Table 2.19*), the status of the LOCAL bit when EN_LRC := Y, and the access level (requires 2AC). When the local/remote supervision setting EN_LRC := Y and LOCAL := 0, control of the OCX/OCY and CCX/CCY bits from the front panel is blocked. When EN_LRC := N, breaker control from the front panel is always allowed. For the settings related to the local/ remote control function, refer to *Local/Remote Control* in *Section 9: Bay Control*.

Select the Outputs menu item from the CONTROL menu as shown in *Figure 8.19* to test (pulse) SEL-700G output contacts and associated circuits. Choose the output contact by navigating through the OUTPUT menu, and test it by pressing the **ENT** pushbutton. Note that testing the output contact requires Level 2 access and reconfirmation.

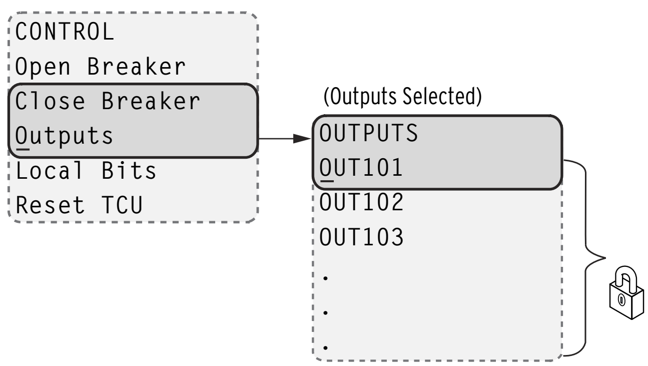


Figure 8.19 CONTROL Menu and OUTPUTS Submenu

Select the Local Bits menu item from the CONTROL menu for local control action. Local bits take the place of traditional panel switches and perform isolation, open, close, or pulse operations.

With the settings as per the example in *Section 4* (see *Local Bits on page 4.252* for more information), Local Bit 1 replaces a supervisory switch. *Figure 8.20* shows the screens in closing the supervisory switch. In this operation, Local Bit LB01 is deasserted (SUPER SW = OPEN). It then changes to asserted (SUPER SW = CLOSE), as shown in the final screen of *Figure 8.20*.

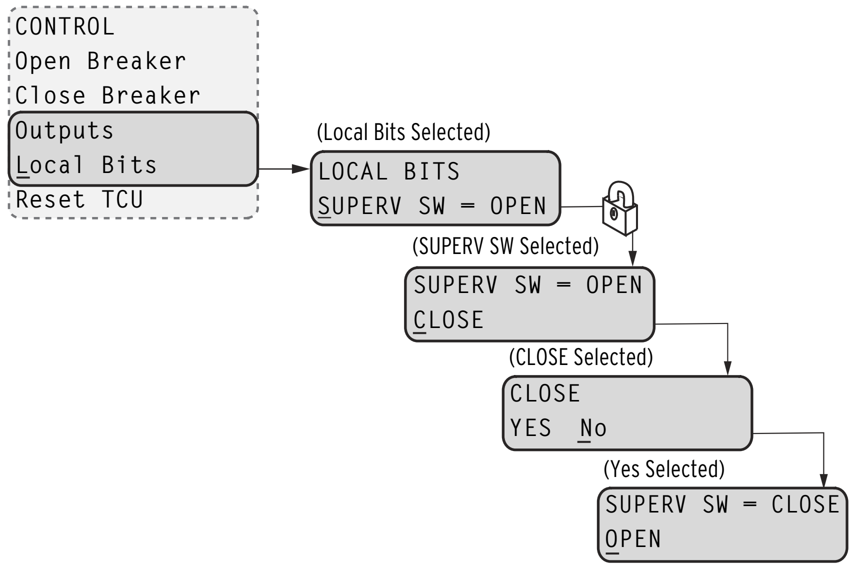


Figure 8.20 CONTROL Menu and LOCAL BITS Submenu

Set/Show Menu. Select the Set/Show menu item on the MAIN menu. The Set/Show menu is used to view or modify the settings (Global, Group, and Port), Active Group, Date, and Time. Note that modifying the settings requires Level 2 access.

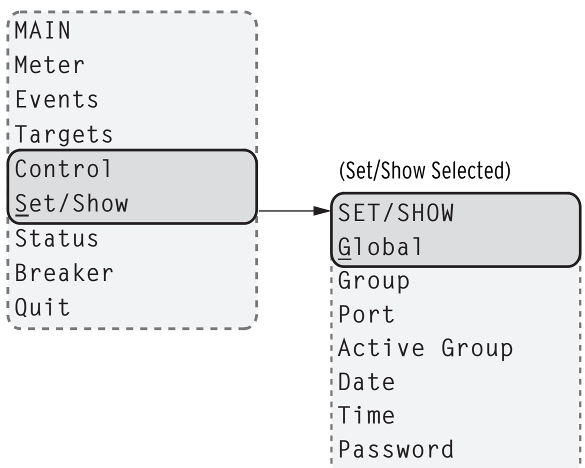


Figure 8.21 MAIN Menu and SET/SHOW Submenu

Each settings class (Global, Group, and Port) includes headings that create subgroups of associated settings as shown in the following illustration. Select the heading that contains the setting of interest, and then navigate to the particular setting. View or edit the setting by pressing the **ENT** pushbutton. For text settings, use the four navigation pushbuttons to scroll through the available alphanumeric and special character settings matrix. For numeric settings, use the **Left Arrow** and **Right Arrow** pushbuttons to select the digit to change and the **Up Arrow** and **Down Arrow** pushbuttons to change the value. Press the **ENT** pushbutton to enter the new setting.

Setting changes can also be made by using ACSELERATOR QuickSet SEL-5030 Software or ASCII **SET** commands via a communications port.

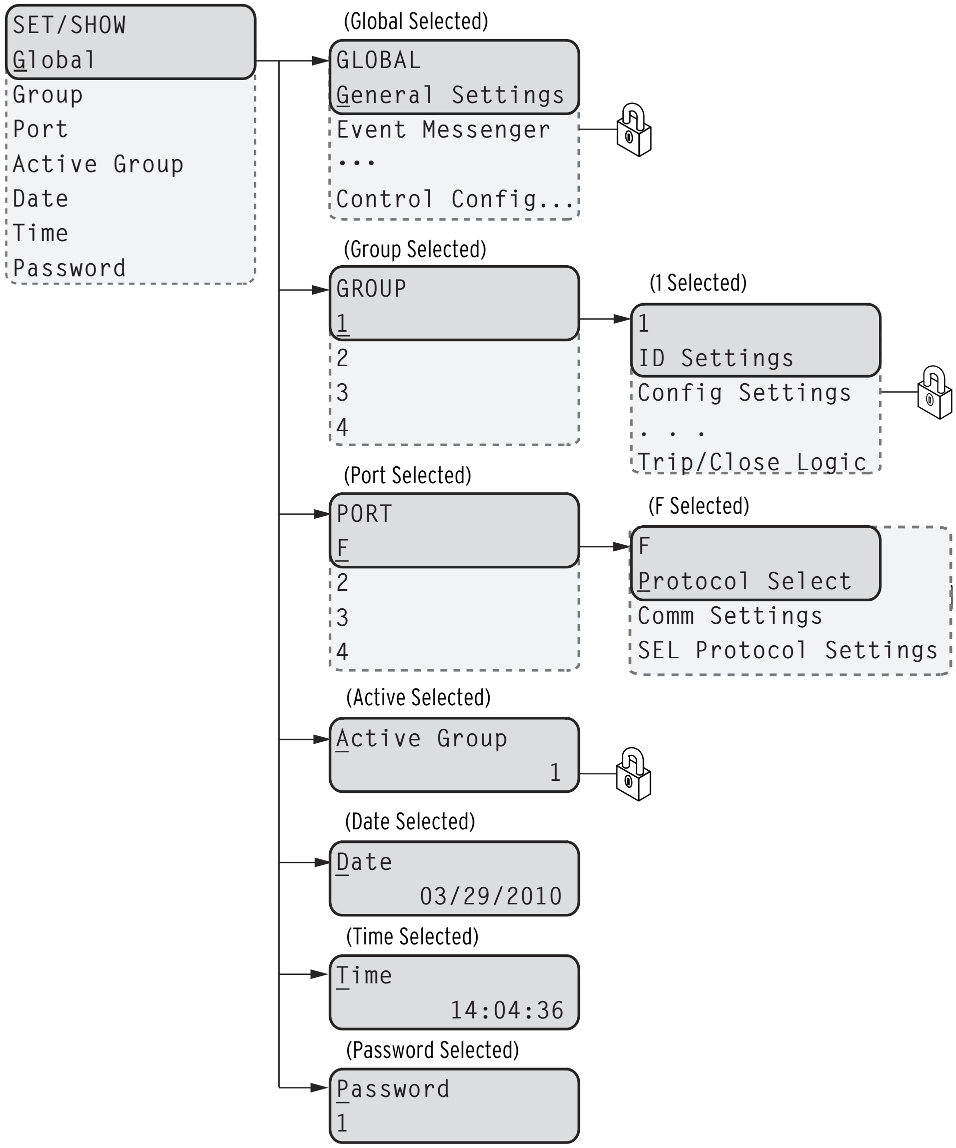


Figure 8.22 SET/SHOW Menu

Status Menu. Select the `Status` menu item on the `MAIN` menu as shown in *Figure 8.23* to access `Relay Status` data and `Reboot Relay`. See *STATUS Command (Relay Self-Test Status) on page 7.70* for the `STATUS` data field description.

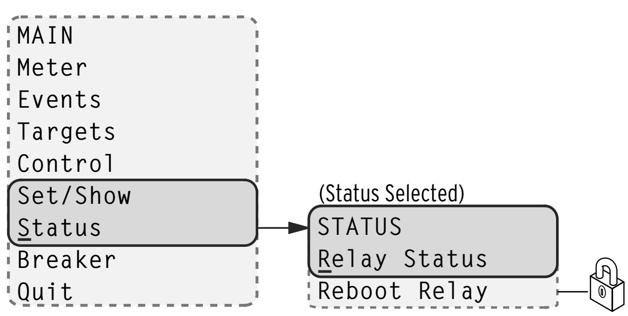


Figure 8.23 MAIN Menu and STATUS Submenu

Breaker Menu. Select the `Breaker` menu item on the `MAIN` menu as shown in *Figure 8.24* to access breaker data or reset the data. See *Breaker Monitor on page 5.16*, in *Section 5: Metering and Monitoring* for a detailed description.

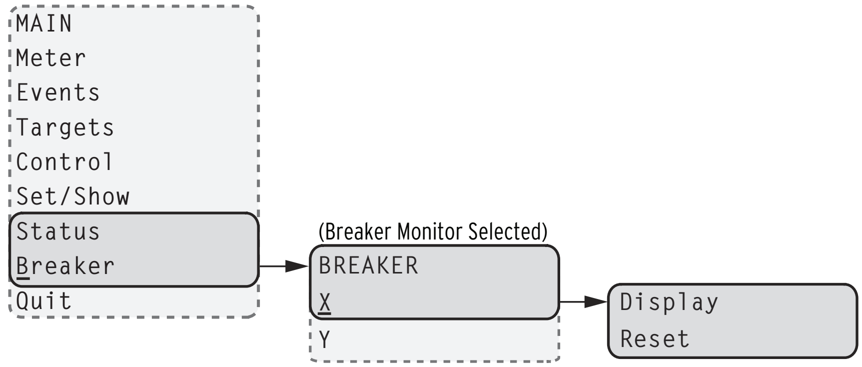


Figure 8.24 MAIN Menu and BREAKER Submenu

Quit. Use the Quit menu item of the MAIN menu to exit Access Level 2 and go to Access Level 1.

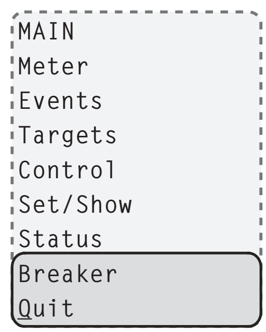


Figure 8.25 Quit Menu Item

Language Support

All of the HMI messages can be displayed in multiple languages (English or Spanish). The relay part number determines which language is displayed on the HMI. The HMI can display either ENGLISH or SPANISH. See *SEL-700G Relay Command Summary* for a list of the Spanish commands.

Operation and Target LEDs

Programmable LEDs

The SEL-700G provides quick confirmation of relay conditions via operation and target LEDs. *Figure 8.26* shows this region with factory-default text on the front-panel configurable labels for the SEL-700G Generator Protection Relay. To view the front-panel factory-default text of the SEL-700GT or SEL-700GW model, refer to *Figure 8.2*. See *Target LED Settings on page 4.253* for the SELOGIC control equations and the tricolor LED color selection settings.

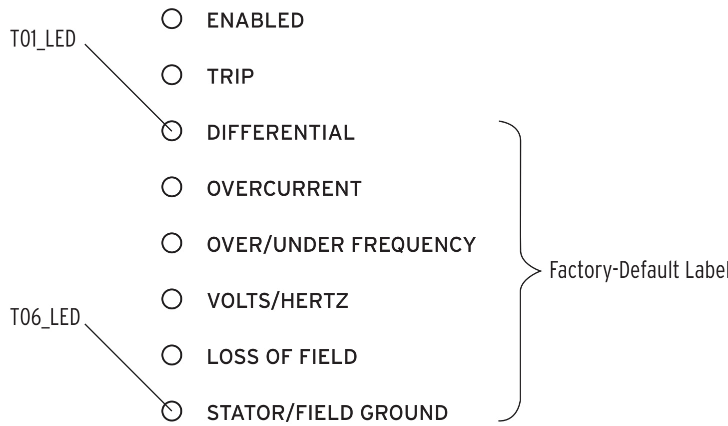


Figure 8.26 Factory-Default Front-Panel LEDs for the SEL-700G Generator Protection Relay

NOTE: There are three versions of factory-default front-panel LED configurations depending on the model (SEL-700G, SEL-700GT, or SEL-700GW).

You can reprogram all of these indicators except the ENABLED and TRIP LEDs to reflect operating conditions other than the factory-default programming described in this subsection.

NOTE: The target LEDs are restored to their previous state after the relay is turned off and then turned back on.

Settings T0*n*_LED are SELOGIC control equations that work with the corresponding T0*n*LEDL latch settings to illuminate the LEDs shown in *Figure 8.26*. Use settings T0*n*LEDC to select the LED color (R: Red, G: Green, A: Amber). Parameter *n* is a number from 1 through 6 that indicates each LED. If the latch setting (T0*n*LEDL) for a certain LED is set to N, then the LED follows the status of the corresponding control equation (T0*n*_LED). When the equation asserts, the LED illuminates, and when the equation deasserts, the LED extinguishes. If the latch setting is set to Y, the LED will assert if a trip condition occurs and the T0*n*_LED equation is asserted within 1.5 cycles of the trip assertion. At this point, the LED latches in. You can reset by using the TARGET RESET pushbutton or the **TAR R** command as long as the target conditions are absent. For a concise listing of the default programming on the front-panel LEDs, see *Table 4.99*.

The SEL-700G comes with slide-in labels for custom LED designations that match custom LED logic. The configurable label kit, which includes blank labels, a word processor template, and instructions, is provided when the SEL-700G is ordered.

The ENABLED LED indicates that the relay is powered correctly, is functional, and has no self-test failures. Trip events illuminate the TRIP LED. The prominent location of the TRIP LED in the top target area aids in recognizing trip events quickly.

The TRIP LED has an additional function that notifies you of warning conditions. When the TRIP LED is flashing, the warning conditions in *Table 8.3* are active when you set the corresponding relay element. For Relay Word bit definitions, see *Appendix L: Relay Word Bits*.

Table 8.3 Possible Warning Conditions (Flashing TRIP LED) (Sheet 1 of 2)

Warning Message	Relay Word Bit Logic Condition
Gen Overload Alarm	49A
Gen Neg Seq Curr Alarm	46Q1T
Gen V/Hz Alarm	24D1T
Diff Cur/Open CT Alarm	87AT

Table 8.3 Possible Warning Conditions (Flashing TRIP LED) (Sheet 2 of 2)

Warning Message	Relay Word Bit Logic Condition
Current Demand Alarm	PHDEMX OR 3I2DEMX OR GNDEMX OR PHDEMY OR 3I2DEMY OR GNDEMY
Breaker Wear Alarm	BCWX OR BCWY
Autosynchronism Failed-Lockout	VSYNCNO OR FSYNCNO
RTD Warning	WDGALRM OR BRGALRM OR AMBALRM OR OTHALRM
RTD Failure	RTDFLT
SEL-2664 FGM Failure	64FFLT
Comm. Loss Warning	COMMLOSS
Comm. Idle Warning	COMMIDLE

TARGET RESET Pushbutton

Target Reset

For a trip event, the SEL-700G latches the trip-involved target LEDs except for the ENABLED LED. Press the TARGET RESET pushbutton to reset the latched target LEDs. When a new trip event occurs and the previously latched trip targets have not been reset, the relay clears the latched targets and displays the new trip targets. Pressing and holding the TARGET RESET pushbutton illuminates all the LEDs. Upon release of the TARGET RESET pushbutton, two possible trip situations can exist: the conditions that caused the relay to trip have cleared, or the trip conditions remain present at the relay inputs. If the trip conditions have cleared, the latched target LEDs turn off. If the trip event conditions remain, the relay re-illuminates the corresponding target LEDs. The TARGET RESET pushbutton also removes the trip automatic message displayed on the LCD menu screens if the trip conditions have cleared.

Figure 8.27 TARGET RESET Pushbutton

Lamp Test

The TARGET RESET pushbutton also provides a front-panel lamp test. Pressing and holding TARGET RESET illuminates all the front-panel LEDs, and these LEDs remain illuminated for as long as TARGET RESET is pressed. The target LEDs return to a normal operational state after release of the TARGET RESET pushbutton.

Other Target Reset Options

Use the ASCII command **TAR R** to reset the target LEDs; see *Table 7.57* for more information. Programming specific conditions in the SELOGIC control equation RSTTRGT is another method for resetting target LEDs. Access RSTTRGT in *Global Settings (SET G Command)*, *Data Reset on page 4.237* for further information.

Front-Panel Operator Control Pushbuttons

The SEL-700G features eight operator-controlled pushbuttons, each with two programmable pushbutton LEDs, for local control as shown in *Figure 8.28*. To view the factory-default operator control pushbuttons and LEDs for the SEL-700GT or SEL-700GW model, refer to *Figure 8.2*.

NOTE: There are three versions of factory-default front-panel pushbuttons and pushbuttons LED configurations depending on the model (SEL-700G, SEL-700GT, and SEL-700GW).

NOTE: SEL-700G relays manufactured before September 15, 2018 have only four pushbuttons (PB01–PB04). SEL-700G relays with four pushbuttons do not have tri-color LEDs for pushbuttons or targets.

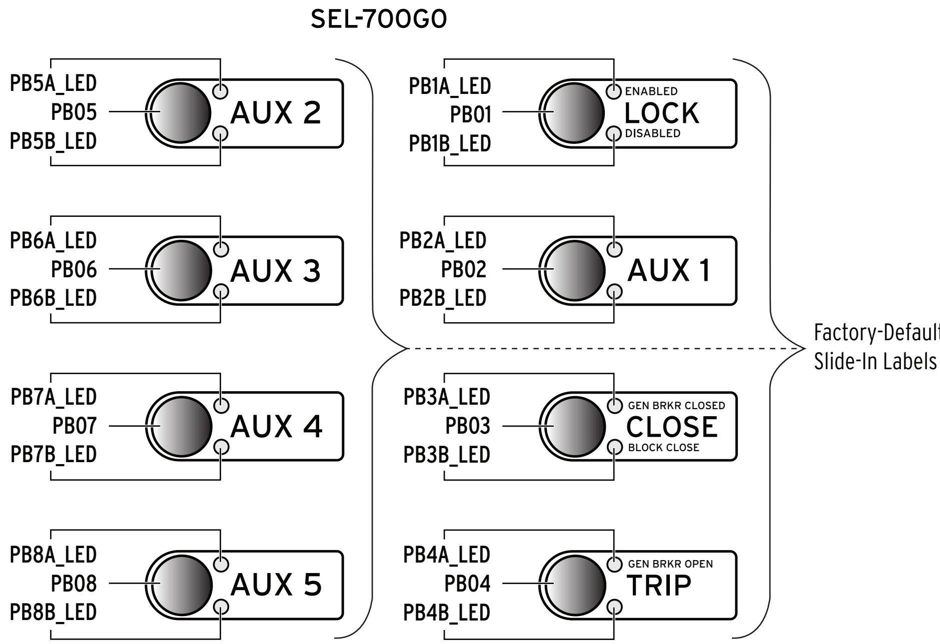


Figure 8.28 Factory-Default Operator Control Pushbuttons and LEDs for the SEL-700G Generator Protection Relay

Pressing any one of these eight pushbuttons asserts the corresponding PB*n* (*n* = 01 through 08) Relay Word bit, and the corresponding PB*n*_PUL Relay Word bit. The PB*n* Relay Word bit remains asserted as long as the pushbutton is pressed, but the PB*n*_PUL Relay Word bit asserts only for the initial processing interval, even if the button is still being pressed. Releasing the pushbutton and then pressing the pushbutton again asserts the corresponding PB*n*_PUL Relay Word bit for another processing interval. The pushbutton LEDs are independent of the pushbutton.

Pushbutton LEDs are programmable through use of the front-panel settings PB*nm*_LED (where *n* = 1 through 8 and *m* = A or B). PB*nm* _LED settings are SELOGIC control equations that, when asserted, illuminate the corresponding LED for as long as the input is asserted. When the input deasserts, the LED also deasserts without latching. Use PB*nm*LEDC settings to select the LED color (R: Red, G: Green, A: Amber) for both the asserted and deasserted states of the LED.

Using SELOGIC control equations, you can readily change the default LED and pushbutton functions. Use the optional slide-in label to mark the pushbuttons and pushbutton LEDs with custom names to reflect any programming changes that you make. Included on the SEL-700G Product Literature CD are word processor templates for printing slide-in labels. See the instructions included in the Configurable Label kit for more information on changing the slide-in labels.

Table 8.4 describes front-panel operator controls based on the factory-default settings and operator control labels for the SEL-700GT and SEL-700GW models. *Table 8.5* describes front-panel operator controls based on the factory-default settings and operator control labels for the SEL-700G0 and SEL-700G1 models.

Table 8.4 SEL-700GT and SEL-700GW Front-Panel Operator Control Functions

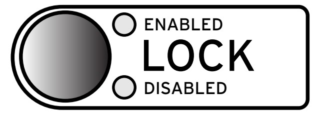
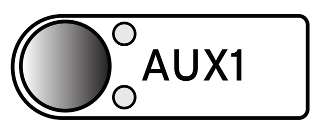
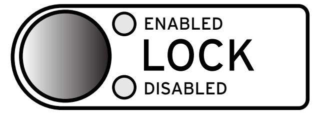
Continually press the LOCK operator control pushbutton for three (3) seconds to engage/disengage the lock function (Latch LT01 functions as Lock with the latch in reset state equivalent to the engaged lock). While this pushbutton is pressed, the corresponding LED flashes on and off, indicating a pending engagement or disengagement of the lock function. The LED illuminates constantly to indicate the engaged state. While the lock function is engaged, the following operator control is "locked in position" (assuming factory-default settings): CLOSE. While "locked in position," this operator control cannot change state if pressed—the corresponding LEDs remain in the same state. When the lock function is engaged, the CLOSE operator control cannot close GEN BRKR or TIE BRKR, but the TRIP operator control can still trip GEN BRKR or TIE BRKR.	 NOTE: LED labels shown are for the SEL-700GT. For the SEL-700GW, substitute GEN BRKR with BRKR X and TIE BRKR with BRKR Y.
Press the SELECT pushbutton to select GEN BRKR or TIE BRKR. If GEN BRKR is selected, GEN BRKR LED is on and if TIE BRKR is selected, TIE BRKR LED is on. The SELECT pushbutton allows a breaker selection before CLOSE or TRIP pushbuttons are used.	
Press the CLOSE operator control pushbutton to close the selected breaker. Corresponding BRKR CLOSED LED illuminates to indicate that the breaker is closed. **Option:** Set a delay, so that the operator can press the CLOSE operator control pushbutton and then move a safe distance away from the breaker before the SEL-700GT or SEL-700GW issues a close (the CLOSE operator control comes with no set delay in the factory settings). With a set delay, press the CLOSE operator control pushbutton momentarily, and notice that the BRKR CLOSED LED flashes on and off during the delay time, indicating a pending close. Abort the pending close by pressing the CLOSE operator control pushbutton again or by pressing the TRIP operator control pushbutton. This delay setting for the CLOSE operator control is SV03PU (range: 0 to 3000 seconds; factory set at 0—no delay). The delay is set via the **SET L** command. See *Table 4.66* for more information.	
Press the TRIP operator control pushbutton to trip the GEN BRKR (and take the control to the lockout state). GEN BRKR OPEN LED illuminates to indicate that the breaker is open. **Option:** Set a delay, so that the operator can press the TRIP operator control pushbutton and then move a safe distance away from the breaker before the SEL-700GT or SEL-700GW issues a trip (the TRIP operator control comes with no set delay in the factory settings). With a set delay, press the TRIP operator control pushbutton momentarily and notice that the corresponding GEN BRKR OPEN LED flashes on and off during the delay time, indicating a pending trip. Abort the pending trip by pressing the TRIP operator control pushbutton again or by pressing the CLOSE operator control pushbutton. This delay setting for the TRIP operator control is SV04PU (range: 0 to 3000 seconds; factory-set at 0—no delay). The delay is set via the **SET L** command. See *Table 4.66* for more information.	
Press the AUXx (x = 1, 2, 3, or 4) operator control pushbutton to enable/disable user-programmed auxiliary control. The corresponding LED can be programmed to illuminate during the enabled state. NOTE: The AUXx operator control does not perform any function with the factory-default settings.	

Table 8.5 SEL-700G and SEL-700G1 Front-Panel Operator Control Functions

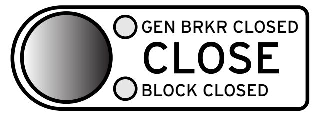
Continually press the LOCK operator control pushbutton for three (3) seconds to engage/disengage the lock function (Latch LT01 functions as Lock with the latch in reset state equivalent to the engaged lock). While this pushbutton is pressed, the corresponding LED flashes on and off, indicating a pending engagement or disengagement of the lock function. The LED illuminates constantly to indicate the engaged state. While the lock function is engaged, the following operator control is "locked in position" (assuming factory-default settings): CLOSE.

While "locked in position," this operator control cannot change state if pressed—the corresponding LEDs remain in the same state. When the lock function is engaged, the CLOSE operator control cannot close GEN BRKR (generator breaker), but the TRIP operator control can still trip GEN BRKR. Note that the LOCK ENABLED condition results in the BLOCK CLOSE LED coming ON.



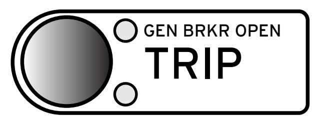
Press the CLOSE operator control pushbutton to close GEN BRKR. The corresponding GEN BRKR CLOSED LED illuminates to indicate that the breaker is closed.

> **Option:** Set a delay, so that the operator can press the CLOSE operator control pushbutton and then move a safe distance away from the breaker before the SEL-700G0, -1 issues a close (the CLOSE operator control comes with no set delay in the factory settings). With a set delay, press the CLOSE operator control pushbutton momentarily, and notice that the BRKR CLOSED LED flashes on and off during the delay time, indicating a pending close. Abort the pending close by pressing the CLOSE operator control pushbutton again or by pressing the TRIP operator control pushbutton. This delay setting for the CLOSE operator control is SV03PU (range: 0 to 3000 seconds; factory set at 0—no delay). The delay is set via the **SET L** command. See *Table 4.66* for more information.



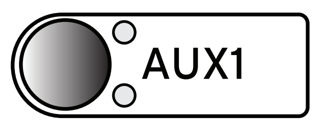
Press the TRIP operator control pushbutton to trip the GEN BRKR (and take the control to the lockout state). The GEN BRKR OPEN LED illuminates to indicate that the breaker is open.

> **Option:** Set a delay, so that the operator can press the TRIP operator control pushbutton and then move a safe distance away from the breaker before the SEL-700G0, -1 issues a trip (the TRIP operator control comes with no set delay in the factory settings). With a set delay, press the TRIP operator control pushbutton momentarily and notice that the GEN BRKR OPEN LED flashes on and off during the delay time, indicating a pending trip. Abort the pending trip by pressing the TRIP operator control pushbutton again or by pressing the CLOSE operator control pushbutton. This delay setting for the TRIP operator control is SV04PU (range: 0 to 3000 seconds; factory set at 0—no delay). The delay is set via the **SET L** command. See *Table 4.66* for more information.



Press the AUXx (x = 1, 2, 3, 4, or 5) operator control pushbutton to enable/disable user-programmed auxiliary control. The corresponding LED can be programmed to illuminate during the enabled state.

NOTE: The AUXx operator control does not perform any function with the factory-default settings.



Touchscreen Display Front Panel

The SEL-700G Feeder Protection Relay can be ordered with an optional touchscreen display (5-inch, color, 800 x 480 pixels). The touchscreen display makes relay data metering, monitoring, and control quick and efficient. The touchscreen display option in the SEL-700G features a straightforward application-driven control structure and includes intuitive and graphical screen designs.

Front-Panel Layout

The touchscreen front panel is the same as the two-line display in regards to the target LEDs, operator control pushbuttons, and the **TARGET RESET** pushbutton. Refer to *Operation and Target LEDs on page 8.12* for a detailed description of these features. In addition, the touchscreen front panel features a **HOME** pushbutton.

Touchscreen Display HMI

This section explains the navigation of the front-panel touchscreen and all the features it supports.

NOTE: The touchscreen display updates every 250 ms.

The touchscreen display allows you to:

- View and control bay screens
- Access metering and monitoring data
- Inspect targets
- View event history, summary data, and SER information
- View relay status and configuration
- Control relay operations
- View and edit settings
- Enable the rotating display
- Program control pushbuttons to jump to a specific screen

Figure 8.29 shows the relay touchscreen display components and indicators.

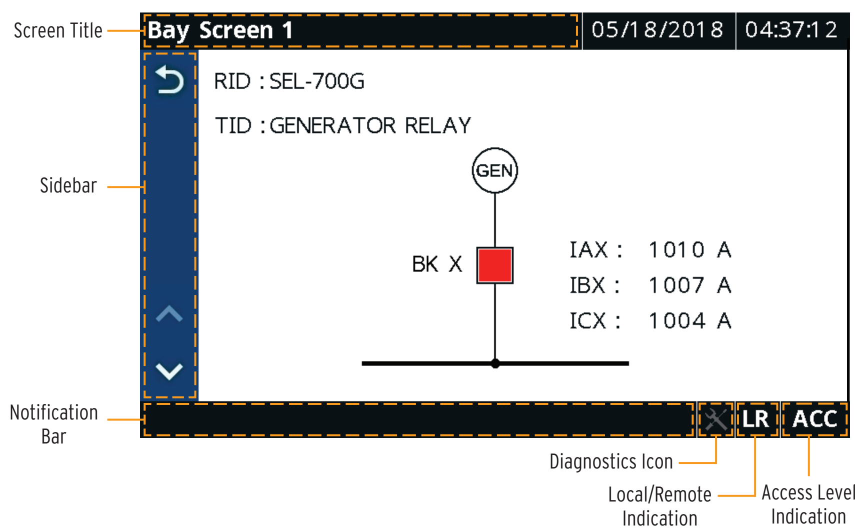
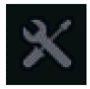


Figure 8.29 Touchscreen Display Components and Indicators

Table 8.6 Touchscreen Display Component and Indicator Descriptions (Sheet 1 of 2)

Display Components and Indicators	Function or Indication
Screen Title	Shows the display name of a screen (see *Figure 8.29*).
Sidebar	Shows the navigation icons (see *Figure 8.29*).
Notification Bar	Shows the notification messages and help text for screens (see *Figure 8.29*).
Diagnostics Icon	ON if there are any warning/diagnostic failures on the unit.

Table 8.6 Touchscreen Display Component and Indicator Descriptions (Sheet 2 of 2)

Display Components and Indicators	Function or Indication
	Normal (no warnings or diagnostic failures present). Icon is OFF.
	Warning. Icon asserts in amber.
	Diagnostic failure. Icon asserts in red.
Local/Remote Indication	Indicates the status of the local/remote control. Refer to *Local/ Remote Control on page 9.7* for more details.
L	When EN_LRC := Y and LOCAL := 1, relay control is in local mode, i.e., OC*n* and CC*n* (*n* = X or Y) bits can be processed via the front panel only.
R	When EN_LRC := Y and LOCAL := 0, relay control is in remote mode, i.e., OC*n* and CC*n* (*n* = X or Y) bits can be processed via remote sources/protocols only.
LR	When EN_LRC := N, relay control is in local/remote control, i.e., OC*n* and CC*n* (*n* = X or Y) bits can be processed from both the front panel and the remote sources/protocols.
Access Level Indication	Indicates the access level that the device is on at the time. Shows ACC if the device is on access level 1 and 2AC if on access level is 2.

Home Pushbutton

Use the **HOME**  pushbutton to wake up the touchscreen after the inactivity timer expires and the screen goes dark. While the default mapping of the **HOME** pushbutton is the Home screen (see *Figure 8.30*), you can program the **HOME** pushbutton to jump to any screen. Refer to *Table 8.18* for a list of screens available for the **HOME** pushbutton. Use the FPHOME setting in the Touchscreen settings of QuickSet to program a specific screen.

Touchscreen Backlight

Adjustment

Touchscreen displays have LED backlights. You can adjust the touchscreen backlight to suit your viewing angle and lighting conditions. To change the backlight settings, tap the **Settings** folder and then tap the **Touchscreen** application. Use the FPBAB setting to adjust the brightness of the display.

Front-Panel Automatic Messages

The relay displays automatic messages that override the present display under the conditions described in *Table 8.7*. Relay failure messages have the highest priority, followed by trip and alarm. When the relay has a trip or alarm condition, the trip and diagnostic messages screen will appear on the display. These messages can also be accessed by tapping the **Trip & Diag. Messages** application in the Device Info folder.

Table 8.7 Front-Panel Automatic Messages

Condition	Front-Panel Message
Relay detects any failure	Displays the latest failure type (refer to *Section 11: Testing and Troubleshooting*).
Relay trip occurs	Displays the type or cause of the trip (refer to *Table 10.1* for a list of trip display messages).
Relay alarm condition occurs	Displays the type of alarm. The TRIP LED also flashes during an alarm condition (refer to *Table 8.3* for a list of the warning conditions).

Front-Panel Security

Use the **Access Level** folder on the Home screen for login/logout operations.

The SEL-700G front panel typically operates at Access Level 1 and allows you to view relay measurements and settings. Particular activities, such as editing settings and controlling output contacts, are restricted to those operators who know the Access Level 2 password.

When an activity requires Access Level 2, an authentication screen appears on the display, which requires you to enter the Access Level 2 password to proceed further. After you have correctly entered the password, you can perform other Access Level 2 operations without re-entering the password. You will have to re-enter the password if the front-panel inactivity timer, FPTO, expires.

See *PASSWORD Command (Change Passwords) on page 7.61* for the list of default passwords and for more information on changing the passwords.

Front-Panel Timeout

To help prevent unauthorized access to password-protected functions, the SEL-700G provides a front-panel time-out setting, FPTO, in the Touchscreen application in the Settings folder. The time-out resets each time you press a front-panel pushbutton or tap the display. Once the time out expires, the access level resets to Access Level 1. You can manually reset the access level by tapping **Logout** in the Access Level folder. The backlight of the display goes dark 60 minutes after the inactivity timer (1–30 min) expires.

Touchscreen

Navigating the Touchscreen Folders and Applications

Use the front-panel touchscreen and pushbuttons to access data measured and stored by the relay and to perform relay operations. All relay information and operations are available through the touchscreen via folders, applications, and the buttons in the sidebar. *Table 8.8* describes the functions of the sidebar buttons.

Table 8.8 Sidebar Buttons

Button	Button Name	Function	Button	Button Name	Function
	Up	Pages up in applications with multiple screens; when on the first screen, this button is disabled.		Back	Returns to the preceding screen, e.g., from applications to folders.
	Down	Pages down in applications with multiple screens; when on the last screen, this button is disabled.		Pause	Stops updating the phasors.
	Left	Pages left on the home screen and in folders with multiple screens; this button is hidden if there is no screen to the left.		Play	Updates the phasor values from the relay as the screen refreshes.
	Right	Pages right on the home screen and in folders with multiple screens; this button is hidden if there is no screen to the right.		Refresh	Reloads the data when new data are available.
	Reset	Resets the accumulating quantities, such as energy, to zero.		Trigger Event	Triggers an event.
	Save	Saves the edited settings to the relay.		Search	Search tool (e.g., search for the status of a Relay Word bit).
	Cancel Save	Cancels the setting edits.		Trash	Deletes the records from the report.

The relay wakes up to the screen set in the FPHOME setting, unless the rotating display is enabled. If the rotating display is enabled and the inactivity time has expired, the relay wakes up to the rotating display. Pressing the **HOME** pushbutton a second time returns you to the screen set in the FPHOME setting.

You can navigate the touchscreen by tapping the folders and applications. Tap a folder or an application to view available applications or access an application, respectively. Folders and applications are labeled according to functionality.

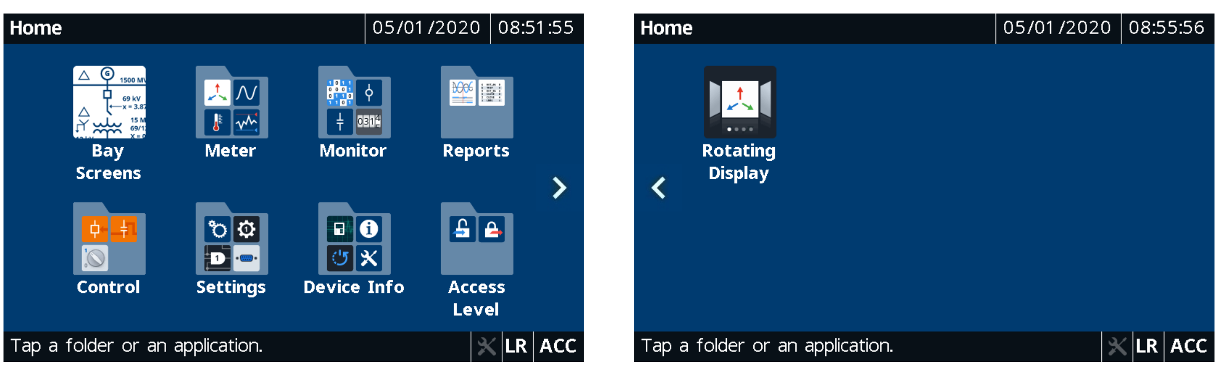


Figure 8.30 Home (Default FPHOME Setting)

Table 8.9 shows a list of folders and applications available on the **Home** screen.

Table 8.9 Home Folders and Applications

Screen Name	Folder or Application Name	Comments
Home	Bay Screens	Always available
	Meter	Always available
	Monitor	Always available
	Reports	Always available
	Control	Always available
	Settings	Always available
	Device Info	Always available
	Access Level	Always available
	Rotating Display	Always available

The applications shown in the folders are based on the part number. For example, if the relay does not have the analog inputs card option, the **Analog Inputs** application is not shown in the **Meter** folder.

Descriptions of the folders and applications on the **Home** screen follow.

Bay Screens

NOTE: Five bay screens are always rendered on the touchscreen. Any unused screens are blank.

Tap this application to navigate to as many as five customer-designed screens (Bay Screen 1 through Bay Screen 5, see *Table 8.18*). You can design these screens using ACSELERATOR Bay Screen Builder SEL-5036 Software. Refer to *Section 9: Bay Control* for the procedure to create custom screens.

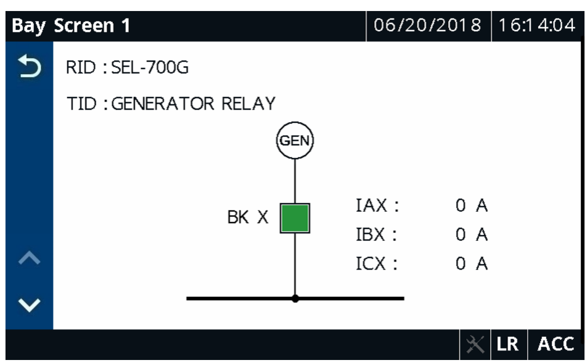


Figure 8.31 Bay Screens Application

Meter

Tapping this folder navigates you to the Meter screen, as shown in *Figure 8.32*. This screen lists all of the available metering applications. The applications on the **Meter** screen are part number dependent. Only those metering applications specific to your part number appear on the **Meter** screen. Tapping an application on the **Meter** screen shows you the report for that particular application.

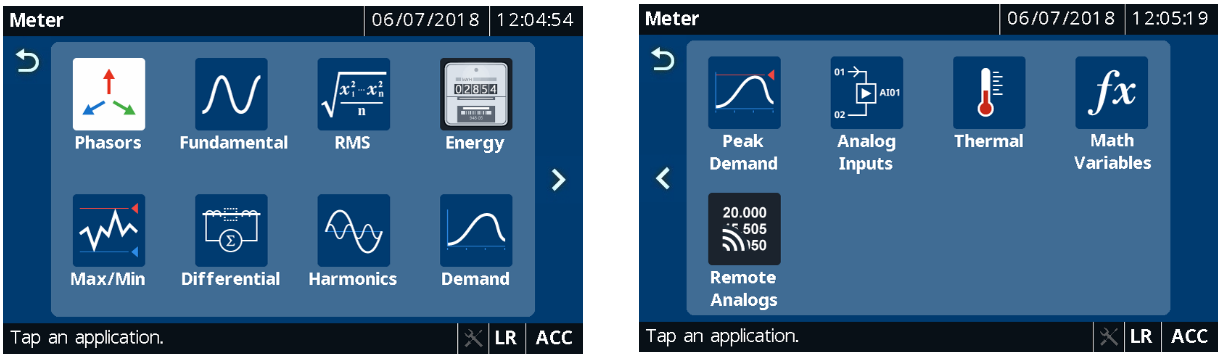


Figure 8.32 Meter Applications

Table 8.10 identifies all the applications available in the **Meter** folder.

Table 8.10 Meter Application Availability

Folder Name	Application Name	Comments[a]
Meter	Phasors	Always available
	Fundamental	Always available
	RMS	Always available
	Energy	Available if the relay supports voltages
	Max/Min	Always available
	Differential	Available for SEL-700G1 or SEL-700G1+ models
	Harmonics	Available for SEL-700G1 or SEL-700G1+ models
	Demand	Always available
	Peak Demand	Always available
	Analog Inputs	Shown when (Slot C = 5*x*) or (Slot D = 5*x*) or (Slot E = 5*x*)
	Thermal	Always available
	Math Variables	Always available
	Remote Analogs	Always available

[a] Refer to the relay part number.

Figure 8.33 and *Figure 8.34* show typical screens for phasor and fundamental metering.

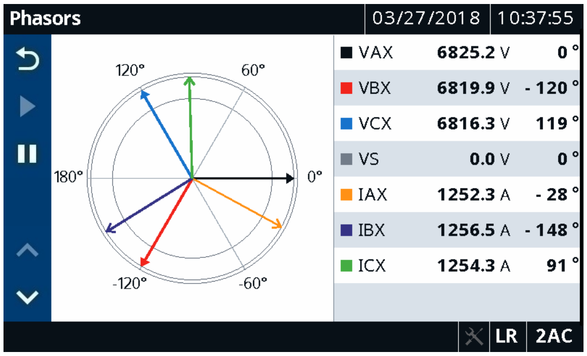


Figure 8.33 Meter Phasors

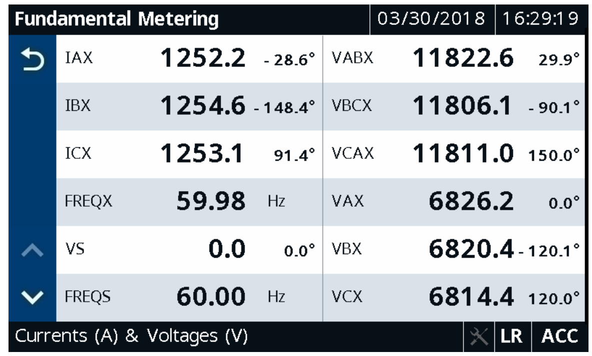


Figure 8.34 Meter Fundamental

A reset feature is provided for the Energy, Max/Min, Thermal, Demand, and Peak Demand applications. Tap the **Reset** button to navigate to the reset confirmation screen. Once you confirm the reset, the data are reset to zero. *Figure 8.35* and *Figure 8.36* show typical screens for energy metering and reset confirmation.

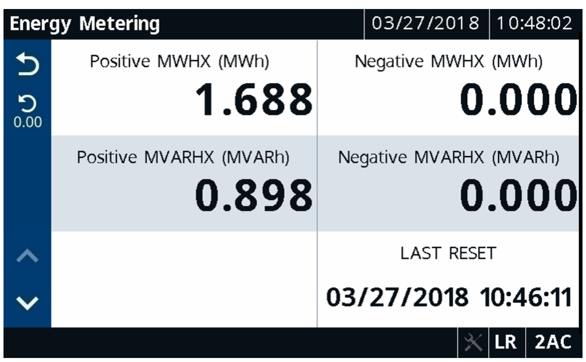


Figure 8.35 Meter Energy

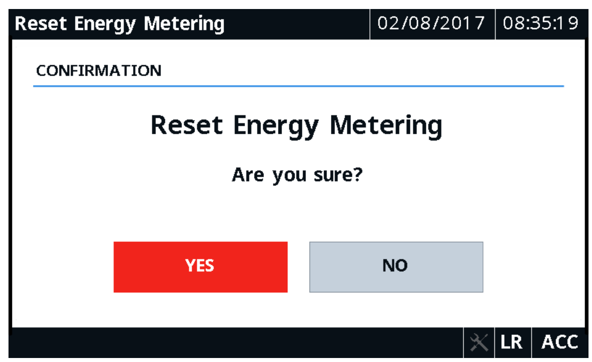


Figure 8.36 Meter Energy Reset

Monitor

Tapping this folder navigates you to the Monitor screen, as shown in *Figure 8.37*. Monitor the status of the Relay Word bits (targets), digital outputs, digital inputs, SELogic counters, and breaker wear data using the respective applications (Relay Word Bits, Digital Outputs, Digital Inputs, SELogic Counters, and Breaker Wear).

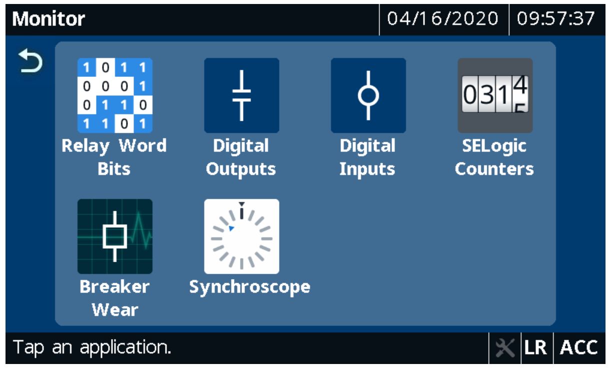


Figure 8.37 Monitor Applications

Table 8.11 identifies all the applications available in the Monitor folder.

Table 8.11 Monitor Application Availability

Folder Name	Application Name	Comments
Monitor	Relay Word Bits	Always available
	Digital Outputs	Always available
	Digital Inputs	Always available
	SELOGIC Counters	Always available
	Breaker Wear	Always available
	Synchroscope	Available for SEL-700G0+, SEL-700G1+, SEL-700GT or SEL-700GT+ models

Tap the **Breaker Wear** application to view accumulated Breaker *n* wear/operations (*n* = X or Y). You can reset the accumulated data by tapping the **Reset** button provided in the sidebar of the Breaker Wear application. Typical screens for the Breaker Wear application are shown in *Figure 8.38* and *Figure 8.39*.

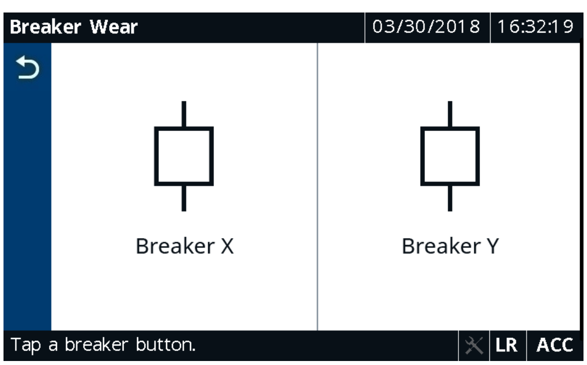


Figure 8.38 Breaker Selection

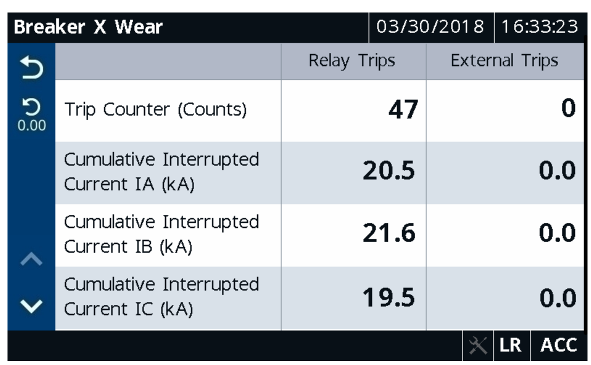


Figure 8.39 Breaker Wear Trips

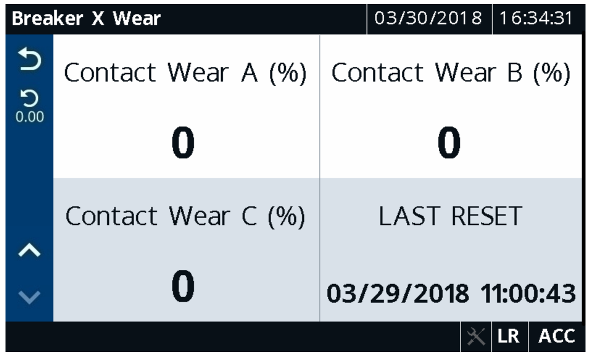


Figure 8.40 Breaker Wear A, B, C, and Last Reset

Monitor the status of the Relay Word bits using the Relay Word Bits screen. Note that asserted Relay Word bits are highlighted in blue. You can use the **Search** button in the Relay Word Bits application to view the status of a Relay Word bit. To search for a Relay Word bit, you must enter the full name of the Relay Word bit in the screen Search Relay Word Bit SEARCH field. *Figure 8.41* and *Figure 8.42* show typical Relay Word bits monitoring screens.

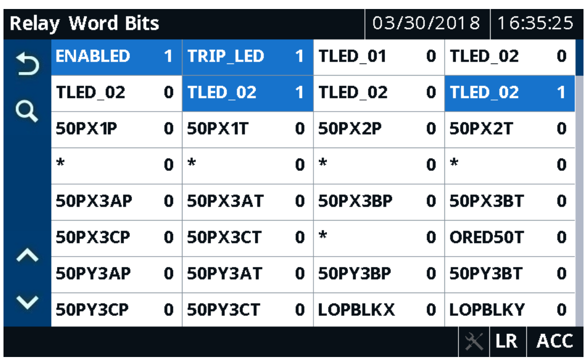


Figure 8.41 Monitor Relay Word Bits

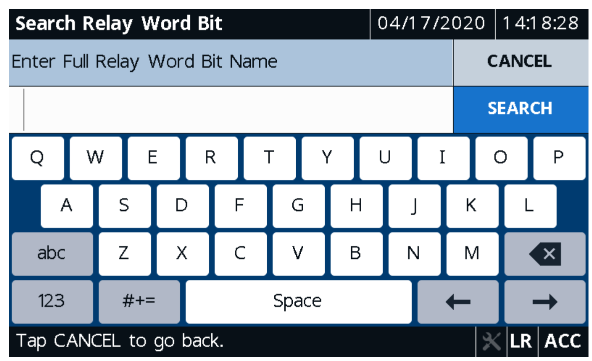


Figure 8.42 Search Relay Word Bits

Tap the Synchroscope application to view the X-Side or Y-Side Synchroscope. See *Synchronism Elements on page 4.161* for more details. The X-Side Synchroscope provides a phasor representation of the difference between the bus (voltage and frequency) and the generator (voltage and frequency).

The X-side synchroscope is available if setting E25X is set to Y. The phasor rotation is displayed if the slip is less than 1.0 Hz. *Figure 8.43* shows a typical X-side synchroscope screen. The bus and compensated generator voltages are displayed in secondary volts.

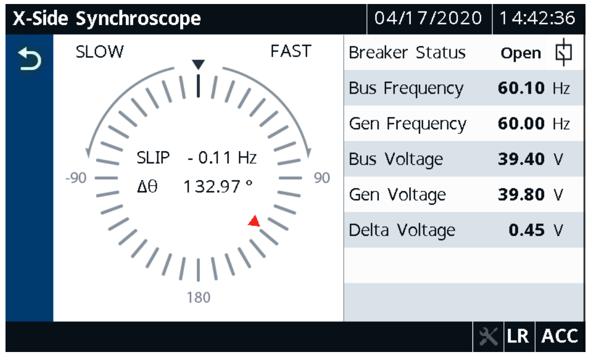


Figure 8.43 X-Side Synchroscope

You may also use the Auto Synchronizer application in the Control Folder (see *Control*) to initiate and visualize autosynchronization of your generator to the system.

The Y-Side Synchroscope provides a phasor representation of the difference between the bus (voltage and frequency) and the tie (voltage and frequency). The Y-side synchroscope is available if setting E25Y is set to Y. The phasor rotation is displayed if Relay Word bit SFY is asserted. See *Figure 4.116* for more details. *Figure 8.44* shows a typical Y-side synchroscope screen. The bus and compensated voltages are displayed in secondary volts.

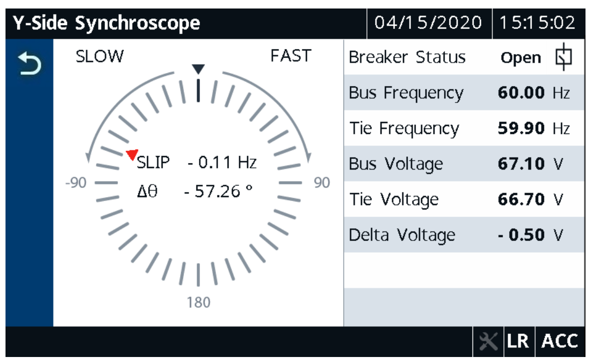


Figure 8.44 Y-Side Synchroscope

Reports

Tapping this folder navigates you to the Reports screen where you can access the Events and SER applications.

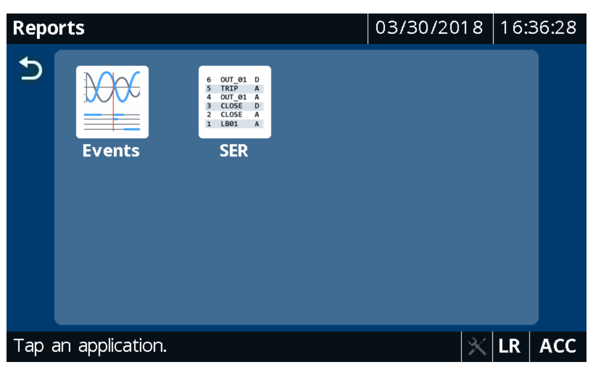


Figure 8.45 Reports Applications

Table 8.12 identifies all the applications available in the Reports folder.

Table 8.12 Reports Application Availability

Folder Name	Application Name	Comments
Reports	Events	Always available
	SER	Always available

To view the summary of a particular event record, tap the event record on the Event History screen. You can also trigger an event from the Event History screen by using the **Trigger Event** button. When new records become available while viewing any of the Reports screens (Events and SER), the up and down buttons are disabled and the footer displays a message to refresh the screen. Update the screen using the **Refresh** button. Tap the **Trash** button on the Event History and Sequential Events Recorder screens and confirm the delete action to remove the records from the relay. *Figure 8.46* through *Figure 8.48* show typical Event History, Event Summary, and Sequential Events Recorder screens.

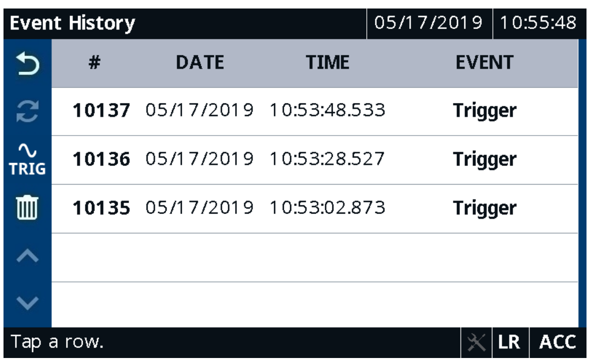


Figure 8.46 Event History

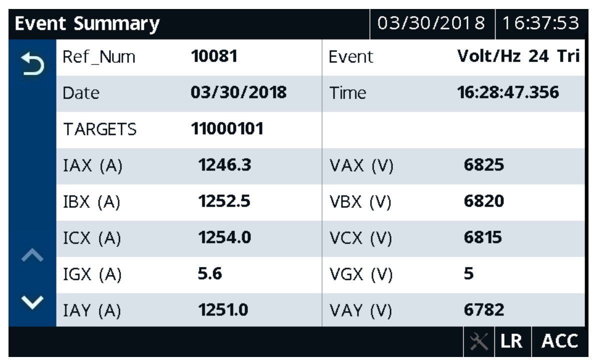


Figure 8.47 Event Summary

Figure 8.48 Sequential Events Recorder

Control

Tapping this folder navigates you to the Control screen, as shown in *Figure 8.49*. Use the Control folder applications Breaker Control, Output Pulsing, and Local Bits to perform breaker control operations, pulse output contacts, or control the local bits.

Breaker Control and Output Pulsing applications require that the breaker jumper be installed on the main board. Refer to *Password, Breaker Control, and SELBOOT Jumper Selection on page 2.19* for information on the breaker jumper.

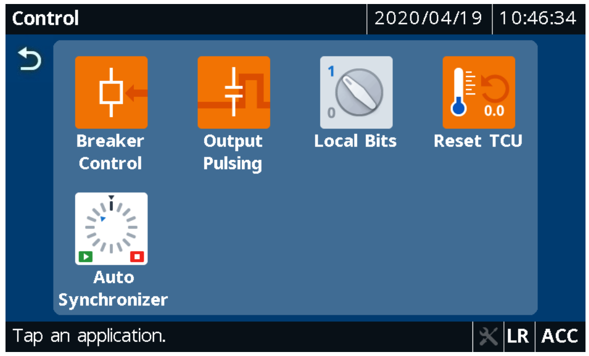


Figure 8.49 Control Applications

Table 8.13 identifies all the applications available in the Control folder.

Table 8.13 Control Application Availability

Folder Name	Application Name	Comments[a]
Control	Breaker Control	Always available
	Output Pulsing	Always available
	Local Bits	Always available
	Reset TCU	Available for SEL-700G0, SEL-700G0+, SEL-700G1, SEL-700G1+, or SEL-700GT models when setting E49T := Y
	Auto Synchronizer	Available for SEL-700G0+, SEL-700G1+, or SEL-700GT+ models

[a] Refer to the relay part number.

To perform breaker control, tap the **Breaker Control** application, select the breaker you want to control, and then tap and confirm the control action. Breaker control through the touchscreen is supervised by (1) the status of the LOCAL bit when EN_LRC := Y, (2) the position of the breaker jumper, and (3) the access level (requires 2AC). When EN_LRC := N, supervision through the LOCAL bit is ignored, while supervision through the breaker jumper and access level are maintained.

When local/remote supervision setting EN_LRC := Y and LOCAL := 0, the OC*n* and CC*n* (*n* = X or Y) bits are not processed from the touchscreen (i.e., breaker control through the touchscreen is blocked). *Figure 8.50* and *Figure 8.51* show typical breaker control screens. For the settings related to the local/remote control function, refer to *Local/Remote Control on page 9.7*.

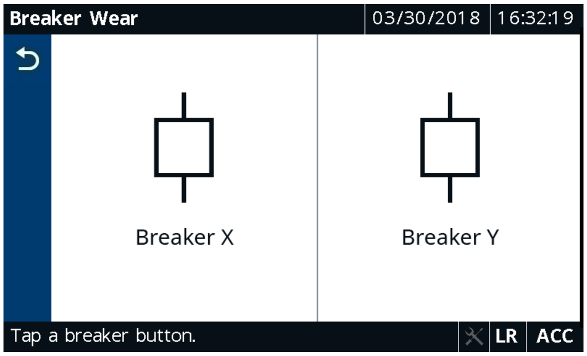


Figure 8.50 Breaker Control Selection

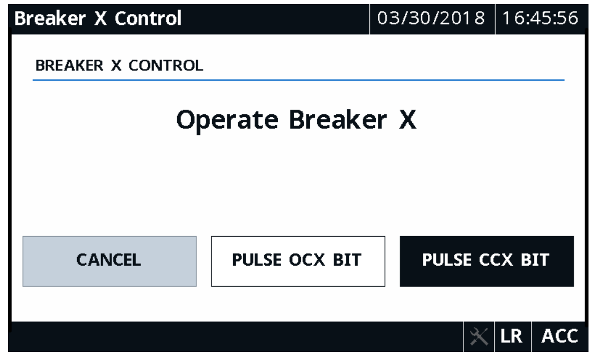


Figure 8.51 Breaker Control Operation

To pulse a digital output contact, tap the **Output Pulsing** application. Navigate to the desired output contact screen, tap the desired output, and confirm the control action. The output tile will be highlighted in blue on assertion, as shown in *Figure 8.52*. An output contact cannot be pulsed if it is already asserted. Pulsing the output contact requires that the breaker jumper be installed and that you have Level 2 access.

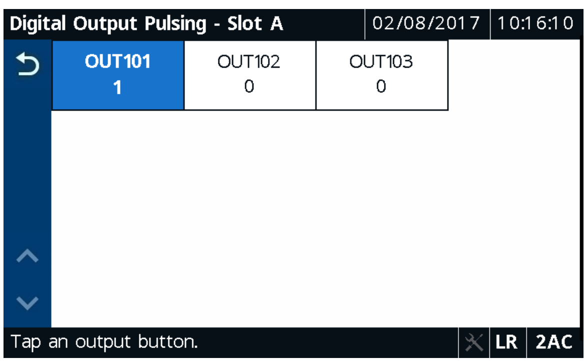


Figure 8.52 Digital Output Pulsing—Slot A

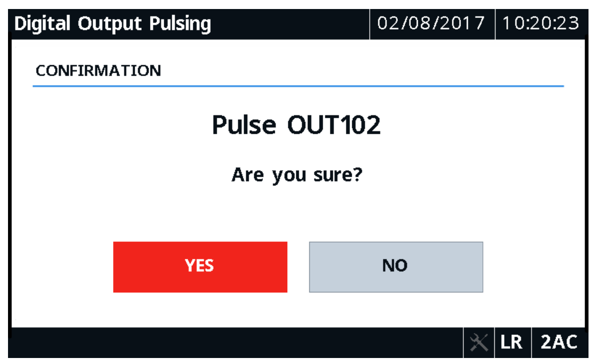


Figure 8.53 Digital Output Pulsing Confirmation

To control the local bits, tap the **Local Bits** application. You can control the desired local bit by tapping on the corresponding row. Depending on the state, tap and confirm the type of action you would like to perform. *Figure 8.54* through *Figure 8.56* show typical local bits control screens.

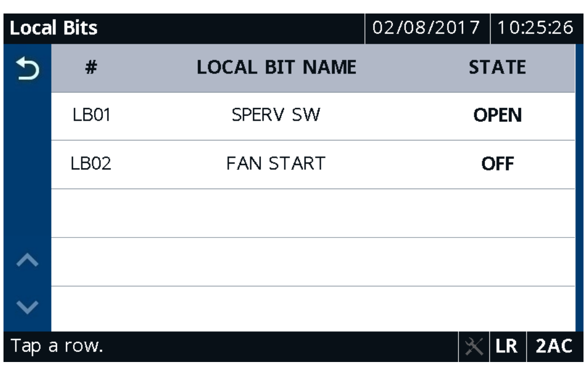


Figure 8.54 Local Bits

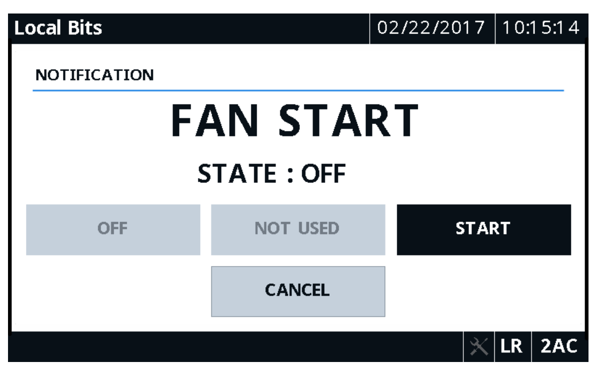


Figure 8.55 Local Bits Notification

Figure 8.56 Local Bits Confirmation

Tap the Reset TCU application to reset the accumulated generator TCU for SEL-700G0, G0+, G1, G1+, or GT+ models when thermal overload element is enabled, or E49T := Y. Note that generator TCU can be reset from the Thermal Meter application in Meter folder as well. *Figure 8.57*shows a typical Reset TCU screen.

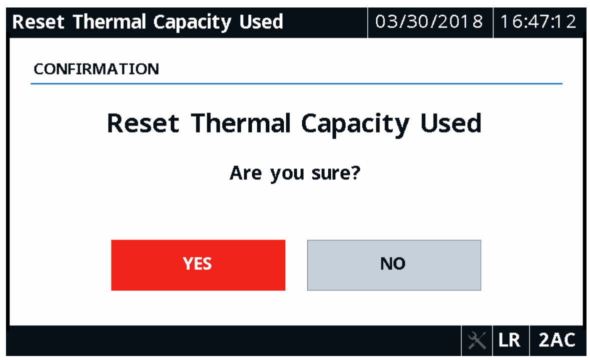


Figure 8.57 Reset TCU

Tap the **Auto Synchronizer** application to initiate and visualize synchronization of the generator to the system via the touchscreen display. The relay must be at Access Level 2 for this application. The synchroscope is available if setting E25X is set to Y and setting EAUTO is set to DIG. Configure the settings in *Table 4.53* and *Table 4.56* as needed for your application.

Figure 8.58 shows a typical screen before you start the autosynchronization process.

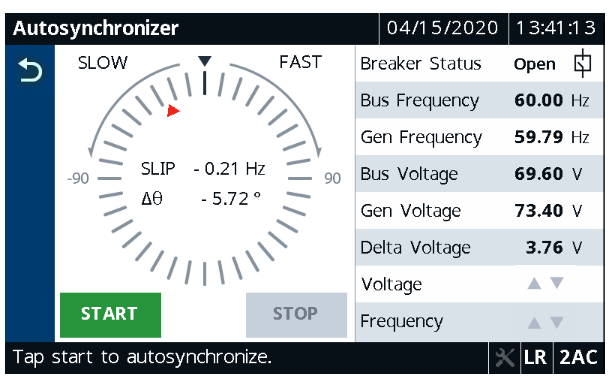


Figure 8.58 Auto Synchronizer

Tap the START button and confirm to start the autosynchronization process.

Autosynchronization can be started only if:

- 59VSX, FREQTRKX, and ZCFREQX are asserted.
- 52AX and TRIPX are deasserted.
- BSYNCHX, VSYNCACT, and FSYNACT are deasserted.

If one of the listed conditions is not true, you cannot start autosynchronization and the relay will display the notification screen shown in *Figure 8.59*.

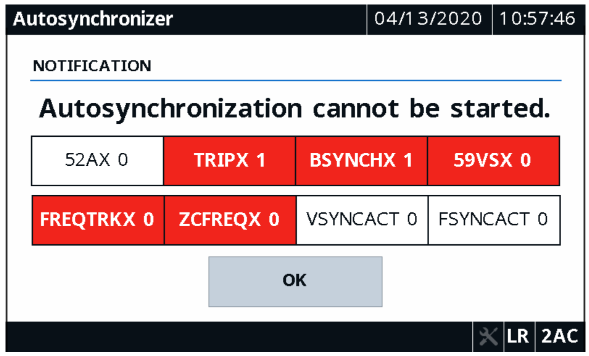


Figure 8.59 Auto Synchronizer Cannot Be Started

See *Figure 4.120* and *Figure 4.122* for logic details.

Throughout the autosynchronization process, you can see the phasor difference between the bus and the generator. The phasor rotation is displayed if the slip is less than 1.0 Hz. The bus and compensated generator voltages are displayed in secondary volts. The status of voltage raise/lower or frequency raise/lower outputs from the SEL-700G to the governor and exciter controllers of a generator can also be viewed on the display. The breaker status is also available on the display throughout the synchronization process, as shown in *Figure 8.60*.

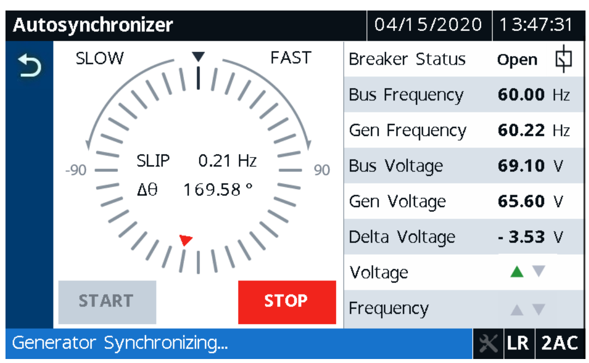


Figure 8.60 Generator Synchronizing

Autosynchronization can be stopped at any time during the synchronization process. Tap the STOP button and confirm to stop the autosynchronization process. If the synchronization process is aborted for conditions other than stop, the relay automatically displays the notification screen shown in *Figure 8.61*.

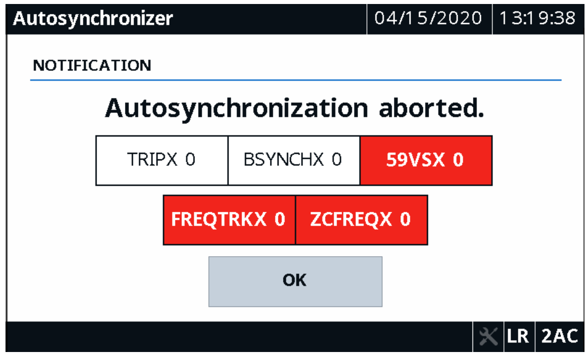


Figure 8.61 Autosynchronization Aborted

When autosynchronization is complete and the breaker is closed, the relay will display a figure similar to *Figure 8.62*.

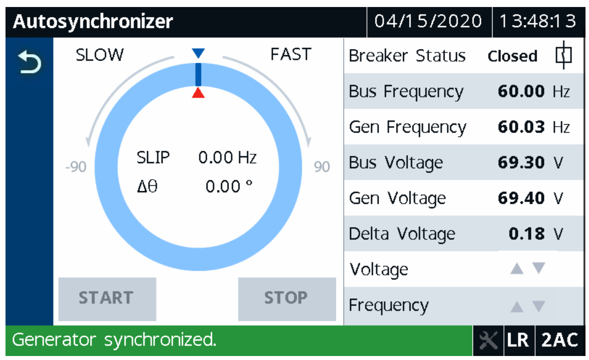


Figure 8.62 Generator Synchronized

Device Info

Tapping this folder navigates you to the Device Info screen where you can access specific device information applications (Status, Configuration, and Trip & Diag. Messages) and the Reboot application.

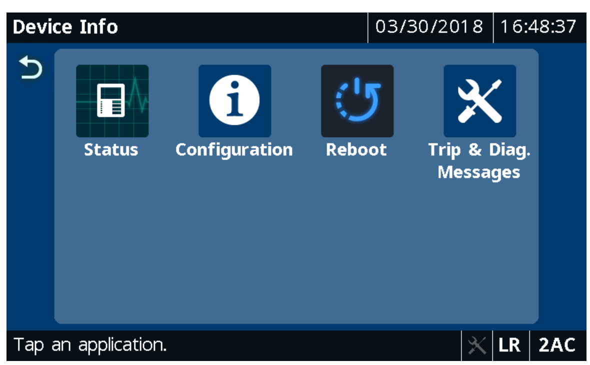


Figure 8.63 Device Info Applications

Table 8.14 identifies all the applications available in the **Device Info** folder.

Table 8.14 Device Info Application Availability

Folder Name	Application Name	Comments
Device Info	Status	Always available
	Configuration	Always available
	Reboot	Always available
	Trip & Diag. Messages	Always available

Tap the **Status** application to view the relay status, firmware version, part number, etc., as shown in *Figure 8.64*. Use the **Configuration** application to view port information, the jumper positions for the breaker, etc., as shown in *Figure 8.65*. If the relay detects any new card in one of the slots, it disables and directs you to accept the change in configuration, as shown in *Figure 8.66*. *Figure 8.64* through *Figure 8.66* show typical screens for device configuration, device status, and trip and diagnostic messages.

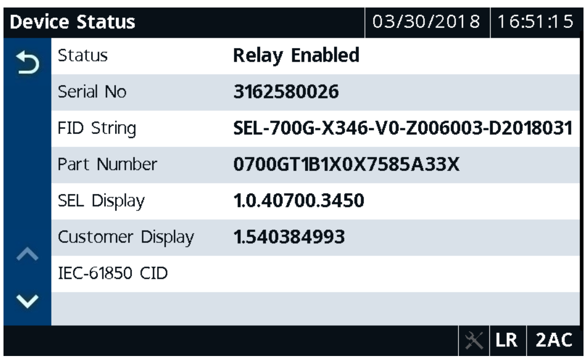


Figure 8.64 Device Status

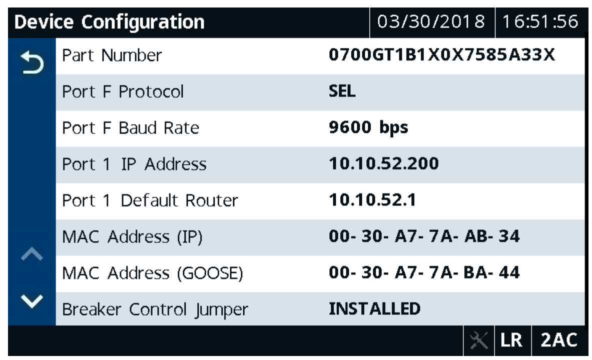


Figure 8.65 Device Configuration

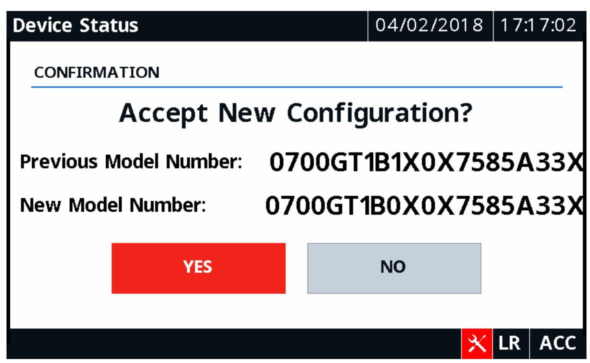


Figure 8.66 Model Number Confirmation

When a diagnostic failure, trip, or warning occurs, the relay displays the diagnostic message on the screen until it is either overridden by the restart of the rotating display or the inactivity timer expires. To view the trip and diagnostic messages, tap the **Trip & Diag. Messages** application in the Device Info folder.

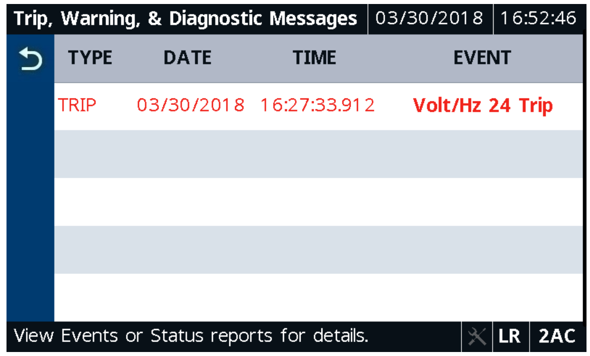


Figure 8.67 Trip and Diagnostic Messages

Access Level

Tapping this folder navigates you to the Access Level screen where you can either log in to or log out of the 2AC level.

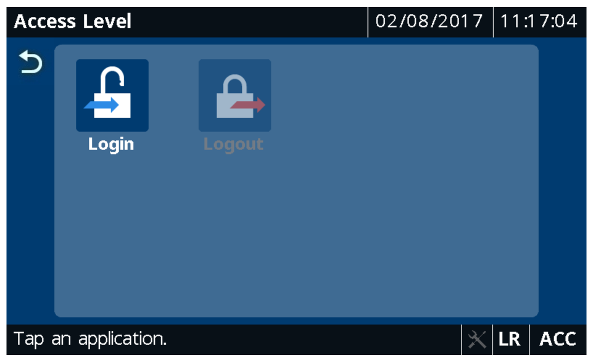


Figure 8.68 Access Level Applications

Table 8.15 identifies all of the applications available in the Access Level folder.

Table 8.15 Access Level Application Availability

Folder Name	Application Name	Comments
Access Level	Login	Always available
	Logout	Always available

Note that when an application requires the 2AC access level and the relay is at ACC, the relay automatically pops up the authentication screen requiring you to enter the password before performing a control operation, editing setting, etc.

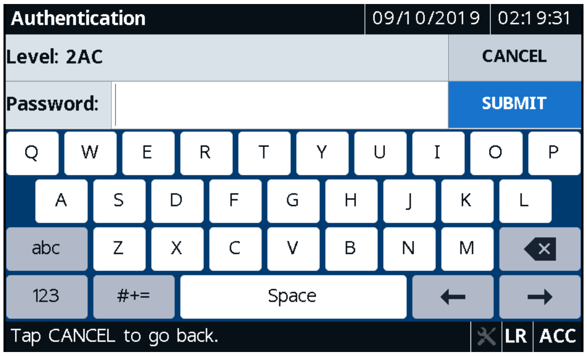


Figure 8.69 Authentication

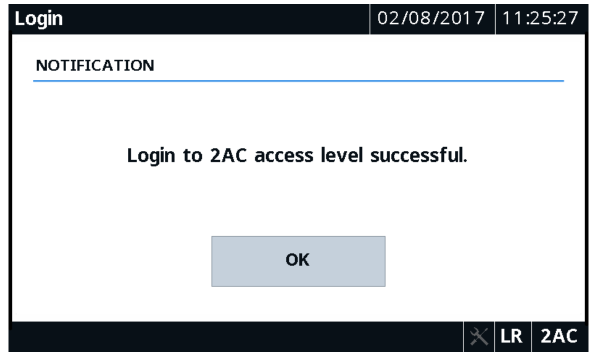


Figure 8.70 Login Confirmation

Settings

Tapping this folder navigates you to the Settings screen where you can access settings applications (Global, Touchscreen) or settings folders (Port, Group, Date and Time) through which you can set or show settings.

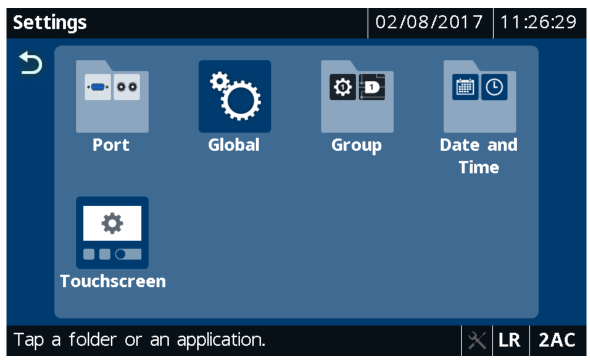


Figure 8.71 Settings Folders and Applications

Table 8.16 identifies all of the folders and applications available in the Settings folder.

Table 8.16 Settings Folder and Application Availability

Folder Name	Folder or Application Name	Comments
Settings	Port	Always available
	Global	Always available
	Group	Always available
	Date and Time	Always available
	Touchscreen	Always available

Table 8.17 identifies all the applications available in each folder (Port, Group, Date and Time) in the Settings folder.

Table 8.17 Settings Folders Port, Group, and Date and Time Application Availability

Folder Name	Application Name	Comments[a]
Port	Port F	Always available
	Port 1	Shown when Slot B ≠ *x*0*x* or *x*1*x*
	Port 2	Shown when E49RTD ≠ EXT
	Port 3	Always available
	Port 4	Shown when Slot C = A*x* or 0*x*, i.e., Slot C has a comms card or is empty
Group	Set 1	Always available
	Logic 1	Always available
	Set 2	Always available
	Logic 2	Always available
	Set 3	Always available
	Logic 3	Always available
	Set 4	Always available
	Logic 4	Always available
Date and Time	Date	Always available
	Time	Always available

[a] Refer to the relay part number.

Figure 8.72 and *Figure 8.73* show typical Port and Group Settings screens.

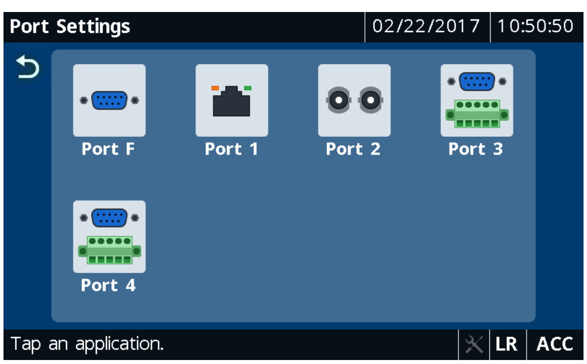


Figure 8.72 Port Settings

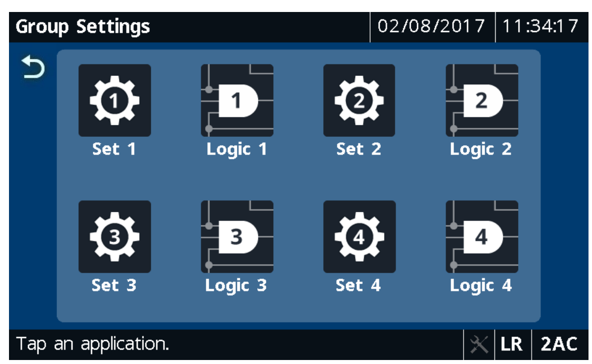


Figure 8.73 Group Settings

To edit a setting, tap on a setting row and enter the Access Level 2 password. If the access level is already at Level 2, the relay does not prompt for password authentication. After entering the value, tap the **Save** button to save your edit, or tap the **Cancel Save** button to cancel the edit (see *Table 8.8*). If the Save/Cancel Save buttons are not visible, tap the **Back** button until they appear. When editing a settings class (e.g., Set 1 in Group Settings), you cannot navigate to another class (e.g., Logic 1) without saving or discarding the settings change made in Set 1.

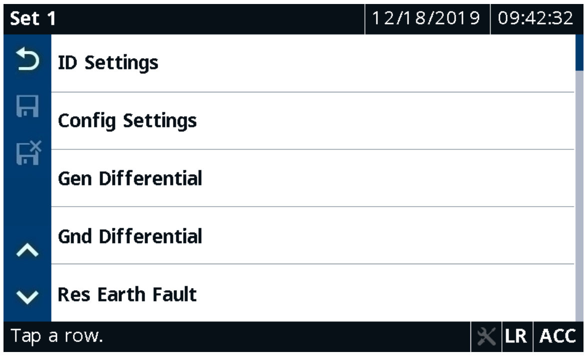


Figure 8.74 Set 1 Settings

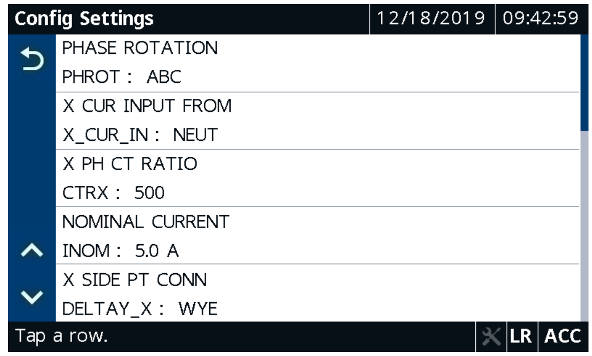


Figure 8.75 Configuration Settings

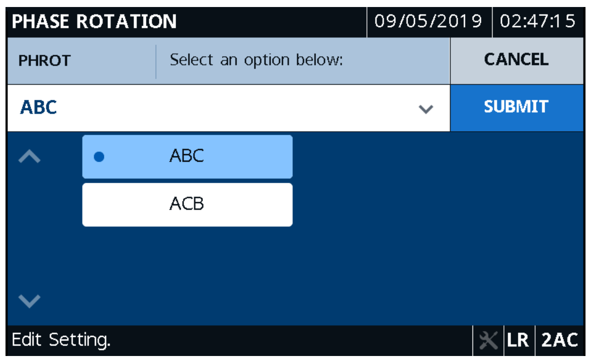


Figure 8.76 Set/Show Settings Edit

You can control the screen brightness, the screen inactivity timer settings, etc., through the Touchscreen application.

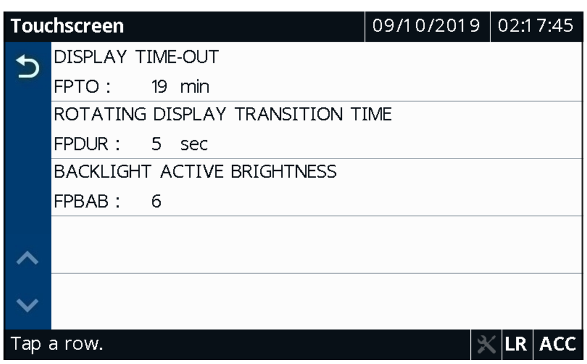


Figure 8.77 Touchscreen Settings

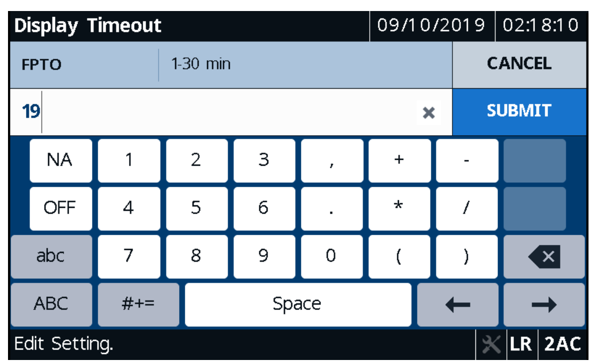


Figure 8.78 Touchscreen Settings Edit

Rotating Display

Tapping this application allows you to start the rotating display. You can pick as many as 16 screens through which the display can rotate after the inactivity timer expires. Refer to *Table 9.7* for the equivalent touchscreen display settings.

Tapping any screen while the display is rotating takes you to that particular screen. You can perform the needed operation and use the **Back** button to return to the Home screen.

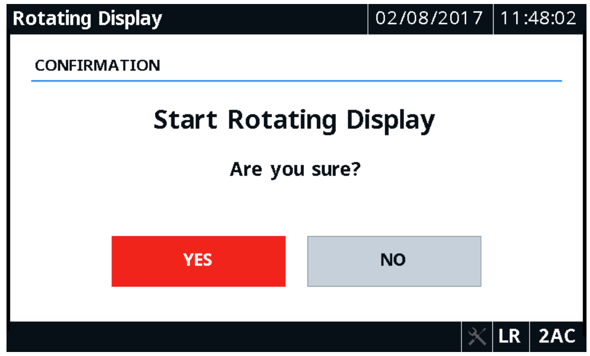


Figure 8.79 Rotating Display

Language Support

All of the HMI messages can be displayed in multiple languages (English or Spanish). The relay part number determines which language is displayed on the HMI. See the *SEL-700G Relay Command Summary* for a list of the commands.

Operation and Target LEDs

Programmable LEDs

The SEL-700G provides quick confirmation of relay conditions via operation and target LEDs. Refer to *Operation and Target LEDs on page 8.12* for details on the **ENABLED**, **TRIP**, programmable LEDs and their operation, and possible warning conditions on the relay.

TARGET RESET Pushbutton

Refer to *TARGET RESET Pushbutton on page 8.14* for the operation of the **TARGET RESET** pushbutton, the lamp test, and other target reset options.

Front-Panel Operator Control Pushbuttons

The SEL-700G touchscreen display features eight operator-controlled pushbuttons, each with two programmable tricolor pushbutton LEDs, for local control, as shown in *Table 8.4*. Refer to *Front-Panel Operator Control Pushbuttons on page 8.15* for details on operator control pushbuttons and LEDs and their programming.

You can use the front-panel operator control pushbuttons to jump to a specific screen while using them for LOCK/TRIP/CLOSE operations, etc. You can program the selectable operator pushbutton screen settings under the Touchscreen settings category in QuickSet and map the button to a specific screen. For example, PB04, which is used to trip a breaker by default, can be programmed to jump to a bay screen by mapping the pushbutton touchscreen setting FPPB04 to Bay Screen 1. When you press PB04, the display jumps to Bay Screen 1, where you can see a visual confirmation of the TRIP action.

Table 8.18 Screens Available for the Rotating Display, HOME Pushbutton[a], and Programmable Pushbuttons (Sheet 1 of 10)

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
Bay Screens				
		Bay Screen 1		Displays Bay Screen 1
		Bay Screen 2		Displays Bay Screen 2
		Bay Screen 3		Displays Bay Screen 3
		Bay Screen 4		Displays Bay Screen 4
		Bay Screen 5		Displays Bay Screen 5
Meter				
	Phasors			
		Phasor Screen 1	IAX_MAG, IAX_ANG, IBX_MAG, IBX_ANG, ICX_MAG, ICX_ANG, VABX_MAG, VABX_ANG, VBCX_MAG, VBCX_ANG, VCAX_MAG, VCAX_ANG	Shown when the model is G0 or G1 and DELTA_X = DELTA
		Phasor Screen 2	IAX_MAG, IAX_ANG, IBX_MAG, IBX_ANG, ICX_MAG, ICX_ANG, VAX_MAG, VAX_ANG, VBX_MAG, VBX_ANG, VCX_MAG, VCX_ANG	Shown when the model is G0 or G1 and DELTA_X = WYE
		Phasor Screen 3	IAX_MAG, IAX_ANG, IBX_MAG, IBX_ANG, ICX_MAG, ICX_ANG, VABX_MAG, VABX_ANG, VBCX_MAG, VBCX_ANG, VCAX_MAG, VCAX_ANG, VS_MAG, VS_ANG	Shown when the model is G0+, G1+, or GT+ and DELTA_X = DELTA
		Phasor Screen 4	IAX_MAG, IAX_ANG, IBX_MAG, IBX_ANG, ICX_MAG, ICX_ANG, VAX_MAG, VAX_ANG, VBX_MAG, VBX_ANG, VCX_MAG, VCX_ANG, VS_MAG, VS_ANG	Shown when the model is G0+, G1+, or GT+ and DELTA_X = WYE
		Phasor Screen 5	IAX_MAG, IAX_ANG, IBX_MAG, IBX_ANG, ICX_MAG, ICX_ANG, IAY_MAG, IAY_ANG, IBY_MAG, IBY_ANG, ICY_MAG, ICY_ANG	Shown when the model is G1, G1+, or GW
		Phasor Screen 6	IAY_MAG, IAY_ANG, IBY_MAG, IBY_ANG, ICY_MAG, ICY_ANG, VABY_MAG, VABY_ANG, VBCY_MAG, VBCY_ANG, VCAY_MAG, VCAY_ANG, VS_MAG, VS_ANG	Shown when the model is GT or GT+ and DELTAY_Y = DELTA

Table 8.18 Screens Available for the Rotating Display, HOME Pushbutton[a], and Programmable Pushbuttons (Sheet 2 of 10)

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
		Phasor Screen 7	IAY_MAG, IAY_ANG, IBY_MAG, IBY_ANG, ICY_MAG, ICY_ANG, VAY_MAG, VAY_ANG, VBY_MAG, VBY_ANG, VCY_MAG, VCY_ANG, VS_MAG, VS_ANG	Shown when the model is GT or GT+ and DELTAY_Y = WYE
	Fundamental			
		Fundamental Screen 1	IAX_MAG, IAX_ANG, IBX_MAG, IBX_ANG, ICX_MAG, ICX_ANG, FREQX, IGX_MAG, IGX_ANG, I1X_MAG, I1X_ANG, 3I2X_MAG, 3I2X_ANG	Shown when the model is GW
		Fundamental Screen 2	IAX_MAG, IAX_ANG, IBX_MAG, IBX_ANG, ICX_MAG, ICX_ANG, FREQX, VS_MAG (if available), VS_ANG (if available), FREQS (if available), VAB_MAG, VABX_ANG, VBCX_MAG, VBCX_ANG, VCAX_MAG, VCAX_ANG	Shown when the model is G0, G0+, or GT+ and DELTAY_X = DELTA VS and FREQS are shown when the model is G0+ or GT+
		Fundamental Screen 3	IN_MAG, IN_ANG, IGX_MAG, IGX_ANG, I1X_MAG, I1X_ANG, 3I2X_MAG, 3I2X_ANG, V1X_MAG, V1X_ANG, 3V2X_MAG, 3V2X_ANG, VHZX, VN_MAG (if available), VN_ANG (if available), VPX3_MAG (if available), VN3_MAG (if available), FLDRES (if available)	Shown when the model is G0, G0+, or GT+ and DELTAY_X = DELTA VN quantity is shown when the model is G0+ VPX3 quantity is shown when the model is G0+ and EXT3V0_X = VS VN3 quantity is shown when the model is G0+ and EXT3V0_X ≠ VN RF quantity is shown when E64F = Y
		Fundamental Screen 4	IAX_MAG, IAX_ANG, IBX_MAG, IBX_ANG, ICX_MAG, ICX_ANG, FREQX, VS_MAG (if available), VS_ANG (if available), FREQS (if available), VABX_MAG, VABX_ANG, VBCX_MAG, VBCX_ANG, VCAX_MAG, VCAX_ANG, VAX_MAG, VAX_ANG, VBX_MAG, VBX_ANG, VCX_MAG, VCX_ANG	Shown when the model is G0, G0+, or GT and DELTAY_X = WYE VS and FREQS quantities are shown when the model is G0+ or GT+

Table 8.18 Screens Available for the Rotating Display, HOME Pushbutton[a], and Programmable Pushbuttons (Sheet 3 of 10)

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
		Fundamental Screen 5	IN_MAG, IN_ANG, IGX_MAG, IGX_ANG, I1X_MAG, I1X_ANG, 3I2X_MAG,3I2X_ANG,VGX-_MAG, VGX_ANG, V1X_MAG, V1X_ANG, 3V2X_MAG, 3V2X_ANG, VHZX, VPX3_MAG (if available), VN3_MAG (if available), VN_MAG (if available), VN_ANG (if available), FLDRES (if available)	Shown when the model is G0, G0+, or GT+ and DELTAY_X = WYE VN quantity is shown when the model is G0+ VPX3 quantity is shown when the model is G0+ VN3 quantity is shown when the model is G0+ and EXT3V0_X ≠ VN] RF quantity is shown when E64F = Y
		Fundamental Screen 6	P3X, Q3X, S3X, PF3X, PFL_X	Shown when the model is G0, G0+, G1, G1+, or GT+
		Fundamental Screen 7	PAX, QAX, SAX, PFAX, PFAL_X, PBX, QBX, SBX, PFBX, PFBL_X, PCX, QCX, SCX, PFCX, PFCL_X	Shown when the model is G0, G0+, G1, G1+, or GT+ and DELTAY_X = WYE
		Fundamental Screen 8	IAY_MAG, IAY_ANG, IBY_MAG, IBY_ANG, ICY_MAG, ICY_ANG, FREQY, IGY_MAG, IGY_ANG, I1Y_MAG, I1Y_ANG, 3I2Y_MAG, 3I2Y_ANG, FLDRES (if available)	Shown when the model is GW RF quantity is shown when E64F = Y
		Fundamental Screen 9	IAY_MAG, IAY_ANG, IBY_MAG, IBY_ANG, ICY_MAG, ICY_ANG, FREQY, VS_MAG, VS_ANG, FREQS, VABY_MAG, VABY_ANG, VBCY_MAG, VBCY_ANG, VCAY_MAG, VCAY_ANG	Shown when the model is GT or GT+ and DELTAY_Y = DELTA
		Fundamental Screen 10	IN_MAG, IN_ANG, IGX_MAG, IGX_ANG, I1X_MAG, I1X_ANG, 3I2X_MAG, 3I2X_ANG, V1X_MAG, V1X_ANG, 3V2X_MAG, 3V2X_ANG	Shown when the model is GT or GT+ and DELTAY_Y = DELTA
		Fundamental Screen 11	IAY_MAG, IAY_ANG, IBY_MAG, IBY_ANG, ICY_MAG, ICY_ANG, FREQY, VS_MAG, VS_ANG, FREQS, VABY_MAG, VABY_ANG, VBCY_MAG, VBCY_ANG, VCAY_MAG, VCAY_ANG, VAY_MAG, VAY_ANG, VBY_MAG, VBY_ANG, VCY_MAG, VCY_ANG	Shown when the model is GT or GT+ and DELTAY_Y = WYE

Table 8.18 Screens Available for the Rotating Display, HOME Pushbutton[a], and Programmable Pushbuttons (Sheet 4 of 10)

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
		Fundamental Screen 12	IN_MAG, IN_ANG, IGY_MAG, IGY_ANG, I1Y_MAG, I1Y_ANG, 3I2Y_MAG,3I2Y_ANG, VGY_MAG, VGY_ANG, V1Y_MAG, V1Y_ANG, 3V2Y_MAG, 3V2Y_ANG	Shown when the model is GT or GT+ and DELTAY_Y = WYE
		Fundamental Screen 13	P3Y, Q3Y, S3Y, PF3Y, PFL_Y	Shown when the model is GT or GT+
		Fundamental Screen 14	PAY, QAY, SAY, PFAY, PFAL_Y, PBY, QBY, SBY, PFBY, PFBL_Y, PCY, QCY, SCY, PFCY, PFCL_Y	Shown when the model is GT or GT+ and DELTAY_Y = WYE
		Fundamental Screen 15	IAX_MAG, IAX_ANG, IBX_MAG, IBX_ANG, ICX_MAG, ICX_ANG, IAY_MAG, IAY_ANG, IBY_MAG, IBY_ANG, ICY_MAG, ICY_ANG, IN_MAG, IN_ANG, FREQX	Shown when the model is G1 or G1+
		Fundamental Screen 16	IGX_MAG, IGX_ANG, I1X_MAG, I1X_ANG, 3I2X_MAG, 3I2_ANG, IGY_MAG, IGY_ANG, I1Y_MAG, I1Y_ANG, 3I2Y_MAG, 3IY_ANG	Shown when the model is G1 or G1+
		Fundamental Screen 17	VABX_MAG,VABX_ANG, VBCX_MAG,VBCX_ANG, VCX_MAG, VCX_ANG, V1X_MAG, V1X_ANG, 3V2X_MAG,3V2X_ANG, VHZX, FLDRES (if available)	Shown when the model is G1 or G1+ and DELTAY_X = DELTA RF quantity is shown when E64F = Y
		Fundamental Screen 18	VAX_MAG, VAX_ANG, VBX_MAG, VBX_ANG, VCX_MAG, VCX_ANG, VABX_MAG,VABX_ANG, VBCX_MAG,VBCX_ANG, VCX_MAG, VCX_ANG, VGX_MAG,VGX_ANG, V1X_MAG, V1X_ANG, 3V2X_MAG,3V2X_ANG, VHZX, FLDRES (if available)	Shown when the model is G1 or G1+ and DELTAY_X=WYE RF quantity is shown when E64F = Y
		Fundamental Screen 19	VS_MAG, VS_ANG, FREQS, VN_MAG, VN_ANG, VN3_MAG, VPX3_MAG	Shown when the model is G1+ VPX3 quantity is shown only when DELTAY_X = WYE or when DELTAY_X = DELTA and EXT3V0_X = VS VN3 quantity is shown only when EXT3V0_X ≠ VN

Table 8.18 Screens Available for the Rotating Display, HOME Pushbutton[a], and Programmable Pushbuttons (Sheet 5 of 10)

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
	RMS			
		RMS Screen 1	IAXRMS, IBXRMS, ICXRMS, IAYRMS, IBYRMS, ICYRMS	Shown when the model is G1, G1+, or GW
		RMS Screen 2	IAXRMS, IBXRMS, ICXRMS, INRMS, VABXRMS,VBCXRMS, VCAXRMS, VSRMS (if available)	Shown when the model is G0, G0+, G1, G1+, or GT+ and DELTAY_X = DELTA VS quantity is shown when the model is G0+, G1+, GT+
		RMS Screen 3	IAXRMS, IBXRMS, ICXRMS, INRMS, VAXRMS, VBXRMS, VCXRMS, VSRMS (if available)	Shown when the model is G0, G0+, G1, G1+, or GT+ and DELTAY_X = WYE VS quantity is shown when the model is G0+, G1+, GT+
		RMS Screen 4	IAYRMS, IBYRMS, ICYRMS, INRMS, VABYRMS, VBCYRMS, VCAYRMS,VSRMS	Shown when the model is GT or GT+ and DELTAY_Y = DELTA
		RMS Screen 5	IAYRMS, IBYRMS, ICYRMS, INRMS, VAYRMS, VBYRMS, VCYRMS, VSRMS	Shown when the model is GT or GT+ and DELTAY_Y = WYE
	Energy			
		Energy Screen 1	MWHPX, MWHNX, MVARHPX, MVARHNX, EM_LRD	Shown when the model is G0, G0+, G1, G1+, or GT+
		Energy Screen 2	MWHPY, MWHNY, MVARHPY, MVARHNY, EM_LRD	Shown when the model is GT or GT+
		Energy Reset Screen	Reset energy data	

Table 8.18 Screens Available for the Rotating Display, HOME Pushbutton[a], and Programmable Pushbuttons (Sheet 6 of 10)

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
	Max/Min			
		Max/Min Screen 1	IAXMX, IAXMN, IBXMX, IBXMN, ICXMX, ICXMN, IGXMX, IGXMN, IAYMX, IAYMN, IBYMX, IBYMN, ICYMX, ICYMN, IGYMX, IGYMN, INMX, INMN,VABXMX, VABXMN, VBCXMX, VBCXMN, VCAXMX, VCAXMN, VAXMX, VAXMN, VBXMX, VBXMN, VCXMX, VCXMN, VABYMX, VABYMN, VBCYMX, VBCYMN, VCAYMX, VCAYMN, VAYMX, VAYMN, VBYMX, VBYMN, VCYMX, VCYMN, VSMX, VSMN, VNMX, VNMN, VN3MX, VN3MN, VP3MX, VP3MN, KVA3XMX, KVA3XMN, KW3XMX, KW3XMN, KVAR3XMX, KVAR3XMN, FREQXMX, FREQXMN, KVA3YMX, KVA3YMN, KW3YMX, KW3YMN, KVAR3YMX, KVAR3YMN, FREQYMX, FREQYMN, RTD1MX–RTD12MX, RTD1MN–RTD12MN, AI301MX–AI304MX, AI301MN–AI304MN, AI401MX–AI404MX, AI401MN–AI404MN, AI501MX–AI504MX, AI501MN–AI504MN, Last Reset Date and Time	X-side and Y-side currents, voltages, RTD, and analog inputs are available only when the part number supports them
		Max/Min Reset Screen	Reset max/min data	Always available
	Differential			
		Differential Metering Screen 1	IOP1, IOP2, IOP3, IRT1, IRT2, IRT3, IOP1F2, IOP2F2, IOP3F2, IOP1F4, IOP2F4, IOP3F4, IOP1F5, IOP2F5, IOP3F5	Shown when the model is G1 or G1+
	Harmonics			
		Harmonic Metering Screen 1	IAX_MAG, IBX_MAG, ICX_MAG (FUND, 2ND, 3RD, 4TH, 5TH) IAX_THD, IBX_THD, ICX_THD, IAY_MAG, IBY_MAG, ICY_MAG (FUND, 2ND, 3RD, 4TH, 5TH) IAY_THD, IBY_THD, ICY_THD	Shown when the model is G1 or G1+

Table 8.18 Screens Available for the Rotating Display, HOME Pushbutton[a], and Programmable Pushbuttons (Sheet 7 of 10)

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
	Demand			
		Demand Screen 1	IAXD, IBXD, ICXD, IGXD, 3I2XD, DM_LRD	Shown when the model is G0, G0+, G1, G1+, GT+, or GW
		Demand Screen 2	IAYD, IBYD, ICYD, IGYD, 3I2YD, DM_LRD	Shown when the model is GT, GT+, or GW
		Demand Reset Screen	Reset demand data	Always available
	Peak Demand			
		Peak Demand Screen 1	IAXPD, IBXPD, ICXPD, IGXPD, 3I2XPD, PM_LRD	Shown when the model is G0, G0+, G1, G1+, GT+, or GW
		Peak Demand Screen 2	IAYPD, IBYPD, ICYPD, IGYPD, 3I2YPD, PM_LRD	Shown when the model is GT, GT+, or GW
		Peak Demand Reset Screen	Reset peak demand data	Always available
	Analog Inputs			
		Analog Inputs Screen 1	AI301–AI304, AI401–AI404, AI501–AI504	Available if the relay supports analog inputs
	Thermal			
		Thermal Screen 1	RTDWDGMX, RTDBRGMX, RTDAMB, RTDOTHMX, TCUGEN, TCURTD	E49T ≠ N or E49RTD ≠ NONE
		Thermal Screen 2	RTD1– RTD12	Shown when E49RTD ≠ NONE
	Math Variables			
		Math Variables Screen 1	MV01–MV32	Shown when EMV ≠ N Shows 12 math variables per page
	Remote Analogs			
		Remote Analogs Screen 1	RA001–RA012	Always available
		Remote Analogs Screen 2	RA013–RA024	Always available
		Remote Analogs Screen 3	RA025–RA036	Always available
		Remote Analogs Screen 4	RA037–RA048	Always available
		Remote Analogs Screen 5	RA049–RA060	Always available
		Remote Analogs Screen 6	RA061–RA072	Always available
		Remote Analogs Screen 7	RA073–RA084	Always available
		Remote Analogs Screen 8	RA085–RA096	Always available
		Remote Analogs Screen 9	RA097–RA108	Always available
		Remote Analogs Screen 10	RA109–RA120	Always available
		Remote Analogs Screen 11	RA121–RA128	Always available

Table 8.18 Screens Available for the Rotating Display, HOME Pushbutton[a], and Programmable Pushbuttons (Sheet 8 of 10)

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
Monitor				
	Relay Word Bits			
		Relay Word Bits Screen 1	Shows status of all the relay word bits	Shows 32 Relay Word bits per page
	Digital Inputs			
		Digital Inputs Screen 1	IN101, IN102	Slot A inputs (always available)
		Digital Inputs Screen 2	IN301, IN302, IN303, IN304	Shown when Slot C= Dx, 1x, or Cx
		Digital Inputs Screen 3	IN301, IN302, IN303	Shown when Slot C = Bx
		Digital Inputs Screen 4	IN301, IN302, IN303, IN304, IN305, IN306, IN307, IN308	Shown when Slot C = 3x
		Digital Inputs Screen 5	IN301, IN302, IN303, IN304, IN305, IN306, IN307, IN308, IN309, IN310, IN311, IN312, IN313, IN314	Shown when Slot C = 4x
		Digital Inputs Screen 6	IN401, IN402, IN403, IN404	Shown when Slot D = Dx, 1x, or Cx
		Digital Inputs Screen 7	IN401, IN402, IN403	Shown when Slot D = Bx
		Digital Inputs Screen 8	IN401, IN402, IN403, IN404, IN405, IN406, IN407, IN408	Shown when Slot D = 3x
		Digital Inputs Screen 9	IN401, IN402, IN403, IN404, IN405, IN406, IN407, IN408, IN409, IN410, IN411, IN412, IN413, IN414	Shown when Slot D = 4x
		Digital Inputs Screen 10	IN501, IN502, IN503, IN504	Shown when Slot E = Dx, 1x, or Cx
		Digital Inputs Screen 11	IN501, IN502, IN503	Shown when Slot E = Bx
		Digital Inputs Screen 12	IN501, IN502, IN503, IN504, IN505, IN506, IN507, IN508	Shown when Slot E = 3x
		Digital Inputs Screen 13	IN501, IN502, IN503, IN504, IN505, IN506, IN507, IN508, IN509, IN510, IN511, IN512, IN513, IN514	Shown when Slot E = 4x
	Digital Outputs			
		Digital Outputs Screen 1	OUT101, OUT102, OUT103	Slot A outputs (always available)
		Digital Outputs Screen 2	OUT301, OUT302, OUT303, OUT304	Shown when Slot C = Bx, 1x, or Cx
		Digital Outputs Screen 3	OUT301, OUT302, OUT303	Shown when Slot C = Dx
		Digital Outputs Screen 4	OUT301, OUT302, OUT303, OUT304, OUT305, OUT306, OUT307, OUT308	Shown when Slot C = 2x
		Digital Outputs Screen 5	OUT401, OUT402, OUT403, OUT404	Shown when Slot D = Bx, 1x, or Cx
		Digital Outputs Screen 6	OUT401, OUT402, OUT403	Shown when Slot D = Dx

Table 8.18 Screens Available for the Rotating Display, HOME Pushbutton[a], and Programmable Pushbuttons (Sheet 9 of 10)

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
		Digital Outputs Screen 7	OUT401, OUT402, OUT403, OUT404, OUT405, OUT406, OUT407, OUT408	Shown when Slot D = 2x
		Digital Outputs Screen 8	OUT501, OUT502, OUT503, OUT504	Shown when Slot E = Bx, 1x, or Cx
		Digital Outputs Screen 9	OUT501, OUT502, OUT503	Shown when Slot E = Dx
		Digital Outputs Screen 10	OUT501, OUT502, OUT503, OUT504, OUT505, OUT506, OUT507, OUT508	Shown when Slot E = 2x
	SELogic Counters			
		SELogic Counters Screen 1	SC01–SC32	Shown when ESC ≠ N Shows 12 SELogic counters per page
	Breaker Wear			
		Breaker Wear Screen 1	INTTX, EXTTX, INTIAX, INTIBX, INTICX, EXTIAX, EXTIBX, EXTICX	Shown when EBMONX = Y
		Breaker Wear Screen 2	WEARAX, WEARBX, and WEARCX, BR1_LRD	Shown when EBMONX = Y
		Breaker Wear Screen 3	INTTY, EXTTY, INTIAY, INTIBY, INTICY, EXTIAY, EXTIBY, EXTICY	Shown when EBMONY = Y
		Breaker Wear Screen 4	WEARAY, WEARBY, WEARCY, BR2_LRD	Shown when EBMONY = Y
	Synchroscope			
		Synchroscope Screen 1	X-side synchroscope screen that displays graphical representation of the phasor difference between the bus and the generator.	Shown for SEL-700G0+, SEL-700G1+, or SEL-700GT+ models and E25X = Y.
		Synchroscope Screen 2	Y-side synchroscope screen that displays graphical representation of the phasor difference between the bus and the tie.	Shown for SEL-700GT or SEL-700GT+ models and E25Y = Y.
Reports				
	Events			
		Event History Screen 1		Shows the event records in the relay
	SER			
		SER Screen 1		Shows the Sequential Event Recorder (SERs) in the relay

Table 8.18 Screens Available for the Rotating Display, HOME Pushbutton[a], and Programmable Pushbuttons (Sheet 10 of 10)

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
Device Info				
	Status			
		Status Screen 1	Status, serial number, FID string, part number, SEL display, customer display, IEC 61850 CID	Always available
		Status Screen 2	Diagnostic status for the relay cards and power supply rails. CARD_C, CARD_D, CARD_E, CARD_Z, FPGA, GPSB, HMI, RAM, ROM, CR_RAM, NON_VOL, CLOCK, RTD, CID_FILE, +0.9V CHK (V), +1.2V CHK (V), +1.5V CHK (V), +1.8V CHK (V), +2.5V CHK (V), +3.3V CHK (V), +3.75V CHK (V), +5.0V CHK (V), –1.25V CHK (V), –5.0V CHK (V), BATT CHK (V)	Always available
		Status Screen 3	DN_MAC_ID, ASA, DN_RATE, DN_STATUS	Shown if the DeviceNet option is available
		Status Screen 4	OFFSETS: IAX, IBX, ICX, IN, VAX, VBX, VCX, IAY, IBY, ICY, VAY, VBY, VCY, VS	Analog input DC offsets are part number dependent
	Configuration			
		Configuration Screen 1	Part number, Port F protocol, Port F baud rate, Port 1 IP address, Port 1 default router, MAC address (IP), MAC address (GOOSE), breaker control jumper, password bypass jumper, rated frequency, phase rotation, nominal phase CTRX rating, nominal phase CTRY rating, nominal neutral CT rating, PTRX connection, PTRY connection, date format	Some of the quantities are part number dependent and will be hidden if the part number does not support them
	Trip & Diag. Messages			
		Trip and Diagnostic Screen 1	Diagnostic failures, trip event types, and warnings	Always available

[a] In addition to the listed screens, the Home screen is available for the HOME pushbutton. By default, the HOME pushbutton is programmed to the Home screen.

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Section 9
Bay Control

Overview

The SEL-700G Relay with the touchscreen display option provides you with the ability to design bay configuration screens to meet your system needs. The bay configuration can be displayed as a single-line diagram (SLD) on the touchscreen. You can create as many as five bay screens with two controllable breakers, as many as eight two-position disconnects, and as many as two three-position disconnects. ANSI and IEC symbols, along with analog and digital labels, are available for you to create detailed single-line diagrams of the bay to indicate the status of the breaker and disconnects, bus voltages, and power flow through the breaker. In addition to single-line diagrams, you can design the screens to show the status of various relay elements via Relay Word bits or to show analog quantities for commissioning or day-to-day operations. These screens can be designed with the help of ACSELERATOR Bay Screen Builder SEL-5036 Software in conjunction with ACSELERATOR QuickSet SEL-5030 Software. Note that the bay screen related settings can only be set via QuickSet (setting via an ASCII terminal is not supported).

This section covers all aspects of the SEL-700G bay control.

Circuit Breaker Symbol Settings and Status Logic

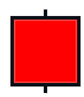
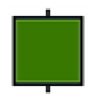
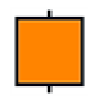
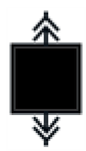
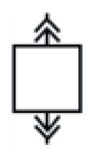
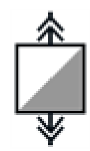
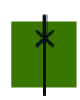
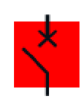
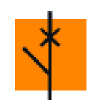
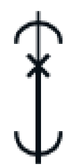
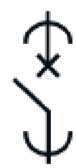
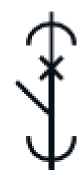
The SEL-700G supports two breakers that can be controlled and monitored via the bay screen. Use the SELOGIC settings 52A*m* and 52B*m* (*m* = X, Y) to map the respective breaker auxiliary contacts to the relay. Because the 52B*m* contact is not always available in all applications, the breaker status logic does not include the 52B*m* contact. The relay uses the 52A*m* Relay Word bit as the status of the breaker in conjunction with the protection elements and trip and close logic. The default setting for 52B*m* is NOT 52A*m*. Map 52A*m* and 52B*m* Relay Word bits to the settings associated with the breaker symbol under the Bay Control settings in QuickSet to display the status of the breaker on the bay screen.

Use SELOGIC to create dual-point status of the breaker with breaker alarm indication. Refer to *Table 9.7* for the Bay Control breaker settings. Refer to *Bay Control Application Example on page 9.19* for example settings. Refer to *Table 4.61* and *52A and 52B Breaker Status Conditions SELOGIC Control*

Equations on page 4.206 for 52A*m* and 52B*m* settings and descriptions. Refer to *Trip/Close Logic Settings on page 4.201* for more information on the breaker trip and close logic.

Table 9.1 provides typical ANSI and IEC breaker symbols that are supported by Bay Screen Builder. Column 1 identifies the standard (ANSI/IEC) and the type of breaker. Columns 3, 4, and 5 identify closed, open, and alarm states of the breaker image, respectively. Bay Screen Builder allows you to set the breaker color sequence property (identified in Column 2) for each of these states. Select the breaker color sequence based on your system convention. For a complete list of ANSI and IEC circuit breaker symbols available to use with the bay screens, refer to the *ACSELERATOR Bay Screen Builder SEL-5036 Software Instruction Manual*, available in the **Help** > **Contents** menu of Bay Screen Builder.

Table 9.1 Circuit Breaker Symbols

Type	Breaker Color Sequence	State 1 (Closed)	State 2 (Open)	State 3 (Alarm)
ANSI Breaker	Red, Green, Amber			
ANSI Truck Operated Breaker	Black, White, Grey			
IEC Breaker	Green, Red, Amber			
IEC Truck Operated Breaker	Transparent			

Disconnect Control Settings

The SEL-700G supports control of as many as eight two-position and two three-position disconnects. Refer to *Table 9.2* and *Table 9.3* for the two- and three-position disconnect settings. The following description applies to both the two- and three-position disconnects enabled by the 89EN2P and 89EN3P settings. Generic setting names are used in the following description for simplicity. For example, the label setting for two-position Switch 1 (89NM2P1) is represented by 89NM*km*, where *k* is the disconnect type (2P, 3PL, or 3PE) and *m* is the disconnect number (*m* = 1–8 if *k* = 2P and *m* = 1–2 if *k* = 3PL or 3PE).

Use the 89NM*km* setting to name the disconnect using a maximum of sixteen characters. The 89A*km* and 89B*km* SELOGIC control equation settings represent the normally open and normally closed disconnect auxiliary contacts. Typically, these SELOGIC control equation settings are set to SEL-700G inputs that are wired to the corresponding auxiliary contacts. *Figure 9.1* shows the dual-point disconnect status logic. The Relay Word bits 89CL*km* and 89OP*km* indicate whether the disconnect is in a fully closed or fully open state, respectively. 89AL*km* indicates the alarm status of the disconnect and asserts when the disconnect is in an undetermined state for longer than the 89A*km*D time setting. The 89AL*km* alarm bit also asserts if the switch fails to start close or open operation after a successful command is issued. Set the 89A*km*D timer longer than the highest expected operation time (undetermined state).

Table 9.2 Two-Position Disconnect Settings[a]

Setting Prompt	Setting Range	Setting Name := Factory Default
EN 2P DISC	N, 1–8	89EN2P := 8
Disconnect m		
2P DISC *m* NAME	16 characters	89NM2P*m* := 2P*m*
DIS *m* N/O CONT	SELOGIC	89A2P*m* := 0
DIS *m* N/C CONT	SELOGIC	89B2P*m* := NOT 89A2P*m*
DIS *m* ALM PU	0.00–300.00 sec	89A2P*m*D := 5.00
DIS *m* SEALIN	OFF, 0.00–300.00 sec	89S2P*m*D := 4.67
DIS *m* IMMOBI	OFF, 0.00–300.00 sec	89I2P*m*D := 0.33
DIS *m* CL CONT	SELOGIC	89RC2P*m* := 89CC2P*m*
DIS *m* CL BLK	SELOGIC	89CB2P*m* := 89AL2P*m*
DIS *m* CL RST	SELOGIC	89CR2P*m* := 89CL2P*m* OR 89CS2P*m* OR 89 ALP2*m*
DIS *m* CL IM RS	SELOGIC	89CT2P*m* := NOT 89OP2P*m*
DIS *m* OP CONT	SELOGIC	89RO2P*m* := 89OCP*m*
DIS *m* OP BLK	SELOGIC	89OB2P*m* := 89AL2P*m*
DIS *m* OP RST	SELOGIC	89OR2P*m* := 89OP2P*m* OR 89OS2P*m* OR 89AL2P*m*
DIS *m* OP IM RS	SELOGIC	89OT2P*m* := NOT 89CL2P *m*

[a] m = 1–8.

Table 9.3 Three-Position Disconnect Settings[a] (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
EN 3P DISC	N, 1–2	89EN3P := N
Disconnect m		
3P DISC *m* NAME	16 characters	89NM3P*m* := 3P*m*
In-Line Disconnect		
LDIS *m* N/O CONT	SELOGIC	89A3PL*m* := 0
LDIS *m* N/C CONT	SELOGIC	89B3PL*m* := NOT 89A3PL*m*
LDIS *m* ALM PU	0.00–300.00 sec	89A3PL*m*D := 5.00
LDIS *m* SEALIN	OFF, 0.00–300.00 sec	89S3PL*m*D := 4.67
LDIS *m* IMMOBI	OFF, 0.00–300.00 sec	89I3PL*m*D := 0.33
LDIS *m* CL CONT	SELOGIC	89RC3PL*m* := 89CC3PL*m*
LDIS *m* CL BLK	SELOGIC	89CB3PL*m* := 89CL3PE*m* OR 89AL3PL*m* OR 89 AL3PE*m*

Table 9.3 Three-Position Disconnect Settings[a] (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
LDIS *m* CL RST	SELOGIC	89CR3PL*m* := 89CL3PL*m* OR 89CS3PL*m* OR 89AL3PL*m*
LDIS *m* CL IM RS	SELOGIC	89CT3PL*m* := NOT 89OP3PL*m*
LDIS *m* OP CONT	SELOGIC	89RO3PL*m* := 89OC3PL*m*
LDIS *m* OP BLK	SELOGIC	89OB3PL*m* := 89CL3PE*m* OR 89AL3PL*m* OR 89AL3PE*m*
LDIS *m* OP RST	SELOGIC	89OR3PL*m* := 89OP3PL*m* OR 89OS3PL*m* OR 89AL3PL*m*
LDIS *m* OP IM RS	SELOGIC	89OT3PL*m* := NOT 89CL3PL*m*
Earthing Disconnect		
EDIS *m* N/O CONT	SELOGIC	89A3P*m* := 0
EDIS *m* N/C CONT	SELOGIC	89B3P*m* := NOT 89A3PE*m*
EDIS *m* ALM PU	0.00–300.00 sec	89A3PE*m*D := 5.00
EDIS *m* SEALIN	OFF, 0.00–300.00 sec	89S3PE*m*D := 4.67
EDIS *m* IMMOBI	OFF, 0.00–300.00 sec	89I3PE*m*D := 0.33
EDIS *m* CL CONT	SELOGIC	89RC3PE*m* := 89CC3PE*m*
EDIS *m* CL BLK	SELOGIC	89CB3PE*m* := 89CL3PL*m* OR 89AL3PL*m* OR 89AL3PE*m*
EDIS *m* CL RST	SELOGIC	89CR3PE*m* := 89CL3PE*m* OR 89CS3PE*m* OR 89AL3PE*m*
EDIS *m* CL IM RS	SELOGIC	89CT3PE*m* := NOT 89OP3PE*m*
EDIS *m* OP CONT	SELOGIC	89RO3PE*m* := 89OC3PE*m*
EDIS *m* OP BLK	SELOGIC	89OB3PE*m* := 89CL3PL*m* OR 89AL3PL*m* OR 89AL3PE*m*
EDIS *m* OP RST	SELOGIC	89OR3PE*m* := 89OP3PE*m* OR 89OS3PE*m* OR 89AL3PE*m*
EDIS *m* OP IM RS	SELOGIC	89OT3PE*m* := NOT 89CE3PL*m*

[a] m = 1–2.

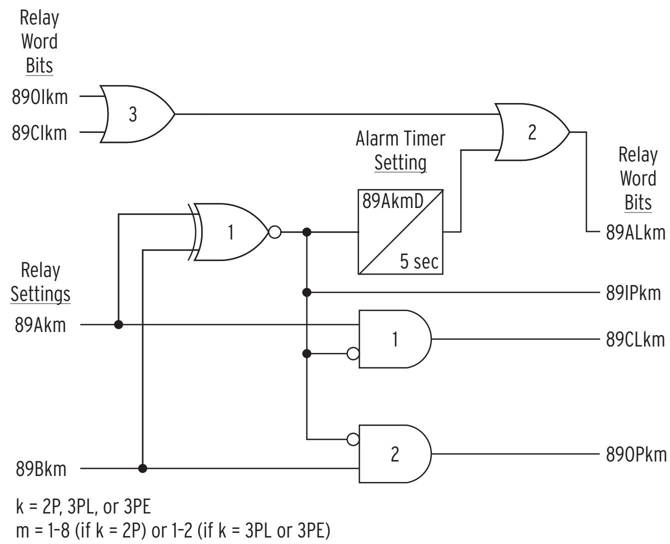


Figure 9.1 Dual-Point Disconnect Status Logic

The close and open logic shown in *Figure 9.2* and *Figure 9.3* are primarily for control of motor operated disconnects. The settings and control described below are not intended for manually operated disconnects and can be ignored. The description of close and open control logic applies to all two- and three-position motor operate disconnects that are enabled.

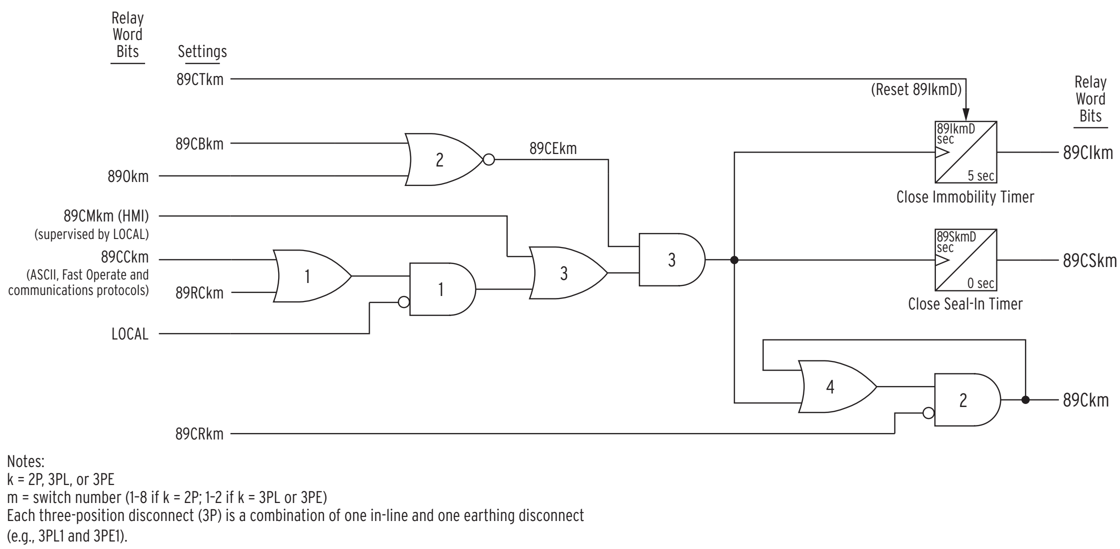


Figure 9.2 Disconnect Close Logic

Close control action of a disconnect can be initiated via the front-panel HMI Bay Screen application (Relay Word bit 89CM*km*) or remotely (i.e., via communications protocols [Relay Word bit 89CC*km*] or the SELOGIC control equation setting [89RC*km*]). Close control from the HMI requires that local control be enabled (Relay Word bit LOCAL asserted). When Relay Word bit LOCAL is asserted, remote close control is blocked. Use the 89CB*km* SELOGIC control equation setting to block both local and remote control, if required. The logic automatically seals-in a successful close signal (Relay Word bit 89C*km*) until the user-defined reset Relay Word bit 89CR*km* asserts. By default, the relay uses the seal-in timer output to avoid a premature reset of the close signal. An immobility timer detects if the disconnect remains in the fully open position for longer than the 89I*km*D time setting after the close signal is issued (89C*km* asserts) by the assertion of Relay Word bit 89CI*km*.

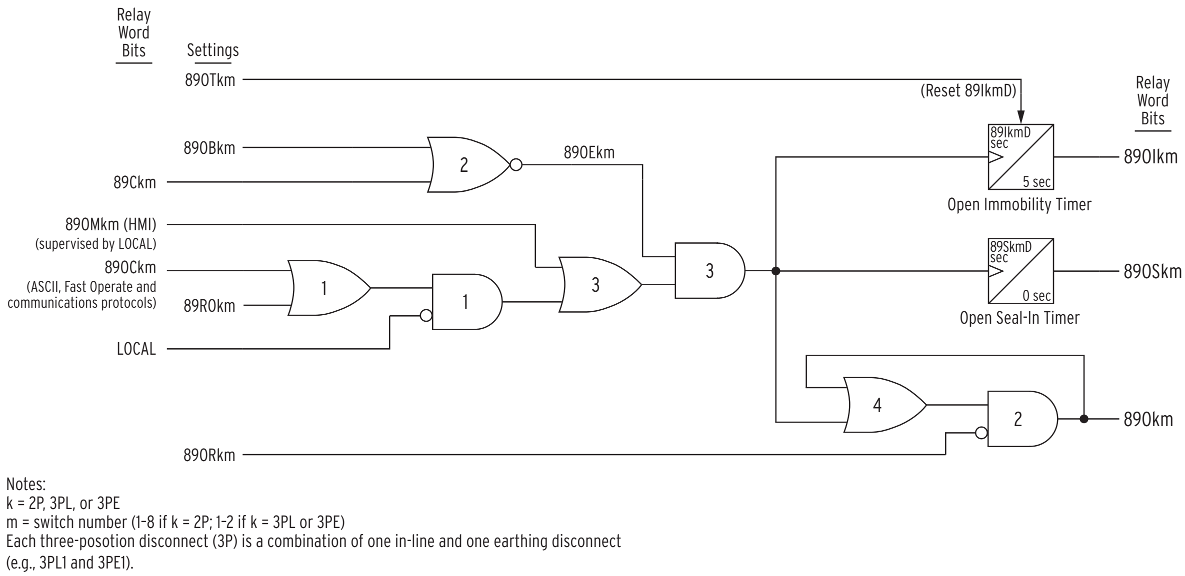


Figure 9.3 Disconnect Open Logic

Similarly, open control action of a disconnect can be initiated via the front-panel HMI (Relay Word bit 89OM*km*) or remotely (i.e., communications protocols [Relay Word bit 89OC*km*] or the SELOGIC control equation setting [89RO*km*]). Open control from the HMI requires that local control be enabled (Relay Word bit LOCAL asserted). When Relay Word bit LOCAL is asserted, remote close is blocked. Use the 89OB*km* SELOGIC control equation setting to block both local and remote control, if required. The logic automatically seals-in a successful open signal (Relay Word bit 89O*km*) until the user-defined reset Relay Word bit 89OR*km* asserts. By default, the relay uses the seal-in timer output to avoid premature reset of the open signal. An immobility timer detects if the disconnect remains in the fully close position for longer than the 89I*km*D time setting after the open signal is issued (89O*km* asserts) by the assertion of Relay Word bit 89OI*km*.

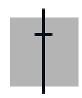
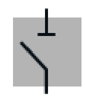
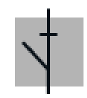
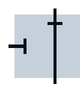
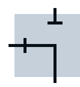
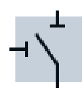
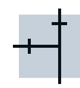
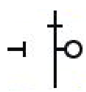
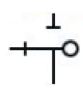
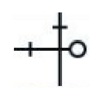
Table 9.4 Disconnect Control Setting Guidelines

Setting	Remarks
89EN*k*	Enable required number of 2- and 3-position switches
89NM*km*	Label each switch with a unique name
89A*km*	SELOGIC control equation for normally open auxiliary contact of the switch
89B*km*	SELOGIC control equation for normally close auxiliary contact of the switch
89A*km*D	Operate alarm delay; set longer than the highest expected operate time of the switch
89S*km*D	Seal-in delay; set longer than the highest expected operate time of the motor operated switch

The factory-default values of all the other settings should be suitable for most applications, however, they must be reviewed and edited for specific requirements.

Refer to *Table 9.5* for the Bay Control disconnect settings. Refer to *Bay Control Application Example on page 9.19* for example settings. *Table 9.5* provides typical ANSI and IEC disconnect symbols that are available to use in bay screen design. Column 1 identifies the standard (ANSI/IEC) and the type of disconnect. Column 2 identifies the interior color property of the disconnect. Columns 3, 4, and 5 identify closed, open, and alarm states of the disconnect. For a complete list of ANSI and IEC disconnect symbols available to use with the bay screens, refer to the *ACSELERATOR Bay Screen Builder SEL-5036 Software Instruction Manual*.

Table 9.5 Disconnect Symbols

Type	Interior Color	State 1 (Closed)	State 2 (Open)	State 3 (Alarm)
ANSI and IEC Disconnect (Two-Position)	Gray			
ANSI and IEC Motor-Operated Disconnect (Two-Position)	Transparent			
ANSI and IEC Disconnect (Three-Position)	Gray	 		
ANSI and IEC Motor-Operated Disconnect (Three-Position)	Transparent	 		

Local/Remote Control

The SEL-700G supports local/remote breaker control functionality through supervision of the OCX/OCY and CCX/CCY breaker control Relay Word bits and local/remote disconnect control functionality through supervision in the disconnect open and close control logic (See *Figure 9.2* and *Figure 9.3*). The supervision can be enabled or disabled with the global setting EN_LRC (see *Table 9.6*). To enable local/remote supervision of the breaker and disconnect control, set EN_LRC := Y. When EN_LC := Y, the LOCAL SELOGIC control equation is available.

Table 9.6 Local/Remote Control Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE LOC REM CON	Y, N	EN_LRC := N
LOCAL CONTROL[a]	SELOGIC	LOCAL := 0

[a] This setting is hidden when EN_LRC := N.

The relay controls the status of the LOCAL Relay Word bit based on the EN_LRC setting and the selection applies to both the breaker and the disconnect control.

- When EN_LRC := Y and LOCAL := 1, the relay processes the open and close commands from the front panel (two-line display or touchscreen). The open and close commands from remote sources/protocols (ASCII terminal, SEL Fast Operate, DNP, Modbus, EtherNet/IP, IEC 61850, etc.) are blocked.
- When EN_LRC := Y and LOCAL := 0, the relay processes the open and close commands from remote sources/protocols (ASCII terminal, SEL Fast Operate, DNP, Modbus, EtherNet/IP, IEC 61850, etc.). The commands from the front panel are blocked (two-line display or touchscreen).
- When EN_LRC := N, the relay processes the open and close commands from both the front panel (two-line display or touchscreen) and remote sources/protocols (ASCII terminal, SEL Fast Operate, DNP, Modbus, EtherNet/IP, IEC 61850, etc.).

Enable the local/remote control for proper supervision of breaker control and operator safety. Map the LOCAL SELOGIC control equation to the status of the local/remote switch on the panel, if available. Alternatively, program one of the front-panel pushbuttons and an LED in conjunction with a SELOGIC latch to mimic the local/remote switch and map it to the LOCAL SELOGIC control equation.

When EN_LRC := Y, the status of the local/remote control is indicated on the footer of the touchscreen as “L” for local (LOCAL = 1) and “R” for remote (LOCAL = 0). If you do not intend to use the built-in local/remote function, and prefer to create your own control function using SELOGIC and remote bits, then set EN_LRC := N. In which case, the footer indicates “LR,” as shown in *Figure 9.4*, indicating that OCX/OCY and CCX/CCY bits are processed from both the touchscreen and remote sources/protocols. Local/remote indication is only available on the SEL-700G touchscreen display model. Refer to *Bay Control Application Example on page 9.19* for example settings.

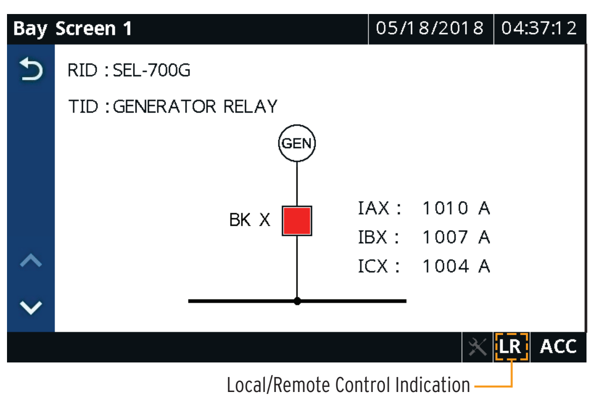


Figure 9.4 Local/Remote Control Mode Indication

Breaker/Disconnect Control Via the Touchscreen

The SEL-700G enables you to control the breaker from the touchscreen or the two-line LCD and the disconnect from the touchscreen. Breakers and disconnects can also be controlled through the front-panel operator control pushbuttons. Refer to *Front-Panel Operator Control Pushbuttons on page 8.15* for a discussion on breaker control via the control pushbuttons.

Refer to *Control Menu on page 8.8* for instructions on breaker control via the two-line LCD. This section discusses breaker and disconnect control via touchscreen.

The touchscreen allows you to control the breaker via two applications: Bay Screens and Breaker Control; however, only the Bay Screens application allows control of the disconnects. The Bay Screens application is available on the Home screen. Breaker and disconnect control via the Bay Screens application requires you to design a bay control single-line diagram. *Figure 9.5* shows a sample single-line diagram with a controllable breaker and analog quantities. For more details on how to design a bay screen, refer to *Bay Control Application Example*.

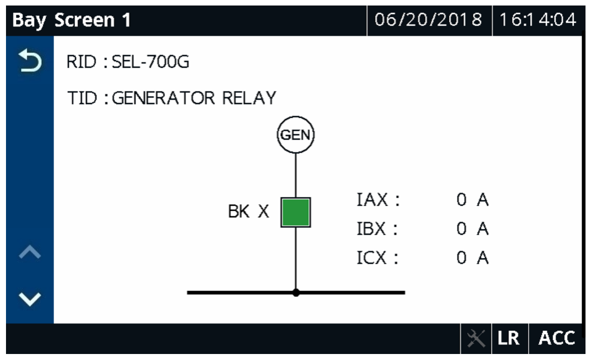


Figure 9.5 Bay Screens Application Display With a Single-Line Diagram

You can also control the breaker via the Breaker Control application, which is available in the Control folder. This application is built-in and is always available for you to perform breaker control. *Figure 9.6* shows the X-side Breaker Control application display.

NOTE: For all SEL-700G models, X-side breaker and analog quantities are used for the default settings associated with Bay Screen 1. For an SEL-700GT model, you need to modify these settings (Breaker Close/Open Status) and analog quantities for the default Bay Screen 1 and use the corresponding Y-side quantities.

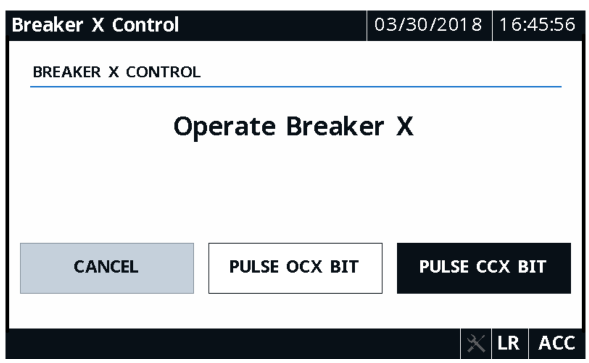


Figure 9.6 Breaker Control Application

The Bay Screens and Breaker Control applications use the OCX/OCY and CCX/CCY bits and require you to program the OCX/OCY and CCX/CCY bits into their respective trip (TRX/TRY) and close (CLX/CLY) SELogic control equations to perform breaker control. For more details on how to program these bits, refer to *Bay Control Application Example*. The Bay Screens and Breaker Control applications use the 89OM*km* and 89CM*km* bits to perform disconnect control (see *Figure 9.3* and *Figure 9.3* for details). The relay checks for the following conditions, in the order shown, in both applications. Only when the conditions are satisfied can you perform breaker control or disconnect control.

1. EN_LRC := Y and Relay Word bit LOCAL is asserted. If EN_LRC := N, then this check is ignored.

2. The breaker control jumper on the main board is installed. The Relay Word bit BKJMP stays asserted when the breaker control jumper is installed. Refer to *Password, Breaker Control, and SELBOOT Jumper Selection on page 2.19* for information on the breaker jumper.

3. You are at Access Level 2. The relay prompts for the Access Level 2 password if you are not at Access Level 2.

When the conditions are satisfied, the application pulses the OCX/OCY or CCX/CCY bit, respectively, depending on your selection for breaker open or close.

Bay Screens Design Using QuickSet and Bay Screen Builder

QuickSet and Bay Screen Builder provide user-friendly interfaces to set the touchscreen settings. The touchscreen settings are not available for setting via ASCII terminal, unlike the other relay settings. The touchscreen settings are only available if the relay part number is configured with the touchscreen display option under the Front-Panel Options drop down menu as shown in *Figure 9.7*. *Figure 9.8* shows the Touchscreen settings in QuickSet.

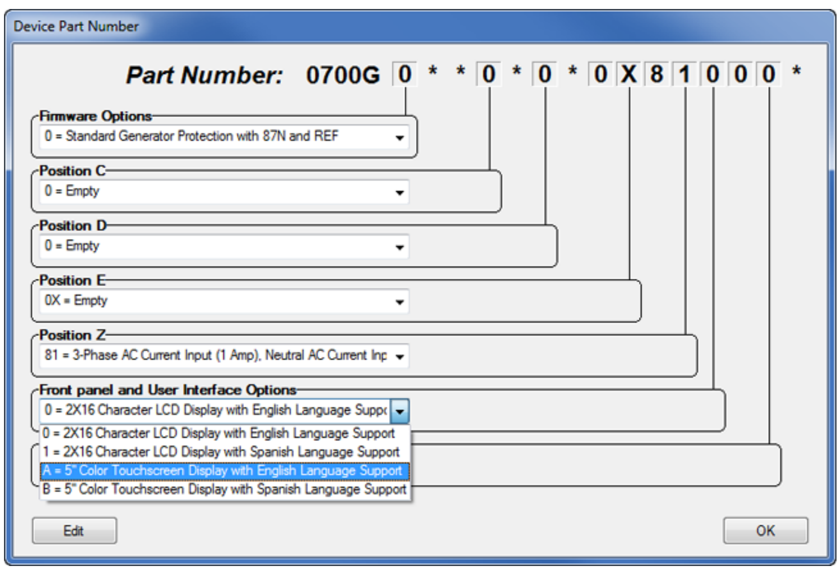


Figure 9.7 QuickSet Front-Panel Options

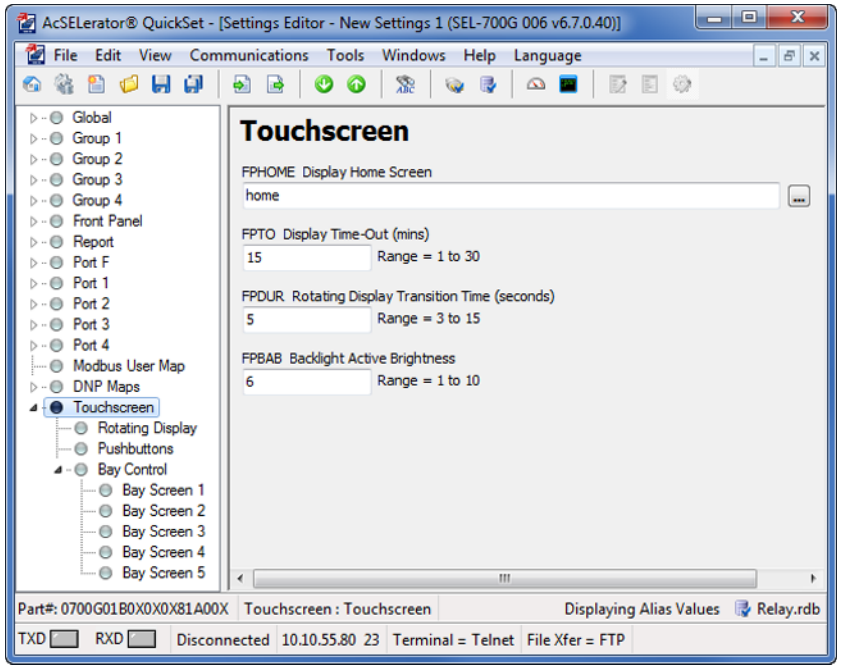


Figure 9.8 QuickSet Touchscreen Settings

NOTE: The settings in Table 9.7 shall be populated under each of the custom screens (sld1–sld5) based on the dynamic symbols chosen by the user.

Table 9.7 Touchscreen Settings (Sheet 1 of 3)

Setting Prompt	Setting Range	Setting Name := Factory Default
Display Settings		
Display Home Screen	See *Table 8.18*	FPHOME := HOME
Display Time-Out	1–30 min	FPTO := 15
Rotating Display Transition Time	3–15 sec	FPDUR := 5
Backlight Active Brightness	1–10	FPBAB := 6
Rotating Display Screen Settings		
Rotating Display 01	See *Table 8.18*	FPRD01 := Bay Screen 1
Rotating Display 02	See *Table 8.18*	FPRD02 :=
• • •	• • •	• • •
Rotating Display 15	See *Table 8.18*	FPRD15 :=
Rotating Display 16	See *Table 8.18*	FPRD16 :=
Pushbutton Settings (nn = 01–08)		
Pushbutton *nn* HMI Screen	OFF, See *Table 8.18*	FPPB*nn* := OFF
Bay Control Breaker Settings		
Breaker Trip Type	3	BK01TTY := 3
Breaker Mode	CONTROL, MONITOR	BK01MOD := MONITOR
Breaker 1 Close Status	Relay Word Bit	BK01CS := 52A1

Table 9.7 Touchscreen Settings (Sheet 2 of 3)

Setting Prompt	Setting Range	Setting Name := Factory Default
Breaker 1 Open Status	Relay Word Bit	BK01OS := 52B1
Breaker 1 Alarm Status	Relay Word Bit	BK01AS := NA
Breaker 1 HMI Close Command	Relay Word Bit	BK01CLC := NA
Breaker 1 HMI Open Command	Relay Word Bit	BK01OPC := NA
Breaker 2 Close Status	Relay Word Bit	BK02CS := 52A2
Breaker 2 Open Status	Relay Word Bit	BK02OS := 52B2
Breaker 2 Alarm Status	Relay Word Bit	BK02AS := NA
Breaker 2 HMI Close Command	Relay Word Bit	BK02CLC := NA
Breaker 2 HMI Open Command	Relay Word Bit	BK02OPC := NA
Breaker 3 Close Status	Relay Word Bit	BK03CS := 52A3
Breaker 3 Open Status	Relay Word Bit	BK03OS := 52B3
Breaker 3 Alarm Status	Relay Word Bit	BK03AS := NA
Breaker 3 HMI Close Command	Relay Word Bit	BK03CLC := NA
Breaker 3 HMI Open Command	Relay Word Bit	BK03OPC := NA
Breaker 4 Close Status	Relay Word Bit	BK04CS := 52A4
Breaker 4 Open Status	Relay Word Bit	BK04OS := 52B4
Breaker 4 Alarm Status	Relay Word Bit	BK04AS := NA
Breaker 4 HMI Close Command	Relay Word Bit	BK04CLC := NA
Breaker 4 HMI Open Command	Relay Word Bit	BK04OPC := NA
Bay Control Disconnect Settings Two-Position Disconnects (m = 1–8)		
Two-Position Disconnect Close Status	Relay Word bit	2DS*m*CS :=
Two-Position Disconnect Open Status	Relay Word Bit	2DS*m*OS :=
Two-Position Disconnect In-Progress Status	Relay Word Bit	2DS*m*IS := NA
Two-Position Disconnect Alarm Status	Relay Word Bit	2DS*m*AS := NA
Two-Position Disconnect HMI Close Command	89CM2P1–89CM2P8	2DS*m*CL := NA
Two-Position Disconnect HMI Open Command	89OM2P1–89OM2P8	2DS*m*OP := NA

Table 9.7 Touchscreen Settings (Sheet 3 of 3)

Setting Prompt	Setting Range	Setting Name := Factory Default
Bay Control Disconnect Settings Three-Position Disconnects (m = 1–2)		
Three-Position In-Line Disconnect Close Status	Relay Word bit	3ID*m*CS :=
Three-Position In-Line Disconnect Open Status	Relay Word Bit	3ID*m*OS :=
Three-Position In-Line Disconnect In-Progress Status	Relay Word Bit	3ID*m*IS := NA
Three-Position In-Line Disconnect Alarm Status	Relay Word Bit	3ID*m*AS := NA
Three-Position In-Line Disconnect HMI Close Command	89CM3PL1–89CM3PL2	3ID*m*CL := NA
Three-Position In-Line Disconnect HMI Open Command	89OM3PL1–89OM3PL2	3ID*m*OP := NA
Three-Position Earthing Disconnect Close Status	Relay Word Bit	3EDmCS :=
Three-Position Earthing Disconnect Open Status	Relay Word Bit	3EDmOS :=
Three-Position Earthing Disconnect In-Progress Status	Relay Word Bit	3EDmIS := NA
Three-Position Earthing Disconnect Alarm Status	Relay Word Bit	3EDmAS := NA
Three-Position Earthing Disconnect HMI Close Command	89CM3PE1–89CM3PE2	3EDmCL := NA
Three-Position Earthing Disconnect HMI Open Command	89OM3PE1–89OM3PE2	3EDmOP := NA
Bay Control Analog Label Settings (qq = 01–32)		
Analog Quantity	Analog Quantity	ALAB01 := STRING_RID
Analog Quantity	Analog Quantity	ALAB02 := STRING_TID
Analog Quantity	Analog Quantity	ALAB03 := IAW1_MAG
Analog Quantity	Analog Quantity	ALAB04 := IBW1_MAG
Analog Quantity	Analog Quantity	ALAB05 := ICW1_MAG
Analog Quantity	Analog Quantity	ALAB06 := IAW2_MAG
Analog Quantity	Analog Quantity	ALAB07 := IBW2_MAG
Analog Quantity	Analog Quantity	ALAB08 := ICW2_MAG
Analog Quantity	Analog Quantity	ALAB*qq* :=
Bay Control Digital Label Settings (qq = 01–32)		
Relay Word Bit	Relay Word Bit Name	DLAB*qq* :=

Display Settings

Use these settings to configure the touchscreen. The selection of the **HOME** pushbutton on the front panel takes you to the screen configured as part of the FPHOME setting. By default, FPHOME is set to the Home screen, which displays the Home screen folders and applications. You can set FPHOME to any screen that you like to view when the **HOME** pushbutton is pressed (see *Table 8.18* for the list of available screens).

To help prevent unauthorized access to password-protected functions, the SEL-700G provides a front-panel timeout setting, FPTO. The timeout resets each time you press a front-panel pushbutton or the screen detects a touch. When the timeout expires, the access level resets to Access Level 1 and switches to the rotating display if at least one screen is configured as part of the rotating display settings, FPRD*kk* (*kk* = 01–16), if not, the display switches to the Home screen. The rotating display transition time setting FPDUR defines the duration that each screen is displayed on the rotating display. Set FPDUR to a transition time most suitable to your application.

Use the FPBAB setting to control the backlight active brightness.

Rotating Display Settings

The SEL-700G allows you to configure as many as 16 screens for the rotating display. Configure the settings FPRD*kk* (*kk* = 01–16) to the screens most suitable to your application. Refer to *Table 8.18* for the list of screens available as part of the FPRD*kk* settings.

Pushbutton Settings

The pushbutton settings FPPB*nn* (*nn* = 01–08) allow you to quickly navigate to a specific screen by pressing the programmed pushbutton. Refer to *Table 8.18* for the list of screens available for the FPPB*nn* settings. Note that a given pushbutton can be configured to navigate to a specific screen but can also be used in SELOGIC (e.g., PB08 Relay Word bit). The relay does not prevent you from configuring a pushbutton for two purposes. Make sure to set dual-purpose pushbuttons with care to ensure safe operation.

Bay Control Breaker Settings

Bay control breaker settings are only available if the designed single-line diagram has a breaker symbol. When QuickSet detects a breaker symbol as part of the single-line diagram, it populates the corresponding settings. The SEL-700G supports two three-pole breaker. The setting BK*pp*TTY (*pp* = 01 or 02) is forced to 3 by default and is not settable. The breakers on the single-line can be configured as monitor-only or as a controllable breaker. Set BK*pp*MOD = MONITOR if you do not want to allow breaker control via the touchscreen. Set BK*pp*MOD = CONTROL if you want to allow breaker control via the touchscreen. Set BK*pp*CS and BK*pp*OS settings to the corresponding Relay Word bits that indicate the close and open status of the breaker. The relay does not support breaker alarm logic, but it can be programmed using SELOGIC. To display breaker alarm status, set the breaker alarm status setting BK*pp*AS to the corresponding Relay Word bit. When BK*pp*MOD := CONTROL, set BK*pp*CLC and BK*pp*OPC settings to the corresponding CCX/CCY and OCX/OCY Relay Word bits. Refer to *Bay Control Application Example on page 9.19* for sample breaker settings.

Bay Control Disconnect Settings

The bay control disconnect settings are only available if the designed single-line diagram has at least one disconnect symbol. When QuickSet detects one or more disconnect symbols as part of the single-line diagram, it populates the corresponding settings. The SEL-700G supports eight two-position and two three-position disconnects. Set the DS*n*CS and DS*n*OS settings to the corresponding Relay Word bits that indicate the close and open status of the disconnect. Map the output of the disconnect alarm logic, 89AL*km* (see *Figure 9.1*), to the corresponding DS*n*AS setting. A successful close or open command from the HMI asserts the corresponding 89CM*km* or 890M*km* Relay Word bit used in *Figure 9.2* or *Figure 9.3*, respectively. Refer to *Bay Control Application Example on page 9.19* for sample disconnect settings.

Bay Control Analog Label Settings

The analog label settings are only available if the designed bay screen has at least one analog label. When QuickSet detects one or more analog labels as part of the bay screen, it populates the corresponding settings. The SEL-700G supports as many as 32 analog labels. Set ALAB*qq* (*qq* = 01–32) to display the desired analog quantity on the bay screen. Refer to the display points column of *Table M.1* for the list of analog quantities available to program into analog labels.

Bay Control Digital Label Settings

The digital label settings are only available if the designed bay screen has at least one digital label. When QuickSet detects one or more digital labels as part of the bay screen, it populates the corresponding settings. The SEL-700G supports as many as 32 digital labels. Set DLAB*qq* (*qq* = 01–32) to display the desired Relay Word bits on the bay screen. Refer to *Table L.1* for the list of Relay Word bits available to program into digital labels.

Bay Screen Builder Software

NOTE: Refer to the Product Literature CD for a list of UTF-8 characters that can be rendered on the bay screen in Bay Screen Builder.

The Bay Screen Builder Software provides an intuitive and powerful interface to design bay screens to meet your application needs. This instruction manual provides only a brief overview of the Bay Screen Builder Software. For more details, refer to the *ACSELERATOR Bay Screen Builder SEL-5036 Software Instruction Manual* available from the **Help** > **Contents** menu in Bay Screen Builder or at selinc.com.

Several of the settings identified in *Table 9.7* are available for you to set depending on the symbols chosen for your single-line diagram. *Figure 9.9* shows the layout of Bay Screen Builder and identifies different menus, panes, and information.

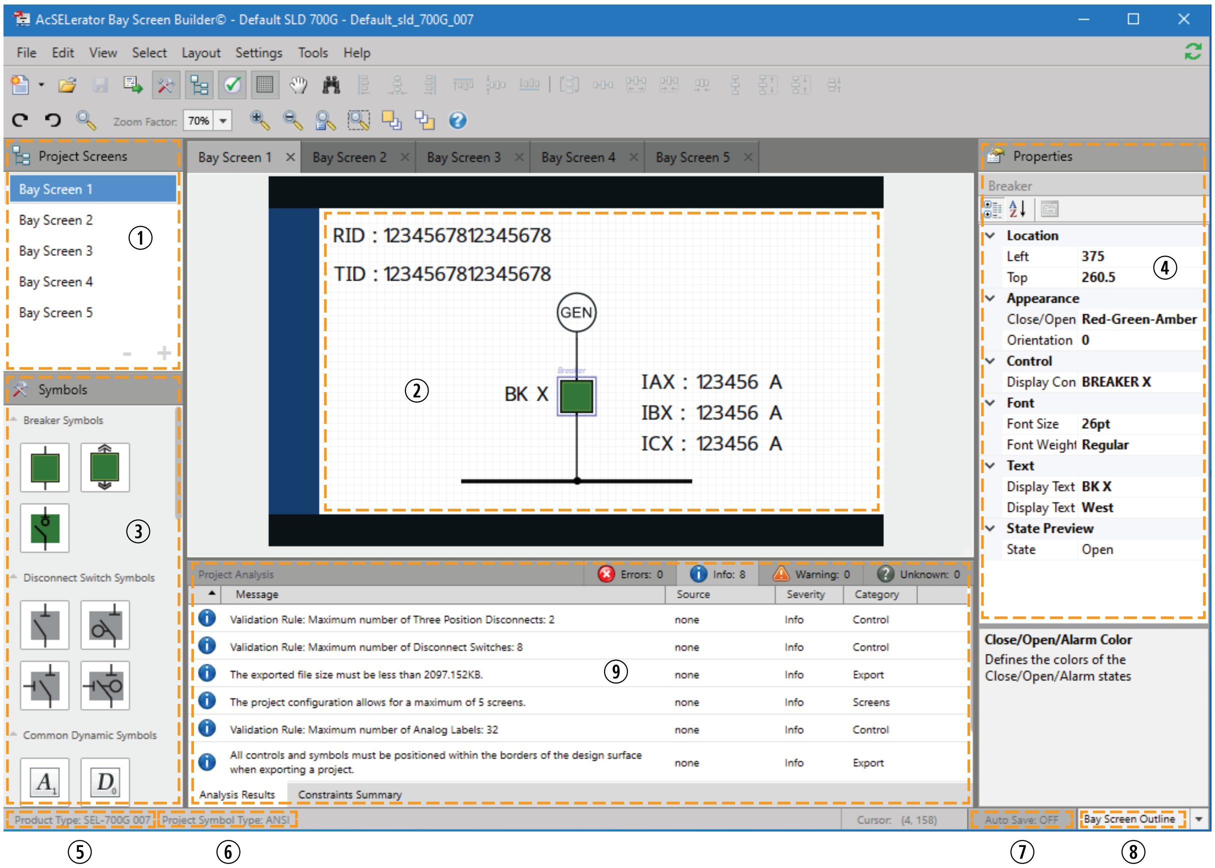


Figure 9.9 Layout of Bay Screen Builder

Descriptions of the different menus, panes, and information in Bay Screen Builder are as follows:

① **Project Screens Pane:** Displays the names of the screens (as many as five) present in a project. Click a screen name to open the screen, and double-click or right-click a screen name to access additional options for that screen.

② **Screen Area:** Displays the selected project screen and its symbols. Create a single-line diagram or a metering or status screen by dragging and dropping symbols from the Symbols pane.

③ **Symbols Pane:** Displays the symbols available for selection. Bay Screen Builder supports several static and a limited number of dynamic ANSI and IEC symbols. Note that for a given project, you can only use either ANSI *or* IEC symbols, not both. While there are no constraints on the number of static symbols, Bay Screen Builder limits the number of dynamic symbols. The following table provides the number of breakers, disconnects, analog labels, and digital labels supported in a given project.

Symbols	Number of Supported Symbols per Project
Breakers	2
Disconnects	8
Analog Labels	32
Digital Labels	32

④ **Properties Pane:** Displays the properties of a selected symbol. Edit the symbol properties as needed for your application. For instance, the breaker color sequence property identified in *Table 9.1* can be set via the appearance property of the breaker symbol (refer to *Edit Symbol Properties on page 9.23*). Bay Screen Builder supports UTF-8 character encoding. Refer to the Product Literature CD for a complete list of UTF-8 characters that can be rendered on the touchscreen display.

⑤ **Product Type:** Displays the name of the QuickSet driver version of the product associated with the selected project (e.g., SEL-700G 006, as shown in *Figure 9.9*). Select the product type in Bay Screen Builder when you create a new project independent of QuickSet. View the Product Type though **Settings** > **Project Settings**. If a project is edited via QuickSet, Bay Screen Builder inherits the product type from the QuickSet settings file.

⑥ **Project Symbol Type:** Displays the symbol type (IEC or ANSI) associated with the selected project as shown in *Figure 9.9*. Select the symbol type when you create a new project. If a project is edited via QuickSet, the ANSI symbol type is selected by default.

⑦ **Auto Save:** Provides a shortcut for changing the auto save setting for the application. Enable **Auto Save** to allow Bay Screen Builder to automatically save your project periodically. Your auto save setting preference is saved when you exit the application and is applied the next time you launch Bay Screen Builder. You can also set **Auto Save** through **Settings** > **Application Settings** > **File Handling**.

⑧ **Bay Screen Outline:** Displays the drop-down list of symbols on the presently open screen. Click a symbol from the list to make it active. The bay screen outline provides an alternate way to select the symbols and is most useful in cases where symbols are crowded or stacked.

⑨ **Project Analysis Pane:** Displays troubleshooting information/messages about the project (Errors, Info, Warning, Unknown). The project analysis pane supports two tabs: **Analysis Results** Analysis Results and Constraints Summary.

The Analysis Results tab displays details about the error, information, warning, and unknown messages for the project. You can use these messages for troubleshooting. Select a message type button to view the messages for that category. For example, click the **Errors** button to view the error messages for the project. Click a column header to sort by the information in that column (see *Figure 9.10*).

The Constraints Summary tab provides information about the rules that apply to the present project. All conditions listed under Symbol Constraints must be satisfied for a project to be valid. You can only publish a valid project, but you can save a project with errors (see *Figure 9.11*).

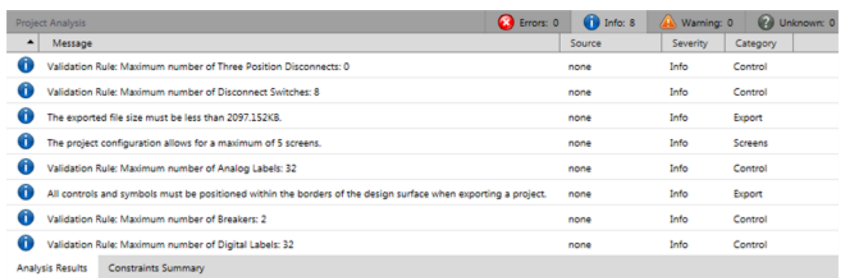


Figure 9.10 Project Analysis Pane: Analysis Results Tab

NOTE: The **Constraints Summary** tab shows the usage and limits of dynamic symbols for an entire project (all screens). Although not constrained, it is recommended that you limit the dynamic symbols to 32 symbols per screen for faster screen updates.

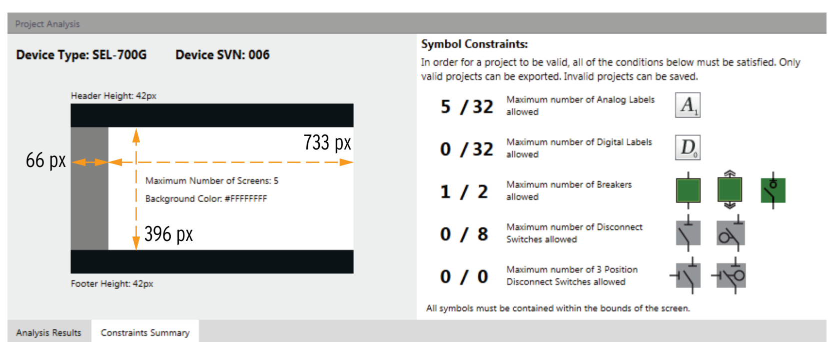


Figure 9.11 Project Analysis Pane: Constraints Summary Tab

You can adjust the size of the panes in the application. If you reconfigure the size of any of these panes, the new size is saved when you exit the application and applies the next time you launch Bay Screen Builder.

Bay Control Application Example

Specific components of bay screens are covered in *Bay Screens Design Using QuickSet and Bay Screen Builder*. This section provides a summarized application example tying all the components together. Refer to the *ACSELERATOR Bay Screen Builder SEL-5036 Software Instruction Manual*, available from the **Help** > **Contents** menu in Bay Screen Builder or at selinc.com, for more specific details regarding bay screen creation and symbol properties.

The SEL-700G supports as many as five custom screens. You can edit the predefined bay screen (Bay Screen 1) and the blank screens (Bay Screen 2, Bay Screen 3, Bay Screen 4, Bay Screen 5) (see *Figure 9.14*). You can also import one of the six predefined bay control single-line diagrams from the instruction manual CD. Refer to *Predefined Bay Control Single-Line Diagrams on page 9.30* for more details.

Consider if you were to create the single-line diagram shown in *Figure 9.12* as part of your application. Use the following step-by-step approach to design the single-line diagram beginning with the predefined bay screen (Bay Screen 1).

Before creating your own diagram, ensure that the number of dynamic symbols in your schematic does not exceed the number allowed by the SEL-700G (see *Figure 9.9* and the symbols pane description).

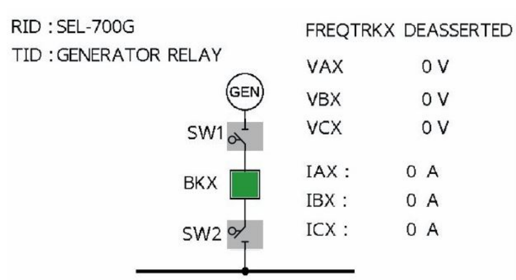


Figure 9.12 Bay Control Single-Line Diagram Schematic

Configure QuickSet for Bay Screen Builder

NOTE: The touchscreen display option is only available for SEL-700G QuickSet drivers 006 and higher.

To use QuickSet and Bay Screen Builder to create bay screens for the SEL-700G, your relay must have the touchscreen MOT configuration (A or B in the 17th place of the part number). When your relay is configured for the touchscreen option, perform the following steps to configure QuickSet to work with Bay Screen Builder.

Step 1. Create an SEL-700G settings file configured for the touchscreen display. Use the **Front-Panel and User Interface Options** drop down to select the touchscreen option (see *Figure 9.13*).

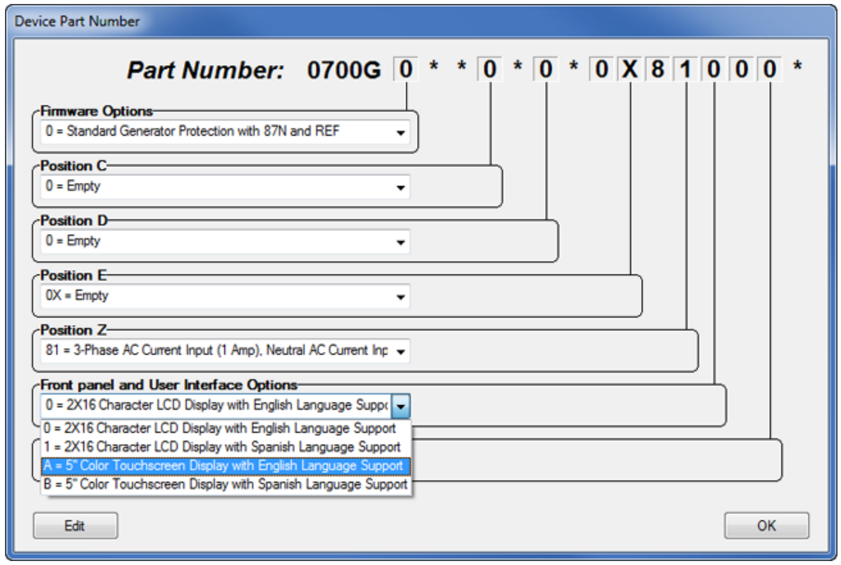


Figure 9.13 Device Part Number Touchscreen Configuration Option

Step 2. Click **OK**.

Step 3. Expand the **Touchscreen** settings class.

Step 4. Click **Bay Control**.

QuickSet displays project management buttons and a project preview that includes a small-scale view of five project screens (one screen with a predefined single-line diagram and four blank screens) and an enlarged view of the predefined single-line diagram, which is selected by default (see *Figure 9.14*).

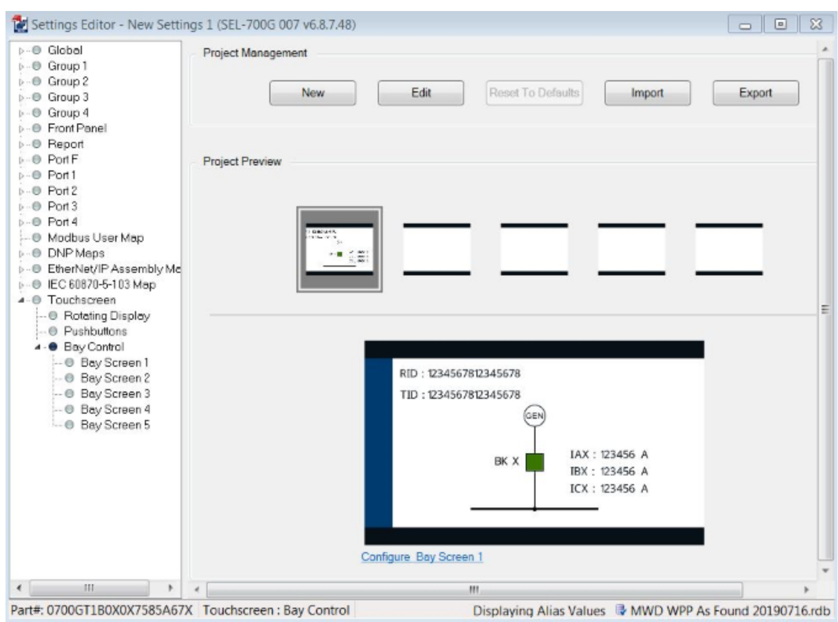


Figure 9.14 QuickSet Bay Control Project Management and Project Preview Display

Build Single-Line Diagrams in Bay Screen Builder

Use Bay Screen Builder to create single-line diagrams to load onto the SEL-700G Relay through QuickSet. To create the single-line diagram shown in *Figure 9.12*, perform the following steps.

Step 1. Select the screen with the predefined single-line diagram shown in *Figure 9.15* as a starting point for your single-line diagram.

Step 2. Click the **Edit** button (*Figure 9.15*) to open the screen with the predefined single-line diagram in Bay Screen Builder.

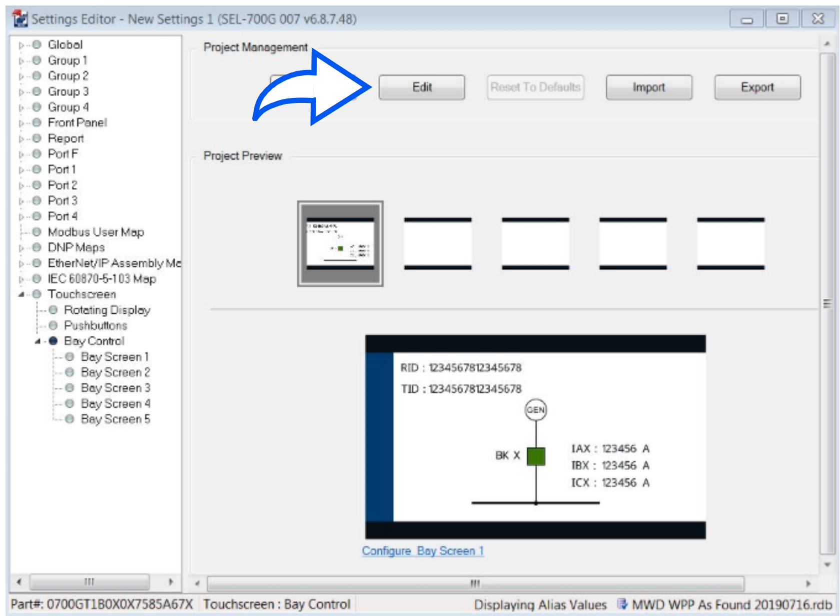


Figure 9.15 Open Single-Line Diagram in Bay Screen Builder

Step 3. Drag-and-drop the additional symbols required for your single-line diagram onto the screen area from the Symbols pane (see *Figure 9.16*).

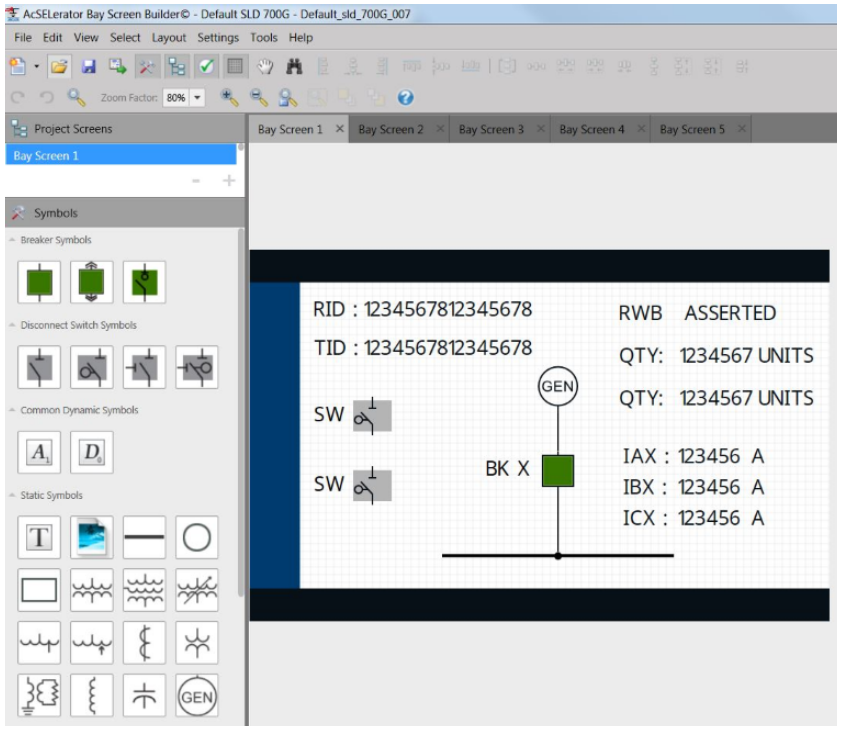
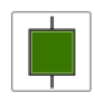
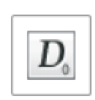
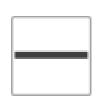


Figure 9.16 Drag-and-Drop Symbols

Table 9.8 lists the number of each symbol required to draw the single-line diagram shown in *Figure 9.12*.

Table 9.8 Symbols Required for the Single-Line Diagram Schematic in Figure 9.12

Symbols Required	Number of Symbols Required	Symbol
Breaker	1	
Disconnects	2	
Generator	1	
Analog labels (display voltages, currents, and power)	8	
Digital labels	1	
Line (draw the bus and connections)	As Needed	

Edit Symbol Properties

All of the symbols in Bay Screen Builder include editable properties. These properties allow you to customize the symbols to your specific application. These properties appear in the right Properties pane of Bay Screen Builder either when you drag a symbol from the left **Symbols** pane and drop it in the screen area or when a symbol in the screen area is selected.

For example, you can use the **Close/Open/Alarm Color** property in the Appearance tab of the breaker properties to select a color scheme for your single-line diagram breaker.

Step 1. Select the existing breaker symbol in the predefined single-line diagram to display the breaker symbol properties in the Properties pane, as shown in *Figure 9.17*.

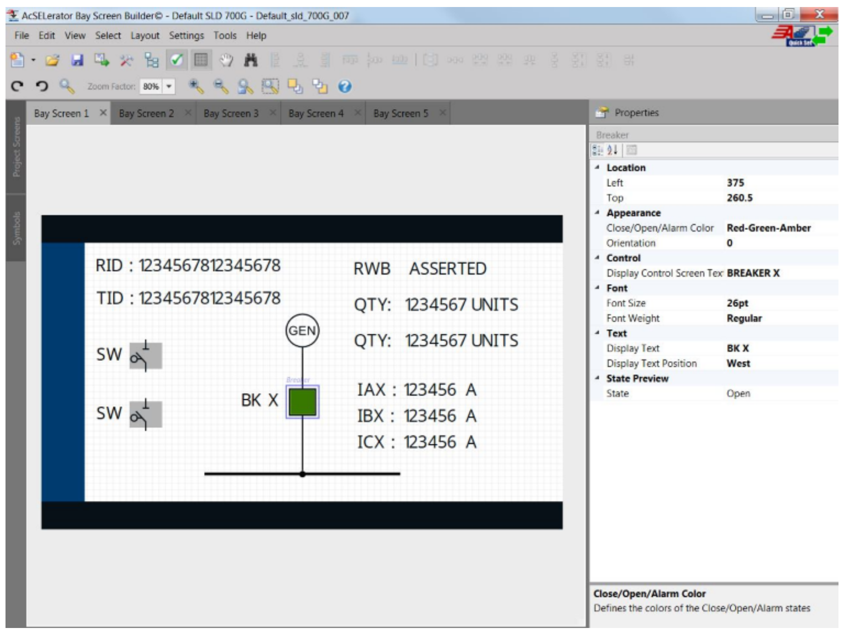


Figure 9.17 Selected Breaker Symbol Settings Displayed in the Properties Pane

Step 2. Select a color option from the drop down menu to edit the Close/Open/Alarm Color property in the Appearance tab (see *Figure 9.18*).

Table 9.1 lists the available options and breaker appearance in each state based on the selected property.

NOTE: If sufficient width is not provided for the value field of the analog label, the label is rendered as "$$$$$."

NOTE: The assignment of breaker Relay Word bits (e.g., 52AX, 52BX) to breaker symbols, or analog quantities (e.g., VAX_MAG) to analog labels, cannot be made in Bay Screen Builder. These assignments can only be made in QuickSet.

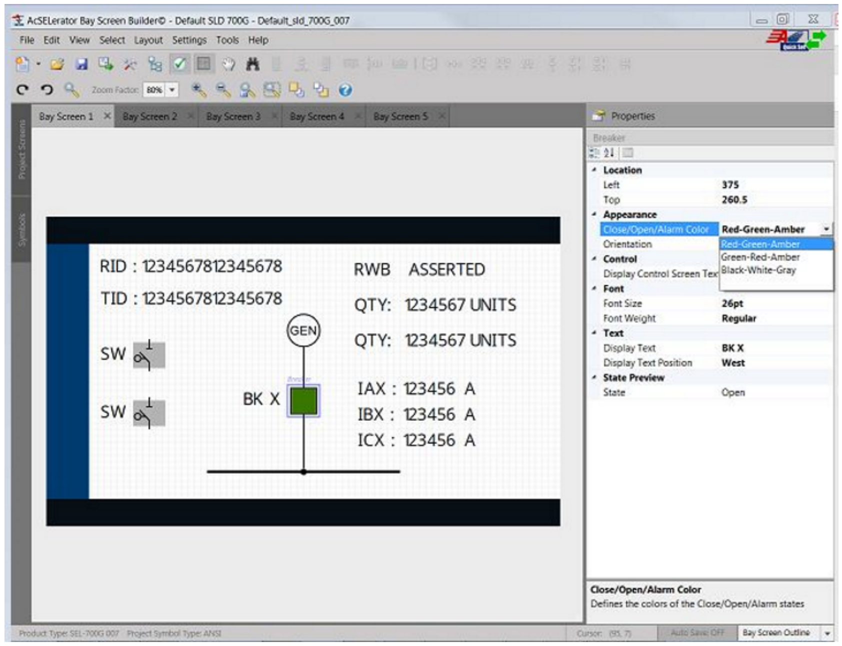


Figure 9.18 Close/Open/Alarm Color Property Drop Down Menu

Step 3. Use the **State Preview** tab to view your breaker close, open, and alarm state color selections.

Step 4. Edit the additional properties as needed for your application.

Select and edit the disconnects, dynamic labels (analog and digital labels), and static symbols, similar to the breaker symbol. Note that some of the symbols have the Text tab that can be edited for custom labeling.

In this example, only Bay Screen 1 has been modified in the project. You can also modify the other screens to add analog/digital labels to monitor the status of the quantities, if necessary. Publish the project using the following process after saving your edits.

Publish Bay Screen Builder Project

When you have completed your single-line diagram in Bay Screen Builder, you are ready to publish your project to QuickSet.

Step 1. Click **Save Project** in the File menu to save your project.

Step 2. Click **Publish Package** in the File menu to publish your project (see *Figure 9.19*). Bay Screen Builder exports the project into QuickSet.

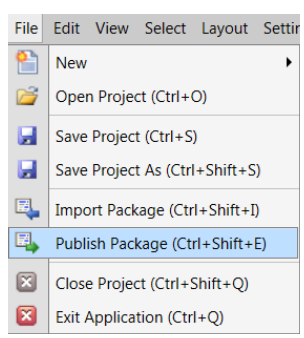


Figure 9.19 Publish Bay Screen Builder Project to QuickSet

Step 3. Allow a few seconds for Bay Screen Builder to publish the project to QuickSet. Respond to the QuickSet prompt, if presented. QuickSet then populates the settings of the updated single-line diagram (see *Figure 9.20*).

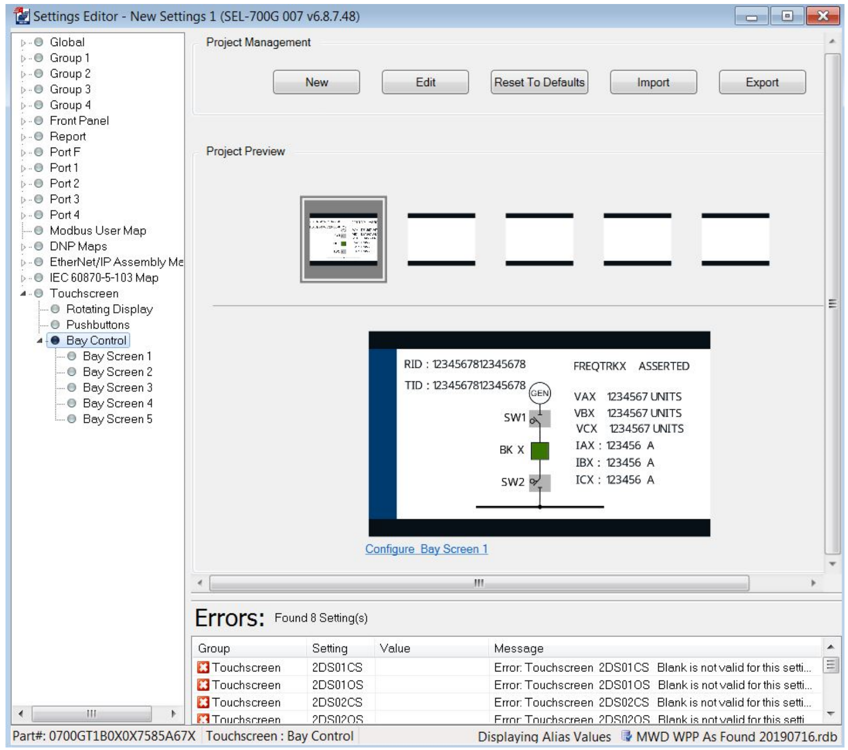


Figure 9.20 QuickSet Updated Single-Line Diagram and Corresponding Settings

Enter QuickSet Settings

The breaker, disconnect, analog and digital label, local/remote, and trip and close settings that follow are the settings applicable to the single-line diagram shown in *Figure 9.12*. Enter the following settings:

Breaker Settings

NOTE: The relay does not support dual-point breaker status (see Bay Control Breaker Settings) and uses the 52An (n = X or Y) Relay Word bit as the state of the breaker in several of the protection elements, including trip and close logic. If you intend to indicate dual-point status on the bay control single-line diagram, make use of SELogic to program this logic similar to the one shown in Figure 9.1.

For *Figure 9.12*, assume the breaker auxiliary contacts 52AX and 52BX are wired to digital inputs IN101 and IN102, respectively. SELogic settings SV01–SV03 are programmed to create dual-point breaker status with alarm to mimic the logic shown in *Figure 9.1*. Breaker settings are included in more than one settings class in QuickSet (**Set 1** and **Logic 1** in **Group**, **Bay Control**). Enter the following settings:

Setting	Example Setting	Comment
Group 1 > Set 1 > Trip and Close Logic		
52AX	IN101	
52BX	IN102	
Group 1 > Logic 1 > SELogic Variables and Timers		
SV01	(52AX AND 52BX) OR (NOT 52AX AND NOT 52BX)	(XNOR gate)

Setting	Example Setting	Comment
SV01PU	0.5	Set pickup time to indicate alarm for undetermined breaker state
SV01DO	0.0	
SV02	NOT SV01 AND 52AX	Indicates breaker close status when asserted
SV02PU	0.0	
SV02DO	0.0	
SV03	NOT SV01 AND 52BX	Indicates breaker open status when asserted
SV03PU	0.0	
SV03DO	0.0	
Touchscreen > Bay Control > Bay Screen 1		
Breaker Mode	CONTROL	Controllable breaker BKX
Breaker Close Status	SV02T	
Breaker Open Status	SV03T	
Breaker Alarm Status	SV01T	
Breaker HMI Close Command	CCX	
Breaker HMI Open Command	OCX	

Disconnect Settings

For this example, the relay has an 8 DI card in Slot C. Also, the disconnect auxiliary contacts 89A and 89B for each of the two disconnects are wired to digital inputs IN301, IN302, IN303, and IN304. Disconnect settings are included in more than one settings class in QuickSet (Global, Bay Control). Enter the following settings:

Setting	Example Setting	Comment
Global > Two-Position Disconnect Settings		
89A2P1	IN301	Disconnect 1, A contact
89B2P1	IN302	Disconnect 1, B contact
89A2P2	IN303	Disconnect 2, A contact
89B2P2	IN304	Disconnect 2, B contact
Touchscreen > Bay Control > Bay Screen 1		
Two-position 1 disconnect close status	89CL2P1	Switch SW1
Two-position 1 disconnect open status	89OP2P1	
Two-position 1 disconnect in-progress status	89IP2P1	
Two-position 1 disconnect alarm status	89AL2P1	
Two-position 1 disconnect HMI close command	89CM2P1	
Two-position 1 disconnect HMI open command	89OM2P1	

Setting	Example Setting	Comment
Two-position 2 disconnect close status	89CL2P2	Switch SW2
Two-position 2 disconnect open status	89OP2P2	
Two-position 2 disconnect in-progress status	89IP2P2	
Two-position 2 disconnect alarm status	89AL2P2	
Two-position 2 disconnect HMI close command	89CM2P2	
Two-position 2 disconnect HMI open command	89OM2P2	

Analog Label Settings

Enter the following Bay Control, Bay Screen 1 settings:

Setting	Example Setting
VAX	VAX_MAG
VBX	VBX_MAG
VCX	VCX_MAG
IAX	IAX_MAG
IBX	IBX_MAG
ICX	ICX_MAG
RID	STRING_RID
TID	STRING_TID

Digital Label Settings

Monitor when frequency tracking is enabled/disabled on the X-side signals, as shown in *Figure 9.12*.

Enter the following Bay Control, Bay Screen 1 setting:

Setting	Example Setting	Comment
FREQTRKX	FREQTRKX	Frequency tracking on the X-side signals enabled/disabled

Local/Remote Control Setting

Figure 9.12 is programmed with the local/remote functionality.

Enter the following Global, Control Configuration setting:

Setting	Example Setting	Comment
EN_LRC	Y	Enable local/remote control

Application With Handheld Local Remote Breaker Control Switch

Assume that the handheld local remote breaker control switch status is wired to IN308 of the relay. In this particular application, when IN308 is asserted, it implies that the breaker control is in LOCAL mode (or SCADA is cut off).

Enter the following Global, Control Configuration setting:

Setting	Example Setting	Comment
LOCAL	IN308	Local/remote control selection

Application Without Handheld Local Remote Breaker Control Switch

Assume that no handheld local remote breaker control switch is available. In such case you can program one of the programmable pushbuttons (e.g., PB05) in conjunction with SELOGIC to switch the breaker control between local and remote. Enter the following settings:

Setting	Example Setting	Comment
Group 1 > Logic 1 > SELOGIC Variables and Timers		
ELAT	1	
SET07	PB05_PUL AND NOT LT07	Local when LT07 is asserted
RST07	PB05_PUL AND LT07	Remote when LT07 is deasserted
Front Panel[a]		
PB5ALEDC	GO	
PB5A_LED	LT07	
PB5BLEDC	GO	
PB5B_LED	NOT LT07	
Global > Control Configuration		
LOCAL	LT07	

[a] Use configurable labels to assign PB5A LED to LOCAL and PB5B LED to REMOTE.

Trip and Close Settings

To be able to perform breaker control from the touchscreen or two-line display, program the OCX and CCX bits in the TRIPX and CLOSEX SELOGIC control equations, respectively.

Enter the following Group settings:

Setting	Example Setting	Comment
TRX	SV06 OR SV07 OR SV08 OR 46Q2T OR 81X1T OR 81X2T OR 81RX1T OR 81RX2T OR OOST OR SV04T OR OCX	Trip logic
CLX	SV03T OR CCX OR SV11T AND 25C	Close logic

Send all active settings to the relay.

To view the designed bay control single-line diagram on the touchscreen display, perform the following steps:

Step 1. Navigate to the **Home** screen.

Step 2. Select the **Bay Screens** application.

Step 3. Use the **Up** and **Down** arrows to view your screens.

With all the previous settings applied to the relay, you have a bay control single-line diagram that provides the status of the breaker and disconnects and provides you with the ability to perform breaker control via the touchscreen, as shown in *Figure 9.21*. In addition, you have the ability to monitor the voltages at the bus, the flow of currents and power through the breaker.

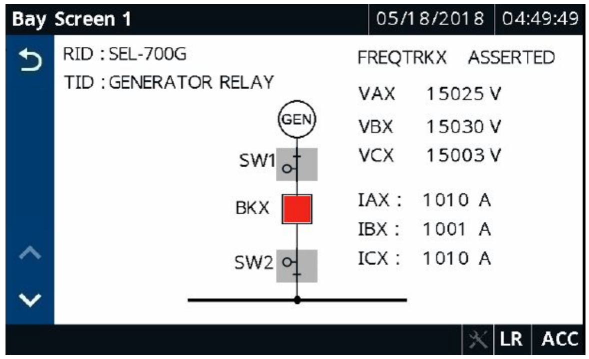


Figure 9.21 Final Bay Screen Builder Rendering

Export/Import Bay Screen Builder Project File

If you plan to use the same Bay Screen Builder project file (*.ldme) across multiple relays, export the file as shown in *Figure 9.22* and save the file to import it to another relay. The *.ldme file does not save the settings associated with the bay control symbols.

Alternatively, QuickSet allows you to save the Bay Screen as well as all of the corresponding analog and digital quantities settings (**Tools** > **Settings** > **Export** > **Touchscreen**).

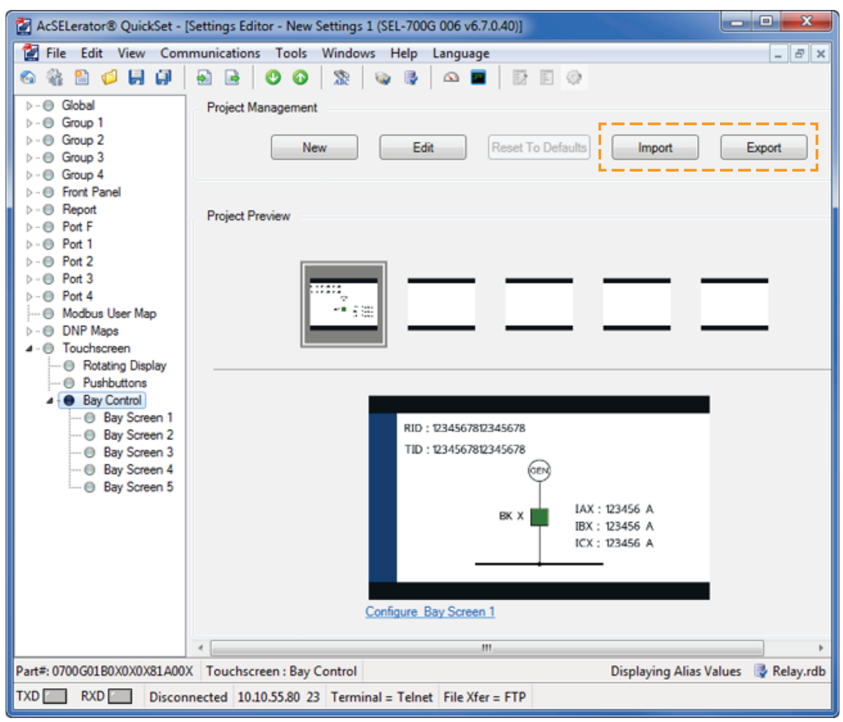


Figure 9.22 Import/Export of the Bay Control Screen in QuickSet

Reset to Defaults

Click **Reset to Defaults** in the QuickSet Project Management section to restore the default project in QuickSet.

Predefined Bay Control Single-Line Diagrams

You can also import a predefined single-line diagram from the instruction manual CD. You can use the predefined single-line diagram as is or edit it to fit your specific application. All of the predefined single-line diagrams are created with either ANSI or IEC symbols. Any one of the single-line diagrams can be imported into Bay Screen Builder. Use the **Import** button in the Project Management section of QuickSet to import one of the screens provided on the instruction manual CD.

ANSI and IEC

The predefined single-line diagrams are provided on the instruction manual CD as .ldme files. Each of the following single-line diagrams is provided as an ANSI and an IEC single-line diagram.

- SEL-700G1 With GSU (generator step-up)
- SEL-700G1 With GSU and Disconnects
- SEL-700G1 (Multiple Units)
- SEL-700GT Tie-Breaker
- SEL-700GT+ With GSU
- SEL-700GT+ With GSU and Disconnects

Figure 9.23 shows the ANSI predefined bay control single-line diagram for an application of the SEL-700G1 with GSU and disconnect.

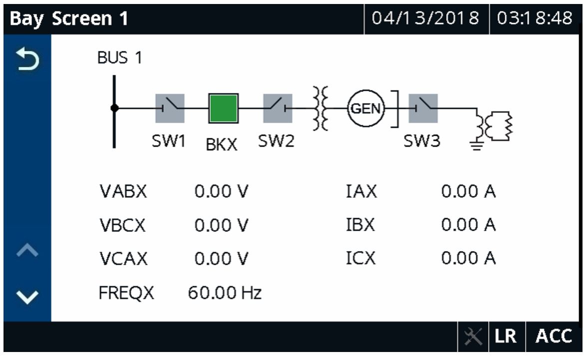


Figure 9.23 ANSI SEL-700G1 With GSU and Disconnects

Figure 9.24 shows the IEC predefined bay control single-line diagram for an application of the SEL-700G1 with GSU and disconnects.

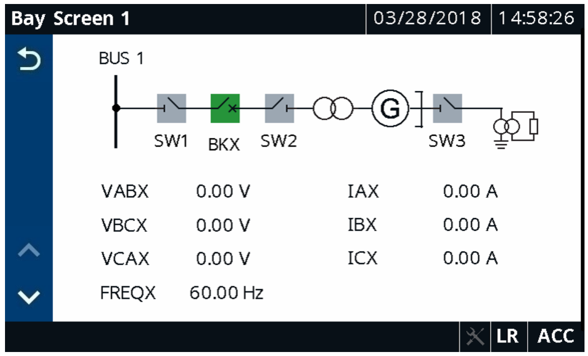


Figure 9.24 IEC SEL-700G1 With GSU and Disconnects

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Section 10
Analyzing Events

Overview

The SEL-700G Generator and Intertie Protection Relay provides several tools (listed below) to analyze the cause of relay operations. Use these tools to help diagnose the cause of the relay operation and more quickly restore the protected equipment to service.

- Event Reporting
  - Event Summary Reports
  - Event History Reports
  - Event Reports
- Sequential Events Recorder Report
  - Resolution: 1 ms
  - Accuracy: ±1/4 cycle

All reports are stored in nonvolatile memory, ensuring that a loss of power to the SEL-700G does not result in lost data. The SEL-700G offers four types of event reports: Standard ASCII (EVE) reports, Compressed ASCII (CEV) reports, Binary COMTRADE reports, and Sequential Event Recorder (SER) reports.

Event Reporting

Analyze events with the following event reporting functions:

- Event Summaries—Enable automatic messaging to allow the relay to send event summaries out from a serial port when port setting AUTO := Y. A summary provides a quick overview of an event. You can also retrieve the summaries by using the **SUMMARY** command.
- Event History—The relay keeps an index of stored nonvolatile event reports. Use the **HISTORY** command to obtain this index. The index includes some of the event summary information so that you can identify and retrieve the appropriate event report.
- Event Reports—These detailed reports are stored in nonvolatile memory for later retrieval and detailed analysis.

Each time an event occurs, a new summary, history record, and report are created. Event report information includes:

- Date and time of the event
- Individual sample analog inputs (currents and voltages)
- Digital states of selected Relay Word bits (listed in *Table L.1*)

- ➤ Event summary, including the front-panel target states at the time of tripping and fault type
- ➤ Group, Logic, Global, and Report settings (that were in service when the event was triggered)
- ➤ Relay part number and serial number to identify the relay model type

Compressed Event Reports

The SEL-700G provides Compressed ASCII and COMTRADE event reports to facilitate event report storage and display. SEL communications processors and SEL-5601-2 SYNCHROWAVE Event Software take advantage of the Compressed ASCII and COMTRADE formats. Use the **CHIS** command to display Compressed ASCII event history information. Use the **CSUM** command to display Compressed ASCII event summary information. Use the **CEVENT** command to display Compressed ASCII event reports.

For accurate event report analysis, use the Compressed Event report with raw (unfiltered) data (**CEV R** command). The regular ASCII Event report is useful for a quick check. See *Table C.2* for further information.

Compressed ASCII Event Reports contain *all* of the Relay Word bits.

Sequential Events Recorder (SER)

The SER report captures digital element state changes over time. Settings allow as many as 96 Relay Word bits to be monitored, in addition to the automatically generated triggers for relay power up, settings changes, and active setting group changes. State changes are time-tagged to the nearest millisecond. SER information is stored when state changes occur.

SER report data are useful in commissioning tests and during operation for system monitoring and control.

Event Reporting

Length

IMPORTANT: Changing the LER setting clears all events in memory. Be sure to save critical event data prior to changing the LER setting.

The SEL-700G provides selectable event report length (LER) and prefault length (PRE). Event report length is either 15, 64, or 180 cycles. Prefault length is 1–10 cycles for LER = 15, 1–59 cycles for LER = 64, and 1–175 cycles for LER = 180. Prefault length is the first part of the total event report length and precedes the event report triggering point. Changing the PRE setting has no effect on the stored reports. The relay stores as many as 8 of the most recent 180-cycle or 21 of the most recent 64-cycle or 44 of the most recent 15-cycle event reports in nonvolatile memory. Refer to the **SET R** command in *SET Command (Change Settings) on page 7.66* and *Report Settings (SET R Command) on page SET.83*.

Triggering

The SEL-700G triggers (generates) an event report when any of the following occur:

- ➤ Relay Word bit TRIP asserts
- ➤ Programmable SELOGIC control equation setting ER asserts (in Report settings)
- ➤ **TRI** (Trigger Event Reports) serial port command executes

Relay Word Bit TRIP

Refer to *Figure 4.134*. If Relay Word bit TRIP asserts to logical 1, an event report is automatically generated. Thus, any Relay Word bit that causes a trip does *not* have to be entered in SELOGIC control equation setting ER.

Programmable SELOGIC Control Equation Setting ER

The programmable SELOGIC control equation event report trigger setting ER is set to trigger event reports for conditions other than trip conditions (see SET R in *SET Command (Change Settings) on page 7.66*). When setting ER detects a logical 0 to logical 1 transition, it generates an event report (if the SEL-700G is not already generating a report that encompasses the new transition). The factory setting is shown in *Event Report Settings on page 4.259*.

TRI (Trigger Event Report) Command

The sole function of the **TRI** serial port command is to generate event reports, primarily for testing purposes. See *TRIGGER Command (Trigger Event Report) on page 7.76* for more information on the **TRI** (Trigger Event Report) command.

Event Summaries

IMPORTANT: Clearing the history report with the **HIS C** or **HIS CA** command clears all event data within the SEL-700G event memory.

NOTE: The **HIS CA** command resets the unique event reference number to 10000.

For every triggered event, the relay generates and stores an event summary. The relay stores as many as 44 of the most recent event summaries (if event report length setting LER := 15), as many as 21 (if LER := 64), or as many as 8 (if LER := 180). When the relay stores a new event summary, it discards the oldest event and event summary if the event memory is full. Event summaries contain the following information:

- Relay and terminal identification (RID and TID)
- Event number, unique event reference number, date, time, event type (see *Table 10.1*), and frequency (FREQX, FREQY)
- Primary magnitudes of phase, neutral (if neutral CT is available), and residual currents (at the instant when maximum event current occurs)
- Primary magnitudes of the line-to-neutral voltage (WYE setting) or phase-to-phase voltages (DELTA setting), neutral voltage and synchronism-check voltage, if available
- Hottest RTD temperatures, SEL-2600 RTD Module or internal RTD card option necessary

The relay includes the event summary in the event report. The identifiers, date, and time information are at the top of the event report, and the remaining information follows at the end (See *Figure 10.3*). The example event summary in *Figure 10.1* corresponds to the standard 15-cycle event report in *Figure 10.3*.

```
=>SUM 10002 <Enter>

SEL-700GT+                              Date: 12/28/2017   Time: 10:52:49.394
INTERTIE RELAY

Serial No = 000000000000000
FID = SEL-700G-X336-V0-Z006003-D20171222                CID = 4610
EVENT LOGS =  3                    REF_NUM    = 10002

Event:       Trigger
Targets      10000000
Freqx, (Hz)  60.00
Freqy, (Hz)  60.00

Current Mag (X Side)
        IAX           IBX           ICX           IGX
(A)     100.5         100.5         100.0         0.71
Current Mag (Y Side)
        IAY           IBY           ICY           IGY
(A)     101.0         100.7         100.7         2.24

Neutral Current Mag
        IN
(A)      0.10


Voltage Mag (X Side)
       VAX    VBX    VCX    VGX
(V)      71     70     71      2

Voltage Mag (Y Side)
       VAY    VBY    VCY    VGY
(V)     124    120    120     22

Sync Voltage Mag
       VS
(V)     121
=>
```

Figure 10.1 Example Event Summary

The relay sends event summaries to all serial ports with setting AUTO := Y each time an event triggers.

Event Logs

The event logs field shows the number of events presently stored in the flash memory of the relay.

Event Reference Number

The event reference number is a unique event identification number assigned to the event. The unique event identification number of any event can be found by issuing the **HIS** command (see *Viewing the Event History on page 10.7* for details). The event reference number starts at 10000 and increments with each new event to a maximum of 42767. The event reference number rolls over to 10000 after reaching the next event after event 42767. The event reference number can be reset to 10000 by using the **HIS CA** command.

Event Type

The `Event` field displays the event type. Event types and the logic used to determine event types are shown in order of priority in *Table 10.1*.

Table 10.1 Event Types (Sheet 1 of 2)

Event Type	Event Type Logic
Diff 87 Trip	(87U OR 87R OR 87N1T OR 87N2T) AND TRIP
REF Trip	(REF1F OR REF1P) AND TRIP
Ph 50 Trip	(50PX1T OR 50PX2T OR 50PX3AT OR 50PX3BT OR 50PX3CT OR 50PY1T OR 50PY2T OR 50PY3AT OR 50PY3BT OR 50PY3CT OR 67PY1T OR 67PY2T) AND TRIP
Gnd 50 Trip	(50GX1T OR 50GX2T OR 50GY1T OR 50GY2T OR 67GX1T OR 67GX2T OR 67GY1T OR 67GY2T) AND TRIP
50Q Trip	(50QX1T OR 50QX2T OR 50QY1T OR 50QY2T OR 67QY1T OR 67QY2T) AND TRIP
Neutral 50 Trip	(50N1T OR 50N2T OR 67N1T OR 67N2T) AND TRIP
Neg Seq 46 Trip	46Q2T AND TRIP
Ph 51 Trip	(51PXT OR 51PYT) AND TRIP
Gnd 51 Trip	(51GXT OR 51GYT) AND TRIP
51Q Trip	(51QXT OR 51QYT) AND TRIP
Neutral 51 Trip	51N1T AND TRIP
PowerElemnt Trip	(3PWRX1T OR 3PWRX2T OR 3PWRX3T OR 3PWRX4T OR 3PWRY1T OR 3PWRY2T OR 3PWRY3T OR 3PWRY4T) AND TRIP
Backup Trip	(21C1T OR 21C2T OR 51VT OR 51CT) AND TRIP
Out of Step Trip	OOST AND TRIP
Volt/Hz 24 Trip	24C2T AND TRIP
Fld loss 40 Trip	(40Z1T OR 40Z2T) AND TRIP
Thermal 49 Trip	49T AND TRIP
64G/64F Gnd Trip	(64F1T OR 64F2T OR 64G1T OR 64G2T) AND TRIP
Frequency Trip	(81T OR 81RT OR BNDT) AND TRIP
Undervolt Trip	(R_TRIG 27PX1T OR R_TRIG 27PPX1T OR R_TRIG 27PY1T OR R_TRIG 27PPY1T OR 27I1T OR 27I2T) AND TRIP
Overvolt Trip	(59PX1T OR 59PPX1T OR 59QX1T OR 59GX1T OR 59PY1T OR 59PPY1T OR 59QY1T OR 59GY1T OR 59I1T OR 59I2T OR 59I3T OR 59I4T) AND TRIP
78VS Trip	78VSO AND TRIP
InadvertEnrgTrip	INADT AND TRIP
RTD Trip	RTDT AND TRIP
RTD Fail Trip	RTDFLT AND TRIP
Breaker Failure Trip	(BFTX OR BFTY) AND TRIP
Remote Trip	REMTRIP AND TRIP
CommIdleLossTrip	(COMMIDLE OR COMMLOSS) AND TRIP

Table 10.1 Event Types (Sheet 2 of 2)

Event Type	Event Type Logic
Trigger	Serial port **TRI** command
ER Trigger	ER Equation assertion
Trip	TRIP with no known cause
Trip*	Upon cycling power on the relay if the **TRIP** LED is latched and no active TRIP exists

Currents, Voltages, and RTD Temperatures

The relay determines the maximum cosine-filtered phase current during an event. The instant the maximum cosine-filtered phase current occurs is marked by an asterisk (*) in the event report (see *Figure 10.3*). This row of data corresponds to the analogs shown in the summary report for the event. Further, the relay looks at DI_A*n*, DI_B*n*, and DI_C*n* (*n* = X or Y) Relay Word bits to determine if the peak detector is active at the trigger point (>) of the event. If active, it will show the peak detector output current in the summary report appended with "pk" string for the corresponding phase current instead of the maximum cosine-filtered phase current identified by the asterisk (*).

The `Current Mag` fields display the primary current magnitudes at the instant when the maximum phase current was measured. The currents that are displayed are listed below (model dependent):

- X and Y-Side CIAX Currents (`IAX`, `IBX`, `ICX`, `IGX [IAX+IBX+ICX]`, `IAY`, `IBY`, `ICY`, `IGY [IAY+IBY+ICY]`)
- Neutral Current (`IN`)

The `Voltage Mag` fields display the primary voltage magnitudes at the instant when the maximum phase current was measured. The voltages that are displayed are listed below (model dependent):

- DELTAY_X or Y := WYE
  - Phase-to-Neutral Voltages (`VAX`, `VBX`, `VCX`, `VAY`, `VBY`, `VCY`)
  - Residual Voltage `VGX` (calculated from `VAX`, `VBX`, `VCX`), `VGY` (calculated from `VAY`, `VBY`, `VCY`)
- DELTAY_X or Y := DELTA
  - Phase-to-Phase Voltages (`VABX`, `VBCX`, `VCAX`, `VABY`, `VBCY`, `VCAY`)
- Sync Voltage (`VS`)
- Neutral Voltage (`VN`)

If the RTDs are connected, the hottest RTD (°C) fields display the hottest RTD reading in each RTD group. The hottest RTD temperatures in degrees centigrade (°C) are listed below:

- Ambient
- Winding
- Bearing
- Other

Event History

The event history report gives you a quick look at recent relay activity. The relay labels each new event in reverse chronological order with `1` as the most recent event. See *Figure 10.2* for a sample event history. Use this report to view the events that are presently stored in the SEL-700G.

The event history contains the following:

- Standard report header
  - Relay and terminal identification
  - Date and time of report
  - Time source (internal or IRIG-B)
- Event number, unique event reference number, date, time, event type (see *Table 10.1*)
- Maximum current
- Frequency
- Target LED status

```
=>>HIS <Enter>

SEL-700G                              Date: 02/24/2010   Time: 19:09:29.444
GENERATOR RELAY                       Time Source: External

FID = SEL-700G-X134-V0-Z001001-D20100224

 #     REF      DATE        TIME                          EVENT          CURRENT   FREQX    TARGETS
 1     10002    02/24/2010  19:08:09.705                  Diff 87 Trip   526.5     60.00    11100000
 2     10001    02/24/2010  19:03:51.756                  Diff 87 Trip   105.2     60.00    11100000
 3     10000    02/24/2010  19:00:20.948                  Volt/Hz 24 Trip  1.4     60.00    11000100

=>>
```

Event Number | Reference Number | Event Type | Maximum Current | Frequency | User-Defined Target LEDs

Figure 10.2 Sample Event History

Viewing the Event History

Access the history report from the communications ports, using the **HIS** command or the analysis menu within ACSELERATOR QuickSet SEL-5030 Software. View and download history reports from Access Level 1 and higher.

Use the **HIS** command from a terminal to obtain the event history. You can specify the number of the most recent events that the relay returns. See *HISTORY Command on page 7.56* for information on the **HIS** command.

Use the front-panel `MAIN > Events > Display` menu to display event history data on the SEL-700G front-panel display.

Use the QuickSet software to retrieve the relay event history. View the **Relay Event History** dialog box via the **Analysis > Get Event Files** menu.

Clearing

Use the **HIS C** command to clear or reset history data from Access Levels 1 and higher. Clear/reset history data at any communications port. This clears all event summaries, history records, and reports. The **HIS C** command does not reset the unique event reference number. This number continues to increment from the present value with each subsequent event. Use the **HIS CA** command to clear all event data and reset the unique event reference number to 10000.

Event Reports

The latest event reports are stored in nonvolatile memory. The SEL-700G Relay captures the following types of data:

- ➤ Analog values
- ➤ Digital states of the protection and control elements, plus status of digital output and input states
- ➤ Event Summary (includes the relay model number and serial number in Compressed ASCII event reports)
- ➤ Settings in service at the time of event triggering, consisting of Group, Logic, Global, and Report settings classes

The SEL-700G supports the following four separate event report types (model dependent):

- ➤ Standard Analog Event Report (**EVE** command)
- ➤ Digital Event Report (**EVE D** command)
- ➤ Differential Event Report (**EVE DIF***z* command, where *z* = 1, 2, or 3 for the three 87 elements)
- ➤ Ground Event Report (**EVE GND** command)

Analog Event Reports (EVE Command)

The analog event report includes:

- ➤ Analog values of currents IAX, IBX, ICX, IN, IAY, IBY, ICY (if available), voltages VAX (VABX), VBX (VBCX), VCX (VCAX), VAY (VABY), VBY (VBCY), VCY (VCAY), VN, VS and frequency FREQX, FREQY. Specific analog quantities depend on the SEL-700G model number
- ➤ Digital states of the base model digital inputs (2) and digital outputs (3)
- ➤ Event summary (includes the serial number of the product)
- ➤ Settings in service at the time of event triggering, consisting of Group, Logic, Global, and Report settings classes

Use the **EVE** command to retrieve the reports. The general command format is:

NOTE: In the SEL-700GT+ model, if X or Y is not specified, the relay defaults to the X-side event report.

EVE ***n*** **R X Y**

where:

n event number (defaults to 1 if it is not specified)

R specifies raw (unfiltered analog) data and displays 32 samples per cycle; if not specified, the data are filtered and display 4 samples per cycle.

X selects X-side voltages and currents as well as IN current. (Only available for the SEL-700GT+ model).

Y selects Y-side voltages and currents as well as VS voltage. (Only available for the SEL-700GT+ model).

The relay displays currents and voltages in primary values as part of the report. If the winding phase CTs are wye connected, the relay can accurately derive the primary currents from the secondary values through multiplying them by the corresponding CT ratio.

Delta-connected CTs, in general, remove zero-sequence current and introduce a phase shift. They also increase magnitude by $\sqrt{3}$ under balanced system conditions and as high as two times under unbalanced condition. As a result, the relay cannot derive the primary currents/quantities accurately. The relay performs the following under all system conditions in the case of delta-connected CTs. The primary currents displayed are derived from the secondary values through multiplying them by the corresponding CT ratio and dividing them by $\sqrt{3}$. The phase angles are not compensated and reflect the same values as measured on the secondary.

Filtered and Unfiltered Analog Event Reports

The SEL-700G samples the power system measurands (ac voltage and ac current) 32 times per power system cycle. A digital filter extracts the fundamental frequency component of the measurands. The relay operates on the filtered values and reports these values in the standard, filtered event report (4 samples per cycle).

To view the raw inputs to the relay, select the unfiltered event report by using the **EVE R** command. Use the unfiltered event reports to observe power system conditions:

- Power system transients on current and voltage channels
- Decaying dc offset during fault conditions on current channels

Raw event reports display one extra cycle of data at the beginning of the report. Also, unlike the filtered report, the raw event report shows the actual relay terminal voltage inputs so if the external connections are for DELTA input, VA = Vab, VB = 0, VC = –Vbc (in primary volts).

Analog Event Report Column Definitions

NOTE: Active channels depend on the specific relay model.

Refer to the example analog event report in *Figure 10.3* to view event report columns. This example event report displays rows of information each 1/4 cycle. Retrieve this report with the **EVE** command.

The columns contain analog values, including ac current, ac voltage, and frequency, followed by base model input and output information. *Table 10.2* summarizes the analog event report columns.

Table 10.2 Analog Event Report Columns Definitions (Sheet 1 of 2)

Column Heading	Column Symbols	Description
IAX		Current measured by channel IAX (primary A)
IBX		Current measured by channel IBX (primary A)
ICX		Current measured by channel ICX (primary A)
IAY		Current measured by channel IAY (primary A)
IBY		Current measured by channel IBY (primary A)
ICY		Current measured by channel ICY (primary A)
IN		Current measured by channel IN (primary A) when neutral CT is present
VAX or VABX		Voltage measured by channel VAX or VABX (primary V)
VBX or VBCX		Voltage measured by channel VBX or VBCX (primary V)
VCX or VCAX		Voltage measured by channel VCX or VCAX calculated from VABX and VBCX (primary V)

Table 10.2 Analog Event Report Columns Definitions (Sheet 2 of 2)

Column Heading	Column Symbols	Description
VAY or VABY		Voltage measured by channel VAY or VABY (primary V)
VBY or VBCY		Voltage measured by channel VBY or VBCY (primary V)
VCY or VCAY		Voltage measured by channel VCY or VCAY calculated from VABY and VBCY (primary V)
VN		Voltage measured by channel VN (primary V)
VS		Voltage measured by channel VS (primary V)
FREQX		Frequency measured by channel FREQX (hertz)
FREQY		Frequency measured by channel FREQY (hertz)
In 12	1 2 b	IN101 AND NOT IN102 NOT IN101 AND IN102 IN101 AND IN102
Out 12	1 2 b	OUT101 AND NOT OUT102 NOT OUT101 AND OUT102 OUT101 AND OUT102
Out 3	3	OUT103

Note that the ac values change from plus to minus (–) values in *Figure 10.3*, indicating the sinusoidal nature of the waveforms.

Other figures help in understanding the information available in the event report current columns:

- *Figure 10.4* shows how analog event report current column data relate to the actual sampled current waveform and rms current values.
- *Figure 10.5* shows how analog event report current column data can be converted to phasor rms current values.

Example 15-Cycle Event Report

Figure 10.3 is an example of a standard analog 15-cycle event report that corresponds to the example SER report in *Figure 10.13*.

In *Figure 10.3*, the trigger row includes an arrow (>) immediately following the last analog column to indicate the trigger point. This is the row that corresponds to the Date and Time values at the top of the event report.

The row including the asterisk (*) immediately following the last analog column identifies the row with the maximum phase current. The maximum phase current is calculated from the row identified with the asterisk and the row one quarter-cycle previous (see *Figure 10.4* and *Figure 10.5*). These currents are listed at the end of the event report in the event summary. If the trigger row (>) and the maximum phase current row (*) are the same row, the * symbol takes precedence.

```
=>>EVE X <Enter>

SEL-700GT                                 Date: 03/30/2018   Time: 16:28:47.356
INTERTIE RELAY
```

Date and Time of Event

```
Serial Number=3162580026
FID=SEL-700G-X346-V0-Z006003-D20180314   CID=A6BC
```

Firmware and Checksum Identifier

```
                                                         O
                                                       I u
                                                       N t
     Currents (Amps Pri)     Voltages (Volts Pri)      1 13
    IAX    IBX    ICX    IN    VAX    VBX    VCX FREQX 2 2
```

Analog and Digital Header

```
[1]
-1172.5  962.5  202.5   0.0  -6758   2551   4200 60.00 . .*
 -440.0 -802.5 1232.5  -0.5    962  -6327   5366 60.00 . .*
 1172.5 -965.0 -207.5   0.0   6757  -2549  -4203 60.00 . .*
  435.0  800.0-1235.0   0.0   -967   6327  -5364 60.00 . .*
```

One Cycle of Data

```
[2]
-1172.5  962.5  207.5  -0.5  -6757   2544   4205 60.00 . .*
 -437.5 -802.5 1232.5   0.0    970  -6329   5361 60.00 . .*
 1170.0 -965.0 -210.0  -0.5   6755  -2542  -4209 60.00 . .*
  435.0  800.0-1235.0   0.0   -975   6330  -5359 60.00 . .*
[3]
-1175.0  960.0  205.0   0.0  -6755   2538   4211 60.00 . .*
 -435.0 -802.5 1235.0  -0.5    977  -6332   5356 60.00 . .*
 1172.5 -965.0 -210.0   0.0   6754  -2535  -4215 60.00 . .*
  432.5  802.5-1235.0   0.0   -981   6332  -5355 60.00 . .*
[4]
-1172.5  960.0  207.5  -0.5  -6755   2531   4216 60.00 . .*
 -435.0 -805.0 1232.5  -0.5    983  -6334   5351 60.00 . .*
 1172.5 -962.5 -210.0   0.0   6753  -2529  -4220 60.00 . .*
  430.0  802.5-1235.0  -0.5   -988   6335  -5351 60.00 . .*
[5]
-1175.0  960.0  210.0  -0.5  -6753   2524   4222 60.00 . .*
 -435.0 -805.0 1232.5   0.0    989  -6337   5348 60.00 . .*
 1172.5 -962.5 -212.5   0.0   6752  -2522  -4226 60.00 . .*

  430.0  805.0-1235.0   0.0   -994   6337  -5346 60.00>. .*
```

Trigger Row

```
[6]
-1175.0  960.0  210.0   0.0  -6753   2518   4228 60.00 . .*
 -435.0 -807.5 1230.0  -0.5    998  -6339   5342 60.00 . .*
 1172.5 -962.5 -212.5   0.0   6751  -2516  -4231 60.00 . .*

  430.0  805.0-1232.5   0.0  -1003   6340  -5341 60.00 . .*
[7]
-1175.5  957.5  210.0   0.0  -6752   2511   4233 60.00 . .*
 -430.5 -807.5 1230.0  -0.5   1006  -6343   5337 60.00 . .*
 1175.0 -960.0 -212.5   0.0   6750  -2509  -4237 60.00 . .*
```

See Figure 10.4 and Figure 10.5

```
427.5  807.5-1232.5   0.5  -1010   6343  -5337 60.00 . .*
[8]
-1175.0  957.5  212.5  -0.5  -6750   2505   4238 60.00 . .*
 -430.0 -810.0 1232.5  -0.5   1012  -6346   5335 60.00 . .*
 1175.0 -960.0 -217.5   0.0   6748  -2503  -4243 59.99 . .*
  425.0  805.0-1235.0   0.0  -1017   6346  -5333 59.99 . .*

 [9]
-1175.0  957.5  217.5  -0.5  -6749   2498   4244 59.99 . .*
 -427.5 -810.0 1232.5  -0.5   1019  -6348   5330 59.99 . .*
 1172.5 -960.0 -217.5   0.0   6748  -2496  -4248 59.99 . .*
  425.0  810.0-1235.0  -0.5  -1024   6348  -5328 59.99 . .*

 [10]
-1177.5  957.5  212.5   0.0  -6748   2491   4251 59.99 . .*
 -427.5 -812.5 1232.5  -0.5   1026  -6351   5326 59.99 . .*
 1172.5 -957.5 -217.5  -0.5   6747  -2488  -4255 59.99 . .*
  422.5  807.5-1235.0   0.0  -1029   6350  -5324 59.99*. .*

[11]
-1177.5  955.0  217.5   0.0  -6748   2484   4256 59.99 . .*
 -425.0 -812.5 1230.0  -0.5   1033  -6352   5319 59.99 . .*
 1175.0 -957.5 -222.5   0.0   6746  -2482  -4260 59.99 . .*
  422.5  810.0-1235.0   0.0  -1038   6353  -5318 59.99 . .*

[12]
-1180.0  955.0  220.0   0.0  -6746   2477   4261 59.99 . .*
 -425.0 -812.5 1232.5  -0.5   1041  -6356   5316 59.99 . .*
 1177.5 -957.5 -222.5  -0.5   6744  -2475  -4266 59.99 . .*
  420.0  812.5-1235.0   0.0  -1045   6356  -5314 59.99 . .*
```

Figure 10.3 Example Standard 15-Cycle Analog Event Report 1/4-Cycle Resolution

```
[13]
-1180.0  955.0  220.0   0.0  -6745   2470   4268 59.99 . .*
 -422.5 -815.0 1232.5  -0.5   1048  -6359   5311 59.99 . .*
 1177.5 -955.0 -222.5  -0.5   6743  -2468  -4271 59.99 . .*
  420.0  812.5-1235.0   0.0  -1053   6359  -5310 59.99 . .*
[14]
-1180.0  952.5  222.5  -0.5  -6743   2463   4273 59.99 . .*
 -422.5 -815.0 1232.5  -0.5   1055  -6362   5308 59.99 . .*
 1177.5 -952.5 -225.0  -0.5   6742  -2461  -4277 59.99 . .*
  420.0  812.5-1232.5   0.0  -1059   6361  -5306 59.99 . .*
[15]
-1180.0  950.0  222.5   0.0  -6742   2457   4279 59.99 . .*
 -422.5 -815.0 1230.0   0.0   1062  -6363   5302 59.99 . .*
 1177.5 -955.0 -225.0   0.0   6741  -2455  -4283 59.99 . .*
  420.0  815.0-1235.0  -0.5  -1066   6363  -5301 59.99 . .*

Serial No = 3162580026      FID = SEL-700G-X346-V0-Z006003-D20180314
CID = A6BC                  EVENT LOGS = 54            REF_NUM = 10081

Event:       Volt/Hz 24 Trip
Targets      11000101
Freqx, (Hz)  60.00
Freqy, (Hz)  60.00

Current Mag (X Side)
        IAX           IBX           ICX           IGX
(A)    1246.3        1252.5        1254.0          5.59

Current Mag (Y Side)
        IAY           IBY           ICY           IGY
(A)    1251.0        1248.1        1260.6          7.91

Neutral Current Mag
        IN
(A)      0.50

Voltage Mag (X Side)
       VAX    VBX    VCX    VGX
(V)    6825   6820   6815      5

Voltage Mag (Y Side)
       VAY    VBY    VCY    VGY
(V)    6782   6777   6782     65

Sync Voltage Mag
       VS
(V)       0

SETTINGS CHANGED SINCE EVENT

Global Settings
FNOM    := 60      FRQTRK  := X       DATE_F  := MDY     METHRES := Y
FAULT   := 51V OR 51C OR 50PX1P OR 46Q2 OR 67PY1P OR 67QY1P OR 67GY1P OR 67N1P OR 51PYP OR
    51QYP OR 51GYP OR TRIP

EMP     := N

TGR     := 3
SS1     := 1
SS2     := 0
SS3     := 0
SS4     := 0

EPMU    := N
IRIGC   := NONE    UTC_OFF := 0.00    DST_BEGM:= OFF
52ABF   := N       BFDX    := 0.50    BFIX    := R_TRIG TRIPX
BFDY    := 0.50    BFIY    := R_TRIG TRIPY

IN101D  := 10      IN102D  := 10
IN301D  := 10      IN302D  := 10      IN303D  := 10      IN304D  := 10
EBMONX  := Y       COSP1X  := 10000   COSP2X  := 150     COSP3X  := 12
KASP1X  := 1.20    KASP2X  := 8.00    KASP3X  := 20.00   BKMONX  := TRIPX

EBMONY  := Y       COSP1Y  := 10000   COSP2Y  := 150     COSP3Y  := 12
KASP1Y  := 1.20    KASP2Y  := 8.00    KASP3Y  := 20.00   BKMONY  := TRIPY

RSTTRGT := 0
RSTENRGY:= 0
RSTMXMN := 0
RSTDEM  := 0
RSTPKDEM:= 0

DSABLSET:= 0
```

Figure 10.3 Example Standard 15-Cycle Analog Event Report 1/4-Cycle Resolution (Continued)

```
TIME_SRC:= IRIG1
89A2P1  := 0
89B2P1  := NOT 89A2P1
89A2P1D := 5.00    89A2P2  := 0
89B2P2  := NOT 89A2P2
89A2P2D := 5.00    89A2P3  := 0
89B2P3  := NOT 89A2P3
89A2P3D := 5.00    89A2P4  := 0
89B2P4  := NOT 89A2P4
89A2P4D := 5.00    89A2P5  := 0
89B2P5  := NOT 89A2P5
89A2P5D := 5.00    89A2P6  := 0
89B2P6  := NOT 89A2P6
89A2P6D := 5.00    89A2P7  := 0
89B2P7  := NOT 89A2P7
89A2P7D := 5.00    89A2P8  := 0
89B2P8  := NOT 89A2P8
89A2P8D := 5.00
EN_LRC  := N       EN_LRC  := N

Group Settings

RID     := SEL-700GT
TID     := INTERTIE RELAY
PHROT   := ABC     CTRX    := 500     INOM    := 5.0     DELTAY_X:= WYE
PTRX    := 100.00  VNOM_X  := 20.00   CTRY    := 500     DELTAY_Y:= WYE
PTRY    := 100.00  VNOM_Y  := 13.80   PTRS    := 1000.00 CTRN    := 100

E87N    := N

EREF    := N

E64F    := N

EBUP    := V       51VP    := 8.00    51VCA   := 0       51VC    := U2
51VTD   := 3.00    51VRS   := Y       51VTC   := NOT LOPX

E40     := Y       40Z1P   := 13.4
40XD1   :=-2.5     40Z1D   := 0.00    40Z2P   := 13.4
40XD2   :=-2.5     40Z2D   := 0.50    40ZTC   := NOT LOPX
E46     := Y
46Q1P   := 8.0     46Q1D   := 30.00   46Q2P   := 8.0     46Q2K   := 10
46QTC   := 1
E49T    := Y       49TTP   := 1.10    GTC1    := 10      GTC2    := OFF
49TAP   := 85
E24     := Y       24D1P   := 105
24D1D   := 1.00    24CCS   := ID      24IP    := 105     24IC    := 2
24ITD   := 0.1
24D2P2  := 176     24D2D2  := 3.00    24CR    := 240.00  24TC    := 1

EINAD   := N

50PX1P  := OFF     50PX2P  := OFF     50PX3P  := OFF     50GX1P  := OFF
50GX2P  := OFF     50QX1P  := OFF     50QX2P  := OFF
51GXP   := OFF
50PY1P  := OFF     50PY2P  := OFF     50PY3P  := OFF     50GY1P  := OFF
50GY2P  := OFF     50QY1P  := OFF     50QY2P  := OFF
51PYP   := OFF     51GYP   := OFF     51QYP   := OFF     50N1P   := OFF
50N2P   := OFF     51NP    := OFF     EDIRX   := N       EDIRY   := N
ELOADY  := N       EPWRX   := 2       3PWRX1P := 50.0    PWRX1T  := -WATTS
PWRX1D  := 20.00   3PWRX2P := 25.0    PWRX2T  := +WATTS  PWRX2D  := 1.00
EPWRY   := N
E81X    := N

E81Y    := N

E81RX   := N
E81RY   := N
E81ACC  := N
```

Figure 10.3 Example Standard 15-Cycle Analog Event Report 1/4-Cycle Resolution (Continued)

```
LOPBLKX := SV13T OR FREQX < MV01

LOPBLKY := SV13T OR FREQX < MV01
27PX1P  := OFF     27PX2P  := OFF
27PPX1P := 93.5    27PPX1D := 0.50    27PPX2P := OFF
27PY1P  := OFF     27PY2P  := OFF
27PPY1P := 93.5    27PPY1D := 0.50    27PPY2P := OFF
59PX1P  := OFF     59PX2P  := OFF
59PPX1P := OFF     59PPX2P := OFF

59PY1P  := OFF     59PY2P  := OFF
59PPY1P := OFF     59PPY2P := OFF

E27V1X  := 1       27V1X1P := 5.0     27V1X1D := 0.50
E59V1X  := N
59QX1P  := OFF     59QX2P  := OFF
59QY1P  := OFF     59QY2P  := OFF
59GX1P  := OFF     59GX2P  := OFF
59GY1P  := OFF     59GY2P  := OFF
27S1P   := OFF     27S2P   := OFF
59S1P   := OFF     59S2P   := OFF

E27I1   := N       E27I2   := N

E59I1   := N       E59I2   := N       E59I3   := N       E59I4   := N

E49RTD  := NONE

E78VS   := OFF

E25X    := Y
25VLOX  := 50.00   25VHIX  := 70.00   25VDIFX := OFF     25RCFX  := 1.000
GENV+   := N       25SLO   :=-0.50    25SHI   := 0.50    25ANG1X := 10
25ANG2X := 20      CANGLE  := 3       SYNCPX  := VAX     TCLOSDX := OFF
CFANGLE := OFF
BSYNCHX := NOT 3POX

E25Y    := N       EAUTO   := DIG     FSYNCT  := 100     FADJRATE:= 0.10
FPULSEI := 5       FPLSMIND:= 0.10    FPLSMAXD:= 1.00    KPULSEI := 5
KPLSMIND:= 0.02    KPLSMAXD:= 0.04    FSYNCST := 0
VSYNCT  := 100     VADJRATE:= 1.00    VPULSEI := 5       VPLSMIND:= 0.10
VPLSMAXD:= 1.00    VSYNCST := 0
EDEM    := ROL     DMTC    := 15      PHDEMPX := OFF     GNDEMPX := OFF
3I2DEMPX:= OFF
PHDEMPY := OFF     GNDEMPY := OFF     3I2DEMPY:= OFF
50LXP   := 0.25    3POXD   := 0.00    50LYP   := 0.25    3POYD   := 0.00
TDURD   := 0.50    CFDX    := 0.50    CFDY    := 0.50
TRX     := SV06 OR SV07 OR SV08 OR 46Q2T OR 81X1T OR 81X2T OR 81RX1T OR 81RX2T OR NOT LT02
    AND SV04T OR OCX

TR1     := SV06 OR SV07 OR SV08
TR2     := SV06 OR SV07 OR LT06
TR3     := SV06 OR SV07

TRY     := SV09 OR SV10 OR LT02 AND SV04T OR OCY

REMTRIP := 0
ULTRX   := 3POX

ULTR1   := NOT TR1
ULTR2   := NOT TR2
ULTR3   := NOT TR3

ULTRY   := 3POY

52AX    := CLOSEX
52BX    := NOT 52AX

CLX     := 25AX1

ULCLX   := 0

52AY    := 0
52BY    := NOT 52AY

CLY     := SV03T AND LT02 OR CCY OR SV12T AND 25AY1

ULCLY   := TRIPY
```

Figure 10.3 Example Standard 15-Cycle Analog Event Report 1/4-Cycle Resolution (Continued)

```
Report Settings

ESERDEL := N

SER1    := 25AX1 CLX 25AX2 OUT101 IN101
SER2    := ORED51T ORED50T 87U 87R OOST 21C1T 21C2T 3PWRX1T 3PWRX2T 3PWRY1T
3PWRY2T REF1F REF1R 24D1T 24C2T RTDT
SER3    := 64G1T 64G2T 64F1T 64F2T 46Q1T 46Q2T LOPX LOPY 81X1T 81X2T 81Y1T
81Y2T
SER4    := CLOSEX

EALIAS  := 4

ALIAS1  :=PB01 FP_LOCK PICKUP DROPOUT
ALIAS2  :=PB02 FP_BRKR_SELECT PICKUP DROPOUT
ALIAS3  :=PB03 FP_CLOSE PICKUP DROPOUT
ALIAS4  :=PB04 FP_TRIP PICKUP DROPOUT

ER      := 0
LER     := 15      PRE     := 5
FMR1NAM := FMR1
FMR1    :=NA
FMR2NAM := FMR2
FMR2    :=NA
FMR3NAM := FMR3
FMR3    :=NA
FMR4NAM := FMR4
FMR4    :=NA
RA01TYPE:= I
RA02TYPE:= I
RA03TYPE:= I
RA04TYPE:= I
RA05TYPE:= I
RA06TYPE:= I
RA07TYPE:= I
RA08TYPE:= I
RA09TYPE:= I
RA10TYPE:= I
RA11TYPE:= I
RA12TYPE:= I
RA13TYPE:= I
RA14TYPE:= I
RA15TYPE:= I
RA16TYPE:= I
RA17TYPE:= I
RA18TYPE:= I
RA19TYPE:= I
RA20TYPE:= I
RA21TYPE:= I
RA22TYPE:= I
RA23TYPE:= I
RA24TYPE:= I
RA25TYPE:= I
RA26TYPE:= I
RA27TYPE:= I
RA28TYPE:= I
RA29TYPE:= I
RA30TYPE:= I
RA31TYPE:= I
RA32TYPE:= I
GSRTRG  := CLX
GSRR    := 0.25    PRESYNC := 2000

LDLIST  := NA

LDAR    := 15

Logic Settings


ELAT    := 6       ESV     := 14      ESC     := N       EMV     := 1

SET01   := R_TRIG SV01T AND NOT LT01
RST01   := R_TRIG SV01T AND LT01
SET02   := R_TRIG SV02T AND NOT LT02 AND PB02
RST02   := R_TRIG SV02T AND LT02 AND PB02
SET03   := (PB03 AND R_TRIG SV02T) AND LT01 AND NOT (52AX AND NOT LT02 OR 52AY AND LT02)
RST03   := (R_TRIG SV02T OR SV03T) AND LT03
SET04   := (PB04 AND R_TRIG SV02T) AND (52AX AND NOT LT02 OR 52AY AND LT02)
RST04   := (R_TRIG SV02T OR SV04T) AND LT04
SET05   := NA
RST05   := NA
SET06   := LB01 OR RB01
RST06   := 3POX
```

Figure 10.3 Example Standard 15-Cycle Analog Event Report 1/4-Cycle Resolution (Continued)

```
SV01PU  := 3.00    SV01DO  := 0.00
SV01    := PB01
SV02PU  := 0.25    SV02DO  := 0.00
SV02    := PB01 OR PB02 OR PB03 OR PB04
SV03PU  := 0.00    SV03DO  := 0.00
SV03    := LT03
SV04PU  := 0.00    SV04DO  := 0.00
SV04    := LT04
SV05PU  := 0.25    SV05DO  := 0.25
SV05    := (PB01 OR PB02 OR LT03 OR LT04) AND NOT SV05T
SV06PU  := 0.00    SV06DO  := 0.00
SV06    := 87N1T OR 87N2T OR REF1P OR 67GX1T OR 67GX2T OR INADT OR 64F2T
SV07PU  := 0.00    SV07DO  := 0.00
SV07    := 51CT OR 51VT OR 51GXT OR 51NT OR 67N1T OR 67N2T OR 49T OR LT06 AND NOT 3PWRX2T AND
    NOT LOPX
SV08PU  := 0.00    SV08DO  := 0.00
SV08    := 24C2T OR 3PWRX1T OR 40Z1T OR 40Z2T
SV09PU  := 0.00    SV09DO  := 0.00
SV09    := 50PY3AT OR 50PY3BT OR 50PY3CT OR 67PY1T OR 67PY2T OR 67GY1T OR 67GY2T OR 67QY1T
    OR 67QY2T
SV10PU  := 0.00    SV10DO  := 0.00
SV10    := 51PYT OR 51GYT OR 51QYT OR 3PWRY1T OR 3PWRY2T OR 81Y1T OR 81Y2T OR 81RY1T OR
    81RY2T
SV11PU  := 0.00    SV11DO  := 2.00
SV11    := 0
SV12PU  := 0.00    SV12DO  := 2.00
SV12    := 0
SV13PU  := 0.00    SV13DO  := 0.20
SV13    := R_TRIG ZCFREQX OR F_TRIG ZCFREQX OR F_TRIG ASYNSDC
SV14PU  := 0.00    SV14DO  := 0.00
SV14    := FREQX > 16.00

Math Variables
MV01    := FREQX * SV14 + MV01 * NOT SV14


OUT101FS:= N       OUT101  := CLOSEX
OUT102FS:= N       OUT102  := 0
OUT103FS:= N       OUT103  := TRIPX
OUT301FS:= N       OUT301  := 0
OUT302FS:= N       OUT302  := 0
OUT303FS:= N       OUT303  := 0
OUT304FS:= N       OUT304  := 0


=>>
```

Figure 10.3 Example Standard 15-Cycle Analog Event Report 1/4-Cycle Resolution (Continued)

Figure 10.4 and *Figure 10.5* look in detail at an example of one cycle of A-phase current (channel IAX) data similar to what is shown in *Figure 10.3*. *Figure 10.4* shows how the event report ac current column data relate to the actual sampled waveform and rms values. *Figure 10.5* shows how the event report current column data can be converted to phasor rms values. Voltages are processed similarly.

In *Figure 10.4*, note that you can use any two rows of current data from the analog event report, 1/4 cycle apart, to calculate rms current values.

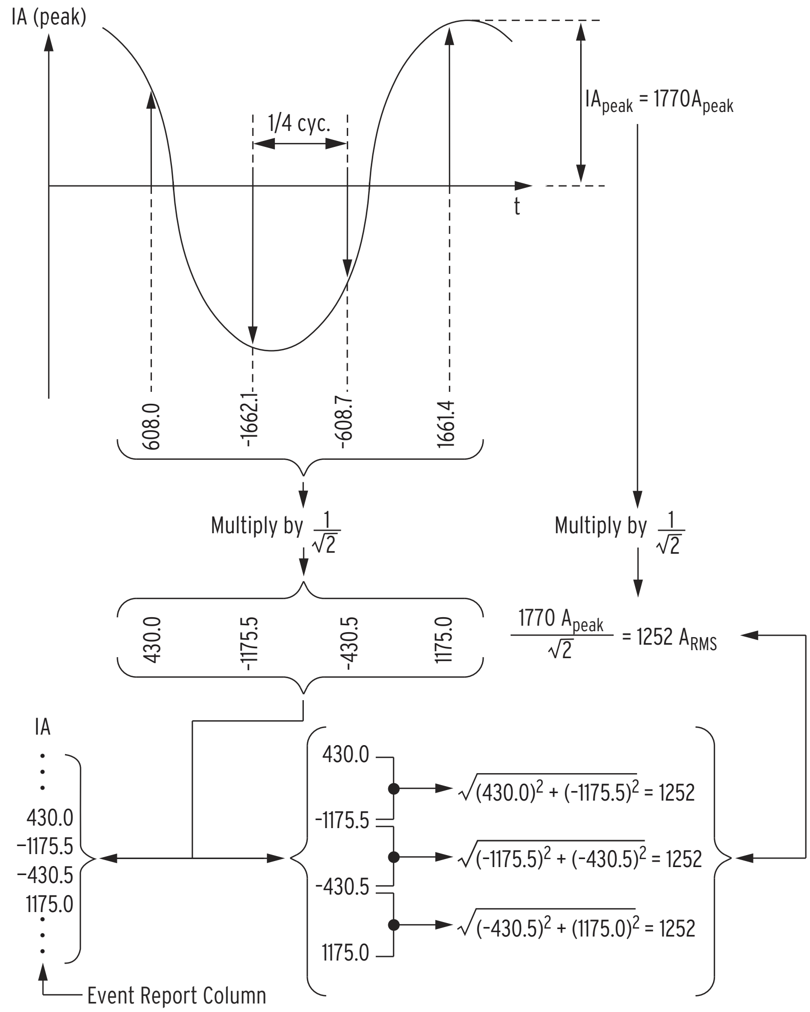


Figure 10.4 Derivation of Analog Event Report Current Values and RMS Current Values From Sampled Current Waveform

In *Figure 10.5*, note that you can use two rows of current data from the analog event report, 1/4 cycle apart, to calculate phasor rms current values. In *Figure 10.5*, at the present sample, the phasor rms current value is:

$$IA = 1252\ A\angle{-20.12°}$$

Equation 10.1

The present sample (IA = 1175.0 A) is a real rms current value that relates to the phasor rms current value:

$$1252\ A \bullet \cos(-20.12°) = 1175.5.5\ A$$

Equation 10.2

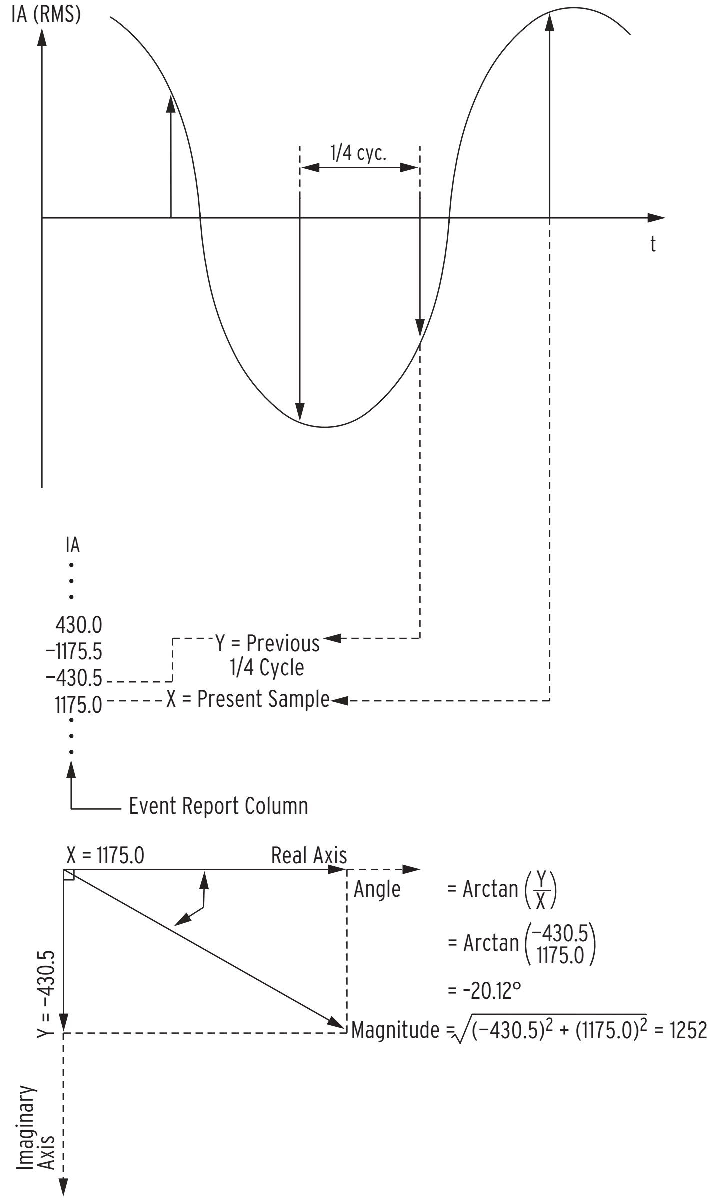


Figure 10.5 Derivation of Phasor RMS Current Values From Event Report Current Values

NOTE: The arctan function of many calculators and computing programs does not return the correct angle for the second and third quadrants (when X is negative). When in doubt, graph the X and Y quantities to confirm that your calculator reports the correct angle.

Retrieving Event Reports Via Ethernet File Transfer

Selected event reports are available as read-only files that can be retrieved using Ethernet File Transfer Protocol (FTP) or Manufacturing Message Specification (MMS). MMS is only available in models that support IEC 61850 and only when IEC 61850 and MMS File transfer are enabled (E61850 := Y, EMMSFS := Y). See *File Transfer Protocol (FTP) and MMS File Transfer on page 7.15*, *Virtual File Interface on page 7.77*, and *MMS on page G.5* for additional information.

The Ethernet file server EVENTS folder contains two types of files for each event stored in the relay:

➤ Compressed, 4 sample/cycle, filtered event, equivalent to issuing a CEV command. These files are named C4.*nnnnn*.cev, where *nnnnn* is the unique event identifier.

➤ Compressed, 32 sample/cycle, unfiltered event, equivalent to issuing a **CEV R** command. These files are named CR.*nnnnn*.cev, where *nnnnn* is the unique event identifier.

The date and time displayed for events are from the time of event trigger. The times are UTC.

The EVENTS folder also contains the event history with unique event identification number (equivalent to the **HIS** command) and the compressed event history (equivalent to the **CHIS** command). See *HISTORY Command on page 7.56*. The Event files can also be retrieved with the **FIL** command. See *FILE Command on page 7.50* and *Compressed Event Reports on page 10.2* for additional information.

CEVENT

The relay provides a Compressed ASCII event report for SCADA and other automation applications. QuickSet uses Compressed ASCII commands to gather event report data. If you want to view the Compressed ASCII event report data, use a terminal to issue ASCII command CEV. A sample of the report appears in *Figure 10.6*; this is a comma-delimited ASCII file. The relay appends a four-digit hex checksum at the end of the line in the Compressed ASCII report.

Items included in the Compressed ASCII event report are similar to the event report, although the relay reports the items in a special order. CEV files (and COMTRADE files) include all Relay Word bits (see *Appendix L: Relay Word Bits*). See *SEL Compressed ASCII Commands on page C.1* for more information on the Compressed ASCII command set.

```
=>>CEV <Enter>
"FID","CEV_VER","PART_NUM","SER_NUM","097C"
"FID=SEL-700G-X339-V0-Z006003-D20170125","2.0.1","0700G11B0X0X7685067X","000000000000000","1299"
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","0ACA"
3,20,2018,7,58,21,197,"043C"
```

Report Header

```
REC_NUM","REF_NUM","NUM_CH_A","NUM_CH_D","FREQX","FREQY","NFREQ","SAM/CYC_A","SAM/
CYC_D","NUM_OF_CYC","PRIM_VAL","CTR_IAX","CTR_IBX","CTR_ICX","CTR_IGX","CTR_IAY","CTR_IBY","CTR_ICY",
"CTR_IGY","CTR_IN","PTR_VAX","PTR_VBX","PTR_VCX","*","*","PTR_VN","PTR_VS","EVENT","GROUP","IAX(A)","
IBX(A)","ICX(A)","IGX(A)","IAY(A)","IBY(A)","ICY(A)","IGY(A)","IN(A)","VAX(V)","VBX(V)","VCX(V)","VGX
(V)","*","*","VN(V)","*","VS(V)","WDG(C)","BRG(C)","AMB(C)","OTH(C)","6C71"
```

Summary Labels

```
1,18185,19,1408,60.0,60.0,60,4,4,15,"YES",500.00,500.00,500.00,500.00,50.00,50.00,50.00,50.00,100.00,
100.00,100.00,100.00,1.0,1.0,100.00,100.00,"Trigger",1,2055.0,2573.3,3101.6,902.92,0.4,0.4,0.6,1.25,3
09.09,6818.123,6928.081,7020.118,172.047,0.000,0.000,1.414,14.142,0.000,"NA","NA","NA","NA","396E"
```

Summary Data

Figure 10.6 Sample Compressed ASCII Event Report

```
"IAX(A)","IBX(A)","ICX(A)","IGX(A)","IAY(A)","IBY(A)","ICY(A)","IGY(A)","IN(A)","VAX(V)","VBX(V)","VC
X(V)","*","*","VN(V)","VS(V)","FREQX(Hz)","*","FREQS(Hz)","TRIG","50PX1P 50PX1T 50PX2P 50PX2T 50PY1P
50PY1T 50PY2P 50PY2T 50PX3AP 50PX3AT 50PX3BP 50PX3BT 50PX3CP 50PX3CT * ORED50T 50PY3AP 50PY3AT 50PY3BP
50PY3BT 50PY3CP 50PY3CT LOPBLKX LOPBLKY * * * * 50QX1P 50QX1T 50QX2P 50QX2T 50GY1P 50GY1T 50GY2P
50GY2T 50QY1P 50QY1T 50QY2P 50QY2T 67GX1P 67GX1T 67GX2P 67GX2T * * * * * * * * * * * * * * * * 46Q1
46Q1T 46Q2 46Q2T 51PXP 51PXT 51QXP 51QXT 51GXP 51GXT * ORED51T 51PYP 51PYT 51QYP 51QYT 51GYP 51GYT
51NP 51NT 87U1 87U2 87U3 87U 87R1 87R2 87R3 87R 87N1 87N1T 87N2 87N2T 40Z1 40Z1T 40Z2 40Z2T 50NREF1
REF1EN 50GREF1 REF1F REF1R REF1P REF1BYP * 64G1 64G1T 64G2 64G2T T64G N64G 51C 51CT 64F1 64F1T 64F2
64F2T 64FFLT * 51V 51VT 27PX1 27PX1T 27PX2 27PX2T 27PY1 27PY1T 27PY2 27PY2T 59PX1 59PX1T 59PX2 59PX2T
59PY1 59PY1T 59PY2 59PY2T 59QX1 59QX1T 59QX2 59QX2T 59GX1 59GX1T 59GX2 59GX2T 59QY1 59QY1T 59QY2
59QY2T 59GY1 59GY1T 59GY2 59GY2T 3PWRX1P 3PWRX1T 3PWRX2P 3PWRX2T 3PWRX3P 3PWRX3T 3PWRX4P 3PWRX4T
3PWRY1P 3PWRY1T 3PWRY2P 3PWRY2T 3PWRY3P 3PWRY3T 3PWRY4P 3PWRY4T 24D1 24D1T 24C2 24C2T 24CR * 81RT BNDT
BFTX BFTY INAD INADT 49A 49T RTDT RTDFLT MPP1P MABC1P MPP2P MABC2P 21C1P 21C1T 21C2P 21C2T REMTRIP
COMMIDLE COMMLOSS COMMFLT ER PMTRIG * TRIP 87BL1 87BL2 87BL3 87HB 87HR1 87HR2 87HR3 87HR TH5 TH5T 51CR
51VR 3P59X 3P59Y 3P27X 3P27Y 27S1 27S1T 27S2 27S2T 59S1 59S1T 59S2 59S2T 81X1T 81X2T 81X3T 81X4T 81X5T
81X6T 81XT 81T 81Y1T 81Y2T 81Y3T 81Y4T 81Y5T 81Y6T 81YT * 81RX1T 81RX2T 81RX3T 81RX4T 81RY1T 81RY2T
81RY3T 81RY4T BND1T BND2T BND3T BND4T BND5T BND6T BFIX BFIY 78R1 78R2 78Z1 SWING OOS OOST ZLOADX
ZLOADY 59VPX 59VSX VDIFX SFX 25AX1 25AX2 25C GSRTRG GENVHI GENVLO GENFHI GENFLO FRAISE FLOWER VRAISE
VLOWER 59VPY 59VSY VDIFY SFY 25AY1 25AY2 CFA BKRCF 51PXR 51QXR 51GXR 51PYR 51QYR 51GYR 51NR 46Q2R
2_4HB1 2_4HB2 2_4HB3 2_4HBL 5HB1 5HB2 5HB3 5HBL 3POX 50LX 52AX 3POY 50LY 52AY 81RXT 81RYT CLOSEX CFX
CCX AST CLOSEY CFY CCY FSYNCTO TRX TRY TR1 TR2 TR3 OCX OCY VSYNCTO TRIPX TRIPY TRIP1 TRIP2 TRIP3 CLX
CLY ASP ULTRX ULTRY ULTR1 ULTR2 ULTR3 ULCLX ULCLY * AMBALRM AMBTRIP OTHALRM OTHTRIP WDGALRM WDGTRIP
BRGALRM BRGTRIP OUT101 OUT102 OUT103 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * IN101
IN102 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * LINKA LINKB PMDOK SALARM WARNING TSOK
IRIGOK FAULT 87AP 87AT LOPX LOPY CFGFLT LINKFAIL PASEL PBSEL ZLOUTY ZLINY VPOLVX VPOLVY RSTENRGY
RSTMXMN RSTDEM RSTPKDEM TESTDB RTDIN RTDA RTDBIAS TRGTR DSABLSET RSTTRGT HALARM RTD1A RTD1T RTD2A
RTD2T RTD3A RTD3T RTD4A RTD4T RTD5A RTD5T RTD6A RTD6T RTD7A RTD7T RTD8A RTD8T RTD9A RTD9T RTD10A
RTD10T RTD11A RTD11T RTD12A RTD12T BND1A BND2A BND3A BND4A BND5A BND6A 64F1C BNDA SG1 SG2 SG3 SG4
TREA1 TREA2 TREA3 TREA4 PHDEMX 3I2DEMX GNDEMX ASYNSDC PHDEMY 3I2DEMY GNDEMY 64F2C BCWX BCWAX BCWBX
BCWCX BCWY BCWAY BCWBY BCWCY DNAUX1 DNAUX2 DNAUX3 DNAUX4 DNAUX5 DNAUX6 DNAUX7 DNAUX8 DNAUX9 DNAUX10
DNAUX11 RELAY_EN * INR1 INR2 INR3 PB01 PB02 PB03 PB04 PB01_PUL PB02_PUL PB03_PUL PB04_PUL PB1A_LED
PB1B_LED PB2A_LED PB2B_LED PB3A_LED PB3B_LED PB4A_LED PB4B_LED TRICOLOR * T01_LED T02_LED T03_LED
T04_LED T05_LED T06_LED FREQTRKX FREQTRKY ZCFREQX ZCFREQY ZCFREQS FREQXOK FREQYOK FREQSOK LB01 LB02
LB03 LB04 LB05 LB06 LB07 LB08 LB09 LB10 LB11 LB12 LB13 LB14 LB15 LB16 LB17 LB18 LB19 LB20 LB21 LB22
LB23 LB24 LB25 LB26 LB27 LB28 LB29 LB30 LB31 LB32 RB01 RB02 RB03 RB04 RB05 RB06 RB07 RB08 RB09 RB10
RB11 RB12 RB13 RB14 RB15 RB16 RB17 RB18 RB19 RB20 RB21 RB22 RB23 RB24 RB25 RB26 RB27 RB28 RB29 RB30
RB31 RB32 SV01 SV02 SV03 SV04 SV05 SV06 SV07 SV08 SV01T SV02T SV03T SV04T SV05T SV06T SV07T SV08T SV09
SV10 SV11 SV12 SV13 SV14 SV15 SV16 SV09T SV10T SV11T SV12T SV13T SV14T SV15T SV16T SV17 SV18 SV19 SV20
SV21 SV22 SV23 SV24 SV17T SV18T SV19T SV20T SV21T SV22T SV23T SV24T SV25 SV26 SV27 SV28 SV29 SV30 SV31
SV32 SV25T SV26T SV27T SV28T SV29T SV30T SV31T SV32T LT01 LT02 LT03 LT04 LT05 LT06 LT07 LT08 LT09 LT10
LT11 LT12 LT13 LT14 LT15 LT16 LT17 LT18 LT19 LT20 LT21 LT22 LT23 LT24 LT25 LT26 LT27 LT28 LT29 LT30
LT31 LT32 SC01QU SC02QU SC03QU SC04QU SC05QU SC06QU SC07QU SC08QU SC01QD SC02QD SC03QD SC04QD SC05QD
SC06QD SC07QD SC08QD SC09QU SC10QU SC11QU SC12QU SC13QU SC14QU SC15QU SC16QU SC09QD SC10QD SC11QD
SC12QD SC13QD SC14QD SC15QD SC16QD SC17QU SC18QU SC19QU SC20QU SC21QU SC22QU SC23QU SC24QU SC17QD
SC18QD SC19QD SC20QD SC21QD SC22QD SC23QD SC24QD SC25QU SC26QU SC27QU SC28QU SC29QU SC30QU SC31QU
SC32QU SC25QD SC26QD SC27QD SC28QD SC29QD SC30QD SC31QD SC32QD RMB8A RMB7A RMB6A RMB5A RMB4A RMB3A
RMB2A RMB1A TMB8A TMB7A TMB6A TMB5A TMB4A TMB3A TMB2A TMB1A RMB8B RMB7B RMB6B RMB5B RMB4B RMB3B RMB2B
RMB1B TMB8B TMB7B TMB6B TMB5B TMB4B TMB3B TMB2B TMB1B LBOKB CBADB RBADB ROKB LBOKA CBADA RBADA ROKA
VB001 VB002 VB003 VB004 VB005 VB006 VB007 VB008 VB009 VB010 VB011 VB012 VB013 VB014 VB015 VB016 VB017
VB018 VB019 VB020 VB021 VB022 VB023 VB024 VB025 VB026 VB027 VB028 VB029 VB030 VB031 VB032 VB033 VB034
VB035 VB036 VB037 VB038 VB039 VB040 VB041 VB042 VB043 VB044 VB045 VB046 VB047 VB048 VB049 VB050 VB051
VB052 VB053 VB054 VB055 VB056 VB057 VB058 VB059 VB060 VB061 VB062 VB063 VB064 VB065 VB066 VB067 VB068
VB069 VB070 VB071 VB072 VB073 VB074 VB075 VB076 VB077 VB078 VB079 VB080 VB081 VB082 VB083 VB084 VB085
VB086 VB087 VB088 VB089 VB090 VB091 VB092 VB093 VB094 VB095 VB096 VB097 VB098 VB099 VB100 VB101 VB102
VB103 VB104 VB105 VB106 VB107 VB108 VB109 VB110 VB111 VB112 VB113 VB114 VB115 VB116 VB117 VB118 VB119
VB120 VB121 VB122 VB123 VB124 VB125 VB126 VB127 VB128 * * * * * * * * * * * * * * * * * * * * * * * *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * DI_A1 DI_B1 DI_C1 DI_A2 DI_B2 DI_C2 FSYNCACT
VSYNCACT TQUAL8 TQUAL4 TQUAL2 TQUAL1 DST DSTP LPSEC LPSECP FDIRPY RDIRPY TUTCS TUTC1 TUTC2 TUTC4 TUTC8
TUTCH 50QFX 50QRX 50GFX 50GRX DIRVEX DIRQGEX DIRIEX DIRQEX 50QFY 50QRY 50GFY 50GRY DIRVEY DIRQGEY
DIRIEY DIRQEY FDIRIX RDIRIX FDIRVX RDIRVX * * FDIRQGX RDIRQGX FDIRIY RDIRIY FDIRVY RDIRVY FDIRQY
RDIRQY FDIRQGY RDIRQGY DIRGFX DIRGRX DIRGFY DIRGRY DIRQFY DIRQRY DIRPFY DIRPRY GX1DIR GX2DIR PY1DIR
QY1DIR GY1DIR PY2DIR QY2DIR GY2DIR 50PDIRY TSNTPB TSNTPP 50NF 50NR FDIRNX RDIRNX FREQFZ 27PPX1 27PPX1T
27PPX2 27PPX2T 27PPY1 27PPY1T 27PPY2 27PPY2T 59PPX1 59PPX1T 59PPX2 59PPX2T 59PPY1 59PPY1T 59PPY2
59PPY2T 27V1X1 27V1X1T 27V1X2 27V1X2T 27V1X3 27V1X3T 27V1X4 27V1X4T 59V1X1 59V1X1T 59V1X2 59V1X2T
59V1X3 59V1X3T 59V1X4 59V1X4T 27V1X5 27V1X5T 27V1X6 27V1X6T 59V1X5 59V1X5T 59V1X6 59V1X6T 67N1P 67N1T
67N2P 67N2T MATHERR * 64FZC DIRNEX * * * * NX1DIR NX2DIR DIRNFX DIRNRX DRDOPT1 DRDOPT2 DRDOPT3 DRDOPT
RHSM HSM * * IA12H IB12H IC12H IA22H IB22H IC22H HR HRT 87SN1 87HSN1 87SN2 87HSN2 87SN3 87HSN3 * *
87SC1 87HSC1 87SC2 87HSC2 87SC3 87HSC3 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
* * 78VSO 78VSBL 89A2P1 89B2P1 89CL2P1 89OP2P1 89A2P2 89B2P2 89CL2P2 89OP2P2 89A2P3 89B2P3 89CL2P3
89OP2P3 89A2P4 89B2P4 89CL2P4 89OP2P4 89A2P5 89B2P5 89CL2P5 89OP2P5 89A2P6 89B2P6 89CL2P6 89OP2P6
89A2P7 89B2P7 89CL2P7 89OP2P7 89A2P8 89B2P8 89CL2P8 89OP2P8 89AL2P1 89AL2P2 89AL2P3 89AL2P4 89AL2P5
89AL2P6 89AL2P7 89AL2P8 52BX 52BY ENLRC LOCAL BKJMP * 27I1 27I1T 27I1RS 27I1TC 27I2 27I2T 27I2RS
27I2TC 59I1 59I1T 59I1RS 59I1TC 59I2 59I2T 59I2RS 59I2TC 59I3 59I3T 59I3RS 59I3TC 59I4 59I4T 59I4RS
59I4TC PB05 PB06 PB07 PB08 PB05_PUL PB06_PUL PB07_PUL PB08_PUL PB5A_LED PB5B_LED PB6A_LED PB6B_LED
PB7A_LED PB7B_LED PB8A_LED PB8B_LED * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *","1102"
```

Column Labels

Figure 10.6 Sample Compressed ASCII Event Report (Continued)

```
-957.5,-1385.0,3092.5,750.0,-0.3,0.0,0.0,-0.3,-147.0,-2944,-3916,6999,0,0,0,-1,59.99,0.00,60.00,
,"000000000000000E00000F00000000000000003000080000001E00000000000042000000FE008000000000000000000000
0000089C220000000000008000000010004 2B0A400000000000000000004040000000000080000000000000000000000000000
000000000000000000000000000000000000000000000000000000000000000000F000000000000C000000000000000C0000F
CFC000000001555555540321111110080000000000000000000","56C6"
1817.5,-2172.5,-130.0,-485.0,0.0,0.0,-0.3,-0.3,272.0,6152,-5712,-538,0,0,0,0,59.99,0.00,60.00,
,"000000000000000E00000F00000000000000003000080000001E00000000000042000000FE008000000000000000000000
0000089C220000000000008000000010004 2B0A400000000000000000004040000000000080000000000000000000000000000
000000000000000000000000000000000000000000000000000000000000000000F000000000000C000000000000000C0000F
CFC000000001555555540321111110080000000000000000000","563F"
955.0,1382.5,-3097.5,-760.0,-0.3,-0.3,-0.3,-0.8,147.0,2939,3919,-7000,0,0,-1,0,59.99,0.00,60.00,
,"000000000000000E00000F00000000000000003000080000001E00000000000042000000FE008000000000000000000000
0000089C220000000000008000000010004 2B0A400000000000000000004040000000000080000000000000000000000000000
000000000000000000000000000000000000000000000000000000000000000000F000000000000C000000000000000C0000F
CFC000000001555555540321111110080000000000000000000","56BF"
-1822.5,2167.5,132.5,477.5,-0.3,-0.3,0.0,-0.5,-273.0,-6155,5709,541,0,0,-1,-1,59.99,0.00,60.00,
,"000000000000000E00000F00000000000000003000080000001E00000000000042000000FE008000000000000000000000
0000089C220000000000008000000010004 2B0A400000000000000000004040000000000080000000000000000000000000000
000000000000000000000000000000000000000000000000000000000000000000F000000000000C000000000000000C0000F
CFC000000001555555540321111110080000000000000000000","5684"
.
.
.
945.0,1392.5,-3097.5,-760.0,0.0,0.0,-0.3,-0.3,145.5,2909,3946,-6997,0,0,0,-1,59.99,0.00,60.00,
,"000000000000000E00000F00000000000000003000080000001E00000000000042000000FE008000000000000000000000
0000089C220000000000008000000010004 2B0A400000000000000000004040000000000080000000000000000000000000000
000000000000000000000000000000000000000000000000000000000000000000F000000000000C000000000000000C0000F
CFC000000001555555540321111110080000000000000000000","5672"
```



```
-1827.5,2162.5,145.0,480.0,-0.3,-0.3,0.0,-0.5,-273.5,-
6168,5690,576,0,0,0,0,59.99,0.00,60.00,">","000000000000000E00000F0000000000000000300008000000 1E00000
0000000420000 00FE008000000000000000000000000000089C220000000000008000000010004 2B0A40000000000000000000404
0000000000080000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
00000F000000000000C000000000000000C0000FCFC000000001555555540321111110080000000000000000000","568E"
```


Event Data (Cycle 1)
The block shown represents four quarter cycles of data.

Event Data
The quarter cycle with the ">" symbol represents the trigger row for the event.


```
-945.0,-1395.0,3095.0,755.0,0.0,-0.3,0.0,-0.3,-145.5,-2907,-3951,6995,0,0,-1,0,59.99,0.00,60.00,
,"000000000000000E00000F0000000000000000300008000000 1E00000000000042000000FE008000000000000000000000
0000089C220000000000008000000010004 2B0A400000000000000000004040000000000080000000000000000000000000000
000000000000000000000000000000000000000000000000000000000000000000F000000000000C000000000000000C0000F
CFC000000001555555540321111110080000000000000000000","56BF"
1825.0,-2165.0,-150.0,-490.0,0.0,0.0,-0.3,-0.3,273.0,6169,-5688,-580,0,0,-1,-1,59.99,0.00,60.00,
,"000000000000000E00000F0000000000000000300008000000 1E00000000000042000000FE008000000000000000000000
0000089C220000000000008000000010004 2B0A400000000000000000004040000000000080000000000000000000000000000
000000000000000000000000000000000000000000000000000000000000000000F000000000000C000000000000000C0000F
CFC000000001555555540321111110080000000000000000000","56A2"
.
.
.
1830.0,-2157.5,-160.0,-487.5,-0.3,-0.3,-0.5,-1.0,273.5,6180,-5675,-605,0,0,-1,0,59.99,0.00,60.00,
,"000000000000000E00000F0000000000000000300008000000 1E00000000000042000000FE008000000000000000000000
0000089C220000000000008000000010004 2B0A400000000000000000004040000000000080000000000000000000000000000
000000000000000000000000000000000000000000000000000000000000000000F000000000000C000000000000000C0000F
CFC000000001555555540321111110080000000000000000000","56DA"
```



```
935.0,1402.5,-3097.5,-760.0,-0.3,-0.3,-0.3,-0.8,144.0,2880,3974,-6994,0,0,-
1,0,59.99,0.00,60.00,"*","000000000000000E00000F0000000000000000300008000000 1E00000000000042000000FE0
08000000000000000000000000000089C220000000000008000000010004 2B0A400000000000000000004040000000000080000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000F00000000000
0C000000000000000C0000FCFC000000001555555540321111110080000000000000000000","5712"
```



```
-1832.5,2155.0,160.0,482.5,0.0,0.0,0.0,0.0,-274.0,-6182,5671,609,0,0,0,0,59.99,0.00,60.00,
,"000000000000000E00000F0000000000000000300008000000 1E00000000000042000000FE008000000000000000000000
0000089C220000000000008000000010004 2B0A400000000000000000004040000000000080000000000000000000000000000
000000000000000000000000000000000000000000000000000000000000000000F000000000000C000000000000000C0000F
CFC000000001555555540321111110080000000000000000000","558B"
-937.5,-1407.5,3092.5,747.5,0.0,-0.3,-0.5,-0.8,-144.5,-2878,-3979,6993,0,0,-1,-2,59.99,0.00,60.00,
,"000000000000000E00000F0000000000000000300008000000 1E00000000000042000000FE008000000000000000000000
0000089C220000000000008000000010004 2B0A400000000000000000004040000000000080000000000000000000000000000
000000000000000000000000000000000000000000000000000000000000000000F000000000000C000000000000000C0000F
CFC000000001555555540321111110080000000000000000000","5740"
```


Event Data
The quarter cycle with the "*" symbol represents the row with the largest measured current for the event. This is the row used for the summary data.

Figure 10.6 Sample Compressed ASCII Event Report (Continued)

```
Global Settings

FNOM    := 60      DATE_F  := MDY     METHRES := Y
FAULT   := 51V OR 51C OR 50PX1P OR 46Q2 OR 21C1P OR 21C2P OR 50PY1P OR 50QY1P OR 50GY1P OR 67N1P OR
    51PYP OR 51QYP OR 51GYP OR TRIP

EMP     := N

TGR     := 3
SS1     := 1
SS2     := 0
SS3     := 0
SS4     := 0

EPMU    := N
.
.
.
```

Global Settings

```
Group Settings

RID     := SEL-700G
TID     := GENERATOR RELAY
PHROT   := ABC     X_CUR_IN:= NEUT    CTRX    := 500     INOM    := 5.0
DELTAY_X:= WYE     PTRX    := 100.00  VNOM_X  := 13.80   CTCONY  := WYE
CTRY    := 50      PTRS    := 100.00  CTRN    := 100     PTRN    := 100.00
E87     := TRANS   MVA     := 25.0    ICOM    := N       VWDGX   := 13.80
VWDGY   := 138.00
TAPX    := 2.09    TAPY    := 2.09
O87P    := 0.30    U87P    := 10.0    87AP    := 0.15    87AD    := 5.00
SLP1    := 25
SLP2    := 70      IRS1    := 6.0
PCT2    := OFF     PCT4    := OFF     PCT5    := 5
TH5P    := OFF     HRSTR   := N       HBLK    := Y

HSM     := 0
O87P2   := 1.25    HSMDOT  := 10.00

E87N    := N

EREF    := N
E64G    := Y
64G1P   := 5.0     64G1D   := 0.75    64G1TC  := 1
64G2P   := 2.5     64RAT   := 1.0     64G2D   := 0.08    64G2TC  := 1
.
.
.
```

Group Settings

```
Report Settings

ESERDEL := N

SER1    := IN101 IN102 PB01 PB02 PB03 PB04 52AX 52AY TRIPX TRIPY TRIP1 TRIP2
TRIP3
SER2    := ORED51T ORED50T 87U 87R OOST 21C1T 21C2T 3PWRX1T 3PWRX2T 3PWRY1T
3PWRY2T REF1F REF1R 24D1T 24C2T RTDT
SER3    := 64G1T 64G2T 64F1T 64F2T 46Q1T 46Q2T LOPX LOPY 81X1T 81X2T 81Y1T
81Y2T
SER4    := SALARM 49T 40Z1T 40Z2T

EALIAS  := 4
.
.
.
```

Report Settings

```
Logic Settings

ELAT    := 6       ESV     := 14      ESC     := N       EMV     := 1
.
.
.
```

Logic Settings

Figure 10.6 Sample Compressed ASCII Event Report (Continued)

The order of the labels in the digital portion of the Column Labels field matches the order of the HEX-ASCII Relay Word. Each numeral in the HEXASCII Relay Word reflects the status of four Relay Word bits from the Digital Column Labels field of the Compressed ASCII event report. The HEX-ASCII Relay Word from the trigger cycle from *Figure 10.6*, follows.

000000000000000E00000F000000000000000030000800000001E00000000000042000000FE008000000
0000000000000000000089C2200000000000080000000100042B0A400000000000000000004040000
00000000800000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000F0000000000000C00000000000000000C0000FCFC0000000015555555
403211111100800000000000000000000

In this HEX-ASCII Relay Word, the sixteenth numeral in the HEX-ASCII Relay Word is an E. In binary, this is 1110. Mapping the labels to the digital Column Labels yields the following:

46Q1	46Q1T	46Q2	46Q2T
1	1	1	0

The 50A1P element picked up at the first sample of the trigger cycle row (see *Figure 10.6*).

Viewing Compressed Event (CEV) Reports

The CEV can be viewed in the following ways:

- ➤ SYNCHROWAVE Event (SEL-5601-2)
- ➤ ACSELERATOR QuickSet SEL-5030 Software via SYNCHROWAVE Event (SEL-5601-2)

Navigate to the **Options** menu under **Tools** and select SYNCHROWAVE Event as the event viewer.

NOTE: If CTCONX or CTCONY is set to DELTA for any given winding, then the corresponding channel currents reported in the CEV reports are compensated in magnitude (i.e., divided by square root 3). The phase angles are not compensated and reflect the same values as measured on the secondary. Refer to Delta-Connected CTs in Section 5: Metering and Monitoring.

To view the saved events using the QuickSet, click **Tools** > **Events** to view an event with either SYNCHROWAVE Event and select the event you want to view (QuickSet remembers the location where you stored the previous event record). You can view multiple events by clicking on **Local Event** > **Add New Event** in SYNCHROWAVE Event.

As shown in *Figure 10.7*, all the analog and digital data can be viewed with SYNCHROWAVE Event (SEL5601-2) or QuickSet via SYNCHROWAVE Event (SEL5601-2). The Export (COMTRADE) feature allows you to export the CEV report in COMTRADE format. Similarly, the Export Data (CSV) feature allows you to export the CEV report in comma separated values (CSV) format.

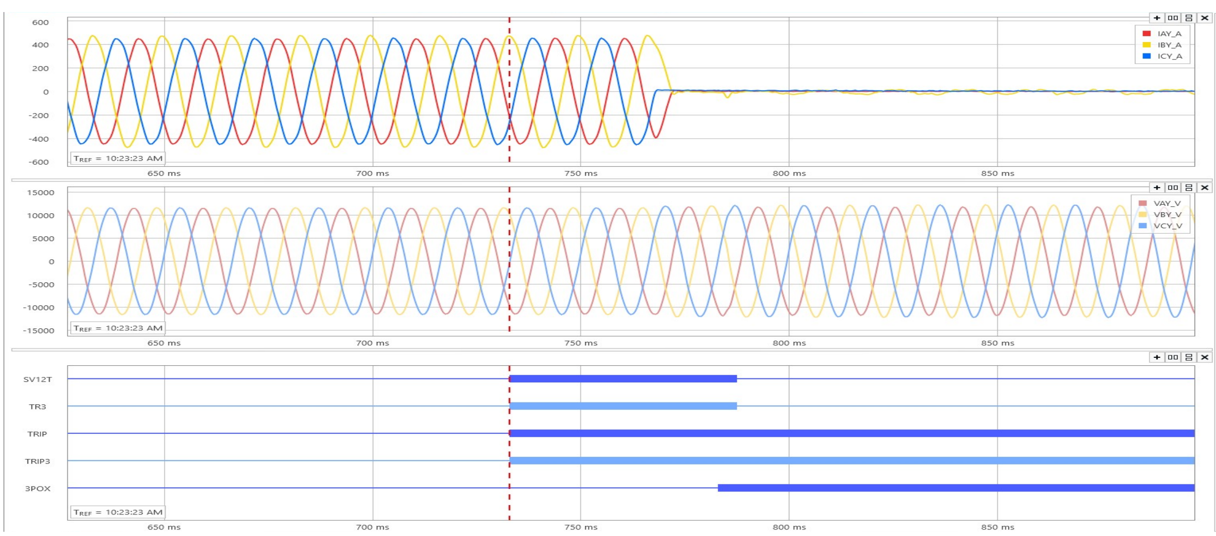


Figure 10.7 Sample CEV Report Viewed With QuickSet Via SYNCHROWAVE Event

With SYNCHROWAVE Event, you have six options for converting CEV reports to COMTRADE:

- ➤ COMTRADE 1999 ASCII
- ➤ COMTRADE 1999 Binary
- ➤ COMTRADE 2013 ASCII
- ➤ COMTRADE 2013 Binary
- ➤ COMTRADE 2013 Binary32
- ➤ COMTRADE 2013 Float32

COMTRADE File Format Event Reports

NOTE: COMTRADE event reports are sampled at 32 samples per cycle, which are equivalent to CEV R event reports.

NOTE: COMTRADE events can be extracted using the **FILE** command (see Section 7: Communications), Ethernet File Transfer Protocol (FTP), or the IEC 61850 Manufacturing Message Specification (MMS). To transfer files using MMS, set EMMSFS to Y.

The SEL-700G stores high-resolution raw oscillography data in binary format and uses COMTRADE file types to output these data:

- ➤ .HDR—header file
- ➤ .CFG—configuration file
- ➤ .DAT—high-resolution raw data file

The .HDR file contains summary information about the event in ASCII format. The .CFG file is an ASCII configuration file that describes the layout of the .DAT file. The .DAT file is in binary format and contains the values for each input channel for each sample in the record. These data conform to the IEEE C.37.111-1999 COMTRADE standard.

.HDR File

NOTE: In COMTRADE event reports, currents and voltages are reported in primary amps and volts, respectively. The data for delta-connected CTs (CTCONn = DELTA) and PTs (DELTAY_n = DELTA) are not compensated for, unlike in a CEV report (n = X or Y). The currents and voltages reported in COMTRADE reports are simply the secondary values seen by the relay at its terminals multiplied by the corresponding CT and PT ratios.

The .HDR file contains the event summary and relay settings information that appears in the event report for the data capture. The settings portion is in a comma-delimited format as illustrated in *Figure 10.8*.

```
FID,"SEL-700G-X344-V0-Z006003-D20180227"
Event_Report_Type,"UVR"
Part_Number,"0700GT1B1X0X7585A63X"
Serial_Number,"20171208"

[Summary]
Time_Source,"Internal"
Event_Logs,"13"
Event_Number,"10882"
Event_Date,"28/02/2018"
Event_Time,"10:53:42.348000"
Event,"Thermal 49 Trip"
Targets,"11000000"
IAX(A),"0.0000"
IBX(A),"0.0050"
ICX(A),"0.0000"
IGX(A),"0.0050"
IN(A),"0.0000"
VAX(V),"1.0000"
VBX(V),"0.0000"
VCX(V),"1.4142"
IAY(A),"0.0000"
IBY(A),"0.0000"
ICY(A),"7.0711"
IGY(A),"7.0711"
VS(V),"0.0000"
VAY(V),"0.0000"
VBY(V),"0.0000"
VCY(V),"10.0000"
Freqx,"60.00"
Freqy,"60.00"
Freqs,"60.00"
```

Event Summary Information

```
SETTINGS CHANGED SINCE EVENT

Global Settings
FNOM    := 60      FRQTRK  := X       DATE_F  := MDY     METHRES := Y
FAULT   := 51V OR 51C OR 50PX1P OR 46Q2 OR 67PY1P OR 67QY1P OR 67GY1P OR 67N1P OR 51PYP OR
    51QYP OR 51GYP OR TRIP

EMP     := N

TGR     := 3
SS1     := 1
SS2     := 0
SS3     := 0
SS4     := 0

EPMU    := N
IRIGC   := NONE    UTC_OFF := 0.00    DST_BEGM:= OFF
52ABF   := N       BFDX    := 0.50    BFIX    := R_TRIG TRIPX
BFDY    := 0.50    BFIY    := R_TRIG TRIPY

IN101D  := 10      IN102D  := 10
IN301D  := 10      IN302D  := 10      IN303D  := 10      IN304D  := 10
EBMONX  := Y       COSP1X  := 10000   COSP2X  := 150     COSP3X  := 12
KASP1X  := 1.20    KASP2X  := 8.00    KASP3X  := 20.00   BKMONX  := TRIPX

EBMONY  := Y       COSP1Y  := 10000   COSP2Y  := 150     COSP3Y  := 12
KASP1Y  := 1.20    KASP2Y  := 8.00    KASP3Y  := 20.00   BKMONY  := TRIPY

RSTTRGT := 0
RSTENRGY:= 0
RSTMXMN := 0
RSTDEM  := 0
RSTPKDEM:= 0

DSABLSET:= 0
```

Global Settings

Figure 10.8 Sample COMTRADE .HDR Header File

```
TIME_SRC:= IRIG1
89A2P1  := 0
89B2P1  := NOT 89A2P1
89A2P1D := 5.00    89A2P2  := 0
89B2P2  := NOT 89A2P2
89A2P2D := 5.00    89A2P3  := 0
89B2P3  := NOT 89A2P3
89A2P3D := 5.00    89A2P4  := 0
89B2P4  := NOT 89A2P4
89A2P4D := 5.00    89A2P5  := 0
89B2P5  := NOT 89A2P5
89A2P5D := 5.00    89A2P6  := 0
89B2P6  := NOT 89A2P6
89A2P6D := 5.00    89A2P7  := 0
89B2P7  := NOT 89A2P7
89A2P7D := 5.00    89A2P8  := 0
89B2P8  := NOT 89A2P8
89A2P8D := 5.00
EN_LRC  := N       EN_LRC  := N
```

Global Settings

```
Group Settings

RID     := SEL-700GT
TID     := INTERTIE RELAY
PHROT   := ABC     CTRX    := 1       INOM    := 5.0     DELTAY_X:= WYE
PTRX    := 100.00  VNOM_X  := 13.80   CTRY    := 500     DELTAY_Y:= WYE
PTRY    := 1000.00 VNOM_Y  := 138.00  PTRS    := 100.00  CTRN    := 100

E87N    := N

EREF    := N

E64F    := N

EBUP    := V       51VP    := 8.00    51VCA   := 0       51VC    := U2
51VTD   := 3.00    51VRS   := Y       51VTC   := NOT LOPX

E40     := Y       40Z1P   := 13.4
40XD1   :=-2.5     40Z1D   := 0.00    40Z2P   := 13.4
40XD2   :=-2.5     40Z2D   := 0.50    40ZTC   := NOT LOPX
E46     := Y
46Q1P   := 8.0     46Q1D   := 30.00   46Q2P   := 8.0     46Q2K   := 10
46QTC   := 1
E49T    := Y       49TTP   := 1.05    GTC1    := 1       GTC2    := OFF
49TAP   := OFF
E24     := Y       24D1P   := 105
24D1D   := 1.00    24CCS   := ID      24IP    := 105     24IC    := 2
24ITD   := 0.1
24D2P2  := 176     24D2D2  := 3.00    24CR    := 240.00  24TC    := 1

EINAD   := N

50PX1P  := OFF     50PX2P  := OFF     50PX3P  := OFF     50GX1P  := OFF
50GX2P  := OFF     50QX1P  := OFF     50QX2P  := OFF
51GXP   := OFF
50PY1P  := OFF     50PY2P  := OFF     50PY3P  := OFF     50GY1P  := OFF
50GY2P  := OFF     50QY1P  := OFF     50QY2P  := OFF
51PYP   := OFF     51GYP   := OFF     51QYP   := OFF     50N1P   := OFF
50N2P   := OFF     51NP    := OFF     EDIRX   := N       EDIRY   := N
ELOADY  := N       EPWRX   := 2       3PWRX1P := 50.0    PWRX1T  := -WATTS
PWRX1D  := 20.00   3PWRX2P := 25.0    PWRX2T  := +WATTS  PWRX2D  := 1.00
EPWRY   := N
E81X    := N

E81Y    := N

E81RX   := N
E81RY   := N
E81ACC  := N


LOPBLKX := SV13T OR FREQX < MV01
```

Group Settings

Figure 10.8 Sample COMTRADE .HDR Header File (Continued)

```
LOPBLKY := SV13T OR FREQX < MV01
27PX1P  := OFF     27PX2P  := OFF
27PPX1P := 93.5    27PPX1D := 0.50    27PPX2P := OFF
27PY1P  := OFF     27PY2P  := OFF
27PPY1P := 93.5    27PPY1D := 0.50    27PPY2P := OFF
59PX1P  := OFF     59PX2P  := OFF
59PPX1P := OFF     59PPX2P := OFF

59PY1P  := OFF     59PY2P  := OFF
59PPY1P := OFF     59PPY2P := OFF

E27V1X  := 1       27V1X1P := 5.0     27V1X1D := 0.50
E59V1X  := N
59QX1P  := OFF     59QX2P  := OFF
59QY1P  := OFF     59QY2P  := OFF
59GX1P  := OFF     59GX2P  := OFF
59GY1P  := OFF     59GY2P  := OFF
27S1P   := OFF     27S2P   := OFF
59S1P   := OFF     59S2P   := OFF

E27I1   := N       E27I2   := N

E59I1   := N       E59I2   := N       E59I3   := N       E59I4   := N

E49RTD  := NONE

E78VS   := OFF

E25X    := N       E25Y    := N       EDEM    := ROL     DMTC    := 15
PHDEMPX := OFF     GNDEMPX := OFF     3I2DEMPX:= OFF
PHDEMPY := OFF     GNDEMPY := OFF     3I2DEMPY:= OFF
50LXP   := 0.25    3POXD   := 0.00    50LYP   := 0.25    3POYD   := 0.00
TDURD   := 0.50    CFDX    := 0.50    CFDY    := 0.50
TRX     := SV06 OR SV07 OR SV08 OR 46Q2T OR 81X1T OR 81X2T OR 81RX1T OR 81RX2T OR NOT LT02
    AND SV04T OR OCX

TR1     := SV06 OR SV07 OR SV08
TR2     := SV06 OR SV07 OR LT06
TR3     := SV06 OR SV07

TRY     := SV09 OR SV10 OR LT02 AND SV04T OR OCY

REMTRIP := 0
ULTRX   := 3POX

ULTR1   := NOT TR1
ULTR2   := NOT TR2
ULTR3   := NOT TR3

ULTRY   := 3POY

52AX    := 0
52BX    := NOT 52AX

CLX     := SV03T AND NOT LT02 OR CCX OR SV11T AND 25C

ULCLX   := TRIPX

52AY    := 0
52BY    := NOT 52AY

CLY     := SV03T AND LT02 OR CCY OR SV12T AND 25AY1

ULCLY   := TRIPY
```

Group Settings

Figure 10.8 Sample COMTRADE .HDR Header File (Continued)

```
Report Settings

ESERDEL := N

SER1    := 49A 49T RTDT RTD1T 50LX IN101
SER2    := ORED51T ORED50T 87U 87R OOST 21C1T 21C2T 3PWRX1T 3PWRX2T 3PWRY1T
3PWRY2T REF1F REF1R 24D1T 24C2T RTDT
SER3    := 64G1T 64G2T 64F1T 64F2T 46Q1T 46Q2T LOPX LOPY 81X1T 81X2T 81Y1T
81Y2T
SER4    := SALARM 49T 40Z1T 40Z2T

EALIAS  := 4

ALIAS1  :=PB01 FP_LOCK PICKUP DROPOUT
ALIAS2  :=PB02 FP_BRKR_SELECT PICKUP DROPOUT
ALIAS3  :=PB03 FP_CLOSE PICKUP DROPOUT
ALIAS4  :=PB04 FP_TRIP PICKUP DROPOUT

ER      := 0
LER     := 15      PRE     := 5
FMR1NAM := FMR1
FMR1    :=NA
FMR2NAM := FMR2
FMR2    :=NA
FMR3NAM := FMR3
FMR3    :=NA
FMR4NAM := FMR4
FMR4    :=NA
RA01TYPE:= I
RA02TYPE:= I
RA03TYPE:= I
RA04TYPE:= I
RA05TYPE:= I
RA06TYPE:= I
RA07TYPE:= I
RA08TYPE:= I
RA09TYPE:= I
RA10TYPE:= I
RA11TYPE:= I
RA12TYPE:= I
RA13TYPE:= I
RA14TYPE:= I
RA15TYPE:= I
RA16TYPE:= I
RA17TYPE:= I
RA18TYPE:= I
RA19TYPE:= I
RA20TYPE:= I
RA21TYPE:= I
RA22TYPE:= I
RA23TYPE:= I
RA24TYPE:= I
RA25TYPE:= I
RA26TYPE:= I
RA27TYPE:= I
RA28TYPE:= I
RA29TYPE:= I
RA30TYPE:= I
RA31TYPE:= I
RA32TYPE:= I
GSRTRG  := CLOSEX AND (25C OR 25AX1 OR 25AX2)
GSRR    := 0.25    PRESYNC := 4790
```

Report Settings

```
Logic Settings


ELAT    := 6       ESV     := 14      ESC     := N       EMV     := 1

SET01   := R_TRIG SV01T AND NOT LT01
RST01   := R_TRIG SV01T AND LT01
SET02   := R_TRIG SV02T AND NOT LT02 AND PB02
RST02   := R_TRIG SV02T AND LT02 AND PB02
SET03   := (PB03 AND R_TRIG SV02T) AND LT01 AND NOT (52AX AND NOT LT02 OR 52AY AND LT02)
RST03   := (R_TRIG SV02T OR SV03T) AND LT03
SET04   := (PB04 AND R_TRIG SV02T) AND (52AX AND NOT LT02 OR 52AY AND LT02)
RST04   := (R_TRIG SV02T OR SV04T) AND LT04
SET05   := NA
RST05   := NA
SET06   := LB01 OR RB01
RST06   := 3POX
```

Logic Settings

Figure 10.8 Sample COMTRADE .HDR Header File (Continued)

`` SV01PU := 3.00 SV01DO := 0.00 SV01 := PB01 SV02PU := 0.25 SV02DO := 0.00 SV02 := PB01 OR PB02 OR PB03 OR PB04 SV03PU := 0.00 SV03DO := 0.00 SV03 := LT03 SV04PU := 0.00 SV04DO := 0.00 SV04 := LT04 SV05PU := 0.25 SV05DO := 0.25 SV05 := (PB01 OR PB02 OR LT03 OR LT04) AND NOT SV05T SV06PU := 0.00 SV06DO := 0.00 SV06 := 87N1T OR 87N2T OR REF1P OR 67GX1T OR 67GX2T OR INADT OR 64F2T SV07PU := 0.00 SV07DO := 0.00 SV07 := 51CT OR 51VT OR 51GXT OR 51NT OR 67N1T OR 67N2T OR 49T OR LT06 AND NOT 3PWRX2T AND NOT LOPX SV08PU := 0.00 SV08DO := 0.00 SV08 := 24C2T OR 3PWRX1T OR 40Z1T OR 40Z2T SV09PU := 0.00 SV09DO := 0.00 SV09 := 50PY3AT OR 50PY3BT OR 50PY3CT OR 67PY1T OR 67PY2T OR 67GY1T OR 67GY2T OR 67QY1T OR 67QY2T SV10PU := 0.00 SV10DO := 0.00 SV10 := 51PYT OR 51GYT OR 51QYT OR 3PWRY1T OR 3PWRY2T OR 81Y1T OR 81Y2T OR 81RY1T OR 81RY2T SV11PU := 0.00 SV11DO := 2.00 SV11 := 0 SV12PU := 0.00 SV12DO := 2.00 SV12 := 0 SV13PU := 0.00 SV13DO := 0.20 SV13 := R_TRIG ZCFREQX OR F_TRIG ZCFREQX OR F_TRIG ASYNSDC SV14PU := 0.00 SV14DO := 0.00 SV14 := FREQX > 16.00 Math Variables MV01 := FREQX * SV14 + MV01 * NOT SV14 OUT101FS:= N OUT101 := 49T OUT102FS:= N OUT102 := 0 OUT103FS:= N OUT103 := TRIPX OUT301FS:= N OUT301 := 0 OUT302FS:= N OUT302 := 0 OUT303FS:= N OUT303 := 0 OUT304FS:= N OUT304 := 0 ```	Logic Settings
SAM/CYC_A = 32 SAM/CYC_D = 4	Analog, Digital, and Input Samples per Cycle Data

Figure 10.8 Sample COMTRADE .HDR Header File (Continued)

.CFG File

The .CFG file contains data that is used to reconstruct the input signals to the relay and the status of Relay Word bits during the event report (see *Figure 10.9*). A <CR><LF> follows each line. If control inputs or control outputs are unavailable because of board loading and configuration, the relay does not report these inputs and outputs in the analog and digital sections of the .CFG file.

SEL-700GT,FID=SEL-700G-X344-V0-Z006003-D20180227,1999	COMTRADE Standard
1427,19A,1408D	Total Channels, Analog, Digital

Figure 10.9 Sample COMTRADE .CFG Configuration File Data

```
1,IAX,A,,A,0.007071,0.0,0,-32767,32767,1.0,1.0,P
2,IBX,B,,A,0.007071,0.0,0,-32767,32767,1.0,1.0,P
3,ICX,C,,A,0.007071,0.0,0,-32767,32767,1.0,1.0,P
4,IGX,,,A,0.007071,0.0,0,-32767,32767,1.0,1.0,P
5,IN,,,A,0.707107,0.0,0,-32767,32767,100.0,1.0,P
6,VAX,A,,V,1.414214,0.0,0,-32767,32767,100.0,1.0,P
7,VBX,B,,V,1.414214,0.0,0,-32767,32767,100.0,1.0,P
8,VCX,C,,V,1.414214,0.0,0,-32767,32767,100.0,1.0,P
9,IAY,A,,A,3.535534,0.0,0,-32767,32767,500.0,1.0,P
10,IBY,B,,A,3.535534,0.0,0,-32767,32767,500.0,1.0,P
11,ICY,C,,A,3.535534,0.0,0,-32767,32767,500.0,1.0,P
12,IGY,,,A,3.535534,0.0,0,-32767,32767,500.0,1.0,P
13,VS,,,V,1.414214,0.0,0,-32767,32767,100.0,1.0,P
14,VAY,A,,V,14.142136,0.0,0,-32767,32767,1000.0,1.0,P
15,VBY,B,,V,14.142136,0.0,0,-32767,32767,1000.0,1.0,P
16,VCY,C,,V,14.142136,0.0,0,-32767,32767,1000.0,1.0,P
17,FREQX,,,Hz,0.01,0.0,0,0,12000,1.0,1.0,P
18,FREQY,,,Hz,0.01,0.0,0,0,12000,1.0,1.0,P
19,FREQS,,,Hz,0.01,0.0,0,0,12000,1.0,1.0,P
20,FREQ_81R,,,Hz,0.01,0.0,0,0,12000,1.0,1.0,P
```

Analog Channel Data

[a] Scale_factor is the value used to convert the equivalent channel analog data in the DAT file to primary units (A or kV peak-to-peak)

```
1,50PY2T,,,0
2,50PT2P,,,0
.
.
.
nnnn[d],rwb_label[b,c],,,0
```

Digital (Status) Channel Data

[b] rwb_label is replaced with Relay Word bit labels as seen in Table L.1

[c] Place holders denoted by asterisk (*), are labeled as UNUSEDxxx (where xxx is the number of the associated label)

[d] nnnn = number of the last Relay Word bit

```
<NFREQ>
0
0,<# of samples>
```

```
dd/mm/yyyy,hh:mm:ss.ssssss
```

First Data Point

```
dd/mm/yyyy,hh:mm:ss.ssssss
```

Trigger Point

```
BINARY
<time stamp multiplication factor>
```

Figure 10.9 Sample COMTRADE .CFG Configuration File Data (Continued)

The configuration file has the following format:

- Relay ID, firmware ID, COMTRADE standard year
- Number and type of channels
- Channel name units and conversion factors
- Digital Relay Word bit names
- System frequency
- Sample rate and number of samples
- Date and time of first data point
- Date and time of trigger point
- Data file type
- Time-stamp multiplication factor

.DAT File

The .DAT file follows the COMTRADE binary standard. The format of the binary data files is sample number, time stamp, data value for each analog channel, and digital channel status data for each sample in the file. There are no data separators in the binary file, and the file contains no carriage return/ line feed characters. The sequential position of the data in the binary file determines the data translation. Refer to the IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems, IEEE C37.111-1999 for more information. Many software applications can read binary COMTRADE files, including SYNCHROWAVE Event and QuickSet.

Retrieving COMTRADE Event Files

COMTRADE files are available as read-only files that can be retrieved using the **FILE** command and Ymodem file transfer, Ethernet File Transfer Protocol (FTP), web server (EHTTP := Y), or Manufacturing Message Specification (MMS). MMS file transfer is only available in models that support IEC 61850 and only when IEC 61850 is enabled (E61850 := Y) and MMS file services is enabled (EMMSFS := Y). See *FILE Command on page 7.50* and *File Transfer Protocol (FTP) and MMS File Transfer on page 7.15* for additional information. You can also retrieve COMTRADE files via QuickSet. Refer to *Section 3: PC Interface*, *View Event History* for details.

Digital Event Report (EVE D Command)

The digital event report includes:

- Digital states of control and protection elements, including overcurrent and voltage elements, plus status of digital inputs and outputs and RTD status
- Event summary (includes the serial number of the product)
- Settings in service at the time of event triggering, consisting of Group, Logic, Global, and Report settings classes

Use the **EVE D *n* X Y** command to view the normal digital report with 4 samples/cycle for report *n* (if not listed, *n* is assumed to be 1). **EVE D R X Y** gives the RAW report with 32 samples/cycle. Use **X** for X-side digital quantities and **Y** for Y-side digital quantities. If X or Y are not specified, the relay defaults to X-side digital quantities.

Refer to the example event report in *Figure 10.10* to view the digital event report columns. This example event report displays rows of information each one-quarter cycle. Retrieve this report with the **EVE D X** command.

Table 10.3 gives the digital event report column definitions for the protection and control elements and the inputs and outputs.

Table 10.3 Digital Event Report Column Definitions (Sheet 1 of 7)

Column Designation	Column Symbols	Column Symbol RWBs
X Side		
50PX1	*	50PX1P picked up
	t	50PX1T picked up
50PX2	*	50PX2P picked up
	t	50PX2T picked up
50PX3A	*	50PX3AP picked up
	t	50PX3AT picked up
50PX3B	*	50PX3BP picked up
	t	50PX3BT picked up
50PX3C	*	50PX3CP picked up
	t	50PX3CT picked up
50GX1/67GX1	*	50GX1P or 67GX1P picked up
	t	50GX1T or 67GX1T picked up
50GX2/67GX2	*	50GX2P or 67GX2T picked up
	t	50GX2T or 67GX2T picked up
50QX1	*	50QX1P picked up
	t	50QX1T picked up

Table 10.3 Digital Event Report Column Definitions (Sheet 2 of 7)

Column Designation	Column Symbols	Column Symbol RWBs
50QX2	*	50QX2P picked up
	t	50QX2T picked up
51PX	*	51PXP picked up
	t	51PXT picked up
	r	51PXR picked up
51GX	*	51GXP picked up
	t	51GXT picked up
	r	51GXR picked up
51QX	*	51QXP picked up
	t	51QXT picked up
	r	51QXR picked up
GX1DIR	1	GX1DIR picked up
GX2DIR	2	GX2DIR picked up
	b	Both GX1DIR and GX2DIR picked up
50N1	*	50N1P picked up
	t	50N1T picked up
50N2	*	50N2P picked up
	t	50N2T picked up
51N1	*	51NP picked up
	t	51NT picked up
	r	51NR picked up
46Q1	*	46Q1 picked up
	t	46Q1T picked up
46Q2	*	46Q2 picked up
	t	46Q2T picked up
	r	46Q2R picked up
21C1	*	21C1P picked up
	t	21C1T picked up
21C2	*	21C2P picked up
	t	21C2T picked up
27PPX1	*	27PPX1 picked up
	t	27PPX1T picked up
27PPX2	*	27PPX2 picked up
	t	27PPX2T picked up
27S1	*	27S1 picked up
	t	27S1T picked up
27S2	*	27S2 picked up
	t	27S2T picked up
59PPX1	*	59PPX1 picked up
	t	59PPX1T picked up
59PPX2	*	59PPX2 picked up
	t	59PPX2T picked up
59GX1	*	59GX1 picked up
	t	59GX1T picked up
59GX2	*	59GX2 picked up
	t	59GX2T picked up

Table 10.3 Digital Event Report Column Definitions (Sheet 3 of 7)

Column Designation	Column Symbols	Column Symbol RWBs
59QX1	*	59QX1 picked up
	t	59QX1T picked up
59QX2	*	59QX2 picked up
	t	59QX2T picked up
59S1	*	59S1 picked up
	t	59S1T picked up
59S2	*	59S2 picked up
	t	59S2T picked up
24D1	*	24D1 picked up
	t	24D1T picked up
24C2	*	24C2 picked up
	t	24C2T picked up
	r	24CR picked up
3PWX1	*	3PWRX1P picked up
	t	3PWRX1T picked up
3PWX2	*	3PWRX2P picked up
	t	3PWRX2T picked up
3PWX3	*	3PWRX3P picked up
	t	3PWRX3T picked up
3PWX4	*	3PWRX4P picked up
	t	3PWRX4T picked up
LOPX	*	LOPX picked up
ZLOADX	*	ZLOADX picked up
78	S	SWING picked up
	O	OOS picked up
	t	OOST picked up
64G1	*	64G1 picked up
	t	64G1T picked up
64G2	*	64G2 picked up
	t	64G2T picked up
40Z1	*	40Z1 picked up
	t	40Z1T picked up
40Z2	*	40Z2 picked up
	t	40Z2T picked up
SFX	*	SFX picked up
25AX	1	25AX1 picked up
	2	25AX2 picked up
	b	Both 25AX1 and 25AX2 picked up
	C	25CX picked up
81X12	1	81X1T picked up
	2	81X2T picked up
	b	Both 81X1T and 81X2T picked up
81X34	3	81X3T picked up
	4	81X4T picked up
	b	Both 81X3T and 81X4T picked up

Table 10.3 Digital Event Report Column Definitions (Sheet 4 of 7)

Column Designation	Column Symbols	Column Symbol RWBs
81X56	5	81X5T picked up
	6	81X6T picked up
	b	Both 81X5T and 81X6T picked up
REF	*	REF1F picked up
	t	REF1P picked up
BFIX	*	BFIX picked up
	t	BFTX picked up
TRIP12	1	TRIP1 picked up
	2	TRIP2 picked up
	B	Both TRIP1 and TRIP2 picked up
TRIP3X	3	TRIP3 picked up
	X	TRIPX picked up
	B	Both TRIP3 and TRIPX picked up
RTD Wdg	w	WDGALRM picked up
	W	WDGTRIP picked up
RTD Brg	b	BRGALRM picked up
	B	BRGTRIP picked up
RTD Oth	o	OTHALRM picked up
	O	OTHTRIP picked up
RTD Amb	a	AMBALRM picked up
	A	AMBTRIP picked up
RTD IN	1	RTDIN asserted
Y Side		
50PY1/67PY1	*	50PY1P or 67PY1P picked up
	t	50PY1T or 67PY1T picked up
50PY2/67PY2	*	50PY2P or 67PY2P picked up
	t	50PY2T or 67PY2T picked up
50PY3A	*	50PY3AP picked up
	t	50PY3AT picked up
50PY3B	*	50PY3BP picked up
	t	50PY3BT picked up
50PY3C	*	50PY3CP picked up
	t	50PY3CT picked up
50GY1/67GY1	*	50GY1P or 67GY1P picked up
	t	50GY1T or 67GY1T picked up
50GY2/67GY2	*	50GY2P or 67GY2P picked up
	t	50GY2T or 67GY2T picked up
50QY1/67QY1	*	50QY1P or 67QY1P picked up
	t	50QY1T or 67QY1T picked up
50QY2/67QY2	*	50QY2P or 67QY2P picked up
	t	50QY2T or 67QY2T picked up
51PY1	*	51PY1P picked up
	t	51PY1T picked up
	r	51PY1R picked up

Table 10.3 Digital Event Report Column Definitions (Sheet 5 of 7)

Column Designation	Column Symbols	Column Symbol RWBs
51GY1	*	51GY1P picked up
	t	51GY1T picked up
	r	51GY1R picked up
51QY1	*	51QY1P picked up
	t	51QY1T picked up
	r	51QY1R picked up
27PPY1	*	27PPY1 picked up
	t	27PPY1T picked up
27PPY2	*	27PPY2 picked up
	t	27PPY2T picked up
59PPY1	*	59PPY1 picked up
	t	59PPY1T picked up
59PPY2	*	59PPY2 picked up
	t	59PPY2T picked up
59GY1	*	59GY1 picked up
	t	59GY1T picked up
59GY2	*	59GY2 picked up
	t	59GY2T picked up
59QY1	*	59QY1 picked up
	t	59QY1T picked up
59QY2	*	59QY2 picked up
	t	59QY2T picked up
3PWY1	*	3PWRY1P picked up
	t	3PWRY1T picked up
3PWY2	*	3PWRY2P picked up
	t	3PWRY2T picked up
3PWY3	*	3PWRY3P picked up
	t	3PWRY3T picked up
3PWY4	*	3PWRY4P picked up
	t	3PWRY4T picked up
LOPY	*	LOPY picked up
ZLOADY	*	ZLOADY picked up
SFY	*	SFY picked up
25AY	1	25AY1 picked up
	2	25AY2 picked up
	b	Both 25AY1 and 25AY2 picked up
81Y12	1	81Y1T picked up
	2	81Y2T picked up
	b	Both 81Y1T and 81Y2T picked up
81Y34	3	81Y3T picked up
	4	81Y4T picked up
	b	Both 81Y3T and 81Y4T picked up
81Y56	5	81Y5T picked up
	6	81Y6T picked up
	b	Both 81Y5T and 81Y6T picked up

Table 10.3 Digital Event Report Column Definitions (Sheet 6 of 7)

Column Designation	Column Symbols	Column Symbol RWBs
BFIY	*	BFIY picked up
	t	BFTY picked up
TRIPY	Y	TRIPY picked up
Inputs 3012	1	IN301 picked up
	2	IN302 picked up
	b	Both IN301 and IN302 picked up
Inputs 3034	3	IN303 picked up
	4	IN304 picked up
	b	Both IN303 and IN304 picked up
Inputs 3056	5	IN305 picked up
	6	IN306 picked up
	b	Both IN305 and IN306 picked up
Inputs 3078	7	IN307 picked up
	8	IN308 picked up
	b	Both IN307 and IN308 picked up
Inputs 4012	1	IN401 picked up
	2	IN402 picked up
	b	Both IN401 and IN402 picked up
Inputs 4034	3	IN403 picked up
	4	IN404 picked up
	b	Both IN403 and IN404 picked up
Inputs 4056	5	IN405 picked up
	6	IN406 picked up
	b	Both IN405 and IN406 picked up
Inputs 4078	7	IN407 picked up
	8	IN408 picked up
	b	Both IN407 and IN408 picked up
Inputs 5012	1	IN501 picked up
	2	IN502 picked up
	b	Both IN501 and IN502 picked up
Inputs 5034	3	IN503 picked up
	4	IN504 picked up
	b	Both IN503 and IN504 picked up
Inputs 5056	5	IN505 picked up
	6	IN506 picked up
	b	Both IN505 and IN506 picked up
Inputs 5078	7	IN507 picked up
	8	IN508 picked up
	b	Both IN507 and IN508 picked up
Outputs 3012	1	OUT301 picked up
	2	OUT302 picked up
	b	Both OUT301 and OUT302 picked up
Outputs 3034	3	OUT303 picked up
	4	OUT304 picked up
	b	Both OUT303 and OUT304 picked up

Table 10.3 Digital Event Report Column Definitions (Sheet 7 of 7)

Column Designation	Column Symbols	Column Symbol RWBs
Outputs 3056	5	OUT305 picked up
	6	OUT306 picked up
	b	Both OUT305 and OUT306 picked up
Outputs 3078	7	OUT307 picked up
	8	OUT308 picked up
	b	Both OUT307 and OUT308 picked up
Outputs 4012	1	OUT401 picked up
	2	OUT402 picked up
	b	Both OUT401 and OUT402 picked up
Outputs 4034	3	OUT403 picked up
	4	OUT404 picked up
	b	Both OUT403 and OUT404 picked up
Outputs 4056	5	OUT405 picked up
	6	OUT406 picked up
	b	Both OUT405 and OUT406 picked up
Outputs 4078	7	OUT407 picked up
	8	OUT408 picked up
	b	Both OUT407 and OUT408 picked up
Outputs 5012	1	OUT501 picked up
	2	OUT502 picked up
	b	Both OUT501 and OUT502 picked up
Outputs 5034	3	OUT503 picked up
	4	OUT504 picked up
	b	Both OUT503 and OUT504 picked up
Outputs 5056	5	OUT505 picked up
	6	OUT506 picked up
	b	Both OUT505 and OUT506 picked up
Outputs 5078	7	OUT507 picked up
	8	OUT508 picked up
	b	Both OUT507 and OUT508 picked up

```
=>>EVE D <Enter>

SEL-700GT                                Date: 03/30/2018   Time: 16:28:47.356
INTERTIE RELAY

Serial Number=
FID=SEL-700G-X346-V0-Z006003-D20180314   CID=A6BC

WindingX
                          22   55                 Z                   TT
50/67    51   G           7722 99555555    3333   L             81     RR RTD R
PPPPPGGQQPGQVCX 555 44 22 PP77 PP999999 22 PPPP L O 7 66 44  2 DDD   BII     T
XXXXXXXXXXXX  D 001 66 11 PPSS PPGGQQSS 44 WWWW O A 8 44 OO S5 XXX R FPP WBOAD
123331212     I NNN QQ CC XX12 XXXXXX12 DC XXXX P D   GG ZZ FA 135 E I13 drtmI
  ABC         R 121 12 12 12   121212   12 1234 X X   12 12 XX 246 F X2X gghbN
[1]
.........rrrr.b ..r .r .. .... ........ tt .t.. . . . .. .. .. ... . t1X .....
.........rrrr.b ..r .r .. .... ........ tt .t.. . . . .. .. .. ... . t1X .....
.........rrrr.b ..r .r .. .... ........ tt .t.. . . . .. .. .. ... . t1X .....
.........rrrr.b ..r .r .. .... ........ tt .t.. . . . .. .. .. ... . t1X .....
[2]
.........rrrr.b ..r .r .. .... ........ tt .t.. . . . .. .. .. ... . t1X .....
.........rrrr.b ..r .r .. .... ........ tt .t.. . . . .. .. .. ... . t1X .....
.........rrrr.b ..r .r .. .... ........ tt .t.. . . . .. .. .. ... . t1X .....
.........rrrr.b ..r .r .. .... ........ tt .t.. . . . .. .. .. ... . t1X .....
```

Figure 10.10 Example Standard 15-cycle Digital Event Report (EVE D X Command) 1/4-Cycle Resolution

```
.
.
.

[14]
.........rrrr.b ..r .r .. .... ........ .. .*.. . . . . .. .. .. ... . .1X .....
.........rrrr.b ..r .r .. .... ........ .. .*.. . . . . .. .. .. ... . .1X .....
.........rrrr.b ..r .r .. .... ........ .. .*.. . . . . .. .. .. ... . .1X .....
.........rrrr.b ..r .r .. .... ........ .. .*.. . . . . .. .. .. ... . .1X .....
[15]
.........rrrr.b ..r .r .. .... ........ .. .*.. . . . . .. .. .. ... . .1X .....
.........rrrr.b ..r .r .. .... ........ .. .*.. . . . . .. .. .. ... . .1X .....
.........rrrr.b ..r .r .. .... ........ .. .*.. . . . . .. .. .. ... . .1X .....
.........rrrr.b ..r .r .. .... ........ .. .*.. . . . . .. .. .. ... . .1X .....

Serial No = 3162580026      FID = SEL-700G-X346-V0-Z006003-D20180314
CID = A6BC                  EVENT LOGS = 54            REF_NUM = 10081

Event:       Volt/Hz 24 Trip
Targets      11000101
Freqx, (Hz)  60.00
Freqy, (Hz)  60.00

Current Mag (X Side)
        IAX           IBX           ICX           IGX
(A)    1246.3        1252.5        1254.0          5.59

Current Mag (Y Side)
        IAY           IBY           ICY           IGY
(A)    1251.0        1248.1        1260.6          7.91

Neutral Current Mag
        IN
(A)      0.50

Voltage Mag (X Side)
       VAX    VBX    VCX    VGX
(V)    6825   6820   6815      5

Voltage Mag (Y Side)
       VAY    VBY    VCY    VGY
(V)    6782   6777   6782     65

Sync Voltage Mag
       VS
(V)       0

SETTINGS CHANGED SINCE EVENT

Global Settings
FNOM    := 60      FRQTRK  := X       DATE_F  := MDY     METHRES := Y
FAULT   := 51V OR 51C OR 50PX1P OR 46Q2 OR 67PY1P OR 67QY1P OR 67GY1P OR 67N1P OR
    51PYP OR 51QYP OR 51GYP OR TRIP

EMP     := N

TGR     := 3
SS1     := 1
SS2     := 0
SS3     := 0
SS4     := 0

EPMU    := N
IRIGC   := NONE    UTC_OFF := 0.00    DST_BEGM:= OFF
52ABF   := N       BFDX    := 0.50    BFIX    := R_TRIG TRIPX
BFDY    := 0.50    BFIY    := R_TRIG TRIPY

IN101D  := 10      IN102D  := 10
IN301D  := 10      IN302D  := 10      IN303D  := 10      IN304D  := 10
EBMONX  := Y       COSP1X  := 10000   COSP2X  := 150     COSP3X  := 12
KASP1X  := 1.20    KASP2X  := 8.00    KASP3X  := 20.00   BKMONX  := TRIPX

EBMONY  := Y       COSP1Y  := 10000   COSP2Y  := 150     COSP3Y  := 12
KASP1Y  := 1.20    KASP2Y  := 8.00    KASP3Y  := 20.00   BKMONY  := TRIPY

RSTTRGT := 0
RSTENRGY:= 0
RSTMXMN := 0
RSTDEM  := 0
RSTPKDEM:= 0

DSABLSET:= 0
```

Figure 10.10 Example Standard 15-cycle Digital Event Report (EVE D X Command) 1/4-Cycle Resolution (Continued)

```
TIME_SRC:= IRIG1
89A2P1  := 0
89B2P1  := NOT 89A2P1
89A2P1D := 5.00    89A2P2  := 0
89B2P2  := NOT 89A2P2
89A2P2D := 5.00    89A2P3  := 0
89B2P3  := NOT 89A2P3
89A2P3D := 5.00    89A2P4  := 0
89B2P4  := NOT 89A2P4
89A2P4D := 5.00    89A2P5  := 0
89B2P5  := NOT 89A2P5
89A2P5D := 5.00    89A2P6  := 0
89B2P6  := NOT 89A2P6
89A2P6D := 5.00    89A2P7  := 0
89B2P7  := NOT 89A2P7
89A2P7D := 5.00    89A2P8  := 0
89B2P8  := NOT 89A2P8
89A2P8D := 5.00
EN_LRC  := N       EN_LRC  := N

Group Settings

RID     := SEL-700GT
TID     := INTERTIE RELAY
PHROT   := ABC     CTRX    := 500     INOM    := 5.0     DELTAY_X:= WYE
PTRX    := 100.00  VNOM_X  := 20.00   CTRY    := 500     DELTAY_Y:= WYE
PTRY    := 100.00  VNOM_Y  := 13.80   PTRS    := 1000.00 CTRN    := 100

E87N    := N

EREF    := N

E64F    := N

EBUP    := V       51VP    := 8.00    51VCA   := 0       51VC    := U2
51VTD   := 3.00    51VRS   := Y       51VTC   := NOT LOPX

E46     := Y
46Q1P   := 8.0     46Q1D   := 30.00   46Q2P   := 8.0     46Q2K   := 10
46QTC   := 1
E49T    := Y       49TTP   := 1.10    GTC1    := 10      GTC2    := OFF
49TAP   := 85
E24     := Y       24D1P   := 105
24D1D   := 1.00    24CCS   := ID      24IP    := 105     24IC    := 2
24ITD   := 0.1
24D2P2  := 176     24D2D2  := 3.00    24CR    := 240.00  24TC    := 1

EINAD   := N

50PX1P  := OFF     50PX2P  := OFF     50PX3P  := OFF     50GX1P  := OFF
50GX2P  := OFF     50QX1P  := OFF     50QX2P  := OFF
51GXP   := OFF
50PY1P  := OFF     50PY2P  := OFF     50PY3P  := OFF     50GY1P  := OFF
50GY2P  := OFF     50QY1P  := OFF     50QY2P  := OFF
51PYP   := OFF     51GYP   := OFF     51QYP   := OFF     50N1P   := OFF
50N2P   := OFF     51NP    := OFF     EDIRX   := N       EDIRY   := N
ELOADY  := N       EPWRX   := 2       3PWRX1P := 50.0    PWRX1T  := -WATTS
PWRX1D  := 20.00   3PWRX2P := 25.0    PWRX2T  := +WATTS  PWRX2D  := 1.00
EPWRY   := N
E81X    := N
```

Figure 10.10 Example Standard 15-cycle Digital Event Report (EVE D X Command) 1/4-Cycle Resolution (Continued)

```
E81Y    := N

E81RX   := N
E81RY   := N
E81ACC  := N

LOPBLKX := SV13T OR FREQX < MV01

LOPBLKY := SV13T OR FREQX < MV01
27PX1P  := OFF     27PX2P  := OFF
27PPX1P := 93.5    27PPX1D := 0.50    27PPX2P := OFF
27PY1P  := OFF     27PY2P  := OFF
27PPY1P := 93.5    27PPY1D := 0.50    27PPY2P := OFF
59PX1P  := OFF     59PX2P  := OFF
59PPX1P := OFF     59PPX2P := OFF

59PY1P  := OFF     59PY2P  := OFF
59PPY1P := OFF     59PPY2P := OFF

E27V1X  := 1       27V1X1P := 5.0     27V1X1D := 0.50
E59V1X  := N
59QX1P  := OFF     59QX2P  := OFF
59QY1P  := OFF     59QY2P  := OFF
59GX1P  := OFF     59GX2P  := OFF
59GY1P  := OFF     59GY2P  := OFF
27S1P   := OFF     27S2P   := OFF
59S1P   := OFF     59S2P   := OFF

E27I1   := N       E27I2   := N

E59I1   := N       E59I2   := N       E59I3   := N       E59I4   := N

E49RTD  := NONE

E78VS   := OFF

E25X    := Y
25VLOX  := 50.00   25VHIX  := 70.00   25VDIFX := OFF     25RCFX  := 1.000
GENV+   := N       25SLO   :=-0.50    25SHI   := 0.50    25ANG1X := 10
25ANG2X := 20      CANGLE  := 3       SYNCPX  := VAX     TCLOSDX := OFF
CFANGLE := OFF
BSYNCHX := NOT 3POX

E25Y    := N       EAUTO   := DIG     FSYNCT  := 100     FADJRATE:= 0.10
FPULSEI := 5       FPLSMIND:= 0.10    FPLSMAXD:= 1.00    KPULSEI := 5
KPLSMIND:= 0.02    KPLSMAXD:= 0.04    FSYNCST := 0
VSYNCT  := 100     VADJRATE:= 1.00    VPULSEI := 5       VPLSMIND:= 0.10
VPLSMAXD:= 1.00    VSYNCST := 0
EDEM    := ROL     DMTC    := 15      PHDEMPX := OFF     GNDEMPX := OFF
3I2DEMPX:= OFF
PHDEMPY := OFF     GNDEMPY := OFF     3I2DEMPY:= OFF
50LXP   := 0.25    3POXD   := 0.00    50LYP   := 0.25    3POYD   := 0.00
TDURD   := 0.50    CFDX    := 0.50    CFDY    := 0.50
TRX     := SV06 OR SV07 OR SV08 OR 46Q2T OR 81X1T OR 81X2T OR 81RX1T OR 81RX2T OR NOT
    LT02 AND SV04T OR OCX

TR1     := SV06 OR SV07 OR SV08
TR2     := SV06 OR SV07 OR LT06
TR3     := SV06 OR SV07

TRY     := SV09 OR SV10 OR LT02 AND SV04T OR OCY

REMTRIP := 0
ULTRX   := 3POX

ULTR1   := NOT TR1
ULTR2   := NOT TR2
ULTR3   := NOT TR3

ULTRY   := 3POY

52AX    := CLOSEX
52BX    := NOT 52AX

CLX     := 25AX1

ULCLX   := 0

52AY    := 0
52BY    := NOT 52AY

CLY     := SV03T AND LT02 OR CCY OR SV12T AND 25AY1

ULCLY   := TRIPY
```

Figure 10.10 Example Standard 15-cycle Digital Event Report (EVE D X Command) 1/4-Cycle Resolution (Continued)

```
Report Settings

ESERDEL := N

SER1    := 25AX1 CLX 25AX2 OUT101 IN101
SER2    := ORED51T ORED50T 87U 87R OOST 21C1T 21C2T 3PWRX1T 3PWRX2T 3PWRY1T
3PWRY2T REF1F REF1R 24D1T 24C2T RTDT
SER3    := 64G1T 64G2T 64F1T 64F2T 46Q1T 46Q2T LOPX LOPY 81X1T 81X2T 81Y1T
81Y2T
SER4    := CLOSEX

EALIAS  := 4

ALIAS1  :=PB01 FP_LOCK PICKUP DROPOUT
ALIAS2  :=PB02 FP_BRKR_SELECT PICKUP DROPOUT
ALIAS3  :=PB03 FP_CLOSE PICKUP DROPOUT
ALIAS4  :=PB04 FP_TRIP PICKUP DROPOUT

ER      := 0
LER     := 15      PRE     := 5
FMR1NAM := FMR1
FMR1    :=NA
FMR2NAM := FMR2
FMR2    :=NA
FMR3NAM := FMR3
FMR3    :=NA
FMR4NAM := FMR4
FMR4    :=NA

RA01TYPE:= I
RA02TYPE:= I
RA03TYPE:= I
.
.
.
RA30TYPE:= I
RA31TYPE:= I
RA32TYPE:= I

GSRTRG  := CLX
GSRR    := 0.25    PRESYNC := 2000

LDLIST  := NA

LDAR    := 15

Logic Settings

ELAT    := 6       ESV     := 14      ESC     := N       EMV     := 1


SET01   := R_TRIG SV01T AND NOT LT01
RST01   := R_TRIG SV01T AND LT01
SET02   := R_TRIG SV02T AND NOT LT02 AND PB02
RST02   := R_TRIG SV02T AND LT02 AND PB02
SET03   := (PB03 AND R_TRIG SV02T) AND LT01 AND NOT (52AX AND NOT LT02 OR 52AY AND
    LT02)
RST03   := (R_TRIG SV02T OR SV03T) AND LT03
SET04   := (PB04 AND R_TRIG SV02T) AND (52AX AND NOT LT02 OR 52AY AND LT02)
RST04   := (R_TRIG SV02T OR SV04T) AND LT04
SET05   := NA
RST05   := NA
SET06   := LB01 OR RB01
RST06   := 3POX
```

Figure 10.10 Example Standard 15-cycle Digital Event Report (EVE D X Command) 1/4-Cycle Resolution (Continued)

```
SV01PU  := 3.00    SV01DO  := 0.00
SV01    := PB01
SV02PU  := 0.25    SV02DO  := 0.00
SV02    := PB01 OR PB02 OR PB03 OR PB04
SV03PU  := 0.00    SV03DO  := 0.00
SV03    := LT03
SV04PU  := 0.00    SV04DO  := 0.00
SV04    := LT04
SV05PU  := 0.25    SV05DO  := 0.25
SV05    := (PB01 OR PB02 OR LT03 OR LT04) AND NOT SV05T
SV06PU  := 0.00    SV06DO  := 0.00
SV06    := 87N1T OR 87N2T OR REF1P OR 67GX1T OR 67GX2T OR INADT OR 64F2T
SV07PU  := 0.00    SV07DO  := 0.00
SV07    := 51CT OR 51VT OR 51GXT OR 51NT OR 67N1T OR 67N2T OR 49T OR LT06 AND NOT
    3PWRX2T AND NOT LOPX
SV08PU  := 0.00    SV08DO  := 0.00
SV08    := 24C2T OR 3PWRX1T OR 40Z1T OR 40Z2T
SV09PU  := 0.00    SV09DO  := 0.00
SV09    := 50PY3AT OR 50PY3BT OR 50PY3CT OR 67PY1T OR 67PY2T OR 67GY1T OR 67GY2T OR
    67QY1T OR 67QY2T
SV10PU  := 0.00    SV10DO  := 0.00
SV10    := 51PYT OR 51GYT OR 51QYT OR 3PWRY1T OR 3PWRY2T OR 81Y1T OR 81Y2T OR 81RY1T
    OR 81RY2T

SV11PU  := 0.00    SV11DO  := 2.00
SV11    := 0
SV12PU  := 0.00    SV12DO  := 2.00
SV12    := 0
SV13PU  := 0.00    SV13DO  := 0.20
SV13    := R_TRIG ZCFREQX OR F_TRIG ZCFREQX OR F_TRIG ASYNSDC
SV14PU  := 0.00    SV14DO  := 0.00
SV14    := FREQX > 16.00

Math Variables
MV01    := FREQX * SV14 + MV01 * NOT SV14

OUT101FS:= N       OUT101  := CLOSEX
OUT102FS:= N       OUT102  := 0
OUT103FS:= N       OUT103  := TRIPX
OUT301FS:= N       OUT301  := 0
OUT302FS:= N       OUT302  := 0
OUT303FS:= N       OUT303  := 0
OUT304FS:= N       OUT304  := 0

=>>
```

Figure 10.10 Example Standard 15-cycle Digital Event Report (EVE D X Command) 1/4-Cycle Resolution (Continued)

Stator Ground Event Report (EVE GND Command)

This report is available in SEL-700G models with Slot E = 72/74/76. These models have the 100% Stator Ground Protection elements (64G). Refer to *100% Stator Ground Protection Elements on page 4.39* for details on these elements.

The ground event report includes:

- Analog quantities:
  - VN1–generator neutral fundamental rms voltage magnitude in volts primary
  - VP3–generator terminal third harmonic rms voltage magnitude in volts primary
  - VN3–generator neutral third harmonic rms voltage magnitude in volts primary
- Digital states of stator ground elements plus the status of base model digital inputs and outputs
- Event summary (includes the serial number of the product)
- Settings in service at the time of event triggering, consisting of Group, Logic, Global, and Report settings classes

Use the **EVE GND *n*** command (*n* is the event number) to retrieve the reports. The relay defaults to ***n*** = 1 if the event number is not specified. The event report rows show data every one-quarter cycle. Refer to the example EVE GND event report in *Figure 10.11* to view the data.

```
=>>EVE GND <Enter>

SEL-700G                                 Date: 05/09/2018   Time: 03:59:07.391
GENERATOR RELAY

Serial Number=000000000000000
FID=SEL-700G-X351-V0-Z006003-D20180501   CID=5E6A

                             O
                       6 TN I u
                       4 66 N t
  Voltages (Volts Pri) GG44 1 13
    VP3    VN3    VN1  12GG 2 2
[1]
   20.0   20.0   14.1  .... . ..
   10.0   10.0   22.4  .... . ..
   14.1   14.1   22.4  .... . ..
   14.1   22.4   14.1  .... . ..
[2]
   22.4   20.0   14.1  .... . ..
   22.4   10.0   31.6  .... . ..
   14.1  430.1  580.8  .... . ..
   41.2  762.8 2898.6> t... . ..

.
.
.

[14]
   42.4   31.6 9996.7  t... . .*
   30.0   22.4  10004  t... . .*
   10.0   28.3  10004* t... . .*
   14.1   28.3  10004  t... . .*
[15]
   14.1   22.4  10016  t... . .*
   14.1   10.0  10016  t... . .*
   14.1   30.0  10010  t... . .*
   22.4   31.6  10002  t... . .*

Serial No = 000000000000000
FID = SEL-700G-X351-V0-Z006003-D20180501               CID = 5E6A
EVENT LOGS =  1            REF_NUM = 10000

Event:       64G/64F Gnd Trip
Targets      11000001
Freqx, (Hz)  60.00

Current Mag (X Side)
        IAX           IBX           ICX           IGX
(A)    3008.2           7.1          11.2       3026.17

Current Mag (Y Side)
        IAY           IBY           ICY           IGY
(A)    2998.2           0.0           5.0       3002.25


Neutral Current Mag
        IN
(A)      0.00

Voltage Mag (X Side)
       VAX    VBX    VCX    VGX
(V)   66998  66979  66964    102

Sync Voltage Mag
       VS
(V)       0

Neutral Voltage Mag
       VN
(V)   10005
=>>
```

Figure 10.11 Example 15-cycle Stator Ground Event Report (EVE GND) 1/4-Cycle Resolution

```
Global Settings
FNOM    := 60      DATE_F  := MDY     METHRES := Y
FAULT   := 0

EMP     := N

TGR     := 3
SS1     := 1
SS2     := 0
SS3     := 0
SS4     := 0

EPMU    := N
IRIGC   := NONE    UTC_OFF := 0.00    DST_BEGM:= OFF
52ABF   := N       BFDX    := 0.50    BFIX    := 0

IN101D  := 10      IN102D  := 10

EBMONX  := Y       COSP1X  := 10000   COSP2X  := 150     COSP3X  := 12
KASP1X  := 1.20    KASP2X  := 8.00    KASP3X  := 20.00   BKMONX  := TRIPX

RSTTRGT := 0
RSTENRGY:= 0
RSTMXMN := 0
RSTDEM  := 0
RSTPKDEM:= 0

DSABLSET:= 0

TIME_SRC:= IRIG1
89A2P1  := 0
89B2P1  := NOT 89A2P1
89A2P1D := 5.00    89A2P2  := 0
89B2P2  := NOT 89A2P2
89A2P2D := 5.00    89A2P3  := 0
89B2P3  := NOT 89A2P3
89A2P3D := 5.00    89A2P4  := 0
89B2P4  := NOT 89A2P4
89A2P4D := 5.00    89A2P5  := 0
89B2P5  := NOT 89A2P5
89A2P5D := 5.00    89A2P6  := 0
89B2P6  := NOT 89A2P6
89A2P6D := 5.00    89A2P7  := 0
89B2P7  := NOT 89A2P7
89A2P7D := 5.00    89A2P8  := 0
89B2P8  := NOT 89A2P8
89A2P8D := 5.00
EN_LRC  := N       EN_LRC  := N

Group Settings

RID     := SEL-700G
TID     := GENERATOR RELAY
PHROT   := ABC     X_CUR_IN:= NEUT    CTRX    := 1000    INOM    := 5.0
DELTAY_X:= WYE     PTRX    := 1000.00 VNOM_X  := 120.00  CTCONY  := WYE
CTRY    := 1000    PTRS    := 1.00    CTRN    := 1000    PTRN    := 1000.00
E87     := NONE

E87N    := N
```

Figure 10.11 Example 15-cycle Stator Ground Event Report (EVE GND) 1/4-Cycle Resolution (Continued)

```
EREF    := Y       50REF1P := 0.25    REF1TC  := 1
REF52BYP:= Y
E64G    := Y
64G1P   := 0.1     64G1D   := 0.00    64G1TC  := 1
64G2P   := 2.5     64RAT   := 1.0     64G2D   := 0.08    64G2TC  := 1

E64F    := N

EBUP    := N       E40     := Y       40Z1P   := 13.4
40XD1   :=-2.5     40Z1D   := 0.00    40Z2P   := 13.4
40XD2   :=-2.5     40Z2D   := 0.50    40ZTC   := NOT LOPX
E46     := N       E49T    := N
E24     := Y       24D1P   := 105
24D1D   := 0.05    24CCS   := I       24IP    := 102     24IC    := 1
24ITD   := 0.1
24CR    := 0.02    24TC    := 1

E78     := N       EINAD   := N

50PX1P  := OFF     50PX2P  := OFF     50PX3P  := OFF     50GX1P  := OFF
50GX2P  := OFF     50QX1P  := OFF     50QX2P  := OFF
51GXP   := OFF
50PY1P  := OFF     50PY2P  := OFF     50PY3P  := OFF     50GY1P  := OFF
50GY2P  := OFF     50QY1P  := OFF     50QY2P  := OFF
50N1P   := OFF     50N2P   := OFF     51NP    := OFF     EDIRX   := N
ZLFX    := 6.50    PLAFX   := 30.00   NLAFX   :=-30.00
EPWRX   := N
E81X    := N

E81RX   := N
E81ACC  := N

LOPBLKX := 0
27PX1P  := OFF     27PX2P  := OFF
27PPX1P := OFF     27PPX2P := OFF
59PX1P  := OFF     59PX2P  := OFF
59PPX1P := OFF     59PPX2P := OFF

E27V1X  := 1       27V1X1P := 5.0     27V1X1D := 0.50
E59V1X  := N
59QX1P  := OFF     59QX2P  := OFF
59GX1P  := OFF     59GX2P  := OFF
27S1P   := OFF     27S2P   := OFF
59S1P   := OFF     59S2P   := OFF

E27I1   := N       E27I2   := N

E59I1   := N       E59I2   := N       E59I3   := N       E59I4   := N

E49RTD  := NONE

E78VS   := OFF

E25X    := N       EDEM    := ROL     DMTC    := 15      PHDEMPX := OFF
GNDEMPX := OFF     3I2DEMPX:= OFF
50LXP   := 0.25    3POXD   := 0.00
TDURD   := 0.50    CFDX    := 0.50    CFDY    := 0.50
TRX     := 64G1T

TR1     := WDGTRIP OR BRGTRIP OR AMBTRIP OR OTHTRIP OR RTDFLT
TR2     := 0
TR3     := 0

TRY     := 0

REMTRIP := 0
ULTRX   := 3POX

ULTR1   := NOT TR1
ULTR2   := NOT TR2
ULTR3   := NOT TR3

ULTRY   := NOT TRY
```

Figure 10.11 Example 15-cycle Stator Ground Event Report (EVE GND) 1/4-Cycle Resolution (Continued)

```
52AX    := 0
52BX    := NOT 52AX

CLX     := SV03T OR CCX OR SV11T AND 25C

ULCLX   := TRIPX

52AY    := 0
52BY    := NOT 52AY

CLY     := 0

ULCLY   := TRIPY


Report Settings

ESERDEL := N

SER1    := 78VSO 24C2T
SER2    := NA
SER3    := NA
SER4    := NA

EALIAS  := 4

ALIAS1  :=PB01 FP_LOCK PICKUP DROPOUT
ALIAS2  :=PB02 FP_BRKR_SELECT PICKUP DROPOUT
ALIAS3  :=PB03 FP_CLOSE PICKUP DROPOUT
ALIAS4  :=PB04 FP_TRIP PICKUP DROPOUT

ER      := 0
LER     := 15       PRE     := 2
FMR1NAM := FMR1
FMR1    :=NA
FMR2NAM := FMR2
FMR2    :=NA
FMR3NAM := FMR3
FMR3    :=NA
FMR4NAM := FMR4
FMR4    :=NA
RA01TYPE:= I
RA02TYPE:= I
RA03TYPE:= I
.
.
.
RA30TYPE:= I
RA31TYPE:= I
RA32TYPE:= I

GSRTRG  := CLOSEX AND (25C OR 25AX1 OR 25AX2)
GSRR    := 0.25    PRESYNC := 4790

LDLIST  := NA

LDAR    := 15

Logic Settings

ELAT    := 6        ESV     := 14      ESC     := N        EMV     := 1

SET01   := R_TRIG SV01T AND NOT LT01
RST01   := R_TRIG SV01T AND LT01
SET02   := 0
RST02   := 0
SET03   := PB03 AND R_TRIG SV02T AND LT01 AND NOT 52AX
RST03   := (R_TRIG SV02T OR SV03T) AND LT03
SET04   := PB04 AND R_TRIG SV02T AND 52AX
RST04   := (R_TRIG SV02T OR SV04T) AND LT04
SET05   := NA
RST05   := NA
SET06   := LB01 OR RB01
RST06   := 3POX
```

Figure 10.11 Example 15-cycle Stator Ground Event Report (EVE GND) 1/4-Cycle Resolution (Continued)

```
SV01PU  := 3.00    SV01DO  := 0.00
SV01    := PB01
SV02PU  := 0.25    SV02DO  := 0.00
SV02    := PB01 OR PB02 OR PB03 OR PB04
SV03PU  := 0.00    SV03DO  := 0.00
SV03    := LT03
SV04PU  := 0.00    SV04DO  := 0.00
SV04    := LT04
SV05PU  := 0.25    SV05DO  := 0.25
SV05    := (PB01 OR PB02 OR LT03 OR LT04) AND NOT SV05T
SV06PU  := 0.00    SV06DO  := 0.00
SV06    := 87R OR 87U OR 87N1T OR 87N2T OR REF1P OR 67GX1T OR 67GX2T OR INADT OR
 64F2T
SV07PU  := 0.00    SV07DO  := 0.00
SV07    := 21C1T OR 21C2T OR 51CT OR 51VT OR 51GXT OR 51NT OR 67N1T OR 67N2T OR
49T OR LT06 AND NOT 3PWRX2T AND NOT LOPX
SV08PU  := 0.00    SV08DO  := 0.00
SV08    := 24C2T OR 3PWRX1T OR 40Z1T OR 40Z2T
SV09PU  := 0.00    SV09DO  := 0.00
SV09    := 0
SV10PU  := 0.00    SV10DO  := 0.00
SV10    := 0
SV11PU  := 0.00    SV11DO  := 2.00
SV11    := 0
SV12PU  := 0.00    SV12DO  := 2.00
SV12    := 0
SV13PU  := 0.00    SV13DO  := 0.20
SV13    := 0
SV14PU  := 0.00    SV14DO  := 0.00
SV14    := 0

Math Variables
MV01    := -IAX_MAG

OUT101FS:= Y       OUT101  := HALARM OR SALARM
OUT102FS:= N       OUT102  := 0
OUT103FS:= N       OUT103  := TRIPX

=>>
```

Figure 10.11 Example 15-cycle Stator Ground Event Report (EVE GND) 1/4-Cycle Resolution (Continued)

Table 10.4 gives the ground event report digital column definitions for the protection and control elements and the base model inputs and outputs.

Table 10.4 Stator Ground Event report (EVE GND) Digital Column Definitions for Protection, Control, and I/O Elements

Column Designation	Column Symbols	Column Symbol RWBs
64G1	*	64G1 picked up
	t	64G1T picked up
64G2	*	64G2 picked up
	t	64G2T picked up
T64G	T	T64G picked up
N64G	N	N64G picked up
In12	1	IN101 picked up
	2	IN102 picked up
	b	Both IN101 and IN102 picked up
Out12	1	OUT101 picked up
	2	OUT102 picked up
	b	Both OUT101 and OUT102 picked up
Out3	*	OUT103 picked up

Differential Event Report (EVE DIFz Command)

The differential event report includes:

- ➤ Differential analog quantities for 87-1, 87-2 and 87-3 differential elements
- ➤ Digital states of differential and harmonic protection elements, plus status of base model digital inputs and outputs
- ➤ Event summary (includes the serial number of the product)
- ➤ Settings in service at the time of event triggering, consisting of Group, Logic, Global, and Report settings classes

Use the **EVE DIF*z* *n*** command to view the normal differential report (*z* = 1 for 87-1 element, *z* = 2 for 87-2 element and *z* = 3 for 87-3 element) with 4 samples/cycle for report *n* (if not listed, *n* is assumed to be 1). This command is only available in models with the differential element.

Refer to the example event report in *Figure 10.12* to view the differential event report columns. This example event report displays rows of information each one-quarter cycle. Retrieve this report with the **EVE DIF1** command.

Table 10.5 gives the differential event report column definitions for the analog quantities IOP*z*, IRT*z*, I*z*F2 and I*z*F5 for *z* = 1, 2 and 3. *Table 10.6* gives the differential event report digital column definitions for the protection and control elements and the base model inputs and outputs.

Table 10.5 Differential Event Report Column Definitions for Analog Quantities

Column Heading	Description
IOP1	Operate current for differential element 87–1 (multiples of TAP)
IRT1	Restraint current for differential element 87–1 (multiples of TAP)
I1F2	Second-harmonic current for differential element 87–1 (multiples of TAP)
I1F4	Fourth-harmonic current for differential element 87–1 (multiples of TAP)
I1F5	Fifth-harmonic current for differential element 87–1 (multiples of TAP)
IOP2	Operate current for differential element 87–2 (multiples of TAP)
IRT2	Restraint current for differential element 87–2 (multiples of TAP)
I2F2	Second-harmonic current for differential element 87–2 (multiples of TAP)
I2F4	Fourth-harmonic current for differential element 87–2 (multiples of TAP)
I2F5	Fifth-harmonic current for differential element 87–2 (multiples of TAP)
IOP3	Operate current for differential element 87–3 (multiples of TAP)
IRT3	Restraint current for differential element 87–3 (multiples of TAP)
I3F2	Second-harmonic current for differential element 87–3 (multiples of TAP)
I3F4	Fourth-harmonic current for differential element 87–3 (multiples of TAP)
I3F5	Fifth-harmonic current for differential element 87–3 (multiples of TAP)

Table 10.6 Differential Event Report Digital Column Definitions for Protection, Control, and I/O Elements (Sheet 1 of 2)

Column Designation	Column Symbols	Column Symbol Relay Word Bits (RWB)
87R	*	87R picked up
87R12	1 2 b	87R1 picked up 87R2 picked up Both 87R1 and 87R2 picked up

Table 10.6 Differential Event Report Digital Column Definitions for Protection, Control, and I/O Elements (Sheet 2 of 2)

Column Designation	Column Symbols	Column Symbol Relay Word Bits (RWB)
87R3	*	87R3 picked up
87U12	1	87U1 picked up
	2	87U2 picked up
	b	Both 87U1 and 87U2 picked up
87U3	*	87U3 picked up
87B12	1	87BL1 picked up
	2	87BL2 picked up
	b	Both 87BL1 and 87BL2 picked up
87B3	*	87BL3 picked up
87HR12	1	87HR1 picked up
	2	87HR2 picked up
	b	Both 87HR1 and 87HR2 picked up
87HR3	*	87HR3 picked up
HB1	2	2_4HB1 picked up
	5	5HB1 picked up
	b	Both 2_4HB1 and 5HB1 picked up
HB2	2	2_4HB2 picked up
	5	5HB2 picked up
	b	Both 2_4HB2 and 5HB2 picked up
HB3	2	2_4HB3 picked up
	5	5HB3 picked up
	b	Both 2_4HB3 and 5HB3 picked up
TH5	a	TH5 picked up
	t	TH5T picked up
In12	1	IN101 picked up
	2	IN102 picked up
	b	Both IN101 and IN102 picked up
Out12	1	OUT101 picked up
	2	OUT102 picked up
	b	Both OUT101 and OUT102 picked up
Out3	*	OUT103 picked up

```
=>>EVE DIF <Enter>

SEL-700G                                    Date: 05/09/2018   Time: 04:08:13.541
GENERATOR RELAY


Serial Number=000000000000000
FID=SEL-700G-X351-V0-Z006003-D20180501   CID=5E6A

                                     Differential         O
        Differential Quantities      8 87 87 87 87       I u
           Multiples of TAP          7 R  U  B  HR HB  T n t
                                     R 13 13 13 13     H 1 13
   IOP1   IRT1   I1F2   I1F4   I1F5    2  2  2  2  123 5 2 2
[1]
  0.002  0.002  0.002  0.050  0.001  . .. .. .. .. ... . . ..
  0.003  0.003  0.002  0.050  0.001  . .. .. .. .. ... . . ..
  0.206  0.206  0.001  0.050  0.008  . .. .. .. .. ... . . ..
  0.288  0.288  0.139  0.038  0.025  . .. .. .. .. ... . . ..
[2]
  0.786  0.786  0.210  0.167  0.025  . .. .. .. .. ... . . ..
  0.876  0.876  0.213  0.192  0.024  . .. .. .. .. ... . . ..
  1.186  1.186  0.141  0.079  0.023  . .. .. .. .. ... . . ..
  1.197  1.197  0.002  0.057  0.002> * 2. .. .. .. ... . . ..

.
.
.

[14]
  1.200  1.200  0.001  0.050  0.002  * b* .. .. b* ... . . .*
  1.201  1.201  0.001  0.050  0.000  * b* .. .. b* ... . . .*
  1.198  1.198  0.001  0.050  0.002  * b* .. .. b* ... . . .*
  1.197  1.197  0.001  0.050  0.003* * b* .. .. b* ... . . .*
[15]
  1.200  1.200  0.002  0.050  0.002  * b* .. .. b* ... . . .*
  1.201  1.201  0.000  0.050  0.001  * b* .. .. b* ... . . .*
  1.199  1.199  0.002  0.050  0.001  * b* .. .. b* ... . . .*
  1.197  1.197  0.001  0.050  0.001  * b* .. .. b* ... . . .*

Serial No = 000000000000000
FID = SEL-700G-X351-V0-Z006003-D20180501                CID = 5E6A
EVENT LOGS =  3             REF_NUM = 10002

Event:       Diff 87 Trip
Targets      11100001
Freqx, (Hz)  60.00

Current Mag (X Side)
        IAX           IBX           ICX           IGX
(A)    2998.1        3002.6        2993.2         20.00

Current Mag (Y Side)
        IAY           IBY           ICY           IGY
(A)    2992.7        5015.5        5005.7       2024.08

Neutral Current Mag
        IN
(A)      0.00

Voltage Mag (X Side)
       VAX    VBX    VCX    VGX
(V)   66987  67007  66959    114

Sync Voltage Mag
       VS
(V)       0

Neutral Voltage Mag
       VN
(V)   10017
```

Figure 10.12 Example Standard 15-Cycle Differential Event Report (EVE DIF2 Command) 1/4-Cycle Resolution

```
Global Settings
FNOM    := 60      DATE_F  := MDY     METHRES := Y
FAULT   := 0

EMP     := N

TGR     := 3
SS1     := 1
SS2     := 0
SS3     := 0
SS4     := 0

EPMU    := N
IRIGC   := NONE    UTC_OFF := 0.00    DST_BEGM:= OFF
52ABF   := N       BFDX    := 0.50    BFIX    := 0

IN101D  := 10      IN102D  := 10

EBMONX  := Y       COSP1X  := 10000   COSP2X  := 150     COSP3X  := 12
KASP1X  := 1.20    KASP2X  := 8.00    KASP3X  := 20.00   BKMONX  := TRIPX

RSTTRGT := 0
RSTENRGY:= 0
RSTMXMN := 0
RSTDEM  := 0
RSTPKDEM:= 0

DSABLSET:= 0

TIME_SRC:= IRIG1
89A2P1  := 0
89B2P1  := NOT 89A2P1
89A2P1D := 5.00    89A2P2  := 0
89B2P2  := NOT 89A2P2
89A2P2D := 5.00    89A2P3  := 0
89B2P3  := NOT 89A2P3
89A2P3D := 5.00    89A2P4  := 0
89B2P4  := NOT 89A2P4
89A2P4D := 5.00    89A2P5  := 0
89B2P5  := NOT 89A2P5
89A2P5D := 5.00    89A2P6  := 0
89B2P6  := NOT 89A2P6
89A2P6D := 5.00    89A2P7  := 0
89B2P7  := NOT 89A2P7
89A2P7D := 5.00    89A2P8  := 0
89B2P8  := NOT 89A2P8
89A2P8D := 5.00
EN_LRC  := N       EN_LRC  := N

Group Settings

RID     := SEL-700G
TID     := GENERATOR RELAY
PHROT   := ABC     X_CUR_IN:= NEUT    CTRX    := 1000    INOM    := 5.0
DELTAY_X:= WYE     PTRX    := 1000.00 VNOM_X  := 120.00  CTCONY  := WYE
CTRY    := 1000    PTRS    := 1.00    CTRN    := 1000    PTRN    := 1000.00
E87     := GEN     TAPX    := 5.00    TAPY    := 5.00
O87P    := 0.30    U87P    := 10.0    87AP    := 0.15    87AD    := 5.00
SLP1    := 25

HSM     := 0
O87P2   := 1.25    HSMDOT  := 10.00

E87N    := N

EREF    := Y       50REF1P := 0.25    REF1TC  := 1
REF52BYP:= Y
E64G    := Y
64G1P   := 0.1     64G1D   := 0.00    64G1TC  := 1
64G2P   := 2.5     64RAT   := 1.0     64G2D   := 0.08    64G2TC  := 1

E64F    := N
```

Figure 10.12 Example Standard 15-Cycle Differential Event Report (EVE DIF2 Command) 1/4-Cycle Resolution (Continued)

```
EBUP    := N       E40     := Y       40Z1P   := 13.4
40XD1   :=-2.5     40Z1D   := 0.00    40Z2P   := 13.4
40XD2   :=-2.5     40Z2D   := 0.50    40ZTC   := NOT LOPX
E46     := N       E49T    := N
E24     := Y       24D1P   := 105
24D1D   := 0.05    24CCS   := I       24IP    := 102     24IC    := 1
24ITD   := 0.1
24CR    := 0.02    24TC    := 1

E78     := N       EINAD   := N

50PX1P  := OFF     50PX2P  := OFF     50PX3P  := OFF     50GX1P  := OFF
50GX2P  := OFF     50QX1P  := OFF     50QX2P  := OFF
51GXP   := OFF
50PY1P  := OFF     50PY2P  := OFF     50PY3P  := OFF     50GY1P  := OFF
50GY2P  := OFF     50QY1P  := OFF     50QY2P  := OFF
50N1P   := OFF     50N2P   := OFF     51NP    := OFF     EDIRX   := N
ZLFX    := 6.50    PLAFX   := 30.00   NLAFX   :=-30.00
EPWRX   := N
E81X    := N

E81RX   := N
E81ACC  := N

LOPBLKX := 0
27PX1P  := OFF     27PX2P  := OFF
27PPX1P := OFF     27PPX2P := OFF
59PX1P  := OFF     59PX2P  := OFF
59PPX1P := OFF     59PPX2P := OFF

E27V1X  := 1       27V1X1P := 5.0     27V1X1D := 0.50
E59V1X  := N
59QX1P  := OFF     59QX2P  := OFF
59GX1P  := OFF     59GX2P  := OFF
27S1P   := OFF     27S2P   := OFF
59S1P   := OFF     59S2P   := OFF

E27I1   := N       E27I2   := N

E59I1   := N       E59I2   := N       E59I3   := N       E59I4   := N

E49RTD  := NONE

E78VS   := OFF

E25X    := N       EDEM    := ROL     DMTC    := 15      PHDEMPX := OFF
GNDEMPX := OFF     3I2DEMPX:= OFF
50LXP   := 0.25    3POXD   := 0.00
TDURD   := 0.50    CFDX    := 0.50    CFDY    := 0.50
TRX     := 87R

TR1     := WDGTRIP OR BRGTRIP OR AMBTRIP OR OTHTRIP OR RTDFLT
TR2     := 0
TR3     := 0

TRY     := 0

REMTRIP := 0
ULTRX   := 3POX

ULTR1   := NOT TR1
ULTR2   := NOT TR2
ULTR3   := NOT TR3

ULTRY   := NOT TRY

52AX    := 0
52BX    := NOT 52AX

CLX     := SV03T OR CCX OR SV11T AND 25C

ULCLX   := TRIPX

52AY    := 0
52BY    := NOT 52AY

CLY     := 0

ULCLY   := TRIPY
```

Figure 10.12 Example Standard 15-Cycle Differential Event Report (EVE DIF2 Command) 1/4-Cycle Resolution (Continued)

```
Report Settings

ESERDEL := N

SER1    := 78VSO 24C2T
SER2    := NA
SER3    := NA
SER4    := NA

EALIAS  := 4

ALIAS1  :=PB01 FP_LOCK PICKUP DROPOUT
ALIAS2  :=PB02 FP_BRKR_SELECT PICKUP DROPOUT
ALIAS3  :=PB03 FP_CLOSE PICKUP DROPOUT
ALIAS4  :=PB04 FP_TRIP PICKUP DROPOUT

ER      := 0
LER     := 15      PRE     := 2
FMR1NAM := FMR1
FMR1    :=NA
FMR2NAM := FMR2
FMR2    :=NA
FMR3NAM := FMR3
FMR3    :=NA
FMR4NAM := FMR4
FMR4    :=NA

RA01TYPE:= I
RA02TYPE:= I
RA03TYPE:= I
.
.
.
RA30TYPE:= I
RA31TYPE:= I
RA32TYPE:= I

GSRTRG  := CLOSEX AND (25C OR 25AX1 OR 25AX2)
GSRR    := 0.25    PRESYNC := 4790

LDLIST  := NA

LDAR    := 15

Logic Settings

ELAT    := 6       ESV     := 14      ESC     := N       EMV     := 1

SET01   := R_TRIG SV01T AND NOT LT01
RST01   := R_TRIG SV01T AND LT01
SET02   := 0
RST02   := 0
SET03   := PB03 AND R_TRIG SV02T AND LT01 AND NOT 52AX
RST03   := (R_TRIG SV02T OR SV03T) AND LT03
SET04   := PB04 AND R_TRIG SV02T AND 52AX
RST04   := (R_TRIG SV02T OR SV04T) AND LT04
SET05   := NA
RST05   := NA
SET06   := LB01 OR RB01
RST06   := 3POX
```

Figure 10.12 Example Standard 15-Cycle Differential Event Report (EVE DIF2 Command) 1/4-Cycle Resolution (Continued)

```
SV01PU  := 3.00    SV01DO  := 0.00
SV01    := PB01
SV02PU  := 0.25    SV02DO  := 0.00
SV02    := PB01 OR PB02 OR PB03 OR PB04
SV03PU  := 0.00    SV03DO  := 0.00
SV03    := LT03
SV04PU  := 0.00    SV04DO  := 0.00
SV04    := LT04
SV05PU  := 0.25    SV05DO  := 0.25
SV05    := (PB01 OR PB02 OR LT03 OR LT04) AND NOT SV05T
SV06PU  := 0.00    SV06DO  := 0.00
SV06    := 87R OR 87U OR 87N1T OR 87N2T OR REF1P OR 67GX1T OR 67GX2T OR INADT OR
 64F2T
SV07PU  := 0.00    SV07DO  := 0.00
SV07    := 21C1T OR 21C2T OR 51CT OR 51VT OR 51GXT OR 51NT OR 67N1T OR 67N2T OR
49T OR LT06 AND NOT 3PWRX2T AND NOT LOPX
SV08PU  := 0.00    SV08DO  := 0.00
SV08    := 24C2T OR 3PWRX1T OR 40Z1T OR 40Z2T
SV09PU  := 0.00    SV09DO  := 0.00
SV09    := 0
SV10PU  := 0.00    SV10DO  := 0.00
SV10    := 0
SV11PU  := 0.00    SV11DO  := 2.00
SV11    := 0
SV12PU  := 0.00    SV12DO  := 2.00
SV12    := 0
SV13PU  := 0.00    SV13DO  := 0.20
SV13    := 0
SV14PU  := 0.00    SV14DO  := 0.00
SV14    := 0

Math Variables
MV01    := -IAX_MAG

OUT101FS:= Y       OUT101  := HALARM OR SALARM
OUT102FS:= N       OUT102  := 0
OUT103FS:= N       OUT103  := TRIPX

==>>
```

Figure 10.12 Example Standard 15-Cycle Differential Event Report (EVE DIF2 Command) 1/4-Cycle Resolution (Continued)

Sequential Events Recorder (SER) Report

The SER report captures relay element state changes over an extended period.

SER report data are useful in commissioning tests and root-cause analysis studies. SER information is stored when state changes occur. The report records the most recent 1024 state changes if a relay element is listed in the SER trigger equations.

SER Triggering

NOTE: A file containing an SER report can be extracted by using the **FILE** command (see Section 7: Communications), the Ethernet File Transfer Protocol (FTP), or the IEC 61850 Manufacturing Message Specification (MMS). To transfer files using MMS, set EMMSFS to Y.

Settings SER1 through SER4 are used to select entries in the SER report. To capture relay element state changes in the SER report, the relay element name must be programmed into one of the four SER trigger equations. Each of the four programmable trigger equations allows entry of as many as 24 relay elements; the SER report can monitor a total of 96 relay elements.

The relay adds a message to the SER to indicate power up or settings change conditions.

```
Relay Powered Up
.
.
.
Relay Settings Changed
```

Each entry in the SER includes the SER row number, date, time, element name, and element state.

SER Aliases

You can rename as many as 32 of the SER trigger conditions by using the ALIAS settings. For instance, the factory-default alias setting 2 renames Relay Word bit PB02 for reporting in the SER:

```
ALIAS2:= PB02 FP_LOCK PICKUP DROPOUT
```

When Relay Word bit PB02 is asserted, the SER report shows the date and time of FP_LOCK PICKUP. When Relay Word bit PB02 is deasserted, the SER report shows the date and time of FP_LOCK DROPOUT. With this and other alias assignments, the SER record is easier for the operator to review. See *Relay Word Bit Aliases on page 4.258* for additional details.

Retrieving and Clearing SER Reports

The SER report is available as a read-only file that can be retrieved using Ethernet File Transfer Protocol (FTP) or Manufacturing Message Specification (MMS). MMS is only available in models that support IEC 61850 and only when IEC 61850 and MMS file transfer are enabled (E61850 := Y, EMMSFS := Y). See *File Transfer Protocol (FTP) and MMS File Transfer on page 7.15*, *Virtual File Interface on page 7.77*, and *MMS on page G.5* for additional information.

See *SER Command (Sequential Events Recorder Report) on page 7.64* for additional details on the **SER** command.

Example SER Report

The example SER report in *Figure 10.13* includes records of events that occurred before the beginning of the event summary report in *Figure 10.3*.

```
=>SER <Enter>

SEL-700G                                   Date: 02/24/2010   Time: 19:15:40.570
GENERATOR RELAY                            Time Source: External

Serial No = 000000000000000
FID = SEL-700G-X134-V0-Z001001-D20100224                  CID = 1C01

#     DATE         TIME              ELEMENT              STATE
5  02/24/2010  19:08:09.705   87R                        Asserted
4  02/24/2010  19:08:09.705   TRIP3                      Asserted
3  02/24/2010  19:08:09.705   TRIP2                      Asserted
2  02/24/2010  19:08:09.705   TRIP1                      Asserted
1  02/24/2010  19:08:09.705   TRIPX                      Asserted

=>
```

Figure 10.13 Example Sequential Events Recorder (SER) Event Report

Synchronism-Check Report

SEL-700G relays equipped with synchronism check (25X) generate a report each time the relay initiates a synchronism-check supervised generator breaker close. The report contains information about the system and generator at the time the close was performed. The relay stores the three latest reports in nonvolatile relay memory. View the report data by using the **SYN *n*** (***n*** is the report number, ***n*** defaults to 1, which is the latest report) command available at Access Level 1 and above. An example of the **SYN** report is shown in *Figure 10.14*. Note that the relay selects phase for the generator voltage based on the SYNCPX setting and reports its magnitude after compensating for the 25RCFX factor (see Vpxc in *Figure 4.109*).

```
=>>SYN <Enter>

SEL-700G                                  Date: 03/04/2010   Time: 03:28:47.279
GENERATOR RELAY                           Time Source: Internal


Serial Number=000000000000000
FID=SEL-700G-X137-V0-Z001001-D20100303   CID=0000

CLOSEX*(25C+25AX1+25AX2) Asserted At:03/04/2010 03:20:55.252
Synch Check Conditions when CLOSEX Asserted:
Slip Freq.    =   0.00Hz Generator Freq.   =  60.00Hz System Freq.   =  60.00Hz
Voltage Diff. =    1.61% Generator Voltage =   0.06kV System Voltage =   0.06kV
Slip-Compensated Phase Angle Difference =  -2.04 degrees
Uncompensated Phase Angle Difference    =  -2.23 degrees

3POX Deasserted At  : 03:20:55.419
Breaker Close Time :  0.167
Average Breaker Close Time =  0.125  (7.5 cycles)
Close Operations           =  20
Last Reset                 =  03/03/2010 03:17:14.618

=>>
```

Figure 10.14 Example SYN Command Response

The synchronism-check report is available as a read-only file that can be retrieved using Ethernet File Transfer Protocol (FTP) or Manufacturing Message Specification (MMS). MMS is only available in models that support IEC 61850 and only when IEC 61850 and MMS file transfer are enabled (E61850 := Y, EMMSFS := Y). See *File Transfer Protocol (FTP) and MMS File Transfer on page 7.15*, *Virtual File Interface on page 7.77*, and *MMS on page G.5* for additional information.

SYN Report Triggering

The relay starts a **SYN** report when a synchronism-check supervised generator breaker close is initiated. The relay defines a synchronism-check supervised close initiation as the rising edge of CLOSEX * (25C + 25AX1 + 25AX2). The relay triggers a SYN report for every synchronism-check supervised close, regardless of which synchronism-check outputs (25C, 25AX1 or 25AX2) you used to supervise CLOSEX assertion. The relay starts the report by recording the time of initiation.

Conditions When CLOSEX Asserted

The **SYN** report shows the generator and system conditions at the time the CLOSEX was initiated. Conditions displayed include present slip frequency, actual generator and system frequencies, percent voltage difference, and actual generator and system voltages. Next, the slip-compensated and uncompensated phase angle differences are shown. The uncompensated phase angle difference is simply the phase angle between the system and generator voltages when CLOSEX was initiated. The relay uses *Equation 10.3* to calculate the slip-compensated phase angle difference:

$$\text{Slip-Compensated Angle} = \text{Ang(VPX)} - \text{Ang(VS)} + (\text{SLIP} \bullet \text{TCLOSDX} \bullet 360) \quad \textbf{Equation 10.3}$$

where:

Ang (VPX) = the generator voltage phase-angle, degrees

Ang (VS) = the system voltage phase-angle, degrees

SLIP = present slip frequency, Hz

TCLOSDX = breaker close time-delay setting, seconds

The result of SLIP • TCLOSDX • 360° is the number of degrees that the generator voltage travels, with respect to the system voltage, during the time that it takes the breaker to close (TCLOSDX), assuming a constant slip frequency equal to SLIP.

When you supervise CLOSEX initiation with the 25C Relay Word bit, the relay asserts 25C when the slip-compensated phase angle is approximately equal to the CANGLE setting. Thus, when you review a SYN report from a 25C supervised CLOSEX, the slip-compensated angle should closely equal the CANGLE setting. The slip-compensated angle tells us what the relay expects the phase angle to be when the breaker actually closes TCLOSDX seconds after CLOSEX initiation.

SYN Report Closure

For the vast majority of breaker close operations, the breaker will close and the three-pole-open condition, 3POX, will deassert. If this occurs within about 99 seconds of CFI assertion, the relay records the time 3POX deasserted, calculates and displays the breaker close time, advances the close operation counter, and accounts for the new close time in the breaker close time average.

If the breaker does not close and slip is not close to 0 Hz, the generator voltage rotates away from the system voltage until the phase angle exceeds the close-failure angle, CFANGLE, setting. If this occurs within about 99 seconds of CFI assertion, the relay reports the message `Close Failed` in the place of the breaker close time and stores the **SYN** report.

If 3POX does not deassert and the uncompensated phase angle difference does not exceed the CFANGLE setting within about 99 seconds of CFI assertion, the relay reports the message `Close Failed` in the place of the breaker close time and stores the **SYN** report.

Use the Breaker Close Time Average

You can use the breaker close time average to refine the TCLOSDX setting. By setting TCLOSDX closer to the actual breaker closing time, the synchronism-check function performs better to cause a breaker close exactly when the generator voltage phase angle difference equals CANGLE.

Reset the Breaker Close Time Average

Use the Access Level 2 **SYN R** command to reset the Breaker Close Time Average and breaker close operations counter. The relay records the date and time of the last reset for inclusion in the **SYN** report.

Generator Autosynchronism Report (CGSR Command)

This report is available in SEL-700G models that support the generator synchronism-check function. Relays with Slot E = 71/72/74/75/76 and Slot Z = 81/85/82/86 support this function. These are the SEL-700G0, SEL-700G1, and the SEL-700GT models.

SEL-700G relays that are equipped with generator synchronism check trigger the generator synchronism report when the SELOGIC control equation GSRTRG transitions from 0 to 1. The report contains 4800 samples of data, each containing the analog and digital information shown in *Table 4.107*. The resolution and number of pre-trigger data samples are defined by settings GSRR and PRESYNC and can be set as necessary. Refer to *Table 4.106* for details on the settings.

The report captures frequency/speed matching and voltage matching during autosynchronism. Refer to *Autosynchronism on page 4.183* for a detailed description.

The report is only available in the Compressed ASCII format and can be viewed using the **CGSR** (Generator Synchronism Report) command. SEL communications processors and SYNCHROWAVE Event take advantage of the Compressed ASCII format. View the report by using QuickSet with SYNCHROWAVE Event. See *Figure 4.126* for an example graphical display of a Generator Autosynchronism Report using SYNCHROWAVE Event.

The generator synchronism report is also available as a read-only file that can be retrieved using Ethernet File Transfer Protocol (FTP) or Manufacturing Message Specification (MMS). MMS is only available in models that support IEC 61850 and only when IEC 61850 and MMS file transfer are enabled (E61850 := Y, EMMSFS := Y). See *File Transfer Protocol (FTP) and MMS File Transfer on page 7.15*, *Virtual File Interface on page 7.77*, and *MMS on page G.5* for additional information.

Use the **GSH** command (Access Level 1 and 2) to view the Generator Synchronism Reports history. Refer to *Figure 7.31* for an example command response. Clear the history and the reports by using the **GSH C** or the **GSH R** command from Access Level 2.

Use the **GST** command from Access Level 1 or 2 to trigger the Generator Autosynchronism Report.

Section 11
Testing and Troubleshooting

Overview

Relay testing is typically divided into two categories:

- Tests performed at the time the relay is installed or commissioned
- Tests performed periodically once the relay is in service

This section provides information on both types of testing for the SEL-700G Relay. Because the SEL-700G is equipped with extensive self-tests, traditional periodic test procedures may be eliminated or greatly reduced.

Should a problem arise during either commissioning or periodic tests, the section on *Troubleshooting on page 11.17* provides a guide to isolating and correcting the problem.

Testing Tools

Serial Port Commands

The following serial port commands assist you during relay testing.

The **METER** command shows the ac currents and voltages (magnitude and phase angle) presented to the relay in primary values. In addition, the command shows power system frequency. Compare these quantities against other devices of known accuracy. The **METER** command is available at the serial ports and front-panel display. See *Section 7: Communications* and *Section 8: Front-Panel Operations*.

The relay generates a 15, 64, or 180-cycle event report in response to faults or disturbances. Each report contains current and voltage information, relay element states, and input/output contact information. If you question the relay response or your test method, use the event report for more information. The **EVENT** command is available at the serial ports. See *Section 10: Analyzing Events*.

The relay provides a Sequential Events Recorder (SER) event report that time-tags changes in relay element and input/output contact states. The SER provides a convenient means to verify the pickup/dropout of any element in the relay. The **SER** command is available at the serial ports. See *Section 10: Analyzing Events*.

Use the **TARGET** command to view the state of relay control inputs, relay outputs, and relay elements individually during a test. The **TARGET** command is available at the serial ports and the front panel. See *Section 7: Communications* and *Section 8: Front-Panel Operations*. You can achieve similar results using the web server. See *Section 3: PC Interface*.

Low-Level Test Interface

The SEL-700G has a low-level test interface on the 4 ACI/3 AVI current/voltage card, 1 ACI neutral current card, or 3 ACI current card (Slot **Z**) and 3 ACI/4 AVI current/voltage card, 2 AVI voltage card, 3 ACI current card, or 3 ACI/2 AVI current/voltage card (Slot **E**). You can test the relay in either of two ways: conventionally by applying ac signals to the relay inputs or by applying low magnitude ac voltage signals to the test interface on the printed circuit boards.

NOTE: The SEL-RTS Relay Test System consists of the SEL-AMS Adaptive Multichannel Source and SEL-5401 Test System Software.

You can use the SEL-RTS Low-Level Relay Test System to provide signals to test the relay. *Figure 11.1* shows the Test Interface connectors. *Figure 11.2* shows the SEL-C700G Cable connection between an SEL- RTS test system and the SEL-700G.

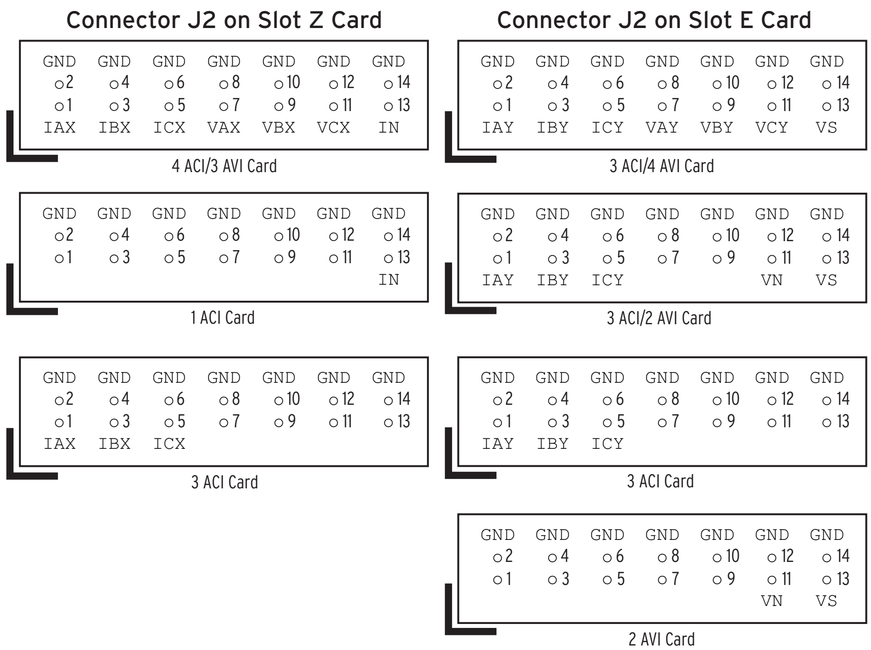


Figure 11.1 Low-Level Test Interface (J2)

NOTE: The SEL-700G Relay can have as many as 14 analog input channels. The SEL-AMS has only as many as 12 analog input channels. This is the reason for C700G cable complexity.

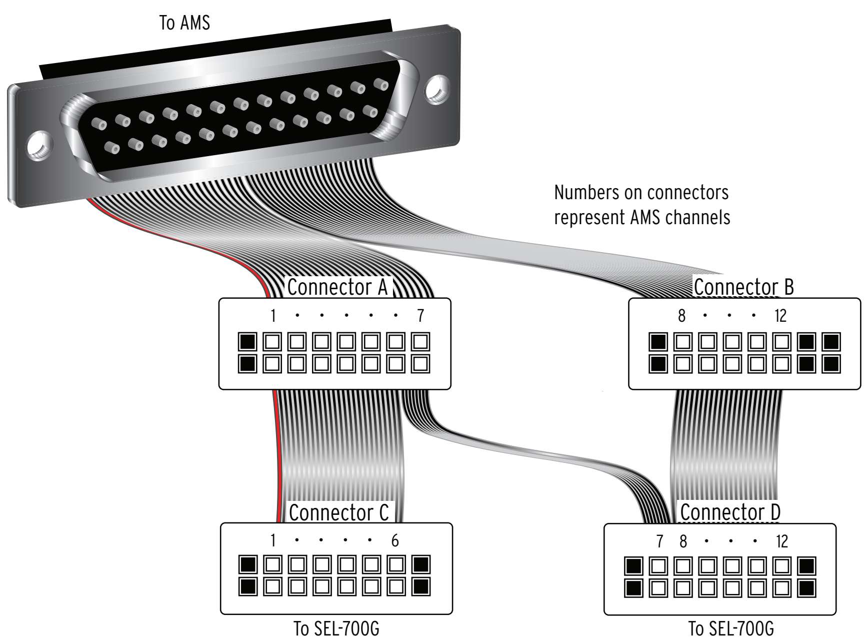


Figure 11.2 SEL-C700G Ribbon Cable Connector Diagram

Table 11.1 shows how to use the C700G cable for measuring the necessary quantities. For example, using C700G Connection Options No. 2 with connector C on Slot Z and D on Slot E, align channel 1 with IAX and CH#7 with IBY on the 4ACI/3AVI and 3AC1/4AVI boards, respectively. Alignment can be changed to get the necessary quantities. *Table 11.2* shows the signal scale factor information the AMS Relay Test System SEL-5401 Software uses for the calibrated inputs.

Table 11.1 SEL-C700G Cable Connection Options[a]

Slot	Connectors								
	Card Connector (J2) Signals[b]	SEL-C700G Cable Connection Options							
		No. 1		No. 2		No. 3		No. 4	
		C700G Connector	AMS CH#	C700G Connector	AMS CH#	C700G Connector	AMS CH#	C700G Connector	AMS CH#
Z	IAX	A	1	C	1	C	1	C	—
	IBX		2		2		2		1
	ICX		3		3		3		2
	VAX		4		4		4		3
	VBX		5		5		5		4
	VCX		6		6		6		5
	IN		7		—		—		6
E	IAY	B	8	D	—	D	7	D	7
	IBY		9		7		8		8
	ICY		10		8		9		9
	VAY		11		9		10		10
	VBY		12		10		11		11
	VCY or VN		—		11		12		12
	VS		—		12		—		—

[a] Only the commonly used connection options are shown; additional connections are possible.
[b] All possible signals are shown; available signals depend on the card type plugged into the slot (see Table 1.1 for details).

Table 11.2 Resultant Scale Factors for Inputs (Sheet 1 of 2)

Channel Label	Circuit Board and Connector	Nominal Input	Scale Factor (A/V or V/V)
IAX	J2 on Slot Z card	5 A/1 A	106.14/21.23
IBX	J2 on Slot Z card	5 A/1 A	106.14/21.23
ICX	J2 on Slot Z card	5 A/1 A	106.14/21.23
VAX	J2 on Slot Z card	250 V	218.4
VBX	J2 on Slot Z card	250 V	218.4
VCX	J2 on Slot Z card	250 V	218.4
IN	J2 on Slot Z card	5 A/1 A	106.14/21.23
IAY	J2 on Slot E card	5 A/1 A	106.14/21.23
IBY	J2 on Slot E card	5 A/1 A	106.14/21.23
ICY	J2 on Slot E card	5 A/1 A	106.14/21.23

Table 11.2 Resultant Scale Factors for Inputs (Sheet 2 of 2)

Channel Label	Circuit Board and Connector	Nominal Input	Scale Factor (A/V or V/V)
VAY	J2 on Slot E card	250 V	218.4
VBY	J2 on Slot E card	250 V	218.4
VCY	J2 on Slot E card	250 V	218.4
VN	J2 on Slot E card	250 V	218.4
VS	J2 on Slot E card	250 V	218.4

⚠CAUTION
Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.

NOTE: You can use the 14-pin connectors of the SEL-RTS ribbon cable C700G. The connectors are not keyed; refer to Table 11.1.

Access the low-level test interface connectors by using the following procedure.

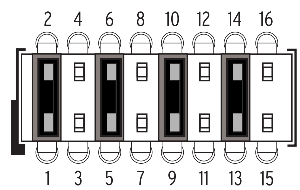
Step 1. Loosen the mounting screws and the ground screw on the back and remove the back cover.

Step 2. Remove the 4 ACI/3 AVI, 1 ACI, or 3 ACI board from Slot **Z**.

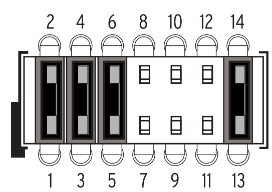
Step 3. Locate the 16-pin jumper assembly J3 on the board and move the four jumpers from CT to AMS positions.

CT position (normal) jumpers are between 1-2, 5-6, 9-10 and 13-14 pin numbers.

AMS position (test) jumpers are between 3-4, 7-8, 11-12 and 15-16 pin numbers.



Step 4. Locate the 14-pin connector J2 on the board. It has four jumpers on pins 1-2, 3-4, 5-6, 13-14. Please remove these jumpers and save them for restoring the relay to normal operation after test.



Connect the low-level signal connector of the C700G cable to J2, as shown in *Figure 11.1* and *Figure 11.2* (for example, ribbon cable C700G connector of SEL-RTS Test System).

Step 5. Insert the 4 ACI/3 AVI, 1 ACI, or 3 ACI board back into its Slot **Z**.

Step 6. Remove the 3 ACI/4 AVI, 2 AVI, 3 ACI, or 3 ACI/2 AVI board board from Slot **E**.

Step 7. Locate jumper assembly J3 and change it from CT (normal position) to AMS (low-level test position) as described in *Step 3*.

Step 8. Locate the 14-pin connector J2 on the board.

It has four jumpers on pins 1-2, 3-4, 5-6, 13-14. Please remove these jumpers and save them for restoring the relay to normal operation after test.

Connect the low-level signal connector of the C700G cable to J2, as shown in *Figure 11.1* and *Figure 11.2* (for example, ribbon cable C700G connector of SEL-RTS Test System).

Step 9. Insert the board back into Slot **E**.

Refer to the SEL-*RTS Instruction Manual* for additional detail.

When simulating a delta PT connection, DELTAY_*m* := DELTA (*m* = X or Y), with the low-level test interface referenced in *Figure 11.1*, apply the following signals:

- Apply low-level test signal VAB to Pin VA.
- Apply low-level test signal –VBC (equivalent to VCB) to Pin VC.
- Do not apply any signal to pin VB.

Commissioning Tests

SEL performs a complete functional check and calibration of each SEL-700G before it is shipped. This helps to ensure that you receive a relay that operates correctly and accurately. Commissioning tests confirm that the relay is properly connected, including the control signal inputs and outputs.

The following connection tests help you enter settings into the SEL-700G and verify that the relay is properly connected. Brief functional tests ensure that the relay settings are correct. It is unnecessary to test every element, timer, and function in these tests. Modify the procedure as necessary to conform to your standard practices. Use the procedure at initial relay installation; you should not need to repeat it unless major changes are made to the relay electrical connections.

Required Equipment

- The SEL-700G, installed and connected according to your protection design
- A PC with serial port, terminal emulation software, and serial communications cable
- *SEL-700G Settings Sheets* with settings appropriate to your application and protection design
- The ac and dc elementary schematics and wiring diagrams for this relay installation
- A continuity tester
- A protective relay ac test source
  - Minimum: single-phase voltage and current with phase angle control
  - Preferred: three-phase voltage and current with phase angle control

Connection Tests

⚠WARNING
Before working on a CT circuit, first apply a short to the secondary winding of the CT.

Step 1. Remove control voltage and ac signals from the SEL-700G by opening the appropriate breaker(s) or removing fuses.

Step 2. Isolate the relay contact assigned to be the TRIP output.

Step 3. Verify correct ac and dc connections by performing point-to-point continuity checks on the associated circuits.

Step 4. Apply ac or dc control voltage to the relay.

After the relay is energized, the front-panel green ENABLED LED should illuminate.

Step 5. Use the appropriate serial cable (SEL cable C234A or equivalent) to connect a PC to the relay.

Step 6. Start the PC terminal emulation software and establish communication with the relay.

Refer to *Section 7: Communications* for more information on serial port communications.

Step 7. Set the correct relay time and date by using either the front-panel or serial port commands (**TIME *hh:mm:ss*** and **DATE *mm/dd/yy*** commands).

Step 8. Using the **SET**, **SET P**, **SET G**, **SET L**, and **SET R** serial port commands, enter the relay settings from the settings sheets for your application.

If you are connecting an external SEL-2600 RTD Module or SEL-2664 Field Ground Module, follow the substeps below; otherwise continue with *Step 9*.

a. Connect the fiber-optic cable to the RTD module or field ground module fiber-optic output.

b. Plug the relay end of the fiber-optic cable into the relay fiber-optic Rx input (Port 2). For an SEL-2600 application, use Port 2; for an SEL-2664 application, use Port 3.

Step 9. Verify the relay ac connections.

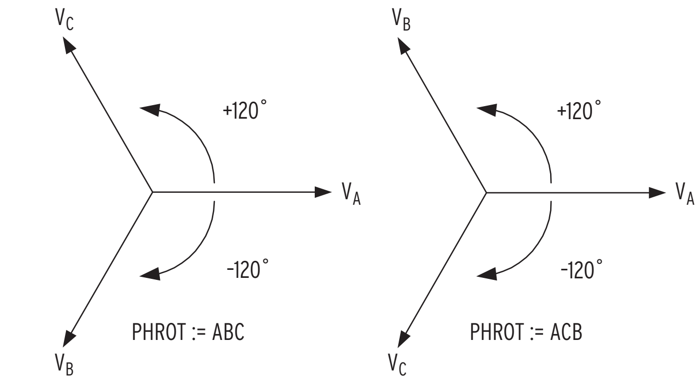
Step 10. Connect the ac test source current or voltage to the appropriate relay terminals.

NOTE: Make sure that the current transformer secondary windings are shorted before they are disconnected from the relay.

a. Disconnect the current transformer and voltage transformer (if present) secondaries from the relay prior to applying test source quantities.

b. If you set the relay to accept phase-to-ground voltages [DELTAY_*m* := WYE (*m* = X or Y)], set the current and/or voltage phase angles as shown in *Figure 11.3*.

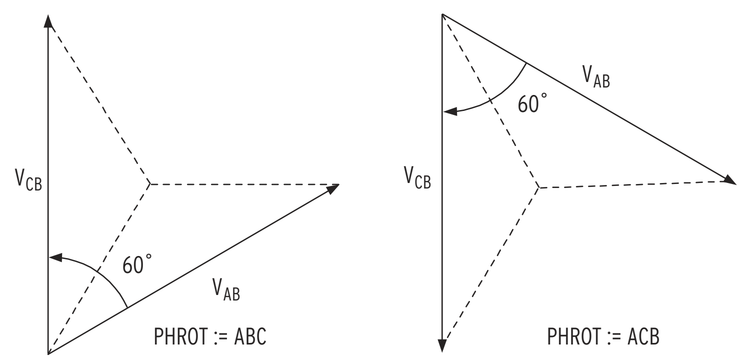
c. If you set the relay to accept delta voltages [(DELTAY_*m* := DELTA (*m* = X or Y)], set the current and/or voltage phase angles as shown in *Figure 11.4*.



When setting PHROT := ABC, set angle V_A = angle I_A = 0°
set angle V_B = angle I_B = –120°
set angle V_C = angle I_C = 120°

When setting PHROT := ACB, set angle V_A = angle I_A = 0°
set angle V_B = angle I_B = 120°
set angle V_C = angle I_C = –120°

Figure 11.3 Three-Phase Wye AC Connections



When setting PHROT := ABC, set angle I_A = 0°
set angle I_B = –120°
set angle I_C = 120°
set angle V_{AB} = +30°
set angle V_{CB} = +90°

When setting PHROT := ACB, set angle I_A = 0°
set angle I_B = 120°
set angle I_C = –120°
set angle V_{AB} = –30°
set angle V_{CB} = –90°

Figure 11.4 Three-Phase Open-Delta AC Connections

Step 11. Apply rated current (1 A or 5 A).

If the relay is equipped with voltage inputs, apply rated voltage for your application.

Step 12. Use the front-panel `METER > Fundamental` function or serial port **METER** command to verify that the relay is measuring the magnitude and phase angle of both voltage and current correctly, taking into account the relay PTRX, PTRY, PTRS, PTRN, CTRX, CTRY, or CTRN (the settings are model dependent) settings and the fact that the quantities are displayed in primary units.

If you are using a current transformer for the neutral, apply a single-phase current to the **IN** terminal. Do not apply voltage.

Step 13. Verify that the relay is measuring the magnitude and phase angle correctly.

The expected magnitude is (applied current) • (CTRN). The expected phase angle is zero (0).

Step 14. Verify control input connections. Using the front-panel `MAIN > Targets > Row 49` function, check the control input status in the relay (**IN101** or **IN102**).

As you apply rated voltage to each input, the position in Row 49 corresponding to that input should change from zero (0) to one (1).

Step 15. Verify output contact operation:

a. For each output contact, set the input to logical 1. This causes the output contact to close. For example, setting OUT101 = 1 causes the output **OUT101** contact to close.

b. Repeat the process for all contact outputs.

Make sure that each contact closure does what you want it to do in the annunciation, control, or trip circuit associated with that contact closure.

Step 16. Perform the protection element tests you want. Perform only enough tests to prove that the relay operates as intended; exhaustive element performance testing is not necessary for commissioning.

Step 17. Connect the relay for tripping duty.

Step 18. Verify that any settings changed during the tests performed in *Step 15* and *Step 16* are changed back to the correct values for your application.

Step 19. Use the serial port commands in *Table 11.3* to clear the relay data buffers and prepare the relay for operation.

This prevents data generated during commissioning testing from being confused with operational data collected later.

Table 11.3 Serial Port Commands That Clear Relay Data Buffers

Serial Port Command	Task Performed
LDP C	Clears Load Profile Data
SER R	Resets Sequential Events Record buffer
SUM R	Resets Event Report and Summary Command buffers

Step 20. When it is safe to do so, energize the equipment/bus.

Step 21. Verify the following ac quantities by using the front-panel `METER > Fundamental` or serial port **METER** command.

- ➢ Phase current magnitudes should be nearly equal.
- ➢ Phase current angles should be balanced, have proper phase rotation, and have the appropriate phase relationship to the phase voltages.

Step 22. If your relay is equipped with voltage inputs, check the following:

- ➢ Phase voltage magnitudes should be nearly equal.
- ➢ Phase voltage phase angles should be balanced and have proper phase rotation.

The SEL-700G is now ready for continuous service.

Verifying the Connection Between the SEL-2664 and the SEL-700G

Step 1. Disconnect the field winding from the SEL-2664.

Step 2. Connect the SEL-2664 to the SEL-700G and set E64F := Y.

Step 3. Record the value of Rf using the **MET** command on SEL-700G. It should read 20000 kΩ..

Step 4. Connect a resistor decade box between the field (+) and field (GND) terminals.

Step 5. Short the field (+) and field (–) terminals.

Step 6. Select the resistor value to be 100k Ω on the resistor decade box.

Step 7. Wait 30 seconds and record the value of Rf using the **MET** command on the SEL-700G. Make sure that the reported Rf value is within the accuracy limits stated in *Section 1: Introduction and Specifications*.

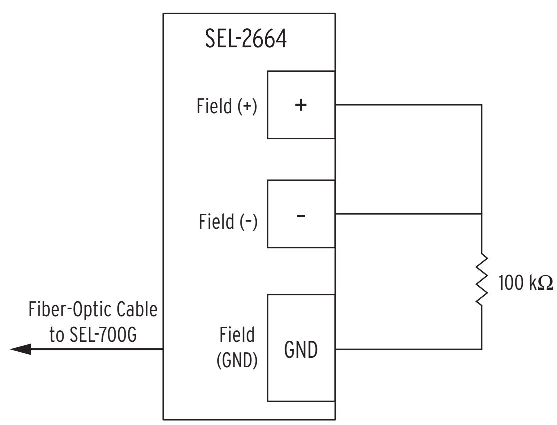


Figure 11.5 Verifying the Connection Between the SEL-2664 and the SEL-700G

Functional Tests

Phase Current Measuring Accuracy

Step 1. Connect the current source to the relay, as shown in *Figure 11.6*.

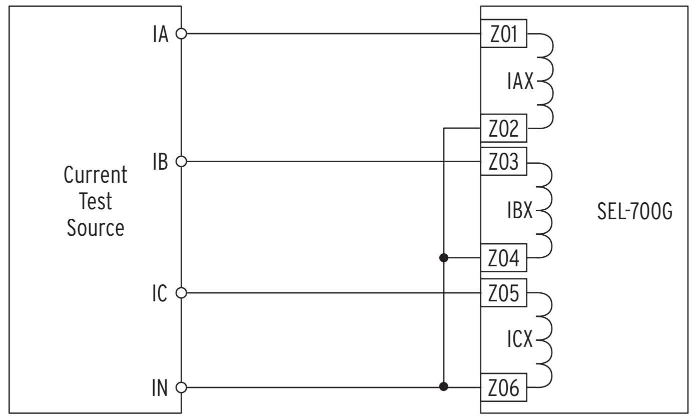


Figure 11.6 CTRX Current Source Connections

Step 2. Using the front-panel SET/SHOW or the serial port **SHO** command, record the CTRX and PHROT setting values.

Step 3. Set the phase current angles to apply balanced three-phase currents in accordance with the PHROT setting. Refer to *Figure 11.3*.

Step 4. Set each phase current magnitude equal to the values listed in Column 1 of *Table 11.4*. Use the front panel to view the phase current values. The relay should display the applied current magnitude times the CTRX setting.

Table 11.4 CTRX Phase Current Measuring Accuracy[a]

|I| Applied (A secondary)[b]	Expected Reading CTRX x |I|	A-Phase Reading (A primary)	B-Phase Reading (A primary)	C-Phase Reading (A primary)
$0.2 \cdot I_{XNOM}$				
$0.9 \cdot I_{XNOM}$				
$2.0 \cdot I_{XNOM}$				

[a] The displayed quantities are model dependent.
[b] I_{XNOM} = rated secondary amps (1 or 5).

Step 5. Use *Figure 11.7* and *Table 11.5* to repeat *Step 1* through *Step 4*.

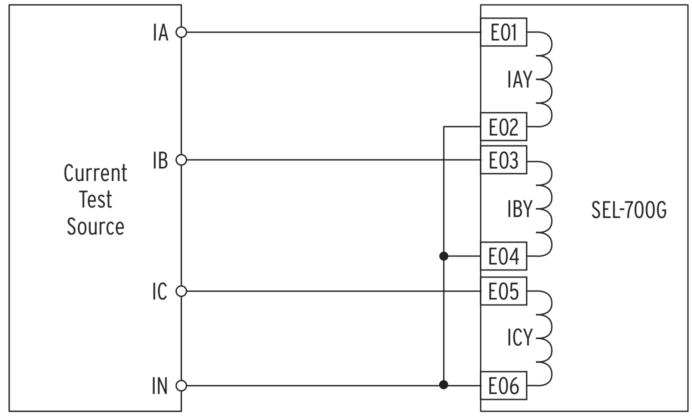


Figure 11.7 CTRY Current Source Connections

Table 11.5 CTRY Phase Current Measuring Accuracy[a]

|I| Applied (A secondary)[b]	Expected Reading CTRY x |I|	A-Phase Reading (A primary)	B-Phase Reading (A primary)	C-Phase Reading (A primary)
$0.2 \cdot I_{YNOM}$				
$0.9 \cdot I_{YNOM}$				
$2.0 \cdot I_{YNOM}$				

[a] The displayed quantities are model dependent.
[b] I_{YNOM} = rated secondary amps (1 or 5).

Power and Power Factor Measuring Accuracy

Wye-Connected Voltages

Perform the following steps to test wye-connected voltages:

Step 1. Connect the current source to the relay, as shown in *Figure 11.6* or *Figure 11.7*.

Step 2. Connect the voltage source to the relay, as shown in *Figure 11.8*. Make sure that DELTAY_*m* := WYE (*m* = X or Y).

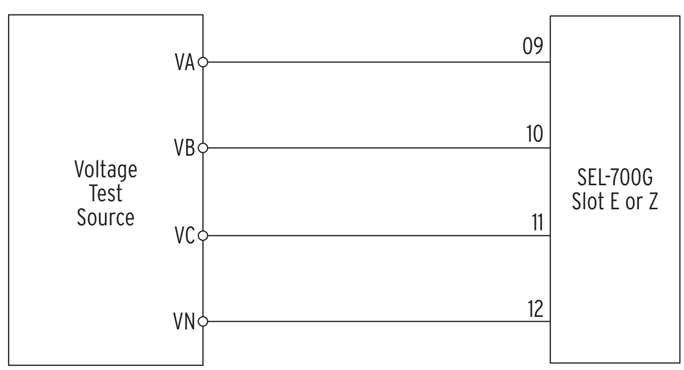


Figure 11.8 Wye Voltage Source Connections

Step 3. Using the front-panel `SET/SHOW` or the serial port **SHOW** command, record the CTR*m*, PTR*m*, and PHROT setting values.

Step 4. Apply the current and voltage quantities shown in Column 1 of *Table 11.6*.

Values are given for PHROT := ABC and PHROT := ACB.

Step 5. Use the front-panel METER function or the serial port **MET** command to verify the results.

Table 11.6 Power Quantity Accuracy—Wye Voltages[a]

Applied Currents and Voltages[b]	Real Power (kW)	Reactive Power (kVAR)	Power Factor (pf)
PHROT := ABC IA*m* = 2.5 ∠–26 IB*m* = 2.5 ∠–146 IC*m* = 2.5 ∠+94	**Expected:** 3P*m* = 3 • 2.5 • 67 • 0.899 • CTR*m* • PTR*m*/1000	**Expected:** 3Q*m* = 3 • 2.5 • 67 • 0.438 • CTR*m* • PTR*m*/1000	**Expected:** pf = 0.90 lag
VA*m* = 67 ∠0 VB*m* = 67 ∠–120 VC*m* = 67 ∠+120	**Measured:**	**Measured:**	**Measured:**
PHROT := ACB IA*m* = 2.5 ∠–26 IB*m* = 2.5 ∠+94 IC*m* = 2.5 ∠–146	**Expected:** 3P*m* = 3 • 2.5 • 67 • 0.899 • CTR*m* • PTR*m*/1000	**Expected:** 3Q*m* = 3 • 2.5 • 67 • 0.438 • CTR*m* • PTR*m*/1000	**Expected:** pf = 0.90 lag
VA*m* = 67 ∠0 VB*m* = 67 ∠+120 VC*m* = 67 ∠–120	**Measured:**	**Measured:**	**Measured:**

[a] The displayed quantities are model dependent.
[b] m = X or Y.

Delta-Connected Voltages

Perform the following steps to test delta-connected voltages:

Step 1. Connect the current source to the relay, as shown in *Figure 11.6* or *Figure 11.7*.

Step 2. Connect the voltage source to the relay, as shown in *Figure 11.9*. Make sure that DELTAY_*m* := DELTA (*m* = X or Y).

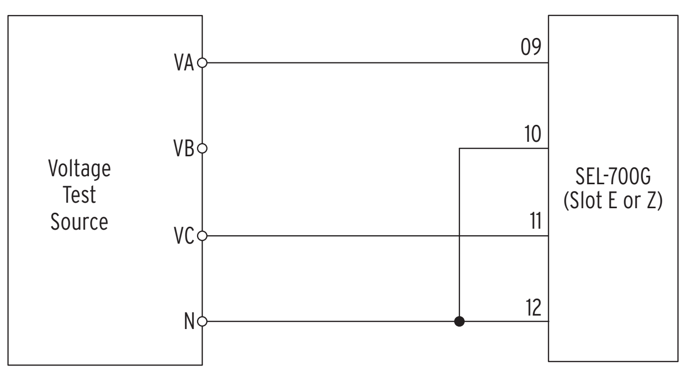


Figure 11.9 Delta Voltage Source Connections

Step 3. Using the front-panel SET/SHOW or the serial port **SHOW** command, record the CTR*m*, PTR*m*, and PHROT setting values.

Step 4. Apply the current and voltage quantities shown in Column 1 of *Table 11.7*.

Values are given for PHROT := ABC and PHROT := ACB.

Step 5. Use the front-panel METER or the serial port **MET** command to verify the results.

Table 11.7 Power Quantity Accuracy—Delta Voltages[a]

Applied Currents and Voltages[b]	Real Power (kW)	Reactive Power (kVAR)	Power Factor (pf)
PHROT := ABC IA*m* = 2.5 ∠–26 IB*m* = 2.5 ∠–146 IC*m* = 2.5 ∠+94	**Expected:** 3P*m* = 1.732 • 2.5 • 120 • 0.899 • CTR*m* • PTR*m*/1000	**Expected:** 3Q*m* = 1.732 • 2.5 • 120 • 0.438 • CTR*m* • PTR*m*/1000	**Expected** pf = 0.90 lag
VA*m* (VAB*m)* = 120 ∠+30 VC*m* (VBC*m*) = 120 ∠+90	**Measured:**	**Measured:**	**Measured:**
PHROT := ACB IA*m* = 2.5 ∠–26 IB*m* = 2.5 ∠+94 IC*m* = 2.5 ∠–146	**Expected:** 3P*m* = 1.732 • 2.5 • 120 • 0.899 • CTR*m* • PTR*m*/1000	**Expected:** 3Q*m* = 1.732 • 2.5 • 120 • 0.438 • CTR*m* • PTR*m*/1000	**Expected:** pf = 0.90 lag
VA*m* (VAB*m*) = 120 ∠–30 VC*m* (VBC*m*) = 120 ∠–90	**Measured:**	**Measured:**	**Measured:**

[a] The displayed quantities are model dependent.
[b] m = X or Y.

Periodic Tests (Routine Maintenance)

Because the SEL-700G is equipped with extensive self-tests, the most effective maintenance task is to monitor the front-panel messages after a self-test failure. In addition, each relay event report generated by a fault should be reviewed. Such reviews frequently reveal problems with equipment external to the relay, such as instrument transformers and control wiring.

The SEL-700G does not require specific routine tests, but your operation standards may require some degree of periodic relay verification. If you need or want to perform periodic relay verification, the following checks are recommended.

Table 11.8 Periodic Relay Checks (Sheet 1 of 2)

Test	Description
Relay Status	Use the front-panel STATUS or serial port **STATUS** command to verify that the relay self-tests have not detected any WARN or FAIL conditions.
Meter	Verify that the relay is correctly measuring current and voltage (if included) by comparing the relay meter readings to separate external meters.

Table 11.8 Periodic Relay Checks (Sheet 2 of 2)

Test	Description
Control Input	Using the front-panel `MAIN > Targets > Row 49` function, check the control input status in the relay. As you apply rated voltage to each input, the position in Row 49 corresponding to that input should change from zero (0) to one (1).
Contact Output	For each output contact, set the input to Logic 1. This causes the output contact to close. For example, setting OUT101 := 1 causes the output **OUT101** contact to close. Repeat the process for all contact outputs. Make sure that each contact closure does what you want it to do in the annunciation, control, or trip circuit associated with that contact closure.

Self-Test

The SEL-700G runs a variety of self-tests. The relay takes the following corrective actions for out-of-tolerance conditions (see *Table 11.9*):

- Protection Disabled: The relay disables protection and control elements and trip/close logic. All output contacts are de-energized. The ENABLED front-panel LED is extinguished.
- ALARM Output: Two Relay Word bits, HALARM and SALARM, signal self-test problems. SALARM is pulsed for software programmed conditions, such as firmware upgrade attempts via Ethernet, settings changes, access level changes, unsuccessful password entry attempts, active group change, copy command, and password change. HALARM is pulsed for hardware self-test warnings. HALARM is continuously asserted (set to logical 1) for hardware self-test failures. You can configure a diagnostic alarm as explained in *Section 4: Protection and Logic Functions*. In the Alarm Status column of *Table 11.9*, Latched indicates that HALARM is continuously asserted, Not Latched indicates that HALARM is pulsed for five seconds, and NA indicates that HALARM is not asserted.
- The relay generates automatic STATUS reports at the serial port for warnings and failures (ports with setting AUTO = Y).
- The relay displays failure messages on the relay front-panel for failures.
- For certain failures, the relay will automatically restart as many as three times. In many instances, this will correct the failure. The failure message might not be fully displayed before automatic restart occurs. Indication that the relay restarted will be recorded in the Sequential Events Recorder (SER).

NOTE: Refer to Access Commands (ACCESS, 2ACCESS, and CAL) for more information on when SALARM is pulsed for access level changes and unsuccessful password entry attempts.

Use the serial port **STATUS** command or front-panel to view relay self-test status. Based on the self-test type, issue the **STA C** command as directed in the Corrective Actions column. Contact SEL if this does not correct the problem.

NOTE: "W" in the STA response indicates a warning for the corresponding quantity.

Table 11.9 Relay Self-Tests (Sheet 1 of 3)

Self-Test Description	Normal Range	Protection Disabled on Failure	Alarm Status	Auto Message on Failure	Front Panel Message on Failure	Corrective Action
Watchdog Timer Periodic Resetting (1/32 cycle)		Yes	De-energized	No	No	
Main Board FPGA (power up) Fail if main board field programmable gate array does not accept program or the version number is incorrect		Yes	Latched	Yes	Status Fail FPGA Failure	Automatic restart. Contact SEL if failure returns.
Mainboard FPGA (run time) Fail on lack of data acquisition interrupts or on detection of a CRC error in the FPGA code		Yes	Latched	Yes	Status Fail FPGA Failure	Automatic restart. Contact SEL if failure returns.
GPSB (back-plane) Communications Fail if GPSB is busy on entry to processing interval		Yes	Latched	Yes	Status Fail GPSB Failure	Automatic restart. Contact SEL if failure returns.
Front-Panel HMI (power up) Two-line display: Fail if ID registers do not match or if FPGA programming is unsuccessful Touchscreen display: Automatic diagnostics identify an issue		No	Not Latched	Yes	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
External RAM (power up) Performs a read/write test on system RAM		Yes	Latched	No	No	
External RAM (run time) Performs a read/write test on system RAM		Yes	Latched	Yes	Status Fail RAM Failure	Automatic restart. Contact SEL if failure returns.
Internal RAM (power up) Performs a read/write test on system CPU RAM		Yes	Latched	No	No	
Internal RAM (run time) Performs a read/write test on system CPU RAM		Yes	Latched	Yes	Status Fail RAM Failure	Automatic restart. Contact SEL if failure returns.
Code Flash (power up) SELBOOT qualifies code with a checksum		NA	NA	NA	NA	
Data Flash (power up) Checksum is computed on critical data		Yes	Latched	Yes	Status Fail Non_Vol Failure	
Data Flash (run time) Checksum is computed on critical data		Yes	Latched	Yes	Status Fail Non_Vol Failure	
Critical RAM (settings) Performs a checksum test on the active copy of settings		Yes	Latched	Yes	Status Fail CR_RAM Failure	Automatic restart. Contact SEL if failure returns.
Critical RAM (run time) Verify instruction matches FLASH image		Yes	Latched	Yes	Status Fail CR_RAM Failure	Automatic restart. Contact SEL if failure returns.
I/O Board Failure Check if ID register matches part number		Yes	Latched	Yes	Status Fail Card [C|D|E] Failure	
DeviceNet Board Failure DeviceNet card does not respond in three consecutive 300 ms time out periods		NA	NA	NA	COMMFLT Warning	
Slot Z Board (power up) Fail if ID register does not match part number		Yes	Latched	Yes	Status Fail Card Z Fail	

Table 11.9 Relay Self-Tests (Sheet 2 of 3)

Self-Test	Description	Normal Range	Protection Disabled on Failure	Alarm Status	Auto Message on Failure	Front Panel Message on Failure	Corrective Action
Slot Z Board A/D Offset Warn	Measure dc offset at each input channel	–50 mV to +50 mV	No	Not Latched	No	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
Slot E Board (power up)	Fail if ID register does not match part number		Yes	Latched	Yes	Status Fail Card E Fail	
Slot E Board A/D Offset Warn	Measure dc offset at each input channel	–50 to +50 mV	No	Not Latched	No	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
+0.9 V Fail	Monitor +0.9 V power supply	0.855 to 0.945 V	Yes	Latched	Yes	Status Fail +0.9 V Failure	
+1.2 V Fail	Monitor +1.2 V power supply	1.152 to 1.248 V	Yes	Latched	Yes	Status Fail +1.2 V Failure	
+1.5 V Fail	Monitor +1.5 V power supply	1.35 to 1.65 V	Yes	Latched	Yes	Status Fail +1.5 V Failure	
+1.8 V Fail	Monitor +1.8 V power supply	1.71 to 1.89 V	Yes	Latched	Yes	Status Fail +1.8 V Failure	
+3.3 V Fail	Monitor +3.3 V power supply	3.07 to 3.53 V	Yes	Latched	Yes	Status Fail +3.3 V Failure	
+5 V Fail	Monitor +5 V power supply	4.65 to 5.35 V	Yes	Latched	Yes	Status Fail +5 V Failure	
+2.5 V Fail	Monitor +2.5 V power supply	2.32 to 2.68 V	Yes	Latched	Yes	Status Fail +2.5 V Failure	
+3.75 V Fail	Monitor +3.75 V power supply	3.48 to 4.02 V	Yes	Latched	Yes	Status Fail +3.75 V Failure	
–1.25 V Fail	Monitor -1.25 V power supply	–1.16 to –1.34 V	Yes	Latched	Yes	Status Fail –1.25 V Failure	
–5 V Fail	Monitor -5 V power supply	–4.65 to –5.35 V	Yes	Latched	Yes	Status Fail –5 V Failure	
Clock Battery	Monitor clock battery	2.3 to 3.5 V	No	Not Latched	Yes	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
Clock Chip	Unable to communicate with clock or fails time keeping test		No	Not Latched	Yes	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.

Table 11.9 Relay Self-Tests (Sheet 3 of 3)

Self-Test	Description	Normal Range	Protection Disabled on Failure	Alarm Status	Auto Message on Failure	Front Panel Message on Failure	Corrective Action
Clock Chip RAM	Clock chip static RAM fails		No	Not Latched	Yes	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
External/Internal RTD	Fails if the internal RTD card or the external RTD reports that at least one enabled RTD input is open or shorted, if there is no communication, or if there is a power supply failure for the external RTD module		NA	NA	No	RTD Failure	STA C, to clear the warning in the status report. Contact SEL if failure returns.
External Field Ground Module (SEL-2664)	Communications status Module status		NA	NA	No	OK/FAIL	
CID (configured IED description) File (access)	Failure to access/read CID file		No	NA	No	Status Fail CID File Failure	
Exception Vector	CPU error		Yes	Latched	NA	Vector nn Relay Disabled	Automatic restart. Contact SEL if failure returns.

Troubleshooting

Table 11.10 Troubleshooting (Sheet 1 of 2)

Symptom/Possible Cause	Diagnosis/Solution
The relay ENABLED front-panel LED is dark.	
Input power is not present or a fuse is blown.	Verify that input power is present. Check fuse continuity.
Self-test failure	View the self-test failure message on the front-panel display.
The relay front-panel display does not show characters.	
The relay front panel has timed out.	Press the **ESC/HOME** pushbutton to activate the display.
The relay is de-energized.	Verify input power and fuse continuity.
The relay does not accurately measure voltages or currents.	
Wiring error	Verify input wiring.
Incorrect PTRX, PTRY, PTRS, PTRN , CTRX, CTRY, or CTRN setting	Verify instrument transformer ratios, connections, and associated settings.
Voltage neutral terminal (N) is not properly grounded.	Verify wiring and connections.
The relay does not respond to commands from a device connected to the serial port.	
Cable is not connected.	Verify the cable connections.
Cable is not the correct type.	Verify the cable pinout.
The relay or device is at an incorrect data rate or has another parameter mismatch.	Verify device software setup.
The relay serial port has received an XOFF, halting communications.	Type **<Ctrl+Q>** to send the relay XON and restart communications.

Table 11.10 Troubleshooting (Sheet 2 of 2)

Symptom/Possible Cause	Diagnosis/Solution
The relay does not respond to faults.	
The relay is improperly set.	Verify the relay settings.
Improper test source settings	Verify the test source settings.
Current or voltage input wiring error	Verify input wiring.
Failed relay self-test	Use the front-panel RELAY STATUS function to view self-test results.

Technical Support

We appreciate your interest in SEL products and services. If you have questions or comments, please contact us at:

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Appendix A
Firmware, ICD, and Manual Versions

Firmware

Determining the Firmware Version

To determine the firmware version, view the status report by using the serial port **STATUS** command or the front panel. The status report displays the firmware identification (FID) string.

The firmware version will be either a standard release or a point release. A standard release adds new functionality to the firmware beyond the specifications of the existing version. A point release is reserved for modifying firmware functionality to conform to the specifications of the existing version.

A standard release is identified by a change in the R-number of the device FID string.

Existing firmware:

FID=SEL-700G-**R100**-V0-Z001001-D*xxxxxxxx*

Standard release firmware:

FID=SEL-700G-**R101**-V0-Z001001-D*xxxxxxxx*

A point release is identified by a change in the V-number of the device FID string.

Existing firmware:

FID=SEL-700G-R100-**V0**-Z001001-D*xxxxxxxx*

Point release firmware:

FID=SEL-700G-R100-**V1**-Z001001-D*xxxxxxxx*

The date code is after the D. For example, the following is firmware version number R100, date code April 16, 2010.

FID=SEL-700G-R100-V0-Z001001-**D20100416**

NOTE: R1xx series firmware can be upgraded to any of the latest firmware versions.

Table A.1, *Table A.2*, and *Table A.3* list the firmware versions, a description of modifications, and the instruction manual date code that corresponds to the firmware versions of each series of firmware. The most recent firmware version is listed first.

Starting with revisions published after March 1, 2022, changes that address security vulnerabilities are marked with “[Cybersecurity]”. Other improvements to cybersecurity functionality that should be evaluated for potential cybersecurity importance are marked with “[Cybersecurity Enhancement]”.

Table A.1 R300 Series Firmware Revision History (Sheet 1 of 5)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-700G-R302-V1-Z008004-D20240329	Includes all the functions of SEL-700G-R302-V0-Z008004-D20220826 with the following additions: ➤ [Cybersecurity] Removed advanced diagnostic commands from Access Level C. ➤ Resolved an issue where the deadband was not applied correctly in the synchronism-check element when the generator voltage was less than the system voltage and was increasing. ➤ Added (FREQTRKX OR ZCFREQX) AND 59VPX AND 59VSX supervision to the 25AX2 and CFA enable logic of the synchronism-check element. ➤ Added the frequency measurements used by the 81R element (FREQ_81R) to the COMTRADE event report. ➤ Improved the accuracy of the data time stamp in the COMTRADE event report. ➤ Improved the resolution of the frequency measurement in the COMTRADE event report. ➤ Resolved an issue where Precision Time Protocol (PTP) was not able to synchronize the time if the PTP transport mechanism setting PTPTR was set equal to LAYER2. This issue affects firmware version R302-V0 only. ➤ Resolved an issue where the synchrophasor data frames could be dropped when used in a UDP_S transport scheme. ➤ Resolved an issue where the IRIGOK Relay Word bit deasserted momentarily with repeated trip triggering. ➤ Resolved an issue with the processing of the math variables.	20240329
SEL-700G-R302-V0-Z008004-D20220826	➤ [Cybersecurity] Resolved a rare, low-risk issue where deliberately crafted Ethernet traffic could cause the relay to perform a diagnostic restart. ➤ [Cybersecurity] Updated a third-party networking software component that removes low-risk security vulnerabilities that could result in temporary loss of Ethernet communications. ➤ Added firmware support for new hardware component suppliers. ➤ Added support for IEEE 802.1Q-2014 Rapid Spanning Tree Protocol (RSTP) for models with the dual Ethernet port option. ➤ Added support for the IEC 61850 Local/Remote control feature defined in the IEC 61850-7-4 standard. ➤ Added support for the IEC 61850 Functional Naming feature. ➤ Added SELOGIC variable SC850SM for IEC 61850 simulation mode. ➤ Increased the number of Relay Word bit aliases to 32. ➤ Improved performance to allow touchscreen operation after a firmware downgrade. ➤ Enhanced the relay firmware to retain configuration settings for the IP address, subnet mask, and default router for Port 1 during a firmware upgrade from any previous 3*xx* firmware version. ➤ Added the ability to select phase-to-phase voltages for the synchronism-check element when used with wye-connected PTs.	20220826

Table A.1 R300 Series Firmware Revision History (Sheet 2 of 5)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Resolved an issue in SEL-700G1+ and SEL-700G0+ models where the filtered event record incorrectly reported the synchronism-based (VS) channel during the asynchronous sampling period. ➤ Resolved an issue with the operation of the 46Q2 Relay Word bit. ➤ Resolved an issue where the range calculation for the Slope SLP12 characteristic led to the incorrect operation of the differential element for a SLP1 slope greater than 50. ➤ Resolved an issue where the relay failed to evaluate analog quantity I850MOD when mapped to a SELOGIC control equation. ➤ Resolved an issue where the LINKFAIL Relay Word bit was not accessible to the user. ➤ Resolved an issue where the relay always remained in IEC 61850 ON mode after issuing the **R_S** command independent of the selected IEC 61850 mode/behavior. ➤ Resolved an issue that caused the touchscreen to incorrectly display “Resend the Touchscreen settings.”	
SEL-700G-R301-V6-Z007004-D20240329	Includes all the functions of SEL-700G-R301-V5-Z007004-D20220826 with the following additions: ➤ [Cybersecurity] Removed advanced diagnostic commands from Access Level C. ➤ Added the frequency measurements used by the 81R element (FREQ_81R) to the COMTRADE event report. ➤ Improved the accuracy of the data time stamp in the COMTRADE event report. ➤ Improved the resolution of the frequency measurement in the COMTRADE event report. ➤ Resolved an issue where the synchrophasor data frames could be dropped when used in a UDP_S transport scheme. ➤ Resolved an issue with the processing of the math variables.	20240329
SEL-700G-R301-V5-Z007004-D20220826	Includes all the functions of SEL-700G-R301-V4-Z007004-D20220225 with the following additions: ➤ Added firmware support for new hardware component suppliers. ➤ Improved performance to allow touchscreen operation after a firmware downgrade. ➤ Resolved an issue with the operation of the 46Q2 Relay Word bit. ➤ Resolved an issue where the relay always remained in IEC 61850 ON mode after issuing the **R_S** command independent of the selected IEC 61850 mode/behavior.	20220826
SEL-700G-R301-V4-Z007004-D20220225	Includes all the functions of SEL-700G-R301-V3-Z007004-D20211213 with the following addition: ➤ [Cybersecurity] Resolved an issue where GOOSE receive messages would no longer be processed during or after a GOOSE data storm on the network.	20220225
SEL-700G-R301-V3-Z007004-D20211213	Includes all the functions of SEL-700G-R301-V2-Z007004-D20210723 with the following addition: ➤ Revised the firmware to allow replacement of the field-programmable gate array (FPGA) part.	20211213

Table A.1 R300 Series Firmware Revision History (Sheet 3 of 5)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-700G-R301-V2-Z007004-D20210723	Includes all the functions of SEL-700G-R301-V1-Z007004-D20210104 with the following additions: ➤ Added the IEC 61850 blocked-by-interlocking control error response. ➤ Resolved an issue where a large number of file read operations could lead to a data retrieval error. ➤ Resolved an issue where the relay restarted when pulse output was canceled from the HMI. ➤ Resolved an issue where EtherNet/IP communication stopped after approximately 25 days. ➤ Resolved an issue where the 25C Relay Word bit was incorrectly supervised by the 25VCDB Relay Word bit instead of the VDIFX Relay Word bit. ➤ Resolved an issue where the Fast Message Read responses did not include the analog quantities. ➤ Resolved an issue where Relay Word bit VDIFY chattered when there were no voltages applied to the relay.	20210723
SEL-700G-R301-V1-Z007004-D20210104	Includes all the functions of SEL-700G-R301-V0-Z007004-D20200930 with the following addition: ➤ Resolved a rare issue where Telnet traffic could cause a diagnostic restart of the relay.	20210104
SEL-700G-R301-V0-Z007004-D20200930	➤ Resolved an issue in touchscreen relay models where repeated triggering of the TRIP/WARN messages resulted in the relay becoming disabled. ➤ Initial firmware version compatible with the SEL-700BT Motor Bus Transfer Relay. Firmware versions R301-V0 and higher are compatible with both the SEL-700G and SEL-700BT relays.	20200930
SEL-700G-R300-V1-Z007004-D20200921	Includes all the functions of SEL-700G-R300-V0-Z007004-D20200331 with the following addition: ➤ Resolved an issue with the EPORT setting for the Ethernet port.	20200921
SEL-700G-R300-V0-Z007004-D20200331	➤ Added support for zipped and digitally signed (.zds) firmware files. These .zds firmware files require the SELBOOT firmware version to be upgraded to R600 first. Firmware files with the .s19 and .z19 extensions cannot be sent to relays with SELBOOT firmware R600. ➤ Added the ability to upgrade relay firmware remotely over an Ethernet network. ➤ Added web server capability to relays equipped with Ethernet. ➤ Added the Synchroscope application to the touchscreen display. The application displays a graphical representation of the phasor difference between the bus and the generator or tie. ➤ Added the Auto Synchronizer application to the touchscreen display. The application can be used to initiate and visually monitor autosynchronization of the generator to the system. ➤ Added control support to the two-position disconnects. ➤ Added two three-position disconnects with control support. ➤ Added support for IEEE 1588-2008 firmware-based Precision Time Protocol (PTP) for time synchronization.	20200331

Table A.1 R300 Series Firmware Revision History (Sheet 4 of 5)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Added IEC 61850 Test Mode with standard operating modes, including On, Blocked, Test, Test/Blocked, and Off. ➤ Added the EtherNet/IP communications option for relays equipped with Ethernet. ➤ Improved Sequential Events Recorder (SER) time-stamp accuracy for digital inputs to 1 ms. ➤ Improved event reports to include settings at the time of the event. ➤ Enhanced the sync-check/autosynchronization function to synchronize systems more quickly. Also added the Group setting CFI (close fail initiate). ➤ Added the ability to trigger event reports from the Event History application on the touchscreen display. ➤ Improved the security of the resistance temperature detector (RTD) FAULT, ALARM, and TRIP indicators by adding an approximately 12-second delay to filter RTD measurements distorted by electrical noise. ➤ Updated the TCP keep-alive settings so they can be turned off or configured as desired. This update applies to all TCP protocols, including Telnet, File Transfer Protocol (FTP), MMS, and C37.118 phasor measurement unit (PMU). ➤ Increased the upper limit of the frequency trip delay setting 81D*n*TD (*n* = 1 to 4) from 240.00 to 400.00 seconds. ➤ Improved the performance of the directional element logic during evolving faults. ➤ Resolved an issue where the positive-sequence voltage-polarized directional element may be blocked for a three-phase fault by the negative-sequence voltage-polarized element enable Relay Word bit, DIRQE. This can occur when the a2 factor is not set appropriately to account for system unbalance. ➤ Resolved an issue where the reference period calculation gets frozen under certain system conditions after the 78VSO Relay Word bit asserts for the first time. This can result in the 78VSO Relay Word bit staying asserted even after the system reverts to normal operating conditions. ➤ Resolved an issue where the inverse overvoltage (59I) element operated incorrectly when 59I*n*OQ = VN and no voltage signals were applied. Only firmware version R200-V0 is affected. ➤ Resolved an issue where the Y-side currents and voltages could spike during fast frequency changes on the X-side. ➤ Resolved an issue where the relay could take as long as two seconds to update the analog quantities listed in *Appendix M: Analog Quantities* after power up or a settings change. ➤ Improved the security and coverage of the third-harmonic voltage differential (64G2) element by modifying the pickup and coverage equations. ➤ Resolved an issue in which the relay continued to send Fast Sequential Events Recorder (SER) data to the real-time automation controller (RTAC) after the relay acknowledged an RTAC disable command.	

Table A.1 R300 Series Firmware Revision History (Sheet 5 of 5)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Addressed an issue with event type mismatch between the **CHI** and **CEV** commands that resulted in real-time automation controllers (RTACs) being unable to collect events with event type strings longer than 14 characters. ➤ Resolved an issue where the real-time automation controller (RTAC) was unable to collect event data. Only firmware version R200-V0 is affected by this issue. ➤ Resolved an issue where the state of Target LED (TLED) data points was not correctly reported in GOOSE messages. ➤ Modified the firmware to increment the state number (stNum) in GOOSE messages for any change of the quality attribute. ➤ Resolved an issue where the TAP setting values were rounded differently between the firmware and PC software. ➤ Resolved an issue where the DISPLAY option was missing from the EVENTS menu in the two-line display. Only firmware version R200-V0 is affected. ➤ Resolved an issue where the Global access control setting DSABLSET did not disable settings edits via the touchscreen interface when DSABLSET := Y. ➤ Resolved an issue in the touchscreen models where editing the DNP3 setting, TIMERQ, resulted in an unresponsive screen until the HOME pushbutton was pressed. ➤ Resolved an issue where the relay enabled 1/2-cycle before the front-end analogs settled down, leading to nuisance events on relay power up. This issue affects firmware version R200-V0 only. ➤ Resolved an issue where the COMTRADE events included event data four times. Firmware versions R200-V0 and higher are affected by this issue.	

Table A.2 R200 Series Firmware Revision History (Sheet 1 of 4)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-700G-R201-V5-Z006003-D20220826	Includes all the functions of SEL-700G-R201-V4-Z006003-D20220225 with the following additions: ➤ Added firmware support for new hardware component suppliers. ➤ Resolved an issue with the operation of the 46Q2 Relay Word bit.	20220826
SEL-700G-R201-V4-Z006003-D20220225	Includes all the functions of SEL-700G-R201-V3-Z006003-D20211213 with the following addition: ➤ [Cybersecurity] Resolved an issue where GOOSE receive messages would no longer be processed during or after a GOOSE data storm on the network.	20220225
SEL-700G-R201-V3-Z006003-D20211213	Includes all the functions of SEL-700G-R201-V2-Z006003-D20210723 with the following addition: ➤ Revised the firmware to allow replacement of the field-programmable gate array (FPGA) part.	20211213
SEL-700G-R201-V2-Z006003-D20210723	Includes all the functions of SEL-700G-R201-V1-Z006003-D20210104 with the following additions: ➤ Resolved an issue where a large number of file read operations could lead to a data retrieval error.	20210723

Table A.2 R200 Series Firmware Revision History (Sheet 2 of 4)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Resolved an issue where the relay restarted when pulse output was canceled from the HMI. ➤ Resolved an issue where the Fast Message Read responses did not include the analog quantities. ➤ Resolved an issue where Relay Word bit VDIFY chattered when there were no voltages applied to the relay.	
SEL-700G-R201-V1-Z006003-D20210104	Includes all the functions of SEL-700G-R201-V0-Z006003-D20200331 with the following additions: ➤ Resolved a rare issue where Telnet traffic could cause a diagnostic restart of the relay. ➤ Resolved an issue in touchscreen relay models where repeated triggering of the TRIP/WARN messages resulted in the relay becoming disabled.	20210104
SEL-700G-R201-V0-Z006003-D20200331	➤ Improved performance of the directional element logic during evolving faults. ➤ Resolved an issue where the positive-sequence voltage-polarized directional element may be blocked for a three-phase fault by the negative-sequence voltage-polarized element enable Relay Word bit, DIRQE. This can occur when the a2 factor is not set appropriately to account for system unbalance. ➤ Resolved an issue where the reference period calculation gets frozen under certain system conditions after the 78VSO Relay Word bit asserts for the first time. This can result in the 78VSO Relay Word bit staying asserted even after the system reverts to normal operating conditions. ➤ Resolved an issue where the inverse overvoltage (59I) element operated incorrectly when 59InOQ = VN and no voltage signals were applied. Only firmware version R200-V0 is affected. ➤ Resolved an issue where the Y-side currents and voltages could spike during fast frequency changes on the X-side ➤ Resolved an issue where the relay could take as long as two seconds to update the analog quantities listed in *Appendix M: Analog Quantities* after power up or a settings change. ➤ Resolved an issue in which the relay continued to send Fast Sequential Events Recorder (SER) data to the real-time automation controller (RTAC) after the relay acknowledged an RTAC disable command. ➤ Addressed an issue with event type mismatch between the **CHI** and **CEV** commands that resulted in real-time automation controllers (RTACs) being unable to collect events with event type strings longer than 14 characters. ➤ Resolved an issue where the real-time automation controller (RTAC) was unable to collect event data. Only firmware version R200-V0 is affected by this issue. ➤ Resolved an issue where the state of Target LED (TLED) data points was not correctly reported in GOOSE messages. ➤ Resolved an issue where the DISPLAY option was missing from the EVENTS menu in the two-line display. Only firmware version R200-V0 and R200-V1 are affected.	20200331

Table A.2 R200 Series Firmware Revision History (Sheet 3 of 4)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Resolved an issue in the touchscreen models where editing the DNP3 setting, TIMERQ, resulted in an unresponsive screen until the HOME pushbutton was pressed. ➤ Resolved an issue where the relay enabled 1/2-cycle before the front-end analogs settled down, leading to nuisance events on relay power up. This issue affects firmware version R200-V0 only.	
SEL-700G-R200-V0-Z006003-D20180629	➤ Enhanced the firmware and hardware of the SEL-700G to have eight pushbuttons on the front panel. Note that SEL-700G relays manufactured after September 15, 2018 have eight pushbuttons. All relays shipped prior to that date have only four pushbuttons. ➤ Added the touchscreen display front-panel option. ➤ Added Spanish language support on all communications ports. Also added an ordering option for a relay with a Spanish overlay and Spanish front-panel HMI. ➤ Enhanced the CPU card design, including the addition of a GOOSE port with a dedicated MAC address to improve GOOSE performance. Note that relays with older CPU cards can be upgraded to firmware version R200 or higher, but the relay will not have the GOOSE performance improvements. ➤ Updated IEC 61850 protocol implementation to IEC 61850 Edition 2. ➤ Added file transfer support in IEC 61850 for CEV and COMTRADE events; LDP, GSH, GSR, SYN, HIS, SER, and BRE reports; and CID and settings files. ➤ Increased the maximum number of GOOSE subscriptions to 64. ➤ Added password authentication and session timeout for MMS services. ➤ Added IEC 62439 Parallel Redundancy Protocol (PRP) for models with the dual Ethernet port option. ➤ Added IEC 60870-5-103 protocol. ➤ Increased the number of DNP sessions from 3 to 5. ➤ Added Modbus Master IP settings. ➤ Added Telnet access setting ETELNET and FTP access setting EFTPSERV to Ethernet Port 1. ➤ Added the enable port setting EPORT to all the communications ports to enhance port security. ➤ Added the MAXACC setting to all of the communication ports, including the front panel, to control limited or full access. Note that the front panel MAXACC setting is not supported in relays with the touchscreen option. ➤ Added an ordering option for a 14 digital input card in Slots C, D, and E. ➤ Added COMTRADE support for events. ➤ Added a unique reference numbering system for HIS, CHIS, SUM, CSUM, EVE, CEV, and CGSR reports. ➤ Increased the number of settings groups from 3 to 4. ➤ Added OFF to all of the 50 element delay settings ranges.	20180629

Table A.2 R200 Series Firmware Revision History (Sheet 4 of 4)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Added the inverse-time over- and undervoltage elements. ➤ Added a vector shift protection function to detect a generator islanding condition based on the phase shift of the voltage waveform. ➤ Added disconnect status logic with double point indication to monitor the status of as many as eight disconnects. ➤ Enhanced the firmware to allow control of two breakers for all SEL-700G models. ➤ Added remote analogs to the relay that can be used to bring in data from an external device. ➤ Added a setting, METHRES, in the Global settings category that allows for turning off the squelching of currents and voltages below a certain level. ➤ Enhanced the SELOGIC processing capacity in the relay. ➤ Revised the firmware to allow mapping energy quantities in the load profile report. ➤ Resolved an issue with changing phase angles even though the magnitude/angles of the analog channels were squelched. ➤ Resolved an issue with the 25Y element in the SEL-700GT+ model; the 59VPY Relay Word bit asserted intermittently when the applied voltage exceeded 25VHIY instead of staying deasserted. ➤ Resolved an issue with the Modbus registers for phase/phase-to-phase max/min voltages that retained a previous value when the DELTA_Y setting was changed. ➤ Resolved an issue with frequency spikes in event reports during synchronization. ➤ Resolved an issue where the vector shift (78VS) element may not operate for islanding conditions preceded by a fault close to the relay. ➤ Revised the firmware to track frequency based on the new setting FRQTRK that allows you to choose X or Y side for tracking. Revised firmware will also disable the asynchronous data conversion, ASYNSDC, when FRQTRK ≠ X. ➤ Revised the firmware to add FREQS to the MET fundamental ASCII report for the SEL-700GT model. ➤ Modified GPSB diagnostics logic to show failure only if the GPSB diagnostics fail three consecutive times within 24 hours. ➤ Revised the firmware to add SLIPX as an analog quantity. ➤ Updated default settings SV13, SV14, MV01, LOPBLKX and LOPBLKY to enhance elements security during asynchronous sampling in the SEL-700GT+ model. ➤ Resolved an issue with the CGSR report and the synchroscope reporting incorrect angles for delta voltages when compared to CEV raw report. ➤ Resolved an issue with RTD biasing where, in certain cases, the biasing caused the relay to TRIP on 49T even when no currents were applied. ➤ Added **TEST DB** command to support relay testing.	

Table A.3 R100 Series Firmware Revision History (Sheet 1 of 5)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-700G-R110-V0-Z005002-D20160831	➤ Revised the ground event report (command **EVE GND**) to use rms values for the voltages. ➤ Resolved a relay disabling issue when the setting EPMU was set to Y and there was a corrupt IRIG signal. ➤ Increased the upper limit for the auto-derived value AO87P2 from 2 • TAP to 3 • TAP when O87P2 is set to AUTO. ➤ Resolved an issue with the operation of the load encroachment function on the Y-side in the SEL-700GT+ model in the presence of both X-side and Y-side signals.	20160831
SEL-700G-R109-V0-Z005002-D20160224	➤ Added OFF to the setting range of the failover time setting, FTIME, to support fast failover switching in dual Ethernet models. ➤ Added the SEL-2664 Field Ground Module status Relay Word bit 64FFLT to the warning list to indicate any failures with the module. ➤ Lowered the minimum threshold for the VNOM_X and VNOM_Y settings from 100 V to 20 V secondary. ➤ Addressed an issue where the oldest 180-cycle event disappeared from the event history after the relay was power cycled or was restarted with the **STA C** command. ➤ Increased the resolution of the 46Q1P and 46Q2P settings to one decimal place. ➤ Removed option D from the NETPORT setting range. ➤ Modified the prompt for the DNP Master IP Address, DNPIP*n*, to distinguish it from the Device IP Address. ➤ Increased the resolution of the slip frequency and the frequency of the VS channel to three decimal places in the compressed generator synchronism report (CGSR). ➤ Added LOPBLKX and LOPBLKY SELOGIC control equation settings to allow for blocking of the LOP logic under user-defined conditions. Also raised the minimum threshold for positive-sequence voltage V1 from 5 V to 10.5 V.	20160224
SEL-700G-R108-V0-Z004002-D20150410	➤ Enhanced the differential element (87) by adding a high security mode of operation to improve the security of the element for external events, such as faults or transformer energization, when there is severe CT saturation. This enhancement includes three new settings and twenty six new Relay Word bits. ➤ Modified the differential element (87) setting CTCX to make it user settable with the range of 0 or 12. In all previous firmware versions, CTCX was automatically set to 0 or 12, depending on the application, and hidden. Following a firmware upgrade and settings conversion using ACSELERATOR QuickSet SEL-5030 Software, the user will need to review the CTCX setting and manually update it to suit the application. ➤ Modified the firmware to hide the X side directional element settings if the setting ORDERX := OFF. ➤ Changed the minimum values of the FPLSMIND and VPLSMIND settings from 0.1 to 0.02 to allow finer frequency and voltage control pulses in the autosynchronizer function. ➤ Revised the firmware to allow the user to set up to two backup elements. The revised EBUP setting range allows the user to choose distance (DC) and voltage restraint (V), or distance (DC) and voltage controlled (C) overcurrent elements.	20150410

Table A.3 R100 Series Firmware Revision History (Sheet 2 of 5)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Revised the firmware for Trip Logic such that RSTTRGT is processed on the rising edge. ➤ Addressed an issue in the firmware where the rotating display stops rotating when the setting RSTTRGT is set to 1 or is asserted continuously. ➤ Revised the firmware to hide the Relay Word bits associated with overcurrent elements based on the part number of the relay. ➤ Revised the REF to improve the sensitivity for applications with different neutral and phase CT ratings. ➤ Modified the firmware to reset Virtual Bits when a new CID file is sent to the relay. ➤ Resolved an issue in R106 and R107 firmware revisions with the relay becoming unresponsive on power-up if the setting NETPORT was set to D in dual Ethernet models with the setting NETMODE set to FIXED or FAILOVER.	
SEL-700G-R107-V0-Z003002-D20140806	➤ Resolved an issue with R106 firmware in which the values of V1 and I1 synchrophasor quantities were always reported as zero. ➤ Resolved a synchrophasor voltage magnitude issue for applied voltages of 200 V or higher with the settings combination FNOM := 50, MRATE := 25, PHCOMP := Y, and PMAPP := NARROW. ➤ Changed the storage of latch and local bits from volatile to nonvolatile memory. ➤ Modified the firmware to make the MATHERR Relay Word bit visible. ➤ Added Y-MODEM over Telnet to support file transfer. ➤ Revised the firmware to support front-panel HMI part replacement; the function of the HMI has not changed. ➤ Resolved an issue in R100–R106 firmware versions where the relay reported RTD failure when both the SEL-2600 (RTD Module) and the SEL-2664 (Field Ground Module) were connected and simultaneously communicating with the relay. ➤ Modified the firmware to report the field resistance value as FFFFh instead of 0 in DNP, Modbus, and IEC 61850 when E64F := N or 64FFLT = 1. Analog quantity FLDRES will report a value of 20 Mohm instead of 0 when E64F := N or 64FFLT = 1. ➤ Modified the firmware to show *FAIL* instead of zero in the MET response for the Field Resistance measurement when E64F = Y and the data are invalid. ➤ Resolved an issue with setting ALTCOOL at a value other than zero when GTC2 = OFF. ➤ Resolved an issue with the thermal element (49T) when GTC1 is set to a value greater than 326 minutes. ➤ Resolved as issue that can cause small jumps in the angle calculations for analog quantities. ➤ Addressed an issue with validating the IPADDR, SUBNETM, DEFRTR, and other IP address and port number settings of enabled protocols. ➤ Revised the firmware to allow anonymous TCP connection from DNP masters when DNPIP*x* is set to 0.0.0.0. ➤ Resolved an issue with settings change (STSET) being reported as OFFLINE via DNP.	20140806

Table A.3 R100 Series Firmware Revision History (Sheet 3 of 5)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Resolved an issue with the DNP Binary Outputs so that they are no longer reported as OFFLINE when the Binary Output is also present in the Binary Input map and the Sequential Events Recorder (SER). ➤ Modified the default data set and report names in the 61850 CID file. Added additional Logical Nodes for Local Bits and MIRRORED BITS status.	
SEL-700G-R106-V0-Z003002-D20130405	➤ Corrected an issue with MET PM, which used UTC to trigger instead of local time. ➤ Improved the synchrophasor algorithm to yield better phasor-based frequency measurements. ➤ Corrected an issue where the front panel showed a blank page after target resetting the TRIP. ➤ Corrected an issue with the data type "Units_0" in the IEC 61850 ICD file by changing the unit data type name to SI Unit. ➤ Added a feature in Modbus to always show the latest event data unless another event is selected. ➤ Improved frequency tracking switching (from X side to Y side) when VAX was removed/reduced. ➤ RTS is forced high and CTS is ignored when the PREDLY setting is OFF to power certain fiber-optic transceivers. ➤ Corrected an Ethernet Failover Switching issue for dual-Ethernet models. ➤ Fixed an issue that caused port settings to not be accepted when the relay settings were downloaded using ACSELERATOR QuickSet SEL-5030 Software. ACSELERATOR QuickSet reported with a message that settings files were not received. ➤ Improved the security of RTD ALARM and TRIP by adding an approximately 6 second delay to qualify the event. ➤ Added a feature in the CEV report to show the part number and serial number of the relay. ➤ Corrected an issue with the 46Q2T element where the operating time was clamping at 1200 seconds instead of 1000 seconds for a 50 Hz system. ➤ Added 64F element to the SEL-700GW model. ➤ Modified Real Time Clock (RTC) diagnostics logic to show failure only if the RTC diagnostics fail three consecutive times. ➤ Revised the event type logic for Neutral 50 Trip to account for 67N1T and 67N2T bits.	20130405
SEL-700G-R105-V0-Z002002-D20111130	➤ Corrected an issue in R103 and R104, where the distance element (21C) picks up correctly but may not trip because of chatter. ➤ Updated error messages for setting interdependency checks to match the global setting AOx0yH.	20111130
SEL-700G-R104-V0-Z002002-D20111007	➤ Added support for Simple Network Time Protocol (SNTP) to Ethernet port (Port 1) including new settings. ➤ Added new settings for time and date management (including daylight saving time) under Global Settings. ➤ Enhanced the firmware to make the serial number visible to the IEC 61850 protocol and revised the ICD file to add serial and part number information to PhyNam DO.	20111007

Table A.3 R100 Series Firmware Revision History (Sheet 4 of 5)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Added a squelch threshold for very low-level secondary voltages (below 0.3 V) and currents (below 3% of INOM) in the rms metering quantities command response. ➤ Fixed an issue with the ENABLED LED which did not turn off when the relay was disabled. ➤ Corrected an issue where the relay was incorrectly allowing the setting combination of CTCONY := DELTA and E87 := G. ➤ Extended overcurrent element definite time delay timers range to 400 seconds. ➤ Added ability (new settings) to bring into the relay external broken delta PT voltage 3V0 either using VS or VN voltage channel. ➤ Added zero-sequence voltage-polarized directional element with IN as operate quantity (67N) in models with generator protection. ➤ Enhanced the REF element by adding setting REF52BYP to enable or disable 52A interlock in the bypass logic. ➤ Added FREQX, FREQY and FREQS measurements to the CEV report (compressed event report). ➤ Corrected IEC 61850 KEMA compliance issue (Sisco library). ➤ Corrected issue of SALARM not asserting for a settings group change. ➤ Corrected DNP polling issue with IN101. ➤ Corrected issue with reading Communications Counter registers (Registers 910–919) using the user map. ➤ Corrected issue with MMS error message in response to IEC 61850 control operation failure. ➤ Corrected issue with RMS Meter values where in some cases the values would spike for a short time. ➤ Corrected issue with Relay Word bit 46Q2R (reset for 46Q2 element) not resetting to state =1 when E46 is turned OFF. ➤ Corrected issue (for IEC 61850 and DNP) of missing SER records upon warm start. ➤ Corrected issue where METER displayed wrong information for “LEAD” and “LAG” in QuickSet. ➤ Corrected primary current magnitude calculation for delta-connected CTs by dividing by square root of 3 factor in the meter and event report delta current quantities.	
SEL-700G-R103-V0-Z001001-D20110324	➤ Corrected the issue with the analog quantities for real power, reactive power, apparent power, and power factor where those values became fixed at zero after power to the relay was cycled. ➤ Corrected the issue with trip logic equations TR1, TR2, and TR3 for the SEL-700GW and SEL-700GT models. These equations were being processed instead of being disabled, which affected the TRIP LED target. ➤ Corrected the issue (R102 only) with inverse time-overcurrent elements (did not accumulate time correctly for FNOM = 50,Hz nominal frequency—times were about 20% faster). ➤ Corrected the issue with TCU alarm function when set to OFF. The relay was still processing and issuing an alarm.	20110324

Table A.3 R100 Series Firmware Revision History (Sheet 5 of 5)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Corrected the issue in R102 firmware with a settings change from ACSELERATOR QuickSet SEL-5030 Software or via terminal mode. When settings with E49RTD enabled were downloaded, the relay became disabled and displayed a VECTOR 40 message. ➤ Made the SEL-700 series Flash driver more robust to prevent unintended writes or erasures.	
SEL-700G-R102-V0-Z001001-D20101206	➤ Corrected LDP command issue (relay will lock up, vector, or respond unpredictably if Load Data Profile (LDP) records overflow the allotted storage space) in R100-101 firmware revisions. ➤ Corrected issue with inverse time-overcurrent elements. (Did not accumulate time correctly at off-nominal frequency). ➤ Implemented improved diagnostics and actions in the relay self-tests. For certain failures, the relay will automatically restart as many as three times.	20101206
SEL-700G-R101-V0-Z001001-D20100521	➤ Implemented calibration improvements.	20100521
SEL-700G-R100-V0-Z001001-D20100416	➤ Initial version.	20100416

SELBOOT Firmware Version and Relay Firmware Compatibility

The SELBOOT revision and the compatible relay firmware versions are listed in *Table A.4*. The new SELBOOT firmware R600 ensures that the relay firmware upgrade file is digitally signed by SEL using a secure hash algorithm that ensures that the file has been provided by SEL and that its contents have not been altered. R300-V0 firmware requires that the SELBOOT firmware be upgraded to R600.

Table A.4 SELBOOT Firmware Revision History

Boot Firmware Identification Number	Summary of Revisions	Firmware Revision Supported	Release Date
SLBT7XX-R602-V0-Z000000-D20220826	➤ Improved the restart performance of the SELBOOT firmware.	R300 and higher	20220826
SLBT7XX-R601-V0-Z000000-D20211116	➤ Revised the SELBOOT firmware to allow replacement of the field-programmable gate array (FPGA) part.	R300 and higher	20211116
SLBT7XX-R600-V0-Z000000-D20200331	➤ The new SELBOOT supports zipped and digitally signed (.zds) firmware files.	R300 and higher	20200331
BOOTLDR-R502-V0-Z000000-D20211116	➤ Revised the SELBOOT firmware to allow replacement of the field-programmable gate array (FPGA) part.	R1*xx*, R2*xx*	20211116
BOOTLDR-R501-V0-Z000000-D20140806	➤ Changed RAM integrated circuit.	R107 to R2*xx*	20140806
BOOTLDR-R500-V0-Z000000-D20100416	➤ Initial version.	R100 to R106	20100416

SEL Display Package Versions

The SEL-700G with the touchscreen display option has display packages for the SEL display and default custom display. *Table A.5* lists the display package version, a description of the modifications, and the instruction manual date code that corresponds to the display package versions. The most recent firmware version is listed first. The version number of this firmware is accessible through the Device Info folder.

Table A.5 SEL Display Package Revision History

SEL Display Package Version	Revisions	Release Date
3.0.50700.3015	➤ Added support for new hardware component suppliers. ➤ Improved performance to allow touchscreen operation after a firmware downgrade.	20220826
3.0.50700.3013	➤ Added support for new hardware component suppliers. ➤ Modified the color touchscreen backlight brightness for more consistent dimming while in standby mode. ➤ Improved the performance of the touchscreen display in rotating display mode. ➤ Resolved an issue where the backlight could flicker during power up.	20211213
3.0.50700.3012	➤ Improved the performance of the touchscreen display in rotating display mode.	20210723
3.0.50700.3000	➤ Added the Synchroscope and Auto Synchronizer applications. ➤ Updated the keyboard layout on the touchscreen display for ease of data entry. ➤ Added the pick list feature for settings that have a fixed list in the settings range. ➤ Added the ability to keep the backlight of the touchscreen always on after the inactivity timer expires. Relays shipped after May 21, 2020 support this feature.	20200331
1.0.50700.2013	➤ Added support for new hardware component suppliers.	20211213
1.0.50700.2000	➤ Initial release.	20180629

SEL Display Package and Relay Firmware Compatibility

The display package and the compatible relay firmware versions are listed in *Table A.6*. The version number of the display package is accessible through the Device Info folder. Display packages may be compatible with more than one relay firmware version.

Table A.6 SEL Display Package Compatibility With Relay Firmware

SEL Display Package Version	Relay Firmware Versions Supported	Release Date
3.0.50700.3015	R301-V5 or higher	20220826
3.0.50700.3013	R301-V3 or higher	20211213
3.0.50700.3012	R301-V2 or higher	20210723
3.0.50700.3000	R300	20200331
1.0.50700.2013	R201-V3 or higher	20211213
1.0.50700.2000	R200, R201	20180629

DeviceNet and Firmware Versions

The firmware on the DeviceNet interface has two versions as listed in *Table A.7*. The version number of this firmware is only accessible via Device Net interface. SEL-700G needs DeviceNet firmware version 1.005.

Table A.7 DeviceNet Card Versions

DeviceNet Card Software Version	Revisions	Release Date
Major Rev: 1, Minor Rev: 5 (Rev 1.005)	Reads product code, DeviceNet card parameter descriptions, etc., from the relay.	20080407

The Electronic Data Sheet (EDS) file is not updated every time a firmware release is made. A new EDS file is released only when there is a change in the Modbus/DeviceNet parameters. The EDS file and an ICON file for the SEL-700G are zipped together on the SEL-700G Product Literature CD (SEL-*xxx*R*xxx*.zip). The file can also be downloaded from the SEL website at selinc.com.

Table A.8 lists the compatibility among the EDS files and the various firmware versions of the relay.

Table A.8 EDS File Compatibility

EDS File	Firmware Revisions Supported	Release Date
SEL-700G3200.EDS	R300	20200331
SEL-700GR200.EDS	R200, R201	20180629
SEL-700GR100.EDS	R100, R101, R102, R103, R104, R105, R106, R107, R108, R109, R110	20100416

ICD File

Determining the ICD File Version

To find the ICD revision number in your relay, view the configVersion using the **ID** command. The configVersion is the last item displayed in the information returned from the **ID** command.

```
configVersion= ICD-700G-R202-V0-Z107004-D20140324
```

The ICD revision number is after the R (e.g., 202) and the release date is after the D. This revision number is not related to the relay firmware revision number. The configVersion revision displays the ICD file version used to create the CID file that is loaded in the relay.

NOTE: The Z number representation is implemented with ICD File Revision R202. Previous ICD File Revisions do not provide an informative Z number.

The configVersion contains other useful information. The Z-number consists of six digits. The first three digits following the Z represent the minimum IED firmware required to be used with the ICD (e.g., 107). The second three digits represent the ICD ClassFileVersion (e.g., 004). The ClassFileVersion increments when there is a major addition or change to the IEC 61850 implementation of the relay.

Table A.9 lists the ICD file versions, a description of modifications, and the instruction manual date code that corresponds to the versions. The most recent version is listed first.

Table A.9 SEL-700G ICD File Revision History (Sheet 1 of 7)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect		Manual Date Code
				File Description	Software Version	
ICD-700G-R303-V0-Z302006-D20220826	➤ Added system logical nodes LGOS, LTIM, LTMS, and LCCH. ➤ Added the IEC 61850 LTRK logical node for service tracking. ➤ Added the IEC 61850 feature for simulation mode.	R302-V0 and higher	006	SEL700G Edition 2, R302-V0 or higher		20220826

Table A.9 SEL-700G ICD File Revision History (Sheet 2 of 7)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	acSELerator Architect		Manual Date Code
				File Description	Software Version	
	➤ Added support for the IEC 61850 Local/ Remote control feature defined in the IEC 61850-7-4 standard. Control messages need to include the orCat value associated with the active control authority. ➤ Added support for the IEC 61850 Functional naming feature. ➤ Added PRBGGIO logical nodes to support pulsing remote bits.					
ICD-700G-R302-V0-Z301006-D20210723	➤ Added the blocked-by-interlocking AddCause to the control error response when an operation fails due to a control interlocking (CILO) check. ➤ Added the new BXCILO1 and BYCILO2 logical nodes and attributes to the PRO logical device for breaker control and status.	R301-V2 and higher	006	SEL700G Edition 2, R301-V2 or higher		20210723
ICD-700G-R301-V0-Z3000006-D20200331	➤ Added the ability to control mode and behavior through an MMS write to the LPHD logical node mode data object (Mod. ctlVal) in logical device CFG. ➤ Added new DC1CSWI1–DC12CSWI12, DC1CILO1–DC12CILO12, and DC1XSWI1–DC12XSWI12 logical nodes and attributes to PRO LDevice for Disconnect Control and Status.	R300 and higher	006	SEL700G Edition 2, R300 or higher		20200331

Table A.9 SEL-700G ICD File Revision History (Sheet 3 of 7)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	acSELerator Architect		Manual Date Code
				File Description	Software Version	
	➤ Added new SYNX1RSYN1, SYNX2RSYN2, SYNY1RSYN3, SYNY2RSYN4 logical nodes and attributes to PRO LDevice for Synchronism Check element status.					
ICD-700G-R300-V0-Z200006-D20180629	➤ Initial ICD file release with Edition 2 support and compatibility. ➤ Updated ClassFileVersion to 006. ➤ Increased maximum GOOSE subscriptions to 64. ➤ Added MMS authentication support. ➤ Made MMS Inactivity Timeout user-configurable with a default value of 900 seconds. ➤ Added filehandling service. ➤ Added support for IEC 61850 group switch, Simulated Goose and stSeld. ➤ Increased number of MMS reports to 14. ➤ Increased number of default datasets to 15. ➤ Removed maxEntries and maxMappedItems.	R200 and higher	006	SEL700G Edition 2, R200 or higher		20180629

Table A.9 SEL-700G ICD File Revision History (Sheet 4 of 7)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	acSELerator Architect		Manual Date Code
				File Description	Software Version	
	➤ Added new I1PTUV19, I2PTUV20, I1PTOV25, I2PTOV26, I3PTOV27, I4PTOV28, P67N1PTOC14, P67N2PTOC15, PPX1PTOV15, PPX2PTOV16, PPY1PTOV17, PPY2PTOV18, PPX1PTUV9, PPX2PTUV10, PPY1PTUV11, PPY2PTUV12, V1X1PTOV19, V1X2PTOV20, V1X3PTOV21, V1X4PTOV22, V1X5PTOV23, V1X6PTOV24, V1X1PTUV13, V1X2PTUV14, V1X3PTUV15, V1X4PTUV16, V1X5PTUV17, V1X6PTUV18, N1PDIF5, N1PDIF6, and FLTRDRE1, Logical Nodes and attributes to PRO LDevice. ➤ Modified Loc attribute of BXXCBR1, and BYXCBR2 Logical Nodes to report LOCAL/Remote Control status. ➤ Added new attributes Loc to BXCSWI1, and BYCSWI2 Logical Nodes to report Local/ Remote Control status. ➤ Added new attributes DmdA.nseq, and PkDmdA.nseq to METXMDST1 Logical Node.					

Table A.9 SEL-700G ICD File Revision History (Sheet 5 of 7)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect File Description	ACSELERATOR Architect Software Version	Manual Date Code
	➤ Added new FLTGGIO36, DCALMGGIO35, DCST1GGIO34, PFLLIGGIO37, RAGGIO24, RAGGIO25, RAGGIO26, RAGGIO27, and SCGGIO35 Logical Nodes and attributes to ANN LDevice. ➤ Added new attributes Ind09–Ind14 to INCGGIO13, INDGGIO15, and INEGGIO17 Logical Nodes ➤ Added new attributes Ind05–Ind08 to OUTCGGIO14, OUTDGGIO16, and OUTEGGIO18 Logical Nodes ➤ Added new attributes Ind09–Ind16 to PBLEDGGIO7 Logical Node ➤ Modified Ind01–Ind16 attributes of MISCGGIO32 Logical Node. ➤ Modified Ind01–Ind19 attributes of PROGGIO33 Logical Node.					
ICD-700G-R202-V0-Z107004-D20140324	➤ Updated configVersion for new format. ➤ Modified default MMS Report and Dataset names. ➤ Updated all Report Control attributes. ➤ Corrected Report Control rptID attributes to display report name instead of dataset name. ➤ Updated orCat control instances to proprietary node.	R107 and higher	004[a]	700G R107 and above		20140806

Table A.9 SEL-700G ICD File Revision History (Sheet 6 of 7)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect		Manual Date Code
				File Description	Software Version	
	➤ Added new LBG-GIO25, and MBOKG-GIO26 Logical Nodes and attributes to ANN LDevice. ➤ Added MATHERR as data source for IND15 attribute in MISCG-GIO26 Logical Node.					
ICD-700G-R201-V0-Z000000-D20130401	➤ Made corrections per KEMA recommendations. ➤ Added new attributes Fs, Vhz, and Rf to METXMMXU1 Logical Node. ➤ Added new attribute VSyn to METYMMXU2 Logical Node. ➤ Modified data types for MaxA, MinA, MaxPhV, MinPhV, MaxP2PV, and MinP2PV attributes in METXMSTA1 and METYMSTA2 Logical Nodes. ➤ Modified data types for DmdA, and PkDmdA attributes in METXMDST1 and METYMDST2 Logical Nodes. ➤ Modified Report control attributes. ➤ Added new OpCntEx attribute to BXXCBR1 and BYXCBR2 Logical Nodes.	R104 and higher	004[a]	700G R104 and above with additional LNs		20130405

Table A.9 SEL-700G ICD File Revision History (Sheet 7 of 7)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect File Description	ACSELERATOR Architect Software Version	Manual Date Code
	➤ Added new Q1PIOC21, Q2PIOC22, DXPTOF13, DYPTOF14, DPTOF15, RPFRC1, RXPFRC2, RYPFRC3, RX1PFRC4, RX2PFRC5, RX3PFRC6, RX4PFRC7, RY1PFRC8, RY2PFRC9, RY3PFRC10, RY4PFRC11, BXRBRF1, and BYRBRF2 Logical Nodes and attributes to PRO LDevice. ➤ Added new RMSXMMXU3, and RMSYMMXU4 Logical Nodes and attributes to MET LDevice. ➤ Added new SYNGGIO24, GENGGIO25, and MISCGGIO26 Logical Nodes and attributes to ANN LDevice. ➤ Added new BWXASCBR1, BWXBSCBR2, BWXCSCBR3, BWYASCBR1, BWYBSCBR2, and BWYCSCBR3 Logical Nodes and attributes to ANN LDevice for Breaker Wear.					
ICD-700G-R200-V0-Z000000-D20110909	➤ Remove UTC offset attribute. ➤ Improved IEC 61850 conformance. ➤ Added Serial and Model Number attributes to PhyNam DO.	R104 and higher	004[a]	700G R104 and above		20111007
ICD-700G-R100-V0-Z000000-D20100416	➤ Initial ICD File Release.	R100–R103	003[b]	700G Standard		20100416

[a] ICD files with ClassFileVersion 004 require R104 or higher firmware and do not work with R100–R103 firmware.
[b] ICD files with ClassFileVersion 003 can also be used with R104 or higher firmware with IEC 61850 device library 004. Architect will convert the ICD file to ClassFileVersion 004 and send to the relay.

Instruction Manual

The date code at the bottom of each page of this manual reflects the creation or revision date. *Table A.10* lists the instruction manual versions and revision descriptions. The most recent manual version is listed first.

Table A.10 Instruction Manual Revision History (Sheet 1 of 16)

Date Code	Summary of Revisions
20240329	Preface ➤ Updated *Compliance Approvals*, *Hazardous Locations Approvals*. Section 1 ➤ Updated *Accessories*. ➤ Updated *Specifications*, *Type Tests*. Section 3 ➤ Updated *Table 3.1: SEL Software Solutions*. Section 4 ➤ Updated *Rate-of-Change-of-Frequency Protection*. ➤ Updated *Synchronism-Check Elements (Generator Breaker, X-Side)*, including *Figure 4.109: Synchronism-Check Function Voltage Elements* and *Figure 4.110: Synchronism-Check Function Voltage Element Characteristic*. ➤ Updated *Figure 4.113: Synchronism-Check Function Angle Elements*. ➤ Updated *Autosynchronism*, including *Figure 4.122: Simplified Block Diagram*. ➤ Added *Figure 4.121: Frequency Correction Characteristics*, *Figure 4.123: Voltage Correction Characteristics When GENV+ = N*, and *Figure 4.124: Voltage Correction Characteristics When GENV+ = Y*. Section 7 ➤ Added *FGS (Fixed GOOSE) Command*. Section 10 ➤ Updated *Table 10.1: Event Types*. ➤ Updated *Figure 10.9: Sample COMTRADE .CFG Configuration File Data*. Appendix A ➤ Updated for firmware version R301-V6 and R302-V1. Appendix E ➤ Updated *Table E.35: Modbus Map* and *Table 3.37: Trigger Conditions for the Trip/Warn Status Register Bits*. Appendix G ➤ Updated *Optional Control Configurations*, *Fixed GOOSE*, and *Table G.37: Logical Device: MET (Metering)*.
20220826	Section 1 ➤ Updated *Specifications*, including *Compliance* and *Communications Protocols*. Section 2 ➤ Updated *Power Connections* and added *I/O Connections*. Section 4 ➤ Updated *Figure 4.2: Percentage Restraint Differential Characteristic*, *Figure 4.5: Differential Element Logic*, *Figure 4.34: Negative-Sequence Overcurrent Element Logic Diagram*, and *Figure 4.124: Loss-of-Potential Generic Logic (Applies to both X and Y Sides)*. ➤ Updated *Table 4.40: Frequency Settings*, *Table 4.53: X-Side Synchronism-Check Settings*, *Table 4.54: Determination of VP Based on SYNCPX and PT Connection Setting Values*, *Table 4.55: Synchronism-Check Settings*, and *Table 4.84: Ethernet Port Settings*. ➤ Updated *Relay Word Bit Aliases*, including *Table 4.103: Enable Alias Settings* and *Table 4.104: SET R SER Alias Settings*.

Table A.10 Instruction Manual Revision History (Sheet 2 of 16)

Date Code	Summary of Revisions
	Settings Sheets ➤ Updated *X-Side Synchronism-Check Elements*, *Y-Side Synchronism-Check Elements*, and *Relay Word Bit Aliases*. ➤ Added *61850 Simulation Mode* and *61850 Local Remote*. ➤ Added settings for RSTP. Section 7 ➤ Updated *Table 7.4: Protocols Supported on the Various Ports*. ➤ Added *Switched Mode* and *Rapid Spanning Tree Protocol (RSTP)*. ➤ Added *Table 7.29: Warning and Error Codes for GOOSE Subscriptions*. ➤ Updated *ID Command* and added *RSTP Command*. Appendix A ➤ Updated *Table A.1: R300 Series Firmware Revision History* for firmware versions R201-V5, R301-V5, and R302-V0. ➤ Updated *Table A.4: SELBOOT Firmware Revision History* for revision R602-V0. ➤ Updated *Table A.5: SEL Display Package Revision History* and *Table A.6: SEL Display Package Compatibility With Relay Firmware* for 3.0.50700.3015. ➤ Updated *Table A.9: SEL-700G ICD File Revision History* for ICD file R303-V0. Appendix B ➤ Updated *Table B.1: Firmware Upgrade Methods*. ➤ Added *Upgrade the SELBOOT Firmware Loader Using a Terminal Emulator*. Appendix G ➤ Added *Functional Naming*, *Local/Remote Control Authority*, and *Service Tracking*. ➤ Updated *Simulation Mode*. ➤ Updated *Table G.23: New Logical Node Extensions* and added *Table G.27: LCCH Physical Communication Channel Supervision*, *Table G.28: LGOS GOOSE Subscription*, and *Table G.29: LTMS Time Master Supervision*. ➤ Updated *Table G.36: Logical Device: PRO (Protection)*, *Table G.37: Logical Device: MET (Metering)*, *Table G.38: Logical Device: CON (Remote Control)*, *Table G.39: Logical Device: ANN (Annunciation)*, and *Table G.40: Logical Device: CFG (Configuration)*. Appendix L ➤ Updated *Table L.1: SEL-700G Relay Word Bits* and *Table L.3: Relay Word Bit Definitions for the SEL-700G*. Appendix N ➤ Updated *Table N.1: IP Port Numbers*. Glossary ➤ Updated for RSTP. Command Summary ➤ Updated for RSTP.
20220225	Appendix A ➤ Updated *Table A.1: R300 Series Firmware Revision History* for firmware version R301-V4. ➤ Updated *Table A.2: R200 Series Firmware Revision History* for firmware version R201-V4.
20211213	Appendix A ➤ Updated *Table A.1: R300 Series Firmware Revision History* for firmware version R301-V3. ➤ Updated *Table A.2: R200 Series Firmware Revision History* for firmware version R201-V3. ➤ Updated *Table A.4: SELBOOT Firmware Revision History* for firmware versions R601-V0 and R502-V0. ➤ Updated *Table A.5: SEL Display Package Revision History* and *Table A.6: SEL Display Package Compatibility With Relay Firmware*.
20210723	Section 1 ➤ Updated *AC Voltage Inputs*. ➤ Updated *RFI and Interference Tests* conducted and radiated emissions. ➤ Updated *Field Ground Protection (64F)*.

Table A.10 Instruction Manual Revision History (Sheet 3 of 16)

Date Code	Summary of Revisions
	Section 2 ➤ Updated *Figure 2.13: Control I/O Connections—Internal RTD Option*. Section 4 ➤ Updated *Synchronism Elements*, including *Figure 4.112: Synchronism-Check Function Slip Elements* and *Figure 4.116: Synchronism-Check Voltage Window and Slip Frequency Elements*. ➤ Updated *Figure 4.136: Typical Generator or Intertie Close CL Logic (SEL-700G or GT)*. ➤ Updated *Event Report Settings*. Section 10 ➤ Updated *Viewing Compressed Event (CEV) Reports*. Appendix A ➤ Updated *Table A.1: R300 Series Firmware Revision History* for firmware version R301-V2. ➤ Updated *Table A.2: R200 Series Firmware Revision History* for firmware version R201-V2. ➤ Updated *Table A.5: SEL Display Package Revision History* and *Table A.6: SEL Display Package Compatibility With Relay Firmware*. ➤ Updated *Table A.9: SEL-700G ICD File Revision History*. Appendix G ➤ Added *Control Interlocking*, including *Figure G.4: CSWI Logical Node Direct Operate Command Request*. ➤ Updated *Table G.6: AddCause Descriptions*. ➤ Updated *Table G.28: Logical Device: PRO (Protection)*.
20210104	Appendix A ➤ Updated *Table A.1: R300 Series Firmware Revision History* for firmware revision R301-V1. ➤ Updated *Table A.2: R200 Series Firmware Revision History* for firmware revision R201-V1.
20200930	Appendix A ➤ Updated *Table A.1: R300 Series Firmware Revision History* for firmware revision R301-V0.
20200921	Appendix A ➤ Updated *Table A.1: R300 Series Firmware Revision History* for firmware revision R300-V1.
20200331	Preface ➤ Updated product labels. ➤ Updated product compliance label. Section 1 ➤ Updated *Table 1.1: Current (ACI) and Voltage (AVI) Card Selection for 700G Models.* ➤ Updated *Table 1.2: SEL-700G Protection Elements.* ➤ Updated *Table 1.4: SEL-700G Front-Panel Options.* ➤ Updated *Specifications*. Section 2 ➤ Updated *Physical Location.* ➤ Added note to *RTD Card (10 RTD).* ➤ Added footnote to Table 2.19: Jumper Functions and Default Positions. ➤ Updated *Figure 2.20: SEL-700G0+ Relay High-Impedance Grounded Generator With Synchronism Check and Without Current Differential Protection.* Section 3 ➤ Renamed section to *Section 3: PC Interface* to account for new web server content. ➤ Updated *Overview* with web server information. ➤ Added *Web Server* section. ➤ Updated *Table 3.1: SEL Software Solutions* to remove reference to ACSELERATOR Analytic Assistant SEL-5601 Software and added SEL-5078-2 SYNCHROWAVE Visualization and Analysis Software. ➤ Added *Web Server*.

Table A.10 Instruction Manual Revision History (Sheet 4 of 16)

Date Code	Summary of Revisions
	Section 4 ➤ Updated *Overview*. ➤ Updated *Ground Differential Element* to describe security of 87NTC element. ➤ Updated description of when the 51V element functions in *Voltage-Controlled/Restrained Time-Overcurrent Elements.* ➤ Added *Frequency Measuring and Tracking*. ➤ Updated *100% Stator Ground Protection Elements.* ➤ Added note to *Table 4.52: RTD Resistance Versus Temperature.* ➤ Added note to *TR Trip Conditions* SELOGIC *Control Equation.* ➤ Updated *Synchronism Elements*. ➤ Updated *Table 4.74: Latch Bits Equation Settings.* ➤ Updated *Table 4.95: Ethernet Port Settings.* ➤ Updated *Figure 4.123: Graphical Display of Generator Autosynchronism Report.* ➤ Updated *Disconnect Control Settings.* ➤ Updated *Local/Remote Control.* ➤ Updated *Figure 4.131: Trip Logic.* ➤ Added *Precision Time Protocol (PTP).* ➤ Updated *Table 4.67:* SELOGIC *Variable Settings.* ➤ Added note to *Access Control*. ➤ Removed note about TCP Keep Alive settings from and added PTP settings to *Table 4.83: Ethernet Port Settings.* ➤ Added PTP settings to *Table 4.84: Port Number Settings That Must Be Unique.* ➤ Updated *SER Chatter Criteria* for which Relay Word bits the relay checks during each processing interval. ➤ Added *Multiple Settings Groups.* ➤ Updated *Table 4.95: Ethernet Port Settings.*
	Section 6 ➤ Updated *Table 6.1: Methods of Accessing Settings*. ➤ Added *View Settings Using the Web Server*.
	Setting Sheets ➤ Updated *Generator Differential, Ground Differential. Restricted Earth Fault (REF), Rotor Ground (64F), System Backup, Loss of Field, Thermal Overload, Voltz Per Hertz, Inadvertent Energization, Y-Side Load Encroachment, X-Side Power Elements, Y-Side Power Elements, X-Side Frequent Accumulators,* and *Phasor Measurement (PMU)* for new hide conditions. ➤ Updated *X-Side Frequency Elements* and *Y-Side Frequency Elements* with new setting ranges for the trip delay setting prompts. ➤ Updated *X-Side Synchronism-Check Elements.* ➤ Added *PTP Settings*. ➤ Updated *Port 1* under *SET PORT p (p = F, 1, 2, 3, or 4) Command* ➤ Added PTP settings to *Table SET.3: Port Number Settings That Must Be Unique*.
	Section 7 ➤ Added *Telnet or the Web Server*. ➤ Updated *Ethernet Port* with recommendations for configuring the Ethernet port. ➤ Added *TCP Keep Alive*. ➤ Added *Embedded Web Server (HTTP)*. ➤ Added *Precision Time Protocol (PTP).* ➤ Added *89CLOSE Command (Close Disconnect)* and *89OPEN Command (Open Disconnect)*. ➤ Added *COM PTP Command.* ➤ Updated *TEST DB Command*.

Table A.10 Instruction Manual Revision History (Sheet 5 of 16)

Date Code	Summary of Revisions
	Section 8 ➤ Added note to *Contrast* under *Two-Line Display Human-Machine Interface.* ➤ Added note to *Touchscreen Display Human-Machine Interface.* ➤ Updated *Table 8.9: Sidebar Buttons.* ➤ Updated *Reports* to include trigger event function. Section 9 ➤ Updated *Disconnect Control Settings.* ➤ Updated *Table 9.5: Disconnect Symbols.* ➤ Updated *Local/Remote Control.* ➤ Updated *Breaker/Disconnect Control Via the Touchscreen.* ➤ Updated *Table 9.7: Touchscreen Settings.* ➤ Updated *Bay Control Disconnect Settings.* Section 10 ➤ Updated *Viewing Compressed Event (CEV) Reports.* ➤ Updated *SYN Report Closure*. Appendix B ➤ Added *Digitally Signed Firmware Files* and *Upgrade the Relay Firmware to R3xx* to *Overview*. ➤ Added *Upgrade the Relay SELBOOT Firmware Loader Using a Terminal Emulator*. ➤ Added *Upgrade the Relay Firmware Using the Web Server.* ➤ Updated note in Step 3 of *Upgrade Firmware Using QuickSet.* ➤ Added a note and updated Step 9 of *Upgrade Firmware Using a Terminal Emulator.* Appendix D ➤ Updated *Time Synchronization* section for priority information. ➤ Added note to *Modem Support*. ➤ Updated *Table D.7: Port DNP3 Protocol Settings.* ➤ Updated *Table D.10: DNP3 Reference Data Map.* ➤ Updated *Table D.12: SEL-700G Object 12 Control Operations.* Appendix E ➤ Updated *Table E.33: Modbus Register Labels for Use With SET M Command.* ➤ Updated *Table E.34: Modbus Register Map*. ➤ Added *Table E.35: Corresponding Relay Word Bits for Trip/Warn Registers.* Appendix G ➤ Added *IEC 61850 Mode/Behavior.* ➤ Updated *Table G. 17: IEC 61850 Settings.* ➤ Updated *Mode, Behavior,* and *Health*, under *Logical Nodes.* ➤ Updated *Table G.28: Logical Device: PRO, Table G.29: Logical Device: MET (Metering), Table G.31: Logical Device: ANN,* and *Table G.32: Logical Device: CFG (Configuration).* Appendix L ➤ Updated *Table L.1: SEL-700G Relay Word Bits.* ➤ Updated *Table L.3: Relay Word Bit Definitions for the SEL-700G.* Appendix M ➤ Updated and added note to *Table M.1: Analog Quantities.* Appendix N ➤ Updated *Table N.1: IP Port Numbers* for PTP and HTTP. Command Summary ➤ Added **89C *m***, **89O *m***, **89C *n m***, and **89O *n m*** commands to *Access Level 2 Commands.*

Table A.10 Instruction Manual Revision History (Sheet 6 of 16)

Date Code	Summary of Revisions
20180629	Preface ➤ Updated *Hazardous Locations Approvals*, including the relay compliance label. ➤ Updated *Product Labels* for the high- and low-voltage supply models. ➤ Added *Copyrighted Software*. Section 1 ➤ Updated *Specifications*, *Compliance* for the touchscreen relay model hazardous locations and ATEX; *Type Tests*; and *Communications Protocols* for IEC 61850 Edition 2, IEC 60870-5-103, and PRP. Section 2 ➤ Updated *Physical Location* and *Relay Mounting* for specific installation and location requirements and for the touchscreen display relay. ➤ Updated *Figure 2.2: Slot Allocations for Different Cards*. ➤ Updated *Card Configuration Procedure* for the touchscreen display relay. ➤ Added *High-Speed, High-Current Interrupting DC Tripping Outputs*. Section 3 ➤ Updated *Table 3.1: SEL Software Solutions* for ACSELERATOR Bay Screen Builder SEL-5036 Software, SEL-5601-2 SYNCHROWAVE Event Software, and SEL-5806 Curve Designer Software. ➤ Added *Touchscreen Settings and Bay Screen Builder*. Section 4 ➤ Added *Inverse-Time Undervoltage Protection*, including *Table 4.45: Operating Quantities for the 27I Element* and *Inverse-Time Overvoltage Protection*, including *Table 4.48: Operating Quantities for the 59I Element*. ➤ Added *Vector Shift Element*. ➤ Updated *52A and 52B Breaker Status Conditions SELOGIC Control Equations* and added notes for disconnect settings and logic and local/remote breaker control. ➤ Updated *Global Settings (SET G Command)*, *General Settings* and *Table 4.70: General Global Settings* for the METHRES setting. ➤ Updated *Group Selection* and *Table 4.72: Setting Group Selection* for setting Group 4. ➤ Added *89A and 89B Disconnect Status SELOGIC Control Equations* and *Local/Remote Breaker Control*. ➤ Updated *Front-Panel Settings (SET F Command)*, *General Settings*, including *Table 4.90: LCD Settings*; *Display Points*, including *Table 4.91: Front-Panel Display Point Settings*; *Target LED Settings*; and *Target LEDs*, including *Table 4.98: Target LED Settings*. ➤ Updated *Table 4.99: Pushbutton LED Settings*. Section 5 ➤ Added *Remote Analog Metering*. Section 6 ➤ Added *View/Change Settings With the Touchscreen Front Panel*. Settings Sheets ➤ Updated *Table SET.1: Range Dependencies for 27I Operating Quantities* and *Table SET.2: Range Dependencies for 59I Operating Quantities*. ➤ Updated *Vector Shift* and *Trip/Close Logic*. ➤ Added *Two-Position Disconnect Settings* and *Control Configuration*. ➤ Updated *SET PORT p* and *Front-Panel Settings (SET F Command)*. ➤ Added *Touchscreen Settings*. ➤ Added *IEC 60870-5-103 Map Settings (SET I Command)*.

Table A.10 Instruction Manual Revision History (Sheet 7 of 16)

Date Code	Summary of Revisions
	Section 7 ➤ Updated *Ethernet Port* for PRP mode and added *PRP Connection Mode*. ➤ Added *IEC 60870-5-103 Protocol* to *Communications Protocols*. ➤ Added *SEL Fast Message* to *SEL Communications Protocols*. ➤ Updated *Access Levels* for EPORT and MAXACC settings. ➤ Updated *CLOSE n Command (Close Breaker n, Where n = X or Y)* for LOCAL control. ➤ Updated *COPY Command*, including *Table 7.12: COPY Command* for setting Group 4. ➤ Updated *GOOSE Command*, including *Table 7.19: GOOSE Command Variants*, *Table 7.20: GOOSE IED Description*, and *Figure 7.26: GOOSE Command Response*. ➤ Updated *OPEN n Command (Open Breaker n, Where n = X or Y)* for LOCAL control. ➤ Added *TEST DB Command*, *Language Support*, and *Virtual File Interface*. Section 8 ➤ Updated *Overview*; added *Figure 8.1: SEL-700G Front-Panel Options*. ➤ Updated *Two-Line Display Front Panel*, including *Figure 8.2: Front-Panel Overview*. ➤ Added *Language Support*. ➤ Updated *Operation and Target LEDs*, *Programmable LEDs* and *Front-Panel Operator Control Pushbuttons*. ➤ Added *Touchscreen Display Front Panel*. Section 9 ➤ Added *Section 9: Bay Control*. Section 10 ➤ Updated *Event Summaries* for the unique reference number, added a note for the reset of the unique reference number to 10000 using the **HIS CA** command, and added *Event Logs* and *Event Reference Number*. ➤ Updated *Event History* for the unique reference number and *Clearing* for the unique reference number and **HIS CA** command. ➤ Updated *Viewing Compressed Event (CEV) Reports*, including a note for compensated magnitudes and added *COMTRADE File Format Event Reports*.\ ➤ Added a note on report extraction using the **FILE** command to *Sequential Events Recorder (SER Report)*, *SER Triggering*. ➤ Updated *Retrieving and Clearing SER Reports* for SER report read-only file retrieval. ➤ Updated *Synchronism-Check Report* for SYN report read-only file retrieval. ➤ Updated *Generator Autosynchronism Report (CGSR Command)* for the generator synchronism report read-only file retrieval. Section 11 ➤ Updated *Commissioning Tests*, including adding *Figure 11.5: Verifying the Connection Between the SEL-2664 and the SEL-700G*. ➤ Updated *Table 11.8: Periodic Relay Checks* in *Periodic Tests (Routine Maintenance)*. ➤ Updated *Self-Test*. ➤ Updated *Table 11.10: Troubleshooting*. Appendix A ➤ Updated for standard and point releases. ➤ Updated *Table A.1: R200 Series Firmware Revision History* for firmware revision R200. ➤ Added *SEL Display Package Versions*, including *Table A.3: SEL Display Package Revision History* and *SEL Display Package and Relay Firmware Compatibility*, including *Table A.4: SEL Display Package Compatibility With Relay Firmware*. ➤ Updated *Table A.6: EDS File Compatibility* for firmware revision R200. ➤ Updated *Table A.7: SEL-700G ICD File Revision History*. Appendix B ➤ Updated *Upgrade Firmware Using a Terminal Emulator* for a note about saving the touchscreen settings before upgrading the firmware and a note to change the relay serial port data rate before issuing the **L_D** command.

Table A.10 Instruction Manual Revision History (Sheet 8 of 16)

Date Code	Summary of Revisions
	Appendix C ➤ Updated *Table C.1: Supported Serial Command Sets* for SEL Fast Message. ➤ Updated *SEL Fast Meter, Fast Operate, Fast SER, and Unsolicited Write*. ➤ Added a note to *SEL Communications Processor* regarding the language port setting and updated for RTAC. ➤ Updated *Table C.15: Communications Processor TARGET Region*. ➤ Added a Fast Operate and breaker jumper note to *Control Points*. ➤ Added *SEL Communications Processor to SEL-700G Unsolicited Write Remote Analog Example*. Appendix D ➤ Updated *DNP3 in the SEL-700G*, including *Table D.7: Port DNP3 Protocol Settings* for the number of DNP sessions. ➤ Updated *DNP3 Documentation*, including *Table D.9: SEL-700G DNP Object List* for the number of DNP sessions, *Table D.10: DNP3 Reference Data Map* for STFAIL and STWARN, *Table D.12: SEL-700G Object 12 Control Operations*. ➤ Updated *Figure D.6: Analog Input Map Entry in QuickSet*, *Figure D.7: AI Point Scaling and Deadband in QuickSet*, *Figure D.9: Analog Output Map Entry in QuickSet*, and *Figure D.11: Binary Output Map Entry in QuickSet*. Appendix E ➤ Updated *Table E.7: 02h SEL-700G Inputs*, *Table E.31: 7Dh Encapsulated Packet Query Errors*, *Table E.33: Modbus Register Labels for Use With SET M Command*, and *Table E.34: Modbus Register Map*. Appendix F ➤ Updated *Features*, *Introduction to IEC 61850*, *IEC 61850 Operation*, *IEC 61850 Configuration*, *Logical Nodes*, *Protocol Implementation Conformance Statement*, and *ASCI Conformance Statements*. ➤ Added *Simulation Mode* and *Potential Client and Automation Application Issues With Edition 2 Upgrades*. ➤ Updated *Figure F.1: SEL-700G Datasets* and *Figure F.2: SEL-700G Predefined Reports*. ➤ Updated *Table F.21: Logical Device: ANN (Annunciation)*, MISCGGIO26, for setting Group 4. Appendix G ➤ Added *Appendix G: IEC 60870-5-103 Communications*. Appendix J ➤ Updated *C37.118 Synchrophasor Protocol*. ➤ Updated *Table J.10: Frequency Tracking Side and Quantity Based on the SEL-700G Model* and *Table J.15: Example Synchrophasor SELOGIC Settings*. Appendix K ➤ Updated *Table K.1: SEL-700G Relay Word Bits*, *Table K.2: Hidden Overcurrent Element Relay Word Bits Per the SEL-700G Model*, and *Table K.3: Relay Word Bit Definitions for the SEL-700G*. Appendix L ➤ Updated for IEC 61850 and IEC 60870-5-103. ➤ Updated *Table L.1: Analog Quantities*. Appendix M ➤ Added *Appendix M: Cybersecurity Features*. Glossary ➤ Updated. Index ➤ Updated. Command Summary ➤ Updated for new commands. ➤ Updated for Spanish commands.

Table A.10 Instruction Manual Revision History (Sheet 9 of 16)

Date Code	Summary of Revisions
20170814	Preface ➤ Updated *General Safety Marks* and *Hazardous Locations Safety Marks* tables. ➤ Updated *Hazardous Locations Approvals* and the compliance label. ➤ Updated the product labels. Section 1 ➤ Updated *Compliance*, *Output Contacts*, *Standard Contacts*, and *Fast Hybrid (High-Speed, High Interrupting)* in *Specifications*. Section 2 ➤ Updated *Physical Locations*.
20160831	Preface ➤ Updated *Safety Information*. ➤ Added *Trademarks*. ➤ Updated *Wire Sizes and Insulation*. ➤ Section 1 ➤ Updated *Table 1.2: Protection Elements in SEL-700G Models*. ➤ Updated *Accessories* in *Models, Options, and Accessories*. ➤ Updated *Power Supply* and *Output Contacts* and added *Fuse Ratings* in *Specifications*. Section 2 ➤ Updated *Thermal Protection of Generator and Prime Mover* and *Field Ground Protection of Generator*. Section 3 ➤ Updated *Text Files* and *Event Waveforms*. Section 4 ➤ Updated *Figure 4.12: AO87P2 Logic*. ➤ Updated *Distance Elements* and *Recommendations* in *System Backup Protection*. ➤ Updated *Volts-Per-Hertz Elements*. ➤ Updated *Figure 4.84: Direction Forward/Reverse Logic for Neutral-Ground Overcurrent Elements*. ➤ Added a note to *Figure 4.87: Positive-Sequence Voltage-Polarized Directional Element for Phase Overcurrent Elements*. ➤ Updated *Figure 4.89: Direction Forward/Reverse Logic for Negative-Sequence Overcurrent Elements*, *Figure 4.90: Direction Forward/Reverse Logic for Phase Overcurrent Elements*, and *Figure 4.120: Loss-of-Potential Generic Logic (Applies to both X and Y Sides)*. ➤ Updated *Loss-of-Potential (LOP) Protection*. ➤ Updated *Table 4.82: Settings That Always, Never, or Conditionally Hide a Display Point*, and *Table 4.87: Example Settings and Displays*. ➤ Updated *High-Impedance Grounded System Considerations for Phase-to-Phase or Three-Phase Faults*. ➤ Added *Port Number Settings Must be Unique* to *PORT 1*. Settings Sheets ➤ Updated *Port Number Settings Must be Unique*. Section 7 ➤ Updated *Table 7.1: SEL-700G Communications Port Interfaces* and *Table 7.34: Meter Class*. ➤ Updated *FTP Server* in *Ethernet Protocols* for the FTP session user name and password. Section 8 ➤ Added a note on target LEDs to *Programmable LEDs*. Section 9 ➤ Updated *Table 9.1: Event Types*. ➤ Updated *Figure 9.9: Example 15-cycle Stator Ground Event Report (EVE GND) 1/4 Cycle Resolution*. Section 10 ➤ Updated External RTD (SEL-2600) in *Table 10.9: Relay Self-Tests*.

Table A.10 Instruction Manual Revision History (Sheet 10 of 16)

Date Code	Summary of Revisions
	Appendix A ➤ Updated *Determining the Firmware Version*. ➤ Updated *Table A.1: Firmware Revision History* for firmware revision R110 information. ➤ Updated *Table A.3: EDS File Compatibility* to include firmware revision R110. Appendix D ➤ Updated *DNP3 in the SEL-700G*. Appendix G ➤ Updated *Figure G.1: DeviceNet Card Component Overview*. Appendix H ➤ Updated *Table H.9: TQUAL Bits Translation to Time Quality*.
20160224	Preface ➤ Updated the *General Safety Marks* and *Other Safety Marks* tables. ➤ Updated *Compliance Approvals*. ➤ Added *Trademarks*. ➤ Updated *Wire Sizes and Insulation*. Section 1 ➤ Updated *Accessories*. ➤ Updated *Compliance*. ➤ Updated *AC Current Input*, *AC Voltage Inputs*, *Output Contacts*, and *Communications Ports*. ➤ Updated *Harmonics* and *Distance Element (21)*. Section 2 ➤ Updated *Analog Input Card Voltage/Current Jumper Selection*. ➤ Updated *Figure 2.4: JMP1 Through JMP4 Locations on 4 AI/4 AO Board*. ➤ Added a note on fast hybrid contacts to *Fail-Safe/Nonfail-Safe Tripping* and updated *Figure 2.15: OUT103 Contact Fail-Safe and Nonfail-Safe Options*. ➤ Updated *SEL-700GT+ Intertie Relay Application*, *Figure 2.26: SEL-700GT+ Relay Typical AC Current and Four-Wire Wye Voltage Connection*. Section 3 ➤ Updated *Synchroscope*. Section 4 ➤ Updated *Configuration Settings*. ➤ Updated *Figure 4.16: 87N Diagram*. ➤ Updated *Restricted Earth Fault Element*. ➤ Added *REF Current Pickup Level* to *Polarizing Quantity* and updated *Figure 4.20: Effect of X_CUR_IN Setting on Polarizing Current*. ➤ Updated *Current Unbalance Elements* and *Table 4.11: Current Unbalance Settings*. ➤ Updated *Figure 4.35: Negative-Sequence Time-Overcurrent Operating Characteristic*. ➤ Updated *Figure 4.53:* SEL-*700G0,* SEL-*700G1,* SEL-*700GT+ Instantaneous Overcurrent (Generator Protection)*, *Figure 4.54:* SEL-*700G Instantaneous Overcurrent (Intertie Protection)*, and *Figure 4.55: Instantaneous Overcurrent (Feeder Protection,* SEL-*700GW)*. ➤ Updated *Over- and Underfrequency Protection*. ➤ Updated *Figure 4.110: Breaker Close Failure Logic Diagram*. ➤ Updated *Autosynchronism*. ➤ Updated *Synchroscope* and *Autosynchronism and Synchronism-Check Reports*. ➤ Updated *Figure 4.119: Graphical Display of Generator Autosynchronism Report*. ➤ Updated *Loss-of-Potential (LOP) Protection* and *Figure 4.120: Loss-of-Potential Generic Logic (Applies to both X and Y Sides)* and added *Table 4.50: Loss of Potential (LOP) Settings*. ➤ Updated *Figure 4.126: Trip Logic*. ➤ Updated *SELOGIC Control Equation Operators*. ➤ Added a note on fast hybrid contacts to *Output Contacts*. ➤ Updated *Table 4.75: Ethernet Port Settings*.

Table A.10 Instruction Manual Revision History (Sheet 11 of 16)

Date Code	Summary of Revisions
	Settings Sheets ➤ Updated *SEL-700G Settings Sheets*. Section 7 ➤ Updated *Failover Mode* and *NETPORT Selection*. ➤ Added a note for serial communications cable designations when using MIRRORED BITS communications to *Port Connector and Communications Cables*. ➤ Updated *COMMUNICATIONS Command*. ➤ Added a note for the **STA S** command to *STATUS Command (Relay Self-Test Status)*. Section 8 ➤ Updated *Table 8.3: Possible Warning Conditions (Flashing TRIP LED)*. ➤ Updated *Figure 8.26: Operator Control Pushbuttons and LEDs*. Section 9 ➤ Updated *Currents, Voltages, and RTD Temperatures*. ➤ Added *Viewing Compressed Event (CEV) Reports*. Appendix A ➤ Updated *Table A.1: Firmware Revision History* for firmware revision R109 information. ➤ Updated *Table A.3: EDS File Compatibility* to include firmware revision R109. Appendix B ➤ Added a note for the firmware loader and Ethernet connections to *Upgrade Firmware Using ACSELERATOR QuickSet*. Appendix D ➤ Updated *Table D.7: Port DNP3 Protocol Settings*. Appendix H ➤ Updated *Ethernet Port Settings for IEEE C37.118 Synchrophasors* and *Synchrophasor Relay Word Bits*. Appendix J ➤ Updated *Table J.1: SEL-700G Relay Word Bits* for Relay Word Bits LOPBLKX and LOPBLKY. ➤ Updated *Table J.3: Relay Word Bit Definitions for the SEL-700G*.
20150521	Appendix A ➤ Updated *Table A.1: Firmware Revision History* for firmware revision R108 information.
20150410	Preface ➤ Updated the *Hazardous Locations Approvals* label. Section 1 ➤ Added the applied current at which the burden is measured for I_{NOM} = 1 A and 5 A in *Specifications*. ➤ Updated *Protection and Control Processing* in *Specifications*. ➤ Updated *Restricted Earth Fault (REF)* section in *Specifications*. Section 2 ➤ Added a note on CT circuits to applicable current card descriptions. ➤ Updated the table footnote for *Table 2.18: Jumper Functions and Default Positions*.

Table A.10 Instruction Manual Revision History (Sheet 12 of 16)

Date Code	Summary of Revisions
	Section 4 ➤ Updated *Generator Protection* section for the enhancement of the differential . ➤ Added *High Security Mode Settings HSM, O87P2, HSMDOT*. ➤ Added *Figure 4.7: Differential Element Output Logic*, *Figure 4.9: Delta IRTn and Delta IOPn External Event Detector Logic*, *Figure 4.10: Second-Harmonic External Event Detector Logic*, *Figure 4.11: High Security Model RESET Logic*, and *Figure 4.12: AO87P2 Logic*. ➤ Updated *Figure 4.2: Percentage Restraint Differential Characteristic*, *Figure 4.3: Winding X Compensated Currents*, *Figure 4.4: Differential Element (87-1)Quantities*, *Figure 4.5: Differential* , *Figure 4.13: Winding Connections, Phase Shifts, and Compensation Direction*, *Figure 4.14: Example 1 for WnCTC Selection*, *Figure 4.15: Effect of X_CUR_IN setting on Residual Current (IG)*, *Figure 4.17: REF Enable Logic*, *Figure 4.18: REF Directional Element*, and *Figure 4.126: Trip Logic*. ➤ Updated *Table 4.3: Differential Element Settings*, *Table 4.8: Compensator Distance Protection Settings*, *Table 4.9: Voltage Controlled/Restraint Time OC Protection Settings*, *Table 4.49: Autosynchronism Settings*, *Table 4.57: SELOGIC Variable Settings*, and *Table 4.61: General Global Settings*. ➤ Updated [CTC(10)] matrix in *The Complete List of Compensation Matrices (m = 1–12)*. Section 5 ➤ Added *Delta-Connected CTs* section. Settings Sheets ➤ Added the X SIDE CT COMP (CTCX), HI SECURITY MODE (HSM), HI SECURITY PU (O87P2), and EXT FLT DET DO (HSMDOT) settings to *Generator Differential* settings. ➤ Updated the FREQ PULS MIN (FPLSMIND), FREQ PULS MAX (FPLSMAXD), VOLT PULS MIN (VPLSMIND), and VOLT PULS MAX (VPLSMAXD) setting ranges in *Autosynchronism* settings. ➤ Updated BACKUP PROT EN (EBUP) setting range in *System Backup*. ➤ Updated setting conditions for *Volt-Control TOC* and *Volt-Restrained TOC*. Section 7 ➤ Updated *PULSE Command* text and added a note on the breaker control jumper. ➤ Added *VEC Command (Show Diagnostic Information)*. Section 9 ➤ Updated the *Analog Event Reports (EVE Command)*. Section 10 ➤ Added a note on CT circuits. ➤ Updated *Table 10.9: Relay Self-Tests*. Appendix A ➤ Updated *Table A.1: Firmware Revision History* for firmware revision R108. ➤ Added *ICD File* section. Appendix E ➤ Updated *Table E.7: 02h* SEL-700G *Inputs*, *Table E.33: Modbus Register Labels for Use With SET M Command*, and *Table E.34: Modbus Register Map*. Appendix F ➤ Updated GOOSE device bits note in *GOOSE* section. ➤ Updated *ACSELERATOR Architect* and *SEL ICD File Versions* sections. Appendix H ➤ Updated *Table H.2: Synchrophasor Order in Data Stream (Voltage and Currents)*. Appendix I Updated the setting description for the RBADPU setting prompt in *Table I.5: MIRRORED BITS Protocol Settings*. Appendix J ➤ Updated *Overview*. ➤ Updated *Table J.1:* SEL-700G *Relay Word Bits* and *Table J.3: Relay Word Bit Definitions for the* SEL-700G. ➤ Added *Table J.2: Hidden Overcurrent Element Relay Word Bits Per the* SEL-700G *Model*. Appendix K ➤ Updated for rms data determination.

Table A.10 Instruction Manual Revision History (Sheet 13 of 16)

Date Code	Summary of Revisions
20150123	Preface ➤ Added *Safety Information* and *General Information*. ➤ Updated the product labels and compliance label. Section 1 ➤ Changed the *Certifications* section title to *Compliance* and relocated the section to the beginning of the *Specifications*. ➤ Updated the *Type Test* compliance specifications in the *Specifications*.
20140806	Section 1 ➤ Updated the entries for the 50N element in *Table 1.2: Protection Elements in SEL-700G Models*. ➤ Updated *Specifications* including *Synchrophasor Accuracy*. Section 2 ➤ Updated *Card Configuration Procedure*. ➤ Added a note stating that the fail-safe option should not be used for fast hybrid output contacts in fail-safe/non-fail-safe tripping. Section 4 ➤ Updated *Figure 4.14: REF Protection Output (Extremely Inverse-Time O/C)*, *Figure 4.110: Simplified Block Diagram, Frequency and Phase Matching*, and *Figure 4.111: Simplified Block Diagram, Voltage Matching Elements*. ➤ Added *Figure 4.20: Phase-to-Phase Distance Element Operating Characteristics*. ➤ Revised the text for the 25C element. The relay asserts the 25C Relay Word bit to initiate a close when the angle difference equals the CANGLE setting. 25C assertion is timed so that, if the slip remains constant and the breaker closes in TCLOSDX ms, the breaker main contacts close the instant the angle difference is equal to CANGLE. Section 5 ➤ Updated the number of time-stamp entries that relay memory can hold for load profiling. Settings Sheets ➤ Added notes for Port settings. ➤ Added *Table SET.1: Port Number Settings Must be Unique*. Section 10 ➤ Updated *Table 10.9: Relay Self-Tests*. Appendix A ➤ Updated for firmware version R107. Appendix B ➤ Added a note to save the calibration settings before the upgrade in *Upgrade Firmware Using a Terminal Emulator*. Appendix D ➤ Updated *Table D.9:* SEL-700G *DNP Object List*. ➤ Updated *Table D.11: DNP3 Default Data Map*. Appendix F ➤ Added a note about GOOSE subscriptions retaining state until overwritten or the device restarts. ➤ Updated *Figure F.1:* SEL-700G *Predefined Reports* and *Figure F.2:* SEL-700G *Datasets.* ➤ Updated *Table F.4: Buffered Report Control Block Client Access* and *Table F.5: Unbuffered Report Control Block Client Access*. ➤ Updated text for *SEL ICD File Versions*. ➤ Updated *Table F.16: Logical Device: PRO (Protection)*, *Table F.17: Logical Device: MET (Metering)*, *Table F.18: Logical Device: CON (Remote Control)*, *Table F.19: Logical Device: ANN (Annunciation)*, and *Table F.20: Logical Device: CFG (Configuration)*.

Table A.10 Instruction Manual Revision History (Sheet 14 of 16)

<table>
<tr><th>Date Code</th><th>Summary of Revisions</th></tr>
<tr><td></td><td>Appendix H
➤ Updated Table H.8: Time-Synchronization Relay Word Bits for PMDOK description.
➤ Added Table H.9: Frequency Tracking Side and Quantity Based on the SEL-700G Model.
Appendix J
➤ Added the MATHERR Relay Word bit to Table J.1: SEL-700G Relay Word Bits and Table J.2: Relay Word Bit Definitions for the SEL-700G.</td></tr>
<tr><td>20130405</td><td>Preface
➤ Updated SEL-700G LED locations drawing.
➤ Updated the product labels for SEL-700G.
Section 1
➤ Added input impedance information to the Specifications under AC Voltage Input.
➤ Added terminal block information under the Terminal Connections category of the Specifications.
➤ Added relay mounting screw size information to the Specifications.
➤ Added Synchrophasor Accuracy to the Specifications.
➤ Added open state leakage current for Fast Hybrid contacts to the Specifications.
Section 2
➤ Revised the Table 2.18: Jumper Functions and Default Positions footnote to clarify the impact of the jumper position on breaker control.
Section 4
➤ Added a note for the CTCX setting under Example of Setting the SEL-700G Relay (Unit Differential).
➤ Added a paragraph under LOP Monitoring and Alarms to explain the LOP Relay Word bit when the relay is first energized.
➤ Added a note for Pole Open Logic.
➤ Added logic diagram Figure 4.10: Effect of X_CUR_IN Setting on Residual Current (IG) to explain the 87N element.
➤ Corrected Table 4.80: Settings That Always, Never, or Conditionally Hide a Display Point for the programmable automation controller setting.
➤ Corrected Table 4.81: Entries for the Four Strings for set and clear strings.
➤ Added a reference to the Microsoft Excel spreadsheet, 64G Element Setting Worksheet.
Section 7
➤ Updated the Fiber-Optic Serial Port paragraph.
➤ Updated +5 Vdc availability statement in +5 Vdc Power Supply.
Section 9
Revised the event type logic for Neutral 50 Trip in Table 9.1: Event Types to account for 67N1T and 67N2T.
Appendix A
➤ Updated Table A.1: Firmware Revision History for firmware version R106.
Appendix B
➤ Added instructions for upgrading firmware using ACSELERATOR QuickSet.
Appendix E
➤ Revised Reading History Data Using Modbus.
Appendix F
➤ Added SEL ICD File Versions.
➤ Revised tables F.7: Metering and Measurement Logical Nodes, F.8: Thermal Metering Data Logical Node Class Definition, and F.9: Demand Metering Statistics Logical Node Class Definition.
➤ Added Table F.10: Circuit Breaker Supervision (Per-Phase) Logical Node Class Definition.
➤ Revised tables F.11: Compatible Logical Nodes With Extensions, F.12: Measurement Logical Node Class Definition, F.13: Measurement Logical Node Class Definition, F.14: Metering Statistics Logical Node Class Definition, and F.15:Circuit Breaker Logical Node Class Definition.
Appendix J
➤ Corrected Relay Word bit definitions for 50N1 and 50N2 elements.</td></tr>
</table>

Table A.10 Instruction Manual Revision History (Sheet 15 of 16)

Date Code	Summary of Revisions
20120903	Preface ➤ Updated product label example in *Product Labels*. Section 1 ➤ Updated *Specifications*.
20111130	Section 1 ➤ Corrected *Compression Plug Mounting Ear Screw Tightening Torque* maximum to 0.25 Nm in *Specifications*. Appendix A ➤ Updated for firmware revision R105. Appendix B ➤ Added recommendation to save all data, including events, before firmware upgrade.
20111007	Preface ➤ Updated compliance label paragraph. Section 1 ➤ Updated for the new setting EXT3V0_X and 67N elements. ➤ Added SNTP protocol to the list of protocols. ➤ In *Specifications* revised the *Low Voltage Supply* range and the *Control Inputs* voltage ranges. Section 2 ➤ Updated *Figure 2.15: Voltage Connections* to show connections for 3V0 input channel. ➤ Added *Figure 2.24: SEL-700G1+ Relay AC Connection Example, Multiple High-Impedance Grounded Generators Connected Directly to a Common Bus, With 67N and Other Protection* and text for SEL-700G1+ application using 67N element. Section 4 ➤ Updated for new configuration setting EXT3V0_X for external 3V0 input. ➤ Revised zero-sequence voltage-polarized directional for residual-ground overcurrent elements to also accept external 3V0 for polarization. ➤ Added zero-sequence voltage-polarized directional for neutral-ground overcurrent elements (67N). ➤ Added Time and Date management and SNTP protocol settings and descriptions. ➤ Updated over- and undervoltage diagrams. ➤ Revised 64G to operate with external 3V0. ➤ Revised REF with REF52BYP setting. Section 5 ➤ Added paragraph on small signal cutoff limits for MET and MET RMS values. ➤ Added note to MET response regarding delta connected CTs and its impact on metered values. Section 6 ➤ Updated for settings changes discussed in Section 4. Section 7 ➤ Added SNTP protocol description. Section 9 ➤ Added a note for the impact of delta-connected CTs on event report current quantities. Section 10 ➤ Revised self-tests write-up to reflect automatic restarts for certain failures. Appendix A ➤ Updated for firmware revision R104. Appendix E ➤ Added *08h Loopback Diagnostic Command* description.

Table A.10 Instruction Manual Revision History (Sheet 16 of 16)

Date Code	Summary of Revisions
	Appendix F ➤ Updated time-related conformance statement. Appendix J ➤ Added new relay word bits for SNTP and directional neutral elements.
20110324	Appendix A ➤ Updated for firmware version R103.
20101217	Section 1 ➤ Revised Analog Output (1AO) accuracy specification to < ±1%, full scale, at 25°C in *Specifications*. ➤ Updated Dielectric (HiPot) type tests in *Specifications*.
20101206	Section 1 ➤ Updated Specifications for UL508 certification. Section 2 ➤ Added *Power Supply Card (PSIO/2D/3DO in Slot A)* description and connection diagram. ➤ Updated *Figure 2.22: SEL-700G1+ Relay Typical AC Current and Four-Wire Wye Voltage Connection With MOT SEL-0700G11A2XBA76850231*. Section 4 ➤ Added Generator Differential Protection example. ➤ Corrected graph in *Figure 4.36: Volts/Hertz Inverse-Time Characteristic, 24IC = 2*. ➤ Created separate logic diagram figures for Load Encroachment elements for X-side and Y-side (*Figure 4.81: Load-Encroachment Logic for X Side* and *Figure 4.82: Load-Encroachment Logic for Y Side*). ➤ Updated Analog Output setting example Section 8 ➤ Updated *Table 8.3: Possible Warning Conditions (Flashing TRIP LED)* to include the warning messages. Section 10 ➤ Added more details on set up and testing with Low Level Test Set. ➤ Listed Watch Dog timer self-test in *Table 10.9: Relay Self-Tests*. Appendix A ➤ Updated for firmware version R102.
20100521	➤ Updated for firmware version R101.
20100416	➤ Initial version.

Appendix B
Firmware Upgrade Instructions

Overview

These instructions guide you through the process of upgrading firmware in the device. The firmware upgrade will be either a standard release or a point release. A standard release adds new functionality to the firmware beyond the specifications of the existing version. A point release is reserved for modifying firmware functionality to conform to the specifications of the existing version.

A standard release is identified by a change in the R-number of the device firmware identification (FID) string.

Existing firmware:

FID=SEL-700G-**R100**-V0-Z001001-D*xxxxxxxx*

Standard release firmware:

FID=SEL-700G-**R101**-V0-Z001001-D*xxxxxxxx*

A point release is identified by a change in the V-number of the device FID string.

Existing firmware:

FID=SEL-700G-R100-**V0**-Z001001-D*xxxxxxxx*

Standard release firmware:

FID=SEL-700G-R100-V1-Z001001-D*xxxxxxxx*

SEL occasionally offers firmware upgrades to improve the performance of your relay. Because SEL-700G relays store firmware in flash memory, changing physical components is unnecessary. Upgrade the relay firmware by downloading a file from a personal computer to the relay via the Ethernet port using the web server, FTP, or Telnet. You can also use the front-panel serial port using ACSELERATOR QuickSet SEL-5030 Software or a terminal emulator, as outlined in the following sections. For relays with the IEC 61850 option, verify the IEC 61850 protocol after the upgrade (see *Protocol Verification for Relays With IEC 61850 Option*).

Table B.1 details the available firmware upgrade methods. Available methods depend on your existing firmware and the firmware version to which you are upgrading.

Table B.1 Firmware Upgrade Methods

Existing Firmware	Upgrade Version	SELBOOT Upgrade Required?	Firmware Upgrade Methods Supported	
			Serial	Ethernet
R1*xx*	R2*xx*	NA	Terminal emulator QuickSet	—
R1*xx* or R2*xx*	R3*xx*	Yes (R600 or higher)	Terminal emulator[a]	—
R3*xx*	R3*xx*[b]	No	Terminal emulator QuickSet	Web server FTP FILE command Terminal emulator

[a] When upgrading from R1xx or R2xx to R3xx, you must first perform the Special Instructions for Upgrading to R300 Series Firmware and then follow the Upgrade the Firmware Using a Terminal Emulator instructions to upgrade your relay firmware.
[b] In firmware versions 302-V0 and higher, the relay firmware retains the Port 1 IP address, subnet mask, and default router settings during a firmware upgrade from any previous R3xx firmware version.

Required Equipment

Gather the following equipment before starting this firmware upgrade:

- PC
- Terminal emulation software that supports Xmodem/CRC or 1k Xmodem/CRC protocol
- Serial communications cable (SEL-C234A or equivalent, or a null-modem cable) or Ethernet cable
- Disk containing the firmware upgrade file (e.g., r*xxx*-v*x*700G.s19, r*xxx*-v*x*700G.z19, or r*xxx*-v*x*700G.zds)
- QuickSet software

Digitally Signed Firmware Files

The SEL-700G supports digitally signed firmware files for firmware versions R300 and higher. These firmware files are compressed to reduce file transfer times and are digitally signed by SEL using a secure hash algorithm. The signature ensures that the file has been provided by SEL and that its contents have not been altered. Once the firmware is uploaded to the relay, the signature of the firmware is verified with a public key number that is stored on the relay from the factory. If the relay cannot verify the signature, it rejects the file.

The name of the digitally signed firmware file is of the form r*xxx*-v*x*700G.zds, where r*xxx*-v*x* is the firmware revision number, 700G indicates the relay type, and .zds is the file extension reserved for digitally signed files. Firmware files with the .s19 extension are not available for firmware versions R300 and higher.

Ethernet Firmware Upgrades

NOTE: The relay pulses the SALARM bit and writes an entry to the relay SER log whenever a firmware upgrade is attempted over Ethernet. Monitoring this bit and reviewing the SER log can help identify possible unauthorized firmware upgrade attempts.

You can upgrade firmware over an Ethernet connection by sending the .zds firmware upgrade files via FTP, HTTP, or Telnet protocols to a relay running SELBOOT version R600 or newer and a relay firmware version identified in *Table B.1*. FTP, HTTP, and Telnet are plain text protocols and do not inherently support message encryption (of relay passwords, etc.). Because of this, SEL strongly recommends you use between the relay and your network a security gateway that provides encrypted communications along with SEL SDN technology to harden your network cybersecurity.

Special Instructions for Upgrading to R300 Series Firmware

The SELBOOT firmware in relays shipped with firmware versions earlier than R300 must be upgraded before you can use digitally signed firmware files. The SELBOOT firmware can be upgraded from version R500, R501, or R502 to version R601 by uploading a special SELBOOT Loader firmware to the relay.

The following instructions assume you have a working knowledge of your PC terminal emulation software.

NOTE: Make sure that the relay and SELBOOT firmware revisions are compatible. Refer to Appendix A: Firmware, ICD, and Manual Versions in this manual. If needed, upgrade the SELBOOT firmware prior to upgrading the relay firmware.

NOTE: To save the calibration settings, perform **SHO C** from the terminal by logging into Access Level C using the Access Level C password. The factory-default password for Access Level C is CLARKE.

NOTE: When you are upgrading an SEL-700G with a touchscreen front-panel display, save all of the relay settings, including the touchscreen settings, using QuickSet.

NOTE: Change the data rate of the relay serial port to 9600 bps before issuing the **L_D** command to start the upgrade process.

Step 1. If the relay is in service, open the relay control circuits.

Step 2. Connect the PC to the front-panel serial port and enter Access Level 2.

Step 3. Save the present relay settings.

You can use the PC software (see *Section 3: PC Interface*) to save and restore settings, or you can use the following steps:

a. Issue the following commands at the ASCII prompt: **SHO**, **SHO L**, **SHO G**, **SHO P**, **SHO F**, **SHO R**, **SHO C**, etc.

b. Record all the settings for possible reentry after the firmware upgrade.

We recommend that you save all stored data in the relay, including events, before the upgrade.

Step 4. Change the data rate of the communications software to 9600 bps and press **<Enter>**.

Step 5. Download the SELBOOT Loader firmware to the relay.

a. Issue the **L_D** command.

b. Type **Y <Enter>** at the following prompt:

```
Disable relay to receive firmware (Y/N)?
```

c. Type **Y <Enter>** at the following prompt:

```
Are you sure (Y,N)?
```

The relay sends the `!>` prompt.

Step 6. Issue the **REC** command to receive the new firmware.

Step 7. Type **Y** to confirm that the existing SELBOOT and relay firmwares can be erased.

Step 8. Press any key (e.g., **<Enter>**) when the relay sends a prompt.

Step 9. Use the Xmodem protocol to send the special SELBOOT Loader firmware (e.g., slbtldr_r6017*xx*.s19) to the relay. The special SELBOOT Loader firmware erases the existing SELBOOT and relay firmwares and loads SELBOOT firmware version SLBT7XX-R601-V0-Z000000-D20211116.

The file transfer typically takes less than 5 minutes at 9600 bps, depending on the product. After the transfer is complete, the relay reboots and displays the SELBOOT `!>` prompt. After the SELBOOT upgrade is complete, upgrade your relay firmware using a terminal emulator. You do not need to save the relay settings and other data again during the firmware upgrade process if you saved them before upgrading SELBOOT. Proceed to *Step 5* in *Upgrade the Firmware Using a Terminal Emulator*.

Figure B.1 shows the entire special SELBOOT upgrade process.

```
=>>L_D <Enter>
Disable relay to receive firmware (Y,N)? Y <Enter>
Are you sure (Y,N)? Y <Enter>
Relay Disabled


BFID=BOOTLDR-R501-V0-Z000000-D20140224
!>REC <Enter>
This command uploads new firmware.
When new firmware is uploaded successfully, IED will erase old firmware,
load new firmware and reboot.

Are you sure you want to erase the existing firmware(Y,N)? Y <Enter>
Press any key to begin transfer and then start transfer at the terminal.
Erasing firmware.
Erase successful.
Writing new firmware.
Upload completed successfully. Attempting a restart.

Upgrading SELBoot


 Preparing S Record...

 Validating S Record...


* * * * * * * * * W A R N I N G * * * * * * * * *

 Do not turn off or cycle power to the relay or it may
 become inoperative and require factory repair !!!

  Performing this operation will require firmware
      to be downloaded to relay after reboot.

 * * * * * * * * * * * * * * * * * * * * * * * * *

 Removing Old SELBoot...

 Writing New SELBoot...

 Removing SELBoot Loader

 SELBoot Loader cleared... Resetting Relay!!!


BFID=SLBT7XX-R601-V0-Z000000-D20211116
!>
```

Figure B.1 Special SELBOOT Upgrade Process

Upgrade the SELBOOT Firmware Loader Using a Terminal Emulator

The process for upgrading SELBOOT is similar to *Upgrade the Firmware Using a Terminal Emulator on page B.6*. To determine if SELBOOT must be updated, do the following:

NOTE: Make sure the relay and SELBOOT firmware revisions are compatible. Refer to Appendix A: Firmware, ICD, and Manual Versions in this manual. If needed, upgrade the SELBOOT firmware prior to upgrading the relay firmware.

Step 1. Establish communication between the relay and a personal computer.

Step 2. From the computer, type **ID <Enter>**.

The relay responds with the following:

```
=ID <Enter>

"FID=SEL-700G-R301-V4-Z007004-D20220225","08EB"
"BFID=SLBT7XX-R601-V0-Z000000-D20211116","094D"
"CID=0D77","025F"
"DEVID=SEL-700G","0408"
"DEVCODE=74","0312"
"PARTNO=0700G01B0X0X0X85027X","0728"
"CONFIG=111122010","041C"
"SPECIAL=0","02DE"
"iedName=SEL_700G_2","0612"
"type=SEL_700G","0490"
"configVersion=ICD-700G-R302-V0-Z301006-D20210723","0D5E"
"LIB61850ID=39236F6A","04D9"
```

Step 3. Locate the Boot Firmware Identifier String (BFID).

Step 4. Find the SELBOOT revision number in the BFID (R*xxx*). If the revision number is lower than the one you see on the firmware CD, follow the process mentioned below. Otherwise, upgrade the relay firmware using one of the methods mentioned later in the section.

Step 5. To upgrade SELBOOT, locate the new SELBOOT file (r*xxx*7*xx*.zds) on the desk provided with the firmware upgrade materials. Follow the instructions under *Upgrade the Firmware Using a Terminal Emulator*. In *Step 6*, replace the **REC** command with **REC BOOT** and follow the prompts.

Step 6. When the relay prompts: `Press any key to begin transfer and then start transfer at the terminal`, press **<Enter>** and select the SELBOOT file.

Step 7. When the SELBOOT upgrade is successful, the relay prompts:

`Erasing SELboot. Writing SELboot.`

`SELboot upload completed successfully. Restarting SELboot.`

Change the data rate of the communications software to 9600 bps and press **<Enter>**.

Step 8. Type **EXI <Enter>** at the SELBOOT `!>` prompt to exit SELBOOT. The relay should display the = prompt.

If the relay does not return the SELBOOT `!>` prompt within two minutes after displaying `Restarting SELboot`, cycle the relay power. The relay should restart and display the = prompt.

Once the SELBOOT upgrade is complete, select a firmware upgrade method as discussed later in the section. It is not necessary to save the relay settings and other data again if you did this before upgrading SELBOOT.

Upgrade the Firmware Using a Terminal Emulator

NOTE: To save the calibration settings, perform **SHO C** from the terminal by logging into Access Level C using the Access Level C password. The factory-default password for Access Level C is CLARKE.

NOTE: When you are upgrading an SEL-700G with a touchscreen front-panel display, save all of the relay settings, including the touchscreen settings, using QuickSet.

NOTE: Make sure that the relay and SELBOOT firmware revisions are compatible. Refer to Appendix A: Firmware, ICD, and Manual Versions in this manual. If needed, upgrade the SELBOOT firmware prior to upgrading the relay firmware.

NOTE: Change the data rate of the relay serial port to 9600 bps before issuing the **L_D** command to start the upgrade process.

NOTE: If you have difficulty at 115200 bps, choose a slower data transfer rate (e.g., 38400 bps or 57600 bps). Be sure to match the relay and PC data rates.

The following instructions assume you have a working knowledge of your PC terminal emulation software.

Step 1. If the relay is in service, open the relay control circuits.

Step 2. Connect the PC to the front-panel serial or Ethernet port and enter Access Level 2.

Step 3. Save the present relay settings.

You can use the PC software (see *Section 3: PC Interface*) to save and restore settings, or you can use the following steps:

a. Issue the following commands at the ASCII prompt: **SHO**, **SHO L**, **SHO G**, **SHO P**, **SHO F**, **SHO R**, **SHO C**, etc.

b. Record all the settings for possible re-entry after the firmware upgrade.

We recommend that you save all stored data in the relay, including events, before the upgrade.

Step 4. Start upgrading the firmware.

a. Issue the **L_D** command.

b. Type **Y <Enter>** at the following prompt:

```
Disable relay to receive firmware (Y/N)?
```

c. Type **Y <Enter>** at the following prompt:

```
Are you sure (Y,N)?
```

The relay sends the `!>` prompt.

If you are using an Ethernet port, proceed to *Step 6*.

Step 5. Change the data rate, if necessary.

a. Type **BAU 115200 <Enter>**.

This changes the data rate of the communications port to 115200 bps.

b. Change the data rate of the PC to 115200 bps to match the relay.

Step 6. Issue the **REC** command to receive the new firmware.

Step 7. Type **Y** to confirm that the existing firmware can be erased.

Step 8. Press any key (e.g., **<Enter>**) when the relay sends a prompt.

Step 9. Start the file transfer.

Use the Xmodem protocol to send the file that contains the new firmware (e.g., r*xxx*-v*x*700G.s19, r*xxx*-v*x*700G.z19, or r*xxx*-v*x*700G.zds).

Firmware files for firmware versions R1xx and R2xx have a .s19 or .z19 extension. Firmware files for firmware versions R300 and higher have a. zds extension. Firmware files with the .s19 or .z19 extension are not available for firmware versions R300 and higher.

The file transfer typically takes less than 15 minutes at 115200 bps, depending on the product. After the transfer is complete, the relay reboots and returns to Access Level 0.

Figure B.2 shows the entire upgrade process.

```
=>>L_D <Enter>

Disable relay to receive firmware (Y,N)? Y <Enter>
Are you sure (Y,N)? Y <Enter>
Relay Disabled

BFID=SLBT7XX-R600-V0-Z000000-D20200331
!>BAU 115200 <Enter>
!>REC <Enter>
This command uploads new firmware.
When new firmware is uploaded successfully, IED will erase old firmware,
load new firmware and reboot.

Are you sure you want to erase the existing firmware(Y,N)? Y <Enter>
Press any key to begin transfer and then start transfer at the terminal. <Enter>
Erasing firmware.
Erase successful.
Writing new firmware.
Upload completed successfully. Attempting a restart.
```

Figure B.2 Firmware File Transfer Process

Step 10. The relay front-panel **ENABLED** LED illuminates if the relay settings are retained through the download.

If the **ENABLED** LED is illuminated, proceed to *Step 11*.

If the **ENABLED** LED is not illuminated or the front panel displays `STATUS FAIL Non_Vol Failure`, use the following procedure to restore the factory-default settings:

a. Set the communications software settings to 9600 bps, 8 data bits, and 1 stop bit.

b. Enter Access Level 2 by issuing the **2AC** command.

c. Issue the **R_S** command to restore the factory-default settings.

The relay then reboots with the factory-default settings.

d. Enter Access Level 2.

e. Issue the **STATUS** command.

If the relay is enabled, go to *Step f*.

If the STATUS report shows option card `FAIL` and `Relay Disabled` and the message:

`Confirm Hardware Config`

`Accept & Reboot (Y/N)?`

Enter **Y**. This saves the relay calibration settings.

The relay responds:

`Config Accepted`

The relay reboots and comes up enabled.

f. Restore relay settings back to the settings saved in *Step 3*.

Step 11. Change the data rate of the PC to match that of the relay prior to *Step 6*, and enter Access Level 2.

Step 12. Issue the **STATUS** command; verify all relay self-test results are OK.

Step 13. Apply current and voltage signals to the relay.

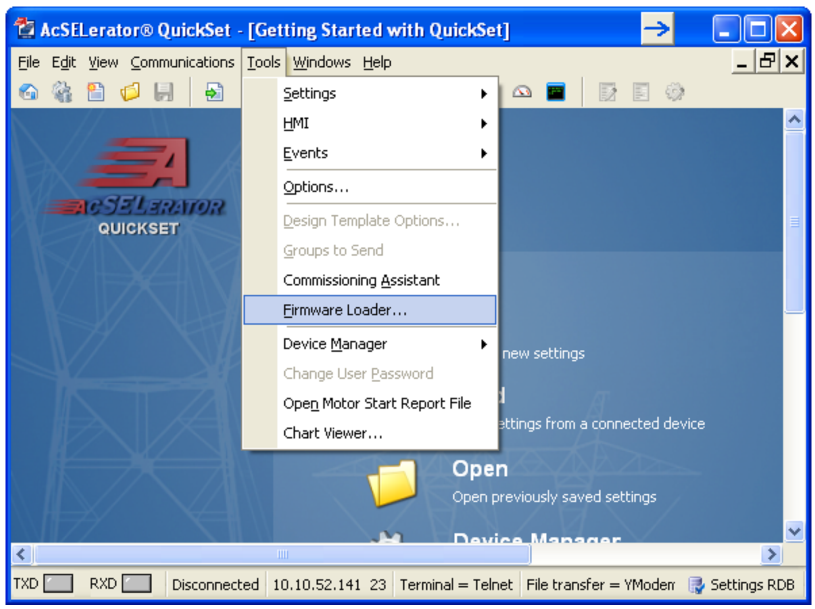
Step 14. Issue the **METER** command; verify that the current and voltage signals are correct.

Step 15. Autoconfigure the SEL communications processor port if you have a communications processor connected.

This step re-establishes automatic data collection between the SEL communications processor and the SEL relay. Failure to perform this step can result in automatic data collection failure when cycling communications processor power.

Upgrade the Firmware Using QuickSet

Select **Tools** > **Firmware Loader** from the QuickSet menu bar to launch a wizard that walks you through the steps to load firmware into your SEL device. Refer to *Section 3: PC Interface* for setup and connection procedures for QuickSet.



NOTE: The firmware loader is not supported on Ethernet port connections.

NOTE: In instances where SELBOOT needs to be upgraded, QuickSet cannot be used to upgrade the relay firmware. Use a terminal emulator to upgrade SELBOOT and then upgrade the relay firmware.

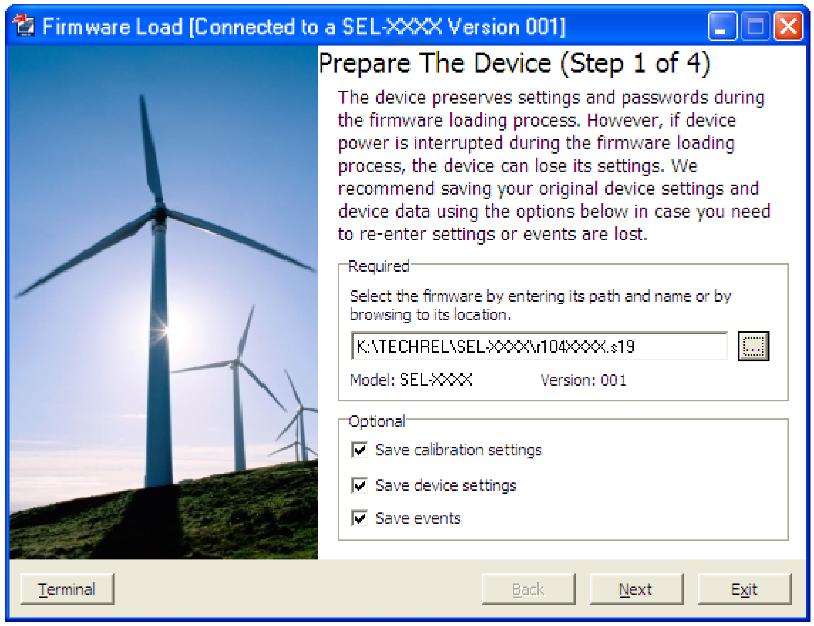
Firmware Loader does not start if:

- ➤ The device is unsupported by QuickSet.
- ➤ The device is not connected to the computer with a communications cable.
- ➤ The device is disabled.

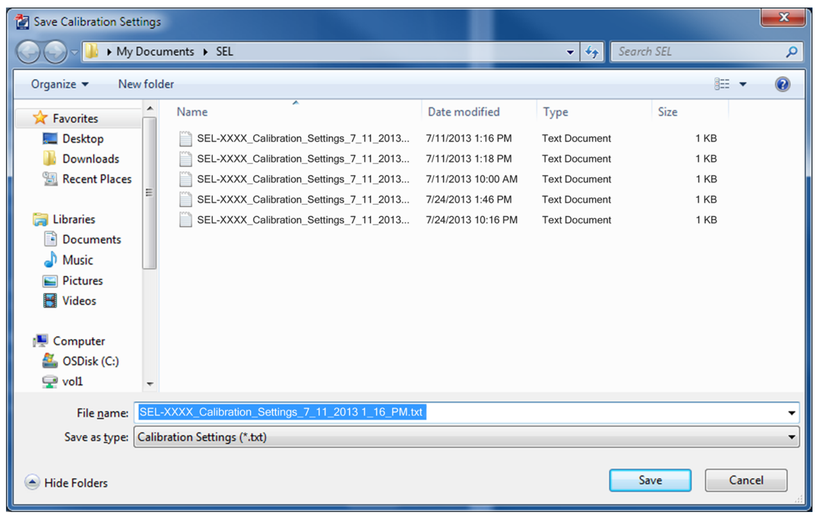
Step 1. If the relay is in service, open the relay control circuits.

Step 2. Prepare the device.

a. Select the firmware to be loaded using the browse control and select **Save calibration settings**, **Save device settings**, and **Save events**. Select **Next** to continue the wizard.

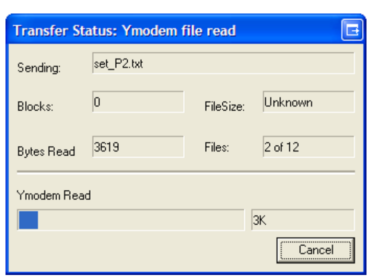


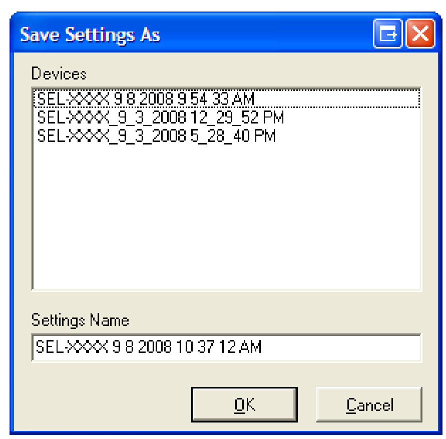
b. Select a file name to save the selected settings or accept the defaults as shown. Click **Save**.



c. The **Transfer Status: Ymodem file read** window shows the transfer progress of the settings file.

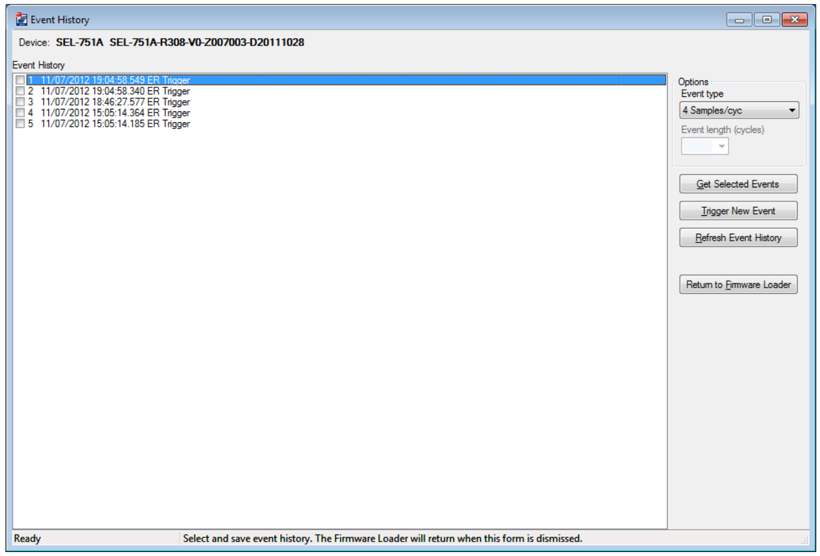
After the device settings are downloaded, select a file name and path to save the settings or accept the default, as shown.





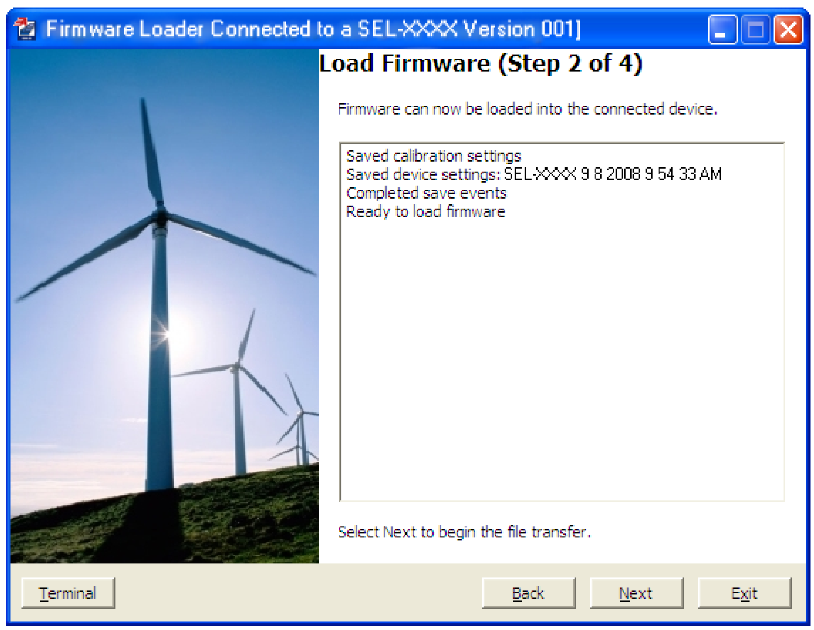
d. Click **Return to Firmware Loader** if this device does not have any event reports.

If there are any event reports to be saved, select the events and click **Get Selected Events**. After saving them, click **Return to Firmware Loader**..



Step 3. Transfer firmware.

Click **Next** to begin the firmware transfer.

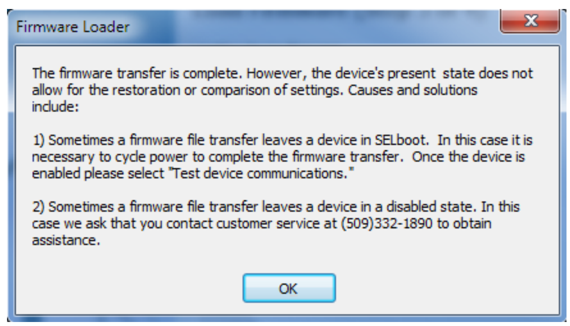


Step 4. Load firmware.

During this step, the device is put in SELBOOT mode. The transfer speed is maximized and the firmware transfer begins.

Step 5. Click **Next** to complete the firmware upgrade

NOTE: The following screen can appear if you have one of the two conditions mentioned.



If the relay is disabled as a result of a settings mismatch between a previous firmware version and a new firmware version, check the **ENABLED** LED on the front panel of the relay. If the **ENABLED** LED is not illuminated or the front panel displays `STATUS FAIL Non_Vol Failure` on the two-line display model, or a settings mismatch notification screen on the touchscreen model, use the following procedure to restore the factory-default settings:

a. Click on the Terminal button on the Firmware Load screen of QuickSet.

b. Set the communications software settings to 9600 bps, 8 data bits, and 1 stop bit.

c. Enter Access Level 2 by issuing the **2AC** command.

d. Issue the **R_S** command to restore the factory-default settings.

The relay reboots and comes up enabled.

Note that the port settings will be restored to the default settings due to the **R_S** command.

If the relay is still disabled, use the following procedure:

e. Enter Access Level 2.

f. Issue the **STATUS** command.

If the STATUS report shows option card `FAIL` and `Relay Disabled` and the message:

```
Confirm Hardware Config
Accept & Reboot (Y/N)?
```

Enter **Y**.

This saves the relay calibration settings. The relay responds:

```
Config Accepted
```

The relay reboots and comes up enabled.

Step 6. Verify device settings.

Select from four verification options, which perform as follows.

Test Device Communications. If the device cannot be restarted, then turn power off and back on to restart it. Once the device is enabled, this option reconnects and reinitializes the device.

Compare Device Settings. This option verifies settings by reading them from the device and comparing them with settings saved to the database.

Restore Device Settings. This option restores settings by writing settings that are saved in the database to the device. Settings are converted automatically, if necessary.

Load Firmware into Another Device. Returns the wizard to *Step 2*: *Prepare Device* to repeat the firmware-loading process with another device.

Upgrade the Firmware Using the Web Server

NOTE: The relay pulses the SALARM bit and writes an entry to the relay SER log whenever a firmware upgrade is attempted over Ethernet. Monitoring this bit and reviewing the SER log can help identify possible unauthorized firmware upgrade attempts.

The web server offers a convenient method for upgrading the relay firmware. Located on the left navigation pane of the screen, the System menu contains the File Management category that allows you to upgrade firmware in the relay. To upgrade the firmware using the web server, the firmware in your relay must be R300 or higher. The firmware is designated with a .zds extension. Refer to *Section 3: PC Interface* for connecting and logging in to the SEL-700G web server using the Ethernet port.

To upgrade relay firmware by using the web server, set the Port 1 settings HTTPACC := 2 and EETHFWU := Y. The web server login page provides Access Level 2 as a user-selectable login access level. If EETHFWU is set to N, you cannot upgrade the firmware over Ethernet regardless of the HTTPACC setting.

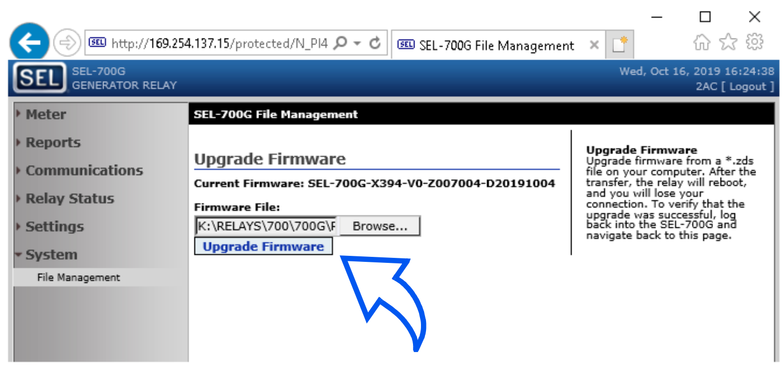
Step 1. In QuickSet, save the current relay settings and other data.

Step 2. Proceed with the firmware upgrade process by performing the following steps:

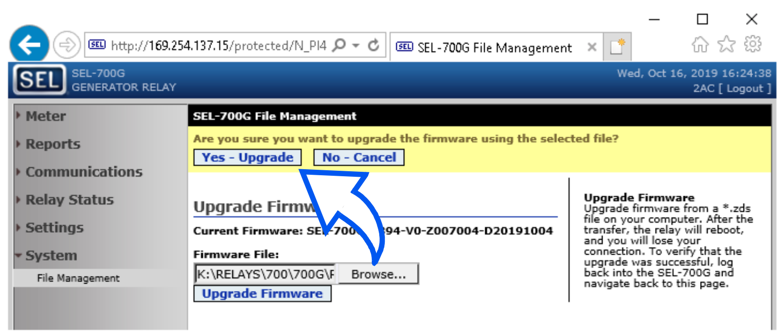
a. Click **System > File Management** from the left navigation pane of the webpage.

b. Click **Browse** to select the firmware you want to send to the relay.

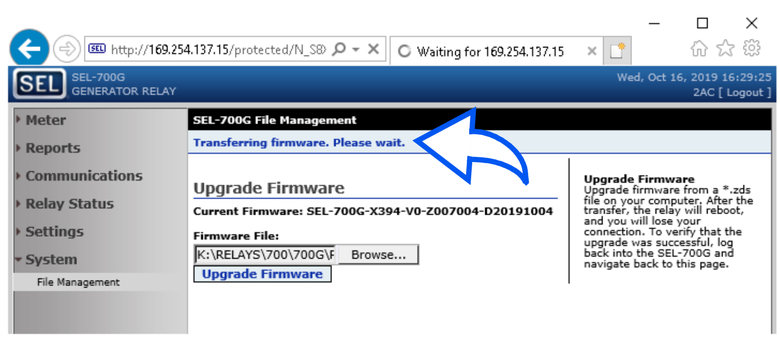
c. Click **Upgrade Firmware** to start the upgrade process.



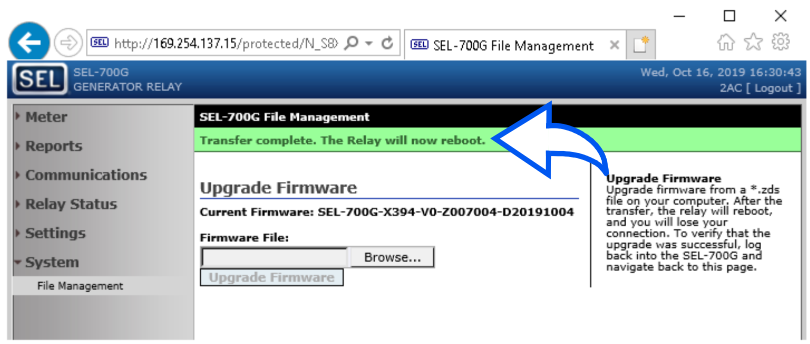
Step 3. Click **Yes - Upgrade** if you want to upgrade using the file selected.



Once the upgrade process is in progress, the relay acknowledges the transfer with the message, **Transferring firmware. Please wait**.



After the relay finishes the firmware transfer, an acknowledgment message appears and the relay reboots.



NOTE: After the relay reboots, if the **ENABLED** LED is not illuminated or if the front panel displays STATUS FAIL Non_Vol Failure on the two-line display model, or a settings mismatch notification screen on the touchscreen model, then open a terminal emulator using the serial port and use the following procedure to restore the factory-default settings. Refer to Upgrade the Firmware Using a Terminal Emulator for terminal emulator setup and connections.

a. Set the communications software settings to 9600 bps, 8 data bits, and 1 stop bit.

b. Enter Access Level 2 by issuing the **2AC** command.

c. Issue the **R_S** command to restore the factory default.

The relay reboots and comes up enabled.

Note that the port settings will be restored to the factory-default settings due to the **R_S** command.

If the relay is still disabled, use the following procedure:

d. Enter Access Level 2.

e. Issue the **STATUS** command.

If the STATUS report shows option card `FAIL` and `Relay Disabled` and the message:

```
Confirm Hardware Config
Accept & Reboot (Y/N)?
```

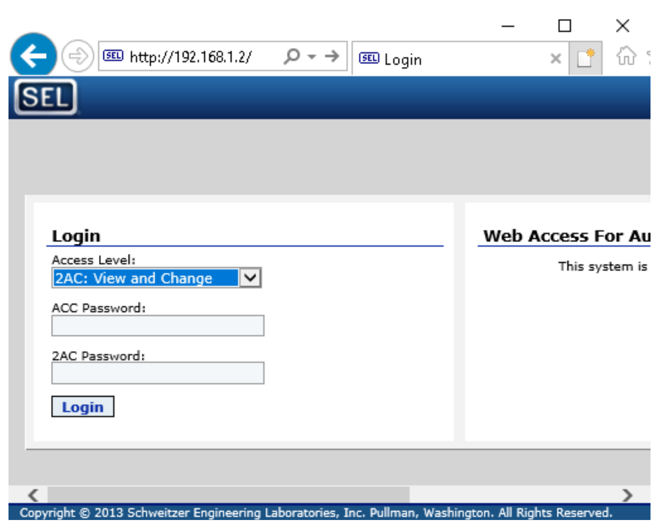
Enter **Y**.

This saves the relay calibration settings. The relay responds:

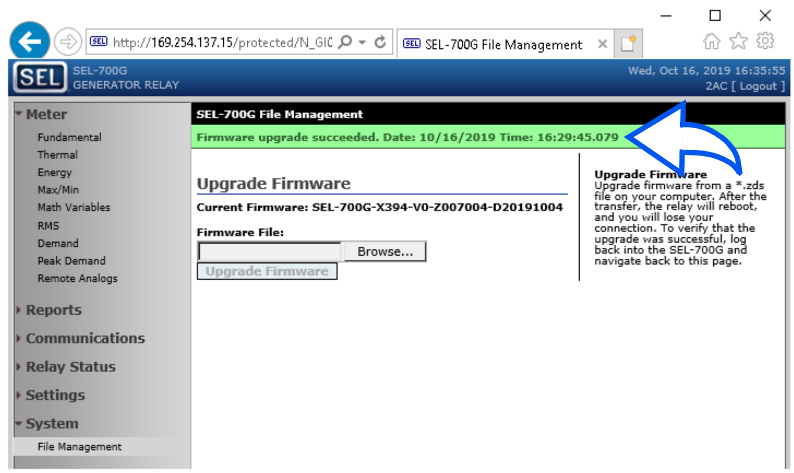
```
Config accepted
```

The relay reboots and comes up enabled.

Step 4. After the relay reboots, the Login screen appears on the web server. Log in to the relay to verify completion of the firmware upgrade process.



An acknowledgment message appears that verifies a successful firmware upgrade.



Step 5. Check that the relay firmware version matches the version that was used for the upgrade and that the relay is enabled.

Click on **Relay Status** > **Self-Tests** to view the status report.

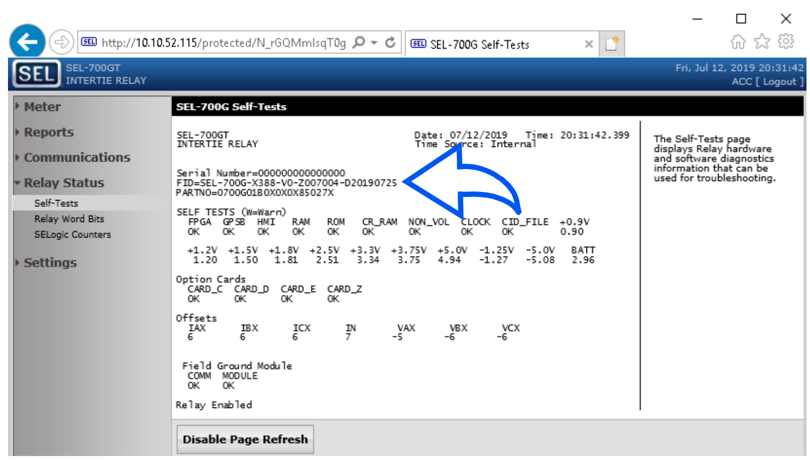


Table B.2 provides messages displayed in the web browser and the relay condition associated with those messages.

Table B.2 Messages Displayed in the Web Browser

User Message	Relay Condition
Firmware upgrade succeeded.	The previous firmware upgrade with a .zds file was successful.
Invalid upgrade file.	The .zds file was not successfully received or validated by the relay.
Upgrade in progress on another interface.	A firmware upgrade is currently being performed through another connection.
Errors during Upgrade File Transfer.	Upgrade failed due to errors during file transfer.

Upgrade the Firmware Using File Transfer Protocol

NOTE: Make sure that the relay and SELBOOT firmware revisions are compatible. Refer to Appendix A: Firmware, ICD, and Manual Versions in this manual. If needed, upgrade the SELBOOT firmware prior to upgrading the relay firmware.

NOTE: The relay pulses the SALARM bit and writes an entry to the relay SER log whenever a firmware upgrade is attempted over Ethernet. Monitoring this bit and reviewing the SER log can help identify possible unauthorized firmware upgrade attempts.

To upgrade firmware using File Transfer Protocol (FTP), the firmware in your relay must be R300 or higher. The firmware is designated with a .zds extension.

To upgrade relay firmware by using FTP, the Port 1 setting FTPACC must be set to 2 or C and EETHFWU must be set to Y. If EETHFWU is set to N, upgrading firmware over an Ethernet connection is disabled regardless of the FTPACC setting.

The following instructions assume you have a working knowledge of the Windows command prompt.

Step 1. If the relay is in service, open the relay control circuits.

Step 2. Connect the PC to the Ethernet port and enter Access Level 2.

Step 3. Save the present relay settings.

You can use the PC software (see *Section 3: PC Interface*) to save and restore settings, or you can use the following steps:

a. Issue the following commands at the ASCII prompt: **SHO**, **SHO L**, **SHO G**, **SHO P**, **SHO F**, **SHO R**, **SHO C**, etc.

b. Record all the settings for possible re-entry after the firmware upgrade.

NOTE: To save the calibration settings, perform **SHO C** from the terminal by logging into Access Level C using the Access Level C password. The factory-default password for Access Level C is CLARKE.

We recommend that you save all stored data in the relay, including events, before the upgrade.

NOTE: When you are upgrading an SEL-700G with a touchscreen front-panel display, save all of the relay settings, including the touchscreen settings, using QuickSet.

NOTE: File name RELAY.zds is not case sensitive.

Step 4. Rename the r*xxx*-v*x*700G.zds file as RELAY.zds.

Step 5. Create an FTP session to connect to the relay using the relay IP address.

Step 6. Enter your FTP username and password.

Step 7. Issue the **CD UPGRADE** command to switch the present relay directory to the UPGRADE directory.

Step 8. Issue the **PUT RELAY.ZDS** command to place the RELAY.zds file in the UPGRADE directory and to send the file to the relay.

When the download is complete, the relay reboots and comes up enabled. During this upgrade process, you will lose the FTP connection, and you must re-establish the FTP connection after the upgrade is complete. Then, navigate to the relay UPGRADE directory, read the error file ERR.TXT and review for any error messages. If the firmware upgraded properly, no errors occurred during the upgrade process and the file is empty. If messages are contained within the file, see *Table B.2* for the error message and what the error means.

Figure B.3 shows the entire upgrade process via Windows command prompt.

```
Microsoft Windows [Version 10.0.17763.805]
(c) 2018 Microsoft Corporation. All rights reserved.

Y:\>FTP 10.39.94.180 <Enter>
Connected to 10.39.94.180.
220 FTP SERVER
550 NOOP requested action not taken.
User (10.39.94.180:(none)): xxxxxx <Enter>
331 User name okay, need password.
Password: xxxxxx <Enter>
230 User logged in, proceed.
ftp> CD UPGRADE <Enter>
250 CWD  requested file action okay, completed.
ftp> PUT RELAY.ZDS <Enter>
200 PORT Command okay.
150 File status okay; about to open data connection.
Connection closed by remote host.
ftp>
```

Figure B.3 Firmware Upgrade Via FTP

Upgrade the Firmware Via Terminal Emulator Using the FILE Command Over Telnet

NOTE: Make sure that the relay and SELBOOT firmware revisions are compatible. Refer to Appendix A: Firmware, ICD, and Manual Versions in this manual. If needed, upgrade the SELBOOT firmware prior to upgrading the relay firmware.

NOTE: The relay pulses the SALARM bit and writes an entry to the relay SER log whenever a firmware upgrade is attempted over Ethernet. Monitoring this bit and reviewing the SER log can help identify possible unauthorized firmware upgrade attempts.

To upgrade firmware using the **FILE** command over Ethernet, the firmware in your relay must be R300 or higher. The firmware is designated with a .zds extension.

To upgrade relay firmware by using the **FILE** Command over Ethernet, the Port 1 setting MAXACC must be set to 2 or C and EETHFWU must be set to Y. If EETHFWU is set to N, upgrading firmware over an Ethernet connection is disabled regardless of the MAXACC setting.

The following procedure assumes that you have a working knowledge of the software being used to upgrade the firmware via **FILE** command.

Step 1. If the relay is in service, open the relay control circuits.

Step 2. Connect the PC to the Ethernet port and enter Access Level 2.

Step 3. Save the present relay settings.

You can use the PC software (see *Section 3: PC Interface*) to save and restore settings, or you can use the following steps:

a. Issue the following commands at the ASCII prompt: **SHO**, **SHO L**, **SHO G**, **SHO P**, **SHO F**, **SHO R**, **SHO C**, etc.

b. Record all the settings for possible re-entry after the firmware upgrade.

We recommend that you save all stored data in the relay, including events, before the upgrade.

NOTE: To save the calibration settings, perform **SHO C** from the terminal by logging into Access Level C using the Access Level C password. The factory-default password for Access Level C is CLARKE.

NOTE: When you are upgrading an SEL-700G with a touchscreen front-panel display, save all of the relay settings, including the touchscreen settings, using QuickSet.

NOTE: File name RELAY.zds is not case sensitive.

Step 4. Rename the r*xxx*-v*x*700G.zds file as RELAY.zds.

Step 5. Save the RELAY.zds file to a directory.

Step 6. Update the active directory to be the directory where the RELAY.zds file is saved.

Step 7. Issue the **FILE WRITE RELAY.ZDS** command to the relay.

Step 8. Send the RELAY.zds file to the relay via Ymodem transfer.

When the upgrade is complete, the relay reboots and comes up enabled.

During this upgrade process, you will lose the Telnet connection, and you must re-establish the Telnet connection after the upgrade is complete. Then, navigate to the relay UPGRADE directory, read the error file ERR.TXT and review for any error messages. If the firmware upgraded properly, no errors occurred during the upgrade process and the file is empty. If messages are contained within the file, see *Table B.2* for the error message and what the error means.

Protocol Verification for Relays With IEC 61850 Option

NOTE: A relay with optional IEC 61850 protocol requires the presence of one valid CID file to enable the protocol. Only transfer a CID file to the relay if you want to implement a change in the IEC 61850 configuration or if new relay firmware does not support the current CID file version. If you transfer an invalid CID file, the relay disables the IEC 61850 protocol, because it no longer has a valid configuration. To restart IEC 61850 protocol operation, you must transfer a valid CID file to the relay.

Perform the following steps to verify that the IEC 61850 protocol is still operational after a relay firmware upgrade and, if not, re-enable it. This procedure assumes that IEC 61850 was operational with a valid CID file immediately before initiating the relay firmware upgrade.

Step 1. Establish an FTP connection to the relay Ethernet port.

Step 2. Open the ERR.TXT file.

If the ERR.TXT file is empty, the relay found no errors during CID file processing and IEC 61850 should be enabled. Go to *Step 3* if ERR.TXT is empty.

If the ERR.TXT file contains error messages relating to CID file parsing, the relay has disabled the IEC 61850 protocol. Use ACSELERATOR Architect SEL-5032 Software to convert the existing CID file and make it compatible again.

a. Install the Architect software upgrade that supports your required CID file version.

b. Run Architect and open the project that contains the existing CID file for the relay.

c. Download the CID file to the relay.

Step 3. Upon connecting to the relay, Architect detects the upgraded relay firmware and prompts you to allow it to convert the existing CID file to a supported version. Once converted, downloaded, and processed, the valid CID file allows the relay to re-enable the IEC 61850 protocol.

Step 4. In the Telnet session, type **GOO <Enter>**.

Step 5. View the GOOSE status and verify that the transmitted and received messages are as expected.

The relay is now ready for your commissioning procedure.

Technical Support

We appreciate your interest in SEL products and services. If you have questions or comments, please contact us at:

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2350 NE Hopkins Court
Pullman, WA 99163-5603 U.S.A.
Tel: +1.509.338.3838
Fax: +1.509.332.7990
Internet: selinc.com/support
Email: info@selinc.com

Appendix C
SEL Communications Processors

SEL Communications Protocols

The SEL-700G Relay supports the SEL protocols and command sets shown in *Table C.1*.

Table C.1 Supported Serial Command Sets

Command Set	Description
SEL ASCII	Use this protocol to send ASCII commands and receive ASCII responses that are human readable with an appropriate terminal emulation program.
SEL Compressed ASCII	Use this protocol to send ASCII commands and receive Compressed ASCII responses that are comma-delimited for use with spreadsheet and database programs or for use by intelligent electronic devices.
SEL Fast Meter	Use this protocol to send binary commands and receive binary meter and target responses.
SEL Fast Operate	Use this protocol to receive binary control commands.
SEL Fast SER	Use this protocol to receive binary Sequential Events Recorder unsolicited responses.
SEL Fast Message	Use this protocol to write remote analog data via unsolicited writes.

SEL ASCII Commands

We originally designed SEL ASCII commands for communication between the relay and a human operator via a keyboard and monitor or a printing terminal. A computer with a serial port can also use the SEL ASCII protocol to communicate with the relay, collect data, and issue commands.

SEL Compressed ASCII Commands

The relay supports a subset of SEL ASCII commands identified as Compressed ASCII commands. Each of these commands results in a comma-delimited message that includes a checksum field. Most spreadsheet and database programs can directly import comma-delimited files. Devices with embedded processors connected to the relay can execute software to parse and interpret comma-delimited messages without expending the customizing and maintenance labor necessary to interpret nondelimited messages. The relay calculates a checksum for each line by numerically summing all of the bytes that precede the checksum field in the message. The program that uses the data can detect transmission errors in the message by summing the characters of the received message and comparing this sum to the received checksum.

Most commands are available only in SEL ASCII or Compressed ASCII format. Selected commands have versions in both standard SEL ASCII and Compressed ASCII formats. Compressed ASCII reports generally have fewer characters than conventional SEL ASCII reports because the compressed reports reduce blanks, tabs, and other white space between data fields to a single comma.

Table C.2 lists the Compressed ASCII commands and contents of the command responses.

Table C.2 Compressed ASCII Commands

Command	Response	Access Level
BNAME	ASCII names of Fast Meter status bits	0
CASCII	Configuration data of all Compressed ASCII commands available at access levels > 0	0
CEVENT	Event report	1
CGSR	Generator Synchronism Report	1
CHISTORY	List of events	1
CLDP	Load Profile Data	1
CMETER	Metering data, including fundamental, thermal demand, peak demand, energy, max/min, rms, analog inputs, and math variables	1
CSE	Sequence Of Events Data	1
CSTATUS	Relay status	1
CSUMMARY	Summary of an event report	1
DNAME	ASCII names of digital I/O reported in Fast Meter	0
ID	Relay identification	0
SNS	ASCII names for SER data reported in Fast Meter	0

Interleaved ASCII and Binary Messages

SEL relays have two separate data streams that share the same physical serial port. Human data communications with the relay consist of ASCII character commands and reports that you view through use of a terminal or terminal emulation package. The binary data streams can interrupt the ASCII data stream to obtain information; the ASCII data stream continues after the interruption. This mechanism uses a single communications channel for ASCII communication (transmission of an event report, for example) interleaved with short bursts of binary data to support fast acquisition of metering data. The device connected to the other end of the link requires software that uses the separate data streams to exploit this feature. However, you do not need a device to interleave data streams to use the binary or ASCII commands. Note that XON, XOFF, and CAN operations operate on only the ASCII data stream.

An example of using these interleaved data streams is when the SEL-700G communicates with an SEL communications processor. These SEL communications processors perform autoconfiguration by using a single data stream and SEL Compressed ASCII and binary messages. In subsequent operations, the SEL communications processor uses the binary data stream for Fast Meter and Fast Operate messages to populate a local database and to perform SCADA operations. At the same time, you can use the binary data stream to connect transparently to the SEL-700G and use the ASCII data stream for commands and responses.

SEL Fast Meter, Fast Operate, Fast SER, and Unsolicited Write

SEL Fast Meter is a binary message that you solicit with binary commands. Fast Operate is a binary message for control. The relay can also send unsolicited Fast SER messages automatically and receive unsolicited SEL Fast Messages (used in the SEL-700G for remote analogs). If the relay is connected to an SEL communications processor, these messages provide the mechanism that the communications processor uses for SCADA or DCS functions that occur simultaneously with ASCII interaction.

SEL Communications Processor

NOTE: If the SEL-700G is connected to any SEL communications processor (SEL-203x or RTAC), the corresponding language port settings must be set to English.

SEL offers SEL communications processors, powerful tools for system integration and automation. The SEL-2030 series and the SEL-2020 communications processors are similar, except that the SEL-2030 series has two slots for network protocol cards. The SEL-3530 Real Time Automation Controller (RTAC) has Ethernet ports as well as serial ports to connect to your SEL relay. These devices provide a single point of contact for integration networks with a star topology, as shown in *Figure C.1*.

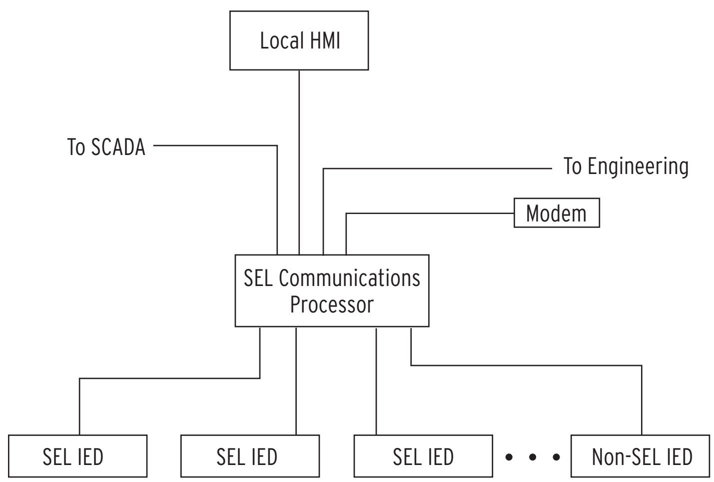


Figure C.1 SEL Communications Processor Star Integration Network

In the star topology network in *Figure C.1* the SEL communications processor offers the following substation integration functions:

- Collection of real-time data from SEL and non-SEL IEDs
- Calculation, concentration, and aggregation of real-time IED data into databases for SCADA, HMI, and other data consumers
- Access to the IEDs for engineering functions including configuration, report data retrieval, and control through local serial, remote dial-in, and Ethernet network connections
- Distribution of IRIG-B time-synchronization signal to IEDs based on external IRIG-B input, internal clock, or protocol interface
- Simultaneous collection of SCADA data and engineering connection to SEL IEDs over a single cable
- Automated dial-out on alarms

The SEL communications processors have 16 serial ports plus a front port. This port configuration does not limit the size of a substation integration project, because you can create a multitiered solution as shown in *Figure C.2*.

In this multitiered system, the lower-tier SEL communications processors forward data to the upper-tier SEL communications processor that serves as the central point of access to substation data and substation IEDs.

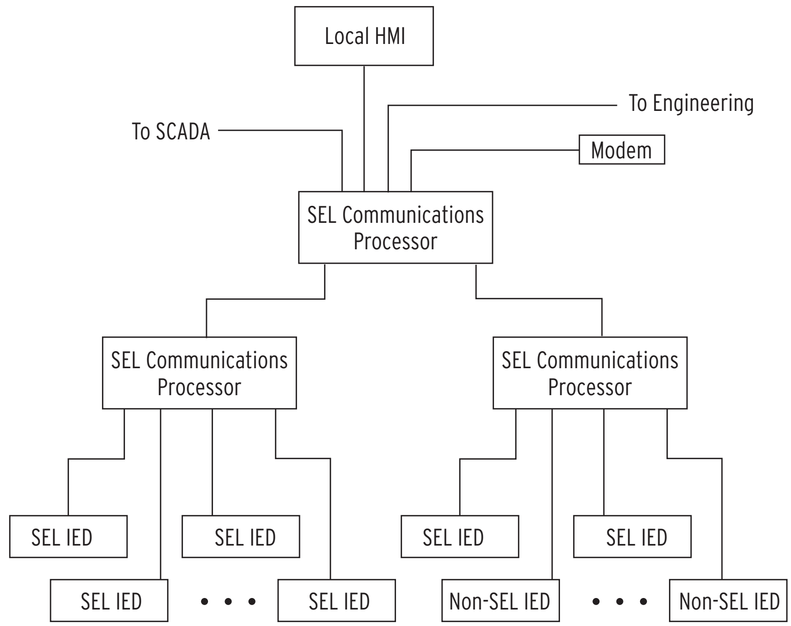


Figure C.2 Multitiered SEL Communications Processor Architecture

You can add additional communications processors to provide redundancy and eliminate possible single points of failure. SEL communications processors provide an integration solution with a reliability comparable to that of SEL relays. In terms of MTBF (mean time between failures), SEL communications processors are 100 to 1000 times more reliable than computer-based and industrial technology-based solutions.

Configuration of an SEL communications processor is different from other general-purpose integration platforms. You can configure SEL communications processors with a system of communication-specific keywords and data movement commands rather than programming in C or another general-purpose computer language. SEL communications processors offer the protocol interfaces listed in *Table C.3*.

Table C.3 SEL Communications Processors Protocol Interfaces (Sheet 1 of 2)

Protocol	Connect to
DNP3 Level 2 Slave	DNP3 masters
Modbus RTU Protocol	Modbus masters
SEL ASCII/Fast Message Slave	SEL protocol masters
SEL ASCII/Fast Message Master	SEL protocol slaves including other communications processors and SEL relays
ASCII and Binary auto messaging	SEL and non-SEL IED master and slave devices
Modbus Plus[a]	Modbus Plus peers with global data and Modbus Plus masters
FTP (File Transfer Protocol)[b]	FTP clients
Telnet[b]	Telnet servers and clients

Table C.3 SEL Communications Processors Protocol Interfaces (Sheet 2 of 2)

Protocol	Connect to
UCA2 GOMSFE[b]	UCA2 protocol masters
UCA2 GOOSE[b]	UCA2 protocol and peers

[a] Requires SEL-2711 Modbus Plus protocol card.
[b] Requires SEL-2701 Ethernet Processor.

SEL Communications Processor and Relay Architecture

You can apply SEL communications processors and SEL relays in a limitless variety of applications that integrate, automate, and improve station operation. Most system integration architectures utilizing SEL communications processors involve either developing a star network or enhancing a multidrop network.

Developing Star Networks

The simplest architecture using both the SEL-700G and an SEL communications processor is shown in *Figure C.1*. In this architecture, the SEL communications processor collects data from the SEL-700G and other station IEDs. The SEL communications processor acts as a single point of access for local and remote data consumers (local HMI, SCADA, engineers). The communications processor also provides a single point of access for engineering operations including configuration and the collection of report-based information.

By configuring a data set optimized to each data consumer, you can significantly increase the utilization efficiency on each link. A system that uses an SEL communications processor to provide a protocol interface to an RTU has a shorter lag time (data latency); communication overhead is much less for a single data exchange conversation to collect all substation data (from a communications processor) than for many conversations necessary to collect data directly from each individual IED. You can further reduce data latency by connecting any SEL communications processor directly to the SCADA master and eliminating redundant communications processing in the RTU.

The SEL communications processor is responsible for the protocol interface, so you can install, test, and even upgrade the system in the future without disturbing protective relays and other station IEDs. This insulation of the protective devices from the communications interface assists greatly in situations where different departments are responsible for SCADA operation, communication, and protection.

SEL communications processors equipped with an SEL-2701 Ethernet Processor can provide a UCA2 interface to SEL-700G relays and other serial IEDs. The SEL-700G data appear in models in a virtual device domain. The combination of the SEL-2701 with an SEL communications processor offers a significant cost savings because you can use existing IEDs or purchase less expensive IEDs. For full details on applying the SEL-2701 with an SEL communications processor, see the SEL-*2701 Ethernet Processor Instruction Manual*.

The engineering connection can use either an Ethernet network connection through the SEL-2701 or a serial port connection. This versatility accommodates the channel that is available between the station and the engineering center. SEL software can use either a serial port connection or an Ethernet network connection from an engineering workstation to the relays in the field.

Enhancing Multidrop Networks

You can also use an SEL communications processor to enhance a multidrop architecture similar to the one shown in *Figure C.3*. In this example, the SEL communications processor enhances a system that uses the SEL-2701 with an Ethernet HMI multidrop network. In the example, there are two Ethernet networks, the SCADA LAN and the Engineering LAN. The SCADA LAN provides real-time data directly to the SCADA Control Center via a protocol gateway and to the HMI.

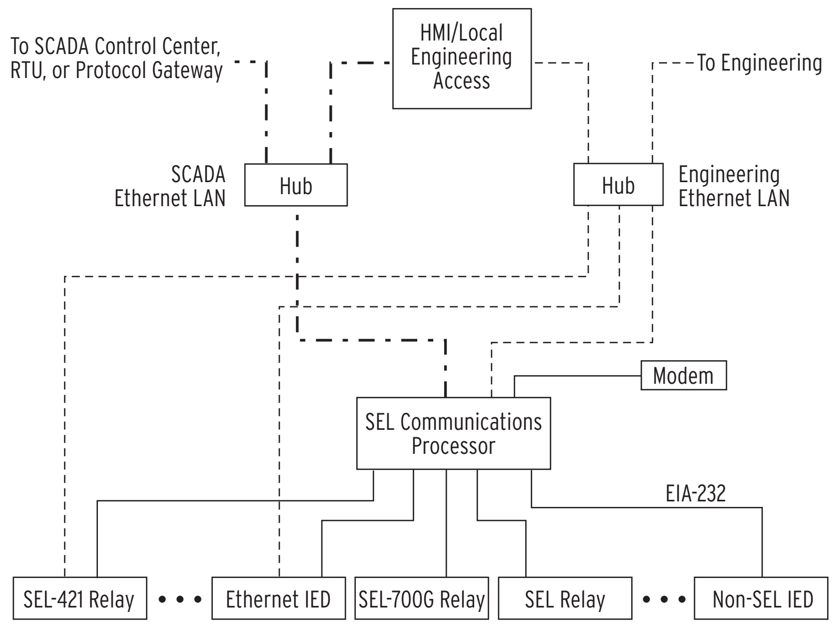


Figure C.3 Enhancing Multidrop Networks With SEL Communications Processors

In this example, the SEL communications processor provides the following enhancements when compared to a system that employs only the multidrop network:

- Ethernet access for IEDs with serial ports
- Backup engineering access through the dial-in modem
- IRIG-B time signal distribution to all station IEDs
- Integration of IEDs without Ethernet
- Single point of access for real-time data for SCADA, HMI, and other uses
- Significant cost savings by use of existing IEDs with serial ports

SEL Communications Processor Example

This example demonstrates the data and control points available in the SEL communications processor when you connect an SEL-700G. The physical configuration used in this example is shown in *Figure C.4*. In this example, the communications processor is an RTAC that is connected to the SEL-700G by using SEL Protocol via ACSELERATOR RTAC software. For more information regarding the RTAC and ACSELERATOR RTAC software, refer to selinc.com.

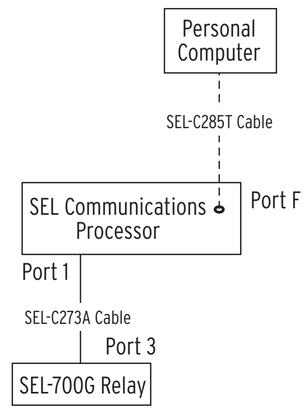


Figure C.4 Example of SEL Relay and SEL Communications Processor Configuration

Table C.4 shows the Port 1 settings for the RTAC.

Table C.4 RTAC Port 1 Settings (Sheet 1 of 2)

Setting	Range	Value
Communications		
SERIAL COMMUNICATIONS PORT	The number of ports depends on the RTAC MOT.	Com_01
SERIAL COMMUNICATIONS PORT TYPE	EIA-232, EIA-485/EIA-422	EIA232
BAUD RATE	Auto-Baud, 300, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200	115200
DATA BITS	8	8
PARITY BIT	None	None
STOP BIT	1	1
RTS_CTS	True, False	False
XON/XOFF	True, False	True
LEVEL 1 PASSWORD	0–32 characters	**********
LEVEL 2 PASSWORD	0–32 characters	**********
ENABLE PASSWORD MONITOR	True, False	False
POLL CASCII RETRIES	0–255	3

Table C.4 RTAC Port 1 Settings (Sheet 2 of 2)

Setting	Range	Value
POLL CASCII INACTIVITY TIMEOUT	100–65535 ms	8000
POLL BINARY RETRIES	0–255	3
POLL BINARY INACTIVITY TIMEOUT	<min>–65535 ms	2500
SLOW POLL MODE MULTIPLIER	1–65535	5
TRANSMIT FAST UNSOLICITED WRITE MESSAGING ON STARTUP	True, False	False
Date-Time		
UTC OFFSET	–720 to 840 minutes	0
DST ENABLED	True, False	True
Event		
ENABLE EVENT COLLECTION	True, False	False
ENABLE COMTRADE COLLECTION	True, False	False
LIST OF EVENT TYPES TO BE COLLECTED		HR
SEL		
VIRTUAL PORT NUMBER	1–254	1

After these settings are configured to align with the Port 1 settings of the SEL-700G, the RTAC will auto-configure the connection. Refer to *Figure C.5* to see what a healthy connection looks like after auto-configuration is complete. Note that ENO and EN are TRUE and that Offline is FALSE.

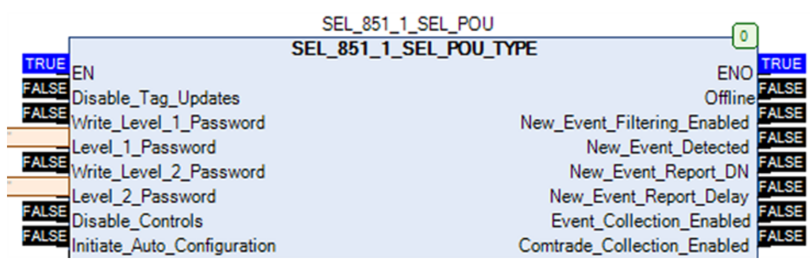


Figure C.5 Healthy Communications Between an RTAC and an SEL-700G

Data Collection

In this example, the RTAC is configured to collect data from the SEL-700G via SEL Protocol, using the list in *Table C.5*.

Table C.5 RTAC Data Collection Automessages

Message Name	Message Type	Command	Poll Period
History	Compressed ASCII	CHI	0
Load Data	Compressed ASCII	CLDP	0
SER	Compressed ASCII	CSE	0
Status	Compressed ASCII	CST	0
Demand Meter	Fast Meter	D2	0
Meter	Fast Meter	D1	1000
Peak Meter	Fast Meter	D3	0

You have the ability to set the poll period for each of the commands in *Table C.5*.

Control Points

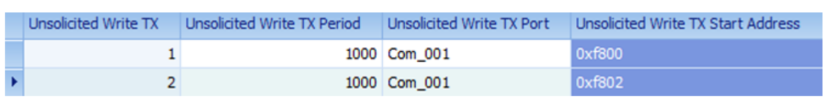
NOTE: To use the Fast Operate function, the breaker jumper must be installed (see Figure 2.7).

The RTAC can automatically pass control messages, called Fast Operate messages, to the SEL-700G. You must enable Fast Operate messages by using the FASTOP setting in the SEL-700G port settings for the port connected to the SEL communications processor.

When you enable Fast Operate functions, the SEL communications processor automatically sends messages to the relay for changes in remote bits RB01–RB32 on the corresponding SEL communications processor port.

SEL Communications Processor to SEL-700G Unsolicited Write Remote Analog Example

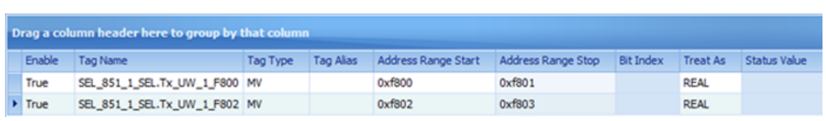
There are two settings that must be configured in the RTAC if you need to write to remote analogs in the SEL-700G. In this example, the required settings needed to write to RA_001.Val and RA_002.Val are provided. The first set of settings is under the Tx UW Messages tab. See *Figure C.6*.



Unsolicited Write TX	Unsolicited Write TX Period	Unsolicited Write TX Port	Unsolicited Write TX Start Address
1	1000	Com_001	0xf800
2	1000	Com_001	0xf802

Figure C.6 Unsolicited Write Remote Analogs Tx UW Messages Settings

In the settings, note the unsolicited write Tx starting addresses. After these two settings are properly configured, Tx UW Message 1 must be configured. See *Figure C.7*. Note the Tag Types being MV and the Datatype being REAL. A similar setup can be used to write to all of the remote analogs.



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Enable	Tag Name	Tag Type	Tag Alias	Address Range Start	Address Range Stop	Bit Index	Treat As	Status Value
True	SEL_851_1_SEL.Tx_UW_1_F800	MV		0xf800	0xf801		REAL	
True	SEL_851_1_SEL.Tx_UW_1_F802	MV		0xf802	0xf803		REAL	

Figure C.7 Tag Type and Datatype for RA_001.Val–RA_032.Val

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Appendix D
DNP3 Communications

Overview

The SEL-700G relays provide a Distributed Network Protocol Version 3.0 (DNP3) Level 2 Outstation interface for direct serial and LAN/WAN network connections to the device.

This section covers the following topics:

Introduction to DNP3

A Supervisory Control and Data Acquisition (SCADA) manufacturer developed the first versions of DNP from the lower layers of IEC 60870-5. Originally designed for use in telecontrol applications, Version 3.0 of the protocol has also become popular for local substation data collection. DNP3 is one of the protocols included in the IEEE Recommended Practice for Data Communication Between Remote Terminal Units (RTUs) and Intelligent Electronic Devices (IEDs) in a Substation.

The DNP Users Group maintains and publishes DNP3 standards. See the DNP Users Group website, dnp.org, for more information on standards, implementers, and tools for working with DNP3.

DNP3 Specifications

DNP3 is a feature-rich protocol with many ways to accomplish tasks, defined in an eight-volume series of specifications. Volume 8 of the specification, called the Interoperability Specification, simplifies DNP3 implementation by providing four standard interoperable implementation levels. The levels are listed in *Table D.1*.

Table D.1 DNP3 Implementation Levels

Level	Description	Equipment Types
1	Simple: limited communication requirements	Meters, simple IEDs
2	Moderately complex: monitoring and metering devices and multifunction devices that contain more data	Protective relays, RTUs
3	Sophisticated: devices with great amounts of data or complex communication requirements	Large RTUs, SCADA masters
4	Enhanced: additional data types and functionality for more complex requirements	Large RTUs, SCADA masters

Each level is a proper superset of the previous lower-numbered level. A higher-level device can act as a master to a lower-level device, but can only use the data types and functions implemented in the lower level device. For example, a typical SCADA master is a Level 3 device and can use Level 2 (or lower) functions to poll a Level 2 (or lower) device for Level 2 (or lower) data. Similarly, a lower-level device can poll a higher-level device, but the lower level device can only access the features and data available to its level.

In addition to the eight-volume DNP3 specification, the protocol is further refined by conformance requirements, optional features, and a series of technical bulletins. The technical bulletins supplement the specifications with discussion and examples of specific features of DNP3.

Data Handling

Objects

DNP3 uses a system of data references called objects, defined by the Basic 4 standard object library. Each subset level specification requires a minimum implementation of object types and recommends several optional object types. DNP3 object types, commonly referred to as objects, are specifications for the type of data the object carries. An object can include a single value or more complex data. Some objects serve as shorthand references for special operations, including collections of data, time synchronization, or even all data within the DNP3 device.

If there can be more than one instance of a type of object, then each instance of the object includes an index that makes it unique. For example, each binary status point (Object 1) has an index. If there are 16 binary status points, these points are Object 1, Index 0 through Object 1, Index 15.

Each object also includes multiple versions called variations. For example, Object 1 (binary inputs) has three variations: 0, 1, and 2. You can use Variation 0 to request all variations, Variation 1 to specify binary input values only, and Variation 2 to specify binary input values with status information.

Each DNP3 device has both a list of objects and a map of object indices. The list of objects defines the available objects, variations, and qualifier codes. The map defines the indices for objects that have multiple instances and defines what data or control points correspond with each index.

A master initiates all DNP3 message exchanges except unsolicited data. DNP3 terminology describes all points from the perspective of the master. Binary points for control that move from the master to the outstation are called binary outputs, while binary status points within the outstation are called binary inputs.

Function Codes

Each DNP3 message includes a function code. Each object has a limited set of function codes that a master can use to manipulate the object. The object listing for the device shows the permitted function codes for each type of object. The most common DNP3 function codes are listed in *Table D.2*.

Table D.2 Selected DNP3 Function Codes

Function Code	Function	Description
1	Read	Request data from the outstation
2	Write	Send data to the outstation
3	Select	First part of a Select-Before-Operate operation
4	Operate	Second part of a Select-Before-Operate operation
5	Direct operate	One-step operation with reply
6	Direct operate, no reply	One-step operation with no reply

Qualifier Codes and Ranges

DNP3 masters use qualifier codes and ranges to make requests for specific objects by index. Qualifier codes specify the style of range, and the range specifies the indices of the objects of interest. DNP3 masters use qualifier codes to compose the shortest, most concise message possible when requesting points from a DNP3 outstation.

For example, the qualifier code 01 specifies that the request for points includes a start address and a stop address. Each of these two addresses uses two bytes. An example request using qualifier code 01 might have the four hexadecimal byte range field, 00h 04h 00h 10h, which specifies points in the range 4 to 16.

Access Methods

DNP3 has many features that help obtain maximum possible message efficiency. DNP3 masters send requests with the least number of bytes using special objects, variations, and qualifiers that reduce the message size. Other features eliminate the continual exchange of static (unchanging) data values. These features optimize use of bandwidth and maximize performance over a connection of any speed.

DNP3 event data collection eliminates the need to use bandwidth to transmit values that have not changed. Event data are time-stamped records that show when observed measurements changed. For binary points, the remote device (DNP3 outstation) logs changes from logical 1 to logical 0 and from logical 0 to logical 1. For analog points, the outstation device logs changes that exceed a deadband. DNP3 outstation devices collect event data in a buffer that either the master can request or the device can send to the master without a request message. Data sent from the outstation to the master without a polling request are called unsolicited data.

DNP3 data fit into one of four event classes: 0, 1, 2, or 3. Class 0 is reserved for reading the present value data (static data). Classes 1, 2, and 3 are event data classes. The meaning of Classes 1 to 3 is arbitrary and defined by the application at hand. With outstations that contain great amounts of data or in large systems, the three event classes provide a framework for prioritizing different types of data. For example, you can poll once a minute for Class 1 data, once an hour for Class 2 data, and once a day for Class 3 data.

DNP3 also supports static polling: simple polling of the present value of data points within the outstation. By combining event data, unsolicited polling, and static polling, you can operate your system in one of the four access methods shown in *Table D.3*.

The access methods listed in *Table D.3* are listed in order of increasing communication efficiency. With various trade-offs, each method is less demanding of communication bandwidth than the previous one. For example, unsolicited report-by-exception consumes less communication bandwidth than polled report-by-exception because that method does not require polling messages from the master. To properly evaluate which access method provides optimum performance for your application, you must also consider overall system size and the volume of data communication expected.

Table D.3 DNP3 Access Methods

Access Method	Description
Polled static	Master polls for present value (Class 0) data only
Polled report-by-exception	Master polls frequently for event data and occasionally for Class 0 data
Unsolicited report-by-exception	Outstation devices send unsolicited event data to the master, and the master occasionally polls for Class 0 data
Quiescent	Master never polls and relies on unsolicited reports only

Binary Control Operations

DNP3 masters use Object 12, control device output block, to perform DNP3 binary control operations. The control device output block has both a trip/close selection and a code selection. The trip/close selection allows a single DNP3 index to operate two related control points such as trip and close or raise and lower. Trip/close pair operation is not recommended for new DNP3 devices, but is often included for interoperability with older DNP3 master implementations.

The control device output block code selection specifies either a latch or pulse operation on the point. In many cases, DNP3 outstations have only a limited subset of the possible combinations of the code field. Sometimes, DNP3 outstations assign special operation characteristics to the latch and pulse selections. *Table D.12* describes control point operation for the SEL-700G.

Conformance Testing

In addition to the protocol specifications, the DNP Users Group has approved conformance-testing requirements for Level 1 and Level 2 devices. Some implementers perform their own conformance specification testing, while some contract with independent companies to perform conformance testing.

Conformance testing does not always guarantee that a master and outstation are fully interoperable (that is, work together properly for all implemented features). Conformance testing does help to standardize the testing procedure and move the DNP3 implementers toward a higher level of interpretability.

DNP3 Serial Network Issues

Data Link Layer Operation

DNP3 employs a three-layer version of the seven-layer OSI (Open Systems Interconnection) model called the enhanced performance architecture. The layer definition helps to categorize functions and duties of various software components that make up the protocol. The middle layer, the Data Link Layer, includes several functions for error checking and media access control.

A feature called data link confirmation is a mechanism that provides positive confirmation of message receipt by the receiving DNP3 device. While this feature helps you recognize a failed device or failed communications link quickly, it also adds significant overhead to the DNP3 conversation. Consider whether you require this link integrity function in your application at the expense of overall system speed and performance.

The DNP3 technical bulletin (*DNP Confirmation and Retry Guidelines 9804-002*) on confirmation processes recommends against using data link confirmations because these processes can add to traffic in situations where communications are marginal. The increased traffic reduces connection throughput further, possibly preventing the system from operating properly.

Network Medium Contention

When more than one device requires access to a single (serial) network medium, you must provide a mechanism to resolve the resulting network medium contention. For example, unsolicited reporting results in network medium contention if you do not design your serial network as a star topology of point-to-point connections or use carrier detection on a multidrop network.

To avoid collisions among devices trying to send messages, DNP3 includes a collision avoidance feature. Before sending a message, a DNP3 device listens for a carrier signal to verify that no other node is transmitting data. The device transmits if there is no carrier or waits for a random time before transmitting. However, if two nodes both detect a lack of carrier at the same instant, these two nodes could begin simultaneous transmission of data and cause a data collision. If your serial network allows for spontaneous data transmission including unsolicited event data transmissions, you also must use application confirmation to provide a retry mechanism for messages lost in data collisions.

DNP3 LAN/WAN Overview

The main process for carrying DNP3 over an Ethernet network (LAN/WAN) involves encapsulating the DNP3 data link layer data frames within the transport layer frames of the IP suite. This allows the IP stack to deliver the DNP3 data link layer frames to the destination in place of the original DNP3 physical layer.

The DNP User Group Technical Committee has recommended the following guidelines for carrying DNP3 over a network:

NOTE: Link layer confirmations are explicitly disabled for DNP3 LAN/WAN. The IP suite provides a reliable delivery mechanism, which is backed up at the application layer by confirmations when necessary.

- DNP3 shall use the IP suite to transport messages over a LAN/WAN
- Ethernet is the recommended physical link, although you can use others
- TCP must be used for WANs
- TCP is strongly recommended for LANs
- UDP can be used for highly reliable single segment LANs
- UDP is necessary if you need broadcast messages
- The DNP3 protocol stack shall be retained in full
- Link layer confirmations shall be disabled

The technical committee has registered a standard port number, 20000, for DNP3 with the Internet Assigned Numbers Authority (IANA). This port is used for either TCP or UDP.

TCP/UDP Selection

The committee recommends the selection of TCP or UDP protocol as per the guidelines in *Table D.4*.

Table D.4 TCP/UDP Selection Guidelines

Use in the case of...	TCP	UDP
Most situations	X	
Non-broadcast or multicast	X	
Mesh Topology WAN	X	
Broadcast		X
Multicast		X
High-reliability single-segment LAN		X
Pay-per-byte, non-mesh WAN, for example, Cellular Digital Packet Data (CDPD)		X
Low priority data, for example, data monitor or configuration information		X

DNP3 in the SEL-700G

The SEL-700G is a DNP3 Level 2 remote (outstation) device without dual end point.

Data Access

Table D.5 lists DNP3 data access methods along with corresponding SEL-700G settings. You must select a data access method and configure each DNP3 master for polling as specified.

NOTE: Because unsolicited messaging is problematic in most circumstances, SEL recommends using the polled report-by-exception access method to maximize performance and minimize risk of configuration problems.

NOTE: In the settings in Table D.5, the suffix n represents the DNP3 session number from 1 to 5. All settings with the same numerical suffix comprise the complete DNP3 session configuration.

Table D.5 Configuring DNP3 Access Methods

Access Method	Master Polling	SEL-700G Settings
Polled static	Class 0	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to 0; UNSOL*n* to No
Polled report-by-exception	Class 0 occasionally, Class 1, 2, 3 frequently	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to the desired event class; UNSOL*n* to No
Unsolicited report-by-exception	Class 0 occasionally, optional Class 1, 2, 3 less frequently; mainly relies on unsolicited messages	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to the desired event class; set UNSOL*n* to Yes and PUNSOL*n* to Yes or No
Quiescent	Class 0, 1, 2, 3 never; relies completely on unsolicited messages	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to the desired event class; set UNSOL*n* and PUNSOL*n* to Yes.

The SEL-700G is an outstation device without dual end point. For a TCP connection, the relay sends out unsolicited messages only if a DNP Master has already established a session and enabled unsolicited messaging for that session. However, the relay automatically dials out and sends unsolicited messages for a serial/modem/UDP connection, as defined by the settings.

In both the unsolicited report-by-exception and quiescent polling methods shown in *Table D.5*, you must make a selection for the PUNSOL*n* setting. This setting enables or disables unsolicited data reporting at power up. If your DNP3 master can send a message to enable unsolicited reporting on the SEL-700G, set PUNSOL*n* to No.

While automatic unsolicited data transmission on power up is convenient, this can cause problems if your DNP3 master is not prepared to start receiving data immediately on power up. If the master does not acknowledge the unsolicited data with an Application Confirm, the device resends the data until it is acknowledged. On a large system, or in systems where the processing power of the master is limited, you may have problems when several devices simultaneously begin sending data and waiting for acknowledgment messages.

The SEL-700G allows you to set the conditions for transmitting unsolicited event data on a class-by-class basis. It also allows you to assign points to event classes on a point-by-point basis (see *DNP3 Documentation on page D.13*). You can prioritize data transmission with these event class features. For example, you might place high-priority points in event Class 1 and set it with low thresholds (NUMEVE*n* and AGEEVE*n* settings) so that changes to these points are sent to the master quickly. You can then place low priority data in event Class 2 with higher thresholds.

If the SEL-700G does not receive an Application Confirm in response to unsolicited data, it waits for ETIMEO*n* seconds and then repeats the unsolicited message. To prevent clogging of the network with unsolicited data retries, the SEL-700G uses the URETRY*n* and UTIMEO*n* settings to increase retry time when the number of retries set in URETRY*n* is exceeded. After URETRY*n* has been exceeded, the SEL-700G pauses UTIMEO*n* seconds and then transmits the unsolicited data again. *Figure D.1* provides an example with URETRY*n* = 2.

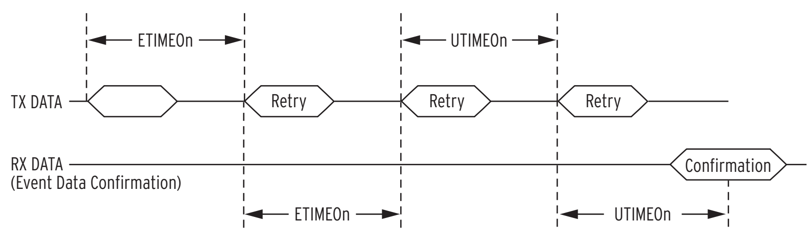

Figure D.1 Application Confirmation Timing With URETRYn = 2

Collision Avoidance

If your application uses unsolicited reporting on a serial network, you must select a half-duplex medium or a medium that includes carrier detection to avoid data collisions. EIA-485 two-wire networks are half-duplex. EIA-485 four-wire networks do not provide carrier detection, while EIA-232 systems can support carrier detection. DNP3 LAN/WAN uses features of the IP suite for collision avoidance, so does not require these settings.

The SEL-700G uses Application Confirmation messages to guarantee delivery of unsolicited event data before erasing the local event data buffer. Data collisions are typically resolved when messages are repeated until confirmed.

The SEL-700G pauses for a random delay between the settings MAXDLY and MINDLY when it detects a carrier through data on the receive line or the CTS pin. For example, if you use the settings of 0.10 seconds for MAXDLY and

0.05 seconds for MINDLY, the SEL-700G inserts a random delay of 50 to 100 ms (milliseconds) between the end of carrier detection and the start of data transmission (see *Figure D.2*).

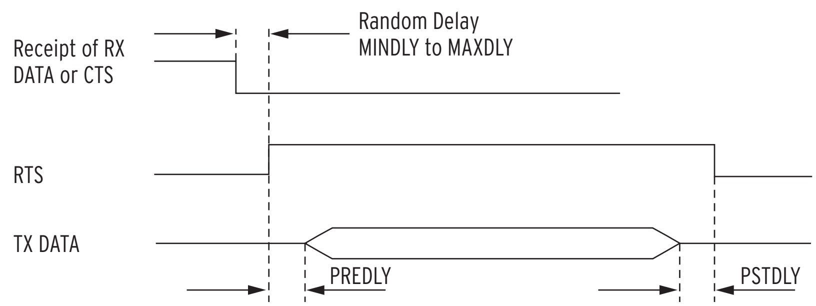

Figure D.2 Message Transmission Timing

Transmission Control

NOTE: PREDLY and POSTDLY settings are only available for EIA-232 and EIA-485 serial port sessions.

If you use a media transceiver (for example, EIA-232 to EIA-485) or a radio system for your DNP3 network, you may need to adjust data transmission properties. Use the PREDLY and POSTDLY settings to provide a delay between RTS signal control and data transmission (see *Figure D.2*). For example, an EIA-485 transceiver typically requires 10 to 20 ms to change from receive to transmit. If you set the pre-delay to 30 ms, you avoid data loss resulting from data transmission beginning at the same time as RTS signal assertion.

Event Data

DNP3 event data objects contain change-of-state and time-stamp information that the SEL-700G collects and stores in a buffer. Points assigned in the Binary Input Map that are also assigned in the Sequential Events Recorder (SER) settings carry the time stamp of actual occurrence. Binary input points not assigned in the SER settings carry a time stamp based on the DNP map scan time. This may be significantly delayed from when the original source changed and should not be used for sequence-of-events determination. The DNP map is scanned approximately twice per second to generate events. You can configure the SEL-700G to either report the data without a polling request from the master (unsolicited data) or hold the data until the master requests this information with an event poll message.

With the event class settings ECLASSB*n*, ECLASSC*n*, and ECLASSA*n*, you can set the event class for binary, counter, and analog inputs for Session *n*. You can use the classes as a simple priority system for collecting event data. The SEL-700G does not treat data of different classes differently with respect to message scanning, but it does allow the master to perform independent class polls.

NOTE: Most RTUs that act as substation DNP3 masters perform an event poll that collects event data of all classes simultaneously. You must confirm that the polling configuration of your master allows independent polling for each class before implementing separate classes in the SEL-700G.

For event data collection, you must also consider and enter appropriate settings for deadband and scaling operation on analog points shown in *Table D.7*. You can either:

- ➤ set and use default deadband and scaling according to data type, or
- ➤ use a custom data map to select deadbands on a point-by-point basis.

See *DNP3 Documentation on page D.13* for a discussion of how to set scaling and deadband operation on a point-by-point basis. You can modify deadbands for analog inputs at run-time by writing to Object 34.

The settings ANADBA*n*, ANADBV*n*, and ANADBM*n* control default deadband operation for each type of analog data. Because DNP3 Objects 30 and 32 use integer data, you must use scaling to send digits after the decimal point and avoid rounding to a simple integer value.

With no scaling, the value of 12.632 would be sent as 12. With a scaling setting of 1, the value transmitted is 126. With a scaling setting of 3, the value transmitted is 12632. You must make certain that the maximum value does not exceed 32767 if you are polling the default 16-bit variations for Objects 30 and 32, but you can send some decimal values using this technique. You must also configure the master to perform the appropriate division on the incoming value to display it properly.

You can set the default analog value scaling with the DECPLA*n*, DECPLV*n*, and DECPLM*n* settings. Application of event reporting deadbands occurs after scaling. For example, if you set DECPLA*n* to 2 and ANADBA*n* to 10, a measured current of 10.14 amps would be scaled to the value 1014 and would have to increase to more than 1024 or decrease to less than 1004 (a change in magnitude of ± 0.1 amps) for the device to report a new event value.

The SEL-700G uses the NUMEVE*n* and AGEEVE*n* settings to decide when to send unsolicited data to the master. The device sends an unsolicited report when the total number of events accumulated in the event buffer for Master *n* reaches NUMEVE*n*. The device also sends an unsolicited report if the age of the oldest event in the master n buffer exceeds AGEEVE*n*. The SEL-700G has the buffer capacities listed in *Table D.6*.

Table D.6 SEL-700G Event Buffer Capacity

Type	Maximum Number of Events
Binary	1024
Analog	100
Counters	32

Binary Controls

The SEL-700G provides more than one way to control individual points. The SEL-700G maps incoming control points either to remote bits or to internal command bits that cause circuit breaker operations. *Table D.12* lists control points and control methods available in the SEL-700G.

A DNP3 technical bulletin (*Control Relay Output Block Minimum Implementation 9701-002*) recommends that you use one point per Object 12, control block output device. You can use this method to perform Pulse On, Pulse Off, Latch On, and Latch Off operations on selected remote bits.

If your master does not support the single-point-per-index messages or single operation database points, you can use the trip/close operation or use the code field in the DNP3 message to specify operation of the points shown in *Control Point Operation on page D.23*.

Time Synchronization

The accuracy of DNP3 time synchronization is insufficient for most protection and oscillography needs. DNP3 time synchronization provides backup time synchronization in the event the device loses primary synchronization through the IRIG-B input. You can enable time synchronization with the TIMERQ*n* setting and then use Object 50, Variation 1, and Object 52, Variation 2, to set the time via the Session *n* DNP3 master (Object 50, Variation 3 for DNP3 LAN/WAN).

By default, the SEL-700G accepts and ignores time set requests (TIMERQ*n* = I for "ignore"). (This mode allows the SEL-700G to use a high accuracy, IRIG time source, but still interoperate with DNP3 masters that send time-synchronization messages.) You can set the SEL-700G to request time synchronization periodically by setting the TIMERQ*n* setting to the desired period. You can also set it to not request, but accept, time synchronization (TIMERQ*n* = M for "master").

The SEL-700G prioritizes its time-synchronization sources. These time sources fall under one of two categories: primary time sources and secondary time sources. IRIG-B (BNC and Serial), PTP, and SNTP are primary time sources. All other time sources such as DNP, IEC 60870-5-103, Modbus, and serial port **TIME** and **DATE** commands are secondary time sources.

If an IRIG-B BNC time source is available, the SEL-700G synchronizes its time with that time source regardless of what other time sources are available. If an IRIG-B BNC time source is not available and an IRIG-B Serial time source is, the SEL-700G synchronizes its time with that IRIG-B Serial time source even if other time sources are available. If an IRIG-B Serial time source is not available and PTP is, the SEL-700G synchronizes its time with that PTP time source even if other time sources are available. If IRIG-B (BNC and Serial) and PTP are not available, but SNTP is, the SEL-700G synchronizes its time with that SNTP time source even if other time sources are available. And finally, if IRIG-B (BNC and Serial), PTP, and SNTP are not available, the SEL-700G synchronizes with the remaining time sources that could be available. These include DNP, IEC 60870-5-103, Modbus, or serial port time and date commands. These four time sources take on the same priority. At any given time, the relay synchronizes with the one that most recently established synchronization with the relay. In summary, time-synchronization prioritization starts with IRIG-B BNC, followed by IRIG-B Serial, followed by PTP, followed by SNTP, followed by DNP, IEC 60870-5-103, Modbus, or serial port **TIME** and **DATE** commands.

Note that when IRIG-B BNC or IRIG-B Serial time sources are available, any remaining time source that could be available can only be used to update the year.

Modem Support

The SEL-700G DNP implementation includes modem support for serial ports. Your DNP3 master can dial-in to the SEL-700G and establish a DNP3 connection. The SEL-700G can automatically dial out and deliver unsolicited DNP3 event data.

When the device dials out, it waits for the "CONNECT" message from the local modem and for assertion of the device CTS line before continuing the DNP transaction. This requires a connection from the modem DCD to the device CTS line.

NOTE: Contact SEL for information on serial cable configurations and requirements for connecting your SEL-700G to other devices.

NOTE: To enable hardware handshaking, set the modem settings to Y if you are using a Null modem cable for DOP protocol implementation.

You can either connect the modem to a computer and configure it before connecting it to the SEL-700G, or program the appropriate modem setup string in the modem startup string setting MSTR. Use the PH_NUM1 and (optional) PH_NUM2 settings to set the phone numbers that you want the SEL-700G to call. The SEL-700G automatically sends the ATDT modem dial command and then the contents of the PH_NUM1 setting when dialing the modem. If PH_NUM2 is set, use the RETRY1 setting to configure the number of times the SEL-700G tries to dial PH_NUM1 before dialing PH_NUM2. Similarly, the RETRY2 setting is the number of attempts the SEL-700G tries to dial PH_NUM2 before trying PH_NUM1. MDTIME sets the length of time from initiating the call to declaring it failed because of no connection, and MDRET sets the time between dial-out attempts.

NOTE: RTS/CTS hardware flow control is not available for a DNP3 modem connection. You must use either X-ON/X-OFF software flow control or set the port data speed slower than the effective data rate of the modem.

The settings PH_NUM1 and PH_NUM2 must conform to the AT modem command set dialing string standard, including:

- A comma (,) inserts a four second pause
- If necessary, use a 9 to reach an outside line
- Include a 1 and the area code if the number requires long distance access
- Add any special codes your telephone service provider designates to block call waiting and other telephone line features.

DNP3 Settings

The DNP port configuration settings available on the SEL-700G are shown in *Table D.7*. You can enable DNP on Ethernet Port 1 or on any of the serial Ports 2 through 4, to a maximum of five concurrent DNP sessions. Each session defines the characteristics of the connected DNP Master, to which you assign one of the three available custom maps. Some settings only apply to DNP LAN/WAN, and are visible only when configuring the Ethernet port. For example, you only have the ability to define multiple sessions on Port 1, the Ethernet port. Likewise, settings applicable to serial DNP are visible only when configuring a serial port.

Table D.7 Port DNP3 Protocol Settings (Sheet 1 of 3)

Name	Description	Range	Default
EDNP[a]	Enable DNP3 Sessions	0–5	0
DNPNUM[a]	DNP3 TCP and UDP Port	1–65534	20000
DNPADR	Device DNP3 address	0–65519	0
Session 1 Settings			
DNPIP1[a,b]	DNP Master IP Address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR1[a]	Transport protocol	UDP, TCP	TCP
DNPUDP1[a]	UDP response port	REQ, 1–65534	20000
REPADR1	DNP3 address of the Master to send messages to	0–65519	1
DNPMAP1	DNP3 Session Custom Map	1–3	1
DVARAI1	Analog Input Default Variation	1–6	4
ECLASSB1	Class for binary event data, 0 disables	0–3	1
ECLASSC1	Class for counter event data, 0 disables	0–3	0
ECLASSA1	Class for analog event data, 0 disables	0–3	2
DECPLA1	Decimal places scaling for Current data	0–3	1
DECPLV1	Decimal places scaling for Voltage data	0–3	1
DECPLM1	Decimal places scaling for Miscellaneous data	0–3	1
ANADBA1	Analog reporting deadband for current; hidden if ECLASSA1 set to 0	0–32767	100
ANADBV1	Analog reporting deadband for voltages; hidden if ECLASSA1 set to 0	0–32767	100
ANADBM1	Analog reporting deadband for miscellaneous analogs; hidden if ECLASSA and ECLASSC set to 0	0–32767	100
TIMERQ1	Time-set request interval, minutes (M = Disables time sync requests, but still accepts and applies time syncs from Master; I = Ignores (does not apply) time syncs from Master)	I, M, 1–32767	I
STIMEO1	Select/operate time-out, seconds	0.0–30.0	1.0
DNPINA1[a,c]	Send Data Link Heartbeat, seconds; hidden if DNPTR1 set to UDP	0.0–7200	120
DRETRY1[d]	Data link retries	0–15	0
DTIMEO1[d]	Data link time-out, seconds; hidden if DRETRY1 set to 0	0.0–5.0	1

Table D.7 Port DNP3 Protocol Settings (Sheet 2 of 3)

Name	Description	Range	Default
ETIMEO1	Event message confirm time-out, seconds	1–50	5
UNSOL1	Enable unsolicited reporting; hidden and set to N if ECLASSB1, ECLASSC1, and ECLASSA1 set to 0	Y, N	N
PUNSOL1	Enable unsolicited reporting at turn on; hidden and set to N if UNSOL1 set to N	Y, N	N
NUMEVE1[e]	Number of events to transmit on	1–200	10
AGEEVE1[e]	Oldest event to transmit on, seconds	0.0–99999.0	2.0
URETRY1[e]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO1[e]	Unsolicited messages offline timeout, seconds	1–5000	60
Session 2 Settings			
DNPIP2[a,b]	DNP Master IP Address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR2[a]	Transport protocol	UDP, TCP	TCP
. . .			
URETRY2[a, e]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO2[a, e]	Unsolicited messages offline timeout, seconds	1–5000	60
Session 3 Settings			
DNPIP3[a,b]	DNP Master IP Address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR3[a]	Transport protocol	UDP, TCP	TCP
. . .			
URETRY3[a, e]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO3[a, e]	Unsolicited messages offline timeout, seconds	1–5000	60
Session 4 Settings			
DNPIP4[a,b]	DNP Master IP Address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR4[a]	Transport protocol	UDP, TCP	TCP
. . .			
URETRY4[a, e]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO4[a, e]	Unsolicited messages offline timeout, seconds	1–5000	60
Session 5 Settings			
DNPIP5[a,b]	DNP Master IP Address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR5[a]	Transport protocol	UDP, TCP	TCP
. . .			
URETRY5[a, e]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO5[a, e]	Unsolicited messages offline timeout, seconds	1–5000	60
Serial Port Settings			
MINDLY[d]	Minimum delay from DCD to TX, seconds	0.00–1.00	0.05
MAXDLY[d]	Maximum delay from DCD to TX, seconds	0.00–1.00	0.10

Table D.7 Port DNP3 Protocol Settings (Sheet 3 of 3)

Name	Description	Range	Default
PREDLY[d]	Settle time from RTS on to TX; Off disables PSTDLY	OFF, 0.00–30.00	0.00
PSTDLY[d]	Settle time from TX to RTS off; hidden if PREDLY set to Off	0.00–30.00	0.00

[a] Available only on Ethernet ports.
[b] Set DNPIPn := 0.0.0.0 to accept connections from any DNP master.
[c] DNPINA*n* allows the user to set the wait time to detect a bad TCP connection. The relay closes the unused TCP connection after the DNPINA*n* response timeout. It is recommended you set this value to less than 20 seconds. Disabling DNPINA*n* violates the DNP3 standard and should be done only for testing.
[d] Available only on serial ports.
[e] Hidden if UNSOLn set to N.

The modem settings in *Table D.8* are only available for DNP3 serial port sessions.

Table D.8 Serial Port DNP3 Modem Settings

Name	Description	Range	Default
MODEM	Modem connected to port; all following settings are hidden if MODEM set to N	Y, N	N
MSTR	Modem startup string	As many as 30 characters	"E0X0&D0S0=4"
PH_NUM1	Primary phone number for dial-out	As many as 30 characters	“”
PH_NUM2	Secondary phone number for dial-out	As many as 30 characters	“”
RETRY1	Retry attempts for primary dial-out; hidden and unused if PH_NUM2 set to “”	1–20	5
RETRY2	Retry attempts for secondary dial-out; hidden and unused if PH_NUM2 set to “”	1–20	5
MDTIME	Time from initiating call to failure because of no connection, seconds	5–300	60
MDRET	Time between dial-out attempts	5–3600	120

DNP3 Documentation

Object List

Table D.9 lists the objects and variations with supported function codes and qualifier codes available in the SEL-700G. The list of objects conforms to the format laid out in the DNP specifications and includes supported objects for DNP3 implementation Level 2 and higher and nonsupported objects for DNP3 implementation Level 2 only. Those that are supported include the function and qualifier codes. The objects that are not supported are shown without any corresponding function and qualifier codes.

Table D.9 SEL-700G DNP Object List (Sheet 1 of 7)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
0	211	Device Attributes—User-specific sets of attributes	1	0	129	0,17
0	212	Device Attributes—Master data set prototypes	1	0	129	0,17
0	213	Device Attributes—Outstation data set prototypes	1	0	129	0,17
0	214	Device Attributes—Master data sets	1	0	129	0,17
0	215	Device Attributes—Outstation data sets	1	0	129	0,17
0	216	Device Attributes—Max binary outputs per request	1	0	129	0,17
0	219	Device Attributes—Support for analog output events	1	0	129	0,17

Table D.9 SEL-700G DNP Object List (Sheet 2 of 7)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
0	220	Device Attributes—Max analog output index	1	0	129	0,17
0	221	Device Attributes—Number of analog outputs	1	0	129	0,17
0	222	Device Attributes—Support for binary output events	1	0	129	0,17
0	223	Device Attributes—Max binary output index	1	0	129	0,17
0	224	Device Attributes—Number of binary outputs	1	0	129	0,17
0	225	Device Attributes—Support for frozen counter events	1	0	129	0,17
0	226	Device Attributes—Support for frozen counters	1	0	129	0,17
0	227	Device Attributes—Support for counter events	1	0	129	0,17
0	228	Device Attributes—Max counter index	1	0	129	0,17
0	229	Device Attributes—Number of counters	1	0	129	0,17
0	230	Device Attributes—Support for frozen analog inputs	1	0	129	0,17
0	231	Device Attributes—Support for analog input events	1	0	129	0,17
0	232	Device Attributes—Max analog input index	1	0	129	0,17
0	233	Device Attributes—Number of analog inputs	1	0	129	0,17
0	234	Device Attributes—Support for double-bit events	1	0	129	0,17
0	235	Device Attributes—Max double-bit binary index	1	0	129	0,17
0	236	Device Attributes—Number of double-bit binaries	1	0	129	0,17
0	237	Device Attributes—Support for binary input events	1	0	129	0,17
0	238	Device Attributes—Max binary input index	1	0	129	0,17
0	239	Device Attributes—Number of binary inputs	1	0	129	0,17
0	240	Device Attributes—Max transmit fragment size	1	0	129	0,17
0	241	Device Attributes—Max receive fragment size	1	0	129	0,17
0	242	Device Attributes—Device manufacturer’s software version	1	0	129	0,17
0	242	Device Attributes—Device manufacturer’s software version	1	0	129	0,17
0	243	Device Attributes—Device manufacturer’s hardware version	1	0	129	0,17
0	245	Device Attributes—User-assigned location name	1	0	129	0,17
0	246	Device Attributes—User assigned ID code/number	1	0	129	0,17
0	247	Device Attributes—User assigned ID code/number	1	0	129	0,17
0	248	Device Attributes—Device serial number	1	0	129	0,17
0	249	Device Attributes—DNP subset and conformance	1	0	129	0,17
0	250	Device Attributes—Device manufacturer’s product name and model	1	0	129	0,17
0	252	Device Attributes—Device manufacturer's name	1	0	129	0,17
0	254	Device Attributes—Non-specific all attributes request	1	0	129	0,17
0	255	Device Attributes—List of attribute variations	1	0	129	0,17

Table D.9 SEL-700G DNP Object List (Sheet 3 of 7)

Obj.	Var.	Description	Request[a] Funct. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Funct. Codes[c]	Response[b] Qual. Codes[d]
1	0	Binary Input—All Variations	1	0, 1, 6, 7, 8, 17, 28		
1	1	Binary Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
1	2[e]	Binary Input With Status	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
2	0	Binary Input Change—All Variations	1	6, 7, 8		
2	1	Binary Input Change Without Time	1	6, 7, 8	129	17, 28
2	2[e]	Binary Input Change With Time	1	6, 7, 8	129, 130	17, 28
2	3	Binary Input Change With Relative Time	1	6, 7, 8	129	17, 28
10	0	Binary Output—All Variations	1	0, 1, 6, 7, 8		
10	1	Binary Output				
10	2[e]	Binary Output Status	1	0, 1, 6, 7, 8	129	0, 1
12	0	Control Block—All Variations				
12	1	Control Relay Output Block	3, 4, 5, 6	17, 28	129	echo of request
12	2	Pattern Control Block	3, 4, 5, 6	7	129	echo of request
12	3	Pattern Mask	3, 4, 5, 6	0, 1	129	echo of request
20	0	Binary Counter—All Variations	1, 7, 8, 9, 10	0, 1, 6, 7, 8, 17, 28		
20	1	32-Bit Binary Counter	1, 7, 8, 9, 10	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
20	2	16-Bit Binary Counter	1, 7, 8, 9, 10	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
20	3	32-Bit Delta Counter				
20	4	16-Bit Delta Counter				
20	5	32-Bit Binary Counter Without Flag	1, 7, 8, 9, 10	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
20	6[e]	16-Bit Binary Counter Without Flag	1, 7, 8, 9, 10	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
20	7	32-Bit Delta Counter Without Flag				
20	8	16-Bit Delta Counter Without Flag				
21	0	Frozen Counter—All Variations				
21	1	32-Bit Frozen Counter				
21	2	16-Bit Frozen Counter				
21	3	32-Bit Frozen Delta Counter				
21	4	16-Bit Frozen Delta Counter				
21	5	32-Bit Frozen Counter With Time of Freeze				
21	6	16-Bit Frozen Counter With Time of Freeze				
21	7	32-Bit Frozen Delta Counter With Time of Freeze				
21	8	16-Bit Frozen Delta Counter With Time of Freeze				
21	9	32-Bit Frozen Counter Without Flag				
21	10	16-Bit Frozen Counter Without Flag				

Table D.9 SEL-700G DNP Object List (Sheet 4 of 7)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
21	11	32-Bit Frozen Delta Counter Without Flag				
21	12	16-Bit Frozen Delta Counter Without Flag				
22	0	Counter Change Event—All Variations	1	6, 7, 8		
22	1	32-Bit Counter Change Event Without Time	1	6, 7, 8	129	17, 28
22	2[e]	16-Bit Counter Change Event Without Time	1	6, 7, 8	129, 130	17, 28
22	3	32-Bit Delta Counter Change Event Without Time				
22	4	16-Bit Delta Counter Change Event Without Time				
22	5	32-Bit Counter Change Event With Time	1	6, 7, 8	129	17, 28
22	6	16-Bit Counter Change Event With Time	1	6, 7, 8	129	17, 28
22	7	32-Bit Delta Counter Change Event With Time				
22	8	16-Bit Delta Counter Change Event With Time				
23	0	Frozen Counter Event—All Variations				
23	1	32-Bit Frozen Counter Event Without Time				
23	2	16-Bit Frozen Counter Event Without Time				
23	3	32-Bit Frozen Delta Counter Event Without Time				
23	4	16-Bit Frozen Delta Counter Event Without Time				
23	5	32-Bit Frozen Counter Event With Time				
23	6	16-Bit Frozen Counter Event With Time				
23	7	32-Bit Delta Counter Change Event With Time				
23	8	16-Bit Delta Counter Change Event With Time				
30[f]	0	Analog Input—All Variations	1	0, 1, 6, 7, 8, 17, 28		
30[f]	1	32-Bit Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[f]	2	16-Bit Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[f]	3	32-Bit Analog Input Without Flag	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[f]	4	16-Bit Analog Input Without Flag	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[f]	5	Short Floating Point Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[f]	6	Long Floating Point Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
31	0	Frozen Analog Input—All Variations				
31	1	32-Bit Frozen Analog Input				
31	2	16-Bit Frozen Analog Input				
31	3	32-Bit Frozen Analog Input With Time of Freeze				
31	4	16-Bit Frozen Analog Input With Time of Freeze				
31	5	32-Bit Frozen Analog Input Without Flag				
31	6	16-Bit Frozen Analog Input Without Flag				
31	7	Short Floating Point Frozen Analog Input				

Table D.9 SEL-700G DNP Object List (Sheet 5 of 7)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
31	8	Long Floating Point Frozen Analog Input				
32[f]	0	Analog Change Event—All Variations	1	6, 7, 8		
32[f]	1	32-Bit Analog Change Event Without Time	1	6, 7, 8	129	17, 28
32[f]	2	16-Bit Analog Change Event Without Time	1	6, 7, 8	129, 130	17, 28
32[f]	3	32-Bit Analog Change Event With Time	1	6, 7, 8	129	17, 28
32[f]	4	16-Bit Analog Change Event With Time	1	6, 7, 8	129	17, 28
32[f]	5	Short Floating Point Analog Change Event	1	6, 7, 8	129	17, 28
32[f]	6	Long Floating Point Analog Change Event	1	6, 7, 8	129	17, 28
32[f]	7	Short Floating Point Analog Change Event With Time	1	6, 7, 8	129	17, 28
32[f]	8	Long Floating Point Analog Change Event With Time	1	6, 7, 8	129	17, 28
33	0	Frozen Analog Event—All Variations				
33	1	32-Bit Frozen Analog Event Without Time				
33	2	16-Bit Frozen Analog Event Without Time				
33	3	32-Bit Frozen Analog Event With Time				
33	4	16-Bit Frozen Analog Event With Time				
33	5	Short Floating Point Frozen Analog Event				
33	6	Long Floating Point Frozen Analog Event				
33	7	Short Floating Point Frozen Analog Event With Time				
33	8	Long Floating Point Frozen Analog Event With Time				
34	0	Analog Deadband—All Variations				
34	1[e]	16-Bit Analog Input Reporting Deadband Object	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
34	2	32-Bit Analog Input Reporting Deadband Object	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
34	3	Floating Point Analog Input Reporting Deadband Object	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
40	0	Analog Output Status—All Variations	1	0, 1, 6, 7, 8	129	
40	1	32-Bit Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
40	2[e]	16-Bit Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
40	3	Short Floating Point Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
40	4	Long Floating Point Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
41	0	Analog Output Block—All Variations				
41	1	32-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
41	2[e]	16-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
41	3	Short Floating Point Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
41	4	Double-Precision Floating Point Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
50	0	Time and Date—All Variations				

Table D.9 SEL-700G DNP Object List (Sheet 6 of 7)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
50	1	Time and Date	1, 2	7, 8 index = 0	129	07, quantity=1
50	2	Time and Date With Interval				
50	3	Time and Date Last Recorded	2			
51	0	Time and Date CTO—All Variations		7 quantity = 1	129	
51	1	Time and Date CTO				
51	2	Unsynchronized Time and Date CTO			129	07, quantity=1
52	0	Time Delay—All Variations				
52	1	Time Delay, Coarse				
52	2	Time Delay, Fine			129	07, quantity=1
60	0	All Classes of Data	1, 20, 21	6, 7, 8		
60	1	Class 0 Data	1, 20, 21	6, 7, 8		
60	2	Class 1 Data	1	6, 7, 8		
60	3	Class 2 Data	1, 20, 21	6, 7, 8		
60	4	Class 3 Data	1, 20, 21	6, 7, 8		
70	1	File Identifier				
70	2	Authentication Object				
70	3	File Command Object				
70	4	File Command Status Object				
70	5	File Transport Object				
70	6	File Transport Status Object				
70	7	File Descriptor Object				
80	1	Internal Indications	2	0, 1 index=7		
81	1	Storage Object				
82	1	Device Profile				
83	1	Private Registration Object				
83	2	Private Registration Object Descriptor				
90	1	Application Identifier				
100	1	Short Floating Point				
100	2	Long Floating Point				
100	3	Extended Floating Point				
101	1	Small Packed Binary-Coded Decimal				
101	2	Medium Packed Binary-Coded Decimal				
101	3	Large Packed Binary-Coded Decimal				
110	all	Octet String				
111	all	Octet String Event				
112	All	Virtual Terminal Output Block				

Table D.9 SEL-700G DNP Object List (Sheet 7 of 7)

Obj.	Var.	Description	Request[a] Funct. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Funct. Codes[c]	Response[b] Qual. Codes[d]
113	All	Virtual Terminal Event Data				
N/A		No object required for the following function codes: 13 cold start 14 warm start 23 delay measurement	13, 14, 23			

[a] Supported in requests from master.
[b] May generate in response to master.
[c] Decimal.
[d] Hexadecimal.
[e] Default variation.
[f] Default variation specified by serial port setting DVARAI (or DVARAIn for Ethernet session n [n = 1, 2, 3, 4, or 5]).

Device Profile

The DNP3 Device Profile document, available on the supplied CD or as a download from the SEL website, contains the standard device profile information for the SEL-700G. This information is also available in XML format. Please refer to this document for complete information on DNP3 Protocol support in the SEL-700G.

Reference Data Map

NOTE: Deadband changes via Object 34 are not stored in nonvolatile memory. Make sure to reissue the Object 34 deadbands after a warm (**STA C**) or cold start (power cycle).

NOTE: Although the reference maps do not show Relay Word bit labels, you can use any Relay Word bit label for creating custom maps.

Table D.10 shows the SEL-700G reference data map. The reference map shows the data available to a DNP3 master. You can use the default map or the custom DNP3 mapping functions of the SEL-700G to retrieve only the points necessary for your application.

The SEL-700G scales analog values by the indicated settings or fixed scaling indicated in the description. Analog deadbands for event reporting use the indicated settings, or ANADBM if you have not specified a setting.

Table D.10 DNP3 Reference Data Map (Sheet 1 of 3)

Object	Labels	Description
Binary Inputs		
01, 02	STFAIL	Relay Diagnostic Failure (HALARM is latched)
	STWARN	Relay Diagnostic Warning (HALARM is pulsed)
	STSET	Relay Settings Change or Relay Restart
	Enabled–TLED_06[a]	Relay Word Elements Target Row 0 (see *Table L.1*)
	50PX1P–89CE39E2[a]	Relay Word Elements (see *Table L.1*)
	PFL_X	X-Side Power Factor Leading for Three-Phase Currents
	PFAL_X	X-side power factor leading for A-phase current
	PFBL_X	X-side power factor leading for B-phase current
	PFCL_X	X-side power factor leading for C-phase current
	PFL_Y	Y-Side Power Factor Leading for Three-Phase Currents
	PFAL_Y	Y-side power factor leading for A-phase current
	PFBL_Y	Y-side power factor leading for B-phase current
	PFCL_Y	Y-side power factor leading for C-phase current
	0	Logical 0
	1	Logical 1

NOTE: When you set EN_LRC := Y (see Table 9.6), the Relay Word bit LOCAL supervises the CCn and OCn (n = X or Y), 89CC2Pm and 89OC2Pm (m = 1–8). and 89CC3Pnm and 89OC3Pnm (n = L or E, m = 1–2) bits. For you to set the aforementioned binaries, the relay should be in remote control mode (i.e., LOCAL = 0). The Relay Word bit LOCAL is determined by the LOCAL SELOGIC control equation (see Table 9.6).

Table D.10 DNP3 Reference Data Map (Sheet 2 of 3)

Object	Labels	Description
Binary Outputs		
10, 12	RB01–RB32	Remote bits RB01–RB32
10, 12	RB01:RB02 RB03:RB04 RB05:RB06 • • • RB29:RB30 RB31:RB32	Remote bit pairs RB01–RB32
10, 12	OCX	Pulse Open Circuit Breaker X command
10, 12	CCX	Pulse Close Circuit Breaker X command
10, 12	OCX:CCX	Open/Close pair for Circuit Breaker X
10, 12	OCY	Pulse Open Circuit Breaker Y command
10, 12	CCY	Pulse Close Circuit Breaker Y command
10, 12	OCY:CCY	Open/Close pair for Circuit Breaker Y
10, 12	89OC2P1-89OC2P8	Pulse Open Two-Position Disconnects 1–8 command
10, 12	89CC2P1-89CC2P8	Pulse Close Two-Position Disconnects 1–8 command
10, 12	89OC2P1:89CC2P1 89OC2P2:89CC2P2 • • • 89OC2P8:89CC2P8	Open/Close Pair for Two-Position Disconnects 1–8
10, 12	89OC3PL1	Pulse Open Three-Position In-Line Disconnect 1 command
10, 12	89CC3PL1	Pulse Close Three-Position In-Line Disconnect 1 command
10, 12	89OC3PL1:89CC3PL1	Open/Close Pair for Three-Position In-Line Disconnect 1
10, 12	89OC3PL2	Pulse Open Three-Position In-Line Disconnect 2 command
10, 12	89CC3PL2	Pulse Close Three-Position In-Line Disconnect 2 command
10, 12	89OC3PL2:89CC3PL2	Open/Close Pair for Three-Position In-Line Disconnect 2
10, 12	89OC3PE1	Pulse Open Three-Position Earthing Disconnect 1 command
10, 12	89CC3PE1	Pulse Close Three-Position Earthing Disconnect 1 command
10, 12	89OC3PE1:89CC3PE1	Open/Close Pair for Three-Position Earthing Disconnect 1
10, 12	89OC3PE2	Pulse Open Three-Position Earthing Disconnect 2 command

Table D.10 DNP3 Reference Data Map (Sheet 3 of 3)

Object	Labels	Description
10, 12	89CC3PE2	Pulse Close Three-Position Earthing Disconnect 2 command
10, 12	89OC3PE2:89CC3PE2	Open/Close Pair for Three-Position Earthing Disconnect 2
Counters		
20, 22	SC*xx*	SELOGIC Counter Values (*xx* = 01–32)
	GROUP	Active Settings Group
Analog Inputs		
30, 32, 34	IAX_MAG–SC32[b] [c]	Analog Quantities from *Table M.1* with an "x" in the DNP column
	SER_NUM	Serial Number
	0	Numeric 0
	1	Numeric 1
Analog Outputs		
40, 41	RA*xxx*	Remote Analogs (RA001 to RA128)
	GROUP	Active Settings Group
	NOOP	No operation, no error

[a] Valid Relay Word bits depend on the relay model.
[b] Valid analog inputs depend on the relay model.
[c] Refer to Analog Inputs on page D.25 for default analog input scaling and deadbands.

NOTE: All fault information analog inputs contain data from the latest captured event (see Appendix M: Analog Quantities).

Default Data Map

The default data map is an automatically generated subset of the reference map. All data maps are initialized to the default values, based on the SEL-700G part number. *Table D.11* shows the SEL-700G default data map. If the default maps are not appropriate, you can also use the custom DNP mapping commands **SET DNP** and **SHOW DNP** to create the map necessary for your application.

Table D.11 DNP3 Default Data Map

Object	Default Index	Point Label
01, 02	0	ENABLED
	1	TRIP
	2	STWARN
	3	STFAIL
	4	STSET
	5	IN101
	6	IN102
	7–99	A portion of these binary inputs can have default values as described in *Default Binary Inputs on page D.22*. Outside that scope, they contain the value NA.
10, 12	0–31	RB01–RB32 Remote Bits
20, 22	0–31	NA
30, 32, 34	0–99	A portion of these analog inputs can have default values as described in *Default Analog Inputs on page D.22*. Outside that scope, they contain the value NA.
40, 41	0–31	NA

Default Binary Inputs

The SEL-700G dynamically creates the default binary input map after you issue an **R_S** command. The SEL-700G uses the part number to determine the presence of digital input cards in Slots 3, 4, and 5. If present, each digital input point label, IN*x*0*y* (where *x* is the slot number and *y* is the point), is added to the default map in numerical order.

Default Analog Inputs

NOTE: Deadband changes via Object 34 are stored in nonvolatile memory. Make sure to reissue the Object 34 deadbands after a warm (**STA C**) or cold start (power cycle).

The SEL-700G dynamically creates the default analog input map after you issue an **R_S** command. The SEL-700G first checks for the current and voltage card option in the part number and adds the following analog quantities depending on the card options available: IAX_MAG, IBX_MAG, ICX_MAG, IGX_MAG, I1X_MAG, 3I2X_MAG, IAY_MAG, IBY_MAG, ICY_MAG, IGY_MAG, I1Y_MAG, 3I2Y_MAG, IN_MAG, VAX_MAG, VBX_MAG, VCX_MAG, VGX_MAG, V1X_MAG, 3V2X_MAG, VAY_MAG, VBY_MAG, VCY_MAG, VGY_MAG, V1Y_MAG, 3V2Y_MAG, VS_MAG, VN_MAG, VN3_MAG, VPX3_MAG, P3X, Q3X, S3X PF3X, FREQX, VHZX, P3Y, Q3Y, S3Y, PF3Y, FREQY. The SEL-700G then uses the part number to determine the presence of analog input cards in Slots 3, 4, and 5. If present, each analog input point label, AI*x*0*y*, where *x* is the slot and *y* is the point number, is added to the default map in numerical order.

Device Attributes (Object 0)

Table D.9 includes the supported Object 0 device attributes and variations. In response to Object 0 requests, the SEL-700G sends attributes that apply to that particular DNP3 session. Because the SEL-700G supports custom DNP3 maps, these values will likely be different for each session.

The SEL-700G uses its internal settings for the following Variations:

- Variation 242-FID string
- Variation 243-Part Number
- Variation 245-TID setting
- Variation 246-RID setting
- Variation 247-RID setting
- Variation 248-Serial Number

Variation 249 shall contain the DNP subset and conformance, “2:2009.” Variation 250 shall contain the product model, “SEL-700G Relay” and Variation 252 shall contain “SEL.”

Binary Inputs

Binary inputs (Objects 1 and 2) are supported as defined by *Table D.11*. The default variation for both static and event inputs is 2. Only the Read function code (1) is allowed with these objects. All variations are supported. Object 2, variation 3 will be responded to, but will contain no data.

Binary inputs are scanned approximately twice per second to generate events. When time is reported with these event objects, it is the time at which the scanner observed the bit change. This may be significantly delayed from when the original source changed and should not be used for sequence-of-events determination. Binary inputs registered with SER are derived from the SER and carry the time stamp of actual occurrence. Some additional binary inputs are available only to communication protocols such as DNP and EtherNet/IP. For example, STWARN and STFAIL are derived from the diagnostic task data. Another binary input, STSET, is derived from the SER and carries the time stamp of actual occurrence. Static reads of this input always show 0.

Binary Outputs

Binary output status (Object 10, Variation 2) is supported. Static reads of points RB01–RB32, OCX/CCX, OCY/CCY, 89OC2P*m*/89CC2P*m* (where *m* = 1–8), or 89OC3P*nm*/89CC3P*nm* (where *n* = L or E, and *m* = 1–2) respond with the on-line bit set and the state of the requested bit. Reads from control-only binary output points respond with the on-line bit set and a state of 0.

The SEL-700G supports Control Relay Output Block objects (Object 12, Variation 1). The control relays correspond to the remote bits and other functions as shown previously. Each DNP Control message contains a Trip/Close code (TRIP, CLOSE, or NUL) and an Operation type (PULSE ON, LATCH ON, LATCH OFF, or NUL). The Trip/Close code works with the Operation Type to produce set, clear, and pulse operations.

Control operations differ slightly for single-point controls compared to paired outputs. Paired outputs correspond to the complementary two-output model, and single-point controls follow the complementary latch or activation model. In the complementary two-output model, paired points only support Trip or Close operations, which, when issued, Pulse On the first or second point in the pair, respectively. Latch commands and Pulse operations without a Trip code are not supported. An operation in progress can be cancelled by issuing a NUL Trip/Close Code with a NUL Operation Type. Single output points support both Pulse and Latch operations. See *Control Point Operation* for details on control operations.

The Status field is used exactly as defined. All other fields are ignored. A pulse operation is asserted for a single processing interval. Exercise caution if sending multiple remote bit pulses in a single message (i.e., point count > 1), because this can result in some of the pulse commands being ignored and the return of an already active status message. The SEL-700G only honors the first 10 points in an Object 12, Variation 1 request. Any additional points in the request return the DNP3 status code TOO_MANY_OBJS.

The SEL-700G also supports Pattern Control Blocks (Object 12, Variations 2 and 3) to control multiple binary output points. Variation 2 defines the control type (Trip/Close, Set/Clear, or Pulse) and the range of points to operate. Variation 3 provides a pattern mask that indicates which points in that range should be operated. Object 12, Variations 2 and 3 define the entire control command: the DNP3 master must send both for a successful control. For example, the DNP3 master sends an Object 12, Variation 2 message to request a Trip of the range of indices 0–7. The DNP3 master then sends an Object 12, Variation 3 message with a hexadecimal value of "BB" as the pattern mask (converted to binary notation: 10111011). Read right to left in increasing bit order, the Pattern Block Control command results in a TRIP of indexes 0, 1, 3 to 5, and 7. Multiple binary output point control operations are not guaranteed to occur during the same processing interval.

Control Point Operation

Use the Trip and Close, Latch On/Off and Pulse On operations with Object 12 control relay output block command messages to operate the points shown in *Table D.12*. Pulse operations provide a pulse with duration of one protection processing interval.

When setting EN_LRC := Y (see *Table 9.6*), the Relay Word bit LOCAL supervises the CC*n* and OC*n* (*n* = X or Y), 89CC2P*m* and 89OC2P*m* (*m* = 1–8), and 89CC3P*nm* and 89OC2P*nm* (*n* = L or E, *m* = 1–2) bits. If the LOCAL bit is asserted (LOCAL = 1), the relay does not set the aforementioned bits. The LOCAL SELOGIC control equation (see *Table 9.6*) determines Relay Word bit LOCAL.

Table D.12 SEL-700G Object 12 Control Operations (Sheet 1 of 2)

Label	Close/Pulse On	Trip/Pulse On	Null/Latch On	Null/Latch Off	Null/Pulse On
RB01–RB32	Pulse Remote Bit RB01–RB32	Pulse Remote Bit RB01–RB32	Set Remote Bit RB01–RB32	Clear Remote Bit RB01–RB32	Pulse Remote Bit RB01–RB32
RB*xx*:RB*yy*	Pulse RB*yy* RB01–RB32	Pulse RB*xx* RB01–RB32	Pulse RB*yy* RB01–RB32	Pulse RB*xx* RB01–RB32	Pulse RB*yy* RB01–RB32
OCX	Open Circuit Breaker X (Pulse OCX)	Open Circuit Breaker X (Pulse OCX)	Open Circuit Breaker X (Pulse OCX)	No Action	Open Circuit Breaker X (Pulse OCX)
CCX	Close Circuit Breaker X (Pulse CCX)	Close Circuit Breaker X (Pulse CCX)	Close Circuit Breaker X (Pulse CCX)	No Action	Close Circuit Breaker X (Pulse CCX)
OCY	Open Circuit Breaker Y (Pulse OCY)	Open Circuit Breaker Y (Pulse OCY)	Open Circuit Breaker Y (Pulse OCY)	No Action	Open Circuit Breaker Y (Pulse OCY)
CCY	Close Circuit Breaker Y (Pulse CCY)	Close Circuit Breaker Y (Pulse CCY)	Close Circuit Breaker Y (Pulse CCY)	No Action	Close Circuit Breaker Y (Pulse CCY)
OCX:CCX	Close Circuit Breaker X (Pulse CCX)	Open Circuit Breaker X (Pulse OCX)	Close Circuit Breaker X (Pulse CCX)	Close Circuit Breaker X (Pulse OCX)	Close Circuit Breaker X (Pulse CCX)
OCY:CCY	Close Circuit Breaker Y (Pulse CCY)	Open Circuit Breaker Y (Pulse OCY)	Close Circuit Breaker Y (Pulse CCY)	Close Circuit Breaker Y (Pulse OCY)	Close Circuit Breaker Y (Pulse CCY)
89OC2P1-89OC2P8	Open 2-Position Disconnect (Pulse 89OC2P1-89OC2P8)	Open 2-Position Disconnect (Pulse 89OC2P1-89OC2P8)	Open 2-Position Disconnect (Pulse 89OC2P1-89OC2P8)	No Action	Open 2-Position Disconnect (Pulse 89OC2P1-89OC2P8)
89CC2P1-89CC2P8	Close 2-Position Disconnect (Pulse 89CC2P1-89CC2P8)	Close 2-Position Disconnect (Pulse 89CC2P1-89CC2P8)	Close 2-Position Disconnect (Pulse 89CC2P1-89CC2P8)	No Action	Close 2-Position Disconnect (Pulse 89CC2P1-89CC2P8)
89OC2Pm: 89CC2Pm	Close 2-Position Disconnect (Pulse 89CC2P1-89CC2P8)	Open 2-Position Disconnect (Pulse 89OC2P1-89OC2P8)	Close 2-Position Disconnect (Pulse 89CC2P1-89CC2P8)	Open 2-Position Disconnect (Pulse 89OC2P1-89OC2P8)	Close 2-Position Disconnect (Pulse 89CC2P1-89CC2P8)
89OC3PL1	Open 3-Position In-Line Disconnect (Pulse 89OC3PL1)	Open 3-Position In-Line Disconnect (Pulse 89OC3PL1)	Open 3-Position In-Line Disconnect (Pulse 89OC3PL1)	No Action	Open 3-Position In-Line Disconnect (Pulse 89OC3PL1)
89CC3PL1	Close 3-Position In-Line Disconnect (Pulse 89CC3PL1)	Close 3-Position In-Line Disconnect (Pulse 89CC3PL1)	Close 3-Position In-Line Disconnect (Pulse 89CC3PL1)	No Action	Close 3-Position In-Line Disconnect (Pulse 89CC3PL1)
89OC3PL1: 89CC3PL1	Close 3-Position In-Line Disconnect (Pulse 89CC3PL1)	Open 3-Position In-Line Disconnect (Pulse 89OC3PL1)	Close 3-Position In-Line Disconnect (Pulse 89CC3PL1)	Open 3-Position In-Line Disconnect (Pulse 89OC3PL1)	Close 3-Position In-Line Disconnect (Pulse 89CC3PL1)
89OC3PL2	Open 3-Position In-Line Disconnect (Pulse 89OC3PL2)	Open 3-Position In-Line Disconnect (Pulse 89OC3PL2)	Open 3-Position In-Line Disconnect (Pulse 89OC3PL2)	No Action	Open 3-Position In-Line Disconnect (Pulse 89OC3PL2)
89CC3PL2	Close 3-Position In-Line Disconnect (Pulse 89CC3PL2)	Close 3-Position In-Line Disconnect (Pulse 89CC3PL2)	Close 3-Position In-Line Disconnect (Pulse 89CC3PL2)	No Action	Close 3-Position In-Line Disconnect (Pulse 89CC3PL2)
89OC3PL2: 89CC3PL2	Close 3-Position In-Line Disconnect (Pulse 89CC3PL2)	Open 3-Position In-Line Disconnect (Pulse 89OC3PL2)	Close 3-Position In-Line Disconnect (Pulse 89CC3PL2)	Open 3-Position In-Line Disconnect (Pulse 89OC3PL2)	Close 3-Position In-Line Disconnect (Pulse 89CC3PL2)

Table D.12 SEL-700G Object 12 Control Operations (Sheet 2 of 2)

Label	Close/Pulse On	Trip/Pulse On	Null/Latch On	Null/Latch Off	Null/Pulse On
89OC3PE1	Open 3-Position Earthing Disconnect (Pulse 89OC3PE1)	Open 3-Position Earthing Disconnect (Pulse 89OC3PE1)	Open 3-Position Earthing Disconnect (Pulse 89OC3PE1)	No Action	Open 3-Position Earthing Disconnect (Pulse 89OC3PE1)
89CC3PE1	Close 3-Position Earthing Disconnect (Pulse 89CC3PE1)	Close 33-Position Earthing Disconnect (Pulse 89CC3PE1)	Close 3-Position Earthing Disconnect (Pulse 89CC3PE1)	No Action	Close 3-Position Earthing Disconnect (Pulse 89CC3PE1)
89OC3PE1: 89CC3PE1	Close 3-Position Earthing Disconnect (Pulse 89CC3PE1)	Open 3-Position Earthing Disconnect (Pulse 89OC3PE1)	Close 3-Position Earthing Disconnect (Pulse 89CC3PE1)	Open 3-Position Earthing Disconnect (Pulse 89OC3PE1)	Close 3-Position Earthing Disconnect (Pulse 89CC3PE1)
89OC3PE2	Open 3-Position Earthing Disconnect (Pulse 89OC3PE2)	Open 3-Position Earthing Disconnect (Pulse 89OC3PE2)	Open 3-Position Earthing Disconnect (Pulse 89OC3PE2)	No Action	Open 3-Position Earthing Disconnect (Pulse 89OC3PE2)
89CC3PE2	Close 3-Position Earthing Disconnect (Pulse 89CC3PE2)	Close 3-Position Earthing Disconnect (Pulse 89CC3PE2)	Close 3-Position Earthing Disconnect (Pulse 89CC3PE2)	No Action	Close 3-Position Earthing Disconnect (Pulse 89CC3PE2)
89OC3PE2: 89CC3PE2	Close 3-Position Earthing Disconnect (Pulse 89CC3PE2)	Open 3-Position Earthing Disconnect (Pulse 89OC3PE2)	Close 3-Position Earthing Disconnect (Pulse 89CC3PE2)	Open 3-Position Earthing Disconnect (Pulse 89OC3PE2)	Close 3-Position Earthing Disconnect (Pulse 89CC3PE2)

Analog Inputs

Analog Inputs (30) and Analog Change Events (32) are supported as defined in *Table D.9*. The DVARAI1 (DVARAI*n* for DNP3 LAN/WAN Session *n*) setting defines the default variation for both static and event inputs. Only the Read function code (1) is allowed with these objects. Unless otherwise indicated, analog values are reported in primary units. See *Appendix M: Analog Quantities* for a list of all available analog inputs.

For all currents, the default scaling is the DECPLA setting on magnitudes and scale factor of 100 on angles. The default deadband for currents is ANADBV on magnitudes and ANADBM on angles. For all voltages, the default scaling is the DECPLV setting on magnitudes and scale factor of 100 on angles. The default deadband for voltages is ANADBV on magnitudes and ANADBM on angles. For all powers and energies, the default scaling is the DECPLM setting and default deadband is ANADBM. For all other quantities, the default scaling is 1 and default deadband is ANADBM.

Default scaling and deadbands can be overridden by per-point scaling and deadband. See *Configurable Data Mapping on page D.25* for more information. Deadbands for analog inputs can also be modified by writing to Object 34.

NOTE: Deadband changes via Object 34 are not stored in nonvolatile memory. Make sure to reissue the Object 34 deadband changes you want to retain after a change to DNP port settings, issuing a **STA C** command, or a relay cold-start (power-cycle).

A deadband check is done after any scaling has been applied. Event class messages are generated whenever an input changes beyond the value given by the appropriate deadband setting. The voltage and current phase angles only generate an event if, in addition to their deadband check, the corresponding magnitude changes beyond its own deadband. Analog inputs are scanned approximately twice a second. All events generated during a scan use the time the scan was initiated.

Configurable Data Mapping

One of the most powerful features of the SEL-700G implementation is the ability to remap DNP3 data and, for analog values, specify per-point scaling and deadbands. Remapping is the process of selecting data from the reference map and organizing it into a data subset optimized for your application. The

SEL-700G uses object and point labels, rather than point indices, to streamline the remapping process. This enables you to quickly create a custom map without having to search for each point index in a large reference map.

You can use any of the three available DNP3 maps simultaneously with as many as five unique DNP3 masters. Each map is initially populated with default data points, as described in *Default Data Map on page D.21*. You can remap the points in a default map to create a custom map with as many as:

- ➤ 100 Binary Inputs
- ➤ 32 Binary Outputs
- ➤ 100 Analog Inputs
- ➤ 32 Analog Outputs
- ➤ 32 Counters

You can use the **SHOW DNP *x* <Enter>** command to view the DNP3 data map settings, where *x* is the DNP3 map number from 1 to 3. See *Figure D.3* for an example display of Map 1.

```
=>>SHO DNP 1 <Enter>

DNP Map 1 Settings

Binary Input Map
BI_00    := ENABLED
BI_01    := TRIP
BI_02    := TRIPX
BI_03    := TRIPY
…
BI_97    := IN101
BI_98    := IN102
BI_99    := 50PX1P

Binary Output Map
BO_00    := RB01
BO_01    := RB02
BO_02    := RB03
…
BO_29    := RB30
BO_30    := RB31
BO_31    := RB32

Analog Input Map
AI_00    := IAX_MAG
AI_01    := IBX_MAG
AI_02    := ICX_MAG
…
AI_95    := FREQX
AI_96    := P3X
AI_97    := Q3X
AI_98    := S3X
AI_99    := PF3X

Analog Output Map
AO_00    := GROUP
AO_01    := RA001
AO_02    := RA002
…
AO_29    := RA029
AO_30    := RA030
AO_31    := RA031

Counter Map
CO_00    := SC01
CO_01    := SC02
CO_02    := SC03
…
CO_29    := SC30
CO_30    := SC31
CO_31    := SC32

=>>
```

Figure D.3 Sample Response to SHO DNP Command

You can also use the **MAP DNP** ***y s*** **<Enter>** command to display DNP3 maps, but the parameter ***y*** is the port number from 1 to 4. Because Port 1, the Ethernet port, can support multiple DNP3 sessions, it may have a different map assigned to each session selected by parameter *s* for Sessions 1 to 5. See *Figure D.4* for an example of a **MAP** command that shows the same map as in *Figure D.3*.

```
=>MAP DNP 1 1 <Enter>

SEL-700GT Date: 06/24/2009 Time: 09:33:39
INTERTIE RELAY Time Source: Internal

Map1
Transport TCP
Device IP Address 10.201.5.3
Master IP Address10.200.0.139
Device DNP TCP and UDP Port 20000
Device DNP Address 15
Master DNP Address 0

Binary Inputs
--------------------------------------------------------------------------------
INDEXPOINT LABEL EVENT CLASSSER TIMESTAMP
0 ENABLED 1
1 TRIP 1
2 TRIPX 1 YES
3 TRIPY 1 YES
…
97 IN101 1 YES
98 IN102 1 YES
99 50PX1P 1

Binary Outputs
--------------------------------------------------------------------------------
INDEX POINT LABEL
0 RB01
1 RB02
2 RB03
…
29 RB30
30 RB31
31 RB32

Counters
--------------------------------------------------------------------------------
INDEX POINT LABEL EVENT CLASSDEADBAND
0 SC01 0 1
1 SC02 0 1
2 SC03 0 1
…
29 SC30 0 1
30 SC31 0 1
31 SC32 0 1

Analog Inputs
--------------------------------------------------------------------------------
INDEX POINT LABEL EVENT CLASS SCALE FACTOR DEADBAND
0IAX_MAG 2 10.0000 1000
1 IBX_MAG 2 10.0000 1000
2 ICX_MAG 2 10.0000 1000
3 IAY_MAG 2 10.0000 1000
4 IBY_MAG 2 10.0000 1000
5 ICY_MAG 2 10.0000 1000
6 IGX_MAG 2 10.0000 1000
7 IGY_MAG 2 10.0000 1000
8 IN_MAG 2 10.0000 1000
9 IAVXMAG 2 10.0000 1000
10 IAVYMAG 2 10.0000 1000
11 3I2XMAG 2 10.0000 1000
12 3I2YMAG 2 10.0000 1000
13 FREQX 2 1.0000 100
14 VAX_MAG 2 10.0000 2000
15 VBX_MAG 2 10.0000 2000
16 VCX_MAG 2 10.0000 2000
17 VGX_MAG 2 10.0000 2000
18 V1X_MAG 2 10.0000 2000
…
…
96 P3X 2 10.0000 100
97 Q3X 2 10.0000 100
98 S3X 2 10.0000 100
99 PF3X 2 10.0000 100
```

Figure D.4 Port MAP Command

```
Analog Outputs
--------------------------------------------------------------------------------
INDEX  POINT LABEL
0      GROUP
1      RA001
2      RA002
...
...
30    RA030
31    RA031

=>
```

Figure D.4 Port MAP Command (Continued)

You can use the command **SET DNP *x***, where ***x*** is the map number, to edit or create custom DNP3 data maps. You can also use ACSELERATOR QuickSet SEL-5030 Software, which is recommended for this purpose.

Scaling factors allow you to overcome the limitations imposed by the integer nature of the default variations of Objects 30 and 32. For example, the device rounds a value of 11.4 A to 11 A. You can use scaling to include decimal point values by multiplying by a number larger than one. If you use 10 as a scaling factor, 11.4 A are transmitted as 114. You must divide the value by 10 in the master to see the original value including one decimal place.

You can also use scaling to avoid overflowing the 16-bit maximum integer value of 32767. For example, if you have a value that can reach 157834, you cannot send it using DNP3 16-bit analog object variations. You could use a scaling factor of 0.1 so that the maximum value reported is 15783. You can then multiply the value by 10 in the master to see a value of 157830. You lose some precision as the last digit is rounded off in the scaling process, but you can transmit the scaled value using standard DNP3 Objects 30 and 32.

You can customize the DNP3 analog input map with per-point scaling, and deadband settings. Per-point customization is not necessary, but class scaling (DECPLA, DECPLV, and DECPLM) and deadband (ANADBA, ANADBV, and ANADBM) settings are applied to indices that do not have per-point entries. Unlike per-point scaling described previously, class-level scaling is specified by an integer in the range 0–3 (inclusive), which indicates the number of decimal place shifts. In other words, select 0 to multiply by 1, 1 for 10, 2 for 100, or 3 for 1000.

If it is important to maintain tight data coherency (that is, all data read of a certain type were sampled or calculated at the same time), then group those data together within your custom map. For example, if you want all the X-Side currents to be coherent, group points IAX_MAG, IBX_MAG, ICX_MAG, and IGX_MAG together in the custom map. If points are not grouped together, they might not come from the same data sample.

The following example describes how to create a custom DNP3 map by point type. The example demonstrates the SEL ASCII command **SET DNP** for each point type, but you can complete the entire configuration without saving changes between point types. To do this, you simply continue entering data and save the entire map at the end. Alternatively, you can use QuickSet to simplify custom data map creation.

Consider a case where you want to set the AI points in a map as shown in *Table D.13*.

Table D.13 Sample Custom DNP3 AI Map

Desired Point Index	Description	Label	Scaling	Deadband
0	X-Side IA magnitude	IAX_MAG	default	default
1	X-Side IB magnitude	IBX_MAG	default	default
2	X-Side IC magnitude	ICX_MAG	default	default
3	Y-Side IA magnitude	IAY_MAG	default	default
4	Three-Phase Real Power	P3X	5	default
5	X-Side AB Phase-to-Phase Voltage Magnitude	VABX-_MAG	default	default
6	X-Side AB Phase-to-Phase Voltage Angle	VABX_ANG	1	15
7	X-Side Frequency	FREQX	.01	1

To set these points as part of custom map 1, you can use the **SET DNP 1 AI_00 TERSE <Enter>** command as shown in *Figure D.5*.

```
=>>SET DNP 1 AI_00 TERSE <Enter>
Analog Input Map

DNP Analog Input Label Name (25 characters)
AI_00   := NA
? > IAX_MAG <Enter>

AI_01   := NA
? > IBX_MAG <Enter>

AI_02   := NA
? > ICX_MAG <Enter>

AI_03   := NA
? > IAY_MAG <Enter>

AI_04   := NA
? > P3X:5 <Enter>

AI_05   := NA
? > VAX_MAG <Enter>

AI_06   := NA
? > VAX_ANG:1:15 <Enter>

AI_07   := NA
? > FREQX:.01:1 <Enter>

AI_08   := NA
? > end <Enter>

Save changes (Y/N) ? Y <Enter>

=>>
```

Figure D.5 Sample Custom DNP3 AI Map Settings

You can also use QuickSet to enter the previous AI map settings as shown in the screen capture in *Figure D.6*. You can enter scaling and deadband settings in the same pop-up dialog used to select the AI point, as shown in *Figure D.7*.

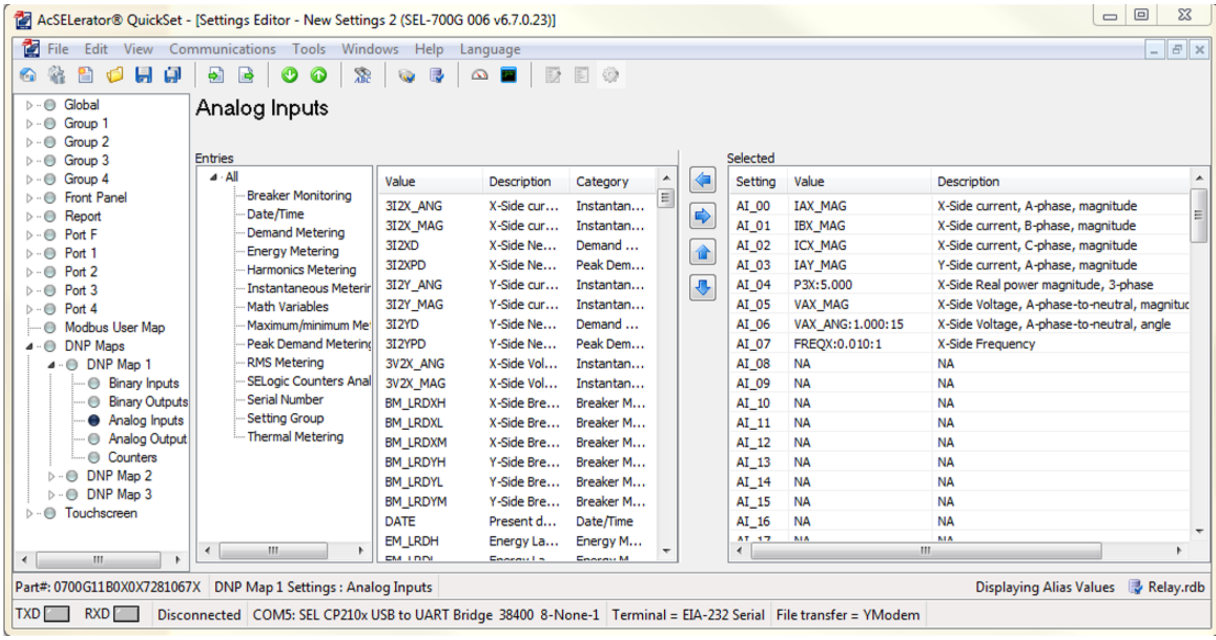

Figure D.6 Analog Input Map Entry in QuickSet

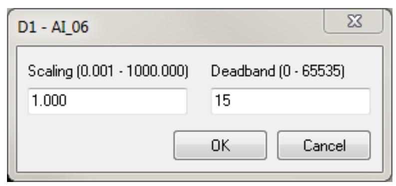

Figure D.7 AI Point Scaling and Deadband in QuickSet

The **SET DNP x AO_00 <Enter>** command allows you to populate the DNP analog output map with any of the 128 remote analogs (RA001–RA128) or the GROUP variable (present settings group) as shown in *Figure D.8*.

```
=>>SET DNP 1 AO_00 TERSE <Enter>

DNP Map 1 Settings

Analog Output Map

DNP Analog Output Label Name (6 characters)    AO_00   := NA        ? group
DNP Analog Output Label Name (6 characters)    AO_01   := NA        ? ra001
DNP Analog Output Label Name (6 characters)    AO_02   := NA        ? ra002
DNP Analog Output Label Name (6 characters)    AO_03   := NA        ? ra120
DNP Analog Output Label Name (6 characters)    AO_04   := NA        ? ra128
DNP Analog Output Label Name (6 characters)    AO_05   := NA        ?
DNP Analog Output Label Name (6 characters)    AO_06   := NA        ? end
Save changes (Y,N)? y
Settings Saved

=>>
```

Figure D.8 Sample Custom DNP3 AO Map Settings

You can also use QuickSet to enter the AO map settings as shown in the screen capture in *Figure D.9*.

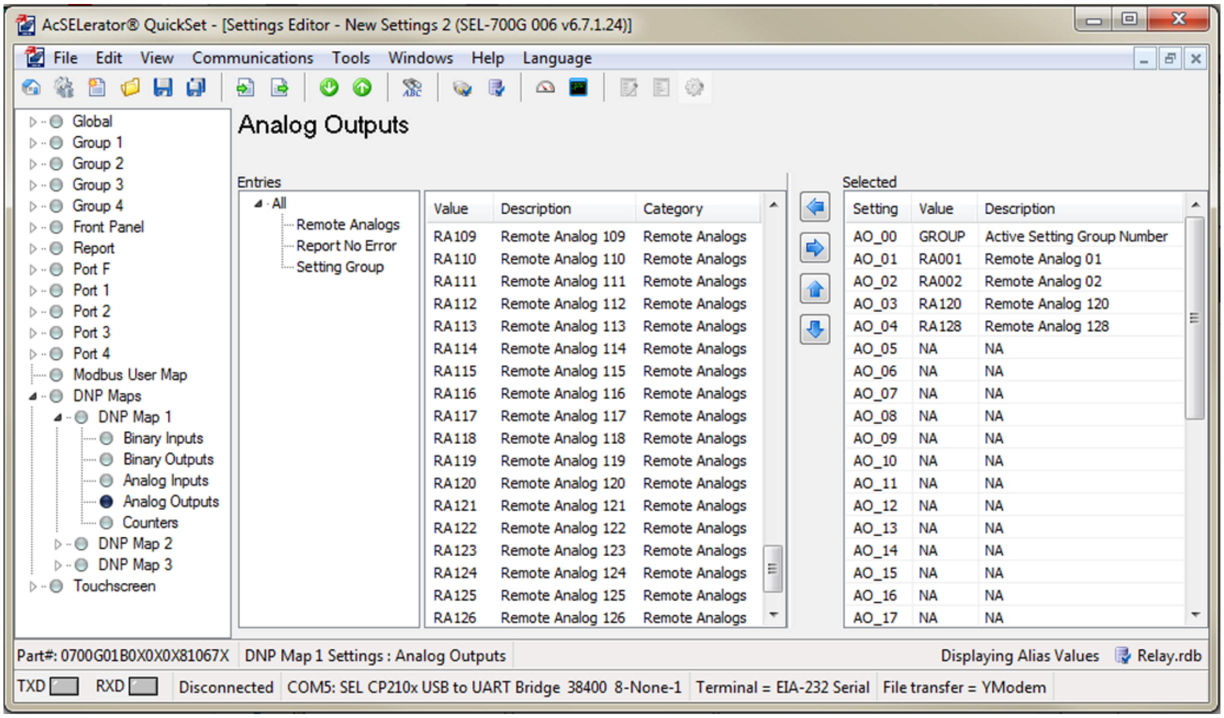

Figure D.9 Analog Output Map Entry in QuickSet

The **SET DNP *x* CO_00 <Enter>** command allows you to populate the DNP counter map with per-point deadbands. Entering these settings is similar to defining the analog input map settings.

You can use the command **SET DNP *x* BO_00 TERSE <Enter>** to change the binary output Map *x* as shown in *Figure D.10*. You can populate the custom BO map with any of the 32 remote bits (RB01–RB32). You can define bit pairs in BO maps by including a colon (:) between the bit labels.

```
=>>SET DNP 1 BO_00 TERSE <Enter>
Binary Output Map

DNP Binary Output Label Name (23 characters)
BO_00    := NA
? > RB01 <Enter>

DNP Binary Output Label Name (23 characters)
BO_01    := NA
? > RB02 <Enter>

DNP Binary Output Label Name (23 characters)
BO_02    := NA
? > RB03:RB04 <Enter>

DNP Binary Output Label Name (23 characters)
BO_03    := NA
? > RB05:RB06 <Enter>

DNP Binary Output Label Name (23 characters)
BO_04    := NA
? > end <Enter>

=>>
```

Figure D.10 Sample Custom DNP3 BO Map Settings

You can also use QuickSet to enter the BO map settings as shown in the screen capture in *Figure D.11*.

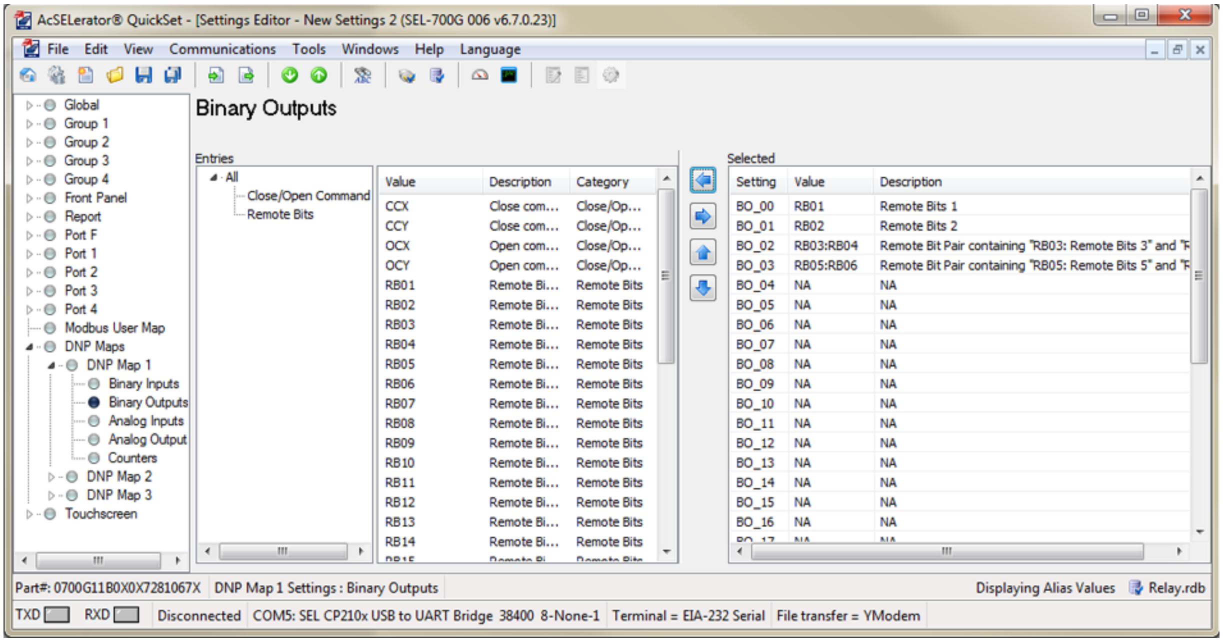

Figure D.11 Binary Output Map Entry in QuickSet

The binary input (BI) maps are modified in a similar manner, but pairs are not allowed.

Appendix E
Modbus Communications

Overview

This appendix describes Modbus RTU communications features supported by the SEL-700G Relay. Complete specifications for the Modbus protocol are available from the Modbus user's group website at modbus.org.

Enable Modbus TCP protocol with the optional Ethernet port settings. The SEL-700G supports as many as two Modbus TCP sessions. The TCP port number for each session is selected with the Ethernet port settings. The default TCP port number is the Modbus TCP registered port 502. Modbus TCP uses the device IP address as the Modbus identifier and accesses the data in the relay by using the same function codes and data maps as Modbus RTU.

Enable Modbus RTU protocol with the serial port settings. When Modbus RTU protocol is enabled, the relay switches the port to Modbus RTU protocol and deactivates the ASCII protocol.

Modbus RTU is a binary protocol that permits communication between a single master device and multiple slave devices. The communication is half duplex—only one device transmits at a time. The master transmits a binary command that includes the address of the necessary slave device. All of the slave devices receive the message, but only the slave device with the matching address responds.

The SEL-700G Modbus communication allows a Modbus master device to do the following:

- ➤ Acquire metering, monitoring, and event data from the relay.
- ➤ Control SEL-700G output contacts.
- ➤ Read the SEL-700G self-test status and learn the present condition of all the relay protection elements.

Communications Protocol

Modbus Queries

Modbus RTU master devices initiate all exchanges by sending a query. The query consists of the fields shown in *Table E.1*.

Table E.1 Modbus Query Fields

Field	Number of Bytes
Slave Device Address	1 byte
Function Code	1 byte
Data Region	0–251 bytes
Cyclical Redundancy Check (CRC)	2 bytes

The SEL-700G SLAVEID setting defines the device address. Set this value to a unique number for each device on the Modbus network. For Modbus communication to operate properly, no two slave devices can have the same address.

The cyclical redundancy check detects errors in the received data. If the relay detects an error, it discards the packet.

Modbus Responses

The slave device sends a response message after it performs the action the query specifies. If the slave cannot execute the query command for any reason, it sends an error response. Otherwise, the slave device response is formatted similarly to the query and includes the slave address, function code, data (if applicable), and a cyclical redundancy check value.

Supported Modbus Function Codes

The SEL-700G supports the Modbus function codes shown in *Table E.2*.

Table E.2 SEL-700G Modbus Function Codes

Codes	Description
01h	Read Discrete Output Coil Status
02h	Read Discrete Input Status
03h	Read Holding Registers
04h	Read Input Registers
05h	Force Single Coil
06h	Preset Single Register
08h	Diagnostic Command
10h	Preset Multiple Registers
60h	Read Parameter Information
61h	Read Parameter Text
62h	Read Enumeration Text
7Dh	Encapsulate Modbus Packet With Control
7Eh	NOP (can only be used with the 7Dh function)

Modbus Exception Responses

The SEL-700G sends an exception code under the conditions described in *Table E.3*.

Table E.3 SEL-700G Modbus Exception Codes

Exception Code	Error Type	Description
1	Illegal Function Code	The received function code is either undefined or unsupported.
2	Illegal Data Address	The received command contains an unsupported address in the data field.
3	Illegal Data Value	The received command contains a value that is out of range.
4	Device Error	The SEL-700G is in the wrong state for the function a query specifies. This also stands for Service Failure for DeviceNet interface applications. The relay is unable to perform the action specified by a query (that is, it cannot write to a read-only register).
6	Busy	The device is unable to process the command at this time, because of a busy resource.

In the event that any of the errors listed in *Table E.3* occur, the relay assembles a response message that includes the exception code in the data field. The relay sets the most significant bit in the function code field to indicate to the master that the data field contains an error code, instead of the necessary data.

Cyclical Redundancy Check

The SEL-700G calculates a 2-byte CRC value through use of the device address, function code, and data region. It appends this value to the end of every Modbus response. When the master device receives the response, it recalculates the CRC. If the calculated CRC matches the CRC sent by the SEL-700G, the master device uses the data received. If there is no match, the check fails and the message is ignored. The devices use a similar process when the master sends queries.

01h Read Discrete Output Coil Status Command

Use function code 01h to read the On/Off status of the selected bits (coils) (see the Modbus Register Map shown in *Table E.14*). You can read the status of as many as 2000 bits per query, using the fields shown in *Table E.4*. Note that the SEL-700G coil addresses start at 0 (for example, Coil 1 is located at address zero). The coil status is packed one coil per bit of the data field. The Least Significant Bit (LSB) of the first data byte contains the starting coil address in the query. The other coils follow towards the high order end of this byte and from low order to high order in subsequent bytes.

Table E.4 01h Read Discrete Output Coil Status Command (Sheet 1 of 2)

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (01h)
2 bytes	Address of the first bit
2 bytes	Number of bits to read
2 bytes	CRC-16

Table E.4 01h Read Discrete Output Coil Status Command (Sheet 2 of 2)

Bytes	Field
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (01h)
1 byte	Bytes of data (*n*)
n bytes	Data
2 bytes	CRC-16

To build the response, the SEL-700G calculates the number of bytes necessary to contain the number of bits requested. If the number of bits requested is not evenly divisible by eight, the device adds one more byte to maintain the balance of bits, padded by zeroes to make an even byte. *Table E.14* includes the coil number and lists all possible coils (identified as Outputs and Remote bits) available in the device. Note that the command depends on the device hardware configuration; the device responds only to installed cards.

The relay responses to errors in the query are shown in *Table E.5*.

Table E.5 Responses to 01h Read Discrete Output Coil Query Errors

Error	Error Code Returned	Communications Counter Increments
Invalid bit to read	Illegal Data Address (02h)	Invalid Address
Invalid number of bits to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

02 Read Input Status Command

Use function code 02h to read the On/Off status of the selected bits (inputs), as shown in *Table E.6*. You can read the status of as many as 2000 bits per query. Note that input addresses start at 0 (for example, Input 1 is located at address zero). The input status is packed one input per bit of the data field. The LSB of the first data byte contains the starting input address in the query. The other inputs follow towards the high order end of this byte, and from low order to high order in subsequent bytes.

Table E.6 02h Read Input Status Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (02h)
2 bytes	Address of the first bit
2 bytes	Number of bits to read
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (02h)
1 byte	Bytes of data (*n*)
n bytes	Data
2 bytes	CRC-16

To build the response, the device calculates the number of bytes necessary to contain the number of bits requested. If the number of bits requested is not evenly divisible by eight, the device adds one more byte to maintain the balance of bits, padded by zeroes to make an even byte.

In each row, the input numbers are assigned from the right-most input to the left-most input (that is, Input 1 is TLED_06 and Input 8 is ENABLED). Input addresses start at 0000 (for example, Input 1 is located at Input Address 0000). *Table E.7* includes the coil address in decimal and lists all possible inputs (Relay Word bits) available in the device. Note that the command depends on the device hardware configuration; the device responds only to installed cards.

Table E.7 02h SEL-700G Inputs

Coil Address (Decimal)	Function Code Supported	Coil Description[a]
0–7	2	Relay Element Status Row 0
8–15	2	Relay Element Status Row 1
16–23	2	Relay Element Status Row 2
•	•	•
•	•	•
•	•	•
1744–1751	2	Relay Element Status Row 218
1752–1759	2	Relay Element Status Row 219
1760–1767	2	Relay Element Status Row 220

[a] The input numbers are assigned from the right-most input to the left-most input in the relay row as show in the following example.
Address 7 = ENABLED
Address 6 = TRIP
Address 5 = T01_LED
Address 4 = T02_LED
Address 3 = T03_LED
Address 2 = T04_LED
Address 1 = T05_LED
Address 0 = T06_LED

The relay responses to errors in the query are shown in *Table E.8*.

Table E.8 Responses to 02h Read Input Query Errors

Error	Error Code Returned	Communications Counter Increments
Invalid bit to read	Illegal Data Address (02h)	Invalid Address
Invalid number of bits to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

03h Read Holding Register Command

Use function code 03h to read directly from the Modbus Register Map shown in *Table E.34*. You can read a maximum of 125 registers at once with this function code. Most masters use 4X references with this function code. If you are accustomed to 4X references with this function code, for five-digit addressing, add 40001 to the standard database address.

Table E.9 03h Read Holding Register Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (03h)
2 bytes	Starting Register Address
2 bytes	Number of Registers to Read
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (03h)
1 byte	Bytes of data (*n*)
n bytes	Data (2–250)
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table E.10*.

Table E.10 Responses to 03h Read Holding Register Query Errors

Error	Error Code Returned	Communications Counter Increments
Illegal register to read	Illegal Data Address (02h)	Invalid Address
Illegal number of registers to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

04h Read Input Register Command

Use function code 04h to read directly from the Modbus Register Map shown in *Table E.34*. You can read a maximum of 125 registers at once with this function code. Most masters use 3X references with this function code. If you are accustomed to 3X references with this function code, for five-digit addressing, add 30001 to the standard database address.

Table E.11 04h Read Input Register Command (Sheet 1 of 2)

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (04h)
2 bytes	Starting Register Address
2 bytes	Number of Registers to Read
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (04h)
1 byte	Bytes of data (*n*)

Table E.11 04h Read Input Register Command (Sheet 2 of 2)

Bytes	Field
n bytes	Data (2–250)
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table E.12*.

Table E.12 Responses to 04h Read Input Register Query Errors

Error	Error Code Returned	Communications Counter Increments
Illegal register to read	Illegal Data Address (02h)	Invalid Address
Illegal number of registers to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

05h Force Single Coil Command

Use function code 05h to set or clear a coil. In *Table E.13*, the command response is identical to the command request.

Table E.13 05h Force Single Coil Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (05h)
2 bytes	Coil Reference
1 byte	Operation Code (FF for bit set, 00 for bit clear)
1 byte	Placeholder (00)
2 bytes	CRC-16

Table E.14 lists the coil numbers supported by the SEL-700G. The physical coils (coils 0–26) are self-resetting. Pulsing a Set remote bit (decimal address 59 through 99) causes the remote bit to be cleared at the end of the pulse.

Table E.14 01h, 05h SEL-700G Output (Sheet 1 of 3)

Coil Address (Decimal)	Function Code Supported	Coil Description
0	01, 05	Pulse OUT101 1 second
1	01, 05	Pulse OUT102 1 second
2	01, 05	Pulse OUT103 1 second
3	01, 05	Pulse OUT301 1 second
4	01, 05	Pulse OUT302 1 second
5	01, 05	Pulse OUT303 1 second
6	01, 05	Pulse OUT304 1 second
7	01, 05	Pulse OUT305 1 second
8	01, 05	Pulse OUT306 1 second
9	01, 05	Pulse OUT307 1 second
10	01, 05	Pulse OUT308 1 second
11	01, 05	Pulse OUT401 1 second
12	01, 05	Pulse OUT402 1 second
13	01, 05	Pulse OUT403 1 second

Table E.14 01h, 05h SEL-700G Output (Sheet 2 of 3)

Coil Address (Decimal)	Function Code Supported	Coil Description
14	01, 05	Pulse OUT404 1 second
15	01, 05	Pulse OUT405 1 second
16	01, 05	Pulse OUT406 1 second
17	01, 05	Pulse OUT407 1 second
18	01, 05	Pulse OUT408 1 second
19	01, 05	Pulse OUT501 1 second
20	01, 05	Pulse OUT502 1 second
21	01, 05	Pulse OUT503 1 second
22	01, 05	Pulse OUT504 1 second
23	01, 05	Pulse OUT505 1 second
24	01, 05	Pulse OUT506 1 second
25	01, 05	Pulse OUT507 1 second
26	01, 05	Pulse OUT508 1 second
27	01, 05	RB01
28	01, 05	RB02
29	01, 05	RB03
30	01, 05	RB04
31	01, 05	RB05
32	01, 05	RB06
33	01, 05	RB07
34	01, 05	RB08
35	01, 05	RB09
36	01, 05	RB10
37	01, 05	RB11
38	01, 05	RB12
39	01, 05	RB13
40	01, 05	RB14
41	01, 05	RB15
42	01, 05	RB16
43	01, 05	RB17
44	01, 05	RB18
45	01, 05	RB19
46	01, 05	RB20
47	01, 05	RB21
48	01, 05	RB22
49	01, 05	RB23
50	01, 05	RB24
51	01, 05	RB25
52	01, 05	RB26
53	01, 05	RB27
54	01, 05	RB28

Table E.14 01h, 05h SEL-700G Output (Sheet 3 of 3)

Coil Address (Decimal)	Function Code Supported	Coil Description
55	01, 05	RB29
56	01, 05	RB30
57	01, 05	RB31
58	01, 05	RB32
59	01, 05	Pulse RB01[a]
60	01, 05	Pulse RB02[a]
61	01, 05	Pulse RB03[a]
62	01, 05	Pulse RB04[a]
63	01, 05	Pulse RB05[a]
64	01, 05	Pulse RB06[a]
65	01, 05	Pulse RB07[a]
66	01, 05	Pulse RB08[a]
67	01, 05	Pulse RB09[a]
68	01, 05	Pulse RB10[a]
69	01, 05	Pulse RB11[a]
70	01, 05	Pulse RB12[a]
71	01, 05	Pulse RB13[a]
72	01, 05	Pulse RB14[a]
73	01, 05	Pulse RB15[a]
74	01, 05	Pulse RB16[a]
75	01, 05	Pulse RB17[a]
76	01, 05	Pulse RB18[a]
77	01, 05	Pulse RB19[a]
78	01, 05	Pulse RB20[a]
79	01, 05	Pulse RB21[a]
80	01, 05	Pulse RB22[a]
81	01, 05	Pulse RB23[a]
82	01, 05	Pulse RB24[a]
83	01, 05	Pulse RB25[a]
84	01, 05	Pulse RB26[a]
85	01, 05	Pulse RB27[a]
86	01, 05	Pulse RB28[a]
87	01, 05	Pulse RB29[a]
88	01, 05	Pulse RB30[a]
89	01, 05	Pulse RB31[a]
90	01, 05	Pulse RB32[a]

[a] Pulsing a Set remote bit causes the remote bit to be cleared at the end of the pulse (1 SELOGIC Processing Interval).

Coil addresses start at 0000 (for example, Coil 1 is located at Coil address 0000). If the device is disabled it responds with error code 4 (Device Error). In addition to Error Code 4, the device responses to errors in the query are shown in *Table E.15*.

Table E.15 Responses to 05h Force Single Coil Query Errors

Error	Error Code Returned	Communications Counter Increments
Invalid bit (coil)	Illegal Data Address (02h)	Invalid Address
Invalid bit state requested	Illegal Data Value (03h)	Illegal Register
Format Error	Illegal Data Value (03h)	Bad Packet Format

06h Preset Single Register Command

The SEL-700G uses this function to allow a Modbus master to write directly to a database register. Refer to the Modbus Register Map in *Table E.34* for a list of registers that can be written by using this function code. If you are accustomed to 4X references with this function code, for six-digit addressing, add 400001 to the standard database addresses.

In *Table E.16*, the command response is identical to the command the master requires.

NOTE: When you set EN_LRC := Y (see Table 9.6), the Relay Word bit LOCAL supervises the CCn and OCn (n = X or Y), 89CC2Pm and 89OC2Pm (m = 1–8), and 89CC3Pnm and 89OC2Pnm (n = L or E, m = 1–2) bits. To set the aforementioned binaries, the relay should be in remote control mode (i.e., LOCAL = 0). The Relay Word bit LOCAL is determined by the LOCAL SELOGIC control equation (see Table 9.6).

Table E.16 06h Preset Single Register Command

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (06h)
2 bytes	Register Address
2 bytes	Data
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table E.17*.

Table E.17 Responses to 06h Preset Single Register Query Errors

Error	Error Code Returned	Communications Counter Increments
Illegal register address	Illegal Data Address (02h)	Invalid Address Illegal Write
Illegal register value	Illegal Data Value (03h)	Illegal Write
Format error	Illegal Data Value (03h)	Bad Packet Format

08h Loopback Diagnostic Command

The SEL-700G uses this function to allow a Modbus master to perform a diagnostic test on the Modbus communications channel and relay. When the subfunction field is 0000h, the relay returns a replica of the received message.

Table E.18 08h Loopback Diagnostic Command (Sheet 1 of 2)

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (08h)
2 bytes	Subfunction (0000h)

Table E.18 08h Loopback Diagnostic Command (Sheet 2 of 2)

Bytes	Field
2 bytes	Data Field
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (08h)
2 bytes	Subfunction (0000h)
2 bytes	Data Field (identical to data in Master request)
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table E.19*.

Table E.19 Responses to 08h Loopback Diagnostic Query Errors

Error	Error Code Returned	Communications Counter Increments
Illegal subfunction code	Illegal Data Value (03h)	Invalid Function Code/Op Code
Format error	Illegal Data Value (03h)	Bad Packet Format

10h Preset Multiple Registers Command

This function code works much like code 06h, except that it allows you to write multiple registers at once, as many as 100 per operation. If you are accustomed to 4X references with the function code, for six-digit addressing, simply add 400001 to the standard database addresses.

Table E.20 10h Preset Multiple Registers Command

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (10h)
2 bytes	Starting Address
2 bytes	Number of Registers to Write
1 byte	Number of Bytes of Data (*n*)
n bytes	Data
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (10h)
2 bytes	Starting Address
2 bytes	Number of Registers
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table E.21*.

Table E.21 10h Preset Multiple Registers Query Error Messages

Error	Error Code Returned	Communications Counter Increments
Illegal register to set	Illegal Data Address (02h)	Invalid Address Illegal Write
Illegal number of registers to set	Illegal Data Value (03h)	Illegal Register Illegal Write
Incorrect number of bytes in query data region	Illegal Data Value (03h)	Bad Packet Format Illegal Write
Invalid register data value	Illegal Data Value (03h)	Illegal Write

60h Read Parameter Information Command

The SEL-700G uses this function to allow a Modbus master to read parameter information from the relay. One parameter (setting) is read in each query.

Table E.22 60h Read Parameter Information Command

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (60h)
2 bytes	Parameter Number
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (60h)
2 bytes	Parameter Number
1 byte	Parameter Descriptor
1 byte	Parameter Conversion
2 bytes	Parameter Minimum Settable Value
2 bytes	Parameter Maximum Settable Value
2 bytes	Parameter Default Value
2 bytes	CRC-16

The Parameter Descriptor field is defined in *Table E.23*.

Table E.23 60h Read Parameter Descriptor Field Definition (Sheet 1 of 2)

Bit	Name	Description
0	RO: Read-only	1 when the setting is read-only
1	H: Hidden	1 when the setting is hidden
2	DBL: 32-bit	1 when the following setting is a fractional value of this setting
3	RA: RAM-only	1 when the setting is not saved in nonvolatile memory
4	RR: Read-only if running	1 when the setting is read-only if in running/operational state
5‘	P: Power Cycle or Reset	1 when the setting change requires a power cycle or reset

Table E.23 60h Read Parameter Descriptor Field Definition (Sheet 2 of 2)

Bit	Name	Description
6	0	Reserved
7	Extend	Reserved to extend the descriptor table

The Parameter Conversion field is defined in *Table E.24*.

Table E.24 60h Read Parameter Conversion Field Definition

Conversion Value	Type	Multiplier	Divisor	Offset	Base
0	Boolean	1	1	0	1
1	Unsigned Integer	1	1	0	1
2	Unsigned Integer	1	10	0	1
3	Unsigned Integer	1	100	0	1
4	Unsigned Integer	1	1000	0	1
5	Hexadecimal	1	1	0	1
6	Integer	1	1	0	1
7	Integer	1	10	0	1
8	Integer	1	100	0	1
9	Integer	1	1000	0	1
10	Enumeration	1	1	0	1
11	Bit Enumeration	1	1	0	1

Use *Equation E.1* to calculate the actual (not scaled) value of the parameter (setting):

$$\text{value} = \frac{(\text{ParameterValue} + \text{Offset}) \bullet \text{Multiplier} \bullet \text{Base}}{\text{Divisor}}$$ **Equation E.1**

Use *Equation E.2* to calculate the scaled setting value:

$$\text{value} = \frac{\text{value} \bullet \text{Divisor}}{\text{Multiplier} \bullet \text{Base}} - \text{Offset}$$ **Equation E.2**

The relay response to errors in the query are shown *Table E.25*.

Table E.25 Responses to 60h Read Parameter Information Query Errors

Error	Error Code Returned	Communications Counter Increments
Illegal parameter to read	Illegal Address (02h)	Invalid Address

61h Read Parameter Text Command

The SEL-700G uses this function to allow a Modbus master to read parameter text from the relay. One parameter text (setting name) is read in each query.

Table E.26 61h Read Parameter Text Command

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (61h)
2 bytes	Parameter Number
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (61h)
2 bytes	Parameter Number
16 bytes	Parameter Text (setting name)
4 bytes	Parameter Units (for example, Amps)
2 bytes	CRC-16

The relay responses to errors in the query are as follows:

Table E.27 61h Read Parameter Text Query Error Messages

Error	Error Code Returned	Communications Counter Increments
Illegal parameter to read	Illegal Address (02h)	Invalid Address

62h Read Enumeration Text Command

The SEL-700G uses this function to allow a Modbus master to read parameter enumeration or bit enumeration values (setting lists) from the relay. One parameter enumeration is read in each query.

Table E.28 62h Read Enumeration Text Command

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (62h)
2 bytes	Parameter Number
1 byte	Enumeration Index
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (62h)
2 bytes	Parameter Number
1 byte	Enumeration Index
16 bytes	Enumeration Text
2 bytes	CRC-16

The relay responses to errors in the query are as follows:

Table E.29 61h Read Parameter Enumeration Text Query Error Messages

Error	Error Code Returned	Communications Counter Increments
Illegal parameter to read	Illegal Address (02h)	Invalid Address
Illegal enumeration in index	Illegal Data Value (03h)	Illegal Register

7Dh Encapsulated Packet With Control Command

The SEL-700G uses this function to allow a Modbus master to perform control operations and another Modbus function with one query. The Device Net card transmits this command periodically to achieve high-speed I/O processing and establish a heartbeat between the DeviceNet card and the main board.

Table E.30 7Dh Encapsulated Packet With Control Command

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Control Command (same as write to 2000h)
1 byte	Embedded Modbus Function
n bytes	Optional Data to Support Modbus Function (0–250)
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Status Information (Register 2100h or 2101h based on Bit 3 in Control Command Word)
1 byte	Embedded Modbus Function
n bytes	Optional data to support the Modbus function (0–250)
2 bytes	CRC-16

Table E.31 shows the format of the relay responses to errors in the query.

Table E.31 7Dh Encapsulated Packet Query Errors

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Status Information (Register 2100h or 2101h based on Bit 3 in Control Command Word)
1 byte	Modbus Function with Error Flag
1 bytes	Function Error Code[a]
2 bytes	CRC-16

[a] If the embedded function code is invalid, then an illegal function code is returned here and the illegal function counter is incremented. This error code is returned by the embedded function for all valid embedded functions.

7Eh NOP Command

This function code has no operation. This allows a Modbus master to perform a control operation without any other Modbus command. This is only used inside of the 7Dh when no regular Modbus query is necessary.

Table E.32 7Eh NOP Command

Bytes	Field
An example of a 7D message response using 7E will have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Status Information
1 byte	Function Code (7Eh)
2 bytes	CRC-16

Reading Parameter Information and Value Using Modbus

Through use of Modbus commands, you can read the present value of a parameter as well as parameter name, units, low limit, high limit, scale, and even the enumeration string (if the parameter is an enumeration type). This means that you can use a general user interface to retrieve and display specific parameter details from the relay. Use the **60h**, **61h**, and **62h** commands to retrieve parameter information, and use the **03** command to retrieve values.

Controlling Output Contacts Using Modbus

The SEL-700G includes registers for controlling some of the outputs. See LOGIC COMMAND (2000h), RESET COMMAND (2001h), and registers in the Reset Settings region for the control features supported by the relay. Use Modbus function codes 06h or 10h to write appropriate flags. Remember that when writing to the Logic command register with output contacts, it is not a bit operation. You must write all the bits in that register together to reflect the state you want for each of the outputs.

User-Defined Modbus Data Region and SET M Command

The SEL-700G Modbus Register Map defines an area of 125 contiguous addresses whose contents are defined by 125 user-settable addresses. This feature allows you to take 125 discrete values from anywhere in the Modbus Register Map and place them in contiguous registers that you can then read in a single command. SEL ASCII command **SET M** provides a convenient method to define the user map addresses. The user map can also be defined by writing to user map registers MOD_001 to MOD_125.

To use the user-defined data region, follow the steps listed below.

Step 1. Define the list of necessary quantities (as many as 125). Arrange the quantities in any order that is convenient for you to use.

Step 2. Refer to *Table E.33* for a list of the Modbus label for each quantity. For more information on the Modbus labels, refer to the respective register in *Table E.34*.

Step 3. Execute **SET M** command from the command line to map user registers 001 to 125 (MOD_001 to MOD_125) using the labels in *Table E.33*.

Note that this step can also be performed using Modbus protocol. Use Modbus Function Code 06h to write to registers MOD_001 through MOD_125.

Step 4. Use Modbus function code 03h or 04h to read the necessary quantities from addresses 126 through 250 (user map values).

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 1 of 6)

Register Address	Label
271	FPGA
272	GPSB
273	HMI
274	RAM
275	ROM
276	CR_RAM
277	NON_VOL
278	CLKSTS
279	CID_FILE
280	RTD
281	P3P3PS
282	P5PS
283	P2P5PS
284	P3P75PS
285	N1P25PS
286	N5PS
287	P0P9PS
288	P1P2PS
289	P1P5PS
290	P1P8PS
291	CLKBAT
292	CARDZ
293	CARDC
294	CARDD
295	CARDE
296	IAXSTS
297	IBXSTS
298	ICXSTS
299	IAYSTS
300	IBYSTS
301	ICYSTS
302	INSTS
303	VAXSTS
304	VBXSTS
305	VCXSTS
306	VAYSTS
307	VBYSTS
308	VCYSTS
309	VSSTS
310	VNSTS
311	F64COMM
312	F64STS
313	RLYSTS
314	SER_NUMH
315	SER_NUML
316–319	Reserved
320	IAX_MAG
321	IAX_ANG
322	IBX_MAG
323	IBX_ANG
324	ICX_MAG
325	ICX_ANG
326	IGX_MAG
327	IGX_ANG
328	3I2X_MAG
329	I1X_MAG
330	VABX_MAG
331	VABX_ANG
332	VBCX_MAG
333	VBCX_ANG
334	VCAX_MAG
335	VCAX_ANG
336	VAX_MAG
337	VAX_ANG
338	VBX_MAG
339	VBX_ANG
340	VCX_MAG
341	VCX_ANG
342	VGX_MAG
343	VGX_ANG
344	3V2X_MAG
345	V1X_MAG
346	PAXH
347	PAXL
348	PBXH
349	PBXL
350	PCXH
351	PCXL
352	P3XH
353	P3XL
354	QAXH
355	QAXL
356	QBXH
357	QBXL
358	QCXH
359	QCXL
360	Q3XH
361	Q3XL
362	SAXH
363	SAXL
364	SBXH
365	SBXL
366	SCXH
367	SCXL
368	S3XH
369	S3XL
370	PFAX
371	PFBX
372	PFCX
373	PF3X
374	FREQX
375	VHZX
376–380	Reserved
381	IAY_MAG
382	IAY_ANG
383	IBY_MAG
384	IBY_ANG
385	ICY_MAG
386	ICY_ANG
387	IGY_MAG
388	IGY_ANG
389	3I2Y_MAG
390	I1Y_MAG
391	VABY_MAG
392	VABY_ANG
393	VBCY_MAG
394	VBCY_ANG
395	VCAY_MAG
396	VCAY_ANG
397	VAY_MAG
398	VAY_ANG
399	VBY_MAG
400	VBY_ANG
401	VCY_MAG
402	VCY_ANG
403	VGY_MAG
404	VGY_ANG
405	3V2Y_MAG
406	V1Y_MAG
407	IN_MAG
408	IN_ANG
409	VS_MAG
410	VS_ANG
411	VN_MAG
412	VN_ANG
413	VN3_MAG
414	VPX3_MAG
415	FLDRES
416	FREQS
417–422	Reserved
423	MWHPXH
424	MWHPXL
425	MWHNXH
426	MWHNXL
427	MVARHPXH
428	MVARHPXL
429	MVARHNXH
430	MVARHNXL
431	MWHPYH
432	MWHPYL
433	MWHNYH
434	MWHNYL
435	MVARHPYH
436	MVARHPYL
437	MVARHNYH
438	MVARHNYL
439	ENRGY_S
440	ENRGYMN
441	ENRGY_H
442	ENRGY_D
443	ENRGYMO
444	ENRGY_Y
445–452	Reserved
453	IAXD
454	IBXD
455	ICXD
456	IGXD
457	3I2XD
458	IAYD
459	IBYD
460	ICYD
461	IGYD
462	3I2YD
463	IAXPD
464	IBXPD
465	ICXPD
466	IGXPD
467	3I2XPD
468	IAYPD
469	IBYPD
470	ICYPD
471	IGYPD
472	3I2YPD
473	PDEM_R_S
474	PDEM_RMN
475	PDEM_R_H
476	PDEM_R_D
477	PDEM_RMO
478	PDEM_R_Y
479	IAX_THD
480	IBX_THD
481	ICX_THD
482	IAY_THD
483	IBY_THD
484	ICY_THD
485	RTDWDGMX

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 2 of 6)

Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label
486	RTDBRGMX	545	IBYMN	593	KVA3YMXL	642	AI401MNH
487	RTDAMB	546	ICYMX	594	KVA3YMNH	643	AI401MNL
488	RTDOTHMX	547	ICYMN	595	KVA3YMNL	644	AI402MXH
489	RTD1	548	IGYMX	596	FREQXMX	645	AI402MXL
490	RTD2	549	IGYMN	597	FREQXMN	646	AI402MNH
491	RTD3	550	INMX	598	FREQYMX	647	AI402MNL
492	RTD4	551	INMN	599	FREQYMN	648	AI403MXH
493	RTD5	552	VABXMX[a]	600	RTD1MX	649	AI403MXL
494	RTD6	553	VABXMN[a]	601	RTD1MN	650	AI403MNH
495	RTD7	554	VBCXMX	602	RTD2MX	651	AI403MNL
496	RTD8	555	VBCXMN[a]	603	RTD2MN	652	AI403MXH
497	RTD9	556	VCAXMX[a]	604	RTD3MX	653	AI403MXL
498	RTD10	557	VCAXMN[a]	605	RTD3MN	654	AI404MNH
499	RTD11	558	VABYMX[a]	606	RTD4MX	655	AI404MNL
500	RTD12	559	VABYMN[a]	607	RTD4MN	656	AI501MXH
501	TCUGEN	560	VBCYMX[a]	608	RTD5MX	657	AI501MXL
502	TCURTD	561	VBCYMN[a]	609	RTD5MN	658	AI501MNH
503–513	Reserved	562	VCAYMX[a]	610	RTD6MX	659	AI501MNL
514	IAXRMS	563	VCAYMN[a]	611	RTD6MN	660	AI502MXH
515	IBXRMS	564	VSMX	612	RTD7MX	661	AI502MXL
516	ICXRMS	565	VSMN	613	RTD7MN	662	AI502MNH
517	IAYRMS	566	VNMX	614	RTD8MX	663	AI502MNL
518	IBYRMS	567	VNMN	615	RTD8MN	664	AI503MXH
519	ICYRMS	568	VN3MX	616	RTD9MX	665	AI503MXL
520	VAXRMS	569	VN3MN	617	RTD9MN	666	AI503MNH
521	VBXRMS	570	VPX3MX	618	RTD10MX	667	AI503MNL
522	VCXRMS	571	VPX3MN	619	RTD10MN	668	AI504MXH
523	VABXRMS	572	KW3XMXH	620	RTD11MX	669	AI504MXL
524	VBCXRMS	573	KW3XMXL	621	RTD11MN	670	AI504MNH
525	VCAXRMS	574	KW3XMNH	622	RTD12MX	671	AI504MNL
526	VAYRMS	575	KW3XMNL	623	RTD12MN	672	MXMN_R_S
527	VBYRMS	576	KVR3XMXH	624	AI301MXH	673	MXMN_RMN
528	VCYRMS	577	KVR3XMXL	625	AI301MXL	674	MXMN_R_H
529	VABYRMS	578	KVR3XMNH	626	AI301MNH	675	MXMN_R_D
530	VBCYRMS	579	KVR3XMNL	627	AI301MNL	676	MXMN_RMO
531	VCAYRMS	580	KVA3XMXH	628	AI302MXH	677	MXMN_R_Y
532	INRMS	581	KVA3XMXL	629	AI302MXL	678–681	Reserved
533	VSRMS	582	KVA3XMNH	630	AI302MNH	682	AI301H
534	IAXMX	583	KVA3XMNL	631	AI302MNL	683	AI301L
535	IAXMN	584	KW3YMXH	632	AI303MXH	684	AI302H
536	IBXMX	585	KW3YMXL	633	AI303MXL	685	AI302L
537	IBXMN	586	KW3YMNH	634	AI303MNH	686	AI303H
538	ICXMX	587	KW3YMNL	635	AI303MNL	687	AI303L
539	ICXMN	588	KVR3YMXH	636	AI304MXH	688	AI304H
540	IGXMX	589	KVR3YMXL	637	AI304MXL	689	AI304L
541	IGXMN	590	KVR3YMNH	638	AI304MNH	690	AI401H
542	IAYMX	591	KVR3YMNL	639	AI304MNL	691	AI401L
543	IAYMN	592	KVA3YMXH	640	AI401MXH	692	AI402H
544	IBYMX			641	AI401MXL	693	AI402L

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 3 of 6)

Register Address	Label
694	AI403H
695	AI403L
696	AI404H
697	AI404L
698	AI501H
699	AI501L
700	AI502H
701	AI502L
702	AI503H
703	AI503L
704	AI504H
705	AI504L
706	MV01H
707	MV01L
708	MV02H
709	MV02L
710	MV03H
711	MV03L
712	MV04H
713	MV04L
714	MV05H
715	MV05L
716	MV06H
717	MV06L
718	MV07H
719	MV07L
720	MV08H
721	MV08L
722	MV09H
723	MV09L
724	MV10H
725	MV10L
726	MV11H
727	MV11L
728	MV12H
729	MV12L
730	MV13H
731	MV13L
732	MV14H
733	MV14L
734	MV15H
735	MV15L
736	MV16H
737	MV16L
738	MV17H
739	MV17L
740	MV18H
741	MV18L
742	MV19H
743	MV19L
744	MV20H
745	MV20L
746	MV21H
747	MV21L
748	MV22H
749	MV22L
750	MV23H
751	MV23L
752	MV24H
753	MV24L
754	MV25H
755	MV25L
756	MV26H
757	MV26L
758	MV27H
759	MV27L
760	MV28H
761	MV28L
762	MV29H
763	MV29L
764	MV30H
765	MV30L
766	MV31H
767	MV31L
768	MV32H
769	MV32L
770	SC01
771	SC02
772	SC03
773	SC04
774	SC05
775	SC06
776	SC07
777	SC08
778	SC09
779	SC10
780	SC11
781	SC12
782	SC13
783	SC14
784	SC15
785	SC16
786	SC17
787	SC18
788	SC19
789	SC20
790	SC21
791	SC22
792	SC23
793	SC24
794	SC25
795	SC26
796	SC27
797	SC28
798	SC29
799	SC30
800	SC31
801	SC32
802-817	Reserved
818	NUMEVE
819	EVESEL
820	EVE_S
821	EVEMN
822	EVE_H
823	EVE_D
824	EVEMO
825	EVE_Y
826	EVE_TYPE
827	EVE_TRGT
828	EVE_IAX
829	EVE_IBX
830	EVE_ICX
831	EVE_IGX
832	EVE_IAY
833	EVE_IBY
834	EVE_ICY
835	EVE_IGY
836	EVE_IN
837	EVE_VABX
838	EVE_VBCX
839	EVE_VCAX
840	EVE_VGX
841	EVE_VABY
842	EVE_VBCY
843	EVE_VCAY
844	EVE_VGY
845	EVE_VS
846	EVE_VN
847	EVE_DY_X
848	EVE_DY_Y
849	EVE_FRQX
850	EVE_FRQY
851	EVE_MAXW
852	EVE_MAXB
853	EVE_MAXA
854	EVE_MAXO
855-864	Reserved
865	INTTX
866	EXTTX
867	INTIAX
868	INTIBX
869	INTICX
870	EXTIAX
871	EXTIBX
872	EXTICX
873	WEARAX
874	WEARBX
875	WEARCX
876	BM_R_SX
877	BM_R_MNX
878	BM_R_HX
879	BM_R_DX
880	BM_R_MOX
881	BM_R_YX
882	INTTY
883	EXTTY
884	INTIAY
885	INTIBY
886	INTICY
887	EXTIAY
888	EXTIBY
889	EXTICY
890	WEARAY
891	WEARBY
892	WEARCY
893	BM_R_SY
894	BM_R_MNY
895	BM_R_HY
896	BM_R_DY
897	BM_R_MOY
898	BM_R_YY
899-900	Reserved
901	TRIP_LO
902	TRIP_HI
903	WARN_LO
904	WARN_HI
905-909	Reserved
910	NUMRCV
911	NUMOTH
912	INVADR
913	BADCRC
914	UARTERR
915	ILLFUNC
916	ILLREG
917	ILLWR
918	BADPKTF

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 4 of 6)

Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label
919	BADPKTL	988	ROW_17	1037	ROW_66	1086	ROW_115
920–925	Reserved	989	ROW_18	1038	ROW_67	1087	ROW_116
926	PAYH	990	ROW_19	1039	ROW_68	1088	ROW_117
927	PAYL	991	ROW_20	1040	ROW_69	1089	ROW_118
928	PBYH	992	ROW_21	1041	ROW_70	1090	ROW_119
929	PBYL	993	ROW_22	1042	ROW_71	1091	ROW_120
930	PCYH	994	ROW_23	1043	ROW_72	1092	ROW_121
931	PCYL	995	ROW_24	1044	ROW_73	1093	ROW_122
932	P3YH	996	ROW_25	1045	ROW_74	1094	ROW_123
933	P3YL	997	ROW_26	1046	ROW_75	1095	ROW_124
934	QAYH	998	ROW_27	1047	ROW_76	1096	ROW_125
935	QAYL	999	ROW_28	1048	ROW_77	1097	ROW_126
936	QBYH	1000	ROW_29	1049	ROW_78	1098	ROW_127
937	QBYL	1001	ROW_30	1050	ROW_79	1099	ROW_128
938	QCYH	1002	ROW_31	1051	ROW_80	1100	ROW_129
939	QCYL	1003	ROW_32	1052	ROW_81	1101	ROW_130
940	Q3YH	1004	ROW_33	1053	ROW_82	1102	ROW_131
941	Q3YL	1005	ROW_34	1054	ROW_83	1103	ROW_132
942	SAYH	1006	ROW_35	1055	ROW_84	1104	ROW_133
943	SAYL	1007	ROW_36	1056	ROW_85	1105	ROW_134
944	SBYH	1008	ROW_37	1057	ROW_86	1106	ROW_135
945	SBYL	1009	ROW_38	1058	ROW_87	1107	ROW_136
946	SCYH	1010	ROW_39	1059	ROW_88	1108	ROW_137
947	SCYL	1011	ROW_40	1060	ROW_89	1109	ROW_138
948	S3YH	1012	ROW_41	1061	ROW_90	1110	ROW_139
949	S3YL	1013	ROW_42	1062	ROW_91	1111	ROW_140
950	PFAY	1014	ROW_43	1063	ROW_92	1112	ROW_141
951	PFBY	1015	ROW_44	1064	ROW_93	1113	ROW_142
952	PFCY	1016	ROW_45	1065	ROW_94	1114	ROW_143
953	PF3Y	1017	ROW_46	1066	ROW_95	1115	ROW_144
954	FREQY	1018	ROW_47	1067	ROW_96	1116	ROW_145
955–970	Reserved	1019	ROW_48	1068	ROW_97	1117	ROW_146
971	ROW_0	1020	ROW_49	1069	ROW_98	1118	ROW_147
972	ROW_1	1021	ROW_50	1070	ROW_99	1119	ROW_148
973	ROW_2	1022	ROW_51	1071	ROW_100	1120	ROW_149
974	ROW_3	1023	ROW_52	1072	ROW_101	1121	ROW_150
975	ROW_4	1024	ROW_53	1073	ROW_102	1122	ROW_151
976	ROW_5	1025	ROW_54	1074	ROW_103	1123	ROW_152
977	ROW_6	1026	ROW_55	1075	ROW_104	1124	Reserved
978	ROW_7	1027	ROW_56	1076	ROW_105	1125	ROW_153
979	ROW_8	1028	ROW_57	1077	ROW_106	1126	ROW_154
980	ROW_9	1029	ROW_58	1078	ROW_107	1127	ROW_155
981	ROW_10	1030	ROW_59	1079	ROW_108	1128	ROW_156
982	ROW_11	1031	ROW_60	1080	ROW_109	1129	ROW_157
983	ROW_12	1032	ROW_61	1081	ROW_110	1130	ROW_158
984	ROW_13	1033	ROW_62	1082	ROW_111	1131	ROW_159
985	ROW_14	1034	ROW_63	1083	ROW_112	1132	ROW_160
986	ROW_15	1035	ROW_64	1084	ROW_113	1133	ROW_161
987	ROW_16	1036	ROW_65	1085	ROW_114	1134	ROW_162

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 5 of 6)

Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label
1135	ROW_163	1183	ROW_211	1231	RA022_H	1279	RA046_H
1136	ROW_164	1184	ROW_212	1232	RA022_L	1280	RA046_L
1137	ROW_165	1185	ROW_213	1233	RA023_H	1281	RA047_H
1138	ROW_166	1186	ROW_214	1234	RA023_L	1282	RA047_L
1139	ROW_167	1187	ROW_215	1235	RA024_H	1283	RA048_H
1140	ROW_168	1188	ROW_216	1236	RA024_L	1284	RA048_L
1141	ROW_169	1189	RA001_H	1237	RA025_H	1285	RA049_H
1142	ROW_170	1190	RA001_L	1238	RA025_L	1286	RA049_L
1143	ROW_171	1191	RA002_H	1239	RA026_H	1287	RA050_H
1144	ROW_172	1192	RA002_L	1240	RA026_L	1288	RA050_L
1145	ROW_173	1193	RA003_H	1241	RA027_H	1289	RA051_H
1146	ROW_174	1194	RA003_L	1242	RA027_L	1290	RA051_L
1147	ROW_175	1195	RA004_H	1243	RA028_H	1291	RA052_H
1148	ROW_176	1196	RA004_L	1244	RA028_L	1292	RA052_L
1149	ROW_177	1197	RA005_H	1245	RA029_H	1293	RA053_H
1150	ROW_178	1198	RA005_L	1246	RA029_L	1294	RA053_L
1151	ROW_179	1199	RA006_H	1247	RA030_H	1295	RA054_H
1152	ROW_180	1200	RA006_L	1248	RA030_L	1296	RA054_L
1153	ROW_181	1201	RA007_H	1249	RA031_H	1297	RA055_H
1154	ROW_182	1202	RA007_L	1250	RA031_L	1298	RA055_L
1155	ROW_183	1203	RA008_H	1251	RA032_H	1299	RA056_H
1156	ROW_184	1204	RA008_L	1252	RA032_L	1300	RA056_L
1157	ROW_185	1205	RA009_H	1253	RA033_H	1301	RA057_H
1158	ROW_186	1206	RA009_L	1254	RA033_L	1302	RA057_L
1159	ROW_187	1207	RA010_H	1255	RA034_H	1303	RA058_H
1160	ROW_188	1208	RA010_L	1256	RA034_L	1304	RA058_L
1161	ROW_189	1209	RA011_H	1257	RA035_H	1305	RA059_H
1162	ROW_190	1210	RA011_L	1258	RA035_L	1306	RA059_L
1163	ROW_191	1211	RA012_H	1259	RA036_H	1307	RA060_H
1164	ROW_192	1212	RA012_L	1260	RA036_L	1308	RA060_L
1165	ROW_193	1213	RA013_H	1261	RA037_H	1309	RA061_H
1166	ROW_194	1214	RA013_L	1262	RA037_L	1310	RA061_L
1167	ROW_195	1215	RA014_H	1263	RA038_H	1311	RA062_H
1168	ROW_196	1216	RA014_L	1264	RA038_L	1312	RA062_L
1169	ROW_197	1217	RA015_H	1265	RA039_H	1313	RA063_H
1170	ROW_198	1218	RA015_L	1266	RA039_L	1314	RA063_L
1171	ROW_199	1219	RA016_H	1267	RA040_H	1315	RA064_H
1172	ROW_200	1220	RA016_L	1268	RA040_L	1316	RA064_L
1173	ROW_201	1221	RA017_H	1269	RA041_H	1317	RA065_H
1174	ROW_202	1222	RA017_L	1270	RA041_L	1318	RA065_L
1175	ROW_203	1223	RA018_H	1271	RA042_H	1319	RA066_H
1176	ROW_204	1224	RA018_L	1272	RA042_L	1320	RA066_L
1177	ROW_205	1225	RA019_H	1273	RA043_H	1321	RA067_H
1178	ROW_206	1226	RA019_L	1274	RA043_L	1322	RA067_L
1179	ROW_207	1227	RA020_H	1275	RA044_H	1323	RA068_H
1180	ROW_208	1228	RA020_L	1276	RA044_L	1324	RA068_L
1181	ROW_209	1229	RA021_H	1277	RA045_H	1325	RA069_H
1182	ROW_210	1230	RA021_L	1278	RA045_L	1326	RA069_L

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 6 of 6)

Register Address	Label	Register Address	Label	Register Address	Label
1327	RA070_H	1375	RA094_H	1423	RA118_H
1328	RA070_L	1376	RA094_L	1424	RA118_L
1329	RA071_H	1377	RA095_H	1425	RA119_H
1330	RA071_L	1378	RA095_L	1426	RA119_L
1331	RA072_H	1379	RA096_H	1427	RA120_H
1332	RA072_L	1380	RA096_L	1428	RA120_L
1333	RA073_H	1381	RA097_H	1429	RA121_H
1334	RA073_L	1382	RA097_L	1430	RA121_L
1335	RA074_H	1383	RA098_H	1431	RA122_H
1336	RA074_L	1384	RA098_L	1432	RA122_L
1337	RA075_H	1385	RA099_H	1433	RA123_H
1338	RA075_L	1386	RA099_L	1434	RA123_L
1339	RA076_H	1387	RA100_H	1435	RA124_H
1340	RA076_L	1388	RA100_L	1436	RA124_L
1341	RA077_H	1389	RA101_H	1437	RA125_H
1342	RA077_L	1390	RA101_L	1438	RA125_L
1343	RA078_H	1391	RA102_H	1439	RA126_H
1344	RA078_L	1392	RA102_L	1440	RA126_L
1345	RA079_H	1393	RA103_H	1441	RA127_H
1346	RA079_L	1394	RA103_L	1442	RA127_L
1347	RA080_H	1395	RA104_H	1443	RA128_H
1348	RA080_L	1396	RA104_L	1444	RA128_L
1349	RA081_H	1397	RA105_H	1445	ROW_217
1350	RA081_L	1398	RA105_L	1446	ROW_218
1351	RA082_H	1399	RA106_H	1447	ROW_219
1352	RA082_L	1400	RA106_L	1448	ROW_220
1353	RA083_H	1401	RA107_H		
1354	RA083_L	1402	RA107_L		
1355	RA084_H	1403	RA108_H		
1356	RA084_L	1404	RA108_L		
1357	RA085_H	1405	RA109_H		
1358	RA085_L	1406	RA109_L		
1359	RA086_H	1407	RA110_H		
1360	RA086_L	1408	RA110_L		
1361	RA087_H	1409	RA111_H		
1362	RA087_L	1410	RA111_L		
1363	RA088_H	1411	RA112_H		
1364	RA088_L	1412	RA112_L		
1365	RA089_H	1413	RA113_H		
1366	RA089_L	1414	RA113_L		
1367	RA090_H	1415	RA114_H		
1368	RA090_L	1416	RA114_L		
1369	RA091_H	1417	RA115_H		
1370	RA091_L	1418	RA115_L		
1371	RA092_H	1419	RA116_H		
1372	RA092_L	1420	RA116_L		
1373	RA093_H	1421	RA117_H		
1374	RA093_L	1422	RA117_L		

[a] Registers report corresponding phase-to-phase values when setting DELTA_Y = DELTA and phase-to-neutral values when setting DELTA_Y = WYE.

Reading History Data Using Modbus

Using the Modbus Register Map (*Table E.34*), you can download a complete history of the last 50 events via Modbus. The history contains the date and time stamp, type of event that triggered the report, currents, and voltages at the time of the event. Please refer to the in the Historical Data section of the Modbus Register Map (*Table E.34*).

To use Modbus to download history data, write the event number (1–50) to the EVENT LOG SEL register at address 819 (when a zero is written to the register, the relay will return event number one). Then read the history of the specific event number you requested from the registers shown in the Historical Data section of the Modbus Register Map (*Table E.34*). After a power cycle, the history data registers will show the history data corresponding to the latest event. This information updates dynamically; as whenever there is a new event, the history data registers update automatically with new event data. If specific event number data have been retrieved using a write to the EVENT LOG SEL register, the event data registers will return that specific event history. These registers will return to the free running latest event history data mode when a zero is written to the event selection register from a prior nonzero selection.

Modbus Register Map

NOTE: Certain Modbus quantities are reported as 32-bit numbers; however, Modbus registers are only 16-bit. This results in displaying the Modbus quantities in a LOW and HIGH register. To determine the 32-bit number, concatenate the LOW register to the end of the HIGH register. For example, if the HIGH register value is 0x5ADC and the LOW register value is 0xF43B, the resulting 32-bit value is 0x5ADCF43B.

Table E.34 lists the data available in the Modbus interface and a data description, range, and scaling information. The table also shows the parameter number for access using the DeviceNet interface. The DeviceNet parameter number is obtained by adding 100 to the Modbus register address.

Table E.34 Modbus Map[a] (Sheet 1 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
0 (R)	Reserved[d]		0	100	1		
User Map Reg							
1 (R/W)	USER REG #1		271	1124	1448	1	101
	• • •						
125 (R/W)	USER REG #125		271	1124	1448	1	225
User Map Register Values							
126 (R)	USER REG#1 VAL		0	65535	0	1	226
	• • •						
250 (R)	USER REG#125 VAL		0	65535	0	1	350
Reserved Area 1							
251–260 (R)	Reserved[d]		0	0	0		351–360
Reset Settings							
261 (R/W)	RESET DATA Bit 0 = TRIP RESET		0	4095	0		361

Table E.34 Modbus Map[a] (Sheet 2 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
	Bit 1 = Reserved[d] Bit 2 = RESET STAT DATA Bit 3 = RESET HIST DATA Bit 4 = RESET COMM CNTR Bit 5 = Reserved[d] Bit 6 = RST ENRGY DATA Bit 7 = RST MX/MN DATA Bit 8 = RST DEMAND Bit 9 = RST PEAK DEMAND Bits 10 = RST BKMONX DATA Bits 11 = RST BKMONY DATA Bits 12 = RST SYNC REPORT Bits 13–15 = Reserved[d]						
262 (R)	Reserved[d]		0	0	0		362
Date/Time Set							
263 (R/W)	SET SEC		0	5999	0	0.01	363
264 (R/W)	SET MIN		0	59	0	1	364
265 (R/W)	SET HOUR		0	23	0	1	365
266 (R/W)	SET DAY		1	31	1	1	366
267 (R/W)	SET MONTH		1	12	1	1	367
268 (R/W)	SET YEAR		2000	9999	2000	1	368
269 (R)	Reserved[d]		0	0	0		369
270 (R)	Reserved[d]		0	0	0		370
Device Status	0 = OK, 1 = Warn, 2 = Fail						
271 (R)	FPGA STATUS		0	2	0		371
272 (R)	GPSB STATUS		0	2	0		372
273 (R)	HMI STATUS		0	2	0		373
274 (R)	RAM STATUS		0	2	0		374
275 (R)	ROM STATUS		0	2	0		375
276 (R)	CR_RAM STATUS		0	2	0		376
277 (R)	NON_VOL STATUS		0	2	0		377
278 (R)	CLOCK STATUS		0	2	0		378
279 (R)	CID FILE STATUS		0	2	0		379
280 (R)	RTD STATUS		0	2	0		380
281 (R)	+3.3V STATUS		0	2	0		381
282 (R)	+5.0V STATUS		0	2	0		382
283 (R)	+2.5V STATUS		0	2	0		383
284 (R)	+3.75V STATUS		0	2	0		384
285 (R)	–1.25V STATUS		0	2	0		385
286 (R)	–5.0V STATUS		0	2	0		386
287 (R)	+0.9V STATUS		0	2	0		387
288 (R)	+1.2V STATUS		0	2	0		388
289 (R)	+1.5V STATUS		0	2	0		389
290 (R)	+1.8V STATUS		0	2	0		390
291 (R)	CLK_BAT STATUS		0	2	0		391
292 (R)	CARD Z STATUS		0	2	0		392
293 (R)	CARD C STATUS		0	2	0		393
294 (R)	CARD D STATUS		0	2	0		394

Table E.34 Modbus Map[a] (Sheet 3 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
295 (R)	CARD E STATUS		0	2	0		395
296 (R)	IAX STATUS		0	2	0		396
297 (R)	IBX STATUS		0	2	0		397
298 (R)	ICX STATUS		0	2	0		398
299 (R)	IAY STATUS		0	2	0		399
300 (R)	IBY STATUS		0	2	0		400
301 (R)	ICY STATUS		0	2	0		401
302 (R)	IN STATUS		0	2	0		402
303 (R)	VAX STATUS		0	2	0		403
304 (R)	VBX STATUS		0	2	0		404
305 (R)	VCX STATUS		0	2	0		405
306 (R)	VAY STATUS		0	2	0		406
307 (R)	VBY STATUS		0	2	0		407
308 (R)	VCY STATUS		0	2	0		408
309 (R)	VS STATUS		0	2	0		409
310 (R)	VN STATUS		0	2	0		410
311 (R)	64F COMM STATUS		0	2	0		411
312 (R)	64F MODUL STATUS		0	2	0		412
313 (R)	RELAY STATUS 0 = ENABLED 1 = DISABLED		0	1	0		413
314 (R)	SERIAL NUMBER H		0	65535	0	1	414
315 (R)	SERIAL NUMBER L		0	65535	0	1	415
316–319 (R)	Reserved[d]		0	0	0		416–419
X-Side Current Data							
320 (R)	IAX CURRENT	A	0	65535	0	1	420
321 (R)	IAX ANGLE	deg	–1800	1800	0	0.1	421
322 (R)	IBX CURRENT	A	0	65535	0	1	422
323 (R)	IBX ANGLE	deg	–1800	1800	0	0.1	423
324 (R)	ICX CURRENT	A	0	65535	0	1	424
325 (R)	ICX ANGLE	deg	–1800	1800	0	0.1	425
326 (R)	IGX CURRENT	A	0	65535	0	1	426
327 (R)	IGX ANGLE	deg	–1800	1800	0	0.1	427
328 (R)	3I2X NSEQ CURR	A	0	65535	0	1	428
329 (R)	I1X PSEQ CURR	A	0	65535	0	1	429
X-Side Voltage Data							
330 (R)	VABX	kV	0	65535	0	0.01	430
331 (R)	VABX ANGLE	deg	–1800	1800	0	0.1	431
332 (R)	VBCX	kV	0	65535	0	0.01	432
333 (R)	VBCX ANGLE	deg	–1800	1800	0	0.1	433
334 (R)	VCAX	kV	0	65535	0	0.01	434
335 (R)	VCAX ANGLE	deg	–1800	1800	0	0.1	435
336 (R)	VAX	kV	0	65535	0	0.01	436
337 (R)	VAX ANGLE	deg	–1800	1800	0	0.1	437
338 (R)	VBX	kV	0	65535	0	0.01	438
339 (R)	VBX ANGLE	deg	–1800	1800	0	0.1	439

Table E.34 Modbus Map[a] (Sheet 4 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
340 (R)	VCX	kV	0	65535	0	0.01	440
341 (R)	VCX ANGLE	deg	–1800	1800	0	0.1	441
342 (R)	VGX	kV	0	65535	0	0.01	442
343 (R)	VGX ANGLE	deg	–1800	1800	0	0.1	443
344 (R)	3V2X NSEQ VOLT	kV	0	65535	0	0.01	444
345 (R)	V1X PSEQ VOLT	kV	0	65535	0	0.01	445
X-Side Power Data							
346 (R)	PAX REAL PWR HI	kW	–32768	32767	0	1	446
347 (R)	PAX REAL PWR LO	kW	–32768	32767	0	1	447
348 (R)	PBX REAL PWR HI	kW	–32768	32767	0	1	448
349 (R)	PBX REAL PWR LO	kW	–32768	32767	0	1	449
350 (R)	PCX REAL PWR HI	kW	–32768	32767	0	1	450
351 (R)	PCX REAL PWR LO	kW	–32768	32767	0	1	451
352 (R)	P3X REAL PWR HI	kW	–32768	32767	0	1	452
353 (R)	P3X REAL PWR LO	kW	–32768	32767	0	1	453
354 (R)	QAX REACTV PWRHI	kVAR	–32768	32767	0	1	454
355 (R)	QAX REACTV PWRLO	kVAR	–32768	32767	0	1	455
356 (R)	QBX REACTV PWRHI	kVAR	–32768	32767	0	1	456
357 (R)	QBX REACTV PWRLO	kVAR	–32768	32767	0	1	457
358 (R)	QCX REACTV PWRHI	kVAR	–32768	32767	0	1	458
359 (R)	QCX REACTV PWRLO	kVAR	–32768	32767	0	1	459
360 (R)	Q3X REACTV PWRHI	kVAR	–32768	32767	0	1	460
361 (R)	Q3X REACTV PWRLO	kVAR	–32768	32767	0	1	461
362 (R)	SAX APPRNT PWRHI	kVA	–32768	32767	0	1	462
363 (R)	SAX APPRNT PWRLO	kVA	–32768	32767	0	1	463
364 (R)	SBX APPRNT PWRHI	kVA	–32768	32767	0	1	464
365 (R)	SBX APPRNT PWRLO	kVA	–32768	32767	0	1	465
366 (R)	SCX APPRNT PWRHI	kVA	–32768	32767	0	1	466
367 (R)	SCX APPRNT PWRLO	kVA	–32768	32767	0	1	467
368 (R)	S3X APPRNT PWRHI	kVA	–32768	32767	0	1	468
369 (R)	S3X APPRNT PWRLO	kVA	–32768	32767	0	1	469
370 (R)	PFAX PWR FACTOR		–100	100	0	0.01	470
371 (R)	PFBX PWR FACTOR		–100	100	0	0.01	471
372 (R)	PFCX PWR FACTOR		–100	100	0	0.01	472
373 (R)	PF3X PWR FACTOR		–100	100	0	0.01	473
374 (R)	X SIDE FREQUENCY	Hz	0	65535	6000	0.01	474
375 (R)	X SIDE V/HZ	%	0	1000	0	0.1	475
376–380 (R)	Reserved[d]		0	0	0		476–480
Y-Side Current Data							
381 (R)	IAY CURRENT	A	0	65535	0	1	481
382 (R)	IAY ANGLE	deg	–1800	1800	0	0.1	482
383 (R)	IBY CURRENT	A	0	65535	0	1	483
384 (R)	IBY ANGLE	deg	–1800	1800	0	0.1	484
385 (R)	ICY CURRENT	A	0	65535	0	1	485
386 (R)	ICY ANGLE	deg	–1800	1800	0	0.1	486

Table E.34 Modbus Map[a] (Sheet 5 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
387 (R)	IGY CURRENT	A	0	65535	0	1	487
388 (R)	IGY ANGLE	deg	–1800	1800	0	0.1	488
389 (R)	3I2Y NSEQ CURR	A	0	65535	0	1	489
390 (R)	I1Y PSEQ CURR	A	0	65535	0	1	490
Y-Side Voltage Data							
391 (R)	VABY	kV	0	65535	0	0.01	491
392 (R)	VABY ANGLE	deg	–1800	1800	0	0.1	492
393 (R)	VBCY	kV	0	65535	0	0.01	493
394 (R)	VBCY ANGLE	deg	–1800	1800	0	0.1	494
395 (R)	VCAY	kV	0	65535	0	0.01	495
396 (R)	VCAY ANGLE	deg	–1800	1800	0	0.1	496
397 (R)	VAY	kV	0	65535	0	0.01	497
398 (R)	VAY ANGLE	deg	–1800	1800	0	0.1	498
399 (R)	VBY	kV	0	65535	0	0.01	499
400 (R)	VBY ANGLE	deg	–1800	1800	0	0.1	500
401 (R)	VCY	kV	0	65535	0	0.01	501
402 (R)	VCY ANGLE	deg	–1800	1800	0	0.1	502
403 (R)	VGY	kV	0	65535	0	0.01	503
404 (R)	VGY ANGLE	deg	–1800	1800	0	0.1	504
405 (R)	3V2Y NSEQ VOLT	kV	0	65535	0	0.01	505
406 (R)	V1Y PSEQ VOLT	kV	0	65535	0	0.01	506
Misc Measurement							
407 (R)	IN CURRENT	A	0	65535	0	1	507
408 (R)	IN ANGLE	deg	–1800	1800	0	0.1	508
409 (R)	VS	kV	0	65535	0	0.01	509
410 (R)	VS ANGLE	deg	–1800	1800	0	0.1	510
411 (R)	VN	kV	0	65535	0	0.01	511
412 (R)	VN ANGLE	deg	–1800	1800	0	0.1	512
413 (R)	VN3	V	0	65535	0	1	513
414 (R)	VPX3	V	0	65535	0	1	514
415 (R)	FIELD GROUND RES FFFFh = Comm Fail or E64F = N	kilohm	0	65535	0	1	515
416 (R)	SYNC FREQUENCY	Hz	0	65535	6000	0.01	516
417–422 (R)	Reserved[d]		0	0	0		517–522
Energy Data							
423 (R)	MWHPX HI	MWhr	0	65535	0	0.001	523
424 (R)	MWHPX LO	MWhr	0	65535	0	0.001	524
425 (R)	MWHNX HI	MWhr	0	65535	0	0.001	525
426 (R)	MWHNX LO	MWhr	0	65535	0	0.001	526
427 (R)	MVARHPX HI	MVRh	0	65535	0	0.001	527
428 (R)	MVARHPX LO	MVRh	0	65535	0	0.001	528
429 (R)	MVARHNX HI	MVRh	0	65535	0	0.001	529
430 (R)	MVARHNX LO	MVRh	0	65535	0	0.001	530
431 (R)	MWHPY HI	MWhr	0	65535	0	0.001	531
432 (R)	MWHPY LO	MWhr	0	65535	0	0.001	532

Table E.34 Modbus Map[a] (Sheet 6 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
433 (R)	MWHNY HI	MWhr	0	65535	0	0.001	533
434 (R)	MWHNY LO	MWhr	0	65535	0	0.001	534
435 (R)	MVARHPY HI	MVRh	0	65535	0	0.001	535
436 (R)	MVARHPY LO	MVRh	0	65535	0	0.001	536
437 (R)	MVARHNY HI	MVRh	0	65535	0	0.001	537
438 (R)	MVARHNY LO	MVRh	0	65535	0	0.001	538
439 (R)	LAST RST TIME—ss		0	5999	0	0.01	539
440 (R)	LAST RST TIME—mm		0	59	0	1	540
441 (R)	LAST RST TIME—hh		0	23	0	1	541
442 (R)	LAST RST DATE—dd		1	31	1	1	542
443 (R)	LAST RST DATE—mm		1	12	1	1	543
444 (R)	LAST RST DATE—yy		2000	9999	2000	1	544
445–452 (R)	Reserved[d]		0	0	0		545–552
Demand Data							
453 (R)	IAX DEMAND	A	0	65535	0	1	553
454 (R)	IBX DEMAND	A	0	65535	0	1	554
455 (R)	ICX DEMAND	A	0	65535	0	1	555
456 (R)	IGX DEMAND	A	0	65535	0	1	556
457 (R)	3I2X DEMAND	A	0	65535	0	1	557
458 (R)	IAY DEMAND	A	0	65535	0	1	558
459 (R)	IBY DEMAND	A	0	65535	0	1	559
460 (R)	ICY DEMAND	A	0	65535	0	1	560
461 (R)	IGY DEMAND	A	0	65535	0	1	561
462 (R)	3I2Y DEMAND	A	0	65535	0	1	562
Peak Demand Data							
463 (R)	IAX PEAK DEMAND	A	0	65535	0	1	563
464 (R)	IBX PEAK DEMAND	A	0	65535	0	1	564
465 (R)	ICX PEAK DEMAND	A	0	65535	0	1	565
466 (R)	IGX PEAK DEMAND	A	0	65535	0	1	566
467 (R)	3I2X PEAK DEMAND	A	0	65535	0	1	567
468 (R)	IAY PEAK DEMAND	A	0	65535	0	1	568
469 (R)	IBY PEAK DEMAND	A	0	65535	0	1	569
470 (R)	ICY PEAK DEMAND	A	0	65535	0	1	570
471 (R)	IGY PEAK DEMAND	A	0	65535	0	1	571
472 (R)	3I2Y PEAK DEMAND	A	0	65535	0	1	572
473 (R)	PEAKD RST TIM—ss		0	5999	0	0.01	573
474 (R)	PEAKD RST TIM—mm		0	59	0	1	574
475 (R)	PEAKD RST TIM—hh		0	23	0	1	575
476 (R)	PEAKD RST DAT—dd		1	31	1	1	576
477 (R)	PEAKD RST DAT—mm		1	12	1	1	577
478 (R)	PEAKD RST DAT—yy		2000	9999	2000	1	578
Harmonic Data							
479 (R)	IAX THD	%	0	65535	0	1	579
480 (R)	IBX THD	%	0	65535	0	1	580
481 (R)	ICX THD	%	0	65535	0	1	581

Table E.34 Modbus Map[a] (Sheet 7 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
482 (R)	IAY THD	%	0	65535	0	1	582
483 (R)	IBY THD	%	0	65535	0	1	583
484 (R)	ICY THD	%	0	65535	0	1	584
RTD Data							
485 (R)	MAX WINDING RTD 7FFFh = Open 8000h = Short 7FFCh = Comm Fail 7FF8h = Stat Fail 7FFEh = Fail 7FF0h = NA	degC	–32768	32767	0	1	585
486 (R)	MAX BEARING RTD	degC	–32768	32767	0	1	586
487 (R)	MAX AMBIENT RTD	degC	–32768	32767	0	1	587
488 (R)	MAX OTHER RTD	degC	–32768	32767	0	1	588
489 (R)	RTD1	degC	–32768	32767	0	1	589
490 (R)	RTD2	degC	–32768	32767	0	1	590
491 (R)	RTD3	degC	–32768	32767	0	1	591
492 (R)	RTD4	degC	–32768	32767	0	1	592
493 (R)	RTD5	degC	–32768	32767	0	1	593
494 (R)	RTD6	degC	–32768	32767	0	1	594
495 (R)	RTD7	degC	–32768	32767	0	1	595
496 (R)	RTD8	degC	–32768	32767	0	1	596
497 (R)	RTD9	degC	–32768	32767	0	1	597
498 (R)	RTD10	degC	–32768	32767	0	1	598
499 (R)	RTD11	degC	–32768	32767	0	1	599
500 (R)	RTD12	degC	–32768	32767	0	1	600
501 (R)	GENERATOR %TCU	%	0	100	0	1	601
502 (R)	RTD %TCU	%	0	100	0	1	602
503 (R)	Reserved[d]		0	0	0		603
Reserved Area 2							
504–513 (R)	Reserved[d]		0	0	0		604–613
RMS Data							
514 (R)	IAX RMS	A	0	65535	0	1	614
515 (R)	IBX RMS	A	0	65535	0	1	615
516 (R)	ICX RMS	A	0	65535	0	1	616
517 (R)	IAY RMS	A	0	65535	0	1	617
518 (R)	IBY RMS	A	0	65535	0	1	618
519 (R)	ICY RMS	A	0	65535	0	1	619
520 (R)	VAX RMS	kV	0	65535	0	0.01	620
521 (R)	VBX RMS	kV	0	65535	0	0.01	621
522 (R)	VCX RMS	kV	0	65535	0	0.01	622
523 (R)	VABX RMS	kV	0	65535	0	0.01	623
524 (R)	VBCX RMS	kV	0	65535	0	0.01	624
525 (R)	VCAX RMS	kV	0	65535	0	0.01	625
526 (R)	VAY RMS	kV	0	65535	0	0.01	626
527 (R)	VBY RMS	kV	0	65535	0	0.01	627

Table E.34 Modbus Map[a] (Sheet 8 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
528 (R)	VCY RMS	kV	0	65535	0	0.01	628
529 (R)	VABY RMS	kV	0	65535	0	0.01	629
530 (R)	VBCY RMS	kV	0	65535	0	0.01	630
531 (R)	VCAY RMS	kV	0	65535	0	0.01	631
532 (R)	IN RMS	A	0	65535	0	1	632
533 (R)	VS RMS	kV	0	65535	0	0.01	633
MAX/MIN MTR Data							
534 (R)	IAX MAX	A	0	65535	0	1	634
535 (R)	IAX MIN	A	0	65535	0	1	635
536 (R)	IBX MAX	A	0	65535	0	1	636
537 (R)	IBX MIN	A	0	65535	0	1	637
538 (R)	ICX MAX	A	0	65535	0	1	638
539 (R)	ICX MIN	A	0	65535	0	1	639
540 (R)	IGX MAX	A	0	65535	0	1	640
541 (R)	IGX MIN	A	0	65535	0	1	641
542 (R)	IAY MAX	A	0	65535	0	1	642
543 (R)	IAY MIN	A	0	65535	0	1	643
544 (R)	IBY MAX	A	0	65535	0	1	644
545 (R)	IBY MIN	A	0	65535	0	1	645
546 (R)	ICY MAX	A	0	65535	0	1	646
547 (R)	ICY MIN	A	0	65535	0	1	647
548 (R)	IGY MAX	A	0	65535	0	1	648
549 (R)	IGY MIN	A	0	65535	0	1	649
550 (R)	IN MAX	A	0	65535	0	1	650
551 (R)	IN MIN	A	0	65535	0	1	651
552 (R)	VABX/VAX MAX	kV	0	65535	0	0.01	652
553 (R)	VABX/VAX MIN	kV	0	65535	0	0.01	653
554 (R)	VBCX/VBX MAX	kV	0	65535	0	0.01	654
555 (R)	VBCX/VBX MIN	kV	0	65535	0	0.01	655
556 (R)	VCAX/VCX MAX	kV	0	65535	0	0.01	656
557 (R)	VCAX/VCX MIN	kV	0	65535	0	0.01	657
558 (R)	VABY/VAY MAX	kV	0	65535	0	0.01	658
559 (R)	VABY/VAY MIN	kV	0	65535	0	0.01	659
560 (R)	VBCY/VBY MAX	kV	0	65535	0	0.01	660
561 (R)	VBCY/VBY MIN	kV	0	65535	0	0.01	661
562 (R)	VCAY/VCY MAX	kV	0	65535	0	0.01	662
563 (R)	VCAY/VCY MIN	kV	0	65535	0	0.01	663
564 (R)	VS MAX	kV	0	65535	0	0.01	664
565 (R)	VS MIN	kV	0	65535	0	0.01	665
566 (R)	VN MAX	kV	0	65535	0	0.01	666
567 (R)	VN MIN	kV	0	65535	0	0.01	667
568 (R)	VN3 MAX	V	0	65535	0	1	668
569 (R)	VN3 MIN	V	0	65535	0	1	669
570 (R)	VPX3 MAX	V	0	65535	0	1	670
571 (R)	VPX3 MIN	V	0	65535	0	1	671

Table E.34 Modbus Map[a] (Sheet 9 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
572 (R)	KW3PX MAX HI	kW	–32768	32767	0	1	672
573 (R)	KW3PX MAX LO	kW	–32768	32767	0	1	673
574 (R)	KW3PX MIN HI	kW	–32768	32767	0	1	674
575 (R)	KW3PX MIN LO	kW	–32768	32767	0	1	675
576 (R)	KVAR3PX MAX HI	kVAR	–32768	32767	0	1	676
577 (R)	KVAR3PX MAX LO	kVAR	–32768	32767	0	1	677
578 (R)	KVAR3PX MIN HI	kVAR	–32768	32767	0	1	678
579 (R)	KVAR3PX MIN LO	kVAR	–32768	32767	0	1	679
580 (R)	KVA3PX MAX HI	kVA	–32768	32767	0	1	680
581 (R)	KVA3PX MAX LO	kVA	–32768	32767	0	1	681
582 (R)	KVA3PX MIN HI	kVA	–32768	32767	0	1	682
583 (R)	KVA3PX MIN LO	kVA	–32768	32767	0	1	683
584 (R)	KW3PY MAX HI	kW	–32768	32767	0	1	684
585 (R)	KW3PY MAX LO	kW	–32768	32767	0	1	685
586 (R)	KW3PY MIN HI	kW	–32768	32767	0	1	686
587 (R)	KW3PY MIN LO	kW	–32768	32767	0	1	687
588 (R)	KVAR3PY MAX HI	kVAR	–32768	32767	0	1	688
589 (R)	KVAR3PY MAX LO	kVAR	–32768	32767	0	1	689
590 (R)	KVAR3PY MIN HI	kVAR	–32768	32767	0	1	690
591 (R)	KVAR3PY MIN LO	kVAR	–32768	32767	0	1	691
592 (R)	KVA3PY MAX HI	kVA	–32768	32767	0	1	692
593 (R)	KVA3PY MAX LO	kVA	–32768	32767	0	1	693
594 (R)	KVA3PY MIN HI	kVA	–32768	32767	0	1	694
595 (R)	KVA3PY MIN LO	kVA	–32768	32767	0	1	695
596 (R)	FREQX MAX	Hz	0	65535	0	0.01	696
597 (R)	FREQX MIN	Hz	0	65535	0	0.01	697
598 (R)	FREQY MAX	Hz	0	65535	0	0.01	698
599 (R)	FREQY MIN	Hz	0	65535	0	0.01	699
MAX/MIN RTD Data							
600 (R)	RTD1 MAX	degC	–32768	32767	0	1	700
601 (R)	RTD1 MIN	degC	–32768	32767	0	1	701
602 (R)	RTD2 MAX	degC	–32768	32767	0	1	702
603 (R)	RTD2 MIN	degC	–32768	32767	0	1	703
604 (R)	RTD3 MAX	degC	–32768	32767	0	1	704
605 (R)	RTD3 MIN	degC	–32768	32767	0	1	705
606 (R)	RTD4 MAX	degC	–32768	32767	0	1	706
607 (R)	RTD4 MIN	degC	–32768	32767	0	1	707
608 (R)	RTD5 MAX	degC	–32768	32767	0	1	708
609 (R)	RTD5 MIN	degC	–32768	32767	0	1	709
610 (R)	RTD6 MAX	degC	–32768	32767	0	1	710
611 (R)	RTD6 MIN	degC	–32768	32767	0	1	711
612 (R)	RTD7 MAX	degC	–32768	32767	0	1	712
613 (R)	RTD7 MIN	degC	–32768	32767	0	1	713
614 (R)	RTD8 MAX	degC	–32768	32767	0	1	714
615 (R)	RTD8 MIN	degC	–32768	32767	0	1	715

Table E.34 Modbus Map[a] (Sheet 10 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
616 (R)	RTD9 MAX	degC	–32768	32767	0	1	716
617 (R)	RTD9 MIN	degC	–32768	32767	0	1	717
618 (R)	RTD10 MAX	degC	–32768	32767	0	1	718
619 (R)	RTD10 MIN	degC	–32768	32767	0	1	719
620 (R)	RTD11 MAX	degC	–32768	32767	0	1	720
621 (R)	RTD11 MIN	degC	–32768	32767	0	1	721
622 (R)	RTD12 MAX	degC	–32768	32767	0	1	722
623 (R)	RTD12 MIN	degC	–32768	32767	0	1	723
MAX/MIN AI3 Data							
624 (R)	AI301 MX—HI	EU	–32768	32767	0	0.001	724
625 (R)	AI301 MX—LO	EU	–32768	32767	0	0.001	725
626 (R)	AI301 MN—HI	EU	–32768	32767	0	0.001	726
627 (R)	AI301 MN—LO	EU	–32768	32767	0	0.001	727
628 (R)	AI302 MX—HI	EU	–32768	32767	0	0.001	728
629 (R)	AI302 MX—LO	EU	–32768	32767	0	0.001	729
630 (R)	AI302 MN—HI	EU	–32768	32767	0	0.001	730
631 (R)	AI302 MN—LO	EU	–32768	32767	0	0.001	731
632 (R)	AI303 MX—HI	EU	–32768	32767	0	0.001	732
633 (R)	AI303 MX—LO	EU	–32768	32767	0	0.001	733
634 (R)	AI303 MN—HI	EU	–32768	32767	0	0.001	734
635 (R)	AI303 MN—LO	EU	–32768	32767	0	0.001	735
636 (R)	AI304 MX—HI	EU	–32768	32767	0	0.001	736
637 (R)	AI304 MX—LO	EU	–32768	32767	0	0.001	737
638 (R)	AI304 MN—HI	EU	–32768	32767	0	0.001	738
639 (R)	AI304 MN—LO	EU	–32768	32767	0	0.001	739
MAX/MIN AI4 Data							
640 (R)	AI401 MX—HI	EU	–32768	32767	0	0.001	740
641 (R)	AI401 MX—LO	EU	–32768	32767	0	0.001	741
642 (R)	AI401 MN—HI	EU	–32768	32767	0	0.001	742
643 (R)	AI401 MN—LO	EU	–32768	32767	0	0.001	743
644 (R)	AI402 MX—HI	EU	–32768	32767	0	0.001	744
645 (R)	AI402 MX—LO	EU	–32768	32767	0	0.001	745
646 (R)	AI402 MN—HI	EU	–32768	32767	0	0.001	746
647 (R)	AI402 MN—LO	EU	–32768	32767	0	0.001	747
648 (R)	AI403 MX—HI	EU	–32768	32767	0	0.001	748
649 (R)	AI403 MX—LO	EU	–32768	32767	0	0.001	749
650 (R)	AI403 MN—HI	EU	–32768	32767	0	0.001	750
651 (R)	AI403 MN—LO	EU	–32768	32767	0	0.001	751
652 (R)	AI404 MX—HI	EU	–32768	32767	0	0.001	752
653 (R)	AI404 MX—LO	EU	–32768	32767	0	0.001	753
654 (R)	AI404 MN—HI	EU	–32768	32767	0	0.001	754
655 (R)	AI404 MN—LO	EU	–32768	32767	0	0.001	755
MAX/MIN AI5 Data							
656 (R)	AI501 MX—HI	EU	–32768	32767	0	0.001	756
657 (R)	AI501 MX—LO	EU	–32768	32767	0	0.001	757

Table E.34 Modbus Map[a] (Sheet 11 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
658 (R)	AI501 MN—HI	EU	–32768	32767	0	0.001	758
659 (R)	AI501 MN—LO	EU	–32768	32767	0	0.001	759
660 (R)	AI502 MX—HI	EU	–32768	32767	0	0.001	760
661 (R)	AI502 MX—LO	EU	–32768	32767	0	0.001	761
662 (R)	AI502 MN—HI	EU	–32768	32767	0	0.001	762
663 (R)	AI502 MN—LO	EU	–32768	32767	0	0.001	763
664 (R)	AI503 MX—HI	EU	–32768	32767	0	0.001	764
665 (R)	AI503 MX—LO	EU	–32768	32767	0	0.001	765
666 (R)	AI503 MN—HI	EU	–32768	32767	0	0.001	766
667 (R)	AI503 MN—LO	EU	–32768	32767	0	0.001	767
668 (R)	AI504 MX—HI	EU	–32768	32767	0	0.001	768
669 (R)	AI504 MX—LO	EU	–32768	32767	0	0.001	769
670 (R)	AI504 MN—HI	EU	–32768	32767	0	0.001	770
671 (R)	AI504 MN—LO	EU	–32768	32767	0	0.001	771
MAX/MIN RST Data							
672 (R)	MX/MN RST TIM—ss		0	5999	0	0.01	772
673 (R)	MX/MN RST TIM—mm		0	59	0	1	773
674 (R)	MX/MN RST TIM—hh		0	23	0	1	774
675 (R)	MX/MN RST DAT—dd		1	31	1	1	775
676 (R)	MX/MN RST DAT—mm		1	12	1	1	776
677 (R)	MX/MN RST DAT—yy		2000	9999	2000	1	777
678–681 (R)	Reserved[d]		0	0	0		778–781
Analog Input Data							
682 (R)	AI301—HI	EU	–32768	32767	0	0.001	782
683 (R)	AI301—LO	EU	–32768	32767	0	0.001	783
684 (R)	AI302—HI	EU	–32768	32767	0	0.001	784
685 (R)	AI302—LO	EU	–32768	32767	0	0.001	785
686 (R)	AI303—HI	EU	–32768	32767	0	0.001	786
687 (R)	AI303—LO	EU	–32768	32767	0	0.001	787
688 (R)	AI304—HI	EU	–32768	32767	0	0.001	788
689 (R)	AI304—LO	EU	–32768	32767	0	0.001	789
690 (R)	AI401—HI	EU	–32768	32767	0	0.001	790
691 (R)	AI401—LO	EU	–32768	32767	0	0.001	791
692 (R)	AI402—HI	EU	–32768	32767	0	0.001	792
693 (R)	AI402—LO	EU	–32768	32767	0	0.001	793
694 (R)	AI403—HI	EU	–32768	32767	0	0.001	794
695 (R)	AI403—LO	EU	–32768	32767	0	0.001	795
696 (R)	AI404—HI	EU	–32768	32767	0	0.001	796
697 (R)	AI404—LO	EU	–32768	32767	0	0.001	797
698 (R)	AI501—HI	EU	–32768	32767	0	0.001	798
699 (R)	AI501—LO	EU	–32768	32767	0	0.001	799
700 (R)	AI502—HI	EU	–32768	32767	0	0.001	800
701 (R)	AI502—LO	EU	–32768	32767	0	0.001	801
702 (R)	AI503—HI	EU	–32768	32767	0	0.001	802
703 (R)	AI503—LO	EU	–32768	32767	0	0.001	803

Table E.34 Modbus Map[a] (Sheet 12 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
704 (R)	AI504—HI	EU	–32768	32767	0	0.001	804
705 (R)	AI504—LO	EU	–32768	32767	0	0.001	805
Math Variables							
706 (R)	MV01—HI		–32768	32767	0	0.01	806
707 (R)	MV01—LO		–32768	32767	0	0.01	807
708 (R)	MV02—HI		–32768	32767	0	0.01	808
709 (R)	MV02—LO		–32768	32767	0	0.01	809
710 (R)	MV03—HI		–32768	32767	0	0.01	810
711 (R)	MV03—LO		–32768	32767	0	0.01	811
712 (R)	MV04—HI		–32768	32767	0	0.01	812
713 (R)	MV04—LO		–32768	32767	0	0.01	813
714 (R)	MV05—HI		–32768	32767	0	0.01	814
715 (R)	MV05—LO		–32768	32767	0	0.01	815
716 (R)	MV06—HI		–32768	32767	0	0.01	816
717 (R)	MV06—LO		–32768	32767	0	0.01	817
718 (R)	MV07—HI		–32768	32767	0	0.01	818
719 (R)	MV07—LO		–32768	32767	0	0.01	819
720 (R)	MV08—HI		–32768	32767	0	0.01	820
721 (R)	MV08—LO		–32768	32767	0	0.01	821
722 (R)	MV09—HI		–32768	32767	0	0.01	822
723 (R)	MV09—LO		–32768	32767	0	0.01	823
724 (R)	MV10—HI		–32768	32767	0	0.01	824
725 (R)	MV10—LO		–32768	32767	0	0.01	825
726 (R)	MV11—HI		–32768	32767	0	0.01	826
727 (R)	MV11—LO		–32768	32767	0	0.01	827
728 (R)	MV12—HI		–32768	32767	0	0.01	828
729 (R)	MV12—LO		–32768	32767	0	0.01	829
730 (R)	MV13—HI		–32768	32767	0	0.01	830
731 (R)	MV13—LO		–32768	32767	0	0.01	831
732 (R)	MV14—HI		–32768	32767	0	0.01	832
733 (R)	MV14—LO		–32768	32767	0	0.01	833
734 (R)	MV15—HI		–32768	32767	0	0.01	834
735 (R)	MV15—LO		–32768	32767	0	0.01	835
736 (R)	MV16—HI		–32768	32767	0	0.01	836
737 (R)	MV16—LO		–32768	32767	0	0.01	837
738 (R)	MV17—HI		–32768	32767	0	0.01	838
739 (R)	MV17—LO		–32768	32767	0	0.01	839
740 (R)	MV18—HI		–32768	32767	0	0.01	840
741 (R)	MV18—LO		–32768	32767	0	0.01	841
742 (R)	MV19—HI		–32768	32767	0	0.01	842
743 (R)	MV19—LO		–32768	32767	0	0.01	843
744 (R)	MV20—HI		–32768	32767	0	0.01	844
745 (R)	MV20—LO		–32768	32767	0	0.01	845
746 (R)	MV21—HI		–32768	32767	0	0.01	846
747 (R)	MV21—LO		–32768	32767	0	0.01	847

Table E.34 Modbus Map[a] (Sheet 13 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
748 (R)	MV22—HI		–32768	32767	0	0.01	848
749 (R)	MV22—LO		–32768	32767	0	0.01	849
750 (R)	MV23—HI		–32768	32767	0	0.01	850
751 (R)	MV23—LO		–32768	32767	0	0.01	851
752 (R)	MV24—HI		–32768	32767	0	0.01	852
753 (R)	MV24—LO		–32768	32767	0	0.01	853
754 (R)	MV25—HI		–32768	32767	0	0.01	854
755 (R)	MV25—LO		–32768	32767	0	0.01	855
756 (R)	MV26—HI		–32768	32767	0	0.01	856
757 (R)	MV26—LO		–32768	32767	0	0.01	857
758 (R)	MV27—HI		–32768	32767	0	0.01	858
759 (R)	MV27—LO		–32768	32767	0	0.01	859
760 (R)	MV28—HI		–32768	32767	0	0.01	860
761 (R)	MV28—LO		–32768	32767	0	0.01	861
762 (R)	MV29—HI		–32768	32767	0	0.01	862
763 (R)	MV29—LO		–32768	32767	0	0.01	863
764 (R)	MV30—HI		–32768	32767	0	0.01	864
765 (R)	MV30—LO		–32768	32767	0	0.01	865
766 (R)	MV31—HI		–32768	32767	0	0.01	866
767 (R)	MV31—LO		–32768	32767	0	0.01	867
768 (R)	MV32—HI		–32768	32767	0	0.01	868
769 (R)	MV32—LO		–32768	32767	0	0.01	869
Device Counters							
770–801 (R)	COUNTER SC01–COUNTER SC32		0	65000	0	1	870–901
Reserved Area3							
802–817 (R)	Reserved[d]		0	0	0		902–917
Historical Data							
818 (R)	NO. EVENT LOGS		0	50	0	1	918
819 (R/W)	EVENT LOG SEL.		0	50	0	1	919
820 (R)	EVENT TIME ss		0	5999	0	0.01	920
821 (R)	EVENT TIME mm		0	59	0	1	921
822 (R)	EVENT TIME hh		0	23	0	1	922
823 (R)	EVENT DAY dd		0	31	1	1	923
824 (R)	EVENT DAY mm		0	12	1	1	924
825 (R)	EVENT DAY yy		0	9999	2000	1	925

Table E.34 Modbus Map[a] (Sheet 14 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
826 (R)	EVENT TYPE 0 = Reserved[d] 1 = DIFF 87 TRIP 2 = REF TRIP 3 = PH 50 TRIP 4 = GND 50 TRIP 5 = 50Q TRIP 6 = NEUTRAL 50 TRIP 7 = NEG SEQ 46 TRIP 8 = PH 51 TRIP 9 = GND 51 TRIP 10 = 51Q TRIP 11 = NEUTRAL 51 TRIP 12 = POWERELEMNT TRIP 13 = UNDERVOLT TRIP 14 = OVERVOLT TRIP 15 = BACKUP TRIP 16 = OUT OF STEP TRIP 17 = VOLT/HZ 24 TRIP 18 = FLD LOSS 40 TRIP 19 = THERMAL 49 TRIP 20 = 64G/64F GND TRIP 21 = FREQUENCY81 TRIP 22 = INADVERTENRGTRIP 23 = RTD TRIP 24 = RTD FAIL TRIP 25 = BKR FAILURE TRIP 26 = REMOTE TRIP 27 = COMMIDLELOSSTRIP 28 = TRIGGER 29 = ER TRIGGER 30 = 78 VECTOR SHIFT 31 = TRIP		0	31	0		926
827 (R)	EVENT TARGETS Bit 0 = TLED_06 Bit 1 = TLED_05 Bit 2 = TLED_04 Bit 3 = TLED_03 Bit 4 = TLED_02 Bit 5 = TLED_01 Bit 6 = TRIP_LED Bit 7 = ENABLED		0	255	0		927
828 (R)	EVENT IAX	A	0	65535	0	1	928
829 (R)	EVENT IBX	A	0	65535	0	1	929
830 (R)	EVENT ICX	A	0	65535	0	1	930
831 (R)	EVENT IGX	A	0	65535	0	1	931
832 (R)	EVENT IAY	A	0	65535	0	1	932
833 (R)	EVENT IBY	A	0	65535	0	1	933
834 (R)	EVENT ICY	A	0	65535	0	1	934
835 (R)	EVENT IGY	A	0	65535	0	1	935
836 (R)	EVENT IN	A	0	65535	0	1	936
837 (R)	EVENT VABX/VAX	kV	0	65535	0	0.01	937
838 (R)	EVENT VBCX/VBX	kV	0	65535	0	0.01	938
839 (R)	EVENT VCAX/VCX	kV	0	65535	0	0.01	939
840 (R)	EVENT VGX	kV	0	65535	0	0.01	940
841 (R)	EVENT VABY/VAY	kV	0	65535	0	0.01	941
842 (R)	EVENT VBCY/VBY	kV	0	65535	0	0.01	942
843 (R)	EVENT VCAY/VCY	kV	0	65535	0	0.01	943
844 (R)	EVENT VGY	kV	0	65535	0	0.01	944
845 (R)	EVENT VS	kV	0	65535	0	0.01	945
846 (R)	EVENT VN	kV	0	65535	0	0.01	946
847 (R)	EVENT DELTA/WYEX 0 = DELTA 1 = WYE		0	1	0		947
848 (R)	EVENT DELTA/WYEY 0 = DELTA 1 = WYE		0	1	0		948
849 (R)	EVENT FREQX	Hz	0	65535	6000	0.01	949

Table E.34 Modbus Map[a] (Sheet 15 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
850 (R)	EVENT FREQY	Hz	0	65535	6000	0.01	950
851 (R)	EVNT MAX WDG RTD	degC	–32768	32767	0	1	951
852 (R)	EVNT MAX BRG RTD	degC	–32768	32767	0	1	952
853 (R)	EVNT MAX AMB RTD	degC	–32768	32767	0	1	953
854 (R)	EVNT MAX OTH RTD	degC	–32768	32767	0	1	954
855–864 (R)	Reserved[d]		0	0	0		955–964
Breaker Monitor Data							
865 (R)	RELAY TRIPX CNT		0	65535	0	1	965
866 (R)	EXTRN TRIPX CNT		0	65535	0	1	966
867 (R)	RELAY TRIPX IA	kA	0	65535	0	1	967
868 (R)	RELAY TRIPX IB	kA	0	65535	0	1	968
869 (R)	RELAY TRIPX IC	kA	0	65535	0	1	969
870 (R)	EXTRN TRIPX IA	kA	0	65535	0	1	970
871 (R)	EXTRN TRIPX IB	kA	0	65535	0	1	971
872 (R)	EXTRN TRIPX IC	kA	0	65535	0	1	972
873 (R)	BKR WEAR POLE AX	%	0	65535	0	1	973
874 (R)	BKR WEAR POLE BX	%	0	65535	0	1	974
875 (R)	BKR WEAR POLE CX	%	0	65535	0	1	975
876 (R)	BKR X RST TIM—ss		0	5999	0	0.01	976
877 (R)	BKR X RST TIM—mm		0	59	0	1	977
878 (R)	BKR X RST TIM—hh		0	23	0	1	978
879 (R)	BKR X RST DAT—dd		1	31	1	1	979
880 (R)	BKR X RST DAT—mm		1	12	1	1	980
881 (R)	BKR X RST DAT—yy		2000	9999	2000	1	981
882 (R)	RELAY TRIPY CNT		0	65535	0	1	982
883 (R)	EXTRN TRIPY CNT		0	65535	0	1	983
884 (R)	RELAY TRIPY IA	kA	0	65535	0	1	984
885 (R)	RELAY TRIPY IB	kA	0	65535	0	1	985
886 (R)	RELAY TRIPY IC	kA	0	65535	0	1	986
887 (R)	EXTRN TRIPY IA	kA	0	65535	0	1	987
888 (R)	EXTRN TRIPY IB	kA	0	65535	0	1	988
889 (R)	EXTRN TRIPY IC	kA	0	65535	0	1	989
890 (R)	BKR WEAR POLE AY	%	0	65535	0	1	990
891 (R)	BKR WEAR POLE BY	%	0	65535	0	1	991
892 (R)	BKR WEAR POLE CY	%	0	65535	0	1	992
893 (R)	BKR Y RST TIM—ss		0	5999	0	0.01	993
894 (R)	BKR Y RST TIM—mm		0	59	0	1	994
895 (R)	BKR Y RST TIM—hh		0	23	0	1	995
896 (R)	BKR Y RST DAT—dd		1	31	1	1	996
897 (R)	BKR Y RST DAT—mm		1	12	1	1	997
898 (R)	BKR Y RST DAT—yy		2000	9999	2000	1	998
899 (R)	Reserved[d]		0	0	0		999
900 (R)	Reserved[d]		0	0	0		1000

Table E.34 Modbus Map[a] (Sheet 16 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
Trip/Warn Data							
The Trip/Warn Status register bits are momentarily set as long as a trip/warn condition exists (see *Table E.35* for the trigger conditions). When a trip event occurs, the elements are latched to the rising edge of the TRIP Relay Word bit and they are not cleared until a target reset is issued from any interface.							
901 (R)	TRIP STATUS LO Bit 0 = 50 PHASE Bit 1 = 50 GROUND Bit 2 = 50 NEGSEQ Bit 3 = 51 PHASE Bit 4 = 51 GROUND Bit 5 = 51 NEGSEQ Bit 6 = NEUTRAL 50 Bit 7 = NEUTRAL 51 Bit 8 = 67 PHASE Bit 9 = 67 GROUND Bit 10 = 67 NEGSEQ Bit 11 = 46 NEGSEQ Bit 12 = 49T THERMAL Bit 13 = GND DIFF 87N Bit 14 = RESTR DIFF 87R Bit 15 = UNRSTR DIFF 87U		0	65535	0		1001
902 (R)	TRIP STATUS HI Bit 0 = UNDERVOLT 27P Bit 1 = OVERVOLT 59P Bit 2 = Reserved[d] Bit 3 = POWER ELEMENTS Bit 4 = FREQUENCY 81 Bit 5 = VOLTS/HERTZ Bit 6 = RESTRCTD EARTH Bit 7 = RTD TRIP Bit 8 = BREAKER FAIL Bit 9 = REMOTE TRIP Bit 10 = BACKUP Bit 11 = 40 FLD LOSS Bit 12 = 64G/64F GND Bit 13 = INADVERTENT ENRG Bit 14 = OUT OF STEP Bit 15 = TRIP		0	65535	0		1002
903 (R)	WARN STATUS LO Bit 0 = BREAKER MONITOR Bit 1 = DEMAND ALARM Bit 2 = RTD FAULT Bit 3 = CONFIG FAULT Bit 4 = COMM FAULT Bit 5 = COMM IDLE Bit 6 = COMM LOSS Bit 7 = DIFF ALARM 87A Bit 8 = 5TH HARMONIC ALM Bit 9 = RTD ALARM Bit 10 = LOSS OF POTNTIAL Bit 11 = AI HI/LO ALARM Bit 12 = 49A THERMAL ALM Bit 13 = HALARM Bit 14 = SALARM Bit 15 = WARNING		0	65535	0		1003

Table E.34 Modbus Map[a] (Sheet 17 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
904 (R)	WARN STATUS HI Bit 0 = UNDERVOLT 27P Bit 1 = OVERVOLT 59P Bit 2 = 46 NEGSEQ Bit 3 = VOLTS/HERTZ Bit 4–Bit 15 = Reserved[d]		0	65535	0		1004
905–909 (R)	Reserved[d]		0	0	0		1005–1009
Commn Counters							
910 (R)	NUM MSG RCVD		0	65535	0	1	1010
911 (R)	NUM OTHER MSG		0	65535	0	1	1011
912 (R)	INVALID ADDR		0	65535	0	1	1012
913 (R)	BAD CRC		0	65535	0	1	1013
914 (R)	UART ERROR		0	65535	0	1	1014
915 (R)	ILLEGAL FUNCTION		0	65535	0	1	1015
916 (R)	ILLEGAL REGISTER		0	65535	0	1	1016
917 (R)	ILLEGAL WRITE		0	65535	0	1	1017
918 (R)	BAD PKT FORMAT		0	65535	0	1	1018
919 (R)	BAD PKT LENGTH		0	65535	0	1	1019
920–925 (R)	Reserved[d]		0	0	0		1020–1025
Y-Side Power Data							
926 (R)	PAY REAL PWR HI	kW	–32768	32767	0	1	1026
927 (R)	PAY REAL PWR LO	kW	–32768	32767	0	1	1027
928 (R)	PBY REAL PWR HI	kW	–32768	32767	0	1	1028
929 (R)	PBY REAL PWR LO	kW	–32768	32767	0	1	1029
930 (R)	PCY REAL PWR HI	kW	–32768	32767	0	1	1030
931 (R)	PCY REAL PWR LO	kW	–32768	32767	0	1	1031
932 (R)	P3Y REAL PWR HI	kW	–32768	32767	0	1	1032
933 (R)	P3Y REAL PWR LO	kW	–32768	32767	0	1	1033
934 (R)	QAY REACTV PWRHI	kVAR	–32768	32767	0	1	1034
935 (R)	QAY REACTV PWRLO	kVAR	–32768	32767	0	1	1035
936 (R)	QBY REACTV PWRHI	kVAR	–32768	32767	0	1	1036
937 (R)	QBY REACTV PWRLO	kVAR	–32768	32767	0	1	1037
938 (R)	QCY REACTV PWRHI	kVAR	–32768	32767	0	1	1038
939 (R)	QCY REACTV PWRLO	kVAR	–32768	32767	0	1	1039
940 (R)	Q3Y REACTV PWRHI	kVAR	–32768	32767	0	1	1040
941 (R)	Q3Y REACTV PWRLO	kVAR	–32768	32767	0	1	1041
942 (R)	SAY APPRNT PWRHI	kVA	–32768	32767	0	1	1042
943 (R)	SAY APPRNT PWRLO	kVA	–32768	32767	0	1	1043
944 (R)	SBY APPRNT PWRHI	kVA	–32768	32767	0	1	1044
945 (R)	SBY APPRNT PWRLO	kVA	–32768	32767	0	1	1045
946 (R)	SCY APPRNT PWRHI	kVA	–32768	32767	0	1	1046
947 (R)	SCY APPRNT PWRLO	kVA	–32768	32767	0	1	1047
948 (R)	S3Y APPRNT PWRHI	kVA	–32768	32767	0	1	1048
949 (R)	S3Y APPRNT PWRLO	kVA	–32768	32767	0	1	1049
950 (R)	PFAY PWR FACTOR		–100	100	0	0.01	1050

Table E.34 Modbus Map[a] (Sheet 18 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
951 (R)	PFBY PWR FACTOR		–100	100	0	0.01	1051
952 (R)	PFCY PWR FACTOR		–100	100	0	0.01	1052
953 (R)	PF3Y PWR FACTOR		–100	100	0	0.01	1053
954 (R)	Y SIDE FREQUENCY	Hz	0	65535	6000	0.01	1054
955–970 (R)	Reserved[d]		0	0	0		1055–1070
Relay Elements							
971–1123 (R)	ROW 0–ROW 152		0	255	0		1071–1123
1124 (R)	Reserved[d]		0	0	0		1224
1125–1188 (R)	ROW 153–ROW216		0	255	0		1225–1288
Remote Analogs 1							
1189 (R/W)	RA001 (0:UW)		–32768	32767	0	0.01	1289
1190 (R/W)	RA001 (1:LW)		–32768	32767	0	0.01	1290
1191 (R/W)	RA002 (0:UW)		–32768	32767	0	0.01	1291
1192 (R/W)	RA002 (1:LW)		–32768	32767	0	0.01	1292
1193 (R/W)	RA003 (0:UW)		–32768	32767	0	0.01	1293
1194 (R/W)	RA003 (1:LW)		–32768	32767	0	0.01	1294
1195 (R/W)	RA004 (0:UW)		–32768	32767	0	0.01	1295
1196 (R/W)	RA004 (1:LW)		–32768	32767	0	0.01	1296
1197 (R/W)	RA005 (0:UW)		–32768	32767	0	0.01	1297
1198 (R/W)	RA005 (1:LW)		–32768	32767	0	0.01	1298
1199 (R/W)	RA006 (0:UW)		–32768	32767	0	0.01	1299
1200 (R/W)	RA006 (1:LW)		–32768	32767	0	0.01	1300
1201 (R/W)	RA007 (0:UW)		–32768	32767	0	0.01	1301
1202 (R/W)	RA007 (1:LW)		–32768	32767	0	0.01	1302
1203 (R/W)	RA008 (0:UW)		–32768	32767	0	0.01	1303
1204 (R/W)	RA008 (1:LW)		–32768	32767	0	0.01	1304
1205 (R/W)	RA009 (0:UW)		–32768	32767	0	0.01	1305
1206 (R/W)	RA009 (1:LW)		–32768	32767	0	0.01	1306
1207 (R/W)	RA010 (0:UW)		–32768	32767	0	0.01	1307
1208 (R/W)	RA010 (1:LW)		–32768	32767	0	0.01	1308
1209 (R/W)	RA011 (0:UW)		–32768	32767	0	0.01	1309
1210 (R/W)	RA011 (1:LW)		–32768	32767	0	0.01	1310
1211 (R/W)	RA012 (0:UW)		–32768	32767	0	0.01	1311
1212 (R/W)	RA012 (1:LW)		–32768	32767	0	0.01	1312
1213 (R/W)	RA013 (0:UW)		–32768	32767	0	0.01	1313
1214 (R/W)	RA013 (1:LW)		–32768	32767	0	0.01	1314
1215 (R/W)	RA014 (0:UW)		–32768	32767	0	0.01	1315
1216 (R/W)	RA014 (1:LW)		–32768	32767	0	0.01	1316
1217 (R/W)	RA015 (0:UW)		–32768	32767	0	0.01	1317
1218 (R/W)	RA015 (1:LW)		–32768	32767	0	0.01	1318
1219 (R/W)	RA016 (0:UW)		–32768	32767	0	0.01	1319
1220 (R/W)	RA016 (1:LW)		–32768	32767	0	0.01	1320
1221 (R/W)	RA017 (0:UW)		–32768	32767	0	0.01	1321
1222 (R/W)	RA017 (1:LW)		–32768	32767	0	0.01	1322
1223 (R/W)	RA018 (0:UW)		–32768	32767	0	0.01	1323

Table E.34 Modbus Map[a] (Sheet 19 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
1224 (R/W)	RA018 (1:LW)		–32768	32767	0	0.01	1324
1225 (R/W)	RA019 (0:UW)		–32768	32767	0	0.01	1325
1226 (R/W)	RA019 (1:LW)		–32768	32767	0	0.01	1326
1227 (R/W)	RA020 (0:UW)		–32768	32767	0	0.01	1327
1228 (R/W)	RA020 (1:LW)		–32768	32767	0	0.01	1328
1229 (R/W)	RA021 (0:UW)		–32768	32767	0	0.01	1329
1230 (R/W)	RA021 (1:LW)		–32768	32767	0	0.01	1330
1231 (R/W)	RA022 (0:UW)		–32768	32767	0	0.01	1331
1232 (R/W)	RA022 (1:LW)		–32768	32767	0	0.01	1332
1233 (R/W)	RA023 (0:UW)		–32768	32767	0	0.01	1333
1234 (R/W)	RA023 (1:LW)		–32768	32767	0	0.01	1334
1235 (R/W)	RA024 (0:UW)		–32768	32767	0	0.01	1335
1236 (R/W)	RA024 (1:LW)		–32768	32767	0	0.01	1336
1237 (R/W)	RA025 (0:UW)		–32768	32767	0	0.01	1337
1238 (R/W)	RA025 (1:LW)		–32768	32767	0	0.01	1338
1239 (R/W)	RA026 (0:UW)		–32768	32767	0	0.01	1339
1240 (R/W)	RA026 (1:LW)		–32768	32767	0	0.01	1340
1241 (R/W)	RA027 (0:UW)		–32768	32767	0	0.01	1341
1242 (R/W)	RA027 (1:LW)		–32768	32767	0	0.01	1342
1243 (R/W)	RA028 (0:UW)		–32768	32767	0	0.01	1343
1244 (R/W)	RA028 (1:LW)		–32768	32767	0	0.01	1344
1245 (R/W)	RA029 (0:UW)		–32768	32767	0	0.01	1345
1246 (R/W)	RA029 (1:LW)		–32768	32767	0	0.01	1346
1247 (R/W)	RA030 (0:UW)		–32768	32767	0	0.01	1347
1248 (R/W)	RA030 (1:LW)		–32768	32767	0	0.01	1348
1249 (R/W)	RA031 (0:UW)		–32768	32767	0	0.01	1349
1250 (R/W)	RA031 (1:LW)		–32768	32767	0	0.01	1350
1251 (R/W)	RA032 (0:UW)		–32768	32767	0	0.01	1351
1252 (R/W)	RA032 (1:LW)		–32768	32767	0	0.01	1352
1253 (R/W)	RA033 (0:UW)		–32768	32767	0	0.01	1353
1254 (R/W)	RA033 (1:LW)		–32768	32767	0	0.01	1354
1255 (R/W)	RA034 (0:UW)		–32768	32767	0	0.01	1355
1256 (R/W)	RA034 (1:LW)		–32768	32767	0	0.01	1356
1257 (R/W)	RA035 (0:UW)		–32768	32767	0	0.01	1357
1258 (R/W)	RA035 (1:LW)		–32768	32767	0	0.01	1358
1259 (R/W)	RA036 (0:UW)		–32768	32767	0	0.01	1359
1260 (R/W)	RA036 (1:LW)		–32768	32767	0	0.01	1360
1261 (R/W)	RA037 (0:UW)		–32768	32767	0	0.01	1361
1262 (R/W)	RA037 (1:LW)		–32768	32767	0	0.01	1362
1263 (R/W)	RA038 (0:UW)		–32768	32767	0	0.01	1363
1264 (R/W)	RA038 (1:LW)		–32768	32767	0	0.01	1364
1265 (R/W)	RA039 (0:UW)		–32768	32767	0	0.01	1365
1266 (R/W)	RA039 (1:LW)		–32768	32767	0	0.01	1366
1267 (R/W)	RA040 (0:UW)		–32768	32767	0	0.01	1367
1268 (R/W)	RA040 (1:LW)		–32768	32767	0	0.01	1368

Table E.34 Modbus Map[a] (Sheet 20 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
1269 (R/W)	RA041 (0:UW)		–32768	32767	0	0.01	1369
1270 (R/W)	RA041 (1:LW)		–32768	32767	0	0.01	1370
1271 (R/W)	RA042 (0:UW)		–32768	32767	0	0.01	1371
1272 (R/W)	RA042 (1:LW)		–32768	32767	0	0.01	1372
1273 (R/W)	RA043 (0:UW)		–32768	32767	0	0.01	1373
1274 (R/W)	RA043 (1:LW)		–32768	32767	0	0.01	1374
1275 (R/W)	RA044 (0:UW)		–32768	32767	0	0.01	1375
1276 (R/W)	RA044 (1:LW)		–32768	32767	0	0.01	1376
1277 (R/W)	RA045 (0:UW)		–32768	32767	0	0.01	1377
1278 (R/W)	RA045 (1:LW)		–32768	32767	0	0.01	1378
1279 (R/W)	RA046 (0:UW)		–32768	32767	0	0.01	1379
1280 (R/W)	RA046 (1:LW)		–32768	32767	0	0.01	1380
1281 (R/W)	RA047 (0:UW)		–32768	32767	0	0.01	1381
1282 (R/W)	RA047 (1:LW)		–32768	32767	0	0.01	1382
1283 (R/W)	RA048 (0:UW)		–32768	32767	0	0.01	1383
1284 (R/W)	RA048 (1:LW)		–32768	32767	0	0.01	1384
1285 (R/W)	RA049 (0:UW)		–32768	32767	0	0.01	1385
1286 (R/W)	RA049 (1:LW)		–32768	32767	0	0.01	1386
1287 (R/W)	RA050 (0:UW)		–32768	32767	0	0.01	1387
1288 (R/W)	RA050 (1:LW)		–32768	32767	0	0.01	1388
1289 (R/W)	RA051 (0:UW)		–32768	32767	0	0.01	1389
1290 (R/W)	RA051 (1:LW)		–32768	32767	0	0.01	1390
1291 (R/W)	RA052 (0:UW)		–32768	32767	0	0.01	1391
1292 (R/W)	RA052 (1:LW)		–32768	32767	0	0.01	1392
1293 (R/W)	RA053 (0:UW)		–32768	32767	0	0.01	1393
1294 (R/W)	RA053 (1:LW)		–32768	32767	0	0.01	1394
1295 (R/W)	RA054 (0:UW)		–32768	32767	0	0.01	1395
1296 (R/W)	RA054 (1:LW)		–32768	32767	0	0.01	1396
1297 (R/W)	RA055 (0:UW)		–32768	32767	0	0.01	1397
1298 (R/W)	RA055 (1:LW)		–32768	32767	0	0.01	1398
1299 (R/W)	RA056 (0:UW)		–32768	32767	0	0.01	1399
1300 (R/W)	RA056 (1:LW)		–32768	32767	0	0.01	1400
1301 (R/W)	RA057 (0:UW)		–32768	32767	0	0.01	1401
1302 (R/W)	RA057 (1:LW)		–32768	32767	0	0.01	1402
1303 (R/W)	RA058 (0:UW)		–32768	32767	0	0.01	1403
1304 (R/W)	RA058 (1:LW)		–32768	32767	0	0.01	1404
1305 (R/W)	RA059 (0:UW)		–32768	32767	0	0.01	1405
1306 (R/W)	RA059 (1:LW)		–32768	32767	0	0.01	1406
1307 (R/W)	RA060 (0:UW)		–32768	32767	0	0.01	1407
1308 (R/W)	RA060 (1:LW)		–32768	32767	0	0.01	1408
1309 (R/W)	RA061 (0:UW)		–32768	32767	0	0.01	1409
1310 (R/W)	RA061 (1:LW)		–32768	32767	0	0.01	1410
1311 (R/W)	RA062 (0:UW)		–32768	32767	0	0.01	1411
1312 (R/W)	RA062 (1:LW)		–32768	32767	0	0.01	1412
1313 (R/W)	RA063 (0:UW)		–32768	32767	0	0.01	1413

Table E.34 Modbus Map[a] (Sheet 21 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
1314 (R/W)	RA063 (1:LW)		–32768	32767	0	0.01	1414
1315 (R/W)	RA064 (0:UW)		–32768	32767	0	0.01	1415
1316 (R/W)	RA064 (1:LW)		–32768	32767	0	0.01	1416
Remote Analogs 2							
1317 (R/W)	RA065 (0:UW)		–32768	32767	0	0.01	1417
1318 (R/W)	RA065 (1:LW)		–32768	32767	0	0.01	1418
1319 (R/W)	RA066 (0:UW)		–32768	32767	0	0.01	1419
1320 (R/W)	RA066 (1:LW)		–32768	32767	0	0.01	1420
1321 (R/W)	RA067 (0:UW)		–32768	32767	0	0.01	1421
1322 (R/W)	RA067 (1:LW)		–32768	32767	0	0.01	1422
1323 (R/W)	RA068 (0:UW)		–32768	32767	0	0.01	1423
1324 (R/W)	RA068 (1:LW)		–32768	32767	0	0.01	1424
1325 (R/W)	RA069 (0:UW)		–32768	32767	0	0.01	1425
1326 (R/W)	RA069 (1:LW)		–32768	32767	0	0.01	1426
1327 (R/W)	RA070 (0:UW)		–32768	32767	0	0.01	1427
1328 (R/W)	RA070 (1:LW)		–32768	32767	0	0.01	1428
1329 (R/W)	RA071 (0:UW)		–32768	32767	0	0.01	1429
1330 (R/W)	RA071 (1:LW)		–32768	32767	0	0.01	1430
1331 (R/W)	RA072 (0:UW)		–32768	32767	0	0.01	1431
1332 (R/W)	RA072 (1:LW)		–32768	32767	0	0.01	1432
1333 (R/W)	RA073 (0:UW)		–32768	32767	0	0.01	1433
1334 (R/W)	RA073 (1:LW)		–32768	32767	0	0.01	1434
1335 (R/W)	RA074 (0:UW)		–32768	32767	0	0.01	1435
1336 (R/W)	RA074 (1:LW)		–32768	32767	0	0.01	1436
1337 (R/W)	RA075 (0:UW)		–32768	32767	0	0.01	1437
1338 (R/W)	RA075 (1:LW)		–32768	32767	0	0.01	1438
1339 (R/W)	RA076 (0:UW)		–32768	32767	0	0.01	1439
1340 (R/W)	RA076 (1:LW)		–32768	32767	0	0.01	1440
1341 (R/W)	RA077 (0:UW)		–32768	32767	0	0.01	1441
1342 (R/W)	RA077 (1:LW)		–32768	32767	0	0.01	1442
1343 (R/W)	RA078 (0:UW)		–32768	32767	0	0.01	1443
1344 (R/W)	RA078 (1:LW)		–32768	32767	0	0.01	1444
1345 (R/W)	RA079 (0:UW)		–32768	32767	0	0.01	1445
1346 (R/W)	RA079 (1:LW)		–32768	32767	0	0.01	1446
1347 (R/W)	RA080 (0:UW)		–32768	32767	0	0.01	1447
1348 (R/W)	RA080 (1:LW)		–32768	32767	0	0.01	1448
1349 (R/W)	RA081 (0:UW)		–32768	32767	0	0.01	1449
1350 (R/W)	RA081 (1:LW)		–32768	32767	0	0.01	1450
1351 (R/W)	RA082 (0:UW)		–32768	32767	0	0.01	1451
1352 (R/W)	RA082 (1:LW)		–32768	32767	0	0.01	1452
1353 (R/W)	RA083 (0:UW)		–32768	32767	0	0.01	1453
1354 (R/W)	RA083 (1:LW)		–32768	32767	0	0.01	1454
1355 (R/W)	RA084 (0:UW)		–32768	32767	0	0.01	1455
1356 (R/W)	RA084 (1:LW)		–32768	32767	0	0.01	1456
1357 (R/W)	RA085 (0:UW)		–32768	32767	0	0.01	1457

Table E.34 Modbus Map[a] (Sheet 22 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
1358 (R/W)	RA085 (1:LW)		–32768	32767	0	0.01	1458
1359 (R/W)	RA086 (0:UW)		–32768	32767	0	0.01	1459
1360 (R/W)	RA086 (1:LW)		–32768	32767	0	0.01	1460
1361 (R/W)	RA087 (0:UW)		–32768	32767	0	0.01	1461
1362 (R/W)	RA087 (1:LW)		–32768	32767	0	0.01	1462
1363 (R/W)	RA088 (0:UW)		–32768	32767	0	0.01	1463
1364 (R/W)	RA088 (1:LW)		–32768	32767	0	0.01	1464
1365 (R/W)	RA089 (0:UW)		–32768	32767	0	0.01	1465
1366 (R/W)	RA089 (1:LW)		–32768	32767	0	0.01	1466
1367 (R/W)	RA090 (0:UW)		–32768	32767	0	0.01	1467
1368 (R/W)	RA090 (1:LW)		–32768	32767	0	0.01	1468
1369 (R/W)	RA091 (0:UW)		–32768	32767	0	0.01	1469
1370 (R/W)	RA091 (1:LW)		–32768	32767	0	0.01	1470
1371 (R/W)	RA092 (0:UW)		–32768	32767	0	0.01	1471
1372 (R/W)	RA092 (1:LW)		–32768	32767	0	0.01	1372
1373 (R/W)	RA093 (0:UW)		–32768	32767	0	0.01	1473
1374 (R/W)	RA093 (1:LW)		–32768	32767	0	0.01	1474
1375 (R/W)	RA094 (0:UW)		–32768	32767	0	0.01	1475
1376 (R/W)	RA094 (1:LW)		–32768	32767	0	0.01	1476
1377 (R/W)	RA095 (0:UW)		–32768	32767	0	0.01	1477
1378 (R/W)	RA095 (1:LW)		–32768	32767	0	0.01	1478
1379 (R/W)	RA096 (0:UW)		–32768	32767	0	0.01	1479
1380 (R/W)	RA096 (1:LW)		–32768	32767	0	0.01	1480
1381 (R/W)	RA097 (0:UW)		–32768	32767	0	0.01	1481
1382 (R/W)	RA097 (1:LW)		–32768	32767	0	0.01	1482
1383 (R/W)	RA098 (0:UW)		–32768	32767	0	0.01	1483
1384 (R/W)	RA098 (1:LW)		–32768	32767	0	0.01	1484
1385 (R/W)	RA099 (0:UW)		–32768	32767	0	0.01	1485
1386 (R/W)	RA099 (1:LW)		–32768	32767	0	0.01	1486
1387 (R/W)	RA100 (0:UW)		–32768	32767	0	0.01	1487
1388 (R/W)	RA100 (1:LW)		–32768	32767	0	0.01	1488
1389 (R/W)	RA101 (0:UW)		–32768	32767	0	0.01	1489
1390 (R/W)	RA101 (1:LW)		–32768	32767	0	0.01	1490
1391 (R/W)	RA102 (0:UW)		–32768	32767	0	0.01	1491
1392 (R/W)	RA102 (1:LW)		–32768	32767	0	0.01	1492
1393 (R/W)	RA103 (0:UW)		–32768	32767	0	0.01	1493
1394 (R/W)	RA103 (1:LW)		–32768	32767	0	0.01	1494
1395 (R/W)	RA104 (0:UW)		–32768	32767	0	0.01	1495
1396 (R/W)	RA104 (1:LW)		–32768	32767	0	0.01	1496
1397 (R/W)	RA105 (0:UW)		–32768	32767	0	0.01	1497
1398 (R/W)	RA105 (1:LW)		–32768	32767	0	0.01	1498
1399 (R/W)	RA106 (0:UW)		–32768	32767	0	0.01	1499
1400 (R/W)	RA106 (1:LW)		–32768	32767	0	0.01	1500
1401 (R/W)	RA107 (0:UW)		–32768	32767	0	0.01	1501
1402 (R/W)	RA107 (1:LW)		–32768	32767	0	0.01	1502

Table E.34 Modbus Map[a] (Sheet 23 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
1403 (R/W)	RA108 (0:UW)		–32768	32767	0	0.01	1503
1404 (R/W)	RA108 (1:LW)		–32768	32767	0	0.01	1504
1405 (R/W)	RA109 (0:UW)		–32768	32767	0	0.01	1505
1406 (R/W)	RA109 (1:LW)		–32768	32767	0	0.01	1506
1407 (R/W)	RA110 (0:UW)		–32768	32767	0	0.01	1507
1408 (R/W)	RA110 (1:LW)		–32768	32767	0	0.01	1508
1409 (R/W)	RA111 (0:UW)		–32768	32767	0	0.01	1509
1410 (R/W)	RA111 (1:LW)		–32768	32767	0	0.01	1510
1411 (R/W)	RA112 (0:UW)		–32768	32767	0	0.01	1511
1412 (R/W)	RA112 (1:LW)		–32768	32767	0	0.01	1512
1413 (R/W)	RA113 (0:UW)		–32768	32767	0	0.01	1513
1414 (R/W)	RA113 (1:LW)		–32768	32767	0	0.01	1514
1415 (R/W)	RA114 (0:UW)		–32768	32767	0	0.01	1515
1416 (R/W)	RA114 (1:LW)		–32768	32767	0	0.01	1516
1417 (R/W)	RA115 (0:UW)		–32768	32767	0	0.01	1517
1418 (R/W)	RA115 (1:LW)		–32768	32767	0	0.01	1518
1419 (R/W)	RA116 (0:UW)		–32768	32767	0	0.01	1519
1420 (R/W)	RA116 (1:LW)		–32768	32767	0	0.01	1520
1421 (R/W)	RA117 (0:UW)		–32768	32767	0	0.01	1521
1422 (R/W)	RA117 (1:LW)		–32768	32767	0	0.01	1522
1423 (R/W)	RA118 (0:UW)		–32768	32767	0	0.01	1523
1424 (R/W)	RA118 (1:LW)		–32768	32767	0	0.01	1524
1425 (R/W)	RA119 (0:UW)		–32768	32767	0	0.01	1525
1426 (R/W)	RA119 (1:LW)		–32768	32767	0	0.01	1526
1427 (R/W)	RA120 (0:UW)		–32768	32767	0	0.01	1527
1428 (R/W)	RA120 (1:LW)		–32768	32767	0	0.01	1528
1429 (R/W)	RA121 (0:UW)		–32768	32767	0	0.01	1529
1430 (R/W)	RA121 (1:LW)		–32768	32767	0	0.01	1530
1431 (R/W)	RA122 (0:UW)		–32768	32767	0	0.01	1531
1432 (R/W)	RA122 (1:LW)		–32768	32767	0	0.01	1532
1433 (R/W)	RA123 (0:UW)		–32768	32767	0	0.01	1533
1434 (R/W)	RA123 (1:LW)		–32768	32767	0	0.01	1534
1435 (R/W)	RA124 (0:UW)		–32768	32767	0	0.01	1535
1436 (R/W)	RA124 (1:LW)		–32768	32767	0	0.01	1536
1437 (R/W)	RA125 (0:UW)		–32768	32767	0	0.01	1537
1438 (R/W)	RA125 (1:LW)		–32768	32767	0	0.01	1538
1439 (R/W)	RA126 (0:UW)		–32768	32767	0	0.01	1539
1440 (R/W)	RA126 (1:LW)		–32768	32767	0	0.01	1540
1441 (R/W)	RA127 (0:UW)		–32768	32767	0	0.01	1541
1442 (R/W)	RA127 (1:LW)		–32768	32767	0	0.01	1542
1443 (R/W)	RA128 (0:UW)		–32768	32767	0	0.01	1543
1444 (R/W)	RA128 (1:LW)		–32768	32767	0	0.01	1544
1445 (R)	ROW 217		0	255	0		1545
1446 (R)	ROW 218		0	255	0		1546

Table E.34 Modbus Map[a] (Sheet 24 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
1447 (R)	ROW 219		0	255	0		1547
1448 (R)	ROW 220		0	255	0		1548
Control I/O Commands							
2000H (Hex) (W)	LOGIC COMMAND Bit 0 = BreakerX Close Bit 1 = BreakerX Open Bit 2 = BreakerY Close Bit 3 = Return Status 0/1 Bit 4 = DN Aux 1 Cmd Bit 5 = DN Aux 2 Cmd Bit 6 = DN Aux 3 Cmd Bit 7 = DN Aux 4 Cmd Bit 8 = DN Aux 5 Cmd Bit 9 = DN Aux 6 Cmd Bit 10 = DN Aux 7 Cmd Bit 11 = DN Aux 8 Cmd Bit 12 = DN Aux 9 Cmd Bit 13 = DN Aux 10 Cmd Bit 14 = DN Aux 11 Cmd Bit 15 = BreakerY Open		0	65535	0	na	
2001H (W)	RESET COMMAND Bit 0 = Trip Reset Bit 1 = Reserved[d] Bit 2 = Reset Stat Data Bit 3 = Reset Hist Data Bit 4 = Reset Comm Cntr Bit 5 = Reserved[d] Bit 6 = Rst Enrgy Data Bit 7 = Rst Mx/Mn Data Bit 8 = Rst Demand Bit 9 = Rst Peak Demand Bit 10 = Rst BkMonX Data Bit 11 = Rst BkMonY Data Bit 12 = Rst Sync Report Bit 13–Bit 15 = Reserved[d]		0	4095	0	na	
2002H (W)	LOGIC COMMAND Bit 0 = 3-position Disconnect In-line 1 Close Bit 1 = 3-position Disconnect In-line 1 Open Bit 2 = 3-position Disconnect Earthing 1 Close Bit 3 = 3-position Disconnect Earthing 1 Open Bit 4 = 3-position Disconnect In-line 2 Close Bit 5 = 3-position Disconnect In-line 2 Open Bit 6 = 3-position Disconnect Earthing 2 Close Bit 7 = 3-position Disconnect Earthing 2 Open Bit 8 = 2-position Disconnect 1 Close Bit 9 = 2-position Disconnect 1 Open Bit 10 = 2-position Disconnect 2 Close Bit 11 = 2-position Disconnect 2 Open		0	255	0	na	

Table E.34 Modbus Map[a] (Sheet 25 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
	Bit 12 = 2-position Disconnect 3 Close Bit 13 = 2-position Disconnect 3 Open Bit 14 = 2-position Disconnect 4 Close Bit 15 = 2-position Disconnect 4 Open						
2003H (W)	LOGIC COMMAND Bit 0 = 2-position Disconnect 5 Close Bit 1 = 2-position Disconnect 5 Open Bit 2 = 2-position Disconnect 6 Close Bit 3 = 2-position Disconnect 6 Open Bit 4 = 2-position Disconnect 7 Close Bit 5 = 2-position Disconnect 7 Open Bit 6 = 2-position Disconnect 8 Close Bit 7 = 2-position Disconnect 8 Open Bit 8 = Reserved[d] Bit 9 = Reserved[d] Bit 10 = Reserved[d] Bit 11 = Reserved[d] Bit 12 = Reserved[d] Bit 13 = Reserved[d] Bit 14 = Reserved[d] Bit 15 = Reserved[d]		0	255	0	na	
Relay Elements							
2100H (R)	FAST STATUS 0 Bit 0 = Faulted/Trip Bit 1 = Warning Bit 2 = IN101 Status Bit 3 = IN102 Status Bit 4 = IN401 Status Bit 5 = IN402 Status Bit 6 = IN403 Status Bit 7 = Reserved[d] Bit 8 = OUT101 Status Bit 9 = OUT102 Status Bit 10 = OUT401 Status Bit 11 = OUT402 Status Bit 12 = OUT403 Status Bit 13 = OUT404 Status Bit 14 = Reserved[d] Bit 15 = Reserved[d]		0	65535	0	na	
2101H (R)	FAST STATUS 1 Bit 0 = Enabled Bit 1 = Reserved[d] Bit 2 = IN404 Status Bit 3 = IN501 Status Bit 4 = IN502 Status Bit 5 = IN503 Status Bit 6 = IN504 Status Bit 7 = Reserved[d] Bit 8 = OUT501 Status Bit 9 = OUT502 Status Bit 10 = OUT503 Status Bit 11 = OUT504 Status Bit 12–Bit 15 = Reserved[d]		0	65535	0	na	
2102H (R)	TRIP STATUS LO					na	
2103H (R)	TRIP STATUS HI					na	

Table E.34 Modbus Map[a] (Sheet 26 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
2104H (R)	WARN STATUS LO					na	
2105H (R)	WARN STATUS HI					na	
2106H (R)	AVERAGE CURRENT					na	
2107H (R)	IAX CURRENT					na	
2108H (R)	IBX CURRENT					na	
2109H (R)	ICX CURRENT					na	
210AH (R)	Reserved[d]					na	
210BH (R)	Reserved[d]					na	
210CH (R)	Reserved[d]					na	
210DH (R)	IGX CURRENT					na	
210EH (R)	IN CURRENT					na	
210FH (R)	Reserved[d]					na	
2110H (R)	FAST STATUS 2 Bit 0 = IN301 Status Bit 1 = IN302 Status Bit 2 = IN303 Status Bit 3 = IN304 Status Bit 4 = OUT301 Status Bit 5 = OUT302 Status Bit 6 = OUT303 Status Bit 7 = OUT304 Status Bit 8 = IN305 Status Bit 9 = IN306 Status Bit 10 = IN307 Status Bit 11 = IN308 Status Bit 12–Bit 15 = Reserved[d]		0	65535	0	na	
2111H (R)	FAST STATUS 3 Bit 0 = IN405 Status Bit 1 = IN406 Status Bit 2 = IN407 Status Bit 3 = IN408 Status Bit 4 = IN505 Status Bit 5 = IN506 Status Bit 6 = IN507 Status Bit 7 = IN508 Status Bit 8–Bit 15 = Reserved[d]		0	65535	0	na	
PAR Group Indices							
3000H (R)	Reserved[d]		0	0	0	na	
3001H (R)	USER MAP REG		1	125	1	1	
3002H (R)	USER MAP REG VAL		126	250	126	1	
3003H (R)	RESERVED AREA1		251	260	251	1	
3004H (R)	RESET SETTINGS		261	262	261	1	
3005H (R)	DATE/TIME SET		263	270	263	1	
3006H (R)	DEVICE STATUS		271	319	271	1	
3007H (R)	XSIDE CURRENT		320	329	320	1	
3008H (R)	XSIDE VOLTAGE		330	345	330	1	
3009H (R)	XSIDE POWER DATA		346	380	346	1	
300AH (R)	YSIDE CURRENT		381	390	381	1	
300BH (R)	YSIDE VOLTAGE		391	406	391	1	
300CH (R)	MISC MEASUREMENT		407	422	407	1	

Table E.34 Modbus Map[a] (Sheet 27 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
300DH (R)	ENERGY DATA		423	452	423	1	
300EH (R)	DEMAND DATA		453	462	453	1	
300FH (R)	PEAK DEMAND DATA		463	478	463	1	
3010H (R)	HARMONIC DATA		479	484	479	1	
3011H (R)	RTD DATA		485	503	485	1	
3012H (R)	RESERVED AREA2		504	513	504	1	
3013H (R)	RMS DATA		514	533	514	1	
3014H (R)	MAX/MIN MTR DATA		534	599	534	1	
3015H (R)	MAX/MIN RTD DATA		600	623	600	1	
3016H (R)	MAX/MIN AI3 DATA		624	639	624	1	
3017H (R)	MAX/MIN AI4 DATA		640	655	640	1	
3018H (R)	MAX/MIN AI5 DATA		656	671	656	1	
3019H (R)	MAX/MIN RST DATA		672	681	672	1	
301AH (R)	ANA INP DATA		682	705	682	1	
301BH (R)	MATH VARIABLES		706	769	706	1	
301CH (R)	DEVICE COUNTERS		770	801	770	1	
301DH (R)	RESERVED AREA3		802	817	802	1	
301EH (R)	HISTORICAL DATA		818	864	818	1	
301FH (R)	BKR MONITOR DATA		865	900	865	1	
3020H (R)	TRIP/WARN DATA		901	909	901	1	
3021H (R)	COMMN COUNTERS		910	925	910	1	
3022H (R)	YSIDE POWER DATA		926	970	926	1	
3023H (R)	RELAY ELEMENTS		971	1188	971	1	
3024H (R)	REMOTE ANALOGS 1		1189	1316	1189	1	
3025H (R)	REMOTE ANALOGS 2		1317	1444	1317	1	
3026H (R)	RELAY ELEMENTS 2		1445	1448	1445		
Product Information							
4000H (R)	VENDOR CODE 865 = SEL		0	65535	865	na	
4001H (R)	PRODUCT CODE		0	65535	106	na	
4002H (R/W)	ASA NUMBER LOW		0	65535		na	
4003H (R/W)	ASA NUMBER HIGH		0	65535		na	
4004H (R)	FIRMWARE REVISION		1	32639		na	
4005H (R)	NUM OF PAR		1	2000	1448	na	
4006H (R)	NUM OF PAR GROUP		1	100	38	na	
4007H (R/W)	MAC ID 64–99= Swr Configurable		1	99	0	na	
4008H (R/W)	DN BAUD RATE 0 = 125 kbps 1 = 250 kbps 2 = 500 kbps 3 = AUTO Swr Configurable		0	9	0	na	
4009H (R/W)	DN STATUS		0	31	0	na	

Table E.34 Modbus Map[a] (Sheet 28 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
	Bit 0 = Explicit Cnxn Bit 1 = I/O Cnxn Bit 2 = Explicit Fault Bit 3 = I/O Fault Bit 4 = I/O Idle Bit 5–Bit 15 = Reserved[d]						
400AH	Reserved[d]						
400BH (R)	CONFIG PAR CKSUM				0	na	
400CH (R)	LANGUAGE CODE 0 = English 1 = French 2 = Spanish (Mexican) 3 = Italian 4 = German 5 = Japanese 6 = Portuguese 7 = Mandarin Chinese 8 = Russian 9 = Dutch				0	na	
400DH (R)	FIRMWARE BUILD NUM		16400	16400	0	na	
400EH	Reserved[d]	ms					
400FH (R)	PRODUCT SUPPORT BITS Bit 0 = 2nd IO Card installed Bit 1–Bit 15 = Reserved[d]					na	
4010H (R/W)	SETTINGS TIMEOUT		500	65535	750	na	
4011H	Reserved[d]						
4012H	Reserved[d]						
4013H	Reserved[d]						
4014H (R)	CONFIGURED BIT Bit 0 = Unit Configured Bit 1–Bit 15 = Reserved[d]				0	na	
4015H (R)	Reserved[d]		0	0	0	na	
4016H (R)	ERROR REGISTER Bit 0–Bit 15 = Reserved[d]		0	65535	0	na	
4017H (R)	ERROR ADDRESS		0	65535	0	na	
4018H–401FH (R)	Reserved[d]		0	0	0	na	

[a] All addresses in this table refer to the register addresses in the Modbus packet.
[b] Registers labeled (R/(W) are read-write registers. Registers labeled (W) are write-only registers. Registers Labeled (R) are read-only registers.
[c] Register Value • Multiplier = System Value as seen by the relay. For example, if Register 321 (IA Angle) reads 300 in decimal, then the system value is 30 degrees (multiplier = 0.1)
[d] Reserved addresses return 0.

Table E.35 Trigger Conditions for Trip/Warn Status Register Bits (Sheet 1 of 3)

Register #	Bit #	Description	Trigger Condition
901	—	TRIP STATUS LO	—
	Bit 0	5O PHASE	50PX1T OR 50PX2T OR 50PY1T OR 50PY2T OR 50PX3AT OR 50PX3BT OR 50PX3CT OR 50PY3AT OR 50PY3BT OR 50PY3CT
	Bit 1	50 GROUND	50GX1T OR 50GX2T OR 50GY1T OR 50GY2T
	Bit 2	50 NEGSEQ	50QXIT OR 50QX2T OR 50QY1T OR 50QY2T
	Bit 3	51 PHASE	51PXT OR 51PYT
	Bit 4	51 GROUND	51GXT OR 51GYT
	Bit 5	51 NEGSEQ	51QXT OR 51QYT
	Bit 6	NEUTRAL 50	50N1T OR 50N2T
	Bit 7	NEUTRAL 51	51NT
	Bit 8	67 PHASE	67PY1T OR 67PY2T
	Bit 9	67 GROUND	67GX1T OR 67GX2T OR 67GY1T OR 67GY2T
	Bit 10	67 NEGSEQ	67QY1T OR 67Q2YT
	Bit 11	46 NEGSEQ	46Q2T
	Bit 12	49T THERMAL	49T
	Bit 13	GND DIFF 87N	87N1T OR 87N2T
	Bit 14	RESTR DIFF 87R	87R
	Bit 15	UNRSTR DIFF 87U	87U

Table E.35 Trigger Conditions for Trip/Warn Status Register Bits (Sheet 2 of 3)

Register #	Bit #	Description	Trigger Condition
902	—	TRIP STATUS HI	—
	Bit 0	UNDERVOLT 27P	27PX1T OR 27PPX1T OR 27V1XT OR 27PY1T OR 27PPY1T
	Bit 1	OVERVOLT 59P	59PX1T OR 59PPX1T OR 59VX1T OR 59QX1T OR 59GX1T OR 59PY1T OR 59PPY1T OR 59QY1T OR 59GY1T
	Bit 2	Reserved	–
	Bit 3	POWER ELEMENTS	3PWRX1T OR 3PWRX2T OR 3PWRX3T OR 3PWRX4T OR 3PWRY1T OR 3PWRY2T OR 3PWRY3T OR 3PWRY4T
	Bit 4	FREQUENCY 81	81T OR 81RT OR BNDT
	Bit 5	VOLTS/HERTZ	24C2T
	Bit 6	RESTRCTD EARTH	REF1P OR REF1F
	Bit 7	RTD TRIP	RTDT
	Bit 8	BREAKER FAIL	BFTX OR BFTY OR BKRCF
	Bit 9	REMOTE TRIP	REMTRIP
	Bit 10	BACKUP	51VT OR 51CT OR 21C1T OR 21C2T
	Bit 11	40 FLD LOSS	40Z1T OR 40Z2T
	Bit 12	64G/64F GND	64G1T OR 64G2T OR 64F1T OR 64F2T
	Bit 13	INADVERTENT ENRG	INADT
	Bit 14	OUT OF STEP	OOST
	Bit 15	TRIP	TRIP
903	—	WARN STAUTS LO	—
	Bit 0	BREAKER MONITOR	BCWX OR BCWY
	Bit 1	DEMAND ALARM	PHDEMX OR 3I2DEMX OR GNDEMX OR PHDEMY OR 3I2DEMY OR GNDEMY
	Bit 2	RTD FAULT	RTDFLT
	Bit 3	CONFIG FAULT	CFGFLT
	Bit 4	COMM FAULT	COMMFLT
	Bit 5	COMM IDLE	COMMIDLE
	Bit 6	COMM LOSS	COMMLOSS
	Bit 7	DIFF ALARM 87A	87AT
	Bit 8	5TH HARMONIC ALM	TH5T
	Bit 9	RTD ALARM	RTDA
	Bit 10	LOSS OF POTENTIAL	LOPX OR LOPY
	Bit 11	AI HI/LO ALARM	AILAL OR AIHAL
	Bit 12	49A THERMAL ALM	49A
	Bit 13	HALARM	HALARM
	Bit 14	SALARM	SALARM
	Bit 15	WARNING	WARNING

Table E.35 Trigger Conditions for Trip/Warn Status Register Bits (Sheet 3 of 3)

Register #	Bit #	Description	Trigger Condition
904	—	WARN STATUS HI	27PX2T OR 27PPX2T OR 27PY2T OR 27PPY2T
	Bit 0	UNDERVOLT 27P	59PX2T OR 59PPX2T OR 59QX2T OR 59GX2T OR 59PY2T OR 59PPY2T OR 59QY2T OR 59GY2T
	Bit 1	OVERVOLT 59P	46Q1T
	Bit 2	46 NEGSEQ	24D1T
	Bit 3	VOLTS/HERTZ	—
	Bit 4	Reserved	—
	Bit 5	Reserved	—
	Bit 6	Reserved	—
	Bit 7	Reserved	—
	Bit 8	Reserved	—
	Bit 9	Reserved	—
	Bit 10	Reserved	—
	Bit 11	Reserved	—
	Bit 12	Reserved	—
	Bit 13	Reserved	—
	Bit 14	Reserved	—
	Bit 15	Reserved	—

Appendix F
EtherNet/IP Communications

Overview

EtherNet/IP, or Ethernet/Industrial Protocol, is an industrial protocol that uses standard Ethernet and TCP/IP technology to transport Common Industrial Protocol (CIP) packets.

The SEL-700G Generator Protection Relay supports EtherNet/IP. This section discusses general specifications for EtherNet/IP implementation, as well as the CIP data model, the allocation of the CIP connections, the EtherNet/IP Port 1 settings, and the Electronic Data Sheet (EDS) file in the SEL-700G.

The SEL-700G supports two ways of exchanging data via EtherNet/IP:

- ➤ **Implicit Message Adapter**. The I/O data is mapped into Assembly object instances. The SEL-700G exchanges this I/O data via EtherNet/IP Implicit Class 1 connections with a remote EtherNet/IP Scanner device using UDP packets.
- ➤ **Explicit Message Server.** The I/O data is mapped into Assembly object instances. The SEL-700G responds to generic TCP EtherNet/IP Explicit message requests initiated by a remote EtherNet/IP Client device.

For more information on EtherNet/IP, visit www.odva.org.

Specifications

Table F.1 EtherNet/IP Specifications (Sheet 1 of 2)

Ethernet/IP Services
Implicit Message Adapter (Class 1) Explicit Message Server (Class 3 and unconnected)
CIP Model-Implemented Objects
Identity Object Message Router Object Assembly Object Connection Manager Object File Object TCP/IP Interface Object Ethernet Link Object Vendor Specific Object

Table F.1 EtherNet/IP Specifications (Sheet 2 of 2)

Implicit Message Adapter	
Number of Connections	As many as eight (two Class 1 connections and six Class 3/unconnected connections)
Class 1 Connection Types	Unicast Multicast
Class 1 Connection Transport Types	Exclusive Owner Input Only Listen Only
Class 1 Connection Trigger Types	Cyclic Change of State
Input Only Heartbeat Connection Point	238
Listen Only Heartbeat Connection Point	237

CIP Data Model

Profile

Table F.2 CIP Data Model Profile

Class Name	Class ID	Number of Instances
Identity Object	0x01	1
Message Router Object	0x02	1
Assembly Object	0x04	Determined by the user/based on the application
Connection Manager Object	0x06	1
File Object	0x37	2
TCP/IP Interface Object	0xF5	1
Ethernet Link Object	0xF6	See *Ethernet Link Object (0xF6)*
Vendor Specific Object	0x64	1

Identity Object (0x01)

Instances Implemented

The SEL-700G supports one instance (Instance ID = 1) of the Identity Object.

Table F.3 Identity Object List of Attributes (Sheet 1 of 2)

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	1	The revision of this CIP Object
2	Max Instance	GET	UINT	1	The maximum Identity Object Instance ID
3	Number of Instances	GET	UINT	1	Total number of Identity Objects
4	Optional Attribute List	GET	[UINT, Array of UINT]	[1, [21]]	[Number of Optional Instance Attributes, List of Optional Instance Attributes]
6	Maximum ID Number Class Attributes	GET	UINT	7	Maximum Class Attribute ID

Table F.3 Identity Object List of Attributes (Sheet 2 of 2)

Attribute ID	Name	Access	Data Type	Default	Description
7	Maximum ID Number Instance Attributes	GET	UINT	21	Maximum Instance Attribute ID
Instance Attributes					
1	Vendor ID	GET	UINT	865	
2	Device Type	GET	UINT	0x2B	
3	Product Code	GET	UINT		The most significant byte is the Device Code (DEVCODE as found in the **ID** command of the SEL-700G) and its least significant byte is the user-configurable Configuration ID as provided in the Ethernet port settings
4	[Major Revision, Minor Revision]	GET	[USINT, USINT]	[1,1]	
5	Status	GET	WORD		Refer to *Table F.4*.
6	Serial Number	GET	UDINT		The low-order 32 bits of the MAC address of the Ethernet port
7	Product Name	GET	STRING		The existing default product name (the default RID string) of the SEL-700G plus the value of the user-configurable Configuration ID as provided in the Ethernet port settings. The general format is, “<Default RID>-<Configuration ID>”.
21	Catalog Number	GET	STRING		The existing default product name (the default RID string) of the SEL-700G plus the value of the user-configurable Configuration ID as provided in the Ethernet port settings. The general format is, “<Default RID>-<Configuration ID>”.

Table F.4 Status WORD Bits Descriptions

Bit Number[a]	Name	Description
0	Owned	TRUE, if at least one scanner has established an Exclusive Owner Class 1 connection to the SEL-700G. FALSE, if the SEL-700G has no active Exclusive Owner connections to a scanner.
2	Configured	Always TRUE.
4 to 7	Extended Device Status	Hexadecimal value: 2: A Class 1 connection has timed out. 3: No Class 1 connection has been established. 6: At least one Class 1 connection is active. 7: In any other case.
11	Major Unrecoverable Fault	TRUE if the product is disabled due to an unrecoverable fault; otherwise, it is FALSE.

[a] The Status WORD bits not listed in this table are always set to FALSE.

Table F.5 Identity Object Supported Services

Service Code	Service Name	Class	Instance	Description
0x01	Get Attributes All	Yes	Yes	Returns a list of all of the values of the attributes.
0x05	Reset	No	Yes	Restarts the EtherNet/IP service in the SEL-700G. Only reset type 0 is allowed.
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.

Message Router Object (0x02)

Table F.6 Message Router Object List of Attributes

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	1	The revision of this CIP Object.
2	Max Instance	GET	UINT	1	The maximum Message Router Object Instance ID.
3	Number of Instances	GET	UINT	1	Total number of Message Router Object Instances.
4	Optional Attribute List	GET	[UINT, Array of UINT]	[3,[1,2,3]]	[Number of Optional Instance Attributes, List of Optional Instance Attributes]
5	Optional Service List	GET	[UINT, Array of UINT]	[1.[10]]	Number of Optional Service Codes followed by the List of Optional Service Codes.
6	Maximum ID Number Class Attributes	GET	UINT	7	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	3	Maximum Instance Attribute ID
Instance Attributes					
1	Class List	GET	[UINT, Array of UINT]		Implemented object list
2	Maximum Connections	GET	UINT		Maximum number of connections supported
3	Number of Connections	GET	UINT		Number of connections currently used

Table F.7 Message Router Supported Services

Service Code	Service Name	Class	Instance	Description
0x01	Get Attribute All	Yes	Yes	Returns a list of all of the attributes.
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.
0x0A	Multiple Service Packet	No	Yes	

Assembly Object (0x04)

Instances Implemented

The SEL-700G settings define the number of Assembly Object Instances based on the number and type of connections configured and the data content of each instance. Each assembly is as large as 500 bytes in size. The SEL-700G supports a total of six assemblies (three Input Assemblies and three Output Assemblies).

Table F.8 Assembly Object List of Attributes

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	2	The revision of this CIP Object
2	Max Instance	GET		Determined by the settings	The maximum Assembly Object Instance ID defined by the user
3	Number of Instances	GET		Determined by the settings	Total number of Assembly Object instances defined by the user
4	Optional Attribute List	GET	[UINT, Array of UINT]	[1,[4]]	[Number of Optional Instance Attributes, List of Optional Instance Attributes]
6	Maximum ID Number Class Attributes	GET	UINT	7	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	4	Maximum Instance Attribute ID
Instance Attributes					
1	Number of Members	GET	UINT		Number of Assembly Members defined by the user
2	Member List	GET	Array of [UINT, UINT, EPATH]		Only 500 bytes are allowed
3	Data	GET, SET	Array of Bytes		Data map defined with **SET E 1**, **2**, or **3**
4	Size	GET	UINT		Number of bytes in Instance Attribute 3

Table F.9 Assembly Object Supported Services

Service Code	Service Name	Class	Instance	Description
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.
0x10	Set Attribute Single	No	Yes	Sets the value of a specific attribute.
0x18	Get Member	No	Yes	Returns the value of a member of the data attribute.
0x19	Set Member	No	Yes	Modifies the value of a member of the data attribute.

Connection Manager Object (0x06)

Table F.10 Connection Manager Object List of Attributes

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	1	The revision of this CIP Object
2	Max Instance	GET	UINT		The maximum Connection Manager Object Instance ID
3	Number of Instances	GET	UINT		Total number of Connection Manager Object Instances
4	Optional Attribute List	GET	[UINT, Array of UINT]	[8,[1,2,3,4,5,6,7,8]]	[Number of Optional Instance Attributes, List of Optional Instance Attributes]
6	Maximum ID Number Class Attributes	GET	UINT	7	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	8	Maximum Instance Attribute ID
Instance Attributes					
1	Open Requests	GET/SET	UINT		Number of FWD Open service requests received
2	Open Format Rejects	GET/SET	UINT		Number of FWD Open service requests rejected because of bad format
3	Open Resource Rejects	GET/SET	UINT		Number of FWD Open service requests rejected because of lack of resources
4	Open Other Rejects	GET/SET	UINT		Number of FWD Open service requests rejected for reasons other than bad format or lack or resources
5	Close Requests	GET/SET	UINT		Number of FWD Close service requests received
6	Close Format Rejects	GET/SET	UINT		Number of FWD Close service requests rejected because of bad format
7	Close Other Rejects	GET/SET	UINT		Number of FWD Open service requests rejected for reasons other than bad format
8	Connection Timeouts	GET/SET	UINT		Number of connection timeouts

Table F.11 Connection Manager Object Supported Services (Sheet 1 of 2)

Service Code	Service Name	Class	Instance	Description
0x01	Get Attribute All	Yes	Yes	Returns a list of all of the attributes.
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.
0x10	Set Attribute Single	No	Yes	Sets the value of a specific attribute.
0x02	Set Attribute All	No	Yes	Sets the value of all attributes.
0x54	Forward Open	No	Yes	Establishes a CIP connection.
0x4E	Forward Close	No	Yes	Closes a CIP connection.

Table F.11 Connection Manager Object Supported Services (Sheet 2 of 2)

Service Code	Service Name	Class	Instance	Description
0x5B	Large Forward Open	No	Yes	Establishes a CIP connection that allows a large connection size.
0x5A	Get Connection Owner	No	Yes	Returns data about the connection that owns the object.

File Object (0x37)

The File Object stores the EDS and icon files. The EDS file is generated by the SEL-700G based on the EtherNet/IP Port 1 settings and the SET E 1, 2, or 3 settings. The relay can retrieve the file using the File Object services. You cannot write an EDS file to the relay using the File Object services.

The SEL-700G implements two instances of the File Object:

- Instance 0xC8 returns an uncompressed version of the EDS file with an embedded icon.
- Instance 0xC9 returns a compressed version of the icon file.

Table F.12 File Object List of Attributes (Sheet 1 of 2)

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	1	The revision of this CIP Object
2	Max Instance	GET	UINT	201	
3	Number of Instances	GET	UINT	2	
6	Maximum ID Number Class Attributes	GET	UINT	32	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	11	Maximum Instance Attribute ID
32	Directory	GET	[UINT, STRINGI, STRINGI] [UINT, STRINGI, STRINGI]	[0xC8,(ENG)‘EDS and Icon Files’, (ENG)‘EDS.txt’] [0xC9,(ENG)‘Related EDS and Icon Files’, (ENG)‘EDSCollection.gz’]	List of all File Object instance and file names present in the SEL-700G and the associated instance numbers
0xC8 Instance Attributes					
1	State	GET	USINT	2	
2	Instance Name	GET	STRINGI	(ENG)‘EDS and Icon Files’	
3	File Format Version	GET	UINT	1	
4	File Name	GET	STRINGI	(ENG)‘EDS.txt’	
5	File Revision	GET	[USINT, USINT]		[Major EDS revision Ethernet port setting, Minor EDS revision Ethernet port setting]
6	File Size	GET	UDINT		Size of the EDS file in bytes
7	File Checksum	GET	UINT		Checksum of the EDS file (2s complement of the 16-bit sum of all octets in the file)
8	Invocation Method	GET	USINT	255	
9	File Save Parameters	GET	USINT	0	
10	File Access Rule	GET	USINT	1	
11	File Encoding Format	GET	USINT	0	

Table F.12 File Object List of Attributes (Sheet 2 of 2)

Attribute ID	Name	Access	Data Type	Default	Description
0xC9 Instance Attributes					
1	State	GET	USINT	2	
2	Instance Name	GET	STRINGI	(ENG)‘Related EDS and Icon Files’	
3	File Format Version	GET	UINT	1	
4	File Name	GET	STRINGI	(ENG)‘EDSCollection.gz’	
5	File Revision	GET	[USINT, USINT]	[1,1]	[Major Revision, Minor Revision]
6	File Size	GET	UDINT		Size of the loaded file in bytes
7	File Checksum	GET	UINT		Checksum of the EDSCollection file (2s complement of the 16-bit sum of all octets in the file)
8	Invocation Method	GET	USINT	255	
9	File Save Parameters	GET	USINT	0	
10	File Access Rule	GET	USINT	1	
11	File Encoding Format	GET	USINT	1	

Table F.13 File Object Supported Services

Service Code	Service Name	Class	Instance	Description
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.
0x4B	Initiate Upload	No	Yes	
0x4F	Upload Transfer	No	Yes	

TCP/IP Interface Object (0xF5)

Instances Implemented

The number of instances of the TCP/IP Interface Object is always 1, regardless of whether the CPU card contains a single Ethernet port or a dual Ethernet port.

Table F.14 TCP/IP Interface Object List of Attributes (Sheet 1 of 2)

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	4	The revision of this CIP Object
2	Max Instance	GET	UINT	1	The maximum TCP/IP Object Instance ID
3	Number of Instances	GET	UINT	1	Total number of TCP/IP Object Instances
4	Optional Attribute List	GET	[UINT, Array of UINT]	[4,[8,9,16,17]]	[Number of Optional Instance Attributes, List of Optional Instance Attributes]

Table F.14 TCP/IP Interface Object List of Attributes (Sheet 2 of 2)

Attribute ID	Name	Access	Data Type	Default	Description
6	Maximum ID Number Class Attributes	GET	UINT	7	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	17	Maximum Instance Attribute ID
Instance Attributes					
1	Status	GET	DWORD	2	
2	Configuration Capability	GET	DWORD	32	Any change in the configuration will be updated when the server is restarted.
3	Configuration Control	GET	DWORD	0	IP addresses must be configured statically. DHCP and DNS are not supported.
4	Physical Link Object	GET	[UINT, EPATH]		[Path size, Path to the corresponding Ethernet link object instance] For a dual Ethernet port CPU card, the value is 00 00 (path size of 0). For a single Ethernet port CPU card, the value is 02 00 20 F6 24 01, where 02 00 is the path size (number of 16-bit words), 20 is the 8-bit class segment type, F6 is the Ethernet Link Object class, 24 is the 8-bit instance segment type, and 01 is Instance 1.
5	Interface Configuration	GET	[UDINT, UDINT, UDINT, UDINT, UDINT, STRING]		[IP address, Network mask, Gateway address, 0, 0, null]
6	Host Name	GET	STRING		When converted to ASCII, this displays, "[Product Name]-[Serial Number]". This attribute cannot be set by the scanner.
8	TTL Value	GET/SET	USINT	1	The scanner can set this attribute.
9	Mcast Config	GET/SET	[USINT, USINT, UINT, UDINT]	[Alloc control, Reserved, Num Mcast, Mcast Start Address]	The scanner can set this attribute only if the control is 01 00. 1st and 2nd Byte: This represents the control. When the value is 00 00, the scanner cannot change the number of multicast connections nor the Mcast Start Address. To change these, all eight bytes must be written at once, e.g., 01 00 *xx xx yy yy yy yy*. 3rd and 4th Byte: Number of multicast connections supported by the product in little endian order. 02 00 is the default value. The maximum number of multicast connections supported is two. 5th–8th Byte: Mcast Start Address according to the default algorithm specified in Section 3-5.3 of Volume 2 of the standard.
13	Encapsulation Inactivity Timeout	GET/SET	UINT	120	The scanner can set this value.
16	Active TCP Connections	GET	UINT	1	
17	Non-CIP Encapsulation Messages per Second	GET	UDINT	0	

Table F.15 TCP/IP Interface Object Supported Services

Service Code	Service Name	Class	Instance	Description
0x01	Get Attribute All	Yes	Yes	Returns a list of all of the attributes.
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.
0x10	Set Attribute Single	No	Yes	Sets the value of a specific attribute.

Ethernet Link Object (0xF6)

Instances Implemented

The number of instances of the Ethernet Link Object depends on whether the CPU card contains a single Ethernet port or a dual Ethernet port. The value will be 1 for a single Ethernet port and 2 for a dual Ethernet port.

Table F.16 Ethernet Link Object List of Attributes

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	4	The revision of this CIP Object
2	Max Instance	GET	UINT		The maximum Ethernet Link Object Instance ID
3	Number of Instances	GET	UINT		Total number of Ethernet Link Object Instances
4	Optional Attribute List	GET	[UINT, Array of UINT]	[1,[10]]	[Number of Optional Instance Attributes, List of Optional Instance Attributes]
6	Maximum ID Number Class Attributes	GET	UINT	7	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	11	Maximum Instance Attribute ID
Instance Attributes					
1	Interface Speed	GET	UINT		Speed (MBPS) in use on the corresponding interface
2	Interface Flags	GET	DWORD		See *Table F.17*
3	Physical Address	GET	USINT[6]		MAC address of the corresponding interface
10	Interface Label	GET	STRING		SEL-700G interface name, e.g., “PORT 1”
11	Interface Capability	GET	[DWORD, USINT]		[Capability bits, Array Element Count]

Table F.17 Interface Flags Bits Descriptions (Sheet 1 of 2)

Bit Number	Name	Description
0	Link Status	0: The Ethernet interface link is inactive. 1: The link is active.
1	Half/Full Duplex	0: The interface is running half duplex. 1: The interface is running full duplex.

Table F.17 Interface Flags Bits Descriptions (Sheet 2 of 2)

Bit Number	Name	Description
2–4	Negotiation Status	Octal unsigned value: 0: Auto negotiation in progress. 1: Auto negotiation and speed detection failed. Using default values. 2: Auto negotiation failed, but detected speed. 3: Successfully negotiated speed and duplex. 4: Auto negotiation not attempted.
5	Manual Setting Requires Reset	Set to 1.

Table F.18 Ethernet Link Object Supported Services

Service Code	Service Name	Class	Instance	Description
0x01	Get Attribute All	Yes	Yes	Returns a list of all of the attributes.
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.

Vendor Specific Object (0x64)

Instances Implemented

The SEL-700G supports one instance (Instance ID = 1) of the Vendor Specific Object.

Table F.19 Vendor Specific Object List of Attributes

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	1	The revision of this CIP Object
2	Max Instance	GET	UINT	1	The maximum Vendor Specific Object Instance ID
3	Number of Instances	GET	UINT	1	Total number of Vendor Specific Object Instances
Instance Attributes					
100	Enabled[a]	GET	BOOL		Relay Enabled Status
101	Trip	GET	BOOL		Protection Trip

[a] This attribute reflects the value of the Relay Word bit indicating Enabled status of the SEL-700G.

Table F.20 Vendor Specific Object Supported Services

Service Code	Service Name	Class	Instance	Description
0x01	Get Attribute All	Yes	Yes	Returns a list of all of the attributes.
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.

CIP Connections and Corresponding Assembly Maps

The SEL-700G supports as many as eight simultaneous CIP connections. Of the eight simultaneous connections, as many as two of them can be Class 1 (I/O) connections and as many as six of them can be a combination of Class 3 messages and Unconnected Message Manager (UCMM) messages. Class 3 connections are created internally by the SEL-700G when the appropriate connection is made by the EtherNet/IP scanner.

When configuring EtherNet/IP (EIP) on Port 1, you can create as many as six Class 1 (I/O) connection configurations. Of these six, only two can be used simultaneously. Of the six available connection configurations, as many as three can be Exclusive Owner connection configurations. The remaining number of connection configurations must be Input Only connection configurations.

An Exclusive Owner connection configuration contains both a Target to Originator (T->O, data flows from the SEL-700G to the scanner) connection and an Originator to Target (O->T, data flows from the scanner to the SEL-700G) connection. An Input Only connection configuration contains a (T->O) connection only. For every distinct (T->O) connection, the SEL-700G automatically creates a Listen Only connection configuration. Listen Only connection configurations do not count against the six Class 1 (I/O) connection configurations. For the SEL-700G, the types of supported connections are shown in *Table F.21*.

The flow of data is represented via assemblies. Input Assemblies 100, 102, and 104 are always associated with (T->O) connections and Output Assemblies 101, 103, and 105 are always associated with (O->T) connections. Note that these Output Assemblies can also be associated with (T->O) connections. The Input Assemblies can contain both binary input (from *Table L.1*) and analog input (from *Table M.1*) data. The Output Assemblies can contain both binary output and analog output data. Input Assembly 100 and Output Assembly 101 consist of data that can be chosen by setting the EtherNet/IP Assembly Map 1 settings using the **SET E 1** command. Similarly, Input Assembly 102 and Output Assembly 103 consist of data that can be chosen by setting the EtherNet/IP Assembly Map 2 settings using the **SET E 2** command. Input Assembly 104 and Output Assembly 105 consist of data that can be chosen by setting the EtherNet/IP Assembly Map 3 settings using the **SET E 3** command. Each of these assembly maps contains 100 binary input points, 100 analog input points, 32 binary output points, and 32 analog output points. It is important to note that the binary output points can take on the value of any remote bit (SET/CLEAR) or any 89OC/89CC bit (SET by the scanner and pulsed by the SEL-700G outside of the EIP library) within the SEL-700G. The OC and CC bits are also allowed (SET by the scanner and pulsed by the SEL-700G outside of the EIP library). To pulse OC and CC in the EtherNet/IP Output Assembly Binary Map, you must pulse the CC bit only. When you write a 1, it pulses CC and when you write a 0, it pulses OC. The analog output points can take on the value of NOOP (writing to this point reports no errors and modifies no internal values). All the remote analogs and the active settings group are controllable.

Both the EIP settings on Port 1 and the configured assembly maps are used by the SEL-700G to create the Electronic Data Sheet (EDS) file. Only the SEL-700G can create and modify the EDS file. Refer to *Electronic Data Sheet File* for more information.

Table F.21 Class 1 Connection Support

Class 1 Connections	Supported Connections
Input Only	Point-to-point Point to-multicast Multicast-to-point Multicast-to-multicast
Listen Only	Point-to-point Point to-multicast Multicast-to-point Multicast-to-multicast
Exclusive Owner	Point-to-point Point to-multicast Multicast-to-point Multicast-to-multicast

EtherNet/IP Settings

Table F.22 shows the EtherNet/IP Port 1 settings in the SEL-700G.

Table F.22 Port 1 EtherNet/IP Protocol Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE ETHERNET/IP	Y, N	EEIP := N
CONFIGURATION ID	0–255	CONFIGID := 0
MAJOR EDS REVISION	1–255	MAJOREDS := 1
MINOR EDS REVISION	1–255	MINOREDS := 1
NUMBER OF IP ADDRESSES FOR EIP SCANNER	OFF, 1–8	NUMIP := 1
IP ADDRESS *zzz.yyy.xxx.www*	*zzz*: 1–126, 128–223 *yyy*: 0–255 *xxx*: 0–255 *www*: 0–255	EIPIP1 := 192.168.1.151 EIPIP2 := 192.168.1.152 EIPIP3 := 192.168.1.153 EIPIP4 := 192.168.1.154 EIPIP5 := 192.168.1.155 EIPIP6 := 192.168.1.156 EIPIP7 := 192.168.1.157 EIPIP8 := 192.168.1.158
NUMBER OF I/O CONNECTIONS	1–6	NUMCONN := 1
APPLICATION TYPE	EXCLUSIVE_OWNER, INPUT_ONLY	APPTYP*n* := INPUT_ONLY
INPUT ASSEMBLY	IA1, IA2, IA3, OA1, OA2, OA3	INASSM*n* := IA1
OUTPUT ASSEMBLY	OA1, OA2, OA3	OUTASSM*n* := OA1

Electronic Data Sheet File

EtherNet/IP uses an EDS file to define the interface between the EIP library and the scanner. The scanner uses this information to determine what objects, attributes, and services are supported by the SEL-700G.

In the SEL-700G, the EDS file consists of the following sections:

- ➤ *File Description Section, [File]*
- ➤ *Device Description Section, [Device]*
- ➤ *Device Classification Section, [Device Classification]*
- ➤ *Parameters Section, [Params]*
- ➤ *Assembly Section, [Assembly]*
- ➤ *Connections Section, [Connection Manager]*
- ➤ *Vendor Specific Object Section*
- ➤ *Capacity Section, [Capacity]*
- ➤ *Ethernet Link Class, [Ethernet Link Class]*

File Description Section, [File]

The File Description Section of the EDS file contains the entries listed in *Table F.23*.

Table F.23 File Description Section Entries

Name	Keyword	Value
File Description Text	DescText	Contains the product specific name <Prod Name> as specified by the product. It is of the format "<Prod Name> EtherNet/IP Adapter EDS File".
File Creation Date	CreateDate	UTC date value that is hardcoded to match the R-release date of the firmware.
File Creation Time	CreateTime	UTC time value that is hardcoded to match the R-release time of the firmware.
Last Modification Date	ModDate	UTC data value that is determined when the EDS file is generated.
Last Modification Time	ModTime	UTC time value that is determined when the EDS file is generated.
EDS Revision	Revision	The format is MAJOREDS.MINOREDS, where MAJOREDS and MINOREDS are populated by the correspondingly named parameters in the Port 1 settings.

Device Description Section, [Device]

The Device Description Section of the EDS file contains the entries listed in *Table F.24*

Table F.24 Device Description Section Entries (Sheet 1 of 2)

Name	Keyword	Value
Vendor ID	VendCode	SEL Vendor ID number, 865
Vendor Name	VendName	"Schweitzer Engineering Laboratories"
Device Type	ProdType	43

Table F.24 Device Description Section Entries (Sheet 2 of 2)

Name	Keyword	Value
Device Type String	ProdTypeStr	"Generic Device Type"
Product Code	ProdCode	The number derived from the Device Code (DEVCODE as found in the **ID** command of the SEL-700G) and Configuration ID as provided in the Ethernet port settings
Major Revision	MajRev	The Major Revision is assigned internally by the SEL-700G
Minor Revision	MinRev	The Minor Revision is assigned internally by the SEL-700G
Product Name	ProdName	Takes on the existing default product name (the default RID string in a two-line display model or the default STRING RID in a touchscreen display model) of the SEL-700G plus the value of the user-configurable Configuration ID as provided in the Port 1 settings. The general format is "<Default RID>-<Configuration ID>".
Catalog Number	Catalog	Takes on the existing default product name (the default RID string in a two-line display model or the default STRING RID in a touchscreen display model) of the SEL-700G plus the value of the user-configurable Configuration ID as provided in the Port 1 settings. The general format is "<Default RID>-<Configuration ID>".
Icon File Name	Icon	SEL700G.ICO
Icon Contents	IconContents	Uncompressed content of characters

Device Classification Section, [Device Classification]

The Device Classification Section of the EDS file contains the entry listed in *Table F.25*.

Table F.25 Device Classification Section Entry

Name	Keyword	Value
Device Classification	Class1	"EtherNetIP"

Parameters Section, [Params]

Each parameter entry is named as *ParamN,* where *N* is a sequential number starting from 1 and ending at the maximum number of parameter object instances as defined in the corresponding assembly map.

All parameters of the EDS file are defined for *ParamN* in *Table F.26*.

Table F.26 Parameters of the EDS File (Sheet 1 of 2)

Label	Value
Reserved	0
Path Size, Path	Left empty
Descriptor	0x0000

Table F.26 Parameters of the EDS File (Sheet 2 of 2)

Label	Value
Data Type	Digitals: BOOL (0xC1) 1 Byte (0 or 1) Analogs: SINT (0xC2) Signed 1 Byte Integer, USINT (0xC6) Unsigned 1 Byte Integer, INT (0xC3) Signed 2 Byte Integer, UINT (0xC7) Unsigned 2 Byte Integer, DINT (0xC4) Signed 4 Byte Integer, UDINT (0xC8) Unsigned 4 Byte Integer, REAL (0xCA) 4 Byte Float, LREAL (0xCB) 8 Byte Float, LINT (0xC5) Signed 8 Byte Integer, or ULINT (0xC9) Unsigned 8 Byte Integer
Data Size (Bytes)	See previous
Name	Takes on the label name as defined in the corresponding assembly map. Names are unique.
Units	The value is “” for digitals. The value is determined internally by the SEL-700G for analogs.
Help String	“”
Min, max, default data values	It is 0,1,0 for digitals and ,,0, for analogs
Mult, div, base, offset scaling	It is ,,,, for all instances
Mult, div, base, offset links	It is ,,,, for all instances
Decimal places	0

RPI Parameter

The Requested Packet Interval (RPI) parameter entry falls immediately after the last parameter object instance as defined previously. This RPI parameter entry, Param(N+1), follows the structure detailed in *Table F.27*.

Table F.27 RPI Parameter Structure

Label	Value
Reserved	0
Path Size, Path	,,
Descriptor	0x0004
Data Type	0xC8
Data Size (Bytes)	4
Name	“RPI Range”
Units	“ms”
Help String	“This parameter limits the range of the RPI value”
Min, max, default data values	100000,,1000000
Mult, div, base, offset scaling	1,1000,1,0
Mult, div, base, offset links	,,,,
Decimal Places	1

Assembly Section, [Assembly]

The Assembly Section of the EDS file contains the entries listed in *Table F.28* for all of the available assemblies in the product.

Table F.28 Assembly Section Entries

Label	Value
Name	*Name* reflects the name of the Assembly type and instance, e.g., Input Assembly 1, Output Assembly 1, Input Assembly 2, etc.
Path	Set to "20 04 24 *InstID* 30 03" where InstID is the hexadecimal representation of the Assembly instance ID number.
Size	*Size_Bytes* reflects the total size in bytes of the mapped parameters in the Assembly instance.
Descriptor	0x0000
Reserved	Left empty
Member Size	Each mapped parameter in the corresponding Assembly instance is included in the EDS file using the following format: Member Size, Member Reference, Member Size, Member Reference, ... Member Size, Member Reference *MemberSize* reflects the data size for each parameter mapped in the corresponding Assembly instance in bits.
Member Reference	*MemberReference* reflects the name of each parameter entry "ParamN" (where N is the parameter instance) mapped in the corresponding Assembly instance.

Connections Section, [Connection Manager]

The Connections Section of the EDS file contains the entries listed in *Table F.29*, *Table F.30*, and *Table F.31*.

Table F.29 Input Only Connection Entries (Sheet 1 of 2)

Field	Value
Trigger and transport	0x02030002
Connection parameters	0x44640305
O->T RPI	Left empty
O->T size	0
O->T format	Left empty
T->O RPI	Set to "*ParamN*" where *N* is the parameter entry that defines the RPI for the device.
T->O size	Left empty
T->O format	*Input_Assem* is set to "*AssemN*" where *N* is the configured input assembly for the connection point.
Connection name string	*Connection_Name* contains "INPUT ONLY" as part of the string. All names are enumerated, e.g., "INPUT ONLY 1", etc.

Table F.29 Input Only Connection Entries (Sheet 2 of 2)

Field	Value
Help string	“”
Path	Set to “20 04 2C EE 2C *In*” where *In* is the hexadecimal representation of the configured input assembly instance ID number.

Table F.30 Listen Only Connection Entries

Field	Value
Trigger and transport	0x01030002
Connection parameters	0x44640305
O->T RPI	Left empty
O->T size	0
O->T format	Left empty
T->O RPI	Set to “*ParamN*” where *N* is the parameter entry that defines the RPI for the device.
T->O size	Left empty
T->O format	*Input_Assem* is set to “AssemN” where *N* is the configured input assembly for the connection point.
Connection name string	*Connection_Name* contains “LISTEN ONLY” as part of the string. All names shall be enumerated, e.g., “LISTEN ONLY 1”, etc.
Help string	“”
Path	Set to “20 04 2C ED 2C *In*” where *In* is the hexadecimal representation of the configured input assembly instance ID number.

Table F.31 Exclusive Owner Connection Entries (Sheet 1 of 2)

Field	Value
Trigger and transport	0x04030002
Connection parameters	0x44640405
O->T RPI	Set to *“ParamN*” where *N* is the parameter entry that defines the RPI for the device.
O->T size	Left empty
O->T format	*Output_Assem* is set to *“AssemN*” where *N* is the configured output assembly for the connection point.
T->O RPI	Set to *“ParamN*” where *N* is the parameter entry that defines the RPI for the device.
T->O size	Left empty
T->O format	*Input_Assem* is set to *“AssemN*” where *N* is the configured input assembly for the connection point.
Connection name string	*Connection_Name* contains “EXCLUSIVE OWNER” as part of the string. All names are enumerated, e.g., “EXCLUSIVE OWNER 1”, etc.

Table F.31 Exclusive Owner Connection Entries (Sheet 2 of 2)

Field	Value
Help string	“”
Path	“20 04 2C *Out* 2C *In*” where *Out* is the hexadecimal representation of the configured output assembly instance ID number and *In* is the hexadecimal representation of the configured input assembly instance ID number.

Vendor Specific Object Section

The Vendor Specific Object Section of the EDS file contains the entries listed in *Table F.32*.

Table F.32 Vendor Specific Object Section Entries

Label	Value
Revision	1
Maximum Instance Number	1
Number of Static Instances	1
Maximum Number of Dynamic Instances	0
Object Name	“Relay Status”
Object Class Code	0x64

Capacity Section, [Capacity]

The Capacity Section of the EDS file contains the entries listed in *Table F.33*.

Table F.33 Capacity Section Entries

Keyword	Value
MaxIOConnections	2
MaxMsgConnections	6

Ethernet Link Class, [Ethernet Link Class]

The Ethernet Link Class Section of the EDS file contains the entries listed in *Table F.34*.

Table F.34 Ethernet Link Class Entries

Keyword	Value
Revision	4
Object_Name	"Ethernet Link Object"
Object_Class_Code	0xF6
MaxInst	It is 2 if a dual Ethernet port CPU card is used. It is 1 if a single Ethernet port CPU card is used.
Number_Of_Static_ Instances	It is 2 if a dual Ethernet port CPU card is used. It is 1 if a single Ethernet port CPU card is used.
Max_Number_Of_ Dynamic_Instances	0
InterfaceLabel1	It is “PORT 1” if a single Ethernet port CPU card is used. It is “PORT 1A” if a dual Ethernet port CPU card is used.
InterfaceLabel2	Does not exist if a single Ethernet port CPU card is used. It is “PORT 1B” if a dual Ethernet port CPU card is used.

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Appendix G
IEC 61850 Communications

Features

The SEL-700G Relay uses Ethernet and IEC 61850 to support the following features:

- **SCADA**—Connect as many as seven simultaneous IEC 61850 manufacturing message specification (MMS) client sessions. The SEL-700G also supports as many as seven buffered and seven unbuffered report control blocks. See *Table G.38* for Logical Node mapping that enables SCADA control via an MMS browser. Controls support the Direct Normal Security and Enhanced Security (Direct or Select Before Operate) control models.
- **Peer-to-Peer Real-Time Status and Control**—Use GOOSE with as many as 64 incoming (receive) and 8 outgoing (transmit) messages. Virtual bits (VB001–VB128) and Remote Analogs (RA001–RA128) can be mapped from incoming GOOSE messages.
- **Configuration**—Use FTP client software or ACSELERATOR Architect SEL-5032 Software to transfer the Substation Configuration Language (SCL) Configured IED Description (CID) file to the relay.
- **Commissioning and Troubleshooting**—Use software such as AX-S4 from Sisco, Inc., to browse the relay logical nodes and verify functionality.

NOTE: The SEL-700G Relay ships with a default CID file installed which supports basic IEC 61850 functionality. A new CID file should be loaded if a change in the relay configuration is required. If an invalid CID file is transferred, the relay will reject the file and revert to the previous valid CID file.

This appendix presents the information you need to use the IEC 61850 features of the SEL-700G:

- *IEC 61850 Introduction*
- *IEC 61850 Operation*
- *IEC 61850 Configuration*
- *Logical Nodes*
- *Protocol Implementation Conformance Statement*
- *ACSI Conformance Statements*

IEC 61850 Introduction

In the early 1990s, the Electric Power Research Institute (EPRI) and the Institute of Electrical and Electronics Engineers, Inc. (IEEE) began to define a Utility Communications Architecture (UCA). They initially focused on inter-control center and substation-to-control center communications and produced the Inter-Control Center Communications Protocol (ICCP) specification. This specification, later adopted by the IEC as 60870-6 TASE.2, became the standard protocol for real-time exchange of data between databases.

In 1994, EPRI and IEEE began work on UCA 2.0 for Field Devices (simply referred to as UCA2). In 1997, they combined efforts with Technical Committee 57 of the IEC to create a common international standard. Their joint efforts created the current IEC 61850 standard.

The IEC 61850 standard, a superset of UCA2, contains most of the UCA2 specification, plus additional functionality. The standard describes client/server and peer-to-peer communications, substation design and configuration, testing, and project standards. The IEC 61850 standard consists of the parts listed in *Table G.1*.

These parts were first published between 2001 and 2004, and they are often referred to as IEC 61850 Edition 1 (Ed1). Selected parts of these standards were released in 2011 and tagged as Edition 2 (Ed2). The SEL-700G Relay is compliant with Ed2.

It is possible and even likely, that an installation can have a mixture of devices that conform to either Ed1 or Ed2. The standard supports backwards compatibility, i.e., Ed2 devices can send and receive messages to and from Ed1 devices. However, there are important considerations to be made when adding Ed2 devices to an existing Ed1 system. Please refer to *Potential Client and Automation Application Issues With Edition 2 Upgrades on page G.86* for more information.

Table G.1 IEC 61850 Document Set (Sheet 1 of 2)

IEC 61850 Sections	Definitions
IEC 61850-1	Introduction and overview
IEC 61850-2	Glossary
IEC 61850-3	General requirements
IEC 61850-4	System and project management
IEC 61850-5	Communications requirements
IEC 61850-6	Configuration description language for substation IEDs
IEC 61850-7-1	Basic communications structure for substations and feeder equipment—Principles and models
IEC 61850-7-2	Basic communications structure for substations and feeder equipment—Abstract Communication Service Interface (ACSI)
IEC 61850-7-3	Basic communications structure for substations and feeder equipment—Common data classes
IEC 61850-7-4	Basic communications structure for substations and feeder equipment—Compatible logical node (LN) classes and data classes

Table G.1 IEC 61850 Document Set (Sheet 2 of 2)

IEC 61850 Sections	Definitions
IEC 61850-8-1	SCSM-Mapping to MMS (ISO/IEC 9506-1 and ISO/IEC 9506-2 over ISO/IEC 8802-3)
IEC 61850-9-1	SCSM-Sampled values over serial multidrop point-to-point link
IEC 61850-9-2	SCSM-Sampled values over ISO/IEC 8802-3
IEC 61850-10	Conformance testing

The IEC 61850 document set, available directly from the IEC at www.iec.ch, contains information necessary for successful implementation of this protocol. SEL strongly recommends that anyone involved with the design, installation, configuration, or maintenance of IEC 61850 systems be familiar with the appropriate sections of this standard.

IEC 61850 Operation

Ethernet Networking

IEC 61850 and Ethernet networking are available as options in the SEL-700G. In addition to IEC 61850, the Ethernet port provides support protocols and data exchange, including FTP and Telnet. Access the SEL-700G Port 1 settings to configure all of the Ethernet settings, including IEC 61850 enable settings.

The SEL-700G Ethernet port supports IEC 61850 services, including transport of logical node objects, over TCP/IP. The Ethernet port can coordinate a maximum of seven concurrent IEC 61850 MMS sessions.

Object Models

The IEC 61850 standard relies heavily on the Abstract Communication Service Interface (ACSI) model to define a set of service and the responses to those services. In terms of network behavior, abstract modeling enables all IEDs to act identically. You can use these abstract models to create objects (data items) and services that exist independently of any underlying protocols. These objects are in conformance with the common data class (CDC) specification IEC 61850-7-3, which describes the type and structure of each element within a logical node. CDCs for status, measurements, controllable analogs and statuses, and settings all have unique CDC attributes. Each CDC attribute belongs to a set of functional constraints that groups the attributes into specific categories such as status (ST), description (DC), and substituted value (SV). Functional constraints, CDCs and CDC attributes are used as building blocks for defining Local Nodes.

UCA2 uses GOMSFE (Generic Object Models for Substation and Feeder Equipment) to present data from station IEDs as a series of objects called models or bricks. The IEC working group has incorporated GOMSFE concepts into the standard, with some modifications to terminology; one change was the renaming of bricks to logical nodes. Each logical node represents a group of data (controls, status, measurements, etc.) associated with a particular function. For example, the MMXU logical node (polyphase measurement unit) contains measurement data and other points associated with three-phase metering including voltages and currents. Each IED can contain many functions such as protection, metering, and control. Multiple logical nodes represent the functions in multifunction devices.

You can organize logical nodes into logical devices that are similar to directories on a computer disk. As represented in the IEC 61850 network, each physical device can contain many logical devices, and each logical device can contain many logical nodes. Many relays, meters, and other IEC 61850 devices contain one primary logical device where all models are organized.

IEC 61850 devices are capable of self-description. You do not need to refer to the specifications for the logical nodes, measurements, and other components to request data from another IEC 61850 device. IEC 61850 clients can request and display a list and description of the data available in an IEC 61850 server device. This process is similar to the autoconfiguration process used within SEL communications processors (SEL-2032 and SEL-2030). Simply run an MMS browser to query devices on an IEC 61850 network and discover what data are available. Self-description also permits extensions to both standard and custom data models. Instead of having to look up data in a profile stored in its database, an IEC 61850 client can simply query an IEC 61850 device and receive a description of all logical devices, logical nodes, and available data.

Unlike other Supervisory Control and Data Acquisition (SCADA) protocols that present data as a list of addresses or indices, IEC 61850 presents data with descriptors in a composite notation made up of components. *Table G.2* shows how the A-phase current expressed as MMXUAphsA$cVal is broken down into its component parts.

Table G.2 Example IEC 61850 Descriptor Components

Components		Description
MMXU	Logical Node	Polyphase measurement unit
A	Data Object	Phase-to-ground amperes
PhsA	Sub-Data Object	A-phase
cVal	Data Attribute	Complex value

Data Mapping

Device data are mapped to IEC 61850 logical nodes (LN) according to rules defined by SEL. Refer to IEC 61850-5:2013(E) and IEC 61850-7-4:2010(E) for the mandatory content and usage of these LNs. The SEL-700G logical nodes are grouped under Logical Devices for organization based on function. See *Table G.3* for descriptions of the Logical Devices in an SEL-700G. See *Logical Nodes on page G.27* for a description of the LNs that make up these Logical Devices.

Table G.3 SEL-700G Logical Devices

Logical Device	Description
ANN	Annunciator elements—alarms, status values
CFG	Configuration elements—datasets and report control blocks
CON	Control elements—Remote bits
MET	Metering or Measurement elements—currents, voltages, power, etc.
PRO	Protection elements—protection functions and breaker control

Functional Naming

Substation design typically starts with a one-line diagram and progresses down to the assignment of functions to IEDs. In this top-down approach, the functions are identified and named independently from the IEDs to which they are assigned.

NOTE: Functional naming is not supported by all MMS clients and GOOSE subscribers. Verify support for this feature before configuring functional names in a publishing IED.

Because a logical device is a grouping of logical nodes that perform a certain high-level function at a substation, the associated name often indicates the assigned function. The functional naming feature allows users to name a logical device based on the function it provides independent of the name of the IED to which the function is assigned. The alternative is product naming, which prepends the IED name to the logical device instance to create the logical device name. The functional name is used on the communications interface for all references to data in the logical device.

The SEL-700G supports functional naming of logical devices. You can add functional names in Architect for supported Edition 2 relays. To enable it in Architect, navigate to **Edit** > **Project Settings** and select the **Enable functional name editing on Server Model tab of supporting IEDs** check box, as shown in *Figure G.1*.

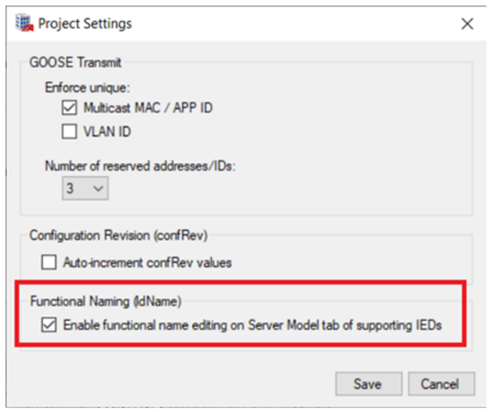


Figure G.1 Enable Functional Naming in Architect

To provide functional names to the logical devices, navigate to the Server Model tab for the IED. Because datasets and control blocks are in the CFG logical device, any functional name given to the CFG logical device instance is used in dataset references, control block references, and in published GOOSE messages, as shown in *Figure G.2*. The IED Server Model also allows the user to change the default logical node prefix and instance values.

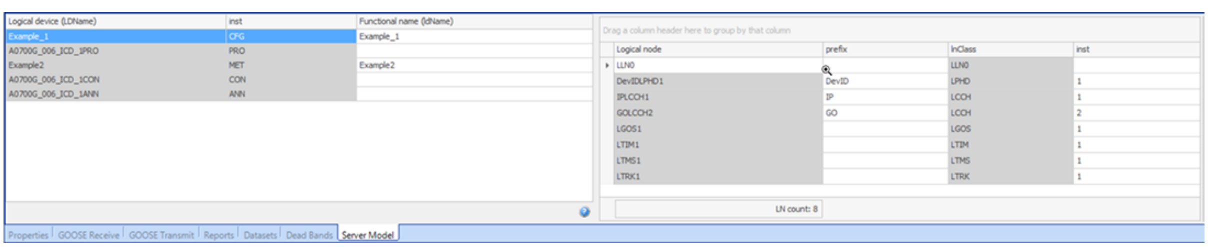


Figure G.2 Server Model View in Architect

MMS

MMS provides services for the application-layer transfer of real-time data within a substation LAN. MMS was developed as a network independent data exchange protocol for industrial networks in the 1980s and standardized as ISO 9506.

In theory, you can map IEC 61850 to any protocol. However, it can be unwieldy and quite complicated to map objects and services to a protocol that only provides access to simple data points via registers or index numbers. MMS supports complex named objects and flexible services that enable mapping to IEC 61850 in a straightforward manner. This was why the UCA users group used MMS for UCA from the start, and why the IEC chose to keep it for IEC 61850. MMS associations are discussed within IEC 61850-8-1, Clause 10 of the Edition 1 standard.

If MMS authentication is enabled, the device authenticates each MMS association by requiring the client to provide the password authentication parameter with a value that is equal to the Access Level 2 password of the SEL-700G.

- ➤ If the correct password authentication parameter is not received, the device returns a not authenticated error code.
- ➤ If the correct password authentication parameter value is received, the device gives a successful association response.

Once an authenticated association is established, the device allows access to all supported MMS services for that association.

File Services

The Ethernet file system allows reading or writing data as files. The file system supports FTP and MMS file transfer. The file system provides:

- ➤ A means for the devices to transfer data as files
- ➤ A hierarchical file structure for the device data

The SEL-700G supports MMS file transfer with or without authentication; the service is intended to support the following:

- ➤ CID file download and upload
- ➤ Settings Files download and upload
- ➤ Retrieval of events, and reports

MMS file services are enabled or disabled via Port 1 settings. See *Virtual File Interface on page 7.77* for details on the files available for MMS file services. For additional details, see *File Transfer Protocol (FTP) and MMS File Transfer on page 7.15*, *Retrieving COMTRADE Event Files on page 10.31*, and *Retrieving Event Reports Via Ethernet File Transfer on page 10.18*.

SCL Files

Substation Configuration Language (SCL) is an XML-based configuration language used to support the exchange of database configuration data between different tools, which may come from different manufacturers. There are four types of SCL files:

- ➤ IED Capability Description file (.ICD)
- ➤ System Specification Description (.SSD) file
- ➤ Substation Configuration Description file (.SCD)
- ➤ Configured IED Description file (.CID)

The ICD file described the capabilities of an IED, including information on LN and GOOSE support. The SSD file describes the single-line diagram of the substation and the necessary LNs. The SCD file contains information on all IEDs, communications configuration data, and a substation description. The CID file, of which there may be several, describes a single instantiated IED within the project, and includes address information.

Datasets

IEC 61850 datasets are lists of references to DataObject attributes for the purpose of efficient observation and transmission of data. Architect ICD files come with predefined datasets that can be used to transfer data via GOOSE messages, or MMS reports. The datasets listed in *Figure G.3* are the defaults for an SEL-700G device. Datasets BRDSet01–BRDSet07 and URDSet01–URDSet07 are preconfigured with common FCDAs to be used for reporting. These datasets can be configured to represent the data you want to monitor. Dataset GPDSet01, which contains breaker status and control data attributes, is used in the default Goose Control Publication.

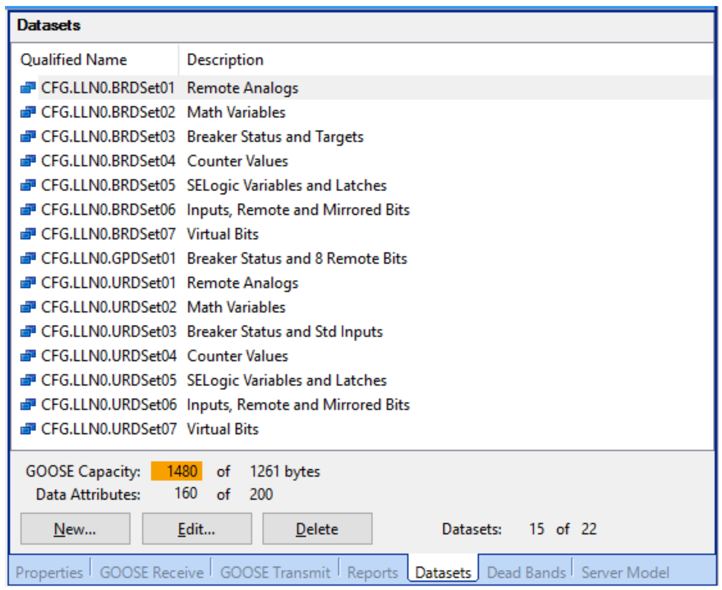


Figure G.3 SEL-700G Datasets

NOTE: Do not edit the dataset names used in reports. Changing or deleting any of those dataset names will cause a failure in generating the corresponding report.

➤ GOOSE: You can use predefined or edited datasets, or create new datasets for outgoing GOOSE transmission.

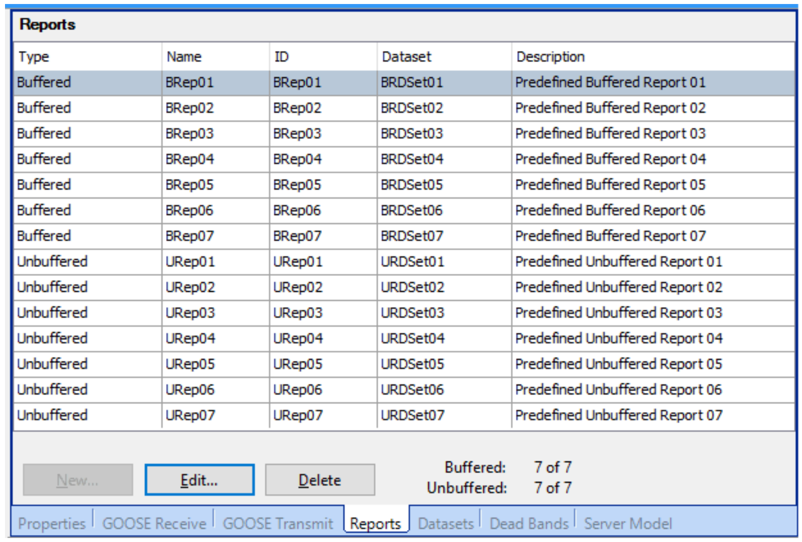
➤ Reports: Fourteen predefined datasets (BRDSet01–BRDSet07 and URDSet01–URDSet07) correspond to the default seven buffered and seven unbuffered reports, respectively. Note that you cannot change the number (14) or type of reports (buffered or unbuffered) within Architect. However, you can alter the data attributes that a dataset contains and so define what data an IEC 61850 client receives with a report.

➤ MMS: You can use predefined or edited datasets, or create new datasets to be monitored by MMS clients.

Reports

NOTE: When configuring buffered and unbuffered reports that contain analog values, only a change in the magnitude values (mag or cVal data attributes) will trigger a data change report.

The SEL-700G supports buffered and unbuffered report control blocks in the report model as defined in IEC 61850-8-1:2011. The predefined reports shown in *Figure G.4* are available by default via IEC 61850. There are 14 report control blocks, seven buffered reports and seven unbuffered.


Reports

Type	Name	ID	Dataset	Description
Buffered	BRep01	BRep01	BRDSet01	Predefined Buffered Report 01
Buffered	BRep02	BRep02	BRDSet02	Predefined Buffered Report 02
Buffered	BRep03	BRep03	BRDSet03	Predefined Buffered Report 03
Buffered	BRep04	BRep04	BRDSet04	Predefined Buffered Report 04
Buffered	BRep05	BRep05	BRDSet05	Predefined Buffered Report 05
Buffered	BRep06	BRep06	BRDSet06	Predefined Buffered Report 06
Buffered	BRep07	BRep07	BRDSet07	Predefined Buffered Report 07
Unbuffered	URep01	URep01	URDSet01	Predefined Unbuffered Report 01
Unbuffered	URep02	URep02	URDSet02	Predefined Unbuffered Report 02
Unbuffered	URep03	URep03	URDSet03	Predefined Unbuffered Report 03
Unbuffered	URep04	URep04	URDSet04	Predefined Unbuffered Report 04
Unbuffered	URep05	URep05	URDSet05	Predefined Unbuffered Report 05
Unbuffered	URep06	URep06	URDSet06	Predefined Unbuffered Report 06
Unbuffered	URep07	URep07	URDSet07	Predefined Unbuffered Report 07

New... Edit... Delete
Buffered: 7 of 7
Unbuffered: 7 of 7
Properties | GOOSE Receive | GOOSE Transmit | Reports | Datasets | Dead Bands | Server Model

Figure G.4 SEL-700G Predefined Reports

For each report control block, there can be just one client association, i.e., only one client can be associated to a report control block (BRCB or URCB) at any given time. The number of reports (14) and the type of reports (buffered or unbuffered) cannot be changed. However, by using Architect, you can reallocate data within each report dataset to present different data attributes for each report beyond the predefined datasets. For buffered reports, connected clients can edit the report parameters shown in *Table G.4*.

Table G.4 Buffered Report Control Block Client Access

RCB Attribute	User changeable (Report Disabled)	User changeable (Report Enabled)	Default Values
RptId	YES		BRep01–BRep07
RptEna	YES	YES	FALSE
OptFlds	YES		seqNum
			timeStamp
			dataSet
			configRef
			reasonCode
			dataRef
BufTm	YES		500
TrgOp	YES		dchg
			qchg
IntgPd	YES		0
GI	YES[a b]	YES[a]	FALSE
PurgeBuf	YES[a]		FALSE
EntryId	YES		0

[a] Exhibits a pulse behavior. Write a one to issue the command. Once command is accepted returns to zero. Always read as zero.
[b] When disabled, a GI is processed and the report buffered if a buffer has been previously established. A buffer is established when the report is enabled for the first time.

Similarly, for unbuffered reports, connected clients can edit the report parameters shown in *Table G.5*.

Table G.5 Unbuffered Report Control Block Client Access

RCB Attribute	User changeable (Report Disabled)	User changeable (Report Enabled)	Default Values
RptId	YES		URep01–URep07
RptEna	YES	YES	FALSE
Resv	YES		FALSE
OptFlds	YES		seqNum
			timeStamp
			dataSet
			configRef
			reasonCode
			dataRef
BufTm	YES		250
TrgOps	YES		dchg
			qchg
IntgPd	YES		0
GI		YES[a]	

[a] Exhibits a pulse behavior. Write a one to issue the command. Once command is accepted, returns to zero. Always read as zero.

For buffered reports, only one client can enable the RptEna attribute of the BRCB at a time resulting in a client association for that BRCB. Once enabled, the associated client has exclusive access to the BRCB until the connection is closed or the client disables the RptEna attribute. Once enabled, all unassociated clients have read only access to the BRCB.

For unbuffered reports, as many as seven clients can enable the RptEna attribute of the URCB at a time, resulting in multiple client associations for that URCB. Once enabled, each client has independent access to a copy of that URCB.

The Resv attribute is writable, however, the SEL-700G does not support reservations. Writing any field of the URCB causes the client to obtain its own copy of the URCB-in essence, acquiring a reservation.

Reports are serviced at a 2 Hz rate. The client can set the IntgPd to any value with a resolution of 1 ms. However, the integrity report is only sent when the period has been detected as having expired. The report service rate of 2 Hz results in a report being sent within 500 ms of expiration of the IntgPd. The new IntgPd begins at the time that the current report is serviced.

Supplemental Software

Examine the data structure and value of the supported IEC 61850 LNs with an MMS browser such as MMS Object Explorer and AX-S4 61850 from Sisco, Inc. The settings necessary to browse an SEL-700G with an MMS browser are as follows:

OSI-PSEL (Presentation Selector)	00000001
OSI-SSEL (Session Selector)	0001
OSI-TSEL (Transport Selector)	0001

Time Stamps and Quality

In addition to the various data values, the two attributes quality and t (time stamp) are available at any time. The relay determines the time stamp when it detects a change in quality or data.

The relay applies a time stamp to all data and quality attributes (Boolean, Bstrings, Analogs, etc.) in the same fashion as when it detects a data or quality change. However, there is a difference in how the relay detects the change between the different attribute types. For points that are assigned as SER points, i.e., programmed in the SER report, the relay detects the change as the receipt of an SER record (which contains the SER time stamp) within the relay.

For all other Booleans or Bstrings, the relay detects the change via the scanner, which compares the last state against the previous state to detect the change. For analogs, the scanner looks at the amount of change relative to the deadband configured for the point to indicate a change and apply the timestamp. In all cases, the relay uses these time stamps for the reporting model.

LN data attributes mapped to points assigned to the SER report have 4 ms SER-accurate time stamps for data change events. To ensure that you get SER-quality time stamps for changes to certain points, you must include those points in the SER report. All other LN data attributes are scanned for data changes on a 1/2-second interval and have 1/2-second time-stamped accuracy. See the SET R command for information on programming the SER report.

The SEL-700G uses GOOSE quality attributes to indicate the quality of the data in its transmitted GOOSE messages. Under normal conditions, all attributes are zero, indicating good quality data. *Figure G.5* shows the GOOSE quality attributes available to devices that subscribe to GOOSE messages from SEL-700G datasets that contain them. Internal status indicators provide the information necessary for the device to set these attributes.

For example, if the device becomes disabled, as shown via status indications (e.g., an internal self-test failure), the SEL-700G sets the Validity attribute to invalid and the Failure attribute to TRUE. Note that the SEL-700G does not set any of the other quality attributes. These attributes always indicate FALSE (0). See the Architect online help for additional information on GOOSE Quality attributes.

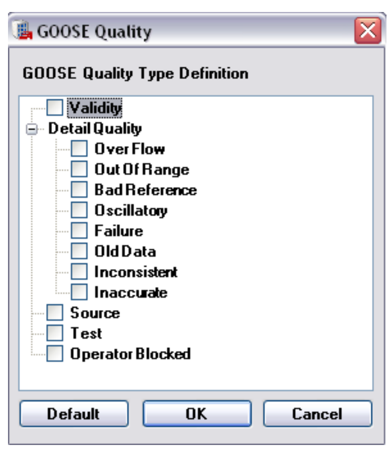


Figure G.5 GOOSE Quality

Control

IEC 61850 Controls

An IEC 61850 server may allow a client to manipulate data related to its outputs, external devices, or internal functions. This is accomplished by the IEC 61850 control model, which provides services to execute control commands. The control models are defined in IEC 61850-7-2 and the mapping to the MMS (Manufacturing Message Specification) application protocol is defined in IEC 61850-8-1. The former describes control functionality while the latter maps the IEC 61850 control primitives to MMS.

The SEL-700G Relay supports four different control models:

- Status Only
- Direct with Normal Security
- Direct with Enhanced Security
- SBO with Enhanced Security

The SEL-700G Relay supports the above control models for SPC and DPC controllable common data classes (CDCs) as defined in IEC 61850-8-1:2004. Other controllable CDCs defined in the standard are either unsupported or must be configured with the status-only control model. Supported CDCs include remote bits RBGGIOn in the CON Logical Device (LD), and breaker and disconnect controls xxXCBRnn and xxXSWInn in the PRO LD. One control model must be selected during initial IED configuration in Architect and is applied throughout the CID file. This control model will apply to all controls in the IED.

Direct Control Models

The "Direct" control models provide the simplest means to initiate actions on the server. In these models, the client issues a control request via MMS, the server validates the request. Once validated, the server attempts to act upon the request. Note that if multiple clients are trying to perform control actions, the server will do nothing to prevent this.

SBO Control Model

NOTE: When an IED is configured with the SBO with Enhanced Security control model, the sboTimeout attribute of the controllable CDCs in the CID file is set to ten seconds. The time-out is not configurable via Architect.

The SBO control model supports the Select or SelectWithValue Service and can be used to prevent multiple clients from performing simultaneous control actions. In this mode, a client has to "reserve" the control object by sending a "select" control command. Once an object is selected, only the client that made the selection is allowed to perform control actions on it. If that client does not send a valid operate request for the object by the time the ten-second selection timer runs out, the object becomes available for selection again. The relay will support as many as ten pending control object selections at any time.

The attribute stSeld (selected status) of the controllable CDC is set to TRUE when a client successfully selects the control object. The attribute is reset to FALSE when either the control (operate) command is successfully executed, an error occurs, or no operate command is received within the select time-out period. The stSeld attribute may trigger a report just like any data attribute with trigger option.

Security in Control Models

NOTE: The maximum time required for a control operation to be completed should be less than the configured time-out period to avoid erroneous command termination reports indicating failure.

"Security" in the control model context refers to additional supervision of the status value by the control object. The "enhanced security" models report additional error information on failed operations to the requesting client than the models with "normal security". Enhanced security control models also provide a command termination report indicating if the control actually reached the new state as commanded within a configurable time-out period.

The time-out period between the execution of a control and the generation of a command termination report indicating failure has a default value of 1 s and is configurable via the CID file. This time-out is not configurable via Architect.

Optional Control Configurations

The SEL-700G supports the pulse configuration option specified in Clause 6.7 of IEC 61850-7-3. Contact the factory if this feature is necessary for your application.

Control Interlocking

The SEL-700G relay uses control interlocking to supervise the open and close control command from MMS Clients. The relay accomplishes it by checking the CSWI logical node control object against an associated CILO logical node data object. The CILO logical node has two data objects: Enable Open (EnaOpn) and Enable Close (EnaCls). When the associated CILO logical node EnaCls and EnaOpn data objects are not asserted, the relay blocks the control operation and sends the AddCause "Blocked-by-interlocking" to the MMS Client.

Program SELOGIC variables SV29 and SV31 to supervise opening and SV30 and SV32 to supervise closing of the circuit breaker. Use settings 89CB*km* and 89OB*km* (*k* = 2P, 3PL, or 3PE, *m* = switch number [1–8 if *k* = 2P; 1–2 if *k* = 3PL or 3PE]) to supervise closing and opening of the 2- or 3-position disconnect switches, respectively.

Figure G.6 shows how the relay responds to a CSWI logical node *write* command request from the MMS client when IEC 61850 control interlocking is applied.

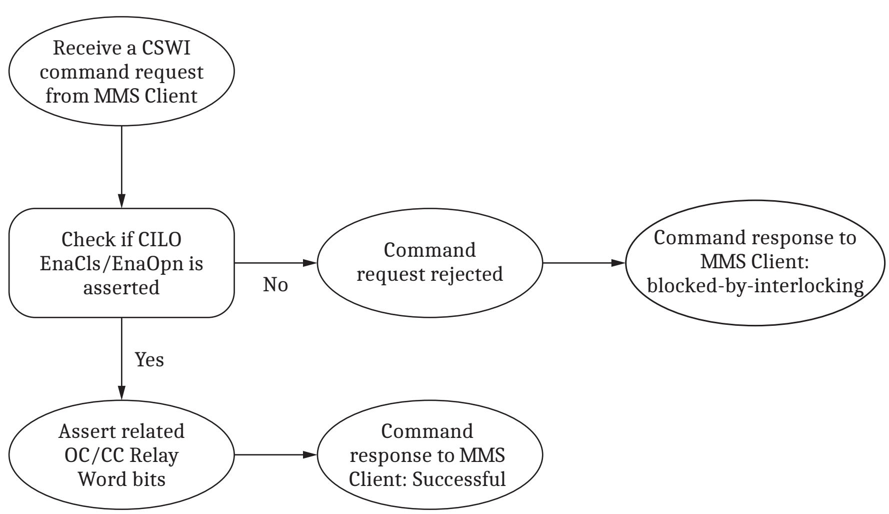


Figure G.6 CSWI Logical Node Direct Operate Command Request

Local/Remote Control Authority

Control commands at a substation originate from one of three levels: remote (network control center) level, station level, or bay level. Under certain operational conditions (e.g., during maintenance), it may be necessary to block control commands from one or more of these levels. The local/remote control feature allows users to enable or disable control authority at any of the three levels. The level at which a control command originates is determined by the value of the origin.orCat (originator category) attribute in the command.

The SEL-700G supports the local/remote control feature defined in IEC 61850-7-4. The feature is supported at the IED level with identical and configurable attributes in the LLN0 logical node in each logical device. *Table G.6* describes the attributes and their data sources.

Table G.6 Control Authority Attributes

Attribute	Data Source	Description
LLN0.Loc.stVal	LOC	Control authority at local (bay) level
LLN0.LocSta.stVal	LOCSTA	Control authority at station level
LLN0.MltLev.setVal	MLTLEV	Multilevel control authority

Using these three attributes, you can enable or disable control authority at any of the three switching levels, as shown in *Table G.7*.

Table G.7 Control Authority Settings

LLN0			orCat Value		
Loc.stVal	LocSta.stVal	MltLev.setVal	Bay (1 or 4)	Station (2 or 3)	Remote (3 or 6)
F	F	F	NA	NA	AA
F	F	T	AA	AA	AA
F	T	F	NA	AA	NA
T	X	X	AA[a]	NA	NA
F	T	T	AA	AA	NA

[a] Commands to CSWI logical nodes that control process level equipment (XCBR/XSWI) are not allowed.
T = True (asserted)
F = False (deasserted)
X = Do not care (true or false)
AA = Command is allowed
NA = Command is not allowed

By default, all three attributes are set to False, so only remote commands are allowed.

You can control the Relay Word bits LOC, LOCSTA, and MLTLEV through SELOGIC control equations. LOCSTA is set to True when the SELOGIC control equation SC850LS asserts and set to False when SC850LS deasserts. LOCSTA may also be controlled through MMS, but if it is set to True through SELOGIC control equations, it cannot be set to False through MMS.

In the SEL-700G, you can place only the XCBR and XSWI logical nodes in local mode by asserting the LOCAL Relay Word bit. This blocks all control commands to the associated CSWI logical nodes.

Control Requests

IEC 61850 control services are implemented by reading and writing to pseudovariables in the relay in response to MMS requests. Similar to how client requests are generated and mapped to MMS read or write service requests, server actions are also mapped to internal commands, read and write actions and MMS information report messages. In the case of an unsuccessful control request, the relay will send the appropriate response PDU indicating that there was a problem and an MMS information report that contains more detailed information about the problem that occurred.

When writing controls, the client must select and write the entire Oper, SBOw, or Cancel structure to the relay. See *Figure G.7* for the attributes of the CON Logical Device and ST and CO functional constraints (FC) of LN RBGGIO1 used for controls of RB01 through RB08.

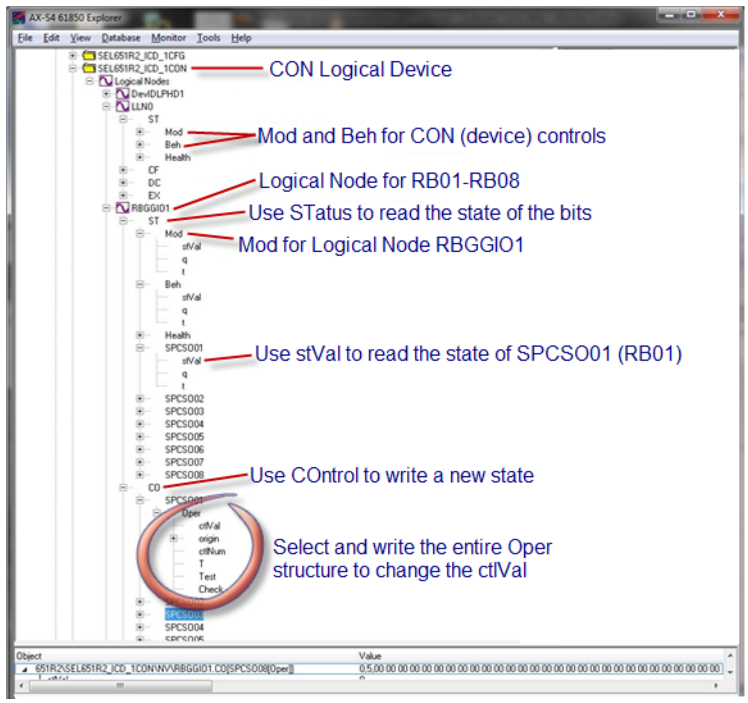


Figure G.7 MMS Client View of the CON Logical Device

Control Error Messages

If a control request results in an error condition, the relay will respond with an AddCause value in an MMS information report. See Clause 20.5.2.9 of IEC 61850-7-2 for additional information on the AddCause values. The SEL-700G Relay supports the AddCause values in *Table G.8* as part of the LastApplError information report.

Table G.8 AddCause Descriptions (Sheet 1 of 2)

AddCause Enumeration	AddCause Description	Error Condition
0	Unknown	No other AddCause value defined within this section applies
2	Blocked-by-switching-hierarchy	Logical node is set to local mode, i.e. Loc.stVal = true
3	Select-failed	Originator category not allowed to issue control commands or SelectWithValue operation fails

Table G.8 AddCause Descriptions (Sheet 2 of 2)

AddCause Enumeration	AddCause Description	Error Condition
4	Invalid-position	For controls with enhanced security, an AddCause of "Invalid-position" (4) will be sent if the control status changes to an unexpected value. If no control status change is detected after the operate time-out period, an AddCause of "Time-limit-over" (16) will be sent.
5	Position-reached	Control status is already at the desired state
6	Parameter-change-in-execution	Control object is already selected by the client, and 1. Logical node is set to local mode i.e., Loc.stVal = true, or 2. Originator category not allowed to issue control commands
8	Blocked-by-mode	Mode of logical device or node is not ON
10	Blocked-by-interlocking	Control operation of switch device failed due to interlock check
12	Command-already-in-execution	Execution of a previous control is not completed
13	Blocked-by-health	Health of logical device or node is not OK
16	Time-limit-over	CommandTermination gives a negative response. (The control failed to reach its intended state prior to time-out.)
18	Object-not-selected	Cancel operation fails

Any AddCause value not specified above is not supported. Control CDC data attributes which are associated with unsupported AddCause values and are not part of a control structure will be accepted but ignored. For example, the attribute CmdBlk.stVal which is associated with the AddCause value "blocked-by-command" and is not part of a SBOw, Oper, or Cancel structure will be ignored.

Group Switch Via MMS

The Group Switch feature in IEC 61850 is primarily a convenience feature for users so that they can institute a settings group switch from an IEC 61850 client without having to revert to the command line or some other tool. However, this has great potential for integration with IEC 61850 SCADA systems which would be able to control setting groups through IEC 61850 MMS.

The IEC 61850 specification outlines a method for switching the current settings group to another preconfigured settings group. The setting group control block, or SGCB, contains the SettingControl element which enables settings group control. An SEL-700G CID file that supports group switch functionality will only contain one SGCB. The SGCB contains the number of settings groups in the relay and may also contain the current active setting group, ActSG. Note that if the CID file contains a value for ActSG, it will be ignored and the relay will use the actual active setting group value for ActSG at the time of CID file download.

When the IEC 61850 functions of the relay are enabled, the selectActiveSG service allows an MMS client to request that the relay change the active setting group. The MMS client can request a group switch by writing a valid setting group number to ActSG. The relay updates the ActSG value under the following conditions:

- ➤ The value written to ActSG is valid and not the current active group
- ➤ There is no group switch in progress
- ➤ The setting of the active group was successful

Note that if the value written to ActSG is the same as the current group, the relay will not attempt to switch settings groups. Please refer to *Multiple Settings Groups on page 4.224* for more information on setting group selection.

Service Tracking

The IEC 61850 standard defines many services to be provided by an IED (server). These services include control services, reporting services, logging services, and group switch control services. IEC 61850 Edition 2 defines the service tracking feature to allow these services to be reported or logged, whether they succeed or fail.

The SEL-700G supports the service tracking feature for control commands, report control block edits, and group switch selection. You can report these services.

Tracking of these services is enabled by data objects in the service tracking logical node LTRK. *Table G.9* lists the service tracking data objects. Their data attributes mirror those in the service request or in the control block that was the target of the service request.

Table G.9 Service Tracking Data Objects

Data Object	CDC	Description
SpcTrk	CTS	Tracks control service requests targeted at a controllable single-point object
DpcTrk	CTS	Tracks control service requests targeted at a controllable double-point object
EncTrk	CTS	Tracks control service requests targeted at a controllable enumerated status object
UrcbTrk	UTS	Tracks unbuffered report control block edits
BrcbTrk	BTS	Tracks buffered report control block edits
SgcbTrk	STS	Tracks active settings group selection

Refer to *Table G.40* for information regarding the available attributes in each tracking data object.

Each tracking data object includes the data attributes objRef, serviceType, and errorCode. The attribute objRef provides the reference to the control object or control block instance that was the target of the service request. The attribute serviceType provides an enumerated value for the specific service requested or executed. *Table G.10* defines the service type enumerations.

Table G.10 IEC 61850 Service Type Enumeration

Service Type	Service Name	Description
16	SelectActiveSG	Active settings group switch request
24	SetBRCBValues	Write request on one or more of the following buffered report control block attributes: RptID, RptEna, OptFlds, BufTm, TrgOps, IntgPd, PurgeBuf, EntryID, or GI
26	SetURCBValues	Write request on one or more of the following unbuffered report control block attributes: RptID, RptEna, OptFlds, BufTm, TrgOps, IntgPd, Resv, or GI
44	SelectWithValue	Select control request
45	Cancel	Cancel control request
46	Operate	Operate control request
47	CommandTermination	Control processing completed on a control object configured with enhanced security control model
54	InternalChange	Report control block has been automatically disabled, i.e., RptEna is set to False after a loss of association with the client

The attribute errorCode provides the error code that indicates whether the service was successful or unsuccessful. *Table G.11* lists the codes and the corresponding ACSI errors.

Table G.11 IEC 61850 ACSI Service Error

Error Code	ACSI Error
0	no-error
1	instance-not-available
3	access-violation
5	parameter-value-inappropriate
6	parameter-value-inconsistent
7	class-not-supported
8	instance-locked-by-other-client
10	type-conflict
11	failed-due-to-communications-constraint
12	failed-due-to-server-constraint

When creating datasets to track the services through information reporting, it is important to include the tracking data objects as a whole object (FCD—functionally constrained data), and not as individual data attributes (FCDA—functional constrained data attribute). Only the objRef attribute has a trigger option (dupd—data update) and can trigger a report. The dupd trigger option must also be enabled in the report control block that is reporting changes in the tracking data objects.

GOOSE

The Generic Object Oriented Substation Event (GOOSE) object within IEC 61850 is for high-speed control messaging. IEC 61850 GOOSE automatically broadcasts messages containing status, controls, and measured values onto the network for use by other devices. IEC 61850 GOOSE sends the messages several times, increasing the likelihood that other devices receive the messages.

IEC 61850 GOOSE objects can quickly and conveniently transfer status, controls, and measured values between peers on an IEC 61850 network. Configure SEL devices to respond to GOOSE messages from other network with Architect software. Also, configure outgoing GOOSE messages for SEL devices in Architect. See the Architect online help for more information.

Each IEC 61850 GOOSE sender includes a text identification string (GOOSE Control Block Reference) in each outgoing message and an Ethernet multicast group address. Devices that receive GOOSE messages use the text identification and multicast group to identify and filter incoming GOOSE messages.

NOTE: Virtual bits and remote analogs mapped to GOOSE subscriptions retain their state until they are overwritten, a new CID file is loaded, or the device is restarted. To reset the virtual bits and remote analogs by restarting the device, issue an **STA C** command or remove and then restore power to the device.

Virtual bits (VB001–VB128) are control inputs that you can map to GOOSE receive messages by using the Architect software. See the VB*nnn* bits in *Table G.39* for details on which logical nodes and names are used for these bits. This information can be useful when searching through device data with MMS browsers. If you intend to use any SEL-700G virtual bits for controls, you must create SELOGIC control equations to define these operations. The Virtual Bit Logical Nodes only contain Virtual Bit status, and only those Virtual Bits that are assigned to an SER report are able to track bit transitions (via reporting) between LN data update scans.

The relay is capable of receiving analog values via peer-to-peer GOOSE messages. Remote Analogs (RA001–RA128) are analog inputs that you can map to values from incoming GOOSE messages.

GOOSE Processing

SEL devices support GOOSE processing as defined by IEC 61850-7-1:2011(E), IEC 61850-7-2:2010(E), and IEC 61850-8-1:2011(E) via the installed Ethernet port.

Outgoing GOOSE messages are processed within the following constraints:

- You can define as many as eight datasets for outgoing GOOSE messages consisting of any data attribute (DA) from any logical node. A single DA can be mapped to one or more outgoing GOOSE datasets, or one or more times within the same outgoing GOOSE dataset. You can also map a single GOOSE dataset to multiple GOOSE control blocks. The number of unique Boolean variables is limited to a combined total of 128 digital bits across all eight outgoing messages.
- The relay transmits all configured GOOSE immediately upon successful initialization. If a GOOSE message is not retriggered; then, following the initial transmission, the relay retransmits that GOOSE based on the minimum time and maximum time configured for that GOOSE message. The first transmission occurs immediately on triggering of an element within the GOOSE dataset. The second transmission occurs Min. Time later. The third transmission occurs Min. Time after the second transmission. The fourth transmission occurs twice Min. Time after the third transmission. All subsequent transmissions occur at the Max Time interval. For example, a message with a Min.

Time of 4 ms and Max. Time of 1000 ms is transmitted upon triggering, then retransmitted at intervals of 4 ms, 4 ms, 8 ms, and then at 1000 ms indefinitely or until another change triggers a new GOOSE message (See IEC 61850-8-1, Sec. 18.1). The default Min Time value is 8 ms. This is also the suggested Min Time value to use.

- GOOSE transmission is squelched (silenced) after a permanent (latching) self-test failure.
- Each outgoing GOOSE includes communications parameters (VLAN, Priority, and Multicast Address) and is transmitted entirely in a single network frame.
- The SEL-700G maintains the configuration of outgoing GOOSE through a power cycle and device reset.

Incoming GOOSE messages are processed within the following constraints:

- You can configure the SEL-700G to subscribe to as many as 64 incoming GOOSE messages.
- Control bits in the relay get data from incoming GOOSE messages which are mapped to virtual bits (VBnnn). Virtual bits are volatile and are reset to zero when a new CID file is loaded, the device is restarted, or they are overwritten by data from a subscribed GOOSE message.
- The SEL-700G recognizes incoming GOOSE messages as valid based on the following content. Any GOOSE message that fails these checks is rejected.
  - Source broadcast MAC address
  - Dataset Reference
  - Application ID
  - GOOSE Control Reference
- Rejection of all DA contained in an incoming GOOSE, based on the accumulation of the following error indications created by inspection of the received GOOSE:
  - **Configuration Mismatch**: the configuration number of the incoming GOOSE changes.
  - **Needs Commissioning**: this Boolean parameter of the incoming GOOSE is true.
  - **Test Mode**: this Boolean parameter of the incoming GOOSE is true.
  - **Decode Error**: the format of the incoming GOOSE is not as configured.
- The SEL-700G discards incoming GOOSE under the following conditions:
  - after a permanent (latching) self-test failure
  - when the relay is disabled
  - when EGSE is set to No

Link-layered priority tagging and virtual LAN is supported as described in Annex C of IEC 61850-8-1:2011.

Simulation Mode

The SEL-700G Relay can be configured to operate in simulation mode. In this mode, the SEL-700G Relay continues to process normal GOOSE messages until a simulated GOOSE message is received for a subscription. Once a simulated GOOSE message is received, only simulated GOOSE messages are processed for that subscription. The simulated mode only terminates when LPHDSIM is returned to FALSE. When the relay is not in the simulation mode, only normal GOOSE messages are processed for all subscriptions. You can place the SEL-700G in simulation mode by setting LPHDSIM (CFG.DevIDLPHD1.Sim.stVal) to true via MMS messaging.

Alternatively, you can use SELOGIC variable SC850SM to set LPHDSIM. The rising edge of SC850SM sets LPHDSIM, and the falling edge of SC850SM clears LPHDSIM. When you use SC850SM to enter simulation mode, the relay rejects MMS attempts to enter or exit simulation mode until SC850SM deasserts.

IEC 61850 Mode/Behavior

The IEC 61850-7-4:2010 standard defines the behavior of the different modes to facilitate testing. The different modes are only available in IEDs with IEC 61850 Edition 2 support.

SEL-700G relays support the following modes:

- On
- Blocked
- Test
- Test/Blocked
- Off

IEC 61850 Behavior is determined by the logical device mode and its logical node mode according to the IEC 61850 standard. For SEL-700G relays, the selected IEC 61850 Mode/Behavior applies to the entire IED, including all the logical devices and all the logical nodes. The behavior of the IED is always the same as the selected mode. *Table G.12* describes the available services based on the mode/behavior of the IED.

Table G.12 IEC 61850 Services Based on Mode/Behavior

Mode	MMS	GOOSE Publication and Subscription
On	Available	Available
Blocked	Available	Available
Test	Available	Available
Test/Blocked	Available	Available
Off	No services[a]	Publication[b]

[a] All MMS control requests to change the mode with Test = false will be processed.
[b] GOOSE publication in Off mode is disabled if EOFFMTX = N.

The analog quantity I850MOD is an enumerated number that corresponds to mode and behavior as shown in *Table G.13*. One way to view the value of this analog quantity is by assigning it to a math variable.

Table G.13 Analog Quantity I850MOD Status Based on the Selected IEC 61850 Mode/Behavior

I850MOD	IEC 61850 Mode/Behavior
1	On
2	Blocked
3	Test
4	Test/Blocked
5	Off
0	Not Supported

Mode/Behavior Control

Enable Mode/Behavior Control

IEC 61850 Mode/Behavior, by default, is disabled in SEL-700G relays. To enable IEC 61850 Mode/Behavior, you must set the Port 1 setting E61850 equal to Y. To enable IEC 61850 Mode/Behavior control, you must set port setting E850MBC equal to Y and the CID file setting controllableModeSupported to True. You can set the controllableModeSupported setting by selecting **Enable control of IEC 61850 Mode/Behavior** when adding an IED to an ACSELERATOR Architect SEL-5032 Software project, as shown in *Figure G.8*.

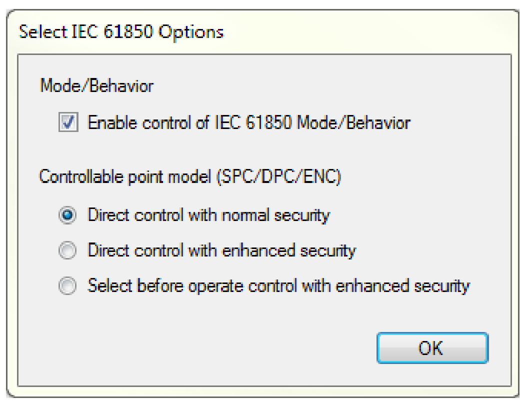


Figure G.8 Set controllableModeSupported = True

Enhances Secure Mode Control

Relay setting E850MBC and CID file setting controllableModeSupported provide security to prevent accidental switching into an unplanned IEC 61850 Mode/Behavior during normal operations. For example, following IED testing, a technician can disable unplanned switching of IEC 61850 Mode/Behavior by setting E850MBC to N after switching the relay back to On mode.

Change Mode Via MMS or SELogic

If IEC 61850 Mode/Behavior is set as controllable, you can control the IEC 61850 Mode/Behavior via MMS writes to the LLN0 logical node mode data object (Mod.ctlVal) in logical device CFG. Note that Mod.ctVal in other logical devices does not accept MMS writes. See *Table G.14* for the list of writable values.

Table G.14 IEC 61850 Mode/Behavior List of Writable Values

Write Values to Mod.ctVal in Logical Device CFG	Selected IEC 61850 Mode/Behavior
1	On
2	Blocked
3	Test
4	Test/Blocked
5	Off

You can also control IEC 61850 Mode/Behavior through use of the **SET G** command with protection SELogic variables SC850TM and SC850BM on the left side of the SELogic control equations. These variables are the SELogic controls for the Test mode and the Blocked mode, respectively.

Table G.15 IEC 61850 Mode/Behavior Evaluated States of SC850TM and SC850BM

SC850TM	SC850BM	Selected IEC 61850 Mode/Behavior
0	0	See note[a]
1	0	Test
0	1	Blocked
1	1	Test/Blocked
See note[b]	See note[b]	Off

[a] The SELogic controls have higher priority than MMS clients in controlling the Test mode and Blocked mode. When SC850TM and SC850BM both evaluate to 0 (false), IEC 61850 Mode/Behavior control is available to MMS clients. If either SC850TM or SC850BM evaluates to 1 (true), SELogic determines the IEC 61850 Mode/Behavior of the IED regardless of MMS control values.

[b] You cannot control Off mode by using SC850TM and SC850BM. When an MMS client causes the IED to be in Off mode, the SELogic controls are disabled and SC850TM and SC850BM are not evaluated.

EXAMPLE G.1 Change Mode Via SELogic

In this example, Pushbuttons PB01 and PB02 control SC850TM. Pushbuttons PB03 and PB04 control SC850BM. If you press PB01, the relay enters Test mode. If you press PB03, the relay transitions from Test mode into Test/Blocked mode. Press PB02 and PB04 to reset Test mode and Blocked mode, respectively.

```
=>>SHO L <Enter>

Latch Bits Eqns
SET01    := PB01
RST01    := PB02
SET02    := PB03
RST02    := PB04
```

```
=>>SHO G <Enter>

IEC 61850 Mode/Behavior Configuration
SC850BM    := LT02
SC850TM    := LT01
```

Mode and Behavior Control

Regardless of mode (On, Blocked, Test, Test/Blocked, Off) the Mod, Beh, and Health quality bitstring will always be quality.validity = Good, quality.failure = False, and quality.test = False. This behavior differs from and is independent of behavior during use of the **TEST DB** command.

Incoming Messages Processing

IEC 61850 incoming data processing is jointly determined by quality validity, test, and operatorBlocked. SEL-700G relays, by default, check if the quality operatorBlocked equals False; if not, the relays treat the messages as invalid. You can disable the default check by changing the quality mask of GOOSE subscriptions. *Figure G.9* illustrates the default quality check for GOOSE subscription in SEL-700G relays.

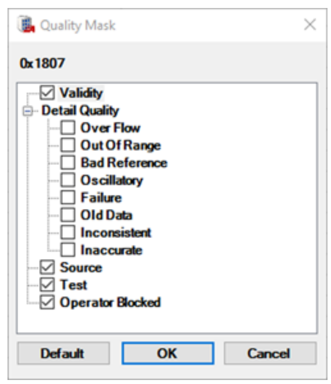


Figure G.9 Default Quality Check on GOOSE Subscription if Quality is Present

Relay Operation for Different IEC 61850 Modes/Behaviors

Mode: On

In On mode, the relay operates as normal; it reports IEC 61850 Mode/Behavior status as On and processes all inputs and outputs as normal. If the quality of the subscribed GOOSE messages satisfies the GOOSE processing (see *GOOSE Processing*), the relay processes the received GOOSE messages as valid. *Table G.16* and *Table G.17* illustrate how the relay handles incoming and outgoing messages while in On Mode.

Table G.16 IEC 61850 Incoming Message Handling in On Mode

IEC 61850 Messages	Incoming Message With Quality Test Bit Set to False (0)	Incoming Message With Quality Test Bit Set to True (1)
MMS	Processed	Processed as invalid
GOOSE	Processed	Processed as invalid

Table G.17 IEC 61850 Outgoing Message Handling in On Mode

IEC 61850 Messages	Outgoing Message Quality Test Bit Status
MMS	False
GOOSE	False

Figure G.10 illustrates the On Mode/Behavior.

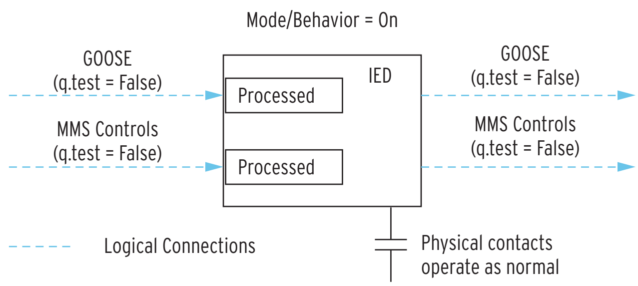


Figure G.10 Relay Operations in On Mode

Mode: Blocked

Blocked mode is similar to On mode, but in Blocked mode, none of the physical contact outputs are operated. However, in Blocked mode, control bits, such as remote bits and output contact bits, do continue to operate. *Figure G.11* illustrates the Blocked Mode/Behavior.

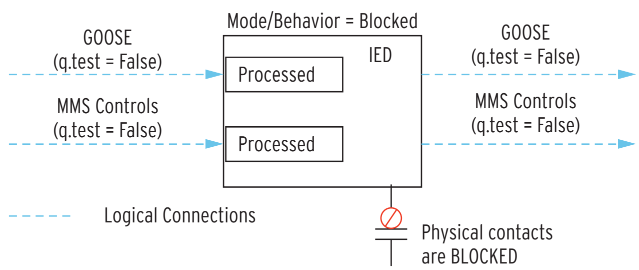


Figure G.11 Relay Operations in Blocked Mode

Mode: Test

In Test mode, the relay processes valid incoming test signals or normal messages and operates physical contact outputs, if triggered. In this mode/behavior, outgoing MMS and GOOSE messages have the quality test bit set to True if the quality test bit is present. If the quality of the subscribed GOOSE messages satisfies the user-defined quality type definition (regardless of whether the quality test bit is set to True or False—see *GOOSE Processing*), the relay processes the received GOOSE messages as valid. *Table G.18* and *Table G.19* illustrate how the relay handles incoming and outgoing messages while in Test Mode.

Table G.18 IEC 61850 Incoming Message Handling in Test Mode

IEC 61850 Messages	Incoming Message With Quality Test Bit Set to False (0)	Incoming Message With Quality Test Bit Set to True (1)
MMS	Not Processed	Processed
GOOSE	Processed	Processed

Table G.19 IEC 61850 Outgoing Message Handling in Test Mode

IEC 61850 Messages	Outgoing Message Quality Test Bit Status
MMS	True
GOOSE	True

Figure G.12 illustrates the Test Mode/Behavior.

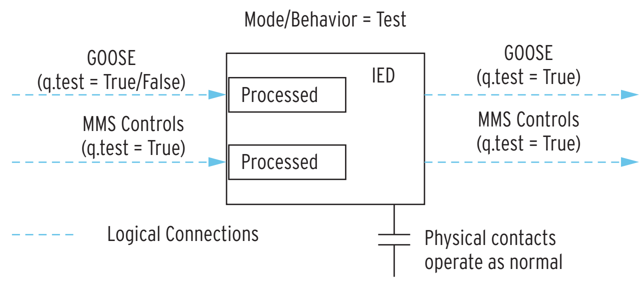


Figure G.12 Relay Operations in Test Mode

Mode: Test/Blocked

In Test/Blocked mode, the relay processes valid incoming test signals or normal messages but blocks any physical contact outputs from operating. In this mode/behavior, outgoing MMS and GOOSE messages have the quality test bit set to True if the quality test bit is present. If the quality of the subscribed GOOSE messages satisfies the user-defined quality type definition (regardless of whether the quality test bit is set to True or False— see *GOOSE Processing*), the relay processes the received GOOSE messages as valid.

Figure G.13 illustrates the Test/Blocked Mode/Behavior.

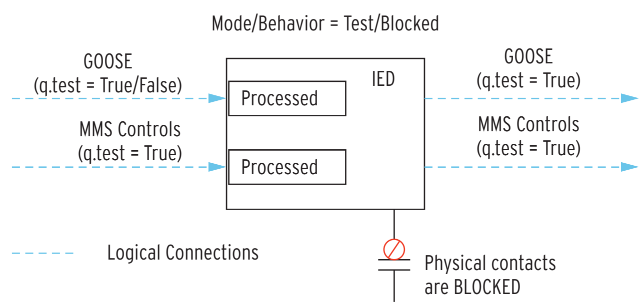


Figure G.13 Relay Operations in Test/Blocked Mode

Mode: Off

In Off mode, the relay no longer processes incoming GOOSE messages. The relay processes MMS control requests to change the IEC 61850 Mode/Behavior if the quality Test bit is set to False. In this mode, the relay is in a disabled state and it no longer trips any physical contact outputs. The Relay Word bit ENABLED is set to False. The device processes MMS control requests to change the active mode of IEC 61850 Mode/Behavior if the quality test bit of the control is set to False. If EOFFMTX is set to Y, the relay continues to transmit GOOSE messages with the quality test bit set to False (0) and the validity set to Invalid (01) if the quality bit is present in the messages. If EOFFMTX is set to N, the relay does not transmit GOOSE messages in this mode. *Table G.20* and *Table G.21* describe how the relay handles incoming and outgoing messages while in Off Mode.

Table G.20 IEC 61850 Incoming Message Handling in Off Mode

IEC 61850 Messages	Incoming Message With Quality Test Bit Set to False (0)	Incoming Messages With Quality Test Bit Set to True (1)
MMS	Relay Only Processes Messages to Control the Mode	Not Processed
GOOSE	Not Processed	Not Processed

Table G.21 IEC 61850 Outgoing Message Handling in Off Mode

IEC 61850 Messages	Outgoing Message Quality Validity Bit
MMS	Invalid
GOOSE	Invalid

Figure G.14 illustrates the Off Mode/Behavior.

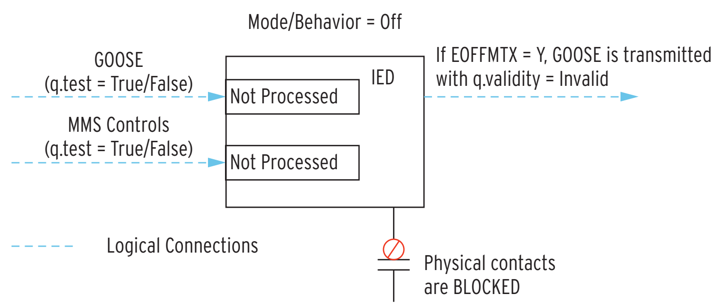


Figure G.14 Relay Operations in Off Mode

IEC 61850 Configuration

Settings

Table G.22 lists IEC 61850 settings. IEC 61850 settings are only available if your device includes the optional IEC 61850 protocol. Configure all other IEC 61850 settings, including subscriptions to incoming GOOSE messages, with Architect.

Table G.22 IEC 61850 Settings

Label	Description	Range	Default
E61850	Enables IEC 61850 protocol	Y, N	N
EGSE[a]	Enables IEC 61850 GSE	Y[b], N	N
EMMSFS[a]	Enables MMS file services	Y[b], N	N
E850MBC[a]	Enables IEC 61850 Mode/Behavior Control	Y[b], N	N
EOFFMTX	Enables GOOSE Tx In Off Mode	Y[b], N	N

[a] These settings are hidden when E61850 is set to N.
[b] Requires that E61850 be set to Y.

Architect Software

The Architect Software enables users to design and commission IEC 61850 substations containing SEL IEDs. Users can use Architect to do the following:

- Organize and configure all SEL IEDs in a substation project.
- Configure incoming and outgoing GOOSE messages.

- ➤ Edit and create GOOSE datasets.
- ➤ Read non-SEL IED Capability Description (ICD) and Configured IED Description (CID) files and determine the available IEC 61850 messaging options.
- ➤ Use or edit preconfigured datasets for reports.
- ➤ Load IEC 61850 CID files into SEL IEDs.
- ➤ Generate ICD and CID files that provide SEL IED descriptions to other manufacturers' tools so they can use SEL GOOSE messages and reporting features.
- ➤ Edit deadband settings for measured values.

NOTE: ICD and CID files from other manufacturers must have IEC 61850 outgoing GOOSE messages with Application IDs (APPIDs) of exactly four characters and VLAN IDs of exactly three characters so that the relay can successfully subscribe to them. If you attempt to configure a relay to subscribe to a GOOSE message that does not meet this criterion, the relay will reject the CID file upon download. Edit ICD and CID files from other manufacturers prior to importing them into Architect by adding leading zeros to the APPID and VLAN ID of outgoing GOOSE messages, as necessary.

Architect provides a graphical user interface (GUI) for users to select, edit, and create IEC 61850 GOOSE messages important for substation protection, coordination, and control schemes. Typically, the user first places icons representing IEDs in a substation container, then edits the outgoing GOOSE messages or creates new ones for each IED. The user can also select incoming GOOSE messages for each IED to receive from any other IEDs in the domain.

Some measured values are reported to IEC 61850 only when the value changes beyond a defined deadband value. Architect allows a deadband to be changed during the CID file configuration. Check and set the deadband values for your particular application when configuring the CID file for a device.

Architect can read ICD and CID files from other manufacturers, enabled the user to perform seamless mapping of the data into SEL IED logic. See the Architect online help for more information.

SEL ICD File Versions

Architect version R.1.1.69.0 and later supports multiple ICD file versions for each type of IED in a project. Because relays with different firmware versions may require different CID file versions, users can manage the CID files of all IEDs within a single project.

Please ensure that you work with the appropriate version of Architect relative to your current configuration, existing project files, and ultimate goals. If you want the best available IEC 61850 functionality for your SEL relay, obtain the latest version of Architect and select the appropriate ICD version(s) for your needs. Architect generates CID files from ICD files, so the ICD file version Architect uses also determines the CID file version generated. Details about the different SEL-700G ICD files can be found in *Table A.9*.

The Logical Nodes description detailed in this manual revision corresponds to the SEL-700G 006 ICD file. Information about the previous SEL-700G 004 ICD files can be found in the previous manual revisions. Please refer to *Table A.9* to find the manual revision corresponding to the ICD file you are using.

Logical Nodes

Each logical device (LD) has a set of common data objects at the top level LN0. These represent the current state of the device, as well as some informational data. These data objects are: Mod (Mode), Beh (Behavior), Health, and NamPlt. See the following for a brief description of each object.

Mode

The SEL-700 series relays include at the top-level LN0 within each LD the following enumerations for **Mod stVal**:

Mod stVal Enumeration	Description
1	On
2	Blocked
3	Test
4	Test/Blocked
5	Off
0	IEC 61850 Mode/Behavior Disabled

The top-level logical node of each LD also includes the following Mod attributes:

Mod.q represents quality.

Mod.t represents time stamps.

Mod.stVal represents the current mode/behavior.

You can control IEC 61850 Mode/Behavior via LLN0COMod$Oper in your CFG logical device.

Behavior

The SEL-700 Series Relay LNs include the following enumerations for **Beh stVal**:

Beh stVal Enumeration	Description
1	On
2	Blocked
3	Test
4	Test/Blocked
5	Off
0	IEC 61850 Mode/Behavior Disabled

Logical nodes also include the following Beh attributes:

Beh q and **Beh t** per the *Time Stamps and Quality* section.

Health

The SEL-700 Series Relay includes at the top-level LN0 within each LD the following enumerations for **Health stVal**:

Health stVal Enumeration	Health stVal Value	Description
1	Ok	RELAY_EN Relay Word bit = 1
3	Alarm	RELAY_EN Relay Word bit = 0

The top-level logical node of each LD also includes the following Health attributes:

Health q and **Health t** per the *Time Stamps and Quality* section.

NamPlt

The top-level LN0 of each LD includes the following NamPlt attributes:

- ➤ NamPlt vendor which is set to “SEL”.
- ➤ NamPlt swRev which contains the relay FID string value.
- ➤ NamPlt d, which is the LD description.

Logical Node Extensions

The following Logical Nodes and Data Classes were created in this device as extensions to the IEC 61850 standard, in accordance with IEC 61850 guidelines.

Table G.23 New Logical Node Extensions

Logical Node	IEC 61850	Description or comments
Thermal Measurements (for equipment or ambient temperature readings)	MTHR	This LN shall be used to represent values from RTDs and to calculate thermal capacity and usage mainly used for Thermal Monitoring.
Demand Metering Statistics	MDST	This LN shall be used for calculation of demand currents in a three-phase system. This shall not be used for billing purposes.
Metering Statistics	MSTA	This LN shall be used for power system metering statistics.
Physical Communication Channel Supervision	LCCH	This LN is used for supervision of physical communication channels
GOOSE Subscription	LGOS	This LN is used for GOOSE subscription statistics
Time Master Supervision	LTMS	This LN is used for time synchronization master supervision

Table G.24 defines the data class, Thermal Metering Data. This class is a collection of simultaneous measurements (or evaluations) that represent the RTD thermal metering values. Valid data depend on the presence and configuration of the RTD module(s).

Table G.24 Thermal Metering Data Logical Node Class Definition

MTHR Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2.		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
EEHealth	INS	External equipment health (RTD Communications Status)		E
Data Objects				
Measured Values				
MaxAmbTmp	MV	Maximum ambient temperature		E
MaxOthTmp	MV	Maximum other temperature		E
Tmp	MV	Temperature		E

[a] Transient data objects–the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory, O: Optional, C: Conditional, E: Extension.

Table G.25 defines the MDST data class, Demand Metering Statistics. This class is a collection of demand currents and energy.

Table G.25 Demand Metering Statistics Logical Node Class Definition

MDST Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2.		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Measured values				
DmdA	WYE	Demand currents		E
DmdAnseq	MV	Negative-sequence demand current		E
PkDmdA	WYE	Peak demand currents		E
PkDmdAnseq	MV	Negative-sequence peak demand current		E
SupWh	BCR[c]	Real energy supply (default supply direction: energy flow towards busbar)		E
SupVArh	BCR[c]	Reactive energy supply (default supply direction: energy flow towards busbar)		E
DmdWh	BCR[c]	Real energy demand (default demand direction: energy flow from busbar away)		E
DmdVArh	BCR[c]	Reactive energy demand (default demand direction: energy flow from busbar away)		E

[a] Transient data objects–the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory, O: Optional, C: Conditional, E: Extension.
[c] For IEC 61850 Edition 1 relays, this data object is defined as MV common data class.

Table G.26 Metering Statistics Logical Node Class Definition (Sheet 1 of 2)

MSTA Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2.		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M

Table G.26 Metering Statistics Logical Node Class Definition (Sheet 2 of 2)

MSTA Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
Data Objects				
Measured and Metered Values				
MaxAmps	MV	Maximum current		E
MinAmps	MV	Minimum current		E
MaxVA	MV	Maximum apparent power		E
MinVA	MV	Minimum apparent power		E
MaxW	MV	Maximum real power		E
MinW	MV	Minimum real power		E
MaxVAr	MV	Maximum reactive power		E
MinVAr	MV	Minimum reactive power		E
MaxA	WYE	Maximum phase currents		E
MinA	WYE	Minimum phase currents		E
MaxPhV	WYE	Maximum phase-to-ground voltages		E
MinPhV	WYE	Minimum phase-to-ground voltages		E
MaxP2PV	DEL	Maximum phase-to-phase voltages		E
MinP2PV	DEL	Minimum phase-to-phase voltages		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory, O: Optional, C: Conditional, E: Extension.

Table G.27 LCCH Physical Communication Channel Supervision

LCCH Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and LN-Instance-ID according to IEC 61850-7-2, Clause 22.		
Data Objects				
Common Logical Node Information				
Beh	ENS	Behavior		M
NamPlt	LPL	Name plate		O
Status Information				
ChLiv	SPS	Physical channel status		M
RedChLiv	SPS	Physical channel status of redundant channel		C
FerCh	INS	Frame error rate on this channel		O
RedFerCh	INS	Frame error rate on redundant channel		O

Table G.27 LCCH Physical Communication Channel Supervision

LCCH Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
Measured and Metered Values				
RxCnt	BCR	Number of received messages		O
RedRxCnt	BCR	Number of received messages on redundant channel		O
TxCnt	BCR	Number of sent messages		O
Controls				
RsStat	SPC	Reset device statistics		E
Settings				
NetMod	ENG	Network mode		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table G.28 LGOS GOOSE Subscription (Sheet 1 of 2)

LGOS Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and LN-Instance-ID according to IEC 61850-7-2, Clause 22		
Data Objects				
Common Logical Node Information				
Beh	ENS	Behavior		M
NamPlt	LPL	Name plate		O
Status Information				
NdsCom	SPS	Subscription needs commissioning		O
St	SPS	Status of the subscription		M
SimSt	SPS	Status showing that Sim messages are received and accepted		O
LastStNum	INS	Last state number received		O
LastSqNum	INS	Last sequence number received		E
LastTal	INS	Last time-allowed-to-live received		E
ConfRevNum	INS	Expected configuration revision number		O
RxConfRev Num	INS	Configuration revision number of the received messages		O
ErrSt	ENS	Current error status of the subscription		E
OosCnt	INS	Number of out-of-sequence (OOS) errors		E
TalCnt	INS	Number of time-allowed-to-live violations		E
DecErrCnt	INS	Number of messages that failed decoding		E
BufOvflCnt	INS	Number of messages lost due to buffer overflow		E

Table G.28 LGOS GOOSE Subscription (Sheet 2 of 2)

LGOS Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
MsgLosCnt	INS	Number of messages lost due to OOS errors (estimated)		E
MaxMsgLos	INS	Max. number of sequential messages lost due to OOS error (estimated)		E
InvQualCnt	INS	Number of mapped incoming GOOSE data with invalid quantity		E
Measured and Metered Values				
TotDwnTm	MV	Total downtime in seconds		E
MaxDwnTm	MV	Maximum continuous downtime in seconds		E
Controls				
RsStat	SPC	Reset/clear statistics		E
Settings				
GoCBRef	ORG	Reference to the subscribed GOOSE control block		O
DatSet	ORG	Configured dataset reference		E
GoID	VSG	Configured GOOSE ID		E
Addr	VSG	Configured multicast MAC address		E
VlanID	ING	Configured VLAN ID		E
VlanPri	ING	Configured VLAD priority		E
AppID	ING	Configured APPID		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table G.29 LTMS Time Master Supervision

LTMS Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and LN-Instance-ID according to IEC 61850-7-2, Clause 22		
Data Objects				
Common Logical Node Information				
Beh	ENS	Behavior		M
NamPlt	LPL	Name plate		O
Status Information				
TmAcc	INS	Number of significant bits in fraction of second in the time accuracy part of the time stamp		O
TmSrc	VSS	Current time source identity		M
SelTmSrcTyp	ENS	Type of the clock source		E

Table G.29 LTMS Time Master Supervision

LTMS Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
SelTmSyn	ENS	Actual time synchronization applied		E
SelTmSynLkd	ENS	Locked status of clock synchronization		E
Measured and Metered Values				
SelTmTosPer	MV	Duration, in milliseconds, between two consecutive top-of-second points on the synchronized time		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table G.30 Compatible Logical Nodes With Extensions

Logical Node	IEC 61850	Description or comments
Measurement	MMXU	This LN is used for power system measurement data.
Metering Statistics	MSTA	This LN is used for power system metering statistics.
Circuit Breaker	XCBR	This LN is used for circuit breaker status and measurement data.
Generic Process I/O	GGIO	This LN is used for remote analog data.
Circuit Breaker Wear Supervision	SCBR	This LN is used for supervision of circuit breakers.

Table G.31 Measurement Logical Node Class Definition (Sheet 1 of 2)

MMXU class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2.		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Measured and Metered Values				
TotW	MV	Total active power		O
TotVAr	MV	Total reactive power		O
TotVA	MV	Total apparent power		O
TotPF	MV	Average power factor		O
Hz	MV	Frequency		O
PPV	DEL	Phase-to-phase voltages		O
PhV	WYE	Phase-to-ground voltages		O

Table G.31 Measurement Logical Node Class Definition (Sheet 2 of 2)

MMXU class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
A	WYE	Phase currents		O
Fs	MV	Synchronizing frequency		E
Vhz	MV	Volts per Hz		E
Rf	MV	Field insulation resistance		E

[a] Transient data objects–the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory, O: Optional, C: Conditional, E: Extension.

Table G.32 Measurement Logical Node Class Definition

MMXU Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2.		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Measured and Metered Values				
TotW	MV	Total active power		O
TotVAr	MV	Total reactive power		O
TotVA	MV	Total apparent power		O
TotPF	MV	Average power factor		O
Hz	MV	Frequency		O
PPV	DEL	Phase-to-phase voltages		O
PhV	WYE	Phase-to-ground voltages		O
A	WYE	Phase currents		O
VSyn	MV	Synchronizing voltage		E

[a] Transient data objects–the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory, O: Optional, C: Conditional, E: Extension.

Table G.33 Circuit Breaker Logical Node Class Definition (Sheet 1 of 2)

XCBR Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2.		

Table G.33 Circuit Breaker Logical Node Class Definition (Sheet 2 of 2)

XCBR Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Status Information				
Loc	SPS	Local control behavior		M
OpCnt	INS	Operation counter		M
OpCntEx	INS	Operation counter – external		E
Measured and Metered Values				
Pos	DPC	Switch position		M
BlkOpn	SPC	Block opening		M
BlkCls	SPC	Block closing		M

[a] Transient data objects–the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory, O: Optional, C: Conditional, E: Extension.

Table G.34 Generic Process I/O Logical Node Class Definition

GGIO Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2.		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Measured Values				
AnIn	MV	Analog input		O
Ra	MV	Remote analog		E
Controls				
SPCSO	SPC	Single point controllable status output		O
Status Information				
Ind	SPS	General indication (binary input)		O

[a] Transient data objects–the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory, O: Optional, C: Conditional, E: Extension.

Table G.35 Circuit Breaker Supervision (Per-Phase) Logical Node Class Definition

SCBR Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2.		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Status Information				
ColOpn	SPS	Open command of trip coil		M
Measured Values				
AbrPrt	MV	Calculated or measured wear (e.g. of main contact), expressed in % where 0% corresponds to new condition		E

[a] Transient data objects–the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory, O: Optional, C: Conditional, E: Extension.

Device Logical Nodes

The following tables, *Table G.36* through *Table G.40*, show the Logical Nodes (LN) supported in the SEL-700G and the associated Relay Word bits or analog quantities.

Table G.36 shows the LN associated with protection elements defined as Logical Device PRO.

Table G.36 Logical Device: PRO (Protection) (Sheet 1 of 21)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = CO			
BXCSWI1	Pos.Oper.ctlVal	CCX:OCX[a]	Close/Open Breaker X
BYCSWI2	Pos.Oper.ctlVal	CCY:OCY[a]	Close/Open Breaker Y
DC1CSWI1	Pos.Oper.ctlVal	89CC2P1:89OC2P1[a]	Two-position Disconnect 1 close/open command
DC2CSWI2	Pos.Oper.ctlVal	89CC2P2:89OC2P2[a]	Two-position Disconnect 2 close/open command
DC3CSWI3	Pos.Oper.ctlVal	89CC2P3:89OC2P3[a]	Two-position Disconnect 3 close/open command
DC4CSWI4	Pos.Oper.ctlVal	89CC2P4:89OC2P4[a]	Two-position Disconnect 4 close/open command
DC5CSWI5	Pos.Oper.ctlVal	89CC2P5:89OC2P5[a]	Two-position Disconnect 5 close/open command
DC6CSWI6	Pos.Oper.ctlVal	89CC2P6:89OC2P6[a]	Two-position Disconnect 6 close/open command
DC7CSWI7	Pos.Oper.ctlVal	89CC2P7:89OC2P7[a]	Two-position Disconnect 7 close/open command
DC8CSWI8	Pos.Oper.ctlVal	89CC2P8:89OC2P8[a]	Two-position Disconnect 8 close/open command
DC9CSWI9	Pos.Oper.ctlVal	89CC3PL1:89OC3PL1[a]	Three-position In-Line Disconnect 1 close/open command
DC10CSWI10	Pos.Oper.ctlVal	89CC3PL2:89OC3PL2[a]	Three-position In-Line Disconnect 2 close/open command
DC11CSWI11	Pos.Oper.ctlVal	89CC3PE1:89OC3PE1[a]	Three-position Earthing Disconnect 1 close/open command
DC12CSWI12	Pos.Oper.ctlVal	89CC3PE2:89OC3PE2[a]	Three-position Earthing Disconnect 2 close/open command

Table G.36 Logical Device: PRO (Protection) (Sheet 2 of 21)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PARTNO	Part number
Functional Constraint = MX[b]			
SYNX1RSYN1	DifHzClc.instMag	SLIPX	Slip Frequency X
SYNX2RSYN2	DifHzClc.instMag	SLIPX	Slip Frequency X
Functional Constraint = ST[b]			
A49PTTR1	Op.general	49A	Thermal alarm
BKR1CILO1	EnaCls.stVal	SV30T	Program SELOGIC variable SV30 to supervise the close operation of Breaker BX
BKR1CILO1	EnaOpn.stVal	SV29T	Program SELOGIC variable SV29 to supervise the open operation of Breaker BX
BXCSWI1	OpCls.general	CCX	Close Breaker X
BXCSWI1	OpOpn.general	OCX	Open Breaker X
BXCSWI1	Loc.stVal	LOC	Control authority at local (bay) level
BXCSWI1	LocSta.stVal	LOCSTA	Control authority at station level
BXCSWI1	Pos.stVal	52AX?1:2[c]	Breaker X position (52A = false, breaker opened; 52A = true, breaker closed)
BXRBRF1	OpEx.general	BFTX	52X breaker failure trip
BXRBRF1	Str.general	BFIX	52X breaker failure initiation asserted
BXXCBR1	BlkCls.stVal	0	Breaker close blocking not configured by default
BXXCBR1	BlkOpn.stVal	0	Breaker open blocking not configured by default
BXXCBR1	CBOpCap.stVal	None	Breaker/Contactor physical operation capabilities not known to relay
BXXCBR1	Loc.stVal	OREDLOC	Logical OR of LOC and LOCAL Relay Word bits
BXXCBR1	OpCnt.stVal	INTTX	X breaker–relay initiated trips counter
BXXCBR1	OpCntEx.stVal	EXTTX	X breaker–external initiated trips counter
BXXCBR1	Pos.stVal	52AX?1:2[c]	Breaker X position (52A = false, breaker opened; 52A = true, breaker closed)
BKR2CILO2	EnaCls.stVal	SV32T	Program SELOGIC variable SV32 to supervise the close operation of Breaker BY
BKR2CILO2	EnaOpn.stVal	SV31T	Program SELOGIC variable SV31 to supervise the open operation of Breaker BY
BYCSWI2	OpCls.general	CCY	Close Breaker Y
BYCSWI2	OpOpn.general	OCY	Open Breaker Y
BYCSWI2	Loc.stVal	LOC	Control authority at local (bay) level
BYCSWI2	LocSta.stVal	LOCSTA	Control authority at station level
BYCSWI2	Pos.stVal	52AY?1:2[c]	Breaker Y position (52A = false, breaker opened; 52A = true, breaker closed)
BYRBRF2	OpEx.general	BFTY	52Y breaker failure trip
BYRBRF2	Str.general	BFIY	52Y breaker failure initiation asserted
BYXCBR2	BlkCls.stVal	0	Breaker close blocking not configured by default
BYXCBR2	BlkOpn.stVal	0	Breaker open blocking not configured by default

Table G.36 Logical Device: PRO (Protection) (Sheet 3 of 21)

Logical Node	Attribute	Data Source	Comment
BYXCBR2	CBOpCap.stVal	None	Breaker/Contactor physical operation capabilities not known to relay
BYXCBR2	Loc.stVal	OREDLOC	Logical OR of LOC and LOCAL Relay Word bits
BYXCBR2	OpCnt.stVal	INTTY	Y breaker–relay initiated trips counter
BYXCBR2	OpCntEx.stVal	EXTTY	Y breaker–external initiated trips counter
BYXCBR2	Pos.stVal	52AY?1:2[c]	Breaker Y position (52A = false, breaker opened; 52A = true, breaker closed)
C1PDIS1	Op.general	21C1T	Zone 1 compensator distance element timed out
C1PDIS1	Str.general	21C1P	Zone 1 compensator distance element instantaneous pickup
C1PDIS1	Str.dirGeneral	unknown	Direction undefined
C2PDIS2	Op.general	21C2T	Zone 2 compensator distance element timed out
C2PDIS2	Str.general	21C2P	Zone 2 compensator distance element instantaneous pickup
C2PDIS2	Str.dirGeneral	unknown	Direction undefined
C2PVPH2	Op.general	24C2T	Level 2 volts/hertz composite element timed out
C2PVPH2	Str.general	24C2	Level 2 volts/hertz composite element pickup
C2PVPH2	Str.dirGeneral	unknown	Direction undefined
D1PVPH1	Op.general	24D1T	Level 1 volts/hertz definite-time element timed out
D1PVPH1	Str.general	24D1	Level 1 volts/hertz instantaneous pickup
D1PVPH1	Str.dirGeneral	unknown	Direction undefined
D87APDIF3	Op.general	87AT	Differential current alarm element trip
D87APDIF3	Str.general	87AP	Differential current alarm element pickup
D87APDIF3	Str.dirGeneral	unknown	Direction undefined
D87RPDIF2	Op.general	87R	Restrained differential element trip
D87RPDIF2	Op.phsA	87R1	Restrained Differential Element 1
D87RPDIF2	Op.phsB	87R2	Restrained Differential Element 2
D87RPDIF2	Op.phsC	87R3	Restrained Differential Element 3
D87UPDIF1	Op.general	87U	Unrestrained differential element trip
D87UPDIF1	Op.phsA	87U1	Unrestrained Differential Element 1 trip
D87UPDIF1	Op.phsB	87U2	Unrestrained Differential Element 2 trip
D87UPDIF1	Op.phsC	87U3	Unrestrained Differential Element 2 trip
DC1CILO1	EnaCls.stVal	89CE2P1	Two-position Disconnect 1 close enabled
DC1CILO1	EnaOpn.stVal	89OE2P1	Two-position Disconnect 1 open enabled
DC2CILO2	EnaCls.stVal	89CE2P2	Two-position Disconnect 2 close enabled
DC2CILO2	EnaOpn.stVal	89OE2P2	Two-position Disconnect 2 open enabled
DC3CILO3	EnaCls.stVal	89CE2P3	Two-position Disconnect 3 close enabled
DC3CILO3	EnaOpn.stVal	89OE2P3	Two-position Disconnect 3 open enabled
DC4CILO4	EnaCls.stVal	89CE2P4	Two-position Disconnect 4 close enabled
DC4CILO4	EnaOpn.stVal	89OE2P4	Two-position Disconnect 4 open enabled
DC5CILO5	EnaCls.stVal	89CE2P5	Two-position Disconnect 5 close enabled

Table G.36 Logical Device: PRO (Protection) (Sheet 4 of 21)

Logical Node	Attribute	Data Source	Comment
DC5CILO5	EnaOpn.stVal	89OE2P5	Two-position Disconnect 5 open enabled
DC6CILO6	EnaCls.stVal	89CE2P6	Two-position Disconnect 6 close enabled
DC6CILO6	EnaOpn.stVal	89OE2P6	Two-position Disconnect 6 open enabled
DC7CILO7	EnaCls.stVal	89CE2P7	Two-position Disconnect 7 close enabled
DC7CILO7	EnaOpn.stVal	89OE2P7	Two-position Disconnect 7 open enabled
DC8CILO8	EnaCls.stVal	89CE2P8	Two-position Disconnect 8 close enabled
DC8CILO8	EnaOpn.stVal	89OE2P8	Two-position Disconnect 8 open enabled
DC9CILO9	EnaCls.stVal	89CE3PL1	Three-position In-Line Disconnect 1 close enabled
DC9CILO9	EnaOpn.stVal	89OE3PL1	Three-position In-Line Disconnect 1 open enabled
DC10CILO10	EnaCls.stVal	89CE3PL2	Three-position In-Line Disconnect 2 close enabled
DC10CILO10	EnaOpn.stVal	89OE3PL2	Three-position In-Line Disconnect 2 open enabled
DC11CILO11	EnaCls.stVal	89CE3PE1	Three-position Earthing Disconnect 1 close enabled
DC11CILO11	EnaOpn.stVal	89OE3PE1	Three-position Earthing Disconnect 1 open enabled
DC12CILO12	EnaCls.stVal	89CE3PE2	Three-position Earthing Disconnect 2 close enabled
DC12CILO12	EnaOpn.stVal	89OE3PE2	Three-position Earthing Disconnect 2 open enabled
DC1CSWI1	OpCls.general	89C2P1	Two-position Disconnect 1 closed
DC1CSWI1	OpOpn.general	89O2P1	Two-position Disconnect 1 open
DC1CSWI1	Loc.stVal	LOC	Control authority at local (bay) level
DC1CSWI1	LocSta.stVal	LOCSTA	Control authority at station level
DC1CSWI1	Pos.stVal	89CL2P1|89OP2P1?0:1:2:3[d]	Two-position Disconnect 1 close/open status
DC2CSWI2	OpCls.general	89C2P2	Two-position Disconnect 2 closed
DC2CSWI2	OpOpn.general	89O2P2	Two-position Disconnect 2 open
DC2CSWI2	Loc.stVal	LOC	Control authority at local (bay) level
DC2CSWI2	LocSta.stVal	LOCSTA	Control authority at station level
DC2CSWI2	Pos.stVal	89CL2P2|89OP2P2?0:1:2:3[d]	Two-position Disconnect 2 close/open status
DC3CSWI3	OpCls.general	89C2P3	Two-position Disconnect 3 closed
DC3CSWI3	OpOpn.general	89O2P3	Two-position Disconnect 3 open
DC3CSWI3	Loc.stVal	LOC	Control authority at local (bay) level
DC3CSWI3	LocSta.stVal	LOCSTA	Control authority at station level
DC3CSWI3	Pos.stVal	89CL2P3|89OP2P3?0:1:2:3[d]	Two-position Disconnect 3 close/open status
DC4CSWI4	OpCls.general	89C2P4	Two-position Disconnect 4 closed
DC4CSWI4	OpOpn.general	89O2P4	Two-position Disconnect 4 open
DC4CSWI4	Loc.stVal	LOC	Control authority at local (bay) level
DC4CSWI4	LocSta.stVal	LOCSTA	Control authority at station level
DC4CSWI4	Pos.stVal	89CL2P4|89OP2P4?0:1:2:3[d]	Two-position Disconnect 4 close/open status
DC5CSWI5	OpCls.general	89C2P5	Two-position Disconnect 5 closed
DC5CSWI5	OpOpn.general	89O2P5	Two-position Disconnect 5 open
DC5CSWI5	Loc.stVal	LOC	Control authority at local (bay) level
DC5CSWI5	LocSta.stVale	LOCSTA	Control authority at station level

Table G.36 Logical Device: PRO (Protection) (Sheet 5 of 21)

Logical Node	Attribute	Data Source	Comment
DC5CSWI5	Pos.stVal	89CL2P5|89OP2P5?0:1:2:3[d]	Two-position Disconnect 5 close/open status
DC6CSWI6	OpCls.general	89C2P6	Two-position Disconnect 6 closed
DC6CSWI6	OpOpn.general	89O2P6	Two-position Disconnect 6 open
DC6CSWI6	Loc.stVal	LOC	Control authority at local (bay) level
DC6CSWI6	LocSta.stVal	LOCSTA	Control authority at station level
DC6CSWI6	Pos.stVal	89CL2P6|89OP2P6?0:1:2:3[d]	Two-position Disconnect 6 close/open status
DC7CSWI7	OpCls.general	89C2P7	Two-position Disconnect 7 closed
DC7CSWI7	OpOpn.general	89O2P7	Two-position Disconnect 7 open
DC7CSWI7	Loc.stVal	LOC	Control authority at local (bay) level
DC7CSWI7	LocSta.stVal	LOCSTA	Control authority at station level
DC7CSWI7	Pos.stVal	89CL2P7|89OP2P7?0:1:2:3[d]	Two-position Disconnect 7 close/open status
DC8CSWI8	OpCls.general	89C2P8	Two-position Disconnect 8 closed
DC8CSWI8	OpOpn.general	89O2P8	Two-position Disconnect 8 open
DC8CSWI8	Loc.stVal	LOC	Control authority at local (bay) level
DC8CSWI8	LocSta.stVal	LOCSTA	Control authority at station level
DC8CSWI8	Pos.stVal	89CL2P8|89OP2P8?0:1:2:3[d]	Two-position Disconnect 8 close/open status
DC9CSWI9	OpCls.general	89C3PL1	Three-position In-Line Disconnect 1 closed
DC9CSWI9	OpOpn.general	89O3PL1	Three-position In-Line Disconnect 1 open
DC9CSWI9	Loc.stVal	LOC	Control authority at local (bay) level
DC9CSWI9	LocSta.stVal	LOCSTA	Control authority at station level
DC9CSWI9	Pos.stVal	89CL3PL1|89OP3PL1?0:1:2:3[d]	Three-position In-Line Disconnect 1 close/open status
DC10CSWI10	OpCls.general	89C3PL2	Three-position In-Line Disconnect 2 closed
DC10CSWI10	OpOpn.general	89O3PL2	Three-position In-Line Disconnect 2 open
DC10CSWI10	Loc.stVal	LOC	Control authority at local (bay) level
DC10CSWI10	LocSta.stVal	LOCSTA	Control authority at station level
DC10CSWI10	Pos.stVal	89CL3PL2|89OP3PL2?0:1:2:3[d]	Three-position In-Line Disconnect 2 close/open status
DC11CSWI11	OpCls.general	89C3PE1	Three-position Earthing Disconnect 1 closed
DC11CSWI11	OpOpn.general	89O3PE1	Three-position Earthing Disconnect 1 open
DC11CSWI11	Loc.stVal	LOC	Control authority at local (bay) level
DC11CSWI11	LocSta.stVal	LOCSTA	Control authority at station level
DC11CSWI11	Pos.stVal	89CL3PE1|89OP3PE1?0:1:2:3[d]	Three-position Earthing Disconnect 1 close/open status
DC12CSWI12	OpCls.general	89C3PE2	Three-position Earthing Disconnect 2 closed
DC12CSWI12	OpOpn.general	89O3PE12	Three-position Earthing Disconnect 2 open
DC12CSWI12	Loc.stVal	LOC	Control authority at local (bay) level
DC12CSWI12	LocSta.stVal	LOCSTA	Control authority at station level
DC12CSWI12	Pos.stVal	89CL3PE2|89OP3PE2?0:1:2:3[d]	Three-position Earthing Disconnect 2 close/open status
DC1XSWI1	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC1XSWI1	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC1XSWI1	Loc.stVal	OREDLOC	Logical OR if LOC and LOCAL Relay Word bits

Table G.36 Logical Device: PRO (Protection) (Sheet 6 of 21)

Logical Node	Attribute	Data Source	Comment
DC1XSWI1	OpCnt.stVal	0	
DC1XSWI1	Pos.stVal	89CL2P1?1:2[c]	Disconnect 1 position
DC1XSWI1	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC1XSWI1	SwTyp.stVal	Disconnector	Disconnect type
DC2XSWI12	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC2XSWI12	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC2XSWI12	Loc.stVal	OREDLOC	Logical OR of LOC and LOCAL Relay Word bits
DC2XSWI12	OpCnt.stVal	0	
DC2XSWI12	Pos.stVal	89CL2P2?1:2[c]	Disconnect 2 position
DC2XSWI12	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC2XSWI12	SwTyp.stVal	Disconnector	Disconnect type
DC3XSWI3	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC3XSWI3	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC3XSWI3	Loc.stVal	OREDLOC	Logical OR of LOC and LOCAL Relay Word bits
DC3XSWI3	OpCnt.stVal	0	
DC3XSWI3	Pos.stVal	89CL2P3?1:2[c]	Disconnect 3 position
DC3XSWI3	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC3XSWI3	SwTyp.stVal	Disconnector	Disconnect type
DC4XSWI4	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC4XSWI4	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC4XSWI4	Loc.stVal	OREDLOC	Logical OR of LOC and LOCAL Relay Word bits
DC4XSWI4	OpCnt.stVal	0	
DC4XSWI4	Pos.stVal	89CL2P4?1:2[c]	Disconnect 4 position
DC4XSWI4	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC4XSWI4	SwTyp.stVal	Disconnector	Disconnect type
DC5XSWI5	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC5XSWI5	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC5XSWI5	Loc.stVal	OREDLOC	Logical OR of LOC and LOCAL Relay Word bits
DC5XSWI5	OpCnt.stVal	0	
DC5XSWI5	Pos.stVal	89CL2P5?1:2[c]	Disconnect 5 position
DC5XSWI5	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC5XSWI5	SwTyp.stVal	Disconnector	Disconnect type
DC6XSWI6	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC6XSWI6	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC6XSWI6	Loc.stVal	OREDLOC	Logical OR of LOC and LOCAL Relay Word bits
DC6XSWI6	OpCnt.stVal	0	
DC6XSWI6	Pos.stVal	89CL2P6?1:2[c]	Disconnect 6 position
DC6XSWI6	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC6XSWI6	SwTyp.stVal	Disconnector	Disconnect type

Table G.36 Logical Device: PRO (Protection) (Sheet 7 of 21)

Logical Node	Attribute	Data Source	Comment
DC7XSWI7	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC7XSWI7	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC7XSWI7	Loc.stVal	OREDLOC	Logical OR of LOC and LOCAL Relay Word bits
DC7XSWI7	OpCnt.stVal	0	
DC7XSWI7	Pos.stVal	89CL2P7?1:2[c]	Disconnect 7 position
DC7XSWI7	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC7XSWI7	SwTyp.stVal	Disconnector	Disconnect type
DC8XSWI8	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC8XSWI8	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC8XSWI8	Loc.stVal	OREDLOC	Logical OR of LOC and LOCAL Relay Word bits
DC8XSWI8	OpCnt.stVal	0	
DC8XSWI8	Pos.stVal	89CL2P8?1:2[c]	Disconnect 8 position
DC8XSWI8	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC8XSWI8	SwTyp.stVal	Disconnector	Disconnect type
DC9XSWI9	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC9XSWI9	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC9XSWI9	Loc.stVal	OREDLOC	Logical OR of LOC and LOCAL Relay Word bits
DC9XSWI9	OpCnt.stVal	0	
DC9XSWI9	Pos.stVal	89CL2PL1?1:2[c]	In-Line Disconnect 1 position
DC9XSWI9	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC9XSWI9	SwTyp.stVal	Disconnector	Disconnect type
DC10XSWI10	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC10XSWI10	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC10XSWI10	Loc.stVal	OREDLOC	Logical OR of LOC and LOCAL Relay Word bits
DC10XSWI10	OpCnt.stVal	0	
DC10XSWI10	Pos.stVal	89CL2PL2?1:2[c]	In-Line Disconnect 2 position
DC10XSWI10	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC10XSWI10	SwTyp.stVal	Disconnector	Disconnect type
DC11XSWI11	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC11XSWI11	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC11XSWI11	Loc.stVal	OREDLOC	Logical OR of LOC and LOCAL Relay Word bits
DC11XSWI11	OpCnt.stVal	0	
DC11XSWI11	Pos.stVal	89CL2PE1?1:2[c]	Earthing Disconnect 1 position
DC11XSWI11	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC11XSWI11	SwTyp.stVal	Disconnector	Disconnect type
DC12XSWI12	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC12XSWI12	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC12XSWI12	Loc.stVal	OREDLOC	Logical OR of LOC and LOCAL Relay Word bits
DC12XSWI12	OpCnt.stVal	0	

Table G.36 Logical Device: PRO (Protection) (Sheet 8 of 21)

Logical Node	Attribute	Data Source	Comment
DC12XSWI12	Pos.stVal	89CL2PE2?1:2[c]	Earthing Disconnect 2 position
DC12XSWI12	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC12XSWI12	SwTyp.stVal	Disconnector	Disconnect type
DPTOF15	Op.general	81T	ORed, X-side and Y-side, over-/underfrequency elements
DPTOF15	Str.general	81T	ORed, X-side and Y-side, over-/underfrequency elements
DPTOF15	Str.dirGeneral	unknown	Direction undefined
DXPTOF1	Op.general	81X1T	X-side, Level 1, over-/underfrequency element
DXPTOF1	Str.general	81X1T	X-side, Level 1, over-/underfrequency element
DXPTOF1	Str.dirGeneral	unknown	Direction undefined
DXPTOF13	Op.general	81XT	ORed, X-side, over-/underfrequency elements
DXPTOF13	Str.general	81XT	ORed, X-side, over-/underfrequency elements
DXPTOF13	Str.dirGeneral	unknown	Direction undefined
DXPTOF2	Op.general	81X2T	X-side, Level 2, over-/underfrequency element
DXPTOF2	Str.general	81X2T	X-side, Level 2, over-/underfrequency element
DXPTOF2	Str.dirGeneral	unknown	Direction undefined
DXPTOF3	Op.general	81X3T	X-side, Level 3, over-/underfrequency element
DXPTOF3	Str.general	81X3T	X-side, Level 3, over-/underfrequency element
DXPTOF3	Str.dirGeneral	unknown	Direction undefined
DXPTOF4	Op.general	81X4T	X-side, Level 4, over-/underfrequency element
DXPTOF4	Str.general	81X4T	X-side, Level 4, over-/underfrequency element
DXPTOF4	Str.dirGeneral	unknown	Direction undefined
DXPTOF5	Op.general	81X5T	X-side, Level 5, over-/underfrequency element
DXPTOF5	Str.general	81X5T	X-side, Level 5, over-/underfrequency element
DXPTOF5	Str.dirGeneral	unknown	Direction undefined
DXPTOF6	Op.general	81X6T	X-side, Level 6, over-/underfrequency element
DXPTOF6	Str.general	81X6T	X-side, Level 6, over-/underfrequency element
DXPTOF6	Str.dirGeneral	unknown	Direction undefined
DYPTOF10	Op.general	81Y4T	Y-side, Level 4, over-/underfrequency element
DYPTOF10	Str.general	81Y4T	Y-side, Level 4, over-/underfrequency element
DYPTOF10	Str.dirGeneral	unknown	Direction undefined
DYPTOF11	Op.general	81Y5T	Y-side, Level 5, over-/underfrequency element
DYPTOF11	Str.general	81Y5T	Y-side, Level 5, over-/underfrequency element
DYPTOF11	Str.dirGeneral	unknown	Direction undefined
DYPTOF12	Op.general	81Y6T	Y-side, Level 6, over-/underfrequency element
DYPTOF12	Str.general	81Y6T	Y-side, Level 6, over-/underfrequency element
DYPTOF12	Str.dirGeneral	unknown	Direction undefined
DYPTOF14	Op.general	81YT	ORed, Y-side, over-/underfrequency elements
DYPTOF14	Str.general	81YT	ORed, Y-side, over-/underfrequency elements
DYPTOF14	Str.dirGeneral	unknown	Direction undefined

Table G.36 Logical Device: PRO (Protection) (Sheet 9 of 21)

Logical Node	Attribute	Data Source	Comment
DYPTOF7	Op.general	81Y1T	Y-side, Level 1, over-/underfrequency element
DYPTOF7	Str.general	81Y1T	Y-side, Level 1, over-/underfrequency element
DYPTOF7	Str.dirGeneral	unknown	Direction undefined
DYPTOF8	Op.general	81Y2T	Y-side, Level 2, over-/underfrequency element
DYPTOF8	Str.general	81Y2T	Y-side, Level 2, over-/underfrequency element
DYPTOF8	Str.dirGeneral	unknown	Direction undefined
DYPTOF9	Op.general	81Y3T	Y-side, Level 3, over-/underfrequency element
DYPTOF9	Str.general	81Y3T	Y-side, Level 3, over-/underfrequency element
DYPTOF9	Str.dirGeneral	unknown	Direction undefined
F1PTOC18	Op.general	64F1T	Level 1 field ground protection element timed out
F1PTOC18	Str.general	64F1	Level 1 field ground protection element instantaneous pickup
F1PTOC18	Str.dirGeneral	unknown	Direction undefined
F2PTOC19	Op.general	64F2T	Level 2 field ground protection element timed out
F2PTOC19	Str.general	64F2	Level 2 field ground protection element instantaneous pickup
F2PTOC19	Str.dirGeneral	unknown	Direction undefined
FLTRDRE1	RcdMade.stVal	FLREP	Event report present
FLTRDRE1	FltNum.stVal	FLRNUM	Unique event ID number
G1PTOC16	Op.general	64G1T	Zone 1 stator ground fault element timed out
G1PTOC16	Str.general	64G1	Zone 1 neutral overvoltage stator ground fault element
G1PTOC16	Str.dirGeneral	unknown	Direction undefined
G2PTOC17	Op.general	64G2T	Zone 2 stator ground fault element timed out
G2PTOC17	Str.general	64G2	Zone 2 third-harmonic voltage stator ground fault element
G2PTOC17	Str.dirGeneral	unknown	Direction undefined
GX1PIOC13	Op.general	50GX1T	X-side Level 1 residual ground instantaneous overcurrent element trip
GX1PIOC13	Str.general	50GX1P	X-side Level 1 residual ground instantaneous overcurrent element pickup
GX1PIOC13	Str.dirGeneral	unknown	Direction undefined
GX1PTOC1	Op.general	67GX1T	X-side Level 1 residual ground directional overcurrent trip
GX1PTOC1	Str.general	67GX1P	X-side Level 1 residual ground directional overcurrent pickup
GX1PTOC1	Str.dirGeneral	unknown	Direction unknown due to settings
GX1PTOV9	Op.general	59GX1T	X-side Level 1 residual ground overvoltage element trip
GX1PTOV9	Str.general	59GX1	X-side Level 1 residual ground overvoltage element pickup
GX1PTOV9	Str.dirGeneral	unknown	Direction undefined
GX2PIOC14	Op.general	50GX2T	X-side Level 2 residual ground instantaneous overcurrent element trip
GX2PIOC14	Str.general	50GX2P	X-side Level 2 residual ground instantaneous overcurrent element pickup

Table G.36 Logical Device: PRO (Protection) (Sheet 10 of 21)

Logical Node	Attribute	Data Source	Comment
GX2PIOC14	Str.dirGeneral	unknown	Direction undefined
GX2PTOC2	Op.general	67GX2T	X-side Level 2 residual ground directional overcurrent trip
GX2PTOC2	Str.general	67GX2P	X-side Level 2 residual ground directional overcurrent pickup
GX2PTOC2	Str.dirGeneral	unknown	Direction unknown due to settings
GX2PTOV10	Op.general	59GX2T	X-side Level 2 residual ground overvoltage element trip
GX2PTOV10	Str.general	59GX2	X-side Level 2 residual ground overvoltage element pickup
GX2PTOV10	Str.dirGeneral	unknown	Direction undefined
GXPTOC12	Op.general	51GXT	X-side residual ground time overcurrent element trip
GXPTOC12	Str.general	51GXP	X-side residual ground time overcurrent element pickup
GXPTOC12	Str.dirGeneral	unknown	Direction undefined
GY1PIOC15	Op.general	50GY1T	Y-side Level 1 residual ground instantaneous overcurrent element trip
GY1PIOC15	Str.general	50GY1P	Y-side Level 1 residual ground instantaneous overcurrent element pickup
GY1PIOC15	Str.dirGeneral	unknown	Direction undefined
GY1PTOC3	Op.general	67GY1T	Y-side Level 1 residual ground directional overcurrent trip
GY1PTOC3	Str.general	67GY1P	Y-side Level 1 residual ground directional overcurrent pickup
GY1PTOC3	Str.dirGeneral	unknown	Direction unknown due to settings
GY1PTOV11	Op.general	59GY1T	Y-side Level 1 residual ground overvoltage element trip
GY1PTOV11	Str.general	59GY1	Y-side Level 1 residual ground overvoltage element pickup
GY1PTOV11	Str.dirGeneral	unknown	Direction undefined
GY2PIOC16	Op.general	50GY2T	Y-side Level 2 residual ground instantaneous overcurrent element trip
GY2PIOC16	Str.general	50GY2P	Y-side Level 2 residual ground instantaneous overcurrent element pickup
GY2PIOC16	Str.dirGeneral	unknown	Direction undefined
GY2PTOC4	Op.general	67GY2T	Y-side Level 2 residual ground directional overcurrent trip
GY2PTOC4	Str.general	67GY2P	Y-side Level 2 residual ground directional overcurrent pickup
GY2PTOC4	Str.dirGeneral	unknown	Direction unknown due to settings
GY2PTOV12	Op.general	59GY2T	Y-side Level 2 residual ground overvoltage element trip
GY2PTOV12	Str.general	59GY2	Y-side Level 2 residual ground overvoltage element pickup
GY2PTOV12	Str.dirGeneral	unknown	Direction undefined
GYPTOC13	Op.general	51GYT	Y-side residual ground time overcurrent element trip
GYPTOC13	Str.general	51GYP	Y-side residual ground time overcurrent element pickup
GYPTOC13	Str.dirGeneral	unknown	Direction unknown due to settings
HB24PHAR1	Str.phsA	2_4HB1	Second- or fourth-harmonic block asserted for Differential Element 1
HB24PHAR1	Str.phsB	2_4HB2	Second- or fourth-harmonic block asserted for Differential Element 2

Table G.36 Logical Device: PRO (Protection) (Sheet 11 of 21)

Logical Node	Attribute	Data Source	Comment
HB24PHAR1	Str.phsC	2_4HB3	Second- or fourth-harmonic block asserted for Differential Element 3
HB24PHAR1	Str.general	2_4HBL	Second- or fourth-harmonic block asserted
HB24PHAR1	Str.dirGeneral	unknown	Direction undefined
HB24PHAR1	Str.dirPhsA	unknown	Direction undefined
HB24PHAR1	Str.dirPhsB	unknown	Direction undefined
HB24PHAR1	Str.dirPhsC	unknown	Direction undefined
HB5PHAR2	Str.phsA	5HB1	Fifth-harmonic block asserted for Differential Element 1
HB5PHAR2	Str.phsB	5HB2	Fifth-harmonic block asserted for Differential Element 2
HB5PHAR2	Str.phsC	5HB3	Fifth-harmonic block asserted for Differential Element 3
HB5PHAR2	Str.general	5HBL	Fifth-harmonic block asserted
HB5PHAR2	Str.dirGeneral	unknown	Direction undefined
HB5PHAR2	Str.dirPhsA	unknown	Direction undefined
HB5PHAR2	Str.dirPhsB	unknown	Direction undefined
HB5PHAR2	Str.dirPhsC	unknown	Direction undefined
I1TPTOV25	Op.general	59I1T	Level 1 inverse overvoltage element trip
I1TPTOV25	Str.general	59I1	Level 1 inverse overvoltage element pickup
I1TPTOV25	Str.dirGeneral	unknown	Direction undefined
I1TPTUV19	Op.general	27I1T	Level 1 inverse undervoltage element trip
I1TPTUV19	Str.general	27I1	Level 1 inverse undervoltage element pickup
I1TPTUV19	Str.dirGeneral	unknown	Direction undefined
I2TPTOV26	Op.general	59I2T	Level 2 inverse overvoltage element trip
I2TPTOV26	Str.general	59I2	Level 2 inverse overvoltage element pickup
I2TPTOV26	Str.dirGeneral	unknown	Direction undefined
I2TPTUV20	Op.general	27I2T	Level 2 inverse undervoltage element trip
I2TPTUV20	Str.general	27I2	Level 2 inverse undervoltage element pickup
I2TPTUV20	Str.dirGeneral	unknown	Direction undefined
I3TPTOV27	Op.general	59I3T	Level 3 inverse overvoltage element trip
I3TPTOV27	Str.general	59I3	Level 3 inverse overvoltage element pickup
I3TPTOV27	Str.dirGeneral	unknown	Direction undefined
I4TPTOV28	Op.general	59I4T	Level 4 inverse overvoltage element trip
I4TPTOV28	Str.general	59I4	Level 4 inverse overvoltage element pickup
I4TPTOV28	Str.dirGeneral	unknown	Direction undefined
LLN0	Loc.stVal	LOC	Control authority at local (bay) level
LLN0	LocSta.stVal	LOCSTA	Control authority at station level
LOPXPTUV5	Op.general	LOPX	X-side loss of potential
LOPXPTUV5	Str.general	LOPX	X-side loss of potential
LOPXPTUV5	Str.dirGeneral	unknown	Direction undefined
LOPYPTUV6	Op.general	LOPY	Y-side loss of potential

Table G.36 Logical Device: PRO (Protection) (Sheet 12 of 21)

Logical Node	Attribute	Data Source	Comment
LOPYPTUV6	Str.general	LOPY	Y-side loss of potential
LOPYPTUV6	Str.dirGeneral	unknown	Direction undefined
N1PDIF5	Op.general	87N1T	Level 1 instantaneous ground differential trip
N1PDIF5	Str.general	87N1	Level 1 instantaneous ground differential pickup
N1PDIF5	Str.dirGeneral	unknown	Direction undefined
N2PDIF6	Op.general	87N2T	Level 2 instantaneous ground differential trip
N2PDIF6	Str.general	87N2T	Level 2 instantaneous ground differential pickup
N2PDIF6	Str.dirGeneral	unknown	Direction undefined
N1PIOC11	Op.general	50N1T	Level 1 instantaneous neutral overcurrent element trip
N1PIOC11	Str.general	50N1P	Level 1 instantaneous neutral overcurrent element pickup
N1PIOC11	Str.dirGeneral	unknown	Direction undefined
N2PIOC12	Op.general	50N2T	Level 2 instantaneous neutral overcurrent element trip
N2PIOC12	Str.general	50N2P	Level 2 instantaneous neutral overcurrent element pickup
N2PIOC12	Str.dirGeneral	unknown	Direction undefined
NPTOC11	Op.general	51NT	Neutral ground time-overcurrent element trip
NPTOC11	Str.general	51NP	Neutral ground time-overcurrent element pickup
NPTOC11	Str.dirGeneral	unknown	Direction unknown due to settings
P3XPDOP1	Op.general	3PWRX1T	X-side three phase Power Element 1 trip
P3XPDOP1	Str.general	3PWRX1P	X-side three phase Power Element 1 pickup
P3XPDOP1	Str.dirGeneral	unknown	Direction undefined
P3XPDOP2	Op.general	3PWRX2T	X-side three phase Power Element 2 trip
P3XPDOP2	Str.general	3PWRX2P	X-side three phase Power Element 2 pickup
P3XPDOP2	Str.dirGeneral	unknown	Direction undefined
P3XPDOP3	Op.general	3PWRX3T	X-side three phase Power Element 3 trip
P3XPDOP3	Str.general	3PWRX3P	X-side three phase Power Element 3 pickup
P3XPDOP3	Str.dirGeneral	unknown	Direction undefined
P3XPDOP4	Op.general	3PWRX4T	X-side three phase Power Element 4 trip
P3XPDOP4	Str.general	3PWRX4P	X-side three phase Power Element 4 pickup
P3XPDOP4	Str.dirGeneral	unknown	Direction undefined
P3YPDOP5	Op.general	3PWRY1T	Y-side three phase Power Element 1 trip
P3YPDOP5	Str.general	3PWRY1P	Y-side three phase Power Element 1 pickup
P3YPDOP5	Str.dirGeneral	unknown	Direction undefined
P3YPDOP6	Op.general	3PWRY2T	Y-side three phase Power Element 2 trip
P3YPDOP6	Str.general	3PWRY2P	Y-side three phase Power Element 2 pickup
P3YPDOP6	Str.dirGeneral	unknown	Direction undefined
P3YPDOP7	Op.general	3PWRY3T	Y-side three phase Power Element 3 trip
P3YPDOP7	Str.general	3PWRY3P	Y-side three phase Power Element 3 pickup
P3YPDOP7	Str.dirGeneral	unknown	Direction undefined
P3YPDOP8	Op.general	3PWRY4T	Y-side three phase Power Element 4 trip

Table G.36 Logical Device: PRO (Protection) (Sheet 13 of 21)

Logical Node	Attribute	Data Source	Comment
P3YPDOP8	Str.general	3PWRY4P	Y-side three phase Power Element 4 pickup
P3YPDOP8	Str.dirGeneral	unknown	Direction undefined
P51CPVOC1	Op.general	51CT	Voltage controlled phase time-overcurrent element 51CT timed out
P51CPVOC1	Str.general	51C	Voltage controlled phase time-overcurrent element pickup
P51CPVOC1	Str.dirGeneral	unknown	Direction unknown due to settings
P51VPVOC2	Op.general	51VT	Voltage restrained phase time-overcurrent element 51VT timed out
P51VPVOC2	Str.general	51V	Voltage restrained phase time-overcurrent element pickup
P51VPVOC2	Str.dirGeneral	unknown	Direction unknown due to settings
P67N1PTOC14	Op.general	67N1T	X-side Level 1 neutral ground directional overcurrent trip
P67N1PTOC14	Str.general	67N1P	X-side Level 1 neutral ground directional overcurrent pickup
P67N1PTOC14	Str.dirGeneral	unknown	Direction unknown due to settings
P67N2PTOC15	Op.general	67N2T	X-side Level 2 neutral ground directional overcurrent trip
P67N2PTOC15	Str.general	67N2P	X-side Level 2 neutral ground directional overcurrent pickup
P67N2PTOC15	Str.dirGeneral	unknown	Direction unknown due to settings
PPX1TPTOV15	Op.general	59PPX1T	X-side Level 1 phase-to-phase overvoltage element trip
PPX1TPTOV15	Str.general	59PPX1	X-side Level 1 phase-to-phase overvoltage element pickup
PPX1TPTOV15	Str.dirGeneral	unknown	Direction undefined
PPX2TPTOV16	Op.general	59PPX2T	X-side Level 2 phase-to-phase overvoltage element trip
PPX2TPTOV16	Str.general	59PPX2	X-side Level 2 phase-to-phase overvoltage element pickup
PPX2TPTOV16	Str.dirGeneral	unknown	Direction undefined
PPY1TPTOV17	Op.general	59PPY1T	Y-side Level 1 phase-to-phase overvoltage element trip
PPY1TPTOV17	Str.general	59PPY1	Y-side Level 1 phase-to-phase overvoltage element pickup
PPY1TPTOV17	Str.dirGeneral	unknown	Direction undefined
PPY2TPTOV18	Op.general	59PPY2T	Y-side Level 2 phase-to-phase overvoltage element trip
PPY2TPTOV18	Str.general	59PPY2	Y-side Level 2 phase-to-phase overvoltage element pickup
PPY2TPTOV18	Str.dirGeneral	unknown	Direction undefined
PPX1TPTUV9	Op.general	27PPXIT	X-side Level 1 phase-to-phase undervoltage element trip
PPX1TPTUV9	Str.general	27PPX1	X-side Level 1 phase-to-phase undervoltage element Pickup
PPX1TPTUV9	Str.dirGeneral	unknown	Direction undefined
PPX2TPTUV10	Op.general	27PPX2T	X-side Level 2 phase-to-phase undervoltage element trip
PPX2TPTUV10	Str.general	27PPX2	X-side Level 2 phase-to-phase undervoltage element pickup
PPX2TPTUV10	Str.dirGeneral	unknown	Direction undefined
PPY1TPTUV11	Op.general	27PPYIT	Y-side Level 1 phase-to-phase undervoltage element trip
PPY1TPTUV11	Str.general	27PPY1	Y-side Level 1 phase-to-phase undervoltage element pickup
PPY1TPTUV11	Str.dirGeneral	unknown	Direction undefined

Table G.36 Logical Device: PRO (Protection) (Sheet 14 of 21)

Logical Node	Attribute	Data Source	Comment
PPY2TPTUV12	Op.general	27PPY2T	Y-side Level 2 phase-to-phase undervoltage element trip
PPY2TPTUV12	Str.general	27PPY2	Y-side Level 2 phase-to-phase undervoltage element pickup
PPY2TPTUV12	Str.dirGeneral	unknown	Direction undefined
PX1PIOC1	Op.general	50PX1T	X-side Level 1 phase instantaneous overcurrent element trip
PX1PIOC1	Str.general	50PX1P	X-side Level 1 phase instantaneous overcurrent element pickup
PX1PIOC1	Str.dirGeneral	unknown	Direction undefined
PX1PTOV1	Op.general	59PX1T	X-side Level 1 phase overvoltage element trip
PX1PTOV1	Str.general	59PX1	X-side Level 1 phase overvoltage element pickup
PX1PTOV1	Str.dirGeneral	unknown	Direction undefined
PX1PTUV1	Op.general	27PX1T	X-side Level 1 phase undervoltage element trip
PX1PTUV1	Str.general	27PX1	X-side Level 1 phase under-voltage element pickup
PX1PTUV1	Str.dirGeneral	unknown	Direction undefined
PX2PIOC2	Op.general	50PX2T	X-side Level 2 phase instantaneous overcurrent element trip
PX2PIOC2	Str.general	50PX2P	X-side Level 2 phase instantaneous overcurrent element pickup
PX2PIOC2	Str.dirGeneral	unknown	Direction undefined
PX2PTOV2	Op.general	59PX2T	X-side Level 2 phase overvoltage element trip
PX2PTOV2	Str.general	59PX2	X-side Level 2 phase overvoltage element pickup
PX2PTOV2	Str.dirGeneral	unknown	Direction undefined
PX2PTUV2	Op.general	27PX2T	X-side Level 2 phase undervoltage element trip
PX2PTUV2	Str.general	27PX2	X-side Level 2 phase undervoltage element pickup
PX2PTUV2	Str.dirGeneral	unknown	Direction undefined
PXAPIOC3	Op.general	50PX3AT	X-side Level 3 A-phase instantaneous overcurrent element trip
PXAPIOC3	Str.general	50PX3AP	X-side Level 3 A-phase instantaneous overcurrent element pickup
PXAPIOC3	Str.dirGeneral	unknown	Direction undefined
PXBPIOC4	Op.general	50PX3BT	X-side Level 3 B-phase instantaneous overcurrent element trip
PXBPIOC4	Str.general	50PX3BP	X-side Level 3 B-phase instantaneous overcurrent element pickup
PXBPIOC4	Str.dirGeneral	unknown	Direction undefined
PXCPIOC5	Op.general	50PX3CT	X-side Level 3 C-phase instantaneous overcurrent element trip
PXCPIOC5	Str.general	50PX3CP	X-side Level 3 C-phase instantaneous overcurrent element pickup
PXCPIOC5	Str.dirGeneral	unknown	Direction undefined
PXPTOC9	Op.general	51PXT	X-side phase time overcurrent element trip
PXPTOC9	Str.general	51PXP	X-side phase time overcurrent element pickup

Table G.36 Logical Device: PRO (Protection) (Sheet 15 of 21)

Logical Node	Attribute	Data Source	Comment
PXPTOC9	Str.dirGeneral	unknown	Direction unknown due to settings
PY1PIOC6	Op.general	50PY1T	Y-side Level 1 phase instantaneous overcurrent element trip
PY1PIOC6	Str.general	50PY1P	Y-side Level 1 phase instantaneous overcurrent element pickup
PY1PIOC6	Str.dirGeneral	unknown	Direction undefined
PY1PTOC5	Op.general	67PY1T	Y-side Level 1 phase directional overcurrent trip
PY1PTOC5	Str.general	67PY1P	Y-side Level 1 phase directional overcurrent pickup
PY1PTOC5	Str.dirGeneral	unknown	Direction unknown due to settings
PY1PTOV3	Op.general	59PY1T	Y-side Level 1 phase overvoltage element trip
PY1PTOV3	Str.general	59PY1	Y-side Level 1 phase overvoltage element pickup
PY1PTOV3	Str.dirGeneral	unknown	Direction undefined
PY1PTUV3	Op.general	27PY1T	Y-side Level 1 phase undervoltage element trip
PY1PTUV3	Str.general	27PY1	Y-side Level 1 phase undervoltage element pickup
PY1PTUV3	Str.dirGeneral	unknown	Direction undefined
PY2PIOC7	Op.general	50PY2T	Y-side Level 2 phase instantaneous overcurrent element trip
PY2PIOC7	Str.general	50PY2P	Y-side Level 2 phase instantaneous overcurrent element pickup
PY2PIOC7	Str.dirGeneral	unknown	Direction undefined
PY2PTOC6	Op.general	67PY2T	Y-side Level 2 phase directional overcurrent trip
PY2PTOC6	Str.general	67PY2P	Y-side Level 2 phase directional overcurrent pickup
PY2PTOC6	Str.dirGeneral	unknown	Direction unknown due to settings
PY2PTOV4	Op.general	59PY2T	Y-side Level 2 phase overvoltage element trip
PY2PTOV4	Str.general	59PY2	Y-side Level 2 phase overvoltage element pickup
PY2PTOV4	Str.dirGeneral	unknown	Direction undefined
PY2PTUV4	Op.general	27PY2T	Y-side Level 2 phase undervoltage element trip
PY2PTUV4	Str.general	27PY2	Y-side Level 2 phase undervoltage element pickup
PY2PTUV4	Str.dirGeneral	unknown	Direction undefined
PYAPIOC8	Op.general	50PY3AT	Y-side Level 3 A-phase instantaneous overcurrent element trip
PYAPIOC8	Str.general	50PY3AP	Y-side Level 3 A-phase instantaneous overcurrent element pickup
PYAPIOC8	Str.dirGeneral	unknown	Direction undefined
PYBPIOC9	Op.general	50PY3BT	Y-side Level 3 B-phase instantaneous overcurrent element trip
PYBPIOC9	Str.general	50PY3BP	Y-side Level 3 B-phase instantaneous overcurrent element pickup
PYBPIOC9	Str.dirGeneral	unknown	Direction undefined
PYCPIOC10	Op.general	50PY3CT	Y-side Level 3 C-phase instantaneous overcurrent element trip
PYCPIOC10	Str.general	50PY3CP	Y-side Level 3 C-phase instantaneous overcurrent element pickup
PYCPIOC10	Str.dirGeneral	unknown	Direction undefined

Table G.36 Logical Device: PRO (Protection) (Sheet 16 of 21)

Logical Node	Attribute	Data Source	Comment
PYPTOC10	Op.general	51PYT	Y-side phase time overcurrent element trip
PYPTOC10	Str.general	51PYP	Y-side phase time overcurrent element pickup
PYPTOC10	Str.dirGeneral	unknown	Direction unknown due to settings
Q1PIOC21	Op.general	46Q1T	Negative-sequence definite-time overcurrent element timed out
Q1PIOC21	Str.general	46Q1	Negative-sequence Level 1instantaneous overcurrent element pickup
Q1PIOC21	Str.dirGeneral	unknown	Direction undefined
Q2PIOC22	Op.general	46Q2T	Negative-sequence time-overcurrent element timed out
Q2PIOC22	Str.general	46Q2	Negative-sequence overcurrent element pickup
Q2PIOC22	Str.dirGeneral	unknown	Direction undefined
QX1PIOC17	Op.general	50QX1T	X-side Level 1 negative-sequence instantaneous overcurrent element trip
QX1PIOC17	Str.general	50QX1P	X-side Level 1 negative-sequence instantaneous overcurrent element pickup
QX1PIOC17	Str.dirGeneral	unknown	Direction undefined
QX1PTOV5	Op.general	59QX1T	X-side Level 1 negative-sequence overvoltage element Trip
QX1PTOV5	Str.general	59QX1	X-side Level 1 negative-sequence overvoltage element Pickup
QX1PTOV5	Str.dirGeneral	unknown	Direction undefined
QX2PIOC18	Op.general	50QX2T	X-side Level 2 negative-sequence instantaneous overcurrent element trip
QX2PIOC18	Str.general	50QX2P	X-side Level 2 negative-sequence instantaneous overcurrent element pickup
QX2PIOC18	Str.dirGeneral	unknown	Direction undefined
QX2PTOV6	Op.general	59QX2T	X-side Level 2 negative-sequence overvoltage element trip
QX2PTOV6	Str.general	59QX2	X-side Level 2 negative-sequence overvoltage element pickup
QX2PTOV6	Str.dirGeneral	unknown	Direction undefined
QXPTOC14	Op.general	51QXT	X-side negative-sequence time overcurrent element trip
QXPTOC14	Str.general	51QXP	X-side negative-sequence time overcurrent element pickup
QXPTOC14	Str.dirGeneral	unknown	Direction unknown due to settings
QY1PIOC19	Op.general	50QY1T	Y-side Level 1 negative-sequence instantaneous overcurrent element trip
QY1PIOC19	Str.general	50QY1P	Y-side Level 1 negative-sequence instantaneous overcurrent element pickup
QY1PIOC19	Str.dirGeneral	unknown	Direction undefined
QY1PTOC7	Op.general	67QY1T	Y-side Level 1 phase negative-sequence trip
QY1PTOC7	Str.general	67QY1P	Y-side Level 1 phase negative-sequence pickup
QY1PTOC7	Str.dirGeneral	unknown	Direction unknown due to settings
QY1PTOV7	Op.general	59QY1T	Y-side Level 1 negative-sequence overvoltage element trip
QY1PTOV7	Str.general	59QY1	Y-side Level 1 negative-sequence overvoltage element pickup

Table G.36 Logical Device: PRO (Protection) (Sheet 17 of 21)

Logical Node	Attribute	Data Source	Comment
QY1PTOV7	Str.dirGeneral	unknown	Direction undefined
QY2PIOC20	Op.general	50QY2T	Y-side Level 2 residual ground instantaneous overcurrent element trip
QY2PIOC20	Str.general	50QY2P	Y-side Level 2 residual ground instantaneous overcurrent element pickup
QY2PIOC20	Str.dirGeneral	unknown	Direction undefined
QY2PTOC8	Op.general	67QY2T	Y-side Level 2 phase negative-sequence trip
QY2PTOC8	Str.general	67QY2P	Y-side Level 2 phase negative-sequence pickup
QY2PTOC8	Str.dirGeneral	unknown	Direction unknown due to settings
QY2PTOV8	Op.general	59QY2T	Y-side Level 2 negative-sequence overvoltage element trip
QY2PTOV8	Str.general	59QY2	Y-side Level 2 negative-sequence overvoltage element pickup
QY2PTOV8	Str.dirGeneral	unknown	Direction undefined
QYPTOC15	Op.general	51QYT	Y-side negative-sequence time overcurrent element trip
QYPTOC15	Str.general	51QYP	Y-side negative-sequence time overcurrent element pickup
QYPTOC15	Str.dirGeneral	unknown	Direction unknown due to settings
REF1PPDIF4	Op.general	REF1P	Restricted earth fault inverse-time O/C element timed-out
REF1PPDIF4	Str.general	REF1F	REF element forward (internal) fault declaration
REF1PPDIF4	Str.dirGeneral	REF1F?0:1	REF element forward (internal) fault declaration (REF1F = false, direction unknown; REF1F = true, direction forward)
RPFRC1	Op.general	81RT	ORed, X-side and Y-side, frequency rate-of-change elements
RPFRC1	Str.general	81RT	ORed, X-side and Y-side, frequency rate-of-change elements
RPFRC1	Str.dirGeneral	unknown	Direction undefined
RTDAPTTR3	Op.general	RTDA	RTD alarm
RTDTPTTR4	Op.general	RTDT	RTD trip
RX1PFRC4	Op.general	81RX1T	X-side, Level 1, time-delayed, frequency rate-of-change element
RX1PFRC4	Str.general	81RX1T	X-side, Level 1, time-delayed, frequency rate-of-change element
RX1PFRC4	Str.dirGeneral	unknown	Direction undefined
RX2PFRC5	Op.general	81RX2T	X-side, Level 2, time-delayed, frequency rate-of-change element
RX2PFRC5	Str.general	81RX2T	X-side, Level 2, time-delayed, frequency rate-of-change element
RX2PFRC5	Str.dirGeneral	unknown	Direction undefined
RX3PFRC6	Op.general	81RX3T	X-side, Level 3, time-delayed, frequency rate-of-change element
RX3PFRC6	Str.general	81RX3T	X-side, Level 3, time-delayed, frequency rate-of-change element
RX3PFRC6	Str.dirGeneral	unknown	Direction undefined

Table G.36 Logical Device: PRO (Protection) (Sheet 18 of 21)

Logical Node	Attribute	Data Source	Comment
RX4PFRC7	Op.general	81RX4T	X-side, Level 4, time-delayed, frequency rate-of-change element
RX4PFRC7	Str.general	81RX4T	X-side, Level 4, time-delayed, frequency rate-of-change element
RX4PFRC7	Str.dirGeneral	unknown	Direction undefined
RXPFRC2	Op.general	81RXT	ORed, X-side, frequency rate-of-change element
RXPFRC2	Str.general	81RXT	ORed, X-side, frequency rate-of-change element
RXPFRC2	Str.dirGeneral	unknown	Direction undefined
RY1PFRC8	Op.general	81RY1T	Y-side, Level 1, time-delayed, frequency rate-of-change element
RY1PFRC8	Str.general	81RY1T	Y-side, Level 1, time-delayed, frequency rate-of-change element
RY1PFRC8	Str.dirGeneral	unknown	Direction undefined
RY2PFRC9	Op.general	81RY2T	Y-side, Level 2, time-delayed, frequency rate-of-change element
RY2PFRC9	Str.general	81RY2T	Y-side, Level 2, time-delayed, frequency rate-of-change element
RY2PFRC9	Str.dirGeneral	unknown	Direction undefined
RY3PFRC10	Op.general	81RY3T	Y-side, Level 3, time-delayed, frequency rate-of-change element
RY3PFRC10	Str.general	81RY3T	Y-side, Level 3, time-delayed, frequency rate-of-change element
RY3PFRC10	Str.dirGeneral	unknown	Direction undefined
RY4PFRC11	Op.general	81RY4T	Y-side, Level 4, time-delayed, frequency rate-of-change element
RY4PFRC11	Str.general	81RY4T	Y-side, Level 4, time-delayed, frequency rate-of-change element
RY4PFRC11	Str.dirGeneral	unknown	Direction undefined
RYPFRC3	Op.general	81RYT	ORed, Y-side, frequency rate-of-change element
RYPFRC3	Str.general	81RYT	ORed, Y-side, frequency rate-of-change element
RYPFRC3	Str.dirGeneral	unknown	Direction undefined
S1PTOV13	Op.general	59S1T	Level 1 sync overvoltage element trip
S1PTOV13	Str.general	59S1	Level 1 sync overvoltage element Pickup
S1PTOV13	Str.dirGeneral	unknown	Direction undefined
S1PTUV7	Op.general	27S1T	Level 1 sync undervoltage element trip
S1PTUV7	Str.general	27S1	Level 1 sync undervoltage element pickup
S1PTUV7	Str.dirGeneral	unknown	Direction undefined
S2PTOV14	Op.general	59S2T	Level 2 sync overvoltage element trip
S2PTOV14	Str.general	59S2	Level 2 sync overvoltage element pickup
S2PTOV14	Str.dirGeneral	unknown	Direction undefined
S2PTUV8	Op.general	27S2T	Level 2 sync undervoltage element trip
S2PTUV8	Str.general	27S2	Level 2 sync undervoltage element pickup

Table G.36 Logical Device: PRO (Protection) (Sheet 19 of 21)

Logical Node	Attribute	Data Source	Comment
S2PTUV8	Str.dirGeneral	unknown	Direction undefined
SYNX1RSYN1	Rel.stVal	25AX1	Generator slip/breaker-time compensated phase angle less than 25ANG1X setting
SYNX1RSYN1	Vind.stVal	VDIFX	Generator and system voltage difference within acceptable bounds
SYNX1RSYN1	HzInd.stVal	SFX	Generator slip frequency is within acceptable bounds (between 25SLO and 25SHI settings)
SYNX2RSYN2	Rel.stVal	25AX2	Generator uncompensated phase angle less than 25ANG2X setting
SYNX2RSYN2	VInd.stVal	VDIFX	Generator and system voltage difference within acceptable bounds
SYNX2RSYN2	HzInd.stVal	SFX	Generator slip frequency is within acceptable bounds (between 25SLO and 25SHI settings)
SYNY1RSYN3	Rel.stVal	25AY1	Intertie slip/breaker-time compensated phase angle less than 25ANG1Y setting
SYNY1RSYN3	Vind.stVal	VDIFY	Intertie and system voltage difference within acceptable bounds
SYNY1RSYN3	HzInd.stVal	SFY	Intertie slip frequency within acceptable bounds (less than 25SF setting)
SYNX2RSYN4	Rel.stVal	25AY2	Intertie slip/breaker-time compensated phase angle less than 25ANG1Y setting
SYNX2RSYN4	Vind.stVal	VDIFY	Slip frequency of voltages VP and VS less than setting 25SF
SYNX2RSYN4	HzInd.stVal	SFY	Intertie slip frequency within acceptable bounds (less than 25SF setting)
T49PTTR2	Op.general	49T	Thermal trip, generator thermal capacity above Level 1
TRIP1PTRC3	Tr.general	TRIP1	Generator field breaker trip
TRIP2PTRC4	Tr.general	TRIP2	Prime mover trip
TRIP3PTRC5	Tr.general	TRIP3	Generator lockout breaker trip
TRIPXPTRC1	Tr.general	TRIPX	X-side (generator main circuit) breaker trip
TRIPYPTRC2	Tr.general	TRIPY	Y-side breaker trip
V1X1TPTOV19	Op.general	59V1X1T	X-side Level 1 positive-sequence overvoltage element trip
V1X1TPTOV19	Str.general	59V1X1	X-side Level 1 positive-sequence overvoltage element pickup
V1X1TPTOV19	Str.dirGeneral	unknown	Direction undefined
V1X2TPTOV20	Op.general	59V1X2T	X-side Level 2 positive-sequence overvoltage element trip
V1X2TPTOV20	Str.general	59V1X2	X-side Level 2 positive-sequence overvoltage element pickup
V1X2TPTOV20	Str.dirGeneral	unknown	Direction undefined
V1X3TPTOV21	Op.general	59V1X3T	X-side Level 3 positive-sequence overvoltage element trip
V1X3TPTOV21	Str.general	59V1X3	X-side Level 3 positive-sequence overvoltage element pickup
V1X3TPTOV21	Str.dirGeneral	unknown	Direction undefined
V1X4TPTOV22	Op.general	59V1X4T	X-side Level 4 positive-sequence overvoltage element trip

Table G.36 Logical Device: PRO (Protection) (Sheet 20 of 21)

Logical Node	Attribute	Data Source	Comment
V1X4TPTOV22	Str.general	59V1X4	X-side Level 4 positive-sequence overvoltage element pickup
V1X4TPTOV22	Str.dirGeneral	unknown	Direction undefined
V1X5TPTOV23	Op.general	59V1X5T	X-side Level 5 positive-sequence overvoltage element trip
V1X5TPTOV23	Str.general	59V1X5	X-side Level 5 positive-sequence overvoltage element pickup
V1X5TPTOV23	Str.dirGeneral	unknown	Direction undefined
V1X6TPTOV24	Op.general	59V1X6T	X-side Level 6 positive-sequence overvoltage element trip
V1X6TPTOV24	Str.general	59V1X6	X-side Level 6 positive-sequence overvoltage element pickup
V1X6TPTOV24	Str.dirGeneral	unknown	Direction undefined
V1X1TPTUV13	Op.general	27V1X1T	X-side Level 1 positive-sequence undervoltage element trip
V1X1TPTUV13	Str.general	27V1X1	X-side Level 1 positive-sequence undervoltage element pickup
V1X1TPTUV13	Str.dirGeneral	unknown	Direction undefined
V1X2TPTUV14	Op.general	27V1X2T	X-side Level 2 positive-sequence undervoltage element trip
V1X2TPTUV14	Str.general	27V1X2	X-side Level 2 positive-sequence undervoltage element pickup
V1X2TPTUV14	Str.dirGeneral	unknown	Direction undefined
V1X3TPTUV15	Op.general	27V1X3T	X-side Level 3 positive-sequence undervoltage element trip
V1X3TPTUV15	Str.general	27V1X3	X-side Level 3 positive-sequence undervoltage element pickup
V1X3TPTUV15	Str.dirGeneral	unknown	Direction undefined
V1X4TPTUV16	Op.general	27V1X4T	X-side Level 4 positive-sequence undervoltage element trip
V1X4TPTUV16	Str.general	27V1X4	X-side Level 4 positive-sequence undervoltage element pickup
V1X4TPTUV16	Str.dirGeneral	unknown	Direction undefined
V1X5TPTUV17	Op.general	27V1X5T	X-side Level 5 positive-sequence undervoltage element trip
V1X5TPTUV17	Str.general	27V1X5	X-side Level 5 positive-sequence undervoltage element pickup
V1X5TPTUV17	Str.dirGeneral	unknown	Direction undefined
V1X6TPTUV18	Op.general	27V1X6T	X-side Level 6 positive-sequence undervoltage element trip
V1X6TPTUV18	Str.general	27V1X6	X-side Level 6 positive-sequence undervoltage element pickup
V1X6TPTUV18	Str.dirGeneral	unknown	Direction undefined
Z40PDUP1	Op.general	40Z1T	Zone 1 time-delayed loss-of-field mho element
Z40PDUP1	Str.general	40Z1	Zone 1 instantaneous loss-of-field mho element
Z40PDUP1	Str.dirGeneral	unknown	Direction undefined
Z40PDUP2	Op.general	40Z2T	Zone 2 time-delayed loss-of-field mho element
Z40PDUP2	Str.general	40Z2	Zone 2 instantaneous loss-of-field mho element
Z40PDUP2	Str.dirGeneral	unknown	Direction undefined

Table G.36 Logical Device: PRO (Protection) (Sheet 21 of 21)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = SP			
LLN0	GrRef.setSrcRef	IdName	Functional name
LLN0	MltLev.setVal	MLTLEV	Multilevel mode of control authority

[a] Writing a 0 to Pos.Oper.ctlVal will cause the Open control bit to assert and writing any other value will cause the Close control bit to assert.
[b] Data validity depends on the relay model and installed card options. Refer to *Section 1: Introduction and Specifications* for different relay models and available card options.
[c] If the breaker/disconnect is closed, value = 10(2). If the breaker/disconnect is open, value = 01(1).
[d] If the disconnect is closed, value = 10(2). If the disconnect is open, value = 01(1). Value = 00(0) indicates in-progress or intermediate state and value = 11(3) indicates alarm or bad state.

Table G.37 shows the LN associated with measuring elements defined as Logical Device MET.

Table G.37 Logical Device: MET (Metering) (Sheet 1 of 7)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PARTNO	Part number
Functional Constraint = MX[a b]			
METMHAI1	ThdAX.phsA.instCVal.mag.f	IAX_THD	X-side A-phase current THD
METMHAI1	ThdAX.phsB.instCVal.mag.f	IBX_THD	X-side B-phase current THD
METMHAI1	ThdAX.phsC.instCVal.mag.f	ICX_THD	X-side C-phase current THD
METMHAI1	ThdAY.phsA.instCVal.mag.f	IAY_THD	Y-side A-phase current THD
METMHAI1	ThdAY.phsB.instCVal.mag.f	IBY_THD	Y-side B-phase current THD
METMHAI1	ThdAY.phsC.instCVal.mag.f	ICY_THD	Y-side C-phase current THD
METXMDST1	DmdA.phsA.instCVal.mag.f	IAXD	X-side A-phase current demand
METXMDST1	DmdA.phsB.instCVal.mag.f	IBXD	X-side B-phase current demand
METXMDST1	DmdA.phsC.instCVal.mag.f	ICXD	X-side C-phase current demand
METXMDST1	DmdA.res.instCVal.mag.f	IGXD	X-side residual current demand
METXMDST1	DmdAnseq.instCVal.mag.f	3I2XD	X-side negative-sequence current demand
METXMDST1	PkDmdA.phsA.instCVal.mag.f	IAXPD	X-side A-phase current peak demand
METXMDST1	PkDmdA.phsB.instCVal.mag.f	IBXPD	X-side B-phase current peak demand
METXMDST1	PkDmdA.phsC.instCVal.mag.f	ICXPD	X-side C-phase current peak demand
METXMDST1	PkDmdA.res.instCVal.mag.f	IGXPD	X-side residual current peak demand
METXMDST1	PkDmdAnseq.instCVal.mag.f	3I2XPD	X-side negative-sequence current peak demand
METXMMXU1	A.phsA.instCVal.ang.f	IAX_ANG	X-side current, A-phase, angle
METXMMXU1	A.phsA.instCVal.mag.f	IAX_MAG	X-side current, A-phase, magnitude
METXMMXU1	A.phsB.instCVal.ang.f	IBX_ANG	X-side current, B-phase, angle
METXMMXU1	A.phsB.instCVal.mag.f	IBX_MAG	X-side current, B-phase, magnitude
METXMMXU1	A.phsC.instCVal.ang.f	ICX_ANG	X-side current, C-phase, angle
METXMMXU1	A.phsC.instCVal.mag.f	ICX_MAG	X-side current, C-phase, magnitude
METXMMXU1	A.res.instCVal.ang.f	IGX_ANG	X-side current, calculated-residual, angle
METXMMXU1	A.res.instCVal.mag.f	IGX_MAG	X-side current, calculated-residual, magnitude
METXMMXU1	A.neut.instCVal.ang.f	IN_ANG	Current, neutral, angle

Table G.37 Logical Device: MET (Metering) (Sheet 2 of 7)

Logical Node	Attribute	Data Source	Comment
METXMMXU1	A.neut.instCVal.mag.f	IN_MAG	Current, neutral, magnitude
METXMMXU1	Fs.instMag.f	FREQS	Synch frequency
METXMMXU1	Hz.instMag.f	FREQX	X-side frequency
METXMMXU1	PhV.phsA.instCVal.ang.f	VAX_ANG	X-side voltage, A-phase-to-neutral, angle
METXMMXU1	PhV.phsA.instCVal.mag.f	VAX_MAG	X-side voltage, A-phase-to-neutral, magnitude
METXMMXU1	PhV.phsB.instCVal.ang.f	VBX_ANG	X-side voltage, B-phase-to-neutral, angle
METXMMXU1	PhV.phsB.instCVal.mag.f	VBX_MAG	X-side voltage, B-phase-to-neutral, magnitude
METXMMXU1	PhV.phsC.instCVal.ang.f	VCX_ANG	X-side voltage, C-phase-to-neutral, angle
METXMMXU1	PhV.phsC.instCVal.mag.f	VCX_MAG	X-side voltage, C-phase-to-neutral, magnitude
METXMMXU1	PhV.res.instCVal.ang.f	VGX_ANG	X-side zero-sequence voltage, angle
METXMMXU1	PhV.res.instCVal.mag.f	VGX_MAG	X-side zero-sequence voltage, magnitude
METXMMXU1	PhV.neut.instCVal.ang.f	VN_ANG	Neutral voltage, angle
METXMMXU1	PhV.neut.instCVal.mag.f	VN_MAG	Neutral voltage, magnitude
METXMMXU1	PPV.phsAB.instCVal.ang.f	VABX_ANG	X-side voltage, A-to-B-phase, angle
METXMMXU1	PPV.phsAB.instCVal.mag.f	VABX_MAG	X-side voltage, A-to-B-phase, magnitude
METXMMXU1	PPV.phsBC.instCVal.ang.f	VBCX_ANG	X-side voltage, B-to-C-phase, angle
METXMMXU1	PPV.phsBC.instCVal.mag.f	VBCX_MAG	X-side voltage, B-to-C-phase, magnitude
METXMMXU1	PPV.phsCA.instCVal.ang.f	VCAX_ANG	X-side voltage, C-to-A-phase, angle
METXMMXU1	PPV.phsCA.instCVal.mag.f	VCAX_MAG	X-side voltage, C-to-A-phase, magnitude
METXMMXU1	Rf.instMag.f	FLDRES	Rotor field ground resistance
METXMMXU1	TotPF.instMag.f	PF3X	X-side power factor, magnitude three-phase
METXMMXU1	TotVA.instMag.f	S3X	X-side apparent power magnitude, three-phase
METXMMXU1	TotVAr.instMag.f	Q3X	X-side reactive power magnitude, three-phase
METXMMXU1	TotW.instMag.f	P3X	X-side real power magnitude, three-phase
METXMMXU1	Vhz.instMag.f	VHZX	X-side V/Hz
METXMSQI1	SeqA.c1.instCVal.ang.f	I1X_ANG	X-side current, positive-sequence, angle
METXMSQI1	SeqA.c1.instCVal.mag.f	I1X_MAG	X-side current, positive-sequence, magnitude
METXMSQI1	SeqA.c2.instCVal.ang.f	3I2X_ANG	X-side current, negative-sequence, angle
METXMSQI1	SeqA.c2.instCVal.mag.f	3I2X_MAG	X-side current, negative-sequence, magnitude
METXMSQI1	SeqA.c3.instCVal.ang.f	IGX_ANG	X-side current, calculated-residual, angle
METXMSQI1	SeqA.c3.instCVal.mag.f	IGX_MAG	X-side current, calculated-residual, magnitude
METXMSQI1	SeqV.c1.instCVal.ang.f	V1X_ANG	X-side voltage, positive-sequence, angle
METXMSQI1	SeqV.c1.instCVal.mag.f	V1X_MAG	X-side voltage, positive-sequence, magnitude
METXMSQI1	SeqV.c2.instCVal.ang.f	3V2X_ANG	X-side voltage, negative-sequence, angle
METXMSQI1	SeqV.c2.instCVal.mag.f	3V2X_MAG	X-side voltage, negative-sequence, magnitude
METXMSQI1	SeqV.c3.instCVal.ang.f	VGX_ANG	X-side zero-sequence voltage, angle
METXMSQI1	SeqV.c3.instCVal.mag.f	VGX_MAG	X-side zero-sequence voltage, magnitude
METXMSTA1	MaxA.phsA.instCVal.mag.f	IAXMX	X-side current, A-phase, maximum magnitude
METXMSTA1	MaxA.phsB.instCVal.mag.f	IBXMX	X-side current, B-phase, maximum magnitude

Table G.37 Logical Device: MET (Metering) (Sheet 3 of 7)

Logical Node	Attribute	Data Source	Comment
METXMSTA1	MaxA.phsC.instCVal.mag.f	ICXMX	X-side current, C-phase, maximum magnitude
METXMSTA1	MaxA.res.instCVal.mag.f	IGXMX	X-side current, residual, maximum magnitude
METXMSTA1	MaxAmps.instMag.f	INMX	Current, neutral, maximum magnitude
METXMSTA1	MaxP2PV.phsAB.instCVal.mag.f	VABXMX	X-side voltage, A-to-B-phase, maximum magnitude
METXMSTA1	MaxP2PV.phsBC.instCVal.mag.f	VBCXMX	X-side voltage, B-to-C-phase, maximum magnitude
METXMSTA1	MaxP2PV.phsCA.instCVal.mag.f	VCAXMX	X-side voltage, C-to-A-phase, maximum magnitude
METXMSTA1	MaxPhV.phsA.instCVal.mag.f	VAXMX	X-side voltage, A-phase-to-neutral, maximum magnitude
METXMSTA1	MaxPhV.phsB.instCVal.mag.f	VBXMX	X-side voltage, B-phase-to-neutral, maximum magnitude
METXMSTA1	MaxPhV.phsC.instCVal.mag.f	VCXMX	X-side voltage, C-phase-to-neutral, maximum magnitude
METXMSTA1	MaxVA.instMag.f	KVA3XMX	X-side apparent power magnitude, three-phase, maximum
METXMSTA1	MaxVAr.instMag.f	KVAR3XMX	X-side reactive power magnitude, three-phase, maximum
METXMSTA1	MaxW.instMag.f	KW3XMX	X-side real power magnitude, three-phase, maximum
METXMSTA1	MinA.phsA.instCVal.mag.f	IAXMN	X-side current, A-phase, minimum magnitude
METXMSTA1	MinA.phsB.instCVal.mag.f	IBXMN	X-side current, B-phase, minimum magnitude
METXMSTA1	MinA.phsC.instCVal.mag.f	ICXMN	X-side current, C-phase, minimum magnitude
METXMSTA1	MinA.res.instCVal.mag.f	IGXMN	X-side current, residual, minimum magnitude
METXMSTA1	MinAmps.instMag.f	INMN	Current, neutral, minimum magnitude
METXMSTA1	MinP2PV.phsAB.instCVal.mag.f	VABXMN	X-side voltage, A-to-B-phase, minimum magnitude
METXMSTA1	MinP2PV.phsBC.instCVal.mag.f	VBCXMN	X-side voltage, B-to-C-phase, minimum magnitude
METXMSTA1	MinP2PV.phsCA.instCVal.mag.f	VCAXMN	X-side voltage, C-to-A-phase, minimum magnitude
METXMSTA1	MinPhV.phsA.instCVal.mag.f	VAXMN	X-side voltage, A-phase-to-neutral, minimum magnitude
METXMSTA1	MinPhV.phsB.instCVal.mag.f	VBXMN	X-side voltage, B-phase-to-neutral, minimum magnitude
METXMSTA1	MinPhV.phsC.instCVal.mag.f	VCXMN	X-side voltage, C-phase-to-neutral, minimum magnitude
METXMSTA1	MinVA.instMag.f	KVA3XMN	X-side apparent power magnitude, three-phase, minimum
METXMSTA1	MinVAr.instMag.f	KVAR3XMN	X-side reactive power magnitude, three-phase, minimum
METXMSTA1	MinW.instMag.f	KW3XMN	X-side real power magnitude, three-phase, minimum
METYMDST2	DmdA.phsA.instCVal.mag.f	IAYD	Y-side A-phase current demand
METYMDST2	DmdA.phsB.instCVal.mag.f	IBYD	Y-side B-phase current demand
METYMDST2	DmdA.phsC.instCVal.mag.f	ICYD	Y-side C-phase current demand
METYMDST2	DmdA.res.instCVal.mag.f	IGYD	Y-side residual current demand
METYMDST2	DmdAnseq.instCVal.mag.f	3I2YD	Y-side negative-sequence current demand
METYMDST2	PkDmdA.phsA.instCVal.mag.f	IAYPD	Y-side A-phase current peak demand

Table G.37 Logical Device: MET (Metering) (Sheet 4 of 7)

Logical Node	Attribute	Data Source	Comment
METYMDST2	PkDmdA.phsB.instCVal.mag.f	IBYPD	Y-side B-phase current peak demand
METYMDST2	PkDmdA.phsC.instCVal.mag.f	ICYPD	Y-side C-phase current peak demand
METYMDST2	PkDmdA.res.instCVal.mag.f	IGYPD	Y-side residual current peak demand
METYMDST2	PkDmdAnseq.instCVal.mag.f	3I2YPD	Y-side negative-sequence current peak demand
METYMMXU2	A.phsA.instCVal.ang.f	IAY_ANG	Y-side current, A-phase, angle
METYMMXU2	A.phsA.instCVal.mag.f	IAY_MAG	Y-side current, A-phase, magnitude
METYMMXU2	A.phsB.instCVal.ang.f	IBY_ANG	Y-side current, B-phase, angle
METYMMXU2	A.phsB.instCVal.mag.f	IBY_MAG	Y-side current, B-phase, magnitude
METYMMXU2	A.phsC.instCVal.ang.f	ICY_ANG	Y-side current, C-phase, angle
METYMMXU2	A.phsC.instCVal.mag.f	ICY_MAG	Y-side current, C-phase, magnitude
METYMMXU2	A.res.instCVal.ang.f	IGY_ANG	Y-side current, calculated-residual, angle
METYMMXU2	A.res.instCVal.mag.f	IGY_MAG	Y-side current, calculated-residual, magnitude
METYMMXU2	A.neut.instCVal.ang.f	IN_ANG	Current, neutral, angle
METYMMXU2	A.neut.instCVal.mag.f	IN_MAG	Current, neutral, magnitude
METYMMXU2	Hz.instMag.f	FREQY	Y-side frequency
METYMMXU2	PhV.phsA.instCVal.ang.f	VAY_ANG	Y-side voltage, A-phase-to-neutral, angle
METYMMXU2	PhV.phsA.instCVal.mag.f	VAY_MAG	Y-side voltage, A-phase-to-neutral, magnitude
METYMMXU2	PhV.phsB.instCVal.ang.f	VBY_ANG	Y-side voltage, B-phase-to-neutral, angle
METYMMXU2	PhV.phsB.instCVal.mag.f	VBY_MAG	Y-side voltage, B-phase-to-neutral, magnitude
METYMMXU2	PhV.phsC.instCVal.ang.f	VCY_ANG	Y-side voltage, C-phase-to-neutral, angle
METYMMXU2	PhV.phsC.instCVal.mag.f	VCY_MAG	Y-side voltage, C-phase-to-neutral, magnitude
METYMMXU2	PhV.res.instCVal.ang.f	VGY_ANG	Y-side zero-sequence voltage, angle
METYMMXU2	PhV.res.instCVal.mag.f	VGY_MAG	Y-side zero-sequence voltage, magnitude
METYMMXU2	PPV.phsAB.instCVal.ang.f	VABY_ANG	Y-side voltage, A-to-B-phase, angle
METYMMXU2	PPV.phsAB.instCVal.mag.f	VABY_MAG	Y-side voltage, A-to-B-phase, magnitude
METYMMXU2	PPV.phsBC.instCVal.ang.f	VBCY_ANG	Y-side voltage, B-to-C-phase, angle
METYMMXU2	PPV.phsBC.instCVal.mag.f	VBCY_MAG	Y-side voltage, B-to-C-phase, magnitude
METYMMXU2	PPV.phsCA.instCVal.ang.f	VCAY_ANG	Y-side voltage, C-to-A-phase, angle
METYMMXU2	PPV.phsCA.instCVal.mag.f	VCAY_MAG	Y-side voltage, C-to-A-phase, magnitude
METYMMXU2	TotPF.instMag.f	PF3Y	Y-side power factor, magnitude 3-phase
METYMMXU2	TotVA.instMag.f	S3Y	Y-side apparent power magnitude, 3-phase
METYMMXU2	TotVAr.instMag.f	Q3Y	Y-side reactive power magnitude, 3-phase
METYMMXU2	TotW.instMag.f	P3Y	Y-side real power magnitude, 3-phase
METYMMXU2	VSyn.instCVal.ang.f	VS_ANG	Synch voltage, angle
METYMMXU2	VSyn.instCVal.mag.f	VS_MAG	Synch voltage, magnitude
METYMSQI2	SeqA.c1.instCVal.ang.f	I1Y_ANG	Y-side current, positive-sequence, angle
METYMSQI2	SeqA.c1.instCVal.mag.f	I1Y_MAG	Y-side current, positive-sequence, magnitude
METYMSQI2	SeqA.c2.instCVal.ang.f	3I2Y_ANG	Y-side current, negative-sequence, angle
METYMSQI2	SeqA.c2.instCVal.mag.f	3I2Y_MAG	Y-side current, negative-sequence, magnitude

Table G.37 Logical Device: MET (Metering) (Sheet 5 of 7)

Logical Node	Attribute	Data Source	Comment
METYMSQI2	SeqA.c3.instCVal.ang.f	IGY_ANG	Y-side current, calculated-residual, angle
METYMSQI2	SeqA.c3.instCVal.mag.f	IGY_MAG	Y-side current, calculated-residual, magnitude
METYMSQI2	SeqV.c1.instCVal.ang.f	V1Y_ANG	Y-side voltage, positive-sequence, angle
METYMSQI2	SeqV.c1.instCVal.mag.f	V1Y_MAG	Y-side voltage, positive-sequence, magnitude
METYMSQI2	SeqV.c2.instCVal.ang.f	3V2Y_ANG	Y-side voltage, negative-sequence, angle
METYMSQI2	SeqV.c2.instCVal.mag.f	3V2Y_MAG	Y-side voltage, negative-sequence, magnitude
METYMSQI2	SeqV.c3.instCVal.ang.f	VGY_ANG	Y-side zero-sequence voltage, angle
METYMSQI2	SeqV.c3.instCVal.mag.f	VGY_MAG	Y-side zero-sequence voltage, magnitude
METYMSTA2	MaxA.phsA.instCVal.mag.f	IAYMX	Y-side current, A-phase, maximum magnitude
METYMSTA2	MaxA.phsB.instCVal.mag.f	IBYMX	Y-side current, B-phase, maximum magnitude
METYMSTA2	MaxA.phsC.instCVal.mag.f	ICYMX	Y-side current, C-phase, maximum magnitude
METYMSTA2	MaxA.res.instCVal.mag.f	IGYMX	Y-side current, residual, maximum magnitude
METYMSTA2	MaxAmps.instMag.f	INMX	Current, neutral, maximum magnitude
METYMSTA2	MaxP2PV.phsAB.instCVal.mag.f	VABYMX	Y-side voltage, A-to-B-phase, maximum magnitude
METYMSTA2	MaxP2PV.phsBC.instCVal.mag.f	VBCYMX	Y-side voltage, B-to-C-phase, maximum magnitude
METYMSTA2	MaxP2PV.phsCA.instCVal.mag.f	VCAYMX	Y-side voltage, C-to-A-phase, maximum magnitude
METYMSTA2	MaxPhV.phsA.instCVal.mag.f	VAYMX	Y-side voltage, A-phase-to-neutral, maximum magnitude
METYMSTA2	MaxPhV.phsB.instCVal.mag.f	VBYMX	Y-side voltage, B-phase-to-neutral, maximum magnitude
METYMSTA2	MaxPhV.phsC.instCVal.mag.f	VCYMX	Y-side voltage, C-phase-to-neutral, maximum magnitude
METYMSTA2	MaxVA.instMag.f	KVA3YMX	Y-side apparent power magnitude, three-phase, maximum
METYMSTA2	MaxVAr.instMag.f	KVAR3YMX	Y-side reactive power magnitude, three-phase, maximum
METYMSTA2	MaxW.instMag.f	KW3YMX	Y-side real power magnitude, three-phase, maximum
METYMSTA2	MinA.phsA.instCVal.mag.f	IAYMN	Y-side current, A-phase, minimum magnitude
METYMSTA2	MinA.phsB.instCVal.mag.f	IBYMN	Y-side current, B-phase, minimum magnitude
METYMSTA2	MinA.phsC.instCVal.mag.f	ICYMN	Y-side current, C-phase, minimum magnitude
METYMSTA2	MinA.res.instCVal.mag.f	IGYMN	Y-side current, residual, minimum magnitude
METYMSTA2	MinAmps.instMag.f	INMN	Current, neutral, minimum magnitude
METYMSTA2	MinP2PV.phsAB.instCVal.mag.f	VABYMN	Y-side voltage, A-to-B-phase, minimum magnitude
METYMSTA2	MinP2PV.phsBC.instCVal.mag.f	VBCYMN	Y-side voltage, B-to-C-phase, minimum magnitude
METYMSTA2	MinP2PV.phsCA.instCVal.mag.f	VCAYMN	Y-side voltage, C-to-A-phase, minimum magnitude
METYMSTA2	MinPhV.phsA.instCVal.mag.f	VAYMN	Y-side voltage, A-phase-to-neutral, minimum magnitude
METYMSTA2	MinPhV.phsB.instCVal.mag.f	VBYMN	Y-side voltage, B-phase-to-neutral, minimum magnitude
METYMSTA2	MinPhV.phsC.instCVal.mag.f	VCYMN	Y-side voltage, C-phase-to-neutral, minimum magnitude

Table G.37 Logical Device: MET (Metering) (Sheet 6 of 7)

Logical Node	Attribute	Data Source	Comment
METYMSTA2	MinVA.instMag.f	KVA3YMN	Y-side apparent power magnitude, three-phase, minimum
METYMSTA2	MinVAr.instMag.f	KVAR3YMN	Y-side reactive power magnitude, three-phase, minimum
METYMSTA2	MinW.instMag.f	KW3YMN	Y-side real power magnitude, three-phase, minimum
RMSXMMXU3	A.phsA.instCVal.mag.f	IAXRMS	X-side rms current, A-phase, magnitude
RMSXMMXU3	A.phsB.instCVal.mag.f	IBXRMS	X-side rms current, B-phase, magnitude
RMSXMMXU3	A.phsC.instCVal.mag.f	ICXRMS	X-side rms current, C-phase, magnitude
RMSXMMXU3	A.neut.instCVal.mag.f	INRMS	Neutral rms current, magnitude
RMSXMMXU3	PhV.phsA.instCVal.mag.f	VAXRMS[c]	X-side rms voltage, A-phase-to-neutral, magnitude
RMSXMMXU3	PhV.phsB.instCVal.mag.f	VBXRMS[c]	X-side rms voltage, B-phase-to-neutral, magnitude
RMSXMMXU3	PhV.phsC.instCVal.mag.f	VCXRMS[c]	X-side rms voltage, C-phase-to-neutral, magnitude
RMSXMMXU3	PPV.phsAB.instCVal.mag.f	VABXRMS[c]	X-side rms voltage, A-to-B-phase, magnitude
RMSXMMXU3	PPV.phsBC.instCVal.mag.f	VBCXRMS[c]	X-side rms voltage, B-to-C-phase, magnitude
RMSXMMXU3	PPV.phsCA.instCVal.mag.f	VCAXRMS[c]	X-side rms voltage, C-to-A-phase, magnitude
RMSYMMXU4	A.phsA.instCVal.mag.f	IAYRMS	Y-side rms current, A-phase, magnitude
RMSYMMXU4	A.phsB.instCVal.mag.f	IBYRMS	Y-side rms current, B-phase, magnitude
RMSYMMXU4	A.phsC.instCVal.mag.f	ICYRMS	Y-side rms current, C-phase, magnitude
RMSYMMXU4	PhV.phsA.instCVal.mag.f	VAYRMS[c]	Y-side rms voltage, A-phase-to-neutral, magnitude
RMSYMMXU4	PhV.phsB.instCVal.mag.f	VBYRMS[c]	Y-side rms voltage, B-phase-to-neutral, magnitude
RMSYMMXU4	PhV.phsC.instCVal.mag.f	VCYRMS[c]	Y-side rms voltage, C-phase-to-neutral, magnitude
RMSYMMXU4	PPV.phsAB.instCVal.mag.f	VABYRMS[c]	Y-side rms voltage, A-to-B-phase, magnitude
RMSYMMXU4	PPV.phsBC.instCVal.mag.f	VBCYRMS[c]	Y-side rms voltage, B-to-C-phase, magnitude
RMSYMMXU4	PPV.phsCA.instCVal.mag.f	VCAYRMS[c]	Y-side rms voltage, C-to-A-phase, magnitude
RMSYMMXU4	VSyn.instCVal.mag.f	VSRMS	RMS voltage, v-sync, magnitude
THERMMTHR1	MaxAmbTmp.instMag.f	RTDAMB[d]	Ambient RTD temperature
THERMMTHR1	MaxOthTmp.instMag.f	RTDOTHMX[d]	Other maximum RTD temperature
THERMMTHR1	Tmp01.instMag.f–Tmp12.instMag.f	RTD1 - RTD12[d]	RTD1–RTD12 temperature
Functional Constraint = ST			
LLN0	Loc.stVal	LOC	Control authority at local (bay) level
LLN0	LocSta.stVal	LOCSTA	Control authority at station level
METXMDST1[e]	DmdVArh.actVal	MVARHNX	Reactive energy, three-phase negative X-side
METXMDST1[d]	DmdWh.actVal	MWHNX	Real energy, three-phase negative X-side
METXMDST1[d]	SupVArh.actVal	MVARHPX	Reactive energy, three-phase positive X-side
METXMDST1[d]	SupWh.actVal	MWHPX	Real energy, three-phase positive X-side
METYMDST2[d]	DmdVArh.actVal	MVARHNY	Reactive energy, three-phase negative Y-side

Table G.37 Logical Device: MET (Metering) (Sheet 7 of 7)

Logical Node	Attribute	Data Source	Comment
METYMDST2[d]	DmdWh.actVal	MWHNY	Real energy, three-phase negative Y-side
METYMDST2[d]	SupVArh.actVal	MVARHPY	Reactive energy, three-phase positive Y-side
METYMDST2[d]	SupWh.actVal	MWHPY	Real energy, three-phase positive Y-side
THERMMTHR1	EEHealth.stVal	RTDFLT?1:3[d]	RTD input or communication status
Functional Constraint = SP			
LLN0	GrRef.setSrcRef	IdName	Functional name
LLN0	MltLev.setVal	MLTLEV	Multilevel mode of control authority

[a] MX values contain instantaneous attributes (instMag and instCVal), which are updated whenever the source updates, and other attributes, which are only updated when the source goes outside the data source's deadband (mag and cVal). Only the instantaneous values are shown in the table.
[b] Data validity depends on the relay model and installed card options. Refer to Section 1: Introduction and Specifications for different relay models and available card options. Refer to Section 5: Metering and Monitoring for the model dependent metering quantities.
[c] If DELTAY_X or DELTAY_Y := WYE, only VAXRMS, VBXRMS, VCXRMS, VAYRMS, VBYRMS, and VCYRMS are calculated. If DELTAY_X or DELTAY_Y := DELTA, only VABXRMS, VBCXRMS, VCAXRMS, VABYRMS, VBCYRMS, and VCAYRMS are calculated.
[d] Valid data depends on E49RTD and RTD1LOC–RTD12LOC settings.
[e] For IEC 61850 Edition 1 relays, this quantity is located under Function Constraint MX.

Table G.38 shows the LN associated with control elements defined as Logical Device CON.

Table G.38 Logical Device: CON (Remote Control)

Logical Node	Status	Control	Relay Word Bit	Comment
Functional Constraint = CO				
RBGGIO1	SPCSO01.stVal–SPCSO08.stVal	SPCSO01.Oper.ctlVal–SPCSO08.Oper.ctlVal	RB01–RB08	Remote Bits RB01–RB08
RBGGIO2	SPCSO09.stVal–SPCSO16.stVal	SPCSO09.Oper.ctlVal–SPCSO16.Oper.ctlVal	RB09–RB16	Remote Bits RB09–RB16
RBGGIO3	SPCSO17.stVal–SPCSO24.stVal	SPCSO17.Oper.ctlVal–SPCSO24.Oper.ctlVal	RB17–RB24	Remote Bits RB17–RB24
RBGGIO4	SPCSO25.stVal–SPCSO32.stVal	SPCSO25.Oper.ctlVal–SPCSO32.Oper.ctlVal	RB25–RB32	Remote Bits RB25–RB32
PRBGGIO1	SPCSO01.stVal–SPCSO08.stVal	SPCSO01.Oper.ctlVal–SPCSO08.Oper.ctlVal	RB01–RB08	Pulse Remote Bits RB01–RB08
PRBGGIO2	SPCSO09.stVal–SPCSO16.stVal	SPCSO09.Oper.ctlVal–SPCSO16.Oper.ctlVal	RB09–RB16	Pulse Remote Bits RB09–RB16
PRBGGIO3	SPCSO17.stVal–SPCSO24.stVal	SPCSO17.Oper.ctlVal–SPCSO24.Oper.ctlVal	RB17–RB24	Pulse Remote Bits RB17–RB24
PRBGGIO4	SPCSO25.stVal–SPCSO32.stVal	SPCSO25.Oper.ctlVal–SPCSO32.Oper.ctlVal	RB25–RB32	Pulse Remote Bits RB25–RB32
Functional Constraint = ST				
LLN0	Loc.stVal	—	LOC	Control authority at local (bay) level
LLN0	LocSta.stVal	LocSta.Oper.ctlVal	LOCSTA	Control authority at station level
Functional Constraint = SP				
LLN0	GrRef.setSrcRef	—	IdName	Functional name
LLN0	MltLev.setVal	—	MLTLEV	Multilevel mode of control authority

Table G.39 shows the LN associated with annunciation elements defined as Logical Device ANN.

Table G.39 Logical Device: ANN (Annunciation) (Sheet 1 of 7)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PARTNO	Part number
Functional Constraint = MX[a]			
AINCGGIO21	AnIn01.instMag.f–AnIn04.instMag.f	AI301–AI304[b]	Analog Inputs (AI301 to AI304)—Slot C
AINDGGIO22	AnIn01.instMag.f–AnIn04.instMag.f	AI401–AI404[b]	Analog Inputs (AI401 to AI404)—Slot D
AINEGGIO23	AnIn01.instMag.f–AnIn04.instMag.f	AI501–AI504[b]	Analog Inputs (AI501 to AI504)—Slot E
BWXASCBR1	AccAbr.instMag.f	WEARAX	X breaker–Contact A wear
BWXBSCBR2	AccAbr.instMag.f	WEARBX	X breaker–Contact B wear
BWXCSCBR3	AccAbr.instMag.f	WEARCX	X breaker–Contact C wear
BWYASCBR4	AccAbr.instMag.f	WEARAY	Y breaker–Contact A wear
BWYBSCBR5	AccAbr.instMag.f	WEARBY	Y breaker–Contact B wear
BWYCSCBR6	AccAbr.instMag.f	WEARCY	Y breaker–Contact C wear
FLTGGIO36	AnIn01.instMag.f	FIAX	X-side A-phase current of the most recent fault event
FLTGGIO36	AnIn02.instMag.f	FIBX	X-side B-phase current of the most recent fault event
FLTGGIO36	AnIn03.instMag.f	FICX	X-side C-phase current of the most recent fault event
FLTGGIO36	AnIn04.instMag.f	FIGX	X-side ground current of the most recent fault event
FLTGGIO36	AnIn05.instMag.f	FIAY	Y-side A-phase current of the most recent fault event
FLTGGIO36	AnIn06.instMag.f	FIBY	Y-side B-phase current of the most recent fault event
FLTGGIO36	AnIn07.instMag.f	FICY	Y-side C-phase current of the most recent fault event
FLTGGIO36	AnIn08.instMag.f	FIGY	Y-side calculated-residual current of the most recent fault event
FLTGGIO36	AnIn09.instMag.f	FIN	Neutral current of the most recent fault event
FLTGGIO36	AnIn10.instMag.f	FFREQX	X-side frequency of the most recent fault event
FLTGGIO36	AnIn11.instMag.f	FFREQY	Y-side frequency of the most recent fault event
MVGGIO12	AnIn01.instMag.f–AnIn32.instMag.f	MV01–MV32[c]	Math Variables (MV01 to MV32)
PFLLIGGIO37	AnIn01.instMag.f	PFAL_X	X-side A-phase power factor lead/lag indicator (1: LEAD, 0:LAG)
PFLLIGGIO37	AnIn02.instMag.f	PFBL_X	X-side B-phase power factor lead/lag indicator (1: LEAD, 0:LAG)
PFLLIGGIO37	AnIn03.instMag.f	PFCL_X	X-side C-phase power factor lead/lag indicator (1: LEAD, 0:LAG)
PFLLIGGIO37	AnIn04.instMag.f	PFL_X	X-side three-phase power factor lead/lag indicator (1: LEAD, 0:LAG)
PFLLIGGIO37	AnIn05.instMag.f	PFAL_X	X-side A-phase power factor lead/lag indicator (1: LEAD, 0:LAG)
PFLLIGGIO37	AnIn06.instMag.f	PFBL_X	X-side B-phase power factor lead/lag indicator (1: LEAD, 0:LAG)
PFLLIGGIO37	AnIn07.instMag.f	PFCL_X	X-side C-phase power factor lead/lag indicator (1: LEAD, 0:LAG)
PFLLIGGIO37	AnIn08.instMag.f	PFL_X	X-side three-phase power factor lead/lag indicator (1: LEAD, 0:LAG)
RAGGIO24	Ra001.instMag.f–Ra032.instMag.f	RA001–RA032	Remote Analogs (RA001 to RA032)
RAGGIO25	Ra033.instMag.f–Ra064.instMag.f	RA033–RA064	Remote Analogs (RA033 to RA064)

Table G.39 Logical Device: ANN (Annunciation) (Sheet 2 of 7)

Logical Node	Attribute	Data Source	Comment
RAGGIO26	Ra065.instMag.f–Ra096.instMag.f	RA065–RA096	Remote Analogs (RA065 to RA096)
RAGGIO27	Ra097.instMag.f–Ra128.instMag.f	RA097–RA128	Remote Analogs (RA097 to RA128)
SCGGIO20	AnIn01.instMag.f–AnIn32.instMag.f	SC01–SC32[d]	SELOGIC Counters (SC01 to SC32)
Functional Constraint = ST			
BWXASCBR1	ColOpn.stVal	OCX	Open Breaker X
BWXBSCBR2	ColOpn.stVal	OCX	Open Breaker X
BWXCSCBR3	ColOpn.stVal	OCX	Open Breaker X
BWYASCBR4	ColOpn.stVal	OCY	Open Breaker Y
BWYBSCBR5	ColOpn.stVal	OCY	Open Breaker Y
BWYCSCBR6	ColOpn.stVal	OCY	Open Breaker Y
DCALMGGIO35	Ind01.stVal	89AL2P1	Two-Position Disconnect 1 alarm
DCALMGGIO35	Ind02.stVal	89AL2P2	Two-Position Disconnect 2 alarm
DCALMGGIO35	Ind03.stVal	89AL2P3	Two-Position Disconnect 3 alarm
DCALMGGIO35	Ind04.stVal	89AL2P4	Two-Position Disconnect 4 alarm
DCALMGGIO35	Ind05.stVal	89AL2P5	Two-Position Disconnect 5 alarm
DCALMGGIO35	Ind06.stVal	89AL2P6	Two-Position Disconnect 6 alarm
DCALMGGIO35	Ind07.stVal	89AL2P7	Two-Position Disconnect 7 alarm
DCALMGGIO35	Ind08.stVal	89AL2P8	Two-Position Disconnect 8 alarm
DCSTSGGIO34	Ind01.stVal	89A2P1	Two-Position Disconnect 1 N/O contact
DCSTSGGIO34	Ind02.stVal	89B2P1	Two-Position Disconnect 1 N/C contact
DCSTSGGIO34	Ind03.stVal	89CL2P1	Two-Position Disconnect 1 closed
DCSTSGGIO34	Ind04.stVal	89OP2P1	Two-Position Disconnect 1 open
DCSTSGGIO34	Ind05.stVal	89A2P2	Two-Position Disconnect 2 N/O contact
DCSTSGGIO34	Ind06.stVal	89B2P2	Two-Position Disconnect 2 N/C contact
DCSTSGGIO34	Ind07.stVal	89CL2P2	Two-Position Disconnect 2 closed
DCSTSGGIO34	Ind08.stVal	89OP2P2	Two-Position Disconnect 2 open
DCSTSGGIO34	Ind09.stVal	89A2P3	Two-Position Disconnect 3 N/O contact
DCSTSGGIO34	Ind10.stVal	89B2P3	Two-Position Disconnect 3 N/C contact
DCSTSGGIO34	Ind11.stVal	89CL2P3	Two-Position Disconnect 3 closed
DCSTSGGIO34	Ind12.stVal	89OP2P3	Two-Position Disconnect 3 open
DCSTSGGIO34	Ind13.stVal	89A2P4	Two-Position Disconnect 4 N/O contact
DCSTSGGIO34	Ind14.stVal	89B2P4	Two-Position Disconnect 4 N/C contact
DCSTSGGIO34	Ind15.stVal	89CL2P4	Two-Position Disconnect 4 closed
DCSTSGGIO34	Ind16.stVal	89OP2P4	Two-Position Disconnect 4 open
DCSTSGGIO34	Ind17.stVal	89A2P5	Two-Position Disconnect 5 N/O contact
DCSTSGGIO34	Ind18.stVal	89B2P5	Two-Position Disconnect 5 N/C contact
DCSTSGGIO34	Ind19.stVal	89CL2P5	Two-Position Disconnect 5 closed

Table G.39 Logical Device: ANN (Annunciation) (Sheet 3 of 7)

Logical Node	Attribute	Data Source	Comment
DCSTSGGIO34	Ind20.stVal	89OP2P5	Two-Position Disconnect 5 open
DCSTSGGIO34	Ind21.stVal	89A2P6	Two-Position Disconnect 6 N/O contact
DCSTSGGIO34	Ind22.stVal	89B2P6	Two-Position Disconnect 6 N/C contact
DCSTSGGIO34	Ind23.stVal	89CL2P6	Two-Position Disconnect 6 closed
DCSTSGGIO34	Ind24.stVal	89OP2P6	Two-Position Disconnect 6 open
DCSTSGGIO34	Ind25.stVal	89A2P7	Two-Position Disconnect 7 N/O contact
DCSTSGGIO34	Ind26.stVal	89B2P7	Two-Position Disconnect 7 N/C contact
DCSTSGGIO34	Ind27.stVal	89CL2P7	Two-Position Disconnect 7 closed
DCSTSGGIO34	Ind28.stVal	89OP2P7	Two-Position Disconnect 7 open
DCSTSGGIO34	Ind29.stVal	89A2P8	Two-Position Disconnect 8 N/O contact
DCSTSGGIO34	Ind30.stVal	89B2P8	Two-Position Disconnect 8 N/C contact
DCSTSGGIO34	Ind31.stVal	89CL2P8	Two-Position Disconnect 8 closed
DCSTSGGIO34	Ind32.stVal	89OP2P8	Two-Position Disconnect 8 open
GENGGIO29	Ind01.stVal	REMTRIP	Remote trip
GENGGIO29	Ind02.stVal	BNDT	ORed abnormal frequency band trip
GENGGIO29	Ind03.stVal	INADT	Inadvertent energization logic timed out
GENGGIO29	Ind04.stVal	OOST	Out-of-step trip
GENGGIO29	Ind05.stVal	TH5T	Fifth-harmonic alarm threshold exceeded for longer than TH5D
GENGGIO29	Ind06.stVal	3POX	X breaker three-pole open
GENGGIO29	Ind07.stVal	3POY	Y breaker three-pole open
GENGGIO29	Ind08.stVal	FREQTRKX	Frequency tracking enable bit for X-side voltages or currents–tracking enabled when bit is asserted
GENGGIO29	Ind09.stVal	FREQTRKY	Frequency tracking enable bit for Y side voltages or currents–tracking enabled when bit is asserted
GENGGIO29	Ind10.stVal	CFA	Generator breaker close failure angle condition
GENGGIO29	Ind11.stVal	BKRCF	Generator breaker close failed
GENGGIO29	Ind12.stVal	CFX	Breaker X close condition failure on
GENGGIO29	Ind13.stVal	CFY	Breaker Y close condition failure on
GENGGIO29	Ind14.stVal	BCWAX	X-side breaker A-phase breaker contact wear has reached 100 percent wear level
GENGGIO29	Ind15.stVal	BCWBX	X-side breaker B-phase breaker contact wear has reached 100 percent wear level
GENGGIO29	Ind16.stVal	BCWCX	X-side breaker C-phase breaker contact wear has reached 100 percent wear level
GENGGIO29	Ind17.stVal	BCWAY	Y-side breaker A-phase breaker contact wear has reached 100 percent wear level
GENGGIO29	Ind18.stVal	BCWBY	Y-side breaker B-phase breaker contact wear has reached 100 percent wear level
GENGGIO29	Ind19.stVal	BCWCY	Y-side breaker C-phase breaker contact wear has reached 100 percent wear level
GENGGIO29	Ind20.stVal–Ind32.stval	0	Reserved for future use

Table G.39 Logical Device: ANN (Annunciation) (Sheet 4 of 7)

Logical Node	Attribute	Data Source	Comment
INAGGIO1	Ind01.stVal–Ind02.stVal	IN101–IN102	Digital Inputs (IN101 to IN102)—Slot A
INCGGIO13	Ind01.stVal–Ind14.stVal	IN301–IN314[b]	Digital Inputs (IN301 to IN314)—Slot C
INDGGIO15	Ind01.stVal–Ind14.stVal	IN401–IN414[b]	Digital Inputs (IN401 to IN414)—Slot D
INEGGIO17	Ind01.stVal–Ind14.stVal	IN501–IN514[b]	Digital Inputs (IN501 to IN514)—Slot E
LBGGIO30	Ind01.stVal–Ind32.stVal	LB01–LB32[e]	Local Bits (LB01 to LB32)
LTGGIO5	Ind01.stVal–Ind32.stVal	LT01–LT32[f]	Latch Bits (LT01 to LT32)
LLN0	Loc.stVal	LOC	Control authority at local (bay) level
LLN0	LocSta.stVal	LOCSTA	Control authority at station level
MBOKGGIO31	Ind01.stVal	ROKA	Channel A, received data OK
MBOKGGIO31	Ind02.stVal	RBADA	Channel A, outage duration over threshold
MBOKGGIO31	Ind03.stVal	CBADA	Channel A, channel unavailability over threshold
MBOKGGIO31	Ind04.stVal	LBOKA	Channel A, looped back OK
MBOKGGIO31	Ind05.stVal	ROKB	Channel B, received data OK
MBOKGGIO31	Ind06.stVal	RBADB	Channel B, outage duration over threshold
MBOKGGIO31	Ind07.stVal	CBADB	Channel B, channel unavailability over threshold
MBOKGGIO31	Ind08.stVal	LBOKB	Channel B, looped back OK
MISCGGIO32	Ind01.stVal	HALARM	Indication of a diagnostic failure or warning that warrants an ALARM
MISCGGIO32	Ind02.stVal	SALARM	Indication of software or user activity that warrants an ALARM
MISCGGIO32	Ind03.stVal	WARNING	Relay Word WARNING
MISCGGIO32	Ind04.stVal	IRIGOK	IRIG-B time sync input data are valid
MISCGGIO32	Ind05.stVal	TSOK	Time synchronization OK
MISCGGIO32	Ind06.stVal	DST	Daylight Savings Time active
MISCGGIO32	Ind07.stVal	LINKA	Asserted when a valid link is detected on Port 1A
MISCGGIO32	Ind08.stVal	LINKB	Asserted when a valid link is detected on Port 1B
MISCGGIO32	Ind09.stVal	LINKFAIL	Asserted when a valid link is not detected on the active port(s)
MISCGGIO32	Ind10.stVal	PASEL	Asserted when Port 1A is active
MISCGGIO32	Ind11.stVal	PBSEL	Asserted when Port 1B is active
MISCGGIO32	Ind12.stVal	MATHERR	Error in SEL Math computation
MISCGGIO32	Ind13.stVal	COMMLOSS	DeviceNet communication failure
MISCGGIO32	Ind14.stVal	COMMFLT	Time-out of internal communication between CPU board and DeviceNet board
MISCGGIO32	Ind15.stVal	TESTDB	Indicates when TESTDB override is active
MISCGGIO32	Ind16.stVal	0	Reserved for future use
PROGGIO33	Ind01.stVal	AMBALRM	Ambient temperature alarm
PROGGIO33	Ind02.stVal	AMBTRIP	Ambient temperature trip

Table G.39 Logical Device: ANN (Annunciation) (Sheet 5 of 7)

Logical Node	Attribute	Data Source	Comment
PROGGIO33	Ind03.stVal	OTHALRM	Other temperature alarm
PROGGIO33	Ind04.stVal	OTHTRIP	Other temperature trip
PROGGIO33	Ind05.stVal	WDGALRM	Winding temperature alarm
PROGGIO33	Ind06.stVal	WDGTRIP	Winding temperature trip
PROGGIO33	Ind07.stVal	BRGALRM	Bearing temperature alarm
PROGGIO33	Ind08.stVal	BRGTRIP	Bearing temperature trip
PROGGIO33	Ind09.stVal	PHDEMX	X-side phase current demand pickup
PROGGIO33	Ind10.stVal	3I2DEMX	X-side negative-sequence current demand pickup
PROGGIO33	Ind11.stVal	GNDEMX	X-side zero-sequence current demand pickup
PROGGIO33	Ind12.stVal	PHDEMY	Y-side phase current demand pickup
PROGGIO33	Ind13.stVal	3I2DEMY	Y-side negative-sequence current demand pickup
PROGGIO33	Ind14.stVal	GNDEMY	Y-side zero-sequence current demand pickup
PROGGIO33	Ind15.stVal	ASYNSDC	Asynchronous sampling data conversion is in process
PROGGIO33	Ind16.stVal	78VSO	Vector shift output
PROGGIO33	Ind17.stVal	78VSBL	Vector shift block condition
PROGGIO33	Ind18.stVal	52BX	Breaker X N/C contact
PROGGIO33	Ind19.stVal	52BY	Breaker Y N/C contact
PROGGIO33	Ind20.stVal–Ind32.stval	0	Reserved for future use
OUTAGGIO2	Ind01.stVal–Ind03.stVal	OUT101–OUT103	Digital Outputs (OUT101 to OUT103)—Slot A
OUTCGGIO14	Ind01.stVal–Ind08.stVal	OUT301–OUT308[b]	Digital Outputs (OUT301 to OUT308)—Slot C
OUTDGGIO16	Ind01.stVal–Ind08.stVal	OUT401–OUT408[b]	Digital Outputs (OUT401 to OUT408)—Slot D
OUTEGGIO18	Ind01.stVal–Ind08.stVal	OUT501–OUT508[b]	Digital Outputs (OUT501 to OUT508)—Slot E
PBLEDGGIO7	Ind01.stVal	PB1A_LED	Pushbutton PB1A LED
PBLEDGGIO7	Ind02.stVal	PB1B_LED	Pushbutton PB1B LED
PBLEDGGIO7	Ind03.stVal	PB2A_LED	Pushbutton PB2A LED
PBLEDGGIO7	Ind04.stVal	PB2B_LED	Pushbutton PB2B LED
PBLEDGGIO7	Ind05.stVal	PB3A_LED	Pushbutton PB3A LED
PBLEDGGIO7	Ind06.stVal	PB3B_LED	Pushbutton PB3B LED
PBLEDGGIO7	Ind07.stVal	PB4A_LED	Pushbutton PB4A LED
PBLEDGGIO7	Ind08.stVal	PB4B_LED	Pushbutton PB4B LED
PBLEDGGIO7	Ind09.stVal	PB5A_LED	Pushbutton PB5A LED
PBLEDGGIO7	Ind10.stVal	PB5B_LED	Pushbutton PB5B LED
PBLEDGGIO7	Ind11.stVal	PB6A_LED	Pushbutton PB6A LED
PBLEDGGIO7	Ind12.stVal	PB6B_LED	Pushbutton PB6B LED
PBLEDGGIO7	Ind13.stVal	PB7A_LED	Pushbutton PB7A LED

Table G.39 Logical Device: ANN (Annunciation) (Sheet 6 of 7)

Logical Node	Attribute	Data Source	Comment
PBLEDGGIO7	Ind14.stVal	PB7B_LED	Pushbutton PB7B LED
PBLEDGGIO7	Ind15.stVal	PB8A_LED	Pushbutton PB8A LED
PBLEDGGIO7	Ind16.stVal	PB8B_LED	Pushbutton PB8B LED
RMBAGGIO8	Ind01.stVal–Ind08.stVal	RMB1A–RMB8A	Receive MIRRORED BITS (RMB1A to RMB8A)
RMBBGGIO10	Ind01.stVal–Ind08.stVal	RMB1B–RMB8B	Receive MIRRORED BITS (RMB1B to RMB8B)
SGGGIO35	Ind01.stVal–Ind04.stVal	SG1–SG4	Setting Group 1 to 4 selection
SVGGIO3	Ind01.stVal–Ind32.stVal	SV01–SV32[g]	SELOGIC Variables (SV01 to SV32)
SVTGGIO4	Ind01.stVal–Ind32.stVal	SV01T–SV32T[g]	SELOGIC Variable Timers (SV01T to SV32T)
SYNGGIO28	Ind01.stVal	AST	Autosynchronism start
SYNGGIO28	Ind02.stVal	ASP	Autosynchronism stop
SYNGGIO28	Ind03.stVal	FSYNCTO	Frequency synch timer timeout
SYNGGIO28	Ind04.stVal	FSYNCACT	Frequency matching–auto synchronization is in progress
SYNGGIO28	Ind05.stVal	FRAISE	Raise frequency for autosynchronism
SYNGGIO28	Ind06.stVal	FLOWER	Lower frequency for autosynchronism
SYNGGIO28	Ind07.stVal	VSYNCTO	Voltage synch timer timeout
SYNGGIO28	Ind08.stVal	VSYNCACT	Voltage matching–auto synchronization is in progress
SYNGGIO28	Ind09.stVal	VRAISE	Raise voltage for autosynchronism
SYNGGIO28	Ind10.stVal	VLOWER	Lower voltage for autosynchronism
SYNGGIO28	Ind11.stVal	59VPX	Generator terminal voltage within voltage window
SYNGGIO28	Ind12.stVal	59VSX	System voltage within voltage window
SYNGGIO28	Ind13.stVal	VDIFX	Generator and system voltage difference within acceptable bounds
SYNGGIO28	Ind14.stVal	SFX	Generator slip frequency is within acceptable bounds (between 25SLO and 25SHI settings)
SYNGGIO28	Ind15.stVal	25AX1	Generator slip/breaker-time compensated phase angle less than 25ANG1X setting
SYNGGIO28	Ind16.stVal	25AX2	Generator uncompensated phase angle less than 25ANG2X setting
SYNGGIO28	Ind17.stVal	GENVHI	Generator voltage greater than system voltage
SYNGGIO28	Ind18.stVal	GENVLO	Generator voltage less than system voltage
SYNGGIO28	Ind19.stVal	GENFHI	Slip frequency greater than 25SHI setting
SYNGGIO28	Ind20.stVal	GENFLO	Slip frequency less than 25SLO setting
SYNGGIO28	Ind21.stVal	59VPY	Intertie terminal voltage within voltage window
SYNGGIO28	Ind22.stVal	59VSY	System voltage within voltage window
SYNGGIO28	Ind23.stVal	VDIFY	Intertie and system voltage difference within acceptable bounds
SYNGGIO28	Ind24.stVal	SFY	Intertie slip frequency within acceptable bounds (less than 25SF setting)
SYNGGIO28	Ind25.stVal	25AY1	Intertie slip/breaker-time compensated phase angle less than 25ANG1Y setting

Table G.39 Logical Device: ANN (Annunciation) (Sheet 7 of 7)

Logical Node	Attribute	Data Source	Comment
SYNGGIO28	Ind26.stVal	25AY2	Intertie slip/breaker-time compensated phase angle less than 25ANG1Y setting
SYNGGIO28	Ind27.stVal–Ind32.stVal	0	Reserved for future use
TLEDGGIO6	Ind01.stVal	ENABLED	ENABLED LED
TLEDGGIO6	Ind02.stVal	TRIP_LED	TRIP LED
TLEDGGIO6	Ind03.stVal–Ind08.stVal	TLED_01–TLED_06	Target LEDs TLED_01 to TLED_06
TMBAGGIO9	Ind01.stVal–Ind08.stVal	TMB1A–TMB8A	Transmit MIRRORED BITS (TMB1A to TMB8A)
TMBBGGIO11	Ind01.stVal–Ind08.stVal	TMB1B–TMB8B	Transmit MIRRORED BITS (TMB1B to TMB8B)
VBGGIO19	Ind001.stVal–Ind128.stVal	VB001–VB128	Virtual Bits (VB001 to VB128)
Functional Constraint = SP			
LLN0	GrRef.setSrcRef	IdName	Functional name
LLN0	MltLev.setVal	MLTLEV	Multilevel mode of control authority

[a] MX values contain instantaneous attributes (instMag and instCVal), which are updated whenever the source updates, and other attributes, which are only updated when the source goes outside the data source's deadband (mag and cVal). Only the instantaneous values are shown in the table.
[b] Active data only if optional I/O card is installed in the slot.
[c] Active data depends on the EMV setting.
[d] Active data depends on the ESC setting.
[e] Active data depends on the ELB setting.
[f] Active data depends on the ELAT setting.
[g] Active data depends on the ESV setting.

Table G.40 Logical Device: CFG (Configuration) (Sheet 1 of 6)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = CO			
DevIDLPHD1	Sim.Oper.ctlVal	LPHDSIM	IEC 61850 logical node for physical device simulation
GOLCCH2	RsStat.Oper.ctlVal	GORST[a]	Reset statistics for GOOSE traffic
IPLCCH1	RsStat.Oper.ctlVal	IPRST[a]	Reset statistics for general IP traffic (excluding GOOSE traffic)
LLN0	LocSta.Oper.ctlVal	SC850LS	SELOGIC control for control authority at station level
LLN0	Mod.Oper.ctlVal[b]	I60MOD[c]	IEC 61850 mode/behavior control
LGOS*n*[d]	RsStat.Oper.ctlVal	GRST*n*[e]	Reset GOOSE statistics for Message *n*
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PARTNO	Part number
DevIDLPHD1	PhyNam.serNum	SER_NUM	Serial number
LLN0	NamPlt.swRev	FID	Firmware revision
Functional Constraint = ST			
DevIDLPHD1	Sim.stVal	LPHDSIM	IEC 61850 logical node for physical device simulation
DevIDLPHD1	PhyHealth.stVal	RELAY_EN	Relay enabled
GOLCCH2	ChLiv.stVal	GOCH[a]	Status of primary GOOSE channel
GOLCCH2	RedChLiv.stVal	GORCH[a]	Status of redundant GOOSE channel. Always reported as false.
GOLCCH2	RxCnt.actVal	GORX[a]	Number of frames received over the primary GOOSE channel

Table G.40 Logical Device: CFG (Configuration) (Sheet 2 of 6)

Logical Node	Attribute	Data Source	Comment
GOLCCH2	RedRxCnt.actVal	GORRX[a]	Number of frames received over the redundant GOOSE channel. Always reported as 0.
GOLCCH2	TxCnt.actVal	GOTX[a]	Number of frames transmitted on both primary and redundant GOOSE channels
GOLCCH2	FerCh.stVal	GOFER[a]	Frame error rate on the primary GOOSE channel
GOLCCH2	RedFerCh.stVal	GORFER[a]	Frame error rate on the redundant GOOSE channel. Always reported as 0.
GOLCCH2	RsStat.stVal	GORST[a]	Status of statistics reset for GOOSE traffic
IPLCCH1	ChLiv.stVal	IPCH[a]	Status of primary IP channel
IPLCCH1	RedChLiv.stVal	IPRCH[a]	Status of redundant IP channel. Always reported as false.
IPLCCH1	RxCnt.actVal	IPRX[a]	Number of frames received over the primary IP channel
IPLCCH1	RedRxCnt.actVal	IPRRX[a]	Number of frames received over the redundant IP channel. Always reported as 0.
IPLCCH1	TxCnt.actVal	IPTX[a]	Number of frames transmitted on both primary and redundant IP channels
IPLCCH1	FerCh.stVal	IPFER[a]	Frame error rate on the primary IP channel
IPLCCH1	RedFerCh.stVal	IPRFER[a]	Frame error rate on the redundant IP channel. Always reported as 0.
IPLCCH1	RsStat.stVal	IPRST[a]	Status of statistics reset for general IP traffic (excludes GOOSE traffic)
LLN0	Mod.stVal	I60MOD[c]	IEC 61850 mode/behavior status
LLN0	Health.stVal	RELAY_EN	Relay enabled
LLN0	Loc.stVal	LOC	Control authority at local (bay) level
LLN0	LocSta.stVal	LOCSTA	Control authority at station level
LGOS*n*[d]	NdsCom.stVal	GNCM*n*[e]	Subscription needs commissioning for GOOSE Message *n*. True if ConfRevNum does not match RxConfRevNum
LGOS*n*[d]	St.stVal	GST*n*[e]	Status of the subscription (True = active, False = not active) for GOOSE Message *n*
LGOS*n*[d]	SimSt.stVal	GSIM*n*[e]	Status showing that simulation messages are received and accepted for GOOSE Message *n*
LGOS*n*[d]	LastStNum.stVal	GLST*n*[e]	Last state number received (StNum) for GOOSE Message *n*
LGOS*n*[d]	LastSqNum.stVal	GLSQ*n*[e]	Last sequence number received (SqNum) for GOOSE Message *n*
LGOS*n*[d]	LastTal.stVal	GTAL*n*[e]	Last time-allowed-to-live received (TTL) for GOOSE Message *n*
LGOS*n*[d]	ConfRevNum.stVal	[f]	Expected configuration revision number for GOOSE Message *n*
LGOS*n*[d]	RxConfRevNum.stVal	GCNF*n*[e]	Received configuration revision number for GOOSE Message *n*
LGOS*n*[d]	ErrSt.stVal[g]	GERR*n*[e]	Error status of the subscription for GOOSE Message *n*
LGOS*n*[d]	OosCnt.stVal	GOOS*n*[e]	Number of out-of-sequence (OOS) errors for GOOSE Message *n*
LGOS*n*[d]	TalCnt.stVal	GTLC*n*[e]	Number of time-allowed-to-live violations for GOOSE Message *n*
LGOS*n*[d]	DecErrCnt.stVal	GDER*n*[e]	Number of messages that failed decoding for GOOSE Message *n*
LGOS*n*[d]	BufOvflCnt.stVal	GBFO*n*[e]	Number of messages lost because of buffer overflow for GOOSE Message *n*
LGOS*n*[d]	MsgLosCnt.stVal	GMSL*n*[e]	Number of messages lost due to OOS errors (estimated) for GOOSE Message *n*

Table G.40 Logical Device: CFG (Configuration) (Sheet 3 of 6)

Logical Node	Attribute	Data Source	Comment
LGOS*n*[d]	MaxMsgLos.stVal	GMXM*n*[e]	Maximum number of sequential messages lost because of OOS error (estimated) for GOOSE Message *n*
LGOS*n*[d]	InvQualCnt.stVal	GIDQ*n*[e]	Number of mapped data with invalid quality for GOOSE Message *n*
LGOS*n*[d]	RsStat.stVal	GRST*n*[e]	Status of statistics reset for GOOSE messages
LTIM	TmDT.stVal	TMDT[a]	Indicates daylight-saving time is currently in effect at the IED location
LTMS	TmAcc.stVal	TSACC[a]	Number of significant bits in the FractionOfSecond (an attribute of TimeStamp) 18: 4 µs accuracy (2^{-18}) 10: 1 ms accuracy (2^{-10}) 7: 10 ms accuracy (2^{-7}) 31: Unknown accuracy
LTMS	TmSrc.stVal	TSSRC[a]	Time-source identity If TmSrcTyp is PTP, TmSrc indicates the grandmaster clock class as defined by IEEE 1588-2008 If TmSrcTyp is SNTP, TmSrc indicates the IP address of the SNTP server For all other values of TmSrcTyp, TmSrc is set to NA
LTMS	SelTmSrcTyp.stVal	TSTYPE[a]	Type of the clock source as defined by Relay Word bits Time.SNTP_PriSrvr, Time.SNTP_BackupSrvr, Time.SyncOk, and Time.IRIG_Ok 1: Unknown 2: SNTP 3: PTP 4: IRIG-B
LTMS	SelTmSyn.stVal	TSSYN[a]	Traceability of the reference time to which the IED is synchronized 3: GlobalAreaClock—TmSrcTyp is PTP with grandmaster clock class of 6, TmSrcTyp is IRIG-B with IRIGC = C37.118, or TmSrcTyp is SNTP 2: LocalAreaClock—TmSrcTyp is PTP with grandmaster clock other than 6 (Future), or TmSrcTyp is IRIG-B with IRIGC ≠ C37.118 1: InternalClock—TmSrcTyp is unknown
LTMS	SelTmSynLkd.stVal	TSSYNLK[a]	Status of clock synchronization: 1: Locked 2: Unlocked for 0–10 seconds 3: Unlocked for 10–100 seconds 4: Unlocked for 100–1000 seconds 5: Unlocked for more than 1000 seconds
Functional Constraint = MX			
LGOS*n*[d]	TotDwnTm.instMag.f	GDWT*n*[e]	Total downtime in seconds for GOOSE Message *n*
LGOS*n*[d]	MaxDwnTm.instMag.f	GMXD*n*[e]	Maximum continuous downtime in seconds for GOOSE Message *n*
LTMS	SelTmTosPer.instMag.f	TSPER[a]	Duration, in milliseconds, between two consecutive top-of-second points on the synchronized time; TmTosPer is set to 0 for time sources other than high-accuracy PTP or IRIG-B
Functional Constraint = SP			
GOLCCH2	NetMod.setVal	NETMODE	Port 1 network operating mode setting 1: Fixed 2: Failover 3: Switched 4: PRP

Table G.40 Logical Device: CFG (Configuration) (Sheet 4 of 6)

Logical Node	Attribute	Data Source	Comment
IPLCCH1	NetMod.setVal	NETMODE	Port 1 network operating mode setting 1: Fixed 2: Failover 3: Switched 4: PRP
LGOS*n*[d]	GoCBRef.setSrcRef	[f]	Configured GOOSE control block reference for GOOSE Message *n*
LGOS*n*[d]	DatSet.setSrcRef	[f]	Configured data set reference for GOOSE Message *n*
LGOS*n*[d]	GoID.setVal	[f]	Configured ID for GOOSE Message *n*
LGOS*n*[d]	Addr.setVal	[f]	Configured multicast MAC address for GOOSE Message *n*
LGOS*n*[d]	VlanID.setVal	[f]	Configured VLAN ID for GOOSE Message *n*
LGOS*n*[d]	VlanPri.setVal	[f]	Configured VLAN priority for GOOSE Message *n*
LGOS*n*[d]	AppID.setVal	[f]	Configured APPID for GOOSE Message *n*
LLN0	MtlLev.setVal	MLTLEV	Multilevel mode of control authority
LTIM	TmOfsTmm.setVal	TMOFFS[a]	Offset of local time from UTC in minutes
LTIM	TmUseDT.setVal	TMUSEDT[a]	Set to True if daylight-saving time is enabled
LTIM	TmChgDT.setTm	TMCHGDT[a]	Local time of next change to daylight-saving time
LTIM	TmChgST.setTm	TMCHGST[a]	Local time of next change to standard time
Functional Constraint = SR			
LTRK1	SpcTrk.objRef	[h]	ACSI reference to the SPC object targeted in the request
LTRK1	SpcTrk.serviceType	[h, i]	Type of service requested or executed
LTRK1	SpcTrk.errorCode	[h, j]	ACSI service error status
LTRK1	SpcTrk.ctlVal	[h]	Control value in the request
LTRK1	SpcTrk.ctlNum	[h]	Control number in the request
LTRK1	SpcTrk.origin.orCat	[h]	Originator category value in the request
LTRK1	SpcTrk.origin.orIdent	[h]	Originator identity value in the request
LTRK1	SpcTrk.T	[h]	Time-stamp value in the request
LTRK1	SpcTrk.Test	[h]	Test value in the request
LTRK1	SpcTrk.Check	[h]	Check condition value in the request
LTRK1	SpcTrk.respAddCause	[h]	AddCause value returned in the response
LTRK1	DpcTrk.objRef	[h]	ACSI reference to the DPC object targeted in the request
LTRK1	DpcTrk.serviceType	[h, i]	Type of service requested or executed
LTRK1	DpcTrk.errorCode	[h, j]	ACSI service error status
LTRK1	DpcTrk.ctlVal	[h]	Control value in the request
LTRK1	DpcTrk.ctlNum	[h]	Control number in the request
LTRK1	DpcTrk.origin.orCat	[h]	Originator category value in the request
LTRK1	DpcTrk.origin.orIdent	[h]	Originator identity value in the request
LTRK1	DpcTrk.T	[h]	Time-stamp value in the request
LTRK1	DpcTrk.Test	[h]	Test value in the request
LTRK1	DpcTrk.Check	[h]	Check condition value in the request
LTRK1	DpcTrk.respAddCause	[h]	AddCause value returned in the response

Table G.40 Logical Device: CFG (Configuration) (Sheet 5 of 6)

Logical Node	Attribute	Data Source	Comment
LTRK1	EncTrk.objRef	h	ACSI reference to the ENC object targeted in the request
LTRK1	EncTrk.serviceType	h, i	Type of service requested or executed
LTRK1	EncTrk.errorCode	h, j	ACSI service error status
LTRK1	EncTrk.ctlVal	h	Control value in the request
LTRK1	EncTrk.ctlNum	h	Control number in the request
LTRK1	EncTrk.origin.orCat	h	Originator category value in the request
LTRK1	EncTrk.origin.orIdent	h	Originator identity value in the request
LTRK1	EncTrk.T	h	Time-stamp value in the request
LTRK1	EncTrk.Test	h	Test value in the request
LTRK1	EncTrk.Check	h	Check condition value in the request
LTRK1	EncTrk.respAddCause	h	AddCause value returned in the response
LTRK1	BrcbTrk.objRef	h	ACSI reference of the BRCB object targeted in the request
LTRK1	BrcbTrk.serviceType	h, i	Type of service requested or executed
LTRK1	BrcbTrk.errorCode	h, j	ACSI service error status
LTRK1	BrcbTrk.rptID	h	RptID attribute value in the request or target BRCB object
LTRK1	BrcbTrk.rptEna	h	RptEna attribute value in the request or target BRCB object
LTRK1	BrcbTrk.datSet	h	DatSet attribute value in the target BRCB object
LTRK1	BrcbTrk.confRev	h	ConfRev attribute value in the target BRCB object
LTRK1	BrcbTrk.optFlds	h	OptFlds attribute value in the request or target BRCB object
LTRK1	BrcbTrk.bufTm	h	BufTm attribute value in the request or target BRCB object
LTRK1	BrcbTrk.sqNum	h	SqNum attribute value in the target BRCB object
LTRK1	BrcbTrk.trgOps	h	TrgOps attribute value in the request or target BRCB object
LTRK1	BrcbTrk.intgPd	h	IntgPd attribute value in the request or target BRCB object
LTRK1	BrcbTrk.gi	h	GI attribute value in the request or target BRCB object
LTRK1	BrcbTrk.purgeBuf	h	PurgeBuf attribute value in the request or target BRCB object
LTRK1	BrcbTrk.entryID	h	EntryID attribute value in the request or target BRCB object
LTRK1	BrcbTrk.timeOfEntry	h	TimeOfEntry attribute value in the request or target BRCB object
LTRK1	UrcbTrk.objRef	h	ACSI reference of the URCB object targeted in the request
LTRK1	UrcbTrk.serviceType	h, i	Type of service requested or executed
LTRK1	UrcbTrk.errorCode	h, j	ACSI service error status
LTRK1	UrcbTrk.rptID	h	RptID attribute value in the request or target URCB object
LTRK1	UrcbTrk.rptEna	h	RptEna attribute value in the request or target URCB object
LTRK1	UrcbTrk.resv	h	Resv attribute value in the request or target URCB object
LTRK1	UrcbTrk.datSet	h	DatSet attribute value in the target URCB object
LTRK1	UrcbTrk.confRev	h	ConfRev attribute value in the target URCB object
LTRK1	UrcbTrk.optFlds	h	OptFlds attrbute value in the request or target URCB object
LTRK1	UrcbTrk.bufTm	h	BufTm attribute value in the request or target URCB object
LTRK1	UrcbTrk.sqNum	h	SqNum attribute value in the target URCB object
LTRK1	UrcbTrk.trgOps	h	TrgOps attribute value in the request or target URCB object

Table G.40 Logical Device: CFG (Configuration) (Sheet 6 of 6)

Logical Node	Attribute	Data Source	Comment
LTRK1	UrcbTrk.intgPd	h	IntgPd attribute value in the request or target URCB object
LTRK1	UrcbTrk.gi	h	GI attribute value in the request or target URCB object
LTRK1	SgcbTrk.objRef	h	ACSI reference of the SGCB object targeted in the request
LTRK1	SgcbTrk.serviceType	h, i	Type of service requested (SelectActiveSG)
LTRK1	SgcbTrk.errorCode	h, j	ACSI service error status
LTRK1	SgcbTrk.numOfSG	h	NumOfSG attribute value in the target SGCB object
LTRK1	SgcbTrk.actSG	h	ActSG attribute value in the request
LTRK1	SgcbTrk.editSG	h	EditSG attribute value in the target SGCB object (0)
LTRK1	SgcbTrk.cnfEdit	h	CnfEdit attribute value in the target SGCB object (FALSE)
LTRK1	SgcbTrk.lActTm	h	LActTm attribute value in the target SGCB object after activation of the settings group

[a] Internal data source and not available to the user.
[b] MMS controls to Mod.Oper are only accepted if IEC 61850 Mode/Behavior is enabled on the relay. Refer to Mode/Behavior Control on page G.21 for more details.
[c] I60MOD is an internal data source derived from the I850MOD analog quantity and is not available to the user.
[d] Where n = 1–16, corresponding to the first 16 GOOSE message subscriptions.
[e] Internal data source not available to the user. See GOOSE on page G.18 for more information.
[f] Data source defined in the IEC 61850 Configured IED Description (CID) file.
[g] Refer to Table 7.29 for a description of each enumeration.
[h] The value depends on the ACSI service type requested, the target object, and the error status.
[i] Refer to Table G.10 for the IEC 61850 service type enumeration.
[j] Refer to Table G.11 for the IEC 61850 ACSI service error.

SEL Nameplate Data

The CID file contains information that describes the physical device attributes according to IEC 61850 standards. The LN0 logical node of each logical device contains the Nameplate DOI (instantiated data object) with the following data.

Table G.41 SEL Nameplate Data

Data Attribute	Value
vendor	"SEL"
swRev	Contents of FID string from **ID** command
configRev	Always 0
1dNs	IEC 61850-7-4:2007A

Protocol Implementation Conformance Statement

The following tables are as shown in the IEC 61850 standard, Part 8-1, Section 24. Note that because the standard explicitly dictates which services and functions must be implemented to achieve conformance, only the optional services and functions are listed.

Table G.42 PICS for A-Profile Support (Sheet 1 of 2)

Profile		Client	Server	Value/Comment
A1	Client/Server	N	Y	
A2	GOOSE/GSE management	Y	Y	Only GOOSE, not GSSE Management

Table G.42 PICS for A-Profile Support (Sheet 2 of 2)

Profile		Client	Server	Value/Comment
A3	GSSE	N	N	
A4	Time Sync	N	N	

Table G.43 PICS for T-Profile Support

Profile		Client	Server	Value/Comment
T1	TCP/IP	N	Y	
T2	OSI	N	N	
T3	GOOSE/GSE	Y	Y	Only GOOSE, Not GSSE
T4	GSSE	N	N	
T5	Time Sync	Y	N	

Refer to the *ACSI Conformance Statements on page G.81* for information on the supported services.

MMS Conformance

The Manufacturing Message Specification (MMS) stack provides the basis for many IEC 61850 Protocol services. *Table G.44* defines the service support requirement and restrictions of the MMS services in the SEL-700 series relays supporting IEC 61850. Generally, only those services whose implementation is not mandatory are shown. Refer to the IEC 61850 standard Part 8-1 for more information.

Table G.44 MMS Service Supported Conformance (Sheet 1 of 3)

MMS Service Supported CBB	Client-CR	Server-CR
	Supported	Supported
status		Y
getNameList		Y
identify		Y
rename		
read		Y
write		Y
getVariableAccessAttributes		Y
defineNamedVariable		
defineScatteredAccess		
getScatteredAccessAttributes		
deleteVariableAccess		
defineNamedVariableList		
getNamedVariableListAttributes		Y
deleteNamedVariableList		
defineNamedType		
getNamedTypeAttributes		
deleteNamedType		
input		

Table G.44 MMS Service Supported Conformance (Sheet 2 of 3)

MMS Service Supported CBB	Client-CR	Server-CR
	Supported	Supported
output		
takeControl		
relinquishControl		
defineSemaphore		
deleteSemaphore		
reportPoolSemaphoreStatus		
reportSemaphoreStatus		
initiateDownloadSequence		
downloadSegment		
terminateDownloadSequence		
initiateUploadSequence		
uploadSegment		
terminateUploadSequence		
requestDomainDownload		
requestDomainUpload		
loadDomainContent		
storeDomainContent		
deleteDomain		
getDomainAttributes		Y
createProgramInvocation		
deleteProgramInvocation		
start		
stop		
resume		
reset		
kill		
getProgramInvocationAttributes		
obtainFile		Y
defineEventCondition		
deleteEventCondition		
getEventConditionAttributes		
reportEventConditionStatus		
alterEventConditionMonitoring		
triggerEvent		
defineEventAction		
deleteEventAction		
alterEventEnrollment		

Table G.44 MMS Service Supported Conformance (Sheet 3 of 3)

MMS Service Supported CBB	Client-CR	Server-CR
	Supported	Supported
reportEventEnrollmentStatus		
getEventEnrollmentAttributes		
acknowledgeEventNotification		
getAlarmSummary		
getAlarmEnrollmentSummary		
readJournal		
writeJournal		
initializeJournal		
reportJournalStatus		
createJournal		
deleteJournal		
fileOpen		Y
fileRead		Y
fileClose		Y
fileRename		
fileDelete		
fileDirectory		Y
unsolicitedStatus		
informationReport		Y
eventNotification		
attachToEventCondition		
attachToSemaphore		
conclude		Y
cancel		Y
getDataExchangeAttributes		
exchangeData		
defineAccessControlList		
getAccessControlListAttributes		
reportAccessControlledObjects		
deleteAccessControlList		
alterAccessControl		
reconfigureProgramInvocation		

Table G.45 lists specific settings for the MMS parameter Conformance Building Block (CBB).

Table G.45 MMS Parameter CBB

MMS Parameter CBB	Client-CR Supported	Server-CR Supported
STR1		YES
STR2		YES
VNAM		YES
VADR		YES
VALT		YES
TPY		YES
VLIS		YES
CEI		

The following Variable Access conformance statements are listed in the order specified in the IEC 61850 standard, Part 8-1. Generally, only those services whose implementation is not mandatory are shown. Refer to the IEC 61850 standard Part 8-1 for more information.

Table G.46 AlternateAccessSelection Conformance Statement

AlternateAccessSelection	Client-CR Supported	Server-CR Supported
accessSelection		YES
component		YES
index		
indexRange		
allElements		
alternateAccess		YES
selectAccess		YES
component		YES
index		
indexRange		
allElements		

Table G.47 VariableAccessSpecification Conformance Statement

VariableAccessSpecification	Client-CR Supported	Server-CR Supported
listOfVariable		YES
variableSpecification		YES
alternateAccess		YES
variableListName		YES

Table G.48 VariableSpecification Conformance Statement

VariableSpecification	Client-CR Supported	Server-CR Supported
name		YES
address		
variableDescription		
scatteredAccessDescription		
invalidated		

Table G.49 Read Conformance Statement

Read	Client-CR Supported	Server-CR Supported
Request		
specificationWithResult		
variableAccessSpecification		
Response		
variableAccessSpecification		YES
listOfAccessResult		YES

Table G.50 GetVariableAccessAttributes Conformance Statement

GetVariableAccessAttributes	Client-CR Supported	Server-CR Supported
Request		
name		
address		
Response		
mmsDeletable		YES
address		
typeSpecification		YES

Table G.51 DefineNamedVariableList Conformance Statement

DefineVariableAccessAttributes	Client-CR Supported	Server-CR Supported
Request		
variableListName		
listOfVariable		
variableSpecification		
alternateAccess		
Response		

Table G.52 GetNamedVariableListAttributes Conformance Statement

GetNamedVariableListAttributes	Client-CR Supported	Server-CR Supported
Request		
ObjectName		
Response		
mmsDeletable		YES
listOfVariable		YES
variableSpecification		YES
alternateAccess		YES

Table G.53 DeleteNamedVariableList

DeleteNamedVariableList	Client-CR Supported	Server-CR Supported
Request		
Scope		
listOfVariableListName		
domainName		
Response		
numberMatched		
numberDeleted		
DeleteNamedVariableList-Error		

GOOSE Services Conformance Statement

Table G.54 GOOSE Conformance

	Subscriber	Publisher	Value/Comment
GOOSE Services	YES	YES	
SendGOOSEMessage		YES	
GetGoReference			
GetGOOSEElementNumber			
GetGoCBValues		YES	
SetGoCBValues			
GSENotSupported			
GOOSE Control Block (GoCB)		YES	

ACSI Conformance Statements

Table G.55 ACSI Basic Conformance Statement (Sheet 1 of 2)

		Client/Subscriber	Server/Publisher	SEL-700G Support
Client-Server Roles				
B11	Server side (of Two-Party Application Association)	-	cl[a]	YES
B12	Client side (of Two-Party Application Association)	cl[a]	-	
SCMS Supported				
B21	SCSM: IEC 61850-8-1 used			YES
B22	SCSM: IEC 61850-9-1 used			
B23	SCSM: IEC 61850-9-2 used			
B24	SCSM: other			
Generic Substation Event Model (GSE)				
B31	Publisher side	-	O[b]	YES
B32	Subscriber side	O[b]	-	YES

Table G.55 ACSI Basic Conformance Statement (Sheet 2 of 2)

		Client/Subscriber	Server/Publisher	SEL-700G Support
Transmission of Sampled Value Model (SVC)				
B41	Published side	-	O[b]	
B42	Subscriber side	O[b]	-	

[a] c1 shall be mandatory if support for LOGICAL-DEVICE model has been declared.
[b] O = Optional.

Table G.56 ACSI Models Conformance Statement (Sheet 1 of 2)

		Client/Subscriber	Server/Publisher	SEL-700G Support
If Server Side (B11) Supported				
M1	Logical device	c2[a]	c2[a]	YES
M2	Logical node	c3[b]	c3[b]	YES
M3	Data	c4[c]	c4[c]	YES
M4	Data set	c5[d]	c5[d]	YES
M5	Substation	O[e]	O[e]	
M6	Setting group control	O[e]	O[e]	
Reporting				
M7	Buffered report control	O[e]	O[e]	YES
M7-1	sequence-number			YES
M7-2	report-time-stamp			YES
M7-3	reason-for-inclusion			YES
M7-4	data-set-name			YES
M7-5	data-reference			YES
M7-6	buffer-overflow			YES
M7-7	entryID			YES
M7-8	BufTm			YES
M7-9	IntgPd			YES
M7-10	G1			YES
M8	Unbuffered report control	O[e]	O[e]	YES
M8-1	sequence-number			YES
M8-2	report-time-stamp			YES
M8-3	reason-for-inclusion			YES
M8-4	data-set-name			YES
M8-5	data-reference			YES
M8-6	BufTm			YES
M8-7	IntgPd			YES
M8-8	GI			YES
Logging				
M9	Log control	O[e]	O[e]	
M9-1	IntgPd	O[e]	O[e]	
M10	Log	O[e]	O[e]	
M11	Control	M[f]	M[f]	YES

Table G.56 ACSI Models Conformance Statement (Sheet 2 of 2)

		Client/Subscriber	Server/Publisher	SEL-700G Support
If GSE (B31/32) Is Supported				
M12	GOOSE	O[e]	O[e]	YES
M12-1	entryID			YES
M12-2	DataRefInc			YES
M13	GSSE	O[e]	O[e]	
If GSE (B41/42) Is Supported				
M14	Multicast SVC	O[e]	O[e]	
M15	Unicast SVC	O[e]	O[e]	
M16	Time	M[f]	M[f]	
M17	File Transfer	O[e]	O[e]	

[a] c2 shall be "M" if support for LOGICAL-NODE model has been declared.
[b] c3 shall be "M" if support for DATA model has been declared.
[c] c4 shall be "M" if support for DATA-SET, Substitution, Report, Log Control, or Time model has been declared.
[d] c5 shall be "M" if support for Report, GSE, or SV models has been declared.
[e] O = Optional.
[f] M = Mandatory.

Table G.57 ACSI Services Conformance Statement (Sheet 1 of 3)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-700G Support
Server (Clause 6)					
S1	ServerDirectory	TP		M[a]	YES
Application Association (Clause 7)					
S2	Associate		M[a]	M[a]	YES
S3	Abort		M[a]	M[a]	YES
S4	Release		M[a]	M[a]	YES
Logical Device (Clause 8)					
S5	LogicalDeviceDirectory	TP	M[a]	M[a]	YES
Logical Node (Clause 9)					
S6	LogicalNodeDirectory	TP	M[a]	M[a]	YES
S7	GetAllDataValues	TP	O[b]	M[a]	YES
Data (Clause 10)					
S8	GetDataValues	TP	M[a]	M[a]	YES
S9	SetDataValues	TP	O[b]	O[b]	
S10	GetDataDirectory	TP	O[b]	M[a]	YES
S11	GetDataDefinition	TP	O[b]	M[a]	YES
Data Set (Clause 11)					
S12	GetDataSetValues	TP	O[b]	M[a]	YES
S13	SetDataSetValues	TP	O[b]	O[b]	
S14	CreateDataSet	TP	O[b]	O[b]	
S15	DeleteDataSet	TP	O[b]	O[b]	
S16	GetDataSetDirectory	TP	O[b]	O[b]	YES

Table G.57 ACSI Services Conformance Statement (Sheet 2 of 3)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-700G Support
Substitution (Clause 12)					
S17	SetDataValues	TP	M[a]	M[a]	
Setting Group Control (Clause 13)					
S18	SelectActiveSG	TP	O[b]	O[b]	
S19	SelectEditSG	TP	O[b]	O[b]	
S20	SetSGvalues	TP	O[b]	O[b]	
S21	ConfirmEditSGVal	TP	O[b]	O[b]	
S22	GetSGValues	TP	O[b]	O[b]	
S23	GetSGCBValues	TP	O[b]	O[b]	
S24	Report	TP	c6[c]	c6[c]	YES
S24-1	data-change (dchg)				YES
S24-2	qchg-change (qchg)				YES
S24-3	data-update (dupd)				
S25	GetBRCBValues	TP	c6[c]	c6[c]	YES
S26	SetBRCBValues	TP	c6[c]	c6[c]	YES
Unbuffered Report Control Block (URCB)					
S27	Report	TP	c6[c]	c6[c]	YES
S27-1	data-change (dchg)				YES
S27-2	qchg-change (qchg)				YES
S27-3	data-update (dupd)				
S28	GetURCBValues	TP	c6[c]	c6[c]	YES
S29	SetURCBValues	TP	c6[c]	c6[c]	YES
Logging (Clause 14)					
Log Control Block					
S30	GetLCBValues	TP	M[a]	M[a]	
S31	SetLCBValues	TP	O[b]	M[a]	
LOG					
S32	QueryLogByTime	TP	c7[d]	M[a]	
S33	QueryLogByEntry	TP	c7[d]	M[a]	
S34	GetLogStatusValues	TP	M[a]	M[a]	
Generic Substation Event Model (GSE) (Clause 14.3.5.3.4)					
GOOSE-Control-Block					
S35	SendGOOSEMessage	MC	c8[e]	c8[e]	YES
S36	GetReference	TP	O[b]	c9[f]	
S37	GetGOOSEElement				
Number	TP	O[b]	c9[f]		
S38	GetGoCBValues	TP	O[b]	O[b]	YES
S39	SetGoCBValues	TP	O[b]	O[b]	
ONLY					
GSSE-Control-Block					
S40	SendGSSEMessage	MC	c8[e]	c8[e]	
S41	GetReference	TP	O[b]	c9[f]	
S42	GetGSSEElement				

Table G.57 ACSI Services Conformance Statement (Sheet 3 of 3)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-700G Support
Number	TP	Ob	c9[f]		
S43	GetGsCBValues	TP	O[b]	O[b]	
S44	GetGsCBValues	TP	O[b]	O[b]	
Transmission of Sample Value Model (SVC) (Clause 16)					
Multicast SVC					
S45	SendMSVMessage	MC	c10[g]	c10[g]	
S46	GetMSVCBValues	TP	O[b]	O[b]	
S47	SetMSVCBValues	TP	O[b]	O[b]	
Unicast SVC					
S48	SendUSVMessage	MC	c10[g]	c10[g]	
S49	GetUSVCBValues	TP	O[b]	O[b]	
S50	SetUSVCBValues	TP	O[b]	O[b]	
Control (Clause 16.4.8)					
S51	Select		M[a]	O[b]	
S52	SelectWithValue	TP	Ma	O[b]	YES
S53	Cancel	TP	O[b]	M[a]	YES
S54	Operate	TP	M[a]	M[a]	YES
S55	Command-Termination	TP	M[a]	M[a]	YES
S56	TimeActivated-Operate	TP	O[b]	O[b]	
File Transfer (Clause 20)					
S57	GetFile	TP	O[b]	M[a]	
S58	SetFile	TP	O[b]	O[b]	
S59	DeleteFile	TP	O[b]	O[b]	
S60	GetFileAttributeValues	TP	O[b]	M[a]	
Time (Clause 5.5)					
T1	Time resolution of internal clock (nearest negative power of 2 in seconds)				20 (1 µs)
T2	Time accuracy of internal clock				7 (10 ms) for SNTP 18 (4 µs) for IRIG-B
	T1				YES (for IRIG-B)
	T2				YES (for IRIG-B)
	T3				YES (for IRIG-B)
	T4				YES (for IRIG-B)
T3	Supported Time Stamp resolution (nearest negative power of 2 in seconds)				7 (10 ms) for SNTP 18 (4 µs) for IRIG-B

[a] M = Mandatory.
[b] O = Optional.
[c] c6 shall declare support for at least one (BRCB or URCB).
[d] c7 shall declare support for at least one (QueryLogByTime or QueryLogAfter).
[e] c8 shall declare support for at least one (SendGOOSEMessage or SendGSSEMessage).
[f] c9 shall declare support if TP association is available.
[g] c10 shall declare support for at least one (SendMSVMessage or SendUSVMessage).

Potential Client and Automation Application Issues With Edition 2 Upgrades

The following are issues that IEC 61850 Edition 1 (Ed1)-based client or automation applications may experience with IEC 61850 Edition 2 (Ed2) ICD and firmware changes. However, such issues may be resolved by reconfiguring the client or automation application or worked around by restoring the Ed1 (CID) configuration. None of these should prevent a client application from dynamically discovering the data in the IED as long as the application adheres to the specification of the standard. Note that upgrading to Ed2 firmware will not break existing Ed1 configurations (CID files) in the field, nor require loading an Ed2 version of the CID file.

Unexpected Error Messages

Some MMS and control errors have been changed in Ed2. Hence, the firmware now issues only the Ed2-compliant errors. Clients or automation applications that rely on the Ed1-compliant errors will not function correctly. You can resolve this by reconfiguring the client or automation application to accept Ed2-compliant errors.

Missing or Unknown Data Objects and Attributes

Ed2 has changed some data object and attribute names, as well as the data types of some attributes. Ed2 also prohibits the use of proprietary CDCs. See *Logical Nodes on page G.27* and the logical nodes tables in each product-specific manual to determine the Ed2 names. This may cause the failure of clients or automation applications that rely on the Ed1 names. A workaround is to use the Ed1 version of the CID file, if available, to configure the IED. You can also resolve this by reconfiguring the client or automation application to accept the Ed2 names.

Unable to Find Operate Time-Out

A proprietary method was used to specify the operate time-out of control objects in the CID files. A client or automation application that relies on this proprietary method will fail to find the operate time-out in the CID file. A workaround is to use the Ed1 CID file to configure the IED. You can also resolve this by reconfiguring the client or automation application to accept the Ed2 control object operate time-outs.

Unexpected Control Block Data Attribute Type

The string type data attributes in control blocks (RptID, DatSet, etc.) have been changed from a maximum length of 65 to 129 characters, i.e., VisString65 to VisString129. Some clients and automation applications might see this as an error when the type is reported in the MMS GetVariableAccessAttributes response. You can resolve this by reconfiguring the client or automation application.

Unexpected Reports

Ed2 requires report buffering to start when the device is turned on, unlike in the Ed1 implementation where report buffering started after the first report enable. If a client or automation application relies on the Ed1 behavior, it might fail or indicate an error if the IED sends buffered reports immediately after the first enable. You can resolve this by reconfiguring the client or automation application.

Failure to Reselect a Control Object Before the Timeout

In Ed1, if a client reselected a control object before the select-before-operate time-out expired, the reselection would succeed and cause the selected time-out to restart. According to Ed2, this reselection is supposed to fail. Ed1-based clients or automation applications that rely on successful reselection might operate incorrectly. You can resolve this by reconfiguring the client or automation application.

Test Control Commands Fail Immediately

In Ed1, if the test attribute was set in a control command structure, the relay would accept the command but perform no action on the target control object. With enhanced control models, the IED would eventually report an operate timeout error after the operate time-out expired. However, in Ed2, any such test commands will fail immediately with an error indicating that the command is blocked because the IED is not in the appropriate mode. Clients or automation applications that depend on the Ed1 behavior might fail. You can resolve this by reconfiguring the client or automation application.

No Reports

Ed2 specifies that no reports are to be generated for a deadbanded attribute if the deadband is set to 0. Previously in Ed1, a deadband of 0 would cause the relay to generate reports for any change in the instantaneous value. Ed1-based clients or automation applications might not operate correctly because of the lack of reports. You can resolve this by reconfiguring the client or automation application.

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Appendix H
IEC 60870-5-103 Communications

Overview

The SEL-700G Generator and Intertie Protection Relay provides the IEC 60870-5-103 interface for direct serial connections to the device.

This section covers the following topics:

➤ *Introduction to IEC 60870-5-103 on page H.1*
➤ *IEC 60870-5-103 in the SEL-700G on page H.9*
➤ *IEC 60870-5-103 Documentation on page H.12*

Introduction to IEC 60870-5-103

The International Electrotechnical Commission (IEC) 60870-5 is a protocol standard developed by the IEC Technical Committee of teleprotection, telecontrol, and telecommunications for electrical engineering and power system automation. It defines systems used for supervisory control and data acquisition (SCADA), including details related to communications between devices. IEC 60870-5-103 is a companion standard that allows interoperability between devices in a control system and protection equipment. The IEC 60870-5 standard consists of the documents listed in *Table H.1*.

Table H.1 IEC 60870-5 Standard Documents

Document	Description
IEC 60870-5-1	Transmission Frame Formats
IEC 60870-5-2	Data Link Transmission Services
IEC 60870-5-3	General Structure of Application Data
IEC 60870-5-4	Definition and Coding of Information Elements
IEC 60870-5-5	Basic Application Functions
IEC 60870-5-6	Guidelines for Conformance Testing IEC 60870-5 Companion Standards
IEC 60870-5-7	Security extensions to IEC 60870-5-1010 and IEC 60870-5-104 protocols

The IEC 60870-5-103 document contains the information necessary for successful implementation of this protocol. SEL strongly recommends that anyone involved with the design, installation, configuration, or maintenance of IEC 60870-5-103 systems be familiar with the appropriate sections of this document.

IEC 60870-5 was designed for wide-spread telecontrol networks. It is an international standard based on an international accepted and proven enhanced performance architecture (EPA) model (see *Table H.2*). The standard provides a balance between efficiency and reliability while using minimal hardware.

Table H.2 IEC 60870-5 Enhanced Performance Architecture Model

Layer	Layer Type
7	Application
•	•
•	•
•	•
2	Datalink
1	Physical

Layer 7 implementation is described in the IEC 60870-5-3 and IEC 60870-5-4 sections of the standard. Layer 2 implementation is described in the IEC 60870-5-2 and IEC 60870-5-1 sections of the standard.

The history of IEC 60870-5 spans from 1990 to 2006. *Table H.3* shows the history during this time period. The first five sections are the basic parts of the standard. The next six describe the companion standards, and the last two sections are test procedures of the standard.

Table H.3 History of IEC 60870-5

Section	Description
IEC 60870-5-1	Transmission Frame Formats
IEC 60870-5-2	Data Link Transmission Services
IEC 60870-5-3	General Structure of Application Data
IEC 60870-5-4	Definition and Coding Information Elements
IEC 60870-5-5	Basic Application Functions
IEC 60870-5-101	CS For Basic Telecontrol Tasks
IEC 60870-5-102	CS For Transmission Of Integrated Totals In Electric Power Systems
IEC 60870-5-103	CS for Informative Interface Of Protection Equipment
IEC 60870-5-104	Network Access For TCS101 Using Standard Transport Profiles
IEC 60870-5-101 Ed 2	Addendums Incorporated In Standard
IEC 60870-5-104 Ed 2	Addendums Incorporated In Standard
IEC 60870-5-601	Conformance Test Procedures For TCS 101
IEC 60870-5-604	Conformance Test Procedures For TCS 104

Data Handling

Master/Slave Communication

The IEC 60870-5-103 standard is such that the IED only sends a message when the Master asks for it. Communication is set up by the Master and the Master controls the communication between the Master and the IED.

Interoperability

The method of data exchange in the SEL-700G involves Application Service Data Units (ASDUs) along with application procedures for transmission of standardized data messages (see *Table H.4*). The data are recognized by any IEC 60870-5-103 Master because the application data take the form of an IEC 60870-5-103 data type and pairs with an IEC 60870-5-103 address, resulting in device interoperability.

Table H.4 SEL-700G ASDU Types

ASDU Type	Description
1	Time Tagged Message
2	Time Tagged Message With Relative Time
4	Time Tagged Measurands With Relative Time
5	Identification
6	Time Synchronization
7	General Interrogation Start
8	General Interrogation Termination
9	Measurands II
20	General Command
205	Non-Standard (defined below)

Type Identification	0xCD (205)							
Variable Structure Qualifier	0x81							
Cause of Transmission	0x01							
Device Address	ADDR							
Function Type	FUN							
Information Number	INF							
Information Element Meter value: 29-bit signed integer ER: 0 valid, 1 invalid	2^7	•	•	•	•	•	•	2^0
	2^{15}	•	•	•	•	•	•	2^8
	2^{23}	•	•	•	•	•	•	2^{16}
	0	ER	0	-2^{28}	•	•	•	2^{24}
Four Octet Binary Time	Defined in 60870-5-103, 7.2.6.28							

Table H.5 lists the available category map settings in the SEL-700G. When configuring the settings with the command line, categories can be selected by entering “>” or “<”.

Table H.5 IEC 60870-5-103 Category Map Settings

Setting Prompt	Scaling/Nominal Value Range	Information Number Range	Function Type Range	Setting Name
103 Binary Input Label	NA	0–255	0–255	103BI00
103 Binary Input Label	NA	0–255	0–255	103BI01
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
103 Binary Input Label	NA	0–255	0–255	103BI99
103 Binary Target Label	NA	0–255	0–255	103BT00
103 Binary Target Label	NA	0–255	0–255	103BT01
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
103 Binary Target Label	NA	0–255	0–255	103BT07
103 Binary Control Label	NA	0–255	0–255	103BO00
103 Binary Control Label	NA	0–255	0–255	103BO01
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
103 Binary Control Label	NA	0–255	0–255	103BO31
103 Fault Analog Label	0.000–99999	0–255	0–255	103FA00
103 Fault Analog Label	0.000–99999	0–255	0–255	103FA01
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
103 Fault Analog Label	0.000–99999	0–255	0–255	103FA31
103 Measurand Label	0.001–999999	0–255	0–255	3MLB000
103 Measurand Label	0.001–999999	0–255	0–255	3MLB001
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
103 Measurand Label	0.001–999999	0–255	0–255	3MLB127
103 Meter Quantity Label	0.000–99999	0–255	0–255	103MQ00
103 Meter Quantity Label	0.000–99999	0–255	0–255	103MQ01
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
103 Meter Quantity Label	0.000–99999	0–255	0–255	103MQ31

Cause of Transmission

The Cause of Transmission (COT) represents the reason the SEL-700G sends a message to the Master. See *Table H.6* for the possible COTs.

Table H.6 IEC 60870-5-103 Cause Of Transmission

Cause of Transmission	Description
1	Spontaneous Events
2	Cyclic
3	Reset Frame Count Bit (FCB)
4	Reset Communication Unit (CU)
5	Start/Restart
6	Power On
7	Test Mode
8	Time Synchronization
9	Initiation Of General Interrogation
10	Termination Of General Interrogation
12	Remote Operation
20	General Command (Control Direction), Positive Acknowledgment Of Command (Monitor)
21	Negative Acknowledgment Of Command (Monitor)
31	Disturbance Recorder
40–44	Generic Commands And Data

Information Number

The Information Number (INF) is one of the two octets of the information object identifier. See *Table H.7* for the range and description of Information Numbers in IEC 60870-5-103.

Table H.7 IEC 60870-5-103 Information Numbers (Sheet 1 of 2)

Function Type	Description
Monitor Direction	
0–15	System Functions
16–31	Status
32–47	Supervision
48–63	Earth Fault
64–127	Short Circuit
128–143	Auto Reclose
144–159	Measurands
160–239	Not Used
240–255	Generic Functions

Table H.7 IEC 60870-5-103 Information Numbers (Sheet 2 of 2)

Function Type	Description
Control Direction	
0–15	System Functions
16–31	General Commands
32–239	Not Used
240–255	Generic Functions

Function Type

The Function Type (FUN) is the second of the two octets of the information object identifier.

Together, the pair [INF, FUN] distinctly characterizes each point within each data class. *Table H.8* and *Table H.9* list the Standard Function Types and Data Map for the IEC 60870-5-103 standard.

Table H.8 IEC 60870-5-103 Standard Function Types

Function Type	Description
128	Distance protection
160	Overcurrent protection
176	Transformer Differential Protection
192	Line Differential Protection
254	Generic Function Type
255	Global Function Type

Table H.9 IEC 60870-5-103 Data Map (Sheet 1 of 3)

INF	Description	GI	ASDU Type	COT	FUN
System functions in monitor direction					
0[a]	End of general interrogation	–	8	10	255
0[a]	Time synchronization	–	6	8	255
2[a]	Reset FCB	–	5	3	According to main FUN
3[a]	Reset CU	–	5	4	According to main FUN
4[a]	Start/restart	–	5	5	According to main FUN
5[a]	Power on	–	5	6	According to main FUN
Status indications in monitor direction[b]					
16	Auto-recloser active	Yes	1	1,7,9,11,12,20,21	128, 160, 192
17	Teleprotection active	Yes	1	1,7,9,11,12,20,21	128, 160
18	Protection active	Yes	1	1,7,9,11,12,20,21	128, 160, 176, 192
19	LED Reset	–	1	1,7,11,12,20,21	128, 160, 176, 192
20	Monitor direction blocked	Yes	1	9,11	128, 160, 176, 192
21	Test mode	Yes	1	9,11	128, 160, 176, 192
22	Local parameter setting	Yes	1	9,11	128, 160, 176, 192

Table H.9 IEC 60870-5-103 Data Map (Sheet 2 of 3)

INF	Description	GI	ASDU Type	COT	FUN
23	Characteristic 1[c]	Yes	1	1,7,9,11,12,20,21	128
24	Characteristic 2[c]	Yes	1	1,7,9,11,12,20,21	128
25	Characteristic 3[c]	Yes	1	1,7,9,11,12,20,21	128
26	Characteristic 4[c]	Yes	1	1,7,9,11,12,20,21	128
27	Auxiliary input 1[d]	Yes	1	1,7,9,11	128, 160, 176, 192
28	Auxiliary input 2[d]	Yes	1	1,7,9,11	128, 160, 176, 192
29	Auxiliary input 3[d]	Yes	1	1,7,9,11	128, 160, 176, 192
30	Auxiliary input 4[d]	Yes	1	1,7,9,11	128, 160, 176, 192
Supervision indications in monitor direction[b]					
32	Measurand supervision I	Yes	1	1,7,9	128, 160
33	Measurand supervision V	Yes	1	1,7,9	128, 160
35	Phase sequence supervision	Yes	1	1,7,9	128, 160
36	Trip circuit supervision	Yes	1	1,7,9	128, 160, 176, 192
37	I>> back-up operation	Yes	1	1,7,9	128
38	Voltage transformer fuse failure	Yes	1	1,7,9	128, 160
39	Teleprotection disturbed	Yes	1	1,7,9	128, 160, 192
46	Group warning	Yes	1	1,7,9	128, 160, 176, 192
47	Group alarm	Yes	1	1,7,9	128, 160, 176, 192
Earth fault indications in monitor direction[b]					
48	Earth Fault L_1	Yes	1	1,7,9	128, 160
49	Earth Fault L_2	Yes	1	1,7,9	128, 160
50	Earth Fault L_3	Yes	1	1,7,9	128, 160
51	Earth fault forward, i.e., line	Yes	1	1,7,9	128, 160
52	Earth fault reverse, i.e., busbar	Yes	1	1,7,9	128, 160
Fault indications in monitor direction[e]					
64	Start/pick-up L[b]	Yes	2	1,7,9	128, 160, 192
65	Start/pick-up L[c]	Yes	2	1,7,9	128, 160, 192
66	Start/pick-up L[d]	Yes	2	1,7,9	128, 160, 192
67	Start/pick-up N	Yes	2	1,7,9	128, 160, 192
68	General trip	–	2	1,7	128, 160, 176, 192
69	Trip L_1	–	2	1,7	128, 160, 176, 192
70	Trip L_2	–	2	1,7	128, 160, 176, 192
71	Trip L_3	–	2	1,7	128, 160, 176, 192
72	Trip I>> (back-up operation)	–	2	1,7	128, 160, 176, 192
73	Fault Location X in ohms	–	4	1,7	128
74	Fault forward / line	–	2	1,7	128, 160
75	Fault reverse / busbar	–	2	1,7	128, 160
76	Teleprotection signal transmitted	–	2	1,7	128, 160
77	Teleprotection signal received	–	2	1,7	128, 160
78	Zone 1	–	2	1,7	128

Table H.9 IEC 60870-5-103 Data Map (Sheet 3 of 3)

INF	Description	GI	ASDU Type	COT	FUN
79	Zone 2	–	2	1,7	128
80	Zone 3	–	2	1,7	128
81	Zone 4	–	2	1,7	128
82	Zone 5	–	2	1,7	128
83	Zone 6	–	2	1,7	128
84	General start / pick-up	Yes	2	1,7,9	128, 160, 176, 192
85	Breaker failure	–	2	1,7	128, 160
86	Trip measuring system L_1	–	2	1,7	176
87	Trip measuring system L_2	–	2	1,7	176
88	Trip measuring system L_3	–	2	1,7	176
89	Trip measuring system E	–	2	1,7	176
90	Trip I>	–	2	1,7	160
91	Trip I>>	–	2	1,7	160
92	Trip IN>	–	2	1,7	160
93	Trip IN>>	–	2	1,7	160
Auto-recloser indications in monitor direction[b]					
128	Circuit breaker on by Auto-recloser	–	1	1,7	128, 160, 192
129	Circuit breaker on by long-time Auto-recloser	–	1	1,7	128, 160, 192
130	Auto-recloser blocked	Yes	1	1,7,9	128, 160, 192
Measurands in monitor direction					
144	Measurand I	–	3.1	2,7	128, 160
145	Measurands I, V	–	3.2	2,7	128, 160
146	Measurands I, V, P, Q	–	3.3	2,7	128
147	Measurands I_N, V_{EN}	–	3.4	2,7	128, 160
148	Measurands $I_{L1,2,3}$, $V_{L1,2,3}$, P, Q, f	–	9	2,7	128
System functions in control direction					
0[a]	Initiation of General Interrogation		7	9	255
0[a]	Time synchronization		6	8	255
General commands in control direction[f]					
16	Auto-recloser on/off	ON/OFF	20	20	128, 160, 192
65	Teleprotection on/off	ON/OFF	20	20	128, 160
66	Protection on/off	ON/OFF	20	20	128, 160, 176, 192
67	LED Reset	ON	20	20	128, 160, 176, 192
68	Activate characteristic 1[c]	ON	20	20	128
69	Activate characteristic 2[c]		20	20	128
70	Activate characteristic 3[c]		20	20	128
71	Activate characteristic 4[c]		20	20	128

[a] The SEL-700G supports these points at the specified INF and FUN.
[b] Referred to as Binary Data in the SEL-700G.
[c] Mapped to settings group indications and control in the SEL-700G.
[d] Mapped to device contact inputs in the SEL-700G.
[e] Referred to as Binary Targets and other Fault Information in the SEL-700G.
[f] Referred to as Binary Controls in the SEL-700G.

IEC 60870-5-103 in the SEL-700G

The IEC 60870-5-103 protocol settings in the SEL-700G contain five parameters that must be set properly to get the most out of the protocol. These parameters are called 103ADDR, 103CYC, 103ACYC, 103ATRI, and 103TIME. *Table H.10* describes each of these parameters.

Table H.10 SEL-700G IEC 60870-5-103 Port Settings

Parameter	Description	Range/Valid Input
103ADDR	Link layer address of the product	0–254
103CYC	Period at which to report cyclic data (measurands)	1–3600 seconds
103ACYC	Meter quantity period to report type ASDU 205 data	OFF, 1–3600 seconds
103ATRI	Relay Word bit used as a meter quantity reporting trigger for type ASDU 205 data	1 Relay Word bit
103TIME	Time synchronization enable	Y, N

The IEC 60870-5-103 standard in the SEL-700G provides six category types namely, Binary Inputs, Binary Targets, Binary Controls, Measurands, Fault Analogs, and Meter Quantities. Each data point within each class type requires an Information Number and a Function Type. Binary Inputs, Binary Targets, and Binary Controls are defined within the map by a Label Name followed by an Information Number followed by a Function Type. Measurands, Fault Analogs, and Meter Quantities are defined within the map by a Label Name followed by the Scale Factor/Nominal Value followed by the Information Number followed by the Function Type. The Nominal Value pertains only to Measurands and is defined within the following formula.

$$\text{Value seen by Master} = \frac{4096 \bullet \text{Label\_Value}}{2.4 \bullet \text{Nominal\_Value}}$$

Consider for example frequency in the Measurand point (FREQ, 60, 0, 1). Conceptually, when the frequency is 60 Hz, which is 0.4167 of 2.4 • Nominal Value (2.4 • 60 = 144), then the value 0.4167 gets encoded as a 13-bit, fixed-point number that has the same bit-wise representation as the integer that is equal to the Value seen by Master or

$$\frac{4096 \bullet \text{FREQ}}{2.4 \bullet 60\ \text{Hz}}$$

Binary Inputs

In the SEL-700G, binary data are reported as ASDU type 1 (Time Tagged Message). Those points, monitored by the SER function of the device, have their changes reported as COT type 1 (Spontaneous Events). The format of a binary input point within the binary input map is “Label, [INF, FUN].” The Label represents any valid binary input point accepted by the SEL-700G. The INF parameter is an integer in the range of 0 to 255. Similarly, the FUN parameter is an integer in the range of 0 to 255. The Label can be entered by itself with the SEL-700G choosing default parameters for INF and FUN. The default parameter for INF is an available, unique value that is selected by the SEL-700G. The default parameter for FUN is 250.

The [INF, FUN] pair needs to either be entered together or not entered at all. The SEL-700G does not accept only one member of the [INF, FUN] pair. Label, INF, and FUN can all be manually entered. No other combinations are valid with the SEL-700G.

Binary Targets

The binary targets are Relay Word bits within the SEL-700G under row zero. They also appear as LEDs on the front panel of the SEL-700G. There are eight binary targets in the SEL-700G namely, ENABLED, TRIP_LED, TLED_01, TLED_02, TLED_03, TLED_04, TLED_05, and TLED_06. In the SEL-700G, binary targets are reported as ASDU type 2 (Time Tagged Message with Relative Time) with COT type 1 (Spontaneous Events). The format of a binary target point within the binary target map is "Label, [INF, FUN]." Label represents any valid binary target point accepted by the SEL-700G. The INF parameter is an integer in the range of 0 to 255. Similarly, the FUN parameter is an integer in the range of 0 to 255. Label can be entered by itself with the SEL-700G choosing default parameters for INF and FUN. The default parameter for INF is an available, unique value that is selected by the SEL-700G. The default parameter for FUN is 250.

The [INF, FUN] pair needs to either be entered together or not entered at all. The SEL-700G does not accept only one member of the [INF, FUN] pair. Also, Label, INF, and FUN can all be manually entered. No other combinations are valid with the SEL-700G.

Fault Analogs

The fault analogs are analog quantities in the SEL-700G used to describe faults recognized by the relay, such as fault current or fault location. These quantities are listed in *Table H.11*. In the SEL-700G, fault analog quantities are reported as ASDU type 4 (Time Tagged Measurands with Relative Time) with COT type 1 (Spontaneous Events). The format of a fault analog point within the fault analog map is "Label, [Scaling, [INF, FUN]]." Label represents any valid fault analog point accepted by the SEL-700G. Scaling is the scaling factor applied to the point prior to being sent out of the relay via the protocol. Its range is 0.000 to 99999.000. The INF parameter is an integer in the range of 0 to 255. Similarly, the FUN parameter is an integer in the range of 0 to 255. Label can be entered by itself with the SEL-700G choosing default parameters for Scaling, INF, and FUN. The Label and Scaling values can also be entered together with the SEL-700G choosing default parameters for the INF and FUN. The default parameter for INF is an available, unique value that is selected by the SEL-700G. The default parameter for FUN is 250. The default value for Scaling is 1.

The [INF, FUN] pair needs to either be entered together or not entered at all. The SEL-700G does not accept only one member of the [INF, FUN] pair. If the [INF, FUN] pair has been entered, then Scaling must also be entered.

For a single Master/SEL-700G session, the SEL-700G stores as many as three sets of event data into a buffer. If the buffer is full as a result of multiple events with the poll cycle, any new event data are discarded. When the buffered data have been reported (using the first-in, first-out (FIFO) principle) to the Master, those data are removed from the buffer to make room for the next event.

Table H.11 SEL-700G Analog Fault Quantities (Sheet 1 of 2)

Analog Fault Quantity	Description
FFREQX	X-side frequency of fault event
FFREQY	Y-side frequency of fault event
FIAX	X-side A-phase current of fault event

Table H.11 SEL-700G Analog Fault Quantities (Sheet 2 of 2)

Analog Fault Quantity	Description
FIBX	X-side B-phase current of fault event
FICX	X-side C-phase current of fault event
FIGX	X-side ground current of fault event
FIAY	Y-side A-phase current of fault event
FIBY	Y-side B-phase current of fault event
FICY	Y-side C-phase current of fault event
FIGY	Y-side ground current of fault event
FIN	Neutral current of fault event

Binary Controls

In the SEL-700G, two types of controls are permitted under this protocol. They are as follows:

- ➤ Latching Single-Point: On/Off operations latch the point to 1 or 0, respectively. The points format is (Label, INF, FUN)
- ➤ Pulsing Single-Point: On operation pulses the point or triggers the point. Off has no effect. The point format is (Label, INF, FUN)

When controls are sent to the SEL-700G successfully, the relay responds with ASDU type 1 (Time Tagged Message) and COT type 20 (Positive Acknowledgment on Command) as well as with ASDU type 1 (Time Tagged Message) and COT type 12 (Remote Operation) if the control was sent remotely. The format of a binary control point within the binary control map is “Label, [INF, FUN].” Label represents any valid binary control point accepted by the SEL-700G. The INF parameter is an integer in the range of 0 to 255. Similarly, the FUN parameter is an integer in the range of 0 to 255. Label can be entered by itself with the SEL-700G choosing default parameters for INF and FUN. The default parameter for INF is an available, unique value to use that is selected by the SEL-700G. The default parameter for FUN is 250.

The [INF, FUN] pair needs to either be entered together or not entered at all. The SEL-700G does not accept only one member of the [INF, FUN] pair. Also, the Label, INF, and FUN can all be manually entered. No other combinations are valid with the SEL-700G.

Measurands

In the SEL-700G, a measurand is defined as a group of at most 16 analog quantities with the same [INF, FUN] pair. The SEL-700G allows at most 8 measurands even if the measurand map is not completely filled with analog quantities (total of 128). Measurands are refreshed for the Master at the expiration of the 103CYC parameter and sent to the Master, once polled by the Master.

In the SEL-700G, measurands are reported as ASDU type 9 (Measurands II) with COT type 2 (Cyclic). The format of an analog quantity within a measurand in the measurand map is “Label, Nominal, [INF, FUN].” Label represents any valid analog quantity accepted by the SEL-700G. Nominal is the nominal value applied to the point prior to being sent out of the relay via the protocol. Its range is 0.001 to 999999.000. The INF parameter is an integer in the range of 0 to 255. Similarly, the FUN parameter is an integer in the range of 0 to 255. You are required to enter the Nominal value. The Label and Nominal values can be entered by themselves with the SEL-700G choosing default parameters for INF and FUN. The default parameter for INF is an available, unique value to use that is selected by the SEL-700G. The default parameter for FUN is 250.

The [INF, FUN] pair needs to either be entered together or not entered at all. The SEL-700G does not accept only one member of the [INF, FUN] pair. And of course, the Label, Nominal, INF, and FUN can all be manually entered. No other combinations are valid with the SEL-700G.

Meter Quantities

The meter quantities are analog quantities in the SEL-700G. In the SEL-700G, meter quantities are reported as ASDU type 205 (Non-Standard) with COT type 1 (Spontaneous Events). The format of a meter quantity point within the meter quantity map is "Label, [Scaling, [INF, FUN]]." Label represents any valid meter quantity point accepted by the SEL-700G. Scaling is the scaling factor applied to the point prior to being sent out of the relay via the protocol. Its range is 0.000 to 99999. The INF parameter is an integer in the range of 0 to 255. Similarly, the FUN parameter is an integer in the range of 0 to 255. Label can be entered by itself with the SEL-700G choosing default parameters for the Scaling, INF, and FUN. Label and Scaling can also be entered together with the SEL-700G choosing default parameters for the INF and FUN. The default parameter for INF is an available, unique value to use that is selected by the SEL-700G. The default parameter for FUN is 250. The default value for Scaling is 1.

In any case, the [INF, FUN] pair needs to either be entered together or not entered at all. The SEL-700G does not accept only one member of the [INF, FUN] pair. If the [INF, FUN] pair has been entered, then Scaling must also be entered.

The SEL-700G begins its response within 45 milliseconds of receiving a complete request. The above classes define the IEC 60870-5-103 data map in the SEL-700G. The SEL-700G provides for only one IEC 60870-5-103 map. The map consists of 332 definable points. These points include 100 binary input points, 8 binary targets, 32 binary controls, 8 measurands (totaling 128 analog quantities), 32 fault analogs, and 32 meter quantities.

Time Synchronization

The SEL-700G supports time synchronization as indicated with the 103TIME parameter under the device port settings. If the value is set to yes, then the device uses the time provided by the Master when the command is given, as long as the SEL-700G is not connected to an external time source, e.g., IRIG, PTP, or SNTP. The SEL-700G sets the internal time validity bit to indicate proper reception of the time-synchronization command sequence from the Master. The date and time should not be trusted unless the validity bit is set. Time synchronization in the SEL-700G should only be used if IRIG, PTP, or SNTP sources are not available.

IEC 60870-5-103 Documentation

The *IEC 60870-5-103 Configuration/Interoperability Guide for the* SEL-700G is available on the supplied CD or as a download from the SEL website and contains the standard device profile information for the SEL-700G. Please refer to this document for complete information on IEC 60870-5-103 configuration and interoperability in the SEL-700G.

Appendix I
DeviceNet Communications

Overview

This appendix describes DeviceNet communications features supported by the SEL-700G Generator and Intertie Protection Relay.

DeviceNet is a low-level communications network that provides direct connectivity among industrial devices, resulting in improved communication and device-level diagnostics that are otherwise either unavailable or inaccessible through expensive hardwired I/O interfaces. Industrial devices for which DeviceNet provides this direct connectivity include limit switches, photoelectric sensors, valve manifolds, motor starters, process sensors, bar code readers, variable frequency drives, panel displays, and operator interfaces.

The *SEL DeviceNet Communications Card User's Guide* contains more information on the installation and use of the DeviceNet card.

DeviceNet Card

NOTE: The DeviceNet option has been discontinued and is no longer available as of September 25, 2017.

The DeviceNet Card is an optional accessory that enables connection of the SEL-700G to the DeviceNet automation network. The card (see *Figure I.1*) occupies the communications expansion Slot **C** in the relay.

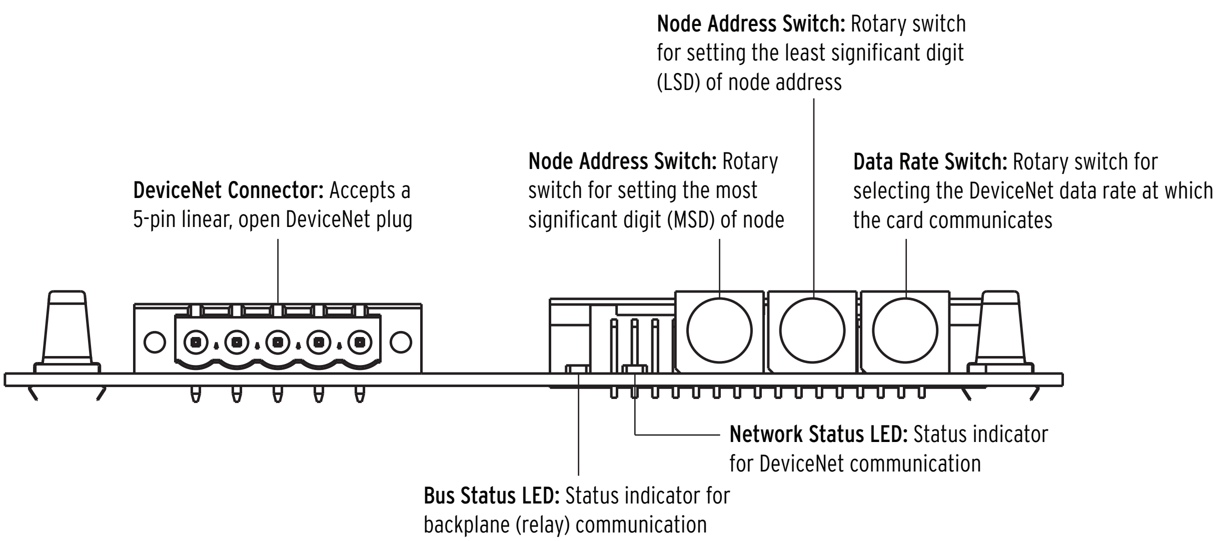

Figure I.1 DeviceNet Card Component Overview

Features

The DeviceNet Card features the following:

- The card receives the necessary power from the DeviceNet network.
- Rotary switches let you set the node address and network data rate prior to mounting in the SEL-700G and applying power. Alternatively, the switches can be set to positions that allow for configuration of these settings over the DeviceNet network, utilizing a network configuration tool such as RSNetWorx for DeviceNet.
- Status indicators report the status of the device bus and network communications. They are visible from the back panel of the SEL-700G as installed.

You can do the following with the DeviceNet interface:

- Retrieve metering data such as the following:
  - Currents
  - Voltages
  - Power
  - Energy
  - Max/Min
  - Analog Inputs
  - Counters
- Read and set time
- Monitor device status, trip/warning status, and I/O status
- Perform high-speed control
- Reset trip, target, and accumulated data
- Retrieve events history

You can configure the DeviceNet interface through the use of address and data transmission rate switches. Indicators on the card at the back of the relay show network status and network activity.

Electronic Data Sheet

The Electronic Data Sheet (EDS) is a specially formatted file that includes configurable parameters for the device and public interfaces to those parameters. The EDS file contains information such as number of parameters; groupings; parameter name; minimum, maximum, and default values; units; data format; and scaling. This information makes possible user-friendly configuration tools (for example, RSNetWorx for DeviceNet or DeviceNet Configurator from OMRON) for device parameter monitoring, modification, or both. The interface to the device can also be easily updated without revision of the configuration software tool itself.

All the registers defined in the Modbus Register Map (*Table E.34*) are available as parameters in a DeviceNet configuration. Parameter names, data ranges, and scaling; enumeration values and strings; parameter groups; and product information are the same as specified in the Modbus Register Map defined in *Table E.34*. The parameter numbers are offset by a count of 100 from the register numbers.

The EDS file for the SEL-700G, SEL-*xxx*R*xxx*.EDS, is located on the SEL-700G Product Literature CD, or can also be downloaded from the SEL website at selinc.com.

Complete specifications for the DeviceNet protocol are available on the Open DeviceNet Vendor’s Association (ODVA) website odva.org. ODVA is an independent supplier organization that manages the DeviceNet specification and supports the worldwide growth of DeviceNet.

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Appendix J

MIRRORED BITS Communications

Overview

> IMPORTANT: Be sure to configure the port before connecting to a MIRRORED BITS device. If you connect an unconfigured port to a MIRRORED BITS device, the device will appear to be locked up.

> NOTE: Complete all of the port settings for a port that you use for MIRRORED BITS communications before you connect an external MIRRORED BITS communications device. If you connect a MIRRORED BITS communications device to a port that is not set for MIRRORED BITS communications operation, the port will be continuously busy.

MIRRORED BITS is a direct relay-to-relay communications protocol that allows IEDs to exchange information quickly, securely, and with minimal expense. Use MIRRORED BITS for functions such as remote control and remote sensing.

The SEL-700G Generator and Intertie Protection Relay supports two MIRRORED BITS communications channels, designated A and B. Use the port setting PROTO to assign one of the MIRRORED BITS communications channels to a serial port; PROTO := MBA for MIRRORED BITS communications Channel A or PROTO := MBB for MIRRORED BITS communications Channel B.

MIRRORED BITS are either Transmit MIRRORED BITS (TMB) or Received MIRRORED BITS (RMB). Transmit MIRRORED BITS include TMB1A–TMB8A (channel A) and TMB1B–TMB8B (channel B). The last letter (A or B) designates with which channel the bits are associated. Received bits include RMB1A–RMB8A and RMB1B–RMB8B.

Control the transmit MIRRORED BITS in SELOGIC control equations. Use the received MIRRORED BITS as arguments in SELOGIC control equations. The channel status bits are ROKA, RBADA, CBADA, LBOKA, ROKB, RBADB, CBADB, and LBOKB. You can also use these channel status bits as arguments in SELOGIC control equations. Use the **COM** command (see *Section 7: Communications*) for additional channel status information.

Because of different applications, the SEL product range supports several variations of the MIRRORED BITS communications protocol. Through port settings, you can set the SEL-700G for compatible operation with SEL-300 series devices, SEL-2505 Remote I/O Modules, and SEL-2100 Logic Processors. When communicating with an SEL-400 series relay, be sure to set the transmission mode setting in the SEL-400 series relay to paced transmission (TXMODE := P).

Operation

Message Transmission

In the SEL-700G, the MIRRORED BITS transmission rate is a function of both the data rate and the power system cycle. At data rates below 9600, the SEL-700G transmits MIRRORED BITS as fast as possible for the given rate. At rates at and above 9600 bps the SEL-700G self-paces, using a technique similar to the SEL-400 series pacing mode. There are no settings to enable or disable the self-pacing mode; the SEL-700G automatically enters the self-pacing mode at data rates of 9600, 19200, and 38400. *Table J.1* shows the transmission rates of the MIRRORED BITS messages at different rates.

NOTE: Exercise caution when applying a MIRRORED BITS channel to relays that protect systems that may not be synchronized, as the automatic pacing modes operate under the assumption that both relays are protecting systems of similar frequency. To maintain MIRRORED BITS channel dependability for this application, it is recommended that you use a data rate of 2400 or 4800.

Table J.1 Number of MIRRORED BITS Messages for Different Data Rates

Data Rate	Transmission Rate of MIRRORED BITS Packets
2400	15 ms
4800	7.5 ms
9600	4 times a power system cycle (automatic pacing mode)
19200	4 times a power system cycle (automatic pacing mode)
38400	4 times a power system cycle (automatic pacing mode)

Transmitting at longer intervals for data rates above 9600 avoids overflowing relays that receive MIRRORED BITS at a slower rate.

Message Reception Overview

During synchronized MIRRORED BITS communications with the communications channel in normal state, the relay decodes and checks each received message. If the message is valid, the relay sends each received logic bit (RMB*n*, where *n* = 1 through 8) to the corresponding pickup and dropout security counters, that in turn set or clear the RMB*n*A and RMB*n*B relay element bits.

Message Decoding and Integrity Checks

Set the RX_ID of the local SEL-700G to match the TX_ID of the remote SEL-700G. The SEL-700G provides indication of the status of each MIRRORED BITS communications channel with Relay Word bits ROKA (receive OK) and ROKB. During normal operation, the relay sets the ROK*c* (*c* = A or B). The relay clears the ROK*c* bit when it detects any of the following conditions:

- The relay is disabled.
- MIRRORED BITS are not enabled.
- Parity, framing, or overrun errors.
- Receive message identification error.
- No message received in the time three messages have been sent when PROTO = MB*c*, or seven messages have been sent when PROTO = MB8*c*.
- Loopback is enabled.

The relay asserts ROK*c* only after successful synchronization as described below and two consecutive messages pass all of the data checks previously described. After ROK*c* is reasserted, received data can be delayed while passing through the security counters described in the following paragraph.

While ROK*c* is deasserted, the relay does not transfer new RMB data to the pickup-dropout security counters described below. Instead, the relay sends one of the user-definable default values to the security counter inputs. For each RMB*n*, use the RXDFLT setting to determine the default state the MIRRORED BITS should use in place of received data if the relay detects an error condition. The setting is a mask of 1s, 0s, and/or Xs (for RMB1A–RMB8A), where X represents the most recently received valid value. The positions of the 1s and 0s correspond to the respective positions of the MIRRORED BITS in the Relay Word bits (see *Appendix L: Relay Word Bits*). *Table J.2* is an extract of *Appendix L: Relay Word Bits*, showing the positions of the MIRRORED BITS.

Table J.2 Positions of the MIRRORED BITS

Bit/ Row	7	6	5	4	3	2	1	0
98	RMB8A	RMB7A	RMB6A	RMB5A	RMB4A	RMB3A	RMB2A	RMB1A
100	RMB8B	RMB7B	RMB6B	RMB5B	RMB4B	RMB3B	RMB2B	RMB1B

Table J.3 shows an example of the values of the MIRRORED BITS for a RXDFLT setting of 10100111.

Table J.3 MIRRORED BITS Values for a RXDFLT Setting of 10100111

Bit/ Row	7	6	5	4	3	2	1	0
98	1	0	1	0	0	1	1	1

Individual pickup and dropout security counters supervise the movement of each received data bit into the corresponding RMB*n* element. You can set each pickup/dropout security counter from 1 to 8. A setting of 1 causes a security counter to pass every occurrence, while a setting of 8 causes a counter to wait for eight consecutive occurrences in the received data before updating the data bits. The pickup and dropout security count settings are separate. Control the security count settings with the settings RMB*n*PU and RMB*n*DO.

A pickup/dropout security counter operates identically to a pickup/dropout timer, except that the counter uses units of counted received messages instead of time. Select a setting for the security counter in accordance with the transmission rate (see *Table J.1*). For example, when transmitting at 2400 bps, a security counter set to 2 counts delays a bit by about 30 ms. However, when operating at 9600 bps, a setting of 2 counts delays a bit by about 8.5 ms.

You must consider the impact of the security counter settings in the receiving relay to determine the channel timing performance, particularly when two relays of different processing rates are communicating via MIRRORED BITS, such as an SEL-321 and an SEL-700G. The SEL-321 processes power system information each 1/8 power system cycle, but, when transmitting at 19200 bps, the SEL-700G processes MIRRORED BITS messages at 4.15 ms at 60 Hz (4 times per power system cycle at 60 Hz). Although the SEL-321 processes power system information each 1/8 power system cycle, the relay processes the MIRRORED BITS pickup/dropout security counters as MIRRORED BITS messages are received. Because the SEL-700G transmits messages at approximately 1/4-cycle processing interval (9600 bps and above, see *Table J.1*), a counter set to two in the SEL-321 delays a received bit by another approximately 1/2 cycle. However, a security counter in the SEL-700G with a setting of two delays a received bit from the SEL-321 by 1/4 cycle, because the SEL-700G is receiving new MIRRORED BITS messages each 1/8 cycle from the SEL-321.

Channel Synchronization

When an SEL-700G detects a communications error, it deasserts ROKA or ROKB. If an SEL-700G detects two consecutive communications errors, it transmits an attention message, which includes the TXID setting. The relay transmits an attention message until it receives an attention message that includes a match to the TXID setting value. If the attention message is successful, the relay has properly synchronized and data transmission resumes. If the attention message is not successful, the relay repeats the attention message until it is successful.

In summary, when a relay detects an error, it transmits an attention message until it receives an attention message with its own TX_ID included. If three or four relays are connected in a ring topology, the attention message goes all the way around the loop until the originating relay receives it. The message then dies and data transmission resumes. This method of synchronization allows the relays to reliably determine which byte is the first byte of the message. It also forces unsynchronized UARTs to become resynchronized. On the down side, this method takes down the entire loop for a receive error at any relay in the loop. This decreases availability. It also makes one-way communications impossible.

Loopback Testing

Use the **LOOP** command to enable loopback testing. In the loopback mode, you loop the transmit port to the receive port of the same relay to verify transmission messages. While in loopback mode, ROK*c* is deasserted, and another user accessible Relay Word bit, LBOK*c* (Loopback OK) asserts and deasserts based on the received data checks (see the *Section 7: Communications* for the ACSII commands).

Channel Monitoring

Based on the results of data checks (described previously), the relay collects information regarding the 255 most recent communications errors. Each record contains at least the following fields:

- DATE—Date when the dropout occurred
- TIME—Time when the dropout occurred
- RECOVERY_DATE—Date when the channel returned to service (if the channel is currently failed, it is displayed and included in the calculations, as if its recovery were to occur at the time the report was requested)
- RECOVERY_TIME—Time when the channel returned to service (if the channel is currently failed, it is displayed and included in the calculations, as if its recovery were to occur at the time the report was requested)
- DURATION—Time elapsed during dropout
- CAUSE—Reason for dropout (see *Message Decoding and Integrity Checks on page J.2*)

There is a single record for each outage, but an outage can evolve. For example, the initial cause could be a data disagreement, but framing errors can extend the outage. If the channel is currently failed, it is displayed and included in the calculations, as if its recovery were to occur at the time the report was requested.

NOTE: Combine error conditions including RBADA, RBADB, CBADA, and CBADB with other alarm conditions using SELOGIC control equations. You can use these alarm conditions to program the relay to take appropriate action when it detects a communications channel failure.

When the duration of an outage on Channel A or B exceeds a user-definable threshold, the relay asserts a user-accessible Relay Word bit, RBADA or RBADB. When channel unavailability exceeds a user-definable threshold for Channel A or B, the relay asserts a user-accessible Relay Word bit, CBADA or CBADB. Use the **COMM** command to generate a long or summary report of the communications errors.

Use the RBADPU setting to determine how long a channel error must last before the meter element RBADA is asserted. RBADA is deasserted when the channel error is corrected. RBADPU is accurate to ±1 second.

Use the CBADPU setting to determine the ratio of channel down time to the total channel time before the meter element CBADA is asserted. The times used in the calculation are those that are available in the COM records. See the *COMMUNICATIONS Command* in *Section 7: Communications* for more information.

MIRRORED BITS Protocol for the Pulsar MBT9600 Four Wire Modem

To use a Pulsar MBT modem, set setting PROTO := MBTA or MBTB (Port settings). Setting PROTO := MBTA or MBTB hides setting SPEED (forces the data rate to 9600), hides setting PARITY (forces parity to a value of 0), hides setting RTSCTS (forces RTSCTS to a value of N), and forces the transmit time to be faster than double the power system cycle. *Table J.4* shows the difference in message transmission periods when not using the Pulsar modem (PROTO ≠ MBTA or MBTB), and using the Pulsar MBT modem (PROTO = MBTA or MBTB).

NOTE: You must consider the idle time in calculations of data transfer latency through a Pulsar MBT modem system.

Table J.4 MIRRORED BITS Communications Message Transmission Period

Data Rate	PROTO ≠ MBTA or MBTB	PROTO = MBTA or MBTB
38400	4 times a power system cycle	n/a
19200	4 times a power system cycle	n/a
9600	4 times a power system cycle	2 times a power system cycle
4800	7.5 ms	n/a

The relay sets RTS to a negative voltage at the EIA-232 connector to signify that MIRRORED BITS communications matches this specification.

Settings

Set PROTO = MBA or MB8A to enable the MIRRORED BITS protocol channel A on this port. Set PROTO = MBB or MB8B to enable the MIRRORED BITS protocol channel B on this port. The standard MIRRORED BITS protocols MBA and MBB use a 6-data bit format for data encoding. The MB8 protocols MB8A and MB8B use an 8-data bit format, which allows MIRRORED BITS to operate on communications channels requiring an 8-data bit format. For the remainder of this section, PROTO = MBA is assumed. *Table J.5* shows the MIRRORED BITS protocol port settings, ranges, and default settings for Port F, Port 3, and Port 4.

Table J.5 MIRRORED BITS Protocol Settings (Sheet 1 of 2)

Setting Prompt	Setting Description	Factory-Default Setting
TXID	MIRRORED BITS ID of This Device (1–4)	2
RXID	MIRRORED BITS ID of Device Receiving From (1–4)	1
RBADPU	Outage Duration to Set RBAD (0–10000 seconds)	60
CBADPU	Channel Unavailability to Set CBAD (1–10000 ppm)	1000

Table J.5 MIRRORED BITS Protocol Settings (Sheet 2 of 2)

Setting Prompt	Setting Description	Factory-Default Setting
RXDFLT	8 char string of 1s, 0s, or Xs	XXXXXXXX
RMB1PU	RMB1 Pickup Debounce Messages (1–8 messages)	1
RMB1DO	RMB1 Dropout Debounce Messages (1–8 messages)	1
RMB2PU	RMB2 Pickup Debounce Messages (1–8 messages)	1
RMB2DO	RMB2 Dropout Debounce Messages (1–8 messages)	1
RMB3PU	RMB3 Pickup Debounce Messages (1–8 messages)	1
RMB3DO	RMB3 Dropout Debounce Messages (1–8 messages)	1
RMB4PU	RMB4 Pickup Debounce Messages (1–8 messages)	1
RMB4DO	RMB4 Dropout Debounce Messages (1–8 messages)	1
RMB5PU	RMB5 Pickup Debounce Messages (1–8 messages)	1
RMB5DO	RMB5 Dropout Debounce Messages (1–8 messages)	1
RMB6PU	RMB6 Pickup Debounce Messages (1–8 messages)	1
RMB6DO	RMB6 Dropout Debounce Messages (1–8 messages)	1
RMB7PU	RMB7 Pickup Debounce Messages (1–8 messages)	1
RMB7DO	RMB7 Dropout Debounce Messages (1–8 messages)	1
RMB8PU	RMB8 Pickup Debounce Messages (1–8 messages)	1
RMB8DO	RMB8 Dropout Debounce Messages (1–8 messages)	1

Appendix K
Synchrophasors

Overview

The SEL-700G Relay provides Phasor Measurement Unit (PMU) capabilities when connected to an IRIG-B time source with an accuracy of ±10 µs or better. Synchrophasor data are available via the **MET PM** ASCII command and the C37.118 Protocol.

Synchrophasor measurement refers to the concept of providing measurements taken on a synchronized schedule in multiple locations. A high-accuracy clock, commonly called a Global Positioning System (GPS) receiver, such as the SEL-2407 Satellite-Synchronized Clock, makes synchrophasor measurement possible.

The availability of an accurate time reference over a large geographic area allows multiple devices, such as SEL-700G relays, to synchronize the gathering of power system data. The accurate clock allows precise event report triggering and other off-line analysis functions. Synchrophasors are still measured if the high-accuracy time source is not connected; however, the data are not time-synchronized to any external reference, as indicated by Relay Word bits TSOK := logical 0 and PMDOK := logical 0.

The SEL-700G Global settings class contains the synchrophasor settings, including the choice of transmitted synchrophasor data set. The Port settings class selects which serial port(s) or Ethernet port you can use for synchrophasor protocol use. See *Settings for Synchrophasors on page K.4*.

The SEL-700G timekeeping function generates status Relay Word bits and time-quality information that is important for synchrophasor measurement. Some protection SELOGIC variables, and programmable digital trigger information is also added to the Relay Word bits for synchrophasors. See *Synchrophasor Relay Word Bits on page K.14*.

When synchrophasor measurement is enabled, the SEL-700G creates the synchrophasor data set at a user-defined rate. Synchrophasor data are available in ASCII format over a serial port set to PROTO = SEL. See *View Synchrophasors Using the MET PM Command on page K.16*.

The value of synchrophasor data increases greatly when the data can be shared over a communications network in real time. A synchrophasor protocol is available in the SEL-700G that allows for a centralized device to collect data efficiently from several phasor measurement units (PMUs). Some possible uses of a system-wide synchrophasor system include the following:

- Power-system state measurement
- Generator Model Validation
- Wide-area network protection and control schemes

- Small-signal analysis
- Power-system disturbance analysis

The SEL-3373 is a phasor data concentrator (PDC) designed to interface with phasor measurement units (PMUs), other PDCs, and synchrophasor vector processors (SVPs). The SEL-3373 has two primary functions. The first is to collect and correlate synchrophasor data from multiple PMUs. The second is to then compact and transmit synchrophasor data either to a data historian for post-analysis or to visualization software (SEL-5702 Synchrowave Operations Software or SEL-5703 Synchrowave Monitoring Software) for real-time viewing of a power system.

Synchrowave Operations quickly translates power system data into visual information. It is a powerful yet easy-to-use solution for displaying and analyzing real-time streaming data, archived data, and relay event data, and provides a time-synchronized, wide-area view of your system. Synchrowave Monitoring includes Event Viewer, providing engineers and operators the ability to view PMU data and perform event analysis by viewing relay event reports directly from Synchrowave Monitoring.

The SEL-3378 Synchrophasor Vector Processor (SVP) is a real-time synchrophasor programmable logic controller. Use the SVP to collect synchrophasor messages from relays and PMUs. The SVP time-aligns incoming messages, processes these messages with an internal logic engine, and sends control command to external devices to perform user-defined actions. Additionally, the SVP can send calculated or derived data to devices such as other SVPs, PDCs, and monitoring systems.

The SEL-700G supports the protocol portion of the IEEE C37.118, Standard for Synchrophasors for Power Systems. In the SEL-700G, this protocol is referred to as C37.118. See *Settings Affect Message Contents on page K.17*.

Synchrophasor Measurement

The phasor measurement unit in the SEL-700G measures voltages and currents on a constant-time basis. These samples are time-stamped with the IRIG time source. The relay then filters the measured samples according to Global setting PMAPP := Fast or Narrow (see *PMAPP on page K.6*).

The phase angle is measured relative to an absolute time reference, which is represented by a cosine function in *Figure K.1*. The time-of-day is shown for the two time marks. The reference is consistent with the phase reference defined in the C37.118 standard. During steady-state conditions, the SEL-700G synchrophasor values can be directly compared to values from other phasor measurement units that conform to C37.118.

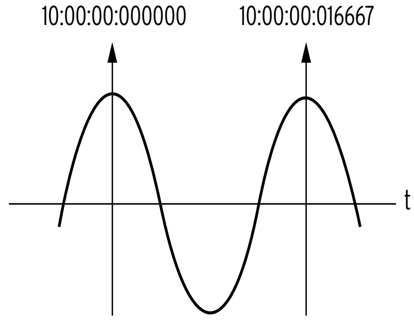

Figure K.1 Phase Reference

The TSOK Relay Word bit asserts when the SEL-700G has determined that the IRIG-B time source has sufficient accuracy and the synchrophasor data meet the specified accuracy. Synchrophasors are still measured if the time source threshold is not met, as indicated by Relay Word bit TSOK = logical 0. The **MET PM** command is not available in this case.

The instrumentation transformers (PTs or CTs) and the interconnecting cables may introduce a time shift in the measured signal. Global settings VXCOMP, VYCOMP, VSCOMP, IXCOMP, and IYCOMP, entered in degrees, are added to the measured phasor angles to create the corrected phasor angles, as shown in *Figure K.2*, *Figure K.3*, and *Equation K.1*. The VXCOMP, VYCOMP, VSCOMP, IXCOMP, and IYCOMP settings may be positive or negative values. The corrected angles are displayed in the **MET PM** command and transmitted as part of synchrophasor messages.

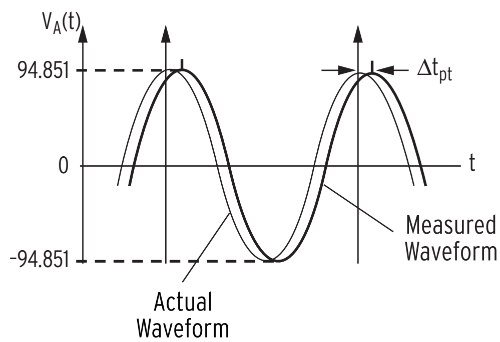

Figure K.2 Waveform at Relay Terminals May Have a Phase Shift

$$\text{Compensation Angle} = \frac{\Delta t_{pt}}{\left(\frac{1}{freq_{nominal}}\right)} \cdot 360° = \Delta t_{pt} \cdot freq_{nominal} \cdot 360°$$ **Equation K.1**

If the time shift on the PT measurement path $\Delta t_{pt} = 0.784$ ms and the nominal frequency, $freq_{nominal} = 60\text{Hz}$, use *Equation K.2* to obtain the correction angle:

$$0.784 \cdot 10^{-3}s \cdot 60s^{-1} \cdot 360° = 16.934°$$ **Equation K.2**

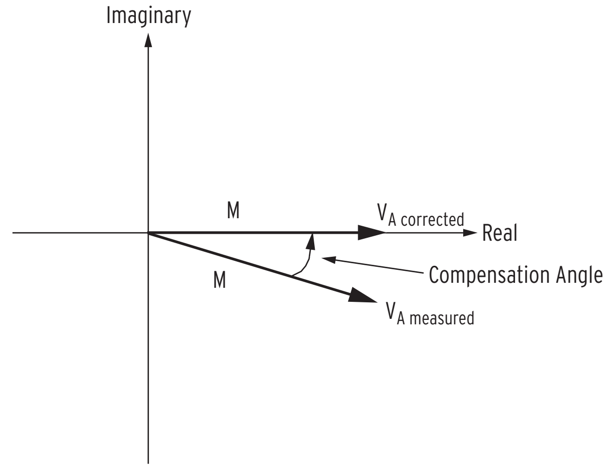

Figure K.3 Correction of Measured Phase Angle

The phasors are rms values scaled in primary units, as determined by Group settings PTRX, PTRY, PTRS (for synchronism-check input), CTRX, CTRY, and CTRN.

Because the sampling reference is based on the GPS clock (IRIG-B signal) and not synchronized to the power system, an examination of successive synchrophasor data sets almost always shows some angular change between samples of the same signal. This is not a malfunction of the relay or the power system, but is merely a result of viewing data from one system with an instrument with an independent time base. In other words, a power system has a nominal frequency of either 50 or 60 Hz, but on closer examination, it is usually running a little faster or slower than nominal.

Settings for Synchrophasors

The phasor measurement unit (PMU) settings are listed in *Table K.1*. Modify these settings when you want to use the C37.118 synchrophasor protocol.

The Global enable setting EPMU must be set to Y before the remaining SEL-700G synchrophasor settings are available. No synchrophasor data collection can take place when EPMU := N.

You must make the serial port settings in *Table K.5* to transmit data with a synchrophasor protocol. It is possible to set EPMU := Y without using any serial ports for synchrophasor protocols. For example, the serial port **MET PM** ASCII command can still be used.

Table K.1 PMU Settings in the SEL-700G for C37.118 Protocol in Global Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE SYNCHRONIZED PHASOR MEASUREMENT	Y, N	EPMU := N[a]
MESSAGES PER SECOND	1, 2, 5, 10, 25, or 50 when NFREQ := 50 1, 2, 4, 5, 10, 12, 15, 20, 30, or 60 when NFREQ := 60	MRATE := 10

Table K.1 PMU Settings in the SEL-700G for C37.118 Protocol in Global Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
PMU APPLICATION	Fast := Fast Response, Narrow := Narrow Bandwidth	PMAPP := NARROW
FREQUENCY-BASED PHASOR COMPENSATION	Y, N	PHCOMP := Y
STATION NAME	16 characters	PMSTN := SEL-700G
PMU HARDWARE ID	1–65534	PMID := 1
PHASOR DATA SET, VOLTAGES	V1, ALL, NA	PHDATAV := V1
VOLTAGE SOURCE	VX, VY, BOTH	PHVOLT := BOTH
X-SIDE ANGLE COMP FACTOR	–179.99 to 180.00 deg	VXCOMP := 0.00
Y-SIDE VOLTAGE ANGLE COMP FACTOR	–179.99 to 180.00 deg	VYCOMP := 0.00
VS VOLTAGE ANGLE COMP FACTOR	–179.99 to 180.00 deg	VSCOMP := 0.00
PHASOR DATA SET, CURRENTS	I1, ALL, NA	PHDATAI := I1
CURRENT SOURCE	IX, IY, BOTH	PHCURR := BOTH
X-SIDE ANGLE COMP FACTOR	–179.99 to 180.00 deg	IXCOMP := 0.00
Y-SIDE ANGLE COMP FACTOR	–179.99 to 180.00 deg	IYCOMP := 0.00
NUMBER OF ANALOG VALUES	0–4	NUMANA := 0
NUMBER OF 16-BIT DIGITIAL STATUS WORDS	0, 1	NUMDSW := 0
TRIGGER REASON BIT 1	SELOGIC	TREA1 := TRIP OR ER
TRIGGER REASON BIT 2	SELOGIC	TREA2 := 81T OR 81RT OR BNDT
TRIGGER REASON BIT 3	SELOGIC	TREA3 := 59PX1T OR 59PX2T OR 59PY1T OR 59PY2T
TRIGGER REASON BIT 4	SELOGIC	TREA4 := 27PX1T OR 27PX2T OR 27PY1T OR 27PY2T
TRIGGER	SELOGIC	PMTRIG := TREA1 OR TREA2 OR TREA3 OR TREA4
IRIG-B CONTROL BITS DEFINITION	NONE, C37.118	IRIGC := NONE

[a] Set EPMU := Y to access the remaining settings.

Certain settings in *Table K.1* are hidden, depending on the status of other settings. For example, if PHDATAI := NA, the IXCOMP and IYCOMP settings are hidden to limit the number of settings for your synchrophasor application. Definitions for the settings in *Table K.1* are as follows:

MRATE

Selects the message rate in messages per second for synchrophasor data streaming on serial ports.

Choose the MRATE setting that suits the needs of your PMU application. This setting is one of seven settings that determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size. See *Communications Bandwidth on page K.18* for detailed information.

PMAPP

Selects the type of digital filters used in the synchrophasor algorithm:

➤ The Narrow Bandwidth setting (N) represents filters with a cutoff frequency approximately one-quarter of MRATE. The response in the frequency domain is narrower, and response in the time domain is slower. This method results in synchrophasor data that are free of aliasing signals and well suited for post disturbance analysis.

➤ The Fast Response setting (F) represents filters with a higher cutoff frequency. The response in frequency domain is wider and the response in the time domain is faster. This method results in synchrophasor data that you can use in synchrophasor applications requiring more speed in tracking system parameters.

PHCOMP

Enables or disables frequency-based compensation for synchrophasors. For most applications, set PHCOMP := Y to activate the algorithm that compensates for the magnitude and angle errors of synchrophasors for frequencies that are off nominal. Use PHCOMP := N if you are concentrating the SEL-700G synchrophasor data with other PMU data that do not employ frequency compensation.

PMSTN and PMID

Defines the name and number of the PMU. The PMSTN setting is an ASCII string with as many as 16 characters. The PMID setting is a numeric value. Use your utility or synchrophasor data concentrator naming convention to determine these settings.

PHDATAV, VXCOMP, VYCOMP, and VSCOMP

PHDATAV selects which voltage synchrophasors to include in the data packet. Consider the burden on your synchrophasor processor and offline storage requirements when deciding how much data to transmit. This setting is one of seven settings that determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size. See *Communications Bandwidth on page K.18* for detailed information.

➤ PHDATAV := V1 transmits only positive-sequence voltage, V_1 (X side and Y side) and V_S (if available)

➤ PHDATAV := ALL transmit V_1, V_A, V_B, V_C, (X side and Y side) and V_S (if available); VAB, VBC, VCA are transmitted if DELTA_Y := DELTA

➤ PHDATAV := NA does not transmit any voltages

Table K.2 describes the order of synchrophasors inside the data packet.

The VXCOMP, VYCOMP, and VSCOMP settings allow correction for any steady-state voltage phase errors (from the potential transformers or wiring characteristics). See *Synchrophasor Measurement on page K.2* for details on this setting.

PHVOLT

PHVOLT selects which voltage side (X or Y or both) to include in the data packet. Consider the burden on your synchrophasor processor and offline storage requirements when deciding how much data to transmit. This setting is one of the seven settings that determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size. See *Communications Bandwidth on page K.18* for detailed information.

PHDATAI, IXCOMP, and IYCOMP

PHDATAI selects which current synchrophasors to include in the data packet. Consider the burden on your synchrophasor processor and offline storage requirements when deciding how much data to transmit. This setting is one of the seven settings that determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size. See *Communications Bandwidth on page K.18* for detailed information.

- PHDATAI := I1 transmits only positive-sequence current, I_1 (X side and Y side, if available)
- PHDATAI := ALL transmits I_1, I_A, I_B, I_C, and I_N (X side and Y side, if available)
- PHDATAI := NA does not transmit any currents

The IXCOMP and IYCOMP settings allow correction for any steady-state phase errors (from the current transformers or wiring characteristics). See *Synchrophasor Measurement on page K.2* for details on these settings.

Table K.2 describes the order of synchrophasors inside the data packet. Synchrophasors are transmitted in the order indicated from the top to the bottom of the table. Real values are transmitted first and imaginary values are transmitted second.

Synchrophasors are only transmitted if specified to be included by the PHDATAV and PHDATAI settings. For example, if PHDATAV := ALL and PHDATAI := I1, selected phase voltages are transmitted first (see PHVOLT setting), followed by VS input voltage, positive-sequence voltage, and positive-sequence current.

PHCURR

PHCURR selects which current side (X or Y or Both) to include in the data packet. Consider the burden on your synchrophasor processor and offline storage requirements when deciding how much data to transmit. This setting is one of the seven settings that determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size. See *Communications Bandwidth on page K.18* for detailed information.

Table K.2 describes the order of synchrophasors inside the data packet.

Table K.2 Synchrophasor Order in Data Stream (Voltages and Currents)

Synchrophasors[a b c] Rectangular Real	Synchrophasors[a b c] Rectangular Imaginary	Included When Global Settings Are as Follows:
V1X	V1X	PHDATAV := V1 or ALL (If selected by PHVOLT setting)
V1Y	V1Y	
VAX	VAX	PHDATAV := ALL (If selected by PHVOLT setting)
VBX	VBX	
VCX	VCX	
VAY	VAY	
VBY	VBY	
VCY	VCY	
VS	VS	
I1X	I1X	PHDATAI := I1 or ALL (If selected by PHCURR setting)
I1Y	I1Y	
IAX	IAX	PHDATAI := ALL (If selected by PHCURR setting)
IBX	IBX	
ICX	ICX	
IAY	IAY	
IBY	IBY	
ICY	ICY	
IN	IN	

[a] Synchrophasors are included in the order shown (for example, voltages, if selected, always precede currents).
[b] Synchrophasors are transmitted as primary values. Relay settings CTRX, CTRY, CTRN, PTRX, PTRY, PTRS are used to scale the values.
[c] When PHDATAV := ALL and DELTA_Y_X := WYE, phase voltages VAX, VBX, and VCX are transmitted.
When PHDATAV := ALL and DELTA_Y_Y := WYE, phase voltages VAY, VBY, and VCY are transmitted.
Phase voltages VABX, VBCX, and VCAX are transmitted when DELTA_Y_X := DELTA.
Phase voltages VABY, VBCY, and VCAY are transmitted when DELTA_Y_Y := DELTA.

NUMANA

Selects the number of user-definable analog values to be included in the synchrophasor data stream. This setting is one of seven settings that determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size. See *Communications Bandwidth on page K.18* for detailed information.

The choices for this setting depend on the synchrophasor system design.

- Setting NUMANA := 0 sends no user-definable analog values.
- Setting NUMANA := 1–4 sends the user-definable analog values, as listed in *Table K.3*.

The format of the user-defined analog data is always floating point, and each value occupies four bytes.

Table K.3 User-Defined Analog Values Selected by the NUMANA Setting

NUMANA Setting	Analog Quantities Sent	Total Number of Bytes Used for Analog Values
0	None	0
1	MV29	4
2	Previous, plus MV30	8
3	Previous, plus MV31	12
4	Previous, plus MV32	16

NUMDSW

Selects the number of user-definable digital status words to be included in the synchrophasor data stream. This setting is one of seven settings that determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size. See *Communications Bandwidth on page K.18* for detailed information.

The choices for this setting depend on the synchrophasor system design. The inclusion of binary data can help indicate breaker status or other operational data to the synchrophasor processor.

- Setting NUMDSW := 0 sends no user-definable binary status words.
- Setting NUMDSW := 1 sends the user-definable binary status words, as listed in *Table K.4*.

Table K.4 User-Defined Digital Status Words Selected by the NUMDSW Setting

NUMDSW Setting	Digital Status Words Sent	Total Number of Bytes Used for Digital Values
0	None	0
1	[SV32, SV31…SV17]	2

TREA1, TREA2, TREA3, TREA4, and PMTRIG

NOTE: The PM Trigger function is not associated with the SEL-700G Event Report Trigger ER, a SELOGIC control equation in the Report settings class.

Defines the programmable trigger bits as allowed by IEEE C37.118.

Each of the four Trigger Reason settings, TREA1–TREA4, and the PMU Trigger setting, PMTRIG, are SELOGIC control equations in the Global settings class. The SEL-700G evaluates these equations and places the results in Relay Word bits with the same names: TREA1–TREA4, and PMTRIG.

The trigger reason equations represent the Trigger Reason bits in the STAT field of the data packet. After the trigger reason bits are set to convey a message, the PMTRIG Equation should be asserted for a reasonable amount of time, to allow the synchrophasor processor to read the TREA1–TREA4 fields.

The SEL-700G automatically sets the TREA1–TREA4 or PMTRIG Relay Word bits based on their default SELOGIC control equation. To change the operation of these bits they must be programmed.

You can use these bits to send various messages at a low bandwidth via the synchrophasor message stream. You can also use Digital Status Words to send binary information directly, without the need to manage the coding of the trigger reason messages in SELOGIC.

Use these Trigger Reason bits if your synchrophasor system design requires these bits. The SEL-700G synchrophasor processing and protocol transmission are not affected by the status of these bits.

IRIGC

NOTE: Set IRIGC = C37.118 only when an IRIG-B000 signal is connected to the relay. Set IRIGC = NONE when an IRIG-B002 (standard IRIG) signal is connected.

Defines if IEEE C37.118 control bit extensions are in use. Control bit extensions contain information such as Leap Second, UTC, Daylight Savings Time (DST), and Time Quality. When your satellite-synchronized clock provides these extensions your relay is able to adjust the synchrophasor time stamp accordingly.

- IRIGC := NONE ignores bit extensions
- IRIGC := C37.118 extracts bit extensions and corrects synchrophasor time accordingly

Serial Port Settings for IEEE C37.118 Synchrophasors

IEEE C37.118 compliant synchrophasors are available via serial or Ethernet port. The associated serial port settings are shown in *Table K.5*.

Table K.5 SEL-700G Serial Port Settings for Synchrophasors

Setting Prompt	Setting Range	Setting Name := Factory Default
PROTOCOL	SEL, MOD, DNET, DNP, EVMSG, PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB[a]	PROTO := SEL[b]
DATA SPEED	300 to 38400	SPEED := 9600
STOP BITS	1, 2	STOPBIT := 1
HDWR HANDSHAKING	Y, N	RTSCTS := N

[a] Some of the other PROTO setting choices may not be available.
[b] Set PROTO = PMU to enable C37.118 synchrophasor protocol on this port.

The serial port settings for PROTO := PMU, shown in *Table K.5*, do not include the settings BITS and PARITY; these two settings are internally fixed as BITS := 8, PARITY := N.

Serial port setting PROTO cannot be set to PMU (see *Table K.5*) when Global setting EPMU := N. Synchrophasors must be enabled (EPMU := Y) before PROTO can be set to PMU.

If you use a computer terminal session or ACSELERATOR QuickSet SEL-5030 Software connected to a serial port, and then set that same serial port PROTO setting to PMU, you lose the ability to communicate with the relay through ASCII commands. If this happens, either connect via another serial port (that has PROTO := SEL) or use the front-panel HMI SET/SHOW screen to change the port PROTO setting back to SEL.

Ethernet Port Settings for IEEE C37.118 Synchrophasors

IEEE C37.118 compliant synchrophasors are available via serial or Ethernet port. The associated Ethernet port settings are shown in *Table K.6*.

Ethernet port setting EPMIP cannot be set when Global setting EPMU := N. Synchrophasors must be enabled (EPMU := Y) before EPMIP can be set.

Table K.6 SEL-700G Ethernet Port Settings for Synchrophasors (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PMU PROCESSING	0–2	EPMIP[a] := 0[b]
PMU OUTPUT 1 TRANSPORT SCHEME	OFF, TCP, UDP_S, UDP_T, UDP_U	PMOTS1 := OFF
PMU OUTPUT 1 CLIENT IP (REMOTE) ADDRESS	www.xxx.yyy.zzz[c, d]	PMOIPA1 := 192.168.1.3
PMU OUTPUT 1 TCP/IP (LOCAL) PORT NUMBER	1–65534[c, d]	PMOTCP1 := 4712

Table K.6 SEL-700G Ethernet Port Settings for Synchrophasors (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
PMU OUTPUT 1 UDP/IP DATA (REMOTE) PORT NUMBER	1–65534[c, e, f]	PMOUDP1 := 4713
PMU OUTPUT 2 TRANSPORT SCHEME	OFF, TCP, UDP_S, UDP_T, UDP_U	PMOTS2 := OFF
PMU OUTPUT 2 CLIENT IP (REMOTE) ADDRESS	www.xxx.yyy.zzz[g]	PMOIPA2 := 192.168.1.4
PMU OUTPUT 2 TCP/IP (LOCAL) PORT NUMBER	1–65534[d, g]	PMOTCP2 := 4722
PMU OUTPUT 2 UDP/IP DATA (REMOTE) PORT NUMBER	1–65534[f, g, h]	PMOUDP2 := 4713

[a] Setting is hidden when EPMU := N.
[b] Set EPMIP := 1 or 2 to access other settings and to enable IEEE C37.118 protocol synchrophasors on this port. Setting EPMIP is not available when Global setting EPMU is set to N.
[c] Setting hidden when PMOTS1 := OFF.
[d] Port number must be unique.
[e] Setting hidden when PMOTS1 := TCP.
[f] Port numbers must be unique for PMOUDP1, PMOUDP2, and DNPUDP1–3, if active.
[g] Setting hidden when PMOTS2 := OFF.
[h] Setting hidden when PMOTS2 := TCP.

Definitions for some of the settings in *Table K.6* are discussed further in the following text.

PMOTS1 and PMOTS2

These settings select the PMU Output Transport Scheme for Session 1 and Session 2, respectively.

PMOTSn := TCP

This setting establishes a single, persistent TCP socket for transmitting and receiving synchrophasor messages (both commands and data), as illustrated in *Figure K.4*.

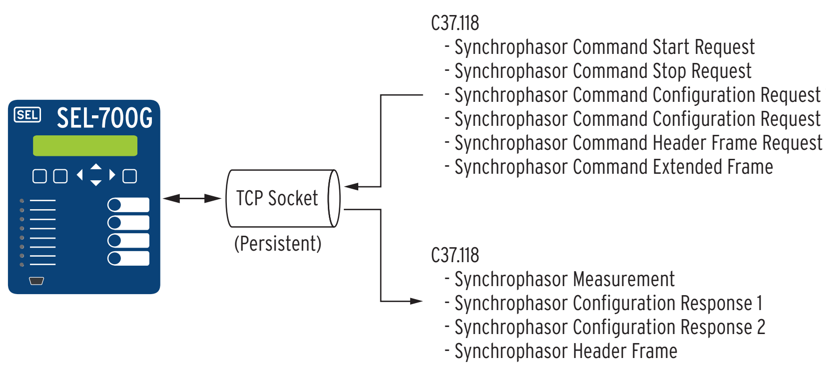

Figure K.4 TCP Connection

PMOTSn := UDP_T

This setting establishes two socket connections. A non-persistent TCP connection is used for receiving synchrophasor command messages as well as synchrophasor configuration and header response messages. A persistent UDP connection is used to transmit synchrophasor data messages. *Figure K.5* depicts the UDP_T connection.

PMOTSn := UDP_U

This setting uses the same connection scheme as the UDP_T setting, except that the synchrophasor configuration and header response messages are sent over the UDP connection, as shown in *Figure K.5*.

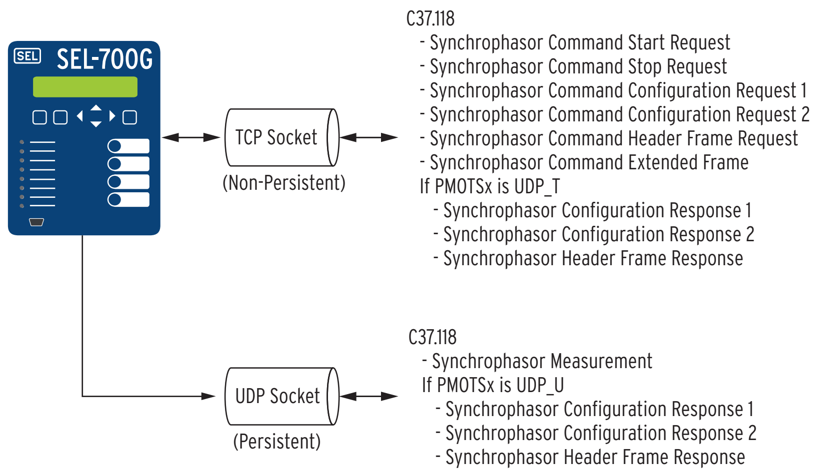

Figure K.5 UDP_T and UDP_U Connections

PMOTSn := UDP_S

NOTE: The UDP setting options (UDP_T, UDP_U, and UDP_S) allow for both Multicast and Unicast IP addresses.

This setting establishes a single persistent UDP socket to transmit synchrophasor messages. Synchrophasor data are transmitted whenever new data are read. With this communications scheme, the relay sends a "Synchrophasor Configuration Response 2" once every minute, as shown in *Figure K.6*.

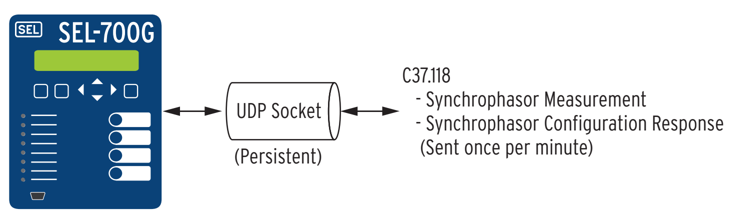

Figure K.6 UDP_S Connection

PMOIPA1 and PMOIPA2

Defines the PMU Output Client IP Address for Session 1 and Session 2, respectively.

PMOTCP1 and PMOTCP2

Defines the TCP/IP (Local) Port Number for Session 1 and Session 2, respectively. The TCP port numbers must all be unique.

PMOUDP1 and PMOUDP2

Defines the UDP/IP (Remote) Port Number for Session 1 and Session 2, respectively. The TCP port numbers must all be unique.

Synchrophasor Relay Word Bits

Table K.7 and *Table K.8* list the SEL-700G Relay Word bits that are related to synchrophasor measurement. The Synchrophasor Trigger Relay Word bits in *Table K.7* follow the state of the SELOGIC control equations of the same name, listed at the bottom of *Table K.1*. These Relay Word bits are included in the IEEE C37.118 synchrophasor data frame STAT field. See *Table K.4* for standard definitions for these settings.

Table K.7 Synchrophasor Trigger Relay Word Bits

Name	Description
PMTRIG	Trigger (SELOGIC)
TREA4	Trigger Reason Bit 4 (SELOGIC)
TREA3	Trigger Reason Bit 3 (SELOGIC)
TREA2	Trigger Reason Bit 2 (SELOGIC)
TREA1	Trigger Reason Bit 1 (SELOGIC)

Time Quality of the IRIG Source

The time-synchronization Relay Word bits in *Table K.8* indicate the present status of the timekeeping function of the SEL-700G.

Table K.8 Time-Synchronization Relay Word Bits

Name	Description
IRIGOK	Asserts while relay time is based on IRIG-B time source.
TSOK	Time Synchronization OK. Asserts while time is based on an IRIG-B time source of sufficient accuracy for synchrophasor measurement.
PMDOK	Phasor measurement data OK. Asserts when the SEL-700G is enabled, synchrophasors are enabled (Global setting EPMU = Y), Relay Word bit TSOK = 1, the frequency is 40–70 Hz, and the positive-sequence voltage(s) V1 > 10 V secondary. The SEL-700GW model uses the positive-sequence current I1 > 0.1 • I_{NOM} secondary, instead of the positive-sequence voltages. A few seconds may be necessary for PMDOK to assert when the relay is first powered, after any of the settings are changed, or when an IRIG-B time signal is first connected.

The Relay Word bit TSOK provides the indication that the time synchronization is OK. The SEL-700G determines the suitability of the IRIG-B signal for normal accuracy by applying several tests:

- Seconds, minutes, and day fields are in range
- Time from two consecutive messages differs by one second, except for leap second or daylight-saving time transitions
- When IRIGC = C37.118, the signal contains the correct parity bit

The SEL-700G determines the suitability of the IRIG-B signal for high-accuracy timekeeping by applying two additional tests:

NOTE: The jitter measurement for the IRIG signal could take as long as 15 seconds to determine. During this time TSOK is not asserted.

- The jitter between positive transitions (rising edges) of the clock signal is less than 500 ns
- The time error information contained in the IRIG-B control field indicates time error is less than 10^{-6} seconds (1 µs)

When IRIGC = NONE, the relay asserts TSOK when only the first test is met. When IRIGC = C37.118 and an appropriate IRIG-B signal is connected, Relay Word bit TSOK only asserts when these two tests are met. The time error information in the IRIG-B control field is mapped to the TQUAL bits in the relay. *Table K.9* provides the information for the TQUAL bits and how they translate to time quality. The values 0 (Locked) and 4 (1 microsecond) indicate that the relay is receiving high-accuracy IRIG.

When IRIG signal is lost, IRIGOK deasserts. However, TSOK remains asserted for a holdover period as long as 15 seconds. If the IRIG signal is not restored within 15 seconds, TSOK also deasserts.

Table K.9 TQUAL Bits Translation to Time Quality

TQUAL8	TQUAL4	TQUAL2	TQUAL1	Value	Time Quality
0	0	0	0	0	Locked
0	0	0	1	1	1 nanosecond
0	0	1	0	2	10 nanoseconds
0	0	1	1	3	100 nanoseconds
0	1	0	0	4	1 microsecond
0	1	0	1	5	10 microseconds
0	1	1	0	6	100 microseconds
0	1	1	1	7	1 millisecond
1	0	0	0	8	10 milliseconds
1	0	0	1	9	100 milliseconds
1	0	1	0	10	1 second
1	0	1	1	11	10 seconds
1	1	0	0	12	100 seconds
1	1	0	1	13	1000 seconds
1	1	1	0	14	10000 seconds
1	1	1	1	15	Fault

The Relay Word bit PMDOK indicates that the phasor measurement data are acceptable and asserts under the following conditions.

- The relay is enabled
- EPMU = Y
- IRIGOK = 1
- TSOK = 1
- The synchrophasor filter buffers are fully primed
- The magnitude of the positive-sequence voltage, |V1| > 10 V
- The frequency is 40–70 Hz

PMDOK takes 15 seconds to assert when the relay is first powered, after any of the settings in *Table K.1* are changed, or when an IRIG-B time signal is first connected. This is because of the delay in time qualification (TSOK to assert).

View Synchrophasors Using the MET PM Command

You can use the **MET PM** serial port ASCII command to view the SEL-700G synchrophasor measurements. See *MET Command (Metering Data) on page 7.59* for general information on the MET command.

There are multiple ways to use the **MET PM** command:

- As a test tool, to verify connections, phase rotation, and scaling
- As an analytical tool, to capture synchrophasor data at an exact time, to compare this information with similar data captured in other phasor measurement unit(s) at the same time
- As a method of periodically gathering synchrophasor data through a communications processor

The **MET PM** command displays the same set of analog synchrophasor information, regardless of the Global settings PHDATAV, PHDATAI, PHVOLT, and PHCURR. The **MET PM** command can function even when no serial ports are sending synchrophasor data—it is unaffected by serial port setting PROTO.

NOTE: To have the MET PM xx:yy:zz response transmitted from a serial port, the corresponding port must have the AUTO setting set to Y (YES).

The **MET PM** command only operates when the SEL-700G is in the IRIG timekeeping mode, as indicated by Relay Word bit TSOK = logical 1.

Figure K.7 shows a sample **MET PM** command response. The synchrophasor data are also available via the **HMI > Meter PM** menu in QuickSet, and have a similar format to *Figure K.7*.

You can use the **MET PM *time*** command to direct the SEL-700G to display the synchrophasor for an exact specified time, in 24-hour format. For example, entering the command **MET PM 14:14:12** results in a response similar to *Figure K.7* occurring just after 14:14:12, with the time stamp 14:14:12.000. See *Section 7: Communications* for complete command options, and error messages.

```
=>MET PM <Enter>

SEL-700G                                 Date: 01/07/2010   Time: 20:55:21.000
GENERATOR RELAY                          Time Source: External

Time Quality   Maximum time synchronization error:    0.000 (ms)  TSOK = 1

Synchrophasors

                     Phase Voltages            Pos. Sequence Voltage
                 VAX       VBX       VCX               V1
MAG (V)         134.00    132.21    135.34            134.31
ANG (DEG)       129.22     10.57    -111.89           128.12

                 VAY       VBY       VCY               V1
MAG (V)         132.12    134.29     131.34           134.31
ANG (DEG)       114.12     11.37    -110.39           115.12

                 VS
MAG (V)         123.41
ANG (DEG)       135.00

                     Phase Currents            Pos. Sequence Current
                 IAX       IBX       ICX               I1X
MAG (A)          24.50     23.54     22.50             23.51
ANG (DEG)        120.22     1.23   -120.21            120.32

                 IAY       IBY       ICY               I1Y
MAG (A)          22.50     24.54     24.52             22.78
ANG (DEG)        122.25     2.33   -121.21            121.32

                 IN
MAG (A)           3.20
ANG (DEG)       141.34

FREQ (Hz) 60.000
Rate-of-change of FREQ (Hz/s)    0.00

Digitals

SV24    SV23    SV22    SV21    SV20    SV19    SV18    SV17
 1       0       0       0       1       0       0       0
SV32    SV31    SV30    SV29    SV28    SV27    SV26    SV25
 0       0       1       0       0       0       0       0

Analogs

MV29      4.567  MV30     100.021  MV31     980.211  MV32      1.001

=>>
```

Figure K.7 Sample MET PM Command Response

IEEE C37.118 Synchrophasor Protocol

The SEL-700G complies with IEEE C37.118, Standard for Synchrophasors for Power Systems. The protocol is available on serial Ports 2, 3, 4, and F by setting the corresponding port setting PROTO := PMU. In addition, synchrophasor data can be accessed through the Ethernet port when the EMPIP setting is enabled.

This section does not cover the details of the protocol, but highlights some of the important features and options that are available.

Settings Affect Message Contents

The SEL-700G allows several options for transmitting synchrophasor data. These are controlled by Global settings described in *Settings for Synchrophasors on page K.4*. You can select how often to transmit the synchrophasor messages (MRATE) and which synchrophasors to transmit (PHDATAV and PHDATAI). The SEL-700G automatically includes the frequency and rate-of-change of frequency in the synchrophasor messages.

The frequency and rate-of-change-of-frequency data reported in the packet depends on the side on which the relay tracks the frequency. Depending on the model, the relay will track the frequency on either the X side or Y side using positive-sequence voltage or current. Refer to *Table K.10* for the side and the positive-sequence quantity the relay uses for tracking and reporting frequency and rate-of-change of frequency based on the model.

Table K.10 Frequency Tracking Side and Quantity Based on the SEL-700G Model

SEL-700G Model	Tracking Side and Quantity
SEL-700G0	X-side positive-sequence voltage
SEL-700G0+	X-side positive-sequence voltage
SEL-700G1	X-side positive-sequence voltage
SEL-700G1+	X-side positive-sequence voltage
SEL-700GT	Y-side positive-sequence voltage
SEL-700GT+	X-side positive-sequence voltage[a]
SEL-700GW	X-side positive-sequence current[b]

[a] The SEL-700GT+ tracks the Y-side frequency if the setting FRQTRK = Y.
[b] The SEL-700GW tracks the Y-side frequency if the X-side frequency quantity is not available.

The relay can include as many as four user-programmable analog values in the synchrophasor message, as controlled by Global setting NUMANA, and 0 or 16 digital status values, as controlled by Global setting NUMDSW.

The SEL-700G always includes the results of four synchrophasor trigger reason SELOGIC control equations TREA1, TREA2, TREA3, and TREA4, and the trigger SELOGIC control equation result PMTRIG, in the synchrophasor message.

Communications Bandwidth

A phasor measurement unit (PMU) that is configured to transmit a single synchrophasor (positive-sequence voltage, for example) at a message rate of once per second places little burden on the communications channel. As more synchrophasors, analog values, or digital status words are added, or if the message rate is increased, some communications channel restrictions come into play.

The C37.118 synchrophasor message format always includes 18 bytes for the message header and terminal ID, time information, status bits, and CRC value. The selection of synchrophasor data, numeric format, programmable analog, and programmable digital data will add to the byte requirements. You can use *Table K.11* to calculate the number of bytes in a synchrophasor message.

Table K.11 Size of a C37.118 Synchrophasor Message

Item	Possible Number of Quantities	Bytes per Quantity	Number of Bytes	
			Minimum	Maximum
Fixed			18	18
Synchrophasors	0–18	4	0	72
Frequency/DFDT	2 (fixed)	2	4	4
Analog Values	0–4	4	0	16
Digital Status Words	0–1	2	0	2
		Total (Minimum and Maximum)	22	112

Table K.12 lists the data settings available on any SEL-700G serial port (setting SPEED), and the maximum message size that can fit within the port bandwidth. Blank entries indicate bandwidths of less than 20 bytes.

Table K.12 Serial Port Bandwidth for Synchrophasors (in Bytes)

Global Setting MRATE	Port Setting SPEED								
	300	600	1200	2400	4800	9600	19200	38400	57600
1	21	42	85	170	340	680	1360	2720	4080
2		21	42	85	170	340	680	1360	2040
4 (60 Hz only)			21	42	85	170	340	680	1020
5				34	68	136	272	544	816
10					34	68	136	272	408
12 (60 Hz only)					28	56	113	226	340
15 (60 Hz only)					21	45	90	181	272
20 (60 Hz only)						34	68	136	204
25 (50 Hz only)						27	54	108	163
30 (60 Hz only)						22	45	90	136
50 (50 Hz only)							27	54	81
60 (60 Hz only)							22	45	68

Referring to *Table K.11* and *Table K.12*, it is clear that the lower SPEED settings are very restrictive.

The smallest practical synchrophasor message would be comprised of one digital status word, and this message would consume 24 bytes (includes frequency and DFDT). This type of message could be sent at any message rate (MRATE = 60) when SPEED := 38400, as much as MRATE := 5 when SPEED := 2400, and as much as MRATE := 1 when SPEED := 600.

Another example application has messages comprised of nine synchrophasors, one digital status word, and two analog values. This type of message would consume 68 bytes. The 68-byte message could be sent at any message rate less than or equal to ten (MRATE) when SPEED := 9600.

Protocol Operation

The SEL-700G only transmits synchrophasor messages over serial ports that have setting PROTO := PMU. The connected device is typically a synchrophasor processor, such as the SEL-3373. The synchrophasor processor controls the PMU functions of the SEL-700G, with IEEE C37.118 commands, including commands to start and stop synchrophasor data transmission, and commands to request a configuration block from the relay, so the synchrophasor processor can automatically build a database structure.

The SEL-700G does not begin transmitting synchrophasors until an enable message is received from the synchrophasor processor. The relay stops synchrophasor transmission when the appropriate command is received from the synchrophasor processor. The SEL-700G can also indicate when a configuration change occurs, so the synchrophasor processor can request a new configuration block and keep its database up-to-date.

The SEL-700G only responds to configuration block request messages when it is in the non-transmitting mode.

IEEE C37.118 PMU Setting Example

A utility is upgrading its system to use the SEL-700G Relay for power-system state measurement. The utility also wants to install phasor measurement units (PMUs) in each substation to collect data to monitor voltages and currents throughout the system.

The PMU data collection requirements call for the following data, collected at 10 messages per second:

- Frequency
- Positive-sequence voltage from the generator
- Three-phase, positive-sequence, and neutral current for the generator
- Indication when the breaker is open
- Indication when the voltage or frequency information is unusable

The utility is able to meet the requirements with the SEL-700G for the generator, an SEL-2407 Satellite-Synchronized Clock, and an SEL-3373 Synchrophasor Processor in each substation.

This example covers the PMU settings in the SEL-700G relays. Some system details:

- The nominal frequency is 60 Hz.
- The generator PTs and wiring have a phase error of 4.20 degrees (lagging) at 60 Hz.
- The generator CTs and wiring have a phase error of 3.50 degrees (lagging) at 60 Hz.
- The synchrophasor data use Port 3, and the maximum data rate allowed is 19200 bps.
- The system designer specifies integer numeric representation for the synchrophasor data, and rectangular coordinates.
- The system designer specifies integer numeric representation for the frequency data.
- The system designer specifies C37.118 synchrophasor response, because the data are being used for system monitoring.

The protection settings are not shown.

The protection engineer performs a bandwidth check, using *Table K.11*, and determines the necessary message size. The system requirements, in order of appearance in *Table K.11*, are:

- ➤ 6 Synchrophasors, in integer representation
- ➤ Integer representation for the frequency data
- ➤ 3 digital status bits, which require one status word

The message size is 18 + 6 • 4 + 2 • 2 + 1 • 2 = 48 bytes. Using *Table K.12*, the engineer verifies that the port data rate of 9600 bps is adequate for the message, at 10 messages per second.

The Protection SELOGIC Variables SV14, SV15, and SV16 are used to transmit the breaker status, loss-of-potential alarm, and frequency measurement status, respectively. Make the Global settings as shown in *Table K.13*.

Table K.13 Example Synchrophasor Global Settings

Setting Prompt	Setting Range	Setting Name := Example Setting Value
NOMINAL SYSTEM FREQUENCY	50, 60 Hz	FNOM := 60
ENABLE SYNCHRONIZED PHASOR MEASUREMENT	Y, N	EPMU := Y
MESSAGES PER SECOND	1, 2, 4, 5, 10, 12, 15, 20, 30, 60	MRATE := 10
PMU APPLICATION	F := Fast Response, N := Narrow Bandwidth	PMAPP := FAST
FREQUENCY-BASED PHASOR COMPENSATION	Y, N	PHCOMP := Y
STATION NAME	16 characters	PMSTN := SAMPLE1
PMU HARDWARE ID	1–65534	PMID := 14
PHASOR DATA SET, VOLTAGES	V1, ALL, NA	PHDATAV := V1
VOLTAGE SOURCE	VX, VY, Both	PHVOLT := VX
PHASE VOLTAGE ANGLE COMPENSATION FACTOR	–179.99 to 180.00 degrees	VXCOMP := 4.20
PHASOR DATA SET, CURRENTS	I1, ALL, NA	PHDATAI := ALL
CURRENT SOURCE	IX, IY, Both	PHCURR := IX
PHASE CURRENT ANGLE COMPENSATION FACTOR	–179.99 to 180.00 degrees	IXCOMP := 3.50
NUMBER OF 16-BIT DIGITAL STATUS WORDS	0 or 1	NUMVSW := 1

Table K.14 Example Synchrophasor Logic Settings

Logic Setting	Description	Value
TREA1	Trigger Reason Bit 1 (SELOGIC control equation)	NA
TREA2	Trigger Reason Bit 2 (SELOGIC control equation)	NA
TREA3	Trigger Reason Bit 3 (SELOGIC control equation)	NA
TREA4	Trigger Reason Bit 4 (SELOGIC control equation)	NA
PMTRIG	Trigger (SELOGIC control equation)	NA

The three Relay Word bits this example requires must be placed in certain SELOGIC variables. Make the settings in *Table K.15* in all settings groups.

Table K.15 Example Synchrophasor SELOGIC Settings

Setting	Value
SV30	52AX
SV31	LOPX
SV32	FREQXOK

Make the *Table K.16* settings for serial Port 3, using the **SET P 3** command.

Table K.16 Example Synchrophasor Port Settings

Setting Prompt	Setting Range	Setting Name := Example Setting Value
PROTOCOL	SEL, MOD, DNP, EVMSG, PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB	PROTO := PMU
DATA SPEED	300 to 38400	SPEED := 19200
STOP BITS	1, 2 bits	STOPBIT := 1
ENABLE HARDWARE HANDSHAKING	Y, N	RTSCTS := N

Appendix L
Relay Word Bits

Overview

The protection and control element results are represented by Relay Word bits in the SEL-700G Relay. Each Relay Word bit has a label name and can be in either of the following states:

- 1 (logical 1)
- 0 (logical 0)

Logical 1 represents an element being picked up or otherwise asserted. Logical 0 represents an element being dropped out or otherwise deasserted.

Table L.1 shows the entire list of Relay Word bits in the relay. *Table L.3* shows the corresponding descriptions. Except for those Relay Word bits identified in *Table L.2*, all other Relay Word bits are visible across all of the models. The Relay Word bits in *Table L.2* are associated with the overcurrent elements. The Relay Word bits marked HIDDEN are not visible and not settable for the models specified in the table. Besides the Relay Word bits presented in *Table L.2*, any bits in *Table L.1* that are not applicable to a specific model, although visible and settable, are inactive and will not change their state. The Relay Word bit row numbers correspond to the row numbers used in the *TARGET Command (Display Relay Word Bit Status) on page 7.73*.

You can use any Relay Word bit (except Row 0) in SELOGIC control equations (see *Section 4: Protection and Logic Functions*) and the Sequential Events Recorder (SER) trigger list settings (see *Section 10: Analyzing Events*).

Table L.1 SEL-700G Relay Word Bits (Sheet 1 of 7)

Bit/Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
TAR 0	ENABLED	TRIP_LED	TLED_01	TLED_02	TLED_03	TLED_04	TLED_05	TLED_06
1	50PX1P[a]	50PX1T[a]	50PX2P[a]	50PX2T[a]	50PY1P[a]	50PY1T[a]	50PY2P[a]	50PY2T[a]
2	50PX3AP[a]	50PX3AT[a]	50PX3BP[a]	50PX3BT[a]	50PX3CP[a]	50PX3CT[a]	[b]	ORED50T
3	50PY3AP[a]	50PY3AT[a]	50PY3BP[a]	50PY3BT[a]	50PY3CP[a]	50PY3CT[a]	LOPBLKX	LOPBLKY
4	50GX1P[a]	50GX1T[a]	50GX2P[a]	50GX2T[a]	50QX1P[a]	50QX1T[a]	50QX2P[a]	50QX2T[a]
5	50GY1P[a]	50GY1T[a]	50GY2P[a]	50GY2T[a]	50QY1P[a]	50QY1T[a]	50QY2P[a]	50QY2T[a]
6	67GX1P[a]	67GX1T[a]	67GX2P[a]	67GX2T[a]	67GY1P[a]	67GY1T[a]	67GY2P[a]	67GY2T[a]
7	67PY1P[a]	67PY1T[a]	67PY2P[a]	67PY2T[a]	67QY1P[a]	67QY1T[a]	67QY2P[a]	67QY2T[a]
8	50N1P[a]	50N1T[a]	50N2P[a]	50N2T[a]	46Q1	46Q1T	46Q2	46Q2T
9	51PXP	51PXT	51QXP	51QXT	51GXP	51GXT	[b]	ORED51T
10	51PYP	51PYT	51QYP	51QYT	51GYP	51GYT	51NP	51NT
11	87U1	87U2	87U3	87U	87R1	87R2	87R3	87R

Table L.1 SEL-700G Relay Word Bits (Sheet 2 of 7)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
12	87N1	87N1T	87N2	87N2T	40Z1	40Z1T	40Z2	40Z2T
13	50NREF1	REF1EN	50GREF1	REF1F	REF1R	REF1P	REF1BYP	b
14	64G1	64G1T	64G2	64G2T	T64G	N64G	51C	51CT
15	64F1	64F1T	64F2	64F2T	64FFLT	b	51V	51VT
16	27PX1	27PX1T	27PX2	27PX2T	27PY1	27PY1T	27PY2	27PY2T
17	59PX1	59PX1T	59PX2	59PX2T	59PY1	59PY1T	59PY2	59PY2T
18	59QX1	59QX1T	59QX2	59QX2T	59GX1	59GX1T	59GX2	59GX2T
19	59QY1	59QY1T	59QY2	59QY2T	59GY1	59GY1T	59GY2	59GY2T
20	3PWRX1P	3PWRX1T	3PWRX2P	3PWRX2T	3PWRX3P	3PWRX3T	3PWRX4P	3PWRX4T
21	3PWRY1P	3PWRY1T	3PWRY2P	3PWRY2T	3PWRY3P	3PWRY3T	3PWRY4P	3PWRY4T
22	24D1	24D1T	24C2	24C2T	24CR	b	81RT	BNDT
23	BFTX	BFTY	INAD	INADT	49A	49T	RTDT	RTDFLT
24	MPP1P	MABC1P	MPP2P	MABC2P	21C1P	21C1T	21C2P	21C2T
25	REMTRIP	COMMIDLE	COMMLOSS	COMMFLT	ER	PMTRIG	b	TRIP
26	87BL1	87BL2	87BL3	87HB	87HR1	87HR2	87HR3	87HR
27	TH5	TH5T	51CR	51VR	3P59X	3P59Y	3P27X	3P27Y
28	27S1	27S1T	27S2	27S2T	59S1	59S1T	59S2	59S2T
29	81X1T	81X2T	81X3T	81X4T	81X5T	81X6T	81XT	81T
30	81Y1T	81Y2T	81Y3T	81Y4T	81Y5T	81Y6T	81YT	b
31	81RX1T	81RX2T	81RX3T	81RX4T	81RY1T	81RY2T	81RY3T	81RY4T
32	BND1T	BND2T	BND3T	BND4T	BND5T	BND6T	BFIX	BFIY
33	78R1	78R2	78Z1	SWING	OOS	OOST	ZLOADX	ZLOADY
34	59VPX	59VSX	VDIFX	SFX	25AX1	25AX2	25C	GSRTRG
35	GENVHI	GENVLO	GENFHI	GENFLO	FRAISE	FLOWER	VRAISE	VLOWER
36	59VPY	59VSY	VDIFY	SFY	25AY1	25AY2	CFA	BKRCF
37	51PXR	51QXR	51GXR	51PYR	51QYR	51GYR	51NR	46Q2R
38	2_4HB1	2_4HB2	2_4HB3	2_4HBL	5HB1	5HB2	5HB3	5HBL
39	3POX	50LX	52AX	3POY	50LY	52AY	81RXT	81RYT
40	CLOSEX	CFX	CCX	AST	CLOSEY	CFY	CCY	FSYNCTO
41	TRX	TRY	TR1	TR2	TR3	OCX	OCY	VSYNCTO
42	TRIPX	TRIPY	TRIP1	TRIP2	TRIP3	CLX	CLY	ASP
43	ULTRX	ULTRY	ULTR1	ULTR2	ULTR3	ULCLX	ULCLY	b
44	AMBALRM	AMBTRIP	OTHALRM	OTHTRIP	WDGALRM	WDGTRIP	BRGALRM	BRGTRIP
45	OUT101	OUT102	OUT103	b	b	b	b	b
46	OUT301	OUT302	OUT303	OUT304	OUT305	OUT306	OUT307	OUT308
47	OUT401	OUT402	OUT403	OUT404	OUT405	OUT406	OUT407	OUT408
48	OUT501	OUT502	OUT503	OUT504	OUT505	OUT506	OUT507	OUT508
49	IN101	IN102	b	b	b	b	b	b
50	IN301	IN302	IN303	IN304	IN305	IN306	IN307	IN308
51	IN401	IN402	IN403	IN404	IN405	IN406	IN407	IN408

Table L.1 SEL-700G Relay Word Bits (Sheet 3 of 7)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
52	IN501	IN502	IN503	IN504	IN505	IN506	IN507	IN508
53	LINKA	LINKB	PMDOK	SALARM	WARNING	TSOK	IRIGOK	FAULT
54	87AP	87AT	LOPX	LOPY	CFGFLT	LINKFAIL	PASEL	PBSEL
55	ZLOUTY	ZLINY	VPOLVX	VPOLVY	RSTENRGY	RSTMXMN	RSTDEM	RSTPKDEM
56	TESTDB	RTDIN	RTDA	RTDBIAS	TRGTR	DSABLSET	RSTTRGT	HALARM
57	RTD1A	RTD1T	RTD2A	RTD2T	RTD3A	RTD3T	RTD4A	RTD4T
58	RTD5A	RTD5T	RTD6A	RTD6T	RTD7A	RTD7T	RTD8A	RTD8T
59	RTD9A	RTD9T	RTD10A	RTD10T	RTD11A	RTD11T	RTD12A	RTD12T
60	BND1A	BND2A	BND3A	BND4A	BND5A	BND6A	64F1C	BNDA
61	SG1	SG2	SG3	SG4	TREA1	TREA2	TREA3	TREA4
62	PHDEMX	3I2DEMX	GNDEMX	ASYNSDC	PHDEMY	3I2DEMY	GNDEMY	64F2C
63	BCWX	BCWAX	BCWBX	BCWCX	BCWY	BCWAY	BCWBY	BCWCY
64	DNAUX1	DNAUX2	DNAUX3	DNAUX4	DNAUX5	DNAUX6	DNAUX7	DNAUX8
65	DNAUX9	DNAUX10	DNAUX11	RELAY_EN	[b]	INR1	INR2	INR3
66	PB01	PB02	PB03	PB04	PB01_PUL	PB02_PUL	PB03_PUL	PB04_PUL
67	PB1A_LED	PB1B_LED	PB2A_LED	PB2B_LED	PB3A_LED	PB3B_LED	PB4A_LED	PB4B_LED
68	TRICOLOR	[b]	T01_LED	T02_LED	T03_LED	T04_LED	T05_LED	T06_LED
69	FREQTRKX	FREQTRKY	ZCFREQX	ZCFREQY	ZCFREQS	FREQXOK	FREQYOK	FREQSOK
70	LB01	LB02	LB03	LB04	LB05	LB06	LB07	LB08
71	LB09	LB10	LB11	LB12	LB13	LB14	LB15	LB16
72	LB17	LB18	LB19	LB20	LB21	LB22	LB23	LB24
73	LB25	LB26	LB27	LB28	LB29	LB30	LB31	LB32
74	RB01	RB02	RB03	RB04	RB05	RB06	RB07	RB08
75	RB09	RB10	RB11	RB12	RB13	RB14	RB15	RB16
76	RB17	RB18	RB19	RB20	RB21	RB22	RB23	RB24
77	RB25	RB26	RB27	RB28	RB29	RB30	RB31	RB32
78	SV01	SV02	SV03	SV04	SV05	SV06	SV07	SV08
79	SV01T	SV02T	SV03T	SV04T	SV05T	SV06T	SV07T	SV08T
80	SV09	SV10	SV11	SV12	SV13	SV14	SV15	SV16
81	SV09T	SV10T	SV11T	SV12T	SV13T	SV14T	SV15T	SV16T
82	SV17	SV18	SV19	SV20	SV21	SV22	SV23	SV24
83	SV17T	SV18T	SV19T	SV20T	SV21T	SV22T	SV23T	SV24T
84	SV25	SV26	SV27	SV28	SV29	SV30	SV31	SV32
85	SV25T	SV26T	SV27T	SV28T	SV29T	SV30T	SV31T	SV32T
86	LT01	LT02	LT03	LT04	LT05	LT06	LT07	LT08
87	LT09	LT10	LT11	LT12	LT13	LT14	LT15	LT16
88	LT17	LT18	LT19	LT20	LT21	LT22	LT23	LT24
89	LT25	LT26	LT27	LT28	LT29	LT30	LT31	LT32
90	SC01QU	SC02QU	SC03QU	SC04QU	SC05QU	SC06QU	SC07QU	SC08QU
91	SC01QD	SC02QD	SC03QD	SC04QD	SC05QD	SC06QD	SC07QD	SC08QD

Table L.1 SEL-700G Relay Word Bits (Sheet 4 of 7)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
92	SC09QU	SC10QU	SC11QU	SC12QU	SC13QU	SC14QU	SC15QU	SC16QU
93	SC09QD	SC10QD	SC11QD	SC12QD	SC13QD	SC14QD	SC15QD	SC16QD
94	SC17QU	SC18QU	SC19QU	SC20QU	SC21QU	SC22QU	SC23QU	SC24QU
95	SC17QD	SC18QD	SC19QD	SC20QD	SC21QD	SC22QD	SC23QD	SC24QD
96	SC25QU	SC26QU	SC27QU	SC28QU	SC29QU	SC30QU	SC31QU	SC32QU
97	SC25QD	SC26QD	SC27QD	SC28QD	SC29QD	SC30QD	SC31QD	SC32QD
98	RMB8A	RMB7A	RMB6A	RMB5A	RMB4A	RMB3A	RMB2A	RMB1A
99	TMB8A	TMB7A	TMB6A	TMB5A	TMB4A	TMB3A	TMB2A	TMB1A
100	RMB8B	RMB7B	RMB6B	RMB5B	RMB4B	RMB3B	RMB2B	RMB1B
101	TMB8B	TMB7B	TMB6B	TMB5B	TMB4B	TMB3B	TMB2B	TMB1B
102	LBOKB	CBADB	RBADB	ROKB	LBOKA	CBADA	RBADA	ROKA
103	VB001	VB002	VB003	VB004	VB005	VB006	VB007	VB008
104	VB009	VB010	VB011	VB012	VB013	VB014	VB015	VB016
105	VB017	VB018	VB019	VB020	VB021	VB022	VB023	VB024
106	VB025	VB026	VB027	VB028	VB029	VB030	VB031	VB032
107	VB033	VB034	VB035	VB036	VB037	VB038	VB039	VB040
108	VB041	VB042	VB043	VB044	VB045	VB046	VB047	VB048
109	VB049	VB050	VB051	VB052	VB053	VB054	VB055	VB056
110	VB057	VB058	VB059	VB060	VB061	VB062	VB063	VB064
111	VB065	VB066	VB067	VB068	VB069	VB070	VB071	VB072
112	VB073	VB074	VB075	VB076	VB077	VB078	VB079	VB080
113	VB081	VB082	VB083	VB084	VB085	VB086	VB087	VB088
114	VB089	VB090	VB091	VB092	VB093	VB094	VB095	VB096
115	VB097	VB098	VB099	VB100	VB101	VB102	VB103	VB104
116	VB105	VB106	VB107	VB108	VB109	VB110	VB111	VB112
117	VB113	VB114	VB115	VB116	VB117	VB118	VB119	VB120
118	VB121	VB122	VB123	VB124	VB125	VB126	VB127	VB128
119	AILW1	AILW2	AILAL	[b]	AIHW1	AIHW2	AIHAL	[b]
120	AI301LW1	AI301LW2	AI301LAL	[b]	AI301HW1	AI301HW2	AI301HAL	[b]
121	AI302LW1	AI302LW2	AI302LAL	[b]	AI302HW1	AI302HW2	AI302HAL	[b]
122	AI303LW1	AI303LW2	AI303LAL	[b]	AI303HW1	AI303HW2	AI303HAL	[b]
123	AI304LW1	AI304LW2	AI304LAL	[b]	AI304HW1	AI304HW2	AI304HAL	[b]
124	AI401LW1	AI401LW2	AI401LAL	[b]	AI401HW1	AI401HW2	AI401HAL	[b]
125	AI402LW1	AI402LW2	AI402LAL	[b]	AI402HW1	AI402HW2	AI402HAL	[b]
126	AI403LW1	AI403LW2	AI403LAL	[b]	AI403HW1	AI403HW2	AI403HAL	[b]
127	AI404LW1	AI404LW2	AI404LAL	[b]	AI404HW1	AI404HW2	AI404HAL	[b]
128	AI501LW1	AI501LW2	AI501LAL	[b]	AI501HW1	AI501HW2	AI501HAL	[b]
129	AI502LW1	AI502LW2	AI502LAL	[b]	AI502HW1	AI502HW2	AI502HAL	[b]
130	AI503LW1	AI503LW2	AI503LAL	[b]	AI503HW1	AI503HW2	AI503HAL	[b]
131	AI504LW1	AI504LW2	AI504LAL	[b]	AI504HW1	AI504HW2	AI504HAL	[b]

Table L.1 SEL-700G Relay Word Bits (Sheet 5 of 7)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
132	DI_A1	DI_B1	DI_C1	DI_A2	DI_B2	DI_C2	FSYNCACT	VSYNCACT
133	TQUAL8	TQUAL4	TQUAL2	TQUAL1	DST	DSTP	LPSEC	LPSECP
134	FDIRPY	RDIRPY	TUTCS	TUTC1	TUTC2	TUTC4	TUTC8	TUTCH
135	50QFX	50QRX	50GFX	50GRX	DIRVEX	DIRQGEX	DIRIEX	DIRQEX
136	50QFY	50QRY	50GFY	50GRY	DIRVEY	DIRQGEY	DIRIEY	DIRQEY
137	FDIRIX	RDIRIX	FDIRVX	RDIRVX	[b]	[b]	FDIRQGX	RDIRQGX
138	FDIRIY	RDIRIY	FDIRVY	RDIRVY	FDIRQY	RDIRQY	FDIRQGY	RDIRQGY
139	DIRGFX	DIRGRX	DIRGFY	DIRGRY	DIRQFY	DIRQRY	DIRPFY	DIRPRY
140	GX1DIR	GX2DIR	PY1DIR	QY1DIR	GY1DIR	PY2DIR	QY2DIR	GY2DIR
141	50PDIRY	TSNTPB	TSNTPP	50NF	50NR	FDIRNX	RDIRNX	FREQFZ
142	27PPX1	27PPX1T	27PPX2	27PPX2T	27PPY1	27PPY1T	27PPY2	27PPY2T
143	59PPX1	59PPX1T	59PPX2	59PPX2T	59PPY1	59PPY1T	59PPY2	59PPY2T
144	27V1X1	27V1X1T	27V1X2	27V1X2T	27V1X3	27V1X3T	27V1X4	27V1X4T
145	59V1X1	59V1X1T	59V1X2	59V1X2T	59V1X3	59V1X3T	59V1X4	59V1X4T
146	27V1X5	27V1X5T	27V1X6	27V1X6T	59V1X5	59V1X5T	59V1X6	59V1X6T
147	67N1P[a]	67N1T[a]	67N2P[a]	67N2T[a]	MATHERR	LINK1	[b]	DIRNEX
148	[b]	[b]	[b]	[b]	NX1DIR	NX2DIR	DIRNFX	DIRNRX
149	DRDOPT1	DRDOPT2	DRDOPT3	DRDOPT	RHSM	HSM	[b]	[b]
150	IA12H	IB12H	IC12H	IA22H	IB22H	IC22H	HR	HRT
151	87SN1	87HSN1	87SN2	87HSN2	87SN3	87HSN3	[b]	[b]
152	87SC1	87HSC1	87SC2	87HSC2	87SC3	87HSC3	[b]	[b]
153	[b]	[b]	[b]	[b]	[b]	[b]	[b]	[b]
154	IN309	IN310	IN311	IN312	IN313	IN314	[b]	[b]
155	IN409	IN410	IN411	IN412	IN413	IN414	[b]	[b]
156	IN509	IN510	IN511	IN512	IN513	IN514	[b]	[b]
157	78VSO	78VSBL	89A2P1	89B2P1	89CL2P1	89OP2P1	89A2P2	89B2P2
158	89CL2P2	89OP2P2	89A2P3	89B2P3	89CL2P3	89OP2P3	89A2P4	89B2P4
159	89CL2P4	89OP2P4	89A2P5	89B2P5	89CL2P5	89OP2P5	89A2P6	89B2P6
160	89CL2P6	89OP2P6	89A2P7	89B2P7	89CL2P7	89OP2P7	89A2P8	89B2P8
161	89CL2P8	89OP2P8	89AL2P1	89AL2P2	89AL2P3	89AL2P4	89AL2P5	89AL2P6
162	89AL2P7	89AL2P8	52BX	52BY	ENLRC	LOCAL	BKJMP	[b]
163	27I1	27I1T	27I1RS	27I1TC	27I2	27I2T	27I2RS	27I2TC
164	59I1	59I1T	59I1RS	59I1TC	59I2	59I2T	59I2RS	59I2TC
165	59I3	59I3T	59I3RS	59I3TC	59I4	59I4T	59I4RS	59I4TC
166	PB05	PB06	PB07	PB08	PB05_PUL	PB06_PUL	PB07_PUL	PB08_PUL
167	PB5A_LED	PB5B_LED	PB6A_LED	PB6B_LED	PB7A_LED	PB7B_LED	PB8A_LED	PB8B_LED
168	[b]	[b]	[b]	[b]	[b]	[b]	[b]	[b]
169	[b]	[b]	[b]	[b]	[b]	[b]	[b]	[b]
170	[b]	[b]	[b]	[b]	[b]	[b]	[b]	[b]
171	[b]	[b]	[b]	[b]	[b]	[b]	[b]	[b]

Table L.1 SEL-700G Relay Word Bits (Sheet 6 of 7)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
172	PTP_TIM	PTP_OK	PTPSYNC	PTPA	PTB	b	b	b
173	LPHDSIM	b	b	b	b	b	b	b
174	SC850TM	SC850BM	SC850SM	SC850LS	LOC	MLTLEV	LOCSTA	OREDLOC
175	25VCDB	25SCDB	CFARMED	b	b	b	b	b
176	89O2P1	89OS2P1	89OI2P1	89OE2P1	89C2P1	89CS2P1	89CI2P1	89CE2P1
177	89O2P2	89OS2P2	89OI2P2	89OE2P2	89C2P2	89CS2P2	89CI2P2	89CE2P2
178	89O2P3	89OS2P3	89OI2P3	89OE2P3	89C2P3	89CS2P3	89CI2P3	89CE2P3
179	89O2P4	89OS2P4	89OI2P4	89OE2P4	89C2P4	89CS2P4	89CI2P4	89CE2P4
180	89O2P5	89OS2P5	89OI2P5	89OE2P5	89C2P5	89CS2P5	89CI2P5	89CE2P5
181	89O2P6	89OS2P6	89OI2P6	89OE2P6	89C2P6	89CS2P6	89CI2P6	89CE2P6
182	89O2P7	89OS2P7	89OI2P7	89OE2P7	89C2P7	89CS2P7	89CI2P7	89CE2P7
183	89O2P8	89OS2P8	89OI2P8	89OE2P8	89C2P8	89CS2P8	89CI2P8	89CE2P8
184	89OC2P1	89RO2P1	89OM2P1	b	89CC2P1	89RC2P1	89CM2P1	b
185	89OC2P2	89RO2P2	89OM2P2	b	89CC2P2	89RC2P2	89CM2P2	b
186	89OC2P3	89RO2P3	89OM2P3	b	89CC2P3	89RC2P3	89CM2P3	b
187	89OC2P4	89RO2P4	89OM2P4	b	89CC2P4	89RC2P4	89CM2P4	b
188	89OC2P5	89RO2P5	89OM2P5	b	89CC2P5	89RC2P5	89CM2P5	b
189	89OC2P6	89RO2P6	89OM2P6	b	89CC2P6	89RC2P6	89CM2P6	b
190	89OC2P7	89RO2P7	89OM2P7	b	89CC2P7	89RC2P7	89CM2P7	b
191	89OC2P8	89RO2P8	89OM2P8	b	89CC2P8	89RC2P8	89CM2P8	b
192	89OC3PL1	89RO3PL1	89OM3PL1	b	89CC3PL1	89RC3PL1	89CM3PL1	b
193	89OC3PE1	89RO3PE1	89OM3PE1	b	89CC3PE1	89RC3PE1	89CM3PE1	b
194	89OC3PL2	89RO3PL2	89OM3PL2	b	89CC3PL2	89RC3PL2	89CM3PL2	b
195	89OC3PE2	89RO3PE2	89OM3PE2	b	89CC3PE2	89RC3PE2	89CM3PE2	b
196	b	b	b	b	b	b	b	b
197	b	b	b	b	b	b	b	b
198	b	b	b	b	b	b	b	b
199	b	b	b	b	b	b	b	b
200	89IP2P1	89IP2P2	89IP2P3	89IP2P4	89IP2P5	89IP2P6	89IP2P7	89IP2P8
201	89A3PL1	89B3PL1	89CL3PL1	89OP3PL1	894L3PL1	89IP3PL1	89AL	b
202	89A3PE1	89B3PE1	89CL3PE1	89OP3PE1	894L3PE1	89IP3PE1	89IP	b
203	89A3PL2	89B3PL2	89CL3PL2	89OP3PL2	894L3PL2	89IP3PL2	b	b
204	89A3PE2	89B3PE2	89CL3PE2	89OP3PE2	894L3PE2	89IP3PE2	b	b
205	89O3PL1	890S3PL1	89OI3PL1	89OE3PL1	89C3PL1	89CS3PL1	89CI3PL1	89CE3PL1
206	89O3PE1	890S3PE1	89OI3PE1	89OE3PE1	89C3PE1	89CS3PE1	89CI3PE1	89CE3PE1
207	89O3PL2	890S3PL2	89OI3PL2	89OE3PL2	89C3PL2	89CS3PL2	89CI3PL2	89CE3PL2
208	89O3PE2	890S3PE2	89OI3PE2	89OE3PE2	89C3PE2	89CS3PE2	89CI3PE2	89CE3PE2
209	b	b	b	b	b	b	b	b
210	b	b	b	b	b	b	b	b
211	b	b	b	b	b	b	b	b

Table L.1 SEL-700G Relay Word Bits (Sheet 7 of 7)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
212	b	b	b	b	b	b	b	b
213	b	b	b	b	b	b	b	b
214	b	b	b	b	b	b	b	b
215	b	b	b	b	b	b	b	b
216	b	b	b	b	b	b	b	b
217	b	b	b	b	b	b	b	b
218	b	b	b	b	b	b	b	b
219	b	b	b	b	b	b	b	b
220	b	b	b	b	b	b	b	b

[a] These Relay Word bits are model dependent. Refer to Table L.2 for models in which these Relay Word bits are hidden.
[b] Reserved for future use.

Table L.2 Hidden Overcurrent Element Relay Word Bits Per the SEL-700G Model[a] (Sheet 1 of 3)

		SEL-700G Model				
Row	RWB	SEL-700G0/G0+	SEL-700G1/G1+	SEL-700GT	SEL-700GT+	SEL-700GW
1	50PX1P			HIDDEN		
	50PX1T			HIDDEN		
	50PX2P			HIDDEN		
	50PX2T			HIDDEN		
	50PY1P	HIDDEN		HIDDEN	HIDDEN	
	50PY1T	HIDDEN		HIDDEN	HIDDEN	
	50PY2P	HIDDEN		HIDDEN	HIDDEN	
	50PY2T	HIDDEN		HIDDEN	HIDDEN	
2	50PX3AP			HIDDEN		
	50PX3AT			HIDDEN		
	50PX3BP			HIDDEN		
	50PX3BT			HIDDEN		
	50PX3CP			HIDDEN		
	50PX3CT			HIDDEN		
	*					
	ORED50T					
3	50PY3AP	HIDDEN				
	50PY3AT	HIDDEN				
	50PY3BP	HIDDEN				
	50PY3BT	HIDDEN				
	50PY3CP	HIDDEN				
	50PY3CT	HIDDEN				

Table L.2 Hidden Overcurrent Element Relay Word Bits Per the SEL-700G Model[a] (Sheet 2 of 3)

		SEL-700G Model				
Row	**RWB**	**SEL-700G0/G0+**	**SEL-700G1/G1+**	**SEL-700GT**	**SEL-700GT+**	**SEL-700GW**
4	50GX1P	HIDDEN	HIDDEN	HIDDEN	HIDDEN	
	50GX1T	HIDDEN	HIDDEN	HIDDEN	HIDDEN	
	50GX2P	HIDDEN	HIDDEN	HIDDEN	HIDDEN	
	50GX2T	HIDDEN	HIDDEN	HIDDEN	HIDDEN	
	50QX1P			HIDDEN		
	50QX1T			HIDDEN		
	50QX2P			HIDDEN		
	50QX2T			HIDDEN		
5	50GY1P	HIDDEN		HIDDEN	HIDDEN	
	50GY1T	HIDDEN		HIDDEN	HIDDEN	
	50GY2P	HIDDEN		HIDDEN	HIDDEN	
	50GY2T	HIDDEN		HIDDEN	HIDDEN	
	50QY1P	HIDDEN		HIDDEN	HIDDEN	
	50QY1T	HIDDEN		HIDDEN	HIDDEN	
	50QY2P	HIDDEN		HIDDEN	HIDDEN	
	50QY2T	HIDDEN		HIDDEN	HIDDEN	
6	67GX1P			HIDDEN		HIDDEN
	67GX1T			HIDDEN		HIDDEN
	67GX2P			HIDDEN		HIDDEN
	67GX2T			HIDDEN		HIDDEN
	67GY1P	HIDDEN	HIDDEN			HIDDEN
	67GY1T	HIDDEN	HIDDEN			HIDDEN
	67GY2P	HIDDEN	HIDDEN			HIDDEN
	67GY2T	HIDDEN	HIDDEN			HIDDEN
7	67PY1P	HIDDEN	HIDDEN			HIDDEN
	67PY1T	HIDDEN	HIDDEN			HIDDEN
	67PY2P	HIDDEN	HIDDEN			HIDDEN
	67PY2T	HIDDEN	HIDDEN			HIDDEN
	67QY1P	HIDDEN	HIDDEN			HIDDEN
	67QY1T	HIDDEN	HIDDEN			HIDDEN
	67QY2P	HIDDEN	HIDDEN			HIDDEN
	67QY2T	HIDDEN	HIDDEN			HIDDEN
8	50N1P	HIDDEN	HIDDEN		HIDDEN	HIDDEN
	50N1T	HIDDEN	HIDDEN		HIDDEN	HIDDEN
	50N2P	HIDDEN	HIDDEN		HIDDEN	HIDDEN
	50N2T	HIDDEN	HIDDEN		HIDDEN	HIDDEN

Table L.2 Hidden Overcurrent Element Relay Word Bits Per the SEL-700G Model[a] (Sheet 3 of 3)

		SEL-700G Model				
Row	**RWB**	**SEL-700G0/G0+**	**SEL-700G1/G1+**	**SEL-700GT**	**SEL-700GT+**	**SEL-700GW**
147	67N1P			HIDDEN		HIDDEN
	67N1T			HIDDEN		HIDDEN
	67N2P			HIDDEN		HIDDEN
	67N2T			HIDDEN		HIDDEN

[a] The Relay Word bits are visible and settable in those models that are not marked HIDDEN.

Definitions

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 1 of 26)

Bit	Definition	Row
2_4HB1	Second or fourth-harmonic block asserted for Differential Element 1	38
2_4HB2	Second or fourth-harmonic block asserted for Differential Element 2	38
2_4HB3	Second or fourth-harmonic block asserted for Differential Element 3	38
2_4HBL	Second or fourth-harmonic block asserted (2_4HB1 OR 2_4HB2 OR 2_4HB3)	38
21C1P	Zone 1 compensator distance element instantaneous pickup	24
21C1T	Zone 1 compensator distance element timed out	24
21C2P	Zone 2 compensator distance element instantaneous pickup	24
21C2T	Zone 2 compensator distance element timed out	24
24C2	Level 2 volts/hertz composite element pickup	22
24C2T	Level 2 volts/hertz composite element timed out	22
24CR	Level 2 volts/hertz element fully reset	22
24D1	Level 1 volts/hertz instantaneous pickup	22
24D1T	Level 1 volts/hertz definite-time element timed out	22
25AX1	Generator slip/breaker-time compensated phase angle (absolute value) less than 25ANG1X setting	34
25AX2	Generator uncompensated phase angle less than 25ANG2X setting	34
25AY1	Intertie slip/breaker-time compensated phase angle less than 25ANG1Y setting	36
25AY2	Intertie slip/breaker-time compensated phase angle less than 25ANG2Y setting	36
25C	Initiate CLOSE to match target close angle	34
25SCDB	Slip frequency within acceptable bounds (within 80 percent of the difference between 25SHI and 25SLO settings)	175
25VCDB	Generator and system voltage difference within acceptable bounds (within 80 percent of 25VDIFX setting)	175
27I1	Level 1 inverse undervoltage element pickup	163
27I1T	Level 1 inverse undervoltage element timeout	163
27I1RS	Level 1 inverse undervoltage element reset	163
27I1TC	Level 1 inverse undervoltage element torque control	163
27I2	Level 2 inverse undervoltage element pickup	163
27I2T	Level 2 inverse undervoltage element timeout	163

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 2 of 26)

Bit	Definition	Row
27I2RS	Level 2 inverse undervoltage element reset	163
27I2TC	Level 2 inverse undervoltage element torque control	163
27PPX1	X-side Level 1 phase-to-phase undervoltage element pickup	142
27PPX1T	X-side Level 1 phase-to-phase undervoltage element trip	142
27PPX2	X-side Level 2 phase-to-phase undervoltage element pickup	142
27PPX2T	X-side Level 2 phase-to-phase undervoltage element trip	142
27PPY1	Y-side Level 1 phase-to-phase undervoltage element pickup	142
27PPY1T	Y-side Level 1 phase-to-phase undervoltage element trip	142
27PPY2	Y-side Level 2 phase-to-phase undervoltage element pickup	142
27PPY2T	Y-side Level 2 phase-to-phase undervoltage element trip	142
27PX1	X-side Level 1 phase undervoltage element pickup	16
27PX1T	X-side Level 1 phase undervoltage element trip	16
27PX2	X-side Level 2 phase undervoltage element pickup	16
27PX2T	X-side Level 2 phase undervoltage element trip	16
27PY1	Y-side Level 1 phase undervoltage element pickup	16
27PY1T	Y-side Level 1 phase undervoltage element trip	16
27PY2	Y-side Level 2 phase undervoltage element pickup	16
27PY2T	Y-side Level 2 phase undervoltage element trip	16
27S1	Level 1 synchronism undervoltage element pickup	28
27S1T	Level 1 synchronism undervoltage element trip	28
27S2	Level 2 synchronism undervoltage element pickup	28
27S2T	Level 2 synchronism undervoltage element trip	28
27V1X1	X-side Level 1 positive-sequence undervoltage element pickup	144
27V1X1T	X-side Level 1 positive-sequence undervoltage element trip	144
27V1X2	X-side Level 2 positive-sequence undervoltage element pickup	144
27V1X2T	X-side Level 2 positive-sequence undervoltage element trip	144
27V1X3	X-side Level 3 positive-sequence undervoltage element pickup	144
27V1X3T	X-side Level 3 positive-sequence undervoltage element trip	144
27V1X4	X-side Level 4 positive-sequence undervoltage element pickup	144
27V1X4T	X-side Level 4 positive-sequence undervoltage element trip	144
27V1X5	X-side Level 5 positive-sequence undervoltage element pickup	146
27V1X5T	X-side Level 5 positive-sequence undervoltage element trip	146
27V1X6	X-side Level 6 positive-sequence undervoltage element pickup	146
27V1X6T	X-side Level 6 positive-sequence undervoltage element trip	146
3I2DEMY	Y-side negative-sequence current demand pickup	62
3I2DEMX	X-side negative-sequence current demand pickup	62
3P27X	X-side three-phase-to-phase undervoltage element pickup	27
3P27Y	Y-side three-phase-to-phase undervoltage element pickup	27
3P59X	X-side three-phase-to-phase overvoltage element pickup	27
3P59Y	Y-side three-phase-to-phase overvoltage element pickup	27
3POX	X breaker three-pole open	39

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 3 of 26)

Bit	Definition	Row
3POY	Y breaker three-pole open	39
3PWRX1P	X-side three-phase Power Element 1 pickup	20
3PWRX1T	X-side three-phase Power Element 1 trip	20
3PWRX2P	X-side three-phase Power Element 2 pickup	20
3PWRX2T	X-side three-phase Power Element 2 trip	20
3PWRX3P	X-side three-phase Power Element 3 pickup	20
3PWRX3T	X-side three-phase Power Element 3 trip	20
3PWRX4P	X-side three-phase Power Element 4 pickup	20
3PWRX4T	X-side three-phase Power Element 4 trip	20
3PWRY1P	Y-side three-phase Power Element 1 pickup	21
3PWRY1T	Y-side three-phase Power Element 1 trip	21
3PWRY2P	Y-side three-phase Power Element 2 pickup	21
3PWRY2T	Y-side three-phase Power Element 2 trip	21
3PWRY3P	Y-side three-phase Power Element 3 pickup	21
3PWRY3T	Y-side three-phase Power Element 3 trip	21
3PWRY4P	Y-side three-phase Power Element 4 pickup	21
3PWRY4T	Y-side three-phase Power Element 4 trip	21
40Z1	Zone 1 instantaneous loss-of-field mho element	12
40Z1T	Zone 1 time-delayed loss-of-field mho element	12
40Z2	Zone 2 instantaneous loss-of-field mho element	12
40Z2T	Zone 2 time-delayed loss-of-field mho element	12
46Q1	Negative-sequence Level 1 instantaneous overcurrent element pickup	8
46Q1T	Negative-sequence definite time-overcurrent element timed out	8
46Q2	Negative-sequence overcurrent element pickup	8
46Q2R	X-side negative-sequence time-overcurrent element reset	37
46Q2T	Negative-sequence time-overcurrent element timed out	8
49A	Thermal alarm, generator thermal capacity above Level 2 (49A)	23
49T	Thermal trip, generator thermal capacity above Level 1	23
50GFX	X-side forward-direction residual-ground overcurrent threshold exceeded	135
50GFY	Y-side forward-direction residual-ground overcurrent threshold exceeded	136
50GREF1	Normalized residual current sensitivity threshold exceeded	13
50GRX	X-side reverse direction residual-ground overcurrent threshold exceeded	135
50GRY	Y-side reverse direction residual-ground overcurrent threshold exceeded	136
50GX1P[a]	X-side Level 1 residual-ground instantaneous overcurrent element pickup	4
50GX1T[a]	X-side Level 1 residual-ground instantaneous overcurrent element trip	4
50GX2P[a]	X-side Level 2 residual-ground instantaneous overcurrent element pickup	4
50GX2T[a]	X-side Level 2 residual-ground instantaneous overcurrent element trip	4
50GY1P[a]	Y-side Level 1 residual-ground instantaneous overcurrent element pickup	5
50GY1T[a]	Y-side Level 1 residual-ground instantaneous overcurrent element trip	5
50GY2P[a]	Y-side Level 2 residual-ground instantaneous overcurrent element pickup	5
50GY2T[a]	Y-side Level 2 residual-ground instantaneous overcurrent element trip	5

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 4 of 26)

Bit	Definition	Row
50LX	Phase instantaneous overcurrent element for load detection (maximum phase current above pickup setting 50LPX)	39
50LY	Phase instantaneous overcurrent element for load detection (maximum phase current above pickup setting 50LPY)	39
50N1P[a]	Level 1 neutral instantaneous overcurrent element pickup	8
50N1T[a]	Level 1 neutral instantaneous overcurrent element trip	8
50N2P[a]	Level 2 neutral instantaneous overcurrent element pickup	8
50N2T[a]	Level 2 neutral instantaneous overcurrent element trip	8
50NREF1	Neutral current sensitivity threshold exceeded	13
50NF	Forward direction neutral-ground overcurrent threshold exceeded	141
50NR	Reverse direction neutral-ground overcurrent threshold exceeded	141
50PDIRY	Three-phase overcurrent threshold exceeded	141
50PX1P[a]	X-side Level 1 phase instantaneous overcurrent element pickup	1
50PX1T[a]	X-side Level 1 phase instantaneous overcurrent element trip	1
50PX2P[a]	X-side Level 2 phase instantaneous overcurrent element pickup	1
50PX2T[a]	X-side Level 2 phase instantaneous overcurrent element trip	1
50PX3AP[a]	X-side Level 3 A-phase instantaneous overcurrent element pickup	2
50PX3AT[a]	X-side Level 3 A-phase instantaneous overcurrent element trip	2
50PX3BP[a]	X-side Level 3 B-phase instantaneous overcurrent element pickup	2
50PX3BT[a]	X-side Level 3 B-phase instantaneous overcurrent element trip	2
50PX3CP[a]	X-side Level 3 C-phase instantaneous overcurrent element pickup	2
50PX3CT[a]	X-side Level 3 C-phase instantaneous overcurrent element trip	2
50PY1P[a]	Y-side Level 1 phase instantaneous overcurrent element pickup	1
50PY1T[a]	Y-side Level 1 phase instantaneous overcurrent element trip	1
50PY2P[a]	Y-side Level 2 phase instantaneous overcurrent element pickup	1
50PY2T[a]	Y-side Level 2 phase instantaneous overcurrent element trip	1
50PY3AP[a]	Y-side Level 3 A-phase instantaneous overcurrent element pickup	3
50PY3AT[a]	Y-side Level 3 A-phase instantaneous overcurrent element trip	3
50PY3BP[a]	Y-side Level 3 B-phase instantaneous overcurrent element pickup	3
50PY3BT[a]	Y-side Level 3 B-phase instantaneous overcurrent element trip	3
50PY3CP[a]	Y-side Level 3 C-phase instantaneous overcurrent element pickup	3
50PY3CT[a]	Y-side Level 3 C-phase instantaneous overcurrent element trip	3
50QFX	X-side forward-direction negative-sequence overcurrent threshold exceeded	135
50QFY	Y-side forward-direction negative-sequence overcurrent threshold exceeded	136
50QRX	X-side reverse direction negative-sequence overcurrent threshold exceeded	135
50QRY	Y-side reverse direction negative-sequence overcurrent threshold exceeded	136
50QX1P[a]	X-side Level 1 negative-sequence instantaneous overcurrent element pickup	4
50QX1T[a]	X-side Level 1 negative-sequence instantaneous overcurrent element trip	4
50QX2P[a]	X-side Level 2 negative-sequence instantaneous overcurrent element pickup	4
50QX2T[a]	X-side Level 2 negative-sequence instantaneous overcurrent element trip	4
50QY1P[a]	Y-side Level 1 negative-sequence instantaneous overcurrent element pickup	5
50QY1T[a]	Y-side Level 1 negative-sequence instantaneous overcurrent element trip	5

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 5 of 26)

Bit	Definition	Row
50QY2P[a]	Y-side Level 2 residual-ground instantaneous overcurrent element pickup	5
50QY2T[a]	Y-side Level 2 residual-ground instantaneous overcurrent element trip	5
51C	Voltage-controlled phase time-overcurrent element pickup (maximum phase current above pickup setting 51CP)	14
51CR	Voltage-controlled phase time-overcurrent element 51CT fully reset	27
51CT	Voltage-controlled phase time-overcurrent element 51CT timed out	14
51GXP	X-side residual-ground time-overcurrent element pickup	9
51GXR	X-side residual-ground time-overcurrent element reset	37
51GXT	X-side residual-ground time-overcurrent element trip	9
51GYP	Y-side residual-ground time-overcurrent element pickup	10
51GYR	Y-side residual-ground time-overcurrent element reset	37
51GYT	Y-side residual-ground time-overcurrent element trip	10
51NP	Neutral-ground time-overcurrent element pickup	10
51NR	Neutral-ground time-overcurrent element reset	37
51NT	Neutral-ground time-overcurrent element trip	10
51PXP	X-side phase time-overcurrent element pickup	9
51PXR	X-side phase time-overcurrent element reset	37
51PXT	X-side phase time-overcurrent element trip	9
51PYP	Y-side phase time-overcurrent element pickup	10
51PYR	Y-side phase time-overcurrent element reset	37
51PYT	Y-side phase time-overcurrent element trip	10
51QXP	X-side negative-sequence time-overcurrent element pickup	9
51QXR	X-side negative-sequence time-overcurrent element reset	37
51QXT	X-side negative-sequence time-overcurrent element trip	9
51QYP	Y-side negative-sequence time-overcurrent element pickup	10
51QYR	Y-side negative-sequence time-overcurrent element reset	37
51QYT	Y-side negative-sequence time-overcurrent element trip	10
51V	Voltage-restrained phase time-overcurrent element pickup (maximum phase current above voltage adjusted pickup setting 51VP)	15
51VR	Voltage-restrained phase time-overcurrent element 51VT fully reset	27
51VT	Voltage-restrained phase time-overcurrent element 51VT timed out	15
52AX	Breaker X N/O contact	39
52AY	Breaker Y N/O contact	39
52BX	Breaker X N/C contact	162
52BY	Breaker Y N/C contact	162
59GX1	X-side Level 1 residual-ground overvoltage element pickup	18
59GX1T	X-side Level 1 residual-ground overvoltage element trip	18
59GX2	X-side Level 2 residual-ground overvoltage element pickup	18
59GX2T	X-side Level 2 residual-ground overvoltage element trip	18
59GY1	Y-side Level 1 residual-ground overvoltage element pickup	19
59GY1T	Y-side Level 1 residual-ground overvoltage element trip	19
59GY2	Y-side Level 2 residual-ground overvoltage element pickup	19

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 6 of 26)

Bit	Definition	Row
59GY2T	Y-side Level 2 residual-ground overvoltage element trip	19
59I1	Level 1 inverse overvoltage element pickup	164
59I1T	Level 1 inverse overvoltage element time out	164
59I1RS	Level 1 inverse overvoltage element reset	164
59I1TC	Level 1 inverse overvoltage element torque control	164
59I2	Level 2 inverse overvoltage element pickup	164
59I2T	Level 2 inverse overvoltage element time out	164
59I2RS	Level 2 inverse overvoltage element reset	164
59I2TC	Level 2 inverse overvoltage element torque control	164
59I3	Level 3 inverse overvoltage element pickup	165
59I3T	Level 3 inverse overvoltage element time out	165
59I3RS	Level 3 inverse overvoltage element reset	165
59I3TC	Level 3 inverse overvoltage element torque control	165
59I4	Level 4 inverse overvoltage element pickup	165
59I4T	Level 4 inverse overvoltage element time out	165
59I4RS	Level 4 inverse overvoltage element reset	165
59I4TC	Level 4 inverse overvoltage element torque control	165
59PPX1	X-side Level 1 phase-to-phase overvoltage element pickup	143
59PPX1T	X-side Level 1 phase-to-phase overvoltage element trip	143
59PPX2	X-side Level 2 phase-to-phase overvoltage element pickup	143
59PPX2T	X-side Level 2 phase-to-phase overvoltage element trip	143
59PPY1	Y-side Level 1 phase-to-phase overvoltage element pickup	143
59PPY1T	Y-side Level 1 phase-to-phase overvoltage element trip	143
59PPY1	Y-side Level 2 phase-to-phase overvoltage element pickup	143
59PPY1T	Y-side Level 2 phase-to-phase overvoltage element trip	143
59PX1	X-side Level 1 phase overvoltage element pickup	17
59PX1T	X-side Level 1 phase overvoltage element trip	17
59PX2	X-side Level 2 phase overvoltage element pickup	17
59PX2T	X-side Level 2 phase overvoltage element trip	17
59PY1	Y-side Level 1 phase overvoltage element pickup	17
59PY1T	Y-side Level 1 phase overvoltage element trip	17
59PY2	Y-side Level 2 phase overvoltage element pickup	17
59PY2T	Y-side Level 2 phase overvoltage element trip	17
59QX1	X-side Level 1 negative-sequence overvoltage element pickup	18
59QX1T	X-side Level 1 negative-sequence overvoltage element trip	18
59QX2	X-side Level 2 negative-sequence overvoltage element pickup	18
59QX2T	X-side Level 2 negative-sequence overvoltage element trip	18
59QY1	Y-side Level 1 negative-sequence overvoltage element pickup	19
59QY1T	Y-side Level 1 negative-sequence overvoltage element trip	19
59QY2	Y-side Level 2 negative-sequence overvoltage element pickup	19
59QY2T	Y-side Level 2 negative-sequence overvoltage element trip	19

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 7 of 26)

Bit	Definition	Row
59S1	Level 1 synchronism overvoltage element pickup	28
59S1T	Level 1 synchronism overvoltage element trip	28
59S2	Level 2 synchronism overvoltage element pickup	28
59S2T	Level 2 synchronism overvoltage element trip	28
59V1X1	X-side Level 1 positive-sequence overvoltage element pickup	145
59V1X1T	X-side Level 1 positive-sequence overvoltage element trip	145
59V1X2	X-side Level 2 positive-sequence overvoltage element pickup	145
59V1X2T	X-side Level 2 positive-sequence overvoltage element trip	145
59V1X3	X-side Level 3 positive-sequence overvoltage element pickup	145
59V1X3T	X-side Level 3 positive-sequence overvoltage element trip	145
59V1X4	X-side Level 4 positive-sequence overvoltage element pickup	145
59V1X4T	X-side Level 4 positive-sequence overvoltage element trip	145
59V1X5	X-side Level 5 positive-sequence overvoltage element pickup	146
59V1X5T	X-side Level 5 positive-sequence overvoltage element trip	146
59V1X6	X-side Level 6 positive-sequence overvoltage element pickup	146
59V1X6T	X-side Level 6 positive-sequence overvoltage element trip	146
59VPX	Generator terminal voltage within voltage window	34
59VPY	Intertie terminal voltage within voltage window	36
59VSX	System voltage within voltage window	34
59VSY	System voltage within voltage window	36
64F1	Level 1 field ground protection element instantaneous pickup	15
64F1C	Instantaneous Level 1 field ground protection element timed out	60
64F1T	Level 1 field ground protection element timed out	15
64F2	Level 2 field ground protection element instantaneous pickup	15
64F2C	Instantaneous Level 2 field ground protection element timed out	62
64F2T	Level 2 field ground protection element timed out	15
64FFLT	Indicate a non-functional SEL-2664 or communication failure	15
64G1	Zone 1 neutral overvoltage stator ground fault element	14
64G1T	Zone 1 stator ground fault element timed out	14
64G2	Zone 2 third-harmonic voltage stator ground fault element	14
64G2T	Zone 2 stator ground fault element timed out	14
67GX1P[a]	X-side Level 1 residual-ground directional overcurrent pickup	6
67GX1T[a]	X-side Level 1 residual-ground directional overcurrent trip	6
67GX2P[a]	X-side Level 2 residual-ground directional overcurrent pickup	6
67GX2T[a]	X-side Level 2 residual-ground directional overcurrent trip	6
67GX2P[a]	X-side Level 2 residual-ground directional overcurrent pickup	6
67GX2T[a]	X-side Level 2 residual-ground directional overcurrent trip	6
67GY1P[a]	Y-side Level 1 residual-ground directional overcurrent pickup	6
67GY1T[a]	Y-side Level 1 residual-ground directional overcurrent trip	6
67N1P[a]	X-side Level 1 neutral-ground directional overcurrent pickup	147
67N1T[a]	X-side Level 1 neutral-ground directional overcurrent trip	147

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 8 of 26)

Bit	Definition	Row
67N2P[a]	X-side Level 2 neutral-ground directional overcurrent pickup	147
67N2T[a]	X-side Level 2 neutral-ground directional overcurrent trip	147
67PY1P[a]	Y-side Level 1 phase directional overcurrent pickup	7
67PY1T[a]	Y-side Level 1 phase directional overcurrent trip	7
67PY2P[a]	Y-side Level 2 phase directional overcurrent pickup	7
67PY2T[a]	Y-side Level 2 phase directional overcurrent trip	7
67QY1P[a]	Y-side Level 1 phase negative-sequence pickup	7
67QY1T[a]	Y-side Level 1 phase negative-sequence trip	7
67QY2P[a]	Y-side Level 2 phase negative-sequence pickup	7
67QY2T[a]	Y-side Level 2 phase negative-sequence trip	7
78R1	Out-of-step right blinder or outer resistance blinder	33
78R2	Out-of-step left blinder or inner resistance blinder	33
78VSBL	Vector shift element block condition	157
78VSO	Vector shift element output	157
78Z1	Out-of-step mho element	33
81RT	ORed, X-side and Y-side, frequency rate-of-change elements	22
81RX1T	X-side, Level 1, time-delayed, frequency rate-of-change element	31
81RX2T	X-side, Level 2, time-delayed, frequency rate-of-change element	31
81RX3T	X-side, Level 3, time-delayed, frequency rate-of-change element	31
81RX4T	X-side, Level 4, time-delayed, frequency rate-of-change element	31
81RXT	ORed, X-side, frequency rate-of-change element	39
81RY1T	Y-side, Level 1, time-delayed, frequency rate-of-change element	31
81RY2T	Y-side, Level 2, time-delayed, frequency rate-of-change element	31
81RY3T	Y-side, Level 3, time-delayed, frequency rate-of-change element	31
81RY4T	Y-side, Level 4, time-delayed, frequency rate-of-change element	31
81RYT	ORed, Y-side, frequency rate-of-change element	39
81T	ORed, X-side and Y-side, over- and underfrequency elements	29
81X1T	X-side, Level 1, over- and underfrequency element	29
81X2T	X-side, Level 2, over- and underfrequency element	29
81X3T	X-side, Level 3, over- and underfrequency element	29
81X4T	X-side, Level 4, over- and underfrequency element	29
81X5T	X-side, Level 5, over- and underfrequency element	29
81X6T	X-side, Level 6, over- and underfrequency element	29
81XT	ORed, X-side, over- and underfrequency elements	29
81Y1T	Y-side, Level 1, over- and underfrequency element	30
81Y2T	Y-side, Level 2, over- and underfrequency element	30
81Y3T	Y-side, Level 3, over- and underfrequency element	30
81Y4T	Y-side, Level 4, over- and underfrequency element	30
81Y5T	Y-side, Level 5, over- and underfrequency element	30
81Y6T	Y-side, Level 6, over- and underfrequency element	30
81YT	ORed, Y-side, over- and underfrequency elements	30

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 9 of 26)

Bit	Definition	Row
87AP	Differential current alarm element pickup	54
87AT	Differential current alarm element trip	54
87BL1	Harmonic block asserted for Differential Element 1	26
87BL2	Harmonic block asserted for Differential Element 2	26
87BL3	Harmonic block asserted for Differential Element 3	26
87HB	Harmonic block differential element asserted	26
87HR	Harmonic restrained element (HR1 OR HR2 OR HR3) * harmonic restrain enable	26
87HR1	Harmonic Restrained Element 1	26
87HR2	Harmonic Restrained Element 2	26
87HR3	Harmonic Restrained Element 3	26
87HSC1	Harmonic Restrained High Security Differential Element 1	152
87HSC2	Harmonic Restrained High Security Differential Element 2	152
87HSC3	Harmonic Restrained High Security Differential Element 3	152
87HSN1	Harmonic Restrained Sensitive Differential Element 1	151
87HSN2	Harmonic Restrained Sensitive Differential Element 2	151
87HSN3	Harmonic Restrained Sensitive Differential Element 3	151
87N1	Level 1 instantaneous ground differential pickup	12
87N1T	Level 1 time-delayed ground differential pickup	12
87N2	Level 2 instantaneous ground differential pickup	12
87N2T	Level 2 time-delayed ground differential pickup	12
87R	Restrained differential element trip (87HR OR 87HB)	11
87R1	Restrained Differential Element 1 (not considering harmonic blocks)	11
87R2	Restrained Differential Element 2 (not considering harmonic blocks)	11
87R3	Restrained Differential Element 3 (not considering harmonic blocks)	11
87SC1	Restrained High Security Differential Element 1 (not considering harmonic blocks)	152
87SC2	Restrained High Security Differential Element 2 (not considering harmonic blocks)	152
87SC3	Restrained High Security Differential Element 3 (not considering harmonic blocks)	152
87SN1	Restrained Sensitive Differential Element 1 (not considering harmonic blocks)	151
87SN2	Restrained Sensitive Differential Element 2 (not considering harmonic blocks)	151
87SN3	Restrained Sensitive Differential Element 3 (not considering harmonic blocks)	151
87U	Unrestrained differential element trip (87U1 OR 87U2 OR 87U3)	11
87U1	Unrestrained Differential Element 1 trip	11
87U2	Unrestrained Differential Element 2 trip	11
87U3	Unrestrained Differential Element 3 trip	11
89A2P1	Two-position Disconnect 1 N/O contact	157
89B2P1	Two-position Disconnect 1 N/C contact	157
89CL2P1	Two-position Disconnect 1 closed	157
89OP2P1	Two-position Disconnect 1 open	157
89A2P2	Two-position Disconnect 2 N/O contact	157
89B2P2	Two-position Disconnect 2 N/C contact	157
89CL2P2	Two-position Disconnect 2 closed	158

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 10 of 26)

Bit	Definition	Row
89OP2P2	Two-position Disconnect 2 open	158
89A2P3	Two-position Disconnect 3 N/O contact	158
89B2P3	Two-position Disconnect 3 N/C contact	158
89CL2P3	Two-position Disconnect 3 closed	158
89OP2P3	Two-position Disconnect 3 open	158
89A2P4	Two-position Disconnect 4 N/O contact	158
89B2P4	Two-position Disconnect 4 N/C contact	158
89CL2P4	Two-position Disconnect 4 closed	159
89OP2P4	Two-position Disconnect 4 open	159
89A2P5	Two-position Disconnect 5 N/O contact	159
89B2P5	Two-position Disconnect 5 N/C contact	159
89CL2P5	Two-position Disconnect 5 closed	159
89OP2P5	Two-position Disconnect 5 open	159
89A2P6	Two-position Disconnect 6 N/O contact	159
89B2P6	Two-position Disconnect 6 N/C contact	159
89CL2P6	Two-position Disconnect 6 closed	160
89OP2P6	Two-position Disconnect 6 open	160
89A2P7	Two-position Disconnect 7 N/O contact	160
89B2P7	Two-position Disconnect 7 N/C contact	160
89CL2P7	Two-position Disconnect 7 closed	160
89OP2P7	Two-position Disconnect 7 open	160
89A2P8	Two-position Disconnect 8 N/O contact	160
89B2P8	Two-position Disconnect 8 N/C contact	160
89CL2P8	Two-position Disconnect 8 closed	161
89OP2P8	Two-position Disconnect 8 open	161
89AL2P1	Two-position Disconnect 1 alarm	161
89A3PE1	Three-position Earthing Disconnect 1 N/O auxiliary contact	202
89A3PE2	Three-position Earthing Disconnect 2 N/O auxiliary contact	204
89A3PL1	Three-position In-line Disconnect 1 N/O auxiliary contact	201
89A3PL2	Three-position In-line Disconnect 2 N/O auxiliary contact	203
89AL	Any two-position or three-position disconnect in alarm	201
89AL3PE1	Three-position Earthing Disconnect 1 alarm	202
89AL3PE2	Three-position Earthing Disconnect 2 alarm	204
89AL3PL1	Three-position In-line Disconnect 1 alarm	201
89AL3PL2	Three-position In-line Disconnect 2 alarm	203
89B3PE1	Three-position Earthing Disconnect 1 N/C auxiliary contact	202
89B3PE2	Three-position Earthing Disconnect 2 N/C auxiliary contact	204
89B3PL1	Three-position In-line Disconnect 1 N/C auxiliary contact	201
89B3PL2	Three-position In-line Disconnect 2 N/C auxiliary contact	203
89C2P1	Two-position Disconnect 1 close output	185
89C2P2	Two-position Disconnect 2 close output	177

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 11 of 26)

Bit	Definition	Row
89C2P3	Two-position Disconnect 3 close output	178
89C2P4	Two-position Disconnect 4 close output	179
89C2P5	Two-position Disconnect 5 close output	180
89C2P6	Two-position Disconnect 6 close output	181
89C2P7	Two-position Disconnect 7 close output	182
89C2P8	Two-position Disconnect 8 close output	183
89C3PE1	Three-position Earthing Disconnect 1 close output	206
89C3PE2	Three-position Earthing Disconnect 2 close output	208
89C3PL1	Three-position In-line Disconnect 1 close output	205
89C3PL2	Three-position In-line Disconnect 2 close output	207
89CC2P1	Two-position Disconnect 1 close command for control via communication protocols	184
89CC2P2	Two-position Disconnect 2 close command for control via communication protocols	185
89CC2P3	Two-position Disconnect 3 close command for control via communication protocols	186
89CC2P4	Two-position Disconnect 4 close command for control via communication protocols	187
89CC2P5	Two-position Disconnect 5 close command for control via communication protocols	188
89CC2P6	Two-position Disconnect 6 close command for control via communication protocols	189
89CC2P7	Two-position Disconnect 7 close command for control via communication protocols	190
89CC2P8	Two-position Disconnect 8 close command for control via communication protocols	191
89CC3PE1	Three-position Earthing Disconnect 1 close command for control via communication protocols	193
89CC3PE2	Three-position Earthing Disconnect 2 close command for control via communication protocols	195
89CC3PL1	Three-position In-line Disconnect 1 close command for control via communication protocols	192
89CC3PL2	Three-position In-line Disconnect 2 close command for control via communication protocols	194
89CE2P1	Two-position Disconnect 1 close enable	176
89CE2P2	Two-position Disconnect 2 close enable	177
89CE2P3	Two-position Disconnect 3 close enable	178
89CE2P4	Two-position Disconnect 4 close enable	179
89CE2P5	Two-position Disconnect 5 close enable	180
89CE2P6	Two-position Disconnect 6 close enable	181
89CE2P7	Two-position Disconnect 7 close enable	182
89CE2P8	Two-position Disconnect 8 close enable	183
89CE3PE1	Three-position Earthing Disconnect 1 close enable	206
89CE3PE2	Three-position Earthing Disconnect 2 close enable	208
89CE3PL1	Three-position In-line Disconnect 1 close enable	205
89CE3PL2	Three-position In-line Disconnect 2 close enable	207
89CI2P1	Two-position Disconnect 1 close immobility timer timed out	176
89CI2P2	Two-position Disconnect 2 close immobility timer timed out	177
89CI2P3	Two-position Disconnect 3 close immobility timer timed out	178
89CI2P4	Two-position Disconnect 4 close immobility timer timed out	179
89CI2P5	Two-position Disconnect 5 close immobility timer timed out	180
89CI2P6	Two-position Disconnect 6 close immobility timer timed out	181
89CI2P7	Two-position Disconnect 7 close immobility timer timed out	182

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 12 of 26)

Bit	Definition	Row
89CI2P8	Two-position Disconnect 8 close immobility timer timed out	183
89CI3PE1	Three-position Earthing Disconnect 1 close immobility timer timed out	206
89CI3PE2	Three-position Earthing Disconnect 2 close immobility timer timed out	208
89CI3PL1	Three-position In-line Disconnect 1 close immobility timer timed out	205
89CI3PL2	Three-position In-line Disconnect 2 close immobility timer timed out	207
89CL3PE1	Three-position Earthing Disconnect 1 closed	202
89CL3PE2	Three-position Earthing Disconnect 2 closed	204
89CL3PL1	Three-position In-line Disconnect 1 closed	201
89CL3PL2	Three-position In-line Disconnect 2 closed	203
89CM2P1	Two-position Disconnect 1 close command for control via front-panel HMI	184
89CM2P2	Two-position Disconnect 2 close command for control via front-panel HMI	185
89CM2P3	Two-position Disconnect 3 close command for control via front-panel HMI	186
89CM2P4	Two-position Disconnect 4 close command for control via front-panel HMI	187
89CM2P5	Two-position Disconnect 5 close command for control via front-panel HMI	188
89CM2P6	Two-position Disconnect 6 close command for control via front-panel HMI	189
89CM2P7	Two-position Disconnect 7 close command for control via front-panel HMI	190
89CM2P8	Two-position Disconnect 8 close command for control via front-panel HMI	191
89CM3PE1	Three-position Earthing Disconnect 1 close command for control via front-panel HMI	193
89CM3PE2	Three-position Earthing Disconnect 2 close command for control via front-panel HMI	195
89CM3PL1	Three-position In-line Disconnect 1 close command for control via front-panel HMI	192
89CM3PL2	Three-position In-line Disconnect 2 close command for control via front-panel HMI	194
89CS2P1	Two-position Disconnect 1 close seal-in timer timed out	176
89CS2P2	Two-position Disconnect 2 close seal-in timer timed out	177
89CS2P3	Two-position Disconnect 3 close seal-in timer timed out	178
89CS2P4	Two-position Disconnect 4 close seal-in timer timed out	179
89CS2P5	Two-position Disconnect 5 close seal-in timer timed out	180
89CS2P6	Two-position Disconnect 6 close seal-in timer timed out	181
89CS2P7	Two-position Disconnect 7 close seal-in timer timed out	182
89CS2P8	Two-position Disconnect 8 close seal-in timer timed out	183
89CS3PE1	Three-position Earthing Disconnect 1 close seal-in timer timed out	206
89CS3PE2	Three-position Earthing Disconnect 2 close seal-in timer timed out	208
89CS3PL1	Three-position In-line Disconnect 1 close seal-in timer timed out	205
89CS3PL2	Three-position In-line Disconnect 2 close seal-in timer timed out	207
89IP	Any two-position or three-position disconnect in alarm	202
89IP2P1	Two-position Disconnect 1 operation in-progress	200
89IP2P2	Two-position Disconnect 2 operation in-progress	200
89IP2P3	Two-position Disconnect 3 operation in-progress	200
89IP2P4	Two-position Disconnect 4 operation in-progress	200
89IP2P5	Two-position Disconnect 5 operation in-progress	200
89IP2P6	Two-position Disconnect 6 operation in-progress	200
89IP2P7	Two-position Disconnect 7 operation in-progress	200

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 13 of 26)

Bit	Definition	Row
89IP2P8	Two-position Disconnect 8 operation in-progress	200
89IP3PE1	Three-position Earthing Disconnect 1 operation in-progress	202
89IP3PE2	Three-position Earthing Disconnect 2 operation in-progress	204
89IP3PL1	Three-position In-line Disconnect 1 operation in-progress	201
89IP3PL2	Three-position In-line Disconnect 2 operation in-progress	203
89O2P1	Two-position Disconnect 1 open output	176
89O2P2	Two-position Disconnect 2 open output	177
89O2P3	Two-position Disconnect 3 open output	178
89O2P4	Two-position Disconnect 4 open output	179
89O2P5	Two-position Disconnect 5 open output	180
89O2P6	Two-position Disconnect 6 open output	181
89O2P7	Two-position Disconnect 7 open output	182
89O2P8	Two-position Disconnect 8 open output	183
89O3PE1	Three-position Earthing Disconnect 1 open output	206
8903PE2	Three-position Earthing Disconnect 2 open output	208
89O3PL1	Three-position In-line Disconnect 1 open output	205
89O3PL2	Three-position In-line Disconnect 2 open output	207
89OC2P1	Two-position Disconnect 1 open command for control via communication protocols	184
89OC2P2	Two-position Disconnect 2 open command for control via communication protocols	185
89OC2P3	Two-position Disconnect 3 open command for control via communication protocols	186
89OC2P4	Two-position Disconnect 4 open command for control via communication protocols	187
89OC2P5	Two-position Disconnect 5 open command for control via communication protocols	188
89OC2P6	Two-position Disconnect 6 open command for control via communication protocols	189
89OC2P7	Two-position Disconnect 7 open command for control via communication protocols	190
89OC2P8	Two-position Disconnect 8 open command for control via communication protocols	191
89OC3PE1	Three-position Earthing Disconnect 1 open command for control via communication protocols	193
89OC3PE2	Three-position Earthing Disconnect 2 open command for control via communication protocols	195
89OC3PL1	Three-position In-line Disconnect 1 open command for control via communication protocols	192
89OC3PL2	Three-position In-line Disconnect 2 open command for control via communication protocols	194
89OE2P1	Two-position Disconnect 1 open enable	176
89OE2P2	Two-position Disconnect 2 open enable	177
89OE2P3	Two-position Disconnect 3 open enable	178
89OE2P4	Two-position Disconnect 4 open enable	179
89OE2P5	Two-position Disconnect 5 open enable	180
89OE2P6	Two-position Disconnect 6 open enable	181
89OE2P7	Two-position Disconnect 7 open enable	182
89OE2P8	Two-position Disconnect 8 open enable	183
89OE3PE1	Three-position Earthing Disconnect 1 open enable	206
89OE3PE2	Three-position Earthing Disconnect 2 open enable	208
89OE3PL1	Three-position In-line Disconnect 1 open enable	205
89OE3PL2	Three-position In-line Disconnect 2 open enable	207

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 14 of 26)

Bit	Definition	Row
890I2P1	Two-position Disconnect 1 open immobility timer timed out	176
890I2P2	Two-position Disconnect 2 open immobility timer timed out	177
890I2P3	Two-position Disconnect 3 open immobility timer timed out	178
890I2P4	Two-position Disconnect 4 open immobility timer timed out	179
890I2P5	Two-position Disconnect 5 open immobility timer timed out	180
890I2P6	Two-position Disconnect 6 open immobility timer timed out	181
890I2P7	Two-position Disconnect 7 open immobility timer timed out	182
890I2P8	Two-position Disconnect 8 open immobility timer timed out	183
89OI3PE1	Three-position Earthing Disconnect 1 open immobility timer timed out	206
89OI3PE2	Three-position Earthing Disconnect 2 open immobility timer timed out	208
89OI3PL1	Three-position In-line Disconnect 1 open immobility timer timed out	205
89OI3PL2	Three-position In-line Disconnect 2 open immobility timer timed out	207
89OM2P1	Two-position Disconnect 1 open command for control via front-panel HMI	184
89OM2P2	Two-position Disconnect 2 open command for control via front-panel HMI	185
89OM2P3	Two-position Disconnect 3 open command for control via front-panel HMI	186
89OM2P4	Two-position Disconnect 4 open command for control via front-panel HMI	187
89OM2P5	Two-position Disconnect 5 open command for control via front-panel HMI	188
89OM2P6	Two-position Disconnect 6 open command for control via front-panel HMI	189
89OM2P7	Two-position Disconnect 7 open command for control via front-panel HMI	190
89OM2P8	Two-position Disconnect 8 open command for control via front-panel HMI	191
89OM3PE1	Three-position Earthing Disconnect 1 open command for control via front-panel HMI	193
89OM3PE2	Three-position Earthing Disconnect 2 open command for control via front-panel HMI	195
89OM3PL1	Three-position In-line Disconnect 1 open command for control via front-panel HMI	192
89OM3PL2	Three-position In-line Disconnect 2 open command for control via front-panel HMI	194
89OP3PE1	Three-position Earthing Disconnect 1 open	202
89OP3PE2	Three-position Earthing Disconnect 2 open	204
89OP3PL1	Three-position In-line Disconnect 1 open	201
89OP3PL2	Three-position In-line Disconnect 2 open	203
89OS2P1	Two-position Disconnect 1 open seal-in timer timed out	176
89OS2P2	Two-position Disconnect 2 open seal-in timer timed out	177
89OS2P3	Two-position Disconnect 3 open seal-in timer timed out	178
89OS2P4	Two-position Disconnect 4 open seal-in timer timed out	179
89OS2P5	Two-position Disconnect 5 open seal-in timer timed out	180
89OS2P6	Two-position Disconnect 6 open seal-in timer timed out	181
89OS2P7	Two-position Disconnect 7 open seal-in timer timed out	182
89OS2P8	Two-position Disconnect 8 open seal-in timer timed out	183
89OS3PE1	Three-position Earthing Disconnect 1 open seal-in timer timed out	206
89OS3PE2	Three-position Earthing Disconnect 2 open seal-in timer timed out	208
89OS3PL1	Three-position In-line Disconnect 1 open seal-in timer timed out	205
89OS3PL2	Three-position In-line Disconnect 2 open seal-in timer timed out	207
89RC2P1	Two-position Disconnect 1 remote close control SELOGIC control equation	184

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 15 of 26)

Bit	Definition	Row
89RC2P2	Two-position Disconnect 2 remote close control SELOGIC control equation	185
89RC2P3	Two-position Disconnect 3 remote close control SELOGIC control equation	186
89RC2P4	Two-position Disconnect 4 remote close control SELOGIC control equation	187
89RC2P5	Two-position Disconnect 5 remote close control SELOGIC control equation	188
89RC2P6	Two-position Disconnect 6 remote close control SELOGIC control equation	189
89RC2P7	Two-position Disconnect 7 remote close control SELOGIC control equation	190
89RC2P8	Two-position Disconnect 8 remote close control SELOGIC control equation	191
89RC3PE1	Three-position Earthing Disconnect 1 remote close control SELOGIC control equation	193
89RC3PE2	Three-position Earthing Disconnect 2 remote close control SELOGIC control equation	195
89RC3PL1	Three-position In-line Disconnect 1 remote close control SELOGIC control equation	192
89RC3PL2	Three-position In-line Disconnect 2 remote close control SELOGIC control equation	194
89RO2P1	Two-position Disconnect 1 remote open control SELOGIC control equation	184
89RO2P2	Two-position Disconnect 2 remote open control SELOGIC control equation	185
89RO2P3	Two-position Disconnect 3 remote open control SELOGIC control equation	186
89RO2P4	Two-position Disconnect 4 remote open control SELOGIC control equation	187
89RO2P5	Two-position Disconnect 5 remote open control SELOGIC control equation	188
89RO2P6	Two-position Disconnect 6 remote open control SELOGIC control equation	189
89RO2P7	Two-position Disconnect 7 remote open control SELOGIC control equation	190
89RO2P8	Two-position Disconnect 8 remote open control SELOGIC control equation	191
89RO3PE1	Three-position Earthing Disconnect 1 remote open control SELOGIC control equation	193
89RO3PE2	Three-position Earthing Disconnect 2 remote open control SELOGIC control equation	195
89RO3PL1	Three-position In-line Disconnect 1 remote open control SELOGIC control equation	192
89RO3PL2	Three-position In-line Disconnect 2 remote open control SELOGIC control equation	194
89AL2P2	Two-position Disconnect 2 alarm	161
89AL2P3	Two-position Disconnect 3 alarm	161
89AL2P4	Two-position Disconnect 4 alarm	161
89AL2P5	Two-position Disconnect 5 alarm	161
89AL2P6	Two-position Disconnect 6 alarm	161
89AL2P7	Two-position Disconnect 7 alarm	162
89AL2P8	Two-position Disconnect 8 alarm	162
5HB1	Fifth-harmonic block asserted for Differential Element 1	38
5HB2	Fifth-harmonic block asserted for Differential Element 2	38
5HB3	Fifth-harmonic block asserted for Differential Element 3	38
5HBL	Fifth-harmonic block asserted (5HB1 OR 5HB2 OR 5HB3)	38
AI301HAL–AI504HAL	Analog Inputs 301–504 warnings/alarms (where *xxx* = 301–504) high alarm limit	120–131
AI301HW1–AI504HW1	Analog Inputs 301–504 warnings/alarms (where *xxx* = 301–504) high warning, Level 1	120–131
AI301HW2–AI504HW2	Analog Inputs 301–504 warnings/alarms (where *xxx* = 301–504) high warning, Level 2	120–131
AI301LAL–AI504LAL	Analog Inputs 301–504 warnings/alarms (where *xxx* = 301–504) low alarm limit	120–131
AI301LW1–AI504LW1	Analog Inputs 301–504 warnings/alarms (where *xxx* = 301–504) low warning, Level 1	120–131
AI301LW2–AI504LW2	Analog Inputs 301–504 warnings/alarms (where *xxx* = 301–504) low warning, Level 2	120–131
AIHAL	Analog inputs high alarm limit, if any AI*xxx*HAL = 1, then AIHAL = 1	119

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 16 of 26)

Bit	Definition	Row
AIHW1	Analog inputs high warning, Level 1, if any AI*xxx*HW1 = 1, then AIHW1 = 1	119
AIHW2	Analog inputs high warning, Level 2, if any AI*xxx*HW2 = 1, then AIHW2 = 1	119
AILAL	Analog inputs low alarm limit, if any AI*xxx*LAL = 1, then AILAL = 1	119
AILW1	Analog inputs low warning, Level 1, if any AI*xxx*LW1 = 1, then AILW1 = 1	119
AILW2	Analog inputs low warning, Level 2, if any AI*xxx*LW2 = 1, then AILW2 = 1	119
AMBALRM	Ambient temperature alarm. AMBALRM asserts if the healthy ambient RTD temperature exceeds its alarm set point.	44
AMBTRIP	Ambient Temperature trip. AMBTRIP asserts when the healthy Ambient RTD temperature exceeds its trip set point.	44
ASP	Autosynchronism stop	42
AST	Autosynchronism start	40
ASYNSDC	Asynchronous sampling data conversion is in process	62
BCWAX	X-side breaker A-phase breaker contact wear has reached 100 percent wear level	63
BCWAY	Y-side breaker A-phase breaker contact wear has reached 100 percent wear level	63
BCWBX	X-side breaker B-phase breaker contact wear has reached 100 percent wear level	63
BCWBY	Y-side breaker B-phase breaker contact wear has reached 100 percent wear level	63
BCWBY	Y-side breaker C-phase breaker contact wear has reached 100 percent wear level	63
BCWCX	X-side breaker C-phase breaker contact wear has reached 100 percent wear level	63
BCWX	BCWX = BCWAX OR BCWBX OR BCWCX	63
BCWY	BCWY = BCWAY OR BCWBY OR BCWCY	63
BFIX	52X breaker failure initiation asserted	32
BFIY	52Y breaker failure initiation asserted	32
BFTX	52X breaker failure trip	23
BKJMP	Asserts if the breaker control jumper is installed on the main board	162
BKRCF	Generator breaker close failed	36
BND1A	Abnormal Frequency Band 1 alarm (measured frequency between UBND1 and LBND1 settings	60
BND1T	Abnormal Frequency Band 1 trip (accumulated off-frequency operating time in band 1 exceeds TBND1 setting)	32
BND2A	Abnormal Frequency Band 2 alarm (measured frequency between LBND1 and LBND2 settings)	60
BND2T	Abnormal Frequency Band 2 trip (accumulated off-frequency operating time in band 2 exceeds TBND2 setting)	32
BND3A	Abnormal Frequency Band 3 alarm (measured frequency between LBND2 and LBND3 settings)	60
BND3T	Abnormal Frequency Band 3 trip (accumulated off-frequency operating time in band 3 exceeds TBND3 setting)	32
BND4A	Abnormal Frequency Band 4 alarm (measured frequency between LBND3 and LBND4 settings)	60
BND4T	Abnormal Frequency Band 4 trip (accumulated off-frequency operating time in band 4 exceeds TBND4 setting)	32
BND5A	Abnormal Frequency Band 5 alarm (measured frequency between LBND4 and LBND5 settings)	60
BND5T	Abnormal Frequency Band 5 trip (accumulated off-frequency operating time in band 5 exceeds TBND5 setting)	32

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 17 of 26)

Bit	Definition	Row
BND6A	Abnormal Frequency Band 6 alarm (measured frequency between LBND5 and LBND6 settings)	60
BND6T	Abnormal Frequency Band 6 trip (accumulated off-frequency operating time in band 6 exceeds TBND6 setting)	32
BNDA	BNDA = BND1A OR BND2A OR BND3A OR BND4A OR BND5A OR BND6A	60
BNDT	BNDT = BND1T OR BND2T OR BND3T OR BND4T OR BND5T OR BND6T	22
BRGALRM	Bearing temperature alarm. BRGALRM asserts when any healthy bearing RTD temperature exceeds its alarm set point, or biased alarm set point.	44
BRGTRIP	Bearing temperature trip and alarm. BRGTRIP asserts when one or two (when EBRGV = Y) healthy winding RTD temperatures exceed their trip or biased trip (when RTDBIAS = Y) set points.	44
CBADA	Channel A, channel unavailability over threshold	102
CBADB	Channel B, channel unavailability over threshold	102
CCX	**CLOSE** command—asserts when serial port command CCX (CLOSE Breaker X) or front panel or Modbus/DeviceNet **CLOSE** command is issued to close Breaker X	40
CCY	**CLOSE** command—asserts when serial port command CCY (CLOSE Breaker Y) or front panel or Modbus/DeviceNet **CLOSE** command is issued to close Breaker Y	40
CFA	Generator breaker close failure angle condition	36
CFARMED	Close fail armed	175
CFGFLT	Asserts on failed settings interdependency check during Modbus setting change	54
CFX	Breaker X close condition failure on	40
CFY	Breaker Y close condition failure on	40
CLOSEX	Close logic output for Breaker X	40
CLOSEY	Close logic output for Breaker Y	40
CLX	Close SELOGIC control equation CLX	42
CLY	Close SELOGIC control equation CLY	42
COMMFLT	Time-out of internal communication between CPU board and DeviceNet board	25
COMMIDLE	Device Net card in programming mode	25
COMMLOSS	Device Net communication failure	25
DI_A1	A-phase distortion index X-side wdg1	132
DI_A2	A-phase distortion index Y-side wdg2	132
DI_B1	B-phase distortion index X-side wdg1	132
DI_B2	B-phase distortion index Y-side wdg2	132
DI_C1	C-phase distortion index X-side wdg1	132
DI_C2	C-phase distortion index Y-side wdg2	132
DIRGFX	X-side forward directional routed to residual overcurrent elements	139
DIRGFY	Y-side forward directional control routed to residual overcurrent elements	139
DIRGRX	X-side reverse directional routed to residual overcurrent elements	139
DIRGRY	Y-side reverse directional control routed to residual overcurrent elements	139
DIRIEX	X-side internal enable for channel IN current-polarized directional element	135
DIRIEY	Y-side internal enable for channel IN current-polarized directional element	136
DIRNEX	X-side internal enable for 3V0 polarized and IN operating directional element	147
DIRNFX	X-side forward directional routed to neutral overcurrent elements	148

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 18 of 26)

Bit	Definition	Row
DIRNRX	X-side reverse directional routed to neutral overcurrent elements	148
DIRPFY	Y-side forward directional control routed to phase overcurrent elements	139
DIRPRY	Y-side reverse directional control routed to phase overcurrent elements	139
DIRQEX	X-side internal enable for negative-sequence voltage-polarized directional element	135
DIRQEY	Y-side internal enable for negative-sequence voltage-polarized directional element	136
DIRQFY	Y-side forward directional control routed to negative-sequence overcurrent elements	139
DIRQGEX	X-side internal enable for negative-sequence voltage-polarized directional element	135
DIRQGEY	Y-side internal enable for negative-sequence voltage-polarized directional element	136
DIRQRY	Y-side reverse directional control routed to negative-sequence overcurrent elements	139
DIRVEX	X-side internal enable for zero-sequence voltage-polarized directional element	135
DIRVEY	Y-side internal enable for zero-sequence voltage-polarized directional element	136
DNAUX1–DNAUX8	DeviceNet/Modbus AUX1–AUX8 assert bit	64
DNAUX9–DNAUX11	DeviceNet/Modbus AUX9–AUX11 assert bit	65
DRDOPT	External event detector (DRDOPT1 OR DRDOPT2 OR DRDOPT3)	149
DRDOPT1	Differential Element 1 external event detector	149
DRDOPT2	Differential Element 2 external event detector	149
DRDOPT3	Differential Element 3 external event detector	149
DSABLSET	SELOGIC control equation: Does not allow settings changes from front-panel interface when asserted	56
DST	Daylight-saving time	133
DSTP	Daylight-saving time pending	133
ENLRC	Asserts when Local/Remote control is enabled by EN_LRC := Y	162
ER	Event report trigger SELOGIC control equation	25
FAULT	Indicates fault condition. Asserts when SELOGIC control equation FAULT result in a logical 1.	53
FDIRIX	X-side forward channel IN current-polarized directional element	137
FDIRIY	Y-side forward channel IN current-polarized directional element	138
FDIRNX	X-side forward 3V0 polarized and IN operating directional element	141
FDIRPY	Y-side forward positive-sequence voltage-polarized directional element	134
FDIRQGX	X-side forward negative-sequence voltage-polarized directional element	137
FDIRQGY	Y-side forward negative-sequence voltage-polarized directional element	138
FDIRVX	X-side forward zero-sequence voltage-polarized directional element	137
FDIRVY	Y-side forward zero-sequence voltage-polarized directional element	138
FDRIRQY	Y-side forward negative-sequence voltage-polarized directional element	138
FLOWER	Lower frequency for autosynchronism	35
FRAISE	Raise frequency for autosynchronism	35
FREQFZ	Synchrophasor bit that asserts if the measured frequency > ±20 Hz from nominal	141
FREQSOK	Phase rate-of-change frequency measurement function detects a valid VS signal	69
FREQTRKX	Frequency tracking enable bit for X-side voltages or currents—tracking enabled when bit is asserted	69
FREQTRKY	Frequency tracking enable bit for Y-side voltages or currents—tracking enabled when bit is asserted	69

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 19 of 26)

Bit	Definition	Row
FREQXOK	Phase rate-of-change frequency measurement function detects a valid V1X/I1X signal	69
FREQYOK	Phase rate-of-change frequency measurement function detects a valid V1Y/I1Y signal	69
FSYNCACT	Frequency matching—Autosynchronization is in progress	132
FSYNCNO	Frequency synchronism timer timeout	40
GENFHI	Slip frequency greater than 25SHI setting	35
GENFLO	Slip frequency less than 25SLO setting	35
GENVHI	Generator voltage greater than system voltage	35
GENVLO	Generator voltage less than system voltage	35
GNDEMX	X-side zero sequence current demand pickup	62
GNDEMY	Y-side zero sequence current demand pickup	62
GSRTRG	Trigger for generator start report	34
GX1DIR	Directional control for element 50GX1/67GX1 and 51GX	140
GX2DIR	Directional control for element 50GX2/67GX2	140
GY1DIR	Directional control for element 50GY1/67GY1 and 51GY	140
GY2DIR	Directional control for element 50GY2/67GY2	140
HALARM	Diagnostics failure	56
HR	Differential element, second-harmonic content detection pickup	150
HRT	Differential element, second-harmonic content detection time-out	150
HSM	High security mode SELOGIC control equation	149
IA12H	Differential element, second-harmonic content detected in IAX	150
IA22H	Differential element, second-harmonic content detected in IAY	150
IB12H	Differential element, second-harmonic content detected in IBX	150
IB22H	Differential element, second-harmonic content detected in IBY	150
IC12H	Differential element, second-harmonic content detected in ICX	150
IC22H	Differential element, second-harmonic content detected in ICY	150
IN101	Contact Input IN101	49
IN102	Contact Input IN102	49
IN301–IN308	Contact Inputs IN301–IN308 (available only with optional I/O module)	50
IN309–IN314	Contact Inputs IN309–IN314 (available only with optional I/O module)	154
IN401–IN408	Contact Inputs IN401–IN408 (available only with optional I/O module)	51
IN409–IN414	Contact Inputs IN409–IN414 (available only with optional I/O module)	155
IN501–IN508	Contact Inputs IN501–IN508 (available only with optional I/O module)	52
IN509–IN514	Contact Inputs IN509–IN514 (available only with optional I/O module)	156
INAD	Inadvertent energization logic pickup	23
INADT	Inadvertent energization logic timed out	23
INR1	87-1 element in high-security mode	65
INR2	87-2 element in high-security mode	65
INR3	87-3 element in high-security mode	65
IRIGOK	IRIG-B time synchronism input data are valid.	53
LB01–LB08	Local Bits 1–8	70
LB09–LB16	Local Bits 9–16	71

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 20 of 26)

Bit	Definition	Row
LB17–LB24	Local Bits 17–24	72
LB25–LB32	Local Bits 25–32	73
LBOKA	Channel A, looped back ok	102
LBOKB	Channel B, looped back ok	102
LINK1	Asserted when a valid link is detected on Port 1	147
LINKA	Asserts if Ethernet Port A detects link	53
LINKB	Asserts if Ethernet Port B detects link	53
LINKFAIL	Failure of active Ethernet port link	54
LOC	SELOGIC control for control authority at local/bay level	174
LOCAL	Asserts when relay control configuration is in LOCAL mode	162
LOCSTA	SELOGIC control for control authority at station level	174
LOPBLKX	X-side loss-of-potential block SELOGIC control equation	3
LOPBLKY	Y-side loss-of-potential block SELOGIC control equation	3
LOPX	X-side loss of potential	54
LOPY	Y-side loss of potential	54
LPHDSIM	IEC 61850 simulation mode	173
LPSEC	Direction of the upcoming leap second. During the time that LPSECP is asserted, if LPSEC is asserted, the upcoming leap second is deleted; otherwise, the leap second is added.	133
LPSECP	Leap second pending	133
LT01–LT08	Latch Bits 1–8	86
LT09–LT16	Latch Bits 9–16	87
LT17–LT24	Latch Bits 17–24	88
LT25–LT32	Latch Bits 25–32	89
MABC1P	Zone 1 three-phase compensator distance element pickup	24
MABC2P	Zone 2 three-phase compensator distance element pickup	24
MATHERR	SELOGIC math error bit asserted for divide-by-zero, etc., in SELOGIC math functions	147
MLTLEV	SELOGIC control for multilevel mode of control authority	174
MPP1P	Zone 1 phase-to-phase compensator distance element pickup	24
MPP2P	Zone 2 phase-to-phase compensator distance element pickup	24
N64G	64G2T pickup for ground near neutral	14
NX1DIR	Directional control for element 50N1/67N1 and 51N	148
NX2DIR	Directional control for element 50N2/67N2	148
OCX	**OPEN** command—asserts when serial port command **OPEN BREAKER X** or front panel or Modbus/DeviceNet **OPEN** command is issued to open Breaker X	41
OCY	**OPEN** command—asserts when serial port command **OPEN BREAKER Y** or front panel or Modbus/DeviceNet **OPEN** command is issued to open Breaker Y	41
OOS	Out-of-step element	33
OOST	Out-of-step trip	33
ORED50T	Logical OR of all the instantaneous overcurrent elements tripped outputs	2
ORED51T	Logical OR of all the time-overcurrent elements tripped Outputs	9
OREDLOC	Logical OR of LOC and LOCAL Relay Word bits	174

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 21 of 26)

Bit	Definition	Row
OTHALRM	Other temperature alarm. OTHALRM asserts when any healthy other RTD temperature exceeds its alarm set point.	44
OTHTRIP	Other temperature trip. OTHTRIP asserts when one or more healthy Other RTD temperatures exceed their trip set points.	44
OUT101	Control equation for Contact Output OUT101	45
OUT102	Control equation for Contact Output OUT102	45
OUT103	Control equation for Contact Output OUT103	45
OUT301–OUT308	Control equation for Contact Outputs OUT301–OUT308 (available only with optional I/O module)	46
OUT401–OUT408	Control equation for Contact Outputs OUT401–OUT408 (available only with optional I/O module)	47
OUT501–OUT508	Control equation for Contact Outputs OUT501–OUT508 (available only with optional I/O module)	48
PASEL	Ethernet Port A is selected for communication	54
PB01	Front-Panel Pushbutton 1 bit (asserted when PB01 is pressed)	66
PB01_PUL	Front-Panel Pushbutton 1 pulse bit (asserted for one processing interval when PB01 is pressed)	66
PB02	Front-Panel Pushbutton 2 bit (asserted when PB02 is pressed)	66
PB02_PUL	Front-Panel Pushbutton 2 pulse bit (asserted for one processing interval when PB02 is pressed)	66
PB03	Front-Panel Pushbutton 3 bit (asserted when PB03 is pressed)	66
PB03_PUL	Front-Panel Pushbutton 3 pulse bit (asserted for one processing interval when PB03 is pressed)	66
PB04	Front-Panel Pushbutton 4 bit (asserted when PB04 is pressed)	66
PB04_PUL	Front-Panel Pushbutton 4 pulse bit (asserted for one processing interval when PB04 is pressed)	66
PB05	Front-Panel Pushbutton 5 bit (asserted when PB05 is pressed)	166
PB05_PUL	Front-Panel Pushbutton 5 pulse bit (asserted for one processing interval when PB05 is pressed)	166
PB06	Front-Panel Pushbutton 6 bit (asserted when PB06 is pressed)	166
PB06_PUL	Front-Panel Pushbutton 6 pulse bit (asserted for one processing interval when PB06 is pressed)	166
PB07	Front-Panel Pushbutton 7 bit (asserted when PB07 is pressed)	166
PB07_PUL	Front-Panel Pushbutton 7 pulse bit (asserted for one processing interval when PB07 is pressed)	166
PB08	Front-Panel Pushbutton 8 bit (asserted when PB08 is pressed)	166
PB08_PUL	Front-Panel Pushbutton 8 pulse bit (asserted for one processing interval when PB08 is pressed)	166
PB1A_LED	SELOGIC control equation: drives LED PB1A	67
PB1B_LED	SELOGIC control equation: drives LED PB1B	67
PB2A_LED	SELOGIC control equation: drives LED PB2A	67
PB2B_LED	SELOGIC control equation: drives LED PB2B	67
PB3A_LED	SELOGIC control equation: drives LED PB3A	67
PB3B_LED	SELOGIC control equation: drives LED PB3B	67
PB4A_LED	SELOGIC control equation: drives LED PB4A	67

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 22 of 26)

Bit	Definition	Row
PB4B_LED	SELOGIC control equation: drives LED PB4B	67
PB5A_LED	SELOGIC control equation: drives LED PB5A	167
PB5B_LED	SELOGIC control equation: drives LED PB5B	167
PB6A_LED	SELOGIC control equation: drives LED PB6A	167
PB6B_LED	SELOGIC control equation: drives LED PB6B	167
PB7A_LED	SELOGIC control equation: drives LED PB7A	167
PB7B_LED	SELOGIC control equation: drives LED PB7B	167
PB8A_LED	SELOGIC control equation: drives LED PB8A	167
PB8B_LED	SELOGIC control equation: drives LED PB8B	167
PBSEL	Ethernet Port B is selected for communication	54
PHDEMX	X-side phase current demand pickup	62
PHDEMY	Y-side phase current demand pickup	62
PMDOK	Assert if data acquisition system is operating correctly	53
PMTRIG	Trigger for synchrophasors	25
PTPA	Asserts when PTP is enabled in PRP mode and the relay is receiving PTP messages on Port 1A	172
PTPB	Asserts when PTP is enabled in PRP mode and the relay is receiving PTP messages on Port 1B	172
PTPSYNC	Asserts if the relay is using PTP time to do time synchronization	172
PTP_OK	Asserts if the PTP time is within the 4 ms local offset	172
PTP_TIM	Asserts if a valid PTP time source is detected	172
PY1DIR	Directional control for element 50PY1/67PY1 and 51PY	140
PY2DIR	Directional control for element 50PY2/67PY2	140
QY1DIR	Directional control for element 50QY1/67QY1 and 51QY	140
QY2DIR	Directional control for element 50QY2/67QY2	140
RB01–RB08	Remote Bits 1–8	74
RB09–RB16	Remote Bits 9–16	75
RB17–RB24	Remote Bits 17–24	76
RB25–RB32	Remote Bits 25–32	77
RBADA	Channel A, outage duration over threshold	102
RBADB	Channel B, outage duration over threshold	102
RDIRIX	X-side reverse channel IN current-polarized directional element	137
RDIRIY	Y-side reverse channel IN current-polarized directional element	138
RDIRNX	X-side reverse 3V0 polarized and IN operating directional element	141
RDIRPY	Y-side reverse positive-sequence voltage-polarized directional element	134
RDIRQGX	X-side reverse negative-sequence voltage -polarized directional element	137
RDIRQGY	Y-side reverse negative-sequence voltage -polarized directional element	138
RDIRQY	Y-side reverse negative-sequence voltage -polarized directional element	138
RDIRVX	X-side reverse zero-sequence voltage -polarized directional element	137
RDIRVY	Y-side reverse zero-sequence voltage -polarized directional element	138
REF1BYP	Restricted earth fault bypass logic	13
REF1EN	Internal enable for the REF element	13

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 23 of 26)

Bit	Definition	Row
REF1F	REF element forward (internal) fault declaration	13
REF1P	Restricted earth fault inverse-time O/C element timed-out	13
REF1R	REF element reverse (external) fault declaration	13
RELAY_EN	OK flag. RELAY_EN status follows the **ENABLED** LED status	65
REMTRIP	Remote trip	25
RHSM	Phase comparison internal fault detector	149
RMB1A–RMB8A	Channel A receive MIRRORED BITS RMB1A through RMB8A	98
RMB1B–RMB8B	Channel B receive MIRRORED BITS RMB1B through RMB8B	100
ROKA	Channel A, received data ok	102
ROKB	Channel B, received data ok	102
RSTDEM	Reset demand meter	55
RSTENRGY	Reset energy metering. Assert when the SELOGIC control equation RSTENRG result is logical 1.	55
RSTMXMN	Reset max/min metering. Assert when the SELOGIC control equation RSTMXMN result is logical 1.	55
RSTPKDEM	Reset peak demand meter	55
RSTTRGT	SELOGIC control equation: reset trip logic and targets when asserted	56
RTD1A–RTD4A	RTD1A through RTD4A: alarms	57
RTD1T–RTD4T	RTD1T through RTD4T: trips	57
RTD5A–RTD8A	RTD5A through RTD8A: alarms	58
RTD5T–RTD8T	RTD5T through RTD8T: trips	58
RTD9A–RTD12A	RTD9A through RTD12A: alarms	59
RTD9T–RTD12T	RTD9T through RTD12T: trips	59
RTDA	Asserts when any RTD alarm (RTD_A) is asserted.	56
RTDBIAS	RTD bias alarm	56
RTDFLT	Asserts when an open or short-circuit condition is detected on any enabled RTD input, or communication with the external RTD module has been interrupted	23
RTDIN	Indicates status of contact connected to SEL-2600A RTD module	56
RTDT	Asserts when any RTD trip (RTD_T) is asserted	23
SALARM	Software Alarms: invalid password, changing access levels, settings changes, active group change, copy command, and password change	53
SC01QD–SC08QD	SELOGIC Counters 01 through 08 asserted when counter = 0	91
SC01QU–SC08QU	SELOGIC Counters 01 through 08 assert when counter = preset value	90
SC09QD–SC16QD	SELOGIC Counters 09 through 16 assert when counter = 0	93
SC09QU–SC16QU	SELOGIC Counters 09 through 16 assert when counter = preset value	92
SC17QD–SC24QD	SELOGIC Counters 17 through 24 asserted when counter = 0	95
SC17QU–SC24QU	SELOGIC Counters 17 through 24 assert when counter = preset value	94
SC25QD–SC32QD	SELOGIC Counters 25 through 32 assert when counter = 0	97
SC25QU–SC32QU	SELOGIC Counters 25 through 32 assert when counter = preset value	96
SC850TM	SELOGIC control for IEC 61850 Test Mode	174
SC850BM	SELOGIC control for IEC 61850 Block Mode	174
SC850SM	SELOGIC control for IEC 61850 Simulation Mode	174

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 24 of 26)

Bit	Definition	Row
SC850LS	SELOGIC control for control authority at station level	174
SFX	Generator slip frequency is within acceptable bounds (between 25SLO and 25SHI settings)	34
SFY	Intertie slip frequency within acceptable bounds (less than 25SF setting)	36
SG1	Asserts when Setting Group 1 is active	61
SG2	Asserts when Setting Group 2 is active	61
SG3	Asserts when Setting Group 3 is active	61
SG4	Asserts when Setting Group 4 is active	61
SV01–SV08	SELOGIC control equation variables SV01 through SV08	78
SV01T–SV08T	SELOGIC control equation variable SV01T through SV08T with settable pickup and dropout time delay	79
SV09–SV16	SELOGIC control equation variables SV09 through SV16	80
SV09T–SV16T	SELOGIC control equation variable SV09T through SV16T with settable pickup and dropout time delay	81
SV17–SV24	SELOGIC control equation variables SV17 through SV24	82
SV17T–SV24T	SELOGIC control equation variable SV17T through SV24T with settable pickup and dropout time delay	83
SV25–SV32	SELOGIC control equation variables SV25 through SV32	84
SV25T–SV32T	SELOGIC control equation variable SV25T through SV32T with settable pickup and dropout time delay	85
SWING	Single blinder: 78R1/78R2 and 78Z1 assert Double blinder: 78R1 and 78R2 assert or only 78R1 asserts	33
T01_LED	SELOGIC control equation: drives T01_LED	68
T02_LED	SELOGIC control equation: drives T02_LED	68
T03_LED	SELOGIC control equation: drives T03_LED	68
T04_LED	SELOGIC control equation: drives T04_LED	68
T05_LED	SELOGIC control equation: drives T05_LED	68
T06_LED	SELOGIC control equation: drives T06_LED	68
T64G	64G2T pickup for ground near generator terminals	14
TESTDB	Command TEST DB (asserts when analog and digital values reported via Modbus, IEC 61850 or Fast Meter protocol may be overridden)	56
TH5	Fifth-harmonic alarm threshold exceeded	27
TH5T	Fifth-harmonic alarm threshold exceeded for longer than TH5D	27
TMB1A–TMB8A	Channel A transmit MIRRORED BITS TMB1A through TMB8A	99
TMB1B–TMB8B	Channel B transmit MIRRORED BITS TMB1B through TMB8B	101
TQUAL1	Time quality bit, add 1 when asserted	133
TQUAL2	Time quality bit, add 2 when asserted	133
TQUAL4	Time quality bit, add 4 when asserted	133
TQUAL8	Time quality bit, add 8 when asserted	133
TR1	Trip 1 SELOGIC control equation	41
TR2	Trip 2 SELOGIC control equation	41
TR3	Trip 3 SELOGIC control equation	41
TREA1	Trigger Reason Bit 1 for synchrophasors	61

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 25 of 26)

Bit	Definition	Row
TREA2	Trigger Reason Bit 2 for synchrophasors	61
TREA3	Trigger Reason Bit 3 for synchrophasors	61
TREA4	Trigger Reason Bit 4 for synchrophasors	61
TRICOLOR	Asserts when the relay detects eight pushbuttons and tricolor LEDs on the front-panel HMI	68
TRGTR	Target Reset. Asserts for one quarter-cycle when you execute a front-panel, serial port target reset command, or Modbus target reset.	56
TRIP	Trip logic output	25
TRIP1	Generator field breaker trip	42
TRIP2	Prime mover trip	42
TRIP3	Generator lockout breaker trip	42
TRIPX	X-side (generator main circuit) breaker trip	42
TRIPY	Y-side breaker trip	42
TRX	Trip X SELOGIC control equation	41
TRY	Trip Y SELOGIC control equation	41
TSNTPB	SNTP Secondary Server is active	141
TSNTPP	SNTP Primary Server is active	141
TSOK	Asserts if current time source accuracy is sufficient for synchronized phasor measurements	53
TUTC1	Offset hours from UTC, binary, add 1 if asserted	134
TUTC2	Offset hours from UTC, binary, add 2 if asserted	134
TUTC4	Offset hours from UTC, binary, add 4 if asserted	134
TUTC8	Offset hours from UTC, binary, add 8 if asserted	134
TUTCH	Offset half-hour from UTC, binary, add 0.5 if asserted	134
TUTCS	Offset hours sign from UTC, subtract the UTC offset if TUTCS is asserted; otherwise, add.	134
ULCLX	Unlatch close conditions SELOGIC control equation CLX state	43
ULCLY	Unlatch close conditions SELOGIC control equation CLY state	43
ULTR1	Unlatch Trip 1 SELOGIC control equation	43
ULTR2	Unlatch trip 2 SELOGIC control equation	43
ULTR3	Unlatch trip 3 SELOGIC control equation	43
ULTRX	Unlatch Trip X SELOGIC control equation	43
ULTRY	Unlatch Trip Y SELOGIC control equation	43
VB001–VB008	Virtual bits used for incoming GOOSE messages (*xxx* = 1–128)	103
VB009–VB016	Virtual bits used for incoming GOOSE messages (*xxx* = 1–128)	104
VB017–VB024	Virtual bits used for incoming GOOSE messages (*xxx* = 1–128)	105
VB025–VB032	Virtual bits used for incoming GOOSE messages (*xxx* = 1–128)	106
VB033–VB040	Virtual bits used for incoming GOOSE messages (*xxx* = 1–128)	107
VB041–VB048	Virtual bits used for incoming GOOSE messages (*xxx* = 1–128)	108
VB049–VB056	Virtual bits used for incoming GOOSE messages (*xxx* = 1–128)	109
VB057–VB064	Virtual bits used for incoming GOOSE messages (*xxx* = 1–128)	110
VB065–VB072	Virtual bits used for incoming GOOSE messages (*xxx* = 1–128)	111

Table L.3 Relay Word Bit Definitions for the SEL-700G (Sheet 26 of 26)

Bit	Definition	Row
VB073–VB080	Virtual bits used for incoming GOOSE messages (*xxx* = 1–128)	112
VB081–VB088	Virtual bits used for incoming GOOSE messages (*xxx* = 1–128)	113
VB089–VB096	Virtual bits used for incoming GOOSE messages (*xxx* = 1–128)	114
VB097–VB104	Virtual bits used for incoming GOOSE messages (*xxx* = 1–128)	115
VB105–VB112	Virtual bits used for incoming GOOSE messages (*xxx* = 1–128)	116
VB113–VB120	Virtual bits used for incoming GOOSE messages (*xxx* = 1–128)	117
VB121–VB128	Virtual bits used for incoming GOOSE messages (*xxx* = 1–128)	118
VDIFX	Generator and system voltage difference within acceptable bounds	34
VDIFY	Intertie and system voltage difference within acceptable bounds	36
VLOWER	Lower voltage for autosynchronism	35
VPOLVX	X-side positive-sequence polarization voltage valid	55
VPOLVY	Y-side positive-sequence polarization voltage valid	55
VRAISE	Raise voltage for autosynchronism	35
VSYNCACT	Voltage Matching – Auto Synchronization is in Progress	132
VSYNCNO	Voltage synchronism timer timeout	41
WARNING	Relay Word bit WARNING. Refer to *Table 8.3* for a list of WARNING conditions.	53
WDGALRM	Winding temperature alarm. WDGALRM asserts if any healthy winding RTD temperature exceeds its alarm set point, or biased alarm set point.	44
WDGTRIP	Winding temperature trip. WDGTRIP asserts when one or two (when EWDGV = Y) healthy winding RTD temperatures exceed their trip or biased trip (when RTDBIAS = Y) set points.	44
ZCFREQS	Zero-crossing frequency measurement function detects a valid signal on the VS channel.	69
ZCFREQX	Zero-crossing frequency measurement function detects a valid signal on the VAX/VABX/IAX channel.	69
ZCFREQY	Zero-crossing frequency measurement function detects a valid signal on the VAY/VABY/IAY channel.	69
ZLINY	Y-side load-encroachment “load in” element	55
ZLOADX	X-side load-encroachment element pickup	33
ZLOADY	Y-side load-encroachment element pickup	33
ZLOUTY	Y-side load-encroachment “load out” element	55

[a] These Relay Word bits are model dependent. Refer to Table L.2 for models in which these Relay Word bits are hidden.

Appendix M
Analog Quantities

The SEL-700G Relay contains several analog quantities that you can use for more than one function. The actual analog quantities available depend on the part number of the relay used. Analog quantities are typically generated and used by a primary function, such as, metering. Selected quantities are made available for one or more supplemental functions, for example, the load profile.

Note that all analog quantities available for use in SELOGIC are processed every 25 ms and may not be suitable for fast-response control and protection applications. Analog quantities for rms data are determined through the use of data averaged over the previous 8 cycles.

Table M.1 lists analog quantities that you can use in the following specific functions:

- Display points (see *Section 8: Front-Panel Operations*)
- SELOGIC control equations (see *Section 4: Protection and Logic Functions*)
- Load profile recorder (see *Section 5: Metering and Monitoring*)
- DNP (see *Appendix D: DNP3 Communications*)
- EtherNet/IP (see *Appendix F: EtherNet/IP Communications*)
- Fast Message Read (FMR)
- IEC 60870-5-103 (see *Appendix H: IEC 60870-5-103 Communications*)
- Modbus (see *Appendix E: Modbus Communications*)
- Fast Meter (FM) (see *Appendix C: SEL Communications Processors*)
- IEC 61850 (see *Appendix G: IEC 61850 Communications*)

NOTE: Quantities that contain X (e.g., IAX_MAG) refer to the X side; quantities that contain Y (e.g., IAY_MAG) refer to the Y side.

Table M.1 Analog Quantities (Sheet 1 of 13)

Name	Description	Units	Display Points	SELOGIC	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/ EtherNet/IP via Ethernet Port	Modbus[a]	Fast Meter	IEC 61850[b]
Fundamental Instantaneous Metering Note 1: When E64F = N or 64FFLT = 1, FLDRES is forced to 20 MΩ and DNP and IEC 61850 report FFFFh.									
IAX_MAG	X-side current, A-phase, magnitude	A pri	X	X	X	X	X	X	X
IAX_ANG	X-side current, A-phase, angle	degrees	X	X	X	X	X		X
IBX_MAG	X-side current, B-phase, magnitude	A pri	X	X	X	X	X	X	X
IBX_ANG	X-side current, B-phase, angle	degrees	X	X	X	X	X		X
ICX_MAG	X-side current, C-phase, magnitude	A pri	X	X	X	X	X	X	X
ICX_ANG	X-side current, C-phase, angle	degrees	X	X	X	X	X		X
IGX_MAG	X-side current, calculated-residual, magnitude	A pri	X	X	X	X	X		X
IGX_ANG	X-side current, calculated-residual, angle	degrees	X	X	X	X	X		X
I1X_MAG	X-side current, positive-sequence, magnitude	A pri	X	X	X	X	X		X
I1X_ANG	X-side current, positive-sequence, angle	degrees	X	X	X	X	X		X
3I2X_MAG	X-side current, negative-sequence, magnitude	A pri	X	X	X	X	X		X
3I2X_ANG	X-side current, negative-sequence, angle	degrees	X	X	X	X	X		X
IAY_MAG	Y-side current, A-phase, magnitude	A pri	X	X	X	X	X	X	X
IAY_ANG	Y-side current, A-phase, angle	degrees	X	X	X	X	X		X
IBY_MAG	Y-side current, B-phase, magnitude	A pri	X	X	X	X	X	X	X
IBY_ANG	Y-side current, B-phase, angle	degrees	X	X	X	X	X		X
ICY_MAG	Y-side current, C-phase, magnitude	A pri	X	X	X	X	X	X	X
ICY_ANG	Y-side current, C-phase, angle	degrees	X	X	X	X	X		X
IGY_MAG	Y-side current, calculated-residual, magnitude	A pri	X	X	X	X	X		X
IGY_ANG	Y-side current, calculated-residual, angle	degrees	X	X	X	X	X		X
I1Y_MAG	Y-side current, positive-sequence, magnitude	A pri	X	X	X	X	X		X
I1Y_ANG	Y-side current, positive-sequence, angle	degrees	X	X	X	X	X		X
3I2Y_MAG	Y-side current, negative-sequence, magnitude	A pri	X	X	X	X	X		X
3I2Y_ANG	Y-side current, negative-sequence, angle	degrees	X	X	X	X	X		X
IN_MAG	Current, neutral, magnitude	A pri	X	X	X	X	X		X
IN_ANG	Current, neutral, angle	degrees	X	X	X	X	X		X
VAX_MAG	X-side voltage, A-phase-to-neutral, magnitude	V pri	X	X	X	X	X	X	X
VAX_ANG	X-side voltage, A-phase-to-neutral, angle	degrees	X	X	X	X	X		X
VBX_MAG	X-side voltage, B-phase-to-neutral, magnitude	V pri	X	X	X	X	X	X	X
VBX_ANG	X-side voltage, B-phase-to-neutral, angle	degrees	X	X	X	X	X		X

Table M.1 Analog Quantities (Sheet 2 of 13)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/ EtherNet/IP via Ethernet Port	Modbus[a]	Fast Meter	IEC 61850[b]
VCX_MAG	X-side voltage, C-phase-to-neutral, magnitude	V pri	X	X	X	X	X	X	X
VCX_ANG	X-side voltage, C-phase-to-neutral, angle	degrees	X	X	X	X	X		X
VABX_MAG	X-side voltage, A-to-B-phase, magnitude	V pri	X	X	X	X	X	X	X
VABX_ANG	X-side voltage, A-to-B-phase, angle	degrees	X	X	X	X	X		X
VBCX_MAG	X-side voltage, B-to-C-phase, magnitude	V pri	X	X	X	X	X	X	X
VBCX_ANG	X-side voltage, B-to-C-phase, angle	degrees	X	X	X	X	X		X
VCAX_MAG	X-side voltage, C-to-A-phase, magnitude	V pri	X	X	X	X	X	X	X
VCAX_ANG	X-side voltage, C-to-A-phase, angle	degrees	X	X	X	X	X		X
VGX_MAG	X-side zero-sequence voltage, magnitude	V pri	X	X	X	X	X		X
VGX_ANG	X-side zero-sequence voltage, angle	degrees	X	X	X	X	X		X
V1X_MAG	X-side voltage, positive-sequence, magnitude	V pri	X	X	X	X	X		X
V1X_ANG	X-side voltage, positive-sequence, angle	degrees	X	X	X	X	X		X
3V2X_MAG	X-side voltage, negative-sequence, magnitude	V pri	X	X	X	X	X		X
3V2X_ANG	X-side voltage, negative-sequence, angle	V pri	X	X	X	X	X		X
VAY_MAG	Y-side voltage, phase A-to-neutral, magnitude	V pri	X	X	X	X	X	X	X
VAY_ANG	Y-side voltage, phase A-to-neutral, angle	degrees	X	X	X	X	X		X
VBY_MAG	Y-side voltage, B-phase-to-neutral, magnitude	V pri	X	X	X	X	X	X	X
VBY_ANG	Y-side voltage, B-phase-to-neutral, angle	degrees	X	X	X	X	X		X
VCY_MAG	Y-side voltage, C-phase-to-neutral, magnitude	V pri	X	X	X	X	X	X	X
VCY_ANG	Y-side voltage, C-phase-to-neutral, angle	degrees	X	X	X	X	X		X
VABY_MAG	Y-side voltage, A-to-B-phase, magnitude	V pri	X	X	X	X	X	X	X
VABY_ANG	Y-side voltage, A-to-B-phase, angle	degrees	X	X	X	X	X		X
VBCY_MAG	Y-side voltage, B-to-C-phase, magnitude	V pri	X	X	X	X	X	X	X
VBCY_ANG	Y-side voltage, B-to-C-phase, angle	degrees	X	X	X	X	X		X
VCAY_MAG	Y-side voltage, C-to-A-phase, magnitude	V pri	X	X	X	X	X	X	X
VCAY_ANG	Y-side voltage, C-to-A-phase, angle	degrees	X	X	X	X	X		X
VGY_MAG	Y-side zero-sequence voltage, magnitude	V pri	X	X	X	X	X		X
VGY_ANG	Y-side zero-sequence voltage, angle	degrees	X	X	X	X	X		X
V1Y_MAG	Y-side voltage, positive-sequence, magnitude	V pri	X	X	X	X	X		X
V1Y_ANG	Y-side voltage, positive-sequence, angle	degrees	X	X	X	X	X		X
3V2Y_MAG	Y-side voltage, negative-sequence, magnitude	V pri	X	X	X	X	X		X
3V2Y_ANG	Y-side voltage, negative-sequence, angle	V pri	X	X	X	X	X		X

Table M.1 Analog Quantities (Sheet 3 of 13)

Name	Description	Units	Display Points	SELOGIC	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/ EtherNet/IP via Ethernet Port	Modbus[a]	Fast Meter	IEC 61850[b]
VS_MAG	Sync voltage, magnitude	V pri	X	X	X	X	X	X	X
VS_ANG	Sync voltage, angle	degrees	X	X	X	X	X		X
VN_MAG	Neutral voltage, magnitude	V pri	X	X	X	X	X		X
VN_ANG	Neutral voltage, angle	degrees	X	X	X	X	X		X
VN3_MAG	Neutral voltage, 3rd-harmonics magnitude	V pri	X	X	X	X	X		X
VPX3_MAG	X-side A-phase voltage, 3rd-harmonics magnitude	V pri	X	X	X	X	X		X
PAX	X-side real power magnitude, A-phase	kW pri	X	X	X	X	X		X
PBX	X-side real power magnitude, B-phase	kW pri	X	X	X	X	X		X
PCX	X-side real power magnitude, C-phase	kW pri	X	X	X	X	X		X
P3X	X-side real power magnitude, 3-phase	kW pri	X	X	X	X	X	X	X
QAX	X-side reactive power magnitude, A-phase	kVAR pri	X	X	X	X	X		X
QBX	X-side reactive power magnitude, B-phase	kVAR pri	X	X	X	X	X		X
QCX	X-side reactive power magnitude, C-phase	kVAR pri	X	X	X	X	X		X
Q3X	X-side reactive power magnitude, 3-phase	kVAR pri	X	X	X	X	X	X	X
SAX	X-side apparent power magnitude, A-phase	kVA pri	X	X	X	X	X		X
SBX	X-side apparent power magnitude, B-phase	kVA pri	X	X	X	X	X		X
SCX	X-side apparent power magnitude, C-phase	kVA pri	X	X	X	X	X		X
S3X	X-side apparent power magnitude, 3-phase	kVA pri	X	X	X	X	X	X	X
PFAX	X-side power factor, magnitude A-phase	unitless	X	X	X	X	X		X
PFBX	X-side power factor, magnitude B-phase	unitless	X	X	X	X	X		X
PFCX	X-side power factor, magnitude C-phase	unitless	X	X	X	X	X		X
PF3X	X-side power factor, magnitude 3-phase	unitless	X	X	X	X	X		X
FREQX	X-side frequency	Hz	X	X	X	X	X	X	X
VHZX	X-side V/Hz	%	X	X	X	X	X		X
PAY	Y-side real power magnitude, A-phase	kW pri	X	X	X	X	X		X
PBY	Y-side real power magnitude, B-phase	kW pri	X	X	X	X	X		X
PCY	Y-side real power magnitude, C-phase	kW pri	X	X	X	X	X		X
P3Y	Y-side real power magnitude, 3-phase	kW pri	X	X	X	X	X	X	X
QAY	Y-side reactive power magnitude, A-phase	kVAR pri	X	X	X	X	X		X
QBY	Y-side reactive power magnitude, B-phase	kVAR pri	X	X	X	X	X		X
QCY	Y-side reactive power magnitude, C-phase	kVAR pri	X	X	X	X	X		X

Table M.1 Analog Quantities (Sheet 4 of 13)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/ EtherNet/IP via Ethernet Port	Modbus[a]	Fast Meter	IEC 61850[b]
Q3Y	Y-side reactive power magnitude, 3-phase	kVAR pri	X	X	X	X	X	X	X
SAY	Y-side apparent power magnitude, A-phase	kVA pri	X	X	X	X	X		X
SBY	Y-side apparent power magnitude, B-phase	kVA pri	X	X	X	X	X		X
SCY	Y-side apparent power magnitude, C-phase	kVA pri	X	X	X	X	X		X
S3Y	Y-side apparent power magnitude, 3-phase	kVA pri	X	X	X	X	X	X	X
PFAY	Y-side power factor, magnitude A-phase	unitless	X	X	X	X	X		X
PFBY	Y-side power factor, magnitude B-phase	unitless	X	X	X	X	X		X
PFCY	Y-side power factor, magnitude C-phase	unitless	X	X	X	X	X		X
PF3Y	Y-side power factor, magnitude 3-phase	unitless	X	X	X	X	X		X
FREQY	Y-side frequency	Hz	X	X	X	X	X	X	X
FLDRES[1]	Rotor field ground resistance	kOhms	X	X	X	X	X		X
FREQS	Synch frequency	Hz	X	X	X	X	X	X	X
Thermal Metering[2] Note 2: Use caution when assigning RTD analog quantities to SELogic control equations or math variables because the conditions RTD open, short, comm fail, stat fail, fail, and NA will be reported as +32767, –32768, +32764, +32760, +32766, and +32752, respectively. Note 3: SEL Fast Message Label name for RTDAMB and RTDOTHMX are AMB and OTH, respectively. Note 4: RTD open is equivalent to +32767 and RTD short is equivalent to –32768 when RTDs are monitored via LDP.									
RTDWDGMX	Maximum winding RTD temperature	°C	X	X	X	X	X		X
RTDBRGMX	Maximum bearing RTD temperature	°C	X	X	X	X	X		X
RTDAMB[3]	Ambient RTD temperature	°C	X	X	X	X	X		X
RTDOTHMX[3]	Other maximum RTD temperature	°C	X	X	X	X	X		X
RTD1 to RTD12[4]	RTD1 temperature to RTD12 temperature	°C	X	X	X	X	X		X
TCUGEN	Generator % thermal capacity used	%	X	X	X	X	X		X
TCURTD	RTD % thermal capacity used	%	X	X	X	X	X		X
Analog Input Metering[5] Note 5: See the engineering unit settings (e.g., AI301EU) of the respective analog input quantity for the unit.									
AI301 to AI304	Analog inputs for an analog card in Slot C	EU	X	X	X	X	X		X
AI401 to AI404	Analog inputs for an analog card in Slot D	EU	X	X	X	X	X		X
AI501 to AI504	Analog inputs for an analog card in Slot E	EU	X	X	X	X	X		X
Energy Metering[6] Note 6: The time when Energy, Maximum/Minimum, Peak Demand, and Breaker Monitoring data were last reset is also reported in Modbus Note 7: This analog quantity is not available for FMR									
EM_LRDH	Energy last reset date/time high word					X[7]			
EM_LRDM	Energy last reset date/time middle word					X[7]			
EM_LRDL	Energy last reset date/time low word					X[7]			

Table M.1 Analog Quantities (Sheet 5 of 13)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/ EtherNet/IP via Ethernet Port	Modbus[a]	Fast Meter	IEC 61850[b]
MWHPX	Real energy, 3-phase positive X-side	MWh pri	X	X	X	X	X		X
MWHNX	Real energy, 3-phase negative X-side	MWh pri	X	X	X	X	X		X
MVARHPX	Reactive energy, 3-phase positive X-side	MVARh pri	X	X	X	X	X		X
MVARHNX	Reactive energy, 3-phase negative X-side	MVARh pri	X	X	X	X	X		X
MWHPY	Real energy, 3-phase positive Y-side	MWh pri	X	X	X	X	X		X
MWHNY	Real energy, 3-phase negative Y-side	MWh pri	X	X	X	X	X		X
MVARHPY	Reactive energy, 3-phase positive Y-side	MVARh pri	X	X	X	X	X		X
MVARHNY	Reactive energy, 3-phase negative Y-side	MVARh pri	X	X	X	X	X		X
Maximum/Minimum Metering[6,8] Note 8: Upon reset, the maximum and minimum metering quantities read +16777216 for MN and -16777216 for MX.									
MM_LRDH	Max/Min last reset date/time high word					X[7]			
MM_LRDM	Max/Min last reset date/time middle word					X[7]			
MM_LRDL	Max/Min last reset date/time low word					X[7]			
IAXMX	X-side current, A-phase, maximum magnitude	A pri	X	X		X	X		X
IBXMX	X-side current, B-phase, maximum magnitude	A pri	X	X		X	X		X
ICXMX	X-side current, C-phase, maximum magnitude	A pri	X	X		X	X		X
IGXMX	X-side current, residual, maximum magnitude	A pri	X	X		X	X		X
IAYMX	Y-side current, A-phase, maximum magnitude	A pri	X	X		X	X		X
IBYMX	Y-side current, B-phase, maximum magnitude	A pri	X	X		X	X		X
ICYMX	Y-side current, C-phase, maximum magnitude	A pri	X	X		X	X		X
IGYMX	Y-side current, residual, maximum magnitude	A pri	X	X		X	X		X
INMX	Current, neutral, maximum magnitude	A pri	X	X		X	X		X
IAXMN	X-side current, A-phase, minimum magnitude	A pri	X	X		X	X		X
IBXMN	X-side current, B-phase, minimum magnitude	A pri	X	X		X	X		X
ICXMN	X-side current, C-phase, minimum magnitude	A pri	X	X		X	X		X
IGXMN	X-side current, residual, minimum magnitude	A pri	X	X		X	X		X
IAYMN	Y-side current, A-phase, minimum magnitude	A pri	X	X		X	X		X
IBYMN	Y-side current, B-phase, minimum magnitude	A pri	X	X		X	X		X
ICYMN	Y-side current, C-phase, minimum magnitude	A pri	X	X		X	X		X
IGYMN	Y-side current, residual, minimum magnitude	A pri	X	X		X	X		X
INMN	Current, neutral, minimum magnitude	A pri	X	X		X	X		X
VABXMX	X-side voltage, A-to-B-phase, maximum magnitude	V pri	X	X		X	X		X

Table M.1 Analog Quantities (Sheet 6 of 13)

Name	Description	Units	Display Points	SELOGIC	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/ EtherNet/IP via Ethernet Port	Modbus[a]	Fast Meter	IEC 61850[b]
VBCXMX	X-side voltage, B-to-C-phase, maximum magnitude	V pri	X	X		X	X		X
VCAXMX	X-side voltage, C-to-A-phase, maximum magnitude	V pri	X	X		X	X		X
VAXMX	X-side voltage, A-phase-to-neutral, maximum magnitude	V pri	X	X		X	X		X
VBXMX	X-side voltage, B-phase-to-neutral, maximum magnitude	V pri	X	X		X	X		X
VCXMX	X-side voltage, C-phase-to-neutral, maximum magnitude	V pri	X	X		X	X		X
VABYMX	Y-side voltage, A-to-B-phase, maximum magnitude	V pri	X	X		X	X		X
VBCYMX	Y-side voltage, B-to-C-phase, maximum magnitude	V pri	X	X		X	X		X
VCAYMX	Y-side voltage, C-to-A-phase, maximum magnitude	V pri	X	X		X	X		X
VAYMX	Y-side voltage, A-phase-to-neutral, maximum magnitude	V pri	X	X		X	X		X
VBYMX	Y-side voltage, B-phase-to-neutral, maximum magnitude	V pri	X	X		X	X		X
VCYMX	Y-side voltage, C-phase-to-neutral, maximum magnitude	V pri	X	X		X	X		X
VSMX	Voltage, synch voltage, maximum magnitude	V pri	X	X		X	X		X
VNMX	Voltage, neutral, maximum magnitude	V pri	X	X		X	X		X
VN3MX	Voltage, neutral-3rd harmonic maximum magnitude	V pri	X	X		X	X		X
VPX3MX	Voltage, phase-3rd harmonic maximum magnitude	V pri	X	X		X	X		X
VABXMN	X-side voltage, A-to-B-phase, minimum magnitude	V pri	X	X		X	X		X
VBCXMN	X-side voltage, B-to-C-phase, minimum magnitude	V pri	X	X		X	X		X
VCAXMN	X-side voltage, C-to-A-phase, minimum magnitude	V pri	X	X		X	X		X
VAXMN	X-side voltage, A-phase-to-neutral, minimum magnitude	V pri	X	X		X	X		X
VBXMN	X-side voltage, B-phase-to-neutral, minimum magnitude	V pri	X	X		X	X		X
VCXMN	X-side voltage, C-phase-to-neutral, minimum magnitude	V pri	X	X		X	X		X

Table M.1 Analog Quantities (Sheet 7 of 13)

Name	Description	Units	Display Points	SELOGIC	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/ EtherNet/IP via Ethernet Port	Modbus[a]	Fast Meter	IEC 61850[b]
VABYMN	Y-side voltage, A-to-B-phase, minimum magnitude	V pri	X	X		X	X		X
VBCYMN	Y-side voltage, B-to-C-phase, minimum magnitude	V pri	X	X		X	X		X
VCAYMN	Y-side voltage, C-to-A-phase, minimum magnitude	V pri	X	X		X	X		X
VAYMN	Y-side voltage, A-phase-to-neutral, minimum magnitude	V pri	X	X		X	X		X
VBYMN	Y-side voltage, B-phase-to-neutral, minimum magnitude	V pri	X	X		X	X		X
VCYMN	Y-side voltage, C-phase-to-neutral, minimum magnitude	V pri	X	X		X	X		X
VSMN	Voltage, synch voltage, minimum magnitude	V pri	X	X		X	X		X
VNMN	Voltage, neutral, minimum magnitude	V pri	X	X		X	X		X
VN3MN	Voltage, neutral-3rd harmonic minimum magnitude	V pri	X	X		X	X		X
VPX3MN	Voltage, phase-3rd harmonic minimum magnitude	V pri	X	X		X	X		X
KVA3XMX	X-side apparent power magnitude, 3-phase, maximum	kVA pri	X	X		X	X		X
KW3XMX	X-side real power magnitude, 3-phase, maximum	kW pri	X	X		X	X		X
KVAR3XMX	X-side reactive power magnitude, 3-phase, maximum	kVAR pri	X	X		X	X		X
KVA3XMN	X-side apparent power magnitude, 3-phase, minimum	kVA pri	X	X		X	X		X
KW3XMN	X-side real power magnitude, 3-phase, minimum	kW pri	X	X		X	X		X
KVAR3XMN	X-side reactive power magnitude, 3-phase, minimum	kVAR pri	X	X		X	X		X
KVA3YMX	Y-side apparent power magnitude, 3-phase, maximum	kVA pri	X	X		X	X		X
KW3YMX	Y-side real power magnitude, 3-phase, maximum	kW pri	X	X		X	X		X
KVAR3YMX	Y-side reactive power magnitude, 3-phase, maximum	kVAR pri	X	X		X	X		X
KVA3YMN	Y-side apparent power magnitude, 3-phase, minimum	kVA pri	X	X		X	X		X
KW3YMN	Y-side real power magnitude, 3-phase, minimum	kW pri	X	X		X	X		X

Table M.1 Analog Quantities (Sheet 8 of 13)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/ EtherNet/IP via Ethernet Port	Modbus[a]	Fast Meter	IEC 61850[b]
KVAR3YMN	Y-side reactive power magnitude, 3-phase, minimum	kVAR pri	X	X		X	X		X
FREQXMX	X-side maximum frequency	Hz	X	X		X	X		X
FREQXMN	X-side minimum frequency	Hz	X	X		X	X		X
FREQYMX	Y-side maximum frequency	Hz	X	X		X	X		X
FREQYMN	Y-side minimum frequency	Hz	X	X		X	X		X
RTD1MX–RTD12MX	RTD1 maximum to RTD12 maximum	°C	X	X		X	X		X
RTD1MN–RTD12MN	RTD1 minimum to RTD12 minimum	°C	X	X		X	X		X
AI301MX–AI304MX	Analog Transducer Input 301–304 maximum[5]	EU	X	X		X	X		X
AI301MN–AI304MN	Analog Transducer Input 301–304 minimum[5]	EU	X	X		X	X		X
AI401MX–AI404MX	Analog Transducer Input 401–404 maximum[5]	EU	X	X		X	X		X
AI401MN–AI404MN	Analog Transducer Input 401–404 minimum[5]	EU	X	X		X	X		X
AI501MX–AI504MX	Analog Transducer Input 501–504 maximum[5]	EU	X	X		X	X		X
AI501MN–AI504MN	Analog Transducer Input 501–504 minimum[5]	EU	X	X		X	X		X
RMS Metering									
IAXRMS	X-side rms current, A-phase, magnitude	A pri	X	X	X	X	X		X
IBXRMS	X-side rms current, B-phase, magnitude	A pri	X	X	X	X	X		X
ICXRMS	X-side rms current, C-phase, magnitude	A pri	X	X	X	X	X		X
IAYRMS	Y-side rms current, A-phase, magnitude	A pri	X	X	X	X	X		X
IBYRMS	Y-side rms current, B-phase, magnitude	A pri	X	X	X	X	X		X
ICYRMS	Y-side rms current, C-phase, magnitude	A pri	X	X	X	X	X		X
INRMS	Neutral rms current, magnitude	A pri	X	X	X	X	X		X
VAXRMS	X-side rms voltage, A-phase-to-neutral, magnitude	V pri	X	X	X	X	X		X
VBXRMS	X-side rms voltage, B-phase-to-neutral, magnitude	V pri	X	X	X	X	X		X
VCXRMS	X-side rms voltage, C-phase-to-neutral, magnitude	V pri	X	X	X	X	X		X
VABXRMS	X-side rms voltage, A-to-B-phase, magnitude	V pri	X	X	X	X	X		X

Table M.1 Analog Quantities (Sheet 9 of 13)

Name	Description	Units	Display Points	SELOGIC	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/ EtherNet/IP via Ethernet Port	Modbus[a]	Fast Meter	IEC 61850[b]
VBCXRMS	X-side rms voltage, B-to-C-phase, magnitude	V pri	X	X	X	X	X		X
VCAXRMS	X-side rms voltage, C-to-A-phase, magnitude	V pri	X	X	X	X	X		X
VAYRMS	Y-side rms voltage, A-phase-to-neutral, magnitude	V pri	X	X	X	X	X		X
VBYRMS	Y-side rms voltage, B-phase-to-neutral, magnitude	V pri	X	X	X	X	X		X
VCYRMS	Y-side rms voltage, C-phase-to-neutral, magnitude	V pri	X	X	X	X	X		X
VABYRMS	Y-side rms voltage, A-to-B-phase, magnitude	V pri	X	X	X	X	X		X
VBCYRMS	Y-side rms voltage, B-to-C-phase, magnitude	V pri	X	X	X	X	X		X
VCAYRMS	Y-side rms voltage, C-to-A-phase, magnitude	V pri	X	X	X	X	X		X
VSRMS	RMS voltage, V-sync, magnitude	V pri	X	X	X	X	X		X
Demand Metering									
IAXD	X-side A-phase current demand	A pri	X	X		X	X		X
IBXD	X-side B-phase current demand	A pri	X	X		X	X		X
ICXD	X-side C-phase current demand	A pri	X	X		X	X		X
IGXD	X-side residual current demand	A pri	X	X		X	X		X
3I2XD	X-side negative-sequence current demand	A pri	X	X		X	X		X
IAYD	Y-side A-phase current demand	A pri	X	X		X	X		X
IBYD	Y-side B-phase current demand	A pri	X	X		X	X		X
ICYD	Y-side C-phase current demand	A pri	X	X		X	X		X
IGYD	Y-side sesidual current demand	A pri	X	X		X	X		X
3I2YD	Y-side negative-sequence current demand	A pri	X	X		X	X		X
Peak Demand Metering[6] Note 9: In addition to the peak demand data, the time when the peak demand data were last reset is also reported in Modbus (the actual labels used in the Modbus Map are not PM_LRDH, PM_LRDM, and PM_LRDL).									
PM_LRDH[9]	Peak demand last reset date/time high word					X[7]			
PM_LRDM[9]	Peak demand last reset date/time middle word					X[7]			
PM_LRDL[9]	Peak demand last reset date/time low word					X[7]			
IAXPD	X-side A-phase current peak demand	A pri	X	X		X	X		X
IBXPD	X-side B-phase current peak demand	A pri	X	X		X	X		X
ICXPD	X-side C-phase current peak demand	A pri	X	X		X	X		X
IGXPD	X-side residual current peak demand	A pri	X	X		X	X		X
3I2XPD	X-side negative-sequence current peak demand	A pri	X	X		X	X		X

Table M.1 Analog Quantities (Sheet 10 of 13)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/ EtherNet/IP via Ethernet Port	Modbus[a]	Fast Meter	IEC 61850[b]
IAYPD	Y-side A-phase current peak demand	A pri	X	X		X	X		X
IBYPD	Y-side B-phase current peak demand	A pri	X	X		X	X		X
ICYPD	Y-side C-phase current peak demand	A pri	X	X		X	X		X
IGYPD	Y-side residual current peak demand	A pri	X	X		X	X		X
3I2YPD	Y-side negative-sequence current peak demand	A pri	X	X		X	X		X
Harmonics Metering									
IAX_THD	X-side A-phase current THD	%	X	X		X	X		X
IBX_THD	X-side B-phase current THD	%	X	X		X	X		X
ICX_THD	X-side C-phase current THD	%	X	X		X	X		X
IAY_THD	Y-side A-phase current THD	%	X	X		X	X		X
IBY_THD	Y-side B-phase current THD	%	X	X		X	X		X
ICY_THD	Y-side C-phase current THD	%	X	X		X	X		X
Breaker Monitoring[6]									
BM_LRDXH	X-side breaker monitor last reset date/time high word					X[7]			
BM_LRDXM	X-side breaker monitor last reset date/time middle word					X[7]			
BM_LRDXL	X-side breaker monitor last reset date/time low word					X[7]			
BM_LRDYH	Y-side breaker monitor last reset date/time high word					X[7]			
BM_LRDYM	Y-side breaker monitor last reset date/time middle word					X[7]			
BM_LRDYL	Y-side breaker monitor last reset date/time low word					X[7]			
INTTX	X breaker—relay initiated trips counter		X	X		X	X		X
EXTTX	X breaker—external initiated trips counter		X	X		X	X		X
INTIAX	X breaker—relay initiated trips cumulative interrupted IA current	kA pri	X	X		X	X		X
INTIBX	X breaker—relay initiated trips cumulative interrupted IB current	kA pri	X	X		X	X		X
INTICX	X breaker—relay initiated trips cumulative interrupted IC current	kA pri	X	X		X	X		X
EXTIAX	X breaker—external initiated trips cumulative interrupted IA current	kA pri	X	X		X	X		X
EXTIBX	X breaker—external initiated trips cumulative interrupted IB current	kA pri	X	X		X	X		X

Table M.1 Analog Quantities (Sheet 11 of 13)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/ EtherNet/IP via Ethernet Port	Modbus[a]	Fast Meter	IEC 61850[b]
EXTICX	X breaker—external initiated trips cumulative interrupted IC current	kA pri	X	X		X	X		X
WEARAX	X breaker—Contact A wear	%	X	X		X	X		X
WEARBX	X breaker—Contact B wear	%	X	X		X	X		X
WEARCX	X breaker—Contact C wear	%	X	X		X	X		X
INTTY	Y breaker—relay initiated trips count		X	X		X	X		X
EXTTY	Y breaker—external initiated trips count		X	X		X	X		X
INTIAY	Y breaker—relay initiated trips cumulative interrupted IA current	kA pri	X	X		X	X		X
INTIBY	Y breaker—relay initiated trips cumulative interrupted IB current	kA pri	X	X		X	X		X
INTICY	Y breaker—relay initiated trips cumulative interrupted IC current	kA pri	X	X		X	X		X
EXTIAY	Y breaker—external initiated trips cumulative interrupted IA current	kA pri	X	X		X	X		X
EXTIBY	Y breaker—external initiated trips cumulative interrupted IB current	kA pri	X	X		X	X		X
EXTICY	Y breaker—external initiated trips cumulative interrupted IC current	kA pri	X	X		X	X		X
WEARAY	Y breaker—Contact A wear	%	X	X		X	X		X
WEARBY	Y breaker—Contact B wear	%	X	X		X	X		X
WEARCY	Y breaker—Contact C wear	%	X	X		X	X		X
Date/Time Note 10: DATE and TIME are also available as DNP Object 50.									
DATE[10]	Present date		X				X		
TIME[10]	Present time		X				X		
YEAR	Year number (0000–9999)			X					
DAYY	Day of year number (1–366)			X					
WEEK	Week number (1–52)			X					
DAYW	Day of week number (1–7)			X					
MINSM	Minutes since midnight			X					
RID/TID Note 11: RID and TID are only available as display point settings (DP01 to DP32). Note 12: STRING_RID and STRING_TID are only available as analog label quantities for the bay screen in the touchscreen display model.									
RID[11]	Relay identifier		X						
TID[11]	Terminal identifier		X						

Table M.1 Analog Quantities (Sheet 12 of 13)

Name	Description	Units	Display Points	SELOGIC	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/ EtherNet/IP via Ethernet Port	Modbus[a]	Fast Meter	IEC 61850[b]
STRING_RID	Relay identifier (Bay Screen)		X[12]						
STRING_TID	Terminal identifier (Bay Screen)		X[12]						
Setting Group									
GROUP	Active Setting Group #		X	X		X	X		X
Math Variables									
MV01 to MV32	Math Variable 01–Math Variable 32		X	X	X	X	X		X
SELOGIC Counters[13] Note 13: SELOGIC counters are also available as a DNP counter object.									
SC01 to SC32	SELOGIC Counter 01–SELOGIC Counter 32		X	X	X	X	X		X
Frequency-Based Quantities									
SLIPX	Slip Frequency (X)	mHz	X	X					X
DFDTX	Rate-of-change of frequency (X)	Hz/sec		X					
DFDTY	Rate-of-change of frequency (Y)	Hz/sec		X					
Remote Analogs[14] Note 14: FM refers to Fast Message support for remote analogs. Remote analogs can be written by issuing an unsolicited Fast Message Write command.									
RA001 to RA128	Remote Analog 01 to Remote Analog 128		X	X	X	X	X	X	X
IEC 61850 Test Mode									
I850MOD	IEC 61850 Test Mode Status			X					X
Fault Event Information									
FFREQX	X-side frequency of the most recent fault; for IEC 60870 fault analogs, X-side frequency of fault event	Hz	X	X		X			X
FFREQY	Y-side frequency of the most recent fault; for IEC 60870 fault analogs, Y-side frequency of fault event	Hz	X	X		X			X
FIAX	X-side Phase A current of most recent fault; for IEC 60870 fault analogs, X-side Phase A current of fault event	A pri	X	X		X			X
FIBX	X-side Phase B current of most recent fault; for IEC 60870 fault analogs, X-side Phase B current of fault event	A pri	X	X		X			X
FICX	X-side Phase C current of most recent fault; for IEC 60870 fault analogs, X-side Phase C current of fault event	A pri	X	X		X			X
FIGX	X-side ground current of most recent fault; for IEC 60870 fault analogs, X-side ground current of fault event	A pri	X	X		X			X

Table M.1 Analog Quantities (Sheet 13 of 13)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/ EtherNet/IP via Ethernet Port	Modbus[a]	Fast Meter	IEC 61850[b]
FIAY	Y-side Phase A current of most recent fault; for IEC 60870 fault analogs, Y-side Phase A current of fault event	A pri	X	X		X			X
FIBY	Y-side B-phase current of most recent fault; for IEC 60870 fault analogs, Y-side Phase B current of fault event	A pri	X	X		X			X
FICY	Y-side C-phase current of most recent fault; for IEC 60870 fault analogs, Y-side Phase C current of fault event	A pri	X	X		X			X
FIGY	Y-side ground current of most recent fault; for IEC 60870 fault analogs, Y-side ground current of fault event	A pri	X	X		X			X
FIN	Neutral current of most recent fault; for IEC 60870 fault analogs, neutral current of fault event	A pri	X	X		X			X
FLREP	Event report present (shall be 1, when an event report is present, and 0 otherwise)								X
FLRNUM	Unique identification number of the latest event								X

[a] Modbus register labels may be different from the corresponding analog quantity labels. See *Appendix E: Modbus Communications* for more information.
[b] IEC 61850 data object labels may be different from the corresponding analog quantity labels. See *Appendix G: IEC 61850 Communications* for more information.

Appendix N
Cybersecurity Features

The SEL-700G provides a number of features to help meet cybersecurity design requirements.

Access Control

The SEL-700G has a number of mechanisms for managing electronic access. These include ways to limit access, provide user authentication, and monitor electronic and physical access.

Physical Port Controls

Each physical serial port and the Ethernet port can be individually disabled using the EPORT setting. By default, all of the ports are enabled. It is good security practice to disable unused ports.

IP Ports

When using Ethernet, there are a number of IP ports available within the SEL-700G. Many of these IP port numbers are configurable. All IP ports can be disabled. *Table N.1* describes each of these.

Table N.1 IP Port Numbers

IP Port Default	Port Selection Setting	Network Protocol	Default Port State	Port Enable Setting	Purpose
21	--	TCP	Enabled	EFTPSERV	FTP access for file transfer of settings and reports
23	TPORT	TCP	Enabled	ETELNET	Telnet access for general engineering terminal access
80	HTTPPORT	TCP	Enabled	EHTTP	Web server access to various relay information
102	--	TCP	Disabled	E61850	IEC 61850 MMS for SCADA functionality
123	SNTPPORT	UDP	Disabled	ESNTP	SNTP time synchronization
319/320	--	UDP	Disabled	EPTP PTPRO = DEFAULT, PTPTR = UDP	PTP time synchronization
502	MODNUM1/ MODNUM2	TCP	Disabled	EMOD	MODBUS for SCADA functionality
2222/ 44818	--	TCP/UDP	Disabled	EEIP	EtherNet/IP for SCADA functionality
4712/ 4713	PMOTCP1/ PMOUDP1	TCP/UDP	Disabled	PMOTS1	Synchrophasor data output, session 1
4722/ 4713	PMOTCP2/ PMOUDP2	TCP/UDP	Disabled	PMOTS2	Synchrophasor data output, session 2
20000	DNPNUM	TCP/UDP	Disabled	EDNP	DNP for SCADA functionality

See *PORT 1 on page 4.239* and *Ethernet Port on page 7.3* for more information on these settings.

Authentication and Authorization

The SEL-700G supports four levels of access, as described in *Access Levels on page 7.26*. Refer to this section to learn how each level is accessed and how to change passwords. It is good security practice to change the default passwords of each access level and to use a unique password for each level.

The MAXACC setting limits the level of access for each port. This permits you to operate under the principle of "least privilege", restricting ports to the levels necessary for the functions performed on those ports.

The SEL-700G supports strong passwords with as many as 12 characters, using any printable character, allowing users to select complex passwords if they so choose. SEL recommends that passwords have a minimum of 8 characters and include at least one of each of the following: lowercase letter, uppercase letter, number, and special character.

Ethernet protocols Telnet and FTP require the proper passwords to gain access to level-protected functions. Ethernet protocol MMS requires a password to gain access if MMS Authentication is enabled via the CID file. See *Section 7: Communications* for more information on access restrictions for the Ethernet protocols.

Monitoring and Logging

NOTE: Refer to Access Commands (ACCESS, 2ACCESS, and CAL) for more information on when SALARM is pulsed for access level changes and unsuccessful password entry attempts.

The SEL-700G provides Relay Word bits that are useful for monitoring relay access:

- SALARM—Pulses for approximately one second whenever a user gains access to Level 2 or higher, when an incorrect password is entered, or when a setting is changed.
- PASEL, PBSEL—Asserted while the Ethernet port(s) is active.
- LINK1, LINKA, LINKB—Asserted while the link is active on the Ethernet port(s). Loss of a link can be an indication that an Ethernet cable has been disconnected.
- LINKFAIL—Asserted if link is lost on the active IP port (ports 1A or 1B).

These bits can be mapped for SCADA monitoring via DNP3, IEC 61850, Modbus, EtherNet/IP, or SEL Fast Message. They also may be added to the SER for later analysis or assigned to output contacts for alarm purposes.

The SEL-700G SER is a useful tool for capturing a variety of relay events. In addition to capturing state changes of user selected Relay Word bits, it captures all power-ups, settings changes, and group switches. See *Sequential Events Recorder (SER) on page 10.2* for more information about SER.

Configuration Management

Many users are concerned about managing the configuration of their relays. The SEL-700G provides mechanisms to help users manage relay configuration.

All settings changes are logged to the SER log. Analysis of this log indicates if any unauthorized settings changes occurred. The SALARM Relay Word bit also indicates changes in the relay configuration by pulsing for approximately one second when any of the following occur:

- Settings are changed or saved
- A password changes
- The relay switches settings groups

See *Self-Test on page 11.14* for more information regarding the Relay Word bit SALARM.

Malware Protection

The SEL-700G has inherent and continuous monitoring for Malware. For a full description of this, see selinc.com/mitigating_malware/.

Firmware Hash Verification

This device supports digitally signed firmware upgrades. SEL uses the SHA-256 secure hash algorithm to compress and digitally sign firmware upgrade files. The signature ensures that the file has been provided by SEL and that its contents have not been altered. When the file is uploaded to the relay, the signature is verified using a public key stored in the relay. If the relay cannot verify the signature, it rejects the file. See *Appendix B: Firmware Upgrade Instructions* for more information on firmware upgrades.

Operating System/ Firmware

SEL-700G relays are embedded devices that do not allow additional software to be installed. SEL-700G relays include a self-test that continually checks running code against the known good baseline version of code in nonvolatile memory. This process is outlined in more detail in the *The SEL Process for Mitigating Malware Risk to Embedded Devices* located at selinc.com/ mitigating_malware/.

SEL-700G relays run in an embedded environment for which there is no commercial anti-virus software available.

Software/Firmware Verification

SEL-700G relays can install firmware updates in the field. Authenticity and integrity of firmware updates can be verified using the Firmware Hash page at selinc.com/products/firmware.

Physical Access Security

Physical security of cybersecurity assets is a common concern. Typically, relays are installed within a control enclosure that provides physical security. Other times, they are installed in boxes within the switch yard. The relay provides some tools that may be useful to help manage physical security, especially when the unit is installed in the switch yard.

You can monitor physical ingress by wiring a door sensor to one of the relay contact inputs. This input can then be mapped for SCADA monitoring or added to the SER log so that you can detect when physical access to the relay occurs. It is also possible to wire an electronic latch to a relay contact output. You could then map this output for SCADA control.

Vulnerability Notification Process

Security Vulnerability Process

SEL provides security disclosure alerts to customers, and SEL instruction manuals document all releases. SEL security vulnerability disclosures are described in *The SEL Process for Disclosing Security Vulnerabilities* located at selinc.com.

Emailed Security Notifications

You can sign up to receive email notifications when SEL releases security notices and service bulletins at selinc.com/support/security-notifications/.

Settings Erasure

It is often desirable to erase the settings from the relay when it is removed from service. You can completely erase all the configuration settings from the SEL-700G using this procedure:

Step 1. Go to Access Level C. See *Access Levels on page 7.26*.

Step 2. Execute the **R_S** command.

Step 3. Allow the relay to restart.

NOTE: Do not erase the settings when sending the relay to the factory for service. SEL needs to be able to see how the relay was configured to properly diagnose any problems.

Once this procedure is complete, all internal instances of user settings and passwords will be erased. Do not do this when sending in the relay for service at the factory. SEL needs to see how the relay was configured in order to properly diagnose many problems.

Glossary

A — Abbreviation for amps or amperes; units of electrical current magnitude.

acSELerator Architect SEL-5032 Software — Design and commissioning tool for IEC 61850 communications.

acSELerator QuickSet SEL-5030 Software — A Windows-based program that simplifies settings and provides analysis support.

Ambient Temperature — Temperature of the ambient air adjacent to the protected equipment. Measured by an RTD whose location setting is AMB.

Analog — In this instruction manual, analog is synonymous with transducer.

ANSI Standard Device Numbers — A list of standard numbers used to represent electrical protection and control relays. The standard device numbers used in this instruction manual include:

21	Distance Element
24	Volts/Hz Element (overexcitation)
25	Synchronism-Check Element
27	Undervoltage Element
27I	Inverse-Time Undervoltage Element
32	Directional Power Element
40	Loss of Field Element
46	Current Unbalance Element
49	Thermal Element
50	Instantaneous Overcurrent Element
51	Inverse-Time Overcurrent Element
52	AC Circuit Breaker
59	Overvoltage Element
59I	Inverse-Time Overvoltage Element
60	Loss-of-Potential Element
64F	Field Ground Element
64G	Stator Ground Element
67	Directional Overcurrent Element
78	Out of Step Element
78VS	Vector Shift Element
81	Frequency Element
81R	Rate-of-Change-of-Frequency Element
87	Differential Element

These numbers are frequently used within a suffix letter to further designate application. The suffix letters used in this instruction manual include:

P	Phase Element
G	Residual/Ground Element
N	Neutral/Ground Element
Q	Negative-Sequence (3I2) Element

Apparent Power, S Complex power expressed in units of volt-amps (VA), kilovolt-amps (kVA), or megavolt-amps (MVA). Accounts for both real (P) and reactive (Q) power dissipated in a circuit: S = P + jQ.

ASCII Abbreviation for American Standard Code for Information Interchange. Defines a standard way to communicate text characters between two electronic devices. The SEL-700G Generator and Intertie Protection Relay uses ASCII text characters to communicate using the relay front- and rear-panel EIA-232 serial ports.

Autosynchronism, Autosynchronization Function that checks the generator frequency and voltage and issues RAISE or LOWER commands to the speed governor and the excitation system to bring the generator frequency and voltage within tight bands and order the breaker to close and complete the process of connecting the generator to the power system when a generator is starting up.

Assert To activate; to fulfill the logic or electrical requirements necessary to operate a device. To apply a short-circuit or closed contact to an SEL-700G input. To set a logic condition to the true state (logical 1). To close a normally-open output contact. To open a normally-closed output contact.

Bay Screen Builder SEL-5036 Software An intuitive and powerful interface to design bay screen to meet application needs.

Breaker Auxiliary Contact A spare electrical contact associated with a circuit breaker that opens or closes to indicate the breaker position. A form-a breaker auxiliary contact (ANSI Standard Device Number 52A) closes when the breaker is closed, opens when the breaker is open. A form-b breaker auxiliary contact (ANSI Standard Device Number 52B) opens when the breaker is closed and closes when the breaker is open.

C37.118 C37.118 IEEE Standard for Synchrophasors for Power Systems.

C37.238 C37.238 IEEE Standard Profile for use of IEEE 1588 Precision Time Protocol in power system applications.

Checksum A numeric identifier of the firmware in the relay. Calculated by the result of a mathematic sum of the relay code.

CID Abbreviation for Checksum Identifier. The checksum of the specific firmware installed in the relay.

CID File IEC 61850 Configured IED Description file. An XML file that contains the configuration for a specific IED.

COMTRADE Abbreviation for Common Format for Transient Data Exchange. The SEL-700G supports the IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems, IEEE C37.111-1999.

Contiguous Items in sequence; the second immediately following the first.

CR_RAM Abbreviation for Critical RAM. Refers to the area of relay Random Access Memory (RAM) where the relay stores mission-critical data.

CRC-16 Abbreviation for Cyclical Redundancy Check-16. A mathematical algorithm applied to a block of digital information to produce a unique, identifying number. Used to ensure that the information was received without data corruption.

CT Abbreviation for current transformer.

Deassert To deactivate; to remove the logic or electrical requirements necessary to operate a device. To remove a short-circuit or closed contact from an SEL-700G input. To clear a logic condition to the false state (logical 0). To open a normally-open output contact. To close a normally-closed output contact.

Delta A phase-to-phase connection of voltage transformers for electrical measuring purposes. Typically, two voltage transformers are used with one primary lead of the first transformer connected to A-phase and the other lead connected to B-phase. The second voltage transformer is connected to measure the voltage from B-phase to C-phase. When two transformers are used, this connection is frequently called "Open-Delta."

Directional Supervision The relay uses directional elements to determine whether protection elements operate based on the direction of a fault relative to the relay.

DNP (Distributed Network Protocol) Manufacturer-developed, hardware independent communications protocol.

Dropout Time The time measured from the removal of an input signal until the output signal deasserts. The time can be settable, as in the case of a logic variable timer, or can be a result of the characteristics of an element algorithm, as in the case of an overcurrent element dropout time.

Ethernet A network physical and data link layer defined by IEEE 802.2 and IEEE 802.3.

EtherNet/IP An Ethernet-based protocol that provides ease of integration for industrial automation applications and provides access to metering data, protection elements, targets, and contact I/O.

Event History A quick look at recent relay activity that includes a standard report header; event number, date, time, and type; maximum fault phase current; and targets.

Event Report A text-based collection of data stored by the relay in response to a triggering condition, such as a fault or command. The data show relay measurements before and after the trigger, in addition to the states of protection elements, relay inputs, and relay outputs each processing interval. After an electrical system fault, use event reports to analyze relay and system performance.

Event Summary A shortened version of stored event reports. An event summary includes items such as event date and time, event type, fault voltages, currents, etc. The relay sends an event report summary (if auto messaging is enabled) to the relay serial port a few seconds after an event.

Fail-Safe Refers to an output contact that is energized during normal relay operation and de-energized when relay power is removed or if the relay fails.

Fast Meter, Fast Operate Binary serial port commands that the relay recognizes at the relay front-and rear-panel EIA-232 serial ports. These commands and the responses from the relay make relay data collection by a communications processor faster and more efficient than transfer of the same data through use of formatted ASCII text commands and responses.

FID Relay firmware identification string. Lists the relay model, firmware version and date code, and other information that uniquely identifies the firmware installed in a particular relay.

Field Ground Element A synchronous generator protection element that detects ground faults in the dc field circuit and trips the generator, if necessary.

Firmware The nonvolatile program stored in the relay that defines relay operation.

Flash A type of nonvolatile relay memory used for storing large blocks of nonvolatile data, such as load profile records.

FTP File transfer protocol.

Fundamental Frequency The component of the measured electrical signal for which frequency is equal to the normal electrical system frequency, usually 50 or 60 Hz. Generally used to differentiate between the normal system frequency and any harmonic frequencies present.

Fundamental Meter Type of meter data presented by the SEL-700G that includes the present values measured at the relay ac inputs. The word "Fundamental" is used to indicate that the values are Fundamental Frequency values and do not include harmonics.

GOOSE IEC 61850 Generic Object Oriented Substation Event. GOOSE objects can quickly and conveniently transfer status, controls, and measured values among peers on an IEC 61850 network.

IA, IB, IC Measured A-, B-, and C-phase currents.

ICD File IEC 61850 IED Capability Description file. An XML file that describes IED capabilities, including information on logical node and GOOSE support.

IEC 60870-5-103 Standard protocol developed by the IEC Technical Committee of teleprotection, telecontrol, and telecommunications for electrical engineering and power system automation. It defines systems used for supervisory control and data acquisition (SCADA), including details related to communications between devices.

IEC 61850 Standard protocol for real-time exchange of data between databases in multi-vendor devices.

IG Residual current, calculated from the sum of the phase currents. In normal, balanced operation, this current is very small or zero. When a ground fault occurs, this current can be large.

IN Neutral current measured by the relay IN input. The IN input is typically connected to the secondary winding of a window-CT for ground fault detection on resistance-grounded systems.

IP Address An identifier for a computer or device on a TCP/IP network. Networks using the TCP/IP protocol route message based on the IP address of the destination. The format of an IP address is a 32-bit numeric address written as four numbers separated by periods. Each number can be zero to 255. For example, 1.160.10.240 could be an IP address.

IRIG-B A time code input that the relay can use to set the internal relay clock.

LCD Abbreviation for Liquid Crystal Display. Used as the relay front-panel alphanumeric display.

LED Abbreviation for Light-Emitting Diode. Used as indicator lamps on the relay front panel.

Load Encroachment The load-encroachment feature allows setting of phase overcurrent elements independent of load levels.

Logical Node In IEC 61850, the smallest part of a function that exchanges data. A logical node (LN) is an object defined by its data and methods. Each logical node represents a group of data (status, controls, measurements, etc.) associated with a particular function.

Loss-of-Field Element A synchronous generator protection element that detects the loss of dc field excitation and trips the generator, if necessary.

Loss-of-Potential Loss of one or more phase voltage inputs to the relay.

MAC Address The Media Access Control (hardware) address of a device connected to a shared network medium, most often used with Ethernet networks.

MIRRORED BITS Protocol for direct relay-to-relay communications.

MMS Manufacturing Message Specification, a data exchange protocol used by IEC 61850.

NEMA Abbreviation for National Electrical Manufacturers Association.

Neutral Overcurrent Element A protection element that causes the relay to trip when the neutral current magnitude (measured by the IN input) exceeds a user-settable value. Used to detect and trip in response to ground faults.

Nominal Frequency Normal electrical system frequency, usually 50 or 60 Hz.

Nonfail-Safe Refers to an output contact that is not energized during normal relay operation. When referred to a trip output contact, the protected equipment remains in operation unprotected when relay power is removed or if the relay fails.

Nonvolatile Memory Relay memory that is able to correctly maintain data it is storing even when the relay is de-energized.

Out-of-Step Element A synchronous generator protection element used to detect loss of synchronism conditions and trip the generator, if necessary.

Overfrequency Element A protection element that causes the relay to trip when the measured electrical system frequency exceeds a settable frequency.

Phase Differential Element A protection element that measures the difference current between two CTs located on the two ends of a winding (generator) or on two windings (transformer) to detect internal faults.

Phase Rotation The sequence of voltage or current phasors in a multi-phase electrical system. In an ABC phase rotation system, the B-phase voltage lags the A-phase voltage by 120 degrees, and the C-phase voltage lags B-phase voltage by 120 degrees. In an ACB phase rotation system, the C-phase voltage lags the A-phase voltage by 120°, and the B-phase voltage lags the C-phase voltage by 120 degrees.

Pickup Time The time measured from the application of an input signal until the output signal asserts. The time can be settable, as in the case of a logic variable timer, or can be a result of the characteristics of an element algorithm, as in the case of an overcurrent element pickup time.

Pinout The definition or assignment of each electrical connection at an interface. Typically refers to a cable, connector, or jumper.

Power, P Real part of the complex power (S) expressed in units of watts (W), kilowatts (kW), or megawatts (MW).

Power Factor The cosine of the angle by which phase current lags phase voltage in an ac electrical circuit. Power factor equals 1.0 for power flowing to a resistive load.

Power, Q Reactive part of the complex power (S) expressed in units of Vars (Var), kilovars (kVar), or megavars (MVar).

Protection and Control Processing Processing interval is four times per power system cycle (except for math variables and analog quantities, which are processed every 25 ms).

PT Abbreviation for potential transformer. Also referred to as a voltage transformer or VT.

PTP Precision Time Protocol, as defined in IEEE 1588-2008 for high-accuracy clock synchronization.

RAM Abbreviation for Random Access Memory. Volatile memory where the relay stores intermediate calculation results, Relay Word bits, and other data that are updated every processing interval.

Rate-of-Change of Frequency Element A protection element that causes the relay to trip when the measured electrical system rate of change of frequency exceeds a settable rate.

Relay Word The collection of relay element and logic results. Each element or result is represented by a unique identifier, known as a Relay Word bit.

Relay Word Bit A single relay element or logic result that the relay updates once each processing interval. A Relay Word bit can be equal to either logical 1 or logical 0. Logical 1 represents a true logic condition, picked up element, or asserted contact input or contact output. Logical 0 represents a false logic condition, dropped out element, or deasserted contact input or contact output. You can use Relay Word bits in SELOGIC control equations to control relay tripping, event triggering, and output contacts, as well as other functions.

Remote Bit A Relay Word bit for which state is controlled by serial port commands, including the **CONTROL** command, binary Fast Operate command, or Modbus command.

Residual Current The sum of the measured phase currents. In normal, balanced operation, this current is very small or zero. When a ground fault occurs, this current can be large.

Restricted Earth Fault Element (REF) Restricted Earth Fault (REF) element provides sensitive protection against ground faults in wye-connected generator windings. The element is “restricted” in the sense that protection is restricted to ground faults within a zone defined by neutral and terminal CT placement.

RMS Abbreviation for root-mean-square. Refers to the effective value of the sinusoidal current and voltage measured by the relay, accounting for the fundamental frequency and higher order harmonics in the signal.

ROM Abbreviation for Read-Only Memory. Nonvolatile memory where the relay firmware is stored.

RSTP Abbreviation for Rapid Spanning Tree Protocol. RSTP provides an improved failover response in Ethernet networks in accordance with IEEE 802.1Q-2014.

RTD Abbreviation for Resistance Temperature Detector. An RTD is made of a metal having a precisely known resistance and temperature coefficient of resistance. The SEL-700G (and the SEL-2600 RTD Module) can measure the resistance of the RTD, and thus determine the temperature at the RTD location. Typically embedded in the motor windings or attached to the races of bearings.

Self-Test A function that verifies the correct operation of a critical device subsystem and indicates if an out-of-tolerance condition is detected. The SEL-700G is equipped with self-tests that validate the relay power supply, microprocessor, memory, and other critical systems.

SELOGIC Control Equation A relay setting that allows you to control a relay function (such as an output contact) by using a logical combination of relay element outputs and fixed logic outputs. Logical AND, OR, INVERT, rising edge [/], and falling edge [\] operators, plus a single level of parentheses are available to use in each control equation setting.

Sequential Events Recorder A relay function that stores a record of the date and time of each assertion and deassertion of every Relay Word bit in a settable list. Provides a useful way to determine the order and timing of events following a relay operation.

SER Abbreviation for Sequential Events Recorder or the relay serial port command to request a report of the latest 1024 sequential events.

Stator Ground Element A synchronous generator protection element that detects ground faults in the generator stator circuit and trips the generator, if necessary.

Synchronism Check When a generator is starting up and getting closer to connecting to the power system, the relay synchronism-check function checks that the generator frequency, voltage and phase are within range for the breaker to close and connect to the power system.

Synchrophasors The word synchrophasor is derived from two words: synchronized phasor. Synchrophasor measurement refers to the concept of providing measurements taken on a synchronized schedule in multiple locations. A high-accuracy clock, commonly a Global Positioning System (GPS) receiver such as the SEL-2407 Satellite-Synchronized Clock, makes synchrophasor measurement possible.

Terminal Emulation Software Personal computer (PC) software that you can use to send and receive ASCII text messages via the PC serial port.

Transducer Device that converts the input to the device to an analog output quantity of either current (±1, 2.5, 5, 10 and 20 mA, or 4–20 ma), or voltage (±1, 2.5, 5, or 10 V).

Underfrequency Element A protection element that causes the relay to trip when the measured electrical system frequency is less than a settable frequency.

VA, VB, VC Measured A-, B-, and C-phase-to-neutral voltages.

VAB, VBC, VCA Measured or calculated phase-to-phase voltages.

VG Residual voltage calculated from the sum of the three phase-to-neutral voltages, if connected.

VS Measured phase-neutral or phase-to-phase synchronism-check voltage.

VT Abbreviation for voltage transformer. Also referred to as a potential transformer or PT.

Vector Shift Element An based on detecting phase shift (vector shift) in the three-phase voltages caused by islanding of a generator and a subsequent sudden increase of loading on the generator.

Wye As used in this instruction manual, a phase-to-neutral connection of voltage transformers for electrical measuring purposes. Three voltage transformers are used with one primary lead of the first transformer connected to A-phase and the other lead connected to ground. The second and third voltage transformers are connected to measure the voltage from B-phase and C-phase-to-ground, respectively. This connection is frequently called "four-wire wye," alluding to the three-phase leads plus the neutral lead.

Z-Number That portion of the relay RID string that identifies the proper ACSELERATOR QuickSet SEL-5030 Software relay driver version when creating or editing relay settings files.

Index

Page numbers appearing in bold mark the location of the topic's primary discussion.

D

E

F

L

M

N

O

P

V

W

Z

SEL-700G Relay Command Summary

The following table lists the front serial port ASCII commands associated with particular activities. The commands are shown in uppercase letters, but you can also enter these with lowercase letters. Commands can be initiated with the three initial letters of the command. Refer to *SEL ASCII Protocol and Commands* for additional details and capabilities of each command.

La siguiente tabla muestra los comandos ASCII del puerto serie frontal asociados con diferentes actividades. Los comandos se pueden usar en mayúsculas o minúsculas. Los comandos se pueden ejecutar usando las primeras tres letras del nombre. Por más detalles consulte la guía *SEL ASCII Protocol and Commands*.

Command	Description
Access Level 0 Commands	
ACC	Goes to Access Level 1. If the main board Access Jumper is not in place, the relay prompts for the entry of the Access Level 1 password.
ID	Relay identification code.
QUIT	Goes to Access Level 0.
Access Level 1 Commands	
2AC	Goes to Access Level 2. If the main board Access Jumper is not in place, the relay prompts for the entry of the Access Level 2 password.
BRE *n*	Displays Breaker *n* monitor data (trips, interrupted current, wear). Select *n* = X or *n* = Y for Breaker X or Breaker Y data.
CEV *n*	Shows compressed event report number *n*, at 1/4-cycle resolution. If *n* is omitted, the most recent compressed event report is displayed.
CEV *n* R	Shows compressed raw event report number *n*, at 1/32-cycle resolution. If *n* is omitted, the most recent compressed event report is displayed.
CEV *n* DIFF	Shows compressed differential element report *n*, at 1/4-cycle resolution. If *n* is omitted, the most recent compressed differential element report is displayed.
CGSR *n*	Shows compressed generator synchronizing Report *n*, where *n* = 1 to 7 (defaults to 1).
COM A	Returns a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.
COM B	Returns a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.

Comando del Puerto Serial	Descripción del Comando
Comandos del Nivel de Acceso 0	
ACC	Ir a Nivel de Acceso 1. Si el jumper de acceso en la tarjeta principal no está en su lugar, el relé pedirá la contraseña de Acceso del Nivel 1.
ID	Código de identificación del relé.
SAL	Ir al Nivel de Acceso 0.
Comandos del Nivel de Acceso 1	
2AC	Ir a Nivel de Acceso 2. Si el jumper de acceso en la tarjeta principal no está en su lugar, el relé pedirá la contraseña de Acceso del Nivel 2.
INT *n*	Mostrar información sobre disparos, corriente interrumpida, desgaste del interruptor *n*. *n* = X or Y.
CEV *n*	Mostrar el reporte comprimido de evento número *n*, resolución de 1/4 de ciclo.
CEV *n* R	Agregue R para mostrar el reporte de evento comprimido sin filtro, resolución 1/32 de ciclo. Si no se especifica *n* se muestra el evento comprimido mas reciente.
CEV *n* DIFF	Mostrar el reporte diferencial de evento *n*, (4 muestras por ciclo). Si se omite *n* se muestra el reporte más reciente.
CGSR *n*	Mostrar el reporte de sincronizacion comprimido numero *n* donde va de 1 a 7. Por defecto, *n* = 1.
COM A	Presentar un resumen de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS Canal A.
COM B	Presentar un resumen de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS Canal B.

Command	Description	Comando del Puerto Serial	Descripción del Comando
COM C	Clears all communications records. If both MIRRORED BITS channels are enabled, omitting the channel specifier (A or B) clears both channels.	**COM D**	Borra todos los registros de comunicaciones. Si los dos canales MIRRORED BITS están habilitados, suprimiendo el especificador decanales (A o B) se borran los dos canales.
COM C A	Clears all communications records for Channel A.	**COM C A**	Borra todos los registros de comunicaciones del Canal A.
COM C B	Clears all communications records for Channel B.	**COM C B**	Borra todos los registros de comunicaciones del Canal B.
COM L A	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.	**COM L A**	Anexa un informe detallado al informe de síntesis de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS del Canal A.
COM L B	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.	**COM L B**	Anexa un informe detallado al informe de síntesis de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS del Canal B.
COM S A	Returns a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.	**COM S A**	Muestra un resumen de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS del Canal A.
COM S B	Returns a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.	**COM S B**	Muestra un resumen de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS del Canal B.
COU *n*	Shows current state of device counters. *n* = repeat the report *n* times, with a 1/2 second delay between each report.	**COU *n***	Muestra el estado actualizado de los contadores del dispositivo. *n* = repite el informe *n* veces, con ½ segundos entre cada informe.
DATE	Shows the date.	**FECHA**	Ver fecha.
DATE *dd/mm/yyyy*	Sets date in DMY format if DATE_F setting is DMY.	**FECHA *dd/mm/yyyy***	Si DATE_F es igual a DMY, ingrese fecha en formato Día Mes Año.
DATE *mm/dd/yyyy*	Sets date in MDY format if DATE_F setting is MDY.	**FECHA *mm/dd/yyyy***	Si DATE_F es MDA, ingrese fecha en formato Mes Día Año.
DATE *yyyy/mm/dd*	Sets date in YMD format if DATE_F setting is YMD.	**FECHA *yyyy/mm/dd***	Si DATE_F es AMD, ingrese fecha en formato Año Mes Día.
ETH	Shows the Ethernet port status.	**ETH**	Mostrar el estado del puerto de Ethernet.
EVE *n m*	Shows standard analog event report *n* with 1/4-cycle resolution. If *n* is omitted, the most recent report is displayed. Parameter *m* is X for X-side and Y for Y-side. If *m* is not specified, the relay defaults to *m* = X.	**EVE *n m***	Mostrar el reporte standard de evento *n*, (4 muestras por ciclo). Si se omite *n*, se muestra el reporte más reciente. El parámetro especifica el lado X o Y. Por omisión *m* = X.
EVE *n* R *m* or **EVE R *n m***	Shows event report with raw (unfiltered) with 1/32-cycle resolution for analog data and with 1/4-cycle resolution for digital data. If *n* is omitted, the most recent report is displayed. Parameter *m* is X for X-side and Y for Y-side. If *m* is not specified, the relay defaults to *m* = X.	**EVE *n* R *m*** o **EVE R *n m***	Mostrar el reporte sin filtrar de evento *n*, (32 muestras por ciclo). Si se omite *n*, se muestra el reporte más reciente. El parámetro especifica el lado X o Y. Por omisión *m* = X.
EVE D *n m*	Shows the digital data event report *n* with 1/4-cycle resolution. If *n* is omitted, the most recent report is displayed. Parameter *m* is X for X-side and Y for Y-side. If *m* is not specified, the relay defaults to *m* = X.	**EVE D *n m***	Mostrar el reporte digital de evento *n*, (4 muestras por ciclo). Si se omite *n*, se muestra el reporte más reciente. El parámetro especifica el lado X o Y. Por omisión *m* = X.

Command	Description
EVE D *n* R *m*	Shows the digital data event report *n* with 1/32-cycle resolution. If *n* is omitted, the most recent report is displayed. Parameter *m* is X for X-side and Y for Y-side. If *m* is not specified, the relay defaults to *m* = X.
EVE DIF1 *n*	Shows Differential Element 1 event report number *n*, with 1/4-cycle resolution.
EVE DIF2 *n*	Shows Differential Element 2 event report number *n*, with 1/4-cycle resolution.
EVE DIF3 *n*	Shows Differential Element 3 event report number *n*, with 1/4-cycle resolution.
EVE GND *n*	Shows ground event report *n* (64G element), with 1/4-cycle resolution.
FIL DIR	Returns a list of files.
FIL READ *filename*	Transfers settings file *filename* from the relay to the PC.
FIL SHOW *filename*	*Filename* displays the contents of the corresponding file.
GEN	Displays generator operating statistics report.
GSH	Displays the generator autosynchronism report history.
GST	Triggers generator autosynchronism report data capture.
GOOSE *k*	Displays transmit and receive GOOSE messaging information. Enter number *k* to scroll the GOOSE data *k* times on the screen.
GROUP	Displays active group setting.
HELP	Displays a short description of selected commands.
HIS *n*	Shows summary of *n* latest event reports, where *n* = 1 is the most recent entry. If *n* is not specified, all event report summaries are displayed.
HIS C or **R**	Clears or resets history buffer.
HIS CA or **RA**	Clears the history events and resets the reference number.
IRIG	Forces synchronization of internal control clock to IRIG-B time-code input.
LDP	Displays signal profile data.
LDP *row1 row2*	Displays load profile report rows from *row1* to *row2*, starting with *row1*. If *row2* is omitted, displays the first *row1* rows.
LDP *date1 date2*	Displays load profile report rows from *date1* to *date2*, starting with *date1*.

Comando del Puerto Serial	Descripción del Comando
EVE D *n* R *m*	Mostrar el reporte digital de evento *n*, (32 muestras por ciclo). Si se omite *n*, se muestra el reporte más reciente. El parámetro especifica el lado X o Y. Por omisión *m* = X.
EVE DIF1 *n*	Mostrar el reporte del elemento diferencial 1, evento *n*, (4 muestras por ciclo).
EVE DIF2 *n*	Mostrar el reporte del elemento diferencial 2, evento *n*, (4 muestras por ciclo).
EVE DIF3 *n*	Mostrar el reporte del elemento diferencial 3, evento *n*, (4 muestras por ciclo).
EVE GND *n*	Mostrar el reporte del elemento 64G, evento *n*, (4 muestras por ciclo).
FIL DIR	Mostrar lista de archivos.
FIL READ *filename*	Transferir el archivo de configuración *filename* del relé a la computadora.
FIL SHOW *filename*	Muestra el contenido del archivo *filename*.
GEN	Muestra estadisticas de operacion del generador.
GSH	Muestra el historial de reportes de sincronismo del generado.
GST	Dispara la captura de datos de sincronismo del generador.
GOOSE *k*	Mostrar información de transmisión y recepción de mensajes GOOSE. Ingresar el numero *k* para mostrar los datos GOOSE *k* veces en la pantalla.
GRUPO	Mostrar el grupo de ajustes activo.
AYU	Mostrar una descripción corta de los comandos elegidos.
HIS *n*	Mostrar el resumen de los últimos *n* informes de eventos, donde *n* = 1 es la entrada más reciente. Si *n* es no está especificado, muestra todos los resúmenes de reportes de eventos.
HIS D o **R**	Borrar la historia de eventos.
HIS DT o **RT**	Borrar eventos y restablecer los numeros de referencia.
IRIG	Forzar la sincronización del reloj interno a IRIG-B.
LDP	Mostrar los datos de perfil carga.
LDP *row1 row2*	Mostrar los datos de perfil carga entra las filas *row1* y *row2*. Si se omite *row2*, muestra las primeras *row1* columnas.
LDP *date1 date2*	Mostrar los datos de perfil carga entra las filas *date1* y *date2*.

Command	Description
LDP C	Clears load profile data.
MAC	Displays the MAC address of the Ethernet port (PORT 1).
MET or **MET F**	Displays fundamental instantaneous metering data.
MET *k*	Displays fundamental metering data *k* times, where *k* is between 1 and 32767.
MET AI	Displays analog input (transducer) data.
MET DE	Displays demand metering data, in primary amperes.
MET DIF	Displays differential metering data.
MET E	Displays energy metering data.
MET H	Displays harmonic report for all differential phase currents, showing fundamental through fifth-harmonic levels and total harmonic distortion (THD %).
MET M	Displays minimum and maximum metering data.
MET MV	Displays SELOGIC math variable data.
MET PE	Displays peak demand metering data, in primary amperes.
MET PM	Displays synchrophasor metering data.
MET RA	Displays remote analog metering data.
MET RD	Resets demand metering values.
MET RE	Resets energy metering data.
MET RM	Resets minimum and maximum metering data.
MET RMS	Displays rms metering data.
MET RP	Resets demand and peak demand metering values.
MET T	Displays thermal capacity used and RTD metering data.
PING *x.x.x.x t*	Determines if Ethernet port is functioning and configured properly. *x.x.x.x* is the IP address and *t* is the PING interval settable from 2 to 255 seconds. Default *t* is 1 second. Press Q to stop.
RSTP	Displays RSTP statistics and the present RSTP configuration of Port 1.
SER	Displays the entire Sequential Events Recorder (SER) report.

Comando del Puerto Serial	Descripción del Comando
LDP D	Borra datos de perfil de carga.
MAC	Mostrar la dirección MAC del puerto de Ethernet (PUERTO 1).
MED o **MED F**	Mostrar los datos de medición fundamentales.
MED *k*	Mostrar los datos de medición fundamentales *k* veces, donde *k* entre 1 y 32767.
MED EA	Mostrar los datos de entrada analógica.
MED DE	Mostrar los datos de demanda de medición en amperes primarios.
MED DIF	Mustra los datos de medicion diferencial.
MED E	Mostrar los datos de medición de energía.
MED A	Mostrar la magnitud de los harmónicos 1 a 5 de las corrientes diferenciales. Adicionalmente muestra THD %.
MED M	Mostrar datos de medición mínimos y máximos.
MED V	Mostrar variables matemáticas SELOGIC.
MED PIC	Mostrar los datos de demanda de medición pico en amperes primarios.
MED PM	Mostrar fasores sincronizados.
MED RA	Mostrar datos analogicos de medición remota.
MED RD	Reiniciar mediciones de demanda.
MED RE	Reiniciar los datos de medición de energía.
MED RM	Reiniciar los datos de medición mínima y máxima.
MED RMS	Mostrar los datos de medición rms.
MED RP	Reiniciar los valores de medición de demanda y de demanda pico.
MED T	Mostrar los datos de capacidad térmica utilizada y de medición RTD.
PING *x.x.x.x t*	Determinar si el puerto Ethernet esta funcionando y configurado adecuadamente. *x.x.x.x* es la dirección IP. *t* es el intervalo entre PINGs, *t* es ajustable entre 2 y 255 segundos. Por omisión, *t* = 1 segundo. Oprima Q para detener.
RSTP	Muestra estadisticas y configuracion RSTP actual.
SER	Mostrar el reporte completo del Registrador de Eventos Secuenciales (SER).

Command	Description
SER *date1*	Displays all the rows in the SER report recorded on the specified date (see **DATE** command for date format).
SER *date1 date2*	Displays all the rows in the SER report recorded between dates *date1* and *date2*, inclusive.
SER *row1*	Displays the latest *row1* rows in the SER report (*row1* = 1–1024, where 1 is the most recent entry).
SER *row1 row2*	Displays rows *row1–row2* in the SER report
SER C or **R**	Clears SER data.
SER D	Displays SER delete report, which shows deleted items (use when SER auto-deletion is selected to remove chatter).
SHO *n*	Displays relay settings for Group *n* (*n* = 1, 2, 3, or 4). If *n* is not specified, default is the active settings group.
SHO DNP *m*	Displays the DNP data map settings for Map *m*, where *m* = 1, 2, or 3.
SHO E *m*	Displays EtherNet/IP Assembly Map settings for Map *m* (*m* = 1, 2, or 3).
SHO F	Displays front-panel settings.
SHO G	Displays global settings.
SHO I	Displays the IEC 60870-5-103 map settings.
SHO L *n*	Displays general logic settings for Group *n* (*n* = 1, 2, 3, or 4). If *n* is not specified, default is the active settings group.
SHO M	Displays Modbus user map settings.
SHO P *n*	Displays port settings, where *n* specifies the port (1, 2, 3, 4, or F); *n* defaults to the active port if not listed.
SHO R	Displays report settings.
STA	Displays relay self-test status.
STA S	Displays SELOGIC usage status report.
SUM *n*	Displays an event summary; *n* is the number of the requested event summary.
SUM C or **R**	Resets event summary buffer.
SYN *n*	Displays generator synchronism-check report.
TAR	Displays default target row or the most recently viewed target row.
TAR *n*	Displays Target Row *n*.

Comando del Puerto Serial	Descripción del Comando
SER *date1*	Mostrar todos las filas en el reporte SER del dia *date1* (vea el commando **DATE** por el formato de fecha).
SER *date1 date2*	Mostrar todos las filas en el reporte SER entre el dia date1 y el dia date2 (vea el commando **DATE** por el formato de fecha)
SER *row1*	Mostrar las ultimas *row1* filas en el reporte SER (*row1* = 1–1024, 1 es la fila más reciente).
SER *row1 row2*	Mostrar las filas entre *row1–row2*.
SER DE	Borrar los datos SER.
SER B	Muestra ítems removidos del SER. Útil cuando la supresión automática de SER esta activada.
MOS *n*	Mostrar ajustes del Grupo *n* del relé (*n* = 1, 2, 3 o 4). Por omisión, muestra grupo de ajustes 1.
MOS DNP *m*	Mostrar ajuestes de mapa de datos DNP para el Mapa *m* (*m* = 1, 2 o 3).
MOS E *m*	Mostrar ajustes EtherNet/IP del mapa numero *m* (*m*=1, 2 o 3).
MOS F	Mostrar ajustes del panel frontal.
MOS G	Mostrar ajustes globales.
MOS I	Mostrar mapa de ajustes IEC 60870-5-103.
MOS L *n*	Mostrar la lógica de configuración general del grupo *n* del relé (*n* = 1, 2, 3 o 4). Por omisión, muestra grupo de ajustes activo.
MOS M	Mostrar ajustes del Mapa del Usuario Modbus.
MOS P *n*	Mostrar configuraciones de puerto, donde *n* especifica el puerto (1, 2, 3, 4 o F); por defecto muestra ajustes del puerto activo.
MOS R	Mostrar configuración de reportes.
EST	Muestar resultados de autotest.
EST S	Mostrar reporte de utilización SELOGIC.
SUM *n*	Muestra un resumen de evento; *n* es el numero del evento seleccionado.
SUM C o **R**	Borrar el buffer de resúmenes de evento.
SIN *n*	Muestra el reporte de verificacion de sincronism del generado.
BAN	Mostrar la fila de banderas por defecto o la última fila de banderas mostrada.
BAN *n*	Mostrar la fila de banderas *n*.

Command	Description
TAR *n k*	Displays Target Row *n*. Repeats display of Row *n* for repeat count *k*.
TAR *name*	Displays the target row with target *name* in the row.
TAR *name k*	Displays the target row with target *name* in the row. Repeats display of this row for repeat count *k*.
TAR R	Resets any latched targets and the most recently viewed target row.
TIME	Displays the time.
TIME *hh*	Sets the time by entering **TIME** followed by hours, as shown (24-hour clock).
TIME *hh:mm*	Sets the time by entering **TIME** followed by hours and minutes, as shown (24-hour clock).
TIME *hh:mm:ss*	Sets time by entering **TIME** followed by hours, minutes, and seconds, as shown (24-hour clock).
TRI	Triggers an event report data capture.
Access Level 2 Commands	
89C *m*	Closes Two-position Disconnect *m*, where *m* = 1–8
89O *m*	Opens Two-position Disconnect *m*, where *m* = 1–8
89C *n m*	Closes Three-position Disconnect *m*, where *m* = 1–2 and *n* = L or E for in-line or earthing disconnect, respectively
89O *n m*	Opens Three-position Disconnect *m*, where *m* = 1–2 and *n* = L or E for in-line or earthing disconnect, respectively
AST	Auto Start—starts generator automatic synchronizing control.
ASP	Auto Stop—stops generator automatic synchronizing control.
ANA *c p t*	Tests analog output channel where *c* is the channel name or number, *p* is a percentage of full scale or either letter “R” or “r” indicates ramp mode, and *t* is the duration of the test in decimal minutes.
BRE *n* R	Resets breaker data for Breaker *n*, where *n* = X or Y.
BRE *n* W	Preloads breaker data for Breaker *n*, where *n* = X or Y.

Comando del Puerto Serial	Descripción del Comando
BAN *n k*	Mostrar la fila de banderas *n k* veces.
BAN *name*	Mostrar la fila de banderas que contiene la bandera *name*.
BAN *name k*	Mostrar la fila de banderas que contiene la bandera *name k* veces.
BAN R	Resetea todas las banderas selladas y la fila de banderas mostrada mas recientemente.
HORA	Ver hora.
HORA *hh*	Configurar la hora ingresando **HORA** seguido por horas como se muestra (relog 24 horas).
HORA *hh:mm*	Configurar la hora ingresando **HORA** seguido por horas y minutos como se muestra (relog 24 horas).
HORA *hh:mm:ss*	Configurar la hora ingresando **HORA** seguido por horas, minutos y segundos como se muestra (relog 24 horas).
TRI	Disparar la captura de un reporte de evento.
Comandos del Nivel de Acceso 2	
89C *m*	Cierra el seccionador de dos-posiciones *m*, donde *m* = 1–8.
89A *m*	Abre el seccionador de dos-posiciones *m*, donde *m* = 1–8.
89C *n m*	Cierra el seccionador de tres-posiciones *m*, donde *m* = 1–2, y *n* = L o E (Línea o Tierra).
89A *n m*	Abre el seccionador de tres-posiciones *m*, donde *m* = 1–2, y *n* = L o E (Línea o Tierra).
AST	Comenzar control de sincronizador automático.
ASP	Detener el control de sincronizador automático.
ANA *c p t*	Probar el canal de salida analógica donde *c* es el nombre o el número del canal, *p* es el porcentaje de escala completa, o las letras “R” o “r” para indicar el modo de rampa y *t* para indicar la duración de la prueba en minutos decimales.
INT *n* R	Reiniciar datos del interruptor, donde *n* es X o Y.
INT *n* W	Precargar datos del interruptor, donde *n* es X o Y.

Command	Description
CAL	Enters Access Level C. If the main board access jumper is not in place, the relay prompts for the entry of the Access Level C password. Access Level C is reserved for SEL use only.
CLO *n*	Closes Circuit Breaker *n*, where *n* = X or Y.
CON RB*nn k*	Selects a remote bit to set, clear, or pulse where *nn* is a number from 01 to 32, representing RB01 through RB32. *k* is S, C, or P for Set, Clear, or Pulse.
COPY *m n*	Copies relay and logic settings from Group *m* to Group *n*.
DTO	Downloads volts/Hz user curve from SEL-5806 Curve Designer Software.
FIL WRITE *filename*	Transfers settings file *filename* from the PC to the relay.
GEN R	Resets generator operating statistics report data.
GROUP *n*	Modifies the active group setting, where *n* = 1, 2, 3 or 4.
L_D	Loads new firmware.
LOO	Enables loopback testing of MIRRORED BITS channels.
LOO A	Enables loopback on MIRRORED BITS Channel A for the next 5 minutes.
LOO B	Enables loopback on MIRRORED BITS Channel B for the next 5 minutes.
LOO R	Disables the loopback on both channels and returns the device to normal operation.
LOO *xx* DATA	Enables loopback mode for *xx* minutes and allows the loopback data to modify the RMB values.
MET WE	Preload energy meter registers.
PARTNO	Allows for updates to the part number after the relay hardware configuration has been changed.
OPE *n*	Opens Circuit Breaker *n*, where *n* = X or Y.
PAS 1	Changes Access Level 1 password.
PAS 2	Changes Access Level 2 password.
PUL OUT*nnn*	Pulse Output Contact *nnn*.
PUL OUT*nnn t*	Pulses Output Contact *nnn*, where *nnn* = OUT101…, for *t* (1 to 30, default is 1) seconds.

Comando del Puerto Serial	Descripción del Comando
CAL	Ingresar al Nivel de Acceso C. Si el jumper de acceso en la tarjeta principal no está en su lugar, el relé pedirá la contraseña de Acceso del Nivel C. El Nivel de Acceso C está reservado para uso exclusivo de SEL.
CER *n*	Cerrar el interruptor *n* donde *n* = X o Y.
CON RB*nn k*	Seleccionar un bit remoto para activar, desactivar o pulsar donde *nn* es un número del 01 al 32, representando desde RB01 hasta RB32. *k* es A, D o P para Activar, Deactivar o Pulsar.
COPY *m n*	Copiar configuración del relé y la configuración lógica del Grupo *m* al Grupo *n*.
DTO	Descargar curva V/Hz del usuario usando SEL-5806 Curve Designer Software.
FIL WRITE *filename*	Transferir el archivo de configuración *filename* de la computadora al relé.
GEN R	Borra los datos estadísticos del generador.
GRUPO *n*	Usar grupo de configuraciones *n*, donde *n* = 1, 2, 3 o 4.
L_D	Cargar un firmware nuevo.
LOO	Habilitar loopback de los canales MIRRORED BITS.
LOO A	Habilitar loopback en Canal MIRRORED BITS A por los siguientes 5 minutos.
LOO B	Habilitar loopback en Canal MIRRORED BITS B por los siguientes 5 minutos.
LOO R	Deshabilita loopback en canales MB A y B.
LOO *xx* DATA	Habilita loopback for xx minutos y permite modificar valores RMB.
MED WE	Cargar registros de medición de energía.
PARTNO	Cambia el número de parte del relé use despues de cambiar una tarjeta del relé.
ABR *n*	Abrir el interruptor *n*, donde *n* = X o Y.
PAS 1	Cambiar la contraseña del Nivel de Acceso 1.
PAS 2	Cambiar la contraseña del Nivel de Acceso 2.
PUL OUT*nnn*	Pulsar el Contacto de Salida *nnn*.
PUL OUT*nnn t*	PUL OUT*nnn t* Pulsar el contacto de salida *nnn* (*nnn* = OUT101…) por *t* (de 1 a 30, el numero predeterminado es 1) segundos.

Command	Description
R_S	Restores the factory-default settings and passwords and reboots the relay; available only after a firmware upgrade.
SET *n*	Modifies settings for Group *n* (*n* = 1, 2, 3, or 4). If *n* is not specified, default is the active settings group.
SET *name*	For all **SET** commands, jumps ahead to a specific setting by entering the setting name, for example, 50PX1P.
SET DNP *n*	Modifies the DNP data map settings for Map n, where n = 1, 2, or 3.
SET E *n*	Modifies EtherNet/IP assembly map settings for Map *n* (*n* = 1, 2, or 3).
SET F	Modifies front-panel settings.
SET G	Modifies global settings.
SET I	Modifies the IEC 60870-5-103 settings.
SET L *n*	Modifies the SELOGIC variable and timer settings for Group *n* (*n* = 1, 2, 3, or 4). If *n* is not specified, default is the active settings group.
SET M	Modifies the Modbus user map settings.
SET P *n*	Modifies the Port *n* settings, where *n* = 1, 2, 3, 4, or F. If not specified, the default is the active port.
SET R	Modifies the report settings.
SET...TERSE	For all **SET** commands, TERSE disables the automatic **SHO** command after the settings entry.
STA C or **R**	Clears the self-test status and restarts the relay.
SYN R	Resets the breaker close time average and breaker close operations counter in the synchronism-check report data.
TEST DB	Displays the present status of digital and analog overrides.
VEC D	Displays the diagnostic vector report.
VEC E	Displays the exception vector report.
Access Level C Commands	
PAS C	Changes Access Level C password.

Comando del Puerto Serial	Descripción del Comando
R_S	Resetea el relé usando ajustes y passwords por defacto y después reinicia el relé. Disponible solamente después de una actualización de firmware.
AJU *n*	Modificar el Grupo *n* de ajustes del relé, donden *n* =1, 2, 3 o 4. Si no se especifica *n*, se modifica el grupo activo.
AJU *name*	Para todos los comandos **SET**, adelántese a un ajuste ingresando el nombre del ajuste, por ejemplo, 50PX1P.
AJU DNP *n*	Modificar la configuración del mapa de datos DNP para el Mapa n, donde n = 1, 2 o 3.
AJU E *n*	Modificar ajustes EtherNet/IP del mapa número *n* (*n* = 1, 2 o 3)
AJU F	Modificar ajustes del panel frontal.
AJU G	Modificar las ajustes globales.
AJU I	Modificar ajustes IEC 60870-5-103.
AJU L *n*	Modifica ajustes SELOGIC, laches, variables lógicas (SV) y matemáticas (MV) en el grupo de ajustes *n* (*n* = 1, 2, 3 o 4). Si no se especifica *n*, se modifica el grupo activo.
AJU M	Modificar las configuración del Mapa del Usuario Modbus.
AJU P *n*	Modificar la configuración del Puerto *n*, donde *n* = 1, 2, 3, 4 o F. Si n no está especificado, el puerto predeterminado es el puerto activo.
AJU R	Modificar los ajustes de reportes.
AJU...TERSO	Para todos los comandos **AJU**, TERSO desactiva los comandos automáticos **MOS** después de modificar los ajustes.
EST C o **R**	Salir del modo de diagnostico automático y reiniciar el relé.
SIN R	Borra los datcos de tiempo de cierre y número de operaciones del interruptor en el reporte de sincronización.
TEST DB	Mostrar el estado actual de variable digitales y analógicas con valores forzados.
VEC D	Mostar reporte standard de reinicio del relé.
VEC E	Mostar reporte de reinicio del relé.
Comandos del Nivel del Acceso C	
PAS C	Cambiar la contraseña del Nivel de Acceso C.

SEL-700G Relay Command Summary

The following table lists the front serial port ASCII commands associated with particular activities. The commands are shown in uppercase letters, but you can also enter these with lowercase letters. Commands can be initiated with the three initial letters of the command. Refer to *SEL ASCII Protocol and Commands* for additional details and capabilities of each command.

La siguiente tabla muestra los comandos ASCII del puerto serie frontal asociados con diferentes actividades. Los comandos se pueden usar en mayúsculas o minúsculas. Los comandos se pueden ejecutar usando las primeras tres letras del nombre. Por más detalles consulte la guía *SEL ASCII Protocol and Commands*.

Command	Description
Access Level 0 Commands	
ACC	Goes to Access Level 1. If the main board Access Jumper is not in place, the relay prompts for the entry of the Access Level 1 password.
ID	Relay identification code.
QUIT	Goes to Access Level 0.
Access Level 1 Commands	
2AC	Goes to Access Level 2. If the main board Access Jumper is not in place, the relay prompts for the entry of the Access Level 2 password.
BRE *n*	Displays Breaker *n* monitor data (trips, interrupted current, wear). Select *n* = X or *n* = Y for Breaker X or Breaker Y data.
CEV *n*	Shows compressed event report number *n*, at 1/4-cycle resolution. If *n* is omitted, the most recent compressed event report is displayed.
CEV *n* R	Shows compressed raw event report number *n*, at 1/32-cycle resolution. If *n* is omitted, the most recent compressed event report is displayed.
CEV *n* DIFF	Shows compressed differential element report *n*, at 1/4-cycle resolution. If *n* is omitted, the most recent compressed differential element report is displayed.
CGSR *n*	Shows compressed generator synchronizing Report *n*, where *n* = 1 to 7 (defaults to 1).
COM A	Returns a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.
COM B	Returns a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.

Comando del Puerto Serial	Descripción del Comando
Comandos del Nivel de Acceso 0	
ACC	Ir a Nivel de Acceso 1. Si el jumper de acceso en la tarjeta principal no está en su lugar, el relé pedirá la contraseña de Acceso del Nivel 1.
ID	Código de identificación del relé.
SAL	Ir al Nivel de Acceso 0.
Comandos del Nivel de Acceso 1	
2AC	Ir a Nivel de Acceso 2. Si el jumper de acceso en la tarjeta principal no está en su lugar, el relé pedirá la contraseña de Acceso del Nivel 2.
INT *n*	Mostrar información sobre disparos, corriente interrumpida, desgaste del interruptor *n*. *n* = X or Y.
CEV *n*	Mostrar el reporte comprimido de evento número *n*, resolución de 1/4 de ciclo.
CEV *n* R	Agregue R para mostrar el reporte de evento comprimido sin filtro, resolución 1/32 de ciclo. Si no se especifica *n* se muestra el evento comprimido mas reciente.
CEV *n* DIFF	Mostrar el reporte diferencial de evento *n*, (4 muestras por ciclo). Si se omite *n* se muestra el reporte más reciente.
CGSR *n*	Mostrar el reporte de sincronizacion comprimido numero *n* donde va de 1 a 7. Por defecto, *n* = 1.
COM A	Presentar un resumen de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS Canal A.
COM B	Presentar un resumen de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS Canal B.

Command	Description
COM C	Clears all communications records. If both MIRRORED BITS channels are enabled, omitting the channel specifier (A or B) clears both channels.
COM C A	Clears all communications records for Channel A.
COM C B	Clears all communications records for Channel B.
COM L A	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.
COM L B	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.
COM S A	Returns a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.
COM S B	Returns a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.
COU *n*	Shows current state of device counters. *n* = repeat the report *n* times, with a 1/2 second delay between each report.
DATE	Shows the date.
DATE *dd/mm/yyyy*	Sets date in DMY format if DATE_F setting is DMY.
DATE *mm/dd/yyyy*	Sets date in MDY format if DATE_F setting is MDY.
DATE *yyyy/mm/dd*	Sets date in YMD format if DATE_F setting is YMD.
ETH	Shows the Ethernet port status.
EVE *n m*	Shows standard analog event report *n* with 1/4-cycle resolution. If *n* is omitted, the most recent report is displayed. Parameter *m* is X for X-side and Y for Y-side. If *m* is not specified, the relay defaults to *m* = X.
EVE *n* R *m* or **EVE R *n m***	Shows event report with raw (unfiltered) with 1/32-cycle resolution for analog data and with 1/4-cycle resolution for digital data. If *n* is omitted, the most recent report is displayed. Parameter *m* is X for X-side and Y for Y-side. If *m* is not specified, the relay defaults to *m* = X.
EVE D *n m*	Shows the digital data event report *n* with 1/4-cycle resolution. If *n* is omitted, the most recent report is displayed. Parameter *m* is X for X-side and Y for Y-side. If *m* is not specified, the relay defaults to *m* = X.

Comando del Puerto Serial	Descripción del Comando
COM D	Borra todos los registros de comunicaciones. Si los dos canales MIRRORED BITS están habilitados, suprimiendo el especificador decanales (A o B) se borran los dos canales.
COM C A	Borra todos los registros de comunicaciones del Canal A.
COM C B	Borra todos los registros de comunicaciones del Canal B.
COM L A	Anexa un informe detallado al informe de síntesis de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS del Canal A.
COM L B	Anexa un informe detallado al informe de síntesis de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS del Canal B.
COM S A	Muestra un resumen de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS del Canal A.
COM S B	Muestra un resumen de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS del Canal B.
COU *n*	Muestra el estado actualizado de los contadores del dispositivo. *n* = repite el informe *n* veces, con ½ segundos entre cada informe.
FECHA	Ver fecha.
FECHA *dd/mm/yyyy*	Si DATE_F es igual a DMY, ingrese fecha en formato Día Mes Año.
FECHA *mm/dd/yyyy*	Si DATE_F es MDA, ingrese fecha en formato Mes Día Año.
FECHA *yyyy/mm/dd*	Si DATE_F es AMD, ingrese fecha en formato Año Mes Día.
ETH	Mostrar el estado del puerto de Ethernet.
EVE *n m*	Mostrar el reporte standard de evento *n*, (4 muestras por ciclo). Si se omite *n*, se muestra el reporte más reciente. El parámetro especifica el lado X o Y. Por omisión *m* = X.
EVE *n* R *m* o **EVE R *n m***	Mostrar el reporte sin filtrar de evento *n*, (32 muestras por ciclo). Si se omite *n*, se muestra el reporte más reciente. El parámetro especifica el lado X o Y. Por omisión *m* = X.
EVE D *n m*	Mostrar el reporte digital de evento *n*, (4 muestras por ciclo). Si se omite *n*, se muestra el reporte más reciente. El parámetro especifica el lado X o Y. Por omisión *m* = X.

Command	Description
EVE D *n* R *m*	Shows the digital data event report *n* with 1/32-cycle resolution. If *n* is omitted, the most recent report is displayed. Parameter *m* is X for X-side and Y for Y-side. If *m* is not specified, the relay defaults to *m* = X.
EVE DIF1 *n*	Shows Differential Element 1 event report number *n*, with 1/4-cycle resolution.
EVE DIF2 *n*	Shows Differential Element 2 event report number *n*, with 1/4-cycle resolution.
EVE DIF3 *n*	Shows Differential Element 3 event report number *n*, with 1/4-cycle resolution.
EVE GND *n*	Shows ground event report *n* (64G element), with 1/4-cycle resolution.
FIL DIR	Returns a list of files.
FIL READ *filename*	Transfers settings file *filename* from the relay to the PC.
FIL SHOW *filename*	*Filename* displays the contents of the corresponding file.
GEN	Displays generator operating statistics report.
GSH	Displays the generator autosynchronism report history.
GST	Triggers generator autosynchronism report data capture.
GOOSE *k*	Displays transmit and receive GOOSE messaging information. Enter number *k* to scroll the GOOSE data *k* times on the screen.
GROUP	Displays active group setting.
HELP	Displays a short description of selected commands.
HIS *n*	Shows summary of *n* latest event reports, where *n* = 1 is the most recent entry. If *n* is not specified, all event report summaries are displayed.
HIS C or **R**	Clears or resets history buffer.
HIS CA or **RA**	Clears the history events and resets the reference number.
IRIG	Forces synchronization of internal control clock to IRIG-B time-code input.
LDP	Displays signal profile data.
LDP *row1 row2*	Displays load profile report rows from *row1* to *row2*, starting with *row1*. If *row2* is omitted, displays the first *row1* rows.
LDP *date1 date2*	Displays load profile report rows from *date1* to *date2*, starting with *date1*.

Comando del Puerto Serial	Descripción del Comando
EVE D *n* R *m*	Mostrar el reporte digital de evento *n*, (32 muestras por ciclo). Si se omite *n*, se muestra el reporte más reciente. El parámetro especifica el lado X o Y. Por omisión *m* = X.
EVE DIF1 *n*	Mostrar el reporte del elemento diferencial 1, evento *n*, (4 muestras por ciclo).
EVE DIF2 *n*	Mostrar el reporte del elemento diferencial 2, evento *n*, (4 muestras por ciclo).
EVE DIF3 *n*	Mostrar el reporte del elemento diferencial 3, evento *n*, (4 muestras por ciclo).
EVE GND *n*	Mostrar el reporte del elemento 64G, evento *n*, (4 muestras por ciclo).
FIL DIR	Mostrar lista de archivos.
FIL READ *filename*	Transferir el archivo de configuración *filename* del relé a la computadora.
FIL SHOW *filename*	Muestra el contenido del archivo *filename*.
GEN	Muestra estadisticas de operacion del generador.
GSH	Muestra el historial de reportes de sincronismo del generado.
GST	Dispara la captura de datos de sincronismo del generador.
GOOSE *k*	Mostrar información de transmisión y recepción de mensajes GOOSE. Ingresar el numero *k* para mostrar los datos GOOSE *k* veces en la pantalla.
GRUPO	Mostrar el grupo de ajustes activo.
AYU	Mostrar una descripción corta de los comandos elegidos.
HIS *n*	Mostrar el resumen de los últimos *n* informes de eventos, donde *n* = 1 es la entrada más reciente. Si *n* es no está especificado, muestra todos los resúmenes de reportes de eventos.
HIS D o **R**	Borrar la historia de eventos.
HIS DT o **RT**	Borrar eventos y restablecer los numeros de referencia.
IRIG	Forzar la sincronización del reloj interno a IRIG-B.
LDP	Mostrar los datos de perfil carga.
LDP *row1 row2*	Mostrar los datos de perfil carga entra las filas *row1* y *row2*. Si se omite *row2*, muestra las primeras *row1* columnas.
LDP *date1 date2*	Mostrar los datos de perfil carga entra las filas *date1* y *date2*.

Command	Description
LDP C	Clears load profile data.
MAC	Displays the MAC address of the Ethernet port (PORT 1).
MET or **MET F**	Displays fundamental instantaneous metering data.
MET *k*	Displays fundamental metering data *k* times, where *k* is between 1 and 32767.
MET AI	Displays analog input (transducer) data.
MET DE	Displays demand metering data, in primary amperes.
MET DIF	Displays differential metering data.
MET E	Displays energy metering data.
MET H	Displays harmonic report for all differential phase currents, showing fundamental through fifth-harmonic levels and total harmonic distortion (THD %).
MET M	Displays minimum and maximum metering data.
MET MV	Displays SELOGIC math variable data.
MET PE	Displays peak demand metering data, in primary amperes.
MET PM	Displays synchrophasor metering data.
MET RA	Displays remote analog metering data.
MET RD	Resets demand metering values.
MET RE	Resets energy metering data.
MET RM	Resets minimum and maximum metering data.
MET RMS	Displays rms metering data.
MET RP	Resets demand and peak demand metering values.
MET T	Displays thermal capacity used and RTD metering data.
PING *x.x.x.x t*	Determines if Ethernet port is functioning and configured properly. *x.x.x.x* is the IP address and *t* is the PING interval settable from 2 to 255 seconds. Default *t* is 1 second. Press Q to stop.
RSTP	Displays RSTP statistics and the present RSTP configuration of Port 1.
SER	Displays the entire Sequential Events Recorder (SER) report.

Comando del Puerto Serial	Descripción del Comando
LDP D	Borra datos de perfil de carga.
MAC	Mostrar la dirección MAC del puerto de Ethernet (PUERTO 1).
MED o **MED F**	Mostrar los datos de medición fundamentales.
MED *k*	Mostrar los datos de medición fundamentales *k* veces, donde *k* entre 1 y 32767.
MED EA	Mostrar los datos de entrada analógica.
MED DE	Mostrar los datos de demanda de medición en amperes primarios.
MED DIF	Mustra los datos de medicion diferencial.
MED E	Mostrar los datos de medición de energía.
MED A	Mostrar la magnitud de los harmónicos 1 a 5 de las corrientes diferenciales. Adicionalmente muestra THD %.
MED M	Mostrar datos de medición mínimos y máximos.
MED V	Mostrar variables matemáticas SELOGIC.
MED PIC	Mostrar los datos de demanda de medición pico en amperes primarios.
MED PM	Mostrar fasores sincronizados.
MED RA	Mostrar datos analogicos de medición remota.
MED RD	Reiniciar mediciones de demanda.
MED RE	Reiniciar los datos de medición de energía.
MED RM	Reiniciar los datos de medición mínima y máxima.
MED RMS	Mostrar los datos de medición rms.
MED RP	Reiniciar los valores de medición de demanda y de demanda pico.
MED T	Mostrar los datos de capacidad térmica utilizada y de medición RTD.
PING *x.x.x.x t*	Determinar si el puerto Ethernet esta funcionando y configurado adecuadamente. *x.x.x.x* es la dirección IP. *t* es el intervalo entre PINGs, *t* es ajustable entre 2 y 255 segundos. Por omisión, *t* = 1 segundo. Oprima Q para detener.
RSTP	Muestra estadisticas y configuracion RSTP actual.
SER	Mostrar el reporte completo del Registrador de Eventos Secuenciales (SER).

Command	Description
SER *date1*	Displays all the rows in the SER report recorded on the specified date (see **DATE** command for date format).
SER *date1 date2*	Displays all the rows in the SER report recorded between dates *date1* and *date2*, inclusive.
SER *row1*	Displays the latest *row1* rows in the SER report (*row1* = 1–1024, where 1 is the most recent entry).
SER *row1 row2*	Displays rows *row1–row2* in the SER report
SER C or **R**	Clears SER data.
SER D	Displays SER delete report, which shows deleted items (use when SER auto-deletion is selected to remove chatter).
SHO *n*	Displays relay settings for Group *n* (*n* = 1, 2, 3, or 4). If *n* is not specified, default is the active settings group.
SHO DNP *m*	Displays the DNP data map settings for Map *m*, where *m* = 1, 2, or 3.
SHO E *m*	Displays EtherNet/IP Assembly Map settings for Map *m* (*m* = 1, 2, or 3).
SHO F	Displays front-panel settings.
SHO G	Displays global settings.
SHO I	Displays the IEC 60870-5-103 map settings.
SHO L *n*	Displays general logic settings for Group *n* (*n* = 1, 2, 3, or 4). If *n* is not specified, default is the active settings group.
SHO M	Displays Modbus user map settings.
SHO P *n*	Displays port settings, where *n* specifies the port (1, 2, 3, 4, or F); *n* defaults to the active port if not listed.
SHO R	Displays report settings.
STA	Displays relay self-test status.
STA S	Displays SELOGIC usage status report.
SUM *n*	Displays an event summary; *n* is the number of the requested event summary.
SUM C or **R**	Resets event summary buffer.
SYN *n*	Displays generator synchronism-check report.
TAR	Displays default target row or the most recently viewed target row.
TAR *n*	Displays Target Row *n*.

Comando del Puerto Serial	Descripción del Comando
SER *date1*	Mostrar todos las filas en el reporte SER del dia *date1* (vea el commando **DATE** por el formato de fecha).
SER *date1 date2*	Mostrar todos las filas en el reporte SER entre el dia date1 y el dia date2 (vea el commando **DATE** por el formato de fecha)
SER *row1*	Mostrar las ultimas *row1* filas en el reporte SER (*row1* = 1–1024, 1 es la fila más reciente).
SER *row1 row2*	Mostrar las filas entre *row1–row2*.
SER DE	Borrar los datos SER.
SER B	Muestra ítems removidos del SER. Útil cuando la supresión automática de SER esta activada.
MOS *n*	Mostrar ajustes del Grupo *n* del relé (*n* = 1, 2, 3 o 4). Por omisión, muestra grupo de ajustes 1.
MOS DNP *m*	Mostrar ajuestes de mapa de datos DNP para el Mapa *m* (*m* = 1, 2 o 3).
MOS E *m*	Mostrar ajustes EtherNet/IP del mapa numero *m* (*m*=1, 2 o 3).
MOS F	Mostrar ajustes del panel frontal.
MOS G	Mostrar ajustes globales.
MOS I	Mostrar mapa de ajustes IEC 60870-5-103.
MOS L *n*	Mostrar la lógica de configuración general del grupo *n* del relé (*n* = 1, 2, 3 o 4). Por omisión, muestra grupo de ajustes activo.
MOS M	Mostrar ajustes del Mapa del Usuario Modbus.
MOS P *n*	Mostrar configuraciones de puerto, donde *n* especifica el puerto (1, 2, 3, 4 o F); por defecto muestra ajustes del puerto activo.
MOS R	Mostrar configuración de reportes.
EST	Muestar resultados de autotest.
EST S	Mostrar reporte de utilización SELOGIC.
SUM *n*	Muestra un resumen de evento; *n* es el numero del evento seleccionado.
SUM C o **R**	Borrar el buffer de resúmenes de evento.
SIN *n*	Muestra el reporte de verificacion de sincronism del generado.
BAN	Mostrar la fila de banderas por defecto o la última fila de banderas mostrada.
BAN *n*	Mostrar la fila de banderas *n*.

Command	Description
TAR *n k*	Displays Target Row *n*. Repeats display of Row *n* for repeat count *k*.
TAR *name*	Displays the target row with target *name* in the row.
TAR *name k*	Displays the target row with target *name* in the row. Repeats display of this row for repeat count *k*.
TAR R	Resets any latched targets and the most recently viewed target row.
TIME	Displays the time.
TIME *hh*	Sets the time by entering **TIME** followed by hours, as shown (24-hour clock).
TIME *hh:mm*	Sets the time by entering **TIME** followed by hours and minutes, as shown (24-hour clock).
TIME *hh:mm:ss*	Sets time by entering **TIME** followed by hours, minutes, and seconds, as shown (24-hour clock).
TRI	Triggers an event report data capture.
Access Level 2 Commands	
89C *m*	Closes Two-position Disconnect *m*, where *m* = 1–8
89O *m*	Opens Two-position Disconnect *m*, where *m* = 1–8
89C *n m*	Closes Three-position Disconnect *m*, where *m* = 1–2 and *n* = L or E for in-line or earthing disconnect, respectively
89O *n m*	Opens Three-position Disconnect *m*, where *m* = 1–2 and *n* = L or E for in-line or earthing disconnect, respectively
AST	Auto Start—starts generator automatic synchronizing control.
ASP	Auto Stop—stops generator automatic synchronizing control.
ANA *c p t*	Tests analog output channel where *c* is the channel name or number, *p* is a percentage of full scale or either letter “R” or “r” indicates ramp mode, and *t* is the duration of the test in decimal minutes.
BRE *n* R	Resets breaker data for Breaker *n*, where *n* = X or Y.
BRE *n* W	Preloads breaker data for Breaker *n*, where *n* = X or Y.

Comando del Puerto Serial	Descripción del Comando
BAN *n k*	Mostrar la fila de banderas *n k* veces.
BAN *name*	Mostrar la fila de banderas que contiene la bandera *name*.
BAN *name k*	Mostrar la fila de banderas que contiene la bandera *name k* veces.
BAN R	Resetea todas las banderas selladas y la fila de banderas mostrada mas recientemente.
HORA	Ver hora.
HORA *hh*	Configurar la hora ingresando **HORA** seguido por horas como se muestra (relog 24 horas).
HORA *hh:mm*	Configurar la hora ingresando **HORA** seguido por horas y minutos como se muestra (relog 24 horas).
HORA *hh:mm:ss*	Configurar la hora ingresando **HORA** seguido por horas, minutos y segundos como se muestra (relog 24 horas).
TRI	Disparar la captura de un reporte de evento.
Comandos del Nivel de Acceso 2	
89C *m*	Cierra el seccionador de dos-posiciones *m*, donde *m* = 1–8.
89A *m*	Abre el seccionador de dos-posiciones *m*, donde *m* = 1–8.
89C *n m*	Cierra el seccionador de tres-posiciones *m*, donde *m* = 1–2, y *n* = L o E (Línea o Tierra).
89A *n m*	Abre el seccionador de tres-posiciones *m*, donde *m* = 1–2, y *n* = L o E (Línea o Tierra).
AST	Comenzar control de sincronizador automático.
ASP	Detener el control de sincronizador automático.
ANA *c p t*	Probar el canal de salida analógica donde *c* es el nombre o el número del canal, *p* es el porcentaje de escala completa, o las letras “R” o “r” para indicar el modo de rampa y *t* para indicar la duración de la prueba en minutos decimales.
INT *n* R	Reiniciar datos del interruptor, donde *n* es X o Y.
INT *n* W	Precargar datos del interruptor, donde *n* es X o Y.

Command	Description
CAL	Enters Access Level C. If the main board access jumper is not in place, the relay prompts for the entry of the Access Level C password. Access Level C is reserved for SEL use only.
CLO *n*	Closes Circuit Breaker *n*, where *n* = X or Y.
CON RB*nn k*	Selects a remote bit to set, clear, or pulse where *nn* is a number from 01 to 32, representing RB01 through RB32. *k* is S, C, or P for Set, Clear, or Pulse.
COPY *m n*	Copies relay and logic settings from Group *m* to Group *n*.
DTO	Downloads volts/Hz user curve from SEL-5806 Curve Designer Software.
FIL WRITE *filename*	Transfers settings file *filename* from the PC to the relay.
GEN R	Resets generator operating statistics report data.
GROUP *n*	Modifies the active group setting, where *n* = 1, 2, 3 or 4.
L_D	Loads new firmware.
LOO	Enables loopback testing of MIRRORED BITS channels.
LOO A	Enables loopback on MIRRORED BITS Channel A for the next 5 minutes.
LOO B	Enables loopback on MIRRORED BITS Channel B for the next 5 minutes.
LOO R	Disables the loopback on both channels and returns the device to normal operation.
LOO *xx* DATA	Enables loopback mode for *xx* minutes and allows the loopback data to modify the RMB values.
MET WE	Preload energy meter registers.
PARTNO	Allows for updates to the part number after the relay hardware configuration has been changed.
OPE *n*	Opens Circuit Breaker *n*, where *n* = X or Y.
PAS 1	Changes Access Level 1 password.
PAS 2	Changes Access Level 2 password.
PUL OUT*nnn*	Pulse Output Contact *nnn*.
PUL OUT*nnn t*	Pulses Output Contact *nnn*, where *nnn* = OUT101…, for *t* (1 to 30, default is 1) seconds.

Comando del Puerto Serial	Descripción del Comando
CAL	Ingresar al Nivel de Acceso C. Si el jumper de acceso en la tarjeta principal no está en su lugar, el relé pedirá la contraseña de Acceso del Nivel C. El Nivel de Acceso C está reservado para uso exclusivo de SEL.
CER *n*	Cerrar el interruptor *n* donde *n* = X o Y.
CON RB*nn k*	Seleccionar un bit remoto para activar, desactivar o pulsar donde *nn* es un número del 01 al 32, representando desde RB01 hasta RB32. *k* es A, D o P para Activar, Deactivar o Pulsar.
COPY *m n*	Copiar configuración del relé y la configuración lógica del Grupo *m* al Grupo *n*.
DTO	Descargar curva V/Hz del usuario usando SEL-5806 Curve Designer Software.
FIL WRITE *filename*	Transferir el archivo de configuración *filename* de la computadora al relé.
GEN R	Borra los datos estadísticos del generador.
GRUPO *n*	Usar grupo de configuraciones *n*, donde *n* = 1, 2, 3 o 4.
L_D	Cargar un firmware nuevo.
LOO	Habilitar loopback de los canales MIRRORED BITS.
LOO A	Habilitar loopback en Canal MIRRORED BITS A por los siguientes 5 minutos.
LOO B	Habilitar loopback en Canal MIRRORED BITS B por los siguientes 5 minutos.
LOO R	Deshabilita loopback en canales MB A y B.
LOO *xx* DATA	Habilita loopback for xx minutos y permite modificar valores RMB.
MED WE	Cargar registros de medición de energía.
PARTNO	Cambia el número de parte del relé use despues de cambiar una tarjeta del relé.
ABR *n*	Abrir el interruptor *n*, donde *n* = X o Y.
PAS 1	Cambiar la contraseña del Nivel de Acceso 1.
PAS 2	Cambiar la contraseña del Nivel de Acceso 2.
PUL OUT*nnn*	Pulsar el Contacto de Salida *nnn*.
PUL OUT*nnn t*	PUL OUT*nnn t* Pulsar el contacto de salida *nnn* (*nnn* = OUT101…) por *t* (de 1 a 30, el numero predeterminado es 1) segundos.

Command	Description
R_S	Restores the factory-default settings and passwords and reboots the relay; available only after a firmware upgrade.
SET *n*	Modifies settings for Group *n* (*n* = 1, 2, 3, or 4). If *n* is not specified, default is the active settings group.
SET *name*	For all **SET** commands, jumps ahead to a specific setting by entering the setting name, for example, 50PX1P.
SET DNP *n*	Modifies the DNP data map settings for Map n, where n = 1, 2, or 3.
SET E *n*	Modifies EtherNet/IP assembly map settings for Map *n* (*n* = 1, 2, or 3).
SET F	Modifies front-panel settings.
SET G	Modifies global settings.
SET I	Modifies the IEC 60870-5-103 settings.
SET L *n*	Modifies the SELOGIC variable and timer settings for Group *n* (*n* = 1, 2, 3, or 4). If *n* is not specified, default is the active settings group.
SET M	Modifies the Modbus user map settings.
SET P *n*	Modifies the Port *n* settings, where *n* = 1, 2, 3, 4, or F. If not specified, the default is the active port.
SET R	Modifies the report settings.
SET...TERSE	For all **SET** commands, TERSE disables the automatic **SHO** command after the settings entry.
STA C or **R**	Clears the self-test status and restarts the relay.
SYN R	Resets the breaker close time average and breaker close operations counter in the synchronism-check report data.
TEST DB	Displays the present status of digital and analog overrides.
VEC D	Displays the diagnostic vector report.
VEC E	Displays the exception vector report.
Access Level C Commands	
PAS C	Changes Access Level C password.

Comando del Puerto Serial	Descripción del Comando
R_S	Resetea el relé usando ajustes y passwords por defacto y después reinicia el relé. Disponible solamente después de una actualización de firmware.
AJU *n*	Modificar el Grupo *n* de ajustes del relé, donden *n* =1, 2, 3 o 4. Si no se especifica *n*, se modifica el grupo activo.
AJU *name*	Para todos los comandos **SET**, adelántese a un ajuste ingresando el nombre del ajuste, por ejemplo, 50PX1P.
AJU DNP *n*	Modificar la configuración del mapa de datos DNP para el Mapa n, donde n = 1, 2 o 3.
AJU E *n*	Modificar ajustes EtherNet/IP del mapa número *n* (*n* = 1, 2 o 3)
AJU F	Modificar ajustes del panel frontal.
AJU G	Modificar las ajustes globales.
AJU I	Modificar ajustes IEC 60870-5-103.
AJU L *n*	Modifica ajustes SELOGIC, laches, variables lógicas (SV) y matemáticas (MV) en el grupo de ajustes *n* (*n* = 1, 2, 3 o 4). Si no se especifica *n*, se modifica el grupo activo.
AJU M	Modificar las configuración del Mapa del Usuario Modbus.
AJU P *n*	Modificar la configuración del Puerto *n*, donde *n* = 1, 2, 3, 4 o F. Si n no está especificado, el puerto predeterminado es el puerto activo.
AJU R	Modificar los ajustes de reportes.
AJU...TERSO	Para todos los comandos **AJU**, TERSO desactiva los comandos automáticos **MOS** después de modificar los ajustes.
EST C o **R**	Salir del modo de diagnostico automático y reiniciar el relé.
SIN R	Borra los datcos de tiempo de cierre y número de operaciones del interruptor en el reporte de sincronización.
TEST DB	Mostrar el estado actual de variable digitales y analógicas con valores forzados.
VEC D	Mostar reporte standard de reinicio del relé.
VEC E	Mostar reporte de reinicio del relé.
Comandos del Nivel del Acceso C	
PAS C	Cambiar la contraseña del Nivel de Acceso C.