SEL-700G

Generator and Intertie Protection Relays

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

Instruction Manual

20150521

SEL SCHWEITZER ENGINEERING LABORATORIES, INC.

PM700G-01

Table of Contents

Section 5: Metering and Monitoring

Section 6: Settings

SEL-700G Settings Sheets

Section 7: Communications

Section 8: Front-Panel Operations

Section 9: Analyzing Events

Section 10: Testing and Troubleshooting

Appendix A: Firmware and Manual Versions

Appendix B: Firmware Upgrade Instructions

Appendix C: SEL Communications Processors

Appendix D: DNP3 Communications

Appendix E: Modbus RTU Communications

Appendix F: IEC 61850 Communications

Appendix G: DeviceNet Communications

Appendix H: Synchrophasors

Appendix I: MIRRORED BITS Communications

Appendix J: Relay Word Bits

List of Tables

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List of Figures

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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 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 Software. 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.

Section 9: Analyzing Events. Describes front-panel LED operation, trip-type front-panel messages, event summary data, standard event reports, and Sequential Events Recorder (SER) report.

Section 10: Testing and Troubleshooting. Describes protection element test procedures, relay self-test, and relay troubleshooting.

Appendix A: Firmware 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 RTU Communications. Describes the Modbus® protocol support provided by the SEL-700G.

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

Appendix G: DeviceNet Communications. Describes the use of DeviceNet (data-link and application protocol) over CAN (hardware protocol).

Appendix H: Synchrophasors. Describes the Phasor Measurement Control Unit (PMCU), and accessing Synchrophasor data via Ethernet port or serial port using ASCII Command (MET PM) and IEEE C37.118 Protocol.

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

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

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

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

Safety Information

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
$\overline{\sim}$	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

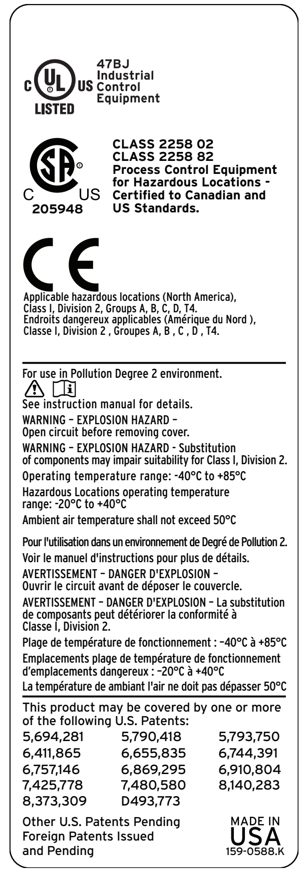
For use in Pollution Degree 2 environment.	Pour l'utilisation dans un environnement de Degré de Pollution 2.
Ambient air temperature shall not exceed 50°C (122°F).	La température ambiante de l'air ne doit pas dépasser 50°C (122°F).
For use on a flat surface of a Type 12 enclosure.	Pour l’utilisation sur une surface plane d'un boîtier de Type 12.
Terminal Ratings Wire Material Use 75°C (167°F) copper conductors only. Tightening Torque Terminal Block: 0.9–1.4 Nm (8–12 in-lbs) 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-lbs)	Valeurs nominales des bornes Matériau de fil 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.
Operating Temperature Range: –40°C to +85°C (–40°F to +185°F).	Plage de température de fonctionnement : –40°C à +85°C (–40°F à +185°F).
Hazardous Locations Operating Temperature Range: –20°C to +40°C (–4°F to +104°F).	Emplacements Plage de température de fonctionnement d’emplacements dangereux : –20°C à +40°C (–4°F à +104°F).

Hazardous Locations Approvals

The figure shows the SEL-700G compliance label that is located on the left side of the device.



Product Compliance Label for the SEL-700G

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** 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.

Other Safety Marks (Sheet 2 of 2)

⚠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.
⚠WARNING To install an option card, the relay must be de-energized and then reenergized. When reenergized, the relay will reboot. Therefore, de-energize the protected motor before installing the option card to prevent damage to the motor.	⚠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 le moteur protégé avant d'installer la carte à option pour empêcher des dégats au moteur.
⚠CAUTION The relay contains devices sensitive to Electrostatic Discharge (ESD). When working on the relay with the front panel removed, work surfaces and personnel must be properly grounded or equipment damage may result.	⚠ATTENTION Le relais contient des pièces sensibles aux décharges électrostatiques. Quand on travaille sur le relais avec les panneaux avant ou du dessus enlevés, toutes les surfaces et le personnel doivent être mis à la terre convenablement pour éviter les dommages à l'équipement.
⚠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 There is danger of explosion if the battery is incorrectly replaced. Replace only with Ray-O-Vac® no. BR2335 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 Ray-O-Vac® no BR2335 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.
⚠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.

Conventions

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 ACSELERATOR QuickSet.

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

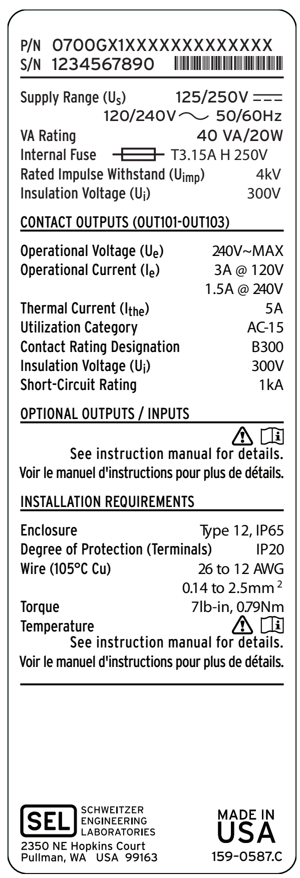
Example	Description
STATUS	Commands typed at a command line interface on a PC.
<Enter>	Single keystroke on a PC keyboard.
<Ctrl + D>	Multiple/combination keystroke on a PC keyboard.
Start > Settings	PC dialog boxes and menu selections. The > character indicates submenus.
CLOSE	Relay front-panel pushbuttons.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

Examples

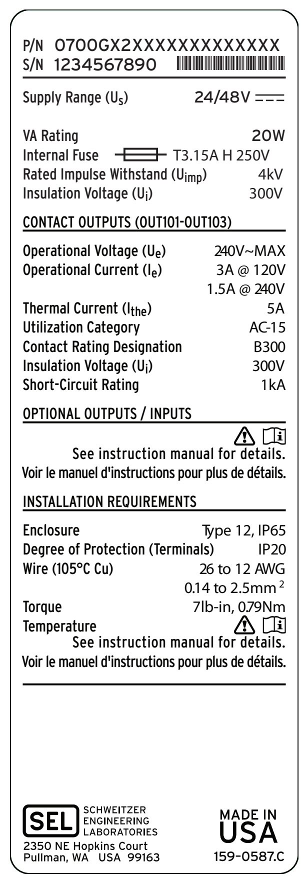
This instruction manual uses several example illustrations and instructions to explain how to effectively operate the SEL-700G. These examples are for demonstration purposes only; the firmware identification information or settings values included in these examples may not necessarily match those in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

Product Labels

You can find the serial number, model number, and rating of the product on the labels located on the left side panel of the relay. The example below shows product labels for high-voltage and low-voltage power supply options.



(for high-voltage supply)



(for low-voltage supply)

LED Emitter

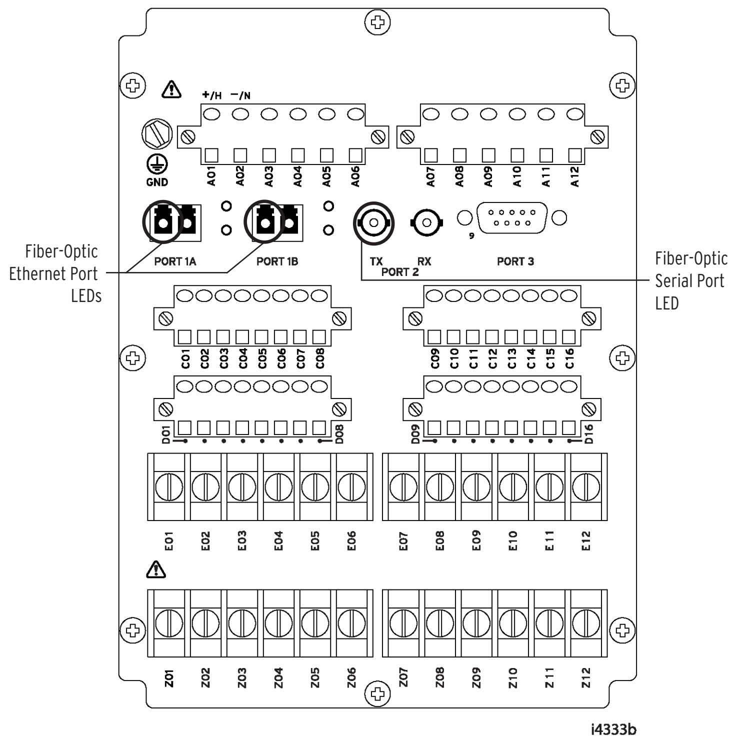
⚠CAUTION
Looking into optical connections, fiber ends, or bulkhead connections can result in hazardous radiation exposure.

⚠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%
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

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.

Connection Type	Minimum Wire Size	Maximum Wire Size
Grounding (Earthing) Connection	18 AWG (0.8 mm^2)	14 AWG (2.1 mm^2)
Current Connection	16 AWG (1.3 mm^2)	12 AWG (3.3 mm^2)
Potential (Voltage) Connection	18 AWG (0.8 mm^2)	14 AWG (2.1 mm^2)
Contact I/O	18 AWG (0.8 mm^2)	14 AWG (2.1 mm^2)
Other Connection	18 AWG (0.8 mm^2)	14 AWG (2.1 mm^2)

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.

Technical Assistance

⚠WARNING
Use of this equipment in a manner other than specified in this manual can impair operator safety safeguards provided by this equipment.

Obtain technical assistance from the following address:

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA 99163-5603 U.S.A.
Phone: +1.509.332.1890
Fax: +1.509.332.7990
Internet: www.selinc.com
E-mail: info@selinc.com

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 1.5*). 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 Protection Elements in SEL-700G Models (Sheet 1 of 2)

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
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			
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 Protection Elements in SEL-700G Models (Sheet 2 of 2)

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	
59X	Overvoltage (P, Q, G)	x	x	x	x		x	
59Y	Overvoltage (P, Q, G)					x	x	
59S	Synchronism Overvoltage		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	
60LOPY	Loss of Potential					x	x	
25 GEN	Synchronism Check		x		x		x	
25 TIE	Synchronism Check					x	x	
	Autosynchronizer		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.

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

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
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.

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 Record (SER)
- Compatibility with SEL-3010 Event Messenger
- A complete suite of accurate metering functions
- Generator operating statistics monitoring
- Breaker wear monitoring
- Load profile recorder
- Generator automatic synchronization report

Communications and Control

- 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
- IRIG-B time-code input

- Modbus® RTU slave, Modbus TCP/IP, DNP3 serial, DNP3 LAN/WAN, Ethernet FTP, Telnet, SNTP, MIRRORED BITS®, IEC 61850, DeviceNet, File Transfer Protocols, and Synchrophasors with C37.118 Protocol
- SEL ASCII, Compressed ASCII, Fast Meter, Fast Operate, Fast SER, and Fast Message Protocols
- Programmable Boolean and math operators, logic functions, and analog compare

Models, Options, and Accessories

Models

Complete ordering information is not provided in this instruction manual. See the latest SEL-700G Model Option Table at www.selinc.com, under SEL Literature, Ordering Information (Model Option Tables). Options and accessories are listed below.

SEL-700G Base Unit

- Front panel with large LCD display
    - Four programmable pushbuttons with eight LEDs
    - Eight target 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, Multimode (ST®) fiber-optic serial port, and 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
  - Additional analog I/O
  - 10 RTD inputs
- Communications Options (Protocol/Ports)
  - EIA-485/EIA-232/Ethernet ports (single/dual, copper or fiber-optic)
  - Modbus TCP/IP protocol
  - DeviceNet
  - IEC 61850 Communications
  - DNP3 serial and LAN/WAN
  - Simple Network Time Protocol (SNTP)

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 62.5/125 µm fiber-optic cable with ST connector for connecting the external RTD module to the SEL-700G
- Remote I/O with SEL-2505 Remote I/O Module (SEL-2812 compatible ST option only)
- SEL-2664S Stator Ground Protection Relay
- SEL-2664 Field Ground Module
- 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 Rear Connector Kit
- Dust Protection Kit

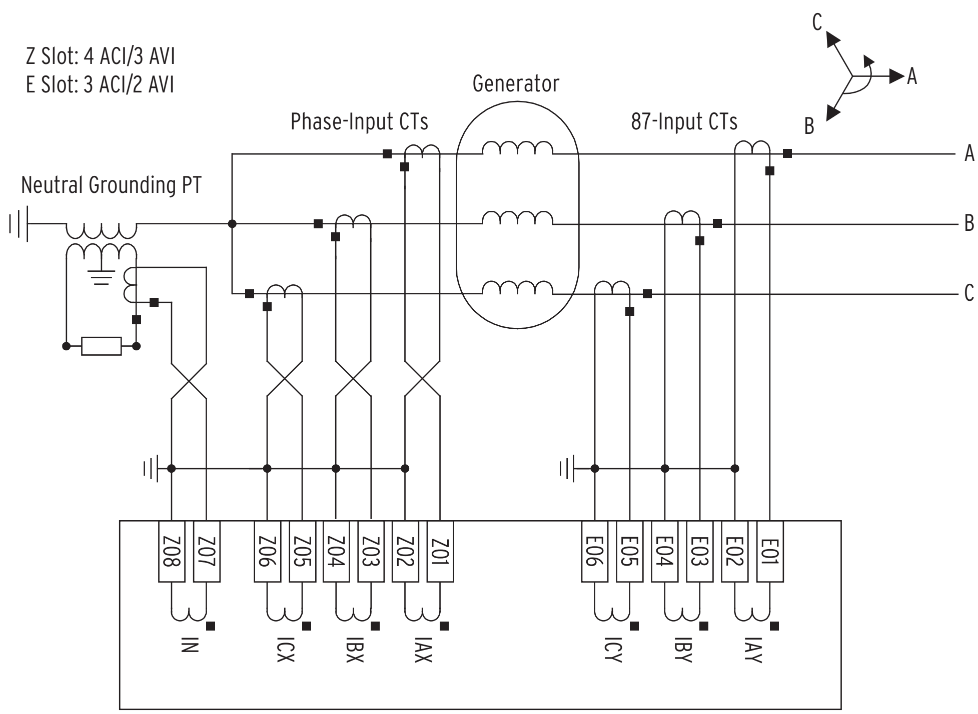
For all SEL-700G mounting accessories for competitor products, including adapter plates, visit *http://www.selinc.com/MountingAccessories/*.

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 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 125/250 Vac/dc 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 *Grounding (Earthing) Connections on page 2.20*.
- 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 Cable C234A (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 1.4*. 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 1.4*.

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.

Step 7. Type **ACC <Enter>** and the appropriate password (see *Table 7.37* for factory default passwords) to go to Access Level 1.

Table 1.4 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

```
=>QUIT <Enter>

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

=
```

Figure 1.2 Response Header

Checking 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 7.51 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 string (FID) and checksum string (CID). 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

ISO 9001:2008 Certified

UL, cUL: Protective Relay Category NRGU, NRGU7 per UL 508, C22.2 No. 14

CE: CE Mark–EMC Directive
Low Voltage Directive
IEC 61010-1:2001
IEC 60947-1
IEC 60947-4-1
IEC 60947-5-1

Hazardous Locations Approvals: Complies with UL 1604, ISA 12.12.01, CSA 22.2 No. 213, and EN 60079-15 (Class I, Division 2)

General

AC Current Input

Phase and Neutral Currents

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

I_{NOM} = 5 A

Continuous Rating: 15 A, 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 A, linear to 19.20 A symmetrical

1 Second Thermal: 100 A

Burden (per Phase): <0.01 VA @ 1 A

Measurement Category: II

AC Voltage Inputs

VNOM (L-L secondary) Range: 100–250 V (if DELTA_Y := DELTA)
100–440 V (if DELTA_Y := WYE)

Rated Continuous Voltage: 300 Vac

10 Second Thermal: 600 Vac

Burden: <0.1 VA

Input Impedance: 4 MΩ differential (phase-phase)
7 MΩ common mode (phase-chassis)

Power Supply

125/250 Vdc or 120/240 Vac

Rated Supply Voltage: 110–240 Vac, 50/60 Hz
110–250 Vdc

Input Voltage Range: 85–264 Vac
85–275 Vdc

Power Consumption: <40 VA (ac)
<20 W (dc)

Interruptions: 50 ms @ 125 Vac/Vdc
100 ms @ 250 Vac/Vdc

24/48 Vdc

Rated Supply Voltage: 24–48 Vdc

Input Voltage Range: 19.2–60 Vdc

Power Consumption: <20 W (dc)

Interruptions: 10 ms @ 24 Vdc
50 ms @ 48 Vdc

Output Contacts

General

OUT103 is a Form C Trip Output, all other outputs are Form A, except for the SELECT 4 DI/3 DO card, which supports two Form C and one Form B outputs.

Mechanical Durability: 100,000 no load operations

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

Thermal: 50 A for 1 s

Contact Protection: 360 Vdc, 40 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: 300 Vac

Utilization Category: AC-15 (control of electromagnetic loads > 72 VA)

Contact Rating Designation: B300 (B = 5 A, 300 = rated insulation voltage)

Voltage Protection Across Open Contacts: 270 Vac, 40 J

Rated Operational Current (I_e): 3 A @ 120 Vac
1.5 A @ 240 Vac

Conventional Enclosed Thermal Current (I_{the}) Rating: 5 A

Rated Frequency: 50/60 ±5 Hz

Electrical Durability Make VA Rating: 3600 VA, cosϕ = 0.3

Electrical Durability Break VA Rating: 360 VA, cosϕ = 0.3

UL/CSA Digital Output Contact Temperature Derating for Operating at Elevated Temperatures

Digital Output Cards Installed	Operating Ambient	Maximum Value of Current (I_{the})	Duty Factor
1–3	less than or equal to 60°C	5.0 A	Continuous
1–3	between 60°C and 70°C	2.5 A	Continuous

Fast Hybrid (high-speed high current interrupting)

Make:	30 A
Carry:	6 A continuous carry at 70°C 4 A continuous carry at 85°C
1 s Rating:	50 A
Open State Leakage Current:	<100 µA
MOV Protection (Maximum Voltage):	250 Vac/330 Vdc
Pickup Time:	<50 µs, resistive load
Dropout Time:	8 ms, resistive load

Break Capacity (10000 operations):

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):

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

NOTE: Per IEC 60255-23:1994, using the simplified method of assessment.

NOTE: Make rating per IEEE C37.90-1989.

Optoisolated Control Inputs

When Used With DC Control Signals

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

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
Simple Network Time Protocol (SNTP) Accuracy:	±5 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:	Front 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 Mb
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 Mb
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, IEC 61850, MIRRORED BITS, EVMSG, 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: LCD contrast is impaired for temperatures below –20°C and above +70°C

DeviceNet Communications Card Rating:	+60°C (140°F) maximum

Operating Environment

Pollution Degree:	2
Overvoltage Category:	II
Atmospheric Pressure:	80–110 kPa
Relative Humidity:	5–95%, noncondensing
Maximum Altitude:	2000 m

Dimensions

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

Weight

2.0 kg (4.4 lbs)

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)

Type Tests

Environmental Tests

Enclosure Protection:	IEC 60529:2001 IP65 enclosed in panel IP20 for terminals IP54 rated terminal dust protection assembly (SEL Part #915900170). 10°C temperature derating applies to the temperature specifications of the relay.
Vibration Resistance:	IEC 60255-21-1:1988, Class 2 Endurance Class 2 Response IEC 60255-21-3:1993, Class 2
Shock Resistance:	IEC 60255-21-2:1988, Class 1 Shock Withstand, Bump Class 2 Shock Response
Cold:	IEC 60068-2-1:2007 –40°C, 16 hours
Damp Heat, Steady State:	IEC 60068-2-78:2001 40°C, 93% relative humidity, 4 days
Damp Heat, Cyclic:	IEC 60068-2-30:2005 25–55°C, 6 cycles, 95% relative humidity
Dry Heat:	IEC 60068-2-2:2007 85°C, 16 hours

Dielectric Strength and Impulse Tests

Dielectric (HiPot):	IEC 60255-5:2000 IEEE C37.90-2005 2.5 kVac on current inputs, voltage inputs, contact I/O 2.0 kVac on analog inputs 1.0 kVac on analog output 2.83 kVdc on power supply
Impulse:	IEC 60255-5:2000 0.5 J, 4.7 kV on power supply, contact I/O, ac current and voltage inputs 0.5 J, 530 V on analog outputs

RFI and Interference Tests

EMC Immunity

Electrostatic Discharge Immunity:	IEC 60255-22-2:2008 IEC 61000-4-2:2008 Severity Level 4 8 kV contact discharge 15 kV air discharge
Radiated RF Immunity:	IEC 60255-22-3:2007 IEC 61000-4-3:2002, 10 V/m IEEE C37.90.2-1995, 35 V/m
Fast Transient, Burst Immunity:	IEC 60255-22-4:2008 IEC 61000-4-4:2004 4 kV @ 2.5 kHz 2 kV @ 5.0 kHz for comm. ports
Surge Immunity:	IEC 60255-22-5:2008 IEC 61000-4-5:2005 2 kV line-to-line 4 kV line-to-earth
Surge Withstand Capability Immunity:	IEC 60255-22-1:1988 2.5 kV common mode 1.0 kV differential mode 1 kV common mode on comm. ports IEEE C37.90.1-2002 2.5 kV oscillatory 4 kV fast transient

Conducted RF Immunity: IEC 60255-22-6:2001
IEC 61000-4-6:2006, 10 Vrms

Magnetic Field Immunity: IEC 61000-4-8:2001
1000 A/m for 3 seconds
100 A/m for 1 minute

EMC Emissions

Conducted Emissions: EN 55011:1998, Class A

Radiated Emissions: EN 55011:1998, Class A

Electromagnetic Compatibility

Product Specific: EN 50263:1999

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 100 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

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): ±5 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 cyc
0.10–400.00 seconds, 0.01 seconds steps, ±0.5% plus ±0.25 cyc for 50Q

Pickup/Dropout Time: <1.5 cyc

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

1 A Model: ±5% plus ±0.02 A

Time Delay Accuracy: ±0.5% plus ±0.25 cycle

Restricted Earth Fault (REF)

Pickup Range (per unit of INOM 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: 1.5 ±0.25 cyc

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

Volts/Hertz (24)

Definite-Time Element

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

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, 15.0–70.0 Hz
Accuracy:	±0.01 Hz (V1 >60 V)
Pickup/Dropout Time:	<4 cycles
Time Delay:	0.00–240.00 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 Trip/Alarm Time Delay:	Approx. 6 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
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: –50.0–0.0 ohms 1 A model: –250.0–0.0 ohms
Zone 2 Offset:	5 A model:–50.0–50.0 ohms 1 A model: –250.0–250.0 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°–0.0°
Pickup Time:	3 cycles (Max)
Zone 1 and Zone 2 Definite-Time Delays:	0.00–400.00 s
Accuracy:	±0.1% plus ± ½ 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 ±½ 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 ±¼ 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 $\lvert I_2 \rvert$ 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–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–0.99 Hz
Maximum Slip Frequency:	–0.99 Hz–1.00 Hz
Steady-State Slip Accuracy:	±0.02 Hz
Close Acceptance Angle 1, 2:	0–80°
Target Close Angle:	–15–15°
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 INOM 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 ±¼ cyc

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 H.9*)
- 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 H.9*)
- 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)

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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. You should 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

You can mount the SEL-700G in a sheltered indoor environment (a building or an enclosed cabinet) that does not exceed the temperature and humidity ratings for the relay. The relay is IEC EN61010-1 rated at Installation/ Overvoltage Category II and Pollution Degree 2. This rating allows mounting of the relay indoors or in an outdoor (extended) enclosure where the relay is protected against exposure to direct sunlight, precipitation, and full wind pressure, but neither temperature nor humidity are controlled.

You can place the relay in extreme temperature and humidity locations. (See *Operating Temperature* and *Operating Environment on page 1.14*.) For EN 61010 certification, the SEL-700G rating is 2000 m (6560 feet) above mean sea level.

In North America, the relay is approved for Class 1, Division 2, Groups A, B, C, D, and T4 hazardous locations.

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 (IP65). For extremely dusty environments, use the optional IP54-rated terminal dust-protection assembly (SEL Part #915900170). 10°C temperature derating applies to the temperature specifications of the relay.

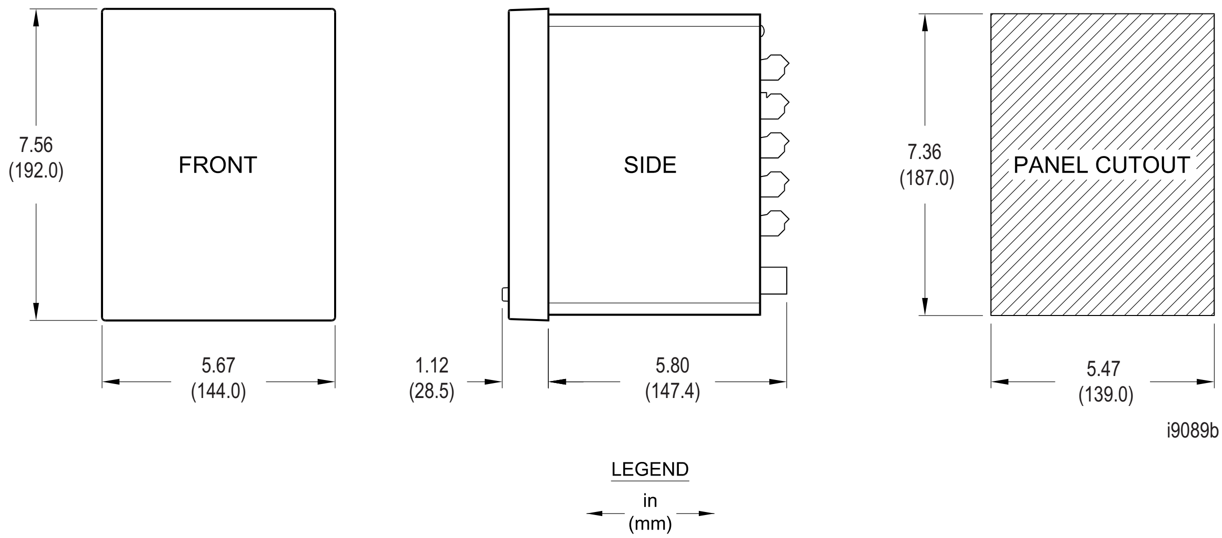


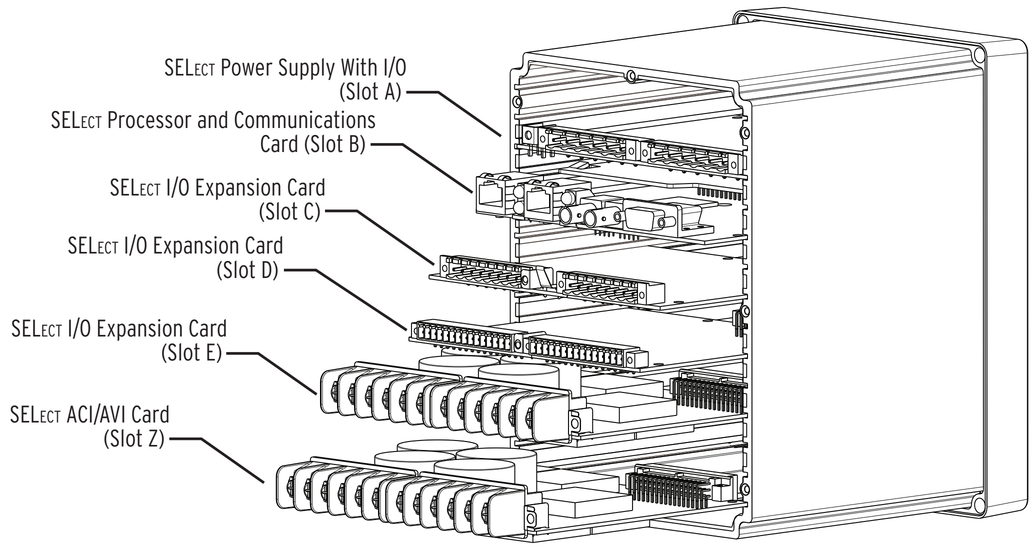
Figure 2.1 Relay Panel-Mount Dimensions

Refer to *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.

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
Slot Number	1		3	4	5	
Software Reference	(e.g., OUT101)		(e.g., IN301)	(e.g., OUT401)	(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 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...)						●
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/2DI/3DO (Slot A)

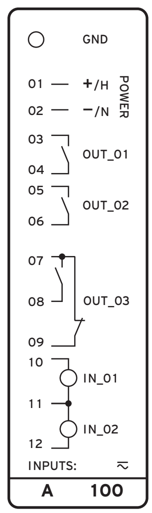
Select appropriate power supply option for the application:

- 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 (Slot 1) 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/2DI/3DO card.

Table 2.1 Power Supply Card Inputs Terminal Designation

<table>
<tr><th>Side-Panel Connections Label</th><th>Terminal Number</th><th>Description</th></tr>
<tr><td rowspan="7">
</td><td></td><td>Ground connection</td></tr>
<tr><td>A01, A02</td><td>Power supply input terminals</td></tr>
<tr><td>A03, A04</td><td>OUT101, driven by OUT101 SELOGIC control equation</td></tr>
<tr><td>A05, A06</td><td>OUT102, driven by OUT102 SELOGIC control equation</td></tr>
<tr><td>A07, A08, A09</td><td>OUT103, driven by OUT103 SELOGIC control equation</td></tr>
<tr><td>A10, A11</td><td>IN101, drives IN101 element</td></tr>
<tr><td>A12, A11</td><td>IN102, drives IN102 element</td></tr>
</table>

Base-Unit CPU/ Communications Ports (Slot B)

Select the communications ports necessary for your application from the following base-unit 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
- Telnet
- C37.118 (Synchrophasor Data)
- Simple Network Time Protocol (SNTP)

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 Slave Level 2
- C37.118 (Synchrophasor Data)

Communications Card (Slot C)

Either the DeviceNet (see *Appendix G: 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 through the use of 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 Slave Level 2
- ➤ C37.118 (Synchrophasor Data)

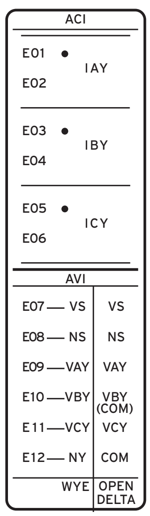
Current/Voltage Card Option (3 ACI/4 AVI)

⚠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.

Table 2.4 3 ACI/4 AVI Current/Voltage Card Inputs Terminal Allocation

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

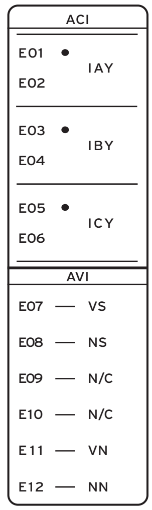
Current/Voltage Card Option (3 ACI/2 AVI)

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

NOTE: When the **VS-NS** 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.

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 3 ACI/2 AVI Current/Voltage Card Inputs Terminal Allocation

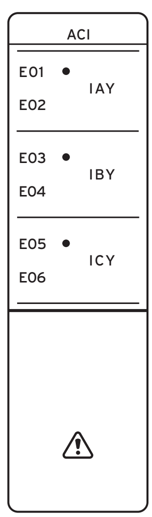
Side-Panel Connections Label	Terminal Number	Description
	E01, E02	IAY, Y-side Phase A current input
	E03, E04	IBY, Y-side Phase B current input
	E05, E06	ICY, Y-side Phase C current input
	E07	VS, synchronism-check voltage input
	E08	NS, common connection for synchronism-check voltage input
	E11	VN,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

Current Card Option (3 ACIE)

⚠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.

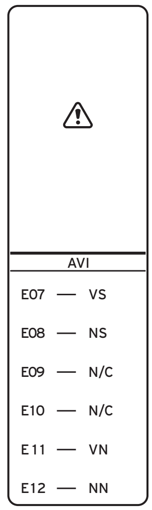
Table 2.6 3 ACIE Current Card Inputs Terminal Allocation

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

Voltage Card Option (2 AVI)

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 2 AVI Voltage Card Inputs Terminal Allocation



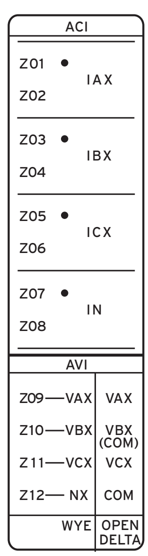
Side-Panel Connections Label	Terminal Number	Description
	E07	VS, synchronism-check voltage input
	E08	NS, common connection for synchronism-check voltage input
	E11	VN, neutral voltage input
	E12	NN, common connection for neutral voltage input

Current/Voltage Card Option (4 ACI/3 AVI)

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

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 4 ACI/3 AVI Current/Voltage Card Inputs Terminal Allocation



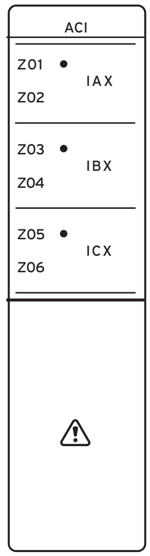
Side-Panel Connections Label	Terminal Number	Description
	Z01, Z02	IAX, X-side Phase A current input
	Z03, Z04	IBX, X-side Phase B current input
	Z05, Z06	ICX, X-side Phase C current input
	Z07, Z08	IN, neutral current input
	Z09	VAX, X-side Phase A voltage input
	Z10	VBX, X-side Phase B voltage input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

Current Card Option (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 3 ACIZ Current Card Inputs Terminal Allocation

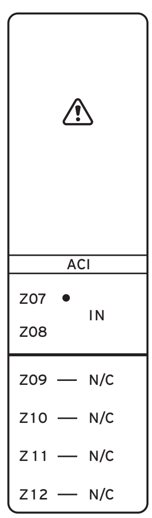
Side-Panel Connections Label	Terminal Number	Description
	Z01, Z02	IAX, X-side Phase A current input
	Z03, Z04	IBX, X-side Phase B current input
	Z05, Z06	ICX, X-side Phase C current input

Current Card Option (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 1 ACI Current/Voltage Card Inputs Terminal Allocation

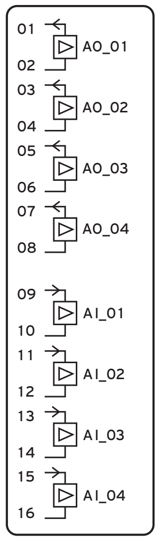
Side-Panel Connections Label	Terminal Number	Description
	Z07, Z08	IN, neutral current input

Analog Input Card (4 AI/4 AO)

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

Supported in only one of the nonbase unit slots (Slot C through Slot E), this card has four analog inputs and four analog outputs (AO). *Table 2.11* shows the terminal allocation

Table 2.11 Four Analog Input/Four Analog Output (4 AI/4 AO) Card Terminal Allocation



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

[a] x=3, 4, or 5 (for example, AI401, AI402, etc., if the card was installed in Slot D).

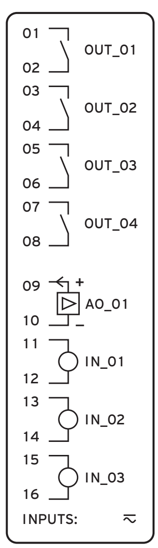
I/O Input Card (3 DI/4 DO/1 AO)

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.

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

Table 2.12 I/O (3 DI/4 DO/1 AO) Card Terminal Allocation



Side-Panel Connections Label	Terminal Number	Software Reference, Description[a]
(see diagram)	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

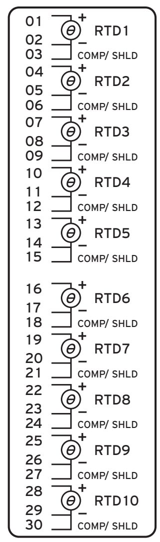
[a] x=3, 4, or 5 (for example, OUT401, OUT402, etc., if the card was installed in Slot D).

RTD Card (10 RTD)

NOTE: All Comp/Shield terminals are internally connected to relay chassis.

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

Table 2.13 RTD (10 RTD) Card Terminal Allocation

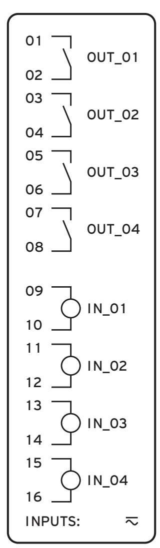
Side-Panel Connections Label	Terminal Number	Description
	01	RTD01 (+)
	02	RTD01 (-)
	03	RTD01 Comp/Shield
	04	RTD02 (+)
	05	RTD02 (-)
	06	RTD02 Comp/Shield
	07	RTD03 (+)
	08	RTD03 (-)
	09	RTD03 Comp/Shield
	•	•
	•	•
	•	•
	28	RTD10 (+)
	29	RTD10 (-)
	30	RTD10 Comp/Shield

I/O Card (4 DI/4 DO)

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

Supported in any nonbase unit slot (Slot **C** through Slot **E**), this card has four digital inputs and four outputs. The four outputs are all normally open contact outputs. Optionally, the outputs can be fast hybrid (high-speed, high-current interrupting) outputs. *Table 2.14* shows the terminal allocation.

Table 2.14 Four Digital Input/Four Digital Output (4 DI/4 DO) Card Terminal Allocation

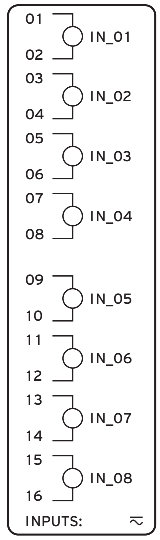
Side-Panel Connections Label	Terminal Number	Software Reference, Description[a]
	01, 02	OUT*x*01, driven by OUT*x*01 SELOGIC control equation
	03, 04	OUT*x*02, driven by OUT*x*02 SELOGIC control equation
	05, 06	OUT*x*03, driven by OUT*x*03 SELOGIC control equation
	07, 08	OUT*x*04, driven by OUT*x*04 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 (for example, OUT401, OUT402, etc., if the card was installed in Slot D).

I/O Card (8 DI)

Supported in any nonbase unit slot (Slot **C** through Slot **E**), this card has eight digital inputs. *Table 2.15* shows the terminal allocation.

Table 2.15 Eight Digital Input (8 DI) Card Terminal Allocation



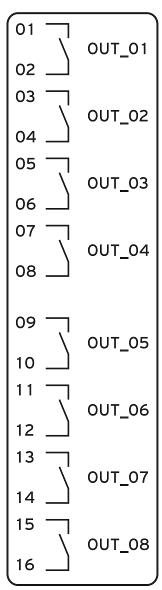
Side-Panel Connections Label	Terminal Number	Description[a]
	01, 02	IN*x*01, drives IN*x*01 element
	03, 04	IN*x*02, drives IN*x*02 element
	05, 06	IN*x*03, drives IN*x*03 element
	07, 08	IN*x*04, drives IN*x*04 element
	09, 10	IN*x*05, drives IN*x*05 element
	11, 12	IN*x*06, drives IN*x*06 element
	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 (e.g., OUT401, OUT402, etc. if the card was installed in Slot D).

I/O Card (8 DO)

Supported in any nonbase unit slot (Slot **C** through Slot **E**), this card has eight digital outputs. The eight digital outputs are all normally open contact outputs. *Table 2.16* shows the terminal allocation.

Table 2.16 Eight Digital Output (8 DO) Card Terminal Allocation



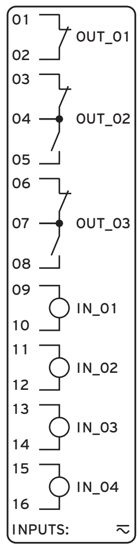
Side-Panel Connections Label	Terminal Number	Description[a]
	01, 02	OUTx01, driven by OUTx01 SELOGIC control equation
	03, 04	OUTx02, driven by OUTx02 SELOGIC control equation
	05, 06	OUTx03, driven by OUTx03 SELOGIC control equation
	07, 08	OUTx04, driven by OUTx04 SELOGIC control equation
	09, 10	OUTx05,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

[a] x=3, 4, or 5 (e.g., OUT401, OUT402, etc. if the card was installed in Slot D).

I/O Card (4 DI/3 DO)

Supported in any nonbase unit slot (Slot **C** through Slot **E**), this card has four digital inputs, one Form-B digital output (normally closed contact output) and two form-C digital output contacts. *Table 2.17* shows the terminal allocation.

Table 2.17 Four Digital Inputs, One Form-B Digital Output, Two Form-C Digital Outputs (4 DI/3 DO) Card Terminal Allocation

Side-Panel Connections Label	Terminal Number	Description[a]
	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 (e.g., OUT401, OUT402, etc. if the card was installed in Slot D).

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 the many diverse applications. Choose the combination of option cards most suited for your application.

Swapping Optional I/O Boards

When an I/O board is moved from one slot to a different slot, the associated settings for the slot the card is moved from will be lost. For example, if a 4 DI/4 DO card is installed in Slot 4 (Slot **D**), the SELOGIC settings OUT401–404 would be available. If OUT401 = IN101 AND 51PYT, and the card is moved to a different slot, then the OUT4xx settings will be lost. This is true for all the digital and analog I/O cards.

Card Installation for Slots C, D, E, and Z

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

⚠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 1. Remove the power supply voltage from terminals A01+ and A02– and remove the ground wire from the green ground screw.

Step 2. Disconnect all the connection plugs.

Step 3. Loosen the eight (8) screws on the rear and remove the rear cover.

Step 4. Remove the plastic filler plate covering the slot associated with the card being installed.

Step 5. Insert the card in the correct slot.

Make sure the contact fingers on the printed circuit board are bent at approximately a 130° angle relative to the board for proper electromagnetic interference protection.

Step 6. Before reattaching the rear cover, check for and remove any foreign material that may remain inside the SEL-700G case.

Step 7. Carefully reattach the rear cover.

Step 8. Tighten the eight (8) screws that secure the rear cover to the case.

Step 9. Apply power supply voltage to terminals A01+ and A02– and reconnect the ground wire to the green ground screw.

Step 10. 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** light is turned on, the card was inserted into the wrong slot. Begin again at *Step 1*.

If you *do* see this message, then proceed to *Step 11*.

Step 11. Press the **ESC** pushbutton.

Step 12. Press the **Down Arrow** pushbutton until STATUS is highlighted.

Step 13. Press the **ENT** pushbutton.

The front panel displays the following:

STATUS

Relay Status

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

The front panel displays the following:

Serial Num

000000000000000000000000

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

The front panel displays the following:

Confirm Hardware

Config (Enter)

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

The front panel displays the following:

Accept New Config?

No Yes

Step 17. Select **Yes** and press the **ENT** pushbutton.

The front panel displays the following:

Config Accepted

Enter to Reboot

Step 18. Press the **ENT** pushbutton.

The relay restarts and the **ENABLED** light 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
                 ↑↑ ↑ ↑      ↑↑
```

Use the **PARTNO** command from the 2AC level to enter the exact part number of the relay.

Step 19. Update the side-panel drawing with the drawing sticker provided in the card kit. If necessary, replace the rear panel with the one applicable for the card and attach the terminal-marking label provided with the card to the rear-panel cover.

Step 20. Reconnect all connection plugs and add any additional wiring/connectors required by the new card.

Slot B CPU Board Replacement

When replacing the Slot B card, please be aware of the following considerations.

- The new card will have the latest firmware when shipped from the factory.
- *Table A.1* in *Appendix A: Firmware and Manual Versions* should be reviewed for firmware changes and new or revised settings to check if any existing settings in the relay, or the application of the relay, will be affected.
- If the IEC 61850 protocol option was used previously, verify that the IEC 61850 protocol is still operational after the replacement. If the protocol is not operational, re-enable the protocol. Refer to *Relays With IEC 61850 Option* for the verification process.
- Save all the settings and event reports before replacing the card.

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 the CAL level.

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

The CAL level default password is CLARKE.

Step 11. From the CAL level, issue the **SET C** command.

Step 12. Enter 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 replacing a power supply card, change the part number accordingly, using the **PARTNO** command from the 2AC level. Install new side stickers on the side of the relay.

Analog Input Card Voltage/Current Jumper Selection

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

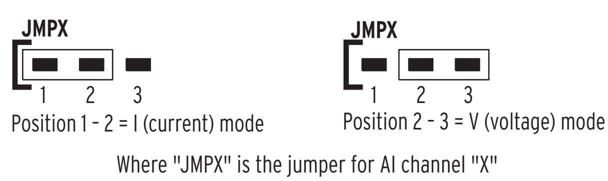


Figure 2.3 Circuit Board of Analog I/O Board, Showing Jumper Selection

Analog Output (AO) Configuration Jumper

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.

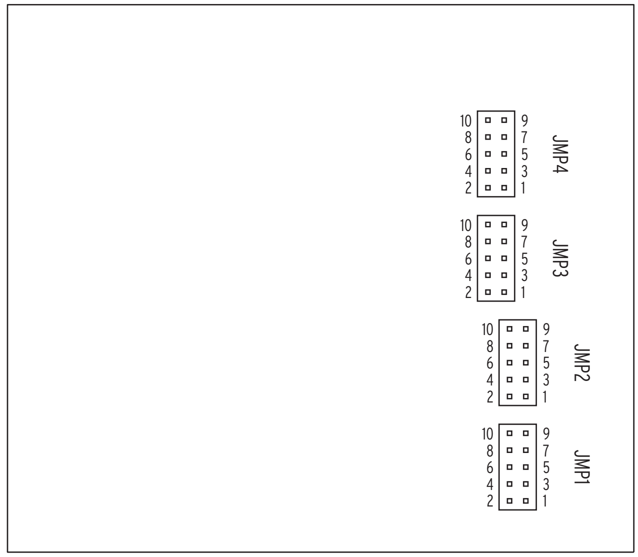


Figure 2.4 JMP1 Through JMP4 Locations on 4 AI/4 AO Board

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.

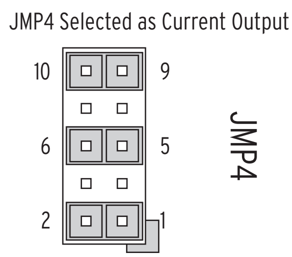


Figure 2.5 Current Output Jumpers

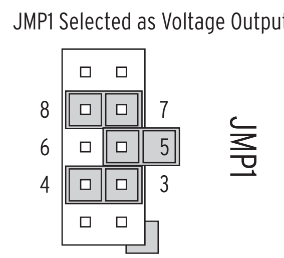


Figure 2.6 Voltage Output Jumpers

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.

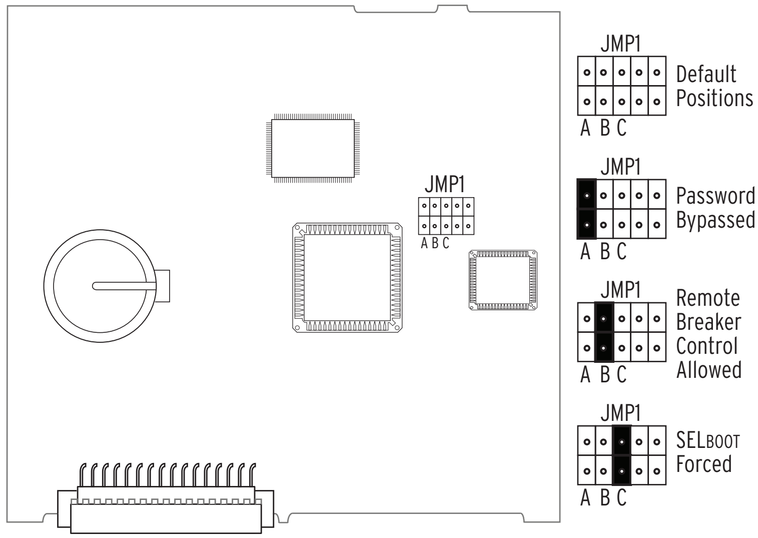


Figure 2.7 Pins for Password, Breaker Control, and SELBOOT Jumper

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 suffers 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 and Level 2 command levels without passwords, position the jumper in position A, as shown in *Figure 2.7* (password bypassed). Although you gain access to Level 2 without a password, the alarm contact still closes momentarily when you access Level 2. *Table 2.18* tabulates the functions of the three sets of pins and jumper default positions.

Table 2.18 Jumper Functions and Default Positions

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

[a] Jumper position affects breaker control using the **PULSE**, **OPEN**, or **CLOSE** command via the serial port, front panel, or communications protocols. Jumper position does not affect breaker control using remote bits, which are always enabled.

Rear-Panel Connections

Rear-Panel and Side-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*, *Figure 2.9*, and *Figure 2.10*.

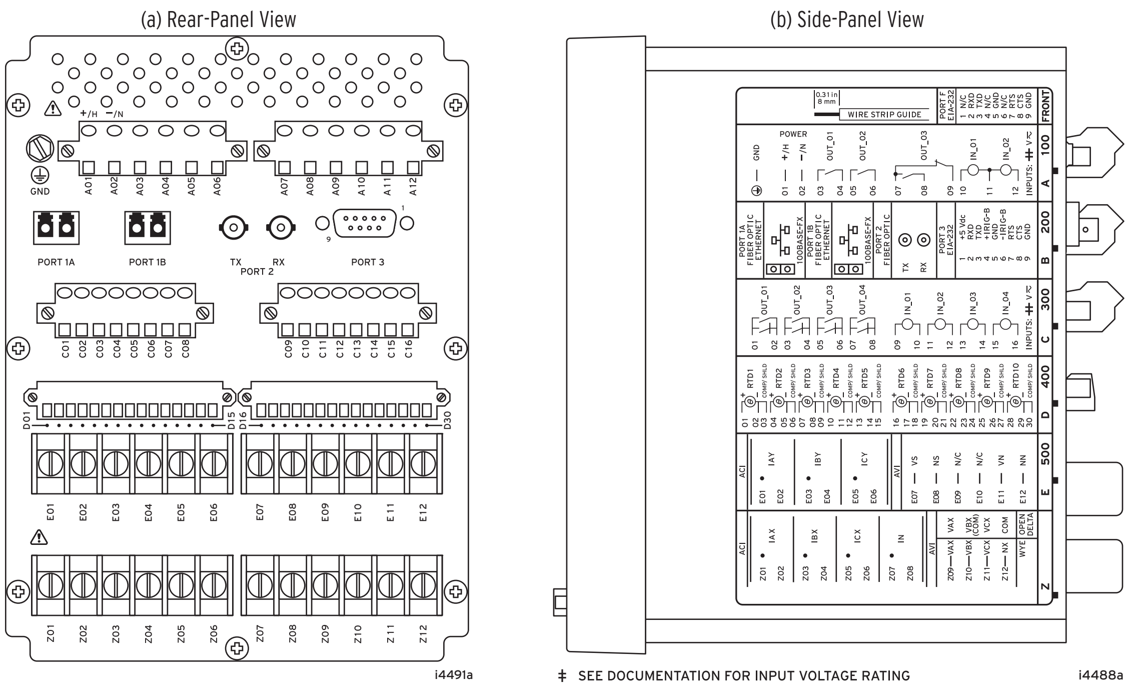


Figure 2.8 SEL-700G1+ With Dual-Fiber Ethernet, Fast Hybrid 4 DI/4 DO, 10 RTDs, 3 ACI/2 AVI, 4 ACI/3 AVI (MOT 0700G11ACA9X76850830)

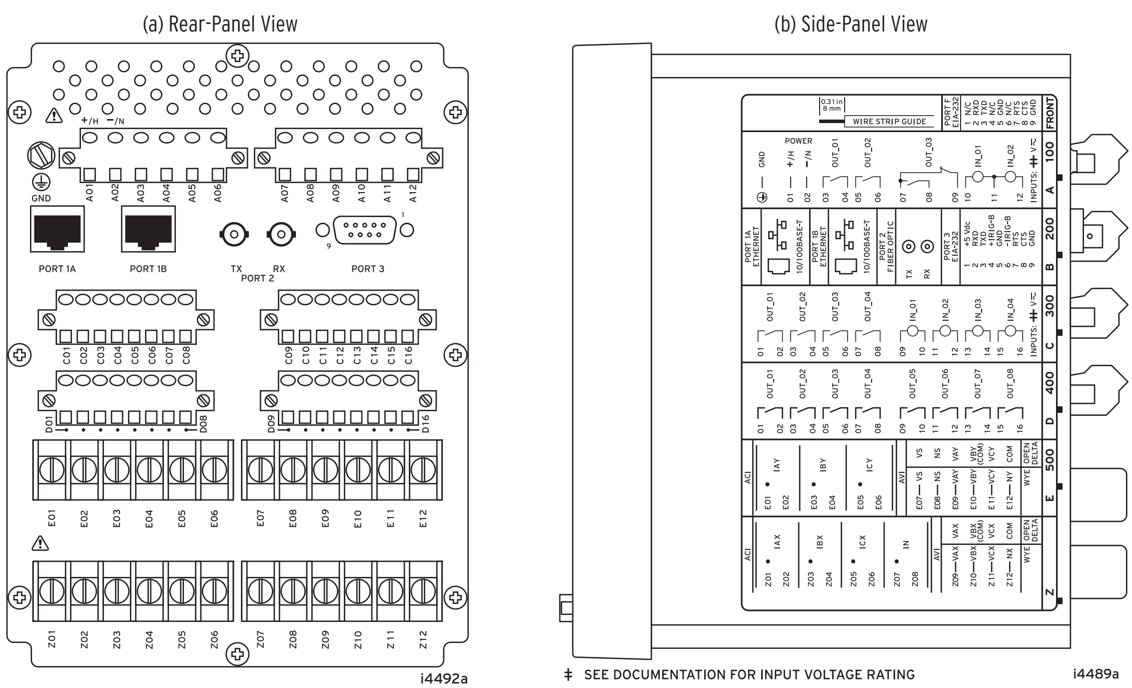


Figure 2.9 SEL-700GT+ With Dual Copper Ethernet, 4 DI/4 DO, 8 DO, 3 ACI/4 AVI, 4 ACI/3 AVI (MOT 0700GT1A2X75850630)

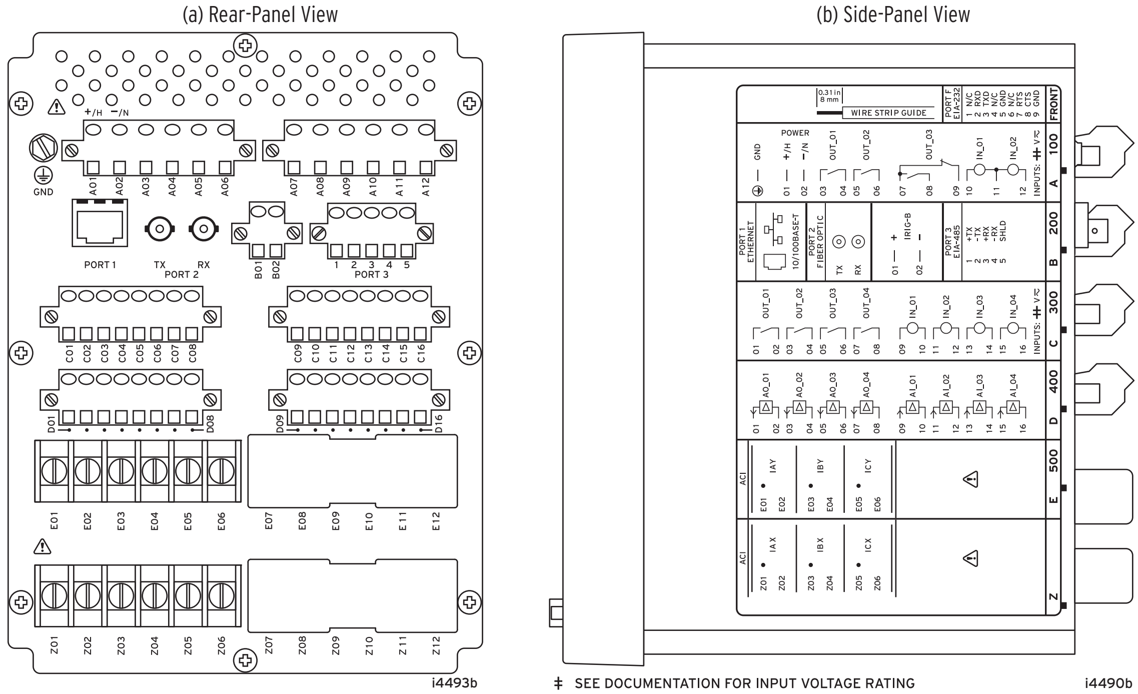


Figure 2.10 SEL-700GW With Copper Ethernet, 4 DI/4 DO, 4 AI/4 AO, 3 ACIE, 3 ACIZ (MOT 0700GW1A1A6X77870310)

Power Connections

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 1.12* 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.

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

> ⚠CAUTION
> The relay contains devices sensitive to Electrostatic Discharge (ESD). When working on the relay with the front panel removed, work surfaces and personnel must be properly grounded or equipment damage may result.

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 current rating for the power disconnect circuit breaker or optional overcurrent device (fuse) should be 20 A.

Operational power is internally fused by a power supply fuse. See *Field Serviceability on page 2.37* for details. Be sure to use fuses that comply with IEC 60127-2.

Grounding (Earthing) Connections

You must connect the ground terminal labeled GND on the rear panel to a rack frame or switchgear ground for proper safety and performance. Use 14 AWG (2.5 mm^2) wire less than 2 m (6.6 feet) in length for the ground connection.

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 AWG 24 through AWG 12. Strip the wires 8 mm (0.31 inches) 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 feet, where metallic cable is not appropriate, SEL offers fiber-optic transceivers or the 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 IRIG-B (**B01** and **B02**) inputs or an SEL communications processor via EIA-232 serial **Port 3**. The available communications processors are the SEL-2032, SEL-2030, SEL-2020, and the SEL-2100 Logic Processor.

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 or C807) 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 Diagram

A more functional representation of two of the control (I/O) connections is shown in *Figure 2.11* and *Figure 2.12*.

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

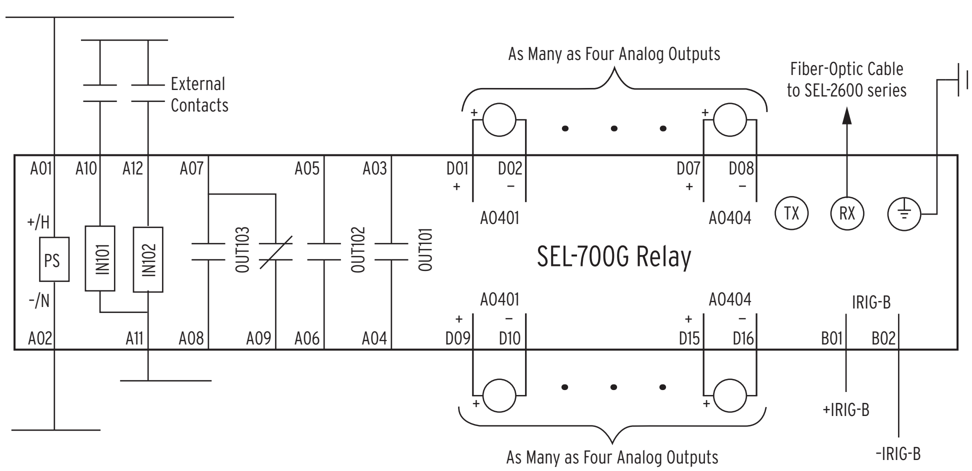


Figure 2.11 Control I/O Connections—4 AI/4 AO Option in Slot D

NOTE: All RTD Comp/Shield terminals are connected internally to the relay chassis.

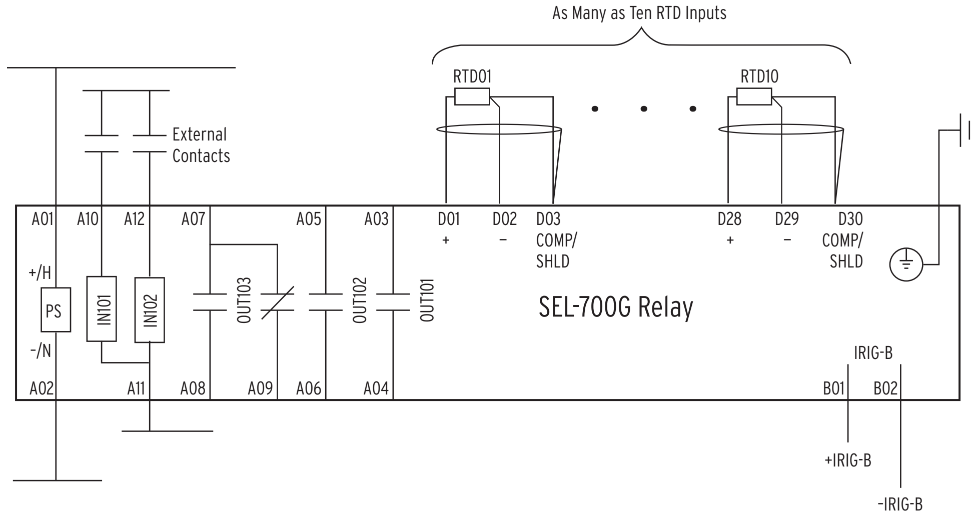


Figure 2.12 Control I/O Connections—Internal RTD Option

Notes:

- ➤ The chassis ground connector located on the rear-panel card Slot A must always be connected to the local ground mat.
- ➤ Power supply rating (125–250 Vac/dc 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 IN101/102 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 62.5/125 μm fiber-optic cable is necessary to connect the SELOGIC with an SEL-2600 series RTD Module. This fiber-optic cable should be 1000 meters or shorter.

NOTE: RTD inputs are not internally protected for electrical surges (IEC 60255-22-1 and IEC 60255-22-5). External protection is recommended if surge protection is necessary.

Table 2.19 shows the maximum cable lengths for the RTD connections.

Table 2.19 Typical Maximum RTD Lead Length

RTD Lead AWG	Maximum Length (meters)
24	290 m
22	455 m
20	730 m
18	1155 m

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 2.13*. 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.

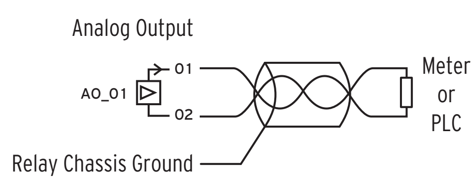


Figure 2.13 Analog Output Wiring Example

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: When using fast hybrid output contacts, do not use the FAILSAFE mode.

Figure 2.14 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.

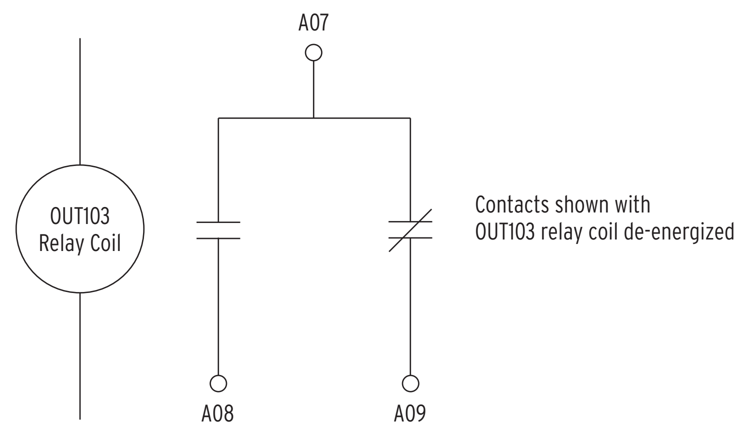


Figure 2.14 Output OUT103 Relay Output Contact Configuration

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

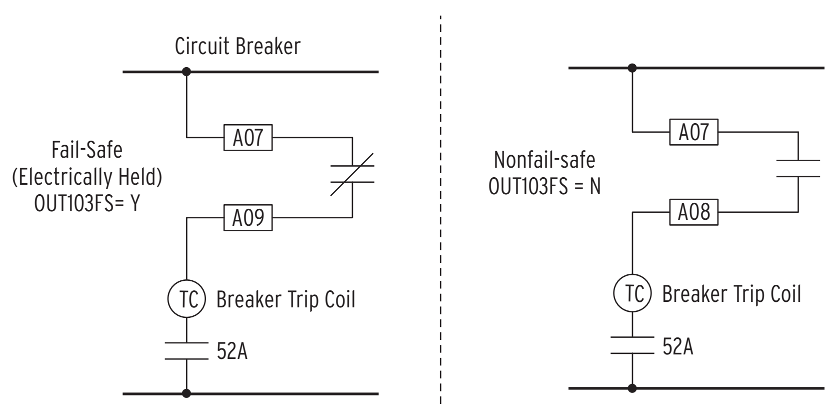


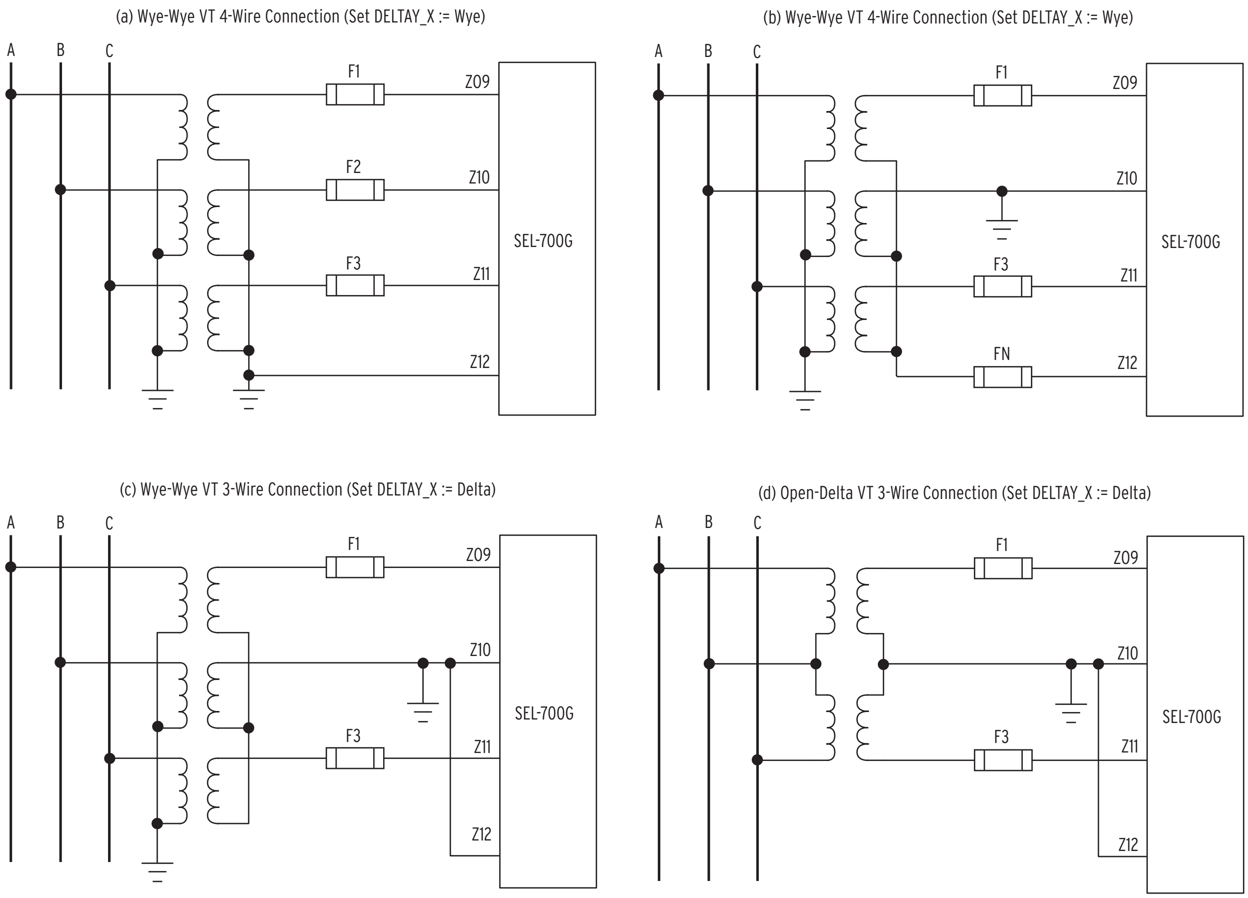
Figure 2.15 OUT103 Contact Fail-Safe and Nonfail-Safe Options

Voltage Connections

With the voltage inputs option, the three-phase voltages can be connected either 3-wire (delta) or 4-wire (wye). *Figure 2.16 (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 2.16 (e)* and *Figure 2.16 (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.



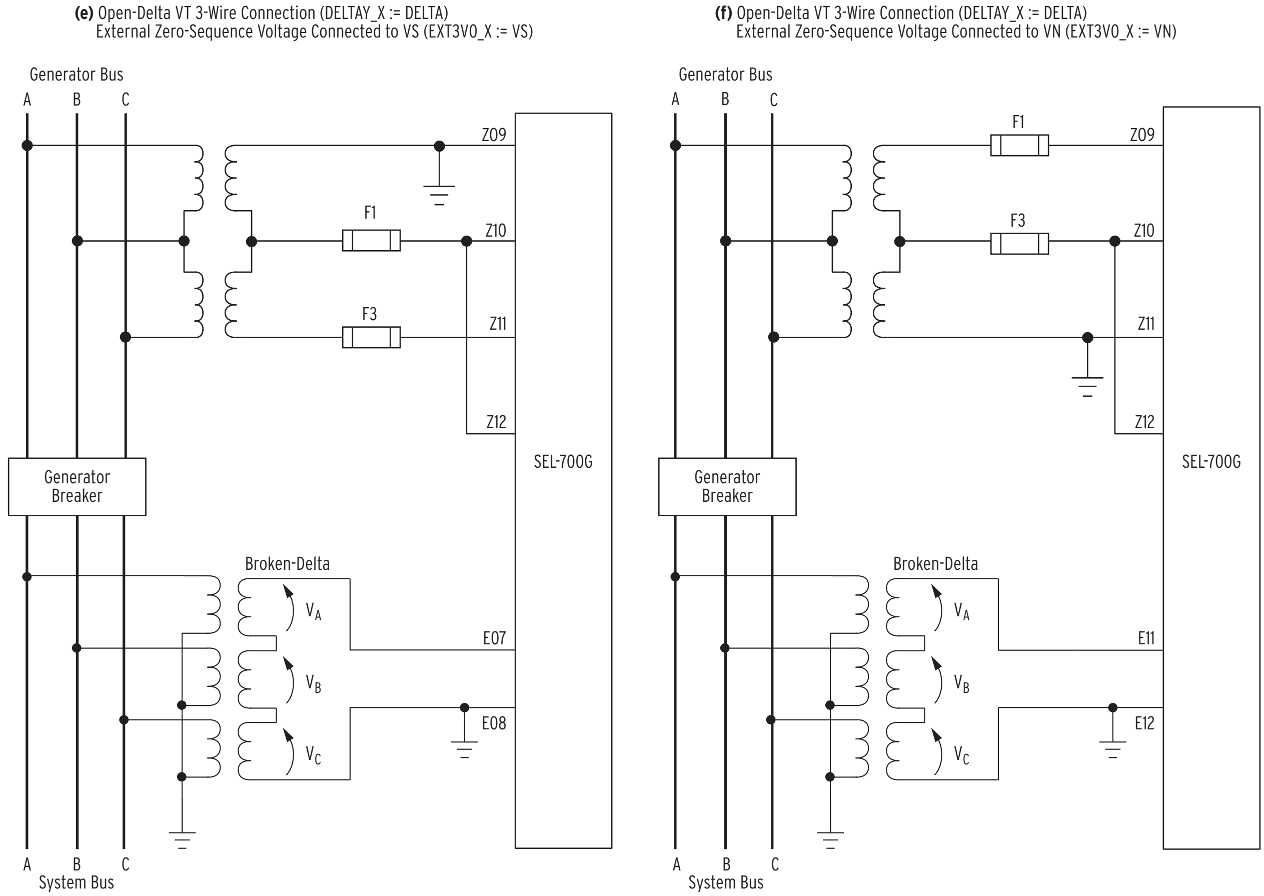


Figure 2.16 Voltage Connections

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 2.17 through *Figure 2.22* show ac and dc connection diagrams and applications for the SEL-700G0, SEL-700G1, SEL-700GT, and SEL-700GW relays.

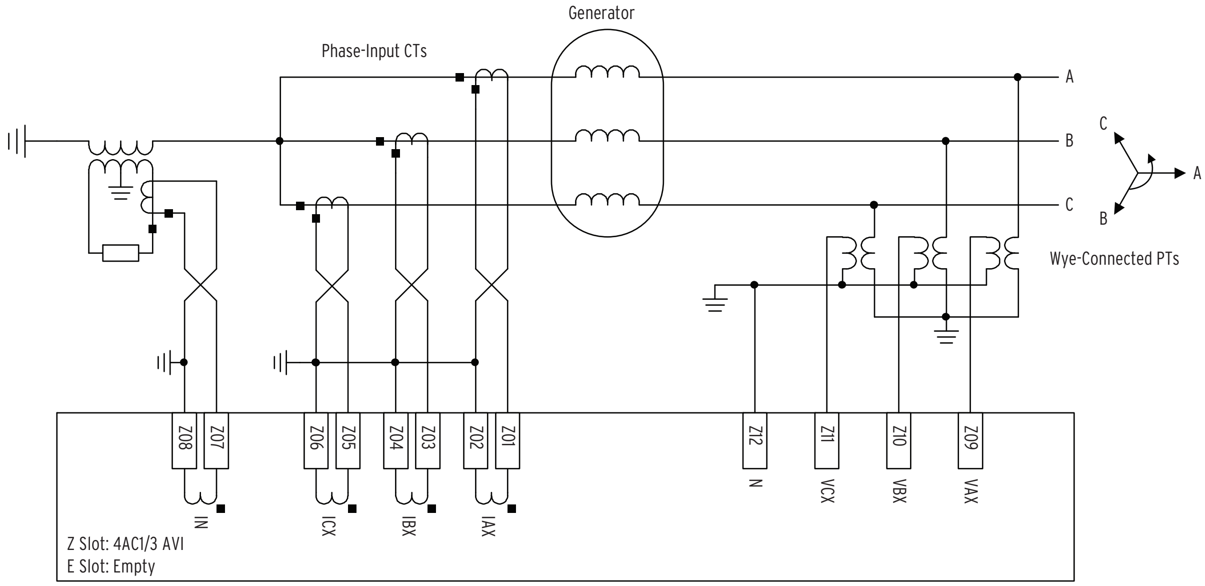


Figure 2.17 SEL-700G0 Relay AC Connection Example—High-Impedance Grounded Generator Without Current Differential Protection

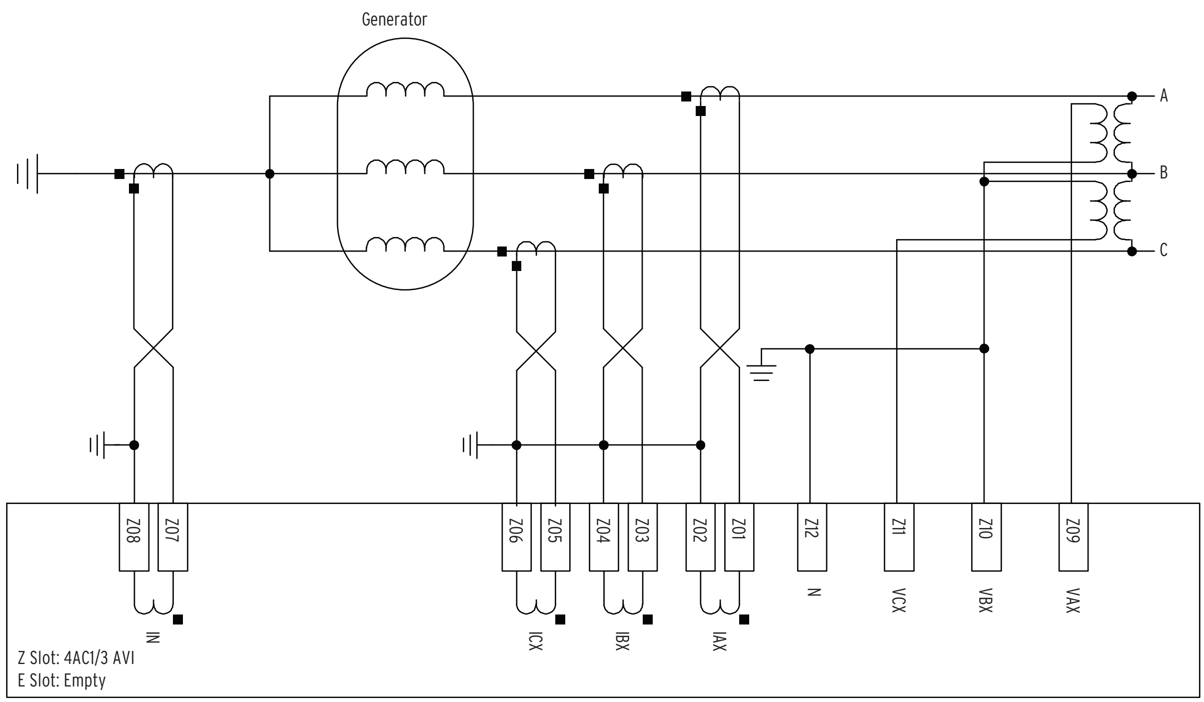


Figure 2.18 SEL-700G0 Relay AC Connection Example—Solidly Grounded Generator With Ground Differential Protection (87N)

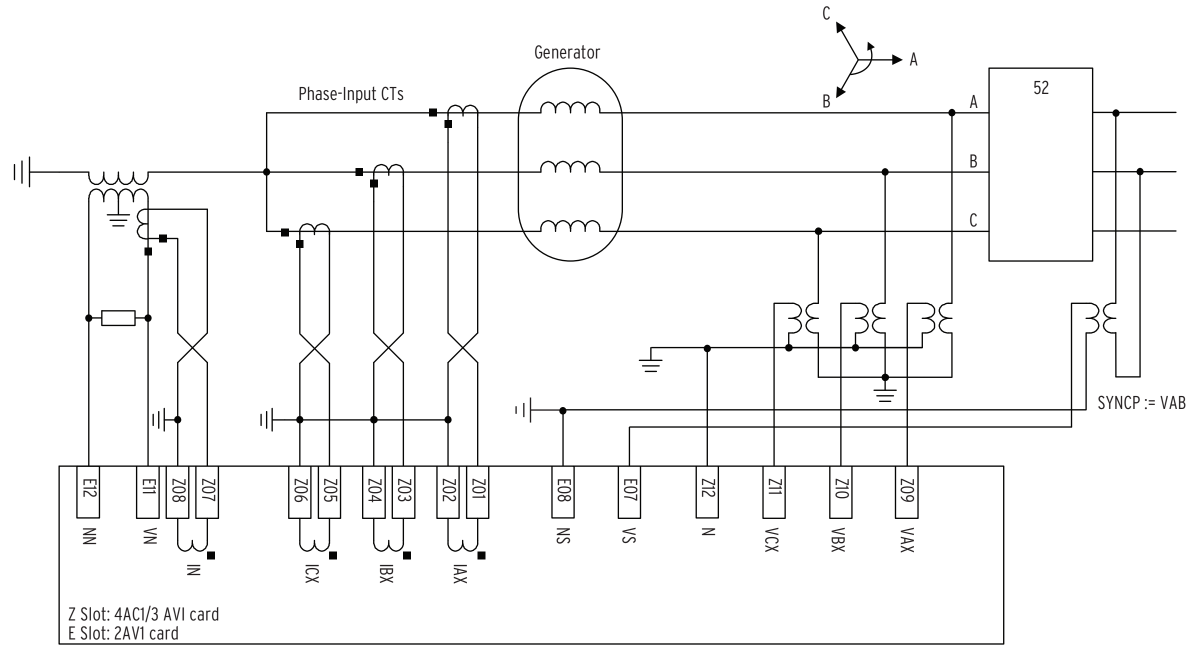


Figure 2.19 SEL-700G0+ Relay High-Impedance Grounded Generator With Synchronism Check and Without Current Differential Protection

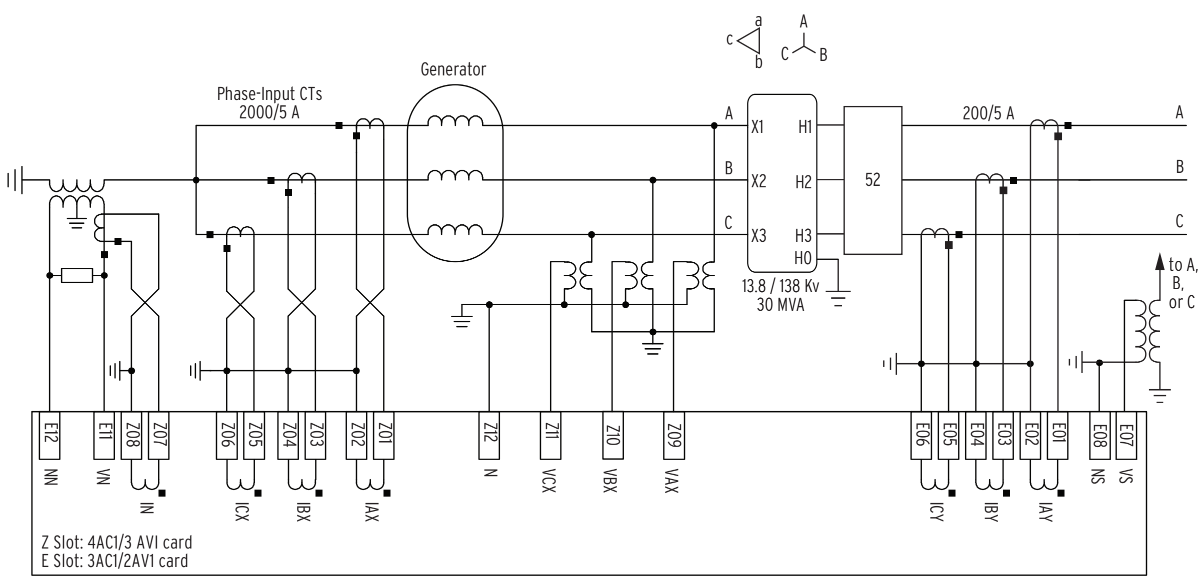


Figure 2.20 SEL-700G1+ Relay AC Connection Example—High-Impedance Grounded Generator With Step-Up Transformer Included in Differential Zone (With Synchronism Check and 100% Stator Ground Protection)

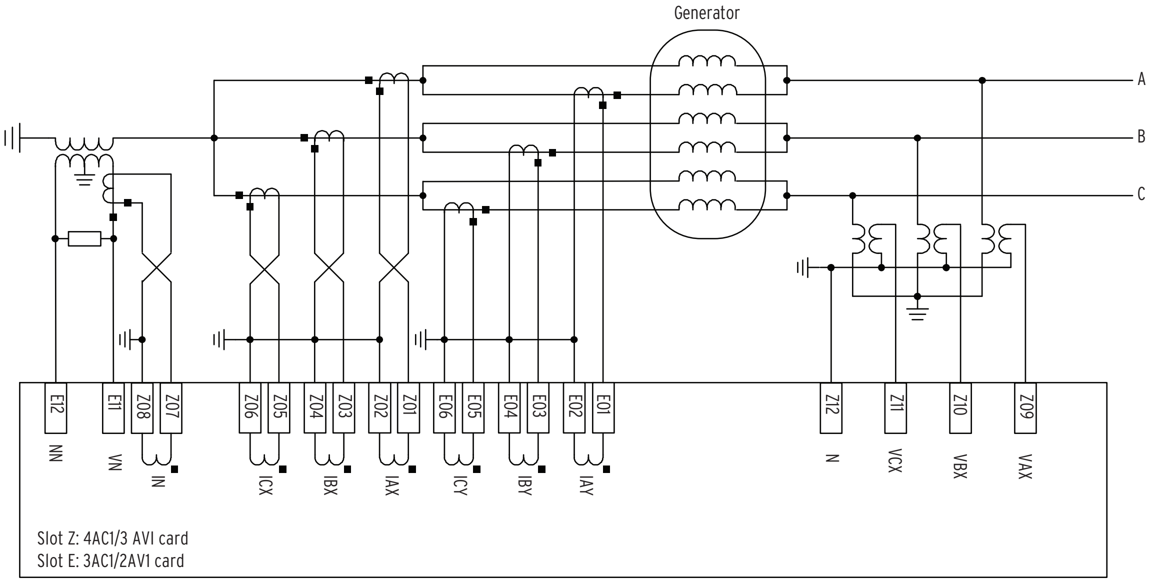


Figure 2.21 SEL-700G1+ Relay AC Connection Example—High-Impedance Grounded Generator With Split-Phase Current Differential Protection

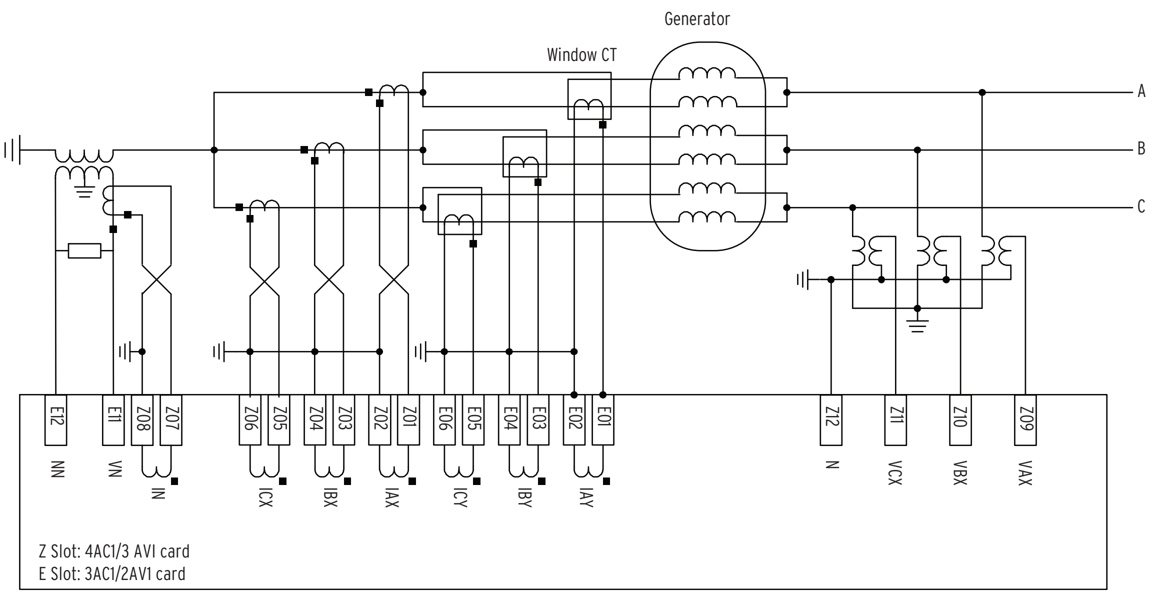


Figure 2.22 SEL-700G1+ Relay High-Impedance Grounded Generator With Split-Phase, Self-Balancing Differential Protection

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

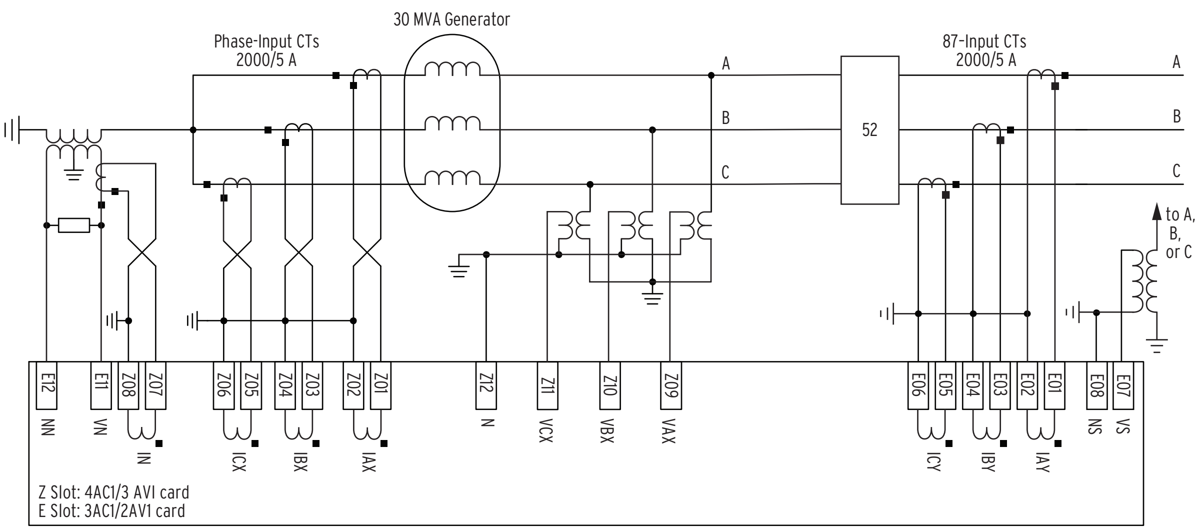
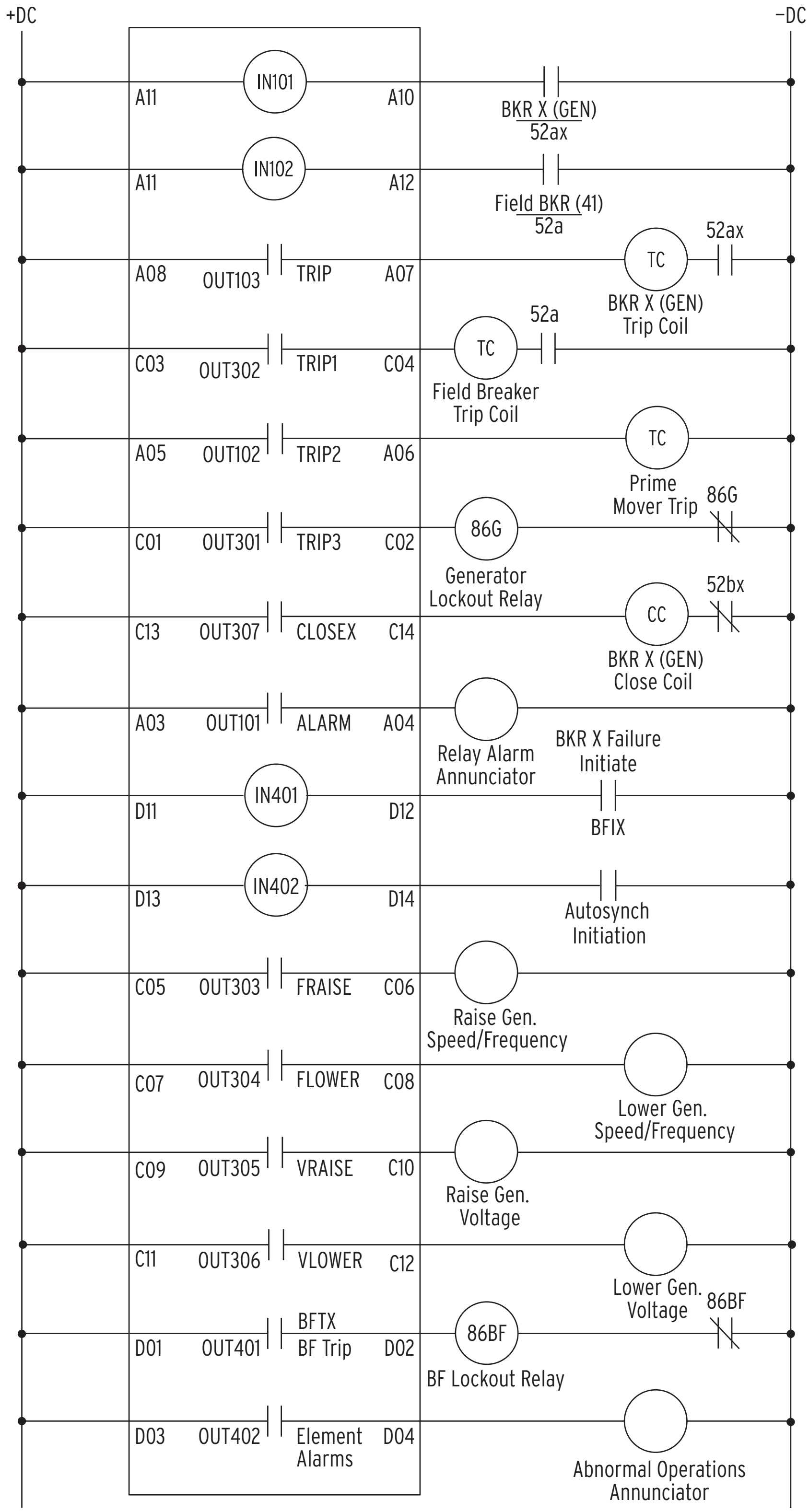


Figure 2.23 SEL-700G1+ Relay Typical AC Current and Four-Wire Wye Voltage Connection With MOT SEL-0700G11A2XBA76850231



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 a SEL-2812MR or 2812MT and a C805 fiber-optic cable).
- Settings changes required are not shown.
- Additional I/O and relay logic may be necessary for a specific application.

Figure 2.24 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 4.86* and *Directional Elements on page 4.100*)
- Zero-Sequence Voltage-Polarized Directional Element With IN as Operate Quantity (67N; refer to *Section 4: Protection and Logic Functions*, *Overcurrent Elements on page 4.86* and *Directional Elements on page 4.100*)

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 4.86* and *Directional Elements on page 4.100* 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).

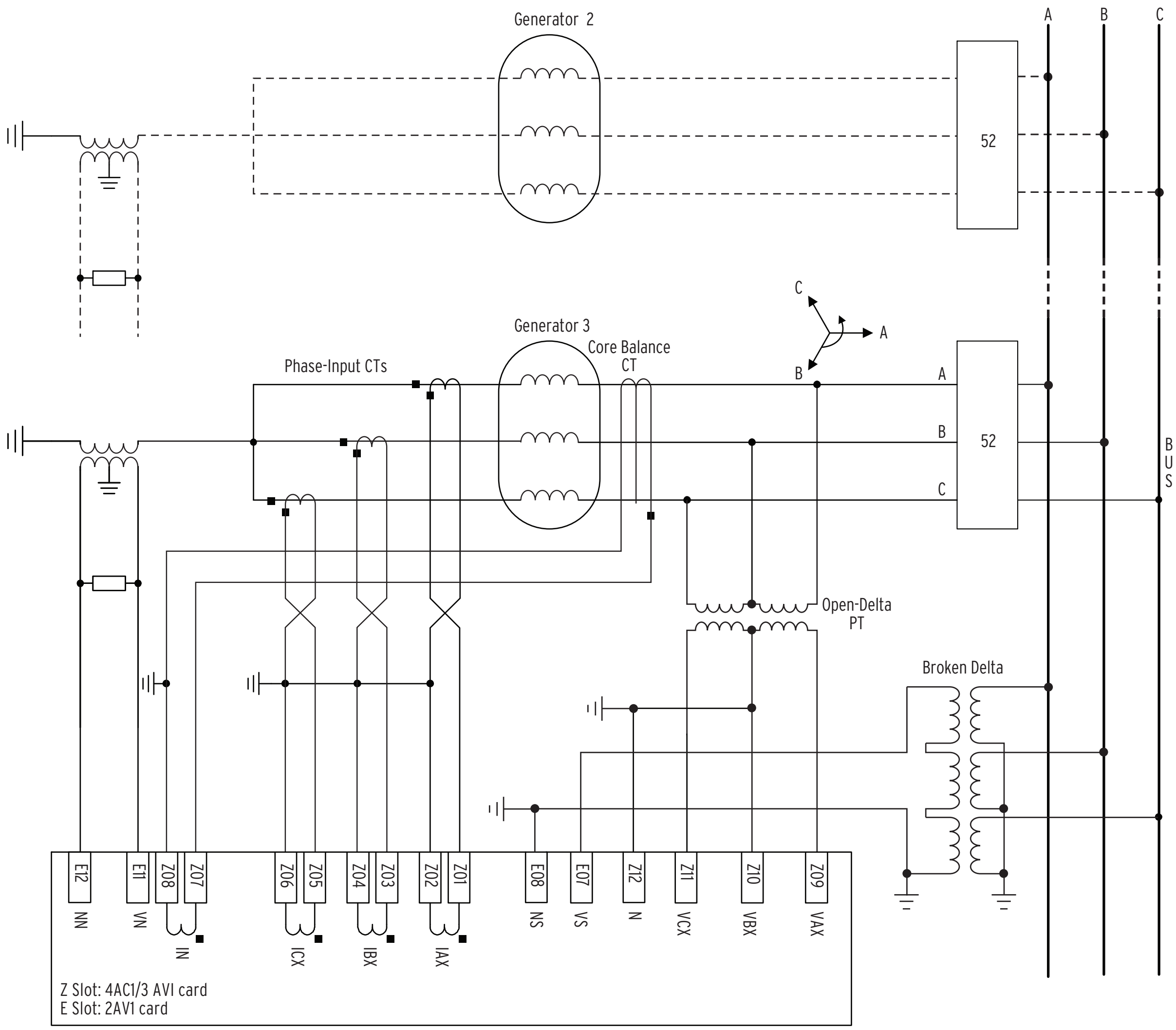


Figure 2.25 SEL-700G1+ Relay AC Connection Example, Multiple High-Impedance Grounded Generators Connected to a Common Bus, With 67N and Other Protection

SEL-700GT Intertie Relay Application

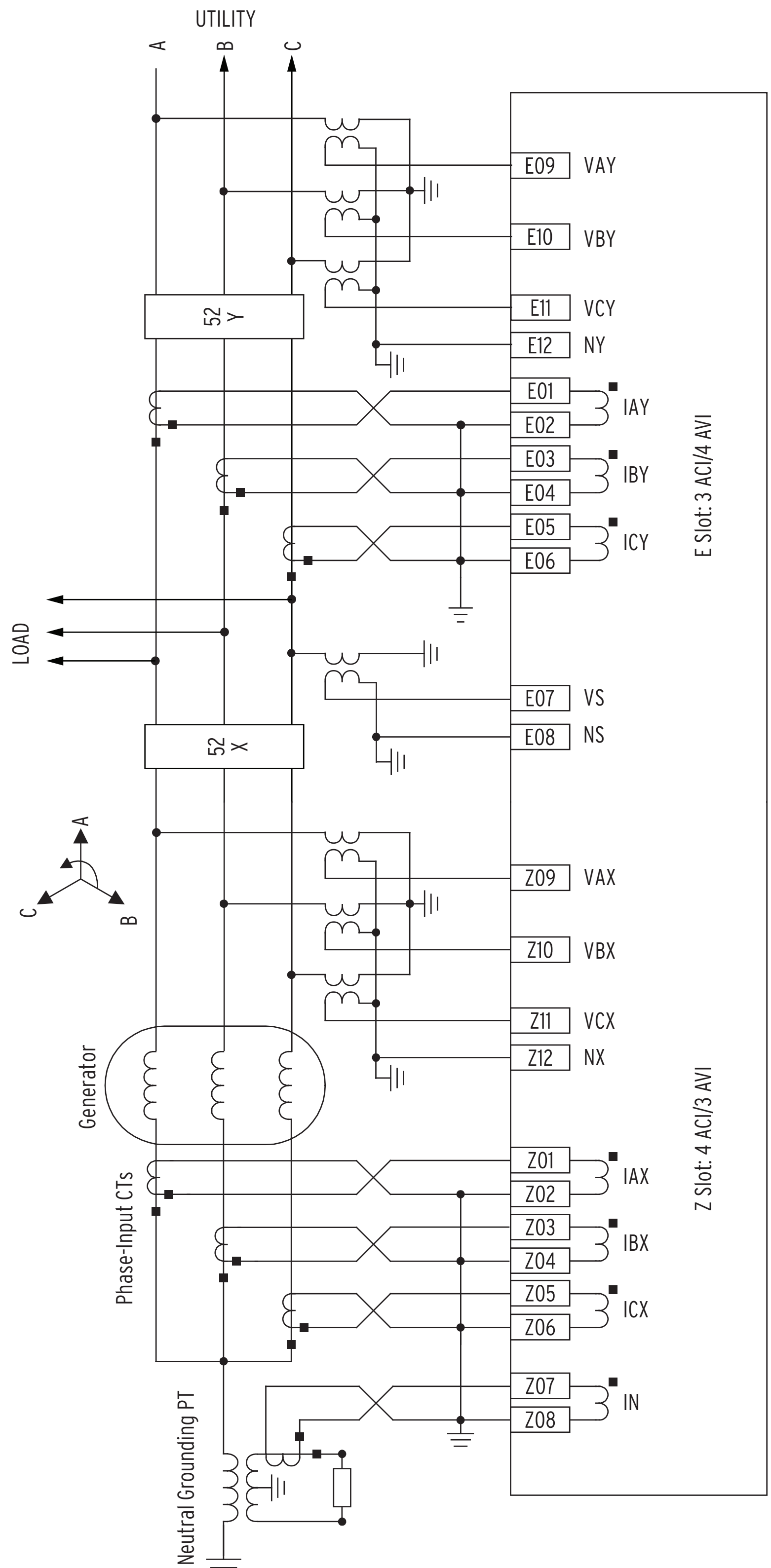
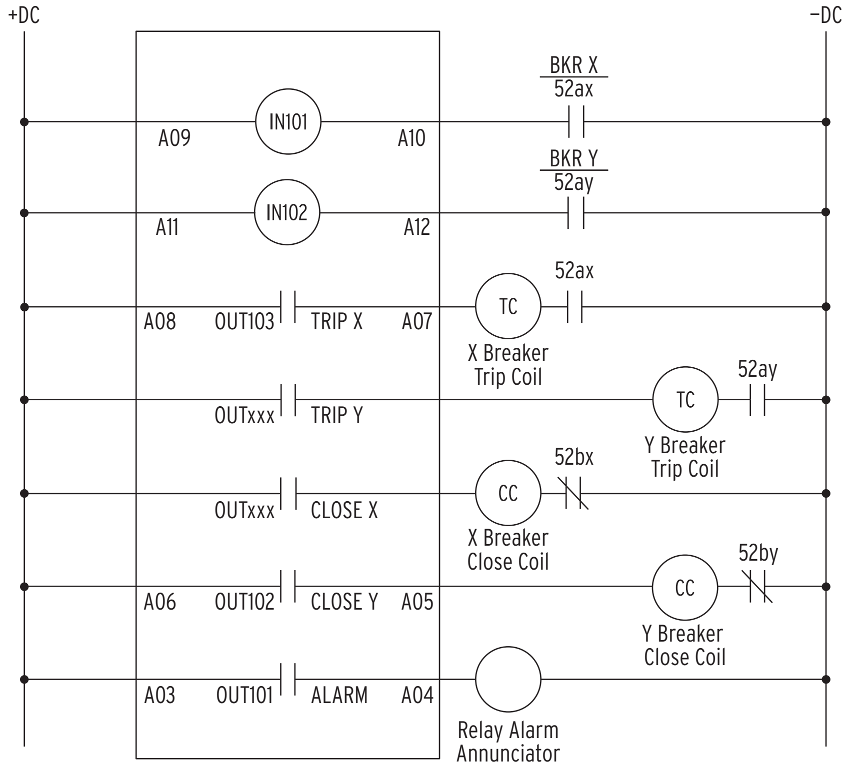


Figure 2.26 SEL-700GT+ Relay Typical AC Current and Four-Wire Wye Voltage Connection



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.
- RTD Inputs—requires SEL-2600 RTD Module or RTD input card in Slot D.

Figure 2.27 SEL-700GT+ Typical DC External Connections

SEL-700GW Wind Generator Relay Application

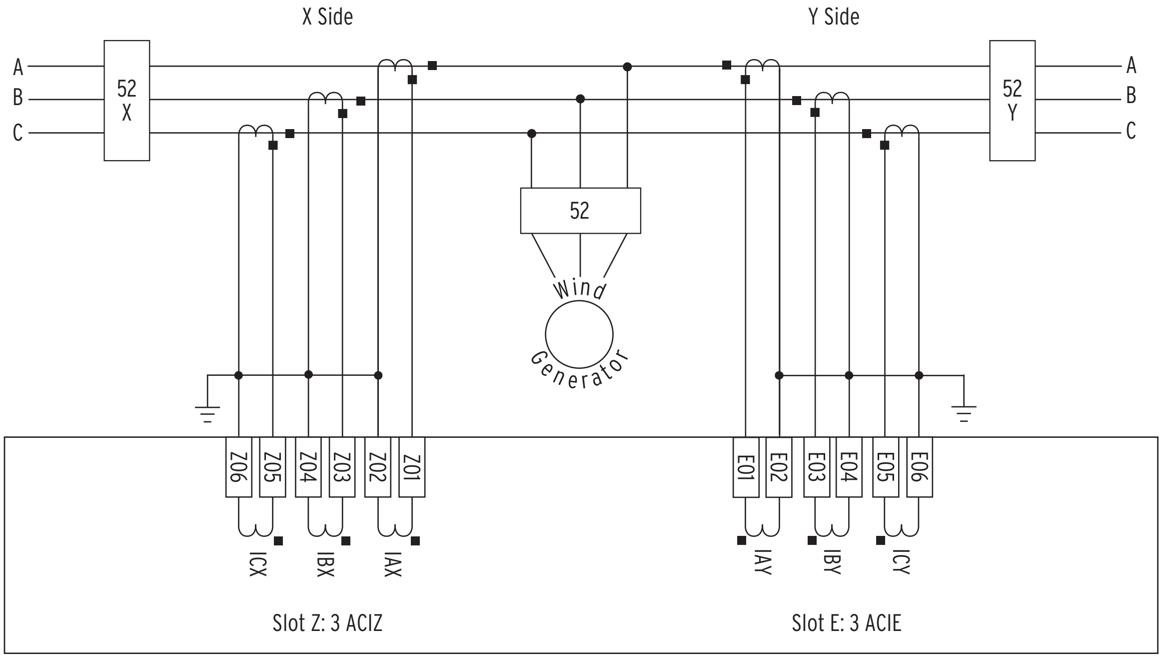
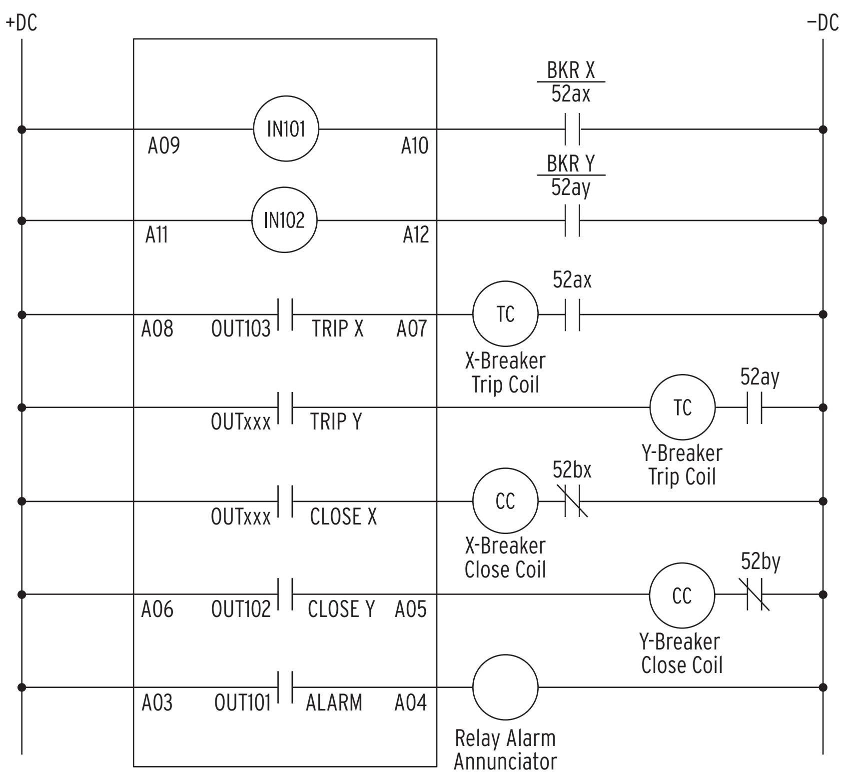


Figure 2.28 SEL-700GW Dual Feeder AC Current Connections



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 2.29 SEL-700GW Typical DC External Connections

Thermal Protection of Generator and Prime Mover

Figure 2.30 shows an application example of an SEL-700G relay and an SEL-2600 RTD Module providing thermal protection for the generator and prime mover.

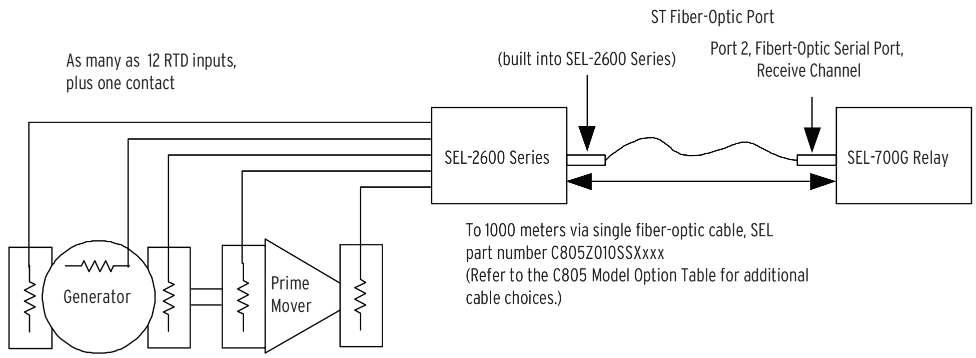


Figure 2.30 Generator Thermal Protection With an SEL-2600 RTD Module and an SEL-700G

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).

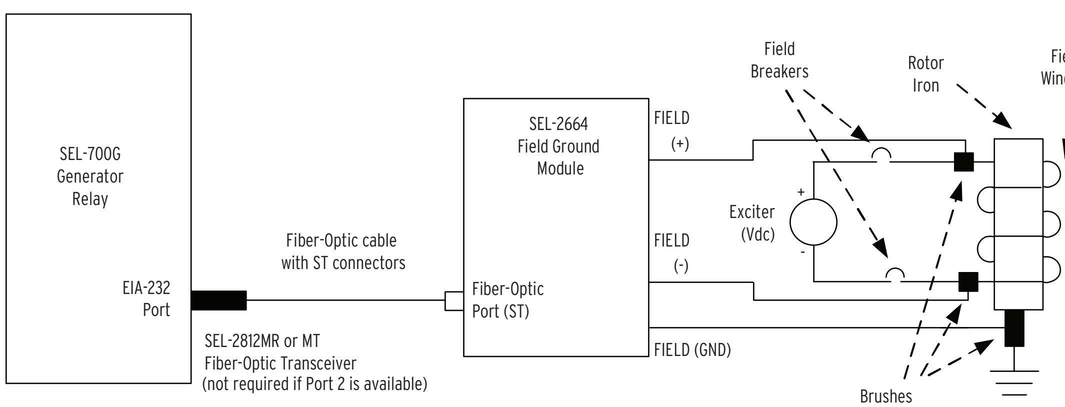


Figure 2.31 Field Ground Protection With an SEL-700G Relay

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 10: 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, Ray-O-Vac® BR2335 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

⚠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.

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.

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 Ray-O-Vac® no. BR2335 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.

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Section 3
PC Software

Overview

This section describes how to get started with the SEL-700G and ACSELERATOR QuickSet SEL-5030 Software. SEL provides many PC software solutions (applications) to support the SEL-700G and other SEL devices. *Table 3.1* lists SEL-700G software solutions.

Table 3.1 SEL Software Solutions

Part Number	Product Name	Description
SEL-5010	SEL-5010 Relay Assistant Software	Manages a connection directory and settings of multiple devices
SEL-5030	ACSELERATOR QuickSet® SEL-5030 Software	See *Table 3.2*
SEL-5032	ACSELERATOR Architect® SEL-5032 Software	Configures IEC 61850 communications
SEL-5040	ACSELERATOR Report Server™ SEL-5040 Software	Automatically retrieves, files, and summarizes reports
SEL-5601	ACSELERATOR Analytic Assistant™ SEL-5601 Software	Converts SEL Compressed ASCII event report files to oscillography
SEL-5801	SEL-5801 Cable Selector Software	Selects the proper SEL cables for your application

ACSELERATOR 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 ACSELERATOR QuickSet applications provided for the SEL-700G.

Table 3.2 ACSELERATOR QuickSet SEL-5030 Software (Sheet 1 of 2)

Application	Description
Rules-Based Settings Editor	Provides on-line or off-line 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 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.
Settings Database Management	ACSELERATOR QuickSet uses a database to manage the settings of multiple devices.

Table 3.2 ACSELERATOR QuickSet SEL-5030 Software (Sheet 2 of 2)

Application	Description
Terminal	Provides a direct connection to the SEL device. Use this feature to ensure proper communications and directly interface with the device.
Help	Provides general ACSELERATOR QuickSet and device-specific ACSELERATOR QuickSet context.

[a] Available only in licensed versions of ACSELERATOR 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 the PC.

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

Step 3. Start ACSELERATOR QuickSet.

Communications

ACSELERATOR 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 ACSELERATOR QuickSet to communicate effectively with the relay.

Step 1. Select **Communications** from the ACSELERATOR QuickSet main menu bar, as shown in *Figure 3.1*.

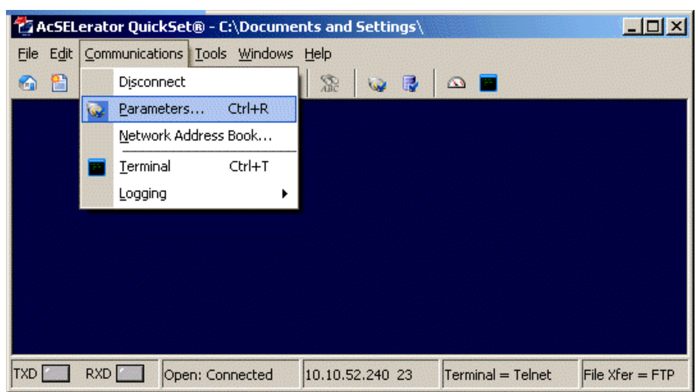


Figure 3.1 Serial Port Communication Dialog Box

Step 2. Select the **Parameters** submenu to display the screen shown in *Figure 3.2*.

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

Step 4. Configure ACSELERATOR QuickSet to match the SEL-700G default settings by entering 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 3.3*.

For the SEL-700G, always select FTP as the File Transfer Option.

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

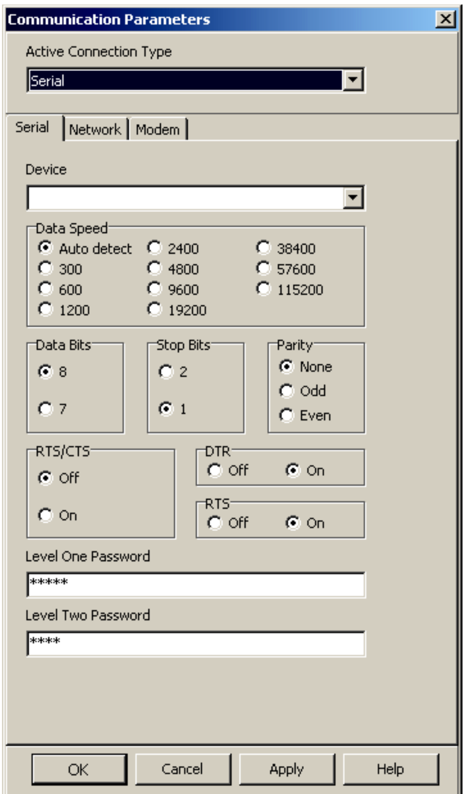


Figure 3.2 Serial Port Communication Parameters Dialog Box

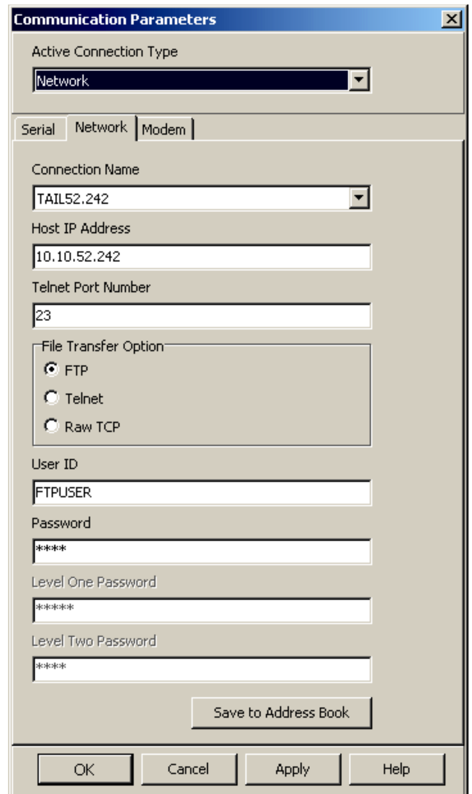


Figure 3.3 Network Communication Parameters Dialog Box

Terminal

Terminal Window

Select **Communications > Terminal** on the ACSELERATOR QuickSet main menu bar to open the terminal window (shown in *Figure 3.4*).

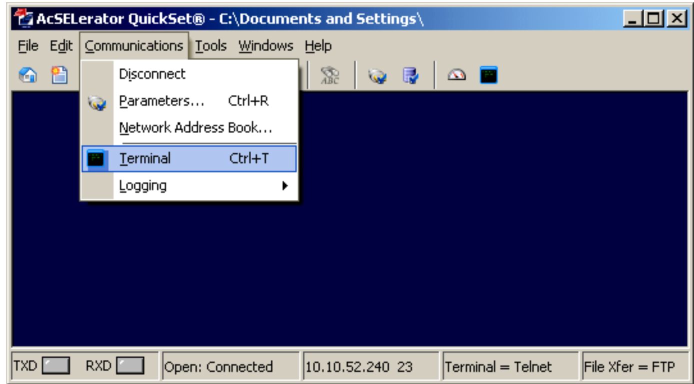


Figure 3.4 Communications Menu

The terminal window is an ASCII interface with the relay. This is a basic terminal emulation. Many third-party terminal emulation programs are available with file transfer encoding schemes. Open the terminal window by either clicking **Communications > Terminal** or by 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. ACSELERATOR 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**.

Drivers 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 3.5*.

```
=ID <Enter>
"FID=SEL-700G-R100-V0-Z001001-D20100429","08EE"
"BFID=BOOTLDR-R500-V0-Z000000-D20090925","0952""CID=9B42","025E"
"DEVID=SEL-700G","0408"
"DEVCODE=74","0316"
"PARTNO=0700G11B0X0X7281033X
"CONFIG=11251201","03F0"
"iedName =TEMPLATE","05DC"
"type =SEL_700G","04B0"
"configVersion =ICD-700G-R100-V0-Z001001-D20070326","0D75"
=
```

Figure 3.5 Device Response to the ID Command

Locate and record the Z-number (Z001001) in the FID string. The first portion of the Z-number (Z001…) determines the ACSELERATOR QuickSet relay settings driver version when you are creating or editing relay settings files. The use of the Device Editor driver version is discussed in more detail later in this section—see *Settings Editor (Editor Mode) on page 3.8*. Compare the part number (PARTNO=700G0XXXXXXXXXXXXXX) with the Model Option Table (MOT) to ensure the correct relay configuration.

Settings Database Management and Drivers

ACSELERATOR QuickSet uses a database to save relay settings. ACSELERATOR QuickSet contains sets of all settings files for each relay specified in the Database Manager. Choose appropriate storage backup methods and a secure location for storing 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 ACSELERATOR QuickSet is Relay.rdb. This database contains example settings files for the SEL products with which you can use ACSELERATOR QuickSet.

Step 2. Enter descriptions for the database and each relay in the database in the **Database Description** and **Settings Description** dialog boxes.

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

Step 4. Highlight one of the relays listed in **Settings in Database** and select the **Copy** option button to create a new collection of settings.

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

Copy/Move Settings Between Databases

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 **Open B** option 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. Select **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 take a device or settings file from **Settings Database B** to **Settings Database A**. **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.

Create a New Database, Copy an Existing Database

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

Step 1. Click **File > Database Manager**, and select the **New** button. ACSELERATOR QuickSet prompts you for a file name.

Step 2. Type the new database name (and location if the new location differs from the existing one), and click **Save**. ACSELERATOR 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 in the **Database Manager** dialog box.

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

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

Step 3. Type a new database name and click the **Open** button.

Settings

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

Settings Editor

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 ACSELERATOR QuickSet menus. ACSELERATOR 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. However, any disabled settings are dimmed when accessed by clicking an item in the tree view.

Settings Menu

ACSELERATOR QuickSet uses a database to store and manage SEL relay settings. Each unique relay has its own record of settings. 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. Use the **Tools** menu to **Convert** and open an existing record. The record is opened in the **Settings Editor** as a **Settings Form** (template) or in **Editor Mode**.

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

Selecting the **New** menu item creates new settings files. ACSELERATOR QuickSet makes the new settings files from the driver that you specify in the **Settings Editor Selection** dialog box. ACSELERATOR QuickSet uses the Z-number in the FID string to create a particular version of settings. To get started making SEL-700G settings with the **Settings Editor** in the **Editor Mode**, select **File > New** from the main menu bar and SEL-700G and **001** from the **Settings Editor Selection** window, as shown in *Figure 3.6*.

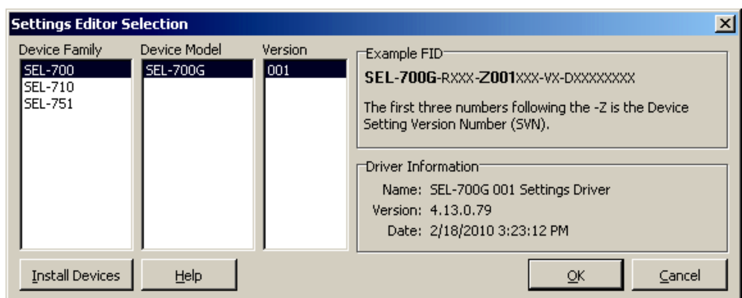


Figure 3.6 Selection of Drivers

After the relay model and settings driver selection, ACSELERATOR QuickSet presents the **Device Part Number** dialog box. Use this dialog box to configure the Relay Editor to produce settings for a relay with options determined by the part number, as shown in *Figure 3.7*. Press **OK** when finished.

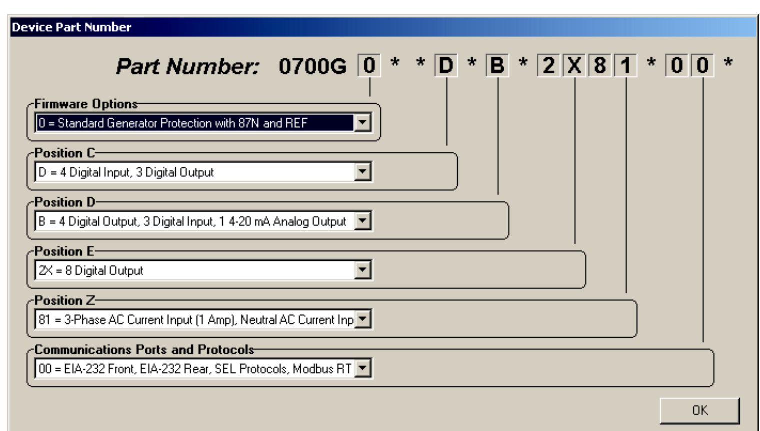


Figure 3.7 Update Part Number

Figure 3.8 shows the **Settings Editor** screen. View the bottom of the Settings Editor window to check the **Settings Driver** number. Compare the ACSELERATOR 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. ACSELERATOR QuickSet uses this first portion of the Z-number to determine the correct **Settings Editor** to display.

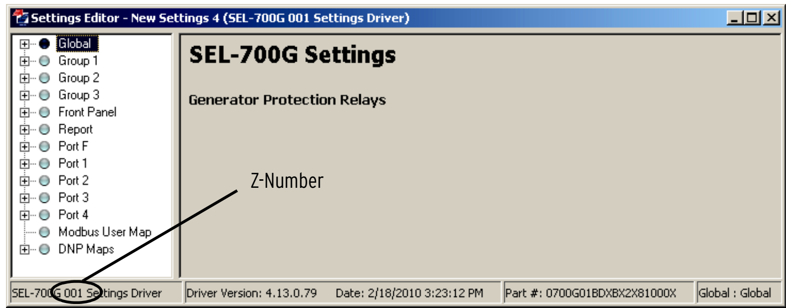


Figure 3.8 New Setting Screen

File > Open

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

File > Read

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

Tools > Settings > Convert

Use the **Convert** menu item 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. ACSELERATOR 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 (Editor Mode)

Use the **Settings Editor (Editor Mode)** to enter settings. These features include the ACSELERATOR QuickSet settings driver version number (the first three digits of the Z-number) in the lower left corner of the Settings Editor.

Entering Settings

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

Step 1. Click the **+** marks 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 on a setting.

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

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

Step 5. If you enter a setting that is out of range or has an error, ACSELERATOR 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. ACSELERATOR QuickSet simplifies this process with the Expression Builder, a rules-based editor for programming SELOGIC control equations. The Expression Builder organizes device elements, analog quantities, and SELOGIC control equation variables.

Access the Expression Builder

Use the Ellipsis buttons [...] in the Settings dialog boxes of **Settings Editor** windows to create expressions, as shown in *Figure 3.9*.

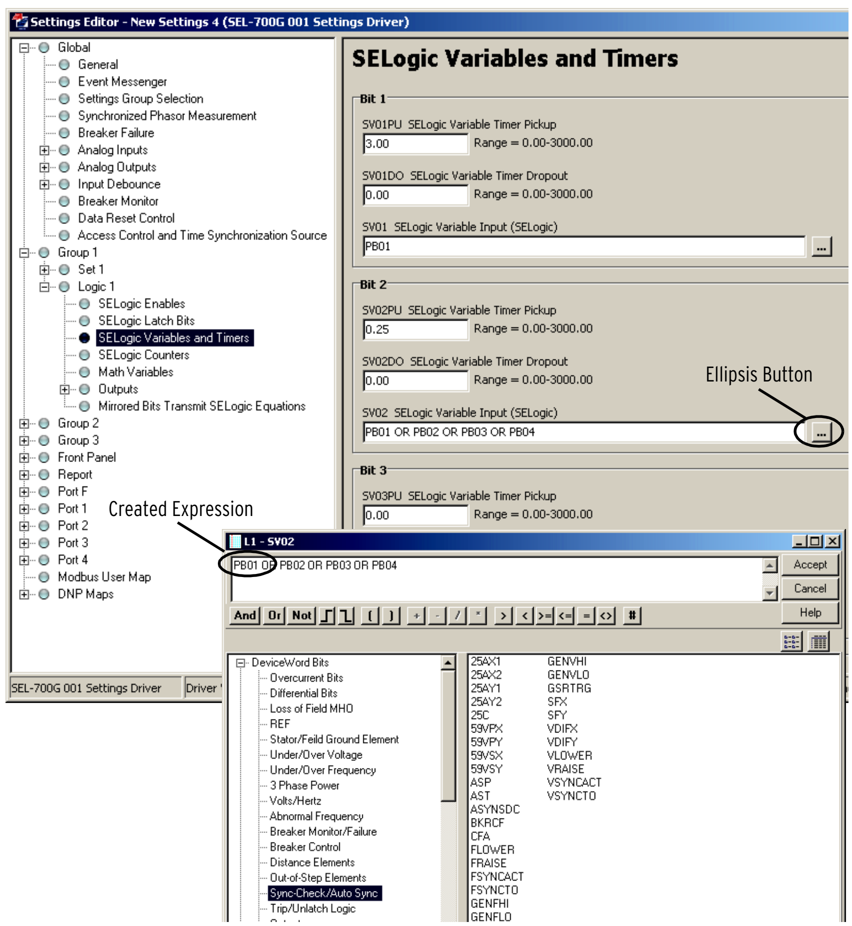


Figure 3.9 Expressions Created With Expression Builder

Expression Builder Organization

The **Expression Builder** dialog box is organized into two main parts representing the left side (LVALUE) and right side (RVALUE) of the SELOGIC control equation. The LVALUE is fixed for all settings.

Using the Expression Builder

Use the right side of the equation (RVALUE) to select broad categories of device elements, analog quantities, counters, timers, latches, and logic variables. Select a category in the RVALUE tree view, and the **Expression Builder** displays all operands for that category in the list box at the bottom right side. From directly underneath the right side of the equation, choose operators to include in the RVALUE. These operators include basic logic, rising- and falling-edge triggers, expression compares, and comments.

File > Save

Select the **Save** menu item from the **File** menu item of the **Settings Editor** once settings are entered into ACSELERATOR QuickSet. This ensures that the settings are not lost.

File > Send

To transfer the edits made in the ACSELERATOR QuickSet edit session, you must send the settings to the relay. Select **Send** from the **File** menu. In the dialog box that opens, select the settings section you want transferred to the relay by checking the appropriate box.

Edit > Part Number

Use this menu item to change the part number if it was entered incorrectly during an earlier step.

Text Files

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

Event Analysis

ACSELERATOR 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 3.10* shows composite screens for retrieving events.

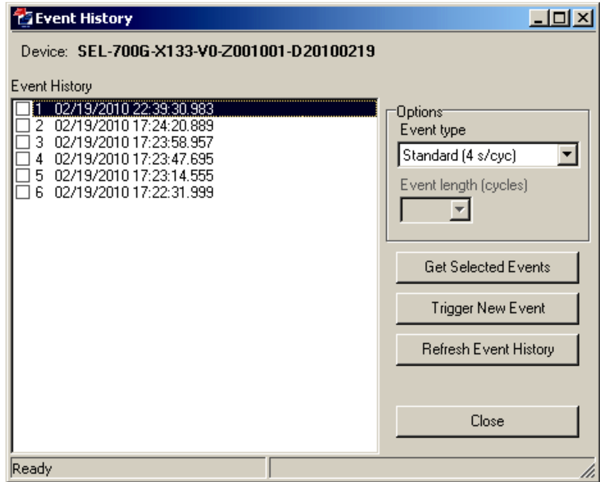


Figure 3.10 Composite Screens for Retrieving Events

Event Waveforms

The relay provides two types of event data captures: event reports that use 4 samples/cycle filtered data and 32 samples/cycle unfiltered (raw) data. See *Section 9: Analyzing Events* for information on recording events. Use the **Options** function in *Figure 3.10* to select the 32 samples/cycle unfiltered (raw) data event (default is 4 samples/cycle filtered data).

View Event History

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 9: 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 3.10*.

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 ACSELERATOR Analytic Assistant, 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 upper right corner, as shown in *Figure 3.11*.

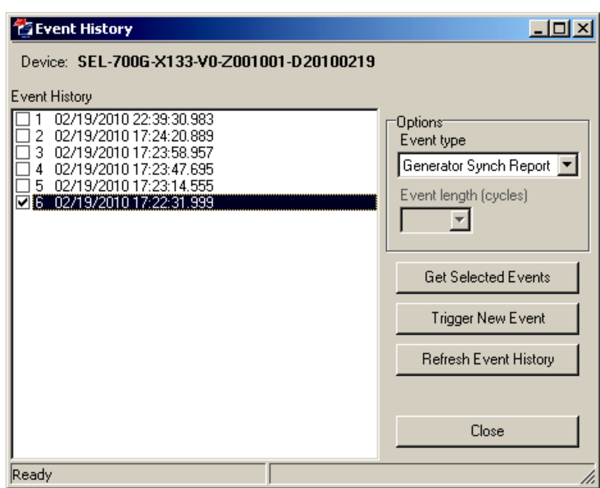


Figure 3.11 Generator Synchronism Report

Get Event

Highlight the event you want to view (for example, Event 3 in *Figure 3.10*), select the event type with the Options Event Type function (4 samples, 32 samples, or Generator Synchronism Report), and click the **Get Selected Event** button. When downloading is complete, ACSELERATOR QuickSet queries whether to save the file on your computer, as shown in *Figure 3.12*.

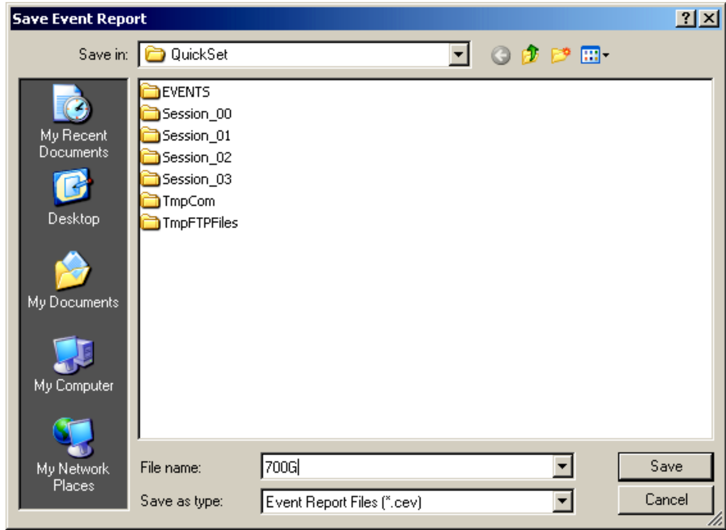


Figure 3.12 Saving the Retrieved Event

Enter a suitable name in the **File name** text box, and select the appropriate location where ACSELERATOR QuickSet should save the event record.

View Event Files

To view the saved events, you need ACSELERATOR Analytic Assistant. Use the **View Event Files** function from the **Tools > Events** menu to select the event you want to view (ACSELERATOR QuickSet remembers the location where you stored the previous event record). Use **View Combined Event Files** to simultaneously view as many as three separate events.

Meter and Control

Click on **Tools > HMI > HMI** to bring up the screen shown in *Figure 3.13*. The HMI tree view shows all the functions available from the HMI function. Unlike the self-configuration of the device, 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 device 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 window displays the status of the two inputs and three outputs of the main board. You cannot change these assignments.

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 the **Update** button 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 LEDs display the status of the 16 front-panel LEDs. Use the front-panel settings to change the front-panel LED assignment.

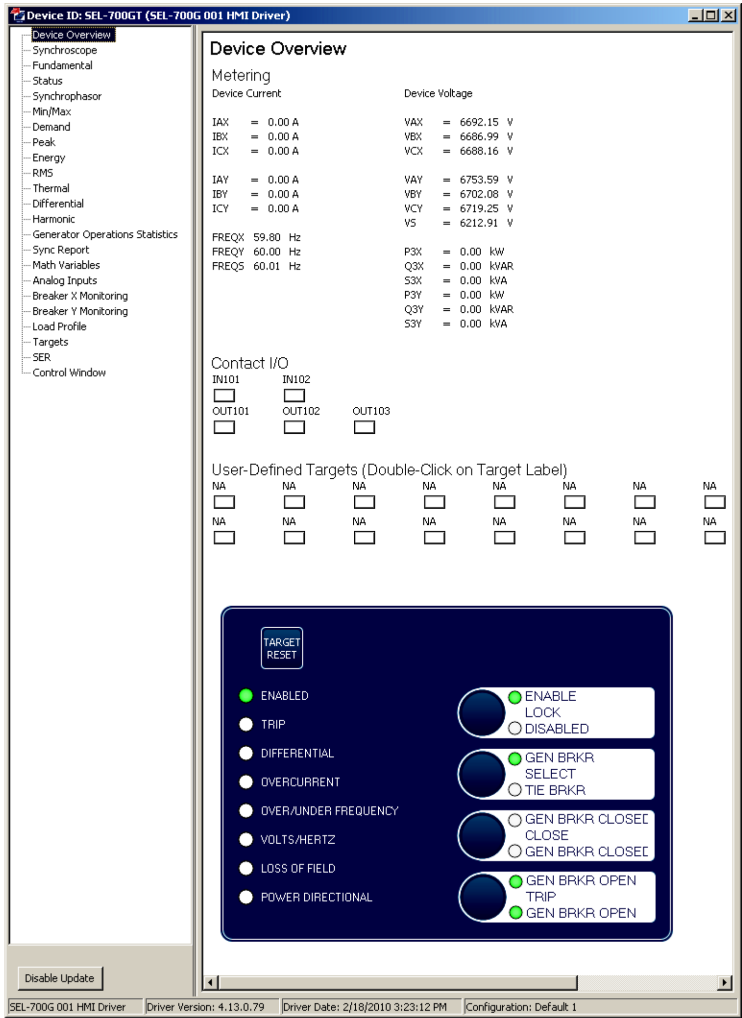


Figure 3.13 Device Overview Screen

Synchroscope

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

Start 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 3.14* shows an example of the SEL-700G synchroscope.

The synchroscope also shows the breaker status (Relay Word bit 52AX) as well as the status of Relay Word Bits: FRAISE, FLOWER, VRAISE, and VLOWER. These indicators correspond to the output of the SEL-700G to the generator's regulator and governor.

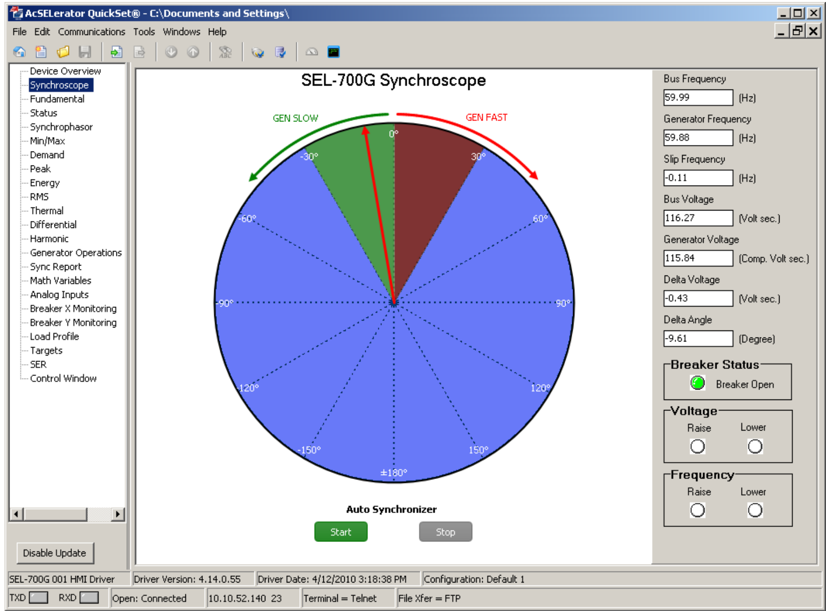


Figure 3.14 Synchroscope

The **Fundamental**, **Min/Max**, **Energy**, etc., screens display the corresponding values.

Click on the **Targets** button to view the status of all the Relay Word bits. When a Relay Word bit has a value of 1 (ENABLED = 1), the Relay Word bit is asserted. Similarly, when a Relay Word bit has a value of 0 (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 3.15 shows the control screen. From here, you can reset metering data and clear the Event History, SER, MIRRORED BITS report, LDP, trigger events, or generator operating statistics. You can also reset the targets, synchronize with IRIG, and set the time and date.

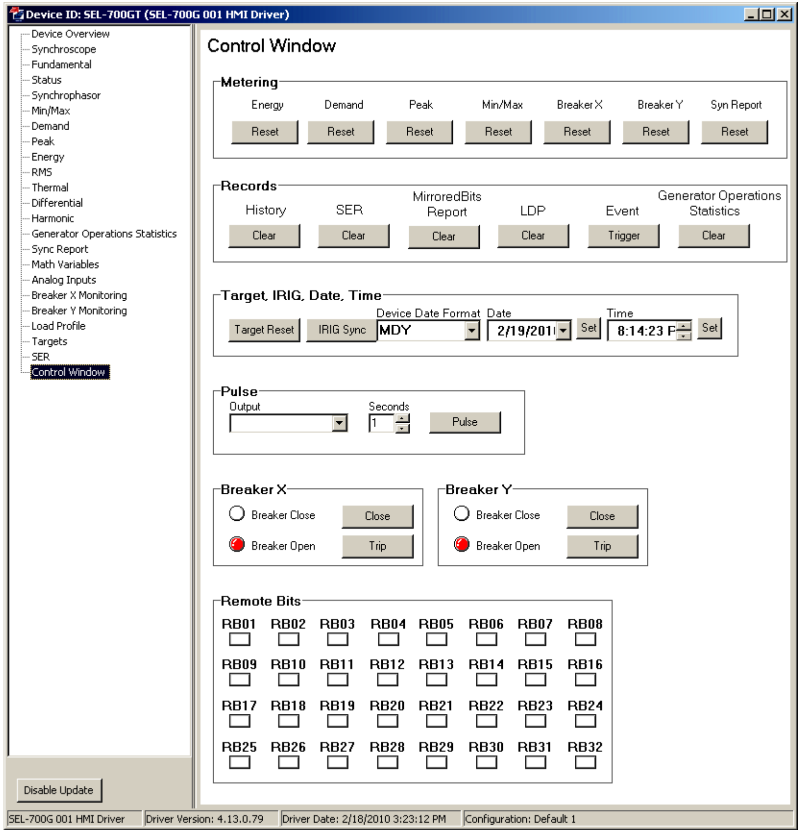


Figure 3.15 Control Screen

To control the Remote bits, click on the appropriate square (RB01–RB32), then select the operation from the box shown in *Figure 3.16*.

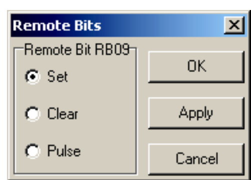


Figure 3.16 Remote Operation Selection

ACSELERATOR QuickSet Help

Various forms of ACSELERATOR 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 ACSELERATOR QuickSet Help

Help	Description
General ACSELERATOR 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.
Database Manager	Select **Help** from the bottom of the **Database Manager** window.

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.

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*
- Zero-Sequence Voltage-Polarized Directional Element With IN as Operate Quantity (67N)
- *Field Ground Protection Elements*
- *System Backup Protection*: Distance, Voltage Controlled/ Restraint OC 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*
- *Over- and Underfrequency Protection*
- *Rate-of-Change-of-Frequency Protection*
- *Over- and Undervoltage Elements*
- *RTD-Based Protection*

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.

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.

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

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.

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 DNP n Command, n = 1, 2, or 3). Shows the DNP user map register settings.

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

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 G.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

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	0.20–1000 kV	VNOM_X := 13.80 kV
EXT ZERO SQ VOLT	NONE, VS, VN	EXT3V0_X := NONE
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	0.20–1000 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.

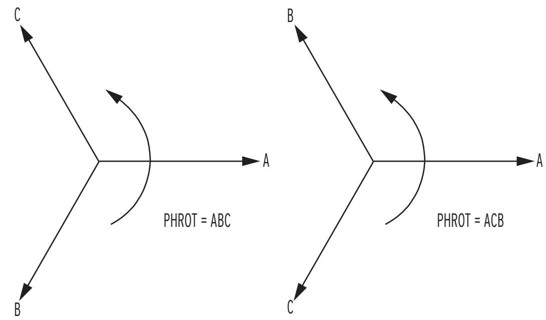


Figure 4.1 Phase Rotation Setting

The X_CUR_IN setting is available only in SEL-700G1 relays. For most applications where the X-side CTs are located on the neutral side of the generator (see *Figure 2.23*), 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:

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

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 2.16* 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 100–250 V (L-L secondary). When setting DELTAY is WYE, then the allowed range of VNOM is 100–440 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. You should 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 2.16* for the voltage connection and *Figure 2.25* 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.

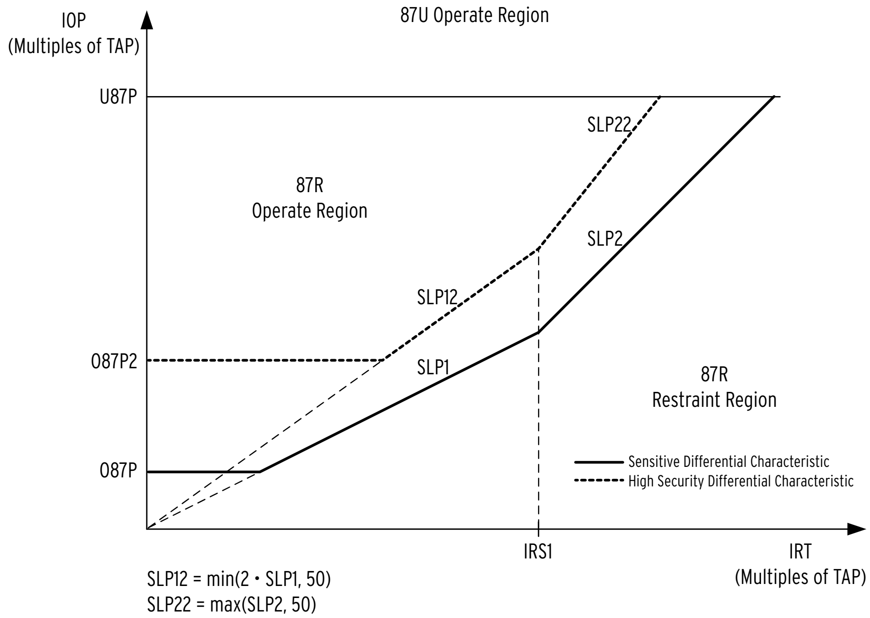


Figure 4.2 Percentage Restraint Differential Characteristic

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.

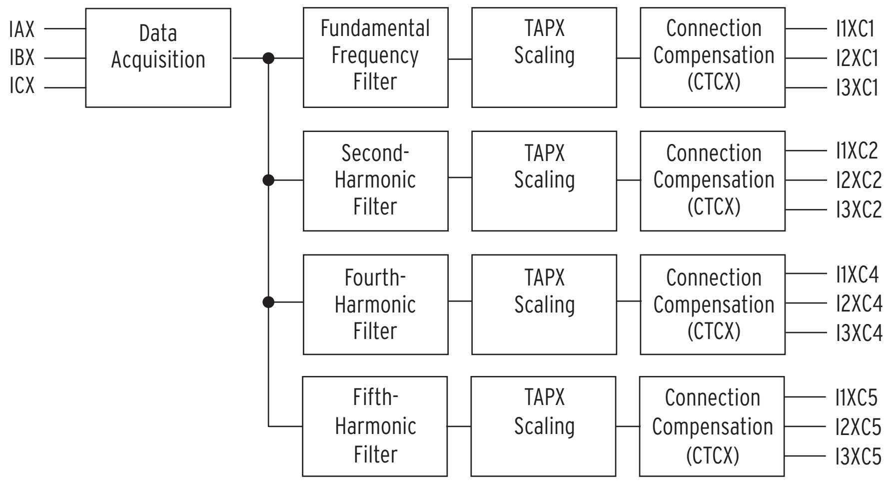


Figure 4.3 Winding X Compensated Currents

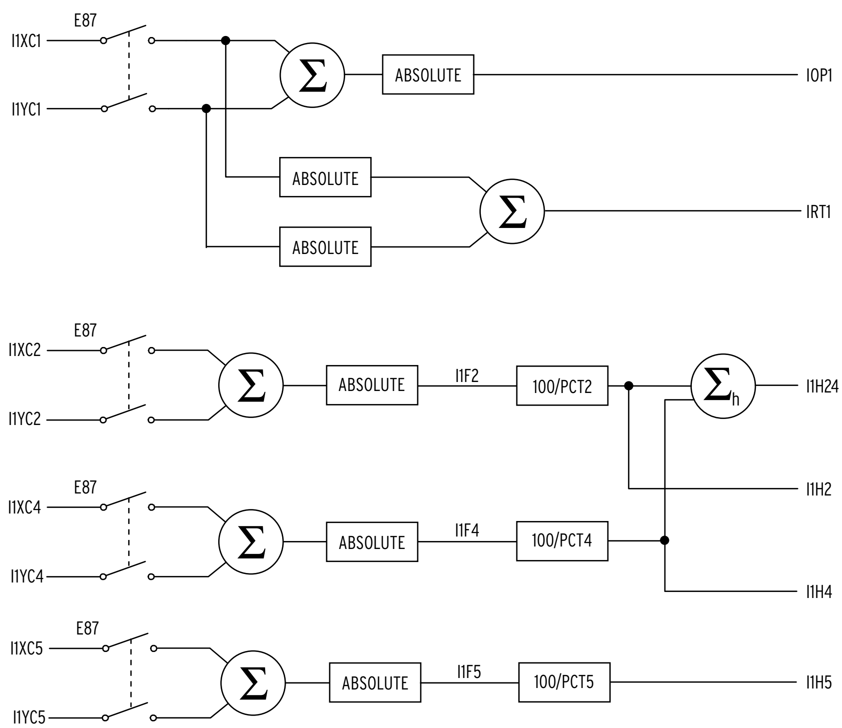


Figure 4.4 Differential Element (87-1) Quantities

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.

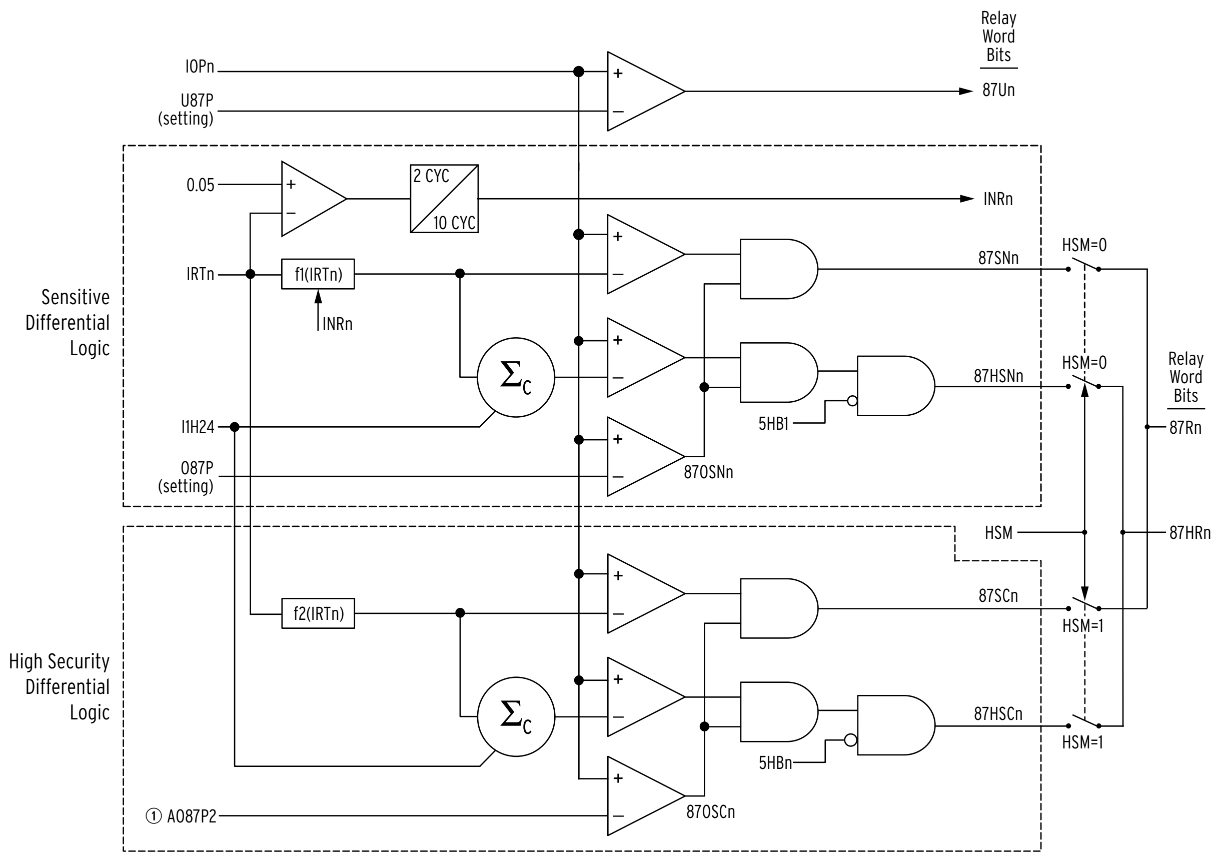
For each restraint element (87R-1, 87R-2, 87R-3), the quantities are summed as phasors and the magnitude becomes the operate quantity (IOP*n*). For a through-current condition, IOP*n* should calculate to about 1 + (–1) = 0, at rated load. Calculation of the restraint quantity (IRT*n*) occurs through 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 = min(2 • SLP1, 50); SLP22 = max(SLP2, 50).

Figure 4.5 Differential Element Logic

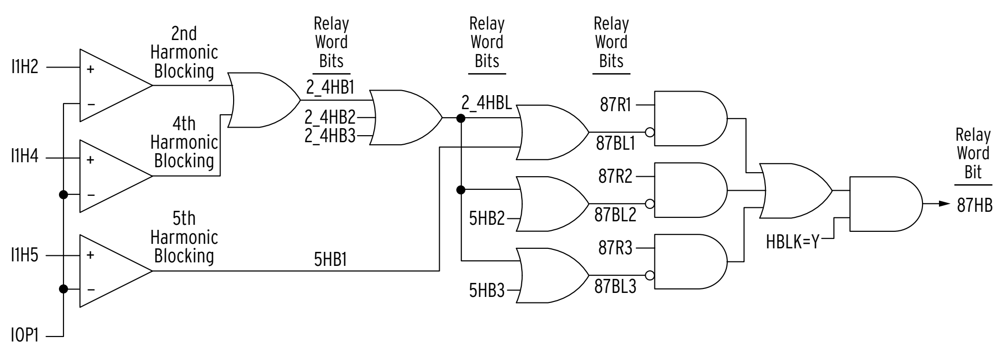


Figure 4.6 Differential Element Harmonic Blocking Logic

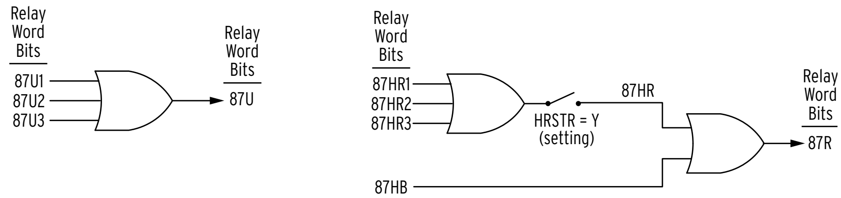


Figure 4.7 Differential Element Output Logic

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:

$$y = m \bullet x + c$$

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 factory default 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
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.

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 (TAP*n*/INOM*n*) to the minimum (TAP*n*/INOM*n*) must be less than or equal to 7.5, where INOM*n* (*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 • INOM*n*/TAP*n*, 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.

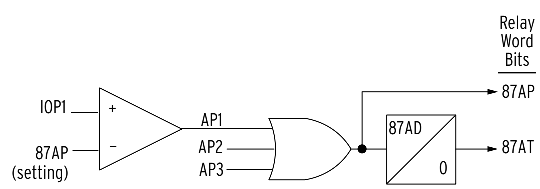


Figure 4.8 Differential Current Alarm Logic Diagram

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 www.selinc.com, or contact your SEL customer service representative.

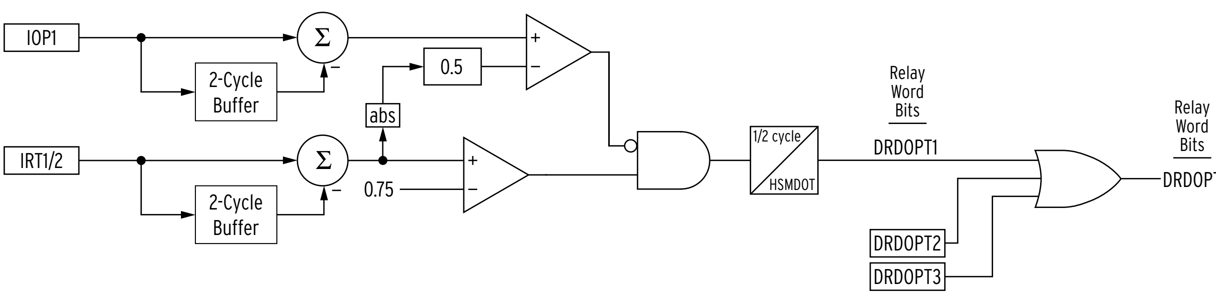


Figure 4.9 Delta IRTn and Delta IOPn External Event Detector Logic

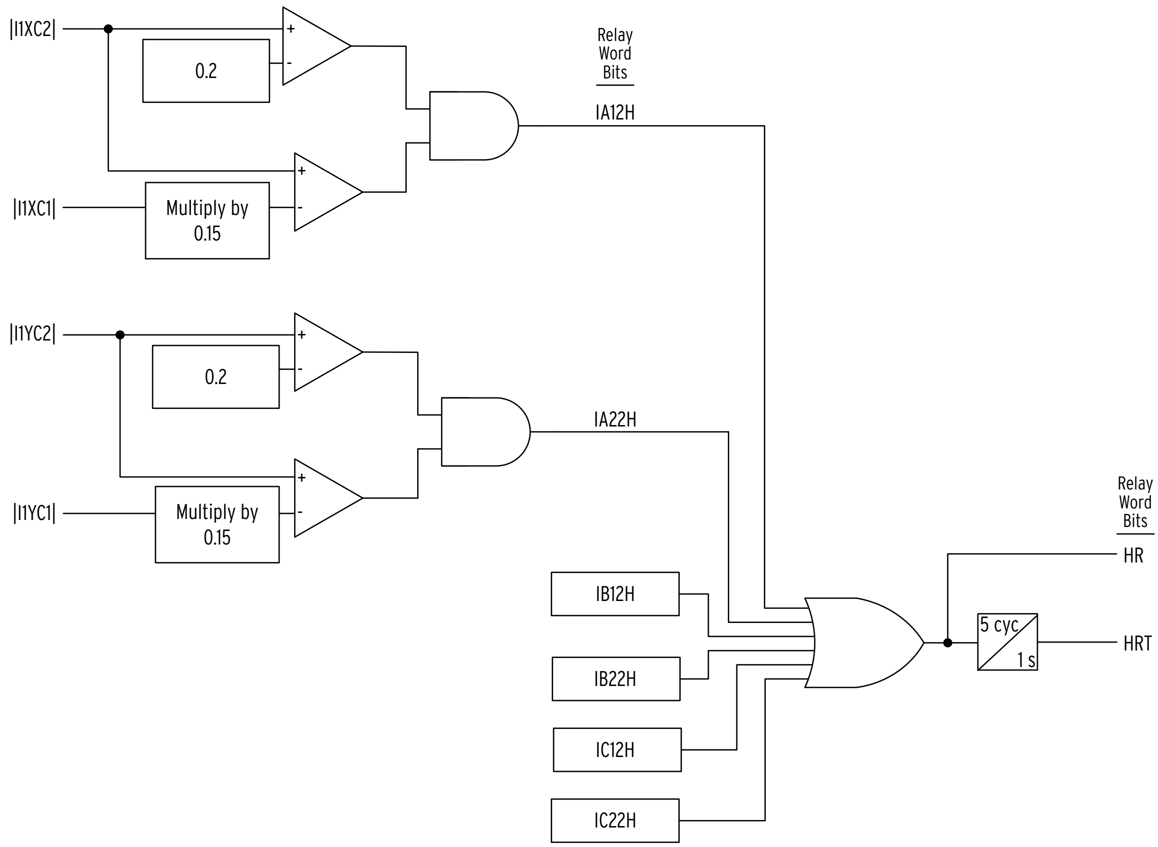


Figure 4.10 Second-Harmonic External Event Detector Logic

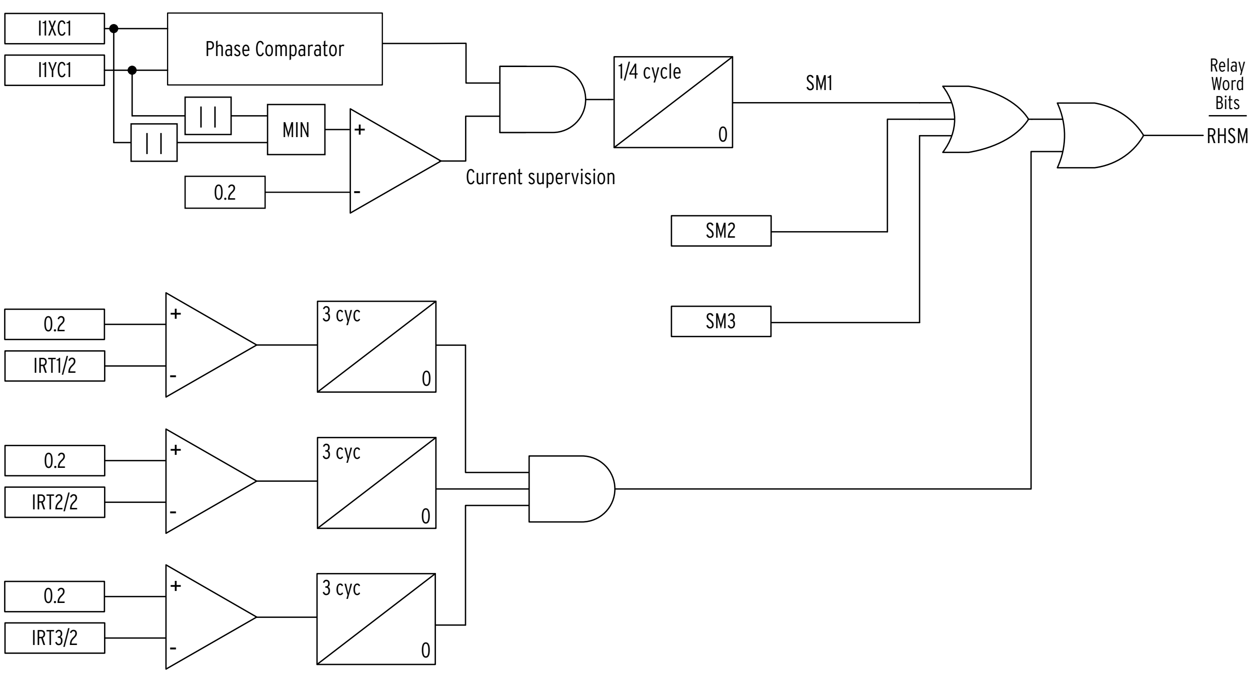
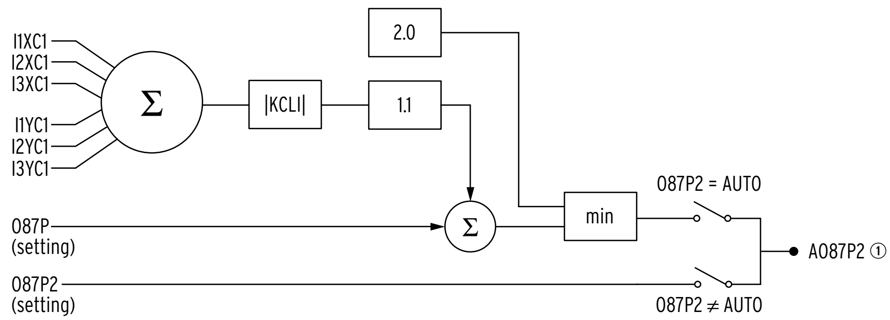


Figure 4.11 High Security Mode RESET Logic



① To Figure 4.5.

Figure 4.12 A087P2 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,

$$I1nC = IAn$$
$$I2nC = IBn$$
$$I3nC = ICn$$

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:

$$[CTC(11)] = \frac{1}{\sqrt{3}} \bullet \begin{bmatrix} 1 & 0 & -1 \\ -1 & 1 & 0 \\ 0 & -1 & 1 \end{bmatrix}$$

that is,

$$I1nC = \frac{(IAn - ICn)}{\sqrt{3}}$$

$$I2nC = \frac{(IBn - IAn)}{\sqrt{3}}$$

$$I3nC = \frac{(ICn - IBn)}{\sqrt{3}}$$

The effect of each compensation on balanced three-phase currents is to rotate them *m* • 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*.

$$[CTC(12)] = \frac{1}{3} \bullet \begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}$$

that is,

$$I1nC = \frac{(+2 \bullet IAn - IBn - ICn)}{3}$$

$$I2nC = \frac{(-IAn + 2 \bullet IBn - ICn)}{3}$$

$$I3nC = \frac{(-IAn - IBn + 2 \bullet ICn)}{3}$$

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.)

$$I1nC = \frac{(+2 \bullet IAn - IBn - ICn)}{3}$$

$$I2nC = \frac{(-IAn + 2 \bullet IBn - ICn)}{3}$$

$$I3nC = \frac{(-IAn - IBn + 2 \bullet ICn)}{3}$$

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.

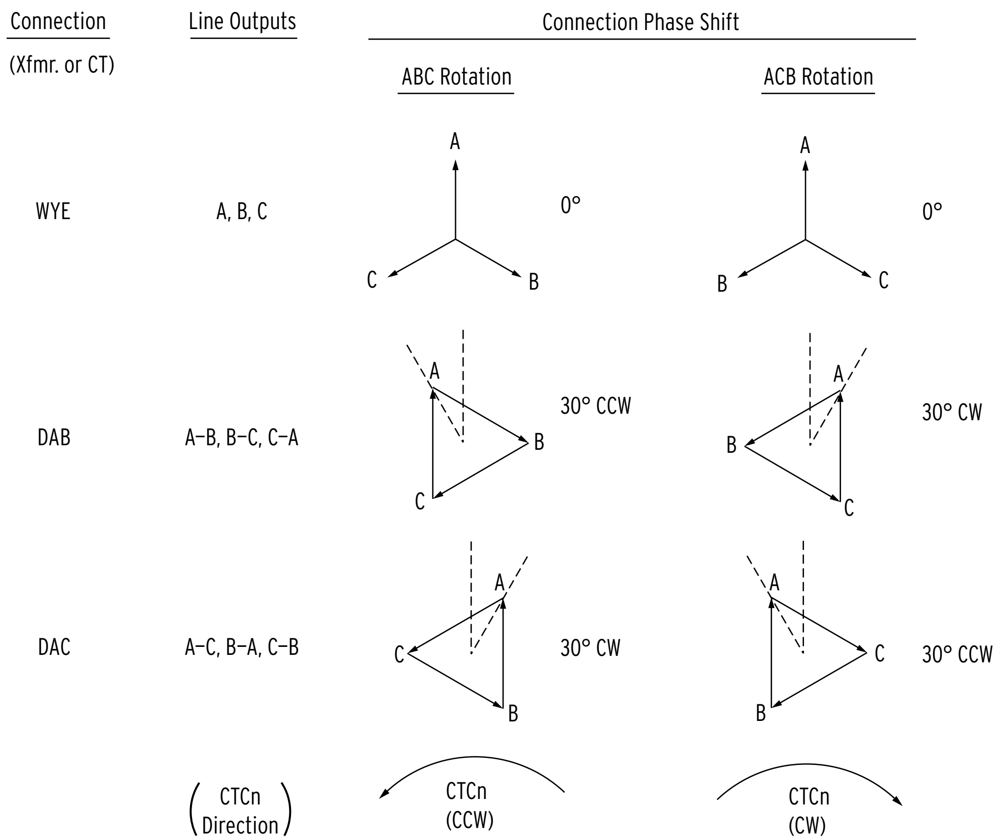


Figure 4.13 Winding Connections, Phase Shifts, and Compensation Direction

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.

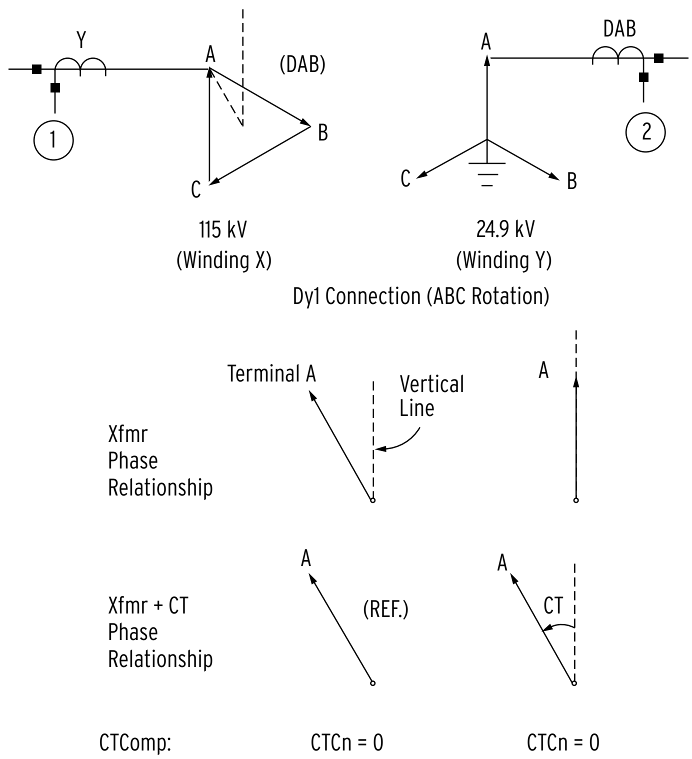


Figure 4.14 Example 1 for WnCTC Selection

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 (TAP*n*/INOM*n*) to the lowest (TAP*n*/INOM*n*) 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 • INOM*n*/TAP*n*, 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.

$$\text{SLP1}_{\text{MIN}}\% = \left(\frac{\text{Err}\%}{(200 - \text{Err}\%) \bullet \text{k}}\right) \bullet 100$$

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 • INOM*n*/TAP*n*, where $n = 1, 2$.

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:

$$\text{TH5P} \geq \text{minimum}\ (0.05 \bullet \text{INOM}n/\text{TAP}n)$$

where:

n = X, Y and INOM*n* is nominal current of 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 2.20 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:

138 kV	13.8 kV
CTCONX = WYE (hidden)	CTCONY = WYE
CTRX = 400	CTRY = 400

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 2.23 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 $0.1 \bullet I_{NOM}$. In this case, O87 must be greater than or equal to $(0.1 \bullet I_{NOMn})/TAPn = 0.5/3.1 = 0.16$.

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 (TAP*n*/INOM*n*) to minimum (TAP*n*/INOM*n*) 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 (0.1-6.2) $\cdot I_{NOM}$.

If the ratio of maximum (TAP*n*/INOM*n*) to minimum (TAP*n*/INOM*n*) 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 2.18 and Figure 2.23 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*.

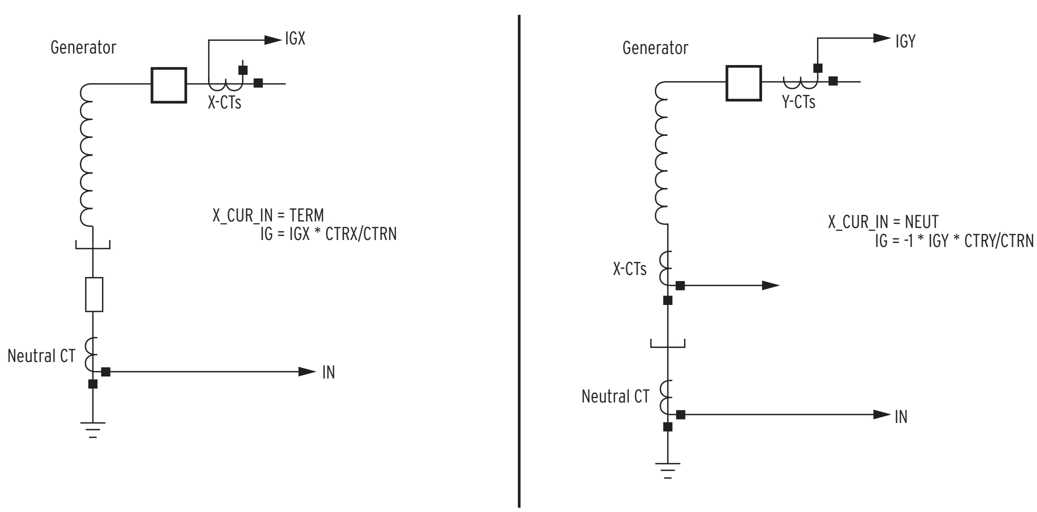


Figure 4.15 Effect of X_CUR_IN Setting on Residual Current (IG)

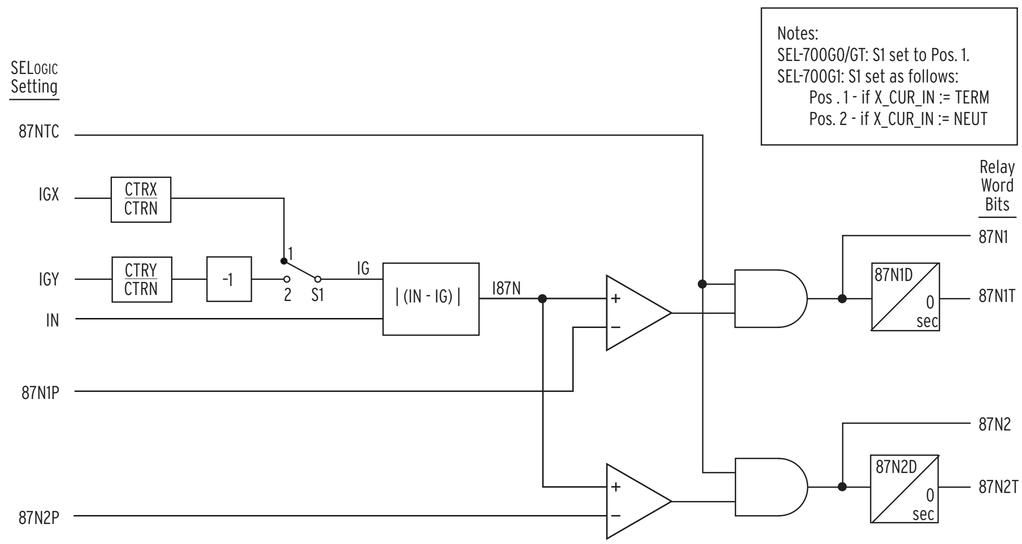


Figure 4.16 87N Element Logic Diagram

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.

The ground differential elements are enabled when the result of 87NTC equals logical 1. The elements are blocked when the 87NTC SELOGIC control equation result equals logical 0. Typically, the element can be enabled continuously, suggesting the logical 1 setting.

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.

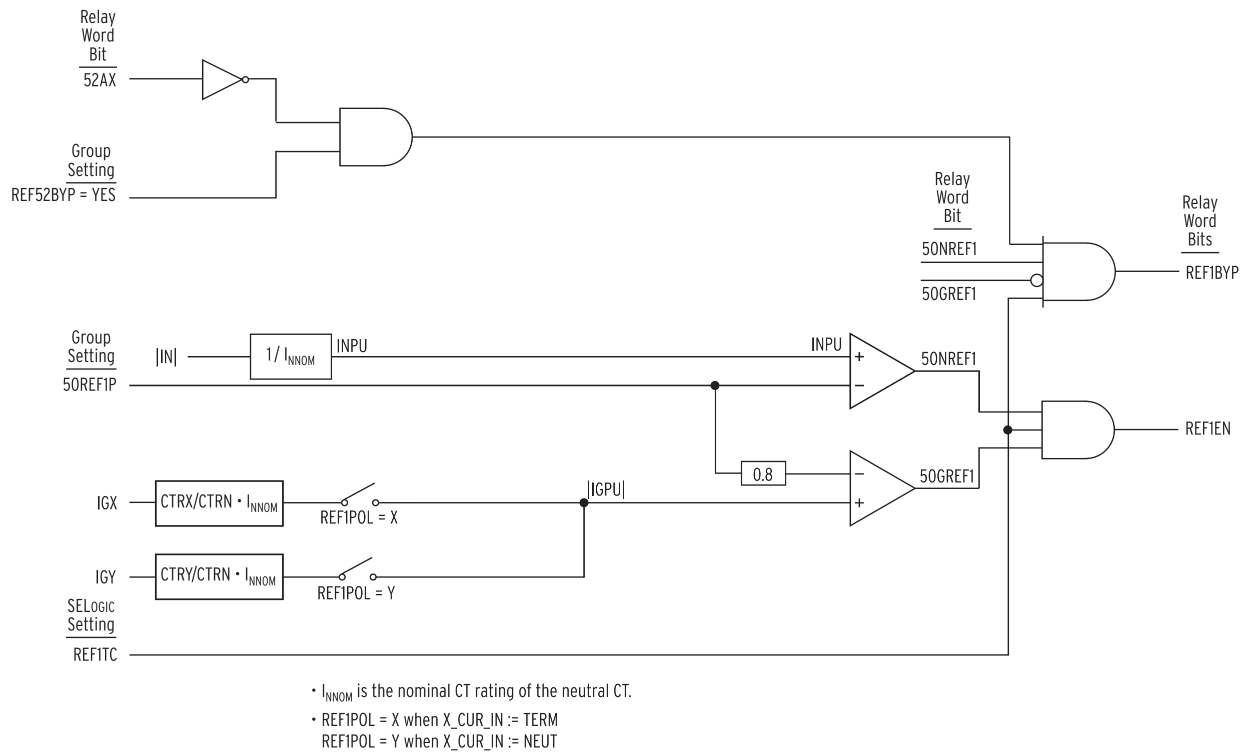


Figure 4.17 REF Enable Logic

Figure 4.18 illustrates the logic of the REF directional element, REF1F. It is at this stage that the element decides whether to operate.

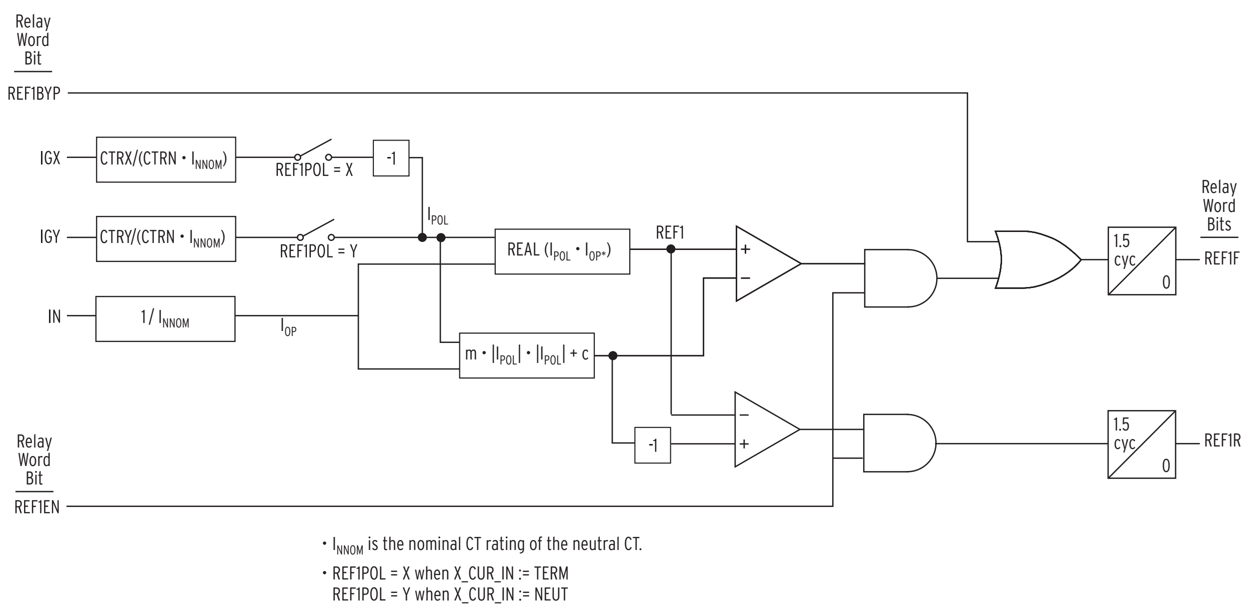


Figure 4.18 REF Directional Element

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.

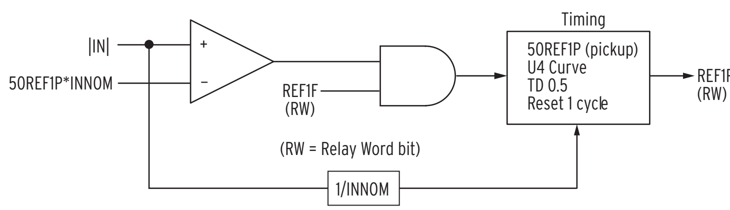


Figure 4.19 REF Protection Output (Extremely Inverse-Time O/C)

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

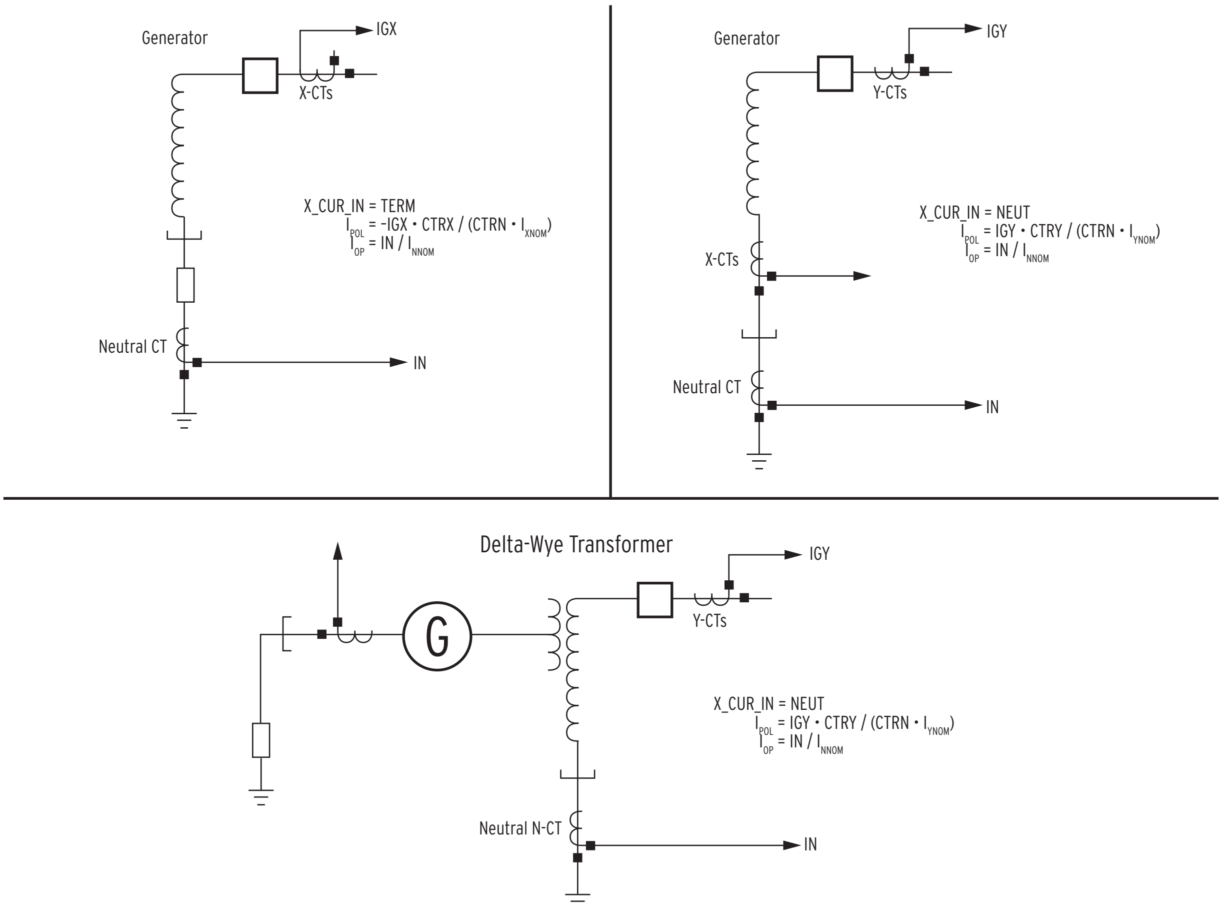
When REF protection is enabled (EREF := Y), the relay automatically configures the protection to use the appropriate phase CT based on X_CUR_IN setting for SEL-700G1 relays. For other relay models, locate the phase CTs on the terminal side of the generator for the REF elements to be effective (as shown in *Figure 2.18*).

The setting REF1TC is a SELOGIC control equation setting that defines the conditions under which the relay enables REF1. A logical state of 1 for this control equation enables the other REF1 settings and satisfies one of the conditions the REF1 element needs to activate.

You can set the neutral current sensitivity threshold to as low as 0.05 times nominal current (0.25 A for 5 A nominal CT current), the minimum neutral current sensitivity of the relay. However, the minimum acceptable value of 50REF1P must be greater than any natural 3I0 unbalance resulting from load conditions.

Polarizing Quantity

Figure 4.20 shows the effect of the X_CUR_IN setting on the polarizing quantity.



(I_{NOM} = 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:

$$IGn = IAn + IBn + ICn \quad (n = X, Y)$$

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.

This function detects stator ground faults in all but the bottom 5 to 10 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 dead band near the middle of the winding. The width of this dead band 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 dead band and vice versa.

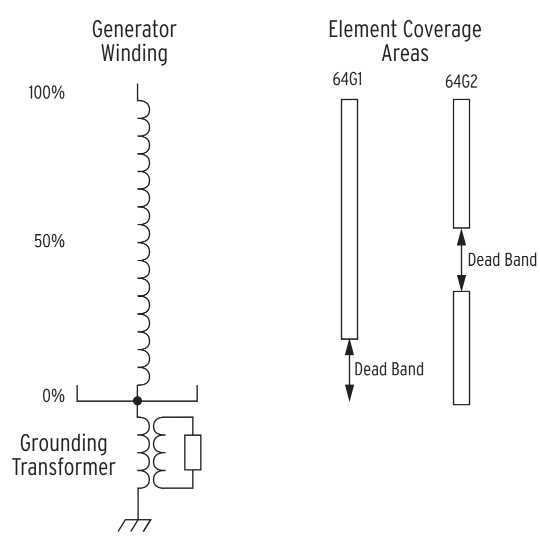


Figure 4.21 64G Element Operating Characteristic

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

Table 4.6 Stator Ground Protection Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
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.

100% Stator Ground Protection Setting Calculation

Collect the following information before setting the 100% Stator Ground Protection.

- Generator nominal voltage, VNOM_X
- Generator grounding transformer ratio to 1 (use 1 if machine is resistance grounded)
- Generator neutral voltage transformer ratio to 1 (use 1 if relay is connected directly to grounding transformer secondary winding)
- 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 dead band whose width is governed by the 64G2P setting. The 64G1 neutral overvoltage element provides sensitive detection of stator faults in the dead band 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 www.selinc.com or by contacting the factory.

Step 1. Operate the generator at no load. 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

Step 2. Increase the generator loading to 100 percent. 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.

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:

$$64RAT = \frac{\langle VN3\_FL + VN3\_NL \rangle}{(VP3\_FL + VP3\_NL)}$$

$$64RAT = \underline{\hspace{6cm}}$$

Step 4. Calculate the minimum secure 64G2P setting by using the following equation:

$$64G2P_{Min} = 1.1 \bullet (0.1 + |64RAT \bullet VP3x - VN3x|) \text{ volts}$$

$$64G2P_{Min} = \underline{\hspace{5cm}} \text{ volts}$$

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. Select the relay setting 64G2P as a value greater than or equal to $64G2P_{Min}$. Higher values for 64G2P generally increase the security of the element. Use *Step 8* and *Step 9* to verify that adequate overlap between 64G1 and 64G2 can be maintained with the selected value of 64G2P.

This equation accounts for the maximum expected element error, and it adds an additional 5 percent measuring error to account for possible potential transformer errors.

Step 8. Use the following equation to calculate the low-winding coverage these settings offer when you operate the machine at no load:

$$64G2_{Min} = \left(\frac{64RAT}{64RAT + \frac{PTRX}{PTRN}} - \frac{64G2P}{\left[64RAT + \frac{PTRX}{PTRN}\right] \bullet [VP3\_NL + VN3\_NL] \bullet \frac{PTRN}{PTRX}} \right) \bullet 100$$

$$64G2_{Min} = \underline{\hspace{3cm}} \%$$

This value should be greater than 15 percent for the most dependable stator ground protection. The referenced spreadsheet performs this calculation automatically.

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 = grounding transformer ratio to 1

Nat = auxiliary transformer ratio to 1, use 1 if relay VN input is connected directly to the grounding transformer secondary

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

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.

standards require third-harmonic neutral undervoltage protection, use the following setting procedure to define the protection settings.

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:

$$64G2P = 0.5 \bullet VN3\_min \text{ V secondary}$$

$$64G2P = \underline{\hspace{6cm}} \text{ V secondary}$$

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

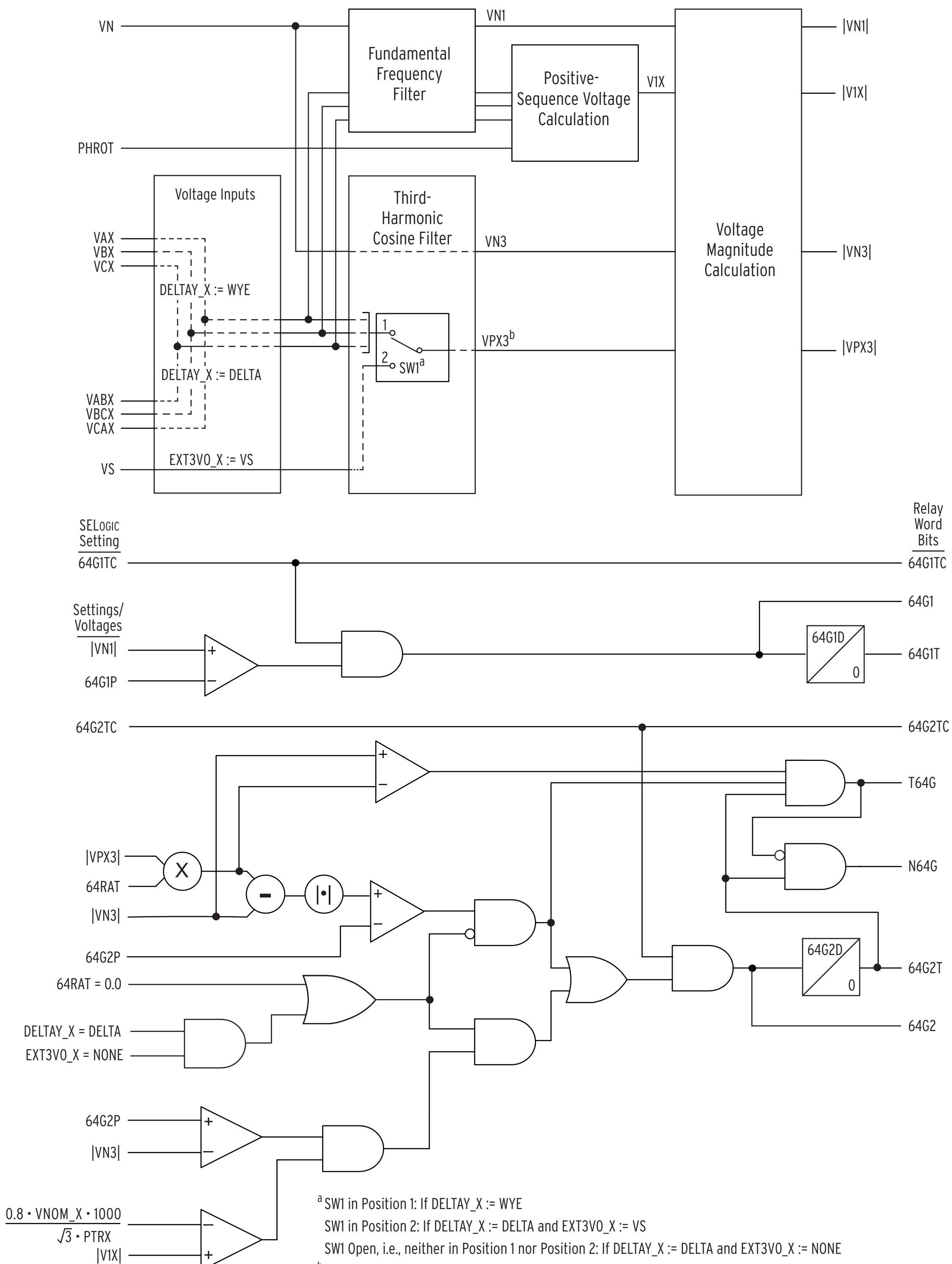
PTRN = Ngt • Nat

Ngt = grounding transformer ratio to 1

Nat = neutral voltage auxiliary transformer ratio to 1, use 1 if relay VN input is connected directly to the grounding transformer secondary

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 and 64G2T Relay Word bits to control outputs for alarming to an operator. Default configuration of the SEL-700G is to shut down the generator by Relay Word bits 64G1T and 64G2T. See *Trip/Close Logic Settings* for more detail.



[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.

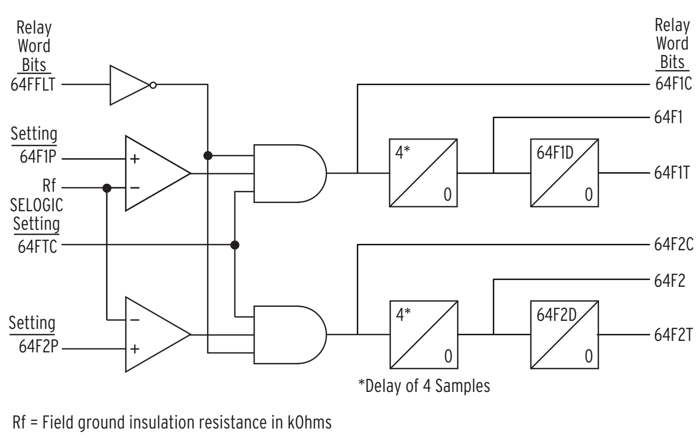


Figure 4.23 Field Ground Protection (64F) Elements Logic

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 2.18*, you can apply an offset equal to the generator impedance as backup protection for phase faults in the generator stator. When the element is used to protect for a phase fault external to the generator differential zone, you should 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 2.17* or *Figure 2.19*, and the element is used to protect for a zero-voltage 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 2.18*, 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.

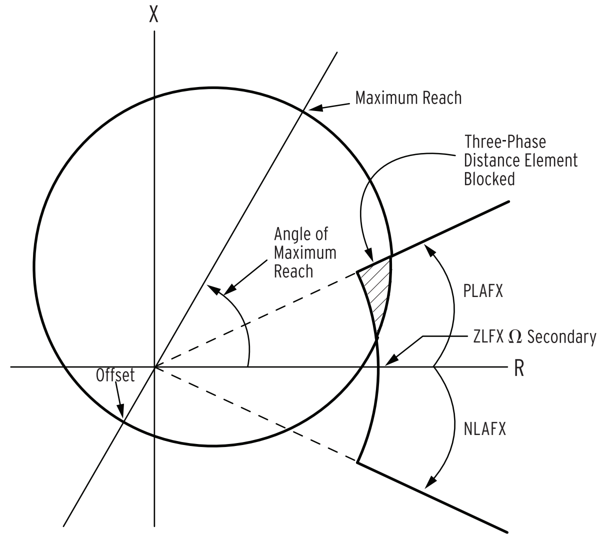


Figure 4.24 Three-Phase Distance Element Operating Characteristics

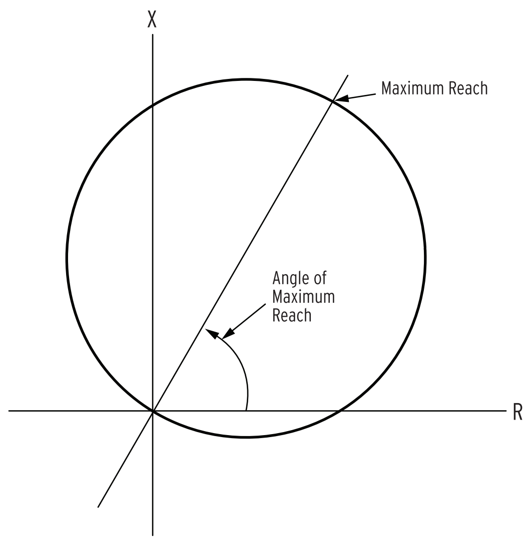
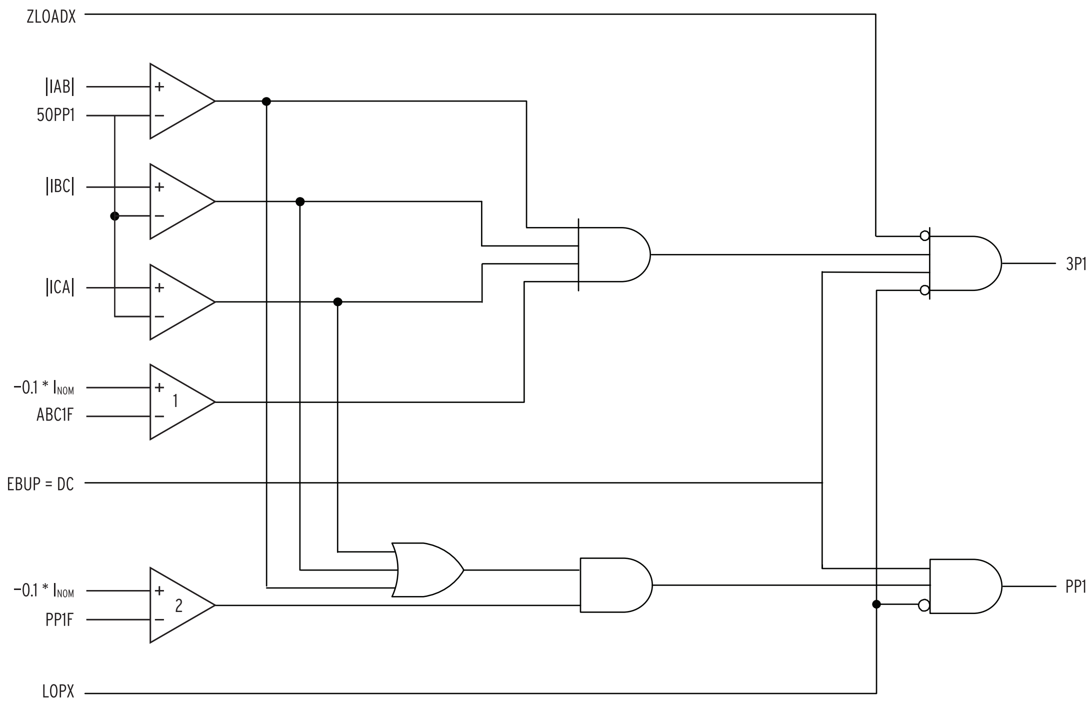


Figure 4.25 Phase-to-Phase Distance Element Operating Characteristics



I_{NOM} is CT rating, 1 A or 5 A (X-CTs).
ABC1F and PP1F are values calculated by compensator distance element.
Zone 2 logic is similar to Zone 1.

Figure 4.26 Zone 1 Compensator Element Logic

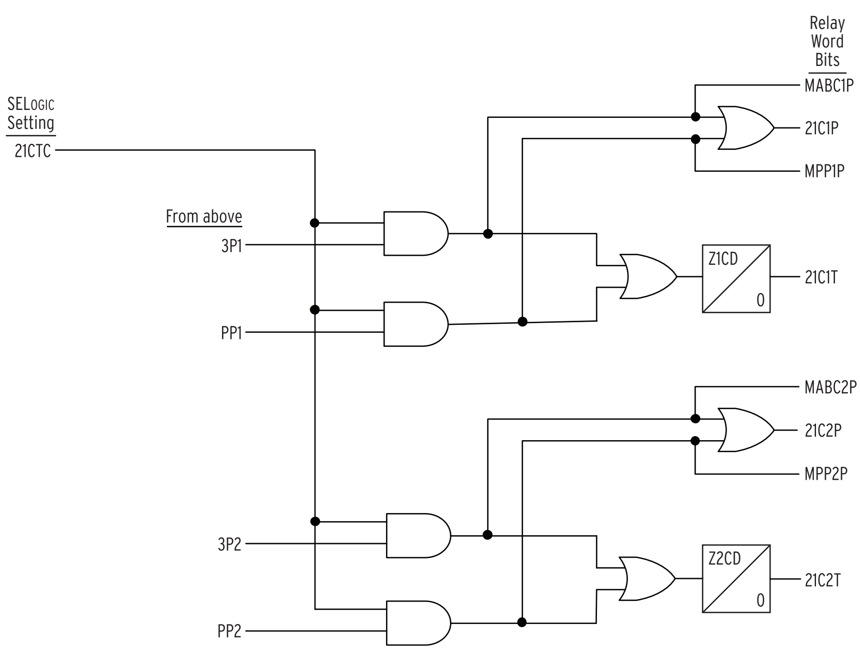


Figure 4.27 Compensator Distance Element Logic

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. This element operates for phase-to-phase and three-phase 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.

$$51CP \leq \frac{IP}{CTRX}$$

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

$$27PPX1P \bullet 0.8 \bullet \text{Vnom volts}$$

where

$$\text{Vnom} = \text{VNOM\_X} \bullet 1000/\text{PTRX}$$

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.

$$51VTC := \text{NOT LOPX}$$

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.

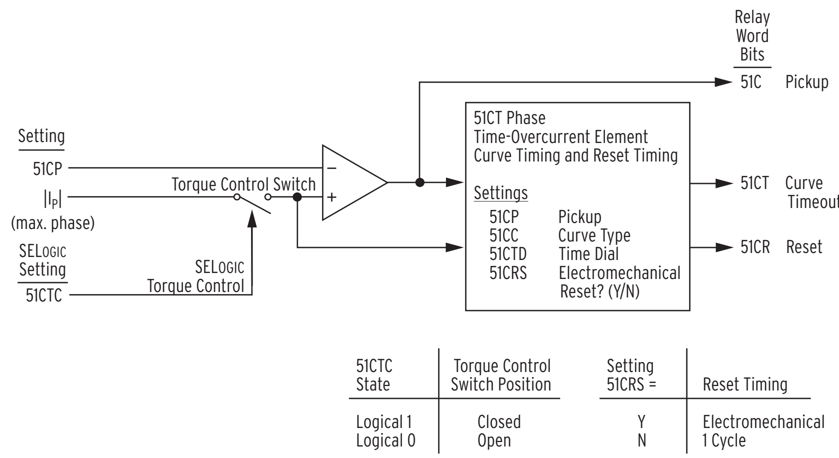


Figure 4.28 Voltage-Controlled Phase Time-Overcurrent Element 51CT

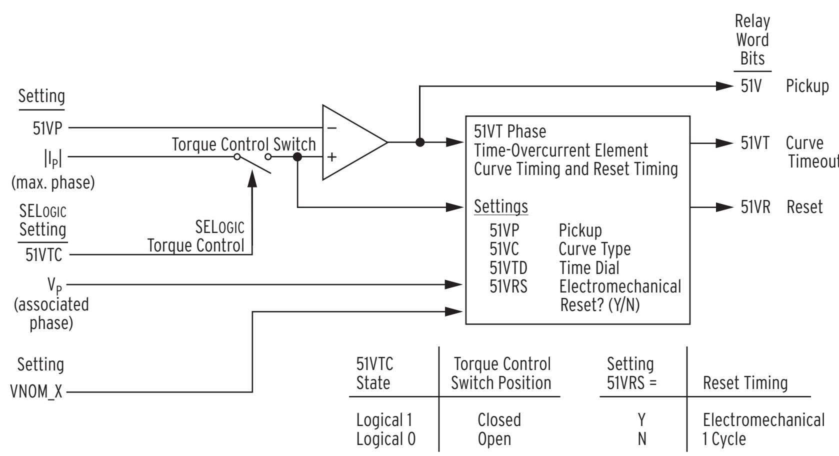


Figure 4.29 Voltage-Restrained Phase Time-Overcurrent Element 51VT

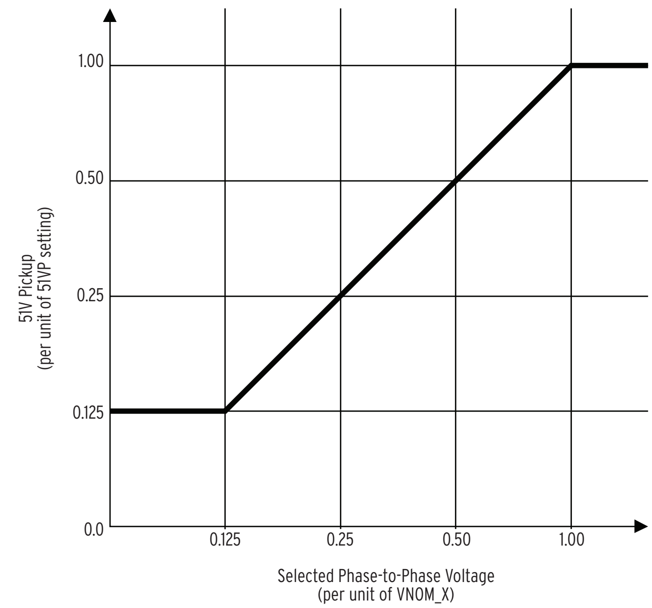


Figure 4.30 51V Element Voltage Restraint Characteristic

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.

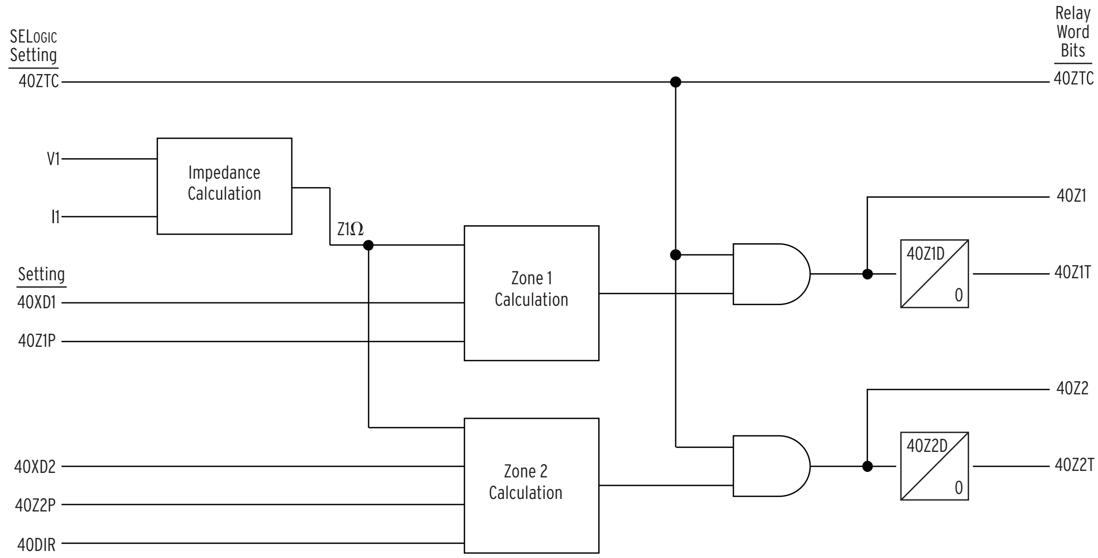


Figure 4.31 Loss-of-Field Logic Diagram

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 (Vnom = 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.

$$40Z1P = \frac{Vnom}{1.73 \bullet INOM}\ \Omega$$

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).

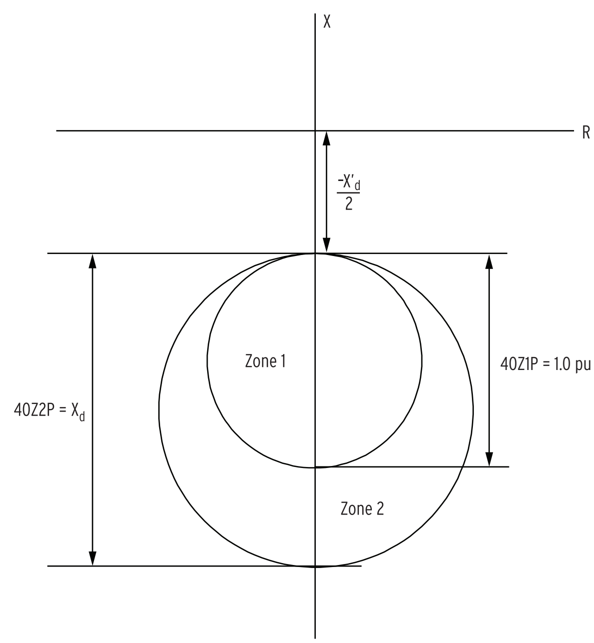


Figure 4.32 Loss-of-Field Element Operating Characteristic, Negative Zone 2 Offset

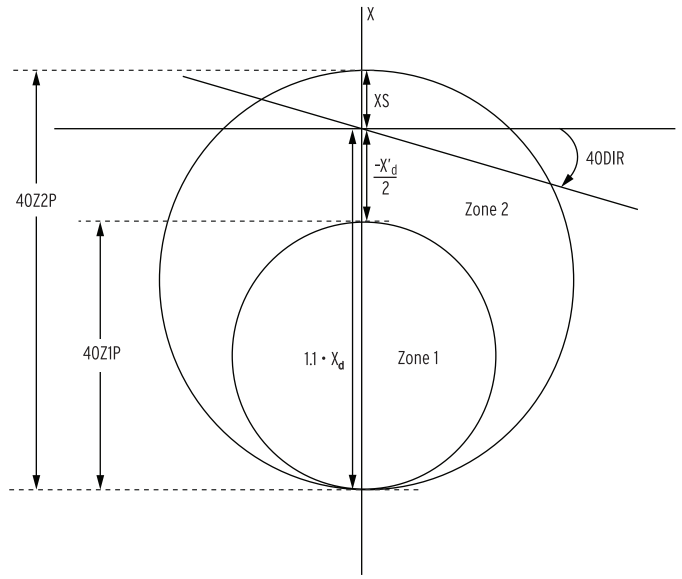


Figure 4.33 Loss-of-Field Element Operating Characteristic, Positive Zone 2 Offset

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 $I_2^2 t$.

The SEL-700G provides a negative-sequence definite time-overcurrent element suitable for unbalance alarm application and an $I_2^2 t$ 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, 2–100 %	46Q1P := 8
LVL1 TIME DELAY	0.02–999.90 s	46Q1D := 30
LVL2 NEG-SEQ O/C	OFF, 2–100 %	46Q2P := 8
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.

The 46Q1 Relay Word bit asserts without time delay when the measured negative-sequence current exceeds 46Q1P percent of INOM. 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.

The 46Q2 Relay Word bit asserts without time delay when the measured negative-sequence current is greater than 46Q2P percent of INOM. 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 –12%

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 –12%

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.

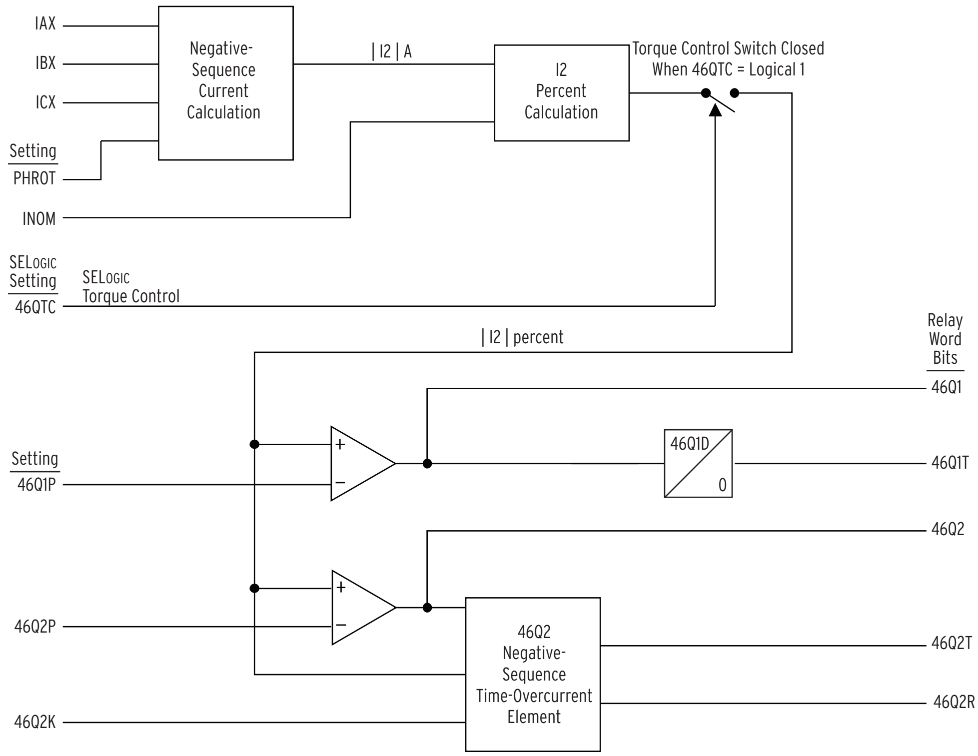
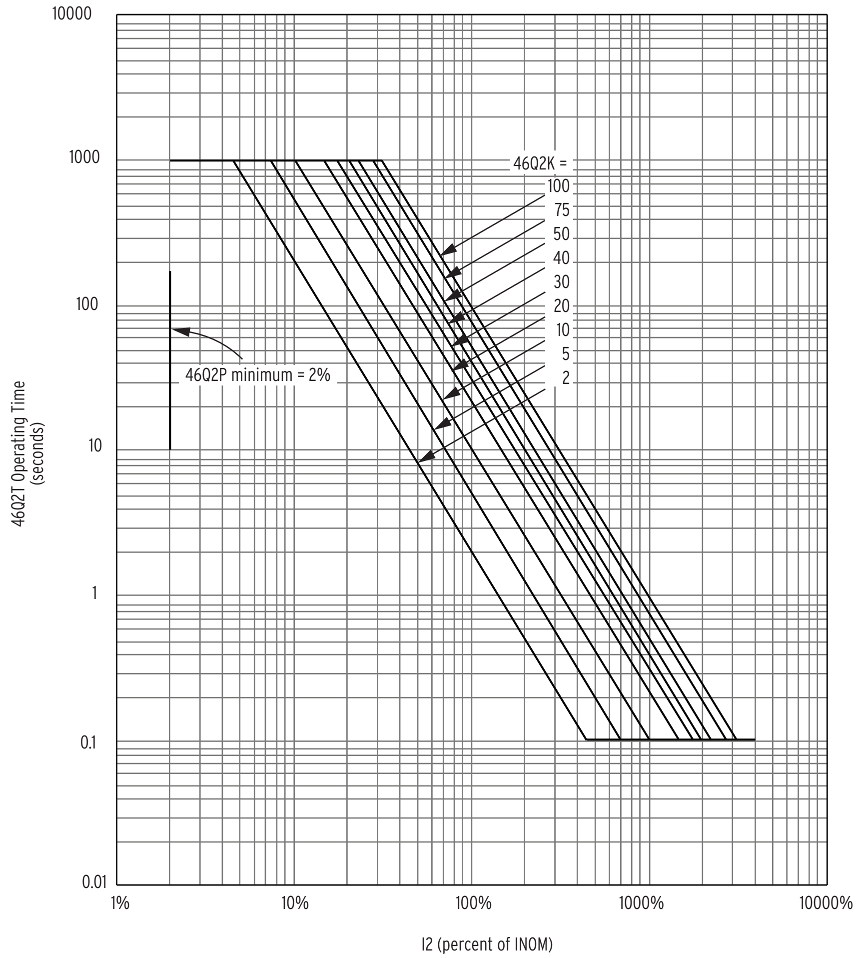


Figure 4.34 Negative-Sequence Overcurrent Element Logic Diagram



$$t_{op} = \frac{46Q2K}{\left(\frac{I2}{INOM}\right)^2} \text{ seconds}$$

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.

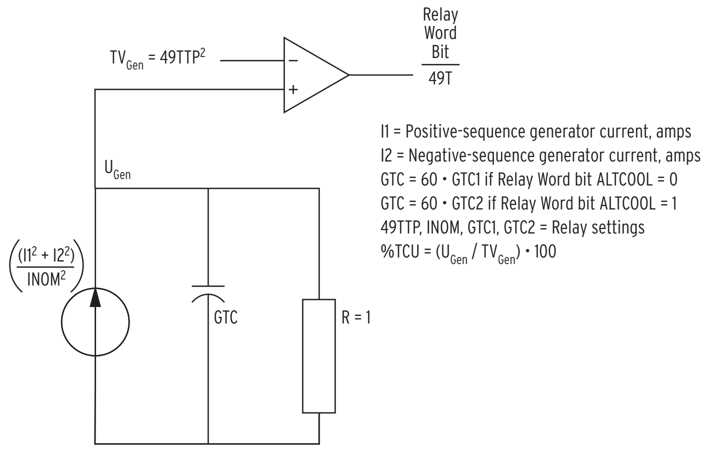


Figure 4.36 Simplified Thermal Model, Generator

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

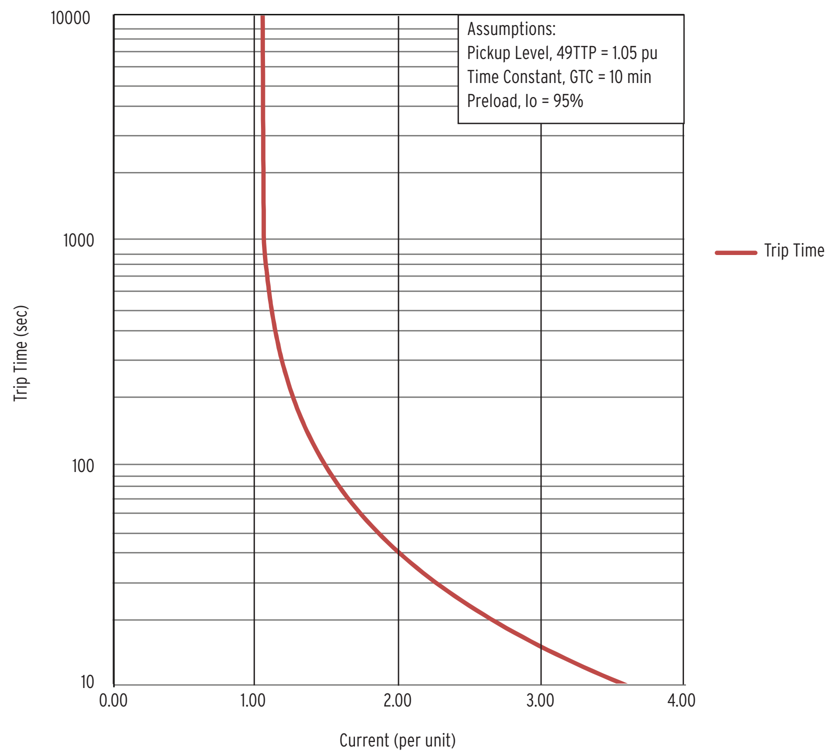


Figure 4.37 Generator Overload Curve

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.

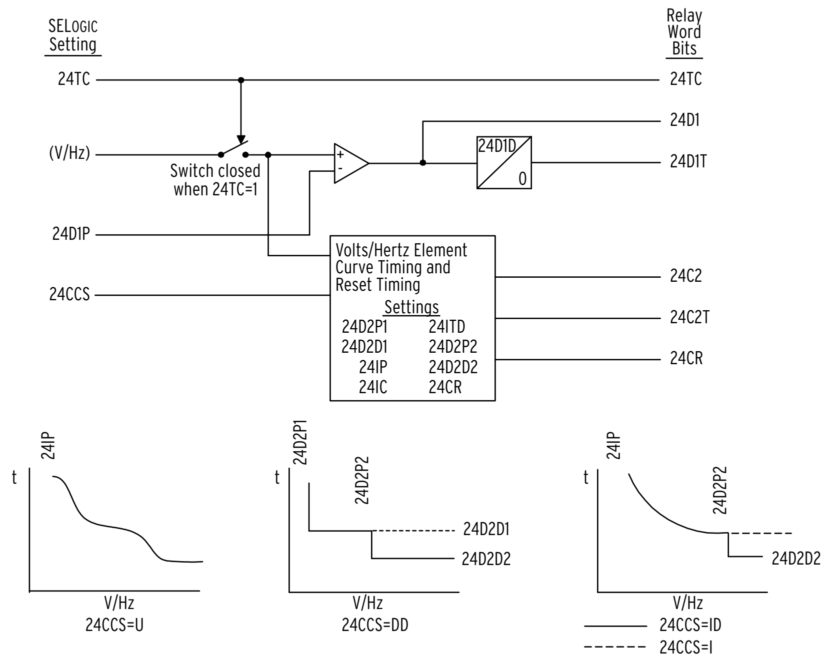


Figure 4.38 Volts/Hertz Element Logic

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, IEEE Guide for AC Generator Protection, Figure 4.5.4-1 and Figure 4.5.4-2.

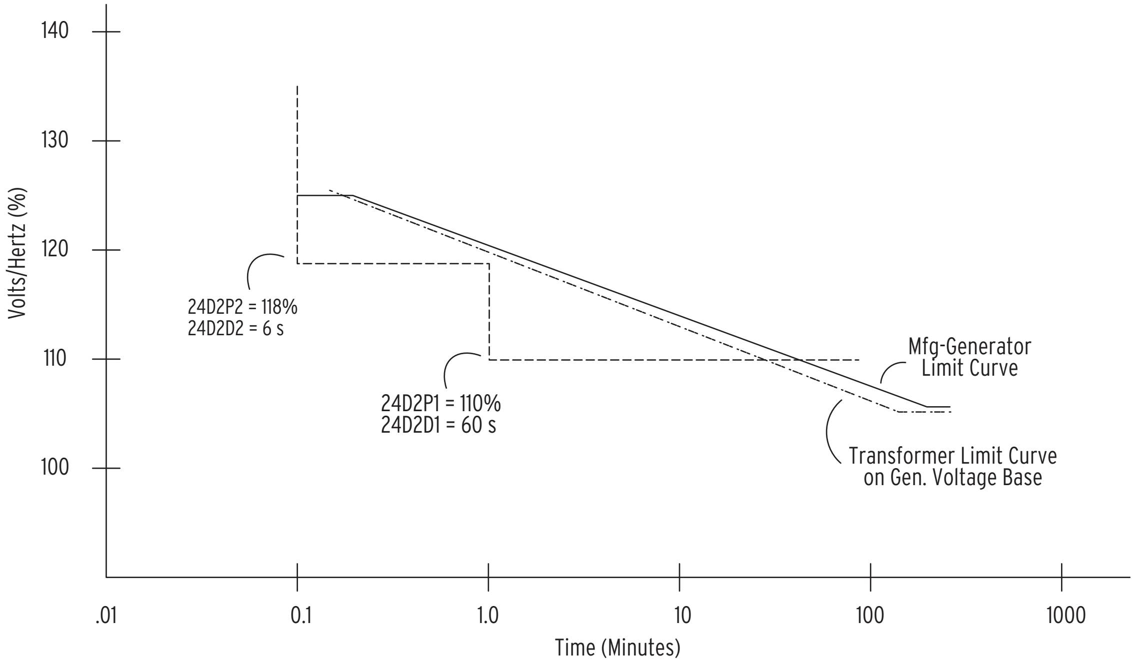


Figure 4.39 Dual-Level Volts/Hertz Time-Delay Characteristic 24CCS = DD

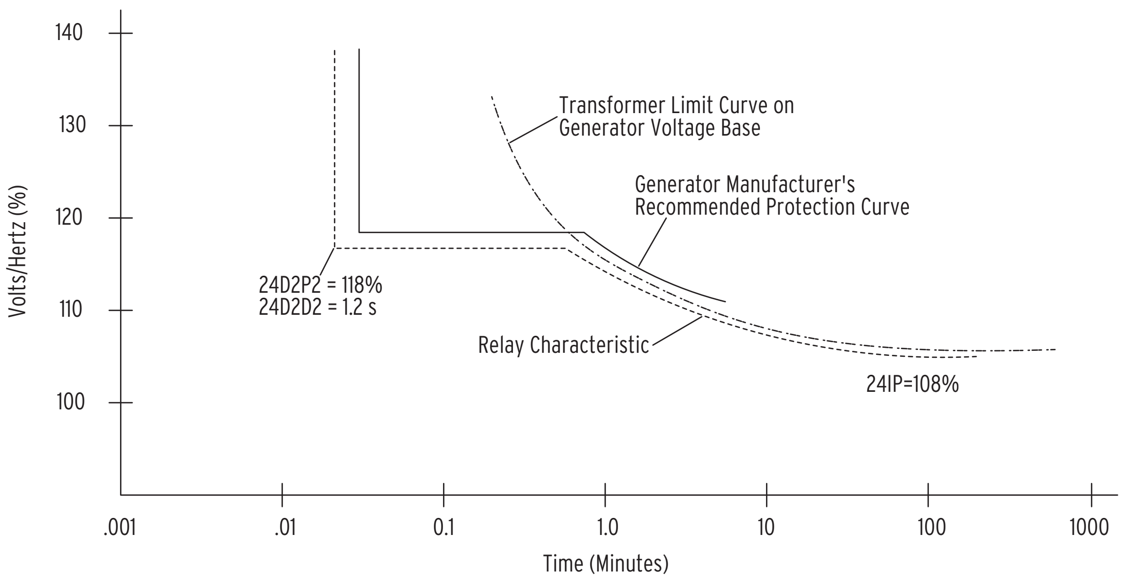


Figure 4.40 Composite Inverse/Definite-Time Overexcitation Characteristic, 24CCS = ID

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.

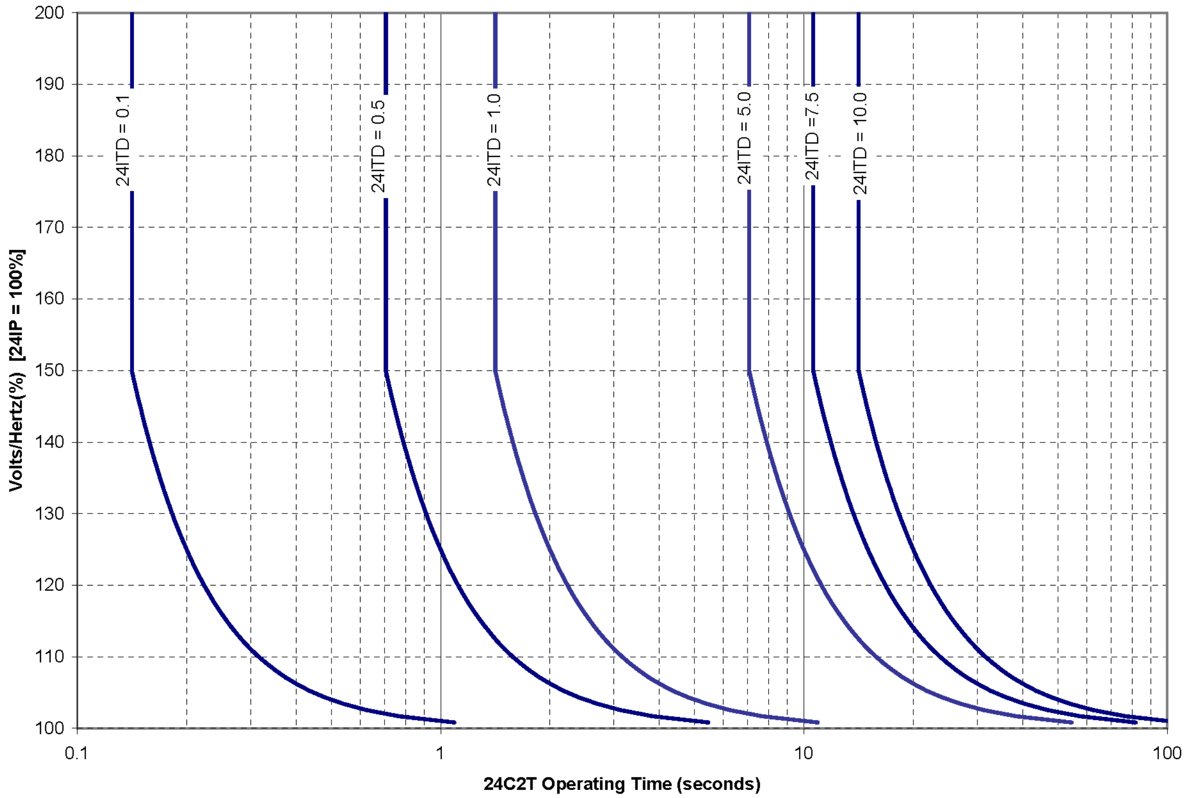
The 24CCS setting defines the overexcitation tripping element time-delay characteristic as shown in *Figure 4.38*. Set 24CCS := OFF if you do not require Level 2 volts/hertz protection. When 24CCS := OFF, the other Level 2 settings are hidden and do not need to be entered.

- When 24CCS := DD, the element operates with a dual-level definite-time characteristic with pickup and delay of 24D2Pn and 24D2Dn (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.

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.

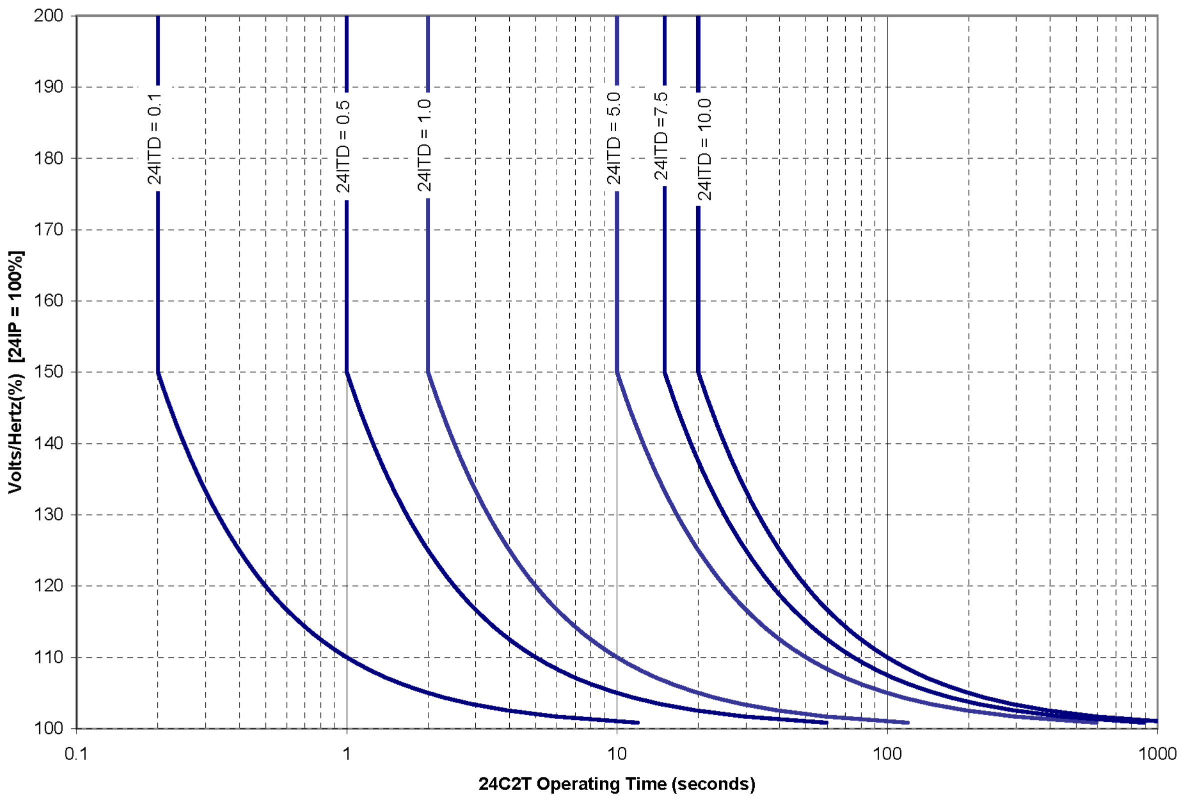
Both volts/hertz elements are disabled when the 24TC SELOGIC control equation equals logical 0. The elements are allowed to operate when the 24TC SELOGIC control equation equals logical 1, the default setting. You can add other supervisory conditions if you need these for your application.



$$t_p = \frac{24ITD}{\left(\left(\frac{\frac{VPP \bullet PTRX}{freq} \bullet \frac{FNOM}{VNOM\_X \bullet 10^3}}{\frac{24IP}{100}}\right) - 1\right)^{0.5}} \text{ seconds} \qquad \text{if V/Hz} \le 1.5 \bullet 24IP$$

$$t_p = 1.414 \bullet 24ITD \text{ seconds} \qquad \text{if V/Hz} > 1.5 \bullet 24IP$$

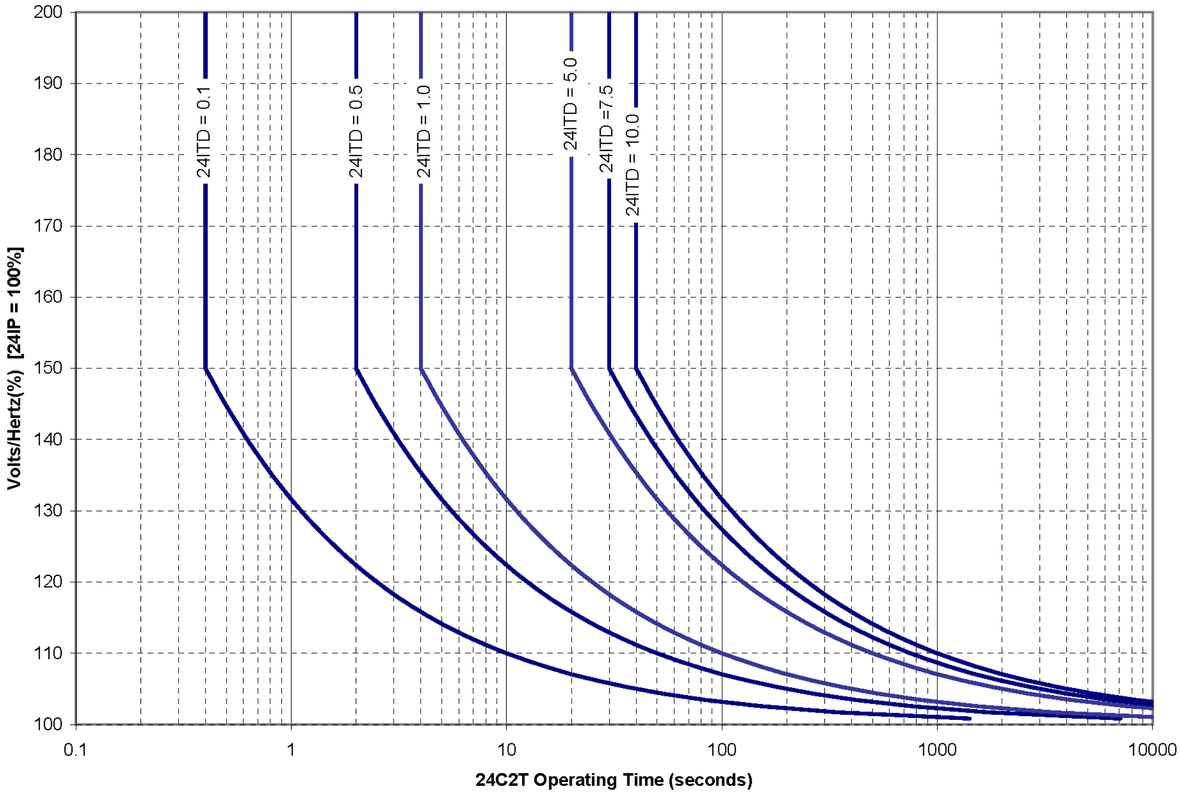
Figure 4.41 Volts/Hertz Inverse-Time Characteristic, 24IC = 0.5



$$t_p = \frac{24ITD}{\left(\left(\frac{\frac{VPP \bullet PTRX}{freq} \bullet \frac{FNOM}{VNOM\_X \bullet 10^3}}{\frac{24IP}{100}}\right) - 1\right)^{1.0}} \text{ seconds} \qquad \text{if } V/Hz \leq 1.5 \bullet 24IP$$

$$t_p = 2.0 \bullet 24ITD \text{ seconds} \qquad \text{if } V/Hz > 1.5 \bullet 24IP$$

Figure 4.42 Volts/Hertz Inverse-Time Characteristic, 24IC = 1



$$t_p = \frac{24ITD}{\left(\left(\frac{\frac{VPP \bullet PTRX}{freq} \bullet \frac{FNOM}{VNOM\_X \bullet 10^3}}{\frac{24IP}{100}}\right) - 1\right)^{2.0}} \text{ seconds} \quad \text{if } V/Hz \le 1.5 \bullet 24IP$$

$$t_p = 4.0 \bullet 24ITD \text{ seconds} \quad \text{if } V/Hz > 1.5 \bullet 24IP$$

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.

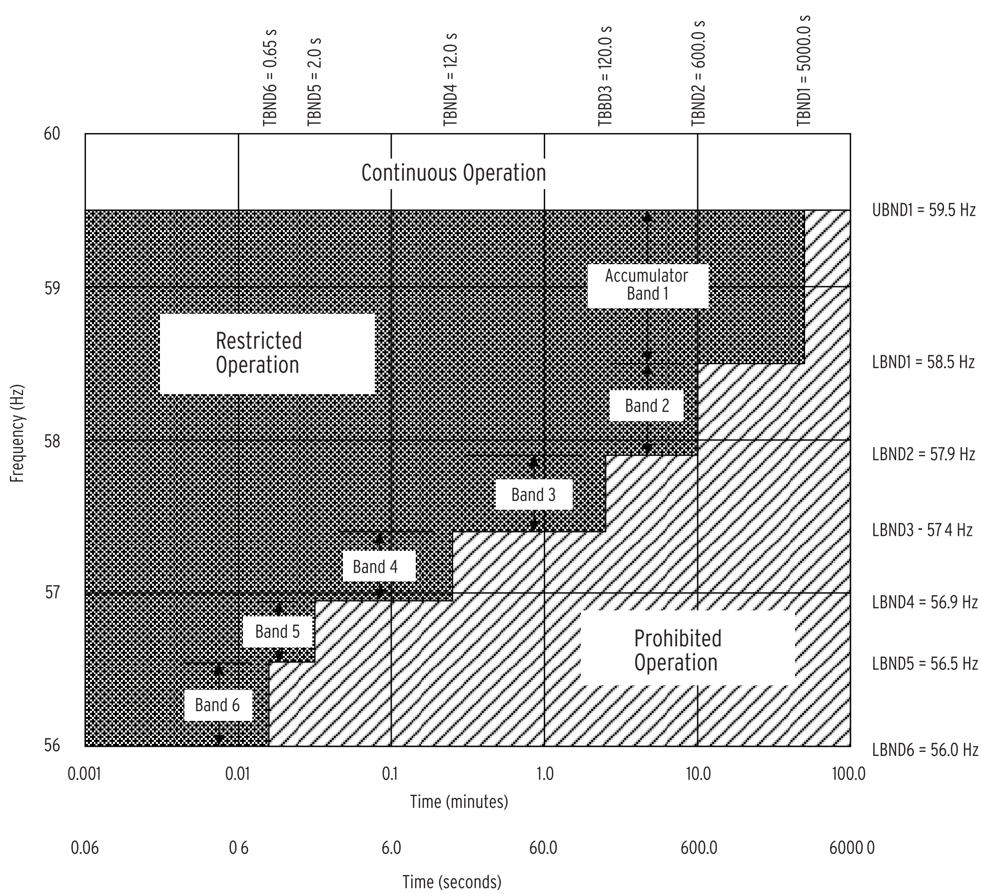


Figure 4.44 Example Turbine Operating Limitations During Abnormal Frequency

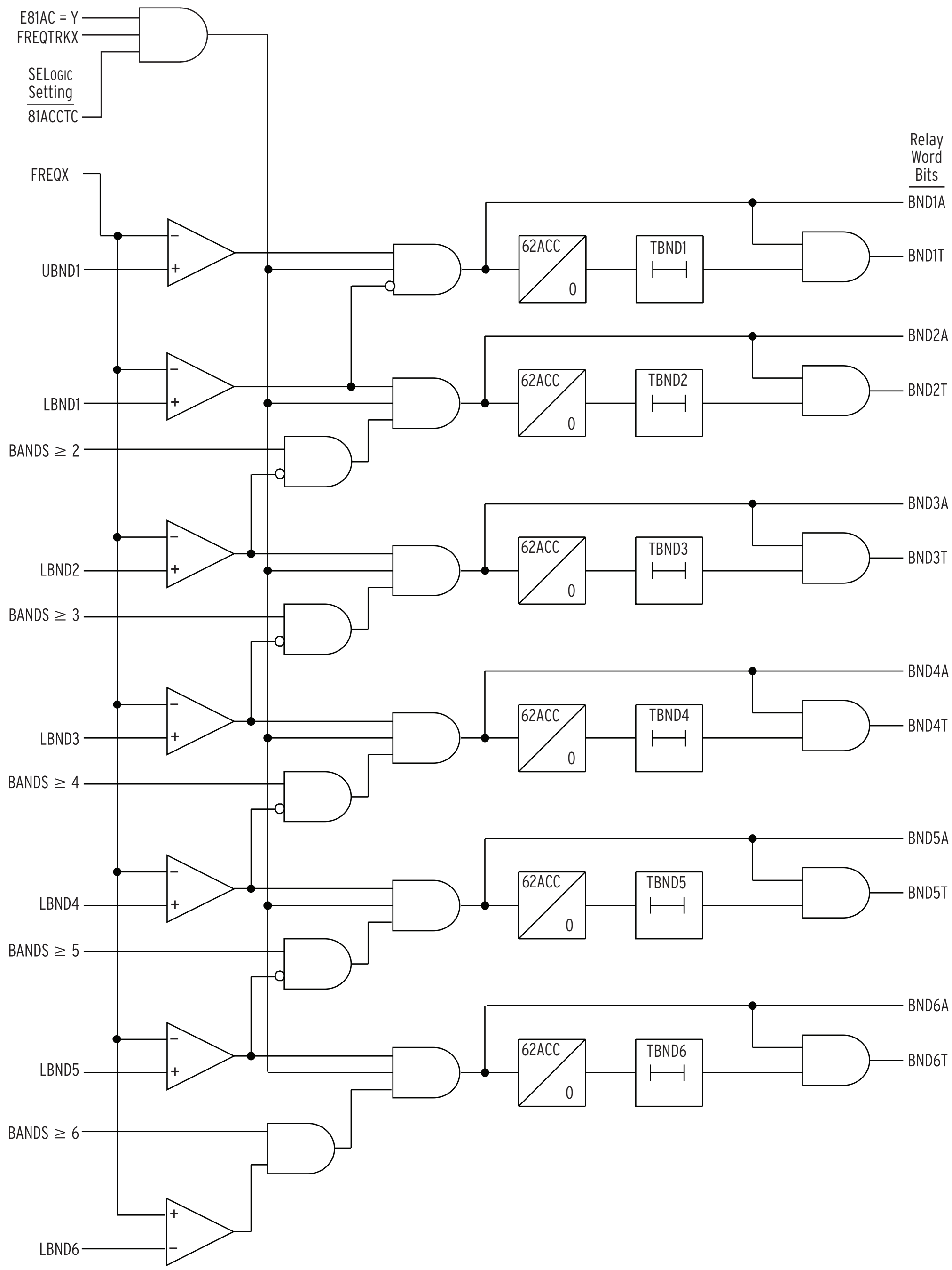


Figure 4.45 Abnormal Frequency Protection Logic Diagram

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.

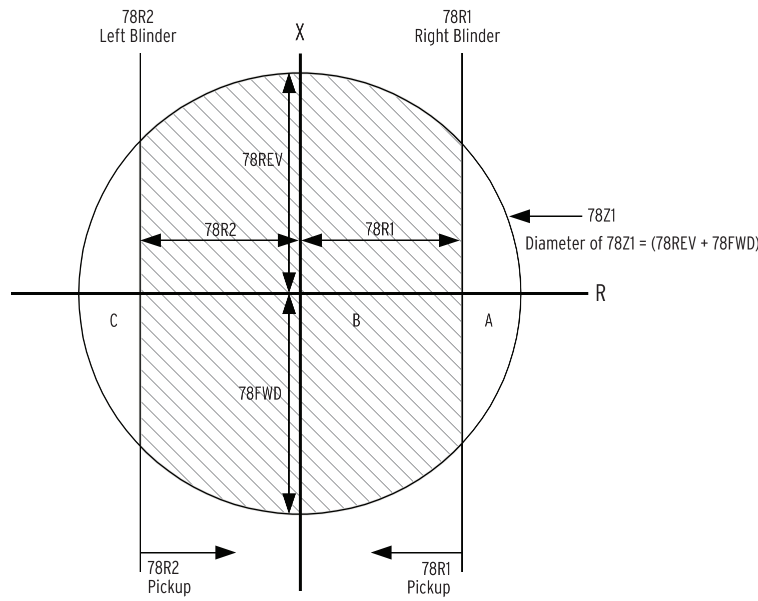


Figure 4.46 Single-Blinder Scheme Operating Characteristics

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.

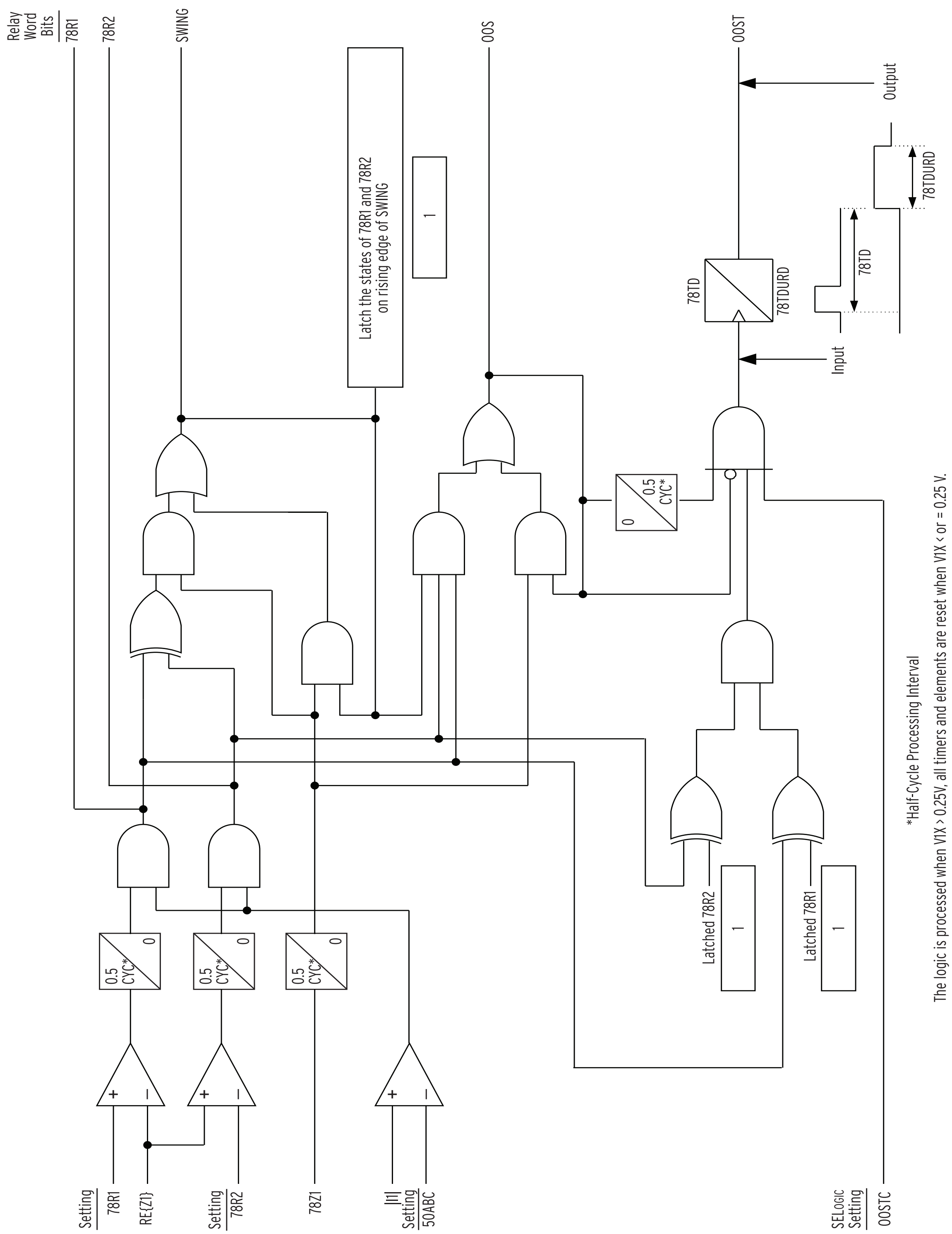


Figure 4.47 Single-Blinder Scheme Logic Diagram

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 4.192* 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

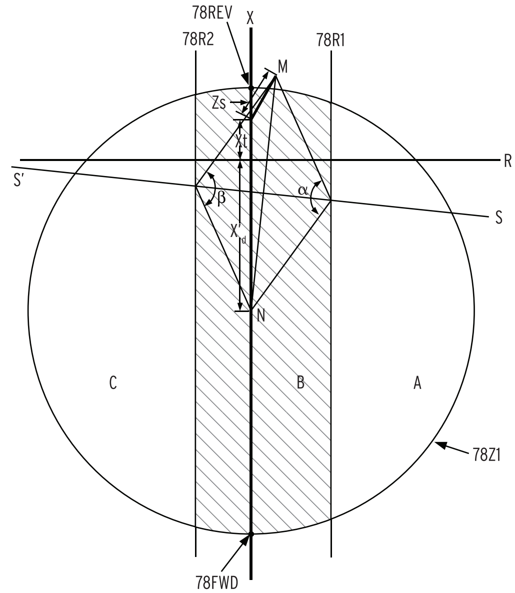
Convert all impedances to generator base kV.

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.



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 and β: Angle of Separation Between Generator and System

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.

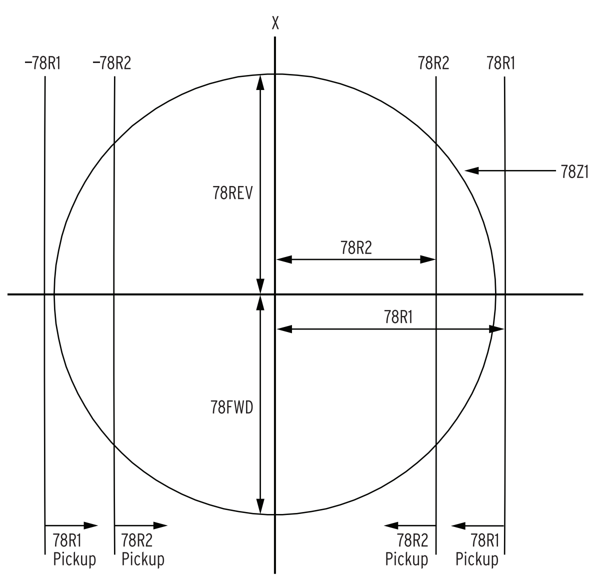


Figure 4.49 Double-Blinder Scheme Operating Characteristics

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.

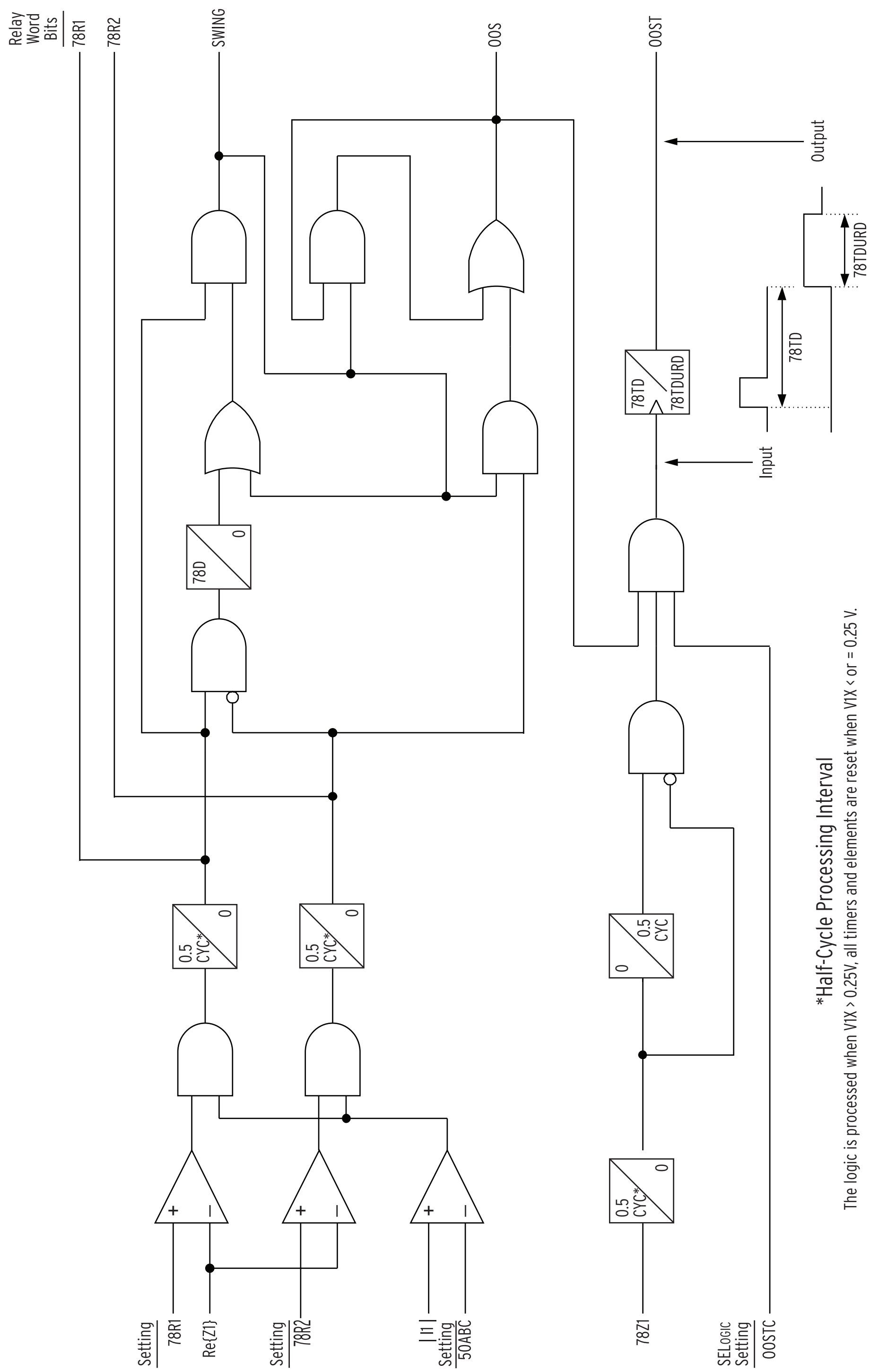


Figure 4.50 Double-Blinder Scheme Logic Diagram

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.

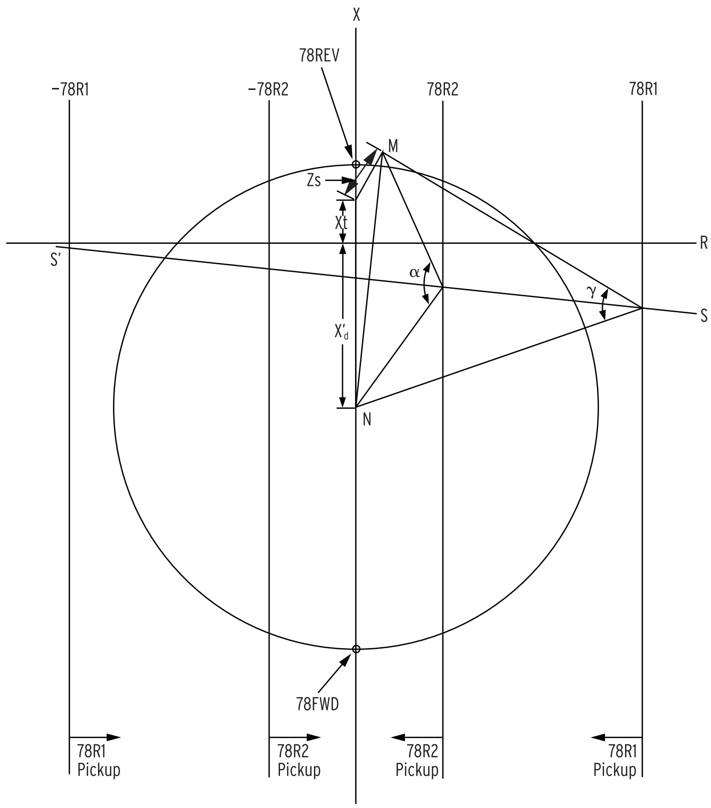
Set the inner blinder 78R2 to detect all out-of-step conditions. To do this, set the inner blinder so that the equivalent machine angle, shown in *Figure 4.51*, is approximately 120 degrees. A separation angle of 120 degrees or greater between two sources generally results in loss of synchronism.

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 reenergized 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 4.184* 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 4.185* for details. You must change the setting if your application requires a different action.

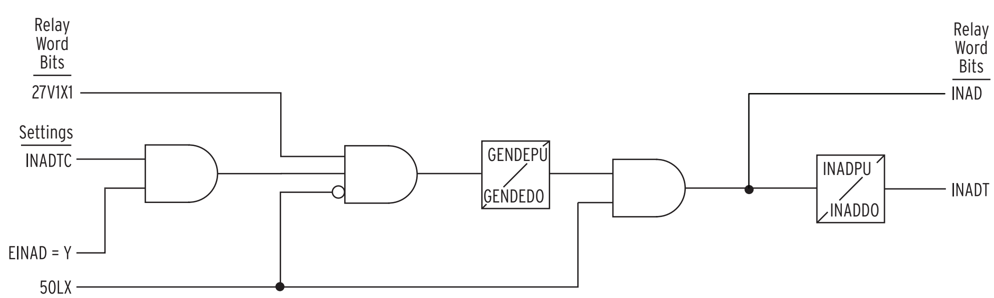


Figure 4.52 Inadvertent Energization Logic Diagram

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 4.51*) 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 4.124*). 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]	50Pm1P := OFF
PHASE IOC DELAY	0.00–400.00 s	50Pm1D := 0.00
PH IOC TRQCTRL	SELOGIC	50Pm1TC := 1
PHASE IOC LEVEL	OFF, 0.50–96.00 A[b]	50Pm2P := OFF
PHASE IOC DELAY	0.00–400.00 s	50Pm2D := 0.00
PH IOC TRQCTRL	SELOGIC	50Pm2TC := 1
PHASE IOC LEVEL	OFF, 0.50–96.00 A[b]	50Pm3P := OFF
PHASE IOC DELAY	0.00–400.00 s	50Pm3D := 0.00
PH IOC TRQCTRL	SELOGIC	50Pm3TC := 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.

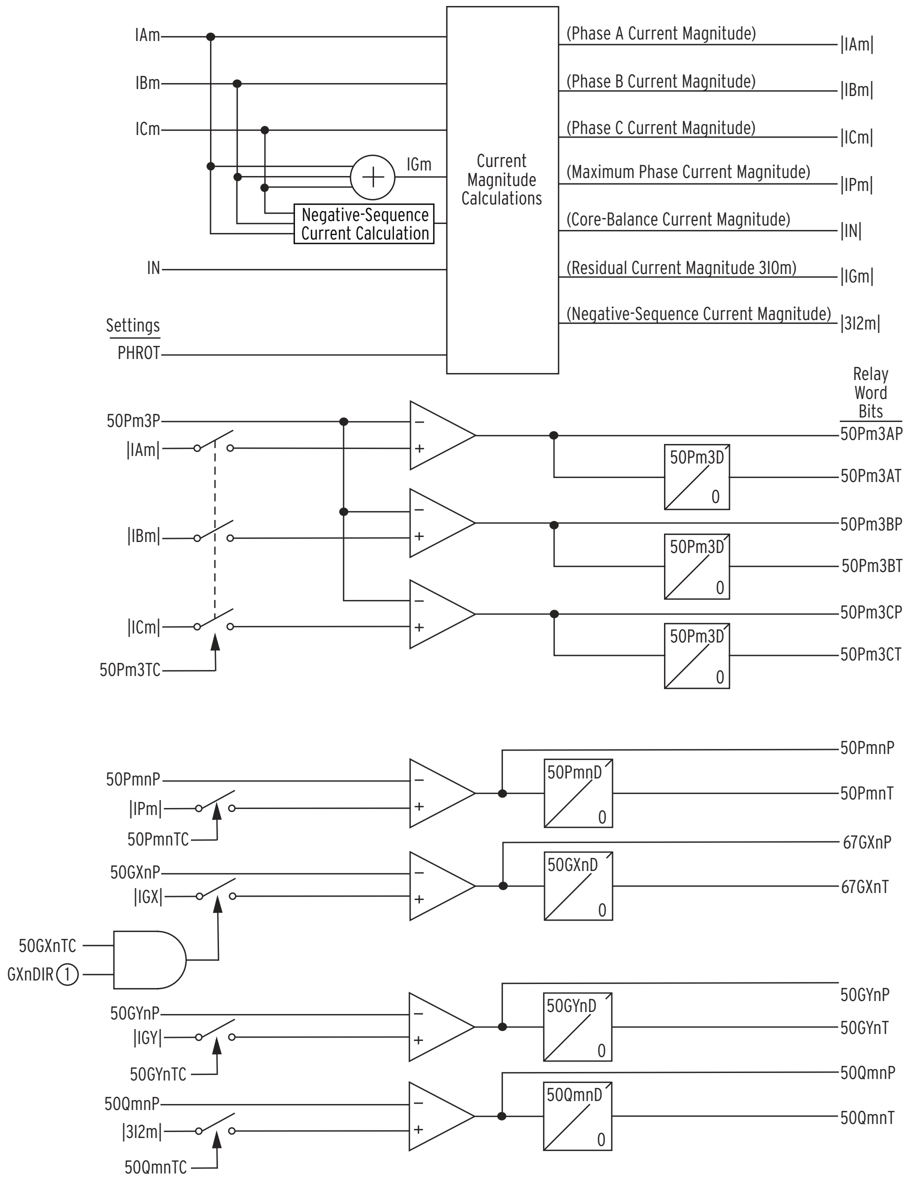
The 50P*m*3 individual phase overcurrent elements are three single-phase overcurrent elements with common pickup and delay settings. *Figure 2.22* shows a typical application using window CTs for differential protection of split-phase winding. The individual phase elements facilitate identification of 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 4.192* and *Table K.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	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	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*).

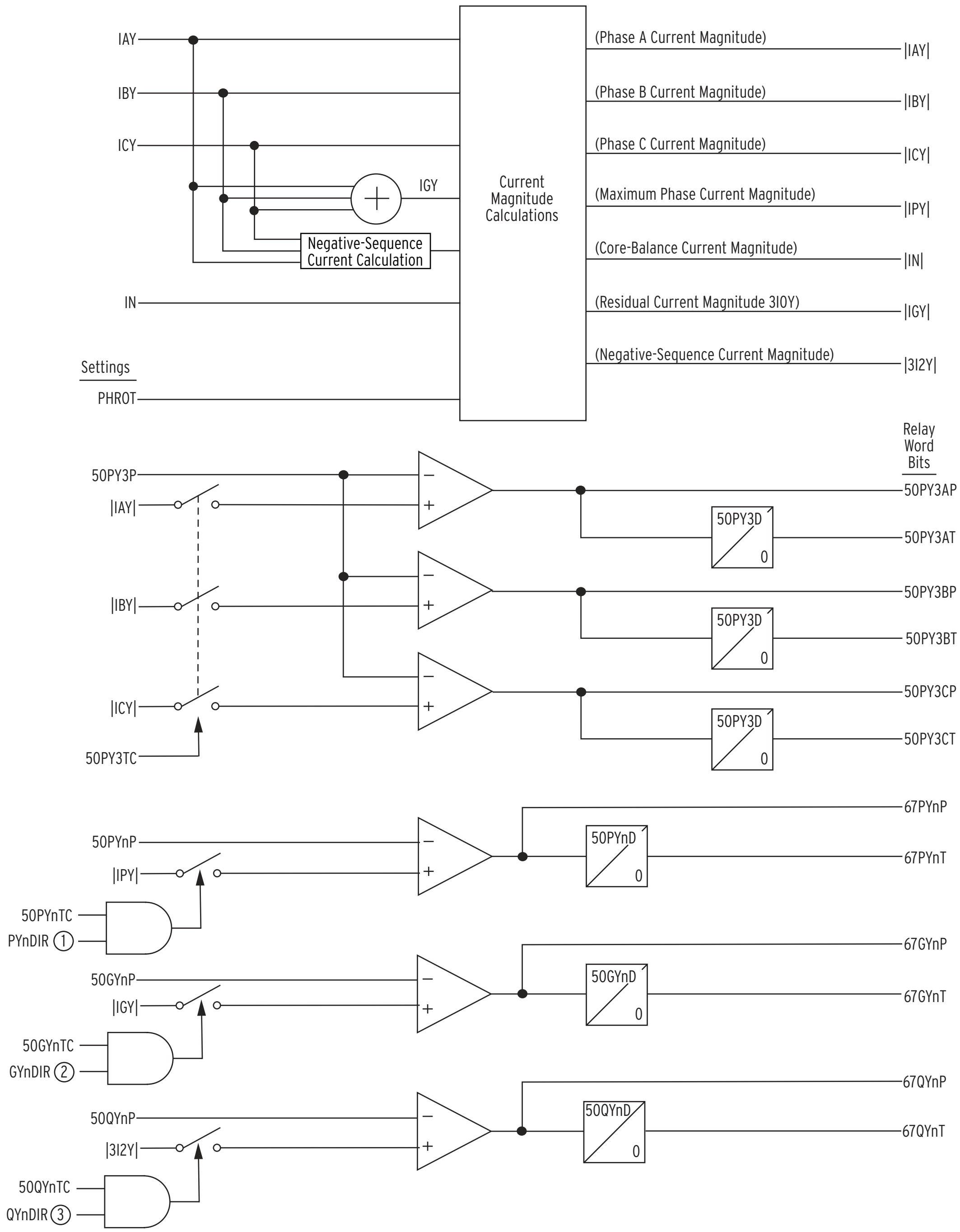


① Figure 4.83
m = X or Y (Y-side elements apply to SEL-700G1 only)
n = 1 or 2

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-700GT+ Instantaneous Overcurrent Element Logic (Generator Protection)



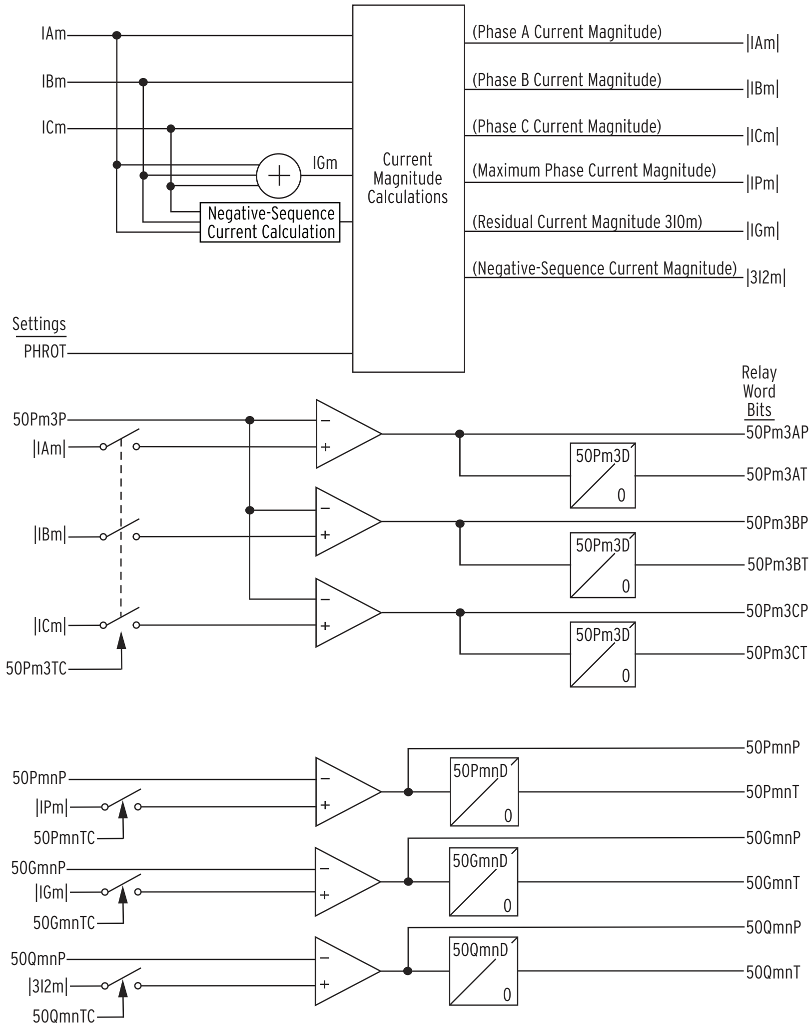
① From Figure 4.90 ② From Figure 4.83 ③ From Figure 4.89

n = 1 or 2.

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)

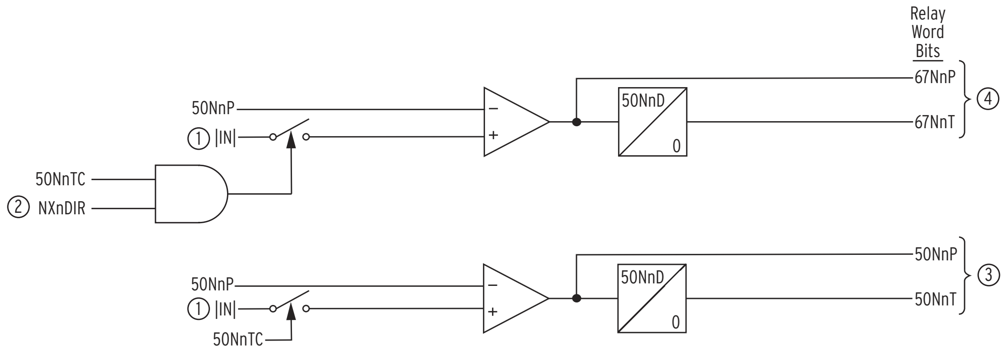


m = X or Y; n = 1 or 2.

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.

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.

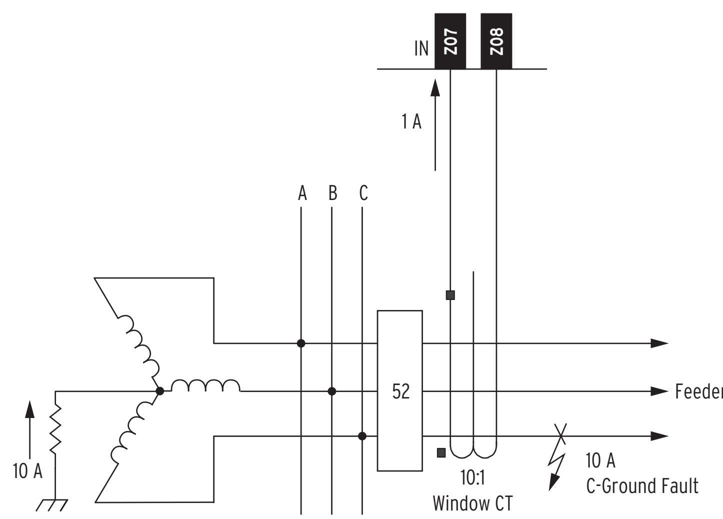


Figure 4.57 Ground Fault Protection Using Core-Balance CT

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	0.00–400.00 s	50P*m*1D := 0.50
RES IOC TRQCTRL	SELOGIC	50P*m*1TC := 1
RES IOC LEVEL	OFF, 0.50–96.00 A[b]	50G*m*2P := OFF
RES IOC DELAY	0.00–400.00 s	50P*m*2D := 0.50
RES IOC TRQCTRL	SELOGIC	50P*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	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	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.

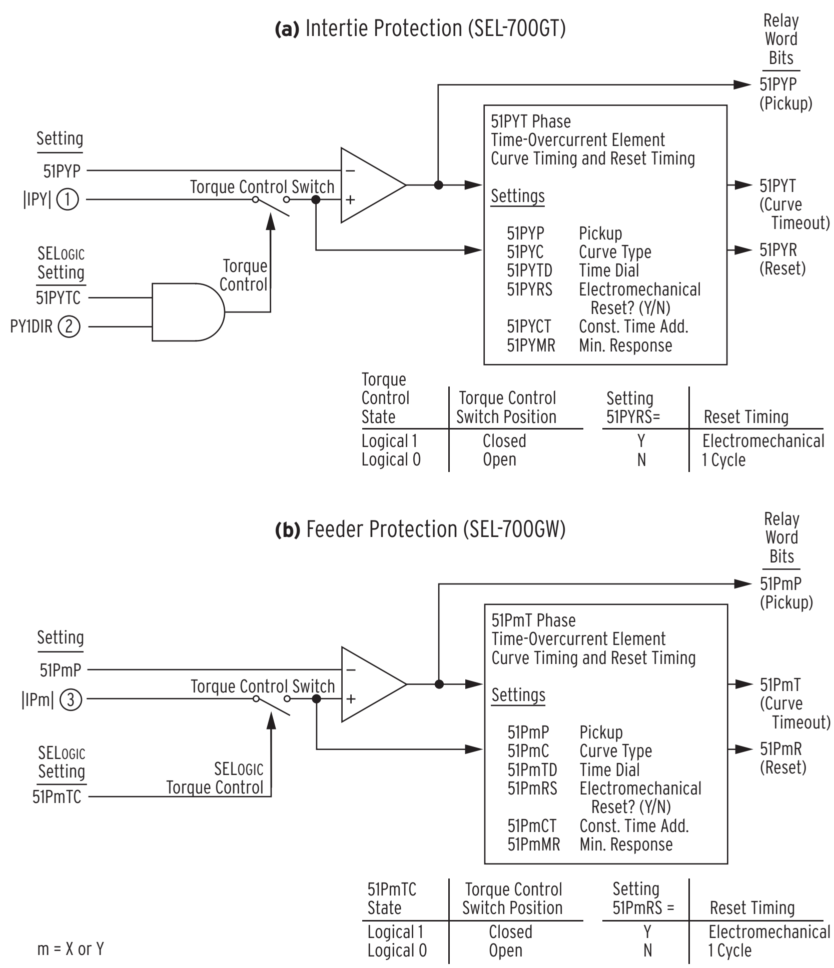
You can use appropriate SELOGIC control equations (for example, when 51NTC := IN401, the 51N element operates only if IN401 is asserted) to torque control each element. You can also control the elements by directional elements depending on the relay model number (refer to *Table 1.2*). Directional elements 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*.



① From Figure 4.54 ② From Figure 4.90 ③ From Figure 4.55

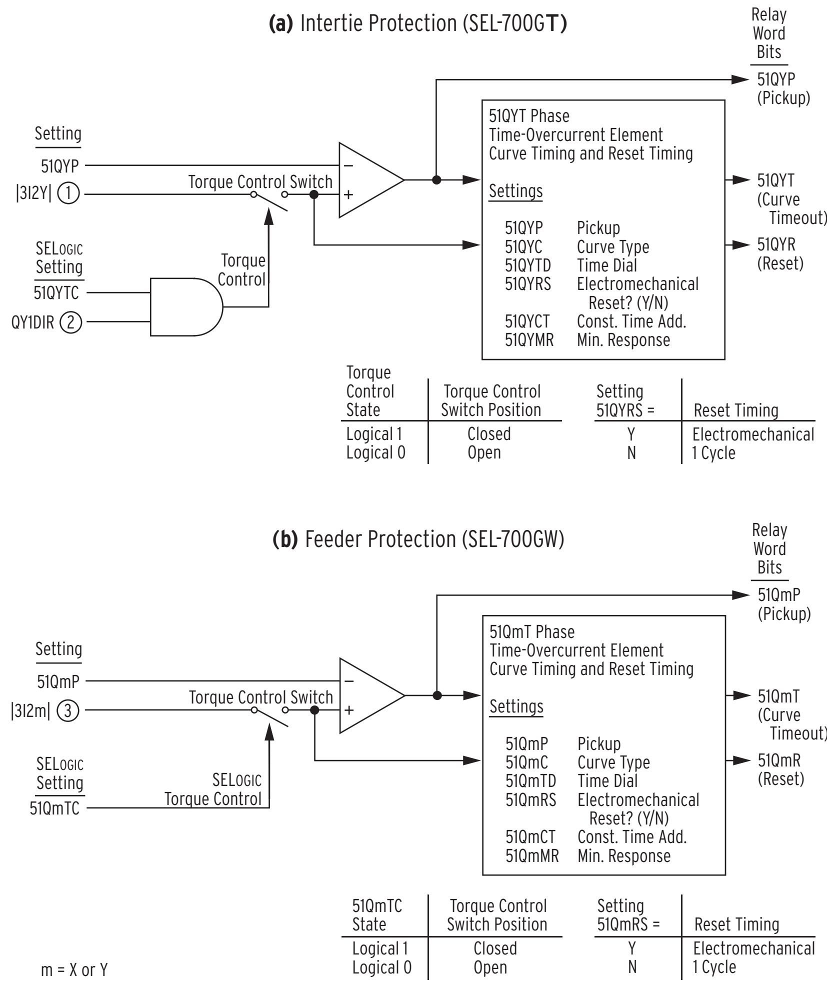
Figure 4.58 Maximum Phase Time-Overcurrent Elements

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

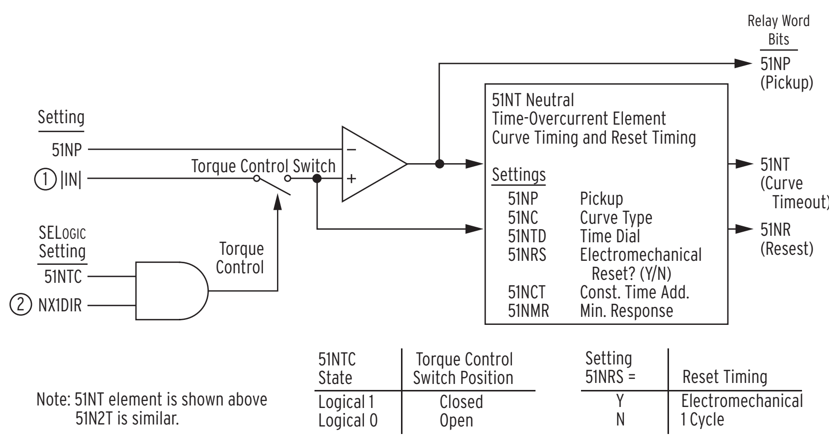
False negative-sequence current can appear transiently when a circuit breaker is closed and a balanced load current suddenly appears. To avoid tripping for this transient condition, do not use a time-dial setting that results in curve times below three cycles.

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

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
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*.

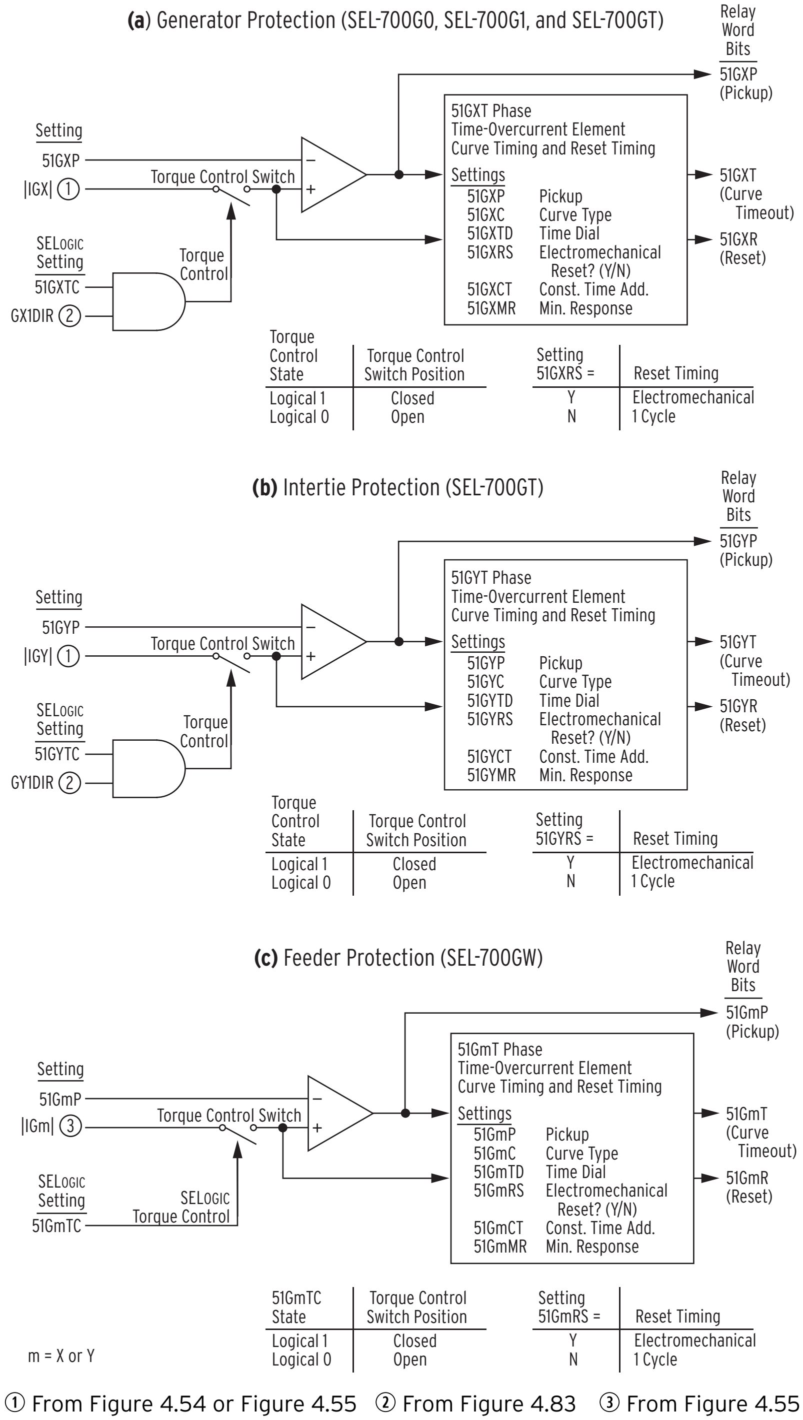


Figure 4.61 Residual Time-Overcurrent Elements

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, IEEE 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]

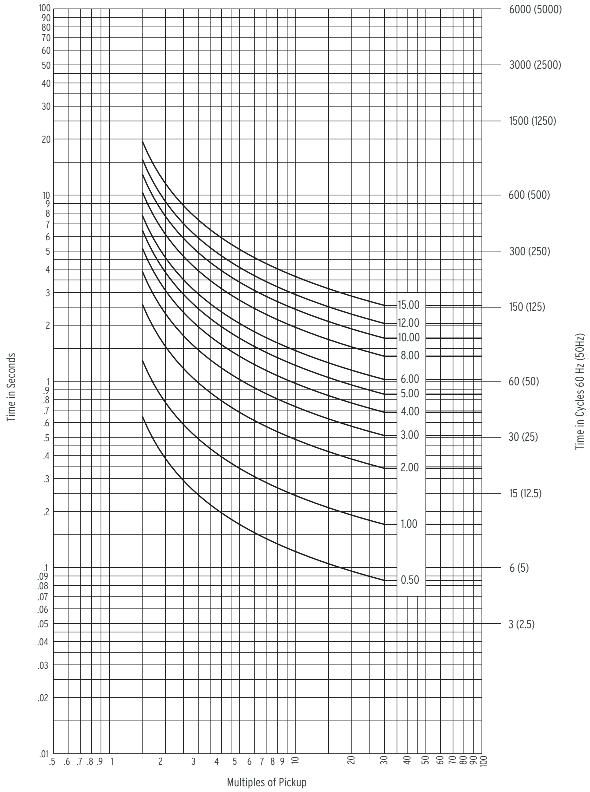


Figure 4.62 U.S. Moderately Inverse Curve: U1

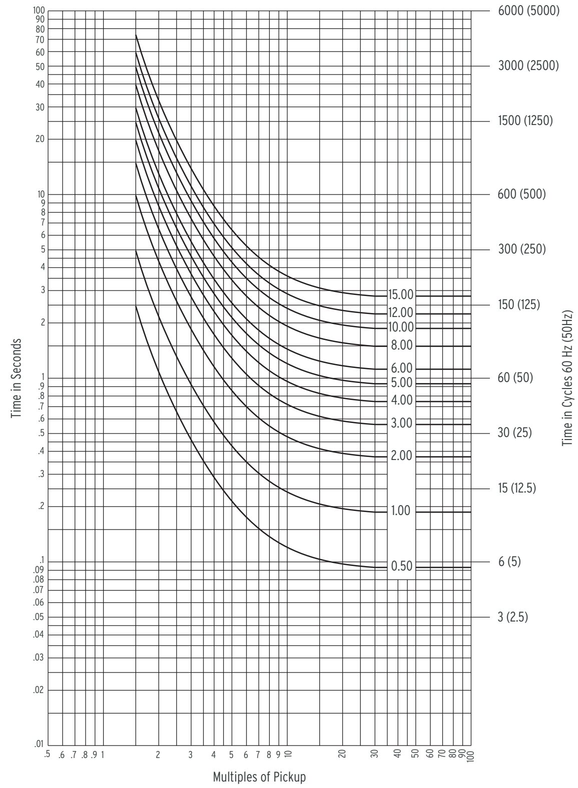


Figure 4.63 U.S. Inverse Curve: U2

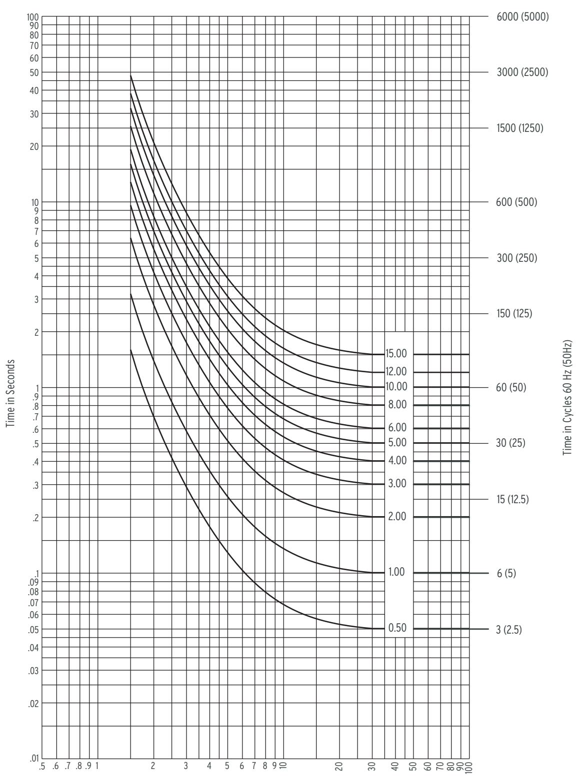


Figure 4.64 U.S. Very Inverse Curve: U3

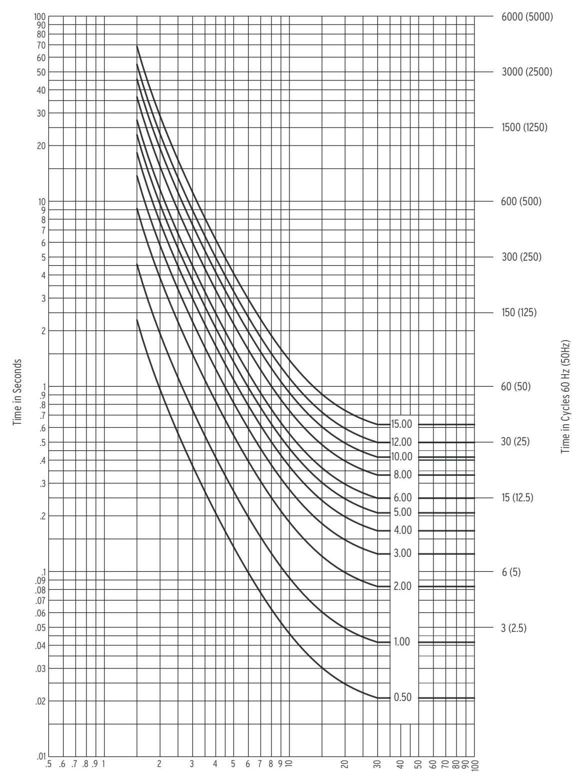


Figure 4.65 U.S. Extremely Inverse Curve: U4

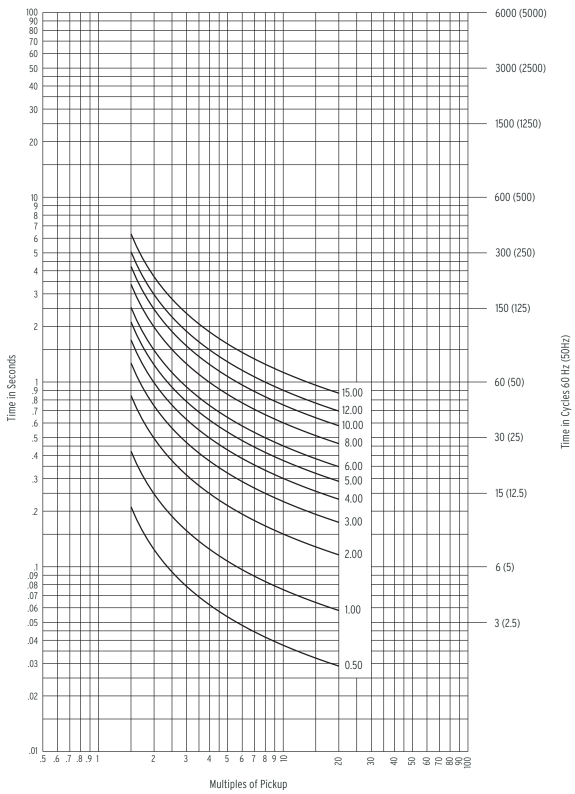


Figure 4.66 U.S. Short-Time Inverse Curve: U5

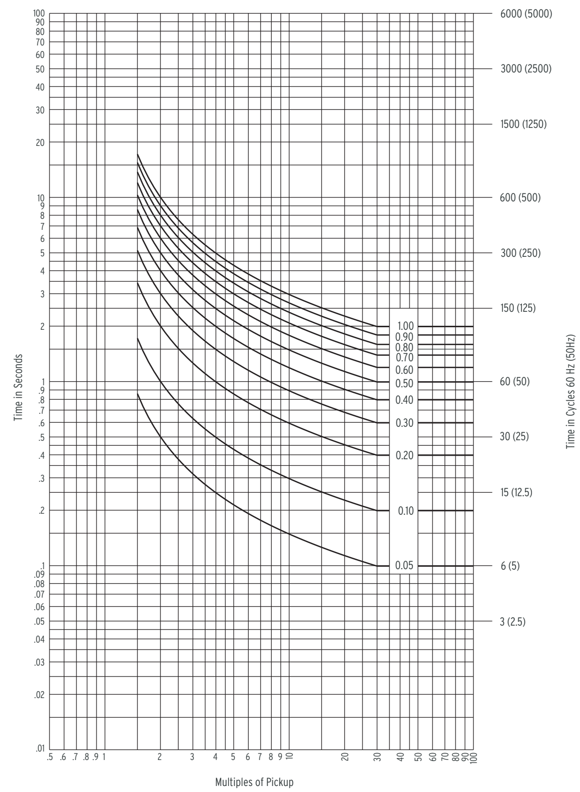


Figure 4.67 IEC Class A Curve (Standard Inverse): C1

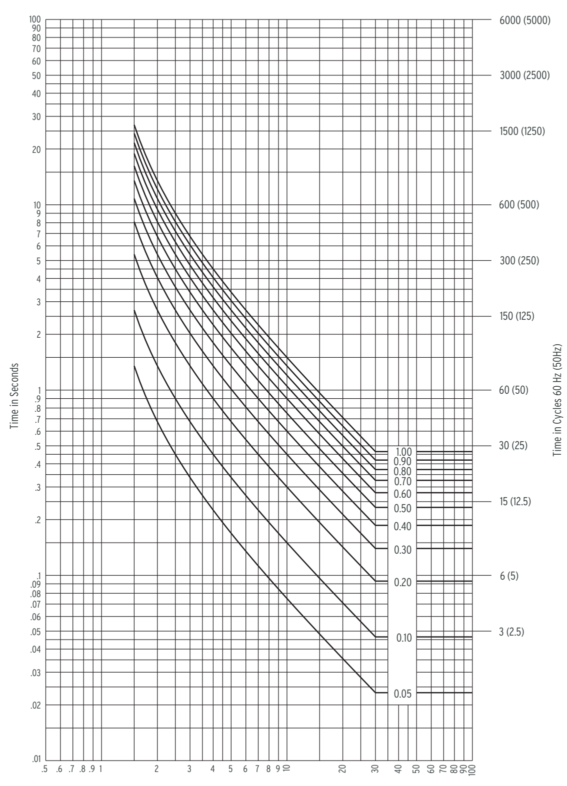


Figure 4.68 IEC Class B Curve (Very Inverse): C2

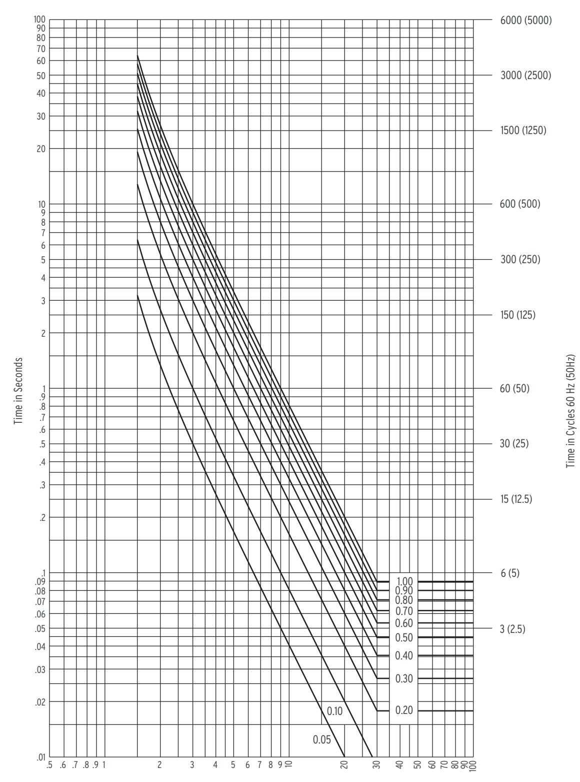


Figure 4.69 IEC Class C Curve (Extremely Inverse): C3

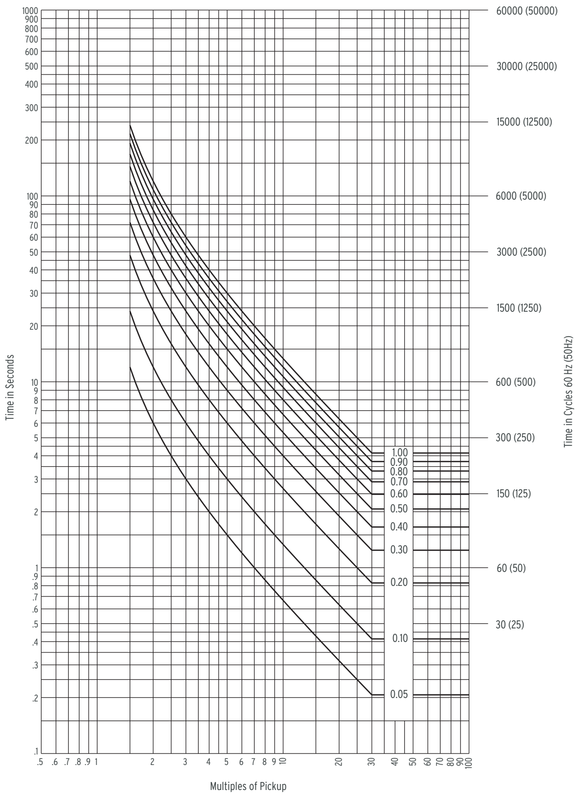


Figure 4.70 IEC Long-Time Inverse Curve: C4

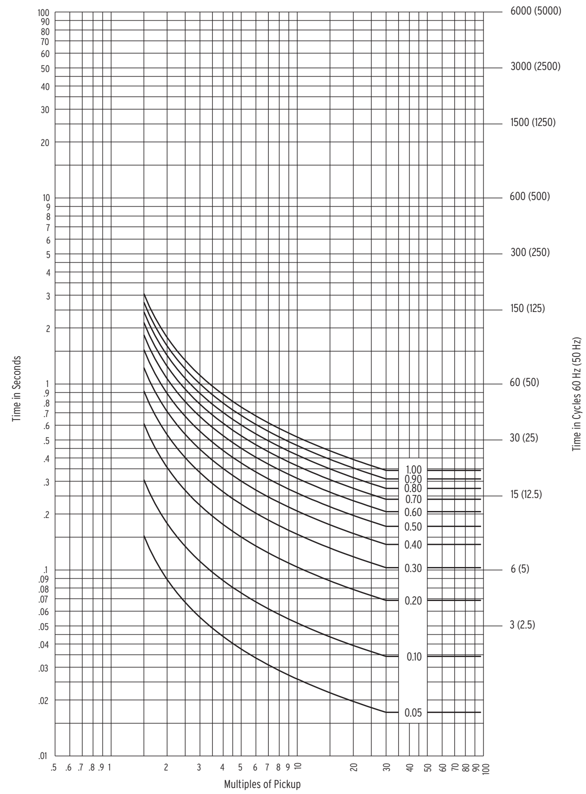


Figure 4.71 IEC Short-Time Inverse Curve: C5

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 4.120*.

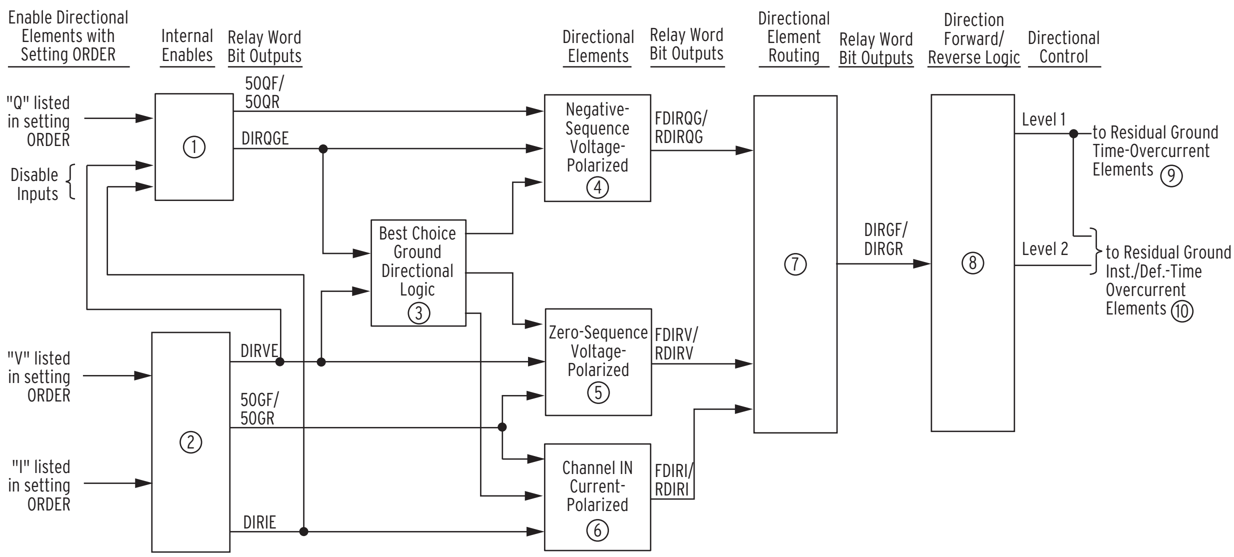
Directional Control for Residual and Neutral Overcurrent Elements

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)

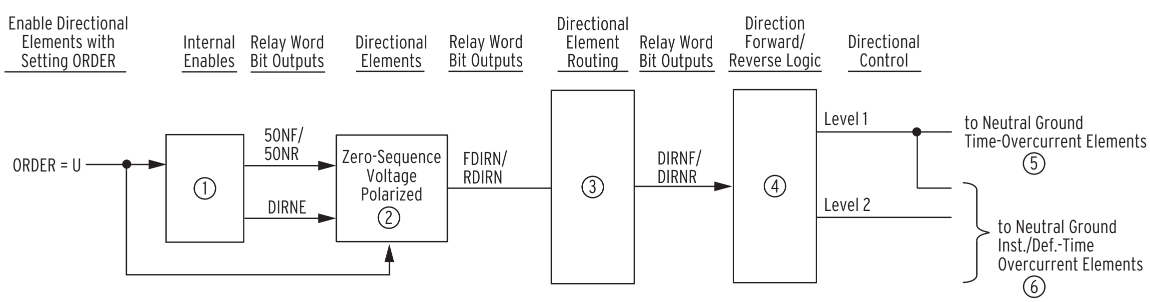
See *Figure 4.72* and *Figure 4.73* for an overview of how these directional elements are enabled and routed to control the residual-ground overcurrent elements and neutral-ground overcurrent elements respectively. Note in *Figure 4.72* and *Figure 4.73* that the ORDER setting enables the directional 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 4.120*.



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



① Figure 4.76 ② Figure 4.80 ③ Figure 4.82 ④ Figure 4.84 ⑤ Figure 4.60 ⑥ Figure 4.56
Order = U can only be set on the X side.

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 2.18*, *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 2.18*, *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 2.16* and *Figure 2.25*.

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 2.16*). 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 2.16* 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 4.105* 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 4.120*.

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 4.120* 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.

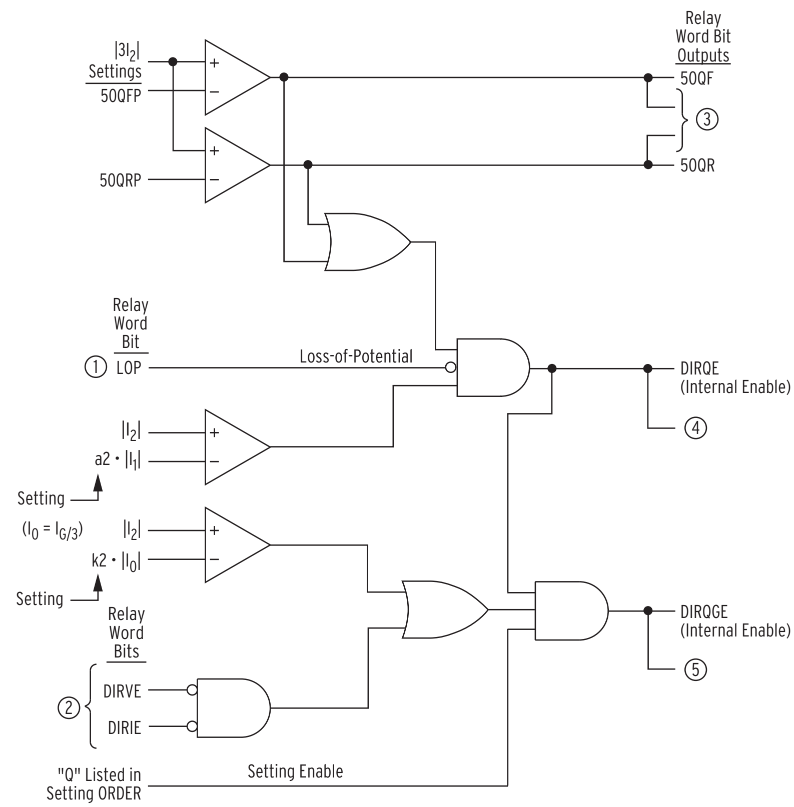
If a level direction setting (for example, DIR1) is set as follows,

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.

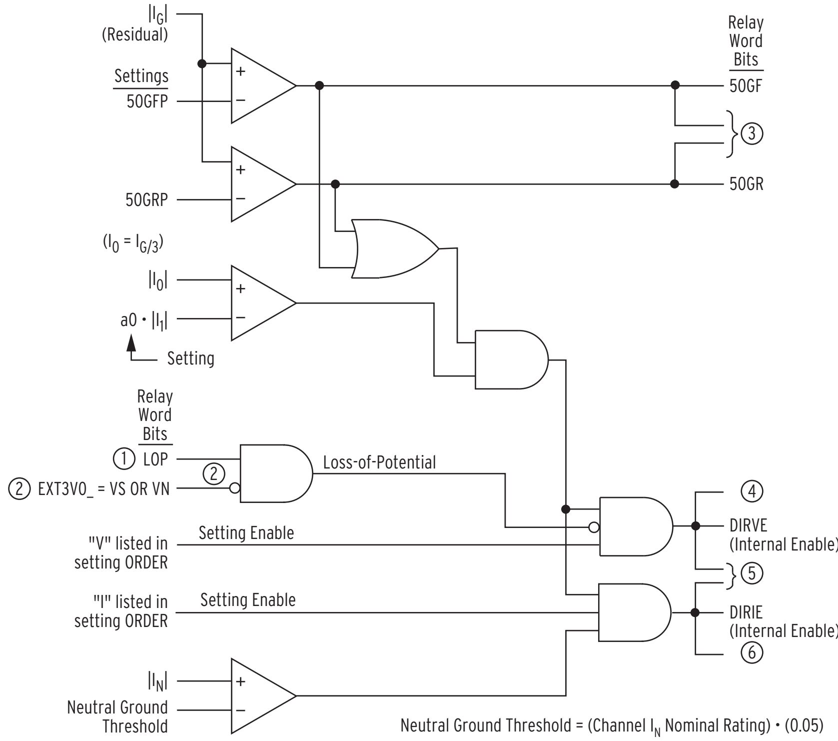
See the beginning of *Directional Control Settings on page 4.120* for a discussion on the operation of level direction settings DIR1 and DIR2 when the directional control enable setting EDIR is set to EDIR := N.

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 4.132* describes how to avoid this limitation for special cases.



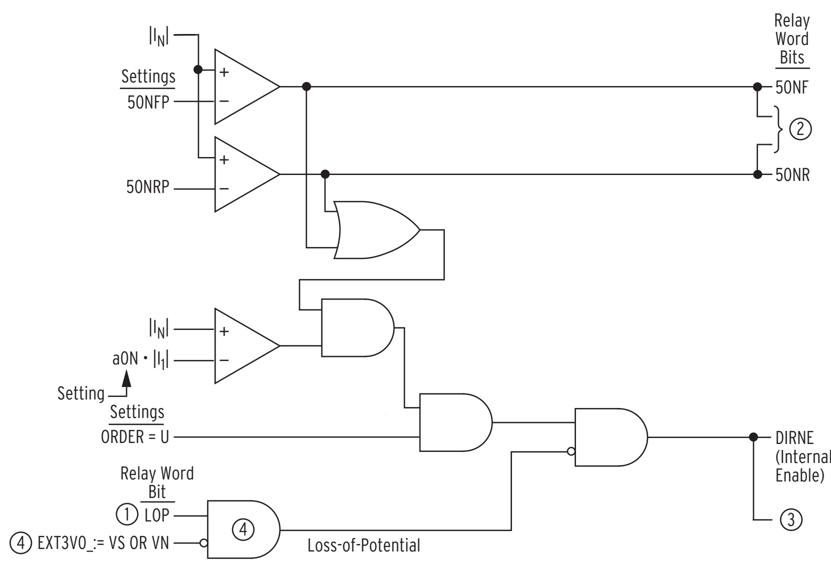
① From Figure 4.120 ② From Figure 4.75 ③ To Figure 4.77 and Figure 4.86
④ To Figure 4.86 ⑤ To Figure 4.77, Table 4.27 and Table 4.28

Figure 4.74 Internal Enables (DIRQE and DIRQGE) Logic for Negative-Sequence Voltage-Polarized Directional Elements



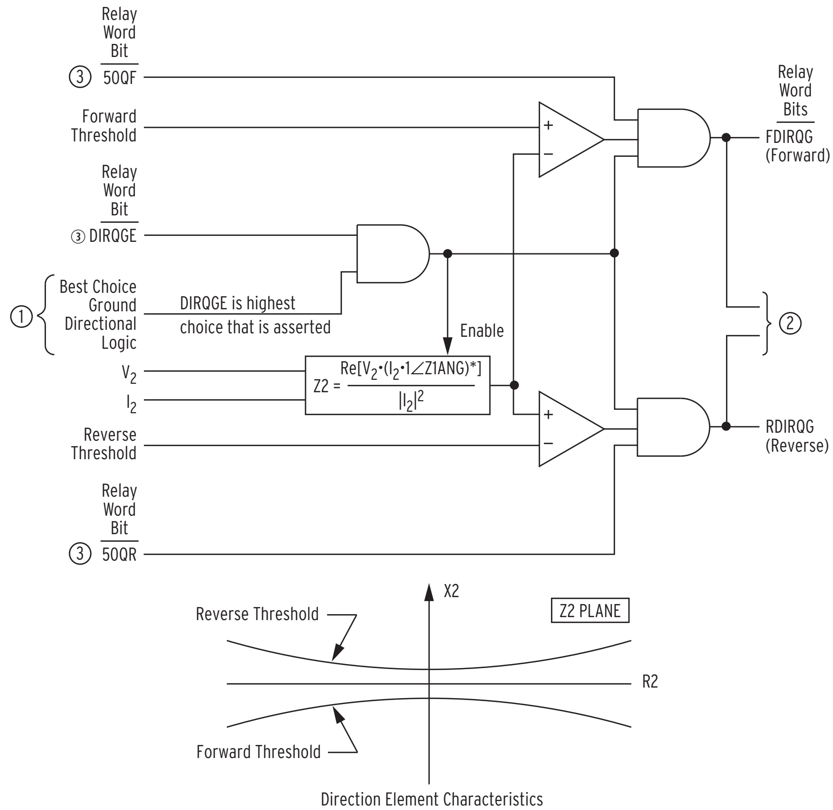
① From Figure 4.120
② EXT3V0_ and the AND gate are applicable to the X side only. For the Y side, Loss-of-Potential = LOP.
③ To Figure 4.78 and Figure 4.79
④ To Figure 4.78 and Figure 4.81
⑤ To Figure 4.74, Table 4.27, and Table 4.28
⑥ To Figure 4.79 and Figure 4.81

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 4.120 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 = $1.25 \cdot Z2F - 0.25 \cdot \left|\frac{V_2}{I_2}\right|$

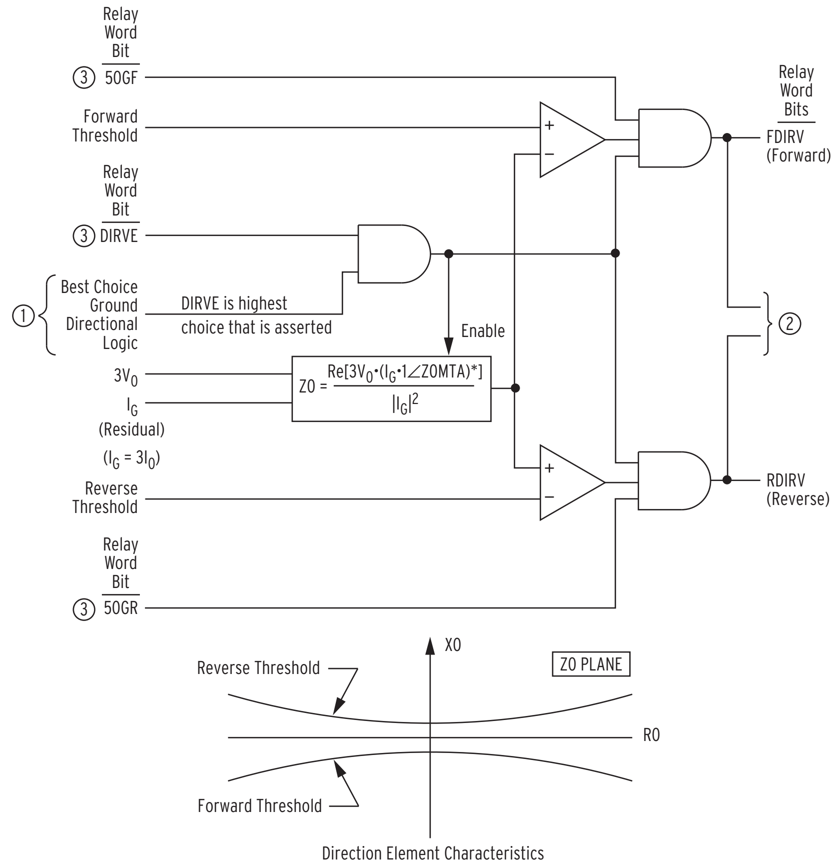
Reverse Threshold:

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



Forward Threshold:

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 $= 1.25 \cdot Z0F - 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

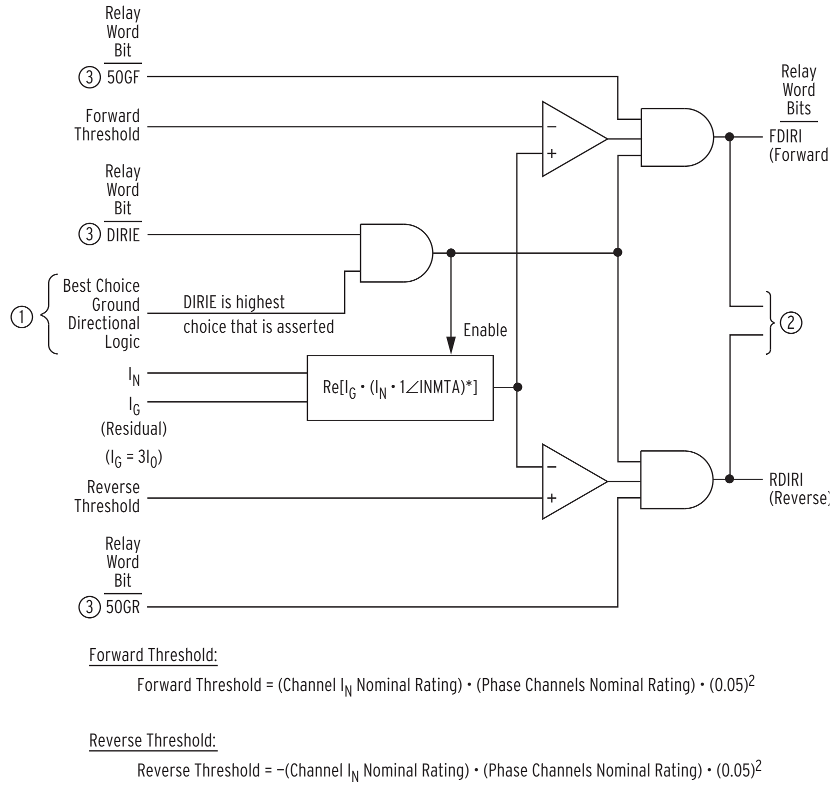
Reverse Threshold:

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 $= 1.25 \cdot Z0R + 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

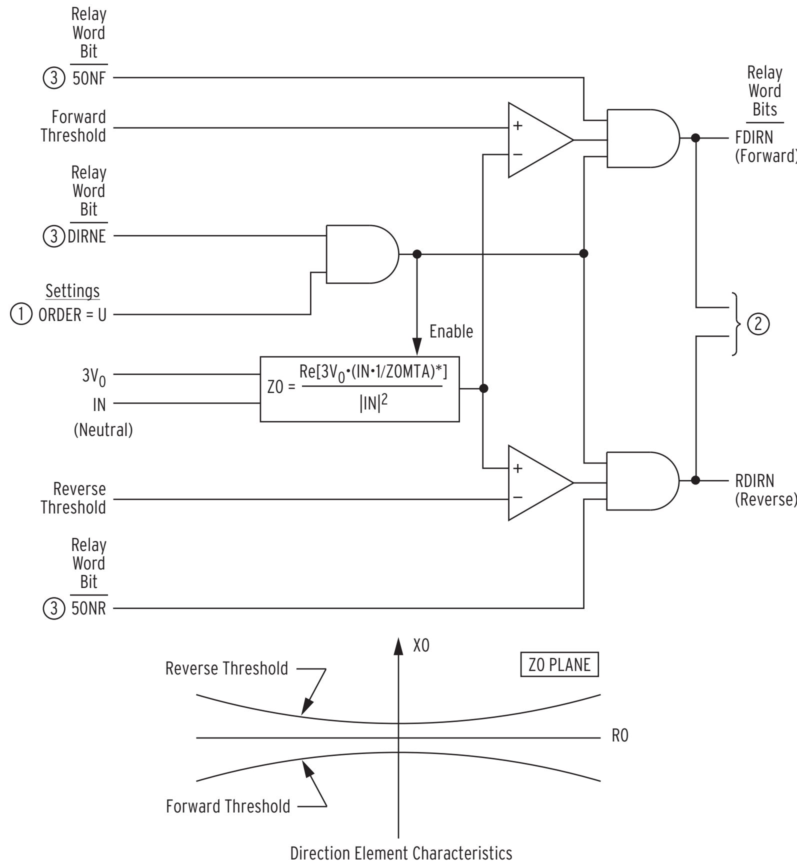
① From Table 4.28 ② To Figure 4.81 ③ From Figure 4.75

Figure 4.78 Zero-Sequence Voltage-Polarized Directional Element for Residual-Ground Overcurrent Elements



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

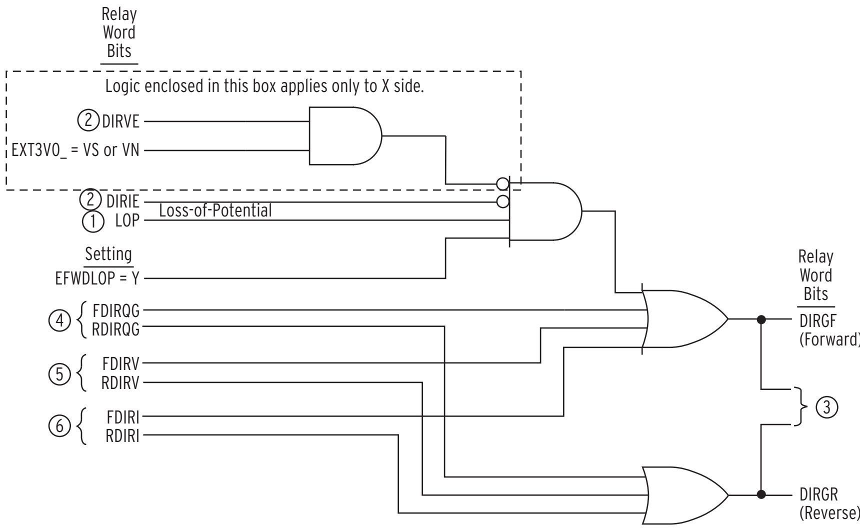
$$\text{Forward Threshold} = 0.75 \cdot Z0F - 0.25 \cdot \left|\frac{3V_0}{IN}\right|$$

Reverse Threshold: Z0R = 0.10 ohm secondary

$$\text{Reverse Threshold} = 0.75 \cdot Z0R + 0.25 \cdot \left|\frac{3V_0}{IN}\right|$$

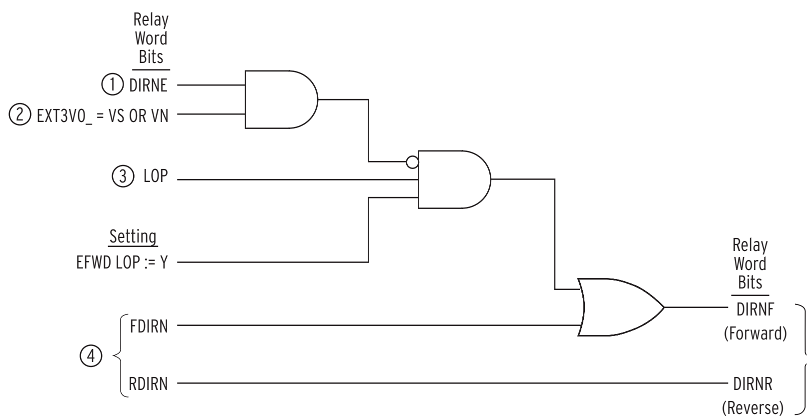
① From Table 4.28 ② To Figure 4.82 ③ From Figure 4.76

Figure 4.80 Zero-Sequence Voltage-Polarized Directional Element for Neutral-Ground Overcurrent Elements



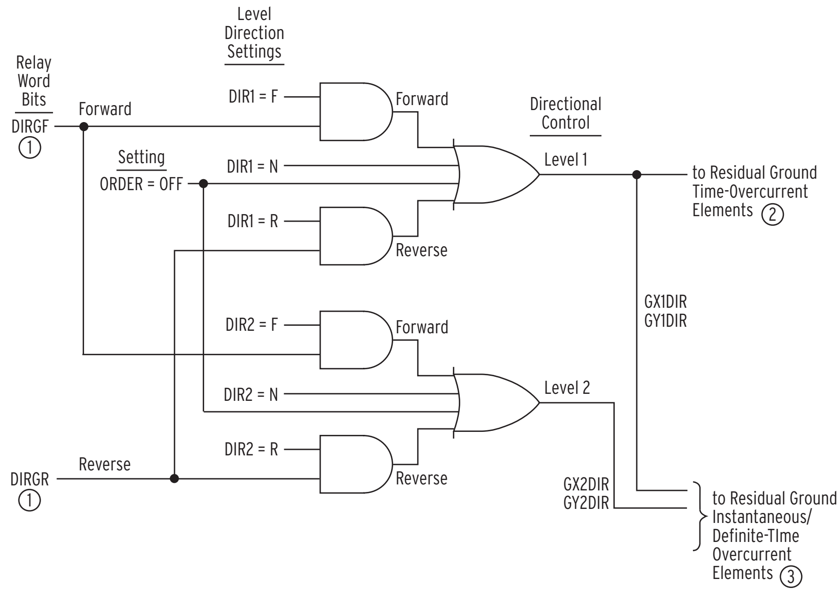
① From Figure 4.120 ② From Figure 4.75 ③ From Figure 4.83
④ From Figure 4.77 ⑤ From Figure 4.78 ⑥ To Figure 4.79

Figure 4.81 Routing of Directional Elements to Residual-Ground Overcurrent Elements



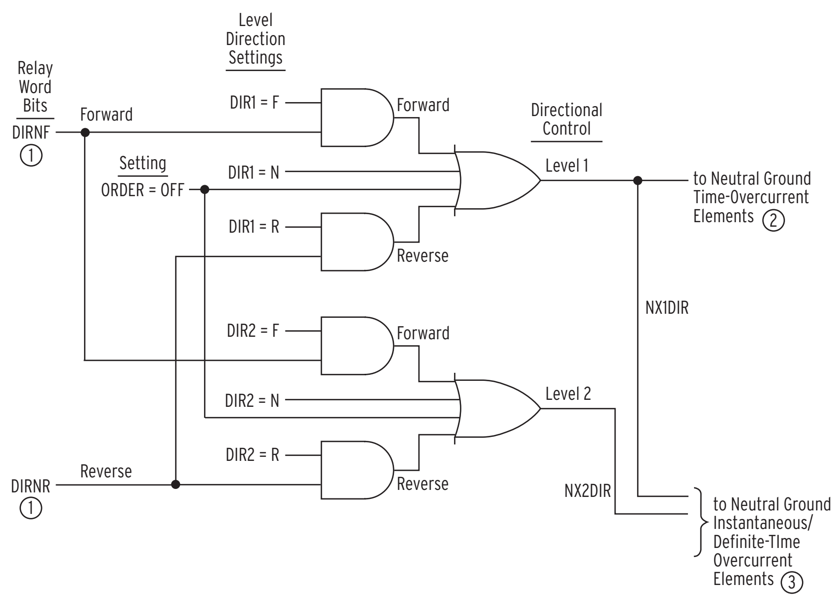
① From Figure 4.76 ② EXT3V0_ and the AND gate are applicable to X side only. It is not applicable to Y side.
③ From Figure 4.120 ④ From Figure 4.80 ⑤ From Figure 4.84

Figure 4.82 Routing of Neutral Directional Element to Neutral-Ground Overcurrent Elements



① From Figure 4.81 ② To Figure 4.61 ③ To Figure 4.54

Figure 4.83 Direction Forward/Reverse Logic for Residual-Ground Overcurrent Elements



① From Figure 4.82 ② To Figure 4.60 ③ To Figure 4.56

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 4.120*.

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.

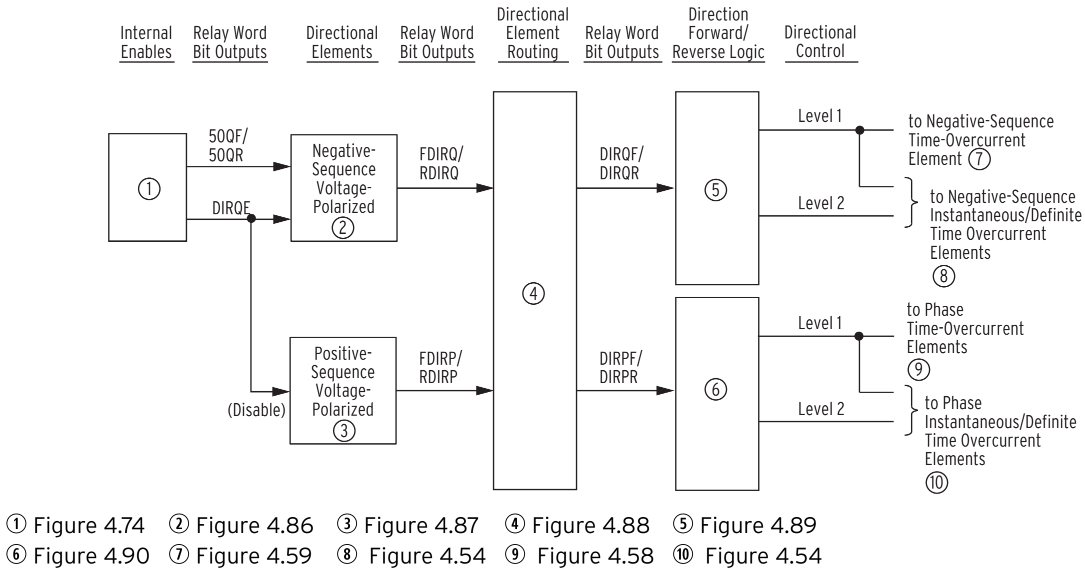


Figure 4.85 General Logic Flow of Directional Control for Negative-Sequence and Phase Overcurrent Elements

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 4.120*.

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 4.120* 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 4.120* 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:

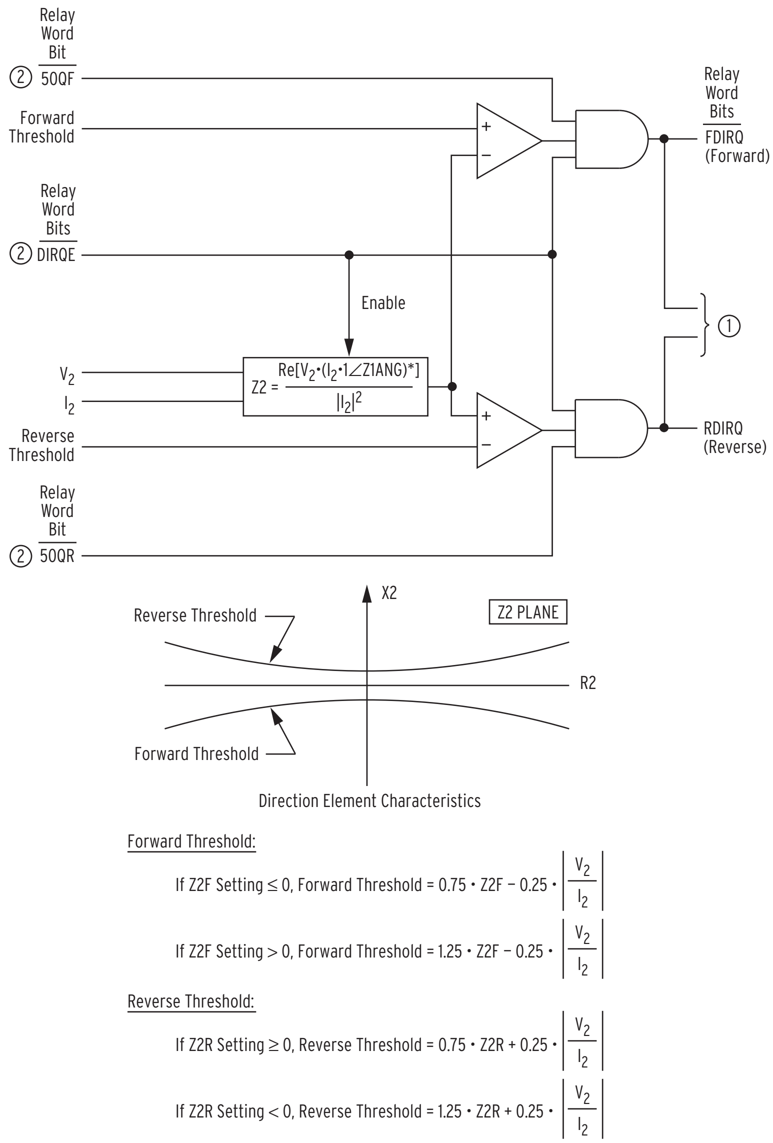
DIR1 := **N** (nondirectional)

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 4.120* 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.

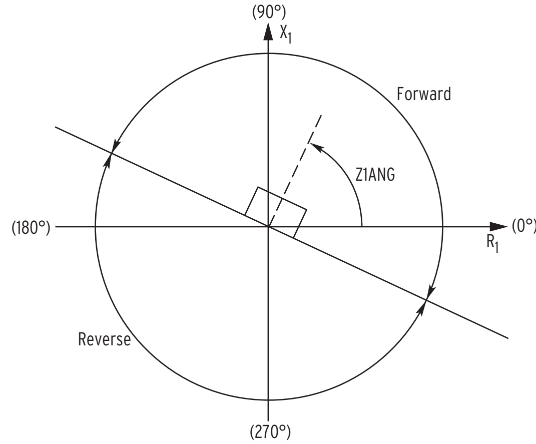
In some applications, level direction settings DIR1 and DIR2 are not flexible enough in assigning the necessary direction for certain overcurrent elements.

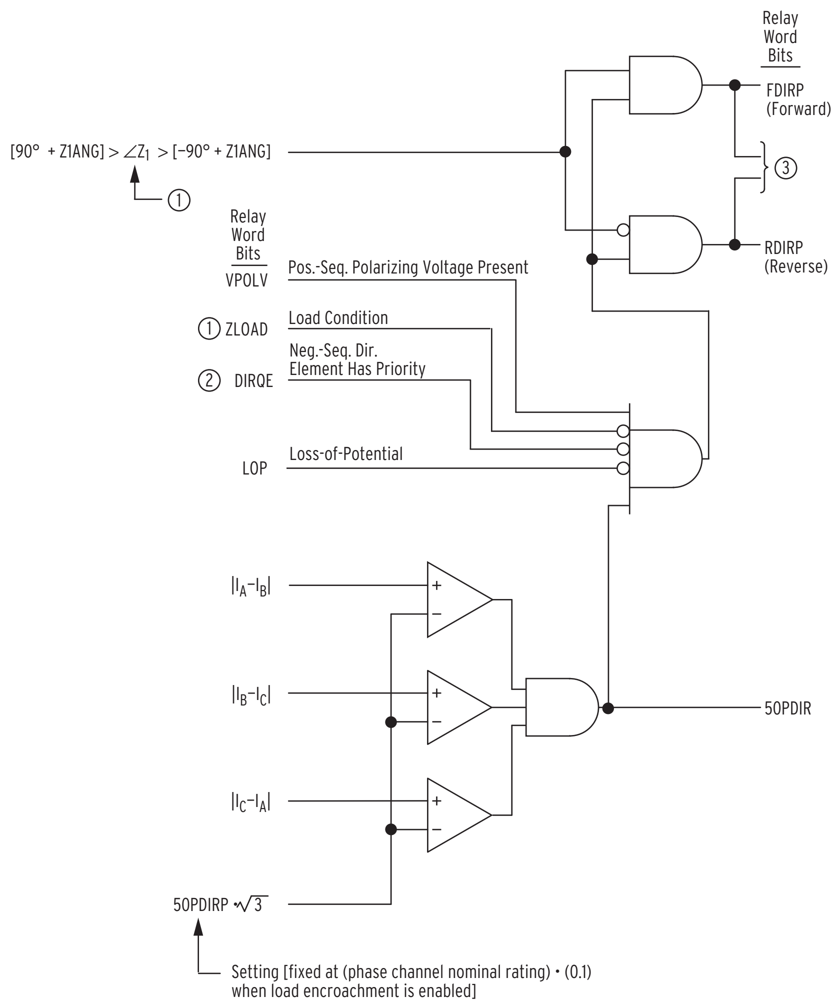
Directional Control Provided by Torque Control Settings on page 4.132 describes how to avoid this limitation for special cases.



① To Figure 4.88 ② From Figure 4.74

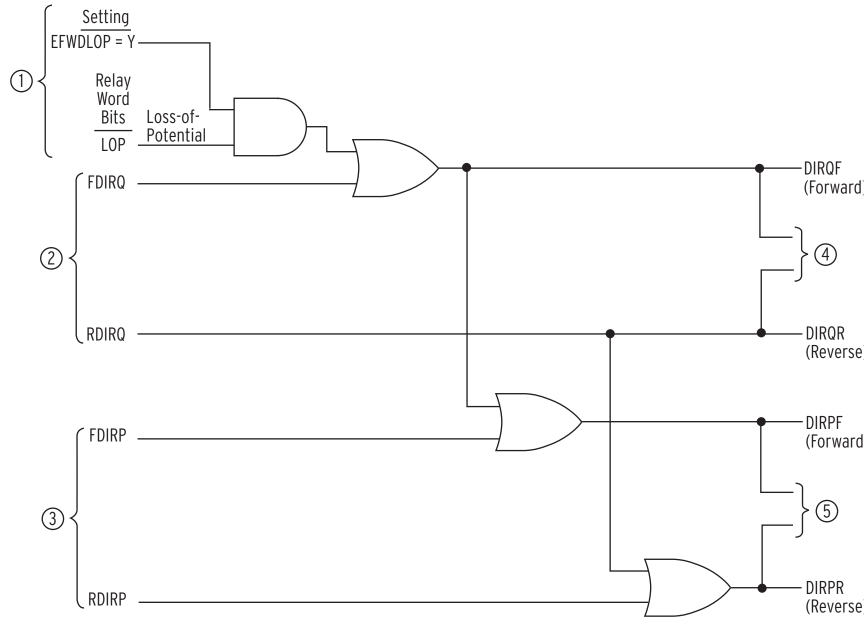
Figure 4.86 Negative-Sequence Voltage-Polarized Directional Element for Negative-Sequence and Phase Overcurrent Elements





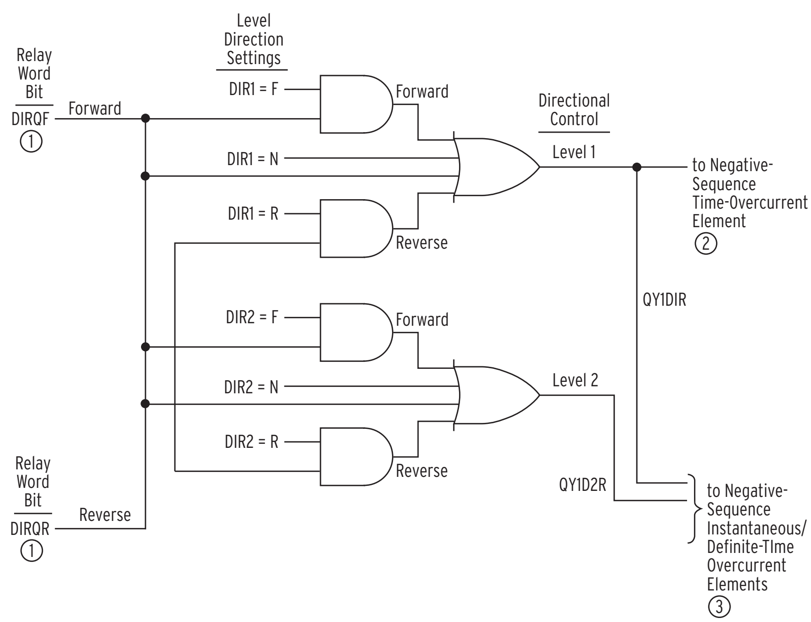
① To Figure 4.94 ② From Figure 4.74 ③ To Figure 4.88

Figure 4.87 Positive-Sequence Voltage-Polarized Directional Element for Phase Overcurrent Elements



① From Figure 4.120 ② From Figure 4.86 ③ From Figure 4.87
④ To Figure 4.89 ⑤ to Figure 4.90

Figure 4.88 Routing of Directional Elements to Negative-Sequence and Phase Overcurrent Elements



① From Figure 4.88 ② From Figure 4.59 ③ From Figure 4.54

Figure 4.89 Direction Forward/Reverse Logic for Negative-Sequence Overcurrent Elements

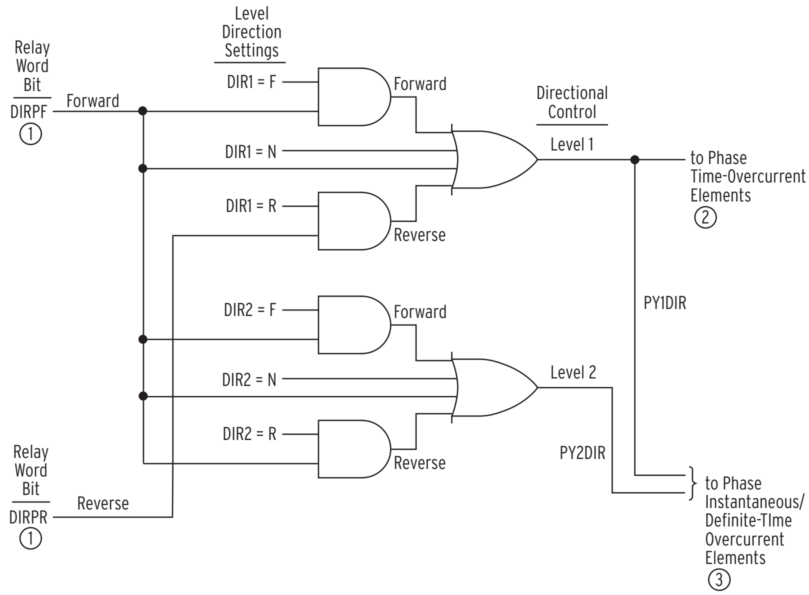


Figure 4.90 Direction Forward/Reverse Logic for Phase Overcurrent Elements

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
POS SQ LN Z ANG	50.00–90.00 deg	Z1ANGX := 68.86

Table 4.31 Directional Element Settings for X Side and Y Side (Sheet 2 of 3)

Setting Prompt	Setting Range	Setting Name := Factory Default
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]
REV DIR NSEQ LVL	0.25–5.00 A[d]	50QRPY := 0.25[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
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 4.132* 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.

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.

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:

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.

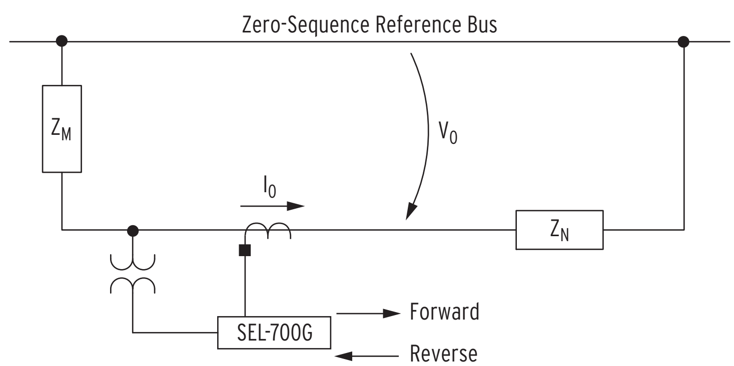


Figure 4.91 Zero-Sequence Impedance Network and Relay Polarity

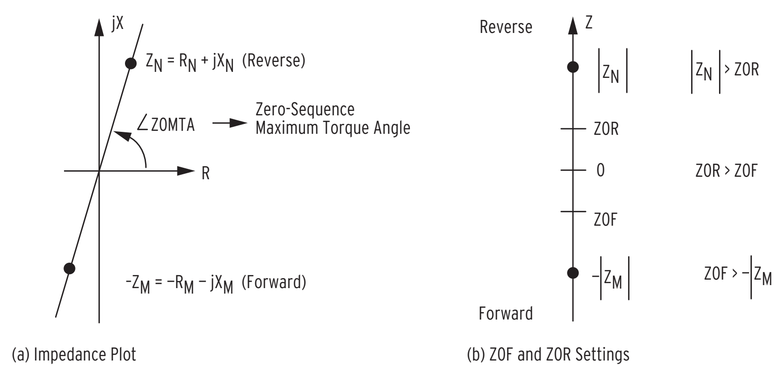


Figure 4.92 Zero-Sequence Impedance Plot for Solidly-Grounded, Mostly Inductive System

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 2.25 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.

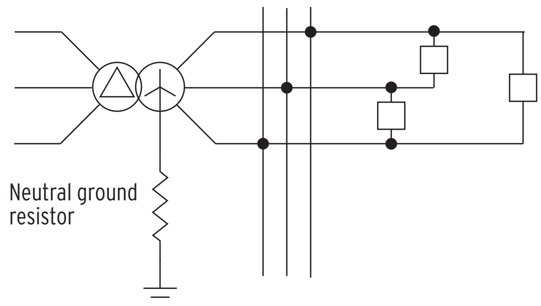


Figure 4.93 Hybrid Power System With Neutral-Ground Resistor

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:

$|IN| > a0N \cdot |I1|$

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 2.25*). 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.) • (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 DIRQE

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.

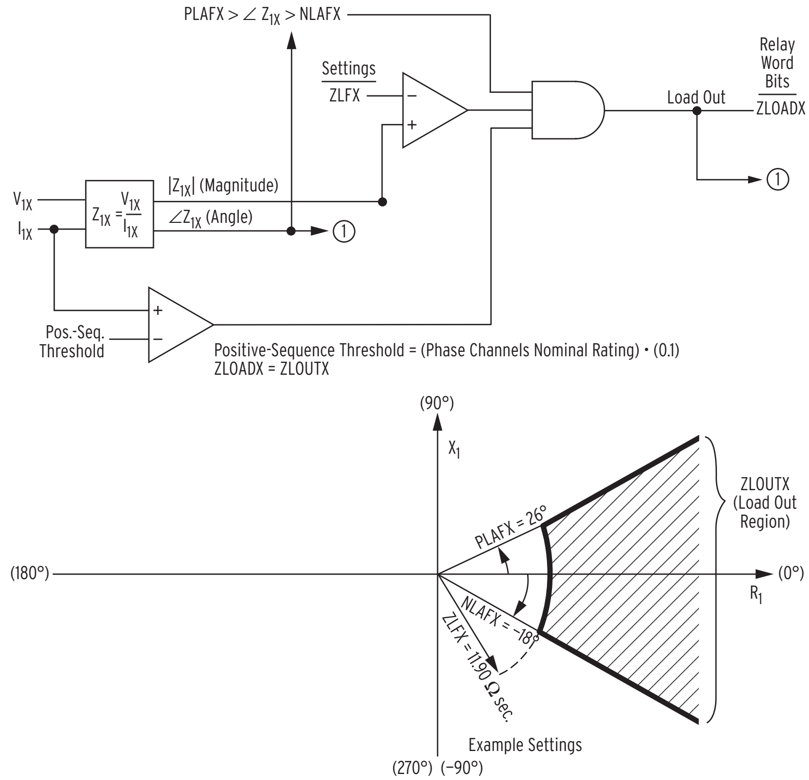
Forward load (load flowing out) lies within the hatched region labeled ZLOUT. Relay Word bit ZLOUT asserts to logical 1 when the load lies within this hatched region.

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:

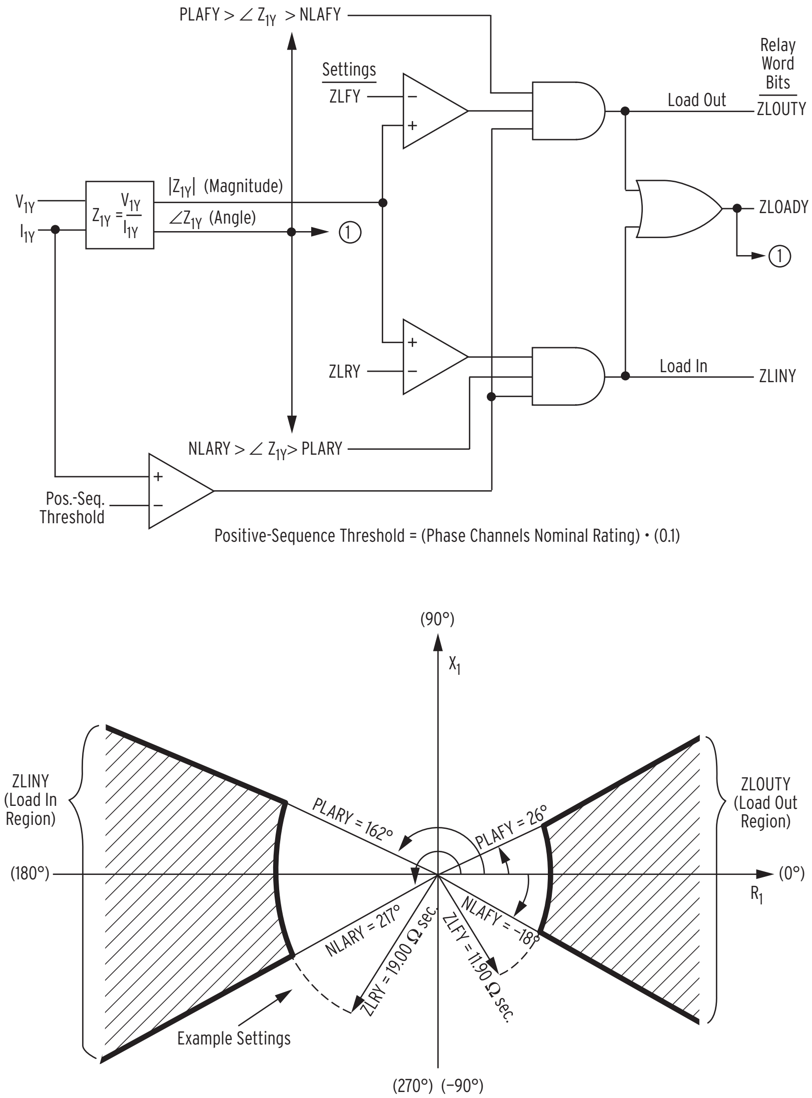
ZLOADY := ZLOUTY OR ZLINY

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:

$$\frac{(\text{line-line voltage in kV})^2 \cdot \text{CT ratio}}{\text{3-phase load in MVA} \cdot \text{PT ratio}}$$

Again, for the maximum forward load:

$$\frac{230^2 \cdot 400}{800 \cdot 2000} = 13.2\ \Omega\text{ secondary}$$

To provide a margin for setting ZLF, multiply by a factor of 0.9:

$$\begin{aligned}\text{ZLF} &= 13.2\ \Omega\text{ secondary} \cdot 0.9\\ &= 11.90\ \Omega\text{ secondary}\end{aligned}$$

For the maximum reverse load:

$$\frac{230^2 \cdot 400}{500 \cdot 2000} = 21.1\ \Omega\text{ secondary}$$

Again, to provide a margin for setting ZLR:

$$\begin{aligned}\text{ZLR} &= 21.1\text{ secondary} \cdot 0.9\\ &= 19.00\ \Omega\text{ secondary}\end{aligned}$$

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.

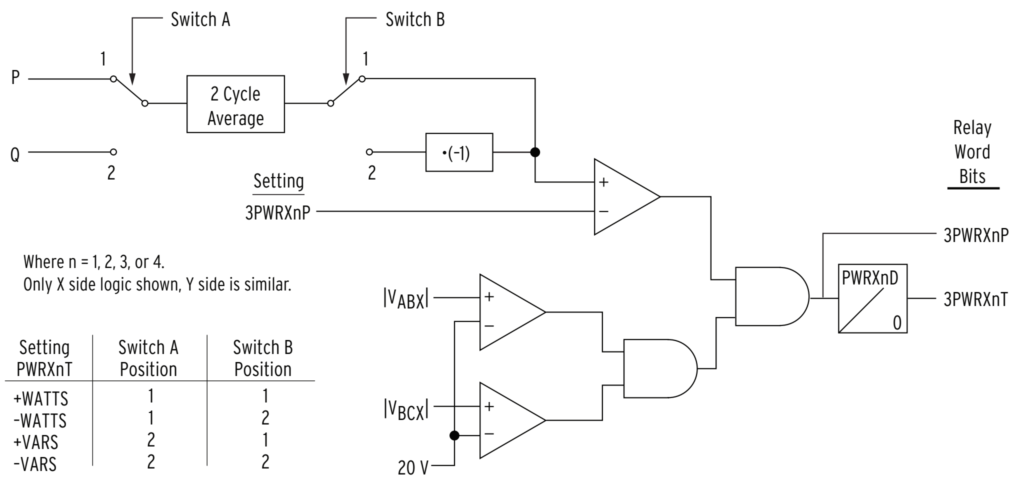


Figure 4.96 Three-Phase Power Elements Logic

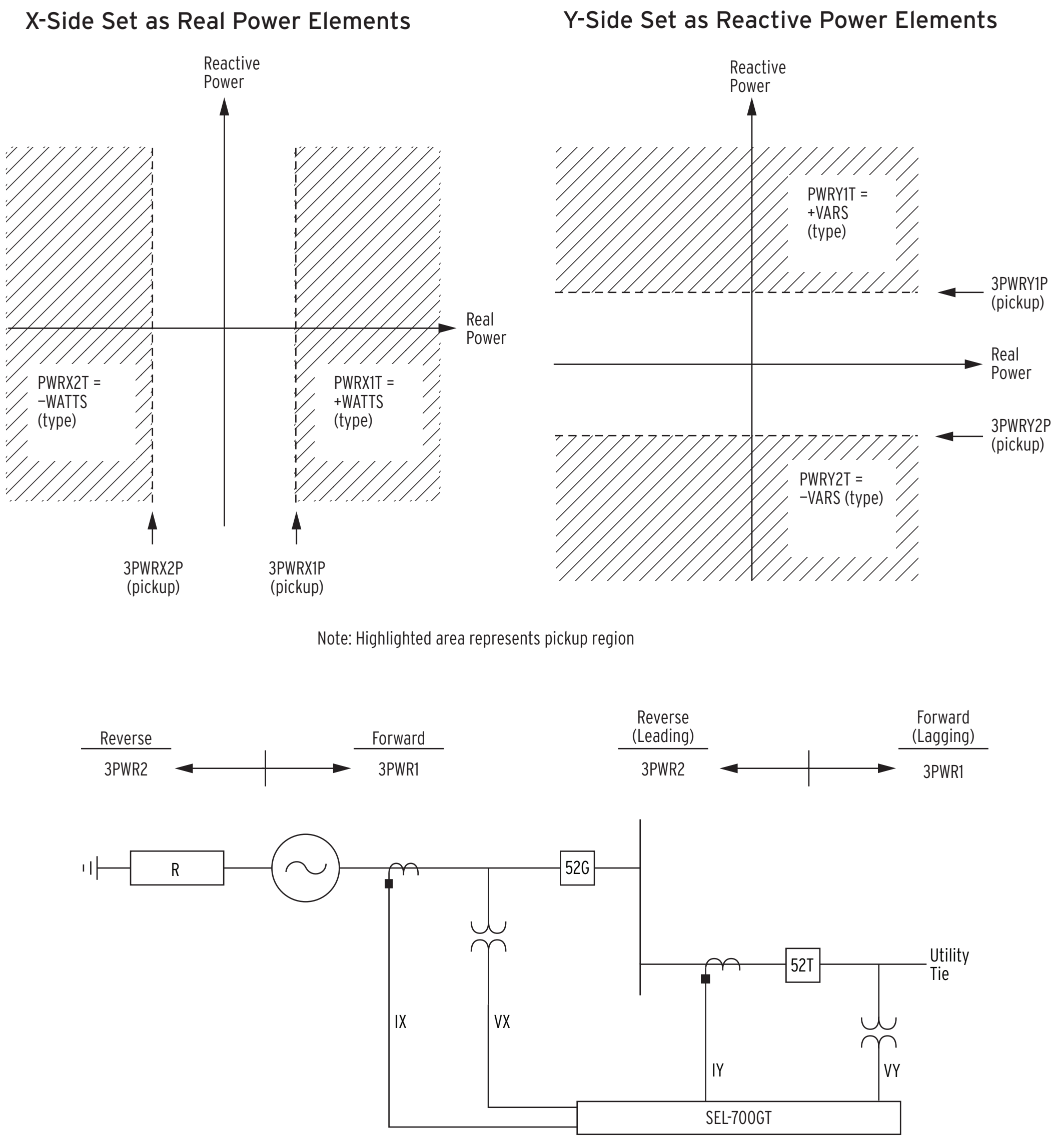


Figure 4.97 Power Elements Operation in the Real/Reactive Power Plane

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.

Over- and Underfrequency Protection

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 sides and the synchronism-check voltage input (VS). While the relay measures the frequency of multiple signals, it uses only one signal (V1X, V1Y, I1X, or I1Y) for frequency tracking. *Table 4.39* shows the signals that the ROC method uses to measure frequency and priority in determining the appropriate signal for frequency tracking in a specific model of the SEL-700G.

Table 4.39 Signals Used for Frequency Measurement and Tracking[a]

Relay Model	Signals Used	Priority for Tracking
SEL-700G0 and SEL-700G1	V1X	—
SEL-700GT	V1Y	—
SEL-700GT+	V1X and V1Y	1. V1X 2. V1Y
SEL-700GW	I1X and I1Y	1. I1X 2. I1Y
SEL-700G0+, SEL-700G1+, and SEL-700GT	VS	Not used for tracking

[a] All signals shown are positive-sequence quantities, except VS.

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 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.

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.

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	0.00–240.00 s	81*m*1TD := 1.00
FREQ*m* TRIP2 LVL	OFF, 15.00–70.00 Hz	81*m*2TP := OFF
FREQ*m* TRIP2 DLY	0.00–240.00 s	81*m*2TD := 1.00
FREQ*m* TRIP3 LVL	OFF, 15.00–70.00 Hz	81*m*3TP := OFF
FREQ*m* TRIP3 DLY	0.00–240.00 s	81*m*3TD := 1.00
FREQ*m* TRIP4 LVL	OFF, 15.00–70.00 Hz	81*m*4TP := OFF
FREQ*m* TRIP4 DLY	0.00–240.00 s	81*m*4TD := 1.00
FREQ*m* TRIP5 LVL	OFF, 15.00–70.00 Hz	81*m*5TP := OFF
FREQ*m* TRIP5 DLY	0.00–240.00 s	81*m*5TD := 1.00
FREQ*m* TRIP6 LVL	OFF, 15.00–70.00 Hz	81*m*6TP := OFF
FREQ*m* TRIP6 DLY	0.00–240.00 s	81*m*6TD := 1.00
FREQ*m* TRQCTRL	SELOGIC	81*m*TC := 1

[a] m = X or Y.

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

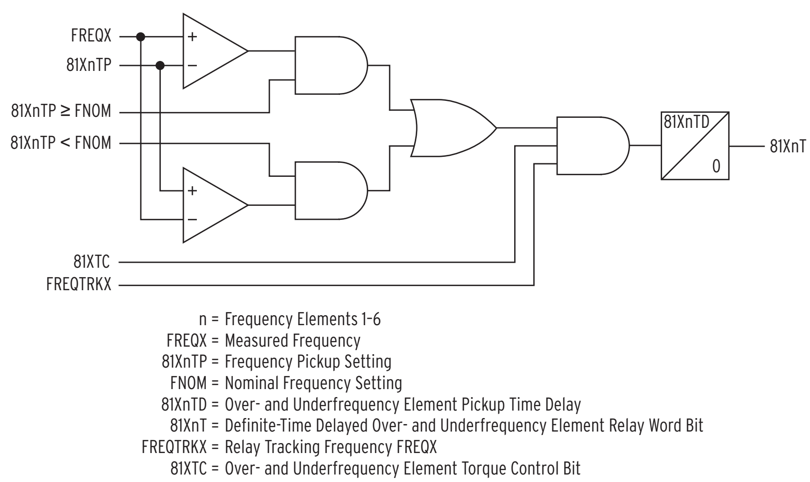
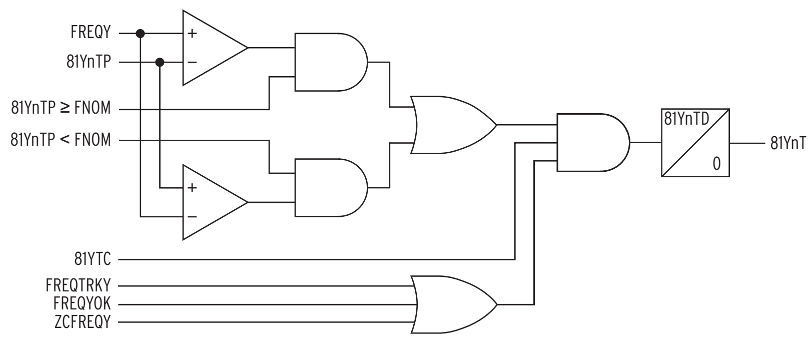


Figure 4.98 X-Side Over- and Underfrequency Element Logic



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 = Relay Tracking Frequency FREQY
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 (Sheet 1 of 2)

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

Table 4.41 Rate-of-Change-of-Frequency Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default[a]
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 element uses an hysteresis (dropout/pickup ratio of 95%) to prevent chattering. *Table 4.42* shows the time windows for different trip level settings.

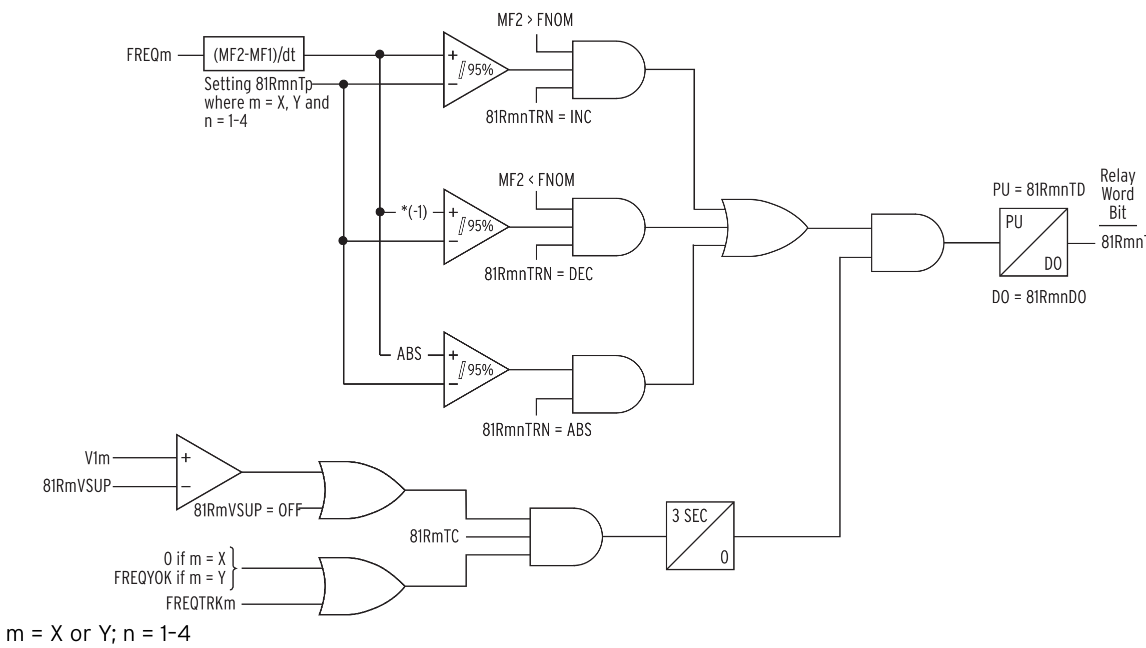


Figure 4.100 81R Frequency Rate-of-Change Scheme Logic

Table 4.42 Time Window Versus 81RmnTP Setting[a] (Sheet 1 of 2)

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

Table 4.42 Time Window Versus 81RmnTP Setting[a] (Sheet 2 of 2)

81RmnTP Setting (Hz/s)	Time-Window (Cycles)
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 2.16*, 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 2.23*), 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 2.16 (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

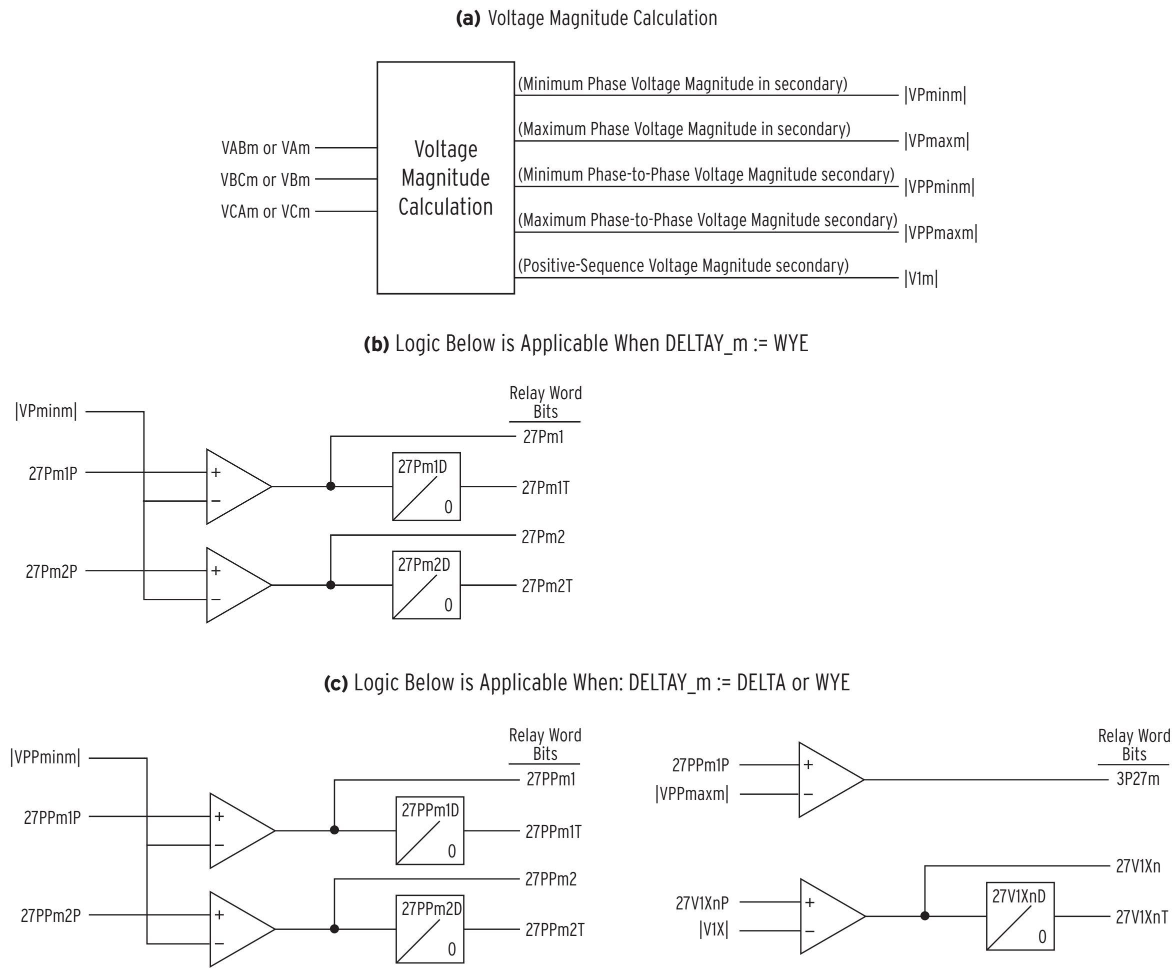
Setting Prompt	Setting Range	Setting Name := Factory Default[a]
PHASE UV LEVEL	OFF, 2.0–300.0 V	27P*m*1P := OFF
PHASE UV DELAY	00.00–120.00 s	27P*m*1D := 0.50
PHASE UV LEVEL	OFF, 2.0–300.0 V	27P*m*2P := OFF
PHASE UV DELAY	00.00–120.00 s	27P*m*2D := 5.00
PH-PH UV LEVEL	OFF, 2.0–300.0 V[b]	27PP*m*1P := 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
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

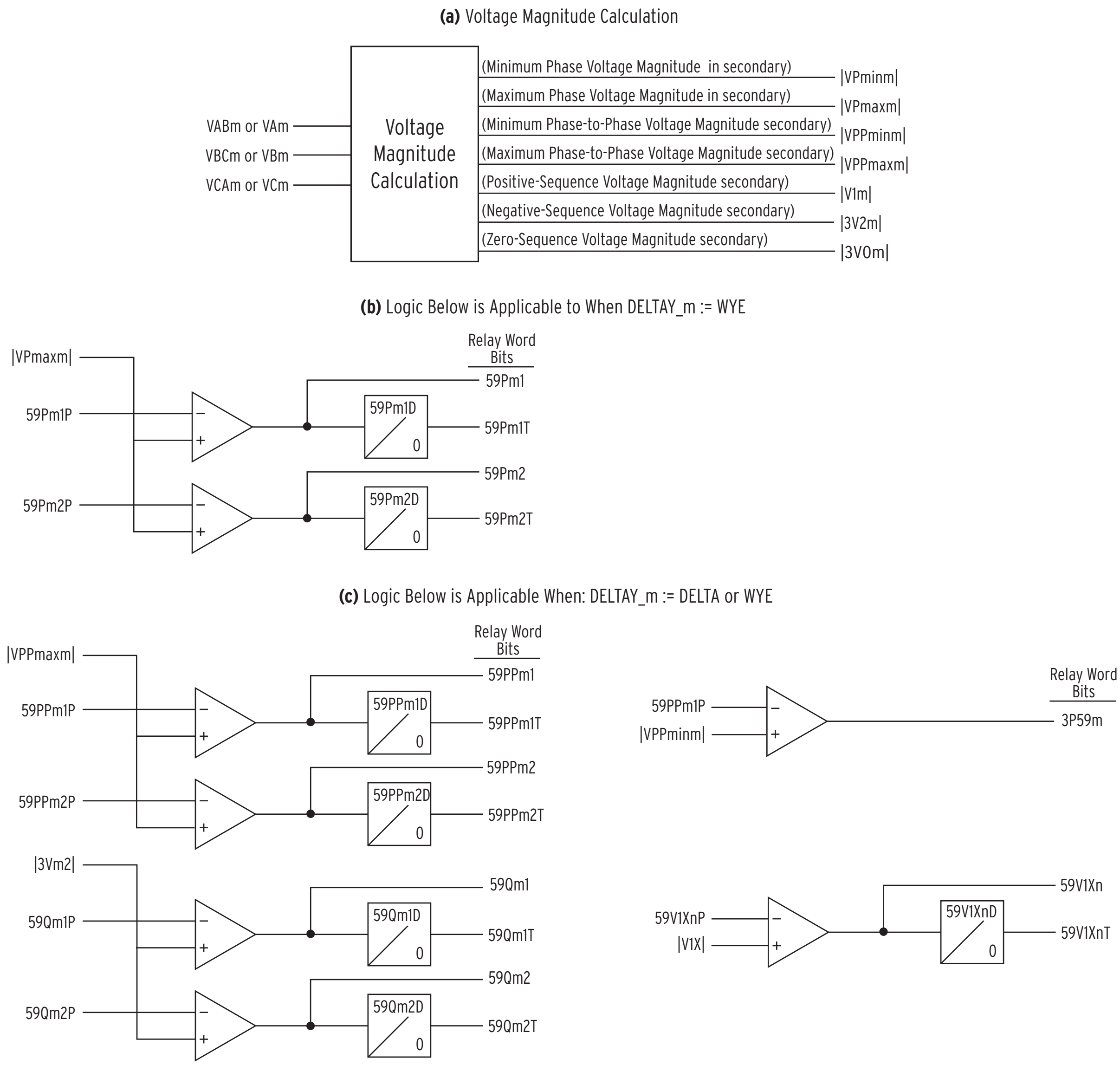
Setting Prompt	Setting Range	Setting Name := Factory Default[a]
PHASE OV LEVEL	OFF, 2.0–300.0 V	59P*m*1P := OFF
PHASE OV DELAY	00.00–120.00 s	59P*m*1D := 0.50
PHASE OV LEVEL	OFF, 2.0–300.0 V	59P*m*2P := OFF
PHASE OV DELAY	00.00–120.00 s	59P*m*2D := 5.00
PH-PH OV LEVEL	OFF, 2.0–300.0 V[b]	59PP*m*1P := 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
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.



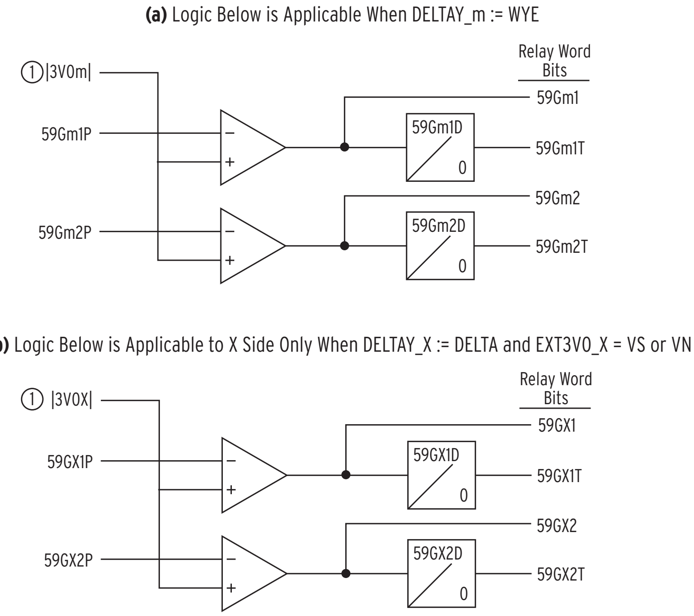
m = X, Y; n = 1–6; All settings in secondary volts.

Figure 4.101 Undervoltage Element Logic



m = X or Y; n = 1–6; All settings in secondary volts.

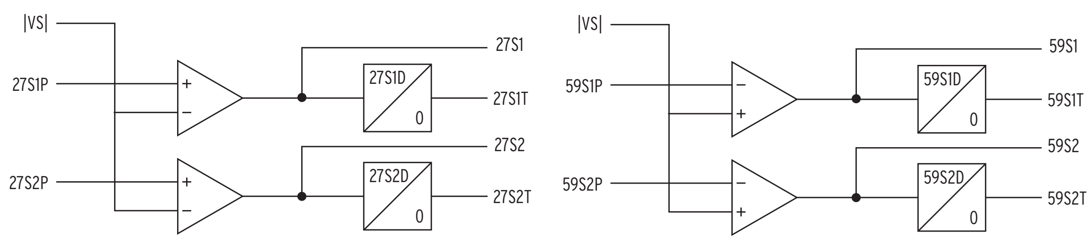
Figure 4.102 Overvoltage Element Logic



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)

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 4.45*. See *Figure 2.11* 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 4.45 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 4.45 RTD Settings (Sheet 1 of 2)

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

Table 4.45 RTD Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
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 ALARM and TRIP are delayed by approximately 6 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 4.45*.

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. *Table 4.46* lists the RTD resistance versus temperature for the four supported RTD types.

Table 4.46 RTD Resistance Versus Temperature (Sheet 1 of 2)

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

Table 4.46 RTD Resistance Versus Temperature (Sheet 2 of 2)

Temp (°F)	Temp (°C)	100 Platinum	120 Nickel	100 Nickel	10 Copper
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-checking 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-checking 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. You should 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 4.47 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

Table 4.47 X-Side Synchronism-Check Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
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, 0, 30, 60, …, 330 deg[a]	SYNCPX := VAX[a]
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 ANGLE	OFF, 3–120 deg	CFANGLE := 30
BLK SYNC CHECK	SELOGIC	BSYNCHX := NOT 3POX

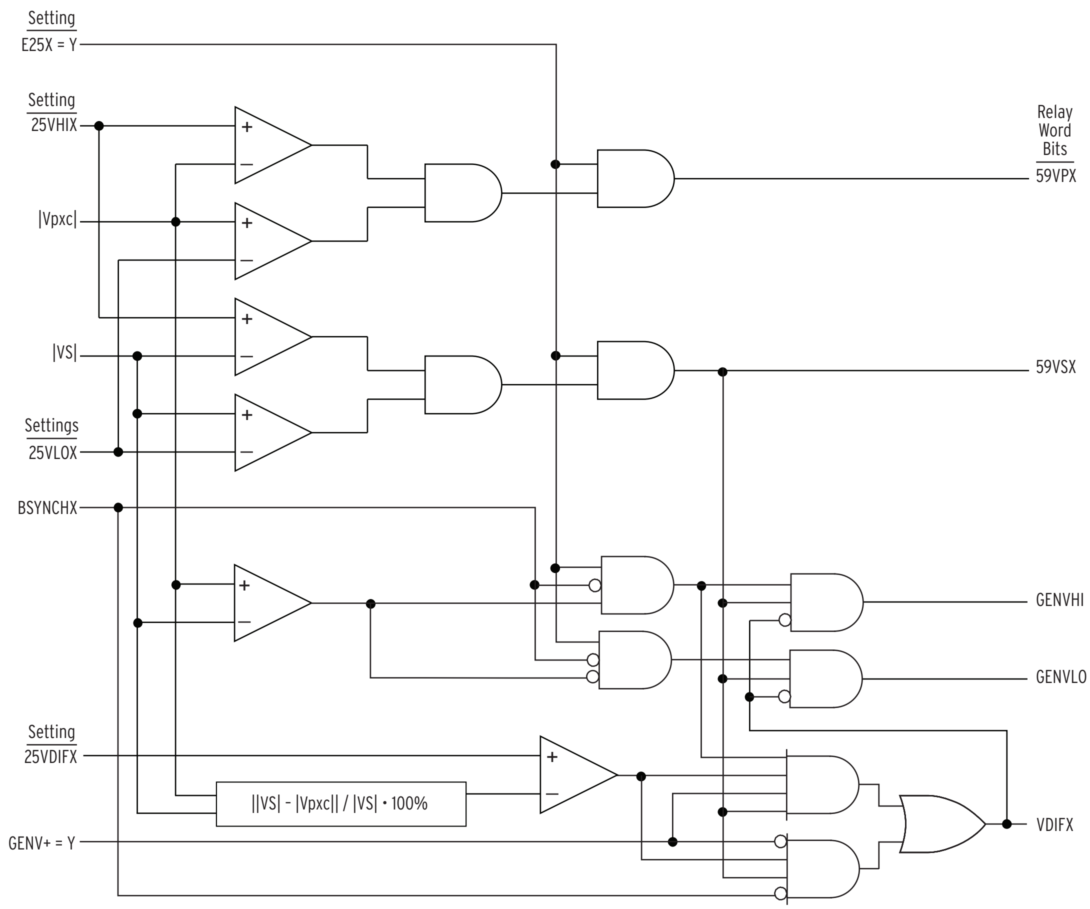
[a] Setting range and default values shown are for DELTAY_X := WYE.
[b] Setting range and default values shown are for DELTAY_X := DELTA.

Set E25X := Y to enable synchronism-checking 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-checking 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.

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. See *Figure 4.105* and *Figure 4.106* for more detail.



Vpxc = 25RCFX * VP (where 25RCFX is the setting and VP is determined by the SYNCPX setting).

Figure 4.105 Synchronism-Check Function Voltage Elements

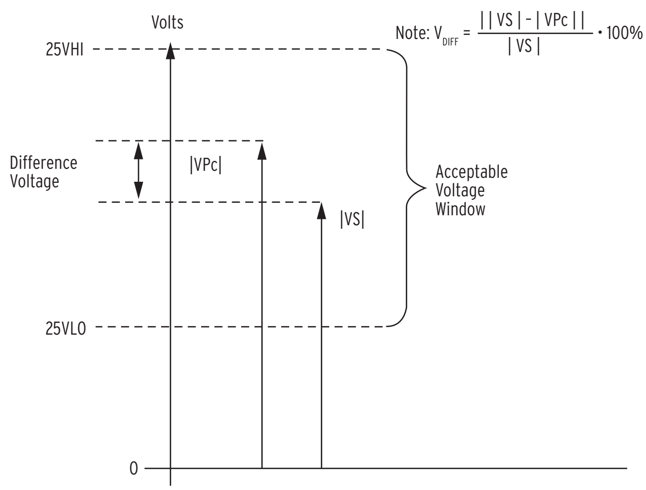


Figure 4.106 Synchronism-Check Function Voltage Element Characteristic

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.

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. Many applications require 25RCFX := 1.000, but some applications may need a different setting. *Figure 4.107* shows four out of several possible configurations and their associated settings and calculations.

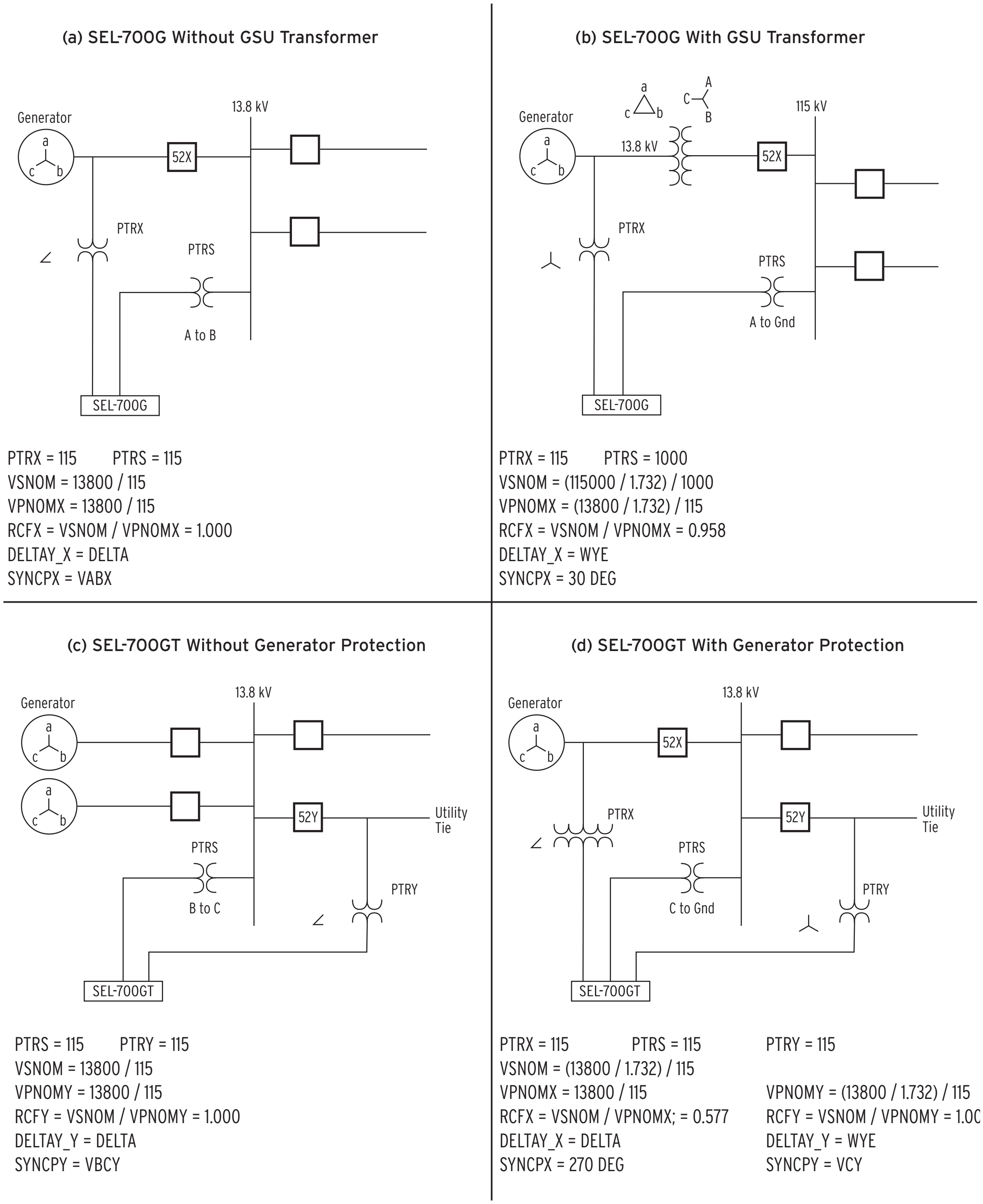


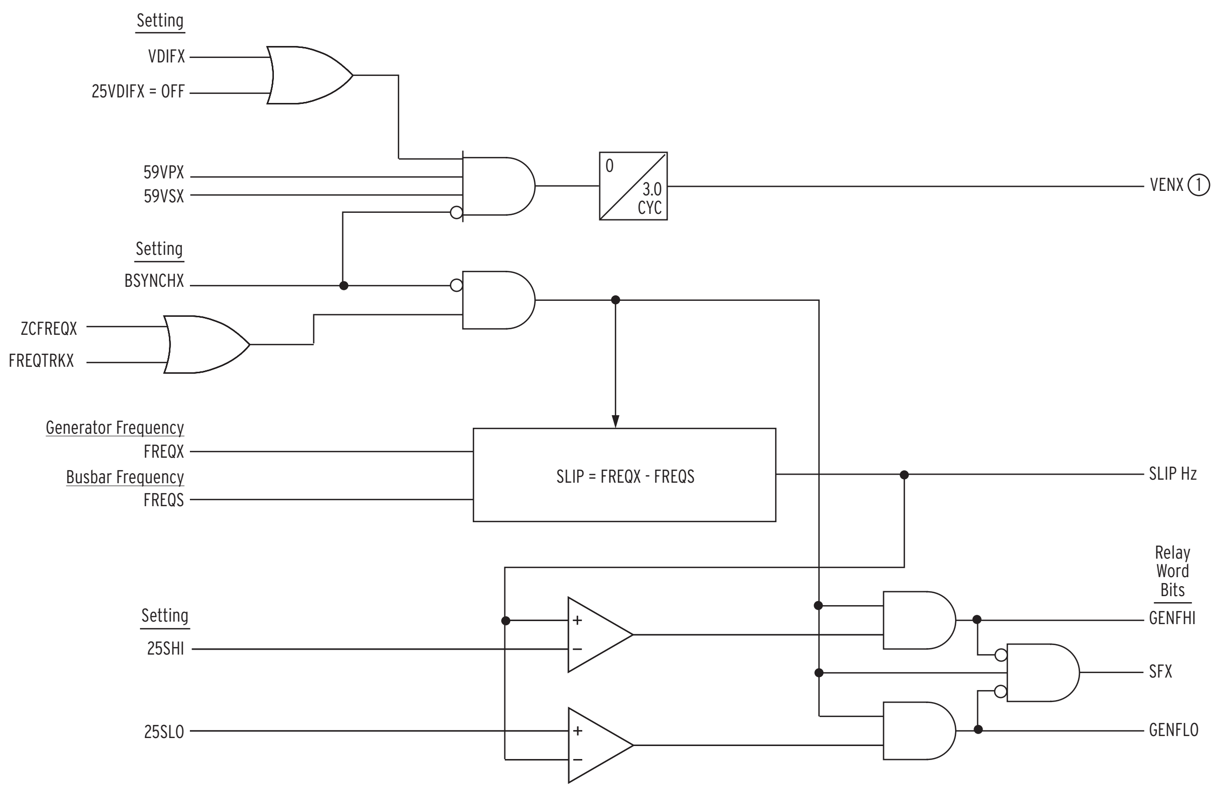
Figure 4.107 Synchronism-Check Function 25RCFX and SYNCPX/SYNCPY Setting Examples

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 slip frequency greater than 0 Hz when the generator frequency is greater than the system frequency.

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.

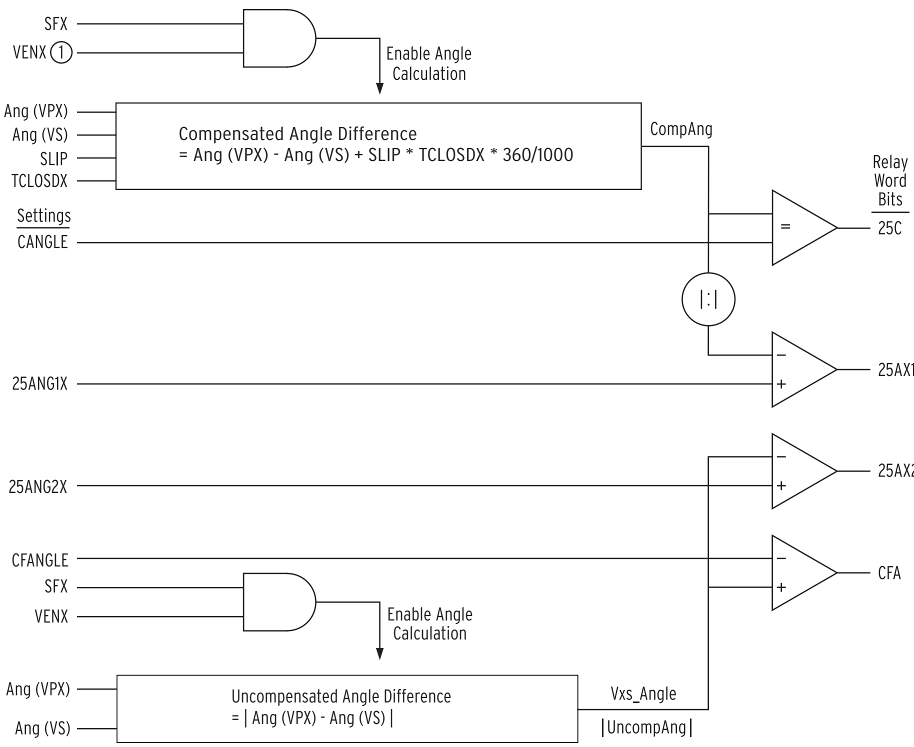
The 25ANG2X setting also defines an acceptable generator breaker closing angle. The relay asserts the 25AX2 Relay Word bit when the generator voltage is within 25ANG2X degrees of the system voltage if the other supervisory conditions also are met. The relay does not account for the breaker time or present slip frequency to adjust the phase angles where 25AX2 is asserted; it is an absolute phase angle comparison.

The 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 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 different is equal to CANGLE. See *Figure 4.108*, *Figure 4.109*, *Figure 4.110*, and *Figure 4.111* for additional detail.



① Figure 4.109

Figure 4.108 Synchronism-Check Function Slip Elements



① Figure 4.108

Figure 4.109 Synchronism-Check Function Angle Elements

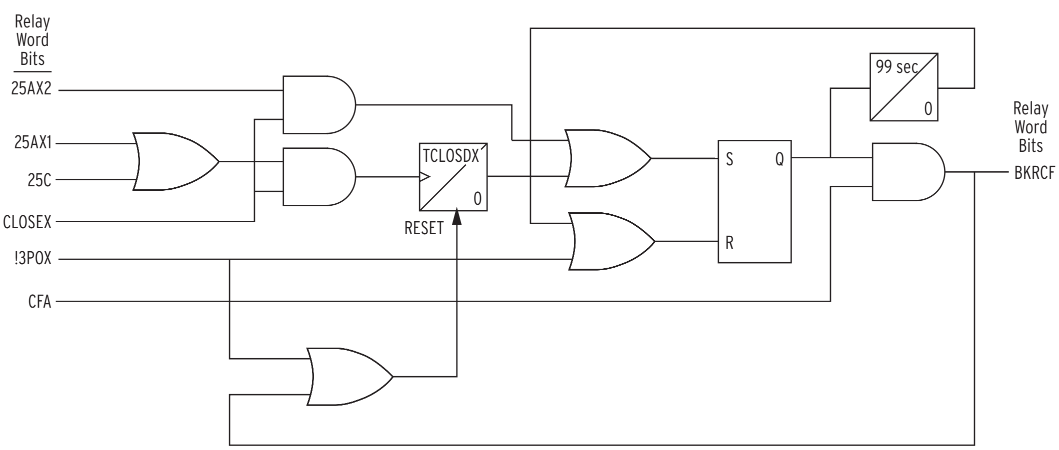


Figure 4.110 Breaker Close Failure Logic Diagram

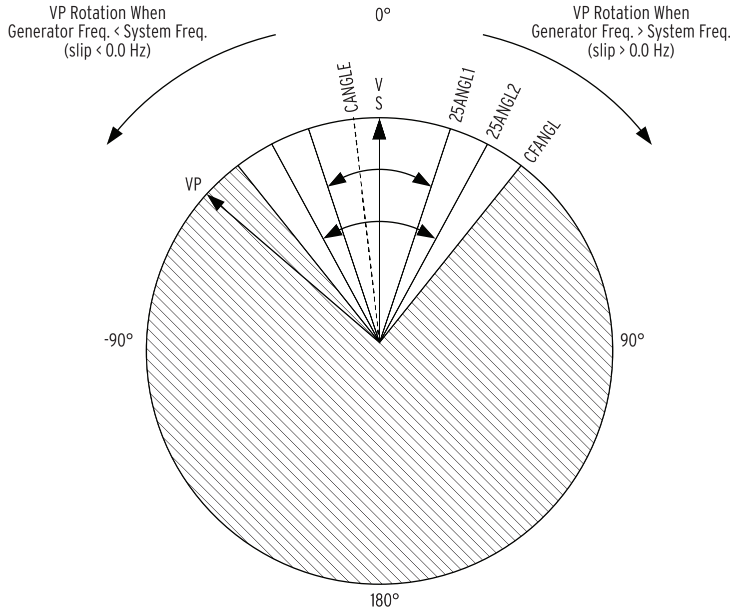


Figure 4.111 Synchronism-Check Function Angle Characteristics

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-checking requirements and practices vary widely for different prime mover types. Be sure to consult your prime mover manufacturer's synchronism-checking 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-phase when DELTAY_X := WYE
- 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 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 4.107* for a few examples of setting SYNCPX. *Figure 4.107 (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 4.162* 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. Setting 25SLO = 0.05 Hz and 25SHI = 0.25 Hz might satisfy that requirement.

Diesel generators may require that a zero or negative slip be present. This tends to unload the machine shaft and crank briefly when the generator breaker closes. Setting 25SLO = –0.25 Hz and 25SHI = 0.0 Hz might satisfy this 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. If the relay initiates a circuit breaker close, the breaker close failure logic is armed. 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 4.107 (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, or VCX (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 4.130* and *Figure 4.131* for additional detail.

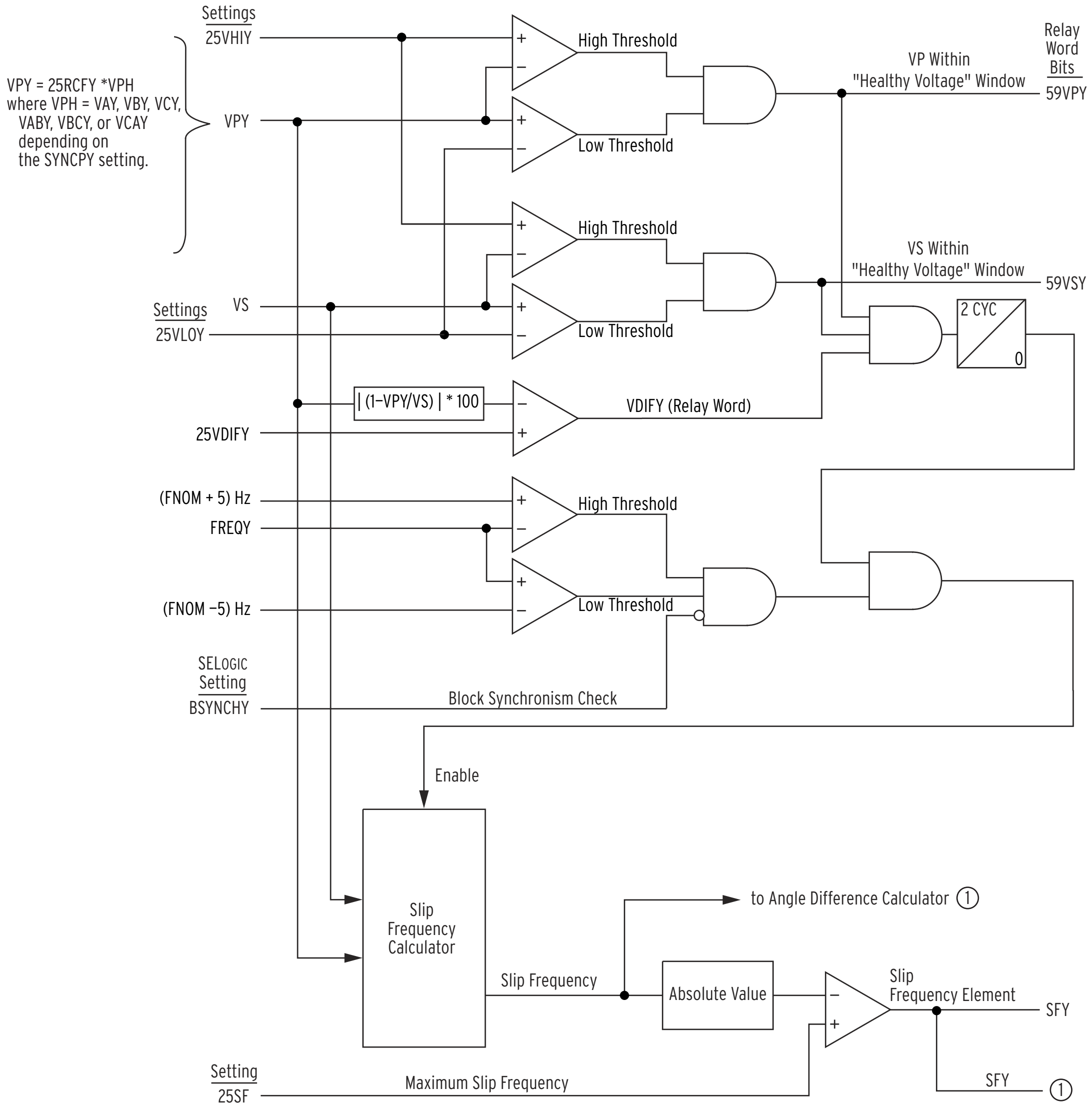
Synchronism-Check Elements (Tie Breaker, Y-Side)

Figure 2.26 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 4.112* and *Figure 4.113*). They have separate angle settings.

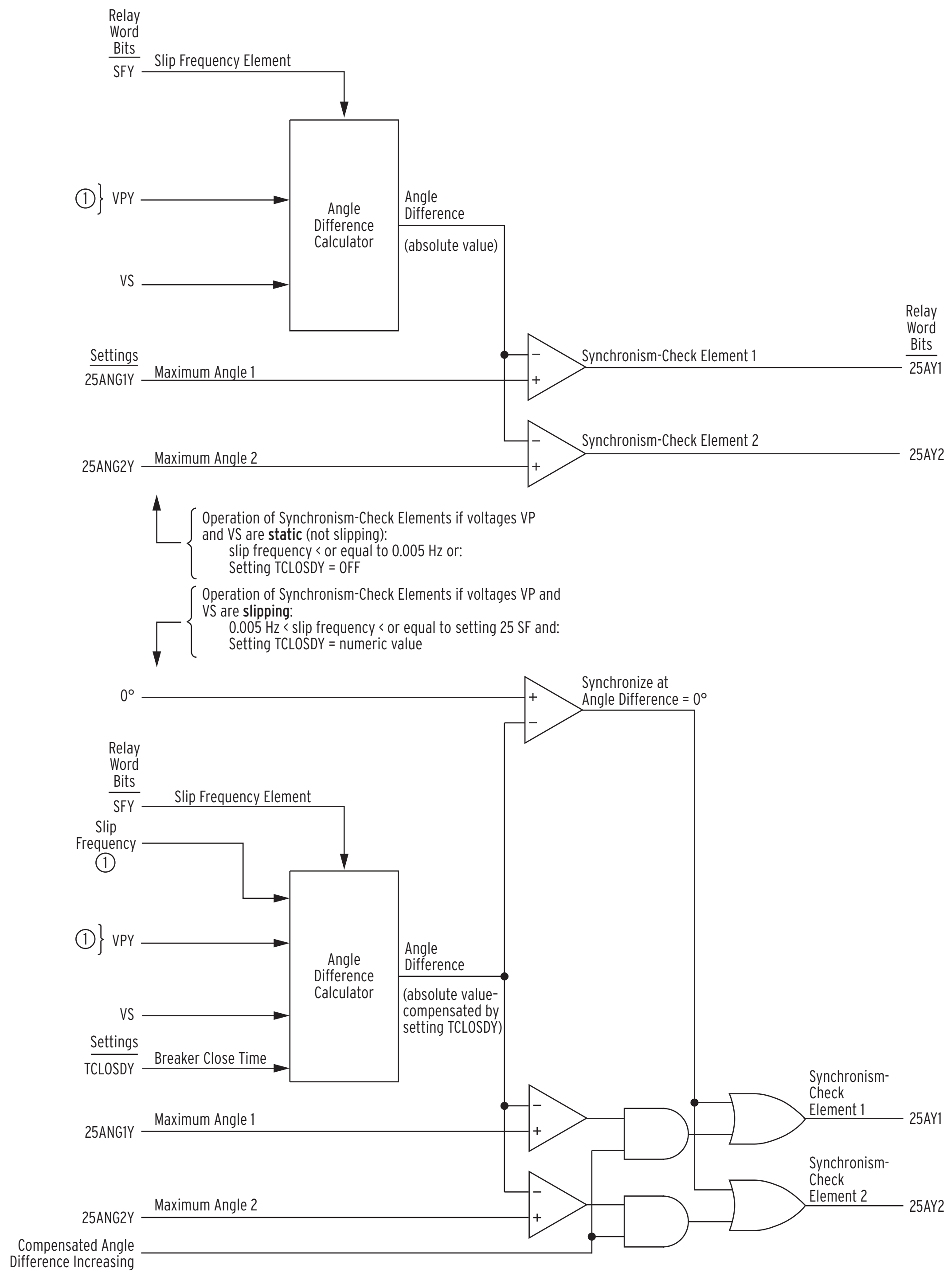
If the voltages are static (voltages not slipping with respect to one another) or setting TCLOSDY := OFF, the two synchronism-check elements operate as shown in the top of *Figure 4.113*. The relay checks these angle settings for synchronism-check closing.

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 4.113*. 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 4.113

Figure 4.112 Synchronism-Check Voltage Window and Slip Frequency Elements



① From Figure 4.112

Figure 4.113 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-phase when using a wye-connected relay
- 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 4.48* and *Setting SYNCPY*).

Table 4.48 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, 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 4.112*). For situations where VS cannot be in phase with VAY, VBY, or VCY, the angle setting choices (0, 30, …, 300, or 330 degrees) are referenced to VAY.

Delta-Connected Voltages. The angle setting choices (0, 30, …, 300, or 330 degrees) for setting SYNCPY are referenced to VABY, and they indicate

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).

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 4.112*). 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 4.107* 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, or VCY • 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 4.107 (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 4.112* and *Figure 4.113*.

Voltage Window. Refer to *Figure 4.112*. 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 4.112*. 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 4.125*)

In addition, synchronism-check operation can be blocked when the relay is tripping:

BSYNCHY := **... OR TRIPY**

Slip Frequency Calculator. Refer to *Figure 4.112*. The synchronism-check element Slip Frequency Calculator in *Figure 4.112* 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 4.112*, 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 4.113* 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 4.113*. 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 = $|(\angle VPY - \angle VS)|$

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.

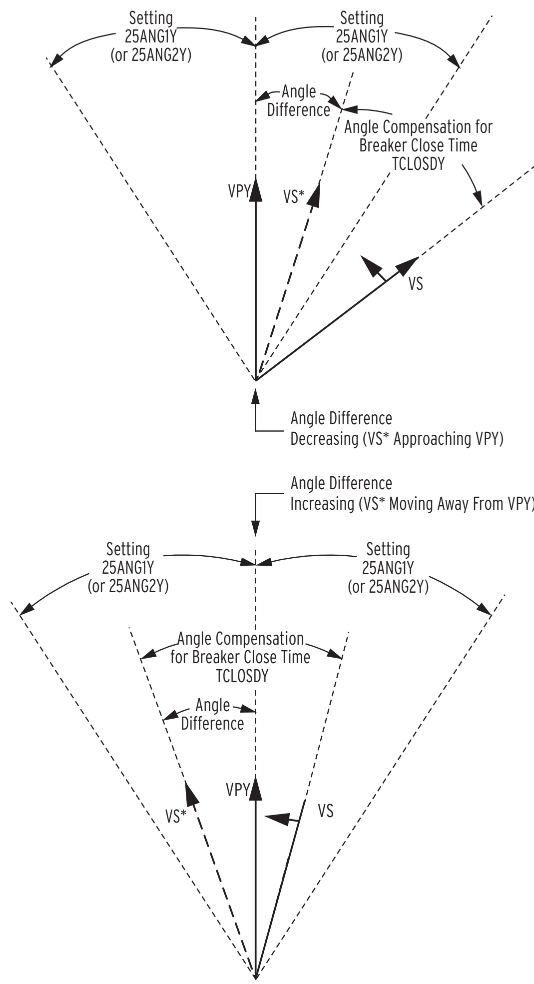


Figure 4.114 Angle Difference Between VPY and VS Compensated by Breaker Close Time (fPY < fS and VPY Shown as Reference in This Example)

Voltages VPY and VS Are "Slipping". Refer to the bottom of *Figure 4.113*. 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 4.114*). 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 4.113*. 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:

NOTE: The angle compensation in Figure 4.114 appears much greater than 3.6 degrees. Figure 4.114 is for general illustrative purposes only.

Angle Difference

= |(∠VPY – ∠VS) + [(fPY – fS) • TCLOSDY • (1 / 1000) • (360°/slip cycle)]|
= |(∠VPY – ∠VS) + [–0.10 • 0.1 • 360°]|
= |(∠VPY – ∠VS) – 3.6°|

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 4.114*.

The top of *Figure 4.114* 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 4.114* 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 4.113*) 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 4.113*.

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 4.113*. 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 4.114* 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 4.114* 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 4.130* 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 4.115* 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.

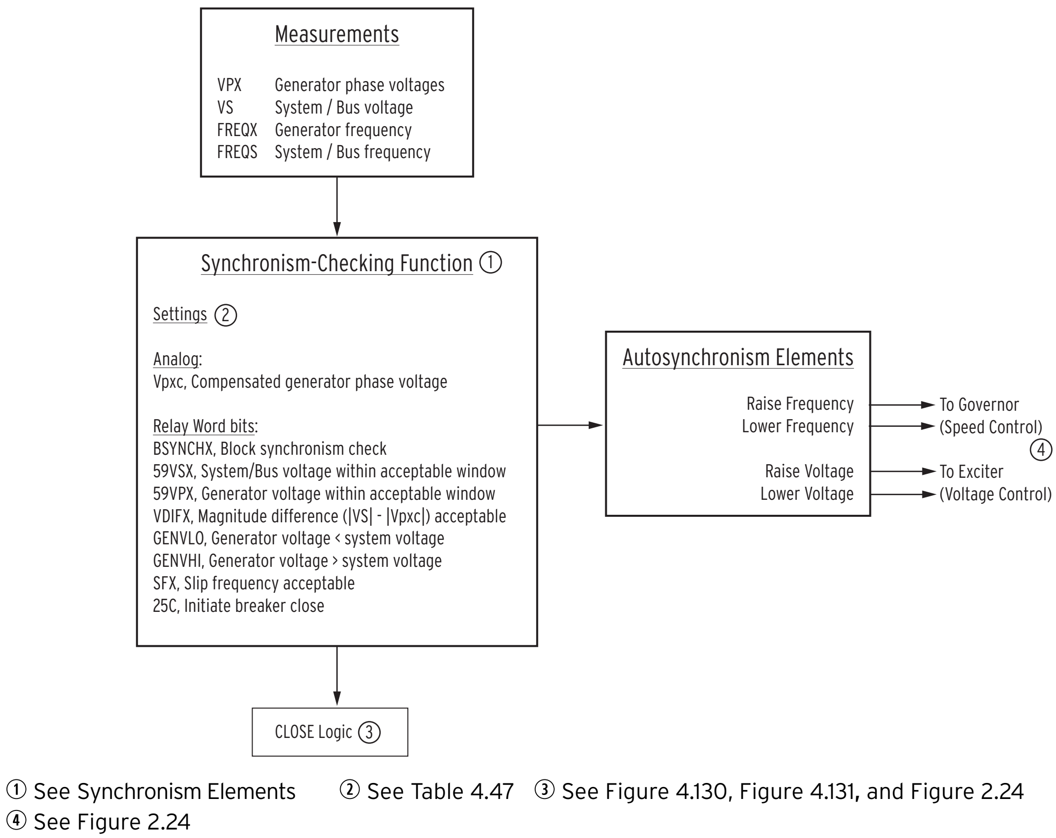


Figure 4.115 Overall Functional Block Diagram

The autosynchronism feature works in conjunction with the X-side synchronism-checking function. You must first enable 25X elements (see *Table 4.47* for detail) and then set EAUTO := DIG to enable the autosynchronism elements. *Figure 4.115* shows the Relay Word bits (and other information) from synchronism check that are also used by the autosynchronism elements.

Table 4.49 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. 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 4.116* for the functional block diagram of the frequency matching function.

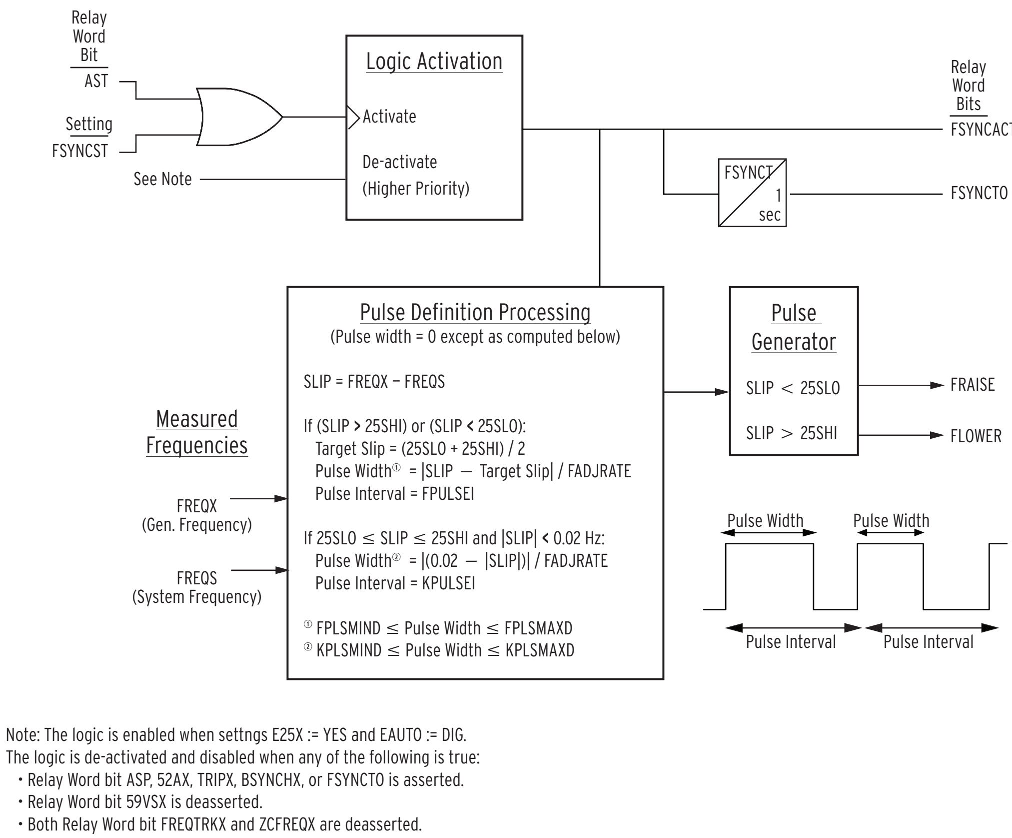


Figure 4.116 Simplified Block Diagram, Frequency and Phase Matching Elements

SEL-700G autosynchronism adjusts the generator frequency to match the frequency of the system. The relay compares generator frequency to that of the system/bus and asserts a Relay Word bit FRAISE or FLOWER, as necessary.

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 4.60* for detail) connected to the governor to control the generator speed/frequency.

As shown in *Figure 4.116*, 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 (25SLO < SLIP < 25SHI). 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 4.116*. Set KPLSMIND, KPLSMAXD, and KPULSEI to define minimum / maximum kick pulse width and interval. Refer to the governor data sheet for relevant information.

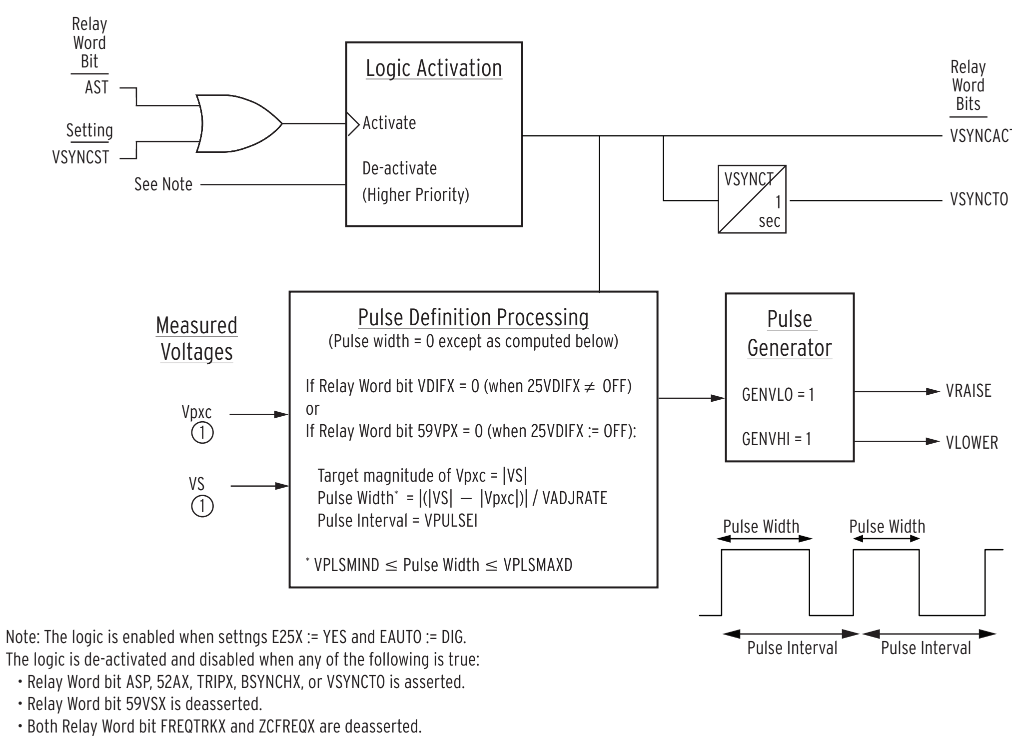
Voltage Matching

Refer to *Figure 4.117* for a functional block diagram of the voltage matching function.

The SEL-700G autosynchronism adjusts the generator voltage to match the system voltage. The relay compares generator voltage magnitude to that of the system/bus and asserts a Relay Word bit VRAISE or VLOWER, as necessary.

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 4.60* 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 4.117*. 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.



① See Figure 4.105

Figure 4.117 Simplified Block Diagram, Voltage Matching Elements

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 and Synchronism-Report

ACSELERATOR QuickSet® SEL-5030 Software provides a synchroscope display when connected to an SEL-700G relay. See *Figure 4.118* for a sample display.

IMPORTANT: The synchroscope display in ACSELERATOR QuickSet® SEL-5030 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.

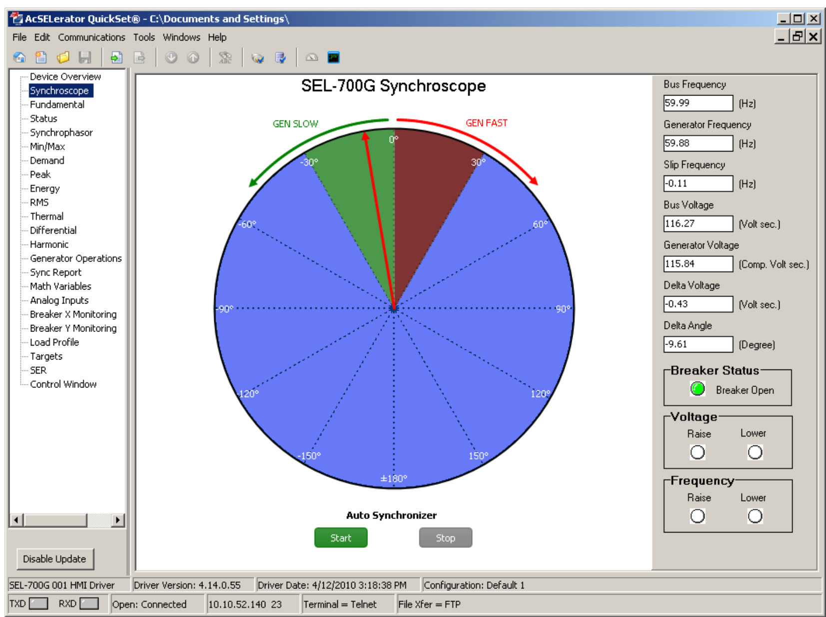


Figure 4.118 Synchroscope

The SEL-700G relay triggers and saves the Generator Autosynchronism Report on the rising edge of Relay Word bit GSRTRG (see *Table 4.94*) or ASCII command GST (see *Section 7: Communications*). See *Figure 4.119* for a sample graphical display of the report and also *Section 3: PC Software* and *Section 9: Analyzing Events* for additional detail.

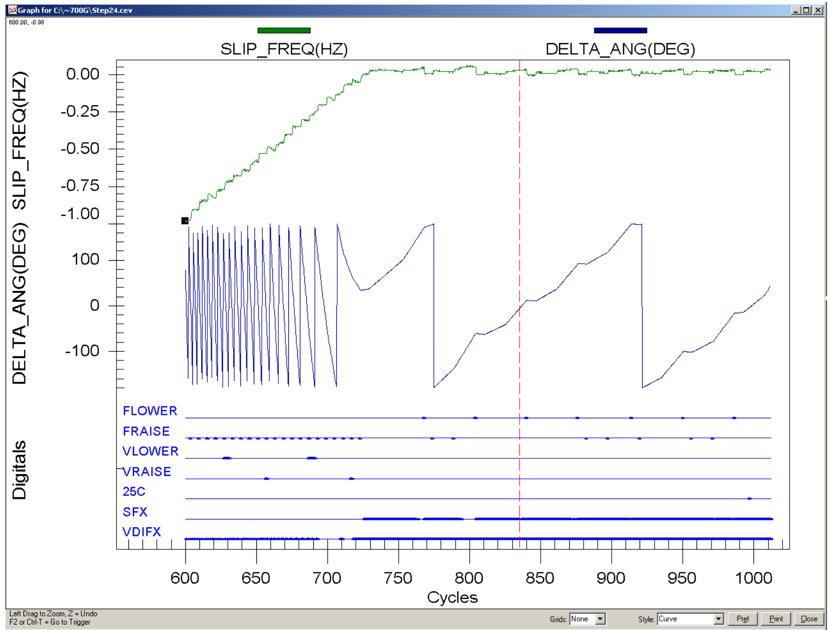


Figure 4.119 Graphical Display of Generator Autosynchronism Report

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.

The relay declares an LOP when there is more than a 25 percent drop in the measured positive-sequence voltage (V1) without a corresponding magnitude or angle change (above a pre-determined threshold) in positive-sequence (I1), negative-sequence (I2), or zero-sequence currents (I0).

If this condition persists for 60 cycles, then the relay latches the LOP Relay Word bit at logical 1. The relay resets LOP as below. When DELTAY_*n* (*n* = X or Y) is set to WYE, the relay resets LOP on the corresponding side (X or Y) under the following conditions (or as long as the following conditions exist):

➤ The respective positive-sequence voltage (V1) is at a level greater than 75 percent of nominal
➤ The respective negative-sequence (V2) and zero-sequence (V0) voltages are both less than 5 V secondary

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 4.105*.

When DELTAY_*n* (*n* = X or Y) is set to DELTA, the relay resets LOP on the corresponding side (X or Y) under these conditions.

➤ The respective positive-sequence voltage (V1) is at a level greater than 75 percent of nominal
➤ The respective negative-sequence voltage (V2) is less than 5 V secondary.

Settings

The LOP function has no settings and is always active. You must incorporate the LOP function in a SELOGIC control equation to supervise relay protection elements (see *Example 4.5*).

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

NOTE: When DELTAY_X := DELTA and EXT3V0_X := VS/VN, the V0 input to the logic is not taken into account.

You should 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.

It should be noted that when the relay is first energized with the generator offline, the relay logic asserts Relay Word bit LOP as it detects no voltage in the circuits. As soon as the generator starts and the relay detects the voltages, the LOP Relay Word bit deasserts. Once the relay control power is ON and the generator is taken offline, the relay does not assert Relay Word bit LOP because it does not detect the zero voltage condition.

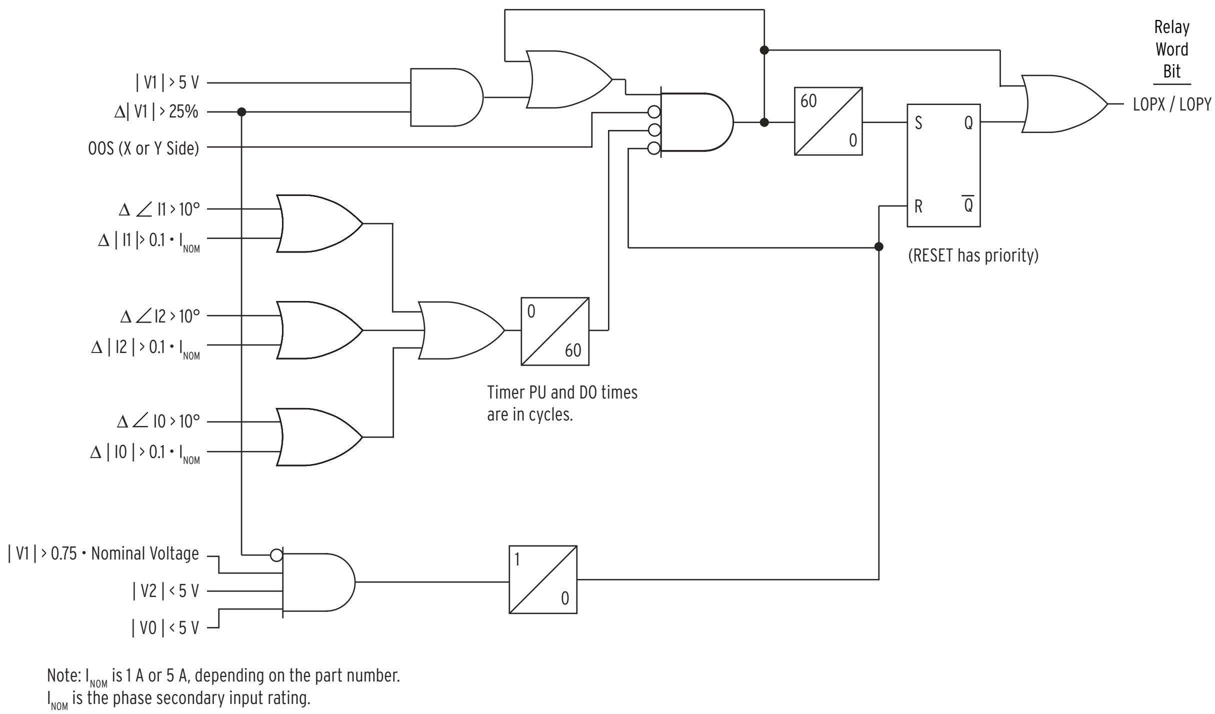


Figure 4.120 Loss-of-Potential Generic Logic (Applies to both X and Y Sides)

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 4.50 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 4.50 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 4.121*. 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.

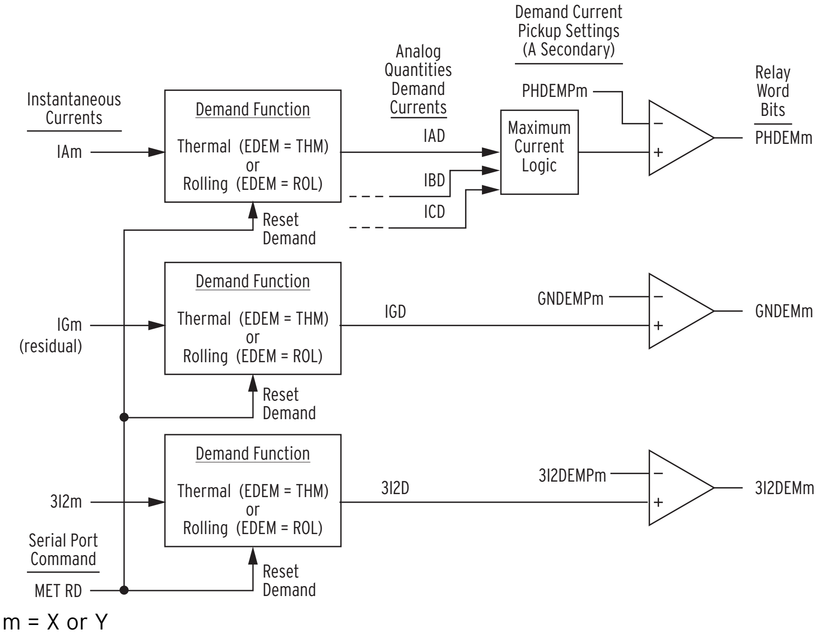


Figure 4.121 Demand Current Logic Outputs

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 4.122* 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").

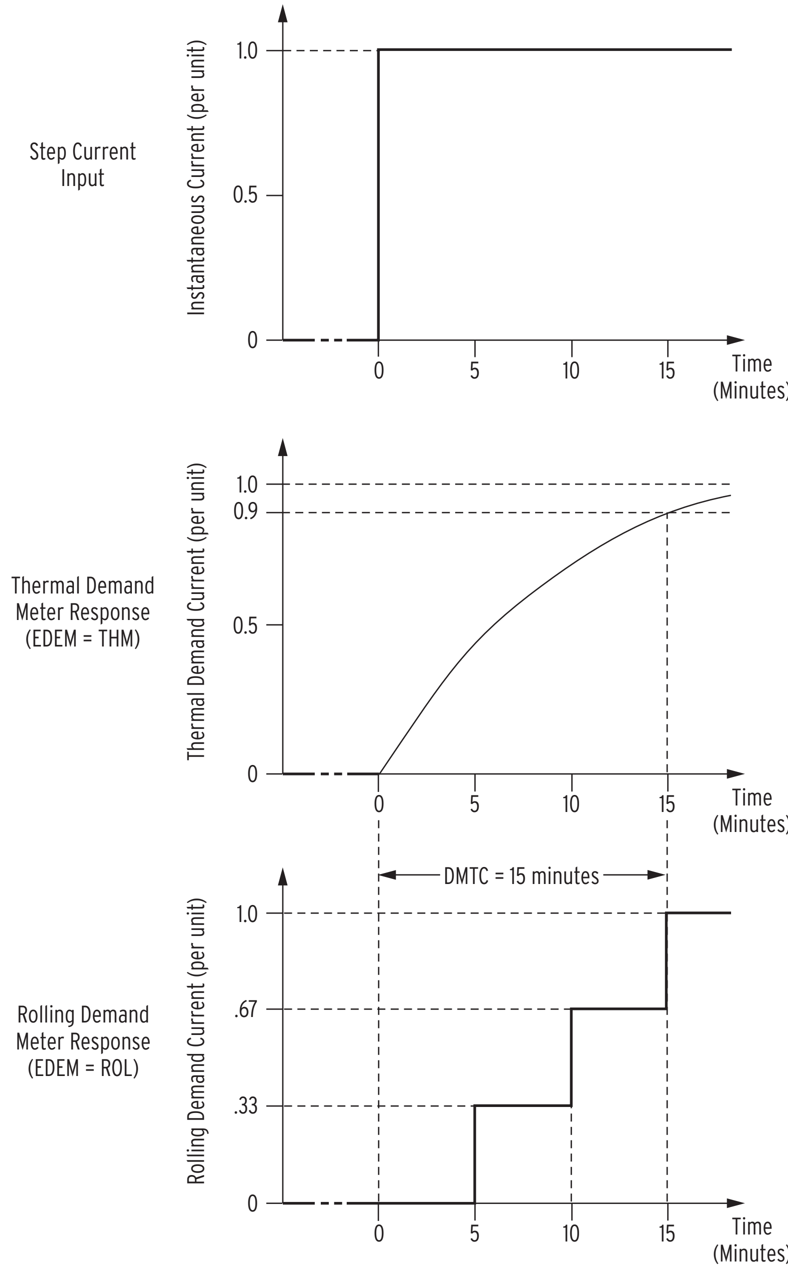


Figure 4.122 Response of Thermal and Rolling Demand Meters to a Step Input (Setting DMTC = 15 minutes)

Thermal Demand Meter Response

The response of the thermal demand meter in *Figure 4.122* (middle) to the step current input (top) is analogous to the series RC circuit in *Figure 4.123*.

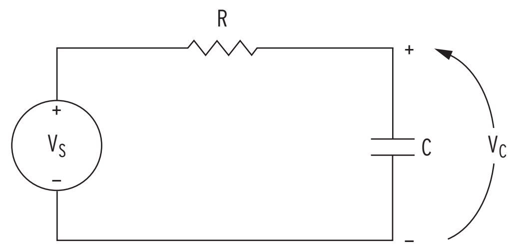


Figure 4.123 Voltage V_S Applied to Series RC Circuit

In the analogy:

- Voltage V_S in *Figure 4.123* corresponds to the step current input in *Figure 4.122* (top).
- Voltage V_C across the capacitor in *Figure 4.123* corresponds to the response of the thermal demand meter in *Figure 4.122* (middle).

If voltage V_S in *Figure 4.123* has been at zero (V_S = 0.0 per unit) for some time, voltage V_C across the capacitor in *Figure 4.123* 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 4.121* (middle) to the step current input (top).

In general, as voltage V_C across the capacitor in *Figure 4.123* 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 4.50*). Note in *Figure 4.122* 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 4.122* (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 4.50*). Note in *Figure 4.122* 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 4.122* 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 4.122* (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 4.51 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.

Figure 4.124 and *Figure 4.125* show the logic diagrams for breaker 52X and 52Y, respectively.

NOTE: The generator is considered running if Relay Word bit 3POX = 0.

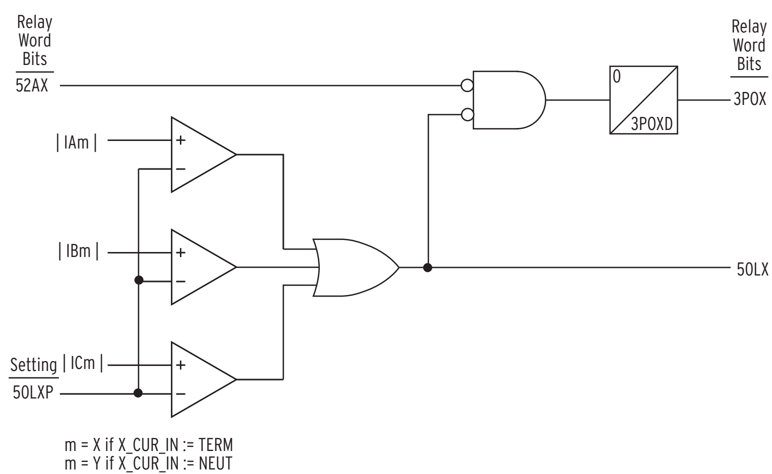


Figure 4.124 Pole Open Logic Diagram, Breaker 52X

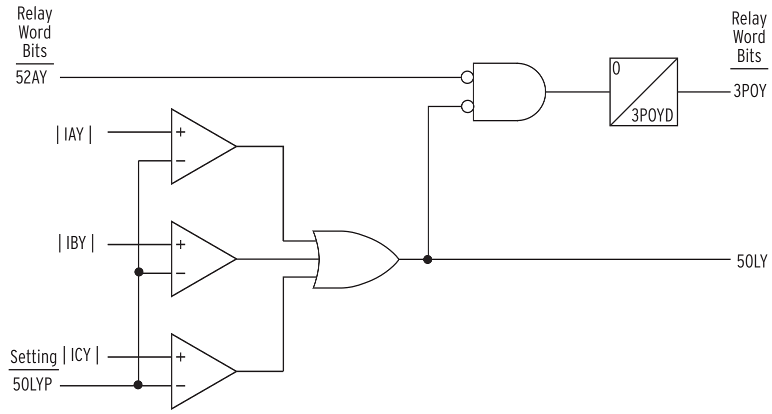


Figure 4.125 Pole Open Logic Diagram, Breaker 52Y

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 4.60 for the output contacts settings.

Table 4.52 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[e]
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 4.52 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[d]
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 4.126*) 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

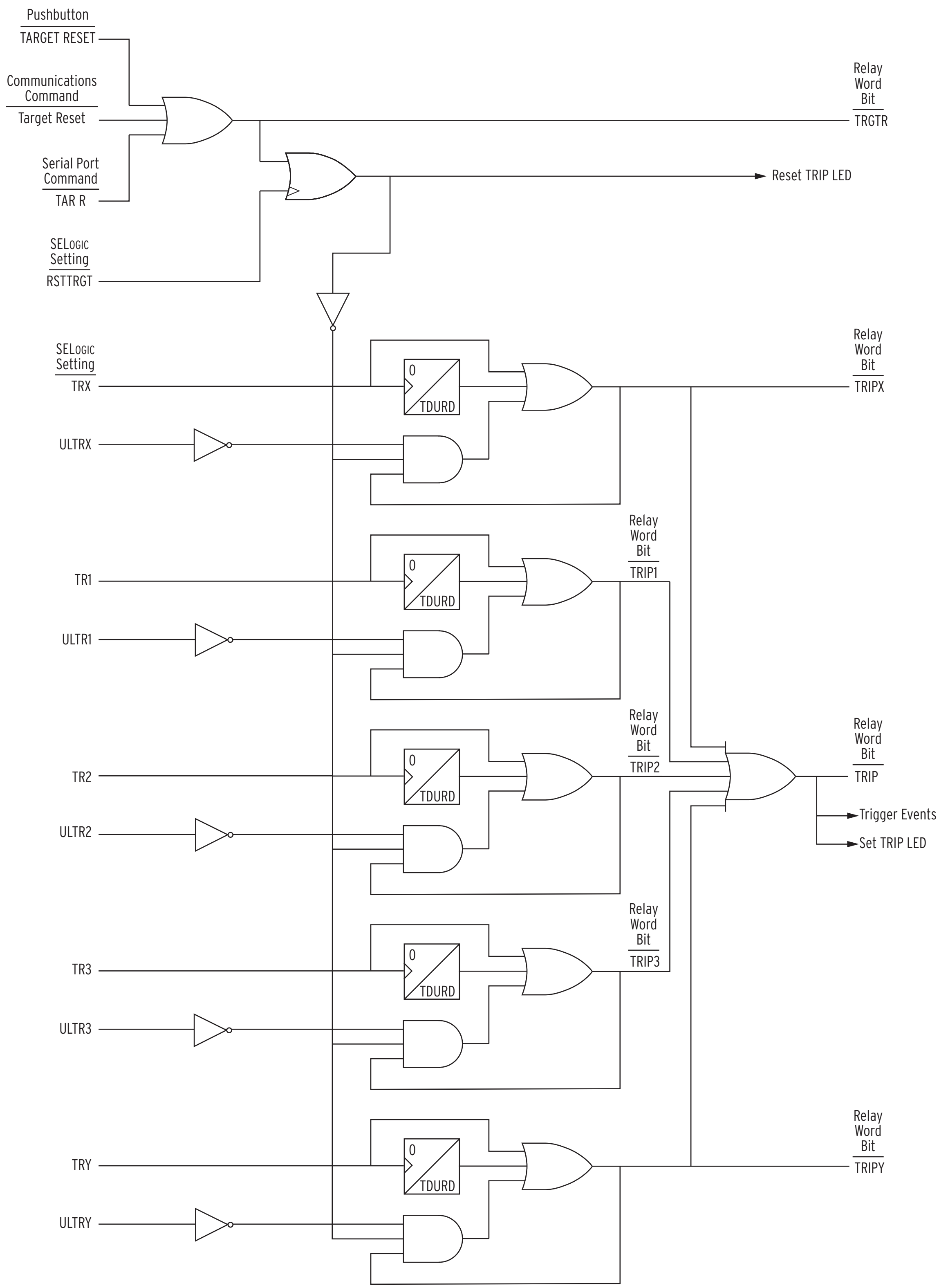


Figure 4.126 Trip Logic

Figure 4.127 through *Figure 4.129* 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.

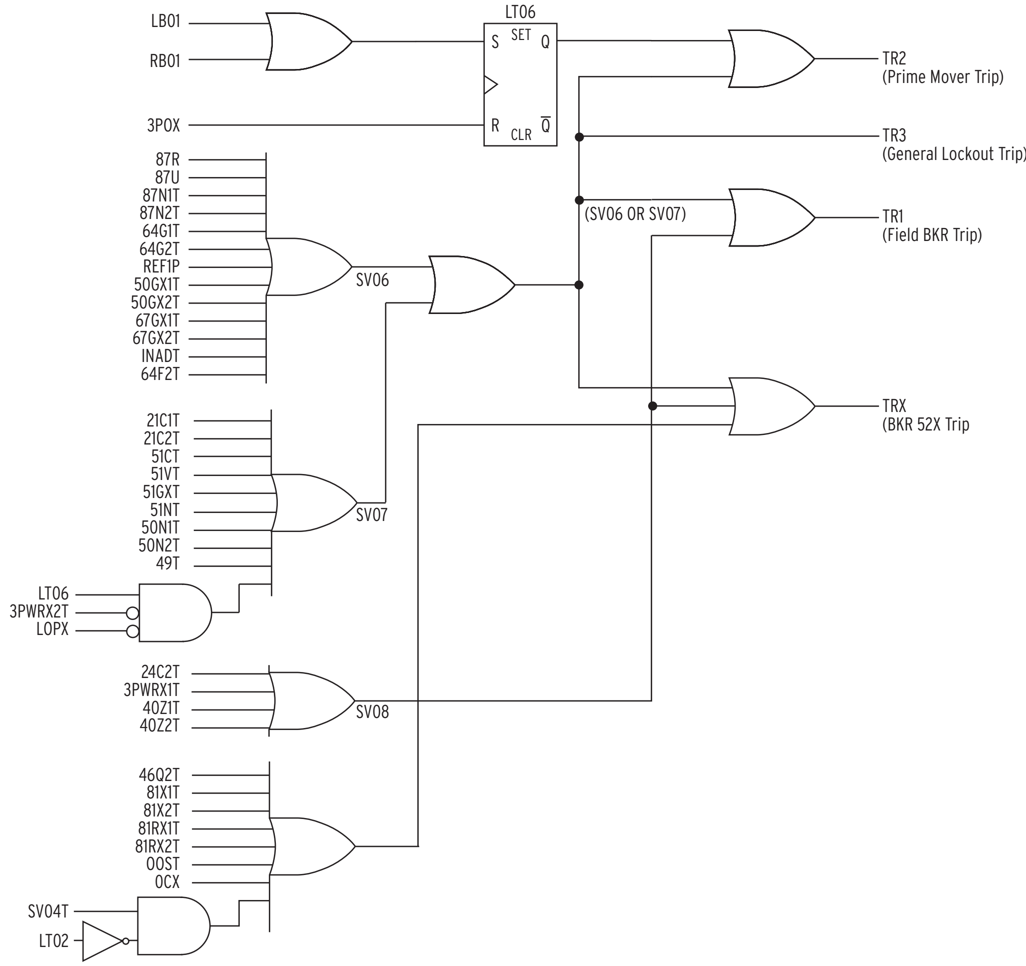


Figure 4.127 Typical Generator Trip TR Logic (SEL-700G0, SEL-700G1, SEL-700GT)

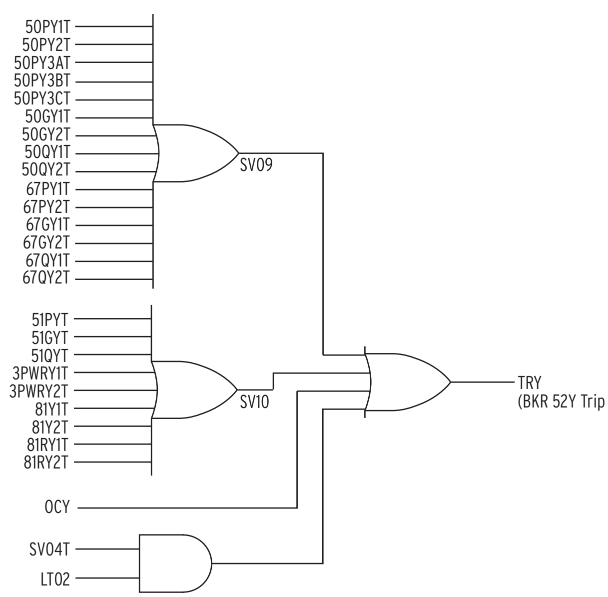


Figure 4.128 Typical Intertie Trip TR Logic (SEL-700GT)

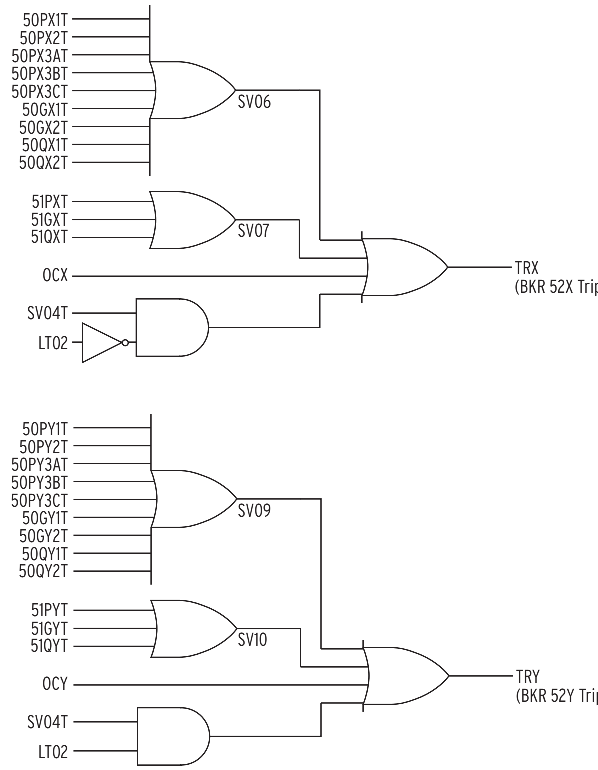


Figure 4.129 Typical Feeder Trip TR Logic (SEL-700GW)

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 4.60* for the output contacts settings. *Figure 2.24*, *Figure 2.27*, and *Figure 2.29* 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 Breaker Status Conditions SELOGIC Control Equation

You can connect an auxiliary contact of the high and low-side breaker to the relay. The SELOGIC control equations 52AX and 52AY allow you to configure the relay for either the 52a or the 52b contact input (or other contact that indicates a closed breaker). The factory default setting assumes no auxiliary contact connection (both 52AX and 52AY := 0).

If you connect the breaker auxiliary contact to a digital input, you must change the factory default logic equation. For example, set 52AX := **IN101** if you connect the 52a contact of breaker 52X to input **IN101**.

Figure 4.130 shows a close logic diagram of breaker 52X; the logic of breaker 52Y is similar.

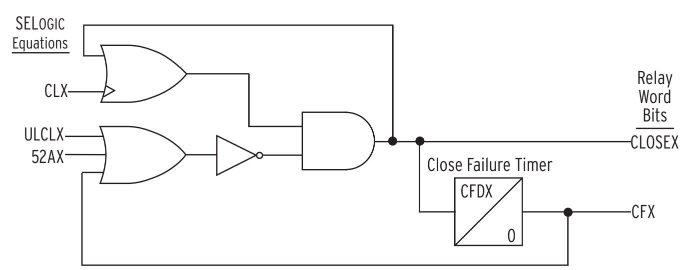


Figure 4.130 Close Logic

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 2.20* 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 4.131* for a typical generator or intertie close logic for the SEL-700G or SEL-700GT and *Figure 4.132* for a typical feeder close logic for the SEL-700GW. Review the default CL*m* equation, and edit it to suit your application.

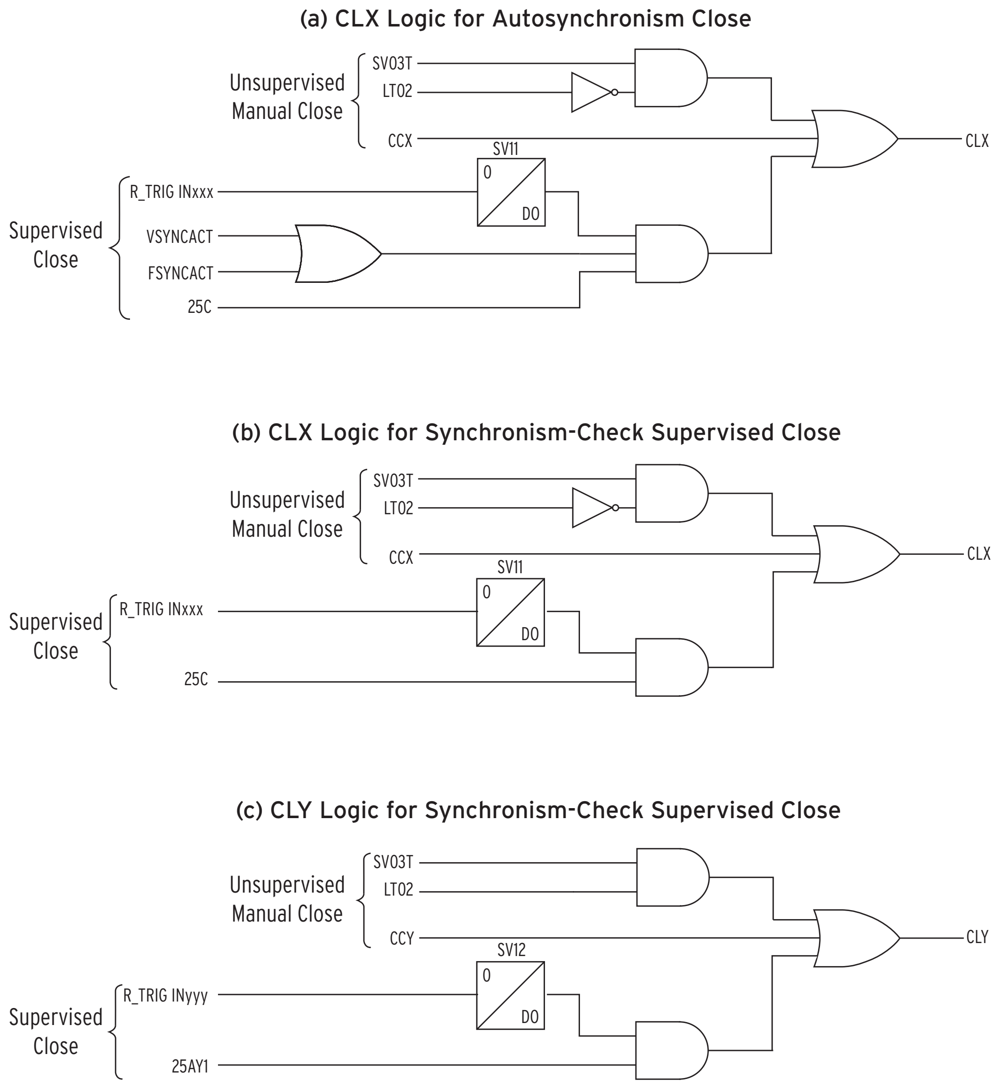


Figure 4.131 Typical Generator or Intertie Close CL Logic (SEL-700G or GT)

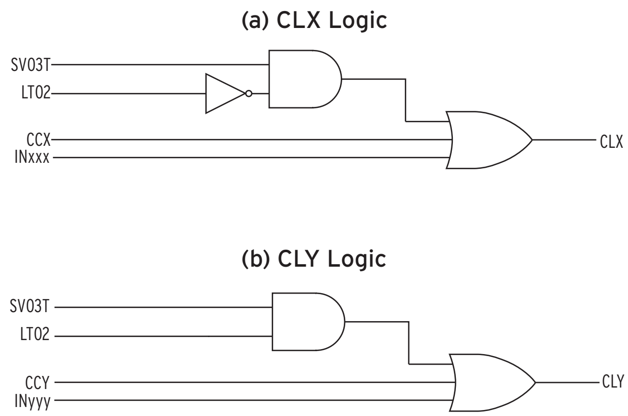


Figure 4.132 Typical Feeder Close CL Logic (SEL-700GW)

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.

SELOGIC Enables

Table 4.53 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 4.53 Enable Settings

Setting Prompt	Setting Range	Default Setting
SELOGIC Latches	N, 1–32	ELAT := 6
SV/Timers	N, 1–32	ESV := 12
SELOGIC Counters	N, 1–32	ESC := N
Math Variables	N, 1–32	EMV := N

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 4.133*). 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).

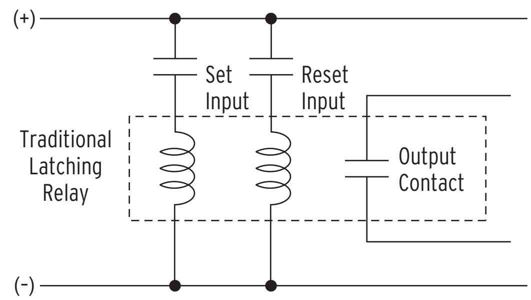


Figure 4.133 Schematic Diagram of a Traditional Latching Device

Thirty-two latch control switches in the SEL-700G provide latching device functionality. *Figure 4.134* 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.

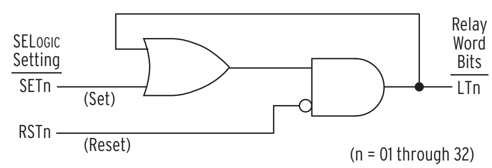


Figure 4.134 Logic Diagram of a Latch Switch

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 4.54* 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 4.53*), but are available for any special needs.

Table 4.54 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 4.194* 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 4.135*. Timers SV01T through SV32T in *Figure 4.135* 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).

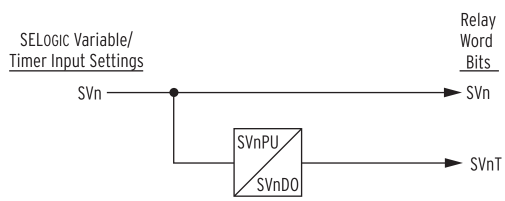


Figure 4.135 SELOGIC Control Equation Variable/Timers SV01/SV01T–SV32T

You can enter as many as 15 elements for each SELOGIC control equation, including a total of 14 elements in parentheses (see *Table 4.55* 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 4.55*. Math SELOGIC control equation settings operate on numerical values, using one or more of the mathematical operators listed in *Table 4.55*. These numerical values can be mathematical variables or real numbers.

The executed result of a math SELOGIC control equation is stored in a math variable. 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 is 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.

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 4.56* for this and other Boolean and math operators and values.

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 4.55 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 4.136*.

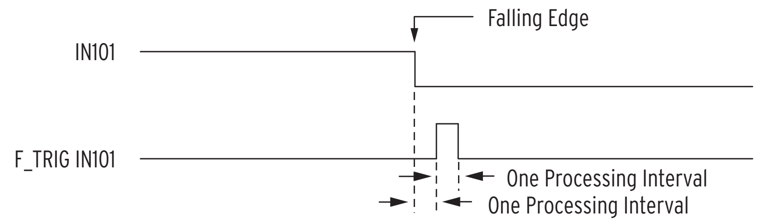


Figure 4.136 Result of Falling-Edge Operator on a Deasserting Input

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 4.56* shows other operators and values that you can use in writing SELOGIC control equations.

Table 4.56 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 4.137* 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)**

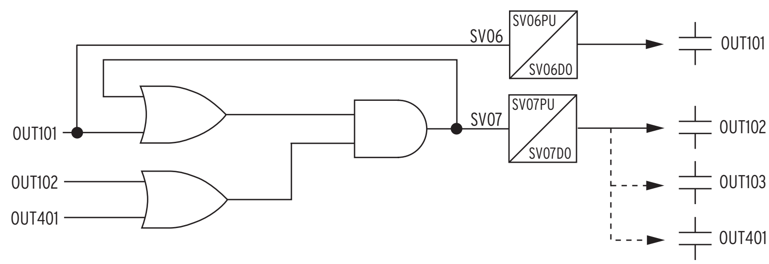


Figure 4.137 Example Use of SELOGIC Variables/Timers

SV/Timers Settings

The SEL-700G includes 32 SELOGIC variables. *Table 4.57* 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 4.53*), but they are available for any special needs.

Table 4.57 SELOGIC Variable Settings (Sheet 1 of 3)

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	Assigned to all buttons.

Table 4.57 SELOGIC Variable Settings (Sheet 2 of 3)

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 4.57 SELOGIC Variable Settings (Sheet 3 of 3)

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 default
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	
• • •	• • •		

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.

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 4.138* shows Counter 01, the first of 32 counters available in the device.

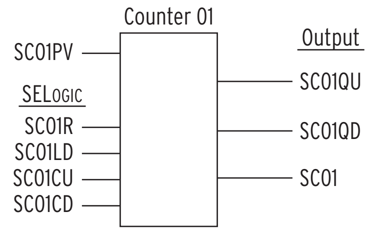


Figure 4.138 Counter 01

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 4.58* describes the counter inputs and outputs, and *Table 4.59* shows the order of precedence of the control inputs.

Table 4.58 Counter Input/Output Description

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).
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 4.59 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.

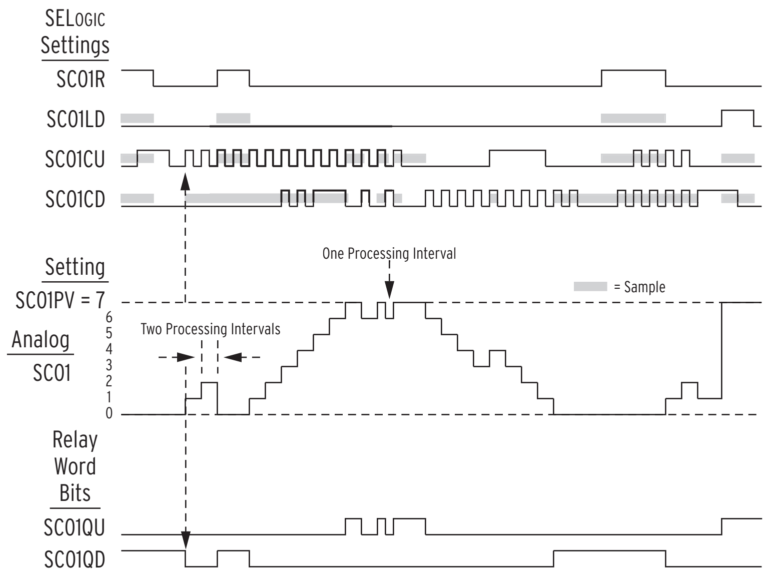


Figure 4.139 Example of the Effects of the Input Precedence

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. When a counter is disabled by a setting, the present count value is forced to 0 (SC*nn* := 0), causing the Relay Word bit SC*nn*QD to assert (SC*nn*QD := logical 1), and the Relay Word bit SC*nn*QU to deassert (SC*nn*QU := logical 0).

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: Four digital outputs in Slot **D** are shown. The outputs in Slots **C** and **E** have similar settings.

Table 4.60 Control Output Equations and Contact Behavior Settings

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
• • •	• • •	• • •

[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 2.11* and *Figure 2.12*.

When TRIP output fail-safe is enabled and the **TRIP** contact is appropriately connected (see *Figure 2.15*), the breaker is automatically tripped when relay control power fails.

MIRRORED BITS Transmit SELOGIC Control Equations

See *Appendix I: 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 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).

Set the SELOGIC control equation FAULT to temporarily block maximum and minimum metering, energy metering, and demand metering.

Table 4.61 General Global Settings

Setting Prompt	Setting Range	Setting Name := Factory Default	Description
RATED FREQ.	50, 60 Hz	FNOM := 60	
DATE FORMAT	MDY, DMY, DMY	DATE_F := MDY	
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 4.62 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 4.6*).

EXAMPLE 4.6 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 4.7 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

Group Selection

The TGR setting defines the delay for which the SS1, SS2, and SS3 SELOGIC control equation logic results must remain stable before the relay enables a new setting group. Typically, a one-second delay is sufficient.

Table 4.63 Setting Group Selection

Setting Prompt	Setting Range	Setting Name := Factory Default
GRP CHG DELAY	0–400 sec	TGR := 3
SELECT GROUP1	SELOGIC	SS1 := 1
SELECT GROUP2	SELOGIC	SS2 := 0
SELECT GROUP3	SELOGIC	SS3 := 0

SS1, SS2, and SS3 are SELOGIC control equations that help define when setting Group 1, 2, and 3 are active. With the settings shown previously, SS1 is set equal to logical 1. Thus, setting Group 1 always is active.

Synchrophasor Measurement

The SEL-700G relay provides Phasor Measurement Control Unit (PMCU) capabilities when connected to an IRIG-B time source. See *Appendix H: Synchrophasors* for description and *Table H.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 H: Synchrophasors* for the description and *Table H.1* for the settings. For SNTP applications, refer to *Simple Network Time Protocol (SNTP) on page 7.12*. For time update from a DNP Master, see *Time Synchronization on page D.9*.

Table 4.64 shows the time and date management settings that are available in the Global settings.

Table 4.64 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 time, 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 7.12* for a description and *Table 7.4* for the settings.

Breaker Failure Setting

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 2.17 connections do not provide breaker currents to the relay.

The SEL-700G provides flexible breaker failure logic for as many as two breakers (see *Figure 4.140*). 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.

Table 4.65 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.

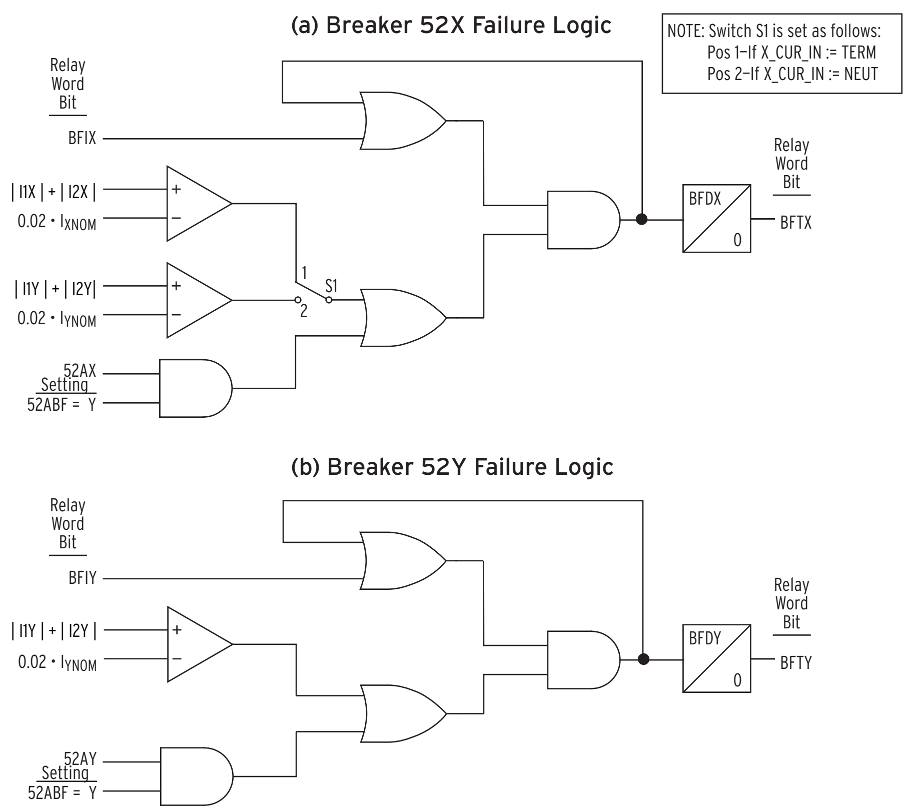


Figure 4.140 Breaker Failure Logic

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 4.141*. Variable *x* displays the slot position (**3** through **5**), and variable *y* displays the transducer (analog) input number (1 through 4).

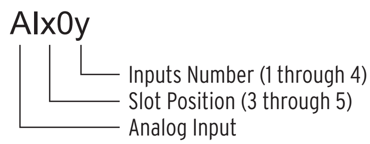


Figure 4.141 Analog Input Card Adaptive Name

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 4.66* summarizes the steps and describes the settings we carry out in this example.

Table 4.66 Summary of Steps

	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
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 AIxOyNAM 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 4.142*. 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 4.142 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 4.67 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 4.67 Analog Input Card in Slot 3

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
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 4.143* shows the *x* and *y* variable allocation for the analog output card.

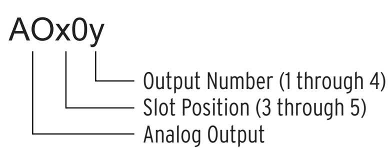


Figure 4.143 Analog Output Number Allocation

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 K: Analog Quantities*.

Table 4.68 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 4.68 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 K: Analog Quantities*) IAX_MAG, Phase A 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 4.144*. 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
? AI301 <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 4.144 Analog Output Settings

Breaker Monitor

The breaker monitor in the SEL-700G helps in scheduling circuit breaker maintenance. Refer to *Breaker Monitor on page 5.15* 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 4.145 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).

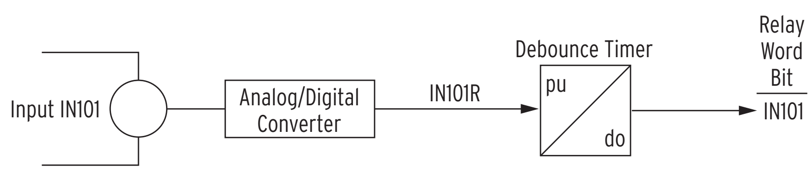


Figure 4.145 DC Mode Processing

AC Mode Processing (AC Control Voltage)

Figure 4.146 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.

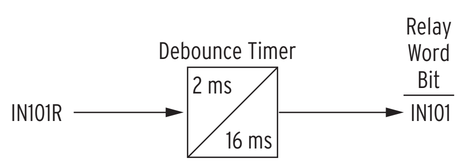


Figure 4.146 AC Mode Processing

Figure 4.147 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 4.147*). If IN101R deasserts (points marked 2 in *Figure 4.147*) 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.

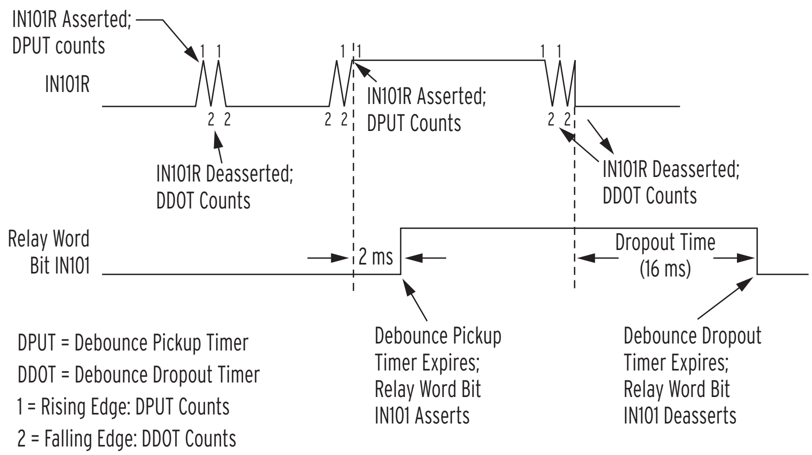


Figure 4.147 Timing Diagram for Debounce Timer Operation When Operating in AC Mode

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 4.69 shows the settings prompt, the setting range, and the factory default settings for a card in Slot C. See the *SEL-700G Settings Sheets* for a complete list of the input debounce settings.

Table 4.69 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 4.123* for more details. The RSTENRGY and RSTMXMN settings reset the Energy and Max/Min Metering values, respectively. You should 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 4.121* for the demand current logic diagram.

Table 4.70 Data Reset Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
RESET TARGETS	SELOGIC	RSTTRGT := 0
RESET ENERGY	SELOGIC	RSTENRGY := 0
RESET MAX/MIN	SELOGIC	RSTMXMN := 0

Table 4.70 Data Reset Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
RESET DEMAND	SELOGIC	RSTDEM := 0
RESET PK DEMAND	SELOGIC	RSTPKDEM := 0

Access Control

NOTE: DSABLSET does not disable the setting changes from the serial ports.

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 4.71* shows the settings prompt, the setting range, and the factory default settings.

Table 4.71 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 4.72* 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 2.21* and *IRIG-B on page 7.5* for additional information.

Table 4.72 Time-Synchronization Source Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
IRIG TIME SOURCE	IRIG1, IRIG2	TIME_SRC := IRIG1

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 an optional fiber-optic serial port; and **Port 3** (rear) can be an EIA-232 or an 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 4.73* through *Table 4.77* for the port settings, also see *Appendix D: DNP3 Communications*, *Appendix E: Modbus RTU Communications*, *Appendix F: IEC 61850 Communications*, *Appendix G: DeviceNet Communications*, *Appendix H: Synchrophasors*, and *Appendix I: MIRRORED BITS Communications*) for additional information on the protocol of interest.

PORT F

Table 4.73 Front-Panel Serial Port Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PROTOCOL	SEL, MOD, EVMSG, PMU	PROTO := SEL
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
SEND AUTOMESSAGE	Y, N	AUTO := N
HDWR HANDSHAKING	Y, N	RTSCTS := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

PORT 1

IMPORTANT: On relay initial power up or Port 1 setting changes or Logic setting changes, you may have to wait as long as two minutes before an additional setting 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 power up).

NOTE: TCP Keep-Alive is enabled with default range settings for PMU TCP sessions even when ETCPKA := N.

Table 4.74 Ethernet Port Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
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
SEND AUTOMESSAGES	Y, N	AUTO := N
FAST OP MESSAGES	Y, N	FASTOP := N
OPERATING MODE	FIXED, FAILOVER, SWITCHED	NETMODE := FAILOVER
FAILOVER TIMEOUT	0.10–65.00 sec	FTIME := 1.00
PRIMARY NETPORT	A, B, D	NETPORT := A
NETWRK PORTA SPD	AUTO, 10, 100 Mbps	NETASPD := AUTO
NETWRK PORTB SPD	AUTO, 10, 100 Mbps	NETBSPD := AUTO
TELNET PORT	23, 1025–65534	TPORT := 23
TELNET TIME OUT	1–30 min	TIDLE := 15
FTP USER NAME	20 characters	FTPUSER := FTPUSER
Enable IEC 61850 Protocol	(Y, N)	E61850 := N
Enable IEC 61850 GSE	(Y, N)	EGSE := N
Enable Modbus Sessions	0–2	EMOD := 0
Modbus TCP Port 1	(1–65534)	MODNUM1 := 502
Modbus TCP Port 2	(1–65534)	MODNUM2 := 502
Enable PMU Processing[a]	0–2	EPMIP := 0
Enable DNP Session[b]	0–3	EDNP := 0

[a] See Appendix H: Synchrophasors for a complete list of Synchrophasor settings and their descriptions.
[b] See Table D.7 for a complete list of the DNP3 session settings.

PORT 2

NOTE: For additional settings when PROTO := MBxx, see Table I.5 as well as MIRRORED BITS Transmit SELOGIC Control Equations **(Hidden if PROTO is not MBxx on any of the communications ports) on page SET.35**. For additional settings when PROTO := DNP, see Table D.7 for a complete list of the DNP3 session settings.

Table 4.75 Fiber-Optic Serial Port Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PROTOCOL	SEL, DNP, MOD, EVMSG, PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB	PROTO := SEL
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
SEND AUTOMESSAGE	Y, N	AUTO := N
FAST OP MESSAGES	Y, N	FASTOP := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

PORT 3

NOTE: For additional settings when PROTO := MBxx, see Table I.5 as well as MIRRORED BITS Transmit SELOGIC Control Equations **(Hidden if PROTO is not MBxx on any of the communications ports) on page SET.35**. For additional settings when PROTO := DNP, see Table D.7 for a complete list of the DNP3 session settings.

Table 4.76 Rear-Panel Serial Port (EIA-232) Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PROTOCOL	SEL, DNP, MOD, EVMSG, PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB	PROTO := SEL
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
SEND AUTOMESSAGE	Y, N	AUTO := N
HDWR HANDSHAKING	Y, N	RTSCTS := N
FAST OP MESSAGES	Y, N	FASTOP := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

PORT 4

NOTE: For additional settings when PROTO := MBxx, see Table I.5 as well as MIRRORED BITS Transmit SELOGIC Control Equations **(Hidden if PROTO is not MBxx on any of the communications ports) on page SET.35**.
For additional settings when PROTO := DNP, see Table D.7 for a complete list of the DNP3 session settings.

Table 4.77 Rear-Panel Serial Port (EIA-232/EIA-485) Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PROTOCOL	SEL, MOD, DNET, DNP, EVMSG, PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB	PROTO := SEL
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
SEND AUTOMESSAGE	Y, N	AUTO := N
HDWR HANDSHAKING	Y, N	RTSCTS := N
FAST OP MESSAGES	Y, N	FASTOP := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

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.

Set PROTO := SEL (standard SEL ASCII protocol), MOD (Modbus RTU protocol), or one of the MIRRORED BITS protocols, as necessary for your application. For detailed information, refer to *Appendix C: SEL Communications Processors*, *Appendix E: Modbus RTU Communications*, and *Appendix I: MIRRORED BITS Communications*.

Use the MBT option if you are using a Pulsar MBT9600 baud modem (see *Appendix I: 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.

Set the AUTO := Y to allow automatic messages at a serial port.

The relay EIA-232 serial ports support software (XON/XOFF) flow control. If you want to enable support for hardware (RTS/CTS) flow control, set the RTSCTS setting equal to Y.

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 4.78* 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 G: DeviceNet Communications* for details on DeviceNet.

Table 4.78 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)

General Settings

Local bits provide control from the front panel (local bits), and display points display selected information on the LCD display. 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.

Table 4.79 Display Point and Local Bit Default Settings

Setting	Setting Prompt	Range	Default
EDP	DISPLAY PTS ENABL	N, 1–32	2
ELB	LOCAL BITS ENABL	N, 1–32	N

To optimize the time you spend on setting the device, the relay makes only the number of enabled display points and enabled local bits 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, such as the device setting entry, when a timeout occurs, 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. 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 liquid crystal display. Use the front-panel auto-message setting FP_AUTO to define displaying of the trip/warning messages. Set FP_AUTO either to Override or add to the Rotating display when the relay triggers a trip/warning message. Set RSTLED := Y to reset the latched LEDs automatically when the breaker or contactor closes.

Table 4.80 LCD Display Settings

Setting	Setting Prompt	Range	Default
FP_TO	LCD TIMEOUT	OFF, 1–30; min	15
FP_CONT	LCD CONTRAST	1–8	5
FP_AUTO	FP AUTOMESSAGES	OVERRIDE, ROTATING	OVERRIDE
RSTLED	CLOSE RESET LEDS	Y, N	Y

Display Points

Use display points to view either the state of internal relay elements (Boolean information) or analog information on the LCD display. Although the LCD screen 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.

Boolean Display Point Entry Composition

Boolean information is the status of Relay Word bits (see *Appendix J: 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 4.81* 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 4.81* shows examples of the settings that always, never, or conditionally hide a display point.

Table 4.81 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

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 display 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 4.82 Entries for the Four Strings

Name	Alias	Set String	Clear String
IN101	TRFR 1 HV BRKR	CLOSED	OPEN

Figure 4.148 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 4.148 Display Point Settings

Figure 4.149 shows the display when both HV and LV breakers are open (both IN101 and IN102 deasserted). *Figure 4.150* shows the display when the HV breaker is closed, and the LV breaker is open (IN101 asserted, but IN102 still deasserted).

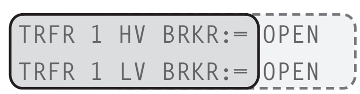


Figure 4.149 Front-Panel Display—Both HV and LV Breakers Open

Figure 4.150 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 4.151*.

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 4.152*.

Figure 4.151 Front-Panel Display—Both HV and LV Breakers Closed

Figure 4.152 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 4.153*.

Figure 4.153 Front-Panel Display—HV Breaker Open, LV Breaker Closed

Name Only

Table 4.83 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 4.83 Binary Entry in the Name String Only

Name	Alias	Set String	Clear String
IN101	—	—	—

Figure 4.154 shows the front-panel display for the entry in *Table 4.83*. Input IN101 is deasserted in this display (IN101=0), but the display changes to IN101=1 when Input IN101 asserts.

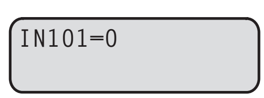


Figure 4.154 Front-Panel Display for a Binary Entry in the Name String Only

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 4.84* shows an entry in the Name string only (leaving the User Text and Formatting string void) with the following syntax:

Table 4.84 Analog Entry in the Name String Only

Name	Alias	Set String	Clear String
AI301	—	—	—

Figure 4.155 shows the front-panel display for the entry in *Table 4.84*, when you use the **SET F** command, as follows:

```
P01    := RID, "{16}"
? AI301 <Enter>
```

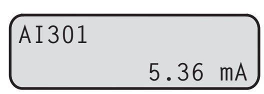


Figure 4.155 Front-Panel Display for an Analog Entry in the Name String Only

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 4.85* 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 4.85 Entry in the Name String and the Alias Strings

Name	Alias	Set String	Clear String
IN101	INPUT IN101	—	—
AI301	TEMPERATURE	—	—

Figure 4.156 shows the front-panel display for the entry in *Table 4.85*. Input IN101 is deasserted in this display (0), and the display changes to INPUT IN101=1 when Input IN101 asserts.

Figure 4.156 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 4.157*.

Figure 4.157 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 4.86* shows other options and front-panel displays for the User Text and Formatting settings.

Table 4.86 Example Settings and Displays

Example Display Point Setting Value	Example Display
AI301,"TEMP {4}deg C"	TEMP 1234° 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

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 (for example, EDP = 5). *Figure 4.158* 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 4.158 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 4.159*.

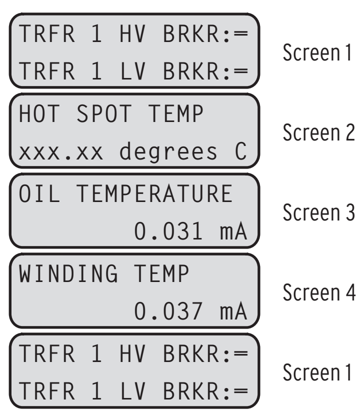


Figure 4.159 Rotating Display

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 display.
- ➤ 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 4.160* 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 4.160 Adding Two Local Bits

Target LED Settings

The SEL-700G offers the following two types of LEDs. See *Figure 8.1* and *Figure 8.26* for the programmable LED locations:

- ➤ Six Target LEDs
- ➤ Eight Pushbutton LEDs

Your can use SELOGIC control equations to program all 14 LEDs. The target LEDs differ from the other LEDs in that they also include a latch function.

Target LEDs

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.

The settings T*n*_LEDL (*n* = 01 through 06) and T*n*_LED (*n* = 01 through 06) control the six front-panel LEDs. With T*n*_LEDL set to Y, the LEDs latch the LED state at TRIP assertion. To reset these latched LEDs, the corresponding LED equation must be deasserted (logical 0) 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 4.87 shows the target LED settings. The factory default settings shown match the as-shipped front-panel overlay (see *Figure 8.1*). You can change the settings to suit your application. See *Section 8: Front-Panel Operations* for slide-in labels for custom LED designations.

Table 4.87 Target LED Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
TRIP LATCH T_LED	Y, N	T01LEDL := Y
LED1 EQUATION	SELOGIC	T01_LED := 87U OR 87R OR 87N1T OR 87N2T[a,b] T01_LED := 50PX1T OR 50PX2T OR 50PX3AT OR 50PX3BT OR 50PX3CT OR 51PXT[c]
TRIP LATCH T_LED	Y, N	T02LEDL := Y
LED2 EQUATION	SELOGIC	T02_LED := ORED50T OR ORED51T OR 46Q1T OR 46Q2T OR 51VT OR 51CT[a,b] T02_LED := 50GX1T OR 50GX2T OR 51GXT[c]
TRIP LATCH T_LED	Y, N	T03LEDL := Y
LED3 EQUATION	SELOGIC	T03_LED := 81T OR 81RT OR BNDT[a,b] T03_LED := 50QX1T OR 50QX2T OR 51QXT[c]
TRIP LATCH T_LED	Y, N	T04LEDL := Y
LED4 EQUATION	SELOGIC	T04_LED := 24D1T OR 24C2T[a,b] T04_LED := 50PY1T OR 50PY2T OR 50PY3AT OR 50PY3BT OR 50PY3CT OR 51PYT[c]
TRIP LATCH T_LED	Y, N	T05LEDL := Y

Table 4.87 Target LED Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
LED5 EQUATION	SELOGIC	T05_LED := 40Z1T OR 40Z2T[a,b] T05_LED := 50GY1T OR 50GY2T OR 51GYT[c]
TRIP LATCH T_LED	Y, N	T06LEDL := Y
LED6 EQUATION	SELOGIC	T06_LED := 64G1T OR 64G2T OR 64F1T OR 64F2T[a] T06_LED := 3PWRX1T OR 3PWRX2T OR 3PWRX3T OR 3PWRX4T OR 3PWRY1T OR 3PWRY2T OR 3PWRY3T OR 3PWRY4T[b] T06_LED := 50QY1T OR 50QY2T OR 51QYT[c]

[a] Default settings shown apply to SEL-700G0 and G1.
[b] Default settings shown apply to SEL-700GT.
[c] 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, …, 4A, 4B) SELOGIC control equation settings. When these Relay Word bits assert, the corresponding LED also asserts.

Table 4.88 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 8.1*). You can change the settings to suit your application. See *Section 8: Front-Panel Operations* for slide-in labels for custom LED designations.

Table 4.88 Pushbutton LED Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
PB1A_LED EQUATION	SELOGIC	PB1A_LED := NOT LT01 OR SV01 AND NOT SV01T AND SV05T
PB1B_LED EQUATION	SELOGIC	PB1B_LED := LT01 OR SV01 AND NOT SV01T AND SV05T
PB2A_LED EQUATION	SELOGIC	PB2A_LED := 0[a] PB2A_LED := NOT LT02 OR SV02 AND NOT SV02T AND SV05T AND PB02[b,c]
PB2B_LED EQUATION	SELOGIC	PB2B_LED := 0[a] PB2B_LED := LT02 OR SV02 AND NOT SV02T AND SV05T AND PB02[b,c]
PB3A_LED EQUATION	SELOGIC	PB3A_LED := 52AX OR (SV03 AND SV05T AND NOT SV03T)[a] PB3A_LED := 52AX OR (SV03 AND SV05T AND NOT SV03T AND NOT LT02)[b c]
PB3B_LED EQUATION	SELOGIC	PB3B_LED := NOT LT01 AND NOT 52AX[a] PB3B_LED := 52AY OR (SV03 AND SV05T AND NOT SV03T AND LT02)[b,c]

Table 4.88 Pushbutton LED Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
PB4A_LED EQUATION	SELOGIC	PB4A_LED := NOT 52AX OR (SV04 AND SV05T AND NOT SV04T)[a] PB4A_LED := NOT 52AX OR (SV04 AND SV05T AND NOT SV04T AND NOT LT02)[b,c]
PB4B_LED EQUATION	SELOGIC	PB4B_LED := 0[a] PB4B_LED := NOT 52AY OR (SV04 AND SV05T AND NOT SV04T AND LT02)[b,c]

[a] Default settings shown apply to SEL-700G0 and G1.
[b] Default settings shown apply to SEL-700GT.
[c] 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 4.90* (see *Appendix J: 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. 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 9: Analyzing Events* for more information).

When detecting oscillating SER items, the relay automatically deletes these oscillating items from SER recording. *Table 4.89* shows the auto-removal settings.

Table 4.89 Auto-Removal Settings

Settings Prompt	Setting Range	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 4.90* shows the settings prompt and the default settings for the four SER trigger equations.

Table 4.90 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 20 unique aliases, as defined by the Enable Alias Settings (EALIAS) setting. Factory default alias settings are shown in *Table 4.92*.

Table 4.91 Enable Alias Settings

Setting Prompt	Setting Range	Setting Name = Factory Default
Enable ALIAS Settings (N, 1–20)	N, 1–20	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 J.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 4.92 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 –ALIAS20	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 triggers an event report when either 64G1 or SWING asserts, even if the event does not result in a trip.

Table 4.93 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.

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.

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 4, 17, or 72 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 checking 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 4.95*. The resolution and number of pre-trigger data samples are defined by the settings GSRR and PRESYNC and can be set as necessary.

Table 4.94 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 *Table 4.118* for a sample graphical display of the report using ACSELERATOR QuickSet. You can also trigger the report with the **GST** command. See *Section 7: Communications* for more detail on ASCII commands.

Table 4.95 Generator Autosynchronism Report Data

Data	Description	Remarks
Analog Data: DELTA_VOLT VS SLIP_FREQ FREQS DELTA_ANGLE	(From *Figure 4.105*) Vpxc_Mag–Vs_Mag Vs_Mag * PTRS FREQX–FREQS FREQS Vxs_Angle	See *Appendix K: 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 J: Relay Word Bits* for descriptions. Use unassigned variables SV27–SV32 to enhance the report as necessary (see *Table 4.56*).

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 K: 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 4.96 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 DNP n Command, n = 1, 2, or 3)

Table 4.97 shows the available settings. See *Appendix D: DNP3 Communications* for additional details.

Table 4.97 DNP Map Settings[a] (Sheet 1 of 2)

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

Table 4.97 DNP Map Settings[a] (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
. . .		
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 4.98 shows the available settings. See *Appendix E: Modbus RTU Communications* for additional details.

Table 4.98 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 RTU Communications for Modbus Register Labels and Factory Default settings.

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Section 5
Metering and Monitoring

Overview

The SEL-700G 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
- EIA-232 serial ports (using SEL ASCII text commands or ACSELERATOR QuickSet® SEL-5030 Software)
- Telnet via Ethernet port
- Modbus® via EIA-485 port or EIA-232 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 via Ethernet port
- C37.118 Synchrophasor Protocol via serial 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 5.15* 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*.

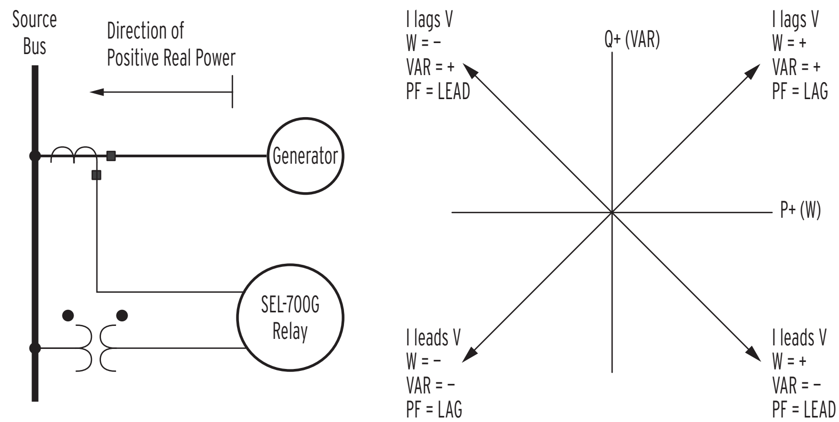

Figure 5.1 Complex Power Measurement Conventions

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 transducer input metering

- Demand and peak demand metering
- Synchrophasor metering
- Differential metering
- Harmonic metering (differential)

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: Phase-to-phase voltages for wye-connected PTs are available in Appendix K: Analog Quantities and can be displayed on the front panel.

NOTE: 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 the square root of 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-700G0 Model

Energy Metering

> **NOTE:** Energy values rollover after 999,999 MVAh and reset to 0.

The SEL-700G with the voltage option includes energy metering. *Table 5.4* lists the energy quantities that are available in the Energy Meter report generated by the **MET E** command.

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 M**(ath) **V**(ariable) 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.

```
=>>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. These values can then be used for automation and control applications within an industrial plant or application.

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
AI405 (HP)        1423
AI406 (mA)           9.013
AI407 (mA)          -3.014
AI408 (mA)          -0.013

=>
```

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 4.179* 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 H.4* in *Appendix H: 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 H.4*, occurring just after 14:14:12, with the time stamp 14:14:12.000. Refer to *Appendix H: 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.

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 5.14* 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 5.14 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 5.15* 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 5.15 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 • INOM A (secondary) and for voltage values is 0.1 V (secondary). The threshold for RMS metering current values is 0.03 • INOM A (secondary) and for voltage values is 0.3 V (secondary).

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 4.234*). Choose which analog quantities you want to monitor from the analog quantities listed in *Appendix K: 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 7.32*. *Figure 5.16* 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 5.16 Device Response to the LDP Command

Breaker Monitor

The breaker monitor in the SEL-700G helps in scheduling circuit breaker maintenance. The breaker monitor is enabled with the 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 (Breaker Monitor Data) on page 7.21* and *BRE n W or R Command (Preload/Reset Breaker Wear) on page 7.22*.

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 5.17*.

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 5.17* 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.

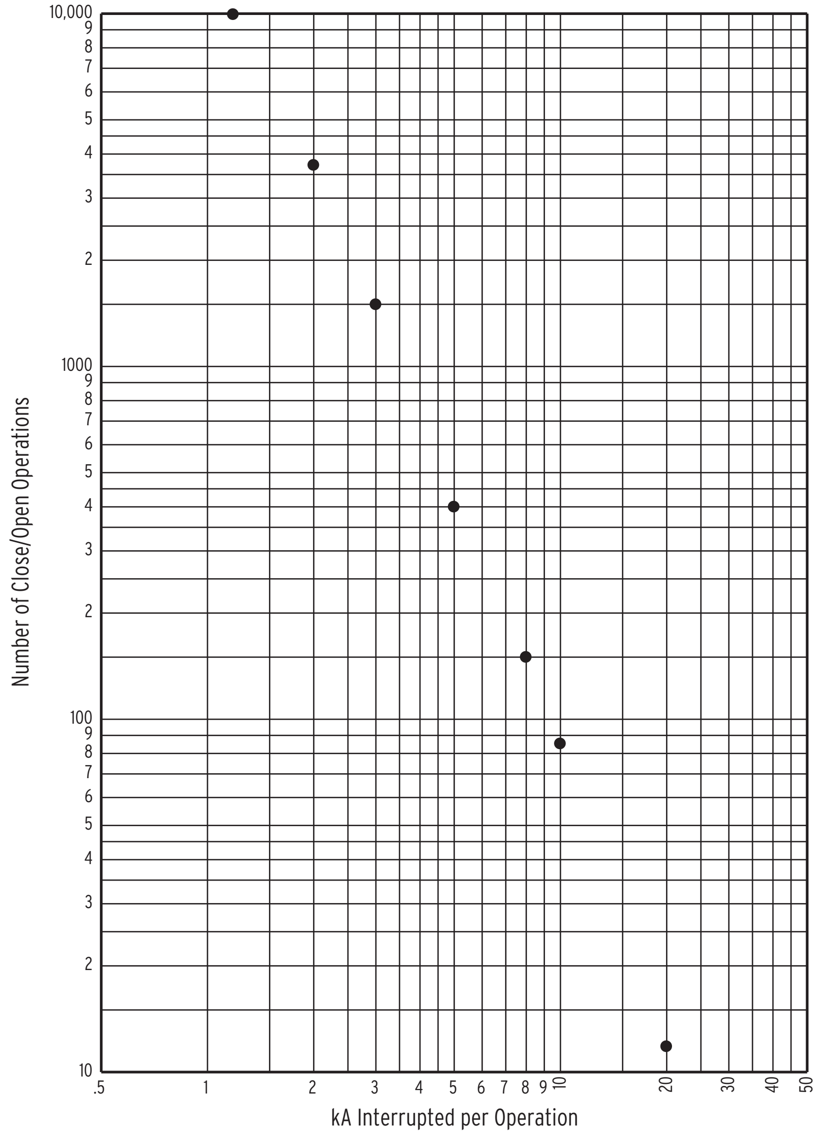

Figure 5.17 Plotted Breaker Maintenance Points for a 25 kV Circuit Breaker

The following settings are made from the breaker maintenance information in *Table 5.10* and *Figure 5.17*:

COSP1*n* = **10000**

COSP2*n* = **150**

COSP3*n* = **12**

KASP1*n* = **1.20**

KASP2*n* = **8.00**

KASP3*n* = **20.00**

Figure 5.18 shows the resultant breaker maintenance curve.

Breaker Maintenance Curve Details

In *Figure 5.18*, 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 5.17*.

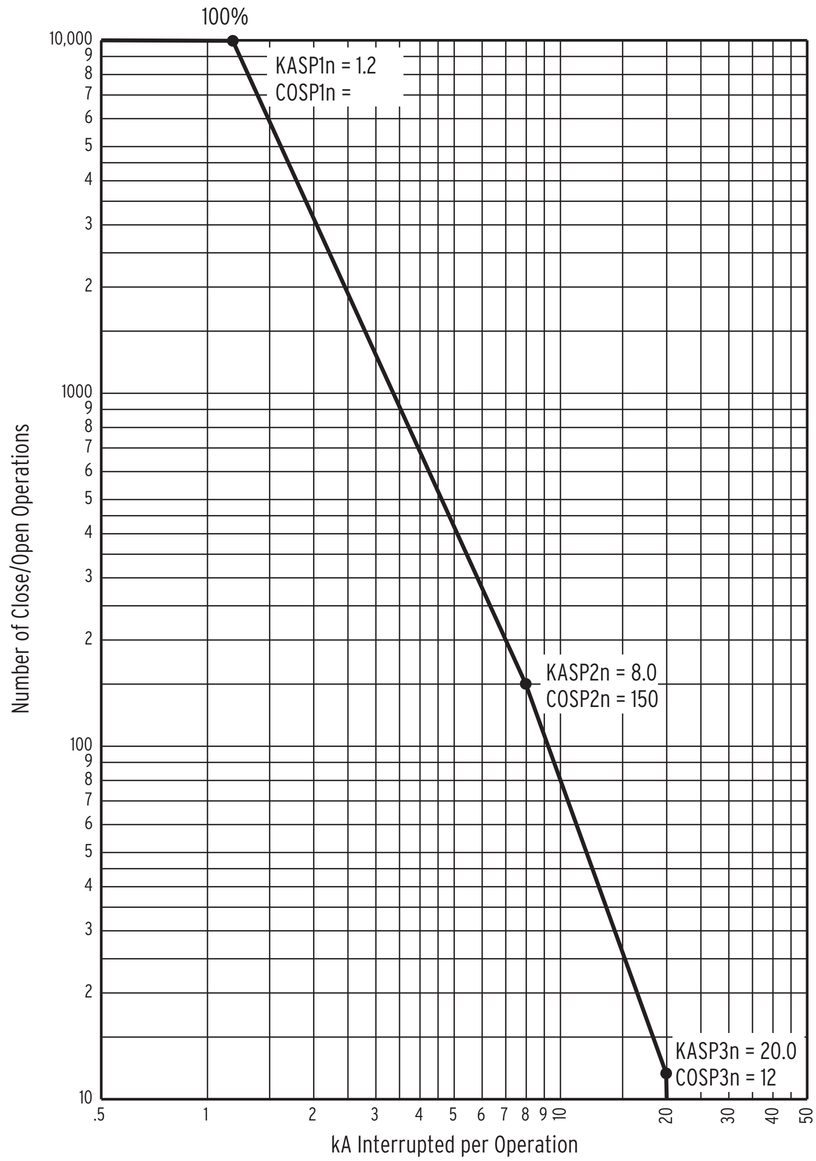

Figure 5.18 SEL-700G Breaker Maintenance Curve for a 25 kV Circuit Breaker

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 5.17*, 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 5.17*.

Each phase (A, B, and C) has its own breaker maintenance curve (like that in *Figure 5.19*), 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 5.19*, 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 5.19*) and the breaker monitor accumulated currents/trips (see *BRE n Command (Breaker Monitor Data) on page 7.21*).

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 5.19*. 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 5.19*, 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.

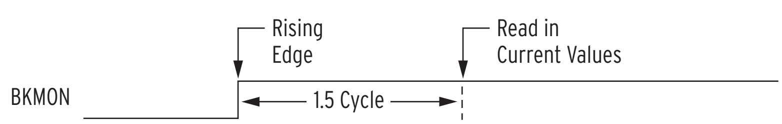

Figure 5.19 Operation of SELOGIC Control Equation Breaker Monitor Initiation Setting

See *Figure 5.24* 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 Examples

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 5.20* through *Figure 5.23*. Also, presume that the circuit breaker interrupting contacts have no wear at first (brand new or recent maintenance performed).

Note in *Figure 5.20* through *Figure 5.23* that the interrupted current in a given figure is the same magnitude for all interruptions (for example, in *Figure 5.21*, 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 5.20*. 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.

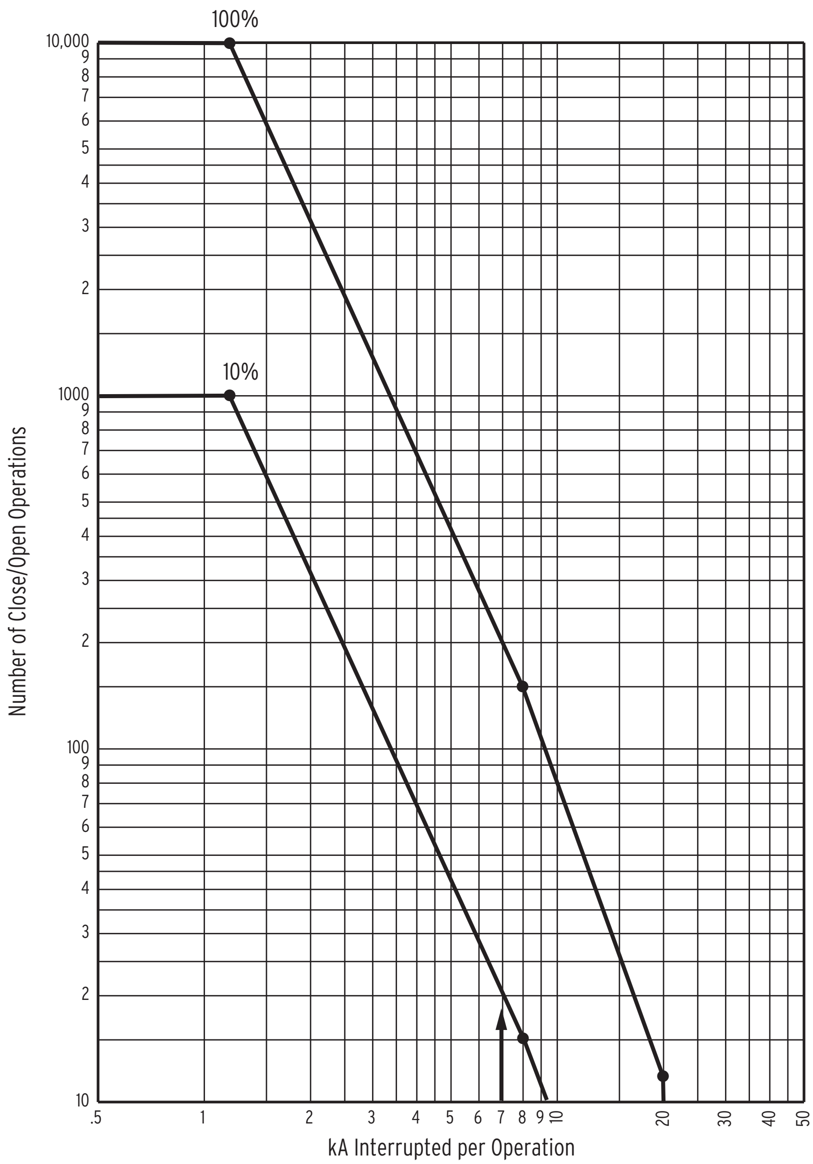

Figure 5.20 Breaker Monitor Accumulates 10 Percent Wear

10 Percent to 25 Percent Breaker Wear

Refer to *Figure 5.21*. 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.

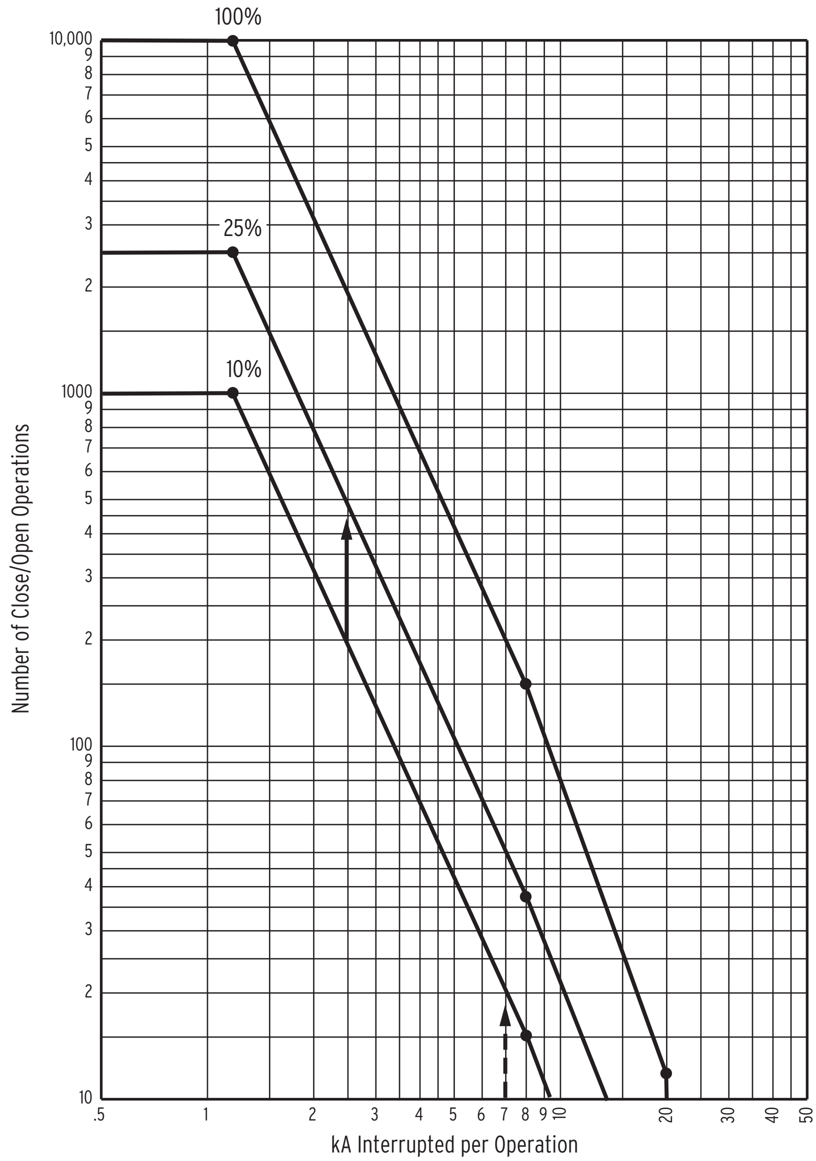

Figure 5.21 Breaker Monitor Accumulates 25 Percent Wear

25 Percent to 50 Percent Breaker Wear

Refer to *Figure 5.22*. 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.

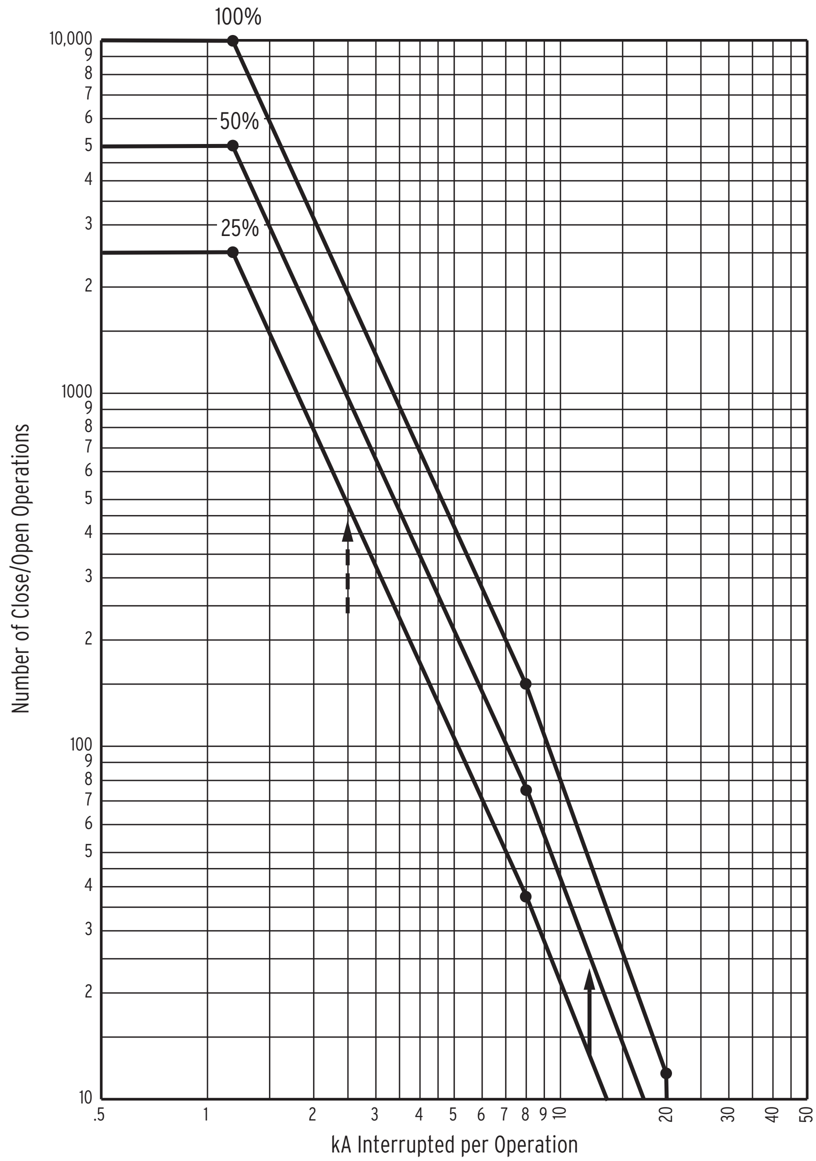

Figure 5.22 Breaker Monitor Accumulates 50 Percent Wear

50 Percent to 100 Percent Breaker Wear

Refer to *Figure 5.23*. 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 5.24*). 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.

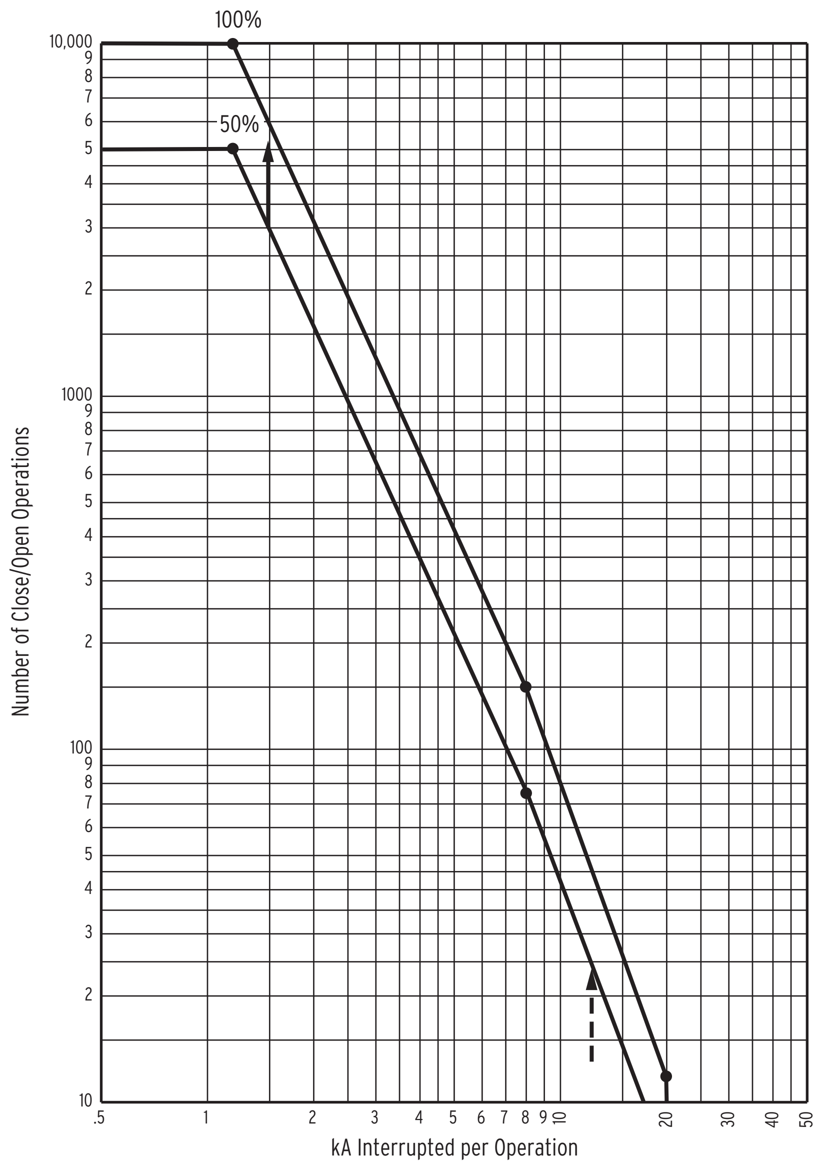

Figure 5.23 Breaker Monitor Accumulates 100 Percent Wear

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*	Phase A breaker*n* contact wear has reached the 100 percent wear level
BCWB*n*	Phase B breaker*n* contact wear has reached the 100 percent wear level
BCWC*n*	Phase C 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 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-phase, 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.

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 5.19* 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 4.64*). If TRIP*n* is asserted (TRIP*n* = logical 1), the current and trip count information is accumulated under relay-initiated trips (Rly Trips). If TRIPn is deasserted (TRIPn = 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 5.19–Figure 5.23*).

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.

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).

Additional Example

Refer to *Figure 5.24*. Output contact **OUTxxx** is set to provide tripping:

OUTxxx*n* = **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.

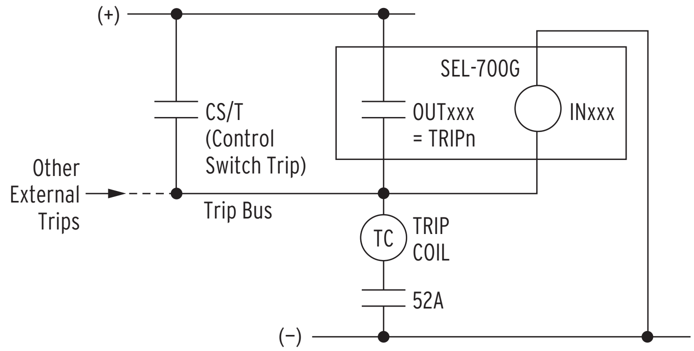

Figure 5.24 Input INxxx Connected to Trip Bus for Breaker Monitor Initiation

If the SELOGIC control equation breaker monitor initiation setting is set:

BKMON*n* = **INxxx**

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).

Section 6
Settings

Overview

SEL-700G Relay stores the settings you enter in nonvolatile memory. Settings are divided into the following eight setting classes:

1. Relay Group *n* (where *n* = 1, 2, or 3)
2. Logic Group *n* (where *n* = 1, 2, or 3)
3. Global
4. Port *p* (where *p* = F, 1 [Ethernet], 2, 3, or 4)
5. Front Panel
6. Report
7. Modbus®
8. DNP3

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

	Serial Port Commands[a]	Front-Panel HMI Set/Show Menu[b]	ACSELERATOR QuickSet® SEL-5030 Software[c]
Display Settings	All settings (**SHO** command)	Global, Group, and Port settings	All settings
Change Settings	All settings (**SET** command)	Global, Group, and Port settings	All settings

[a] Refer to Section 7: Communications for detailed information on set up and use of the serial communications port and Ethernet port.
[b] Refer to Section 8: Front-Panel Operations for detailed information on the front-panel layout, menus and screens, and operator control pushbuttons.
[c] Refer to Section 3: PC Software for detailed information.

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.

View/Change Settings With Front Panel

You can use the pushbuttons on the front panel to view/change settings. *Section 8: Front-Panel Operations* presents 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).

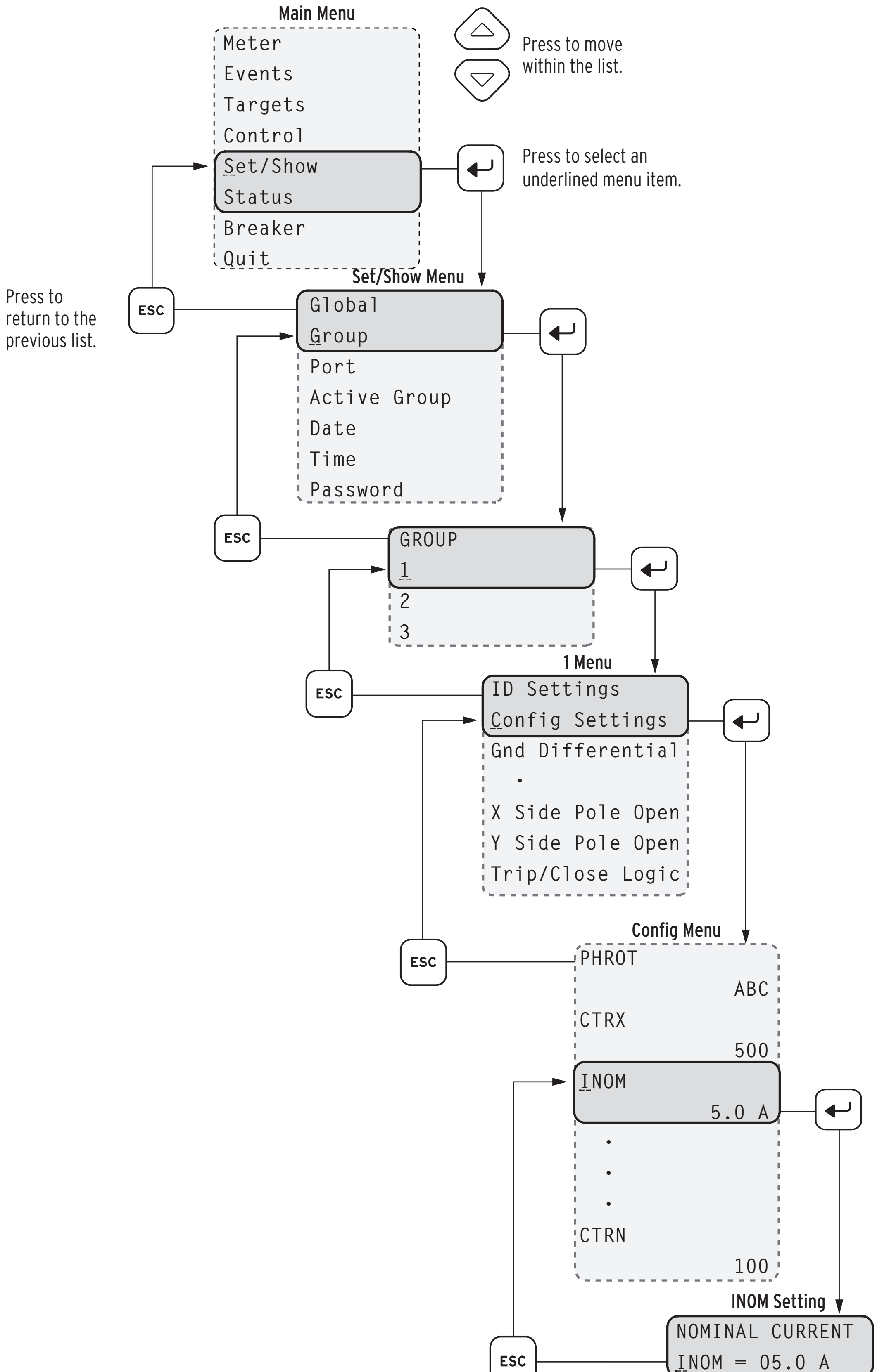

Figure 6.1 Front-Panel Setting Entry Example for the SEL-700GT Relay

View/Change Settings 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
SHOW *n*	Show relay group settings: *n* specifies the settings group (1, 2, or 3); *n* defaults to active settings group if not listed.
SHO L *n*	Show logic settings: *n* specifies the settings group (1, 2, or 3); *n* defaults to 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 R	Show Sequential Event Report (SER) and Event Report settings.
SHO M	Show Modbus settings.
SHO D	Show DNP3 map settings.

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*	Relay	Protection elements, timers, etc., for settings group *n* (1, 2, or 3)
SET L *n*	Logic	SELOGIC control equations for settings group *n* (1, 2, or 3)
SET G	Relay	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 R	Reports	SER and Event Report settings
SET M	Modbus	Modbus user map
SET D	DNP	DNP3 map settings

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 ALARM Relay Word bit is set momentarily, and the ENABLED LED extinguishes while the relay is disabled.

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 blank (1) or is 1, 2, or 3 when *n* = G or L for group settings.
m	is left blank or is F, 1, 2, 3, or 4 when *n* = P.
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 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 Messages	Setting/Function	Correct the Condition
CTR*m*, TAP*m* 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.

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. ACSELERATOR 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 (0.20–1000.00 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 (0.20–1000.00 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)

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

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 kilohms)	**64F1P :=**_______________
64F LVL 1 DELAY (0.00–99.00 s) (Hidden if 64F1P := OFF)	**64F1D :=**_______________
64F LVL 2 PICKUP (OFF, 0.5–200.0 kilohms)	**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, 2–100 %)	**46Q1P :=** ________________
LVL1 TIME DELAY (0.02–999.90 s) (Hidden if 46Q1P := OFF)	**46Q1D :=** ________________
LVL2 NEQ-SEQ O/C (OFF, 2–100 %)	**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 (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 (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 (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 (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 (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 (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 (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 (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 (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 (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 (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 (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 (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 (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 (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 (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 –5.00 and 5.00 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 (0.00–240.00 s) (Hidden if 81X1TP := OFF)	**81X1TD :=**_______________
FREQX TRIP2 LVL (OFF, 15.00–70.00 Hz) (Hidden if E81X < 2)	**81X2TP :=**_______________
FREQX TRIP2 DLY (0.00–240.00 s) (Hidden if 81X2TP := OFF)	**81X2TD :=**_______________
FREQX TRIP3 LVL (OFF, 15.00–70.00 Hz) (Hidden if E81X < 3)	**81X3TP :=**_______________
FREQX TRIP3 DLY (0.00–240.00 s) (Hidden if 81X3TP := OFF)	**81X3TD :=**_______________
FREQX TRIP4 LVL (OFF, 15.00–70.00 Hz) (Hidden if E81X < 4)	**81X4TP :=**_______________
FREQX TRIP4 DLY (0.00–240.00 s) (Hidden if 81X4TP := OFF)	**81X4TD :=**_______________
FREQX TRIP5 LVL (OFF, 15.00–70.00 Hz) (Hidden if E81X < 5)	**81X5TP :=**_______________
FREQX TRIP5 DLY (0.00–240.00 s) (Hidden if 81X5TP := OFF)	**81X5TD :=**_______________

FREQX TRIP6 LVL (OFF, 15.00–70.00 Hz) (Hidden if E81X < 6)	**81X6TP :=**_______________
FREQX TRIP6 DLY (0.00–240.00 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 (0.00–240.00 s) (Hidden if 81Y1TP := OFF)	**81Y1TD :=**_______________
FREQY TRIP2 LVL (OFF, 15.00–70.00 Hz) (Hidden if E81Y < 2)	**81Y2TP :=**_______________
FREQY TRIP2 DLY (0.00–240.00 s) (Hidden if 81Y2TP := OFF)	**81Y2TD :=**_______________
FREQY TRIP3 LVL (OFF, 15.00–70.00 Hz) (Hidden if E81Y < 3)	**81Y3TP :=**_______________
FREQY TRIP3 DLY (0.00–240.00 s) (Hidden if 81Y3TP := OFF)	**81Y3TD :=**_______________
FREQY TRIP4 LVL (OFF, 15.00–70.00 Hz) (Hidden if E81Y < 4)	**81Y4TP :=**_______________
FREQY TRIP4 DLY (0.00–240.00 s) (Hidden if 81Y4TP := OFF)	**81Y4TD :=**_______________
FREQY TRIP5 LVL (OFF, 15.00–70.00 Hz) (Hidden if E81Y < 5)	**81Y5TP :=**_______________
FREQY TRIP5 DLY (0.00–240.00 s) (Hidden if 81Y5TP := OFF)	**81Y5TD :=**_______________
FREQY TRIP6 LVL (OFF, 15.00–70.00 Hz) (Hidden if E81Y < 6)	**81Y6TP :=**_______________
FREQY TRIP6 DLY (0.00–240.00 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 :=**_______________

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 :=**________________

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 :=**________________

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, 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 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, 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 :=** ________________
RES CURR DEM LVL (OFF, 0.50–16.00 A [5 A I_{XNOM}], 0.10–3.20 A [1 A I_{XNOM}])	**GNDEMPX :=** ________________

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) (Shown if Slot Z = 83/87or Slot E = 71/75) **TRY :=**_______________

REMOTE TRIP EQN (SELOGIC) **REMTRIP :=**_______________

UNLATCH X-SIDE TRIP (SELOGIC) (Hidden if Slot Z = 84/88) **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) (Shown if Slot Z = 83/87 or Slot E = 71/75) **ULTRY :=**_______________

BREAKER X STATUS (SELOGIC) (Hidden if Slot Z = 84/88) **52AX :=**_______________

CLOSE X EQUATION (SELOGIC) **CLX :=**_______________

UNLATCH CLOSE X (SELOGIC) (Hidden if Slot Z = 84/88) **ULCLX :=**_______________

BREAKER Y STATUS (SELOGIC) (Shown if Slot Z = 83/87 or Slot E = 71/75) **52AY :=**_______________

CLOSE Y EQUATION (SELOGIC) (Shown if Slot Z = 83/87 or Slot E = 71/75) **CLY :=**_______________

UNLATCH CLOSE Y (SELOGIC) (Shown if Slot Z = 83/87 or Slot E = 71/75) **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 := ________________

SET10 := ________________

RST10 := ________________

SET11 := ________________

RST11 := ________________

SET12 := ________________

RST12 := ________________

SET13 := ________________

RST13 := ________________

SET14 := ________________

RST14 := ________________

SET15 := ________________

RST15 := ________________

SET16 := ________________

RST16 := ________________

SET17 := ________________

RST17 := ________________

SET18 := ________________

RST18 :=________________

SET19 :=________________

RST19 :=________________

SET20 :=________________

RST20 :=________________

SET21 :=________________

RST21 :=________________

SET22 :=________________

RST22 :=________________

SET23 :=________________

RST23 :=________________

SET24 :=________________

RST24 :=________________

SET25 :=________________

RST25 :=________________

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 :=________________________________

OUT405 FAIL-SAFE (Y, N) **OUT405FS :=**________________

OUT405 :=________________________________

Slot D Output (Hidden if output option not included; OUT405–OUT408 only available with 8 DO card)

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 :=**________________
DATE FORMAT (MDY, YMD, DMY)	**DATE_F :=**________________
FAULT CONDITION (SELOGIC)	**FAULT :=**________________

____

EVE MSG PTS ENABL (N, 1–32)	**EMP :=**________________

Event Messenger Points

(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 :=**_______________

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 :=**________________

AI*x*02 LO ALARM (OFF, –99999.000 to +99999.000) **AIx02LAL :=**________________

AI*x*02 HI WARN L1 (OFF, –99999.000 to +99999.000) **AIx02HW1 :=**________________

AI*x*02 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AIx02HW2 :=**
AI*x*02 HI ALARM (OFF, –99999.000 to +99999.000)	**AIx02HAL :=**

AIx03

AI*x*03 TAG NAME (8 characters 0–9, A–Z, _)	**AIx03NAM :=**
AI*x*03 TYPE (I, V)	**AIx03TYP :=**
If AIx03TYP = I	
AI*x*03 LOW IN VAL (–20.480 to +20.480 mA)	**AIx03L :=**
AI*x*03 HI IN VAL (–20.480 to +20.480 mA)	**AIx03H :=**
If AIx03TYP = V	
AI*x*03 LOW IN VAL (–10.240 to +10.240 V)	**AIx03L :=**
AI*x*03 HI IN VAL (–10.240 to +10.240 V)	**AIx03H :=**
AI*x*03 ENG UNITS (16 characters)	**AIx03EU :=**
AI*x*03 EU LOW (–99999.000 to +99999.000)	**AIx03EL :=**
AI*x*03 EU HI (–99999.000 to +99999.000)	**AIx03EH :=**
AI*x*03 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AIx03LW1 :=**
AI*x*03 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AIx03LW2 :=**
AI*x*03 LO ALARM (OFF, –99999.000 to +99999.000)	**AIx03LAL :=**
AI*x*03 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AIx03HW1 :=**
AI*x*03 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AIx03HW2 :=**
AI*x*03 HI ALARM (OFF, –99999.000 to +99999.000)	**AIx03HAL :=**

AIx04

AI*x*04 TAG NAME (8 characters 0–9, A–Z, _)	**AIx04NAM :=**
AIx04 TYPE (I, V)	**AIx04TYP :=**
If AIx04TYP = I	
AI*x*04 LOW IN VAL (–20.480 to +20.480 mA)	**AIx04L :=**
AI*x*04 HI IN VAL (–20.480 to +20.480 mA)	**AIx04H :=**
If AIx04TYP = V	
AI*x*04 LOW IN VAL (–10.240 to +10.240 V)	**AIx04L :=**
AI*x*04 HI IN VAL (–10.240 to +10.240 V)	**AIx04H :=**
AI*x*04 ENG UNITS (16 characters)	**AIx04EU :=**
AI*x*04 EU LOW (–99999.000 to +99999.000)	**AIx04EL :=**
AI*x*04 EU HI (–99999.000 to +99999.000)	**AIx04EH :=**
AI*x*04 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AIx04LW1 :=**
AI*x*04 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AIx04LW2 :=**
AI*x*04 LO ALARM (OFF, –99999.000 to +99999.000)	**AI*x*04LAL :=**
AI*x*04 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*04HW1 :=**
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 :=**_______________

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 :=**_______________

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 :=**_______________

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 :=**_______________

SET PORT p (p = F, 1, 2, 3, or 4) Command

PORT F

PROTOCOL (SEL, MOD, EVMSG, PMU) **PROTO :=**_______________

Communications

SPEED (300, 1200, 2400, 4800, 9600, 19200, 38400 bps) **SPEED :=**_______________

DATA BITS (7, 8 bits) (Hidden if PROTO := MOD, EVMSG, or PMU) **BITS :=**_______________

PARITY (O, E, N) (Hidden if PROTO := EVMSG or PMU) **PARITY :=**_______________

STOP BITS (1, 2 bits) (Hidden if PROTO := MOD or EVMSG) **STOP :=**_______________

PORT TIME-OUT (0–30 min) (Hidden if PROTO := MOD, EVMSG, or PMU) **T_OUT :=**_______________

HDWR HANDSHAKING (Y, N) (Hidden if PROTO := MOD or EVMSG) **RTSCTS :=**_______________

SEND AUTOMESSAGE (Y, N) (Hidden if PROTO := MOD, EVMSG, or PMU) **AUTO :=**_______________

Modbus

MODBUS SLAVE ID (1–247) (Hidden if PROTO := SEL, EVMSG, or PMU) **SLAVEID :=**_______________

PORT 1

(Ethernet Port in Slot B; hidden if Ethernet option not included)
(IP addresses are entered using zzz = 1–126, 128–223; yyy = 0–255; xxx = 0–255; www = 0–255)

IP ADDRESS (zzz.yyy.xxx.www) **IPADDR :=**_______________

SUBNET MASK (zzz.yyy.xxx.www) **SUBNETM :=**_______________

DEFAULT ROUTER (zzz.yyy.xxx.www) **DEFRTR :=**_______________

Note: Setting DEFRTR = 0.0.0.0 disables the default router.

Enable TCP Keep-Alive (Y, N) **ETCPKA :=**_______________

Note: TCP Keep-Alive is enabled with default range settings for PMU TCP sessions even when ETCPKA := N.

TCP Keep-Alive Idle Range (1–20 s) (Hidden if ETCPKA := N) **KAIDLE :=**_______________

TCP Keep-Alive Interval Range (1–20 s) (Hidden if ETCPKA := N) **KAINTV :=**_______________

TCP Keep-Alive Count Range (1–20) (Hidden if ETCPKA := N) **KACNT :=**_______________

FAST OP MESSAGES (Y, N) **FASTOP :=**_______________

OPERATING MODE (FIXED, FAILOVER, SWITCHED) (Hidden if not dual redundant Ethernet Port option) **NETMODE :=**_______________

FAILOVER TIMEOUT (0.10–65.00 s) (Hidden if not dual redundant Ethernet Port option or if NETMODE is not set to FAILOVER) **FTIME :=**_______________

PRIMARY NETPORT (A, B, D) (Hidden if not dual redundant Ethernet Port option) **NETPORT :=**_______________

NETWRK PORTA SPD (AUTO, 10, 100 Mbps) (Hidden if not dual redundant Ethernet Port option) **NETASPD :=**_______________

NETWRK PORTB SPD (AUTO, 10, 100 Mbps) (Hidden if not dual redundant Ethernet Port option) **NETBSPD :=**_______________

TELNET PORT (23, 1025–65534) **TPORT :=**_______________

Note: See Table SET.1 and the note at the end of Port 1 settings.

TELNET TIME-OUT (1–30 min) **TIDLE :=**_______________

FTP USER NAME (20 characters) **FTPUSER :=**_______________

Enable IEC 61850 Protocol (Y, N) (Hidden if 61850 not supported) **E61850 :=**_______________

Enable IEC 61850 GSE (Y, N) (Hidden if E61850 := N) **EGSE :=**_______________

Enable Modbus Sessions (0–2) **EMOD :=**_______________

Modbus TCP Port1 (1–65534) (Hidden if EMOD := 0) **MODNUM1 :=**_______________

Note: See Table SET.1 and the note at the end of Port 1 settings.

Modbus TCP Port2 (1–65534) (Hidden if EMOD := 0 or 1) **MODNUM2 :=**_______________

Note: See Table SET.1 and the note at the end of Port 1 settings.

Modbus Timeout 1(15–900 s) (Hidden if EMOD := 0) **MTIMEO1 :=**_______________

Modbus Timeout 2 (15–900 s) (Hidden if EMOD := 0 or 1) **MTIMEO2 :=**_______________

SEL Synchrophasor Protocol Settings

Enable PMU Processing (0–2) **EPMIP :=**_______________

PMU Output 1 Transport Scheme (OFF, TCP, UDP_S, UDP_T, UDP_U) (Hidden if EPMIP:=0) **PMOTS1 :=**_______________

PMU Output 1 Client IP Address [zzz.yyy.xxx.www] (15 characters) (Hidden if PMOTS1:=OFF) **PMOIPA1 :=**_______________

Note: PMOIPA1 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 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 :=**_______________

Note: 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.1 and the note at the end of Port 1 settings.

PMU Output 1 UDP/IP Data Port Number (1–65534) (Shown only when EPMIP $\neq 0$ and PMOTS1 :$\neq$ TCP) **PMOUDP1 :=**_______________

PMU Output 2 Transport Scheme (OFF, TCP, UDP_S, UDP_T, UDP_U) (Hidden if EPMIP := 0 or 1) **PMOTS2 :=**_______________

PMU Output 2 Client IP Address [zzz.yyy.xxx.www] (15 characters) (Hidden if PMOTS2 := OFF) **PMOIPA2 :=**_______________

Note: 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 :=**_______________

Note: 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.1 and the note at the end of Port 1 settings.

PMU Output 2 UDP/IP Data Port Number (1–65534) (Shown only when EPMIP = 2 and PMOTS2 :$\neq$ TCP) **PMOUDP2 :=**_______________

Port 1 DNP3 Protocol

(Hidden unless DNP3 is selected as an option)

Enable DNP Sessions (0–3) **EDNP :=**_______________

(All DNP3 Protocol settings are hidden if EDNP := 0)

DNP TCP and UDP Port (1–65534) **DNPNUM :=**_______________

Note: See Table SET.1 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.

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) **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 Dead-Band Counts (0–32767) (Hidden if ECLASSA1 := 0)	**ANADBA1 :=**________________
Volts Reporting Dead-Band Counts (0–32767) (Hidden if ECLASSA1 := 0)	**ANADBV1 :=**________________
Misc Data Reporting Dead-Band 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 s)	**ETIMEO1 :=**________________
Enable Unsolicited Reporting (Y, N) (Hidden if ECLASSA1 := 0, ECLASSB1 := 0, ECLASSC1 := 0, and ECLASSV1 := 0)	**UNSOL1 :=**________________
Enable Unsolicited Reporting at Power-Up (Y, N) (Hidden if UNSOL1 := N)	**PUNSOL1 :=**________________
Number of Events to Transmit On (1–200) (Hidden if UNSOL1 := N)	**NUMEVE1 :=**________________
Oldest Event to Tx On (0.0–99999.0 s) (Hidden if UNSOL1 := N)	**AGEEVE1 :=**________________
Unsolicited Message Max Retry Attempts (2–10) (Hidden if UNSOL1 := N)	**URETRY1 :=**________________
Unsolicited Message Offline Time-Out (1–5000 s) (Hidden if UNSOL1 := N)	**UTIMEO1 :=**________________

Session 2 (All DNP Session 2 settings are hidden if EDNP < 2.)

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 Event 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 Dead-Band Counts (0–32767) (Hidden if ECLASSA2 := 0)	**ANADBA2 :=**________________
Volts Reporting Dead-Band Counts (0–32767) (Hidden if ECLASSA2 := 0)	**ANADBV2 :=**________________
Misc Data Reporting Dead-Band 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 s)	**ETIMEO2 :=**
Enable Unsolicited Reporting (Y, N) (Hidden if ECLASSA2 := 0, ECLASSB2 := 0, ECLASSC2 := 0, and ECLASSV2 := 0)	**UNSOL2 :=**
Enable Unsolicited Reporting at Power-Up (Y, N) (Hidden if UNSOL2 := N)	**PUNSOL2 :=**
Number of Events to Transmit On (1–200) (Hidden if UNSOL2 := N)	**NUMEVE2 :=**
Oldest Event to Tx On (0.0–99999.0 s) (Hidden if UNSOL2 := N)	**AGEEVE2 :=**
Unsolicited Message Max Retry Attempts (2–10) (Hidden if UNSOL2 := N)	**URETRY2 :=**
Unsolicited Message Offline Time-Out (1–5000 s) (Hidden if UNSOL2 := N)	**UTIMEO2 :=**

Session 3 (All DNP Session 3 settings are hidden if EDNP < 3.)

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 Event 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 Dead-Band Counts (0–32767) (Hidden if ECLASSA3 := 0)	**ANADBA3 :=**
Volts Reporting Dead-Band Counts (0–32767) (Hidden if ECLASSA3 := 0)	**ANADBV3 :=**
Misc Data Reporting Dead-Band Counts (0–32767) (Hidden if ECLASSA3 := 0 and ECLASSC3 := 0)	**ANADBM3 :=**
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) (Hidden if DNPTR3 := UDP)	**DNPINA3 :=**
Event Message Confirm Time-Out (1–50 s)	**ETIMEO3 :=**
Enable Unsolicited Reporting (Y, N) (Hidden if ECLASSA3 := 0, ECLASSB3 := 0, ECLASSC3 := 0, and ECLASSV3 := 0)	**UNSOL3 :=**
Enable Unsolicited Reporting at Power-Up (Y, N) (Hidden if UNSOL3 := N)	**PUNSOL3 :=**
Number of Events to Transmit On (1–200) (Hidden if UNSOL3 := N)	**NUMEVE3 :=**
Oldest Event to Tx On (0.0–99999.0 s) (Hidden if UNSOL3 := N)	**AGEEVE3 :=**
Unsolicited Message Max Retry Attempts (2–10) (Hidden if UNSOL3 := N)	**URETRY3 :=**
Unsolicited Message Offline Time-Out (1–5000 s) (Hidden if UNSOL3 := N)	**UTIMEO3 :=**

SNTP Client Protocol Settings

Enable SNTP Client (OFF, UNICAST, MANYCAST, BROADCAST)	**ESNTP :=**

Make the following settings when ESNTP ≠ OFF.

Primary Server IP Address (zzz.yyy.xxx.www)	**SNTPPSIP :=**

Note: To accept updates from any server when ESNTP = BROADCAST, set SNTPPSIP to 0.0.0.0; only IP addresses in the range 224.0.0.1 through 239.255.255.255 are valid when ESNTP = MANYCAST.

Make the following setting when ESNTP = UNICAST.

Backup Server IP Address (zzz.yyy.xxx.www) **SNTPBSIP :=**_______________

SNTP IP (Local) Port Number (1–65534) **SNTPPORT :=**_______________

Note: See Table SET.1 and the note at the end of Port 1 settings.

SNTP Update Rate (15–3600 seconds) **SNTPRATE: =**_______________

Make the following setting when ESNTP = UNICAST or MANYCAST.

SNTP Timeout (5–20 seconds) **SNTPTO : =**_______________

Note: SNTPTO must be less than setting SNTPRATE.

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.1* 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.1 Port Number Settings That Must be Unique

Setting	Name	Setting Required When
TPORT	Telnet Port	Always
MODNUM1	Modbus TCP Port 1	EMOD > 0
MODNUM2	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

PORT 2

(Fiber-Optic Serial Port in Slot B; hidden if E49RTD := EXT)

PROTOCOL **PROTO :=**_______________
(SEL, DNP, MOD, EVMSG, PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB)

Communications

SPEED (300, 1200, 2400, 4800, 9600, 19200, 38400 bps) **SPEED :=**_______________

DATA BITS (7, 8 bits) (Hidden if PROTO := MOD, DNP, PMU, EVMSG, or MB_) **BITS :=**_______________

PARITY (O, E, N) **PARITY :=**_______________
(Hidden if E49RTD := EXT or if PROTO := EVMSG, PMU, or MB_)

STOP BITS (1, 2 bits) (Hidden if PROTO := MOD, EVMSG, or MB_) **STOP :=**_______________

PORT TIME-OUT (0–30 min) (Hidden if PROTO := MOD, PMU, EVMSG, or MB_) **T_OUT :=**_______________

SEND AUTOMESSAGE (Y, N) **AUTO :=**_______________
(Hidden if PROTO := MOD, DNP, PMU, EVMSG, or MB_)

FAST OP MESSAGES (Y, N) **FASTOP :=**_______________
(Hidden if PROTO := MOD, DNP, PMU, EVMSG, or MB_)

HDWR HANDSHAKING (Y, N) **RTSCTS :=**_______________
(Hidden if PROTO := MOD, DNP, SEL, PMU, EVMSG, or MB_)

Modbus

MODBUS SLAVE ID (1–247) (Hidden if PROTO := SEL, EVMSG, or MB_) **SLAVEID :=**_______________

DNP3 Protocol (Hidden if PROTO := SEL, EVMSG, MB, PMU, 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 :=**_______________
Currents Scaling Decimal Places (0–3)	**DECPLA1 :=**_______________
Voltages Scaling Decimal Places (0–3)	**DECPLV1 :=**_______________
Misc Data Scaling Decimal Places (0–3)	**DECPLM1 :=**_______________
Amps Reporting Dead-Band Counts (0–32767) (Hidden if ECLASSA1 := 0)	**ANADBA1 :=**_______________
Volts Reporting Dead-Band Counts (0–32767) (Hidden if ECLASSA1 := 0)	**ANADBV1 :=**_______________
Misc Data Reporting Dead-Band Counts (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 (0–15)	**DRETRY1 :=**_______________
Seconds to Data Link Time-Out (0–5) (Hidden if DRETRY1 := 0)	**DTIMEO1 :=**_______________
Event Message Confirm Time-Out (1–50 s)	**ETIMEO1 :=**_______________
Enable Unsolicited Reporting (Y, N) (Hidden if ECLASSA1 := 0, ECLASSB1 := 0 and ECLASSC1 := 0)	**UNSOL1 :=**_______________
Enable Unsolicited Reporting at Power-Up (Y, N) (Hidden if UNSOL1 := N)	**PUNSOL1 :=**_______________
Number of Events to Transmit On (1–200) (Hidden if UNSOL1 := N)	**NUMEVE1 :=**_______________
Oldest Event to Tx On (0.0–99999.0 s) (Hidden if UNSOL1 := N)	**AGEEVE1 :=**_______________
Unsolicited Message Max Retry Attempts (2–10) (Hidden if UNSOL1 := N)	**URETRY1 :=**_______________
Unsolicited Message Offline Time-Out (1–5000 s) (Hidden if UNSOL1 := N)	**UTIMEO1 :=**_______________

MIRRORED BITS Protocol (Hidden if PROTO := SEL, EVMSG, or MOD)

MB Transmit Identifier (1–4)	**TXID :=**_______________
MB Receive Identifier (1–4)	**RXID :=**_______________
MB RX Bad Pickup Time (0–10000 s)	**RBADPU :=**_______________
PPM MB Channel Bad Pickup (1–10000)	**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 :=**_______________

PORT 4

(EIA-232/485 Port or DeviceNet Port in Slot C)

PROTOCOL (SEL, DNP, MOD, DNET, EVMSG, PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB) **PROTO :=**_______________

Interface Select (Hidden if PROTO := DNET)

COMM INTERFACE (232, 485) **COMMINF :=**_______________

Communications

SPEED (300–38400 bps) (Hidden if PROTO := DNET) **SPEED :=**_______________

DATA BITS (7, 8 bits) (Hidden if PROTO := DNP, MOD, PMU, EVMSG, MB_, or DNET) **BITS :=**_______________

PARITY (O, E, N) (Hidden 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, or DNET) **T_OUT :=**_______________

HDWR HANDSHAKING (Y, N) (Hidden if COMMINF := 485 or PROTO := MOD, DNP, EVMSG, MB_, or DNET) **RTSCTS :=**_______________

SEND AUTOMESSAGE (Y, N) (Hidden if PROTO := DNP, MOD, EVMSG, MB_, PMU, or DNET) **AUTO :=**_______________

FAST OP MESSAGES (Y, N) (Hidden if PROTO := DNP, MOD, EVMSG, MB_, PMU, or DNET) **FASTOP :=**_______________

Modbus

MODBUS SLAVE ID (1–247) (Hidden if PROTO := SEL, EVMSG, MB_, or DNET) **SLAVEID :=**_______________

DNP3 Protocol (Hidden if PROTO := SEL, EVMSG, MB, PMU , DNET 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 :=**_______________

Currents Scaling Decimal Places (0–3) **DECPLA1 :=**_______________

Voltages Scaling Decimal Places (0–3) **DECPLV1 :=**_______________

Misc Data Scaling Decimal Places (0–3) **DECPLM1 :=**_______________

Amps Reporting Dead-Band Counts (0–32767) (Hidden if ECLASSA1 := 0) **ANADBA1 :=**_______________

Volts Reporting Dead-Band Counts (0–32767) (Hidden if ECLASSA1 := 0)	**ANADBV1 :=**_______________
Misc Data Reporting Dead-Band 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 (0–15)	**DRETRY1 :=**_______________
Seconds to Data Link Time-Out (0–5) (Hidden if DRETRY1 := 0)	**DTIMEO1 :=**_______________
Event Message Confirm Time-Out (1–50 s)	**ETIMEO1 :=**_______________
Enable Unsolicited Reporting (Y, N) (Hidden if ECLASSA1 := 0, ECLASSB1 := 0, ECLASSC1 := 0, and ECLASSV1 := 0)	**UNSOL1 :=**_______________
Enable Unsolicited Reporting at Power-Up (Y, N) (Hidden if UNSOL1 := N)	**PUNSOL1 :=**_______________
Number of Events to Transmit On (1–200) (Hidden if UNSOL1 := N)	**NUMEVE1 :=**_______________
Oldest Event to Tx On (0.0–99999.0 s) (Hidden if UNSOL1 := N)	**AGEEVE1 :=**_______________
Unsolicited Message Max Retry Attempts (2–10) (Hidden if UNSOL1 := N)	**URETRY1 :=**_______________
Unsolicited Message Offline Time-Out (1–5000 s) (Hidden if UNSOL1 := N)	**UTIMEO1 :=**_______________
Minimum Seconds from DCD to TX (0.00–1.00)	**MINDLY :=**_______________
Maximum Seconds from DCD to TX (0.00–1.00)	**MAXDLY :=**_______________
Settle Time from RTS On to TX (OFF, 0.00–30.00 s)	**PREDLY :=**_______________
Settle Time from TX to RTS OFF (0.00–30.00 s)	**PSTDLY :=**_______________

Modem Protocol (for DNP3 Session and EIA232 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 s)	**MDTIME :=**_______________
Time Between Dial-Out Attempts (5–3600 s)	**MDRET :=**_______________

MIRRORED BITS Protocol (Hidden if PROTO := SEL, EVMSG, or MOD)

MB Transmit Identifier (1–4)	**TXID :=**_______________
MB Receive Identifier (1–4)	**RXID :=**_______________
MB RX Bad Pickup Time (0–10000 s)	**RBADPU :=**_______________
PPM MB Channel Bad Pickup (1–10000 s)	**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 :=**_______________

Front-Panel Settings (SET F Command)

General

DISPLY PTS ENABL (N, 1–32)	**EDP :=**_______________
LOCAL BITS ENABL (N, 1–32)	**ELB :=**_______________
LCD TIMEOUT (OFF, 1–30 min)	**FP_TO :=**_______________
LCD CONTRAST (1–8)	**FP_CONT :=**_______________
FP AUTOMESSAGES (OVERRIDE, ROTATING)	**FP_AUTO :=**_______________
CLOSE RESET LEDS (Y, N)	**RSTLED :=**_______________

Target LED

TRIP LATCH T_LED (Y, N)	**T01LEDL :=**_______________
LED1 EQUATION (SELOGIC)	**T01_LED :=**_______________
TRIP LATCH T_LED (Y, N)	**T02LEDL :=**_______________
LED2 EQUATION (SELOGIC)	**T02_LED :=**_______________
TRIP LATCH T_LED (Y, N)	**T03LEDL :=**_______________
LED3 EQUATION (SELOGIC)	**T03_LED :=**_______________
TRIP LATCH T_LED (Y, N)	**T04LEDL :=**_______________
LED4 EQUATION (SELOGIC)	**T04_LED :=**_______________
TRIP LATCH T_LED (Y, N)	**T05LEDL :=**_______________
LED5 EQUATION (SELOGIC)	**T05_LED :=**_______________
TRIP LATCH T_LED (Y, N)	**T06LEDL :=**_______________
LED6 EQUATION (SELOGIC)	**T06_LED :=**_______________
PB1A_LED EQUATION (SELOGIC)	**PB1A_LED :=**_______________

PB1B_LED EQUATION (SELOGIC) **PB1B_LED :=**________________

PB2A_LED EQUATION (SELOGIC) **PB2A_LED :=**________________

PB2B_LED EQUATION (SELOGIC) **PB2B_LED :=**________________

PB3A_LED EQUATION (SELOGIC) **PB3A_LED :=**________________

PB3B_LED EQUATION (SELOGIC) **PB3B_LED :=**________________

PB4A_LED EQUATION (SELOGIC) **PB4A_LED :=**________________

PB4B_LED EQUATION (SELOGIC) **PB4B_LED :=**________________

Display Points

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 :=**__________

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, 1–20)

EALIAS :=__________	**ALIAS11 :=**__________
ALIAS1 :=__________	**ALIAS12 :=**__________
ALIAS2 :=__________	**ALIAS13 :=**__________
ALIAS3 :=__________	**ALIAS14 :=**__________
ALIAS4 :=__________	**ALIAS15 :=**__________
ALIAS5 :=__________	**ALIAS16 :=**__________
ALIAS6 :=__________	**ALIAS17 :=**__________
ALIAS7 :=__________	**ALIAS18 :=**__________
ALIAS8 :=__________	**ALIAS19 :=**__________
ALIAS9 :=__________	**ALIAS20 :=**__________
ALIAS10 :=__________	

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 :=**________________

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 RTU 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 :=________________
MOD_028 :=________________
MOD_029 :=________________
MOD_030 :=________________
MOD_031 :=________________
MOD_032 :=________________
MOD_033 :=________________
MOD_034 :=________________
MOD_035 :=________________
MOD_036 :=________________
MOD_037 :=________________
MOD_038 :=________________

MOD_039 := ____________________
MOD_040 := ____________________
MOD_041 := ____________________
MOD_042 := ____________________
MOD_043 := ____________________
MOD_044 := ____________________
MOD_045 := ____________________
MOD_046 := ____________________
MOD_047 := ____________________
MOD_048 := ____________________
MOD_049 := ____________________
MOD_050 := ____________________
MOD_051 := ____________________
MOD_052 := ____________________
MOD_053 := ____________________
MOD_054 := ____________________
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MOD_056 := ____________________
MOD_057 := ____________________
MOD_058 := ____________________
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MOD_072 := ____________________
MOD_073 := ____________________
MOD_074 := ____________________
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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 := ____________________
MOD_089 := ____________________
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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 :=____________
BI_53 :=____________
BI_54 :=____________
BI_55 :=____________

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 := ____________________

AI_39 := ____________________

AI_40 := ____________________

AI_41 := ____________________

AI_42 := ____________________

AI_43 := ____________________

AI_44 := ____________________

AI_45 := ____________________

AI_46 := ____________________

AI_47 := ____________________

AI_48 := ____________________

AI_49 := ____________________

AI_50 := ____________________

AI_51 := ____________________

AI_52 := ____________________

AI_53 := ____________________

AI_54 := ____________________

AI_55 := ____________________

AI_56 := ____________________

AI_57 := ____________________

AI_58 := ____________________

AI_59 := ____________________

AI_60 := ____________________

AI_61 := ____________________

AI_62 := ______
AI_63 := ______
AI_64 := ______
AI_65 := ______
AI_66 := ______
AI_67 := ______
AI_68 := ______
AI_69 := ______
AI_70 := ______
AI_71 := ______
AI_72 := ______
AI_73 := ______
AI_74 := ______
AI_75 := ______
AI_76 := ______
AI_77 := ______
AI_78 := ______
AI_79 := ______
AI_80 := ______
AI_81 := ______
AI_82 := ______
AI_83 := ______
AI_84 := ______
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_16 :=** ______
CO_01 := ______	**CO_17 :=** ______
CO_02 := ______	**CO_18 :=** ______
CO_03 := ______	**CO_19 :=** ______
CO_04 := ______	**CO_20 :=** ______
CO_05 := ______	**CO_21 :=** ______
CO_06 := ______	**CO_22 :=** ______
CO_07 := ______	**CO_23 :=** ______
CO_08 := ______	**CO_24 :=** ______
CO_09 := ______	**CO_25 :=** ______
CO_10 := ______	**CO_26 :=** ______
CO_11 := ______	**CO_27 :=** ______
CO_12 := ______	**CO_28 :=** ______
CO_13 := ______	**CO_29 :=** ______
CO_14 := ______	**CO_30 :=** ______
CO_15 := ______	**CO_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	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[b]	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 applicable SEL-2600 RTD Module or SEL-2664 Field Ground Module Instruction Manual for information on the fiber-optic interface.
[b] Refer to Appendix G: 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 (50 feet) in low noise environments. Use the optional EIA-485 port for communications distances as far as 1200 m (4000 feet) 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-2800 series fiber-optic transceivers
- ➤ SEL-2890 Ethernet Transceiver
- ➤ SEL-3010 Event Messenger
- ➤ SEL-2505 Remote I/O Module (with SEL-2812 compatible ST® option only for fiber-optic link to Port 2)

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:

- ➤ Baud 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.

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. In addition to failover mode, the unit can operate in a "fixed connection (to netport) mode" or in a "switched mode" (as an unmanaged switch).

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.

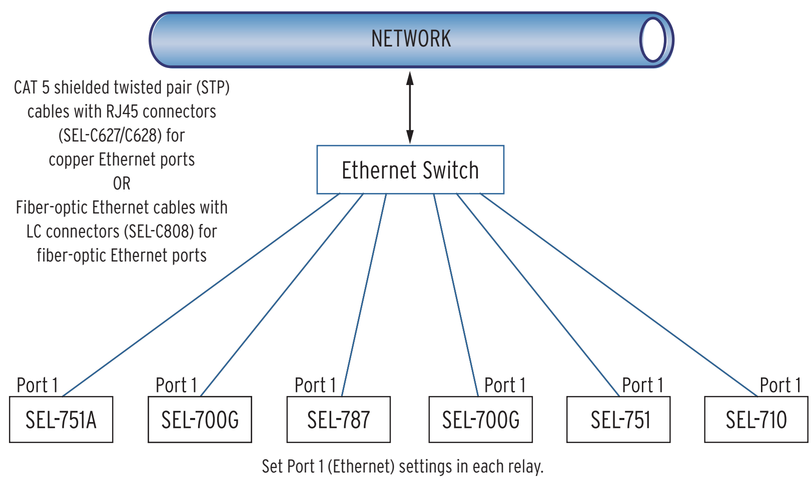


Figure 7.1 Simple Ethernet Network Configuration

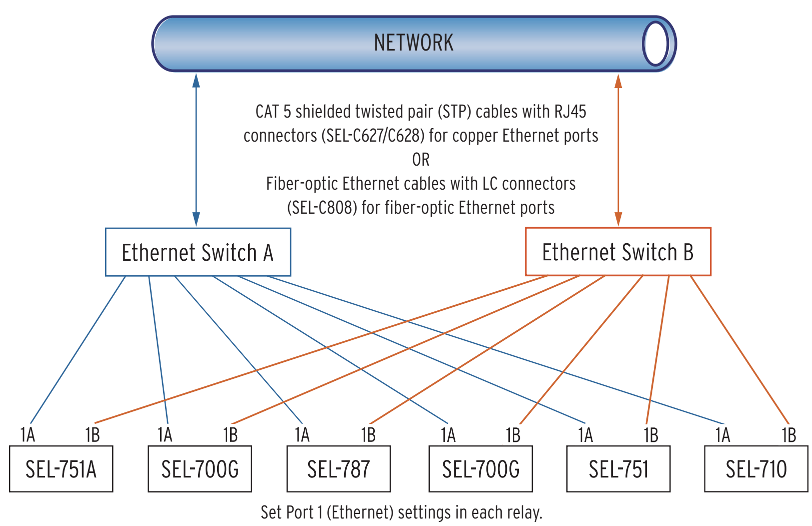


Figure 7.2 Ethernet Network Configuration With Dual Redundant Connections (Failover Mode)

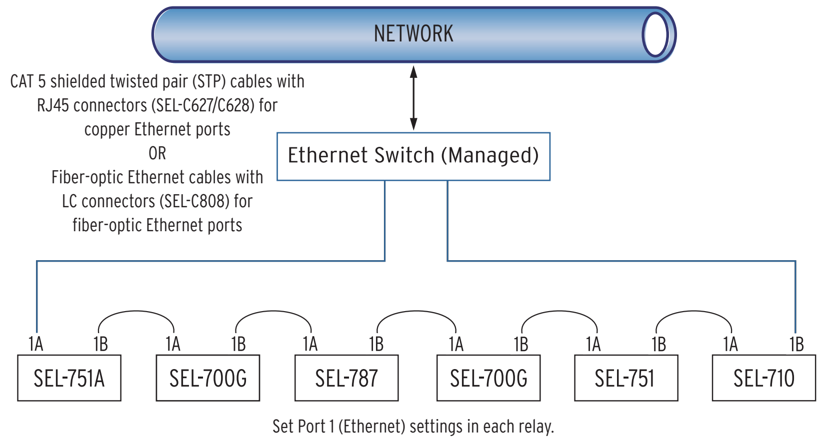


Figure 7.3 Ethernet Network Configuration With Ring Structure (Switched Mode)

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 network port failover time you want.

Step 3. Set NETPORT to the network interface you want.

On startup, the relay communicates through the NETPORT (primary port) you 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.

After failover, while communicating with 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 your port of choice for communications on a change of settings, at failure of the standby port, or on 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 alternates checking for the link status of the primary and standby ports.

Unmanaged Switch Mode

If you have a network configuration where you want to use the relay as an unmanaged switch, set NETMODE to SWITCHED. In this mode, both links are enabled. The relay responds to the messages it receives on either port. The relay transmits out of the other port, without modification, all messages a network port receives that are not addressed to the relay. In this mode, the relay ignores the NETPORT setting.

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.

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 setting 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

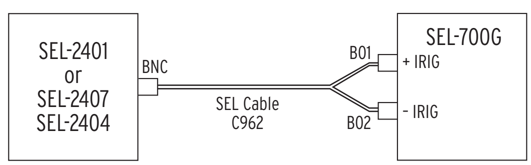
The NETPORT setting gives you the option to select the primary port of communication in failover or fixed communications modes. Selecting “D” for this setting disables both the ports. This selection provides you the security of being able to turn off the ports even when these ports are physically connected to the network.

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.

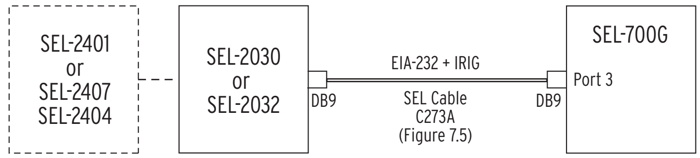
Set Global setting IRIG TIME SOURCE to TIME_SRC := IRIG1.

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 Cable C273A to bring IRIG-B input with the EIA-232 Port. Refer to *Figure 7.5* for a connection diagram.

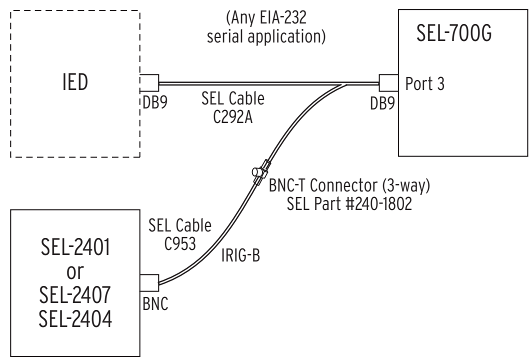
Refer to *Figure 7.6* on how to connect a SEL Time Source (SEL-2401, SEL-2404, SEL-2407) for IRIG-B Input to Port 3.



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)



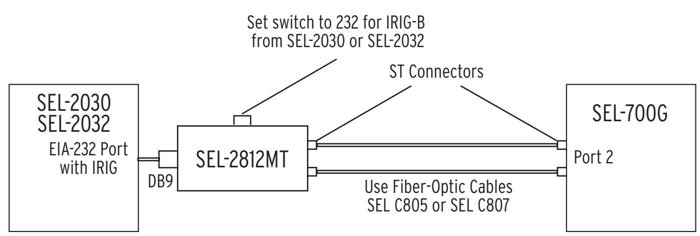
If you use Port 3, you cannot use a **B01–B02** input or Port 2.

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)

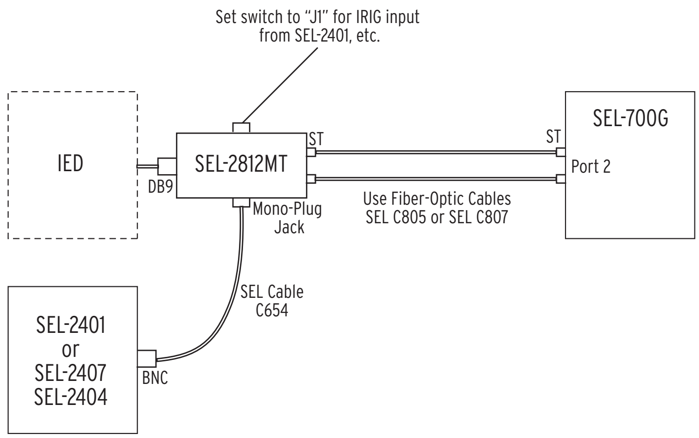
You can use Fiber-Optic Serial Port 2 to bring IRIG-B Input to the relay as shown in *Figure 7.7* and *Figure 7.8*.



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.

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 7.2*. You can connect to a standard 9-pin computer port with SEL Cable C234A; wiring for this cable is shown in *Figure 7.10*. SEL Cable C234A 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 www.selinc.com.

For best performance, SEL Cable C234A should be no more than 15 meters (50 feet) 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 EIA-232 serial port DB-9 connector pinout for the SEL-700G.

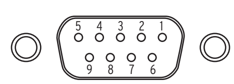


Figure 7.9 EIA-232 DB-9 Connector Pin Numbers

Table 7.2 shows the pin functions for the EIA-232 and EIA-485 serial ports.

Table 7.2 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.

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.

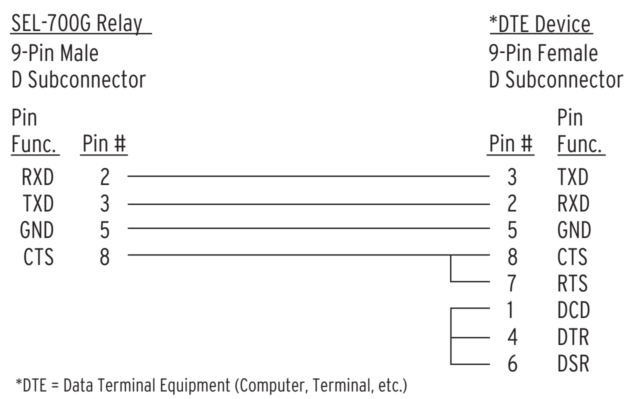


Figure 7.10 SEL Cable C234A—SEL-700G to DTE Device

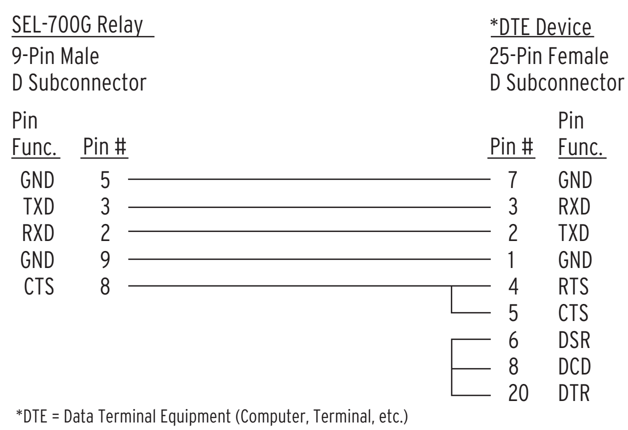


Figure 7.11 SEL Cable C227A—SEL-700G to DTE Device

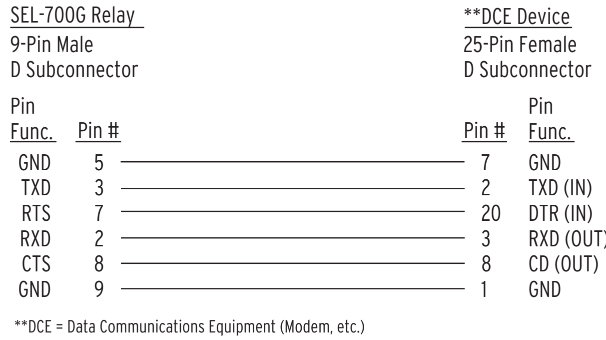


Figure 7.12 SEL Cable C222—SEL-700G to Modem

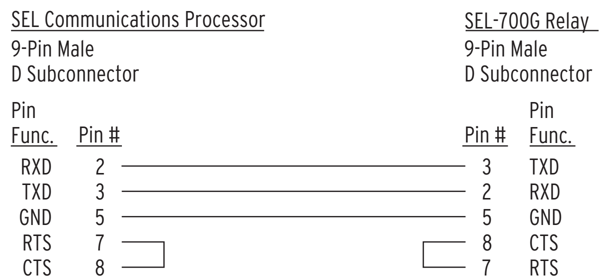


Figure 7.13 SEL Cable C272A—SEL-700G to SEL Communications Processor (Without IRIG-B Signal)

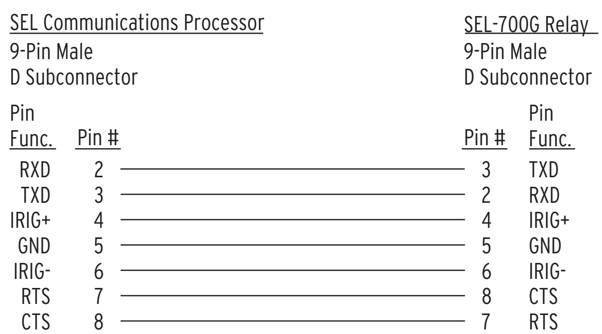


Figure 7.14 SEL Cable C273A—SEL-700G to SEL Communications Processor (With IRIG-B Signal)

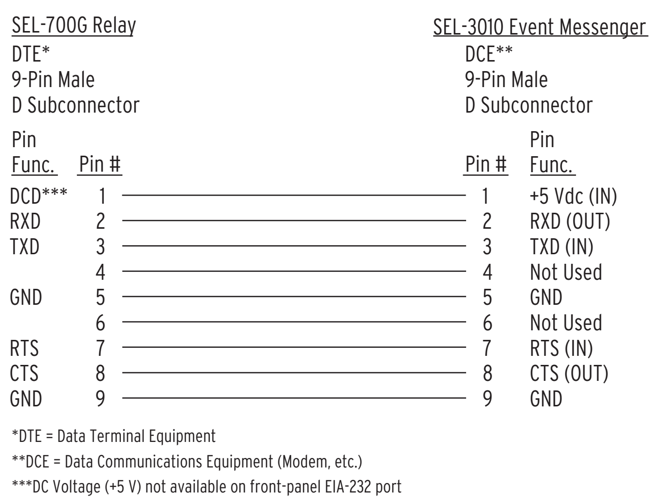


Figure 7.15 SEL Cable C387—SEL-700G to SEL-3010

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 7.3* shows the ports and the protocols available on each port.

NOTE: FTP, Modbus, and DeviceNet protocols ignore the hide rules of the settings.

Table 7.3 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, 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)
PORT 2	All the protocols supported by **Port 3**
PORT 3	SEL ASCII and Compressed ASCII Protocols, SEL Fast Meter, SEL Fast Operate, SEL Fast SER, SEL Settings File Transfer, SEL MIRRORED BITS, DNP3, Modbus RTU Slave, C37.118 Protocol (synchrophasor data), and Event Messenger
PORT 4	All the protocols supported by **Port 3** or DeviceNet

[a] PORT 1 concurrently supports two Modbus, three DNP3 LAN/WAN, two FTP, two Telnet, two C37.118 Protocol, one SNTP, and six IEC 61850 sessions.

SEL Communications Protocols

SEL ASCII. This protocol is described in *SEL ASCII Protocol and Commands on page 7.14*.

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 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.

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.

C37.118 Protocol

The SEL-700G provides C37.118 protocol (synchrophasor data) support at Ethernet Port 1 and any of the serial ports F, 2, 3, or 4. The protocol is described in *Appendix H: Synchrophasors*.

Modbus RTU Protocol

The SEL-700G provides Modbus RTU support. Modbus is an optional protocol described in *Appendix E: Modbus RTU Communications*.

DNP3 (Distributed Network Protocol)

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 G: DeviceNet 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, DNP3 LAN/WAN, C37.118 Protocol (synchrophasor data), and IEC 61850 protocols.

You should 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.

FTP Server

Use the single FTP (File Transfer Protocol) session to access the following files:

CFG.XML	Configuration read-only file in XML format
CFG.TXT	Configuration read-only file in TXT format
ERR.TXT	Error read-only file in text format
SET_61850.CID	IEC 61850 CID read-write file
SET_xx.TXT	Setting files in TXT format

FTP is a standard TCP/IP protocol for exchanging files. A free FTP application is included with most web browser software. You can also obtain a free or inexpensive FTP application from the Internet. When you connect to the relay Ethernet port, you will find files stored in the root (top-level) directory.

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

Use a Ping client with the relay Ping server to verify that your network configuration is correct.

Ping is an application based on ICMP over an IP network. A free Ping application is included with most computer operating systems.

IEC 61850

Use as many as six 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 16 incoming messages and 8 outgoing messages. For more details on the IEC 61850 protocol, see *Appendix F: 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*
- *AN2009-32: Using SEL Satellite-Synchronized Clocks With the SEL-3332 or SEL-3351 to Output NTP*
- *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 7.4* shows each setting associated with SNTP.

Table 7.4 Settings Associated With SNTP

Setting	Range	Description
ESNTP	UNICAST, MANYCAST, BROADCAST	Selects the mode of operation of SNTP. See descriptions in *SNTP Operation Modes*.
SNTPPSIP	Valid IP Address	Selects primary NTP server when ENSTP = UNICAST, or broadcast address when ESNTP = MANYCAST or BROADCAST.
SNTPPSIB	Valid IP Address	Selects backup NTP server when ESNTP = UNICAST.
SNTPPORT	1–65534	Ethernet port used by SNTP. Leave at default value unless otherwise necessary.
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 ENSTP = BROADCAST.
SNTPTO	5–20 seconds	Determines the time the relay will wait for the NTP master to respond when ENSTP = UNICAST or MANYCAST.

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

SNTP time-synchronization accuracy is limited by the accuracy of the SNTP Server and by the networking environment. The highest degree of SNTP time synchronization can be achieved by minimizing the number of switches and routers between the SNTP Server and the SEL-700G. Network monitoring software can also be used 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.

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.

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 7.5* lists these messages.

Table 7.5 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 9: 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 7.43*.

Access Levels

Commands can be issued 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)

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 7.18* 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

The CAL access level is intended for use by the SEL factory, and for use by SEL field service personnel to help diagnose troublesome installations. A list of commands at the CAL level is available from SEL upon request. Do not enter the CAL access level 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 7.6 lists the header items and their definitions.

Table 7.6 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 4.3*.
`[TID Setting]:`	This is the TID (Terminal Identifier) setting. The relay ships with the default setting `TID = GENERATOR RELAY`; see *ID Settings on page 4.3*.
`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.

Access Commands (ACCESS, 2ACCESS, and CAL)

The **ACC, 2AC,** and **CAL** commands (see *Table 7.7*) 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 7.15* for a discussion of placing the relay in an access level.

Table 7.7 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 7.36* 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 7.36*. 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 7.8* for the command description and *Table 7.9* for 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 7.8 ANALOG Command

Command	Description	Access Level
ANA *c p t*	Temporarily assigns a value to an analog output channel.	2

Table 7.9 ANALOG Command Format

Parameter	Description
c	Parameter *c* is the analog channel (either the channel name, for example, A0301, or the channel number, for example, 301).
p	Parameter *p* is a percentage of full scale, or either the letter "R" or "r" to indicate ramp mode.
t	Parameter *t* is the 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 A0301 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 A0301 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 4.172* 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 4.172* for further details.

BRE n Command (Breaker Monitor Data)

Use the **BRE *n*** command to view the breaker monitor report. Select *n* = X or *n* = Y for Breaker X or Breaker Y data, respectively. See *Breaker Monitor on page 5.15* 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 7.16 BRE X Command Response

BRE n W or R Command (Preload/Reset Breaker Wear)

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. Select *n* = X or *n* = Y for Breaker X or Breaker Y data, respectively.

```
=>>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 7.17 BRE X W Command Response

Use the **BRE *n* R** command to reset the breaker *n* monitored data. Select *n* = X or *n* = Y for Breaker X or Breaker Y data, respectively.

```
=>>BRE X R <Enter>

Reset Breaker Monitor Data (Y/N)?Y
Clearing Complete

=>>
```

Figure 7.18 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 the ACSELERATOR Analytic Assistant™ SEL-5601 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** (**CEV**) command to display Compressed ASCII event reports. See *Table C.2* for further information. Compressed ASCII Event Reports contain all of the Relay Word bits. The **CEV R** command gives 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 the ACSELERATOR Analytic Assistant take advantage of the Compressed ASCII format. Refer to *Section 9: Analyzing Events* for more details on the generator autosynchronism report.

CLOSE n Command (Close Breaker n)

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 (for example, OUTxxx = CLOSE ***n***) to close a circuit breaker *n* (see *Table 4.53* and *Figure 4.130* through *Figure 4.132* for factory default setting CL *n* and close logic). Select *n* = X or *n* = Y for Breaker X or Breaker Y data, respectively.

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 jumper (see *Table 2.15*). If the Breaker jumper is not in place (Breaker jumper = OFF), the relay does not execute the **CLO *n*** command and responds with the following.

```
=>>CLO X <Enter>
Command Aborted: No BRKR Jumper
=>>
```

COMMUNICATIONS Command

The **COM *x*** command (see *Table 7.10*) displays communications statistics for the MIRRORED BITS communications channels. For more information on MIRRORED BITS communications, see *Appendix I: MIRRORED BITS Communications*.

The summary report includes information on the failure of ROKA or ROKB. The `Last error` 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 7.10 COM Command

Command	Description	Access Level
COM S A or **COM S B**	Return 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	Return a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.	1
COM B	Return 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
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 7.11*) to control remote bits (Relay Word bits RB01–RB32). You can use the **CON** function from the front panel (`Control > Outputs`) to pulse the outputs. 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 7.12*.

Table 7.11 CONTROL Command

Command	Description	Access Level
CON RB*nn*[a] *k*[b]	Set a Remote Bit to set, clear, or pulse.	2

[a] Parameter nn is a number from 01 to 32, representing RB01 through RB32.
[b] Parameter k is S, C, or P.

Table 7.12 Three Remote Bit States

Subcommand	Description	Access Level
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

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 7.13*) to copy the settings of settings Group *j* to the settings of settings Group *k*. The settings of settings Group *j* effectively overwrite the settings of settings Group *k*. Parameters *j* and *k* can be any available settings group number 1 through 3.

Table 7.13 COPY Command

Command	Description	Access Level
COPY *j k*[a]	Copy settings in Group *j* to settings in Group *k*.	2

[a] Parameters j and k are 1–3.

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 7.14*).

Table 7.14 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 7.15*) to view and set the relay date.

Table 7.15 Date Command

Command	Description	Access Level
DATE	Display the internal clock date.	1
DATE ***date***	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) displays the Ethernet port (Port 1) status, as shown in *Figure 7.19* for the redundant fiber-optic (FX) Ethernet **Port 1A** and **Port 1B** configuration. Copper Ethernet port is labelled as TX. The non-redundant port response is similar.

```
=>>ETH <Enter>

SEL-700G                                            Date: 02/28/2010 Time: 10:41:37
GENERATOR 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

 PRIMARY PORT:  PORT 1A
 ACTIVE PORT:   PORT 1B

             LINK   SPEED  DUPLEX   MEDIA
PORT 1A      Up    100M     Full    FX
PORT 1B      Down   --       --     FX

=>>
```

Figure 7.19 Ethernet Port (PORT 1) Status Report

The non-redundant port response is as shown in *Figure 7.20*.

```
=>>ETH <Enter>

SEL-700G                                             Date: 02/28/2010 Time: 10:41:44
GENERATOR 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 7.20 Non-Redundant Port Response

EVENT Command (Event Reports)

Use the **EVE** command (see *Table 7.16* and *Table 7.17*) to view event reports. See *Section 9: Analyzing Events* for further details on retrieving and analyzing event reports. See the *HISTORY Command on page 7.31* for details on clearing event reports.

Table 7.16 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

Table 7.17 EVENT Command Format

Parameter	Description
n	Parameter *n* specifies the event report number to be returned. Use the **HIS** command to determine the event report number of the event you want to display. If *n* is not specified, the relay displays event report 1 by default.
m	Parameter *m* is '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 7.18*) 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 the settings hidden by a part number. Use FTP or TELNET over Ethernet to transfer files.

Table 7.18 FILE Command

Command	Description	Access Level
FIL DIR	Return a list of files.	1
FIL READ *filename*	Transfer settings file *filename* from the relay to the PC.	1
FIL WRITE *filename*	Transfer settings file *filename* from the PC to the relay.	2
FIL SHOW *filename*	Filename 1 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 7.19 GEN Command Variants

Command Variant	Description	Access Level
GEN	Display generator operating profile information.	1
GEN R	Reset 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 7.21 GEN Command Response

GSH Command

The **GSH** command (see *Table 7.20*) 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 7.22*).

Table 7.20 GSH Command Variants

Command Variant	Description	Access Level
GSH	Display generator autosynchronism report history.	1
GSH C or R	Clear 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 7.22 GSH Command Response

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 7.21*.

Table 7.21 GOOSE Command Variants

Command Variant	Description	Access Level
GOOSE	Display GOOSE information.	1
GOOSE count	Display GOOSE information count times.	1

The information displayed for each GOOSE IED is described in *Table 7.22*.

Table 7.22 GOOSE IED Description (Sheet 1 of 2)

IED	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) (for example, SEL_700G_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) (for example, SEL_700G_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 GOOSE message sent.

Table 7.22 GOOSE IED Description (Sheet 2 of 2)

IED	Description
TTL (Time to Live)	This field contains the time (in ms) before the next message is expected.
Code	This text field contains warning or error condition text when appropriate 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) (for example, SEL_700G_1/LLN0$DSet13).
Receive Data Set Reference	This field represents the datSetRef (Data Set Reference) that includes the iedName (IED name), ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and datSet (Data Set Name) (for example, SEL_700G_1CFG/LLN0$DSet13).

An example response to the **GOOSE** commands is shown in *Figure 7.23*.

```
#>GOOSE <Enter>

GOOSE Transmit Status

   MultiCastAddr   Ptag:Vlan  StNum      SqNum      TTL    Code
----------------------------------------------------------------------------
SEL_700G_2CFG/LLN0$GO$GooseDSet13
   01-0C-CD-01-00-04  4:1     2          20376      50
   Data Set: SEL_700G_2CFG/LLN0$DSet13


GOOSE Receive Status

   MultiCastAddr   Ptag:Vlan  StNum      SqNum      TTL    Code
----------------------------------------------------------------------------

SEL_700G_1CFG/LLN0$GO$NewGOOSEMessage5
   01-0C-CD-01-00-05  4:0     1          100425     160
   Data Set: SEL_700G_1CFG/LLN0$DSet10

SEL_700G_1CFG/LLN0$GO$NewGOOSEMessage3
   01-0C-CD-01-00-03  4:0     1          98531      120
   Data Set: SEL_700G_1CFG/LLN0$DSet05

SEL_700G_1CFG/LLN0$GO$NewGOOSEMessage2
   01-0C-CD-01-00-02  4:0     1          97486      200
   Data Set: SEL_700G_1CFG/LLN0$DSet04

SEL_700G_1CFG/LLN0$GO$NewGOOSEMessage1
   01-0C-CD-01-00-01  4:0     1          96412      190
   Data Set: SEL_700G_1CFG/LLN0$DSet03

SEL_387E_1CFG/LLN0$GO$NewGOOSEMessage5
   01-0C-CD-01-00-06  4:0     1          116156     140
   Data Set: SEL_387E_1CFG/LLN0$DSet10

SEL_387E_1CFG/LLN0$GO$NewGOOSEMessage4
   01-0C-CD-01-00-05  4:0     1          116041     130
   Data Set: SEL_387E_1CFG/LLN0$DSet06
```

Figure 7.23 GOOSE Command Response (Sheet 1 of 2)

```
SEL_387E_1CFG/LLN0$GO$NewGOOSEMessage2
   01-0C-CD-01-00-02  4:0     1          115848     120
   Data Set: SEL_387E_1CFG/LLN0$DSet04

SEL_387E_1CFG/LLN0$GO$NewGOOSEMessage1
   01-0C-CD-01-00-01  4:0     1          115798     150
   Data Set: SEL_387E_1CFG/LLN0$DSet03

=>
```

Figure 7.23 GOOSE Command Response (Sheet 2 of 2)

GROUP Command

Use the **GROUP** command (see *Table 7.23*) to display the active settings group or try to force an active settings group change.

Table 7.23 GROUP Command

Command	Description	Access Level
GROUP	Display the active settings group.	1
GROUP *n* [a]	Change the active group to Group *n*.	2

[a] Parameter n indicates group numbers 1–3.

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–SS3 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 7.24*) 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 7.24 HELP Command

Command	Description	Access Level
HELP	Display a list of each command available at the present access level with a one-line description.	1
HELP *command*	Display information on the command ***command***.	1

HISTORY Command

Use the **HIS** command (see *Table 7.25*) 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 9: Analyzing Events*.

Table 7.25 HISTORY Command

Command	Description	Access Level
HIS	Return event histories with the oldest at the bottom of the list and the most recent at the top of the list.	1
HIS ***n***	Return 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	Clear/reset the event history and all corresponding event reports from nonvolatile memory.	1

IDENTIFICATION Command

Use the **ID** command (see *Table 7.26*) to extract device identification codes.

Table 7.26 IDENTIFICATION Command

Command	Description	Access Level
ID	Return a list of device identification codes.	0

IRI Command

Use the **IRI** command to direct the relay to read the demodulated IRIG-B time code at the serial port or IRIG-B input (see *Table 7.27*).

Table 7.27 IRI Command

Command	Description	Access Level
IRI	Force 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 **IRI** command to synchronize the relay clock with IRIG-B. Use the **IRI** command to determine if the relay is properly reading the IRIG-B signal.

LDP Command (Load Profile Report)

Use the **LDP** commands (see *Table 7.28* and *Table 7.29*) to view and manage the Load Profile report (see *Figure 5.15*). If there are no stored data and an **LDP** command is issued, the relay responds with `No data available`.

Table 7.28 LDP Commands

Command	Description	Access Level
LDP ***row1 row2*** **LDP** ***date1 date2***	Use the **LDP** command to display a numeric progression of all 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	Use this command to clear the load profile report from nonvolatile memory.	1

Table 7.29 LDP Command Parameters

Parameter	Description
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.

L_D Command (Load Firmware)

Use the **L_D** command (see *Table 7.30*) to load firmware. See *Appendix A: Firmware 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.

Table 7.30 L_D Command (Load Firmware)

Command	Description	Access Level
L_D	Download firmware to the control.	2

Only download firmware to the front port.

LOOPBACK Command

The **LOO** command (see *Table 7.31*) is used for testing the MIRRORED BITS communications channel for proper communication. For more information on MIRRORED BITS, see *Appendix I: 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 7.31 LOO Command

Command	Description	Access Level
LOO	Enable loopback testing of MIRRORED BITS channels.	2
LOO A	Enable loopback on MIRRORED BITS Channel A for the next 5 minutes.	2
LOO B	Enable loopback on MIRRORED BITS Channel B for the next 5 minutes.	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:

```
=>>MAC <Enter>
Port 1 MAC Address: 00-30-A7-03-5A-12
=>>
```

MET Command (Metering Data)

The **MET** command (see *Table 7.32*, *Table 7.33*, and *Table 7.34*) provides access to the relay metering data.

Table 7.32 Meter Command

Command	Description	Access Level
MET *c n*	Display metering data.	1
MET *c* R	Reset metering data.	2

Table 7.33 Meter Command Parameters

Parameter	Description
c	Parameter for identifying meter class.
n	Parameter used to specify number of times (1–32767) to repeat the meter response.

Table 7.34 Meter Class

c	Meter Class
F	Fundamental Metering
E[a b]	Energy Metering
M[a]	Maximum/Minimum Metering
R	RMS Metering
T	Thermal and RTD Metering
AI	Analog Input (transducer) Metering
DIF	Differential Element Metering
H	Harmonic Metering for Differential Currents
DE[a]	Demand Metering
PE[a]	Peak Demand Metering
PM	Synchrophasor Metering
MV	SELOGIC Math Variable Metering

[a] Reset metering available.
[b] Preload energy using MET WE.

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)

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, for example, the TR*n* SELOGIC control equation to assert the TRIP*n* Relay Word bit, which in turn asserts an output contact (for example, OUTxxx = TRIP*n*) to open a circuit breaker (see *Table 4.52* and *Figure 4.127* through *Figure 4.129* for factory default settings and trip logic). Select *n* = X or *n* = Y for Breaker X or Breaker Y, respectively.

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** command is supervised by the main board Breaker jumper (see *Table 2.15*). If the Breaker jumper is not in place (Breaker jumper = OFF), the relay does not execute the **OPE** command and responds with the following.

```
=>>OPE X <Enter>
Command Aborted: No BRKR Jumper
=>>
```

PASSWORD Command (Change Passwords)

Use the **PAS** command (see *Table 7.35* and *Table 7.36*) to change existing passwords.

Table 7.35 PASSWORD Command

Command	Description	Access Level
PAS *level*	Change password for Access Level ***level***.	2

⚠**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.

Table 7.36 PAS Command Format

Parameter	Description
level	Parameter ***level*** represents the relay Access Levels 1, 2 or C.

The factory default passwords are as shown in *Table 7.37*.

Table 7.37 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 command sequence in *Figure 7.24*.

```
=>>PAS 1 <Enter>
Old PW: ? ***** <Enter>
New PW: ? *********** <Enter>
Confirm PW: ? *********** <Enter>
Password Changed

=>>
```

Figure 7.24 Command Sequence to Change Password

Similarly, use **PAS 2** to change Level 2 passwords and PAS C to change Level C passwords.

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.

Table 7.38 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	! " # $ % & ' ( ) * + , - . / : ; < = > ? @ [\ ] ^ _ ` {	} ~

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 2) allows a user of the relay to determine if a host is reachable across an IP network and/or if the Ethernet port (Port 1) is functioning or configured correctly. A typical **PING** command response is shown in *Figure 7.25*.

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 7.25 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 7.39*) to pulse any of the relay control 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 control outputs are **OUT*nnn***, where ***nnn*** represents the output location by card slot position (first digit) and output number (second and third digit). For example, OUTPUT 301 refers to output 01 in slot **3** (Slot **C**).

Table 7.39 PUL OUTnnn Command

Command	Description	Access Level
PUL OUT*nnn*[a]	Pulse output OUT*nnn* for 1 second.	2
PUL OUT*nnn s*[b]	Pulse output OUT*nnn* for *s* seconds.	2

[a] Parameter nnn is a control output number.
[b] Parameter s is time in seconds, with a range of 1–30.

QUIT Command

Use the **QUIT** command (see *Table 7.40*) to revert to Access Level 0.

Table 7.40 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).

R_S Command (Restore Factory Defaults)

Use the **R_S** command (see *Table 7.41*) to restore factory default settings.

Table 7.41 R_S Command (Restore Factory Defaults)

Command	Description	Access Level
R_S	Restore the factory default settings and passwords and reboot 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 7.42* and *Table 7.43*) to view and manage the Sequential Events Recorder report. See *Section 9: Analyzing Events* for further details on SER reports.

Table 7.42 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

Table 7.43 SER Command Format (Sheet 1 of 2)

Parameter	Description
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.

Table 7.43 SER Command Format (Sheet 2 of 2)

Parameter	Description
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.

If the requested SER report rows do not exist, the relay responds with `No SER data`.

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)* for more information on SER automatic deletion and reinsertion.

Table 7.44 SER D Command

Command	Description	Access Level
SER D	List 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 7.45* and *Table 7.46*).

Table 7.45 SET Command (Change Settings)

Command	Description	Access Level
SET *n s* TERSE	Set the Relay settings, beginning at the first setting for group *n* (*n* = 1, 2, or 3).	2
SET L *n s* TERSE	Set general logic settings for group *n* (*n* = 1, 2, or 3).	2
SET G *s* TERSE	Set global settings.	2
SET P *n s* TERSE	Set serial port settings. *n* specifies the **PORT** (**1**, **2**, **3**, **4**, or **F**); *n* defaults to the active port if not listed.	2
SET R *s* TERSE	Set report settings such as Sequential Events Recorder (SER) and Event Report (ER) settings.	2
SET F *s* TERSE	Set front-panel settings.	2
SET M *s* TERSE	Set Modbus User Map settings.	2
SET DNP *m s* TERSE	Set DNP Map *m* settings where *m* = 1, 2, or 3	2

Table 7.46 SET Command Format

Parameter	Description
s	Append ***s***, the name of the specific setting you want to view and jumps to this setting. If ***s*** is not entered, the relay starts at the first setting.
TERSE	Append **TERSE** 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 7.47*.

Table 7.47 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 7.48* for the **SHOW** command settings and *Table 7.49* for the command format.

Table 7.48 SHOW Command (Show/View Settings)

Command	Description	Access Level
SHO *n s*	Shows Relay settings for group *n* (*n = 1, 2, or 3*).	1
SHO L *n s*	Shows general logic settings for group *n* (*n = 1, 2, or 3*).	1
SHO G *s*	Shows global settings.	1
SHO P *n s*	Shows serial port settings. ***n*** specifies the **PORT** (**1**, **2**, **3**, **4**, or **F**); ***n*** defaults to the active port if not listed.	1
SHO R *s*	Shows report settings such as Sequential Events Recorder (SER) and Event Report (ER) settings.	1
SHO F *s*	Shows front-panel settings.	1
SHO M *s*	Shows Modbus User Map settings.	1
SHO DNP *m s*	Shows DNP Map *m* settings where *m* = 1, 2, or 3	1

Table 7.49 SHOW Command Format

Parameter	Description
s	Appends, ***s***, the name of the specific setting you want to view, and jumps to this setting. If ***s*** is not entered, the relay starts at the first setting.

```
=>>SHO <Enter>
=>SHOW

Group 1
Relay Settings

ID Settings
RID      := SEL-700GT
TID      := INTERTIE RELAY

Config Settings
PHROT    := ABC          CTRX     := 500          INOM     := 5.0
DELTAY_X := WYE          PTRX     := 100.00       VNOM_X   := 13.80
CTRY     := 500          DELTAY_Y := WYE          PTRY     := 100.00
VNOM_Y   := 13.80        PTRS     := 100.00       CTRN     := 100

Gnd Differential
E87N     := N

Res Earth Fault
EREF     := N

Rotor Ground
E64F     := N

System Backup
EBUP     := V

Volt-Restr TOC
51VP     := 8.00         51VCA    := 0            51VC     := U2
51VTD    := 3.00         51VRS    := Y
51VTC    := NOT LOPX

Loss of Field
E40      := Y            40Z1P    := 13.4         40XD1    := -2.5
40Z1D    := 0.00         40Z2P    := 13.4         40XD2    := -2.5
40Z2D    := 0.50
40ZTC    := NOT LOPX

Curr Unbalance
E46      := Y            46Q1P    := 8            46Q1D    := 30.00
46Q2P    := 8            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
```

Figure 7.26 SHOW Command Example (Sheet 1 of 3)

```
YSide Max Ph 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

X Side Ld Encrch
ZLFX     := 6.50          PLAFX    := 30.00         NLAFX    := -30.00

Y Side Ld Encrch
ELOADY   := N

X Side Pwr Elem
EPWRX    := N

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

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 Z-Seq Overvolt
59GY1P   := OFF           59GY2P   := OFF

Sync U/Ovr Volt
27S1P    := OFF           27S2P    := OFF           59S1P    := OFF
59S2P    := OFF
```

Figure 7.26 SHOW Command Example (Sheet 2 of 3)

```
RTD Settings
E49RTD   := NONE

X Side SyncCheck
E25X     := N

Y Side SyncCheck
E25Y     := N

Demand Mtr Set
EDEM     := ROL          DMTC     := 15           PHDEMPX  := 5.00
GNDEMPX  := 1.00         3I2DEMPX := 1.00         PHDEMPY  := 5.00
GNDEMPY  := 1.00         3I2DEMPY := 1.00

X Side Pole Open
50LXP    := 0.25         3POXD    := 0.00

Y Side Pole Open
50LYP    := 0.25         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
CLX      := SV03T AND NOT LT02 OR CCX
ULCLX    := TRIPX
52AY     := 0
CLY      := SV03T AND LT02 OR CCY
ULCLY    := TRIPY

=>>
```

Figure 7.26 SHOW Command Example (Sheet 3 of 3)

STATUS Command (Relay Self-Test Status)

The **STA** command (see *Table 7.50*) displays the status report.

Table 7.50 STATUS Command (Relay Self-Test Status)

Command	Description	Access Level
STA *n*	Display the relay self-test information ***n*** times (***n*** = 1–32767). Defaults to 1 if ***n*** is not specified.	1
STA S	Display the memory and execution utilization for the SELOGIC control equations.	1
STA C or **R**	Reboot the relay and clear self-test warning and failure status results.	2

Refer to *Section 10: Testing and Troubleshooting* for self-test thresholds and corrective actions, as well as hardware configuration conflict resolution. *Table 7.51* shows the status report definitions and message formats for each test.

Table 7.51 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 7.51 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 FGPA 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)	DC offset in hardware circuits of current channels, *n* = X or Y	Voltage/WARN
Voltage Offset (VA*n*, VB*n*, VC*n*, VS, VN)	DC offset in hardware circuits of voltage channels, *n* = X or Y	Voltage/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

Refer to *Figure 1.3* and *Figure 1.4* for **STATUS** command response outputs.

Figure 7.27 shows the typical relay output for the **STATUS S** command, showing available SELOGIC control equation capability.

```
=>S>TA 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
Execution (%)   79       79       79
Group (%)       83       83       83
Logic (%)       87       87       87

=>>
```

Figure 7.27 Typical Relay Output for STATUS S Command

SUMMARY Command

The **SUM** command (see *Table 7.52*) displays an event summary in human-readable format.

Table 7.52 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

Each event summary report shows the date, time, current magnitudes (primary values), frequency, and, if the relay has the voltage option, voltage magnitudes (primary values). 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 9: Analyzing Events*.

Table 7.53 SYN Command

Command	Description	Access Level
SYN *n*	Displays the *n* generator synchronism-check report (n = 1, 2, or 3; defaults to 1 if not specified)	1
SYN R	Reset the breaker close time average and breaker close operations counter.	2

TARGET Command (Display Relay Word Bit Status)

The **TAR** command (see *Table 7.54* and *Table 7.55*) displays the status of front-panel target LEDs or Relay Word bit, whether these LEDs or Relay Word bits are asserted or deasserted.

Table 7.54 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 last displayed target row.	1
TAR R	Clears front-panel tripping targets. Unlatches the trip logic for testing purposes (see *Figure 8.1*). Shows Relay Word Row 0.	1

NOTE: The **TARGET R** command cannot reset the latched targets if a TRIP condition is present.

Table 7.55 TARGET Command Format

Parameter	Description
name	Display the Relay Word row with Relay Word bit name.
n	Show Relay Word row number ***n***.
k	Repeat ***k*** times (1–32767)

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 7.56*. All Relay Word rows are described in *Table J.1* and *Table J.3*.

Relay Word bits are used in SELOGIC control equations. See *Appendix J: Relay Word Bits*.

The **TAR** command does not remap the front-panel target LEDs, as is done in some previous SEL relays.

Table 7.56 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

TIME Command (View/Change Time)

The **TIME** command (see *Table 7.57*) 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 7.57 TIME Command (View/Change Time)

Command	Description	Access Level
TIME	Display the present internal clock time.	1
TIME *hh:mm*	Set the internal clock to ***hh:mm***.	1
TIME *hh:mm:ss*	Set the internal clock to ***hh:mm:ss***.	1

Use the **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 7.58*) to trigger the SEL-700G to record data for the high-resolution oscillography and event reports.

Table 7.58 TRIGGER Command (Trigger Event Report)

Command	Description	Access Level
TRI	Trigger event report data capture.	1

When you issue the **TRI** command, the SEL-700G responds with `Triggered`. If the event did not trigger within one second, the relay responds with `Did not trigger`. See *Section 9: 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 7.59 VEC Command

Command	Description	Access Level
VEC D	Displays the standard vector report	2
VEC E	Displays the extended vector report	2

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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. Use the front panel to analyze operating information, view and change relay settings, and perform control functions. The SEL-700G features a straightforward menu-driven control structure presented on the front-panel liquid crystal display (LCD). Front-panel targets and other LEDs give a clear indication of the SEL-700G operation status. The features that help you operate the relay from the front panel include the following:

- Reading metering
- Inspecting targets
- Accessing settings
- Controlling relay operations
- Viewing diagnostics

Front-Panel Layout

Figure 8.1 shows and identifies the following regions:

- Human-machine interface (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.

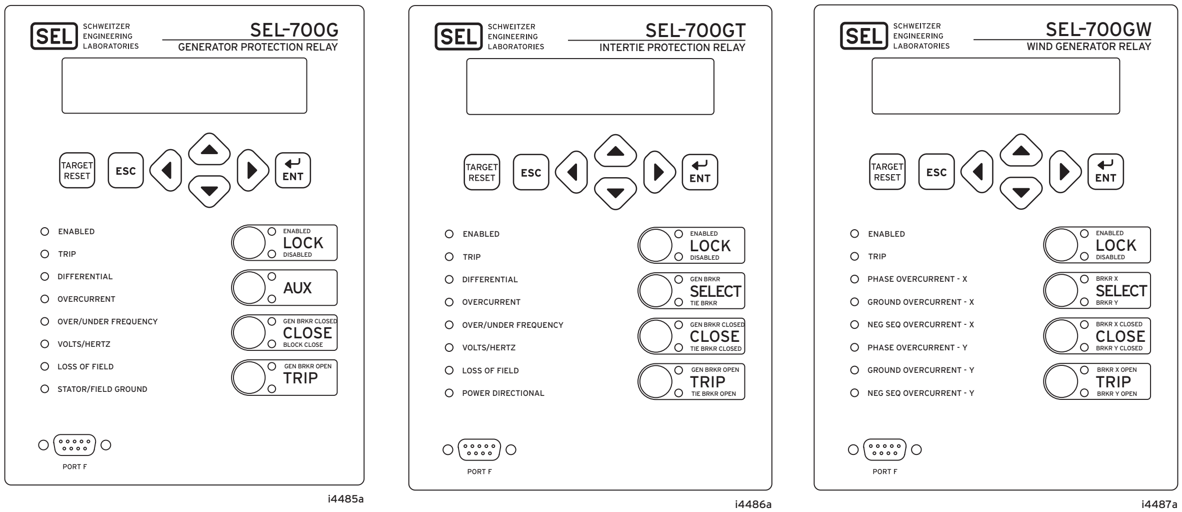


Figure 8.1 Front-Panel Overview

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.

Human-Machine Interface

Contrast

NOTE: See the Preface for an explanation of typographic conventions used to describe menus, the front-panel display, and the front-panel pushbuttons.

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 10: Testing and Troubleshooting*).
Relay trip has occurred	Displays the type or cause of the trip. Refer to *Table 9.1* 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.

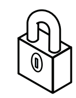


Figure 8.2 Access Level Security Padlock Symbol

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 8.3* for you to enter the password. See *PASSWORD Command (Change Passwords) on page 7.36* for the list of default passwords and for more information on changing passwords.

Figure 8.3 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 display. Use the keypad (shown in *Figure 8.4*) 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.

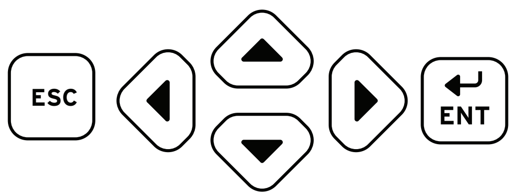
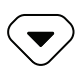
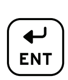


Figure 8.4 Front-Panel Pushbuttons

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 8.5 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.

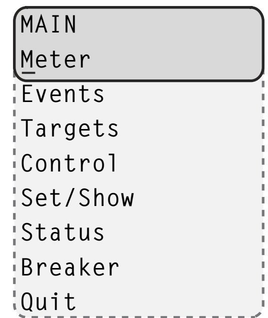


Figure 8.5 Main Menu

Meter Menu

Select the Meter menu item from the MAIN menu as shown in *Figure 8.6* 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.

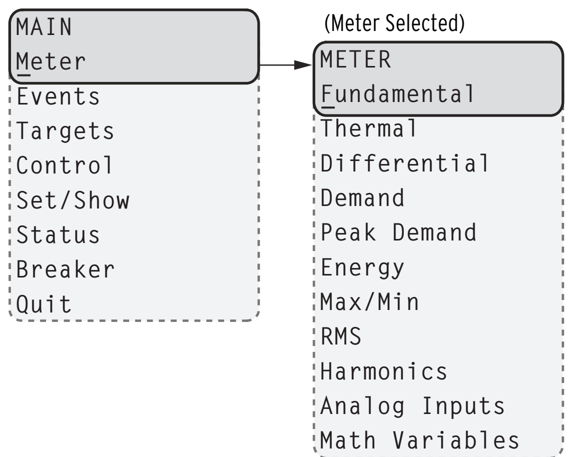


Figure 8.6 MAIN Menu and METER Submenu

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 8.7*.

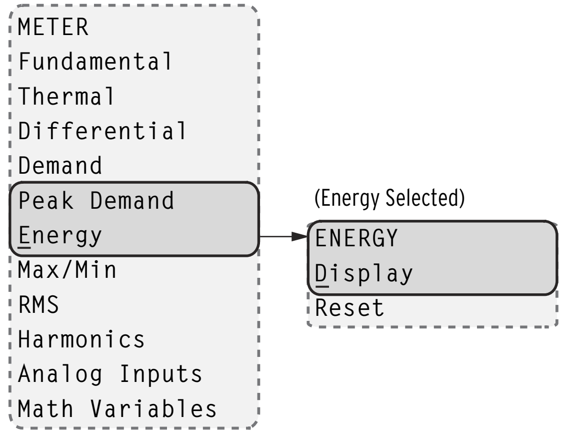


Figure 8.7 METER Menu and ENERGY Submenu

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 8.8*.

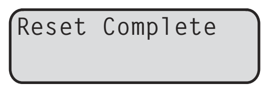


Figure 8.8 Relay Response When Energy (or Max/Min, Demand, Peak Demand) Metering Is Reset

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 8.9*.

Figure 8.9 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 8.10*.

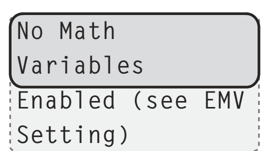


Figure 8.10 Relay Response When No Math Variables Enabled

Events Menu

Select the Events menu item from the MAIN menu as shown in *Figure 8.11*. EVENTS menu has Display and Clear as menu items. Select Display to view events and Clear to delete all events data.

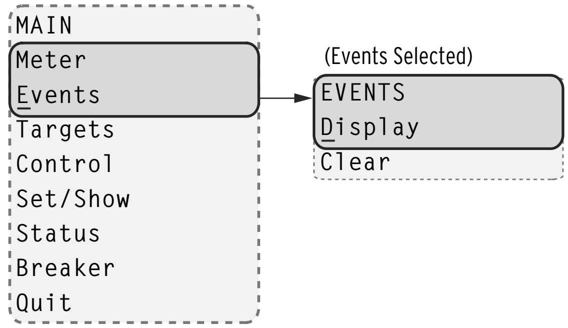


Figure 8.11 MAIN Menu and EVENTS Submenu

Figure 8.12 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.

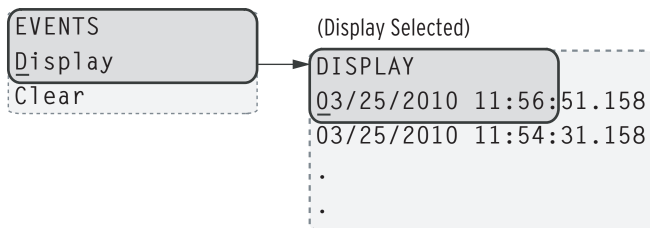


Figure 8.12 EVENTS Menu and DISPLAY Submenu

When you select Display and no event data are available, the relay displays as shown in *Figure 8.13*.

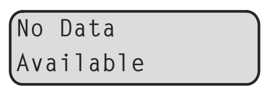


Figure 8.13 Relay Response When No Event Data Available

When you select Clear from the EVENTS menu and confirm the selection, the relay displays as shown in *Figure 8.14* after it clears the events data.

Figure 8.14 Relay Response When Events Are Cleared

Targets Menu

Select the Targets menu item on the MAIN menu as shown in *Figure 8.15* to view the binary state of the target rows. Each target row has eight Relay Word bits as shown in *Table J.1*.

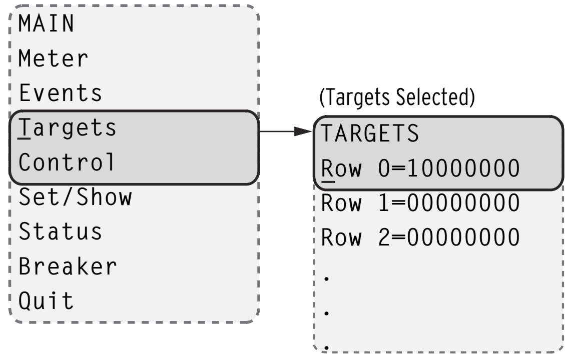


Figure 8.15 MAIN Menu and TARGETS Submenu

Select the target row to display two consecutive Relay Word bits with name and binary state as shown in *Figure 8.16*.

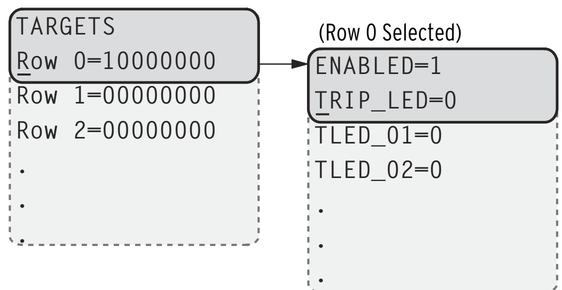


Figure 8.16 TARGETS Menu Navigation

Control Menu

Select the Control menu item on the MAIN menu as shown in *Figure 8.17* to go to the CONTROL menu.

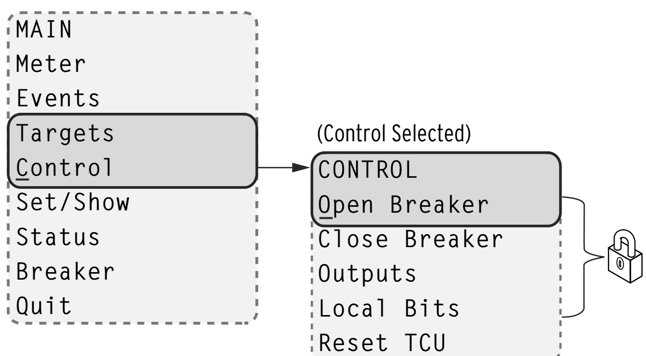


Figure 8.17 MAIN Menu and CONTROL Submenu

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 4.51* for the TRX or TRY equations and *Table J.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 4.51* and *Figure 4.126*). Note that this requires Level 2 access.

Select the Outputs menu item from the CONTROL menu as shown in *Figure 8.18* 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.

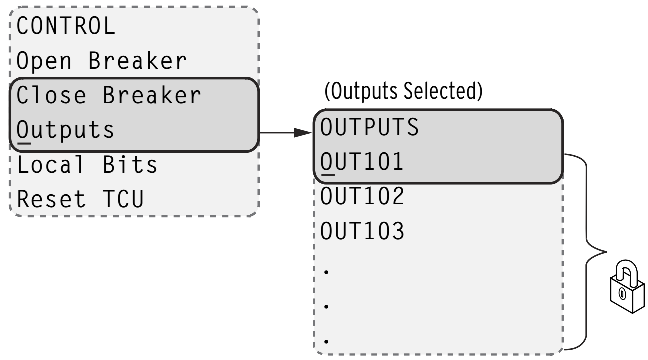


Figure 8.18 CONTROL Menu and OUTPUTS Submenu

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 4.227* for more information), local bit 1 replaces a supervisory switch. *Figure 8.19* 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 8.19*.

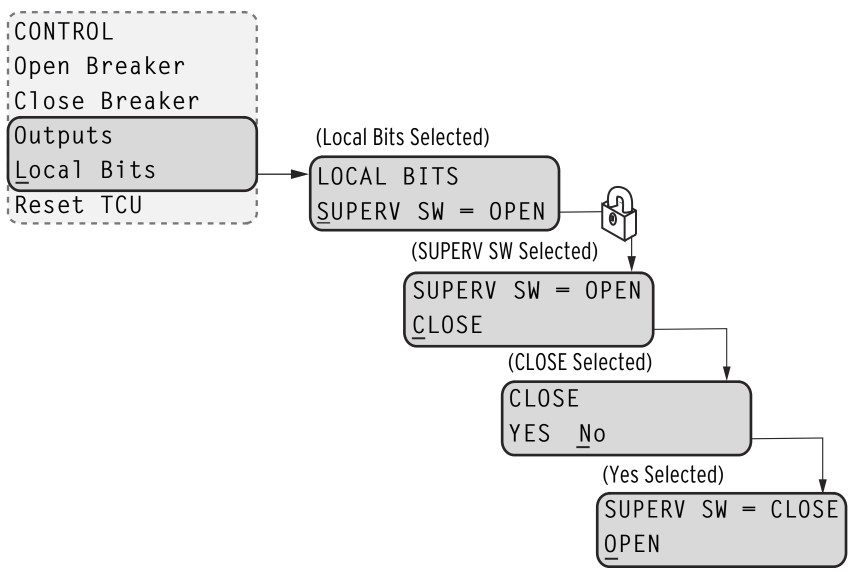


Figure 8.19 CONTROL Menu and LOCAL BITS Submenu

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.

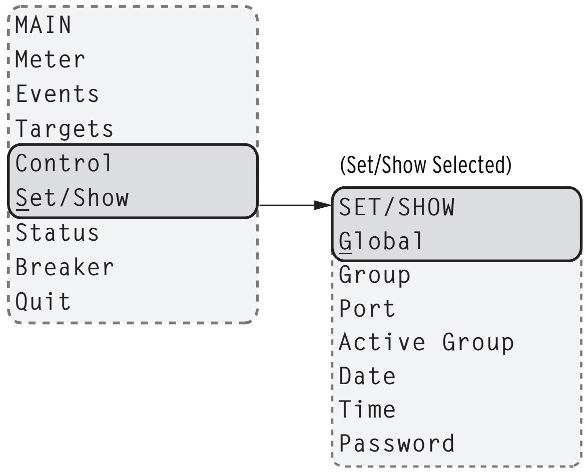


Figure 8.20 MAIN Menu and SET/SHOW Submenu

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.

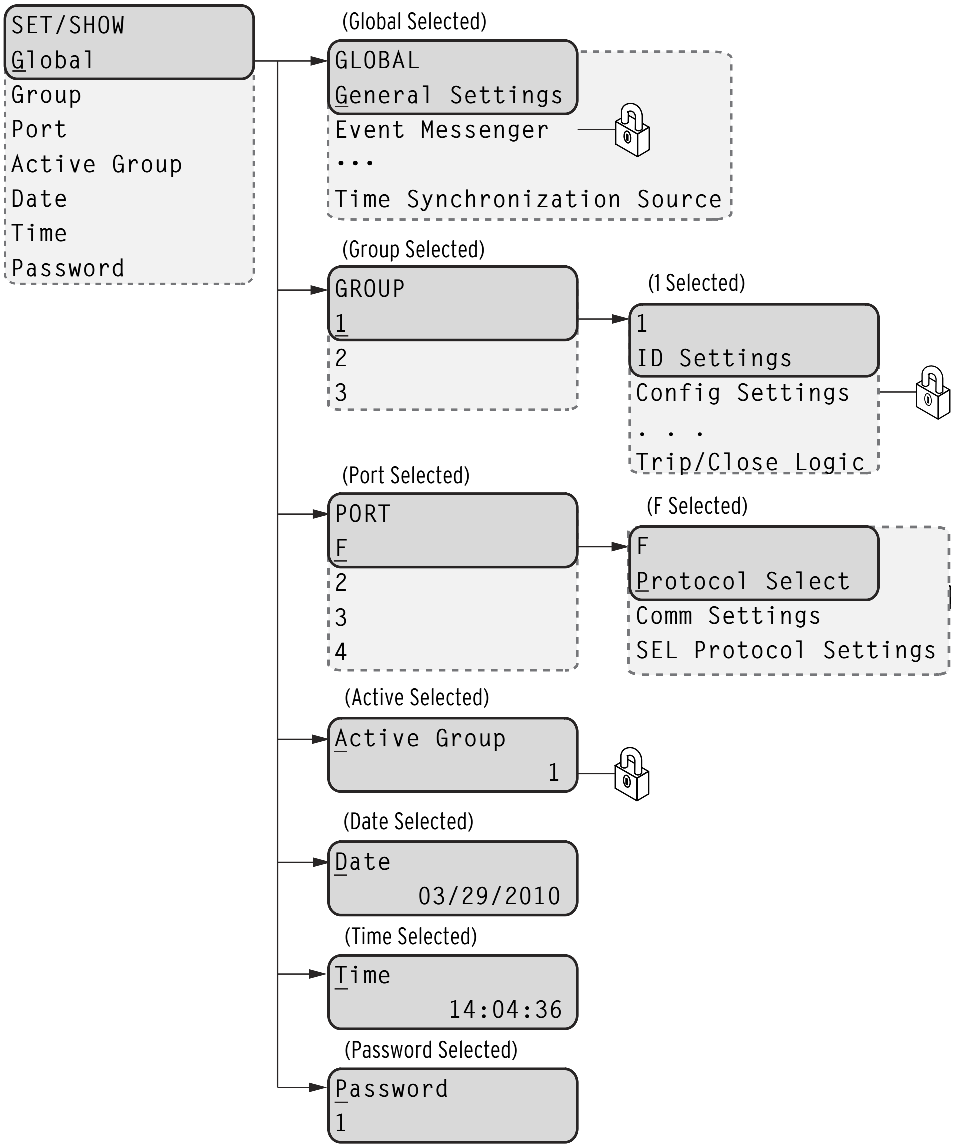


Figure 8.21 SET/SHOW Menu

Status Menu

Select the Status menu item on the MAIN menu as shown in *Figure 8.22* to access Relay Status data and Reboot Relay. See *STATUS Command (Relay Self-Test Status) on page 7.43* for the **STATUS** data field description.

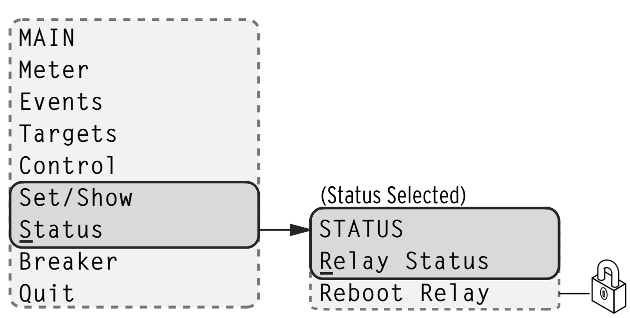


Figure 8.22 MAIN Menu and Status Submenu

Breaker Monitor Menu

Select the Breaker menu item on the MAIN menu as shown in *Figure 8.23* to access Breaker data or Reset the data. See *Breaker Monitor on page 5.15*, in *Section 5: Metering and Monitoring* for a detailed description.

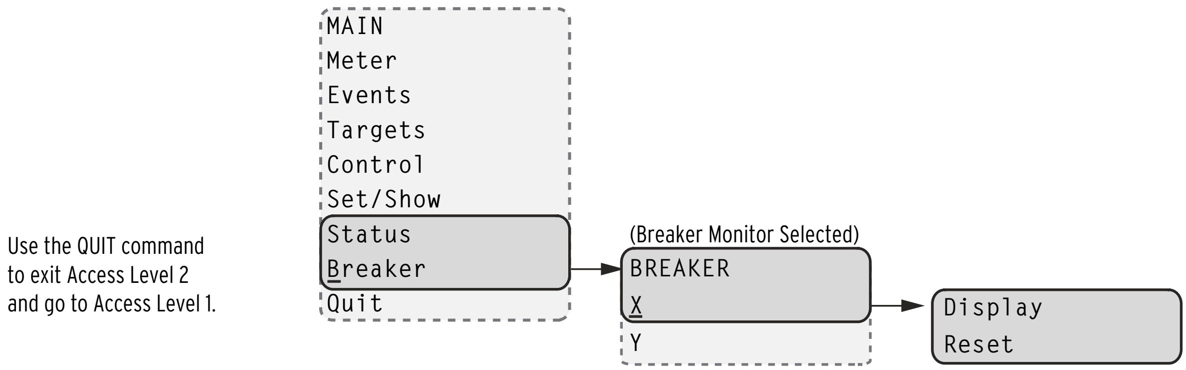


Figure 8.23 MAIN Menu and Breaker Monitor Submenu

Operation and Target LEDs

Programmable LEDs

The SEL-700G provides quick confirmation of relay conditions via operation and target LEDs. *Figure 8.24* shows this region with factory default text on the front-panel configurable labels. See *Target LED Settings on page 4.229* for the SELOGIC control equations.

NOTE: There are three versions of factory default front-panel LED configurations depending on the model (SEL-700G, SEL-700GT, or SEL-700GW).

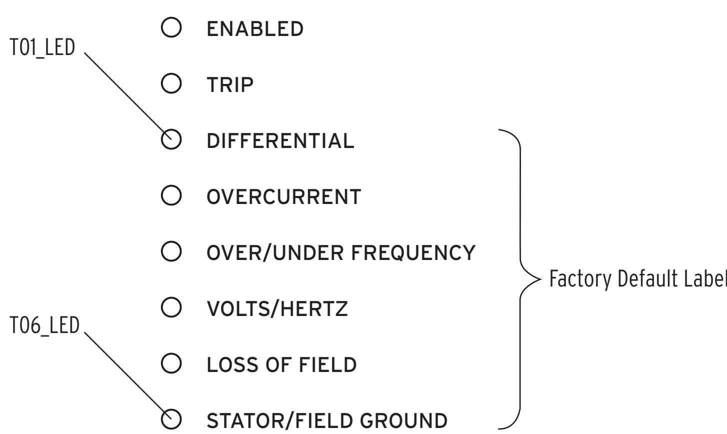


Figure 8.24 Factory Default Front-Panel LEDs for the SEL-700G Generator Protection Relay

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.

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 8.24*. 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 will follow the status of the corresponding control equation (T0*n*_LED). When the equation asserts, the LED will illuminate, and when the equation deasserts, the LED will extinguish. If the latch setting is set to Y, the LED will only assert if a trip condition occurs and the T0*n*_LED equation is asserted at the time of the trip. At this point, the LED will latch in and can be reset 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 4.87*.

The SEL-700G comes with slide-in labels for custom LED designations that match custom LED logic. The Configurable Label Kit includes blank labels, word processor templates, and instructions.

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 J: Relay Word Bits*.

Table 8.3 Possible Warning Conditions (Flashing TRIP LED)

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
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
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 8.25 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 7.12* 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 4.216* for further information.

Front-Panel Operator Control Pushbuttons

The SEL-700G features four operator-controlled pushbuttons, each with two programmable pushbutton LEDs, for local control as shown in *Figure 8.26*.

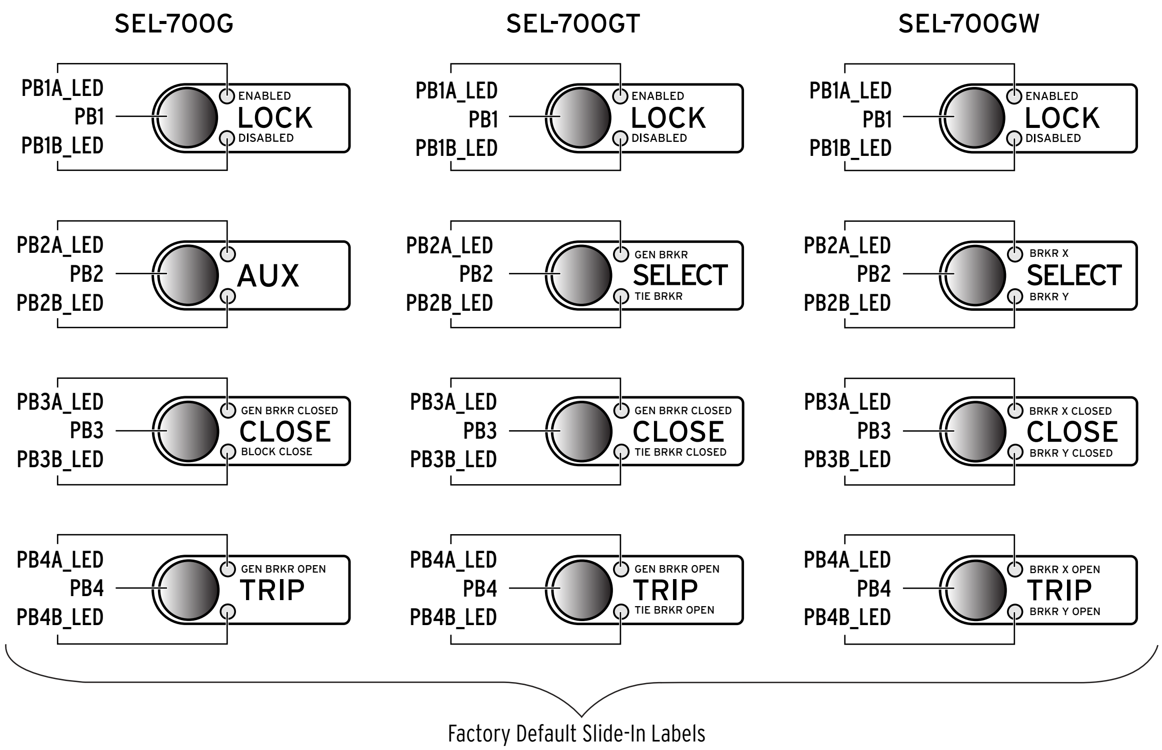


Figure 8.26 Operator Control Pushbuttons and LEDs

Pressing any one of these four pushbuttons asserts the corresponding PB*n* (*n* = 01 through 04) 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 4 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.

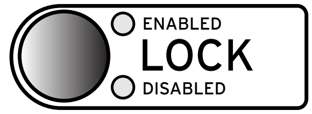
Using SELOGIC control equations, you can readily change the default LED and pushbutton functions. Use the optional slide-in label to mark the pushbuttons and pushbutton LEDs with custom names to reflect any programming changes that you make. Included on the SEL-700G Product Literature CD are word processor 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.

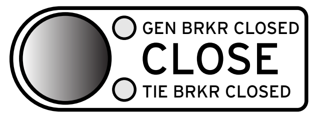


NOTE: LED labels shown are for the SEL-700GT. For the SEL-700GW, substitute GEN BRKR with BRKR X and TIE BRKR with BRKR X.

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.

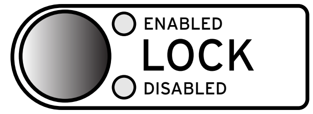
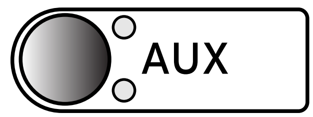
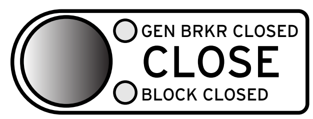
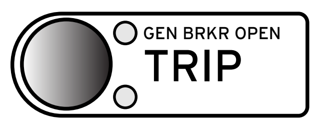
Option: Set a delay, so that the operator can press the CLOSE operator control pushbutton and then move a safe distance away from the breaker before the SEL-700GT or SEL-700GW issues a close (the CLOSE operator control comes with no set delay in the factory settings). With a set delay, press the CLOSE 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 4.56* 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 4.56* for more information.

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 AUX operator control pushbutton to enable/disable user-programmed auxiliary control. The corresponding LED can be programmed to illuminate during the enabled state. NOTE: The AUX operator control does not perform any function with the factory default settings.	
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 4.56* 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 4.56* for more information.	

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Section 9
Analyzing Events

Overview

The SEL-700G 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.

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 the appropriate event report can be identified and retrieved.
- 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 J.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 retrieved)

The SEL-700G provides Compressed ASCII event reports to facilitate event report storage and display. SEL communications processors and the ACSELERATOR Analytic Assistant™ SEL-5601 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** command to display Compressed ASCII event reports. 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 4 of the most recent 180-cycle or 17 of the most recent 64-cycle or 72 of the most recent 15-cycle event reports in nonvolatile memory. Refer to the **SET R** command in *SET Command (Change Settings) on page 7.39* and *Report Settings (SET R Command) on page SET.61*.

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 4.126*. 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 7.39*). 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 4.233*.

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 7.46* for more information on the **TRI** (Trigger Event Report) command.

Event Summaries

IMPORTANT: Clearing the HISTORY report with the **HIS C** command also clears all event data within the SEL-700G event memory.

For every triggered event, the relay generates and stores an event summary. The relay stores at least the most recent 72 if event report length setting LER := 15 or at least 17 if LER := 64 or at least 4 if LER := 180 event summaries. 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, date, time, event type (see *Table 9.1*), and frequency (FREQX, FREQY)
- The primary magnitudes of phase, neutral (if neutral CT is available), and residual currents (at the instant when maximum event current occurs)
- The 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

NOTE: Figure 9.3 is on multiple pages.

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 9.3*). The example event summary in *Figure 9.1* corresponds to the standard 15-cycle event report in *Figure 9.3*.

```
=>>SUM <Enter>
SEL-700G                                 Date: 02/24/2010   Time: 19:08:09.705
GENERATOR RELAY

Serial No = 000000000000000
FID = SEL-700G-X134-V0-Z001001-D20100224                CID = 1C01
EVENT LOGS =  3

Event:      Diff 87 Trip
Targets     11100000
Freqx (Hz)  60.00

Current Mag (X Side)
        IAX           IBX           ICX           IGX
(A)     104.5         526.5         102.8        424.43

Current Mag (Y Side)
        IAY           IBY           ICY           IGY
(A)     100.7         100.6         105.1          5.32

Neutral Current Mag
        IN
(A)      0.10

Voltage Mag (X Side)
       VAX    VBX    VCX    VGX
(V)    6690   6691   6683    178

Sync Voltage Mag
       VS
(V)    1039

Neutral Voltage Mag
       VN
(V)    7583
=>>
```

Figure 9.1 Example Event Summary

The relay sends event summaries to all serial ports with setting AUTO := Y each time an event triggers.

Event Type

The Event field displays the event type. Event types and the logic used to determine event types are shown in *Table 9.1*.

Table 9.1 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-IRIG 27PX1T OR R-IRIG 27PPX1T OR R-IRIG 27PY1T OR R-IRIG 27PPY1T) AND TRIP
Overvolt Trip	(59PX1T OR 59PPX1T OR 59QX1T OR 59GX1T OR 59PY1T OR 59PPY1T OR 59QY1T OR 59GY1T) 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

Table 9.1 Event Types (Sheet 2 of 2)

Event Type	Event Type Logic
Remote Trip	REMTRIP AND TRIP
CommIdleLossTrip	(COMMIDLE OR COMMLOSS) AND TRIP
Trigger	Serial port **TRI** command
ER Trigger	ER Equation assertion
Trip	TRIP with no known cause

Currents, Voltages, and RTD Temperatures

The relay determines the maximum phase current during an event. The instant the maximum phase current occurs is marked by an asterisk (*) in the event report (see *Figure 9.3*). This row of data corresponds to the analogs shown in the summary report for the event.

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 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, BY, 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 9.2* 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, date, time, event type (see *Table 9.1*)
- ➤ 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

 #       DATE          TIME            EVENT           CURRENT    FREQX      TARGETS
 1     02/24/2010   19:08:09.705   Diff 87 Trip          526.5    60.00      11100000
 2     02/24/2010   19:03:51.756   Diff 87 Trip          105.2    60.00      11100000
 3     02/24/2010   19:00:20.948   Volt/Hz 24 Trip         1.4    60.00      11000100

=>>
```

Event Number | Event Type | Maximum Current | Frequency | User-Defined Target LEDs

Figure 9.2 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 7.31* 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 ACSELERATOR 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.

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
- Settings in service at the time of event retrieval, 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
- Relay Settings

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: Figure 9.3 is on multiple pages.

NOTE: Active channels depend on the specific relay model.

Refer to the example analog event report in *Figure 9.3* 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 9.2* summarizes the analog event report columns.

Table 9.2 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)
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)

Table 9.2 Analog Event Report Columns Definitions (Sheet 2 of 2)

Column Heading	Column Symbols	Description
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 9.3*, indicating the sinusoidal nature of the waveforms.

Other figures help in understanding the information available in the event report current columns:

- ➤ *Figure 9.4* shows how analog event report current column data relate to the actual sampled current waveform and rms current values.
- ➤ *Figure 9.5* shows how analog event report current column data can be converted to phasor rms current values.

Example 15-Cycle Event Report

The following example of a standard analog 15-cycle event report in *Figure 9.3* also corresponds to the example SER report in *Figure 9.9*. In *Figure 9.3*, 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 9.4* and *Figure 9.5*). 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 <Enter>
```

```
SEL-700G                                Date: 02/24/2010   Time: 19:08:09.705
GENERATOR RELAY
```

Date and Time of Event

```
Serial Number=000000000000000
FID=SEL-700G-X134-V0-Z001001-D20100224   CID=1C01
```

Firmware and Checksum Identifier

```
                                                                         O
                                                                       I u
                                                                       N t
               Currents (Amps Pri)            Voltages (Volts Pri)     1 13
    IAX    IBX    ICX    IAY    IBY    ICY    VAX    VBX    VCX    VS FREQX 2 2
```

Analog and Digital Header

```
[1]
  -61.0  -44.0  103.0   53.5   47.0 -105.0  -3747  -2971   6655   604 59.99 . ..
   84.5  -93.5    8.0  -85.5   88.5   -3.5   5543  -5995    617  -846 59.99 . ..
   60.0   43.5 -103.5  -54.0  -47.5  104.0   3744   2973  -6657  -605 59.99 . ..
  -85.0   93.0   -8.5   85.0  -89.5    3.5  -5547   5993   -614   846 59.99 . ..
```

One Cycle of Data

Figure 9.3 Example Standard 15-Cycle Analog Event Report 1/4-Cycle Resolution (Sheet 1 of 5)

```
 [2]
   -60.5  -43.5  102.5   53.5   47.0 -105.0  -3742  -2977   6656   603 59.99 . ..
    84.5  -93.5    8.0  -85.5   89.0   -3.5   5546  -5992    610  -847 59.99 . ..
    60.0   43.5 -103.5  -53.5  -47.5  104.5   3738   2979  -6658  -604 59.99 . ..
   -84.5   93.0   -8.5   84.5  -89.5    3.0  -5549   5988   -608   847 59.99 . ..
 [3]
   -60.5  -44.0  103.0   53.0   47.0 -104.5  -3737  -2983   6657   602 59.99 . ..
    84.5  -93.0    8.0  -85.0   88.5   -3.5   5550  -5988    603  -849 59.99 . ..
    60.0   43.5 -103.5  -53.5  -47.5  104.0   3734   2983  -6658  -603 59.99 . ..
   -85.0   93.0   -8.5   84.5  -89.5    3.0  -5553   5986   -601   847 59.99 . ..
 [4]
   -60.5  -44.0  103.0   53.5   47.0 -104.5  -3732  -2987   6657   601 59.99 . ..
    84.5 -202.0    8.0  -85.5   89.0   -3.5   5553  -5986    597  -848 59.99 . ..
    60.0   89.5 -103.5  -54.0  -47.5  104.0   3727   2991  -6659  -602 59.99 . ..
   -85.0  388.5   -8.0   85.0  -89.5    3.0  -5556   5983   -595   847 59.99 . ..
 [5]
   -60.5 -178.5  103.0   53.5   46.5 -105.0  -3726  -2995   6658   600 59.99 . ..
    85.0 -468.0    7.5  -85.5   89.0   -3.5   5557  -5983    591  -849 59.99*. ..
    59.5  221.0 -103.5  -54.0  -47.5  104.5   3722   2997  -6660  -601 59.99 . ..
   -85.0  467.0   -8.0   85.0  -89.0    2.5  -5560   5980   -589   849 59.99>. ..
 [6]
   -60.5 -221.5  103.0   53.0   47.0 -105.0  -3721  -3001   6660   599 59.99 . .*
    85.0 -467.5    7.0  -85.5   88.5   -3.5   5560  -5980    584  -850 59.99 . .*
    60.0  221.0 -103.0  -53.5  -47.5  104.5   3716   3003  -6661  -600 59.99 . .*
   -85.5  467.0   -7.5   85.0  -89.5    2.5  -5563   5977   -582   849 59.99 . .*
 [7]
   -60.5 -221.5  102.5   53.0   47.5 -105.0  -3715  -3007   6659   599 59.99 . .*
    84.5 -467.0    7.0  -85.5   88.5   -3.0   5564  -5977    578  -850 59.99 . .*
    59.5  221.5 -103.5  -53.5  -48.0  104.0   3712   3007  -6660  -599 59.99 . .*
   -85.5  466.5   -7.5   85.0  -89.0    2.5  -5567   5974   -576   849 59.99 . .*

 [8]
   -60.0 -222.0  103.0   52.5   47.5 -104.5  -3710  -3011   6659   598 59.99 . .*
    84.5 -467.0    7.0  -85.5   88.5   -3.0   5568  -5974    572  -851 59.99 . .*
    59.5  222.0 -103.5  -53.5  -48.0  104.0   3706   3012  -6660  -598 59.99 . .*
   -85.0  466.0   -7.5   85.0  -89.0    2.5  -5571   5972   -570   850 59.99 . .*
 [9]
   -60.0 -222.5  102.5   53.0   47.5 -105.0  -3705  -3017   6659   596 59.99 . .*
    85.0 -466.5    7.5  -85.5   88.5   -2.5   5572  -5972    565  -852 59.99 . .*
    59.5  222.5 -103.5  -53.5  -48.0  104.5   3701   3020  -6661  -596 59.99 . .*
   -85.5  466.0   -8.0   85.5  -89.5    2.0  -5574   5969   -563   850 59.99 . .*
 [10]
   -60.0 -223.0  103.5   52.5   47.5 -105.0  -3699  -3024   6660   595 59.99 . .*
    85.0 -466.5    7.0  -86.0   89.0   -2.5   5575  -5968    559  -851 59.99 . .*
    59.5  222.5 -104.0  -53.0  -48.5  104.5   3695   3025  -6662  -596 59.99 . .*
   -85.5  466.0   -7.5   85.0  -89.0    2.0  -5578   5966   -557   851 59.99 . .*
```

Figure 9.3 Example Standard 15-Cycle Analog Event Report 1/4-Cycle Resolution (Sheet 2 of 5)

```
[11]
  -60.0 -223.5  103.0   52.5   48.0 -104.5  -3694  -3028   6661   595 59.99 . .*
   85.0 -466.5    7.0  -85.5   88.5   -2.5   5578  -5966    553  -853 59.99 . .*
   59.0  223.0 -103.5  -53.0  -48.5  104.0   3691   3030  -6662  -596 59.99 . .*
  -85.5  466.0   -7.5   85.5  -89.0    2.0  -5581   5964   -551   852 59.99 . .*
[12]
  -60.0 -224.0  103.5   52.5   48.0 -105.0  -3689  -3035   6661   594 59.99 . .*
   85.0 -466.0    6.5  -85.5   88.5   -2.5   5582  -5962    546  -854 59.99 . .*
   59.0  223.5 -104.0  -53.0  -48.5  104.5   3686   3035  -6663  -595 59.99 . .*
  -85.5  466.0   -7.0   85.5  -89.0    2.0  -5584   5960   -544   852 59.99 . .*
[13]
  -59.5 -224.5  103.0   52.5   48.0 -105.0  -3683  -3039   6662   593 59.99 . .*
   85.0 -466.0    6.5  -86.0   88.5   -2.0   5585  -5959    540  -854 59.99 . .*
   59.0  224.0 -103.5  -52.5  -48.5  104.5   3680   3041  -6663  -593 59.99 . .*
  -86.0  465.5   -7.0   85.5  -89.0    2.0  -5588   5958   -539   853 59.99 . .*
[14]
  -59.5 -224.5  103.0   52.0   48.0 -105.0  -3679  -3045   6662   592 59.99 . .*
   85.5 -466.0    6.5  -86.0   88.5   -2.5   5589  -5957    535  -854 59.99 . .*
   59.0  224.5 -103.5  -53.0  -49.0  104.5   3675   3048  -6664  -593 59.99 . .*
  -85.5  465.0   -7.0   85.5  -89.0    2.0  -5591   5954   -532   854 59.99 . .*
[15]
  -59.5 -225.0  103.0   52.5   48.5 -104.5  -3673  -3051   6663   591 59.99 . .*
   85.5 -465.5    6.5  -86.0   88.0   -2.0   5592  -5954    528  -856 59.99 . .*
   59.0  225.0 -103.5  -53.0  -48.5  104.5   3669   3052  -6665  -592 59.99 . .*
  -85.5  465.0   -7.0   85.5  -88.5    1.5  -5595   5952   -524   855 59.99 . .*

Serial No = 000000000000000
FID = SEL-700G-X134-V0-Z001001-D20100224                CID = 1C01
EVENT LOGS =  3

Event:      Diff 87 Trip
Targets     11100000
Freqx (Hz)  59.99

Current Mag (X Side)
        IAX           IBX           ICX           IGX
(A)     104.5         526.5         102.8        424.43

Current Mag (Y Side)
        IAY           IBY           ICY           IGY
(A)     100.7         100.6         105.1          5.32

Neutral Current Mag
        IN
(A)      0.10
Voltage Mag (X Side)
       VAX    VBX    VCX    VGX
(V)    6690   6691   6683    178

Sync Voltage Mag
       VS
(V)    1039

Neutral Voltage Mag
       VN
(V)    7583
Global Settings
FNOM    := 60      DATE_F  := MDY
FAULT   := 51V OR 51C OR 50PX1P OR 46Q2 OR 21C1P OR 21C2P OR 50PY1P OR 50QY1P OR
 50GY1P OR 50N1P OR 51PYP OR 51QYP OR 51GYP OR TRIP

EMP     := N

TGR     := 3
SS1     := 1
SS2     := 0
SS3     := 0



EPMU    := N
52ABF   := N       BFDX    := 0.50    BFIX    := R_TRIG TRIPX

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

RSTTRGT := 0
RSTENRGY:= 0
RSTMXMN := 0
RSTDEM  := 0
RSTPKDEM:= 0

DSABLSET:= 0
```

Figure 9.3 Example Standard 15-Cycle Analog Event Report 1/4-Cycle Resolution (Sheet 3 of 5)

```
TIME_SRC:= IRIG1   TIME_SRC:= IRIG1

Group Settings

RID     := SEL-700G
TID     := GENERATOR RELAY
PHROT   := ABC     X_CUR_IN:= NEUT    CTRX    := 500     INOM    := 1.0
DELTAY_X:= WYE     PTRX    := 100.00  VNOM_X  := 13.80   CTCONY  := WYE
CTRY    := 500     PTRS    := 100.00  CTRN    := 100     PTRN    := 100.00
E87     := GEN
TAPX    := 1.00    TAPY    := 1.00
O87P    := 0.30    U87P    := 10.0    87AP    := 0.15    87AD    := 5.00
SLP1    := 25

E87N    := N

EREF    := N
E64G    := N
E64F    := N

EBUP    := DC      Z1C     := 40.0
Z1CO    := 0.0     Z1CD    := 0.00    50PP1   := 0.10    Z1ANG   := 88
Z2C     := 80.0
Z2CO    := 0.0     Z2CD    := 0.00    50PP2   := 0.10    Z2ANG   := 85
21CTC   := NOT 3POX
E40     := N       E46     := N       E49T    := N
E24     := N       E78     := N       EINAD   := N

50PX1P  := OFF     50PX2P  := OFF     50PX3P  := OFF     50GX1P  := OFF
50GX2P  := OFF     50QX1P  := OFF     50QX2P  := OFF
51GXP   := OFF     51GXC   := U3      51GXTD  := 1.50    51GXRS  := N
51GXCT  := 0.00    51GXMR  := 0.00    51GXTC  := 1
50PY1P  := OFF     50PY1D  := 0.00    50PY1TC := 1
50PY2P  := OFF     50PY2D  := 0.00    50PY2TC := 1
50PY3P  := OFF     50PY3D  := 0.00    50PY3TC := 1
50GY1P  := OFF     50GY2P  := OFF     50QY1P  := OFF     50QY2P  := OFF
50N1P   := OFF     50N2P   := OFF     51NP    := OFF     51NC    := U3
51NTD   := 1.50    51NRS   := N
51NCT   := 0.00    51NMR   := 0.00    51NTC   := 1

EDIRX   := N       ZLFX    := 32.50   PLAFX   := 30.00   NLAFX   :=-30.00
EPWRX   := N
E81X    := N
E81RX   := N
E81ACC  := N
27PX1P  := OFF     27PX2P  := OFF
27PPX1P := 93.5    27PPX1D := 0.50    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
E49RTD  := NONE    E25X    := N       EDEM    := ROL     DMTC    := 15
PHDEMPX := 1.00    GNDEMPX := 0.20    3I2DEMPX:= 0.20
50LXP   := 0.05    3POXD   := 0.00
TDURD   := 0.50    CFDX    := 0.50
TRX     := SV06 OR SV07 OR SV08 OR 46Q2T OR 81X1T OR 81X2T OR 81RX1T OR 81RX2T O
R OOST OR SV04T OR OCX
TR1     := SV06 OR SV07 OR SV08
TR2     := SV06 OR SV07 OR LT06
TR3     := SV06 OR SV07

REMTRIP := 0
ULTRX   := 3POX

ULTR1   := NOT TR1
ULTR2   := NOT TR2
ULTR3   := NOT TR3
52AX    := 0

CLX     := SV03T OR CCX

ULCLX   := TRIPX
```

Figure 9.3 Example Standard 15-Cycle Analog Event Report 1/4-Cycle Resolution (Sheet 4 of 5)

```
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

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
GSRTRG  := CLOSEX AND (25C OR 25AX1 OR 25AX2)
GSRR    := 0.25    PRESYNC := 4790

LDLIST  := NA

LDAR    := 15

Logic Settings

ELAT    := 6       ESV     := 10      ESC     := N       EMV     := N

SET01   := R_TRIG SV01T AND NOT LT01
RST01   := R_TRIG SV01T AND LT01
SET02   := NA
RST02   := NA
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

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 64G1T OR 64G2T OR REF1P OR 50GX1T OR
50GX2T 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 50N1T OR 50N2T O
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    := NA
SV10PU  := 0.00    SV10DO  := 0.00
SV10    := NA

OUT101FS:= Y       OUT101  := HALARM OR SALARM
OUT102FS:= N       OUT102  := 0
OUT103FS:= N       OUT103  := TRIPX
OUT301FS:= N       OUT301  := 0
OUT302FS:= N       OUT302  := 0
OUT303FS:= N       OUT303  := 0

=>
```

Figure 9.3 Example Standard 15-Cycle Analog Event Report 1/4-Cycle Resolution (Sheet 5 of 5)

Figure 9.4 and *Figure 9.5* look in detail at an example of one cycle of A-phase current (channel IAX) data similar to what is shown in *Figure 9.3*. *Figure 9.4* shows how the event report ac current column data relate to the actual sampled waveform and rms values. *Figure 9.5* shows how the event report current column data can be converted to phasor rms values. Voltages are processed similarly.

In *Figure 9.4*, 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.

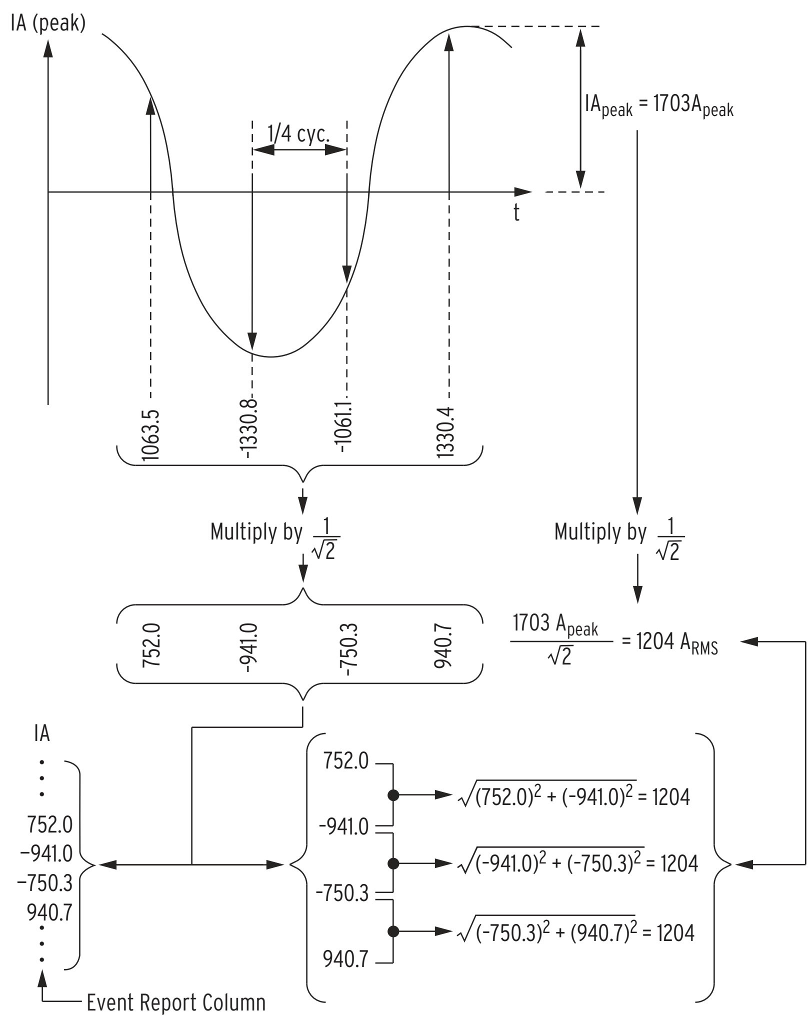

Figure 9.4 Derivation of Analog Event Report Current Values and RMS Current Values From Sampled Current Waveform

In *Figure 9.5*, 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 9.5*, at the present sample, the phasor rms current value is:

$$IA = 1204 \text{ A } \angle{-38.6°} \quad \textbf{Equation 9.1}$$

The present sample (IA = 940.7 A) is a real rms current value that relates to the phasor rms current value:

$$1204 \text{ A} \bullet \cos(-38.6°) = 940.7 \text{ A} \quad \textbf{Equation 9.2}$$

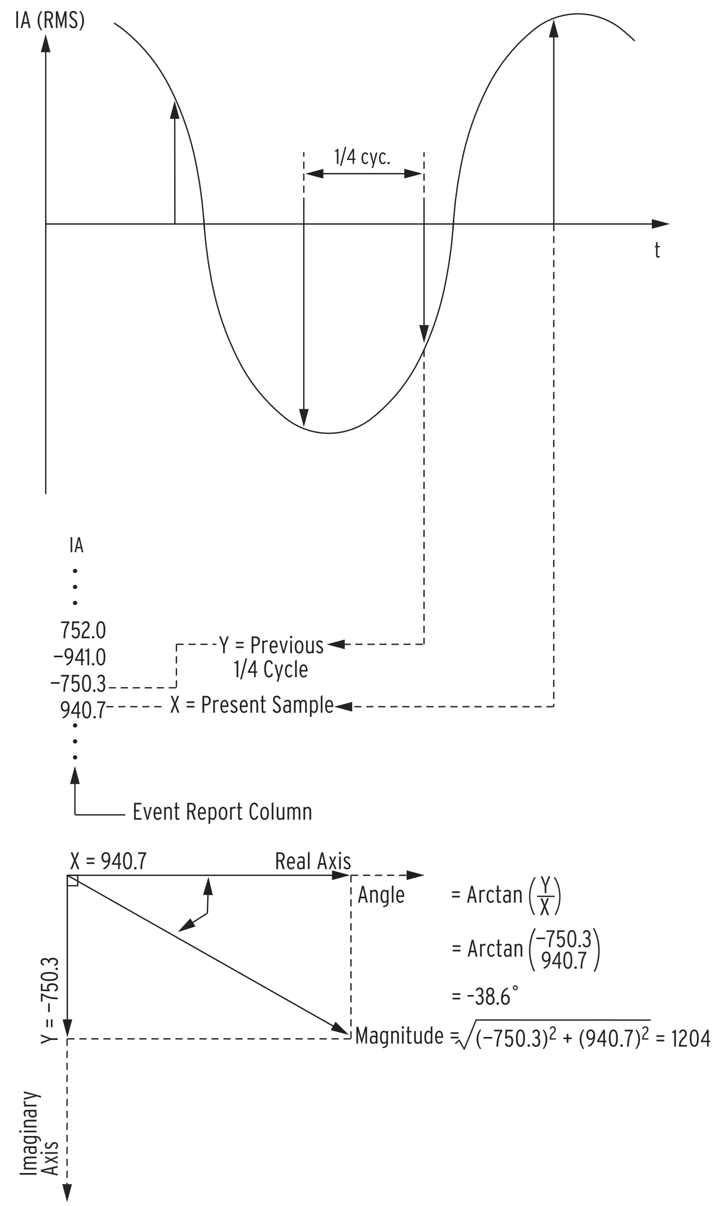

Figure 9.5 Derivation of Phasor RMS Current Values From Event Report Current Values

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.

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
- Relay Settings

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 9.6* to view the digital event report columns. This example event report displays rows of information each 1/4 cycle. Retrieve this report with the **EVE D X** command.

Table 9.3 gives the digital event report column definitions for the protection and control elements and the inputs and outputs.

Table 9.3 Digital Event Report Column Definitions (Sheet 1 of 6)

Column Designation	Column Symbols	Column Symbol RWBs
X Side		
50PX1	* t	50PX1P picked up 50PX1T picked up
50PX2	* t	50PX2P picked up 50PX2T picked up
50PX3A	* t	50PX3AP picked up 50PX3AT picked up
50PX3B	* t	50PX3BP picked up 50PX3BT picked up
50PX3C	* t	50PX3CP picked up 50PX3CT picked up
50GX1/67GX1	* t	50GX1P or 67GX1P picked up 50GX1T or 67GX1T picked up
50GX2/67GX2	* t	50GX2P or 67GX2T picked up 50GX2T or 67GX2T picked up
50QX1	* t	50QX1P picked up 50QX1T picked up
50QX2	* t	50QX2P picked up 50QX2T picked up
51PX	* t r	51PXP picked up 51PXT picked up 51PXR picked up
51GX	* t r	51GXP picked up 51GXT picked up 51GXR picked up
51QX	* t r	51QXP picked up 51QXT picked up 51QXR picked up
GX1DIR GX2DIR	1 2 b	GX1DIR picked up GX2DIR picked up Both GX1DIR and GX2DIR picked up
50N1	* t	50N1P picked up 50N1T picked up
50N2	* t	50N2P picked up 50N2T picked up
51N1	* t r	51NP picked up 51NT picked up 51NR picked up
46Q1	* t	46Q1 picked up 46Q1T picked up
46Q2	* t r	46Q2 picked up 46Q2T picked up 46Q2R picked up

Table 9.3 Digital Event Report Column Definitions (Sheet 2 of 6)

Column Designation	Column Symbols	Column Symbol RWBs
21C1	* t	21C1P picked up 21C1T picked up
21C2	* t	21C2P picked up 21C2T picked up
27PPX1	* t	27PPX1 picked up 27PPX1T picked up
27PPX2	* t	27PPX2 picked up 27PPX2T picked up
27S1	* t	27S1 picked up 27S1T picked up
27S2	* t	27S2 picked up 27S2T picked up
59PPX1	* t	59PPX1 picked up 59PPX1T picked up
59PPX2	* t	59PPX2 picked up 59PPX2T picked up
59GX1	* t	59GX1 picked up 59GX1T picked up
59GX2	* t	59GX2 picked up 59GX2T picked up
59QX1	* t	59QX1 picked up 59QX1T picked up
59QX2	* t	59QX2 picked up 59QX2T picked up
59S1	* t	59S1 picked up 59S1T picked up
59S2	* t	59S2 picked up 59S2T picked up
24D1	* t	24D1 picked up 24D1T picked up
24C2	* t r	24C2 picked up 24C2T picked up 24CR picked up
3PWX1	* t	3PWRX1P picked up 3PWRX1T picked up
3PWX2	* t	3PWRX2P picked up 3PWRX2T picked up
3PWX3	* t	3PWRX3P picked up 3PWRX3T picked up
3PWX4	* t	3PWRX4P picked up 3PWRX4T picked up
LOPX	*	LOPX picked up
ZLOADX	*	ZLOADX picked up
78	S O t	SWING picked up OOS picked up OOST picked up
64G1	* t	64G1 picked up 64G1T picked up

Table 9.3 Digital Event Report Column Definitions (Sheet 3 of 6)

Column Designation	Column Symbols	Column Symbol RWBs
64G2	* t	64G2 picked up 64G2T picked up
40Z1	* t	40Z1 picked up 40Z1T picked up
40Z2	* t	40Z2 picked up 40Z2T picked up
SFX	*	SFX picked up
25AX	1 2 b C	25AX1 picked up 25AX2 picked up Both 25AX1 and 25AX2 picked up 25CX picked up
81X12	1 2 b	81X1T picked up 81X2T picked up Both 81X1T and 81X2T picked up
81X34	3 4 b	81X3T picked up 81X4T picked up Both 81X3T and 81X4T picked up
81X56	5 6 b	81X5T picked up 81X6T picked up Both 81X5T and 81X6T picked up
REF	* t	REF1F picked up REF1P picked up
BFIX	* t	BFIX picked up BFTX picked up
TRIP12	1 2 B	TRIP1 picked up TRIP2 picked up Both TRIP1 and TRIP2 picked up
TRIP3X	3 X B	TRIP3 picked up TRIPX picked up Both TRIP3 and TRIPX picked up
RTD Wdg	w W	WDGALRM picked up WDGTRIP picked up
RTD Brg	b B	BRGALRM picked up BRGTRIP picked up
RTD Oth	o O	OTHALRM picked up OTHTRIP picked up
RTD Amb	a A	AMBALRM picked up AMBTRIP picked up
RTD IN	1	RTDIN asserted
Y Side		
50PY1/67PY1	* t	50PY1P or 67PY1P picked up 50PY1T or 67PY1T picked up
50PY2/67PY2	* t	50PY2P or 67PY2P picked up 50PY2T or 67PY2T picked up
50PY3A	* t	50PY3AP picked up 50PY3AT picked up
50PY3B	* t	50PY3BP picked up 50PY3BT picked up
50PY3C	* t	50PY3CP picked up 50PY3CT picked up

Table 9.3 Digital Event Report Column Definitions (Sheet 4 of 6)

Column Designation	Column Symbols	Column Symbol RWBs
50GY1/67GY1	* t	50GY1P or 67GY1P picked up 50GY1T or 67GY1T picked up
50GY2/67GY2	* t	50GY2P or 67GY2P picked up 50GY2T or 67GY2T picked up
50QY1/67QY1	* t	50QY1P or 67QY1P picked up 50QY1T or 67QY1T picked up
50QY2/67QY2	* t	50QY2P or 67QY2P picked up 50QY2T or 67QY2T picked up
51PY1	* t r	51PY1P picked up 51PY1T picked up 51PY1R picked up
51GY1	* t r	51GY1P picked up 51GY1T picked up 51GY1R picked up
51QY1	* t r	51QY1P picked up 51QY1T picked up 51QY1R picked up
27PPY1	* t	27PPY1 picked up 27PPY1T picked up
27PPY2	* t	27PPY2 picked up 27PPY2T picked up
59PPY1	* t	59PPY1 picked up 59PPY1T picked up
59PPY2	* t	59PPY2 picked up 59PPY2T picked up
59GY1	* t	59GY1 picked up 59GY1T picked up
59GY2	* t	59GY2 picked up 59GY2T picked up
59QY1	* t	59QY1 picked up 59QY1T picked up
59QY2	* t	59QY2 picked up 59QY2T picked up
3PWY1	* t	3PWRY1P picked up 3PWRY1T picked up
3PWY2	* t	3PWRY2P picked up 3PWRY2T picked up
3PWY3	* t	3PWRY3P picked up 3PWRY3T picked up
3PWY4	* t	3PWRY4P picked up 3PWRY4T picked up
LOPY	*	LOPY picked up
ZLOADY	*	ZLOADY picked up
SFY	*	SFY picked up
25AY	1 2 b	25AY1 picked up 25AY2 picked up Both 25AY1 and 25AY2 picked up

Table 9.3 Digital Event Report Column Definitions (Sheet 5 of 6)

Column Designation	Column Symbols	Column Symbol RWBs
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
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

Table 9.3 Digital Event Report Column Definitions (Sheet 6 of 6)

Column Designation	Column Symbols	Column Symbol RWBs
Outputs 3034	3	OUT303 picked up
	4	OUT304 picked up
	b	Both OUT303 and OUT304 picked up
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-700G                                 Date: 02/24/2010   Time: 19:08:09.705
GENERATOR RELAY
Serial Number=000000000000000
FID=SEL-700G-X134-V0-Z001001-D20100224   CID=1C01

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 00 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]
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . ... .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . ... .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . ... .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . ... .....
[2]
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . ... .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . ... .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . ... .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . ... .....
```

Figure 9.6 Example Standard 15-cycle Digital Event Report (EVE D X Command) 1/4 Cycle Resolution (Sheet 1 of 2)

```
[3]
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . ... .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . ... .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . ... .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . ... .....
[4]
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . ... .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . ... .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . ... .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . ... .....
[5]
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . ... .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . ... .....*
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . ... .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . ... .....>
[6]
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . *bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
[7]
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
[[8]
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
[9]
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....

[10]
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
[11]
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
[12]
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....

[13]
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
[14]
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
[15]
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
.........rrr..b ..r .. .. .... ........ .r .... . * . .. .. .. ... . .bb .....
```

Figure 9.6 Example Standard 15-cycle Digital Event Report (EVE D X Command) 1/4 Cycle Resolution (Sheet 2 of 2)

NOTE: The Event Summary and Settings are not shown here, because they are similar to Figure 9.3.

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 4.37* for details on these elements.

The ground event report includes:

- Analog quantities:
  - VN1–generator neutral fundamental voltage magnitude in volts primary.

- ➢ VP3–generator terminal third harmonic voltage magnitude in volts primary.
- ➢ VN3–generator neutral third harmonic voltage magnitude in volts primary.

- ➤ Digital states of stator ground elements plus the status of base model digital inputs and outputs.
- ➤ Event summary.
- ➤ Relay settings

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 ¼ cycle. Refer to the example EVE GND event report in *Figure 9.7* to view the data.

```
=>EVE GND <Enter>

SEL-700G                                Date: 03/04/2010   Time: 13:08:36.687
GENERATOR RELAY

Serial Number=000000000000000
FID=SEL-700G-X136-V0-Z001001-D20100302   CID=107A

                               O
                       6 TN I u
                       4 66 N t
  Voltages (Volts Pri) GG44 1 13
    VP3    VN3    VN1  12GG 2 2
[1]
   -2.0   -1.0   -1.0  .... . ..
    0.0    0.0   -1.0  .... . ..
   -1.0    0.0    0.0  .... . ..
   -3.0   -1.0    0.0* .... . ..
[2]
   -3.0   -1.0    0.0  .... . ..
   -1.0    0.0   -1.0  .... . ..
   -1.0    0.0    0.0  .... . ..
   -2.0   -1.0    0.0  .... . ..

[3]
   -2.0   -1.0   -1.0  .... . ..
   -1.0    0.0   -1.0  .... . ..
    0.0    0.0    0.0  .... . ..
   -2.0    0.0    0.0  .... . ..

[4]
   -1.0   -1.0   -1.0  .... . ..
   -1.0   -1.0   -1.0  .... . ..
   -2.0    0.0    0.0  .... . ..
   -1.0    0.0   -1.0  .... . ..

[5]
   -2.0   -1.0    0.0  .... . ..
    0.0   -1.0    0.0  .... . ..
   -2.0   -1.0   -1.0  .... . ..
   -3.0    0.0   -1.0> .... . ..
[6]
   -2.0    0.0    0.0  .... . ..
    0.0   -1.0    0.0  .... . ..
   -1.0    0.0   -1.0  .... . ..
   -2.0   -1.0    0.0  .... . ..

[7]
   -2.0    0.0   -1.0  .... . ..
   -1.0    0.0   -1.0  .... . ..
   -1.0   -1.0    0.0  .... . ..
   -2.0   -1.0    0.0  .... . ..
[8]
   -1.0    0.0    0.0  .... . ..
    1.0    0.0   -1.0  .... . ..
   -1.0    0.0   -1.0  .... . ..
   -2.0    0.0    0.0  .... . ..
```

Figure 9.7 Example 15-cycle Stator Ground Event Report (EVE GND) 1/4 Cycle Resolution (Sheet 1 of 2)

NOTE: The Event Summary and Settings are not shown here, because they are similar to those in Figure 9.3.

```
[9]
   -3.0    0.0   -1.0  .... . ..
   -1.0    0.0   -1.0  .... . ..
   -2.0   -1.0   -1.0  .... . ..
   -1.0   -1.0   -1.0  .... . ..
[10]
   -2.0    0.0   -1.0  .... . ..
    0.0    0.0    0.0  .... . ..
   -1.0    0.0    0.0  .... . ..
   -2.0    0.0   -1.0  .... . ..
[11]
   -2.0   -1.0    0.0  .... . ..
   -2.0   -1.0   -1.0  .... . ..
   -1.0    0.0   -1.0  .... . ..
   -3.0    0.0    0.0  .... . ..
[12]
   -2.0    0.0    0.0  .... . ..
   -1.0   -1.0    0.0  .... . ..
   -1.0   -1.0   -1.0  .... . ..
   -3.0    0.0   -1.0  .... . ..
[13]
   -3.0    0.0    0.0  .... . ..
   -3.0   -1.0    0.0  .... . ..
   -1.0    0.0   -1.0  .... . ..
   -1.0   -1.0    0.0  .... . ..

[14]
   -2.0   -1.0   -1.0  .... . ..
   -3.0    0.0   -1.0  .... . ..
   -1.0   -1.0    0.0  .... . ..
   -1.0   -1.0   -1.0  .... . ..
[15]
   -3.0    0.0   -1.0  .... . ..
   -1.0   -1.0    0.0  .... . ..
   -1.0   -1.0    0.0  .... . ..
   -3.0    0.0   -1.0  .... . ..

=>>
```

Figure 9.7 Example 15-cycle Stator Ground Event Report (EVE GND) 1/4 Cycle Resolution (Sheet 2 of 2)

Table 9.4 gives the ground event report digital column definitions for the protection and control elements and the base model inputs and outputs.

Table 9.4 Stator Ground Event report (EVE GND) Digital Column Definitions for Protection, Control, and I/O Elements

Column Designation	Column Symbols	Column Symbol RWBs
64G1	* t	64G1 picked up 64G1T picked up
64G2	* t	64G2 picked up 64G2T picked up
T64G	T	T64G picked up
N64G	N	N64G picked up
In12	1 2 b	IN101 picked up IN102 picked up Both IN101 and IN102 picked up
Out12	1 2 b	OUT101 picked up OUT102 picked up 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
- ➤ Relay settings

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 9.8* to view the differential event report columns. This example event report displays rows of information each ¼ cycle. Retrieve this report with the **EVE DIF1** command.

Table 9.5 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 9.6* gives the differential event report digital column definitions for the protection and control elements and the base model inputs and outputs.

Table 9.5 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 9.6 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
87R3	*	87R3 picked up
87U12	1 2 b	87U1 picked up 87U2 picked up Both 87U1 and 87U2 picked up
87U3	*	87U3 picked up

Table 9.6 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)
87B12	1 2 b	87BL1 picked up 87BL2 picked up Both 87BL1 and 87BL2 picked up
87B3	*	87BL3 picked up
87HR12	1 2 b	87HR1 picked up 87HR2 picked up Both 87HR1 and 87HR2 picked up
87HR3	*	87HR3 picked up
HB1	2 5 b	2_4HB1 picked up 5HB1 picked up Both 2_4HB1 and 5HB1 picked up
HB2	2 5 b	2_4HB2 picked up 5HB2 picked up Both 2_4HB2 and 5HB2 picked up
HB3	2 5 b	2_4HB3 picked up 5HB3 picked up Both 2_4HB3 and 5HB3 picked up
TH5	a t	TH5 picked up TH5T picked up
In12	1 2 b	IN101 picked up IN102 picked up Both IN101 and IN102 picked up
Out12	1 2 b	OUT101 picked up OUT102 picked up Both OUT101 and OUT102 picked up
Out3	*	OUT103 picked up

```
=>>EVE DIF2 <Enter>

SEL-700G                                Date: 02/24/2010   Time: 19:08:09.705
GENERATOR RELAY


Serial Number=000000000000000
FID=SEL-700G-X134-V0-Z001001-D20100224   CID=1C01

                                     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
   IOP2   IRT2   I2F2   I2F4   I2F5    2  2  2  2  123 5 2 2
[1]
  0.168  0.574  0.004  0.047  0.001  . .. .. .. .. ... . . ..
  0.168  0.574  0.002  0.047  0.001  . .. .. .. .. ... . . ..
  0.081  0.489  0.004  0.046  0.001  . .. .. .. .. ... . . ..
  0.081  0.488  0.002  0.046  0.002  . .. .. .. .. ... . . ..
[2]
  0.011  0.408  0.001  0.046  0.002  . .. .. .. .. ... . . ..
  0.012  0.408  0.002  0.046  0.001  . .. .. .. .. ... . . ..
  0.011  0.408  0.002  0.080  0.000  . .. .. .. .. ... . . ..
  0.009  0.408  0.001  0.047  0.002  . .. .. .. .. ... . . ..
[3]
  0.011  0.406  0.005  0.080  0.003  . .. .. .. .. ... . . ..
  0.012  0.406  0.001  0.047  0.002  . .. .. .. .. ... . . ..
  0.011  0.408  0.004  0.047  0.001  . .. .. .. .. ... . . ..
  0.009  0.408  0.002  0.047  0.002  . .. .. .. .. ... . . ..
```

Figure 9.8 Example Standard 15-Cycle Differential Event Report (EVE DIF2 Command) 1/4 Cycle Resolution (Sheet 1 of 2)

```
[4]
  0.226  0.615  0.001  0.047  0.044  . .. .. .. .. ... . . . ..
  0.241  0.644  0.126  0.057  0.044  . .. .. .. .. ... . . . ..
  0.604  1.000  0.252  0.077  0.047  . .. .. .. .. ... . . . ..
  0.654  1.057  0.188  0.017  0.047  . .. .. .. .. ... . . . ..
[5]
  0.803  1.203  0.090  0.051  0.002  . .. .. .. .. ... . . . ..
  0.834  1.237  0.009  0.019  0.002* . .. .. .. 2. ... . . . ..
  0.832  1.235  0.001  0.055  0.001  . .. .. .. 2. ... . . . ..
  0.833  1.235  0.011  0.043  0.000> * 2. .. .. 2. ... . . . ..
[6]
  0.834  1.235  0.001  0.047  0.003  * 2. .. .. 2. ... . . .*
  0.834  1.235  0.001  0.047  0.004  * 2. .. .. 2. ... . . .*
  0.831  1.236  0.002  0.057  0.002  * 2. .. .. 2. ... . . .*
  0.831  1.236  0.001  0.047  0.001  * 2. .. .. 2. ... . . .*

[7]
  0.833  1.235  0.002  0.057  0.003  * 2. .. .. 2. ... . . .*
  0.833  1.235  0.001  0.047  0.004  * 2. .. .. 2. ... . . .*
  0.831  1.235  0.003  0.048  0.002  * 2. .. .. 2. ... . . .*
  0.832  1.235  0.001  0.048  0.001  * 2. .. .. 2. ... . . .*
[8]
  0.834  1.235  0.002  0.048  0.001  * 2. .. .. 2. ... . . .*
  0.833  1.236  0.001  0.048  0.001  * 2. .. .. 2. ... . . .*
  0.830  1.235  0.001  0.048  0.000  * 2. .. .. 2. ... . . .*
  0.831  1.235  0.001  0.047  0.000  * 2. .. .. 2. ... . . .*
[9]
  0.833  1.235  0.001  0.046  0.003  * 2. .. .. 2. ... . . .*
  0.833  1.235  0.001  0.047  0.003  * 2. .. .. 2. ... . . .*
  0.830  1.236  0.002  0.047  0.001  * 2. .. .. 2. ... . . .*
  0.831  1.236  0.001  0.047  0.001  * 2. .. .. 2. ... . . .*
[10]
  0.833  1.236  0.001  0.046  0.001  * 2. .. .. 2. ... . . .*
  0.831  1.236  0.001  0.046  0.003  * 2. .. .. 2. ... . . .*
  0.830  1.236  0.002  0.047  0.003  * 2. .. .. 2. ... . . .*
  0.832  1.236  0.001  0.048  0.001  * 2. .. .. 2. ... . . .*
[11]
  0.834  1.236  0.002  0.048  0.002  * 2. .. .. 2. ... . . .*
  0.833  1.236  0.001  0.048  0.003  * 2. .. .. 2. ... . . .*
  0.831  1.236  0.002  0.048  0.002  * 2. .. .. 2. ... . . .*
  0.832  1.236  0.001  0.047  0.001  * 2. .. .. 2. ... . . .*
[12]
  0.833  1.235  0.001  0.047  0.002  * 2. .. .. 2. ... . . .*
  0.832  1.235  0.001  0.047  0.002  * 2. .. .. 2. ... . . .*
  0.831  1.236  0.002  0.047  0.001  * 2. .. .. 2. ... . . .*
  0.833  1.237  0.001  0.047  0.001  * 2. .. .. 2. ... . . .*
[13]
  0.833  1.236  0.002  0.047  0.002  * 2. .. .. 2. ... . . .*
  0.833  1.236  0.001  0.047  0.002  * 2. .. .. 2. ... . . .*
  0.831  1.236  0.003  0.046  0.001  * 2. .. .. 2. ... . . .*
  0.832  1.236  0.002  0.046  0.001  * 2. .. .. 2. ... . . .*


[14]
  0.754  1.317  0.001  0.033  0.003  * 2. .. .. 2. ... . . .*
  0.753  1.318  0.001  0.046  0.003  * 2. .. .. 2. ... . . .*
  0.750  1.317  0.001  0.065  0.001  * 2. .. .. 2. ... . . .*
  0.751  1.317  0.001  0.046  0.001  * 2. .. .. 2. ... . . .*
[15]
  0.833  1.235  0.001  0.066  0.003  * 2. .. .. 2. ... . . .*
  0.833  1.235  0.002  0.047  0.004  * 2. .. .. 2. ... . . .*
  0.832  1.235  0.000  0.034  0.002  * 2. .. .. 2. ... . . .*
  0.832  1.236  0.003  0.047  0.001  * 2. .. .. 2. ... . . .*
```

NOTE: The Event Summary and Settings are not shown here, because they are similar to those in Figure 9.3.

Figure 9.8 Example Standard 15-Cycle Differential Event Report (EVE DIF2 Command) 1/4 Cycle Resolution (Sheet 2 of 2)

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

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 20 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 4.232* for additional details.

Retrieving and Clearing SER Reports

See *SER Command (Sequential Events Recorder Report) on page 7.38* for details on the **SER** command.

Example SER Report

The example SER report in *Figure 9.9* includes records of events that occurred before the beginning of the event summary report in *Figure 9.3*.

```
=>>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 9.9 Example Sequential Events Recorder (SER) Event Report

Synchronism-Checking Report

SEL-700G relays equipped with synchronism checking (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 9.10*. 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 4.105*).

```
=>>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 9.10 Example SYN Command Response

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 9.3* to calculate the slip-compensated phase angle difference:

$$\text{Slip-Compensated Angle} = \text{Ang(VPX)} - \text{Ang(VS)} + (\text{SLIP} \bullet \text{TCLOSDX} \bullet 360) \quad \textbf{Equation 9.3}$$

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 CLOSEX initiation, 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 CLOSEX initiation, 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 CLOSEX initiation, 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 checking 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 4.95*. 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 4.94* for details on the settings.

The report captures frequency/speed matching and voltage matching during autosynchronism. Refer to *Autosynchronism on page 4.172* 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 the ACSELERATOR Analytic Assistant take advantage of the Compressed ASCII format. View the report by using ACSELERATOR QuickSet with the ACSELERATOR Analytic Assistant. See *Figure 4.119* for an example graphical display of a Generator Autosynchronism Report using ACSELERATOR Analytic Assistant.

Use the **GSH** command (Access Level 1 and 2) to view the Generator Synchronism Reports history. Refer to *Figure 7.22* 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.

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Section 10

Testing and Troubleshooting

Overview

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

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 10.16* 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 9: 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 9: 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*.

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 10.1* shows the Test Interface connectors. *Figure 10.2* shows the Cable C700G connection between an SEL- RTS test system and the SEL-700G.

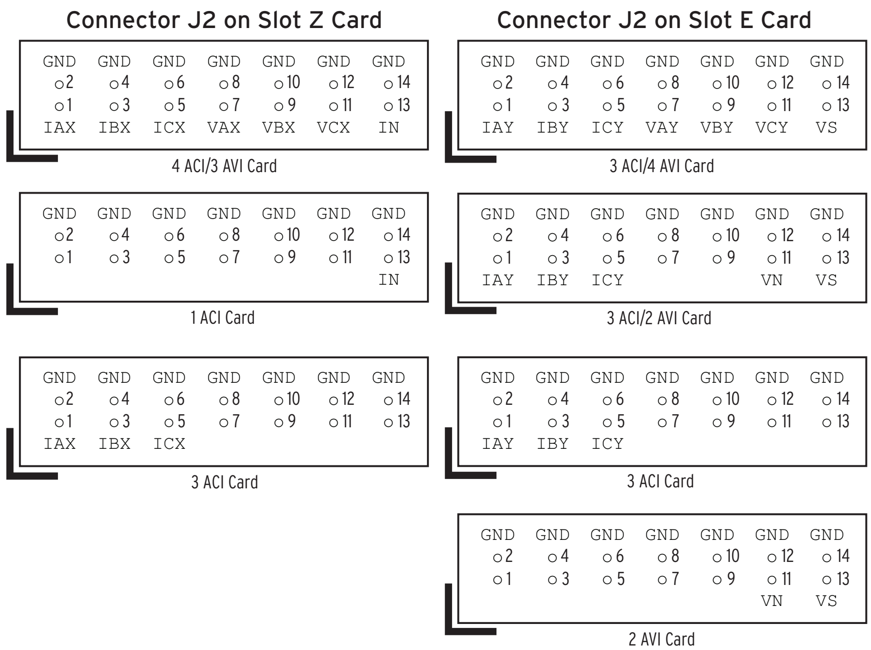


Figure 10.1 Low-Level Test Interface (J2)

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.

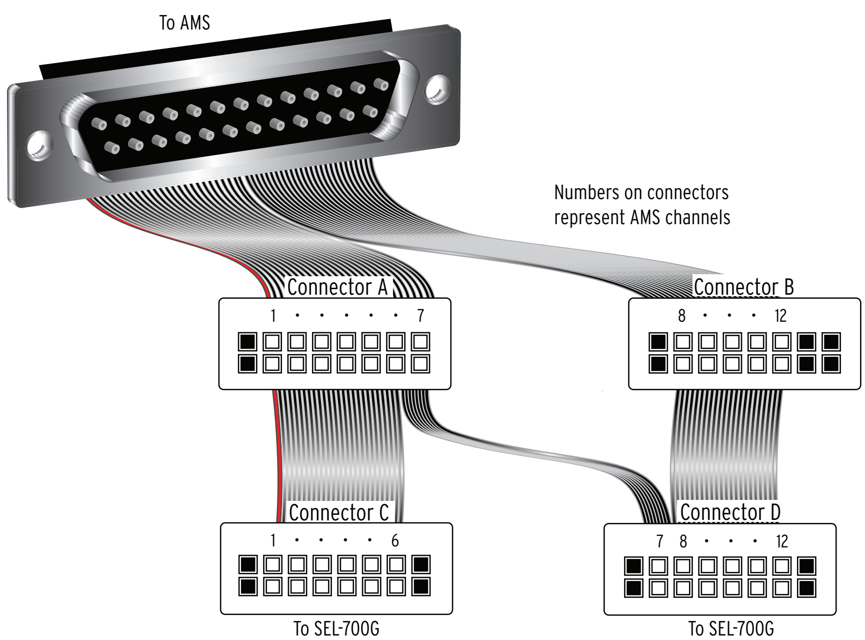


Figure 10.2 C700G Ribbon Cable Connector Diagram

Table 10.1 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 10.2* shows the signal scale factor information the AMS Relay Test System SEL-5401 Software uses for the calibrated inputs.

Table 10.1 Cable C700G Connection Options[a]

Slot	Connectors								
	Card Connector (J2) Signals[b]	Cable C700G 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 10.2 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 10.2 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
The relay contains devices sensitive to Electrostatic Discharge (ESD). When working on the relay with the front panel removed, work surfaces and personnel must be properly grounded or equipment damage may result.

NOTE: You can use the 14-pin connectors of the SEL-RTS ribbon cable C700G. The connectors are not keyed; refer to Table 10.1: Cable C700G Connection Options.

Access the low-level test interface connectors by using the following procedure.

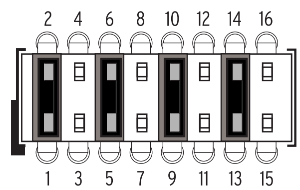
Step 1. Loosen the mounting screws and the ground screw on the back and remove the back cover.

Step 2. Remove the 4 ACI/3 AVI, 1 ACI, or 3 ACI board from Slot **Z**.

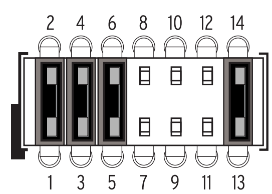
Step 3. Locate the 16-pin jumper assembly J3 on the board and move the four jumpers from CT to AMS positions.

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 10.1* and *Figure 10.2* (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 10.1* and *Figure 10.2* (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 10.1*, 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, control signal inputs, and control outputs are properly connected.

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

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.

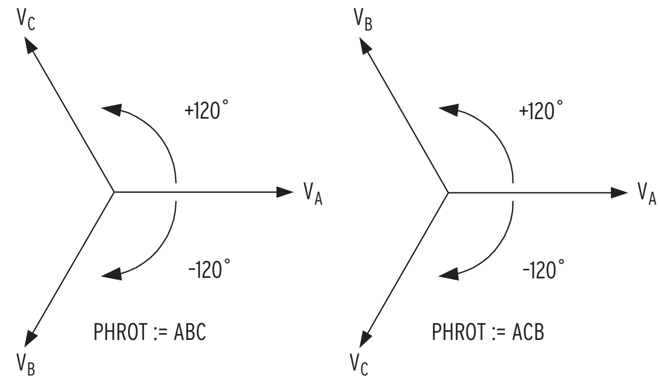
Step 10. Connect the ac test source current or voltage to the appropriate relay terminals.

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 10.3*.

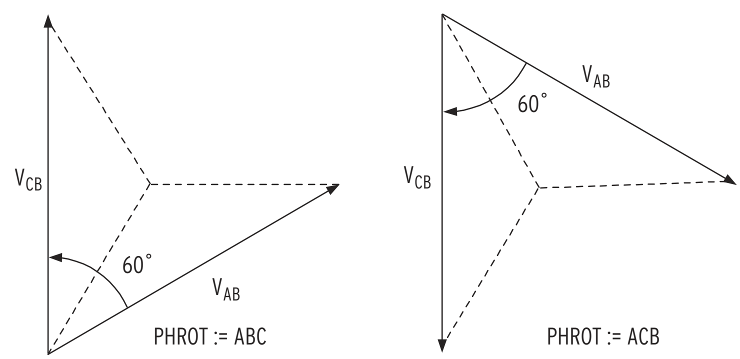
c. If you set the relay to accept delta voltages [(DELTAY_*m* := DELTA (*m* = X or Y)], set the current and/or voltage phase angles as shown in *Figure 10.4*.



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 10.3 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 10.4 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 10.3* 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 10.3 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.

Functional Tests

Phase Current Measuring Accuracy

Step 1. Connect the current source to the relay, as shown in *Figure 10.5*.

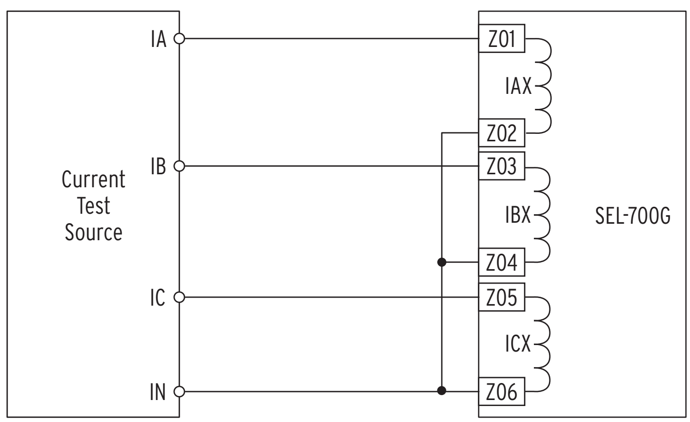


Figure 10.5 CTRX Current Source Connections

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 10.3*.

Step 4. Set each phase current magnitude equal to the values listed in Column 1 of *Table 10.4*. Use the front panel to view the phase current values. The relay should display the applied current magnitude times the CTRX setting.

Table 10.4 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 10.6* and *Table 10.5* to repeat *Step 1* through *Step 4*.

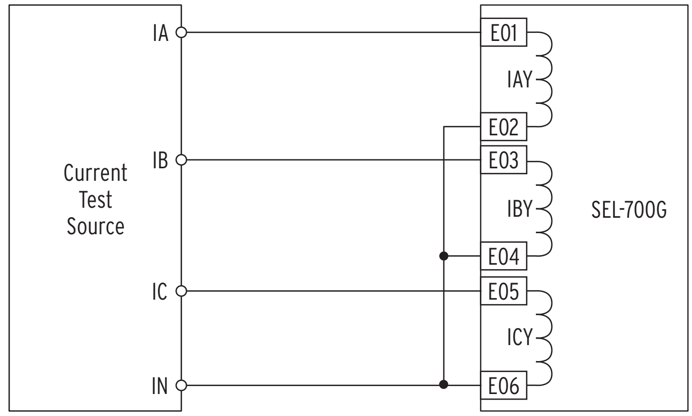


Figure 10.6 CTRY Current Source Connections

Table 10.5 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 • I_{YNOM}				
0.9 • I_{YNOM}				
2.0 • 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 10.5* or *Figure 10.6*.

Step 2. Connect the voltage source to the relay, as shown in *Figure 10.7*. Make sure that DELTAY_*m* := WYE (*m* = X or Y).

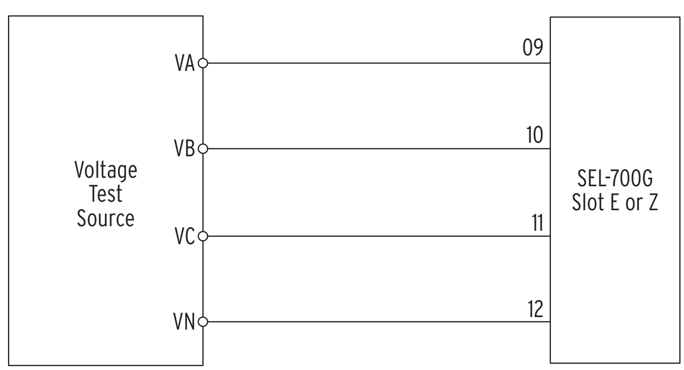


Figure 10.7 Wye Voltage Source Connections

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 10.6*.

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 10.6 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 10.5* or *Figure 10.6*.

Step 2. Connect the voltage source to the relay, as shown in *Figure 10.8*. Make sure that DELTAY_*m* := DELTA (*m* = X or Y).

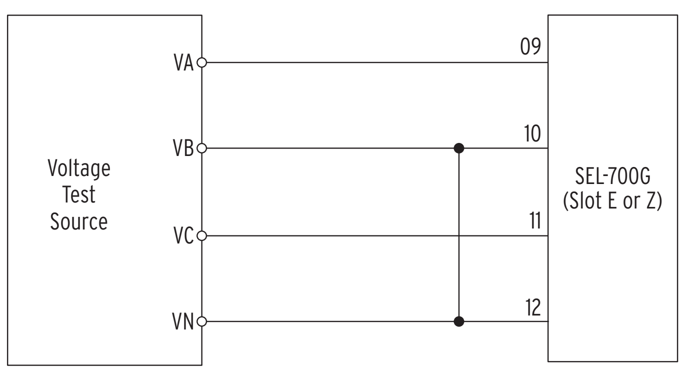


Figure 10.8 Delta Voltage Source Connections

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 10.7*.

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 10.7 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
VAB*m* = 120 ∠+30 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
VAB*m* = 120 ∠–30 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 10.8 Periodic Relay Checks

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.
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 10.9*):

- 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 settings changes, access level changes, three consecutive 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 10.9*, 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 LCD display 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).

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.

Table 10.9 Relay Self Tests (Sheet 1 of 4)

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	
Mainboard FPGA (power up)	Fail if mainboard Field Programmable Gate Array does not accept program or the version number is incorrect		Yes	Latched	Yes	Status Fail FPGA Failure	Automatic restart[a]
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[a]
GPSB (back-plane) communications	Fail if GPSB is busy on entry to processing interval		Yes	Latched	Yes	Status Fail GPSB Failure	STA C, to clear the warning in the status report. Contact SEL if failure returns.

Table 10.9 Relay Self Tests (Sheet 2 of 4)

Self Test	Description	Normal Range	Protection Disabled on Failure	Alarm Status	Auto Message on Failure	Front Panel Message on Failure	Corrective Action
Front-Panel HMI (power up)	Fail if ID registers do not match expected or if FPGA programming is unsuccessful		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[a]
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[a]
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[a]
Critical RAM (run time)	Verify instruction matches FLASH image		Yes	Latched	Yes	Status Fail CR_RAM Failure	Automatic restart[a]
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 CT Card Fail	
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.
ADCCHK (Slot Z)	A/D reference channel check	<2.375 V or >2.625 V	Yes	Latched	Yes	Status Fail Card Z Fail	Automatic restart[a]
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.

Table 10.9 Relay Self Tests (Sheet 3 of 4)

Self Test	Description	Normal Range	Protection Disabled on Failure	Alarm Status	Auto Message on Failure	Front Panel Message on Failure	Corrective Action
ADCCHK (Slot E)	A/D reference channel check	<2.375 V or >2.625 V	Yes	Latched	Yes	Status Fail Card E Fail	Automatic restart[a]
+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.
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 RTD (SEL-2600)	Fail if no comm, or the external RTD module reports open RTDs, shorted RTDs, a power supply failure		NA	NA	No	RTD Failure	
External Field Ground Module (SEL-2664)	Communications status Module status		NA	NA	No	OK/FAIL	

Table 10.9 Relay Self Tests (Sheet 4 of 4)

Self Test	Description	Normal Range	Protection Disabled on Failure	Alarm Status	Auto Message on Failure	Front Panel Message on Failure	Corrective Action
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[a]

[a] Contact SEL if failure returns.

Troubleshooting

Table 10.10 Troubleshooting

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** 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 baud 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.
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.

Factory Assistance

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

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Fax: +1.509.332.7990
Internet: www.selinc.com or www.selindustrial.com
Email: info@selinc.com

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Appendix A

Firmware and Manual Versions

Firmware

Determining the Firmware Version in Your Relay

To find the firmware version number in your SEL-700G Relay, use the **STA** command (see *STATUS Command (Relay Self-Test Status) on page 7.43* for more information on the **STA** command). The firmware revision number is after the R, and the release date is after the D. For example, the following is firmware revision number 100, release date April 16, 2010.

FID=SEL-700G-R100-V0-Z001001-D20100416

Table A.1 lists the firmware versions, a description of modifications, and the instruction manual date code that corresponds to firmware versions. The most recent firmware version is listed first.

Table A.1 Firmware Revision History (Sheet 1 of 5)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-700G-R108-V0-Z004002-D20150410	➤ Manual update only (see *Table A.5*).	20150521
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. ➤ 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.	20150410

Table A.1 Firmware Revision History (Sheet 2 of 5)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
	➤ Revised the firmware to hide the Relay Word bits associated with overcurrent elements based on the part number of the relay. ➤ Revised the REF element logic 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	➤ Manual update only (see *Table A.5*).	20150123
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.1 Firmware Revision History (Sheet 3 of 5)

Firmware Identification (FID) Number	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 time 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 SIUnit. ➤ 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	➤ Manual update only (see *Table A.5*).	20120903
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.1 Firmware Revision History (Sheet 4 of 5)

Firmware Identification (FID) Number	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.1 Firmware Revision History (Sheet 5 of 5)

Firmware Identification (FID) Number	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	➤ Manual update only (see *Table A.5*).	20101217
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

DeviceNet and Firmware Versions

The firmware on the DeviceNet interface has two versions as listed in *Table A.2*. The version number of this firmware is only accessible via Device Net interface. SEL-700G needs DeviceNet firmware version 1.005.

Table A.2 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
Major Rev: 1, Minor Rev: 1 (Rev 1.001)	Base version (card defines product code = 100, fixed descriptions for DeviceNet Card parameters, etc.)	20030612

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-xxxRxxx.EXE). The file can also be downloaded from the SEL website at www.selinc.com.

Table A.3 lists the compatibility among the EDS files and the various firmware versions of the relay.

Table A.3 EDS File compatibility

EDS File	Firmware Revisions Supported	Release Date
SEL-700GR100.EDS	R100, R101, R102, R103, R104, R105, R106, R107, R108 (with Device Net version 1.005)	20100416

ICD File

Determining the ICD File Version in Your Relay

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 61850 implementation of the relay.

Table A.4 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.4 SEL-700G ICD Revision History (Sheet 1 of 3)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect File Description	Architect Software Version	Manual Date Code
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. ➤ Added new LBGGIO25, and MBOKGGIO26 Logical Nodes and attributes to ANN LDevice. ➤ Added MATHERR as data source for IND15 attribute in MISCGGIO26 Logical Node.	R107 and higher	004 [a]	700G R107 and above	1.1.145.0 and higher	20140806
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.	R104 and higher	004[a]	700G R104 and above with additional LNs	1.1.128.0 and higher	20130405

Table A.4 SEL-700G ICD Revision History (Sheet 2 of 3)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect File Description	Architect Software Version	Manual Date Code
	➤ 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. ➤ 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.					

Table A.4 SEL-700G ICD Revision History (Sheet 3 of 3)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect File Description	Architect Software Version	Manual Date Code
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	1.1.102.0 and higher	20111007
ICD-700G-R100-V0-Z000000-D20100416	➤ Initial ICD File Release.	R100-R103	003[b]	700G Standard	1.1.90.0 and higher	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 be used with R104 or higher firmware with 61850 device library 004 also. 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.5* lists the instruction manual release dates and a description of modifications. The most recent instruction manual revisions are listed at the top.

Table A.5 Instruction Manual Revision History (Sheet 1 of 5)

Revision Date	Summary of Revisions
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*. Section 4 ➤ Updated *Generator Protection* section for the enhancement of the differential element logic. ➤ 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 Element Logic*, *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.

Table A.5 Instruction Manual Revision History (Sheet 2 of 5)

Revision Date	Summary of Revisions
	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 I ➤ Updated the setting description for the RBADPU setting prompt in *Table I.5: MIRRORED BITS Protocol Settings*. Appendix H ➤ Updated *Table H.2: Synchrophasor Order in Data Stream (Voltage and Currents)*. 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.
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/nonfail-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*.

Table A.5 Instruction Manual Revision History (Sheet 3 of 5)

Revision Date	Summary of Revisions
	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)*. 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.
20130405	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*.

Table A.5 Instruction Manual Revision History (Sheet 4 of 5)

Revision Date	Summary of Revisions
	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.
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 element logic for residual-ground overcurrent elements to also accept external 3V0 for polarization. ➤ Added zero-sequence voltage-polarized directional element logic for neutral-ground overcurrent elements (67N). ➤ Added Time and Date management and SNTP protocol settings and descriptions. ➤ Updated over- and undervoltage diagrams. ➤ Revised 64G element logic to operate with external 3V0. ➤ Revised REF element logic 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.

Table A.5 Instruction Manual Revision History (Sheet 5 of 5)

Revision Date	Summary of Revisions
	Appendix A ➤ Updated for firmware revision R104. Appendix E ➤ Added *08h Loopback Diagnostic Command* description. 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.

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Appendix B
Firmware Upgrade Instructions

Overview

These firmware upgrade instructions apply to all SEL-700 series industrial products except the SEL-701 Relay and SEL-734 Meter.

SEL occasionally offers firmware upgrades to improve the performance of your relay. Because the SEL-700G Relays store firmware in flash memory, changing physical components is not necessary. Upgrade the relay firmware by downloading a file from a personal computer to the relay via the front-panel serial port via ACSELERATOR QuickSet or terminal emulator as outlined in the following sections. For relays with IEC 61850 option, verify IEC 61850 protocol after the upgrade (see *Relays With IEC 61850 Option*).

Required Equipment

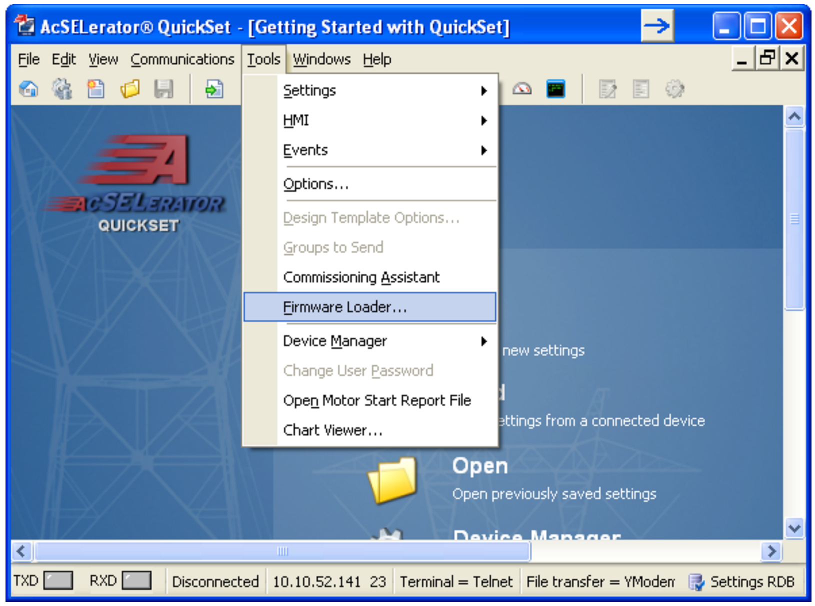
NOTE: Firmware releases are also available as zip files (.z19). Use the zip file for faster download.

Gather the following equipment before starting this firmware upgrade:

- Personal computer (PC)
- Terminal emulation software that supports Xmodem/CRC or 1k Xmodem/CRC protocol
- Serial communications cable (SEL Cable C234A or equivalent, or a null-modem cable)
- Disk containing the firmware upgrade file (for example, r1017xxx.s19 or r1017xxx.z19)
- ACSELERATOR QuickSet Software

Upgrade Firmware Using ACSELERATOR QuickSet

Select **Tools** > **Firmware Loader** from the ACSELERATOR 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 Software* for setup and connection procedures for ACSELERATOR QuickSet.



Firmware Loader will not start if:

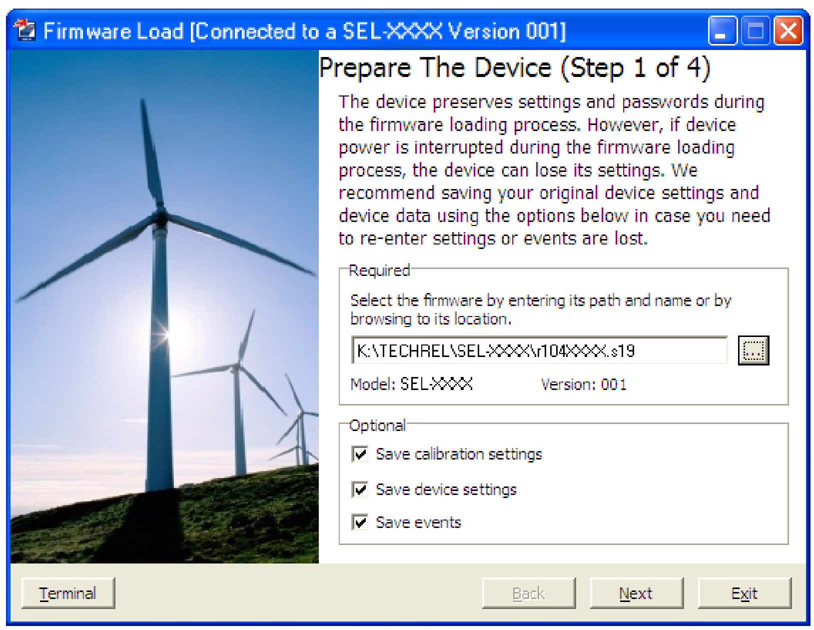
➤ The device is unsupported by ACSELERATOR QuickSet.

➤ The device is not connected to the computer with a communications cable.

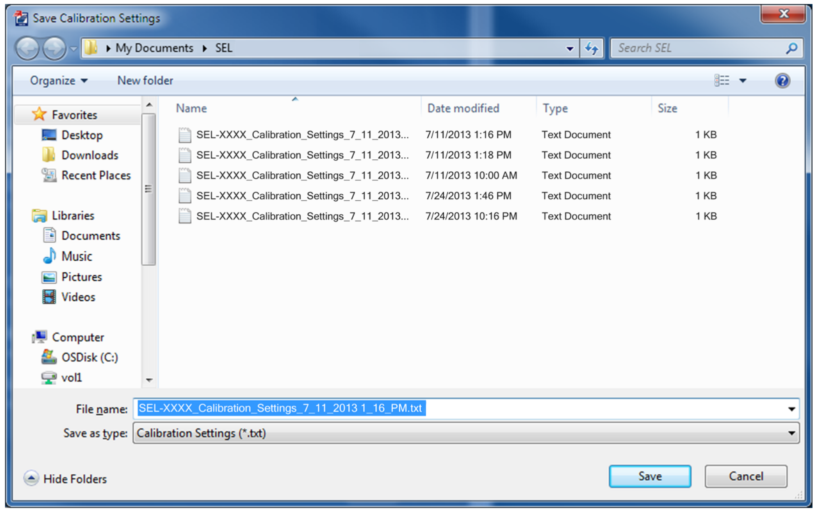
➤ The device is disabled.

Step 1. Prepare the device.

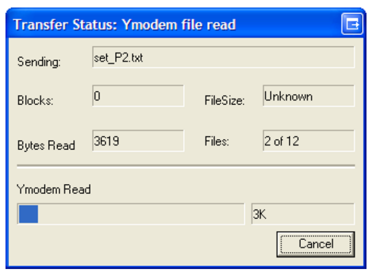
a. Select the firmware to be loaded using the browse control and select **Save calibration settings**, **Save device settings**, and **Save events**. Select **Next** to continue the wizard.

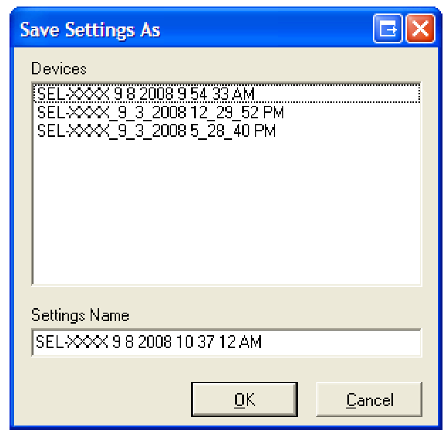


b. Select a file name to save the selected settings or accept the defaults as shown. Click **Save**.



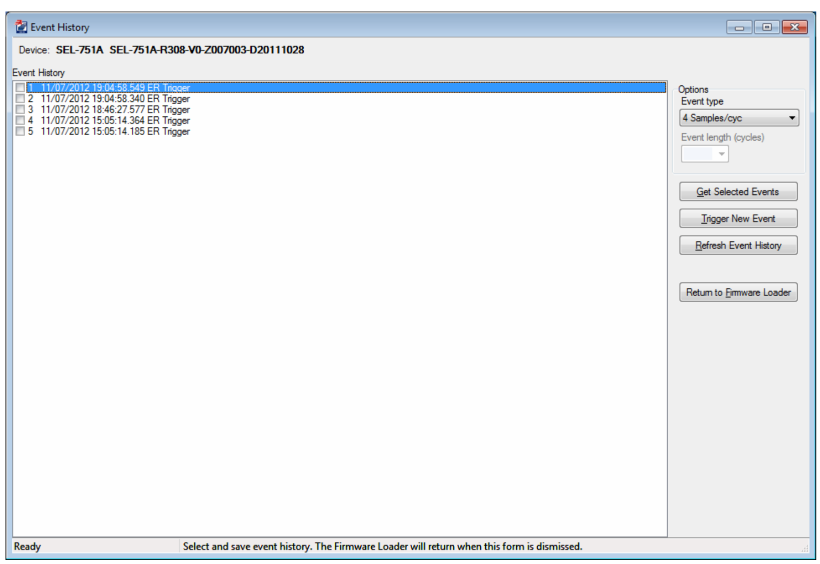
c. The **Transfer Status**: **Ymodem file read** window shows the transfer progress of the settings file. Clicking **Cancel** will stop the transfer.
After the device settings are downloaded, select a file name and path to save the settings or accept the default, as shown.





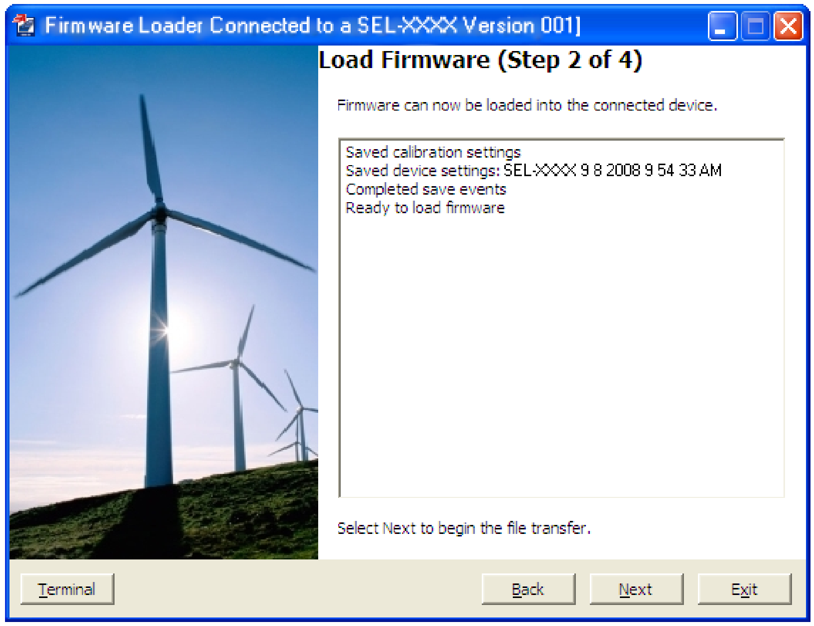
d. Click **Return to Firmware Loader** if this product does not have any event reports.

If there are any event reports to be saved, click the **Get Selected Event** button after selecting the events. After saving them, click the **Return to Firmware Loader** button.



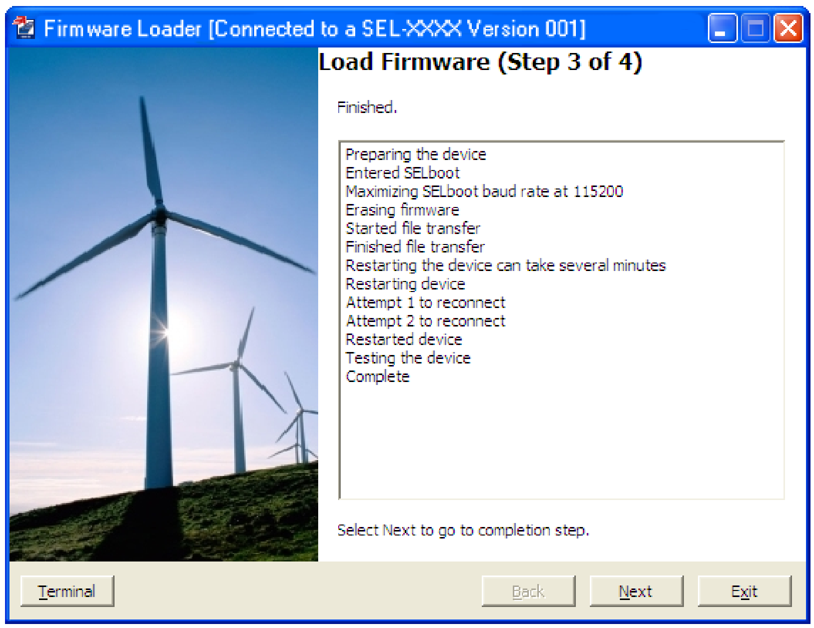
Step 2. Transfer Firmware.

Click **Next** to begin the firmware transfer.



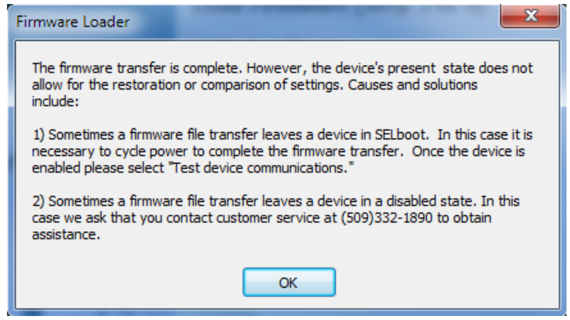
Step 3. Load Firmware.

During this step, the device is put in SELBOOT. The transfer speed is maximized and the firmware transfer begins.



NOTE: The following screen can appear if you have one of the two conditions mentioned.

If the relay is disabled as mentioned in condition number 2, check for the **ENABLED** LED on the front panel of the relay. If the **ENABLED** LED is not illuminated or the front panel displays `STATUS FAIL` or `Non_Vol Failure`, use the following procedure to restore the factory default settings:



a. Click on the Terminal button on the Firmware Load screen of ACSELERATOR QuickSet.

b. Set the communications software settings to 9600 baud, 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.

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 will save the relay calibration settings. The relay will respond:

```
Config Accepted
```

The relay will reboot and come up **ENABLED**.

Step 4. Verify Device.

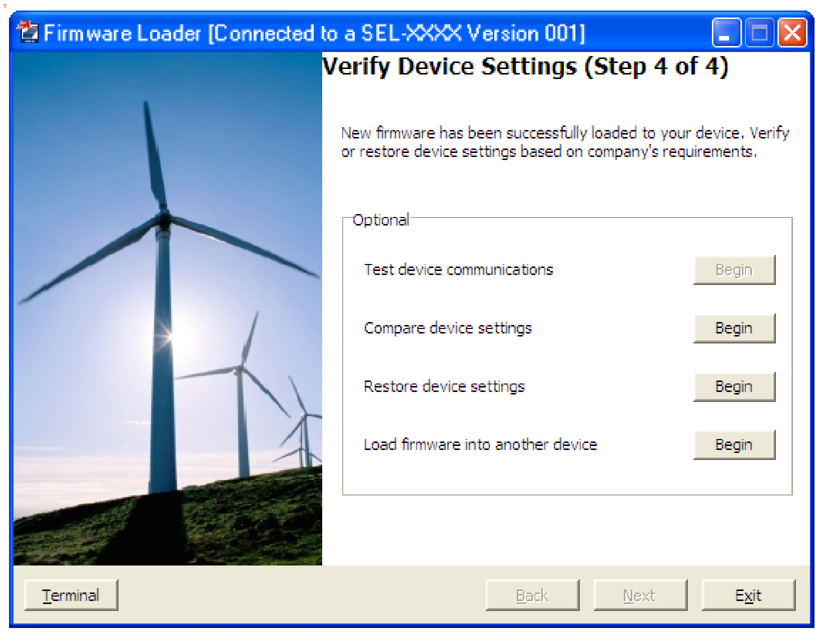
Four verification options are provided and when enabled these options perform as follows.

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 re-initializes 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 saved in the database to the device. Settings are converted automatically, if necessary.

Load Firmware into Another Device. Returns the wizard to *Step 1: Prepare Device* to repeat the firmware-loading process with another device.



Upgrade Firmware Using a Terminal Emulator

The following instructions assume you have a working knowledge of your personal computer terminal emulation software. In particular, you must be able to modify your serial communications parameters (baud rate, data bits, parity, etc.), select transfer protocol (Xmodem/CRC or 1k Xmodem/CRC), and transfer files (for example, send and receive binary files).

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 (described in the instruction manual PC software section) to save and restore settings easily. Otherwise, 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.

NOTE: To save the calibration settings, perform **SHO C** from the terminal by logging into CAL level using the CAL level password. The factory-default password for CAL level is CLARKE.

b. Record all the settings for possible re-entry after the firmware upgrade.

c. We recommend that you save all stored data in the relay, including EVENTS, before the upgrade.

Step 4. Start upgrading of firmware.

a. Issue the **L_D** command to the relay.

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 will send the `!>` prompt.

Step 5. Change the baud rate, if necessary.

NOTE: If you have difficulty at 115200 bps, choose a slower data transfer rate (for example, 38400 bps or 57600 bps). Be sure to match the relay and PC data rates.

a. Type **BAU 115200 <Enter>**.

This will change the baud rate of the communications port to 115200.

b. Change the baud rate of the PC to 115200 to match the relay.

Step 6. Begin the transfer of new firmware to the relay by issuing the **REC** command.

Step 7. Type **Y** to erase the existing firmware or press **<Enter>** to abort.

Step 8. Press any key (for example, **<Enter>**) when the relay sends a prompt.

Step 9. Start the file transfer.

Select the send file option in your communications software.

Use the Xmodem protocol and send the file that contains the new firmware (for example, r101xxx.s19 or r101xxx.z19).

The file transfer takes less than 5–15 minutes at 115200 baud, depending on the product. After the transfer is complete, the relay will reboot and return to Access Level 0.

Figure B.1 shows the entire process.

```
=>>L_D <Enter>

Disable relay to receive firmware (Y,N)? Y <Enter>
Are you sure (Y,N)? Y <Enter>
Relay Disabled

BFID=BOOTLDR-R500-V0-Z000000-D20090925
!>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.1 Firmware File Transfer Process

Step 10. The relay illuminates the **ENABLED** front-panel LED if the relay settings were 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` or `Non_Vol Failure`, use the following procedure to restore the factory default settings:

a. Set the communications software settings to 9600 baud, 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 will then reboot 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 will save the relay calibration settings.

The relay will respond:

`Config Accepted`

The relay will reboot and come up **ENABLED**.

f. Restore relay settings back to the settings saved in *Step 3*.

Step 11. Change the baud rate of the PC to match that of the relay prior to *Step 5*, 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.

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. You should 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 will disable 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 ACSELERATOR Architect software upgrade that supports your required CID file version.

b. Run ACSELERATOR 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, ACSELERATOR Architect will detect the upgraded relay firmware and prompt 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.

Factory Assistance

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

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA 99163-5603 U.S.A.
Telephone: +1.509.332.1890
Fax: +1.509.332.7990
Email: info@selinc.com
Internet: www.selinc.com

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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 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, and Fast SER

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. 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

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. These devices provide a single point of contact for integration networks with a star topology, as shown in *Figure C.1*.

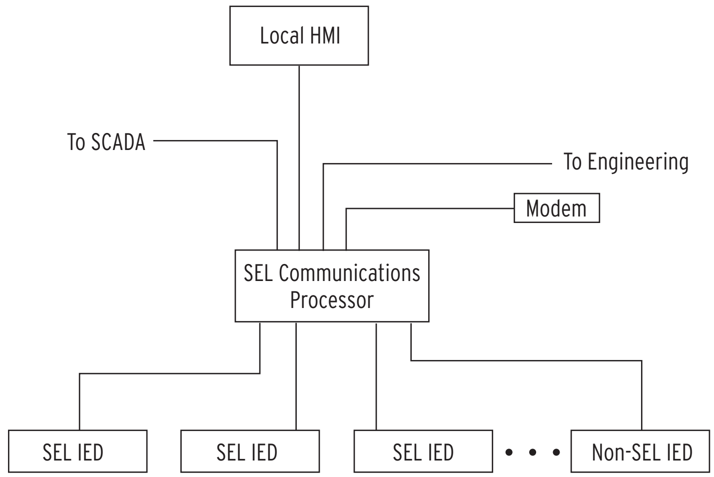

Figure C.1 SEL Communications Processor Star Integration Network

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.

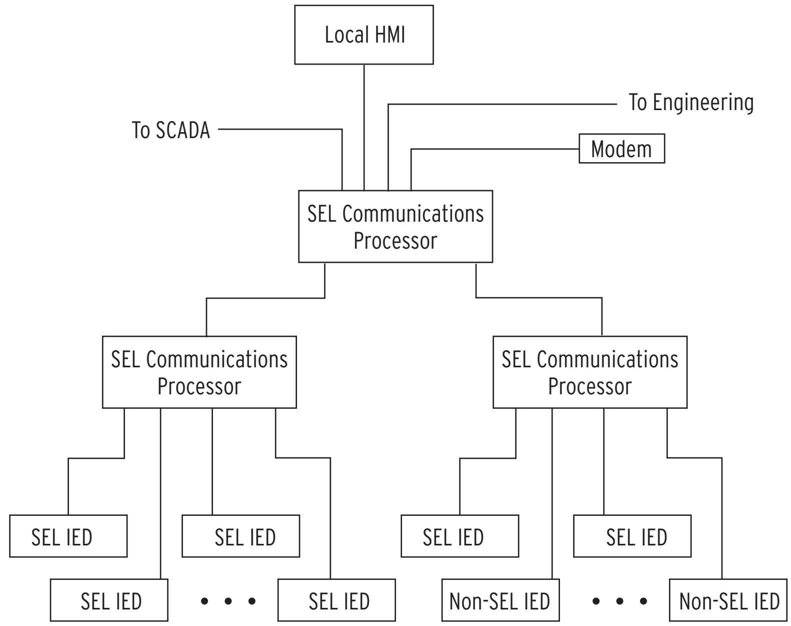

Figure C.2 Multitiered SEL Communications Processor Architecture

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

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
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 (Human Machine Interface).

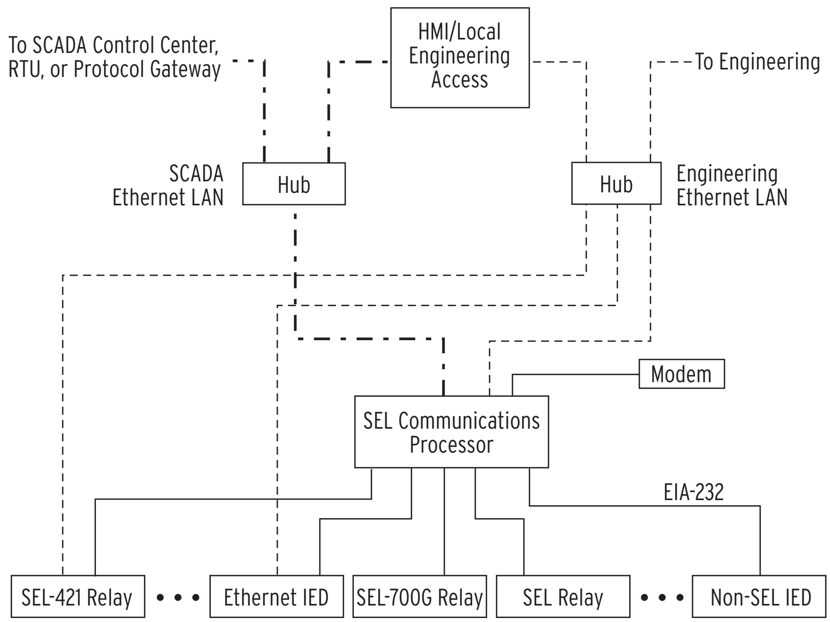

Figure C.3 Enhancing Multidrop Networks With SEL Communications Processors

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*.

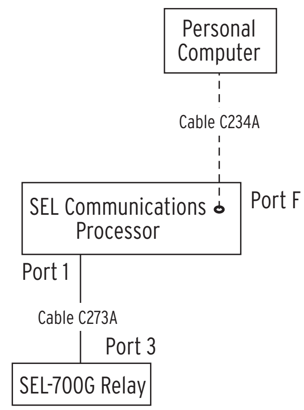

Figure C.4 Example of SEL Relay and SEL Communications Processor Configuration

Table C.4 shows the Port 1 settings for the SEL communications processor.

Table C.4 SEL Communications Processor Port 1 Settings

Setting Name	Setting	Description
DEVICE	S	Connected device is an SEL device
CONFIG	Y	Allow autoconfiguration for this device
PORTID	*Relay 1*	Name of connected relay[a]
BAUD	19200	Channel speed of 19200 bits per second[a]
DATABIT	8	Eight data bits[a]
STOPBIT	1	One stop bit
PARITY	N	No parity
RTS_CTS	N	Hardware flow control enabled
XON_XOFF	Y	Enable XON/XOFF flow control
TIMEOUT	30	Idle timeout that terminates transparent connections of 30 seconds

[a] Automatically collected by the SEL communications processor during autoconfiguration.

Data Collection

The SEL communications processor is configured to collect data from the SEL-700G, using the list in *Table C.5*.

Table C.5 SEL Communications Processor Data Collection Automessages

Message	Data Collected
20METER	Power system metering data
20DEMAND	Demand metering data
20TARGET	Selected Relay Word bit elements
20HISTORY	History Command (ASCII)
20STATUS	Status Command (ASCII)
20EVENTS	Standard 4 sample/cycle event report (data with settings)
20EVENT	Standard 4 sample/cycle event report (data only)

Table C.6 shows the automessage (**SET A**) settings for the SEL communications processor.

Table C.6 SEL Communications Processor Port 1 Automatic Messaging Settings

Setting Name	Setting	Description
AUTOBUF	Y	Save unsolicited messages
STARTUP	ACC\nOTTER\n	Automatically log-in at Access Level 1
SEND_OPER	Y	Send Fast Operate messages for remote bit and breaker bit control
REC_SER	N	Automatic sequential event recorder data collection disabled
NOCONN	NA	No SELOGIC® control equation entered to selectively block connections to this port
MSG_CNT	3	Three automessages
ISSUE1	P00:00:01.0	Issue Message 1 every second
MESG1	20METER	Collect metering data
ISSUE2	P00:00:01.0	Issue Message 2 every second
MESG2	20TARGET	Collect Relay Word bit data
ISSUE3	P00:01:00.0	Issue Message 3 every minute
MESG3	20DEMAND	Collect demand metering data
ARCH_EN	N	Archive memory disabled
USER	0	No USER region registers reserved

Table C.7 shows the map of regions in the SEL communications processor for data collected from the SEL-700G. Use the **MAP *n*** command to view these data.

Table C.7 SEL Communications Processor Port 1 Region Map

Region	Data Collection Message Type	Region Name	Description
D1	Binary	METER	Relay metering data
D2	Binary	TARGET	Relay Word bit data
D3	Binary	DEMAND	Demand meter data
D4–D8	n/a	n/a	Unused
A1–A3	n/a	n/a	Unused
USER	n/a	n/a	Unused

Relay Metering Data

Table C.9 through *Table C.15* show the meter data for different models of the SEL-700G that are available in the SEL communications processor and the location and data type for the memory areas within D1 (Data Region 1). The type field indicates the data type and size. The "int" type is a 16-bit integer. The "float type" is a 32-bit IEEE floating point number. Use the **VIE *n*:D1** command to view these data.

Table C.8 Communications Processor METER Region Map for GW Model

Item	Starting Address	Type
_YEAR	2000h	int
DAY_OF_YEAR	2001h	int
TIME (ms)	2002h	int[2]
MONTH	2004h	char
DATE	2005h	char
YEAR	2006h	char
HOUR	2007h	char
MIN	2008h	char
SECONDS	2009h	char
MSEC	200Ah	int
IAX	200Bh	float
IBX	200Dh	float
ICX	200Fh	float
IAY	2011h	float
IBY	2013h	float
ICY	2015h	float
FREQX	2017h	float
FREQY	2019h	float

Table C.9 Communications Processor METER Region Map for GO Model Without Synchronism (Sheet 1 of 2)

Item	Starting Address	Type
_YEAR	2000h	int
DAY_OF_YEAR	2001h	int
TIME (ms)	2002h	int[2]
MONTH	2004h	char
DATE	2005h	char
YEAR	2006h	char
HOUR	2007h	char
MIN	2008h	char
SECONDS	2009h	char
MSEC	200Ah	int
IAX	200Bh	float
IBX	200Dh	float
ICX	200Fh	float
VAX (wye) or VABX (delta)	2011h	float

Table C.9 Communications Processor METER Region Map for GO Model Without Synchronism (Sheet 2 of 2)

Item	Starting Address	Type
VBX (wye) or VBCX (delta)	2013h	float
VCX (wye) or VCAX (delta)	2015h	float
P3X	2017h	float
Q3X	2019h	float
S3X	201Bh	float
FREQX	201Dh	float

Table C.10 Communications Processor METER Region Map for GO Model With Synchronism

Item	Starting Address	Type
_YEAR	2000h	int
DAY_OF_YEAR	2001h	int
TIME (ms)	2002h	int[2]
MONTH	2004h	char
DATE	2005h	char
YEAR	2006h	char
HOUR	2007h	char
MIN	2008h	char
SECONDS	2009h	char
MSEC	200Ah	int
IAX	200Bh	float
IBX	200Dh	float
ICX	200Fh	float
VAX (wye) or VABX (delta)	2011h	float
VBX (wye) or VBCX (delta)	2013h	float
VCX (wye) or VCAX (delta)	2015h	float
VS	2017h	float
P3X	2019h	float
Q3X	201Bh	float
S3X	201Dh	float
FREQX	201Fh	float
VSXANG	2021h	float
FREQS	2023h	float

Table C.11 Communications Processor METER Region Map for G1 Model Without Synchronism

Item	Starting Address	Type
_YEAR	2000h	int
DAY_OF_YEAR	2001h	int
TIME (ms)	2002h	int[2]
MONTH	2004h	char
DATE	2005h	char
YEAR	2006h	char
HOUR	2007h	char
MIN	2008h	char
SECONDS	2009h	char
MSEC	200Ah	int
IAX	200Bh	float
IBX	200Dh	float
ICX	200Fh	float
IAY	2011h	float
IBY	2013h	float
ICY	2015h	float
VAX (wye) or VABX (delta)	2017h	float
VBX (wye) or VBCX (delta)	2019h	float
VCX (wye) or VCAX (delta)	201Bh	float
P3X	201Dh	float
Q3X	201Fh	float
S3X	2021h	float
FREQX	2023h	float

Table C.12 Communications Processor METER Region Map for G1 Model With Synchronism (Sheet 1 of 2)

Item	Starting Address	Type
_YEAR	2000h	int
DAY_OF_YEAR	2001h	int
TIME (ms)	2002h	int[2]
MONTH	2004h	char
DATE	2005h	char
YEAR	2006h	char
HOUR	2007h	char
MIN	2008h	char
SECONDS	2009h	char
MSEC	200Ah	int
IAX	200Bh	float
IBX	200Dh	float
ICX	200Fh	float
IAY	2011h	float

Table C.12 Communications Processor METER Region Map for G1 Model With Synchronism (Sheet 2 of 2)

Item	Starting Address	Type
IBY	2013h	float
ICY	2015h	float
VAX (wye) or VABX (delta)	2017h	float
VBX (wye) or VBCX (delta)	2019h	float
VCX (wye) or VCAX (delta)	201Bh	float
VS	201Dh	float
P3X	201Fh	float
Q3X	2021h	float
S3X	2023h	float
FREQX	2025h	float
VSXANG	2027h	float
FREQS	2029h	float

Table C.13 Communications Processor METER Region Map for GT Model With Single Synchronism

Item	Starting Address	Type
_YEAR	2000h	int
DAY_OF_YEAR	2001h	int
TIME (ms)	2002h	int[2]
MONTH	2004h	char
DATE	2005h	char
YEAR	2006h	char
HOUR	2007h	char
MIN	2008h	char
SECONDS	2009h	char
MSEC	200Ah	int
IAY	200Bh	float
IBY	200Dh	float
ICY	200Fh	float
VAY (wye) or VABY (delta)	2011h	float
VBY (wye) or VBCY (delta)	2013h	float
VCY (wye) or VCAY (delta)	2015h	float
VS	2017h	float
P3Y	2019h	float
Q3Y	201Bh	float
S3Y	201Dh	float
FREQY	201Fh	float

Table C.14 Communications Processor METER Region Map for GT Model With Dual Single Synchronism

Item	Starting Address	Type
_YEAR	2000h	int
DAY_OF_YEAR	2001h	int
TIME (ms)	2002h	int[2]
MONTH	2004h	char
DATE	2005h	char
YEAR	2006h	char
HOUR	2007h	char
MIN	2008h	char
SECONDS	2009h	char
MSEC	200Ah	int
IAX	200Bh	float
IBX	200Dh	float
ICX	200Fh	float
IAY	2011h	float
IBY	2013h	float
ICY	2015h	float
VAX (wye) or VABX (delta)	2017h	float
VBX (wye) or VBCX (delta)	2019h	float
VCX (wye) or VCAX (delta)	201Bh	float
VAY (wye) or VABY (delta)	201Dh	float
VBY (wye) or VBCY (delta)	201Fh	float
VCY (wye) or VCAY (delta)	2021h	float
VS	2023h	float
P3X	2025h	float
Q3X	2027h	float
S3X	2029h	float
P3Y	202Bh	float
Q3Y	202Dh	float
S3Y	202Fh	float
FREQX	2031h	float
FREQY	2033h	float
VSXANG	2035h	float
FREQS	2037h	float

Relay Word Bits Information

Table C.15 lists the Relay Word bit data available in the SEL communications processor TARGET region.

Table C.15 Communications Processor TARGET Region

Address	Relay Word Bits (in Bits 7–0)							
	7	6	5	4	3	2	1	0
2804h	*	*	*	*	*	PWRUP	STSET	*
2805h	See *Table J.1*, Row 0							
2806h	See *Table J.1*, Row 1							
2807h	See *Table J.1*, Row 2							
2808h	See *Table J.1*, Row 3							
2809h	See *Table J.1*, Row 4							
280Ah	See *Table J.1*, Row 5							
280Bh	See *Table J.1*, Row 6							
280Ch	See *Table J.1*, Row 7							
280Dh	See *Table J.1*, Row 8							
280Eh	See *Table J.1*, Row 9							
280Fh	See *Table J.1*, Row 10							
2810h	See *Table J.1*, Row 11							
2811h	See *Table J.1*, Row 12							
• • •	• • •							
2899h	See *Table J.1*, Row 148							

Control Points

The SEL communications processor 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. You must also enable Fast Operate messages in the SEL communications processor by setting the automessage setting SEND_OPER equal to Y.

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. In this example, if you set RB01 on **Port 1** in the SEL communications processor, it automatically sets RB01 in the SEL-700G.

Breaker bits BR1 and BR2 operate differently from remote bits. There are two breaker bits in the SEL-700G. For Circuit Breaker *n*, when you set BR*n*, the SEL communications processor sends a message to the SEL-700G that asserts the OC*n* bit for one processing interval. If you clear BR*n*, the SEL communications processor sends a message to the SEL-700G that asserts the CC*n* bit for one processing interval. OC*n* opens the breaker (via SELOGIC control equation TR x) and CC*n* closes the breaker (via SELOGIC control equation CL x). See *Figure 4.126* and *Figure 4.130* for the breaker trip and breaker close logic diagrams, respectively.

Demand Data

Table C.16 lists the demand data available in the SEL communications processor and the location and data type for the memory areas within D3 (Data Region 3). The type field indicates the data type and size. The type "int" is a 16-bit integer. The type "float" is a 32-bit IEEE floating point number.

Table C.16 Communications Processor DEMAND Region Map

Item	Starting Address	Type
_YEAR	3000h	int
DAY_OF_YEAR	3001h	int
TIME (ms)	3002h	int[2]
MONTH	3004h	char
DATE	3005h	char
YEAR	3006h	char
HOUR	3007h	char
MIN	3008h	char
SECONDS	3009h	char
MSEC	300Ah	int
IAXD(A)[a]	300Bh	float
IBXD(A)[a]	300Dh	float
ICXD(A)[a]	300Fh	float
IGXD(A)[a]	3011h	float
3I2XD(A)[a]	3013h	float
IAYD(A)	3015h	float
IBYD(A)	3017h	float
ICYD(A)	3019h	float
IGYD(A)	301Bh	float
3I2YD(A)	301Dh	float

[a] If the model doesn't have X-side current inputs, then the starting address of Y-side demand data items are shifted up to where X-side quantities are.

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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, www.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 dead band. 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 Interconnect) 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. You should 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 because of 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 Internet Protocol (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
- User Datagram Protocol (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.

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 below, the suffix n represents the DNP3 session number from 1 to 3. All settings with the same numerical suffix comprise the complete DNP3 session configuration.

Table D.5 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 necessary 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 necessary 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 necessary event class; set UNSOL*n* and PUNSOL*n* to Yes.

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, you should 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 the information 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.12*). 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.

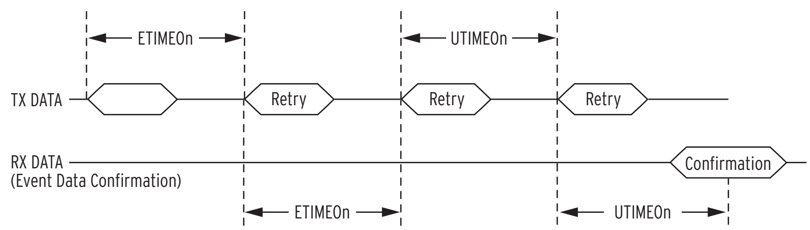

Figure D.1 Application Confirmation Timing With URETRYn = 2

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*).

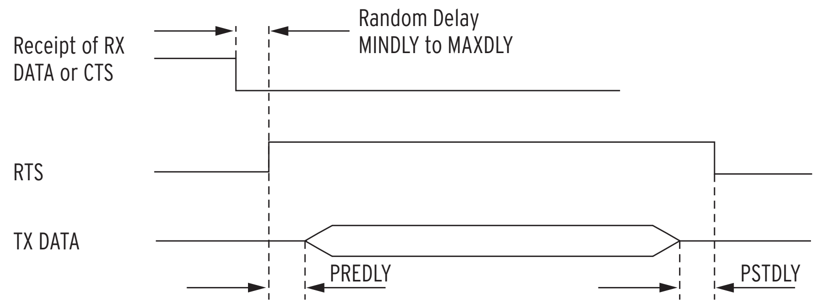

Figure D.2 Message Transmission Timing

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 once 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 dead band and scaling operation on analog points shown in *Table D.7*. You can either:

- ➤ set and use default dead band and scaling according to data type, or
- ➤ use a custom data map to select dead bands on a point-by-point basis.

See *DNP3 Documentation on page D.12* for a discussion of how to set scaling and dead-band operation on a point-by-point basis. Dead bands for analog inputs can be modified at run-time by writing to object 34.

The settings ANADBA*n*, ANADBV*n*, and ANADBM*n* control default dead-band 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 dead bands 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.

Phase angles have a default scale factor of 10 and the ANADBM dead-band setting applies to them. For the angles to generate events, the corresponding magnitude also has to exceed its dead-band setting (ANADBA).

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 *Configurable Data Mapping 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.) It can be set to request time synchronization periodically by setting the TIMERQ*n* setting to the necessary period. It can also be set to not request, but accept time synchronization (TIMERQ*n* = M for "master").

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.

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. You should 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, the RETRY1 setting is used 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 DNP3 port configuration settings available on the SEL-700G are shown in *Table D.7*. You can enable DNP3 on Ethernet Port 1 or on any of the serial Ports 2 through 4, to a maximum of three concurrent DNP3 sessions. Each session defines the characteristics of the connected DNP3 Master, to which you assign one of the three available custom maps.

Because some settings apply only to serial DNP3, they are visible only when configuring a serial port. Likewise, settings that apply only to DNP3 LAN/WAN 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. The IP address for each session must be unique. Setting the IP address to 0.0.0.0 allows any master IP address to connect to the session, as long as that IP address is not configured for another DNP3 session. Only one connection is supported on the session at a time.

Extreme care should be observed to ensure network security, especially when setting the IP address to 0.0.0.0, as there is no limitation on the DNP3 master that may connect to the session.

Table D.7 Port DNP3 Protocol Settings (Sheet 1 of 2)

Name	Description	Range	Default
EDNP[a]	Enable DNP3 Sessions	0–3	0
DNPNUM[a]	DNP3 TCP and UDP Port	1–65534	20000
DNPADR	Device DNP3 address	0–65534	0
Session 1 Settings			
DNPIP1[a]	IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR1[a b]	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 dead band for current; hidden if ECLASSA1 set to 0	0–32767	100
ANADBV1	Analog reporting dead band for voltages; hidden if ECLASSA1 set to 0	0–32767	100
ANADBM1	Analog reporting dead band 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]	Send Data Link Heartbeat, seconds; hidden if DNPTR1 set to UDP	0.0–7200	120
DRETRY1[c]	Data link retries	0–15	3
DTIMEO1[c]	Data link time-out, seconds; hidden if DRETRY3 1 set to 0	0.0–5.0	1
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 power up; hidden and set to N if UNSOL1 set to N	Y, N	N
NUMEVE1[d]	Number of events to transmit on	1–200	10
AGEEVE1[d]	Oldest event to transmit on, seconds	0.0–99999.0	2.0
URETRY1[d]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO1[d]	Unsolicited messages offline timeout, seconds	1–5000	60
Session 2 Settings			
DNPIP2[a]	IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR2[a]	Transport protocol	UDP, TCP	TCP
. . .			
URETRY2[a, d]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO2[a, d]	Unsolicited messages offline timeout, seconds	1–5000	60

Table D.7 Port DNP3 Protocol Settings (Sheet 2 of 2)

Name	Description	Range	Default
Session 3 Settings			
DNPIP3[a]	IP address (zzz.yyy.xxx.www)	15 characters	""
DNPTR3[a]	Transport protocol	UDP, TCP	TCP
. . .			
URETRY3[a,d]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO3[a,d]	Unsolicited messages offline timeout, seconds	1–5000	60
Serial Port Settings			
MINDLY[c]	Minimum delay from DCD to TX, seconds	0.00–1.00	0.05
MAXDLY[c]	Maximum delay from DCD to TX, seconds	0.00–1.00	0.10
PREDLY[c]	Settle time from RTS on to TX; Off disables PSTDLY	OFF, 0.00–30.00	0.00
PSTDLY[c]	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. The DNP IP address of each session (DNPIP1, DNPIP2, etc.) must be unique. Set DNPIPn := 0.0.0.0 to accept connections from any DNP master.
[b] If DNPIPn is 0.0.0.0, DNPIPn must be set to TCP.
[c] Available only on serial ports.
[d] 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 above 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 6)

Obj.	Var.	Description	Request[a] Funct. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Funct. Codes[c]	Response[b] 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
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

Table D.9 SEL-700G DNP Object List (Sheet 2 of 6)

Obj.	Var.	Description	Request[a] Funct. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Funct. Codes[c]	Response[b] Qual. Codes[d]
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
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				

Table D.9 SEL-700G DNP Object List (Sheet 3 of 6)

Obj.	Var.	Description	Request[a] Funct. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Funct. Codes[c]	Response[b] Qual. Codes[d]
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				
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

Table D.9 SEL-700G DNP Object List (Sheet 4 of 6)

Obj.	Var.	Description	Request[a] Funct. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Funct. Codes[c]	Response[b] Qual. Codes[d]
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				
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 Dead Band—All Variations				
34	1[e]	16-Bit Analog Input Reporting Dead-Band Object	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
34	2	32-Bit Analog Input Reporting Dead-Band Object	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
34	3	Floating Point Analog Input Reporting Dead-Band 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

Table D.9 SEL-700G DNP Object List (Sheet 5 of 6)

Obj.	Var.	Description	Request[a] Funct. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Funct. Codes[c]	Response[b] Qual. Codes[d]
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				
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				

Table D.9 SEL-700G DNP Object List (Sheet 6 of 6)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
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				
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, or3]).

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: Dead-band changes via Object 34 are not stored in nonvolatile memory. Make sure to reissue the Object 34 dead bands 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 dead bands 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 2)

Object	Labels	Description
Binary Inputs		
01, 02	STFAIL	Relay Diagnostic Failure
	STWARN	Relay Diagnostic Warning
	STSET	Relay Settings Change or Relay Restart
	Enabled–TLED_06[a]	Relay Word Elements Target Row 0 (see *Table J.1*)
	50PX1P–59V1X6T[a]	Relay Word Elements (see *Table J.1*)
	PFL_X	X-Side Power Factor Leading for Three-Phase Currents
	PFL_Y	Y-Side Power Factor Leading for Three-Phase Currents
	0	Logical 0
	1	Logical 1

Table D.10 DNP3 Reference Data Map (Sheet 2 of 2)

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
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 K.1* with an “x” in the DNP column
	SER_NUM	Serial Number
	0	Numeric 0
	1	Numeric 1
Analog Outputs		
40, 41	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.22 for default analog input scaling and dead bands.

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.20*. 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.20*. 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: Dead-band changes via Object 34 are stored in nonvolatile memory. Make sure to reissue the Object 34 dead bands after a warm (HIS 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 cards are present, the SEL-700G adds each analog input point label, AI*x*0*y*, where *x* is the slot and *y* is the point number, to the default map in numerical order to the DNP map.

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.9*. 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 once 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 DNP. 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 RB1–RB32, OCX/CCX and OCY/CCY 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. You should exercise caution if sending multiple remote bit pulses in a single message (i.e., point count > 1), because this may 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.

The default binary output data map is populated with the RB01–RB32 point labels.The binary input (BI) maps are modified in a similar manner, but pairs are not allowed.

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.

Table D.12 SEL-700G Object 12 Control Operations

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	Not Supported	Not Supported	Not Supported
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)	Not Supported	Not Supported	Not Supported
OCY:CCY	Close Circuit Breaker Y (Pulse CCY)	Open Circuit Breaker Y (Pulse OCY)	Not Supported	Not Supported	Not Supported

Analog Inputs

Analog Inputs (30) and Analog Change Events (32) are supported as defined in *Table D.9*. The default variation for both static and event inputs is defined by the DVARAI1 (DVARAI*n* for DNP3 LAN/WAN session *n*) setting. Only the Read function code (1) is allowed with these objects.

Unless otherwise indicated, analog values are reported in primary units. See *Appendix K: Analog Quantities* for a list of all available analog inputs. A dead-band check is done after any scaling has been applied. For all currents, the default scaling is the DECPLA setting on magnitudes and scale factor of 100 on angles. The default dead band 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 dead band for voltages is ANADBV on magnitudes and ANADBM on angles. For all powers and energies, the default scaling is the DECPLM setting and default dead band is ANADBM. For all other quantities, the default scaling is 1 and default dead band is ANADBM.

You can use per-point scaling and dead band to override default scaling and dead bands. See *Configurable Data Mapping on page D.23* for more information. Dead bands for analog inputs can also be modified by writing to object 34.

NOTE: Dead-band changes via Object 34 are not stored in nonvolatile memory. Make sure to reissue the Object 34 dead-band 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 dead-band 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 dead-band setting. The voltage and current phase angles only generate an event if, in addition to their dead-band check, the corresponding magnitude changes beyond its own dead band. Analog inputs are scanned at approximately a 1 second rate, except for Fault analog inputs below. 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 dead bands. 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 three unique DNP3 masters. Each map is initially populated with default data points, as described in *Default Data Map on page D.19*. 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    := NOOP
AO_02    := NA
…
AO_29    := NA
AO_30    := NOOP
AO_31    := NOOP

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 3. 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

Analog Outputs
-------------------------------------------------------------------------------
INDEX POINT LABEL
0 GROUP
1 NOOP
```

Figure D.4 Port MAP Command

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 amps to 11 amps. 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 amps 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 dead-band settings. Per-point customization is not necessary, but class scaling (DECPLA, DECPLV, and DECPLM) and dead-band (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, you should 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 you should group those data together within your custom map. For example, if you want all the X-Side currents to be coherent, you should 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 ACSELERATOR 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 (Sheet 1 of 2)

Desired Point Index	Description	Label	Scaling	Dead Band
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	3-Phase Real Power	P3X	5	default
5	X-Side AB Phase-to-Phase Voltage Magnitude	VABX_MAG	default	default

Table D.13 Sample Custom DNP3 AI Map (Sheet 2 of 2)

Desired Point Index	Description	Label	Scaling	Dead Band
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 ACSELERATOR QuickSet to enter the previous AI map settings as shown in the screen capture in *Figure D.6*. You can enter scaling and dead-band settings in the same pop-up dialog used to select the AI point, as shown in *Figure D.7*.

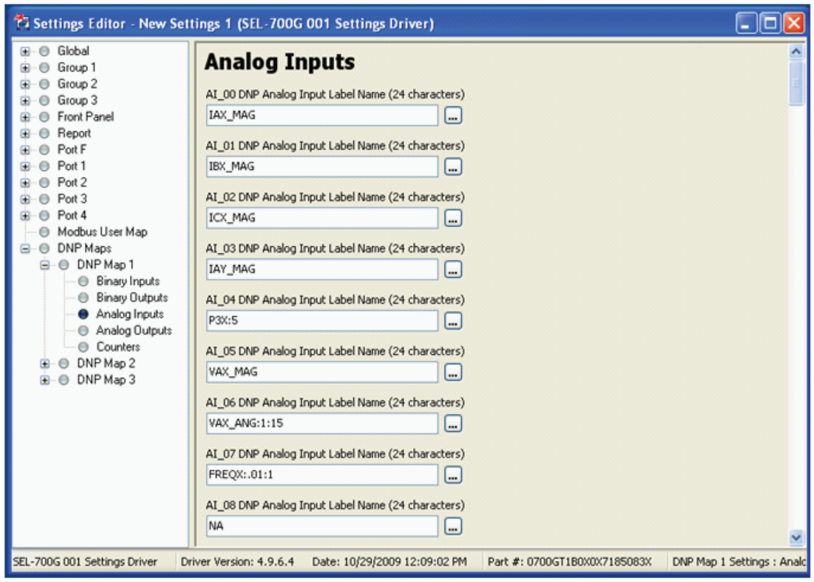

Figure D.6 Analog Input Map Entry in ACSELERATOR QuickSet Software

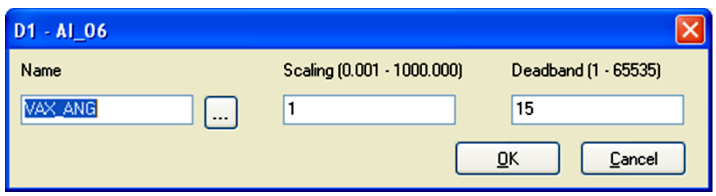

Figure D.7 AI Point Label, Scaling, and Dead Band in ACSELERATOR QuickSet

The **SET DNP** ***x*** **CO_00 <Enter>** command allows you to populate the DNP counter map with per-point dead bands. 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.8*. 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.8 Sample Custom DNP3 BO Map Settings

You can also use ACSELERATOR QuickSet to enter the BO map settings as shown in the screen capture in *Figure D.9*.

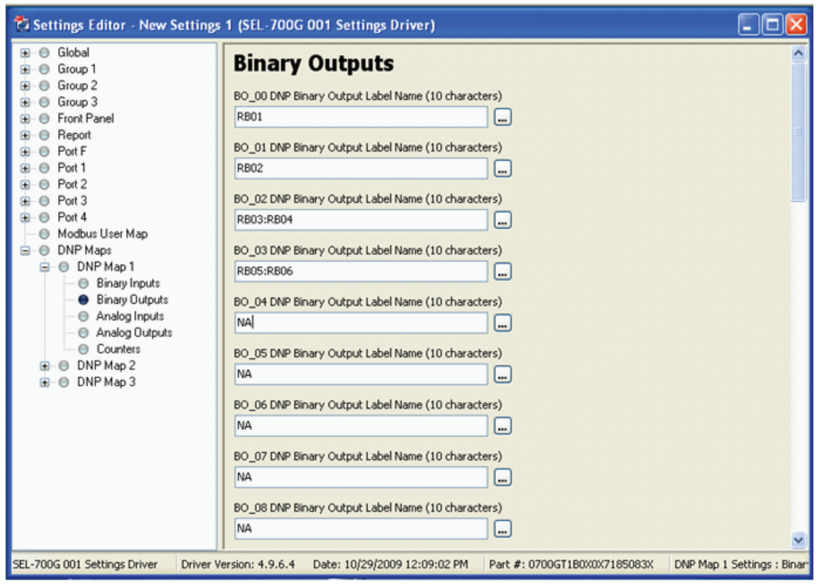

Figure D.9 Binary Output Map Entry in ACSELERATOR QuickSet Software

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Appendix E
Modbus RTU 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 www.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 (Sheet 1 of 4)

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
24–31	2	Relay Element Status Row 3
32–39	2	Relay Element Status Row 4
40–47	2	Relay Element Status Row 5
48–55	2	Relay Element Status Row 6
56–63	2	Relay Element Status Row 7
64–71	2	Relay Element Status Row 8
72–79	2	Relay Element Status Row 9
80–87	2	Relay Element Status Row 10
88–95	2	Relay Element Status Row 11
96–103	2	Relay Element Status Row 12
104–111	2	Relay Element Status Row 13
112–119	2	Relay Element Status Row 14
120–127	2	Relay Element Status Row 15
128–135	2	Relay Element Status Row 16
136–143	2	Relay Element Status Row 17
144–151	2	Relay Element Status Row 18
152–159	2	Relay Element Status Row 19
160–167	2	Relay Element Status Row 20
168–175	2	Relay Element Status Row 21
176–183	2	Relay Element Status Row 22
184–191	2	Relay Element Status Row 23
192–199	2	Relay Element Status Row 24
200–207	2	Relay Element Status Row 25
208–215	2	Relay Element Status Row 26
216–223	2	Relay Element Status Row 27
224–231	2	Relay Element Status Row 28
232–239	2	Relay Element Status Row 29
240–247	2	Relay Element Status Row 30
248–255	2	Relay Element Status Row 31
256–263	2	Relay Element Status Row 32
264–271	2	Relay Element Status Row 33

Table E.7 02h SEL-700G Inputs (Sheet 2 of 4)

Coil Address (Decimal)	Function Code Supported	Coil Description[a]
272–279	2	Relay Element Status Row 34
280–287	2	Relay Element Status Row 35
288–295	2	Relay Element Status Row 36
296–303	2	Relay Element Status Row 37
304–311	2	Relay Element Status Row 38
312–319	2	Relay Element Status Row 39
320–327	2	Relay Element Status Row 40
328–335	2	Relay Element Status Row 41
336–343	2	Relay Element Status Row 42
344–351	2	Relay Element Status Row 43
352–359	2	Relay Element Status Row 44
360–367	2	Relay Element Status Row 45
368–375	2	Relay Element Status Row 46
376–383	2	Relay Element Status Row 47
384–391	2	Relay Element Status Row 48
392–399	2	Relay Element Status Row 49
400–407	2	Relay Element Status Row 50
408–415	2	Relay Element Status Row 51
416–423	2	Relay Element Status Row 52
424–431	2	Relay Element Status Row 53
432–439	2	Relay Element Status Row 54
440–447	2	Relay Element Status Row 55
448–455	2	Relay Element Status Row 56
456–463	2	Relay Element Status Row 57
464–471	2	Relay Element Status Row 58
472–479	2	Relay Element Status Row 59
480–487	2	Relay Element Status Row 60
488–495	2	Relay Element Status Row 61
496–503	2	Relay Element Status Row 62
504–511	2	Relay Element Status Row 63
512–519	2	Relay Element Status Row 64
520–527	2	Relay Element Status Row 65
528–535	2	Relay Element Status Row 66
536–543	2	Relay Element Status Row 67
544–551	2	Relay Element Status Row 68
552–559	2	Relay Element Status Row 69
560–567	2	Relay Element Status Row 70
568–575	2	Relay Element Status Row 71
576–583	2	Relay Element Status Row 72
584–591	2	Relay Element Status Row 73
592–599	2	Relay Element Status Row 74
600–607	2	Relay Element Status Row 75
608–615	2	Relay Element Status Row 76

Table E.7 02h SEL-700G Inputs (Sheet 3 of 4)

Coil Address (Decimal)	Function Code Supported	Coil Description[a]
616–623	2	Relay Element Status Row 77
624–631	2	Relay Element Status Row 78
632–639	2	Relay Element Status Row 79
640–647	2	Relay Element Status Row 80
648–655	2	Relay Element Status Row 81
656–663	2	Relay Element Status Row 82
664–671	2	Relay Element Status Row 83
672–679	2	Relay Element Status Row 84
680–687	2	Relay Element Status Row 85
688–695	2	Relay Element Status Row 86
696–703	2	Relay Element Status Row 87
704–711	2	Relay Element Status Row 88
712–719	2	Relay Element Status Row 89
720-727	2	Relay Element Status Row 90
728–735	2	Relay Element Status Row 91
736–743	2	Relay Element Status Row 92
744–751	2	Relay Element Status Row 93
752–759	2	Relay Element Status Row 94
760–767	2	Relay Element Status Row 95
768–775	2	Relay Element Status Row 96
776–783	2	Relay Element Status Row 97
784–791	2	Relay Element Status Row 98
792–799	2	Relay Element Status Row 99
800–807	2	Relay Element Status Row 100
808–815	2	Relay Element Status Row 101
816–823	2	Relay Element Status Row 102
824–831	2	Relay Element Status Row 103
832–839	2	Relay Element Status Row 104
840–847	2	Relay Element Status Row 105
848–855	2	Relay Element Status Row 106
856–863	2	Relay Element Status Row 107
864–871	2	Relay Element Status Row 108
872–879	2	Relay Element Status Row 109
880–887	2	Relay Element Status Row 110
888–895	2	Relay Element Status Row 111
896–903	2	Relay Element Status Row 112
904–911	2	Relay Element Status Row 113
912–919	2	Relay Element Status Row 114
920–927	2	Relay Element Status Row 115
928–935	2	Relay Element Status Row 116
936–943	2	Relay Element Status Row 117
944–951	2	Relay Element Status Row 118
952–959	2	Relay Element Status Row 119

Table E.7 02h SEL-700G Inputs (Sheet 4 of 4)

Coil Address (Decimal)	Function Code Supported	Coil Description[a]
960–967	2	Relay Element Status Row 120
968–975	2	Relay Element Status Row 121
976–983	2	Relay Element Status Row 122
984–991	2	Relay Element Status Row 123
992–999	2	Relay Element Status Row 124
1000–1007	2	Relay Element Status Row 125
1008–1015	2	Relay Element Status Row 126
1016–1023	2	Relay Element Status Row 127
1024–1031	2	Relay Element Status Row 128
1032–1039	2	Relay Element Status Row 129
1040–1047	2	Relay Element Status Row 130
1048–1055	2	Relay Element Status Row 131
1056–1063	2	Relay Element Status Row 132
1064–1071	2	Relay Element Status Row 133
1072–1079	2	Relay Element Status Row 134
1080–1087	2	Relay Element Status Row 135
1088–1095	2	Relay Element Status Row 136
1096–1103	2	Relay Element Status Row 137
1104–1111	2	Relay Element Status Row 138
1112–1119	2	Relay Element Status Row 139
1120–1127	2	Relay Element Status Row 140
1128–1135	2	Relay Element Status Row 141
1136–1143	2	Relay Element Status Row 142
1144–1151	2	Relay Element Status Row 143
1152–1159	2	Relay Element Status Row 144
1160–1167	2	Relay Element Status Row 145
1168–1175	2	Relay Element Status Row 146
1176–1183	2	Relay Element Status Row 147
1184–1191	2	Relay Element Status Row 148
1192–1199	2	Relay Element Status Row 149
1200–1207	2	Relay Element Status Row 150
1208–1215	2	Relay Element Status Row 151
1216–1223	2	Relay Element Status Row 152

[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

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*)
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 4)

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

Table E.14 01h, 05h SEL-700G Output (Sheet 2 of 4)

Coil Address (Decimal)	Function Code Supported	Coil Description
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
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

Table E.14 01h, 05h SEL-700G Output (Sheet 3 of 4)

Coil Address (Decimal)	Function Code Supported	Coil Description
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
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]

Table E.14 01h, 05h SEL-700G Output (Sheet 4 of 4)

Coil Address (Decimal)	Function Code Supported	Coil Description
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.

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

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (08h)
2 bytes	Subfunction (0000h)
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 (Sheet 1 of 2)

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

Table E.20 10h Preset Multiple Registers Command (Sheet 2 of 2)

Bytes	Field
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

Table E.23 60h Read Parameter Descriptor Field Definition (Sheet 2 of 2)

Bit	Name	Description
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
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	Hexidecimal	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
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.

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 5)

Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label
271	FPGA	315	SER_NUML	359	QCXL	403	VGY_MAG
272	GPSB	316	RES_316	360	Q3XH	404	VGY_ANG
273	HMI	317	RES_317	361	Q3XL	405	3V2Y_MAG
274	RAM	318	RES_318	362	SAXH	406	V1Y_MAG
275	ROM	319	RES_319	363	SAXL	407	IN_MAG
276	CR_RAM	320	IAX_MAG	364	SBXH	408	IN_ANG
277	NON_VOL	321	IAX_ANG	365	SBXL	409	VS_MAG
278	CLKSTS	322	IBX_MAG	366	SCXH	410	VS_ANG
279	CID_FILE	323	IBX_ANG	367	SCXL	411	VN_MAG
280	RTD	324	ICX_MAG	368	S3XH	412	VN_ANG
281	P3P3PS	325	ICX_ANG	369	S3XL	413	VN3_MAG
282	P5PS	326	IGX_MAG	370	PFAX	414	VPX3_MAG
283	P2P5PS	327	IGX_ANG	371	PFBX	415	FLDRES
284	P3P75PS	328	3I2X_MAG	372	PFCX	416	FREQS
285	N1P25PS	329	I1X_MAG	373	PF3X	417	RES_417
286	N5PS	330	VABX_MAG	374	FREQX	418	RES_418
287	P0P9PS	331	VABX_ANG	375	VHZX	419	RES_419
288	P1P2PS	332	VBCX_MAG	376	RES_376	420	RES_420
289	P1P5PS	333	VBCX_ANG	377	RES_377	421	RES_421
290	P1P8PS	334	VCAX_MAG	378	RES_378	422	RES_422
291	CLKBAT	335	VCAX_ANG	379	RES_379	423	MWHPXH
292	CARDZ	336	VAX_MAG	380	RES_380	424	MWHPXL
293	CARDC	337	VAX_ANG	381	IAY_MAG	425	MWHNXH
294	CARDD	338	VBX_MAG	382	IAY_ANG	426	MWHNXL
295	CARDE	339	VBX_ANG	383	IBY_MAG	427	MVARHPXH
296	IAXSTS	340	VCX_MAG	384	IBY_ANG	428	MVARHPXL
297	IBXSTS	341	VCX_ANG	385	ICY_MAG	429	MVARHNXH
298	ICXSTS	342	VGX_MAG	386	ICY_ANG	430	MVARHNXL
299	IAYSTS	343	VGX_ANG	387	IGY_MAG	431	MWHPYH
300	IBYSTS	344	3V2X_MAG	388	IGY_ANG	432	MWHPYL
301	ICYSTS	345	V1X_MAG	389	3I2Y_MAG	433	MWHNYH
302	INSTS	346	PAXH	390	I1Y_MAG	434	MWHNYL
303	VAXSTS	347	PAXL	391	VABY_MAG	435	MVARHPYH
304	VBXSTS	348	PBXH	392	VABY_ANG	436	MVARHPYL
305	VCXSTS	349	PBXL	393	VBCY_MAG	437	MVARHNYH
306	VAYSTS	350	PCXH	394	VBCY_ANG	438	MVARHNYL
307	VBYSTS	351	PCXL	395	VCAY_MAG	439	ENRGY_S
308	VCYSTS	352	P3XH	396	VCAY_ANG	440	ENRGYMN
309	VSSTS	353	P3XL	397	VAY_MAG	441	ENRGY_H
310	VNSTS	354	QAXH	398	VAY_ANG	442	ENRGY_D
311	F64COMM	355	QAXL	399	VBY_MAG	443	ENRGYMO
312	F64STS	356	QBXH	400	VBY_ANG	444	ENRGY_Y
313	RLYSTS	357	QBXL	401	VCY_MAG	445	RES_445
314	SER_NUMH	358	QCXH	402	VCY_ANG	446	RES_446

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 2 of 5)

Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label
447	RES_447	491	RTD3	535	IAXMN	579	KVR3XMNL
448	RES_448	492	RTD4	536	IBXMX	580	KVA3XMXH
449	RES_449	493	RTD5	537	IBXMN	581	KVA3XMXL
450	RES_450	494	RTD6	538	ICXMX	582	KVA3XMNH
451	RES_451	495	RTD7	539	ICXMN	583	KVA3XMNL
452	RES_452	496	RTD8	540	IGXMX	584	KW3YMXH
453	IAXD	497	RTD9	541	IGXMN	585	KW3YMXL
454	IBXD	498	RTD10	542	IAYMX	586	KW3YMNH
455	ICXD	499	RTD11	543	IAYMN	587	KW3YMNL
456	IGXD	500	RTD12	544	IBYMX	588	KVR3YMXH
457	3I2XD	501	TCUGEN	545	IBYMN	589	KVR3YMXL
458	IAYD	502	TCURTD	546	ICYMX	590	KVR3YMNH
459	IBYD	503	RES_503	547	ICYMN	591	KVR3YMNL
460	ICYD	504	RES_504	548	IGYMX	592	KVA3YMXH
461	IGYD	505	RES_505	549	IGYMN	593	KVA3YMXL
462	3I2YD	506	RES_506	550	INMX	594	KVA3YMNH
463	IAXPD	507	RES_507	551	INMN	595	KVA3YMNL
464	IBXPD	508	RES_508	552	VABXMX	596	FREQXMX
465	ICXPD	509	RES_509	553	VABXMN	597	FREQXMN
466	IGXPD	510	RES_510	554	VBCXMX	598	FREQYMX
467	3I2XPD	511	RES_511	555	VBCXMN	599	FREQYMN
468	IAYPD	512	RES_512	556	VCAXMX	600	RTD1MX
469	IBYPD	513	RES_513	557	VCAXMN	601	RTD1MN
470	ICYPD	514	IAXRMS	558	VABYMX	602	RTD2MX
471	IGYPD	515	IBXRMS	559	VABYMN	603	RTD2MN
472	3I2YPD	516	ICXRMS	560	VBCYMX	604	RTD3MX
473	PDEM_R_S	517	IAYRMS	561	VBCYMN	605	RTD3MN
474	PDEM_RMN	518	IBYRMS	562	VCAYMX	606	RTD4MX
475	PDEM_R_H	519	ICYRMS	563	VCAYMN	607	RTD4MN
476	PDEM_R_D	520	VAXRMS	564	VSMX	608	RTD5MX
477	PDEM_RMO	521	VBXRMS	565	VSMN	609	RTD5MN
478	PDEM_R_Y	522	VCXRMS	566	VNMX	610	RTD6MX
479	IAX_THD	523	VABXRMS	567	VNMN	611	RTD6MN
480	IBX_THD	524	VBCXRMS	568	VN3MX	612	RTD7MX
481	ICX_THD	525	VCAXRMS	569	VN3MN	613	RTD7MN
482	IAY_THD	526	VAYRMS	570	VPX3MX	614	RTD8MX
483	IBY_THD	527	VBYRMS	571	VPX3MN	615	RTD8MN
484	ICY_THD	528	VCYRMS	572	KW3XMXH	616	RTD9MX
485	RTDWDGMX	529	VABYRMS	573	KW3XMXL	617	RTD9MN
486	RTDBRGMX	530	VBCYRMS	574	KW3XMNH	618	RTD10MX
487	RTDAMB	531	VCAYRMS	575	KW3XMNL	619	RTD10MN
488	RTDOTHMX	532	INRMS	576	KVR3XMXH	620	RTD11MX
489	RTD1	533	VSRMS	577	KVR3XMXL	621	RTD11MN
490	RTD2	534	IAXMX	578	KVR3XMNH	622	RTD12MX

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 3 of 5)

Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label
623	RTD12MN	667	AI503MNL	711	MV03L	755	MV25L
624	AI301MXH	668	AI504MXH	712	MV04H	756	MV26H
625	AI301MXL	669	AI504MXL	713	MV04L	757	MV26L
626	AI301MNH	670	AI504MNH	714	MV05H	758	MV27H
627	AI301MNL	671	AI504MNL	715	MV05L	759	MV27L
628	AI302MXH	672	MXMN_R_S	716	MV06H	760	MV28H
629	AI302MXL	673	MXMN_RMN	717	MV06L	761	MV28L
630	AI302MNH	674	MXMN_R_H	718	MV07H	762	MV29H
631	AI302MNL	675	MXMN_R_D	719	MV07L	763	MV29L
632	AI303MXH	676	MXMN_RMO	720	MV08H	764	MV30H
633	AI303MXL	677	MXMN_R_Y	721	MV08L	765	MV30L
634	AI303MNH	678	RES_678	722	MV09H	766	MV31H
635	AI303MNL	679	RES_679	723	MV09L	767	MV31L
636	AI304MXH	680	RES_680	724	MV10H	768	MV32H
637	AI304MXL	681	RES_681	725	MV10L	769	MV32L
638	AI304MNH	682	AI301H	726	MV11H	770	SC01
639	AI304MNL	683	AI301L	727	MV11L	771	SC02
640	AI401MXH	684	AI302H	728	MV12H	772	SC03
641	AI401MXL	685	AI302L	729	MV12L	773	SC04
642	AI401MNH	686	AI303H	730	MV13H	774	SC05
643	AI401MNL	687	AI303L	731	MV13L	775	SC06
644	AI402MXH	688	AI304H	732	MV14H	776	SC07
645	AI402MXL	689	AI304L	733	MV14L	777	SC08
646	AI402MNH	690	AI401H	734	MV15H	778	SC09
647	AI402MNL	691	AI401L	735	MV15L	779	SC10
648	AI403MXH	692	AI402H	736	MV16H	780	SC11
649	AI403MXL	693	AI402L	737	MV16L	781	SC12
650	AI403MNH	694	AI403H	738	MV17H	782	SC13
651	AI403MNL	695	AI403L	739	MV17L	783	SC14
652	AI403MXH	696	AI404H	740	MV18H	784	SC15
653	AI403MXL	697	AI404L	741	MV18L	785	SC16
654	AI404MNH	698	AI501H	742	MV19H	786	SC17
655	AI404MNL	699	AI501L	743	MV19L	787	SC18
656	AI501MXH	700	AI502H	744	MV20H	788	SC19
657	AI501MXL	701	AI502L	745	MV20L	789	SC20
658	AI501MNH	702	AI503H	746	MV21H	790	SC21
659	AI501MNL	703	AI503L	747	MV21L	791	SC22
660	AI502MXH	704	AI504H	748	MV22H	792	SC23
661	AI502MXL	705	AI504L	749	MV22L	793	SC24
662	AI502MNH	706	MV01H	750	MV23H	794	SC25
663	AI502MNL	707	MV01L	751	MV23L	795	SC26
664	AI503MXH	708	MV02H	752	MV24H	796	SC27
665	AI503MXL	709	MV02L	753	MV24L	797	SC28
666	AI503MNH	710	MV03H	754	MV25H	798	SC29

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 4 of 5)

Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label
799	SC30	843	EVE_VCAY	887	EXTIAY	931	PCYL
800	SC31	844	EVE_VGY	888	EXTIBY	932	P3YH
801	SC32	845	EVE_VS	889	EXTICY	933	P3YL
802	RES_802	846	EVE_VN	890	WEARAY	934	QAYH
803	RES_803	847	EVE_DY_X	891	WEARBY	935	QAYL
804	RES_804	848	EVE_DY_Y	892	WEARCY	936	QBYH
805	RES_805	849	EVE_FRQX	893	BM_R_SY	937	QBYL
806	RES_806	850	EVE_FRQY	894	BM_R_MNY	938	QCYH
807	RES_807	851	EVE_MAXW	895	BM_R_HY	939	QCYL
808	RES_808	852	EVE_MAXB	896	BM_R_DY	940	Q3YH
809	RES_809	853	EVE_MAXA	897	BM_R_MOY	941	Q3YL
810	RES_810	854	EVE_MAXO	898	BM_R_YY	942	SAYH
811	RES_811	855	RES_855	899	RES_899	943	SAYL
812	RES_812	856	RES_856	900	RES_900	944	SBYH
813	RES_813	857	RES_857	901	TRIP_LO	945	SBYL
814	RES_814	858	RES_858	902	TRIP_HI	946	SCYH
815	RES_815	859	RES_859	903	WARN_LO	947	SCYL
816	RES_816	860	RES_860	904	WARN_HI	948	S3YH
817	RES_817	861	RES_861	905	RES_905	949	S3YL
818	NUMEVE	862	RES_862	906	RES_906	950	PFAY
819	EVESEL	863	RES_863	907	RES_907	951	PFBY
820	EVE_S	864	RES_864	908	RES_908	952	PFCY
821	EVEMN	865	INTTX	909	RES_909	953	PF3Y
822	EVE_H	866	EXTTX	910	NUMRCV	954	FREQY
823	EVE_D	867	INTIAX	911	NUMOTH	955	RES_955
824	EVEMO	868	INTIBX	912	INVADR	956	RES_956
825	EVE_Y	869	INTICX	913	BADCRC	957	RES_957
826	EVE_TYPE	870	EXTIAX	914	UARTERR	958	RES_958
827	EVE_TRGT	871	EXTIBX	915	ILLFUNC	959	RES_959
828	EVE_IAX	872	EXTICX	916	ILLREG	960	RES_960
829	EVE_IBX	873	WEARAX	917	ILLWR	961	RES_961
830	EVE_ICX	874	WEARBX	918	BADPKTF	962	RES_962
831	EVE_IGX	875	WEARCX	919	BADPKTL	963	RES_963
832	EVE_IAY	876	BM_R_SX	920	RES_920	964	RES_964
833	EVE_IBY	877	BM_R_MNX	921	RES_921	965	RES_965
834	EVE_ICY	878	BM_R_HX	922	RES_922	966	RES_966
835	EVE_IGY	879	BM_R_DX	923	RES_923	967	RES_967
836	EVE_IN	880	BM_R_MOX	924	RES_924	968	RES_968
837	EVE_VABX	881	BM_R_YX	925	RES_925	969	RES_969
838	EVE_VBCX	882	INTTY	926	PAYH	970	RES_970
839	EVE_VCAX	883	EXTTY	927	PAYL	971	ROW_0
840	EVE_VGX	884	INTIAY	928	PBYH	972	ROW_1
841	EVE_VABY	885	INTIBY	929	PBYL	973	ROW_2
842	EVE_VBCY	886	INTICY	930	PCYH	974	ROW_3

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 5 of 5)

Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label
975	ROW_4	1019	ROW_48	1063	ROW_92	1107	ROW_136
976	ROW_5	1020	ROW_49	1064	ROW_93	1108	ROW_137
977	ROW_6	1021	ROW_50	1065	ROW_94	1109	ROW_138
978	ROW_7	1022	ROW_51	1066	ROW_95	1110	ROW_139
979	ROW_8	1023	ROW_52	1067	ROW_96	1111	ROW_140
980	ROW_9	1024	ROW_53	1068	ROW_97	1112	ROW_141
981	ROW_10	1025	ROW_54	1069	ROW_98	1113	ROW_142
982	ROW_11	1026	ROW_55	1070	ROW_99	1114	ROW_143
983	ROW_12	1027	ROW_56	1071	ROW_100	1115	ROW_144
984	ROW_13	1028	ROW_57	1072	ROW_101	1116	ROW_145
985	ROW_14	1029	ROW_58	1073	ROW_102	1117	ROW_146
986	ROW_15	1030	ROW_59	1074	ROW_103	1118	ROW_147
987	ROW_16	1031	ROW_60	1075	ROW_104	1119	ROW_148
988	ROW_17	1032	ROW_61	1076	ROW_105	1120	ROW_149
989	ROW_18	1033	ROW_62	1077	ROW_106	1121	ROW_150
990	ROW_19	1034	ROW_63	1078	ROW_107	1122	ROW_151
991	ROW_20	1035	ROW_64	1079	ROW_108	1123	ROW_152
992	ROW_21	1036	ROW_65	1080	ROW_109	1124	NA
993	ROW_22	1037	ROW_66	1081	ROW_110		
994	ROW_23	1038	ROW_67	1082	ROW_111		
995	ROW_24	1039	ROW_68	1083	ROW_112		
996	ROW_25	1040	ROW_69	1084	ROW_113		
997	ROW_26	1041	ROW_70	1085	ROW_114		
998	ROW_27	1042	ROW_71	1086	ROW_115		
999	ROW_28	1043	ROW_72	1087	ROW_116		
1000	ROW_29	1044	ROW_73	1088	ROW_117		
1001	ROW_30	1045	ROW_74	1089	ROW_118		
1002	ROW_31	1046	ROW_75	1090	ROW_119		
1003	ROW_32	1047	ROW_76	1091	ROW_120		
1004	ROW_33	1048	ROW_77	1092	ROW_121		
1005	ROW_34	1049	ROW_78	1093	ROW_122		
1006	ROW_35	1050	ROW_79	1094	ROW_123		
1007	ROW_36	1051	ROW_80	1095	ROW_124		
1008	ROW_37	1052	ROW_81	1096	ROW_125		
1009	ROW_38	1053	ROW_82	1097	ROW_126		
1010	ROW_39	1054	ROW_83	1098	ROW_127		
1011	ROW_40	1055	ROW_84	1099	ROW_128		
1012	ROW_41	1056	ROW_85	1100	ROW_129		
1013	ROW_42	1057	ROW_86	1101	ROW_130		
1014	ROW_43	1058	ROW_87	1102	ROW_131		
1015	ROW_44	1059	ROW_88	1103	ROW_132		
1016	ROW_45	1060	ROW_89	1104	ROW_133		
1017	ROW_46	1061	ROW_90	1105	ROW_134		
1018	ROW_47	1062	ROW_91	1106	ROW_135		

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 *Historical Data* section in the map.

To use Modbus to download history data, write the event number (1–50) to the EVENT LOG SEL register at address 819. 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 stay frozen with 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

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 Register Map[a] (Sheet 1 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
0 (R)	Reserved[c]		0	100	1		
User Map Reg							
1 (R/W)	USER REG #1		271	1124	1124	1	101
	•						
	•						
	•						
125 (R/W)	USER REG #125		271	1124	1124	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[c]		0	0	0		351–360
Reset Settings							
261 (R/W)	RESET DATA Bit 0 = TRIP RESET Bit 1 = Reserved Bit 2 = RESET STAT DATA Bit 3 = RESET HIST DATA Bit 4 = RESET COMM CNTR Bit 5 = Reserved Bit 6 = RST ENRGY DATA Bit 7 = RST MX/MN DATA		0	4095	0		361

Table E.34 Modbus Register Map[a] (Sheet 2 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
	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						
262 (R)	Reserved[c]		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[c]		0	0	0		369
270 (R)	Reserved[c]		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
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

Table E.34 Modbus Register Map[a] (Sheet 3 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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[c]		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
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

Table E.34 Modbus Register Map[a] (Sheet 4 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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[d]	kW	–32768	32767	0	1	446
347 (R)	PAX REAL PWR LO[d]	kW	–32768	32767	0	1	447
348 (R)	PBX REAL PWR HI[d]	kW	–32768	32767	0	1	448
349 (R)	PBX REAL PWR LO[d]	kW	–32768	32767	0	1	449
350 (R)	PCX REAL PWR HI[d]	kW	–32768	32767	0	1	450
351 (R)	PCX REAL PWR LO[d]	kW	–32768	32767	0	1	451
352 (R)	P3X REAL PWR HI[d]	kW	–32768	32767	0	1	452
353 (R)	P3X REAL PWR LO[d]	kW	–32768	32767	0	1	453
354 (R)	QAX REACTV PWRHI[d]	kVAR	–32768	32767	0	1	454
355 (R)	QAX REACTV PWRLO[d]	kVAR	–32768	32767	0	1	455
356 (R)	QBX REACTV PWRHI[d]	kVAR	–32768	32767	0	1	456
357 (R)	QBX REACTV PWRLO[d]	kVAR	–32768	32767	0	1	457
358 (R)	QCX REACTV PWRHI[d]	kVAR	–32768	32767	0	1	458
359 (R)	QCX REACTV PWRLO[d]	kVAR	–32768	32767	0	1	459
360 (R)	Q3X REACTV PWRHI[d]	kVAR	–32768	32767	0	1	460
361 (R)	Q3X REACTV PWRLO[d]	kVAR	–32768	32767	0	1	461
362 (R)	SAX APPRNT PWRHI[d]	kVA	–32768	32767	0	1	462
363 (R)	SAX APPRNT PWRLO[d]	kVA	–32768	32767	0	1	463
364 (R)	SBX APPRNT PWRHI[d]	kVA	–32768	32767	0	1	464
365 (R)	SBX APPRNT PWRLO[d]	kVA	–32768	32767	0	1	465
366 (R)	SCX APPRNT PWRHI[d]	kVA	–32768	32767	0	1	466
367 (R)	SCX APPRNT PWRLO[d]	kVA	–32768	32767	0	1	467
368 (R)	S3X APPRNT PWRHI[d]	kVA	–32768	32767	0	1	468
369 (R)	S3X APPRNT PWRLO[d]	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[c]		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
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

Table E.34 Modbus Register Map[a] (Sheet 5 of 28)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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)	BUS FREQUENCY	Hz	0	65535	6000	0.01	516
417–422	(R)	Reserved[c]		0	0	0		517–522
Energy Data								
423	(R)	MWHPX HI[d]	MWhr	0	65535	0	0.001	523
424	(R)	MWHPX LO[d]	MWhr	0	65535	0	0.001	524
425	(R)	MWHNX HI[d]	MWhr	0	65535	0	0.001	525
426	(R)	MWHNX LO[d]	MWhr	0	65535	0	0.001	526
427	(R)	MVARHPX HI[d]	MVRh	0	65535	0	0.001	527
428	(R)	MVARHPX LO[d]	MVRh	0	65535	0	0.001	528
429	(R)	MVARHNX HI[d]	MVRh	0	65535	0	0.001	529
430	(R)	MVARHNX LO[d]	MVRh	0	65535	0	0.001	530
431	(R)	MWHPY HI[d]	MWhr	0	65535	0	0.001	531
432	(R)	MWHPY LO[d]	MWhr	0	65535	0	0.001	532
433	(R)	MWHNY HI[d]	MWhr	0	65535	0	0.001	533
434	(R)	MWHNY LO[d]	MWhr	0	65535	0	0.001	534
435	(R)	MVARHPY HI[d]	MVRh	0	65535	0	0.001	535
436	(R)	MVARHPY LO[d]	MVRh	0	65535	0	0.001	536

Table E.34 Modbus Register Map[a] (Sheet 6 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
437 (R)	MVARHNY HI[d]	MVRh	0	65535	0	0.001	537
438 (R)	MVARHNY LO[d]	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[c]		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
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

Table E.34 Modbus Register Map[a] (Sheet 7 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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[c]		0	0	0		603
Reserved Area 2							
504–513 (R)	Reserved[c]		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
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

Table E.34 Modbus Register Map[a] (Sheet 8 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
572 (R)	KW3PX MAX HI[d]	kW	–32768	32767	0	1	672
573 (R)	KW3PX MAX LO[d]	kW	–32768	32767	0	1	673
574 (R)	KW3PX MIN HI[d]	kW	–32768	32767	0	1	674

Table E.34 Modbus Register Map[a] (Sheet 9 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
575 (R)	KW3PX MIN LO[d]	kW	–32768	32767	0	1	675
576 (R)	KVAR3PX MAX HI[d]	kVAR	–32768	32767	0	1	676
577 (R)	KVAR3PX MAX LO[d]	kVAR	–32768	32767	0	1	677
578 (R)	KVAR3PX MIN HI[d]	kVAR	–32768	32767	0	1	678
579 (R)	KVAR3PX MIN LO[d]	kVAR	–32768	32767	0	1	679
580 (R)	KVA3PX MAX HI[d]	kVA	–32768	32767	0	1	680
581 (R)	KVA3PX MAX LO[d]	kVA	–32768	32767	0	1	681
582 (R)	KVA3PX MIN HI[d]	kVA	–32768	32767	0	1	682
583 (R)	KVA3PX MIN LO[d]	kVA	–32768	32767	0	1	683
584 (R)	KW3PY MAX HI[d]	kW	–32768	32767	0	1	684
585 (R)	KW3PY MAX LO[d]	kW	–32768	32767	0	1	685
586 (R)	KW3PY MIN HI[d]	kW	–32768	32767	0	1	686
587 (R)	KW3PY MIN LO[d]	kW	–32768	32767	0	1	687
588 (R)	KVAR3PY MAX HI[d]	kVAR	–32768	32767	0	1	688
589 (R)	KVAR3PY MAX LO[d]	kVAR	–32768	32767	0	1	689
590 (R)	KVAR3PY MIN HI[d]	kVAR	–32768	32767	0	1	690
591 (R)	KVAR3PY MIN LO[d]	kVAR	–32768	32767	0	1	691
592 (R)	KVA3PY MAX HI[d]	kVA	–32768	32767	0	1	692
593 (R)	KVA3PY MAX LO[d]	kVA	–32768	32767	0	1	693
594 (R)	KVA3PY MIN HI[d]	kVA	–32768	32767	0	1	694
595 (R)	KVA3PY MIN LO[d]	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
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

Table E.34 Modbus Register Map[a] (Sheet 10 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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[d]							
624 (R)	AI301 MX—HI[d]	EU	–32768	32767	0	0.001	724
625 (R)	AI301 MX—LO[d]	EU	–32768	32767	0	0.001	725
626 (R)	AI301 MN—HI[d]	EU	–32768	32767	0	0.001	726
627 (R)	AI301 MN—LO[d]	EU	–32768	32767	0	0.001	727
628 (R)	AI302 MX—HI[d]	EU	–32768	32767	0	0.001	728
629 (R)	AI302 MX—LO[d]	EU	–32768	32767	0	0.001	729
630 (R)	AI302 MN—HI[d]	EU	–32768	32767	0	0.001	730
631 (R)	AI302 MN—LO[d]	EU	–32768	32767	0	0.001	731
632 (R)	AI303 MX—HI[d]	EU	–32768	32767	0	0.001	732
633 (R)	AI303 MX—LO[d]	EU	–32768	32767	0	0.001	733
634 (R)	AI303 MN—HI[d]	EU	–32768	32767	0	0.001	734
635 (R)	AI303 MN—LO[d]	EU	–32768	32767	0	0.001	735
636 (R)	AI304 MX—HI[d]	EU	–32768	32767	0	0.001	736
637 (R)	AI304 MX—LO[d]	EU	–32768	32767	0	0.001	737
638 (R)	AI304 MN—HI[d]	EU	–32768	32767	0	0.001	738
639 (R)	AI304 MN—LO[d]	EU	–32768	32767	0	0.001	739
MAX/MIN AI4 Data[d]							
640 (R)	AI401 MX—HI[d]	EU	–32768	32767	0	0.001	740
641 (R)	AI401 MX—LO[d]	EU	–32768	32767	0	0.001	741
642 (R)	AI401 MN—HI[d]	EU	–32768	32767	0	0.001	742
643 (R)	AI401 MN—LO[d]	EU	–32768	32767	0	0.001	743
644 (R)	AI402 MX—HI[d]	EU	–32768	32767	0	0.001	744
645 (R)	AI402 MX—LO[d]	EU	–32768	32767	0	0.001	745
646 (R)	AI402 MN—HI[d]	EU	–32768	32767	0	0.001	746
647 (R)	AI402 MN—LO[d]	EU	–32768	32767	0	0.001	747
648 (R)	AI403 MX—HI[d]	EU	–32768	32767	0	0.001	748
649 (R)	AI403 MX—LO[d]	EU	–32768	32767	0	0.001	749
650 (R)	AI403 MN—HI[d]	EU	–32768	32767	0	0.001	750
651 (R)	AI403 MN—LO[d]	EU	–32768	32767	0	0.001	751
652 (R)	AI404 MX—HI[d]	EU	–32768	32767	0	0.001	752
653 (R)	AI404 MX—LO[d]	EU	–32768	32767	0	0.001	753
654 (R)	AI404 MN—HI[d]	EU	–32768	32767	0	0.001	754
655 (R)	AI404 MN—LO[d]	EU	–32768	32767	0	0.001	755
MAX/MIN AI5 Data							
656 (R)	AI501 MX—HI[d d]	EU	–32768	32767	0	0.001	756
657 (R)	AI501 MX—LO[d]	EU	–32768	32767	0	0.001	757
658 (R)	AI501 MN—HI[d d]	EU	–32768	32767	0	0.001	758
659 (R)	AI501 MN—LO[d]	EU	–32768	32767	0	0.001	759
660 (R)	AI502 MX—HI[d d]	EU	–32768	32767	0	0.001	760

Table E.34 Modbus Register Map[a] (Sheet 11 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
661 (R)	AI502 MX—LO[d]	EU	–32768	32767	0	0.001	761
662 (R)	AI502 MN—HI[d d]	EU	–32768	32767	0	0.001	762
663 (R)	AI502 MN—LO[d]	EU	–32768	32767	0	0.001	763
664 (R)	AI503 MX—HI[d d]	EU	–32768	32767	0	0.001	764
665 (R)	AI503 MX—LO[d]	EU	–32768	32767	0	0.001	765
666 (R)	AI503 MN—HI[d]	EU	–32768	32767	0	0.001	766
667 (R)	AI503 MN—LO[d]	EU	–32768	32767	0	0.001	767
668 (R)	AI504 MX—HI[d]	EU	–32768	32767	0	0.001	768
669 (R)	AI504 MX—LO[d]	EU	–32768	32767	0	0.001	769
670 (R)	AI504 MN—HI[d]	EU	–32768	32767	0	0.001	770
671 (R)	AI504 MN—LO[d]	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[c]		0	0	0		778–781
Analog Input Data							
682 (R)	AI301—HI[d]	EU	–32768	32767	0	0.001	782
683 (R)	AI301—LO[d]	EU	–32768	32767	0	0.001	783
684 (R)	AI302—HI[d]	EU	–32768	32767	0	0.001	784
685 (R)	AI302—LO[d]	EU	–32768	32767	0	0.001	785
686 (R)	AI303—HI[d]	EU	–32768	32767	0	0.001	786
687 (R)	AI303—LO[d]	EU	–32768	32767	0	0.001	787
688 (R)	AI304—HI[d]	EU	–32768	32767	0	0.001	788
689 (R)	AI304—LO[d]	EU	–32768	32767	0	0.001	789
690 (R)	AI401—HI[d]	EU	–32768	32767	0	0.001	790
691 (R)	AI401—LO[d]	EU	–32768	32767	0	0.001	791
692 (R)	AI402—HI[d]	EU	–32768	32767	0	0.001	792
693 (R)	AI402—LO[d]	EU	–32768	32767	0	0.001	793
694 (R)	AI403—HI[d]	EU	–32768	32767	0	0.001	794
695 (R)	AI403—LO[d]	EU	–32768	32767	0	0.001	795
696 (R)	AI404—HI[d]	EU	–32768	32767	0	0.001	796
697 (R)	AI404—LO[d]	EU	–32768	32767	0	0.001	797
698 (R)	AI501—HI[d]	EU	–32768	32767	0	0.001	798
699 (R)	AI501—LO[d]	EU	–32768	32767	0	0.001	799
700 (R)	AI502—HI[d]	EU	–32768	32767	0	0.001	800
701 (R)	AI502—LO[d]	EU	–32768	32767	0	0.001	801
702 (R)	AI503—HI[d]	EU	–32768	32767	0	0.001	802
703 (R)	AI503—LO[d]	EU	–32768	32767	0	0.001	803
704 (R)	AI504—HI[d]	EU	–32768	32767	0	0.001	804
705 (R)	AI504—LO[d]	EU	–32768	32767	0	0.001	805

Table E.34 Modbus Register Map[a] (Sheet 12 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
Math Variables							
706 (R)	MV01—HI[d]		–32768	32767	0	0.01	806
707 (R)	MV01—LO[d]		–32768	32767	0	0.01	807
708 (R)	MV02—HI[d]		–32768	32767	0	0.01	808
709 (R)	MV02—LO[d]		–32768	32767	0	0.01	809
710 (R)	MV03—HI[d]		–32768	32767	0	0.01	810
711 (R)	MV03—LO[d]		–32768	32767	0	0.01	811
712 (R)	MV04—HI[d]		–32768	32767	0	0.01	812
713 (R)	MV04—LO[d]		–32768	32767	0	0.01	813
714 (R)	MV05—HI[d]		–32768	32767	0	0.01	814
715 (R)	MV05—LO[d]		–32768	32767	0	0.01	815
716 (R)	MV06—HI[d]		–32768	32767	0	0.01	816
717 (R)	MV06—LO[d]		–32768	32767	0	0.01	817
718 (R)	MV07—HI[d]		–32768	32767	0	0.01	818
719 (R)	MV07—LO[d]		–32768	32767	0	0.01	819
720 (R)	MV08—HI[d]		–32768	32767	0	0.01	820
721 (R)	MV08—LO[d]		–32768	32767	0	0.01	821
722 (R)	MV09—HI[d]		–32768	32767	0	0.01	822
723 (R)	MV09—LO[d]		–32768	32767	0	0.01	823
724 (R)	MV10—HI[d]		–32768	32767	0	0.01	824
725 (R)	MV10—LO[d]		–32768	32767	0	0.01	825
726 (R)	MV11—HI[d]		–32768	32767	0	0.01	826
727 (R)	MV11—LO[d]		–32768	32767	0	0.01	827
728 (R)	MV12—HI[d]		–32768	32767	0	0.01	828
729 (R)	MV12—LO[d]		–32768	32767	0	0.01	829
730 (R)	MV13—HI[d]		–32768	32767	0	0.01	830
731 (R)	MV13—LO[d]		–32768	32767	0	0.01	831
732 (R)	MV14—HI[d]		–32768	32767	0	0.01	832
733 (R)	MV14—LO[d]		–32768	32767	0	0.01	833
734 (R)	MV15—HI[d]		–32768	32767	0	0.01	834
735 (R)	MV15—LO[d]		–32768	32767	0	0.01	835
736 (R)	MV16—HI[d]		–32768	32767	0	0.01	836
737 (R)	MV16—LO[d]		–32768	32767	0	0.01	837
738 (R)	MV17—HI[d]		–32768	32767	0	0.01	838
739 (R)	MV17—LO[d]		–32768	32767	0	0.01	839
740 (R)	MV18—HI[d]		–32768	32767	0	0.01	840
741 (R)	MV18—LO[d]		–32768	32767	0	0.01	841
742 (R)	MV19—HI[d]		–32768	32767	0	0.01	842
743 (R)	MV19—LO[d]		–32768	32767	0	0.01	843
744 (R)	MV20—HI[d]		–32768	32767	0	0.01	844
745 (R)	MV20—LO[d]		–32768	32767	0	0.01	845
746 (R)	MV21—HI[d]		–32768	32767	0	0.01	846
747 (R)	MV21—LO[d]		–32768	32767	0	0.01	847
748 (R)	MV22—HI[d]		–32768	32767	0	0.01	848
749 (R)	MV22—LO[d]		–32768	32767	0	0.01	849

Table E.34 Modbus Register Map[a] (Sheet 13 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
750 (R)	MV23—HI[d]		–32768	32767	0	0.01	850
751 (R)	MV23—LO[d]		–32768	32767	0	0.01	851
752 (R)	MV24—HI[d]		–32768	32767	0	0.01	852
753 (R)	MV24—LO[d]		–32768	32767	0	0.01	853
754 (R)	MV25—HI[d]		–32768	32767	0	0.01	854
755 (R)	MV25—LO[d]		–32768	32767	0	0.01	855
756 (R)	MV26—HI[d]		–32768	32767	0	0.01	856
757 (R)	MV26—LO[d]		–32768	32767	0	0.01	857
758 (R)	MV27—HI[d]		–32768	32767	0	0.01	858
759 (R)	MV27—LO[d]		–32768	32767	0	0.01	859
760 (R)	MV28—HI[d]		–32768	32767	0	0.01	860
761 (R)	MV28—LO[d]		–32768	32767	0	0.01	861
762 (R)	MV29—HI[d]		–32768	32767	0	0.01	862
763 (R)	MV29—LO[d]		–32768	32767	0	0.01	863
764 (R)	MV30—HI[d]		–32768	32767	0	0.01	864
765 (R)	MV30—LO[d]		–32768	32767	0	0.01	865
766 (R)	MV31—HI[d]		–32768	32767	0	0.01	866
767 (R)	MV31—LO[d]		–32768	32767	0	0.01	867
768 (R)	MV32—HI[d]		–32768	32767	0	0.01	868
769 (R)	MV32—LO[d]		–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[c]		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 Register Map[a] (Sheet 14 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
826 (R)	EVENT TYPE		0	30	0		926
	0 = TRIP* 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 = TRIP						
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 Register Map[a] (Sheet 15 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	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[c]		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[c]		0	0	0		999
900 (R)	Reserved[c]		0	0	0		1000

Table E.34 Modbus Register Map[a] (Sheet 16 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
Trip/Warn Data							
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 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 Register Map[a] (Sheet 17 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	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 through Bit 15 = Reserved		0	65535	0		1004
905–909 (R)	Reserved[c]		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[c]		0	0	0		1020–1025
Y-Side Power Data							
926 (R)	PAY REAL PWR HI[d]	kW	–32768	32767	0	1	1026
927 (R)	PAY REAL PWR LO[d]	kW	–32768	32767	0	1	1027
928 (R)	PBY REAL PWR HI[d]	kW	–32768	32767	0	1	1028
929 (R)	PBY REAL PWR LO[d]	kW	–32768	32767	0	1	1029
930 (R)	PCY REAL PWR HI[d]	kW	–32768	32767	0	1	1030
931 (R)	PCY REAL PWR LO[d]	kW	–32768	32767	0	1	1031
932 (R)	P3Y REAL PWR HI[d]	kW	–32768	32767	0	1	1032
933 (R)	P3Y REAL PWR LO[d]	kW	–32768	32767	0	1	1033
934 (R)	QAY REACTV PWRHI[d]	kVAR	–32768	32767	0	1	1034
935 (R)	QAY REACTV PWRLO[d]	kVAR	–32768	32767	0	1	1035
936 (R)	QBY REACTV PWRHI[d]	kVAR	–32768	32767	0	1	1036
937 (R)	QBY REACTV PWRLO[d]	kVAR	–32768	32767	0	1	1037
938 (R)	QCY REACTV PWRHI[d]	kVAR	–32768	32767	0	1	1038
939 (R)	QCY REACTV PWRLO[d]	kVAR	–32768	32767	0	1	1039
940 (R)	Q3Y REACTV PWRHI[d]	kVAR	–32768	32767	0	1	1040
941 (R)	Q3Y REACTV PWRLO[d]	kVAR	–32768	32767	0	1	1041
942 (R)	SAY APPRNT PWRHI[d]	kVA	–32768	32767	0	1	1042
943 (R)	SAY APPRNT PWRLO[d]	kVA	–32768	32767	0	1	1043
944 (R)	SBY APPRNT PWRHI[d]	kVA	–32768	32767	0	1	1044
945 (R)	SBY APPRNT PWRLO[d]	kVA	–32768	32767	0	1	1045
946 (R)	SCY APPRNT PWRHI[d]	kVA	–32768	32767	0	1	1046
947 (R)	SCY APPRNT PWRLO[d]	kVA	–32768	32767	0	1	1047
948 (R)	S3Y APPRNT PWRHI[d]	kVA	–32768	32767	0	1	1048
949 (R)	S3Y APPRNT PWRLO[d]	kVA	–32768	32767	0	1	1049
950 (R)	PFAY PWR FACTOR		–100	100	0	0.01	1050
951 (R)	PFBY PWR FACTOR		–100	100	0	0.01	1051

Table E.34 Modbus Register Map[a] (Sheet 18 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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[c]		0	0	0		1055–1070
Relay Elements							
971 (R)	ROW 0 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		1071
972 (R)	ROW 1 Bit 0 = 50PY2T Bit 1 = 50PY2P Bit 2 = 50PY1T Bit 3 = 50PY1P Bit 4 = 50PX2T Bit 5 = 50PX2P Bit 6 = 50PX1T Bit 7 = 50PX1P		0	255	0		1072
973 (R)	ROW 2 Bit 0 = ORED50T Bit 1 = * Bit 2 = 50PX3CT Bit 3 = 50PX3CP Bit 4 = 50PX3BT Bit 5 = 50PX3BP Bit 6 = 50PX3AT Bit 7 = 50PX3AP		0	255	0		1073
974 (R)	ROW 3 Bit 0 = * Bit 1 = * Bit 2 = 50PY3CT Bit 3 = 50PY3CP Bit 4 = 50PY3BT Bit 5 = 50PY3BP Bit 6 = 50PY3AT Bit 7 = 50PY3AP		0	255	0		1074
975 (R)	ROW 4 Bit 0 = 50QX2T Bit 1 = 50QX2P Bit 2 = 50QX1T Bit 3 = 50QX1P Bit 4 = 50GX2T Bit 5 = 50GX2P Bit 6 = 50GX1T Bit 7 = 50GX1P		0	255	0		1075

Table E.34 Modbus Register Map[a] (Sheet 19 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
976 (R)	ROW 5 Bit 0 = 50QY2T Bit 1 = 50QY2P Bit 2 = 50QY1T Bit 3 = 50QY1P Bit 4 = 50GY2T Bit 5 = 50GY2P Bit 6 = 50GY1T Bit 7 = 50GY1P		0	255	0		1076
977 (R)	ROW 6 Bit 0 = 67GY2T Bit 1 = 67GY2P Bit 2 = 67GY1T Bit 3 = 67GY1P Bit 4 = 67GX2T Bit 5 = 67GX2P Bit 6 = 67GX1T Bit 7 = 67GX1P		0	255	0		1077
978 (R)	ROW 7 Bit 0 = 67QY2T Bit 1 = 67QY2P Bit 2 = 67QY1T Bit 3 = 67QY1P Bit 4 = 67PY2T Bit 5 = 67PY2P Bit 6 = 67PY1T Bit 7 = 67PY1P		0	255	0		1078
979 (R)	ROW 8 Bit 0 = 46Q2T Bit 1 = 46Q2 Bit 2 = 46Q1T Bit 3 = 46Q1 Bit 4 = 50N2T Bit 5 = 50N2P Bit 6 = 50N1T Bit 7 = 50N1P		0	255	0		1079
980 (R)	ROW 9 Bit 0 = ORED51T Bit 1 = * Bit 2 = 51GXT Bit 3 = 51GXP Bit 4 = 51QXT Bit 5 = 51QXP Bit 6 = 51PXT Bit 7 = 51PXP		0	255	0		1080
981 (R)	ROW 10 Bit 0 = 51NT Bit 1 = 51NP Bit 2 = 51GYT Bit 3 = 51GYP Bit 4 = 51QYT Bit 5 = 51QYP Bit 6 = 51PYT Bit 7 = 51PYP		0	255	0		1081

Table E.34 Modbus Register Map[a] (Sheet 20 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
982 (R)	ROW 11 Bit 0 = 87R Bit 1 = 87R3 Bit 2 = 87R2 Bit 3 = 87R1 Bit 4 = 87U Bit 5 = 87U3 Bit 6 = 87U2 Bit 7 = 87U1		0	255	0		1082
983 (R)	ROW 12 Bit 0 = 40Z2T Bit 1 = 40Z2 Bit 2 = 40Z1T Bit 3 = 40Z1 Bit 4 = 87N2T Bit 5 = 87N2 Bit 6 = 87N1T Bit 7 = 87N1		0	255	0		1083
984 (R)	ROW 13 Bit 0 = * Bit 1 = REF1BYP Bit 2 = REF1P Bit 3 = REF1R Bit 4 = REF1F Bit 5 = 50GREF1 Bit 6 = REF1EN Bit 7 = 50NREF1		0	255	0		1084
985 (R)	ROW 14 Bit 0 = 51CT Bit 1 = 51C Bit 2 = N64G Bit 3 = T64G Bit 4 = 64G2T Bit 5 = 64G2 Bit 6 = 64G1T Bit 7 = 64G1		0	255	0		1085
986 (R)	ROW 15 Bit 0 = 51VT Bit 1 = 51V Bit 2 = * Bit 3 = 64FFLT Bit 4 = 64F2T Bit 5 = 64F2 Bit 6 = 64F1T Bit 7 = 64F1		0	255	0		1086
987 (R)	ROW 16 Bit 0 = 27PY2T Bit 1 = 27PY2 Bit 2 = 27PY1T Bit 3 = 27PY1 Bit 4 = 27PX2T Bit 5 = 27PX2 Bit 6 = 27PX1T Bit 7 = 27PX1		0	255	0		1087

Table E.34 Modbus Register Map[a] (Sheet 21 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
988 (R)	ROW 17 Bit 0 = 59PY2T Bit 1 = 59PY2 Bit 2 = 59PY1T Bit 3 = 59PY1 Bit 4 = 59PX2T Bit 5 = 59PX2 Bit 6 = 59PX1T Bit 7 = 59PX1		0	255	0		1088
989 (R)	ROW 18 Bit 0 = 59GX2T Bit 1 = 59GX2 Bit 2 = 59GX1T Bit 3 = 59GX1 Bit 4 = 59QX2T Bit 5 = 59QX2 Bit 6 = 59QX1T Bit 7 = 59QX1		0	255	0		1089
990 (R)	ROW 19 Bit 0 = 59GY2T Bit 1 = 59GY2 Bit 2 = 59GY1T Bit 3 = 59GY1 Bit 4 = 59QY2T Bit 5 = 59QY2 Bit 6 = 59QY1T Bit 7 = 59QY1		0	255	0		1090
991 (R)	ROW 20 Bit 0 = 3PWRX4T Bit 1 = 3PWRX4P Bit 2 = 3PWRX3T Bit 3 = 3PWRX3P Bit 4 = 3PWRX2T Bit 5 = 3PWRX2P Bit 6 = 3PWRX1T Bit 7 = 3PWRX1P		0	255	0		1091
992 (R)	ROW 21 Bit 0 = 3PWRY4T Bit 1 = 3PWRY4P Bit 2 = 3PWRY3T Bit 3 = 3PWRY3P Bit 4 = 3PWRY2T Bit 5 = 3PWRY2P Bit 6 = 3PWRY1T Bit 7 = 3PWRY1P		0	255	0		1092
993 (R)	ROW 22 Bit 0 = BNDT Bit 1 = 81RT Bit 2 = * Bit 3 = 24CR Bit 4 = 24C2T Bit 5 = 24C2 Bit 6 = 24D1T Bit 7 = 24D1		0	255	0		1093

Table E.34 Modbus Register Map[a] (Sheet 22 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
994 (R)	ROW 23 Bit 0 = RTDFLT Bit 1 = RTDT Bit 2 = 49T Bit 3 = 49A Bit 4 = INADT Bit 5 = INAD Bit 6 = BFTY Bit 7 = BFTX		0	255	0		1094
995 (R)	ROW 24 Bit 0 = 21C2T Bit 1 = 21C2P Bit 2 = 21C1T Bit 3 = 21C1P Bit 4 = MABC2P Bit 5 = MPP2P Bit 6 = MABC1P Bit 7 = MPP1P		0	255	0		1095
996 (R)	ROW 25 Bit 0 = TRIP Bit 1 = * Bit 2 = PMTRIG Bit 3 = ER Bit 4 = COMMFLT Bit 5 = COMMLOSS Bit 6 = COMMIDLE Bit 7 = REMTRIP		0	255	0		1096
997 (R)	ROW 26 Bit 0 = 87HR Bit 1 = 87HR3 Bit 2 = 87HR2 Bit 3 = 87HR1 Bit 4 = 87HB Bit 5 = 87BL3 Bit 6 = 87BL2 Bit 7 = 87BL1		0	255	0		1097
998 (R)	ROW 27 Bit 0 = 3P27Y Bit 1 = 3P27X Bit 2 = 3P59Y Bit 3 = 3P59X Bit 4 = 51VR Bit 5 = 51CR Bit 6 = TH5T Bit 7 = TH5		0	255	0		1098
999 (R)	ROW 28 Bit 0 = 59S2T Bit 1 = 59S2 Bit 2 = 59S1T Bit 3 = 59S1 Bit 4 = 27S2T Bit 5 = 27S2 Bit 6 = 27S1T Bit 7 = 27S1		0	255	0		1099
1000–1015 (R)	ROW 29–ROW 44		0	255	0		1100–1115

Table E.34 Modbus Register Map[a] (Sheet 23 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1016 (R)	ROW 45		0	255	0		1116
	Bit 0 = *						
	Bit 1 = *						
	Bit 2 = *						
	Bit 3 = *						
	Bit 4 = *						
	Bit 5 = OUT103						
	Bit 6 = OUT102						
	Bit 7 = OUT101						
1017 (R)	ROW 46		0	255	0		1117
	Bit 0 = OUT308						
	Bit 1 = OUT307						
	Bit 2 = OUT306						
	Bit 3 = OUT305						
	Bit 4 = OUT304						
	Bit 5 = OUT303						
	Bit 6 = OUT302						
	Bit 7 = OUT301						
1018 (R)	ROW 47		0	255	0		1118
	Bit 0 = OUT408						
	Bit 1 = OUT407						
	Bit 2 = OUT406						
	Bit 3 = OUT405						
	Bit 4 = OUT404						
	Bit 5 = OUT403						
	Bit 6 = OUT402						
	Bit 7 = OUT401						
1019 (R)	ROW 48		0	255	0		1119
	Bit 0 = OUT508						
	Bit 1 = OUT507						
	Bit 2 = OUT506						
	Bit 3 = OUT505						
	Bit 4 = OUT504						
	Bit 5 = OUT503						
	Bit 6 = OUT502						
	Bit 7 = OUT501						
1020 (R)	ROW 49		0	255	0		1120
	Bit 0 = *						
	Bit 1 = *						
	Bit 2 = *						
	Bit 3 = *						
	Bit 4 = *						
	Bit 5 = *						
	Bit 6 = IN102						
	Bit 7 = IN10I						
1021 (R)	ROW 50		0	255	0		1121
	Bit 0 = IN308						
	Bit 1 = IN307						
	Bit 2 = IN306						
	Bit 3 = IN305						
	Bit 4 = IN304						
	Bit 5 = IN303						
	Bit 6 = IN302						
	Bit 7 = IN301						

Table E.34 Modbus Register Map[a] (Sheet 24 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1022 (R)	ROW 51 Bit 0 = IN408 Bit 1 = IN407 Bit 2 = IN406 Bit 3 = IN405 Bit 4 = IN404 Bit 5 = IN403 Bit 6 = IN402 Bit 7 = IN401		0	255	0		1122
1023 (R)	ROW 52 Bit 0 = IN508 Bit 1 = IN507 Bit 2 = IN506 Bit 3 = IN505 Bit 4 = IN504 Bit 5 = IN503 Bit 6 = IN502 Bit 7 = IN501		0	255	0		1123
1024–1119 (R)	ROW 53–ROW 152		0	255	0		1124–1223
1124 (R)	Reserved[c]		0	0	0		1224
Control I/O Commands							
2000H 6	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 6	RESET COMMAND Bit 0 = Trip Reset Bit 1 = Reserved Bit 2 = Reset Stat Data Bit 3 = Reset Hist Data Bit 4 = Reset Comm Cntr Bit 5 = Reserved 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 = Reserved Bits 14 = Reserved Bits 15 = Reserved		0	4095	0	na	

Table E.34 Modbus Register Map[a] (Sheet 25 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
Relay Elements							
2100H (R)	FAST STATUS 0 Bit 0 = Faulted Bit 1 = Warning Bit 2 = IN1/IN101 Status Bit 3 = IN2/IN102 Status Bit 4 = IN3/IN401 Status Bit 5 = IN4/IN402 Status Bit 6 = IN5/IN403 Status Bit 7 = Reserved Bit 8 = AUX1/OUT101 Status Bit 9 = AUX2/OUT102 Status Bit 10 = AUX3/OUT401 Status Bit 11 = AUX4/OUT402 Status Bit 12 = AUX5/OUT403 Status Bit 13 = AUX6/OUT404 Status Bit 14 and Bit 15 = Reserved		0	65535	0	na	
2101H (R)	FAST STATUS 1 Bit 0 = Enabled Bit 1 = Reserved Bit 2 = IN6/IN404 Status Bit 3 = IN7/IN501 Status Bit 4 = IN8/IN502 Status Bit 5 = IN9/IN503 Status Bit 6 = IN10/IN504 Status Bit 7 = Reserved Bit 8 = AUX7/OUT501 Status Bit 9 = AUX8/OUT502 Status Bit 10 = AUX9/OUT503 Status Bit 11 = AUX10/OUT504 Status Bit 12 through Bit 15 = Reserved		0	65535	0	na	
2102H (R)	TRIP STATUS LO[d]					na	
2103H (R)	TRIP STATUS HI[d]					na	
2104H (R)	WARN STATUS LO[d]					na	
2105H (R)	WARN STATUS HI[d]					na	
2106H (R)	AVERAGE CURRENT					na	
2107H (R)	IAX CURRENT					na	
2108H (R)	IBX CURRENT					na	
2109H (R)	ICX CURRENT					na	
210AH (R)	Reserved[c]					na	
210BH (R)	Reserved[c]					na	
210CH (R)	Reserved[c]					na	
210DH (R)	IGX CURRENT					na	
210EH (R)	IN CURRENT					na	
210FH (R)	Reserved[c]					na	

Table E.34 Modbus Register Map[a] (Sheet 26 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
2110H (R)	FAST STATUS 2 Bit 0 = IN11/IN301 Status Bit 1 = IN12/IN302 Status Bit 2 = IN13/IN303 Status Bit 3 = IN14/IN304 Status Bit 4 = OUT11/OUT301 Status Bit 5 = OUT12/OUT302 Status Bit 6 = OUT13/OUT303 Status Bit 7 = OUT14/OUT304 Status Bit 8 = IN15/IN305 Status Bit 9 = IN16/IN306 Status Bit 10 = IN17/IN307 Status Bit 11 = IN18/IN308 Status Bit 12 through Bit 15 = Reserved		0	65535	0	na	
2111H (R)	FAST STATUS 3 Bit 0 = IN19/IN405 Status Bit 1 = IN20/IN406 Status Bit 2 = IN21/IN407 Status Bit 3 = IN22/IN408 Status Bit 4 = IN23/IN505 Status Bit 5 = IN24/IN506 Status Bit 6 = IN25/IN507 Status Bit 7 = IN26/IN508 Status Bit 8 through Bit 15 = Reserved		0	65535	0	na	
PAR Group Indices							
3000H (R)	Reserved[c]		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	
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	

Table E.34 Modbus Register Map[a] (Sheet 27 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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	1124	971	1	
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	1124	na	
4006H (R)	NUM OF PAR GROUP		1	100	35	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 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 through Bit 15 = Reserved		0	31	0	na	
400AH	not used						
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	not used	ms					

Table E.34 Modbus Register Map[a] (Sheet 28 of 28)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
400FH (R)	PRODUCT SUPPORT BITS Bit 0 = 2nd IO Card installed Bit 1 through Bit 15 = Reserved					na	
4010H (R/W)	SETTINGS TIMEOUT		500	65535	750	na	
4011H	Reserved[c]						
4012H	Reserved[c]						
4013H	Reserved[c]						
4014H (R)	CONFIGURED BIT Bit 0 = Unit Configured Bit 1through Bit 15 = Reserved				0	na	
4015H (R)	Reserved[c]		0	0	0	na	
4016H (R)	ERROR REGISTER Bit 0 through Bit 15 = Reserved		0	65535	0	na	
4017H (R)	ERROR ADDRESS		0	65535	0	na	
4018H–401FH (R)	Reserved[c]		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]Reserved addresses return 0.
[d]HI and LO are a pair of registers that represent the high word and the low word of 32-bit values. The full 32-bit number is formed by combining the two registers before interpreting the magnitude of the 32-bit quantity.

Appendix F
IEC 61850 Communications

Features

NOTE: The SEL-700G supports one CID file, which should be transferred only if a change in the relay configuration is necessary. If an invalid CID file is transferred, the relay will no longer have a valid IEC 61850 configuration, and the protocol will stop operating. To restart protocol operation, a valid CID must be transferred to the relay.

The SEL-700G Relay supports the following features using Ethernet and IEC 61850:

- SCADA—Connect as many as six simultaneous IEC 61850 MMS client sessions. The SEL-700G also supports as many as six buffered and six unbuffered report control blocks. See the CON Logical Device Table for Logical Node mapping that enables SCADA control via a Manufacturing Messaging Specification (MMS) browser. Controls support the direct control, Select Before Operate control (SBO), and SBO with enhanced security control models.
- Peer-to-Peer Real-Time Status and Control—Use GOOSE with as many as 16 incoming (receive) and 8 outgoing (transmit) messages. virtual bits (VB001–VB128) 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 MMS Object Explorer and AX-S4 MMS from Sisco, Inc., to browse the relay logical nodes and verify functionality.

This appendix presents the information you need to use the IEC 61850 features of the SEL-700G:

- Introduction to IEC 61850
- IEC 61850 Operation
- IEC 61850 Configuration
- Logical Nodes
- Logical Node Extensions
- Protocol Implementation Conformance Statement
- ACSI Conformance Statement

Introduction to IEC 61850

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 F.1*.

Table F.1 IEC 61850 Document Set

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	Communication requirements
IEC 61850-6	Configuration description language for substation IEDs
IEC 61850-7-1	Basic communication structure for substations and feeder equipment-Principles and models
IEC 61850-7-2	Basic communication structure for substations and feeder equipment—Abstract Communication Service Interface (ACSI)
IEC 61850-7-3	Basic communication structure for substations and feeder equipment-Common data classes
IEC 61850-7-4	Basic communication structure for substations and feeder equipment—Compatible logical node (LN) classes and data classes
IEC 61850-8-1	SCSM-Mapping to Manufacturing Messaging Specification (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 http://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 these documents.

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 Ethernet port supports IEC 61850 services, including transport of Logical Node objects, over TCP/IP. The Ethernet port can coordinate a maximum of six concurrent IEC 61850 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. These abstract models are used 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.

Logical nodes can be organized 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 F.2* shows how the A-phase current expressed as MMXUAphsA$cVal is broken down into its component parts.

Table F.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	Phase A
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 61850-5:2003(E) and IEC 61850-7-4:2003(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 F.3* for descriptions of the Logical Devices in an SEL-700G. See Logical Nodes for a description of the LNs that make up these Logical Devices.

Table F.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

MMS

Manufacturing Messaging Specification (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 that start, and why the IEC chose to keep it for IEC 61850.

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 ACSELERATOR Architect software. Also, configure outgoing GOOSE messages for SEL devices in ACSELERATOR Architect. See the ACSELERATOR 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: Device bits mapped to GOOSE subscriptions retain state until overwritten, a new CID file is loaded, or the device is restarted. To reset the device bits 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 using the ACSELERATOR Architect software. See the VB*nnn* bits in *Table F.14* 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.

File Services

The Ethernet File System allows reading or writing data as files. The File System supports FTP. The File System provides:

- ➤ A means for the devices to transfer data as files
- ➤ A hierarchical file structure for the device data (root level only for SEL-700 series devices)

SCL Files

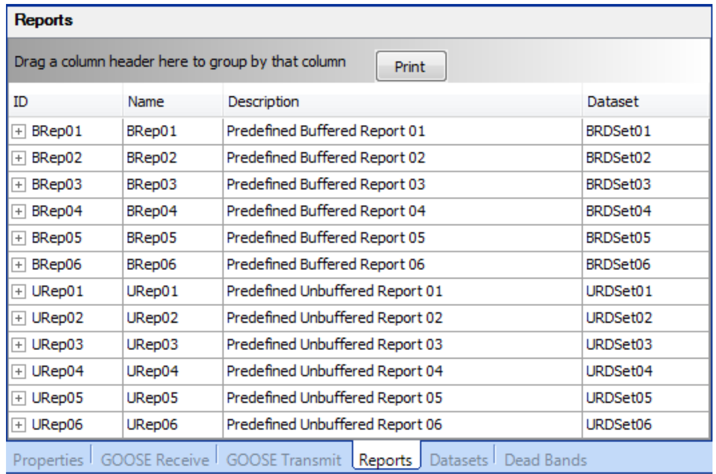
Substation Configuration Language (SCL) is an XML-based configuration language used to support the exchange of database configuration data between different tools, which may come from different manufacturers. There are four types of SCL files:

- ➤ 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.

Reports

The SEL-700G supports buffered and unbuffered report control blocks in the report model as defined in IEC 61850-8-1:2004(E). The predefined reports shown in *Figure F.1* are available by default via IEC 61850.



ID	Name	Description	Dataset
BRep01	BRep01	Predefined Buffered Report 01	BRDSet01
BRep02	BRep02	Predefined Buffered Report 02	BRDSet02
BRep03	BRep03	Predefined Buffered Report 03	BRDSet03
BRep04	BRep04	Predefined Buffered Report 04	BRDSet04
BRep05	BRep05	Predefined Buffered Report 05	BRDSet05
BRep06	BRep06	Predefined Buffered Report 06	BRDSet06
URep01	URep01	Predefined Unbuffered Report 01	URDSet01
URep02	URep02	Predefined Unbuffered Report 02	URDSet02
URep03	URep03	Predefined Unbuffered Report 03	URDSet03
URep04	URep04	Predefined Unbuffered Report 04	URDSet04
URep05	URep05	Predefined Unbuffered Report 05	URDSet05
URep06	URep06	Predefined Unbuffered Report 06	URDSet06

Figure F.1 SEL-700G Predefined Reports

There are 12 report control blocks, six buffered reports and six unbuffered. For each report control block, there can be just one client association, that is, only one client can be associated to a report control block (BRCB or URCB) at any given time. The number of reports (12) and the type of reports (buffered or unbuffered) cannot be changed. However, by using ACSELERATOR 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 F.4*.

Table F.4 Buffered Report Control Block Client Access

RCB Attribute	User changeable (Report Disabled)	User changeable (Report Enabled)	Default Values
RptId	YES		BRep01–BRep06
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 a command is accepted, it 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 F.5*.

Table F.5 Unbuffered Report Control Block Client Access

RCB Attribute	User changeable (Report Disabled)	User changeable (Report Enabled)	Default Values
RptId	YES		URep01–URep06
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]	0

[a] Exhibits a pulse behavior. Write a one to issue the command. Once command is accepted, it 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 six (6) 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 their 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.

Datasets

Datasets are configured using ACSELERATOR Architect and contain data attributes that represent real data values within the SEL-700G device. See *Logical Nodes* for the logical node tables that list the available data attributes for each logical node and the Relay Word bit mapping for these data attributes.

The datasets listed in *Figure F.2* are the defaults for an SEL-700G device. Datasets BRDSet01–BRDSet06 and URDSet01–URDSet06 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.

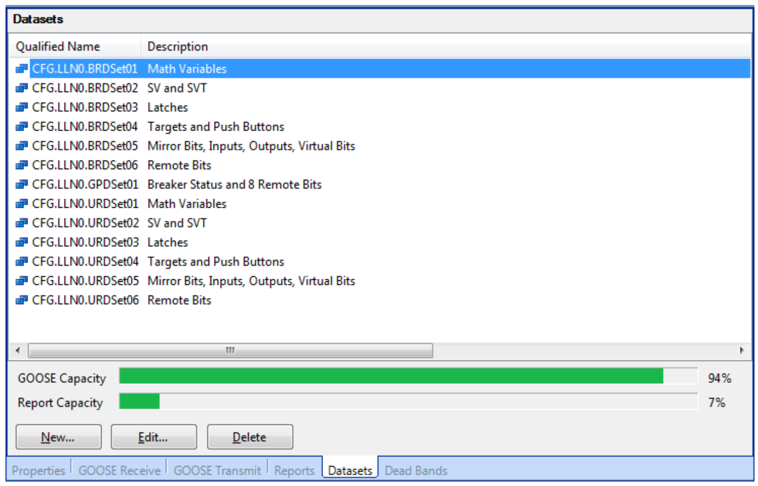


Figure F.2 SEL-700G Datasets

Within ACSELERATOR Architect, IEC 61850 datasets have two main purposes:

- GOOSE—You can use predefined or edited datasets, or create new datasets for outgoing GOOSE transmission.
- Reports—Twelve predefined datasets (BRDSet01 to BRDSet06 and URDSet01 to URDSet06) correspond to the default six buffered and six unbuffered reports. Note that you cannot change the number (12) or type of reports (buffered or unbuffered) within ACSELERATOR 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.

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.

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 MMS 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 data or quality change.

The timestamp is applied to all data and quality attributes (Boolean, Bstrings, Analogs, etc.) in the same fashion when the relay 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, that is, programmed in the SER report, the relay detects the change as the receipt of an SER record (which contains the SER timestamp) 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 dead band configured for the point to indicate a change and apply the timestamp. In all cases, these timestamps are used for the reporting model.

Functionally Constrained Data Attributes mapped to points assigned to the SER report have 4 ms SER-accurate timestamps for data change events. To ensure that you get SER-quality timestamps for changes to certain points, you must include those points in the SER report. All other FCDAs are scanned for data changes on a 1/2-second interval and have 1/2-second timestamp 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 F.3* 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 (for example, 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 ACSELERATOR Architect online help for additional information on GOOSE Quality attributes.

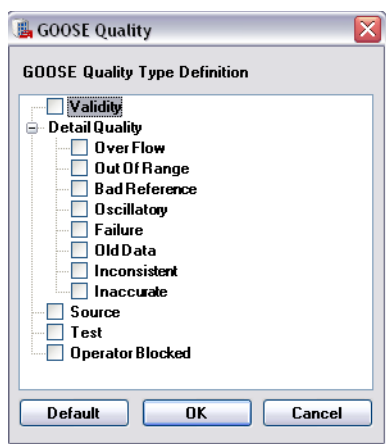


Figure F.3 GOOSE Quality

GOOSE Processing

SEL devices support GOOSE processing as defined by IEC 61850-7-1:2003(E), IEC 61850-7-2:2003(E), and IEC 61850-8-1:2004(E) via the installed Ethernet port. Outgoing GOOSE messages are processed in accordance with the following constraints:

- You can define as many as eight 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, or one or more times within the same outgoing GOOSE. A user can also map a single GOOSE dataset to multiple GOOSE control blocks.
- The SEL-700G transmits all configured GOOSE immediately upon successful initialization. If a GOOSE is not retriggered, then, following initial transmission, the SEL-700G retransmits that GOOSE on a curve. The curve begins at 10 ms and doubles for each retransmission until leveling at the maximum specified in the CID file for that GOOSE. For example, a message with a maximum retransmit interval of 100 ms is retransmitted at intervals of 10 ms, 20 ms, 40 ms, 80 ms, and 100 ms, then repeated every 100 ms until a trigger causes the transmission sequence to be repeated. The time-to-live reported in each transmitted message, is three times the current interval, or two times the interval, if the maximum time-to-live has been reached (30 ms, 60 ms, 120 ms, 240 ms, and 200 ms for the previous example; see IEC 61850-8-1, sec. 18.1).
- GOOSE transmission is squelched (silenced) after a permanent (latching) self-test failure.
- Each outgoing GOOSE includes communication 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 in accordance with the following constraints:

- You can configure the SEL-700G to subscribe to as many as 16 incoming GOOSE messages.

  The SEL-700G recognizes incoming GOOSE messages as valid based on the following content. Any GOOSE message that fails these checks shall be 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 61850-8-1:2004(E).

IEC 61850 Configuration

Settings

Table F.6 lists IEC 61850 settings. IEC 61850 settings are only available if your device includes the optional IEC 61850 protocol.

Table F.6 IEC 61850 Settings

Label	Description	Range	Default
E61850	IEC 61850 interface enable	Y, N	N
EGSE	Outgoing IEC 61850 GSE message enable	Y[a], N	N

[a] Requires E61850 set to Y to send IEC 61850 GSE messages.

Configure all other IEC 61850 settings, including subscriptions to incoming GOOSE messages, with ACSELERATOR Architect software.

ACSELERATOR Architect

The ACSELERATOR Architect Software enables users to design and commission IEC 61850 substations containing SEL IEDs. Users can use ACSELERATOR 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 will provide SEL IED descriptions to other manufacturers' tools so they can use SEL GOOSE messages and reporting features.
- Edit dead-band settings for measured values.

ACSELERATOR 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 dead-band value. ACSELERATOR Architect allows a dead band to be changed during the CID file configuration. Check and set the dead-band values for your particular application when configuring the CID file for a device.

ACSELERATOR Architect has the capability to read other manufacturers' ICD and CID files, enabling the user to map the data seamlessly into SEL IED logic. See the ACSELERATOR Architect online help for more information.

SEL ICD File Versions

ACSELERATOR Architect generates CID files from ICD files so the ICD file version ACSELERATOR Architect uses also determines the CID file version generated. Details about the different SEL-700G ICD files can be found in *Table A.4*.

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 F.7 New Logical Node Extensions

Logical Node	IEC 61850	Description or Comments
Thermal Measurements (for equipment or ambient temperature readings)	MTHR	This LN will 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 will be used for calculation of demand currents in a three-phase system. This shall not be used for billing purposes.
Circuit Breaker Supervision	SCBR	Circuit breaker supervision abrasion and operation values.

Table F.8 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 F.8 Thermal Metering Data Logical Node Class Definition (Sheet 1 of 2)

Data Object Name	Common Data Class	Explanation	T[a]	M/O/C/E[b]
MTHR Class				
LNName		The name will be composed of the class name, 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
Tmp01	MV	Temperature 1		E
Tmp02	MV	Temperature 2		E
Tmp03	MV	Temperature 3		E
Tmp04	MV	Temperature 4		E
Tmp05	MV	Temperature 5		E
Tmp06	MV	Temperature 6		E
Tmp07	MV	Temperature 7		E
Tmp08	MV	Temperature 8		E

Table F.8 Thermal Metering Data Logical Node Class Definition (Sheet 2 of 2)

Data Object Name	Common Data Class	Explanation	T[a]	M/O/C/E[b]
Tmp09	MV	Temperature 9		E
Tmp10	MV	Temperature 10		E
Tmp11	MV	Temperature 11		E
Tmp12	MV	Temperature 12		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 F.9 defines the MDST data class, Demand Metering Statistics. This class is a collection of demand currents and energy.

Table F.9 Demand Metering Statistics Logical Node Class Definition

Data Object Name	Common Data Class	Explanation	T[a]	M/O/C/E[b]
MDST Class				
LNName		The name shall be composed of the class name, 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
PkDmdA	WYE	Peak demand currents		E
SupWh	MV	Real energy supply (default supply direction: energy flow towards busbar)		E
SupVArh	MV	Reactive energy supply (default supply direction: energy flow towards busbar)		E
DmdWh	MV	Real energy demand (default demand direction: energy flow from busbar away)		E
DmdVArh	MV	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.

Table F.10 Circuit Breaker Supervision (Per-Phase) Logical Node Class Definition

Data Object Name	Common Data Class	Explanation	T[a]	M/O/C/E[b]
SCBR Class				
LNName		The name shall be composed of the class name, 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.

Table F.11 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.

Table F.12 Measurement Logical Node Class Definition (Sheet 1 of 2)

Data Object Name	Common Data Class	Explanation	T[a]	M/O/C/E[b]
MMXU Class				
LNName		The name shall be composed of the class name, 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

Table F.12 Measurement Logical Node Class Definition (Sheet 2 of 2)

Data Object Name	Common Data Class	Explanation	T[a]	M/O/C/E[b]
PPV	DEL	Phase-to-phase voltages		O
PhV	WYE	Phase-to-ground voltages		O
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 F.13 Measurement Logical Node Class Definition

Data Object Name	Common Data Class	Explanation	T[a]	M/O/C/E[b]
MMXU Class				
LNName		The name shall be composed of the class name, 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 F.14 Metering Statistics Logical Node Class Definition

Data Object Name	Common Data Class	Explanation	T[a]	M/O/C/E[b]
MSTA Class				
LNName		The name shall be composed of the class name, 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				
MaxAmps	MV	Maximum current		O
MinAmps	MV	Minimum current		O
MaxVA	MV	Maximum apparent power		O
MinVA	MV	Minimum apparent power		O
MaxW	MV	Maximum real power		O
MinW	MV	Minimum real power		O
MaxVAr	MV	Maximum reactive power		O
MinVAr	MV	Minimum reactive power		O
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 F.15 Circuit Breaker Logical Node Class Definition (Sheet 1 of 2)

Data Object Name	Common Data Class	Explanation	T[a]	M/O/C/E[b]
XCBR Class				
LNName		The name shall be composed of the class name, 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				
Loc	SPS	Local control behavior		M
OpCnt	INS	Operation counter		M
OpCntEx	INS	Operation counter–external		E

Table F.15 Circuit Breaker Logical Node Class Definition (Sheet 2 of 2)

Data Object Name	Common Data Class	Explanation	T[a]	M/O/C/E[b]
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.

Logical Nodes

The following tables, *Table F.16* through *Table F.20*, show the Logical Nodes (LN) supported in the SEL-700G and the associated Relay Word bits or measured quantities. *Table F.16* shows the LN associated with protection elements defined as Logical Device PRO.

Table F.16 Logical Device: PRO (Protection) (Sheet 1 of 11)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = CO			
BXCSWI1	Pos.Oper.ctlVal	CCX[a]	Close Breaker X
BYCSWI2	Pos.Oper.ctlVal	CCY[a]	Close Breaker Y
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PARTNO	Part number
Functional Constraint = ST[b]			
A49PTTR1	Op.general	49A	Thermal alarm
BXCSWI1	OpCls.general	CCX	Close Breaker X
BXCSWI1	OpOpn.general	OCX	Open Breaker X
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	0	Breaker/Contactor local control status not configured by default
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)
BYCSWI2	OpCls.general	CCY	Close Breaker Y
BYCSWI2	OpOpn.general	OCY	Open Breaker Y

Table F.16 Logical Device: PRO (Protection) (Sheet 2 of 11)

Logical Node	Attribute	Data Source	Comment
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
BYXCBR2	CBOpCap.stVal	None	Breaker/Contactor physical operation capabilities not known to relay
BYXCBR2	Loc.stVal	0	Breaker/Contactor local control status not configured by default
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
DPTOF15	Op.general	81T	ORed, X-side and Y-side, over- and underfrequency elements
DPTOF15	Str.general	81T	ORed, X-side and Y-side, over- and underfrequency elements
DPTOF15	Str.dirGeneral	unknown	Direction undefined
DXPTOF1	Op.general	81X1T	X-Side, Level 1, over- and underfrequency element

Table F.16 Logical Device: PRO (Protection) (Sheet 3 of 11)

Logical Node	Attribute	Data Source	Comment
DXPTOF1	Str.general	81X1T	X-Side, Level 1, over- and underfrequency element
DXPTOF1	Str.dirGeneral	unknown	Direction undefined
DXPTOF13	Op.general	81XT	ORed, X-side, over- and underfrequency elements
DXPTOF13	Str.general	81XT	ORed, X-side, over- and underfrequency elements
DXPTOF13	Str.dirGeneral	unknown	Direction undefined
DXPTOF2	Op.general	81X2T	X-Side, Level 2, over- and underfrequency element
DXPTOF2	Str.general	81X2T	X-Side, Level 2, over- and underfrequency element
DXPTOF2	Str.dirGeneral	unknown	Direction undefined
DXPTOF3	Op.general	81X3T	X-Side, Level 3, over- and underfrequency element
DXPTOF3	Str.general	81X3T	X-Side, Level 3, over- and underfrequency element
DXPTOF3	Str.dirGeneral	unknown	Direction undefined
DXPTOF4	Op.general	81X4T	X-Side, Level 4, over- and underfrequency element
DXPTOF4	Str.general	81X4T	X-Side, Level 4, over- and underfrequency element
DXPTOF4	Str.dirGeneral	unknown	Direction undefined
DXPTOF5	Op.general	81X5T	X-Side, Level 5, over- and underfrequency element
DXPTOF5	Str.general	81X5T	X-Side, Level 5, over- and underfrequency element
DXPTOF5	Str.dirGeneral	unknown	Direction undefined
DXPTOF6	Op.general	81X6T	X-Side, Level 6, over- and underfrequency element
DXPTOF6	Str.general	81X6T	X-Side, Level 6, over- and underfrequency element
DXPTOF6	Str.dirGeneral	unknown	Direction undefined
DYPTOF10	Op.general	81Y4T	Y-Side, Level 4, over- and underfrequency element
DYPTOF10	Str.general	81Y4T	Y-Side, Level 4, over- and underfrequency element
DYPTOF10	Str.dirGeneral	unknown	Direction undefined
DYPTOF11	Op.general	81Y5T	Y-Side, Level 5, over- and underfrequency element
DYPTOF11	Str.general	81Y5T	Y-Side, Level 5, over- and underfrequency element
DYPTOF11	Str.dirGeneral	unknown	Direction undefined
DYPTOF12	Op.general	81Y6T	Y-Side, Level 6, over- and underfrequency element
DYPTOF12	Str.general	81Y6T	Y-Side, Level 6, over- and underfrequency element
DYPTOF12	Str.dirGeneral	unknown	Direction undefined
DYPTOF14	Op.general	81YT	ORed, Y-side, over- and underfrequency elements
DYPTOF14	Str.general	81YT	ORed, Y-side, over- and underfrequency elements
DYPTOF14	Str.dirGeneral	unknown	Direction undefined
DYPTOF7	Op.general	81Y1T	Y-Side, Level 1, over- and underfrequency element
DYPTOF7	Str.general	81Y1T	Y-Side, Level 1, over- and underfrequency element
DYPTOF7	Str.dirGeneral	unknown	Direction undefined
DYPTOF8	Op.general	81Y2T	Y-Side, Level 2, over- and underfrequency element
DYPTOF8	Str.general	81Y2T	Y-Side, Level 2, over- and underfrequency element
DYPTOF8	Str.dirGeneral	unknown	Direction undefined
DYPTOF9	Op.general	81Y3T	Y-Side, Level 3, over- and underfrequency element

Table F.16 Logical Device: PRO (Protection) (Sheet 4 of 11)

Logical Node	Attribute	Data Source	Comment
DYPTOF9	Str.general	81Y3T	Y-Side, Level 3, over- and 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
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
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

Table F.16 Logical Device: PRO (Protection) (Sheet 5 of 11)

Logical Node	Attribute	Data Source	Comment
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 tip
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
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
LOPXPTUV5	Op.general	LOPX	X-side loss of potential
LOPXPTUV5	Str.general	LOPX	X-side loss of potential
LOPXPTUV5	Str.dirGeneral	unknown	Direction undefined

Table F.16 Logical Device: PRO (Protection) (Sheet 6 of 11)

Logical Node	Attribute	Data Source	Comment
LOPYPTUV6	Op.general	LOPY	Y-side loss of potential
LOPYPTUV6	Str.general	LOPY	Y-side loss of potential
LOPYPTUV6	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
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

Table F.16 Logical Device: PRO (Protection) (Sheet 7 of 11)

Logical Node	Attribute	Data Source	Comment
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
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 undervoltage 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 Phase A instantaneous overcurrent element trip
PXAPIOC3	Str.general	50PX3AP	X-Side, Level 3 Phase A instantaneous overcurrent element pickup
PXAPIOC3	Str.dirGeneral	unknown	Direction undefined
PXBPIOC4	Op.general	50PX3BT	X-Side, Level 3 Phase B instantaneous overcurrent element trip
PXBPIOC4	Str.general	50PX3BP	X-Side, Level 3 Phase B instantaneous overcurrent element pickup
PXBPIOC4	Str.dirGeneral	unknown	Direction undefined
PXCPIOC5	Op.general	50PX3CT	X-Side, Level 3 Phase C instantaneous overcurrent element trip
PXCPIOC5	Str.general	50PX3CP	X-Side, Level 3 Phase C 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
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

Table F.16 Logical Device: PRO (Protection) (Sheet 8 of 11)

Logical Node	Attribute	Data Source	Comment
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 Phase A instantaneous overcurrent element trip
PYAPIOC8	Str.general	50PY3AP	Y-Side, Level 3 Phase A instantaneous overcurrent element pickup
PYAPIOC8	Str.dirGeneral	unknown	Direction undefined
PYBPIOC9	Op.general	50PY3BT	Y-Side, Level 3 Phase B instantaneous overcurrent element trip
PYBPIOC9	Str.general	50PY3BP	Y-Side, Level 3 Phase B instantaneous overcurrent element pickup
PYBPIOC9	Str.dirGeneral	unknown	Direction undefined
PYCPIOC10	Op.general	50PY3CT	Y-Side, Level 3 Phase C instantaneous overcurrent element trip
PYCPIOC10	Str.general	50PY3CP	Y-Side, Level 3 Phase C instantaneous overcurrent element pickup
PYCPIOC10	Str.dirGeneral	unknown	Direction undefined
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 1 instantaneous 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

Table F.16 Logical Device: PRO (Protection) (Sheet 9 of 11)

Logical Node	Attribute	Data Source	Comment
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
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

Table F.16 Logical Device: PRO (Protection) (Sheet 10 of 11)

Logical Node	Attribute	Data Source	Comment
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
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

Table F.16 Logical Device: PRO (Protection) (Sheet 11 of 11)

Logical Node	Attribute	Data Source	Comment
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
S2PTUV8	Str.dirGeneral	unknown	Direction undefined
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
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

[a] Writing a 0 to BnCSWIm.CO.Pos.Oper.ctlVal will cause OCn to assert and writing any other value will cause CCn to assert; (n = X or Y) and (m = 1 or 2).
[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/contactor is closed, value = 10(2); if the breaker/contactor is opened, value = 01(1).

Table F.17 shows the LN associated with measuring elements defined as Logical Device MET.

Table F.17 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]			
METXMDST1	DmdA.phsA.instCVal.mag.f	IAXD	X-Side Phase A current demand
METXMDST1	DmdA.phsB.instCVal.mag.f	IBXD	X-Side Phase B current demand
METXMDST1	DmdA.phsC.instCVal.mag.f	ICXD	X-Side Phase C current demand
METXMDST1	DmdA.res.instCVal.mag.f	IGXD	X-Side residual current demand

Table F.17 Logical Device: MET (Metering) (Sheet 2 of 7)

Logical Node	Attribute	Data Source	Comment
METXMDST1	DmdA.nseq.instCVal.mag.f	3I2XD	X-side negative-sequence current demand
METXMDST1	DmdVArh.instMag.f	MVARHNX	Reactive energy, 3-phase negative X-side
METXMDST1	DmdWh.instMag.f	MWHNX	Real energy, 3-phase negative X-side
METXMDST1	PkDmdA.phsA.instCVal.mag.f	IAXPD	X-Side Phase A current peak demand
METXMDST1	PkDmdA.phsB.instCVal.mag.f	IBXPD	X-Side Phase B current peak demand
METXMDST1	PkDmdA.phsC.instCVal.mag.f	ICXPD	X-Side Phase C current peak demand
METXMDST1	PkDmdA.res.instCVal.mag.f	IGXPD	X-side residual current peak demand
METXMDST1	PkDmdA.nseq.instCVal.mag.f	3I2XPD	X-side negative-sequence current peak demand
METXMDST1	SupVArh.instMag.f	MVARHPX	Reactive energy, 3-phase positive X-side
METXMDST1	SupWh.instMag.f	MWHPX	Real energy, 3-phase positive X-side
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
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

Table F.17 Logical Device: MET (Metering) (Sheet 3 of 7)

Logical Node	Attribute	Data Source	Comment
METXMMXU1	TotPF.instMag.f	PF3X	X-side power factor, magnitude 3-phase
METXMMXU1	TotVA.instMag.f	S3X	X-side apparent power magnitude, 3-phase
METXMMXU1	TotVAr.instMag.f	Q3X	X-side reactive power magnitude, 3-phase
METXMMXU1	TotW.instMag.f	P3X	X-side real power magnitude, 3-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
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, 3-phase, maximum
METXMSTA1	MaxVAr.instMag.f	KVAR3XMX	X-side reactive power magnitude, 3-phase, maximum
METXMSTA1	MaxW.instMag.f	KW3XMX	X-side real power magnitude, 3-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

Table F.17 Logical Device: MET (Metering) (Sheet 4 of 7)

Logical Node	Attribute	Data Source	Comment
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, 3-phase, minimum
METXMSTA1	MinVAr.instMag.f	KVAR3XMN	X-side reactive power magnitude, 3-phase, minimum
METXMSTA1	MinW.instMag.f	KW3XMN	X-side real power magnitude, 3-phase, minimum
METYMDST2	DmdA.phsA.instCVal.mag.f	IAYD	Y-Side Phase A current demand
METYMDST2	DmdA.phsB.instCVal.mag.f	IBYD	Y-Side Phase B current demand
METYMDST2	DmdA.phsC.instCVal.mag.f	ICYD	Y-Side Phase C current demand
METYMDST2	DmdA.res.instCVal.mag.f	IGYD	Y-side residual current demand
METYMDST2	DmdA.nseq.instCVal.mag.f	3I2YD	Y-side negative-sequence current demand
METYMDST2	DmdVArh.instMag.f	MVARHNY	Reactive energy, 3-phase negative Y-side
METYMDST2	DmdWh.instMag.f	MWHNY	Real energy, 3-phase negative Y-side
METYMDST2	PkDmdA.phsA.instCVal.mag.f	IAYPD	Y-Side Phase A current peak demand
METYMDST2	PkDmdA.phsB.instCVal.mag.f	IBYPD	Y-Side Phase B current peak demand
METYMDST2	PkDmdA.phsC.instCVal.mag.f	ICYPD	Y-Side Phase C current peak demand
METYMDST2	PkDmdA.res.instCVal.mag.f	IGYPD	Y-side residual current peak demand
METYMDST2	PkDmdA.nseq.instCVal.mag.f	3I2YPD	Y-side negative-sequence current peak demand
METYMDST2	SupVArh.instMag.f	MVARHPY	Reactive energy, 3-phase positive Y-side
METYMDST2	SupWh.instMag.f	MWHPY	Real energy, 3-phase positive Y-side
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

Table F.17 Logical Device: MET (Metering) (Sheet 5 of 7)

Logical Node	Attribute	Data Source	Comment
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
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, 3-phase, maximum

Table F.17 Logical Device: MET (Metering) (Sheet 6 of 7)

Logical Node	Attribute	Data Source	Comment
METYMSTA2	MaxVAr.instMag.f	KVAR3YMX	Y-side reactive power magnitude, 3-phase, maximum
METYMSTA2	MaxW.instMag.f	KW3YMX	Y-side real power magnitude, 3-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
METYMSTA2	MinVA.instMag.f	KVA3YMN	Y-side apparent power magnitude, 3-phase, minimum
METYMSTA2	MinVAr.instMag.f	KVAR3YMN	Y-side reactive power magnitude, 3-phase, minimum
METYMSTA2	MinW.instMag.f	KW3YMN	Y-side real power magnitude, 3-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	X-side RMS voltage, A-phase-to-neutral, magnitude
RMSXMMXU3	PhV.phsB.instCVal.mag.f	VBXRMS	X-side RMS voltage, B-phase-to-neutral, magnitude
RMSXMMXU3	PhV.phsC.instCVal.mag.f	VCXRMS	X-side RMS voltage, C-phase-to-neutral, magnitude
RMSXMMXU3	PPV.phsAB.instCVal.mag.f	VABXRMS	X-side RMS voltage, A-to-B-phase, magnitude
RMSXMMXU3	PPV.phsBC.instCVal.mag.f	VBCXRMS	X-side RMS voltage, B-to-C-phase, magnitude
RMSXMMXU3	PPV.phsCA.instCVal.mag.f	VCAXRMS	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	Y-side RMS voltage, A-phase-to-neutral, magnitude
RMSYMMXU4	PhV.phsB.instCVal.mag.f	VBYRMS	Y-side RMS voltage, B-phase-to-neutral, magnitude
RMSYMMXU4	PhV.phsC.instCVal.mag.f	VCYRMS	Y-side RMS voltage, C-phase-to-neutral, magnitude
RMSYMMXU4	PPV.phsAB.instCVal.mag.f	VABYRMS	Y-side RMS voltage, A-to-B-phase, magnitude
RMSYMMXU4	PPV.phsBC.instCVal.mag.f	VBCYRMS	Y-side RMS voltage, B-to-C-phase, magnitude
RMSYMMXU4	PPV.phsCA.instCVal.mag.f	VCAYRMS	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[c]	Ambient RTD temperature

Table F.17 Logical Device: MET (Metering) (Sheet 7 of 7)

Logical Node	Attribute	Data Source	Comment
THERMMTHR1	MaxOthTmp.instMag.f	RTDOTHMX[c]	Other maximum RTD temperature
THERMMTHR1	Tmp01.instMag.f–Tmp12.instMag.f	RTD1–RTD12[c]	RTD1–RTD12 temperature
Functional Constraint = ST			
THERMMTHR1	EEHealth.stVal	RTDFLT?1:3[c]	RTD input or communication status

[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 foes 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 of available card options. Refer to Section 5: Metering and Monitoring for the model dependent metering quantities.
[c] Valid data depends on E49RTD and RTD1LOC–RTD12LOC.

Table F.18 shows the LN associated with control elements defined as Logical Device CON.

Table F.18 Logical Device: CON (Remote Control)

Logical Node	Status	Control	Relay Word Bit	Comment
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

Table F.19 shows the LN associated with annunciation elements defined as Logical Device ANN.

Table F.19 Logical Device: ANN (Annunciation) (Sheet 1 of 5)

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	AbrPrt.instMag.f	WEARAX	X Breaker–Contact A wear
BWXBSCBR2	AbrPrt.instMag.f	WEARBX	X Breaker–Contact B wear
BWXCSCBR3	AbrPrt.instMag.f	WEARCX	X Breaker–Contact C wear
BWYASCBR4	AbrPrt.instMag.f	WEARAY	Y Breaker–Contact A wear
BWYBSCBR5	AbrPrt.instMag.f	WEARBY	Y Breaker–Contact B wear
BWYCSCBR6	AbrPrt.instMag.f	WEARCY	Y Breaker–Contact C wear

Table F.19 Logical Device: ANN (Annunciation) (Sheet 2 of 5)

Logical Node	Attribute	Data Source	Comment
MVGGIO12	AnIn01.instMag.f–AnIn32.instMag.f	MV01–MV32[c]	Math Variables (MV01 to MV32)
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
GENGGIO25	Ind01.stVal	REMTRIP	Remote trip
GENGGIO25	Ind02.stVal	BNDT	Ored abnonrmal frequency band trip
GENGGIO25	Ind03.stVal	INADT	Inadvertent energization logic timed out
GENGGIO25	Ind04.stVal	OOST	Out-of-step trip
GENGGIO25	Ind05.stVal	TH5T	Fifth-harmonic alarm threshold exceeded for longer than TH5D
GENGGIO25	Ind06.stVal	3POX	X breaker three-pole open
GENGGIO25	Ind07.stVal	3POY	Y breaker three-pole open
GENGGIO25	Ind08.stVal	FREQTRKX	Frequency tracking enable bit for X-side voltages or currents–tracking enabled when bit is asserted
GENGGIO25	Ind09.stVal	FREQTRKY	Frequency tracking enable bit for Y-side voltages or currents–tracking enabled when bit is asserted
GENGGIO25	Ind10.stVal	CFA	Generator breaker close failure angle condition
GENGGIO25	Ind11.stVal	BKRCF	Generator breaker close failed
GENGGIO25	Ind12.stVal	CFX	Breaker X close condition failure on
GENGGIO25	Ind13.stVal	CFY	Breaker Y close condition failure on
GENGGIO25	Ind14.stVal	BCWAX	X-side breaker A-phase breaker contact wear has reached 100 percent wear level
GENGGIO25	Ind15.stVal	BCWBX	X-side breaker B-phase breaker contact wear has reached 100 percent wear level
GENGGIO25	Ind16.stVal	BCWCX	X-side breaker C-phase breaker contact wear has reached 100 percent wear level
GENGGIO25	Ind17.stVal	BCWAY	Y-side breaker A-phase breaker contact wear has reached 100 percent wear level
GENGGIO25	Ind18.stVal	BCWBY	Y-side breaker B-phase breaker contact wear has reached 100 percent wear level
GENGGIO25	Ind19.stVal	BCWCY	Y-side breaker C-phase breaker contact wear has reached 100 percent wear level
GENGGIO25	Ind20.stVal–Ind32.stval	0	Reserved for future use
INAGGIO1	Ind01.stVal–Ind02.stVal	IN101–IN102	Digital Inputs (IN101 to IN102)—Slot A
INCGGIO13	Ind01.stVal–Ind08.stVal	IN301–IN308[b]	Digital Inputs (IN301 to IN308)—Slot C
INDGGIO15	Ind01.stVal–Ind08.stVal	IN401–IN408[b]	Digital Inputs (IN401 to IN408)—Slot D

Table F.19 Logical Device: ANN (Annunciation) (Sheet 3 of 5)

Logical Node	Attribute	Data Source	Comment
INEGGIO17	Ind01.stVal–Ind08.stVal	IN501–IN508[b]	Digital Inputs (IN501 to IN508)—Slot E
LBGGIO25	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)
MBOKGGIO26	Ind01.stVal	ROKA	Channel A, received data ok
MBOKGGIO26	Ind02.stVal	RBADA	Channel A, outage duration over threshold
MBOKGGIO26	Ind03.stVal	CBADA	Channel A, channel unavailability over threshold
MBOKGGIO26	Ind04.stVal	LBOKA	Channel A, looped back ok
MBOKGGIO26	Ind05.stVal	ROKB	Channel B, received data ok
MBOKGGIO26	Ind06.stVal	RBADB	Channel B, outage duration over threshold
MBOKGGIO26	Ind07.stVal	CBADB	Channel B, channel unavailability over threshold
MBOKGGIO26	Ind08.stVal	LBOKB	Channel B, looped back ok
MISCGGIO26	Ind01.stVal–Ind03.stVal	SG1–SG3	Setting Group 1 to 3 selection
MISCGGIO26	Ind04.stVal	HALARM	Indication of a diagnostic failure or warning that warrants an ALARM
MISCGGIO26	Ind05.stVal	SALARM	Indication of software or user activity that warrants an ALARM
MISCGGIO26	Ind06.stVal	WARNING	Relay Word WARNING
MISCGGIO26	Ind07.stVal	IRIGOK	IRIG-B time synch input data are valid
MISCGGIO26	Ind08.stVal	TSOK	Time synchronization OK
MISCGGIO26	Ind09.stVal	DST	Daylight Savings Time active
MISCGGIO26	Ind10.stVal	LINKA	Asserted when a valid link is detected on Port 1A
MISCGGIO26	Ind11.stVal	LINKB	Asserted when a valid link is detected on Port 1B
MISCGGIO26	Ind12.stVal	LINKFAIL	Asserted when a valid link is not detected on the active port(s)
MISCGGIO26	Ind13.stVal	PASEL	Asserted when Port 1A is active
MISCGGIO26	Ind14.stVal	PBSEL	Asserted when Port 1B is active
MISCGGIO26	Ind15.stVal	MATHERR	Error in SELMath computation
MISCGGIO26	Ind16.stVal	0	Reserved for future use
OUTAGGIO2	Ind01.stVal–Ind03.stVal	OUT101– OUT103	Digital Outputs (OUT101 to OUT103)—Slot A
OUTCGGIO14	Ind01.stVal–Ind04.stVal	OUT301–OUT304[b]	Digital Outputs (OUT301 to OUT304)—Slot C
OUTDGGIO16	Ind01.stVal–Ind04.stVal	OUT401–OUT404[b]	Digital Outputs (OUT401 to OUT404)—Slot D
OUTEGGIO18	Ind01.stVal–Ind04.stVal	OUT501–OUT504[b]	Digital Outputs (OUT501 to OUT504)—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

Table F.19 Logical Device: ANN (Annunciation) (Sheet 4 of 5)

Logical Node	Attribute	Data Source	Comment
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)
SVGGIO3	Ind01.stVal–Ind32.stVal	SV01–SV32[e]	SELOGIC Variables (SV01 to SV32)
SVTGGIO4	Ind01.stVal–Ind32.stVal	SV01T–SV32T[g]	SELOGIC Variable Timers (SV01T to SV32T)
SYNGGIO24	Ind01.stVal	AST	Autosynchronism start
SYNGGIO24	Ind02.stVal	ASP	Autosynchronism stop
SYNGGIO24	Ind03.stVal	FSYNCTO	Frequency synch timer timeout
SYNGGIO24	Ind04.stVal	FSYNCACT	Frequency matching–auto synchronization is in progress
SYNGGIO24	Ind05.stVal	FRAISE	Raise frequency for autosynchronism
SYNGGIO24	Ind06.stVal	FLOWER	Lower frequency for autosynchronism
SYNGGIO24	Ind07.stVal	VSYNCTO	Voltage synch timer timeout
SYNGGIO24	Ind08.stVal	VSYNCACT	Voltage matching–auto synchronization is in progress
SYNGGIO24	Ind09.stVal	VRAISE	Raise voltage for autosynchronism
SYNGGIO24	Ind10.stVal	VLOWER	Lower voltage for autosynchronism
SYNGGIO24	Ind11.stVal	59VPX	Generator terminal voltage within voltage window
SYNGGIO24	Ind12.stVal	59VSX	System voltage within voltage window
SYNGGIO24	Ind13.stVal	VDIFX	Generator and system voltage difference within acceptable bounds
SYNGGIO24	Ind14.stVal	SFX	Generator slip frequency is within acceptable bounds (between 25SLO and 25SHI settings)
SYNGGIO24	Ind15.stVal	25AX1	Generator slip/breaker-time compensated phase angle less than 25ANG1X setting
SYNGGIO24	Ind16.stVal	25AX2	Generator uncompensated phase angle less than 25ANG2X setting
SYNGGIO24	Ind17.stVal	GENVHI	Generator voltage greater than system voltage
SYNGGIO24	Ind18.stVal	GENVLO	Generator voltage less than system voltage
SYNGGIO24	Ind19.stVal	GENFHI	Slip frequency greater than 25SHI setting
SYNGGIO24	Ind20.stVal	GENFLO	Slip frequency less than 25SLO setting
SYNGGIO24	Ind21.stVal	59VPY	Intertie terminal voltage within voltage window
SYNGGIO24	Ind22.stVal	59VSY	System voltage within voltage window
SYNGGIO24	Ind23.stVal	VDIFY	Intertie and system voltage difference within acceptable bounds
SYNGGIO24	Ind24.stVal	SFY	Intertie slip frequency within acceptable bounds (less than 25SF setting)
SYNGGIO24	Ind25.stVal	25AY1	Intertie slip/breaker-time compensated phase angle less than 25ANG1Y setting
SYNGGIO24	Ind26.stVal	25AY2	Intertie slip/breaker-time compensated phase angle less than 25ANG1Y setting
SYNGGIO24	Ind27.stVal–Ind32.stVal	0	Reserved for future use
TLEDGGIO6	Ind01.stVal	ENABLED	ENABLED LED
TLEDGGIO6	Ind02.stVal	TRIP_LED	TRIP LED

Table F.19 Logical Device: ANN (Annunciation) (Sheet 5 of 5)

Logical Node	Attribute	Data Source	Comment
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)

[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.

Table F.20 Logical Device: CFG (Configuration)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PARTNO	Part number
DevIDLPHD1	PhyNam.serNum	SER_NUM	Serial number
LLN0	NamPlt.swRev	FID	Firmware revision

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 F.21 PICS for A-Profile Support

Profile		Client	Server	Value/Comment
A1	Client/Server	N	Y	
A2	GOOSE/GSE management	Y	Y	Only GOOSE, not GSSE Management
A3	GSSE	N	N	
A4	Time Sync	N	N	

Table F.22 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	N	N	

Refer to the ACSI Conformance statements in the Reference Manual for information on the supported services.

MMS Conformance

The Manufacturing Messaging Specification (MMS) stack provides the basis for many IEC 61850 Protocol services. *Table F.23* defines the service support requirement and restrictions of the MMS services in the SEL-700 series products 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 F.23 MMS Service Supported Conformance (Sheet 1 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR 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		
output		
takeControl		
relinquishControl		
defineSemaphore		
deleteSemaphore		
reportPoolSemaphoreStatus		
reportSemaphoreStatus		
initiateDownloadSequence		
downloadSegment		
terminateDownloadSequence		
initiateUploadSequence		
uploadSegment		
terminateUploadSequence		
requestDomainDownload		
requestDomainUpload		
loadDomainContent		
storeDomainContent		
deleteDomain		
getDomainAttributes		Y
createProgramInvocation		
deleteProgramInvocation		

Table F.23 MMS Service Supported Conformance (Sheet 2 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
start		
stop		
resume		
reset		
kill		
getProgramInvocationAttributes		
obtainFile		
defineEventCondition		
deleteEventCondition		
getEventConditionAttributes		
reportEventConditionStatus		
alterEventConditionMonitoring		
triggerEvent		
defineEventAction		
deleteEventAction		
alterEventEnrollment		
reportEventEnrollmentStatus		
getEventEnrollmentAttributes		
acknowledgeEventNotification		
getAlarmSummary		
getAlarmEnrollmentSummary		
readJournal		
writeJournal		
initializeJournal		
reportJournalStatus		
createJournal		
deleteJournal		
fileOpen		
fileRead		
fileClose		
fileRename		
fileDelete		
fileDirectory		
unsolicitedStatus		
informationReport		Y
eventNotification		
attachToEventCondition		
attachToSemaphore		
conclude		Y
cancel		Y
getDataExchangeAttributes		
exchangeData		
defineAccessControlList		
getAccessControlListAttributes		

Table F.23 MMS Service Supported Conformance (Sheet 3 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
reportAccessControlledObjects		
deleteAccessControlList		
alterAccessControl		
ReconfigureProgramInvocation		

Table F.24 lists specific settings for the MMS parameter Conformance Building Block (CBB).

Table F.24 MMS Parameter CBB

MMS Parameter CBB	Client-CR Supported	Server-CR Supported
STR1		Y
STR2		Y
VNAM		Y
VADR		Y
VALT		Y
TPY		Y
VLIS		Y
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 F.25 Alternate Access Selection Conformance Statement

Alternate Access Selection	Client-CR Supported	Server-CR Supported
accessSelection		Y
component		Y
index		
indexRange		
allElements		
alternateAccess		Y
selectAccess		Y
component		Y
index		
indexRange		
allElements		

Table F.26 VariableAccessSpecification Conformance Statement

VariableAccessSpecification	Client-CR Supported	Server-CR Supported
listOfVariable		Y
variableSpecification		Y
alternateAccess		Y
variableListName		Y

Table F.27 VariableSpecification Conformance Statement

VariableSpecification	Client-CR Supported	Server-CR Supported
name		Y
address		
variableDescription		
scatteredAccessDescription		
invalidated		

Table F.28 Read Conformance Statement

Read	Client-CR Supported	Server-CR Supported
Request		
specificationWithResult		
variableAccessSpecification		
Response		
variableAccessSpecification		Y
listOfAccessResult		Y

Table F.29 GetVariableAccessAttributes Conformance Statement

GetVariableAccessAttributes	Client-CR Supported	Server-CR Supported
Request		
name		
address		
Response		
mmsDeletable		Y
address		
typeSpecification		Y

Table F.30 DefineNamedVariableList Conformance Statement (Sheet 1 of 2)

DefineVariableAccessAttributes	Client-CR Supported	Server-CR Supported
Request		
variableListName		
listOfVariable		

Table F.30 DefineNamedVariableList Conformance Statement (Sheet 2 of 2)

DefineVariableAccessAttributes	Client-CR Supported	Server-CR Supported
variableSpecification		
alternateAccess		
Response		

Table F.31 GetNamedVariableListAttributes Conformance Statement

GetNamedVariableListAttributes	Client-CR Supported	Server-CR Supported
Request		
ObjectName		
Response		
mmsDeletable		Y
listOfVariable		Y
variableSpecification		Y
alternateAccess		Y

Table F.32 DeleteNamedVariableList

DeleteNamedVariableList	Client-CR Supported	Server-CR Supported
Request		
Scope		
listOfVariableListName		
domainName		
Response		
numberMatched		
numberDeleted		
DeleteNamedVariableList-Error		

GOOSE Services Conformance Statement

Table F.33 GOOSE Conformance

	Subscriber	Publisher	Value/Comment
GOOSE Services	Y	Y	
SendGOOSEMessage		Y	
GetGoReference			
GetGOOSEElementNumber			
GetGoCBValues		Y	
SetGoCBValues			
GSENotSupported			
GOOSE Control Block (GoCB)		Y	

ACSI Conformance Statements

Table F.34 ACSI Basic Conformance Statement

		Client/Subscriber	Server/Publisher	SEL-700G Support
Client-Server Roles				
B11	Server side (of Two-Party Application-Association)	-	c1[a]	YES
B12	Client side (of Two-Party Application-Association)	c1[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
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 F.35 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

Table F.35 ACSI Models Conformance Statement (Sheet 2 of 2)

		Client/Subscriber	Server/Publisher	SEL-700G Support
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
M-8-8	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[g]	YES
If GSE (B31/32) Is Supported				
M12	GOOSE	O[e]	O[e]	YES
M12-1	entryID			YES
M12-2	DataReflnc			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.
[g] M = mandatory.

Table F.36 ACSI Services Conformance Statement (Sheet 1 of 4)

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

Table F.36 ACSI Services Conformance Statement (Sheet 2 of 4)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-700G Support
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
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

Table F.36 ACSI Services Conformance Statement (Sheet 3 of 4)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-700G Support
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				
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

Table F.36 ACSI Services Conformance Statement (Sheet 4 of 4)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-700G Support
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 TimeStamp 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).

Appendix G

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

The DeviceNet Card is an optional accessory that enables connection of the SEL-700G to the DeviceNet automation network. The card (see *Figure G.1*) occupies the communications expansion Slot **C** in the relay.

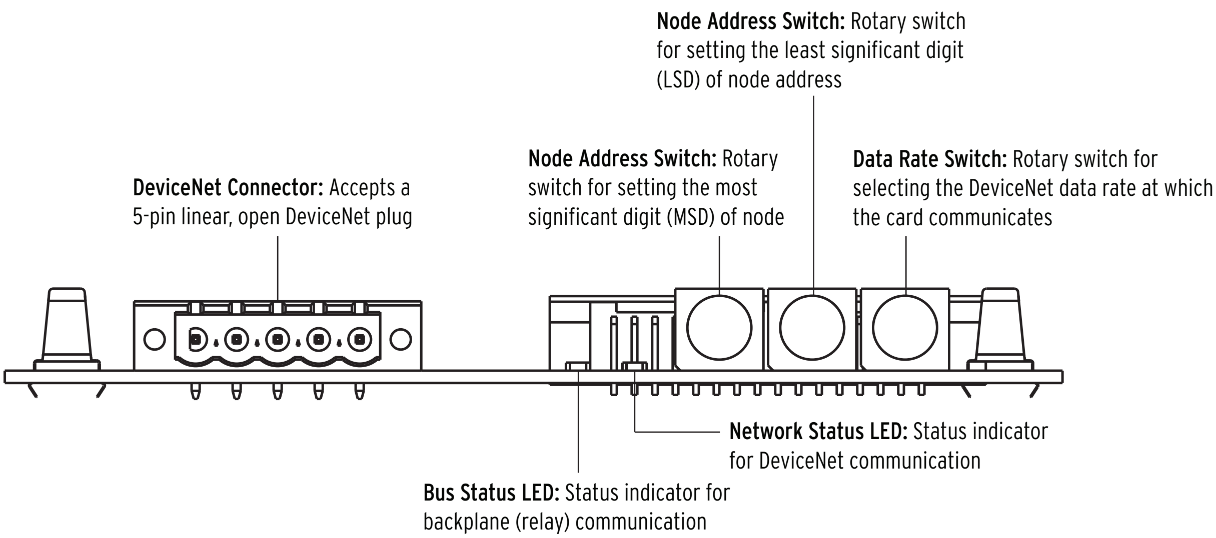


Figure G.1 DeviceNet Card Component Overview

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 www.selinc.com.

Complete specifications for the DeviceNet protocol are available on the Open DeviceNet Vendor's Association (ODVA) website www.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 H
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 H.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 H.10*.

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 H.11*.

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-3306 Synchrophasor Processor is a PC-based communications processor specifically designed to interface with PMUs. The SEL-3306 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 for real-time viewing of a power system.

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 H.12*.

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 H.5*).

The phase angle is measured relative to an absolute time reference, which is represented by a cosine function in *Figure H.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.

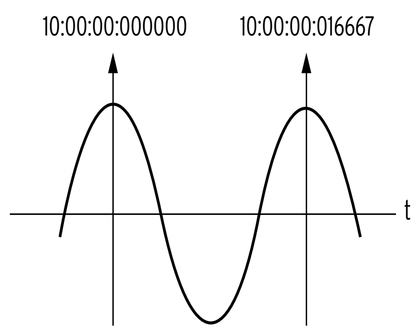

Figure H.1 Phase Reference

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 H.2*, *Figure H.3*, and *Equation H.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.

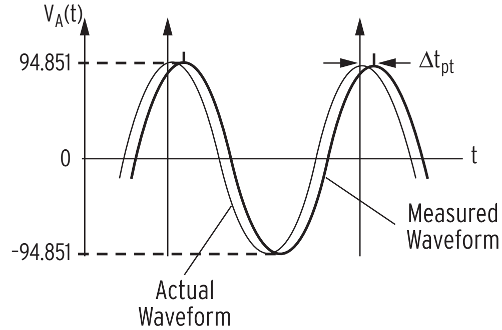

Figure H.2 Waveform at Relay Terminals May Have a Phase Shift

$$\text{Compensation Angle} = \frac{\Delta t_{pt}}{\left(\frac{1}{\text{freq}_{\text{nominal}}}\right)} \bullet 360°$$

$$= \Delta t_{pt} \bullet \text{freq}_{\text{nominal}} \bullet 360° \quad \textbf{Equation H.1}$$

If the time shift on the PT measurement path Δt_{pt} = 0.784 ms and the nominal frequency, $\text{freq}_{\text{nominal}}$ = 60Hz, use *Equation H.2* to obtain the correction angle:

$$0.784 \bullet 10^{-3}\text{s} \bullet 60\text{s}^{-1} \bullet 360° = 16.934° \quad \textbf{Equation H.2}$$

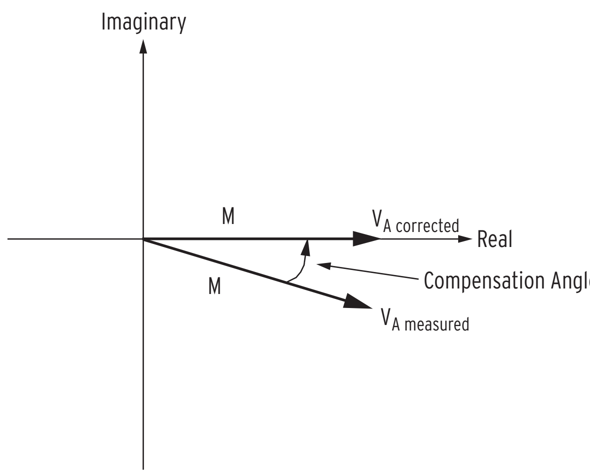

Figure H.3 Correction of Measured Phase Angle

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 H.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 H.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 H.1 PMU Settings in the SEL-700G for C37.118 Protocol in Global Settings (Sheet 1 of 2)

Setting	Description	Default
EPMU	Enable Synchronized Phasor Measurement (Y, N)	N[a]
MRATE	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)	10
PMAPP	PMU Application (Fast := Fast Response, Narrow := Narrow Bandwidth)	NARROW
PHCOMP	Frequency-Based Phasor Compensation (Y, N)	Y
PMSTN	Station Name (16 characters)	SEL-700G
PMID	PMU Hardware ID (1–65534)	1
PHDATAV	Phasor Data Set, Voltages (V1, ALL, NA)	V1
PHVOLT	Voltage Source (VX, VY, BOTH)	BOTH
VXCOMP	X-Side Angle Comp Factor (–179.99 to 180 deg)	0.00
VYCOMP	Y-Side Voltage Angle Comp Factor (–179.99 to 180 deg)	0.00
VSCOMP	VS Voltage Angle Comp Factor (–179.99 to 180 deg)	0.00
PHDATAI	Phasor Data Set, Currents (I1, ALL, NA)	I1
PHCURR	Current Source (IX, IY, BOTH)	BOTH
IXCOMP	X-Side Angle Comp Factor (–179.99 to 180 deg)	0.00
IYCOMP	Y-Side Angle Comp Factor (–179.99 to 180 deg)	0.00
NUMANA	Number of Analog Values (0–4)	0

Table H.1 PMU Settings in the SEL-700G for C37.118 Protocol in Global Settings (Sheet 2 of 2)

Setting	Description	Default
NUMDSW	Number of 16-bit Digital Status Words (0, 1)	0
TREA1	Trigger Reason Bit 1 (SELOGIC)	TRIP OR ER
TREA2	Trigger Reason Bit 2 (SELOGIC)	81T OR 81RT OR BNDT
TREA3	Trigger Reason Bit 3 (SELOGIC)	59PX1T OR 59PX2T OR 59PY1T OR 59PY2T
TREA4	Trigger Reason Bit 4 (SELOGIC)	27PX1T OR 27PX2T OR 27PY1T OR 27PY2T
PMTRIG	Trigger (SELOGIC)	TREA1 OR TREA2 OR TREA3 OR TREA4
IRIGC	IRIG-B Control Bits Definition (NONE, C37.118)	NONE

[a] Set EPMU := Y to access the remaining settings.

Certain settings in *Table H.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 H.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 H.13* 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 ¼ 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 H.13* for detailed information.

- PHDATAV := V1 transmits only positive-sequence voltage, V_1
- 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 H.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 H.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 H.13* 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 H.13* for detailed information.

- PHDATAI := I1 transmits only positive-sequence current, I_1
- 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 H.2* for details on these settings.

Table H.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 H.13* for detailed information.

Table H.2 Synchrophasor Order in Data Stream (Voltages and Currents)

Synchrophasors[a b c]		Included When Global Settings Are as Follows:
Rectangular		
Real	Imaginary	
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 H.13* 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 H.3*.

The format of the user-defined analog data is always floating point, and each value occupies four bytes.

Table H.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 H.13* 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 H.4*.

Table H.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

Defines if IEEE C37.118 control bit extensions are in use. Control bit extensions contain information such as Leap Second, UTC time, Daylight Savings Time, 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 H.5*.

Table H.5 SEL-700G Serial Port Settings for Synchrophasors

Setting	Description	Default
PROTO	Protocol (SEL, MOD, DNET, DNP, EVMSG, PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB)[a]	SEL[b]
SPEED	Data Speed (300 to 38400)	9600
STOPBIT	Stop Bits (1, 2)	1
RTSCTS	HDWR HANDSHAKING (Y, N)	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 H.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 H.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 H.6*.

Table H.6 SEL-700G Ethernet Port Settings for Synchrophasors

Setting	Description	Default
EPMIP[a]	Enable PMU Processing (0–2)	0[b]
PMOTS1	PMU Output 1 Transport Scheme (OFF, TCP, UDP_S, UDP_T, UDP_U)	OFF
PMOIPA1	PMU Output 1 Client IP (Remote) Address (www.xxx.yyy.zzz)	192.168.1.3
PMOTCP1	PMU Output 1TCP/IP (Local) Port Number (1–65534)	4712
PMOUDP1	PMU Output 1 UDP/IP Data (Remote) Port Number (1–65534)	4713
PMOTS2	PMU Output 2 Transport Scheme (OFF, TCP, UDP_S, UDP_T, UDP_U)	OFF
PMOIPA2	PMU Output 2 Client IP (Remote) Address (www.xxx.yyy.zzz)	192.168.1.4
PMOTCP2	PMU Output 2 TCP/IP (Local) Port Number (1–65534)	4722
PMOUDP2	PMU Output 2 UDP/IP Data (Remote) Port Number (1–65534)	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.

Ethernet port setting EPMIP cannot be set (see *Table H.6*) when Global setting EPMU := N. Synchrophasors must be enabled (EPMU := Y) before EPMIP can be set.

Synchrophasor Relay Word Bits

Table H.7 and *Table H.8* list the SEL-700G Relay Word bits that are related to synchrophasor measurement. The Synchrophasor Trigger Relay Word bits in *Table H.7* follow the state of the SELOGIC control equations of the same name, listed at the bottom of *Table H.1*. These Relay Word bits are included in the IEEE C37.118 synchrophasor data frame STAT field. See *Table H.4* for standard definitions for these settings.

Table H.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)

The Time-Synchronization Relay Word bits in *Table H.8* indicate the present status of the timekeeping function of the SEL-700G.

Table H.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 • INOM 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.

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 7.34* 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 H.4 shows a sample **MET PM** command response. The synchrophasor data are also available via the **HMI > Meter PM** menu in ACSELERATOR QuickSet, and have a similar format to *Figure H.4*.

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 H.4* 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 H.4 Sample MET PM Command Response

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.

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 H.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 H.9* 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 H.9 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
SEL-700GW	X-side positive-sequence current

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 H.10* to calculate the number of bytes in a synchrophasor message.

Table H.10 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 H.11 lists the baud 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 H.11 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 H.10* and *Table H.11*, 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-3306. 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-3306 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 neutral CTs and wiring have a phase error of 3.50 degrees (lagging) at 60 Hz.
- The synchrophasor data use Port 3, and the maximum baud allowed is 19200.
- 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 H.10*, and determines the necessary message size. The system requirements, in order of appearance in *Table H.10*, 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 H.11*, the engineer verifies that the port baud of 9600 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 H.12*.

Table H.12 Example Synchrophasor Global Settings

Setting	Description	Value
FNOM	Nominal System Frequency (50, 60 Hz)	60
EPMU	Enable Synchronized Phasor Measurement (Y, N)	Y
MRATE	Messages per Second (1, 2, 4, 5, 10, 12, 15, 20, 30, 60)	10
PMAPP	PMU Application (F := Fast Response, N := Narrow Bandwidth)	FAST
PHCOMP	Frequency-Based Phasor Compensation (Y, N)	Y
PMSTN	Station Name (16 characters)	SAMPLE1
PMID	PMU Hardware ID (1–65534)	14
PHDATAV	Phasor Data Set, Voltages (V1, ALL, NA)	V1
PHVOLT	Voltage Source (VX, VY, Both)	VX
VXCOMP	Phase Voltage Angle Compensation Factor (–179.99 to 180 degrees)	4.20
PHDATAI	Phasor Data Set, Currents (I1, ALL, NA)	ALL
PHCURR	Current Source (IX, IY, Both)	IX
IXCOMP	Phase Current Angle Compensation Factor (–179.99 to 180 degrees)	3.50
NUMDSW	Number of 16-bit Digital Status Words (0 or 1)	1

Table H.13 Example Synchrophasor Logic Settings

Logic Setting	Description	Value
TREA1	Trigger Reason Bit 1 (SELOGIC Equation)	NA
TREA2	Trigger Reason Bit 2 (SELOGIC Equation)	NA
TREA3	Trigger Reason Bit 3 (SELOGIC Equation)	NA
TREA4	Trigger Reason Bit 4 (SELOGIC Equation)	NA
PMTRIG	Trigger (SELOGIC Equation)	NA

The three Relay Word bits this example requires must be placed in certain SELOGIC variables. Make the settings in *Table H.14* in all seven setting groups.

Table H.14 Example Synchrophasor SELOGIC Settings

Setting	Value
SV14	52AX
SV15	LOPX
SV16	FREQXOK

Make the *Table H.15* settings for serial port 3, using the **SET P 3** command.

Table H.15 Example Synchrophasor Port Settings

Setting	Description	Value
PROTO	Protocol (SEL, MOD, DNP, EVMSG , PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB)	PMU
SPEED	Data Speed (300 to 38400)	19200
STOPBIT	Stop Bits (1, 2 bits)	1
RTSCTS	Enable Hardware Handshaking (Y, N)	N

Appendix I

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 baud rate and the power system cycle. At baud rates below 9600, the SEL-700G transmits Mirrored Bits as fast as possible for the given baud. At rates at and above 9600 baud 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 baud rates of 9600, 19200, and 38400. *Table I.1* shows the transmission rates of the Mirrored Bits messages at different baud.

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 baud rates of 2400 or 4800.

Table I.1 Number of MIRRORED BITS Messages for Different Baud

Baud 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 baud 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). Upon detecting any of the following conditions, the relay clears the ROK*c* bit when:

- 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 described previously. After ROK*c* is reasserted, received data may be delayed while passing through the security counters described below.

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 J: Relay Word Bits*). *Table I.2* is an extract of *Appendix J: Relay Word Bits*, showing the positions of the MIRRORED BITS.

Table I.2 Positions of the MIRRORED BITS

Bit/ Row	7	6	5	4	3	2	1	0
88	RMB8A	RMB7A	RMB6A	RMB5A	RMB4A	RMB3A	RMB2A	RMB1A
90	RMB8B	RMB7B	RMB6B	RMB5B	RMB4B	RMB3B	RMB2B	RMB1B

Table I.3 shows an example of the values of the MIRRORED BITS for a RXDFLT setting of 10100111.

Table I.3 MIRRORED BITS Values for a RXDFLT Setting of 10100111

Bit/ Row	7	6	5	4	3	2	1	0
88	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 I.1*). For example, when transmitting at 2400 baud, a security counter set to 2 counts delays a bit by about 30 ms. However, when operating at 9600 baud, 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 baud, 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 baud and above, see *Table I.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 I.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 9600 Baud 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 baud 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 I.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 I.4 MIRRORED BITS Communications Message Transmission Period

Baud	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 I.5* shows the MIRRORED BITS protocol port settings, ranges, and default settings for Port F, Port 3, and Port 4.

Table I.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
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

Table I.5 MIRRORED BITS Protocol Settings (Sheet 2 of 2)

Setting Prompt	Setting Description	Factory Default Setting
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 J

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 J.1 shows the entire list of Relay Word bits in the relay. *Table J.3* shows the corresponding descriptions. Except for those Relay Word bits identified in *Table J.2*, all other Relay Word bits are visible across all of the models. The Relay Word bits in *Table J.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 J.2*, any bits in *Table J.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 7.45*.

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 9: Analyzing Events*).

Table J.1 SEL-700G Relay Word Bits (Sheet 1 of 5)

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	50PX1T	50PX2P	50PX2T	50PY1P	50PY1T	50PY2P	50PY2T
2	50PX3AP	50PX3AT	50PX3BP	50PX3BT	50PX3CP	50PX3CT	a	ORED50T
3	50PY3AP	50PY3AT	50PY3BP	50PY3BT	50PY3CP	50PY3CT	a	a
4	50GX1P	50GX1T	50GX2P	50GX2T	50QX1P	50QX1T	50QX2P	50QX2T
5	50GY1P	50GY1T	50GY2P	50GY2T	50QY1P	50QY1T	50QY2P	50QY2T
6	67GX1P	67GX1T	67GX2P	67GX2T	67GY1P	67GY1T	67GY2P	67GY2T
7	67PY1P	67PY1T	67PY2P	67PY2T	67QY1P	67QY1T	67QY2P	67QY2T
8	50N1P	50N1T	50N2P	50N2T	46Q1	46Q1T	46Q2	46Q2T
9	51PXP	51PXT	51QXP	51QXT	51GXP	51GXT	a	ORED51T
10	51PYP	51PYT	51QYP	51QYT	51GYP	51GYT	51NP	51NT
11	87U1	87U2	87U3	87U	87R1	87R2	87R3	87R

Table J.1 SEL-700G Relay Word Bits (Sheet 2 of 5)

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	a
14	64G1	64G1T	64G2	64G2T	T64G	N64G	51C	51CT
15	64F1	64F1T	64F2	64F2T	64FFLT	a	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	a	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	a	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	a
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	a
44	AMBALRM	AMBTRIP	OTHALRM	OTHTRIP	WDGALRM	WDGTRIP	BRGALRM	BRGTRIP
45	OUT101	OUT102	OUT103	a	a	a	a	a
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	a	a	a	a	a	a
50	IN301	IN302	IN303	IN304	IN305	IN306	IN307	IN308
51	IN401	IN402	IN403	IN404	IN405	IN406	IN407	IN408

Table J.1 SEL-700G Relay Word Bits (Sheet 3 of 5)

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	[a]	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	[a]	BNDA
61	SG1	SG2	SG3	64F1C	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	[a]	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	[a]	[a]	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 J.1 SEL-700G Relay Word Bits (Sheet 4 of 5)

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	[a]	AIHW1	AIHW2	AIHAL	[a]
120	AI301LW1	AI301LW2	AI301LAL	[a]	AI301HW1	AI301HW2	AI301HAL	[a]
121	AI302LW1	AI302LW2	AI302LAL	[a]	AI302HW1	AI302HW2	AI302HAL	[a]
122	AI303LW1	AI303LW2	AI303LAL	[a]	AI303HW1	AI303HW2	AI303HAL	[a]
123	AI304LW1	AI304LW2	AI304LAL	[a]	AI304HW1	AI304HW2	AI304HAL	[a]
124	AI401LW1	AI401LW2	AI401LAL	[a]	AI401HW1	AI401HW2	AI401HAL	[a]
125	AI402LW1	AI402LW2	AI402LAL	[a]	AI402HW1	AI402HW2	AI402HAL	[a]
126	AI403LW1	AI403LW2	AI403LAL	[a]	AI403HW1	AI403HW2	AI403HAL	[a]
127	AI404LW1	AI404LW2	AI404LAL	[a]	AI404HW1	AI404HW2	AI404HAL	[a]
128	AI501LW1	AI501LW2	AI501LAL	[a]	AI501HW1	AI501HW2	AI501HAL	[a]
129	AI502LW1	AI502LW2	AI502LAL	[a]	AI502HW1	AI502HW2	AI502HAL	[a]
130	AI503LW1	AI503LW2	AI503LAL	[a]	AI503HW1	AI503HW2	AI503HAL	[a]
131	AI504LW1	AI504LW2	AI504LAL	[a]	AI504HW1	AI504HW2	AI504HAL	[a]

Table J.1 SEL-700G Relay Word Bits (Sheet 5 of 5)

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	[a]	[a]	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	67N1T	67N2P	67N2T	MATHERR	[a]	[a]	DIRNEX
148	[a]	[a]	[a]	[a]	NX1DIR	NX2DIR	DIRNFX	DIRNRX
149	DRDOPT1	DRDOPT2	DRDOPT3	DRDOPT	RHSM	HSM	[a]	[a]
150	IA12H	IB12H	IC12H	IA22H	IB22H	IC22H	HR	HRT
151	87SN1	87HSN1	87SN2	87HSN2	87SN3	87HSN3	[a]	[a]
152	87SC1	87HSC1	87SC2	87HSC2	87SC3	87HSC3	[a]	[a]

[a] Reserved for future use.

Table J.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	

Table J.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**
2	50PX3AP			HIDDEN		
	50PX3AT			HIDDEN		
	50PX3BP			HIDDEN		
	50PX3BT			HIDDEN		
	50PX3CP			HIDDEN		
	50PX3CT			HIDDEN		
	b					
	ORED50T					
3	50PY3AP	HIDDEN				
	50PY3AT	HIDDEN				
	50PY3BP	HIDDEN				
	50PY3BT	HIDDEN				
	50PY3CP	HIDDEN				
	50PY3CT	HIDDEN				
	b					
	b					
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

Table J.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**
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
	[b]					
	[b]					
	[b]					
	[b]					
147	67N1P			HIDDEN		HIDDEN
	67N1T			HIDDEN		HIDDEN
	67N2P			HIDDEN		HIDDEN
	67N2T			HIDDEN		HIDDEN
	[b]					
	[b]					
	[b]					
	[b]					

[a] The Relay Word bits are visible and settable in those models that are not marked HIDDEN.
[b] Reserved for future use.

Definitions

Table J.3 Relay Word Bit Definitions for the SEL-700G (Sheet 1 of 22)

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

Table J.3 Relay Word Bit Definitions for the SEL-700G (Sheet 2 of 22)

Bit	Definition	Row
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
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

Table J.3 Relay Word Bit Definitions for the SEL-700G (Sheet 3 of 22)

Bit	Definition	Row
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
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

Table J.3 Relay Word Bit Definitions for the SEL-700G (Sheet 4 of 22)

Bit	Definition	Row
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	X-side Level 1 residual-ground instantaneous overcurrent element pickup	4
50GX1T	X-side Level 1 residual-ground instantaneous overcurrent element trip	4
50GX2P	X-side Level 2 residual-ground instantaneous overcurrent element pickup	4
50GX2T	X-side Level 2 residual-ground instantaneous overcurrent element trip	4
50GY1P	Y-side Level 1 residual-ground instantaneous overcurrent element pickup	5
50GY1T	Y-side Level 1 residual-ground instantaneous overcurrent element trip	5
50GY2P	Y-side Level 2 residual-ground instantaneous overcurrent element pickup	5
50GY2T	Y-side Level 2 residual-ground instantaneous overcurrent element trip	5
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	Level 1 neutral instantaneous overcurrent element pickup	8
50N1T	Level 1 neutral instantaneous overcurrent element trip	8
50N2P	Level 2 neutral instantaneous overcurrent element pickup	8
50N2T	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

Table J.3 Relay Word Bit Definitions for the SEL-700G (Sheet 5 of 22)

Bit	Definition	Row
50PDIRY	Three-phase overcurrent threshold exceeded	141
50PX1P	X-side Level 1 phase instantaneous overcurrent element pickup	1
50PX1T	X-side Level 1 phase instantaneous overcurrent element trip	1
50PX2P	X-side Level 2 phase instantaneous overcurrent element pickup	1
50PX2T	X-side Level 2 phase instantaneous overcurrent element trip	1
50PX3AP	X-side Level 3 Phase A instantaneous overcurrent element pickup	2
50PX3AT	X-side Level 3 Phase A instantaneous overcurrent element trip	2
50PX3BP	X-side Level 3 Phase B instantaneous overcurrent element pickup	2
50PX3BT	X-side Level 3 Phase B instantaneous overcurrent element trip	2
50PX3CP	X-side Level 3 Phase C instantaneous overcurrent element pickup	2
50PX3CT	X-side Level 3 Phase C instantaneous overcurrent element trip	2
50PY1P	Y-side Level 1 phase instantaneous overcurrent element pickup	1
50PY1T	Y-side Level 1 phase instantaneous overcurrent element trip	1
50PY2P	Y-side Level 2 phase instantaneous overcurrent element pickup	1
50PY2T	Y-side Level 2 phase instantaneous overcurrent element trip	1
50PY3AP	Y-side Level 3 Phase A instantaneous overcurrent element pickup	3
50PY3AT	Y-side Level 3 Phase A instantaneous overcurrent element trip	3
50PY3BP	Y-side Level 3 Phase B instantaneous overcurrent element pickup	3
50PY3BT	Y-side Level 3 Phase B instantaneous overcurrent element trip	3
50PY3CP	Y-side Level 3 Phase C instantaneous overcurrent element pickup	3
50PY3CT	Y-side Level 3 Phase C 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	X-side Level 1 negative-sequence instantaneous overcurrent element pickup	4
50QX1T	X-side Level 1 negative-sequence instantaneous overcurrent element trip	4
50QX2P	X-side Level 2 negative-sequence instantaneous overcurrent element pickup	4
50QX2T	X-side Level 2 negative-sequence instantaneous overcurrent element trip	4
50QY1P	Y-side Level 1 negative-sequence instantaneous overcurrent element pickup	5
50QY1T	Y-side Level 1 negative-sequence instantaneous overcurrent element trip	5
50QY2P	Y-side Level 2 residual-ground instantaneous overcurrent element pickup	5
50QY2T	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

Table J.3 Relay Word Bit Definitions for the SEL-700G (Sheet 6 of 22)

Bit	Definition	Row
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	Circuit Breaker X, Contact A	39
52AY	Circuit Breaker Y, Contact A	39
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

Table J.3 Relay Word Bit Definitions for the SEL-700G (Sheet 7 of 22)

Bit	Definition	Row
59GY2	Y-side Level 2 residual-ground overvoltage element pickup	19
59GY2T	Y-side Level 2 residual-ground overvoltage element trip	19
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
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

Table J.3 Relay Word Bit Definitions for the SEL-700G (Sheet 8 of 22)

Bit	Definition	Row
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
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
64F1	Level 1 field ground protection element instantaneous pickup	15
64F1C	Instantaneous Level 1 field ground protection element timed out	61
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	X-side Level 1 residual-ground directional overcurrent pickup	6
67GX1T	X-side Level 1 residual-ground directional overcurrent trip	6
67GX2P	X-side Level 2 residual-ground directional overcurrent pickup	6
67GX2T	X-side Level 2 residual-ground directional overcurrent trip	6
67GX2P	X-side Level 2 residual-ground directional overcurrent pickup	6
67GX2T	X-side Level 2 residual-ground directional overcurrent trip	6
67GY1P	Y-side Level 1 residual-ground directional overcurrent pickup	6

Table J.3 Relay Word Bit Definitions for the SEL-700G (Sheet 9 of 22)

Bit	Definition	Row
67GY1T	Y-side Level 1 residual-ground directional overcurrent trip	6
67N1P	X-side Level 1 neutral-ground directional overcurrent pickup	147
67N1T	X-side Level 1 neutral-ground directional overcurrent trip	147
67N2P	X-side Level 2 neutral-ground directional overcurrent pickup	147
67N2T	X-side Level 2 neutral-ground directional overcurrent trip	147
67PY1P	Y-side Level 1 phase directional overcurrent pickup	7
67PY1T	Y-side Level 1 phase directional overcurrent trip	7
67PY2P	Y-side Level 2 phase directional overcurrent pickup	7
67PY2T	Y-side Level 2 phase directional overcurrent trip	7
67QY1P	Y-side Level 1 phase negative-sequence pickup	7
67QY1T	Y-side Level 1 phase negative-sequence trip	7
67QY2P	Y-side Level 2 phase negative-sequence pickup	7
67QY2T	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
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

Table J.3 Relay Word Bit Definitions for the SEL-700G (Sheet 10 of 22)

Bit	Definition	Row
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
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

Table J.3 Relay Word Bit Definitions for the SEL-700G (Sheet 11 of 22)

Bit	Definition	Row
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
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
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

Table J.3 Relay Word Bit Definitions for the SEL-700G (Sheet 12 of 22)

Bit	Definition	Row
BFIX	52X Breaker Failure Initiation asserted	32
BFIY	52Y Breaker Failure Initiation asserted	32
BFTX	52X Breaker Failure trip	23
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
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 setpoint, or biased alarm setpoint.	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) setpoints.	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
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

Table J.3 Relay Word Bit Definitions for the SEL-700G (Sheet 13 of 22)

Bit	Definition	Row
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	Phase A distortion index wdg1	132
DI_A2	Phase A distortion index wdg2	132
DI_B1	Phase B distortion index wdg1	132
DI_B2	Phase B distortion index wdg2	132
DI_C1	Phase C distortion index wdg1	132
DI_C2	Phase C distortion index 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
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

Table J.3 Relay Word Bit Definitions for the SEL-700G (Sheet 14 of 22)

Bit	Definition	Row
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
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
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

Table J.3 Relay Word Bit Definitions for the SEL-700G (Sheet 15 of 22)

Bit	Definition	Row
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
IN102	Contact Input IN102	49
IN10I	Contact Input IN101	49
IN301–IN304	Contact inputs IN301–IN304 (available only with optional I/O module	50
IN305–IN308	Contact inputs IN305–IN308 (available only with optional I/O module	50
IN401–IN404	Contact inputs IN401–IN404 (available only with optional I/O module	51
IN405–IN408	Contact inputs IN405–IN408 (available only with optional I/O module	51
IN501–IN504	Contact inputs IN501–IN504 (available only with optional I/O module	52
IN505–IN508	Contact inputs IN505–IN508 (available only with optional I/O module	52
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
LB17–LB24	Local Bits 17–24	72
LB25–LB32	Local Bits 25–32	73

Table J.3 Relay Word Bit Definitions for the SEL-700G (Sheet 16 of 22)

Bit	Definition	Row
LBOKA	Channel A, looped back ok	102
LBOKB	Channel B, looped back ok	102
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
LOPX	X-side loss of potential	54
LOPY	Y-side loss of potential	54
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
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 Breaker1 command is issued	41
OCY	Open command—asserts when serial port command Open Breaker Y or Front Panel or Modbus/ DeviceNet Open Breaker2 command is issued	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
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

Table J.3 Relay Word Bit Definitions for the SEL-700G (Sheet 17 of 22)

Bit	Definition	Row
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
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
PB4B_LED	SELOGIC control equation: drives LED PB4B	67
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
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

Table J.3 Relay Word Bit Definitions for the SEL-700G (Sheet 18 of 22)

Bit	Definition	Row
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
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	Relay data quality flag	65
REMTRIP	Remote trip	25
RHSM	Phase comparison internal fault detector	149
RMB1A–RMB8A	Channel A receive mirror bits RMB1A through RMB8A	98
RMB1B–RMB8B	Channel B receive mirror 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

Table J.3 Relay Word Bit Definitions for the SEL-700G (Sheet 19 of 22)

Bit	Definition	Row
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
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
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

Table J.3 Relay Word Bit Definitions for the SEL-700G (Sheet 20 of 22)

Bit	Definition	Row
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
TH5	Fifth-harmonic alarm threshold exceeded	27
TH5T	Fifth-harmonic alarm threshold exceeded for longer than TH5D	27
TMB1A–TMB8A	Channel A transmit mirror bits TMB1A through TMB8A	99
TMB1B–TMB8B	Channel B transmit mirror 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
TREA2	Trigger Reason Bit 2 for synchrophasors	61
TREA3	Trigger Reason Bit 3 for synchrophasors	61
TREA4	Trigger Reason Bit 4 for synchrophasors	61
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

Table J.3 Relay Word Bit Definitions for the SEL-700G (Sheet 21 of 22)

Bit	Definition	Row
TSOK	Asserts if current time source accuracy is sufficient for synchronized phasor measurements	53
TUTC1	Offset hours from UTC time, binary, add 1 if asserted	134
TUTC2	Offset hours from UTC time, binary, add 2 if asserted	134
TUTC4	Offset hours from UTC time, binary, add 4 if asserted	134
TUTC8	Offset hours from UTC time, binary, add 8 if asserted	134
TUTCH	Offset half-hour from UTC time, binary, add 0.5 if asserted	134
TUTCS	Offset hours sign from UTC time, subtract the UTC offset if TUTCS is asserted; otherwise, add.	134
ULCL3	Unlatch trip 2 SELOGIC control equation	43
ULCL3	Unlatch trip 3 SELOGIC control equation	43
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
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
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

Table J.3 Relay Word Bit Definitions for the SEL-700G (Sheet 22 of 22)

Bit	Definition	Row
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 WARNING	53
WDGALRM	Winding Temperature Alarm. WDGALRM asserts if any healthy winding RTD temperature exceeds its alarm setpoint, or biased alarm setpoint.	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) setpoints.	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

Appendix K

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 100 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 K.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*.)
- Fast Meter (see *Appendix C: SEL Communications Processors*.)

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.

For a list of analog quantities available for Modbus communications, see *Appendix E: Modbus RTU Communications*. For a list of analog quantities available for IEC61850 communications, refer to the logical nodes information in *Appendix F: IEC 61850 Communications*.

Table K.1 Analog Quantities (Sheet 1 of 9)

Label	Description	Units	Display Points	SELOGIC	Load Profile	DNP	Fast Meter
Fundamental Instantaneous Metering							
IAX_MAG	A-phase line current	A primary	x	x	x	x	x
IAX_ANG	Angle of the A-phase line current	degrees	x	x	x	x	
IBX_MAG	B-phase line current	A primary	x	x	x	x	x
IBX_ANG	Angle of the B-phase line current	degrees	x	x	x	x	
ICX_MAG	C-phase line current	A primary	x	x	x	x	x
ICX_ANG	Angle of the C-phase line current	degrees	x	x	x	x	
IGX_MAG	Calculated-residual current	A primary	x	x	x	x	
IGX_ANG	Angle of the calculated-residual current	degrees	x	x	x	x	
I1X_MAG	Positive-sequence current	A primary	x	x	x	x	
I1X_ANG	Angle of the positive-sequence current	degrees	x	x	x	x	

Table K.1 Analog Quantities (Sheet 2 of 9)

Label	Description	Units	Display Points	SELOGIC	Load Profile	DNP	Fast Meter
3I2X_MAG	Negative-sequence current	A primary	x	x	x	x	
3I2X_ANG	Angle of the negative-sequence current	degrees	x	x	x	x	
IAY_MAG	A-phase line current	A primary	x	x	x	x	x
IAY_ANG	Angle of the A-phase line current	degrees	x	x	x	x	
IBY_MAG	B-phase line current	A primary	x	x	x	x	x
IBY_ANG	Angle of the B-phase line current	degrees	x	x	x	x	
ICY_MAG	C-phase line current	A primary	x	x	x	x	x
ICY_ANG	Angle of the C-phase line current	degrees	x	x	x	x	
IGY_MAG	Calculated-residual current	A primary	x	x	x	x	
IGY_ANG	Angle of the calculated-residual current	degrees	x	x	x	x	
I1Y_MAG	Positive-sequence current	A primary	x	x	x	x	
I1Y_ANG	Angle of the positive-sequence current	degrees	x	x	x	x	
3I2Y_MAG	Negative-sequence current	A primary	x	x	x	x	
3I2Y_ANG	Angle of the negative-sequence current	degrees	x	x	x	x	
IN_MAG	Neutral current	A primary	x	x	x	x	
IN_ANG	Angle of the neutral current	degrees	x	x	x	x	
VAX_MAG	A-phase-to-neutral voltage	V primary	x	x	x	x	x
VAX_ANG	Angle of the A-phase-to-neutral voltage	degrees	x	x	x	x	
VBX_MAG	B-phase-to-neutral voltage	V primary	x	x	x	x	x
VBX_ANG	Angle of the B-phase-to-neutral voltage	degrees	x	x	x	x	
VCX_MAG	C-phase-to-neutral voltage	V primary	x	x	x	x	x
VCX_ANG	Angle of the C-phase-to-neutral voltage	degrees	x	x	x	x	
VABX_MAG	A-to-B phase voltage	V primary	x	x	x	x	x
VABX_ANG	Angle of the A-to-B phase voltage	degrees	x	x	x	x	
VBCX_MAG	B-to-C phase voltage	V primary	x	x	x	x	x
VBCX_ANG	Angle of the B-to-C phase voltage	degrees	x	x	x	x	
VCAX_MAG	C-to-A phase voltage	V primary	x	x	x	x	x
VCAX_ANG	Angle of the C-to-A phase voltage	degrees	x	x	x	x	
VGX_MAG	Zero-sequence phase voltage	V primary	x	x	x	x	
VGX_ANG	Angle of the zero-sequence voltage	degrees	x	x	x	x	
V1X_MAG	Positive-sequence voltage	V primary	x	x	x	x	
V1X_ANG	Angle of the positive-sequence voltage	degrees	x	x	x	x	
3V2X_MAG	Negative-sequence voltage	V primary	x	x	x	x	
3V2X_ANG	Angle of the negative-sequence voltage	V primary	x	x	x	x	
VAY_MAG	A-phase-to-neutral voltage	V primary	x	x	x	x	x
VAY_ANG	Angle of the A-phase-to-neutral voltage	degrees	x	x	x	x	
VBY_MAG	B-phase-to-neutral voltage	V primary	x	x	x	x	x
VBY_ANG	Angle of the A-phase-to-neutral voltage	degrees	x	x	x	x	
VCY_MAG	C-phase-to-neutral voltage	V primary	x	x	x	x	x
VCY_ANG	Angle of the C-phase-to-neutral voltage	degrees	x	x	x	x	

Table K.1 Analog Quantities (Sheet 3 of 9)

Label	Description	Units	Display Points	SELOGIC	Load Profile	DNP	Fast Meter
VABY_MAG	A-to-B phase voltage	V primary	x	x	x	x	x
VABY_ANG	Angle of the A-to-B phase voltage	degrees	x	x	x	x	
VBCY_MAG	B-to-C phase voltage	V primary	x	x	x	x	x
VBCY_ANG	Angle of the B-to-C phase voltage	degrees	x	x	x	x	
VCAY_MAG	C-to-A phase voltage	V primary	x	x	x	x	x
VCAY_ANG	Angle of the C-to-A phase voltage	degrees	x	x	x	x	
VGY_MAG	Zero-sequence voltage	V primary	x	x	x	x	
VGY_ANG	Angle of the zero-sequence voltage	degrees	x	x	x	x	
V1Y_MAG	Positive-sequence voltage	V primary	x	x	x	x	
V1Y_ANG	Angle of the positive-sequence voltage	degrees	x	x	x	x	
3V2Y_MAG	Negative-sequence voltage	V primary	x	x	x	x	
3V2Y_ANG	Angle of the negative-sequence voltage	V primary	x	x	x	x	
VS_MAG	Synchronized voltage	V primary	x	x	x	x	x
VS_ANG	Angle of synchronized voltage	degrees	x	x	x	x	
VN_MAG	Neutral voltage	V primary	x	x	x	x	
VN_ANG	Angle of neutral voltage	degrees	x	x	x	x	
VN3_MAG	Neutral voltage, 3rd harmonic	V primary	x	x	x	x	
VPX3_MAG	Calculated zero-sequence voltage, 3rd harmonic	V primary	x	x	x	x	
PAX	A-phase real power	kW primary	x	x	x	x	
PBX	B-phase real power	kW primary	x	x	x	x	
PCX	C-phase real power	kW primary	x	x	x	x	
P3X	3-phase real power	kW primary	x	x	x	x	x
QAX	A-phase reactive power	kVAR primary	x	x	x	x	
QBX	B-phase reactive power	kVAR primary	x	x	x	x	
QCX	C-phase reactive power	kVAR primary	x	x	x	x	
Q3X	3-phase reactive power	kVAR primary	x	x	x	x	x
SAX	A-phase apparent power	kVA primary	x	x	x	x	
SBX	B-phase apparent power	kVA primary	x	x	x	x	
SCX	C-phase apparent power	kVA primary	x	x	x	x	
S3X	3-phase apparent power	kVA primary	x	x	x	x	x
PFAX	A-phase power factor	unitless	x	x	x	x	
PFBX	B-phase power factor	unitless	x	x	x	x	
PFCX	C-phase power factor	unitless	x	x	x	x	
PF3X	3-phase power factor	unitless	x	x	x	x	
FREQX	Frequency	Hz	x	x	x	x	x
VHZX	V/Hz	%	x	x	x	x	
PAY	A-phase real power	kW primary	x	x	x	x	
PBY	B-phase real power	kW primary	x	x	x	x	
PCY	C-phase real power	kW primary	x	x	x	x	
P3Y	3-phase real power	kW primary	x	x	x	x	x

Table K.1 Analog Quantities (Sheet 4 of 9)

Label	Description	Units	Display Points	SELOGIC	Load Profile	DNP	Fast Meter
QAY	A-phase reactive power	kVAR primary	x	x	x	x	
QBY	B-phase reactive power	kVAR primary	x	x	x	x	
QCY	C-phase reactive power	kVAR primary	x	x	x	x	
Q3Y	3-phase reactive power	kVAR primary	x	x	x	x	x
SAY	A-phase apparent power	kVA primary	x	x	x	x	
SBY	B-phase apparent power	kVA primary	x	x	x	x	
SCY	C-phase apparent power	kVA primary	x	x	x	x	
S3Y	3-phase apparent power	kVA primary	x	x	x	x	x
PFAY	A-phase power factor	unitless	x	x	x	x	
PFBY	B-phase power factor	unitless	x	x	x	x	
PFCY	C-phase power factor	unitless	x	x	x	x	
PF3Y	3-phase power factor	unitless	x	x	x	x	
FREQY	Frequency	Hz	x	x	x	x	x
FLDRES[a]	Rotor field ground resistance	kilohms	x	x	x	x	
FREQS	Frequency	Hz	x	x	x	x	x
Thermal Metering							
RTDWDGMX	Maximum winding RTD temperature	°C	x	x	x	x	
RTDBRGMX	Maximum bearing RTD temperature	°C	x	x	x	x	
RTDAMB	Ambient RTD temperature	°C	x	x	x	x	
RTDOTHMX	Other maximum RTD temperature	°C	x	x	x	x	
RTD1–RTD12[b]	RTD1 temperature to RTD12 temperature	°C	x	x	x	x	
TCUGEN	Generator % Thermal Capacity Used	%	x	x	x	x	
TCURTD	RTD % Thermal Capacity Used	%	x	x	x	x	
Analog Input Metering							
AI301 to AI304	Analog inputs for an analog card in Slot C[c]	EU	x	x	x	x	
AI401 to AI404	Analog inputs for an analog card in Slot D[c]	EU	x	x	x	x	
AI501 to AI504	Analog inputs for an analog card in Slot E[c]	EU	x	x	x	x	
Energy Metering							
EM_LRDH	Energy last reset date/time high word					x	
EM_LRDM	Energy last reset date/time middle word					x	
EM_LRDL	Energy last reset date/time low word					x	
MWHPX	3-phase real energy IN	MWh primary	x	x	x	x	
MWHNX	3-phase real energy OUT	MWh primary	x	x	x	x	
MVARHPX	3-phase reactive energy IN	MVARh primary	x	x	x	x	
MVARHNX	3-phase reactive energy OUT	MVARh primary	x	x	x	x	
MWHPY	3-phase real energy IN	MWh primary	x	x	x	x	
MWHNY	3-phase real energy OUT	MWh primary	x	x	x	x	
MVARHPY	3-phase reactive energy IN	MVARh primary	x	x	x	x	
MVARHNY	3-phase reactive energy OUT	MVARh primary	x	x	x	x	

Table K.1 Analog Quantities (Sheet 5 of 9)

Label	Description	Units	Display Points	SELOGIC	Load Profile	DNP	Fast Meter
Maximum/Minimum Metering							
MM_LRDH	Max/min last reset date/time high word					x	
MM_LRDM	Max/min last reset date/time middle word					x	
MM_LRDL	Max/min last reset date/time low word					x	
IAXMX	A-phase maximum current	A primary	x	x		x	
IBXMX	B-phase maximum current	A primary	x	x		x	
ICXMX	C-phase maximum current	A primary	x	x		x	
IGXMX	Calculated residual maximum current	A primary	x	x		x	
IAYMX	A-phase maximum current	A primary	x	x		x	
IBYMX	B-phase maximum current	A primary	x	x		x	
ICYMX	C-phase maximum current	A primary	x	x		x	
IGYMX	Calculated residual maximum current	A primary	x	x		x	
INMX	Neutral maximum current	A primary	x	x		x	
IAXMN	A-phase minimum current	A primary	x	x		x	
IBXMN	B-phase minimum current	A primary	x	x		x	
ICXMN	C-phase minimum current	A primary	x	x		x	
IGXMN	Calculated residual minimum current	A primary	x	x		x	
IAYMN	A-phase minimum current	A primary	x	x		x	
IBYMN	B-phase minimum current	A primary	x	x		x	
ICYMN	C-phase minimum current	A primary	x	x		x	
IGYMN	Calculated residual minimum current	A primary	x	x		x	
INMN	Neutral minimum current	A primary	x	x		x	
VABXMX	A-to-B phase maximum voltage	V primary	x	x		x	
VBCXMX	B-to-C phase maximum voltage	V primary	x	x		x	
VCAXMX	C-to-A phase maximum voltage	V primary	x	x		x	
VAXMX	A-phase maximum voltage	V primary	x	x		x	
VBXMX	B-phase maximum voltage	V primary	x	x		x	
VCXMX	C-phase maximum voltage	V primary	x	x		x	
VABYMX	A-to-B phase maximum voltage	V primary	x	x		x	
VBCYMX	B-to-C phase maximum voltage	V primary	x	x		x	
VCAYMX	C-to-A phase maximum voltage	V primary	x	x		x	
VAYMX	A-phase maximum voltage	V primary	x	x		x	
VBYMX	B-phase maximum voltage	V primary	x	x		x	
VCYMX	C-phase maximum voltage	V primary	x	x		x	
VSMX	Vsync maximum voltage	V primary	x	x		x	
VNMX	Neutral maximum voltage	V primary	x	x		x	
VN3MX	Neutral maximum voltage, 3rd harmonic	V primary	x	x		x	
VP3MX	Calculated zero-sequence maximum voltage, 3rd harmonic	V primary	x	x		x	
VABYMN	A-to-B phase minimum voltage	V primary	x	x		x	

Table K.1 Analog Quantities (Sheet 6 of 9)

Label	Description	Units	Display Points	SELogic	Load Profile	DNP	Fast Meter
VBCYMN	B-to-C phase minimum voltage	V primary	x	x		x	
VCAYMN	C-to-A phase minimum voltage	V primary	x	x		x	
VAYMN	A-phase minimum voltage	V primary	x	x		x	
VBYMN	B-phase minimum voltage	V primary	x	x		x	
VCYMN	C-phase minimum voltage	V primary	x	x		x	
VSMN	Vsync minimum voltage	V primary	x	x		x	
VNMN	Neutral minimum voltage	V primary	x	x		x	
VN3MN	Neutral minimum voltage, 3rd harmonic	V primary	x	x		x	
VP3MN	Calculated zero-sequence minimum voltage, 3rd harmonic	V primary	x	x		x	
KVA3XMX	3-phase maximum apparent power	kVA primary	x	x		x	
KW3XMX	3-phase maximum real power	kW primary	x	x		x	
KVAR3XMX	3-phase maximum reactive power	kVAR primary	x	x		x	
KVA3XMN	3-phase minimum apparent power	kVA primary	x	x		x	
KW3XMN	3-phase minimum real power	kW primary	x	x		x	
KVAR3XMN	3-phase minimum reactive power	kVAR primary	x	x		x	
KVA3YMX	3-phase maximum apparent power	kVA primary	x	x		x	
KW3YMX	3-phase maximum real power	kW primary	x	x		x	
KVAR3YMX	3-phase maximum reactive power	kVAR primary	x	x		x	
KVA3YMN	3-phase minimum apparent power	kVA primary	x	x		x	
KW3YMN	3-phase minimum real power	kW primary	x	x		x	
KVAR3YMN	3-phase minimum reactive power	kVAR primary	x	x		x	
FREQXMX	Maximum frequency	Hz	x	x		x	
FREQXMN	Minimum frequency	Hz	x	x		x	
FREQYMX	Maximum frequency	Hz	x	x		x	
FREQYMN	Minimum frequency	Hz	x	x		x	
RTD1MX–RTD12MX	RTD1 maximum to RTD12 maximum	°C	x	x		x	
RTD1MN–RTD12MN	RTD1 minimum to RTD12 minimum	°C	x	x		x	
AI301MX–AI304MX	Analog transducer input 301–304 maximum[c]	EU	x	x		x	
AI301MN–AI304MN	Analog transducer input 301–304 minimum[c]	EU	x	x		x	
AI401MX–AI404MX	Analog transducer input 401–404 maximum[c]	EU	x	x		x	
AI401MN–AI404MN	Analog transducer input 401–404 minimum[c]	EU	x	x		x	
AI501MX–AI504MX	Analog transducer input 501–504 maximum[c]	EU	x	x		x	
AI501MN–AI504MN	Analog transducer input 501–504 minimum[c]	EU	x	x		x	

Table K.1 Analog Quantities (Sheet 7 of 9)

Label	Description	Units	Display Points	SELOGIC	Load Profile	DNP	Fast Meter
RMS Metering							
IAXRMS	A-phase rms current	A primary	x	x	x	x	
IBXRMS	B-phase rms current	A primary	x	x	x	x	
ICXRMS	C-phase rms current	A primary	x	x	x	x	
IAYRMS	A-phase rms current	A primary	x	x	x	x	
IBYRMS	B-phase rms current	A primary	x	x	x	x	
ICYRMS	C-phase rms current	A primary	x	x	x	x	
INRMS	Neutral rms current	A primary	x	x	x	x	
VAXRMS	A-phase rms voltage	V primary	x	x	x	x	
VBXRMS	B-phase rms voltage	V primary	x	x	x	x	
VCXRMS	C-phase rms voltage	V primary	x	x	x	x	
VABXRMS	A-to-B phase rms voltage	V primary	x	x	x	x	
VBCXRMS	B-to-C phase rms voltage	V primary	x	x	x	x	
VCAXRMS	C-to-A phase rms voltage	V primary	x	x	x	x	
VAYRMS	A-phase rms voltage	V primary	x	x	x	x	
VBYRMS	B-phase rms voltage	V primary	x	x	x	x	
VCYRMS	C-phase rms voltage	V primary	x	x	x	x	
VABYRMS	A-to-B phase rms voltage	V primary	x	x	x	x	
VBCYRMS	B-to-C phase rms voltage	V primary	x	x	x	x	
VCAYRMS	C-to-A phase rms voltage	V primary	x	x	x	x	
VSRMS	Vsync rms voltage	V primary	x	x	x	x	
Demand Metering							
IAXD	A-phase current demand	A primary	x	x		x	
IBXD	B-phase current demand	A primary	x	x		x	
ICXD	C-phase current demand	A primary	x	x		x	
IGXD	Residual current demand	A primary	x	x		x	
3I2XD	Negative-sequence current demand	A primary	x	x		x	
IAYD	A-phase current demand	A primary	x	x		x	
IBYD	B-phase current demand	A primary	x	x		x	
ICYD	C-phase current demand	A primary	x	x		x	
IGYD	Residual current demand	A primary	x	x		x	
3I2YD	Negative-sequence current demand	A primary	x	x		x	
Peak Demand Metering							
PM_LRDH	Peak demand last reset date/time high word					x	
PM_LRDM	Peak demand last reset date/time middle word					x	
PM_LRDL	Peak demand last reset date/time low word					x	
IAXPD	A-phase current peak demand	A primary	x	x		x	
IBXPD	B-phase current peak demand	A primary	x	x		x	
ICXPD	C-phase current peak demand	A primary	x	x		x	
IGXPD	Residual current peak demand	A primary	x	x		x	

Table K.1 Analog Quantities (Sheet 8 of 9)

Label	Description	Units	Display Points	SELogic	Load Profile	DNP	Fast Meter
3I2XPD	Negative-sequence current peak demand	A primary	x	x		x	
IAYPD	A-phase current peak demand	A primary	x	x		x	
IBYPD	B-phase current peak demand	A primary	x	x		x	
ICYPD	C-phase current peak demand	A primary	x	x		x	
IGYPD	Residual current peak demand	A primary	x	x		x	
3I2YPD	Negative-sequence current peak demand	A primary	x	x		x	
Harmonics Metering							
IAX_THD	A-phase current THD	%	x	x		x	
IBX_THD	B-phase current THD	%	x	x		x	
ICX_THD	C-phase current THD	%	x	x		x	
IAY_THD	A-phase current THD	%	x	x		x	
IBY_THD	B-phase current THD	%	x	x		x	
ICY_THD	C-phase current THD	%	x	x		x	
Breaker Monitoring							
BM_LRDHX	Breaker monitor last reset date/time high word					x	
BM_LRDMX	Breaker monitor last reset date/time middle word					x	
BM_LRDLX	Breaker monitor last reset date/time low word					x	
BM_LRDHY	Breaker monitor last reset date/time high word					x	
BM_LRDMY	Breaker monitor last reset date/time middle word					x	
BM_LRDLY	Breaker monitor last reset date/time low word					x	
INTTX	Internal trips—counter		x	x		x	
EXTTX	External trips—counter		x	x		x	
INTIAX	A-phase accumulated current—internal trips	kA primary	x	x		x	
INTIBX	B-phase accumulated current—internal trips	kA primary	x	x		x	
INTICX	C-phase accumulated current—internal trips	kA primary	x	x		x	
EXTIAX	A-phase accumulated current—external trips	kA primary	x	x		x	
EXTIBX	B-phase accumulated current—external trips	kA primary	x	x		x	
EXTICX	C-phase accumulated current—external trips	kA primary	x	x		x	
WEARAX	A-phase breaker wear	%	x	x		x	
WEARBX	B-phase breaker wear	%	x	x		x	
WEARCX	C-phase breaker wear	%	x	x		x	
INTTY	Internal trips—counter		x	x		x	
EXTTY	External trips—counter		x	x		x	
INTIAY	A-phase accumulated current—internal trips	kA primary	x	x		x	
INTIBY	B-phase accumulated current—internal trips	kA primary	x	x		x	
INTICY	C-phase accumulated current—internal trips	kA primary	x	x		x	
EXTIAY	A-phase accumulated current—external trips	kA primary	x	x		x	
EXTIBY	B-phase accumulated current—external trips,	kA primary	x	x		x	
EXTICY	C-phase accumulated current—external trips,	kA primary	x	x		x	
WEARAY	A-phase breaker wear	%	x	x		x	

Table K.1 Analog Quantities (Sheet 9 of 9)

Label	Description	Units	Display Points	SELOGIC	Load Profile	DNP	Fast Meter
WEARBY	B-phase breaker wear	%	x	x		x	
WEARCY	C-phase breaker wear	%	x	x		x	
Date/Time							
DATE	Present date		x			x[d]	
TIME	Present time		x			x[d]	
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							
RID[e]	Relay identifier		x				
TID[e]	Terminal identifier		x				
Setting Group							
GROUP	Active setting group #		x	x		x[f]	
Math Variables							
MV01–MV32	Math variable 01 to math variable 32		x	x	x	x	
SELOGIC Counters							
SC01–SC32	SELOGIC counter 01 to SELOGIC counter 32		x	x	x	x[f]	
Serial Number							
SER_NUM	Serial number of the relay					x	

[a] When E64F = N or 64FFLT = 1, FLDRES will be forced to 20MΩ and DNP and IEC 61850 will report FFFFh.
[b] RTD open is equivalent to +32767 and RTD short is equivalent to –32768 when Rtds are monitored via LDP.
[c] See the engineering unit settings (for example, AI301EU) of the respective analog input quantity for the unit.
[d] Available as DNP object 50.
[e] RID and TID are only available as display point settings (DP01 to DP32).
[f] Available as DNP counter object.

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Glossary

A Abbreviation for amps or amperes; units of electrical current magnitude.

ACSELERATOR QuickSet® SEL-5030 Software A Windows®-based program that simplifies settings and provides analysis support.

ACSELERATOR Architect® SEL-5032 Software Design and commissioning tool for IEC 61850 communications.

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
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
60	Loss-of-Potential Element
64F	Field Ground Element
64G	Stator Ground Element
67	Directional Overcurrent Element
78	Out of Step 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.

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.

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.

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.”

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.

EEPROM Abbreviation for Electrically Erasable Programmable Read-Only Memory. Nonvolatile memory where relay settings, event reports, SER records, and other nonvolatile data are stored.

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.

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.

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.

IA, IB, IC Measured A-, B-, and C-phase currents.

IEC 61850 Standard protocol for real-time exchange of data between databases in multivendor 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.

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.

MIRRORED BITS Protocol for direct relay-to-relay communications.

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.

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), kilovolt-watts (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 (W), kilovars (kVar), or megavars (MVar).

PT Abbreviation for potential transformer. Also referred to as a voltage transformer or VT.

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 winding. 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.

RTD Abbreviation for Resistance Temperature Device. 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.

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).

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.

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.

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.

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

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SEL-700G Relay Command Summary

The table below lists the front serial port ASCII commands associated with particular activities. The commands are shown in uppercase letters, but they can also be entered using lowercase letters.

Serial Port Command	Command Description
Access Level 0 Commands	
ACC	Goes to Access Level 1.
ID	Relay identification code.
QUI	Goes to Access Level 0.
Access Level 1 Commands	
2AC	Goes to Access Level 2.
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. Attach R for compressed raw report, at 1/32-cycle resolution.
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.
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	Appends a long report to the summary report of the last 255 records in the MIRRORED BITS communications buffer.
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	Returns a summary report of the last 255 records in the MIRRORED BITS communications buffer.
COU *n*	Shows current state of device counters. *n* = repeat the report *n* times, with a 1/2 second delay between each report.
DAT	Views the date.
DAT *dd/mm/yyyy*	Enters date in DMY format.
DAT *mm/dd/yyyy*	Enters date in MDY format if DATE_F setting is MDY.
DAT *yyyy/mm/dd*	Enters date in YMD format if DATE_F setting is YMD.
ETH	Shows the Ethernet port status.
EVE *n*	Shows event report *n* with 4 samples per cycle. If *n* is omitted, most recent report is displayed.
EVE R *n*	Shows event report *n* with raw (unfiltered) 32 samples per cycle analog data and 4 samples per cycle digital data.
FIL DIR	Returns a list of files.

Serial Port Command	Command Description
FIL READ *filename*	Transfers settings file *filename* from the relay to the PC.
FIL SHOW *filename*	Filename 1 displays contents of the file *filename*.
GEN	Displays generator operating statistics report.
GSH	Displays the generator autosynchronism report history.
GST	Triggers generator autosynchronism report data capture.
GOO *k*	Displays transmit and receive GOOSE messaging information. Enter number *k* to scroll the GOOSE data *k* times on the screen.
GRO	Displays active group setting.
HEL	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.
IRIG	Forces synchronization of internal control clock to IRIG-B time-code input.
LDP	Displays signal profile data.
LDP C	Clears signal profile data.
MAC	Displays the MAC address of the Ethernet port (PORT 1).
MET	Displays instantaneous metering data.
MET *k*	Displays instantaneous metering data *k* times, where *k* is between 1 and 32767.
MET AI	Displays analog input (transducer) data.
MET DEM *k*	Displays demand metering data, in primary amperes. Enter *k* to scroll metering ***k*** times on screen.
MET DIF *k*	Displays differential metering data. Enter *k* to scroll metering *k* times on the screen.
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 PEA *k*	Displays peak demand metering data, in primary amperes. Enter *k* to scroll metering k times on screen.
MET PM	Displays synchrophasor 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 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 or 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.
SER	Displays all Sequential Events Recorder (SER) data.
SER *d1*	Displays all **SER** records made on date *d1*.
SER *d1 d2*	Displays all **SER** records made from dates *d2* to *d1*, inclusive, starting with *d2*.
SER *n*	Displays the *n* most recent **SER** records starting with record *n*.
SER *n1 n2*	Displays **SER** records *n2* to *n1*, starting with *n2*.

Serial Port Command	Command Description
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, or 3). If *n* is not specified, default is the active settings group.
SHO F	Displays front-panel settings.
SHO G	Displays global settings.
SHO L *n*	Displays general logic settings for group *n* (*n* = 1, 2, or 3). 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	Displays an event summary.
SUM R or **C**	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*.
TAR *n k*	Displays target row *n*. Repeat 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. Repeat display of this row for repeat count *k*.
TAR R	Resets any latched targets and the most recently viewed target row.
TIM	Views time.
TIM *hh:mm:ss*	Sets time by entering **TIM** followed by hours, minutes, and seconds, as shown (24-hour clock).
TRI	Triggers an event report data capture.
Access Level 2 Commands	
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.
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.
COP *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.

Serial Port Command	Command Description
GRO *n*	Modifies active group setting.
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.
MET WE	Preload energy meter registers.
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 *n t*	Pulses Output Contact *n* (*n* = OUT101…) for *t* (1 to 30, default is 1) seconds.
SET *n*	Modifies relay settings for group *n* (*n* = 1, 2, or 3). 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, 50P1P.
SET F	Modifies front-panel settings.
SET G	Modifies global settings.
SET L *n*	Modifies SELOGIC variable and timer settings for group *n* (*n* = 1, 2, or 3). If *n* is not specified, default is the active settings group.
SET M	Modifies Modbus User Map settings.
SET P *n*	Modifies port *n* settings (*n* = 1, 2, 3, 4, or F; if not specified, the default is the active port).
SET R	Modifies report settings.
SET … TERSE	For all **SET** commands, **TERSE** disables the automatic **SHO** command after the settings entry.
STA R or **C**	Clears self-test status and restart relay.
SYN R	Resets the breaker close time average and breaker close operations counter in the synchronism-check report data.
VEC D	Displays standard vector diagnostics report (useful to the factory in troubleshooting).
VEC E	Displays extended vector diagnostics report (useful to the factory in troubleshooting).
Access Level C Command	
PAS C	Changes Access Level 2 password.

SEL-700G Relay Command Summary

The table below lists the front serial port ASCII commands associated with particular activities. The commands are shown in uppercase letters, but they can also be entered using lowercase letters.

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ACC	Goes to Access Level 1.
ID	Relay identification code.
QUI	Goes to Access Level 0.
Access Level 1 Commands	
2AC	Goes to Access Level 2.
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. Attach R for compressed raw report, at 1/32-cycle resolution.
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.
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	Appends a long report to the summary report of the last 255 records in the MIRRORED BITS communications buffer.
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	Returns a summary report of the last 255 records in the MIRRORED BITS communications buffer.
COU *n*	Shows current state of device counters. *n* = repeat the report *n* times, with a 1/2 second delay between each report.
DAT	Views the date.
DAT *dd/mm/yyyy*	Enters date in DMY format.
DAT *mm/dd/yyyy*	Enters date in MDY format if DATE_F setting is MDY.
DAT *yyyy/mm/dd*	Enters date in YMD format if DATE_F setting is YMD.
ETH	Shows the Ethernet port status.
EVE *n*	Shows event report *n* with 4 samples per cycle. If *n* is omitted, most recent report is displayed.
EVE R *n*	Shows event report *n* with raw (unfiltered) 32 samples per cycle analog data and 4 samples per cycle digital data.
FIL DIR	Returns a list of files.

Serial Port Command	Command Description
FIL READ *filename*	Transfers settings file *filename* from the relay to the PC.
FIL SHOW *filename*	Filename 1 displays contents of the file *filename*.
GEN	Displays generator operating statistics report.
GSH	Displays the generator autosynchronism report history.
GST	Triggers generator autosynchronism report data capture.
GOO *k*	Displays transmit and receive GOOSE messaging information. Enter number *k* to scroll the GOOSE data *k* times on the screen.
GRO	Displays active group setting.
HEL	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.
IRIG	Forces synchronization of internal control clock to IRIG-B time-code input.
LDP	Displays signal profile data.
LDP C	Clears signal profile data.
MAC	Displays the MAC address of the Ethernet port (PORT 1).
MET	Displays instantaneous metering data.
MET *k*	Displays instantaneous metering data *k* times, where *k* is between 1 and 32767.
MET AI	Displays analog input (transducer) data.
MET DEM *k*	Displays demand metering data, in primary amperes. Enter *k* to scroll metering ***k*** times on screen.
MET DIF *k*	Displays differential metering data. Enter *k* to scroll metering *k* times on the screen.
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 PEA *k*	Displays peak demand metering data, in primary amperes. Enter *k* to scroll metering k times on screen.
MET PM	Displays synchrophasor 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 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 or 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.
SER	Displays all Sequential Events Recorder (SER) data.
SER *d1*	Displays all **SER** records made on date *d1*.
SER *d1 d2*	Displays all **SER** records made from dates *d2* to *d1*, inclusive, starting with *d2*.
SER *n*	Displays the *n* most recent **SER** records starting with record *n*.
SER *n1 n2*	Displays **SER** records *n2* to *n1*, starting with *n2*.

Serial Port Command	Command Description
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, or 3). If *n* is not specified, default is the active settings group.
SHO F	Displays front-panel settings.
SHO G	Displays global settings.
SHO L *n*	Displays general logic settings for group *n* (*n* = 1, 2, or 3). 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	Displays an event summary.
SUM R or **C**	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*.
TAR *n k*	Displays target row *n*. Repeat 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. Repeat display of this row for repeat count *k*.
TAR R	Resets any latched targets and the most recently viewed target row.
TIM	Views time.
TIM *hh:mm:ss*	Sets time by entering **TIM** followed by hours, minutes, and seconds, as shown (24-hour clock).
TRI	Triggers an event report data capture.
Access Level 2 Commands	
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.
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.
COP *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.

Serial Port Command	Command Description
GRO *n*	Modifies active group setting.
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.
MET WE	Preload energy meter registers.
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 *n t*	Pulses Output Contact *n* (*n* = OUT101…) for *t* (1 to 30, default is 1) seconds.
SET *n*	Modifies relay settings for group *n* (*n* = 1, 2, or 3). 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, 50P1P.
SET F	Modifies front-panel settings.
SET G	Modifies global settings.
SET L *n*	Modifies SELOGIC variable and timer settings for group *n* (*n* = 1, 2, or 3). If *n* is not specified, default is the active settings group.
SET M	Modifies Modbus User Map settings.
SET P *n*	Modifies port *n* settings (*n* = 1, 2, 3, 4, or F; if not specified, the default is the active port).
SET R	Modifies report settings.
SET … TERSE	For all **SET** commands, **TERSE** disables the automatic **SHO** command after the settings entry.
STA R or **C**	Clears self-test status and restart relay.
SYN R	Resets the breaker close time average and breaker close operations counter in the synchronism-check report data.
VEC D	Displays standard vector diagnostics report (useful to the factory in troubleshooting).
VEC E	Displays extended vector diagnostics report (useful to the factory in troubleshooting).
Access Level C Command	
PAS C	Changes Access Level 2 password.