SEL-700G

Generator and Intertie Protection Relays

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

Instruction Manual

20120903

SEL SCHWEITZER ENGINEERING LABORATORIES, INC.

⚠ 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.

⚠ 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.

⚠ 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. Dispose of used batteries according to the manufacturer's instructions.

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

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

⚠ 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.

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

⚠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 equipment before installing the option card to prevent damage to the equipment.

⚠ 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.

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

⚠ 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.

⚠ 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.

⚠ ATTENTION
Il y a un danger d'explosion si la pile électrique n'est pas correctement remplacée. Utiliser exclusivement Ray-O-Vac® No. BR2335 ou un équivalent recommandé par le fabricant. Se débarrasser des piles usagées suivant les instructions du fabricant.

⚠ ATTENTION
Regarder vers les connecteurs optiques, les extrémités des fibres oules connecteurs de cloison peut entraîner une exposition à des rayonnements dangereux.

⚠ 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.

⚠ 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.

⚠ 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.

⚠ AVERTISSEMENT
Pour installer une carte à option, le relais doit être éteint et ensuite rallumé. Quand il est rallumé, le relais redémarrera. Donc, il faut éteindre l'équipementprotégé avant d'installer la carte à option pour empêcher des dégats à l'équipement.

⚠ 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 accés non-autorisé á l'équipement peut être possible. SEL décline toute responsabilité pour tout dommage résultant de cet accés non-autorisé.

⚠ 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
Tout contact avec les bornes de l'appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.

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This product is covered by the standard SEL 10-year warranty. For warranty details, visit www.selinc.com or contact your customer service representative.

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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*.

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.

Typographic Conventions

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 current version of your SEL-700G.

Safety and General Information

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

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

⚠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.

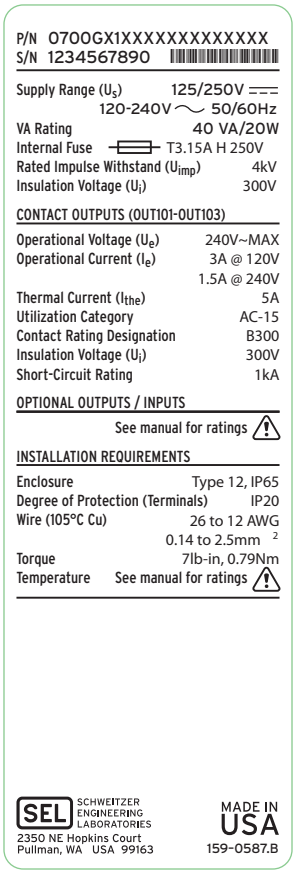
Symbols

The following symbols from EN 61010-1 are often marked on SEL products.

Symbol 14		Caution, Risk of Danger—Consult Documentation for Additional Information
Symbol 6		Protective (Safety) Ground Conductor Terminal
Symbol 1		Direct Current
Symbol 2		Alternating Current
Symbol 3		Direct and Alternating Current
Symbol 5		Earth (Ground) Terminal

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

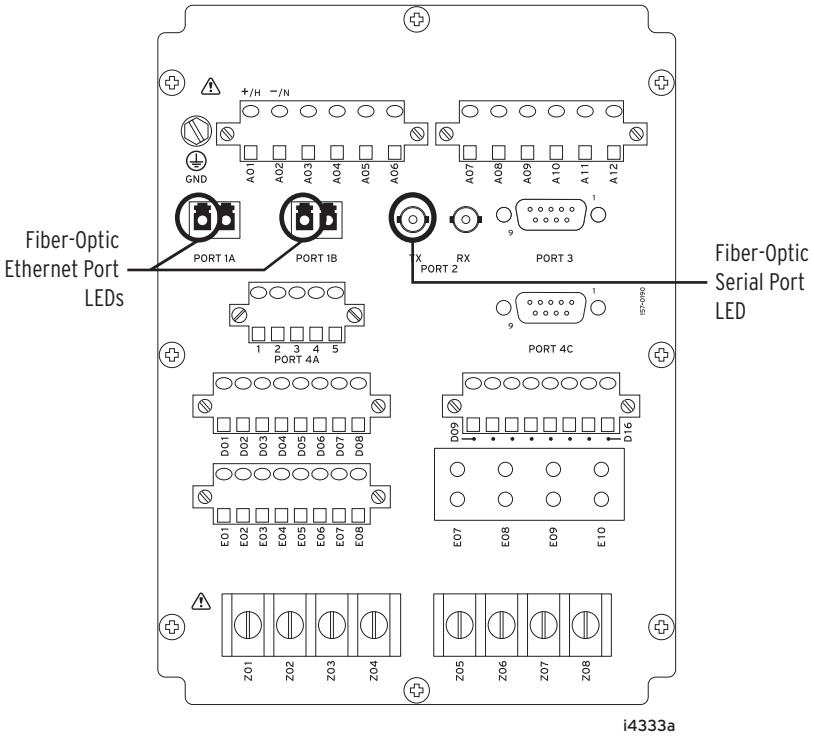
⚠CAUTION
Looking into optical connections, fiber ends, or bulkhead connections can result in hazardous radiation exposure.

⚠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).

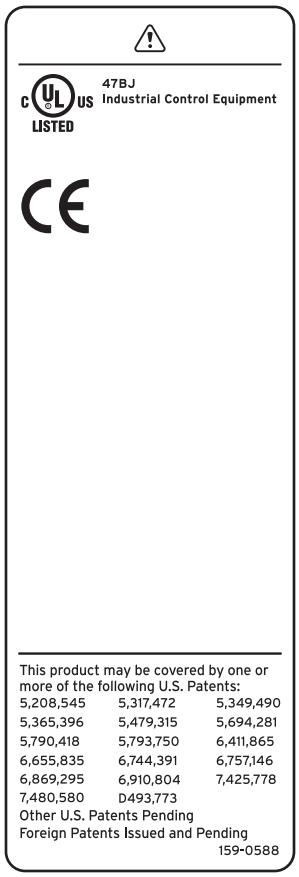


SEL-700G LED Locations

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.

Compliance 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

Environmental Conditions and Voltage Information

The following table lists important environmental and voltage information.

Condition	Range/Description
Indoor/outdoor use	Indoor
Altitude	Up 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	Up to ±10% of Nominal voltage
Overvoltage	Category II
Pollution	Degree 2
Atmospheric pressure	80 to 110 kPa

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 may 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 (2.5 mm^2)
Current Connection	16 AWG (1.5 mm^2)	12 AWG (4 mm^2)
Potential (Voltage) Connection	18 AWG (0.8 mm^2)	14 AWG (2.5 mm^2)
Contact I/O	18 AWG (0.8 mm^2)	14 AWG (2.5 mm^2)
Other Connection	18 AWG (0.8 mm^2)	14 AWG (2.5 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 USA
Phone: +1.509.332.1890
Fax: +1.509.332.7990
Internet: www.selinc.com
E-mail: info@selinc.com

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Section 1
Introduction and Specifications

Overview

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

This manual contains the information needed 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 3)

PROTECTION ELEMENTS		Basic Generator Protection	Basic With			Intertie Protection	Intertie and Generator Protection	Wind Generator Protection
			21C, 25, 64G, 78	21C, 78, 87	21C, 25, 64G, 78, 87			
		700G0	700G0+	700G1	700G1+	700GT	700GT+	700GW
87	Phase Differential			X	X			
87N	Ground Differential	X	X	X	X		X	
REF	Restricted Earth Fault	X	X	X	X		X	
49T	Thermal Overload	X	X	X	X		X	
50PX	Phase Overcurrent	X	X	X	X		X	X
50N	Neutral Overcurrent	X	X	X	X	X	X	
50GX	Ground Overcurrent	X	X	X	X		X	X
50QX	Neg.-Seq. Overcurrent	X	X	X	X		X	X
51PX	Phase Time-Overcurrent							X
51N	Neutral Time-Overcurrent	X[a]	X[a]	X[a]	X[a]	X	X[a]	
51GX	Ground Time-Overcurrent	X[a]	X[a]	X[a]	X[a]		X[a]	X
51QX	Neg.-Seq. Time-Overcurrent							X

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

PROTECTION ELEMENTS		Basic Generator Protection	Basic With			Intertie Protection	Intertie and Generator Protection	Wind Generator Protection
			21C, 25, 64G, 78	21C, 78, 87	21C, 25, 64G, 78, 87			
		700G0	700G0+	700G1	700G1+	700GT	700GT+	700GW
67GX	Directional Ground Overcurrent	x	x	x	x		x	
67N	Directional Neutral Overcurrent	x	x	x	x		x	
46	Current Unbalance	x	x	x	x		x	
51C	Voltage-Controlled TOC	x	x	x	x		x	
51V	Voltage-Restrained TOC	x	x	x	x		x	
BFX	Breaker Failure	x	x	x	x		x	x
27X	Undervoltage	x	x	x	x		x	
59X	Overvoltage (P, Q, G)	x	x	x	x		x	
27S	Synchronism Undervoltage		x		x	x	x	
59S	Synchronism Overvoltage		x		x	x	x	
60LOPX	Loss of Potential	x	x	x	x		x	
24	Volts/Hz	x	x	x	x		x	
32X	Directional Power	x	x	x	x		x	
40	Loss of Field	x	x	x	x		x	
81X	Over/Underfrequency	x	x	x	x		x	
81RX	Rate-of-Change of Frequency	x	x	x	x		x	
64F	Field Ground	x	x	x	x		x	
25 GEN	Synchronism Check		x		x		x	
21C	Compensator Distance		x	x	x			
78	Out of Step		x	x	x			
64G	100% Stator Ground		x		x			
INAD	Inadvertent Energization	x	x	x	x		x	
49RTD	RTDs		x	x	x	x	x	x
50PY	Phase Overcurrent			x	x	x	x	x
50GY	Ground Overcurrent			x	x	x	x	x
50QY	Neg.-Seq. Overcurrent			x	x	x	x	x
51PY	Phase Time-Overcurrent					x[a]	x[a]	x
51GY	Ground Time-Overcurrent					x[a]	x[a]	x
51QY	Neg.-Seq. Time-Overcurrent					x[a]	x[a]	x
67PY	Directional Phase Overcurrent					x	x	
67GY	Directional Ground Overcurrent					x	x	
67QY	Directional Neg.-Seq. Overcurrent					x	x	
27Y	Undervoltage					x	x	
59Y	Overvoltage (P, Q, G)					x	x	
BFY	Breaker Failure					x	x	x
25 TIE	Synchronism Check					x	x	

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

PROTECTION ELEMENTS		Basic Generator Protection	Basic With			Intertie Protection	Intertie and Generator Protection	Wind Generator Protection
			21C, 25, 64G, 78	21C, 78, 87	21C, 25, 64G, 78, 87			
		700G0	700G0+	700G1	700G1+	700GT	700GT+	700GW
32Y	Directional Power					x	x	
81Y	Over/Underfrequency					x	x	
81RY	Rate-of-Change of Frequency					x	x	
60LOPY	Loss of Potential					x	x	
	Autosynchronizer		x		x		x	

[a] These inverse time-overcurrent elements have directional control.

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-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

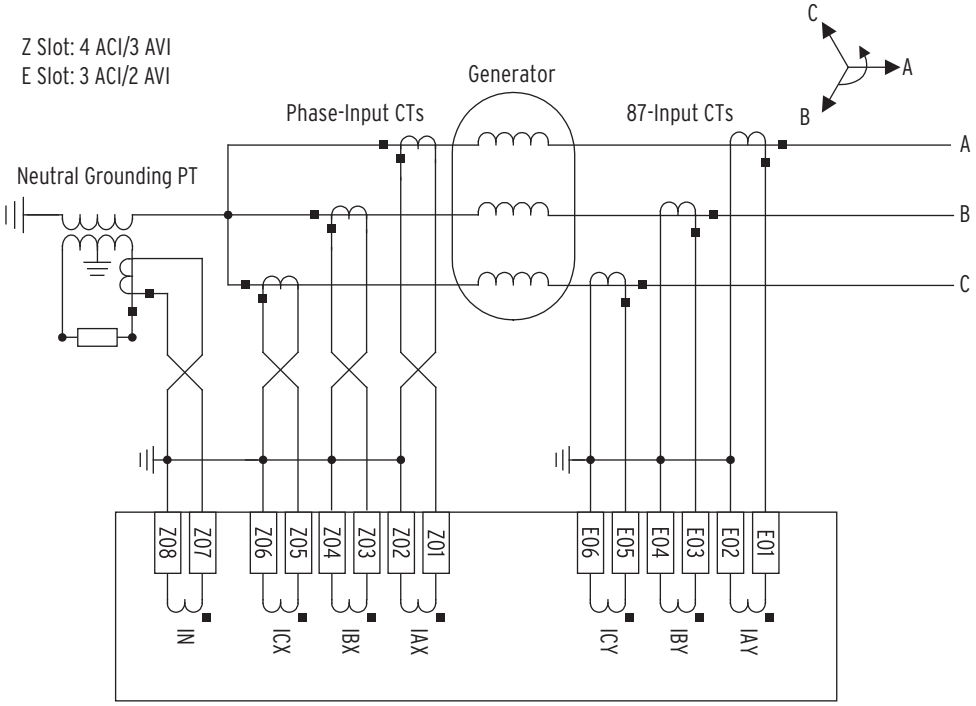
For all SEL-700G mounting accessories for competitor products, including adapter plates, visit *http://www.selinc.com/MountingAccessories/*.

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 2.18*.
- 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 required 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 = 0000000000000000
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

General

AC Current Input

Phase and Neutral Currents

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

INOM = 5 A

Rated Range (X/R = 40):	0.1–96.0 A
Continuous Rating:	15 A
1 Second Thermal:	500 A
Rated Frequency:	50/60 ±5 Hz
Burden (per Phase):	<0.1 VA

INOM = 1 A

Rated Range (X/R = 40):	0.02–19.20 A
Continuous Rating:	3 A
1 Second Thermal:	100 A
Rated Frequency:	50/60 ±5 Hz
Burden (per Phase):	< 0.01 VA
Measurement Category:	II

AC Voltage Inputs

Rated Operating Voltage:	100–250 Vac
Rated Continuous Voltage:	300 Vac
10 Second Thermal:	600 Vac
Rated Frequency:	50/60 ±5 Hz
Burden:	< 0.1 VA

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:	10,000 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

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
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 MΩ (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 (RJ-45 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)

Terminal Connections

Current Inputs 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:	0.225 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 60068-2-6:1995 3 G, 10–150 Hz IEC 60255-21-1:1988, Class 1 IEC 60255-21-3:1993, Class 2
Shock Resistance:	IEC 60255-21-2:1988, Class 1
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

Certifications

ISO 9001:	This product was designed and manufactured under an ISO 9001 certified quality management system.
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

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:	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 2 times per cycle.

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 ±0.02 • I_{NOM} A secondary (Steady State pickup)
Time Delay:	0.00–400.00 seconds, 0.01 seconds steps, ±0.5% ±0.25 cyc 0.10–400.00 seconds, 0.01 seconds steps, ±0.5% ±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 ±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, ±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% ±0.10 A
1 A Model:	±5% ±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% ±0.10 A
1 A Model:	±5% ±0.02 A
Time Delay Accuracy:	±0.5% ±0.25 cycle

Restricted Earth Fault (REF)

5 A Model:	0.25–15.00 A, 0.01 A steps
1 A Model:	0.05–3.00 A, 0.01 A steps
Pickup Accuracy (A secondary):	
5 A Model:	±5% ±0.10 A
1 A Model:	±5% ±0.02 A
ANSI Extremely Inverse TOC Curve (U4 with 0.5 Time Dial)	
Accuracy:	±5 cycles, ±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 ±2 V
Pickup/Dropout Time:	<1.5 cycle
Time Delay:	0.00–120.00 seconds, 0.01 second steps
Accuracy:	±0.5% ±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 ±2 V
Pickup/Dropout Time:	<1.5 cycle
Time Delay:	0.00–120.00 seconds, 0.01 second steps
Accuracy:	±0.5% ±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% ±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% ±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% ±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% ±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:	up to 1.4 Vac (peak) at 50 Hz or greater frequency

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%, ±0.1 ohm 1 A mode: ±5%, ±0.5 ohm
Definite-Time Delay:	0.00–400.00 s
Accuracy:	±0.1%, ±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, ±5% of (offset + diameter) 1 A model: ±0.5 ohm, ±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%, ± 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%, ±0.10 A 1 A Model: ±5%, ±0.02 A
Time Dials:	US: 0.50–15.00, 0.01 steps IEC: 0.05–1.00, 0.01 steps
Timing:	±4%, ±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%, ±0.10 A 1 A Model: ±5%, ±0.02 A
Time Dials:	US: 0.50–15.00, 0.01 steps IEC: 0.05–1.00, 0.01 steps
Timing:	±4%, ±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%, ±0.1 V
Pickup Time:	1.5 cycles (Max)
Definite-Time Delay:	0.00–400.00 s
Accuracy:	±0.1%, ± 0.25 cycle
Third-Harmonic Voltage Differential or Third-Harmonic Neutral Undervoltage Pickup 64G2:	0.1–20.0 V
Steady-State Pickup Accuracy:	±5%, ±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%, ±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% ±500 ohms for 48 ± VF ± 825 Vdc
	±5% ±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% ±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, ±5% of diameter 1 A model: ±0.5 ohm, ±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%, ±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% , ±0.10 A 1 A Model: ±5% , ±0.02 A
Pickup Time:	1.5 cycles (Max)
Time Delay Range:	0.00–5.00 s
Time Delay Accuracy:	±0.5%, ±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, ±3% 1 A Model: ±0.005 A, ±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%, ±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%, ±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, ±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%, ±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%, ±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*Inom, where Inom = 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%, ±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 Inom = 1 A)
3-Phase Average Current:	±2% of reading
Differential Quantities:	±5% of reading, ±0.1 A (5 A nominal), ±0.02 A (1 A nominal)
Current Harmonics:	±5% of reading, ±0.1 A (5 A nominal), ±0.02 A (1 A nominal)
IG (Residual Current):	±3% of reading, ±2° (±5.0° at 0.2–0.5 A for relays with Inom = 1 A)
IN (Neutral Current):	±1% of reading, ±1° (±2.5° at 0.2–0.5 A for relays with Inom = 1 A)
3I2 Negative-Sequence Current:	±3% of reading
System Frequency:	±0.01 Hz of reading for frequencies within 20–70 Hz (V1 > 60 V)
Line-to-Line Voltages:	±2% of reading, ±1° for voltages within 24–264 V
3-Phase Average Line-to-Line Voltage:	±2% of reading for voltages within 24–264 V
Line-to-Ground Voltages:	±2% of reading, ±1° for voltages within 24–264 V
3-Phase Average Line-to-Ground Voltages:	±2% of reading for voltages within 24–264 V
Voltage Harmonics:	±5% of reading, ±0.5 V
3V2 Negative-Sequence Voltage:	±3% 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

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.

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.

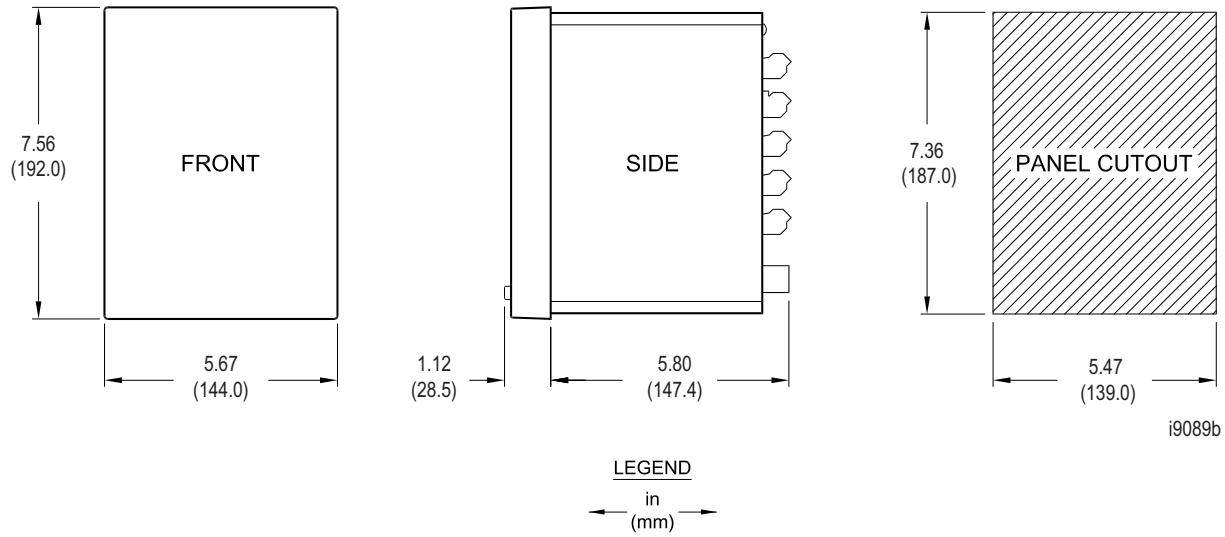


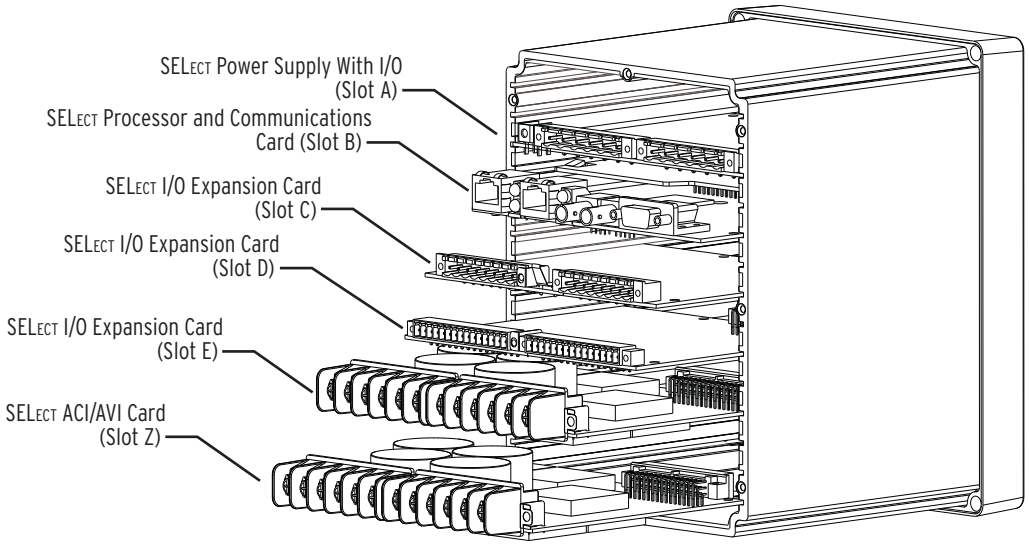
Figure 2.1 Relay Panel-Mount Dimensions

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 BO1, BO2 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). Only one input can be used at a time).
[c] Digital or analog.

Figure 2.2 Slot Allocations for Different Cards

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

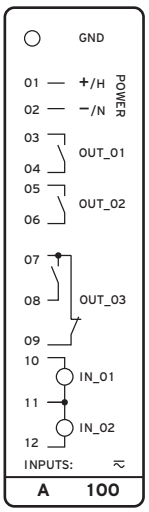
Select appropriate power supply option for the application:

- 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

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

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 using the **Port 4** Setting COMM Interface. *Table 2.3* shows the port number, interface, and type of connector for the two protocols.

Table 2.3 Communications Card Interfaces and Connectors

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

The communications card supports the following protocols:

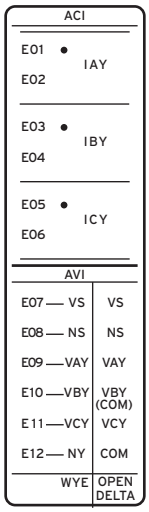
- Modbus RTU Slave
- SEL ASCII and Compressed ASCII
- SEL Fast Meter
- SEL Fast Operate
- SEL Fast SER
- SEL Fast Message Unsolicited Write
- SEL Settings File Transfer
- SEL MIRRORED BITS (MBA, MBB, MB8A, MB8B, MBTB, MBTA)
- Event Messenger
- DNP3 Slave Level 2
- C37.118 (Synchrophasor Data)

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

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.

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 EXT3VO_X must also be set accordingly.

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

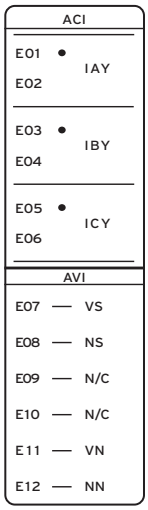
Side-Panel Connections Label	Terminal Number	Description
	**E01, E02**	IAY, Y-side Phase A current input
	E03, E04	IBY, Y-side Phase B current input
	E05, E06	ICY, Y-side Phase C current input
	E07	VS, synchronism-check voltage input
	E08	NS, common connection for synchronism-check voltage input
	E09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

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.

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 EXT3VO_X must also be set accordingly. Refer to *Section 4: Protection and Logic Functions* for more details.

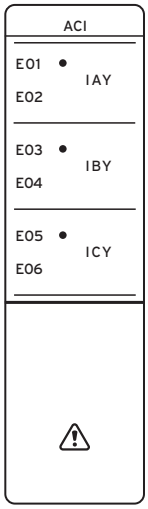
Table 2.5 3 ACI/2 AVI Current/Voltage Card Inputs Terminal Allocation

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)

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.

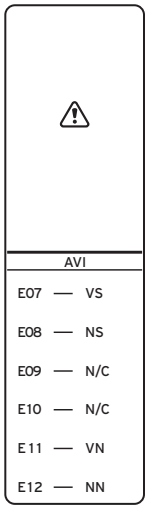
Table 2.6 3 ACIE Current Card Inputs Terminal Allocation

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.

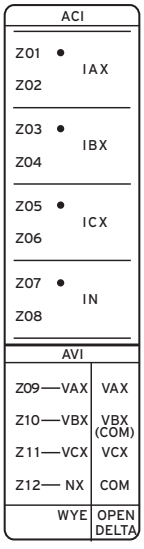
Table 2.7 2 AVI Voltage Card Inputs Terminal Allocation

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)

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.

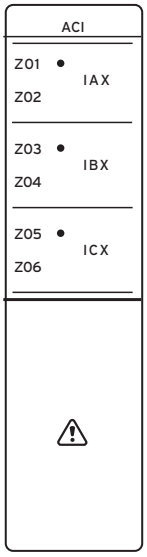
Table 2.8 4 ACI/3 AVI Current/Voltage Card Inputs Terminal Allocation

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)

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.

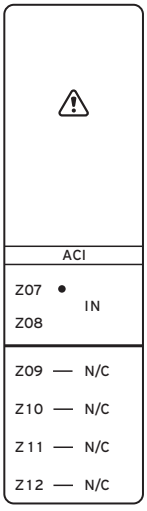
Table 2.9 3 ACIZ Current Card Inputs Terminal Allocation

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)

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

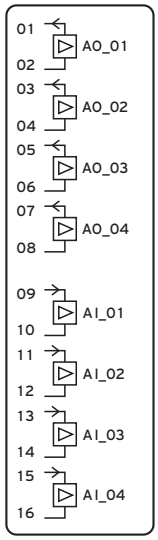
Side-Panel Connections Label	Terminal Number	Description
	Z07, Z08	IN, neutral current input

Analog Input Card (4 AI/4 AO)

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

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

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]
	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).

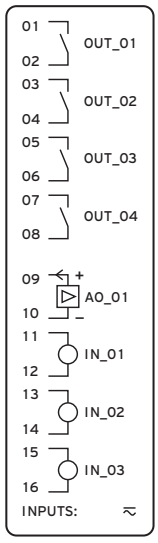
I/O Input Card (3 DI/4 DO/1 AO)

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.

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.

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

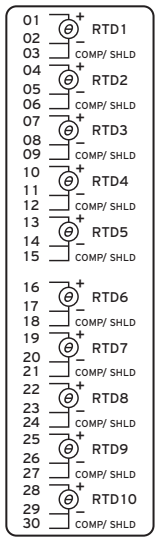
[a] x=3, 4, or 5 (for example, OUT401, OUT402, etc., if the card was installed in Slot D).

RTD Card (10 RTD)

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

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

Table 2.13 RTD (10 RTD) Card Terminal Allocation

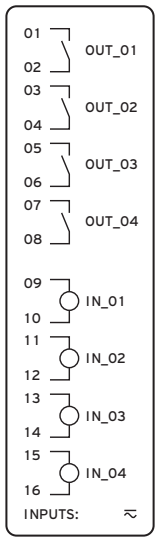
Side-Panel Connections Label	Terminal Number	Description
	01	RTD01 (+)
	02	RTD01 (-)
	03	RTD01 Comp/Shield
	04	RTD02 (+)
	05	RTD02 (-)
	06	RTD02 Comp/Shield
	07	RTD03 (+)
	08	RTD03 (-)
	09	RTD03 Comp/Shield
	•	•
	•	•
	•	•
	28	RTD10 (+)
	29	RTD10 (-)
	30	RTD10 Comp/Shield

I/O Card (4 DI/4 DO)

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.

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

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

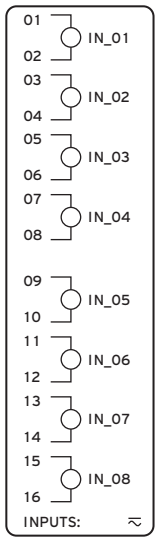
Side-Panel Connections Label	Terminal Number	Software Reference, Description[a]
	01, 02	OUT*x*01, driven by OUT*x*01 SELOGIC control equation
	03, 04	OUT*x*02, driven by OUT*x*02 SELOGIC control equation
	05, 06	OUT*x*03, driven by OUT*x*03 SELOGIC control equation
	07, 08	OUT*x*04, driven by OUT*x*04 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

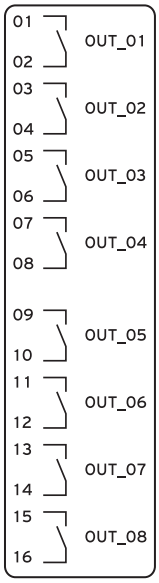
Side-Panel Connections Label	Terminal Number	Description[a]
	01, 02	IN*x*01, drives IN*x*01 element
	03, 04	IN*x*02, drives IN*x*02 element
	05, 06	IN*x*03, drives IN*x*03 element
	07, 08	IN*x*04, drives IN*x*04 element
	09, 10	IN*x*05, drives IN*x*05 element
	11, 12	IN*x*06, drives IN*x*06 element
	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 (8DO)

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

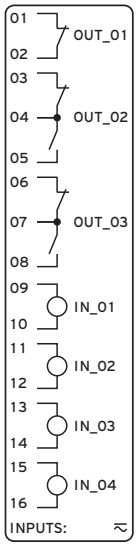
Side-Panel Connections Label	Terminal Number	Description[a]
	01, 02	OUTx01, driven by OUTx01 SELOGIC control equation
	03, 04	OUTx02, driven by OUTx02 SELOGIC control equation
	05, 06	OUTx03, driven by OUTx03 SELOGIC control equation
	07, 08	OUTx04, driven by OUTx04 SELOGIC control equation
	09, 10	OUTx05, 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).

I/O 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 program the I/O settings using the **SET** command).

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.

Following a change in configuration, the relay is always disabled until you accept the new relay configuration. To change the configuration, perform the following steps.

⚠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. De-energize the relay.

Step 2. Remove the eight rear-panel screws, ground screw, plug-in connectors, and the rear panel.

Step 3. Remove the card from the relay.

Step 4. Insert the new card into the slot.

Step 5. Replace the rear panel, reinstall all screws and connectors, and energize the unit.

Step 6. If the option card is in the proper slot, the front panel displays the following:

STATUS FAIL
XXX 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 7*.

Step 7. Press the **ESC** pushbutton.

Step 8. Press the **Down Arrow** pushbutton until STATUS is highlighted.

Step 9. Press the **ENT** pushbutton.

The front panel displays the following:

Confirm Hardware
Config (Enter)

Step 10. Press the **ENT** pushbutton.

The front panel displays the following:

Accept Config?
Yes No

Step 11. Select **Yes** and press the **ENT** pushbutton.

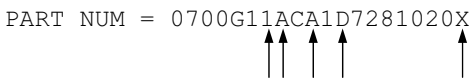
The front panel displays the following:

Config Accepted
Enter to Restart

Step 12. Press **ENT**.

The relay restarts and the **ENABLED** light is turned on, indicating that the option card was installed correctly.

After reconfiguration, the relay updates the part number, except for the digits shown below. These digits remain unchanged; these digits retain the same character as before the reconfiguration. Also, a communications card installed in Slot **C** is reflected as an empty slot in the part number. Use the **Status** command to view the part number.



Step 13. Attach the terminal marking label (provided with the card) to the rear cover so that the **INTERFACE CARD EXPANSION SLOT** is covered.

Step 14. Reconnect all connection plugs, and add any additional wiring/ connectors required by the new option card.

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.

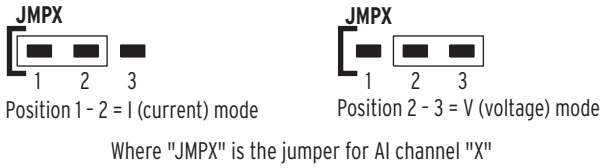


Figure 2.3 Circuit Board of Analog I/O Board, Showing Jumper Selection

Analog Output (AO) Configuration Jumper

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.

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

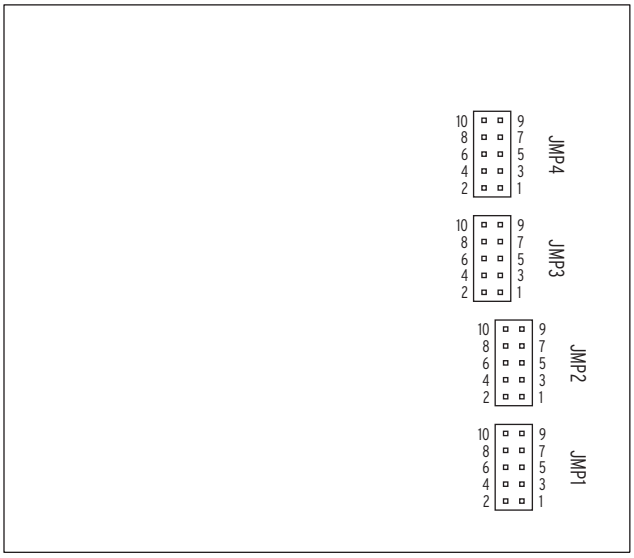


Figure 2.4 JMP1 Through JMP4 Locations on 4 AI/4 AO Board

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.

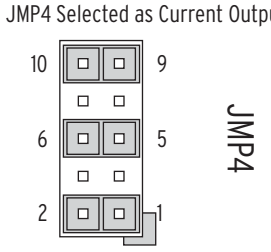


Figure 2.5 Current Output Jumpers

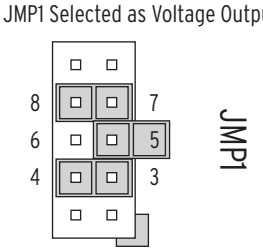


Figure 2.6 Voltage Output Jumpers

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.

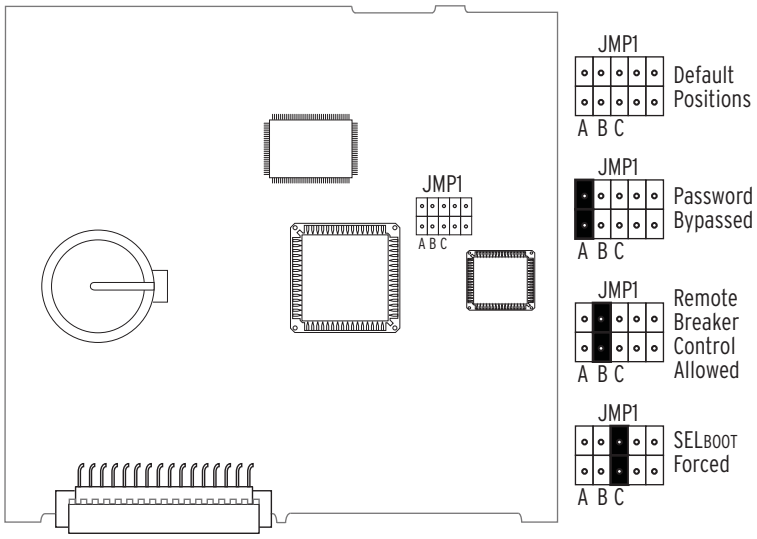


Figure 2.7 Pins for Password, Breaker Control, and SELBOOT Jumper

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 may 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] Enable/Disable serial port, front panel, and Fast Operate commands for breaker control.

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*.

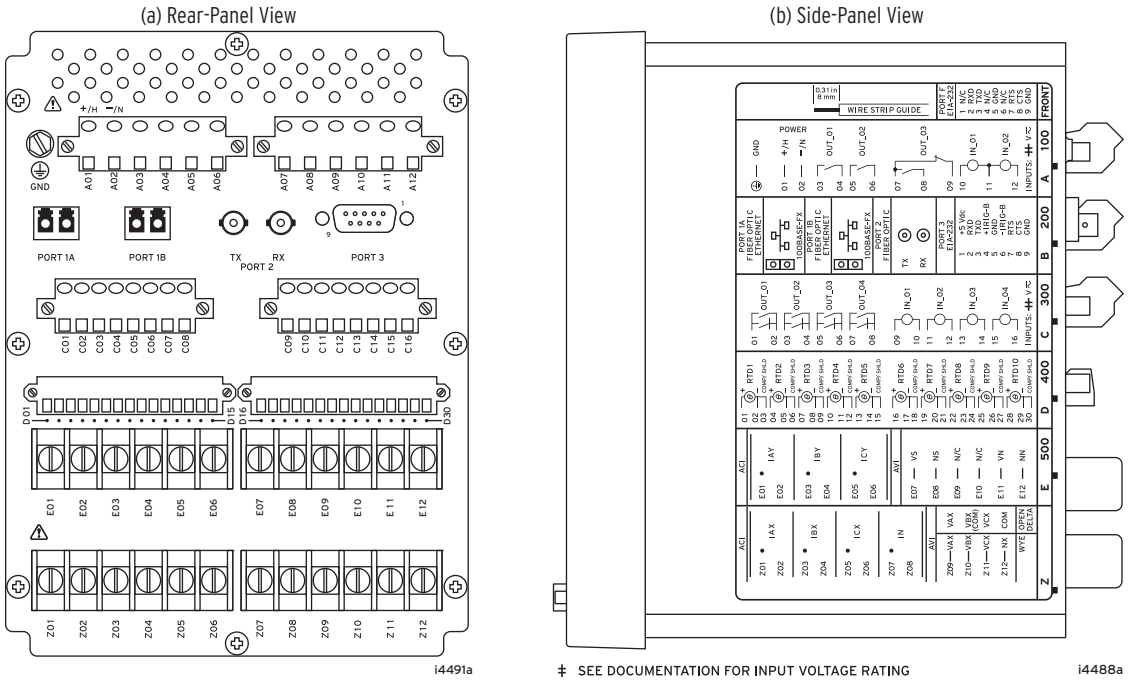


Figure 2.8 SEL-700G1+ With Dual-Fiber Ethernet, Fast Hybrid 4 DI/4 DO, 10 RTDs, 3 ACI/2 AVI, 4 ACI/3 AVI (MOT 0700G11ACA9X76850830)

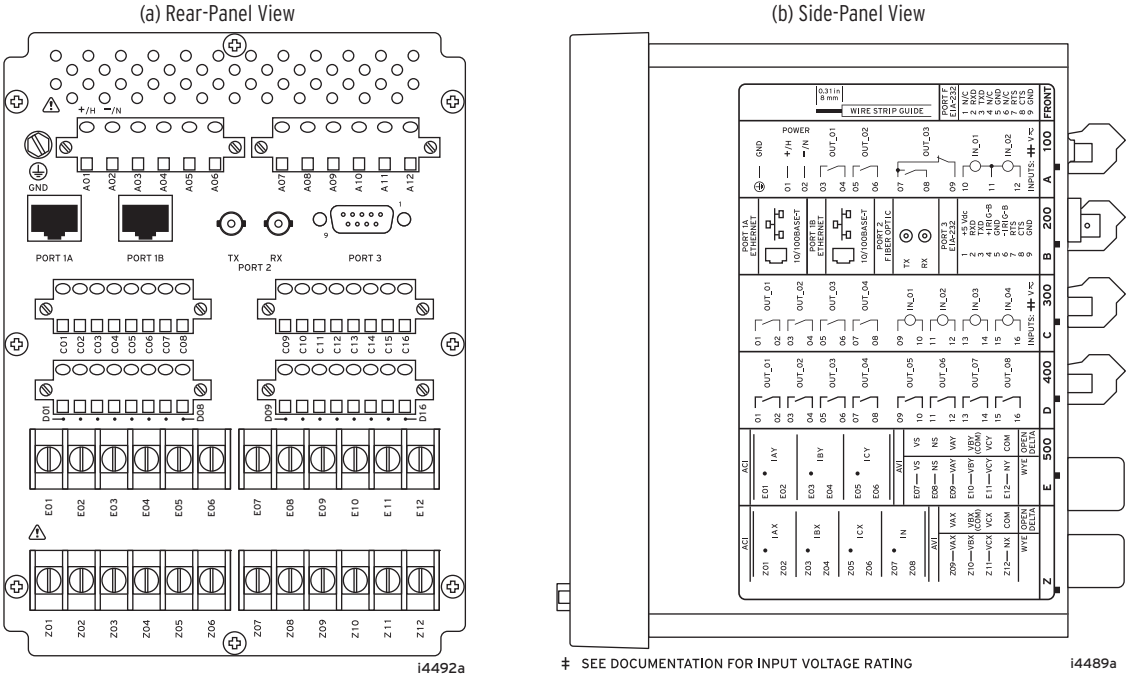


Figure 2.9 SEL-700GT+ With Dual Copper Ethernet, 4 DI/4 DO, 8 DO, 3 ACI/4 AVI, 4 ACI/3 AVI (MOT 0700GT1A2X75850630)

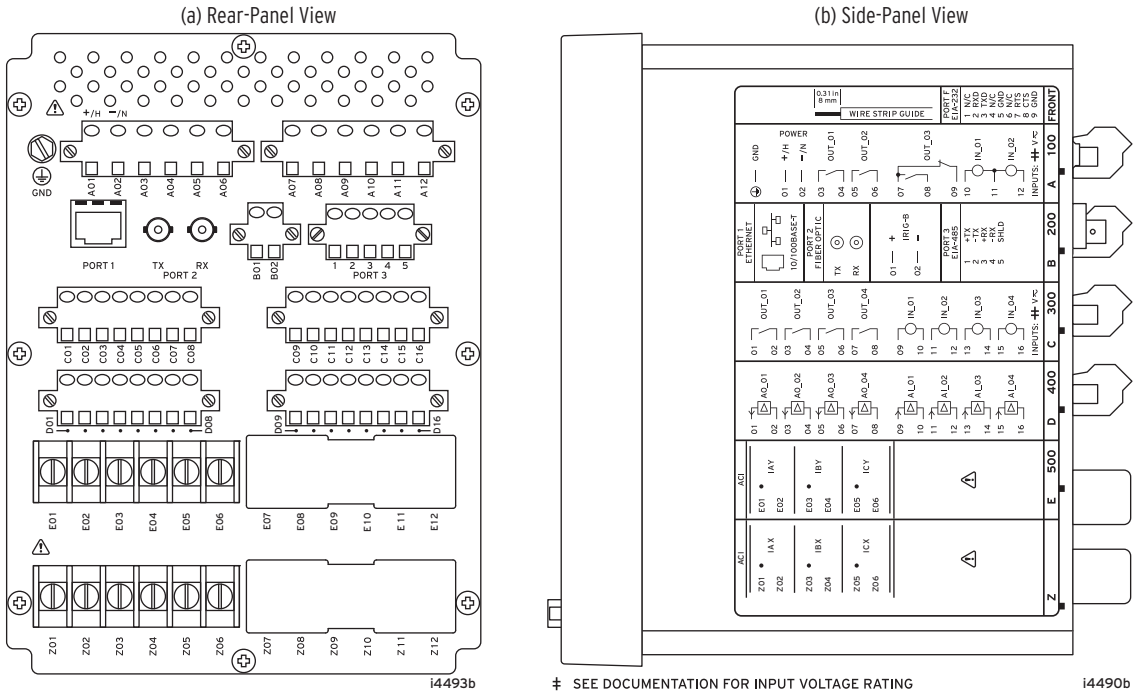


Figure 2.10 SEL-700GW With Copper Ethernet, 4 DI/4 DO, 4 AI/4 AO, 3 ACIE, 3 ACIZ (MOT 0700GW1A1A6X77870310)

Power Connections

⚠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.

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 (2.5 mm^2) to 16 AWG (1.5 mm^2) size wire to connect to the **POWER** terminals.

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. Be sure to locate this device within 3.0 m (9.8 feet) of the relay.

Operational power is internally fused by a power supply fuse. See *Field Serviceability on page 2.35* 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. IRIG-B (**B01** and **B02**) inputs or an SEL communications processor via EIA-232 serial **Port 3** may be used. 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 *: /* , 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 RJ-45 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.

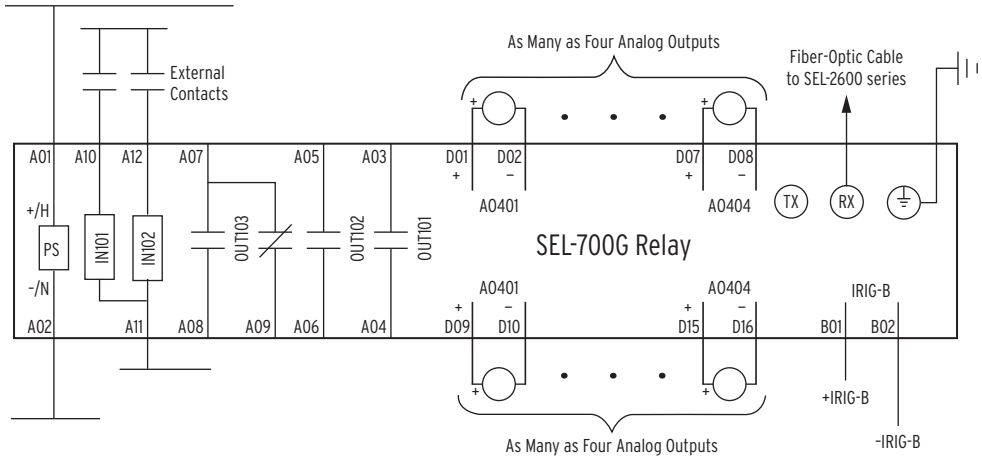


Figure 2.11 Control I/O Connections—4 AI/4 AO Option in Slot D

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

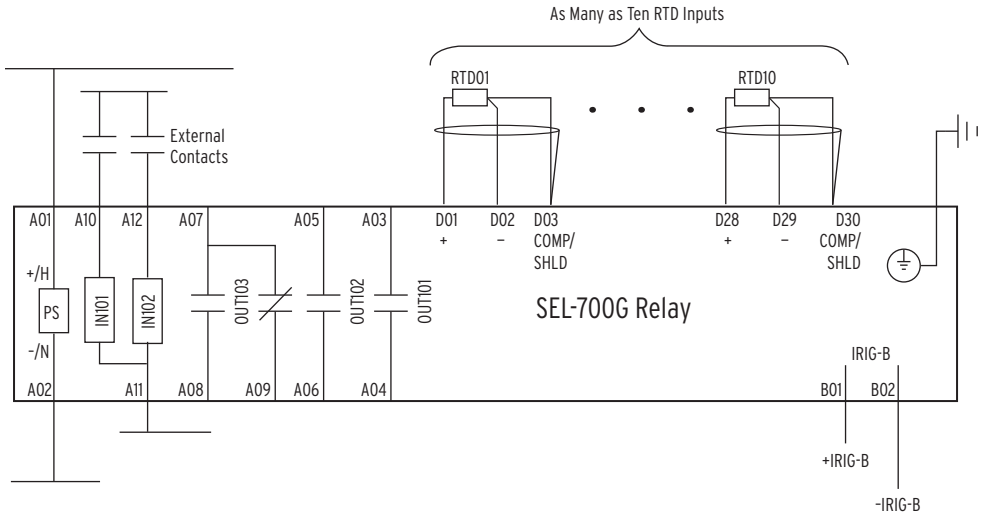


Figure 2.12 Control I/O Connections—Internal RTD Option

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** may 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 required 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 desired.

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

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

Figure 2.13 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.

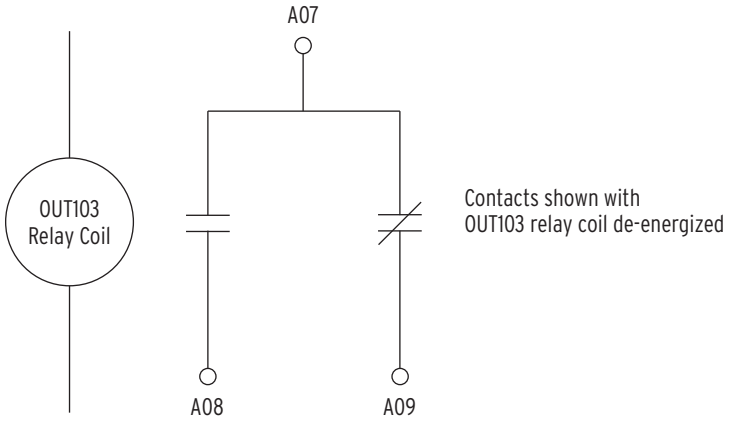


Figure 2.13 Output OUT103 Relay Output Contact Configuration

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

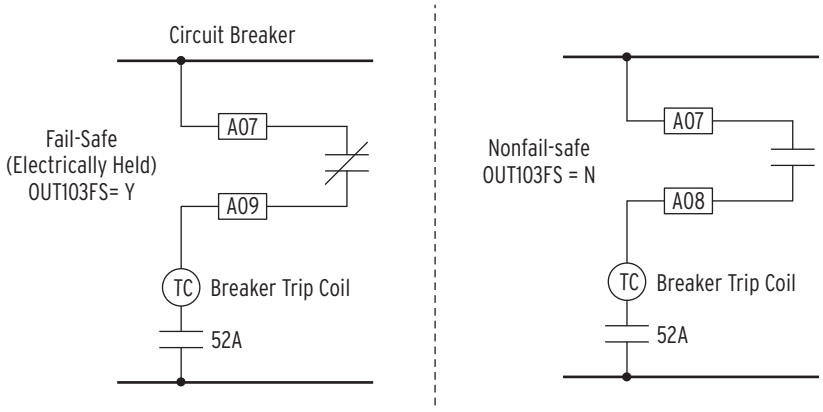


Figure 2.14 OUT103 Contact Fail-Safe and Nonfail-Safe Options

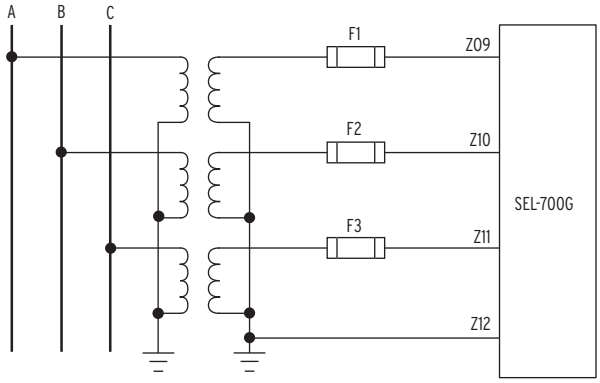
Voltage Connections

With the voltage inputs option, the three-phase voltages may be connected either 3-wire (delta) or 4-wire (wye). *Figure 2.15 (a–d)* show typical methods for connecting three-phase voltages. The relay also allows the user to connect external zero-sequence voltage (3V0) to **VS-NS** or **VN-NN** inputs, as shown in *Figure 2.15 (e)* and *Figure 2.15 (f)*, respectively, when the terminal PTs are delta connected. Refer to *SEL-700G1+ Generator Relay Application Example 2*, *Illustrating the 67N Element* and *Section 4: Protection and Logic Functions* for more details.

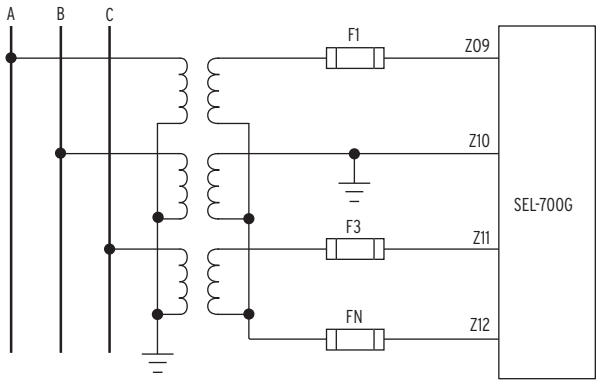
Notes:

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

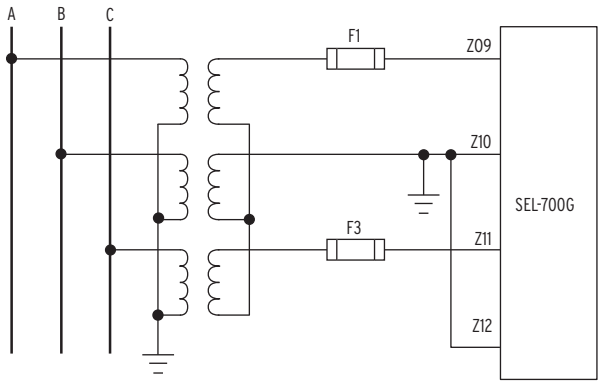
(a) Wye-Wye VT 4-Wire Connection (Set DELTAY_X := Wye)



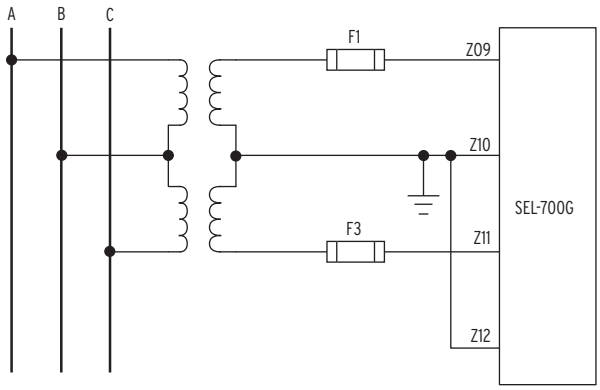
(b) Wye-Wye VT 4-Wire Connection (Set DELTAY_X := Wye)



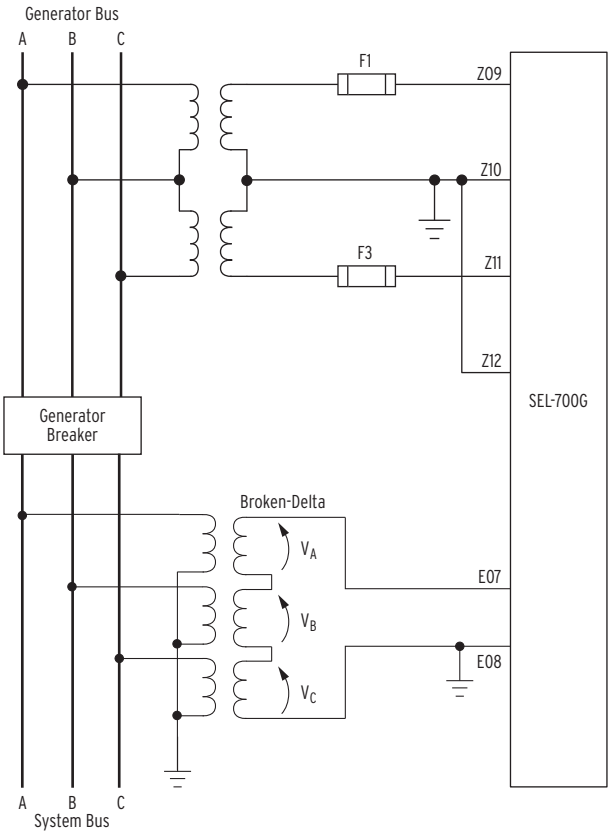
(c) Wye-Wye VT 3-Wire Connection (Set DELTAY_X := Delta)



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



(e) Open-Delta VT 3-Wire Connection (DELTAY_X := DELTA)
External Zero-Sequence Voltage Connected to VS (EXT3V0_X := VS)



(f) Open-Delta VT 3-Wire Connection (DELTAY_X := DELTA)
External Zero-Sequence Voltage Connected to VN (EXT3V0_X := VN)

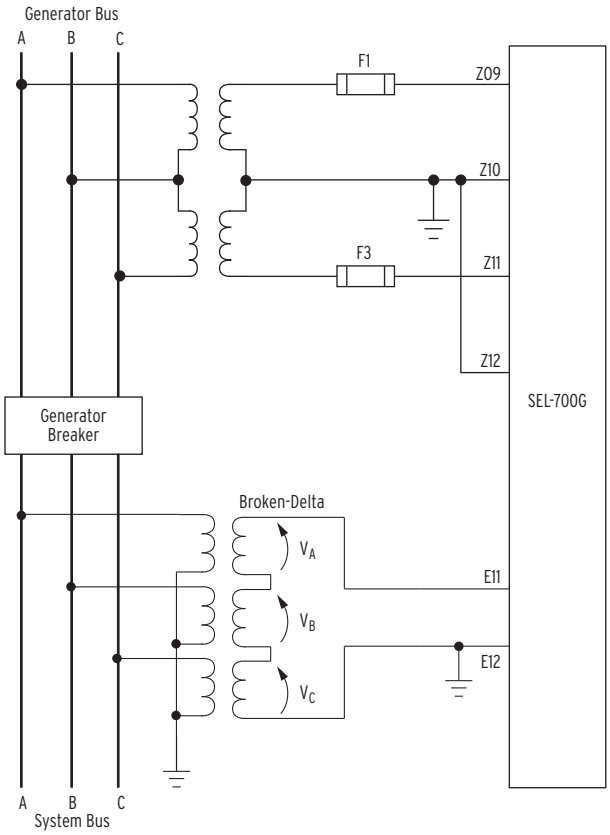


Figure 2.15 Voltage Connections

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 EXT3VO_X must also be set accordingly. Refer to *Section 4: Protection and Logic Functions* for more details.

Figure 2.16 through *Figure 2.21* show ac and dc connection diagrams and applications for the SEL-700G0, SEL-700G1, SEL-700GT, and SEL-700GW relays.

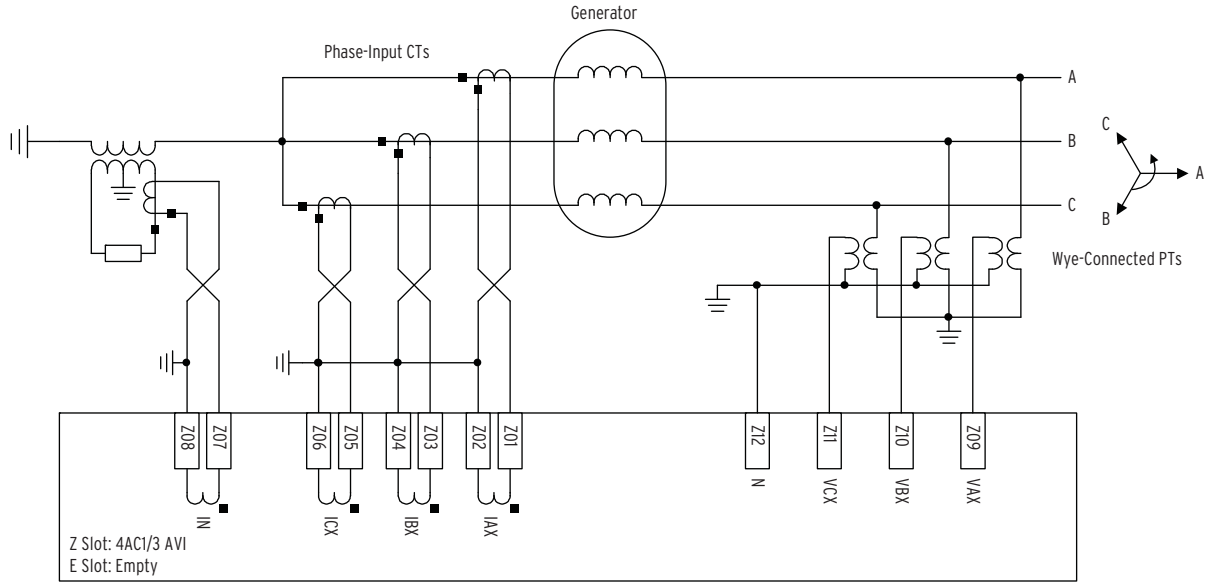


Figure 2.16 SEL-700G0 Relay AC Connection Example—High-Impedance Grounded Generator Without Current Differential Protection

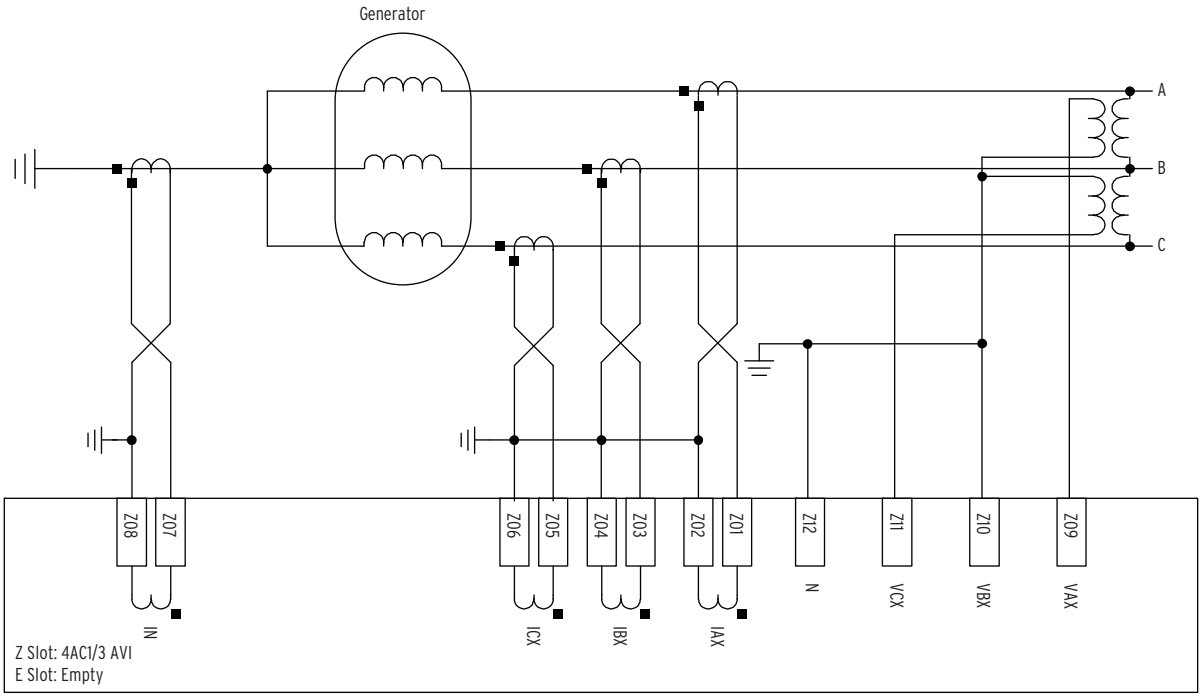


Figure 2.17 SEL-700G0 Relay AC Connection Example—Solidly Grounded Generator With Ground Differential Protection (87N)

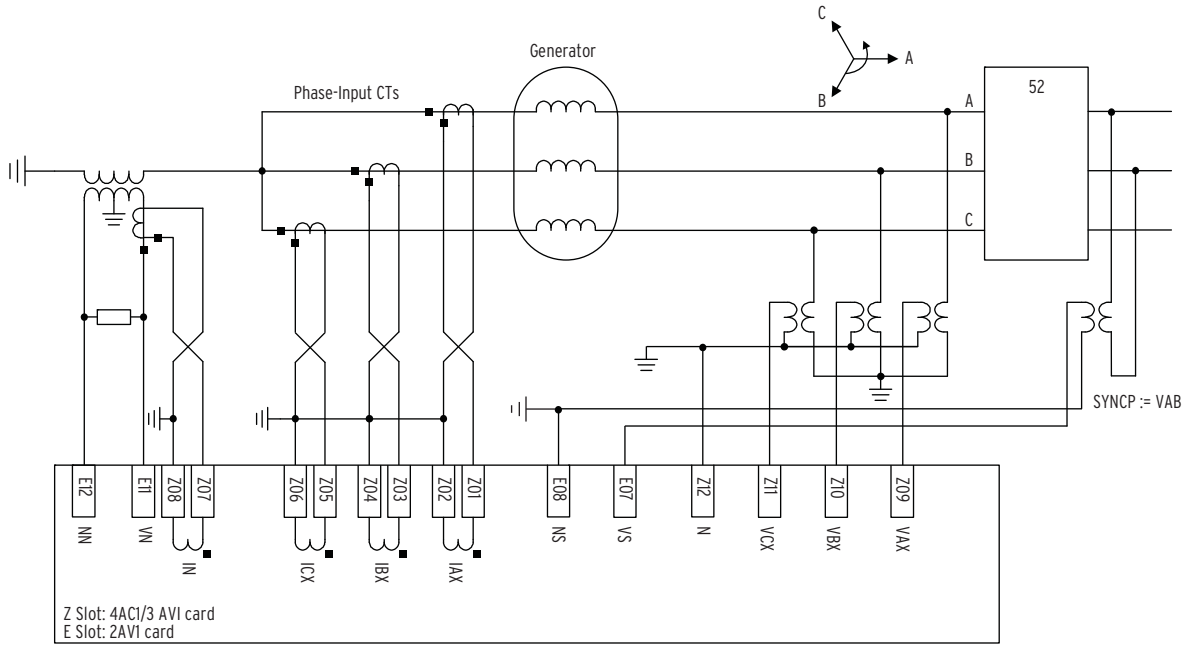


Figure 2.18 SEL-700G0+ Relay High-Impedance Grounded Generator With Synchronism Check and Without Current Differential Protection

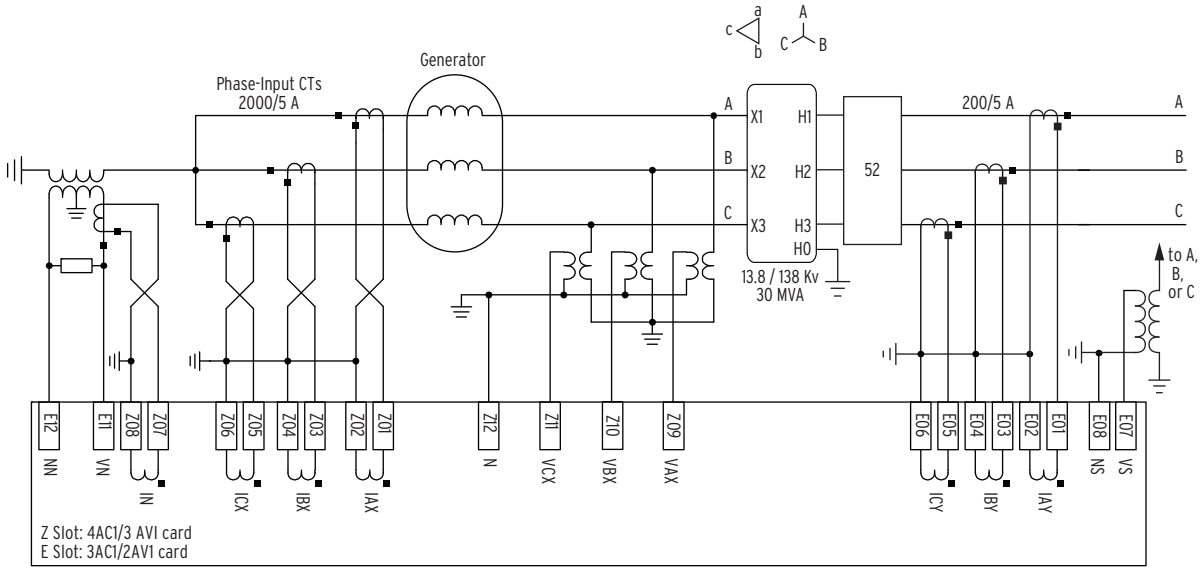


Figure 2.19 SEL-700G1+ Relay AC Connection Example—High-Impedance Grounded Generator With Step-Up Transformer Included in Differential Zone (With Synchronism Check and 100% Stator Ground Protection)

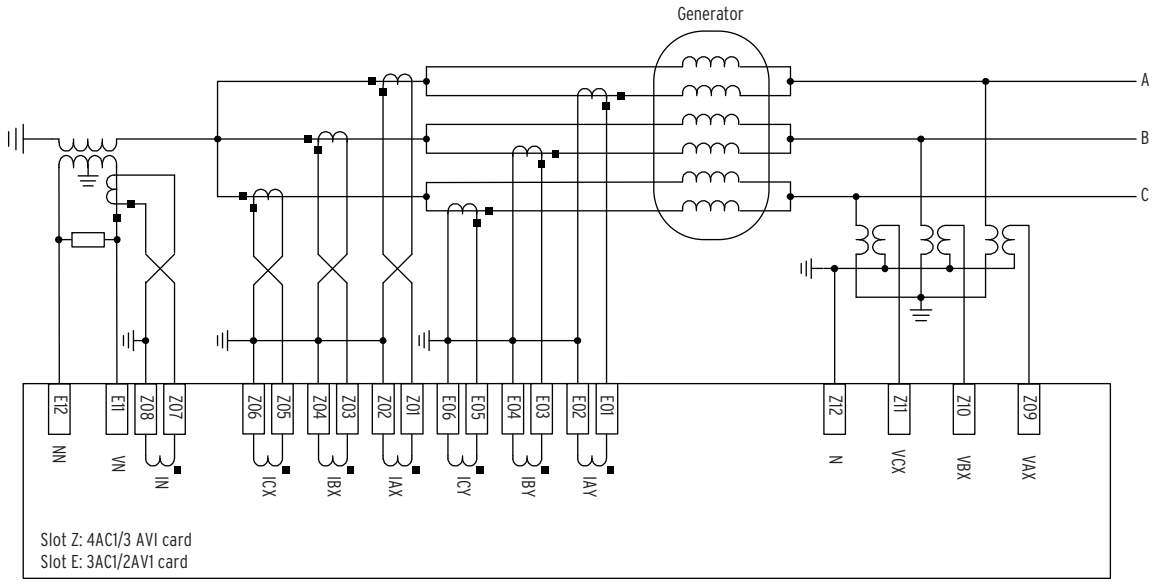


Figure 2.20 SEL-700G1+ Relay AC Connection Example—High-Impedance Grounded Generator With Split-Phase Current Differential Protection

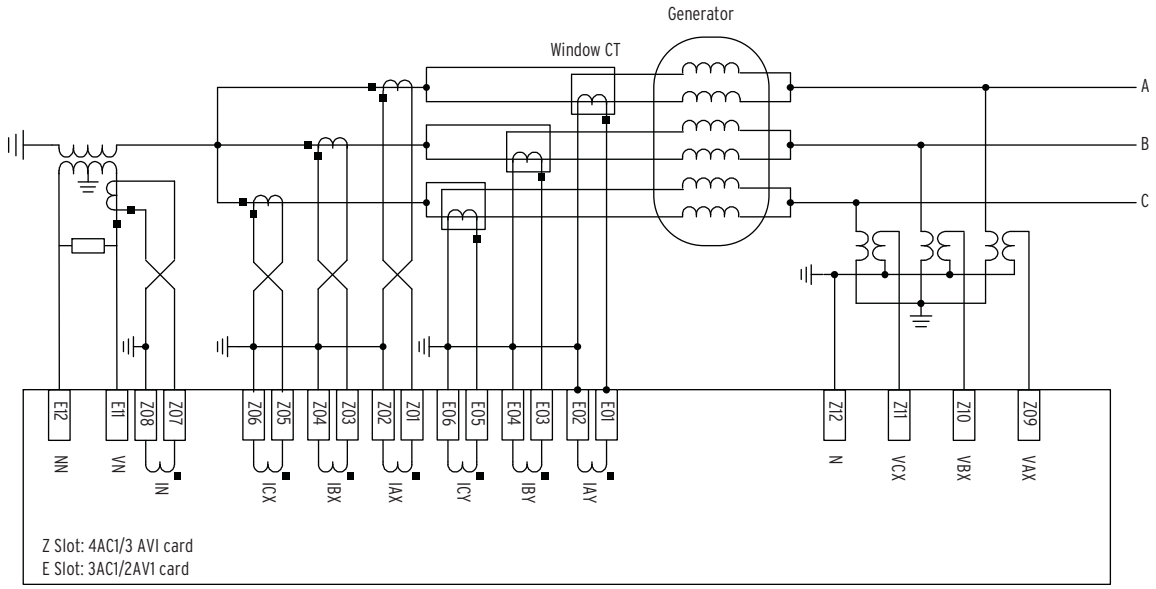


Figure 2.21 SEL-700G1+ Relay High-Impedance Grounded Generator With Split-Phase, Self-Balancing Differential Protection

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
- Synchronism-Check (25X) and Autosynchronism functions

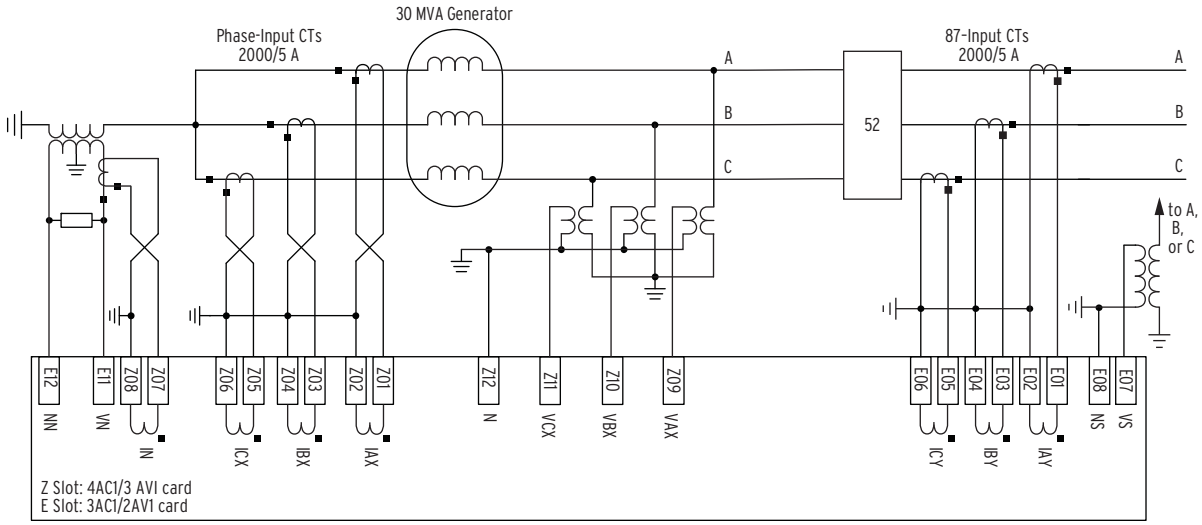
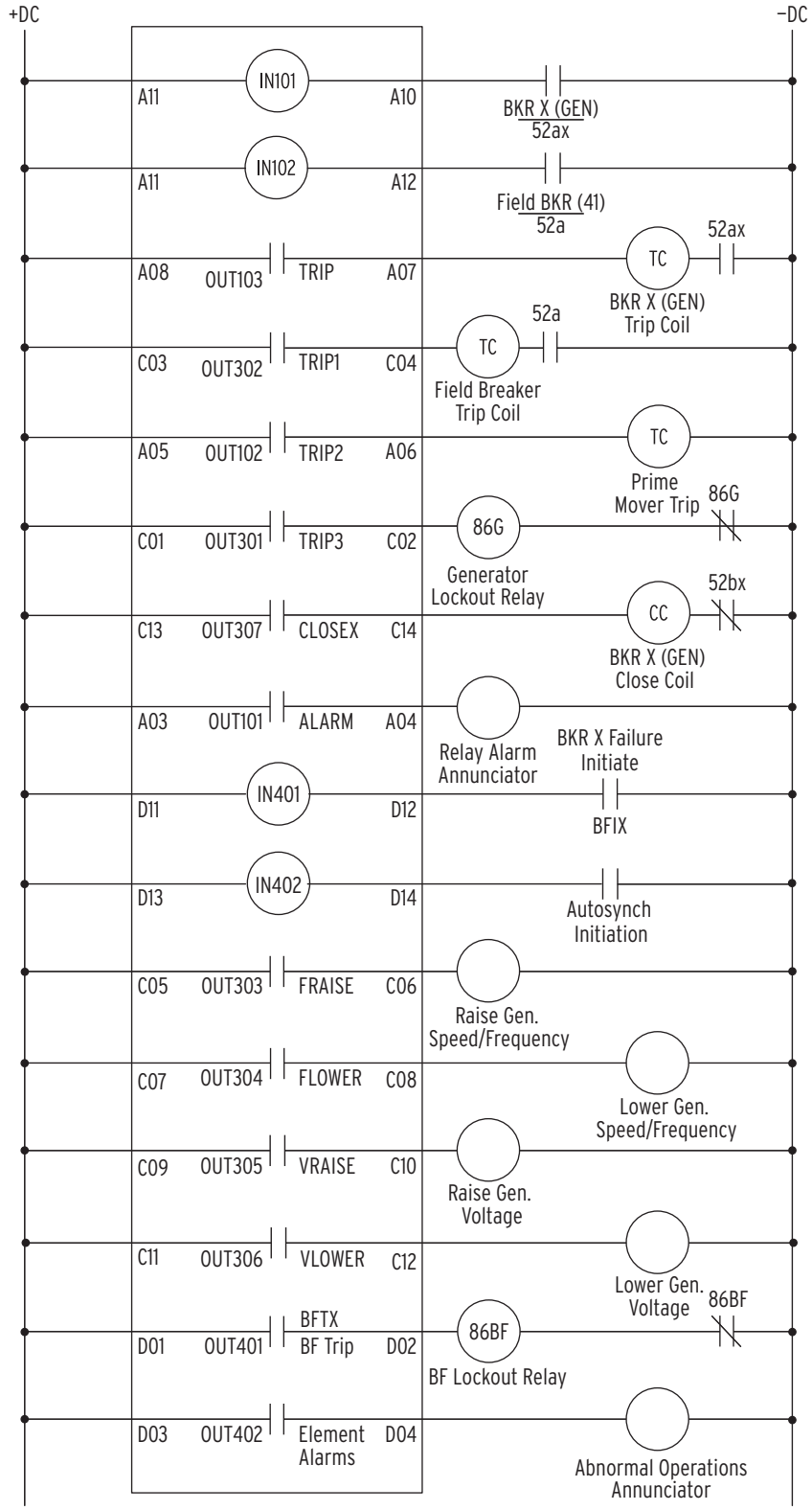


Figure 2.22 SEL-700G1+ Relay Typical AC Current and Four-Wire Wye Voltage Connection With MOT SEL-0700G11A2XBA76850231



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 2.23 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
- 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 one of the available voltage inputs can be used 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). The external 3V0 can be used 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 4.81* and *Directional Elements on page 4.103*)
- Zero-Sequence Voltage-Polarized Directional Element With IN as Operate Quantity (67N; refer to *Section 4: Protection and Logic Functions*, *Overcurrent Elements on page 4.81* and *Directional Elements on page 4.103*)

Note that the 67G element listed above could be achieved by setting the 50G element with the appropriate directional control setting. Similarly, the 67N element listed above 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 4.81* and *Directional Elements on page 4.103* for more information.

SEL recommends that the external 3V0 connected to **VS-NS** or **VN-NN** inputs for use with the above 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).

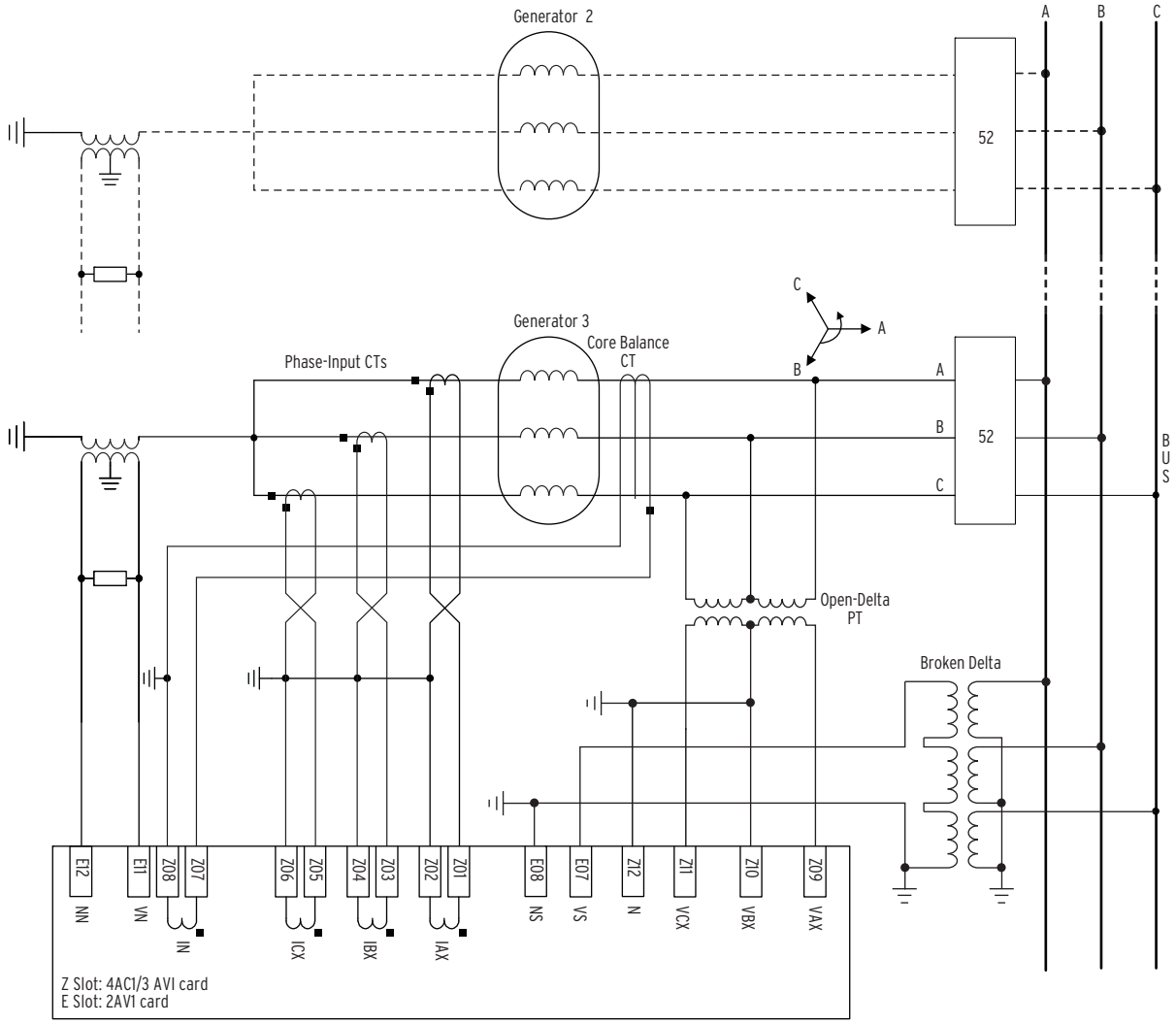


Figure 2.24 SEL-700G1+ Relay AC Connection Example, Multiple High-Impedance Grounded Generators Connected to a Common Bus, With 67N and Other Protection

SEL-700GT Intertie Relay Application

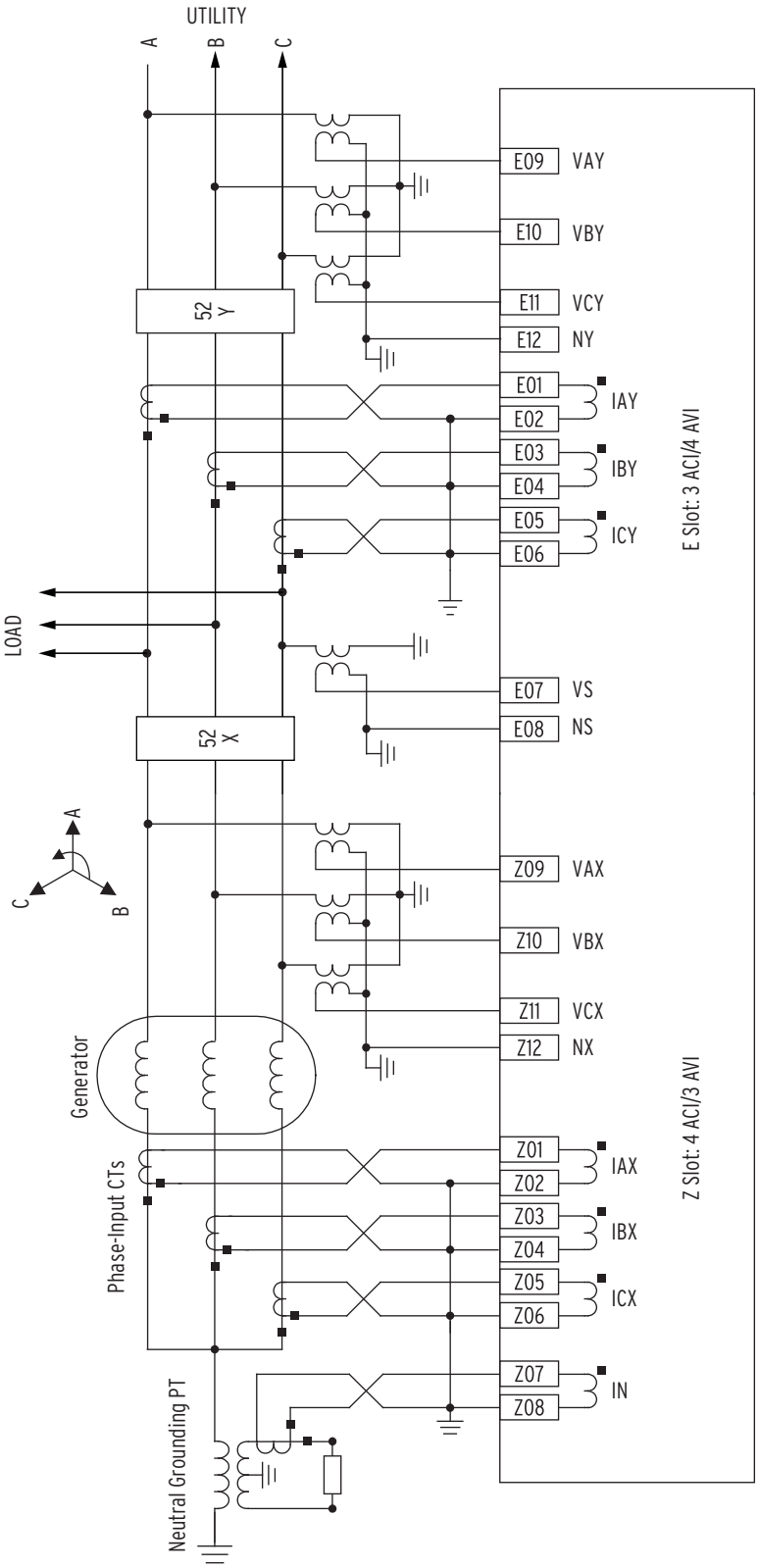
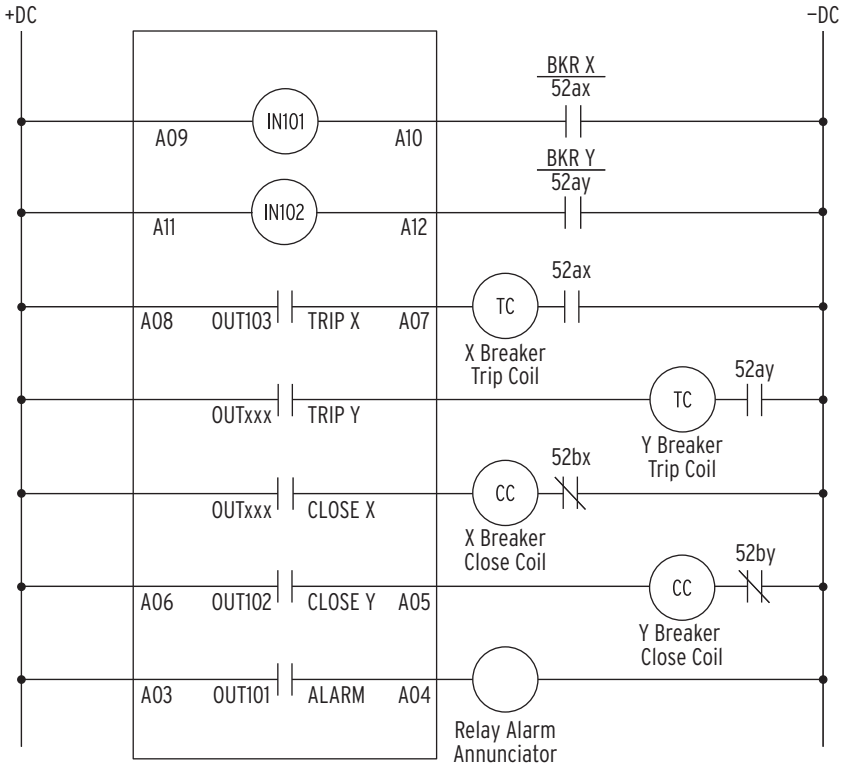


Figure 2.25 SEL-700GT+ Relay Typical AC Current and Four-Wire Wye Voltage Connection



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.

Figure 2.26 SEL-700GT+ Typical DC External Connections

SEL-700GW Wind Generator Relay Application

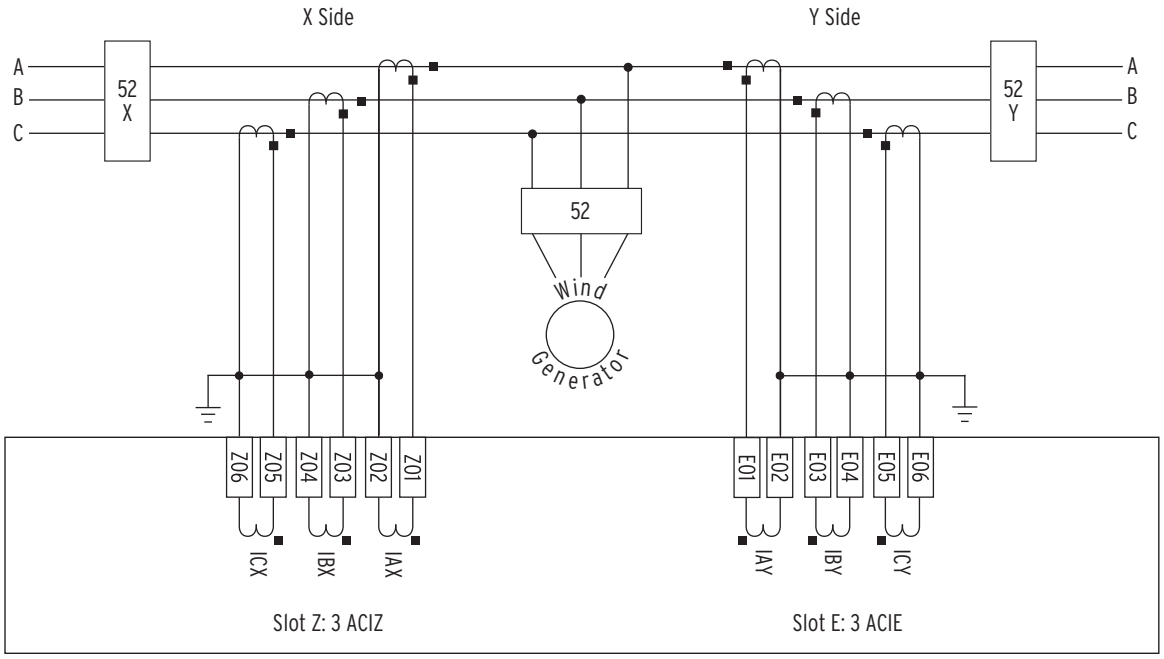
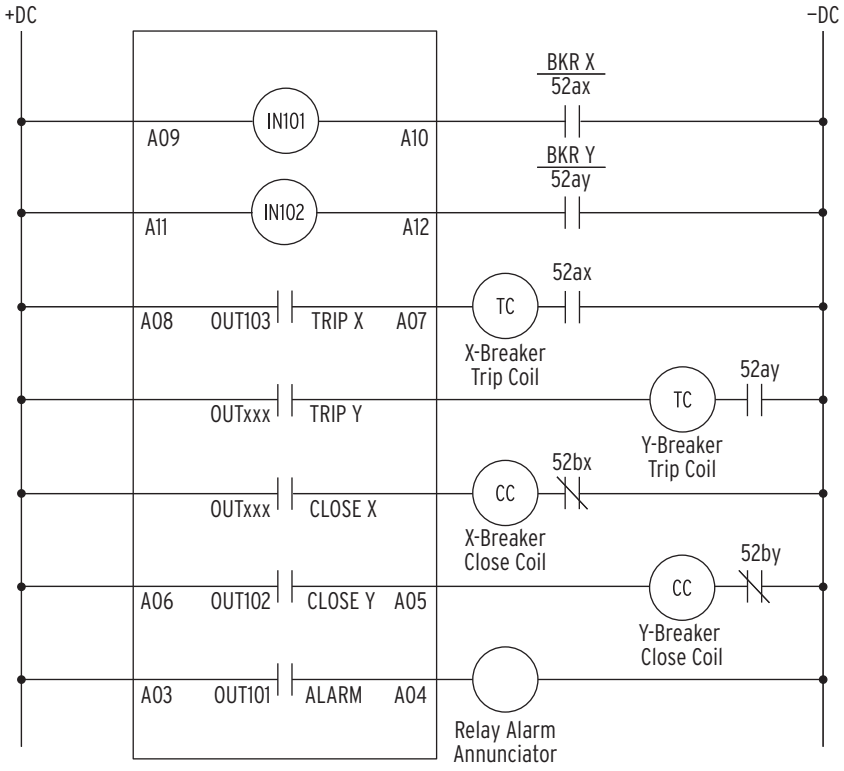


Figure 2.27 SEL-700GW Dual Feeder AC Current Connections



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.

Figure 2.28 SEL-700GW Typical DC External Connections

Thermal Protection of Generator and Prime Mover

Figure 2.29 shows an application example of an SEL-700G relay and an SEL-2600 RTD Module providing thermal protection for the generator and prime mover.

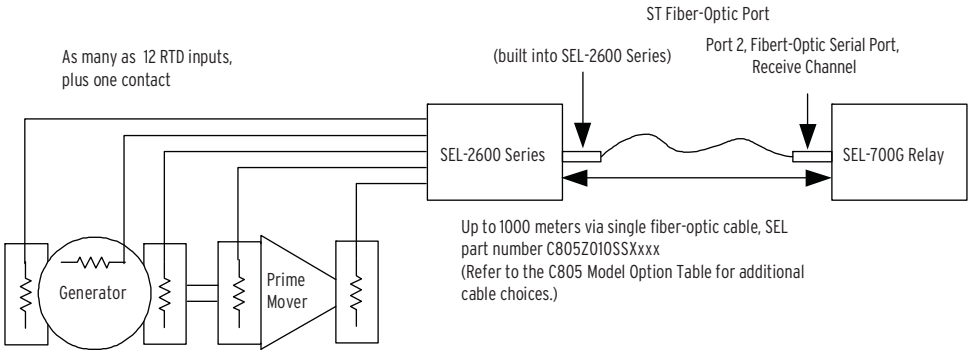


Figure 2.29 Generator Thermal Protection With an SEL-2600 RTD Module and an SEL-700G

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).

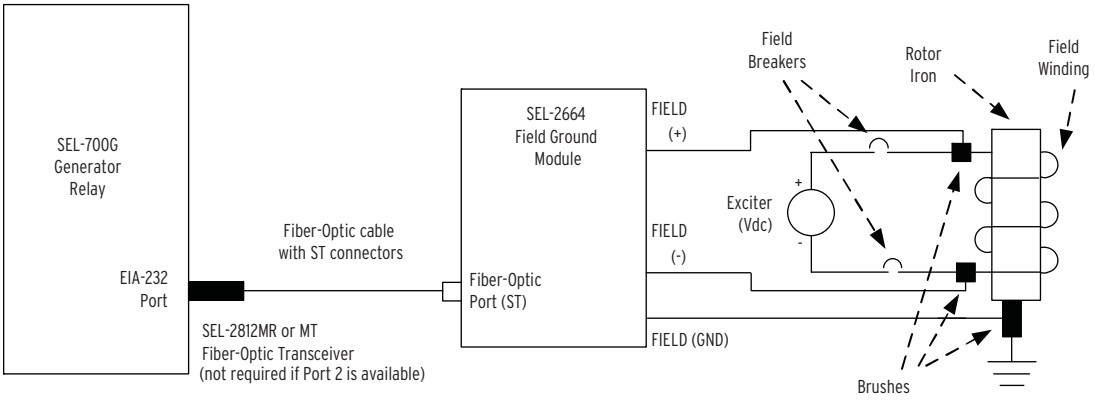


Figure 2.30 Field Ground Protection With an SEL-700G Relay

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 *:/,* 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. Dispose of used batteries according to the manufacturer's instructions.

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-5031	ACSELERATOR QuickSet Designer® SEL-5031 Software	Customizes SEL-700G settings for specific applications
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)

Terminal	Provides a direct connection to the SEL device. Use this communication method to interface directly with the device.
Rules-Based Settings Editor	Provides on-line or off-line relay settings that include interdependency checks. Use this feature to create and manage settings for multiple relays in a database.
Event Analysis	Provides oscillography and other event analysis tools.
Meter and Control	Provides Human Machine Interface (HMI) for metering and control features.

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

Setting Database Management	ACSELERATOR QuickSet uses a database to manage the settings of multiple devices.
Help	Provides general ACSELERATOR QuickSet and relay-specific ACSELERATOR QuickSet context help.

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*.

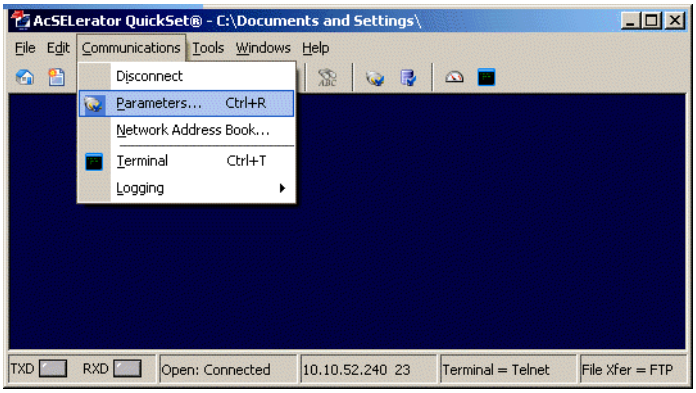


Figure 3.1 Serial Port Communication Dialog Box

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.

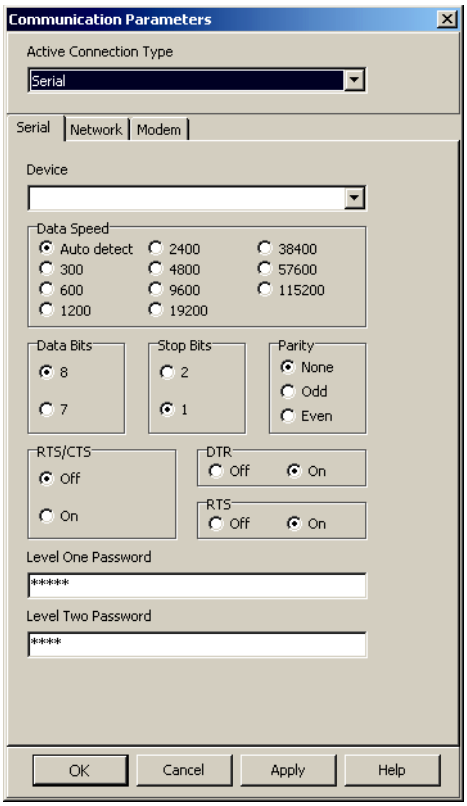


Figure 3.2 Serial Port Communication Parameters Dialog Box

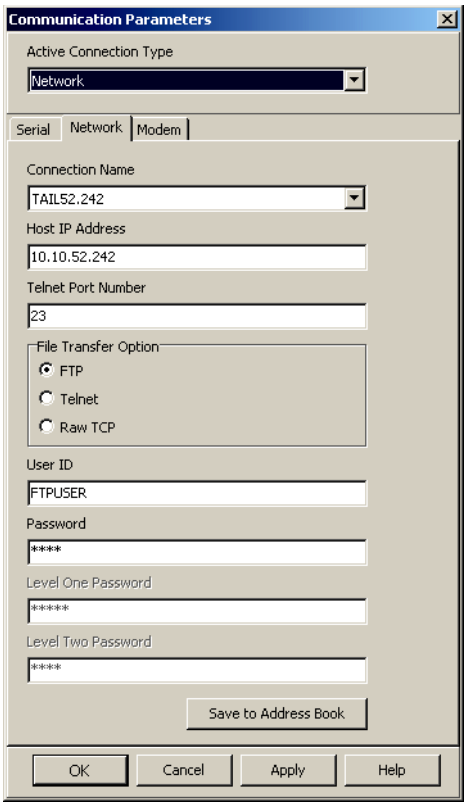


Figure 3.3 Network Communication Parameters Dialog Box

Terminal

Terminal Window

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

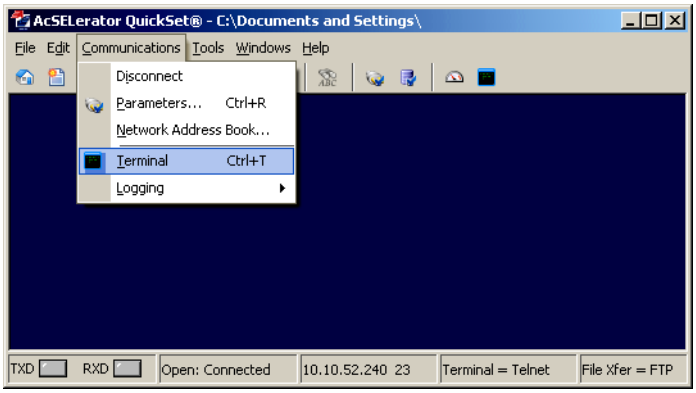


Figure 3.4 Communications Menu

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=700GXXXXXXXXXXXXX) 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.

Active Database

Change the active database to the one that needs to be modified by selecting **File > Active Database** on the main menu bar.

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 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 setting in the **A** database,

b. Select **Copy** or **Move**, and click the **>** button to create a new device or setting in the **B** database.

Step 4. Reverse this process to take devices from the **B** database to the **A** database. **Copy** creates an identical device that appears in both databases. **Move** removes the device from one database and places the device 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 **Create New Database** 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 Databases** tab in the **Database Manager** dialog box.

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

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

Step 3. Type a new database name, click the **Open** button, and click **Yes**; the program creates a new empty database. Load devices into the new database as in *Copy/Move Settings Between Databases on page 3.5*.

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*.

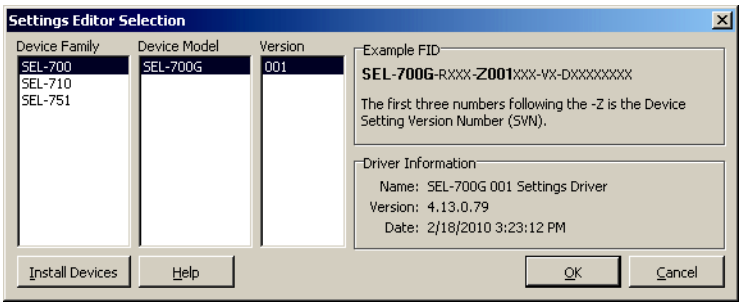


Figure 3.6 Selection of Drivers

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.

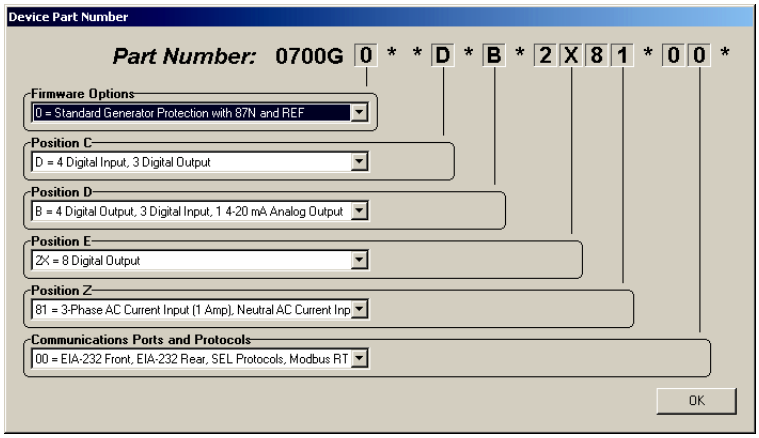


Figure 3.7 Update Part Number

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.

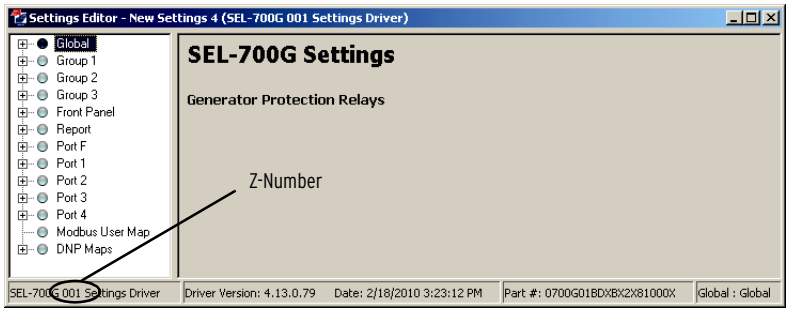


Figure 3.8 New Setting Screen

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 required.

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*.

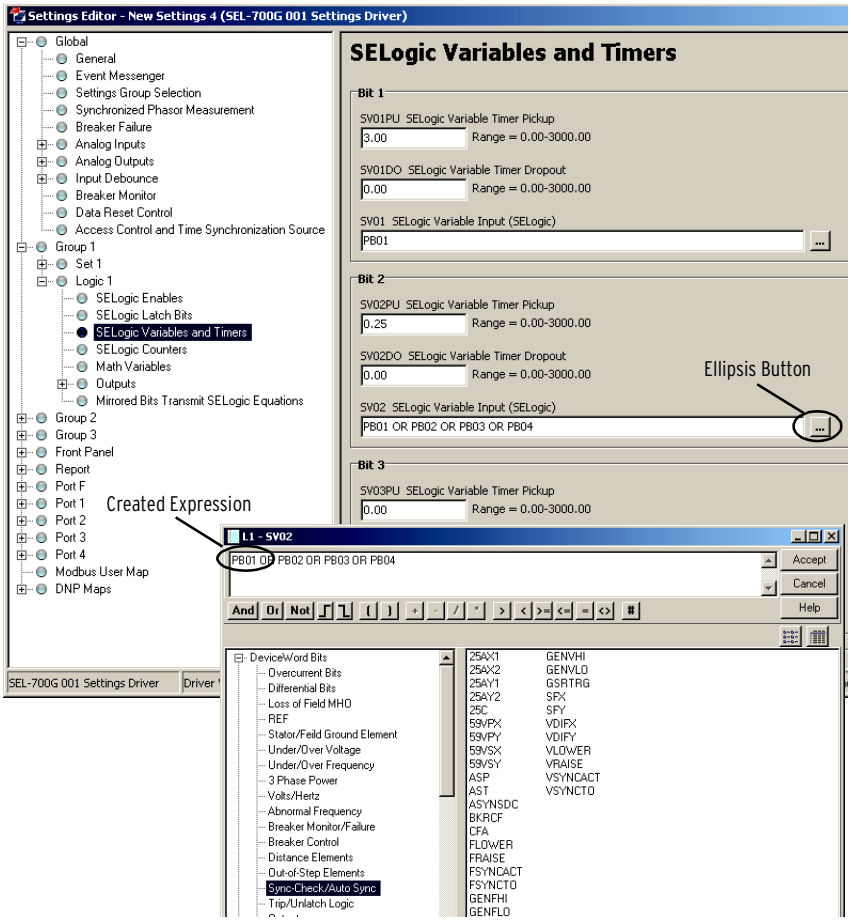


Figure 3.9 Expressions Created With Expression Builder

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.

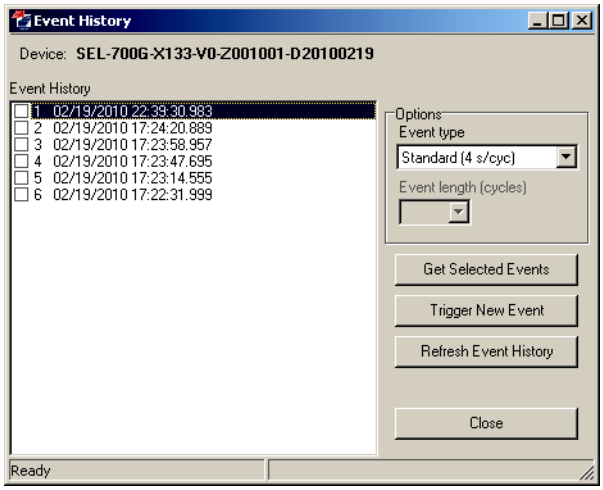


Figure 3.10 Composite Screens for Retrieving Events

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*.

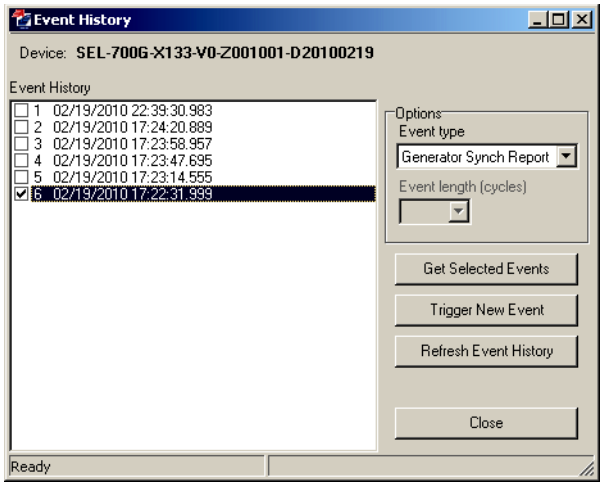


Figure 3.11 Generator Synchronism Report

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*.

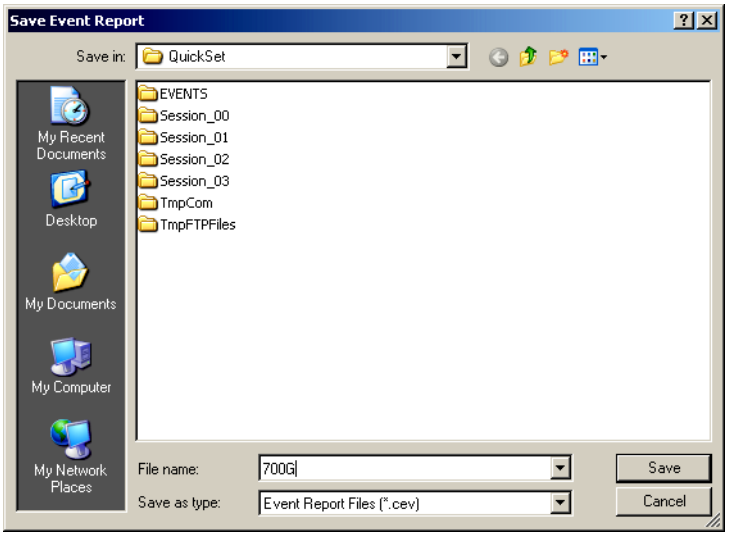


Figure 3.12 Saving the Retrieved Event

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.

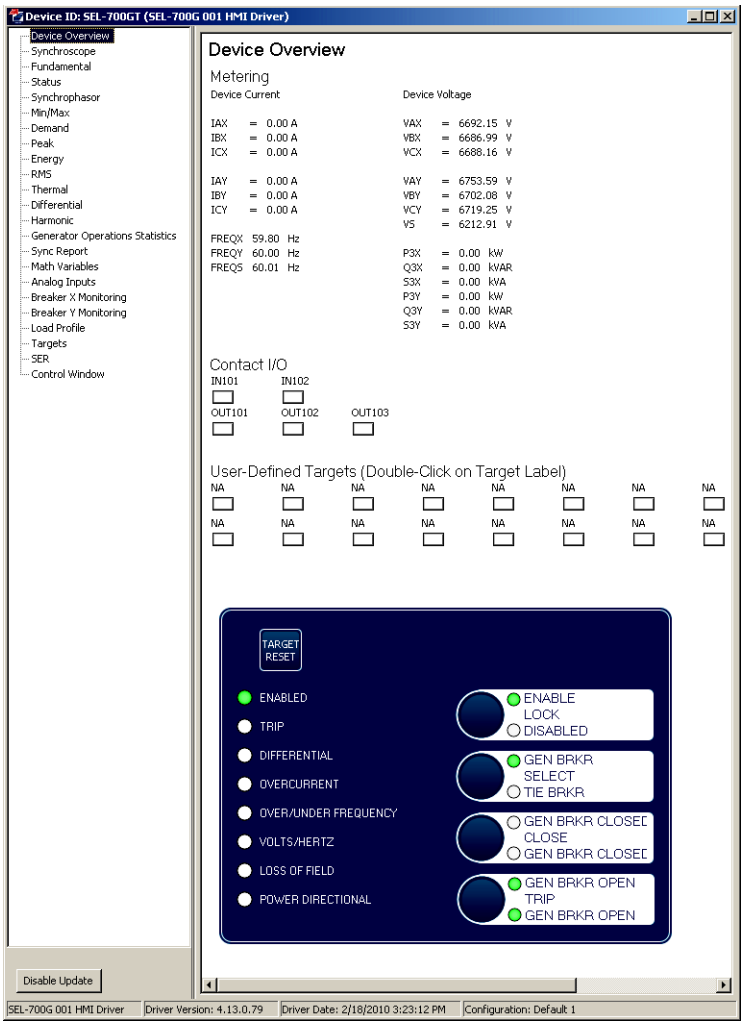


Figure 3.13 Device Overview Screen

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.

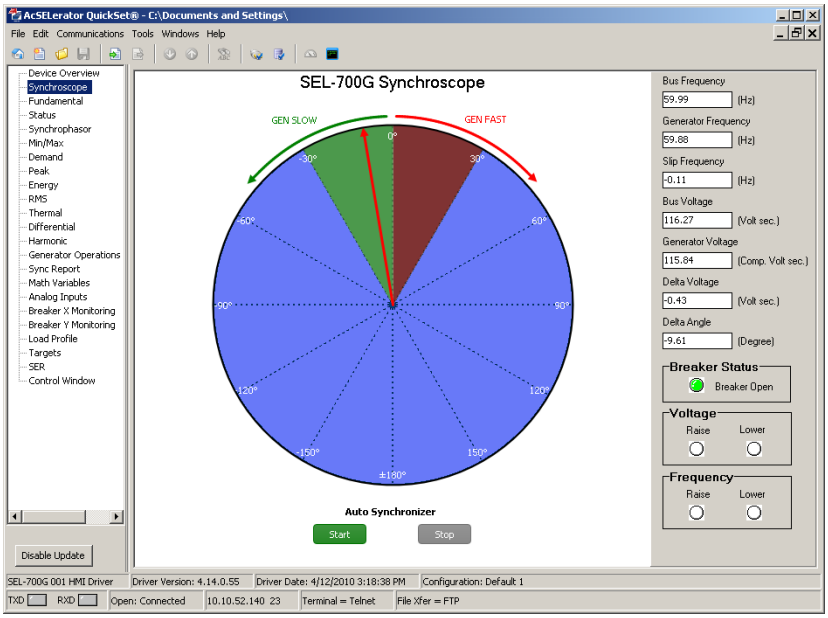


Figure 3.14 Synchroscope

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.

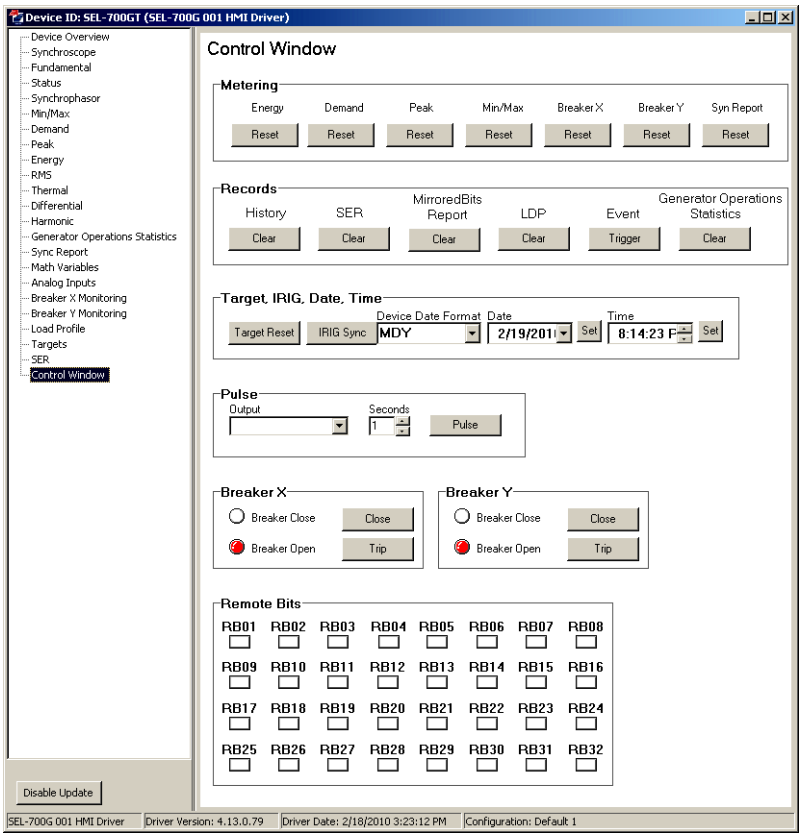


Figure 3.15 Control Screen

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

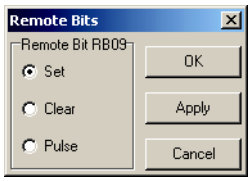


Figure 3.16 Remote Operation Selection

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.

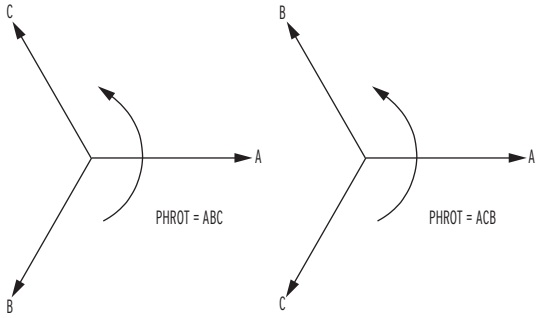


Figure 4.1 Phase Rotation Setting

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 2.22*), 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 4.10*) and Restricted Earth Fault (see *Figure 4.11*) 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:

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

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 2.15* 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 the user 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 2.15* for the voltage connection and *Figure 2.24* for an application example.

Generator Protection

Phase Differential Element

Protect your apparatus with optional dual-slope percentage differential protection included in SEL-700G1 relays. Percentage differential protection provides more sensitive and secure protection than traditional differential protection; the dual-slope characteristic compensates for CT ratio mismatches, CT ratio errors, CT saturation, and errors because of tap changing.

The relay allows you to choose either generator or transformer differential with harmonic blocking, harmonic restraint, or both, providing stability during transformer inrush conditions. Even-numbered harmonics (second and fourth) provide security during 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 currents. *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.

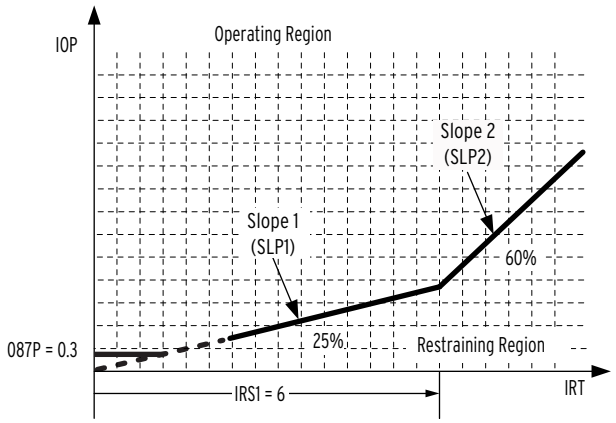


Figure 4.2 Percentage Restraint Differential Characteristic

The four settings that define the characteristic are as follows:

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

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

Figure 4.3, *Figure 4.4*, and *Figure 4.5* 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 (not shown) harmonics of the input currents.

When we use 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 the per-unit value common 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 ensures 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.

NOTE: Setting CTCX is not available for changing. It is hidden and is set automatically by the relay.

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 currents with element 87-2, and I3 currents with element 87-3.

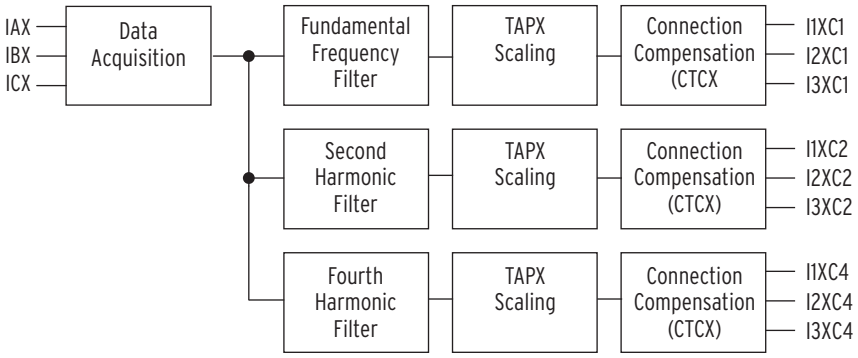


Figure 4.3 Winding X Compensated Currents

Figure 4.4 illustrates how the IOP1 (operate), IRT1 (restraint), I1H24 (harmonic restraint), I1H2 (second harmonic), and I1H4 (fourth 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.

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

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 calculates to about (| 1 | + | –1 |) = 2 at rated load.

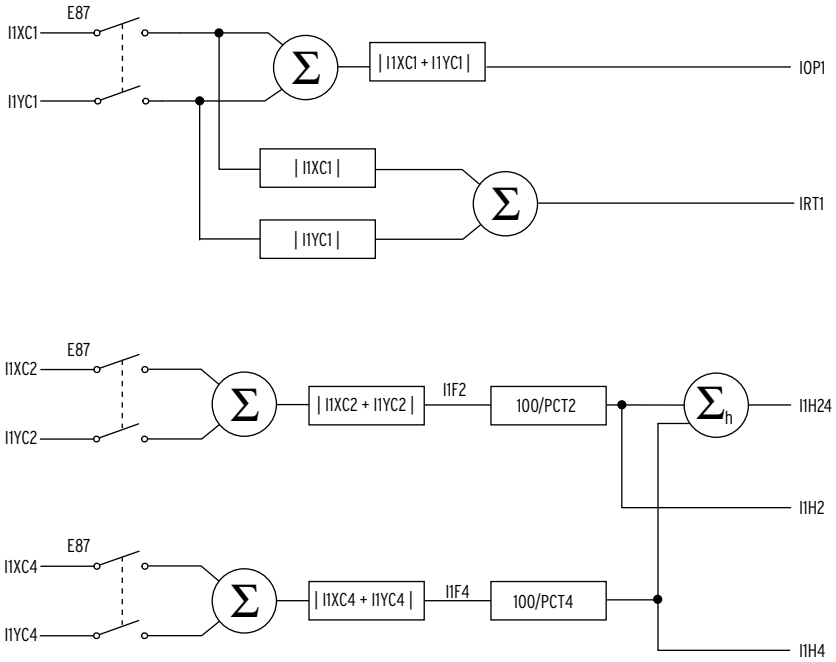


Figure 4.4 Differential Element (87-1) Quantities

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 the lower left corner of *Figure 4.5*. 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. Operating current elements 87O*n* (87O1, 87O2, 87O3) are not available as Relay Word bits.

Restrained elements (87R1, 87R2, and 87R3) determine whether the IOP quantity is greater than the restraint quantity (see the differential characteristic shown in *Figure 4.2*.) This characteristic is modified by increasing the restraint current 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 line of *Figure 4.5* implements the *Figure 4.2* characteristic. The differential element calculates a threshold as a function of IRT*n*. IOP*n* must exceed this threshold to assert 87R*n*. The function uses the SLP1, SLP2, and IRS1 setting values, along with IRT*n*, to calculate the IOP value. The relay uses SLOPE2 in place of SLOPE1 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 differential element decision logic compares the calculated value, denoted f(IRT*n*), to the actual IOP*n*. If IOP*n* is greater, one input of the AND gate at the right receives a logic 1. Comparison of IOP*n* with the O87P setting determines the second AND input. If IOP*n* is greater than O87P, the bit 87O*n* asserts. The AND gate condition then is satisfied, and Relay Word bit 87R*n* asserts, indicating operation of the restrained differential element, *n*. This does not, as yet, produce a trip. The relay still needs the results of the harmonic blocking decision logic, which is described later.

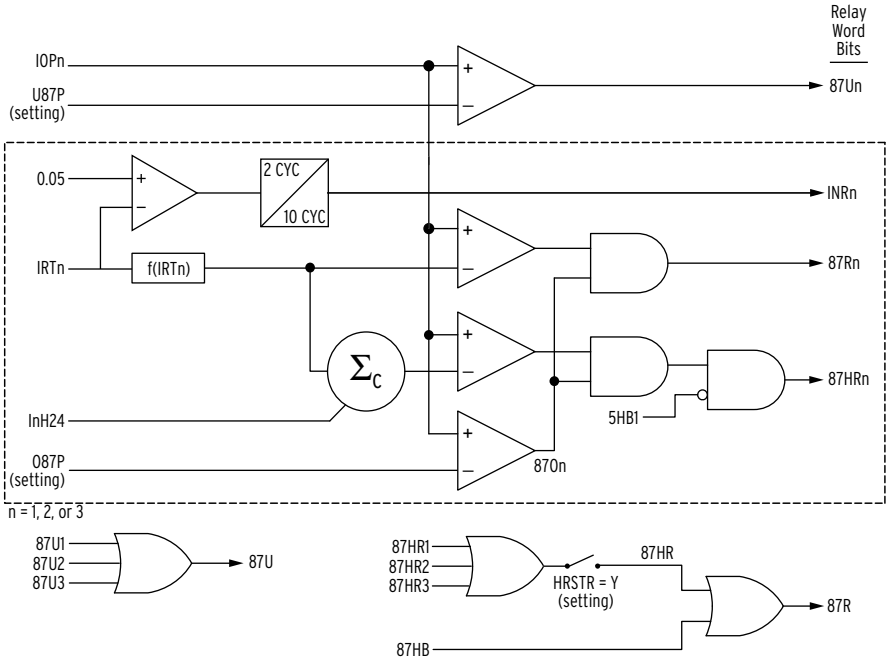


Figure 4.5 Differential Element Decision Logic

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—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 the simple case of Slope 1, a straight line through the origin. The general equation for a line is:

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

More specifically, in the SEL-700G:

$$IOP := SLP1 \bullet IRT + c$$

Because the line starts at the origin, the value of c is normally zero. The sum of the second- and fourth-harmonic currents now forms the constant c in the equation, raising the relay characteristic proportionally to the harmonic values.

Harmonic Blocking

While the restrained differential elements are making decisions, a parallel blocking decision process occurs regarding the magnitudes of specific 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 by the sum of second and fourth harmonic in the operate current. 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 only disables tripping of that element. 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). This threshold and timer may be useful for transformer applications in or near generating stations.

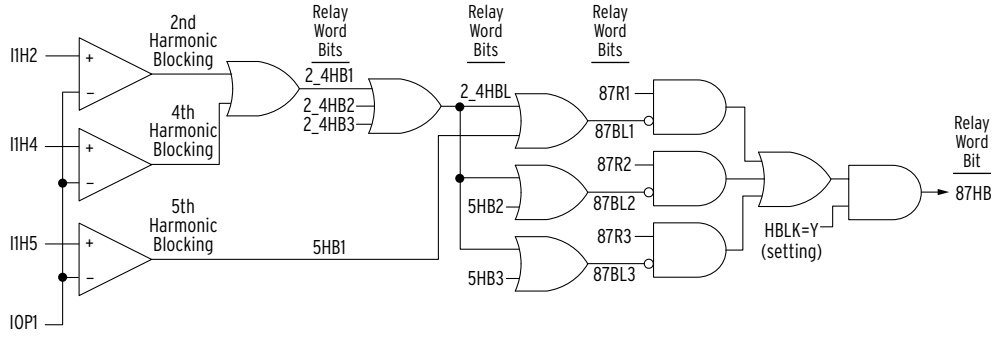


Figure 4.6 Differential Element Harmonic Blocking Logic

Relay Word bits 87R and 87U are high-speed elements that must shut down the generator. 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
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

[a] Range shown is for I_{NOM} = 5 A; range for I_{NOM} = 1 A is 0.1–6.20 A.

NOTE: Setting CTCX is not available for changing. It is hidden and is set automatically by the relay.

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 FOA (Forced Oil and Air cooled) 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 TAPY values automatically. You can also directly enter TAP values when MVA := OFF.

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 the user, in the next group of settings, to define the amount of shift needed 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 winding currents. The relay automatically sets CTCX to 0 or 12 (when ICOM := N or Y). These settings account for phase shifts in transformer winding connections and also in CT connections. For example, this correction is necessary if all 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, but high enough to avoid operation because of steady-state CT error and transformer excitation current. TAP • O87P must be greater than or equal to 0.1 • Inom (nominal rating of CTs) for each TAP value.

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 4.7* for the logic diagram of this feature. Assertion of Relay Word bit 87AT indicates a problem in the differential current circuit (for example, open CT). You must program the 87AT bit to take an appropriate action (alarm, display message, SER, etc.).

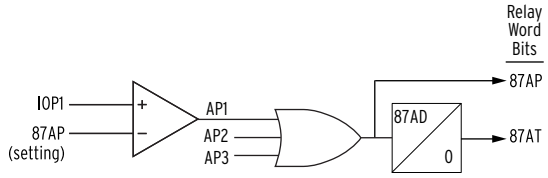


Figure 4.7 Differential Current Alarm Logic Diagram

Use the restraint slope percentage settings to discriminate between internal and external faults. Set SLP1 or SLP2 to accommodate current differences from power transformer tap-changer, CT saturation, CT errors, and relay error.

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. You 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 necessary 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 about 10 times TAP. The unrestrained differential element responds only 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 second-harmonic and/or fourth-harmonic current to fundamental current (IF2/IF1, IF4/IF1) is greater than the PCT2 or PCT4 setting respectively. Also, the differential element automatically goes into a high security mode for 10 cycles when the transformer is energized (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 (primarily fifth harmonic), which 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.

The fifth-harmonic alarm level and delay settings (TH5P and TH5D) use the presence of the fifth-harmonic differential current to assert a Relay Word bit TH5T. This bit indicates transformer excitation. 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 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 it allows faster differential element tripping for an energized transformer fault. Differential tripping through the harmonic restraint logic is slightly slower, but it provides a dependable tripping function when energizing a faulted transformer that might otherwise have the differential tripping element blocked by common harmonic blocking 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

$O87P_{300G/387/587} = O87P_{700G1}$
$SLP1_{300G/387/587} = 2 \bullet SLP1_{700G1}$
$SLP2_{300G/387/587} = 2 \bullet SLP2_{700G1}$
$IRS1_{300G/387/587} = 1/2 \bullet IRS1_{700G1}$
$U87P_{300G/387/587} = U87P_{700G1}$

General Discussion of Connection Compensation. The general expression for current compensation is as follows:

$$\begin{bmatrix} IAnC \\ IBnC \\ ICnC \end{bmatrix} = [CTC(m)] \bullet \begin{bmatrix} IAn \\ IBn \\ ICn \end{bmatrix}$$

where IA*n*, etc., are the three-phase currents entering terminal "*n*" of the relay; IA*n*C, etc., are the corresponding phase currents after compensation (*n* = X, Y); and [CTC(*m*)] is the three-by-three compensation matrix.

Setting CTC*n* := *m* specifies which [CTC(*m*)] matrix the relay is to use. The setting values can be 0, 1, 2, …, 11, 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 rotation rotate in a counterclockwise direction when multiplied by [CTC(*m*)]. If a given set of such currents is multiplied by all 12 of the CTC matrices, the resulting compensated values would seem to move completely around the circle in a counterclockwise direction, returning to the original start position. This is the same as successively multiplying [CTC(1)] times the original currents, then times each successive compensated result value, a total of 12 times.

If a balanced set of currents with ACB phase rotation undergoes the same exercise, the rotations by the [CTC(*m*)] matrices are clockwise. This is because the compensation matrices, when performing phasor addition or subtraction involving B or C phases, produce "mirror image" shifts relative to Phase A, when the relay uses ACB phase rotation 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 stated otherwise.

The "0" setting value should create no changes at all in the currents, but should merely multiply 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,

$$IAnC = IAn$$
$$IBnC = IBn$$
$$ICnC = ICn$$

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 CTCn := 1, the relay uses the following [CTC(m)] matrix:

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

that is,

$$\mathrm{IA}n\mathrm{C} = \frac{(\mathrm{IA}n - \mathrm{IB}n)}{\sqrt{3}}$$

$$\mathrm{IB}n\mathrm{C} = \frac{(\mathrm{IB}n - \mathrm{IC}n)}{\sqrt{3}}$$

$$\mathrm{IC}n\mathrm{C} = \frac{(\mathrm{IC}n - \mathrm{IA}n)}{\sqrt{3}}$$

The “1”1 setting performs a 330-degree compensation (11 • 30) in the counterclockwise direction, or a 30-degree compensation in the clockwise direction, as would a delta CT connection of type DAC (30-degree lagging). The name for this connection comes from the fact that the polarity end of the A phase CT connects to the nonpolarity end of the C phase CT, and so on, in forming the delta. Thus, for CTC*n* := 11, the relay uses the following [CTC(m)] matrix:

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

that is,

$$\mathrm{IA}n\mathrm{C} = \frac{(\mathrm{IA}n - \mathrm{IC}n)}{\sqrt{3}}$$

$$\mathrm{IB}n\mathrm{C} = \frac{(\mathrm{IB}n - \mathrm{IA}n)}{\sqrt{3}}$$

$$\mathrm{IC}n\mathrm{C} = \frac{(\mathrm{IC}n - \mathrm{IB}n)}{\sqrt{3}}$$

The effect of each compensation on balanced three-phase currents is to rotate them m • 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 currents, as do all of the matrices having non-zero values of *m*.

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

that is,

$$\mathrm{IA}n\mathrm{C} = \frac{(+2 \bullet \mathrm{IA}n - \mathrm{IB}n - \mathrm{IC}n)}{3}$$

$$\mathrm{IB}n\mathrm{C} = \frac{(-\mathrm{IA}n + 2 \bullet \mathrm{IB}n - \mathrm{IC}n)}{3}$$

$$\mathrm{IC}n\mathrm{C} = \frac{(-\mathrm{IA}n - \mathrm{IB}n + 2 \bullet \mathrm{IC}n)}{3}$$

We could use this type of compensation in applications having wye-connected transformer windings (no phase shift) with wye CT connections for each winding. Using CTC*n* := 12 for each winding removes zero-sequence components, just as connection of the CTs in delta would do, but without producing a phase shift. (One might also use CTC*n* := 1 or 11 for this same application, yielding compensation similar to that from connection of the CTs on both sides in DAB or DAC.)

The Complete List of Compensation Matrices (m = 1–12)

$$[\mathrm{CTC}(1)] = \frac{1}{\sqrt{3}} \bullet \begin{bmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ -1 & 0 & 1 \end{bmatrix} \qquad [\mathrm{CTC}(2)] = \frac{1}{3} \bullet \begin{bmatrix} 1 & -2 & 1 \\ 1 & 1 & -2 \\ -2 & 1 & 1 \end{bmatrix}$$

$$[\mathrm{CTC}(3)] = \frac{1}{\sqrt{3}} \bullet \begin{bmatrix} 0 & -1 & 1 \\ 1 & 0 & -1 \\ -1 & 1 & 0 \end{bmatrix} \qquad [\mathrm{CTC}(4)] = \frac{1}{3} \bullet \begin{bmatrix} -1 & -1 & 2 \\ 2 & -1 & -1 \\ -1 & 2 & -1 \end{bmatrix}$$

$$[\mathrm{CTC}(5)] = \frac{1}{\sqrt{3}} \bullet \begin{bmatrix} -1 & 0 & 1 \\ 1 & -1 & 0 \\ 0 & 1 & -1 \end{bmatrix} \qquad [\mathrm{CTC}(6)] = \frac{1}{3} \bullet \begin{bmatrix} -2 & 1 & 1 \\ 1 & -2 & 1 \\ 1 & 1 & -2 \end{bmatrix}$$

$$[\mathrm{CTC}(7)] = \frac{1}{\sqrt{3}} \bullet \begin{bmatrix} -1 & 1 & 0 \\ 0 & -1 & 1 \\ 1 & 0 & -1 \end{bmatrix} \qquad [\mathrm{CTC}(8)] = \frac{1}{3} \bullet \begin{bmatrix} -1 & 2 & -1 \\ -1 & -1 & 2 \\ 2 & -1 & -1 \end{bmatrix}$$

$$[\mathrm{CTC}(9)] = \frac{1}{\sqrt{3}} \bullet \begin{bmatrix} 0 & 1 & -1 \\ -1 & 0 & 1 \\ 1 & -1 & 0 \end{bmatrix} \qquad [\mathrm{CTC}(10)] = \frac{1}{3} \bullet \begin{bmatrix} 1 & 1 & -2 \\ -2 & 1 & -1 \\ 1 & -2 & 1 \end{bmatrix}$$

$$[\mathrm{CTC}(11)] = \frac{1}{\sqrt{3}} \bullet \begin{bmatrix} 1 & 0 & -1 \\ -1 & 1 & 0 \\ 0 & -1 & 1 \end{bmatrix} \qquad [\mathrm{CTC}(12)] = \frac{1}{3} \bullet \begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}$$

The matrices for odd values of m (1, 3, 5, 7, 9, 11) are constructed similarly, 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 and phase relationships, the CT connections, and the system phase rotation (ABC or ACB). The following brief review discusses the nature of various connections, their phase shifts, and the reference motion for selecting CTC*n* based on system phase rotation.

Winding Connection Review. *Figure 4.8* shows the three basic winding connections, consisting of a wye connection and the two possible delta connections.

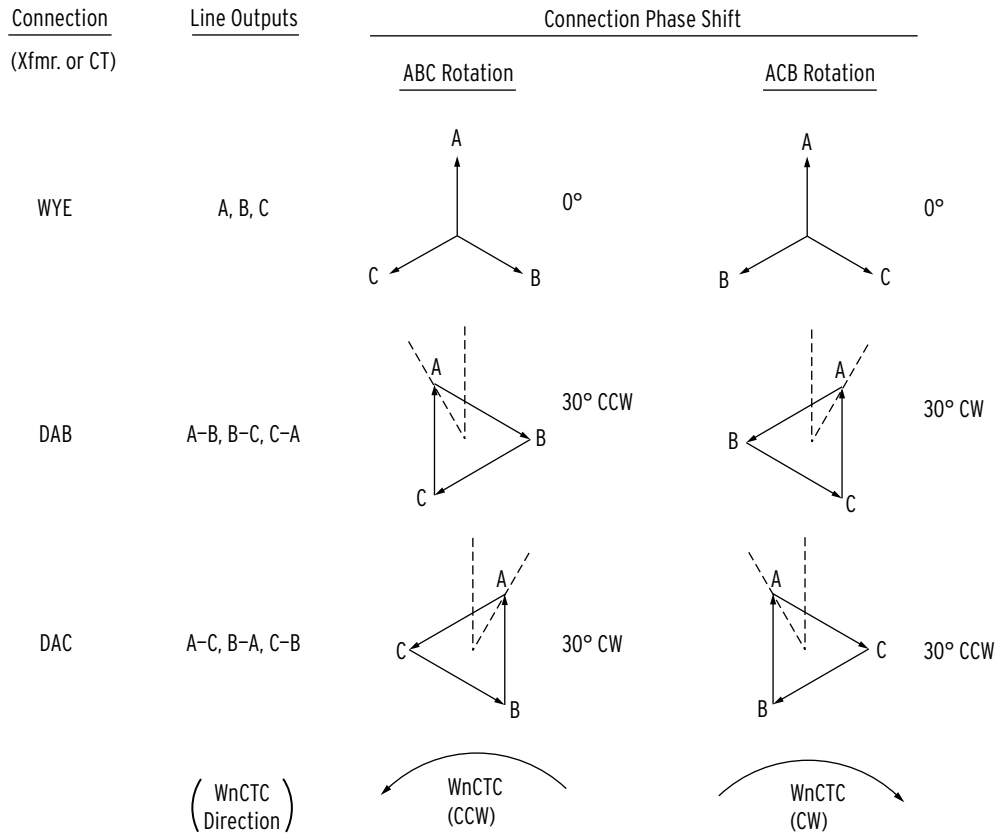


Figure 4.8 Winding Connections, Phase Shifts, and Compensation Direction

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 4.8*, 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 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 A-B, B-C, and C-A, respectively, in terms of the winding currents. In the DAC connection, the line currents from the A, B, and C line terminals are A-C, B-A, and C-B, respectively, in terms of the winding currents. The phase shift produced by each physical type of delta depends on the system phase rotation.

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 rotation, 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 rotation. In the ACB phase rotation, C lags A by 120 degrees, and B leads A by 120 degrees. Terminal A line current is still A-B, but the current now lags A winding current by 30 degrees.

The DAC connection produces opposite shifts to DAB. In the ABC phase rotation, line current from terminal A is A-C, which lags A winding current by 30 degrees. In the ACB phase rotation, 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 4.8* 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 nonreferenced winding to line it up with the reference. This number ranges from 0 to 12 increments. For ABC phase rotation, begin at the winding direction and proceed in a CCW direction until reaching the reference. For ACB phase rotation, begin at the winding direction and proceed in a CW direction until reaching the reference. *Figure 4.8* 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 removes 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 4.9* 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 4.9* illustrates.

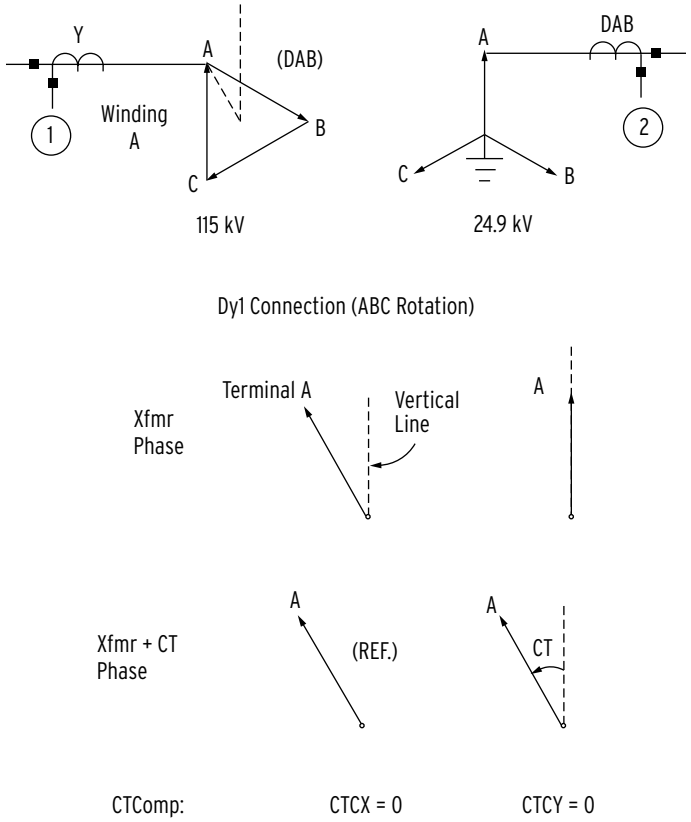


Figure 4.9 Example for CTCn Selection

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 line following the transformer drawings in *Figure 4.9* and note that the delta winding A line terminal direction is at 30 degrees CCW from the A winding direction (vertical), as we would expect for a DAB connection with ABC phase rotation. The A winding of the 24.9 kV winding is vertical.

Step 2. Adjust the CT connections.

In this case, the primary winding with wye CTs needs no adjustment. The 24.9 kV winding, with DAB CTs, needs a 30-degree correction in the CCW direction. *Figure 4.9* shows this adjustment in the second line under the transformer drawings.

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 the complete circle of 360 degrees, as the reference. Both windings would then receive adjustments to correlate them with this reference. As *Figure 4.9* illustrates, the primary winding direction serves as reference in the example.

Step 4. Choose the CTC*n* settings for the windings.

NOTE: Setting CTCX is not available for changing. It is hidden and is set automatically by the relay.

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. 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* eliminates 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 required from the relay.

Winding Line-to-Line Voltages. Set VWDGX and VWDGY equal to the nominal line-to-line transformer terminal voltages of Winding X and Winding Y, respectively. If the transformer differential zone includes a load tap-changer, 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 the settings entered for the particular winding (*n* identifies the winding, X or Y.)

$$\mathrm{TAP}n = \frac{\mathrm{MVA} \bullet 1000}{\sqrt{3} \bullet \mathrm{VWDG}n \bullet \mathrm{CTR}n} \bullet \mathrm{C}$$

where

C = 1 if CTCON*n* setting := WYE (wye-connected CTs)
C = $\sqrt{3}$ if CTCON*n* setting := DELTA (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 (I_{NOMn} is the nominal rating of the CTs):

- The TAP settings are within the range $0.1 \bullet I_{NOMn}$ and $6.2 \bullet I_{NOMn}$
- The ratio $\frac{(\text{Higher TAPn}/I_{NOMn})}{(\text{Lower TAPn}/I_{NOMn})} \leq 7.5$

Restrained Element Operating Current Pickup. The O87P setting range is 0.1 to 1.0; we suggest an O87P setting of 0.3. The setting must be at a minimum for increased sensitivity but high enough to avoid operation because of steady-state CT error and transformer excitation current. The setting must also yield an operating current greater than or equal to $0.1 \bullet I_{NOMn}$, when multiplied by the corresponding TAP*n*. Stated another way,

$$O87P \geq (0.1 \bullet I_{NOMn}) / TAPn$$

The above restriction applies to each winding side (irrespective of TAP magnitudes) when 1 A and 5 A nominal CTs are used in the same relay.

EXAMPLE 4.3 Restraint Slope Percentage Example

The current transformer error, e, is equal to ±10 percent. In per unit:

e = 0.1

The voltage ratio variation of the power transformer load tap-changer, LTC, is from 90 percent to 110 percent. In per unit:

a = 0.1

In a through-current situation, the worst-case theoretical differential current occurs when all of the input currents are measured with maximum positive CT error, and all of the output currents are measured with maximum negative CT error as well as being offset by maximum LTC variation. Therefore, the maximum differential current expected for through-current conditions is:

$$Idmax = (1 + e) \bullet \sum_{"IN"} IW_n - \frac{1 - e}{1 + a} \bullet \sum_{"OUT"} IW_n$$

where the summation terms are the total input and output power transformer secondary currents after tap compensation. Because these summations must be equal for external faults and load current, we can express the maximum differential current as a percentage of winding current:

$$1 + e - \frac{1 - e}{1 + a} = \frac{2 \bullet e + a + e \bullet a}{1 + a} \bullet 100\% = 28.18\%$$

Note that the restraint current is defined as the sum of the winding currents, which equals 2.0 per unit for the through current condition. Therefore, the differential current as a percentage of the restraint current (also known as slope) is $SLOPE = (28.18/2.0) = 14.09\%$.

In addition to the error calculated above, we have to consider additional errors from the transformer excitation current (<3 percent) and relay measurement error (< or = 5 percent). The maximum total error comes to about 18 percent (considering 2.0 per unit restraint current). Therefore, if we use only one slope, a conservative slope setting, SLP1, is about 18 percent. This represents a fixed percentage differential application and is a good average setting to cover the entire current range.

A two-slope, or variable-percentage differential application, improves sensitivity in the region where CT error is small and increases security in the

high-current region where CT error is great. We must define both slopes, as well as the slope 1 limit or crossover point, IRS1. If we assume CT error to be only 1 percent, we can set SLP1 at about 15 percent. A good choice for IRS1 is about 3.0 per unit of tap, while the SLP2 setting should probably be in the 25 percent to 70 percent range to avoid problems with CT saturation at high currents.

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 about 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 U87P must be set lower than $31 \bullet I_{NOMn}/TAPn$.

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 resulting from point-on-wave switching. Relays typically use even harmonics to detect inrush conditions and to prevent misoperations resulting from inrush. The largest even-harmonic current component is usually second harmonic. Fourth harmonic follows. 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.

Use the presence of the 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. You can set a delay, TH5D, that prevents the relay from indicating the transient presence of the fifth-harmonic currents.

Consider triggering an event report if the transformer excitation current exceeds the fifth-harmonic threshold.

There are two criteria for setting TH5P:

$$TH5P \bullet TAPn \geq 0.05 \bullet I_{NOMn}$$

where

n = X, Y and I_{NOMn} is nominal current of corresponding CT

Example of Setting the SEL-700G Relay (Unit Differential). The example represents a typical transformer application and demonstrates the use of CT compensation settings and tap calculations.

Figure 2.19 illustrates an application that uses a 13.8 kV to 138 kV transformer with a maximum rating of 30 MVA. Both windings have wye-connected current transformers that have 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 the settings for the current transformer connection and ratio for each winding. All CTs connect in wye. The ratios are equal to primary current divided by secondary current. The settings are as follows:

13.8 kV	**138 kV**
	CTCONY := WYE
CTRX := 400	CTRY := 40

Step 3. Set the transformer maximum rating. We use this rating for all windings in the later tap calculation:

MVA := 30

Step 4. Decide whether to use internal CT compensation and determine the 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 := 12 CTCY := 11

The relay multiplies 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:

$$TAPn = \frac{MVA \bullet 1000}{\sqrt{3} \bullet VWDGn \bullet CTRn} \bullet C$$

where

$C = 1$ for wye CTs

Thus, we have the following:

$$TAPX = \frac{30MVA \bullet 1000}{\sqrt{3} \bullet 13.8kV \bullet 400}$$

$$TAPX = 3.14$$

$$TAPY = \frac{30MVA \bullet 1000}{\sqrt{3} \bullet 138kV \bullet 40}$$

$$TAPY = 3.14$$

The relay calculates these taps automatically if MVA is given. If MVA is set to OFF, the user must calculate the taps and enter them individually.

The relay checks for a violation of the maximum tap ratio and notifies the user 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 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 = 3.0 (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)

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 $(0.1 \bullet I_{NOMn})/TAPn = 0.5/3.14 = 0.159$. 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 2.22 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 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. 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)

Remember that the O87P setting must yield an operating current value of at least 0.1 • I_{NOM}. In this case, O87 must be greater than or equal to (0.1 • I_{NOMn})/TAP*n* = 0.5/3.1 = 0.16.

Therefore, the O87P setting of 0.3 is valid.

The differential unit settings are complete for this specific application. At this point, you can also choose to set backup overcurrent elements. More discussion of these elements is at the end of this section.

Application Guidelines

It is vital that you select adequate current transformers for a transformer 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 can apply two restraint inputs to the relay. You can 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, C voltage ratings, and core dimensions.
- 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 is 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 for a Multiwinding Transformer.

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 $\sqrt{3} \bullet I_{HS}$. Select the nearest standard ratio such that I_{REL} is between $0.1 \bullet I_{NOM}$ and $1.0 \bullet I_{NOM}$ A secondary, where I_{NOM} is the relay nominal secondary current, 1 A or 5 A.

Step 3. Select the remaining CT ratios (for example, CTRY) 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 $\sqrt{3} \bullet I_{LS}$. Select the nearest standard ratio such that I_{REL} is between $0.1 \bullet I_{NOM}$ and $1.0 \bullet I_{NOM}$ A secondary.

The SEL-700G calculates settings TAPX and TAPY if the ratio (higher TAPn/I_{NOMn})/(lower TAPn/I_{NOMn}) is less than or equal to 7.5. When the relay calculates the tap settings, it reduces CT mismatch to less than 1 percent. Allowable tap settings are in the range $(0.1\text{-}6.2) \bullet I_{NOMn}$.

If the ratio (higher TAPn/I_{NOMn})/(lower TAPn/I_{NOMn}) is greater than 7.5, select a different CT ratio to meet the above 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 $20 \bullet I_{NOM}$. 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 you use a tap other than the maximum. Derate the CTC 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 2.17 and Figure 2.22 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 phase residual current automatically, as shown in *Figure 4.10* below.

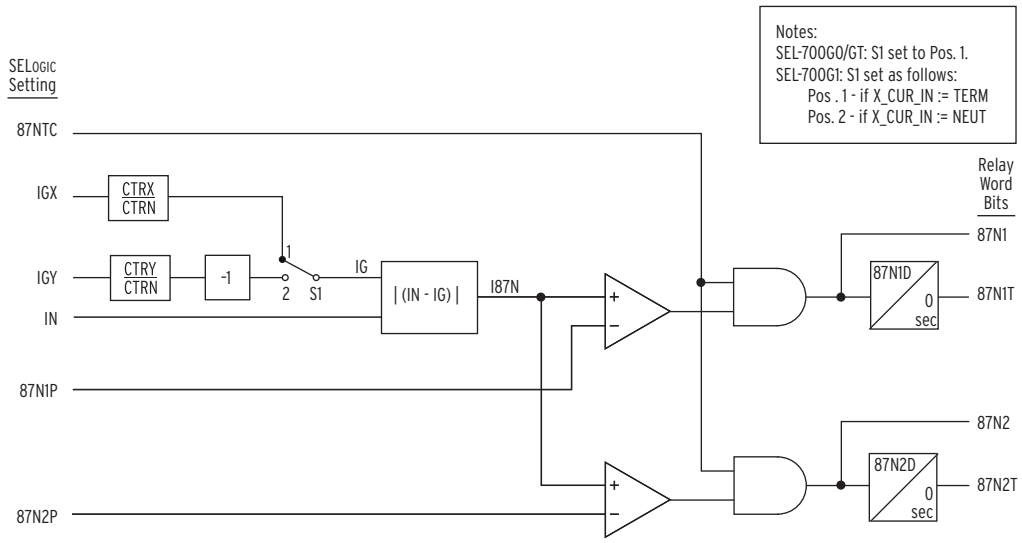


Figure 4.10 87N Element Logic Diagram

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 4.11 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 4.11*). REF1BYP could be blocked, if intended for the above fault, by setting REF52BYP := NO.

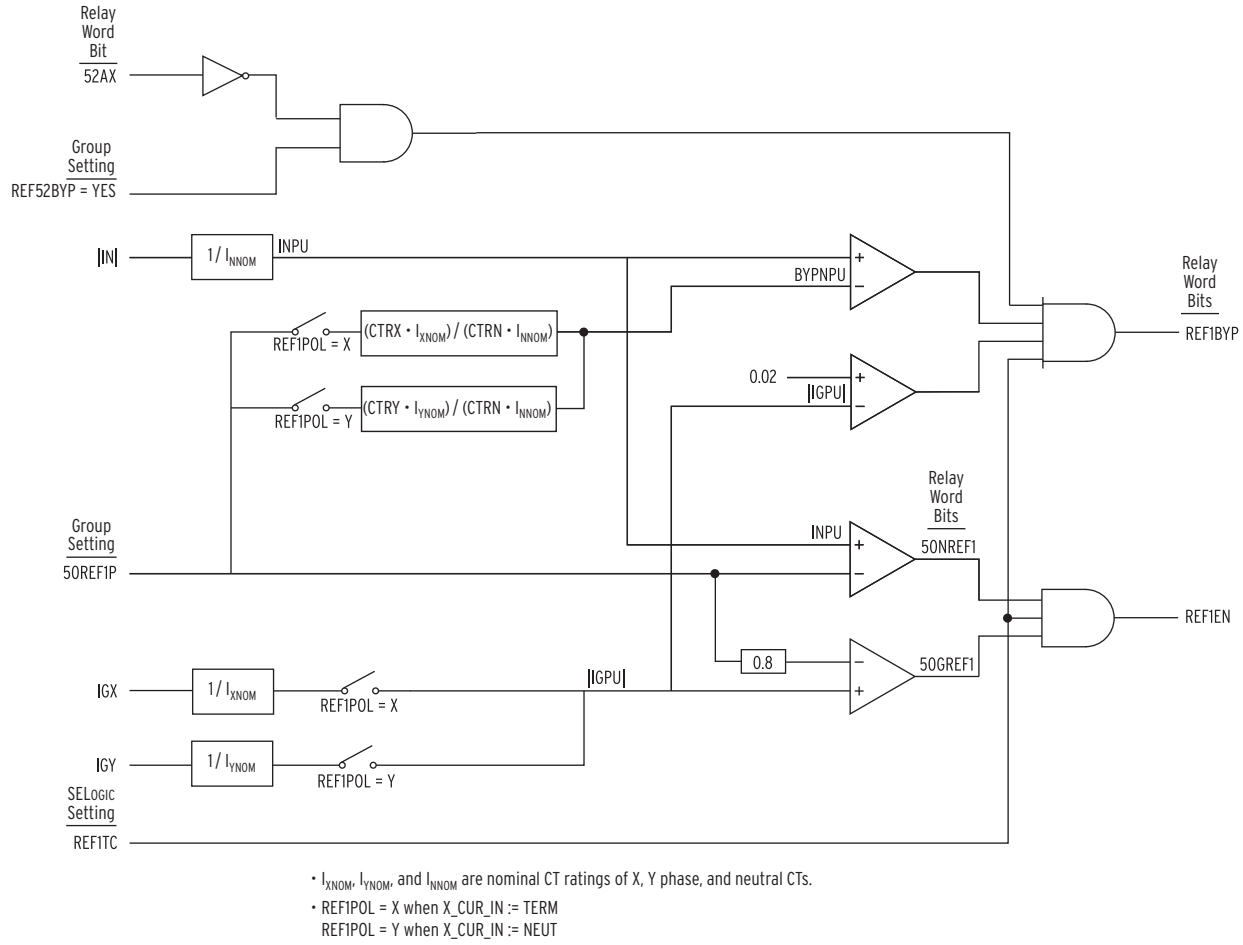


Figure 4.11 REF Enable Logic

Figure 4.12 illustrates the logic of the REF directional element, REF1F. It is at this stage that the element decides whether to operate.

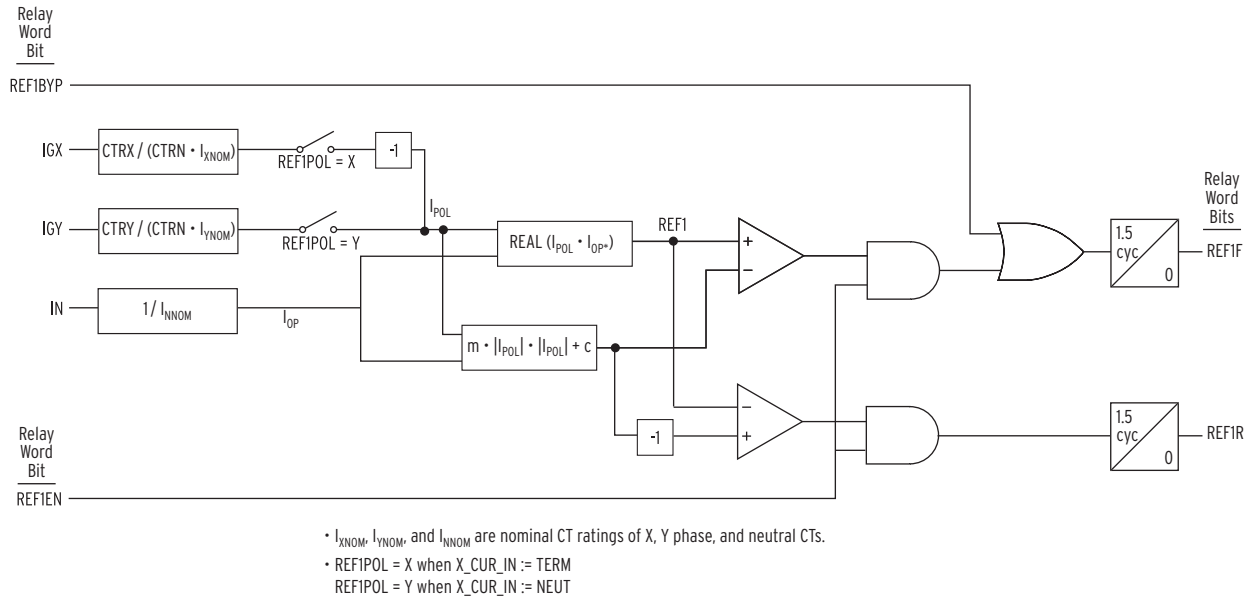


Figure 4.12 REF Directional Element

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 4.13* 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.

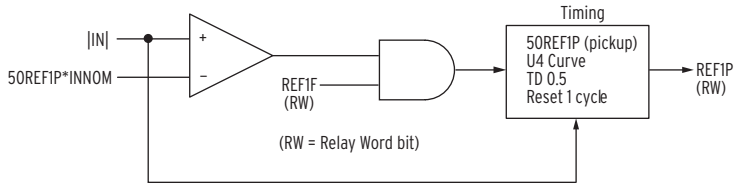


Figure 4.13 REF Protection Output (Extremely Inverse-Time O/C)

Relay Word bit REF1F (forward fault) torque controls the timing curve, and IN1 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 2.17*).

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.

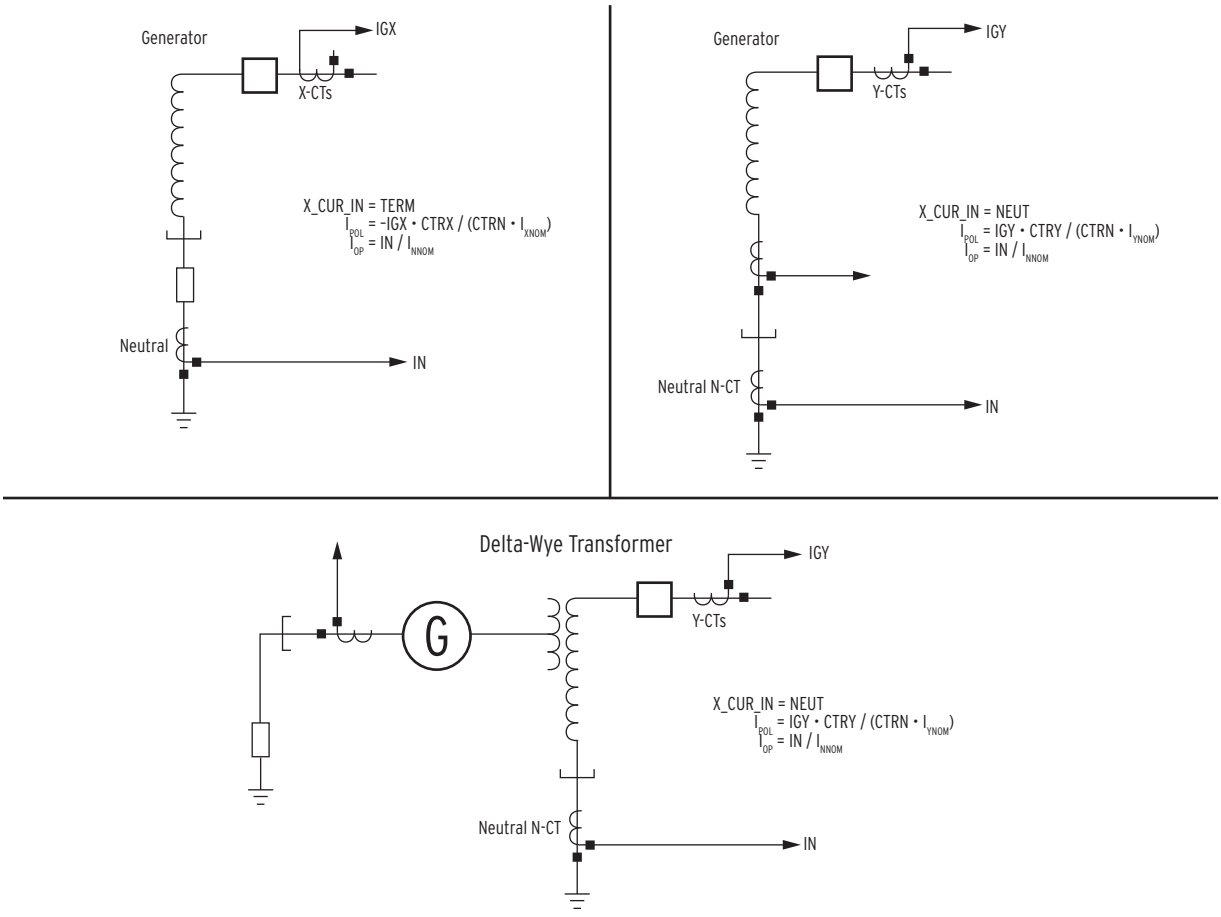
You can set the neutral current sensitivity threshold to as low as 0.05 times nominal current (0.25 A for 5 A nominal CT current), the minimum neutral current sensitivity of the relay. However, the minimum acceptable value of 50REF1P must meet two criteria:

1. 50REF1P must be greater than the highest unbalance expected by load conditions.
2. 50REF1P must be greater than a minimum value determined by the relationship of the CTR*n* values used in the REF function.

You must set the threshold setting, 50REF1P, at the greater of the two criteria values. Determine criterion one for load unbalance. The second criterion relates to the relative sensitivity of the winding CTs compared to the neutral CT. See sample calculations in *REF Current Pickup Level on page 4.33*.

Polarizing Quantity

Figure 4.14 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 4.14 Effect of X_CUR_IN Setting on Polarizing Current

Calculation of the residual current for X and Y CTs is as follows:

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

REF Current Pickup Level

The second criterion of 50REF1P relates to the relative sensitivity of the winding CTs compared to the neutral CT. Use the following equation to determine the minimum second criterion for 50REF1P:

$$50REF1P \geq 0.05 \bullet \left[\frac{MAX(I_{nNOM} \bullet CTRn)}{(\textcircled{?}CTRN \bullet I_{NNOM})} \right]$$

where $MAX(I_{nNOM} \bullet CTRn)$ is the primary rating of the CTs being used for the REF function.

The X_CUR_IN setting defines which phase CT currents the relay uses for REF, as shown in *Figure 4.14*.

EXAMPLE 4.4 An example 50REF1P calculation:

Assuming that CTRN = 40, I_{NNOM} = 5 A, (I_{NOM} • CTR) = (160 • 5) = 800, and the load unbalance is 10 percent:

$$50REF1P \geq 0.05 \bullet \frac{800}{40 \bullet 5}$$

$$50REF1P \geq 0.20 \text{ pu}$$

The second criterion minimum setting for 50REF1P is 0.20 pu. With a 10 percent load unbalance, we can assume that the second criterion value is 0.1 pu. Because 50REF1P must be set at the greater of the two criteria values, we would select a setting of 0.20 pu.

100% Stator Ground Protection Elements

The SEL-700G provides a two-zone function designed to detect stator winding ground faults on resistance and high-impedance grounded generators. The Zone 1 element, 64G1, uses a fundamental-frequency neutral overvoltage element that is sensitive to faults in the middle and upper portions of the winding. The Zone 2 element, 64G2, uses a third-harmonic voltage differential function to detect faults in the upper and lower portions of the winding. By using the two zones together, the relay provides 100 percent stator ground fault coverage.

NOTE: Most generators produce enough third-harmonic voltage for proper application of the 64G2 element; however, some generators (for example, those with 2/3 pitch winding) may not. In those cases, the element based on the third-harmonic voltage, such as the 64G2, cannot be used for 100 percent Stator Ground Protection.

When a ground fault occurs high in the winding of a resistance or high-impedance grounded generator, a voltage appears at the generator neutral. The neutral voltage magnitude during the fault is proportional to the fault location within the winding. For instance, if a fault occurs 85 percent up the winding from the neutral point, the neutral voltage is 85 percent of the generator rated line-neutral voltage. The SEL-700G asserts the 64G1 Relay Word bit when neutral voltage is greater than the 64G1P setting.

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.

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 4.15 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.

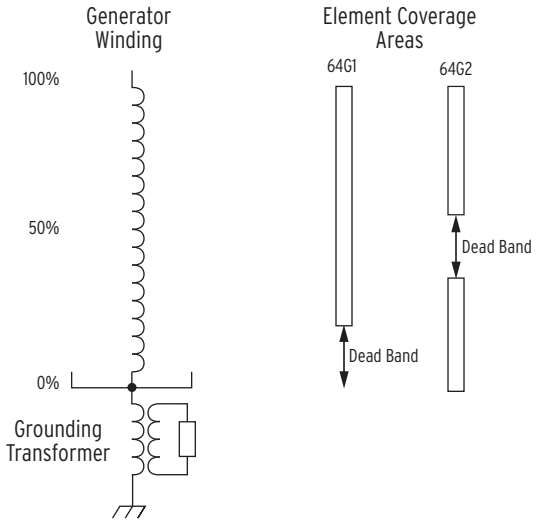


Figure 4.15 64G Element Operating Characteristic

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.

The Zone 2 stator ground element also may be applied 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 the user 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 the user to program 64G2 only as neutral third-harmonic undervoltage protection.

Note: If EXT3V0_X := VN, then the 64G element is disabled.

The 64G1P setting defines the sensitivity of the relay fundamental frequency neutral overvoltage element used to detect stator ground faults in the middle and upper areas of the generator winding. The 64G1D setting defines the Zone 1 element time delay.

The 64G2P setting defines the sensitivity of the relay third-harmonic voltage differential function used to detect stator ground faults in the lower and upper areas of the generator winding. The 64RAT setting defines a balancing ratio used to provide consistent element performance over the range of machine operation. The 64G2D setting defines the Zone 2 element time delay.

Setting 64RAT is hidden and set to 0.0 when setting DELTAY_X := DELTA and EXT3V0_X := NONE.

The 64G1TC torque-control setting disables Zone 1 when its result is logical 0 and enables Zone 1 when its result is logical 1. Setting 64G2TC works similarly for Zone 2.

Table 4.6 Stator Ground Protection Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
64G PROT EN	Y, N	E64G := Y
NEUTRAL O/V LVL	OFF, 0.1–150.0 V	64G1P := 5
ZONE 1 TIMER	0.00–400.00 s	64G1D := 0.75
64G1 TRQCTRL	SELOGIC	64G1TC := 1
DIFF VOLT LVL	OFF, 0.1–20.0 V	64G2P := 2.5
ZONE 2 RATIO	0.0–5.0	64RAT := 1.0
ZONE 2 TIMER	0.00–400.00 s	64G2D := 0.08
64G2 TRQCTRL	SELOGIC	64G2TC := 1

Loss-of-Potential and Other Supervision

When 64G2 is configured as a third-harmonic voltage differential element, the relay must have information about the level of third-harmonic voltage at the

generator terminal. If the potential transformers are lost, the 64G2 element operates and causes an unnecessary trip unless the SEL-700G relay loss-of-potential detection logic (by setting 64G2TC := NOT LOPX AND 52AX, for example) supervises the element.

Note: 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 calculations below, you can use the Microsoft® Excel spreadsheet, 64G Element Setting Worksheet, available on the SEL website 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:

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

$64RAT =$ _____

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

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

$64G2P_{Min} =$ _____ 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:

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

$64G2_{Min} =$ _____ %

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

NOTE: Perform the procedure when the relay is first installed, but after the generator being protected is connected to its step-up transformer or bus. Remove the 64G2T Relay Word bit from the relay tripping SELOGIC control equation. Use 64G1P := 5 V during the test. Set the balance of tripping functions according to the requirements of the particular generator. Leave these tripping functions in service to protect the generator in the event that a fault occurs during the test sequence.

Typically, the minimum neutral third-harmonic voltage occurs at no-load conditions. However, some cases have been observed where the minimum voltage occurs with the machine partially loaded. Therefore, we recommend measuring the neutral third-harmonic voltage at various real and reactive load conditions to find the minimum voltage.

Step 1. Operate the generator at various loads. Use the SEL-700G **METER** command and record the values of neutral third-harmonic voltage.

VN3_min := VN3/PTRN = _____Minimum third harmonic neutral voltage V secondary.

Step 2. Set the 64RAT setting equal to 0.0 to disable third-harmonic voltage differential protection and enable third-harmonic neutral undervoltage protection. The relay does this automatically and hides the 64RAT setting if DELTAY_X := D.

64RAT := 0.0

Step 3. Set the 64G2P setting approximately 50 percent of the generator minimum third-harmonic neutral voltage:

64G2P = 0.5 • VN3_min V secondary

64G2P = _____ 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

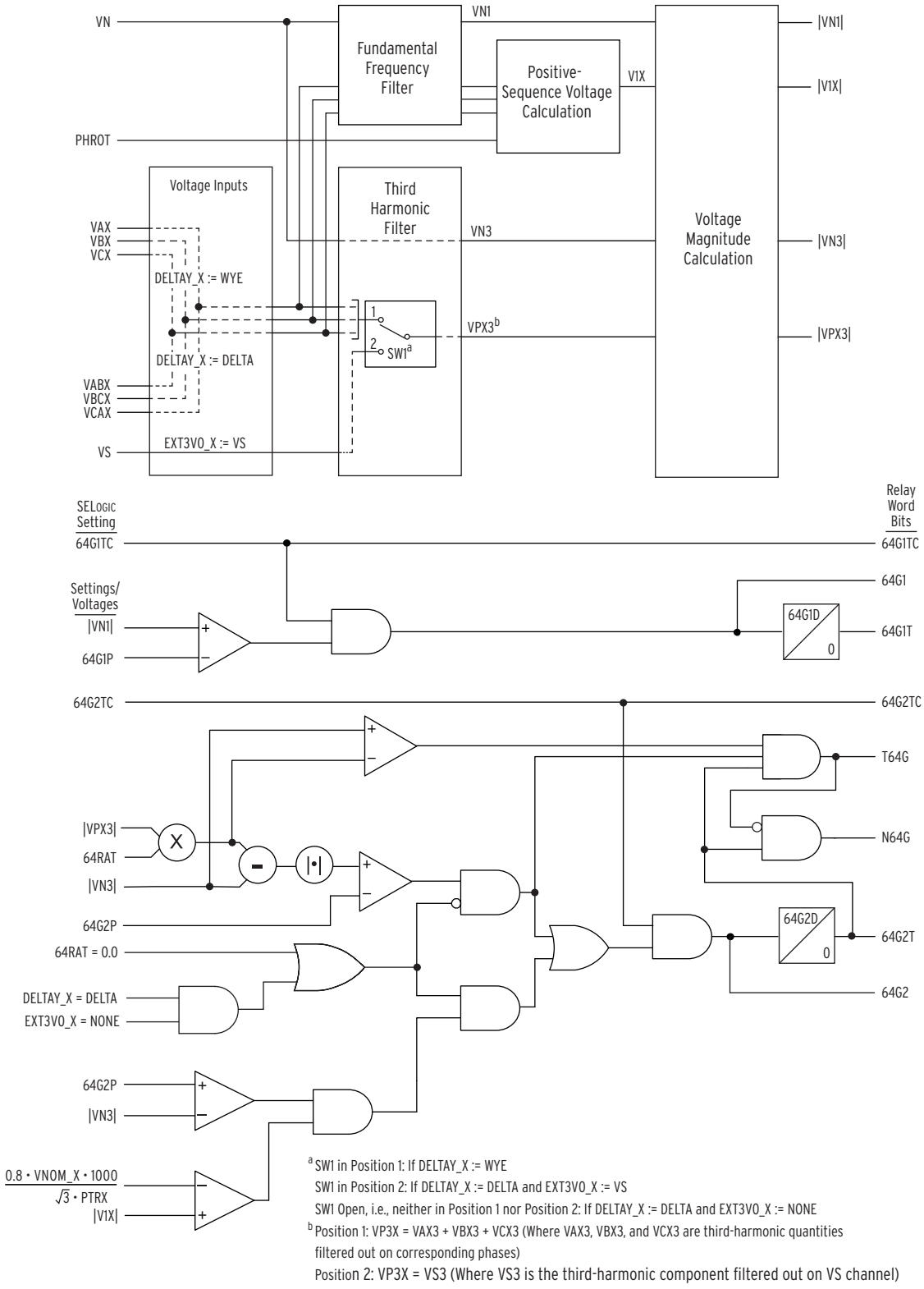
PTRN = Ngt • Nat

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 4.16 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.

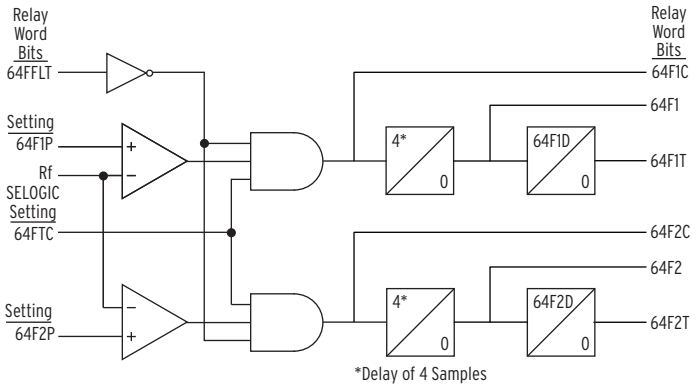
Set the EIA-232 port in the SEL-700G to SEL protocol and 9600 baud rate to start receiving the insulation resistance value from the SEL-2664. Refer to *Figure 2.30* for the connection diagram.

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 4.17*). 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.



Rf = Field ground insulation resistance in kOhms

Figure 4.17 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 of the available elements, Distance (DC), Voltage Restraint (V), or Voltage Controlled (C) Overcurrent elements.

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 up to 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, V, C, DC	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 2.17*, 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.

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.

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.

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). Other supervisory conditions may be added if your application requires.

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 required 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 required 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 required for each zone depends on the location of the relay current transformers. If current transformers are connected near the generator neutral, as in *Figure 2.16* or *Figure 2.18*, 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 2.17*, 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 required for your application.

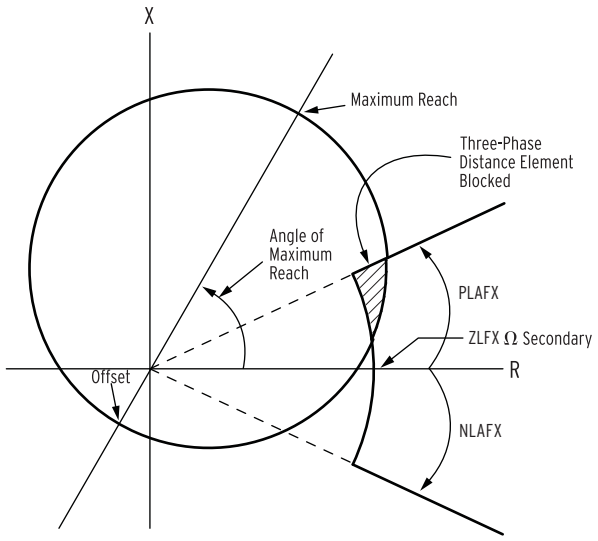
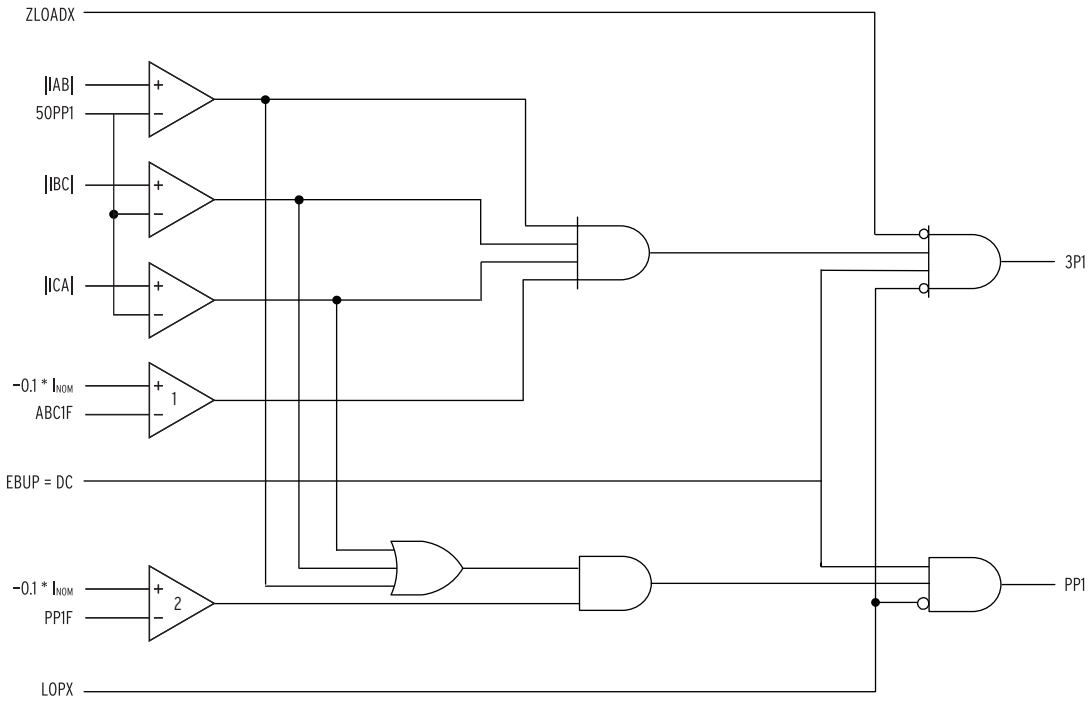


Figure 4.18 Three-Phase Distance Element Operating Characteristics



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 4.19 Zone 1 Compensator Element Logic

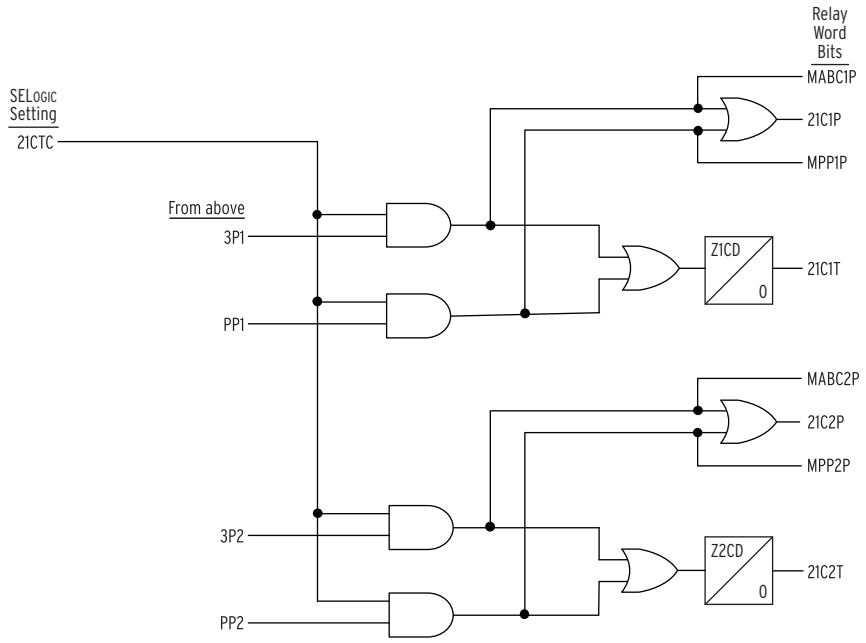


Figure 4.20 Compensator Distance Element Logic

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 typically is 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 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
System Backup		
BACKUP PROT EN	N, V, C or N, V, C, DC	EBUP := V
Voltage-Controlled TOC		
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		
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 4.55* through *Figure 4.64*.

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 (transient reactance X'_d may be used 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 AND NOT LOPX
```

To enable and set the undervoltage element, set

```
27PPX1P • 0.8 • Vnom volts
```

where

```
Vnom = VNOM_X • 1000/PTRX
```

With the previous settings, the 51C element is enabled whenever the generator voltage is less than 80 percent of nominal, as long as there is no simultaneous loss-of-potential condition. You can choose to use a different undervoltage element pickup setting.

Voltage-Restrained Time-Overcurrent Settings. When using the 51V element, set the 51VP pickup setting greater than the maximum generator phase current expected under full voltage, nonfault conditions. Divide this current by the phase current transformer ratio, CTRX, to find the element pickup current in secondary amps.

$$51VP > \frac{\text{max load current}}{CTRX} \text{ amps}$$

Select a curve shape and time-dial that allow this element to coordinate with the system primary protection.

$$51VC = U2$$
$$51VTD = 3.00$$

Apply electromechanical reset emulation if the system phase overcurrent relays are induction disk relays; otherwise, electromechanical reset emulation is not necessary.

$$51VRS = N$$

Because this element reduces its pickup setting automatically as generator voltage decreases, the element should not be permitted to operate if there is a blown potential transformer fuse condition. To prevent misoperation if a potential transformer fuse blows, the element is torque controlled by the NOT LOPX Relay Word bit.

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

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.

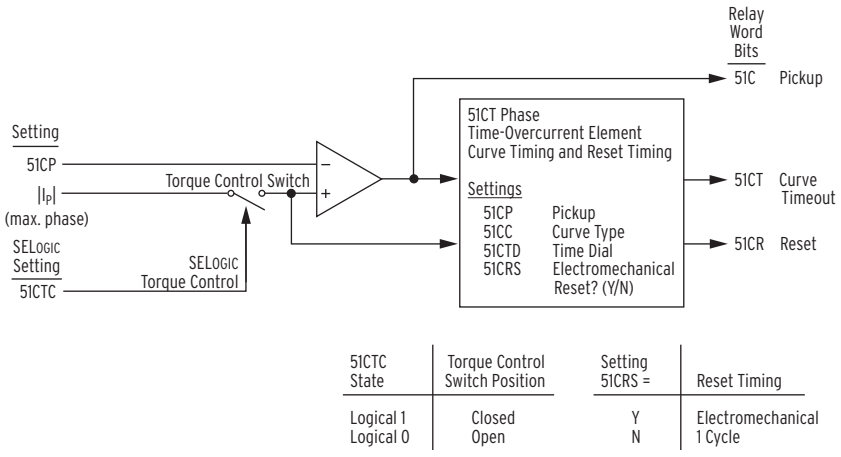


Figure 4.21 Voltage-Controlled Phase Time-Overcurrent Element 51CT

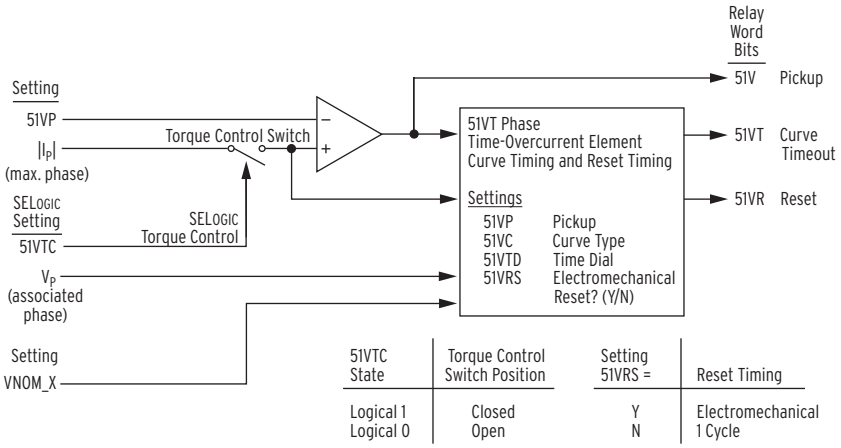


Figure 4.22 Voltage-Restrained Phase Time-Overcurrent Element 51VT

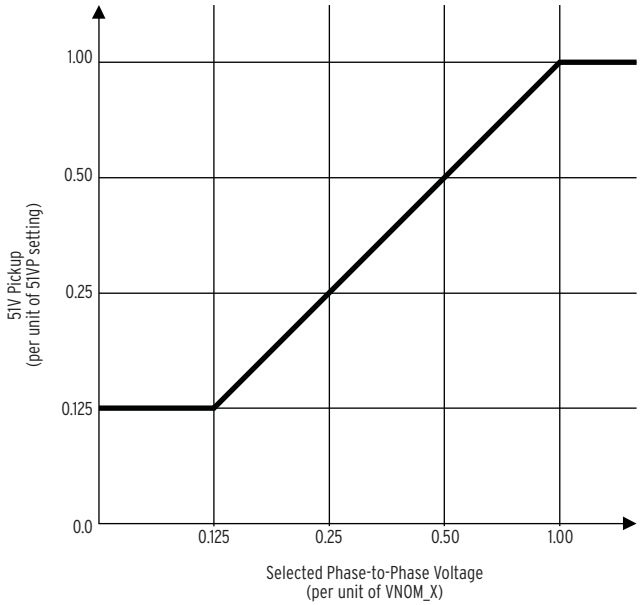


Figure 4.23 51V Element Voltage Restraint Characteristic

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 4.25*. 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 4.26*. 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.

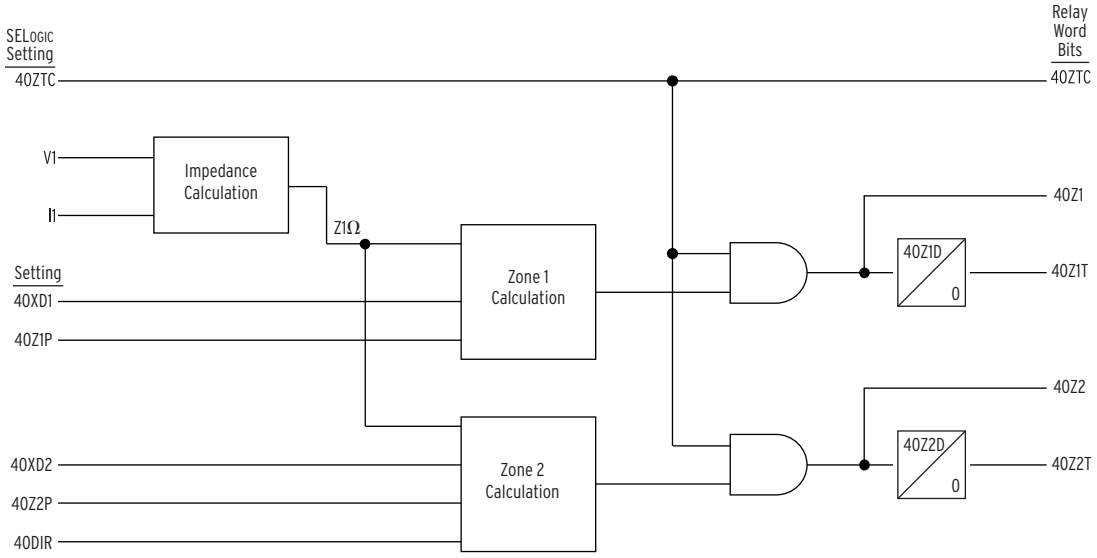


Figure 4.24 Loss-of-Field Logic Diagram

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 required, 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 1 second.

$$40Z2D = 1.0 \text{ second}$$

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 required. 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.

$$\text{Set } 27V1X1P = \frac{0.8 * VNOM\_X * 1000}{1.732 * PTRX}$$

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 above, to cause generator breaker and field breaker tripping (see Trip/Close Logic Settings for details).

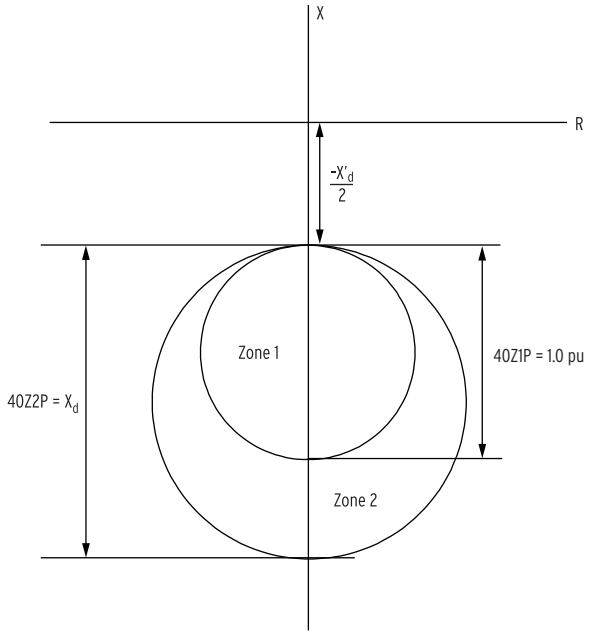


Figure 4.25 Loss-of-Field Element Operating Characteristic, Negative Zone 2 Offset

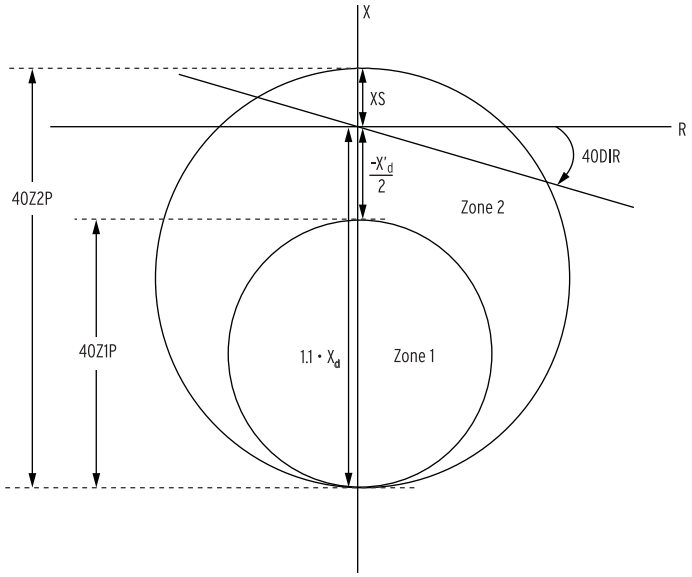


Figure 4.26 Loss-of-Field Element Operating Characteristic, Positive Zone 2 Offset

Current Unbalance Elements

Generator unbalance current causes high rotor heating. IEEE Standard C50.13-1977 defined the ability of generators to withstand unbalance current in terms of negative-sequence current. The standard defines a continuous withstand capability as well as a short-time capability, expressed in terms of I_2^2t.

The SEL-700G provides a negative-sequence definite time-overcurrent element suitable for unbalance alarm application and an I_2^2t time-overcurrent element for unbalance current tripping. The negative-sequence overcurrent elements are supervised by the 46QTC torque-control setting.

Table 4.11 Current Unbalance Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
NEG-SEQ OC ENBL	Y, N	E46 := Y
LVL1 NEG-SEQ O/C	OFF, 2–100 %	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 required, 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.

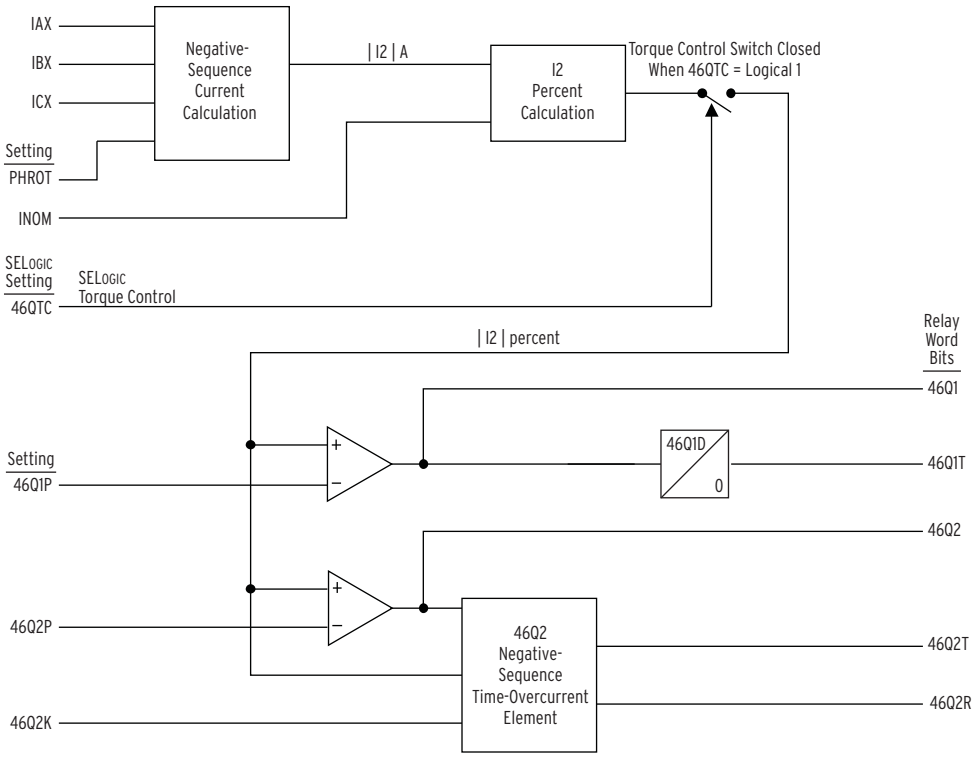
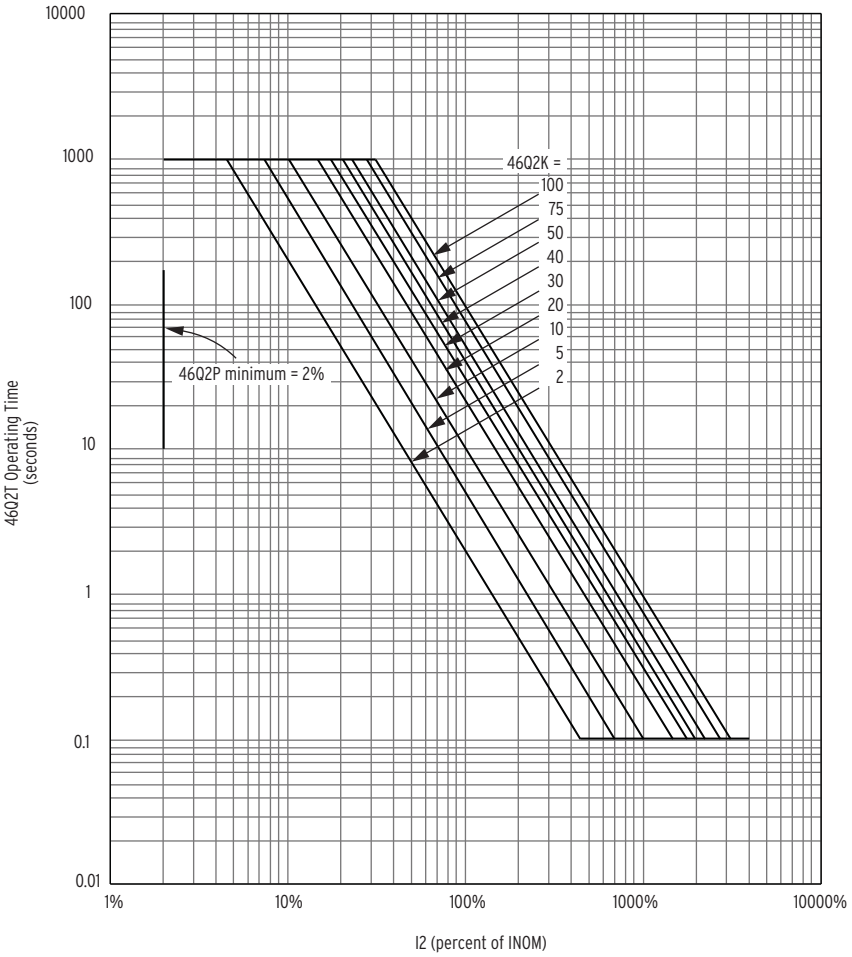


Figure 4.27 Negative-Sequence Overcurrent Element Logic Diagram



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

Figure 4.28 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 4.29* 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.

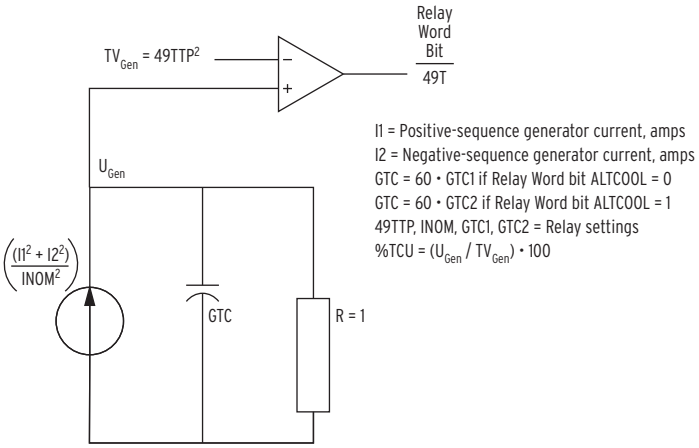


Figure 4.29 Simplified Thermal Model, Generator

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 4.30 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

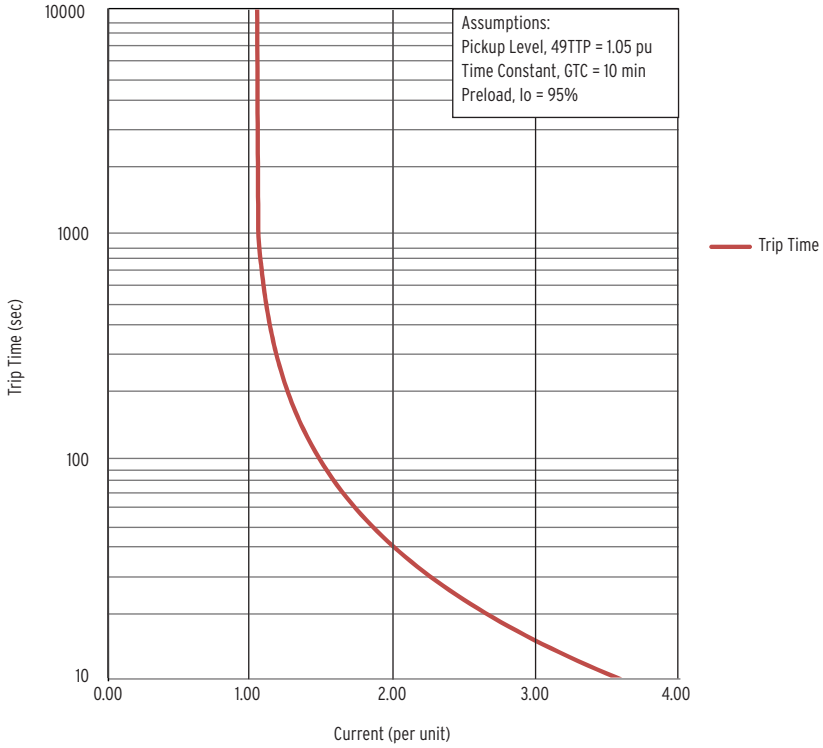


Figure 4.30 Generator Overload Curve

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 4.31 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.

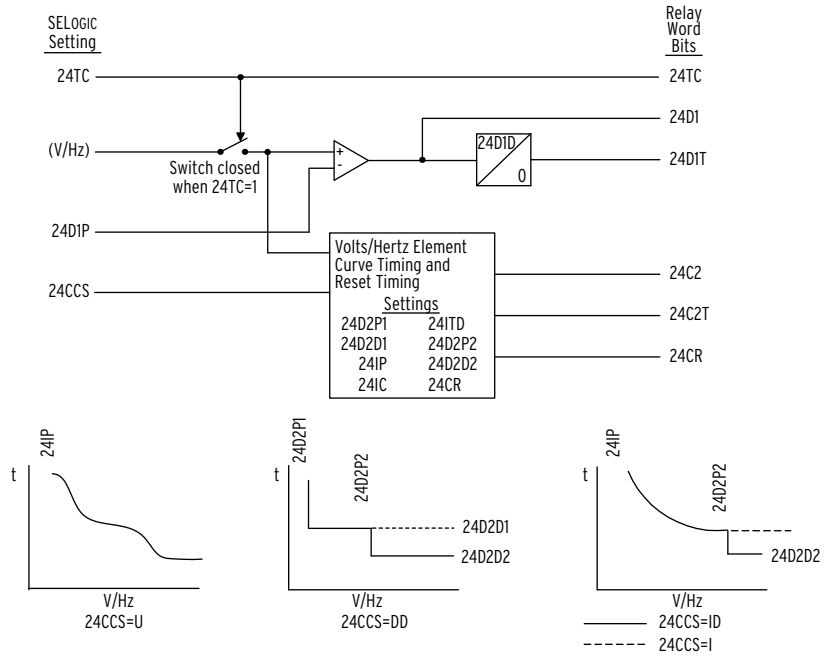


Figure 4.31 Volts/Hertz Element Logic

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 4.32 and *Figure 4.33* are similar to IEEE C37.102-2006, IEEE Guide for AC Generator Protection, Figure 4.5.4-1 and Figure 4.5.4-2.

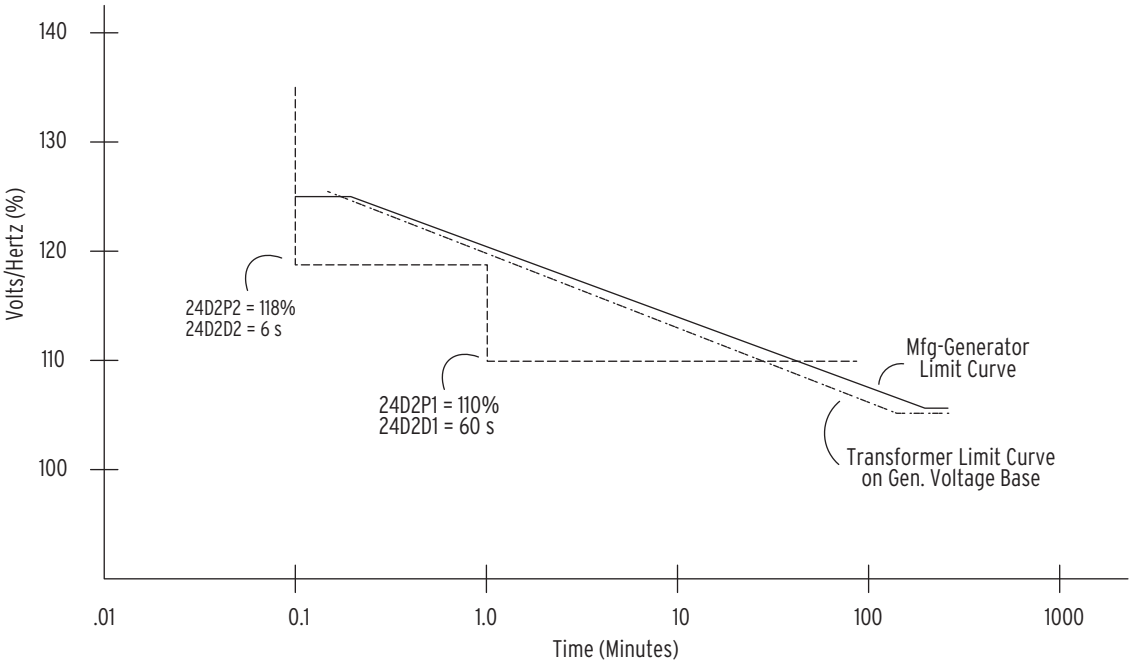


Figure 4.32 Dual-Level Volts/Hertz Time-Delay Characteristic 24CCS = DD

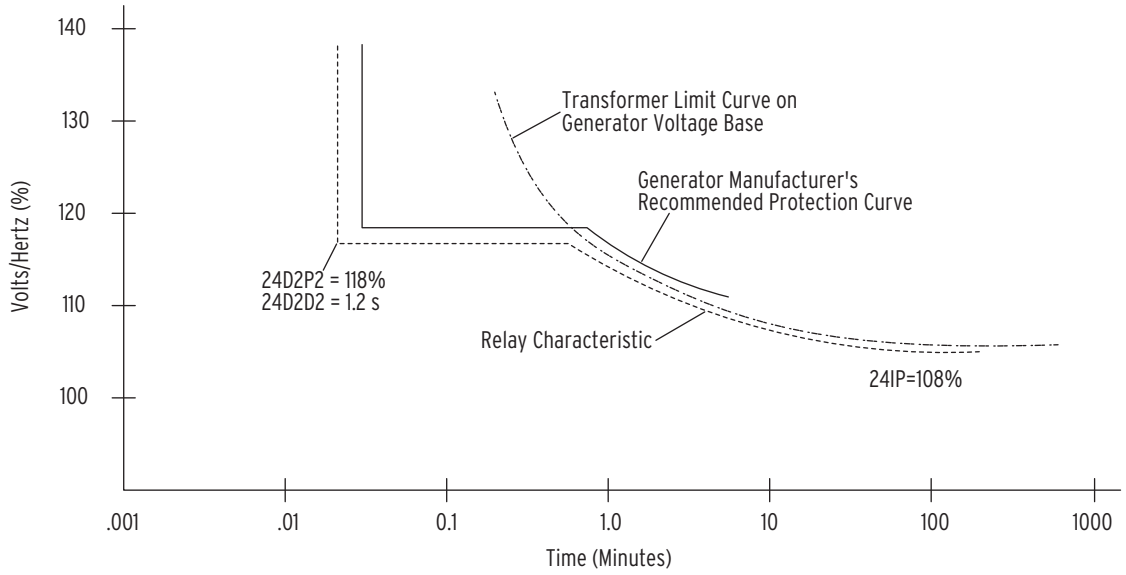


Figure 4.33 Composite Inverse/Definite-Time Overexcitation Characteristic, 24CCS = ID

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.

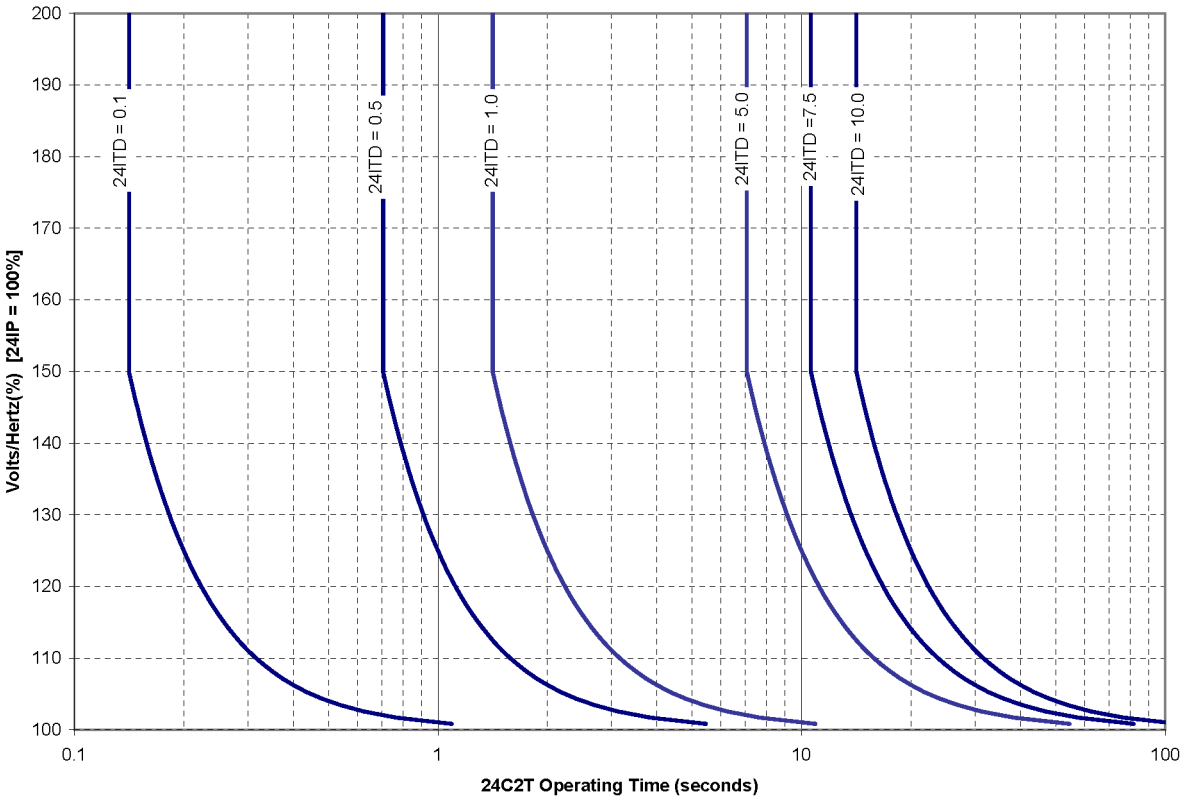
The 24CCS setting defines the overexcitation tripping element time-delay characteristic as shown in *Figure 4.31*. Set 24CCS := OFF if you do not require Level 2 volts/hertz protection. When 24CCS := OFF, the other Level 2 settings are hidden and do not need to be entered.

- 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 4.34* through *Figure 4.36*).
- 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.

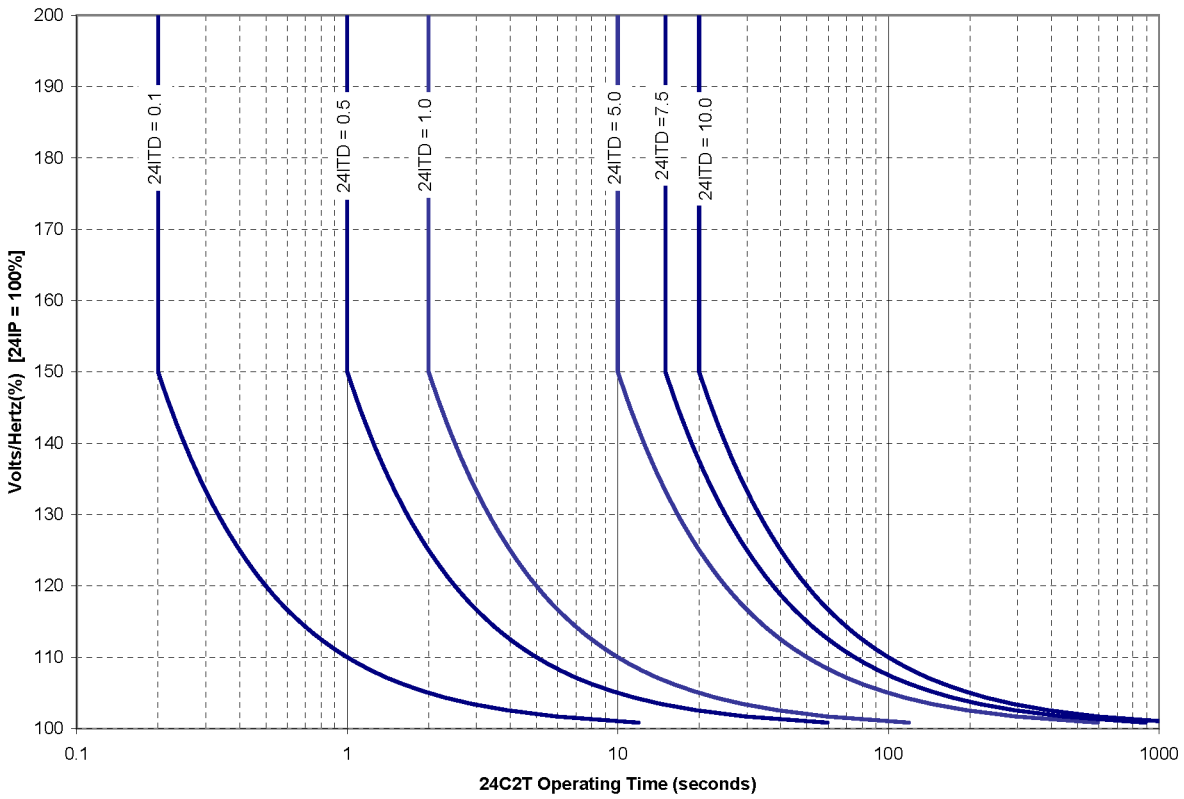
Both volts/hertz elements are disabled when the 24TC SELOGIC control equation equals logical 0. The elements are allowed to operate when the 24TC SELOGIC control equation equals logical 1, the default setting. You can add other supervisory conditions if you need these for your application.



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

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

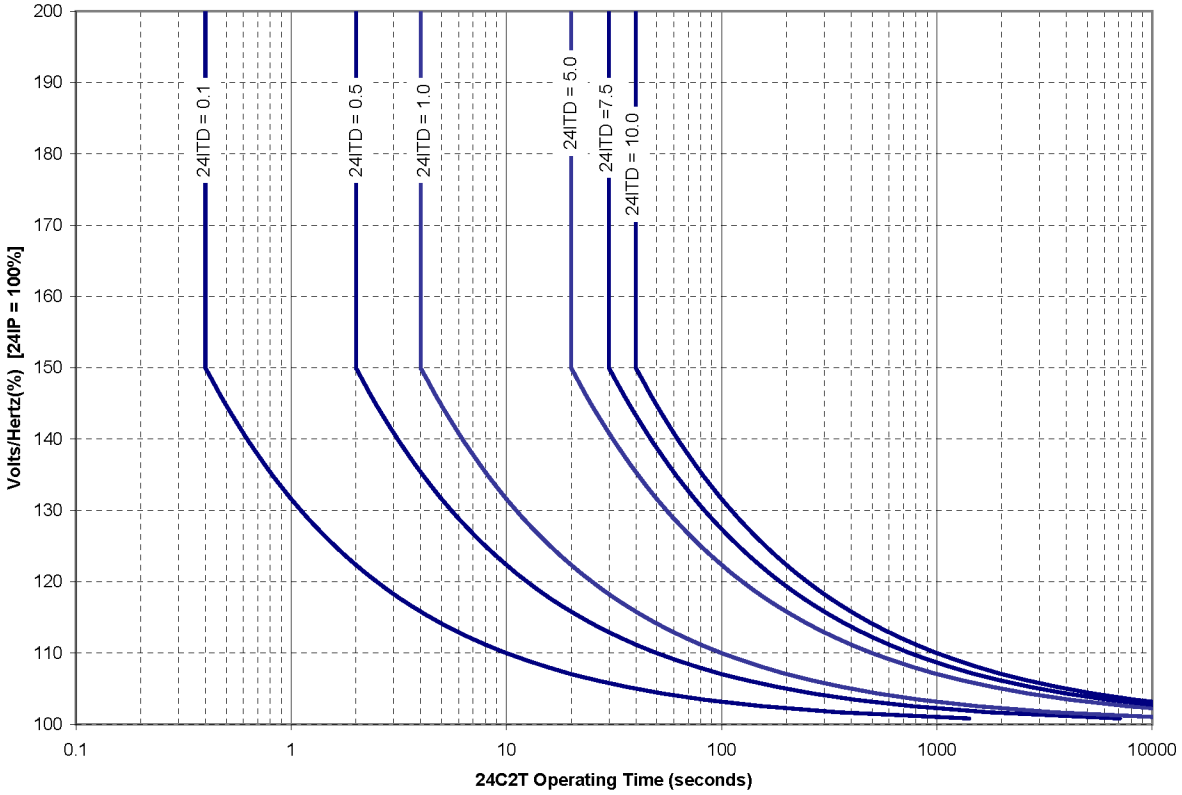
Figure 4.34 Volts/Hertz Inverse-Time Characteristic, 24IC = 0.5



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

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

Figure 4.35 Volts/Hertz Inverse-Time Characteristic, 24IC = 1



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

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

Figure 4.36 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 can be used for alarm and/or trip as necessary.

The accumulator values are nonvolatile and are retained through relay power-off cycles. The accumulator values may be viewed or reset with the relay serial port **GENERATOR** command.

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 4.38*).

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 4.37* 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.

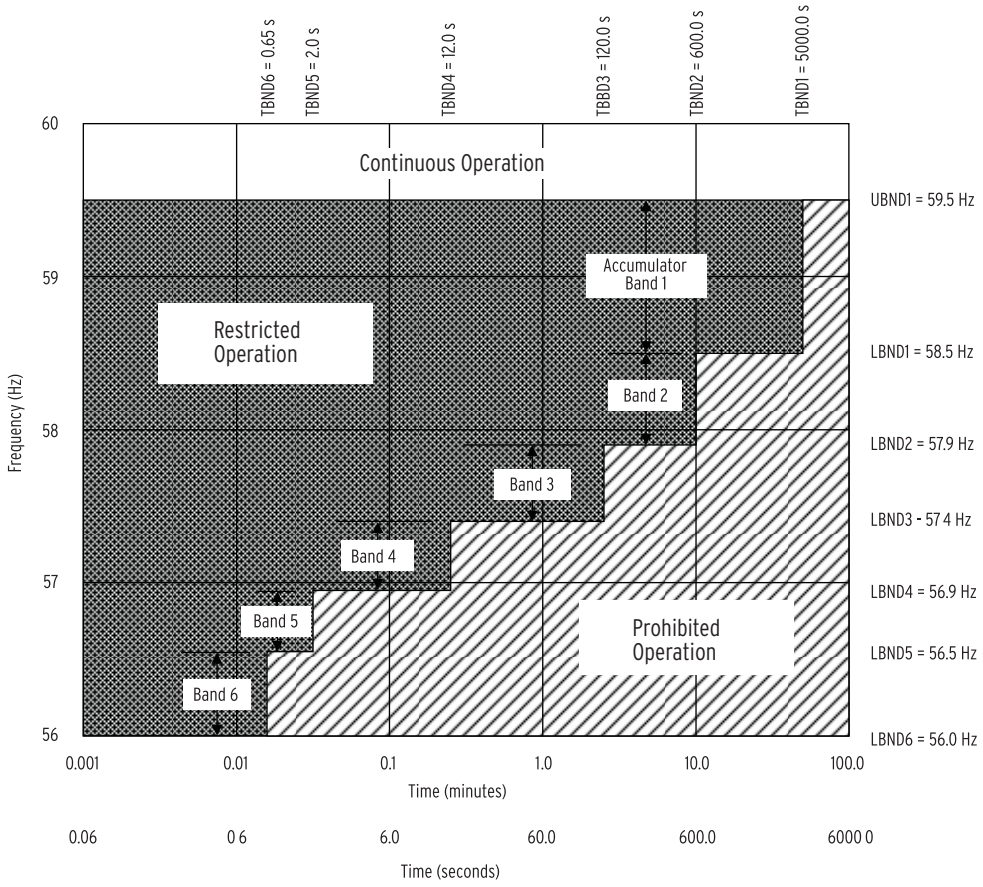


Figure 4.37 Example Turbine Operating Limitations During Abnormal Frequency

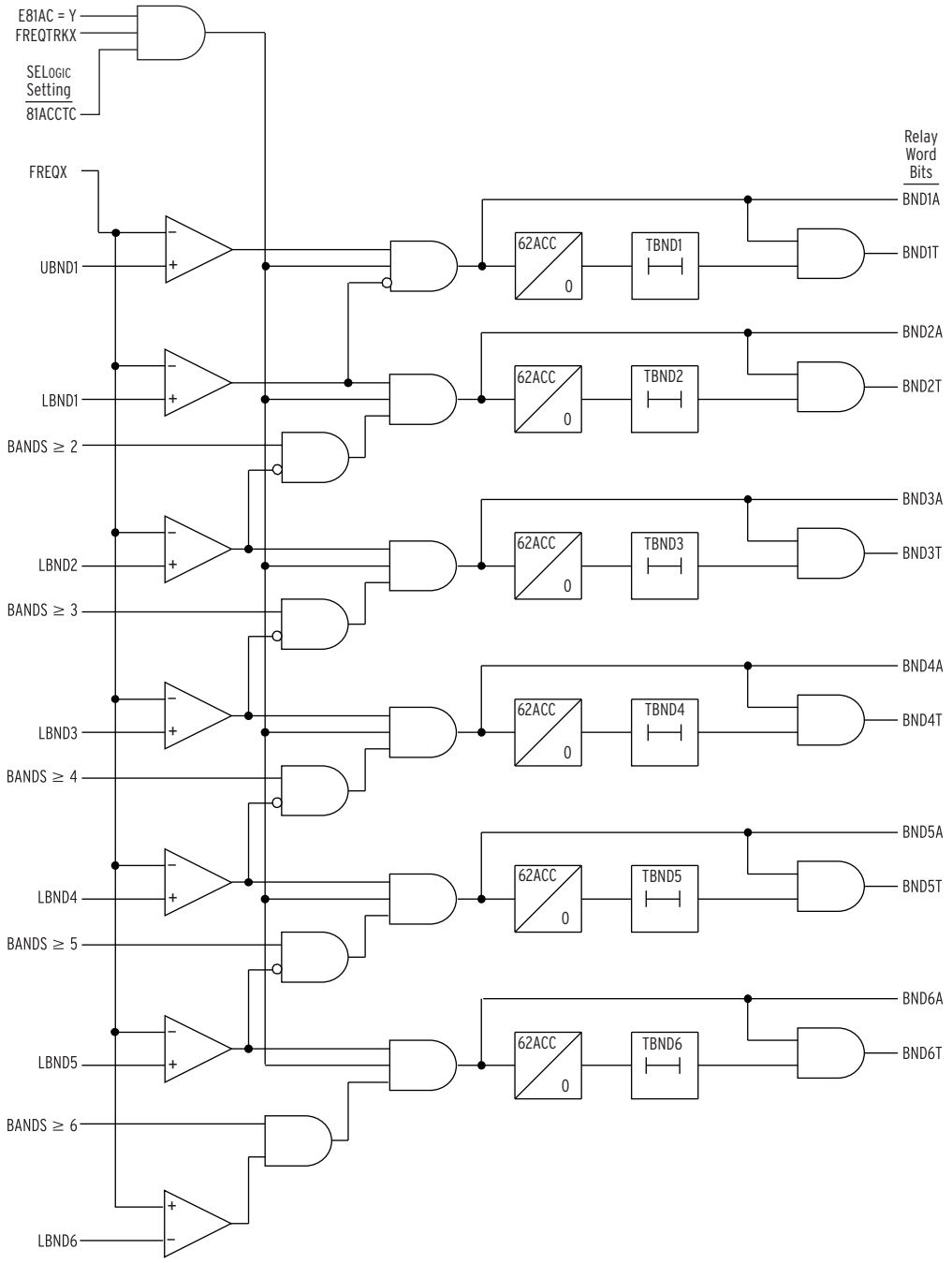


Figure 4.38 Abnormal Frequency Protection Logic Diagram

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 required, set E78 := N.

Single-Blinder Scheme

The single-blinder scheme, shown in *Figure 4.39*, consists of mho element 78Z1, right blinder 78R1, and left blinder 78R2.

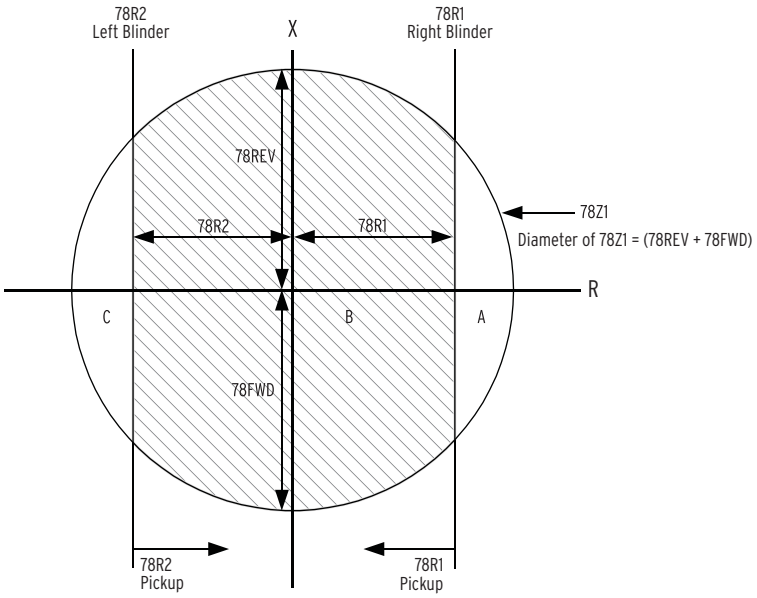


Figure 4.39 Single-Blinder Scheme Operating Characteristics

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 above 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 4.40 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.

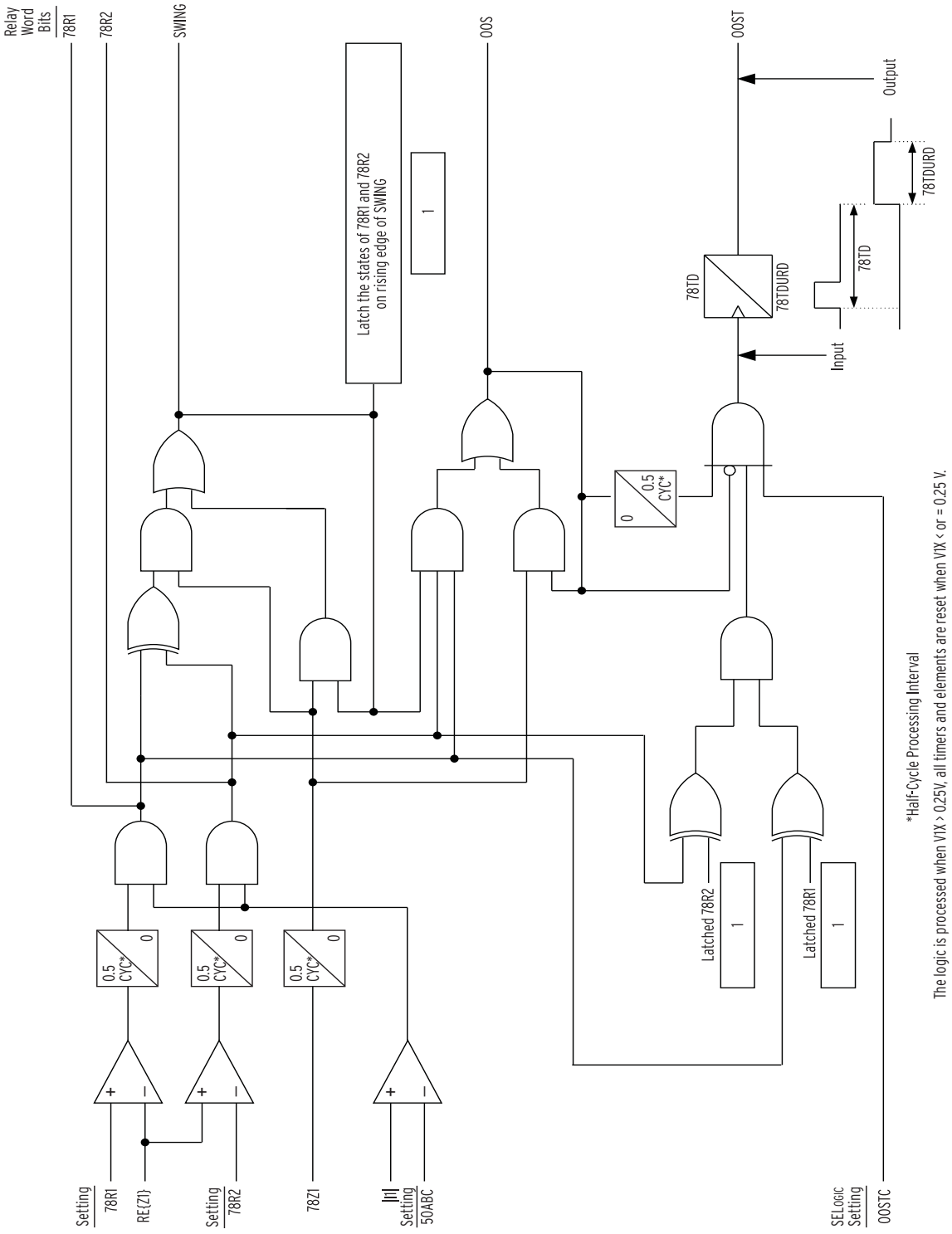


Figure 4.40 Single-Blinder Scheme Logic Diagram

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 4.194* 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 needed

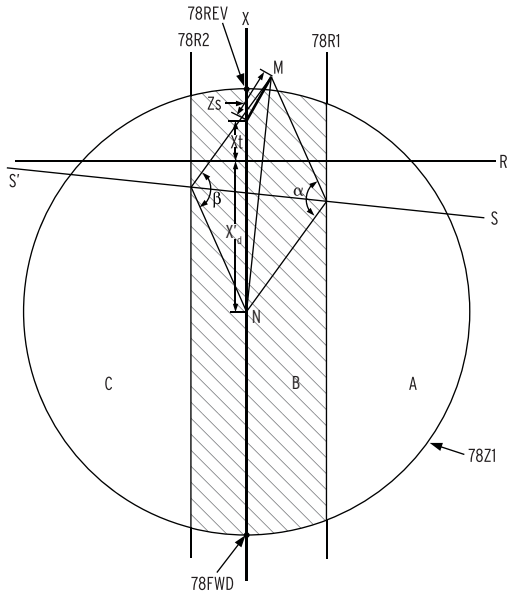
  Convert all impedances to generator base kV.

Recommendations. *Figure 4.41* 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 4.41*. 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 4.41 Single-Blinder Typical Settings

Double-Blinder Scheme

The double-blinder scheme, shown in *Figure 4.42*, 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.

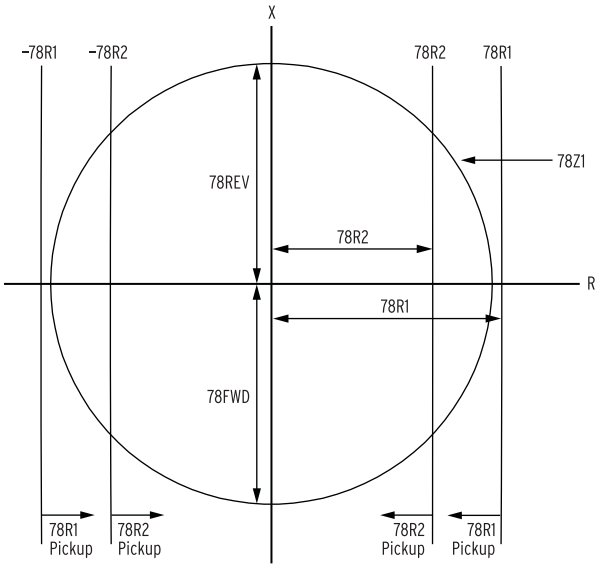


Figure 4.42 Double-Blinder Scheme Operating Characteristics

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 4.43* 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.

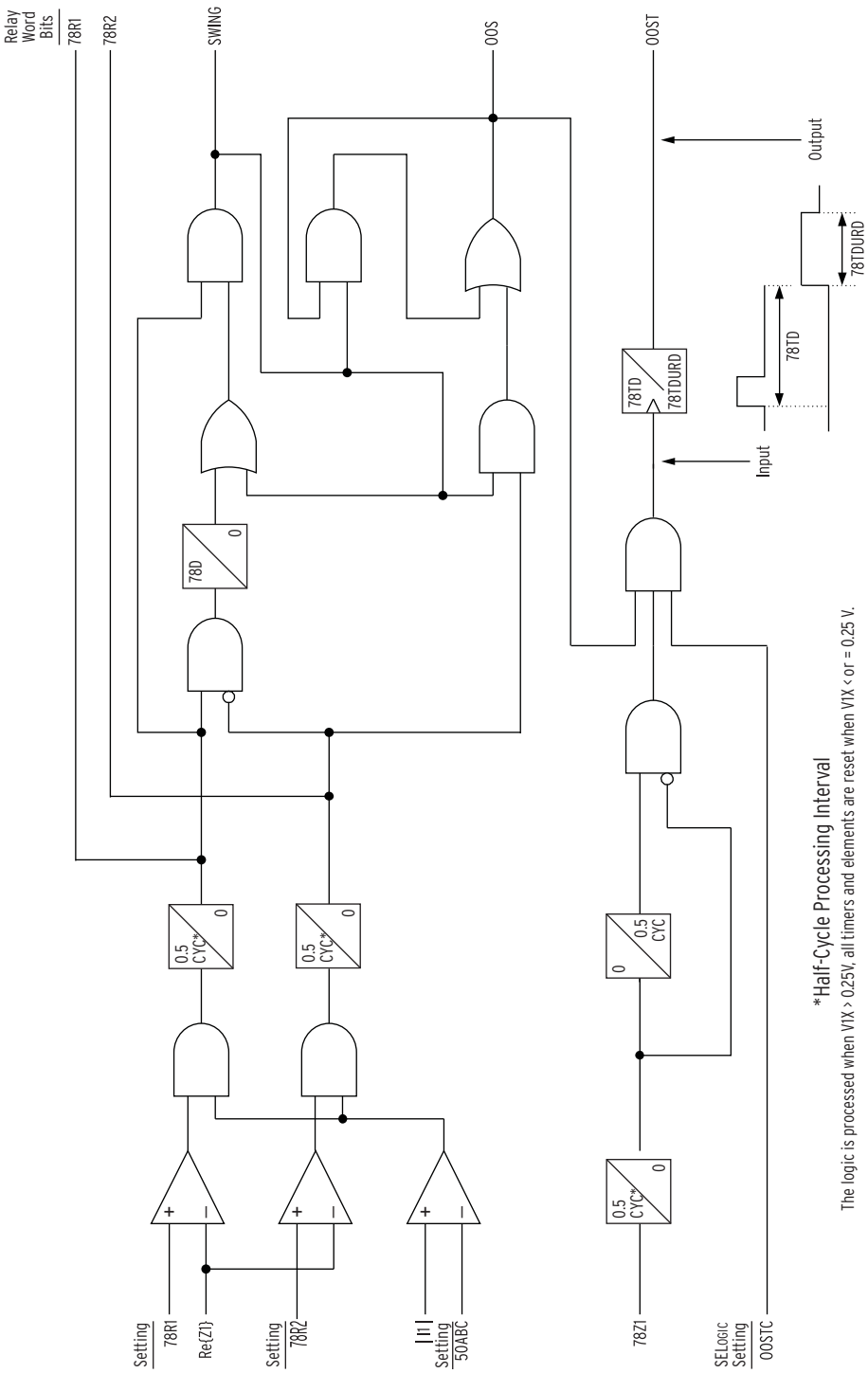


Figure 4.43 Double-Blinder Scheme Logic Diagram

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 needed.

Convert all impedances to generator base kV.

Recommendations. *Figure 4.44* 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 4.44* for details.

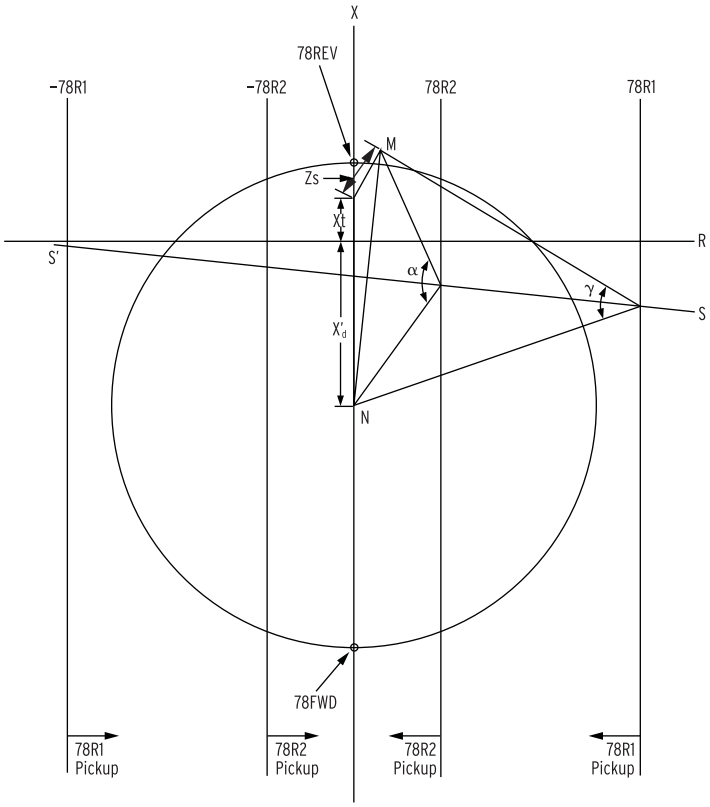
Set the inner blinder 78R2 to detect all out-of-step conditions. To do this, set the inner blinder so that the equivalent machine angle, shown in *Figure 4.44*, is approximately 120 degrees. A separation angle of 120 degrees or greater between two sources generally results in loss of synchronism.

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 4.44 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 4.186* 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 current is detected during an inadvertent energization.

See *Figure 4.45* 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 4.187* for details. You must change the setting if your application requires a different action.

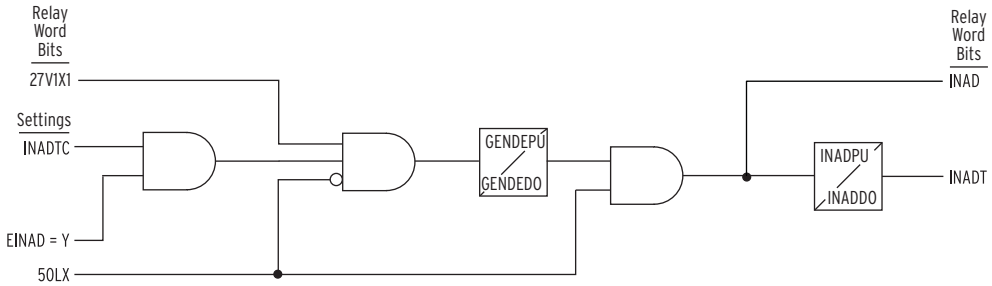


Figure 4.45 Inadvertent Energization Logic Diagram

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 required 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 4.117*). 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 4.46*, *Figure 4.47* and *Figure 4.49*. Refer to *Table 1.2* for the available elements in specific relay models.

Each element can be torque controlled using 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 4.46*). 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.

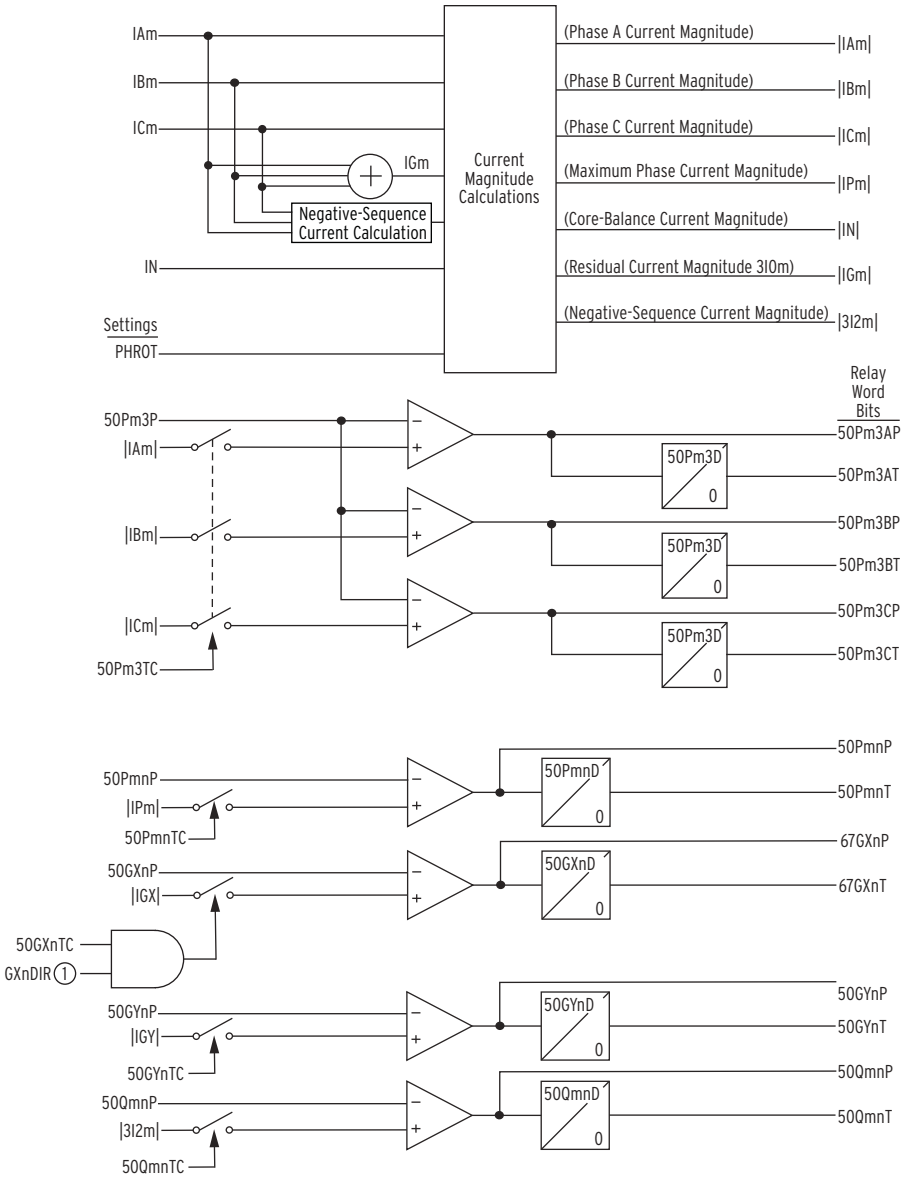
The 50P*m*3 individual phase overcurrent elements are three single-phase overcurrent elements with common pickup and delay settings. *Figure 2.21* shows a typical application using window CTs for differential protection of split-phase winding. The individual phase elements facilitate identification of 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)t o create the required elements. See *Logic Settings (SET L Command) on page 4.194* 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 4.46*).



① Figure 4.76

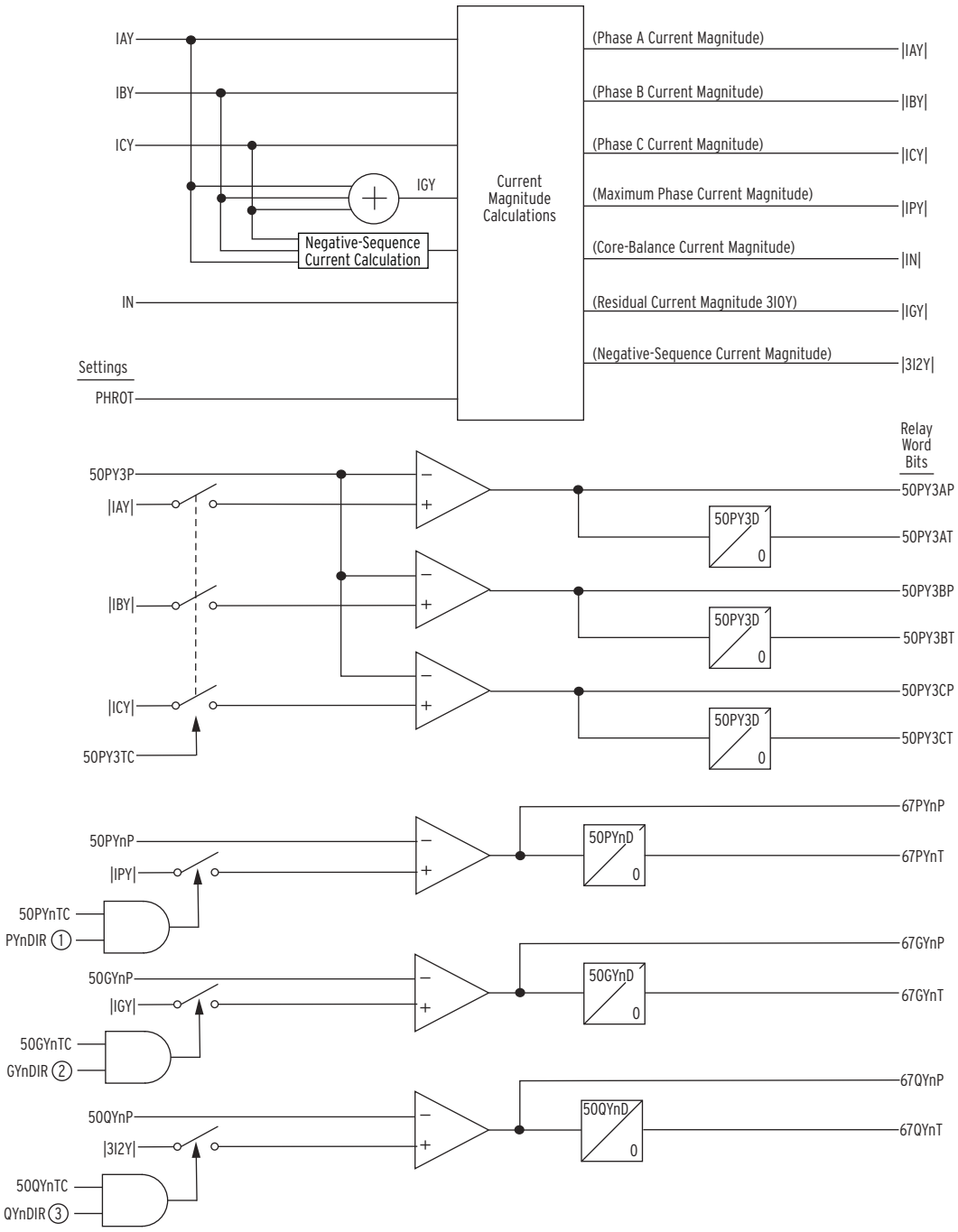
m = X or Y (Y-side elements apply to SEL-700G1 only)

n = 1 or 2

Torque Control switch position = Closed when the corresponding control bit is asserted (e.g., 50PY3TC = 1); open when it is de-asserted.

Not shown in the figure, Relay Word bit ORED50T is asserted if any of the 50Pm3AT, 50Pm3BT, 50Pm3CT, 50PmnT, 67PYnT, 50QmnT, 67QXnT, 50GmnT, 67GmnT, 50NnT, or 67NnT Relay Word bits are asserted.

Figure 4.46 SEL-700G0, SEL-700G1, SEL-700GT+ Instantaneous Overcurrent Element Logic (Generator Protection)



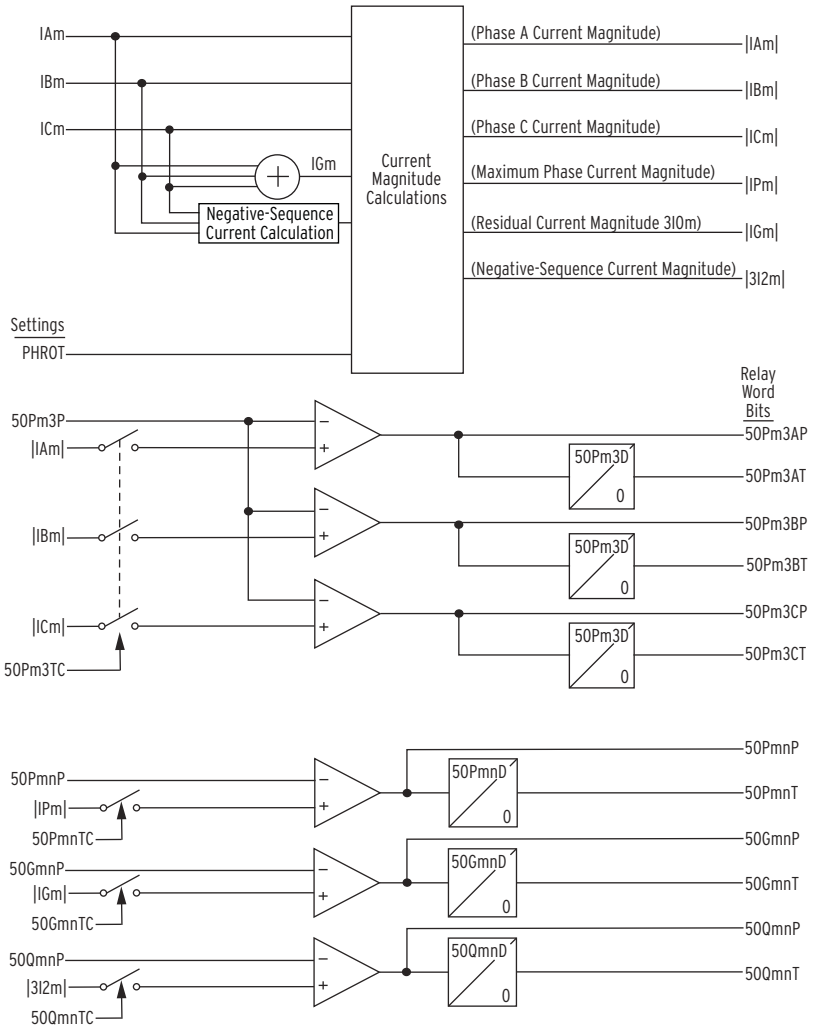
① From Figure 4.83 ② From Figure 4.76 ③ From Figure 4.82

n = 1 or 2.

Torque Control switch position = Closed when corresponding control bit is asserted (e.g., 50PY3TC = 1); open when it is de-asserted.

Not shown in the figure, Relay Word bit ORED50T is asserted if any of the 50Pm3AT, 50Pm3BT, 50Pm3CT, 50PmnT, 67PYnT, 50QmnT, 67QXnT, 50GmnT, 67GmnT, 50NnT or 67NnT Relay Word bits are asserted.

Figure 4.47 SEL-700GT Instantaneous Overcurrent Element Logic (Intertie Protection)

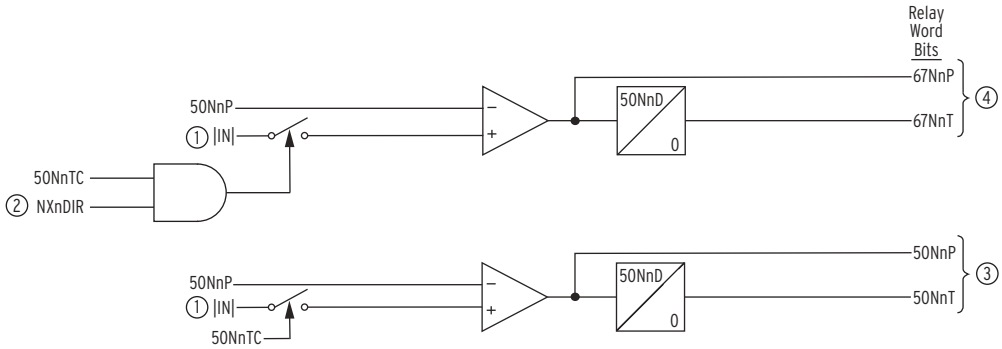


m = X or Y; n = 1 or 2.

Torque Control switch position = Closed when corresponding control bit is asserted (e.g., 50PY3TC = 1); open when it is de-asserted.

Not shown in the figure, Relay Word bit ORED50T is asserted if any of the 50Pm3AT, 50Pm3BT, 50Pm3CT, 50PmnT, 67PYnT, 50QmnT, 67QXnT, 50GmnT, 67GmnT, or 50NnT Relay Word bits are asserted.

Figure 4.48 Instantaneous Overcurrent Element Logic (Feeder Protection, SEL-700GW)



① From Figure 4.46 ② From Figure 4.77 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 de-asserted.

Not shown in the figure, Relay Word bit ORED50T is asserted if any of the 50Pm3AT, 50Pm3BT, 50Pm3CT, 50PmnT, 67PYnT, 50QmnT, 67QXnT, 50GmnT, 67GmnT, 50NnT, or 67NnT Relay Word bits are asserted.

Figure 4.49 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 4.49*, 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 4.5 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 4.50. Setting the Neutral OC CT Ratio (CTRN) equal to 10 and Neutral Trip Lvl (50N1P) equal to 0.5 A or lower with 0.10-second time delay ensures that the element quickly detects and trips for feeder ground faults.

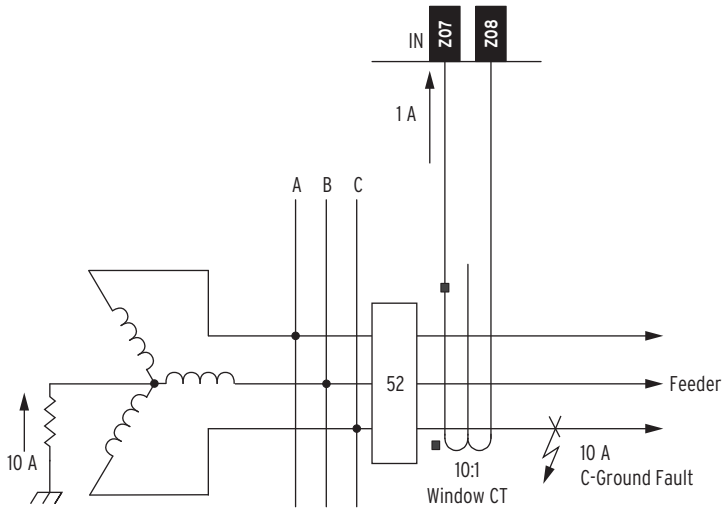


Figure 4.50 Ground Fault Protection Using Core-Balance CT

NOTE: Phase CT ratios are typically higher than core-balance (CB) CT ratios. For this reason, the relay sensitivity to ground faults is less when the residual overcurrent element is used instead of the CB element. A separate ground fault detection method should be used if a CB CT is not available in applications where resistance grounding reduces the available ground fault current.

Table 4.19 Residual Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default[a]
RES IOC LEVEL	OFF, 0.50–96.00 A[b]	50G*m*1P := OFF
RES IOC DELAY	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 4.55* through *Figure 4.64* 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.

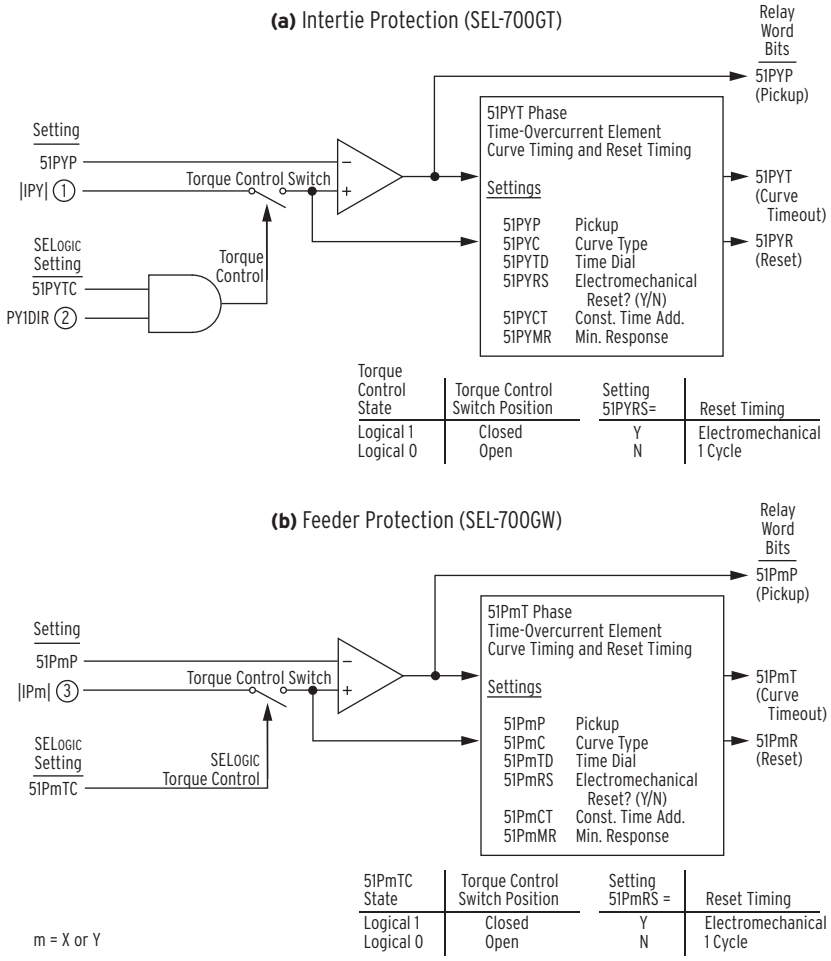
You can use appropriate SELOGIC control equations (for example, when 51NTC := IN401, the 51N element operates only if IN401 is asserted) to torque control each element. You can also control the elements by directional elements depending on the relay model number (refer to *Table 1.2*). Directional elements 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 4.51*.



① From Figure 4.47 ② From Figure 4.83 ③ From Figure 4.48

Figure 4.51 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 4.52*.

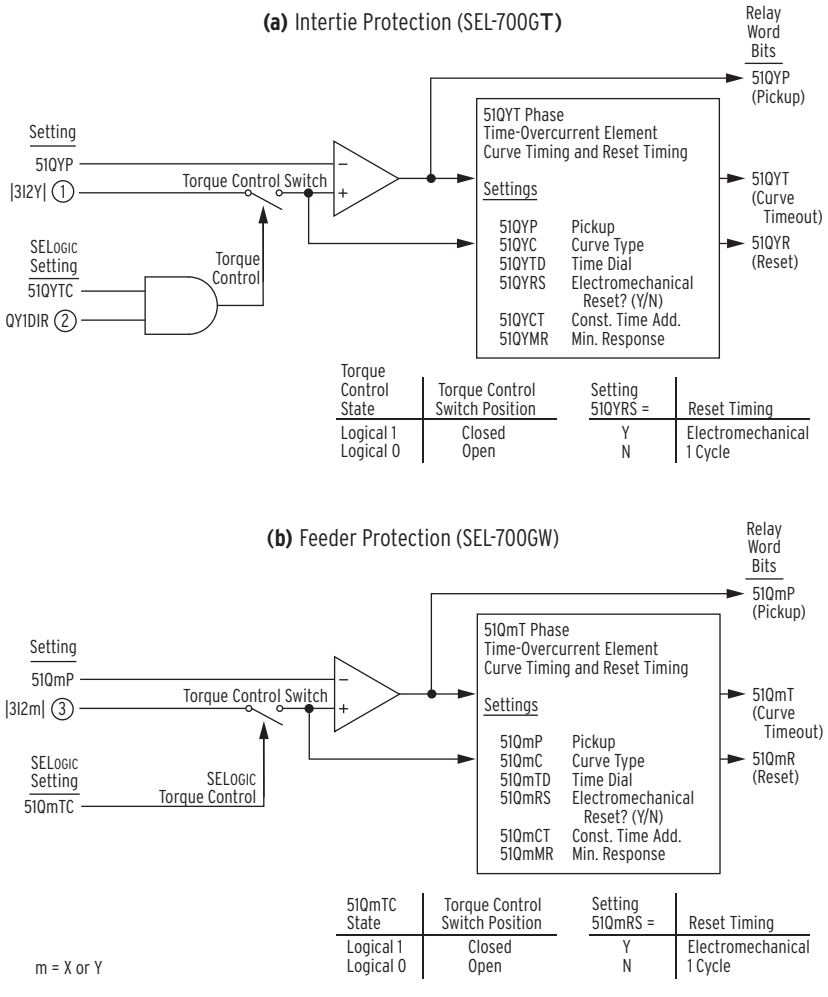


Figure 4.52 Negative-Sequence Time-Overcurrent Elements

False negative-sequence current can appear transiently when a circuit breaker is closed and a balanced load current suddenly appears. To avoid tripping for

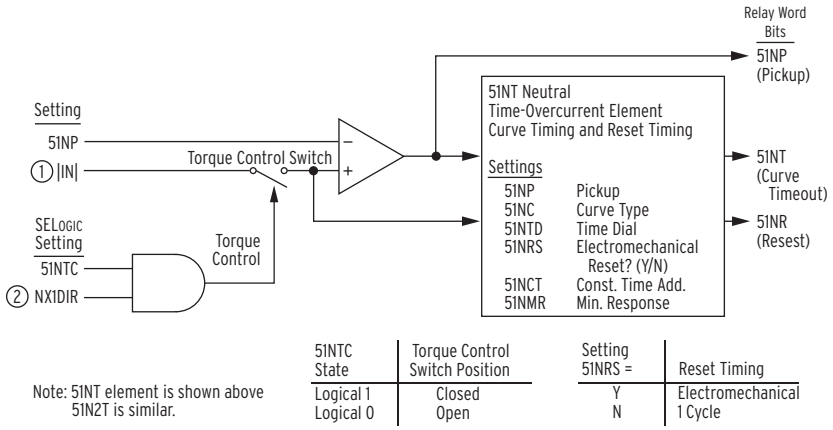
this transient condition, do not use a time-dial setting that results in curve times below three cycles.

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 4.53*.



① From Figure 4.46 or Figure 4.47 ② From Figure 4.77

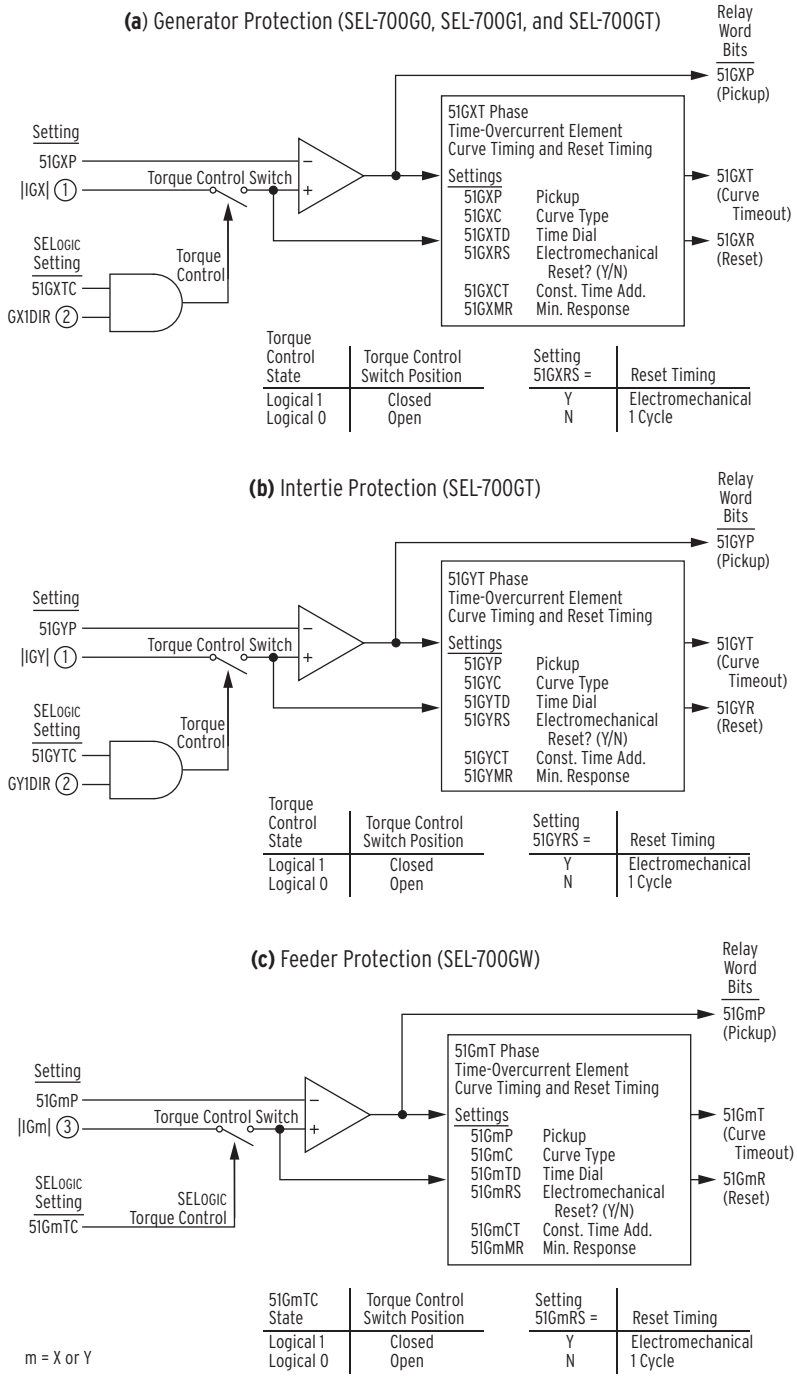
Figure 4.53 Neutral Time-Overcurrent Element 51NT

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 4.54*.



① From Figure 4.47 or Figure 4.48 ② From Figure 4.76 ③ From Figure 4.48

Figure 4.54 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 4.51*–*Figure 4.54*). The U.S. and IEC time-overcurrent relay curves are shown in *Figure 4.55*–*Figure 4.64*. Curves U1, U2, and U3 (*Figure 4.55*–*Figure 4.57*)

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 4.55*
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 4.56*
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 4.57*
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 4.58*
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 4.59*

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 4.60*
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 4.61*
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 4.62*
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 4.63*
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 4.64*

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]

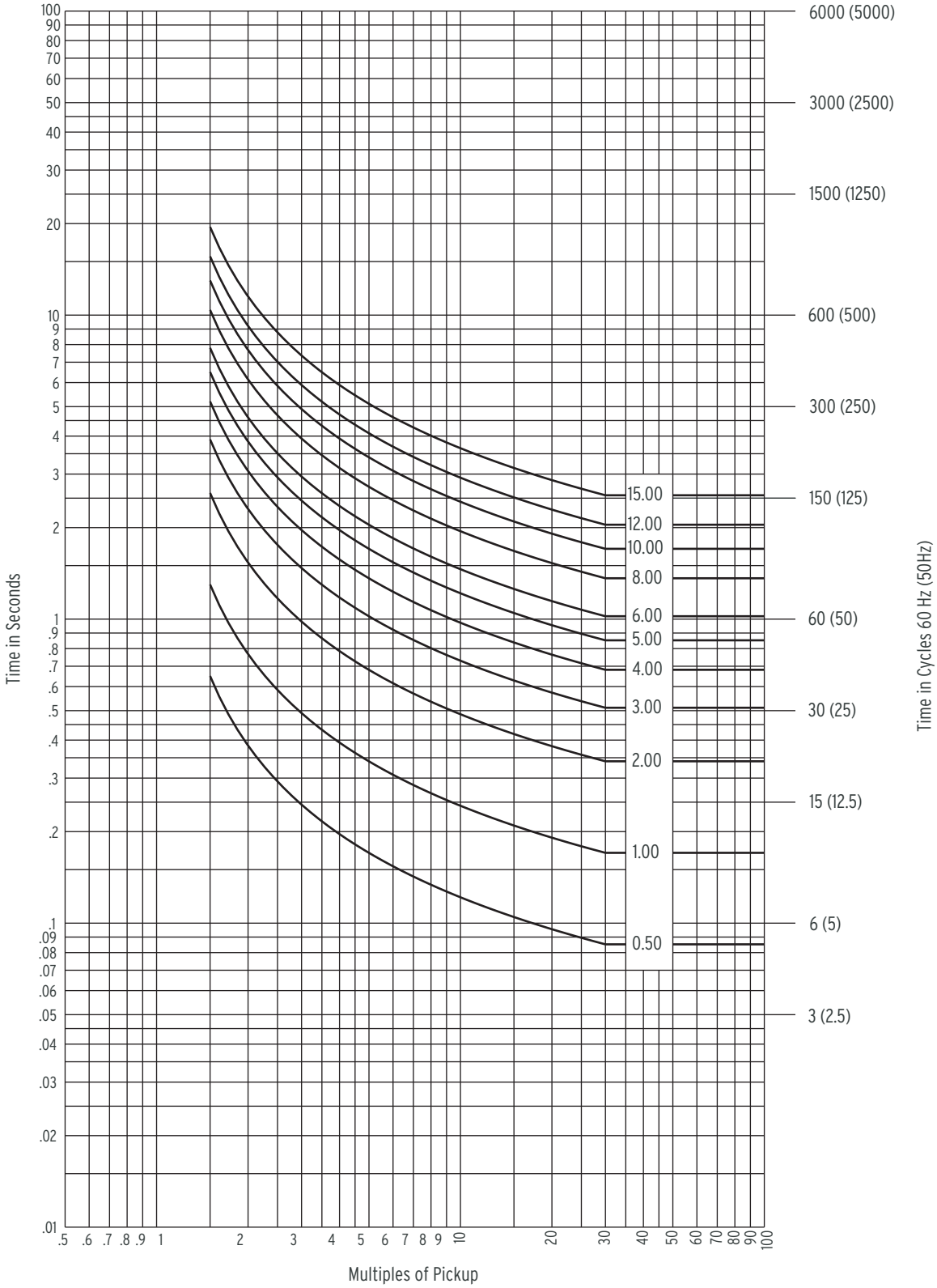


Figure 4.55 U.S. Moderately Inverse Curve: U1

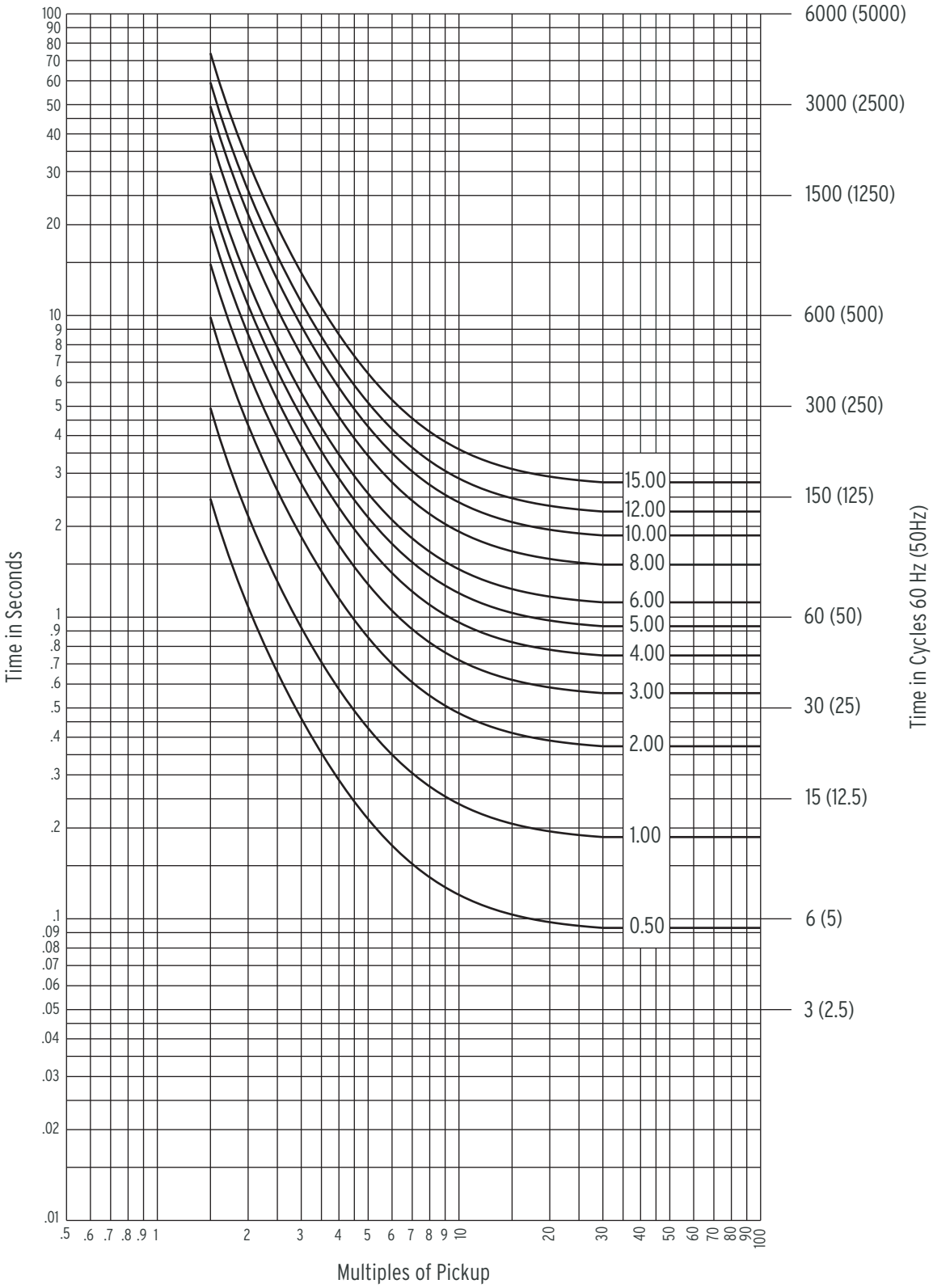


Figure 4.56 U.S. Inverse Curve: U2

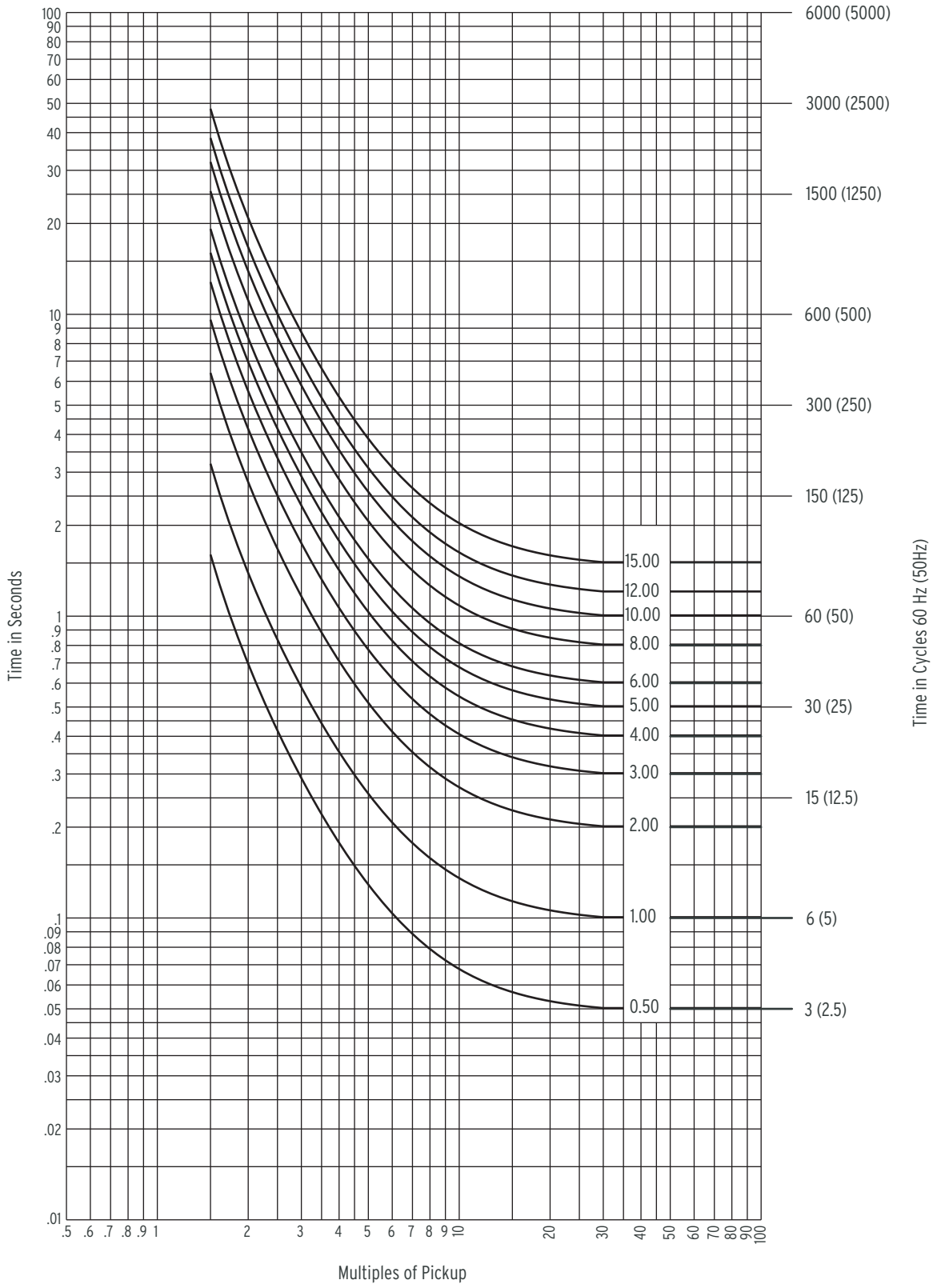


Figure 4.57 U.S. Very Inverse Curve: U3

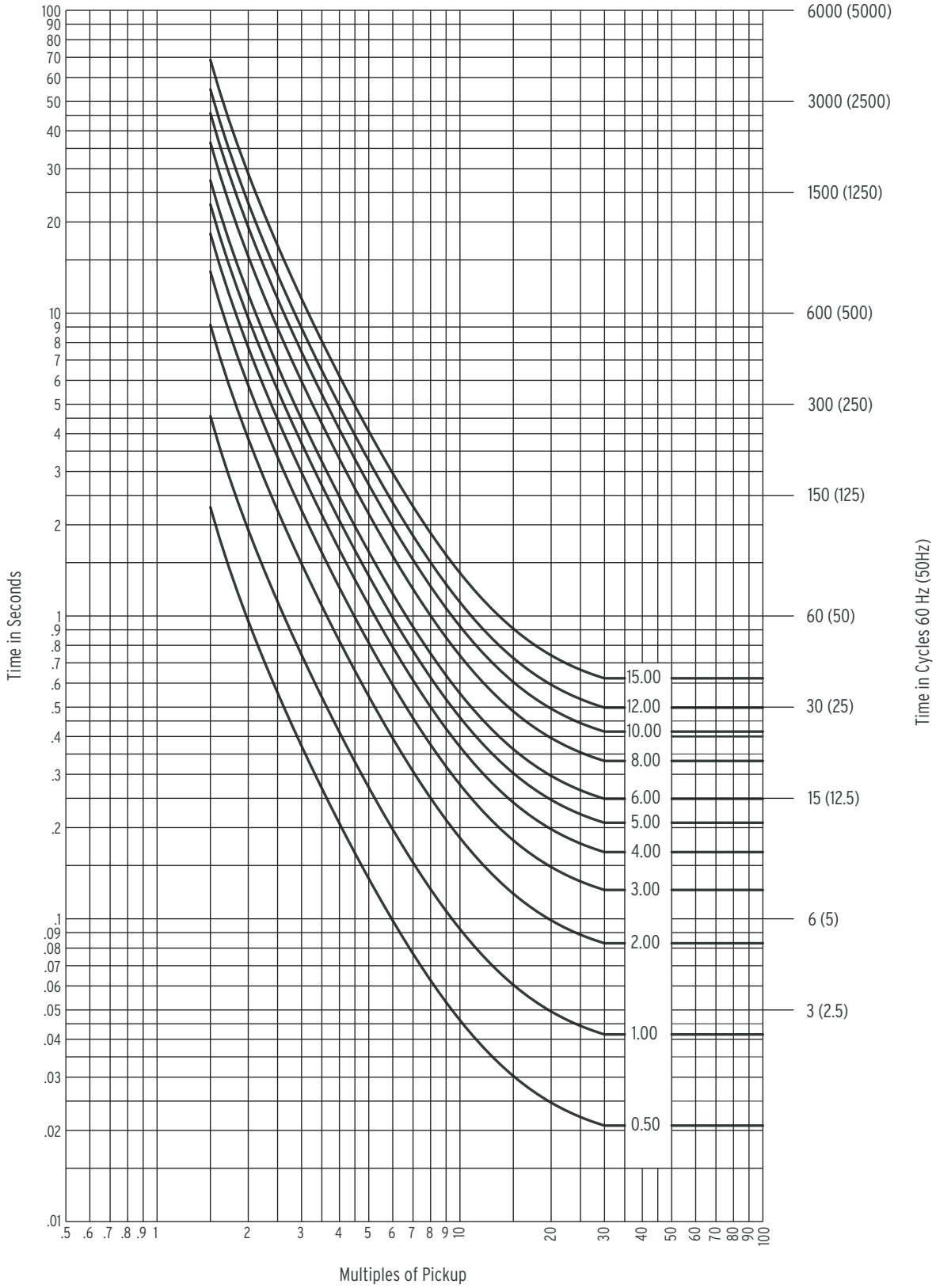


Figure 4.58 U.S. Extremely Inverse Curve: U4

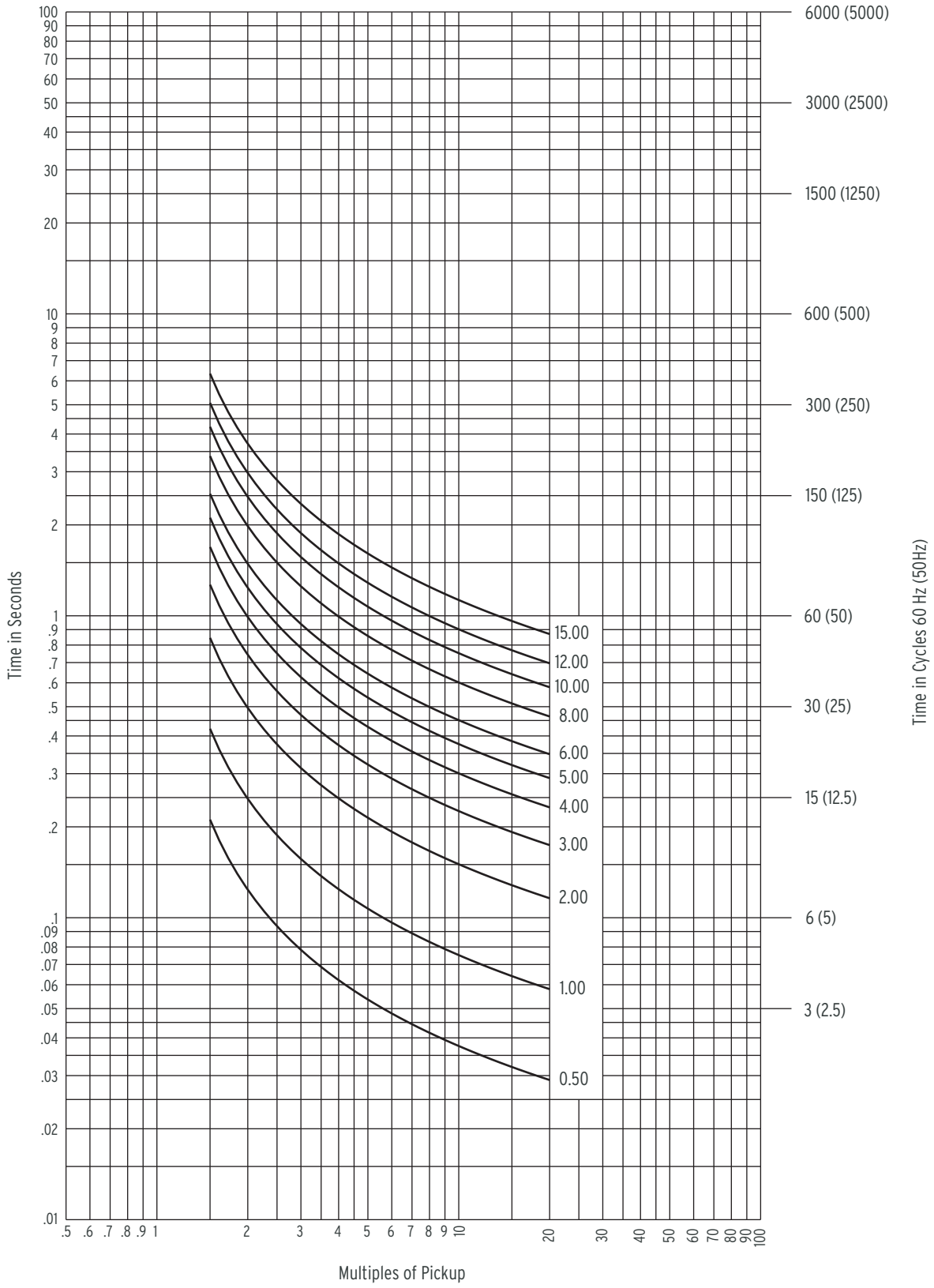


Figure 4.59 U.S. Short-Time Inverse Curve: U5

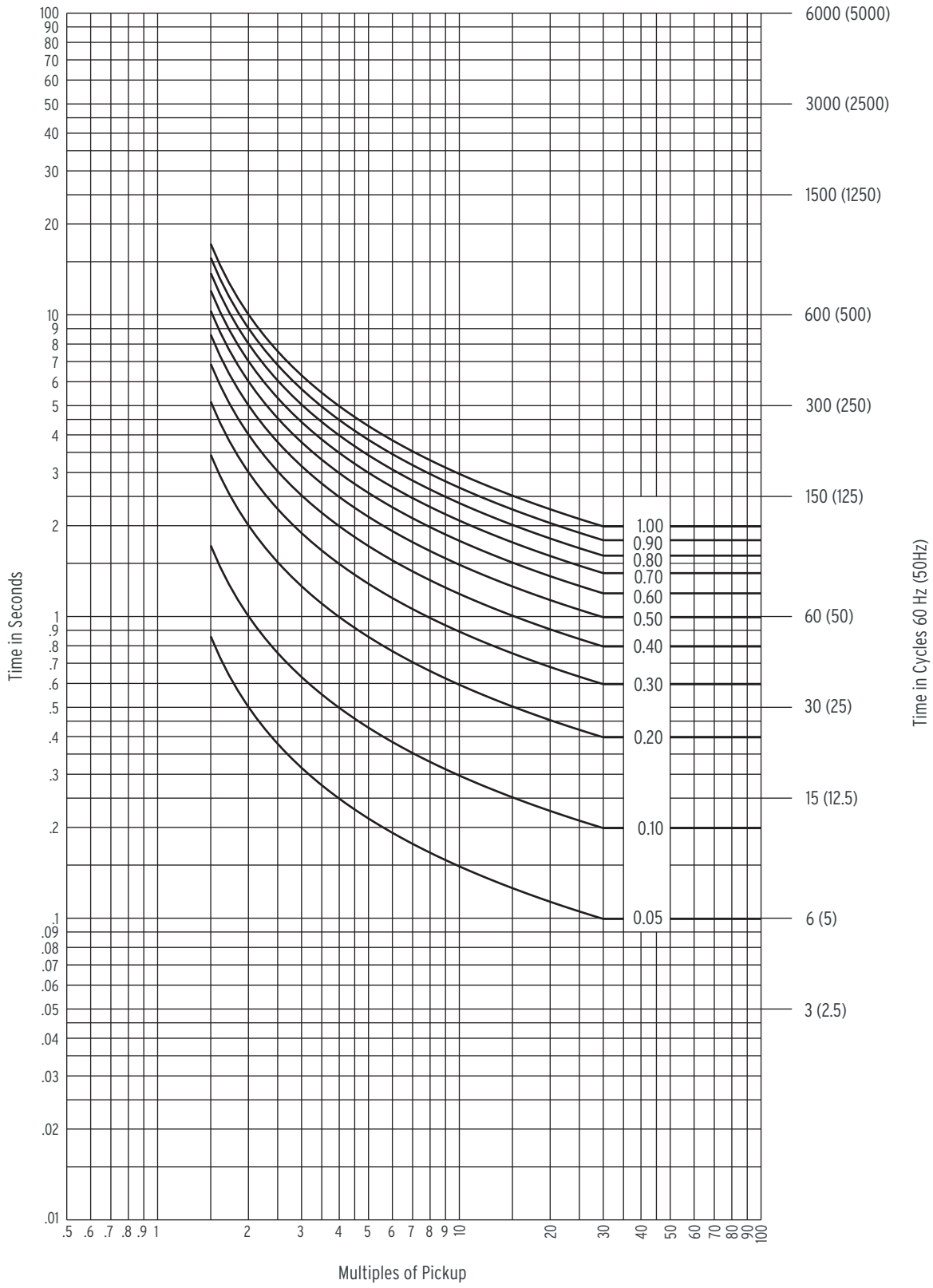


Figure 4.60 IEC Class A Curve (Standard Inverse): C1

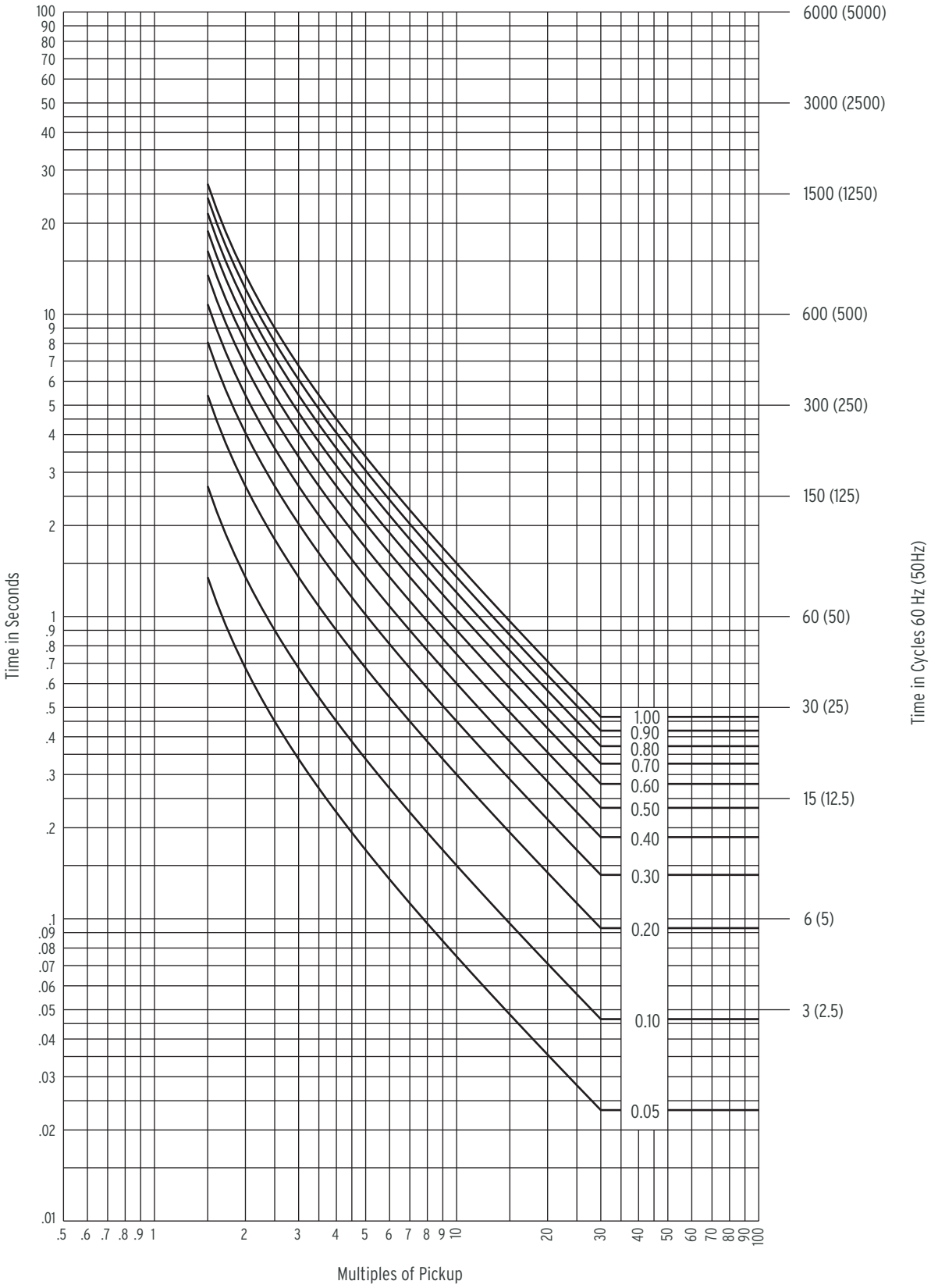


Figure 4.61 IEC Class B Curve (Very Inverse): C2

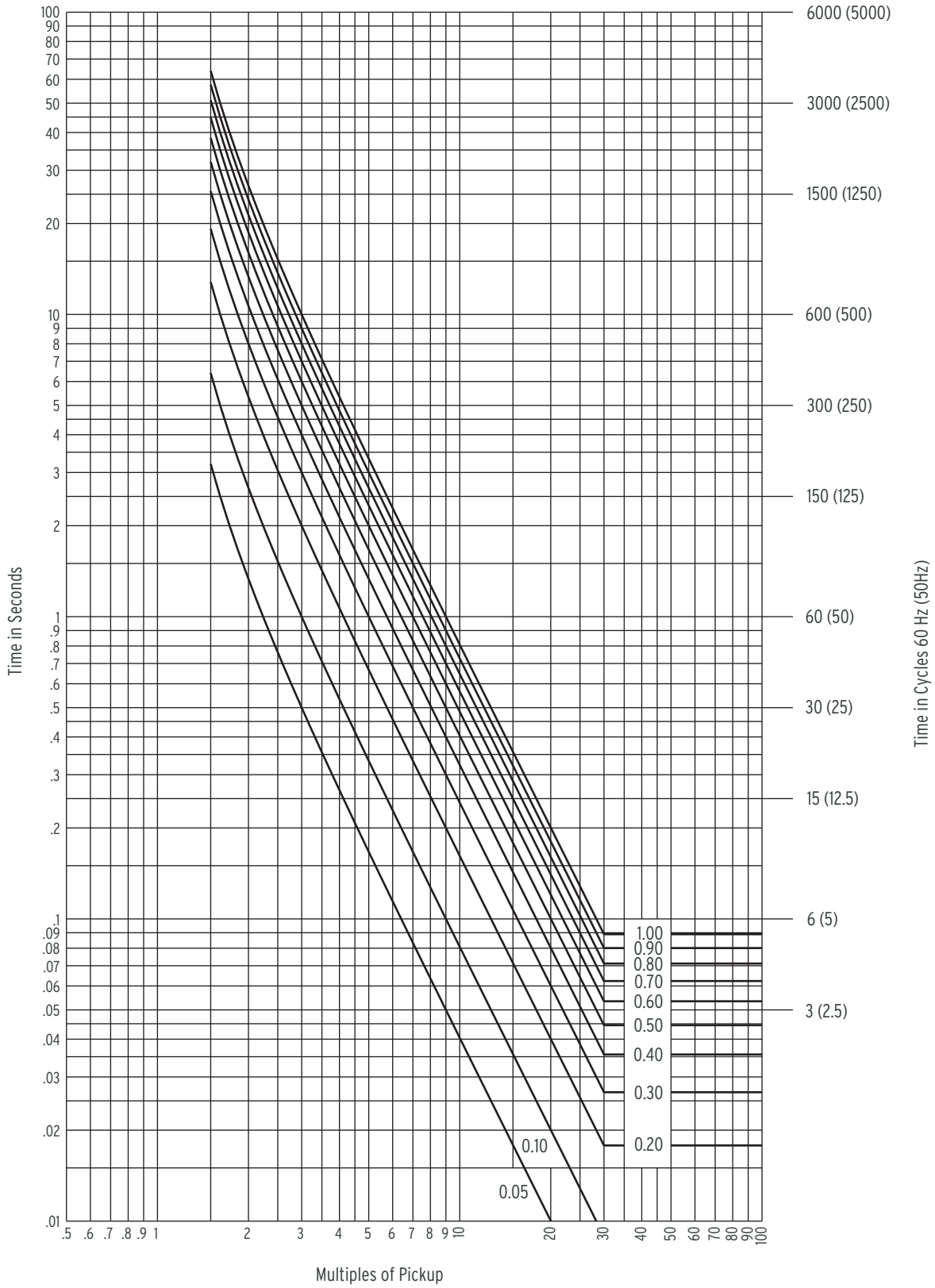


Figure 4.62 IEC Class C Curve (Extremely Inverse): C3

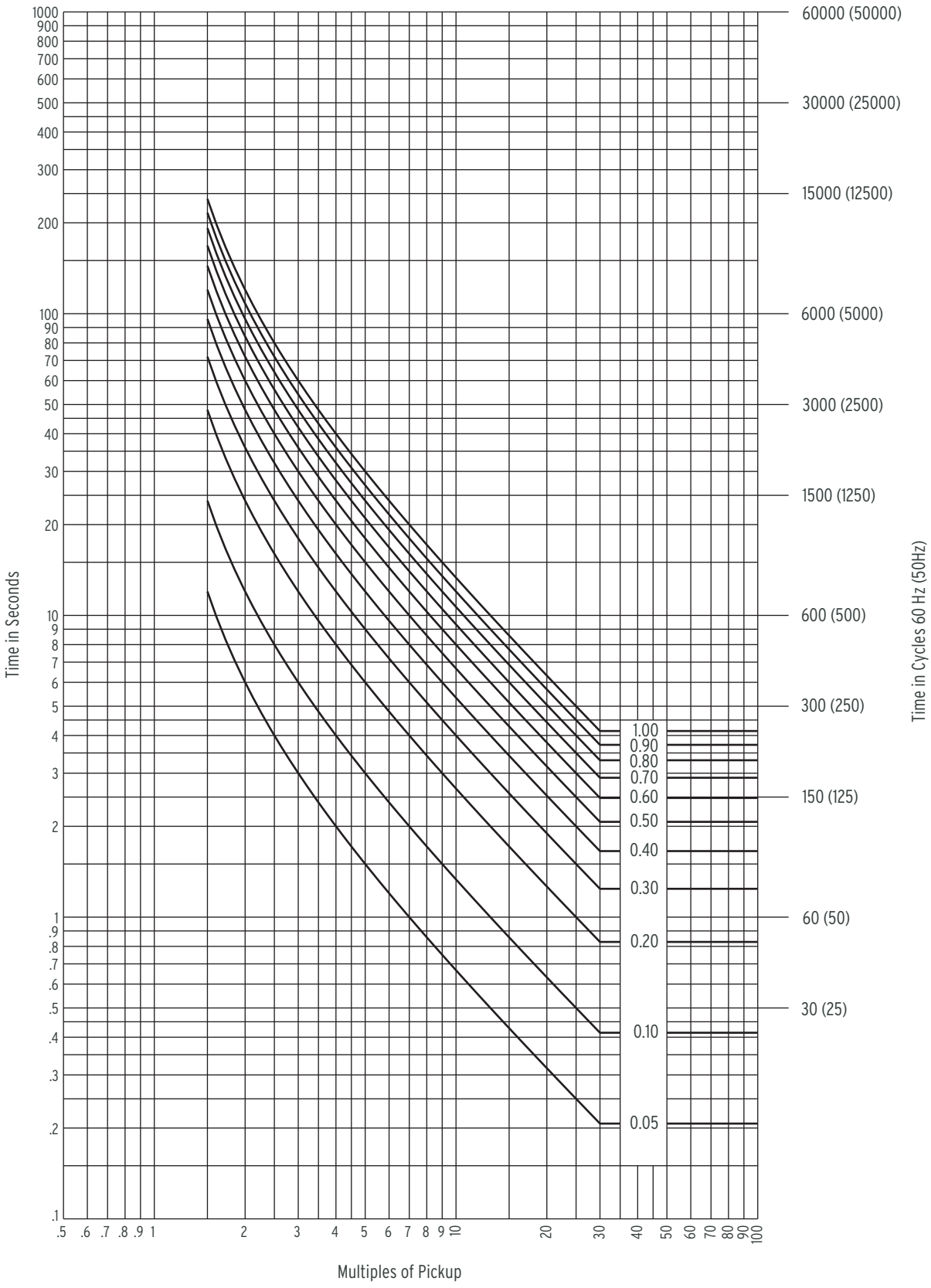


Figure 4.63 IEC Long-Time Inverse Curve: C4

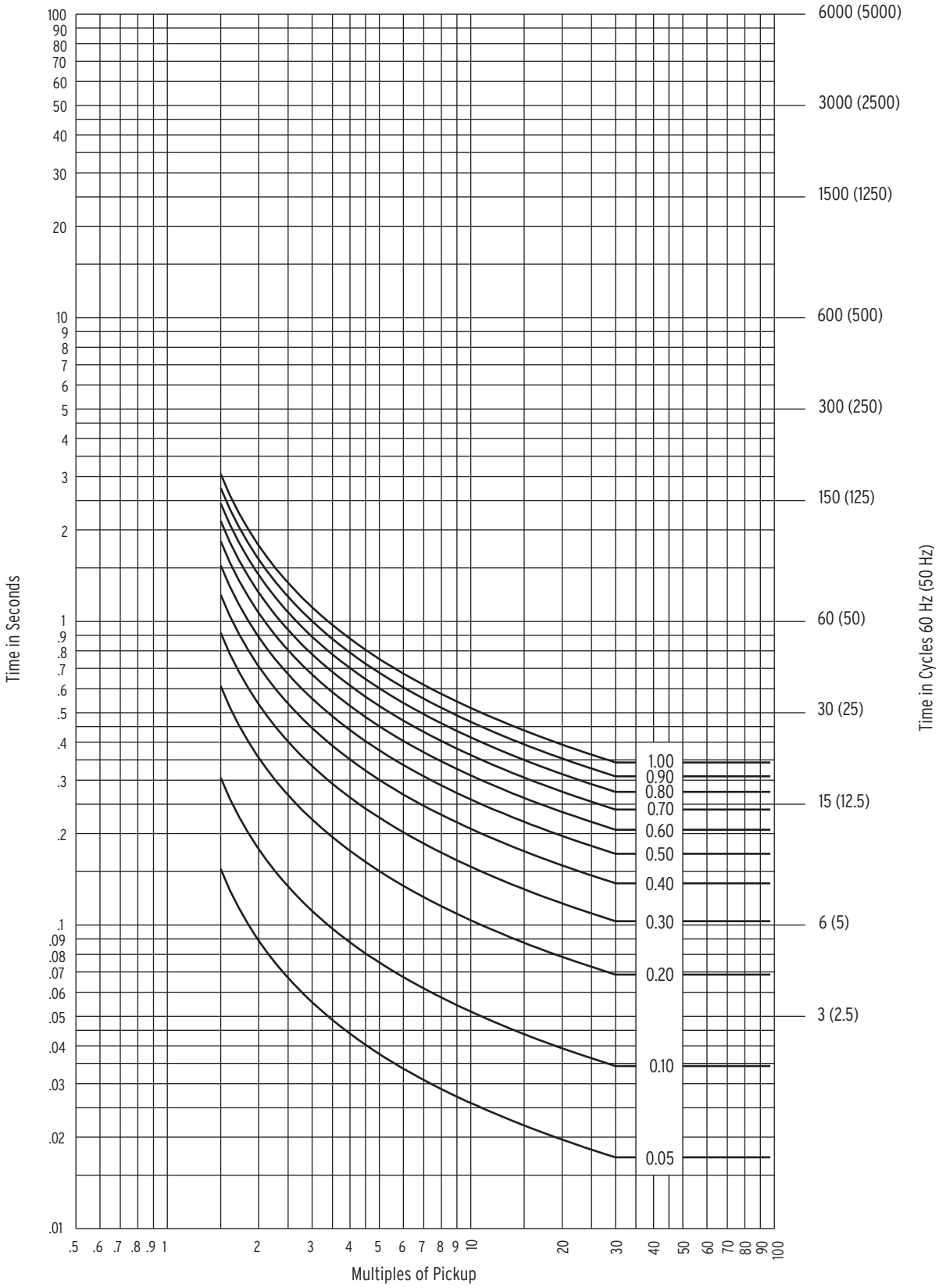


Figure 4.64 IEC Short-Time Inverse Curve: C5

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 required. Setting EDIR and other directional control settings are described in *Directional Control Settings on page 4.122*.

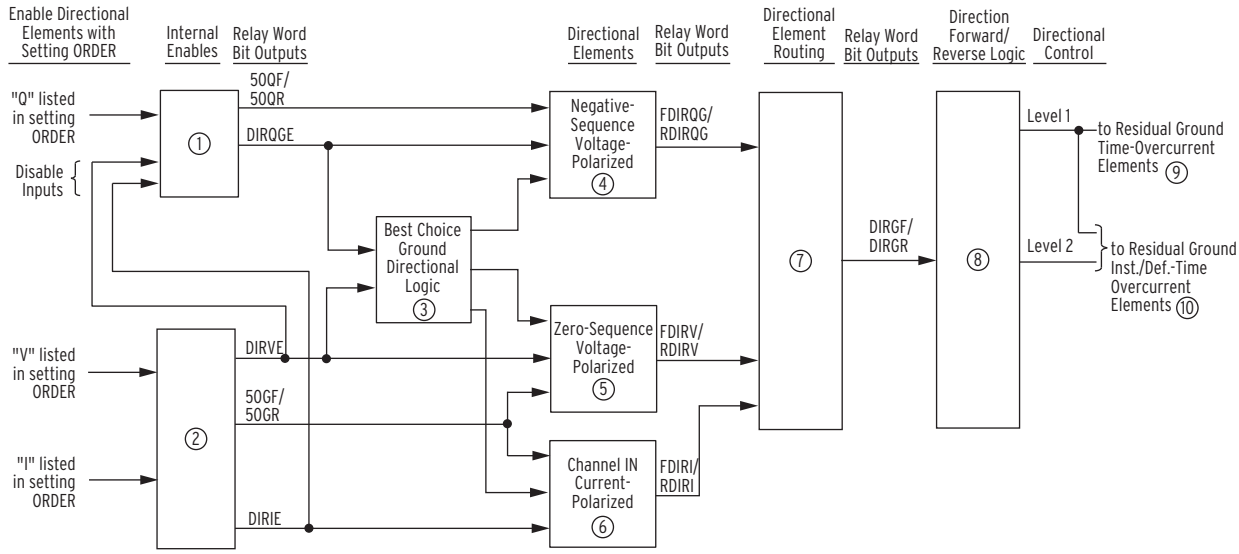
Directional Control for Residual and Neutral Overcurrent Elements

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)

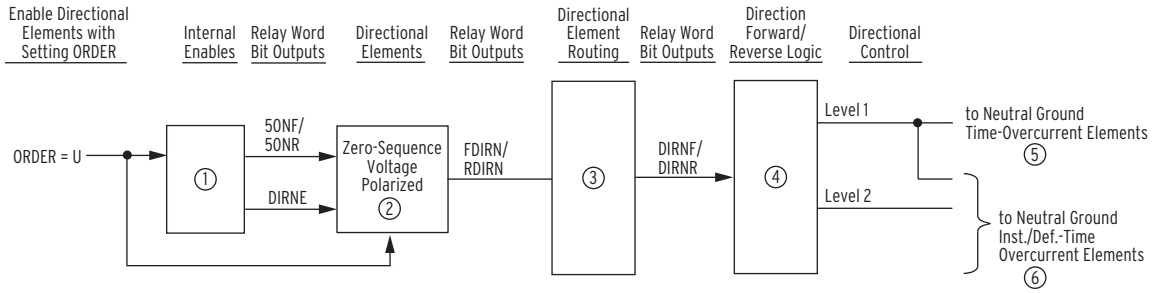
See *Figure 4.65* and *Figure 4.66* for an overview of how these directional elements are enabled and routed to control the residual-ground overcurrent elements and neutral-ground overcurrent elements respectively. Note in *Figure 4.65* and *Figure 4.66* that the ORDER setting enables the directional 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 4.122*.



① Figure 4.67 ② Figure 4.68 ③ Table 4.27 and Table 4.28 ④ Figure 4.70 ⑤ Figure 4.71
⑥ Figure 4.72 ⑦ Figure 4.74 ⑧ Figure 4.76 ⑨ Figure 4.54 ⑩ Figure 4.46 and Figure 4.47

Figure 4.65 General Logic Flow of Directional Control for Residual Ground Overcurrent Elements



① Figure 4.69 ② Figure 4.73 ③ Figure 4.75 ④ Figure 4.77 ⑤ Figure 4.53 ⑥ Figure 4.49
Order = U can only be set on the X side.

Figure 4.66 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 4.67*, *Figure 4.70*	All models, except SEL-700GW
V	Zero-sequence voltage-polarized (with IG as operate quantity)	DIRVE	*Figure 4.68*, *Figure 4.71*	
I	Channel IN current polarized	DIRIE	*Figure 2.17*, *Figure 4.69*, *Figure 4.72*	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 2.17*, *Figure 4.69*, *Figure 4.73*	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 the user 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 2.15* and *Figure 2.24*.

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 4.71* and *Figure 4.73*) 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 2.15*). 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 the user 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 2.15* for various voltage connections.

Internal Enables. Refer to *Figure 4.67*, *Figure 4.68*, and *Figure 4.69*. *Table 4.27* lists the internal enables and their correspondence to the ground directional elements.

Note that *Figure 4.67* has extra internal enable DIRQE, which is used in the directional element logic that controls negative-sequence and phase overcurrent elements (see *Figure 4.78*).

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 4.107* 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 4.122*.

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 4.65*, *Figure 4.66*, *Figure 4.71*, *Figure 4.72*, and *Figure 4.73*). 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 4.65* and *Figure 4.74* for routing of directional elements to residual-ground overcurrent elements and *Figure 4.66* and *Figure 4.75* 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 4.76* and *Figure 4.77*.

Loss-of-Potential. Refer to *Figure 4.113* 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 4.67*, *Figure 4.68*, and *Figure 4.69*).

- 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 4.74*).

- 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 4.76*) 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 above 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 4.74*. 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 4.75*).

- 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 4.77*) 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 4.75*. 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 4.65*, *Figure 4.66*, *Figure 4.76* and *Figure 4.77*.

With the forward Relay Word bits, DIRGF and DIRNF and the reverse Relay Word bits, DIRGR and DIRNR, in *Figure 4.76* and *Figure 4.77*, 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.

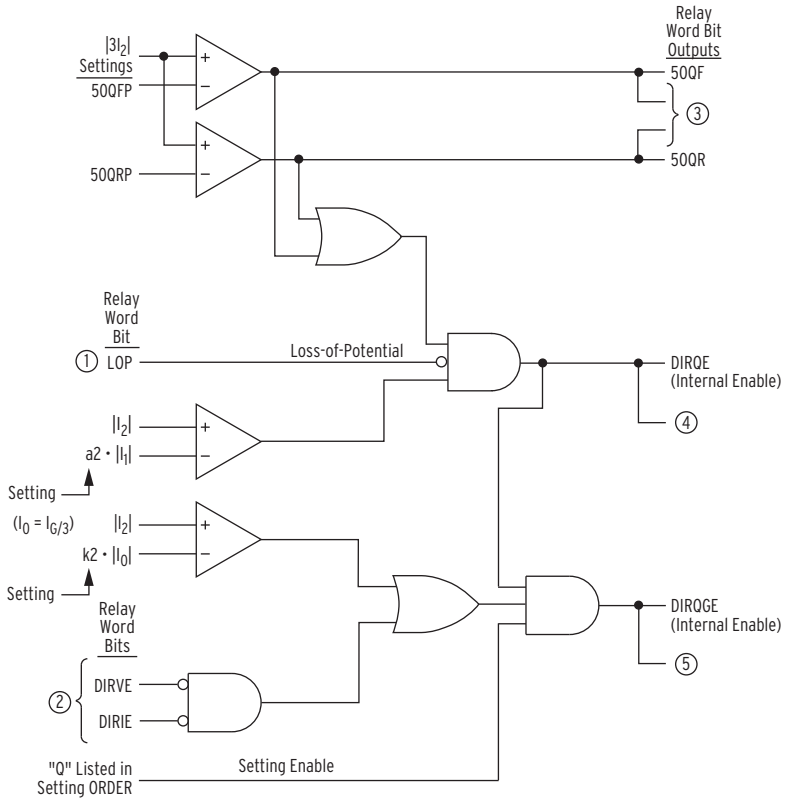
If a level direction setting (for example, DIR1) is set as follows,

DIR1 := **N** (nondirectional)

then the corresponding Level 1 directional control outputs in *Figure 4.76* and *Figure 4.77* assert to logical 1. The referenced Level 1 overcurrent elements in *Figure 4.76* and *Figure 4.77* are then not controlled by the directional control logic.

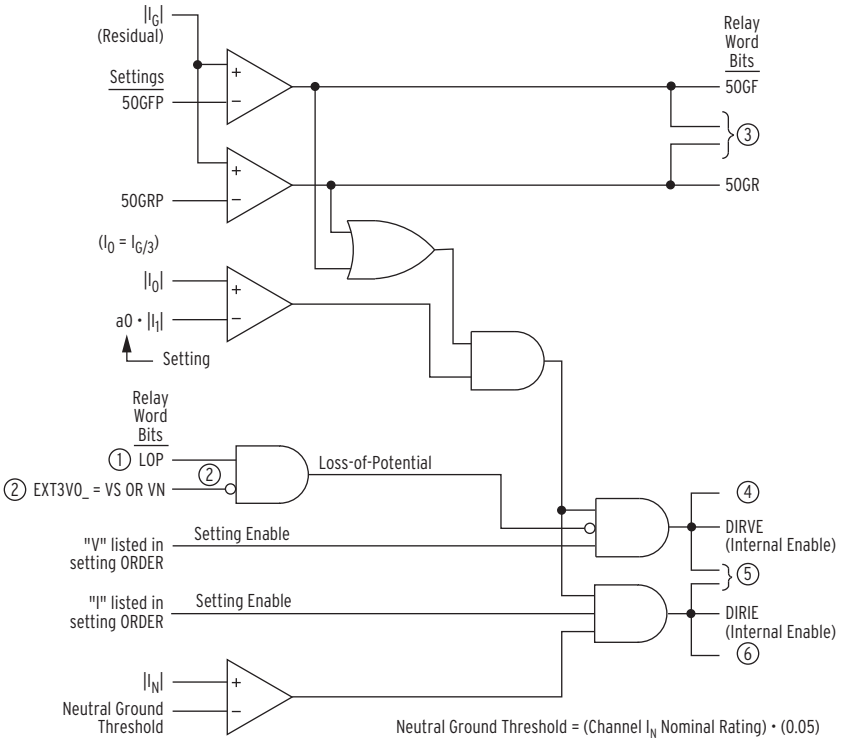
See the beginning of *Directional Control Settings on page 4.122* for a discussion on the operation of level direction settings DIR1 and DIR2 when the directional control enable setting EDIR is set to EDIR := N.

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



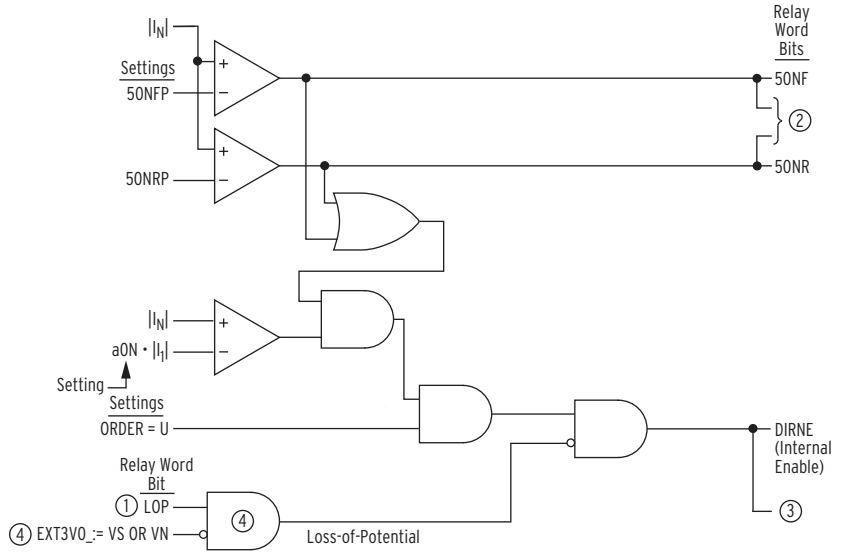
① From Figure 4.113 ② From Figure 4.68 ③ To Figure 4.70 and Figure 4.79
④ To Figure 4.79 ⑤ To Figure 4.70, Table 4.27 and Table 4.28

Figure 4.67 Internal Enables (DIRQE and DIRQGE) Logic for Negative-Sequence Voltage-Polarized Directional Elements



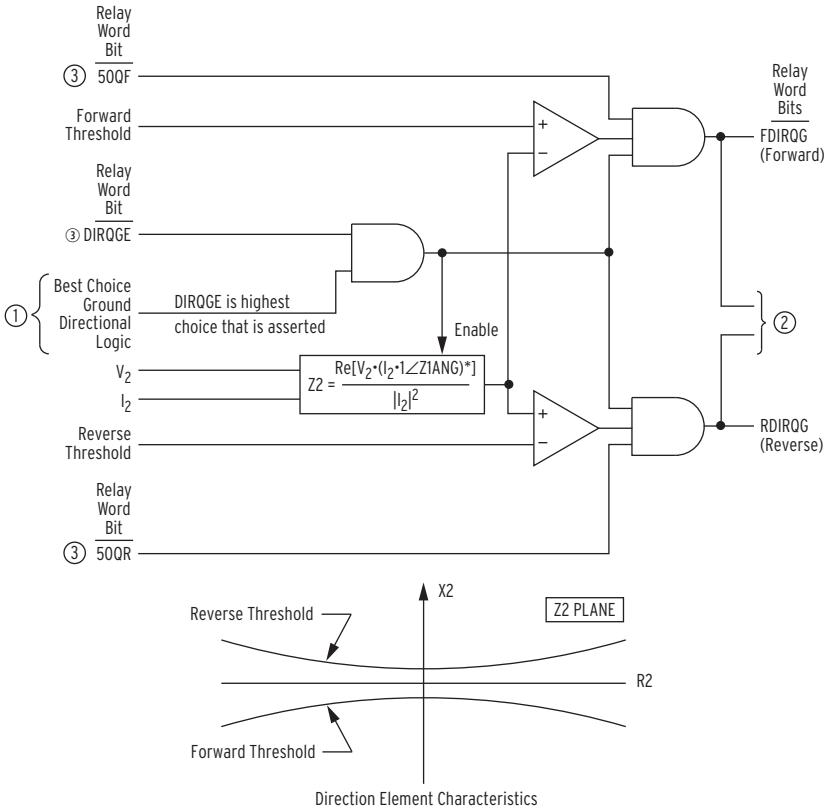
1 From Figure 4.113
2 EXT3V0_ and the AND gate are applicable to the X side only. For the Y side, Loss-of-Potential = LOP.
3 To Figure 4.71 and Figure 4.72
4 To Figure 4.71 and Figure 4.74
5 To Figure 4.67, Table 4.27, and Table 4.28
6 To Figure 4.72 and Figure 4.74

Figure 4.68 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 4.113 2 To Figure 4.73
3 To Figure 4.73, Figure 4.75, 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 4.69 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 = $1.25 \cdot Z2F - 0.25 \cdot \left| \frac{V_2}{I_2} \right|$

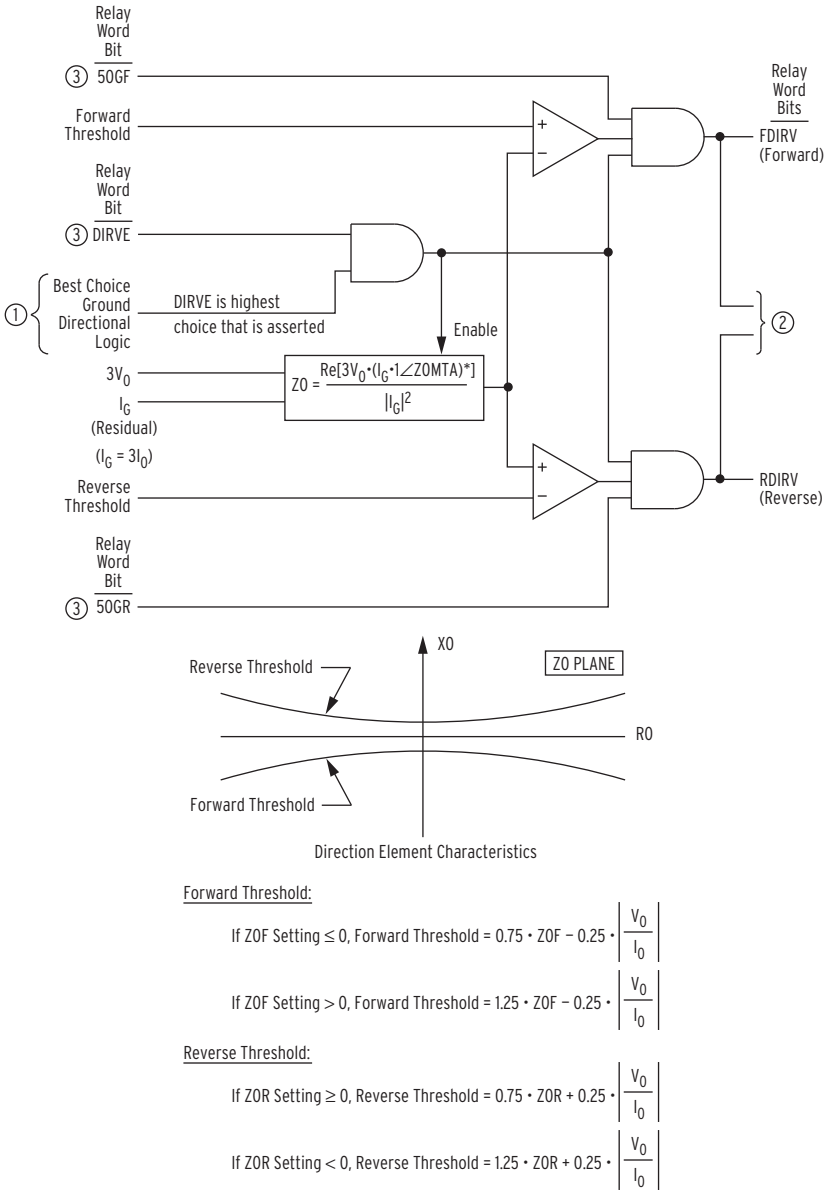
Reverse Threshold:

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 = $1.25 \cdot Z2R + 0.25 \cdot \left| \frac{V_2}{I_2} \right|$

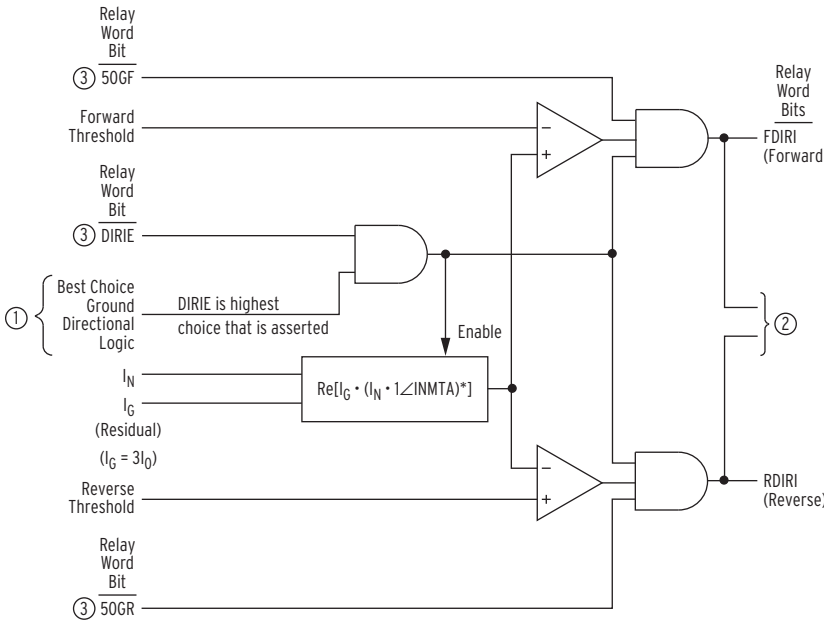
① From Table 4.28 ② To Figure 4.74 ③ From Figure 4.67

Figure 4.70 Negative-Sequence Voltage-Polarized Directional Element for Residual-Ground Overcurrent Elements



① From Table 4.28 ② To Figure 4.74 ③ From Figure 4.68

Figure 4.71 Zero-Sequence Voltage-Polarized Directional Element for Residual-Ground Overcurrent Elements



Forward Threshold:

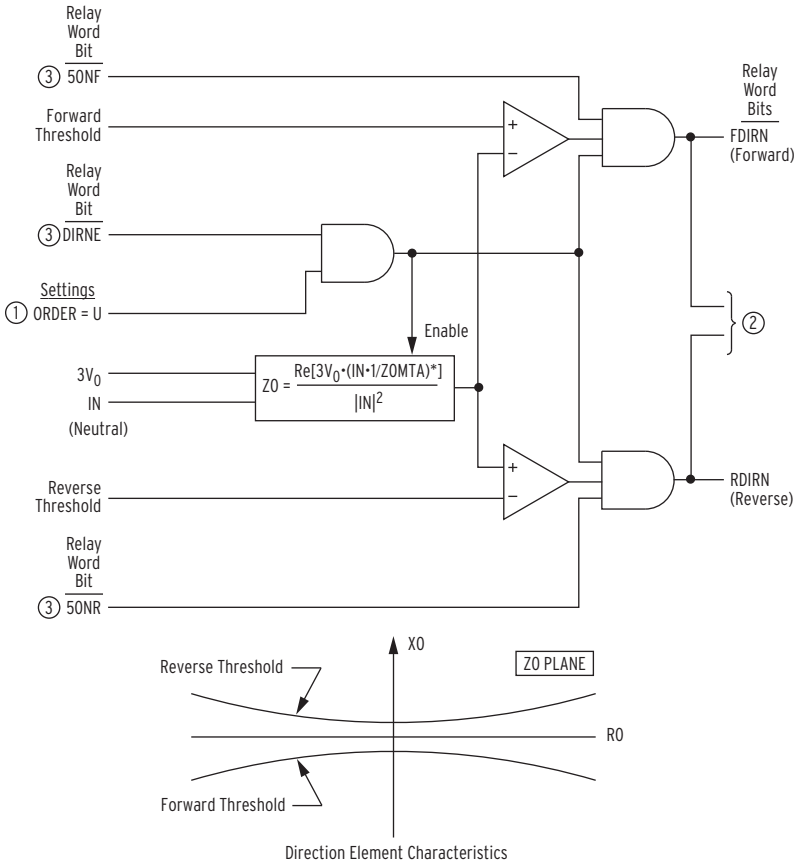
Forward Threshold = (Channel I_N Nominal Rating) • (Phase Channels Nominal Rating) • $(0.05)^2$

Reverse Threshold:

Reverse Threshold = −(Channel I_N Nominal Rating) • (Phase Channels Nominal Rating) • $(0.05)^2$

① From Table 4.4 ② To Figure 4.74 ③ From Figure 4.68

Figure 4.72 Channel IN Current-Polarized Directional Element



Forward Threshold: Z0F = −0.10 ohm secondary

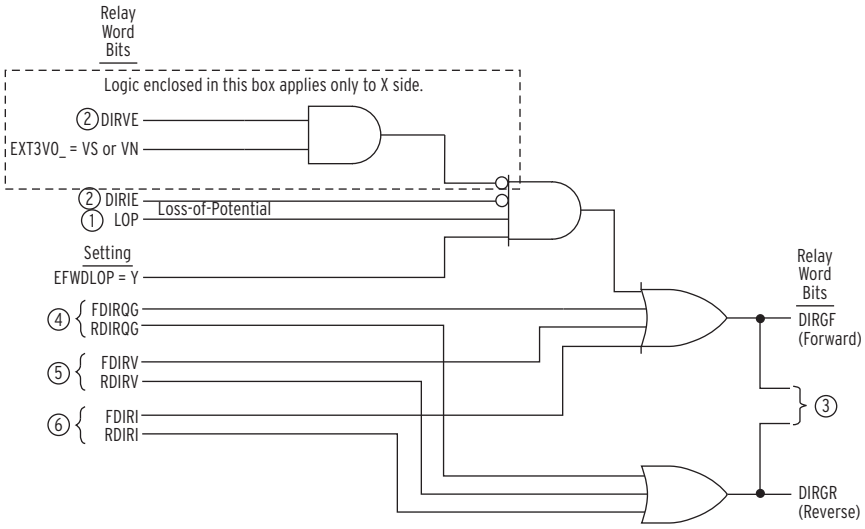
$$\text{Forward Threshold} = 0.75 \cdot Z0F - 0.25 \cdot \left| \frac{3V_0}{IN} \right|$$

Reverse Threshold: Z0R = 0.10 ohm secondary

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

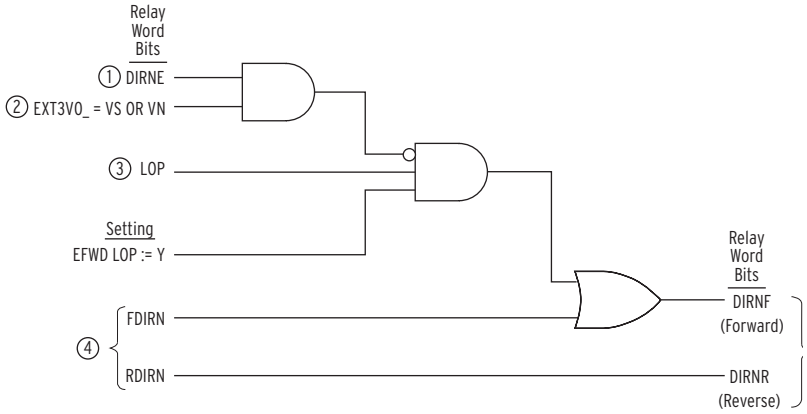
① From Table 4.28 ② To Figure 4.75 ③ From Figure 4.69

Figure 4.73 Zero-Sequence Voltage-Polarized Directional Element for Neutral-Ground Overcurrent Elements



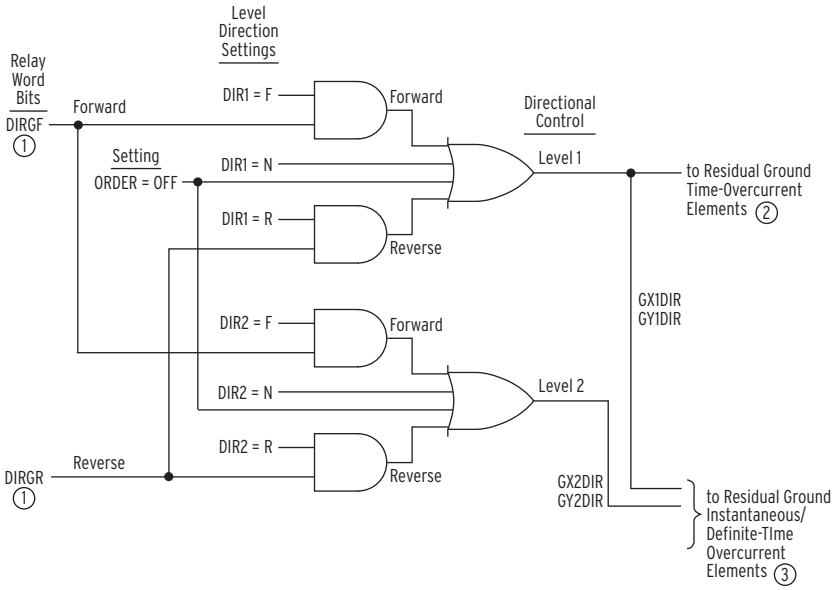
① From Figure 4.113 ② From Figure 4.68 ③ From Figure 4.76
④ From Figure 4.70 ⑤ From Figure 4.71 ⑥ To Figure 4.72

Figure 4.74 Routing of Directional Elements to Residual-Ground Overcurrent Elements



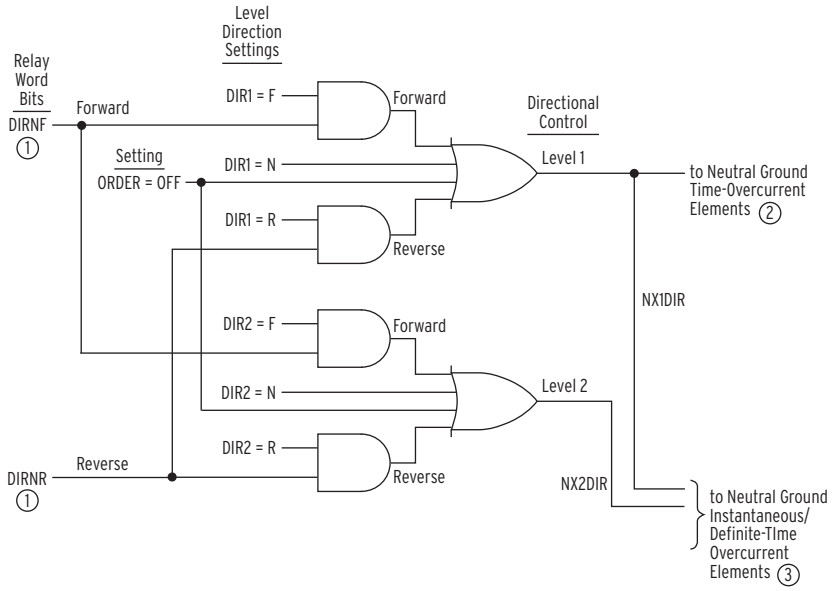
① From Figure 4.69 ② EXT3VO_ and the AND gate are applicable to X side only. It is not applicable to Y side.
③ From Figure 4.113 ④ From Figure 4.73 ⑤ From Figure 4.77

Figure 4.75 Routing of Neutral Directional Element to Neutral-Ground Overcurrent Elements



① From Figure 4.74 ② To Figure 4.54 ③ To Figure 4.47

Figure 4.76 Direction Forward/Reverse Logic for Residual-Ground Overcurrent Elements



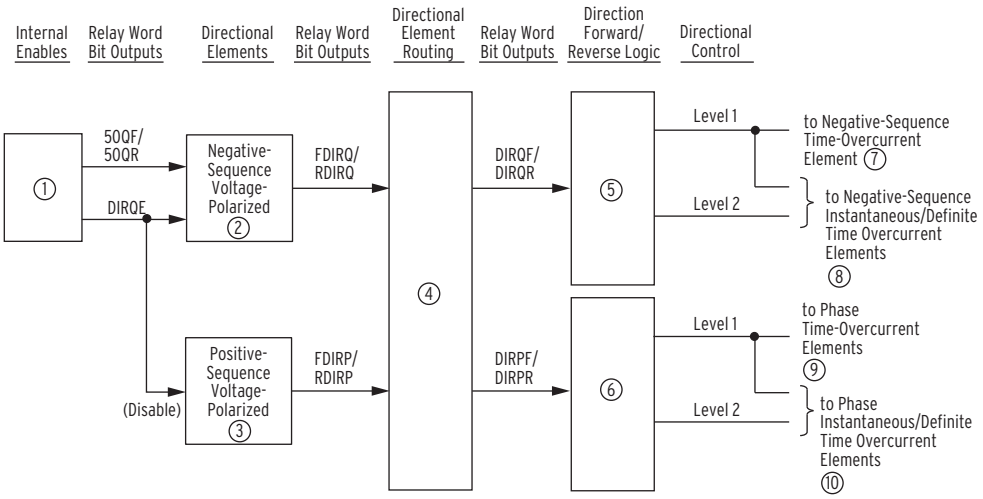
① From Figure 4.75 ② To Figure 4.53 ③ To Figure 4.49

Figure 4.77 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 4.122*.

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 4.78* gives an overview of how the

negative-sequence voltage-polarized and positive-sequence voltage-polarized directional elements are enabled and routed to control the negative-sequence and phase overcurrent elements.



① Figure 4.67 ② Figure 4.79 ③ Figure 4.80 ④ Figure 4.81 ⑤ Figure 4.82
⑥ Figure 4.83 ⑦ Figure 4.52 ⑧ Figure 4.47 ⑨ Figure 4.51 ⑩ Figure 4.47

Figure 4.78 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 4.67* and *Figure 4.78*. The internal enable DIRQE corresponds to the negative-sequence voltage-polarized directional element.

Note that *Figure 4.67* 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 4.65*).

The settings involved with internal enable DIRQE in *Figure 4.67* (for example, settings a2, k2) are explained in *Directional Control Settings on page 4.122*.

Directional Elements

Refer to *Figure 4.78*, *Figure 4.82*, and *Figure 4.80*. 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 4.67* and *Figure 4.80*).

Refer to *Figure 4.113* and the accompanying text for more information on loss-of-potential.

Note in *Figure 4.78* and *Figure 4.80* 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 4.80* 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 4.87*).

Directional Element Routing

Refer to *Figure 4.78* and *Figure 4.81*. 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 4.82* and *Figure 4.83*.

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 4.67* and *Figure 4.80*), 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 4.113* and the accompanying text for more information on loss-of-potential.

Direction Forward/Reverse Logic

Refer to *Figure 4.78*, *Figure 4.82*, and *Figure 4.83*. 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:

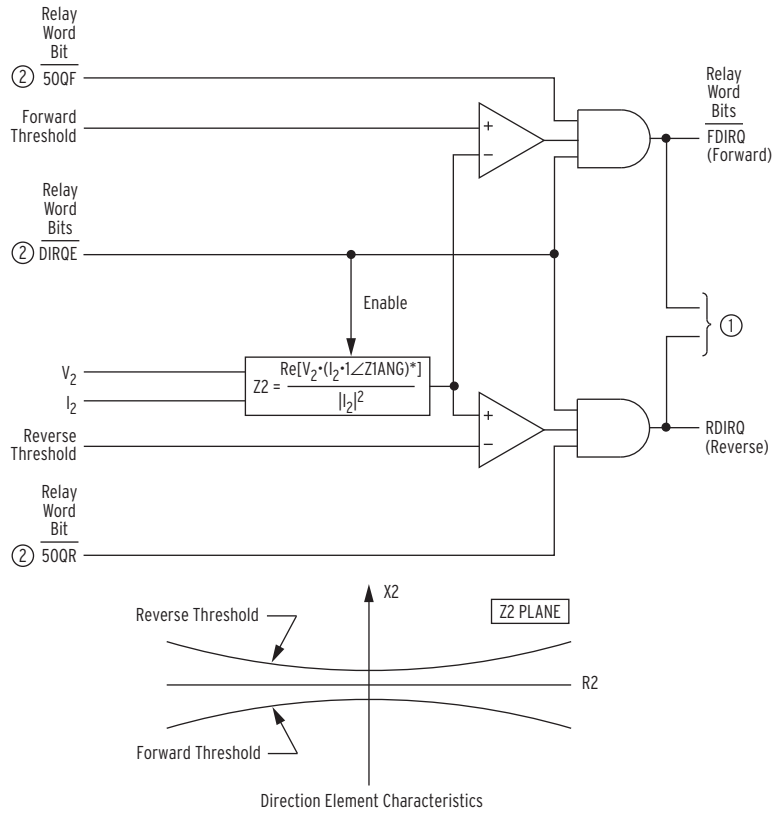
DIR1 := **N** (nondirectional)

then the corresponding Level 1 directional control outputs in *Figure 4.82* and *Figure 4.83* assert to logical 1. The referenced Level 1 overcurrent elements in *Figure 4.82* and *Figure 4.83* are not controlled by the directional control logic.

See *Directional Control Settings on page 4.122* 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 4.134 describes how to avoid this limitation for special cases.



Forward Threshold:

If Z2F Setting ≤ 0, Forward Threshold = $0.75 \cdot Z2F - 0.25 \cdot \left| \frac{V_2}{I_2} \right|$

If Z2F Setting > 0, Forward Threshold = $1.25 \cdot Z2F - 0.25 \cdot \left| \frac{V_2}{I_2} \right|$

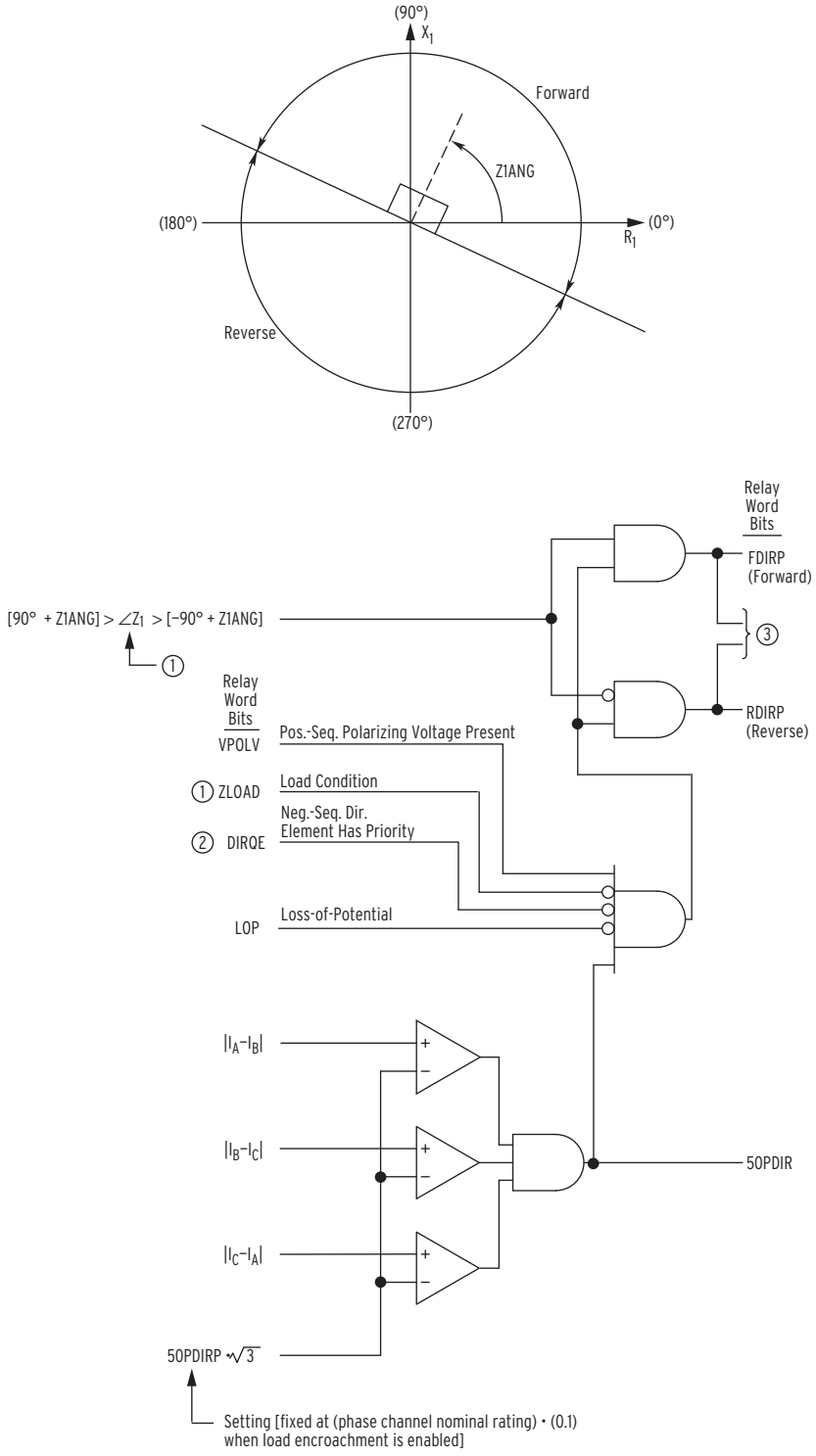
Reverse Threshold:

If Z2R Setting ≥ 0, Reverse Threshold = $0.75 \cdot Z2R + 0.25 \cdot \left| \frac{V_2}{I_2} \right|$

If Z2R Setting < 0, Reverse Threshold = $1.25 \cdot Z2R + 0.25 \cdot \left| \frac{V_2}{I_2} \right|$

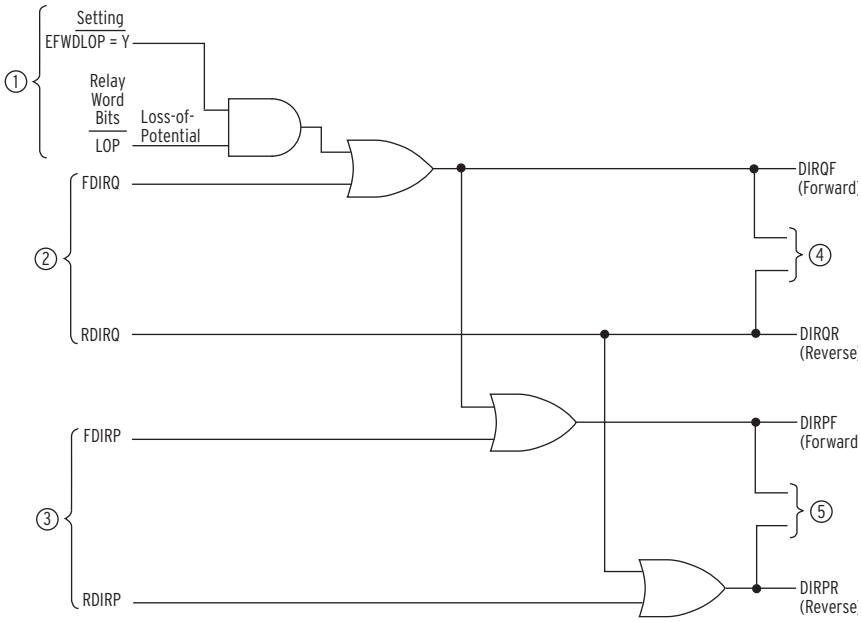
① To Figure 4.81 ② From Figure 4.67

Figure 4.79 Negative-Sequence Voltage-Polarized Directional Element for Negative-Sequence and Phase Overcurrent Elements



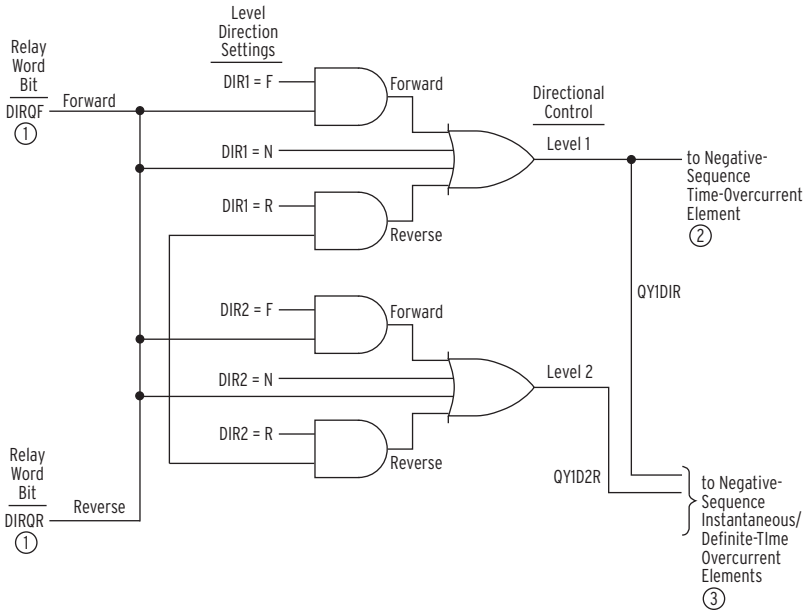
① To Figure 4.87 ② From Figure 4.67 ③ To Figure 4.81

Figure 4.80 Positive-Sequence Voltage-Polarized Directional Element for Phase Overcurrent Elements



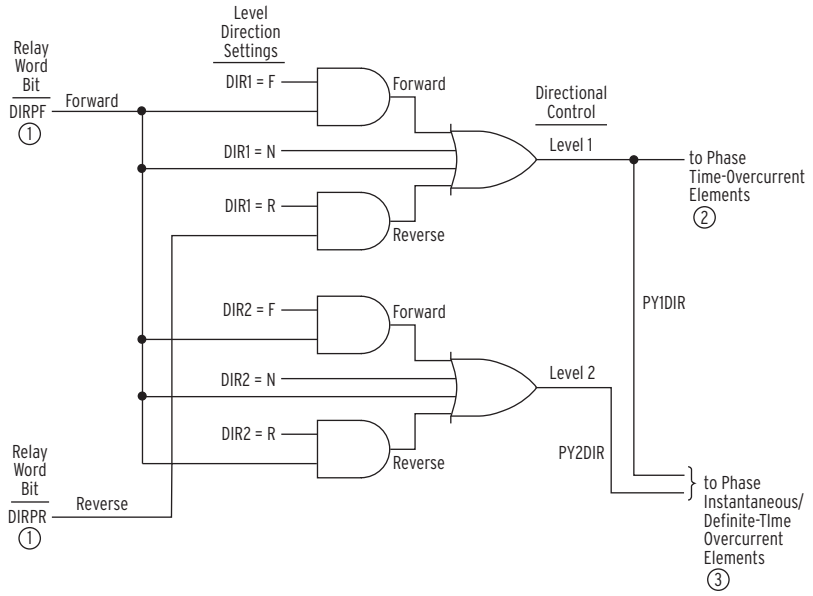
① From Figure 4.113 ② From Figure 4.79 ③ From Figure 4.80
④ To Figure 4.82 ⑤ to Figure 4.83

Figure 4.81 Routing of Directional Elements to Negative-Sequence and Phase Overcurrent Elements



① From Figure 4.81 ② From Figure 4.52 ③ From Figure 4.47

Figure 4.82 Direction Forward/Reverse Logic for Negative-Sequence Overcurrent Elements



① From Figure 4.81 ② Figure 4.51 ③ Figure 4.47

Figure 4.83 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 4.76*, *Figure 4.77*, *Figure 4.82*, and *Figure 4.83* assert to logical 1. The overcurrent elements referenced in *Figure 4.76*, *Figure 4.77*, *Figure 4.82*, and *Figure 4.83* 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 EXT3VO_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 the user goes back and changes the directional control enable setting to EDIR := Y.

The remaining directional control settings are *not* set automatically if setting EDIR := AUTO. They have to be set by the user, whether 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 the user) are used in every application. The 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 4.76*, *Table 4.77*, *Figure 4.82*, and *Figure 4.83* 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 4.47*) 67PY1T (*Figure 4.47*) 51PYP(*Figure 4.51*) 51PYT (*Figure 4.51*)	67G*m*1P (*Figure 4.46* and *Figure 4.47*) 67G*m*1T (*Figure 4.46* and *Figure 4.47*) 51G*m*P (*Figure 4.54*) 51G*m*T (*Figure 4.54*)	67QY1 (*Figure 4.47*) 67QY1T (*Figure 4.47*) 51QYP (*Figure 4.52*) 51QYT (*Figure 4.52*)	67N1P (*Figure 4.49*) 67N1T (*Figure 4.49*) 51NP (*Figure 4.53*) 51NT (*Figure 4.53*)
DIR2*m*	67PY2P (*Figure 4.47*) 67PY2T (*Figure 4.47*)	67G*m*2P (*Figure 4.46* and *Figure 4.47*) 67G*m*2T (*Figure 4.46* and *Figure 4.47*)	67QY2P (*Figure 4.47*) 67QY2T (*Figure 4.47*)	67N2P (*Figure 4.49*) 67N2T (*Figure 4.49*)

[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 4.134* 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 4.70*) 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 4.67*), then the second listed directional element (V = zero-sequence voltage-polarized directional element; see *Figure 4.71*) 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 4.7*), 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 4.76*).

Another example, if setting:

ORDERX := **V**

then the zero-sequence voltage-polarized directional element (see *Figure 4.71*) 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 4.68*), 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 4.76*).

Another example, if setting:

ORDERX := **U**

then the zero-sequence voltage-polarized directional element (see *Figure 4.73*) 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 4.69*), 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 4.77*). 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 4.76* and *Figure 4.77* that setting ORDER := OFF effectively makes the residual-ground and neutral-ground overcurrent elements nondirectional (the directional control outputs of *Figure 4.76* and *Figure 4.77*, 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 4.80*).

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 4.70* and *Figure 4.82*).

If enable setting EDIR := Y, the user calculates and enters 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 4.84 and *Figure 4.85* 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 4.67*). 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 4.67*). 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 4.6*) 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 ($|I_2| > 0.1 \bullet |I_1|$).

k2—Zero-Sequence Current Restraint Factor, I_2/I_0. Note the internal enable logic outputs in *Figure 4.67*:

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 4.70*) to be enabled:

$$|I_2| > k2 \bullet |I_0|$$

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 above 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:

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 ($|I_2| > 0.2 \bullet |I_0|$). 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 4.68*). 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 4.68*). 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 4.68*. 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 ($|I_0| > 0.1 \bullet |I_1|$).

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 4.71* and *Figure 4.73*). 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 4.73*) for use with the zero-sequence voltage-polarized directional element with IN as operate quantity.

When ORDER is set to contain V and if the enable setting EDIR := Y, the user calculates and enters 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*)

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.

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 4.84* 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 4.84* 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 4.85a*, with resultant Z0F and Z0R settings as in *Figure 4.85b*. The zero-sequence line angle noted in *Figure 4.85a* (∠Z0MTA) is the same angle found in *Figure 4.71* and *Figure 4.73* (in the equation box with the Enable line). Note that the Z0MTA shown in *Figure 4.71* and *Figure 4.73* 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 4.84* and *Figure 4.85* just provide a theoretical background.

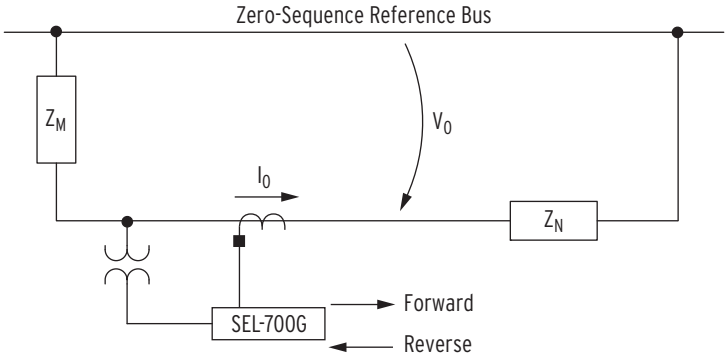


Figure 4.84 Zero-Sequence Impedance Network and Relay Polarity

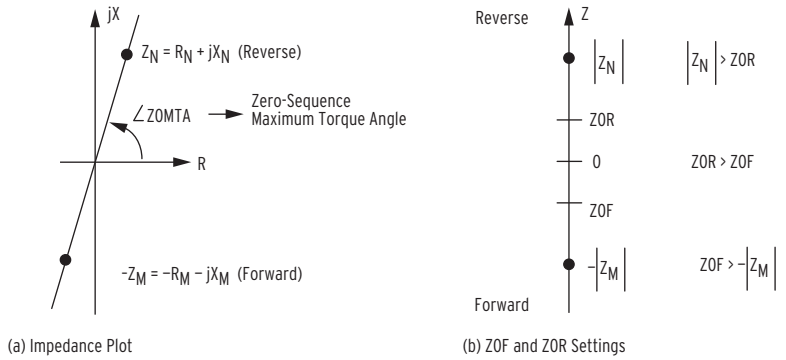


Figure 4.85 Zero-Sequence Impedance Plot for Solidly-Grounded, Mostly Inductive System

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 4.86*, 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 2.24 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.

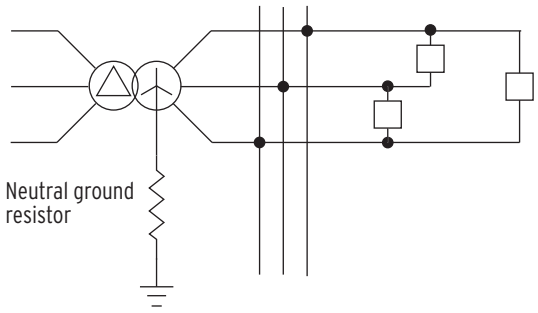


Figure 4.86 Hybrid Power System With Neutral-Ground Resistor

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 4.69*). 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 4.69*). 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 4.69*). The following comparison is made as part of internal enable DIRNE:

$$|IN| > a0N \bullet |I1|$$

IN is the secondary current measured by neutral channel IN. I1 is the positive-sequence secondary current derived from the phase current channels IA, IB, and IC. Presumably, channel IN is connected in such a manner that it sees the system zero-sequence current (e.g., channel IN is connected to a core-balance CT through which the three phase conductors pass; in such a connection, channel IN sees 3I0 zero- sequence current, IN = 3I0; see *Figure 2.24*). 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:

$$a0N = (3I0 \text{ pri.}/I1 \text{ pri.}) \bullet (CTRX/CTRN)$$

3I0 pri. = standing system unbalance current (zero-sequence; A primary)

I1 pri. = maximum load current (positive-sequence; A primary)

Adjust the final setting value of a0N from the above derived value of a0N, depending on your security philosophy, etc. The a0N factor increases the security of the zero-sequence voltage-polarized directional element. It keeps the elements from operating for zero-sequence current as a result of any system unbalance.

High-Impedance Grounded System Considerations for Phase-to-Phase or Three-Phase Faults

On high-impedance grounded systems (when setting ORDERX := U), phase-to-phase or unbalanced three-phase faults can cause the high-impedance grounded element to operate on false quantities. To prevent this situation, consider 67N element for example, use the SELOGIC torque control equation 50N1TC as follows:

50N1TC := 59V1X1 AND NOT 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 4.76*, *Figure 4.77*, *Figure 4.82*, and *Figure 4.83*.

Suppose that the Level 1 overcurrent elements are required to be set 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 above overcurrent elements are used to make the elements directional (forward or reverse) or nondirectional. The required settings are:

DIR1Y := **N** (“turned off”; see *Figure 4.76*, *Figure 4.82*, and *Figure 4.83*)
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, in order 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 4.87* and *Figure 4.88*. 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 4.87* and *Figure 4.88*. For a balanced load condition, I_1 = phase current magnitude.

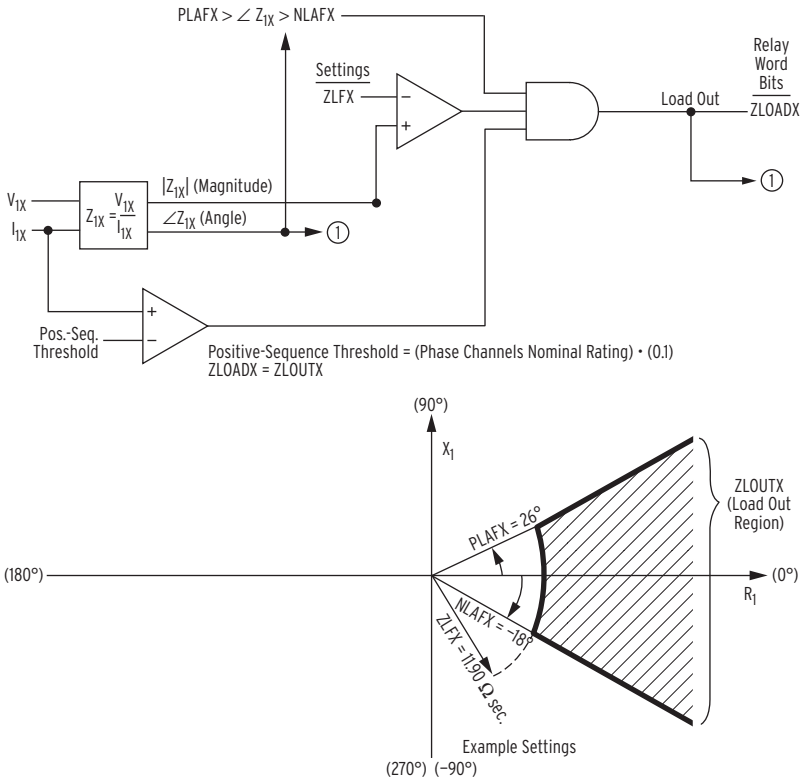
Forward load (load flowing out) lies within the hatched region labeled ZLOUT. Relay Word bit ZLOUT asserts to logical 1 when the load lies within this hatched region.

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:

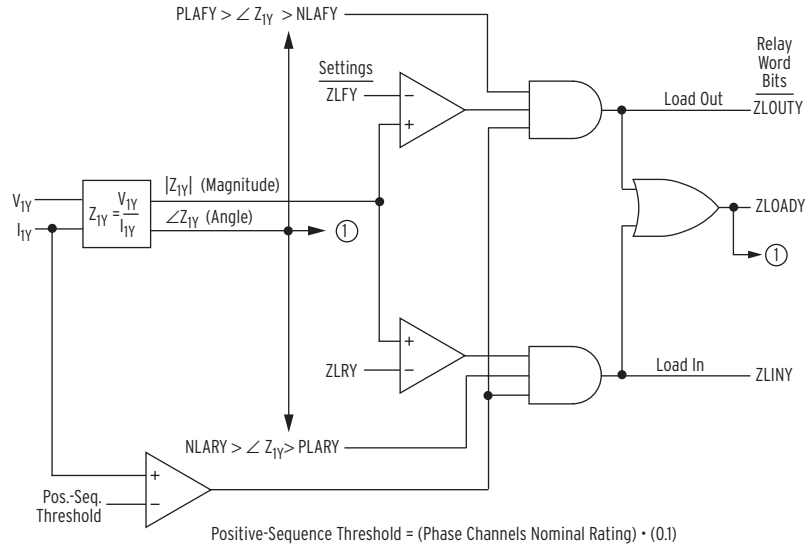
ZLOADY := ZLOUTY OR ZLINY

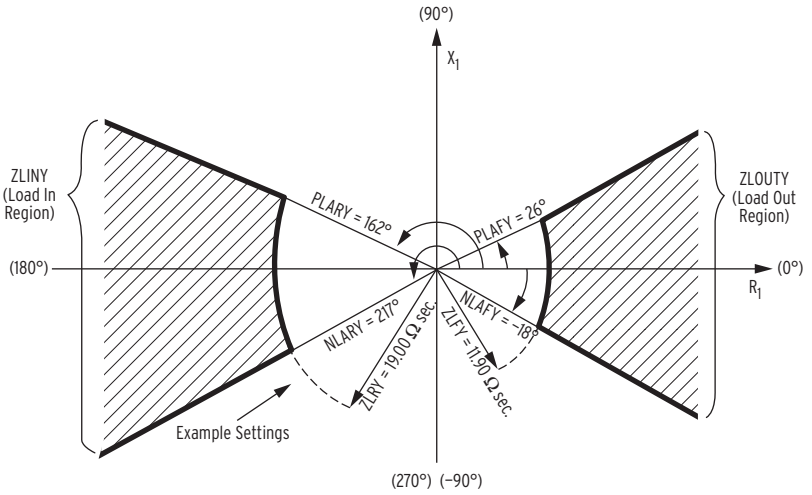
ZLOADX := ZLOUTX



① To Figure 4.80

Figure 4.87 Load-Encroachment Logic for X Side





① To Figure 4.80

Figure 4.88 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:

$$\begin{aligned} 800\ \text{MVA} \bullet (1/3) &= 267\ \text{MVA per phase} \\ 230\ \text{kV} \bullet (1/\sqrt{3}) &= 132.8\ \text{kV line-to-neutral} \\ 267\ \text{MVA} \bullet (1/132.8\ \text{kV}) \bullet (1000\text{kV/MV}) &= 2010\ \text{A primary} \\ 2010\ \text{A primary} \bullet (1/\text{CT ratio}) &= 2010\ \text{A primary} \bullet (1\ \text{A secondary}/400\ \text{A primary}) \\ &= 5.03\ \text{A secondary} \\ 132.8\ \text{kV} \bullet (1000\ \text{V/kV}) &= 132800\ \text{V primary} \\ 132800\ \text{V primary} \bullet (1/\text{PT ratio}) &= 132800\ \text{V primary} \bullet (1\ \text{V secondary}/2000\ \text{V primary}) \\ &= 66.4\ \text{V secondary} \end{aligned}$$

Now, calculate the equivalent secondary impedance:

$$\frac{66.4\ \text{V secondary}}{5.03\ \text{A secondary}} = 13.2\ \Omega\ \text{secondary}$$

This secondary value can be calculated more expediently with the following equation:

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

Again, for the maximum forward load:

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

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

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

For the maximum reverse load:

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

Again, to provide a margin for setting ZLR:

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

Convert Power Factors to Equivalent Load Angles. The power factor (forward load) can vary from 0.90 lag to 0.95 lead.

Setting PLAF := $\cos^{-1}(0.90) = 26^\circ$

Setting NLAF := $\cos^{-1}(0.95) = -18^\circ$

The power factor (reverse load) can vary from 0.80 lag to 0.95 lead.

Setting PLAR := $180^\circ - \cos^{-1}(0.95) = 180^\circ - 18^\circ = 162^\circ$

Setting NLAR := $180^\circ + \cos^{-1}(0.80) = 180^\circ + 37^\circ = 217^\circ$

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)

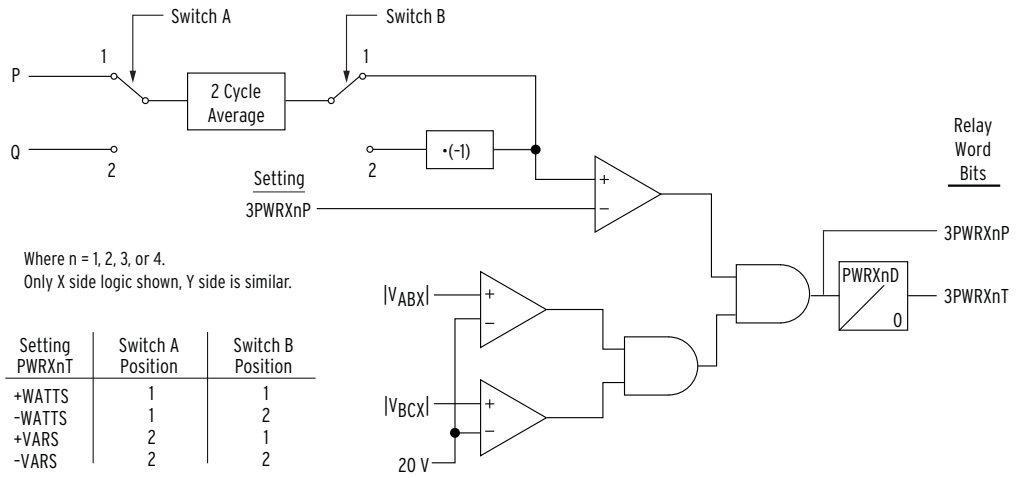
Setting Prompt	Setting Range	Setting Name := Factory Default[a]
ENABLE PWR ELEM	N, 1–4 N, 1–4	EPWRX := 2 EPWRY := N
3PH PWR ELEM PU	OFF, 1.0–6500.0 VA (secondary VA)[b]	3PWR*m*1P := 50
PWR ELEM TYPE	+WATTS, –WATTS, +VARS, –VARS	PWR*m*1T := -WATTS
PWR ELEM DELAY	0.00–240.00 s	PWR*m*1D := 20.00
3PH PWR 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

Table 4.38 Power Element Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default[a]
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
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 & 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 4.89* shows the power element logic diagram, and *Figure 4.90* shows the operation in the real/reactive power plane.



Setting PWRXnT	Switch A Position	Switch B Position
+WATTS	1	1
-WATTS	1	2
+VARS	2	1
-VARS	2	2

Figure 4.89 Three-Phase Power Elements Logic

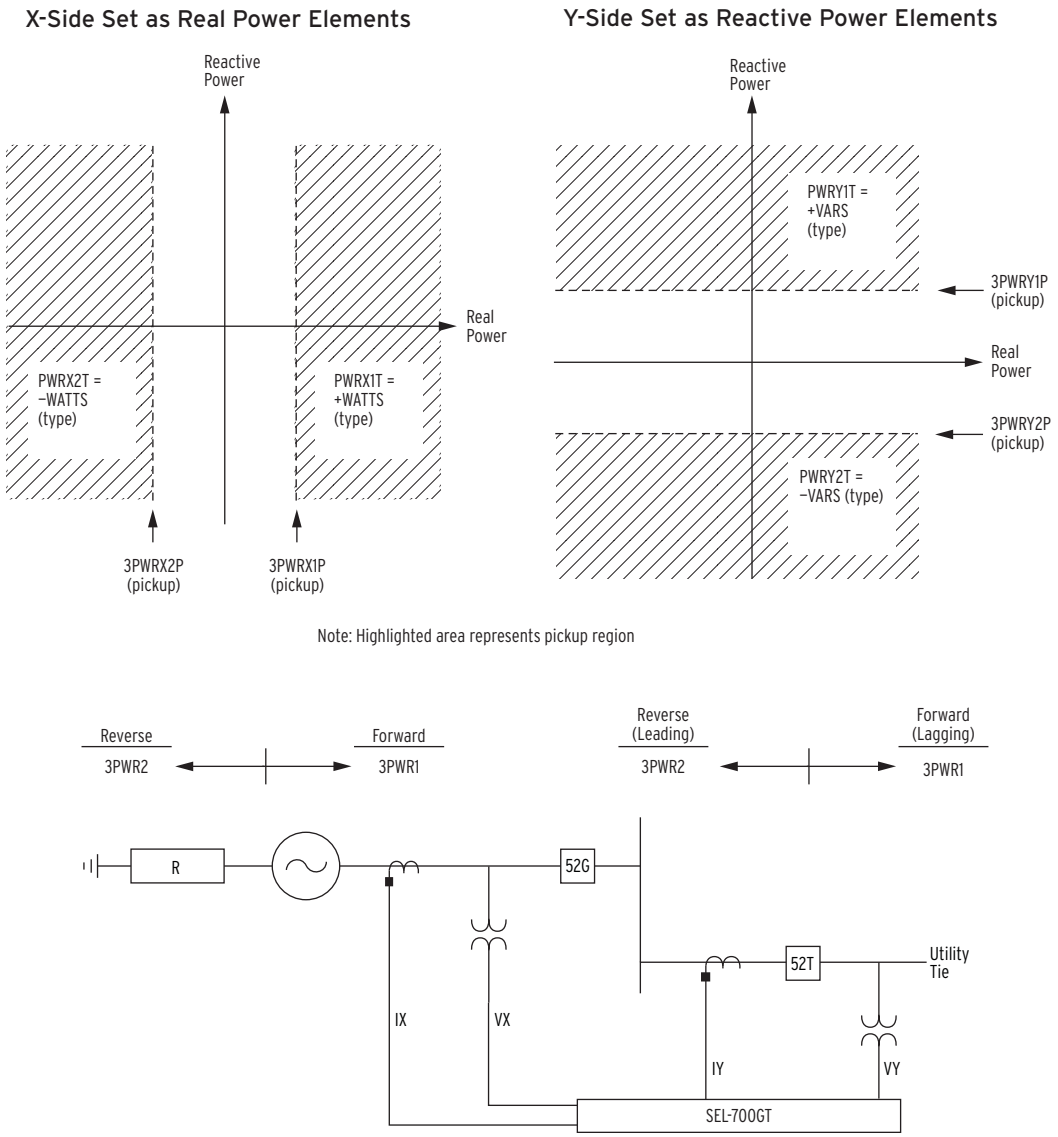


Figure 4.90 Power Elements Operation in the Real/Reactive Power Plane

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 4.89*. 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

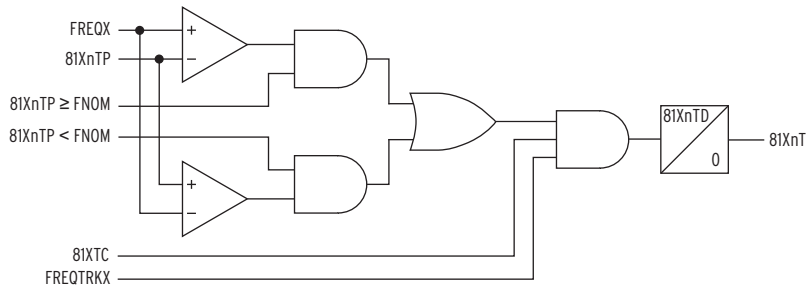
[a] m = X or Y.

Figure 4.91 and *Figure 4.92* show the logic diagrams for the X and Y-side frequency elements. Additionally SEL-700G asserts Relay Word bits 81XT, 81YT, and 81T using the following logic equations:

81XT = 81X1T OR 81X2T OR…OR 81X6T

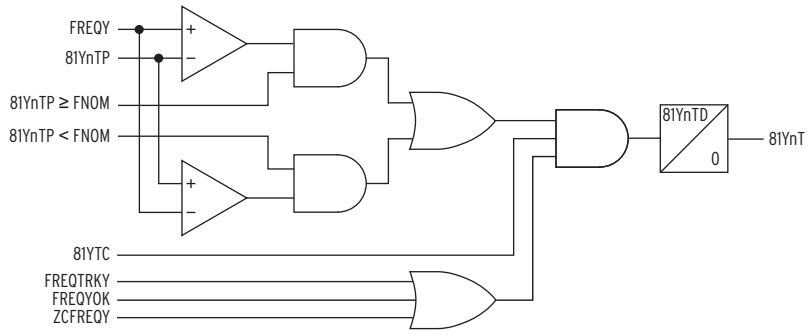
81YT = 81Y1T OR 81Y2T OR…OR 81Y6T

81T = 81XT OR 81YT



n = Frequency Elements 1-6
FREQX = Measured Frequency
81XnTP = Frequency Pickup Setting
FNOM = Nominal Frequency Setting
81XnTD = Over- and Underfrequency Element Pickup Time Delay
81XnT = Definite-Time Delayed Over- and Underfrequency Element Relay Word Bit
FREQTRKX = Relay Tracking Frequency FREQX
81XTC = Over- and Underfrequency Element Torque Control Bit

Figure 4.91 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 4.92 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

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 LEVEL	OFF, 0.10–15.00 Hz/s	81R*m*4TP := OFF
FREQ*m* ROC TREND	INC, DEC, ABS	81R*m*4TRN := ABS
FREQ*m* ROC PU DLY	0.10–60.00 s	81R*m*4TD := 1.00
FREQ*m* ROC DO DLY	0.00–60.00 s	81R*m*4DO := 0.00
FREQ*m* ROC VSUPER	OFF, 12.5–300.0 V	81R*m*VSUP := OFF
FREQ*m* ROC TRQCTRL	SELOGIC	81R*m*TC := 1

[a] m = X or Y.

Use the E81R setting to enable the number of elements you want. *Figure 4.93* 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.

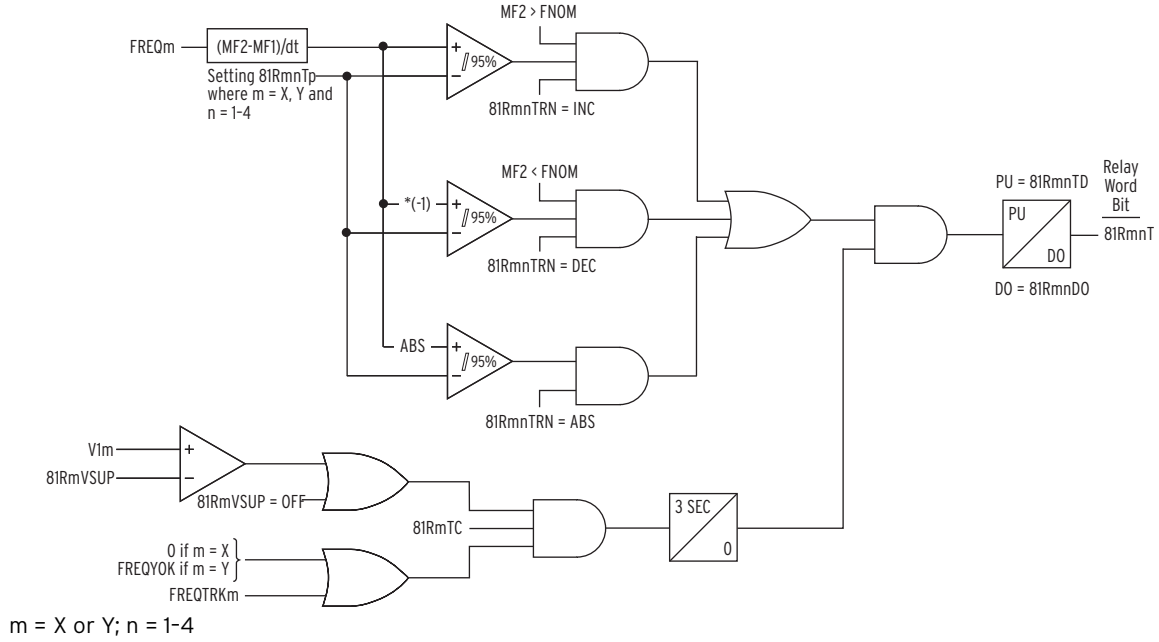


Figure 4.93 81R Frequency Rate-of-Change Scheme Logic

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

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

81RmnTP Setting (Hz/s)	Time-Window (Cycles)
0.46–0.38	18
0.37–0.33	21
0.32–0.29	24
0.28–0.26	27
< 0.25	30

[a] (m = X or Y; n = 1–4).

Set 81R*mn*TRN Trend to INC or DEC to limit the operation of the element to increasing or decreasing frequency, respectively. Also, when set to INC or DEC, the element is supervised by nominal frequency, FNOM. Set the trend to ABS if you want the element to disregard the frequency trend.

Voltage supervision: A minimum positive-sequence voltage is required for the operation of the 81R element when the level is specified by the 81R*m*VSUP setting. Set 81R*m*VSUP := OFF if no voltage supervision is required. 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) required by 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 2.15*, 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 2.22*), 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 the user to connect external zero-sequence voltage to **VS-NS** or **VN-NN** inputs (EXT3V0_X := VS or VN), as in *Figure 2.15 (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 4.96*. 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 4.95 (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).

These elements can be used 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 4.94* to *Figure 4.97* 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

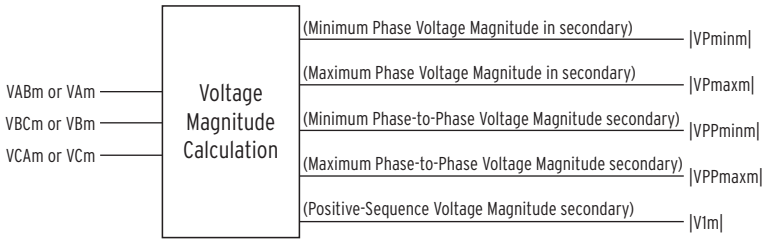
[a] m = X or Y; n = 1–6.
[b] Setting range shown is for DELTAY_m := DELTA.
[c] Setting range shown is for DELTAY_m := WYE.

Table 4.44 Overvoltage Settings

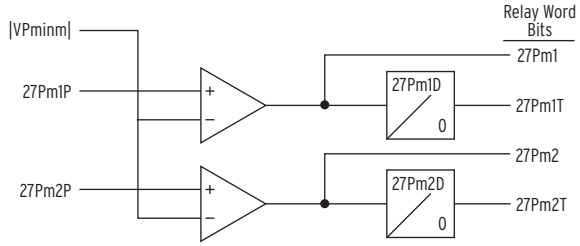
Setting Prompt	Setting Range	Setting Name := Factory Default[a]
PHASE OV LEVEL	OFF, 2.0–300.0 V	59P*m*1P := OFF
PHASE OV DELAY	00.00–120.00 s	59P*m*1D := 0.50
PHASE OV LEVEL	OFF, 2.0–300.0 V	59P*m*2P := OFF
PHASE OV DELAY	00.00–120.00 s	59P*m*2D := 5.00
PH-PH OV LEVEL	OFF, 2.0–300.0 V[b]	59PP*m*1P :=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

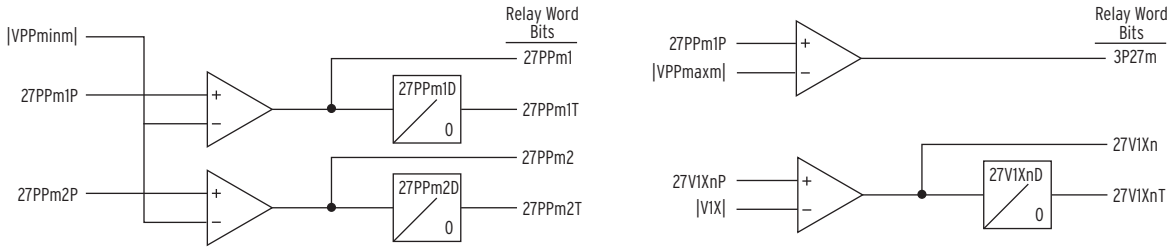
(a) Voltage Magnitude Calculation



(b) Logic Below is Applicable When DELTAY_m := WYE



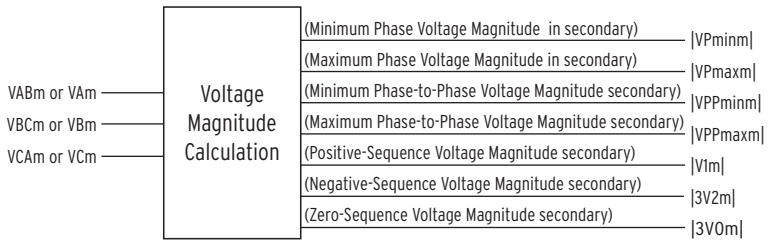
(c) Logic Below is Applicable When: DELTAY_m := DELTA or WYE



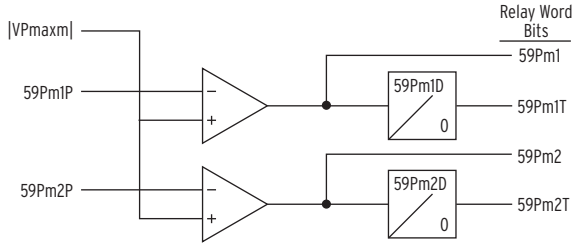
m = X, Y; n = 1–6; All settings in secondary volts.

Figure 4.94 Undervoltage Element Logic

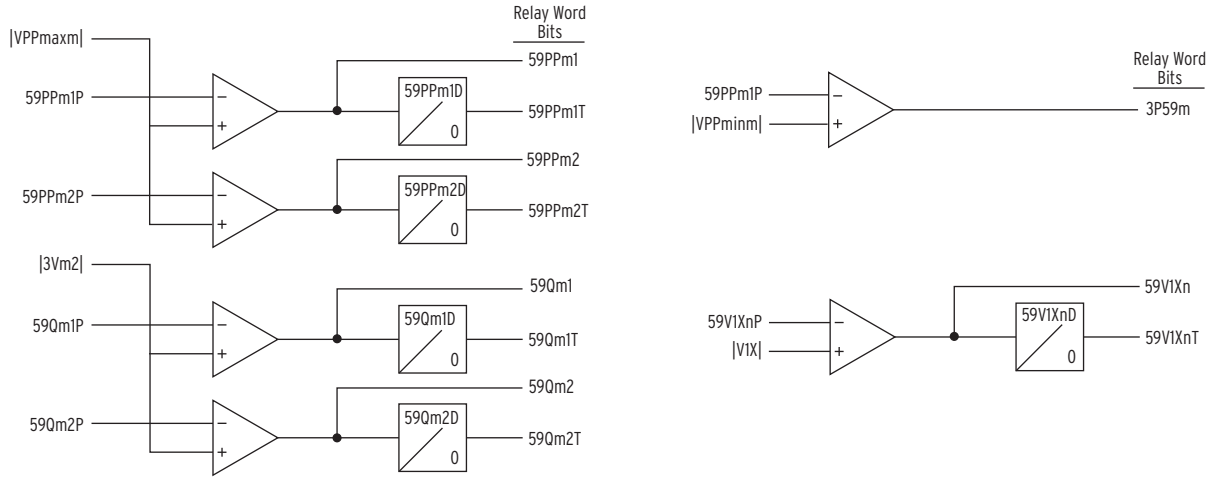
(a) Voltage Magnitude Calculation



(b) Logic Below is Applicable to When DELTAY_m := WYE



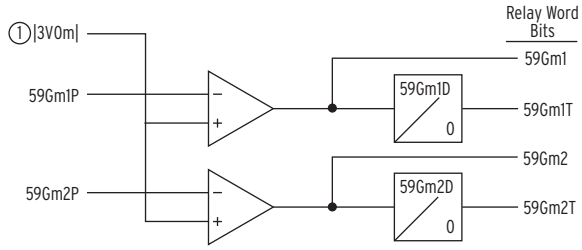
(c) Logic Below is Applicable When: DELTAY_m := DELTA or WYE



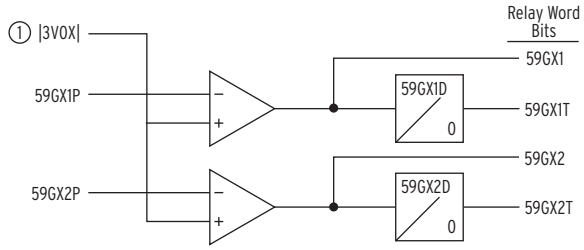
m = X or Y; n = 1–6; All settings in secondary volts.

Figure 4.95 Overvoltage Element Logic

(a) Logic Below is Applicable When DELTAY_m := WYE



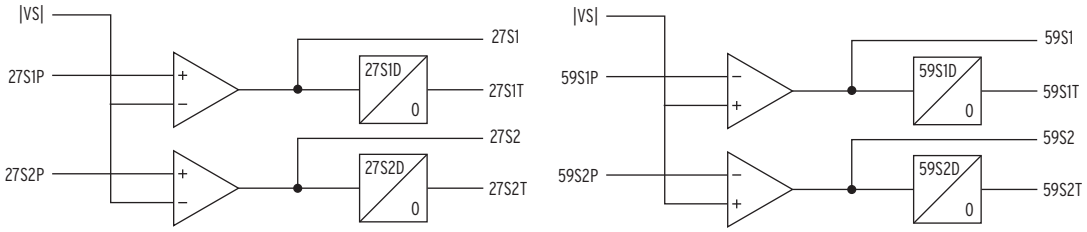
(b) Logic Below is Applicable to X Side Only When DELTAY_X := DELTA and EXT3V0_X = VS or VN



m = X or Y; All settings in secondary volts

① Figure 4.95 (a)

Figure 4.96 Zero-Sequence Overvoltage Elements (59G)



27Sn and 59Sn are disabled if EXT3V0_X := VS

n = 1–2; All settings in secondary volts

Figure 4.97 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]	Up to 10 Characters	RTD1NAM :=
RTD1 TYPE	PT100, NI100, NI120, CU10	RTD1TY := PT100
RTD1 TRIP LEVEL	OFF, 1–250 degC	TRTMP1 := OFF
RTD1 WARN LEVEL	OFF, 1–250 degC	ALTMP1 := OFF

Table 4.45 RTD Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
• • •	• • •	• • •
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

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 required 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
446	230.00	186.82	340.14	268.90	17.95

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

Temp (°F)	Temp (°C)	100 Platinum	120 Nickel	100 Nickel	10 Copper
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
MAX SLIP FREQ	–0.99 to 1.00 Hz	25SHI := 0.10
MAX ANGLE 1	0–80 deg	25ANG1X := 5

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

Setting Prompt	Setting Range	Setting Name := Factory Default
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

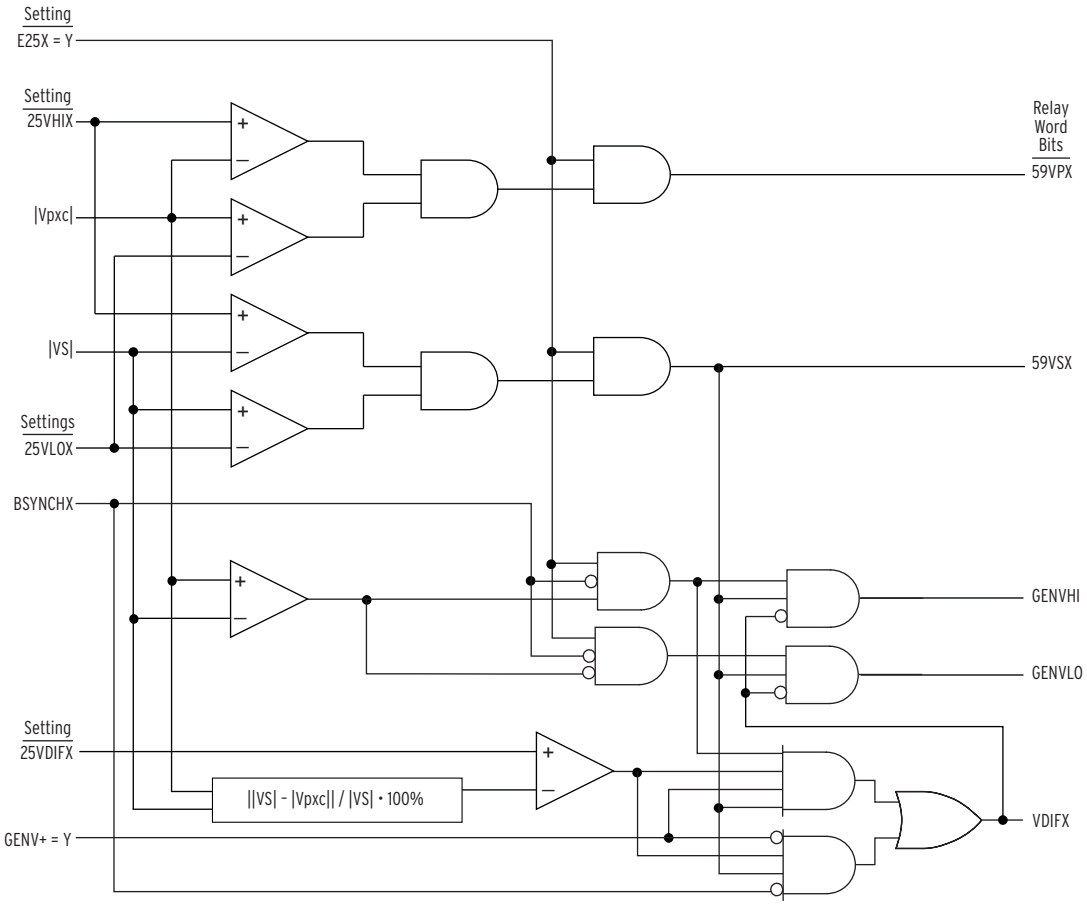
[a] Setting range and default values shown are for DELTAY_X := WYE.
[b] Setting range and default values shown are for DELTAY_X := DELTA.

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 4.98* and *Figure 4.99* for more detail.



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

Figure 4.98 Synchronism-Check Function Voltage Elements

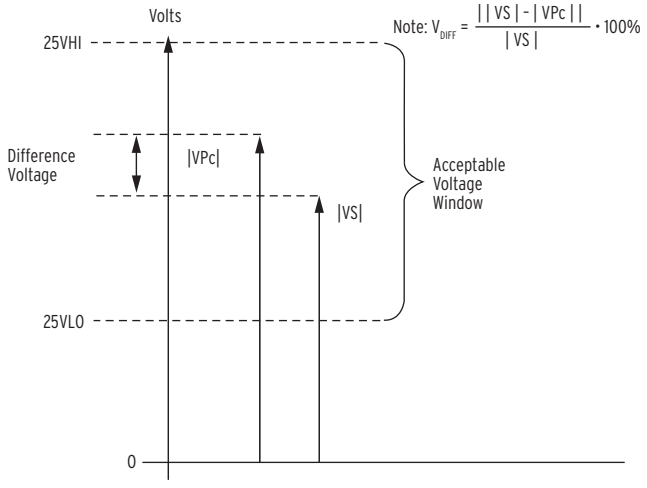


Figure 4.99 Synchronism-Check Function Voltage Element Characteristic

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 4.100* shows four out of several possible configurations and their associated settings and calculations.

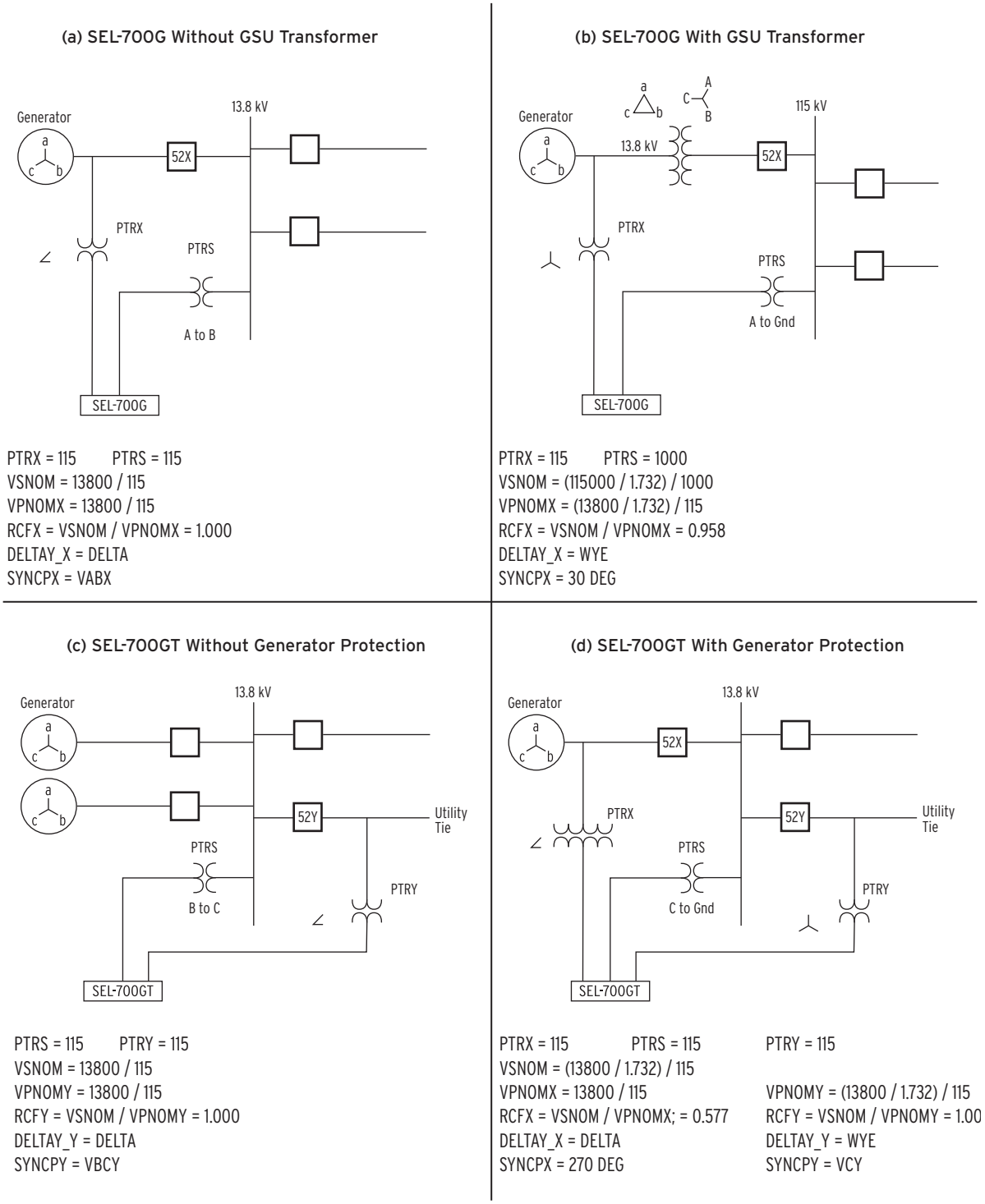


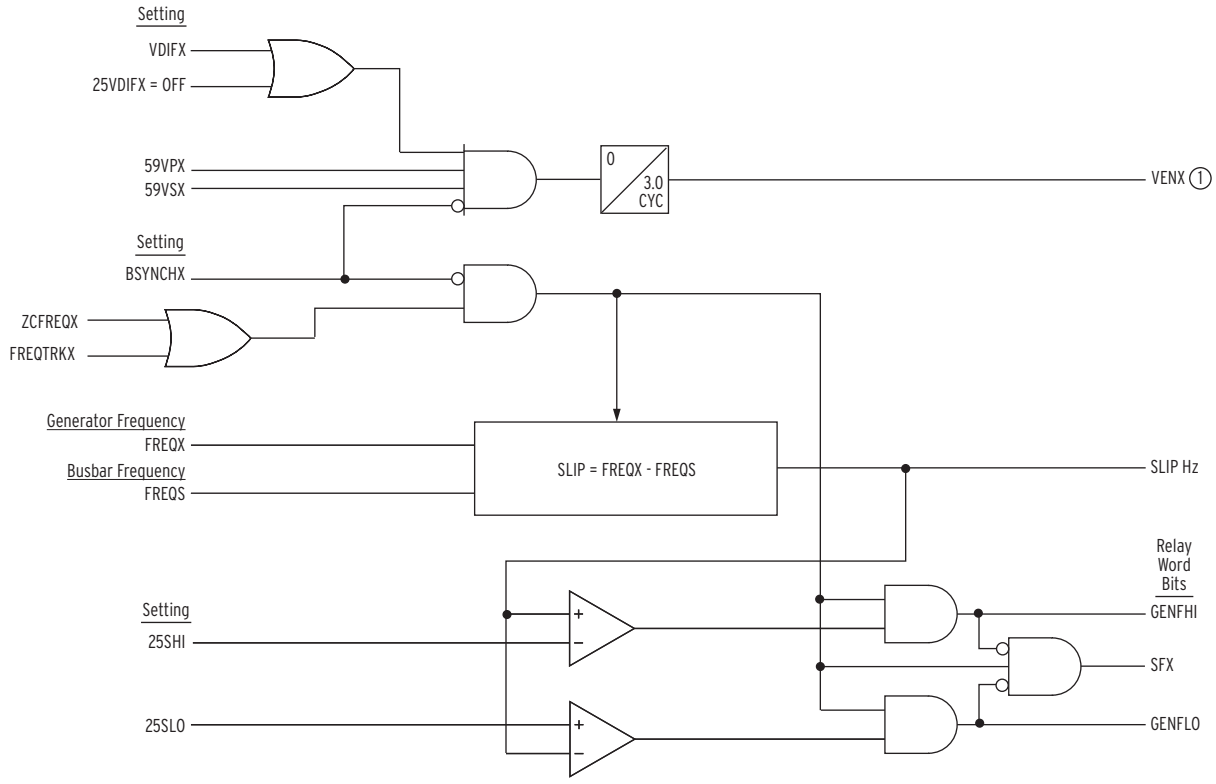
Figure 4.100 Synchronism-Check Function 25RCFX and SYNCPX/SYNCPY Setting Examples

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.

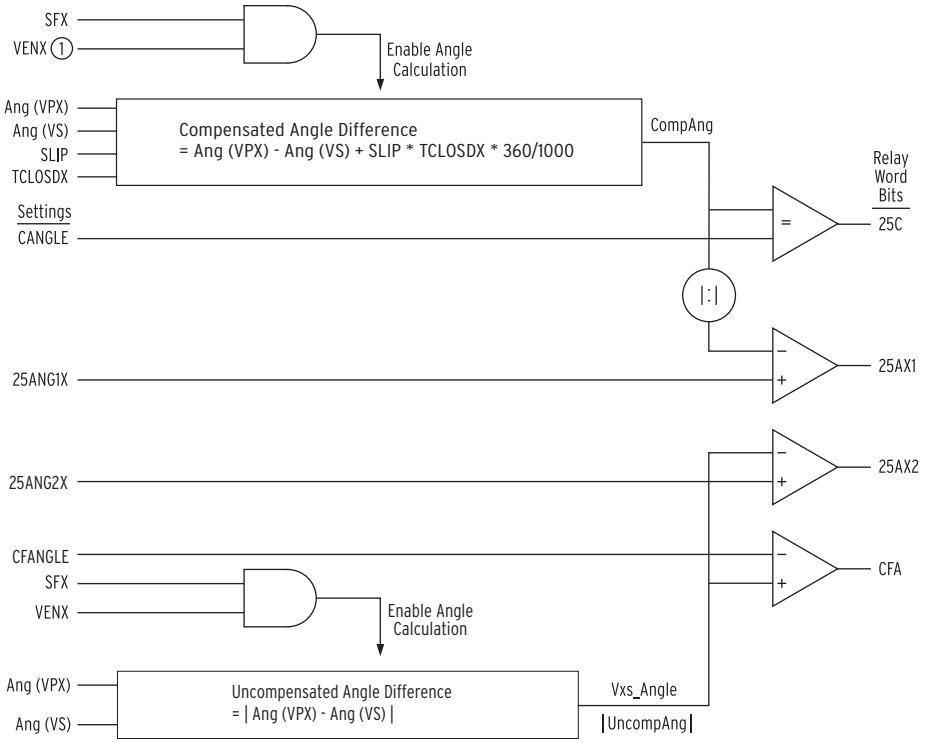
The 25ANG2X setting also defines an acceptable generator breaker closing angle. The relay asserts the 25AX2 Relay Word bit when the generator voltage is within 25ANG2X degrees of the system voltage if the other supervisory conditions also are met. The relay does not account for the breaker time or present 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 for 1/4 cycle to initiate a close. 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. See *Figure 4.101*, *Figure 4.102*, *Figure 4.103*, and *Figure 4.104* for additional detail.



① Figure 4.102

Figure 4.101 Synchronism-Check Function Slip Elements



(1) Figure 4.101

Figure 4.102 Synchronism-Check Function Angle Elements

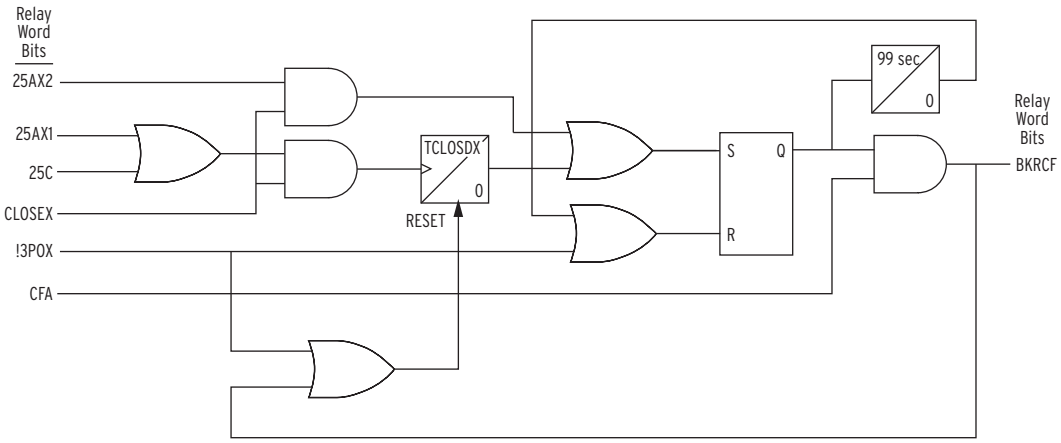


Figure 4.103 Breaker Close Failure Logic Diagram

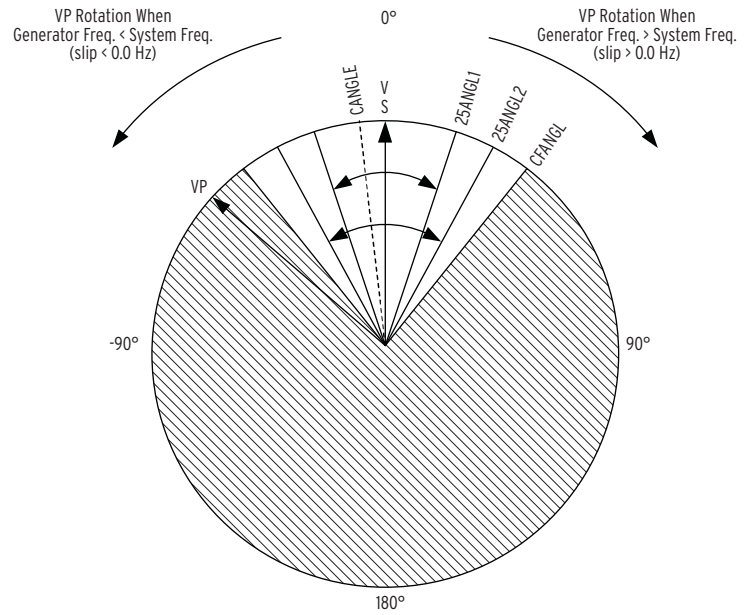


Figure 4.104 Synchronism-Check Function Angle Characteristics

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). Other supervisory conditions may be added if your application requires.

⚠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 required 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 4.100* for a few examples of setting SYNCPX. *Figure 4.100 (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 may 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. Magnitude differences

may be introduced by unmatched voltage transformer or step-up transformer ratios.

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 4.164* 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 above. 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, a breaker failure lockout signal can be used 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 4.100 (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 shown below:

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 4.123* and *Figure 4.124* for additional detail.

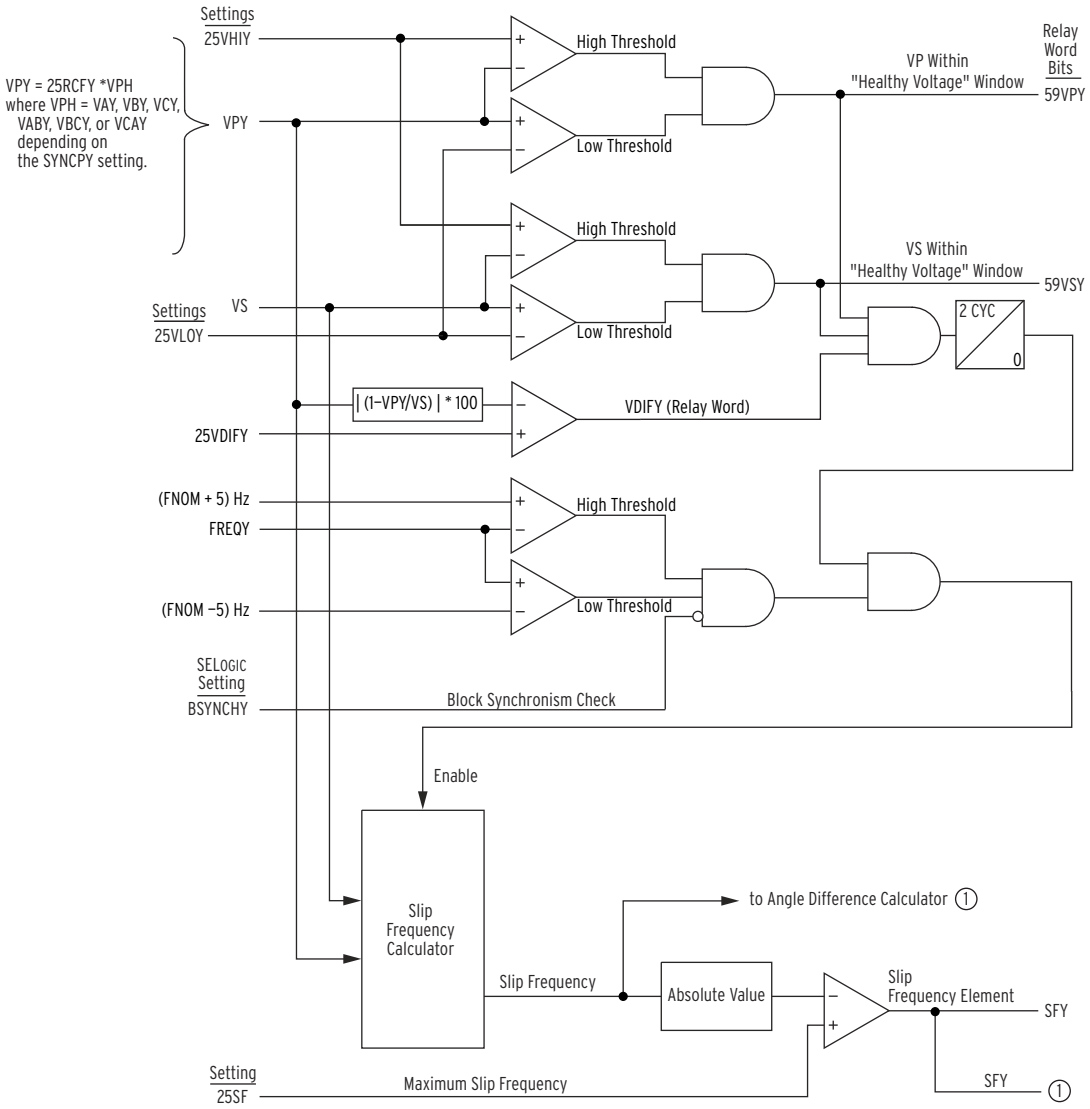
Synchronism-Check Elements (Tie Breaker, Y-Side)

Figure 2.25 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 4.105* and *Figure 4.106*). They have separate angle settings.

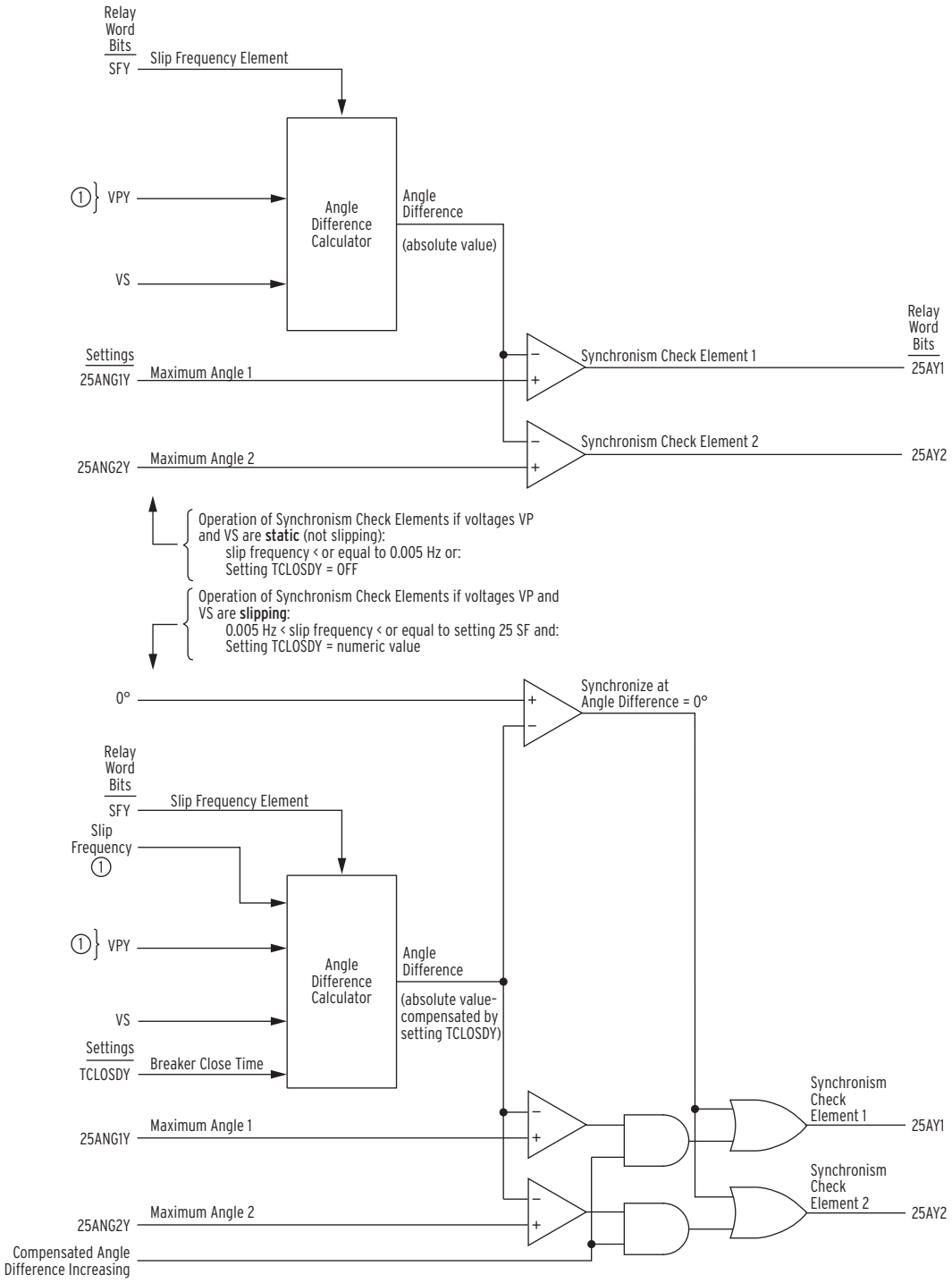
If the voltages are static (voltages not slipping with respect to one another) or setting TCLOSDY := OFF, the two synchronism-check elements operate as shown in the top of *Figure 4.106*. The relay checks these angle settings for synchronism-check closing.

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 4.106*. 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 4.106

Figure 4.105 Synchronism-Check Voltage Window and Slip Frequency Elements



① From Figure 4.105

Figure 4.106 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.

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 4.105*). 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 := 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).

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 4.105*). 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 4.100* 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 4.100 (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 4.105* and *Figure 4.106*.

Voltage Window. Refer to *Figure 4.105*. 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, Relay Word bits 59VPY and 59VSY can be used in other logic at the same time they are used 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 4.105*. 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 needed when the circuit breaker is open):

BSYNCHY := **NOT 3POY** (see *Figure 4.118*)

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

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

Slip Frequency Calculator. Refer to *Figure 4.105*. The synchronism-check element Slip Frequency Calculator in *Figure 4.105* 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 4.105*, 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 4.106* 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 4.106*. If the slip frequency is less than or equal to 0.005 Hz, the angle difference calculator does *not* take into account breaker close time—it presumes voltages VPY and VS are "static" (not "slipping" with respect to one another). This would usually be the case for an open breaker with voltages VPY and VS, which are paralleled via some other electric path in the power system. The angle difference calculator calculates the angle difference between voltages VPY and VS:

Angle Difference = |(∠VPY – ∠VS)|

For example, if SYNCPY := 90 (indicating VS constantly lags VPY = VAY by 90 degrees), but VS actually lags VAY by 100 angular degrees on the power system at a given instant, the angle difference calculator automatically accounts for the 90 degrees and:

$$\text{Angle Difference} = |(\angle \text{VPY} - \angle \text{VS})| = 10^\circ$$

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.

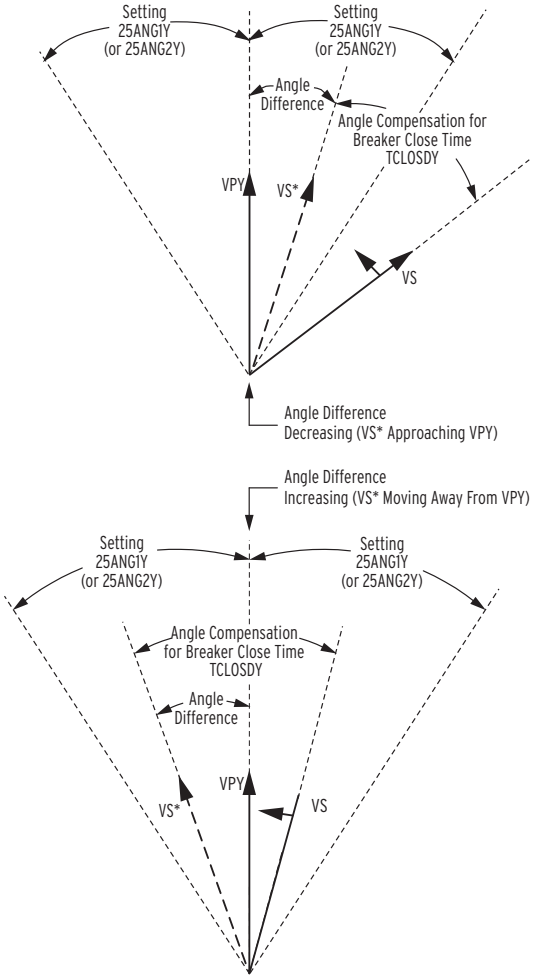


Figure 4.107 Angle Difference Between VPY and VS Compensated by Breaker Close Time (fPY < fS and VPY Shown as Reference in This Example)

Voltages VPY and VS Are "Slipping". Refer to the bottom of *Figure 4.106*. 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 4.107*). The angle difference calculator calculates the angle difference between voltages VPY and VS, compensated with the breaker close time:

$$\text{Angle Difference} = |(\angle\text{VPY} - \angle\text{VS}) + [(\text{fPY} - \text{fS}) \bullet \text{TCLOSDY} \bullet (1 / 1000) \bullet (360^\circ/\text{slip cycle})]|$$

Angle Difference Example (Voltages VPY and VS Are "Slipping"). Refer to the bottom of *Figure 4.106*. For example, if the breaker close time is 100 ms, set TCLOSDY := 100. Presume that the slip frequency is the example slip frequency calculated previously. The angle difference calculator calculates the angle difference between voltages VPY and VS, compensated with the breaker close time:

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

Intermediate calculations:

(fPY – fS) = (59.95 Hz – 60.05 Hz) = –0.10 Hz = –0.10 slip cycles/second
TCLOSDY • (1 / 1000) = 0.1 second

Resulting in:

Angle Difference

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

NOTE: The angle compensation in Figure 4.107 appears much greater than 3.6 degrees. Figure 4.107 is for general illustrative purposes only.

During the breaker close time (TCLOSDY), the voltage angle difference between voltages VPY and VS changes by 3.6 degrees. This angle compensation is applied to voltage VS, resulting in derived voltage VS*, as shown in *Figure 4.107*.

The top of *Figure 4.107* 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 4.107* 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 4.106*) 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 4.106*.

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 4.106*. 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 4.107* 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 4.107* 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 4.123* for additional detail.

SEL-700GT can be applied for synchronism-check supervised closing of breaker 52Y.

EXAMPLE 4.6 For Manual Closing by Input IN302 Set

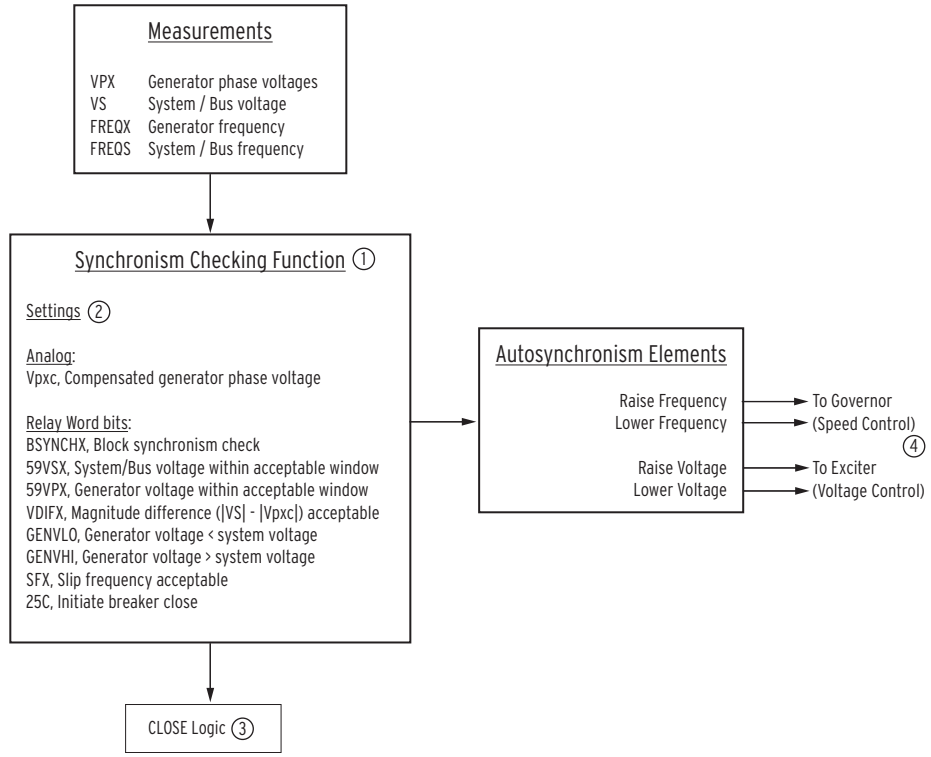
```
CLY := ... OR SV12T AND 25AY1
SV12 := R_TRIG IN302
SV12PU := 0.00
SV12DO := as necessary
```

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 4.108* for an overall block diagram. The relay uses system and compensated generator phase voltages (VS and Vpxc, respectively) and provides an autosynchronism function that:

- Controls generator frequency so that the slip frequency difference between VS and Vpxc is within an acceptable frequency window.
- Controls generator frequency so that the compensated angle difference between Vpxc and VS is within an acceptable window.
- Controls generator voltage, Vpxc, so that Vpxc is within an acceptable magnitude window.



① See Synchronism Elements ② See Table 4.47 ③ See Figure 4.123, Figure 4.124, and Figure 2.23
④ See Figure 2.23

Figure 4.108 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 4.108* shows the Relay Word bits (and other information) from synchronism check that are also used by the autosynchronism elements.

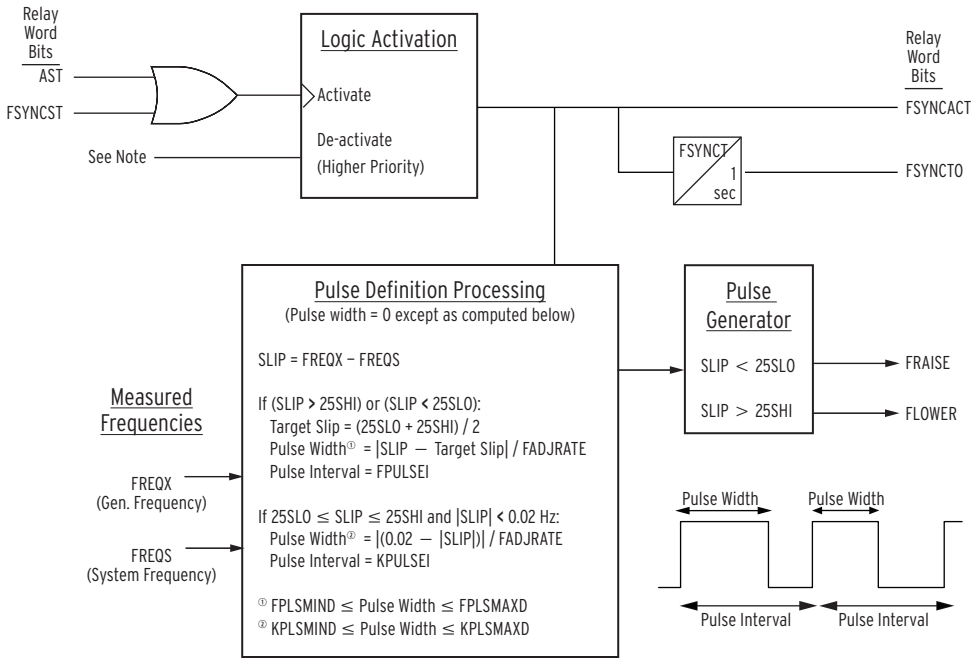
Table 4.49 Autosynchronism Settings

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	0.10–60 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	0.10–60.00 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 4.109* for the functional block diagram of the frequency matching function.



Note: The logic is enabled when settngs E25X := YES and EAUTO := DIG.
The logic is de-activated and disabled when any of the following is true:
- Relay Word bit ASP, 52AX, TRIPX, BSYNCHX, or FSYNCTO is asserted.
- Relay Word bit 59VSX is de-asserted.
- Both Relay Word bit FREQTRKX and ZCFREQX are de-asserted.

Figure 4.109 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 needed.

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

As shown in *Figure 4.109*, 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 required 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

In some cases (that is, either 25SLO or 25SHI is set within +/- 0.02 Hz), the correction pulses described in *Frequency Matching* above 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 4.109*. Set KPLSMIND, KPLSMAXD, and KPULSEI to define minimum / maximum kick pulse width and interval. Refer to the governor data sheet for relevant information.

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.

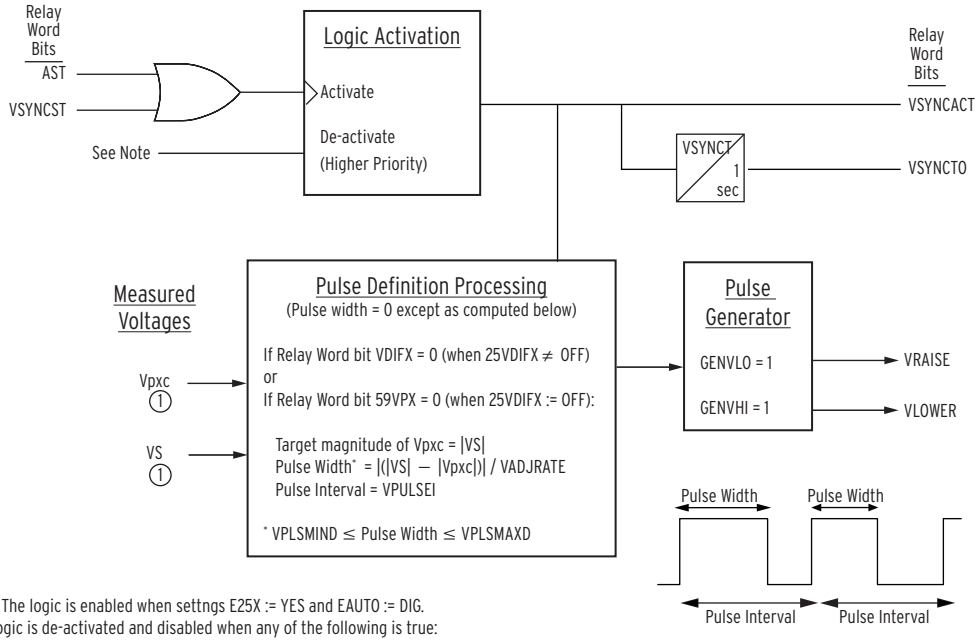
Voltage Matching

Refer to *Figure 4.110* 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 needed.

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 4.58* 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 4.110*. This width is proportional to how far the magnitude is from the target magnitude. Set VADJRATE equal to the exciter/voltage regulator's rate of response to the control pulses. Also, set VPLSMIND and VPLSMAXD to define the minimum and maximum limits of the computed pulse widths.



Note: The logic is enabled when settngs E25X := YES and EAUTO := DIG.
The logic is de-activated and disabled when any of the following is true:
- Relay Word bit ASP, 52AX, TRIPX, BSYNCHX, or VSYNCTO is asserted.
- Relay Word bit 59VSX is de-asserted.
- Both Relay Word bit FREQTRKX and ZCFREQX are de-asserted.

① See Figure 4.98

Figure 4.110 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 required 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 4.111* 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.

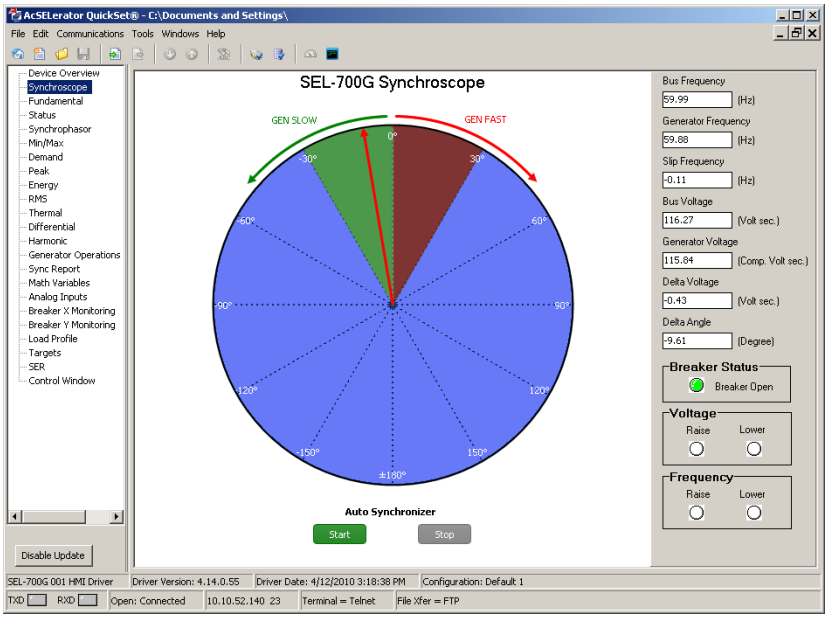


Figure 4.111 Synchroscope

The SEL-700G relay triggers and saves the Generator Autosynchronism Report on the rising edge of Relay Word bit GSRTRG (see *Table 4.91*) or ASCII command GST (see *Section 7: Communications*). See *Figure 4.112* for a sample graphical display of the report and also *Section 3: PC Software* and *Section 9: Analyzing Events* for additional detail.

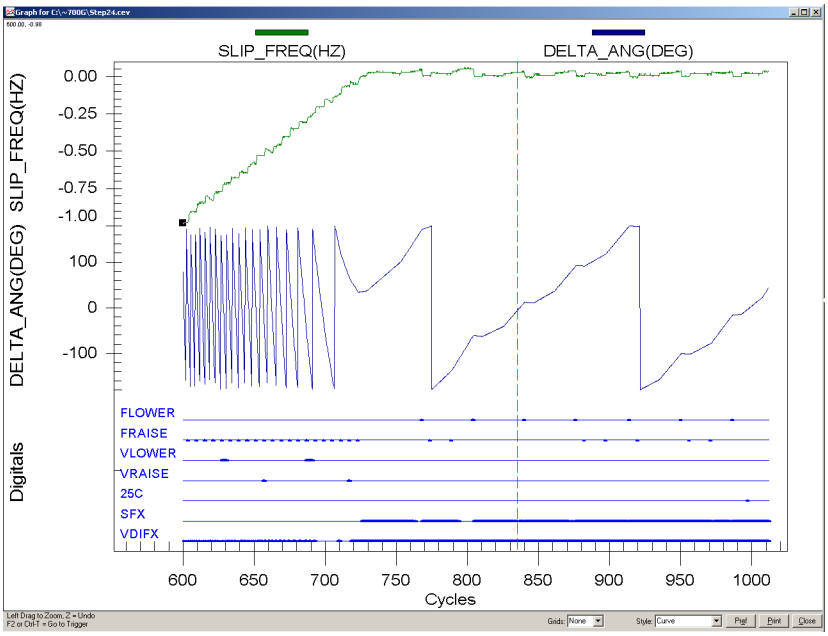


Figure 4.112 Graphical Display of Generator Autosynchronism Report

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 required by 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

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.

NOTE: (Applies to X Side Only). When the global setting EXT3VO_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 4.107*.

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 4.7*).

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 4.7*). 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 4.7 Supervising Protection Elements by LOP

See Figure 4.68 and Figure 4.70 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

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.

NOTE: When DELTAY_X := DELTA and EXT3VO_X := VS/VN, the VO input to the logic is not taken into account.

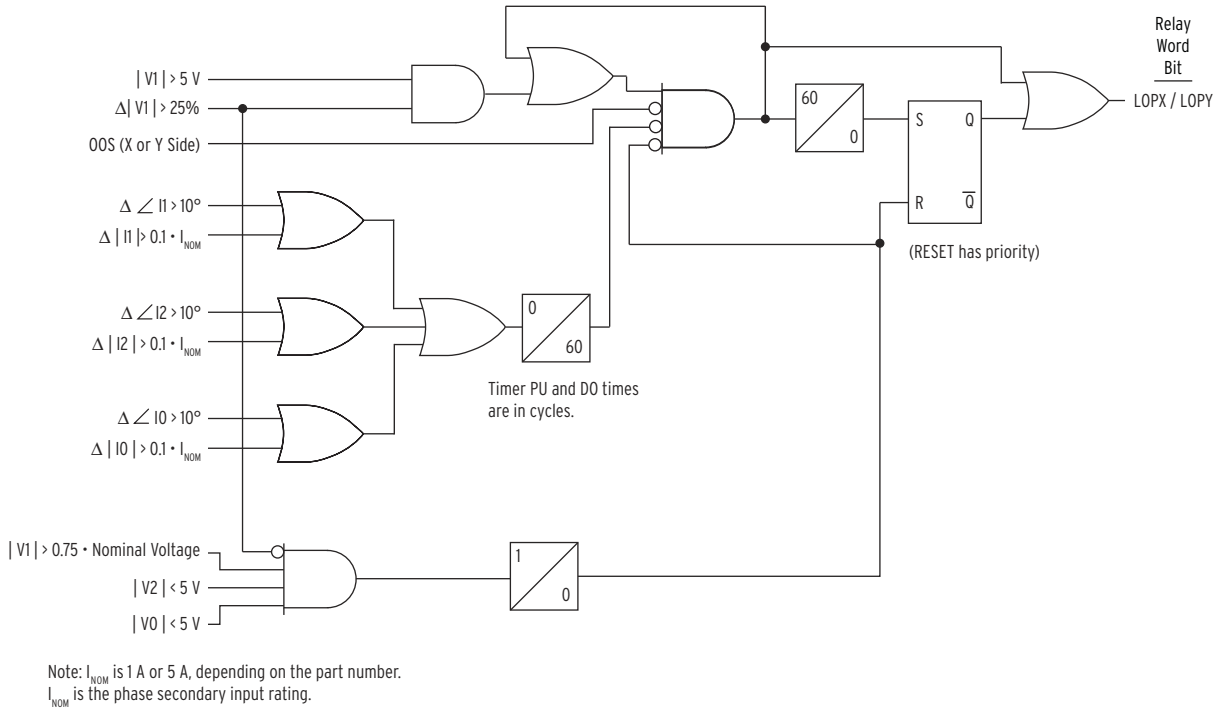


Figure 4.113 Loss-of-Potential Generic Logic (Applies to both X and Y Sides)

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 4.114*. 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.

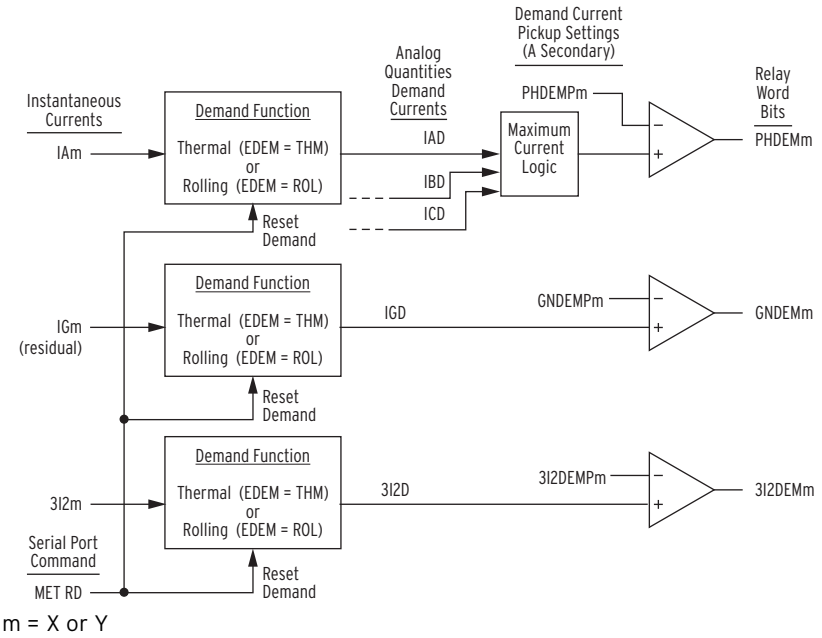


Figure 4.114 Demand Current Logic Outputs

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 4.115* 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").

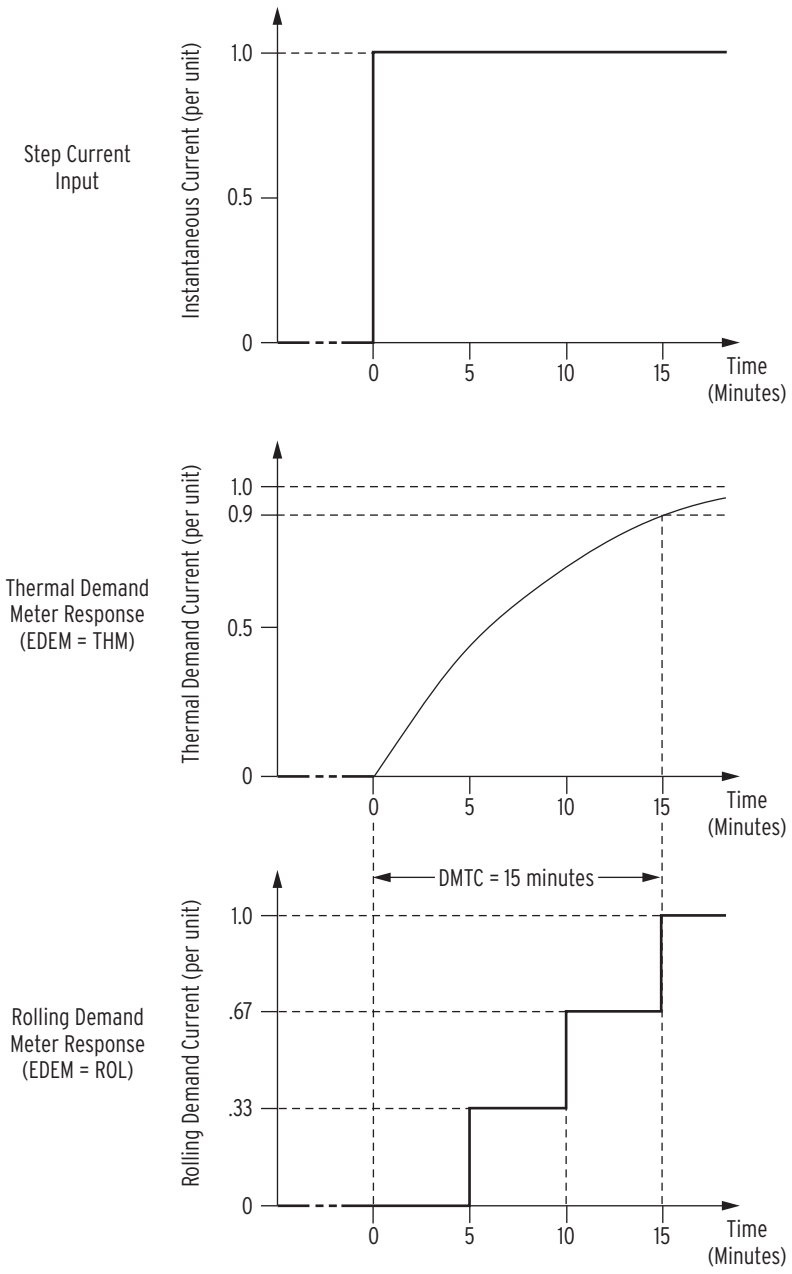


Figure 4.115 Response of Thermal and Rolling Demand Meters to a Step Input (Setting DMTC = 15 minutes)

Thermal Demand Meter Response

The response of the thermal demand meter in *Figure 4.115* (middle) to the step current input (top) is analogous to the series RC circuit in *Figure 4.116*.

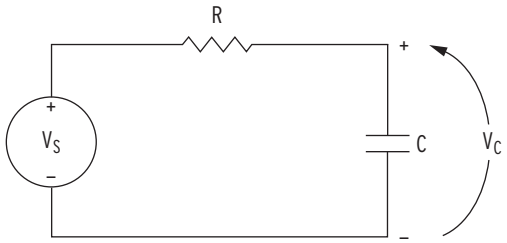


Figure 4.116 Voltage V_S Applied to Series RC Circuit

In the analogy:

- Voltage V_S in *Figure 4.116* corresponds to the step current input in *Figure 4.115* (top).
- Voltage V_C across the capacitor in *Figure 4.116* corresponds to the response of the thermal demand meter in *Figure 4.115* (middle).

If voltage V_S in *Figure 4.116* has been at zero (V_S = 0.0 per unit) for some time, voltage V_C across the capacitor in *Figure 4.116* 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 4.114* (middle) to the step current input (top).

In general, as voltage V_C across the capacitor in *Figure 4.116* 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 4.115* 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 4.115* (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 4.115* 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 4.115* 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 4.115* (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 4.117 and *Figure 4.118* show the logic diagrams for breaker 52X and 52Y, respectively.

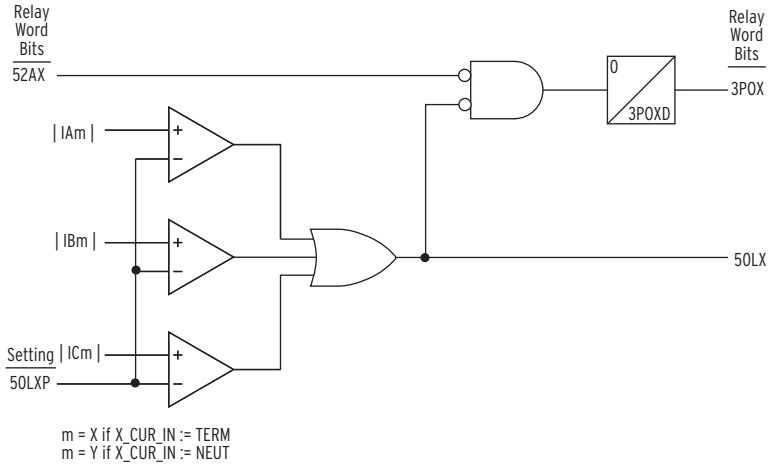


Figure 4.117 Pole Open Logic Diagram, Breaker 52X

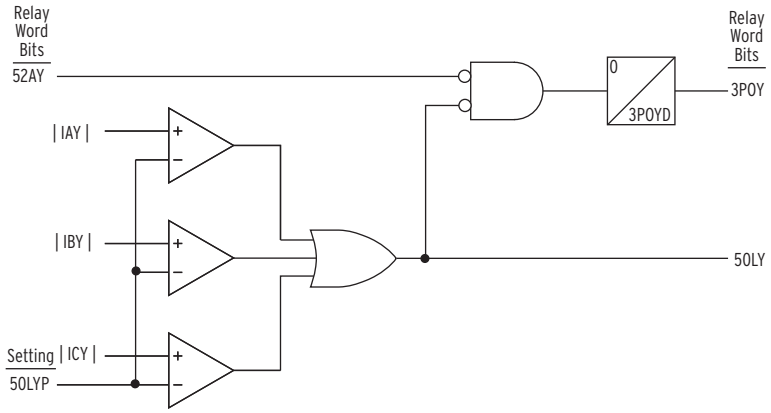


Figure 4.118 Pole Open Logic Diagram, Breaker 52Y

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 a Relay Word bit can be used. 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 4.58 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-700GO 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 4.119*) 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

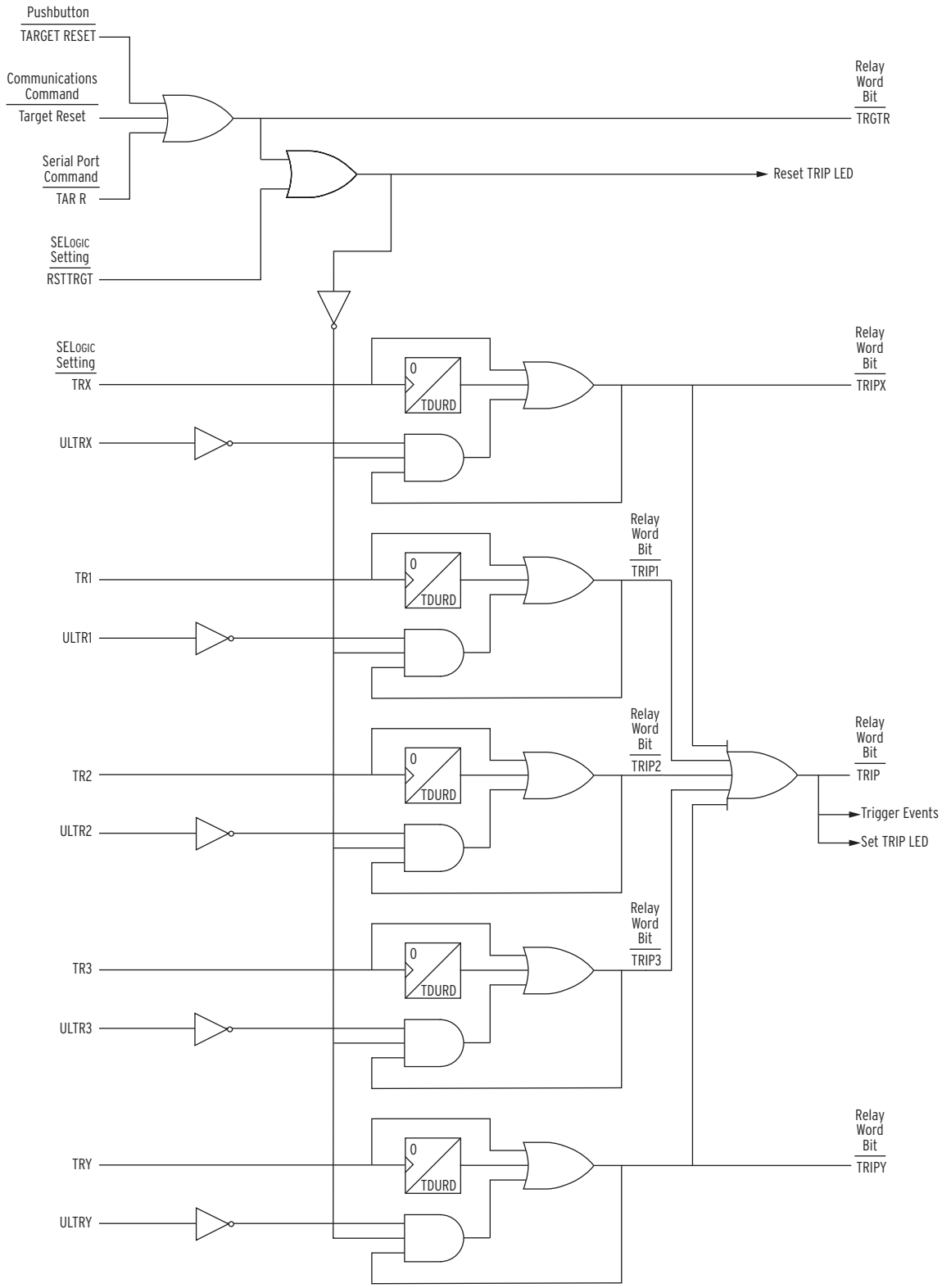


Figure 4.119 Trip Logic

Figure 4.120 through *Figure 4.122* 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.

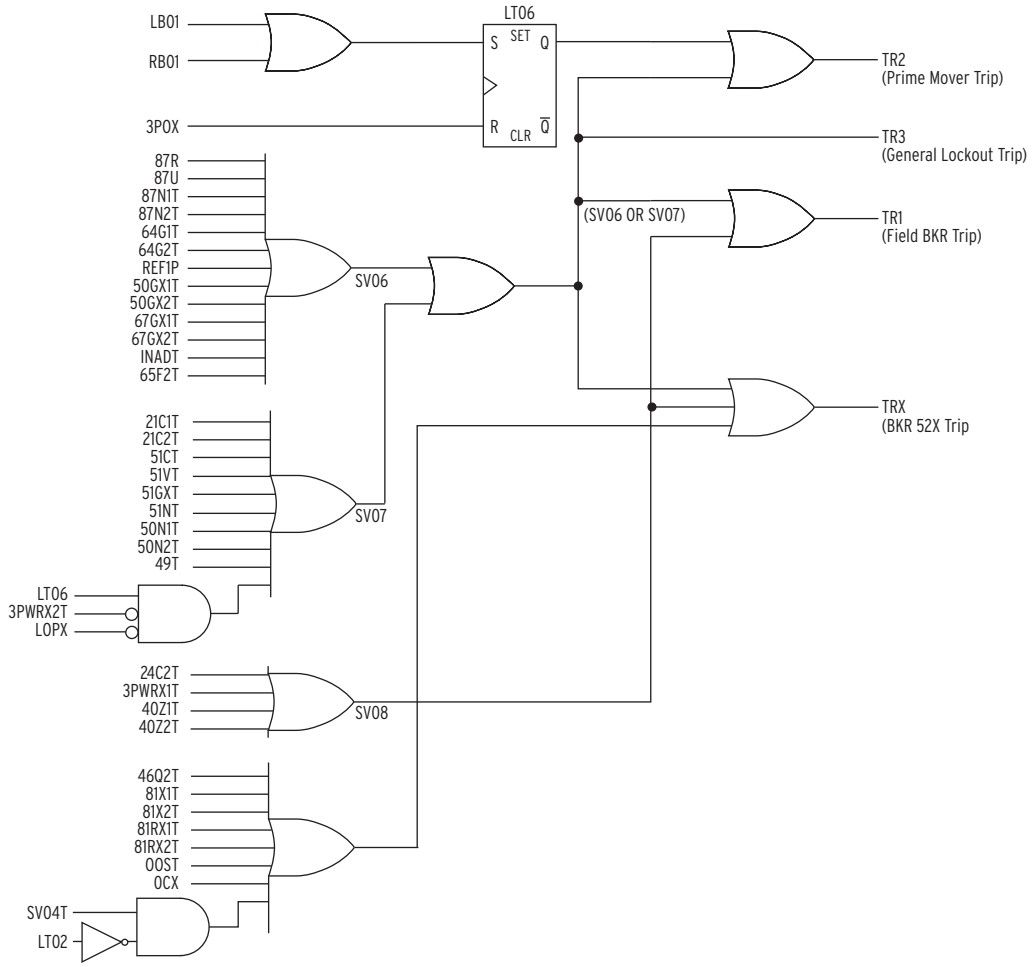


Figure 4.120 Typical Generator Trip TR Logic (SEL-700G0, SEL-700G1, SEL-700GT)

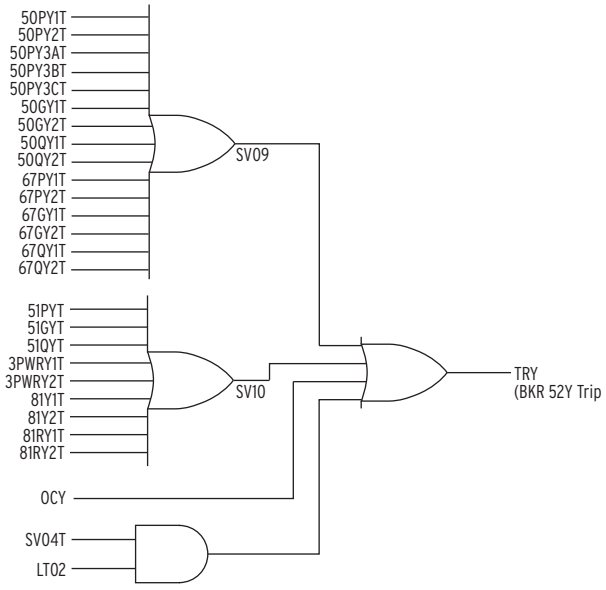


Figure 4.121 Typical Intertie Trip TR Logic (SEL-700GT)

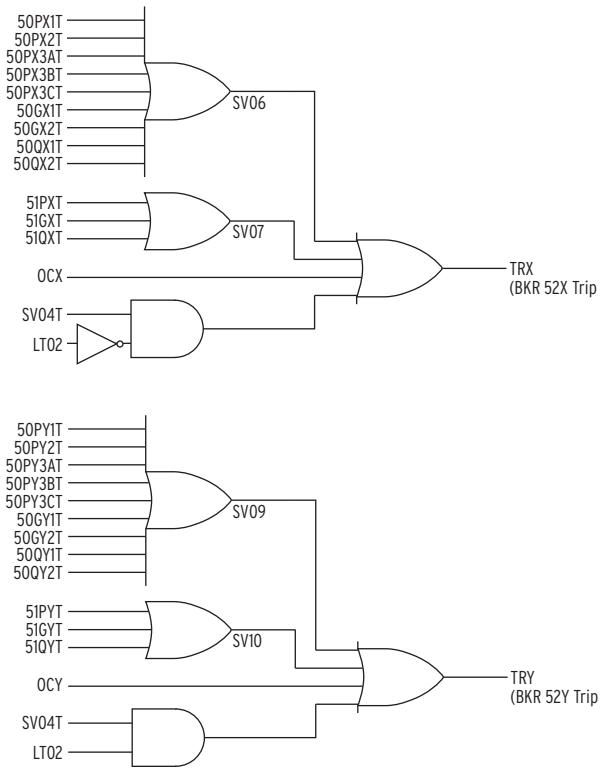


Figure 4.122 Typical Feeder Trip TR Logic (SEL-700GW)

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 4.58* for the output contacts settings. *Figure 2.23*, *Figure 2.26*, and *Figure 2.28* 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 required 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 4.123 shows a close logic diagram of breaker 52X; the logic of breaker 52Y is similar.

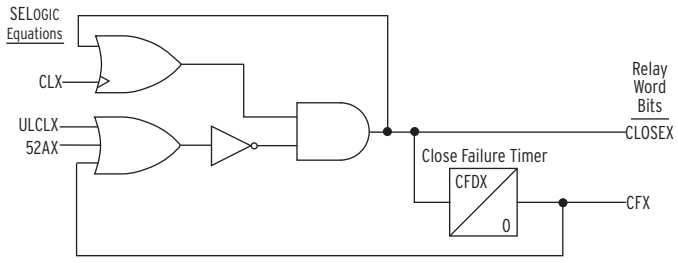


Figure 4.123 Close Logic

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 2.19* 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 required Relay Word bits. See *Figure 4.124* for a typical generator or intertie close logic for the SEL-700G or SEL-700GT and *Figure 4.125* for a typical feeder close logic for the SEL-700GW. Review the default CL*m* equation, and edit it to suit your application.

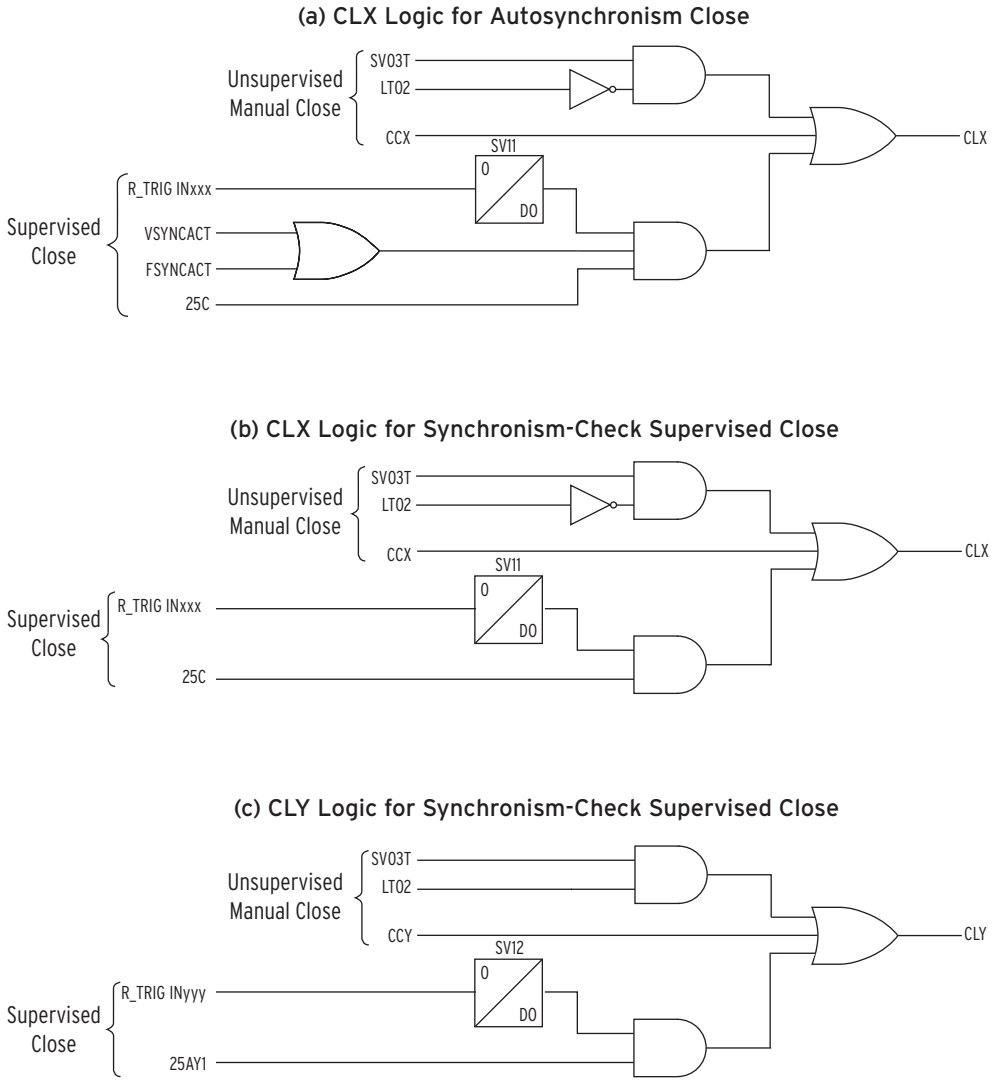


Figure 4.124 Typical Generator or Intertie Close CL Logic (SEL-700G or GT)

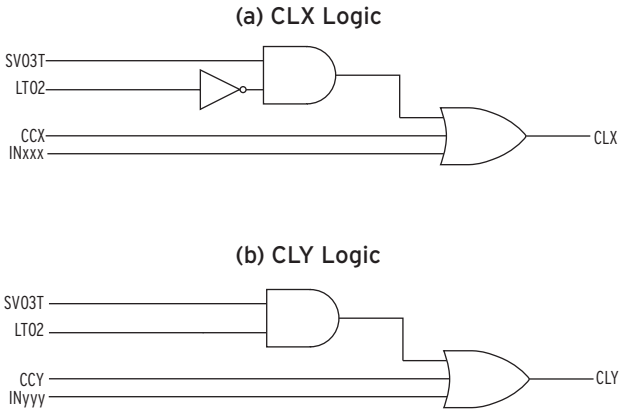


Figure 4.125 Typical Feeder Close CL Logic (SEL-700GW)

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 all 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 4.126*). 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).

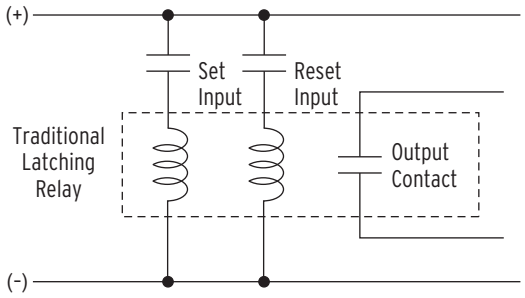


Figure 4.126 Schematic Diagram of a Traditional Latching Device

Thirty-two latch control switches in the SEL-700G provide latching device functionality. *Figure 4.127* 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.

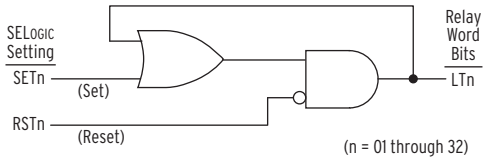


Figure 4.127 Logic Diagram of a Latch Switch

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, & 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, & 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 4.196* 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 70 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 4.128*. Timers SV01T through SV32T in *Figure 4.128* 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).

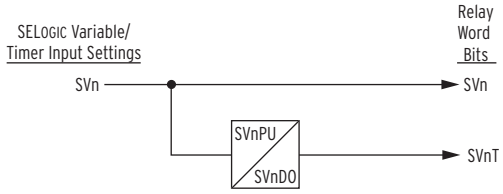


Figure 4.128 SELOGIC Control Equation Variable/Timers SV01/SV01T–SV32T

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	Mathematical
/	divide	
+	add	Mathematical
-	subtract	
<, >, <=, >=	comparison	Boolean
=	equality	Boolean
<>	inequality	
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 above example, the logic within the parentheses is processed first and then the two parentheses resultants are ANDed together. Use up to 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 above 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 4.129*.

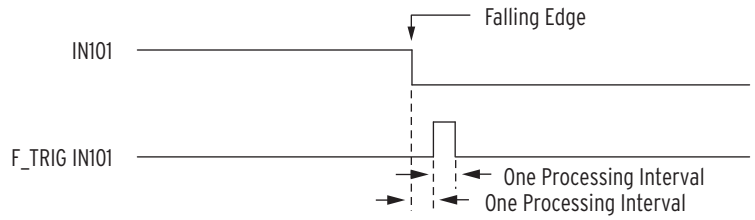


Figure 4.129 Result of Falling-Edge Operator on a Deasserting Input

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 4.130* 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)**

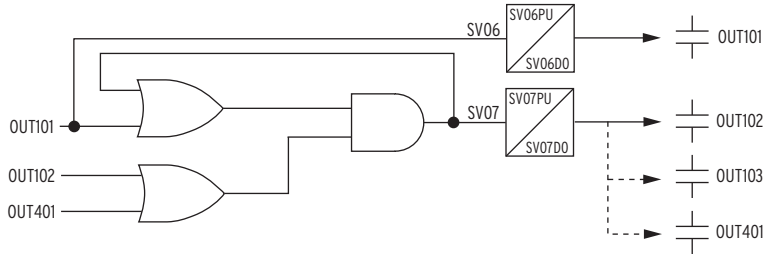


Figure 4.130 Example Use of SELOGIC Variables/Timers

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 := 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	Assigned to generator fault, inadvertent energization, and manual trips for all SEL-700G0, SEL-700G1, & SEL-700GT models.
		SV06 := 50PX1T OR 50PX2T OR 50PX3AT OR 50PX3BT OR 50PX3CT OR 50GX1T OR 50GX2T OR 50QX1T OR 50QX2T	Assigned to X-side instantaneous elements for SEL-700GW.
SV TIMER PICKUP	0.00–3000.00	SV07PU := 0.00	
SV TIMER DROPOUT	0.00–3000.00	SV07DO := 0.00	
SV INPUT	SELOGIC	SV07 := 21C1T OR 21C2T OR 51CT OR 51VT OR 51GXT OR 51NT OR 50N1T OR 50N2T OR 49T OR LT06 AND NOT 3PWRX2T AND NOT LPOX	Assigned to prolonged system faults, overload, and neutral overcurrent trips for all SEL-700G0, SEL-700G1, & SEL-700GT models.
		SV07 := 51PXT OR 51GXT OR 51QXT	Assigned to X-side time-overcurrent trips for SEL-700GW.
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, & GT models.
		SV08 := 0	Not used in SEL-700GW default

Table 4.57 SELOGIC Variable Settings (Sheet 3 of 3)

Setting Prompt	Setting Range	Default Settings	Description
SV TIMER PICKUP	0.00–3000.00	SV09PU := 0.00	.
SV TIMER DROPOUT	0.00–3000.00	SV09DO := 0.00	
SV INPUT	SELOGIC	SV09 := 50PY1T OR 50PY2T OR 50PY3AT OR 50PY3BT OR 50PY3CT OR 50GY1T OR 50GY2T OR 50QY1T OR 50QY2T OR 67PY1T OR 67PY2T OR 67GY1T OR 67GY2T OR 67QY1T OR 67QY2T	Assigned to Y-side instantaneous overcurrent trips for all 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-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 & 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	
• • •	• • •		

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.

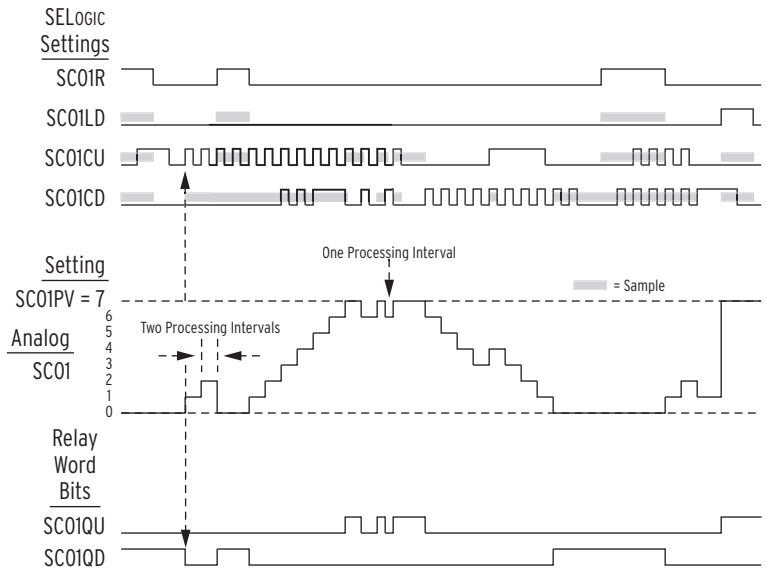


Figure 4.131 Example of the Effects of the Input Precedence

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 above 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.

Table 4.58 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.

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.

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 2.14*), 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 4.59 General Global Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
RATED FREQ.	50, 60 Hz	FNOM := 60
DATE FORMAT	MDY, DMY,	DATE_F := MDY
FAULT CONDITION	SELOGIC	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

Event Messenger Points

The SEL-700G can be configured 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 any device capable of receiving ASCII messages can be used.

Table 4.60 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 can be used 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 4.8*).

EXAMPLE 4.8 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 (up to 6, defaults to 6 if omitted)

f indicates floating point value (use %d for the nearest whole number)

EXAMPLE 4.9 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 4.61 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 above, 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 4.62 shows the time and date management settings that are available in the Global settings.

Table 4.62 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 HTTP (Web) Server uses the UTC_OFF setting to calculate UTC timestamps in request headers.

The relay also 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 2.16* connections do not provide breaker currents to the relay.

The SEL-700G provides flexible breaker failure logic for up to two breakers (see *Figure 4.132*). 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 4.63 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.

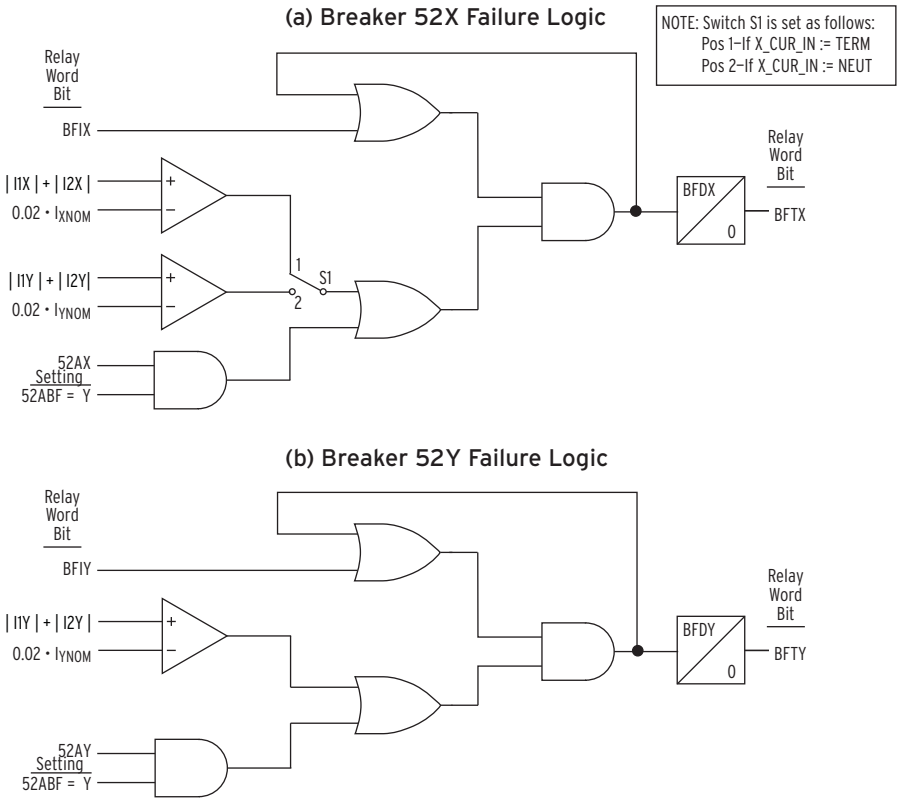


Figure 4.132 Breaker Failure Logic

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

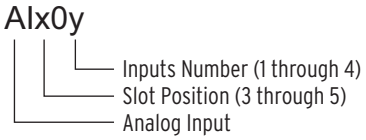


Figure 4.133 Analog Input Card Adaptive Name

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

Table 4.64 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 AIx0yNAM setting cannot accept the following and will issue the Invalid Element message:
Analog Quantities
Duplicate Names
Other AI Names

Because the analog card is in Slot **3**, type **SET G AI301NAM <Enter>** to go directly to the setting for Slot **3**, Input 1. Although the device accepts alphanumeric characters, the name for the AI*x*0*y*NAM setting must begin with an alpha character (A through Z) and not a number. The device displays the following prompt:

```
AI301 TAG NAME (8 Characters)   AI301NAM:= AI301 ?
```

Use the Instrument Tag Name to give the analog quantity a more descriptive name. This tag name, instead of the default name of AI301, appears in reports (EVENT, METER, and SUMMARY). SELOGIC control equations, signal profiles, and Fast Message Read use the default names. Use up to 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 4.134*. 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 4.134 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 4.65 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 4.65 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 4.135* shows the *x* and *y* variable allocation for the analog output card.

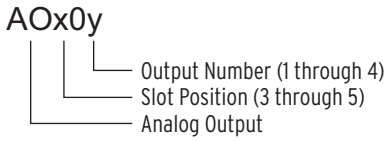


Figure 4.135 Analog Output Number Allocation

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 4.66 shows the setting prompt, setting range, and factory default settings for an analog card in Slot **3**.

Table 4.66 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).

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

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 4.136*. 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 4.136 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 4.137 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).

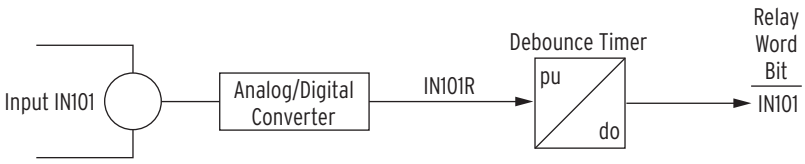


Figure 4.137 DC Mode Processing

AC Mode Processing (AC Control Voltage)

Figure 4.138 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.

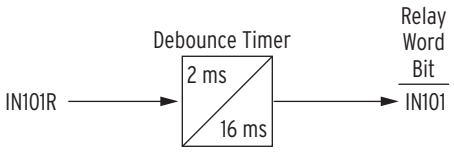


Figure 4.138 AC Mode Processing

Figure 4.139 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 4.139*). If IN101R deasserts (points marked 2 in *Figure 4.139*) 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.

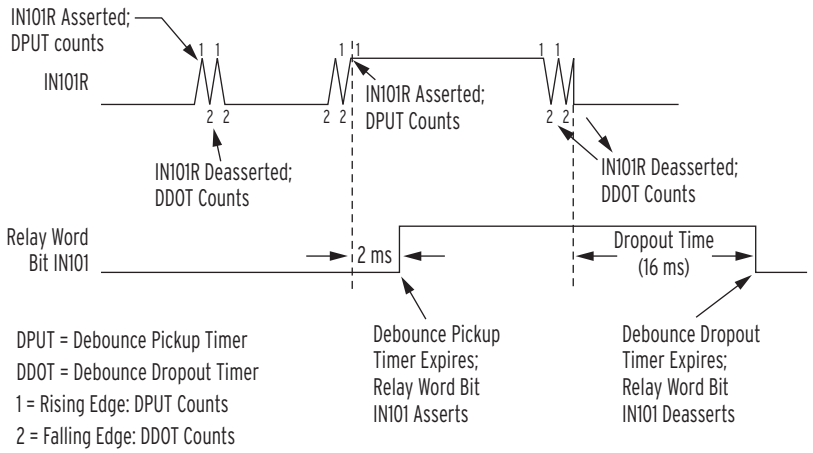


Figure 4.139 Timing Diagram for Debounce Timer Operation When Operating in AC Mode

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 4.67 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 4.67 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 4.116* 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 4.114* for the demand current logic diagram.

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

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

Table 4.68 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 4.69* 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 2.19* and *IRIG-B on page 7.5* for additional information.

Table 4.69 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 4.70* through *Table 4.74* 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 4.70 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).

Table 4.71 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 Equations (Hidden if PROTO is not MBxx on any of the communications ports) on page SET.36. For additional settings when PROTO := DNP, see Table D.7 for a complete list of the DNP3 session settings.

Table 4.72 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 Equations (Hidden if PROTO is not MBxx on any of the communications ports) on page SET.36. For additional settings when PROTO := DNP, see Table D.7 for a complete list of the DNP3 session settings.

Table 4.73 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 Equations (Hidden if PROTO is not MBxx on any of the communications ports) on page SET.36. For additional settings when PROTO := DNP, see Table D.7 for a complete list of the DNP3 session settings.

Table 4.74 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 4.75* 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 4.75 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 up to 32 display points. Use the ELB setting to enable up to 32 local bits.

Table 4.76 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 4.77 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 up to 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 4.78* 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 4.78* shows examples of the settings that always, never, or conditionally hide a display point.

Table 4.78 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 4.79 Entries for the Four Strings

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

Figure 4.140 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)                       TO1LEDL := 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 4.140 Display Point Settings

Figure 4.141 shows the display when both HV and LV breakers are open (both IN101 and IN102 deasserted). *Figure 4.142* shows the display when the HV breaker is closed, and the LV breaker is open (IN101 asserted, but IN102 still deasserted).

Figure 4.141 Front-Panel Display—Both HV and LV Breakers Open

Figure 4.142 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 4.143*.

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 4.144*.

Figure 4.143 Front-Panel Display—Both HV and LV Breakers Closed

Figure 4.144 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:

```
DPO1    := 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 4.145*.

Figure 4.145 Front-Panel Display—HV Breaker Open, LV Breaker Closed

Name Only

Table 4.80 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:

```
DPO1    := RID, "{16}"
 ? IN101 <Enter>
```

Table 4.80 Binary Entry in the Name String Only

Name	Alias	Set String	Clear String
IN101	—	—	—

Figure 4.146 shows the front-panel display for the entry in *Table 4.80*. Input IN101 is deasserted in this display (`IN101=0`), but the display changes to `IN101=1` when Input IN101 asserts.

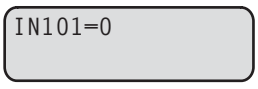


Figure 4.146 Front-Panel Display for a Binary Entry in the Name String Only

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

Table 4.81 Analog Entry in the Name String Only

Name	Alias	Set String	Clear String
AI301	—	—	—

Figure 4.147 shows the front-panel display for the entry in *Table 4.81*, when you use the **SET F** command, as follows:

```
PO1    := RID, “{16}”
? AI301 <Enter>
```

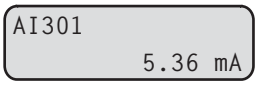


Figure 4.147 Front-Panel Display for an Analog Entry in the Name String Only

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 4.82* 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 4.82 Entry in the Name String and the Alias Strings

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

Figure 4.148 shows the front-panel display for the entry in *Table 4.82*. Input IN101 is deasserted in this display (0), and the display changes to `INPUT IN101=1` when Input IN101 asserts.

Figure 4.148 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 4.149*.

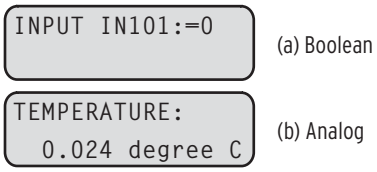


Figure 4.149 Front-Panel Display for an Entry in (a) Boolean Name and Alias Strings and (b) Analog Name, User Text and Formatting Strings, and Engineering Units

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

Table 4.83 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 4.150* 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)                       TO1LEDL := 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 4.150 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 4.151*.

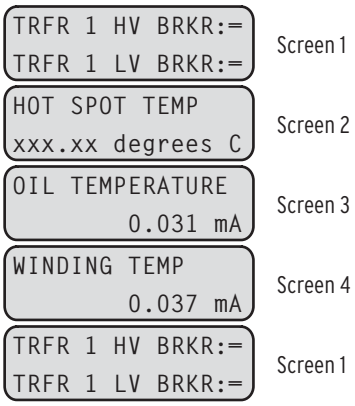


Figure 4.151 Rotating Display

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 4.152* 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)                       TO1LEDL := 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 4.152 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 4.84 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 4.84 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 4.84 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-700GO 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 4.85 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 4.85 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 4.85 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-700GO 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 4.87* (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 4.86* shows the auto-removal settings.

Table 4.86 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.

The user 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 4.87* shows the settings prompt and the default settings for the four SER trigger equations.

Table 4.87 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 up to 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 in the SER settings above 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 up to 20 unique aliases, as defined by the Enable Alias Settings (EALIAS) setting. Factory default alias settings are shown in *Table 4.89*.

Table 4.88 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 4.89 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 4.90 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 4.92*. The resolution and number of pre-trigger data samples are defined by the settings GSRR and PRESYNC and can be set as necessary.

Table 4.91 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 4.111* 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 4.92 Generator Autosynchronism Report Data

Data	Description	Remarks
Analog Data: DELTA_VOLT VS SLIP_FREQ FREQS DELTA_ANGLE	(From *Figure 4.98*) 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 up to 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 4.93 Load Profile Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
LDP LIST	0, Up to 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 4.94 shows the available settings. See *Appendix D: DNP3 Communications* for additional details.

Table 4.94 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 4.94 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 4.95 shows the available settings. See *Appendix E: Modbus RTU Communications* for additional details.

Table 4.95 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.

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 up to 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 4000 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*.

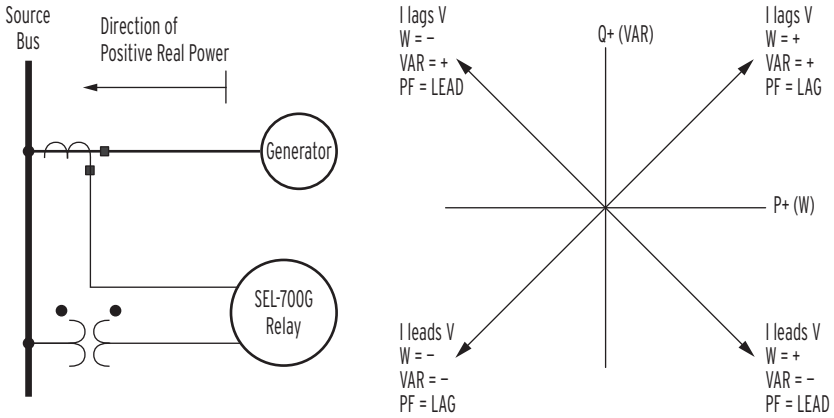


Figure 5.1 Complex Power Measurement Conventions

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 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

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) ➤ 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 (requires SEL-2664 Field Ground Module)

All angles are displayed between –180 and +180 degrees. The angles are referenced to VAB*n,* VAN*n* (for delta- or wye-connected PT, respectively), or IA*n* (*n* = X or Y). If the voltage channels are not supported, if VAB*n* < 13 V (for delta-connected PT), or if VAN*n* < 13 V (for wye-connected PT), the angles are referenced to IA*n* current. If the relay includes both X and Y-side quantities, the angles are referenced to the X-side quantity. *Figure 5.2* shows an example of the **METER** command report.

```
=>MET <Enter>

SEL-700G                                Date: 02/24/2010   Time: 11:43:44.875
GENERATOR RELAY                         Time Source: Internal

                IAX      IBX      ICX      IGX      I1X     3I2X
Mag (A pri.)    505.1    501.2    499.4      6.9    501.9      3.2
Angle (deg)     -30.0   -149.9     89.9    -44.8    -30.0     -4.0

                IAY      IBY      ICY      IGY      I1Y     3I2Y
Mag (A pri.)    500.7    502.5    500.1      9.2    501.1      4.9
Angle (deg)     150.0     30.6    -89.1     40.7    150.5     83.8

                IN
Mag (A pri.)      0.0
Angle (deg)     143.8

                VAX      VBX      VCX      VGX      V1X     3V2X
Mag (V pri.)  9978.0   9982.1   9986.7     53.6   9982.2     38.6
Angle (deg)      0.0   -120.3    120.0    151.5     -0.1     27.1

                VS       VN
Mag (V pri.)      0.0     0.00
Angle (deg)    -102.7    16.9

                VN3     VPX3
Mag (V pri.)     0.66     3.94

                          AX             BX             CX             3PX
Real Pwr (kW)               4362           4348           4312          13023
Reactive Pwr (kVAR)         2523           2474           2505           7503
Apparent Pwr (kVA)          5040           5003           4987          15029
Pwr Factor                  0.87           0.87           0.87           0.87
                           LAG            LAG            LAG            LAG

                FREQX  FREQS
Frequency (Hz)  60.00  60.00

V/Hz (%)                 100.5
Field Resistance (kOhm)  19276.6

=>
```

Figure 5.2 METER Command Report for SEL-700G1 With Synchronism Check and Neutral Voltage Inputs

Thermal Metering

The thermal metering function reports the RTD meter values (see *Table 5.2* for details) and also reports the state of connected RTDs, if any have failed (see *Table 5.3* for details). The report also displays % generator thermal capacity used and % RTD-based thermal capacity used quantities for selected models with thermal model element.

Table 5.2 Thermal Meter Values

Relay Option	Thermal Values
With External SEL-2600 RTD Module or Internal RTD Option	All RTD Temperatures
Models With Thermal Model Element Enabled	% Generator Thermal Capacity Used % RTD-based Thermal Capacity Used

Table 5.3 RTD Input Status Messages

Message	Status
Open	RTD leads open
Short	RTD leads shorted
Comm Fail	Fiber-optic communications to SEL-2600 RTD Module have failed
Stat Fail	SEL-2600 RTD Module self-test status failure

Figure 5.3 provides an example of the **METER T** command report.

```
=>MET T <Enter>
SEL-700G                                Date: 02/24/2010   Time: 15:09:23.117
GENERATOR RELAY                         Time Source: Internal
Max Winding RTD    96 C
Max Bearing RTD    72 C
Ambient RTD        35 C
Max Other RTD     168 C
 RTD1 WDG      91 C
 RTD2 WDG      94 C
 RTD3 WDG      96 C
 RTD4 BRG      24 C
 RTD5 BRG      48 C
 RTD6 BRG      72 C
 RTD7 AMB      35 C
 RTD8 OTH 1   120 C
 RTD9 OTH 2   144 C
RTD10 OTH 3   168 C
Generator TCU (%)   76.2
RTD TCU (%)         72
=>>
```

Figure 5.3 MET T Report for SEL-700GO Model

Energy Metering

The SEL-700G with the voltage option includes energy metering. *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.

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

```
=>>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 the user 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 (Sheet 1 of 2)

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.

Table 5.4 Maximum/Minimum Meter Values (Sheet 2 of 2)

Relay Option	Maximum/Minimum Meter Values
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 4.181* 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 it 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. The **METER PM** *xx:yy:zzz* command can be used 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 4.235*). 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 4,000 time-stamped entries. For example, if you choose to monitor 10 values at a rate of every 15 minutes, you could store 41.67 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.

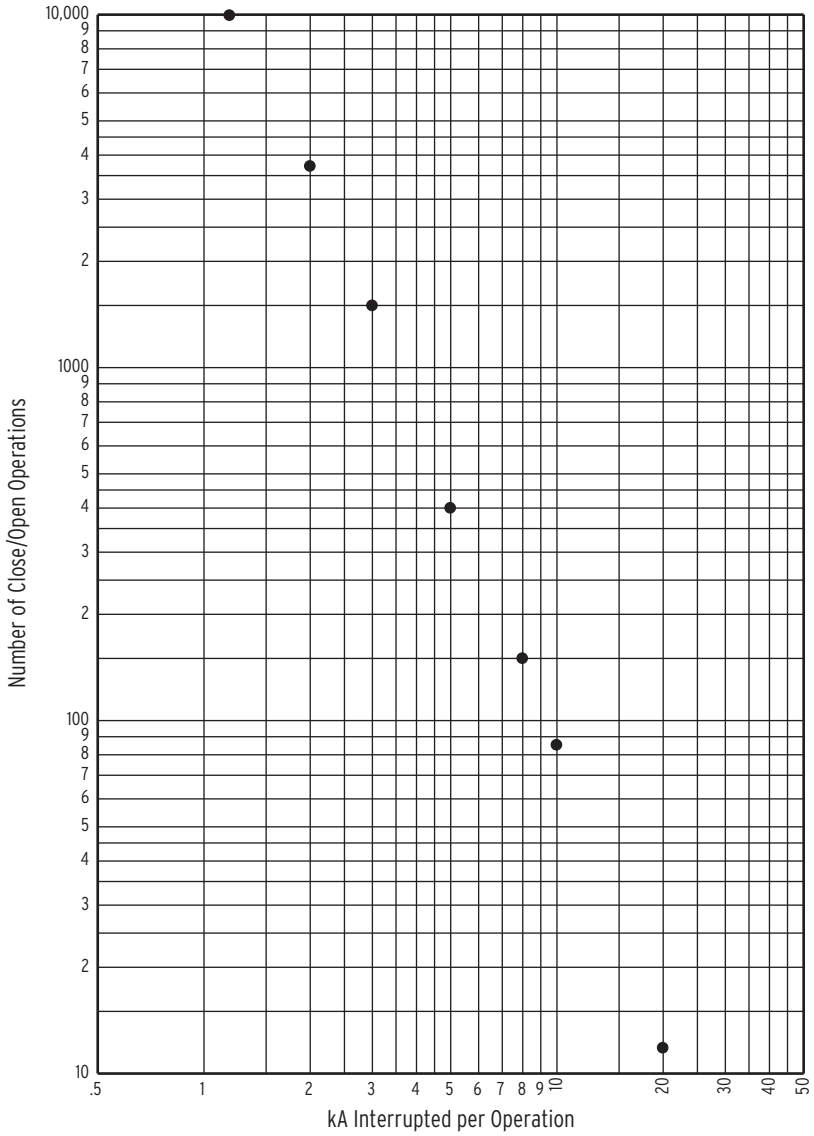


Figure 5.17 Plotted Breaker Maintenance Points for a 25 kV Circuit Breaker

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*.

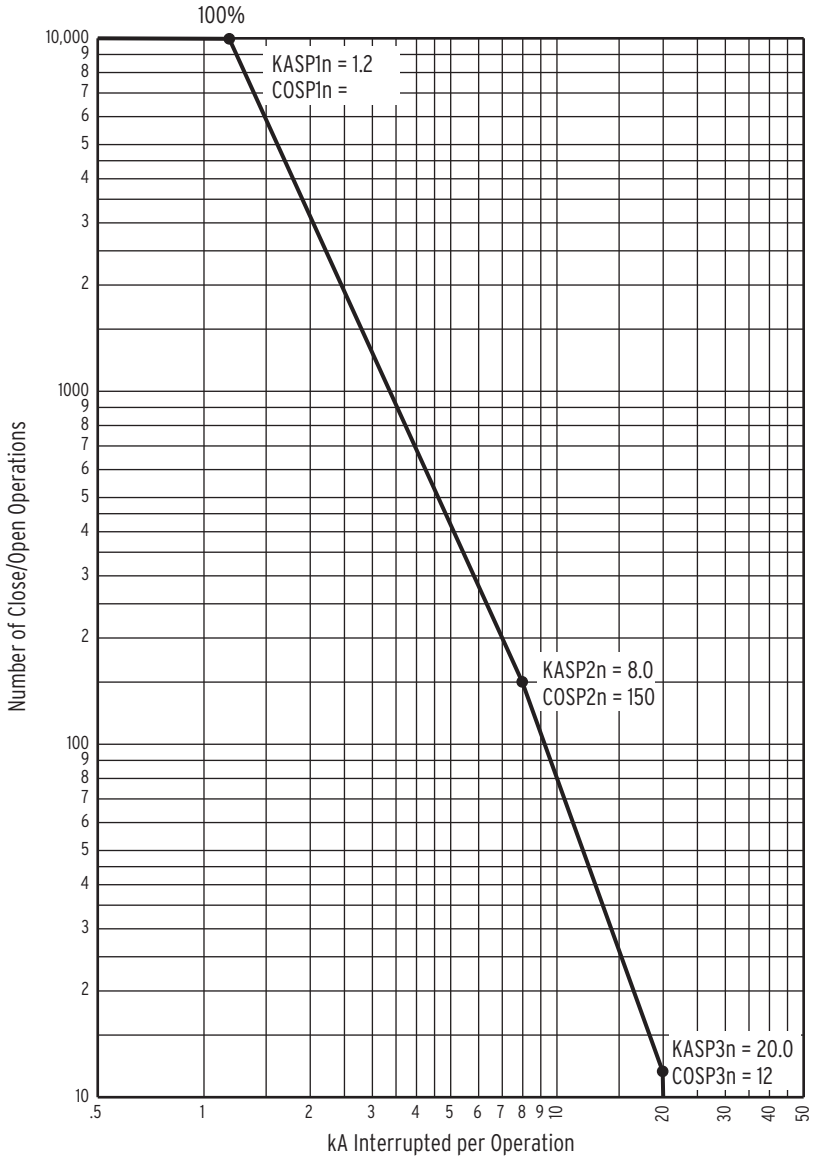


Figure 5.18 SEL-700G Breaker Maintenance Curve for a 25 kV Circuit Breaker

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 4.29*)

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.

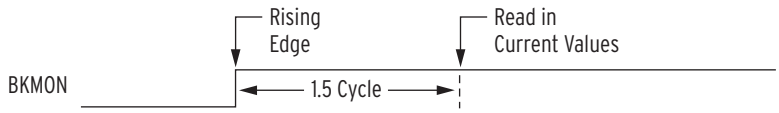


Figure 5.19 Operation of SELOGIC Control Equation Breaker Monitor Initiation Setting

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.

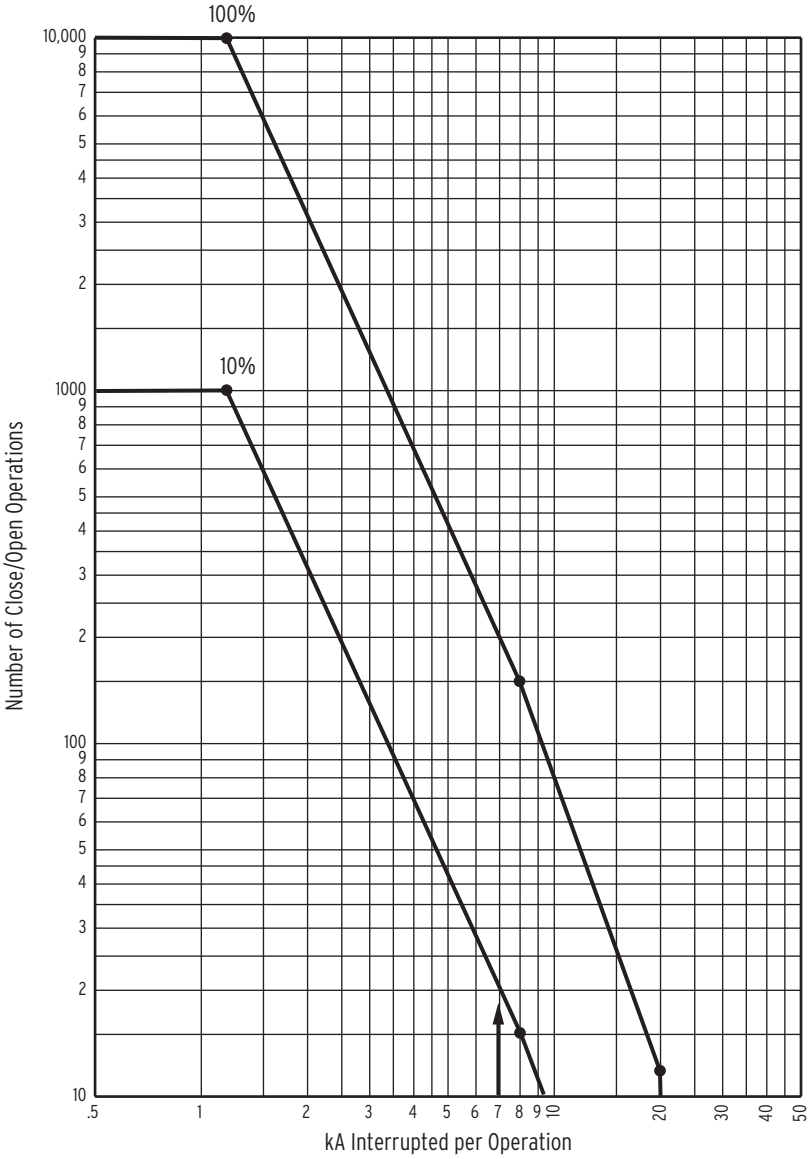


Figure 5.20 Breaker Monitor Accumulates 10 Percent Wear

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.

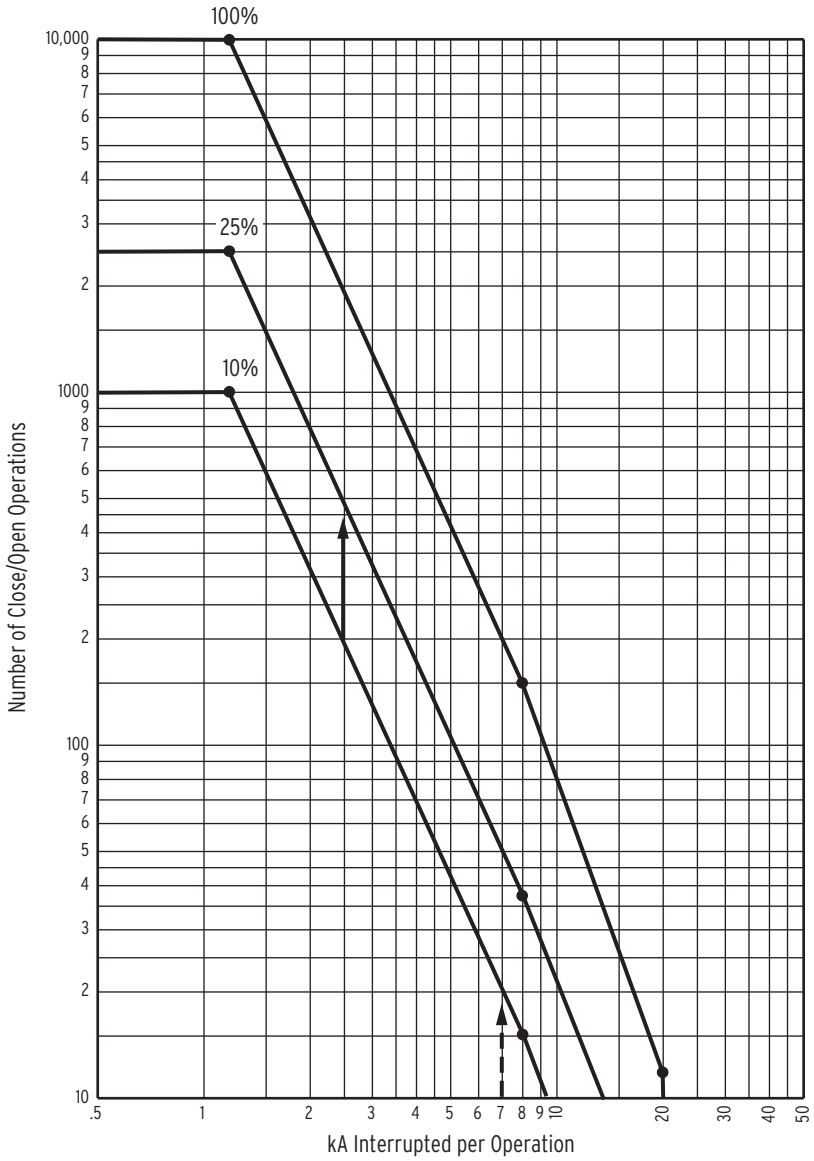


Figure 5.21 Breaker Monitor Accumulates 25 Percent Wear

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.

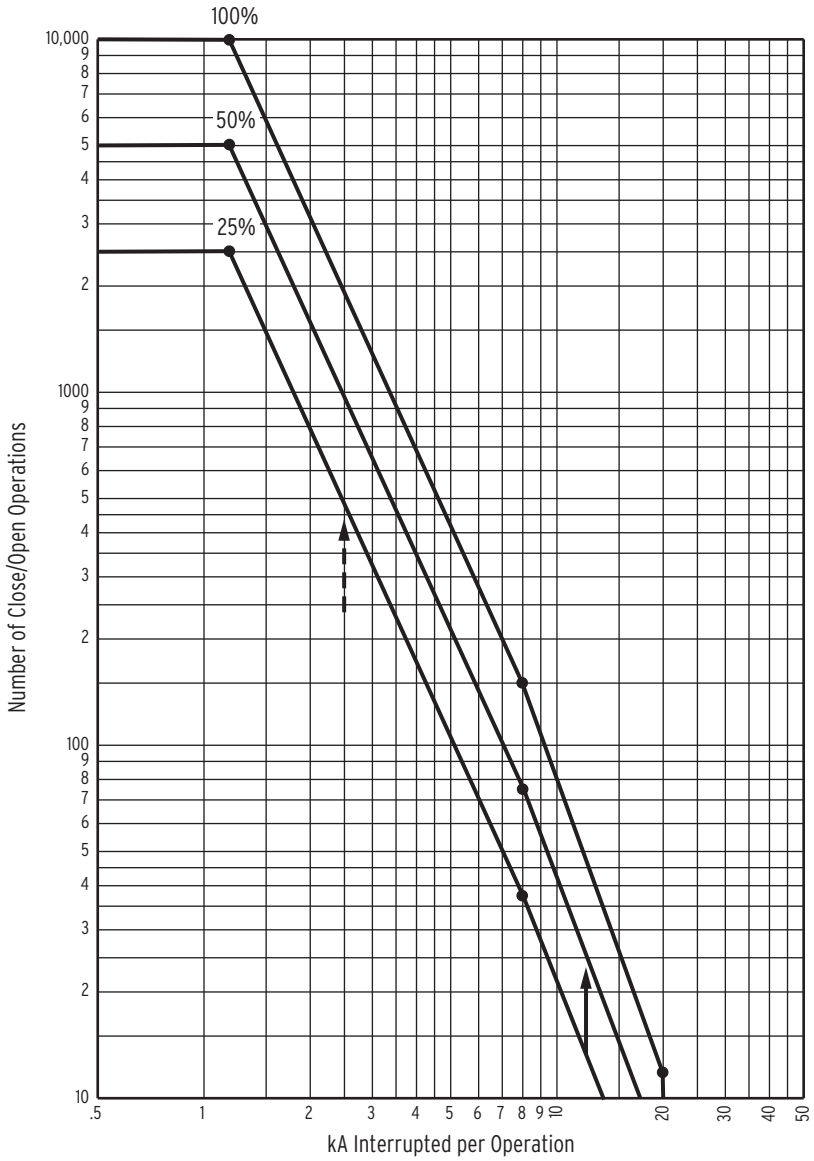


Figure 5.22 Breaker Monitor Accumulates 50 Percent Wear

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.

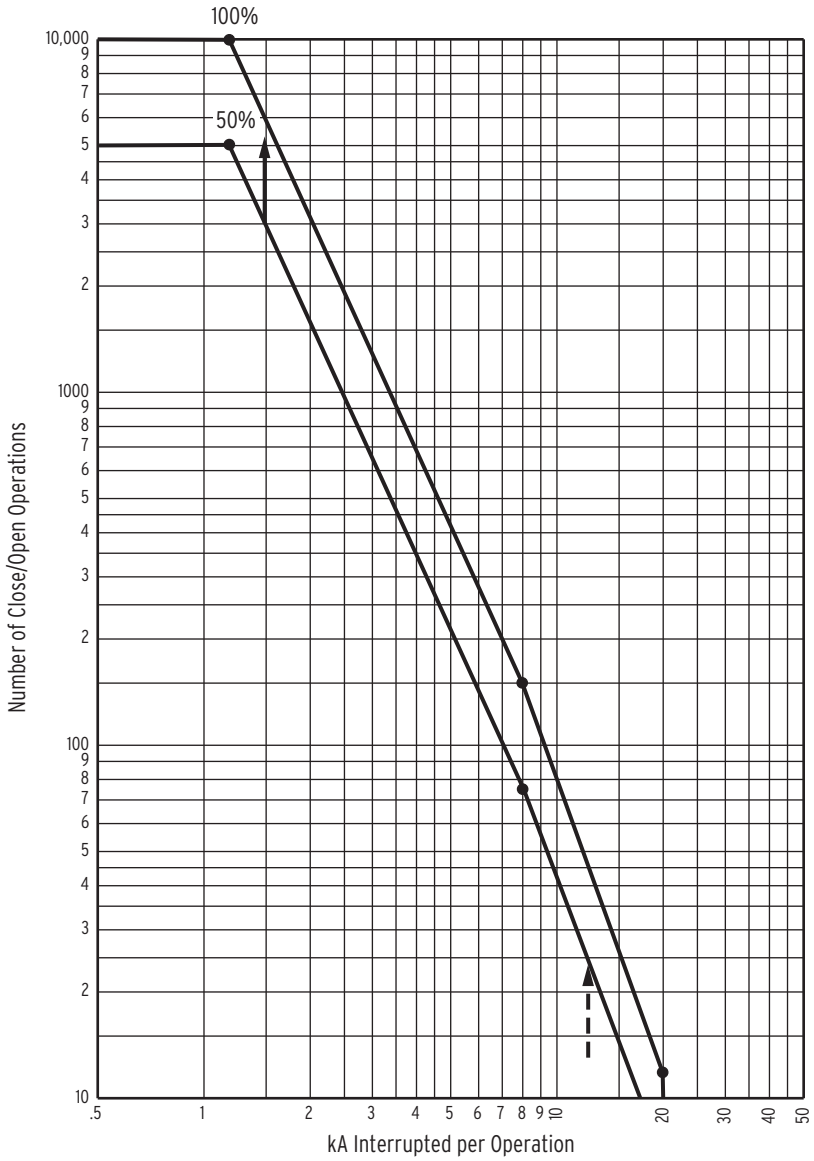


Figure 5.23 Breaker Monitor Accumulates 100 Percent Wear

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

These logic outputs can be used 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 4.29 on page 4.59*). 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.

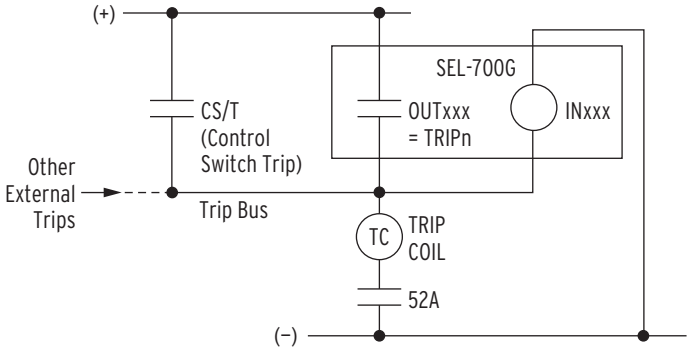


Figure 5.24 Input INxxx Connected to Trip Bus for Breaker Monitor Initiation

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 above list, there are five port setting instances, one for each port. Settings may be viewed or set 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
```

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).

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.

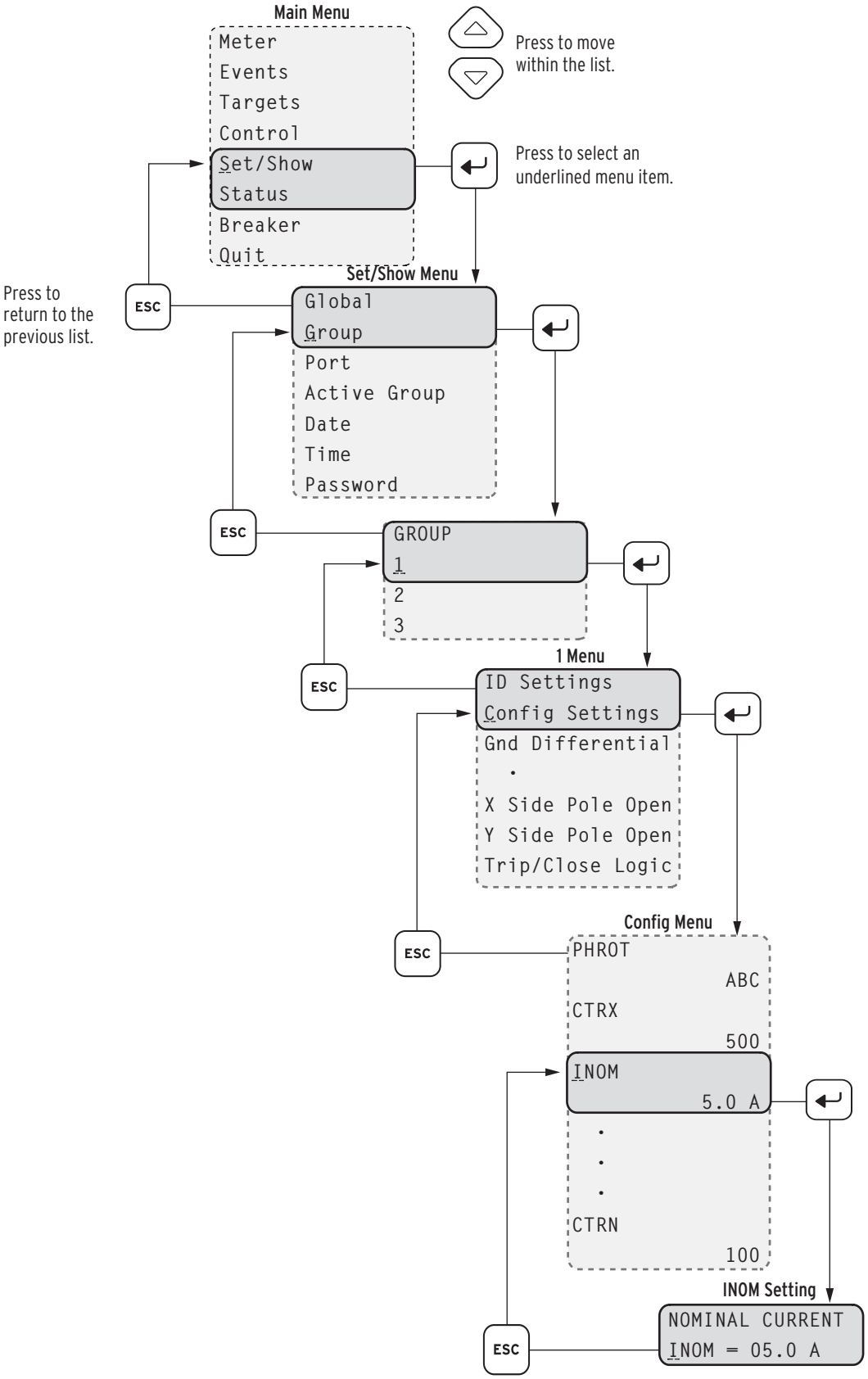


Figure 6.1 Front-Panel Setting Entry Example for the SEL-700GT Relay

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 :=** _____

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 :=** _____

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 EXT3VO_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 = 83/84/87/88)

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) (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, or DC)

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, or DC)

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) **51QXC :=** _____
(Hidden if 51QXP := OFF)

NSEQ TOC TDIAL (0.50–15.00 [if 51Q_C := U_], 0.05–1.00 [if 51Q_C := C_]) **51QXTD :=** _____
(Hidden if 51QXP := OFF)

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 **51PYC :=** _____
(U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) (Hidden if 51PYP := OFF)

PHASE TOC TDIAL (0.50–15.00 [if 51P_C := U_], **51PYTD :=** _____
0.05–1.00 [if 51P_C := C_]) (Hidden if 51PYP := OFF)

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) **51GYC :=** _____
(Hidden if 51GYP := OFF)

RES TOC TDIAL (0.50–15.00 [if 51G_C := U_], 0.05–1.00 [if 51G_C := C_]) **51GYTD :=** _____
(Hidden if 51GYP := OFF)

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) **51QYC :=** _____
(Hidden if 51QYP := OFF)

NSEQ TOC TDIAL (0.50 to 15.00 [if 51Q_C := U_], 0.05 to 1.00 [if 51Q_C := C_]) **51QYTD :=** _____
(Hidden if 51QYP := OFF)

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 & 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 :=**

RTD Settings

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 (0.01–60.00 s)	**FPLSMIND :=**
FREQ PULS MAX (0.01–60.00 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 (0.01–60.00 s) **VPLSMIND :=** _____

VOLT PULS MAX (0.01–60.00 s) **VPLSMAXD :=** _____

VMATCH START (SELOGIC) **VSYNCST :=** _____

Demand Metering

ENABLE DEM MTR (THM, ROL) **EDEM :=** _____

DEM TIME CONSTNT (5, 10, 15, 30, 60 min) **DMTC :=** _____

X-Side Demand Metering (Hidden if Slot Z = 84/88)

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

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

3I2 CURR DEM LVL (OFF, 0.50–16.00 A [5 A I_{XNOM}], 0.10–3.20 A [1 A I_{XNOM}]) **3I2DEMPX :=** _____

Y-Side Demand Metering (Shown if Slot E = 71/75 or Slot Z = 83/87)

PH CURR DEM LVL (OFF, 0.50–16.00 A [5 A I_{YNOM}], 0.10–3.20 A [1 A I_{YNOM}]) **PHDEMPY :=** _____

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

3I2 CURR DEM LVL (OFF, 0.50–16.00 A [5 A I_{YNOM}], 0.10–3.20 A [1 A I_{YNOM}]) **3I2DEMPY :=** _____

X-Side Pole Open Element (Hidden if Slot Z = 84/88)

LOAD DETECTION (OFF, 0.25–96.00 A [5 A I_{XNOM}], 0.05–19.20 A [1 A I_{XNOM}]) **50LXP :=** _____

3POLE OPEN DELAY (0.00–1.00 s) **3POXD :=** _____

Y-Side Pole Open Element (Shown if Slot E = 71/75 or if Slot Z = 83/87)

LOAD DETECTION (OFF, 0.25–96.00 A [5 A I_{YNOM}], 0.05–19.20 A [1 A I_{YNOM}]) **50LYP :=** _____

3POLE OPEN DELAY (0.00–1.00 s) **3POYD :=** _____

Trip/Close Logic

MIN TRIP TIME (0.00–400.00 s) **TDURD :=** _____

CLOSE X FAIL DLY (0.00–400.00 s) (Hidden if Slot Z = 84/88) **CFDX :=** _____

CLOSE Y FAIL DLY (0.00–400.00 s) (Shown if Slot Z = 83/87 or Slot E = 71/75) **CFDY :=** _____

X-SIDE BRKR TRIP EQN (SELOGIC) **TRX :=** _____

GEN FIELD BRKR TRIP EQN (SELOGIC) (Hidden if Slot Z = 83/84/87/88) **TR1 :=** _____

PRIME MOVER TRIP EQN (SELOGIC) (Hidden if Slot Z = 83/84/87/88) **TR2 :=** _____

GEN LOCKOUT TRIP EQN (SELOGIC) (Hidden if Slot Z = 83/84/87/88) **TR3 :=** _____

Y-SIDE BRKR TRIP EQN (SELOGIC) (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 :=

Latch Bits Equations

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/Timers

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/Timers

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/Timers

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/Timers

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 :=**

Counters Equations

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 :=**

Counters Equations

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 :=**

Counters Equations

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 :=**

Counters Equations

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 :=

Math Variables

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 := _____

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 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 :=** _____

Event Messenger Points

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 :=** _____

Event Messenger Points

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 :=** _____

Event Messenger Points

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.)

AI*x*01

AI*x*01 TAG NAME (8 characters 0–9, A–Z, _) **AI*x*01NAM :=** _____

AI*x*01 TYPE (I, V) **AI*x*01TYP :=** _____

If AI*x*01TYP = 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 AI*x*01TYP = 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 :=** _____

AI*x*02

AI*x*02 TAG NAME (8 characters 0–9, A–Z, _) **AIx02NAM :=** _____

AI*x*02 TYPE (I, V) **AIx02TYP :=** _____

If AI*x*02TYP = 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 AI*x*02TYP = 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 :=** _____

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.)

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

AI*x*03

AI*x*03 TAG NAME (8 characters 0–9, A–Z, _) **AIx03NAM :=** _____

AI*x*03 TYPE (I, V) **AIx03TYP :=** _____

If AI*x*03TYP = 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 AI*x*03TYP = 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 :=** _____

AI*x*04

AI*x*04 TAG NAME (8 characters 0–9, A–Z, _) **AIx04NAM :=** _____

AIx04 TYPE (I, V) **AIx04TYP :=** _____

If AI*x*04TYP = 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 AI*x*04TYP = 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) **AIx04LAL :=** _____

AI*x*04 HI WARN L1 (OFF, –99999.000 to +99999.000) **AIx04HW1 :=** _____

AI*x*04 HI WARN L2 (OFF, –99999.000 to +99999.000) **AIx04HW2 :=** _____

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.)

AI*x*04 HI ALARM (OFF, –99999.000 to +99999.000) **AI*x*04HAL :=** _____

AO*x*01

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 AO*x*01TYP = 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 AO*x*01TYP = 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 :=** _____

AO*x*02

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 AO*x*02TYP = 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 AO*x*02TYP = 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 :=** _____

AO*x*03

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 AO*x*03TYP = 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 :=** _____

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.)

If AO*x*03TYP = 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 :=** _____

AO*x*04

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 AO*x*04TYP = 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 AO*x*04TYP = 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 ADDRESS (zzz.yyy.xxx.www) **IPADDR :=** _____

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

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

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

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 :=** _____

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 :=** _____

PORT 1 (Ethernet Port in Slot B; hidden if Ethernet option not included)

Modbus TCP Port1 (1–65534) (Hidden if EMOD := 0)[a] **MODNUM1 :=** _____

Modbus TCP Port2 (1–65534) (Hidden if EMOD := 0 or 1)[a] **MODNUM2 :=** _____

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

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

[a] Excludes the following port numbers: 20 (FTP Data), 21 (FTP Control), TPORT setting, 102 (IEC 61850), 23 (Telnet), SNTPPORT, and DNPNUM setting if present.

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.

PMU Output 1 TCP/IP Port Number (1–65534) (Shown only when EPMIP ≠ 0 and PMOTS1 :≠ UDP_S) **PMOTCP1 :=** _____

Note: PMOTCP1 cannot be set to the same number as PMOTCP2.

Note: PMOTCP1 cannot be set to 20, 21, 23, 102, 502, MODNUM1, MODNUM2, the TPORT setting value, or the DNPNUM setting value when PMOTS1 = TCP, DP_T, or UDP_U.

PMU Output 1 UDP/IP Data Port Number (1–65534) (Shown only when EPMIP ≠ 0 and PMOTS1 :≠ 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.

PMU Output 2 TCP/IP Port Number (1–65534) (Shown only when EPMIP := 2 and PMOTS2 :≠ UDP_S) **PMOTCP2 :=** _____

Note: PMOTCP2 cannot be set to the same number as PMOTCP1.

Note: PMOTCP2 cannot be set to 20, 21, 23, 102, 502, MODNUM1, MODNUM2, the TPORT setting value, or the DNPNUM setting value when PMOTS2 = TCP, UDP_T, or UDP_U.

PMU Output 2 UDP/IP Data Port Number (1–65534) (Shown only when EPMIP = 2 and PMOTS2 :≠ 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 :=** _____

DNP Address (0–65519) **DNPADR :=** _____

Session 1

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 :=** _____

Port 1 DNP3 Protocol (Hidden unless DNP3 is selected as an option)

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 :=**

Port 1 DNP3 Protocol (Hidden unless DNP3 is selected as an option)

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.

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: SNTPPORT cannot be set to 20, 21, 102, 502, 23, TPORT, or DNPNUM

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

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

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) (Hidden if E49RTD := EXT or if PROTO := EVMSG, PMU, or MB_) **PARITY :=** _____

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

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

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

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

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

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 :=** _____

PORT 2 (Fiber-Optic Serial Port in Slot B; hidden if E49RTD := EXT)

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 3 (EIA-232/485 Port in Slot B)

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

Communications

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

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

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

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

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

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

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

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

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 (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 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 :=** _____

PORT 3 (EIA-232/485 Port in Slot B)

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 EIA-232 port only)

Modem Connected to Port (Y, N)	**MODEM :=**
Modem Startup String (30 characters)	**MSTR :=**
Phone Number for Dial-Out (30 characters)	**PH_NUM1 :=**
Phone Number for Dial-Out (30 characters)	**PH_NUM2 :=**
Retry Attempts for Phone 1 Dial-Out (1–20)	**RETRY1 :=**
Retry Attempts for Phone 2 Dial-Out (1–20)	**RETRY2 :=**
Time to Attempt Dial (5–300 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)	**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 :=** _____

PORT 4 (EIA-232/485 Port or DeviceNet Port in Slot C)

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 :=** _____

Target 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 Points

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 :=** _____

Local Bits Labels

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 :=** _____

Local Bits Labels

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 :=**

Local Bits Labels

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* = Up to 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 up to 15 characters long. Use NA to disable setting.

Enable ALIAS (N, 1–20)

EALIAS := _____

ALIAS1 := _____ **ALIAS11 :=** _____

ALIAS2 := _____ **ALIAS12 :=** _____

ALIAS3 := _____ **ALIAS13 :=** _____

ALIAS4 := _____ **ALIAS14 :=** _____

ALIAS5 := _____ **ALIAS15 :=** _____

ALIAS6 := _____ **ALIAS16 :=** _____

ALIAS7 := _____ **ALIAS17 :=** _____

ALIAS8 := _____ **ALIAS18 :=** _____

ALIAS9 := _____ **ALIAS19 :=** _____

ALIAS10 := _____ **ALIAS20 :=** _____

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, Up to 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_037 :=** _____
MOD_002 := _____	**MOD_038 :=** _____
MOD_003 := _____	**MOD_039 :=** _____
MOD_004 := _____	**MOD_040 :=** _____
MOD_005 := _____	**MOD_041 :=** _____
MOD_006 := _____	**MOD_042 :=** _____
MOD_007 := _____	**MOD_043 :=** _____
MOD_008 := _____	**MOD_044 :=** _____
MOD_009 := _____	**MOD_045 :=** _____
MOD_010 := _____	**MOD_046 :=** _____
MOD_011 := _____	**MOD_047 :=** _____
MOD_012 := _____	**MOD_048 :=** _____
MOD_013 := _____	**MOD_049 :=** _____
MOD_014 := _____	**MOD_050 :=** _____
MOD_015 := _____	**MOD_051 :=** _____
MOD_016 := _____	**MOD_052 :=** _____
MOD_017 := _____	**MOD_053 :=** _____
MOD_018 := _____	**MOD_054 :=** _____
MOD_019 := _____	**MOD_055 :=** _____
MOD_020 := _____	**MOD_056 :=** _____
MOD_021 := _____	**MOD_057 :=** _____
MOD_022 := _____	**MOD_058 :=** _____
MOD_023 := _____	**MOD_059 :=** _____
MOD_024 := _____	**MOD_060 :=** _____
MOD_025 := _____	**MOD_061 :=** _____
MOD_026 := _____	**MOD_062 :=** _____
MOD_027 := _____	**MOD_063 :=** _____
MOD_028 := _____	**MOD_064 :=** _____
MOD_029 := _____	**MOD_065 :=** _____
MOD_030 := _____	**MOD_066 :=** _____
MOD_031 := _____	**MOD_067 :=** _____
MOD_032 := _____	**MOD_068 :=** _____
MOD_033 := _____	**MOD_069 :=** _____
MOD_034 := _____	**MOD_070 :=** _____
MOD_035 := _____	**MOD_071 :=** _____
MOD_036 := _____	**MOD_072 :=** _____

Modbus User Map

User Map Register Label Name (8 characters)
(See *Appendix E: Modbus RTU Communications* for additional details)

MOD_073 := _____ **MOD_100 :=** _____
MOD_074 := _____ **MOD_101 :=** _____
MOD_075 := _____ **MOD_102 :=** _____
MOD_076 := _____ **MOD_103 :=** _____
MOD_077 := _____ **MOD_104 :=** _____
MOD_078 := _____ **MOD_105 :=** _____
MOD_079 := _____ **MOD_106 :=** _____
MOD_080 := _____ **MOD_107 :=** _____
MOD_081 := _____ **MOD_108 :=** _____
MOD_082 := _____ **MOD_109 :=** _____
MOD_083 := _____ **MOD_110 :=** _____
MOD_084 := _____ **MOD_111 :=** _____
MOD_085 := _____ **MOD_112 :=** _____
MOD_086 := _____ **MOD_113 :=** _____
MOD_087 := _____ **MOD_114 :=** _____
MOD_088 := _____ **MOD_115 :=** _____
MOD_089 := _____ **MOD_116 :=** _____
MOD_090 := _____ **MOD_117 :=** _____
MOD_091 := _____ **MOD_118 :=** _____
MOD_092 := _____ **MOD_119 :=** _____
MOD_093 := _____ **MOD_120 :=** _____
MOD_094 := _____ **MOD_121 :=** _____
MOD_095 := _____ **MOD_122 :=** _____
MOD_096 := _____ **MOD_123 :=** _____
MOD_097 := _____ **MOD_124 :=** _____
MOD_098 := _____ **MOD_125 :=** _____
MOD_099 := _____

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 up to 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_34 :=** _____
BI_01 := _____	**BI_35 :=** _____
BI_02 := _____	**BI_36 :=** _____
BI_03 := _____	**BI_37 :=** _____
BI_04 := _____	**BI_38 :=** _____
BI_05 := _____	**BI_39 :=** _____
BI_06 := _____	**BI_40 :=** _____
BI_07 := _____	**BI_41 :=** _____
BI_08 := _____	**BI_42 :=** _____
BI_09 := _____	**BI_43 :=** _____
BI_10 := _____	**BI_44 :=** _____
BI_11 := _____	**BI_45 :=** _____
BI_12 := _____	**BI_46 :=** _____
BI_13 := _____	**BI_47 :=** _____
BI_14 := _____	**BI_48 :=** _____
BI_15 := _____	**BI_49 :=** _____
BI_16 := _____	**BI_50 :=** _____
BI_17 := _____	**BI_51 :=** _____
BI_18 := _____	**BI_52 :=** _____
BI_19 := _____	**BI_53 :=** _____
BI_20 := _____	**BI_54 :=** _____
BI_21 := _____	**BI_55 :=** _____
BI_22 := _____	**BI_56 :=** _____
BI_23 := _____	**BI_57 :=** _____
BI_24 := _____	**BI_58 :=** _____
BI_25 := _____	**BI_59 :=** _____
BI_26 := _____	**BI_60 :=** _____
BI_27 := _____	**BI_61 :=** _____
BI_28 := _____	**BI_62 :=** _____
BI_29 := _____	**BI_63 :=** _____
BI_30 := _____	**BI_64 :=** _____
BI_31 := _____	**BI_65 :=** _____
BI_32 := _____	**BI_66 :=** _____
BI_33 := _____	**BI_67 :=** _____

Binary Input Map

DNP Binary Input Label Name (10 characters)

BI_68 := _____ **BI_84 :=** _____
BI_69 := _____ **BI_85 :=** _____
BI_70 := _____ **BI_86 :=** _____
BI_71 := _____ **BI_87 :=** _____
BI_72 := _____ **BI_88 :=** _____
BI_73 := _____ **BI_89 :=** _____
BI_74 := _____ **BI_90 :=** _____
BI_75 := _____ **BI_91 :=** _____
BI_76 := _____ **BI_92 :=** _____
BI_77 := _____ **BI_93 :=** _____
BI_78 := _____ **BI_94 :=** _____
BI_79 := _____ **BI_95 :=** _____
BI_80 := _____ **BI_96 :=** _____
BI_81 := _____ **BI_97 :=** _____
BI_82 := _____ **BI_98 :=** _____
BI_83 := _____ **BI_99 :=** _____

Binary Output Map

DNP Binary Output Label Name (10 characters)

BO_00 := _____ **BO_16 :=** _____
BO_01 := _____ **BO_17 :=** _____
BO_02 := _____ **BO_18 :=** _____
BO_03 := _____ **BO_19 :=** _____
BO_04 := _____ **BO_20 :=** _____
BO_05 := _____ **BO_21 :=** _____
BO_06 := _____ **BO_22 :=** _____
BO_07 := _____ **BO_23 :=** _____
BO_08 := _____ **BO_24 :=** _____
BO_09 := _____ **BO_25 :=** _____
BO_10 := _____ **BO_26 :=** _____
BO_11 := _____ **BO_27 :=** _____
BO_12 := _____ **BO_28 :=** _____
BO_13 := _____ **BO_29 :=** _____
BO_14 := _____ **BO_30 :=** _____
BO_15 := _____ **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 := _____

Analog Input Map

DNP Analog Input Label Name (24 characters)

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 := _____

Analog Input Map

DNP Analog Input Label Name (24 characters)

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_16 :=** _____
AO_01 := _____	**AO_17 :=** _____
AO_02 := _____	**AO_18 :=** _____
AO_03 := _____	**AO_19 :=** _____
AO_04 := _____	**AO_20 :=** _____
AO_05 := _____	**AO_21 :=** _____
AO_06 := _____	**AO_22 :=** _____
AO_07 := _____	**AO_23 :=** _____
AO_08 := _____	**AO_24 :=** _____
AO_09 := _____	**AO_25 :=** _____
AO_10 := _____	**AO_26 :=** _____
AO_11 := _____	**AO_27 :=** _____
AO_12 := _____	**AO_28 :=** _____
AO_13 := _____	**AO_29 :=** _____
AO_14 := _____	**AO_30 :=** _____
AO_15 := _____	**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 :=** _____

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Section 7
Communications

Overview

A communications interface and protocol are required 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 (RJ-45 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 up to 15 m (50 feet) in low noise environments. Use the optional EIA-485 port for communications distances up to 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 for safety and large (500 m to 8 km) communications distances.

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 a failure in the primary network is detected. 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.

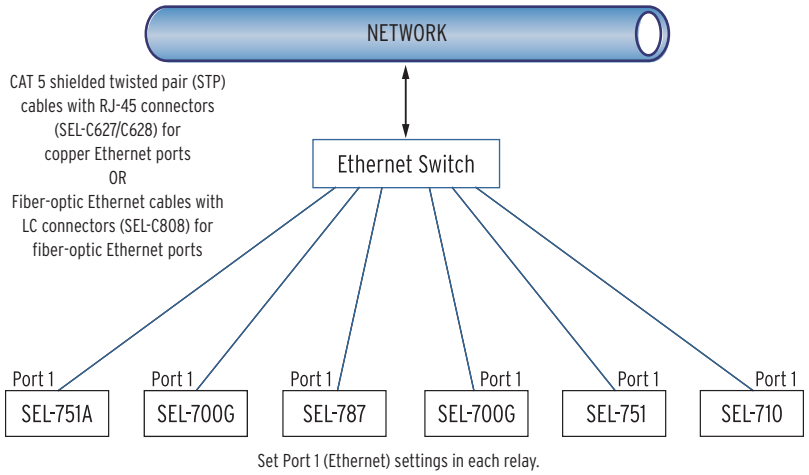


Figure 7.1 Simple Ethernet Network Configuration

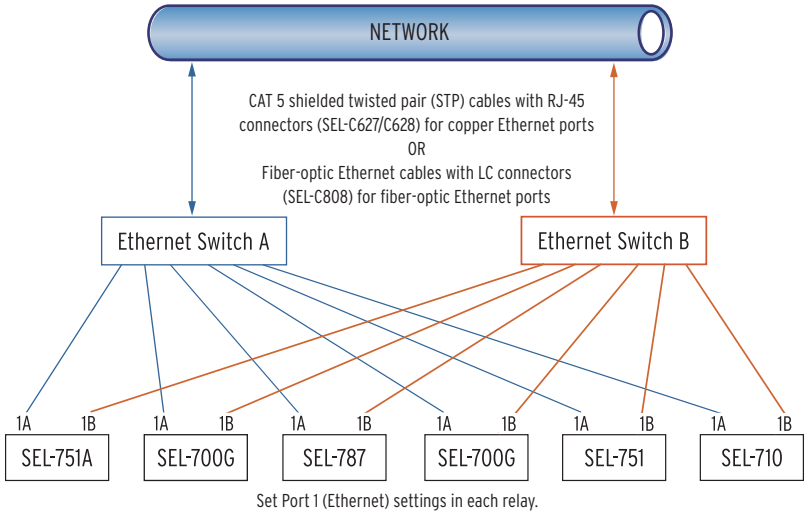


Figure 7.2 Ethernet Network Configuration With Dual Redundant Connections (Failover Mode)

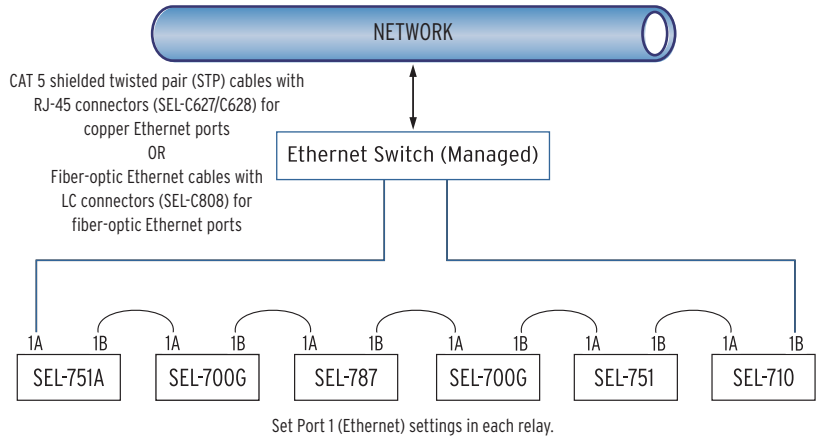


Figure 7.3 Ethernet Network Configuration With Ring Structure (Switched Mode)

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

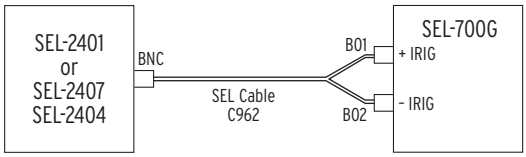
The NETPORT setting gives you the option to select the primary port of communication in failover or fixed communications modes. Selecting "D" for this setting disables both the ports. This selection provides you the security of being able to turn off the ports even when these ports are physically connected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

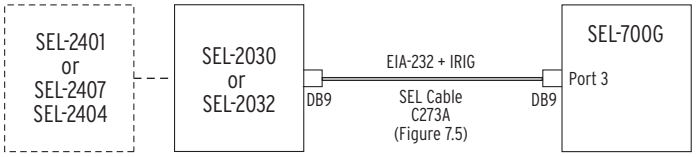
Set Global setting IRIG TIME SOURCE to TIME_SRC := IRIG1.

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.

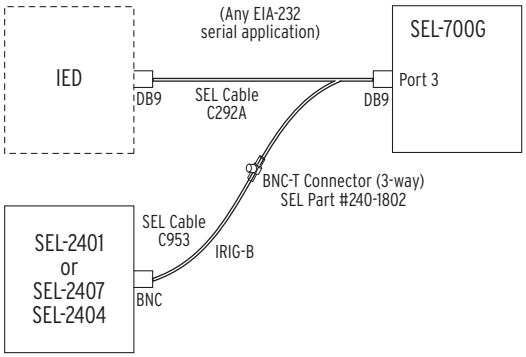
Refer to *Figure 7.6* on how to connect a SEL Time Source (SEL-2401, SEL-2404, SEL-2407) for IRIG-B Input to Port 3.



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)



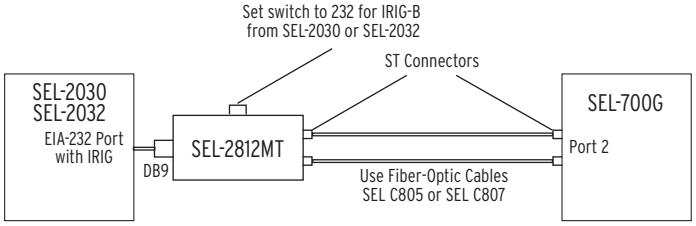
If you use Port 3, you cannot use a **B01–B02** input or Port 2.

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)

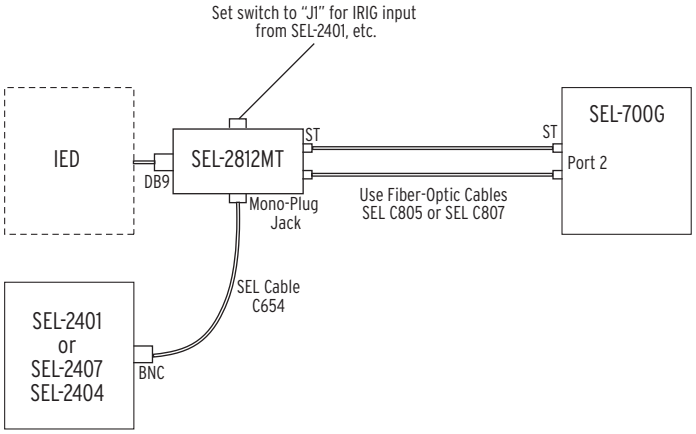
Fiber-Optic Serial Port 2 can be used to bring IRIG-B Input to the relay as shown in *Figure 7.7* and *Figure 7.8*.



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 in any combination of Pins 1, 3, and 7 without the need for hardware jumpers.

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.

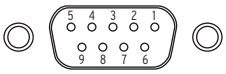


Figure 7.9 EIA-232 DB-9 Connector Pin Numbers

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.

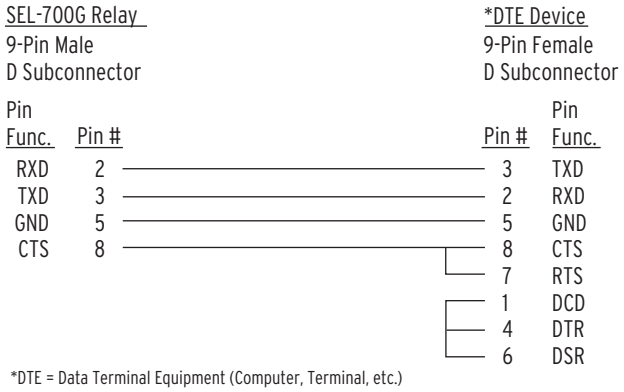


Figure 7.10 SEL Cable C234A–SEL-700G to DTE Device

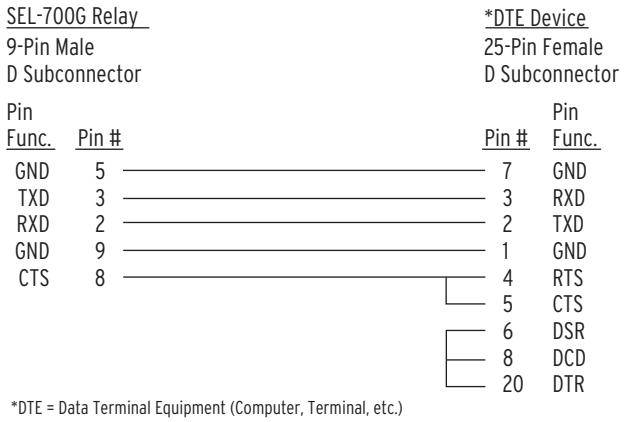
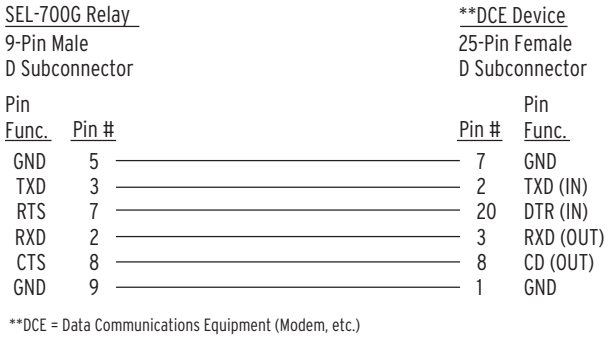


Figure 7.11 SEL Cable C227A–SEL-700G to DTE Device



**DCE = Data Communications Equipment (Modem, etc.)

Figure 7.12 SEL Cable C222–SEL-700G to Modem

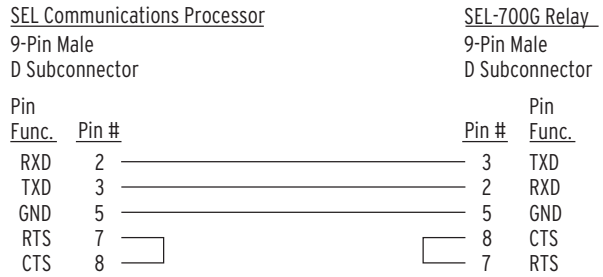


Figure 7.13 SEL Cable C272A–SEL-700G to SEL Communications Processor (Without IRIG-B Signal)

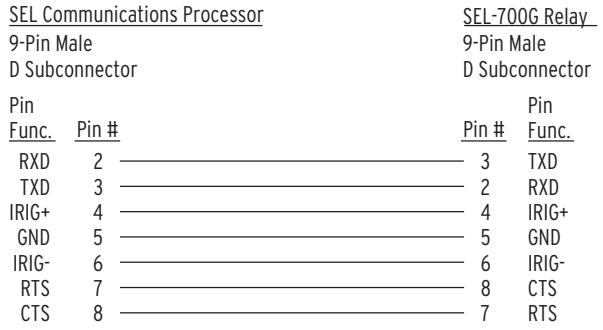
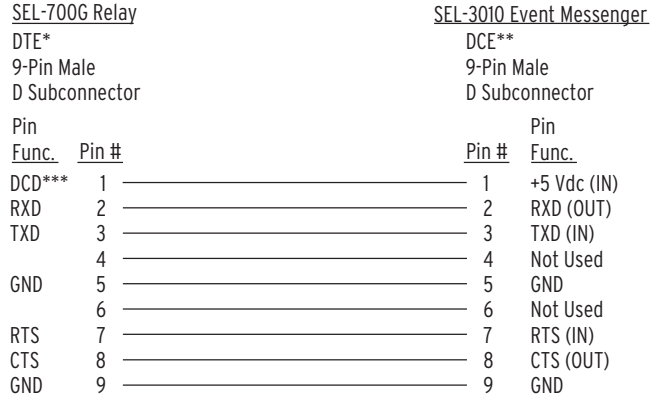


Figure 7.14 SEL Cable C273A–SEL-700G to SEL Communications Processor (With IRIG-B Signal)



*DTE = Data Terminal Equipment

**DCE = Data Communications Equipment (Modem, etc.)

***DC Voltage (+5 V) not available on front-panel EIA-232 port

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.

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.

NOTE: FTP, Modbus, and DeviceNet protocols ignore the hide rules of the settings.

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 in order 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 required.
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 a self-test warning or failure condition is detected. 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 required by 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 required 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 required conditions are met. The relay responds automatically with a message if conditions are not met, giving a specific explanation. See *Autosynchronism on page 4.174* 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 4.174* 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 4.123* through *Figure 4.125* 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 above 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. **FIL** command is not supported in Telnet TCP/IP over Ethernet. Use FTP 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 can be used 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 shown below.

```
=>>OPE X <Enter>
Open Breaker X (Y,N)? Y <Enter>
=>>
```

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[ab]	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 4.120* through *Figure 4.122* 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 above 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

Table 7.36 PAS Command Format

Parameter	Description
level	Parameter ***level*** represents the relay Access Levels 1, 2 or C.

⚠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.

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 shown below:

- #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

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. If the output is open, the **PUL** command momentarily closes the output; if the output is closed, the **PUL** command momentarily opens the output. 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 (up to 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.2*.

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.

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.

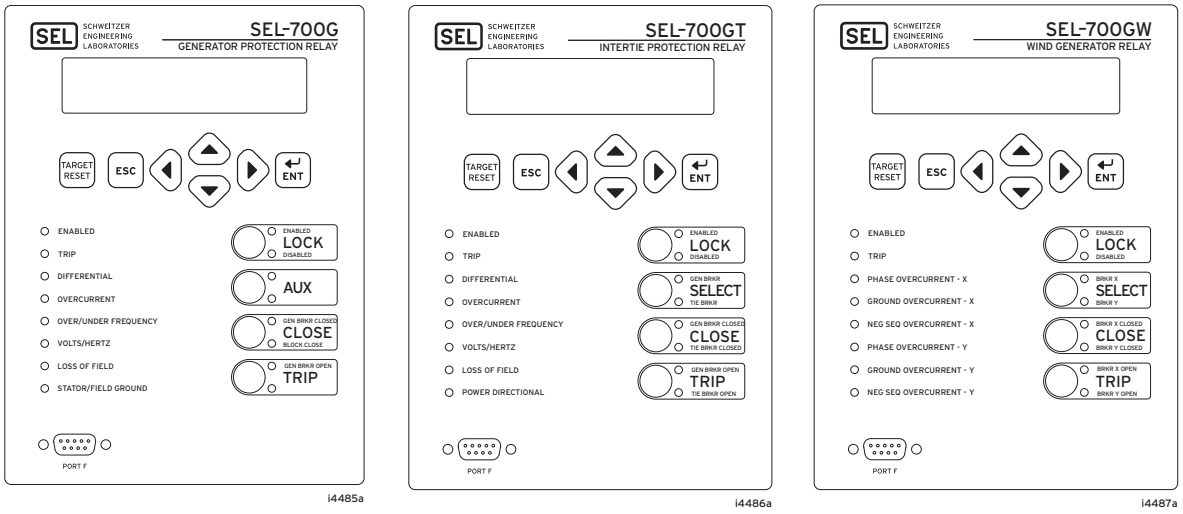


Figure 8.1 Front-Panel Overview

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.

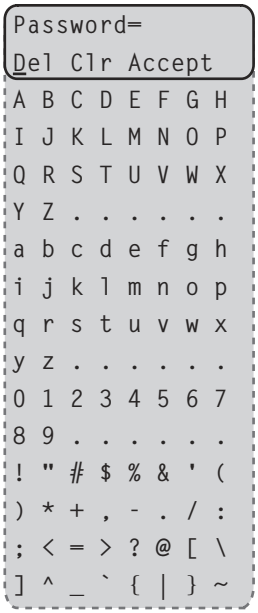
Figure 8.2 Access Level Security Padlock Symbol

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.

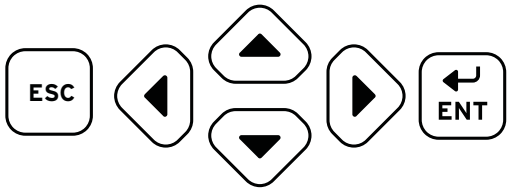


Figure 8.4 Front-Panel Pushbuttons

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.

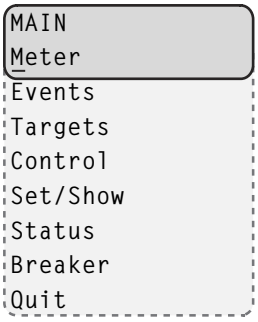


Figure 8.5 Main Menu

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.

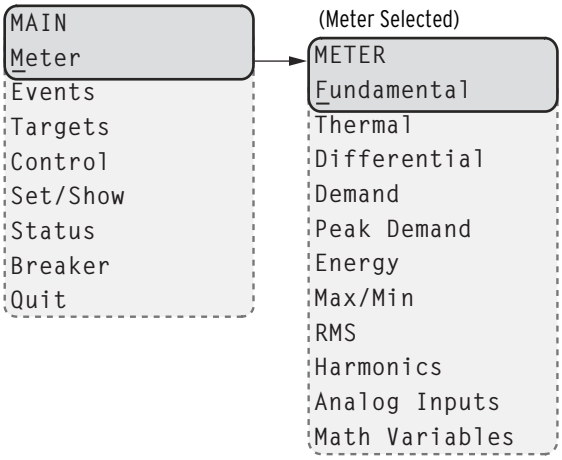


Figure 8.6 MAIN Menu and METER Submenu

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*.

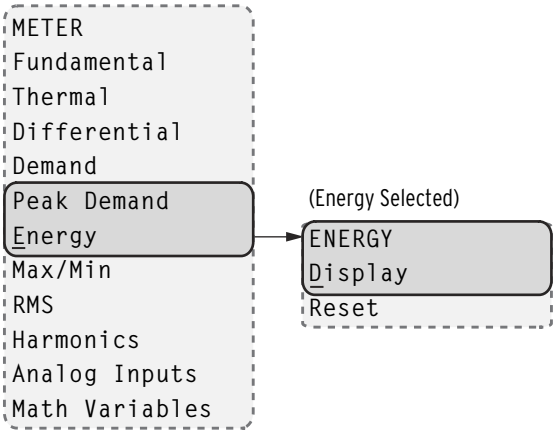


Figure 8.7 METER Menu and ENERGY Submenu

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*.

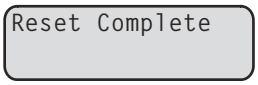


Figure 8.8 Relay Response When Energy (or Max/Min, Demand, Peak Demand) Metering Is Reset

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*.

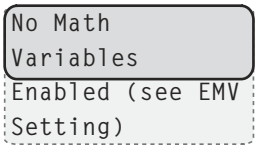


Figure 8.10 Relay Response When No Math Variables Enabled

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.

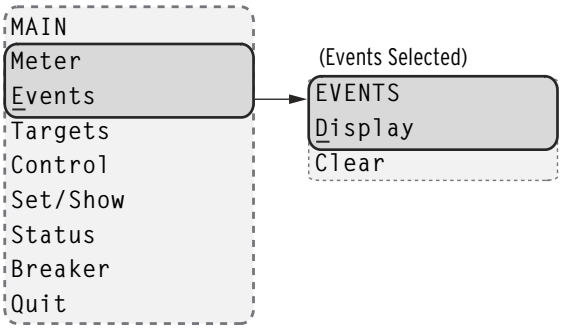


Figure 8.11 MAIN Menu and EVENTS Submenu

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.

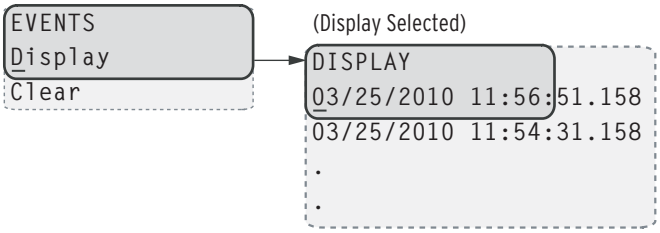


Figure 8.12 EVENTS Menu and DISPLAY Submenu

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*.

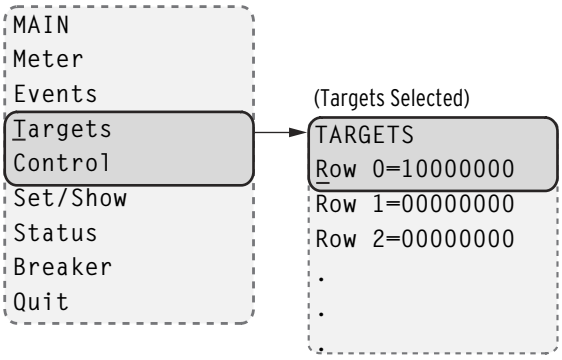


Figure 8.15 MAIN Menu and TARGETS Submenu

Select the target row to display two consecutive Relay Word bits with name and binary state as shown in *Figure 8.16*.

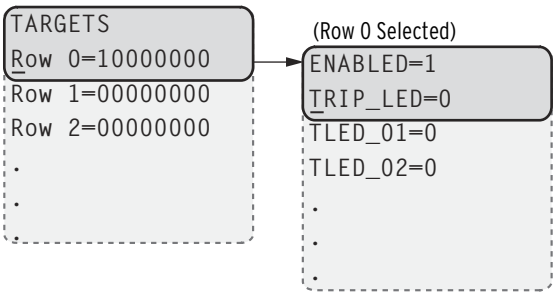


Figure 8.16 TARGETS Menu Navigation

Control Menu

Select the `Control` menu item on the `MAIN` menu as shown in *Figure 8.17* to go to the `CONTROL` menu.

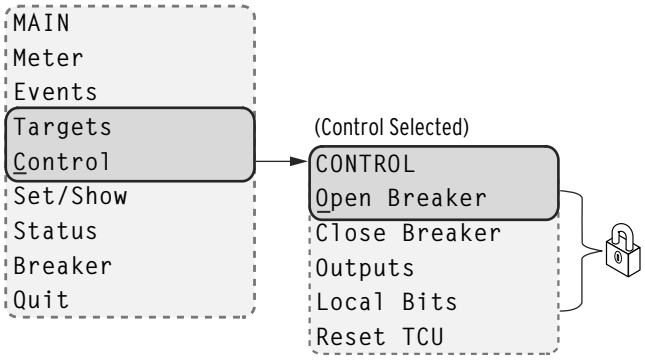


Figure 8.17 MAIN Menu and CONTROL Submenu

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® equations (see *Table 4.51* for the TRX or TRY equations and *Table J.2* 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 equation (see *Table 4.51* and *Figure 4.119*). 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.

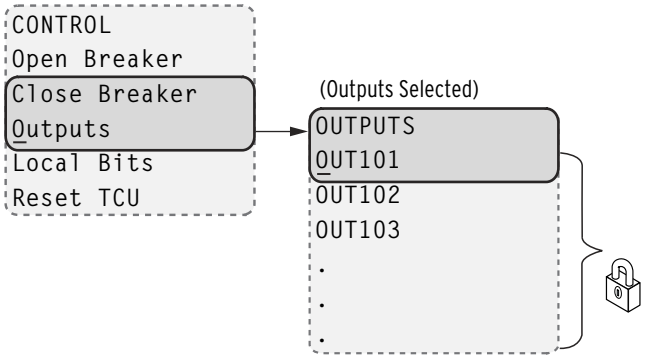


Figure 8.18 CONTROL Menu and OUTPUTS Submenu

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 4.228* 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*.

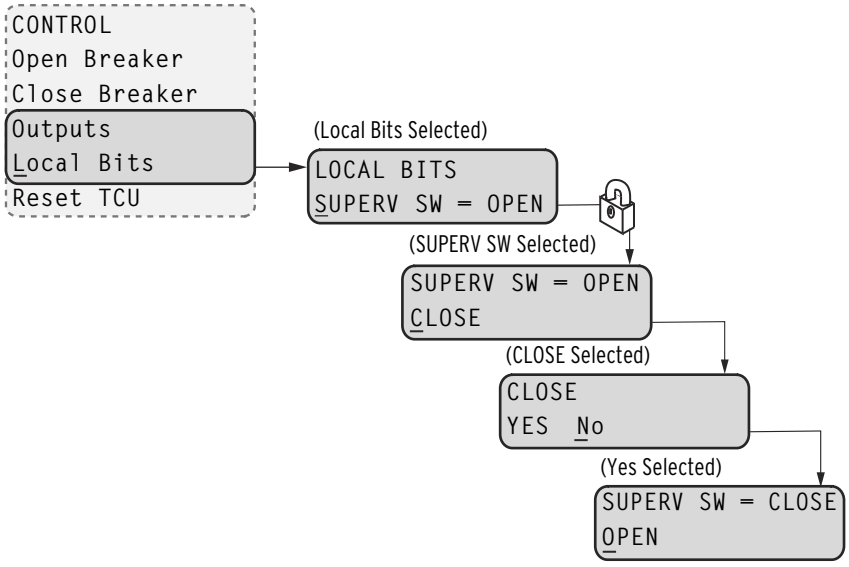


Figure 8.19 CONTROL Menu and LOCAL BITS Submenu

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.

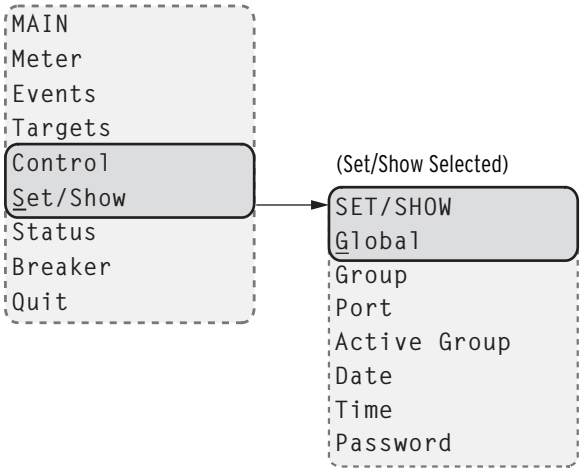


Figure 8.20 MAIN Menu and SET/SHOW Submenu

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.

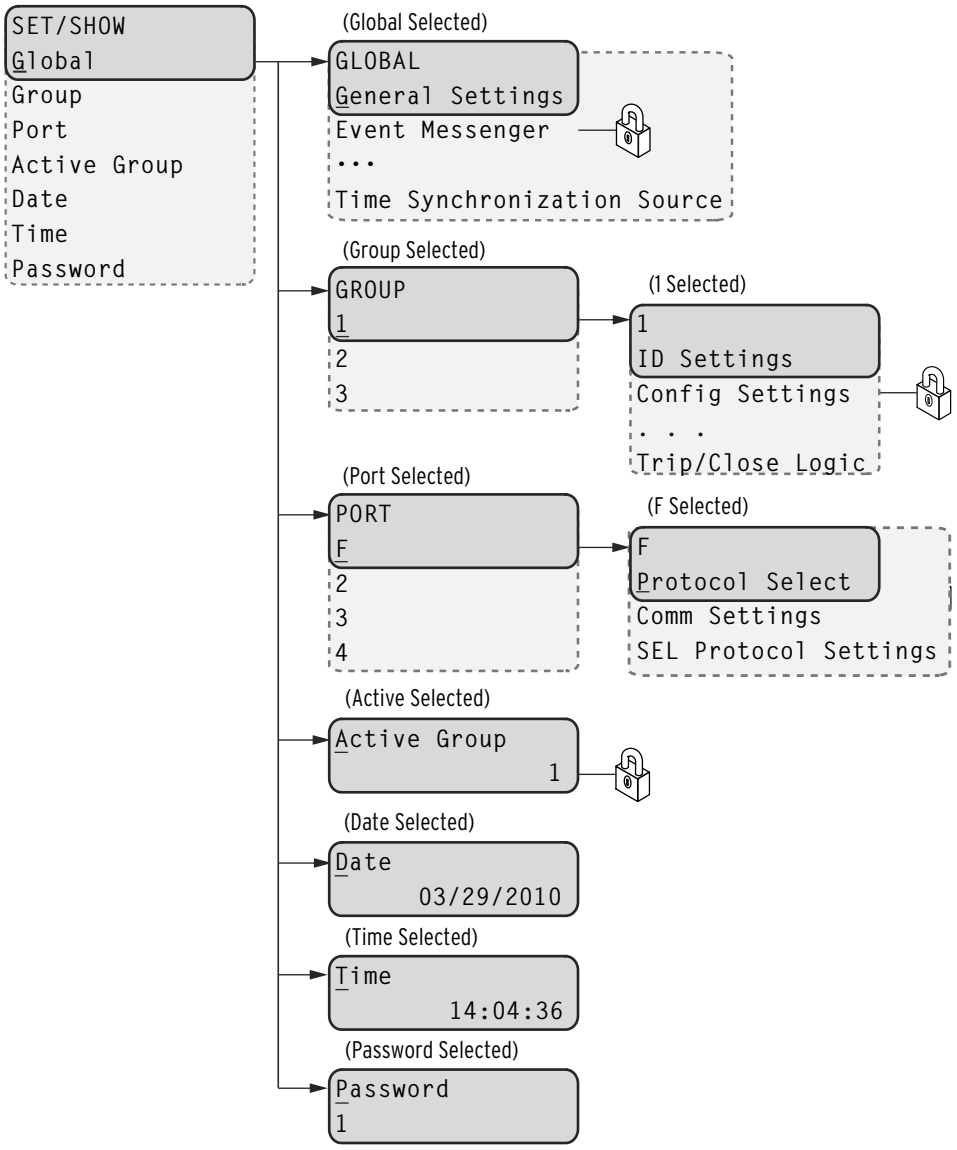


Figure 8.21 SET/SHOW Menu

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.

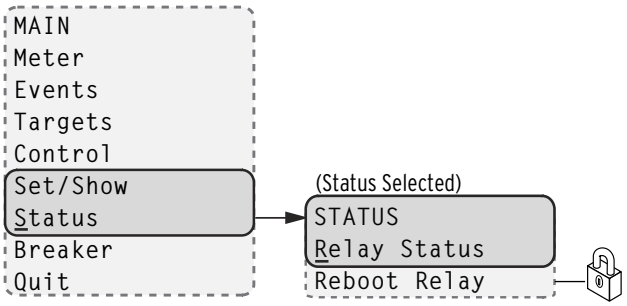


Figure 8.22 MAIN Menu and Status Submenu

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.

Use the QUIT command to exit Access Level 2 and go to Access Level 1.

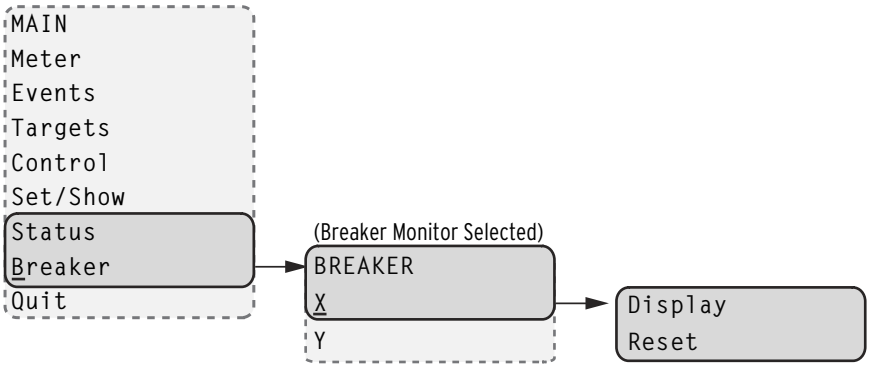


Figure 8.23 MAIN Menu and Breaker Monitor Submenu

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 4.230* 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).

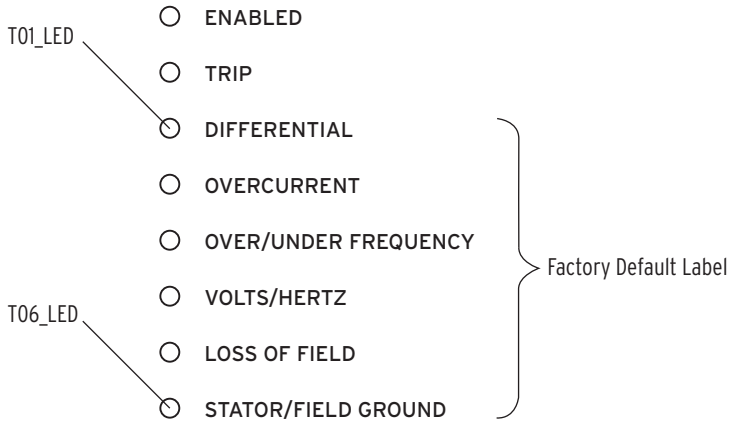


Figure 8.24 Factory Default Front-Panel LEDs for the SEL-700G Generator Protection Relay

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 4.84*.

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 4.217* 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*.

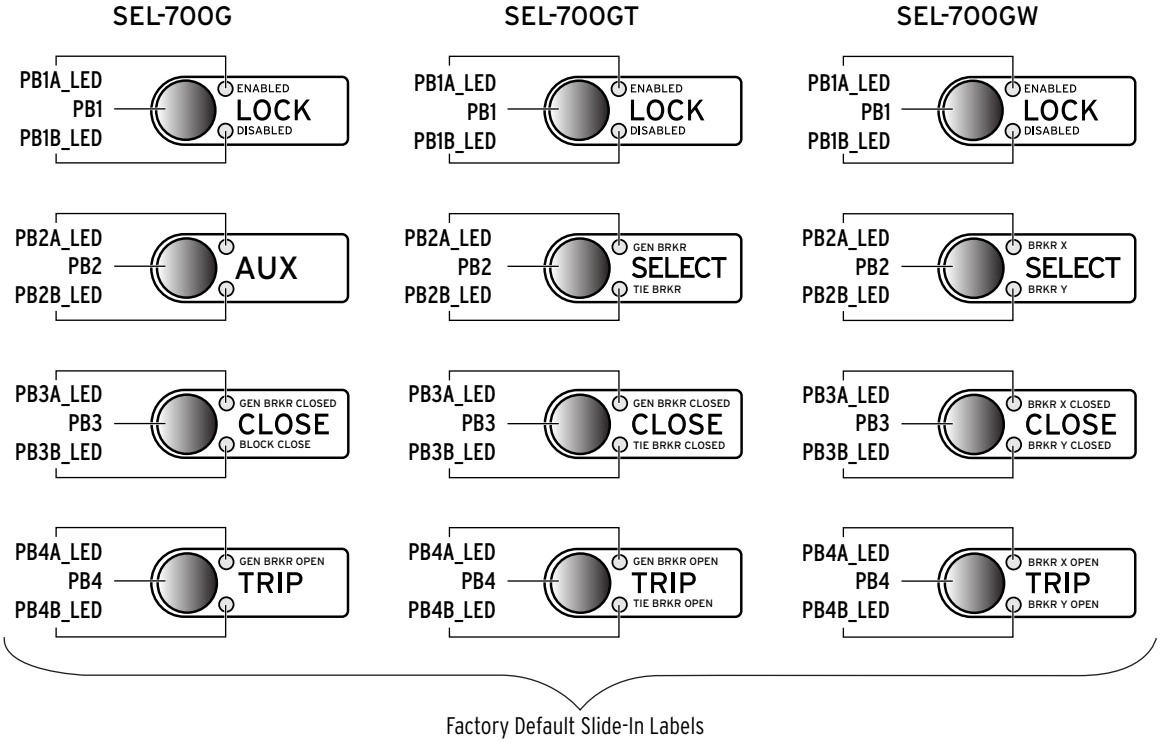


Figure 8.26 Operator Control Pushbuttons and LEDs

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

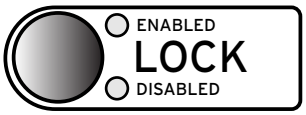
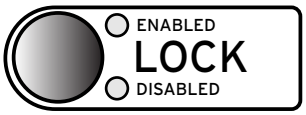
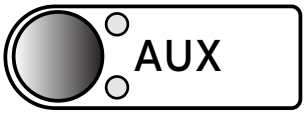
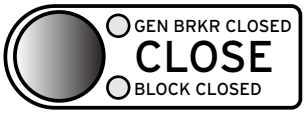
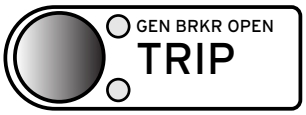
Continually press the **LOCK** operator control pushbutton for three (3) seconds to engage/disengage the lock function (Latch LT01 functions as Lock with the latch in reset state equivalent to the engaged lock). While this pushbutton is pressed, the corresponding LED flashes on and off, indicating a 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. The summaries may also be retrieved 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 recorded)

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 up to 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.63*.

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 4.119*. 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 4.234*.

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 required

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) 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

Table 9.1 Event Types (Sheet 2 of 2)

Event Type	Event Type Logic
RTD Fail Trip	RTDFLT AND TRIP
Breaker Failure Trip	(BFTX OR BFTY) AND TRIP
Remote Trip	REMTRIP AND TRIP
CommIdleLossTrip	(COMMIDLE OR COMMLOSS) AND TRIP
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 trigger, 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)

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.

The event reports are primarily intended to show the relay inputs (secondary values). During faults it is not possible to reproduce the primary line currents accurately as the delta-connected CTs filter out the zero-sequence component of the line current.

Wye-connected CTs do not have any such issue.

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:

EVE *n* **R X Y**

NOTE: In the SEL-700GT+ model, if X or Y is not specified, the relay defaults to the X-side event report.

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 is filtered and displays 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).

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

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)
In 12	1 2 b	IN101 AND NOT IN102 NOT IN101 AND IN102 IN101 AND IN102

Table 9.2 Analog Event Report Columns Definitions

Column Heading	Column Symbols	Description
Out 12	1	OUT101 AND NOT OUT102
	2	NOT OUT101 AND OUT102
	b	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>
                                                  ┌──────────────┬──────────── Date and Time of Event
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 ──────────── Firmware Checksum Identifier
        Firmware 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
[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 . ..
[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 . ..  ├ One Cycle of Data
  -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 . ..
```

Figure 9.3 Example Standard 15-Cycle Analog Event Report 1/4-Cycle Resolution (Sheet 1 of 5)

```
[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 . .*
[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 = 0000000000000000
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
```

Figure 9.3 Example Standard 15-Cycle Analog Event Report 1/4-Cycle Resolution (Sheet 2 of 5)

```
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


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
```

Figure 9.3 Example Standard 15-Cycle Analog Event Report 1/4-Cycle Resolution (Sheet 3 of 5)

```
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

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
```

Figure 9.3 Example Standard 15-Cycle Analog Event Report 1/4-Cycle Resolution (Sheet 4 of 5)

```
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 any two rows of current data from the analog event report, 1/4 cycle apart, can be used to calculate rms current values.

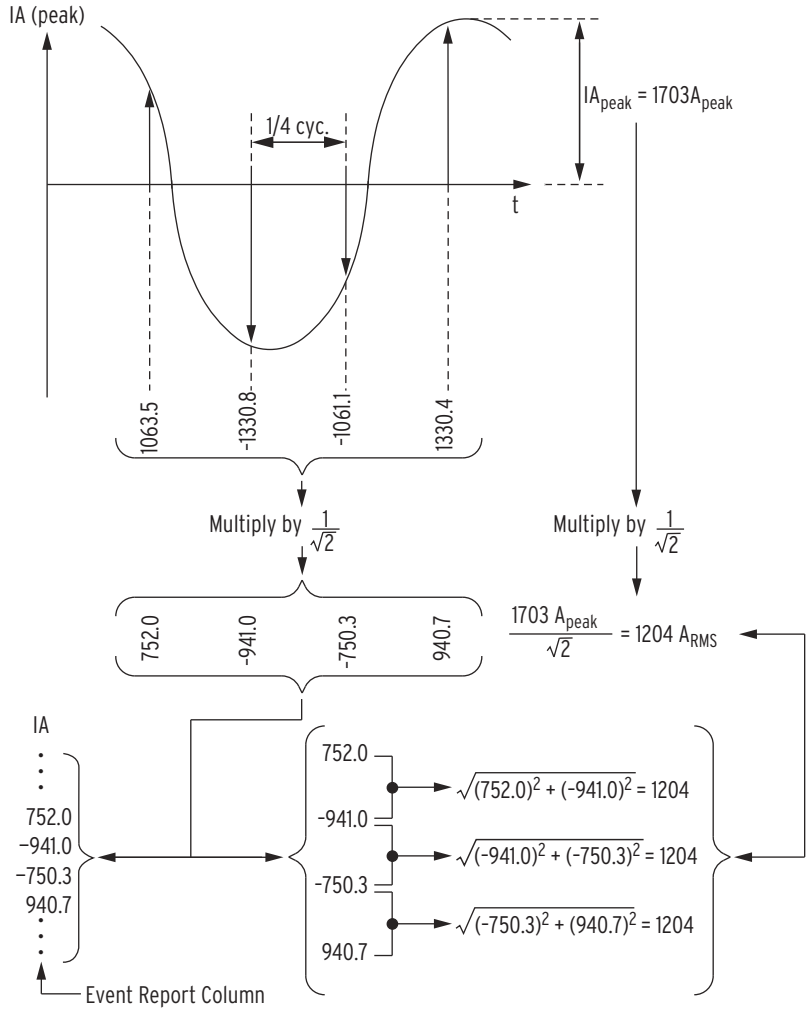


Figure 9.4 Derivation of Analog Event Report Current Values and RMS Current Values From Sampled Current Waveform

In *Figure 9.5*, note that two rows of current data from the analog event report, 1/4 cycle apart, can be used to calculate phasor rms current values. In *Figure 9.5*, at the present sample, the phasor rms current value is:

$$IA = 1204\ A\ \angle -38.6^\circ \quad \textbf{Equation 9.1}$$

The present sample (IA = 940.7 A) is a real rms current value that relates to the phasor rms current value:

$$1204\ A \bullet \cos(-38.6^\circ) = 940.7\ A \quad \textbf{Equation 9.2}$$

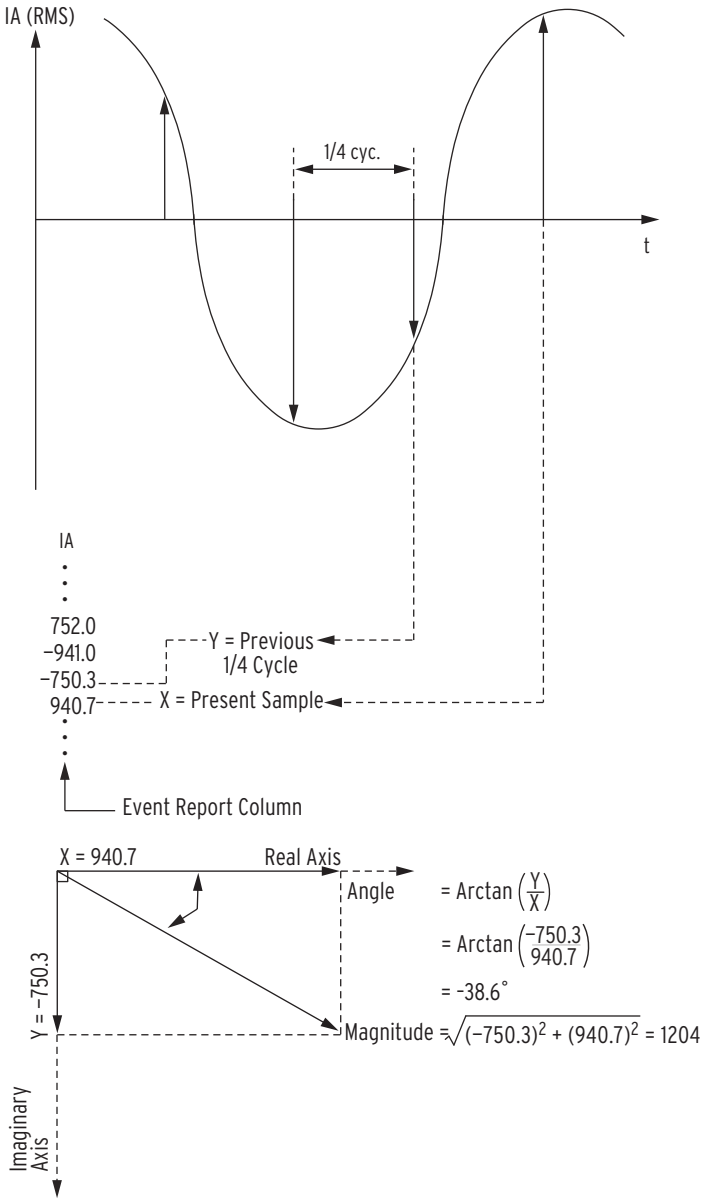


Figure 9.5 Derivation of Phasor RMS Current Values From Event Report Current Values

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 7)

Column Designation	Column Symbols	Column Symbol RWBs
X Side		
50PX1	*	50PX1P picked up
	t	50PX1T picked up
50PX2	*	50PX2P picked up
	t	50PX2T picked up
50PX3A	*	50PX3AP picked up
	t	50PX3AT picked up
50PX3B	*	50PX3BP picked up
	t	50PX3BT picked up
50PX3C	*	50PX3CP picked up
	t	50PX3CT picked up
50GX1/67GX1	*	50GX1P or 67GX1P picked up
	t	50GX1T or 67GX1T picked up
50GX2/67GX2	*	50GX2P or 67GX2T picked up
	t	50GX2T or 67GX2T picked up
50QX1	*	50QX1P picked up
	t	50QX1T picked up
50QX2	*	50QX2P picked up
	t	50QX2T picked up
51PX	*	51PXP picked up
	t	51PXT picked up
	r	51PXR picked up
51GX	*	51GXP picked up
	t	51GXT picked up
	r	51GXR picked up
51QX	*	51QXP picked up
	t	51QXT picked up
	r	51QXR picked up
GX1DIR	1	GX1DIR picked up
GX2DIR	2	GX2DIR picked up
	b	Both GX1DIR and GX2DIR picked up
50N1	*	50N1P picked up
	t	50N1T picked up
50N2	*	50N2P picked up
	t	50N2T picked up
51N1	*	51NP picked up
	t	51NT picked up
	r	51NR picked up
46Q1	*	46Q1 picked up
	t	46Q1T picked up

Table 9.3 Digital Event Report Column Definitions (Sheet 2 of 7)

Column Designation	Column Symbols	Column Symbol RWBs
46Q2	*	46Q2 picked up
	t	46Q2T picked up
	r	46Q2R picked up
21C1	*	21C1P picked up
	t	21C1T picked up
21C2	*	21C2P picked up
	t	21C2T picked up
27PPX1	*	27PPX1 picked up
	t	27PPX1T picked up
27PPX2	*	27PPX2 picked up
	t	27PPX2T picked up
27S1	*	27S1 picked up
	t	27S1T picked up
27S2	*	27S2 picked up
	t	27S2T picked up
59PPX1	*	59PPX1 picked up
	t	59PPX1T picked up
59PPX2	*	59PPX2 picked up
	t	59PPX2T picked up
59GX1	*	59GX1 picked up
	t	59GX1T picked up
59GX2	*	59GX2 picked up
	t	59GX2T picked up
59QX1	*	59QX1 picked up
	t	59QX1T picked up
59QX2	*	59QX2 picked up
	t	59QX2T picked up
59S1	*	59S1 picked up
	t	59S1T picked up
59S2	*	59S2 picked up
	t	59S2T picked up
24D1	*	24D1 picked up
	t	24D1T picked up
24C2	*	24C2 picked up
	t	24C2T picked up
	r	24CR picked up
3PWX1	*	3PWRX1P picked up
	t	3PWRX1T picked up
3PWX2	*	3PWRX2P picked up
	t	3PWRX2T picked up
3PWX3	*	3PWRX3P picked up
	t	3PWRX3T picked up
3PWX4	*	3PWRX4P picked up
	t	3PWRX4T picked up
LOPX	*	LOPX picked up

Table 9.3 Digital Event Report Column Definitions (Sheet 3 of 7)

Column Designation	Column Symbols	Column Symbol RWBs
ZLOADX	*	ZLOADX picked up
78	S	SWING picked up
	O	OOS picked up
	t	OOST picked up
64G1	*	64G1 picked up
	t	64G1T picked up
64G2	*	64G2 picked up
	t	64G2T picked up
40Z1	*	40Z1 picked up
	t	40Z1T picked up
40Z2	*	40Z2 picked up
	t	40Z2T picked up
SFX	*	SFX picked up
25AX	1	25AX1 picked up
	2	25AX2 picked up
	b	Both 25AX1 and 25AX2 picked up
	C	25CX picked up
81X12	1	81X1T picked up
	2	81X2T picked up
	b	Both 81X1T and 81X2T picked up
81X34	3	81X3T picked up
	4	81X4T picked up
	b	Both 81X3T and 81X4T picked up
81X56	5	81X5T picked up
	6	81X6T picked up
	b	Both 81X5T and 81X6T picked up
REF	*	REF1F picked up
	t	REF1P picked up
BFIX	*	BFIX picked up
	t	BFTX picked up
TRIP12	1	TRIP1 picked up
	2	TRIP2 picked up
	B	Both TRIP1 and TRIP2 picked up
TRIP3X	3	TRIP3 picked up
	X	TRIPX picked up
	B	Both TRIP3 and TRIPX picked up
RTD Wdg	w	WDGALRM picked up
	W	WDGTRIP picked up
RTD Brg	b	BRGALRM picked up
	B	BRGTRIP picked up
RTD Oth	o	OTHALRM picked up
	O	OTHTRIP picked up
RTD Amb	a	AMBALRM picked up
	A	AMBTRIP picked up
RTD IN	1	RTDIN asserted

Table 9.3 Digital Event Report Column Definitions (Sheet 4 of 7)

Column Designation	Column Symbols	Column Symbol RWBs
Y Side		
50PY1/67PY1	*	50PY1P or 67PY1P picked up
	t	50PY1T or 67PY1T picked up
50PY2/67PY2	*	50PY2P or 67PY2P picked up
	t	50PY2T or 67PY2T picked up
50PY3A	*	50PY3AP picked up
	t	50PY3AT picked up
50PY3B	*	50PY3BP picked up
	t	50PY3BT picked up
50PY3C	*	50PY3CP picked up
	t	50PY3CT picked up
50GY1/67GY1	*	50GY1P or 67GY1P picked up
	t	50GY1T or 67GY1T picked up
50GY2/67GY2	*	50GY2P or 67GY2P picked up
	t	50GY2T or 67GY2T picked up
50QY1/67QY1	*	50QY1P or 67QY1P picked up
	t	50QY1T or 67QY1T picked up
50QY2/67QY2	*	50QY2P or 67QY2P picked up
	t	50QY2T or 67QY2T picked up
51PY1	*	51PY1P picked up
	t	51PY1T picked up
	r	51PY1R picked up
51GY1	*	51GY1P picked up
	t	51GY1T picked up
	r	51GY1R picked up
51QY1	*	51QY1P picked up
	t	51QY1T picked up
	r	51QY1R picked up
27PPY1	*	27PPY1 picked up
	t	27PPY1T picked up
27PPY2	*	27PPY2 picked up
	t	27PPY2T picked up
59PPY1	*	59PPY1 picked up
	t	59PPY1T picked up
59PPY2	*	59PPY2 picked up
	t	59PPY2T picked up
59GY1	*	59GY1 picked up
	t	59GY1T picked up
59GY2	*	59GY2 picked up
	t	59GY2T picked up
59QY1	*	59QY1 picked up
	t	59QY1T picked up
59QY2	*	59QY2 picked up
	t	59QY2T picked up

Table 9.3 Digital Event Report Column Definitions (Sheet 5 of 7)

Column Designation	Column Symbols	Column Symbol RWBs
3PWY1	*	3PWRY1P picked up
	t	3PWRY1T picked up
3PWY2	*	3PWRY2P picked up
	t	3PWRY2T picked up
3PWY3	*	3PWRY3P picked up
	t	3PWRY3T picked up
3PWY4	*	3PWRY4P picked up
	t	3PWRY4T picked up
LOPY	*	LOPY picked up
ZLOADY	*	ZLOADY picked up
SFY	*	SFY picked up
25AY	1	25AY1 picked up
	2	25AY2 picked up
	b	Both 25AY1 and 25AY2 picked up
81Y12	1	81Y1T picked up
	2	81Y2T picked up
	b	Both 81Y1T and 81Y2T picked up
81Y34	3	81Y3T picked up
	4	81Y4T picked up
	b	Both 81Y3T and 81Y4T picked up
81Y56	5	81Y5T picked up
	6	81Y6T picked up
	b	Both 81Y5T and 81Y6T picked up
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

Table 9.3 Digital Event Report Column Definitions (Sheet 6 of 7)

Column Designation	Column Symbols	Column Symbol RWBs
Inputs 4056	5	IN405 picked up
	6	IN406 picked up
	b	Both IN405 and IN406 picked up
Inputs 4078	7	IN407 picked up
	8	IN408 picked up
	b	Both IN407 and IN408 picked up
Inputs 5012	1	IN501 picked up
	2	IN502 picked up
	b	Both IN501 and IN502 picked up
Inputs 5034	3	IN503 picked up
	4	IN504 picked up
	b	Both IN503 and IN504 picked up
Inputs 5056	5	IN505 picked up
	6	IN506 picked up
	b	Both IN505 and IN506 picked up
Inputs 5078	7	IN507 picked up
	8	IN508 picked up
	b	Both IN507 and IN508 picked up
Outputs 3012	1	OUT301 picked up
	2	OUT302 picked up
	b	Both OUT301 and OUT302 picked up
Outputs 3034	3	OUT303 picked up
	4	OUT304 picked up
	b	Both OUT303 and OUT304 picked up
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

Table 9.3 Digital Event Report Column Definitions (Sheet 7 of 7)

Column Designation	Column Symbols	Column Symbol RWBs
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 .... . * . .. .. .. ... . ... .....
[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 .....
```

Figure 9.6 Example Standard 15-cycle Digital Event Report (EVE D X Command) 1/4 Cycle Resolution (Sheet 1 of 2)

NOTE: The Event Summary and Settings are not shown here, because they are similar to Figure 9.3.

```
[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)

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 4.33* 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  .... . ..
[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  .... . ..
```

NOTE: The Event Summary and Settings are not shown here, because they are similar to those in Figure 9.3.

Figure 9.7 Example 15-cycle Stator Ground Event Report (EVE GND) 1/4 Cycle Resolution (Sheet 1 of 2)

```
[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	*	64G1 picked up
	t	64G1T picked up
64G2	*	64G2 picked up
	t	64G2T picked up
T64G	T	T64G picked up
N64G	N	N64G picked up
In12	1	IN101 picked up
	2	IN102 picked up
	b	Both IN101 and IN102 picked up
Out12	1	OUT101 picked up
	2	OUT102 picked up
	b	Both OUT101 and OUT102 picked up
Out3	*	OUT103 picked up

Differential Event Report (EVE DIFz Command)

The differential event report includes:

- Differential analog quantities for 87-1, 87-2 and 87-3 differential elements
- Digital states of differential and harmonic protection elements, plus status of base model digital inputs and outputs
- Event summary
- 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 IOPz, IRTz, IzF2 and IzF5 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	87R1 picked up
	2	87R2 picked up
	b	Both 87R1 and 87R2 picked up
87R3	*	87R3 picked up
87U12	1	87U1 picked up
	2	87U2 picked up
	b	Both 87U1 and 87U2 picked up
87U3	*	87U3 picked up
87B12	1	87BL1 picked up
	2	87BL2 picked up
	b	Both 87BL1 and 87BL2 picked up
87B3	*	87BL3 picked up
87HR12	1	87HR1 picked up
	2	87HR2 picked up
	b	Both 87HR1 and 87HR2 picked up
87HR3	*	87HR3 picked up
HB1	2	2_4HB1 picked up
	5	5HB1 picked up
	b	Both 2_4HB1 and 5HB1 picked up
HB2	2	2_4HB2 picked up
	5	5HB2 picked up
	b	Both 2_4HB2 and 5HB2 picked up

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)
HB3	2	2_4HB3 picked up
	5	5HB3 picked up
	b	Both 2_4HB3 and 5HB3 picked up
TH5	a	TH5 picked up
	t	TH5T picked up
In12	1	IN101 picked up
	2	IN102 picked up
	b	Both IN101 and IN102 picked up
Out12	1	OUT101 picked up
	2	OUT102 picked up
	b	Both OUT101 and OUT102 picked up
Out3	*	OUT103 picked up

```
=>>EVE 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  . .. .. .. .. ... . . ..
[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. ... . . .*
```

Figure 9.8 Example Standard 15-Cycle Differential Event Report (EVE DIF2 Command) 1/4 Cycle Resolution (Sheet 1 of 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. ... . . .*
```

Figure 9.8 Example Standard 15-Cycle Differential Event Report (EVE DIF2 Command) 1/4 Cycle Resolution (Sheet 2 of 2)

NOTE: The Event Summary and Settings are not shown here, because they are similar to those in Figure 9.3.

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 4.233* 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 4.98*).

```
=>>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 4.92*. 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 4.91* for details on the settings.

The report captures frequency/speed matching and voltage matching during autosynchronism. Refer to *Autosynchronism on page 4.174* 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 4.112* 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 on page 7.29* for an example command response. Clear the history and the reports by using the **GSH C** or the **GSH R** command from Access Level 2.

Use the **GST** command from Access Level 1 or 2 to trigger the Generator Autosynchronism Report.

Section 10
Testing and Troubleshooting

Overview

Relay testing is typically divided into two categories:

- Tests performed at the time the relay is installed or commissioned
- Tests performed periodically once the relay is in service

This section provides information on both types of testing for the SEL-700G Relay. Because the SEL-700G is equipped with extensive self-tests, traditional periodic test procedures may be eliminated or greatly reduced.

Should a problem arise during either commissioning or periodic tests, the section on *Troubleshooting on page 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.

The SEL-RTS Low-Level Relay Test System can be used 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.

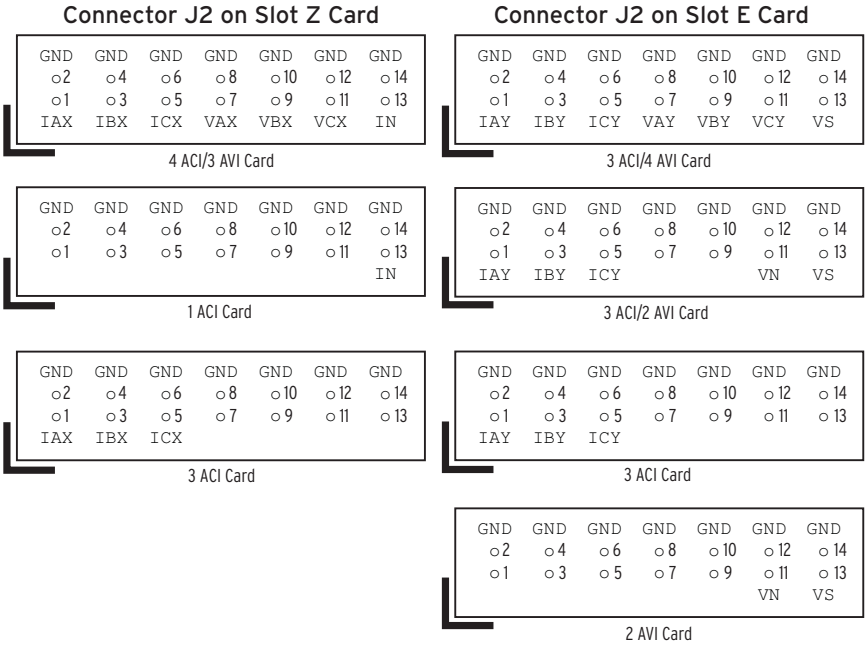


Figure 10.1 Low-Level Test Interface (J2)

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.

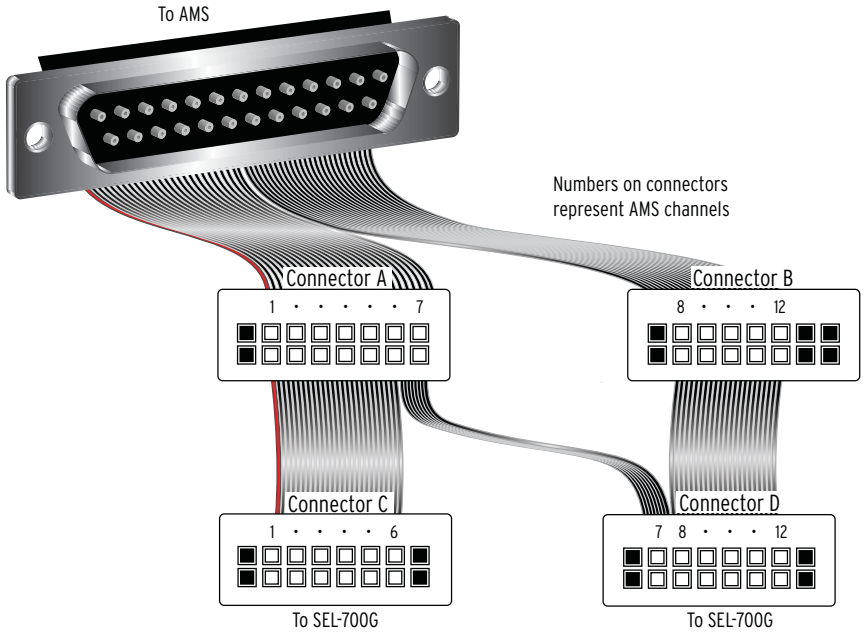


Figure 10.2 C700G Ribbon Cable Connector Diagram

Table 10.1 shows how to use the C700G cable for measuring the required 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 required 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
VAY	J2 on Slot E card	250 V	218.4
VBY	J2 on Slot E card	250 V	218.4

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)
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

Access the low-level test interface connectors by using the following procedure.

⚠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: The 14-pin connectors of the SEL-RTS ribbon cable C700G can be used. The connectors are not keyed; refer to Table 10.1: Cable C700G Connection Options.

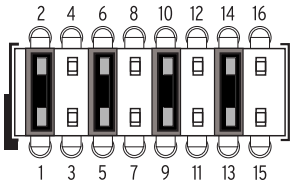
Step 1. Loosen the mounting screws and the ground screw on the back and remove the back cover.

Step 2. Remove the 4 ACI/3 AVI, 1 ACI, or 3 ACI board from Slot Z.

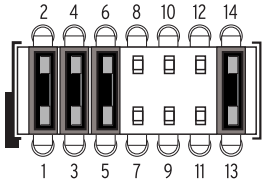
Step 3. Locate the 16-pin jumper assembly J3 on the board and move the four jumpers from CT to AMS positions.

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.

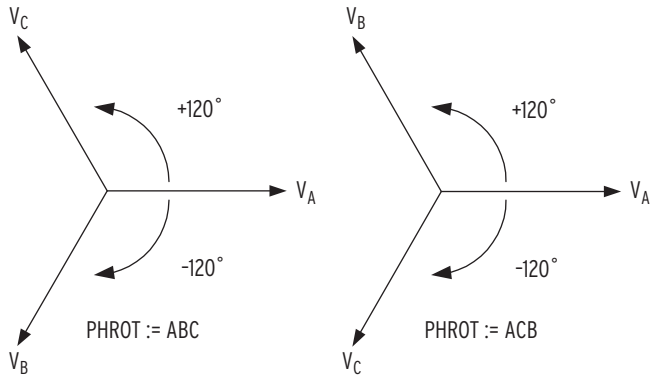
Step 10. Connect the ac test source current or voltage to the appropriate relay terminals.

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*.

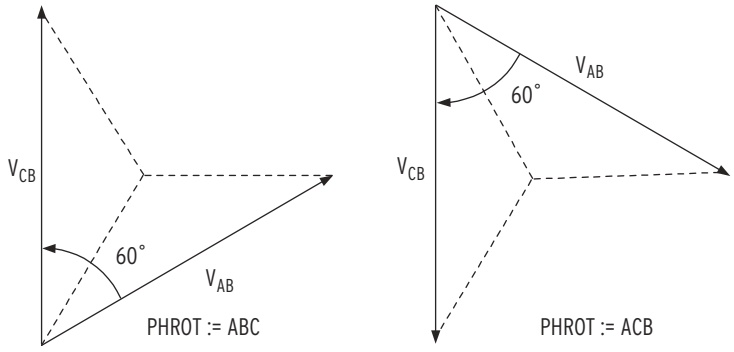
c. If you set the relay to accept delta voltages [(DELTAY_*m* := DELTA (*m* = X or Y)], set the current and/or voltage phase angles as shown in *Figure 10.4*.



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*.

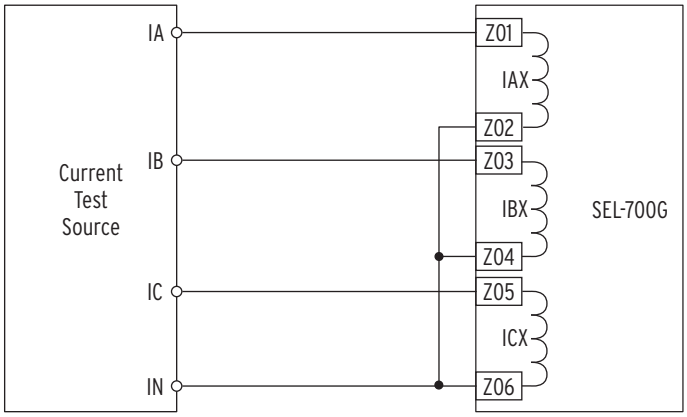


Figure 10.5 CTRX Current Source Connections

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 • I_{XNOM}				
0.9 • I_{XNOM}				
2.0 • 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*.

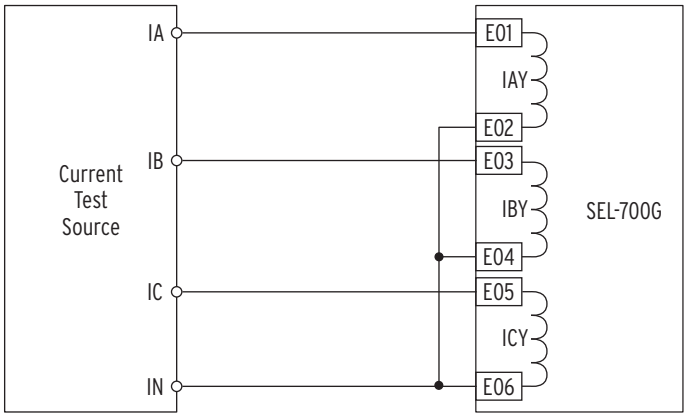


Figure 10.6 CTRY Current Source Connections

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).

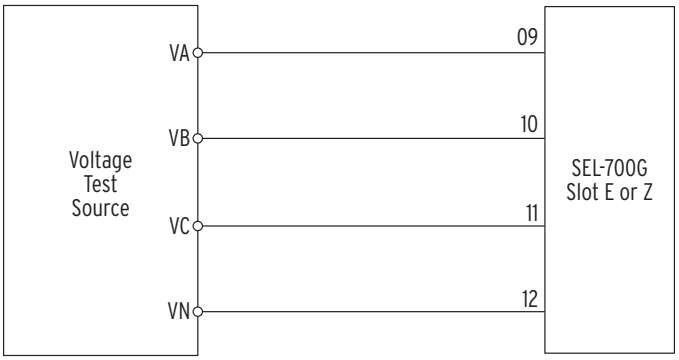


Figure 10.7 Wye Voltage Source Connections

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 VA*m* = 67 ∠0 VB*m* = 67 ∠–120 VC*m* = 67 ∠+120	**Expected:** 3P*m* = 3 • 2.5 • 67 • 0.899 • CTR*m* • PTR*m*/1000 **Measured:**	**Expected:** 3Q*m* = 3 • 2.5 • 67 • 0.438 • CTR*m* • PTR*m*/1000 **Measured:**	**Expected:** pf = 0.90 lag **Measured:**
PHROT := ACB IA*m* = 2.5 ∠–26 IB*m* = 2.5 ∠+94 IC*m* = 2.5 ∠–146 VA*m* = 67 ∠0 VB*m* = 67 ∠+120 VC*m* = 67 ∠–120	**Expected:** 3P*m* = 3 • 2.5 • 67 • 0.899 • CTR*m* • PTR*m*/1000 **Measured:**	**Expected:** 3Q*m* = 3 • 2.5 • 67 • 0.438 • CTR*m* • PTR*m*/1000 **Measured:**	**Expected:** pf = 0.90 lag **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).

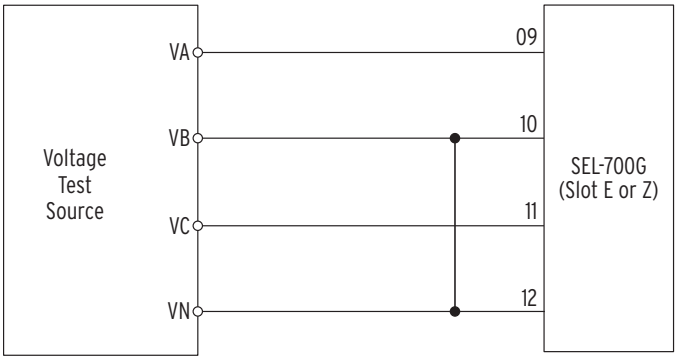


Figure 10.8 Delta Voltage Source Connections

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, and three consecutive unsuccessful password entry attempts. HALARM is pulsed for hardware self-test warnings. HALARM is continuously asserted (set to logical 1) for hardware self-test failures. A diagnostic alarm may be configured 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 3)

Self Test	Description	Normal Range	Protection Disabled on Failure	Alarm Status	Auto Message on Failure	Front Panel Message on Failure	Corrective Action
Watchdog Timer Periodic resetting (1/32 cycle)			Yes	De-energized	No	No	
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

Table 10.9 Relay Self Tests (Sheet 2 of 3)

Self Test	Description	Normal Range	Protection Disabled on Failure	Alarm Status	Auto Message on Failure	Front Panel Message on Failure	Corrective Action
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
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		
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		
+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	

Table 10.9 Relay Self Tests (Sheet 3 of 3)

Self Test	Description	Normal Range	Protection Disabled on Failure	Alarm Status	Auto Message on Failure	Front Panel Message on Failure	Corrective Action
+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		
Clock Chip	Unable to communicate with clock or fails time keeping test		No	Not Latched	Yes		
Clock Chip RAM	Clock chip static RAM fails		No	Not Latched	Yes		
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	
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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Pullman, WA 99163-5603 USA
Tel: +1.509.332.1890
Fax: +1.509.332.7990
Internet: www.selinc.com or www.selindustrial.com
Email: info@selinc.com

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 2)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
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.	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. ➤ 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. ➤ 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.	20111007

Table A.1 Firmware Revision History (Sheet 2 of 2)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
	➤ 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. ➤ 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.	20110324
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 up to three times.	20101206
SEL-700G-R101-V0-Z001001-D20100521	➤ Implemented calibration improvements.	20100521
SEL-700G-R100-V0-Z001001-D20100416	➤ Initial version.	20100416

IEC 61850 and ACSELERATOR Architect Versions

Newer SEL-700G firmware uses a different software library from earlier versions and is unable to process previous version CID files. ACSELERATOR Architect® SEL-5032 Software generates CID files from ICD files, so the ICD file version number and CID file version number are the same. If downloaded to the SEL-700G, an incompatible CID file will generate file parse errors during processing and disable the IEC 61850 protocol.

If you perform an SEL-700G firmware upgrade that spans different file version compatibilities, the relay may be unable to process the stored CID file. See the SEL-700G firmware upgrade instructions for CID file conversion procedures.

See *Table A.2* for compatibilities between ACSELERATOR Architect, ICD/CID files, and SEL-700G firmware versions.

Table A.2 ACSELERATOR Architect CID File Compatibility

ACSELERATOR Architect Software Version	ACSELERATOR Architect ICD/CID File Version	SEL-700G Firmware
R.1.1.90.0 or later	Version 004	R104 and later
R.1.1.100.0 or later	Version 003	R100–R103

DeviceNet and Firmware Versions

The firmware on the DeviceNet interface has two versions as listed in *Table A.3*. The version number of this firmware is only accessible via Device Net interface. SEL-700G needs DeviceNet firmware version 1.005.

Table A.3 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.4 lists the compatibility among the EDS files and the various firmware versions of the relay.

Table A.4 EDS File compatibility

EDS File	Firmware Revisions Supported	Release Date
SEL-700GR100.EDS	R100, R101, R102, R103, R104, R105 (with Device Net version 1.005)	20100416

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 3)

Revision Date	Summary of Revisions
20120903	Preface ➤ Updated product label example in *Product Labels*. Section 1 ➤ Updated *Specifications*.
20111130	Section 1 Corrected *Compression Plug Mounting Ear Screw Tightening Torque* maximum to 0.25 Nm in *Specifications*. Appendix A ➤ Updated for firmware revision R105. Appendix B ➤ Added recommendation to save all data, including events, before firmware upgrade.

Table A.5 Instruction Manual Revision History (Sheet 2 of 3)

Revision Date	Summary of Revisions
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. **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*.

Table A.5 Instruction Manual Revision History (Sheet 3 of 3)

Revision Date	Summary of Revisions
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

SEL occasionally offers firmware upgrades to improve the performance of your relay. Because the SEL-700G Relay stores 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 as outlined in the following sections.

Required Equipment

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, r101700G.s19 or r101700G.z19)

NOTE: Firmware releases are also available as zip files (.z19). Use the zip file for faster download.

Upgrade Instructions

The instructions below 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 current relay settings.

PC software (described in *Section 3: PC Software*) can be used 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**, etc.

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. In rare cases where power is lost during upgrade, the data may be lost.

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.

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.

Step 5. Change the baud rate, if desired.

a. Type **BAU 115200 <Enter>**.

This changes 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, for example, use the Xmodem or 1k Xmodem protocol, and send the file that contains the new firmware (for example, r101700G.s19 or r101700G.z19).

The file transfer takes approximately 10–15 minutes at 115200 baud and with 1k Xmodem transfer protocol. After the transfer is complete, the relay reboots and returns 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
!>BAU 115200 <Enter>
!>REC <Enter>
Caution! This command erases the firmware.
If you erase the firmware then new firmware
must be loaded before returning the IED to service.
Are you sure you want to erase the existing firmware(Y/N)? Y <Enter>
Erasing firmware.
Erase successful.
Press any key to begin transfer and then start transfer at the terminal. <Enter>
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, EEPROM FAILURE`, 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 then reboots with the factory default settings.

d. Enter Access Level 2.

e. 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 that 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-2032, SEL-2030, SEL-2020 port if you have a Communications Processor connected.

This step re-establishes automatic data collection between the SEL-2032, SEL-2030, or SEL-2020 Communications Processor and the SEL relay. Failure to perform this step can result in automatic data collection failure when cycling communications processor power.

Complete Step 16 only if your relay supports the IEC 61850 protocol.

Step 16. Verify IEC 61850 Operation.

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, as 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; 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.

a. Establish an FTP Connection to the relay Ethernet port.

b. 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 c* 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.

i) Install the ACSELERATOR Architect software upgrade that supports your required CID file version.

ii) Run ACSELERATOR Architect and open the project that contains the existing CID file for the relay.

iii) Download the CID file to the relay.

c. Upon connecting to the relay, ACSELERATOR Architect detects the upgraded relay firmware and prompts you to allow it to convert the existing CID file to a supported version. Once converted, downloaded, and processed, the valid CID file allows the relay to re-enable the IEC 61850 protocol.

d. In the Telnet session, type **GOO** and press **<Enter>.**

e. View the GOOSE status and verify that the transmitted and received messages are as expected.

The relay is now ready for your commissioning procedure.

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 needed 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*.

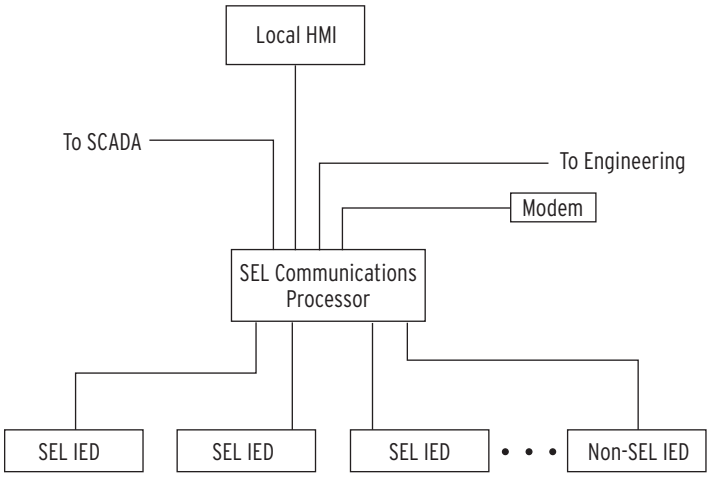

Figure C.1 SEL Communications Processor Star Integration Network

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.

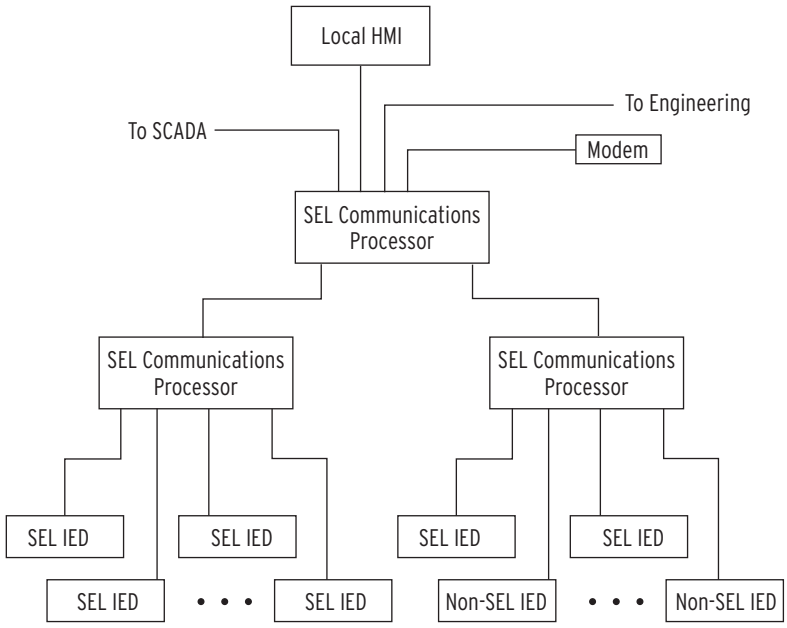

Figure C.2 Multitiered SEL Communications Processor Architecture

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 required 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 communication 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).

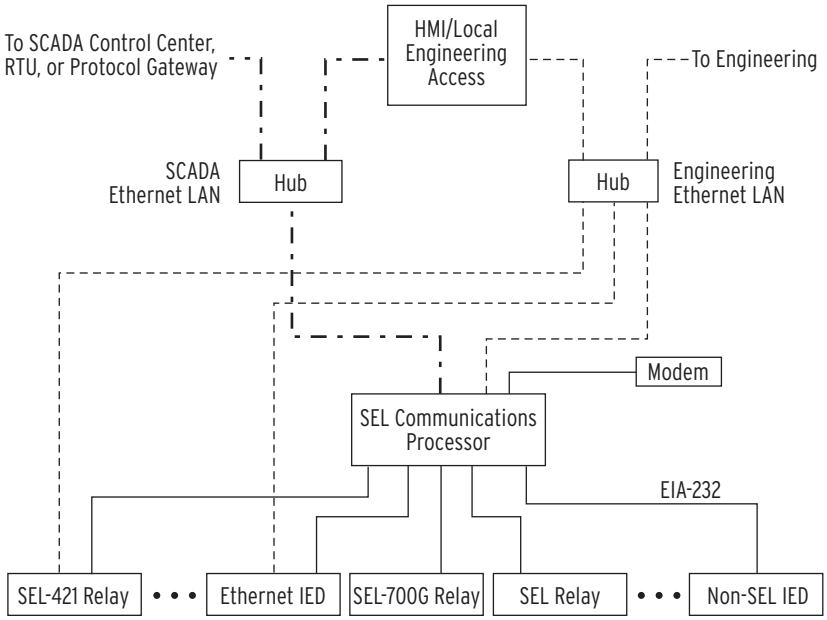

Figure C.3 Enhancing Multidrop Networks With SEL Communications Processors

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*.

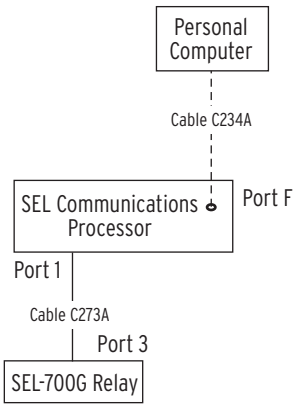

Figure C.4 Example of SEL Relay and SEL Communications Processor Configuration

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 equation TR x) and CC*n* closes the breaker (via SELOGIC Equation CL x). See *Figure 4.119* and *Figure 4.123* 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 on page D.1*
- ➤ *DNP3 in the SEL-700G on page D.6*
- ➤ *DNP3 Documentation on page D.12*

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 may 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. In order 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.13* 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 due to 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:

- DNP3 shall use the IP suite to transport messages over a LAN/WAN
- Ethernet is the recommended physical link, though others may be used
- TCP must be used for WANs
- TCP is strongly recommended for LANs
- User Datagram Protocol (UDP) may be used for highly reliable single segment LANs
- UDP is necessary if broadcast messages are required
- The DNP3 protocol stack shall be retained in full
- Link layer confirmations shall be disabled

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 required.

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 desired event class; UNSOL*n* to No
Unsolicited report-by-exception	Class 0 occasionally, optional Class 1, 2, 3 less frequently; mainly relies on unsolicited messages	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to the desired event class; set UNSOL*n* to Yes and PUNSOL*n* to Yes or No
Quiescent	Class 0, 1, 2, 3 never; relies completely on unsolicited messages	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to the desired event class; set UNSOL*n* and PUNSOL*n* to Yes.

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 it is acknowledged. On a large system, or in systems where the processing power

of the master is limited, you may have problems when several devices simultaneously begin sending data and waiting for acknowledgement 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 may 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. In order 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.

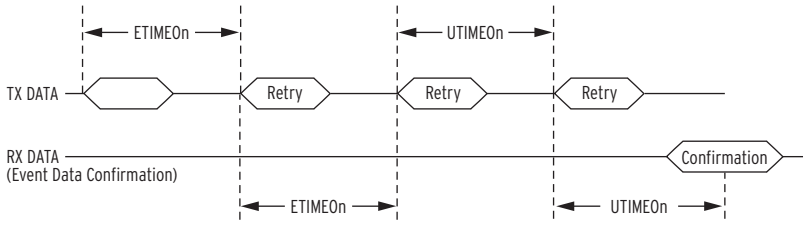

Figure D.1 Application Confirmation Timing With URETRYn = 2

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*).

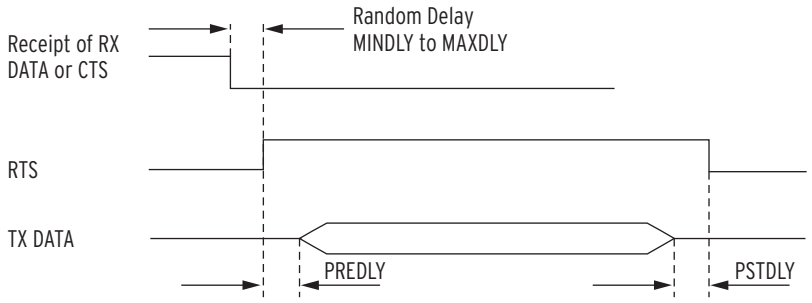

Figure D.2 Message Transmission Timing

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 it 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.13* 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.22*.

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 desired 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, up 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. Some settings only apply to DNP3 LAN/WAN, and are visible only when configuring the Ethernet Port. For example, you only have the ability to define multiple sessions on port 1, the ethernet port. Likewise, settings applicable to serial DNP3 are visible only when configuring a serial port.

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]	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[b]	Data link retries	0–15	3
DTIMEO1[b]	Data link time-out, seconds; hidden if DRETRY1 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[c]	Number of events to transmit on	1–200	10
AGEEVE1[c]	Oldest event to transmit on, seconds	0.0–99999.0	2.0
URETRY1[c]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO1[c]	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,c]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO2[a,c]	Unsolicited messages offline timeout, seconds	1–5000	60
Session 3 Settings			
DNPIP3[a]	IP address (zzz.yyy.xxx.www)	15 characters	""

Table D.7 Port DNP3 Protocol Settings (Sheet 2 of 2)

Name	Description	Range	Default
DNPTR3[a]	Transport protocol	UDP, TCP	TCP
.			
.			
.			
URETRY3[a,c]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO3[a,c]	Unsolicited messages offline timeout, seconds	1–5000	60
Serial Port Settings			
MINDLY[b]	Minimum delay from DCD to TX, seconds	0.00–1.00	0.05
MAXDLY[b]	Maximum delay from DCD to TX, seconds	0.00–1.00	0.10
PREDLY[b]	Settle time from RTS on to TX; Off disables PSTDLY	OFF, 0.00–30.00	0.00
PSTDLY[b]	Settle time from TX to RTS off; hidden if PREDLY set to Off	0.00–30.00	0.00

[a] Available only on Ethernet ports.
[b] Available only on serial ports.
[c] 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	Up to 30 characters	"E0X0&D0S0=4"
PH_NUM1	Primary phone number for dial-out	Up to 30 characters	""
PH_NUM2	Secondary phone number for dial-out	Up to 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 due to 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 supported objects conforms to the format laid out in the DNP specifications and includes both supported and unsupported objects. Those that are supported include the function and qualifier codes. The objects that are not supported are shown without any corresponding function and qualifier codes.

Table D.9 SEL-700G DNP Object List (Sheet 1 of 7)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
0	211	Device Attributes—User-specific sets of attributes	1	0	129	0,17
0	212	Device Attributes—Master data set prototypes	1	0	129	0,17

Table D.9 SEL-700G DNP Object List (Sheet 2 of 7)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
0	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
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

Table D.9 SEL-700G DNP Object List (Sheet 3 of 7)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
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				
21	3	32-Bit Frozen Delta Counter				
21	4	16-Bit Frozen Delta Counter				

Table D.9 SEL-700G DNP Object List (Sheet 4 of 7)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
21	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
31	0	Frozen Analog Input—All Variations				
31	1	32-Bit Frozen Analog Input				

Table D.9 SEL-700G DNP Object List (Sheet 5 of 7)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
31	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
40	4	Long 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 6 of 7)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
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				
101	1	Small Packed Binary-Coded Decimal				
101	2	Medium Packed Binary-Coded Decimal				
101	3	Large Packed Binary-Coded Decimal				

Table D.9 SEL-700G DNP Object List (Sheet 7 of 7)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
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

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 required by 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.

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 DNP3 Reference Data Map (Sheet 1 of 2)

Object	Labels	Description
Binary Inputs		
01, 02	STFAIL	
	STWARN	
	STSET	
	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	Remote bit pairs RB01–RB32
	RB03:RB04	
	RB05:RB06	
	•	
	•	
	•	
	RB29:RB30	
	RB31: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.29 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 required 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 & 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 above. 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 may 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), since 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.

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.

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 may use any of the three available DNP3 maps simultaneously with up to three unique DNP3 masters. Each map is initially populated with default data points, as described in *Default Data Map on page D.19*. You may remap the points in a default map to create a custom map with up to:

- 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 may 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 required, 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 above, 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 was sampled or calculated at the same time), then you should group that 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 the entire configuration may be completed without saving changes between point types. To do this, you simply continue entering data and save the entire map at the end. Alternately, 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.12*.

Table D.12 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.12 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_OO TERSE <Enter>
Analog Input Map

DNP Analog Input Label Name (25 characters)
AI_OO   := NA
? > IAX_MAG <Enter>

AI_O1   := NA
? > IBX_MAG <Enter>

AI_O2   := NA
? > ICX_MAG <Enter>

AI_O3   := NA
? > IAY_MAG <Enter>

AI_O4   := NA
? > P3X:5 <Enter>

AI_O5   := NA
? > VAX_MAG <Enter>

AI_O6   := NA
? > VAX_ANG:1:15 <Enter>

AI_O7   := NA
? > FREQX:.O1:1 <Enter>

AI_O8   := NA
? > end <Enter>

Save changes (Y/N) ? Y <Enter>

=>>
```

Figure D.5 Sample Custom DNP3 AI Map Settings

You may also use ACSELERATOR QuickSet to enter the above 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*.

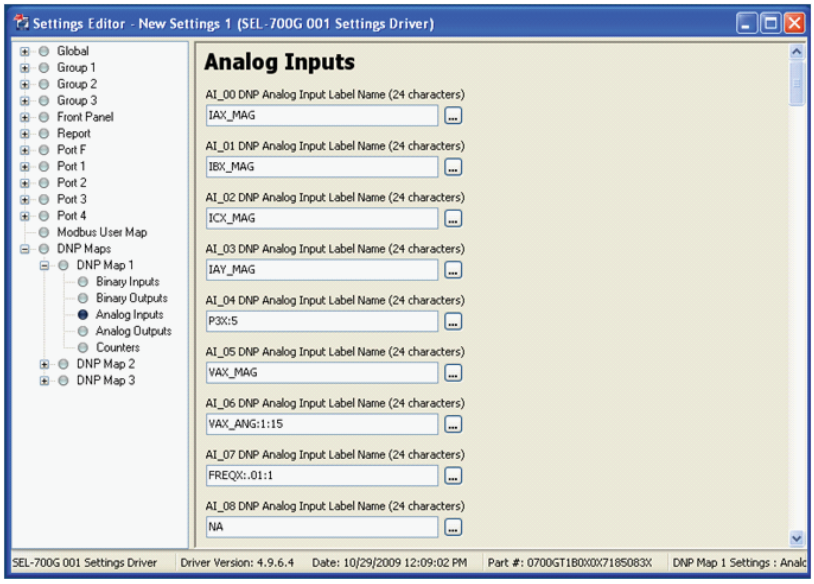

Figure D.6 Analog Input Map Entry in ACSELERATOR QuickSet Software

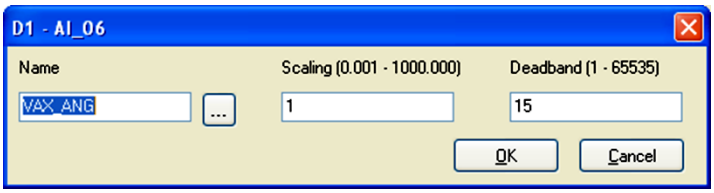

Figure D.7 AI Point Label, Scaling, and Dead Band in ACSELERATOR QuickSet

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 may 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 may also use ACSELERATOR QuickSet to enter the BO map settings as shown in the screen capture in *Figure D.9*.

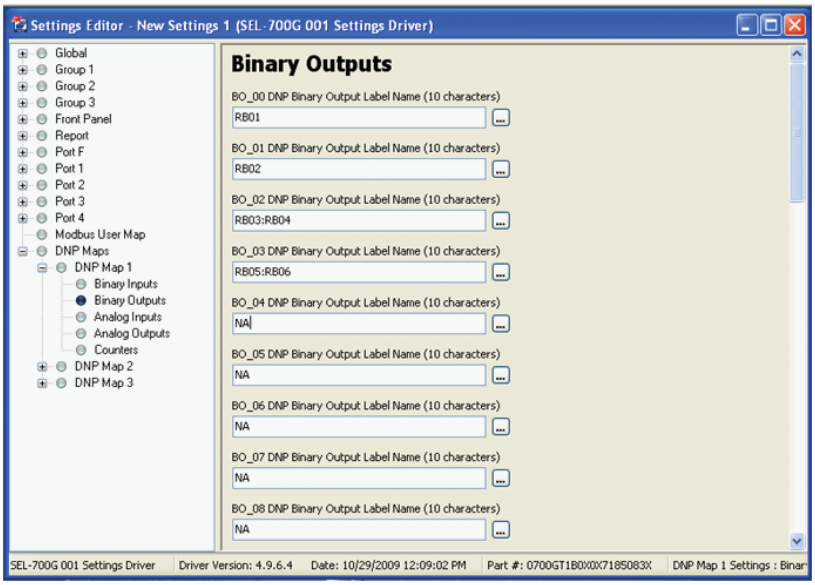

Figure D.9 Binary Output Map Entry in ACSELERATOR QuickSet Software

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.13*. Pulse operations provide a pulse with duration of one protection processing interval.

Table D.13 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.

Default scaling and dead bands may be overridden by per-point scaling and dead band. See *Configurable Data Mapping on page D.22* for more information. Dead bands for analog inputs can also be modified by writing to object 34.

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.

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).

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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 up to 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 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 desired 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 may have the same address.

The cyclical redundancy check detects errors in the received data. If an error is detected, the relay 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, due to 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 required 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 required 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	Communication 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 required 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

[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 = TO1_LED
Address 4 = TO2_LED
Address 3 = TO3_LED
Address 2 = TO4_LED
Address 1 = TO5_LED
Address 0 = TO6_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	Communication 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	Communication 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	Communication 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 or the breaker jumper is not installed, 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	Communication 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 required by the master.

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	Communication 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	Communication 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, up to 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	Communication 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):

$$value = \frac{(ParameterValue + Offset) \bullet Multiplier \bullet Base}{Divisor} \qquad \textbf{Equation E.1}$$

Use *Equation E.2* to calculate the scaled setting value:

$$value = \frac{value \bullet Divisor}{Multiplier \bullet Base} - Offset \qquad \textbf{Equation E.2}$$

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	Communication 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 shown below.

Table E.27 61h Read Parameter Text Query Error Messages

Error	Error Code Returned	Communication 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 shown below.

Table E.29 61h Read Parameter Enumeration Text Query Error Messages

Error	Error Code Returned	Communication 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 required.

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. All the bits in that register need to be written 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 desired quantities (up to 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 desired 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
271	FPGA
272	GPSB
273	HMI
274	RAM
275	ROM
276	CR_RAM
277	NON_VOL
278	CLKSTS
279	CID_FILE
280	RTD
281	P3P3PS
282	P5PS
283	P2P5PS
284	P3P75PS
285	N1P25PS
286	N5PS
287	P0P9PS
288	P1P2PS
289	P1P5PS
290	P1P8PS
291	CLKBAT
292	CARDZ
293	CARDC
294	CARDD
295	CARDE
296	IAXSTS
297	IBXSTS
298	ICXSTS
299	IAYSTS
300	IBYSTS
301	ICYSTS
302	INSTS
303	VAXSTS
304	VBXSTS
305	VCXSTS
306	VAYSTS
307	VBYSTS
308	VCYSTS
309	VSSTS
310	VNSTS
311	F64COMM
312	F64STS
313	RLYSTS
314	SER_NUMH
315	SER_NUML
316	RES_316
317	RES_317
318	RES_318
319	RES_319
320	IAX_MAG
321	IAX_ANG
322	IBX_MAG
323	IBX_ANG
324	ICX_MAG
325	ICX_ANG
326	IGX_MAG
327	IGX_ANG
328	3I2X_MAG
329	I1X_MAG
330	VABX_MAG
331	VABX_ANG
332	VBCX_MAG
333	VBCX_ANG
334	VCAX_MAG
335	VCAX_ANG
336	VAX_MAG
337	VAX_ANG
338	VBX_MAG
339	VBX_ANG
340	VCX_MAG
341	VCX_ANG
342	VGX_MAG
343	VGX_ANG
344	3V2X_MAG
345	V1X_MAG
346	PAXH
347	PAXL
348	PBXH
349	PBXL
350	PCXH
351	PCXL
352	P3XH
353	P3XL
354	QAXH
355	QAXL
356	QBXH
357	QBXL
358	QCXH
359	QCXL
360	Q3XH
361	Q3XL
362	SAXH
363	SAXL
364	SBXH
365	SBXL
366	SCXH
367	SCXL
368	S3XH
369	S3XL
370	PFAX
371	PFBX
372	PFCX
373	PF3X
374	FREQX
375	VHZX
376	RES_376
377	RES_377
378	RES_378
379	RES_379
380	RES_380
381	IAY_MAG
382	IAY_ANG
383	IBY_MAG
384	IBY_ANG
385	ICY_MAG
386	ICY_ANG
387	IGY_MAG
388	IGY_ANG
389	3I2Y_MAG
390	I1Y_MAG
391	VABY_MAG
392	VABY_ANG
393	VBCY_MAG
394	VBCY_ANG
395	VCAY_MAG
396	VCAY_ANG
397	VAY_MAG
398	VAY_ANG
399	VBY_MAG
400	VBY_ANG
401	VCY_MAG
402	VCY_ANG
403	VGY_MAG
404	VGY_ANG
405	3V2Y_MAG
406	V1Y_MAG
407	IN_MAG
408	IN_ANG
409	VS_MAG
410	VS_ANG
411	VN_MAG
412	VN_ANG
413	VN3_MAG
414	VPX3_MAG
415	FLDRES
416	FREQS
417	RES_417
418	RES_418
419	RES_419
420	RES_420
421	RES_421
422	RES_422
423	MWHPXH
424	MWHPXL
425	MWHNXH
426	MWHNXL
427	MVARHPXH
428	MVARHPXL
429	MVARHNXH
430	MVARHNXL
431	MWHPYH
432	MWHPYL
433	MWHNYH
434	MWHNYL
435	MVARHPYH
436	MVARHPYL
437	MVARHNYH
438	MVARHNYL
439	ENRGY_S
440	ENRGYMN
441	ENRGY_H
442	ENRGY_D
443	ENRGYMO
444	ENRGY_Y
445	RES_445
446	RES_446

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 2 of 5)

Register Address	Label
447	RES_447
448	RES_448
449	RES_449
450	RES_450
451	RES_451
452	RES_452
453	IAXD
454	IBXD
455	ICXD
456	IGXD
457	3I2XD
458	IAYD
459	IBYD
460	ICYD
461	IGYD
462	3I2YD
463	IAXPD
464	IBXPD
465	ICXPD
466	IGXPD
467	3I2XPD
468	IAYPD
469	IBYPD
470	ICYPD
471	IGYPD
472	3I2YPD
473	PDEM_R_S
474	PDEM_RMN
475	PDEM_R_H
476	PDEM_R_D
477	PDEM_RMO
478	PDEM_R_Y
479	IAX_THD
480	IBX_THD
481	ICX_THD
482	IAY_THD
483	IBY_THD
484	ICY_THD
485	RTDWDGMX
486	RTDBRGMX
487	RTDAMB
488	RTDOTHMX
489	RTD1
490	RTD2

Register Address	Label
491	RTD3
492	RTD4
493	RTD5
494	RTD6
495	RTD7
496	RTD8
497	RTD9
498	RTD10
499	RTD11
500	RTD12
501	TCUGEN
502	TCURTD
503	RES_503
504	RES_504
505	RES_505
506	RES_506
507	RES_507
508	RES_508
509	RES_509
510	RES_510
511	RES_511
512	RES_512
513	RES_513
514	IAXRMS
515	IBXRMS
516	ICXRMS
517	IAYRMS
518	IBYRMS
519	ICYRMS
520	VAXRMS
521	VBXRMS
522	VCXRMS
523	VABXRMS
524	VBCXRMS
525	VCAXRMS
526	VAYRMS
527	VBYRMS
528	VCYRMS
529	VABYRMS
530	VBCYRMS
531	VCAYRMS
532	INRMS
533	VSRMS
534	IAXMX

Register Address	Label
535	IAXMN
536	IBXMX
537	IBXMN
538	ICXMX
539	ICXMN
540	IGXMX
541	IGXMN
542	IAYMX
543	IAYMN
544	IBYMX
545	IBYMN
546	ICYMX
547	ICYMN
548	IGYMX
549	IGYMN
550	INMX
551	INMN
552	VABXMX
553	VABXMN
554	VBCXMX
555	VBCXMN
556	VCAXMX
557	VCAXMN
558	VABYMX
559	VABYMN
560	VBCYMX
561	VBCYMN
562	VCAYMX
563	VCAYMN
564	VSMX
565	VSMN
566	VNMX
567	VNMN
568	VN3MX
569	VN3MN
570	VPX3MX
571	VPX3MN
572	KW3XMXH
573	KW3XMXL
574	KW3XMNH
575	KW3XMNL
576	KVR3XMXH
577	KVR3XMXL
578	KVR3XMNH

Register Address	Label
579	KVR3XMNL
580	KVA3XMXH
581	KVA3XMXL
582	KVA3XMNH
583	KVA3XMNL
584	KW3YMXH
585	KW3YMXL
586	KW3YMNH
587	KW3YMNL
588	KVR3YMXH
589	KVR3YMXL
590	KVR3YMNH
591	KVR3YMNL
592	KVA3YMXH
593	KVA3YMXL
594	KVA3YMNH
595	KVA3YMNL
596	FREQXMX
597	FREQXMN
598	FREQYMX
599	FREQYMN
600	RTD1MX
601	RTD1MN
602	RTD2MX
603	RTD2MN
604	RTD3MX
605	RTD3MN
606	RTD4MX
607	RTD4MN
608	RTD5MX
609	RTD5MN
610	RTD6MX
611	RTD6MN
612	RTD7MX
613	RTD7MN
614	RTD8MX
615	RTD8MN
616	RTD9MX
617	RTD9MN
618	RTD10MX
619	RTD10MN
620	RTD11MX
621	RTD11MN
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
975	ROW_4
976	ROW_5
977	ROW_6
978	ROW_7
979	ROW_8
980	ROW_9
981	ROW_10
982	ROW_11
983	ROW_12
984	ROW_13
985	ROW_14
986	ROW_15
987	ROW_16
988	ROW_17
989	ROW_18
990	ROW_19
991	ROW_20
992	ROW_21
993	ROW_22
994	ROW_23
995	ROW_24
996	ROW_25
997	ROW_26
998	ROW_27
999	ROW_28
1000	ROW_29
1001	ROW_30
1002	ROW_31
1003	ROW_32
1004	ROW_33
1005	ROW_34
1006	ROW_35
1007	ROW_36
1008	ROW_37
1009	ROW_38
1010	ROW_39
1011	ROW_40
1012	ROW_41
1013	ROW_42
1014	ROW_43
1015	ROW_44
1016	ROW_45
1017	ROW_46
1018	ROW_47
1019	ROW_48
1020	ROW_49
1021	ROW_50
1022	ROW_51
1023	ROW_52
1024	ROW_53
1025	ROW_54
1026	ROW_55
1027	ROW_56
1028	ROW_57
1029	ROW_58
1030	ROW_59
1031	ROW_60
1032	ROW_61
1033	ROW_62
1034	ROW_63
1035	ROW_64
1036	ROW_65
1037	ROW_66
1038	ROW_67
1039	ROW_68
1040	ROW_69
1041	ROW_70
1042	ROW_71
1043	ROW_72
1044	ROW_73
1045	ROW_74
1046	ROW_75
1047	ROW_76
1048	ROW_77
1049	ROW_78
1050	ROW_79
1051	ROW_80
1052	ROW_81
1053	ROW_82
1054	ROW_83
1055	ROW_84
1056	ROW_85
1057	ROW_86
1058	ROW_87
1059	ROW_88
1060	ROW_89
1061	ROW_90
1062	ROW_91
1063	ROW_92
1064	ROW_93
1065	ROW_94
1066	ROW_95
1067	ROW_96
1068	ROW_97
1069	ROW_98
1070	ROW_99
1071	ROW_100
1072	ROW_101
1073	ROW_102
1074	ROW_103
1075	ROW_104
1076	ROW_105
1077	ROW_106
1078	ROW_107
1079	ROW_108
1080	ROW_109
1081	ROW_110
1082	ROW_111
1083	ROW_112
1084	ROW_113
1085	ROW_114
1086	ROW_115
1087	ROW_116
1088	ROW_117
1089	ROW_118
1090	ROW_119
1091	ROW_120
1092	ROW_121
1093	ROW_122
1094	ROW_123
1095	ROW_124
1096	ROW_125
1097	ROW_126
1098	ROW_127
1099	ROW_128
1100	ROW_129
1101	ROW_130
1102	ROW_131
1103	ROW_132
1104	ROW_133
1105	ROW_134
1106	ROW_135
1107	ROW_136
1108	ROW_137
1109	ROW_138
1110	ROW_139
1111	ROW_140
1112	ROW_141
1113	ROW_142
1114	ROW_143
1115	ROW_144
1116	ROW_145
1117	ROW_146
1118	ROW_147
1119	ROW_148
1120	na

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*).

Modbus Register Map

Table E.34 lists the data available in the Modbus interface and its 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 27)

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	1120	1120	1	101
	•						
	•						
	•						
125 (R/W)	USER REG #125		271	1120	1120	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 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		0	4095	0		361
262 (R)	Reserved[c]		0	0	0		362

Table E.34 Modbus Register Map[a] (Sheet 2 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
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

Table E.34 Modbus Register Map[a] (Sheet 3 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
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

Table E.34 Modbus Register Map[a] (Sheet 4 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
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

Table E.34 Modbus Register Map[a] (Sheet 5 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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	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
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

Table E.34 Modbus Register Map[a] (Sheet 6 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
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

Table E.34 Modbus Register Map[a] (Sheet 7 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
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

Table E.34 Modbus Register Map[a] (Sheet 8 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
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

Table E.34 Modbus Register Map[a] (Sheet 9 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
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

Table E.34 Modbus Register Map[a] (Sheet 10 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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[dd]	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[dd]	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[dd]	EU	–32768	32767	0	0.001	760
661 (R)	AI502 MX—LO[d]	EU	–32768	32767	0	0.001	761
662 (R)	AI502 MN—HI[dd]	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[dd]	EU	–32768	32767	0	0.001	764
665 (R)	AI503 MX—LO[d]	EU	–32768	32767	0	0.001	765

Table E.34 Modbus Register Map[a] (Sheet 11 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
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

Table E.34 Modbus Register Map[a] (Sheet 12 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
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

Table E.34 Modbus Register Map[a] (Sheet 13 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
826 (R)	EVENT TYPE		0	30	0		926
	0 = TRIP*		16 = OUT OF STEP TRIP				
	1 = DIFF 87 TRIP		17 = VOLT/HZ 24 TRIP				
	2 = REF TRIP		18 = FLD LOSS 40 TRIP				
	3 = PH 50 TRIP		19 = THERMAL 49 TRIP				
	4 = GND 50 TRIP		20 = 64G/64F GND TRIP				
	5 = 50Q TRIP		21 = FREQUENCY81 TRIP				
	6 = NEUTRAL 50 TRIP		22 = INADVERTENRGTRIP				
	7 = NEG SEQ 46 TRIP		23 = RTD TRIP				
	8 = PH 51 TRIP		24 = RTD FAIL TRIP				
	9 = GND 51 TRIP		25 = BKR FAILURE TRIP				
	10 = 51Q TRIP		26 = REMOTE TRIP				
	11 = NEUTRAL 51 TRIP		27 = COMMIDLELOSSTRIP				
	12 = POWERELEMNT TRIP		28 = TRIGGER				
	13 = UNDERVOLT TRIP		29 = ER TRIGGER				
	14 = OVERVOLT TRIP		30 = TRIP				
	15 = BACKUP TRIP						

Table E.34 Modbus Register Map[a] (Sheet 14 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
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

Table E.34 Modbus Register Map[a] (Sheet 15 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
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

Table E.34 Modbus Register Map[a] (Sheet 16 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
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

Table E.34 Modbus Register Map[a] (Sheet 17 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
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

Table E.34 Modbus Register Map[a] (Sheet 18 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
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

Table E.34 Modbus Register Map[a] (Sheet 19 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
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

Table E.34 Modbus Register Map[a] (Sheet 20 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
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

Table E.34 Modbus Register Map[a] (Sheet 21 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
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

Table E.34 Modbus Register Map[a] (Sheet 22 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
1016 (R)	ROW 45 Bit 0 = * Bit 1 = * Bit 2 = * Bit 3 = * Bit 4 = * Bit 5 = OUT103 Bit 6 = OUT102 Bit 7 = OUT101		0	255	0		1116
1017 (R)	ROW 46 Bit 0 = OUT308 Bit 1 = OUT307 Bit 2 = OUT306 Bit 3 = OUT305 Bit 4 = OUT304 Bit 5 = OUT303 Bit 6 = OUT302 Bit 7 = OUT301		0	255	0		1117

Table E.34 Modbus Register Map[a] (Sheet 23 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1018 (R)	ROW 47 Bit 0 = OUT408 Bit 1 = OUT407 Bit 2 = OUT406 Bit 3 = OUT405 Bit 4 = OUT404 Bit 5 = OUT403 Bit 6 = OUT402 Bit 7 = OUT401		0	255	0		1118
1019 (R)	ROW 48 Bit 0 = OUT508 Bit 1 = OUT507 Bit 2 = OUT506 Bit 3 = OUT505 Bit 4 = OUT504 Bit 5 = OUT503 Bit 6 = OUT502 Bit 7 = OUT501		0	255	0		1119
1020 (R)	ROW 49 Bit 0 = * Bit 1 = * Bit 2 = * Bit 3 = * Bit 4 = * Bit 5 = * Bit 6 = IN102 Bit 7 = IN10I		0	255	0		1120
1021 (R)	ROW 50 Bit 0 = IN308 Bit 1 = IN307 Bit 2 = IN306 Bit 3 = IN305 Bit 4 = IN304 Bit 5 = IN303 Bit 6 = IN302 Bit 7 = IN301		0	255	0		1121
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 148		0	255	0		1124–1219
1120 (R)	Reserved[c]		0	0	0		1220

Table E.34 Modbus Register Map[a] (Sheet 24 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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	
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	

Table E.34 Modbus Register Map[a] (Sheet 25 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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	
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	

Table E.34 Modbus Register Map[a] (Sheet 26 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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	
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	1120	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	1120	na	

Table E.34 Modbus Register Map[a] (Sheet 27 of 27)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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					
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.

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Appendix F
IEC 61850 Communications

Features

The SEL-700G Relay supports the following features using Ethernet and IEC 61850:

- SCADA—Connect up to six simultaneous IEC 61850 MMS client sessions. The SEL-700G also supports up to 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.

NOTE: The SEL-700G supports one CID file, which should be transferred only if a change in the relay configuration is required. 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.

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 may 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 is 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.

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 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 required 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.

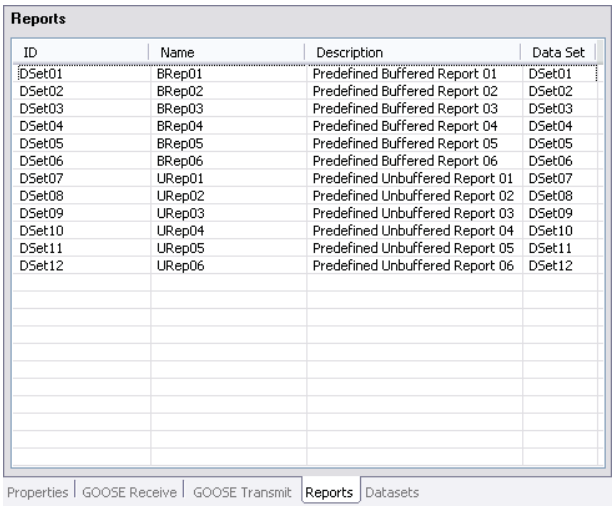

Figure F.1 SEL-700G Predefined Reports

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 may 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		FALSE
RptEna	YES	YES	FALSE
OptFlds	YES		SegNum
			timeStamp
			dataSet
			reasonCode
			dataRef
BufTm	YES		500
TrgOp	YES		dchg
			qchg
IntgPd	YES		FALSE
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 may 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		FALSE
RptEna	YES	YES	FALSE
Resv	YES		FALSE
OptFlds	YES		segNum
			timeStamp
			dataSet
			reasonCode
			dataRef
BufTm	YES		250
TrgOps	YES		dchg
			qchg
IntgPd	YES		FALSE
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, up to 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

The list of datasets in *Figure F.2* is the default for an SEL-700G device.

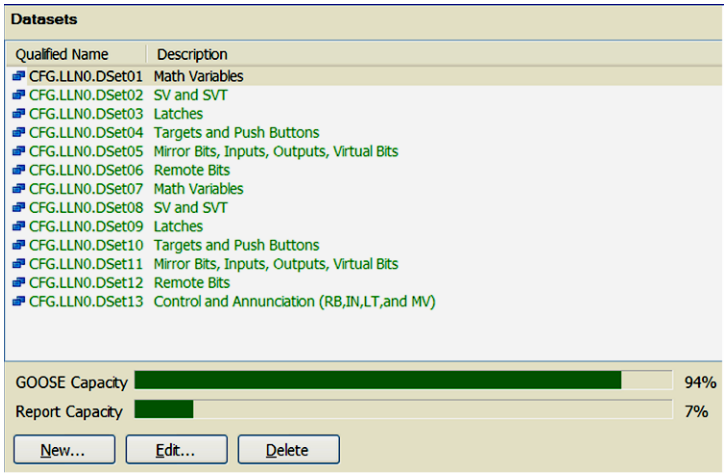

Figure F.2 SEL-700G Datasets

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 (DSet01 to DSet12) 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 needed to browse an SEL-700G with an MMS browser are shown below:

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 time stamp is determined when data or quality change is detected.

The timestamp is applied to all data and quality attributes (Boolean, Bstrings, Analogs, etc.) in the same fashion when a data or quality change is detected. However, there is a difference in how the change is detected between the different attribute types. For points that are assigned as SER points, that is, programmed in the SER report, the change is detected as the receipt of an SER record (which contains the SER timestamp) within the relay.

For all other Booleans or Bstrings, the change is detected 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. In order 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.

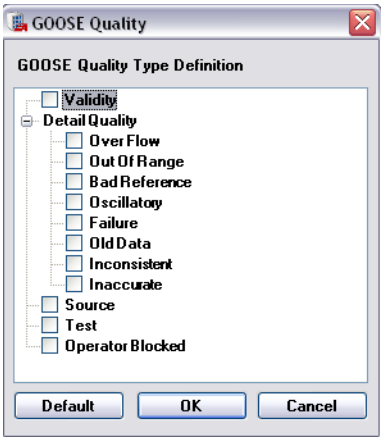

Figure F.3 GOOSE Quality

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:

- The user can define up to 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 example above; 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:

- The user 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 protection and integration engineers to design and commission IEC 61850 substations containing SEL IEDs.

Engineers can use ACSELERATOR Architect to:

- Organize and configure all SEL IEDs in a substation project
- Configure incoming and outgoing GOOSE messages
- Read non-SEL IED Capability Description (ICD) and Configured IED Description (CID) files and determine the available IEC 61850 messaging options
- Load device settings and IEC 61850 CID files into SEL IEDs
- Generate ICD files that provide SEL IED descriptions to other manufacturer's tools so they can use SEL GOOSE messages and reporting features
- Configure protection, logic, control, and communication settings of all SEL IEDs in the substation

ACSELERATOR Architect provides a Graphical User Interface (GUI) for engineers to select, edit, and create IEC 61850 GOOSE messages important for substation protection, coordination, and control schemes. Typically, the engineer first places icons representing IEDs in a substation container, then edits the outgoing GOOSE messages or creates new ones for each IED. The engineer may also select incoming GOOSE messages for each IED to receive from any other IEDs in the domain. ACSELERATOR Architect has the capability to read other manufacturer's ICD and CID files, enabling the engineer to map the data seamlessly into SEL IED logic. See the ACSELERATOR Architect Instruction Manual or online help for more information.

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 Metering and Measurement Logical Nodes

Logical Node	IEC 61850	Description or comments
Thermal Measurements (for equipment or ambient temperature readings)	MTHR	To acquire values from RTDs and to calculate thermal capacity and usage mainly used for Thermal Monitoring.
Demand Metering Statistics	MDST	This LN shall be used for calculation of demand currents and energy in a three-phase system. This shall not be used for billing purposes

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 depends on the presence and configuration of the RTD module(s).

Table F.8 Thermal Metering Data (Sheet 1 of 2)

Attribute Name	Type	Explanation	T	M/O/E
MTHR Class				
LNName		Shall be inherited from Logical-Node Class (see IEC 61850-7-2).		
Data				
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
Measured Values				
MaxWdgTmp	MV	Maximum Winding Temperature		E
MaxBrgTmp	MV	Maximum Bearing Temperature		E
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
Tmp09	MV	Temperature 9		E

Table F.8 Thermal Metering Data (Sheet 2 of 2)

Attribute Name	Type	Explanation	T	M/O/E
Tmp10	MV	Temperature 10		E
Tmp11	MV	Temperature 11		E
Tmp12	MV	Temperature 12		E

Table F.9 defines the extensions to the MSTA data class, Metering Statistics, defined in the IEC 61850 standard.

Table F.9 MSTA Class

Attribute Name	Type	Explanation	T	M/O/E
Measured values				
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

Table F.10 defines the MDST data class, Demand Metering Statistics. This class is a collection of demand currents and energy.

Table F.10 MDST Class

Attribute Name	Type	Explanation	T	M/O/E
LNName		Shall be inherited from Logical Node Class (see IEC 61850-7-2)		
Data				
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
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

Logical Nodes

The following tables, *Table F.11* through *Table F.14*, show the Logical Nodes (LN) supported in the SEL-700G and the associated Relay Word bits or measured quantities. *Table F.11* shows the LN associated with protection elements defined as Logical Device PRO.

Table F.11 Logical Device: PRO (Protection) (Sheet 1 of 6)

Logical Node	Status	Relay Word Bit	Comment
PX1PIOC1	Str.general	50PX1P	
PX1PIOC1	Op.general	50PX1T	
PX2PIOC2	Str.general	50PX2P	
PX2PIOC2	Op.general	50PX2T	
PXAPIOC3	Str.general	50PX3AP	
PXAPIOC3	Op.general	50PX3AT	
PXBPIOC4	Str.general	50PX3BP	
PXBPIOC4	Op.general	50PX3BT	
PXCPIOC5	Str.general	50PX3CP	
PXCPIOC5	Op.general	50PX3CT	
PY1PIOC6	Str.general	50PY1P	
PY1PIOC6	Op.general	50PY1T	
PY2PIOC7	Str.general	50PY2P	
PY2PIOC7	Op.general	50PY2T	
PYAPIOC8	Str.general	50PY3AP	
PYAPIOC8	Op.general	50PY3AT	
PYBPIOC9	Str.general	50PY3BP	
PYBPIOC9	Op.general	50PY3BT	
PYCPIOC10	Str.general	50PY3CP	
PYCPIOC10	Op.general	50PY3CT	
N1PIOC11	Str.general	50N1P	
N1PIOC11	Op.general	50N1T	
N2PIOC12	Str.general	50N2P	
N2PIOC12	Op.general	50N2T	
GX1PIOC13	Str.general	50GX1P	
GX1PIOC13	Op.general	50GX1T	
GX2PIOC14	Str.general	50GX2P	
GX2PIOC14	Op.general	50GX2T	
GY1PIOC15	Str.general	50GY1P	
GY1PIOC15	Op.general	50GY1T	
GY2PIOC16	Str.general	50GY2P	
GY2PIOC16	Op.general	50GY2T	
QX1PIOC17	Str.general	50QX1P	

Table F.11 Logical Device: PRO (Protection) (Sheet 2 of 6)

Logical Node	Status	Relay Word Bit	Comment
QX1PIOC17	Op.general	50QX1T	
QX2PIOC18	Str.general	50QX2P	
QX2PIOC18	Op.general	50QX2T	
QY1PIOC19	Str.general	50QY1P	
QY1PIOC19	Op.general	50QY1T	
QY2PIOC20	Str.general	50QY2P	
QY2PIOC20	Op.general	50QY2T	
GX1PTOC1	Str.general	67GX1P	
GX1PTOC1	Op.general	67GX1T	
GX2PTOC2	Str.general	67GX2P	
GX2PTOC2	Op.general	67GX2T	
GY1PTOC3	Str.general	67GY1P	
GY1PTOC3	Op.general	67GY1T	
GY2PTOC4	Str.general	67GY2P	
GY2PTOC4	Op.general	67GY2T	
PY1PTOC5	Str.general	67PY1P	
PY1PTOC5	Op.general	67PY1T	
PY2PTOC6	Str.general	67PY2P	
PY2PTOC6	Op.general	67PY2T	
QY1PTOC7	Str.general	67QY1P	
QY1PTOC7	Op.general	67QY1T	
QY2PTOC8	Str.general	67QY2P	
QY2PTOC8	Op.general	67QY2T	
PXPTOC9	Str.general	51PXP	
PXPTOC9	Op.general	51PXT	
PYPTOC10	Str.general	51PYP	
PYPTOC10	Op.general	51PYT	
NPTOC11	Str.general	51NP	
NPTOC11	Op.general	51NT	
GXPTOC12	Str.general	51GXP	
GXPTOC12	Op.general	51GXT	
GYPTOC13	Str.general	51GYP	
GYPTOC13	Op.general	51GYT	
QXPTOC14	Str.general	51QXP	
QXPTOC14	Op.general	51QXT	
QYPTOC15	Str.general	51QYP	
QYPTOC15	Op.general	51QYT	
G1PTOC16	Str.general	64G1	

Table F.11 Logical Device: PRO (Protection) (Sheet 3 of 6)

Logical Node	Status	Relay Word Bit	Comment
G1PTOC16	Op.general	64G1T	
G2PTOC17	Str.general	64G2	
G2PTOC17	Op.general	64G2T	
F1PTOC18	Str.general	64F1	
F1PTOC18	Op.general	64F1T	
F2PTOC19	Str.general	64F2	
F2PTOC19	Op.general	64F2T	
P51CPVOC1	Str.general	51C	
P51CPVOC1	Op.general	51CT	
P51VPVOC2	Str.general	51V	
P51VPVOC2	Op.general	51VT	
D87UPDIF1	Op.general	87U	
D87UPDIF1	Op.PhsA	87U1	
D87UPDIF1	Op.PhsB	87U2	
D87UPDIF1	Op.PhsC	87U3	
D87RPDIF2	Op.general	87R	
D87RPDIF2	Op.PhsA	87R1	
D87RPDIF2	Op.PhsB	87R2	
D87RPDIF2	Op.PhsC	87R3	
D87APDIF3	Str.general	87AP	
D87APDIF3	Op.general	87AT	
REF1PPDIF4	Str.general	REF1F	
REF1PPDIF4	Str.dirGeneral	REF1F	
REF1PPDIF4	Op.general	REF1P	
Z40PDUP1	Str.general	40Z1	
Z40PDUP1	Op.general	40Z1T	
Z40PDUP2	Str.general	40Z2	
Z40PDUP2	Op.general	40Z2T	
HB24PHAR1	Str.general	2_4HBL	2_4HB1+2_4HB2+2_4HB3
HB24PHAR1	Str.PhsA	2_4HB1	
HB24PHAR1	Str.PhsB	2_4HB2	
HB24PHAR1	Str.PhsC	2_4HB3	
HB5PHAR2	Str.general	5HBL	5HB1+5HB2+5HB3
HB5PHAR2	Str.PhsA	5HB1	
HB5PHAR2	Str.PhsB	5HB2	
HB5PHAR2	Str.PhsC	5HB3	
DXPTOF1	Str.general	81X1T	
DXPTOF1	Op.general	81X1T	

Table F.11 Logical Device: PRO (Protection) (Sheet 4 of 6)

Logical Node	Status	Relay Word Bit	Comment
DXPTOF2	Str.general	81X2T	
DXPTOF2	Op.general	81X2T	
DXPTOF3	Str.general	81X3T	
DXPTOF3	Op.general	81X3T	
DXPTOF4	Str.general	81X4T	
DXPTOF4	Op.general	81X4T	
DXPTOF5	Str.general	81X5T	
DXPTOF5	Op.general	81X5T	
DXPTOF6	Str.general	81X6T	
DXPTOF6	Op.general	81X6T	
DYPTOF7	Str.general	81Y1T	
DYPTOF7	Op.general	81Y1T	
DYPTOF8	Str.general	81Y2T	
DYPTOF8	Op.general	81Y2T	
DYPTOF9	Str.general	81Y3T	
DYPTOF9	Op.general	81Y3T	
DYPTOF10	Str.general	81Y4T	
DYPTOF10	Op.general	81Y4T	
DYPTOF11	Str.general	81Y5T	
DYPTOF11	Op.general	81Y5T	
DYPTOF12	Str.general	81Y6T	
DYPTOF12	Op.general	81Y6T	
PX1PTUV1	Str.general	27PX1	
PX1PTUV1	Op.general	27PX1T	
PX2PTUV2	Str.general	27PX2	
PX2PTUV2	Op.general	27PX2T	
PY1PTUV3	Str.general	27PY1	
PY1PTUV3	Op.general	27PY1T	
PY2PTUV4	Str.general	27PY2	
PY2PTUV4	Op.general	27PY2T	
LOPXPTUV5	Str.general	LOPX	
LOPXPTUV5	Op.general	LOPX	
LOPYPTUV6	Str.general	LOPY	
LOPYPTUV6	Op.general	LOPY	
S1PTUV7	Str.general	27S1	
S1PTUV7	Op.general	27S1T	
S2PTUV8	Str.general	27S2	
S2PTUV8	Op.general	27S2T	

Table F.11 Logical Device: PRO (Protection) (Sheet 5 of 6)

Logical Node	Status	Relay Word Bit	Comment
PX1PTOV1	Str.general	59PX1	
PX1PTOV1	Op.general	59PX1T	
PX2PTOV2	Str.general	59PX2	
PX2PTOV2	Op.general	59PX2T	
PY1PTOV3	Str.general	59PY1	
PY1PTOV3	Op.general	59PY1T	
PY2PTOV4	Str.general	59PY2	
PY2PTOV4	Op.general	59PY2T	
QX1PTOV5	Str.general	59QX1	
QX1PTOV5	Op.general	59QX1T	
QX2PTOV6	Str.general	59QX2	
QX2PTOV6	Op.general	59QX2T	
QY1PTOV7	Str.general	59QY1	
QY1PTOV7	Op.general	59QY1T	
QY2PTOV8	Str.general	59QY2	
QY2PTOV8	Op.general	59QY2T	
GX1PTOV9	Str.general	59GX1	
GX1PTOV9	Op.general	59GX1T	
GX2PTOV10	Str.general	59GX2	
GX2PTOV10	Op.general	59GX2T	
GY1PTOV11	Str.general	59GY1	
GY1PTOV11	Op.general	59GY1T	
GY2PTOV12	Str.general	59GY2	
GY2PTOV12	Op.general	59GY2T	
S1PTOV13	Str.general	59S1	
S1PTOV13	Op.general	59S1T	
S2PTOV14	Str.general	59S2	
S2PTOV14	Op.general	59S2T	
C1PDIS1	Str.general	21C1P	
C1PDIS1	Op.general	21C1T	
C2PDIS2	Str.general	21C2P	
C2PDIS2	Op.general	21C2T	
D1PVPH1	Str.general	24D1	
D1PVPH1	Op.general	24D1T	
C2PVPH2	Str.general	24C2	
C2PVPH2	Op.general	24C2T	
P3XPDOP1	Str.general	3PWRX1P	
P3XPDOP1	Op.general	3PWRX1T	

Table F.11 Logical Device: PRO (Protection) (Sheet 6 of 6)

Logical Node	Status	Relay Word Bit	Comment
P3XPDOP2	Str.general	3PWRX2P	
P3XPDOP2	Op.general	3PWRX2T	
P3XPDOP3	Str.general	3PWRX3P	
P3XPDOP3	Op.general	3PWRX3T	
P3XPDOP4	Str.general	3PWRX4P	
P3XPDOP4	Op.general	3PWRX4T	
P3YPDOP5	Str.general	3PWRY1P	
P3YPDOP5	Op.general	3PWRY1T	
P3YPDOP6	Str.general	3PWRY2P	
P3YPDOP6	Op.general	3PWRY2T	
P3YPDOP7	Str.general	3PWRY3P	
P3YPDOP7	Op.general	3PWRY3T	
P3YPDOP8	Str.general	3PWRY4P	
P3YPDOP8	Op.general	3PWRY4T	
A49PTTR1	Op.general	49A	
T49PTTR2	Op.general	49T	
RTDAPTTR3	Op.general	RTDA	
RTDTPTTR4	Op.general	RTDT	
TRIPXPTRC1	Tr.general	TRIPX	
TRIPYPTRC2	Tr.general	TRIPY	
TRIP1PTRC3	Tr.general	TRIP1	
TRIP2PTRC4	Tr.general	TRIP2	
TRIP3PTRC5	Tr.general	TRIP3	
BXXCBR1	Pos.stVal	52AX	Result of 52AX SELOGIC setting
BXXCBR1	Pos.Opcnt	INTTX	
BXCSWI1	Pos.stVal	52AX	Result of 52AX SELOGIC setting
BXCSWI1	Pos.Oper.ctlVal	CCX	
BXCSWI1	OpOpn.general	OCX	
BXCSWI1	OpCls.general	CCX	
BYXCBR2	Pos.stVal	52AY	Result of 52AY SELOGIC setting
BXXCBR2	Pos.Opcnt	INTTY	
BYCSWI2	Pos.stVal	52AY	Result of 52AY SELOGIC setting
BYCSWI2	Pos.Oper.ctlVal	CCY	
BYCSWI2	OpOpn.general	OCY	
BYCSWI2	OpCls.general	CCY	

Table F.12 shows the LN associated with measuring elements defined as Logical Device MET.

Table F.12 Logical Device: MET (Metering) (Sheet 1 of 5)

Logical Node	Measurand	Comment
Fundamental Metering[a]		
METXMMXU1	TotW.mag	X-side three-phase real power P magnitude
METXMMXU1	TotVAr.mag	X-side three-phase reactive power Q magnitude
METXMMXU1	TotVA.mag	X-side three-phase apparent power S magnitude
METXMMXU1	TotPF.mag	X-side three-phase power factor
METXMMXU1	Hz.mag	X-side measured frequency
METXMMXU1	PPV.phsAB.cVal.mag	X-side AB-phase voltage magnitude when DELTA_Y = D
METXMMXU1	PPV.phsAB.cVal.ang	X-side AB-phase voltage angle when DELTA_Y = D
METXMMXU1	PPV.phsBC.cVal.mag	X-side BC-phase voltage magnitude when DELTA_Y = D
METXMMXU1	PPV.phsBC.cVal.ang	X-side BC-phase voltage angle when DELTA_Y = D
METXMMXU1	PPV.phsCA.cVal.mag	X-side CA-phase voltage magnitude when DELTA_Y = D
METXMMXU1	PhV.phsA.cVal.mag	X-side A-phase voltage magnitude when DELTA_Y = Y
METXMMXU1	PhV.phsA.cVal.ang	X-side A-phase voltage angle when DELTA_Y = Y
METXMMXU1	PhV.phsB.cVal.mag	X-side B-phase voltage magnitude when DELTA_Y = Y
METXMMXU1	PhV.phsB.cVal.ang	X-side B-phase voltage angle when DELTA_Y = Y
METXMMXU1	PhV.phsC.cVal.mag	X-side C-phase voltage magnitude when DELTA_Y = Y
METXMMXU1	PhV.phsC.cVal.ang	X-side C-phase voltage angle when DELTA_Y = Y
METXMMXU1	PhV.res.cVal.mag	X-side residual voltage magnitude when DELTA_Y = Y
METXMMXU1	PhV.res.cVal.ang	X-side residual voltage angle when DELTA_Y = Y
METXMMXU1	PhV.neut.cVal.mag	Neutral voltage magnitude when DELTA_Y = Y
METXMMXU1	PhV.neut.cVal.ang	Neutral voltage angle when DELTA_Y = Y
METXMMXU1	A.phsA.cVal.mag	X-side A-phase current magnitude
METXMMXU1	A.phsA.cVal.ang	X-side A-phase current angle
METXMMXU1	A.phsB.cVal.mag	X-side B-phase current magnitude
METXMMXU1	A.phsB.cVal.ang	X-side B-phase current angle
METXMMXU1	A.phsC.cVal.mag	X-side C-phase current magnitude
METXMMXU1	A.phsC.cVal.ang	X-side C-phase current angle
METXMMXU1	A.res.cVal.mag	X-side residual current magnitude
METXMMXU1	A.res.cVal.ang	X-side residual current angle
METXMMXU1	A.neut.cVal.mag	Neutral current magnitude
METXMMXU1	A.neut.cVal.ang	Neutral current angle
METXMMXU1	W.phsA.mag	X-side A-phase real power magnitude
METXMMXU1	W.phsB.mag	X-side B-phase real power magnitude
METXMMXU1	W.phsC.mag	X-side C-phase real power magnitude
METXMMXU1	VAr.phsA.mag	X-side A-phase reactive power magnitude
METXMMXU1	VAr.phsB.mag	X-side B-phase reactive power magnitude

Table F.12 Logical Device: MET (Metering) (Sheet 2 of 5)

Logical Node	Measurand	Comment
METXMMXU1	VAr.phsC.mag	X-side C-phase reactive power magnitude
METXMMXU1	VA.phsA.mag	X-side A-phase apparent power magnitude
METXMMXU1	VA.phsB.mag	X-side B-phase apparent power magnitude
METXMMXU1	VA.phsC.mag	X-side C-phase apparent power magnitude
METXMMXU1	PF.phsA.mag	X-side A-phase power factor
METXMMXU1	PF.phsB.mag	X-side B-phase power factor
METXMMXU1	PF.phsC.mag	X-side C-phase power factor
METYMMXU1	TotW.mag	Y-side 3-phase real power P magnitude
METYMMXU1	TotVAr.mag	Y-side 3-phase reactive power Q magnitude
METYMMXU1	TotVA.mag	Y-side 3-phase apparent power S magnitude
METYMMXU1	TotPF.mag	Y-side 3-phase power factor
METYMMXU1	Hz.mag	Y-side measured frequency
METYMMXU2	PPV.phsAB.cVal.mag	Y-side AB-phase voltage magnitude when DELTA_Y = D
METYMMXU1	PPV.phsAB.cVal.ang	Y-side AB-phase voltage angle when DELTA_Y = D
METYMMXU1	PPV.phsBC.cVal.mag	Y-side BC-phase voltage magnitude when DELTA_Y = D
METYMMXU1	PPV.phsBC.cVal.ang	Y-side BC-phase voltage angle when DELTA_Y = D
METYMMXU1	PPV.phsCA.cVal.mag	Y-side CA-phase voltage magnitude when DELTA_Y = D
METYMMXU1	PhV.phsA.cVal.mag	Y-side A-phase voltage magnitude when DELTA_Y = Y
METYMMXU1	PhV.phsA.cVal.ang	Y-side A-phase voltage angle when DELTA_Y = Y
METYMMXU1	PhV.phsB.cVal.mag	Y-side B-phase voltage magnitude when DELTA_Y = Y
METYMMXU1	PhV.phsB.cVal.ang	Y-side B-phase voltage angle when DELTA_Y = Y
METYMMXU1	PhV.phsC.cVal.mag	Y-side C-phase voltage magnitude when DELTA_Y = Y
METYMMXU1	PhV.phsC.cVal.ang	Y-side C-phase voltage angle when DELTA_Y = Y
METYMMXU1	PhV.res.cVal.mag	Y-side residual voltage magnitude when DELTA_Y = Y
METYMMXU1	PhV.res.cVal.ang	Y-side residual voltage angle when DELTA_Y = Y
METYMMXU1	A.phsA.cVal.mag	Y-side A-phase current magnitude
METYMMXU1	A.phsA.cVal.ang	Y-side A-phase current angle
METYMMXU1	A.phsB.cVal.mag	Y-side B-phase current magnitude
METYMMXU1	A.phsB.cVal.ang	Y-side B-phase current angle
METYMMXU1	A.phsC.cVal.mag	Y-side C-phase current magnitude
METYMMXU1	A.phsC.cVal.ang	Y-side C-phase current angle
METYMMXU1	A.res.cVal.mag	Y-side residual current magnitude
METYMMXU1	A.res.cVal.ang	Y-side residual current angle
Thermal Metering[b]		
THERMMTHR1	MaxWdgTmp.mag	Maximum winding RTD temperature
THERMMTHR1	MaxBrgTmp.mag	Maximum bearing RTD temperature
THERMMTHR1	MaxAmbTmp.mag	Maximum ambient RTD temperature
THERMMTHR1	MaxOthTmp.mag	Maximum other RTD temperature
THERMMTHR1	Tmp01.mag to Tmp12.mag	RTD temperatures (RTD1 to RTD12)

Table F.12 Logical Device: MET (Metering) (Sheet 3 of 5)

Logical Node	Measurand	Comment
Sequence Quantities[a]		
METXMSQI1	SeqA.c1.cVal.mag	X-side positive-sequence current magnitude
METXMSQI1	SeqA.c1.cVal.ang	X-side positive-sequence current angle
METXMSQI1	SeqA.c2.cVal.mag	X-side negative-sequence current magnitude
METXMSQI1	SeqA.c2.cVal.ang	X-side negative-sequence current angle
METXMSQI1	SeqA.c3.cVal.mag	X-side zero-sequence current magnitude
METXMSQI1	SeqA.c3.cVal.ang	X-side zero-sequence current angle
METXMSQI1	SeqV.c1.cVal.mag	X-side positive-sequence voltage magnitude
METXMSQI1	SeqV.c1.cVal.ang	X-side positive-sequence voltage angle
METXMSQI1	SeqV.c2.cVal.mag	X-side negative-sequence voltage magnitude
METXMSQI1	SeqV.c2.cVal.ang	X-side negative-sequence voltage angle
METXMSQI1	SeqV.c3.cVal.mag	X-side zero-sequence voltage magnitude
METXMSQI1	SeqV.c3.cVal.ang	X-side zero-sequence voltage angle
METYMSQI1	SeqA.c1.cVal.mag	Y-side positive-sequence current magnitude
METYMSQI1	SeqA.c1.cVal.ang	Y-side positive-sequence current angle
METYMSQI1	SeqA.c2.cVal.mag	Y-side negative-sequence current magnitude
METYMSQI1	SeqA.c2.cVal.ang	Y-side negative-sequence current angle
METYMSQI1	SeqA.c3.cVal.mag	Y-side zero-sequence current magnitude
METYMSQI1	SeqA.c3.cVal.ang	Y-side zero-sequence current angle
METYMSQI1	SeqV.c1.cVal.mag	Y-side positive-sequence voltage magnitude
METYMSQI1	SeqV.c1.cVal.ang	Y-side positive-sequence voltage angle
METYMSQI1	SeqV.c2.cVal.mag	Y-side negative-sequence voltage magnitude
METYMSQI1	SeqV.c2.cVal.ang	Y-side negative-sequence voltage angle
METYMSQI1	SeqV.c3.cVal.mag	Y-side zero-sequence voltage magnitude
METYMSQI1	SeqV.c3.cVal.ang	Y-side zero-sequence voltage angle
Metering Statistics[a]		
METXMSTA1	MaxA.phsA.mag	X-side A-phase current maximum magnitude
METXMSTA1	MaxA.phsB.mag	X-side B-phase current maximum magnitude
METXMSTA1	MaxA.phsC.mag	X-side C-phase current maximum magnitude
METXMSTA1	MaxA.res.mag	X-side residual current maximum magnitude
METXMSTA1	MinA.phsA.mag	X-side A-phase current minimum magnitude
METXMSTA1	MinA.phsB.mag	X-side B-phase current minimum magnitude
METXMSTA1	MinA.phsC.mag	X-side C-phase current minimum magnitude
METXMSTA1	MinA.res.mag	X-side residual current minimum magnitude
METXMSTA1	MaxAmps.mag	Neutral current maximum magnitude
METXMSTA1	MinAmps.mag	Neutral current minimum magnitude
METXMSTA1	MaxPhV.phsA.mag	X-side A-phase voltage maximum magnitude
METXMSTA1	MaxPhV.phsB.mag	X-side B-phase voltage maximum magnitude
METXMSTA1	MaxPhV.phsC.mag	X-side C-phase voltage maximum magnitude

Table F.12 Logical Device: MET (Metering) (Sheet 4 of 5)

Logical Node	Measurand	Comment
METXMSTA1	MinPhV.phsA.mag	X-side A-phase voltage minimum magnitude
METXMSTA1	MinPhV.phsB.mag	X-side B-phase voltage minimum magnitude
METXMSTA1	MinPhV.phsC.mag	X-side C-phase voltage minimum magnitude
METXMSTA1	MaxP2PV.phsAB.mag	X-side AB-phase voltage maximum magnitude
METXMSTA1	MaxP2PV.phsBC.mag	X-side BC-phase voltage maximum magnitude
METXMSTA1	MaxP2PV.phsCA.mag	X-side CA-phase voltage maximum magnitude
METXMSTA1	MinP2PV.phsAB.mag	X-side AB-phase voltage minimum magnitude
METXMSTA1	MinP2PV.phsBC.mag	X-side BC-phase voltage minimum magnitude
METXMSTA1	MinP2PV.phsCA.mag	X-side CA-phase voltage minimum magnitude
METXMSTA1	MaxVA.mag	X-side 3-phase VA maximum magnitude
METXMSTA1	MinVA.mag	X-side 3-phase VA minimum magnitude
METXMSTA1	MaxW.mag	X-side 3-phase W maximum magnitude
METXMSTA1	MinW.mag	X-side 3-phase W minimum magnitude
METXMSTA1	MaxVAr.mag	X-side 3-phase VAr maximum magnitude
METXMSTA1	MinVAr.mag	X-side 3-phase VAr minimum magnitude
METYMSTA1	MaxA.phsA.mag	Y-side A-phase current maximum magnitude
METYMSTA1	MaxA.phsB.mag	Y-side B-phase current maximum magnitude
METYMSTA1	MaxA.phsC.mag	Y-side C-phase current maximum magnitude
METYMSTA1	MaxA.res.mag	Y-side residual current maximum magnitude
METYMSTA1	MinA.phsA.mag	Y-side A-phase current minimum magnitude
METYMSTA1	MinA.phsB.mag	Y-side B-phase current minimum magnitude
METYMSTA1	MinA.phsC.mag	Y-side C-phase current minimum magnitude
METYMSTA1	MinA.res.mag	Y-side residual current minimum magnitude
METYMSTA1	MaxPhV.phsA.mag	Y-side A-phase voltage maximum magnitude.
METYMSTA1	MaxPhV.phsB.mag	Y-side B-phase voltage maximum magnitude
METYMSTA1	MaxPhV.phsC.mag	Y-side C-phase voltage maximum magnitude
METYMSTA1	MinPhV.phsA.mag	Y-side A-phase voltage minimum magnitude
METYMSTA1	MinPhV.phsB.mag	Y-side B-phase voltage minimum magnitude
METYMSTA1	MinPhV.phsC.mag	Y-side C-phase voltage minimum magnitude
METYMSTA1	MaxP2PV.phsAB.mag	Y-side AB-phase voltage maximum magnitude
METYMSTA1	MaxP2PV.phsBC.mag	Y-side BC-phase voltage maximum magnitude
METYMSTA1	MaxP2PV.phsCA.mag	Y-side CA-phase voltage maximum magnitude
METYMSTA1	MinP2PV.phsAB.mag	Y-side AB-phase voltage minimum magnitude
METYMSTA1	MinP2PV.phsBC.mag	Y-side BC-phase voltage minimum magnitude
METYMSTA1	MinP2PV.phsCA.mag	Y-side CA-phase voltage minimum magnitude
METYMSTA1	MaxVA.mag	Y-side 3-phase VA maximum magnitude
METYMSTA1	MinVA.mag	Y-side 3-phase VA minimum magnitude
METYMSTA1	MaxW.mag	Y-side 3-phase W maximum magnitude

Table F.12 Logical Device: MET (Metering) (Sheet 5 of 5)

Logical Node	Measurand	Comment
METYMSTA1	MinW.mag	Y-side 3-phase W minimum magnitude
METYMSTA1	MaxVAr.mag	Y-side 3-phase VAr maximum magnitude
METYMSTA1	MinVAr.mag	Y-side 3-phase VAr minimum magnitude
Demand Metering Statistics[a]		
METXMDST1	DmdA.phsA.mag	X-side demand, phase A current
METXMDST1	DmdA.phsB.mag	X-side demand, phase B current
METXMDST1	DmdA.phsC.mag	X-side demand, phase C current
METXMDST1	DmdA.res.mag	X-side demand, current, residual
METXMDST1	DmdA.nseq.mag	X-side demand, current, negative-sequence
METXMDST1	PkDmdA.phsA.mag	X-side peak demand, phase A current
METXMDST1	PkDmdA.phsB.mag	X-side peak demand, phase B current
METXMDST1	PkDmdA.phsC.mag	X-side peak demand, phase C current
METXMDST1	PkDmdA.res.mag	X-side peak demand, current, residual
METXMDST1	PkDmdA.nseq.mag	X-side peak demand, current, negative-sequence
METXMDST1	SupWh.mag	X-side energy, real (MWh)—supply direction flows toward busbar
METXMDST1	SupVArh.mag	X-side energy, reactive (MVArh)—supply direction toward busbar
METXMDST1	DmdWh.mag	X-side energy, real (MWh)—demand direction flows away from busbar
METXMDST1	DmdVArh.mag	X-side energy, reactive (MVArh)—demand direction away from busbar
METYMDST1	DmdA.phsA.mag	Y-side demand, phase A current
METYMDST1	DmdA.phsB.mag	Y-side demand, phase B current
METYMDST1	DmdA.phsC.mag	Y-side demand, phase C current
METYMDST1	DmdA.res.mag	Y-side demand, current, residual
METYMDST1	DmdA.nseq.mag	Y-side demand, current, negative-sequence
METYMDST1	PkDmdA.phsA.mag	Y-side peak demand, phase A current
METYMDST1	PkDmdA.phsB.mag	Y-side peak demand, phase B current
METYMDST1	PkDmdA.phsC.mag	Y-side peak demand, phase C current
METYMDST1	PkDmdA.res.mag	Y-side peak demand, current, residual
METYMDST1	PkDmdA.nseq.mag	Y-side peak demand, current, negative-sequence
METYMDST1	SupWh.mag	Y-side energy, real (MWh)—supply direction flows toward busbar
METYMDST1	SupVArh.mag	Y-side energy, reactive (MVArh)—supply direction toward busbar
METYMDST1	DmdWh.mag	Y-side energy, real (MWh)—demand direction flows away from busbar
METYMDST1	DmdVArh.mag	Y-side energy, reactive (MVArh)—demand direction away from busbar

[a] Data validity depends on the relay model and installed card options. Refer to Section 1: Introduction and Specifications for different relay models and available card options. Refer to Section 5: Metering and Monitoring for the model dependent metering quantities.
[b] Valid data depends on E49RTD and RTD1LOC–RTD12LOC settings.

Table F.13 shows the LN associated with control elements defined as Logical Device CON.

Table F.13 Logical Device: CON (Control)

Logical Node	Status	Control	Relay Word Bit
RBGGIO1	SPCSO01.stVal to SPCSO08.stVal	SPCSO01.ctlVal to SPCSO08.ctlVal	Remote Bits (RB01 to RB08)
RBGGIO2	SPCSO09.stVal to SPCSO16.stVal	SPCSO09.ctlVal to SPCSO16.ctlVal	Remote Bits (RB09 to RB16)
RBGGIO3	SPCSO17.stVal to SPCSO24.stVal	SPCSO17.ctlVal to SPCSO24.ctlVal	Remote Bits (RB17 to RB24)
RBGGIO4	SPCSO25.stVal to SPCSO32.stVal	SPCSO25.ctlVal to SPCSO32.ctlVal	Remote Bits (RB25 to RB32)

Table F.14 shows the LN associated with annunciation elements defined as Logical Device ANN.

Table F.14 Logical Device: ANN (Annunciation)

Logical Node	Status	Relay Word Bit
Analog Quantities		
MVGGIO12	AnIn01.mag to AnIn32.mag	Math Variables (MV01 to MV32)[a]
SCGGIO20	AnIn01.mag to AnIn32.mag	SELOGIC Counters (SC01 to SC32)[b]
AINCGGIO21	AnIn01.mag to AnIn04.mag	Analog Inputs (AI301 to AI304)—Slot C[c]
AINDGGIO22	AnIn01.mag to AnIn04.mag	Analog Inputs (AI401 to AI404)—Slot D[c]
AINEGGIO23	AnIn01.mag to AnIn04.mag	Analog Inputs (AI501 to AI504)—Slot E[c]
Relay Word Bits		
INAGGIO1	Ind01.stVal to Ind02.stVal	Digital Inputs (IN101 to IN102)—Slot A
OUTAGGIO2	Ind01.stVal to Ind03.stVal	Digital Outputs (OUT101 to OUT103)—Slot A
SVGGIO3	Ind01.stVal to Ind32.stVal	SELOGIC Variables (SV01 to SV32)[d]
SVTGGIO4	Ind01.stVal to Ind32.stVal	SELOGIC Variable Timers (SV01T to SV32T)[d]
LTGGIO5	Ind01.stVal to Ind32.stVal	Latch Bits (LT01 to LT32)[e]
TLEDGGIO6	Ind01.stVal to Ind08.stVal	Target LEDs (ENABLED, TRIP_LED, TLED_01 to TLED_06)
PBLEDGGIO7	Ind01.stVal to Ind08.stVal	Pushbutton LEDs (PB1A_LED to PB4B_LED)
RMBAGGIO8	Ind01.stVal to Ind08.stVal	Receive MIRRORED BITS (RMB1A to RMB8A)
TMBAGGIO9	Ind01.stVal to Ind08.stVal	Transmit MIRRORED BITS (TMB1A to TMB8A)
RMBBGGIO10	Ind01.stVal to Ind08.stVal	Receive MIRRORED BITS (RMB1B to RMB8B)
TMBBGGIO11	Ind01.stVal to Ind08.stVal	Transmit MIRRORED BITS (TMB1B to TMB8B)
INCGGIO13	Ind01.stVal to Ind08.stVal	Digital Inputs (IN301 to IN308)—Slot C[c]
OUTCGGIO14	Ind01.stVal to Ind04.stVal	Digital Outputs (OUT301 to OUT304)—Slot C[c]
INDGGIO15	Ind01.stVal to Ind08.stVal	Digital Inputs (IN401 to IN408)—Slot D[c]
OUTDGGIO16	Ind01.stVal to Ind04.stVal	Digital Outputs (OUT401 to OUT404)—Slot D[c]
INEGGIO17	Ind01.stVal to Ind08.stVal	Digital Inputs (IN501 to IN508)—Slot E[c]
OUTEGGIO18	Ind01.stVal to Ind04.stVal	Digital Outputs (OUT501 to OUT504)—Slot E[c]
VBGGIO19	Ind001.stVal to Ind128.stVal	Virtual Bits (VB001 to VB128)

[a] Active data depends on the EMV setting.
[b] Active data depends on the ESC setting.
[c] Active data only if an I/O card is installed in the slot.
[d] Active data depends on the ESV setting.
[e] Active data depends on the ELT setting.

Protocol Implementation Conformance Statement

The following tables are as shown in the IEC 61850 standard, Part 8-1, Section 24. Note that since the standard explicitly dictates which services and functions must be implemented to achieve conformance, only the optional services and functions are listed.

Table F.15 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.16 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.17* 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.17 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		

Table F.17 MMS Service Supported Conformance (Sheet 2 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
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		
start		
stop		
resume		
reset		
kill		
getProgramInvocationAttributes		
obtainFile		
defineEventCondition		
deleteEventCondition		
getEventConditionAttributes		
reportEventConditionStatus		
alterEventConditionMonitoring		
triggerEvent		
defineEventAction		
deleteEventAction		
alterEventEnrollment		
reportEventEnrollmentStatus		

Table F.17 MMS Service Supported Conformance (Sheet 3 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
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		
reportAccessControlledObjects		
deleteAccessControlList		
alterAccessControl		
ReconfigureProgramInvocation		

Table F.18 lists specific settings for the MMS parameter Conformance Building Block (CBB).

Table F.18 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.19 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.20 VariableAccessSpecification Conformance Statement

VariableAccessSpecification	Client-CR Supported	Server-CR Supported
listOfVariable		Y
variableSpecification		Y
alternateAccess		Y
variableListName		Y

Table F.21 VariableSpecification Conformance Statement

VariableSpecification	Client-CR Supported	Server-CR Supported
name		Y
address		
variableDescription		
scatteredAccessDescription		
invalidated		

Table F.22 Read Conformance Statement

Read	Client-CR Supported	Server-CR Supported
Request		
specificationWithResult		
variableAccessSpecification		
Response		
variableAccessSpecification		Y
listOfAccessResult		Y

Table F.23 GetVariableAccessAttributes Conformance Statement

GetVariableAccessAttributes	Client-CR Supported	Server-CR Supported
Request		
name		
address		
Response		
mmsDeletable		Y
address		
typeSpecification		Y

Table F.24 DefineNamedVariableList Conformance Statement

DefineVariableAccessAttributes	Client-CR Supported	Server-CR Supported
Request		
variableListName		
listOfVariable		
variableSpecification		
alternateAccess		
Response		

Table F.25 GetNamedVariableListAttributes Conformance Statement

GetNamedVariableListAttributes	Client-CR Supported	Server-CR Supported
Request		
ObjectName		
Response		
mmsDeletable		Y
listOfVariable		Y
variableSpecification		Y
alternateAccess		Y

Table F.26 DeleteNamedVariableList

DeleteNamedVariableList	Client-CR Supported	Server-CR Supported
Request		
Scope		
listOfVariableListName		
domainName		
Response		
numberMatched		
numberDeleted		
DeleteNamedVariableList-Error		

GOOSE Services Conformance Statement

Table F.27 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.28 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.29 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.29 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.30 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.30 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.30 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]	

Table F.30 ACSI Services Conformance Statement (Sheet 4 of 4)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-700G Support
Control (Clause 16.4.8)					
S51	Select		M[a]	O[b]	
S52	SelectWithValue	TP	Ma	O[b]	YES
S53	Cancel	TP	O[b]	M[a]	YES
S54	Operate	TP	M[a]	M[a]	YES
S55	Command-Termination	TP	M[a]	M[a]	YES
S56	TimeActivated-Operate	TP	O[b]	O[b]	
File Transfer (Clause 20)					
S57	GetFile	TP	O[b]	M[a]	
S58	SetFile	TP	O[b]	O[b]	
S59	DeleteFile	TP	O[b]	O[b]	
S60	GetFileAttributeValues	TP	O[b]	M[a]	
Time (Clause 5.5)					
T1	Time resolution of internal clock (nearest negative power of 2 in seconds)				20 (1 µs)
T2	Time accuracy of internal clock				7 (10 ms) for SNTP 18 (4 µs) for IRIG-B
	T1				YES (for IRIG-B)
	T2				YES (for IRIG-B)
	T3				YES (for IRIG-B)
	T4				YES (for IRIG-B)
T3	Supported 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.

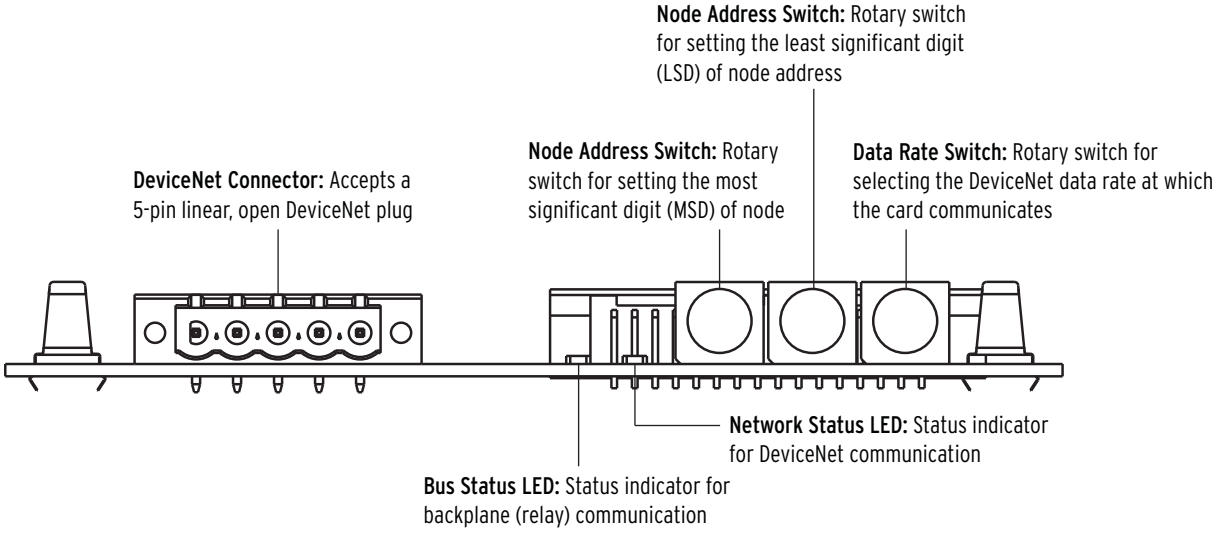

Figure G.1 DeviceNet Card Component Overview

Features

The DeviceNet Card features the following:

- The card receives the required 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

The DeviceNet interface can be configured 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 is 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 can be used 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.

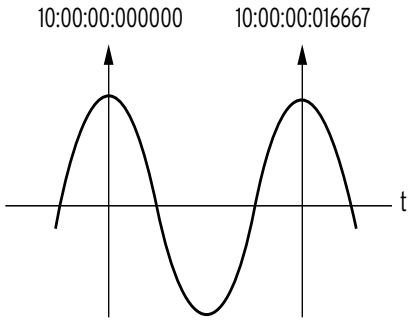

Figure H.1 Phase Reference

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 meets 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.

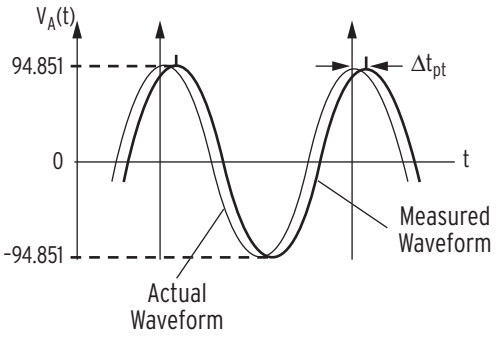

Figure H.2 Waveform at Relay Terminals May Have a Phase Shift

$$\text{Compensation Angle} = \frac{\Delta t_{pt}}{\left(\frac{1}{\text{freq}_{nominal}}\right)} \bullet 360^\circ$$

$$= \Delta t_{pt} \bullet \text{freq}_{nominal} \bullet 360^\circ \quad \textbf{Equation H.1}$$

If the time shift on the PT measurement path $\Delta t_{pt} = 0.784$ ms and the nominal frequency, $\text{freq}_{nominal} = 60$Hz, use *Equation H.2* to obtain the correction angle:

$$0.784 \bullet 10^{-3}\text{s} \bullet 60\text{s}^{-1} \bullet 360^\circ = 16.934^\circ \quad \textbf{Equation H.2}$$

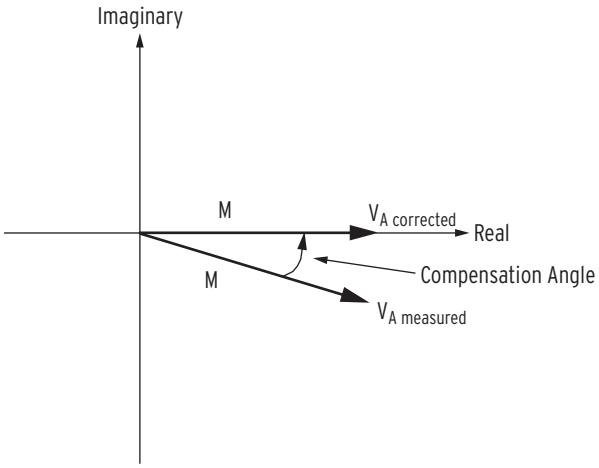

Figure H.3 Correction of Measured Phase Angle

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 can be used 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[abc]		Included When Global Settings Are as Follows:
Polar		
Magnitude	Angle	
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	Above, plus MV30	8
3	Above, plus MV31	12
4	Above, 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

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.

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.

The SEL-700G automatically sets the TREA1–TREA4 or PMTRIG Relay Word bits based on their default SELOGIC equation. To change the operation of these bits they must be programmed.

These bits may be used to send various messages at a low bandwidth via the synchrophasor message stream. Digital Status Words may also be used 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 and synchrophasors are enabled (Global setting EPMU := Y).

View Synchrophasors Using the MET PM Command

The **MET PM** serial port ASCII command may be used 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, in order to compare it 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: In order 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 is also available via the **HMI > Meter PM** menu in ACSELERATOR QuickSet, and has a similar format to *Figure H.4*.

The **MET PM *time*** command can be used 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 relay can include up to 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 equations TREA1, TREA2, TREA3, and TREA4, and the trigger SELOGIC 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. *Table H.9* can be used to calculate the number of bytes in a synchrophasor message.

Table H.9 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.10 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.10 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.9* and *Table H.10*, 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, up to MRATE := 5 when SPEED := 2400, and up to 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 is being used for system monitoring.

The protection settings are not shown.

The protection engineer performs a bandwidth check, using *Table H.9*, and determines the required message size. The system requirements, in order of appearance in *Table H.9*, 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.10*, 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.11*.

Table H.11 Example Synchrophasor Global Settings (Sheet 1 of 2)

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

Table H.11 Example Synchrophasor Global Settings (Sheet 2 of 2)

Setting	Description	Value
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.12 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 required in this example must be placed in certain SELogic variables. Make the settings in *Table H.13* in all seven setting groups.

Table H.13 Example Synchrophasor SELOGIC Settings

Setting	Value
SV14	52AX
SV15	LOPX
SV16	FREQXOK

Make the *Table H.14* settings for serial port 3, using the **SET P 3** command.

Table H.14 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

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.

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.

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.

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 above. 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 an error condition is detected. 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 above), 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 communication 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 and *Table J.2* show a list of Relay Word bits and corresponding descriptions. The Relay Word bit row numbers correspond to the row numbers used in the **TAR** command (see *TARGET Command (Display Relay Word Bit Status) on page 7.45*). All Relay Word bits, irrespective of the model number, are visible in the relay. However, the bits that are not applicable to specific model are inactive and will not change their state.

Any Relay Word bit (except Row 0) can be used 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
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

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
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
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

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
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
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

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
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]
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

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
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	[a]	[a]	[a]	DIRNEX
148	[a]	[a]	[a]	[a]	NX1DIR	NX2DIR	DIRNFX	DIRNRX

[a] Reserved for future use.

Definitions

Table J.2 Relay Word Bit Definitions for the SEL-700G (Sheet 1 of 21)

Bit	Definition	Row
2_4HB1	Second or fourth-harmonic block asserted for differential element 1	38
2_4HB2	Second or fourth-harmonic block asserted for differential element 2	38
2_4HB3	Second or fourth-harmonic block asserted for differential element 3	38
2_4HBL	Second or fourth-harmonic block asserted (2_4HB1 OR 2_4HB2 OR 2_4HB3)	38
21C1P	Zone 1 compensator distance element instantaneous pickup	24
21C1T	Zone 1 compensator distance element timed out	24
21C2P	Zone 2 compensator distance element instantaneous pickup	24
21C2T	Zone 2 compensator distance element timed out	24
24C2	Level 2 volts/hertz composite element pickup	22
24C2T	Level 2 volts/hertz composite element timed out	22
24CR	Level 2 volts/hertz element fully reset	22
24D1	Level 1 volts/hertz instantaneous pickup	22
24D1T	Level 1 volts/hertz definite-time element timed out	22
25AX1	Generator slip/breaker-time compensated phase angle (absolute value) less than 25ANG1X setting	34
25AX2	Generator uncompensated phase angle less than 25ANG2X setting	34

Table J.2 Relay Word Bit Definitions for the SEL-700G (Sheet 2 of 21)

Bit	Definition	Row
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
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

Table J.2 Relay Word Bit Definitions for the SEL-700G (Sheet 3 of 21)

Bit	Definition	Row
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
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

Table J.2 Relay Word Bit Definitions for the SEL-700G (Sheet 4 of 21)

Bit	Definition	Row
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	N-side Level 1 phase instantaneous overcurrent element pickup	8
50N1T	N-side Level 1 phase instantaneous overcurrent element trip	8
50N2P	N-side Level 2 phase instantaneous overcurrent element pickup	8
50N2T	N-side Level 2 phase instantaneous overcurrent element trip	8
50NREF1	Neutral current sensitivity threshold exceeded	13
50NF	Forward direction neutral-ground overcurrent threshold exceeded	141
50NR	Reverse direction neutral-ground overcurrent threshold exceeded	141
50PDIRY	Three-phase overcurrent threshold exceeded	141
50PX1P	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

Table J.2 Relay Word Bit Definitions for the SEL-700G (Sheet 5 of 21)

Bit	Definition	Row
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
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

Table J.2 Relay Word Bit Definitions for the SEL-700G (Sheet 6 of 21)

Bit	Definition	Row
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
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

Table J.2 Relay Word Bit Definitions for the SEL-700G (Sheet 7 of 21)

Bit	Definition	Row
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
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

Table J.2 Relay Word Bit Definitions for the SEL-700G (Sheet 8 of 21)

Bit	Definition	Row
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
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

Table J.2 Relay Word Bit Definitions for the SEL-700G (Sheet 9 of 21)

Bit	Definition	Row
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-/underfrequency elements	29
81X1T	X-side, Level 1, over-/underfrequency element	29
81X2T	X-side, Level 2, over-/underfrequency element	29
81X3T	X-side, Level 3, over-/underfrequency element	29
81X4T	X-side, Level 4, over-/underfrequency element	29
81X5T	X-side, Level 5, over-/underfrequency element	29
81X6T	X-side, Level 6, over-/underfrequency element	29
81XT	ORed, X-side, over-/underfrequency elements	29
81Y1T	Y-side, Level 1, over-/underfrequency element	30
81Y2T	Y-side, Level 2, over-/underfrequency element	30
81Y3T	Y-side, Level 3, over-/underfrequency element	30
81Y4T	Y-side, Level 4, over-/underfrequency element	30
81Y5T	Y-side, Level 5, over-/underfrequency element	30
81Y6T	Y-side, Level 6, over-/underfrequency element	30
81YT	ORed, Y-side, over-/underfrequency elements	30
87AP	Differential current alarm element pickup	54

Table J.2 Relay Word Bit Definitions for the SEL-700G (Sheet 10 of 21)

Bit	Definition	Row
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
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
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

Table J.2 Relay Word Bit Definitions for the SEL-700G (Sheet 11 of 21)

Bit	Definition	Row
AMBTRIP	Ambient Temperature trip. AMBTRIP asserts when the healthy Ambient RTD temperature exceeds its trip set point.	44
ASP	Autosynchronism stop	42
AST	Autosynchronism start	40
ASYNSDC	Asynchronous sampling data conversion is in process	62
BCWAX	X-side breaker A-phase breaker contact wear has reached 100 percent wear level	63
BCWAY	Y-side breaker A-phase breaker contact wear has reached 100 percent wear level	63
BCWBX	X-side breaker B-phase breaker contact wear has reached 100 percent wear level	63
BCWBY	Y-side breaker B-phase breaker contact wear has reached 100 percent wear level	63
BCWBY	Y-side breaker C-phase breaker contact wear has reached 100 percent wear level	63
BCWCX	X-side breaker C-phase breaker contact wear has reached 100 percent wear level	63
BCWX	BCWX = BCWAX OR BCWBX OR BCWCX	63
BCWY	BCWY = BCWAY OR BCWBY OR BCWCY	63
BFIX	52X Breaker Failure Initiation asserted	32
BFIY	52Y Breaker Failure Initiation asserted	32
BFTX	52X Breaker Failure trip	23
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

Table J.2 Relay Word Bit Definitions for the SEL-700G (Sheet 12 of 21)

Bit	Definition	Row
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
CLOSEX	Close logic output for Breaker X	40
CLOSEY	Close logic output for Breaker Y	40
CLX	Close SELOGIC equation CLX	42
CLY	Close SELOGIC 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

Table J.2 Relay Word Bit Definitions for the SEL-700G (Sheet 13 of 21)

Bit	Definition	Row
DIRNRX	X-side reverse directional routed to neutral overcurrent elements	148
DIRPFY	Y-side forward directional control routed to phase overcurrent elements	139
DIRPRY	Y-side reverse directional control routed to phase overcurrent elements	139
DIRQEX	X-side internal enable for negative-sequence voltage-polarized directional element	135
DIRQEY	Y-side internal enable for negative-sequence voltage-polarized directional element	136
DIRQFY	Y-side forward directional control routed to negative-sequence overcurrent elements	139
DIRQGEX	X-side internal enable for negative-sequence voltage-polarized directional element	135
DIRQGEY	Y-side internal enable for negative-sequence voltage-polarized directional element	136
DIRQRY	Y-side reverse directional control routed to negative-sequence overcurrent elements	139
DIRVEX	X-side internal enable for zero-sequence voltage-polarized directional element	135
DIRVEY	Y-side internal enable for zero-sequence voltage-polarized directional element	136
DNAUX1–DNAUX8	DeviceNet/ModBus AUX1–AUX8 assert bit	64
DNAUX9–DNAUX11	DeviceNet/ModBus AUX9–AUX11 assert bit	65
DSABLSET	SELOGIC equation: Does not allow settings changes from front-panel interface when asserted.	56
DST	Daylight savings time	133
DSTP	Daylight savings time pending	133
ER	Event report trigger SELOGIC equation	25
FAULT	Indicates fault condition. Asserts when SELOGIC control equation FAULT result in a logical 1.	53
FDIRIX	X-side forward channel IN current-polarized directional element	137
FDIRIY	Y-side forward channel IN current-polarized directional element	138
FDIRNX	X-side forward 3V0 polarized and IN operating directional element	141
FDIRPY	Y-side forward positive-sequence voltage-polarized directional element	134
FDIRQGX	X-side forward negative-sequence voltage-polarized directional element	137
FDIRQGY	Y-side forward negative-sequence voltage-polarized directional element	138
FDIRVX	X-side forward zero-sequence voltage-polarized directional element	137
FDIRVY	Y-side forward zero-sequence voltage-polarized directional element	138
FDRIRQY	Y-side forward negative-sequence voltage-polarized directional element	138
FLOWER	Lower frequency for autosynchronism	35
FRAISE	Raise frequency for autosynchronism	35
FREQFZ	Synchrophasor Bit that asserts if the measured frequency > +/- 20 Hz from nominal	141
FREQSOK	Phase rate-of-change frequency measurement function detects a valid VS signal	69
FREQTRKX	Frequency tracking enable bit for X-side voltages or currents—tracking enabled when bit is asserted	69
FREQTRKY	Frequency tracking enable bit for Y-side voltages or currents—tracking enabled when bit is asserted	69

Table J.2 Relay Word Bit Definitions for the SEL-700G (Sheet 14 of 21)

Bit	Definition	Row
FREQXOK	Phase rate-of-change frequency measurement function detects a valid V1X/I1X signal	69
FREQYOK	Phase rate-of-change frequency measurement function detects a valid V1Y/I1Y signal	69
FSYNCACT	Frequency matching—Autosynchronization is in progress	132
FSYNCNO	Frequency synchronism timer timeout	40
GENFHI	Slip frequency greater than 25SHI setting	35
GENFLO	Slip frequency less than 25SLO setting	35
GENVHI	Generator voltage greater than system voltage	35
GENVLO	Generator voltage less than system voltage	35
GNDEMX	X-side zero sequence current demand pickup	62
GNDEMY	Y-side zero sequence current demand pickup	62
GSRTRG	Trigger for generator start report	34
GX1DIR	Directional control for element 50GX1/67GX1 and 51GX	140
GX2DIR	Directional control for element 50GX2/67GX2	140
GY1DIR	Directional control for element 50GY1/67GY1 and 51GY	140
GY2DIR	Directional control for element 50GY2/67GY2	140
HALARM	Diagnostics failure	56
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 is 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.2 Relay Word Bit Definitions for the SEL-700G (Sheet 15 of 21)

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
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.2 Relay Word Bit Definitions for the SEL-700G (Sheet 16 of 21)

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 equation: drives LED PB1A	67
PB1B_LED	SELOGIC equation: drives LED PB1B	67
PB2A_LED	SELOGIC equation: drives LED PB2A	67
PB2B_LED	SELOGIC equation: drives LED PB2B	67
PB3A_LED	SELOGIC equation: drives LED PB3A	67
PB3B_LED	SELOGIC equation: drives LED PB3B	67
PB4A_LED	SELOGIC equation: drives LED PB4A	67
PB4B_LED	SELOGIC 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.2 Relay Word Bit Definitions for the SEL-700G (Sheet 17 of 21)

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
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 equation: reset trip logic and targets when asserted	56
RTD1A–RTD4A	RTD1A through RTD4A: alarms	57
RTD1T–RTD4T	RTD1T through RTD4T: trips	57
RTD5A–RTD8A	RTD5A through RTD8A: alarms	58
RTD5T–RTD8T	RTD5T through RTD8T: trips	58

Table J.2 Relay Word Bit Definitions for the SEL-700G (Sheet 18 of 21)

Bit	Definition	Row
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	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
T01_LED	SELOGIC equation: drives T01_LED	68

Table J.2 Relay Word Bit Definitions for the SEL-700G (Sheet 19 of 21)

Bit	Definition	Row
T02_LED	SELOGIC equation: drives T02_LED	68
T03_LED	SELOGIC equation: drives T03_LED	68
T04_LED	SELOGIC equation: drives T04_LED	68
T05_LED	SELOGIC equation: drives T05_LED	68
T06_LED	SELOGIC 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 Equation	41
TR2	Trip 2 SELOGIC Equation	41
TR3	Trip 3 SELOGIC 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 equation	41
TRY	Trip Y SELOGIC equation	41
TSNTPB	SNTP Secondary Server is active	141
TSNTPP	SNTP Primary Server is active	141
TSOK	Asserts if current time source accuracy is sufficient for synchronized phasor measurements	53

Table J.2 Relay Word Bit Definitions for the SEL-700G (Sheet 20 of 21)

Bit	Definition	Row
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 equation	43
ULCL3	Unlatch trip 3 SELOGIC equation	43
ULCLX	Unlatch close conditions SELOGIC equation CLX state	43
ULCLY	Unlatch close conditions SELOGIC equation CLY state	43
ULTR1	Unlatch trip 1 SELOGIC equation	43
ULTRX	Unlatch trip X SELOGIC equation	43
ULTRY	Unlatch trip Y SELOGIC 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
VPOLVX	X-side positive-sequence polarization voltage valid	55
VPOLVY	Y-side positive-sequence polarization voltage valid	55

Table J.2 Relay Word Bit Definitions for the SEL-700G (Sheet 21 of 21)

Bit	Definition	Row
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

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Appendix K
Analog Quantities

The SEL-700G Relay contains several analog quantities that can be used 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.

Table K.1 lists analog quantities that can be used in the following specific functions:

- Display points (see *Section 8: Front-Panel Operations*.)
- SELOGIC control equations (see *Section 4: Protection and Logic Functions*.)
- Display points (see *Section 8: Front-Panel Operations*.)
- 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	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	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[a]	EU	x	x	x	x	
AI401 to AI404	Analog inputs for an analog card in Slot D[a]	EU	x	x	x	x	
AI501 to AI504	Analog inputs for an analog card in Slot E[a]	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[a]	EU	x	x		x	
AI301MN–AI304MN	Analog transducer input 301–304 minimum[a]	EU	x	x		x	
AI401MX–AI404MX	Analog transducer input 401–404 maximum[a]	EU	x	x		x	
AI401MN–AI404MN	Analog transducer input 401–404 minimum[a]	EU	x	x		x	
AI501MX–AI504MX	Analog transducer input 501–504 maximum[a]	EU	x	x		x	
AI501MN–AI504MN	Analog transducer input 501–504 minimum[a]	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[b]	
TIME	Present time		x			x[b]	
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	Relay identifier		x				
TID	Terminal identifier		x				
Setting Group							
GROUP	Active setting group #		x	x		x[c]	
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[c]	
Serial Number							
SER_NUM	Serial number of the relay					x	

[a] See the engineering unit settings (for example, AI301EU) of the respective analog input quantity for the unit.
[b] Available as DNP object 50.
[c] 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 needed 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 needed 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 multi-vendor devices.

IG Residual current, calculated from the sum of the phase currents. In normal, balanced operation, this current is very small or zero. When a ground fault occurs, this current can be large.

IN Neutral current measured by the relay IN input. The IN input is typically connected to the secondary winding of a window-CT for ground fault detection on resistance-grounded systems.

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), kilovoltwatts (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 can be used 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.

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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.
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.

Serial Port Command	Command Description
Access Level 0 Commands	
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Access Level 1 Commands	
2AC	Goes to Access Level 2.
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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.
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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.
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MET PM	Displays synchrophasor metering data.
MET RD	Resets demand metering values.
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MET RM	Resets minimum and maximum metering data.
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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.
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TIM *hh:mm:ss*	Sets time by entering **TIM** followed by hours, minutes, and seconds, as shown (24-hour clock).
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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.
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PAS 1	Changes Access Level 1 password.
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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.
Access Level C Command	
PAS C	Changes Access Level 2 password.