SEL-751 Relay

Feeder Protection Relay

Instruction Manual

20170927

SCHWEITZER ENGINEERING LABORATORIES, INC.

PM751-01

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Preface

Manual Overview

The SEL-751 Feeder Protection Relay Instruction Manual describes common aspects of feeder 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-751; lists the relay specifications.

Section 2: Installation. Describes how to mount and wire the SEL-751; 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-751 to a PC for communication; shows serial port pinouts; lists and defines serial port commands. Describes the communications port interfaces and protocols supported by the relay for serial and Ethernet.

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

Section 9: Bay Control. Describes how to configure and design the bay control screens for SEL-751 relays with the touchscreen display (5-inch, color, 800 x 480 pixels).

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

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

Appendix A: Firmware, ICD, and Manual Versions. Lists the present relay firmware version and details differences between the present and previous 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-751 with SEL communications processors for total substation automation solutions.

Appendix D: DNP3 Communications. Describes the DNP3 protocol support provided by the SEL-751.

Appendix E: Modbus RTU Communications. Describes the Modbus protocol support provided by the SEL-751.

Appendix F: IEC 61850 Communications. Describes IEC 61850 implementation in the SEL-751.

Appendix G: IEC 60870-5-103 Communications. Describes the IEC 60870-5-103 protocol support provided by the SEL-751.

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

Appendix I: Synchrophasors. Describes the Phasor Measurement Control Unit (PMCU), and accessing synchrophasor data through the use of IEEE C37.118 Protocol.

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

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

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

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

SEL-751 Relay Command Summary. Briefly describes the serial port commands that are fully described in *Section 7: Communications*.

Safety Information

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

Dangers, Warnings, and Cautions

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

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

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

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

Safety Symbols

The following symbols are often marked on SEL products.

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

Safety Marks

The following statements apply to this device.

General Safety Marks

⚠CAUTION There is danger of explosion if the battery is incorrectly replaced. Replace only with Ray-O-Vac no. BR2335 or equivalent recommended by manufacturer. See Owner's Manual for safety instructions. The battery used in this device may present a fire or chemical burn hazard if mistreated. Do not recharge, disassemble, heat above 100°C or incinerate. Dispose of used batteries according to the manufacturer's instructions. Keep battery out of reach of children.	⚠ATTENTION Une pile remplacée incorrectement pose des risques d'explosion. Remplacez seulement avec un Ray-O-Vac no BR2335 ou un produit équivalent recommandé par le fabricant. Voir le guide d'utilisateur pour les instructions de sécurité. La pile utilisée dans cet appareil peut présenter un risque d'incendie ou de brûlure chimique si vous en faites mauvais usage. Ne pas recharger, démonter, chauffer à plus de 100°C ou incinérer. Éliminez les vieilles piles suivant les instructions du fabricant. Gardez la pile hors de la portée des enfants.
For use in Pollution Degree 2 environment.	Pour l'utilisation dans un environnement de Degré de Pollution 2.
Ambient air temperature shall not exceed 50°C (122°F).	La température de l'air ambiant ne doit pas dépasser 50°C (122°F).
For use on a flat surface of a Type 12 enclosure.	Destiné à l'utilisation sur une surface plane d'un boîtier de Type 12.
Terminal Ratings Wire Material Use 75°C (167°F) copper conductors only. Tightening Torque CT Terminal Blocks: 0.9–1.4 Nm (8–12 in-lb) Compression Plug: 0.5–1.0 Nm (4.4–8.8 in-lb) Compression Plug Mounting Ear Screw: 0.18–0.025 Nm (1.6–2.2 in-lb)	Spécifications des bornes Type de filage Utiliser seulement des conducteurs en cuivre spécifiés à 75°C (167°F). Couple de serrage CT bornes : 0,9–1,4 Nm (8–12 livres-pouce) Fiche à compression : 0,5–1,0 Nm (4,4–8,8 livres-pouce) Vis à oreille de montage de la fiche à compression : 0,18–0,025 Nm (1,6–2,2 livres-pouce)

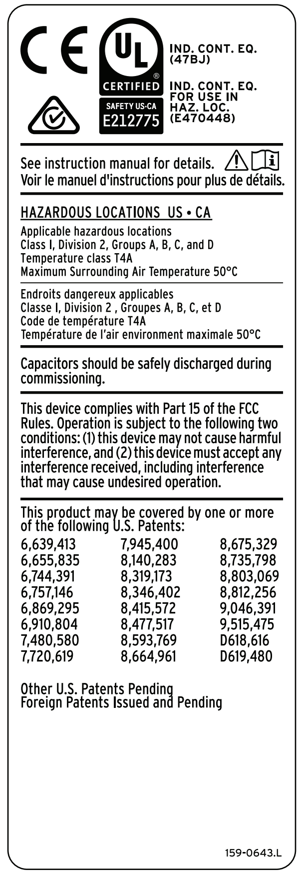
Hazardous Locations Safety Marks

⚠WARNING – EXPLOSION HAZARD Open circuit before removing cover.	⚠AVERTISSEMENT – DANGER D'EXPLOSION Ouvrir le circuit avant de déposer le couvercle.
⚠WARNING – EXPLOSION HAZARD Substitution of components may impair suitability for Class I, Division 2.	⚠AVERTISSEMENT – DANGER D'EXPLOSION La substitution de composants peut détériorer la conformité à Classe I, Division 2.
Operating Temperature Range: –40°C to +85°C (–40°F to +185°F).	Plage de température de fonctionnement: –40°C à +85°C (–40°F à +185°F).

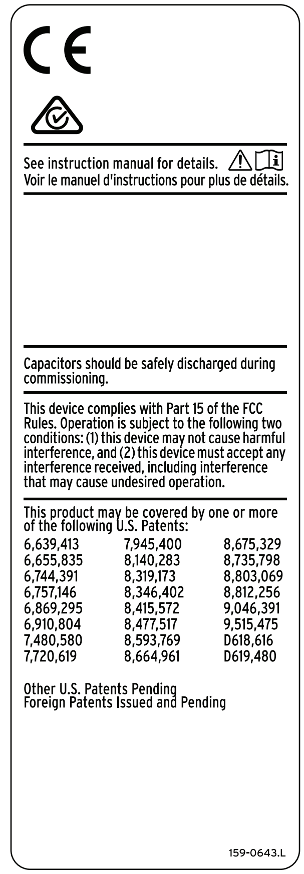
Hazardous Locations Approvals

The SEL-751 is UL certified for hazardous locations to Canadian and U.S. standards. In North America, the relay is approved for Hazardous Locations Class I, Division 2, Groups A, B, C, and D, and temperature class T4A in the maximum surrounding air temperature of 50°C.

The figure shows the compliance label that is located on the left side of the device.



(Two-Line Display)



(Touchscreen Display)

Product Compliance Labels for the SEL-751 With Two-Line Display and With the Touchscreen Display

Other Safety Marks (Sheet 1 of 2)

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

Other Safety Marks (Sheet 2 of 2)

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

General Information

Typographic Conventions

There are many ways to communicate with the SEL-751. The three primary methods are:

- ➤ Using a command line interface on a PC terminal emulation window.
- ➤ Using the two-line display front-panel menus and pushbuttons or the touchscreen display.
- ➤ Using ACSELERATOR QuickSet.

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

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

Trademarks

Trademarks appearing in this manual are shown in the following table.

SEL Trademarks	
ACSELERATOR Analytic Assistant®	MIRRORED BITS®
ACSELERATOR Architect®	SEL-2407®
ACSELERATOR QuickSet®	SELOGIC®
Arc Sense™	SYNCHROWAVE®
Best Choice Ground Directional Element®	time-overlight®
Other Trademarks[a]	
DeviceNet™	Ray-O-Vac®
IEEE®	ST®
Modbus®	Windows®
OMRON®	

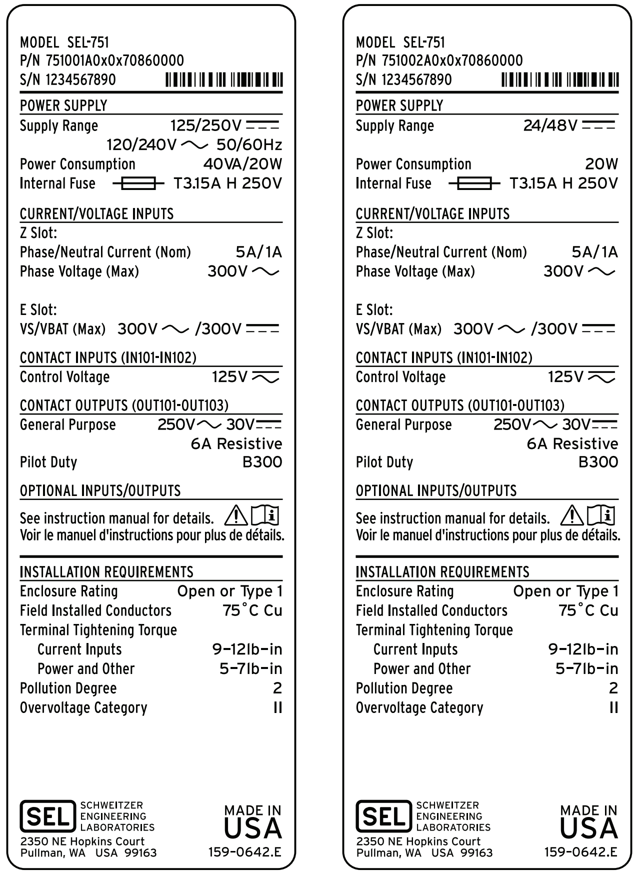
[a] All brand or product names appearing in this document are the trademark or registered trademark of their respective holders.

Examples

This instruction manual uses several example illustrations and instructions to explain how to effectively operate the SEL-751. These examples are for demonstration purposes only; the firmware identification information or settings values included in these examples may not necessarily match those in the present version of your SEL-751.

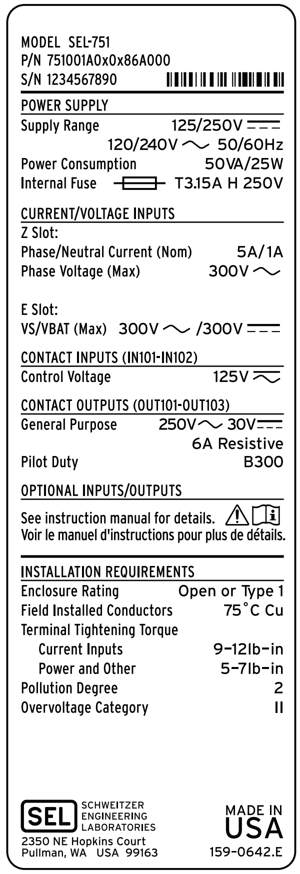
Product Labels

The following labels are the product labels for the high voltage and low voltage power supply options for the two-line display and the touchscreen display. The labels are located on the left side panel of the product. The labels show the serial number, model number, and the ratings of the product.

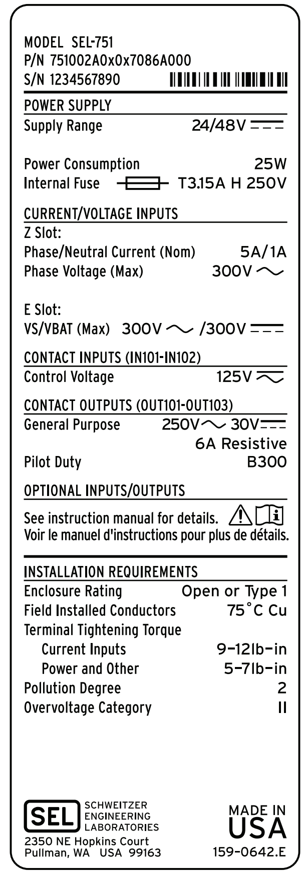


(High-Voltage Supply) (Low-Voltage Supply)

Product Labels for the SEL-751 With the Two-Line Display



(High-Voltage Supply)



(Low-Voltage Supply)

Product Labels for the SEL-751 With the Touchscreen Display

LED Emitter

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

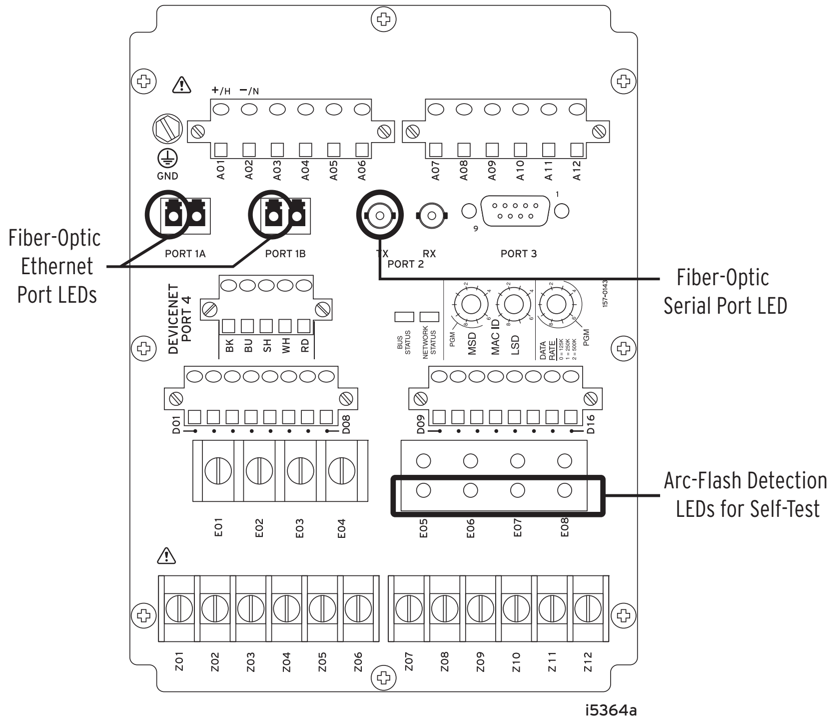
⚠CAUTION
Looking into optical connections, fiber ends, or bulkhead connections can result in hazardous radiation exposure.

The following table shows LED information specific to the SEL-751 (see *Figure 2.9* for the location of the ports using these LEDs on the relay).

SEL-751 LED Information

Item	Fiber-Optic Ethernet Port 1 (1A, 1B)	Port 2	Arc-Flash Channel 1–8
Mode	Multimode	Multimode	Multimode
Wavelength	1300 nm	820 nm	640 nm
Source	LED	LED	LED
Connector type	LC	ST	V-pin
Typical output power	–15.7 dBm	–16 dBm	–12 dBm

The following figure shows the LED location specific to the SEL-751 (see *Figure 2.9* for the complete rear-panel drawing).



SEL-751 LED Locations

LED Safety Warnings and Precautions

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

Environmental Conditions and Voltage Information

The following table lists important environmental and voltage information.

Condition	Range/Description
Indoor/outdoor use	Indoor
Altitude[a]	To 2000 m
Temperature	
IEC Performance Rating (per IEC/EN 60068-2-1 and IEC/EN 60068-2-2)	–40 to +85°C
Relative humidity	5 to 95%
Main supply voltage fluctuations	To ±10% of nominal voltage

Condition	Range/Description
Overvoltage	Category II
Pollution	Degree 2
Atmospheric pressure	80 to 110 kPa

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

Wire Sizes and Insulation

Wire sizes for grounding (earthing), current, voltage, and contact connections are dictated by the terminal blocks and expected load currents. You can use the following table as a guide in selecting wire sizes.

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

[a] See Table 2.18: Typical Maximum RTD Lead Length.

Instructions for Cleaning and Decontamination

Use a mild soap or detergent solution and a damp cloth to carefully clean the SEL-751 chassis when necessary. Clean the touchscreen display gently with a moist cotton cloth. Avoid using abrasive materials, polishing compounds, and harsh chemical solvents (such as xylene or acetone) on any surface of the relay.

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Technical Assistance

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

Obtain technical assistance from the following address:

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA 99163-5603 U.S.A.
Tel: +1.509.338.3838
Fax: +1.509.332.7990
Internet: selinc.com
Email: info@selinc.com

Section 1
Introduction and Specifications

Overview

The SEL-751 Feeder Protection Relay provides a comprehensive combination of protection, fault-locating features, monitoring, control, and communication in an industrial package. The base relay includes current, voltage, frequency, and power protection elements. Arc-flash detector-based, RTD-based, directional control-based, and high-impedance-based fault detection protection are available as options.

This manual contains the information necessary to install, set, test, operate, and maintain any SEL-751. You need not review the entire manual to perform specific tasks.

Features

Protection Features

The SEL-751 protection features depend on the model selected. The models are configured with specific current/voltages input cards. The current/voltage inputs 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" (for 300 Vac phase voltage inputs), with the letter "L" (for 8 Vac LEA phase voltage inputs), or with the letter "A" (for no ac voltage inputs). The second number represents the phase and neutral CT ratings in the SEL-751 two-line and touchscreen display Model Options Tables (MOT, see *Models, Options, and Accessories*). For example, "81" in the MOT for Slot Z indicates a SELECT 4 ACI/3 AVI card with three-phase ac current inputs (1 A nominal), neutral ac current input (1 A nominal), and three-phase ac voltage inputs (300 Vac).

Slot E cards are assigned a two-digit code beginning with the number "7" (for 300 Vac voltage inputs) or the letter "L" (for 8 Vac LEA phase voltage inputs) in the SEL-751 two-line and touchscreen display Model Options Tables (MOT). For example, "70" in the MOT for Slot E indicates a SELECT 2 AVI/ 4 AFDI card with Vsyc (300 Vac), Vbat (300 V) input, and 4 arc-flash detection inputs.

Table 1.1 shows the phase and neutral current ratings choices for the different SEL-751 MOT choices. Phase current inputs are 1 A or 5 A nominal rating and neutral current inputs are 1 A, 5 A, or 200 mA nominal rating.

Table 1.1 Phase and Neutral Current Ratings Selection for the SEL-751 Models

Current Rating	MOT String Digit Number 15
1 Amp Phase, 1 Amp Neutral	1
1 Amp Phase, 5 Amp Neutral	2
1 Amp Phase, 200 mA Neutral	3
5 Amp Phase, 5 Amp Neutral	5
5 Amp Phase, 1 Amp Neutral	6
5 Amp Phase, 200 mA Neutral	7

Table 1.2 shows current (ACI) and voltage (AVI) card selection for the SEL-751 models.

Table 1.2 Current (ACI) and Voltage (AVI) Card Selection for SEL-751 Models

Model Description	Slot Z Card Option (MOT String Digital Number 14, 15)	Slot Z Inputs	Slot E Card Option (MOT String Digits Number 12, 13)	Slot E Inputs
Base SEL-751 With AC Voltages (300 Vac)	4 ACI/3 AVI (81, 82, 83, 85, 86, 87)	IA, IB, IC, IN, VA, VB, VC	None (0X)	None
Base SEL-751 With LEA AC Voltages (8 Vac)	4 ACI/3 AVI (L1, L2, L3, L5, L6, L7)	IA, IB, IC, IN, VA, VB, VC	None (0X)	None
SEL-751 With AC Phase Voltages (300 Vac), Vsync (300 Vac), Vbat (300 V) Input, and 4 Arc-Flash Detections Inputs	4 ACI/3 AVI (81, 82, 83, 85, 86, 87)	IA, IB, IC, IN, VA, VB, VC	2 AVI/4 AFDI (70)	VS, VBAT, AF1, AF2, AF3, AF4
SEL-751 With LEA AC Phase Voltages (8 Vac), LEA Vsync (8 Vac), Vbat (300 V) Input, and 4 Arc-Flash Detection Inputs	4 ACI/3 AVI (L1, L2, L3, L5, L6, L7)	IA, IB, IC, IN, VA, VB, VC	2 AVI/4 AFDI (L0)	VS, VBAT, AF1, AF2, AF3, AF4
SEL-751 AC Currents Only	4 ACI (A1, A2, A3, A5, A6, A7)	IA, IB, IC, IN	None (0X)	None

The SEL-751 offers an extensive variety of protection features, depending on the model and options selected. *Table 1.3* lists the protection features available in different models.

Table 1.3 SEL-751 Protection Elements (Sheet 1 of 3)

Protection Element		Slot Z 4 ACI/3 AVI Card With 1 A or 5 A Neutral Channel	Slot Z 4 ACI/3 AVI Card With 200 mA Neutral Channel	Slot Z 4 ACI Card (Current Only Model) With 1 A or 5 A Neutral Channel
50P	Max. Phase Overcurrent	X	X	X
67P	Max. Phase Overcurrent With Directional Control	X[a]	X[b]	
50Q	Neg.-Seq. Overcurrent	X	X	X
67Q	Neg.-Seq. Overcurrent With Directional Control	X[a]	X[b]	
50G	Residual Overcurrent	X	X	X
67G	Residual Overcurrent With Directional Control	X[a]	X[b]	
50N	Neutral Overcurrent	X	X	X

Table 1.3 SEL-751 Protection Elements (Sheet 2 of 3)

Protection Element		Slot Z 4 ACI/3 AVI Card With 1 A or 5 A Neutral Channel	Slot Z 4 ACI/3 AVI Card With 200 mA Neutral Channel	Slot Z 4 ACI Card (Current Only Model) With 1 A or 5 A Neutral Channel
67N	Neutral Overcurrent With Directional Control		X[b]	
51*m*P	Phase Time Overcurrent (*m* = A, B, C)	X	X	X
51P	Max. Phase Time Overcurrent	X	X	X
51P	Max. Phase Time Overcurrent With Directional Control	X[a]	X[b]	
51G	Residual Time Overcurrent	X	X	X
51G	Residual Time Overcurrent With Directional Control	X[a]	X[b]	
51Q	Neg.-Seq. Time Overcurrent	X	X	X
51Q	Neg.-Seq. Time Overcurrent With Directional Control	X[a]	X[b]	
51N	Neutral Time Overcurrent	X	X	X
51N	Neutral Time Overcurrent With Directional Control		X[b]	
SEF	Sensitive Earth Fault		X	
HBL	Second- and Fifth-Harmonic Blocking	X	X	X
FLOC	Fault Locator	X	X	
27	Undervoltage (Phase, Phase-to-Phase, Vsync)	X	X	
59	Overvoltage (Phase, Phase-to-Phase, Seq., Vsync)	X	X	
27I	Inverse Time Undervoltage (Phase, Phase-to-Phase, Seq., Vsync)	X	X	
59I	Inverse Time Overvoltage (Phase, Phase-to-Phase, Seq., Vsync)	X	X	
60LOP	Loss of Potential	X	X	
32	Directional Power	X	X	
49T	IEC Thermal (line/cable)	X	X	X
55	Power Factor	X	X	
78VS	Vector Shift	X	X	
81	Over- and Underfrequency	X	X	X
81R	Rate-of-Change of Frequency	X	X	
81RF	Fast Rate-of-Change of Frequency	X	X	
25	Synchronism Check	X	X	
BF	Breaker Failure	X	X	X
49RTD	RTDs	X[c]	X[c]	X[c]
79	Reclosing	X[c]	X[c]	X[c]

Table 1.3 SEL-751 Protection Elements (Sheet 3 of 3)

Protection Element		Slot Z 4 ACI/3 AVI Card With 1 A or 5 A Neutral Channel	Slot Z 4 ACI/3 AVI Card With 200 mA Neutral Channel	Slot Z 4 ACI Card (Current Only Model) With 1 A or 5 A Neutral Channel
HIF AST	High-Impedance Fault Detection With Arc Sense Technology	X[c]	X[c]	
AFT	Arc-Flash Detection	X[c]	X[c]	X[c]

[a] Available when ordered with the directional option. The 1 A/5 A neutral channel is suitable for solidly grounded systems and also impedance-grounded systems, depending on the available fault current level.
[b] Available when ordered with the directional option. The 200 mA neutral channel is suitable for ungrounded, low-impedance grounded, high-impedance grounded, and Petersen coil grounded applications.
[c] Available as ordering options.

The SEL-751 offers three front-panel HMI layouts that are model and option dependent. *Table 1.4* lists the HMI options for the SEL-751 front panel.

Table 1.4 SEL-751 Front-Panel Options

Model/Display Description	Front-Panel Option (MOT String Digit Number 16)	Number of Pushbuttons	LED Type
SEL-751[a] With Two-Line Display (2 x 16 characters)	0	8	Tricolor
SEL-751[a] With Two-Line Display (2 x 16 characters)	1	4	Tricolor
SEL-751[b] With Touchscreen Display (5-inch, color, 800 x 480 pixels)	A	8	Tricolor

[a] For ordering options, refer to the SEL-751 two-line display MOT.
[b] For ordering options, refer to the SEL-751 touchscreen display MOT.

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
- Breaker Wear Monitoring
- Load Profile Report
- High-Impedance Fault (HIF) Compressed Event Report (option)

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, Simple Network Time Protocol (SNTP), DNP3 serial, DNP3 LAN/WAN, Ethernet FTP, Telnet, MIRRORED BITS, Event Messenger, IEC 61850 Edition 2, IEC 60870-5-103, 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

Language Support

- The standard relay front-panel overlay is in English; a Spanish overlay is available as an ordering option. Text displayed on the HMI display will correspond to the ENGLISH or SPANISH ordering option.
- All of the ASCII command responses can be displayed in English or Spanish. When you set the port setting LANG to either ENGLISH or SPANISH, the SEL-751 ASCII commands display in the corresponding language.

Models, Options, and Accessories

Models

Complete ordering information is not provided in this instruction manual. See the latest Model Option Table for the SEL-751 with the two-line display and the SEL-751 with the touchscreen display at selinc.com, under Support > Product Literature > Ordering Information (Model Option Tables). Options and accessories are as follows:

SEL-751 Base Unit

- Front panel with two-line display or with touchscreen display
  - Eight programmable pushbuttons, each with two tricolor LEDs
  - Eight target tricolor LEDs (six programmable)
  - Operator control interface
  - EIA-232 port
- Power supply card with two digital inputs and three digital outputs (Slot **A**)
- Processor and communications card (Slot **B**)
  - EIA-232 serial port with IRIG-B time code input
  - Multimode (ST) fiber-optic serial port
- Three expansion slots for optional cards (Slots **C**, **D**, **E**)
- Four ac current inputs (1 A/5 A/200 mA neutral only)/three ac voltage inputs (300 V or 8 V LEA) card (Slot **Z**)
- 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

- Firmware options
  - Autoreclosing control
  - Directional control for overcurrent elements (solid or low-impedance grounded systems only)
  - Directional control for overcurrent elements (low-impedance grounded systems; ungrounded, high-impedance grounded systems; and Petersen coil-grounded systems—requires 200 mA neutral CT)
  - High-impedance fault (HIF) detection using Arc Sense technology
- Current/Voltage input options (see *Table 1.1*)
  - AC currents only model (no voltages)
- 2 AVI/4 AFDI card option with
  - Synchronism-check voltage input (300 V or 8 V LEA)
  - DC station battery monitor
  - 4 arc-flash detector inputs
- 8 AFDI card option
  - 8 arc-flash detector inputs
- Input/output (I/O) options
  - Additional digital I/O (4 DI/4 DO, 4 DI/3 DO, 8 DI, 8 DO, 3 DI/4 DO/1 AO, 14 DI)
  - Additional analog I/O (4 AI/4 AO, 8 AI)
  - 10 RTD inputs
- Front-panel HMI options (see *Table 1.4*)
- Communications options (protocol/ports)
  - EIA-485/EIA-232/Ethernet ports (single/dual, copper or fiber-optic)
  - AC currents only model (no voltages) with no fiber-optic serial port
  - Simple Network Time Protocol (SNTP)
  - Modbus TCP/IP
  - DeviceNet
  - IEC 61850 Edition 2
  - IEC 60870-5-103
  - DNP3 serial and LAN/WAN
- Language Options
  - The relay supports English or Spanish language as an ordering option

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-751
- SEL-2505 Remote I/O Module (with SEL-2812 compatible ST fiber-optic port) for connection to relay fiber-optic serial Port 2, or use SEL-2505 with EIA-232 (DB-9) serial port to connect to EIA-232 Port 3 on the relay.
- SEL-C804 and SEL-C814 Multimode Fiber-Optic Arc-Flash Detection (AFD) Sensors and Accessories
- SEL-751 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
- Relay Wire Termination Kits—See *Application Note AN2014-08*.

For all SEL-751 mounting accessories for competitor products, including adapter plates, visit selinc.com/applications/mountingselector/.

Applications

The SEL-751 Feeder Protection Relay has many power system protection, monitoring, and control applications. *Figure 1.1* shows some of the typical protection applications for the SEL-751. You can use the SEL-751 directional and nondirectional overcurrent functions to protect virtually any power system circuit or device including lines, feeders, transformers, capacitor banks, reactors, and generators. Over- and underfrequency, over- and undervoltage, and synchronism-check elements are well suited for applications at distributed generation sites. Directional power elements in the SEL-751 also make the relay suitable for utility or customer interface protection where customer generation is present.

You can use powerful SELOGIC control equations in all SEL-751 models to provide custom protection and control applications. SEL application guides and technical support personnel are available to help with unique applications.

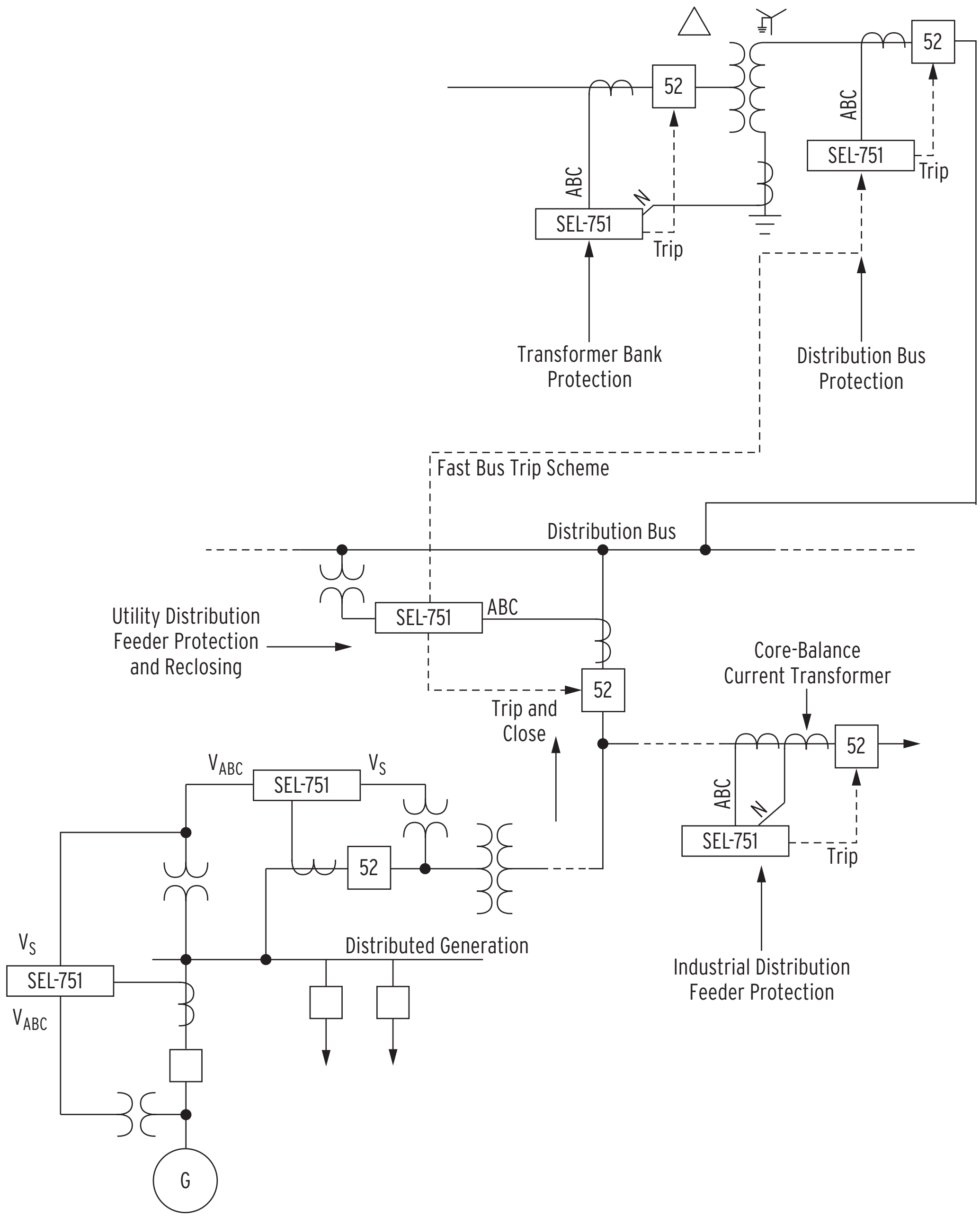


Figure 1.1 SEL-751 Feeder Protection Relay Applied Throughout the Power System

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

- ➤ With internal or external RTD module for thermal protection
- ➤ With arc-flash detection and protection
- ➤ High-impedance fault (HIF) detection and protection for feeders

Figure 1.2 shows typical current connections. Refer to *Section 2: Installation* for additional applications and the related connection diagrams.

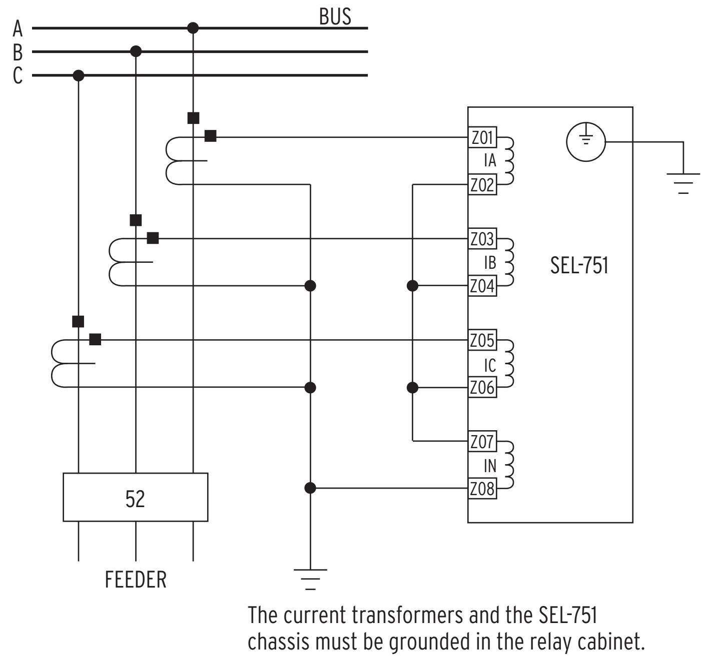


Figure 1.2 Typical Current Connections

Getting Started

Understanding basic relay operation principles and methods will help you use the SEL-751 effectively. This section presents the fundamental knowledge you need to operate the SEL-751, 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 relay operation.

Powering the Relay

Power the SEL-751 with 110–240 Vac/110–250 Vdc or 24–48 Vdc, depending on the part number.

- Observe proper polarity, as indicated by the **+/H** (Terminal **A01**) and the **–/N** (Terminal **A02**) on the power connections.
- Connect the ground lead; see *Grounding (Earthing) Connections on page 2.23*.
- Once connected to power, the relay does an internal self-check and the **ENABLED** LED illuminates.

Establishing Communication

The SEL-751 has three EIA-232 serial communications ports. The following steps require PC terminal emulation software and an SEL Cable C234A (or equivalent) to connect the SEL-751 to the PC. See *Section 7: Communications* for further information on serial communications connections and the necessary cable pinout.

Step 1. Connect the PC and the SEL-751 by using the serial communications cable.

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

Step 3. Start the PC terminal emulation program.

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

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

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

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

Table 1.5 SEL-751 Serial Port Settings

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

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

You will see a computer screen display similar to *Figure 1.3*. If you see jumbled characters, change the terminal emulation type in the PC terminal emulation program.

```
=>QUIT <Enter>
Feeder xyz          Date: 03/10/2011   Time: 10:31:43
Station 1           Time Source: Internal
=
```

Figure 1.3 Response Header

Step 7. Type **ACC <Enter>** and the appropriate password (see *Table 7.34* for factory-default passwords) to go to Access Level 1.

Step 8. Type **QUIT <Enter>** to view the relay report header.

Checking Relay Status

Use the **STA** serial port command to view the SEL-751 operational status. Note that offsets are shown only when the relay is online and tracking frequency. If the DC offset exceeds a warning threshold, the analog value has a “w” next to it. Analog channel dc offset and monitored component status are listed in the status report depicted in *Figure 1.4*.

```
=>>STA <Enter>

SEL-751                                   Date: 01/24/2017   Time: 14:06:58.751
FEEDER RELAY                              Time Source: Internal

Serial Num = 012345678901234
FID = SEL-751-X386-V0-Z007002-D20170116                CID = B3B2
PART NUM = 751301B6X6X7081A23X

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   1.20

  +1.5V  +1.8V  +2.5V  +3.3V  +3.75V  +5.0V  -1.25V  -5.0V   BATT
  1.50   1.80   2.50   3.33   3.74    5.04   -1.25   -5.01   3.10

Option Cards
  CARD_C  CARD_D  CARD_E  CARD_Z
  OK      OK      OK      OK

Offsets
   IA    IB    IC    IN    VA    VB    VC    VS
  12    12    12    8     -4    -7    -5    -7

  Relay Enabled

=>>
```

Figure 1.4 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 1.5* applies. If a communications card with Modbus RTU protocol is present, the status report depicted in *Figure 1.4* applies.

```
=>STA <Enter>

SEL-751                                   Date: 03/14/2011   Time: 14:03:48.984
FEEDER RELAY                              Time Source: Internal

Serial Num = 000000000000000
FID = SEL-751-X139-V0-Z001001-D20110309                CID = 05A2
PART NUM = 751501BA3CA70860230

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   1.20

  +1.5V  +1.8V  +2.5V  +3.3V  +3.75V  +5.0V  -1.25V  -5.0V   BATT
  1.50   1.80   2.51   3.35   3.77    4.98   -1.26   -5.04   3.04

Option Cards
  CARD_C  CARD_D  CARD_E  CARD_Z
  OK      OK      OK      OK

DeviceNet
  DN_MAC_ID     ASA      DN_RATE   DN_STATUS
  4          1a25 df42h  AUTO      0000 0000

Offsets
    IA    IB    IC    IN    VA    VB    VC    VS
   12    12    12    8     -4    -7    -5    -7
  Relay Enabled
=>
```

Figure 1.5 STA Command Response—Communications Card/DeviceNet Protocol

Table 7.45 provides the definition of each status report designator and *Table 11.8* shows all the self-tests performed by the relay. The beginning of the status report printout (see *Figure 1.5*) contains the relay serial 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-751. If the date stored in the relay is July 29, 2010, and the DATE_F setting is MDY, the relay replies:

```
7/29/2010
```

If the DATE_F setting is YMD, the relay replies:

```
2010/7/29
```

If the DATE_F setting is DMY, the relay replies:

```
29/7/2010
```

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, 2010 (DATE_F := MDY), enter the following at the action prompt:

```
DAT 5/2/10
```

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-751. The relay replies with the stored time. For example

```
13:52:44
```

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

Changing the Time

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

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

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

Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

47 CFR 15B, Class A

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

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

Note: UL has not yet developed requirements for products intended to detect and mitigate an arc flash; consequently, UL has not evaluated the performance of this feature. While UL is developing these requirements, it will place no restriction on the use of this product for arc-flash detection and mitigation. For test results performed by an independent laboratory and other information on the performance and verification of this feature, please contact SEL customer service.

UL Certified for Hazardous Locations to U.S. and Canadian standards (File E470448)

CE Mark

RCM Mark

General

AC Current Input

Phase and Neutral Currents

I_{NOM} = 200 mA, 1 A, or 5 A secondary, depending on model.

I_{NOM} = 5 A

Continuous Rating:	3 • I_{NOM} @ 85°C, linear to 100 A symmetrical 4 • I_{NOM} @ 55°C, linear to 100 A symmetrical
1-Second Thermal:	500 A
Burden (per phase):	<0.1 VA @ 5 A

I_{NOM} = 1 A

Continuous Rating:	3 • I_{NOM} @ 85°C, linear to 20 A symmetrical 4 • I_{NOM} @ 55°C, linear to 20 A symmetrical
1-Second Thermal:	100 A
Burden (per phase):	<0.01 VA @ 1 A

I_{NOM} = 200 mA

Continuous Rating:	4 A, linear to 4 A symmetrical
1-Second Thermal:	20 A
Burden (per phase):	<0.01 VA @ 0.2 A

Measurement Category:	II

AC Voltage Input

V_{NOM} (L-L) Setting Range:	20–250 V (if DELTA_Y := DELTA) 20–480 V (if DELTA_Y := WYE)

300 Vac Voltage Inputs

Rated Continuous Voltage:	300 Vac
10-Second Thermal:	600 Vac
Burden:	<0.1 VA
Input Impedance:	4 MΩ differential (phase-to-phase)

Low-Energy Analog (LEA) Voltage Inputs

Rated Continuous Voltage:	8 Vac (phase-to-neutral)
Nominal LEA Voltage:	0.5–6.8 Vrms (phase-to-neutral)
Input Range:	±12 V_{peak}
10-second Thermal:	300 Vac (phase-to-neutral)
Burden:	<0.1 VA
Input Impedance:	2 MΩ single-ended (phase-to-neutral) 4 MΩ differential (phase-to-phase)

Power Supply

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

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 85–300 Vdc
Power Consumption:	<50 VA (ac) <25 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:	19.2–60.0 Vdc
Power Consumption:	<25 W (dc)
Interruptions:	10 ms @ 24 Vdc 50 ms @ 48 Vdc

Fuse Ratings

LV Power Supply Fuse

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

HV Power Supply Fuse

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

Fuses are not serviceable.

Output Contacts

General

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

Dialectric Test Voltages: 2500 Vac

Impulse Withstand Voltage (U_{IMP}): 4700 V

Mechanical Durability: 100,000 no-load operations

Standard Contacts

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

DC Output Ratings

Rated Operational Voltage: 250 Vdc

Rated Voltage Range: 19.2–275 Vdc

Rated Insulation Voltage: 300 Vdc

Make: 30 A @ 250 Vdc per IEEE C37.90

Continuous Carry: 6 A @ 70°C
4 A @ 85°C

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 (excluding EN 61010-1): 300 Vac

Contact Rating Designation: B300

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

Utilization Category: AC-15

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

Voltage Protection Across Open Contacts: 270 Vac, 40 J

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

DC Output Ratings

Rated Operational Voltage: 250 Vdc

Rated Voltage Range: 19.2–275 Vdc

Rated Insulation Voltage: 300 Vdc

Make: 30 A @ 250 Vdc per IEEE C37.90

Carry: 6 A @ 70°C
4 A @ 85°C

1 s Rating: 50 A

Open State Leakage Current: <500 µA

MOV Protection (maximum voltage): 250 Vac/330 Vdc

Pickup Time: <50 µs, resistive load

Dropout Time: <8 ms, resistive load

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

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

Cyclic Capacity (4 cycles in 1 second, followed by 2 minutes idle for thermal dissipation) per IEC 60255-0-20:1974:

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

AC Output Ratings

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

Optoisolated Control Inputs

When Used With DC Control Signals

250 V: ON for 200.0–312.5 Vdc
OFF below 150 Vdc

220 V: ON for 176–275 Vdc
OFF below 132 Vdc

125 V: ON for 100.0–156.2 Vdc
OFF below 75 Vdc

110 V: ON for 88.0–137.5 Vdc
OFF below 66 Vdc

48 V: ON for 38.4–60.0 Vdc
OFF below 28.8 Vdc

24 V: ON for 15–30 Vdc
OFF below 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)

	1 A0	4 A0
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 Inputs (Optional)

Maximum Input Range:	±20 mA ±10 V Operational range set by user
Input Impedance:	200 Ω (current mode) >10 kΩ (voltage mode)
Accuracy at 25°C:	
With User Calibration:	0.05% 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)

Arc-Flash Detectors (Optional)

Multimode fiber-optic receiver/transmitter pair

Fiber Type:	1000 µm diameter, 640 nm wavelength, plastic, clear-jacketed, or black-jacketed
Connector Type:	V-Pin

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} ≥2.2 V
Off (0) State:	V_{il} ≤ 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 Internal Clock:	±5 ms
Unsynchronized Clock Drift:	2 minutes per year typical

Communications Ports

Standard EIA-232 (2 ports)

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

EIA-485 Port (optional)

Location:	Rear Panel
Data Speed:	300–19200 bps

Ethernet Port (optional)

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

Standard Multimode Fiber-Optic Port

Location:	Rear Panel
Data Speed:	300–38400 bps

Fiber-Optic Ports Characteristics

Port 1 (or 1A, 1B) Ethernet

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

Port 2 Serial

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

Channels 1-8 Arc-Flash Detectors (AFDI)

Diagnostic Wavelength:	640 nm
Optical Connector Type:	V-Pin
Fiber Type:	Multimode
Typical TX Power:	–12 dBm

Point Sensor

Minimum Receive Sensitivity:	–52.23 dB
Point Sensor Diagnostic Worst Case Loss:	–28 dB
Link Budget:	12.23 dB
Black-Jacketed Fiber Worst Case Loss:	–0.19 dBm
Black-Jacketed Fiber Typical Loss:	–0.17 dBm
ST or V-Pin Connector Splice Loss:	–2.00 dB
Approximate Range:	As much as 35 m

Fiber Sensor

Minimum Receive Sensitivity:	–29.23 dB
Link Budget:	17.23 dB
Clear-Jacketed Fiber Worst Case Loss:	–0.19 dBm
Clear-Jacketed Fiber Typical Loss:	–0.17 dBm
ST or V-Pin Connector Splice Loss:	–2.00 dB
Approximate Range:	As much as 70 m

Optional Communications Cards

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

Communications Protocols

SEL, Modbus, DNP3, FTP, TCP/IP, Telnet, SNTP, IEC 61850 Edition 2, IEC 60870-5-103, PRP, 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 IEC/EN 60068-2-2)

Note: Not applicable to UL applications.
Note: Two-line display contrast is impaired for temperatures below –20°C and above +70°C.
Note: Touchscreen display is impaired for temperatures below –20°C and above +70°C.

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

Operating Environment

Pollution Degree:	2
Overvoltage Category:	II
Atmospheric Pressure:	80–110 kPa
Relative Humidity:	5–95%, noncondensing
Maximum Altitude Without Derating (consult the factory for higher altitude derating):	2000 m

Dimensions

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

Weight

2.7 kg (6.0 lb)

Relay Mounting Screw (#8-32) Tightening Torque

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

Terminal Connections

Terminal Block

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

Terminal Block Tightening Torque

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

Compression Plug Tightening Torque

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

Compression Plug Mounting Ear Screw Tightening Torque

Minimum:	0.225 Nm (1.6 in-lb)
Maximum:	0.25 Nm (2.2 in-lb)

Type Tests

Electromagnetic Compatibility Emissions

Conducted Emissions:	EN 61000-6-4:2007 Class A FCC 47 CFR 15.109:2014 Class A FCC 47 CFR 15.109(g):2014 Class A IEC 60255-26:2013 Class A
Radiated Emissions:	EN 61000-6-4:2007 Class A FCC 47 CFR 15.107:2014 Class A IEC 60255-26:2013 Class A

Electromagnetic Compatibility Immunity

Conducted RF Immunity:	IEC 60255-26:2013; Section 7.2.8 Severity Level: 10 Vrms IEC 61000-4-6:2008 Severity Level: 10 Vrms
Electrostatic Discharge Immunity:	IEC 61000-4-2:2008 IEC 60255-26:2013; Section 7.2.3 IEEE C37.90.3:2001 Severity Level 4 8 kV contact discharge 15 kV air discharge
Fast Transient, Burst Immunity:	IEC 61000-4-4:2011 IEC 60255-26:2013; Section 7.2.5 4 kV @ 5.0 kHz 2 kV @ 5.0 kHz for comm. ports
Magnetic Field Immunity:	IEC 61000-4-8:2009 Severity Level: 1000 A/m for 3 seconds 100 A/m for 1 minute IEC 61000-4-9: 2001 Severity Level: 1000 A/m IEC 61000-4-10:2001 Severity Level: 100 A/m
Power Supply Immunity:	IEC 60255-26:2013; Section 7.2.11 IEC 60255-26:2013; Section 7.2.12 IEC 60255-26:2013; Section 7.2.13 IEC 61000-4-11:2004 IEC 61000-4-17:1999 IEC 61000-4-29:2000
Radiated RF Immunity:	IEC 61000-4-3:2010 IEC 60255-26:2013; Section 7.2.4 10 V/m IEEE C37.90.2-2004 35 V/m

Surge Immunity:	IEC 61000-4-5:2005 IEC 60255-26:2013; Section 7.2.7 2 kV line-to-line 4 kV line-to-earth
Surge Withstand Capability Immunity:	IEC 60255-26:2013; Section 7.2.6 EN 61000-4-18:2010 2.5 kV common mode 1 kV differential mode 1 kV common mode on comm. ports IEEE C37.90.1-2002 2.5 kV oscillatory 4 kV fast transient

Environmental

Cold:	IEC 60068-2-1:2007 Severity Level: 16 hours at –40°C
Damp Heat, Cyclic:	IEC 60068-2-30:2005 Severity Level: 25°C to 55°, 6 cycles, Relative Humidity: 95%
Damp Heat, Steady State:	IEC 60068-2-78:2001 Severity Level: 93% RHMin, 40°C; 10 days
Dry Heat:	IEC 60068-2-2:2007 Severity Level: 16 hours at +85°C
Enclosure Protection:	IEC 60529:2001 + CRDG:2003 IP65 enclosed in panel (2-line display models) IP54 enclosed in panel (touchscreen models) IP20 for terminals IP50 for terminals enclosed in the dust-protection assembly (protection against solid foreign objects only (SEL Part #915900170). 10°C temperature derating applies to the temperature specifications of the relay.
Vibration Resistance:	IEC 60255-21-1:1988
Endurance:	Class 2
Response:	Class 2
Shock Resistance:	IEC 60255-21-2:1988
Withstand:	Class 1
Response:	Class 2
Bump:	Class 1
Seismic Resistance:	IEC 60255-21-3:1993
Quake Response:	Class 2

Safety

Dielectric Test (Hi-Pot):	IEC 60255-27:2013; Section 10.6.4.3 IEEE C37.90-2005 Severity Level: 2500 Vac on contact inputs, contact outputs, and analog inputs. 3100 Vdc on power supply. Type Tested for 1 minute.
Impulse Voltage Test:	IEC 60255-27:2013 Section 10.6.4.2 ac or dc Severity Level: 0.5 J, 5 kV IEEE C37.90:2005 Severity Level: 0.5 J, 5 kV

Processing Specifications and Oscillography

AC Voltage and Current Inputs:	32 samples per power system cycle
Frequency Tracking Range:	15–70 Hz
Digital Filtering:	One-cycle cosine after low-pass analog filtering. Net filtering (analog plus digital) rejects dc and all harmonics greater than the fundamental.
Protection and Control Processing:	Processing interval is 4 times per power system cycle (except for math variables and analog quantities, which are processed every 25 ms). Analog quantities for rms data are derived from data averaged from the previous 8 cycles
Arc-Flash Processing:	Arc-Flash light is sampled 32 times per cycle. Arc-Flash current, light, and 2 fast hybrid outputs are processed 16 times per cycle.

Oscillography

Length:	15, 64, or 180 cycles
Sampling Rate:	16 samples per cycle unfiltered, 4 samples per cycle filtered
Trigger:	Programmable with Boolean expression
Format:	ASCII and Compressed ASCII Binary COMTRADE (32 samples per cycle unfiltered)
Time-Stamp Resolution:	1 ms
Time-Stamp Accuracy:	±5 ms

Sequential Events Recorder

Time-Stamp Resolution:	1 ms
Time-Stamp Accuracy (with respect to time source):	5 ms

Relay Elements

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

Pickup Setting Range, A Secondary:	
5 A models:	0.25–100.00 A, 0.01 A steps
1 A models:	0.05–20.00 A, 0.01 A steps
200 mA model:	0.01–4.00 A, 0.01 A steps (50N)
Accuracy:	±3% plus ±0.02 • I_{NOM} A secondary (Steady State) ±5% plus ±0.02 • I_{NOM} A secondary (Transient) ±6% plus ±0.02 • I_{NOM} A secondary (Transient for 50Q)
Time Delay:	0.00–400.00 seconds, 0.01 seconds steps 0.1–400.0 seconds, 0.1 second steps (50Q)
Pickup/Dropout Time:	<1.5 cycles

Arc-Flash Instantaneous Overcurrent (50PAF, 50NAF)

Pickup Setting Range, A Secondary:

5 A models:	0.50–100.00 A, 0.01-A steps
1 A models:	0.10–20.00 A, 0.01 A-steps
Accuracy:	0 to +10% of setting plus ±0.02 • I_{NOM} A secondary (Steady State pickup)
Pickup/Dropout Time:	2–5 ms/1 cycle

Arc-Flash Time-Overlight (TOL1–TOL8)

Pickup Setting Range, % of Full Scale:	3.0–80.0% (Point Sensor) 0.6–80.0% (Fiber Sensor)
Pickup/Dropout Time:	2–5 ms/1 cycle

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

Pickup Setting Range, A Secondary:

5 A models:	0.25–24.00 A, 0.01 A steps (51N)
1 A models:	0.05–4.80 A, 0.01 A steps (51N)
Accuracy:	±5% of setting plus ±0.02 • I_{NOM} A secondary (Steady State pickup)

Time Dial

US:	0.50–15.00, 0.01 steps
IEC:	0.01–1.50, 0.01 steps
Accuracy:	±1.5 cycles, plus ±4% between 2 and 30 multiples of pickup (within rated range of current)

IEC Thermal Element (49IEC)

Setting Range:	Trip Pickup, 1–150% Alarm Pickup, 1–100%
Pickup Accuracy:	±2% (for $I \geq I_{NOM}$) ±5% (for $0.4 \cdot I_{NOM} < I < I_{NOM}$)
Time to Trip/Reset Accuracy:	±5% plus ±0.5 s of the calculated value

Undervoltage (27P, 27PP, 27S)

Setting Range:	OFF, 2.00–300.00 V (Phase elements, phase-to-phase elements with delta inputs or synchronism voltage input) OFF, 2.00–520.00 V (Phase-to-phase elements with wye inputs)
Accuracy:	±1% of setting plus ±0.5 V
Time Delay:	0.00–120.00 seconds, 0.01-second steps
Pickup/Dropout Time:	<1.5 cycles

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

Setting Range:	OFF, 2.00–300.00 V (Phase elements, phase-to-phase elements with delta inputs or synchronism voltage input) OFF, 2.00–520.00 V (Phase-to-phase elements with wye inputs)
Accuracy:	±1% of setting plus ±0.5 V
Time Delay:	0.00–120.00 seconds, 0.01-second steps
Pickup/Dropout Time:	<1.5 cycles

Inverse-Time Undervoltage (27I)

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

Inverse-Time Overvoltage (59I)

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

Harmonic Blocking

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

Vector Shift (78VS)

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

Power Elements (32)

Instantaneous/Definite Time, 3 Phase Elements Type:	+W, –W, +VAR, –VAR

Pickup Setting Range, VA Secondary:

5 A models:	1.0–6500.0 VA, 0.1 VA steps
1 A models:	0.2–1300.0 VA, 0.1 VA steps
Accuracy:	±0.10 A • (L-L voltage secondary) plus ±5% of setting at unity power factor for power elements and zero power factor for reactive power elements (5 A nominal) ±0.02 A • (L-L voltage secondary) plus ±5% of setting at unity power factor for power elements and zero power factor for reactive power elements (1 A nominal)
Time Delay:	0.0–240.0 seconds, 0.1-second steps
Pickup/Dropout Time:	<10 cycles

Power Factor (55)

Setting Range:	OFF, 0.05–0.99
Accuracy:	±5% of full scale for current ≥ 0.5 • I_{NOM}
Time Delay:	1–240 seconds, 1-second steps

Frequency (81)

Setting Range:	Off, 15.00–70.00 Hz
Accuracy:	±0.01 Hz (V1 >60 V) with voltage tracking ±0.05 Hz (I1 >0.8 • I_{NOM}) with current tracking
Time Delay:	0.00–240.00 seconds, 0.01 second steps
Pickup/Dropout Time:	<4 cycles

Rate-of-Change of Frequency (81R)

Setting Range:	OFF, 0.10–15.00 Hz/s
Accuracy:	±100 mHz/s, plus ±3.33% of pickup
Time Delay:	0.10–60.00 seconds, 0.01 second steps

Synchronism Check (25)

Pickup Range, Secondary Voltage:	0.00–300.00 V
Pickup Accuracy, Secondary Voltage:	±1% plus ±0.5 volts (over the range of 2–300 V)
Slip Frequency Pickup Range:	0.05 Hz–0.50 Hz
Slip Frequency Pickup Accuracy:	±0.02 Hz
Phase Angle Range:	0–80°
Phase Angle Accuracy:	±4°

Load-Encroachment Detection

Setting Range

5 A Model:	0.10–128.00 ohms secondary, 0.01 ohms steps
1 A Model:	0.50–640.00 ohms secondary, 0.01 ohms steps
Forward Load Angle:	–90° to +90°
Forward Load Angle:	+90° to +270°

Accuracy

Impedance Measurement:	±5% plus ±0.5 ohms
Angle Measurement:	±3°

Station Battery Voltage Monitor

Operating Range:	0–350 Vdc (300 Vdc for UL purposes)
Pickup Range:	20.00–300.00 Vdc
Pickup accuracy:	±2% of setting plus ±2 Vdc

Timers

Setting Range:	Various
Accuracy:	±0.5% of setting plus ±1/4 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:	As high as 1.4 Vac (peak) at 50 Hz or greater frequency
RTD Trip/Alarm Time Delay:	Approx. 6 s

Metering

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 (1.33–6.67 V secondary with 8 V LEA option), unless otherwise noted.

Phase Currents:	±1% of reading, ±1° (±2.5° at 0.2–0.5 A for relays with I_{NOM} = 1 A)
Three-Phase Average Current:	±1% of reading
IG (Residual Current):	±2% of reading, ±2° (±5.0° at 0.2–0.5 A for relays with I_{NOM} = 1 A)
IN (Neutral Current):	±1% of reading, ±1° (±2.5° at 0.2–0.5 A for relays with I_{NOM} = 1 A) ±1.6 mA and ±1% (0.04–4.0 A) (0.2 A nominal channel IN current input)
I1 Positive-Sequence Current:	±2% of reading
3I2 Negative-Sequence Current:	±2% of reading
System Frequency:	±0.01 Hz of reading for frequencies within 15–70 Hz (V1 > 60 V)
Line-to-Line Voltages:	±1% of reading, ±1° for voltages
Three-Phase Average Line-to-Line Voltage:	±1% of reading for voltages within 24–264 V
Line-to-Ground Voltages:	±1% of reading, ±1° for voltages within 24–264 V (0.64–7.04 V for LEA inputs)
Three-Phase Average Line-to-Ground Voltages:	±1% of reading for voltages within 24–264 V (0.64–7.04 V for LEA inputs)
Voltage Imbalance (%):	±2% of reading
V1 Positive-Sequence Voltage:	±2% of reading for voltages within 24–264 V (0.64–7.04 V for LEA inputs)
3V2 Negative-Sequence Voltage:	±2% of reading for voltages within 24–264 V (0.64–7.04 V for LEA inputs)
Real Three-Phase Power (kW):	±3% of reading for 0.10 < pf < 1.00
Reactive Three-Phase Power (kVAR):	±3% of reading for 0.00 < pf < 0.90
Apparent Three-Phase Power (kVA):	±3% of reading
Power Factor:	±2% of reading
RTD Temperatures:	±2°C

Energy Meter

Accumulators:	Separate IN and OUT accumulators updated once per second, transferred to nonvolatile storage 4 times per day.
ASCII Report Resolution:	0.001 MWh
Accuracy:	The accuracy of the energy meter depends on applied current and power factor as shown in the power metering accuracy specifications above. The additional error introduced by accumulating power to yield energy is negligible when power changes slowly compared to the processing rate of once per second.

Synchrophasor Accuracy

Maximum Message Rate

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

The voltage accuracy specifications are only applicable for the model options with standard voltage inputs (not applicable to LEA option).

The current accuracy specifications are applicable for all 1 A and 5 A options.

Note: For the SEL-751 current only model, the accuracy specifications for currents are only applicable when the applied signal frequency equals FNOM.

Accuracy for Voltages

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

Conditions

- At maximum message rate
- When phasor has the same frequency as the positive-sequence voltage
- Frequency-based phasor compensation is enabled PHCOMP := Y)
- The narrow bandwidth filter is selected (PMAPP := N)

Range

Frequency:	±5.0 Hz of nominal (50 or 60 Hz)
Magnitude:	30 V–250 V
Phase Angle:	–179.99° to 180.00°
Out-of-Band Interfering Frequency (Fs):	10 Hz ≤ Fs ≤ (2 • FNOM)

Accuracy for Currents

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

Conditions

- At maximum message rate
- When phasor has the same frequency as the positive-sequence voltage
- Frequency-based phasor compensation is enabled (PHCOMP := Y)
- The narrow bandwidth filter is selected (PMAPP := N)

Range

Frequency:	±5.0 Hz of nominal (50 or 60 Hz)
Magnitude:	(0.4–2) • I_{NOM} (I_{NOM} = 1 A or 5 A)
Phase Angle:	–179.99° to 180.00°
Out-of-Band Interfering Frequency (Fs):	10 Hz ≤ Fs ≤ (2 • FNOM)

Section 2
Installation

Overview

The first steps in applying the SEL-751 Feeder Protection 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-751. 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-751 product page on the SEL website. With custom labels, you can 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-751 helps to ensure years of trouble-free protection. Use the following guidelines for proper physical installation of the SEL-751.

Physical Location

You can mount the SEL-751 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 1.16*.) For EN 61010 certification, the SEL-751 rating is 2000 m (6560 ft) above mean sea level. In North America, the relay is approved for Hazardous Locations Class I, Division 2, Groups A, B, C, and D, and temperature class T4A in the maximum surrounding air temperature of 50°C.

Relay Mounting

To flush mount the SEL-751 in a panel, cut a rectangular hole with the dimensions shown in *Figure 2.1*. Use the supplied front-panel gasket for protection against dust and water ingress into the panel. The relay is rated IP65 when the two-line display model is enclosed in a panel and rated IP54 when the touchscreen display model is enclosed in a panel. For extremely dusty environments, use the optional IP50-rated terminal dust-protection assembly (protection against solid foreign objects only) (SEL Part 915900170).
A 10°C-temperature derating applies to the temperature specifications of the relay when using Part 915900170.

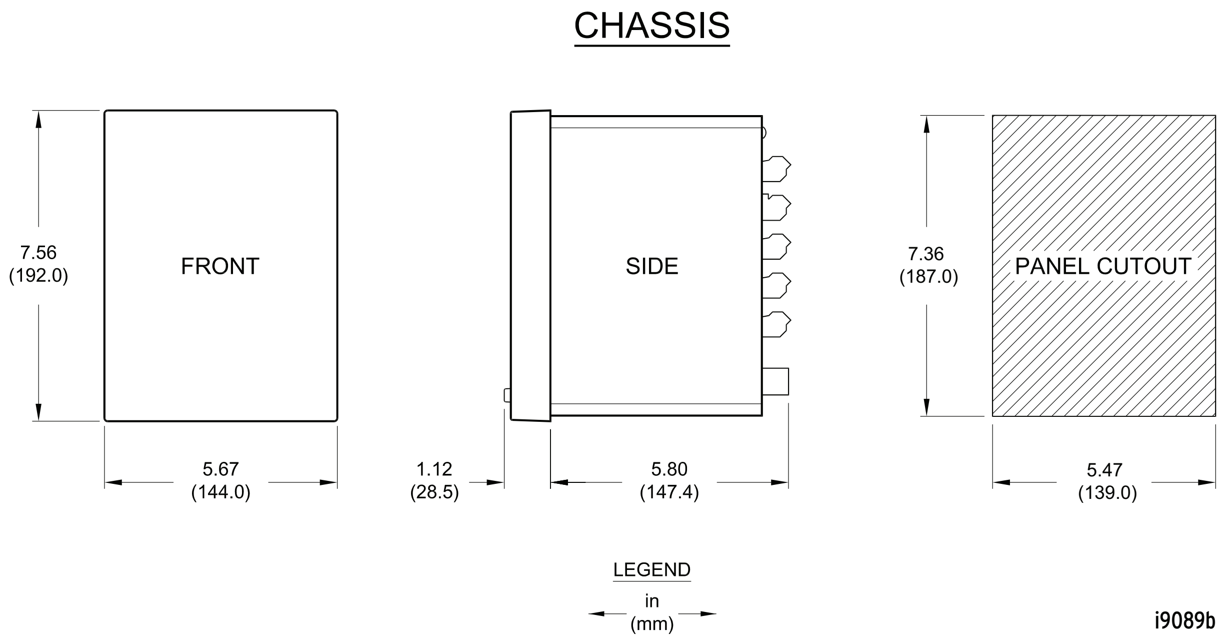


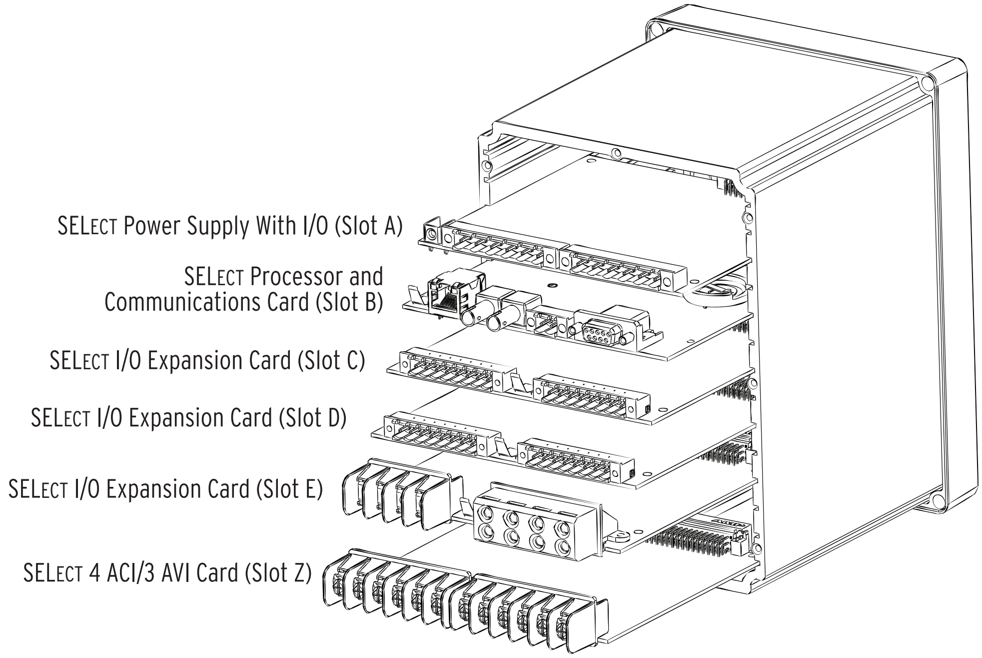
Figure 2.1 Relay Panel-Mount Dimensions

Refer to *Section 1: Introduction and Specifications*, *Models, Options, and Accessories on page 1.5* for information on mounting accessories.

I/O Configuration

Your SEL-751 offers flexibility in tailoring I/O to your specific application. In total, the SEL-751 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 voltage cards are available for the SEL-751. *Figure 2.2* shows the slot allocations for the cards.

Because installations differ substantially, the SEL-751 offers a variety of card configurations to provide options for the many diverse applications. Choose the combination of option cards most suited for your application from the following selection.



	Rear-Panel Slot					
	A	**B**	**C**	**D**	**E**	**Z**
Software Reference	1 (e.g., OUT101)	n/a	3 (e.g., IN301)	4 (e.g., OUT401)	5 (e.g., AI501)	n/a
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 voltage/arc-flash card	4 ACI/3 AVI card in base unit
Card Type						
SELECT EIA-232/485			•	n/a	n/a	n/a
SELECT DeviceNet			•	n/a	n/a	n/a
SELECT 3 DI/4 DO/1 AO (one card per relay)			•	•	•	n/a
SELECT 4 DI/4 DO			•	•	•	n/a
SELECT 4 DI/3 DO (1 Form B, 2 Form C)			•	•	•	n/a
SELECT 8 DI			•	•	•	n/a
SELECT 8 DO			•	•	•	n/a
SELECT 8 AI			•	•	•	n/a
SELECT 14 DI			•	•	•	n/a
SELECT 4 AI/4 AO (one card per relay)			•	•	•	n/a
SELECT 10 RTD			n/a	•	n/a	n/a
SELECT 2 AVI/4 AFDI (MOT…x70x…)			n/a	n/a	•	n/a
SELECT 2 AVI/4 AFDI (MOT…xL0x…)			n/a	n/a	•	n/a
SELECT 8 AFDI (MOT…x77x…)			n/a	n/a	•	n/a
SELECT 4 ACI/3 AVI (MOT…x81/82/83/85/86/87x…)			n/a	n/a	n/a	•
SELECT 4 ACI/3 AVI (MOT…xL1/L2/L3/L5/L6/L7x…)			n/a	n/a	n/a	•
SELECT 4 ACI (MOT...xA1/A2/A3/A5/A6/A7x...)			n/a	n/a	n/a	•

[a] Power supply, two inputs, and three outputs.
[b] IRIG-B, EIA-232/485, fiber-optic serial and/or Ethernet ports (the IRIG-B input option is available on terminals B01, B02 for all models except models with a fiber-optic Ethernet port (Port 1) and dual copper Ethernet port (Port 1) that have Port 3 as an EIA-232 serial port and can input IRIG-B via the EIA-232 port and an SEL communications processor). IRIG-B input is also supported via Port 2 (EIA-232 fiber-optic serial port).
[c] Digital or analog.

Figure 2.2 Slot Allocations for Different Cards

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

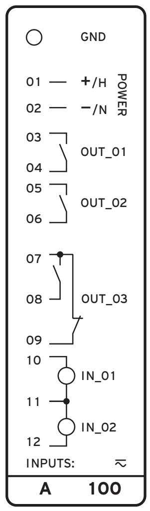
Select appropriate power supply option for the application:

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

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

This card is supported in Slot A of the SEL-751. It has two digital inputs and three digital outputs (two normally open Form A contact outputs and one Form C output). *Table 2.1* shows the terminal designation for the PSIO/2 DI/3 DO card.

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

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

Communications Ports (Slot B)

Select the communications ports necessary for your application from the 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	Optional	Isolated multimode fiber-optic serial port with ST connectors
3	Rear Panel	Standard	Either nonisolated EIA-232 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:

- SEL ASCII and Compressed ASCII
- SEL Fast Meter
- SEL Fast Operate
- SEL Fast SER
- SEL Fast Message Unsolicited Write
- SEL Settings File Transfer
- C37.118 (Synchrophasor Data)
- Modbus TCP/IP
- DNP3 LAN/WAN
- IEC 61850
- Simple Network Time Protocol (SNTP)
- FTP
- Telnet

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, MBTA, MBTB)
- Event Messenger
- DNP3 Level 2 Outstation
- C37.118 (Synchrophasor Data)
- IEC 60870-5-103

Communications Card

Either the DeviceNet (see *Appendix H: 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**, a nonisolated EIA-232 serial port interface, supporting the +5 Vdc interface

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

Table 2.3 Communications Card Interfaces and Connectors

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

The communications card supports all of 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, MBTA, MBTB)
- Event Messenger
- DNP3 Level 2 Outstation
- C37.118 (Synchrophasor Data)
- IEC 60870-5-103

Current/Voltage Card (4 ACI/3 AVI)

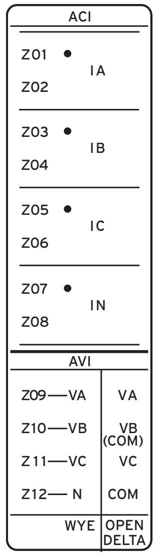
⚠WARNING
Before working on a CT circuit, first apply a short to the secondary winding of the CT.

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) or **…x83x…**(1 A phase, 200 mA neutral CTs), or **…x87x…**(5 A phase, 200 mA neutral CTs). Supported in Slot Z of the SEL-751, this card has current inputs for three-phase CTs, neutral current CTs, and 300 Vac voltage inputs for three-phase (wye or delta) PTs.

MOT…xL1x…(1 A phase, 1 A neutral CTs), or **…xL5x…**(5 A phase, 5 A neutral CTs), or **…xL2x…**(1 A phase, 5 A neutral CTs), or **…xL6x…** (5 A phase, 1 A neutral CTs) or **…xL3x…** (1 A phase, 200 mA neutral CTs), or **…xL7x…**(5 A phase, 200 mA neutral CTs). Supported in Slot Z of the SEL-751, this card has current inputs for three-phase CTs, neutral current CTs, and 8 Vac LEA voltage inputs for three-phase (wye or delta) PTs.

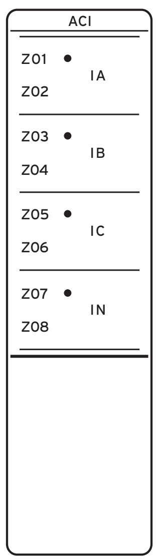
The 4 ACI/3 AVI current/voltage card inputs terminal designation for the card with LEA voltage inputs and the regular voltage inputs is as shown in *Table 2.4*.

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

Side-Panel Connections Label	Terminal Number	Description
	Z01	IA, A-Phase current input
	Z02	
	Z03	IB, B-Phase current input
	Z04	
	Z05	IC, C-Phase current input
	Z06	
	Z07	IN, Neutral current input
	Z08	
	Z09	VA, A-Phase voltage input
	Z10	VB, B-Phase voltage input
	Z11	VC, C-Phase voltage input
	Z12	N, common connection for VA, VB, VC

Current Card (4 ACI)

Table 2.5 Current Inputs (4 ACI) Card Terminal Designations

Side-Panel Connections Label	Terminal Number	Description
	Z01	IA, A-Phase current input
	Z02	
	Z03	IB, B-Phase current input
	Z04	
	Z05	IC, C-Phase current input
	Z06	
	Z07	IN, Neutral current input
	Z08	

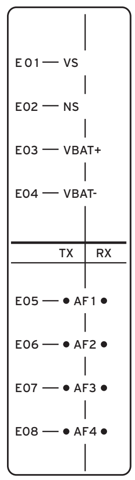
Voltage/Arc-Flash Detection Inputs Card (2 AVI/4 AFDI)

MOT…x70x… Supported only in Slot E of the SEL-751, this card has 300 Vac synchronism-check voltage input (VS), station dc battery monitor input (VBAT), and four fiber-optic transmit and receive inputs (AF1–AF4).

MOT…xL0x… Supported only in Slot E of the SEL-751, this card has 8 V LEA synchronism-check voltage input (VS), station dc battery monitor input (VBAT), and four fiber-optic transmit and receive inputs (AF1–AF4).

The terminal designations for both **MOT…x70x…** and **…xL0x…** are shown in *Table 2.6*.

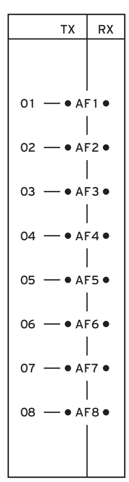
Table 2.6 Voltage/Arc-Flash Detection Inputs (2 AVI/4 AFDI) Card Terminal Designations

Side-Panel Connections Label	Terminal Number	Description
	E01	VS, synchronism-check voltage input
	E02	NS, common connection for synchronism-check voltage input
	E03	VBAT+ station battery (positive) voltage input
	E04	VBAT– station battery (negative) voltage input
	E05	AF1 Channel TX and RX Inputs
	E06	AF2 Channel TX and RX Inputs
	E07	AF3 Channel TX and RX Inputs
	E08	AF4 Channel TX and RX Inputs

Eight Arc-Flash Detection Inputs (8 AFDI)

MOT…x77x… Supported only in Slot E of the SEL-751 relay, this card has eight arc-flash fiber-optic transmit and receive inputs (AF1–AF8). *Table 2.7* shows the terminal designations.

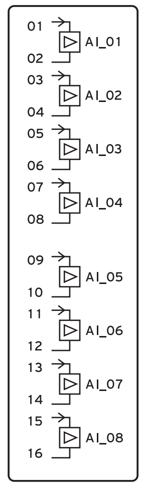
Table 2.7 Eight Arc-Flash Detection Inputs (8 AFDI) Card Terminal Designations

Side-Panel Connections Label	Terminal Number	Description
	E01	AF1 Channel TX and RX Inputs
	E02	AF2 Channel TX and RX Inputs
	E03	AF3 Channel TX and RX Inputs
	E04	AF4 Channel TX and RX Inputs
	E05	AF5 Channel TX and RX Inputs
	E06	AF6 Channel TX and RX Inputs
	E07	AF7 Channel TX and RX Inputs
	E08	AF8 Channel TX and RX Inputs

Analog Inputs Card (8 AI)

Supported in any nonbase unit slot (Slot **C** through Slot **E**), this card has eight analog inputs. *Table 2.8* shows the terminal designation.

Table 2.8 Eight Analog Inputs (8 AI) Card Terminal Designations



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

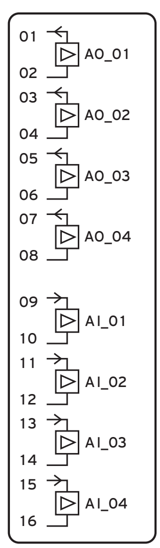
[a] x = 3, 4, or 5 (e.g., AI401, AI402, etc., if the card is installed in Slot D).

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

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

Supported in any one of the nonbase unit slots (Slot **C** through Slot **E**), this card has four analog inputs and four analog outputs (**AO**). *Table 2.9* shows the terminal designation.

Table 2.9 Four Analog Inputs/Four Analog Outputs (4 AI/4 AO) Card Terminal Designations



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

[a] x=3, 4, or 5 (e.g., AI401, AI402, etc., if the card is installed in Slot D).

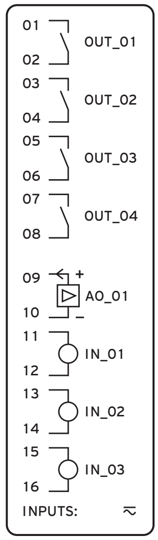
I/O Card (3 DI/4 DO/1 AO)

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

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

Supported in one nonbase unit slot (Slot **C**, **D**, or **E**), this card has three digital inputs, four digital outputs, and one analog output. *Table 2.10* shows the terminal designations.

Table 2.10 I/O (3 DI/4 DO/1 AO) Card Terminal Designations



Side-Panel Connections Label	Terminal Number	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 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

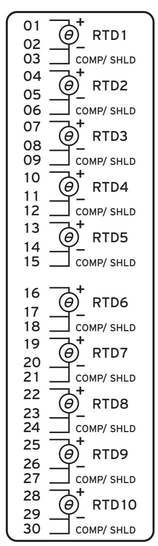
[a] x=3, 4, or 5 (e.g., OUT401, OUT402, etc., if the card is installed in Slot D).

RTD Card (10 RTD)

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

Supported in Slot **D** only, this card has 10 three-wire RTD inputs. *Table 2.11* shows the terminal designations.

Table 2.11 RTD (10 RTD) Card Terminal Designations

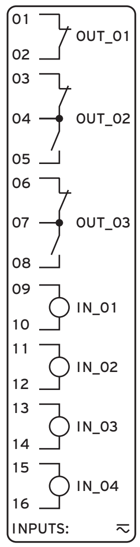


Side-Panel Connections Label	Terminal Number	Description
	01	RTD01 (+)
	02	RTD01 (–)
	03	RTD01 Comp/Shield
	04	RTD02 (+)
	05	RTD02 (–)
	06	RTD02 Comp/Shield
	07	RTD03 (+)
	08	RTD03 (–)
	09	RTD03 Comp/Shield
	•	•
	•	•
	•	•
	28	RTD10 (+)
	29	RTD10 (–)
	30	RTD10 Comp/Shield

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 2.12* shows the terminal designations.

Table 2.12 Four Digital Inputs, One Form B Digital Output, Two Form C Digital Outputs (4 DI/3 DO) Card Terminal Designations

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

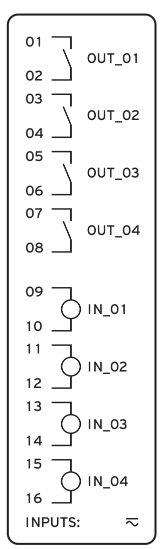
[a] x=3, 4, or 5 (e.g., OUT401, OUT402, etc. if the card is installed in Slot D).

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 either all normally open contact outputs or all fast hybrid (high-speed, high-current interrupting) outputs. *Table 2.13* shows the terminal designations.

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

Table 2.13 Four Digital Inputs/Four Digital Outputs (4 DI/4 DO) Card Terminal Designations

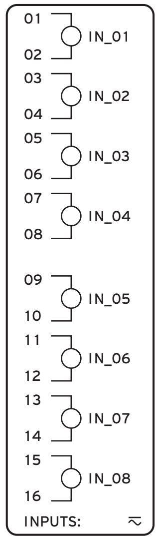
Side-Panel Connections Label	Terminal Number	Description[a]
	01, 02	OUT*x*01, driven by OUT*x*01 SELOGIC control equation
	03, 04	OUT*x*02, driven by OUT*x*02 SELOGIC control equation
	05, 06	OUT*x*03, driven by OUT*x*03 SELOGIC control equation
	07, 08	OUT*x*04, driven by OUT*x*04 SELOGIC control equation
	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 (e.g., OUT401, OUT402, etc., if the card is 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 2.14* shows the terminal designations.

Table 2.14 Eight Digital Inputs (8 DI) Card Terminal Designations

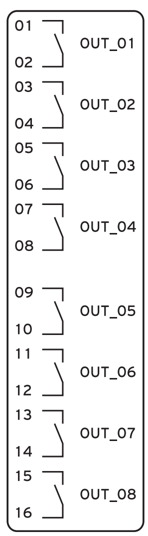
Side-Panel Connections Label	Terminal Number	Description[a]
	01, 02	IN*x*01, drives IN*x*01 element
	03, 04	IN*x*02, drives IN*x*02 element
	05, 06	IN*x*03, drives IN*x*03 element
	07, 08	IN*x*04, drives IN*x*04 element
	09, 10	IN*x*05, drives IN*x*05 element
	11, 12	IN*x*06, drives IN*x*06 element
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

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

I/O Card (8 DO)

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

Table 2.15 Eight Digital Outputs (8 DO) Card Terminal Designations

Side-Panel Connections Label	Terminal Number	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	OUT*x*05, driven by OUT*x*05 SELOGIC control equation
	11, 12	OUT*x*06, driven by OUT*x*06 SELOGIC control equation
	13, 14	OUT*x*07, driven by OUT*x*07 SELOGIC control equation
	15, 16	OUT*x*08, driven by OUT*x*08 SELOGIC control equation

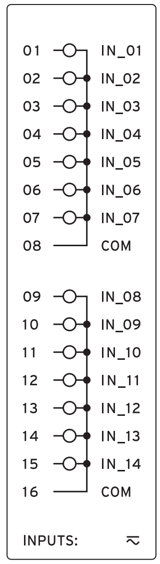
[a] x=3, 4, or 5 (e.g., OUT401, OUT402, etc. if the card is installed in Slot D).

The 8 DO card shown previously is all Form A contacts. Refer to the SEL-751 Model Option Table for all the variants available (8A, 8B, 4A/4B, 2A/6B, 6A/2B).

I/O Card (14 DI)

Supported in any nonbase unit slot (Slot **C** through Slot **E**), this card has fourteen digital inputs. *Table 2.16* shows the terminal designations.

Table 2.16 Fourteen Digital Inputs (14 DI) Card Terminal Designations

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

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

Card Configuration Procedure

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

The SEL-751 offers flexibility in tailoring I/O to your specific application. The SEL-751 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, communication, RTD, arc-flash detectors, and voltage/current cards are available for the SEL-751 in Slots **C**, **D**, and **E**. *Figure 2.2* shows the slot allocations for the cards. Because installations differ substantially, the SEL-751 offers a variety of card configurations that provide options for the many diverse applications. Choose the combination of option cards most suited for your application.

Swapping Optional I/O Boards

When an I/O board is moved from one slot to a different slot, the associated settings for the slot the card is moved from are lost. For example, if a 4 DI/4 DO card is installed in Slot 4 (Slot **D**), the SELOGIC control equation settings OUT401–404 would be available. If OUT401 = IN101 AND 51P1T, and the card is moved to a different slot, then the OUT4xx settings are lost. This is true for all the digital and analog I/O cards.

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

The SEL-751 Relay can be upgraded by adding as many as three (3) optional cards.

Installation

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

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

Step 2. Disconnect all the connection plugs.

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

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

Step 5. Insert the option card in the correct slot.

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

Step 6. Before reattaching the rear cover, check for and remove any foreign material that may remain inside the SEL-751 case.

Step 7. Carefully reattach the rear cover.

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

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

Step 10. If the option card is in the proper slot, the front panel displays the following:

```
STATUS FAIL
X Card Failure
```

If you *do not* see this message and the **ENABLED** light is turned on, the card was inserted into the wrong slot. Begin again at *Step 1*.

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

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

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

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

The front panel displays the following:

```
STATUS
Relay Status
```

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

The front panel displays the following:

```
Serial Num
000000000000000000000000
```

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

The front panel displays the following:

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

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

The front panel displays the following:

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

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

The front panel displays the following:

```
Config Accepted
Enter to Reboot
```

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

The relay restarts and the **ENABLED** light is turned on to indicate the option card was installed correctly.

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

```
PART NUM = 751001B5X1X7086020X
```

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

Step 19. Update the side-panel drawing with the drawing sticker provided in the option card kit. If necessary, replace the rear panel with the one applicable for the option card and attach the terminal-marking label provided with the card to the rear-panel cover. Also, contact SEL for an updated product serial number label with the updated part number.

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

Slot B CPU Board Replacement

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

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

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

Step 1. Turn off the power to the relay.

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

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

Step 4. Remove the rear panel.

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

Step 6. Install the new rear panel and reconnect the terminal blocks and CT/PT wires.

Step 7. Apply new side stickers to the relay.

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

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

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

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

The CAL level default password is CLARKE.

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

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

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

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

Slot A Power Supply Card

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

Analog Input Card Voltage/Current Jumper Selection

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

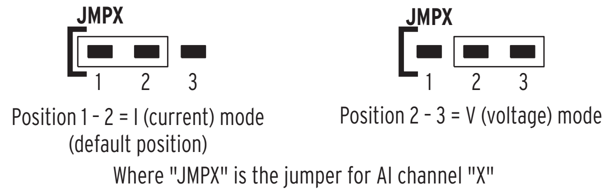


Figure 2.3 Circuit Board of Analog I/O Board, Showing Jumper Selection

Analog Output (AO) Configuration Jumper

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.

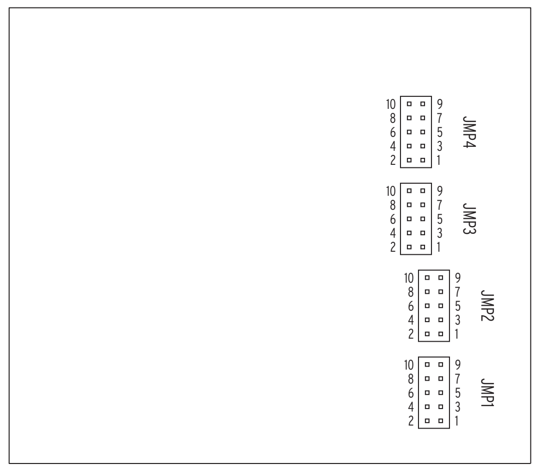


Figure 2.4 JMP1 Through JMP4 Locations on 4 AI/4 AO Board

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.

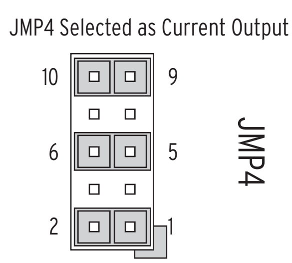


Figure 2.5 Current Output Jumpers

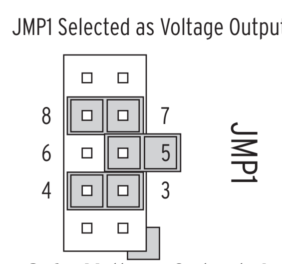


Figure 2.6 Voltage Output Jumpers

Password, Breaker Control, and SELBOOT Jumper Selection

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

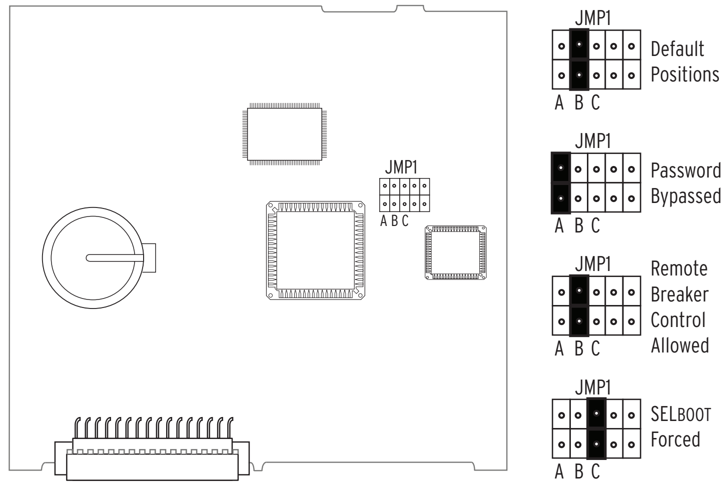


Figure 2.7 Pins for Password, Breaker Control, and SELBOOT Jumper

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-751 experiences an internal failure, communication with the relay may be compromised. Forcing the relay to SELBOOT provides you with a way to download new firmware. To force the relay to SELBOOT, place the jumper in position C, as shown in *Figure 2.7* (SELBOOT Forced). After the relay is forced to SELBOOT, you can only communicate with it via the front-panel port.

To gain access to Level 1 and Level 2 command levels without passwords, place 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 accessing Level 2. See *Table 2.17* for the functions of the three sets of pins and their jumper default positions.

Table 2.17 Jumper Functions and Default Positions

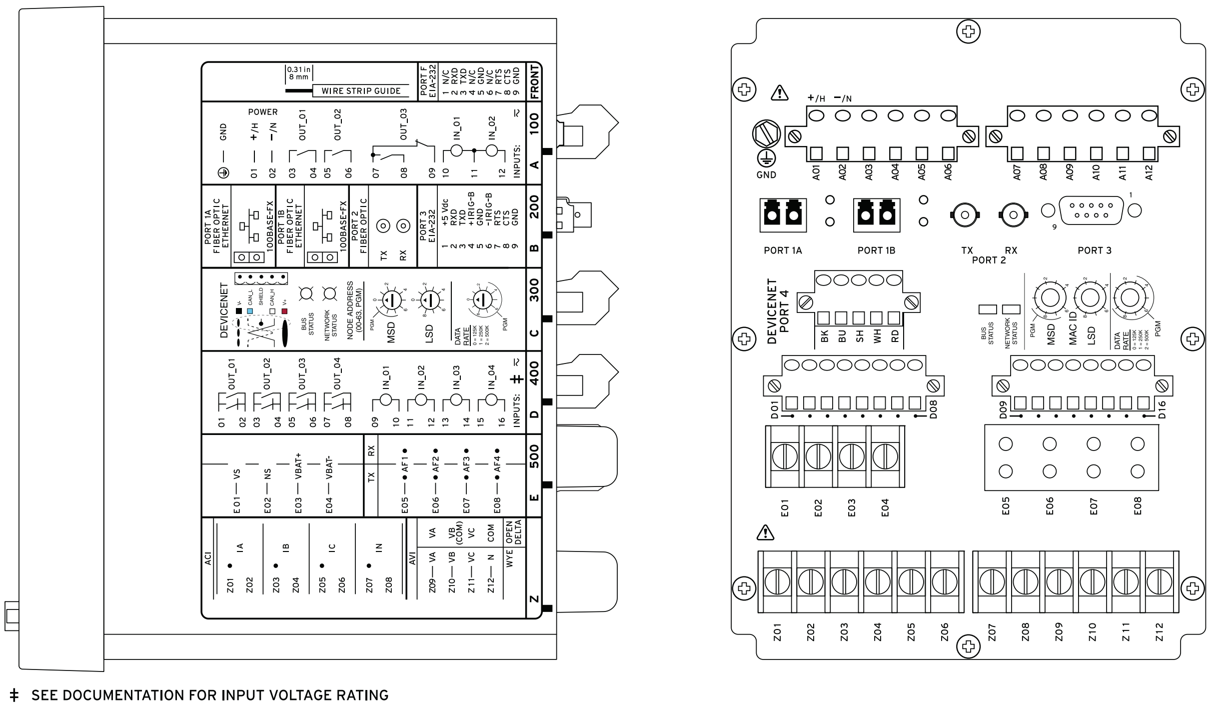
Pin8s	Jumper Default Position	Description
A	Not bypassed (requires password)	Password bypass
B	On (breaker control enabled)	Enable breaker control[a]
C	Not bypassed (not forced SELBOOT)	SELBOOT Forced

[a] Enable/disable serial port, front panel, and Fast Operate commands for the breaker control. The jumper position affects the breaker control using the OPEN or CLOSE commands and output contact control using the PULSE command via the serial port, the front-panel menu-driven user interface, or the communications protocols. The jumper position does not affect the operation of the local bits, the remote bits, or the front-panel programmable pushbuttons.

Relay Connections

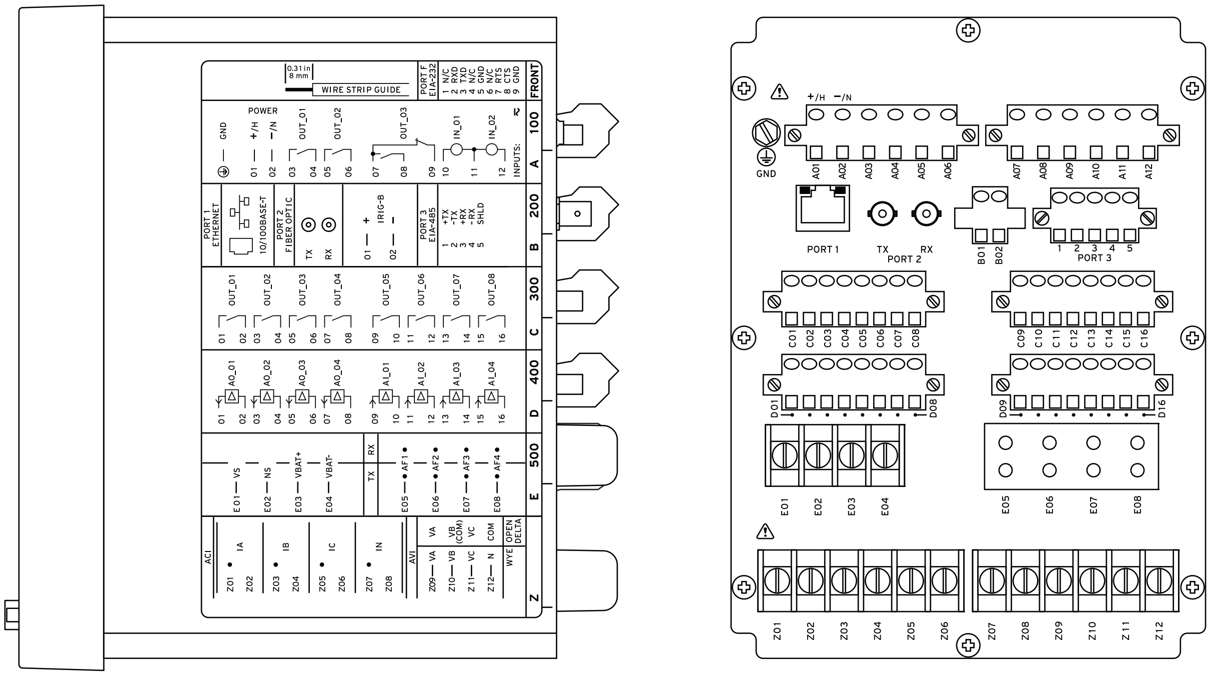
Side-Panel and Rear-Panel Diagrams

The physical layout of the connectors on the side-panel and rear-panel diagrams of seven sample configurations of the SEL-751 are shown in *Figure 2.8* through *Figure 2.14*.



(A) Side-Panel Input and Output Designations (B) Rear-Panel Layout

Figure 2.8 Dual Fiber Ethernet With 2 AVI/4 AFDI Voltage Option With Arc-Flash Detector Inputs, DeviceNet Card, and Fast Hybrid 4 DI/4 DO Card (Relay MOT 751501AA3CA70850830)

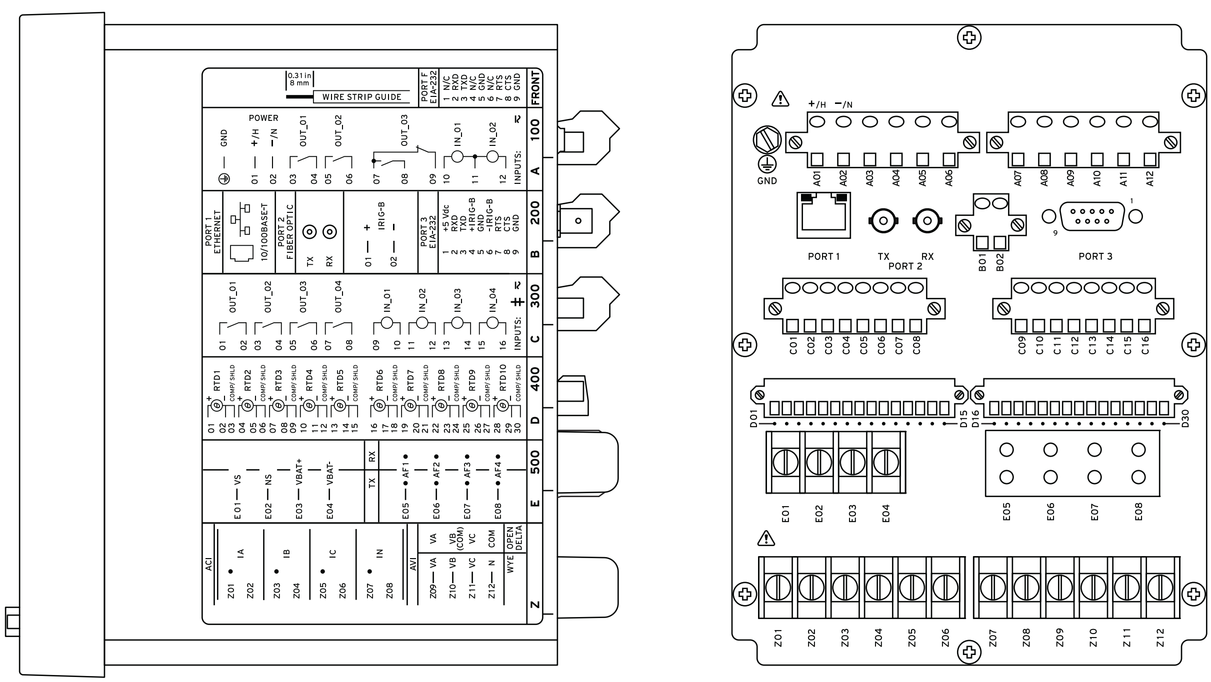


‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(A) Side-Panel Input and Output Designations

(B) Rear-Panel Layout

Figure 2.9 Single Copper Ethernet, EIA-485 Communication, 8 DO (Form A) Card, 4 AI/4 AO Card, and 2 AVI/4 AFDI Voltage Option With Arc-Flash Detector Inputs (Relay MOT 751201A2A6X70810320)

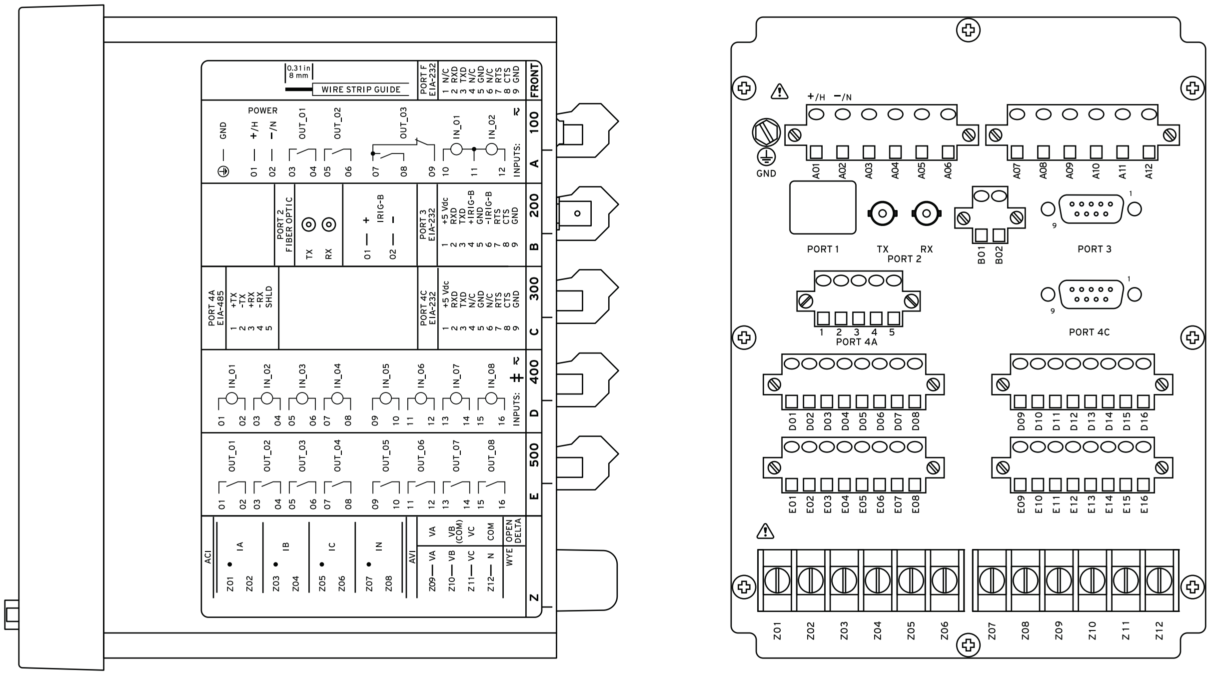


‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(A) Side-Panel Input and Output Designations

(B) Rear-Panel Layout

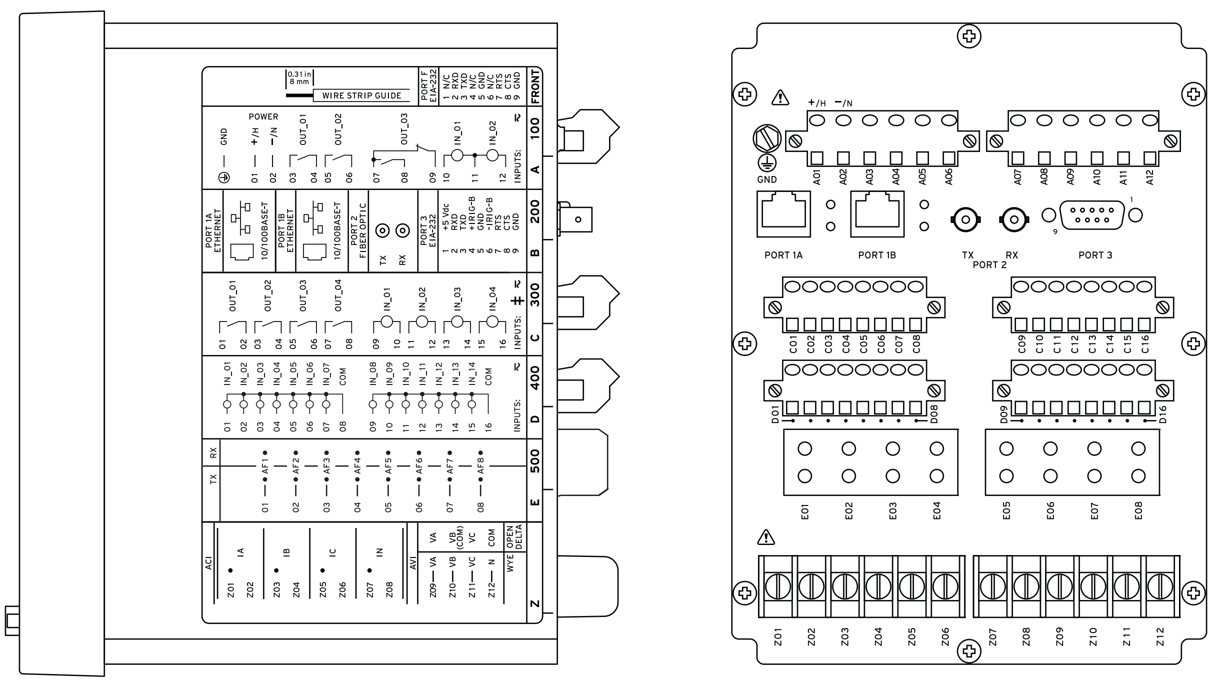
Figure 2.10 Single Copper Ethernet With EIA-232 Communication, 10 RTD Card, 4 DI/4 DO Card and 2 AVI/4 AFDI Voltage Option Card With Arc-Flash Detector Inputs (Relay MOT 751501A1A9X70850230)



‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(A) Side-Panel Input and Output Designations (B) Rear-Panel Layout

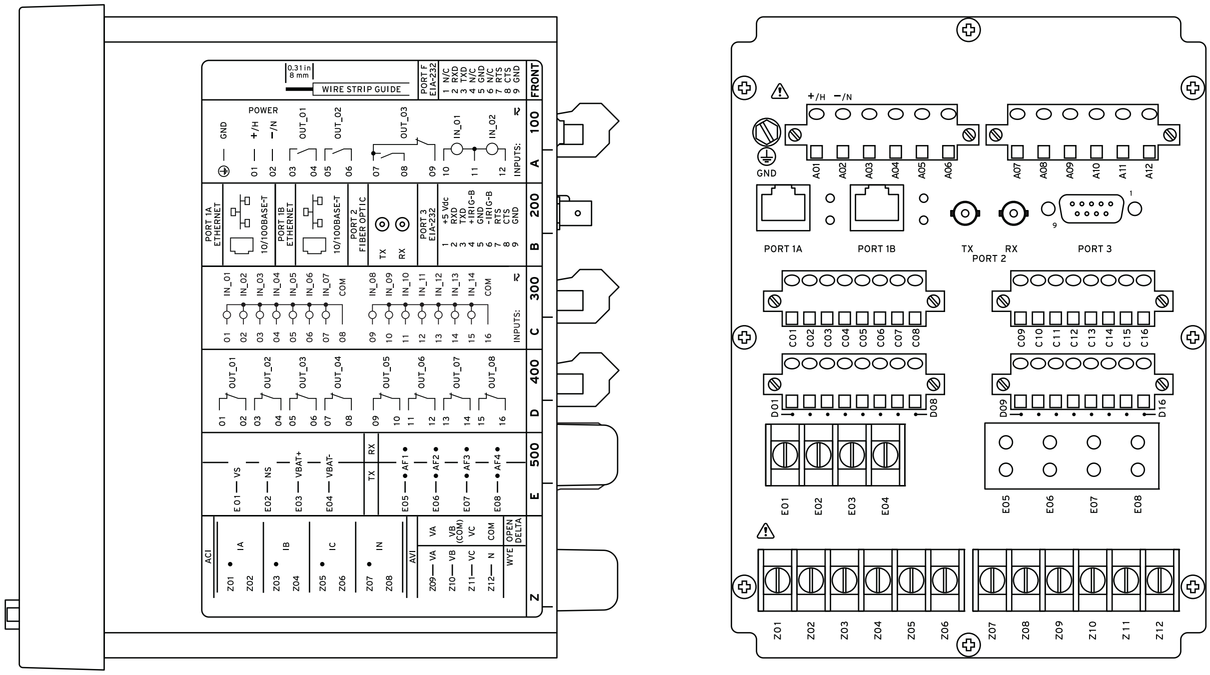
Figure 2.11 No Ethernet, EIA-232 Serial Communications, EIA-232/EIA-485 Communications Card, 8 DI Card, and 8 DO Card (Form A) (Relay MOT 751401AA03A2A850000)



‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(A) Side-Panel Input and Output Designations (B) Rear-Panel Layout

Figure 2.12 Dual Copper Ethernet, 4 DI/4 DO Card, 14 DI Card, 8 AFDI With Arc-Flash Detector Inputs, 4 ACI/3 AVI Card With 5 A Phase, 200 mA Neutral, and Three-Phase AC Voltage Inputs (300 Vac) (Relay MOT 7515S1A1A4A77870671)

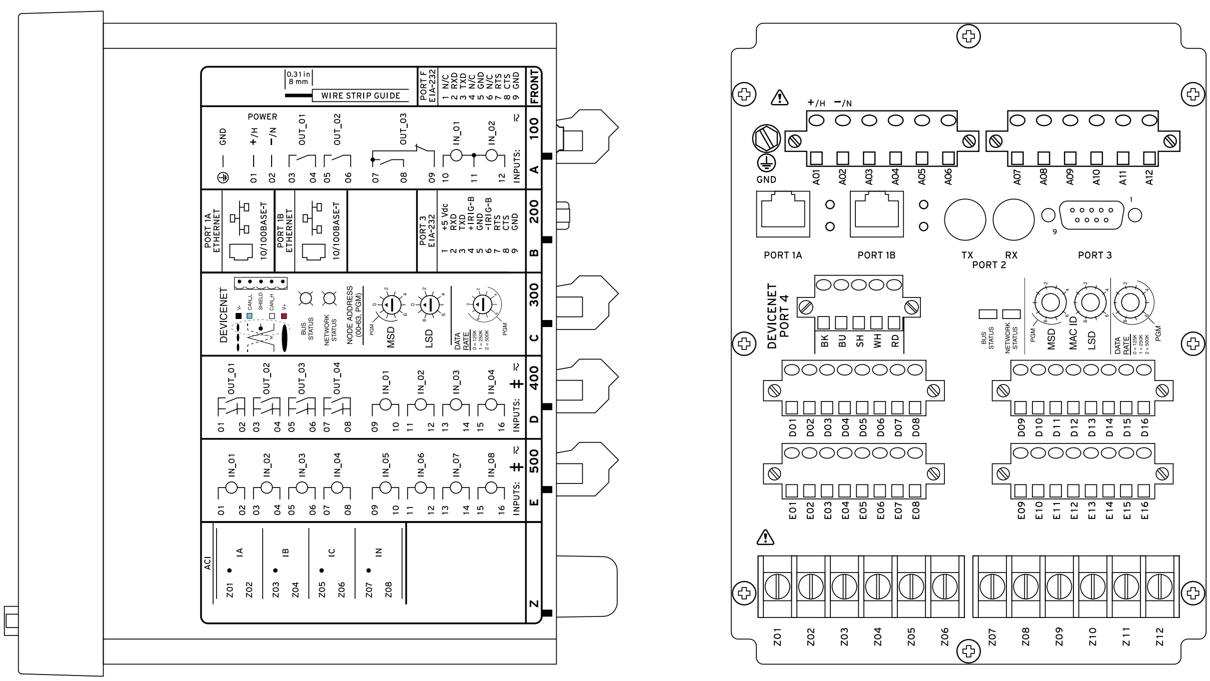


‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(A) Side-Panel Input and Output Designations

(B) Rear-Panel Layout

Figure 2.13 Dual Copper Ethernet, 14 DI Card, 8 DO (Form B) Card, 2 AVI/4 AFDI Card With LEA Vsync, Vbat Inputs, and 4 Arc-Flash Detection Inputs, 4 ACI/3 AVI Card With 5 A Phase, 200 mA Neutral, and Three-Phase LEA Voltage Inputs (8 Vac) (Relay MOT 751501A4A2BL0L70671)



‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(A) Side-Panel Input and Output Designations

(B) Rear-Panel Layout

Figure 2.14 Dual 10/100 Base-T Ethernet, EIA-232 Rear Port, Without Single Multimode ST Fiber-Optic Serial Port Rear, With DeviceNet Card, Fast Hybrid 4 DI/4 DO Card, 8 DI Card and 4 ACI Card (No Voltage Inputs) (Relay MOT 751001AA3CA3AA50F30)

Power Connections

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

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

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

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-751; this device should interrupt both the hot (**+/H**) and neutral (**—/N**) power leads. The maximum current rating for the power disconnect circuit breaker or optional overcurrent device (fuse) should be 20 A.

Operational power is internally fused by a power supply fuse. See *Field Serviceability on page 2.50* 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 (2.1 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 screwdriver. All EIA-232 ports accept 9-pin D-subminiature male connectors.

For connecting devices at distances farther than 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-751 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 you should use only one at a time. You can use IRIG-B (**B01** and **B02**) inputs or an SEL communications processor via EIA-232 serial **Port 3**. The available communications processors are the SEL-2032, SEL-2030, SEL-2020, and the SEL-2100 Logic Processor. You can also use the SEL-3530 Real-Time Automation Controller (RTAC) to provide IRIG-B input.

The models with fiber-optic Ethernet and dual copper Ethernet do not have the terminals **B01** and **B02** for IRIG-B but have IRIG-B input via EIA-232 **Port 3**. The third option for IRIG-B is via fiber-optic serial **Port 2**. Use an SEL-2812MT Transceiver to connect to the SEL-2030, SEL-2032, or SEL-3530 RTAC and bring the IRIG-B signal with the EIA-232 input. Use a fiber-optic cable pair with ST connectors (SEL-C805 or SEL-C807) to connect to **Port 2** on the SEL-751. Refer to *Section 7: Communications* for details on IRIG-B connections examples and on SEL-2401/2407/2404 for time source.

Ethernet Port

The SEL-751 can be ordered with an optional single/dual 10/100BASE-T or 100BASE-FX Ethernet port. Connect to Port 1 of the device by using a standard RJ45 connector for the copper port and an LC connector for the fiber-optic port.

Fiber-Optic Serial Port

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

I/O Diagram

A more functional representation of two of the control (I/O) connections is shown in *Figure 2.15* and *Figure 2.16*.

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

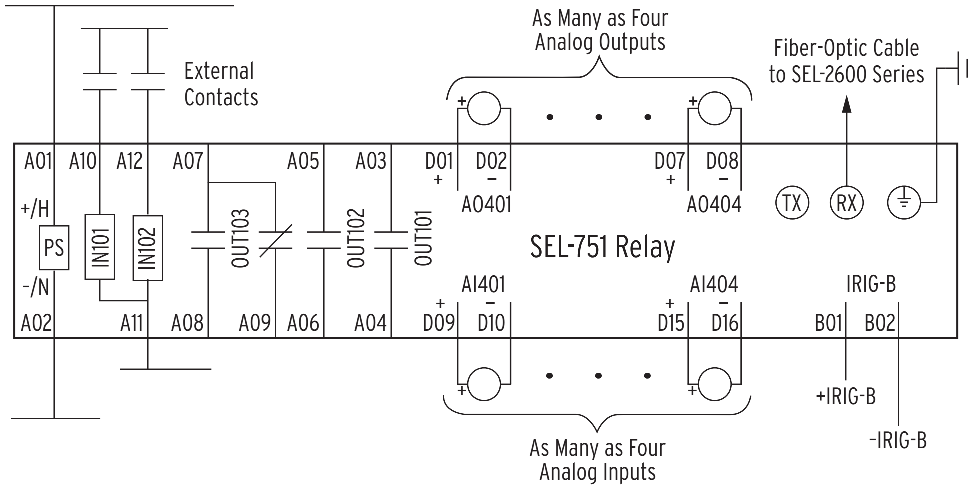


Figure 2.15 Control I/O Connections—4 AI/4 AO Option in Slot D and Fiber-Optic Port in Slot B

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

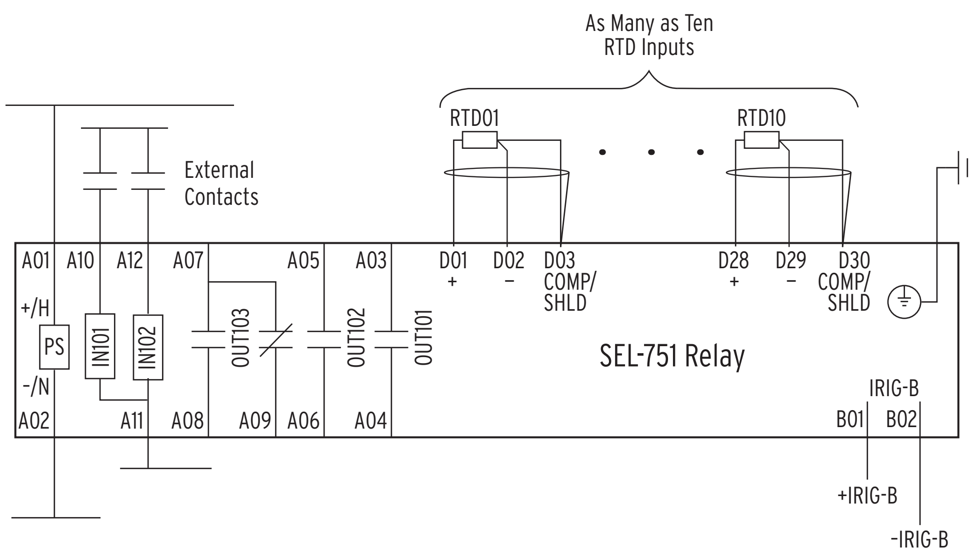


Figure 2.16 Control I/O Connections—Internal RTD Option in Slot D

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 (110–240 Vac, 110–250 Vdc or 24–48 Vdc) depends on relay part number.
- ➤ Optoisolated inputs IN101 and IN102 are standard and located on the card in Slot **A**.
- ➤ All optoisolated inputs are single-rated: 24, 48, 110, 125, 220, or 250 Vac/Vdc. Standard inputs IN101/102 can have a different rating than the optional IN401/402/403/404 (not shown).
- ➤ Output contacts OUT101, OUT102, and OUT103 are standard and are located on the card in Slot **A**.
- ➤ The analog (transducer) outputs shown are located on the optional I/O expansion card in Slot D.
- ➤ The fiber-optic serial port is located on the card in Slot **B**. A Simplex 62.5/125 µm fiber-optic cable is necessary for connecting to 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 you want surge protection.

Table 2.18 shows the maximum cable lengths for the RTD connections.

Table 2.18 Typical Maximum RTD Lead Length

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

Analog Output Wiring

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

Connect the two terminals of the analog output as shown in *Figure 2.17*. Also connect the analog output cable shield to ground at the relay chassis ground, programmable logic controller (PLC), or meter location. Do not connect the shield to ground at both locations.

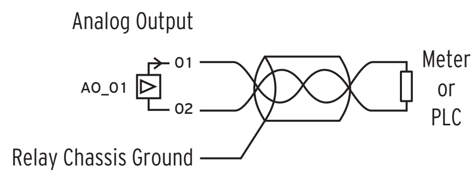


Figure 2.17 Analog Output Wiring Example

AC/DC Control Connection Diagrams

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

Fail-Safe/Nonfail-Safe Tripping

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

Figure 2.18 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.

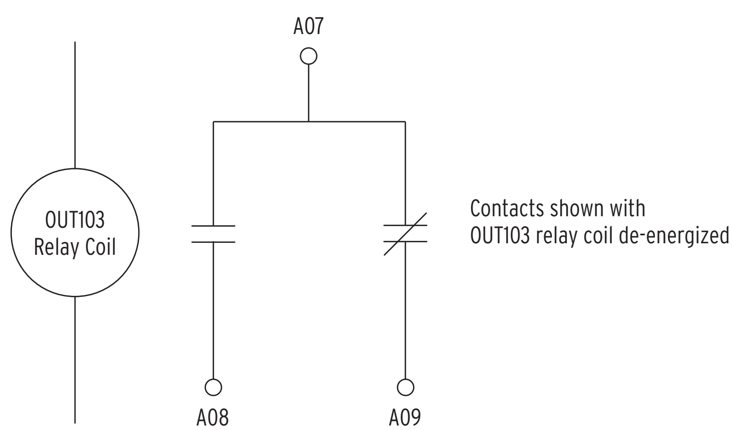


Figure 2.18 Output OUT103 Relay Output Contact Configuration

The SEL-751 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-751 is powered and operational.
- ➤ When the SEL-751 generates a trip signal, the relay coil is de-energized.
- ➤ The relay coil is also de-energized if the SEL-751 power supply voltage is removed or if the SEL-751 fails (self-test status is FAIL).

Figure 2.19 shows fail-safe and nonfail-safe wiring methods to control breakers.

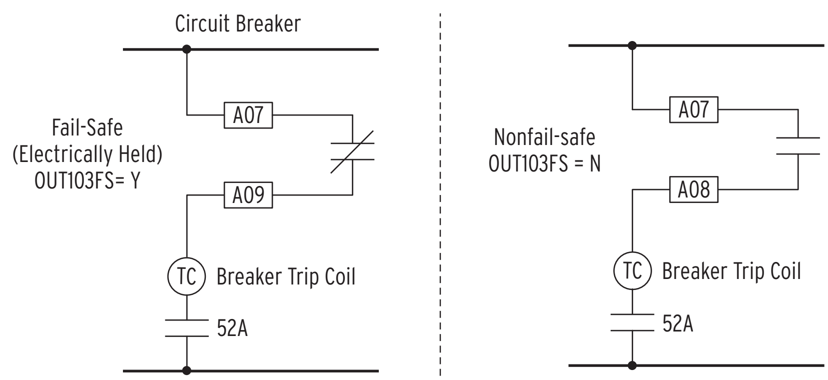


Figure 2.19 OUT103 Contact Fail-Safe and Nonfail-Safe Options

Voltage Connections

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

With the voltage inputs option, you can connect the ac voltages directly, use a wye-wye VT connection (set DELTA_Y := WYE), an open-delta VT connection (set DELTA_Y := DELTA), or a single-phase VT (set SINGLEV := Y). *Figure 2.20* and *Figure 2.21* show the methods of connecting single-phase and three-phase voltages.

When the voltage inputs to the relay are connected in wye as shown in *Figure 2.21 (a): Direct Connection*, *Figure 2.21 (b)*: *Wye-Wye VT Connections With LEA Inputs*) or *Figure 2.21 (c): Wye-Wye VT Connection*, the relay computes the zero-sequence voltage as the following:

3V0 = VA + VB + VC

When the voltage inputs to the relay are connected via an open-delta VT as shown in *Figure 2.21* (d)–*Figure 2.21* (f), the relay cannot calculate zero-sequence voltage (3V0). Relay functions that require zero-sequence voltage may be disabled, unless another 3V0 voltage source is supplied to the relay via terminal VS-NS and VSCONN is set to 3V0 as in *Figure 2.21* (e) and *Figure 2.21* (f). With setting VSCONN := 3V0, voltage input VS (terminals VS, NS) expects 3V0 voltage (VS = 3V0 = VA + VB + VC) with the polarity shown in the figures. Setting VSCONN := 3V0 disables the synchronism-check element. To enable synchronism check element set VSCONN := VS. Set VSCONN accordingly per your application needs.

Some installations do not have all three voltage phases available to connect to the relay as shown in *Figure 2.20 (a)* and *Figure 2.20 (b)*. In such cases set DELTA_Y to WYE or DELTA according and set SINGLEV := Y. In those cases the relay will disable some of the voltage based functions as specified in *Table 4.4*.

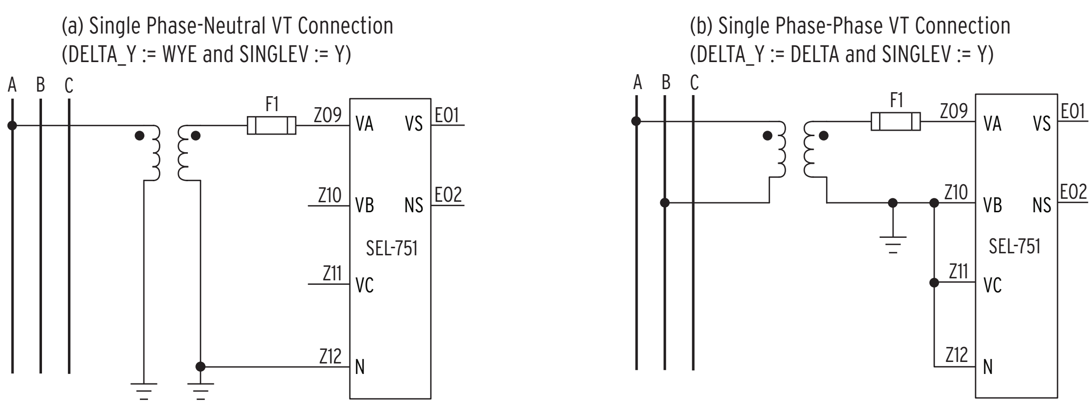


Figure 2.20 Single-Phase Voltage Connections

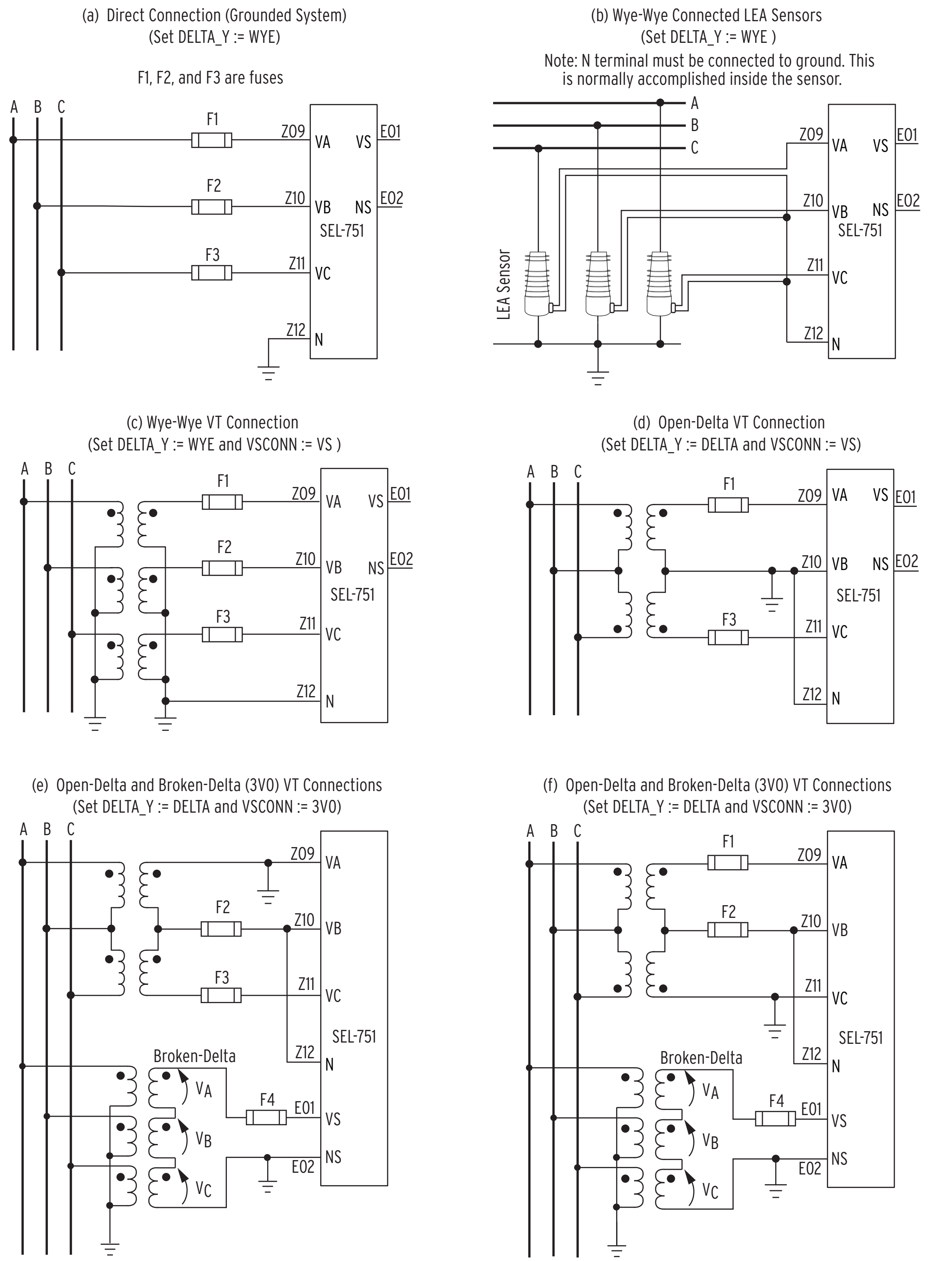


Figure (b) shows LEA inputs, which support only wye-wye connections. Refer to Under- and Overvoltage Functions on page 4.97 and LEA Ratio and Angle Correction Factors (Global Settings) on page 4.8 for the LEA settings and ratio correction factor calculations.

Figure (d) shows an open-delta VT connection with B-Phase (Z10) grounded. You can choose to ground A-Phase or C-Phase instead of B-Phase, as shown in figures (e) and (f), provided all other connections remain as shown. Terminals E01 or E02 can be used to input VAB voltage from the bus to the VS/NS input on the relay with NS terminal grounded.

Figure 2.21 Voltage Connections

Potential Transformer Ratios and PT Nominal Secondary Voltage Settings

The relay setting PTR is the overall potential ratio from the primary system to the relay phase voltage inputs VA-VB-VC-N. For example, on a 12.5 kV phase-to-phase primary system with wye-connected 7200:120 V PTs (setting DELTA_Y := WYE, and the relay wired as shown in *Figure 2.21* (*c*)), the correct PTR setting is 60. For the same 12.5 kV system connected through 12470:115 V PTs in an open-delta configuration (setting DELTA_Y := DELTA, and the relay wired as shown in *Figure 2.21 (d)*, *Figure 2.21 (e)* or *Figure 2.21 (f))*, the correct PTR setting is 108.44.

Single-phase voltage connections follow the same rationale. Refer to *Figure 2.20 (a)* and *Figure 2.20 (b)*. For example, with a single-phase voltage connection to the VA-N terminals (DELTA_Y := WYE and SINGLEV := Y) from a 12.5 kV phase-to-phase primary system with a line-neutral connected 7200:120 V PT, the correct PTR setting is 60. For the same 12.5 kV system connected through 12470:115 V PTs in a line-to-line configuration (DELTA_Y := DELTA and SINGLEV := Y) the correct PTR setting is 108.44.

The relay setting PTRS is the overall potential ratio from the synchronizing or broken-delta voltage source to the relay VS-NS voltage inputs. For example, in a synchronism-check application (setting VSCONN := VS), with phase-to-ground voltage connected from a 12.5 kV phase-to-phase primary system through a 7200:120 V PT, the correct PTRS setting is 60.

In an application that uses a broken-delta PT connection to create a 3V0 zero-sequence voltage signal (setting VSCONN := 3V0 and the relay VS-NS terminals wired as shown in *Figure 2.21 (e)* or *Figure 2.21 (f)*) with three PTs connected wye (primary)/broken delta (secondary) with ratios of 7200:120, the correct PTRS setting is 60. If the application includes a step-down transformer in addition (not show in the figure), it must also be included in the overall PTRS ratio calculation. If a 400:250 step-down instrumentation transformer is in the circuit, the correct PTRS setting would be 60 • 1.6 = 96.00.

Settings PTR and PTRS are used in the event report and **METER** commands to report power system values in primary units. Settings PTR and PTRS are also used when the setting VSCONN := 3V0, to scale the measured VS voltage into the same voltage base as voltage inputs VA-VB-VC-N for certain directional functions in *Section 4: Protection and Logic Functions*. If no VTs are connected to voltage inputs VA-VB-VC-N, make setting PTR the same value as setting PTRS. The ratio of the PTRS and PTR settings (PTRS/PTR) must be less than 1000 and greater than 0.001 when VSCONN := 3V0. The relay setting VNOM is the nominal secondary voltage connected to voltage inputs VA-VB-VC-N. For wye-connected or delta-connected PTs, VNOM is the phase-to-phase secondary voltage value.

For example, for a 10 kV (phase-to-phase) system with wye-connected VTs rated 7200:120 V (PTR := 60), the setting for VNOM would be: 10000 V/60 = 166.66 V. For a 12.5 kV (phase-to-phase) system with open-delta connected VTs rated 14000:115 V (PTR := 121.74), the setting for VNOM would be 12500 V/121.74 = 102.68 V.

The SEL-751 automatically sets VNOM := OFF and hides the setting when the setting SINGLEV := Y. In *Table 4.4*, a setting of SINGLEV := OFF is shown to disable/turn-off a number of features. Effectively, VNOM := OFF signifies that a full three-phase voltage source is not connected to voltage inputs VA-VB-VC-N. Even with VNOM := OFF, voltage can still be connected to voltage inputs VA-VB-VC-N (for example, single-phase voltage connected to voltage input VA-N), as discussed.

Station DC Battery Monitor

Use the station dc battery monitor (one of the options available with the Voltage Card options) in the SEL-751 to alarm for undervoltage and overvoltage dc battery conditions and to view how station dc battery voltage fluctuates during tripping, closing, and other dc control functions. The monitor measures station dc battery voltage applied to the rear-panel terminals E03 (VBAT+) and E04 (VBAT–) of the SELECT 2 AVI/4 AFDI voltage/arc-flash card in Slot E. Refer to *Section 5: Metering and Monitoring* for details on the station dc battery monitor function and settings.

AC/DC Connections and Applications

Figure 2.22 shows typical phase and neutral current connections for a feeder application. *Figure 2.23* through *Figure 2.32* show ac/dc connection diagrams for various applications. See *Figure 2.20* and *Figure 2.21* for other voltage connections.

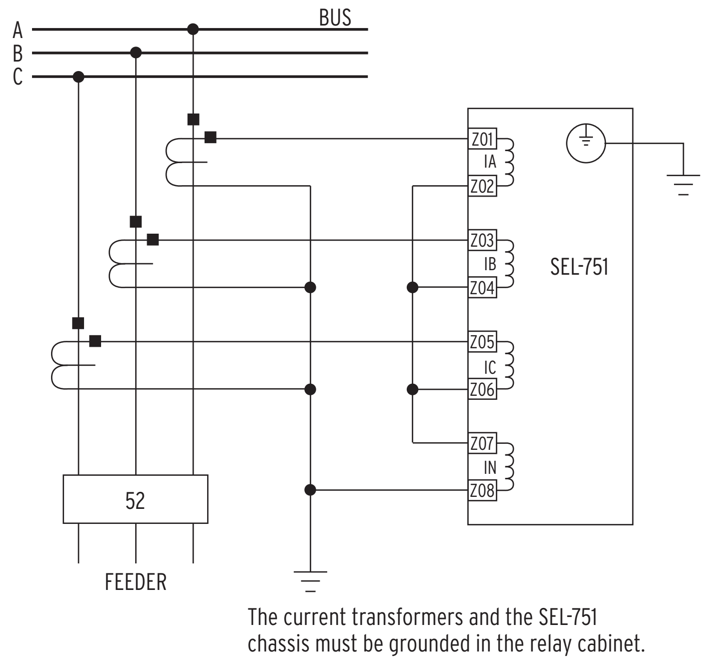
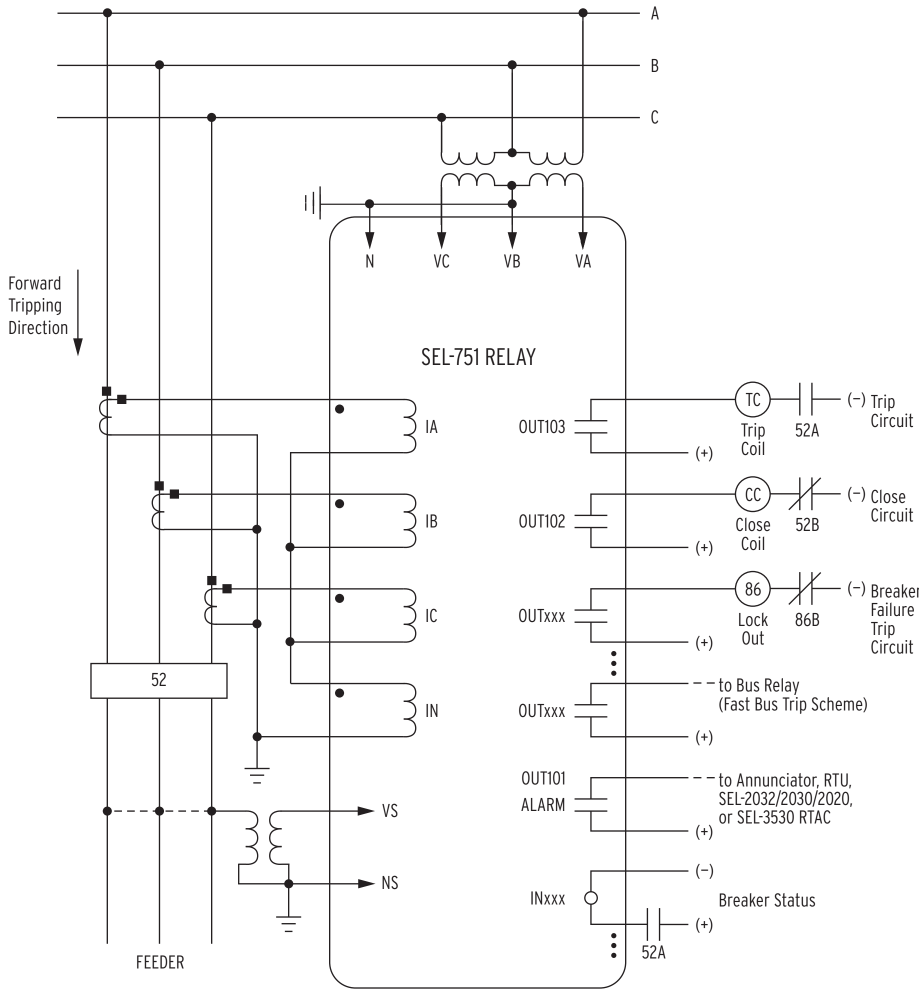


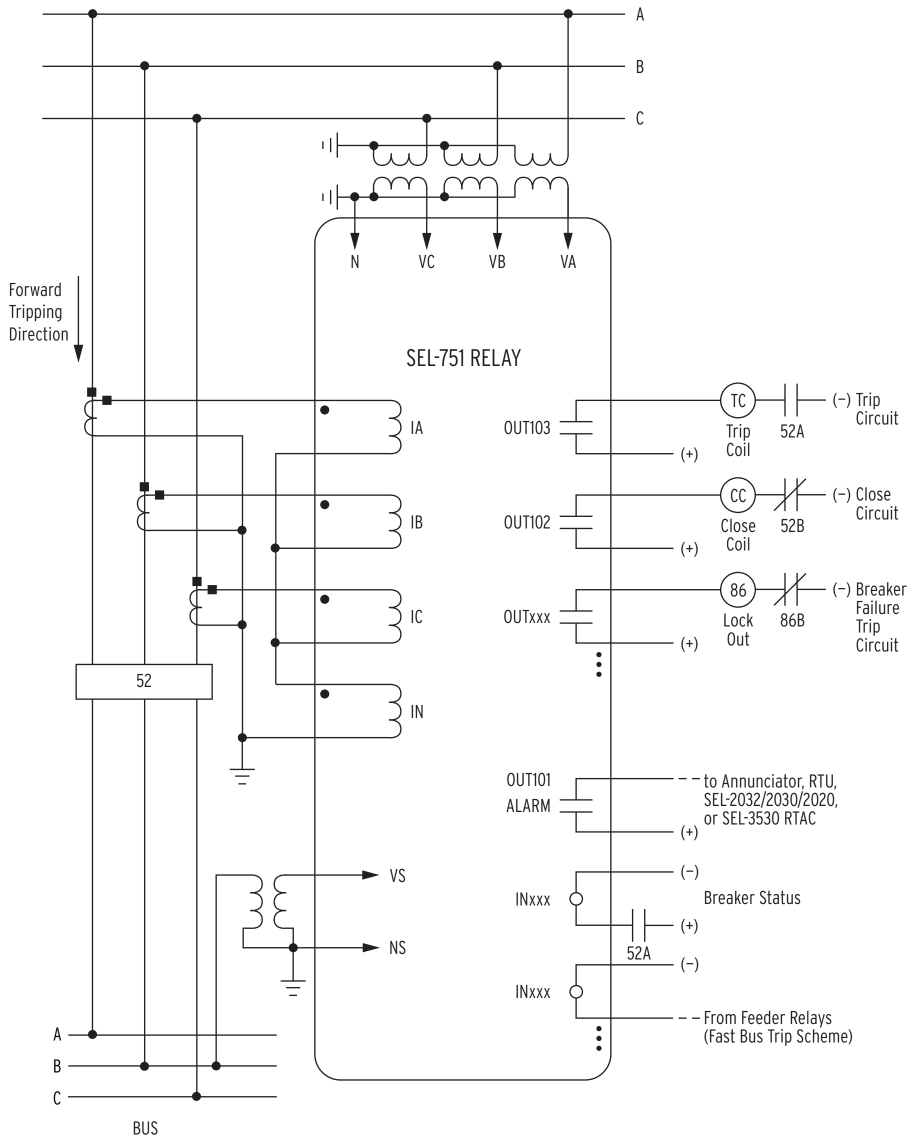
Figure 2.22 Typical Current Connections



Voltages are necessary for voltage elements, synchronism-check elements, voltage-polarized directional elements, fault location, and metering (e.g., voltage, KW, KVAR). INxxx and OUTxxx indicate user-configurable optional digital inputs and outputs. Voltage channel VS is shown connected with VSCONN := VS for use in voltage and synchronism-check elements and voltage metering. You can use the VS voltage channel for other voltage inputs such as 3V0 from a broken delta PT connection by setting VSCONN := 3V0 for use with zero-sequence voltage polarized directional elements. Setting VSCONN := 3V0 disables synchronism-check elements.

Channel IN provides current I_N for the neutral ground overcurrent elements. Separate from Channel IN, the residual ground overcurrent elements operate from the internally derived residual current I_G ($I_G = 3I_0 = I_A + I_B + I_C$). But in this residual connection example, the neutral ground and residual ground overcurrent elements operate the same because $I_N = I_G$.

Figure 2.23 SEL-751 Provides Overcurrent Protection and Reclosing for a Distribution Feeder (Includes Fast Bus Trip Scheme) (Delta-Connected PTs)



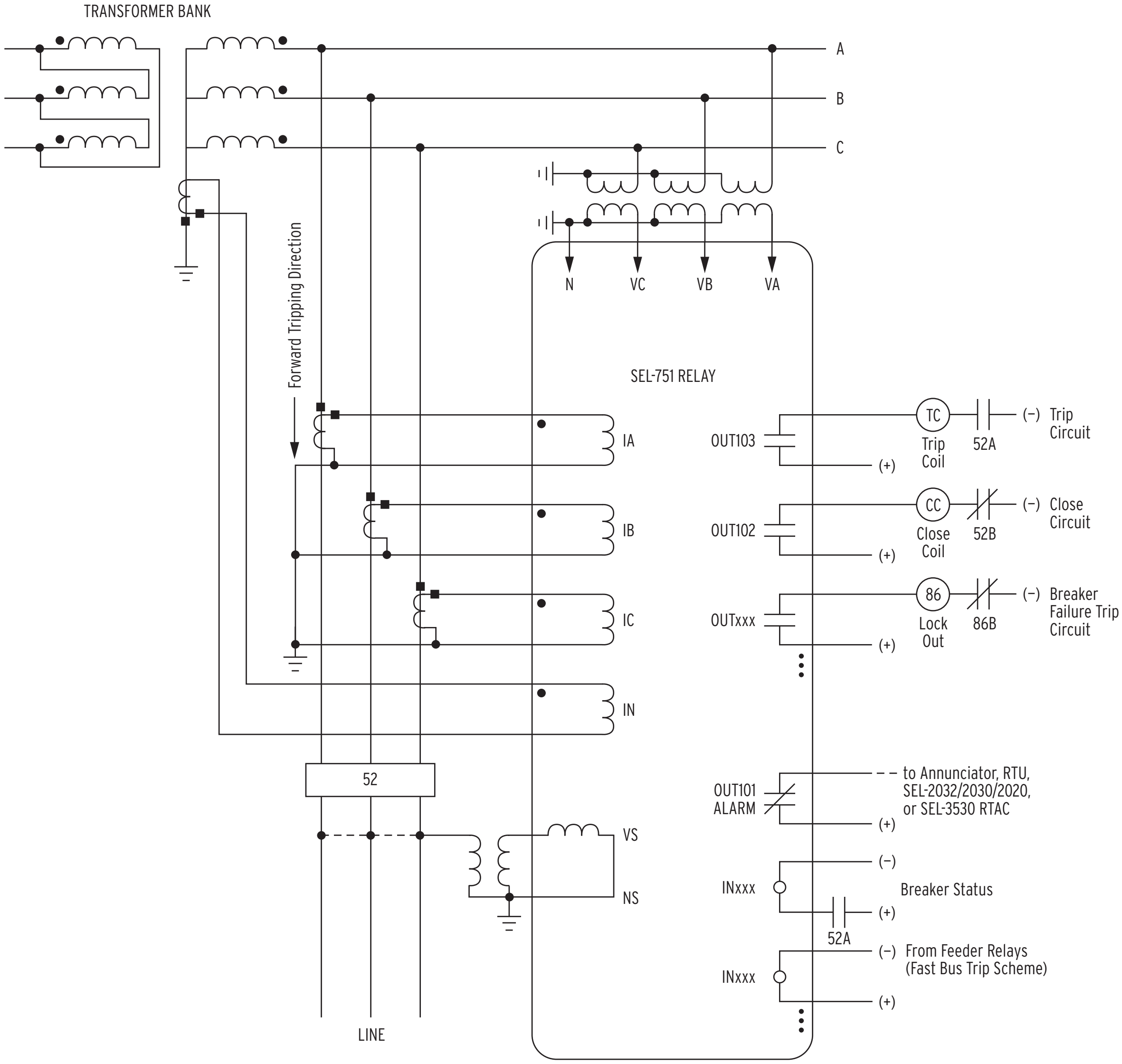
Voltages are necessary for voltage elements, synchronism-check elements, voltage-polarized directional elements, fault location, and metering (e.g., voltage, KW, KVAR). INxxx and OUTxxx indicate user-configurable optional digital inputs and outputs. Voltage channel VS is shown connected with VSCONN := VS for use in voltage and synchronism-check elements and voltage metering. You can use VS voltage channel for other voltage inputs such as 3VO from a broken delta PT connection by setting VSCONN := 3VO for use with zero-sequence voltage polarized directional elements. Setting VSCONN := 3VO disables synchronism-check elements.

Channel **IN** provides current I_N for the neutral ground overcurrent elements. Separate from Channel **IN**, the residual ground overcurrent elements operate from the internally derived residual current I_G ($I_G = 3I_0 = I_A + I_B + I_C$). But in this residual connection example, the neutral ground and residual-ground overcurrent elements operate the same because $I_N = I_G$.

Although automatic reclosing is probably not necessary in this example, output contact **OUT102** can close the circuit breaker via initiation from various means (serial port communications, optoisolated input assertion, etc.) with desired supervision (e.g., synchronism check).

INxxx is shown for use with a fast bus trip scheme. The fast bus trip scheme is often referred to as a reverse-interlocking or zone-interlocking scheme.

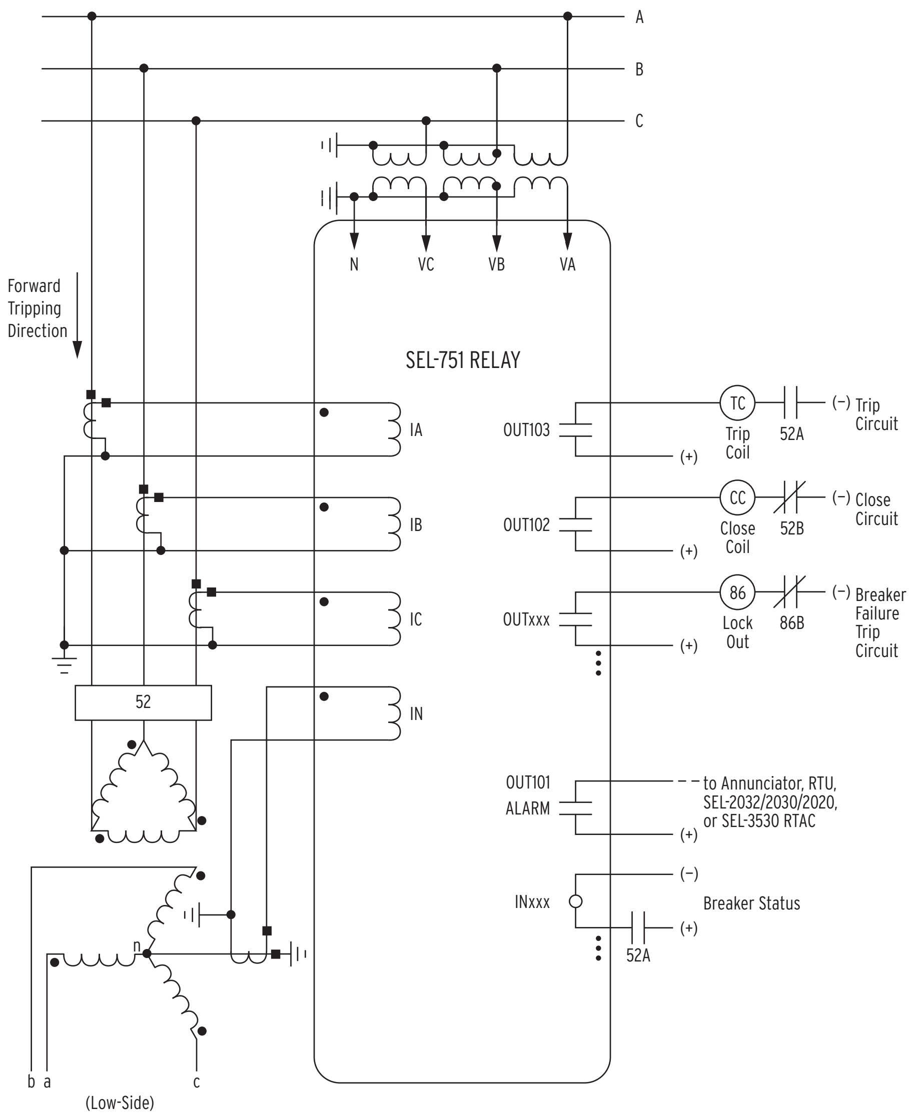
Figure 2.24 SEL-751 Provides Overcurrent Protection for a Distribution Bus (Includes Fast Bus Trip Scheme) (Wye-Connected PTs)



Voltage Channel VS does not need to be connected. Here, it is shown connected for use in voltage and synchronism-check elements and voltage metering. See Figure 2.21 (d and e) on for synchronism-check VS connection (VSCONN := VS) and broken-delta VS connection (VSCONN := 3V0).

In this example, current Channel IN provides current polarization for a directional element used to control ground overcurrent elements. Separate from Channel IN, the residual ground overcurrent elements operate from the internally derived residual current I_G ($I_G = 3I_0 = I_A + I_B + I_C$).

Figure 2.25 Transmission Line Directional Overcurrent Protection and Reclosing With Current-Polarization Source Connected to Channel IN (Wye-Connected PTs)

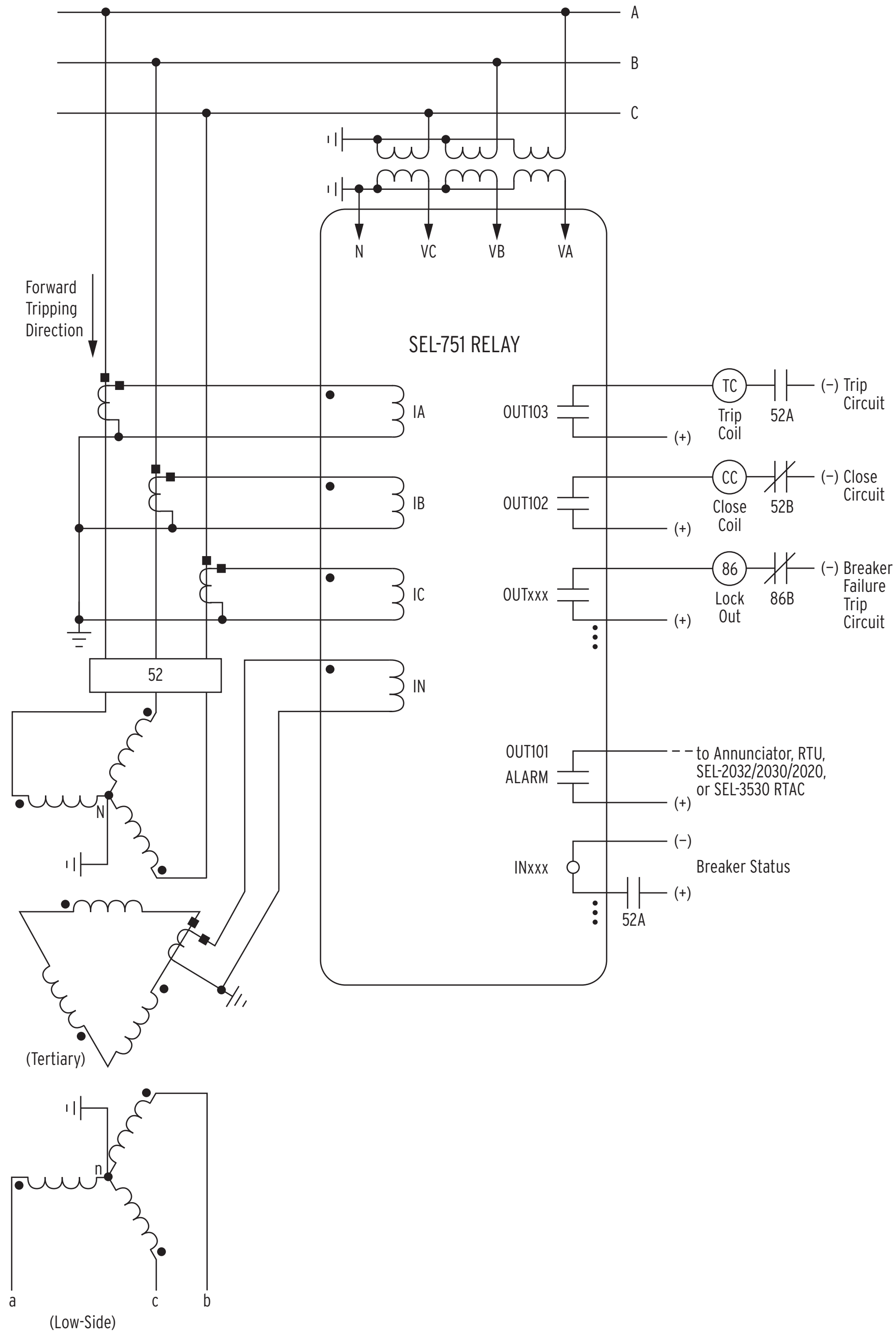


Voltages are necessary for voltage elements, synchronism-check elements, voltage-polarized directional elements, fault location, and metering (e.g., voltage, KW, KVAR). INxxx and OUTxxx indicate user-configurable optional digital inputs and outputs.

Although automatic reclosing is probably not necessary in this example, output contact OUT102 can close the circuit breaker via initiation from various means (serial port communications, optoisolated input assertion, etc.), with desired supervision (e.g., hot bus check).

For sensitive earth fault (SEF) applications, the SEL-751 should be ordered with channel IN rated at 0.2 A nominal. See AC Current Input specifications on page 1.13. See neutral ground overcurrent element pickup specifications in Table 4.9 and Table 4.15.

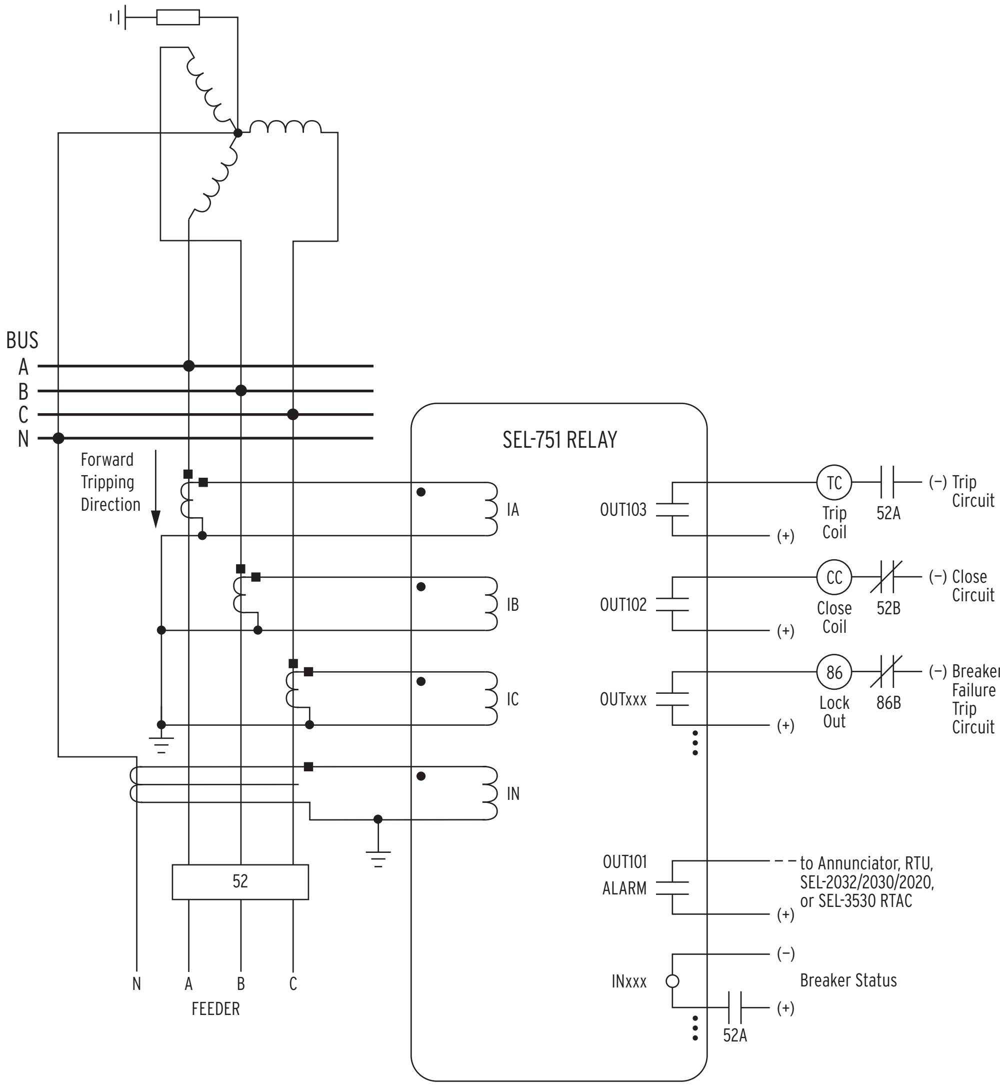
Figure 2.26 SEL-751 Provides Overcurrent Protection for a Delta-Wye Transformer Bank (Wye-Connected PTs)



Voltages are necessary for voltage elements, synchronism-check elements, voltage-polarized directional elements, fault location, and metering (e.g., voltage, KW, KVAR). INxxx and OUTxxx indicate user-configurable optional digital inputs and outputs.

Although automatic reclosing is probably not necessary in this example, output contact OUT102 can close the circuit breaker via initiation from various means (serial port communications, optoisolated input assertion, etc.), with desired supervision (e.g., hot bus check).

Figure 2.27 SEL-751 Provides Overcurrent Protection for a Transformer Bank With a Tertiary Winding (Wye-Connected PTs)



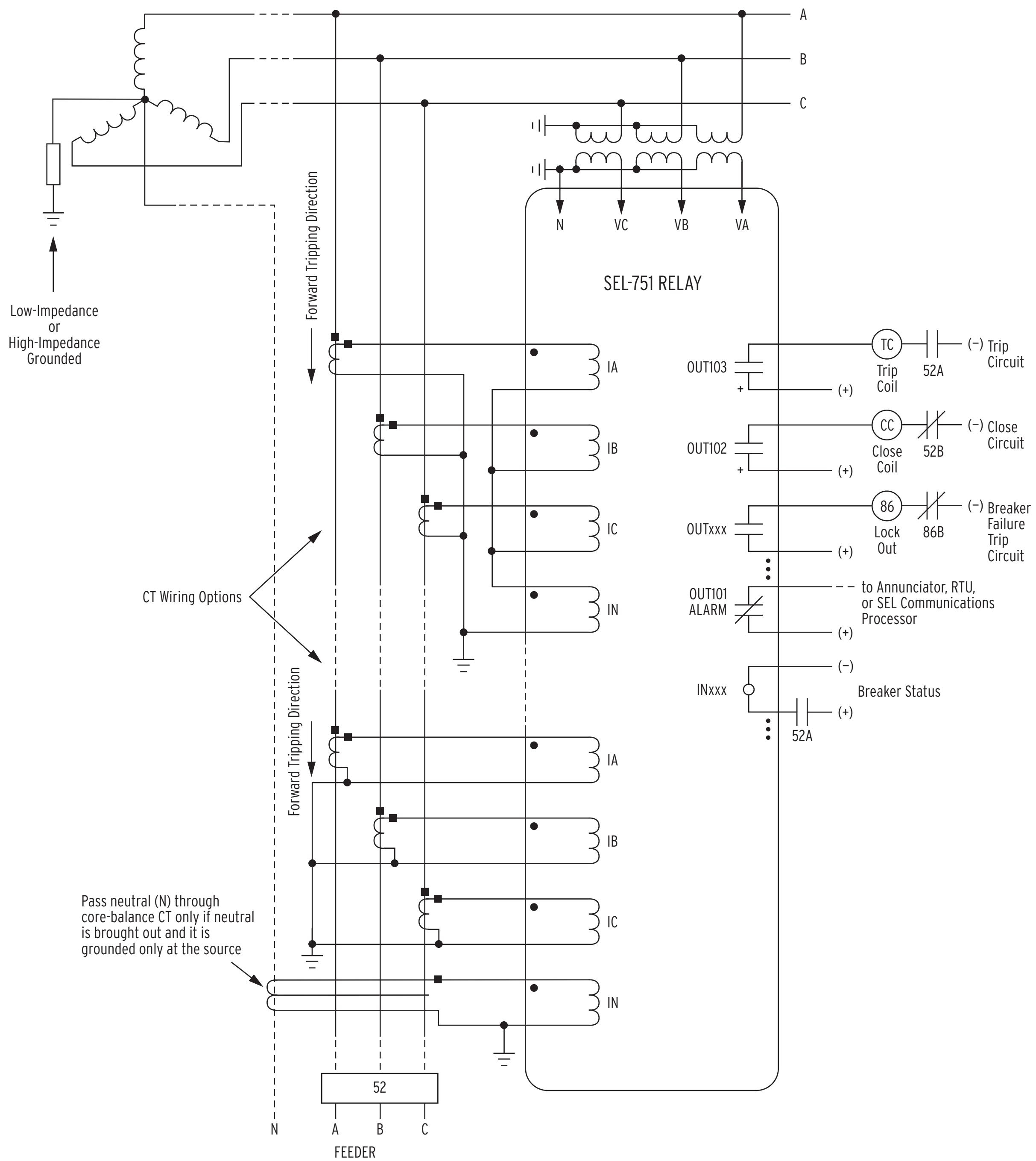
A core-balance current transformer is often referred to as a zero-sequence, ground fault, or window current transformer.

Pass neutral (N) through the core-balance CT only if the neutral is brought out and it is grounded only at the source.

Voltages are necessary for voltage elements, synchronism-check elements, voltage-polarized directional elements, fault location, and metering (e.g., voltage, KW, KVAR). INxxx and OUTxxx indicate user-configurable optional digital inputs and outputs.

Although automatic reclosing is probably not necessary in this example, output contact OUT102 can close the circuit breaker via initiation from various means (serial port communications, optoisolated input assertion, etc.), with desired supervision.

Figure 2.28 SEL-751 Provides Overcurrent Protection for an Industrial Distribution Feeder (Core-Balance Current Transformer Connected to Channel IN)

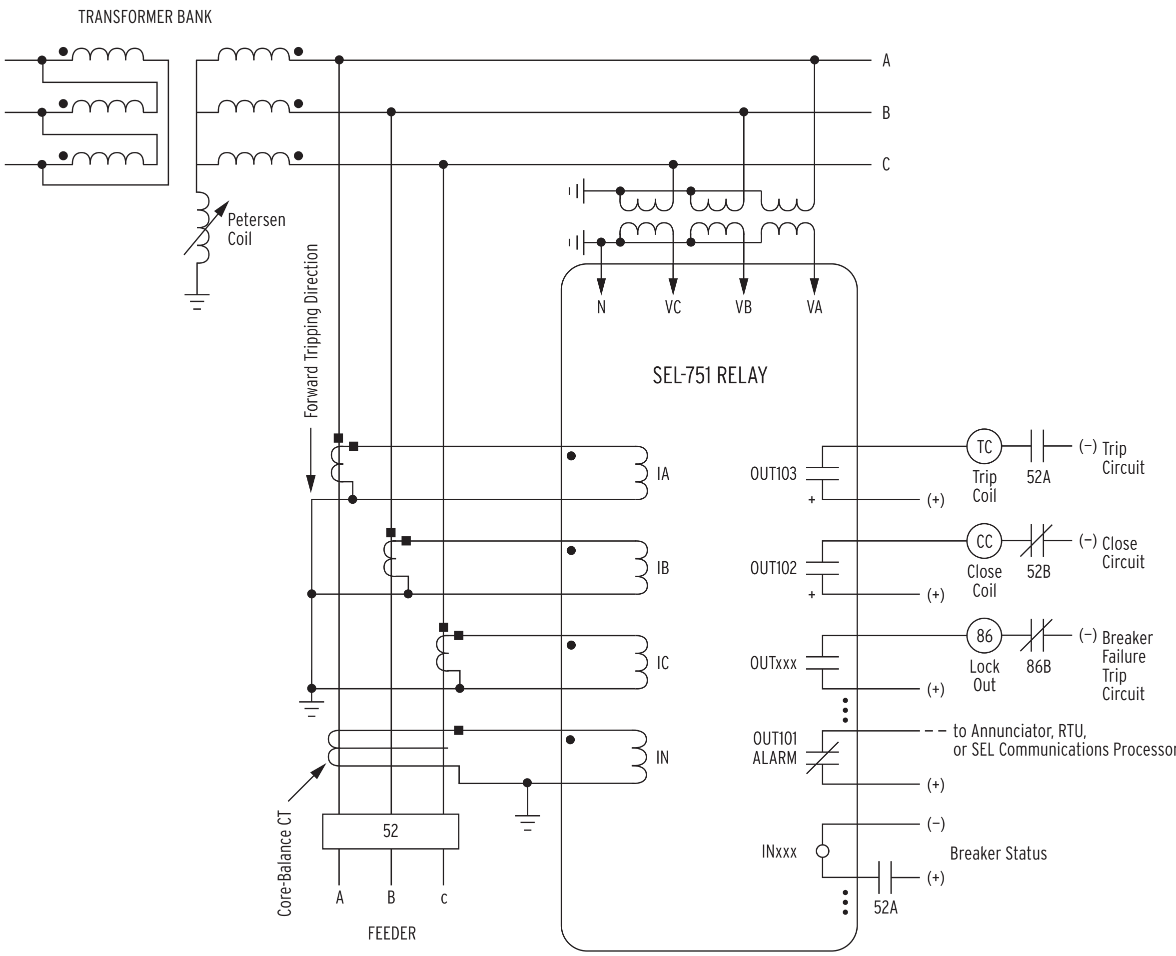


A core-balance current transformer is often referred to as a zero-sequence, ground fault, or window current transformer.

The lower CT wiring option (with the core-balance current transformer) is the preferred option (greater sensitivity; no false residual currents due to CT saturation, etc.).

Directional control for a low-impedance grounded system is selected with setting ORDER containing S. Directional control for a high-impedance grounded system is selected with setting ORDER := U (see Table 4.19–Table 4.21). Nondirectional sensitive earth fault (SEF) protection is also available.

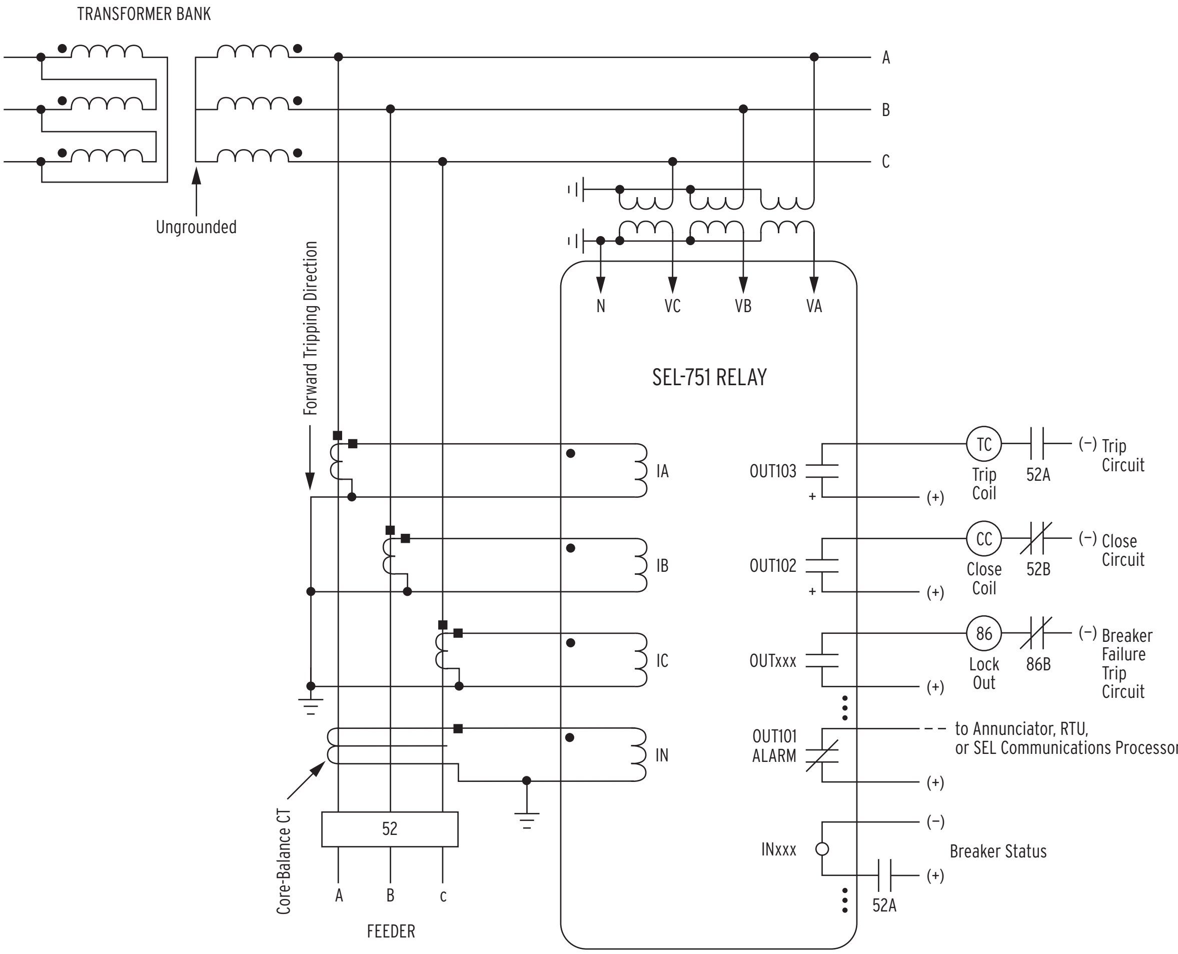
Figure 2.29 SEL-751 Provides Overcurrent Protection for a High-Impedance or Low-Impedance Grounded System (Wye-Connected PTs)



A core-balance current transformer is often referred to as a zero-sequence, ground fault, or window current transformer.

Directional control for a Petersen coil-grounded system is selected with setting ORDER containing P (see Table 4.19–Table 4.21). Nondirectional sensitive earth fault (SEF) protection is also available.

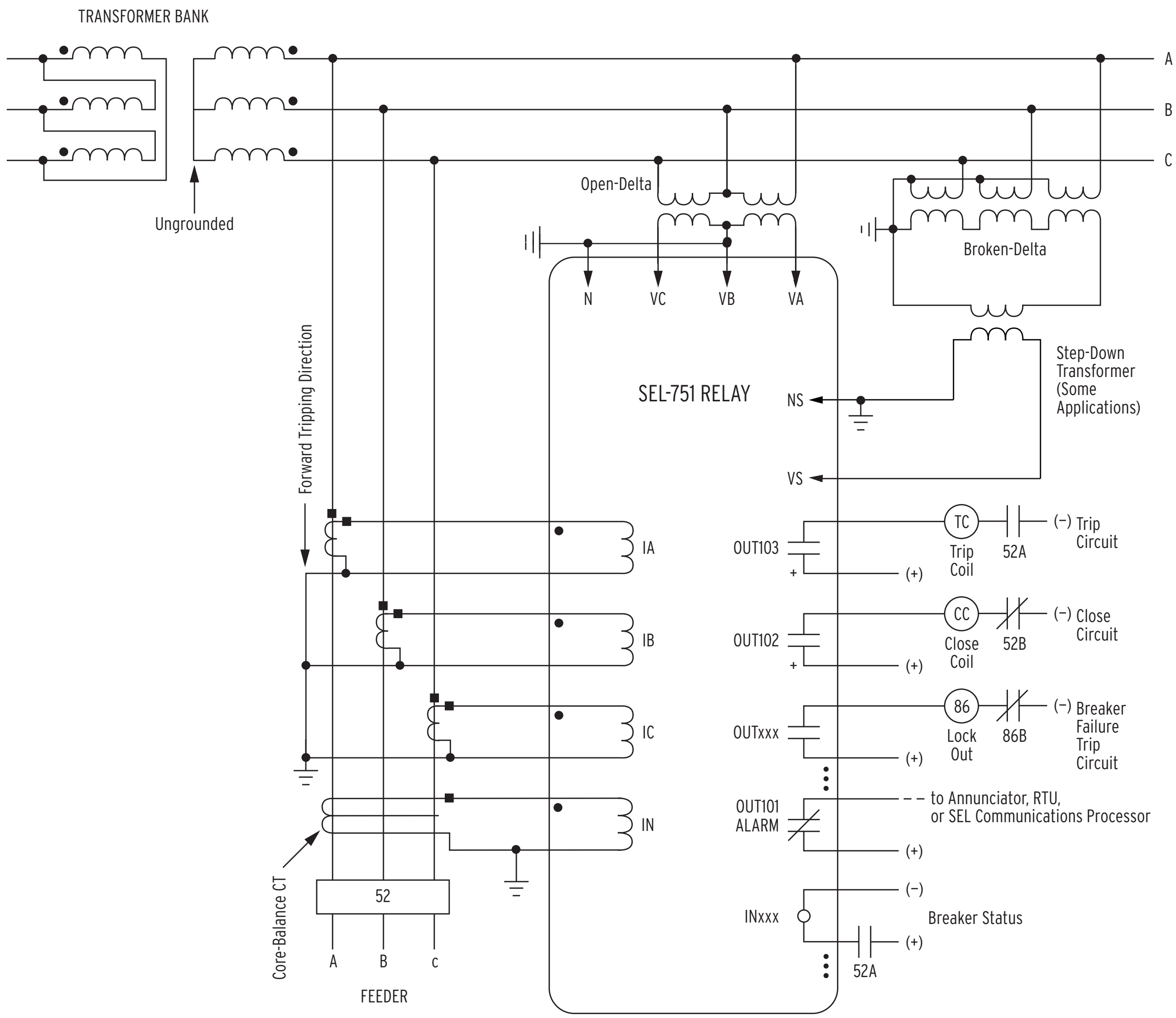
Figure 2.30 SEL-751 Provides Overcurrent Protection for a Petersen Coil-Grounded System (Wye-Connected PTs)



A core-balance current transformer is often referred to as a zero-sequence, ground fault, or window current transformer.

Directional control for an ungrounded system is selected with setting ORDER := U (see Table 4.19–Table 4.21). Nondirectional sensitive earth fault (SEF) protection is also available.

Figure 2.31 SEL-751 Provides Overcurrent Protection for an Ungrounded System (Wye-Connected PTs)



A core-balance current transformer is often referred to as a zero-sequence, ground fault, or window current transformer.

Directional control for an ungrounded system is selected with setting ORDER := U (see Table 4.19—Table 4.21). Nondirectional sensitive earth fault (SEF) protection is also available.

The voltage inputs can accept open-delta PT (three-wire) connection (as shown) when setting DELTA_Y := DELTA.

VB must be externally tied to **N**, as shown.

The zero-sequence voltage $3V_0$ (from the "broken-delta" connection) is shown coming from a step-down instrumentation transformer, and connecting to voltage input **VS-NS**. To use this connection, make setting VSCONN := $3V_0$. Make group setting PTRS as shown in Section 4: Protection and Logic Functions.

The step-down transformer is required when the maximum expected residual voltage exceeds the relay voltage channel rating.

The polarity of voltage input **VS-NS** connection should be verified prior to placing the relay into service.

Figure 2.32 SEL-751 Provides Overcurrent Protection for an Ungrounded System (Open-Delta Connected PTs, Broken-Delta 3V0 Connection)

Arc-Flash Protection: System Installation

This section describes an arc-flash system installation, the sensor characteristics, and an arc-flash application. Refer to *Section 4: Protection and Logic Functions* for a description of arc-flash protection and the relay settings. *Section 11: Testing and Troubleshooting* gives a description of the commissioning tests to verify the installation. Also, refer to Application Guide *AG2011-01: Using the* SEL-751 *and* SEL-751*A for Arc-Flash Detection*, available on the SEL website, for more details.

Figure 2.33 shows main system components comprising: current input card, the arc-flash/voltage input card with sensor terminal block, and the fiber-optic-based point-sensor assembly. *Figure 2.10* shows the rear-panel layout and the side-panel I/O designations for a relay model with the 2 AVI/4 AFDI card for arc-flash protection. *Figure 2.12* shows the rear-panel layout and the side-panel I/O designations for a relay model with the 8 AFDI card. Installation instructions for the 8 AFDI card are similar to the 2 AVI/4 AFDI card.

Figure 2.33 SEL-751 With a 2 AVI/4 AFDI Option Card and the Fiber-Optic-Based Point-Sensor

Light-Sensor Installation

An arc-flash system installation starts by selecting the best sensor location and the safest path for bringing the sensor fibers back to the relay. The actual sensor location varies depending on the type of switchgear being protected. Although arc-flash light is easily reflected off painted surfaces, make sure to avoid shadows/light obstruction caused by the insulating baffles or moving parts of the breaker truck assembly.

While fiber-optic sensors are inherently nonconductive, they are not intended for direct contact with energized parts, and must be suspended within 25 mm (1 in) of the grounded surface. Make sure to observe the original high-voltage clearance and creepage requirements. Sensors should be permanently affixed through the use of supplied mounting grommets or permanent cable ties. *Figure 2.34* shows an example of a typical black-jacketed fiber installation.

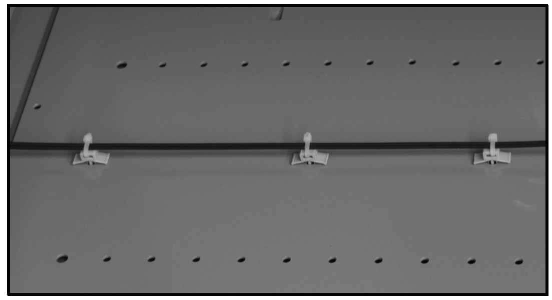


Figure 2.34 Black-Jacketed Fiber installation Example

Fiber-bending radius must be kept greater than 50 mm (2 in). Care should be exercised when crossing from a moving part (such as control cabinet door) to a stationary switchgear enclosure. Use standard wiring practices with bundled fibers and well-defined strain relief points. Additional attention is necessary to prevent moving parts, such as a breaker truck assembly, from inadvertently damaging the arc-flash sensor fibers. Although easily detected by the sensor diagnostics, such problems can be eliminated through careful installation planning. Once routed, fiber sensors are connected to the SEL-751 as shown in *Figure 2.33*.

Point-Sensor Installation

The point-sensor is optimized for monitoring confined switchgear spaces where the distance between sensors and the potential sources of arc (energized parts) can be kept below 2 m. Such spaces typically include breaker compartments, outgoing and incoming cable compartments, and potential transformer (PT) compartments. *Figure 2.35* shows a schematic diagram of the point-sensor assembly.

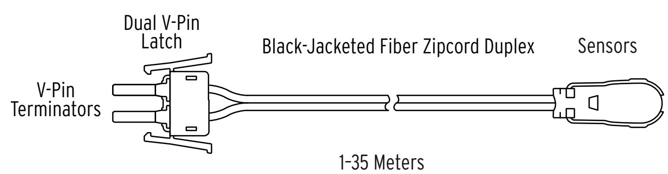
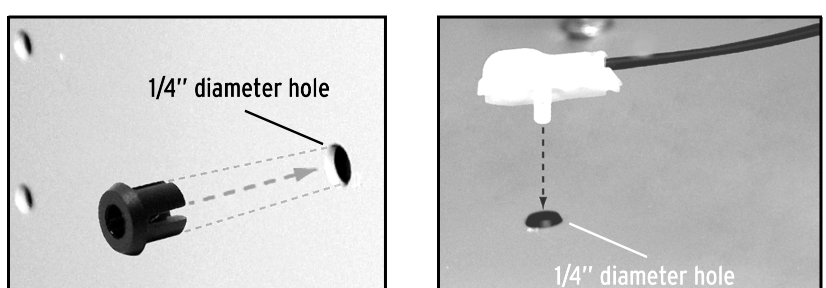


Figure 2.35 Point-Sensor Assembly

The sensor is mounted flush on the switchgear cabinet wall, using a standard 1/4-inch hole. Mounting steps are shown in *Figure 2.36*.



1. Mounting Grommet Insertion (1/4″ diameter hole)
2. Sensor Insertion (1/4″ diameter hole)

Figure 2.36 Point-Sensor Installation

The point sensor is omnidirectional with a slight loss of sensitivity at the fiber entry point. *Figure 2.37* through *Figure 2.39* show the sensor directivity pattern. The point sensor must be located in clear view of the energized parts, which are most likely to cause an arc-flash event.

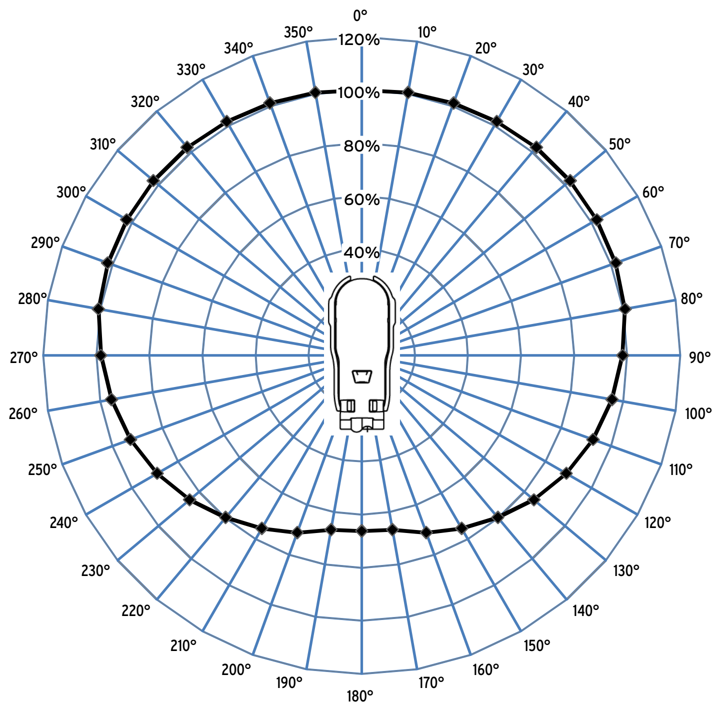


Figure 2.37 Point-Sensor Directivity (0–360° Around the Mounting Plane)

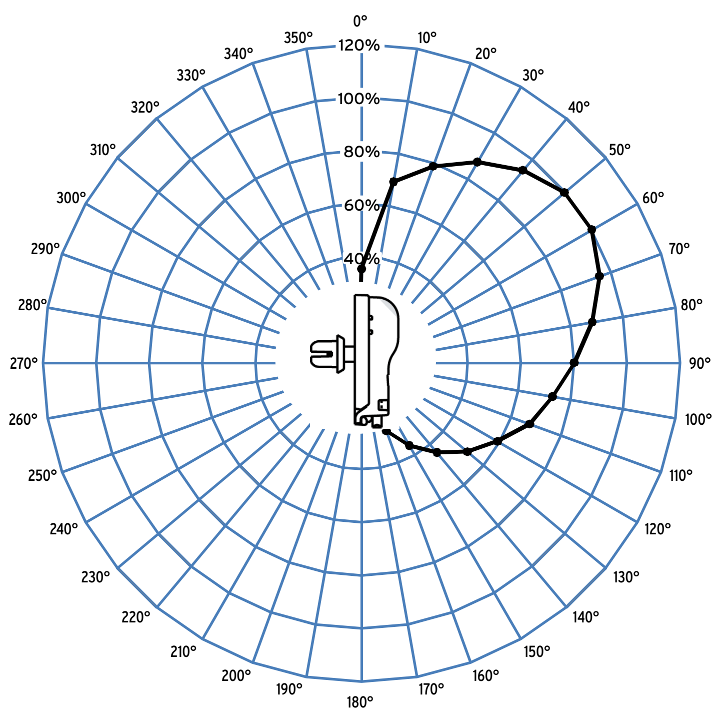


Figure 2.38 Point-Sensor Directivity (Front to Back, Above the Mounting Plane)

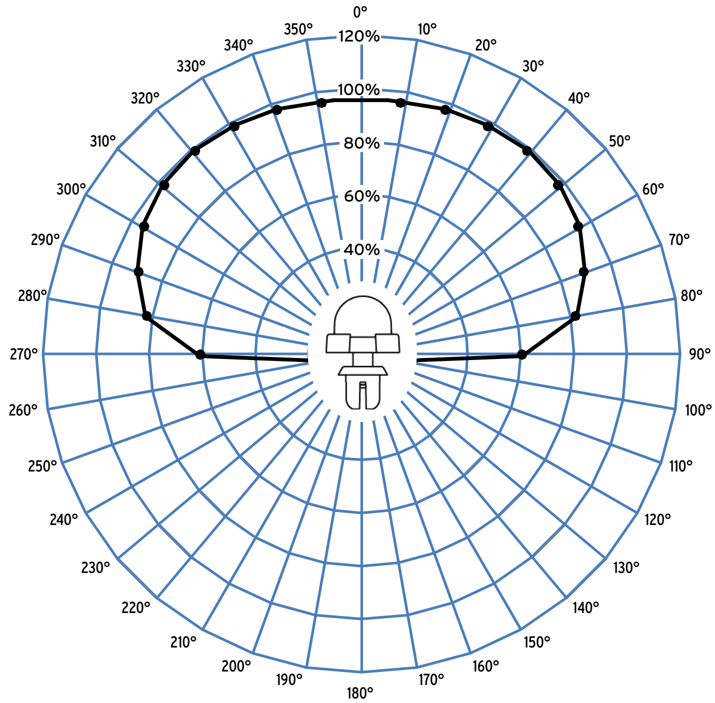
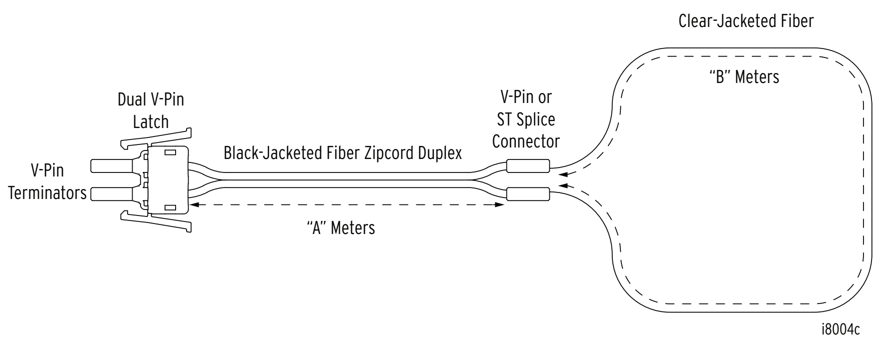


Figure 2.39 Point-Sensor Directivity (Left to Right, Above the Mounting Plane)

Fiber Sensor Installation

The clear-jacketed fiber sensor is optimized for monitoring of large distributed resources, such as switchgear system bus enclosures. The clear-jacketed fiber sensor is omnidirectional and can be mounted in close proximity to the switchgear enclosure walls. *Figure 2.40* shows a schematic diagram of the clear-jacketed fiber sensor. *Figure 2.41* shows a clear-jacketed fiber sensor mounting example photo.



Total loop length = 2 • A + B (allowed range 3 to 70 meters)
Range for A: 1 to 30 meters
Range for B: 1 to 50 meters

Figure 2.40 Clear-Jacketed Fiber Sensor Assembly

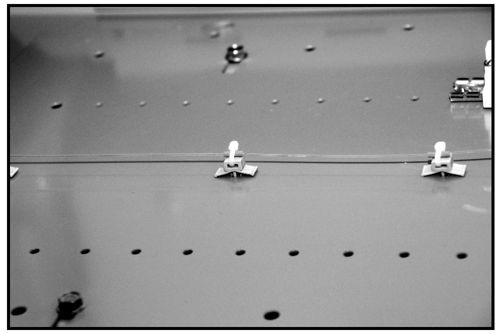


Figure 2.41 Clear-Jacketed Fiber Sensor Mounting Example

A clear-jacketed fiber sensor consists of the major components shown in *Figure 2.42*. Two connector options (V-pin and ST) are available to transition from the black-jacketed to the clear-jacketed fiber section, as shown in *Figure 2.43*. The ST connector option is generally superior because of positive locking.

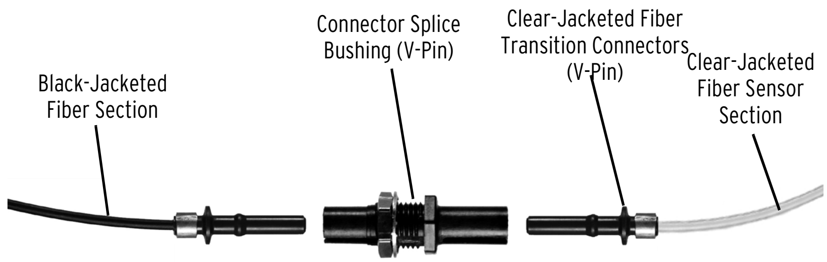
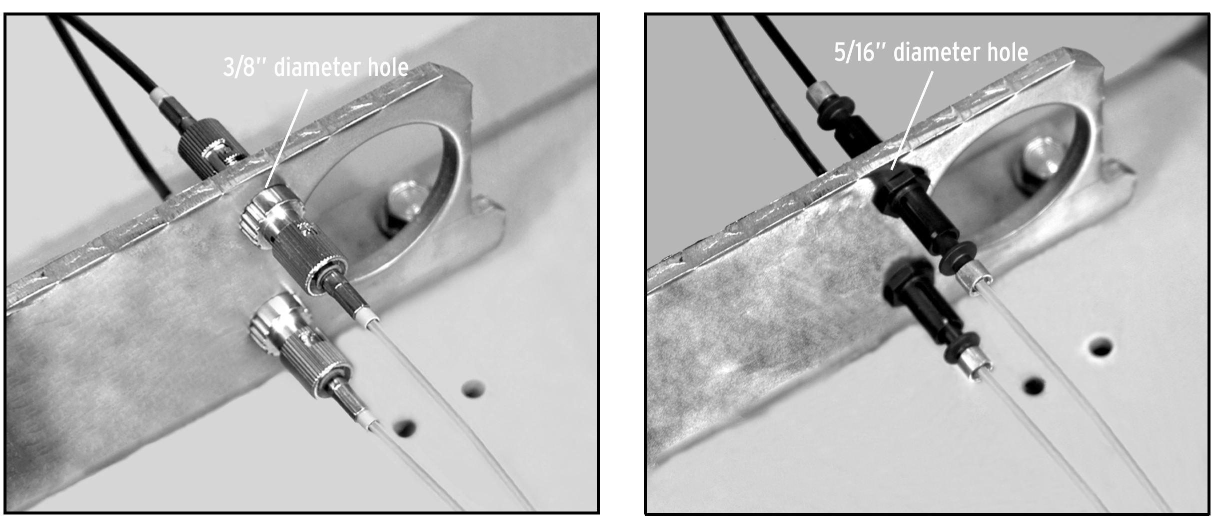


Figure 2.42 Clear-Jacketed Fiber Sensor Components (V-Pin Style)

For correct operation, a clear-jacketed fiber sensor must be located within 2 m of the arcing site, with at least 0.5 m of the fiber sensor exposed to the light. The maximum length of the clear-jacketed fiber sensor is limited to 70 m and includes both, clear-jacketed fiber and black-jacketed fiber sections (the black-jacketed section is counted twice because of its dual-fiber construction). Transition between the two sections is accomplished by using a connector splice as shown in *Figure 2.43*.



ST Connection (3/8″ diameter hole)

V-Pin Connection (5/16″ diameter hole)

Figure 2.43 Clear-Jacketed Fiber Sensor Showing Transition From Clear- to Black-Jacketed Fiber Section

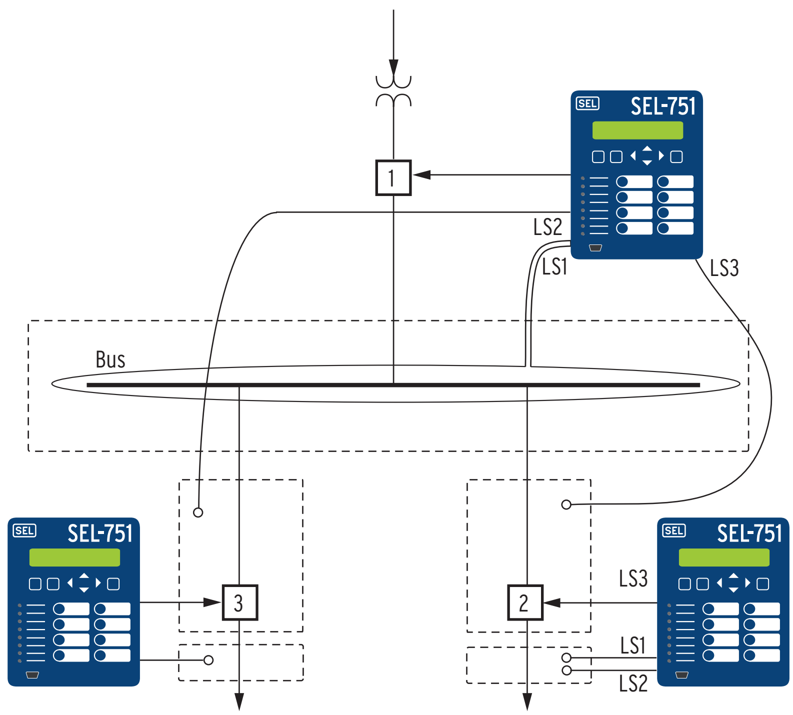
The clear-jacketed fiber loop should be returned through the same general area as the forward path, providing dual opportunity to sense the same arc-flash event. This approach ensures that the maximum distance between the relay and the light-producing event remains below 35 m, irrespective of the SEL-751 dual V-pin connector orientation.

Application Example

Figure 2.44 shows a typical switchgear application example with one incoming and two radial (outgoing) feeders. All three feeders are protected with an SEL-751 controlling breakers 1, 2, and 3. Radial feeder breakers 2 and 3 must be tripped for downstream faults, normally located in the outgoing cable termination compartment. To obtain better coverage, multiple sensors can be installed in the same compartment, as shown in the lower right corner of the *Figure 2.44* with sensors marked LS1 and LS2.

Bus compartment and the outgoing breaker compartments for breakers 2 and 3 are protected by the incoming feeder breaker 1, with sensors LS1, LS2, and LS3 connected directly to the incoming feeder relay (upper right hand corner of *Figure 2.44*). Sensor LS1 is implemented as a clear-jacketed fiber loop enclosing entire length of the bus.

When desired, you can use radial feeder relays sensors (such as LS3 connected to the lower right hand relay) to transfer trip the upstream breaker. Logic equations for this function are shown in *Output Logic Programming* in *Section 4: Protection and Logic Functions*.



LS1–LS4 are arc-flash detection inputs, point or clear-jacketed fiber sensors.

Figure 2.44 Switchgear Application Example

Ordering Arc-Flash Fiber Sensors

Arc-flash fiber sensors can be ordered with or without splices. To configure the standard multimode fiber-optic arc-flash detection point and fiber-loop sensor cable assemblies without additional splice connectors, use the C804 Multimode Fiber-Optic Arc-Flash Detection (AFD) Sensors Model Option Table (MOT). For multimode fiber optic arc-flash detection sensors with additional splice connectors, refer to the SEL-C814 Arc-Flash Detection (AFD) Fiber Cables and Accessories MOT. The losses and budget values shown in *Table 2.19* are typical values.

Table 2.19 Optical Budget Calculations

Link Budget[a]		Loss Data[b]	
Bare-Fiber Sensor	17 dB	ST connector splice	2 dB
Point Sensor	12.25 dB	V-Pin connector splice	2 dB
		Bare-fiber	0.175 dB/m
		Jacketed fiber	0.175 dB/m

[a] Link budget is calculated after allowing for the losses of the dual V-pin latch. When using a point sensor it allows for the sensor loss as well.
[b] Link losses are calculated by adding up the fiber loss and the splice connector losses. The link losses should be less than the link budget.

NOTE: Jacketed fiber in a zipcord duplex configuration includes two fiber lengths. Loss calculations must account for the total length of the fiber. This is accounted for in the examples as a "x 2" multiplier.

Link Optical Loss Calculation Examples

This example shows a bare-fiber sensor with two V-Pin or ST connectors and an **A** dimension of 15 meters and a **B** dimension of 40 meters. Two connectors is the standard configuration, as shown in *Figure 2.45*.

Link Budget	17 dB
– (2 dB x # of connector splices)	–4 dB
– (0.175 dB/m x **A** dimension x 2)	–5.25 dB
– (0.175 dB/m x **B** dimension)	–7 dB
Total Link Losses =	–16.25 dB

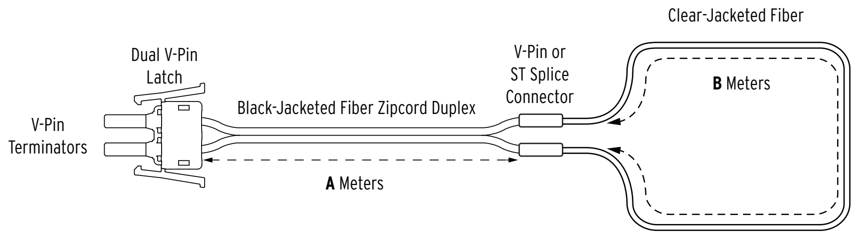


Figure 2.45 Bare-Fiber Sensor Assembly With Two Splices

This example shows a point sensor with an **A** dimension of 30 m, as shown in *Figure 2.46*.

Link Budget	12.25 dB
– (0.175 dB/m x **A** dimension x 2)	–10.5 dB
Total Link Losses =	–10.5 dB

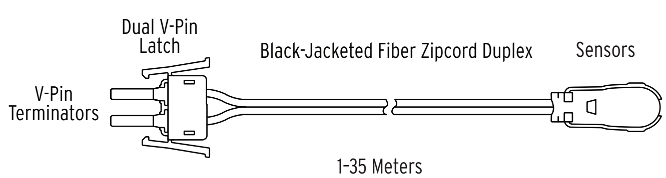


Figure 2.46 Point Sensor Assembly

Splice connectors can be added for the arc-flash fiber sensors to meet the shipping needs for large switchgears that require multiple splits for transportation. For multimode fiber-optic arc-flash detection sensors with additional splice connectors, refer to the SEL-C814 Arc-Flash Detection (AFD) Fiber Cables and Accessories MOT.

Ordering Examples Using the SEL-C814 Model Option Table

This example of a bare-fiber sensor with four ST connectors and an **A** dimension of 15 meters, as shown in *Figure 2.47*, shows the part numbers generated using an SEL-C814 MOT and the link optical loss calculations.Two connectors is the standard configuration.

Link Budget	17 dB
– (2 dB x # of connector splices)	–8 dB
– (0.175 dB x **A** dimension x 2)	–5.25 dB
Link Losses = available for **B** meters	3.75 dB
÷ (0.175 dB/m)	21.42 meters maximum **B** dimension

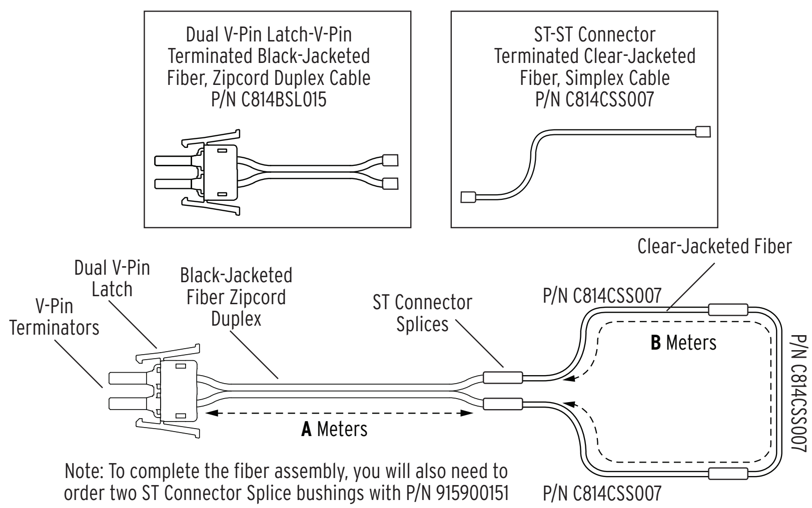
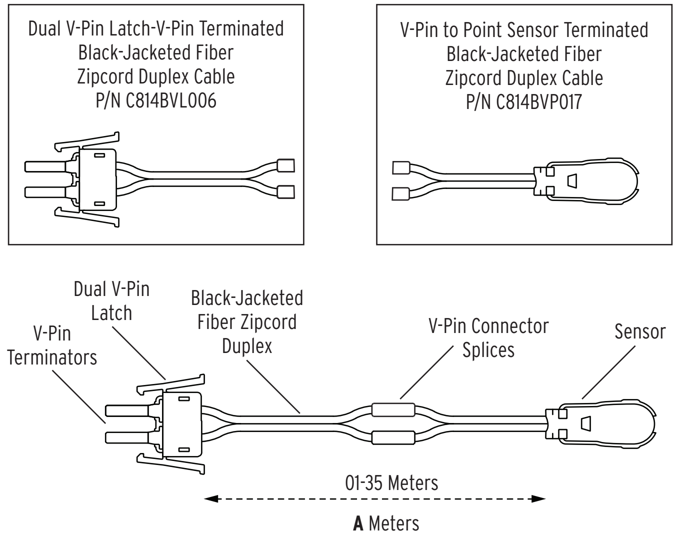


Figure 2.47 Bare-Fiber Sensor Assembly With Two Additional ST Splice Connectors

This example of a point sensor with two V-pin connectors, as shown in *Figure 2.48*, shows the part numbers generated using a C814 MOT and the link optical loss calculations.

Link Budget	12.25 dB
– (2 dB x # of connector splices)	–4 dB
Link Losses = available for **A** meters	8.25 dB
÷ (2 x 0.175 dB/m)	23.6 meters maximum **A** dimension



Note: To complete the fiber assembly, you will also need to order two ST connector splice bushings with P/N 915900148.

Figure 2.48 Point Sensor Assembly With Two V-Pin Splice Connectors

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-751 firmware can be upgraded in the field; refer to *Appendix B: Firmware Upgrade Instructions* for firmware upgrade instructions. You may know 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 can determine whether the analog front-end (not monitored by relay self-test) is functional. Refer to *Section 11: Testing and Troubleshooting* for detailed testing and troubleshooting information.

The only two components that can be replaced in the field are the power supply fuse and the real-time clock battery. A lithium battery powers the clock (date and time) if the external power source is lost or removed. The battery is a 3 V lithium coin cell, Ray-O-Vac BR2335 or equivalent. At room temperature (25°C), the battery will operate 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 eight 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 3.15A (ceramic), Schurter T 3.15A H 250V, or equivalent.

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

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

Real-Time Clock Battery Replacement

> ⚠ **CAUTION**
> There is danger of explosion if the battery is incorrectly replaced. Replace only with Ray-O-Vac no. BR2335 or equivalent recommended by manufacturer. See Owner's Manual for safety instructions. The battery used in this device may present a fire or chemical burn hazard if mistreated. Do not recharge, disassemble, heat above 100°C or incinerate. Dispose of used batteries according to the manufacturer's instructions. Keep battery out of reach of children.

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

Step 1. De-energize the relay.

Step 2. Remove the eight 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

SEL provides many PC software solutions (applications) to support the SEL-751 Relay and other SEL devices. *Table 3.1* lists SEL-751 software solutions.

Table 3.1 SEL Software Solutions

Part Number	Product Name	Description
SEL-5010	SEL-5010 Relay Assistant Software	Manages a connection directory and settings of multiple devices.
SEL-5030	ACSELERATOR QuickSet SEL-5030 Software	See *Table 3.2*.
SEL-5032	ACSELERATOR Architect SEL-5032 Software	Configures IEC 61850 communications.
SEL-5036	ACSELERATOR Bay Screen Builder SEL-5036 Software	Designs and manages bay screens in conjunction with SEL-5030 for the SEL-751 with color touchscreen display.
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.

This section describes how to get started with the SEL-751 and ACSELERATOR QuickSet. QuickSet is a powerful setting, event analysis, and measurement tool that aids in setting, applying, and using the SEL-751. *Table 3.2* shows the suite of QuickSet applications provided for the SEL-751.

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

Application	Description
Rules-Based Settings Editor	Provides online or offline device settings that include interdependency checks. Use this feature to create and manage settings for multiple devices in a database.
HMI	Provides a summary view of device operation. Use this feature to simplify commissioning testing.
Design Templates[a]	Allows you to customize device settings to particular applications and store those settings in Design Templates. You can lock settings to match your standards or lock and hide settings that are not used.
Event Analysis	Provides oscillography and other event analysis tools.
Bay Control	Allows you to design new bay screens and edit existing bay screens by launching ACSELERATOR Bay Screen Builder SEL-5036 Software for SEL-751 relays with the color touchscreen display.
Setting Database Management	QuickSet uses a database to manage the settings of multiple devices.

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

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

[a] Available only in licensed versions of QuickSet.

Setup

Follow the steps outlined in *Section 2: Installation* to prepare the SEL-751 for use. Perform the following steps to initiate communications:

Step 1. Connect the appropriate communications cable between the SEL-751 and the PC.

Step 2. Apply power to the SEL-751.

Step 3. Start ACSELERATOR QuickSet.

Communications

QuickSet uses relay communications **Port 1** through **Port 4**, or **Port F** (front panel) to communicate with the SEL-751. Perform the following steps to configure QuickSet to communicate effectively with the relay.

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

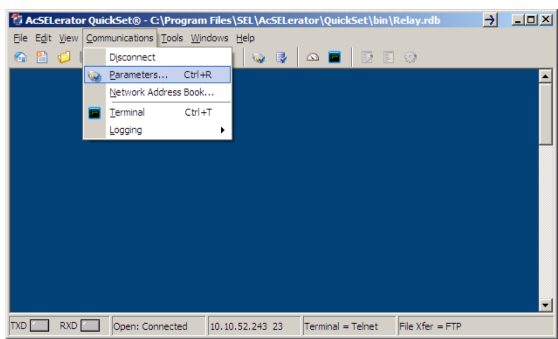


Figure 3.1 Serial Port Communications Dialog Box

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 QuickSet to match the SEL-751 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-751, always select FTP as the File Transfer Option.

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

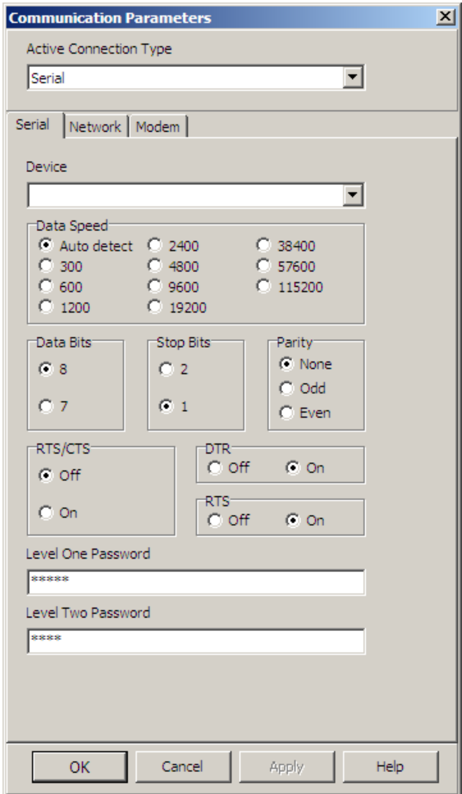


Figure 3.2 Serial Port Communication Parameters Dialog Box

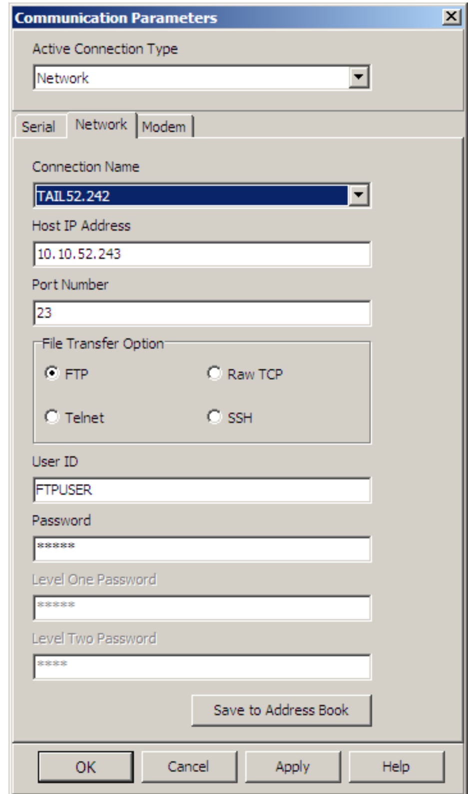


Figure 3.3 Network Communication Parameters Dialog Box

Terminal

Terminal Window

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

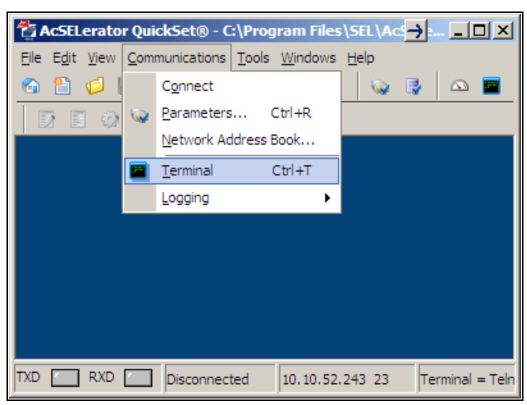


Figure 3.4 Communications Menu

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. 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*.

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

```
=ID <Enter>
"FID=SEL-751-X397-V0-Z007003-D20170305","08BC"
"BFID=BOOTLDR-R500-V0-Z000000-D20090925","0952"
"CID=9B42","025E"
"DEVID=SEL-751","0408"
"DEVCODE=77","0316"
"PARTNO=751001B6X3X7183021X","06D9"
"CONFIG=11251201","03F0"
"SEL DISPLAY PACKAGE=1.0.32768.873","086A"
"CUSTOMER DISPLAY PACKAGE=1.542556555","099A"
"iedName =TEMPLATE","05DC"
"type =SEL_751","04B0"
"configVersion =ICD-751-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 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 3.9*. Compare the part number (PARTNO=7510XXXXXXXXXXXXXX) with the Model Option Table (MOT) to ensure the correct relay configuration. The SEL display package version can be found in *Table A.3*. The customer display package (CDP) version has a unique ID code based on the total number of seconds from 1/1/2000 to the time stamp when the Bay Screen project file was created.

Settings Database Management and Drivers

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

Database Manager

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

Settings Database

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

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

Step 2. Enter descriptions for the database and for each relay or 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.

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. 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**. 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.

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

Step 2. Click the **Open B** button; 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 offers the capability of creating settings for one or more SEL-751 Relays. Store existing relay settings downloaded from SEL-751 Relays with QuickSet, creating a library of relay settings, then modify and upload these settings from the settings library to an SEL-751. QuickSet makes setting the relay easy and efficient. However, you do not have to use QuickSet to configure the SEL-751; you can use an ASCII terminal or a computer running terminal emulation software. QuickSet provides the advantages of rules-based settings checks, SELOGIC control equation Expression Builder, operator control and metering HMI, event analysis, and help.

Settings Editor

The Settings Editor shows the relay settings in easy-to-understand categories. The SEL-751 settings structure makes setting the relay easy and efficient. Settings are grouped logically, and relay elements that are not used in the selected protection scheme are not accessible. For example, if there is only one analog card installed in the relay, you can access settings for this one card only. Settings for the other slots are dimmed (grayed) in the QuickSet menus. 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

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-751 and then create and open a new record. Use **Tools** menu to **Convert** and open an existing record. The record is opened in the **Setting Editor** as a **Setting 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
File > New	Open a New record
File > Open	Open an existing record
File > Read	Read device settings and then create and open a new record
Tools > Settings > Convert	Convert and open an existing record

File > New

Selecting the **New** menu item creates new settings files. QuickSet makes the new settings files from the driver that you specify in the **Settings Editor Selection** dialog box. QuickSet uses the Z-number in the FID string to create a particular version of settings. To get started making SEL-751 settings with the **Settings Editor** in the **Editor Mode**, select **File > New** from the main menu bar, and SEL-751 and **004** from the **Settings Editor Selection** window as shown in *Figure 3.6*.

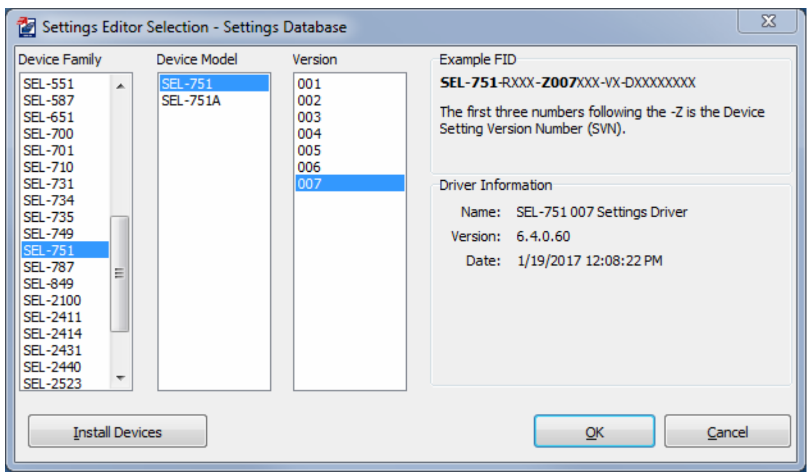


Figure 3.6 Selection of Drivers

After the relay model and settings driver selection, 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.

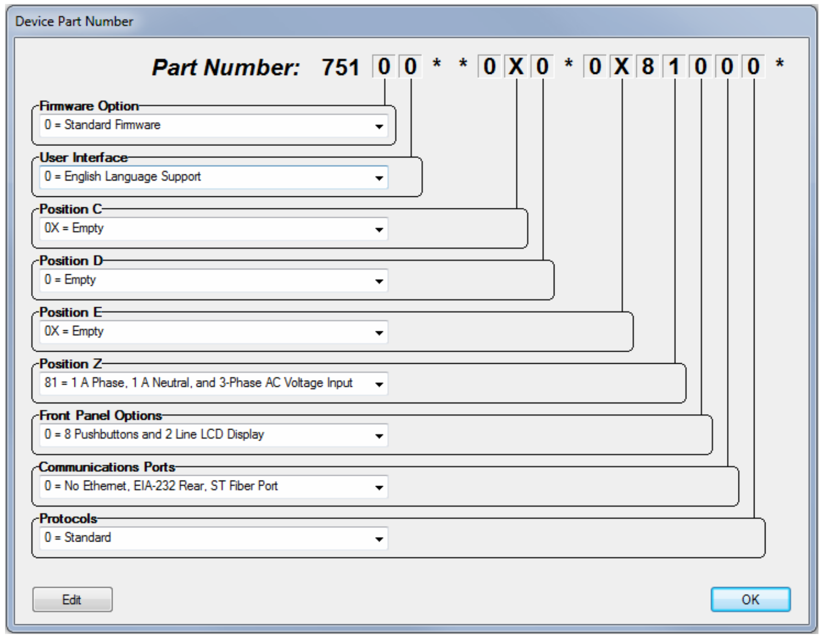


Figure 3.7 Update Part Number

Figure 3.8 shows the **Settings Editor** screen. View the bottom of the Settings Editor window to check the **Settings Driver** number. Compare the QuickSet Settings Driver number and the first portion of the Z-number in the FID string (select **Tools > HMI > HMI > Status**). These numbers must match. QuickSet uses this first portion of the Z-number to determine the correct **Settings Editor** to display.

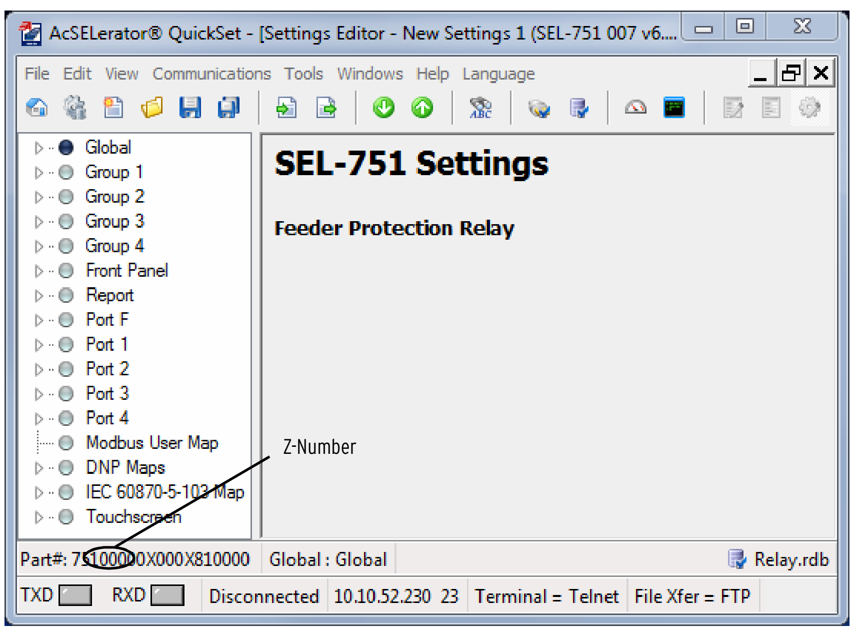


Figure 3.8 New Setting Screen

File > Open

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

File > Read

When the **Read** menu item is selected, QuickSet reads the device settings from a connected device. As QuickSet reads the device, a **Transfer Status** window appears. 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, you would use this utility to upgrade an existing settings file to a newer version because devices are using a newer version number. QuickSet provides a **Convert Settings** report that shows missed, changed, and invalid settings created as a result of the conversion. Review this report to determine whether changes are necessary.

Settings Editor (Editor Mode)

Use the **Settings Editor (Editor Mode)** to enter settings. These features include the 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, QuickSet shows the error at the bottom of the **Settings Editor**. Double-click the error listing to go to the setting and enter valid input.

Expression Builder

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

SELOGIC control equations are a powerful means for customizing device performance. QuickSet simplifies this process with 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*.

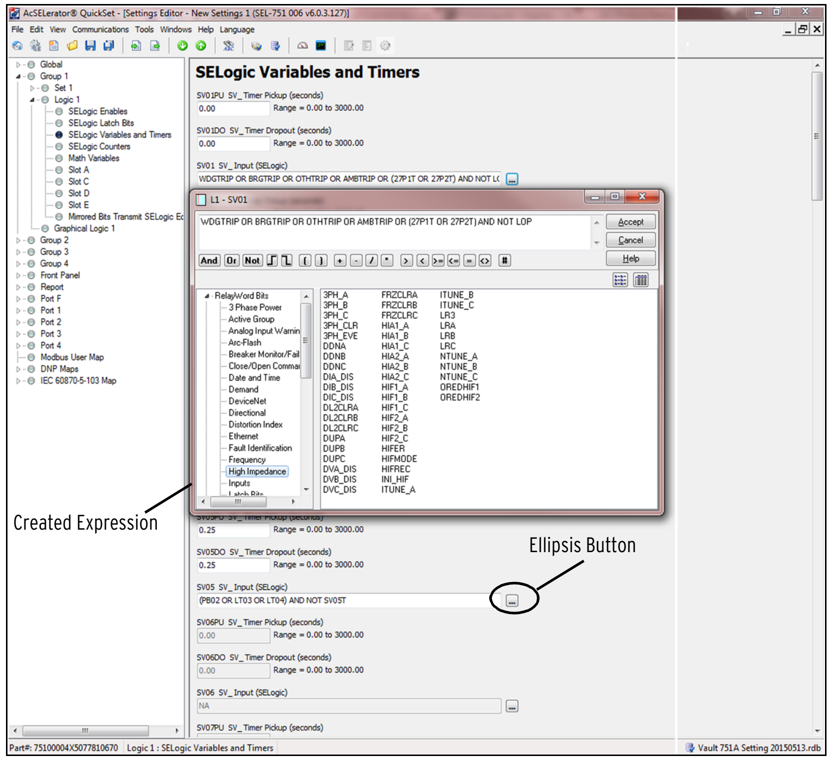


Figure 3.9 Expressions Created With Expression Builder

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. 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.

Touchscreen Settings and Bay Screen Builder

The touchscreen settings are available when the touchscreen display option is selected as part of the front-panel options. This option provides you with the ability to design bay screen one-line diagrams with the help of Bay Screen Builder SEL-5036 Software. For more information, refer to *Bay Screens Design Using QuickSet and Bay Screen Builder on page 9.6*.

File > Save

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

File > Send

To transfer the edits made in the QuickSet edit session, you must send the settings to the relay. 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 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-751 stores to evaluate the performance of a system (select **Tools > Events > Get Event Files**). *Figure 3.10* shows composite screens for retrieving events.

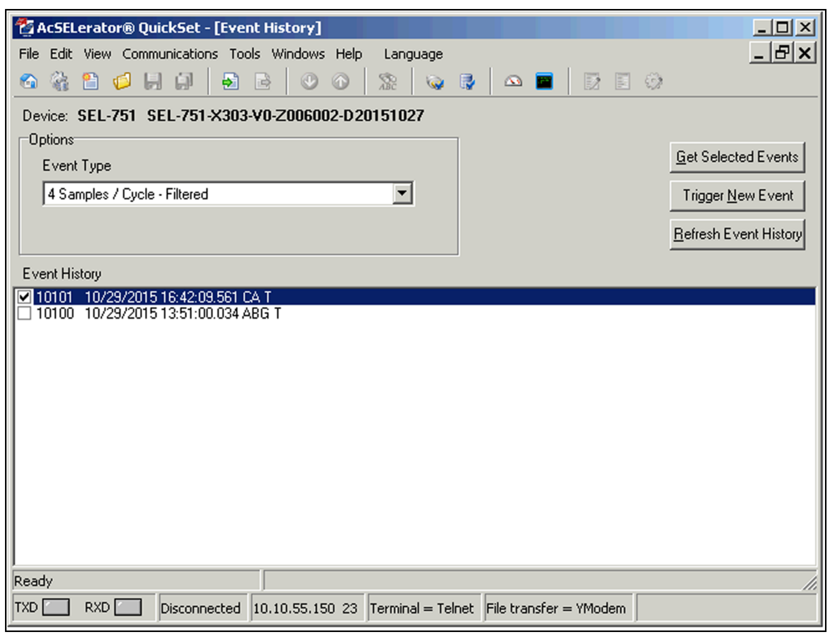


Figure 3.10 Composite Screens for Retrieving Events

Event Waveforms

NOTE: High-impedance fault events are only available with the Arc Sense technology (AST) option. The HIF Events can take as long as an hour to download (at 38400 baud). Increase the baud rate before downloading.

QuickSet allows you to download three types of event data captures from the relay: event reports that use 4 samples/cycle filtered data, 32 samples/cycle unfiltered (raw) data, or high-impedance fault data. See *Section 10: 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, or high-impedance fault data (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 10: Analyzing Events*. To download event files from the device, click **Tools > Events > Get Event Files**. The **Event History** dialog box appears, as shown in *Figure 3.10*.

The SEL-751 is capable of capturing three types of events (4 samples/cycle filtered, 32 samples/cycle raw, and high-impedance fault). These three types of events can be captured in either the compressed ASCII (.cev) or COMTRADE format. QuickSet allows for downloading of the .cev events. For information on how to download COMTRADE events from the relay see *Section 10: Analyzing Events*. The drop-down menu under Event Type allows the selection of which type of event to retrieve using QuickSet.

Get Event

Highlight the event you want to view (e.g., Event 3 in *Figure 3.10*), select the event type with the Options Event type function (4 samples or 32 samples), and click the **Get Selected Event** button. When downloading is complete, QuickSet queries whether to save the file on your computer, as shown in *Figure 3.11*.

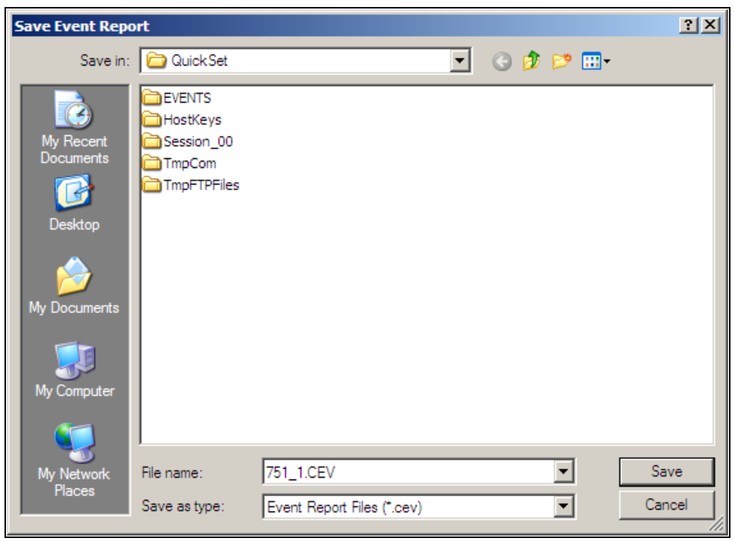


Figure 3.11 Saving the Retrieved Event

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

View Event Files

To view the saved events, you need the SEL-5601 software package. Use the **View Event Files** function from the **Tools > Events** menu to select the event you want to view (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 3.12*. 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.

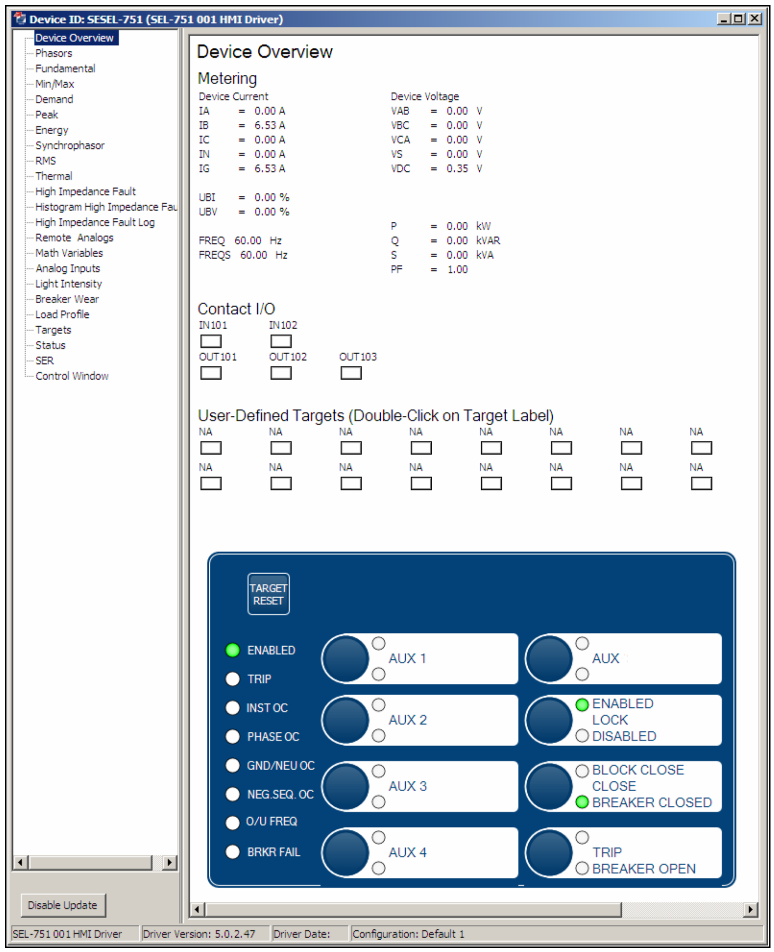


Figure 3.12 Device Overview Screen

You can assign any Relay Word bit to the 16 user-defined target LEDs. To change the present assignment, double-click on the text above the square you want to change. After double-clicking on the text, a box with available Relay Word bits appears in the lower left corner of the screen. Select the appropriate Relay Word bit, and click 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 24 front-panel LEDs. Use the front-panel settings to change the front-panel LED assignment. 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 3.13 shows the control screen. From here you can reset metering data clear the Event History, SER, MIRRORED BITS report, LDP, or trigger events. You can also reset the targets, synchronize with IRIG, and set the time and date. If supported, you can run arc-flash sensor diagnostic tests.

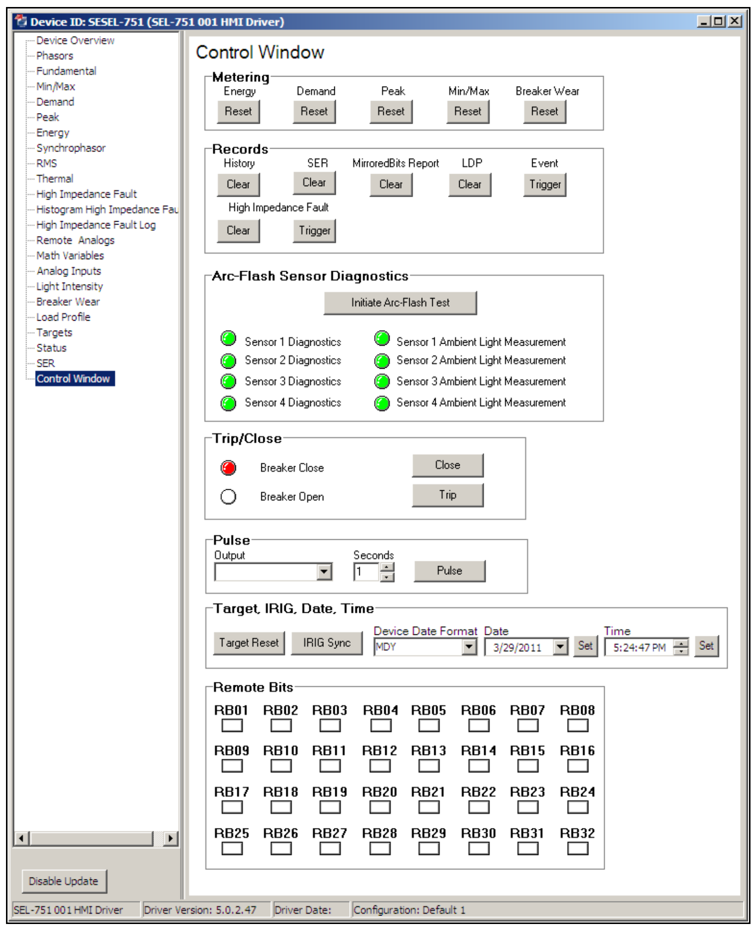


Figure 3.13 Control Screen

To control the Remote bits, click on the appropriate square, then select the operation from the box shown in *Figure 3.14*.

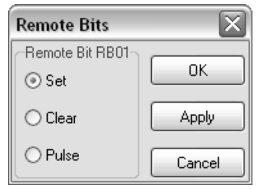


Figure 3.14 Remote Operation Selection

Language Support

NOTE: If the SEL-751 is connected to any SEL communications processor (SEL-203x or RTAC), the corresponding LANG port setting must be set to ENGLISH.

QuickSet has multi-language support. Click on the **Language** menu to choose from English, Spanish, French, or Chinese, as seen in *Figure 3.15*. Selecting any of these choices converts the menu items in QuickSet to the selected language.

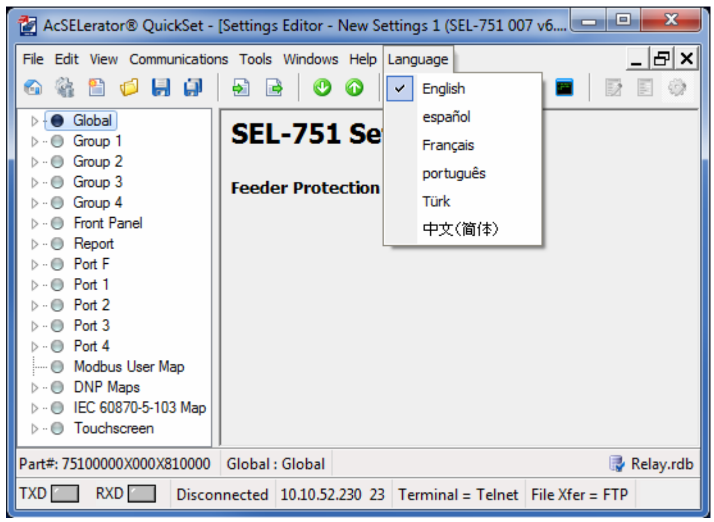


Figure 3.15 Language Support Options

Additionally, if Spanish or English is selected from the **Language** menu, the relay settings displayed by QuickSet are converted into the corresponding language as shown in *Figure 3.16*.

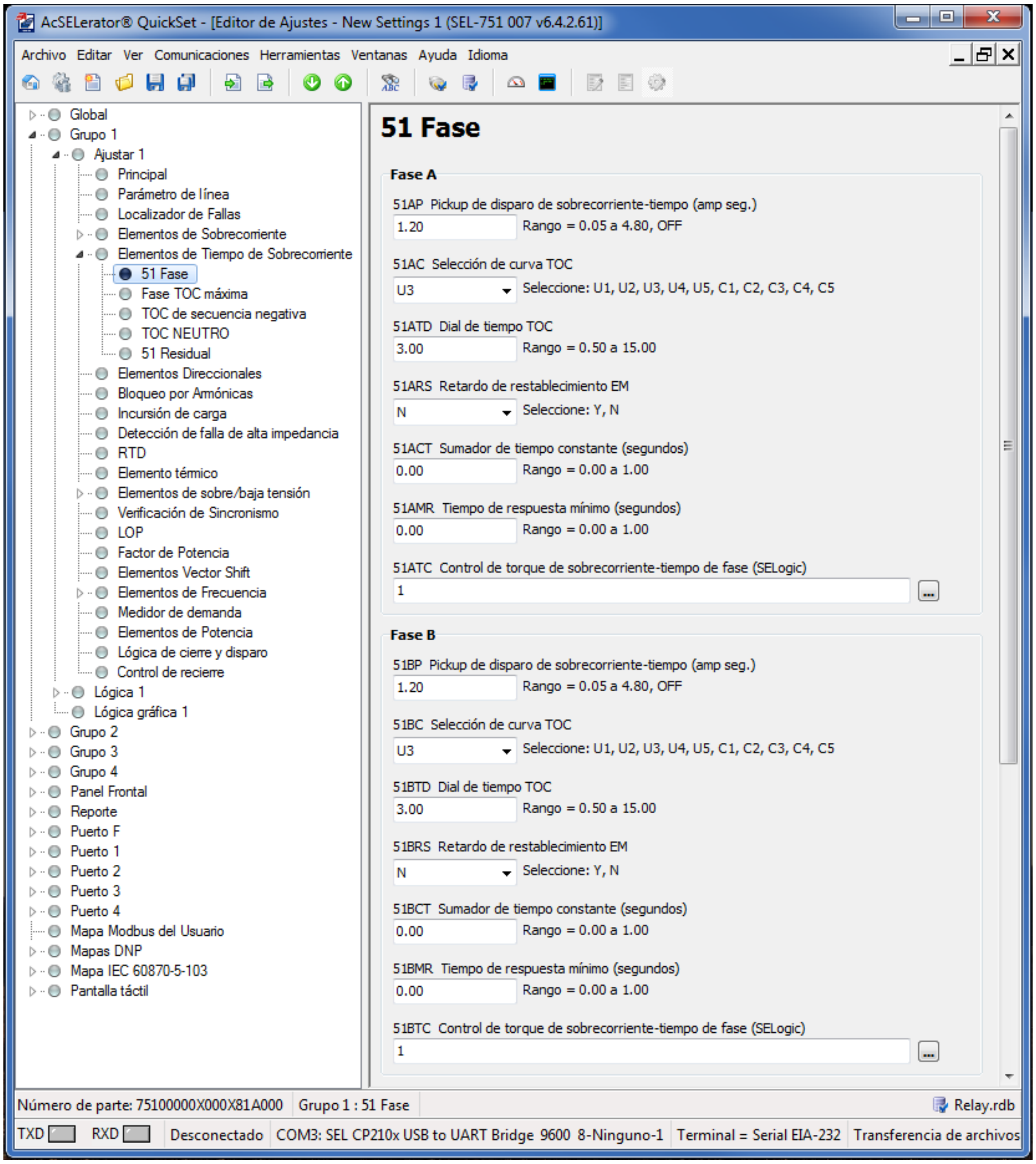


Figure 3.16 Spanish Settings QuickSet Display

NOTE: Once the HMI screen is displayed in QuickSet, the LANG setting does not affect the displayed HMI. To change the language of the HMI, the HMI must be closed, and the LANG setting must be changed, and the HMI reopened.

Each communications port (serial or Ethernet) on the SEL-751 can be independently set to display either English or Spanish. Changing the port setting LANG to SPANISH or ENGLISH results in the QuickSet HMI and all of its available functions to display in the corresponding language. For example, if the **Control Window** is selected in the HMI while the setting LANG := SPANISH, QuickSet displays the Control Window (Ventana de Control) in *Figure 3.17*.

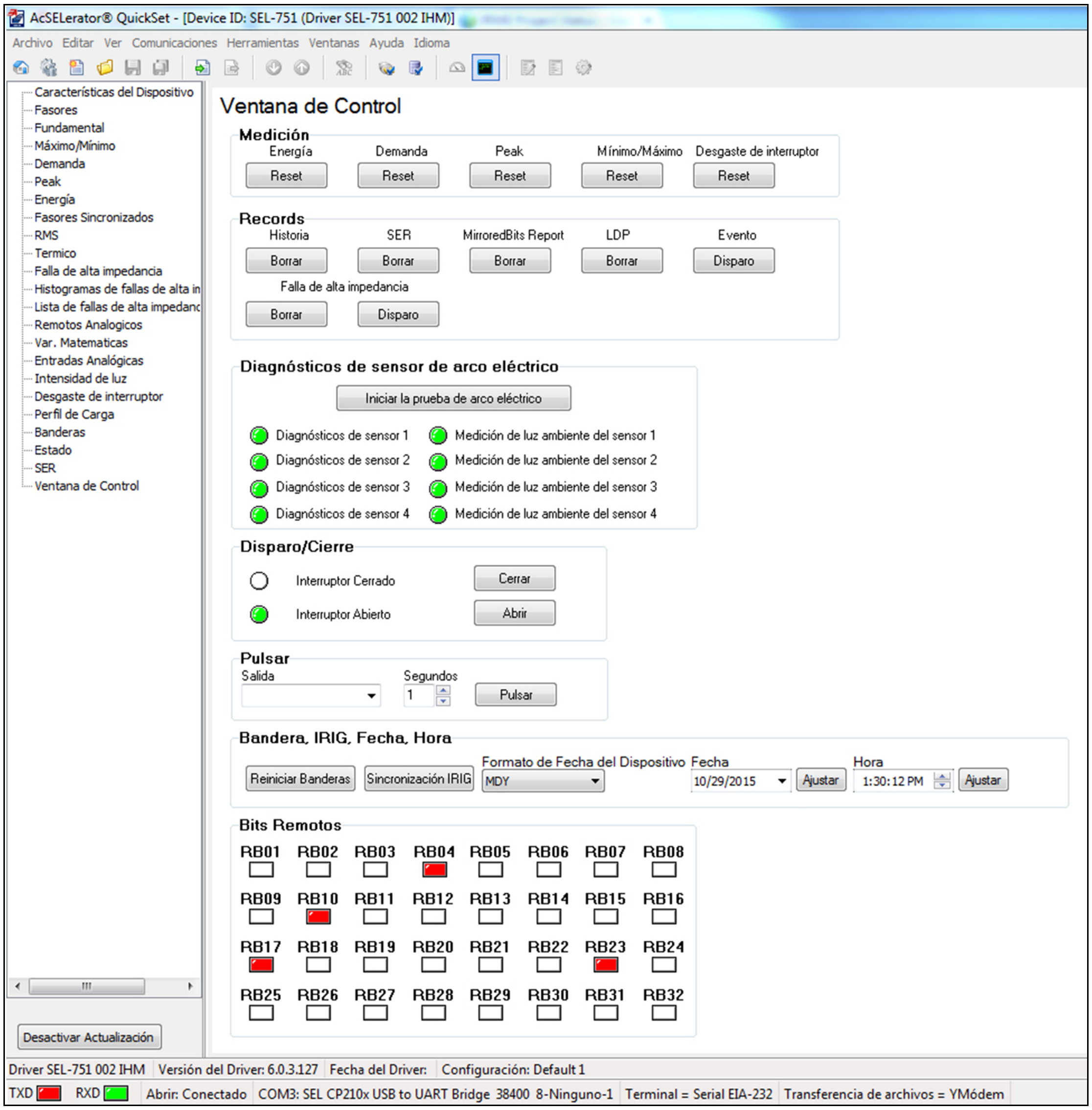


Figure 3.17 Spanish Control Window (Ventana de Control) Display

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 QuickSet Help

Help	Description
General QuickSet	Select **Help** from the main menu bar
SEL-751 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-751 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-751 Feeder Protection 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.

This section includes the following subsections:

Application Data. Lists information that you need to know about the protected equipment before calculating the relay settings. Lists the settings for protection elements included in all models of the SEL-751.

Group Settings (SET Command).

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

Low-Energy Analog (LEA) Voltage Inputs. Discusses the settings associated with LEA voltage inputs.

Overcurrent Elements. Lists the settings associated with overcurrent, time-overcurrent and directional elements.

High-Impedance Fault Detection With Arc Sense Technology. Lists the settings associated with high-impedance fault detection.

Second- and Fifth-Harmonic Blocking Logic. Lists the settings associated with second- and fifth-harmonic blocking logic.

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

IEC Thermal Elements. Lists the settings associated with IEC thermal elements.

Under- and Overvoltage Functions. Lists the settings associated with the under- and overvoltage elements.

Synchronism-Check Elements. Lists the settings associated with synchronism-check elements.

Power Elements. Lists the settings associated with power elements.

Power Factor Elements. Lists the settings associated with power factor elements.

Loss-of-Potential (LOP) Protection. Lists the logic and settings associated with the LOP element.

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

Frequency Protection. Lists the settings associated with over/under frequency, rate-of-change-of-frequency and fast rate-of-change-of-frequency.

Trip/Close Logic. Lists Trip and Close logic.

Reclose Supervision Logic. Describes the logic that supervises automatic reclosing when an open interval time times out—a final condition check right before the close logic asserts the close output contact.

Reclose Logic. Describes all the reclosing relay settings and logic necessary for automatic reclosing (besides the final close logic and reclose supervision logic described previously).

Demand Metering. Lists the settings associated with demand metering.

Logic Settings (SET L Command). 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.

Arc-Flash Protection. Lists the settings for the arc-flash elements including arc-flash overcurrent and time-overlight elements.

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.

Station DC Battery Monitor. Describes station dc battery monitor function and lists the settings.

Breaker Monitor. Lists the settings and describes the breaker monitor function that you can use 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 control equation settings for resetting targets, energy metering, max/min metering, demand metering and peak demand metering.

Access Control. Describes the SELOGIC control equation setting you would use for disabling settings changes from the relay front panel.

Time Synchronization Source. Describes the setting you would use for choosing IRIG1 or IRIG2 as the time synchronization source.

89A and 89B Disconnect Switch Status SELOGIC Control Equations. Describes the settings and logic associated with the disconnect switches.

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

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

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

Report Settings (SET R Command). Lists the settings for the sequential event reports, event, 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.

See *Section 6: Settings* for a list of all settings (*SEL-751 Settings Sheets*) and various methods of accessing them. All current and voltage settings in the SEL-751 are in secondary.

NOTE: The DeviceNet port parameters can only be set at the rear of the relay on the DeviceNet card (see Figure H.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*), the EIA-485 port (see *Appendix E: Modbus RTU Communications*), or the Ethernet port (see *Section 7: Communications*).

Application Data

It is faster and easier for you to calculate settings for the SEL-751 if you collect the following information before you begin:

- System phase rotation and nominal frequency
- Current transformer primary and secondary ratings and connections
- Voltage transformer or low-energy analog (LEA) voltage sensor ratios and connections, if used
- Type and location of resistance temperature devices (RTDs), if used
- Highest expected load current
- Expected fault current magnitudes for ground and three-phase faults

Group Settings (SET Command)

ID Settings

All models of the SEL-751 have the identifier settings described 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-751
UNIT ID LINE 2	16 Characters	TID := FEEDER RELAY

The SEL-751 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 feeder.

Configuration Settings

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

Table 4.2 CT Configuration Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PHASE CT RATIO	1–5000	CTR := 120
NEUTRAL CT RATIO	1–5000	CTRN := 120

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.

Table 4.3 shows the voltage settings. The voltage configuration settings configure the relay voltage inputs to correctly measure and scale the voltage signals. The relay can be ordered with different secondary voltage input configurations—standard voltage inputs rated for 300 Vac or LEA voltage inputs rated for 8 Vac. Refer to *Figure 2.21* for different voltage connections.

Table 4.3 Voltage Configuration Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PHASE PT RATIO	1.00–10000.00	PTR := 180.00
PHASE LEA RATIO	37.50–500000.00	LEA_R := 180.00
PHASE LEA SCALE	1.00–13333.33[a]	LEA_SC := 4.80
SYNCV PT RATIO	1.00–10000.00	PTRS := 180.00
SYNCV LEA RATIO	37.50–500000.00	LEA_S_R := 180.00
SYNCV LEA SCALE	1.00–13333.33[a]	LEA_S_SC := 4.80
XFMR CONNECTION	WYE, DELTA	DELTA_Y := DELTA
VS CONNECTION	VS, 3V0	VSCONN := VS
LINE VOLTAGE	OFF, 20.00–250.00 V[b]	VNOM := 120.00
SINGLE V INPUT	Y, N	SINGLEV := N

[a] Autocalculated.
[b] The line voltage setting range is 20.00–480.00 if DELTA_Y := WYE.

The voltage configuration settings configure the relay voltage inputs to correctly measure and scale the voltage signals. The relay can be ordered with different secondary voltage input configurations—standard voltage inputs rated for 300 Vac or LEA voltage inputs rated for 8 Vac. Refer to *Figure 2.21* for different voltage connections.

The PTR and PTRS settings are applicable and available for setting when the relay is ordered with standard voltage inputs (300 Vac). The LEA_R, LEA_SC, LEA_S_R, and LEA_S_SC settings are applicable to the relay with LEA inputs (8 Vac). The LEA_R and LEA_S_R settings are settable while the LEA_SC and LEA_S_SC settings are autocalculated by the relay and not available for setting as explained in *Low-Energy Analog (LEA) Voltage Inputs*. The DELTA_Y, VSCONN, VNOM, and SINGLEV settings are applicable to either of the voltage input options.

Set the phase PT ratio (PTR) setting equal to the VT ratio. The synchronism-check voltage input VS is an optional single phase-to-neutral or phase-to-phase voltage input. Set the synchronism-check voltage input PT ratio (PTRS) setting equal to the VT ratio of the VS input.

EXAMPLE 4.2 Phase VT Ratio Setting Calculations

Consider a 13.8 kV feeder application where you use 14400:120 V rated voltage transformers (connected in open delta).

Set PTR := 14400/120 := 120 and DELTA_Y := DELTA.

Set the phase LEA ratio (LEA_R) setting equal to the marked LEA sensor ratio. The synchronism-check voltage input VS is an optional single phase-to-neutral or phase-to-phase voltage input. Set the synchronism-check voltage input LEA ratio (LEA_S_R) setting equal to the marked LEA sensor ratio of the VS input.

EXAMPLE 4.3 Phase LEA Ratio Setting Calculations

Consider a 13.8 kV feeder application where you have a 2500:1 ratio LEA sensor (connected in wye).

Set LEA_R := 2500/1 := 2500 and DELTA_Y := WYE.

When phase-to-phase potentials are connected to the relay, set DELTA_Y to DELTA. When phase-to-neutral potentials are connected to the relay, set DELTA_Y to WYE.

In applications where only a single voltage is available, set SINGLEV equal to Y. As shown in *Figure 2.20*, the single voltage must be connected to the A-phase input, but it can be an A-N or an A-B voltage. Be sure to set DELTA_Y equal to WYE for an A-N input or DELTA_Y equal to DELTA for an A-B input voltage. When you set SINGLEV equal to Y, the relay performance changes in the following ways:

- **Power and Voltage Elements**. When you use one voltage, the relay assumes that the system voltages are balanced in both magnitude and phase angle. Power, power factor, and positive-sequence impedance are calculated assuming balanced voltages.
- **Metering.** When you use one voltage, the relay displays magnitude and phase angle for the measured PT. The relay displays zero for the magnitudes of the unmeasured voltages. Balanced voltages are assumed for power, power factor, VG, and 3V2 metering.

Table 4.4 Effect on Group Settings When SINGLEV := Y (Sheet 1 of 2)

Identifier Settings		
Group Setting	**Change**	**Reason**
VNOM	Forced to OFF and hidden	Loss-of-Potential logic requires three-phase voltage.
Line Parameter Settings		
Z1MAG, Z1ANG, Z0MAG, Z0ANG, Z0SMAG, Z0SANG	Hidden	Impedance calculations require three-phase voltage.

Table 4.4 Effect on Group Settings When SINGLEV := Y (Sheet 2 of 2)

Identifier Settings		
Group Setting	**Change**	**Reason**
Enable Settings		
EDIR	Setting may be forced to OFF and hidden	See *Table SET.1: Range Dependencies for the EDIR Setting*.
ELOAD, EFLOC	Forced to N and hidden	These functions require three-phase voltage.
Directional Element Settings (available when EDIR := Y or AUTO)		
ORDER	Refer to *Table SET.2: Range Dependencies for the ORDER Setting* for the ORDER setting dependencies on the SINGLEV setting.	Associated directional element requires three-phase voltage.
50PDIRP, Z2F, Z2R, a2, k2, 50QFP, 50QRP	Hidden	Associated voltage elements require three-phase voltage.
Overvoltage Elements		
59G1P, 59G2P, 59Q1P, 59Q2P	Forced to OFF and hidden	These functions require three-phase voltage.
27InOQ (n=1, 2)	Refer to *Table SET.3: Range Dependencies for 27I Operating Quantities*	These functions require three-phase voltages.
59InOQ (n=1, 2, 3, 4)	Refer to *Table SET.4: Range Dependencies for 59I Operating Quantities*	These functions require three-phase voltages.
Vector Shift Settings		
E78VS	Hidden	Element enable requires three-phase voltages

VNOM Range Check

The relay performs a range check for the VNOM setting that depends upon the voltage-input delta or wye configuration. When the setting DELTA_Y is DELTA, then the allowed range of the VNOM is OFF, 20–250 V (l-l). When the setting DELTA_Y is WYE, then the allowed range of VNOM is OFF, 20–480 V (l-l).

Note that the VNOM setting is always in line-to-line voltage, 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) to avoid a 1.73 increase in terminal voltages from a line-to-ground fault.

EXAMPLE 4.4 VNOM Setting Calculation for Standard Voltage Inputs

Consider a 10 kV (phase-to-phase) system with wye-connected VTs rated 7200:120 (PTR := 60).

The setting for VNOM would be VNOM := 10000/60 := 166.67.

In the case of LEA sensors, the calculated VNOM should be scaled by 37.5 (300/8) to set VNOM at the 300 V base as shown in the following example. The scaling (37.5) is explained in *Low-Energy Analog (LEA) Voltage Inputs*.

EXAMPLE 4.5 VNOM Setting Calculation for LEA Voltage Inputs

Consider a 10 kV (phase-to-phase) system with a wye-connected LEA sensor with a ratio of 2500:1 (LEA_R := 2500).

The setting for VNOM would be VNOM := 10000/2500 • 37.5 := 150.0

Table 4.5 Main Relay Functions That Change With VNOM := OFF

Relay Function	When VNOM := Numeric Value	When VNOM := OFF
Load-encroachment logic (enable setting ELOAD)	Available	Not available
Negative-sequence and positive-sequence voltage polarized directional elements	Available	DIRQE is disabled, FDIRP/ RDIRP disabled, ground directional element ORDER setting choice “Q” not selectable
Phase and negative-sequence element directional control	Available	Not available (defaults to “nondirectional” in levels DIR1–DIR4)
Loss-of-potential logic	Available	Not available
Voltage unbalance logic	Available	Not available
Vector shift element	Available	Not available

Low-Energy Analog (LEA) Voltage Inputs

The SEL-751 can be ordered with different secondary ac input voltage configurations—standard voltage inputs rated for 300 V and LEA voltage inputs rated for 8 V. The LEA voltage inputs are suitable for C37.92 compliant high-impedance sensors, such as capacitive voltage dividers and resistive voltage dividers (see *Figure 4.1*).

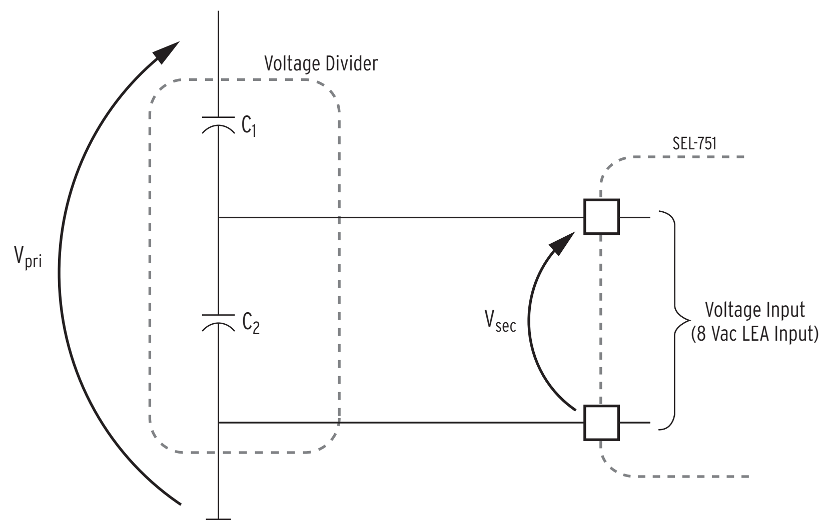


Figure 4.1 Low-Energy Analog Voltage Sensor (Capacitive Voltage Divider)

Derived LEA Scale for 8 Vac LEA Voltage Inputs and Voltage-Related Settings

Irrespective of the voltage input option, standard (300 Vac) or LEA (8 Vac), all the voltage related settings are based at 300 V. For example, the 59 element pickup range for standard voltage inputs is 2.0–300.0 V and this range will remain the same for LEA inputs as well. To maintain the same 300 V base across different voltage options, such as LEA inputs, the relay scales up the input signal by a factor of 37.5 (300 V/8 V). Likewise, you can scale the voltage related pickup settings accordingly to convert the settings from 8 V to 300 V base. Refer to *Example 4.6*. With LEA voltage inputs the relay sees 8 Vac on the voltage inputs as 300 Vac secondary (8 • 37.5 = 300 V). Further, to realize accurate primary voltage metering, the relay uses the derived LEA scales, LEA_SC and LEA_S_SC. These scale factors are autocalculated by the relay based on LEA_R and LEA_S_R settings, respectively. The LEA scale is derived as follows:

LEA_SC = LEA_R • (8/300)

where LEA_R is the marked LEA sensor ratio.

The ratio of V_{pri} to V_{sec} of the voltage divider shown in *Figure 4.1* is referred to as true ratio. Ideally, the marked LEA sensor ratio should equal the true ratio. If not, apply the following additional ratio correction factors.

For example, if an LEA sensor has an LEA sensor ratio of 1400:1,

LEA_R = 1400

LEA_SC = 1400 • 8/300 = 37.33

EXAMPLE 4.6 Voltage Setting Conversion to 300 V Base

A voltage divider (10000 ratio) is connected between a 12.47 kV system (7.2 kV line-to-neutral) and the LEA inputs.

7200 V / 10000 = 0.72 V
(actual voltage divider output to the 8 Vac LEA inputs; 8 V base)

0.72 V • (300/8) = 27 V
(the relay thinks it is looking at 27 V on a 300 V base, not 0.72 V on an 8 V base)

27 V is the nominal adjusted secondary voltage—adjusted by the 300/8 factor from an 8 V base to a 300 V base. For this same example, if a 0.8 V output of the 8 Vac LEA (8 V base) is deemed an overvoltage condition, then an overvoltage element pickup setting (e.g., 59P1P) could be set at 59P1P = 0.8 V • (300/8) = 30 V (300 V base).

LEA Ratio and Angle Correction Factors (Global Settings)

In the SEL-751 with LEA voltage inputs, Global settings VARCF, VBRCF, VCRCF, VSRCF, VAPAC, VBPAC, VCPAC, and VSPAC are applied to their respective voltage inputs, **VA**, **VB**, **VC**, and **VS**. These normalized secondary voltages are used throughout the SEL-751. Refer to *Table 4.69* under Global Settings for these settings.

Ratio Correction Factors (RCF) for Voltage Inputs

The ratio correction factor (RCF) settings minimize the magnitude error by compensating for the irregularities (on a per-phase basis) of the voltage dividers connected between the primary voltage system and the LEA inputs. The derivation of the RCF value for a voltage divider for a particular phase is defined as follows:

$$RCF = \frac{\text{true ratio}}{\text{marked ratio}} = \frac{V_{pri}/V_{\text{sec}}}{\text{LEA\_R}} = \frac{V_{pri}}{V_{\text{sec}} \bullet \text{LEA\_R}}$$

Equation 4.1

where:

V_{pri}	=	test voltage applied to the primary side of the voltage divider
V_{sec}	=	resultant voltage measured on the secondary side of the voltage divider
True ratio	=	V_{pri} / V_{sec}
Marked ratio	=	LEA_R = effective nominal LEA sensor ratio of the voltage divider connected between the primary voltage system and the LEA input.

The marked LEA sensor ratio of the voltage divider is always provided by the manufacturer and often the per phase RCF values are also provided.

If the voltage divider is perfect, then

V_{pri} / V_{sec} = LEA_R and RCF = 1.000

Therefore, the measured voltage divider performance equals the marked ratio of the voltage divider, as given by the manufacturer. But such perfect conditions are usually not the case.

If the voltage divider is putting out more voltage (V_{sec}) than nominally expected for an applied voltage input (V_{pri}), then

V_{pri} / V_{sec} < LEA_R and RCF < 1.000

An example of an RCF value less than 1.000 is found in *Example 4.7*. In this example, setting VBRCF = 0.883 brings down the too-high voltage on voltage input **VB** (0.82 V is brought down to nominal 0.72 V).

If the voltage divider is putting out less voltage (V_{sec}) than nominally expected for an applied voltage input (V_{pri}), then

V_{pri} / V_{sec} > LEA_R and RCF > 1.000

EXAMPLE 4.7 Normalizing Voltages With Ratio Correction Factors

A voltage divider is connected to the 8 Vac LEA voltage inputs (see Figure 4.1). The RCF values per phase for the voltage divider are given as follows:

V_{ARCF} = 1.078 (voltage input **VA**)
V_{BRCF} = 0.883 (voltage input **VB**)
V_{CRCF} = 1.112 (voltage input **VC**)

The marked ratio of the voltage divider is given as:

LEA_R = 10000

What are the true ratios of each phase of the voltage divider?

true ratio = V_{pri}/V_{sec}

V_{pri} and V_{sec} are measured in manufacturer tests to derive RCF values as shown in Equation 4.1 and accompanying explanation. From Equation 4.1:

RCF • LEA_R = V_{pri}/V_{sec} = true ratio
1.078 • 10000 = 10780 (true ratio for voltage input **VA**)
0.883 • 10000 = 8830 (true ratio for voltage input **VB**)
1.112 • 10000 = 11120 (true ratio for voltage input **VC**)

Note that these true ratios vary from 8830 to 11120, while the marked ratio of the voltage divider is given as 10000.

Consider what is happening in *Example 4.7*. First, assume the primary voltage (V_{pri}) is the same magnitude for each phase. When this primary voltage is run through the respective true ratios, the secondary voltage outputs vary widely. Presuming a primary voltage of 12.47 kV (7.2kV line-to-neutral), the resultant secondary voltages are listed below:

7200 V / 10780 = 0.67 V (true secondary voltage to voltage input **VA**)

7200 V / 8830 = 0.82 V (true secondary voltage to voltage input **VB**)

7200 V / 11120 = 0.65 V (true secondary voltage to voltage input **VC**)

Note that the true secondary voltages to voltage inputs **VA** and **VC** are running low (below the normalized secondary voltage 0.72 V = 7200 V / 10000), while the voltage to voltage input **VB** is running high (above the normalized secondary voltage 0.72 V). But the RCF values adjust these true secondary voltages to normalized secondary voltage:

0.67 V • 1.078 = 0.72 V (normalized voltage from voltage input **VA**)

0.82 V • 0.883 = 0.72 V (normalized voltage from voltage input **VB**)

0.65 V • 1.112 = 0.72 V (normalized voltage from voltage input **VC**)

Again, the normalized secondary voltage (0.72 V) is the same for all three phases in this example, because the primary voltage is assumed to be the same magnitude for each phase (7200 V). The relay uses these normalized secondary voltages for all the voltage-based protection elements and metering. The true secondary voltages cannot be seen (via the SEL-751) unless the RCF values are set to unity (RCF := 1.000).

Phase Angle Compensation (PAC) for Voltage Inputs

Use the VAPAC, VBPAC, VCPAC, and VSPAC voltage phase-angle correction Global settings for the voltage inputs **VA**, **VB**, **VC**, and **VS**, respectively. These settings compensate for the phase error caused by the voltage divider and the cable connected to the relay. Use a positive phase angle correction setting if the resulting phase error is negative and vice versa. For example, if the resulting phase error on the **VA** input is –1.00 degree, then set VAPAC := 1.00 degrees.

Line Parameter Settings

Table 4.6 Line Parameter Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
POS SQ LN Z MAG	0.10–510.00 ohms[a]	Z1MAG := 2.14[a]
POS SQ LN Z ANG	5.00–90.00 deg	Z1ANG := 68.86
ZERO SQ LN Z MAG	0.10–510.00 ohms[a]	Z0MAG := 6.38[a]
ZERO SQ LN Z ANG	5.00–90.00 deg	Z0ANG := 72.47
ZERO SQ SR Z MAG	0.10–510.00 ohms[a]	Z0SMAG := .36[a]
ZERO SQ SR Z ANG	0.00–90.00 deg	Z0SANG := 84.61
LINE LENGTH	0.10–999.00	LL := 0.10–999

[a] Settings ranges and default ohm values shown are for 5 A nominal CT rating. Multiply by 5 for 1 A CTs.

NOTE: The relay does not require line impedance settings when setting SINGLEV= Y, and hides these settings from the **SET** and **SHO** commands.

The line would typically use line impedance settings Z1MAG, Z1ANG, Z0MAG, and Z0ANG in the fault locator and in automatically making directional element settings Z2F, Z2R, Z0F, and Z0R. Use a corresponding line length setting (LL) in the fault locator.

If the protected line belongs to a hybrid power system, such as shown in *Figure 4.46*, refer to *Z0MTA—Zero-Sequence Maximum Torque Angle* for information on the Z0MTA setting.

On both hybrid and solidly grounded power systems, Z0ANG must be set to the actual zero-sequence line angle to allow correct fault locator operation for forward faults involving ground.

The line impedance settings Z1MAG, Z1ANG, Z0MAG, and Z0ANG are set in Ω secondary. Line impedance (Ω primary) is converted to Ω secondary:

Ω primary • (CTR/PTR) = Ω secondary

where:

CTR = phase (**IA, IB, IC**) current transformer ratio

PTR = phase (**VA, VB, VC**) potential transformer ratio

Line length setting LL is unitless and corresponds to the line impedance settings. For example, if a particular line length is 15 miles, enter the line impedance values (Ω secondary) and then enter the corresponding line length:

LL = 15.00 (miles)

If this length of line is measured in kilometers rather than miles, then enter:

LL = 24.14 (kilometers)

Fault Location

The relay reports the fault location if the EFLOC setting := Y and the fault locator operates successfully after an event report is generated. If the fault locator does not operate successfully, $$$$$$ is listed in the field. Fault location is based on the line impedance settings Z1MAG, Z1ANG, Z0MAG, and Z0ANG; source impedance settings Z0SMAG and Z0SANG; and corresponding line length setting LL. Because the fault locating function requires three-phase voltages, the Group setting EFLOC cannot be set to Y when Group setting VNOM := OFF. Similarly, the Group setting EFLOC is hidden and set to N internally when the Group setting SINGLEV := Y or the relay is ordered with no voltage inputs.

Table 4.7 Fault Locator Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
FLT LOC ENABLE	Y, N	EFLOC := N

Overcurrent Elements

Four levels of instantaneous/definite-time elements are available for phase, neutral, residual, and negative-sequence overcurrent as shown in *Table 4.8* through *Table 4.11* and in *Figure 4.2*.

Each element can be torque controlled through the use of appropriate SELOGIC control equations (for example, when 50P1TC := IN401, the 50P1 element is operational only if IN401 is asserted).

Table 4.8 Maximum Phase Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
MAXP OC TRIP LVL	OFF, 0.25–100.00 A [a] 0.05–20.00 A [b]	50P1P := 10.00 50P1P := 2.00
MAXP OC TRIP DLY	OFF, 0.00–400.00 sec	50P1D := 0.00
MAXP OC TRQ CON	SELOGIC	50P1TC := 1
MAXP OC TRIP LVL	OFF, 0.25–100.00 A [a] 0.05–20.00 A [b]	50P2P := 10.00 50P2P := 2.00
MAXP OC TRIP DLY	OFF, 0.00–400.00 sec	50P2D := 0.00
MAXP OC TRQ CON	SELOGIC	50P2TC := 1
MAXP OC TRIP LVL	OFF, 0.25–100.00 A [a] 0.05–20.00 A [b]	50P3P := 10.00 50P3P := 2.00
MAXP OC TRIP DLY	OFF, 0.00–400.00 sec	50P3D := 0.00
MAXP OC TRQ CON	SELOGIC	50P3TC := 1
MAXP OC TRIP LVL	OFF, 0.25–100.00 A [a] 0.05–20.00 A [b]	50P4P := 10.00 50P4P := 2.00
MAXP OC TRIP DLY	OFF, 0.00–400.00 sec	50P4D := 0.00
MAXP OC TRQ CON	SELOGIC	50P4TC := 1

[a] For I_{NOM} = 5 A.
[b] For I_{NOM} = 1 A.

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.

NOTE: When using the output of harmonic blocking logic to torque-control 50 elements set with a pickup greater than 8 • INOM, the harmonic blocking could nullify the peak detector feature of the corresponding 50 element. Refer to the Second- and Fifth-Harmonic Blocking Logic on page 4.86.

The phase instantaneous overcurrent elements (50P1 through 50P4; see *Figure 4.2*) normally operate by using the output of the one cycle cosine-filtered phase current. During severe CT saturation, the cosine-filtered phase current magnitude can be substantially reduced because of the high harmonic content and reduced magnitude of the distorted secondary waveform. If the overcurrent element relied only on the output of the cosine-filtered secondary current, the operation of any high-set instantaneous overcurrent element might be severely delayed and jeopardized. For any phase instantaneous overcurrent element in the SEL-751 that is set greater than eight times the relay current input rating (40 A in a 5 A relay), the overcurrent element also operates on the output of a bipolar peak detector if the current waveform is highly distorted, as is the case with severe CT saturation. This ensures fast operation of the 50P*n* 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.

NOTE: If channel IN is rated 0.2 A nominal, then it is recommended that 50NnD (n = 1–4) be set to at least a minimum 2-cycle time delay.

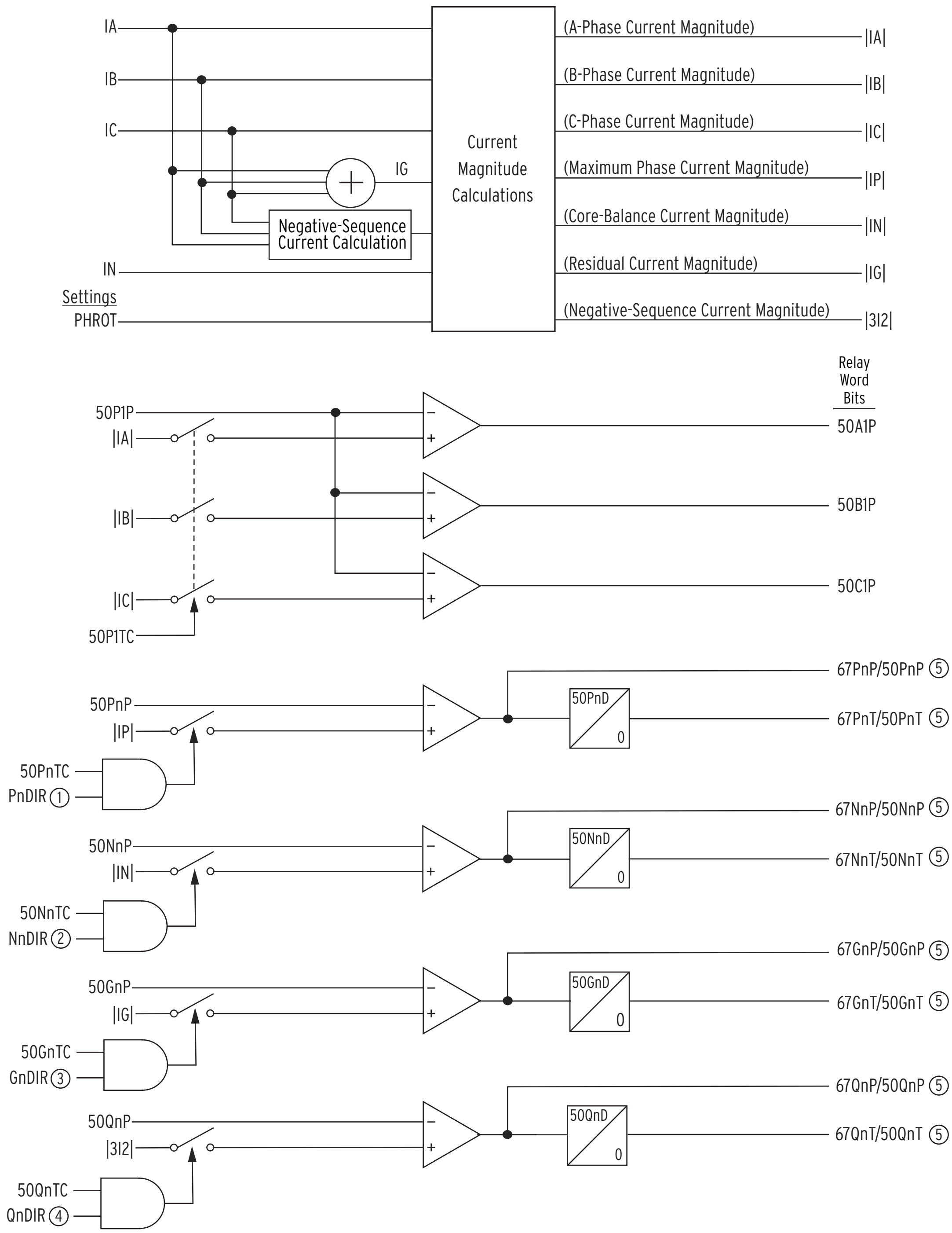
NOTE: When a switch or breaker closes, the three poles may not close at the same time, creating a momentary current unbalance condition. To override this condition use an overcurrent trip delay (for example, 50NnD := 0.05 s).

Table 4.9 Neutral Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
NEUT OC TRIP LVL	OFF, 0.25–100.00 A[a] 0.05–20.00 A[b] 0.01–4.00 A[c]	50N1P := OFF
NEUT OC TRIP DLY	OFF, 0.00–400.00 sec	50N1D := 0.50
NEUT OC TRQ CON	SELOGIC	50N1TC := 1
NEUT OC TRIP LVL	OFF, 0.25–100.00 A[a] 0.05–20.00 A[b] 0.01–4.00 A[c]	50N2P := OFF
NEUT OC TRIP DLY	OFF, 0.00–400.00 sec	50N2D := 0.50
NEUT OC TRQ CON	SELOGIC	50N2TC := 1
NEUT OC TRIP LVL	OFF, 0.25–100.00 A[a] 0.05–20.00 A[b] 0.01–4.00 A[c]	50N3P := OFF
NEUT OC TRIP DLY	OFF, 0.00–400.00 sec	50N3D := 0.50
NEUT OC TRQ CON	SELOGIC	50N3TC := 1
NEUT OC TRIP LVL	OFF, 0.25–100.00 A[a] 0.05–20.00 A[b] 0.01–4.00 A[c]	50N4P := OFF
NEUT OC TRIP DLY	OFF, 0.00–400.00 sec	50N4D := 0.50
NEUT OC TRQ CON	SELOGIC	50N4TC := 1

[a] For I_{NOM} = 5 A.
[b] For I_{NOM} = 1 A.
[c] For I_{NOM} = 0.2 A.

The relay offers two types of ground fault detecting overcurrent elements. The neutral overcurrent elements (50N1T through 50N4T) operate with current measured by the IN input. The residual (RES) overcurrent elements (50G1T through 50G4T) operate with the current derived from the phase currents.



1 To Figure 4.41; 2 From Figure 4.35; 3 From Figure 4.34; 4 From Figure 4.40; 5 Residual Current Magnitude IIGI is the calculated residual current. Not shown in the figure, Relay Word bit ORED50T is asserted if any of the 50PnT, 67PnT, 50NnT, 67NnT, 50GnT, 67GnT, 50QnT or 67QnT Relay Word bits are asserted (n = 1 to 4).

When	For Trip	For Pickup	Nonfunctional
EDIR := Y or AUTO	Use 67PnT, 67NnT, 67QnT, and 67GnT	Use 67PnP, 67NnP, 67QnP, and 67GnP	50PnT, 50NnT, 50QnT, 50GnT, 50PnP, 50NnP, 50QnP, and 50GnP
EDIR := N or[a]	Use 50PnT, 50NnT, 50QnT, and 50GnT	Use 50PnP, 50NnP, 50QnP, and 50GnP	67PnT, 67NnT, 67QnT, 67GnT, 67PnP, 67NnP, 67QnP, and 67GnP

[a] When the directional control option is not ordered and EDIR is automatically set to N and hidden.

Figure 4.2 Instantaneous Overcurrent Element Logic

When a core-balance CT is connected to the relay **IN** input, as in *Figure 2.28*, 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.

Table 4.10 Residual Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
RES OC TRIP LVL	OFF, 0.25–100.00 A[a] 0.05–20.00 A[b]	50G1P := OFF
RES OC TRIP DLY	OFF, 0.00–400.00 sec	50G1D := 0.50
RES OC TRQ CON	SELOGIC	50G1TC := 1
RES OC TRIP LVL	OFF, 0.25–100.00 A[a] 0.05–20.00 A[b]	50G2P := OFF
RES OC TRIP DLY	OFF, 0.00–400.00 sec	50G2D := 0.50
RES OC TRQ CON	SELOGIC	50G2TC := 1
RES OC TRIP LVL	OFF, 0.25–100.00 A[a] 0.05–20.00 A[b]	50G3P := OFF
RES OC TRIP DLY	OFF, 0.00–400.00 sec	50G3D := 0.50
RES OC TRQ CON	SELOGIC	50G3TC := 1
RES OC TRIP LVL	OFF, 0.25–100.00 A[a] 0.05–20.00 A[b]	50G4P := OFF
RES OC TRIP DLY	OFF, 0.00–400.00 sec	50G4D := 0.50
RES OC TRQ CON	SELOGIC	50G4TC := 1

[a] For I_{NOM} = 5 A.
[b] For I_{NOM} = 1 A.

NOTE: When a switch or breaker closes, the three poles may not close at the same time, creating a momentary current unbalance condition. To override this condition use an overcurrent trip delay (for example, 50GnD = 0.05 s).

Table 4.11 Negative-Sequence Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
NSEQ OC TRIP LVL	OFF, 0.25–100.00 A[a] 0.05–20.00 A[b]	50Q1P := OFF
NSEQ OC TRIP DLY	OFF, 0.0–400.0 sec	50Q1D := 0.2
NSEQ OC TRQ CON	SELOGIC	50Q1TC := 1
NSEQ OC TRIP LVL	OFF, 0.25–100.00 A[a] 0.05–20.00 A[b]	50Q2P := OFF
NSEQ OC TRIP DLY	OFF, 0.0–400.0 sec	50Q2D := 0.2
NSEQ OC TRQ CON	SELOGIC	50Q2TC := 1
NSEQ OC TRIP LVL	OFF, 0.25–100.00 A[a] 0.05–20.00 A[b]	50Q3P := OFF
NSEQ OC TRIP DLY	OFF, 0.0–400.0 sec	50Q3D := 0.2
NSEQ OC TRQ CON	SELOGIC	50Q3TC := 1
NSEQ OC TRIP LVL	OFF, 0.25–100.00 A[a] 0.05–20.00 A[b]	50Q4P := OFF
NSEQ OC TRIP DLY	OFF, 0.0–400.0 sec	50Q4D := 0.2
NSEQ OC TRQ CON	SELOGIC	50Q4TC := 1

[a] For I_{NOM} = 5 A.
[b] For I_{NOM} = 1 A.

NOTE: When a switch or breaker closes, the three poles may not close at the same time, creating a momentary current unbalance condition. To override this condition use an overcurrent trip delay (for example, 50QnD = 0.05 s).

The relay offers four negative-sequence overcurrent elements to detect phase-to-phase faults, phase reversal, single phasing, and unbalance load.

When the overcurrent trip delay (50P1D through 50P4D, 50N1D through 50N4D, 50G1D through 50G4D and 50Q1D through 50Q4D) is set to OFF, the time delayed overcurrent element is disabled and the output Relay Word bits (50P1T through 50P4T, 50N1T through 50N4T, 50G1T through 50G4T and 50Q1T through 50Q4T) keep deasserted.

Pickup and Reset Time Curves

Figure 4.3 and *Figure 4.4* show pickup and reset time curves applicable to all nondirectional instantaneous overcurrent elements with sinusoidal waveforms applied (60 Hz or 50 Hz relays). These times do not include output contact operating time and, thus, are accurate for determining element operation time for use in internal SELOGIC control equations. Output contact pickup/dropout time is approximately 4 ms (0.25 cycle for a 60 Hz relay; 0.20 cycle for a 50 Hz relay).

NOTE: The pickup time curve in Figure 4.3 is not valid for conditions with a saturated CT, where the resultant current to the relay is nonsinusoidal.

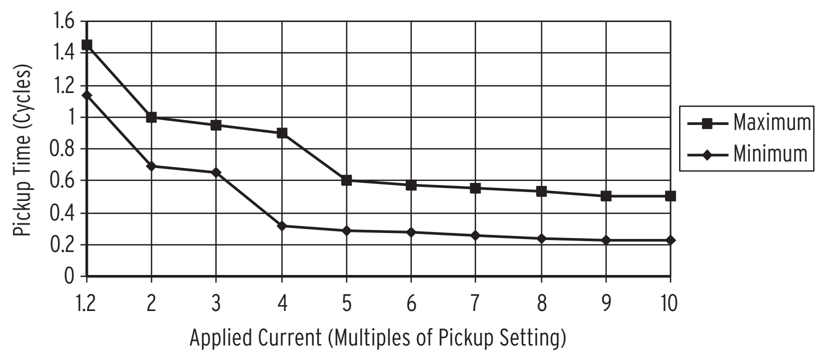


Figure 4.3 Instantaneous Overcurrent Element Pickup Time Curve

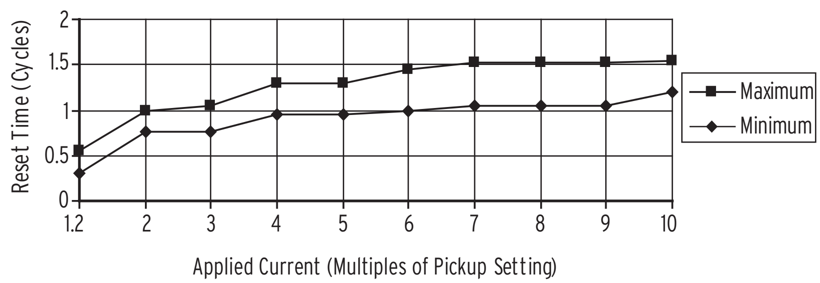


Figure 4.4 Instantaneous Overcurrent Element Reset Time Curve

Time-Overcurrent Elements

One level of inverse-time element is available for A-, B-, C-phases, and negative-sequence overcurrent. Also, two levels of inverse-time elements are available for maximum phase, neutral, and residual overcurrent. See *Table 4.12* through *Table 4.16* for available settings.

You can select from five U.S. and five IEC inverse characteristics. *Table 4.17* and *Table 4.18* show equations for the curves and *Figure 4.10* through *Figure 4.19* 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 the curve times no faster than a minimum response time.

Each element can be torque controlled through use of appropriate SELOGIC control equations (e.g., when 51P1TC := IN401 the 51P1 element is operational only if IN401 is asserted).

Table 4.12 A-, B-, and C-Phase Time-Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
TOC TRIP LVL	OFF, 0.25–24.00 A[a], 0.05–4.80 A[b]	51AP := 6.00 51AP := 1.2
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51AC := U3
TOC TIME DIAL	0.50–15.00[c], 0.01–1.50[d]	51ATD := 3.00
EM RESET DELAY	Y, N	51ARS := N
CONST TIME ADDER	0.00–1.00 sec	51ACT := 0.00
MIN RESPONSE TIM	0.00–1.00	51AMR := 0.00
TOC TRQ CONTROL	SELOGIC	51ATC := 1
TOC TRIP LVL	OFF, 0.25–24.00 A[a], 0.05–4.80 A[b]	51BP := 6.00 51BP := 1.2
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51BC := U3
TOC TIME DIAL	0.50–15.00[c], 0.01–1.50[d]	51BTD := 3.00
EM RESET DELAY	Y, N	51BRS := N
CONST TIME ADDER	0.00–1.00 sec	51BCT := 0.00
MIN RESPONSE TIM	0.00–1.00	51BMR := 0.00
TOC TRQ CONTROL	SELOGIC	51BTC := 1
TOC TRIP LVL	OFF, 0.25–24.00 A[a], 0.05–4.80 A[b]	51CP := 6.00 51CP := 1.2
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51CC := U3
TOC TIME DIAL51_C	0.50–15.00[c], 0.01–1.50[d]	51CTD := 3.00
EM RESET DELAY	Y, N	51CRS := N
CONST TIME ADDER	0.00–1.00 sec	51CCT := 0.00
MIN RESPONSE TIM	0.00–1.00	51CMR := 0.00
TOC TRQ CONTROL	SELOGIC	51CTC := 1

[a] For I_{NOM} = 5 A.
[b] For I_{NOM} = 1 A.
[c] For 51_C := U_.
[d] For 51_C := C_.

The phase time-overcurrent elements, 51AT, 51BT, and 51CT, respond to A-, B-, and C-phase currents, respectively, as shown in *Figure 4.5*.

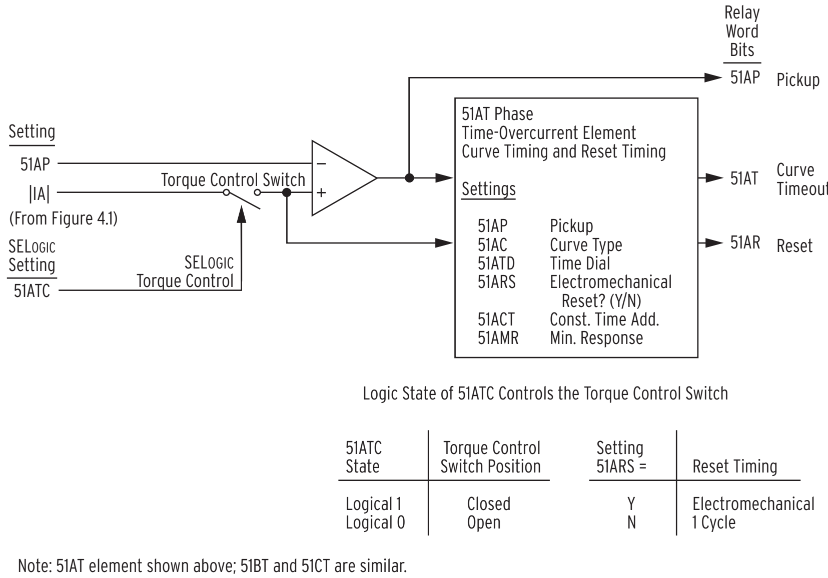


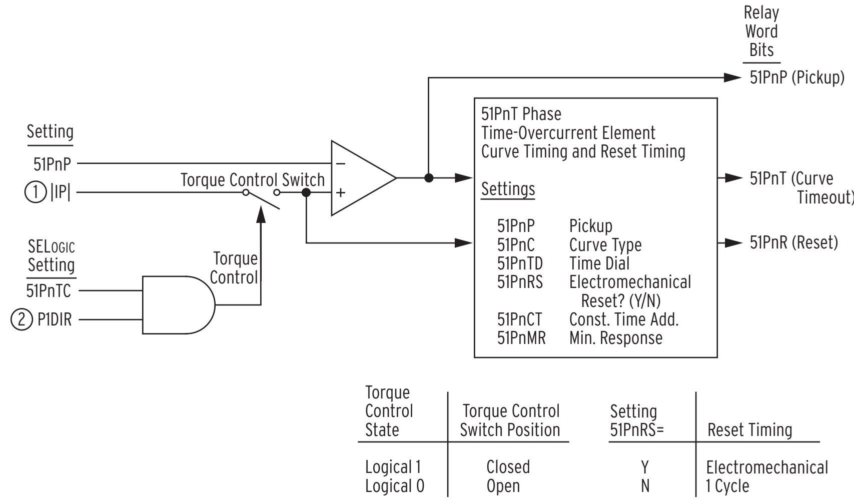
Figure 4.5 Phase Time-Overcurrent Elements 51AT, 51BT, and 51CT

Table 4.13 Maximum Phase Time-Overcurrent

Setting Prompt	Setting Range	Setting Name := Factory Default
TOC TRIP LVL	OFF, 0.25–24.00 A[a], 0.05–4.80 A[b]	51P1P := 6.00 51P1P := 1.2
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51P1C := U3
TOC TIME DIAL	0.50–15.00[c], 0.01–1.50[d]	51P1TD := 3.00
EM RESET DELAY	Y, N	51P1RS := N
CONST TIME ADDER	0.00–1.00 sec	51P1CT := 0.00
MIN RESPONSE TIM	0.00–1.00	51P1MR := 0.00
TOC TRQ CONTROL	SELOGIC	51P1TC := 1
TOC TRIP LVL	OFF, 0.25–24.00 A[a], 0.05–4.80 A[b]	51P2P := 6.00 51P2P := 1.2
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51P2C := U3
TOC TIME DIAL	0.50–15.00[c], 0.01–1.50[d]	51P2TD := 3.00
EM RESET DELAY	Y, N	51P2RS := N
CONST TIME ADDER	0.00–1.00 sec	51P2CT := 0.00
MIN RESPONSE TIM	0.00–1.00	51P2MR := 0.00
TOC TRQ CONTROL	SELOGIC	51P2TC := 1

[a] For I_{NOM} = 5 A.
[b] For I_{NOM} = 1 A.
[c] For 51_C := U_.
[d] For 51_C := C_.

The maximum phase time-overcurrent elements, 51P1T and 51P2T, respond to the highest of A-, B-, and C-phase currents as shown in *Figure 4.6*.



n = 1 or 2.

① From Figure 4.2; ② To Figure 4.41.

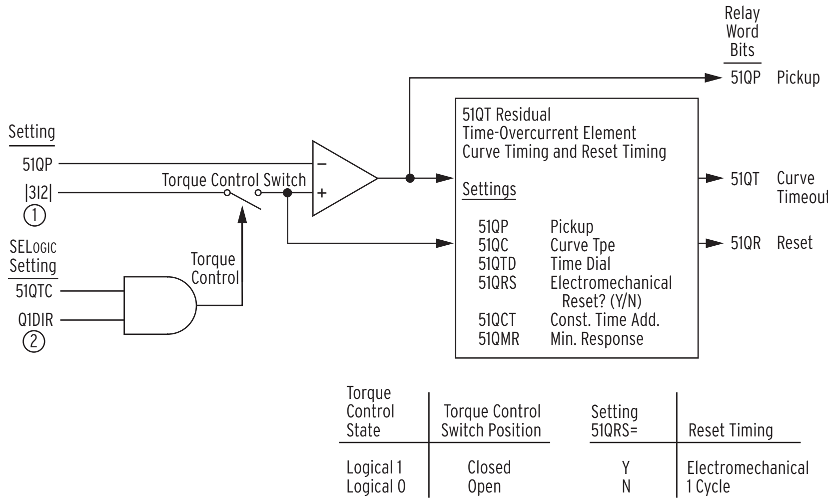
Figure 4.6 Maximum Phase Time-Overcurrent Elements 51P1T and 51P2T

Table 4.14 Negative-Sequence Time-Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
TOC TRIP LVL	OFF, 0.25–24.00 A[a], 0.05–4.80 A[b]	51QP := 6.00 51QP := 1.2
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51QC := U3
TOC TIME DIAL	0.50–15.00[c], 0.01–1.50[d]	51QTD := 3.00
EM RESET DELAY	Y, N	51QRS := N
CONST TIME ADDER	0.00–1.00 sec	51QCT := 0.00
MIN RESPONSE TIM	0.00–1.00	51QMR := 0.00
TOC TRQ CONTROL	SELOGIC	51QTC := 1

[a] For I_{NOM} = 5 A.
[b] For I_{NOM} = 1 A.
[c] For 51_C := U_.
[d] For 51_C := C_.

The negative-sequence time-overcurrent element 51QT responds to the 3I2 current as shown *Figure 4.7*.



① From Figure 4.2; ② Figure 4.40.

Figure 4.7 Negative-Sequence Time-Overcurrent Element 51QT

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

Table 4.15 Neutral Time-Overcurrent Settings (Sheet 1 of 2)

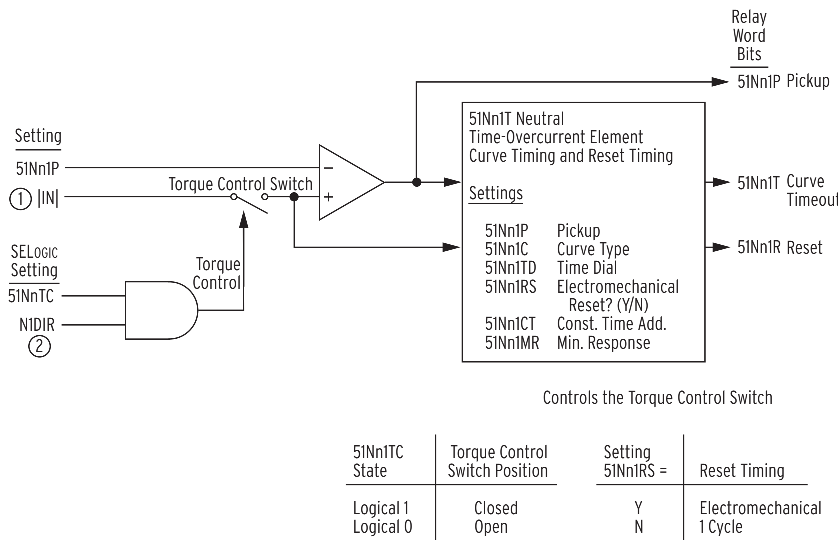
Setting Prompt	Setting Range	Setting Name := Factory Default
TOC TRIP LVL	OFF, 0.25–24.00 A[a] 0.05–4.80 A[b] 10.00–960.00 mA[c]	51N1P := OFF
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51N1C := U3
TOC TIME DIAL	0.50–15.00[d] 0.01–1.50[e]	51N1TD := 1.50
EM RESET DELAY	Y, N	51N1RS := N
CONST TIME ADDER	0.00–1.00 sec	51N1CT := 0.00
MIN RESPONSE TIM	0.00–1.00	51N1MR := 0.00
TOC TRQ CONTROL	SELOGIC	51N1TC := 1
TOC TRIP LVL	OFF, 0.25–24.00 A[a] 0.05–4.80 A[b] 10.00–960.00 mA[c]	51N2P := OFF
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51N2C := U3
TOC TIME DIAL	0.50–15.00[d] 0.01–1.50[e]	51N2TD := 1.50
EM RESET DELAY	Y, N	51N2RS := N
CONST TIME ADDER	0.00–1.00 sec	51N2CT := 0.00

Table 4.15 Neutral Time-Overcurrent Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
MIN RESPONSE TIM	0.00–1.00	51N2MR := 0.00
TOC TRQ CONTROL	SELOGIC	51N2TC := 1

[a] For I_{NOM} = 5 A.
[b] For I_{NOM} = 1 A.
[c] For I_{NOM} = 0.2 A.
[d] For 51_C := U_.
[e] For 51_C := C_.

The neutral time-overcurrent elements, 51N1T and 51N2T, respond to neutral channel current IN as shown *Figure 4.8*.



n = 1 or 2

① From Figure 4.2; ② Figure 4.35

Figure 4.8 Neutral Time-Overcurrent Elements 51N1T and 51N2T

Table 4.16 Residual Time-Overcurrent Settings (Sheet 1 of 2)

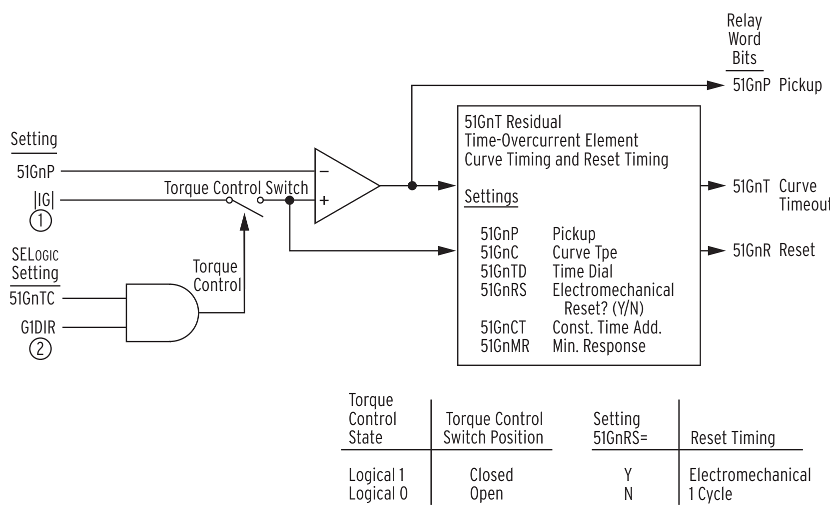
Setting Prompt	Setting Range	Setting Name := Factory Default
TOC TRIP LVL	OFF, 0.25–24.00 A[a], 0.05–4.80 A[b]	51G1P := 0.50 51G1P := 0.10
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51G1C := U3
TOC TIME DIAL	0.50–15.00[c], 0.01–1.50[d]	51G1TD := 1.50
EM RESET DELAY	Y, N	51G1RS := N
CONST TIME ADDER	0.00–1.00 sec	51G1CT := 0.00
MIN RESPONSE TIM	0.00–1.00	51G1MR := 0.00
TOC TRQ CONTROL	SELOGIC	51G1TC := 1
TOC TRIP LVL	OFF, 0.25–24.00 A[a], 0.05–4.80 A[b]	51G2P := 0.50 51G2P := 0.10
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51G2C := U3

Table 4.16 Residual Time-Overcurrent Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
TOC TIME DIAL	0.50–15.00[c], 0.01–1.50[d]	51G2TD := 1.50
EM RESET DELAY	Y, N	51G2RS := N
CONST TIME ADDER	0.00–1.00 sec	51G2CT := 0.00
MIN RESPONSE TIM	0.00–1.00	51G2MR := 0.00
TOC TRQ CONTROL	SELOGIC	51G2TC := 1

[a] For I_{NOM} = 5 A.
[b] For I_{NOM} = 1 A.
[c] For 51_C := U_.
[d] For 51_C := C_.

The residual time-overcurrent elements, 51G1T and 51G2T, respond to residual current IG as shown in *Figure 4.9*.



n = 1 or 2

① From Figure 4.2; ② From Figure 4.34

Figure 4.9 Residual Time-Overcurrent Elements 51G1T and 51G2T

Time-Overcurrent Curves

NOTE: The time-overcurrent curves in Figure 4.10 through Figure 4.19 show operating times flattening at M = 30 (30 multiples of pickup). This is true for the overcurrent pickup set equal to the CT nominal rating (I_{NOM}) and no significant dc offset. The flattening may start at different points depending on the actual pickup setting, e.g., if pickup is 4.8 • I_{NOM}, the curve starts flattening at M = 30/4.8 = 6.25.

The following information describes the curve timing for the curve and time dial settings made for the time-overcurrent elements (see *Figure 4.5* through *Figure 4.9*). The U.S. and IEC time-overcurrent relay curves are shown in *Figure 4.10* through *Figure 4.19*. Curves U1, U2, and U3 (*Figure 4.10* through *Figure 4.12*) 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 51AT, 51BT, 51CT, 51PIT, 51P2T, 51N1T, 51N2T, 51G1T, 51G2T, or 51QT are asserted.

Table 4.17 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 4.10*
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 4.11*
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 4.12*
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 4.13*
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 4.14*

where:
t_p = operating time in seconds (see *Note on page 4.22*)
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 4.18 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 4.15*
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 4.16*
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 4.17*
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 4.18*
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 4.19*

where:
t_p = operating time in seconds (see *Note on page 4.22*)
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]

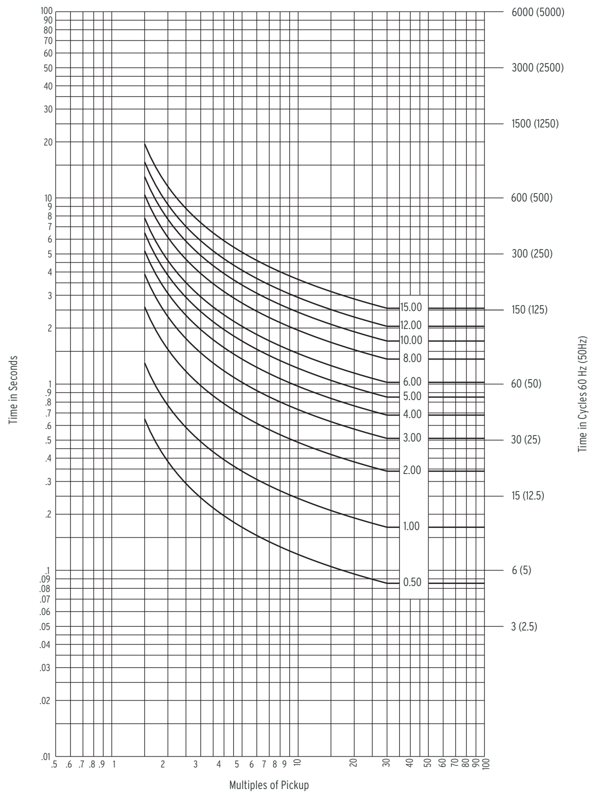


Figure 4.10 U.S. Moderately Inverse Curve: U1

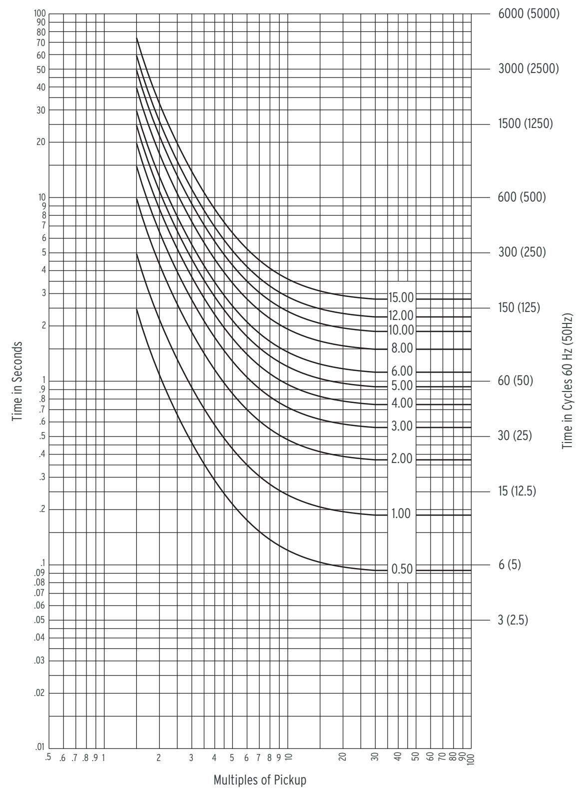


Figure 4.11 U.S. Inverse Curve: U2

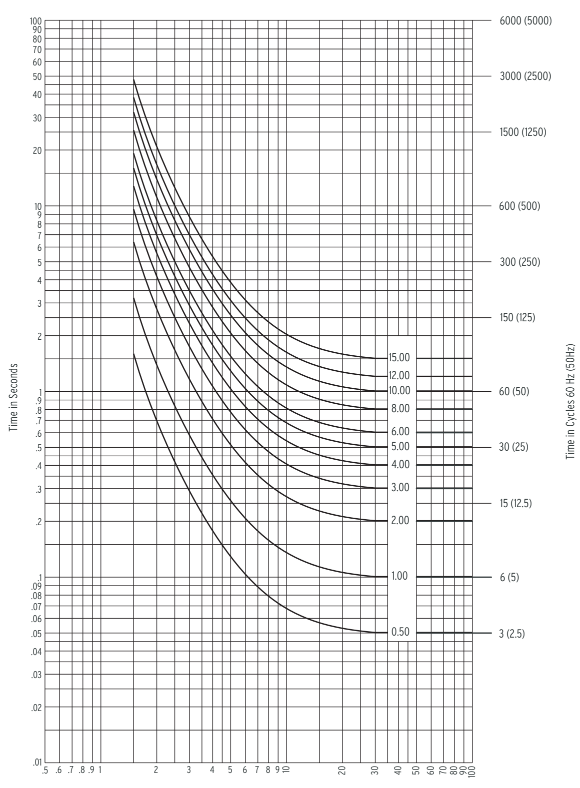


Figure 4.12 U.S. Very Inverse Curve: U3

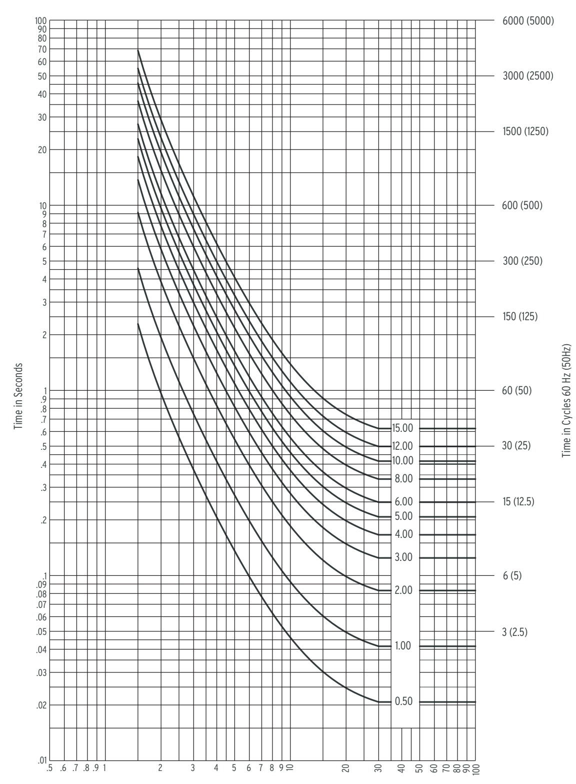


Figure 4.13 U.S. Extremely Inverse Curve: U4

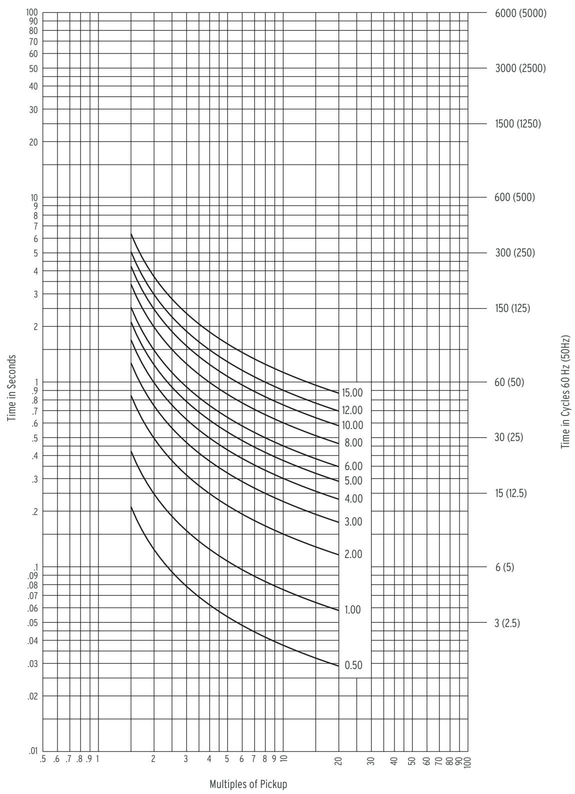


Figure 4.14 U.S. Short-Time Inverse Curve: U5

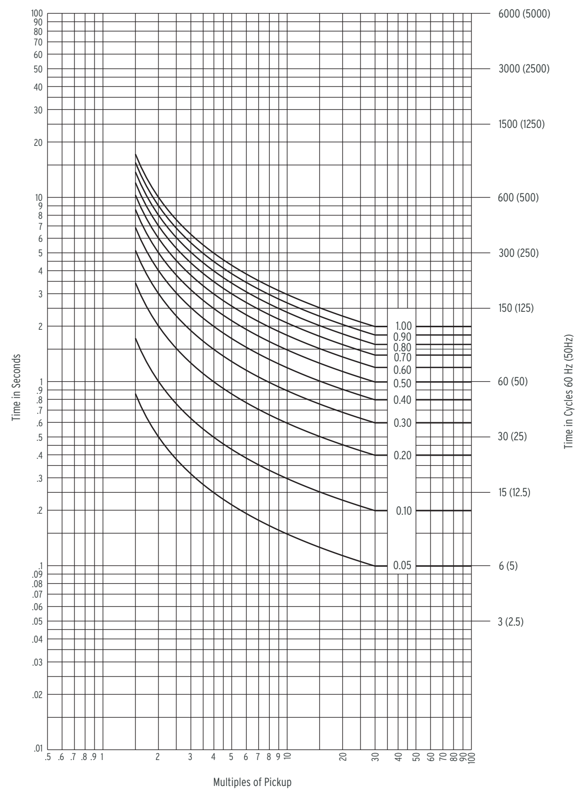


Figure 4.15 IEC Class A Curve (Standard Inverse): C1

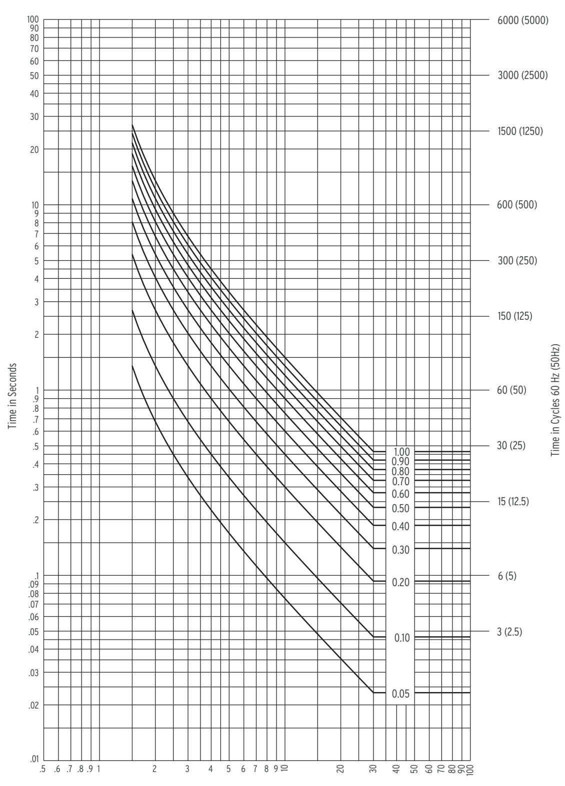


Figure 4.16 IEC Class B Curve (Very Inverse): C2

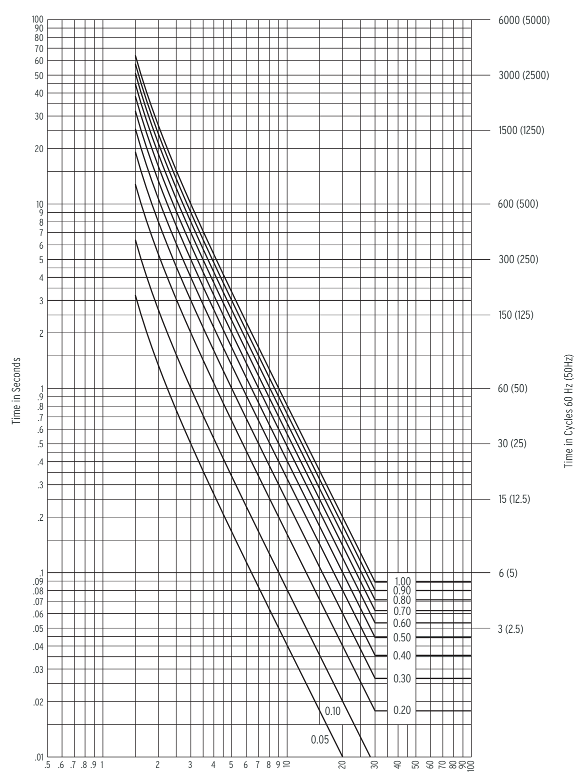


Figure 4.17 IEC Class C Curve (Extremely Inverse): C3

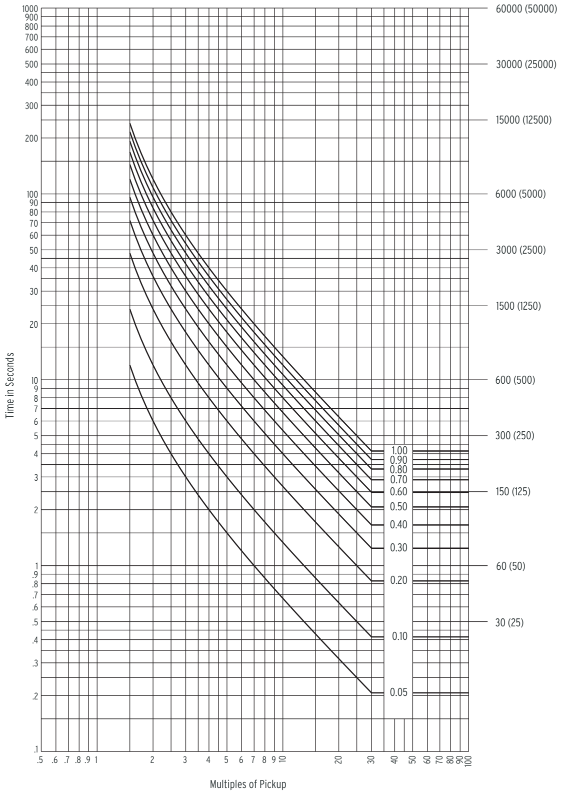


Figure 4.18 IEC Long-Time Inverse Curve: C4

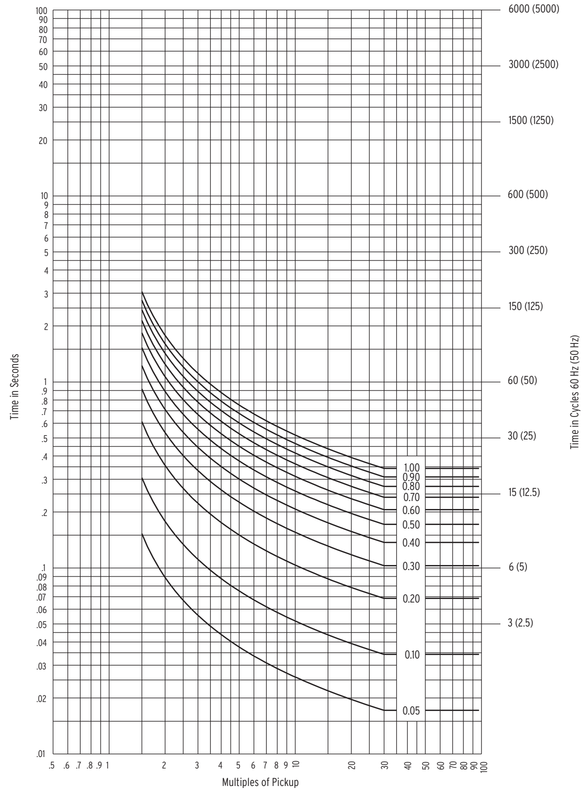


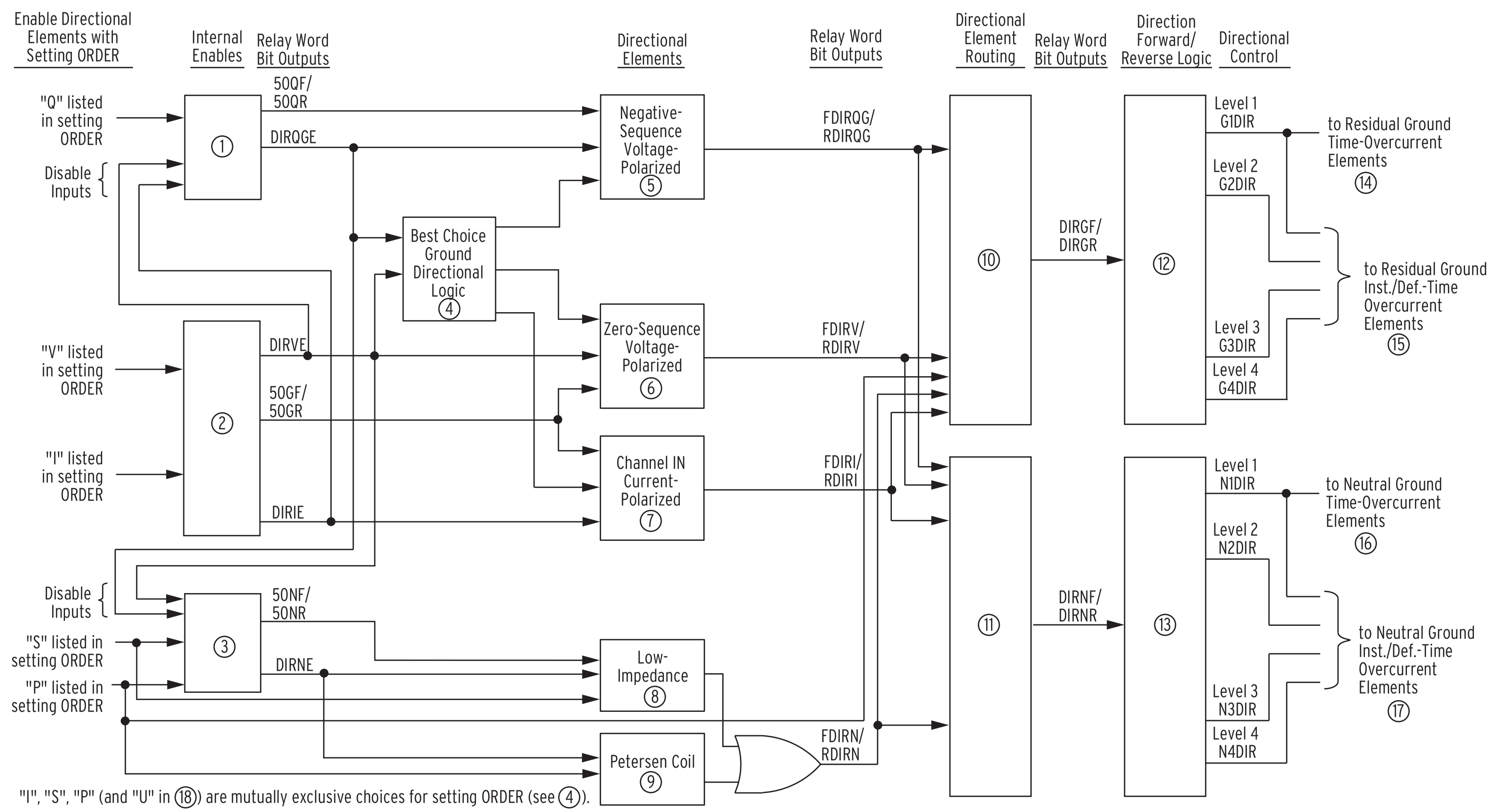
Figure 4.19 IEC Short-Time Inverse Curve: C5

Directional Control for Neutral-Ground and Residual-Ground 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 4.53*.

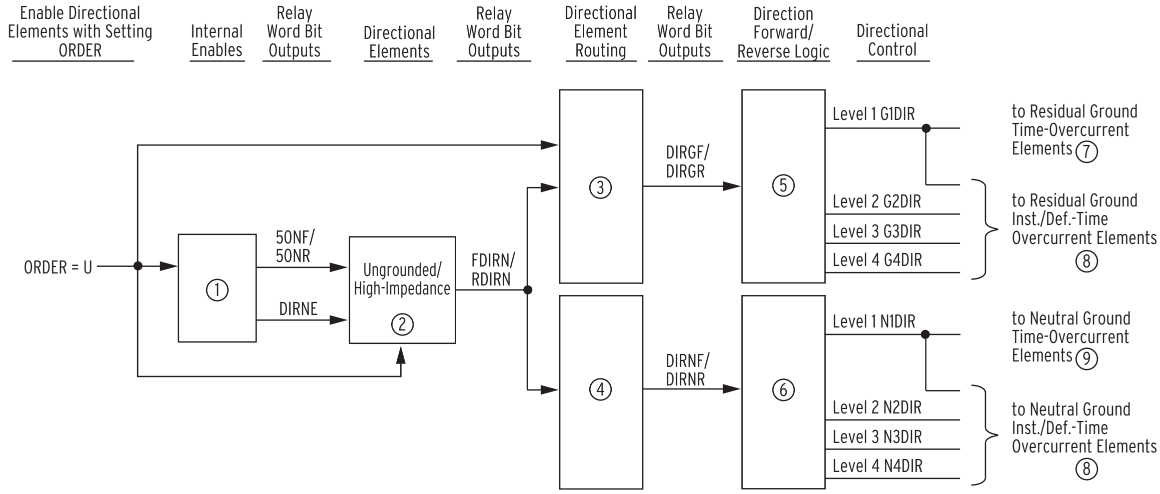
Six directional elements are available to control the neutral ground and residual ground overcurrent elements. Not all are available simultaneously. These six directional elements are:

- ➤ Negative-sequence voltage-polarized directional element
- ➤ Zero-sequence voltage-polarized directional element
- ➤ Channel IN current-polarized directional element
- ➤ Zero-sequence voltage-polarized directional element (low-impedance grounded system)
- ➤ Wattmetric and incremental conductance directional elements (Petersen coil-grounded system)
- ➤ Zero-sequence voltage-polarized directional element (ungrounded/high-impedance grounded system)



① Figure 4.23; ② Figure 4.24; ③ Figure 4.25; ④ Table 4.19 and Table 4.20; ⑤ Figure 4.26; ⑥ Figure 4.27; ⑦ Figure 4.28; ⑧ Figure 4.29; ⑨ Figure 4.30; ⑩ Figure 4.32; ⑪ Figure 4.33; ⑫ Figure 4.34; ⑬ Figure 4.35; ⑭ Figure 4.9; ⑮ Figure 4.2; ⑯ Figure 4.8; ⑰ Figure 4.2; ⑱ Figure 4.21.

Figure 4.20 General Logic Flow of Directional Control for Neutral Ground and Residual Ground Overcurrent Elements (Excluding Ungrounded/High-Impedance Grounded Systems)



① Figure 4.25; ② Figure 4.31; ③ Figure 4.32; ④ Figure 4.33; ⑤ Figure 4.34; ⑥ Figure 4.35; ⑦ Residual Time-Overcurrent Elements 51G1T and 51G2T; ⑧ Figure 4.2; ⑨ Figure 4.8; ⑩ Figure 4.9.

Figure 4.21 General Logic Flow of Directional Control for Neutral Ground and Residual Ground Overcurrent Elements (Ungrounded/High-Impedance Grounded Systems; ORDER := U)

Table 4.19 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 4.23*, *Figure 4.26*	All models (not dependent on neutral channel [IN])
V	Zero-sequence voltage-polarized	DIRVE	*Figure 4.24*, *Figure 4.27*	
I	Channel IN current polarized	DIRIE	*Figure 2.25*, *Figure 4.24*, *Figure 4.28*	Models with a 1 A or 5 A nominal neutral channel (IN)
S[a]	Zero-sequence voltage-polarized (Low-impedance)	DIRNE (Low-impedance)	*Figure 2.28*, *Figure 4.25*, *Figure 4.29*	Models with a 0.2 A nominal neutral channel (IN)
P[a]	Wattmetric and incremental conductance (Petersen coil)	DIRNE (Petersen coil)	*Figure 2.30*, *Figure 4.25*, *Figure 4.30*	
U[a]	Zero-sequence voltage-polarized (Ungrounded/ high-impedance)	DIRNE (Ungrounded/ high-impedance)	*Figure 2.28*, *Figure 2.29*, *Figure 2.31*, *Figure 4.25*, *Figure 4.31*	

[a] S, P, and U are mutually exclusive—they cannot be listed together in the ORDER setting.

NOTE: The neutral channel (IN) can also be ordered as a 0.2 A nominal neutral channel without directional option for use as nondirectional sensitive earth fault (SEF) protection.

Table 4.20 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 (independent on neutral channel [IN])
Q	DIRQGE			
QV	DIRQGE	DIRVE		
V	DIRVE			
VQ	DIRVE	DIRQGE		
I	DIRIE			Additional setting combinations for models with a 1 A or 5 A nominal neutral channel (IN)
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	
VS	DIRVE	DIRNE (Low-impedance)		Additional setting combinations for models with a 0.2 A nominal neutral channel (IN)[a]
VQS	DIRVE	DIRQGE	DIRNE (Low-impedance)	
QVS	DIRQGE	DIRVE	DIRNE (Low-impedance)	
P	DIRNE (Petersen coil)			
QP	DIRQGE	DIRNE (Petersen coil)		
QVP	DIRQGE	DIRVE	DIRNE (Petersen coil)	
VP	DIRVE	DIRNE (Petersen coil)		
VQP	DIRVE	DIRQGE	DIRNE (Petersen coil)	
U	DIRNE (Ungrounded/high-impedance)			

[a] S, P, and U are mutually exclusive and are the last (or only) listed choice for the order setting.

Table 4.21 Ground Directional Element Availability by Voltage Connection Settings

Element Designation in ORDER Setting	Availability[a] When VNOM ≠ OFF VSCONN = VS		Availability[a] When VNOM ≠ OFF VSCONN = 3V0	Availability[a] When VNOM = OFF VSCONN = VS	Availability[a] When VNOM = OFF VSCONN = 3V0
	DELTA_Y = WYE	DELTA_Y = DELTA	DELTA_Y = WYE or DELTA_Y = DELTA	DELTA_Y = WYE, DELTA_Y = DELTA, or SINGLEV = Y	DELTA_Y = WYE, DELTA_Y = DELTA, or SINGLEV = Y
Q	Yes	Yes	Yes	No[b]	No[b]
V	Yes	No	Yes	No[b]	Yes
I	Yes	Yes	Yes	Yes	Yes
S	Yes	No	Yes	No[b]	Yes
P	Yes	No	Yes	No[b]	Yes
U	Yes	No	Yes	No[b]	Yes

[a] Subject to availability of elements by relay model shown in Table 4.19 and Table 4.20.
[b] The displayed setting range for the ORDER setting may show these element choices, but the relay will not accept these choices when a settings save is attempted.

NOTE: If setting SINGLEV:=Y then, setting VNOM is set to OFF.

Figure 4.20 and *Figure 4.21* give an overview of how these directional elements are enabled and routed to control the neutral ground and residual ground overcurrent elements.

Note in *Figure 4.20* and *Figure 4.21* that setting ORDER enables the directional elements. Setting ORDER can be set with the elements listed and defined in *Table 4.19*, subject to the setting combination constraints in *Table 4.20*. Note that *Table 4.19* and *Table 4.20* also list the directional element availability, per model (according to the neutral channel [IN] rating).

NOTE: When group settings SINGLEV := Y and VSCONN = 3V0, EDIR cannot be set to AUTO.

Table 4.21 details the availability of the ground directional elements for the various combinations of the DELTA_Y, VSCONN, SINGLEV, and VNOM settings. If none of the ground directional elements are available (per *Table 4.19* through *Table 4.21*), setting EDIR (directional control enable) can only be set to N. Refer to *Figure 2.20* and *Figure 2.21* for information on DELTA_Y, VSCONN, and SINGLEV settings and how they translate to physical connections.

NOTE: When VNOM = OFF, setting VSCONN = VS and the relay has a 0.2 A nominal neutral rating, EDIR can only be set to N.

Also, note that *Table 4.19* through *Table 4.21* (and lower left-hand corner of *Figure 4.20*) detail the mutual exclusivity of ORDER setting choices I, S, P, and U. If particular directional elements are not available (because of model type) or are not listed in setting ORDER, these elements are *defeated* and *nonoperational*.

For example, suppose that setting choice S is listed in setting ORDER. By virtue of not being available or not being listed in setting ORDER, the directional elements corresponding to setting choices I, P, and U (see *Table 4.19*, *Figure 4.20*, and *Figure 4.21*) are *defeated* and *nonoperational*. So, for unavailable setting choice I, corresponding internal enable DIRIE = logical 0 and directional outputs FDIRI = logical 0 and RDIRI = logical 0. Similarly, for the directional elements corresponding to unlisted setting choices P and U, the logic outputs are at a logical 0 state.

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 *Directional Control Settings on page 4.53*.

Internal Enables

Refer to *Figure 4.20*, *Figure 4.21*, *Figure 4.23*, *Figure 4.24*, and *Figure 4.25*.

Table 4.19 lists the internal enables and their correspondence to the ground directional elements.

Note that *Figure 4.23* has extra internal enable DIRQE, which is used in the directional element logic that controls negative-sequence and phase overcurrent elements (see *Figure 4.36*).

Also, note that if a loss-of-potential condition occurs (Relay Word bit LOP asserts), all the internal directional enables (except for DIRIE) are disabled (see *Figure 4.23*, *Figure 4.24*, and *Figure 4.25*), unless VSCONN = 3V0. In that case, the directional-element enables in *Figure 4.24* and *Figure 4.25* are not affected by LOP.

The channel IN current-polarized directional element (with corresponding internal enable DIRIE; *Figure 4.24*) does not use voltage in making direction decisions, thus a loss-of-potential condition does not disable the element. Refer to *Figure 4.73* and accompanying text for more information on loss-of-potential.

The settings involved with the internal enables (e.g., settings a2, k2, a0, a0N) are explained in *Directional Control Settings on page 4.53*.

Switch Between I_N and I_G for Low-Impedance Grounded and Ungrounded/High-Impedance Grounded Systems

If an ungrounded or high-impedance grounded system (setting ORDER := U) has appreciable circuit length, the capacitance levels can be such that appreciable current flows for a ground fault. A low-impedance grounded system (setting ORDER contains S) can also have appreciable current flow for a ground fault.

The 0.2 A nominal neutral channel (IN) can measure up to 5 A secondary. Under certain conditions, the logic in *Figure 4.25* (and *Figure 4.29* and *Figure 4.31*) switches from monitoring neutral channel current I_N to monitoring residual ground current I_G. Residual ground current I_G is derived internally from phase current channels IA, IB, and IC; I_G is effectively $3I_0$ and has a much higher upper range than neutral channel current I_N. As shown in *Figure 4.22*, the relay uses the settings CTR and CTRN, along with the magnitudes of I_G and I_N, to determine when current I_N might exceed 5 amperes. When such a condition is detected, the relay switches to I_G. The switching logic is designed such that the switch may occur when neutral current is less than 5 amperes.

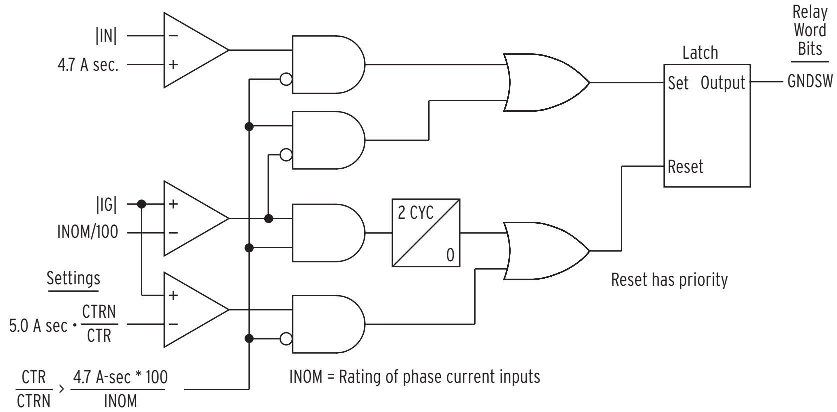


Figure 4.22 Logic for Relay Word bit GNDSW

Relay Word bit GNDSW indicates whether the directional element for low-impedance grounded or ungrounded/high-impedance grounded systems is operating on neutral channel (**IN**) current I_N (GNDSW = logical 1) or on residual ground current I_G instead (GNDSW = logical 0).

This switching of currents (from I_N to I_G) requires the 50NFP/50NRP settings (based on current I_N) in the *Figure 4.24* logic to be effectively changed to the new I_G base. This is done internally with CT ratio settings:

50NFP • CTRN/CTR (I_G base)

50NRP • CTRN/CTR (I_G base)

If the logic in *Figure 4.25* (and *Figure 4.29* and *Figure 4.31*) operates on neutral current I_N, then settings 50NFP and 50NRP are not adjusted, and just operate as:

50NFP (I_N base)

50NRP (I_N base)

This transition is "seamless" if the lower detection threshold of the residual ground current I_G (0.05 A secondary for 5 A nominal phase; 0.01 A secondary for 1 A nominal) effectively overlaps with the upper detection threshold of neutral channel current I_N (5 A secondary):

CTR/CTRN ≤ (5 A/0.05 A) = 100 (5 A nominal phase inputs)

CTR/CTRN ≤ (5 A/0.01 A) = 500 (1 A nominal phase inputs)

There is no effective overlap if:

CTR/CTRN > 100 (5 A nominal phase inputs)

CTR/CTRN > 500 (1 A nominal phase inputs)

With no effective overlap, when the neutral channel current I_N exceeds the upper detection threshold of neutral channel IN (5 A secondary), the unit still operates on the neutral channel current I_N until the lower detection threshold of the residual ground current I_G (0.05 A secondary for 5 A nominal phase; 0.01 A secondary for 1 A nominal) is reached. It is better to have effective overlap:

CTR/CTRN ≤ 100 (5 A nominal phase inputs)

CTR/CTRN ≤ 500 (1 A nominal phase inputs)

This I_N to I_G (or I_G to I_N) current switching discussed for *Figure 4.25*, *Figure 4.29*, and *Figure 4.31* also has an effect on zero-sequence impedance settings Z0F and Z0R (see *Figure 4.29* and *Figure 4.31*). Z0F and Z0R (Ω secondary) are set in reference to the phase current inputs (**IA**, **IB**, and **IC**; residual current I_G is derived internally from these phase currents). However, settings Z0F and Z0R are applied to *Figure 4.29* and *Figure 4.31*, where neutral current I_N (from neutral current channel IN) is also applied when GNDSW is asserted. Settings Z0F and Z0R are adjusted internally (with CT ratio settings) to operate on this I_N current base:

Z0F • CTRN/CTR (I_N base)

Z0R • CTRN/CTR (I_N base)

If the logic in *Figure 4.25*, *Figure 4.29*, and *Figure 4.31* operates on residual current I_G, as a result of current switching, then settings Z0F and Z0R are not adjusted, and just operate as:

Z0F (I_G base)

Z0R (I_G base)

Zero-Sequence Voltage Sources

The directional elements that rely on zero-sequence voltage $3V_0$ (ORDER setting choices: V, S, P, and U, shown in *Figure 4.27* and *Figure 4.29* through *Figure 4.31*) may use either a calculated 3V0 from the wye-connected voltages VA, VB, and VC, or a measured 3V0 from the VS channel, which is typically connected to a broken-delta PT secondary. Setting VSCONN selects the zero-sequence voltage source to be used by the affected directional elements.

When VSCONN := 3V0, 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 **VA**, **VB**, and **VC** terminals, and the resulting signal is applied to the directional element "3V0" inputs.

When VSCONN := VS, the calculated zero-sequence voltage from terminals **VA**, **VB**, and **VC** is applied to the directional element "3V0" inputs, provided that the relay is connected to wye-connected PTs (DELTA_Y := WYE). If the relay is connected to open-delta PTs (DELTA_Y := DELTA), 3V0 cannot be calculated from the **VA**, **VB**, and **VC** terminals, and the directional elements that require zero-sequence voltage are unavailable.

When testing the relay, it is important to note that the **METER** command VG (3V0) quantity, when available, is always the calculated value from the wye-connected PT inputs, even when VSCONN := 3V0. The **METER** command VS quantity is always the measured value from the **VS-NS** terminals.

Refer to *Figure 2.21: Voltage Connections (e)* and *(f)* for Broken-Delta VS Connection (setting VSCONN := 3V0).

Best Choice Ground Directional Element Logic

The Best Choice Ground Directional Element logic determines which directional element should be enabled to operate. The neutral ground and residual ground overcurrent elements set for directional control are then controlled by this enabled directional element.

Table 4.20 is the embodiment of the Best Choice Ground Directional Element logic. Note in *Table 4.20* that any of the directional elements corresponding to S, P, or U that operate on 0.2 A nominal neutral channel (IN) are listed last (or by themselves) in any of the available setting combinations for the ORDER setting. This is because preference is given to selected directional elements that operate off of bigger signals (i.e., directional elements corresponding to Q and V). Setting choice "I" cannot be listed with S, P, or U.

Figure 4.20 shows no control emanating from the Best Choice Ground Directional Element logic to the directional elements corresponding to S or P (*Figure 4.29*, and *Figure 4.30*, respectively). This Best Choice Ground Directional Element logic for the directional elements corresponding to S or P is effectively handled with the "disable inputs" (internal enables DIRQGE and DIRVE) running into the internal enable logic of *Figure 4.25*. If neither DIRQGE nor DIRVE are asserted (and thus their corresponding directional elements are not enabled), then the internal enable logic of *Figure 4.25* is free to run for the last directional element selected in setting ORDER (if S or P is the last element listed in setting ORDER).

Setting choice U (ungrounded/high-impedance grounded) 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, I, or P are listed by themselves in setting ORDER.

Directional Elements

Refer to *Figure 4.20*, *Figure 4.21*, and *Figure 4.26* through *Figure 4.31*. The Best Choice Ground Directional Element logic in *Table 4.20* determines which directional element will run.

Note in *Figure 4.30* that the incremental conductance directional element outputs FDIRC/RDIRC do not propagate to directional outputs FDIRN/RDIRN, respectively, as do the wattmetric directional element outputs FDIRW/RDIRW. Incremental conductance elements are used more for alarming purposes than for controlling overcurrent elements for tripping. Incremental conductance elements provide more sensitivity for detecting high-resistance faults on Petersen coil-grounded systems (as compared to the wattmetric elements). For more information on the operation and application of incremental conductance elements for Petersen coil- (resonant) grounded systems, see the paper: *Review of Ground Fault Protection Methods for Grounded, Ungrounded, and Compensated Distribution System* by Jeff Roberts, Hector Altuve, and Daqing Hou, presented at the 28th Annual Western Protective Relay Conference, Spokane, Washington, October 22–24, 2001.

Directional Element Routing

Refer to *Figure 4.20*, *Figure 4.21*, *Figure 4.32*, and *Figure 4.33*. 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 4.34* and *Figure 4.35*.

Loss of Potential

Note if *all* the following are true:

- Enable setting EFWDLOP := Y,
- Global setting VSCONN := VS,
- A loss-of-potential condition occurs (Relay Word bit LOP asserts),
- And internal enable DIRIE (for channel IN current-polarized directional element) is not asserted

then the forward logic point (Relay Word bit DIRGF in *Figure 4.32* and DIRNF in *Figure 4.33*) asserts to logical 1, thus, enabling the residual ground (*Figure 4.34*) and neutral ground (*Figure 4.35*) overcurrent elements that are set direction forward (with settings DIR1 := F, DIR2 := F, etc.). These direction forward overcurrent elements effectively become nondirectional and provide overcurrent protection during a loss-of-potential condition.

If Global setting VSCONN := 3V0 and setting EFWDLOP := Y, the LOP condition will not cause the forward directional outputs to assert when either directional element enable DIRVE or DIRNE is asserted, as shown at the top of *Figure 4.32* and *Figure 4.33*. In this situation, the elements that are enabled by signals DIRVE and DIRNE are still able to operate reliably during a loss-of-potential condition, so there is no need to force the forward outputs to assert. However, when DIRVE or DIRNE are not asserted, a standing LOP condition will force the forward outputs to assert continuously. Consider this when determining residual- and 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 pick up and start timing.

As detailed previously in *Internal Enables on page 4.31*, 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.

Refer to *Figure 4.73* and accompanying text for more information on loss-of-potential.

Direction Forward/Reverse Logic

Refer to *Figure 4.20*, *Figure 4.21*, *Figure 4.34*, and *Figure 4.35*.

The forward (Relay Word bit DIRGF in *Figure 4.34* and DIRNF in *Figure 4.35*) and reverse (Relay Word bit DIRGR in *Figure 4.34* and DIRNR in *Figure 4.35*) logic points are routed to the different levels of overcurrent protection by the level direction settings DIR1 through DIR4 and corresponding G*n*DIR and N*n*DIR (*n* = 1–4) Relay Word bits.

Table 4.25 shows the overcurrent elements that are controlled by each level direction setting. Note in *Table 4.25* that all the time-overcurrent elements (51_T elements) are controlled by the DIR1 level direction setting.

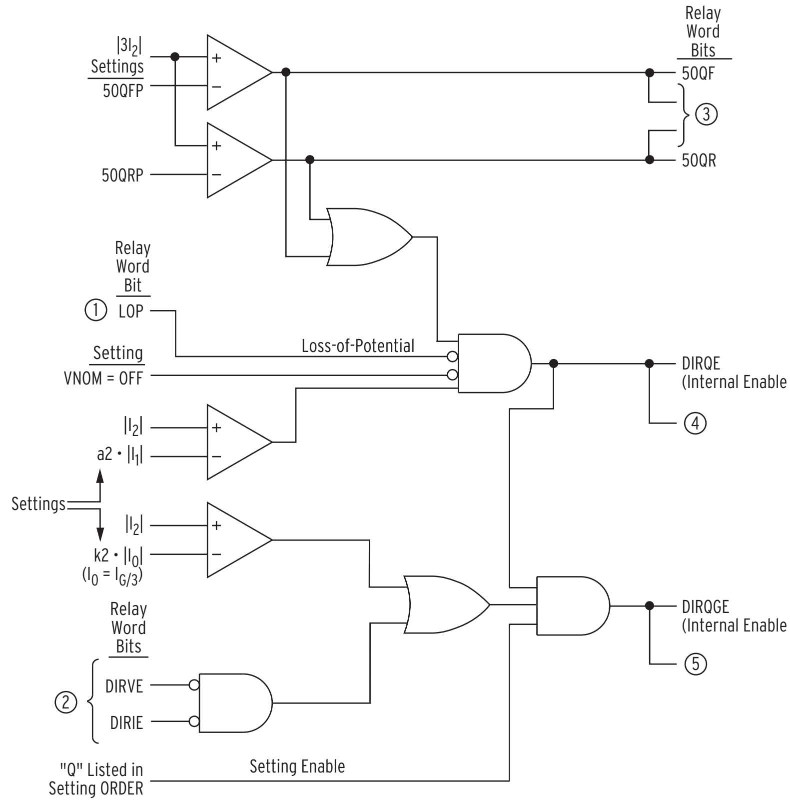
If a level direction setting (e.g., DIR1) is set:

DIR1 = **N** (nondirectional)

then the corresponding Level 1 directional control outputs in *Figure 4.34* and *Figure 4.35* assert to logical 1. The referenced Level 1 overcurrent elements in *Figure 4.34* and *Figure 4.35* are then not controlled by the directional control logic.

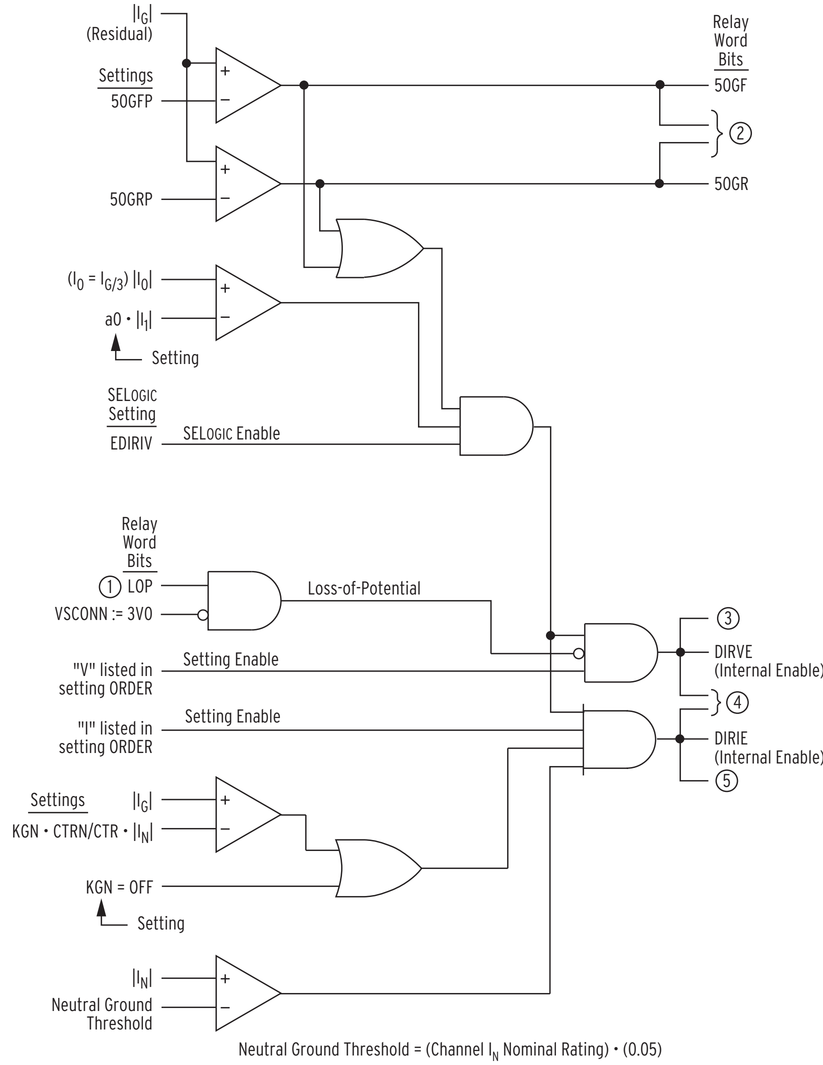
See the beginning of *Directional Control Settings on page 4.53* for a discussion of the operation of level direction settings DIR1 through DIR4 when the directional control enable setting EDIR is set to EDIR := N.

In some applications, level direction settings DIR1 through DIR4 are not flexible enough in assigning the desired direction for certain overcurrent elements. *Directional Control Provided by Torque Control Settings on page 4.77* describes how to avoid this limitation for special cases.



① From Figure 4.73; ② From Figure 4.24; ③ to Figure 4.26 and Figure 4.37;
④ to Figure 4.37 and Figure 4.38; ⑤ to Figure 4.25, Table 4.19, and Table 4.20.

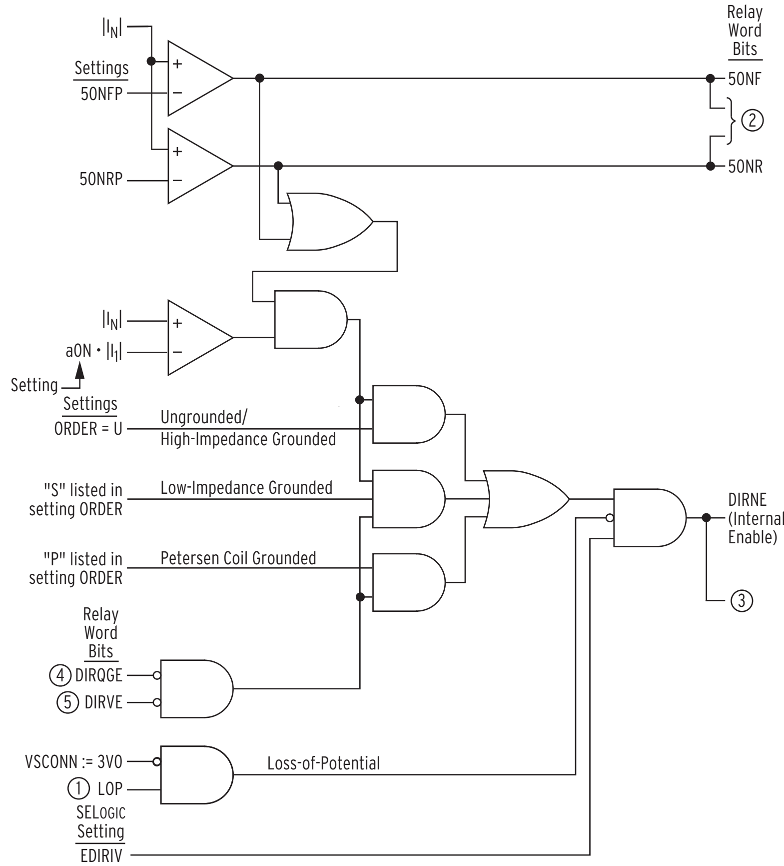
Figure 4.23 Internal Enables (DIRQE and DIRQGE) Logic for Negative-Sequence Voltage-Polarized Directional Elements



① From Figure 4.73; ② to Figure 4.27 and Figure 4.28; ③ to Figure 4.25 and Figure 4.27; ④ to Figure 4.23, Figure 4.32, Figure 4.33, Table 4.19, and Table 4.20; ⑤ to Figure 4.28.

Figure 4.24 Internal Enables (DIRVE and DIRIE) Logic for Zero-Sequence Voltage-Polarized and Channel IN Current-Polarized Directional Elements

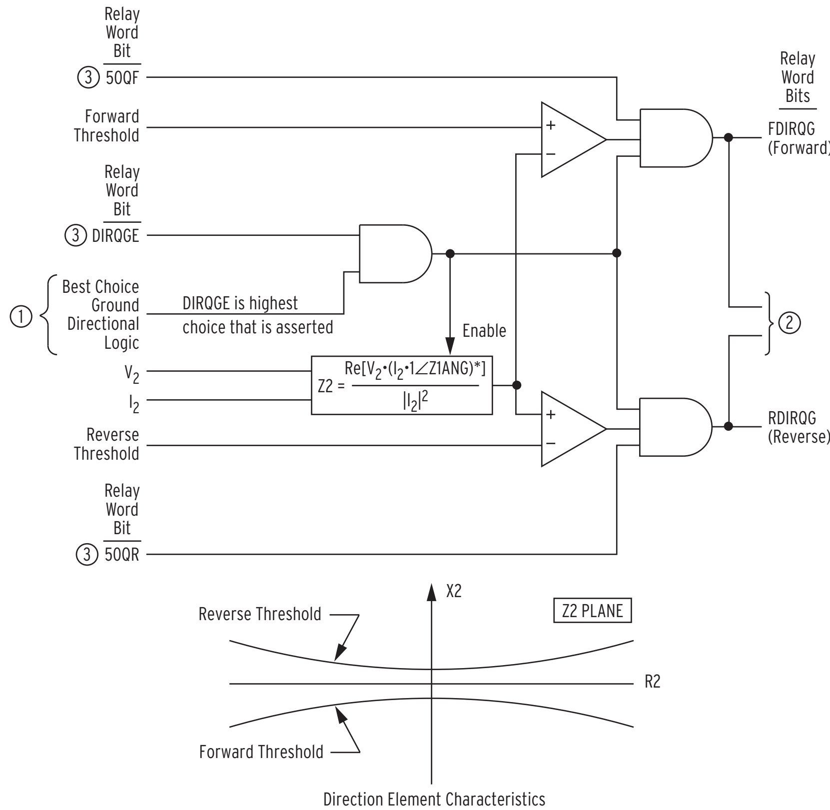
NOTE: Residual ground current I_G is used in place of neutral current I_N under certain circumstances. See Switch Between I_N and I_G for Low-Impedance Grounded and Ungrounded/High-Impedance Grounded Systems on page 4.31.



① From Figure 4.73; ② to Figure 4.29 and Figure 4.31; ③ to Figure 4.20, Figure 4.21, Figure 4.29, Figure 4.30, Figure 4.31, Table 4.19, and Table 4.20; ④ from Figure 4.23; ⑤ from Figure 4.24.

Figure 4.25 Internal Enable (DIRNE) Logic for Zero-Sequence Voltage-Polarized Directional Elements (Low-Impedance Grounded, Petersen Coil-Grounded, and Ungrounded/High-Impedance Grounded Systems)

Refer to *EDIRIV—SELOGIC Control Equation Enable on page 4.76* for information on using SELOGIC setting EDIRIV.



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

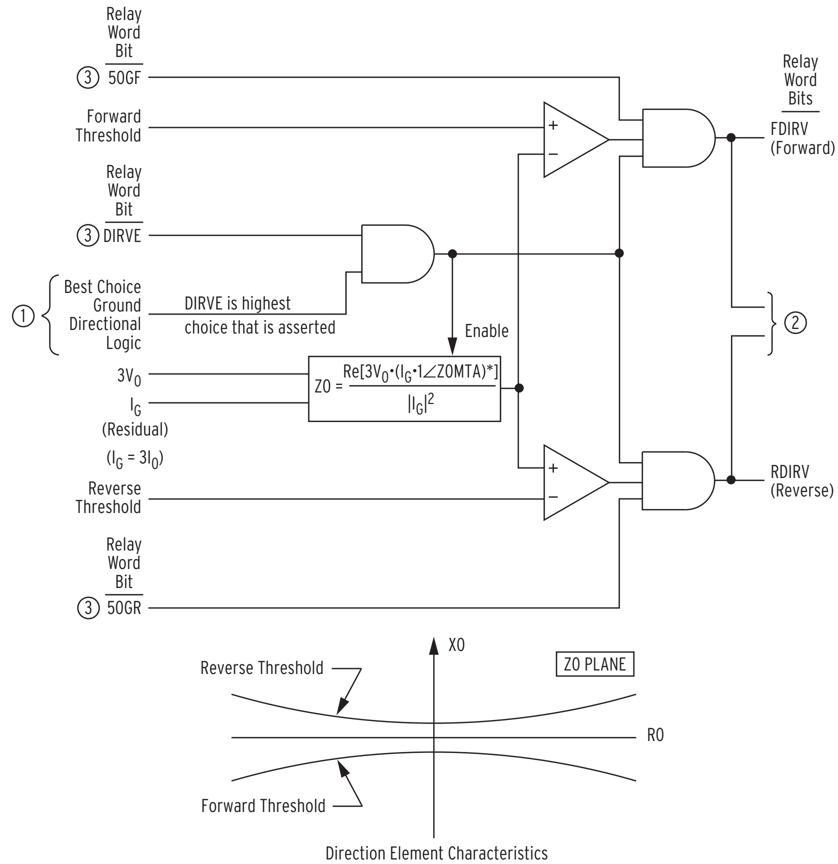
Reverse Threshold:

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 4.20; ② to Figure 4.32 and Figure 4.33; ③ from Figure 4.23.

Figure 4.26 Negative-Sequence Voltage-Polarized Directional Element for Neutral Ground and Residual Ground Overcurrent Elements



Forward Threshold:

If Z0F Setting ≤ 0, Forward Threshold $= 0.75 \cdot Z0F - 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

If Z0F Setting > 0, Forward Threshold $= 1.25 \cdot Z0F - 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

Reverse Threshold:

If Z0R Setting ≥ 0, Reverse Threshold $= 0.75 \cdot Z0R + 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

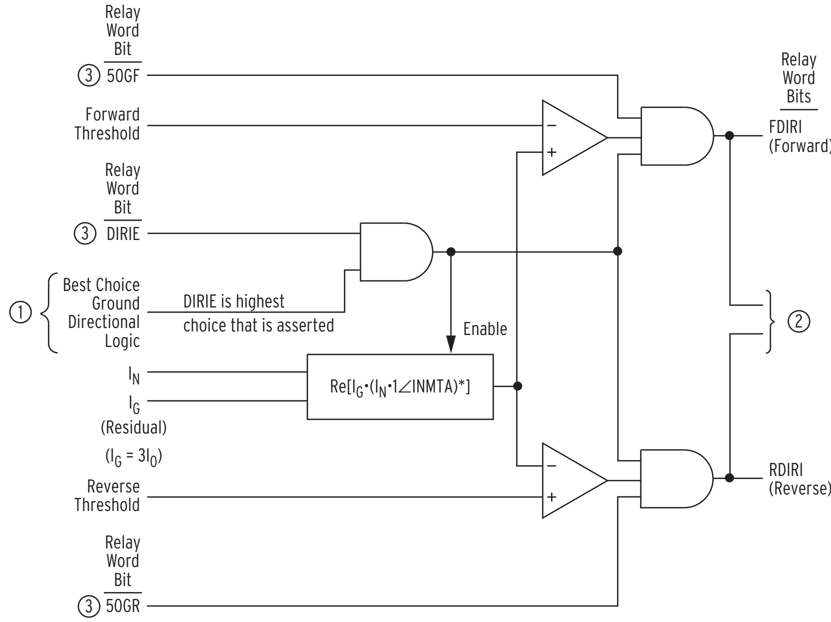
If Z0R Setting < 0, Reverse Threshold $= 1.25 \cdot Z0R + 0.25 \cdot \left|\frac{V_0}{I_0}\right|$

① From Table 4.20; ② to Figure 4.32 and Figure 4.33; ③ from Figure 4.24.

Figure 4.27 Zero-Sequence Voltage-Polarized Directional Element

The 3V0 input to *Figure 4.27* may be either a calculated value (when VSCONN := VS and DELTA_Y := WYE) or a measured value (when VSCONN := 3V0). See *Zero-Sequence Voltage Sources on page 4.33*.

NOTE: Group setting INMTA is hidden and forced to 0.00 when KGN = OFF.



Forward Threshold:

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

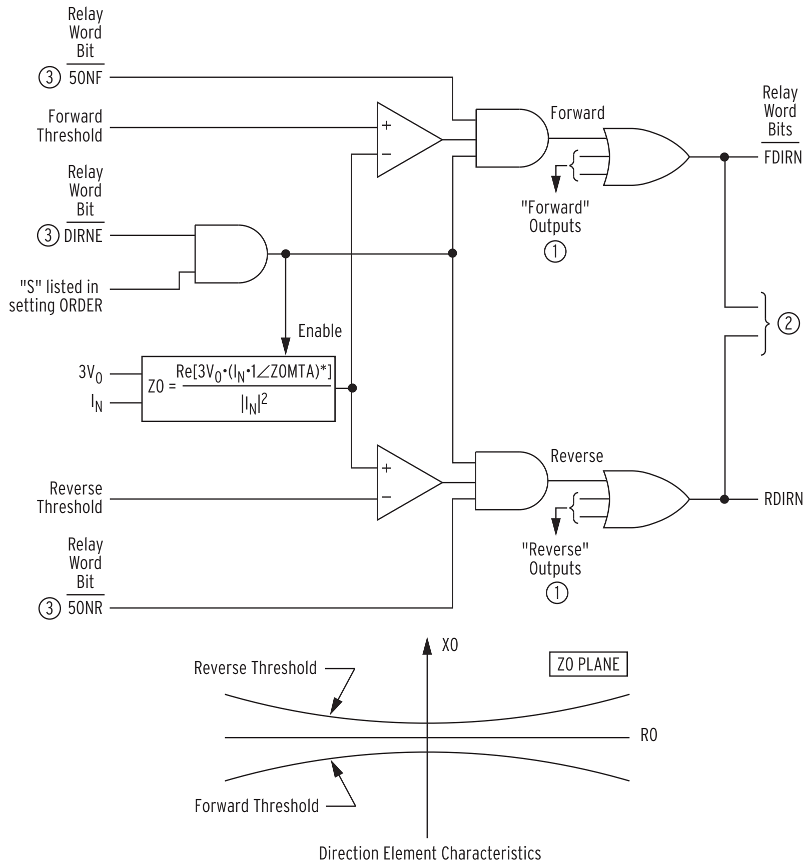
Reverse Threshold:

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

① From Table 4.20; ② to Figure 4.32 and Figure 4.33; ③ from Figure 4.24.

Figure 4.28 Channel IN Current-Polarized Directional Element

NOTE: Residual ground current I_G is used in place of neutral current I_N under certain conditions. See Switch Between I_N and I_G for Low-Impedance Grounded and Ungrounded/High-Impedance Grounded Systems on page 4.31



Forward Threshold:

If Z0F Setting ≤ 0, Forward Threshold = 0.75 • Z0F − 0.25 • $\left|\frac{3V_0}{I_N}\right|$

If Z0F Setting > 0, Forward Threshold = 1.25 • Z0F − 0.25 • $\left|\frac{3V_0}{I_N}\right|$

Reverse Threshold:

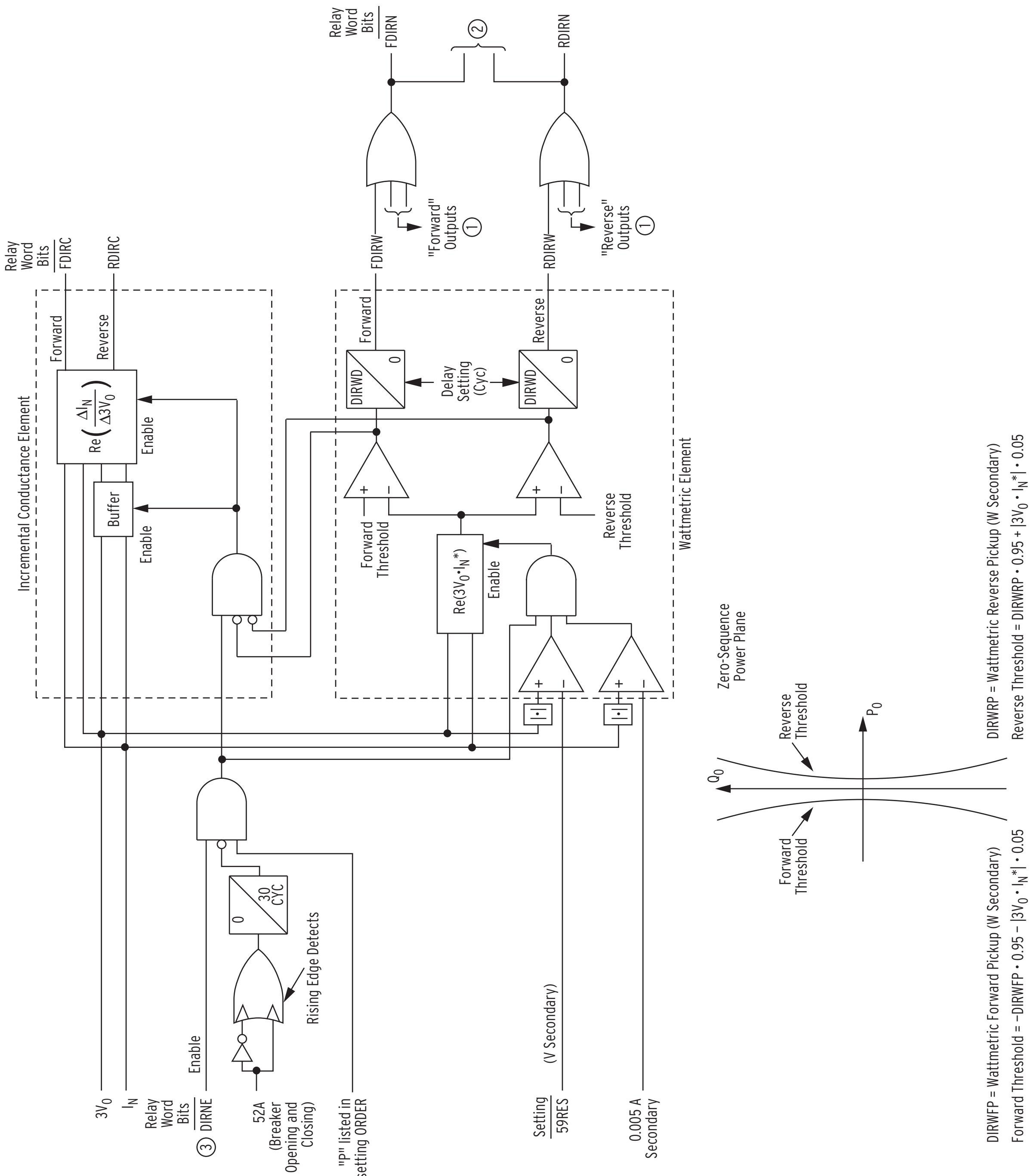
If Z0R Setting ≥ 0, Reverse Threshold = 0.75 • Z0R + 0.25 • $\left|\frac{3V_0}{I_N}\right|$

If Z0R Setting < 0, Reverse Threshold = 1.25 • Z0R + 0.25 • $\left|\frac{3V_0}{I_N}\right|$

① From Figure 4.30 and Figure 4.31; ② to Figure 4.32 and Figure 4.33;
③ from Figure 4.25.

Figure 4.29 Zero-Sequence Voltage-Polarized Directional Element (Low-Impedance Grounded Systems)

The 3V0 input to *Figure 4.29* may be either a calculated value (when VSCONN := VS and DELTA_Y := WYE) or a measured value (when VSCONN := 3V0). See *Zero-Sequence Voltage Sources on page 4.33*.

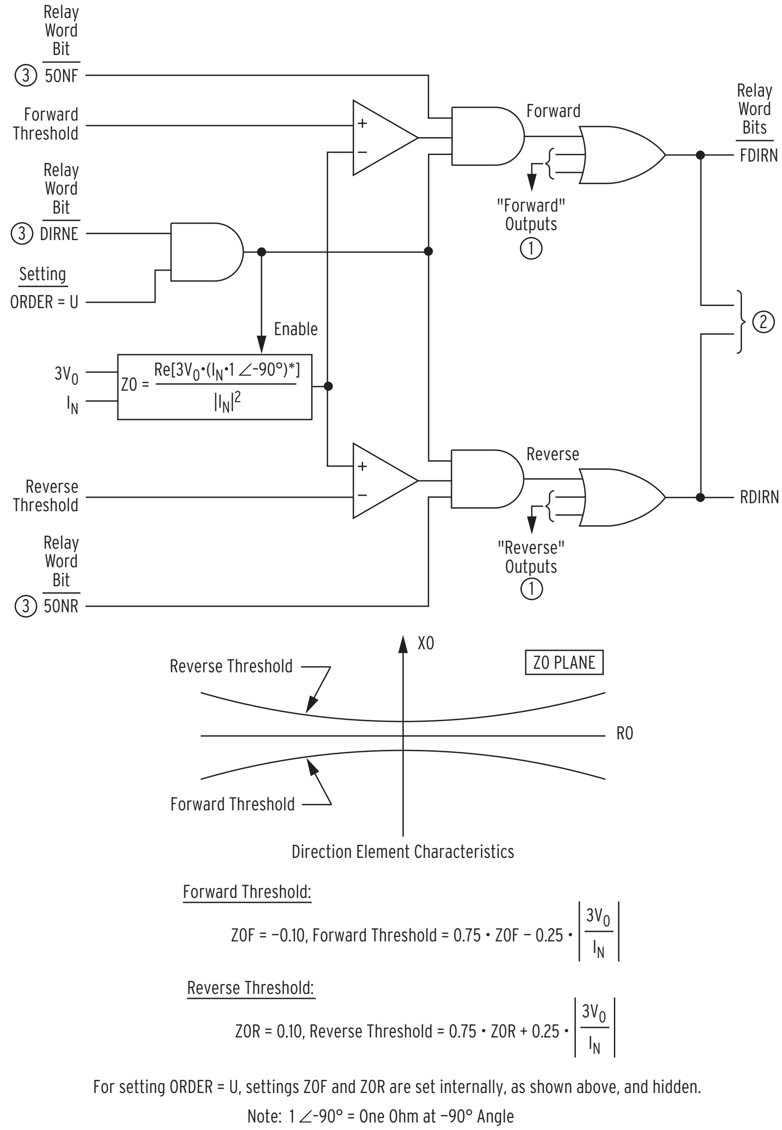


① From Figure 4.29 and Figure 4.31; ② to Figure 4.32 and Figure 4.33; ③ from Figure 4.25.

Figure 4.30 Wattmetric and Incremental Conductance Directional Elements (Petersen Coil-Grounded Systems)

The 3V0 input to *Figure 4.30* may be either a calculated value (when VSCONN := VS and DELTA_Y := WYE) or a measured value (when VSCONN := 3V0). See *Zero-Sequence Voltage Sources on page 4.33*.

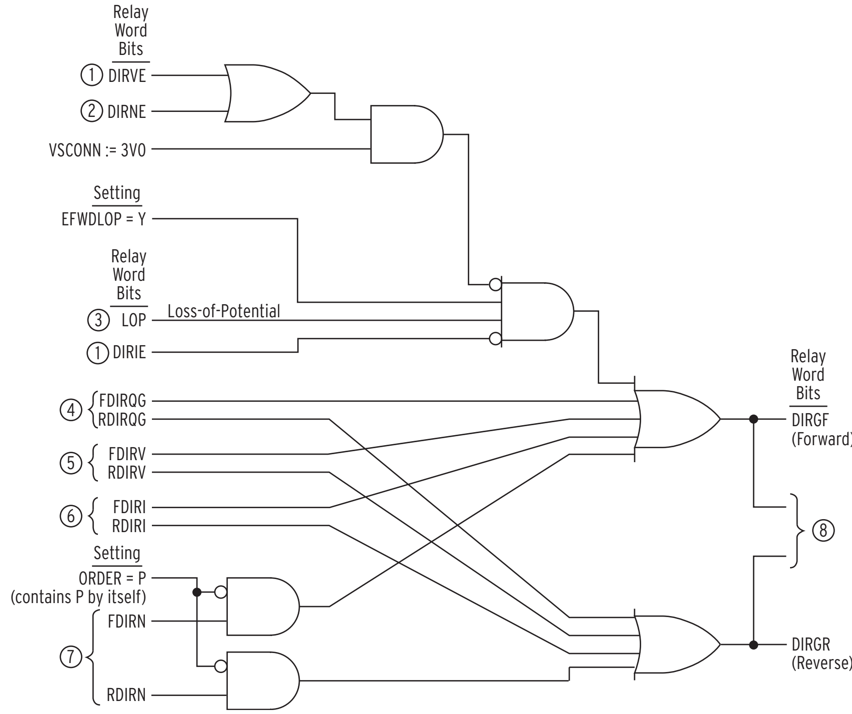
NOTE: Residual ground current I_G is used in place of neutral current I_N under certain conditions. See Switch Between I_N and I_G for Low-Impedance Grounded and Ungrounded/High-Impedance Grounded Systems on page 4.31



① From Figure 4.29 and Figure 4.30; ② to Figure 4.32 and Figure 4.33;
③ from Figure 4.25.

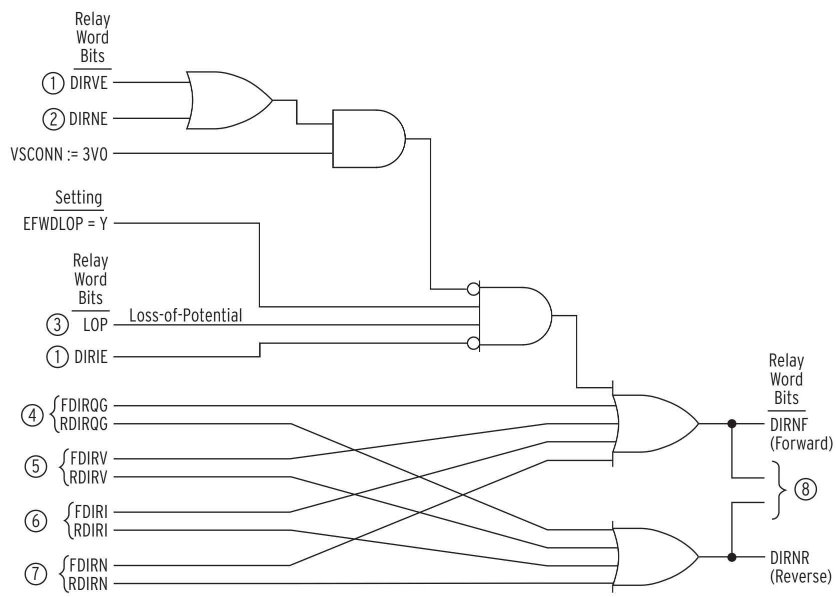
Figure 4.31 Zero-Sequence Voltage-Polarized Directional Element (Ungrounded/High-Impedance Grounded Systems)

The 3V0 input to *Figure 4.31* may be either a calculated value (when VSCONN := VS and DELTA_Y := WYE) or a measured value (when VSCONN := 3V0). See *Zero-Sequence Voltage Sources on page 4.33*.



① From Figure 4.24; ② from Figure 4.25; ③ from Figure 4.73;
④ from Figure 4.26; ⑤ from Figure 4.27; ⑥ from Figure 4.28;
⑦ from Figure 4.29, Figure 4.30, or Figure 4.31; ⑧ to Figure 4.34.

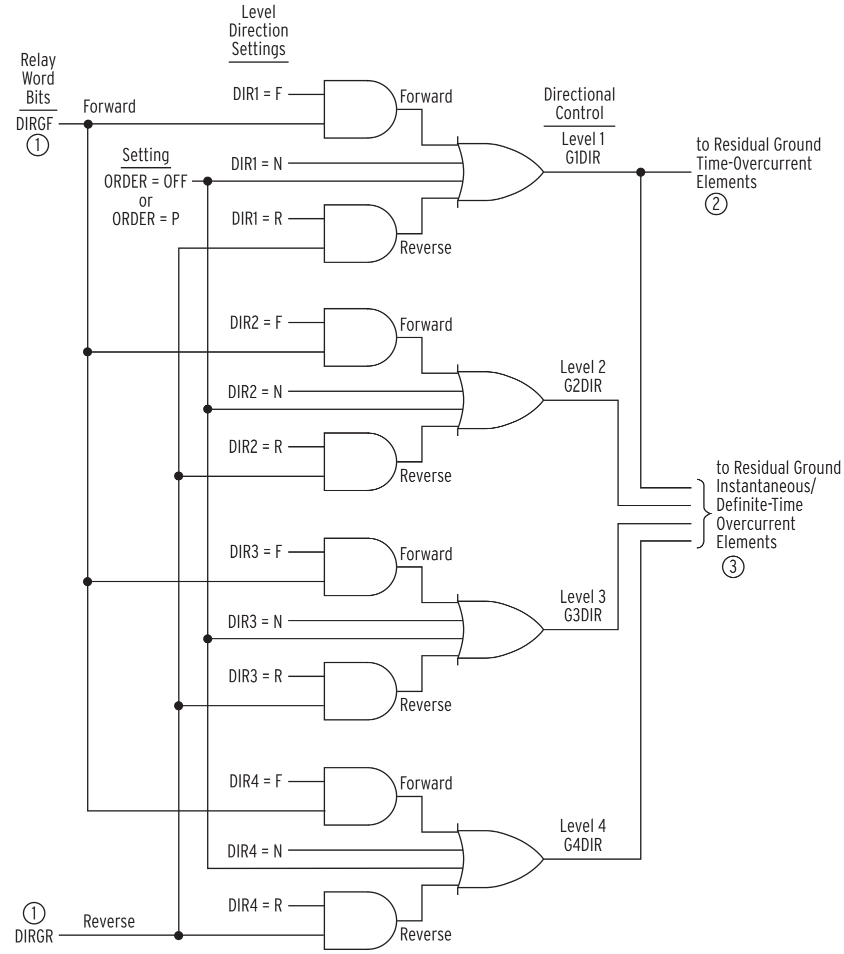
Figure 4.32 Routing of Directional Elements to Residual Ground Overcurrent Elements



① From Figure 4.24; ② from Figure 4.25; ③ from Figure 4.73;
④ from Figure 4.26; ⑤ from Figure 4.27; ⑥ from Figure 4.28;
⑦ from Figure 4.29, Figure 4.30, or Figure 4.31; ⑧ to Figure 4.35.

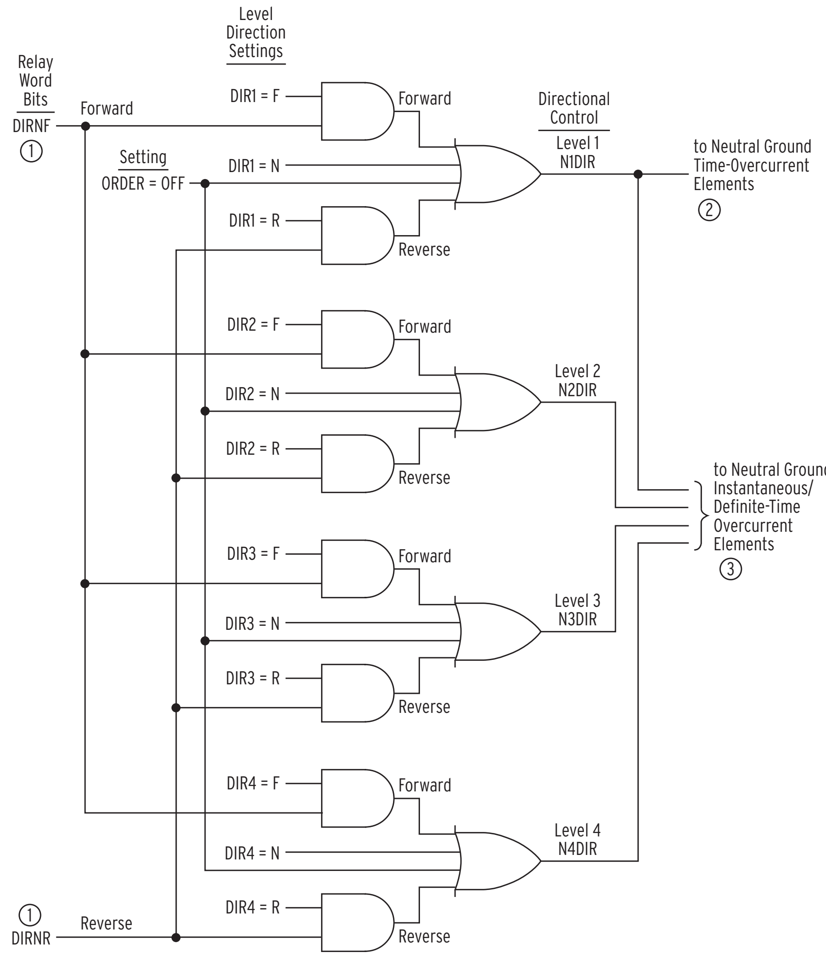
Figure 4.33 Routing of Directional Elements to Neutral Ground Overcurrent Elements

The 3V0 input to *Figure 4.30* may be either a calculated value (when VSCONN := VS and DELTA_Y := WYE) or a measured value (when VSCONN := 3V0). See *Zero-Sequence Voltage Sources on page 4.33*.



① From Figure 4.32; ② Figure 4.9; ③ Figure 4.2.

Figure 4.34 Direction Forward/Reverse Logic for Residual Ground Overcurrent Elements



① From Figure 4.33; ② Figure 4.8; ③ Figure 4.2.

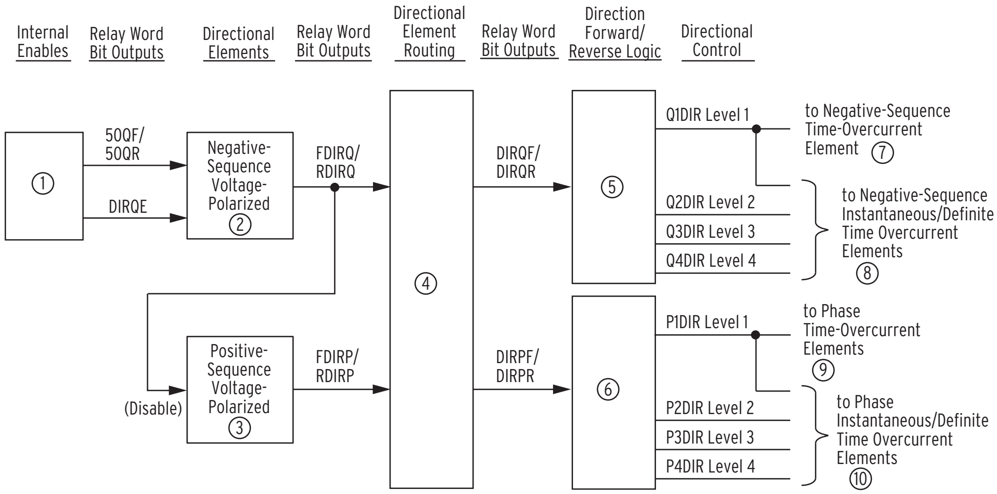
Figure 4.35 Direction Forward/Reverse Logic for Neutral Ground Overcurrent Elements

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 4.53*.

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 4.36* 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.

If three-phase voltage signals are not available, make the setting VNOM = OFF. If SINGLEV := Y, setting VNOM is set to OFF. This turns off the negative-sequence voltage-polarized and positive-sequence voltage-polarized elements to prevent them from operating on false voltage quantities, yet still allows the Best-Choice Ground Directional Element logic, if available, to operate for ground faults. This shut-down logic is shown in the center portions of *Figure 4.23* and *Figure 4.38*.



① Figure 4.23; ② Figure 4.37; ③ Figure 4.38; ④ Figure 4.39; ⑤ Figure 4.40; ⑥ Figure 4.41; ⑦ Figure 4.7;
⑧ Figure 4.2; ⑨ Figure 4.6; ⑩ Figure 4.2.

Figure 4.36 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, available on the SEL website, or contact SEL for assistance.

Internal Enables

Refer to *Figure 4.23* and *Figure 4.36*.

The internal enable DIRQE corresponds to the negative-sequence voltage-polarized directional element.

Note that *Figure 4.23* 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 4.20*).

The settings involved with internal enable DIRQE in *Figure 4.23* (e.g., settings a2, k2) are explained in *Directional Control Settings on page 4.53*.

Directional Elements

Refer to *Figure 4.36*, *Figure 4.37*, and *Figure 4.38*.

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 4.23* and *Figure 4.38*).

Refer to *Figure 4.73* and accompanying text for more information on loss-of-potential.

Note in *Figure 4.36* and *Figure 4.38* that 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 4.38* 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 4.7*).

Directional Element Routing

Refer to *Figure 4.36* and *Figure 4.39*.

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 4.40* and *Figure 4.41*.

Loss-of-Potential

If EFWDLOP := Y and 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, etc.). These direction forward overcurrent elements effectively become nondirectional and provide overcurrent protection during a loss-of-potential condition.

As detailed previously (in *Figure 4.23* and *Figure 4.38*), 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 4.73* and accompanying text for more information on loss-of-potential.

Direction Forward/Reverse Logic

Refer to *Figure 4.36*, *Figure 4.40*, and *Figure 4.41*.

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 through DIR4.

Table 4.25 shows the overcurrent elements that are controlled by each level direction setting. Note in *Table 4.25* that all the time-overcurrent elements (51_T elements) are controlled by the DIR1 level direction setting.

If a level direction setting (e.g., DIR1) is set:

DIR1 = **N** (nondirectional)

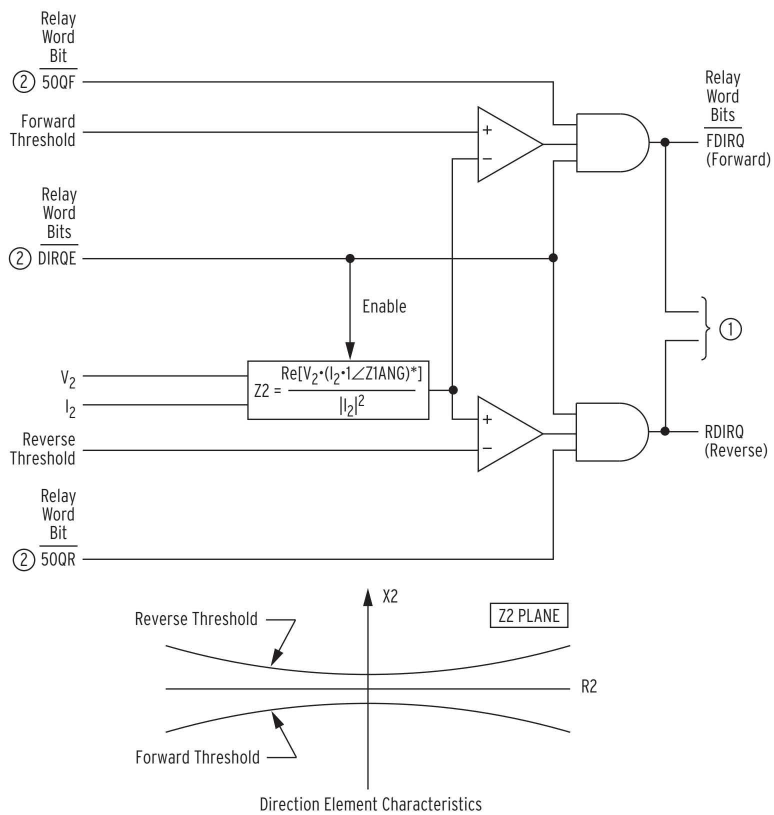
then the corresponding Level 1 directional control outputs in *Figure 4.40* and *Figure 4.41* assert to logical 1. The referenced Level 1 overcurrent elements in *Figure 4.40* and *Figure 4.41* are then not controlled by the directional control logic.

NOTE: When SINGLEV = Y, Group setting VNOM is hidden and forced to OFF internally.

If Group setting VNOM := OFF, then the directional control outputs in *Figure 4.40* and *Figure 4.41* assert to logical 1. This effectively makes the phase and negative-sequence elements nondirectional, even in cases where EDIR can still be set.

See the beginning of *Directional Control Settings on page 4.53* for a discussion of the operation of level direction settings DIR1 through DIR4 when the directional control enable setting EDIR is set to EDIR := N.

In some applications, level direction settings DIR1 through DIR4 are not flexible enough in assigning the desired direction for certain overcurrent elements. *Directional Control Provided by Torque Control Settings on page 4.77* describes how to avoid this limitation for special cases.



Forward Threshold:

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

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

Reverse Threshold:

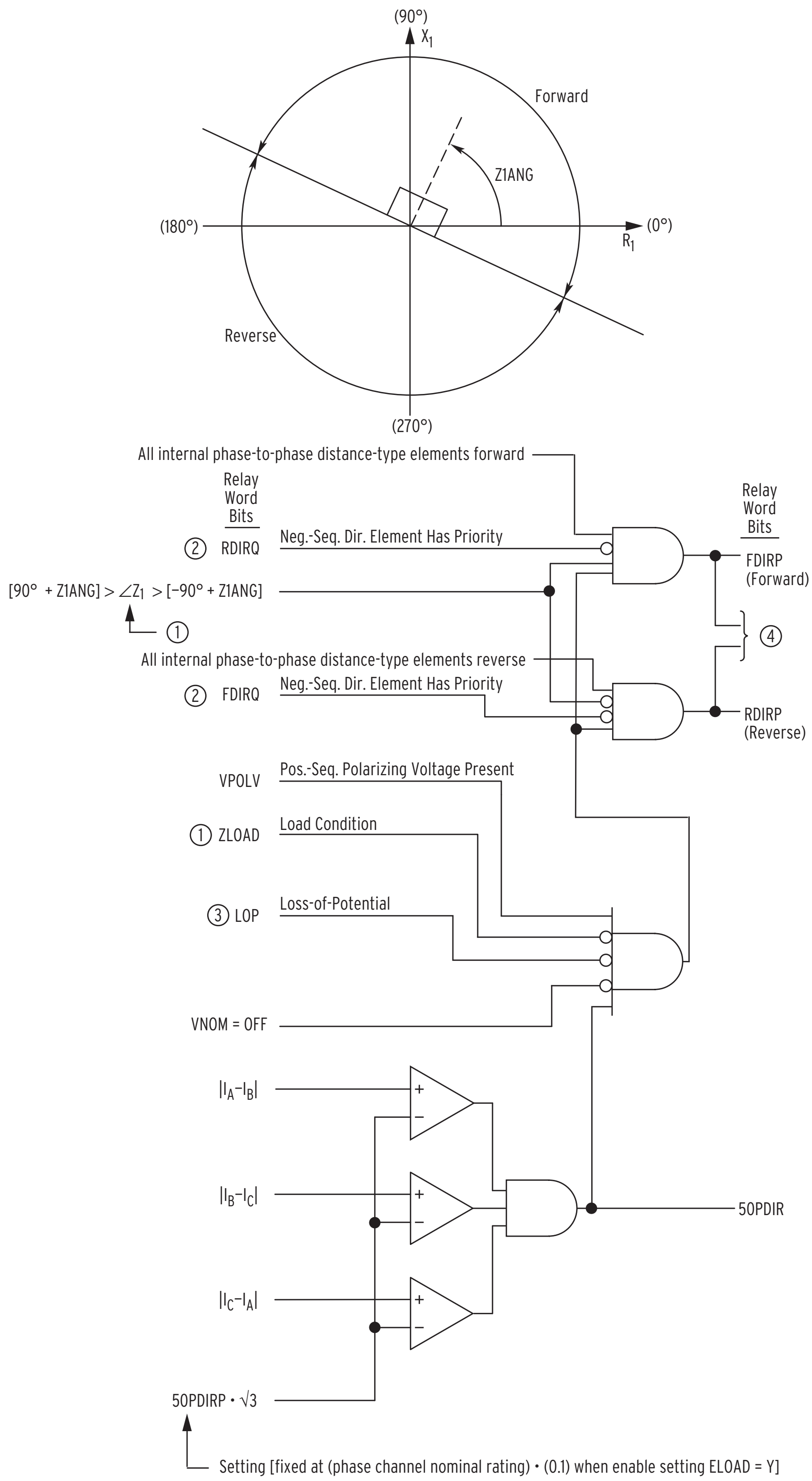
$$\text{If Z2R Setting} \geq 0, \text{Reverse Threshold} = 0.75 \cdot \text{Z2R} + 0.25 \cdot \left|\frac{V_2}{I_2}\right|$$

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

① To Figure 4.38 and Figure 4.39; ② from Figure 4.23.

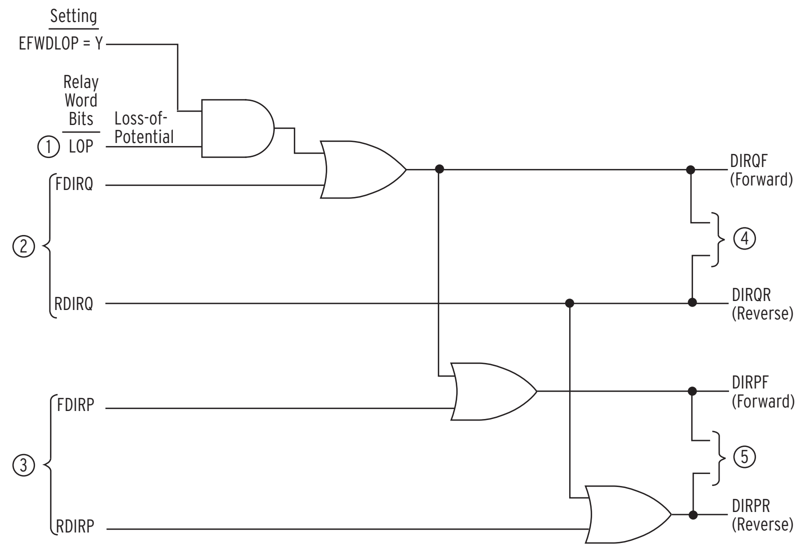
Figure 4.37 Negative-Sequence Voltage-Polarized Directional Element for Negative-Sequence and Phase Overcurrent Elements

NOTE: The positive-sequence voltage-polarized directional element uses positive-sequence memory voltage as the polarizing voltage.



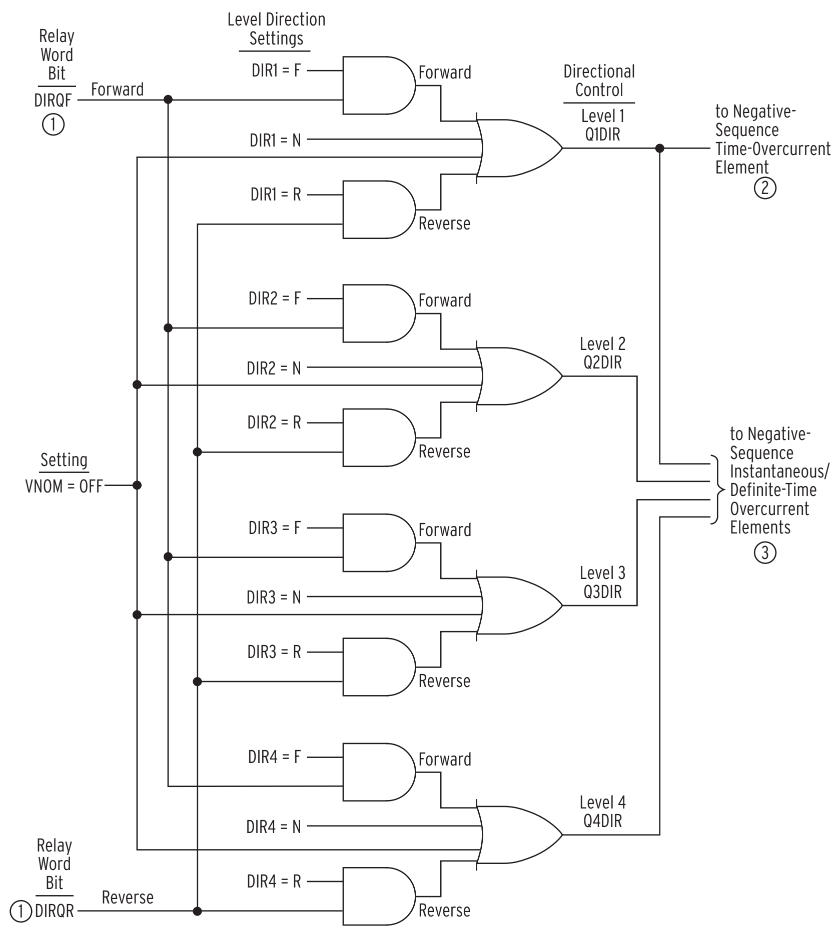
① From Figure 4.54; ② from Figure 4.37; ③ from Figure 4.73; ④ to Figure 4.39.

Figure 4.38 Positive-Sequence Voltage-Polarized Directional Element for Phase Overcurrent Elements



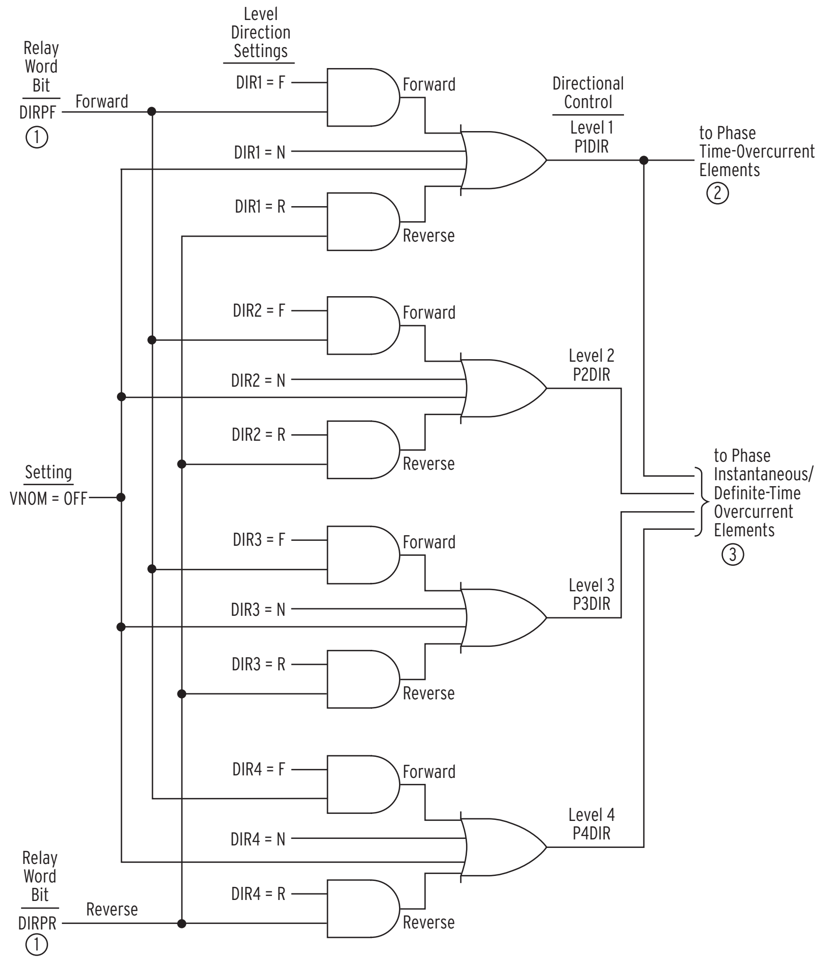
① From Figure 4.73; ② from Figure 4.37; ③ from Figure 4.38;
④ to Figure 4.40; ⑤ to Figure 4.41.

Figure 4.39 Routing of Directional Elements to Negative-Sequence and Phase Overcurrent Elements



① From Figure 4.39; ② Figure 4.7; ③ Figure 4.2.

Figure 4.40 Direction Forward/Reverse Logic for Negative-Sequence Overcurrent Elements



① From Figure 4.39; ② Figure 4.6; ③ Figure 4.2.

Figure 4.41 Direction Forward/Reverse Logic for Phase Overcurrent Elements

Directional Control Settings

Table 4.22 and *Table 4.23* show all the directional element settings. The Wattmetric element settings for Petersen coil-grounded systems are shown in *Table 4.23*.

Table 4.22 Directional Control Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
DIR CONTROL ENBL	Y, AUTO, N	EDIR := N
FWD DIR ON LOP	Y, N	EFWDLOP := Y
DIR CONTROL LVL1	F, R, N	DIR1 := N
DIR CONTROL LVL2	F, R, N	DIR2 := N
DIR CONTROL LVL3	F, R, N	DIR3 := N
DIR CONTROL LVL4	F, R, N	DIR4 := N
GND DIR PRIORITY	Q, V, I, U, S, P, OFF [a]	ORDER := OFF
PH DIR 3PH LVL	0.50–10.00 A [b]	50PDIRP := 3.00 [b]
FWD DIR Z2 LVL	–128.00 to 128.00 ohm [c]	Z2F := –0.06 [c]
REV DIR Z2 LVL	–128.00 to 128.00 ohm [c]	Z2R := 0.06 [c]

Table 4.22 Directional Control Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
FWD DIR NSEQ LVL	0.25–5.00 A[b]	50QFP := 0.50[b]
REV DIR NSEQ LVL	0.25–5.00 A[b]	50QRP := 0.25[b]
I1 RST FAC I2/I1	0.02–0.50	a2 := 0.10
I0 RST FAC I2/I0	0.10–1.20	k2 := 0.20
FWD DIR RES LVL	0.05–5.00 A[b]	50GFP := 0.50[b]
REV DIR RES LVL	0.05–5.00 A[b]	50GRP := 0.25[b]
RES FACTOR IG/IN	OFF, 0.001–0.100	KGN := OFF
MAX TRQ ANG	0.00–85.00 deg	INMTA := 0.00
I1 RST FAC I0/I1	0.001–0.50	a0 := 0.10
FWD DIR Z0 LVL	–128.00 to 128.00 ohm[c]	Z0F := 3.20
REV DIR Z0 LVL	–128.00 to 128.00 ohm[c]	Z0R := 3.4
ZRO SQ MX TQ ANG	–90.00 to –5.00 deg and +5.00 to +90.00 deg	Z0MTA := 72.47
FWD DIR LVL	0.005-5.000 A[d]	50NFP := 0.010
REV DIR LVL	0.005-5.000 A[d]	50NRP := 0.005
RES FACTOR	0.001–0.500	a0n := 0.001
ENABLE V0 IN DIR	SELOGIC	EDIRIV := 1

[a] Refer to Table 4.21 and Table SET.2 on page SET.6 of the SEL-751 Settings Sheets for the availability of different ORDER setting options based on voltage connection and nominal rating neutral CT.
[b] Setting ranges and default values shown are for 5 A nominal CT rating. Divide by 5 for 1 A CTs.
[c] Setting ranges and default values shown are for 5 A nominal CT rating. Multiply by 5 for 1 A CTs.
[d] Setting ranges are for 0.2 A nominal neutral CT.

Table 4.23 Wattmetric Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
3V0 59 PICKUP	1–430 V	59RES := 22
FWD WATT PICKUP	0.001–150 W	DIRWFP := 0.5
REV WATT PICKUP	0.001–150 W	DIRWRP := 0.5
WATTMETRIC DLY	0.0–18000.0 sec	DIRWD := 0.5

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)

DIR3 = **N** (no directional control for Level 3 overcurrent elements)

DIR4 = **N** (no directional control for Level 4 overcurrent elements)

With the above settings, the directional control outputs in *Figure 4.34*, *Figure 4.35*, *Figure 4.40*, and *Figure 4.41* assert to logical 1. The overcurrent elements referenced in *Figure 4.34*, *Figure 4.35*, *Figure 4.40*, and *Figure 4.41* are then not controlled by the directional control logic.

NOTE: Depending on relay model and DELTA_Y := DELTA and SINGLEV := Y, Group setting EDIR might not offer the AUTO settings choice, or EDIR might be hidden. When EDIR is hidden, it is internally set to N. See discussion following Table 4.21.

There is one case that does not allow Group setting EDIR := Y or AUTO. If all three of the following are true, EDIR can only be set to "N."

- The relay model has a 0.2 A or 0.05 A nominal neutral channel.
- Setting VSCONN := VS.
- Setting VNOM := OFF.

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

NOTE: Settings Z2F, Z2R, Z0F, and Z0R are calculated based on the line impedance settings Z1MAG and Z0MAG. Enter Z1MAG and Z0MAG values appropriate for the application when EDIR := AUTO.

If

EDIR = **AUTO**

then Z0MTA is set equal to Z0ANG and Z0MTA is hidden.

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.

Setting EDIR := AUTO is designed for line protection applications where CT polarity is such that the forward tripping direction is toward the line, as shown in *Figure 2.22*. When EDIR := AUTO and negative-sequence or zero-sequence voltage is low, the negative-sequence and zero-sequence directional elements declare unbalanced faults forward. Where directional elements are used in applications that do not involve lines, or where the CT polarity is reversed, setting EDIR := AUTO might be inappropriate. See Application Guide *AG2009-17, Enabling Sensitive Directional Elements for Non-Line Protection Applications with SEL-351 Series Relays*, or contact SEL for assistance.

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:

NOTE: Group settings KGN and INMTA are only available when EDIR = Y.

DIR1, DIR2, DIR3, DIR4, ORDER, 50PDIRP, KGN, INMTA, 50NFP, 50NRP, a0N, 59RES, DIRWFP, DIRWRP, DIRWD, and EDIRIV (EDIRIV is a SELOGIC setting)

All these settings are explained in detail in the remainder of this subsection.

Not all 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 4.24 Directional Control Settings Not Made for Particular Conditions

Settings hidden/not made:	for condition:
50PDIRP	setting ELOAD := Y
50GFP, 50GRP, a0	setting ORDER does not contain V or I
Z0F, Z0R, Z0MTA	setting ORDER does not contain V or S
59RES, DIRWFP, DIRWRP, DIRWD	setting ORDER does not contain P
50NFP, 50NRP, a0N	setting ORDER does not contain S or U
KGN, INMTA	setting ORDER does not contain I or EDIR := AUTO
INMTA	setting KGN := OFF

Settings

DIR1—Level 1 Overcurrent Element Direction Setting
DIR2—Level 2 Overcurrent Element Direction Setting
DIR3—Level 3 Overcurrent Element Direction Setting
DIR4—Level 4 Overcurrent Element Direction Setting

Setting Range:

F = Direction Forward

R = Direction Reverse

N = Nondirectional

Table 4.25 shows the overcurrent elements that are controlled by each level direction setting. Note in *Table 4.25* that all the time-overcurrent elements (51_T elements) are controlled by the DIR1 level direction setting. *Figure 4.34*, *Figure 4.35*, *Figure 4.40*, and *Figure 4.41* show the logic implementation of the control listed in *Table 4.25*.

Table 4.25 Overcurrent Elements Controlled by Level Direction Settings DIR1 Through DIR4 (Corresponding Overcurrent Element Figure Numbers in Parentheses)

Level Direction Settings	Phase	Neutral Ground	Residual Ground	Negative-Sequence
DIR1	67P1P (*Figure 4.2*) 67P1T (*Figure 4.2*) 51P1P (*Figure 4.6*) 51P1T (*Figure 4.6*) 51P2P (*Figure 4.6*) 51P2T (*Figure 4.6*)	67N1P (*Figure 4.2*) 67N1T (*Figure 4.2*) 51N1P (*Figure 4.8*) 51N1T (*Figure 4.8*) 51N2P (*Figure 4.8*) 51N2T (*Figure 4.8*)	67G1P (*Figure 4.2*) 67G1T (*Figure 4.2*) 51G1P (*Figure 4.9*) 51G1T (*Figure 4.9*) 51G2P (*Figure 4.9*) 51G2T (*Figure 4.9*)	67Q1P (*Figure 4.2*) 67Q1T (*Figure 4.2*) 51QP (*Figure 4.7*) 51QT (*Figure 4.7*)
DIR2	67P2P (*Figure 4.2*) 67P2T (*Figure 4.2*	67N2P (*Figure 4.2*) 67N2T (*Figure 4.2*)	67G2P (*Figure 4.2*) 67G2T (*Figure 4.2*)	67Q2P (*Figure 4.2*) 67Q2T (*Figure 4.2*)
DIR3	67P3P (*Figure 4.2*) 67P3T (*Figure 4.2*)	67N3P (*Figure 4.2*) 67N3T (*Figure 4.2*)	67G3P (*Figure 4.2*) 67G3T (*Figure 4.2*)	67Q3P (*Figure 4.2*) 67Q3T (*Figure 4.2*)
DIR4	67P4P (*Figure 4.2*) 67P4T (F*Figure 4.2*)	67N4P (*Figure 4.2*) 67N4T (*Figure 4.2*)	67G4P (*Figure 4.2*) 67G4T (*Figure 4.2*)	67Q4P (*Figure 4.2*) 67Q4T (*Figure 4.2*)

In some applications, level direction settings DIR1 through DIR4 are not flexible enough in assigning the desired direction for certain overcurrent elements. *Directional Control Provided by Torque Control Settings on page 4.77* 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 4.19*, subject to the setting combination constraints in *Table 4.20* and *Table 4.21*. Note that *Table 4.19* and *Table 4.20* also list directional element availability per model (according to the neutral channel [IN] rating). *Table 4.21* lists the ground directional element availability as a result of the voltage connection settings.

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:

ORDER = **QVS**

then the first listed directional element (Q = negative-sequence voltage-polarized directional element; see *Figure 4.26*) is the first priority directional element to provide directional control for the neutral ground and residual ground overcurrent elements.

If the negative-sequence voltage-polarized directional element is not operable (i.e., it does not have sufficient operating quantity as indicated by its internal enable, DIRQGE, not being asserted; see *Figure 4.23*), then the second listed directional element (V = zero-sequence voltage-polarized directional element; see *Figure 4.27*) provides directional control for the neutral ground and residual ground overcurrent elements.

If the zero-sequence voltage-polarized directional element is not operable (i.e., it does not have sufficient operating quantity as indicated by its internal enable, DIRVE, not being asserted; see *Figure 4.24*), then the third listed directional element (S = zero-sequence voltage-polarized directional element [low-impedance]; see *Figure 4.29*) provides directional control for the neutral ground and residual ground overcurrent elements.

If the zero-sequence voltage-polarized directional element (low-impedance) is not operable (i.e., it does not have sufficient operating quantity as indicated by its internal enable, DIRNE [low-impedance], not being asserted; see *Figure 4.25*), then no directional control is available. The neutral ground and residual ground overcurrent elements will not operate, even though these elements are designated with the DIR*n* (*n* = 1–4) settings to be directionally controlled (see *Figure 4.34* and *Figure 4.35*).

Another example, if setting:

ORDER = **V**

then the zero-sequence voltage-polarized directional element (V = zero-sequence voltage-polarized directional element; see *Figure 4.27*) provides directional control for the neutral ground and residual ground overcurrent elements at all times (assuming it has sufficient operating quantity). If there is not sufficient operating quantity during an event (i.e., internal enable DIRVE is not asserted; see *Figure 4.24*), then no directional control is available. The neutral ground and residual ground overcurrent elements will not operate, even though these elements are designated with the DIR*n* (*n* = 1–4) settings to be directionally controlled (see *Figure 4.34* and *Figure 4.35*).

If setting:

ORDER = **OFF**

then all of the ground directional elements are inoperable. Note in *Figure 4.34* and *Figure 4.35* that setting ORDER := OFF effectively makes the neutral ground and residual ground overcurrent elements nondirectional (the directional control outputs of *Figure 4.34* and *Figure 4.35* are continuously asserted to logical 1).

Petersen Coil Considerations for Setting ORDER. Note in *Figure 4.34* that if setting ORDER := P, the residual ground overcurrent elements are not controlled by the directional control logic (much like when ORDER := OFF). In such a scenario, where only the wattmetric directional element provides ground overcurrent element directional control (setting ORDER := P), presumably there is no bypass around the Petersen coil. With the tuned Petersen coil in place (and not shorted out by a bypass), very little current flows for a ground fault. With such low current levels, the neutral-ground overcurrent elements (referenced in *Figure 4.35*) are the elements that detect the ground fault, not the residual-ground overcurrent elements (referenced in *Figure 4.34*). The residual ground overcurrent elements (including forward and reverse fault detectors 50GF and 50GR, respectively; see *Figure 4.24*) should be set above any ground fault current level with the Petersen coil in place.

If there is a bypass around the Petersen coil and the bypass is used at times (i.e., shorting out the Petersen coil), much higher currents can flow for a ground fault when the bypass is closed. In such a scenario, setting ORDER should be set something like ORDER := QP or ORDER := QVP (see *Table 4.20*). Then, the residual ground elements (*Figure 4.34*) are controlled by the directional control logic and provide directional protection for higher ground fault currents.

50PDIRP—Phase Directional Element Three-Phase Current Pickup

The 50PDIRP 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 4.38*).

If the load-encroachment logic is enabled (enable setting ELOAD := Y), then setting 50PDIRP is not made or displayed, but is fixed internally at:

0.5 A secondary (5 A nominal phase current inputs, **IA**, **IB**, **IC**)

0.1 A secondary (1 A nominal phase current inputs, **IA**, **IB**, **IC**)

Z2F—Forward Directional Z2 Threshold
Z2R—Reverse Directional Z2 Threshold

Z2F and Z2R are used to calculate the Forward and Reverse Thresholds, respectively, for the negative-sequence voltage-polarized directional elements (see *Figure 4.26* and *Figure 4.37*).

If enable setting EDIR := Y, settings Z2F and Z2R (negative-sequence impedance values) are calculated and entered by the user, but setting Z2R must be greater in value than setting Z2F by 0.1 Ω secondary.

NOTE: If Z2F or Z2R exceeds the setting range, the quantity is set to the upper limit of the setting range.

Z2F and Z2R Set Automatically. If enable setting EDIR := AUTO, settings Z2F and Z2R (negative-sequence impedance values) are calculated automatically, using the positive-sequence line impedance magnitude setting Z1MAG as follows:

Z2F = **Z1MAG/2** (Ω secondary)

Z2R = **Z1MAG/2 + z** (Ω secondary; "z" listed in table below)

Relay Configuration	z (Ω secondary)
5 A nominal current	0.2
1 A nominal current	1.0

Figure 4.44 and *Figure 4.45* and supporting text concern the zero-sequence impedance network, 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, though the preceding method of automatically making settings Z2F and Z2R usually suffices.

50QFP—Forward Directional Negative-Sequence Current Pickup
50QRP—Reverse Directional Negative-Sequence Current Pickup

The 50QFP setting (3I2 current value) is the pickup for the forward fault detector 50QF of the negative-sequence voltage-polarized directional elements (see *Figure 4.23*). Ideally, the setting is above normal load unbalance and below the lowest expected negative-sequence current magnitude for unbalanced forward faults.

The 50QRP setting (3I2 current value) is the pickup for the reverse fault detector 50QR of the negative-sequence voltage-polarized directional elements (see *Figure 4.23*). Ideally, the setting is above normal load unbalance and below the lowest expected negative-sequence current magnitude for unbalanced reverse faults.

50QFP and 50QRP Set Automatically. If enable setting EDIR := AUTO, 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

Refer to *Figure 4.23*.

The a2 factor 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 because of line asymmetries, CT saturation during three-phase faults, etc.

a2 Set Automatically. 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 4.23*:

- 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 neutral ground and 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 4.26*) to be enabled:

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

Equation 4.2

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:

$$I_0 = \frac{I_G}{3}$$
$$3I_0 = I_G = I_A + I_B + I_C$$

Equation 4.3

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.

k2 Set Automatically. 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 at least one of the internal enables DIRVE or DIRIE is asserted.

50GFP—Forward Directional Residual Ground Current Pickup
50GRP—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 (3I0 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 4.24*). Ideally, this setting is above normal load unbalance and below the lowest expected zero-sequence current magnitude for unbalanced forward faults.

The 50GRP setting (3I0 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 4.24*). Ideally, this setting is above normal load unbalance and below the lowest expected zero-sequence current magnitude for unbalanced reverse faults.

See *Petersen Coil Considerations for Setting ORDER on page 4.58* for more information on setting 50GFP and 50GRP for a Petersen coil-grounded system.

50GFP and 50GRP Set Automatically. If enable setting EDIR := AUTO, 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)

Operation of the Channel IN Current-Polarized Directional Element

Figure 4.28 shows the logic for the current polarized directional element for ground faults. Traditional elements of this type use the directional characteristics shown in *Figure 4.42*, where the maximum torque line of the element is in phase with the polarizing current, I_N. This is adequate for solidly-grounded and most low-impedance grounded systems.

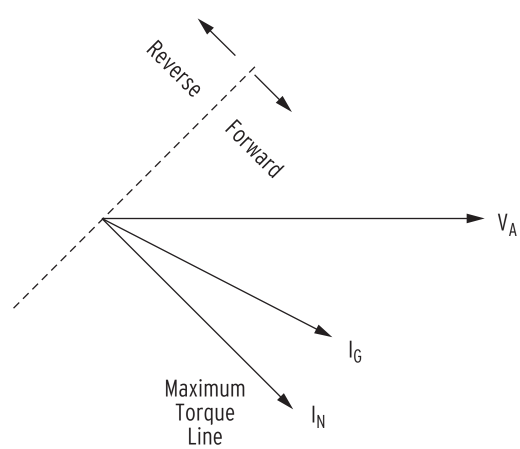


Figure 4.42 Traditional Channel IN Current-Polarized Directional Element

In certain impedance grounded systems with high line charging capacitance, capacitive currents can cause the traditional element to improperly declare reverse currents as forward, causing unfaulted circuits to trip during ground faults. This can be prevented by adjustment of the maximum torque angle using the setting INMTA, as shown in *Figure 4.43*.

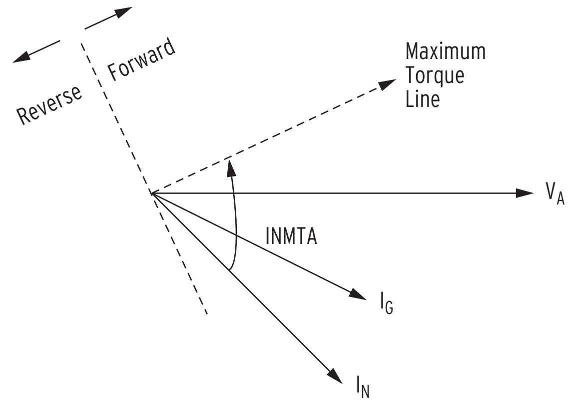


Figure 4.43 Current-Polarized Directional Element Characteristic When INMTA ≠ 0.00

KGN—Neutral Restraint Factor

If setting ORDER does not contain I (no channel IN current-polarized directional elements are enabled), or EDIR := N, or EDIR := AUTO, then setting KGN is not made or displayed and KGN is set to OFF internally.

When traditional operation of the Channel IN Current-Polarized Directional Element is desired, set KGN := OFF. With this setting, the maximum torque line of the element is in phase with the polarizing current, I_N, that is, INMTA is effectively 0 (see *Figure 4.42*). This is the proper setting for solidly-grounded and most impedance grounded applications.

When KGN is set to a value other than OFF, the measured residual current, IG, must be greater than KGN • I_N • CTRN/CTR before the element is allowed to operate (see *Figure 4.24*). This provides additional security for the directional element when there is false residual current because of mismatch of the phase CTs of an unfaulted feeder. The neutral channel current, I_N, is scaled by CTRN/CTR to place it on the same base as the residual current, I_G.

INMTA—Neutral Maximum Torque Angle

If KGN := OFF, then setting INMTA is not made or displayed and INMTA is set to 0 internally.

The polarizing quantity I_N of the Channel IN Current-Polarized Directional Element is rotated INMTA degrees counter-clockwise (see *Figure 4.43*).

See the technical paper *Selecting Directional Elements for Impedance-Grounded Distribution Systems* by Ronald Lavorin, Daqing Hou, Hector J. Altuve, Normann Fischer, and Fernando Calero, available on the SEL website for more information on how to determine the settings for KGN and INMTA.

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.

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 because of line asymmetries, CT saturation during three-phase faults, etc. Refer to *Figure 4.24*.

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:

$$I_0 = \frac{I_G}{3}$$

$$3I_0 = I_G = I_A + I_B + I_C$$

Equation 4.4

a0 Set Automatically. 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—Forward Directional Z0 Threshold
Z0R—Reverse Directional Z0 Threshold

If setting ORDER does not contain V or S (no zero-sequence voltage-polarized directional element is enabled), then settings Z0F and Z0R are not made by the user or displayed.

Z0F and Z0R are used to calculate the Forward and Reverse Thresholds, respectively, for the zero-sequence voltage-polarized directional elements (see *Figure 4.27* and *Figure 4.29*).

If enable setting EDIR := Y, settings Z0F and Z0R (zero-sequence impedance values) are calculated by the user and entered by the user, but setting Z0R must be greater in value than setting Z0F by 0.1 Ω secondary.

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. However, settings Z0F and Z0R are applied to Figure 4.29, and Figure 4.31, where neutral current I_N, from neutral current channel **IN**, is also applied. Settings Z0F and Z0R are adjusted internally (with CT ratio settings) to operate on this I_N current base, when needed (effectively, Z0F • CTRN/CTR and Z0R • CTRN/CTR). See Internal Enables on page 4.31.

Z0F and Z0R Set Automatically. If enable setting EDIR := AUTO, settings Z0F and Z0R (zero-sequence impedance values) are calculated 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 below)

Relay Configuration	z (Ω secondary)
5 A nominal current	0.2
1 A nominal current	1.0

If setting ORDER := U (ungrounded or high-impedance grounded system; see *Figure 4.31*), the following settings are made internally and hidden:

Z0F = **-0.10 Ω secondary**

Z0R = **0.10 Ω secondary**

Deriving Z0F and Z0R Settings. *Figure 4.44* shows the voltage and current polarity for an SEL-751 in a zero-sequence impedance network (the same approach can be instructive for negative-sequence impedance analysis, too). For a forward fault, the SEL-751 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-751 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 4.44* is a solidly-grounded system (mostly inductive; presume uniform system angle), and the load is connected line-to-neutral, the impedance plot (in the R + jX plane) would appear as in *Figure 4.45a*, with resultant Z0F and Z0R settings as in *Figure 4.45b*. The zero-sequence line angle noted in *Figure 4.45a* (∠Z0MTA) is the same angle found in *Figure 4.27* and *Figure 4.29* (in the equation box with the Enable line).

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 4.44* and *Figure 4.45* just provide a theoretical background.

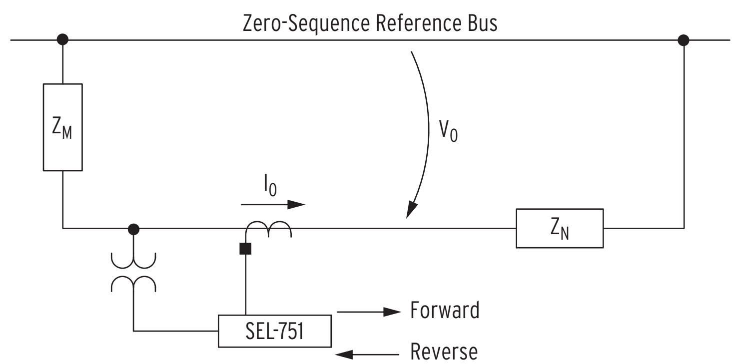


Figure 4.44 Zero-Sequence Impedance Network and Relay Polarity

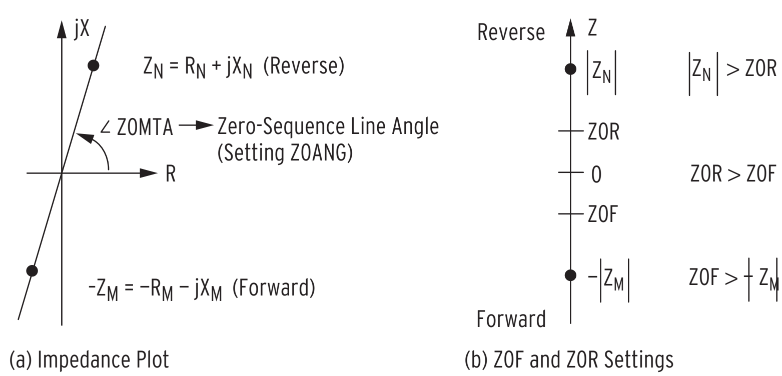


Figure 4.45 Zero-Sequence Impedance Plot for Solidly-Grounded, Mostly Inductive System

Z0MTA—Zero-Sequence Maximum Torque Angle

The Z0MTA setting is at the heart of the zero-sequence voltage-polarized directional element of *Figure 4.27*. Z0MTA is only available if both of the following conditions are true:

➤ enable setting EDIR := AUTO or Y

➤ setting ORDER contains the value "V" or "S"

Otherwise, Z0MTA is hidden and of no consequence. Z0MTA can be set one of two ways:

NOTE: STILL MAKE SETTING Z0ANG WHEN EDIR = Y
Even though setting Z0MTA is not automatically set equal to the value of setting Z0ANG when enable setting E32 = Y, setting Z0ANG should still be made for fault location purposes.

➤ If enable setting EDIR := AUTO, then Z0MTA is automatically set equal to the value of setting Z0ANG (the setting range of Z0MTA encompasses that of setting Z0ANG).

As long as EDIR := AUTO, Z0MTA can be seen, but not changed. This automatic setting mode is primarily for traditional applications, where the angle of the zero-sequence system impedance behind the relay is deemed to be essentially the same as the angle of the zero-sequence line impedance in front of it (see *Figure 4.44* and *Figure 4.45*[a]).

➤ If enable setting EDIR := Y, then Z0MTA is set independently within its setting range.

This option is primarily used for such applications as low-impedance grounded systems, which are discussed in the balance of this subsection.

The distribution system in *Figure 4.46* is low-impedance grounded at the substation by either of the following methods:

➤ a resistance in the transformer bank neutral

➤ a grounding bank with a resistance in its broken-delta secondary (effectively making it a neutral resistance)

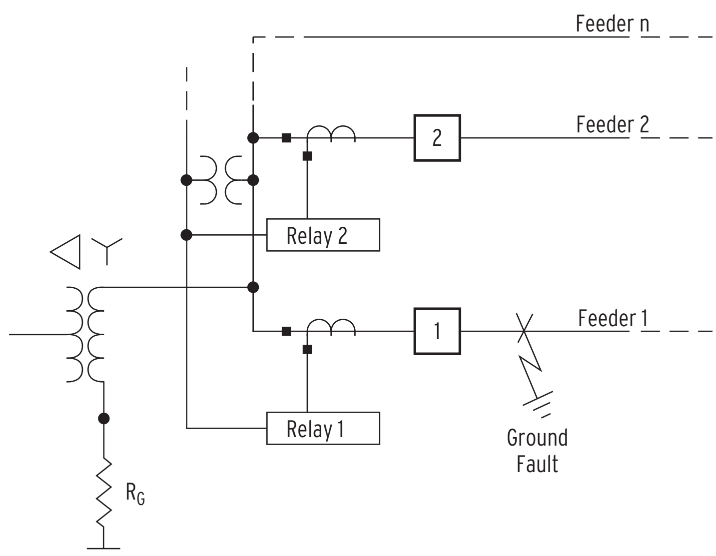


Figure 4.46 Low-Impedance Grounded Distribution System With a Ground Fault on Feeder 1

A grounding bank is installed if low-impedance grounding is desired at a substation and the transformer bank is to remain ungrounded. *Figure 4.46* also shows a ground fault out on Feeder 1 (a forward fault from the perspective of Relay 1). This example assumes that SEL-751 relays (Relay 1, Relay 2, etc.) are installed at feeder positions in a distribution substation.

Figure 4.47 shows the resultant zero-sequence impedance network for the ground fault on Feeder 1 in *Figure 4.46*. V_0 in *Figure 4.47* is the zero-sequence voltage seen by all the relays connected to the distribution substation bus three-phase voltage.

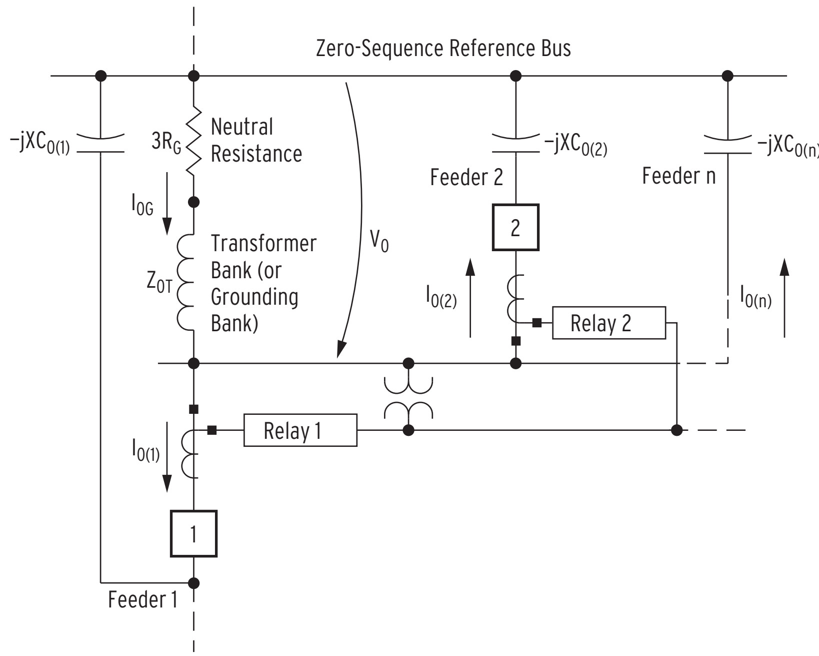


Figure 4.47 Zero-Sequence Impedance Network for Low-Impedance Grounded Distribution System With a Ground Fault on Feeder 1

Impedance definitions for *Figure 4.47*:

- $-jXC_{0(1)}$ = zero-sequence capacitive reactance for Feeder 1 (the faulted feeder)
- $-jXC_{0(2)}$ = zero-sequence capacitive reactance for Feeder 2
- $-jXC_{0(n)}$ = zero-sequence capacitive reactance for the cumulative other feeders
- Z_{0T} = transformer bank (or grounding bank) zero-sequence impedance
- R_G = neutral resistance, connected to transformer bank (or grounding bank)

The zero-sequence capacitive reactance values of the feeders are much larger than the zero-sequence feeder line impedances, so the zero-sequence feeder line impedances are ignored in this fault analysis.

Current definitions for *Figure 4.47*:

- $I_{0(1)}$ = zero-sequence current flow for Feeder 1 (forward direction for Relay 1)
- $I_{0(2)}$ = zero-sequence current flow for Feeder 2 (forward direction for Relay 2)

- $I_{0(n)}$ = zero-sequence current flow for cumulative other feeders (forward direction for relays on other feeders)
- I_{0G} = zero-sequence current flow through neutral resistance R_G and transformer bank (or grounding bank)

Presume there is a substantial capacitance-creating network (e.g., underground cable) on the individual feeders. As cable capacitance increases, capacitive reactance decreases, allowing for increased capacitive current flow. For the ground fault in *Figure 4.46* (a reverse fault from the perspective of Relay 2), Relay 2 sees zero-sequence current $I_{0(2)}$ flow toward the zero-sequence capacitive reactance $-jXC_{0(2)}$. If this current flow is high enough, a false trip may occur, unless otherwise prevented (e.g., by directional control).

Figure 4.48 plots the increase in zero-sequence current I_{0G} resulting from decreasing neutral resistance R_G.

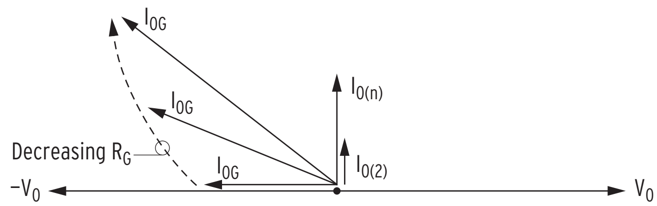


Figure 4.48 Decreasing Neutral Resistance R_G Results in Increasing Zero-Sequence Current I_{OG}

Vectorially add currents $I_{0(2)}$ and $I_{0(n)}$ to I_{0G} (per direction in *Figure 4.47*):

$$I_{0(1)} = I_{0G} - I_{0(2)} - I_{0(n)}$$

Figure 4.49 plots the increase in zero-sequence current $I_{0(1)}$ (seen by Relay 1) resulting from decreasing neutral resistance R_G.

NOTE: APPLY ZOMTA TO HIGH- RESISTANCE GROUNDED SYSTEM?
This example for the ZOMTA setting discussion addresses low-impedance grounded systems. A high-resistance grounded system (with its lower zero-sequence current values for ground fault conditions) requires that channel IN be connected to a separate current transformer, instead of in a factory-standard residual connection with the phase current channels.

Such a separate current transformer would have the three primary phase wires running through its core, eliminating any false residual current. Such current transformer applications are often referred to by one of the following names: flux-summing, core-balance, zero-sequence, ground fault, or window current transformers.

Other settings (see Figure 4.24 and Figure 4.27) also have to be considered to make sure they are sensitive enough for a high-resistance grounded system application.

The technical paper referenced at the end of this subsection also discusses directional element applications for high-resistance grounded systems.

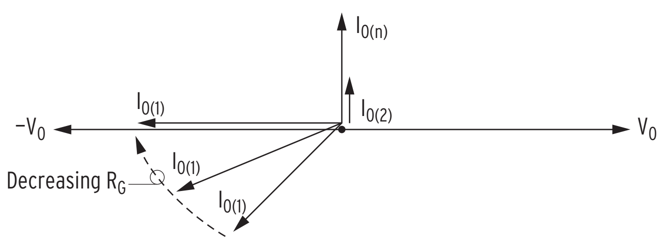


Figure 4.49 Decreasing Neutral Resistance R_G Results in Increasing Zero-Sequence Current $I_{O(1)}$ (Seen by Relay 1)

In *Figure 4.49*, the lowest magnitude of zero-sequence current $I_{0(1)}$ (at 225 degrees from zero-sequence voltage V_0) represents a high-resistance grounded system. The following (absolute value) comparisons are typically true for a high-resistance grounded system:

- $3R_G >> Z_{0T}$ (ignore transformer bank [or grounding bank] impedance Z_{0T})
- $3R_G$ = resultant impedance from the parallel combination of zero-sequence capacitive reactance values $-jXC_{0(2)}$ and $-jXC_{0(n)}$ (the total capacitive reactance behind Relay 1)

As neutral resistance R_G decreases, zero-sequence current $I_{0(1)}$ increases in *Figure 4.49*. The system is moving away from being a high-resistance grounded system toward being a low-resistance grounded system.

The zero-sequence voltage/current vector values of *Figure 4.49* are converted (using polarity and impedances in *Figure 4.47*) to the apparent zero-sequence impedances that the respective relays see, as plotted in *Figure 4.50*:

- Ground fault on Feeder 1 is in the forward direction for Relay 1:

  $V_0/(-I_{0(1)})$ = parallel combination of zero-sequence impedance values $-jXC_{0(2)}$, $-jXC_{0(n)}$, and $3R_G + Z_{0T}$

  $V_0/I_{0(1)}$ = –(parallel combination of zero-sequence impedance values $-jXC_{0(2)}$, $-jXC_{0(n)}$, and $3R_G + Z_{0T}$)

  $V_0/I_{0(1)}$ = the negative value of the aggregate zero-sequence impedance behind Relay 1

- Ground fault on Feeder 1 is in the reverse direction for Relay 2:

  $V_0/I_{0(2)} = -jXC_{0(2)}$

  $V_0/I_{0(2)}$ = the zero-sequence capacitive reactance for Feeder 2 in front of Relay 2

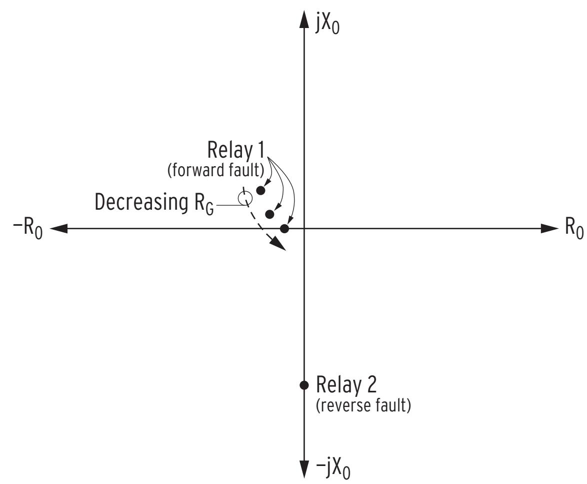


Figure 4.50 Zero-Sequence Impedance Plots for Ground Fault on Low-Impedance Grounded Distribution System

Presuming that all of the feeders in this distribution substation example have roughly the same amount of capacitance-creating network (e.g., underground cable), then the following applies:

- The Relay 1 apparent zero-sequence impedance plot in *Figure 4.50* is representative of a ground fault in front of any relay in the substation (forward fault).
- The Relay 2 apparent zero-sequence impedance plot in *Figure 4.50* is representative of a ground fault behind any relay in the substation (e.g., a ground fault on another parallel feeder; reverse fault).

The forward/reverse impedance plots in *Figure 4.50* appear asymmetric, especially when compared to *Figure 4.45*(a) for a solidly grounded system with sources at each end. The Z0MTA setting in *Figure 4.45*(a) would (by inspection) be approximately 75 degrees.

Contrastingly, the Z0MTA setting for *Figure 4.50* has to allow the forward/reverse characteristic to fit in between the forward/reverse impedance plots. The forward impedance plot is the most critical to accommodate—one definitely wants to operate for a forward fault. This necessitates a Z0MTA setting of approximately –40 degrees (for the lowest value of neutral resistance R_G), as shown in *Figure 4.51* for this example. Necessary settings are as follows:

Group Settings

EDIR := **Y**

Z0F := **–0.05**

Z0R := **0.05**

Z0MTA := **–40.00**

Other directional settings also have to be made (see *Figure 4.24* and *Figure 4.27*).

All these settings, zero-sequence voltage, and zero-sequence current converge on the zero-sequence voltage-polarized directional element in *Figure 4.27* (and its preceding enable logic in *Figure 4.24*) to produce the directional characteristic in *Figure 4.51*.

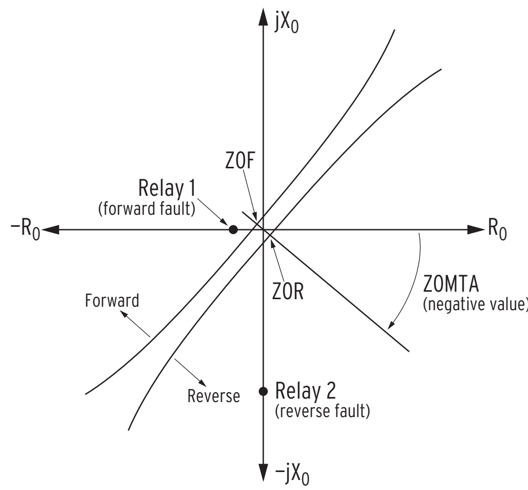


Figure 4.51 Z0MTA Setting Provides Forward/Reverse Ground Fault Discrimination in a Low-Impedance Grounded Distribution System

For more details on applying the Z0MTA setting on low-impedance grounded systems, refer to the following technical paper (available at selinc.com):

> *Selecting Directional Elements for Impedance-Grounded Distribution Systems* by Ronald Lavorin (Southern California Edison), Daqing Hou, Héctor J. Altuve, Normann Fischer, and Fernando Calero (Schweitzer Engineering Laboratories, Inc.)

In this paper, especially see pertinent discussion on modified DIRV (zero-sequence voltage-polarized directional) elements in the following subsections:

- V. Modified Directional Elements for Low-Impedance-Grounded Systems with High Charging Capacitances
- VI. Analysis of a Practical Resistance-Grounded System

  This subsection includes setting considerations involving the transformer bank (or grounding bank) zero-sequence impedance Z_{0T} and the neutral resistance R_G.

50NFP—Forward Directional Neutral Ground Current Pickup 50NRP—Reverse Directional Neutral Ground Current Pickup

If setting ORDER does not contain S or U (zero-sequence voltage-polarized directional elements: low-impedance or ungrounded/high-impedance grounded, are not enabled) or the model does not have a 0.2 A nominal neutral channel (IN), then settings 50NFP and 50NRP are not made or displayed.

NOTE: 50NFP and 50NRP (A secondary) are set in terms of the neutral current I_N, from neutral current channel IN. However, as discussed in Internal Enables on page 4.31, settings 50NFP and 50NRP are applied to Figure 4.25, Figure 4.29, and Figure 4.31, where residual current I_G (derived from phase current channels **IA**, **IB**, and **IC**) can be applied, depending on current magnitudes. Settings 50NFP and 50NRP are adjusted internally to operate on this residual current I_G base, when needed (effectively, 50NFP • CTRN/CTR and 50NRP • CTRN/CTR).

The 50NFP setting (I_N current value) is the pickup for the forward fault detector 50NF of the zero-sequence voltage-polarized directional elements: low-impedance or ungrounded/high-impedance grounded (see *Figure 4.25*). Ideally, this setting is above normal load unbalance and below the lowest expected zero-sequence current magnitude for unbalanced forward faults.

The 50NRP setting (I_N current value) is the pickup for the reverse fault detector 50NR of the zero-sequence voltage-polarized directional elements: low-impedance or ungrounded/high-impedance grounded (see *Figure 4.25*). Ideally, this setting is above normal load/system unbalance and below the lowest expected zero-sequence current magnitude for unbalanced reverse faults.

a0N—Positive-Sequence Current Restraint Factor, I_N/I_1

If setting ORDER does not contain S or U (zero-sequence voltage-polarized directional elements: low-impedance grounded or ungrounded/high-impedance grounded, are not enabled) or the model does not have a 0.2 A nominal neutral channel (IN), then setting a0N is not made or displayed.

Refer to *Figure 4.25*. The following comparison is made as part of internal enable DIRNE (for low-impedance grounded and ungrounded/high-impedance grounded systems):

$$|I_N| > a0N \bullet |I_1|$$

I_N is the secondary current measured by neutral channel **IN**. I_1 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 $3I_0$ zero-sequence current, $I_N = 3I_0$; see *Figure 2.29*, *Figure 2.31*, and *Figure 2.32*).

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 CTR, respectively).

From a primary system study, load profile values, or metering values, derive a0N as follows:

$$a0N = (3I_0 \text{ pri.}/I_1 \text{ pri.}) \bullet (CTR/CTRN)$$

$3I_0$ pri. = standing system unbalance current (zero-sequence; A primary)

I_1 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 elements: low-impedance grounded or ungrounded/high-impedance grounded. It keeps the elements from operating for zero-sequence current (system unbalance), which circulates because of line asymmetries, etc.

59RES—Wattmetric $3V_0$ Overvoltage Pickup (Petersen Coil-Grounded System)

If setting ORDER does not contain P (Petersen coil directional element is not enabled) or the model does not have a 0.2 A nominal neutral channel (**IN**), then setting 59RES is not made or displayed.

Setting 59RES should be set greater than the value of $3V_0$ zero-sequence voltage present for normal system unbalance. It is part of the enabling logic for the wattmetric element part of the Petersen coil directional element (see *Figure 4.30*).

The $3V_0$ input to *Figure 4.30* may come either from a calculation or from a direct measurement, as described in *Zero-Sequence Voltage Sources on page 4.33*. When using a broken-delta PT connection to terminals **VS-NS** as the zero-sequence voltage source (VSCONN := 3V0), there are some special considerations in making the 59RES setting that are related to the scaling of the **VS-NS** input signal. The 59RES setting must be entered on the same secondary base as the voltage terminals **VA**, **VB**, and **VC**. See *Settings Considerations for Petersen Coil-Grounded Systems on page 4.73* for an example.

DIRWFP and DIRWRP—Wattmetric Forward and Reverse Pickups (Petersen Coil-Grounded System)

If setting ORDER does not contain P (Petersen coil directional element is not enabled) or the model does not have a 0.2 A nominal neutral channel (**IN**), then settings DIRWFP and DIRWRP are not made or displayed.

Quantities needed to make the DIRWFP and DIRWRP wattmetric pickups calculations are:

$3V_0$ zero-sequence voltage in secondary (from inputs, **VA**, **VB**, **VC**; or input **VS** when VSCONN := 3V0)

I_N current in secondary (from 0.2 A nominal neutral channel input, **IN**)

The $3V_0$ input to *Figure 4.30* may come either from a calculation or from a direct measurement, as described in *Zero-Sequence Voltage Sources on page 4.33*. When using a broken-delta PT connection to terminals **VS-NS** as the zero-sequence voltage source (VSCONN := 3V0), there are some special considerations in making the DIRWFP and DIRWRP settings that are related to the scaling of the **VS-NS** input signal. The DIRWFP and DIRWRP settings must be entered on the same secondary base as the voltage terminals **VA**, **VB**, and **VC**. See *Settings Considerations for Petersen Coil-Grounded Systems on page 4.73* for an example.

I_N is the current measured by current channel **IN**. Channel **IN** is connected in such a manner that it monitors the system zero-sequence current (e.g., channel **IN** is connected to a window CT through which the three phase conductors pass and thus monitors $3I_0$ zero-sequence current, see *Figure 2.30*). With such a connection:

$$I_N = 3I_0$$

In *Figure 2.30*, only one feeder position is shown, but one can imagine the bus extending to the right, with other feeder positions. The Petersen coil in the transformer neutral is tuned to cancel out the cumulative zero-sequence line capacitance of all the connected feeders. The Petersen coil and the zero-sequence line capacitance are a parallel LC circuit. In a "tuned state," they create a high impedance circuit and thus a power system that is essentially ungrounded (with much less current flow than a traditional ungrounded system). In such an optimum tuned state, little current flows through the Petersen coil. Some Petersen coils are continually adjusted automatically, as load levels/system topology change, so that tuning remains optimum. The "tuned circuit" resists sustaining an arc, so many ground faults are self-extinguished by the circuit itself (no circuit breaker operation necessary).

Consider a permanent line-to-ground fault out on the feeder in *Figure 2.30* (refer to the relay and feeder shown in *Figure 2.30* as Relay 1 and Feeder 1, respectively; other feeders on the same bus, though not shown in *Figure 2.30*, are then Relay 2/Feeder 2, etc.). In the zero-sequence network view in *Figure 4.52*, Relay 2 (on unfaulted Feeder 2) sees mostly capacitance in front of it. Assuming a "tuned circuit," $I_0 = 0$ at the fault. Thus, the entire zero-sequence capacitance shown in *Figure 4.52* is canceled out by the inductance of the Petersen coil. So, with Feeder 1 capacitance C_1 in front of Relay 1, the system behind Relay 1 appears net inductive.

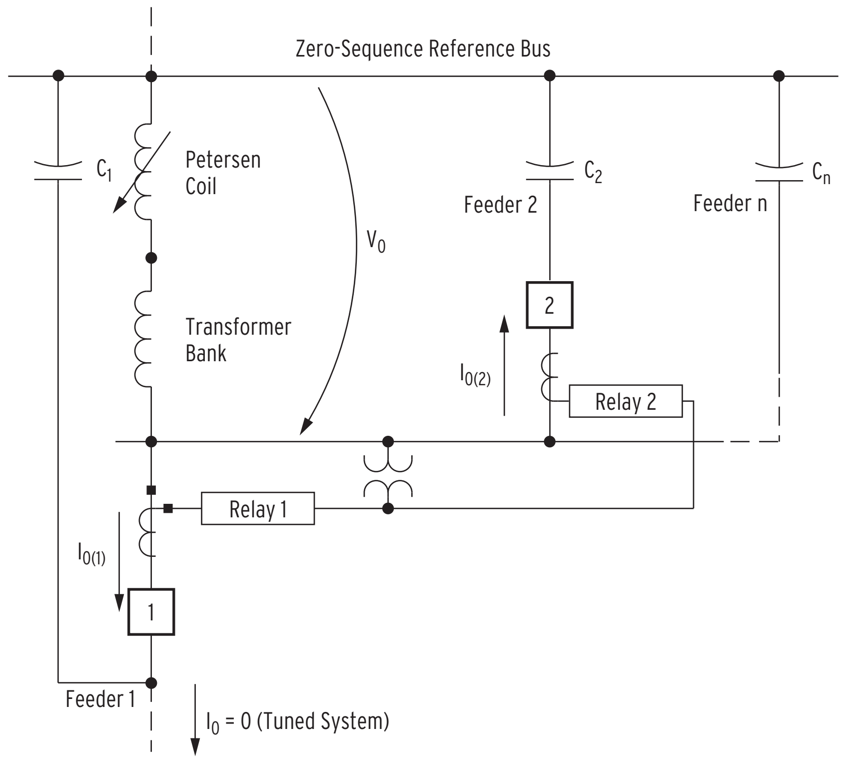


Figure 4.52 Zero-Sequence Impedance Network for Ground Fault on Feeder 1

Figure 4.53 shows the zero-sequence vector relationships described above for *Figure 4.52* (note: the zero-sequence currents $I_{0(1)}$ and $I_{0(2)}$ are what the relays respectively "see," per standard current transformer connections—see *Figure 2.30*). The vectors shown in *Figure 4.53* are perhaps somewhat over-dramatic as far as angle differences—they are primarily for illustrative purposes.

There is always some resistance in a circuit and thus the V_0 and I_0 vector relationship is not 90 degrees, as shown in *Figure 4.53*. This system resistance provides the "real power component" with which the wattmetric directional element (*Figure 4.30*) operates. Whether the zero-sequence network behind Relay 1 appears net capacitive or net inductive, the wattmetric (real power) portion for Relay 1/faulted Feeder 1 (labeled "WF") is polar-opposite of the wattmetric (real power) portion for Relay 2/unfaulted Feeder 2 (labeled "WR"). The calculations for the DIRWFP and DIRWRP wattmetric pickups are made as follows:

$$\text{Real}\ (3V_0 \bullet \text{conjugate}\ [3I_0]) = |3V_0| \bullet |3I_0| \bullet \cos(\angle 3V_0 - \angle 3I_0) = |3V_0| \bullet |I_N| \bullet \cos(\angle 3V_0 - \angle I_N)$$

The cosine part of the previous calculation reveals forward or reverse fault direction: forward faults produce negative calculation values and reverse faults produce positive calculation values on Petersen coil-grounded systems. Calculate the DIRWFP and DIRWRP wattmetric pickup settings (in watts secondary), with a margin of more sensitivity than the minimum detected ground faults (forward and reverse, respectively). Enter wattmetric settings as positive values.

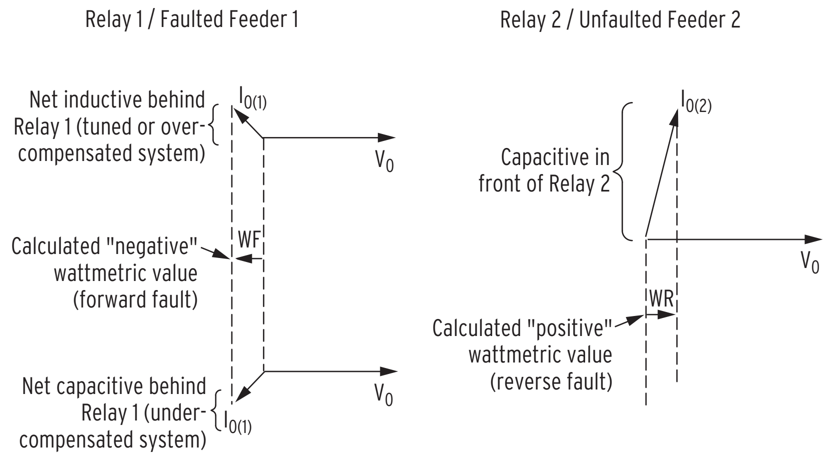


Figure 4.53 Wattmetric Element Operation for Ground Fault on Feeder 1

The sum of settings DIRWFP and DIRWRP must be 0.1 watts secondary or greater:

DIRWFP + DIRWRP ≥ 0.1 watts secondary

In *Figure 4.53*, the calculated wattmetric value for a forward fault is a negative value (shown as WF), while that for a reverse fault is a positive value (shown as WR). Again, corresponding settings DIRWFP and DIRWRP are both entered as positive values, with some margin of sensitivity. The above "0.1 watts secondary" rule is effectively the minimum distance between settings DIRWFP and DIRWRP in the wattmetric plane (setting DIRWFP is put on the "negative" side of the wattmetric plane: i.e., "–DIRWFP"; see *Figure 4.30*).

DIRWD—Wattmetric Delay (Petersen Coil-Grounded System)

If setting ORDER does not contain P (Petersen coil directional element is not enabled) or the model does not have a 0.2 A nominal neutral channel (**IN**), then setting DIRWD is not made or displayed.

Settings Considerations for Petersen Coil-Grounded Systems

The Petersen coil elements require a zero-sequence voltage source, which is calculated from voltages V_A, V_B, and V_C when the relay is wye connected (DELTA_Y := WYE and VSCONN := VS), or which is measured from the **VS** channel when the relay is connected to a broken-delta $3V_0$ source and VSCONN := 3V0. Three of the required Petersen coil element settings, 59RES, DIRWFP, and DIRWRP, depend on the type of $3V_0$ voltage source and on the PTR and PTRS group settings.

When VSCONN := VS and the relay is wye connected (DELTA_Y := WYE), the $3V_0$ source is in secondary volts on the **VA**, **VB**, **VC** input terminal base. In fact, $3V_0$ is calculated from the measured V_A, V_B, and V_C voltages. The 59RES, DIRWFP, and DIRWRP settings are set in terms of this same base.

An example system similar to *Figure 2.30*, with wye-connected PTs (PT ratio 7200:120; setting PTR = 7200/120 = 60) and a core-flux summation CT (CT ratio 50:5; setting CTRN = 50/5 = 10), is used to demonstrate the required setting scaling.

If the desired zero-sequence voltage pickup for the Wattmetric element in primary $3V_0$ is 400 V primary, obtain the proper setting for 59RES by dividing the primary voltage by the PT ratio for voltage inputs **VA**, **VB**, and **VC**:

$$59RES = \frac{\text{V primary}}{PTR} = \frac{\text{400 V primary}}{60} = \text{6.67 V secondary}$$

If the desired forward Wattmetric element threshold is 24 kW primary, and the desired reverse threshold is 10 kW primary, the correct settings are:

$$DIRWFP = \frac{\text{W primary}}{PTR \bullet CTRN} = \frac{\text{24000 W primary}}{60 \bullet 10} = \text{40.000 W secondary}$$

$$DIRWRP = \frac{\text{W primary}}{PTR \bullet CTRN} = \frac{\text{10000 W primary}}{60 \bullet 10} = \text{16.667 W secondary}$$

When VSCONN := 3V0, with a broken-delta $3V_0$ voltage source connected to the **VS** channel (terminals **VS-NS**), PTRS must be properly set to give the signal on the **VS** channel the correct scaling in primary units, as displayed under **VS** in the **METER** command response, available via serial port or front panel.

The example value PTRS := 96, as specified in *Potential Transformer Ratios and PT Nominal Secondary Voltage Settings on page 2.30*, is used for subsequent examples. The relay internally converts the **VS** channel signal to the **VA**, **VB**, **VC** voltage base before using it as the $3V_0$ quantity, as shown in *Table 4.26*. Thus, when the zero-sequence voltage pickup for the Wattmetric element is known in terms of the system primary voltage level, the required calculation for setting 59RES is the same as the calculation for the VSCONN := VS example shown previously, which converts the primary zero-sequence voltage value into a secondary value on the **VA**, **VB**, **VC** input terminal base.

Using the example quantities from the VSCONN := VS subsection:

$$59RES = \frac{\text{V primary}}{PTR} = \frac{\text{400 V primary}}{60} = \text{6.67 V secondary}$$

Note that the primary voltage is divided by the PTR setting, *not* the PTRS setting.

Similarly, the derivation of the DIRWFP and DIRWRP settings, if they are known in primary Watts, follows the same formula as before:

$$DIRWFP = \frac{\text{W primary}}{PTR \bullet CTRN} = \frac{\text{24000 W primary}}{60 \bullet 10} = \text{40.000 W secondary}$$

$$DIRWRP = \frac{\text{W primary}}{PTR \bullet CTRN} = \frac{\text{10000 W primary}}{60 \bullet 10} = \text{16.667 W secondary}$$

However, if the desired voltage pickup for the Wattmetric element is known in terms of **VS** channel volts (secondary), then the setting value must be scaled by PTRS/PTR prior to entry. This prescaling makes the 59RES setting match the scaling the relay does when it internally converts the **VS** channel value to the VA, VB, VC voltage base.

For our example system, the desired $3V_0$ pickup in terms of the voltage applied to channel **VS** is:

$$\text{Voltage value (VS channel base)} = \frac{\text{V primary}}{PTRS}$$

The example $3V_0$ pickup value in terms of the voltage applied to channel **VS** is:

$$\text{Voltage value (VS channel base)} = \frac{\text{400 V primary}}{96} = \text{4.167 V secondary}$$

The 59RES setting is determined as follows:

$$\begin{aligned} \text{59RES} &= \text{V secondary (VS base)} \bullet \frac{PTRS}{PTR} \\ &= 4.167 \bullet \frac{96}{60} = \text{6.67 V secondary} \end{aligned}$$

As expected, this is the same value as before.

Similarly, if the desired Wattmetric pickup for the Wattmetric element is known in terms of **VS** channel volts (secondary) and IN channel current (secondary), then the setting value must be scaled by PTRS/PTR prior to entry. This prescaling makes the DIRWFP and DIRWRP settings match the scaling the relay does when it converts the **VS** value into the VA, VB, VC voltage base.

For our example system, the desired Wattmetric pickup in terms of the voltage applied to channel **VS** and the current applied to channel **IN** is:

$$\text{Wattmetric value (VS and IN Base)} = \frac{\text{W primary}}{PTRS \bullet CTRN}$$

Forward = 24000 W / (96 • 10) = 25 W secondary

Reverse = 10000 W / (96 • 10) = 10.417 W secondary

The DIRWFP and DIRWRP settings are determined as follows:

$$\begin{aligned} DIRWFP &= \text{W secondary (VS and IN base)} \bullet \frac{PTRS}{PTR} \\ &= 25\text{ W} \bullet \frac{96}{60} = \text{40.000 W secondary (VA, VB, VC, and IN base)} \end{aligned}$$

$$\begin{aligned} DIRWRP &= \text{W secondary (VS and IN base)} \bullet \frac{PTRS}{PTR} \\ &= 10.417\text{ W} \bullet \frac{96}{60} \\ &= \text{16.667 W secondary (VA, VB, VC, and IN base)} \end{aligned}$$

These details are important in relay testing, when the signal applied to the **VS-NS** terminals represents a $3V_0$ zero-sequence voltage signal, and VSCONN := 3V0. When making test settings or interpreting test results, remember that the relay scales the measured value by PTRS/PTR before using it in the Petersen coil directional element and in the various zero-sequence voltage-polarized directional elements.

Table 4.26 Effect of Settings VSCONN and DELTA_Y on Petersen Coil Directional Elements

Relay Function	When VSCONN := VS and DELTA_Y := WYE	When VSCONN := VS and DELTA_Y := DELTA	When VSCONN := 3V0 (DELTA_Y := WYE or DELTA, and SINGLEV := Y)
Wattmetric and incremental conductance elements (ORDER setting choice "P").	Use 3V0 calculated from V_A, V_B, V_C as polarizing voltage.	ORDER cannot be set to contain "P" (no zero-sequence voltage source is available)	Use V_S • (PTRS/PTR) as 3V0 polarizing voltage.[a]

[a] The PTRS/PTR adjustment brings the broken-delta 3V0 quantity to the same base voltage as the relay settings 59RES, DIRWFP, and DIRWRP, which are based on the VA, VB, VC voltage base.

EDIRIV—SELOGIC Control Equation Enable

Refer to *Figure 4.24* and *Figure 4.25*.

SELOGIC control equation setting EDIRIV must be asserted to logical 1 to enable the zero-sequence voltage-polarized and channel IN current-polarized directional elements for directional control of neutral ground and residual ground overcurrent elements.

For most applications, set EDIRIV directly to logical 1:

EDIRIV = **1** (numeral 1)

For situations where zero-sequence source isolation can occur (e.g., by opening a circuit breaker) and result in possible mutual coupling problems for the zero-sequence voltage-polarized and channel IN current-polarized directional elements, SELOGIC control equation setting EDIRIV should be deasserted to logical 0. In this example, connect a circuit breaker auxiliary contact from the isolating circuit breaker to the SEL-751:

EDIRIV = **IN102** (52a connected to optoisolated input **IN102**)

Almost any desired control can be set in SELOGIC control equation setting EDIRIV.

Ungrounded/High-Impedance Grounded System Considerations for Setting EDIRIV

On ungrounded/high-impedance grounded systems (when setting ORDER := U), phase-to-phase or unbalanced three-phase faults can cause the ungrounded/high-impedance grounded element to operate on false quantities. To prevent this situation, SELOGIC setting EDIRIV may be used as follows:

EDIRIV := **V1GOOD * !DIRQE**

The V1GOOD Relay Word bit (V1GOOD asserts if the positive sequence voltage is greater than 75%*VNOM/sqrt(3) and deasserts during a three-phase fault, and the DIRQE Relay Word bit (see *Figure 4.23*) asserts during a phase-to-phase fault. If either one of these occur, the EDIRIV setting evaluates to logical 0, and the ungrounded/high-impedance grounded directional element is blocked (see *Figure 4.25*).

When a switch or breaker closes, the three poles may not close at the same time, creating a momentary current unbalance condition. To avoid any possible operation of the ungrounded/high-impedance grounded element for this momentary current unbalance condition, use the EDIRIV SELOGIC to override this condition, as in the following example.

EDIRV := **SV01T OR ....**

SV01PU := **0.05**

SV01DO := **0.00**

SV01 := **52A**

Directional Control Provided by Torque Control Settings

For most applications, the level direction settings DIR1 through DIR4 are used to set overcurrent elements direction forward, reverse, or nondirectional. *Table 4.25* shows the overcurrent elements that are controlled by each level direction setting. Note in *Table 4.25* that all the time-overcurrent elements (51_T elements) are controlled by the DIR1 level direction setting. See *Figure 4.34*, *Figure 4.35*, *Figure 4.40*, and *Figure 4.41*.

Suppose that the Level 1 overcurrent elements should be set as follows:

67P1P direction forward

67G1P direction forward

51P1T direction forward

51N1T nondirectional

51G1T direction forward

To accomplish this, the DIR1 setting is "turned off," and the corresponding SELOGIC torque-control settings for the above overcurrent elements are used to make the elements directional (forward or reverse) or nondirectional. The required settings are:

DIR1 = **N** ("turned off"; see *Figure 4.34*, *Figure 4.35*, *Figure 4.40*, and *Figure 4.41*)

50P1TC = **DIRPF** (direction forward; see *Figure 4.2*)

50G1TC = **DIRGF** (direction forward; see *Figure 4.2*)

51P1TC = **DIRPF** (direction forward; see *Figure 4.6*)

51N1TC = **1** (nondirectional; see *Figure 4.8*)

51G1TC = **DIRGF** (direction forward; see *Figure 4.9*)

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 logic (see *Figure 4.54*) and settings are enabled/ disabled with setting ELOAD. If the Group setting VNOM := OFF, then ELOAD is not available. See *Table 4.3* for more details on the VNOM setting.

The load-encroachment feature allows certain elements (system backup, phase directional, etc.) to be set without regard for load levels. For example, to obtain necessary system backup sensitivity, you may want to set the impedance element reach very long. Because of the long reach setting, the phase distance element would pick up during heavy load.

Load-Encroachment Settings

The SEL-751 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 4.27 Load-Encroachment Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
LOAD ENCROACH EN	Y, N	ELOAD := N
FWD LD IMPEDANCE	0.10–128.00 ohm[a]	ZLF := 6.50[a]
POS-FWD LD ANGLE	–90.00 to 90.00 deg	PLAF := 30.00
NEG-FWD LD ANGLE	–90.00 to 90.00 deg	NLAF := –30.00
REV LD IMPEDANCE	0.10–128.00 ohm[a]	ZLR := 6.50[a]
POS-REV LD ANGLE	90.00 to 270.00 deg	PLAR := 150
NEG-REV LD ANGLE	90.00 to 270.00 deg	NLAR := 210.00

[a] Setting ranges and default ohm values shown are for 5 A nominal CT rating. Multiply by 5 for 1 A CTs.

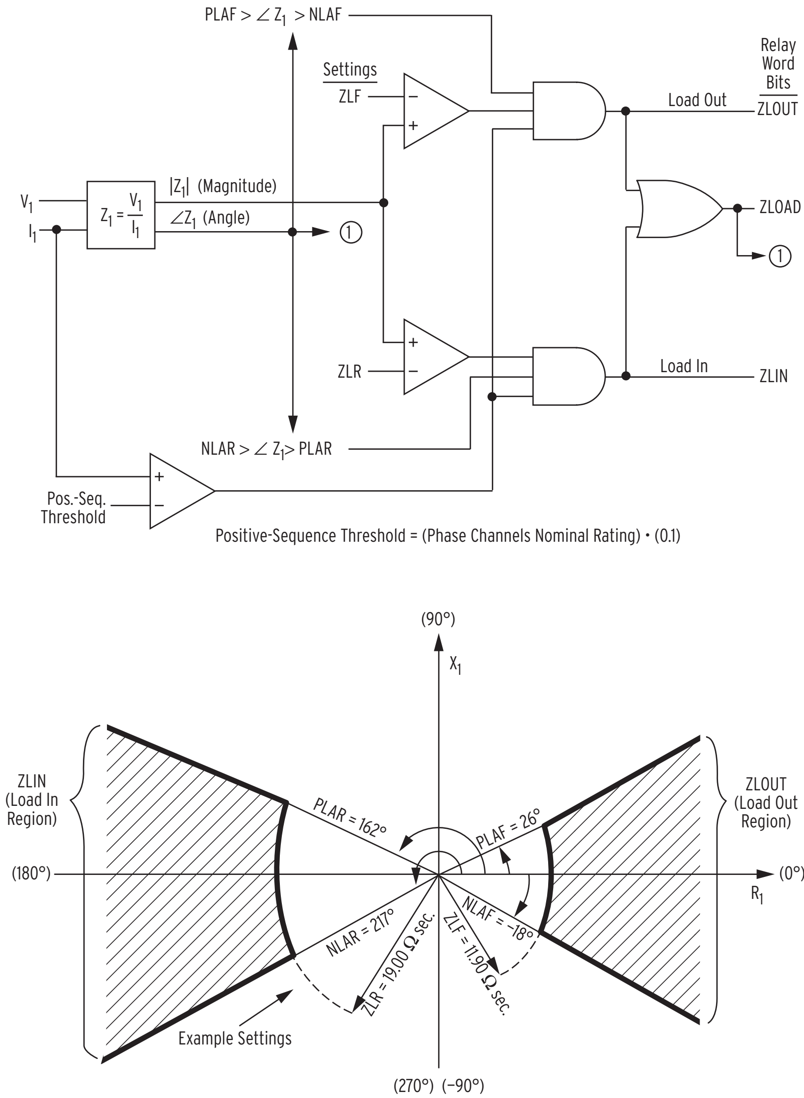
Note that a positive-sequence impedance calculation (Z_1) is made in the load-encroachment logic in *Figure 4.54*. Load is largely a balanced condition, so apparent positive-sequence impedance is a good load measure. The load-encroachment logic operates only if the positive-sequence current (I_1) is greater than the positive-sequence threshold defined in *Figure 4.54*. 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.

Relay Word bit ZLOAD is the OR-combination of ZLOUT and ZLIN:

ZLOAD := ZLOUT OR ZLIN



① To Figure 4.38

Figure 4.54 Load-Encroachment Logic

Load-Encroachment Examples

EXAMPLE 4.8 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.

EXAMPLE 4.9 Convert Maximum Loads to Equivalent Secondary Impedances

Start with maximum forward load:

800 MVA • (1/3) = 267 MVA per phase

230 kV • (1/√ 3) = 132.8 kV line-to-neutral

267 MVA • (1/132.8 kV) • (1000kV/MV) = 2010 A primary

2010 A primary • (1/CT ratio) = 2010 A primary • (400) = 5.03 A secondary

132.8 kV • (1000 V/kV) = 132800 V primary

132800 V primary • (1/PT ratio) = 132800 V primary • (2000) = 66.4 V secondary

Now, calculate the equivalent secondary impedance:

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

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

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

Again, for the maximum forward load:

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

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

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

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:

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

EXAMPLE 4.10 Convert Power Factors to Equivalent Load Angles

The power factor (forward load) can vary from 0.90 lag to 0.95 lead.

Setting PLAF := $\cos^{-1}$ (0.90) = 26°
Setting NLAF := $\cos^{-1}$ (0.95) = –18°

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

Setting PLAR := 180° – $\cos^{-1}$ (0.95) = 180° - 18° = 162°
Setting NLAR := 180° + $\cos^{-1}$ (0.80) = 180° + 37° = 217°

High-Impedance Fault Detection With Arc Sense Technology

High-impedance faults (HIF) are short-circuit faults with fault currents smaller than those a traditional overcurrent protective relay can detect. Almost all HIFs involve the ground directly or indirectly. The main causes of HIFs are tree branches touching a phase conductor; dirty or failing insulators that cause flash-overs between a phase conductor and the ground; or downed conductors touching the ground.

Staged downed-conductor fault tests in North America indicate that downed conductor HIFs generate quite small fault currents. The HIF current of multi-grounded systems depends highly on the surface types upon which a conductor falls, and the fault current varies from zero to less than 100 amperes.

The probability of HIF detection is dependent on the type of surface involved (asphalt, reinforced concrete, grass, etc.) and the moisture content of the surface (dry/wet). Both of these factors affect the conductivity, as seen by the fault current levels in *Figure 4.55*. While it is not possible to detect an HIF on an asphalt surface, the probability of HIF detection increases for more conductive surfaces (e.g., wet grass). Low levels of fault current make it extremely difficult to detect all HIFs while preventing the relay from causing nuisance trips/alarms. Refer to the technical paper *High-Impedance Fault Detection–Field Tests and Dependability Analysis* by Daqing Hou, available at selinc.com, for more information.

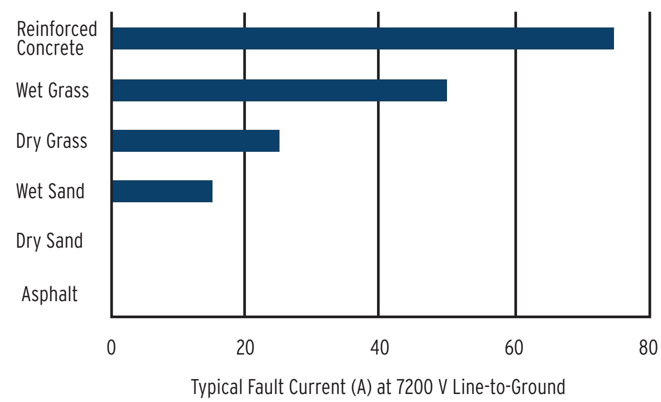


Figure 4.55 High-Impedance Fault Current Levels Depend on Ground Surface Type

NOTE: Detecting high-impedance faults has challenged utilities and researchers for years, especially in situations where a fault occurs on asphalt or dry sand or generates little or virtually no fault current. As is commonly known, not all HIFs are detectable. Detecting HIFs potentially reduces the risks associated with these faults. The SEL HIF detection method increases the likelihood that an HIF is detected.

NOTE: High-impedance fault detection using Arc Sense technology is only applicable for solidly grounded and low-impedance grounded systems.

High-impedance fault detection with Arc Sense technology (AST) is available in select SEL-751 models. The part number indicates whether or not the relay supports high-impedance fault detection.

HIF detection is based on the odd-harmonics and inter-harmonic components present in the current signal. HIF detection requires the current to be at least five percent of the nominal load current.

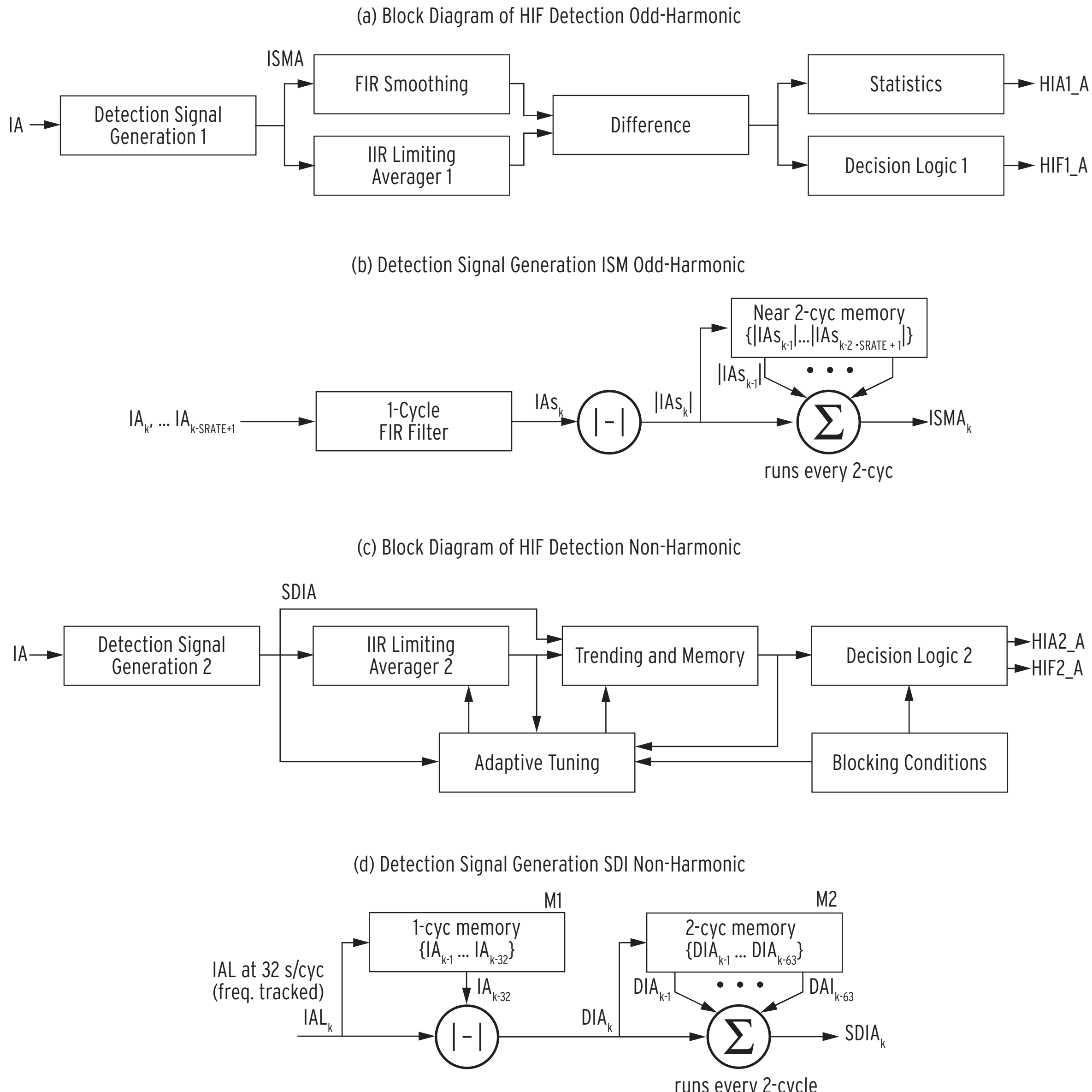
The HIF detection method shown in *Figure 4.56* incorporates the following key elements:

- An informative quantity that reveals HIF signatures as much as possible without being affected by loads and other system operation conditions.
- A running average of the quantity that provides a stable prefault reference.

- An adaptive tuning feature that learns and tunes out feeder ambient load conditions. (Note: A minimum of 0.05 • I_{NOM} load current is expected for successful tuning.)
- Decision logic to differentiate an HIF condition from other system conditions such as switching operations and noisy loads.

The HIF detection element derives a Sum of Difference current (SDI) that represents the total non-harmonic contents of the phase currents to detect an HIF signature. An averaging filter generates a stable reference of SDI and adapts to the ambient conditions of feeder loads. In turn, an adapted detection threshold is established based on the trends of the measured SDI and you would use decision logic to separate normal trending from the existence of an HIF on the distribution system. The SEL technical paper, *Detection of High-Impedance Faults in Power Distribution Systems* by Daqing Hou, details additional information about this HIF detection method.

Additional HIF detection logic measures the total odd-harmonic content (ISM), maintains long-term and short-term histograms of ISM, and generates HIF alarms by comparing the difference between two histograms. When the difference between the two histograms is not substantial, the long-term histogram is updated through an IIR filtering process from the short-term histogram. The long-term histogram therefore adapts to the feeder ambient load conditions and increases the overall HIF detection security.



Note: A-phase logic is shown above; B-phase and C-phase are similar.

Figure 4.56 HIF Detection Block Diagram

HIF Detection Settings

NOTE: It is recommended to use EHIF := Y for field tests and follow the initial tuning process.

Table 4.28 lists the relay settings corresponding to high-impedance fault detection. High-impedance fault detection is enabled by group setting EHIF := Y or T. When EHIF is set to Y, the detection algorithm begins calculating a running average of the applicable algorithm quantity to provide a stable prefault reference. This initial tuning asserts Relay Word bits ITUNE_*x* (where *x* = A, B, C). This process takes 24 hours but is interrupted by a change in the EHIF setting value, a change in the FNOM setting value, a loss of load current, or a relay trip condition.

Once interrupted, the initial tuning restarts the next time the relay detects load current. If necessary, it can be restarted with the **INI HIF** command or by asserting the programmable SELOGIC control equation HIFITUNE. See *INI HIF Command* in *Section 7: Communications* for more information on the **INI HIF** command. After the initial tuning process, the relay retains the learned value for four hours. If a line is de-energized for more than four hours, the relay restarts the initial tuning process upon the re-energization of the line. When EHIF is set to T, the detection algorithm bypasses the 24-hour tuning process and is available immediately for testing purposes. The relay must be tracking frequency in order for the high-impedance fault detection algorithm to work; if the relay is not tracking frequency, the algorithm is disabled.

The SEL-751 can be applied to systems where long-term reconfiguration occurs. For example, long-term distribution system reconfiguration may occur during certain abnormal conditions to minimize the number of people that are affected. Such reconfiguration can impact the effectiveness of the HIF algorithm. The HIF algorithm adapts to minor changes in load, but large changes may cause the long-term reference quantity to inaccurately represent the existing system conditions. To prevent system reconfiguration from adversely impacting the performance of the HIF algorithm, the programmable SELOGIC control equation HIFITUNE can be used to restart the 24-hour initial tuning process after the system has reconfigured.

High-impedance fault detection sensitivity is controlled by the group SELOGIC control equation setting HIFMODE. Assertion of this logic equation sets Relay Word bit HIFMODE and increases the sensitivity of the detection algorithm.

NOTE: A minimum of 0.05 • INOM load current is expected for successful tuning of the HIF detection algorithm.

Table 4.28 High-Impedance Fault (HIF) Detection Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
HIF EN	Y, N, T	EHIF := N
HIF DETECTION SENSITIVITY	SELOGIC	HIFMODE := 0
HIF EVENT REPORT EXT. TRIGGER[a]	SELOGIC	HIFER := 0
BEGIN 24 HOUR INITIAL HIF TUNING	SELOGIC	HIFITUNE := 0

[a] SEL recommends that you use edge-triggered Relay Word bits in the HIFER SELOGIC equation; otherwise, there may be issues when triggering multiple reports if the HIFER SELOGIC equation has multiple Relay Word bits and one of the Relay Word bits is asserted for a prolonged period of time (e.g., HIFER := R_TRIG 51G1P OR R_TRIG 51G1T).

EXAMPLE 4.11 HIFMODE Programming and Operation

As detailed previously, assertion of the HIFMODE SELOGIC control equation controls the sensitivity of the high-impedance fault detection algorithm. Field experience may suggest that downed conductor events that lead to high-impedance faults might occur more frequently during periods of storm activity. Furthermore, conductor configuration could make it likely that a downed conductor might initially create a high-current fault by making temporary contact with another conductor. This fault would be detected and cleared; disappearing upon a successful autoreclosure. The downed conductor would then be creating a high-impedance fault. It is during this time that it would be desirable to increase the sensitivity of the high-impedance fault detection algorithm. For example, a successful reclosure Relay Word bit could trigger a timer input. The dropout period of the timer is set to the period of time that is desired for increased detection sensitivity.

Enter the following Group Settings:

EHIF := Y

HIFMODE := SV16T AND 52A

Enter the following Logic Settings:

SV16PU := 0.00 # Pickup set to 0.00 sec

SV16DO := 1800 # Dropout set to 30.0 minutes on a 60 Hz system

SV16 := R_TRIG 79RI # (in reclose cycle state)

EXAMPLE 4.12 HIFITUNE Operation

For this example, assume that the following conditions occur:

- ➤ The HIF algorithm is operating in normal tuning mode.
- ➤ The system configuration changes permanently or for the long term. (The line that the SEL-751 is protecting may have picked up/dropped off significant load.)

Since the line configuration being monitored by the SEL-751 has changed, the load characteristics of the system may have also changed. You should consider forcing the HIF algorithm into the 24-hour initial tuning mode by asserting (manually or remotely) the SELOGIC control equation, HIFITUNE, or by issuing the INI HIF command.

While the recloser is timing towards the reset state after a successful reclosure Relay Word bit 79RI asserts the output for SV Timer 16. The timer stays asserted for the duration of the dropout setting, which is 30 minutes in this example. During this 30 minutes, the timer assertion maintains the assertion of HIFMODE, assuring a window of time for increased sensitivity of the HIF detection algorithm.

Group SELOGIC control equation setting HIFER allows for the automatic triggering of HIF detection event reports. Assertion of HIFER sets the Relay Word bit HIFREC and triggers an event report.

HIF Detection Logical Outputs

The SEL-751 indicates HIF detection through the Relay Word Bit outputs detailed in *Table 4.29*. You can use Relay word bits in custom logic programming to indicate high-impedance fault detection activity.

Because the small amount of fault current from an HIF may not be a danger to power system operation, service continuity may be enhanced by using HIF detection to only alarm for a downed conductor (i.e., not including the HIF1_*x*, HIA1_*x*, HIF2_*x*, and HIA2_*x* Relay Word bits in the TRIP equation directly). The utility may dispatch a crew to patrol the affected feeder without interrupting service to customers and may issue a public advisory notice about the danger. The ultimate decision depends on the operational policies of your utility.

Table 4.29 HIF Relay Word Bits (Sheet 1 of 2)

HIF Activity	Relay Word Bits
HIF ISM ALARM	HIA1_A, HIA1_B, HIA1_C
HIF SDI ALARM	HIA2_A, HIA2_B, HIA2_C
HIF ISM FAULT	HIF1_A, HIF1_B, HIF1_C
HIF SDI FAULT	HIF2_A, HIF2_B, HIF2_C
HIF Externally Triggered Event	HIFER
HIF Detection Mode Sensitivity	HIFMODE
HIF Event Report is being collected	HIFREC
Freeze and retain the learned HIF quantities during a system disturbance	FRZCLRA, FRZCLRB, FRZCLRC
Current Disturbance	DIA_DIS, DIB_DIS, DIC_DIS
Voltage Disturbance	DVA_DIS, DVB_DIS, DVC_DIS
Disable HIF Decision Logic	DL2CLRA, DL2CLRB, DL2CLRC
Initial HIF Tuning in Progress	ITUNE_A, ITUNE_B, ITUNE_C

Table 4.29 HIF Relay Word Bits (Sheet 2 of 2)

HIF Activity	Relay Word Bits
Begin 24-Hour Initial HIF Tuning Process	HIFITUNE, INI_HIF
Normal HIF Tuning in Progress	NTUNE_A, NTUNE_B, NTUNE_C
Increase the HIF Tuning Threshold	DUPA, DUPB, DUPC
Decrease the HIF Tuning Threshold	DDNA, DDNB, DDNC
Load Reduction Detected	LRA, LRB, LRC, LR3

HIF Detection Event Reports and Histories

The SEL-751 stores HIF detection information as compressed events and as event summaries, logs, and histories. See *High-Impedance Fault Event Summary on page 10.30*, *High-Impedance Fault Compressed Event Report on page 10.34*, and *Figure 7.20*, *Figure 5.15: MET H (HIF) Command Response*, *Figure 7.28: LOG H (HIF) Command Response*, and *Figure 7.27: HSG Command Response* for more information.

Second- and Fifth-Harmonic Blocking Logic

When a distribution feeder supplies many transformers, magnetizing inrush currents may cause sensitive overcurrent elements to operate when the line is energized. The second-harmonic blocking logic can prevent this by blocking such elements until inrush currents have subsided. As shown in *Figure 4.57* and *Figure 4.58*, this logic uses the ratio of the second-harmonic content of each phase to the fundamental current of the same phase to calculate the percent harmonic content. The fifth-harmonic blocking logic is analogous to the second-harmonic logic.

When the SELOGIC torque-control equation HBL2TC evaluates to logical 1, and if the second-harmonic content of a particular phase (e.g., IAHC2 for A-phase in *Figure 4.57*) exceeds the adjustable pickup threshold HBL2P for the pickup time delay HBL2PU, the blocking Relay Word bit for that phase asserts. Once the output is asserted, if the second-harmonic content falls below the threshold for the dropout time delay HBL2DO, the output deasserts. If any of the phase outputs asserts, Relay Word bit HBL2T also asserts. The same logic applies to fifth-harmonic blocking.

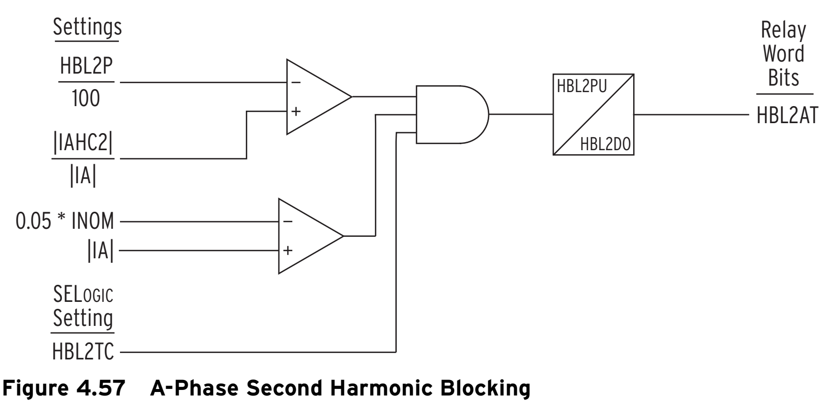


Figure 4.57 A-Phase Second Harmonic Blocking

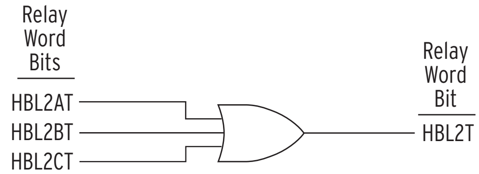


Figure 4.58 Three-Phase Second- and Fifth-Harmonic Blocking Logic

Table 4.30 Second-Harmonic Blocking Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
2ND HARM BLOCK	Y, N	EHBL2 := N
2ND HARM PU	5–100%	HBL2P := 10
2ND HARM PU DLY	0.00–320.00 sec	HBL2PU := 0.00
2ND HARM DO DLY	0.00–320.00 sec	HBL2DO := 0.00
2ND HARM TC	SELOGIC	HBL2TC := 1
5TH HARM BLOCK	Y, N	EHBL5 := N
5TH HARM PU	5–100%	HBL5P := 10
5TH HARM PU DLY	0.00–320.00 sec	HBL5PU := 0.00
5TH HARM DO DLY	0.00–320.00 sec	HBL5DO := 0.00
5TH HARM TC	SELOGIC	HBL5TC := 1

Second- and fifth-harmonic blocking elements are typically used to supervise sensitive overcurrent elements. CT saturation during faults can cause the relay to measure harmonic currents. The harmonic blocking elements may also assert briefly when the fundamental frequency current changes. Either condition might delay the supervised element. Set an unsupervised element above the expected inrush current to provide fast protection during large faults. Set the harmonic blocking timer pickup for more than one cycle in applications that cannot tolerate the element operating because of current changes.

EXAMPLE 4.13 Instantaneous Overcurrent Element Blocking

In this example, including second-harmonic blocking element HBL2T in the torque-control equation for Level 1 phase overcurrent element 67P1 helps prevent operation because of transformer inrush.

50P1P := **10.00 A**
50P2P := **20.00 A**
50P1D := **0.03 sec**
50P1TC := **!HBL2T**
50P2TC := **1**
TR := **...+ 67P1T + 67P2T +...**

The Level 1 time delay 50P1D allows time for the blocking element to assert. Level 2 phase overcurrent element setting 50P2P is high enough that the element does not operate when the line is energized but low enough to operate for high current faults when current transformer saturation or fundamental frequency current change might briefly block the Level 1 element.

EXAMPLE 4.14 Time-Overcurrent Element Blocking

For time-overcurrent elements, it may be desirable for the element to continue timing when transformer inrush is detected, yet trip the breaker if the time-overcurrent element remains asserted after the inrush conditions have subsided.

51P1P := **6.00 A**
51AP := **10.00 A**
51BP := **10.00 A**
51CP := **10.00 A**
HBL2DO := **0.03 sec**
51P1TC := **1**
51ATC := **1**
51BTC := **1**
51CTC := **1**
TR := **...+ 51P1T * !HBL2T + 51AT + 51BT + 51CT +...**
ER := **...+ /51P1P + /51P1T +...**

In this example, 51P1T is allowed to assert regardless of the state of the second-harmonic blocking element. However, 51P1T cannot cause a trip if HBL2T is asserted. Dropout timer HBL2DO ensures that the blocking condition is maintained until 51P1T deasserts. If electromechanical reset is disabled (51P1RS := N), 51P1T remains asserted for 1 cycle after the phase current falls below pickup setting 51P1P. HBL2DO may be increased to provide additional security should the second-harmonic current fall below the pickup threshold before the fundamental frequency current falls below the overcurrent element pickup. Because the relay may not trip when 51P1T asserts, the ER Event Report Trigger SELOGIC control equation is modified to trigger an event report. This event report can be used to evaluate the effectiveness of the harmonic blocking and determine if setting adjustments are necessary.

EXAMPLE 4.15 Changing the Pickup of a Time-Overcurrent Element

Use the second-harmonic blocking elements to increase the pickup current of a time-overcurrent element during inrush conditions without changing the time delay characteristics. For example,

51P1P := **6.00 A**
51AP := **15.00 A**
51BP := **15.00 A**
51CP := **15.00 A**
50P3P := **12.00 A**
51P1TC := **!HBL2T + 50P3**
51ATC := **1**
51BTC := **1**
51CTC := **1**
TR := **...+ 51PT + 51AT + 51BT + 51CT +...**

In this example, the maximum-phase time-overcurrent element operates if the harmonic blocking element is deasserted or the phase current exceeds the Level 3 phase instantaneous overcurrent setting. If harmonic blocking is asserted and the phase current is below the Level 3 phase instantaneous overcurrent setting, the time-overcurrent element 51P1P does not operate. Thus the pickup of the maximum-phase time-overcurrent element 51P1 is increased from 6 amperes secondary to 12 amperes secondary during inrush. Once the maximum phase current exceeds 50P3P, the timing of the 51P1 element does not change, so coordination is maintained for large faults.

As shown in Figure 4.6, if the torque control equation 51PTC deasserts, the Level 1 phase time-overcurrent element may fully or partially reset. When second-harmonic blocking elements are included in torque control equations for time-overcurrent elements, the element will need to time from reset after the blocking element deasserts. Consider this when evaluating time-overcurrent coordination and when reviewing event reports in which harmonic blocking has operated.

RTD-Based Protection

RTD Input Function

When you connect an SEL-2600 RTD Module (select E49RTD := EXT) or order the internal resistance temperature device (RTD) card option (select E49RTD := INT), the SEL-751 offers several protection and monitoring functions, settings for which are described in *Table 4.31*. See *Figure 2.15* for the RTD module fiber-optic cable connections. If the relay does not have internal or external RTD inputs, set E49RTD := NONE.

NOTE: The SEL-751 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 4.31 shows Location, Type, and Trip/Warn Level settings only for RTD1; settings for RTD2–RTD12 are similar.

NOTE: RTD curves in SEL products are based on the DIN/IEC 60751 standard.

Table 4.31 RTD Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
RTD ENABLE	INT, EXT, NONE	E49RTD := NONE
RTD1 LOCATION	OFF, WDG, BRG, AMB, OTH	RTD1LOC := OFF
RTD1 TYPE	PT100, NI100, NI120, CU10	RTD1TY := PT100
RTD1 TRIP LEVEL	OFF, 1–250°C	TRTMP1 := OFF
RTD1 WARN LEVEL	OFF, 1–250°C	ALTMP1 := OFF
• • •	• • •	• • •
WIND TRIP VOTING	Y, N	EWDGV := N
BEAR TRIP VOTING	Y, N	EBRGV := N

RTD Location

The relay allows you to independently define the location of each monitored RTD by using the RTD location setting, RTDnLOC.

Define the RTD location settings by using the following suggestions:

- ➤ If an RTD is not connected to an input or has failed in place and is not to be replaced, set the RTD location for that input equal to OFF.
- ➤ For RTDs embedded in motor 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 another apparatus, set the RTD location equal to OTH.

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 for setting RTD*n*TY are:

- 100-ohm platinum (PT100)
- 100-ohm nickel (NI100)
- 120-ohm nickel (NI120)
- 10-ohm copper (CU10)

RTD Trip/Warning Levels

The SEL-751 provides temperature warnings and trips through use of the RTD temperature measurements and the warning and trip temperature settings, ALTMP*n* and TRTMP*n*, in *Table 4.17*.

NOTE: To improve security, RTD ALARM and TRIP are delayed by approximately 6 seconds.

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 EWDGV equals Y. Only one excessive temperature indication is necessary if the winding trip voting is not enabled. The bearing trip voting, EBRGV, 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 4.32* lists the RTD resistance versus temperature for the four supported RTD types.

Table 4.32 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

Table 4.32 RTD Resistance Versus Temperature (Sheet 2 of 2)

Temp (°F)	Temp (°C)	100 Platinum	120 Nickel	100 Nickel	10 Copper
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	179.53	315.31	249.80	17.17
428	220.00	183.17	327.54	259.20	17.56
446	230.00	186.82	340.14	268.90	17.95
464	240.00	190.45	353.14	278.90	18.34
482	250.00	194.08	366.53	289.10	18.73

IEC Thermal Elements

The SEL-751 implements three independent thermal elements that conform to the IEC 60255-149 standard. Use these elements to activate a control action or issue a warning or alarm when your power line overheats as a result of adverse operating conditions. For simplicity, the equations used to represent the thermal element calculations are presented in generic form. These equations are applicable to all three elements (n = 1, 2, and 3) presented in *Table 4.33*.

The relay computes the thermal level, THRL, of the protected equipment. The thermal level is a ratio between the estimated actual temperature of the equipment and the steady state temperature of the equipment when the equipment is operating at a maximum current value.

For each thermal element, you can select two sets of heating time constants (TCONH[x], x = 1 or 2) and two sets of cooling time constants (TCONC[x], x = 1 or 2) to cover a variety of heating and cooling conditions. The SELOGIC setting THST allows the user to switch between the two time constants. When THST = 0, the element uses the heating and cooling time constants TCONH[1] and TCONC[1], respectively. When THST = 1, the corresponding element uses the heating and cooling time constants TCONH[2] and TCONC[2], respectively.

The relay computes the thermal level using the following equations:

If $THIEQ \geq IEQPU$

$$THRL_t = (THRL_{t-1}) \bullet \left(\frac{TCONH[x]}{TCONH[x] + \Delta t}\right) + \left(\frac{THIEQ_t}{IMC}\right)^2 \bullet \left(\frac{\Delta t}{TCONH[x] + \Delta t}\right) \bullet FAMB$$

Equation 4.5

If THIEQ < $IEQPU$

$$THRL_t = (THRL_{t-1}) \bullet \left(\frac{TCONC[x]}{TCONC[x] + \Delta t}\right)$$

Equation 4.6

where:

$THRL_t$ = The thermal level at time t

$THRL_{t-1}$ = The thermal level from the previous processing interval

Δt = The processing interval for the element, which is once every power system cycle (i.e., 50 or 60 Hz). Δt is expressed in seconds for use in *Equation 4.5* and *Equation 4.6*.

$THIEQ$ = The equivalent heating current at time t, given in per unit

$IEQPU$ = The equivalent heating current pick up threshold setting, given in per unit

IMC = The maximum continuous current, given in per unit

$TCONH[x]$ = User-selectable equipment hot time constant which models the thermal characteristics of the equipment when it is energized in state x. The TCONH[x] setting is in minutes and expressed in seconds for use in *Equation 4.5*, *Equation 4.6*, and *Equation 4.11*.

$TCONC[x]$ = User-selectable equipment cold time constant that models the thermal characteristics of the equipment when it is de-energized in state x. The TCONC[x] setting is in minutes and expressed in seconds for use in *Equation 4.5*, *Equation 4.6*, and *Equation 4.12*

$FAMB$ = The ambient temperature factor

x = State of the thermal element that decides the set of time constants to use; x can be 1 or 2

The relay calculates the equivalent heating current, THIEQ, according to *Equation 4.7*.

$$THIEQ = \frac{THRO}{I_{NOM}}$$

Equation 4.7

where:

$THRO$ = User-selectable thermal model operating current

I_{NOM} = Nominal current rating of the input associated with THRO operating current (i.e., 1 A or 5 A)

Additionally, the relay calculates the maximum continuous current (IMC), according to *Equation 4.8*:

$$IMC = KCONS \bullet IBAS$$

Equation 4.8

where:

$KCONS$ = User-selectable maximum operating temperature of the equipment

$IBAS$ = Basic current value in per unit

Lastly, the relay computes the ambient temperature factor, FAMB, according to *Equation 4.9*:

$$FAMB = \frac{TMAX - 40°C}{TMAX - TAMB}$$

Equation 4.9

where:

$TMAX$ = User-selectable maximum operating temperature of the equipment

$TAMB$ = Ambient temperature measurement from user-selectable temperature probe

The thermal capacity used is a percentage representation of how close to the thermal limit the protected power apparatus is. It is calculated using *Equation 4.10*.

$$THTCU_t = \frac{THRL_t}{(THLT/100)} \bullet 100$$

Equation 4.10

If $FAMB \bullet [THIEQ_t/IMC]^2 > THLT/100$, the relay calculates the time before trip using *Equation 4.11*. This indicates an overload condition before the thermal level reaches the alarm or tripping threshold. The time indication allows an operator to take appropriate actions ahead of time.

$$THTRIP_t =$$

$$TCONH[x] \bullet \ln\left(\frac{FAMB \bullet [THIEQ_t/IMC]^2 - THRL_t}{FAMB \bullet [THIEQ_t/IMC]^2 - THLT/100}\right)$$

Equation 4.11

If $FAMB \bullet [THIEQ_t/IMC]^2 \le THLT/100$, the relay reports 9999 seconds.

If the thermal lockout Relay Word bit THRLT is asserted and THIEQ < IEQPU, the relay calculates the time to release the thermal element using *Equation 4.12*.

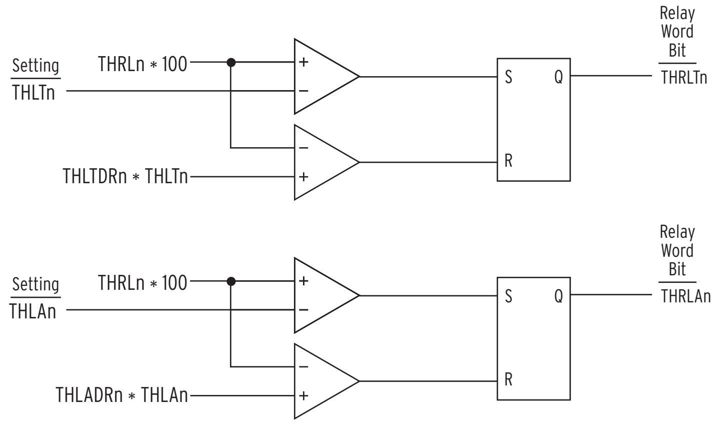
$$THRLS_t = TCONC[x] \bullet \ln\left(\frac{THRL_t}{THLTDR \bullet THLT/100}\right)$$

Equation 4.12

Otherwise, the relay does not calculate the time to lockout release.

Thermal Element Logic

Figure 4.59 shows the thermal alarming and tripping logic for each of the three thermal elements (*n* = 1, 2, or 3).



n = 1, 2, or 3.

Figure 4.59 Thermal Alarm and Trip Logic

When considering settings levels for the thermal elements alarming and tripping functions, note from *Equation 4.5* that the relay calculates the steady state thermal level as shown in *Equation 4.13*:

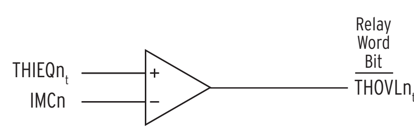
$$THRL_{SS} = \left(\frac{THIEQ}{IMC}\right)^2 \bullet FAMB$$

Equation 4.13

From this equation, the per-unit thermal level that the relay computes depends on the per unit current flowing through the equipment (THIEQ), and the KCONS and IBAS settings. These make up the IMC value and the ambient temperature factor, FAMB. Given this information, you can set the thermal level alarm and trip thresholds when considering the various operating current levels and temperatures that the equipment may be subjected to.

The relay makes the three calculated thermal levels THRL*n* available as analog quantities. Additionally, the three thermal level alarming Relay Word bits, THRLA*n*, as well as the three thermal level tripping Relay Word bits, THRLT*n*, are available.

Figure 4.60 shows the logic for thermal element current overload.



n = 1, 2, or 3.

Figure 4.60 Thermal Element Current Overload Logic

Thermal Element Settings

See *Table 4.33* for a list of the prompt, ranges, and default settings for the following thermal element settings. The enable IEC thermal element (E49IEC) setting enables 1, 2, or 3 independent thermal elements.

The ambient temperature measurement (TAMB) setting specifies the remote thermal device (RTD), such as the SEL-2600, internal RTD card, or remote analogs input that are used to measure the ambient temperature surrounding the device. The ambient temperature measured, TAMB, is used to calculate the ambient temperature factor, FAMB*n* (*n* = 1–3), as defined by *Equation 4.9*. If TAMB is set to OFF, FAMB*n* is then forced to 1. If TAMB is not set to OFF, the FAMB*n* value is supervised by the THAMBH Relay Word bit. If this bit is asserted, indicating the ambient temperature measurement is accurate, then the relay computes the FAMB*n* values using *Equation 4.9*. If the THAMBH bit is deasserted, then the FAMB*n* value is forced to 1.

If TAMB := RA, the THAMBH bit asserts when the relay receives five consecutive healthy data packets. A healthy packet is a valid data packet with the received temperature measurement in the data packet within –50°C to +250°C. The THAMBH bit has a dropout time of THAMBDO seconds and deasserts if no healthy data packets are received for THAMBDO seconds.

If TAMB := RTD, the relay looks at the internal status bits associated with the ambient temperature RTD (RTD*n*LOC := AMB, where *n* = 1–10 for E49RTD := INT, and *n* = 1–12 for E49RTD := EXT). The THAMBH bit deasserts if any one of the internal status bits associated with the ambient RTD assert, indicating open, short, diagnostic fail, or communication fail.

The TAMBLOC setting specifies the location of the ambient temperature measurement. If the ambient temperature measurement is from an RTD, then this setting should be the number of the ambient temperature measurement RTD. If the ambient temperature measurement is from a remote analog, then this setting should be the number of the remote analog receiving the ambient temperature measurement.

The THAMBDO setting defines the dropout time of THAMBH, the ambient temperature measurement health Relay Word bit.

The thermal model operating quantity (THRO*n*) must use a current that includes all of the additional heating effects of the current passing through the protected equipment. For this reason, the operating current choices are the three individual phase rms currents or the IMAX current, which is the maximum rms current seen among the three-phase currents.

The basic current value in per unit (IBAS*n*) setting accounts for the specified limiting value of the current for which the relay is required not to operate at when considering steady state conditions. The product of the basic current value, IBAS*n* (*n* = 1–3), and the basic current correction factor, KCONS*n* (described below), is the maximum continuous current, IMC, used by the relay in computing the thermal level.

The basic current correction factor (KCONS*n*) setting dictates the maximum continuous load current of the protected equipment. The product of the basic current value, IBAS*n*, and the basic current correction factor, KCONS*n*, is the maximum continuous current, IMC*n*, used by the relay in computing the thermal level.

The thermal element time constant state switch (THST*n*) setting enables the user to switch between two thermal element time constant states. The two states correspondingly use two sets of time constants for thermal calculation to cover the variety of heating and cooling conditions.

The heating thermal time constant (TCONH*nx*) setting defines the heating thermal time constant of thermal element *n* in state *x* of the equipment when the equipment is energized (i.e., when the current is above the IEQPU value).

The cooling thermal time constant (TCONC*n*) setting defines the cooling thermal time constant of thermal element *n* in state *x* of the equipment when the equipment is de-energized (i.e., when the current is below the IEQPU value).

The thermal level alarm limit (THLA*n*) setting specifies the percentage thermal level when the relay asserts the thermal alarm Relay Word bit.

The thermal level trip limit (THLT*n*) setting specifies the percentage thermal level when the relay asserts the thermal trip Relay Word bit.

The maximum temperature of the equipment (TMAX*n*) setting specifies the maximum operating temperature of the protected equipment. This setting is used to calculate FAMB*n* (see *Equation 4.9*). When TAMB := OFF, the TMAX*n* setting is ineffective, i.e., the relay does not use TMAX*n* in the FAMB*n* calculation and FAMB*n* is forced to 1.

The thermal element reset (RSTTH*n*) setting specifies the conditions that reset the thermal element *n* calculation to 0.

The equivalent heating current pickup value in per unit (IEQPU*n*) is used by the relay to switch between the hot and cold time constant thermal equations. This setting defines what the equipment considers to be insignificant operating current that results in negligible heating effects. Typically this value is very close to zero, corresponding to when the protected equipment is de-energized.

The thermal level trip dropout ratio (THLTDR*n*) setting defines the dropout ratio of thermal level trip. If the thermal level drops below THLTDR*n* • THLT*n*, Relay Word bit THRLT resets.

The thermal level trip dropout ratio (THLADR*n*) setting defines the dropout ratio of thermal level alarm. If the thermal level drops below THLADR*n* • THLA*n*, Relay Word bit THRLA resets.

Table 4.33 IEC Thermal Element Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default[a]
ENABLE IEC THML ELEM	N, 1–3	E49IEC := N
AMB TMP SRC	OFF, RTD, RA	TAMB := OFF
AMB TMP SRC LOC	1–12, if TAMB := RTD 1–128, if TAMB := RA	TAMBLOC := 1
TMP HLTH DO TIME	0.1–900.0 sec	THAMBDO := 1.0
OPERATING QTY	IARMS, IBRMS, ICRMS, IMAX	THRO1 := IARMS THRO2 := IBRMS THRO3 := ICRMS
BASIC CURR VALUE	0.1–3.0 PU	IBAS*n* := 1.0
CURRENT CORR FAC	1.00–2.00	KCONS*n* := 1.00
CURRENT PU	0.05–1.0 PU	IEQPU*n* := 0.05
TIME CONS SWI	SELOGIC	THST*n* := 0
HEAT TIME CONS	1–500 min	TCONH*nx* := 60
COOL TIME CONS	1–500 min	TCONC*nx* := 60
TRIP PU	1–150%	THLT*n* := 100
ALARM PU	1–100%	THLA*n* := 50
TRIP DO RATIO	0.01–0.99 PU	THLTDR*n* := 0.98

Table 4.33 IEC Thermal Element Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default[a]
ALARM DO RATIO	0.01–0.99 PU	THLADR*n* := 0.98
MAXIMUM TMP	80–300°C	TMAX*n* := 155
RESET THML	SELOGIC	RSTTH*n* := 0

[a] n = 1–3 and x = 1–2.

Under- and Overvoltage Functions

When you connect the SEL-751 voltage inputs to phase-to-phase connected VTs (single-phase or three-phase), as in *Figure 2.20* or *Figure 2.21*, the relay provides two levels of phase-to-phase overvoltage and undervoltage elements.

When you connect the SEL-751 voltage inputs to phase-to-neutral connected VTs (single-phase or three-phase), as in *Figure 2.20* or *Figure 2.21*, the relay provides two levels of phase-to-neutral, phase-to-phase overvoltage and undervoltage elements. Two levels of negative-sequence overvoltage elements are available when the VTs are connected in three-phase as shown in *Figure 2.21*. Two levels of zero-sequence overvoltage elements are available when the voltage inputs are connected in wye configuration (DELTA_Y := WYE) as shown in *Figure 2.21*. When a synchronism voltage input is present (e.g., VS input shown in *Figure 2.21*) the SEL-751 provides two levels of VS under- and overvoltage elements. You can use these elements to control reclosing logic described later.

Each of the elements has an associated time delay, except the three-phase under- and overvoltage elements, 3P27 and 3P59. You can use these elements as you choose for tripping and warning. *Figure 4.61* and *Figure 4.62* show the logic diagrams for the undervoltage and overvoltage elements, respectively. To disable any of these elements, set the level settings equal to OFF.

Table 4.34 Undervoltage Function

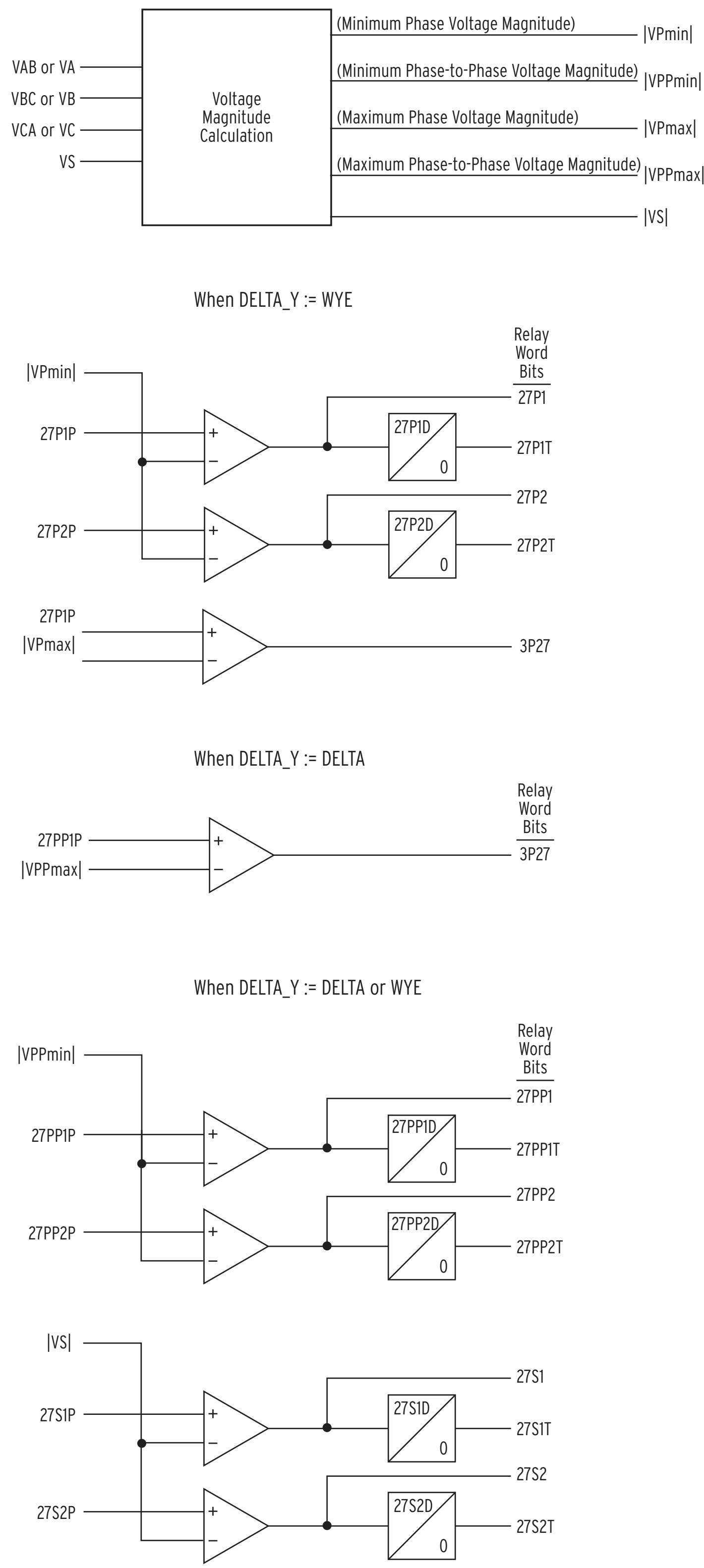
Setting Prompt	Setting Range	Setting Name := Factory Default
UV TRIP1 LEVEL	OFF, 2.00–300.00 V	27P1P := OFF
UV TRIP1 DELAY	0.00–120.00 sec	27P1D := 0.50
UV TRIP2 LEVEL	OFF, 2.00–300.00 V	27P2P := OFF
UV TRIP2 DELAY	0.00–120.00 sec	27P2D := 5.00
PP UV TRIP1 LEVEL	OFF, 2.00–300.00 V[a]	27PP1P := OFF
PP UV TRIP1 LEVEL	OFF, 2.00–520.00 V[b]	27PP1P := OFF
PP UV TRIP1 DELAY	0.00–120.00 sec	27PP1D := 0.50
PP UV TRIP2 LEVEL	OFF, 2.00–300.00 V[a]	27PP2P := OFF
PP UV TRIP2 LEVEL	OFF, 2.00–520.00 V[b]	27PP2P := OFF
PP UV TRIP2 DELAY	0.00–120.00 sec	27PP2D := 0.50
UVS LEVEL 1	OFF, 2.00–300.00 V	27S1P := OFF
UVS DELAY 1	0.00–120.00 sec	27S1D := 0.50
UVS LEVEL 2	OFF, 2.00–300.00 V	27S2P := OFF
UVS DELAY 2	0.00–120.00 sec	27S2D := 0.50

[a] Setting range shown is for DELTA_Y := DELTA.
[b] Setting range shown is for DELTA_Y := WYE.

Table 4.35 Overvoltage Function

Setting Prompt	Setting Range	Setting Name := Factory Default
OV TRIP1 LEVEL	Off, 2.00–300.00 V	59P1P := OFF
OV TRIP1 DELAY	0.00–120.00 sec	59P1D := 0.50
OV TRIP2 LEVEL	Off, 2.00–300.00 V	59P2P := OFF
OV TRIP2 DELAY	0.00–120.00 sec	59P2D := 5.00
PP OV TRIP1 LEVEL	Off, 2.00–300.00 V[a]	59PP1P := OFF
PP OV TRIP1 LEVEL	Off, 2.00–520.00 V[b]	59PP1P := OFF
PP OV TRIP1 DELAY	0.00–120.00 sec	59PP1D := 0.50
PP OVTRIP2 LEVEL	Off, 2.00–300.00 V[a]	59PP2P := OFF
PP OV TRIP2 LEVEL	Off, 2.00–520.00 V[b]	59PP2P := OFF
PP OV TRIP2 DELAY	0.00–120.00 sec	59PP2D := 5.00
ZS OV TRIP1 LVL	Off, 2.00–300.00 V	59G1P := OFF
ZS OV TRIP1 DLY	0.00–120.00 sec	59G1D := 0.50
ZS OV TRIP2 LVL	Off, 2.00–300.00 V	59G2P := OFF
ZS OV TRIP2 DLY	0.00–120.00 sec	59G2D := 5.00
NSQ OV TRIP1 LVL	Off, 2.00–300.00 V	59Q1P := OFF
NSQ OV TRIP1 DLY	0.00–120.00 sec	59Q1D := 0.50
NSQ OV TRIP2 LVL	Off, 2.00–300.00 V	59Q2P := OFF
NSQ OV TRIP2 DLY	0.00–120.00 sec	59Q2D := 5.00
UVS LEVEL 1	Off, 2.00–300.00 V	59S1P := OFF
UVS DELAY 1	0.00–120.00 sec	59S1D := 0.50
UVS LEVEL 2	Off, 2.00–300.00 V	59S2P := OFF
UVS DELAY 2	0.00–120.00 sec	59S2D := 0.50

[a] Setting range shown is for DELTA_Y := DELTA.
[b] Setting range shown is for DELTA_Y := WYE.



Note: 27S1P, 27S2P, 27P1P, 27P2P, 27PP1P, and 27PP2P are settings

Figure 4.61 Undervoltage Element Logic

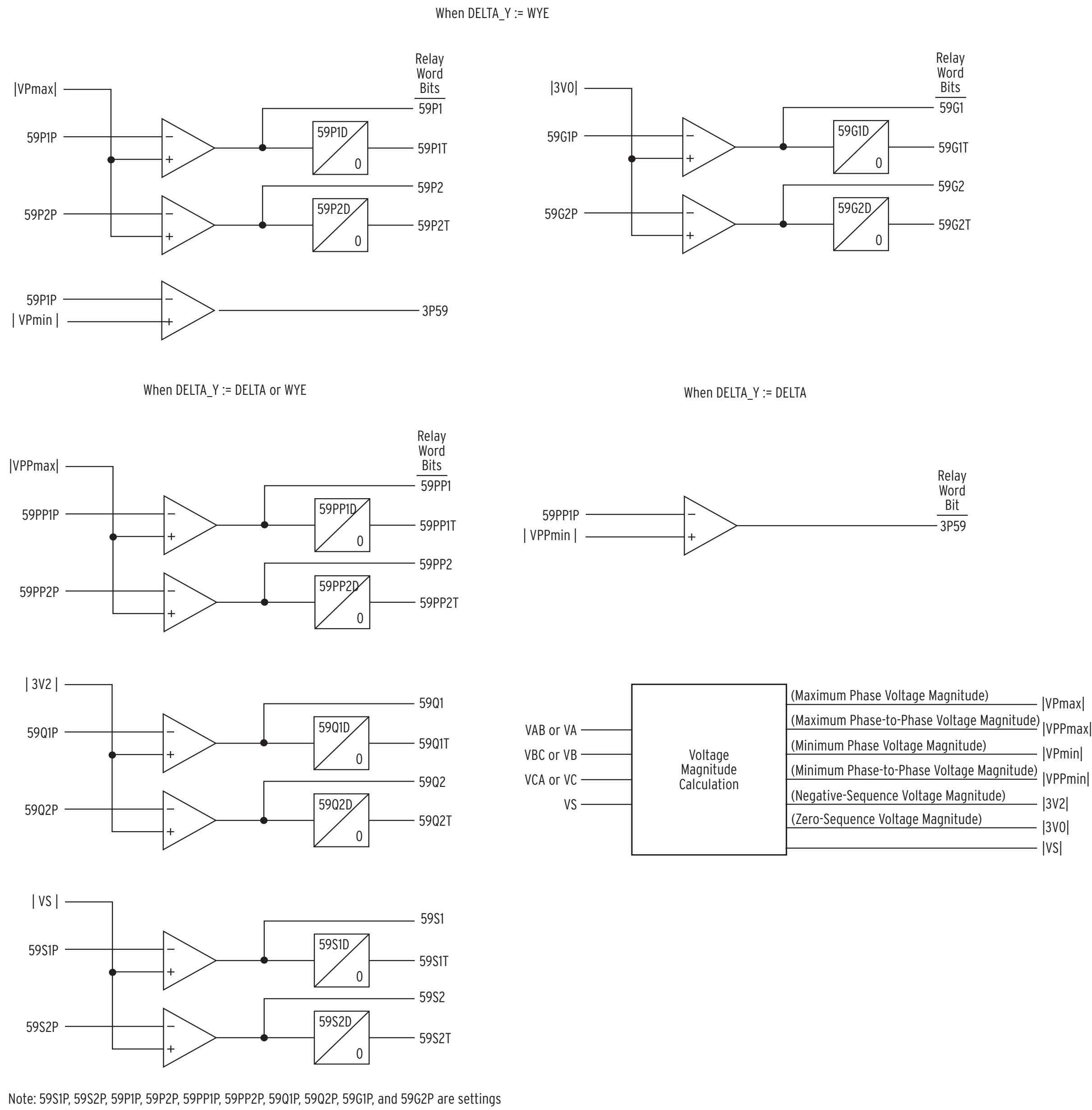


Figure 4.62 Overvoltage Element Logic

Inverse-Time Undervoltage Protection

The SEL-751 provides two inverse-time undervoltage protection elements (27I1 and 27I2). Based on relay hardware options and settings, the 27I element offers the flexibility of using various analog quantities as operating quantities. The availability of these analog quantities is contingent on the settings DELTA_Y, VSCONN, and SINGLEV, as indicated in *Table 4.36*.

Table 4.36 Operating Quantities for the 27I Element

Settings			Operating Quantities Available in 27InOQ Setting Range[a]									
DELTA_Y	**VSCONN**	**SINGLEV**	**VAB**	**VBC**	**VCA**	**VA**	**VB**	**VC**	**V1**	**VS**	**MINLL**	**MINLN**
DELTA	3V0	N	#	#	#	—	—	—	#	—	#	—
DELTA	3V0	Y	#	—	—	—	—	—	—	—	—	—
DELTA	VS	N	#	#	#	—	—	—	#	#	#	—
DELTA	VS	Y	#	—	—	—	—	—	—	#	—	—
WYE	VS	N	$	$	$	#	#	#	#	#	$	#
WYE	VS	Y	—	—	—	#	—	—	—	#	—	—
WYE	3V0	N	$	$	$	#	#	#	#	—	$	#
WYE	3V0	Y	—	—	—	#	—	—	—	—	—	—

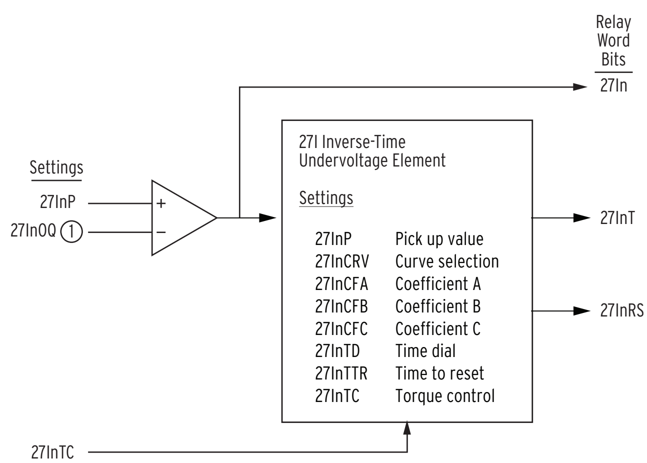
= 2.00–300.00 V $ = 2.00–520.00 V — Operating quantity is not available

The "#" and "$" signs indicate the setting range for 27InP (n = 1 or 2).

[a] The physical meanings of the operating quantities are described as follows:

VAB: Magnitude of A-to-B-phase voltage
VBC: Magnitude of B-to-C-phase voltage
VCA: Magnitude of C-to-A-phase voltage
VA: Magnitude of A-phase voltage
VB: Magnitude of B-phase voltage
VC: Magnitude of C-phase voltage
V1: Magnitude of positive-sequence voltage
VS: Magnitude of Vsync voltage
MINLL: Magnitude of the minimum phase-to-phase voltage
MINLN: Magnitude of the minimum phase-to-neutral voltage

Figure 4.63 shows the inputs, settings and outputs of the inverse-time undervoltage element.



n = 1 or 2. ① Refer to Table 4.36.

Figure 4.63 Logic Diagram of the Inverse-Time Undervoltage Element

When the fundamental frequency component of the operating quantity falls below the pickup setting (27InP), Relay Word bit 27In asserts. The timer does not start to integrate unless the operating quantity falls below 0.975 • 27InP. The inverse-time undervoltage protection element has the characteristic defined by *Equation 4.14*.

$$TTT_n = 27InTD \bullet \left(27InCFB + \frac{27InCFA}{\left(1 - \frac{27InOQ}{27InP}\right)^{27InCFC}} \right)$$

Equation 4.14

The settings used are listed in *Table 4.37*.

Table 4.37 Inverse-Time Undervoltage Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
27I ENABLE	Y, N	E27I*n* := N
OPERATING QTY	Refer to *Table 4.36*	27I*n*OQ := VAB
PICKUP LVL	Refer to *Table 4.36*	27I*n*P := 120.00
CURVE	CURVEA, CURVEB, COEF	27I*n*CRV := CURVEA
COEFF A	0.00–3.00	27I*n*CFA := 1
COEFF B	0.00–3.00	27I*n*CFB := 0
COEFF C	0.01–3.00	27I*n*CFC := 1
TIME DIAL	0.00–16.00	27I*n*TD := 1.00
RESET TIME	0.00–1.00 sec	27I*n*TTR := 0.01
TRQ CONTROL	SELOGIC	27I*n*TC := 1

The SEL-751 provides three curve options for each of the 27I elements, settable via the 27InCRV setting—CURVEA, CURVEB, and COEF (user programmable curve). CURVEA is compliant with IEC 60255-127 and is the IEC standard curve as shown in *Figure 4.64*. CURVEB is a non-standard curve as shown in *Figure 4.64*. The curve option COEF is the user programmable curve. Set the coefficient related settings 27InCFA, 27InCFB and 27InCFC to realize the curve that meets your application needs. *Table 4.38* shows the parameters of the three curves. Note that when 27InCRV is set to CURVEA or CURVEB the coefficient related settings 27InCFA, 27InCFB and 27InCFC are forced to the values shown in *Table 4.38* and hidden.

Table 4.38 Specification Of Inverse-Time Undervoltage Protection Element

Curve Description	Curve Defining Constants		
	27InCFA	27InCFB	27InCFC
Curve A	1	0	1
Curve B	0.98	1.28	2.171
Programmable Curve	0.00–3.00	0.00–3.00	0.01–3.00
n = 1 or 2.			

When the operating quantity exceeds the pickup level, 27I*n*P, then the output remains deasserted. If the operating quantity exceeds the pickup level for the reset time setting, 27I*n*TTR, then the time integrator resets to 0.

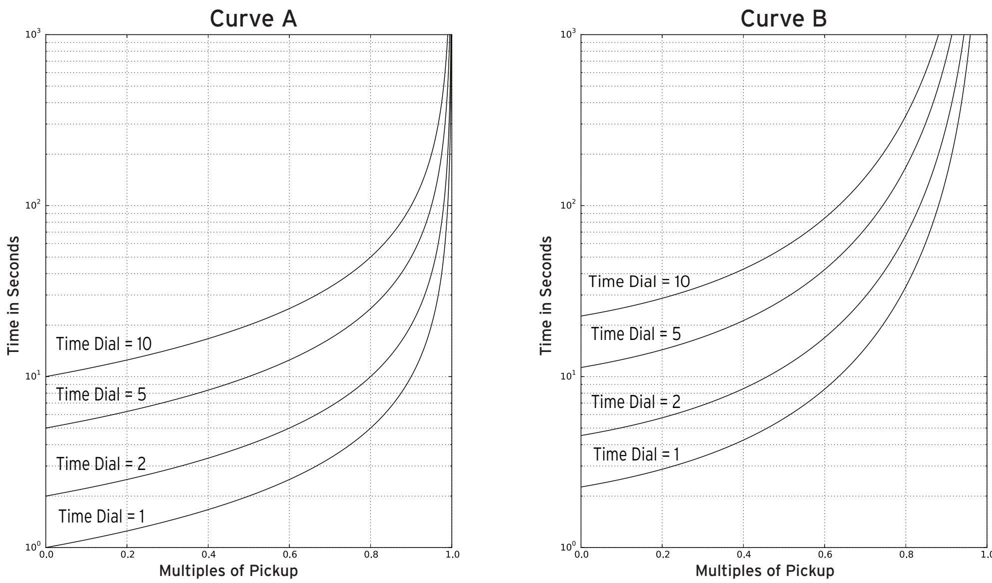


Figure 4.64 Inverse Time-Undervoltage Element Curves

Inverse-Time Overvoltage Protection

There are four inverse-time overvoltage elements (59I) available. Based on relay hardware options and settings, the 59I element offers the flexibility of using various analog quantities as operating quantities. The availability of these analog quantities is contingent on the settings DELTA_Y, VSCONN, and SINGLEV, as indicated in *Table 4.39*.

Table 4.39 Operating Quantities for the 59I Element

Settings			Operating Quantities Available in 59InOQ Setting Range[a]												
DELTA_Y	VSCONN	SINGLEV	VAB	VBC	VCA	VA	VB	VC	VG	V1	3V2	3V0	VS	MAXLL	MAXLN
DELTA	3V0	N	#	#	#	—	—	—	—	#	#	#	—	#	—
DELTA	3V0	Y	#	—	—	—	—	—	—	—	—	#	—	—	—
DELTA	VS	N	#	#	#	—	—	—	—	#	#	—	#	#	—
DELTA	VS	Y	#	—	—	—	—	—	—	—	—	—	#	—	—
WYE	VS	N	$	$	$	#	#	#	#	#	#	—	#	$	#
WYE	VS	Y	—	—	—	#	—	—	—	—	—	—	#	—	—
WYE	3V0	N	$	$	$	#	#	#	#	#	#	#	—	$	#
WYE	3V0	Y	—	—	—	#	—	—	—	—	—	#	—	—	—

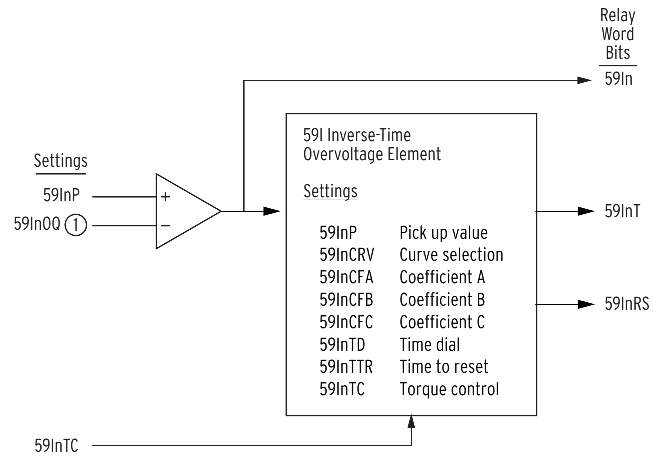
= 2.00–300.00 V $ = 2.00–520.00 V — Operating quantity is not available

The "#" and "$" signs indicate the setting range for 59InP (n = 1, 2, 3, or 4).

[a] The physical meanings of the operating quantities are described as follows:

VAB: Magnitude of A-to-B phase voltage
VBC: Magnitude of B-to-C phase voltage
VCA: Magnitude of C-to-A phase voltage
VA: Magnitude of A-phase voltage
VB: Magnitude of B-phase voltage
VC: Magnitude of C-phase voltage
VG: Magnitude of zero-sequence voltage
V1: Magnitude of positive-sequence voltage
3V2: Magnitude of negative-sequence voltage
3V0: Magnitude of measured zero-sequence voltage from VS channel
VS: Magnitude of Vsync voltage
MAXLL: Magnitude of the maximum phase-to-phase voltage
MAXLN: Magnitude of the maximum phase-to-neutral voltage

Figure 4.65 shows the inputs, settings and outputs of the inverse-time overvoltage element.



n = 1, 2, 3, or 4. ① Refer to *Table 4.39*.

Figure 4.65 Logic Diagram of the Inverse-Time Overvoltage Element

When the fundamental frequency component of the operating quantity exceeds the pickup setting, 59I*n*P, Relay Word bit 59I*n* asserts. The timer won't start to integrate unless the operating quantity exceeds 1.025 • 59I*n*P. The inverse-time overvoltage protection element has the characteristic defined by *Equation 4.15*.

$$TTT_n = 59InTD \bullet \left(59InCFB + \frac{59InCFA}{\left(\frac{59InOQ}{59InP}\right)^{59InCFC} - 1} \right)$$

Equation 4.15

The settings used are listed in *Table 4.40*.

Table 4.40 Inverse-Time Overvoltage Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
59I ENABLE	Y, N	E59I*n* := N
OPERATING QTY	Refer to *Table 4.39*	59I*n*OQ := VAB
PICKUP LVL	Refer to *Table 4.39*	59I*n*P := 120.00
CURVE	CURVEA, CURVEB, CURVEC, COEF	59I*n*CRV := CURVEA
COEFF A	0.00–6.00	59I*n*CFA := 3.88
COEFF B	0.00–3.00	59I*n*CFB := 0.96
COEFF C	0.01–3.00	59I*n*CFC := 2.00
TIME DIAL	0.00–16.00	59I*n*TD := 1.00
RESET TIME	0.00–1.00 sec	59I*n*TTR := 0.01
TRQ CONTROL	SELOGIC	59I*n*TC := 1

The SEL-751 provides four curve options for each of the 59I elements, settable via the 59I*n*CRV setting—CURVEA, CURVEB, CURVEC, and COEF (user-programmable curve). The characteristics of Curve A, Curve B, and Curve C are shown in *Figure 4.66*.

The curve option COEF is the user-programmable curve. Set the coefficient related settings 59I*n*CFA, 59I*n*CFB, and 59I*n*CFC to realize the curve that meets your application needs. *Table 4.41* shows the parameters of the three curves. Note that when 59I*n*CRV is set to CURVEA, CURVEB, or CURVEC the coefficient related settings 59I*n*CFA, 59I*n*CFB, and 59I*n*CFC are forced to the values shown in *Table 4.41* and hidden.

Table 4.41 Specification of Inverse-Time Overvoltage Protection Element

Curve Description	Curve Defining Constants		
	59InCFA	59InCFB	59InCFC
Curve A	3.88	0.96	2
Curve B	5.64	0.24	2
Curve C	0.14	0	0.02
Programmable Curve	0.00–6.00	0.00–3.00	0.01–3.00
n = 1, 2, 3, or 4.			

When the operating quantity remains lower than the pickup level, 59I*n*P, then the output remains deasserted. If the operating quantity gets lower than the pickup level for the reset time setting, 59I*n*TTR, then the time integrator resets to 0.

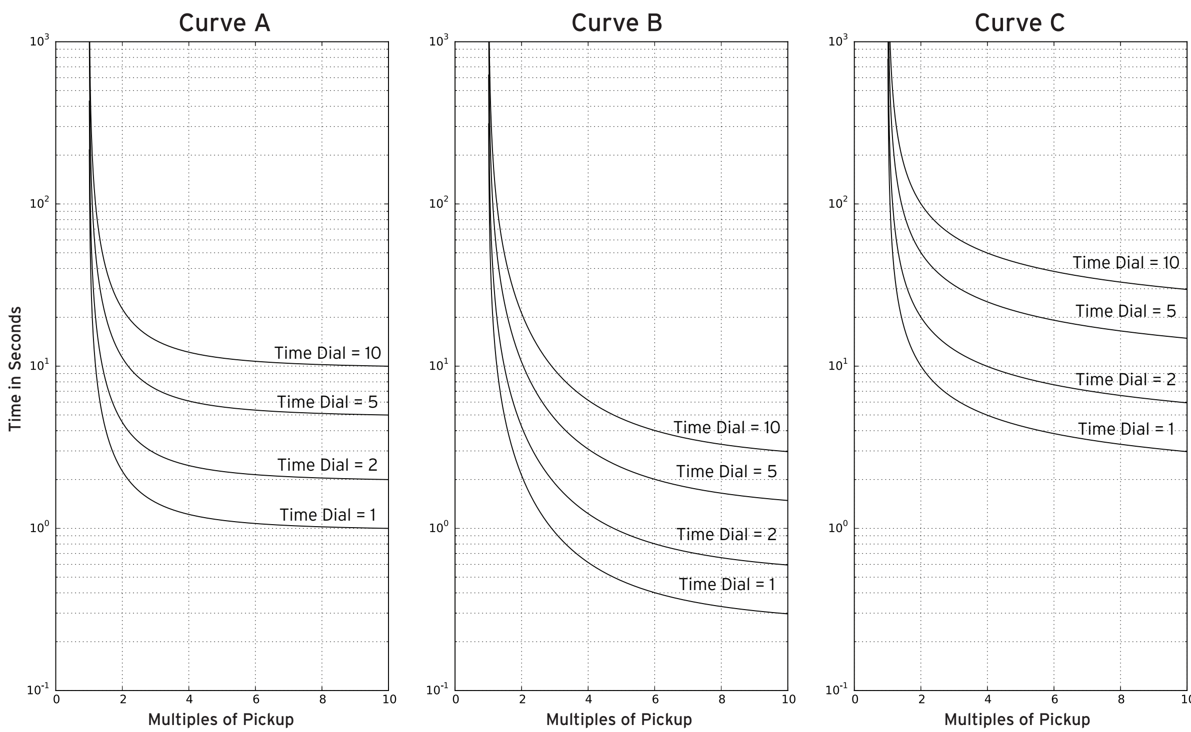


Figure 4.66 Inverse Time-Overvoltage Element Curves

Synchronism-Check Elements

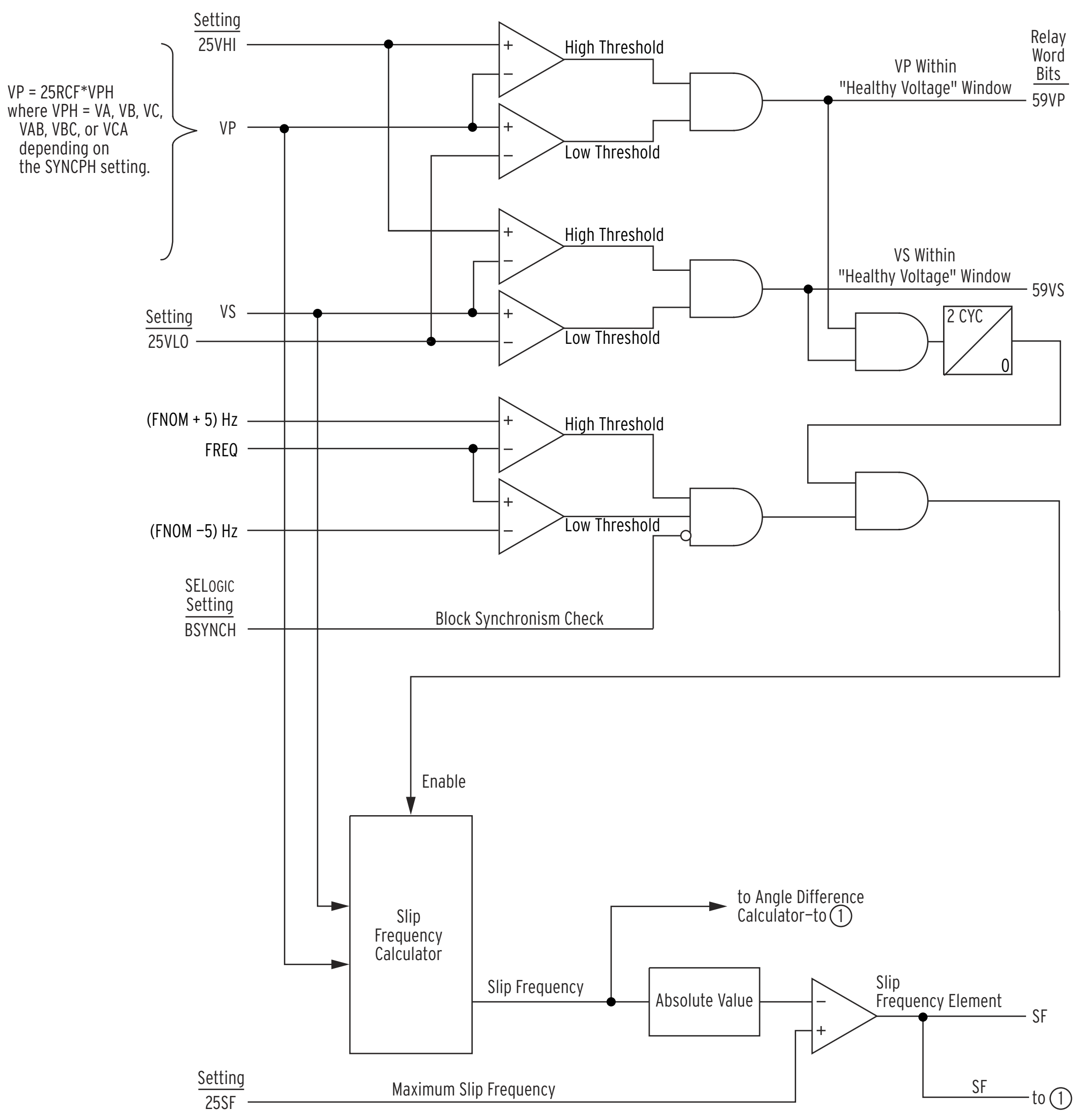
NOTE: The synchronism-check element is only available when VSCONN := VS.

Figure 2.23, and *Figure 2.24* show examples where synchronism check can be applied. Synchronism-check voltage input **VS** is connected to one side of the circuit breaker, on any phase you want. 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 use the same voltage window (to assure healthy voltage), frequency window (FNOM ±5 Hz), and slip frequency settings (see *Figure 4.67* and *Figure 4.68*). They have separate angle settings.

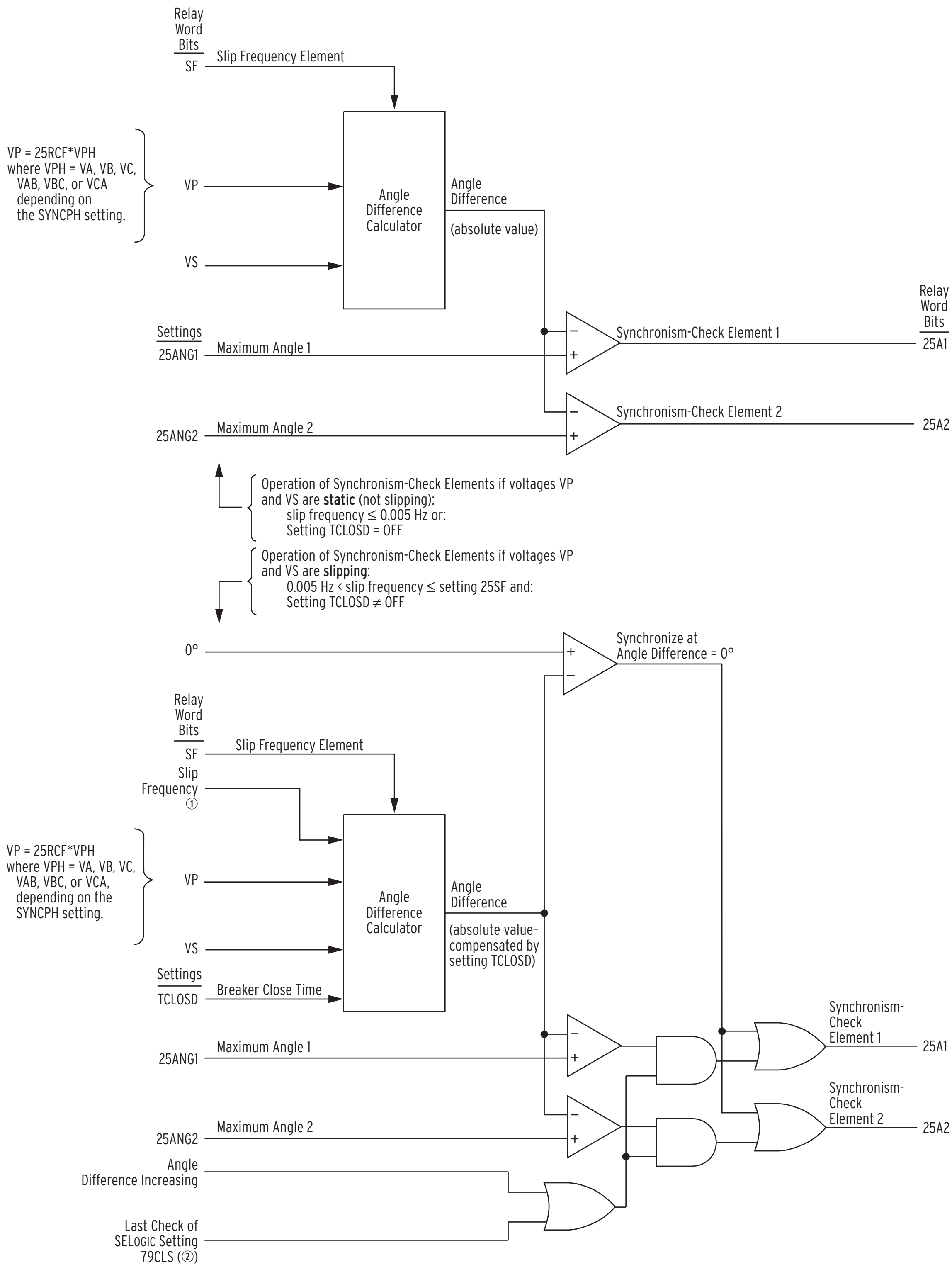
If the voltages are static (voltages not slipping with respect to one another) or setting TCLOSD := OFF, the two synchronism-check elements operate as shown in the top of *Figure 4.68*. The angle settings are checked for synchronism-check closing.

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 4.68*. 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 4.68

Figure 4.67 Synchronism-Check Voltage Window and Slip Frequency Elements



① From Figure 4.67; ② see Figure 4.81.

Figure 4.68 Synchronism-Check Elements

These 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 SYNCPH setting (see *Table 4.42* and *Setting SYNCPH on page 4.108*).

NOTE: The synchronism-check element is only available when VSCONN := VS.

Table 4.42 Synchronism-Check Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
SYNCH CHECK	Y, N	E25 := N
VS WINDOW LOW	0.00–300.00 V	25VLO := 105.00
VS WINDOW HIGH	0.00–300.00 V	25VHI := 130.00
V RATIO COR FAC	0.50–2.00	25RCF := 1.00
MAX SLIP FREQ	0.05–0.50 Hz	25SF := 0.20
MAX ANGLE 1	0–80 deg	25ANG1 := 25
MAX ANGLE 2	0–80 deg	25ANG2 := 40
SYNCH PHASE	VA, VB, VC, or 0, 30, 60, 90, 120, 150, 180, 210, 240, 270, 300, 330 deg lag VA[a]	SYNCPH := VA
SYNCH PHASE	VAB, VBC, VCA, or 0, 30, 60, 90, 120, 150, 180, 210, 240, 270, 300, 330 deg lag VAB[b]	SYNCPH := VAB
BRKR CLOSE TIME	OFF, 1-1000 ms	TCLOSD := 50
BLK SYNCH CHECK	SV	BSYNCH := 52A

[a] Range shown for DELTA_Y := WYE.
[b] Range shown for DELTA_Y := DELTA.

Setting SYNCPH

Enable the two single-phase synchronism-check elements by setting E25 := Y.

Wye-Connected Voltages

NOTE: Settings SYNCPH := 0 and SYNCPH := VA are effectively the same (voltage VS is directly synchronism checked with voltage VA; VS does not lag VA). The relay displays the setting entered (SYNCPH := VA or SYNCPH := 0).

The angle setting choices (0, 30, …, 300, or 330 degrees) for setting SYNCPH are referenced to VA, and they indicate how many degrees VS constantly lags VA. In this case, voltage input **VA-N** has to be connected and has to meet the “healthy voltage” criteria (settings 25VHI and 25VLO—see *Figure 4.68*). For situations where VS cannot be in phase with VA, VB, or VC, the angle setting choices (0, 30, …, 300, or 330 degrees) are referenced to VA.

Delta-Connected Voltages

The angle setting choices (0, 30, …, 300, or 330 degrees) for setting SYNCPH are referenced to VAB, and they indicate how many degrees VS constantly lags VAB. In this application, voltage input **VA-VB** has to be connected and has

NOTE: Settings SYNCPH := 0 and SYNCPH := VAB are effectively the same (voltage VS is directly synchronism checked with voltage VAB; VS does not lag VAB). The relay displays the setting entered (SYNCPH := VAB or SYNCPH := 0).

to meet the “healthy voltage” criteria (settings 25VHI and 25VLO—see *Figure 4.67*). For situations where VS cannot be in phase with VAB, VBC, or VCA, the angle setting choices (0, 30, …, 300, or 330 degrees) are referenced to VAB.

Figure 2.23 shows a relay wired with delta-connected phase PTs, and a C-phase-to-ground connected VS-NS input. With ABC rotation, the correct SYNCPH setting for this example is 270 degrees, the amount that VC lags VAB. However, the setting angle is 90 degrees for the ACB phase rotation.

Use the voltage ratio correction factor (setting 25RCF) to compensate magnitude of the phase voltage to match the synchronism voltage VS. Many applications require 25RCF := 1.00, however some applications may need a different setting. For example, *Figure 2.23* requires 25RCF := PTR / (1.732*PTRS). This is 0.58 if the PTR and PTRS are equal.

See the Application Guide entitled *Compensate for Constant Phase Angle Difference in Synchronism Check with the SEL-351 Relay Family* (also applies to SEL-751) for more information on setting SYNCPH with an angle setting.

Synchronism-Check Elements Voltage Inputs

The two synchronism-check elements are single-phase elements, for both of which you would use single-phase voltage inputs VP and VS:

1. VP Phase input voltage (VA, VB, or VC*25RCF for Delta_Y := Wye; VAB, VBC, or VCA*25RCF for Delta_Y := Delta), designated by setting SYNCPH (If SYNCPH is set to one of the angle settings, then VP = VA*25RCF or VAB*25RCF depending on the Delta_Y setting.)
2. VS Synchronism-check voltage, from SEL-751 rear-panel voltage input VS

For example, if the rear-panel voltage input VS-NS is connected to B-phase (or BC phase-to-phase for delta) then set SYNCPH := VB (or VBC for delta). The voltage across terminals VB-N (or VB-VC for delta) is synchronism checked with the voltage across terminals VS-NS (see *Figure 2.23*).

System Frequencies Determined from Voltages VA (or VAB for Delta) 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 VP determines the frequency on the other side.

Synchronism-Check Elements Operation

Refer to *Figure 4.67* and *Figure 4.68*.

Voltage Window

Refer to *Figure 4.67*. Single-phase voltage inputs VP and VS are compared to a voltage window, to verify that the voltages are “healthy” and lie within settable voltage limits 25VLO and 25VHI. If both voltages are within the voltage window, the following Relay Word bits assert:

59VP indicates that voltage VP is within voltage window setting limits 25VLO and 25VHI

59VS indicates that voltage VS is within voltage window setting limits 25VLO and 25VHI

Other Uses for Voltage Window Elements

If voltage limits 25VLO and 25VHI are applicable to other control schemes, you can use Relay Word bits 59VP and 59VS in other logic at the same time that you use them in the synchronism-check logic.

If you are not using synchronism check, you can still use Relay Word bits 59VP and 59VS in other logic, with voltage limit settings 25VLO and 25VHI set as desired. Enable the synchronism-check logic (setting E25 := Y) and make settings 25LO, 25HI, and 25RCF. Apply Relay Word bits 59VP and 59VS in the logic scheme you want, using SELOGIC control equations. Even though synchronism-check logic is enabled, you do not need to use the synchronism-check logic outputs (Relay Word bits SF, 25A1, and 25A2).

Block Synchronism-Check Conditions

Refer to *Figure 4.67*. The synchronism-check element slip frequency calculator runs if both voltages VP and VS are healthy (59VP and 59VS asserted to logical 1) and the SELOGIC control equation setting BSYNCH (Block Synchronism Check) is deasserted (= logical 0). Setting BSYNCH is most commonly set to block synchronism-check operation when the circuit breaker is closed (synchronism check is only necessary when the circuit breaker is open):

BSYNCH := **52A** (see *Figure 4.80*)

In addition, you can block synchronism-check operation when the relay is tripping:

BSYNCH := **... OR TRIP**

Slip Frequency Calculator

Refer to *Figure 4.67*. The synchronism-check element Slip Frequency Calculator in *Figure 4.67* runs if voltages VP and VS are healthy (59VP and 59VS asserted to logical 1) and the SELOGIC control equation setting BSYNCH (Block Synchronism Check) is deasserted (= logical 0). The Slip Frequency Calculator output is:

Slip Frequency = fP – fS (in units of Hz = slip cycles/second)

fP = frequency of voltage VP (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 (e.g., VS) by another voltage (e.g., VP). Both voltages are thought of as revolving phasor-wise, so the “slipping” of VS past VP is the relative revolving of VS past VP.

For example, in *Figure 4.67*, if voltage VP 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 VP, but in fact "slipping" ahead of voltage VP. In a time period of one second, the angular distance between voltage VP and voltage VS changes by 0.10 slip cycles, which translates into:

$$0.10 \text{ slip cycles/second} \bullet (360°/\text{slip cycle}) \bullet 1 \text{ second} = 36°$$

Thus, in a time period of one second, the angular distance between voltage VP and voltage VS changes by 36 degrees.

The absolute value of the Slip Frequency output is run through a comparator and if the slip frequency is less than the maximum slip frequency setting, 25SF, Relay Word bit SF asserts to logical 1.

Angle Difference Calculator

The synchronism-check element Angle Difference Calculator in *Figure 4.68* runs if the slip frequency is less than the maximum slip frequency setting 25SF (Relay Word bit SF is asserted).

Voltages VP and VS Are "Static". Refer to top of *Figure 4.68*. 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 VP and VS are "static" (not "slipping" with respect to one another). This would usually be the case for an open breaker with voltages VP and VS that are paralleled via some other electric path in the power system. The Angle Difference Calculator calculates the angle difference between voltages VP and VS:

$$\text{Angle Difference} = |(\angle VP - \angle VS)|$$

For example, if SYNCPH := 90 (indicating VS constantly lags VP = VA by 90 degrees), but VS actually lags VA by 100 angular degrees on the power system at a given instant, the Angle Difference Calculator automatically accounts for the 90 degrees and:

$$\text{Angle Difference} = |(\angle VP - \angle VS)| = 10°$$

Also, if breaker close time setting TCLOSD := OFF, the Angle Difference Calculator does not take into account breaker close time, even if the voltages VP and VS are "slipping" with respect to one another. Thus, synchronism-check elements 25A1 or 25A2 assert to logical 1 if the Angle Difference is less than corresponding maximum angle setting 25ANG1 or 25ANG2.

Voltages VP and VS Are "Slipping". Refer to bottom of *Figure 4.68*. If the slip frequency is greater than 0.005 Hz and breaker close time setting TCLOSD ≠ OFF, the Angle Difference Calculator takes the breaker close time into account with breaker close time setting TCLOSD (set in ms; see *Figure 4.69*). The Angle Difference Calculator calculates the Angle Difference between voltages VP and VS, compensated with the breaker close time:

$$\text{Angle Difference} = |(\angle VP - \angle VS) + [(fP - fS) \bullet \text{TCLOSD} \bullet (1 / 1000) \bullet (360°/\text{slip cycle})]|$$

Angle Difference Example (Voltages VP and VS are "Slipping"). Refer to bottom of *Figure 4.68*. For example, if the breaker close time is 100 ms, set TCLOSD := 100. Presume the slip frequency is the example slip frequency calculated previously. The Angle Difference Calculator calculates the angle difference between voltages VP and VS, compensated with the breaker close time:

$$\text{Angle Difference} = |(\angle VP - \angle VS) + [(fP - fS) \bullet \text{TCLOSD} \bullet (1 / 1000) \bullet (360°/\text{slip cycle})]|$$

NOTE: The angle compensation in Figure 4.69 appears much greater than 3.6 degrees. Figure 4.69 is for general illustrative purposes only.

Intermediate calculations:

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

Resulting in:

Angle Difference

= |(∠VP – ∠VS) + [(fP – fS) • TCLOSD • (1 / 1000) • (360°/slip cycle)]|
= |(∠VP – ∠VS) + [–0.10 • 0.1 • 360°]|
= |(∠VP – ∠VS) – 3.6°|

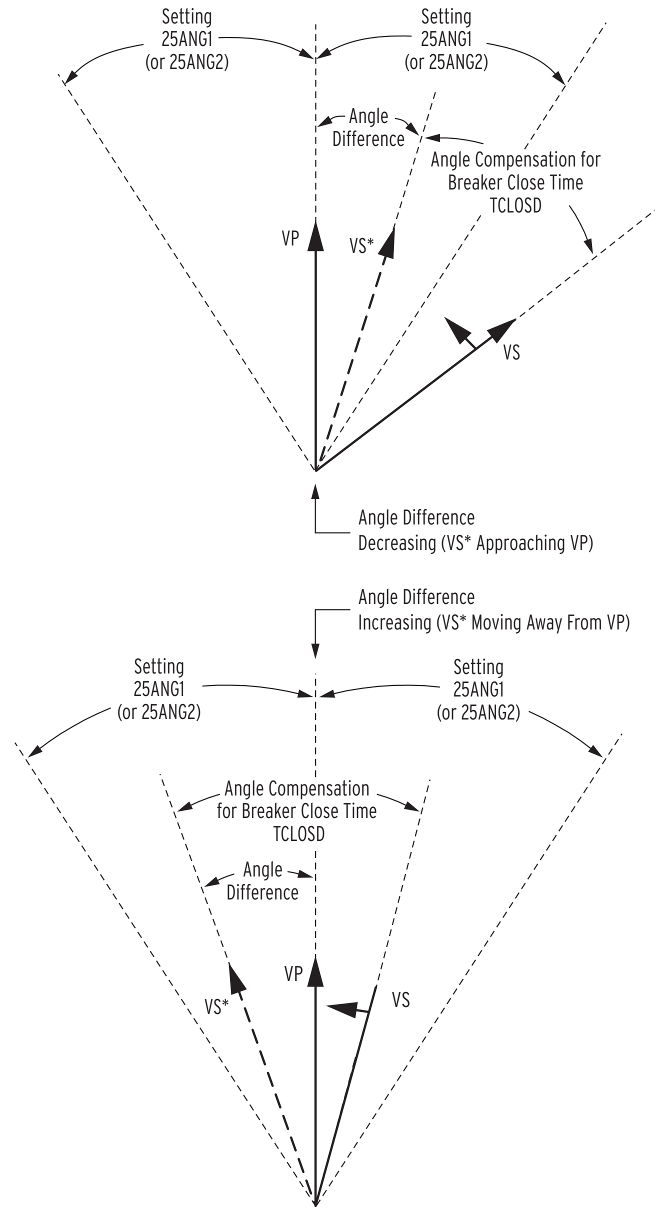


Figure 4.69 Angle Difference Between VP and VS Compensated by Breaker Close Time (fP < fS and VP Shown as Reference in This Example)

During the breaker close time (TCLOSD), the voltage angle difference between voltages VP and VS changes by 3.6 degrees. This angle compensation is applied to voltage VS, resulting in derived voltage VS*, as shown in *Figure 4.69*.

The top of *Figure 4.69* shows the Angle Difference *decreasing*—VS* is approaching VP. Ideally, circuit breaker closing is initiated when VS* is in phase with VP (Angle Difference = 0 degrees). Then when the circuit breaker main contacts finally close, VS is in phase with VP, minimizing system shock.

The bottom of *Figure 4.69* shows the Angle Difference *increasing*—VS* is moving away from VP. Ideally, circuit breaker closing is initiated when VS* is in phase with VP (Angle Difference = 0 degrees). Then when the circuit breaker main contacts finally close, VS is in phase with VP. But in this case, VS* has already moved past VP. To initiate circuit breaker closing when VS* is in phase with VP (Angle Difference = 0 degrees), VS* has to slip around another revolution, relative to VP.

Synchronism-Check Element Outputs

Synchronism-check element outputs (Relay Word bits 25A1 and 25A2 in *Figure 4.68*) assert to logical 1 for the conditions explained in the following text.

Voltages VP and VS Are "Static" or Setting TCLOSD := OFF. To implement a simple fixed-angle synchronism-check scheme, set TCLOSD := OFF and 25SF = 0.50. With these settings, the synchronism check is performed as described in the top of *Figure 4.68*.

If there is the possibility of a high slip frequency, exercise caution if you use synchronism-check elements 25A1 or 25A2 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. Qualify the breaker close command with a time delay, such as:

SV06 := **25A1**
CL := **CC and SV06T**

Set SV06PU with enough pickup delay to ensure that the slip frequency is low enough for the circuit breaker to close within the synchronism-check window.

Voltages VP and VS Are "Slipping" and Setting TCLOSD ≠ OFF.

Refer to bottom of *Figure 4.68*. If VP and VS are "slipping" with respect to one another and breaker close time setting TCLOSD ≠ OFF, the Angle Difference (compensated by breaker close time TCLOSD) changes through time. Synchronism-check element 25A1 or 25A2 asserts to logical 1 for any one of the following three scenarios.

1. The top of *Figure 4.69* shows the Angle Difference *decreasing*—VS* is approaching VP. When VS* is in phase with VP (Angle Difference = 0 degrees), synchronism-check elements 25A1 and 25A2 assert to logical 1.
2. The bottom of *Figure 4.69* shows the Angle Difference *increasing*—VS* is moving away from VP. VS* was in phase with VP (Angle Difference = 0 degrees), but has now moved past VP. If the Angle Difference is *increasing*, but the Angle Difference is still less than maximum angle settings 25ANG1 or 25ANG2, then corresponding synchronism-check elements 25A1 or 25A2 assert to logical 1.

   In this scenario of the Angle Difference increasing, but still being less than maximum angle settings 25ANG1 or 25ANG2, the operation of corresponding synchronism-check elements 25A1 and 25A2 becomes *less restrictive*. Synchronism-check breaker closing does not have to wait for voltage VS* to slip around again in phase with VP (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.

3. Refer to *Reclose Supervision Logic on page 4.131*.

   Refer to the bottom of *Figure 4.81*. If timer 79CLSD is set greater than zero (e.g., 79CLSD := 100 ms) and it times out without SELOGIC control equation setting 79CLS (Reclose Supervision) asserting to logical 1, the relay goes to the 89lockout state (see top of *Figure 4.82*).

   Refer to the top of *Figure 4.81*. If timer 79CLSD is set to zero (79CLSD := 0.00), SELOGIC control equation setting 79CLS (Reclose Supervision) is checked only once to see if it is asserted to logical 1. If it is not asserted to logical 1, the relay goes to the lockout state.

   Refer to the top of *Figure 4.69*. Ideally, a circuit breaker closing is initiated when VS* is in phase with VP (Angle Difference = 0 degrees). Then when the circuit breaker main contacts finally close, VS is in phase with VP, minimizing system shock. But with time limitations imposed by timer 79CLSD, this may not be possible. To try to avoid going to the lockout state, the following logic is employed.

   If 79CLS has not asserted to logical 1 while timer 79CLSD is timing (or timer 79CLSD is set to zero and only one check of 79CLS is made), the synchronism-check logic at the bottom of *Figure 4.68* becomes *less restrictive* at the “instant” timer 79CLSD is going to time out (or make the single check). It drops the requirement of waiting until the *decreasing* Angle Difference (VS* approaching VP) brings VS* in phase with VP (Angle Difference = 0 degrees). Instead, it just checks to see that the Angle Difference is less than angle settings 25ANG1 or 25ANG2.

   If the Angle Difference is less than angle setting 25ANG1 or 25ANG2, then the corresponding Relay Word bit, 25A1 or 25A2, asserts to logical 1 for that “instant” (asserts for 1/4 cycle).

   For example, if SELOGIC control equation setting 79CLS (Reclose Supervision) is set as follows:

   79CLS := **25A1 OR ...**

   and the angle difference is less than angle setting 25ANG1 at that “instant,” setting 79CLS asserts to logical 1 for 1/4 cycle, allowing the sealed-in open interval time-out to propagate on to the close logic in *Figure 4.80*. Element 25A2 operates similarly.

Synchronism-Check Applications for Automatic Reclosing and Manual Closing

Refer to *Trip/Close Logic on page 4.128* and *Reclose Supervision Logic on page 4.131*.

For example, set 25ANG1 = 15 degrees and use the resultant synchronism-check element in the reclosing relay logic to supervise automatic reclosing, e.g.,

79CLS := **25A1 OR ...** (see *Figure 4.81*)

Set 25ANG2 = 25° and use the resultant synchronism-check element in manual close logic to supervise manual closing (for example, assert **IN301** to initiate manual close), e.g.,

CL := **IN301 AND (25A2 OR ...)** (see *Figure 4.80*)

In this example, the angular difference across the circuit breaker can be greater for a manual close (25 degrees) than for an automatic reclose (15 degrees).

A single output contact (e.g., OUT102 := CLOSE) can provide the close function for both automatic reclosing and manual closing (see *Figure 4.80* for logic output).

Power Elements

You can enable as many as two independent three-phase power elements in the SEL-751. Each enabled element can be set to detect real power or reactive power. When voltage inputs to the relay are from delta-connected PTs or when you use a single voltage input, the relay cannot account for unbalance in the voltages in calculating the power. When you use one voltage (only the VA or VAB) and set SINGLEV := Y, the relay assumes that the system voltages are balanced in both magnitude and phase angle. Power and power factor are calculated assuming balanced voltages. Take this into consideration in applying the power elements.

Table 4.43 Voltages When Setting SINGLEV := Y

DELTA_Y Setting	PHROT Setting	Voltages
WYE	ABC	VA = |Va| ∠ϕ° VB = |Va| ∠ϕ–120° VC = |Va| ∠ϕ+120°
WYE	ACB	VA = |Va| ∠ϕ° VB = |Va| ∠ϕ+120° VC = |Va| ∠ϕ–120°
DELTA	ABC	VAB = |Vab| ∠ϕ° VBC = |Vab| ∠ϕ–120° VCA = |Vab| ∠ϕ+120°
DELTA	ACB	VAB = |Vab| ∠ϕ° VBC = |Vab| ∠ϕ+120° VCA = |Vab| ∠ϕ–120°

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 power protection/control
- VAR control for capacitor banks

Table 4.44 Power Element Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PWR ELEM	N, 3P1, 3P2	EPWR := N
3PH PWR ELEM PU	OFF, 1.0–6500.0 VA[a] (secondary)	3PWR1P := OFF
PWR ELEM TYPE	+WATTS, –WATTS, +VARS, –VARS	PWR1T := +VARS

Table 4.44 Power Element Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
PWR ELEM DELAY	0.0–240.0 s	PWR1D := 0.0
3PH PWR ELEM PU	OFF, 1.0–6500.0 VA[a] (secondary)	3PWR2P := OFF
PWR ELEM TYPE	+WATTS, –WATTS, +VARS, –VARS	PWR2T := +VARS
PWR ELEM DELAY	0.0–240.0 s	PWR2D := 0.0

[a] The range shown is for 5 A input; range for 1 A input is OFF, 0.2–1300.0 VA.

EPWR := 3P1 enables one three-phase power element. Set EPWR := 3P2 if you want to use both elements.

Set the element pickup, 3PH PWR ELEM PU, to the values you want. *Figure 4.70* shows the power element logic diagram and *Figure 4.71* shows the operation in the Real/Reactive power plane.

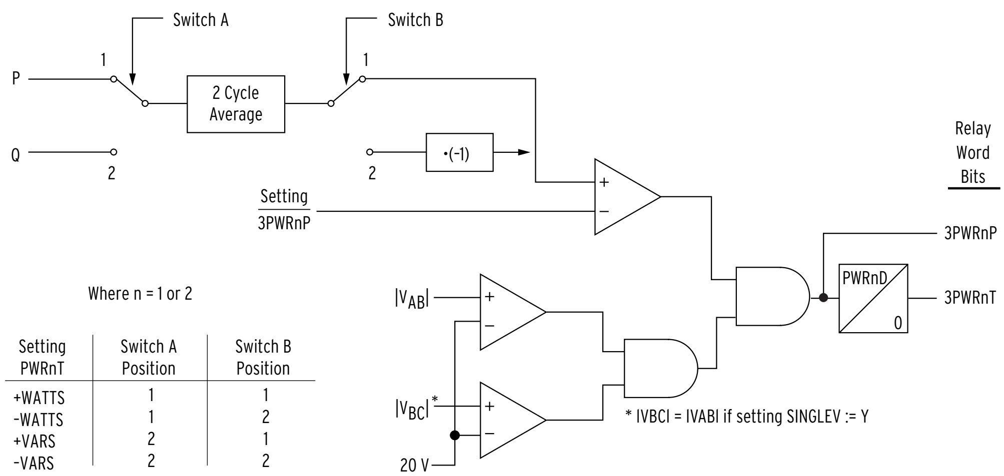


Figure 4.70 Three-Phase Power Elements Logic

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 two power element time delay settings, PWR1D and PWR2D, 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.

The power elements are not supervised by any relay elements other than the minimum voltage check shown in *Figure 4.70*. 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.

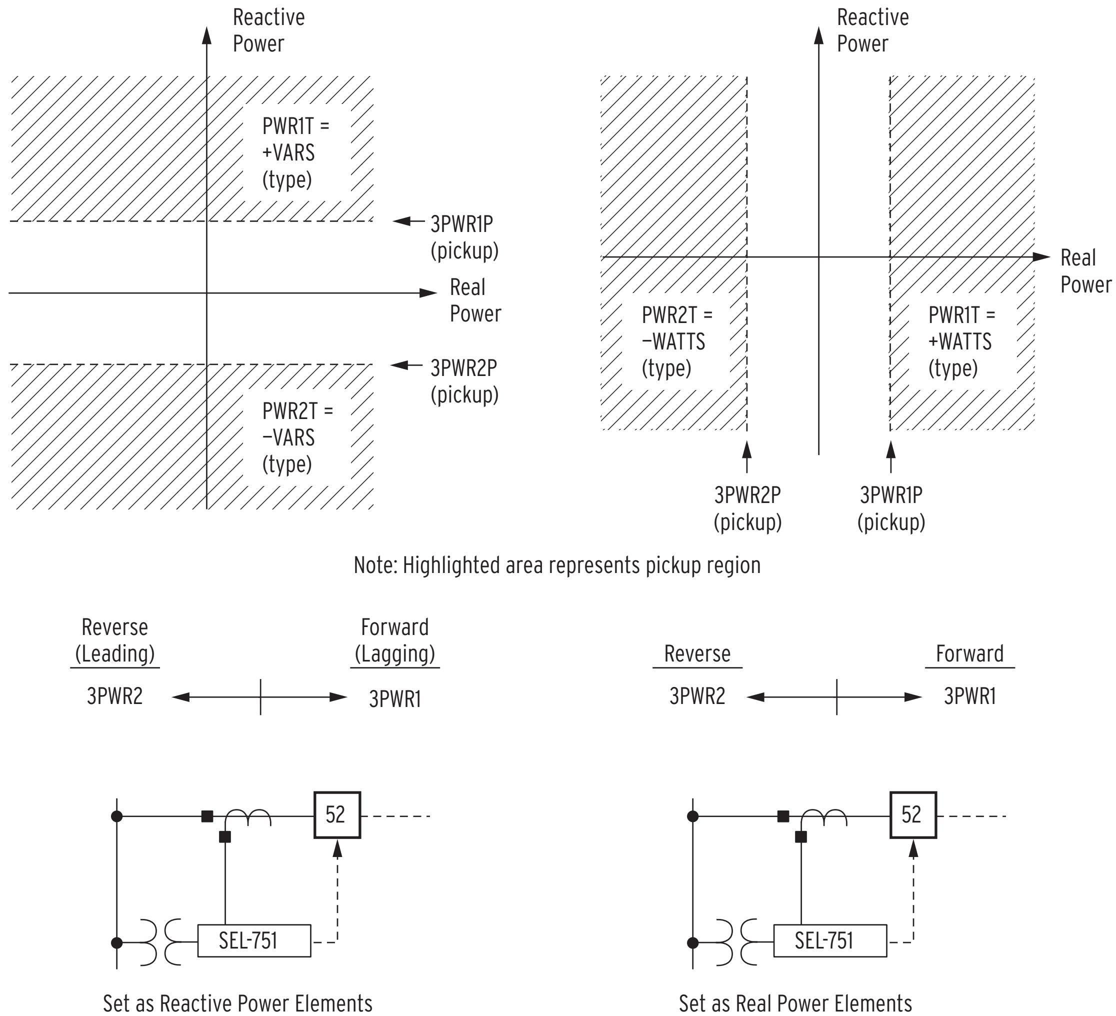


Figure 4.71 Power Elements Operation in the Real/Reactive Power Plane

Power Factor Elements

Table 4.45 Power Factor Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PF LAG TRIP LEVL	OFF, 0.05–0.99	55LGTP := OFF
PF LD TRIP LEVEL	OFF, 0.05–0.99	55LDTP := OFF
PF TRIP DELAY	1–240 sec	55TD := 1
PF LAG WARN LEVL	OFF, 0.05–0.99	55LGAP := OFF
PF LD WARN LEVEL	OFF, 0.05–0.99	55LDAP := OFF
PF WARN DELAY	1–240 sec	55AD := 1
PF ARMING DELAY	0–5000	55DLY := 0

If the measured power factor falls below the leading or lagging level for longer than the time-delay setting, the relay can issue a warning or trip signal. The power factor elements are enabled 55DLY seconds after Relay Word 52A is asserted (breaker closed), however when 55DLY := 0 the element is always enabled irrespective of the 52A status. *Figure 4.72* shows the logic diagram for the power factor elements. You can use these elements to detect synchronous motor out-of-step or loss-of-field conditions. Refer to *Figure 5.1* for the relay power measurement convention.

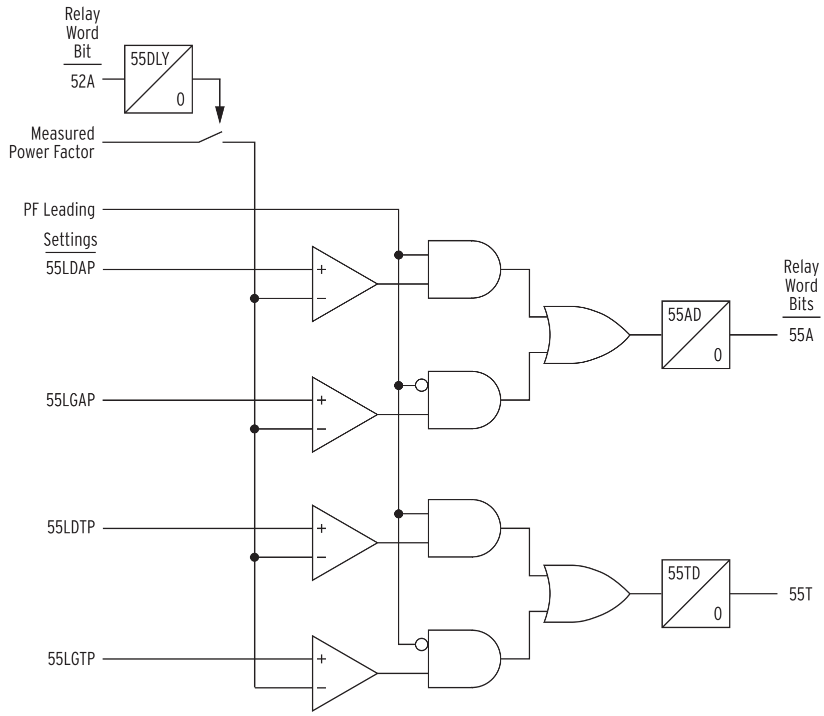


Figure 4.72 Power Factor Elements Logic

Loss-of-Potential (LOP) Protection

The SEL-751 sets Relay Word bit LOP (loss-of-potential) upon detecting a loss of relay ac voltage input such as that caused by blown potential fuses or by the operation of molded-case circuit breakers. Because accurate relaying potentials are necessary for certain protection elements (undervoltage 27 elements, for example), you can use the LOP function to supervise these protection elements. Refer to *Figure 4.73* for the LOP logic.

The relay declares an LOP when there is more than a 20 percent drop in the measured positive-sequence voltage (V1) with no corresponding magnitude or angle change (greater than a pre-determined threshold) in positive-sequence (I1), negative-sequence (I2), or zero-sequence currents (I0).

If this condition persists for 1 second, then the relay latches the LOP Relay Word bit at logical 1. The relay resets LOP when the positive-sequence voltage (V1) returns to a level greater than 0.75 • Nominal Voltage while negative-sequence voltage (V2) and zero-sequence voltage (V0) are both less than 5 V secondary (VNOM is a relay setting).

Settings

The LOP function is always active unless blocked by the corresponding SELOGIC control equation, LOPBLK (see *Table 4.46* for the setting and *Figure 4.73* for the LOP logic). The default value is LOPBLK := 0. Certain switching operations can result in LOP assertion when the drop in V1 is greater than 20 percent with no or very little change in sequence currents. Consider using LOPBLK to avoid assertion of LOP under such conditions. You must incorporate the LOP function in a SELOGIC control equation to supervise relay protection elements (see *Example 4.16*).

Table 4.46 Loss-of-Potential (LOP) Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
LOP BLOCK	SELOGIC	LOPBLK := 0

LOP Impact on Other Protection Elements

Undervoltage and directional power elements 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 4.16*). 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 4.16 Supervising Voltage-Element Tripping With LOP

The factory-default setting supervises undervoltage trip by the LOP as shown by the following:

SV01 := **... OR (27P1T OR 27P2T) AND NOT LOP**

Similarly, if you want the additional voltage-affected elements (e.g., 55T) to act only when there are correct relaying potentials voltage, use the following in the equation:

... OR (27P1T OR 27P2T OR 55T) AND NOT LOP ...

and remove 55T from TR

You can supervise each element separately or as a group when these elements occur in the trip equations, as shown in this example.

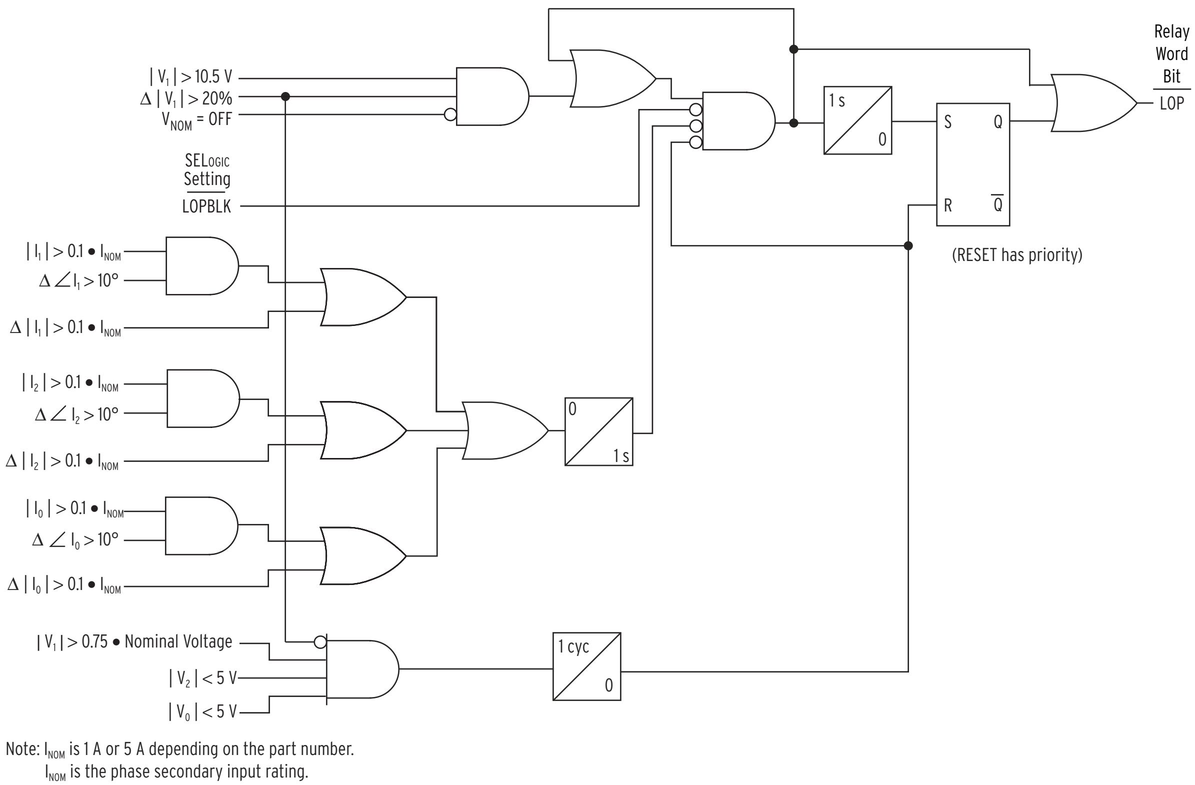


Figure 4.73 Loss-of-Potential (LOP) Logic

LOP Monitoring and Alarms

You should take steps to immediately correct an LOP problem so that normal protection is rapidly re-established. 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.

Vector Shift Element

The vector shift element is used to detect islanding conditions of distributed generators (DGs) or loss of mains, and disconnect these DGs from the utility network under these conditions. Failure to trip islanded generators can lead to problems relating to out-of-synchronism reclosing, equipment damage, unstable operation, degradation of power quality and personnel safety.

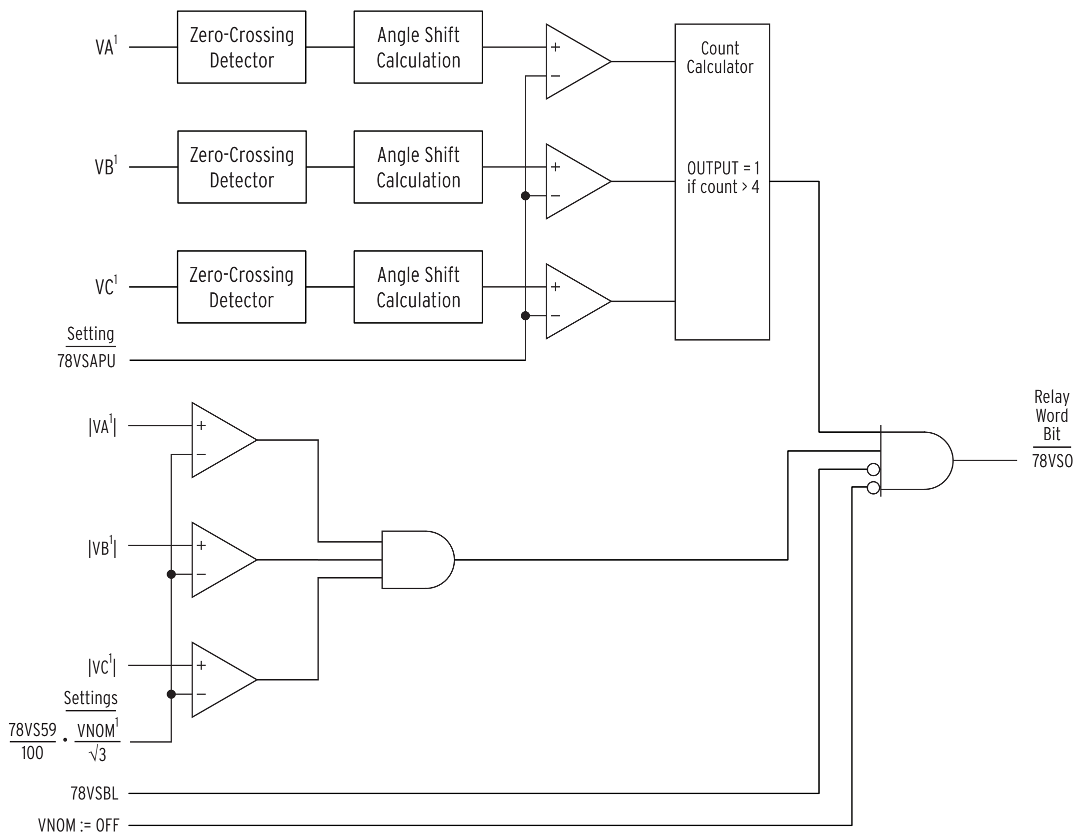
The vector shift element in the SEL-751 is designed for applications where a DG is connected to either the utility or other main generators that require fast disconnection upon detection of an islanding condition. The vector shift element operates within three cycles providing fast and reliable island detection; this operating time is fast enough to prevent out-of-synchronism reclosing of the network feeders avoiding generator damage and any adverse affects.

Islanding is a three-phase phenomenon: therefore, the vector shift monitoring is performed on all of the three phases of the voltage signals. Detection of a vector shift condition occurs when there are sudden phase variations on all three phases of the voltage waveforms. At the moment of islanding, the sudden change in load current causes a sudden change in the periods of the voltage signals. This element measures the difference in the present period duration and a reference period (as explained below). This difference is then converted to degrees and compared against the user-defined setting 78VSAPU.

Vector Shift Element Logic

The logic diagram of the vector shift element in *Figure 4.74* displays the steps performed to detect an islanding condition:

➤ Zero-crossing based period estimation
➤ Angle shift calculation and angle shift threshold check
➤ Angle shift count calculator
➤ Blocking conditions



[1]The logic diagram shown applies when DELTA_Y := WYE.
When DELTA_Y := DELTA, the quantities VA, VB, and VC are replaced by VAB, VBC, and VCA, respectively. In addition, VNOM is not divided by √3.
The element is disabled when VNOM := OFF.

Figure 4.74 Logic Diagram of the Vector Shift Element

The element performs period calculations on each of the voltage inputs, **VA**, **VB**, and **VC**. Zero-crossing detection logic is used to perform the period calculations. The time stamps of two consecutive positive-going zero-crossings or two consecutive negative-going zero-crossings are used in determining the period. The relay establishes a reference period for each phase using the previous 32 period measurements. The initialization period for this element requires at least 16 cycles of voltage signal to establish an accurate reference period. During the initialization period, this element does not detect an islanding condition.

In each quarter-cycle, the relay calculates the difference between the present period on each phase with the corresponding reference period. This difference is expressed in degrees to determine the angle shift and compared against the setting 78VSAPU. If the calculated angle shift is greater than the angle shift threshold setting 78VSAPU, the comparator output for the corresponding phase will be one; this output is fed to the angle shift count calculator logic.

The count calculator receives angle shift detection information from all three phases and records the number of times that the angle shift threshold of all phases has been exceeded in two consecutive quarter-cycles. If the angle shift count exceeds four and no blocking conditions exist, 78VSO is asserted indicating an islanding or loss of mains condition.

Power system short circuit conditions can also cause the voltage angle change to exceed the angle shift setting threshold. To prevent possible false tripping, the vector shift element is blocked for undervoltage conditions. If any of the phase voltages fall below the voltage supervision threshold setting 78VS59, the output of the vector shift element is blocked. You can program the 78VSBL SELOGIC control equation to provide additional blocking conditions as required in your application.

Depending on the DG loading conditions, a vector shift occurs once when an islanding event happens, causing a change in two consecutive period measurements after which the voltage stabilizes. For this reason, a delayed operation of the element is not applicable. Although the vector shift element allows for fast and reliable detection of DG islanding conditions, the limitation of this element needs to be realized. This element is based on the sudden phase change in the voltage waveform. If there is no load current change between the DG and the utility at the point of common coupling, there is no vector shift and this element does not detect the islanding condition. For this element to operate properly, the load change must be at least 20 percent of the rated power of the DG.

The vector shift element (78VS) and the fast rate-of-change-of-frequency element (81RF) can be used to detect islanding conditions. The vector shift element is designed to detect islanding conditions at the moment when the islanding condition happens and typically responds within 1.5–3 cycles after the islanding condition occurs. On the other hand, 81RF is designed to detect islanding conditions during and after the voltage shift occurs; the 81RF element complements the 78VS element by providing more dependable protection.

Vector Shift Element Settings

See *Table 4.47* for the range and default settings for the vector shift element.

Set E78VS := Y to enable the vector shift element. Set the vector shift angle pickup threshold setting 78VSAPU to the desired angle to detect a vector shift condition. The factory-default value of this setting is 10 degrees. Determine this setting based on the generator impedance and your studies.

The vector shift voltage supervision threshold setting 78VS59 defines the minimum voltage magnitude required for this element in percentage of the nominal voltage setting VNOM. The factory-default threshold is 80 percent of the VNOM setting. If VNOM setting is OFF, then the vector shift element is turned off.

The vector shift SELOGIC control equation, 78VSBL, allows you to define additional blocking conditions of the vector shift element. For instance, block the element for a few cycles when the DG breaker is closed to keep the element secure from operating under this condition.

Table 4.47 Vector Shift Element Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
EN VECTOR SHIFT	Y, N	E78VS := N
VS ANGLE PU THR	2.0–30.0 deg	78VSAPU := 10.0
VS VOLT SUPV THR	20.0–100.0%	78VS59 := 80
VS BLOCK	SELOGIC	78VSBL := 0

Frequency Protection

NOTE: The relay measures system frequency for these elements with the positive-sequence voltage if the voltage input is present and the applied positive-sequence voltage is greater than 10 volts. Otherwise, the relay uses positive-sequence current as long as the minimum magnitude is 0.1 • (Nominal CT Rating). The measured frequency is set to nominal frequency setting (FNOM) if the signal is below the minimum level.

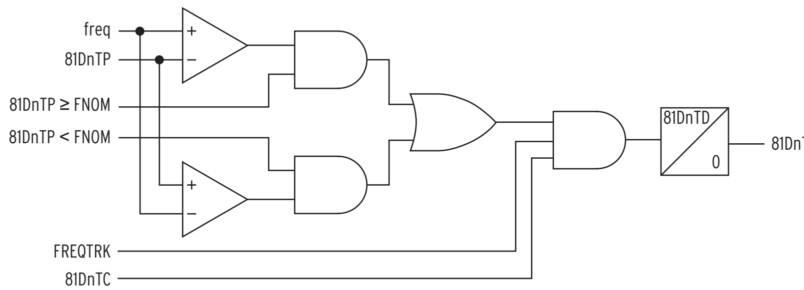
NOTE: Additionally, the Relay Word bit ORED81T := 81D1T OR 81D2T OR ... 81D6T.

The SEL-751 provides six trip over- or underfrequency elements with independent level and time-delay settings. *Table 4.48* lists the ranges and 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. *Figure 4.75* shows the logic diagram for the frequency elements.

Table 4.48 Frequency Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
FREQ1 TRIP LEVEL	OFF, 15.00–70.00 Hz	81D1TP := OFF
FREQ1 TRIP DELAY[a]	0.00–240.00 sec	81D1TD := 1.00
81D1 TRQCTRL	SELOGIC	81D1TC := 1
FREQ2 TRIP LEVEL	OFF, 15.00–70.00 Hz	81D2TP := OFF
FREQ2 TRIP DELAY[a]	0.00–240.00 sec	81D2TD := 1.00
81D2 TRQCTRL	SELOGIC	81D2TC := 1
FREQ3 TRIP LEVEL	OFF, 15.00–70.00 Hz	81D3TP := OFF
FREQ3 TRIP DELAY[a]	0.00–240.00 sec	81D3TD := 1.00
81D3 TRQCTRL	SELOGIC	81D3TC := 1
FREQ4 TRIP LEVEL	OFF, 15.00–70.00 Hz	81D4TP := OFF
FREQ4 TRIP DELAY[a]	0.00–240.00 sec	81D4TD := 1.00
81D4 TRQCTRL	SELOGIC	81D4TC := 1
FREQ5 TRIP LEVEL	OFF, 15.00–70.00 Hz	81D5TP := OFF
FREQ5 TRIP DELAY[a]	0.00–240.00 sec	81D5TD := 1.00
81D5 TRQCTRL	SELOGIC	81D5TC := 1
FREQ6 TRIP LEVEL	OFF, 15.00–70.00 Hz	81D6TP := OFF
FREQ6 TRIP DELAY[a]	0.00–240.00 sec	81D6TD := 1.00
81D6 TRQCTRL	SELOGIC	81D6TC := 1

[a] Frequency element time delays are best set no less than five cycles. The relay requires at least three cycles to measure frequency.



n = Frequency Elements 1–6
freq = Measured Frequency
81DnTP = Frequency Pickup Setting
FNOM = Nominal Frequency Setting
81DnTD = Over- and Underfrequency Element Pickup Time Delay
81DnT = Definite-Time Delayed Over- and Underfrequency Element Relay Word Bit
FREQTRK = Relay Is Tracking Frequency
81DnTC = SELOGIC Setting for Torque Control of Frequency Element

Figure 4.75 Over- and Underfrequency Element Logic

Rate-of-Change-of-Frequency (81R) 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 remedial action, such as load shedding, is taken. You can use the rate-of-change-of-frequency element to detect and initiate a remedial action. The SEL-751 provides four rate-of-change-of-frequency elements. *Table 4.49* shows the settings available for the elements.

Table 4.49 Rate-of-Change-of-Frequency Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE 81R	N, 1–4	E81R := N
81R VOLTAGE SUP	OFF, 12.5–300.0 V	81RVSUP := 12.5
81R CURRENT SUP	OFF, 0.1–2.0 * I_{NOM}[a]	81RISUP := OFF
81R1 TRIP LEVEL	OFF, 0.10–15.00 Hz/sec	81R1TP := OFF
81R1 TREND	INC, DEC, ABS	81R1TRND := ABS
81R1 TRIP DELAY	0.10–60.00 sec	81R1TD := 1.00
81R1 DO DELAY	0.00–60.00 sec	81R1DO := 0.00
81R1 TRQCTRL	SELOGIC	81R1TC := 1
81R2 TRIP LEVEL	OFF, 0.10–15.00 Hz/sec	81R2TP := OFF
81R2 TREND	INC, DEC, ABS	81R2TRND := ABS
81R2 TRIP DELAY	0.10–60.00 sec	81R2TD := 1.00
81R2 DO DELAY	0.00–60.00 sec	81R2DO := 0.00
81R2 TRQCTRL	SELOGIC	81R2TC := 1
81R3 TRIP LEVEL	OFF, 0.10–15.00 Hz/sec	81R3TP := OFF
81R3 TREND	INC, DEC, ABS	81R3TRND := ABS
81R3 TRIP DELAY	0.10–60.00 sec	81R3TD := 1.00
81R3 DO DELAY	0.00–60.00 sec	81R3DO := 0.00
81R3 TRQCTRL	SELOGIC	81R3TC := 1

Table 4.49 Rate-of-Change-of-Frequency Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
81R4 TRIP LEVEL	OFF, 0.10–15.00 Hz/sec	81R4TP := OFF
81R4 TREND	INC, DEC, ABS	81R4TRND := ABS
81R4 TRIP DELAY	0.10–60.00 sec	81R4TD := 1.00
81R4 DO DELAY	0.00–60.00 sec	81R4DO := 0.00
81R4 TRQCTRL	SELOGIC	81R4TC := 1

[a] I_{NOM} is nominal rating of the phase CTs (1 A or 5 A).

Use E81R setting to enable the number of elements you want; *Figure 4.76* shows the element logic. The SEL-751 measures frequency (mf1) and second frequency (mf2) after a time window (dt) determined by Trip Level setting (81R*n*TP). Hysteresis is such that pickup is 100 percent of 81R*n*TP setting and dropout is 95 percent. *Table 4.50* shows the time windows for different trip level settings. Additionally, the Relay Word bit ORED81RT := 81R1T OR 81R2T OR 81R3T OR 81R4T.

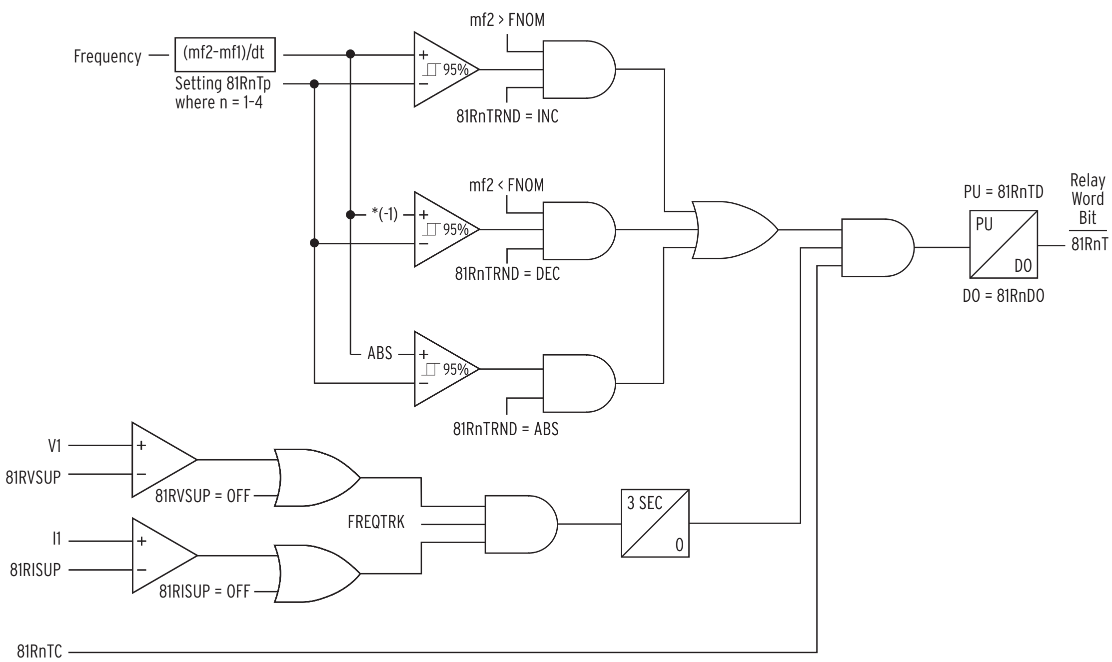


Figure 4.76 81R Frequency Rate-of-Change Scheme Logic

Table 4.50 Time Window Versus 81RnTP Setting (Sheet 1 of 2)

81RnTP Setting (Hz/sec)	Time Window (Cycles)
15.00–2.33	3
2.32–1.17	6
1.16–0.78	9
0.77–0.58	12
0.57–0.47	15
0.46–0.38	18
0.37–0.33	21

Table 4.50 Time Window Versus 81RnTP Setting (Sheet 2 of 2)

81RnTP Setting (Hz/sec)	Time Window (Cycles)
0.32–0.29	24
0.28–0.26	27
< 0.25	30

Set 81R*n* Trend to INC or DEC to limit 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 and current supervision: A minimum positive-sequence voltage and/or current is necessary for the operation of the 81R element when the levels are specified by the 81RISUP and 81RVSUP settings, respectively. Set 81RISUP := OFF if no current supervision is necessary and similarly 81RVSUP := OFF if no voltage supervision is necessary. In any case, the element is also supervised by Relay Word FREQTRK, which ensures that the relay is tracking and measuring the system frequency.

Use the Relay Word bit 81R*n*T to operate output contacts to open appropriate breaker(s) as necessary for your load-shedding scheme.

Fast Rate-of-Change-of-Frequency (81RF) Protection

The fast rate-of-change-of-frequency protection, 81RF, provides a faster response compared to the frequency (81) and rate-of-change-of-frequency (81R) elements. The fast operating speed makes the 81RF element suitable for detecting islanding conditions.

The element uses a characteristic (see *Figure 4.77*) based on frequency deviation from nominal frequency (DF = FREQ – FNOM) and rate-of-change-of-frequency (DF3C) to detect islanding conditions. The element uses a time window of three cycles to calculate the value of DF3C. Under steady-state conditions, the operating point is close to the origin. During islanding conditions, depending on the accelerating or decelerating of the islanded system, the operating point enters Trip Region 1 or Trip Region 2 of the characteristic. The elements uses the settings 81RFDFP in Hz and 81RFRP in Hz/s to configure the characteristic (see *Table 4.51*).

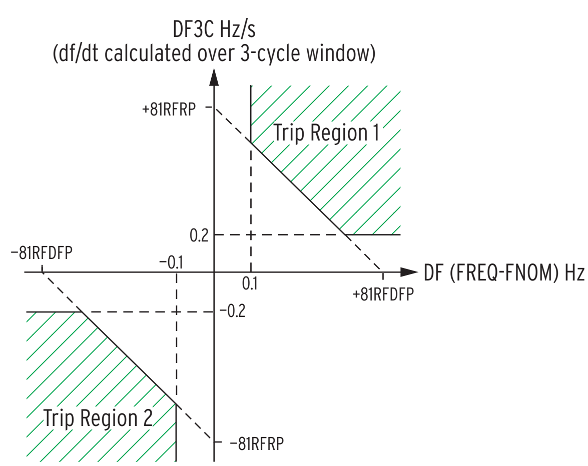


Figure 4.77 81RF Characteristics

An explanation of ways to mitigate Aurora threats to power systems can be found in the SEL technical paper, *Mitigating the Aurora Vulnerability With Existing Technology*, available on the SEL website. More detailed application considerations can be found in the SEL *Application Guide, AG2010-03*, *Aurora Mitigation Using the* SEL-751 *Relay*, also available on the SEL website.

Table 4.51 Fast Rate-of-Change-of-Frequency Settings

Setting Prompt	Range	Setting Name := Factory Default
ENABLE 81RF	Y, N	E81RF := N
FREQDIF SETPOINT	0.1–10.0 Hz	81RFDFP := 1.0
DFDT SETPOINT	0.2–15.0 Hz/sec	81RFRP := 2.5
81RF PU DELAY	0.10–1.00 sec	81RFPU := 0.10
81RF DO DELAY	0.00–1.00 sec	81RFDO := 0.10
81RF VOLTAGE BLK	OFF, 2–300 V[a]	81RFVBLK := OFF
	OFF, 2–520 V[b]	81RFVBLK := OFF
81RF CURRENT BLK	OFF, 0.1–20 A • I_{NOM}	81RFIBLK := 10 • I_{NOM}
81RF BLOCK	SELOGIC	81RFBL := 0
81RF BLOCK DO	0.02–5.00 sec	81RFBLDO := 1.00

[a] Setting range shown is for DELTA_Y := DELTA.
[b] Setting range shown is for DELTA_Y := WYE.

Figure 4.78 shows the logic diagram of the 81RF element. Enable the element by setting E81RF to Y (Yes). Settings 81RFDFP and 81RFRP configure the 81RF characteristics. These settings are typically coordinated with the frequency (81) and rate-of-change-of-frequency (81R) element settings. The slope of the characteristic, 81RFSLP, shown in the logic diagram is equal to –1 • (81RFRP/81RFDFP).

Use 81RFVBLK or 81RFIBLK to block the operation of the 81RF element for undervoltage or overcurrent fault conditions. You can use the 81RFBL SELOGIC control equation to include additional blocking elements. 81RFI asserts if the operating point is in Trip Region 1 or Trip Region 2. Program the 81RFT Relay Word bit in one of the relay outputs for the intended operation.

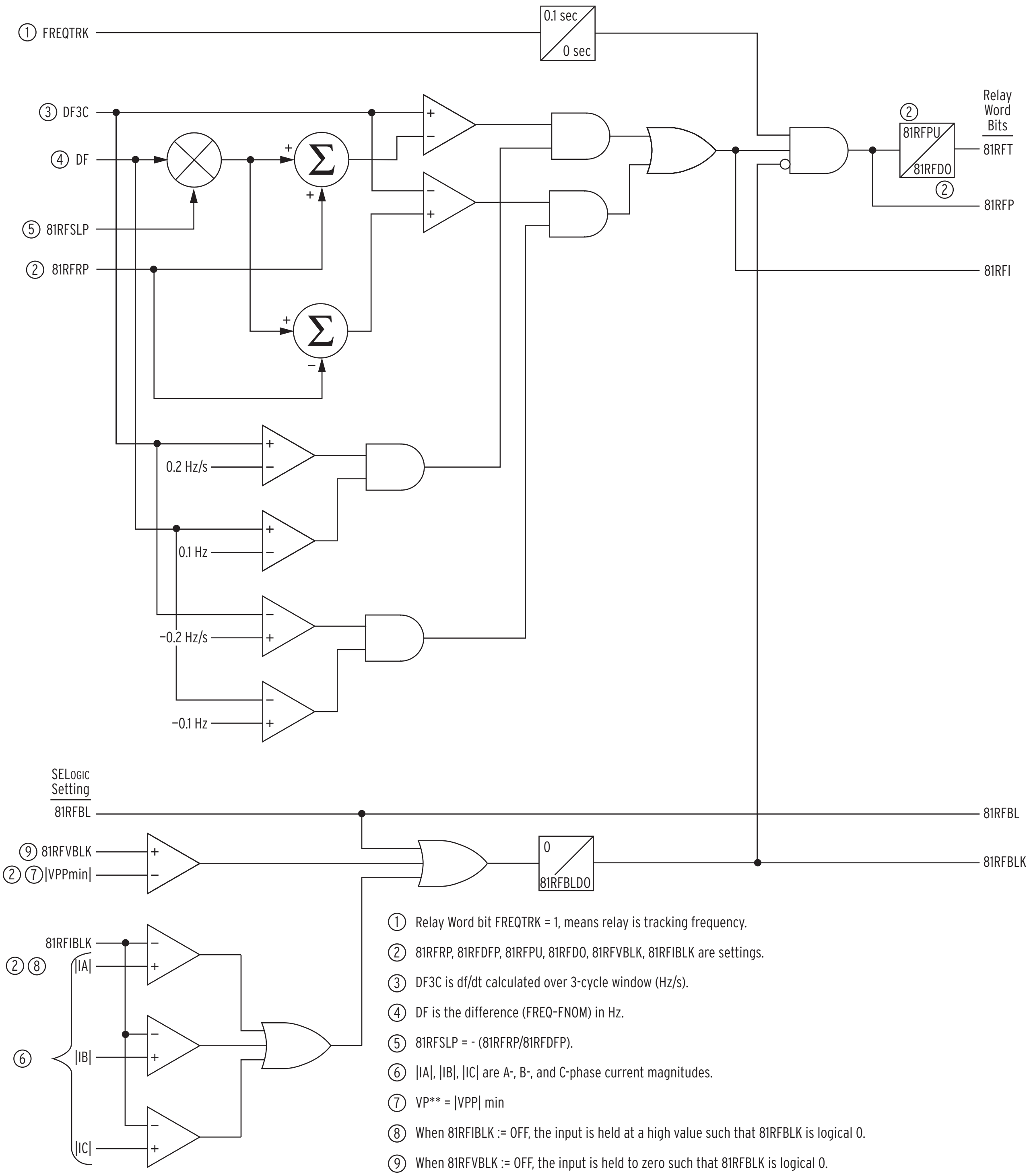


Figure 4.78 81RF Fast Rate-of-Change-of-Frequency Logic

Trip/Close Logic

The SEL-751 tripping logic is designed to trip the circuit breakers. The relay logic lets you define the conditions that cause a trip, the conditions that unlatch the trip, and the performance of the relay output contact. *Figure 4.79* illustrates the tripping logic.

NOTE: The factory-default assignment of the Relay Word bit TRIP is the output **OUT103**. See Table 4.65 for the output contacts settings.

Table 4.52 Trip/Close Logic Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
MIN TRIP TIME	0.0–400.0 sec	TDURD := 0.5
CLOSE FAIL DLY	OFF, 0.0–400.0 sec	CFD := 1.0
TRIP EQUATION	SV	TR := ORED50T OR ORED51T OR ORED81T OR REMTRIP OR OC OR SV04T
REMOTE TRIP EQN	SV	REMTRIP := 0
UNLATCH TRIP	SV	ULTRIP := NOT (51P1P OR 51G1P OR 51N1P OR 52A)
BRKR N/O CONT	SV	52A := 0
BRKR N/C CONT	SV	52B := NOT 52A
CLOSE EQUATION	SV	CL := SV03T AND LT02 OR CC
UNLATCH CLOSE	SV	ULCL := 0

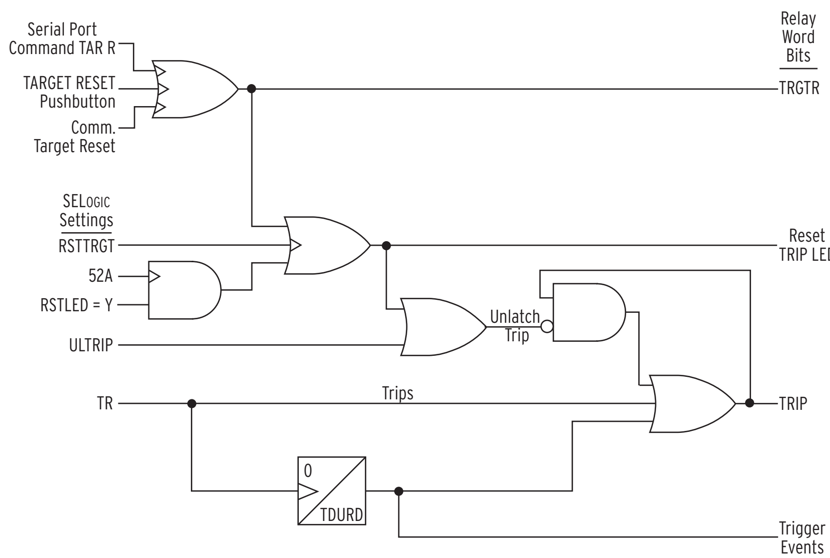


Figure 4.79 Trip Logic

The trip logic settings, including the SELOGIC control equations, are described in the following text.

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

The SEL-751 TR SELOGIC control equation provides the trip logic to trip the breaker. The Relay Word bit TRIP is associated with the TR SELOGIC control equation.

The default TR setting is shown in *Table 4.52* and includes protective elements Relay Word bits, front panel or serial port (including Modbus and DeviceNet) initiated **OPEN** command (Relay Word bit OC), and remote trips (Relay Word bit REMTRIP).

The trip conditions trigger an event report. The relay controls the tripping output contact(s) when the Relay Word bit TRIP appears in an output contact SELOGIC control equation. Default relay settings have output **OUT103** set to TRIP and fail-safe setting **OUT103FS** at N (see *Fail-Safe/Nonfail-Safe Tripping on page 2.26*).

NOTE: You can use an indirect mapping (e.g., SV01) as in the factory-default setting. See Table 4.62 for the SV01 settings.

Set the TR SELOGIC control equation to include an OR combination of all the Relay Word bits that you want to cause the relay to trip. The factory-default setting already includes all commonly necessary Relay Word bits.

REMTRIP Remote Trip Conditions SELOGIC Control Equation

The REMTRIP SELOGIC control equation is intended to define a remote trip condition. For example, the following settings trip the breaker by input IN303 via REMTRIP.

```
REMTRIP := IN303
TR := ... OR REMTRIP
```

The HMI displays `Remote Trip` to indicate the trip by Remote trip logic.

You can map any Relay Word bit or SELOGIC control equation to the REMTRIP to trip the breaker. For example, you can map a control input to REMTRIP. Add REMTRIP to the TR SELOGIC control equation (as in the default settings) to quickly see from the HMI target that it was a `Remote Trip` that tripped the breaker.

Unlatch Trip Logic

Following a fault, the trip signal is maintained until all of the following conditions are true:

NOTE: Factory default setting of the ULTRIP provides an automatic reset of the trip when breaker opens and selected 50/51 elements are not picked up.

- Minimum trip duration time (TDURD) passes.
- The TR SELOGIC control equation result deasserts to logical 0.
- One of the following occurs:
  - Unlatch Trip SELOGIC control equation setting ULTRIP asserts to logical 1.
  - Target Reset SELOGIC control equation setting RSTTRGT asserts to logical 1.
  - Target Reset Relay Word TRGTR asserts. The TRGTR is asserted when the front-panel **TARGET RESET** pushbutton is pressed or a target reset serial port command is executed (ASCII, Modbus, or DeviceNet).

52A and 52B Breaker Status SELOGIC Control Equations

NOTE: For the disconnect switch settings and logic, refer to Disconnect Switch Symbol Settings and Status Logic. For the touchscreen relay option, refer to Table 9.3 for typical disconnect switch symbols. For the settings related to bay control disconnect switch symbols, refer to Table 9.5 and the corresponding descriptions.

Use the SELOGIC settings 52A and 52B to map the respective breaker auxiliary contacts to the relay. Because the 52B contact is not always available for the purpose of reducing the number of I/O required, the breaker status logic does not include the 52B contact. The relay uses the 52A Relay Word bit as the status of the breaker in conjunction with the protection elements and trip and close logic. The default 52B setting is NOT 52A. The factory-default setting assumes no auxiliary contact connection (52A := 0).

NOTE: For the settings related to the local/remote breaker control function, refer to Local/Remote Breaker Control on page 9.3. For breaker control via the front panel pushbuttons, refer to Front-Panel Operator Control Pushbuttons on page 8.15. For breaker control via the two-line display, refer to Control Menu on page 8.9. For breaker control via the touchscreen, refer to Breaker Control Via the Touchscreen on page 9.5.

If you connect the breaker auxiliary contacts to digital inputs, you must change the factory-default logic equations for 52A and 52B. For example, set 52A := IN101 and 52B := IN102 if you connect the 52a and 52b contacts to inputs IN101 and IN102, respectively.

The SEL-751 Relay with the touchscreen display option additionally provides the ability to design detailed single-line diagrams and display the breaker and disconnect switch status. Refer to *Table 9.1* for typical circuit breaker symbols available for display on the bay screens. For settings related to bay control breaker symbols, refer to *Table 9.5* and the corresponding description.

CL Close SELOGIC Control Equation

The SEL-751 Close Logic offers three ways to close the circuit breaker:

- ➤ Conditions mapped to CL
- ➤ Front-panel or serial port (including Modbus and DeviceNet) **CLOSE** command
- ➤ Automatic reclosing when open interval times out (qualified by SELOGIC control equation setting 79CLS—see *Figure 4.81*).

The relay controls the closing output contact(s) when the Relay Word bit CLOSE appears in an output contact SELOGIC control equation. Default relay settings have output OUT102 set to CLOSE. See *Figure 2.23* for typical close circuit connection.

Set the CL SELOGIC control equation to include an OR-combination of all Relay Word bits that you want to cause the relay to close breaker. The factory-default setting already includes all commonly necessary Relay Word bits.

Unlatch Close Logic

Once the CLOSE bit is asserted it is sealed-in until any of the following conditions are true:

- ➤ Unlatch Close SELOGIC control equation setting ULCL asserts to logical 1.
- ➤ Relay Word 52A asserts to logical 1.
- ➤ Close failure Relay Word bit asserts to logical 1.

Close Failure Logic

Set the close failure delay (setting CFD) equal to highest breaker close time plus a safety margin. If the breaker fails to close, the Relay Word CF asserts for 1/4 cycle. Use the CF bit as desired.

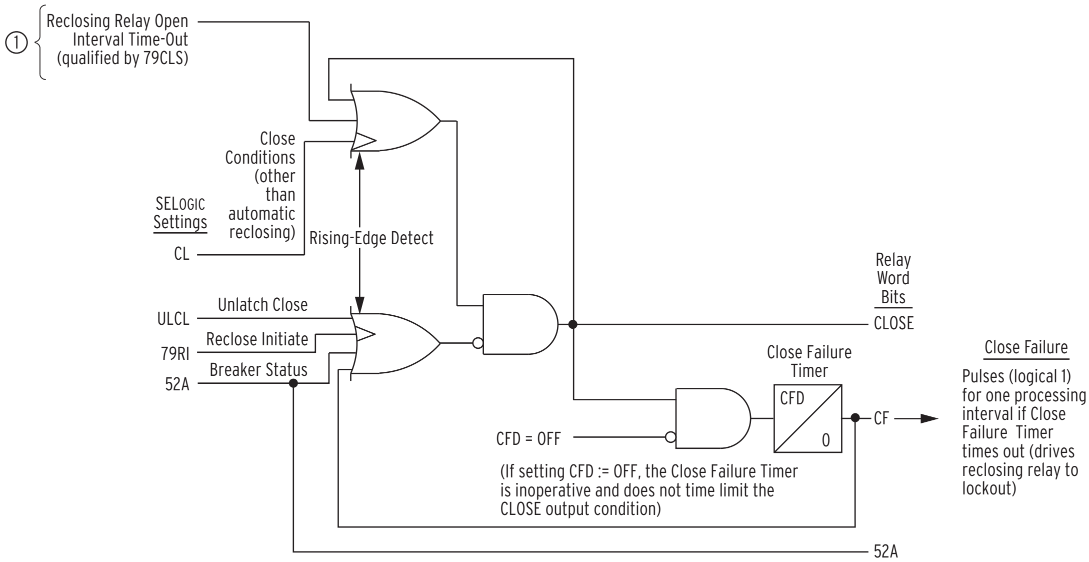
Reclose Supervision Logic

Note that one of the inputs into the close logic in *Figure 4.80* is:

Reclosing Relay Open Interval Time-Out (qualified by 79CLS)

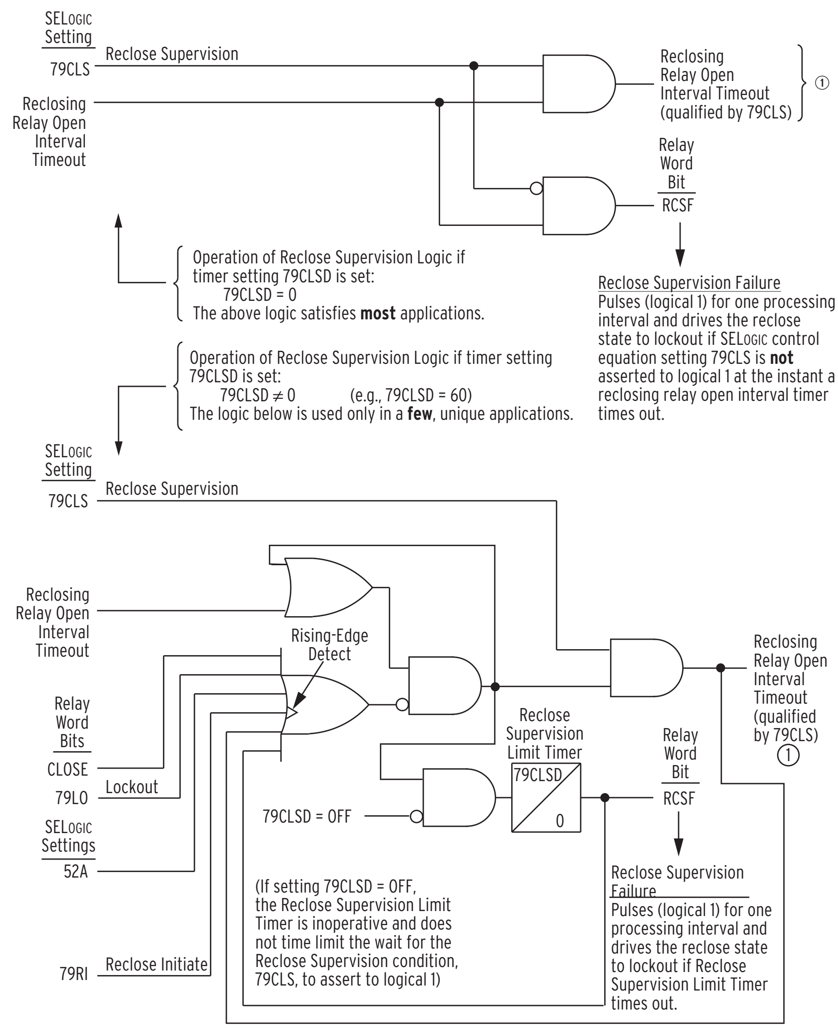
NOTE: The close logic is inoperative if 52A is set to 0 in SEL-751 models with reclosing option.

This input into the close logic in *Figure 4.80* is the indication that a reclosing relay open interval has timed out (see *Figure 4.82*), a qualifying condition (SELOGIC control equation setting 79CLS) has been met, and thus automatic reclosing of the circuit breaker should proceed by asserting the CLOSE Relay Word bit to logical 1. This input into the close logic in *Figure 4.80* is an output of the reclose supervision logic in the following *Figure 4.81*.



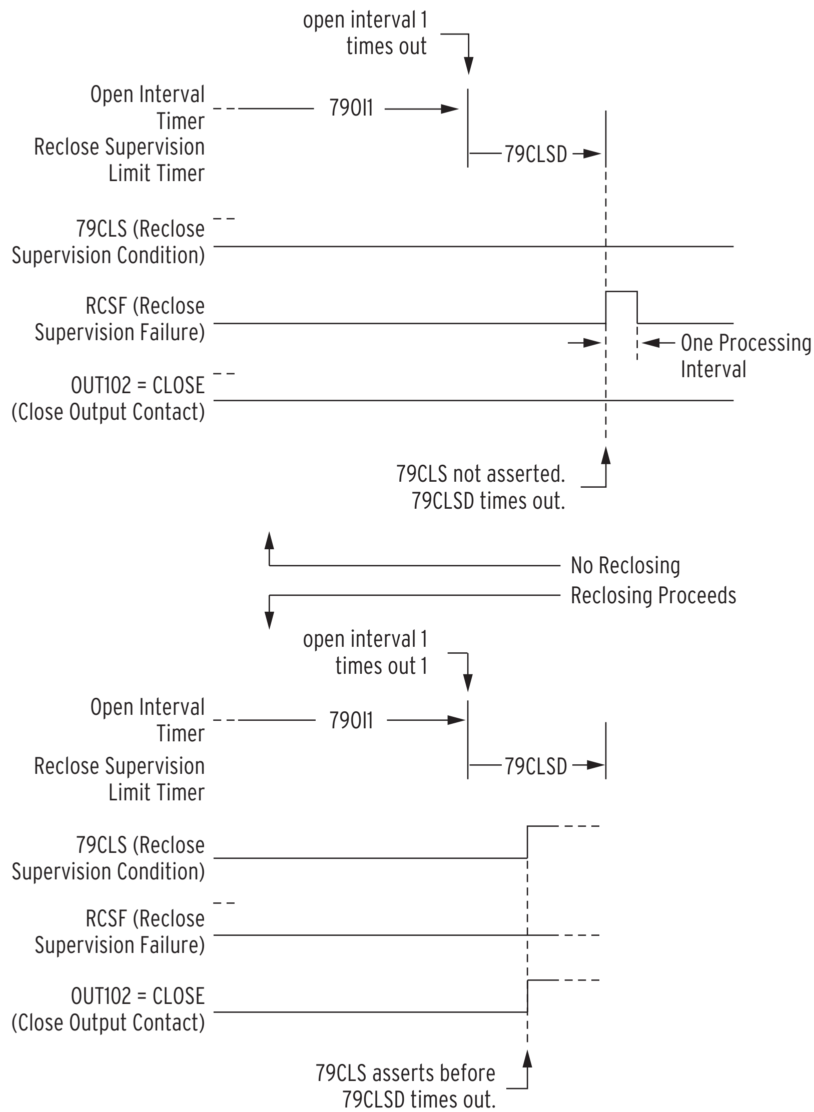
① From Figure 4.81

Figure 4.80 Close Logic



① To Figure 4.80

Figure 4.81 Reclose Supervision Logic (Following Open Interval Time-Out)



(Refer to Bottom of Figure 4.81)

Figure 4.82 Reclose Supervision Limit Timer Operation

Settings and General Operation

Figure 4.81 contains the following SELOGIC control equation setting:

```
79CLS (reclose supervision conditions—checked after
reclosing relay open interval time-out)
```

and setting:

79CLSD (Reclose Supervision Limit Time)

See the *Table 4.54* for Recloser Control settings.

For Most Applications

Refer to the top of *Figure 4.81*.

For most applications, the Reclose Supervision Limit Time setting should be set to zero seconds:

79CLSD := **0.00**

With this setting, the logic in the top of *Figure 4.81* is operative. When an open interval times out, the SELOGIC control equation reclose supervision setting 79CLS is *checked just once*.

If 79CLS is *asserted* to logical 1 at the instant of an open interval time-out, then the now-qualified open interval time-out propagates onto the final close logic in *Figure 4.81* to automatically reclose the circuit breaker.

If 79CLS is *deasserted* to logical 0 at the instant of an open interval time-out, the following occurs:

- ➤ No automatic reclosing takes place.
- ➤ Relay Word bit RCSF (Reclose Supervision Failure indication) asserts to logical 1 for one processing interval.
- ➤ If setting E79 := 1, 2, 3, or 4, the reclosing relay is driven to the lockout state.
- ➤ If setting E79 := C1, C2, C3, or C4, the reclosing relay increments the shot counter and starts timing on the next open interval. This operation emulates a rotating drum timer style reclosing relay—going on to the next open interval time and reclose opportunity if supervising conditions for the present reclose opportunity are not satisfied. If the reclosing relay increments to the last shot value (no more open intervals left; see *Figure 4.86* and *Table 4.55*), the reclosing relay is then driven to the lockout state.

See *Example 4.17*.

For A Few, Unique Applications

Refer to the bottom of *Figure 4.81* and *Figure 4.82*.

For a few unique applications, the Reclose Supervision Limit Time setting is *not* set equal to zero seconds, e.g.,

79CLSD := **1.00 second**

With this setting, the logic in the bottom of *Figure 4.81* is operative. When an open interval times out, the SELOGIC control equation reclose supervision setting 79CLS is then *checked for a time window* equal to setting 79CLSD.

If 79CLS *asserts* to logical 1 at any time during this 79CLSD time window, then the now-qualified open interval time-out propagates onto the final close logic in *Figure 4.80* to automatically reclose the circuit breaker.

If 79CLS remains *deasserted* to logical 0 during this entire 79CLSD time window, when the time window times out, the following occurs:

- ➤ No automatic reclosing takes place.
- ➤ Relay Word bit RCSF (Reclose Supervision Failure indication) asserts to logical 1 for one processing interval.
- ➤ If setting E79 := 1, 2, 3, or 4, the reclosing relay is driven to lockout state.

The logic in the bottom of *Figure 4.81* is explained in more detail in the following text.

Set Reclose Supervision Logic.

Refer to the bottom of *Figure 4.81*. If *all* the following are true:

- The close logic output CLOSE (also see *Figure 4.80*) is *not* asserted (Relay Word bit CLOSE = logical 0).
- The reclosing relay is *not* in the lockout state (Relay Word bit 79LO = logical 0).
- The circuit breaker is open (52A = logical 0).
- The reclose initiation condition (79RI) is *not* making a rising edge (logical 0 to logical 1) transition.
- The Reclose Supervision Limit Timer is *not* timed out (Relay Word bit RCSF = logical 0).

then a reclosing relay open interval time-out seals as shown in *Figure 4.81*. Then, when 79CLS asserts to logical 1, the sealed-in reclosing relay open interval time-out condition propagates through *Figure 4.75* and on to the close logic in *Figure 4.80*.

Unlatch Reclose Supervision Logic.

Refer to the bottom of *Figure 4.81*. If the reclosing relay open interval time-out condition is sealed-in, it stays sealed-in until *one* of the following occurs:

- The close logic output CLOSE (also see *Figure 4.81*) asserts (Relay Word bit CLOSE = logical 1).
- The reclosing relay goes to the lockout state (Relay Word bit 79LO = logical 1).
- The circuit breaker closes (52A = logical 1).
- The reclose initiation condition (79RI) makes a rising-edge (logical 0 to logical 1) transition.
- SELOGIC control equation setting 79CLS asserts (79CLS = logical 1).
- The Reclose Supervision Limit Timer times out (Relay Word bit RCSF = logical 1 for one processing interval).

The Reclose Supervision Limit Timer is inoperative if setting 79CLSD := OFF. With 79CLSD := OFF, reclose supervision condition 79CLS is not time limited. When an open interval times out, reclose supervision condition 79CLS is checked indefinitely until one of the other unlatch conditions listed previously comes true.

The unlatching of the sealed-in reclosing relay open interval time-out condition by the assertion of SELOGIC control equation setting 79CLS indicates successful propagation of a reclosing relay open interval time-out condition on to the close logic in *Figure 4.80*. See *Example 4.18*.

EXAMPLE 4.17 Settings Example 1

Refer to the top of Figure 4.81 and Figure 4.83.

SEL-751 Relays are installed at both ends of a transmission line in a high-speed reclose scheme. After both circuit breakers open for a line fault, the SEL-751 (1) recloses circuit breaker 52/1 first, followed by the SEL-751(2) reclosing circuit breaker 52/2, after a synchronism check across circuit breaker 52/2.

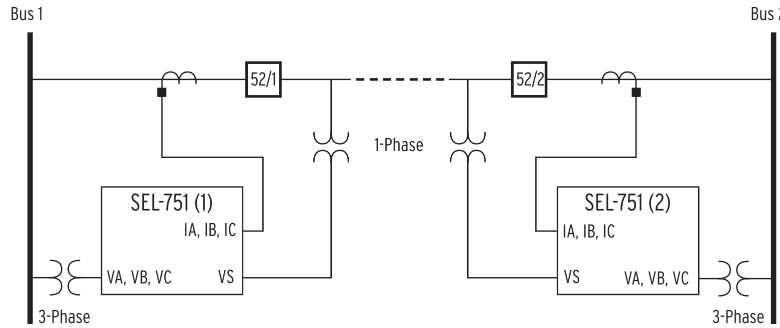


Figure 4.83 SEL-751 Relays Installed at Both Ends of a Transmission Line in a High-Speed Reclose Scheme

SEL-751 (1) Relay

Before allowing circuit breaker 52/1 to be reclosed after an open interval time-out, the SEL-751(1) checks that Bus 1 voltage is hot and the transmission line voltage is dead. This requires reclose supervision settings:

79CLSD := **0.00 seconds** (only one check)

79CLS := **59VP AND 27S1**

where:

59VP = Bus 1 is hot

27S1 = monitored single-phase transmission line voltage (channel VS) is dead

SEL-751 (2) Relay

The SEL-751(2) checks that Bus 2 voltage is hot, the transmission line voltage is hot, and in synchronism after the reclosing relay open interval times out, before allowing circuit breaker 52/2 to be reclosed. This requires reclose supervision settings:

79CLSD := **0.00 seconds** (only one check)

79CLS := **25A1**

where:

25A1 = selected Bus 2 phase voltage (VA, VB, or VC) is in synchronism with monitored single-phase transmission line voltage (channel VS) and both are hot

Other Setting Considerations for SEL-751(1) and SEL-751(2) Relays

Refer to *Skip Shot (79SKP) and Stall Open Interval Timing (79STL) Settings on page 4.147*.

SELOGIC control equation setting 79STL stalls open interval timing if it asserts to logical 1. If setting 79STL is deasserted to logical 0, open interval timing can continue. The SEL-751(1) has no intentional open interval timing stall condition (circuit breaker 52/1 closes first after a transmission line fault):

79STL := **0**

The SEL-751(2) starts open interval timing after circuit breaker 52/1 at the remote end has re-energized the line. The SEL-751(2) has to see Bus 2 hot, transmission line hot, and in synchronism across open circuit breaker 52/2 for open interval timing to begin. Thus, SEL-751(2) open interval timing is stalled when the transmission line voltage and Bus 2 voltage are *not* in synchronism across open circuit breaker 52/2:

79STL := **NOT 25A1**

A transient synchronism-check condition across open circuit breaker 52/2 could possibly occur if circuit breaker 52/1 recloses into a fault on one phase of the transmission line. The other two unfaulted phases would be briefly energized until circuit breaker 52/1 is tripped again. If channel VS of the SEL-751 (2) is connected to one of these briefly energized phases, synchronism-check element 25A1 could momentarily assert to logical 1.

So that this possible momentary assertion of synchronism-check element 25A1 does not cause any inadvertent reclose of circuit breaker 52/2, make sure the open interval timers in the SEL-751 (2) are set with some appreciable time greater than the momentary energization time of the faulted transmission line. Or, run the synchronism-check element 25A1 through a programmable timer before using it in the preceding 79CLS and 79STL settings for the SEL-751 (2) (see *Figure 4.80*). Note the built-in 2-cycle qualification of the synchronism-check voltages shown in *Figure 4.67*.

EXAMPLE 4.18 Settings Example 2

Refer to subsection Synchronism-Check Elements on page 4.106. Also refer to Figure 4.82 and Figure 4.83.

If the synchronizing voltages across open circuit breaker 52/2 are "slipping" with respect to one another, the Reclose Supervision Limit Timer setting 79CLSD should be set greater than zero so there is time for the slipping voltages to come into synchronism. For example:

79CLSD := **1.00 second**

79CLS := **25A1**

The status of synchronism-check element 25A1 is checked continuously during the 60-cycle window. If the slipping voltages come into synchronism while timer 79CLSD is timing, synchronism-check element 25A1 asserts to logical 1 and reclosing proceeds.

In the previous referenced subsection, note item 3 under Synchronism-Check Element Outputs on page 4.113, Voltages VP and VS are "Slipping." Item 3 describes a last attempt for a synchronism-check reclose before timer 79CLSD times out (or setting 79CLSD := 0.00 and only one check is made).

If E79 := 3 (which allows three automatic reclose attempts) and the slipping voltages fail to come into synchronism while timer 79CLSD is timing (resulting in a reclose supervision failure, causing RCSF to assert for one processing interval), then the reclosing relay goes to the lockout state.

If E79 := C3 (which allows three automatic reclose attempts) and the slipping voltages fail to come into synchronism while timer 79CLSD is timing (resulting in a reclose supervision failure, causing RCSF to assert for one processing interval), then the reclosing relay increments the shot counter and starts timing on the next open interval. This operation emulates a rotating drum timer style reclosing relay—going onto the next open interval time and reclose opportunity if supervising conditions for the present reclose opportunity are not true. If the reclosing relay increments to the last shot value (no more open intervals left; see Figure 4.86 and Table 4.55), the reclosing relay is then driven to the lockout state.

Reclose Logic

Note that input:

Reclosing Relay Open Interval Time-Out

in *Figure 4.81* is the logic input that is qualified by SELOGIC control equation setting 79CLS, and then propagated on to the close logic in *Figure 4.80* to automatically reclose a circuit breaker. The explanation that follows in this reclosing relay subsection describes all the reclosing relay settings and logic that eventually result in this open interval time-out logic input into *Figure 4.81*. Other aspects of the reclosing relay are also explained. As many as four (4) automatic reclosures (shots) are available.

The reclose enable setting, E79, has setting choices N, 1, 2, 3, 4, C1, C2, C3, and C4. Setting E79 := N defeats the reclosing relay. Setting choices 1–4 and C1–C4 are the number of automatic reclosures (see *Open Interval Timers on page 4.141*) you want. With setting choices 1–4, the reclosing relay goes to the lockout state on reclose supervision failure (refer to *Reclose Supervision Logic on page 4.131*).

With setting choices C1–C4, however, the reclosing relay does not go to the lockout state on reclose supervision failure. Instead, the reclosing relay increments the shot counter and starts timing on the next open interval. This operation emulates a rotating drum timer style reclosing relay—going on to the next open interval time and reclose opportunity when supervising conditions for the present reclose opportunity are not true.

Reclosing Relay States and General Operation

Figure 4.84 explains in general the different states of the reclosing relay and its operation.

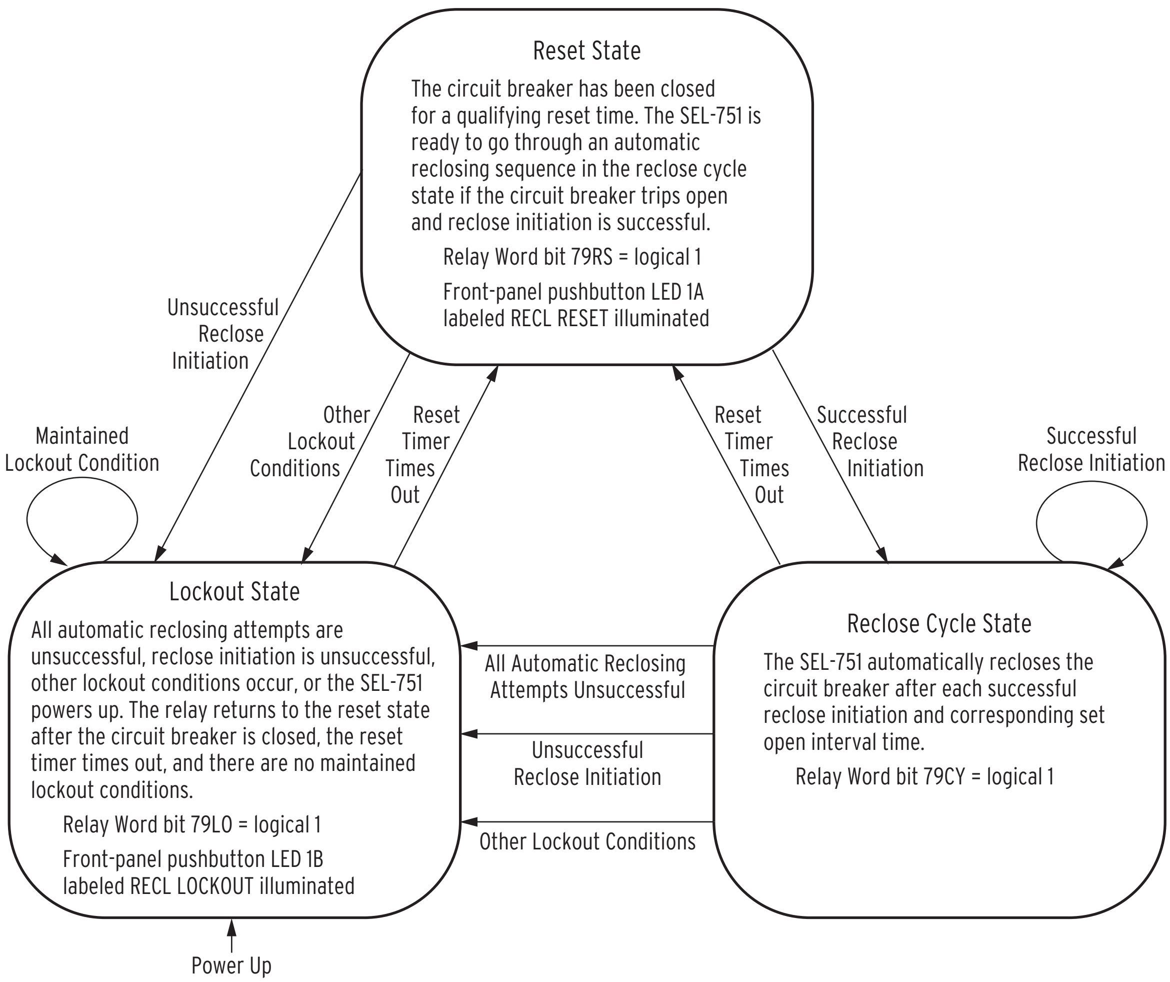


Figure 4.84 Reclosing Relay States and General Operation

Table 4.53 Relay Word Bit and Front-Panel Correspondence to Reclosing Relay States

Reclosing Relay State	Corresponding Relay Word Bit	Corresponding Front-Panel LED
Reset	79RS	RECL RESET (Pushbutton LED 1A)
Reclose Cycle	79CY	
Lockout	79LO	RECL LOCKOUT (Pushbutton LED 1B)

The reclosing relay is in one (and only one) of these states (listed in *Table 4.53*) at any time. When in a given state, the corresponding Relay Word bit asserts to logical 1, and the LED illuminates. Automatic reclosing only takes place when the relay is in the Reclose Cycle State.

Lockout State

The reclosing relay goes to the lockout state if any *one* of the following occurs:

- The shot counter is equal to or greater than the last shot at time of reclose initiation (e.g., all automatic reclosing attempts are unsuccessful—see *Figure 4.82*).
- Reclose initiation is unsuccessful because of SELOGIC control equation setting 79RIS (see *Reclose Initiate and Reclose Initiate Supervision Settings (79RI and 79RIS, Respectively) on page 4.144*).
- The circuit breaker opens without reclose initiation (e.g., an external trip).
- The shot counter is equal to or greater than last shot, and the circuit breaker is open [e.g., the shot counter is driven to last shot with SELOGIC control equation setting 79DLS while open interval timing is in progress. See *Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, Respectively) on page 4.146*].
- The close failure timer (setting CFD) times out (see *Figure 4.80*).
- SELOGIC control equation setting 79DTL = logical 1 (see *Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, Respectively)*).
- The Reclose Supervision Limit Timer (setting 79CLSD) times out (see *Figure 4.81* and top of *Figure 4.82*) and the reclose enable setting, E79, has setting choices N, 1, 2, 3, 4, C1, C2, C3, and C4.
- A new reclose initiation occurs while the reclosing relay is timing on an open interval (e.g., flashover in the tank while breaker is open).

The **OPEN** command is included in the reclosing relay logic via the factory SELOGIC control equation settings:

79DTL := **OC OR ...** (drive-to-lockout)

Relay Word bit OC asserts for execution of the **OPEN** command. See *OPEN Command (Open Breaker) on page 7.43* for more information on the **OPEN** command. Also, see *Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, Respectively) on page 4.146*.

Reclosing Relay States and Settings/Setting Group Changes

If individual settings are changed for the active setting group *or* the active setting group is changed, *all* of the following occur:

- ➤ The reclosing relay remains in the state it was in before the settings change.
- ➤ The shot counter is driven to last shot (last shot corresponding to the new settings; see discussion on last shot that follows).
- ➤ The reset timer is loaded with reset time setting 79RSLD (see discussion on reset timing later in this section).

If the relay happened to be in the Reclose Cycle State and was timing on an open interval before the settings change, the relay would be in the Reclose Cycle State after the settings change, but the relay would immediately go to the lockout state. This is because the breaker is open, and the relay is at last shot after the settings change, and thus no more automatic reclosures are available.

If the circuit breaker remains closed through the settings change, the reset timer times out on reset time setting 79RSLD after the settings change and goes to the Reset State (if it is not already in the Reset State), and the shot counter returns to shot = 0. If the relay happens to trip during this reset timing, the relay immediately goes to the lockout state, because shot = last shot.

Defeat the Reclosing Relay

If *any one* of the following reclosing relay settings are made then the reclosing relay is defeated, and no automatic reclosing can occur.

- ➤ Reclose enable setting E79 := N.
- ➤ Open Interval 1 time setting 79OI1 := 0.00.

If the reclosing relay is defeated, the following also occur:

- ➤ All three reclosing relay state Relay Word bits (79RS, 79CY, and 79LO) are forced to logical 0 (see *Table 4.53*).
- ➤ All shot counter Relay Word bits (SH0, SH1, SH2, SH3, and SH4) are forced to logical 0 (the shot counter is explained later in this section).
- ➤ The front-panel LEDs **RECL RESET** and **RECL LOCKOUT** are both extinguished.

Close Logic Can Still Operate When the Reclosing Relay Is Defeated

If the reclosing relay is defeated, the close logic (see *Figure 4.80*) can still operate if SELOGIC control equation circuit breaker status setting 52A is set to something other than numeral 0 or NA. Making the setting 52A := 0 or NA defeats the close logic *and* also defeats the reclosing relay.

For example, if 52A := IN101, a 52A circuit breaker auxiliary contact is connected to input **IN101**. If the reclosing relay does not exist, the close logic still operates, allowing closing to take place via SELOGIC control equation setting CL (close conditions, other than automatic reclosing). See *Trip/Close Logic* for more discussion on SELOGIC control equation settings 52A and CL.

Reclosing Control Settings

The reclosing control settings are shown in *Table 4.54*:

Table 4.54 Reclosing Control Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE RECLOSER	N, 1–4, C1–C4, Shots	E79 := N
OPEN INTERVAL 1	0.00–3000.00 sec	79OI1 := 0.00
OPEN INTERVAL 2	0.00–3000.00 sec	79OI2 := 0.00
OPEN INTERVAL 3	0.00–3000.00 sec	79OI3 := 0.00
OPEN INTERVAL 4	0.00–3000.00 sec	79OI4 := 0.00
RST TM FROM RECL	0.00–3000.00 sec	79RSD := 15.00
RST TM FROM LO	0.00–3000.00 sec	79RSLD := 5.00
RECLS SUPV TIME	OFF, 0.00–3000.00 sec	79CLSD := OFF
RECLOSE INITIATE	SV	79RI := TRIP
RCLS INIT SUPVSN	SV	79RIS := 52A OR 79CY
DRIVE-TO-LOCKOUT	SV	79DTL := OC OR SV04T
DRIVE-TO-LSTSHOT	SV	79DLS := 79LO
SKIP SHOT	SV	79SKP := 0
STALL OPN INTRVL	SV	79STL := TRIP
BLOCK RESET TMNG	SV	79BRS := TRIP
SEQ COORDINATION	SV	79SEQ := 0
RCLS SUPERVISION	SV	79CLS := 1

The operation of open interval timers is affected by SELOGIC control equation settings discussed later in this section.

Open Interval Timers

The reclose enable setting, E79, determines the number of open interval time settings that can be set. For example, if setting E79 := 3, the first three open interval time settings in *Table 4.54*, are made available for setting.

If an open interval time is set to zero, then that open interval time is not operable, *and* neither are the open interval times that follow it.

In the factory settings in *Table 4.54*, the open interval 2 time setting 79OI2 is the first open interval time setting set equal to zero:

79OI2 := **0.00 seconds**

Thus, open interval times 79OI2, 79OI3, and 79OI4 are not operable. In the factory settings, both open interval times 79OI3 and 79OI4 are set to zero. But if the settings were:

79OI2 := **0.00 seconds**

79OI3 := **15.00 seconds** (set to some value other than zero)

open interval time 79OI3 would still be inoperative, because a preceding open interval time is set to zero (i.e., 79OI2 := 0.00).

If open interval 1 time setting, 79OI1, is set to zero (79OI1 := 0.00 seconds), no open interval timing takes place, and the reclosing relay is defeated.

The open interval timers time consecutively; they do not have the same beginning time reference point. For example, with settings 79OI1 := 0.50, and 79OI2 := 10.00, open interval 1 time setting, 79OI1, times first. If subsequent first reclosure is not successful, then open interval 2 time setting, 79OI2, starts timing. If the subsequent second reclosure is not successful, the relay goes to the lockout state. See the example time line in *Figure 4.85*.

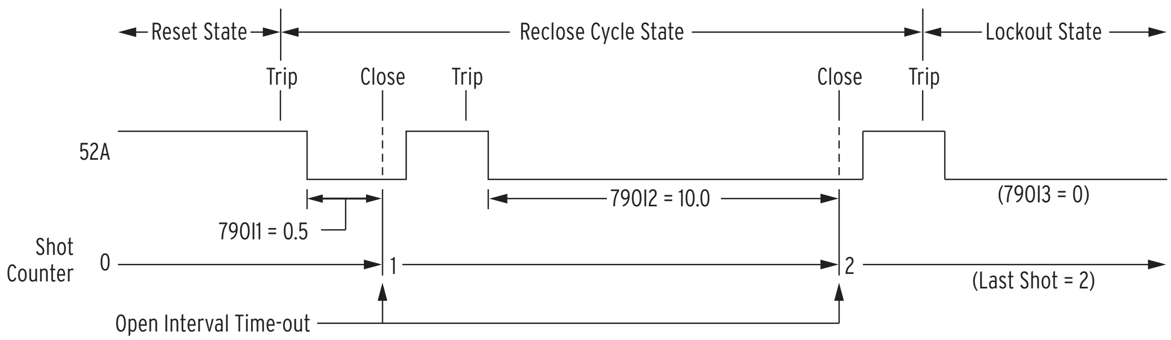


Figure 4.85 Reclosing Sequence From Reset to Lockout With Example Settings

SELOGIC control equation setting 79STL (stall open interval timing) can be set to control open interval timing (see *Skip Shot (79SKP) and Stall Open Interval Timing (79STL) Settings on page 4.147*).

Determination of Number of Reclosures (Last Shot)

The number of reclosures is equal to the number of open interval time settings that precede the first open interval time setting set equal to zero. The "last shot" value is also equal to the number of reclosures.

In the previous example settings, two set open interval times precede open interval 3 time, which is set to zero (79OI3 := 0.00):

79OI1 := **0.50**

79OI2 := **10.00**

79OI3 := **0.00**

For this example:

Number of reclosures (last shot) = 2 = the number of set open interval times that precede the first open interval set to zero.

Observe Shot Counter Operation

Observe the reclosing relay shot counter operation, especially during testing, using ASCII command **TARGET** (e.g., *TARGET Command (Display Relay Word Bit Status) on page 7.53* for detail).

Reset Timer

The reset timer qualifies circuit breaker closure before taking the relay to the reset state from the reclose cycle state or the lockout state. Circuit breaker status is determined by the SELOGIC control equation setting 52A. (See *Trip/Close Logic on page 4.128* for more discussion on SELOGIC control equation setting 52A.

Setting 79RSD. Qualifies closures when the relay is in the reclose cycle state. These closures are usually automatic reclosures resulting from open interval time-out.

It is also the reset time that the sequence coordination schemes (see *Sequence Coordination Setting (79SEQ) on page 4.150*) use.

Setting 79RSLD. Qualifies closures when the relay is in the lockout state. These closures are usually manual closures. These manual closures can originate external to the relay, via the **CLOSE** command, or via the SELOGIC control equation setting CL (see *Figure 4.80*).

Setting 79RSLD is also the reset timer the relay uses when it powers up, has individual settings changed for the active setting group, or the active setting group is changed (see *Reclosing Relay States and Settings/Setting Group Changes on page 4.140*).

Typically, setting 79RSLD is set less than setting 79RSD. Setting 79RSLD emulates reclosing relays with motor-driven timers that have a relatively short reset time from the lockout position to the reset position.

The 79RSD and 79RSLD settings are set independently (setting 79RSLD can even be set greater than setting 79RSD, if desired). SELOGIC control equation setting 79BRS (block reset timing) can be set to control reset timing (see *Block Reset Timing Setting (79BRS) on page 4.149*).

Monitoring Open Interval and Reset Timing

Open interval and reset timing can be monitored with the following Relay Word bits:

Relay Word Bits	Definition
OPTMN	Indicates that the open interval timer is *actively* timing
RSTMN	Indicates that the reset timer is *actively* timing

If the open interval timer is actively timing, OPTMN asserts to logical 1. When the relay is not timing on an open interval (e.g., it is in the reset state or in the lockout state), OPTMN deasserts to logical 0. The relay can only time on an open interval when it is in the reclose cycle state, but just because the relay is in the reclose cycle state does not necessarily mean the relay is timing on an open interval. The relay only times on an open interval after successful reclose initiation and no stall conditions are present (see *Skip Shot (79SKP) and Stall Open Interval Timing (79STL) Settings on page 4.147*).

If the reset timer is actively timing, RSTMN asserts to logical 1. If the reset timer is not timing, RSTMN deasserts to logical 0. See *Block Reset Timing Setting (79BRS) on page 4.149*.

Reclosing Relay Shot Counter

Refer to *Figure 4.85*. The shot counter increments for each reclose operation. For example, when the relay is timing on open interval 1, 79OI1, it is at shot = 0. When the open interval times out, the shot counter increments to shot = 1 and so forth for the set open intervals that follow. The shot counter cannot increment beyond the last shot for automatic reclosing (see *Determination of Number of Reclosures (Last Shot) on page 4.142*). The shot counter resets back to shot = 0 when the reclosing relay returns to the Reset State.

Table 4.55 Shot Counter Correspondence to Relay Word Bits and Open Interval Times

Shot	Corresponding Relay Word Bit	Corresponding Open Interval
0	SH0	79OI1
1	SH1	79OI2
2	SH2	79OI3
3	SH3	79OI4
4	SH4	

When the shot counter is at a particular shot value (e.g., shot = 2), the corresponding Relay Word bit asserts to logical 1 (e.g., SH2 = logical 1).

The shot counter also increments for sequence coordination operation. The shot counter can increment beyond the last shot for sequence coordination (see *Sequence Coordination Setting (79SEQ) on page 4.150*).

Reclose Initiate and Reclose Initiate Supervision Settings (79RI and 79RIS, Respectively)

The reclose initiate setting 79RI is a rising-edge detect setting. The reclose initiate supervision setting 79RIS supervises setting 79RI. When setting 79RI senses a rising edge (logical 0 to logical 1 transition), setting 79RIS has to be at logical 1 (79RIS := logical 1) in order for open interval timing to be initiated.

If 79RIS := logical 0 when setting 79RI senses a rising edge (logical 0 to logical 1 transition), the relay goes to the lockout state.

EXAMPLE 4.19 Factory Settings Example

With factory settings:

79RI := **TRIP**

79RIS := **52A OR 79CY**

the transition of the TRIP Relay Word bit from logical 0 to logical 1 initiates open interval timing only if the 52A or 79CY Relay Word bit is at logical 1 (52A = logical 1, or 79CY = logical 1). You must assign an input as the breaker status input (e.g., 52A := IN101).

The circuit breaker has to be closed (circuit breaker status 52A = logical 1) at the instant of the first trip of the auto-reclose cycle in order for the SEL-751 to successfully initiate reclosing and start timing on the first open interval. The SEL-751 is not yet in the reclose cycle state (79CY = logical 0) at the instant of the first trip.

Then for any subsequent trip operations in the auto-reclose cycle, the SEL-751 is in the reclose cycle state (79CY = logical 1) and the SEL-751 successfully initiates reclosing for each trip. Because of factory setting 79RIS := 52A OR 79CY, successful reclose initiation in the reclose cycle state (79CY = logical 1) is not dependent on the circuit breaker status (52A). This allows successful reclose initiation for the case of an instantaneous trip, but the circuit breaker status indication is slow—the instantaneous trip (reclose initiation) occurs before the SEL-751 sees the circuit breaker close.

If a flashover occurs in a circuit breaker tank during an open interval (circuit breaker open and the SEL-751 calls for a trip), the SEL-751 goes immediately to lockout.

EXAMPLE 4.20 Additional Settings Example

The preceding settings example initiates open interval timing on rising edge of the TRIP Relay Word bit. The following is an example of reclose initiation on the opening of the circuit breaker.

Presume input **IN101** is connected to a 52a circuit breaker auxiliary contact (52A := IN101).

With setting:

79RI := **NOT 52A**

the transition of the 52A Relay Word bit from logical 1 to logical 0 (breaker opening) initiates open interval timing. Setting 79RI looks for a logical 0 to logical 1 transition, thus Relay Word bit 52A is inverted in the 79RI setting.

The reclose initiate supervision setting 79RIS supervises setting 79RI. With settings:

79RI := **NOT 52A**

79RIS := **TRIP**

the transition of the 52A Relay Word bit from logical 1 to logical 0 initiates open interval timing only if the TRIP Relay Word bit is at logical 1 (TRIP = logical 1). Thus, the TRIP Relay Word bit has to be asserted when the circuit breaker opens to initiate open interval timing. With a long enough setting of the Minimum Trip Duration Timer (TDURD), the TRIP Relay Word bit still asserts to logical 1 when the circuit breaker opens (see Figure 4.44).

If the TRIP Relay Word bit is at logical 0 (TRIP = logical 0) when the circuit breaker opens (logical 1 to logical 0 transition), the relay goes to the lockout state. This helps prevent reclose initiation for circuit breaker openings caused by trips external to the relay.

If circuit breaker status indication (52A) is slow, additional setting change ULCL := 0 (unlatch close; refer to Figure 4.80 and accompanying explanation) may need to be made when 79RI := NOT 52A. ULCL := 0 avoids going to lockout prematurely for an instantaneous trip after an auto-reclose by not turning CLOSE off until the circuit breaker status indication tells the relay that the breaker is closed. The circuit breaker anti-pump circuitry should take care of the TRIP and CLOSE being on together for a short period of time.

Other Settings Considerations

In *Example 4.20*, the preceding additional setting example, the reclose initiate setting (79RI) includes input **IN101**, which is connected to a 52a breaker auxiliary contact (52A := IN101).

79RI := **NOT 52A**

If a 52b breaker auxiliary contact is connected to input **IN101** (52A := NOT IN101), the reclose initiate setting (79RI) remains the same.

If no reclose initiate supervision is desired, make the following setting:

79RIS := **1** (numeral 1)

Setting 79RIS := logical 1 at all times. Any time setting 79R1 detects a logical 0 to logical 1 transition, the relay initiates open interval timing (unless prevented by other means).

If the following setting is made:

79RI := **0** (numeral 0)

reclosing never takes place (reclosing is never initiated). The reclosing relay is effectively inoperative.

If the following setting is made:

79RIS := **0** (numeral 0)

reclosing never takes place (the reclosing relay goes directly to the lockout state any time reclosing is initiated). The reclosing relay is effectively inoperative.

Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, Respectively)

When 79DTL := logical 1, the reclosing relay goes to the lockout state (Relay Word bit 79LO = logical 1), and the front-panel **LO** (Lockout) LED illuminates.

79DTL has a 1 second dropout time. This keeps the drive-to-lockout condition up 1 second after 79DTL has reverted back to 79DTL := logical 0. This is useful for situations where both of the following conditions are true:

- Any of the trip and drive-to-lockout conditions are “pulsed” conditions (e.g., the **OPEN** command Relay Word bit, OC, asserts for only 1/4 cycle—refer to *Factory Settings Example on page 4.146*).
- Reclose initiation is by the breaker contact opening (e.g., 79RI := NOT 52A—refer to *Additional Settings Example on page 4.145*).

Then the drive-to-lockout condition overlaps reclose initiation and the SEL-751 stays in lockout after the breaker trips open.

When 79DLS := logical 1, the reclosing relay goes to the last shot, if the shot counter is not at a shot value greater than or equal to the calculated last shot (see *Reclosing Relay Shot Counter on page 4.144*).

EXAMPLE 4.21 Factory Settings Example

The drive-to-lockout factory setting is:

79DTL := **OC OR SV04T**

Relay Word bit OC asserts for execution of the **OPEN** command. See the Note in the lockout state discussion, following Table 4.53.

Relay Word bit SV04T asserts for execution of the **OPEN** command from the front-panel pushbutton (see Table 8.4 for more detail).

The drive-to-last shot factory setting is:

79DLS := **79LO**

One open interval is also set in the factory settings, resulting in last shot = 1. Any time the relay is in the lockout state (Relay Word bit 79LO = logical 1), the relay is driven to last shot (if the shot counter is not already at a shot value greater than or equal to shot = 1):

79DLS := **79LO** = logical 1

Thus, the relay is driven to the lockout state (by setting 79DTL) and, subsequently, last shot (by setting 79DLS).

EXAMPLE 4.22 Additional Settings Example

To drive the relay to the lockout state for fault current greater than a certain level when tripping (e.g., level of phase instantaneous overcurrent element 50P3P), make settings similar to the following:

79DTL := **TRIP AND 50P3P OR ...**

Additionally, if the reclosing relay should go to the lockout state for an underfrequency trip, make settings similar to the following:

79DTL := **TRIP AND 81D1T OR ...**

Other Settings Considerations

If no special drive-to-lockout or drive-to-last shot conditions are desired, make the following settings:

79DTL := **0** (numeral 0)

79DLS := **0** (numeral 0)

With settings 79DTL and 79DLS inoperative, the relay still goes to the lockout state (and to last shot) if an entire automatic reclose sequence is unsuccessful.

Overall, settings 79DTL or 79DLS are necessary to take the relay to the lockout state (or to last shot) for immediate circumstances.

Skip Shot (79SKP) and Stall Open Interval Timing (79STL) Settings

The skip shot setting 79SKP causes the relay to skip a reclose shot. Thus, the relay skips an open interval time and uses the next open interval time instead.

If 79SKP = logical 1 at the instant of successful reclose initiation (see preceding discussion on settings 79RI and 79RIS), the relay increments the shot counter to the next shot and then loads the open interval time corresponding to the new shot (see *Table 4.55*). If the new shot is the “last shot,” no open interval timing takes place, and the relay goes to the lockout state if the circuit breaker is open (see *Lockout State on page 4.139*).

After successful reclose initiation, open interval timing does not start until allowed by the stall open interval timing setting 79STL. If 79STL = logical 1, open interval timing is stalled. If 79STL = logical 0, open interval timing can proceed.

If an open interval time has not yet started timing (79STL = logical 1 still), the 79SKP setting is still processed. In such conditions (open interval timing has not yet started timing), if 79SKP = logical 1, the relay increments the shot counter to the next shot and then loads the open interval time corresponding to the new shot (see *Table 4.55*). If the new shot turns out to be the “last shot,” no open interval timing takes place, and the relay goes to the lockout state if the circuit breaker is open (see *Lockout State on page 4.139*).

If the relay is in the middle of timing on an open interval and 79STL changes state to 79STL = logical 1, open interval timing stops where it is. If 79STL changes state back to 79STL = logical 0, open interval timing resumes where it left off. Use the OPTMN Relay Word bit to monitor open interval timing (see *Monitoring Open Interval and Reset Timing on page 4.143*).

EXAMPLE 4.23 Factory Settings Example

The skip shot function is not enabled in the factory settings:

79SKP := **0** (numeral 0)

The stall open interval timing factory setting is:

79STL := **TRIP**

After successful reclose initiation, open interval timing does not start as long as the trip condition is present (Relay Word bit TRIP = logical 1). As discussed previously, if an open interval time has not yet started timing (79STL = logical 1 still), the 79SKP setting is still processed. Once the trip condition goes away (Relay Word bit TRIP = logical 0), open interval timing can proceed.

EXAMPLE 4.24 Additional Settings Example 1

With skip shot setting:

79SKP := **50P2P AND SH0**

if shot = 0 (Relay Word bit SH0 = logical 1) and phase current is greater than the phase instantaneous overcurrent element 50P2 threshold (Relay Word bit 50P2P = logical 1), at the instant of successful reclose initiation, the shot counter is incremented from shot = 0 to shot = 1. Then, open interval 1 time (setting 79OI1) is skipped, and the relay times on the open interval 2 time (setting 79OI2) instead.

Table 4.56 Open Interval Time Example Settings

Shot	Corresponding Relay Word Bit	Corresponding Open Interval	Open Interval Time Example Setting (seconds)
0	SH0	79OI1	0.50
1	SH1	79OI2	10

In Table 4.56, note that the open interval 1 time (setting 79OI1) is a short time, while the following open interval 2 time (setting 79OI2) is significantly longer. For a high magnitude fault (greater than the phase instantaneous overcurrent element 50P2 threshold), open interval 1 time is skipped, and open interval timing proceeds on the following open interval 2 time.

Once the shot is incremented to shot = 1, Relay Word bit SH0 = logical 0 and then setting 79SKP = logical 0, regardless of Relay Word bit 50P2P.

EXAMPLE 4.25 Additional Settings Example 2

If you use the SEL-751 Relay on a feeder with a line-side independent power producer (cogenerator), the utility should not reclose into a line still energized by an islanded generator. To monitor line voltage and block reclosing, connect a line-side single-phase potential transformer to channel VS on the SEL-751 as shown in Figure 4.86.

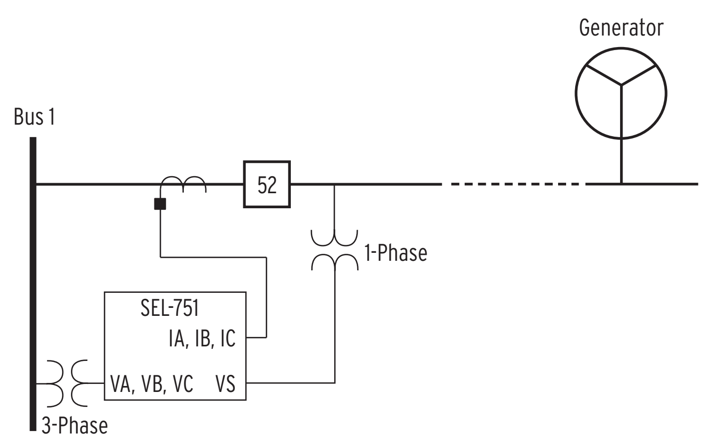


Figure 4.86 Reclose Blocking for Islanded Generator

If the line is energized, channel VS overvoltage element 59S1 can be set to assert. Make the following setting:

79STL := **59S1 OR ...**

If line voltage is present, Relay Word bit 59S1 asserts, stalling open interval timing (reclose block). If line voltage is not present, Relay Word bit 59S1 deasserts, allowing open interval timing to proceed (unless some other set condition stalls open interval timing).

EXAMPLE 4.26 Additional Settings Example 3

Refer to Figure 4.83 and accompanying setting example, showing an application for setting 79STL.

Other Settings Considerations

If no special skip shot or stall open interval timing conditions are desired, make the following settings:

79SKP := **0** (numeral 0)

79STL := **0** (numeral 0)

Block Reset Timing Setting (79BRS)

The block reset timing setting 79BRS keeps the reset timer from timing. Depending on the reclosing relay state, the reset timer can be loaded with either reset time:

79RSD (Reset Time from Reclose Cycle)

or

79RSLD (Reset Time from Lockout)

Depending on how setting 79BRS is set, none, one, or both of these reset times can be controlled. If the reset timer is timing and then 79BRS asserts to:

79BRS = logical 1

reset timing is stopped and does not begin timing again until 79BRS deasserts to:

79BRS = logical 0

When reset timing starts again, the reset timer is fully loaded. Thus, successful reset timing has to be continuous. Use the RSTMN Relay Word bit to monitor reset timing (see *Monitoring Open Interval and Reset Timing on page 4.143*).

EXAMPLE 4.27 Factory Settings Example

The reset timing is blocked if Relay Word bit TRIP is asserted, regardless of the reclosing relay state:

79BRS := **TRIP**

EXAMPLE 4.28 Additional Settings Example 1

The block reset timing setting is:

79BRS := **(51P1P OR 51G1P) AND 79CY**

Relay Word bit 79CY corresponds to the reclose cycle state. The reclosing relay is in one of the three reclosing relay states at any one time (see Figure 4.84 and Table 4.53).

When the relay is in the reset or lockout states, Relay Word bit 79CY is deasserted to logical 0. Thus, the 79BRS setting has no effect when the relay is in the reset or lockout states. When a circuit breaker is closed from lockout, there could be cold load inrush current that momentarily picks up a time-overcurrent element [e.g., phase time-overcurrent element 51P1 pickup (51P1P) asserts momentarily]. But, this assertion has no effect on reset timing because the relay is in the lockout state (79CY = logical 0). The relay times immediately on reset time 79RSLD and takes the relay from the lockout state to the Reset State with no additional delay because 79BRS is deasserted to logical 0.

When the relay is in the Reclose Cycle State, Relay Word bit 79CY is asserted to logical 1. Thus, the example 79BRS setting can function to block reset timing if time-overcurrent pickup 51P1P or 51G1P is picked up while the relay is in the Reclose Cycle State. This helps prevent repetitive "trip-reclose" cycling.

EXAMPLE 4.29 Additional Settings Example 2

If the block reset timing setting is:

79BRS := **51P1P OR 51G1P**

then reset timing is blocked if time-overcurrent pickup 51P1P or 51G1P is picked up, regardless of the reclosing relay state.

Sequence Coordination Setting (79SEQ)

The sequence coordination setting 79SEQ keeps the relay in step with a downstream line recloser in a sequence coordination scheme, which prevents overreaching SEL-751 overcurrent elements from tripping for faults beyond the line recloser. This is accomplished by incrementing the shot counter and supervising overcurrent elements with resultant shot counter elements.

In order for the sequence coordination setting 79SEQ to increment the shot counter, *both* the following conditions must be true:

- ➤ No trip present (Relay Word bit TRIP = logical 0)
- ➤ Circuit breaker closed (SELOGIC control equation setting 52A = logical 1, effectively)

The sequence coordination setting 79SEQ is usually set with some overcurrent element pickups. If the previous two conditions are both true, and a set overcurrent element pickup asserts for at least 1.25 cycles and then deasserts, the shot counter increments by one count. This assertion/deassertion indicates that a downstream device (e.g., line recloser—see *Figure 4.87*) has operated to clear a fault. Incrementing the shot counter keeps the SEL-751 "in step" with the downstream device, as is shown in *Additional Settings Example 1 on page 4.150* and *Additional Settings Example 2 on page 4.152*.

Every time a sequence coordination operation occurs, the shot counter is incremented, and the reset timer is loaded up with reset time 79RSD. Sequence coordination can increment the shot counter beyond last shot, but no further than shot = 4. The shot counter returns to shot = 0 after the reset timer times out. Reset timing is subject to SELOGIC control equation setting 79BRS (see *Block Reset Timing Setting (79BRS) on page 4.149*).

Sequence coordination operation does not change the reclosing relay state. For example, if the relay is in the Reset State and there is a sequence coordination operation, it remains in the Reset State.

EXAMPLE 4.30 Factory Settings Example

Sequence coordination is not enabled in the factory settings:

79SEQ := **0**

EXAMPLE 4.31 Additional Settings Example 1

With sequence coordination setting:

79SEQ := **79RS AND 51P1P**

sequence coordination is operable only when the relay is in the Reset State (79RS = logical 1). Refer to Figure 4.87 and Figure 4.88.

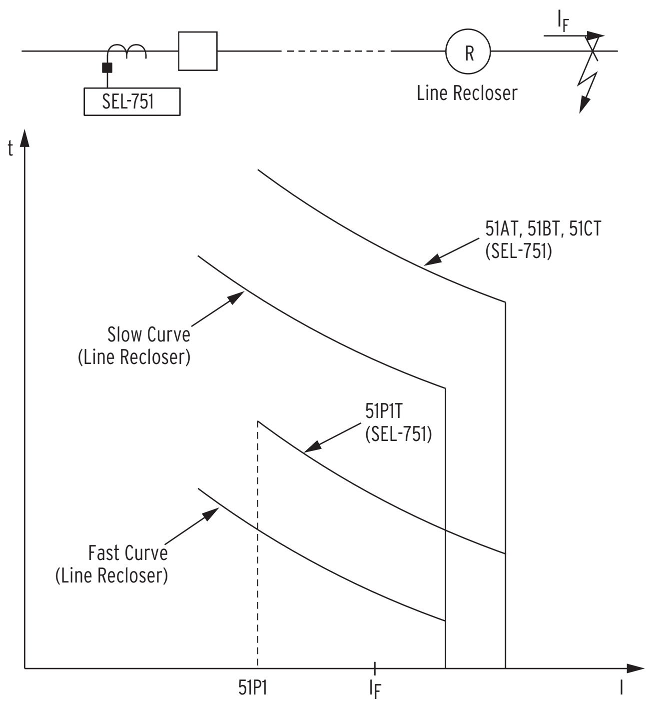
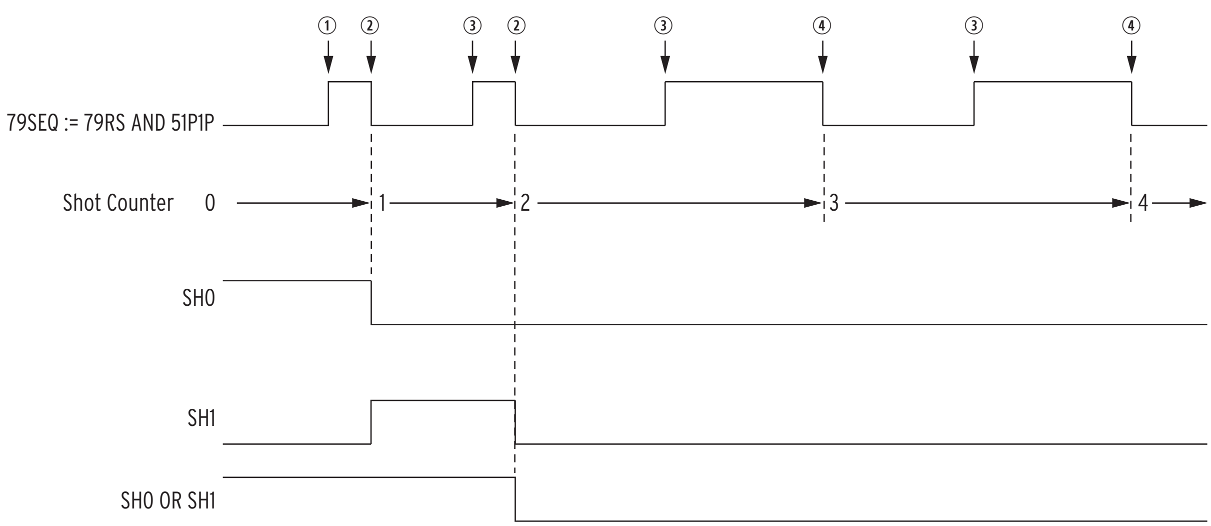


Figure 4.87 Sequence Coordination Between the SEL-751 and a Line Recloser

Assume that the line recloser is set to operate twice on the fast curve and then twice on the slow curve. The slow curve is allowed to operate after two fast curve operations because the fast curves are then inoperative for tripping. The SEL-751 phase time-overcurrent element 51P1T is coordinated with the line recloser fast curve. The SEL-751 single-phase time-overcurrent elements 51AT, 51BT, and 51CT are coordinated with the line recloser slow curve.



① Fault occurs beyond line recloser; ② fault cleared by line recloser fast curve; ③ line recloser recloses into fault; ④ fault cleared by line recloser slow curve.

Figure 4.88 Operation of SEL-751 Shot Counter for Sequence Coordination With Line Recloser (Additional Settings Example 1)

If the SEL-751 is in the Reset State (79RS = logical 1) and then a permanent fault beyond the line recloser occurs (fault current I_F in Figure 4.87), the line recloser fast curve operates to clear the fault.

The SEL-751 also sees the fault. The phase time-overcurrent pickup 51P1P asserts and then deasserts without tripping, incrementing the relay shot counter from:

shot = 0 to shot = 1

When the line recloser recloses its circuit breaker, the line recloser fast curve operates again to clear the fault. The SEL-751 also sees the fault again. The phase time-overcurrent pickup 51P1P asserts and then deasserts without tripping, incrementing the relay shot counter from:

shot = 1 to shot = 2

The line recloser fast curve is now disabled after operating twice. When the line recloser recloses its circuit breaker, the line recloser slow curve operates to clear the fault. The relay does not operate on its faster-set phase time-overcurrent element 51P1 (51P1T is "below" the line recloser slow curve) because the shot counter is now at shot = 2. For this sequence coordination scheme, the SELOGIC control equation trip equation is:

TR := **51P1T AND (SH0 OR SH1) OR 51AT OR 51BT OR 51CT**

NOTE: Sequence coordination can increment the shot counter beyond last shot in this example (last shot = 2 in this factory setting example) but no further than shot = 4.

The following Example 2 limits sequence coordination shot counter incrementing.

With the shot counter at shot = 2, Relay Word bits SH0 (shot = 0) and SH1 (shot = 1) are both deasserted to logical 0. This keeps the 51PT phase time-overcurrent element from tripping. The 51P1T phase time-overcurrent element is still operative, and its pickup (51P1P) can still assert and then deassert, thus continuing the sequencing of the shot counter to shot = 3, etc. The 51P1T phase time-overcurrent element cannot cause a trip because shot ≥ 2, and SH0 and SH1 both are deasserted to logical 0.

The shot counter returns to shot = 0 after the reset timer (loaded with reset time 79RSD) times out.

EXAMPLE 4.32 Additional Settings Example 2

Review preceding Example 1.

Assume that the line recloser in Figure 4.87 is set to operate twice on the fast curve and then twice on the slow curve for faults beyond the line recloser.

Assume that the SEL-751 is set to operate once on 51P1T and then twice on 51AT, 51BT, or 51CT for faults between the SEL-751 and the line recloser. This results in the following trip setting:

TR := **51P1T AND SH0 OR 51AT OR 51BT OR 51CT**

This requires that two open interval settings be made (see Table 4.54 and Figure 4.85). This corresponds to the last shot being:

last shot = 2

If the sequence coordination setting is:

79SEQ := **79RS AND 51P1P**

and there is a permanent fault beyond the line recloser, the shot counter of the SEL-751 increments all the way to shot = 4 (see Figure 4.88). If there is a coincident fault *between* the SEL-751 and the line recloser, the SEL-751 trips and goes to the lockout state. Any time the shot counter is at a value equal to or greater than last shot and the relay trips, it goes to the lockout state.

To avoid this problem, make the following sequence coordination setting:

79SEQ := **79RS AND 51P1P AND SH0**

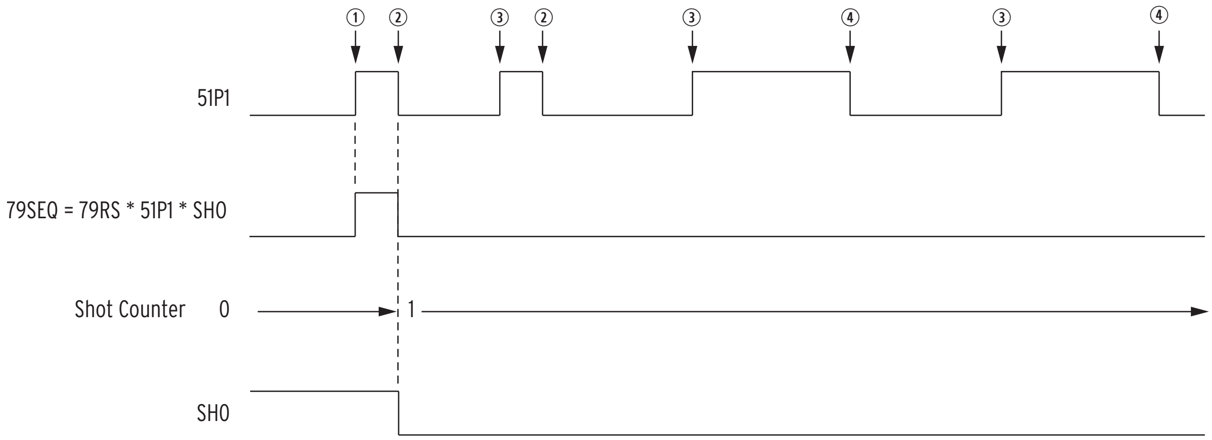
Refer to Figure 4.89.

If the SEL-751 is in the Reset State (79RS = logical 0) with the shot counter reset (shot = 0; SH0 = logical 1) and then a permanent fault beyond the line recloser occurs (fault current I_F in Figure 4.87), the line recloser fast curve operates to clear the fault. The SEL-751 also sees the fault. The phase time-overcurrent pickup 51P1P asserts and then deasserts without tripping, incrementing the relay shot counter from:

shot = 0 to shot = 1

Now the SEL-751 cannot operate on its faster-set phase time-overcurrent element 51P1T because the shot counter is at shot = 1 (SH0 = logical 0):

TR := **51P1T AND SH0 OR 51AT OR 51BT OR 51CT = (logical 0) OR 51AT OR 51BT OR 51CT**



① Fault occurs beyond line recloser; ② fault cleared by line recloser fast curve; ③ line recloser recloses into fault; ④ fault cleared by line recloser slow curve.

Figure 4.89 Operation of SEL-751 Shot Counter for Sequence Coordination With Line Recloser (Additional Settings Example 2)

The line recloser continues to operate for the permanent fault beyond it, but the SEL-751 shot counter does not continue to increment. Sequence coordination setting 79SEQ is effectively disabled by the shot counter incrementing from shot = 0 to shot = 1.

79SEQ := **79RS AND 51P1P AND (logical 0) = Logical 0**

The shot counter stays at shot = 1.

Thus, if there is a coincident fault between the SEL-751 and the line recloser, the SEL-751 operates on 51AT, 51BT, or 51CT and then recloses once, instead of going straight to the lockout state (shot = 1 < last shot = 2).

As stated earlier, the reset time setting 79RSD takes the shot counter back to shot = 0 after a sequence coordination operation increments the shot counter. Make sure that reset time setting 79RSD is set long enough to maintain the shot counter at shot = 1 as shown in Figure 4.89.

Reclose Supervision Setting (79CLS)

See *Reclose Supervision Logic on page 4.131*.

Demand Metering

The SEL-751 provides demand and peak demand metering, selectable between thermal and rolling demand types, for the following values:

- IA, IB, IC, phase currents (A primary)
- IG Residual ground current
  (A primary; IG = 3I0 = IA + IB + IC)
- 3I2 Negative-sequence current (A primary)

Table 4.57 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 4.57 Demand Meter Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE DEM MTR	THM, ROL	EDEM := THM
DEM TIME CONSTNT	5, 10, 15, 30, 60 min	DMTC := 5
PH CURR DEM LVL	OFF, 0.50-16.00 A[a] OFF. 0.10-3.20 A[b]	PHDEMP := 5.00[a] PHDEMP := 1.00 b
RES CURR DEM LVL	OFF, 0.50-16.00 A[a] OFF, 0.10-3.2 A[b]	GNDEMP := 1.00[a] GNDEMP := 0.20[b]
3I2 CURR DEM LVL	OFF, 0.50-16.00 A[a] OFF, 0.10-3.2 A[b]	3I2DEMP := 1.00[a] 3I2DEMP := 0.20[b]

[a] For I_{NOM} = 5 A.
[b] For I_{NOM} = 1 A.

The demand current level settings are applied to demand current meter outputs as shown in *Figure 4.90*.

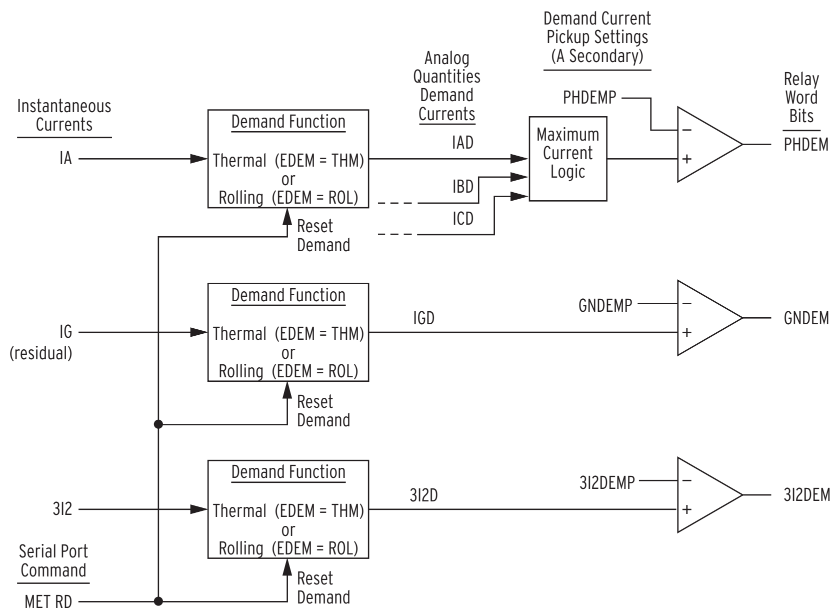


Figure 4.90 Demand Current Logic Outputs

For example, when residual ground demand current IGD exceeds 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.

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.

Comparison of Thermal and Rolling Demand Meters

The example in *Figure 4.91* 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”).

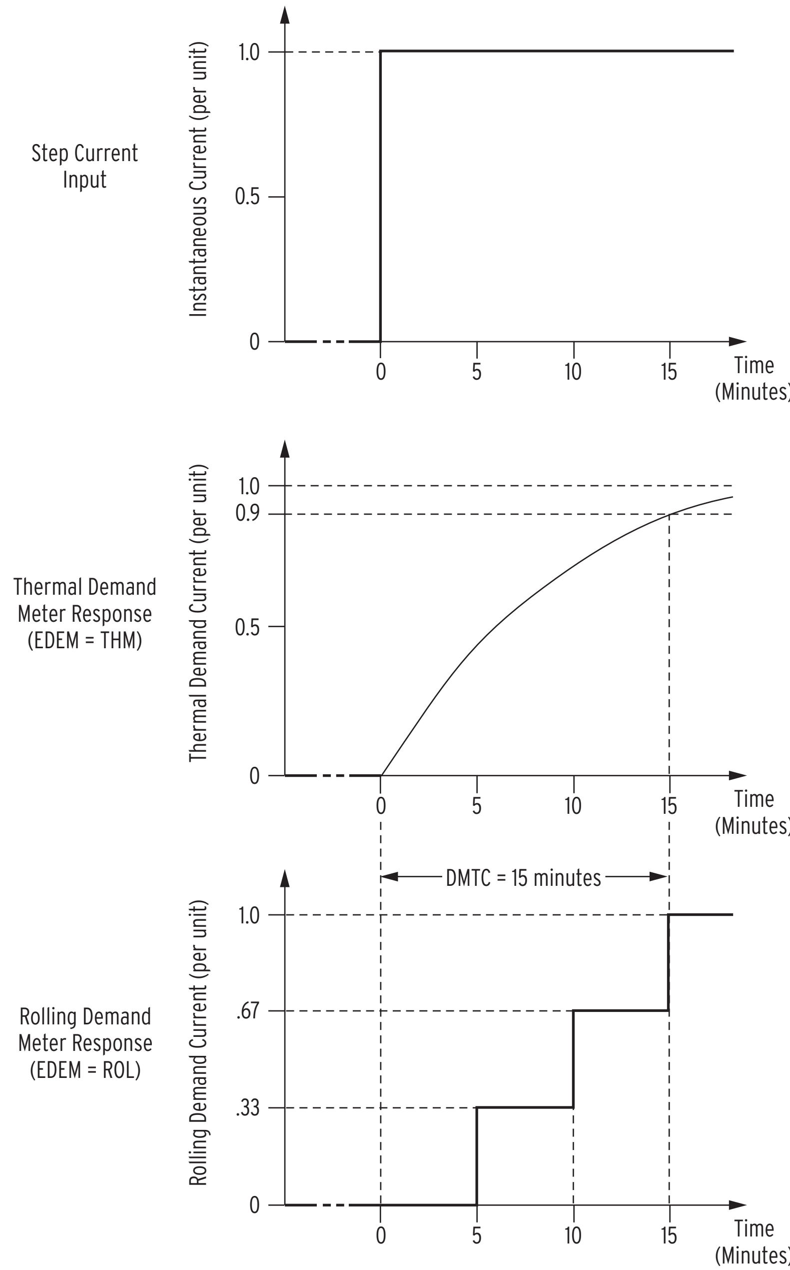


Figure 4.91 Response of Thermal and Rolling Demand Meters to a Step Input (Setting DMTC = 15 minutes)

Thermal Demand Meter Response

The response of the thermal demand meter in *Figure 4.91* (middle) to the step current input (top) is analogous to the series RC circuit in *Figure 4.92*.

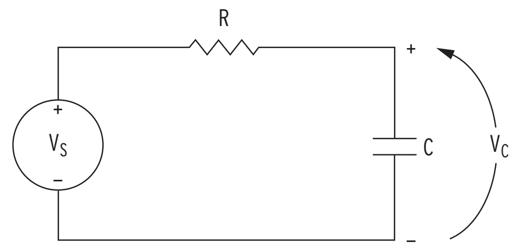


Figure 4.92 Voltage VS Applied to Series RC Circuit

In the analogy:

Voltage VS in *Figure 4.92* corresponds to the step current input in *Figure 4.91* (top).

Voltage VC across the capacitor in *Figure 4.92* corresponds to the response of the thermal demand meter in *Figure 4.91* (middle).

If voltage VS in *Figure 4.92* has been at zero (VS = 0.0 per unit) for some time, voltage VC across the capacitor in *Figure 4.92* is also at zero (VC = 0.0 per unit). If voltage VS is suddenly stepped up to some constant value (VS = 1.0 per unit), voltage VC 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 4.90* (middle) to the step current input (top).

In general, as voltage VC across the capacitor in *Figure 4.92* 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 4.57*). Note that in *Figure 4.91*, 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 you first apply the step current input.

The SEL-751 updates thermal demand values approximately every second.

Rolling Demand Meter Response

The response of the rolling demand meter in *Figure 4.91* (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 4.57*). Note in *Figure 4.91*, 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 (e.g., 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 4.91* 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 4.91* (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.

Logic Settings (SET L Command)

The following discussion lists the settings associated with latches, timers, counters, math variables, and output contacts.

SELOGIC Enables

Table 4.58 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 4.58 Enable Settings

Setting Prompt	Setting Range	Default Setting
SELOGIC Latches	N, 1–32	ELAT := 4
SV/Timers	N, 1–32	ESV := 5
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-751 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 returns 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 4.93*). 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 (e.g., SCADA, RTU).

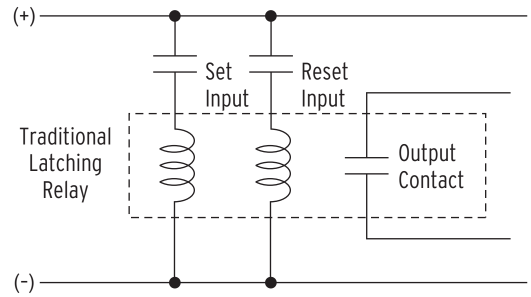


Figure 4.93 Schematic Diagram of a Traditional Latching Device

Thirty-two latch control switches in the SEL-751 provide latching device functionality. *Figure 4.94* shows the logic diagram of a latch switch. The output of the latch control switch is a Relay Word bit LT*n* (*n* = 01–32), called a latch bit.

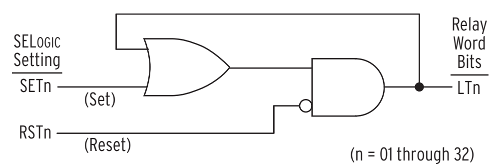


Figure 4.94 Logic Diagram of a Latch Switch

If setting SET*n* asserts to logical 1, latch bit LT*n* asserts to logical 1. If setting RST*n* asserts to logical 1, 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-751 includes 32 latches. *Table 4.59* shows the **SET** and **RESET** default settings for Latch 1 through Latch 4. The remaining latches are all set to NA.

Table 4.59 Latch Bits Equation Settings

Settings Prompt	Setting Range	Setting Name := Factory Default
SET01	SELogic	SET01 := NA
RST01	SELogic	RST01 := NA
SET02	SELogic	SET02 := R_TRIG SV02T AND NOT LT02
RST02	SELogic	RST02 := R_TRIG SV02T AND LT02
SET03	SELogic	SET03 := PB03_PUL AND LT02 AND NOT 52A
RST03	SELogic	RST03 := (PB03_PUL OR PB04_PUL OR SV03T) AND LT03
SET04	SELogic	SET04 := PB04_PUL AND 52A
RST04	SELogic	RST04 := (PB03_PUL OR PB04_PUL OR SV04T) AND LT04
• • •	• • •	• • •
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 (e.g., LT02 := logical 1) when power is lost, it is asserted (LT02 := logical 1) when power is restored. If a latch bit is deasserted (e.g., 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 4.160* explanation. If the individual settings change causes a change in 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 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.*

Settings SET*n* and RST*n* cannot result in continuous cyclical operation of latch bit LT*n*. Use timers to qualify 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 settings. Each SELOGIC control equation variable/timer has a SELOGIC control equation setting input and variable/timer outputs as shown in *Figure 4.95*. Timers SV01T through SV32T in *Figure 4.95* 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).

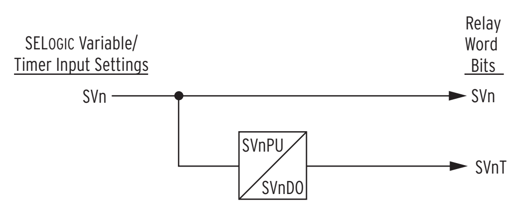


Figure 4.95 SELOGIC Control Equation Variable/Timers SV01/SV01T–SV32T

You can enter as many as 15 elements per SELOGIC control equation, including a total of 14 elements in parentheses (see *Table 4.60* 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 you have already used the equals sign (=) as an equality comparison, both Boolean type and math type of 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 4.60*. Math SELOGIC control equation settings operate on numerical values, using one or more of the Mathematical operators listed in *Table 4.60*. These numerical values can be mathematical variables or actual real numbers.

The relay converts variables from decimal to integer before performing math operations, i.e., scales it by multiplying by 128 followed by rounding. After the math operations, the relay converts the result back from integer to decimal by scaling the value down by 128 before reporting the results. This effectively means that math calculations are rounded. See *Example 4.33* for an explanation on improving the accuracy of the math operations by managing the processing order.

EXAMPLE 4.33 Improving the Accuracy of Math Operations

If MV01 : = (60/4160) • 100,000, the relay performs the 60/4160 calculation and scales it by 128, then rounds this up to a 2. The relay then multiplies it by 100,000 and stores it as 200,000. When the number is reported it divides out the scale factor (128) and reports 1562.5.

Alternately, If MV01 := (60 • 100,000) / 4160, the relay multiplies (60 • 00,000) and then scales by 128 and then divides by 4160. This result is then rounded and stored as 184,615. The relay then divides 184,615 by 128 and reports 1442.3.

Example 4.33 illustrates how important it is to avoid calculations where a small number is divided by a large number followed by multiplication. It will amplify the error significantly.

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 is –16777215.99. Similarly, when the MV02 := executed result is +16777238.00, MV02 is +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 4.61* for this and other Boolean and math operators and values.

Operator Precedence

When you combine several operators and operands within a single expression, the SEL-751 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 the left to the 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 4.60 SELOGIC Control Equation Operators (Listed in Operator Precedence)

Operator	Function	Function Type (Boolean and/ or Mathematical)
( )	parentheses	Boolean and Mathematical (highest precedence)
–	negation	Mathematical
NOT	NOT	Boolean
R_TRIG	rising-edge trigger/detect	Boolean
F_TRIG	falling-edge trigger/detect	Boolean
* /	multiply divide	Mathematical
+ -	add subtract	Mathematical
<, >, <=, >=	comparison	Boolean
= <>	equality inequality	Boolean
AND	AND	Boolean
OR	OR	Boolean (lowest precedence)

Parentheses Operator ( )

You can use more than one set of parentheses in a SELOGIC control equation setting. For example, the following Boolean SELOGIC control equation setting has two sets of parentheses:

SV04 := **(SV04 OR IN102) AND (PB01_LED OR RB01)**

In the previous example, the logic within the parentheses is processed first and then the two parentheses resultants are ANDed together. Use as many as 14 sets of parentheses in a single SELOGIC control equation setting. The parentheses can be “nested” (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, i.e., 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, i.e., 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, i.e., OUT101 := NOT (logical 0 OR logical 0) = NOT (logical 0) = logical 1.

In a Math SELOGIC control equation, use the NOT operator with any Relay Word bits. This allows a simple if/else type equation, as shown in the following example.

MV01 := **12 * IN101 + (MV01 + 1) * NOT IN101**

The previous equation sets MV01 to 12 whenever IN101 asserts, otherwise it increments MV01 by 1 each time the equation is executed.

Boolean Rising-Edge Operator (R_TRIG)

Apply the rising-edge operator, R_TRIG, to individual Relay Word bits only; you cannot apply R_TRIG to groups of elements within parentheses. When any Relay Word bit asserts (going from logical 0 to logical 1), R_TRIG interprets this logical 0 to logical 1 transition as a “rising edge” and asserts to logical 1 for one processing interval.

For example, the Boolean SELOGIC control equation event report generation setting uses rising-edge operators:

ER := **R_TRIG IN101 OR R_TRIG IN102**

The rising-edge operators detect a logical 0 to logical 1 transition each time one of 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 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 4.96*.

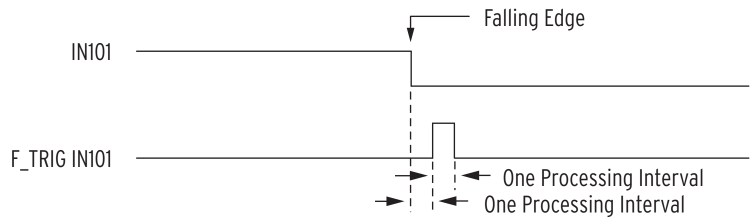


Figure 4.96 Result of Falling-Edge Operator on a Deasserting Input

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 you use Relay Word bits (which are effectively Boolean resultants, equal to logical 1 or logical 0) in mathematical operations, the relay treats these as numerical values 0 and 1, depending on whether 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 greater than a certain value, an output contact is asserted:

OUT103 := **MV01 > 8**

If the math variable (MV01) is greater than 8 in value, output contact OUT103 asserts (OUT103 = logical 1). If the math variable (MV01) is less than or equal to 8 in value, output contact OUT103 deasserts (OUT103 = logical 0).

Boolean Equality (=) and Inequality (<>) Operators

Equality and inequality operators operate similar 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 is asserted:

OUT102 := **MV01 <> 45**

If the math variable (MV01) is not equal to 45 in value, output contact OUT102 asserts (effectively OUT102 := logical 1). If the math variable (MV01) is equal to 45 in value, output contact OUT102 deasserts (effectively OUT102 := logical 0). *Table 4.61* shows other operators and values that you can use in writing SELOGIC control equations.

Table 4.61 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 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 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 4.97* 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)**

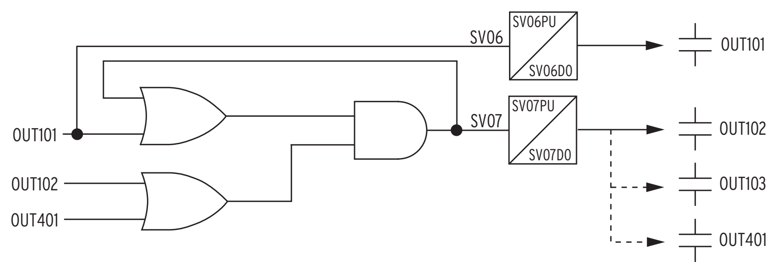


Figure 4.97 Example Use of SELOGIC Variables/Timers

SV/Timers Settings

The SEL-751 includes 32 SELOGIC variables. *Table 4.62* shows the pickup, dropout, and equation settings for SV/Timers.

Table 4.62 SELOGIC Variable Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
SV TIMER PICKUP	0.00–3000.00	SV01PU := 0.00
SV TIMER DROPOUT	0.00–3000.00	SV01DO := 0.00
SV INPUT	SELOGIC	SV01 := NA
SV TIMER PICKUP	0.00–3000.00	SV02PU := 3.00
SV TIMER DROPOUT	0.00–3000.00	SV02DO := 0.00
SV INPUT	SELOGIC	SV02 := PB02
SV TIMER PICKUP	0.00–3000.00	SV03PU := 0.00
SV TIMER DROPOUT	0.00–3000.00	SV03DO := 0.00
SV INPUT	SELOGIC	SV03 := LT03
SV TIMER PICKUP	0.00–3000.00	SV04PU := 0.00
SV TIMER DROPOUT	0.00–3000.00	SV04DO := 0.00

Table 4.62 SELOGIC Variable Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
SV INPUT	SELOGIC	SV04 := LT04
SV TIMER PICKUP	0.00–3000.00	SV05PU := 0.25
SV TIMER DROPOUT	0.00–3000.00	SV05DO := 0.25
SV INPUT	SELOGIC	SV05 := (PB02 OR LT03 OR LT04) AND NOT SV05T
• • •	• • •	• • •

The pickup times of 0 for the SV03PU and SV04PU settings shown previously provide immediate Close and Trip actions from front-panel pushbuttons. For a delayed Close, set SV03PU to the desired delay. Similarly, set SV04PU for a delayed Trip action. See *Table 8.4* for more detail.

Counter Variables

NOTE: These counter elements conform to the standard counter function block #3 in IEC 1131-3 First Edition 1993-03 International Standard for Programmable controllers—Part 3: Programming languages.

NOTE: If setting SCnnCD is set to NA, the entire counter nn is disabled.

NOTE: If setting SCnnCU is set to NA, the counter counts downwards only.

SELOGIC counters are up- or down-counting elements, updated every processing interval.

Each counter element consists of one count setting, four control inputs, two digital outputs, and one analog output. *Figure 4.98* shows Counter 01, the first of 32 counters available in the device.

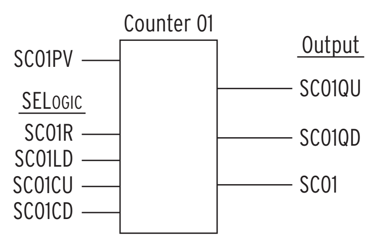


Figure 4.98 Counter 01

Digital output SC01QD asserts when the counter is at position zero, and Digital output SC01QU asserts when the counter reaches the programmable count value. Use the reset input (SC01R) to force the count to zero, and the analog output (SC*nn*) with analog comparison operators. *Table 4.63* describes the counter inputs and outputs, and *Table 4.64* shows the order of precedence of the control inputs.

Table 4.63 Counter Input/Output Description (Sheet 1 of 2)

Name	Type	Description
SC*nn*LD	Active High Input	Load counter with the preset value to assert the output (SC*n*QU) (follows SELOGIC setting).
SC*nn*PV	Input Value	This Preset Value is loaded when SC*n*LD pulsed. This Preset Value is the number of counts before the output (SC*n*QU) asserts (follows SELOGIC setting).
SC*nn*CU	Rising-Edge Input	Count Up increments the counter (follows SELOGIC setting).
SC*nn*CD	Rising-Edge Input	Count Down decrements the counter (follows SELOGIC setting).
SC*nn*R	Active High Input	Reset counter to zero (follows SELOGIC setting)

Table 4.63 Counter Input/Output Description (Sheet 2 of 2)

Name	Type	Description
SC*nn*QU	Active High Output	This Q Up output asserts when the Preset Value (maximum count) is reached (SC*n* = SC*n*PV, *n* = 01 to 32).
SC*nn*QD	Active High Output	This Q Down output asserts when the counter is equal to zero (SC*n* = 0, *n* = 01 to 32).
SC*nn*	Output Value	This counter output is an analog value that you can use with analog comparison operators in a SELOGIC control equation and view using the **COU** command.

Table 4.64 Order of Precedence of the Control Inputs

Order	Input
1	SC*nn*R
2	SC*nn*LD
3	SC*nn*CU
4	SC*nn*CD

Figure 4.99 shows an example of the effects of the input precedence, with SC01PV set to 7. The vertical dashed line indicates the relationship between 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.

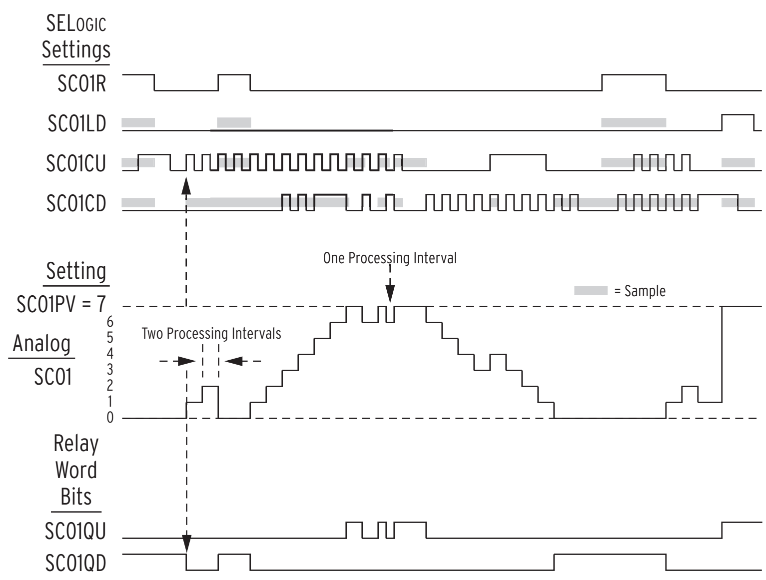


Figure 4.99 Example of the Effects of the Input Precedence

The shaded areas illustrate the precedence of the inputs:

- When SC01R is asserted, the SC01LD input is ignored.
- When SC01R or SC01LD is asserted, rising edges on the SC01CU or SC01CD inputs are ignored.

- ➤ When input SC01CU has a rising edge, a rising edge on SC01CD is ignored (unless SC01 is already at the maximum value SC01PV (= 7), in which case SC01CU is ignored, and the SC01CD is processed). An example of this exception appears in the previous diagram, just before the "one processing interval" notation.

A maintained logical 1 state on the SC01CU or SC01CD inputs is ignored (after the rising edge is processed). A rising edge received on the SC01CU or SC01CD inputs is ignored when the SC01R or SC01LD inputs are asserted.

A maintained logical 1 on the SC01CU or SC01CD inputs does not get treated as a rising edge when the SC01R or SC01LD input deasserts.

The same operating principles apply for all of the counters: SC01–SC*mm*, where *mm* = the number of enabled counters. When a counter is disabled by setting, the present count value is forced to 0 (SC*nn* := 0), causing Relay Word bit SC*nn*QD to assert (SC*nn*QD := logical 1), and Relay Word bit SC*nn*QU to deassert (SC*nn*QU := logical 0).

Output Contacts

Table 4.65 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 := CLOSE
OUT103 FAIL-SAFE	Y, N	OUT103FS := N
OUT103	SELOGIC	OUT103 := TRIP
• • •	• • •	• • •
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
• • •	• • •	• • •

NOTE: When an output contact is not used for a specific function you must set the associated SELOGIC control equation to either 0 or 1.

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

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

The SEL-751 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.

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 2.15* and *Figure 2.16*.

When TRIP output fail-safe is enabled and the **TRIP** contact is appropriately connected (see *Figure 2.19*), the breaker is automatically tripped when relay control power fails.

MIRRORED BITS Transmit SELOGIC Control Equations

See *Appendix J: MIRRORED BITS Communications* and *SEL-751 Settings Sheets* for details.

Global Settings (SET G Command)

General Settings

Table 4.66 General Global Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PHASE ROTATION	ABC, ACB	PHROT := ABC
RATED FREQ.	50, 60 Hz	FNOM := 60
DATE FORMAT	MDY, YMD, DMY	DATE_F := MDY
MET CUTOFF THRES	Y, N	METHRES := Y
FAULT CONDITION	SELOGIC	FAULT := 50G1P OR 50N1P OR 51P1P OR 51QP OR 50Q1P OR TRIP

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.

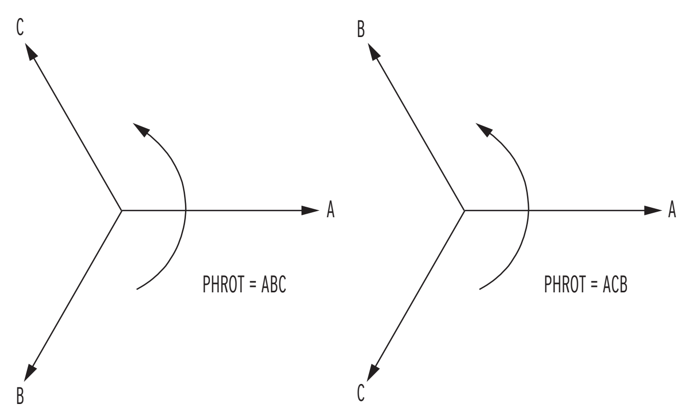


Figure 4.100 Phase Rotation Setting

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).

The METHRES setting governs how various metering functions behave when the metered value is smaller than a fixed threshold. Refer to *Small Signal Cut-off for Metering on page 5.14* for more details.

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

Event Messenger Points

You can configure the SEL-751 to automatically send an ASCII message on a communications port when the trigger condition is satisfied. Use the **SET P** command to set PROTO := EVMSG on the desired port to select that port. This feature is designed to send messages to the SEL-3010 Event Messenger, however, you can use any device capable of receiving ASCII messages.

Table 4.67 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 you want.

Set each of MPTR*xx* (*xx* = 01–32) to the desired Relay Word bit, the rising edge of which defines the trigger condition.

MPAQ*xx* is an optional setting that you can use to specify an analog quantity to be formatted into a single message as described next.

Use MPTX*xx* to construct the desired message. Note that by default the analog quantity value, if specified, is added at the end of the message, rounded to the nearest integer value (see *Example 4.34*).

EXAMPLE 4.34 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

Location and resolution of the analog quantity value within the message can be specified by using "%.pf",

where

% defines location of the value

p defines number of digits (as many as 6, defaults to 6 if omitted)

f indicates floating point value (use %d if nearest whole number is desired)

EXAMPLE 4.35 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

Table 4.68 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
SELECT GROUP4	SELOGIC	SS4 := 0

The TGR setting defines the amount of time that the SS1, SS2, SS3, and SS4 SELOGIC control equation logic results must remain stable before the relay enables a new setting group. Typically, a one-second delay is sufficient.

SS1, SS2, SS3, and SS4 are SELOGIC control equations that help define when settings Groups 1, 2, 3, and 4 are active. With the settings shown previously, SS1 is set equal to logical 1, thus setting Group 1 always is active.

LEA Ratio Correction Settings

Table 4.69 LEA Ratio and Phase Correction Settings for Phase Voltages

Setting Prompt	Setting Range	Setting Name := Factory Default
VA RATIO CORRECT	0.500–1.500	VARCF := 1.000
VB RATIO CORRECT	0.500–1.500	VBRCF := 1.000
VC RATIO CORRECT	0.500–1.500	VCRCF := 1.000
VA ANGLE CORRECT	–10.0 to 10.0 deg	VAPAC := 0.0
VB ANGLE CORRECT	–10.0 to 10.0 deg	VBPAC := 0.0
VC ANGLE CORRECT	–10.0 to 10.0 deg	VCPAC := 0.0

Table 4.70 LEA Ratio and Phase Correction Settings for Synchronism-Check Voltage

Setting Prompt	Setting Range	Setting Name := Factory Default
VS RATIO CORRECT	0.500–1.500	VSRCF := 1.000
VS ANGLE CORRECT	–10.0 to 10.0 deg	VSPAC := 0.0

The LEA ratio correction factor (RCF) settings—VARCF, VBRCF, VCRCF, and VSRCF—compensate for irregularities (on a per-phase basis) of voltage dividers connected between the primary voltage system and the corresponding LEA inputs. The LEA phase correction (PAC) settings—VAPAC, VBPAC, VCPAC, and VSPAC—compensate for the phase shift on the corresponding channels caused by the voltage divider and the shielded cable bringing the voltages to the SEL-751. Refer to *Ratio Correction Factors (RCF) for Voltage Inputs on page 4.8* for the discussion on the RCF and PAC settings.

Synchrophasor Measurement

The SEL-751 provides Phasor Measurement Control Unit (PMCU) capabilities when connected to an IRIG-B time source. See *Appendix I: Synchrophasors* for the description and *Table I.1* for the settings.

Time and Date Management Settings

The SEL-751 supports several methods of updating the relay time and date. For IRIG-B and Phasor Measurement Unit (PMU) synchrophasor applications, refer to *Appendix I: Synchrophasors* for the description and *Table I.1* for the settings. For SNTP applications, refer to *Simple Network Time Protocol (SNTP) on page 7.14*. For time update from a DNP Master, see *Time Synchronization on page D.9*.

Table 4.71 shows the time and date management settings that are available in the Global settings.

Table 4.71 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 Savings Time, and Time Quality. When your satellite-synchronized clock provides these extensions, your relay adjusts the synchrophasor time-stamp accordingly.

- IRIGC := NONE ignores bit extensions
- IRIGC := C37.118 extracts bit extensions and corrects synchrophasor time accordingly

Coordinated Universal Time (UTC) Offset Setting

The SEL-751 has a Global setting UTC_OFF, settable from –24.00 to 24.00 hours, in 0.25 hour increments. 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-751 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-751 changes 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-751 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 enters 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 you use an IRIG-B time source, 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-751 Port 1 (Ethernet Port) supports the SNTP Client protocol. See *Section 7: Communications*, *Simple Network Time Protocol (SNTP) on page 7.14* for a description and *Table 7.5* for the settings.

Breaker Failure Setting

Table 4.72 Breaker Failure Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
52A INTERLOCK	Y, N	52ABF := N
CURRENT DETECTOR	0.10–10.00 A[a]	50BFP:=0.1
BK FAILURE DELAY	0.00–2.00 sec	BFD :=0.50
AUX TIMER DELAY	Off, 0.01–2.00 sec	ATD :=OFF
BK FAIL INITIATE	SELOGIC	BFI =:R_TRIG TRIP

[a] Setting ranges and default Amp values shown are for 5 A nominal CT rating. Divide by 5 for 1 A CTs.

The SEL-751 provides flexible breaker failure logic (see *Figure 4.101*). In the default breaker failure logic, assertion of Relay Word bit TRIP starts the BFD timer if any of the phase current remains greater than the 50BFP setting. If any of the phase current remains greater than the threshold (50BFP) for BFD delay setting, Relay Word bit BFT asserts. Use the BFT to operate an output relay to trip appropriate backup breakers.

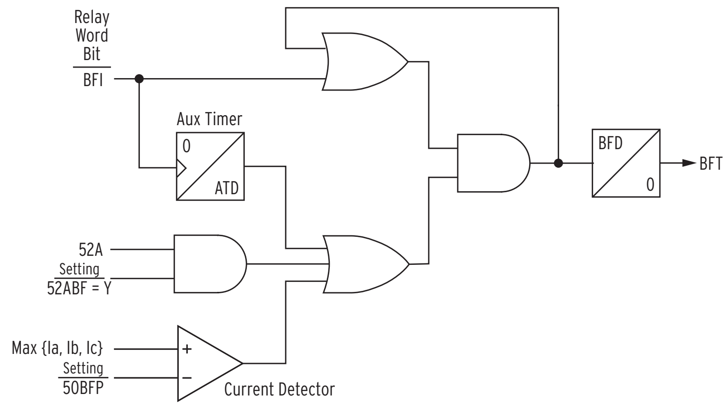


Figure 4.101 Breaker Failure Logic

Changing the BFI or the 52ABF, ATD, 50BFP settings can modify the default breaker failure logic.

- Set BFI := R_TRIG TRIP AND NOT IN102 if input IN102 is manual trip only and breaker failure initiation is not desired when the tripping is caused by this input.
- Set 52ABF := Y if you want the breaker failure logic to bypass the current detector when the breaker is closed.
- Aux timer (ATD) may be used to start the BFD timer in sequential trip applications where the current detector may not operate on initiation of the logic. If used, the ATD time must be set lower than the BFD time setting for secure operation.

Arc-Flash Protection

The SEL-751 offers advanced arc-flash protection capability aimed at minimizing the hazards associated with high energy arc (faults) in metal-enclosed and metal-clad switchgear. The system supports as many as eight fiber-optic light sensors capable of detecting the high energy arc-flash events and tripping the breaker within milliseconds of the fault. Light sensors are supervised with an instantaneous overcurrent element offering enhanced security against false trips. Each of the eight sensors can be routed to multiple tripping outputs by using SELOGIC control equations, offering ultimate flexibility in creating multiple protection zones (breaker truck cabinet, bus, PT cubicle, etc.).

SEL-751 arc-flash protection is exceptionally fast. Typical relay operating times are in the order of 2–5 ms when equipped with the optional fast hybrid (high-speed) output card. With standard, electromechanical outputs, tripping time increases to 7–13 ms. Fault clearing time is typically longer, determined by the breaker operating time, which often adds three to five cycles.

This system supports two distinct types of fiber-optic light sensors. The first type is the omni-directional ***point sensor*** optimized for installation in individual switchgear compartments. The second sensor is the ***clear-jacketed fiber*** loop sensor optimized for protection of long, distributed resources, such as the switchgear bus compartment. Supervision of both types of sensors comes from use of a loopback-based attenuation measurement method, and you can use both sensors interchangeably on each of the eight light inputs. Refer to *Application Guide AG2011-01: Using the* SEL-751 *and* SEL-751*A for Arc-Flash Detection* for more details.

Arc-Flash Overcurrent Elements (50PAF, 50NAF)

Table 4.73 shows the settings for the arc-flash instantaneous overcurrent elements. Two elements are provided; the three-phase overcurrent element 50PAF and the neutral overcurrent element 50NAF.

Table 4.73 Arc-Flash Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
AF PH OC TRP LVL	OFF, 0.50–100.00 A[a] 0.10–20.00 A[b]	50PAFP := OFF
AF N OC TRP LVL	OFF, 0.50–100.00 A[a] 0.10–20.00 A[b]	50NAFP := OFF

[a] For I_{NOM} = 5 A (Phase and Neutral respectively).
[b] For I_{NOM} = 1 A (Phase and Neutral respectively).

NOTE: The 50NAFP setting is not available with the 0.2 A neutral channel option.

The arc-flash overcurrent elements use raw A/D converter samples, with the sampling rate of 16 samples per cycle. Individual samples are compared with the setting threshold as shown in *Figure 4.102*, followed by a security counter requiring that two samples in a row be greater than the setting threshold. Although both elements operate on instantaneous current values, additional scaling is applied to present settings in the user-friendly “rms” format.

Fast overcurrent detectors do not reject harmonics and therefore have a natural tendency to “overreach” under high harmonic load conditions. To avoid unintended element pickup, Arc-flash trip level 50PAFP should be set at least 2 times the expected maximum load. Temporary activation of the arc-flash overcurrent element during inrush/load pickup conditions is expected and is normally taken into account by the arc-flash “light based” supervision.

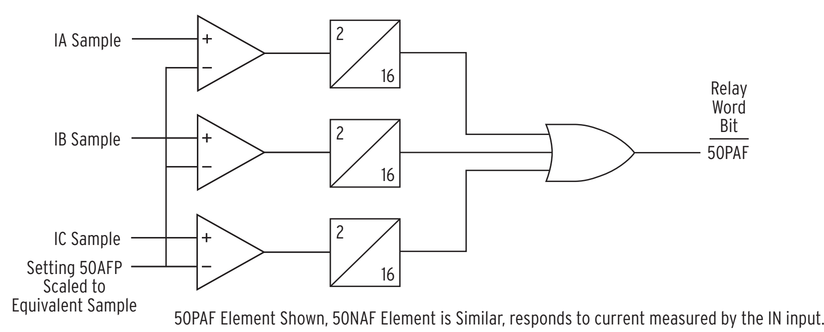


Figure 4.102 Arc-Flash Instantaneous Overcurrent Element Logic

Arc-Flash Time-Overlight Elements (TOL1 through TOL8)

The SEL-751 offers as many as eight fiber-optic light sensor inputs. Each input is associated with one inverse time-overlight element offering enhanced security coupled with exceptionally fast operation. Shape of the inverse-time characteristic is fixed offering robust rejection of unrelated light events without adding unnecessary settings. *Table 4.74* shows the arc-flash time-overlight element settings.

Each sensor channel has a user selectable sensor type (NONE, POINT, or FIBER) representing the type of sensor installed. Keyword POINT represents a point sensor, while the keyword FIBER represents a clear-jacketed fiber loop sensor.

TOL Pickup parameter makes it possible to set the individual light threshold levels for each of the eight sensors. Pickup level is expressed in the percent of full scale, which is directly related to the light intensity level measured by the sensor.

When necessary, channel sensitivity can be compared to a light intensity level expressed in lux as shown in *Table 4.75*. However, because light sensitivity is associated with fiber length (which is installation dependent), TOL element settings are expressed as a percentage of the available A/D converter range.

Table 4.74 Arc-Flash Time-Overlight Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
SENSOR 1 TYPE	NONE, POINT, FIBER	AFSENS1 := NONE
TOL 1 PICKUP	3.0–80.0 %[a] 0.6–80.0 %[b]	TOL1P := 3.0
SENSOR 2 TYPE	NONE, POINT, FIBER	AFSENS2 := NONE
TOL 2 PICKUP	3.0–80.0 %[a] 0.6–80.0 %[b]	TOL2P := 3.0
SENSOR 3 TYPE	NONE, POINT, FIBER	AFSENS3 := NONE
TOL 3 PICKUP	3.0–80.0 %[a] 0.6–80.0 %[b]	TOL3P := 3.0
SENSOR 4 TYPE	NONE, POINT, FIBER	AFSENS4 := NONE
TOL 4 PICKUP	3.0–80.0 %[a] 0.6–80.0 %[b]	TOL4P := 3.0
• • •	• • •	• • •
SENSOR 8 TYPE	NONE, POINT, FIBER	AFSENS8 := NONE
TOL 8 PICKUP	3.0–80.0 %[a] 0.6–80.0 %[b]	TOL8P := 3.0
AFD OUTPUT SLOT	101_3, 301_4, 401_4	AOUTSLOT := 101_3

[a] Setting range with point sensor.
[b] Setting range with fiber sensor.

The default processing interval in the SEL-751 is one-fourth of the power system cycle. However, to obtain a faster arc-flash protection you can select two outputs that are processed every 1/16 of a power system cycle. Use the setting AOUTSLOT to select these outputs. For instance, if Slot **3** is selected (AOUTSLOT := 301_4) the SELOGIC control equations OUT301 through OUT304 are processed at 1/16 of a cycle rate. To get the fastest possible operate time use the contacts selected by the AOUTSLOT setting for tripping. *Figure 4.103* shows the TOL element logic diagram.

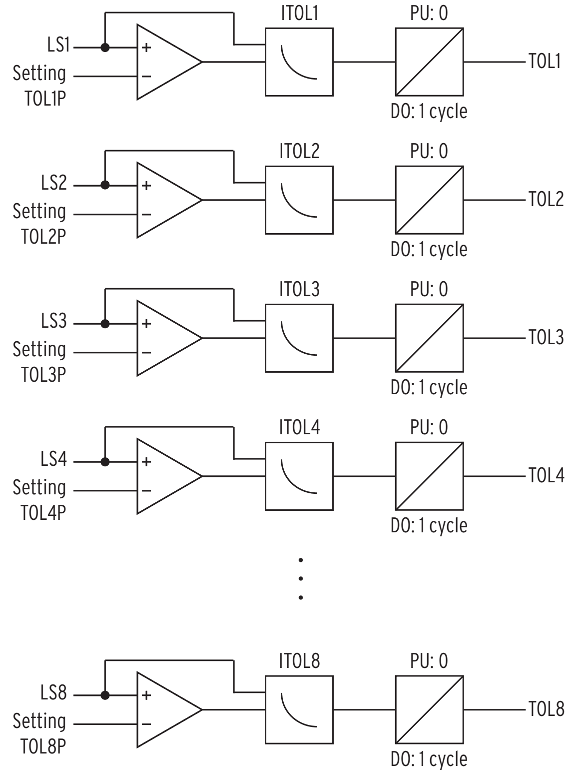


Figure 4.103 Inverse Time-Overlight Element Logic

Figure 4.104 shows the inverse time-overlight element curve shape. The element uses 32 samples per cycle data, processed 16 times per cycle. TOL element algorithm ensures that the light must be present for a minimum of two samples, regardless of the light level. It also ensures that for low light levels, element operation cannot be delayed for more than ¼ of a power system cycle.

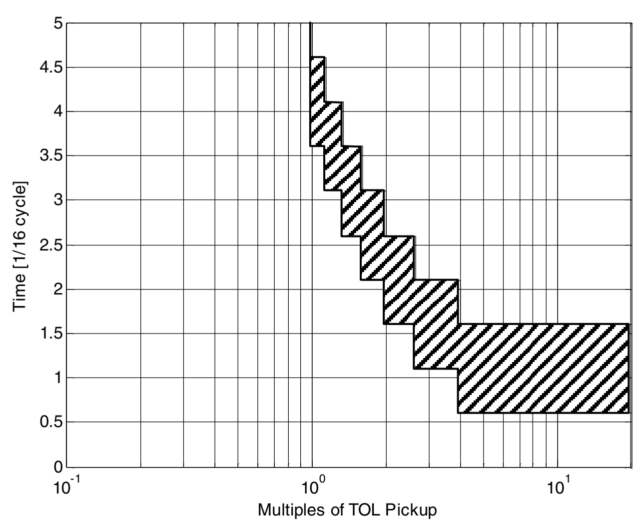


Figure 4.104 TOL Element Inverse Curve Characteristic

Setting the Arc-Flash Time-Overlight Element

Given the critical nature of the arc-flash protection function it is recommended that the element be set based on the ambient light level. This approach guarantees maximum sensitivity coupled with the fastest tripping time.

Typical ambient light levels are shown in *Table 4.75*. It is easy to see, that the arc-flash event significantly exceeds virtually all illumination levels normally found in a substation environment. The only exception is exposure to direct sunlight, which can easily reach or exceed arc-flash TOL element setting thresholds.

TOL Pickup is typically set based on the ambient light level. Ambient light is continuously measured and can be easily displayed by using the front-panel `METER > Light Intensity` menu as well as **MET L** command. Set the TOL pickup to the lowest possible light intensity level but greater than the highest-expected ambient light intensity level at each light-sensor installation.

Table 4.75 Typical Ambient Illumination Light Levels

Light Level	Example
50 lux	Living room
80 lux	Brightly lit room
500 lux	Brightly lit office
1,000 lux	TV studio
> 20,000 lux	Direct sunlight
20,000 to >1,000,000 lux	Arc-flash event[a]

[a] A. D. Stokes, D. K. Sweeting, "Electric Arc Burn Hazards", IEEE Transactions on industry applications, Vol. 42, No. 1. January/February 2006.

Arc-flash protection, in general, requires both the measuring of an overcurrent (50PAF) and the detection of light (TOL*n*). The output logic should in most cases be the AND of the 50PAF and TOL*n* outputs. In applications where intermittent loss of load can be tolerated (noncritical loads), it may be desirable to operate without overcurrent element supervision (OUTxxx := TOL*n*), relying only on the light detection element instead of having the overcurrent element (50PAF) supervise the light element (TOLn) in the output logic (OUTxxx := 50PAF AND TOL*n*). This approach offers fastest tripping times, but is less secure (can be tripped with the light input only).

Output Logic Programming

As stated earlier, arc-flash protection involves detecting an overcurrent as well as light (arc). Location of the light sensors and source(s) of the arc energy must also be considered in developing the trip output logic. If the relay detects both signals simultaneously, it is desirable to trip the "source breaker(s)."

The Relay Word bits for arc-flash protection (see *Figure 4.102* and *Figure 4.103*) are: 50PAF, 50NAF, TOL1, TOL2, TOL3, TOL4, TOL5, TOL6, TOL7 and TOL8.

NOTE: When using fast hybrid output contacts, do not use the FAILSAFE mode for those outputs.

As described earlier, you select two output contacts for high-speed processing by setting AOUTSLOT appropriately. You should use the high-speed contact, instead of the default OUT103 shown in *Table 4.65*, for arc-flash tripping. Also to ensure all the advantages of the trip logic (trip seal-in, event report trigger, etc.) the arc-flash trip should be included in the trip equation TR (see *Table 4.52* and *Figure 4.44* for detail).

To get additional speed, select the fast hybrid output option card (4DI/4DO). This card contains trip duty rated solid state output contacts, which operate within 50 µs (as much as 8 ms faster than the standard electromechanical outputs).

EXAMPLE 4.36 Output Logic Programming Example 1:

SEL-751 applied at the source breaker.

Assume light sensors LS1, LS2, and LS3 are located downstream of the source breaker and output contacts in Slot **3** are selected for high-speed processing (AOUTSLOT := 301_4).

Set:

OUT301FS := **N**

OUT301 := **(50PAF OR 50NAF) AND (TOL1 OR TOL2 OR TOL3) OR TRIP**

TR := **ORED50T OR ORED51T OR ... OR (50PAF OR 50NAF) AND (TOL1 OR TOL2 OR TOL3**)

EXAMPLE 4.37 Output Logic Programming Example 2:

SEL-751 applied at the radial feeder breaker.

Assume light sensors LS1 and LS2 are located downstream, LS3 is located upstream of the feeder breaker, and output contacts in Slot **3** are selected for the high speed processing (AOUTSLOT := 301_4).

Set:

OUT301FS := **N,** OUT302FS := **N**

OUT301 := **(50PAF OR 50NAF) AND (TOL1 OR TOL2) OR TRIP**

OUT302 := **TOL3**

TR := **ORED50T OR ORED51T OR ... OR (50PAF OR 50NAF) AND (TOL1 OR TOL2)**

Use the OUT302 contact to trip upstream breaker. Note that OUT302 does not include overcurrent element supervision. When desired, this supervision should be added by upstream relay(s). For instance, you can do the following:

- ➤ Connect OUT302 of breaker 2 relay to drive IN302 of the breaker 1 relay
- ➤ Add IN302 to the OR string of TOLn in both OUT301 and TR equations of breaker 1 relay.

You can use MIRRORED BITS instead of IN302 for faster operation if desired.

Analog Inputs

The SEL-751 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

Because of the flexibility to install different cards in the rear-panel slots on the device, the setting prompt adapts to the *x* and *y* variables shown in *Figure 4.105*. Variable *x* displays the slot position (**3** through **5**), and variable *y* displays the transducer (analog) input number (1 through 4 or 8).

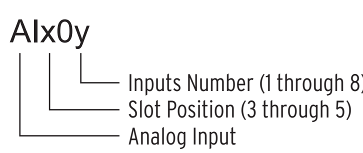


Figure 4.105 Analog Input Card Adaptive Name

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 mA or ±1 mV.

Signal offset compensation factor calculation procedure:

Step 1. Turn the SEL-751 on and allow it to warm up for a few minutes.

Step 2. Set the analog inputs for each analog channel to the desired 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).

Step 3. Short each analog input in turn at the device terminals by using short, low resistance leads with solid connections.

Step 4. Issue the command **MET AI 10** to obtain 10 measurements for each channel.

Step 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).

Step 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 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-751 to boot up, perform self-diagnostics, and detect installed cards.

Table 4.76 summarizes the steps and describes the settings we carry out in this example.

Table 4.76 Summary of Steps (Sheet 1 of 2)

	Step	Activity	Terse Description
General	1	SET G AI301NAM	Access settings for INPUT 1
	2	TX_TEMP	Enter a Tag name
	3	I	Select type of analog input; “I” for current
Transducer High/Low Output	4	4	Enter transducer low output (LOW IN VAL)
	5	20	Enter transducer high output (HI IN VAL)
Level	6	Degrees C	Enter Engineering unit
	7	–50	Enter Engineering unit value LOW
	8	150	Enter Engineering unit value HIGH

Table 4.76 Summary of Steps (Sheet 2 of 2)

	Step	Activity	Terse Description
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 issues 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 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 appears in reports (EVENT, METER, and SUMMARY) instead of the default name of AI301. SELOGIC control equations, Signal Profiles, and Fast Message Read use the default names. Use as many as eight valid tag name characters to name the analog quantity. Valid tag names 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 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-751 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, i.e., 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 exceed 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 the three higher values as shown in *Figure 4.106*. 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 4.106 Settings to Configure Input 1 as a 4–20 mA Transducer Measuring Temperatures Between –50°C and 150°C

Analog (DC Transducer) Input Board

Table 4.77 shows the setting prompt, setting range, and factory-default settings for an analog input card in Slot 3. For the name setting (AI301NAM, for example), enter only alphanumeric and underscore characters. Characters are not case sensitive, but the device converts all lowercase characters to uppercase. Although the device accepts alphanumeric characters, the name AI301NAM setting must begin with an alpha character (A–Z) and not a number.

Table 4.77 Analog Input Card Settings in Slot 3 (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
AI301 TAG NAME	8 characters 0–9, A–Z, _	AI301NAM := AI301
AI301 TYPE	I, V	AI301TYP := I
AI301 LOW IN VAL	–20.480 to +20.480 mA	AI301L := 4.000
AI301 HI IN VAL	–20.480 to +20.480 mA	AI301H := 20.000
AI301 LOW IN VAL	–10.240 to +10.240 V	AI301L := 0.000[a]
AI301 HI IN VAL	–10.240 to +10.240 V	AI301H := 10.000[a]
AI301 ENG UNITS	16 characters	AI301EU := mA
AI301 EU LOW	–99999.000 to +99999.000	AI301EL := 4.000
AI301 EU HI	–99999.000 to +99999.000	AI301EH := 20.000
AI301 LO WARN 1	OFF, –99999.000 to +99999.000	AI301LW1 := OFF
AI301 LO WARN 2	OFF, –99999.000 to +99999.000	AI301LW1 := OFF
AI301 LO ALARM	OFF, –99999.000 to +99999.000	AI301LAL := OFF

Table 4.77 Analog Input Card Settings in Slot 3 (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
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, i.e., when AI301TYP := V.

Analog Outputs

If an SEL-751 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 4.107* shows the *x* and *y* variable allocation for the analog output card.

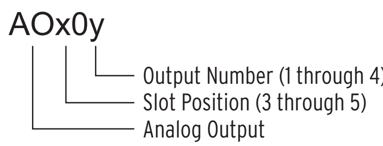


Figure 4.107 Analog Output Number Allocation

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 L: Analog Quantities*.

Table 4.78 shows the setting prompt, setting range, and factory-default settings for an analog card in Slot **3**.

NOTE: The SEL-751 hides the following settings with default values when you use a 3 DI/4 DO/1 AO card:
AOxx1TYP := I
AOxx1L := 4.000
AOxx1H := 20.000

Table 4.78 Analog Output Card Settings 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, i.e., when AO301TYP := V.

EXAMPLE 4.38 Analog Quantity IA_MAG, A-Phase Current Magnitude in Primary Amperes (0 to 3000 A Range), Using a -20 to +20 mA Analog Output Channel

In this example, assume we want to display in the control room the analog quantity (refer to *Appendix L: Analog Quantities*) IA_MAG, A-Phase 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 4.108*. 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 IA_MAG current is 0 A primary and +20 mA when it is 3000 A primary.

```
=>>SET G AO301AQ TERSE <Enter>
Global
AO 301 Settings
AO301 ANALOG QTY (OFF, 1 analog quantity)
AO301AQ := OFF
? IA_MAG <Enter>
AO301 TYPE (I,V)                              AO301TYP:= I         ? <Enter>
AO301 AQTY LO (-2147483647.000 to 2147483647.000)
                                              AO301AQL:= 4.000     ? 0 <Enter>
AO301 AQTY HI (-2147483647.000 to 2147483647.000)
                                              AO301AQH:= 20.000    ? 3000 <Enter>
AO301 LO OUT VAL (-20.480 to 20.480 mA)       AO301L  := 4.000     ? -20<Enter>
AO301 HI OUT VAL (-20.480 to 20.480 mA)       AO301H  := 20.000    ? 20<Enter>
AO 302 Settings
AO302 ANALOG QTY (OFF, 1 analog quantity)
AO302AQ := OFF
? END <Enter>
Save changes (Y,N)? Y <Enter>
Settings Saved
=>>
```

Figure 4.108 Analog Output Settings

Station DC Battery Monitor

The station dc battery monitor in the SEL-751 can alarm for under- or overvoltage dc battery conditions and give a view of how much the station dc battery voltage dips when tripping, closing, and other dc control functions take place. Refer to *Station DC Battery Monitor on page 5.15* for a detailed description and *Table 5.9* for settings.

Breaker Monitor

The breaker monitor in the SEL-751 helps in scheduling circuit breaker maintenance. Refer to *Breaker Monitor on page 5.19* for a detailed description and *Table 5.11* for settings.

Digital Input Debounce

To comply with different control voltages, the SEL-751 offers dc debounce modes as well as 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 you use it in device logic and the time stamping in the SER. Following is a description of the two modes.

DC Mode Processing (DC Control Voltage)

Figure 4.109 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 *Figure 4.109*, Input IN101 becomes IN101R (internal variable), after electrical isolation. On assertion, IN101R starts Debounce Timer, producing 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, i.e., 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, still use Relay Word bit IN101 in logic programming, but set the debounce time delay to 0 (IN101D := 0).

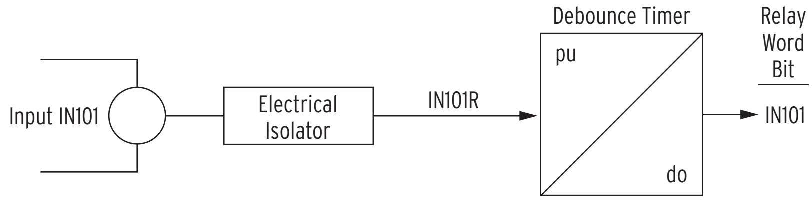


Figure 4.109 DC Mode Processing

AC Mode Processing (AC Control Voltage)

Figure 4.110 shows IN101R from Input IN101 applied to a pickup/dropout timer. Different from 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.

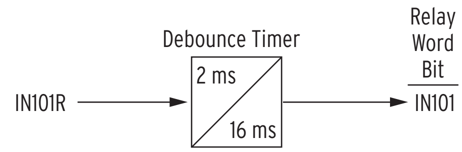


Figure 4.110 AC Mode Processing

Figure 4.111 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 4.111*). If IN101R deasserts (points marked 2 in *Figure 4.111*) before expiration of the pickup time setting, Relay Word bit IN101 does not assert, and 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.

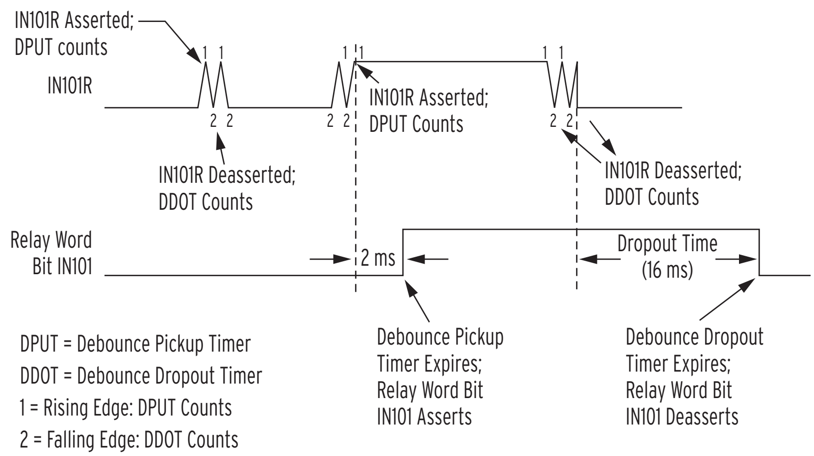


Figure 4.111 Timing Diagram for Debounce Timer Operation When Operating in AC Mode

Deassertion follows the same logic. On the falling edge of IN101R, the dropout timer starts timing. If IN101R remains deasserted for a period longer than the dropout timer setting, then Relay Word bit IN101 deasserts to a logical 0.

Table 4.79 shows the settings prompt, setting range, and factory-default settings for a card in Slot **C**. See the *SEL-751 Settings Sheets* for a complete list of input debounce settings.

Table 4.79 Slot C Input Debounce Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
IN301 Debounce	AC, 0–65000 ms	IN301D := 10
IN302 Debounce	AC, 0–65000 ms	IN302D := 10
IN303 Debounce	AC, 0–65000 ms	IN303D := 10
IN304 Debounce	AC, 0–65000 ms	IN304D := 10
IN305 Debounce	AC, 0–65000 ms	IN305D := 10
IN306 Debounce	AC, 0–65000 ms	IN306D := 10
IN307 Debounce	AC, 0–65000 ms	IN307D := 10
IN308 Debounce	AC, 0–65000 ms	IN308D := 10

Data Reset

NOTE: You cannot use the high-speed outputs selected by AOUTSLOT setting being Form A in fail safe mode, so these should be disabled (set OUTxxxFS := N).

The RSTTRGT setting resets the trip output and front-panel TRIP LED, provided there is no trip condition present. See *Figure 4.79* 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 4.90* for the demand current logic diagram.

Table 4.80 Data Reset Settings

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

Access Control

NOTE: DSABLSET does not disable the setting changes from the serial 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 a contact input (e.g., 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 settings through use of the serial port commands. *Table 4.81* shows the prompt, range, and factory-default name for this setting.

Table 4.81 Setting Change Disable Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
DISABLE SETTINGS	SELOGIC	DSABLSET := 0

Time Synchronization Source

The SEL-751 accepts a demodulated IRIG-B time signal. *Table 4.82* shows the setting to identify the input for the signal. Set TIME_SRC := IRIG1 when you use relay terminals B01/B02 or EIA-232 serial Port 3 for the time signal input. When you use fiber-optic Port 2 for the signal, set the TIME_SRC := IRIG2. Refer to *IRIG-B Time-Code Input on page 2.23* and *IRIG-B on page 7.6* for additional information.

Table 4.82 Time Synchronization Source Setting

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

89A and 89B Disconnect Switch Status SELogic Control Equations

The SEL-751 supports as many as five monitor-only, two-position disconnects. For the disconnect switch settings and logic, refer to *Disconnect Switch Symbol Settings and Status Logic on page 9.2*. The SEL-751 Relay with the touchscreen display option additionally provides the ability to design detailed single-line diagrams and display the breaker and disconnect switch status. Refer to *Table 9.3* for typical disconnect switch symbols available for display on the bay screens. For the settings related to bay control disconnect switch symbols, refer to *Table 9.5* and the corresponding description.

Local/Remote Breaker Control

The SEL-751 supports local/remote control of the breaker through supervision of the OC and CC breaker control bits. For the settings related to the local/remote control function, refer to *Local/Remote Breaker Control on page 9.3*. For breaker control via front-panel pushbuttons, refer to *Front-Panel Operator Control Pushbuttons on page 8.15*. For breaker control via the two-line display, refer to *Control Menu on page 8.9*. The touchscreen allows you to control the breaker through two applications, **Bay Screens** and **Breaker Control**. For breaker control via the touchscreen display, refer to *Breaker Control Via the Touchscreen on page 9.5*.

Port Settings (SET P Command)

The SEL-751 provides 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) is optionally an EIA-232 or EIA-485 port. On the optional communications card, you can select Port 4 as either EIA-485 or EIA-232 (not both) with the COMMINF setting. See *Table 4.83* through *Table 4.88* for the port settings, also see appropriate Appendix for additional information on the protocol (DNP, MODBUS, IEC-61850, DeviceNet, Synchrophasors, and Mirrored Bits) of interest.

PORT F

Table 4.83 Front-Panel Serial Port Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PORT	Y, N	EPORT := Y
PROTOCOL	SEL, MOD, EVMSG, PMU	PROTO := SEL
MAXIMUM ACCESS LEVEL	1, 2, C	MAXACC := 2
SPEED	300–38400 bps	SPEED := 9600
DATA BITS	7, 8 bits	BITS := 8
PARITY	O, E, N	PARITY := N
STOP BITS	1, 2 bits	STOP := 1
PORT TIME-OUT	0–30 min	T_OUT := 5
HDWR HANDSHAKING	Y, N	RTSCTS := N

Table 4.83 Front-Panel Serial Port Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
LANGUAGE	ENGLISH, SPANISH	LANG := ENGLISH
SEND AUTOMESSAGE	Y, N	AUTO := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

PORT 1

IMPORTANT: Upon 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 4.84 Ethernet Port Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PORT	Y, N	EPORT := Y
IP ADDRESS	zzz.yyy.xxx.www	IPADDR := 192.168.1.2
SUBNET MASK	15 characters	SUBNETM := 255.255.255.0
DEFAULT ROUTER	15 characters	DEFRTR := 192.168.1.1
ENABLE TCP KEEP-ALIVE	(Y, N)	ETCPKA := Y
TCP KEEP-ALIVE IDLE RANGE	1–20 sec	KAIDLE := 10
TCP KEEP-ALIVE INTERVAL RANGE	1–20 sec	KAINTV := 1
TCP KEEP-ALIVE COUNT RANGE	1–20	KACNT := 6
OPERATING MODE	FIXED, FAILOVER, SWITCHED, PRP	NETMODE := FAILOVER
FAILOVER TIMEOUT	OFF, 0.10–65.00 sec	FTIME := 1.00
PRIMARY NETPORT	A, B	NETPORT := A
PRP ENTRY TIMEOUT	400–10000 msec	PRPTOUT := 500
PRP DESTINATION ADDR LSB	0–255	PRPADDR := 0
PRP SUPERVISION TX INTERVAL	1–10 sec	PRPINTV := 2
NETWRK PORTA SPD	AUTO, 10, 100 Mbps	NETASPD := AUTO
NETWRK PORTB SPD	AUTO, 10, 100 Mbps	NETBSPD := AUTO
ENABLE TELNET	Y, N	ETELNET := Y
MAXIMUM ACCESS LEVEL	1, 2, C	MAXACC := 2
LANGUAGE	ENGLISH, SPANISH	LANG := ENGLISH
TELNET PORT	23, 1025–65534	TPORT := 23
TELNET CONNECT BANNER	254 characters	TCBAN := TERMINAL SERVER
TELNET TIME OUT	1–30 min	TIDLE := 15

Table 4.84 Ethernet Port Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
FAST OP MESSAGES	Y, N	FASTOP := N

NOTE: The FAST OP MESSAGES setting only functions when using SEL Fast Operate protocol to operate/set/pulse breaker bits and remote bits. This setting has no effect on Modbus, DNP, or IEC 61850 protocols.

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE FTP	Y, N	EFTPSERV := Y
FTP MAXIMUM ACCESS LEVEL	1, 2, C	FTPACC := 2
FTP USER NAME	20 characters	FTPUSER := FTPUSER
FTP CONNECT BANNER	254 characters	FTPCBAN := FTP SERVER
FTP IDLE TIME-OUT	5-255 min	FTPIDLE := 5
ENABLE IEC 61850 PROTOCOL	Y, N	E61850 := N
ENABLE IEC 61850 GSE	Y, N	EGSE := N
ENABLE MMS FILE SERVICES	Y, N	EMMSFS := N
ENABLE MODBUS SESSIONS	0–2	EMOD := 0
MODBUS MASTER IP ADDRESS	zzz.yyy.xxx.www[a]	MODIP1 := 0.0.0.0
MODBUS MASTER IP ADDRESS	zzz.yyy.xxx.www[a]	MODIP2 := 0.0.0.0
MODBUS TCP PORT 1	1–65534	MODNUM1 := 502
MODBUS TCP PORT 2	1–65534	MODNUM2 := 502
MODBUS TIMEOUT 1	15–900 sec	MTIMEO1 := 15
MODBUS TIMEOUT 2	15–900 sec	MTIMEO2 := 15
ENABLE PMU PROCESSING[b]	0–2	EPMIP := 0
ENABLE DNP SESSIONS[c]	0–5	EDNP := 0
ENABLE SNTP CLIENT[d]	OFF, UNICAST, MANYCAST, BROADCAST	ESNTP := OFF

[a] MODIP1 and MODIP2 cannot share an address and must be unique (except when 0.0.0.0, which effectively disables security and allows any master to communicate).
[b] See Appendix I: Synchrophasors for a complete list of synchrophasor settings and their descriptions.
[c] See Table D.1 for a complete list of the DNP3 session settings.
[d] See Table 7.5 for a complete list of SNTP settings and their descriptions.

Port Number Settings Must be Unique

When making the SEL-751 Port 1 settings, port number settings cannot be used for more than one protocol. The relay checks all of the settings shown in *Table 4.85* before saving changes. If a port number is used more than once, or if it matches any of the fixed port numbers (20, 21, 23, 102, 502), the relay displays an error message and returns to the first setting that is in error or contains a duplicate value.

Table 4.85 Port Number Settings That Must be Unique (Sheet 1 of 2)

Setting	Name	Setting Required When
TPORT	Telnet Port	Always
MODNUM1[a]	Modbus TCP Port 1	EMOD > 0

Table 4.85 Port Number Settings That Must be Unique (Sheet 2 of 2)

Setting	Name	Setting Required When
MODNUM2[a]	Modbus TCP Port 2	EMOD > 1
PMOTCP1	PMU Output 1 TCP/IP (Local) Port Number	PMOTS1 := TCP, UDP_T, or UDP_U
PMOTCP2	PMU Output 2 TCP/IP (Local) Port Number	PMOTS2 := TCP, UDP_T, or UDP_U
DNPNUM	DNPTCP and UDP Port	EDNP > 0
SNTPPORT	SNTPIP (Local) Port Number	ESNTP ≠ OFF

[a] MODNUM1 and MODNUM2 can have the same port number. The relay displays an error message if this number matches with the port numbers of other protocols.

PORT 2

NOTE: For additional settings when PROTO := MBxx, see Table J.5 as well as MIRRORED BITS Transmit SELOGIC Control Equations.

For additional settings when PROTO := DNP, see Table D.7 for a complete list of the DNP3 session settings.

Refer to Appendix G: IEC 60870-5-103 Communications for more information on IEC 60870-6-103.

NOTE: All port settings are hidden if the relay is ordered without the Port 2 option. See the SEL-751 MOT for details.

Table 4.86 Fiber-Optic Serial Port Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PORT	Y, N	EPORT := Y
PROTOCOL	SEL, DNP, MOD, EVMSG, PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB, 103	PROTO := SEL
MAXIMUM ACCESS LEVEL	1, 2, C	MAXACC := 2
SPEED	300–38400 bps	SPEED := 9600
DATA BITS	7, 8 bits	BITS := 8
PARITY	O, E, N	PARITY := N
STOP BITS	1, 2 bits	STOP := 1
PORT TIME-OUT	0–30 min	T_OUT := 5
LANGUAGE	ENGLISH, SPANISH	LANG := ENGLISH
SEND AUTOMESSAGE	Y, N	AUTO := N
FAST OP MESSAGES	Y, N	FASTOP := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

PORT 3

NOTE: For additional settings when PROTO := MBxx, see Table J.5 as well as MIRRORED BITS Transmit SELOGIC Control Equations.

For additional settings when PROTO := DNP, see Table D.7 for a complete list of the DNP3 session settings.

Refer to Appendix G: IEC 60870-5-103 Communications for more information on IEC 60870-6-103.

Table 4.87 Rear-Panel Serial Port (EIA-232) Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PORT	Y, N	EPORT := Y
PROTOCOL	SEL, DNP, MOD, EVMSG, PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB, 103	PROTO := SEL
MAXIMUM ACCESS LEVEL	1, 2, C	MAXACC := 2
SPEED	300–38400 bps	SPEED := 9600
DATA BITS	7, 8 bits	BITS := 8
PARITY	O, E, N	PARITY := N
STOP BITS	1, 2 bits	STOP := 1
PORT TIMEOUT	0–30 min	T_OUT := 5

Table 4.87 Rear-Panel Serial Port (EIA-232) Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
HDWR HANDSHAKING	Y, N	RTSCTS := N
LANGUAGE	ENGLISH, SPANISH	LANG := ENGLISH
SEND AUTOMESSAGE	Y, N	AUTO := N
FAST OP MESSAGES	Y, N	FASTOP := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

PORT 4

Table 4.88 Rear-Panel Serial Port (EIA-232/EIA-485) Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PORT	Y, N	EPORT := Y
PROTOCOL	SEL, MOD, DNET, DNP, EVMSG, PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB, 103	PROTO := SEL
MAXIMUM ACCESS LEVEL	1, 2, C	MAXACC := 2
COMM INTERFACE	232, 485	COMMINF := 232
SPEED	300–38400 bps	SPEED := 9600
DATA BITS	7, 8 bits	BITS := 8
PARITY	O, E, N	PARITY := N
STOP BITS	1, 2 bits	STOP := 1
PORT TIMEOUT	0–30 min	T_OUT := 5
HDWR HANDSHAKING	Y, N	RTSCTS := N
LANGUAGE	ENGLISH, SPANISH	LANG := ENGLISH
SEND AUTOMESSAGE	Y, N	AUTO := N
FAST OP MESSAGES	Y, N	FASTOP := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

NOTE: For additional settings when PROTO := MBxx, see Table J.5 as well as MIRRORED BITS Transmit SELOGIC Control Equations.

For additional settings when PROTO := DNP, see Table D.7 for a complete list of the DNP3 session settings.

Refer to Appendix G: IEC 60870-5-103 Communications for more information on IEC 60870-6-103.

The EPORT and MAXACC settings provide users with access controls for the corresponding port. Setting EPORT to N disables the port and hides the remaining port settings. The MAXACC setting selects the highest access level for the port.

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*, *Appendix F: IEC*

61850 Communications, *Appendix G: IEC 60870-5-103 Communications*, *Appendix H: DeviceNet Communications*, *Appendix I: Synchrophasors*, and *Appendix J: Mirrored Bits Communications*.

Use the MBT option if you are using a Pulsar MBT9600 baud modem (see *Appendix J: Mirrored Bits Communications* for more information). With this option set, the relay transmits a message every second processing interval and the device deasserts the RTS signal on the EIA-232 connector. Also, the device monitors the CTS signal on the EIA-232 connector, which the modem deasserts if the channel has too many errors. The modem uses the device RTS signal to determine whether the MB or MB8 Mirrored Bits protocol is in use.

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

On Ports F, 1, 2, 3, and 4, when PROTO := SEL, use the LANG setting to communicate with the relay in English or Spanish. Refer to the *SEL-751 Relay Command Summary* for the commands.

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

Set FASTOP := Y to enable binary Fast Operate messages at the serial port. Set FASTOP := N to block binary Fast Operate messages. Refer to *Appendix C: SEL Communications Processors* for the description of the SEL-751 Fast Operate commands.

Set PROTO := DNET to establish communications when you use the DeviceNet card. *Table 4.89* shows the additional settings, which can be set only at the rear on the DeviceNet card. Once the relay detects the DeviceNet card, all **Port 4** settings are hidden. Refer to *Appendix H: DeviceNet Communications* for details on DeviceNet.

Table 4.89 Rear-Panel DeviceNet Port Settings

Setting Name	Setting Range
MAC_ID	0–63
ASA	8 Hex characters assigned by factory
DN_Rate	125, 250, 500 kbps

Front-Panel Settings (SET F Command)

General Settings

The SEL-751 supports various front-panel options (see *Table 1.4*). This section covers all of the front-panel related settings, except the touchscreen display settings. Refer to *Table 9.5* for the touchscreen display settings. The touchscreen display settings are not settable via the **SET F** command.

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-751 arrives, four display points are already enabled, but no local bits are enabled. If more display points are necessary for your application, use the EDP setting to enable as many as 32 display points. Use the ELB setting to enable as many as 32 local bits. The EDP setting and the corresponding display point settings are not available for the touchscreen display model. The touchscreen display model provides you with the ability to configure bay screens with analog and digital labels, similar to the display point functionality in the two-line display model. Refer to *Section 9: Bay Control* for the procedure to create configurable bay screens.

Table 4.90 Display Point and Local Bit Default Settings

Setting	Setting Prompt	Range	Default
EDP[a]	DISPLAY PTS ENABL	N, 1–32	4
ELB	LOCAL BITS ENABL	N, 1–32	N

[a] The setting EDP is not supported in the touchscreen display model.

To optimize the time you spend on setting the device, only the number of enabled display points and enabled local bits become available for use. Use the front-panel LCD timeout setting FP_TO as a security measure. If the display is within an Access Level 2 function when a timeout occurs, such as the device setting entry, the function is automatically terminated (without saving changes) after inactivity for this length of time. After terminating the function, the front-panel display returns to the default display. The FP_TO setting is not available in the touchscreen display model. Refer to *Section 9: Bay Control* for the touchscreen display settings.

If you prefer to disable the front-panel timeout function during device testing, set the LCD timeout equal to OFF. Use the front-panel LCD contrast setting FP_CONT to adjust the contrast of the liquid crystal display. The FP_CONT setting is not available in the touchscreen display model. Use the front-panel auto-message setting FP_AUTO to define displaying of Trip/Warning message. Set FP_AUTO either to OVERRIDE or add to the Rotating display when the relay triggers a Trip/Warning message. Refer to *Table 9.5* for the equivalent touchscreen display settings. Note that the FP_AUTO setting is not available in the touchscreen display model. The touchscreen display provides settings that allow you to choose from a wide range of screens, including custom screens, that can be displayed as part of the rotating display. The touchscreen automatically flashes a screen overriding the rotating display in the case of trip or diagnostic failures. Refer to *Section 8: Front-Panel Operations* for more information on trip and diagnostic messages. Set RSTLED := Y to reset the latched LEDs automatically when the breaker or contactor closes.

NOTE: All Target LED settings can be found in Table 4.98

Table 4.91 LCD Display Settings

Setting	Setting Prompt	Range	Default
FP_TO[a]	LCD TIMEOUT	OFF, 1–30; min	15
FP_CONT[a]	LCD CONTRAST	1–16	10
FP_AUTO[a]	FP AUTOMESSAGES	OVERRIDE, ROTATING	OVERRIDE
RSTLED	CLOSE RESET LEDS	Y, N	Y
MAXACC[a]	MAXIMUM ACCESS LEVEL	1, 2	2

[a] The settings FP_TO, FP_CONT, FP_AUTO, and MAXACC are not supported in the touchscreen display model.

The MAXACC setting (under Front-Panel Settings) selects the highest access level for the front-panel. If MAXACC is set to 1, the front panel only allows metering and read access to settings. If MAXACC is set to 2, the front panel allows breaker control and read/write access to settings.

Display Points

NOTE: The rotating display is updated approximately every two (2) seconds.

Use display points to view either the state of internal relay elements (Boolean information) or analog information on the LCD display. Although the LCD screen displays a maximum of 16 characters at a time, you can enter as many as 60 valid characters. Valid characters are 0–9, A–Z, -, /, ", {, }, space. For text exceeding 16 characters, the LCD displays the first 16 characters, 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 K: 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 the following). 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 4.92* shows the various display appearances resulting from entering data in selected strings.

Hidden (No Display)

A display point is hidden when 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 4.92* shows examples of settings that always, never, or conditionally hide a display point.

Table 4.92 Settings That Always, Never, or Conditionally Hide a Display Point

Programmable Automation Controller Setting	Name	Alias	Set String	Clear String	Comment
DP01 := IN101, TRFR1, CLOSED, OPEN	IN101	TRFR1	CLOSED	OPEN	Never hidden
DP01 := IN101, TRFR1	IN101	TRFR1	—	—	Never hidden
DP01 := NA	—	—	—	—	Always hidden
DP01 := IN101,,,	IN101	—	—	—	Always hidden
DP01 := IN101, TRFR1,,	IN101	TRFR1	—	—	Always hidden
DP01 := IN101, TRFR1, CLOSED,	IN101	TRFR1	CLOSED	—	Hidden when IN101 is deasserted
DP01 := IN101, “TRFR 1”,, OPEN	IN101	TRFR 1	—	OPEN	Hidden when IN101 is asserted
DP01 := 1,{}	1	{}	—	—	Empty line
DP01 := 1,“Fixed Text”	1	Fixed Text	—	—	Displays the fixed text
DP01 := 0	0	—	—	—	Hides the display point

Following are examples of selected display point settings, showing the resulting front-panel displays. For example, at a certain station we want to display the status of both HV and LV circuit breakers of Transformer 1. When the HV circuit breaker is open, we want the LCD display to show: `TRFR 1 HV BRKR: OPEN`, and 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-751, we are ready to program the display points, using the following information for the HV breaker (LV breaker 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 4.93 Entries for the Four Strings

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

Figure 4.112 shows the settings for the example, using 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>
.
.
.
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, "IAV CURR {5} A"
? END <Enter>
Save changes (Y,N)? Y <Enter>
Settings Saved
=>>
```

Figure 4.112 Display Point Settings

Figure 4.113 shows the display when both HV and LV breakers are open (both IN101 and IN102 deasserted). *Figure 4.114* shows the display when the HV breaker is closed, and the LV breaker is open (IN101 asserted, but IN102 still deasserted).

```
TRFR 1 HV BRKR:= OPEN
TRFR 1 LV BRKR:= OPEN
```

Figure 4.113 Front-Panel Display—Both HV and LV Breakers Open

```
TRFR 1 HV BRKR:= CLOSED
TRFR 1 LV BRKR:= OPEN
```

Figure 4.114 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, using 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 4.115*. 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 4.116*.

```
TRFR 1 HV BRKR:= CLOSED
TRFR 1 LV BRKR:= CLOSED
```

Figure 4.115 Front-Panel Display—Both HV and LV Breakers Closed

```
TRFR 1 LV BRKR:= CLOSED
```

Figure 4.116 Front-Panel Display—HV Breaker Open, LV Breaker Closed

If you want the relay to display a blank state when IN101 deasserts instead of removing the line altogether, use the curly brackets { } for the Clear String, as follows:

```
DP01    := RID, "{16}"
 ? IN101,"TRFR 1 HV BRKR:",CLOSED,{} <Enter>
```

When Input IN101 now deasserts, the relay still displays the line with the HV breaker information, but the state is left blank, as shown in *Figure 4.117*.

```
TRFR 1 HV BRKR:=
TRFR 1 LV BRKR:= CLOSED
```

Figure 4.117 Front-Panel Display—HV Breaker Open, LV Breaker Closed

Name Only

Table 4.94 shows an entry in the Name String only (leaving the Alias string, Set String, and Clear String void). Using the **SET F** command, select DP01. Set DP01 as follows.

```
DP01    := RID, "{16}"
 ? IN101 <Enter>
```

Table 4.94 Binary Entry in the Name String Only

Name	Alias	Set String	Clear String
IN101	—	—	—

Figure 4.118 shows the front-panel display for the entry in *Table 4.94*. Input IN101 is deasserted in this display (`IN101=0`), but changes to `IN101=1` when Input IN101 asserts.

```
IN101=0
```

Figure 4.118 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 4.95* shows an entry in the Name string only (leaving the User Text and Formatting string void) with the following syntax:

Table 4.95 Analog Entry in the Name String Only

Name	Alias	Set String	Clear String
AI301	—	—	—

Figure 4.119 shows the front-panel display for the entry in *Table 4.95*. Using the **SET F** command, select DP01. Set DP01 as follows:

```
DP01    := RID, “{16}”
 ? AI301 <Enter>
```

Figure 4.119 Front-Panel Display for an Analog Entry in the Name String Only

Name and Alias

For a more descriptive name of the Relay Word bit, enter the Relay Word bit in the Name String, and an alias name in User Text and Formatting String. *Table 4.96* shows a Boolean entry in the Name and Alias Strings (DP01) and an entry in the Name and User Text and Formatting Strings (DP02), using the **SET F** command, select DP01. Set DP01 as follows:

```
DP01    := RID, “{16}”
 ? IN101,"INPUT IN101:" <Enter>
DP02    := TID, “{16}”
 ? AI301,TEMPERATURE: <Enter>
```

Table 4.96 Entry in the Name String and the Alias Strings

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

Figure 4.120 shows the front-panel display for the entry in *Table 4.96*. Input IN101 is deasserted in this display (0), and the display changes to `INPUT IN101=1` when Input IN101 asserts.

Figure 4.120 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 as shown in *Figure 4.121*.

Figure 4.121 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, i.e., DP01 = 1,"DEFAULT" and DP02 = 1,"SETTINGS." *Table 4.97* shows other options and front-panel displays for the User Text and Formatting settings.

Table 4.97 Example Settings and Displays

Example Display Point Setting Value	Example Display
AI301,"TEMP {4} deg C"	TEMP 1234 deg C
AI301,"TEMP = {4.1}"	TEMP := xx.x
AI301,"TEMP = {5}"	TEMP := 1230
AI301,"TEMP = {4.2,0.001} C"	TEMP := 1.23 C
AI301,"TEMP HV HS1 = {4,1000}"	TEMP HV HS1 =1234
1,{}	Empty line
1,"Fixed Text"	Fixed Text
0	Hides the display point

Following is an example of an application of analog settings. Assume 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 have installed an analog card in relay Slot **C**, and connected 4–20 mA transducers inputs to analog inputs AI301 (hot-spot temperature), AI302 (oil temperature), and AI303 (winding temperature).

First enable enough display points for the analog measurements (e.g. EDP = 5). *Figure 4.122* 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>
.
.
.
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, "IAV CURR {5} A"
? AI301,"HOT SPOT TEMP" <Enter>
DISPLAY POINT DP04 (60 characters)
DP04    := IG_MAG, "GND CURR {5} %"
? 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 4.122 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, as shown in *Figure 4.123*.

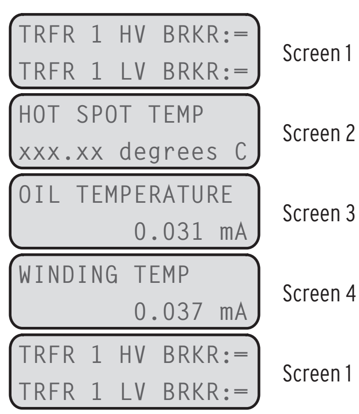


Figure 4.123 Rotating Display

To change the temperature units to more descriptive engineering units, enter the desired units with the AI*xxx*EU (e.g., 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 state of the local bits is stored in nonvolatile memory every second. When power to the device is restored, the local bits return 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 seven valid characters (0–9, A–Z, -, /, ., space) for the remainder:

- NLB*nn*: Name the switch (normally the function that the switch performs, such as SUPERV SW) that appears on the front-panel display.
- CLB*nn*: Clear 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*: Set 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*: Pulse 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 4.124* 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>
.
.
.
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 4.124 Adding Two Local Bits

Target LED Settings

The SEL-751 offers the following types of LEDs. See *Figure 8.2* and *Figure 8.27* for the programmable LED locations:

- One Enable and one TRIP tricolored LEDs
- Six tricolored Target LEDs
- Sixteen tricolored Pushbutton LEDs

You can program all 22 LEDs by using SELOGIC control equations, the only difference being that the Target LEDs also include a latch function.

Target LEDs

The ENABLED and TRIP LEDs are not programmable. Except for choosing the LED illuminated color (LEDENAC or LEDTRPC), they are fixed-function LEDs. The ENABLED LED illuminates when the SEL-751 is powered correctly, is functional, and has no self-test failures. The TRIP LED illuminates and latches in at the rising-edge of any trip that comes from the trip logic. The LEDENAC setting is not supported in the touchscreen display model. For touchscreen display relays, the illuminated color of the **ENABLED** LED is fixed at green.

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 by using TARGET RESET if the target conditions are absent.

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 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 4.98 Target LED Settings (Sheet 1 of 2)

Setting Prompt	Setting Range[a]	Setting Name := Factory Default
ENA_LED COLOR[b]	R, G, A	LEDENAC := G
TRIP_LED COLOR	R, G, A	LEDTRPC :=R
TRIP LATCH T_LED	Y, N	T01LEDL := Y
TARGET T_LED ASSERTED COLOR	R, G, A	T01LEDC := R
LED1 EQUATION	SELOGIC	T01_LED := ORED50T
TRIP LATCH T_LED	Y, N	T02LEDL := Y
TARGET T_LED ASSERTED COLOR	R, G, A	T02LEDC := R
LED2 EQUATION	SELOGIC	T02_LED := 51AT OR 51BT OR 51CT OR 51P1T OR 51P2T
TRIP LATCH T_LED	Y, N	T03LEDL := Y
TARGET T_LED ASSERTED COLOR	R, G, A	T03LEDC := R

Table 4.98 Target LED Settings (Sheet 2 of 2)

Setting Prompt	Setting Range[a]	Setting Name := Factory Default
LED3 EQUATION	SELOGIC	T03_LED := 51N1T OR 51G1T OR 51N2T OR 51G2T
TRIP LATCH T_LED	Y, N	T04LEDL := Y
TARGET T_LED ASSERTED COLOR	R, G, A	T04LEDC := R
LED4 EQUATION	SELOGIC	T04_LED := 51QT
TRIP LATCH T_LED	Y, N	T05LEDL := Y
TARGET T_LED ASSERTED COLOR	R, G, A	T05LEDC := R
LED5 EQUATION	SELOGIC	T05_LED := 81D1T OR 81D2T OR 81D3T OR 81D4T
TRIP LATCH T_LED	Y, N	T06LEDL := N
TARGET T_LED ASSERTED COLOR	R, G, A	T06LEDC := R
LED6 EQUATION	SELOGIC	T06_LED := (BFT OR T06_LED) AND NOT TRGTR

[a] R = Red, G = Green, and A = Amber.
[b] The setting LEDENAC is not supported in the touchscreen display model.

Pushbutton LEDs

Enter any of the Relay Word bits (or combinations of Relay Word bits) as conditions in the PB*p*_LED (*p* = 1A, 1B, . . . 8A, 8B) SELOGIC control equation settings. When these Relay Word bits assert, the corresponding LED also asserts. *Table 4.99* shows the setting prompts, settings ranges, and default settings for the LEDs.

Table 4.99 Pushbutton LED Settings[a] (Sheet 1 of 2)

Setting Prompt	Setting Range[b]	Setting Name := Factory Default
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB1ALEDC := AO
PB1A_LED EQUATION	SELOGIC	PB1A_LED := 79RS
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB1BLEDC := AO
PB1B_LED EQUATION	SELOGIC	PB1B_LED := 79LO
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB2ALEDC := AO
PB2A_LED EQUATION	SELOGIC	PB2A_LED := NOT LT02 OR SV02 AND NOT SV02T AND SV05T
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB2BLEDC := AO
PB2B_LED EQUATION	SELOGIC	PB2B_LED := LT02 OR SV02 AND NOT SV02T AND SV05T
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB3ALEDC := AO
PB3A_LED EQUATION	SELOGIC	PB3A_LED := NOT LT02 AND NOT 52A
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB3BLEDC := AO
PB3B_LED EQUATION	SELOGIC	PB3B_LED := 52A OR SV03 AND NOT SV03T AND SV05T

Table 4.99 Pushbutton LED Settings[a] (Sheet 2 of 2)

Setting Prompt	Setting Range[b]	Setting Name := Factory Default
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB4ALEDC := AO
PB4A_LED EQUATION	SELOGIC	PB4A_LED := 0
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB4BLEDC := AO
PB4B_LED EQUATION	SELOGIC	PB4B_LED := NOT 52A OR SV04 AND NOT SV04T AND SV05T
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB5ALEDC := AO
PB5A_LED EQUATION	SELOGIC	PB5A_LED := 0
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB5BLEDC := AO
PB5B_LED EQUATION	SELOGIC	PB5B_LED := 0
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB6ALEDC := AO
PB6A_LED EQUATION	SELOGIC	PB6A_LED := 0
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB6BLEDC := AO
PB6B_LED EQUATION	SELOGIC	PB6B_LED := 0
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB7ALEDC := AO
PB7A_LED EQUATION	SELOGIC	PB7A_LED := 0
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB7BLEDC := AO
PB7B_LED EQUATION	SELOGIC	PB7B_LED := 0
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB8ALEDC := AO
PB8A_LED EQUATION	SELOGIC	PB8A_LED := 0
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB8BLEDC := AO
PB8B_LED EQUATION	SELOGIC	PB8B_LED := 0

[a] The pushbutton LED settings, PB5A/PB5B–PB8A/PB8B, are hidden for relay models with four-pushbuttons.
[b] Setting is a two-letter combination of the letters R, G, A, O, where: asserted/deasserted color choices: R = Red, G = Green, =Amber, O = Off. Asserted and deasserted colors must be different.

Report Settings (SET R Command)

The report settings use Relay Word bits for the SER trigger as shown in *Table 4.101* (see *Appendix K: 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 containing the Relay Word bit(s), new state, time stamp, and checksum (see *Section 10: Analyzing Events* for more information).

When detecting oscillating SER items, the relay automatically deletes these oscillating items from SER recording. *Table 4.100* shows the auto-removal settings.

Table 4.100 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 deleted from recording, the item(s) are ignored for the next nine intervals. At the ninth interval, the chatter criteria is again checked and, if the point does not exceed the criteria, it is automatically reinserted into recording at the starting of the tenth interval. You can enable or disable the autodeletion function via the SER settings. Any autodeletion notice entry is lost during changes of 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 4.101* shows the settings prompt and default settings for the four SER trigger equations.

Table 4.101 SER[a] Trigger Settings

Setting Prompt	Setting Name := Factory Default
SER1	SER1 := IN101 IN102 51P1T 51G1T 50P1P 50N1T 51N1T PB01 PB02 PB03 PB04
SER2	SER2 := CLOSE 52A CC
SER3	SER3 := 81D1T 81D2T
SER4	SER4 := SALARM

[a] Use as many as 24 Relay Word elements separated by spaces or commas for each setting.

Relay Word Bit Aliases

Table 4.102 Enable Alias Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Enable ALIAS Settings (N, 1–20)	N, 1–20	EALIAS = 4

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 previous SER settings are displayed in the SER report. In addition, the Alias settings allow you to change the text displayed when a particular element is asserted and deasserted. The relay permits as many as 20 unique aliases, as defined by the Enable Alias Settings (EALIAS) setting. Factory default alias settings are shown in *Table 4.103*.

Define the enabled alias settings by entering the Relay Word bit name, a space, the alias you want, 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 K.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. If you want to clear a string, simply type **NA**.

Table 4.103 SET R SER Alias Settings

Setting Prompt	Relay Word Bit	Alias	Asserted Text	Deasserted Text
ALIAS1 :=	PB01	FP_AUX1	PICKUP	DROPOUT
ALIAS2 :=	PB02	FP_LOCK	PICKUP	DROPOUT
ALIAS3 :=	PB03	FP_CLOSE	PICKUP	DROPOUT
ALIAS4 :=	PB04	FP_TRIP	PICKUP	DROPOUT
ALIAS5 –ALIAS20	NA			

Event Report Settings

NOTE: Event report data stored in the relay is lost when you change the LER setting, You must save the data before changing the setting.

Table 4.104 Event Report Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
EVENT TRIGGER	SELOGIC	ER := R_TRIG 51P1P OR R_TRIG 51G1P OR R_TRIG 50P1P OR R_TRIG 50G1P OR R_TRIG 51N1P OR R_TRIG CF
EVENT LENGTH	15, 64, 180 cyc	LER := 15
PREFAULT LENGTH	1–175 cyc[a]	PRE := 5

[a] The range shown is for LER := 180. The generalized range is 1 - (LER-5) cyc.

Event reports can be either 15 cycles, 64 cycles, or 180 cycles in length as determined by the LER setting. For LER of 15, the prefault length, PRE, must be in the range of 1–10. The relay can hold as many as seventy-nine 15-cycle event reports, eighteen 64-cycle event reports, or six 180-cycle event reports.

HIF Event Report Settings

Table 4.105 HIF Event Report Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
HIF EVENT LENGTH	2, 5, 10, 20 min	HIFLER := 10

Load Profile Settings

Use the LDLIST setting to declare the analog quantities you want included in the Load Profile Report. Enter as many as 17 analog quantities, separated by spaces or commas, into LDLIST setting. See *Appendix L: Analog Quantities* for a list of the available Analog Quantities. Also set the LDAR to the desired acquisition rate for the report.

IMPORTANT: All stored load data are lost when changing the LDLIST.

Table 4.106 Load Profile Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
LDP LIST	NA, as many as 17 Analog Quantities	LDLIST := NA
LDP ACQ RATE	5, 10, 15, 30, 60 min	LDAR := 15

DNP Map Settings (Set DNP n Command, n = 1, 2, or 3)

Table 4.107 shows the available settings. See *Appendix D: DNP3 Communications* for additional details.

Table 4.107 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_LED
DNP Binary Input Label Name	10 characters	BI_02 := TLED_01
DNP Binary Input Label Name	10 characters	BI_03 := TLED_02
. . .		
DNP Binary Input Label Name	10 characters	BI_99 := NA
DNP Binary Output Label Name	10 characters	BO_00 := RB01
. . .		
DNP Binary Output Label Name	10 characters	BO_31 := RB32
DNP Analog Input Label Name	24 characters	AI_00 := IA_MAG
DNP Analog Input Label Name	24 characters	AI_01 := IB_MAG
. . .		
DNP Analog Input Label Name	24 characters	AI_99 := NA
DNP Analog Output Label Name	6 characters	AO_00 := NA

Table 4.107 DNP Map Settings[a] (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
•		
•		
•		
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 complete list of the DNP Map Labels and factory-default settings.

Modbus Map Settings (SET M Command)

Modbus User Map

Table 4.108 shows the available settings. See *Appendix E: Modbus RTU Communications* for additional details.

Table 4.108 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.

Touchscreen Settings

The touchscreen settings apply to relays that support the color touchscreen display and are discussed in *Section 9: Bay Control* (see *Table 9.5*).

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Section 5

Metering and Monitoring

Overview

The SEL-751 Feeder Protection Relay includes metering functions to display the present values of current, voltage, analog inputs, 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 (by 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 Edition 2 via Ethernet port
- IEC 60870-5-103 via EIA-232 or EIA-485 port
- C37.118 Synchrophasor Protocol via serial port or Ethernet port

Feeder load monitoring and trending are possible by using the Load Profile function. The relay automatically configures itself to save as many as 17 quantities (selected from the Analog Quantities) every 5, 10, 15, 30, or 60 minutes. The data are stored in nonvolatile memory. As many as 6500 time samples are stored.

Station DC Battery Monitor is available as an option in the SEL-751 with the 2 AVI/4 AFDI Voltage/arc-flash detection card. Refer to *Station DC Battery Monitor on page 5.15* for description and application details.

The Breaker Monitor feature is available in all SEL-751 Relays. Refer to *Breaker Monitor on page 5.19* for description and application details.

Power Measurement Conventions

The SEL-751 uses the IEEE convention for power measurement. The implications of this convention are depicted in *Figure 5.1*.

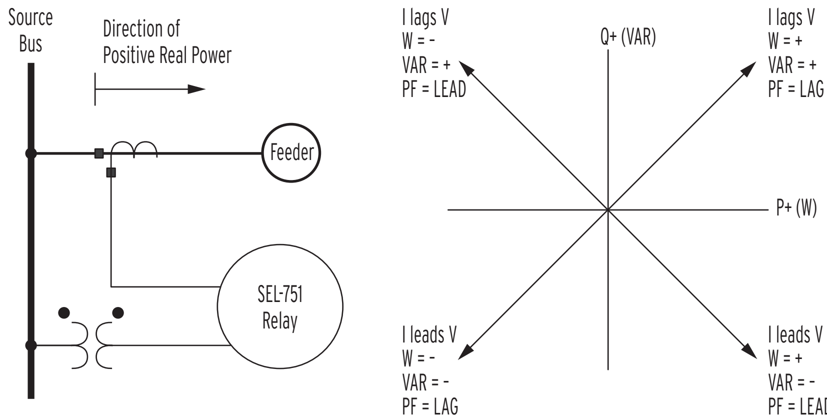

Figure 5.1 Complex Power Measurement Conventions

Metering

The SEL-751 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)
- Energy metering
- Maximum and minimum metering
- Math variable metering
- RMS metering
- Analog transducer input metering
- Demand and peak demand metering
- Synchrophasor metering
- Light metering for arc-flash detection (AFD)
- Remote analog metering
- HIF metering (high-impedance fault progress metering)—available in relays with the Arc-Sense Technology option for HIF detection

Fundamental Metering

Table 5.1 details each of the fundamental meter data types in the SEL-751. *Section 8: Front-Panel Operations* and *Section 7: Communications* describe how to access the various types of meter data by using the relay front panel and communications ports.

Table 5.1 Measured Fundamental Meter Values

Relay Option	Meter Values
All Models	Line Currents IA, IB, IC and IN (Core-Balance Ground Fault Current) magnitudes (A primary) and phase angles (deg) IG (Residual Ground Fault Current) magnitude (A primary) and phase angle (deg) IAV (Average Current Magnitude A primary) Positive-Sequence Current (I1 A primary) Negative-Sequence Current (3I2 A primary) Current Unbalance (%)[a] System Frequency (Hz) (FREQ)
With AC Voltage Inputs in Slot Z	VAB, VBC, VCA or VAN, VBN, VCN, VG magnitudes (V primary) and phase angles (deg) VAV, Average Voltage (L-L or L-N [V primary]) Positive-Sequence Voltage (V1[V primary]) Negative-Sequence Voltage (3V2 [V primary]) Voltage Unbalance %[a] Real Power (kW)[b] Reactive Power (kVAR)[b] Apparent Power (kVA)[b] Power Factor[b]
With Sync-Check and DC Station Battery Voltages and Arc-Flash Detection Inputs Option (2 AVI/4 AFDI Card MOT...x70/L0x...)	VS (synchronism-check voltage) magnitude (V primary) and phase angle (deg) Synchronism-check voltage frequency FREQS (Hz) VDC (station battery voltage) (Vdc)

[a] Current Unbalance % = 0 when IAV ≤ 0.25 * I_{NOM}; Voltage Unbalance = 0 when VAV ≤ 0.25 * Vnm, where Vnm = VNOM/1.732 when wye; VNOM when delta.
[b] Three-phase measurements for delta-connected PTs and three-phase and single-phase measurements for wye-connected PTs.

NOTE: Calculated phase-to-phase voltages for wye-connected PTs are available in the analog quantities and can be selected as display points. See Appendix L: Analog Quantities.

All angles are displayed between –180 and +180 degrees. The angles are referenced to VAB or VAN (for delta- or wye-connected PT, respectively) or IA. The angles are referenced to IA current if the secondary voltage VAB < 13 V (for delta-connected PT) or the secondary voltage VAN < 13 V (for wye-connected PT) when using the 300 Vac voltage inputs; or, VAN < 0.34 V (for wye-connected PT) when using the 8 Vac rms LEA voltage inputs. *Figure 5.2* shows an example of the **METER** command report.

The SEL-751 calculates percent unbalance current in one of two ways, depending on the magnitude of the average current. When the average current (I_{av}) is greater than the CT rated current (I_{NOM}) the relay calculates the percent unbalance as shown in *Equation 5.1*.

$$UBI\% = 100 \bullet \frac{I_m}{I_{av}}$$

Equation 5.1

When the average current is less than the I_{NOM} current, the relay calculates the percent unbalance as shown *Equation 5.2*.

$$UBI\% = 100 \bullet \frac{I_m}{I_{NOM}}$$

Equation 5.2

where:

UBI% = Current unbalance percentage

I_m = Maximum deviation of I_{av} from highest and lowest magnitudes of the phase currents

I_{av} = Magnitude of the average phase current

I_{NOM} = CT rated current

In either case, UBI% is not calculated if the average phase current magnitude is less than 25 percent of the I_{NOM} current. Voltage unbalance percent is calculated in a similar manner.

The SEL-751 calculates the voltage unbalance percent in one of two ways, depending on the magnitude of the average voltage. When the average voltage (V_{av}) is greater than the rated voltage Vnm, where Vnm = VNOM/1.732 when Wye, VNOM when Delta, the relay calculates the percent unbalance as shown in *Equation 5.3*.

$$UBV\% = 100 \bullet \frac{V_m}{V_{av}}$$

Equation 5.3

When the average voltage is less than Vnm, the relay calculates the percent unbalance as shown in *Equation 5.4*.

$$UBV\% = 100 \bullet \frac{V_m}{V_{nm}}$$

Equation 5.4

where:

UBV% = Voltage unbalance percentage

V_m = Maximum deviation of Vav from highest and lowest magnitudes of the phase voltages

V_{av} = Magnitude of the average voltage
(|VAN| + |VBN| + |VCN|)/3 when Wye;
(|VAB| + |VBC| + |VCA|)/3 when Delta

Vnm = VNOM/1.732 when Wye, VNOM when Delta

In either case, the UBV% is not calculated if the average voltage magnitude is less than 25 percent of the Vnm voltage.

```
=>>MET <Enter>

SEL-751                                 Date: 02/23/2012   Time: 00:47:50.504
FEEDER RELAY                            Time Source: Internal

                 IA         IB         IC         IN         IG         I1
Mag (A pri.)     1809.0     1804.0     1806.7     120.8      18.8       1806.5
Angle (deg)      -2.9       -122.5     117.9      -1.5       -116.6     -2.5

Ave Curr Mag     (A pri.)     1806.6
Neg-Seq Curr 3I2 (A pri.)       26.3
Current Imb (%)                  0.1

                 VAB        VBC        VCA        V1         VS
Mag (V pri.)    20851.0    20845.6    20965.8    12059.3    12238.0
Angle (deg)        30.2      -89.5      150.4        0.4       -2.8

                 VA         VB         VC         VG
Mag (V pri.)    12056.9    12060.9    12060.8      140.9
Angle (deg)         0.0     -119.7      120.8     -124.6


Avg Phase (V pri.)           12060
Neg-Seq Volt 3V2 (V pri.)      135.9
Voltage Imb (%)                  0.0

                           A              B              C              3P
Real Pwr (kW)             21783          21732          21763          65278
Reactive Pwr (kVAR)        1097           1068           1071           3236
Apparent Pwr (kVA)        21811          21758          21790          65359
Pwr Factor                    1.00           1.00           1.00           1.00
                             LAG            LAG            LAG            LAG

                FREQ   FREQS
Frequency (Hz)  59.99  59.99

VDC (V)   27.0

=>>
```

Figure 5.2 METER Command Report With Voltage/Arc-Flash Detection 2 AVI/4 AFDI Card in Slot E and 4 ACI/3 AVI Card in Slot Z

Thermal Metering

The thermal metering function reports the present values of RTD input temperatures and several quantities related to the cable/line thermal protection function. *Table 5.2* shows the thermal meter values. To enter a starting thermal capacity or to reset the thermal capacity, use the **THE** command (See *Figure 7.32*.).

Table 5.2 Thermal Meter Values

Relay Option	Thermal Values[a]
With External SEL-2600 RTD Module or Internal RTD Option	All RTD Temperatures
All Models	Thermal Element *n* Current (THIEQ*n* pu) Thermal Element *n* TCU (THTCU*n* %) Thermal Element *n* Trip Time (THTRIP*n* s) Thermal Element *n* Release Time (THRLS*n* s)

[a] where n = 1, 2, or 3.

The thermal meter function also reports the state of connected RTDs, if any have failed. *Table 5.3* shows the failure messages and their meanings.

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

NOTE: The maximum time to thermal trip is 3600 seconds (values greater than this are displayed as 9999 seconds).

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

```
=>>MET T <Enter>

SEL-751                                  Date: 07/06/2015   Time: 16:09:00.847
FEEDER RELAY                             Time Source: Internal

Max Winding RTD  NA
Max Bearing RTD  NA
Ambient RTD        75 C
Max Other RTD      70 C

 RTD 1 OTH     20 C
 RTD 2 OTH     25 C
 RTD 3 OTH     30 C
 RTD 4 OTH     35 C
 RTD 5 OTH     38 C
 RTD 6 OTH     45 C
 RTD 7 OTH     50 C
 RTD 8 OTH     55 C
 RTD 9 OTH     60 C
RTD 10 OTH     65 C
RTD 11 OTH     70 C
RTD 12 AMB     75 C

Thermal Element 1 Current (pu)          0.404
Thermal Element 1 TCU (%)               0.5
Thermal Element 1 Trip Time (sec)    9999
Thermal Element 1 Release Time (sec)  9999
Thermal Element 2 Current (pu)          0.396
Thermal Element 2 TCU (%)               2.6
Thermal Element 2 Trip Time (sec)    9999
Thermal Element 2 Release Time (sec)    58
Thermal Element 3 Current (pu)          0.399
Thermal Element 3 TCU (%)               0.4
Thermal Element 3 Trip Time (sec)    9999
Thermal Element 3 Release Time (sec)  9999

=>>
```

Figure 5.3 METER T Command Report With RTDs

Energy Metering

The SEL-751 includes energy metering in models with AC voltage inputs. Use this form of metering to quantify real, reactive, and apparent energy supplied to the feeder load. Following are the energy meter values.

- MWh3P-OUT—Real three-phase energy (out of bus, into feeder)
- MWh3P-IN—Real three-phase energy (from feeder into bus)
- MVARh3P-OUT—Reactive three-phase energy (out of bus, into feeder)
- MVARh3P-IN—Reactive three-phase energy (from feeder, into bus)
- MVAh3P—Apparent three-phase energy
- Last date and time of energy meter quantities were reset

NOTE: Energy values rollover after 99999.999 MVAh and reset to 0.

Figure 5.4 shows the device response to the **METER E** command.

```
=>MET E <Enter>

SEL-751                                  Date: 12/01/2010   Time: 15:43:28
FEEDER RELAY                              Time Source: External

Energy
MWh3P-IN (MWh)              1.325
MWh3P-OUT (MWh)           135.660
MVARh3P-IN (MVArh)          2.231
MVARh3P-OUT (MVArh)         8.627
MVAh3P (MVAh)             135.954

LAST RESET = 11/09/2010 03:54:34

=>
```

Figure 5.4 METER E Command Response

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 METER RE Command Response

Energy metering values are stored to nonvolatile memory four times per day and within one minute of the energy metering values being reset.

Maximum and Minimum Metering

Maximum and minimum metering allows you to determine maximum and minimum operating quantities such as currents, voltages, power, analog input quantities, RTD quantities and frequency. *Table 5.4* lists the max/min metering quantities.

Table 5.4 Maximum/Minimum Meter Values

Relay Option	Max/Min Meter Values
All Models	Maximum and minimum line currents I_A, I_B, I_C, and I_N (core-balance ground fault current) magnitudes (A primary) Maximum and minimum I_G (residual ground fault current) magnitude (A primary)
With AC Phase Voltage Inputs	Maximum and minimum V_{AB}, V_{BC}, V_{CA} or V_{AN}, V_{BN}, V_{CN} magnitudes (V primary) Maximum and minimum real, reactive and apparent three-phase power (kW, kVAR, kVA) Maximum and minimum system frequency (Hz)
With Voltage Arc-Flash Detection 2 AVI/4 AFDI Card Option in Slot E	Maximum and minimum V_S magnitudes (V primary)
With RTD Option or SEL-2600 RTD Module	Maximum and minimum RTD temperatures (°C)
With Analog Input Option	Maximum and minimum analog input values (engineering units)

All maximum and minimum metering values have the date and time that they 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:

- Current values I_A, I_B, I_C, and I_N: 3 percent of the nominal CT rating.
- Current value I_G: I_A, I_B, and I_C must all be greater than their thresholds.
- Voltage (secondary) values (phase and phase-to-phase): 7.5 V and 13 V, respectively or 0.2 V and 0.35 V, respectively when using the 8 Vac rms LEA voltage inputs.
- Power values (real, reactive, and apparent): All three currents (I_A, I_B, I_C) and all three voltages (V_A, V_B, V_C or V_{AB}, V_{BC}, V_{CA}) must be greater than their thresholds.

Figure 5.6 shows an example device response to the **METER M** command.

```
=>>MET M <Enter>

SEL-751                               Date: 12/02/2010   Time: 15:46:02
FEEDER RELAY                           Time Source: External

                  MAX        DATE       TIME       MIN        DATE       TIME
IA (A)           1005.8  12/02/2010  15:41:43       19.8  11/09/2010  03:55:41
IB (A)           1097.1  12/02/2010  15:41:26      197.3  11/16/2010  11:41:10
IC (A)            972.7  12/02/2010  15:45:11      206.0  11/16/2010  11:40:47
IN (A)              0.5  11/11/2010  18:20:00        0.4  11/16/2010  11:39:43
IG (A)            155.9  12/02/2010  15:42:32        0.4  11/12/2010  00:31:39
VAB (V)          6650.4  12/02/2010  15:45:45     6647.4  12/02/2010  15:41:14
VBC (V)          6671.9  12/02/2010  15:42:56     6666.8  12/02/2010  15:39:54
VCA (V)          7505.1  12/02/2010  15:41:05     7502.9  12/02/2010  15:45:42
VS (V)           6741.4  12/02/2010  15:45:11     6647.4  12/02/2010  15:41:14
KW3P (kW)        7797.2  11/11/2010  13:45:15   -11108    12/02/2010  15:41:42
KVAR3P (kVAR)    5031.8  12/02/2010  15:42:49    -1396.3  12/02/2010  15:45:24
KVA3P (kVA)     12187    12/02/2010  15:41:42      608.1  11/16/2010  11:42:27
FREQ (Hz)          60.1  11/16/2010  11:36:54       60.0  12/02/2010  15:45:23

LAST RESET = 11/09/2010 03:54:34

=>>
```

Figure 5.6 METER M Command Response

To reset maximum/minimum meter values, issue the **METER RM** command as shown in *Figure 5.7*. The max/min meter values can be reset from the serial port, Modbus, the front panel, or assertion of the RSTMXMN Relay Word bit. 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 5.7 METER RM Command Response

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-751 includes 32 math variables. When you receive your SEL-751, 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 5.8* 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-751                                Date: 02/17/2011   Time: 12:32:10
FEEDER 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 5.8 METER MV Command Response

RMS Metering

The SEL-751 includes root-mean-square (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
All Models	RMS current IA, IB, IC, and IN magnitudes (A primary)
With AC Phase Voltage Inputs	VAB, VBC, VCA or VAN, VBN, VCN magnitudes (V primary)
With Voltage/Arc-Flash Detection 2 AVI/4 AFDI Card Option	VS magnitude (V primary)

RMS quantities contain the total signal content 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 5.9 shows the **METER RMS** command.

```
=>>MET RMS <Enter>

SEL-751                                Date: 12/02/2010   Time: 15:45:49
FEEDER RELAY                            Time Source: External

                IA       IB       IC       IN
RMS (A pri.)    998.3   1080.5    963.2      0.0

                VAB      VBC      VCA      VS
RMS (V pri.)     6648     6707     7502     6741

=>>
```

Figure 5.9 METER RMS Command Response

Analog Input Metering

The SEL-751 can monitor analog (transducer) quantities that it is measuring if equipped with optional analog inputs. Analog input metering shows transducer values from standard voltage and current transducers. You can then use these values for automation and control applications within an industrial plant or application.

Through the 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 5.10* shows an example of analog input metering

```
=>MET AI <Enter>

SEL-751                                   Date: 11/28/2010   Time: 16:22:22
FEEDER 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 5.10 METER AI Command Response

Arc-Flash Light Intensity Metering

When the SEL-751 is ordered with the arc-flash detection (AFD) option (order the 2 AVI /4 AFDI card or 8 AFDI card for slot E), the relay provides light metering data with the METER LIGHT (**METER L** command) report. The light inputs LS1–LS4 for 2AVI/ 4AFDI card or LS1-LS8 for 8AFDI card are given in percent of full scale.

Figure 5.11 provides an example of the **METER L** (Light) command report for a 2 AVI/ 4 AFDI card.

```
=>>MET L <Enter>

SEL-751                                   Date: 12/01/2010   Time: 15:45:14
FEEDER RELAY                               Time Source: External

Light Intensity
LS1 (%)    2.4
LS2 (%)    1.9
LS3 (%)    0.7
LS4 (%)    2.3

=>>
```

Figure 5.11 METER L (Light) Command Response

Demand Metering

The SEL-751 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* provides an example of the **METER DE** (Demand) command report and *Figure 5.13* provides an example of the **METER PE** (Peak Demand) command report. Refer to *Demand Metering on page 4.153* for detailed descriptions and settings selection.

Table 5.6 Demand Values

Relay Option	Demand/Peak Demand Values
All Models	Demand/peak demand values of line currents IA, IB, and IC magnitudes (A primary) Demand/peak demand value of IG (residual ground current) magnitude (A primary) Demand/peak demand value of negative-sequence current (3I2) magnitude (A primary)
With AC Phase Voltage Inputs	Demand/peak demand value of single-phase kilowatts, kWA, B, C (wye-connected voltage inputs only) Demand/peak demand value of three-phase kilowatts, kW3P Demand/peak demand value if single-phase kilovars kVARA, B, C (wye-connected voltage inputs only) Demand/peak demand value of three-phase kilovars, kVAR3P

```
=>>MET DE <Enter>

SEL-751                                 Date: 08/30/2012   Time: 19:43:35.170
FEEDER RELAY                            Time Source: Internal

                   IAD      IBD      ICD      IGD     3I2D
DEMAND (A pri.)   1001.9   1009.6   1014.5     19.3     16.2

                       A          B          C          3P
DEMAND IN (kW)            0          0          0          0
DEMAND OUT (kW)         843        849        853       2545
DEMAND IN (kVAR)          0          0          0          0
DEMAND OUT (kVAR)       541        546        551       1639

LAST RESET = 08/29/2012 01:10:16
```

Figure 5.12 MET DE Command Response

```
=>>MET PE <Enter>

SEL-751                                 Date: 08/30/2012   Time: 19:43:43.590
FEEDER RELAY                            Time Source: Internal

                    IAPD     IBPD     ICPD     IGPD     3I2PD
PEAK DEM (A pri.)   1003.5   1014.1   1016.9    116.2    104.2

                            A          B          C          3P
PEAK DEMAND IN (kW)          999       1010       1012       3020
PEAK DEMAND OUT (kW)         845        853        856       2546
PEAK DEMAND IN (kVAR)         80         86         76        226
PEAK DEMAND OUT (kVAR)       543        549        554       1640

LAST RESET = 08/29/2012 01:10:16
```

Figure 5.13 MET PE Command Response

Peak demand metering values are stored to nonvolatile memory four times per day and within one minute of the peak demand metering values being reset. Demand metering is stored in volatile memory only and the data is lost when power to the relay is removed.

Synchrophasor Metering

You can use the **METER PM** serial port ASCII command to view the SEL-751 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 and to compare it with similar data captured in other phasor measurement unit(s) at the same time.

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:zz** response transmitted from a serial port, the corresponding port must have the AUTO setting set to YES (Y).

NOTE: When **METER PM** is set for an exact specified time (time trigger), the **METER PM** response shows the time in UTC time (not local time).

The **METER PM** command only operates when the SEL-751 is in the IRIG timekeeping mode, as indicated by Relay Word bit TSOK = logical 1. *Table 5.7* shows the measured values for the **METER PM** command. *Figure I.7* in *Appendix I: Synchrophasors*, shows a sample **METER PM** command response. You can use the **METER PM XX:XX:XXX** command to direct the SEL-751 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 I.7*, occurring just after 14:14:12, with the time stamp 14:14:12.000. Refer to *Appendix I: Synchrophasors*, for further details on synchrophasor measurements, settings, C37.118 Protocol, etc.

Table 5.7 Synchrophasor Measured Values

Relay Option	Meter Values
Currents (all models)	Currents: IA, IB, IC, IN, I1 (positive-sequence current) magnitudes (A primary) and phase angles (deg)
Digitals	TSOK and SV17–SV32 Relay Word Bit status
Analogs	MV29–MV32 Math Variables[a]
	System Frequency (Hz)
	Rate-of-change-of-frequency (Hz/Second)
Voltages (models with voltage inputs)	Voltage phasors: VA, VB, VC, VS (if VS option is available), and V1 (positive-sequence voltage), magnitudes (V or kV primary) and phase angles (deg)

[a] These data are calculated every 25 ms. Only the data that occur at the "Top of the Second" are used for METER PM responses.

Remote Analog Metering

Use remote analog metering to verify the values received from an external device. The SEL-751 includes 128 remote analog variables. In *Appendix C: SEL Communications Processors*, we show how to enter remote analog settings in an SEL Communications Processor and the SEL-751. *Figure 5.14* shows the device response to the **METER RA** command for the settings in *Appendix C: SEL Communications Processors*.

```
=>>MET RA <Enter>

SEL-751                                        Date: 02/11/2011   Time: 13:42:23
FEEDER RELAY                                    Time Source: External

RA01       1.00
RA02 -32767.00
RA03      -1.00
RA04       0.00
RA05    1000.59
RA06   -1000.61
RA07    2411.01
RA08    2410.99
RA09   98303.00
RA10  -98303.00
RA11  -38400.00
RA12  -65536.00
RA13       0.00
RA14       0.00
RA15       0.00
 •          •
 •          •
 •          •
RA126      0.00
RA127      0.00
RA128      0.00

=>>
```

Figure 5.14 MET RA Command Response

High-Impedance Fault Metering (HIF)

NOTE: The HIF odd-harmonic alarm and fault output bits are HIA1_A, HIA1_B, HIA1_C and HIF1_A, HIF1_B, HIF1_C, respectively. The HIF non-harmonic alarm and fault output bits are HIA2_A, HIA2_B, HIA2_C and HIF2_A, HIF2_B, HIF2_C, respectively. The Relay Word bits assert when the corresponding percentage values reach 100%.

When the SEL-751 is ordered with the Arc Sense technology (AST) option for high-impedance fault detection, the relay provides high-impedance fault metering data with the METER HIF (**MET H** command) report. The **MET HIF** command displays the progress of HIF detection alarm and fault in percent of their preset pickup values (see *Table 5.8* for details).

Table 5.8 High-Impedance Fault Metering Measured Values

Relay Option	High-Impedance Fault (HIF) Metering Values
All models with the AST option	Odd-harmonic alarm and fault values ALG.1 A, ALG.1 B, and ALG.1 C for Phases A, B and C in percent of preset alarm and fault thresholds. Non-harmonic alarm and fault values ALG.2 A, ALG.2 B, and ALG.2 C for Phases A, B and C in percent of preset alarm and fault thresholds.

If HIF enable setting EHIF is set to N, the command response is `HIF Not Enabled`. If setting EHIF is set to Y and any of the initial tuning Relay Word Bits ITUNE_A, ITUNE_B or ITUNE_C is asserted, the command response is `HIF Algorithm Tuning in Progress`. Initial tuning is a 24-hour window.

Figure 5.15 provides an example of **MET HIF** command report.

```
=>>MET HIF <Enter>

                                                 Date: 03/31/2011   Time: 14:19:20.655
                                                 Time Source: Internal


           ALG.1 A    ALG.1 B    ALG.1 C    ALG.2 A    ALG.2 B    ALG.2 C
Alarm (%)     0.00       0.00       0.00     100.00       0.00       0.00
Fault (%)     0.00       0.00       0.00       0.00       0.00       0.00


=>>
```

Figure 5.15 MET H (HIF) Command Response

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 • I_{NOM} A (secondary) and for voltage values with 300 V inputs is 0.1 V (secondary) or with 8 V LEA inputs is 0.0026 V (secondary). The threshold for rms metering current values is 0.03 • I_{NOM} A (secondary) and for voltage values with 300 V inputs is 0.3 V (secondary) or with 8 V LEA inputs is 0.008 V (secondary).

The Global setting METHRES (*Table 4.66*) controls how these metering functions work when the metered value is smaller than the previously stated thresholds.

METHRES := Y

Set METHRES := Y to force the fundamental and rms metering values of currents and voltages to zero when the corresponding applied signals fall below the previously stated thresholds.

METHRES := N

Set METHRES := N to bypass the meter threshold checks and disable the metering cutoff.

Load Profiling

The SEL-751 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 4.208*). Choose which analog quantities you want to monitor from the analog quantities listed in *Appendix L: Analog Quantities*. Set these quantities into the LDLIST load profile list report setting.

The relay memory can hold data for 6500 time-stamped entries. For example, if you choose to monitor 10 values at a rate of every 15 minutes, you could store 66 days worth of data.

Use the serial port LDP command described in *LDP Command (Load Profile Report)* to download the load rate profile data. See *Figure 5.16* for an example of an **LDP** serial port command response.

```
=>LDP <Enter>

SEL-751                                   Date: 02/21/2011   Time: 13:07:02
FEEDER RELAY                               Time Source: Internal

#      DATE         TIME          IAV       VAVE          P          PF
20  02/21/2011  11:31:24.468    277.636   13823.97   5908.951      0.889
19  02/21/2011  11:36:24.301    278.050   13824.34   5920.197      0.889
18  02/21/2011  11:41:24.035    278.012   13819.86   5920.606      0.890
17  02/21/2011  11:46:24.623    277.661   13824.90   5912.636      0.889
16  02/21/2011  11:51:24.885    278.072   13821.30   5922.041      0.890
15  02/21/2011  11:56:23.873    277.917   13821.33   5914.892      0.889
14  02/21/2011  12:01:23.923    277.630   13821.01   5907.527      0.889
13  02/21/2011  12:06:24.010    278.048   13821.97   5917.934      0.889
12  02/21/2011  12:11:24.140    277.988   13824.35   5917.830      0.889
11  02/21/2011  12:16:24.290    277.780   13820.97   5918.148      0.890
10  02/21/2011  12:21:24.203    277.740   13819.82   5920.595      0.891
9   02/21/2011  12:26:24.507    277.256   13823.17   5907.525      0.890
8   02/21/2011  12:31:24.332    277.973   13822.21   5921.495      0.890
7   02/21/2011  12:36:24.541    277.740   13819.83   5916.932      0.890
6   02/21/2011  12:41:24.791    288.393   13819.60   6593.658      0.955
5   02/21/2011  12:46:24.720    288.589   13820.86   6844.973      0.991
4   02/21/2011  12:51:23.816    288.547   13822.20   6843.819      0.991
3   02/21/2011  12:56:24.174    288.246   13821.41   6838.310      0.991
2   02/21/2011  13:01:24.750    288.232   13823.61   6835.954      0.991
1   02/21/2011  13:06:24.658    288.709   13820.80   6847.213      0.991

=>
```

Figure 5.16 LDP Command Response

Station DC Battery Monitor

The station dc battery monitor in the SEL-751 can alarm for under- or overvoltage dc battery conditions and give a view of how much the station dc battery voltage dips when tripping, closing, and other dc control functions take place. The monitor function is available with the voltage/arc-flash detection 2 AVI/4 AFDI card option in slot E of the relay. The monitor measures the station dc battery voltage applied to the rear-panel terminals labeled E3 (VBAT+) and E4 (VBAT–). The station dc battery monitor settings (DCLOP and DCHIP) are available via the **SET G** command (see *Table 5.9* and *Global Settings (SET G Command) on page SET.31*).

DC Under- and Overvoltage Elements

Table 5.9 Station DC Battery Monitor Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
DC UNDER VOLT PU	(OFF, 20.00-300.00) Vdc	DCLOP := OFF
DC OVER VOLT PU	(OFF, 20.00-300.00) Vdc	DCHIP := OFF

Refer to *Figure 5.17*. The station dc battery monitor compares the measured station battery voltage (Vdc) to the undervoltage (low) and overvoltage (high) pickups DCLOP and DCHIP. The setting range for pickup settings DCLOP and DCHIP is:

20 to 300 Vdc, 0.01Vdc increments

This range allows the SEL-751 to monitor nominal battery voltages of 24, 48, 110, 125, 220, and 250V. When testing the pickup settings DCLOP and DCHIP, do not operate the SEL-751 outside of its power supply limits. See *Specifications*: *General on page 1.13* for the various power supply specifications. The power supply rating is located on the serial number sticker on the relay side panel.

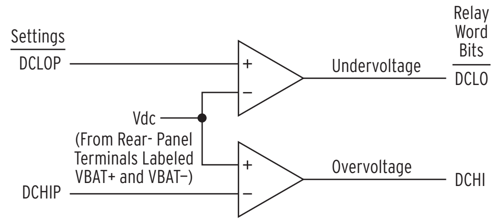

Figure 5.17 DC Under- and Overvoltage Elements

Logic outputs DCLO and DCHI in *Figure 5.17* operate as follows:

DCLO = 1 (logical 1), if Vdc ≤ pickup setting DCLOP
= 0 (logical 0), if Vdc > pickup setting DCLOP

DCHI = 1 (logical 1), if Vdc ≥ pickup setting DCHIP
= 0 (logical 0), if Vdc < pickup setting DCHIP

Create Desired Logic for DC Under- and Overvoltage Alarming

Pickup settings DCLOP and DCHIP are set independently. Thus, they can be set:

DCLOP < DCHIP or DCLOP > DCHIP

Figure 5.18 shows the resultant dc voltage elements that can be created with SELOGIC control equations for these two setting cases. In these two examples, the resultant dc voltage elements are time-qualified by timer SV*n*T and then routed to output contact OUT*xxx* for alarm purposes.

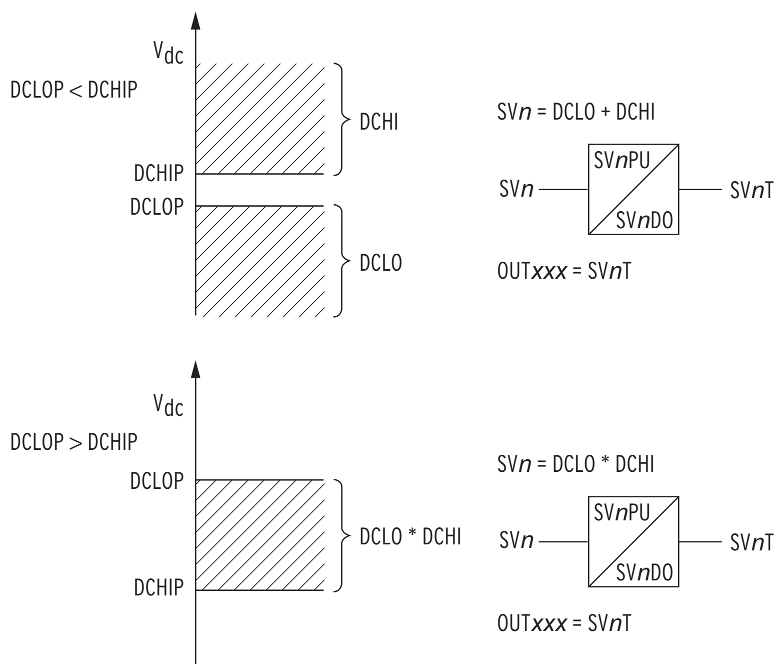

Figure 5.18 Create DC Voltage Elements With SELOGIC Control Equations

DCLO < DCHI (Top of Figure 5.18)

Output contact OUT*xxx* asserts when:

Vdc ≤ DCLOP or Vdc ≥ DCHIP

Pickup settings DCLOP and DCHIP are set such that output contact OUT*xxx* asserts when dc battery voltage becomes less than or greater than allowable limits.

If the relay loses power entirely (Vdc = 0 V)

Vdc = < DCLOP

then output contact OUT*xxx* should logically assert (according to top of *Figure 5.18*), but cannot because of the total loss of power (all output contacts deassert on total loss of power). Thus, the resultant dc voltage element at the bottom of *Figure 5.18* would probably be a better choice—see following discussion.

DCLO > DCHI (Bottom of Figure 5.18)

Output contact OUT*xxx* asserts when:

DCHIP ≤ Vdc ≤ DCLOP

Pickup settings DCLOP and DCHIP are set such that output contact OUT*xxx* asserts when dc battery voltage stays between allowable limits.

If the relay loses power entirely (Vdc = 0 V)

Vdc = < DCHIP

then output contact OUT*xxx* should logically deassert (according to bottom of *Figure 5.18*), and this is surely what happens for a total loss of power (all output contacts deassert on total loss of power).

Additional Application

You can use the dc voltage elements for alarming and for disabling reclosing.

For example, if the station dc batteries have a problem and the station dc battery voltage is declining, drive the reclosing relay to lockout:

79DTL = **NOT (SVnT) OR ...**

Timer output SV*n*T is from the bottom of *Figure 5.18*. When dc voltage falls below pickup DCHIP, timer output SV*n*T drops out (= logical 0), driving the relay to lockout:

79DTL = **NOT (SVnT) OR ... = NOT (logical 0) OR ... = logical OR**

Circuit breaker tripping and closing requires station dc battery energy. If the station dc batteries are having a problem and the station dc battery voltage is declining, the relay should not reclose after a trip—there might not be enough dc battery energy to trip a second time after a reclose.

View Station DC Battery Voltage

Via Serial Port

The **METER** command displays the station dc battery voltage (labeled VDC).

Via Front Panel

The information available via the previously discussed **METER** serial port command is also available via the front-panel Meter Menu. See *Figure 8.7*.

Analyze Station DC Battery Voltage

The station dc battery voltage is displayed in column Vdc in the example event report in *Figure 10.3*. Changes in station dc battery voltage for an event (e.g., circuit breaker tripping) can be observed. Use the **EVE** command to retrieve event reports as discussed in *Section 10: Analyzing Events*.

Station DC Battery Voltage Dips During Circuit Breaker Tripping

Event reports are automatically generated when the TRIP Relay Word bit asserts (TRIP is the logic output of *Figure 4.79*). For example, output contact OUT103 is set to trip:

OUT103 = **TRIP**

Anytime output contact OUT103 closes and energizes the circuit breaker trip coil, any dip in station dc battery voltage can be observed in column Vdc in the event report.

To generate an event report for external trips, program an optoisolated input IN*xyz* (monitoring the trip bus) in the SELOGIC control equation event report generation setting:

ER = **R_TRIG(INxyz) OR...**

Anytime the trip bus is energized, any dip in station dc battery voltage can be observed in column Vdc in the event report.

Station DC Battery Voltage Dips During Circuit Breaker Closing

To generate an event report when the SEL-751 closes the circuit breaker, make the SELOGIC control equation event report generation setting:

ER = **R_TRIG(OUT102) OR...**

In this example, output contact OUT102 is set to close:

OUT102 = **CLOSE** (CLOSE is the logic output of *Figure 4.80*)

Anytime output contact **OUT102** closes and energizes the circuit breaker close coil, any dip in station dc battery voltage can be observed in column Vdc in the event report.

This event report generation setting (ER := R_TRIG(OUT102) OR **...**) might be made just as a testing setting. Generate several event reports when doing circuit breaker close testing and observe the “signature” of the station dc battery voltage in column Vdc in the event reports.

Station DC Battery Voltage Dips Anytime

To generate an event report anytime there is a station dc battery voltage dip, set the dc voltage element directly in the SELOGIC control equation event report generation setting:

ER = **F_TRIG(SVnT) OR ...**

Timer output SV*n*T is an example dc voltage element from the bottom of *Figure 5.18*. Anytime dc voltage falls below pickup DCHIP, timer output SV4T drops out (logical 1 to logical 0 transition), creating a falling-edge condition that generates an event report. Also, you can use the Sequential Event Recorder (SER) report to time-tag station dc battery voltage dips.

Breaker Monitor

The breaker monitor in the SEL-751 helps in scheduling circuit breaker maintenance. The breaker monitor is enabled with the enable setting:

EBMON := **Y**

The breaker monitor settings in *Table 5.11* are available via the **SET G** commands (see *Table 6.3*). Also refer to *BRE Command (Breaker Monitor Data) on page 7.24* and *BRE Command (Preload/Reset Breaker Wear) on page 7.24*.

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 5.19*.

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 5.19* for a breaker maintenance curve. To estimate this breaker maintenance curve in the SEL-751 breaker monitor, three set points are entered:

Set Point 1 COSP1	**maximum** number of close/open operations with corresponding current interruption level.
Set Point 2 COSP2	number of close/open operations that correspond to some **midpoint** current interruption level.
Set Point 3 COSP3	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

Setting Prompt	Setting Range	Setting Name := Factory Default
Breaker Monitor	(Y,N)	EBMON := Y
CL/OPN OPS SETPT 1	(0–65000)	COSP1 := 10000[a]
CL/OPN OPS SETPT 2	(0–65000)	COSP2 := 150[b c]
CL/OPN OPS SETPT 3	(0–65000)	COSP3 := 12
kA PRI INTERRPTD 1	(0.10–999.00 kA)	KASP1 := 1.20[d]
kA PRI INTERRPTD 2	(0.10–999.00 kA)	KASP2 := 8.00
kA PRI INTERRPTD 3	(0.10–999.00 kA)	KASP3 := 20.00[e]
BRKR MON CONTROL	SELOGIC	BKMON := TRIP

[a] COSP1 must be set greater than COSP2.
[b] COSP2 must be set greater than or equal to COSP3.
[c] If KASP2 is set the same as KASP3, then COSP2 must be set the same as COSP3.
[d] KASP1 must be set less than KASP2 and KASP2 must be less than or equal to KASP3.
[e] KASP3 must be set at least five times (but no more than 100 times) the KASP1 setting value.

The following settings are made from the breaker maintenance information in *Table 5.10* and *Figure 5.19*. *Figure 5.20* shows the resultant breaker maintenance curve.

COSP1 = **10000**

COSP2 = **150**

COSP3 = **12**

KASP1 = **1.20**

KASP2 = **8.00**

KASP3 = **20.00**

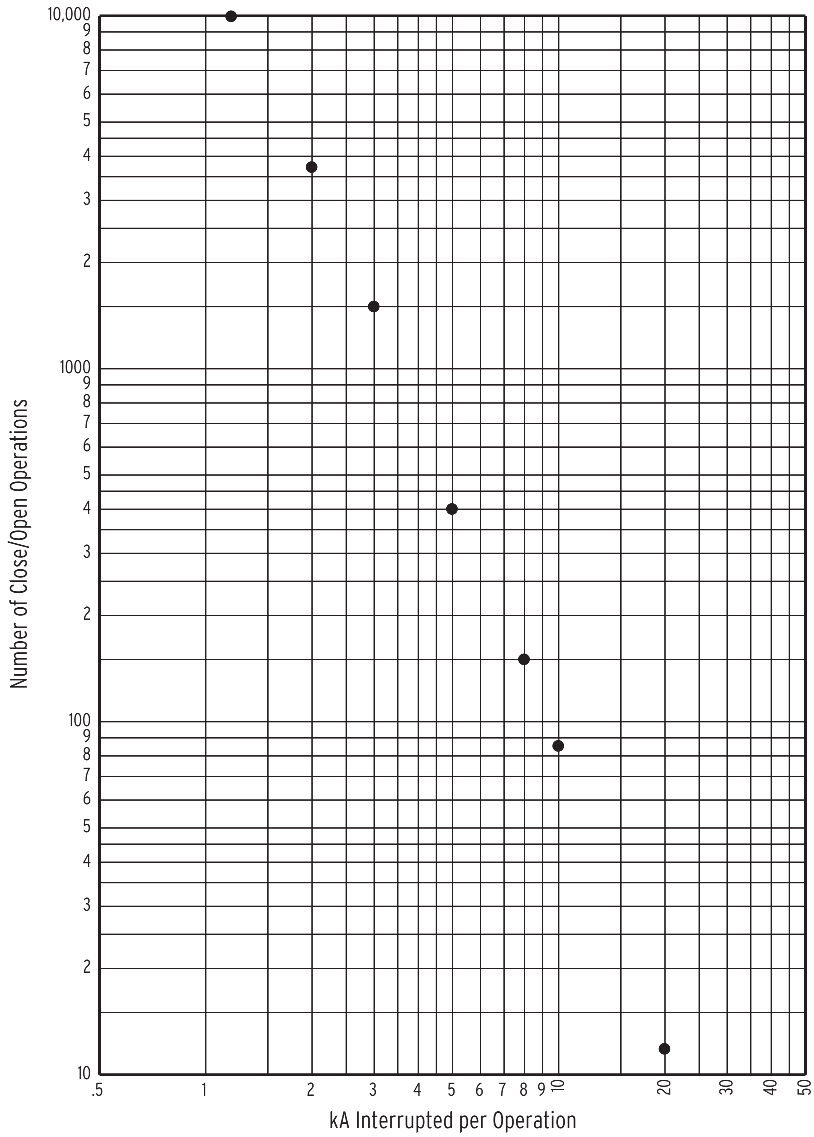

Figure 5.19 Plotted Breaker Maintenance Points for a 25 kV Circuit Breaker

Breaker Maintenance Curve Details

In *Figure 5.20*, note that set points KASP1, COSP1 and KASP3, COSP3 are set with breaker maintenance information from the two extremes in *Table 5.10* and *Figure 5.19*.

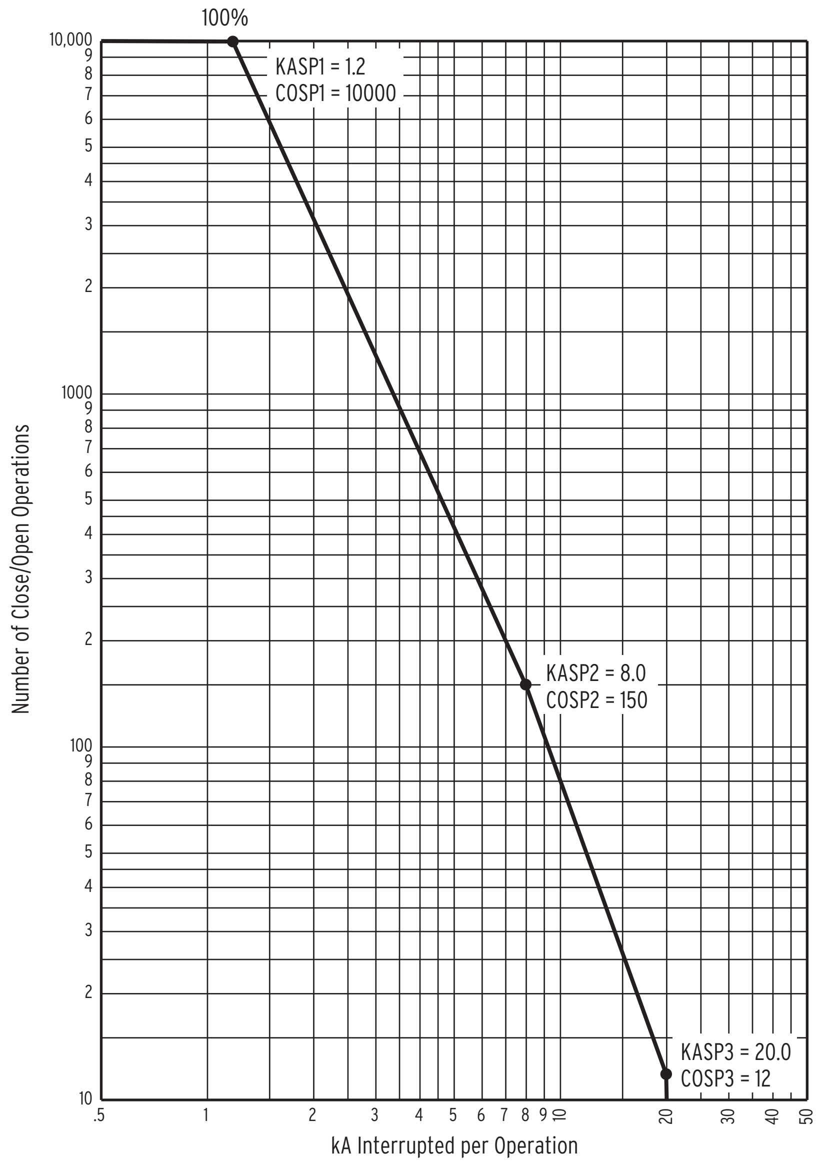

Figure 5.20 SEL-751 Breaker Maintenance Curve for a 25 kV Circuit Breaker

In this example, set point KASP2, COSP2 happens to be from an in-between breaker maintenance point in the breaker maintenance information in *Table 5.10* and *Figure 5.19*, but it does not have to be. Set point KASP2, COSP2 should be set to provide the best "curve-fit" with the plotted breaker maintenance points in *Figure 5.19*.

Each phase (A, B, and C) has its own breaker maintenance curve (like that in *Figure 5.20*), because the separate circuit breaker interrupting contacts for phases A, B, and C do not necessarily interrupt the same magnitude current (depending on fault type and loading).

In *Figure 5.20*, note that the breaker maintenance curve levels off horizontally above set point KASP1, COSP1. This is the close/open operation limit of the circuit breaker (COSP1 = 10000), regardless of interrupted current value.

Also, note that the breaker maintenance curve falls vertically below set point KASP3, COSP3. This is the maximum interrupted current limit of the circuit breaker (KASP3 = 20.0 kA). If the interrupted current is greater than setting KASP3, the interrupted current is accumulated as a current value equal to setting KASP3.

Operation of SELogic Control Equation Breaker Monitor Initiation Setting BKMON

The SELogic control equation breaker monitor initiation setting BKMON in *Table 5.11* determines when the breaker monitor reads in current values (Phases A, B, and C) for the breaker maintenance curve (see *Figure 5.20*) and the breaker monitor accumulated currents/trips (see *BRE Command (Breaker Monitor Data) on page 7.24*).

The BKMON 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 = **TRIP** (TRIP is the logic output of *Figure 4.79*)

Refer to *Figure 5.21*. When BKMON asserts (Relay Word bit TRIP goes from logical 0 to logical 1), the breaker monitor reads in the current values and applies them to the breaker monitor maintenance curve and the breaker monitor accumulated currents/trips.

As detailed in *Figure 5.21*, the breaker monitor actually reads in the current values 1.5 cycles after the assertion of BKMON. 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.

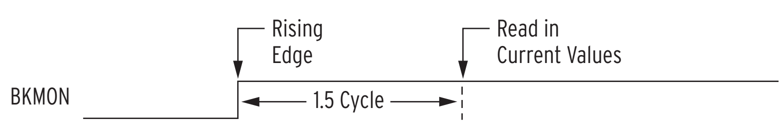

Figure 5.21 Operation of SELogic Control Equation Breaker Monitor Initiation Setting

See *Figure 5.26* and accompanying text for more information on setting BKMON. The operation of the breaker monitor maintenance curve, when new current values are read in, is explained in the following example.

Breaker Monitor Operation Example

As stated earlier, each phase (A, B, and C) has its own breaker maintenance curve. For this example, presume that the interrupted current values occur on a single phase in *Figure 5.22–Figure 5.25*. Also, presume that the circuit breaker interrupting contacts have no wear at first (brand new or recent maintenance performed).

Note in the following four figures (*Figure 5.22–Figure 5.25*) that the interrupted current in a given figure is the same magnitude for all the interruptions (e.g., in *Figure 5.23*, 2.5 kA is interrupted 290 times). This is not realistic, but helps in demonstrating 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 5.22*. 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 and 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.

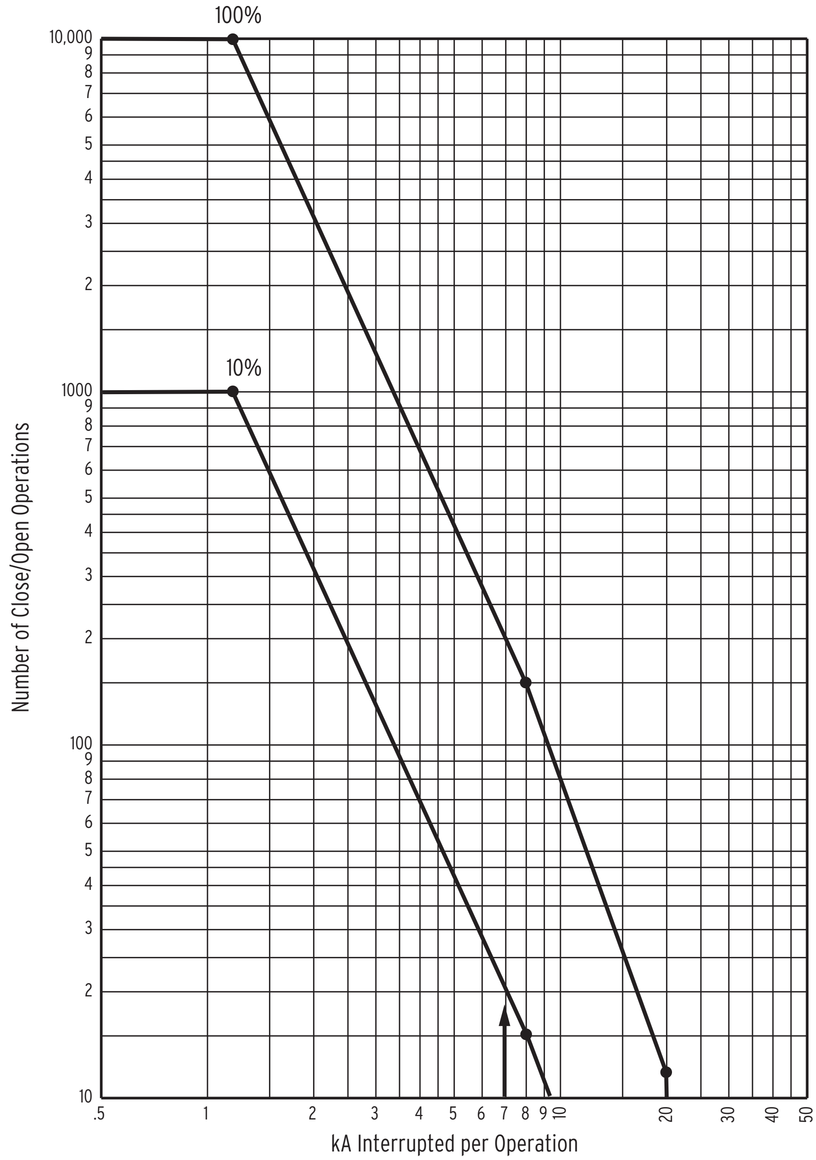

Figure 5.22 Breaker Monitor Accumulates 10 Percent Wear

10 Percent to 25 Percent Breaker Wear

Refer to *Figure 5.23*. 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 and 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.

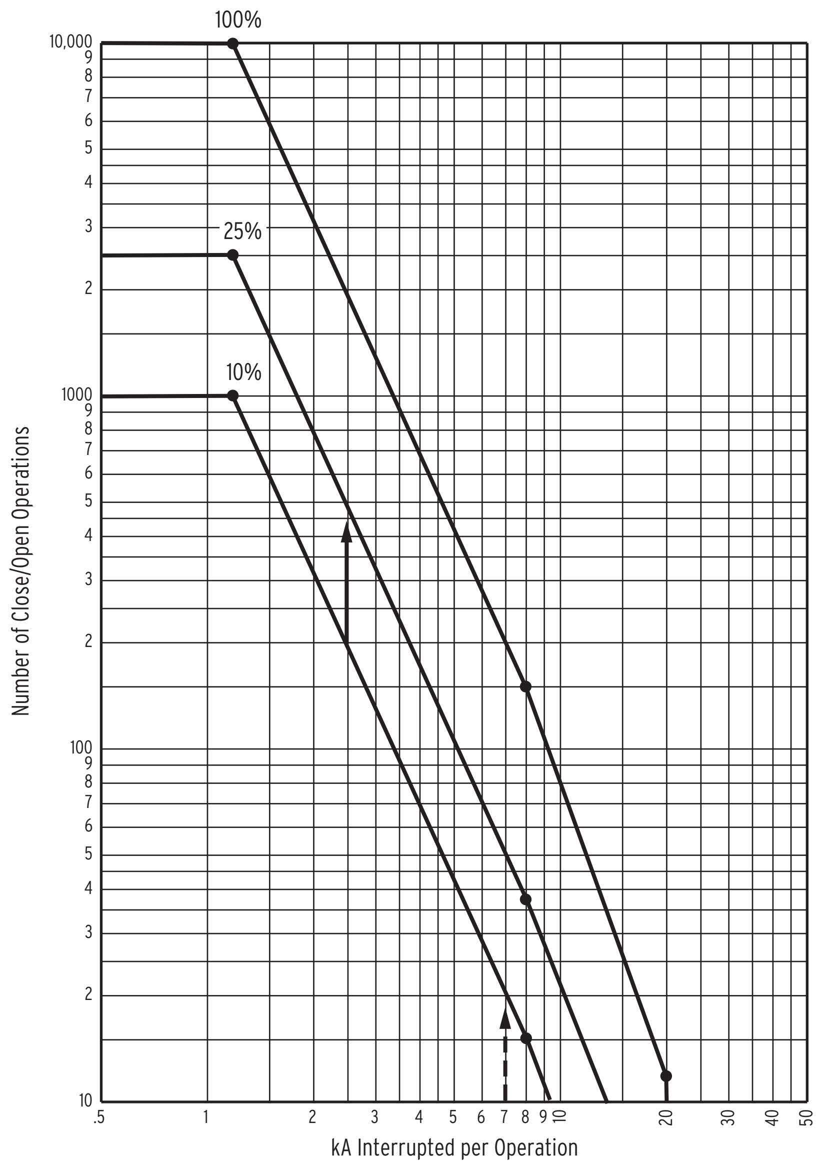

Figure 5.23 Breaker Monitor Accumulates 25 Percent Wear

25 Percent to 50 Percent Breaker Wear

Refer to *Figure 5.24*. 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 and 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.

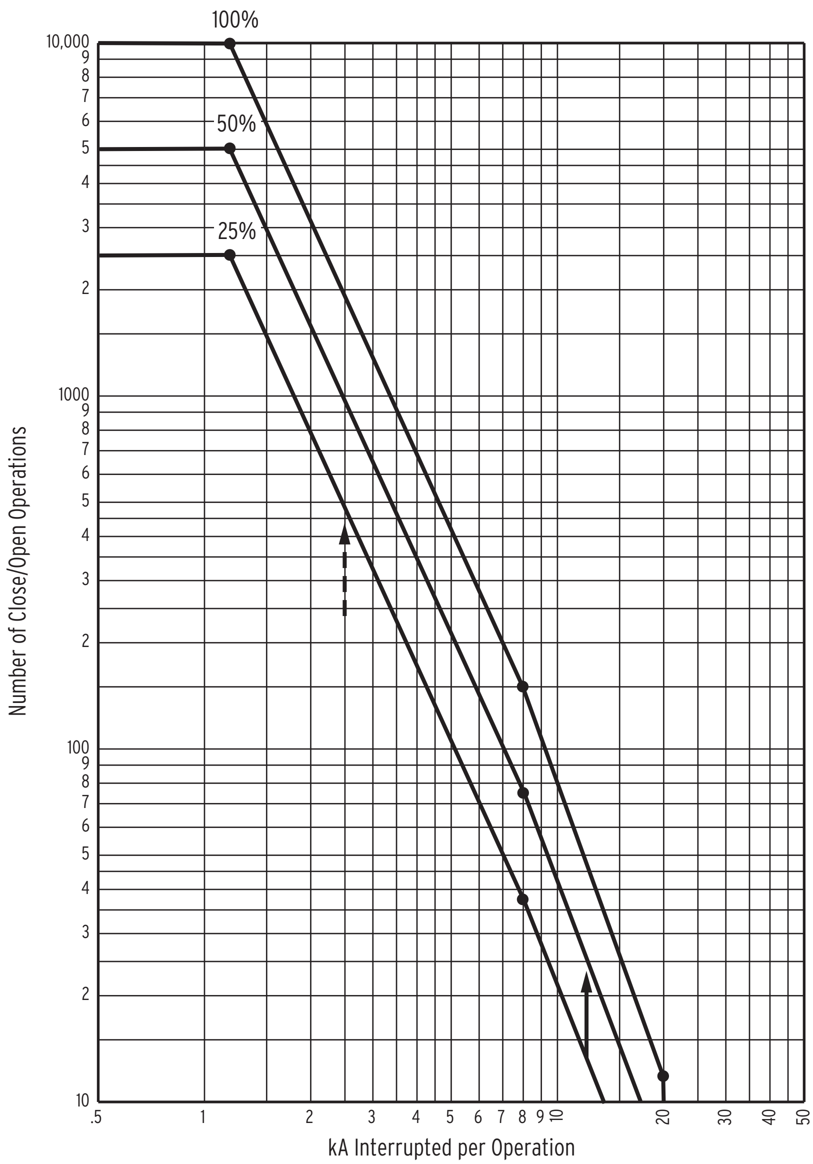

Figure 5.24 Breaker Monitor Accumulates 50 Percent Wear

50 Percent to 100 Percent Breaker Wear

Refer to *Figure 5.25*. 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 R** command (see *View or Reset Breaker Monitor Information on page 5.28*). But the current and trip counts continue to be accumulated, until reset by the **BRE R** command.

Additionally, logic outputs assert for alarm or other control applications—see the following discussion.

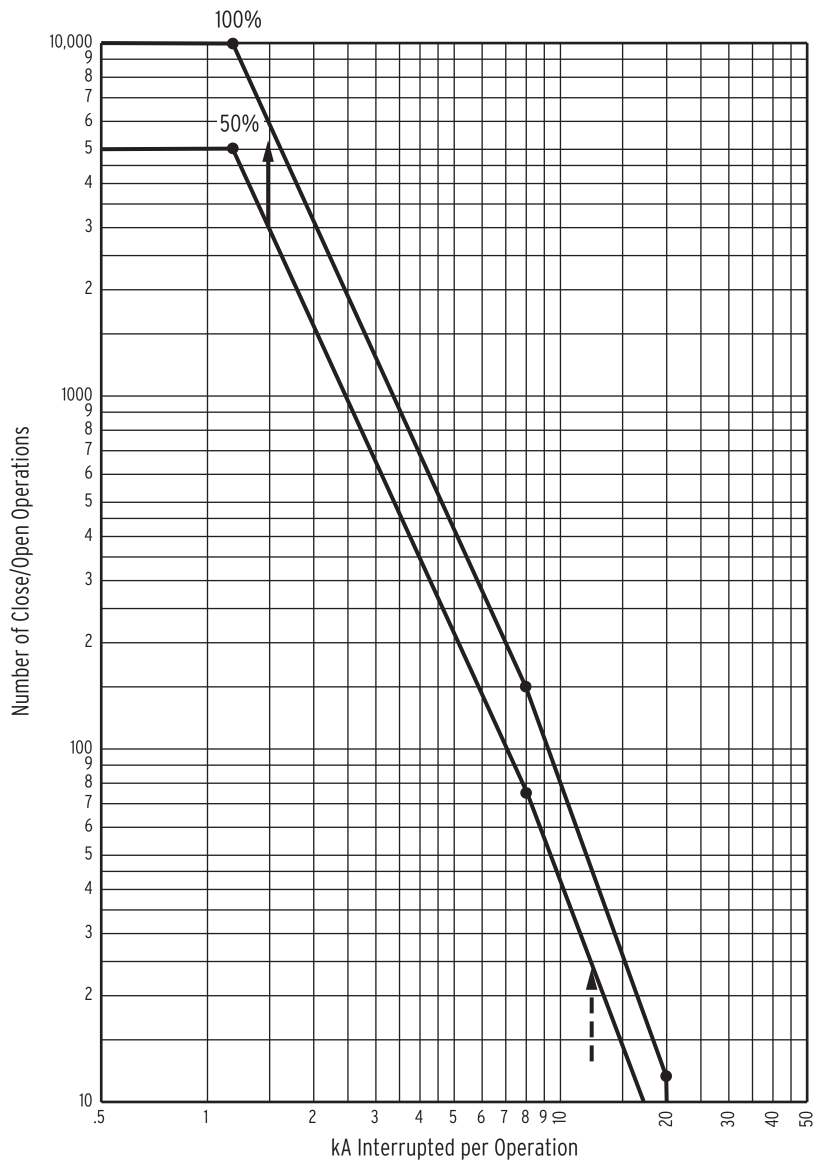

Figure 5.25 Breaker Monitor Accumulates 100 Percent Wear

Breaker Monitor Output

When the breaker maintenance curve for a particular phase (A, B, or C) reaches the 100 percent wear level (see *Figure 5.25*), a corresponding Relay Word bit (BCWA, BCWB, or BCWC) asserts.

Relay Word Bits	Definition
BCWA	A-Phase breaker contact wear has reached the 100 percent wear level
BCWB	B-Phase breaker contact wear has reached the 100 percent wear level
BCWC	C-Phase breaker contact wear has reached the 100 percent wear level
BCW	BCWA or BCWB or BCWC

EXAMPLE 5.1 Example Applications

These logic outputs can be used to alarm:

OUT*xxx* = **BCW**

or drive the relay to lockout the next time the relay trips:

79DTL = **TRIP AND BCW**

View or Reset Breaker Monitor Information

Accumulated breaker wear/operations data are retained if the relay loses power or the breaker monitor is disabled (setting EBMON := N). The accumulated data can only be reset if the **BRE R** command is executed (see the following discussion on the **BRE R** command).

Via Serial Port

See *Section 7: Communications*. The **BRE** 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 R** command)

See *Section 7: Communications*. The **BRE W** command allows the trip counters, accumulated values, and percent breaker wear to be preloaded for each individual phase.

The **BRE 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 = logical 1). Execution of the **BRE R** command resets the wear levels for all three phases back to 0 percent and consequently causes Relay Word bit BCWA to deassert (BCWA = logical 0).

Via Front Panel

The information and reset functions available via the previously discussed serial port commands **BRE** and **BRE 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** command response that the accumulated number of trips and accumulated interrupted current are separated into two groups of data: that generated by **relay initiated trips** (Rly Trips) and that generated by **externally initiated trips** (Ext Trips). The categorization of these data is determined by the status of the TRIP Relay Word bit when the SELOGIC control equation breaker monitor initiation setting BKMON operates.

Refer to *Figure 5.21* and accompanying explanation. If BKMON newly asserts (logical 0 to logical 1 transition), the relay reads in the current values (Phases A, B, and C). Now the decision has to be made: where is this current and trip count information accumulated? Under **relay initiated trips or externally initiated trips**?

To make this determination, the status of the TRIP Relay Word bit is checked at the instant BKMON newly asserts (TRIP is the logic output of *Figure 4.79*). If TRIP is asserted (TRIP = logical 1), the current and trip count information is accumulated under **relay initiated trips** (Rly Trips). If TRIP is deasserted (TRIP = 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 5.21–Figure 5.25*).

Relay initiated trips (Rly Trips) are also referred to as **internally initiated trips** (Int Trips) in the course of this manual; the terms are interchangeable.

EXAMPLE 5.2 Factory Default Setting Example

As discussed previously, the SELOGIC control equation breaker monitor initiation factory-default setting is:

BKMON = **TRIP**

Thus, any new assertion of BKMON is deemed a relay trip, and the current and trip count information is accumulated under relay initiated trips (Rly Trips).

EXAMPLE 5.3 Additional Example

Refer to Figure 5.26. Output contact **OUT103** is set to provide tripping:

OUT103 = **TRIP**

Note that optoisolated input **INxxx** monitors the trip bus. If the trip bus is energized by output contact **OUT103**, an external control switch, or some other external trip, then **INxxx** is asserted.

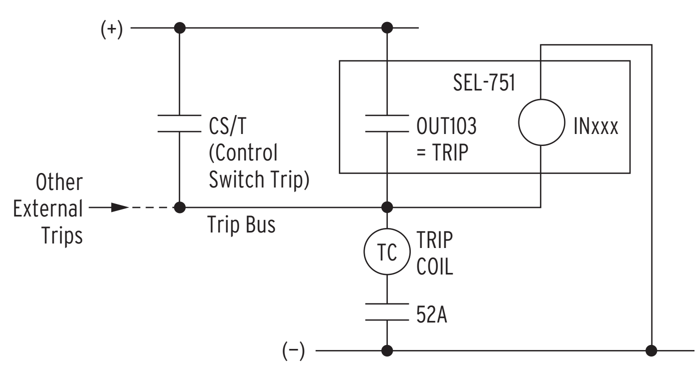

Figure 5.26 Input INxxx Connected to Trip Bus for Breaker Monitor Initiation

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

BKMON = **INxxx**

then the SEL-751 breaker monitor sees all trips.

If output contact **OUT103** asserts, energizing the trip bus, the breaker monitor deems it a relay initiated trip. This is because when BKMON is newly asserted (input **INxxx** energized), the TRIP 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 is newly asserted (input **INxxx** energized), the TRIP Relay Word bit is deasserted. Thus, the current and trip count information is accumulated under externally initiated trips (Ext Trips).

Section 6
Settings

Overview

The SEL-751 Feeder Protection Relay stores the settings you enter in nonvolatile memory. Settings are divided into the following ten setting classes:

1. Relay Group *n* (where *n* = 1, 2, 3, or 4)
2. Logic Group *n* (where *n* = 1, 2, 3, or 4)
3. Global
4. Port *p* (where *p* = F, 1 [Ethernet], 2, 3, or 4)
5. Front Panel
6. Report
7. Modbus
8. DNP3
9. IEC 60870-5-103
10. Touchscreen (this setting class is only available for models with the color touchscreen display).

Some setting classes have multiple instances. In the previous list, there are five port setting instances, one for each port. Settings can be viewed or set in several ways, as shown in *Table 6.1*.

Table 6.1 Methods of Accessing Settings[a]

	Serial Port Commands[b]	Front-Panel HMI Set/Show Menu[c]	ACSELERATOR QuickSet SEL-5030 (PC software)[d]
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] These setting access methods do not apply to the touchscreen settings.
[b] Refer to Section 7: Communications for detailed information on setup and use of the serial communications port and Ethernet port.
[c] Refer to Section 8: Front-Panel Operations for detailed information on the front-panel layout, menus and screens, and operator control pushbuttons.
[d] Refer to Section 3: PC Software for detailed information.

The *SEL-751 Settings Sheets* at the end of this section list all SEL-751 settings, the setting definitions, and input ranges. Refer to *Section 4: Protection and Logic Functions* for detailed information on individual elements and settings.

Touchscreen settings are only available through QuickSet for models with the color touchscreen display. These settings are not available via ASCII terminal, unlike the other relay settings. Refer to *Section 9: Bay Control* for detailed information on individual settings.

View/Change Settings With the Two-Line Front Panel

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

Enter the front-panel menu by pushing the **ESC** pushbutton. The following message displays:

```
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-751 Settings Sheets*. Use the **Up Arrow**, **Down Arrow**, **Left Arrow**, and **Right Arrow** pushbuttons to scroll through the relay settings. View and change the settings according to your needs by selecting and editing them. After viewing or changing the RELAY settings, press the **ESC** pushbutton until the following message appears:

```
Save Changes?
Yes   No
```

NOTE: Each SEL-751 is shipped with default factory settings. Calculate the settings for your application to ensure secure and dependable protection. Document the settings on the SEL-751 Settings Sheets at the end of this section before entering new settings in the relay.

Select and enter the appropriate command by pushing the **ENT** pushbutton. Select Yes to save the settings changes and No to discard the changes.

Figure 6.1 shows a front-panel menu navigation example for the relay to enter the PHASE PT RATIO, PTR setting.

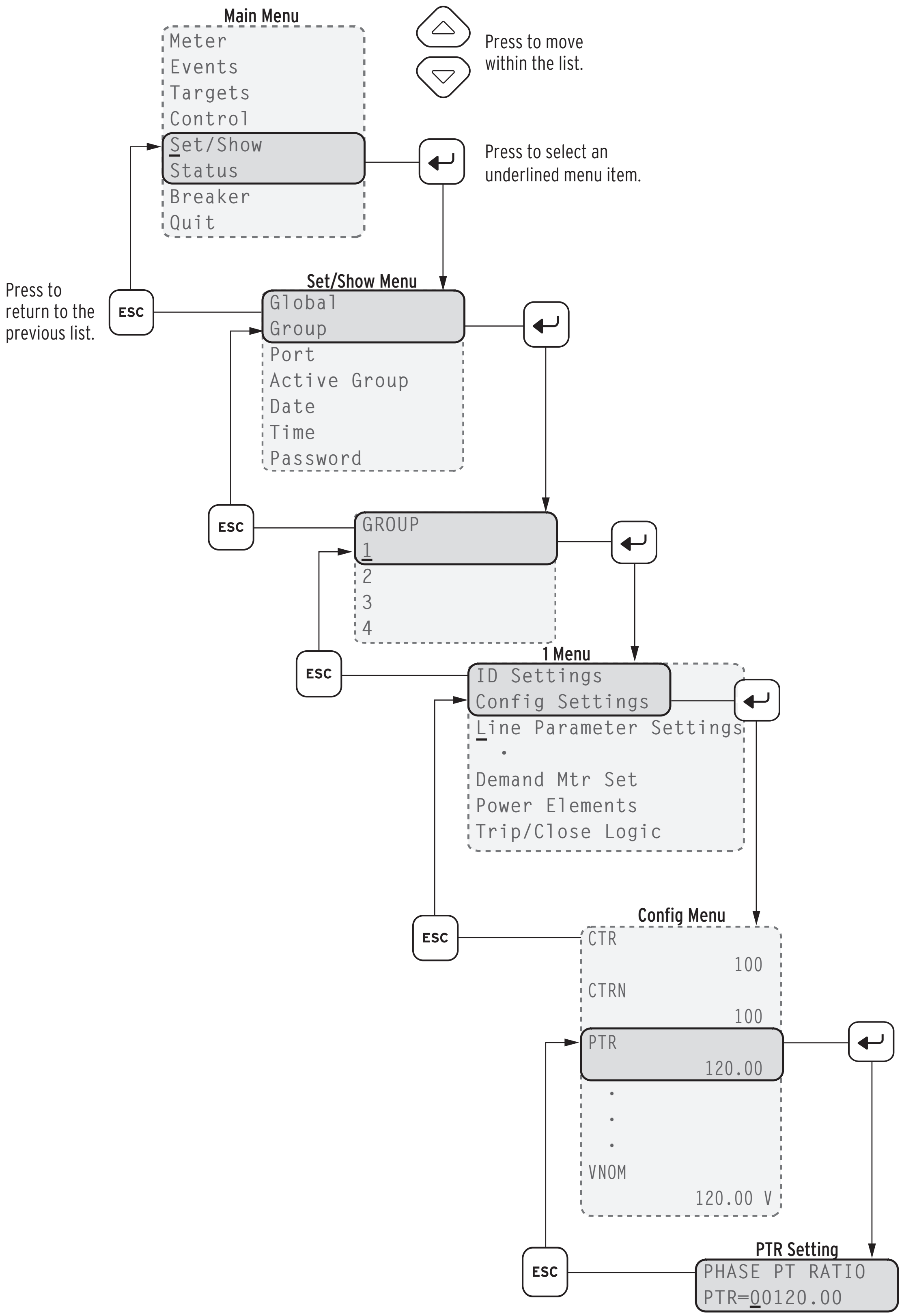

Figure 6.1 Front-Panel Setting Entry Example

View/Change Settings With the Touchscreen Front Panel

You can view or change Port, Global, Group, Date and Time, and Touchscreen settings using the touchscreen display. Tapping the **Settings** folder on the **Home** screen navigates you to the **Settings** screen through which you can view or change settings. Refer to *Touchscreen Display Front Panel* for detailed information on how to view or change settings using the touchscreen display.

View/Change Settings Over Communications Port

Refer to *Section 7: Communications* for information on how to set up and access the relay serial or Ethernet port with a personal computer and how to use ASCII commands to communicate with the relay.

View Settings

Use the **SHOW** command to view relay settings. The **SHOW** command is available from Access Level 1 and Access Level 2. *Table 6.2* lists the **SHOW** command options.

Table 6.2 SHOW Command Options

Command	Description
SHOW *n*	Show relay group settings: *n* specifies the settings group (1, 2, 3, or 4); *n* defaults to active settings group if not listed.
SHO L *n*	Show logic settings: *n* specifies the settings group (1, 2, 3, or 4); *n* defaults to 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 Events Recorder (SER) Report and Event Report settings.
SHO M	Show Modbus settings.
SHO D	Show DNP3 map settings.
SHO I	Show IEC 60870-5-103 map settings.

You can append a setting name to each of the commands to specify the first setting to display (e.g., **SHO 50P1P** displays the relay settings starting with setting 50P1P). 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.

NOTE: The **SET** command is not available for as long as 90 seconds after the relay is powered up and as long as 40 seconds after a setting change. If you issue a **SET** command during this period, the relay responds with the following message:

```
Command Unavailable;
Relay Configuration in
Progress, Try Again.
```

Table 6.3 SET Command Options (Sheet 1 of 2)

Command	Settings Type	Description
SET *n*	Relay	Protection elements, timers, etc., for settings group *n* (1, 2, 3, or 4)
SET L *n*	Logic	SELOGIC control equations for settings group *n* (1, 2, 3, or 4)
SET G	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)

Table 6.3 SET Command Options (Sheet 2 of 2)

Command	Settings Type	Description
SET F	Front Panel	Front-panel display and LED settings
SET R	Reports	SER and Event Report settings
SET M	Modbus	Modbus user map settings
SET D	DNP3	DNP3 map settings
SET I	IEC 60870-5-103	IEC 60870-5-103 user map

You can append a setting name to each of the commands to specify the first setting to display (e.g., **SET 50P1P** displays the relay settings starting with setting 50P1P). The default is the first setting.

When you issue the **SET** command, the relay presents a list of settings one at a time. Enter a new setting or press **<Enter>** to accept the existing setting. Editing keystrokes are listed in *Table 6.4*.

Table 6.4 SET Command Editing Keystrokes

Press Key(s)	Results
<Enter>	Retains the setting and moves to the next setting.
^ <Enter>	Returns to the previous setting.
< <Enter>	Returns to the previous setting category.
> <Enter>	Moves to the next setting category.
END <Enter>	Exits the editing session, then prompts you to save the settings.
<Ctrl+X>	Aborts the editing session without saving changes.

The relay checks each entry to ensure that the entry is within the setting range. If it is not in range, an `Out of Range` message is generated, and the relay prompts you for the setting again.

When all the settings are entered, the relay displays the new settings and prompts you for approval to enable them. Press **Y <Enter>** to enable the new settings. The relay is disabled for as long as five seconds while it saves the new settings. The SALARM Relay Word bit is set momentarily, and in the two-line display model, the ENABLED LED extinguishes while the relay is disabled. In the touchscreen display model, the ENABLED LED stays illuminated while the relay saves the setting.

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 **50P1P** 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.

SEL-751 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 serial ports. See *Section 4: Protection and Logic Functions* for detailed descriptions of the settings.

- ➤ Some settings require an optional module. Refer to the SEL-751 Model Option Table, and the notes to the following settings for details on which settings are available in a specific model. ACSELERATOR QuickSet SEL-5030 Software, 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.
- ➤ 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 CT RATIO (1–5000) **CTR** := ________

NEUTRAL CT RATIO (1–5000) **CTRN** := ________

PHASE PT RATIO (1.00–10000.00) *(Shown if Slot Z = 8x)* **PTR** := ________

PHASE LEA RATIO (37.50–500000.00) *(Shown if Slot Z = Lx)* **LEA_R** := ________

PHASE LEA SCALE (1.00–13333.33 [autocalculated]) *(Shown if Slot Z = Lx)* **LEA_SC** := ________

SYNCV PT RATIO (1.00–10000.00) (*Shown if Slot E = 70*) **PTRS** := ________

SYNCV LEA RATIO (37.50–500000.00) (*Shown if Slot E = L0*) **LEA_S_R** := ________

SYNCV LEA SCALE (1.00–13333.33 [autocalculated]) *(Shown if Slot E = L0)* **LEA_S_SC** := ________

XFMR CONNECTION (WYE, DELTA) *(Hidden if Slot Z = Ax)* **DELTA_Y** := ________

VS CONNECTION (VS, 3V0) (*Shown if Slot E = 70 or L0)* **VSCONN** := ________

SINGLE V INPUT (Y, N) *(Hidden if Slot Z = Ax)* **SINGLEV** := ________

LINE VOLTAGE (OFF, 20.00–250.00 V{if DELTA_Y := DELTA}, OFF, 20.00–480.00 V{if DELTA_Y := WYE}) *(Hidden and set to OFF when Slot Z = Ax or SINGLEV = Y)* **VNOM** := ________

Line Parameters

(Hidden if VNOM := OFF)

POS SQ LN Z MAG (0.10–510.00 ohm {5 A nom}, (0.50–2550.00 ohm {1 A nom}) **Z1MAG** := ________

POS SQ LN Z ANG (5.00–90.00 deg) **Z1ANG** := ________

ZERO SQ LN Z MAG (0.10–510.00 ohm {5 A nom}, (0.50–2550.00 ohm {1 A nom}) **Z0MAG** := ________

ZERO SQ LN Z ANG (5.00–90.00 deg) **Z0ANG** := ________

ZERO SQ SR Z MAG (0.10–510.00 ohm {5 A nom}, (0.50–2550.00 ohm {1 A nom}) *(Hidden if DELTA_Y := WYE)*	**Z0SMAG :=** ______________
ZERO SQ SR Z ANG (0.00–90.00 deg) *(Hidden if := DELTA_Y := WYE)*	**Z0SANG :=** ______________
LINE LENGTH (0.10–999.00 unitless)	**LL :=** ______________

Fault Locator

(Hidden if Slot Z = Ax)

FLT LOC ENABLE (Y, N) *(Hidden and set to N if VNOM := OFF)*	**EFLOC :=** ______________

Maximum Phase Overcurrent

MAXP OC TRIP LVL (OFF, 0.25–100.00 A {5 A nom}, 0.05–20.00 A {1 A nom})	**50P1P :=** ______________
MAXP OC TRIP DLY (OFF, 0.00–400.00 s) *(Hidden if 50P1P := OFF)*	**50P1D :=** ______________
MAXP OC TRQ CON (SELOGIC) *(Hidden if 50P1P := OFF)*	**50P1TC :=** ______________
MAXP OC TRIP LVL (OFF, 0.25–100.00 A {5 A nom}, 0.05–20.00 A {1 A nom})	**50P2P :=** ______________
MAXP OC TRIP DLY (OFF, 0.00–400.00 s) *(Hidden if 50P2P := OFF)*	**50P2D :=** ______________
MAXP OC TRQ CON (SELOGIC) *(Hidden if 50P2P := OFF)*	**50P2TC :=** ______________
MAXP OC TRIP LVL (OFF, 0.25–100.00 A {5 A nom}, 0.05–20.00 A {1 A nom})	**50P3P :=** ______________
MAXP OC TRIP DLY (OFF, 0.00–400.00 s) *(Hidden if 50P3P := OFF)*	**50P3D :=** ______________
MAXP OC TRQ CON (SELOGIC) *(Hidden if 50P3P := OFF)*	**50P3TC :=** ______________
MAXP OC TRIP LVL (OFF, 0.25–100.00 A {5 A nom}, 0.05–20.00 A {1 A nom})	**50P4P :=** ______________
MAXP OC TRIP DLY (OFF, 0.00–400.00 s) *(Hidden if 50P4P := OFF)*	**50P4D :=** ______________
MAXP OC TRQ CON (SELOGIC) *(Hidden if 50P4P := OFF)*	**50P4TC :=** ______________

Neutral Overcurrent

NEUT OC TRIP LVL (OFF, 0.25–100.00 A {5 A nom}, 0.05–20.00 A {1 A nom}), 0.01–4.00 A {0.2 A nom})	**50N1P :=** ______________
NEUT OC TRIP DLY (OFF, 0.00–400.00 s) *(Hidden if 50N1P := OFF)*	**50N1D :=** ______________
NEUT OC TRQ CON (SELOGIC) *(Hidden if 50N1P := OFF)*	**50N1TC :=** ______________
NEUT OC TRIP LVL (OFF, 0.25–100.00 A {5 A nom}, 0.05–20.00 A {1 A nom}, 0.01–4.00 A {0.2 A nom})	**50N2P :=** ______________
NEUT OC TRIP DLY (OFF, 0.00–400.00 s) *(Hidden if 50N2P := OFF)*	**50N2D :=** ______________
NEUT OC TRQ CON (SELOGIC) *(Hidden if 50N2P := OFF)*	**50N2TC :=** ______________
NEUT OC TRIP LVL (OFF, 0.25–100.00 A {5 A nom}, 0.05–20.00 A {1 A nom}, 0.01–4.00 A {0.2 A nom})	**50N3P :=** ______________
NEUT OC TRIP DLY (OFF, 0.00–400.00 s) *(Hidden if 50N3P := OFF)*	**50N3D :=** ______________
NEUT OC TRQ CON (SELOGIC) *(Hidden if 50N3P := OFF)*	**50N3TC :=** ______________
NEUT OC TRIP LVL (OFF, 0.25–100.00 A {5 A nom}, 0.05–20.00 A {1 A nom}, 0.01–4.00 A {0.2 A nom})	**50N4P :=** ______________
NEUT OC TRIP DLY (OFF, 0.00–400.00 s) *(Hidden if 50N4P := OFF)*	**50N4D :=** ______________
NEUT OC TRQ CON (SELOGIC) *(Hidden if 50N4P := OFF)*	**50N4TC :=** ______________

Residual Overcurrent

RES OC TRIP LVL (OFF, 0.25–100.00 A {5 A nom}, 0.05–20.00 A {1 A nom})	**50G1P :=** ______________
RES OC TRIP DLY (OFF, 0.00–400.00 s) *(Hidden if 50G1P := OFF)*	**50G1D :=** ______________
RES OC TRQ CON (SELOGIC) *(Hidden if 50G1P := OFF)*	**50G1TC :=** ______________
RES OC TRIP LVL (OFF, 0.25–100.00 A {5 A nom}, 0.05–20.00 A {1 A nom})	**50G2P :=** ______________
RES OC TRIP DLY (OFF, 0.00–400.00 s) *(Hidden if 50G2P := OFF)*	**50G2D :=** ______________
RES OC TRQ CON (SELOGIC) *(Hidden if 50G2P := OFF)*	**50G2TC :=** ______________
RES OC TRIP LVL (OFF, 0.25–100.00 A {5 A nom}, 0.05–20.00 A {1 A nom})	**50G3P :=** ______________
RES OC TRIP DLY (OFF, 0.00–400.00 s) *(Hidden if 50G3P := OFF)*	**50G3D :=** ______________
RES OC TRQ CON (SELOGIC) *(Hidden if 50G3P := OFF)*	**50G3TC :=** ______________
RES OC TRIP LVL (OFF, 0.25–100.00 A {5 A nom}, 0.05–20.00 A {1 A nom})	**50G4P :=** ______________
RES OC TRIP DLY (OFF, 0.00–400.00 s) *(Hidden if 50G4P := OFF)*	**50G4D :=** ______________
RES OC TRQ CON (SELOGIC) *(Hidden if 50G4P := OFF)*	**50G4TC :=** ______________

Negative-Sequence Overcurrent

NSEQ OC TRIP LVL (OFF, 0.25–100.00 A {5 A nom}, 0.05–20.00 A {1 A nom})	**50Q1P :=** ______________
NSEQ OC TRIP DLY (OFF, 0.00–400.0 s) *(Hidden if 50Q1P := OFF)*	**50Q1D :=** ______________
NSEQ OC TRQ CON (SELOGIC) *(Hidden if 50Q1P := OFF)*	**50Q1TC :=** ______________
NSEQ OC TRIP LVL (OFF, 0.25–100.00 A {5 A nom}, 0.05–20.00 A {1 A nom})	**50Q2P :=** ______________
NSEQ OC TRIP DLY (OFF, 0.00–400.0 s) *(Hidden if 50Q2P := OFF)*	**50Q2D :=** ______________
NSEQ OC TRQ CON (SELOGIC) *(Hidden if 50Q2P := OFF)*	**50Q2TC :=** ______________
NSEQ OC TRIP LVL (OFF, 0.25–100.00 A {5 A nom}, 0.05–20.00 A {1 A nom})	**50Q3P :=** ______________
NSEQ OC TRIP DLY (OFF, 0.00–400.0 s) *(Hidden if 50Q3P := OFF)*	**50Q3D :=** ______________
NSEQ OC TRQ CON (SELOGIC) *(Hidden if 50Q3P := OFF)*	**50Q3TC :=** ______________
NSEQ OC TRIP LVL (OFF, 0.25–100.00 A {5 A nom}, 0.05–20.00 A {1 A nom})	**50Q4P :=** ______________
NSEQ OC TRIP DLY (OFF, 0.00–400.0 s) *(Hidden if 50Q4P := OFF)*	**50Q4D :=** ______________
NSEQ OC TRQ CON (SELOGIC) *(Hidden if 50Q4P := OFF)*	**50Q4TC :=** ______________

Phase Time-Overcurrent

TOC TRIP LVL (OFF, 0.25–24.00 A {5 A nom}, 0.05–4.80 A {1 A nom})	**51AP :=** ______________
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51AP := OFF)*	**51AC :=** ______________
TOC TIME DIAL (0.50–15.00 {if 51AC := U_}, 0.01–1.50 {if 51AC := C_}) *(Hidden if 51AP := OFF)*	**51ATD :=** ______________
EM RESET DELAY (Y, N) *(Hidden if 51AP := OFF)*	**51ARS :=** ______________
CONST TIME ADDER (0.00–1.00 s) *(Hidden if 51AP := OFF)*	**51ACT :=** ______________
MIN RESPONSE TIM (0.00–1.00 s) *(Hidden if 51AP := OFF)*	**51AMR :=** ______________
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51AP := OFF)*	**51ATC :=** ______________
TOC TRIP LVL (OFF, 0.25–24.00 A {5 A nom}, 0.05–4.80 A {1 A nom})	**51BP :=** ______________
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) (Hidden if 51BP := OFF)	**51BC :=** ______________
TOC TIME DIAL (0.50–15.00 {if 51BC := U_}, 0.01–1.50 {if 51BC := C_}) *(Hidden if 51BP := OFF)*	**51BTD :=** ______________

EM RESET DELAY (Y, N) *(Hidden if 51BP := OFF)*	**51BRS :=** ______________
CONST TIME ADDER (0.00–1.00 s) *(Hidden if 51BP := OFF)*	**51BCT :=** ______________
MIN RESPONSE TIM (0.00–1.00 s) *(Hidden if 51BP := OFF)*	**51BMR :=** ______________
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51BP := OFF)*	**51BTC :=** ______________
TOC TRIP LVL (OFF, 0.25–24.00 A {5 A nom}, 0.05–4.80 A {1 A nom})	**51CP :=** ______________
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51CP := OFF)*	**51CC :=** ______________
TOC TIME DIAL (0.50–15.00 {if 51CC := U_}, 0.01–1.50 {if 51CC := C_}) *(Hidden if 51CP := OFF)*	**51CTD :=** ______________
EM RESET DELAY (Y, N) *(Hidden if 51CP := OFF)*	**51CRS :=** ______________
CONST TIME ADDER (0.00–1.00 s) *(Hidden if 51CP := OFF)*	**51CCT :=** ______________
MIN RESPONSE TIM (0.00–1.00 s) *(Hidden if 51CP := OFF)*	**51CMR :=** ______________
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51CP := OFF)*	**51CTC :=** ______________

Maximum Phase Time-Overcurrent

TOC TRIP LVL (OFF, 0.25–24.00 A {5 A nom}, 0.05–4.80 A {1 A nom})	**51P1P :=** ______________
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51P1P := OFF)*	**51P1C :=** ______________
TOC TIME DIAL (0.50–15.00 {if 51P1C := U_}, 0.01–1.50 {if 51P1C := C_}) *(Hidden if 51P1P := OFF)*	**51P1TD :=** ______________
EM RESET DELAY (Y, N) *(Hidden if 51P1P := OFF)*	**51P1RS :=** ______________
CONST TIME ADDER (0.00–1.00 s) *(Hidden if 51P1P := OFF)*	**51P1CT :=** ______________
MIN RESPONSE TIM (0.00–1.00 s) *(Hidden if 51P1P := OFF)*	**51P1MR :=** ______________
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51P1P := OFF)*	**51P1TC :=** ______________
TOC TRIP LVL (OFF, 0.25–24.00 A {5 A nom}, 0.05–4.80 A {1 A nom})	**51P2P :=** ______________
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51P2P := OFF)*	**51P2C :=** ______________
TOC TIME DIAL (0.50–15.00 {if 51P2C := U_}, 0.01–1.50 {if 51P2C := C_}) *(Hidden if 51P2P := OFF)*	**51P2TD :=** ______________
EM RESET DELAY (Y, N) *(Hidden if 51P2P := OFF)*	**51P2RS :=** ______________
CONST TIME ADDER (0.00–1.00 s) *(Hidden if 51P2P := OFF)*	**51P2CT :=** ______________
MIN RESPONSE TIM (0.00–1.00 s) *(Hidden if 51P2P := OFF)*	**51P2MR :=** ______________
TOC TRQ CONTROL (SELOGIC) (Hidden if 51P2P := OFF)	**51P2TC :=** ______________

Negative-Sequence Time-Overcurrent

TOC TRIP LVL (OFF, 0.25–24.00 A {5 A nom}, 0.05–4.80 A {1 A nom})	**51QP :=** ______________
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51QP := OFF)*	**51QC :=** ______________
TOC TIME DIAL (0.50–15.00 {if 51QC := U_}, 0.01–1.50 {if 51QC := C_}) *(Hidden if 51QP := OFF)*	**51QTD :=** ______________
EM RESET DELAY (Y, N) *(Hidden if 51QP := OFF)*	**51QRS :=** ______________
CONST TIME ADDER (0.00–1.00 s) *(Hidden if 51QP := OFF)*	**51QCT :=** ______________
MIN RESPONSE TIM (0.00–1.00 s) *(Hidden if 51QP := OFF)*	**51QMR :=** ______________
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51QP := OFF)*	**51QTC :=** ______________

Neutral Time-Overcurrent

TOC TRIP LVL (OFF, 0.25–24.00 A {5 A nom}, 0.05–4.80 A {1 A nom}, 10.00–960.00 mA {0.2 A nom})	**51N1P :=** ______________
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51N1P := OFF)*	**51N1C :=** ______________
TOC TIME DIAL (0.50–15.00 {if 51N1C := U_}, 0.01–1.50 {if 51N1C := C_}) *(Hidden if 51N1P := OFF)*	**51N1TD :=** ______________
EM RESET DELAY (Y, N) *(Hidden if 51N1P := OFF)*	**51N1RS :=** ______________
CONST TIME ADDER (0.00–1.00 s) *(Hidden if 51N1P := OFF)*	**51N1CT :=** ______________
MIN RESPONSE TIM (0.00–1.00 s) *(Hidden if 51N1P := OFF)*	**51N1MR :=** ______________
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51N1P := OFF)*	**51N1TC :=** ______________
TOC TRIP LVL (OFF, 0.25–24.00 A {5 A nom}, 0.05–4.80 A {1 A nom}, 10.00–960.00 mA {0.2 A nom})	**51N2P :=** ______________
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51N2P := OFF)*	**51N2C :=** ______________
TOC TIME DIAL (0.50–15.00 {if 51N2C := U_}, 0.01–1.50 {if 51N2C := C_}) *(Hidden if 51N2P := OFF)*	**51N2TD :=** ______________
EM RESET DELAY (Y, N) *(Hidden if 51N2P := OFF)*	**51N2RS :=** ______________
CONST TIME ADDER (0.00–1.00 s) *(Hidden if 51N2P := OFF)*	**51N2CT :=** ______________
MIN RESPONSE TIM (0.00–1.00 s) *(Hidden if 51N2P := OFF)*	**51N2MR :=** ______________
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51N2P := OFF)*	**51N2TC :=** ______________

Residual Time-Overcurrent

TOC TRIP LVL (OFF, 0.25–24.00 A {5 A nom}, 0.05–4.80 A {1 A nom})	**51G1P :=** ______________
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51G1P := OFF)*	**51G1C :=** ______________
TOC TIME DIAL (0.50–15.00 {if 51G1C := U_}, 0.01–1.50 {if 51G1C := C_}) *(Hidden if 51G1P := OFF)*	**51G1TD :=** ______________
EM RESET DELAY (Y, N) *(Hidden if 51G1P := OFF)*	**51G1RS :=** ______________
CONST TIME ADDER (0.00–1.00 s) *(Hidden if 51G1P := OFF)*	**51G1CT :=** ______________
MIN RESPONSE TIM (0.00–1.00 s) *(Hidden if 51G1P := OFF)*	**51G1MR :=** ______________
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51G1P := OFF)*	**51G1TC :=** ______________
TOC TRIP LVL (OFF, 0.25–24.00 A {5 A nom}, 0.05–4.80 A {1 A nom})	**51G2P :=** ______________
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51G2P := OFF)*	**51G2C :=** ______________
TOC TIME DIAL (0.50–15.00 {if 51G2C := U_}, 0.01–1.50 {if 51G2C := C_}) *(Hidden if 51G2P := OFF)*	**51G2TD :=** ______________
EM RESET DELAY (Y, N) *(Hidden if 51G2P := OFF)*	**51G2RS :=** ______________
CONST TIME ADDER (0.00–1.00 s) *(Hidden if 51G2P := OFF)*	**51G2CT :=** ______________
MIN RESPONSE TIM (0.00–1.00 s) *(Hidden if 51G2P := OFF)*	**51G2MR :=** ______________
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51G2P := OFF)*	**51G2TC :=** ______________

Directional Control

(Hidden and EDIR is set to N if firmware option in the MOT is 0, 1, 3, or if Slot Z = Ax)

DIR CONTROL ENBL (Y, AUTO, N) **EDIR :=** ______________

Table SET.1 Range Dependencies for the EDIR Setting

VSCONN	SINGLEV[a]/VNOM	IN Nominal Current	EDIR Range
3V0	SINGLEV := Y	0.2 A or 1 A or 5 A	Y, N (AUTO is hidden from the range)
VS	SINGLEV := Y	0.2 A	EDIR hidden and forced to N
VS	VNOM := OFF	0.2 A	EDIR hidden and forced to N

[a] When SINGLEV := Y, VNOM is forced to OFF and hidden.

(The following directional control settings are hidden if EDIR := N.)

FWD DIR ON LOP (Y, N) *(Hidden and set to N if VNOM := OFF)* **EFWDLOP :=** ______________

DIR CONTROL LVL1 (F, R, N) **DIR1 :=** ______________

DIR CONTROL LVL2 (F, R, N) **DIR2 :=** ______________

DIR CONTROL LVL3 (F, R, N) **DIR3 :=** ______________

DIR CONTROL LVL4 (F, R, N) **DIR4 :=** ______________

GND DIR PRIORITY
Range is determined by the following table. **ORDER :=** ______________

Table SET.2 Range Dependencies for the ORDER Setting

DELTA_Y	SINGLEV	IN Nominal Current	VSCONN	ORDER Range
WYE	N	5 A or 1 A	VS	I, V, Q, IV, VI, QV, VQ, IQ, QI, IVQ, IQV, VQI, VIQ, QIV, QVI, OFF
DELTA	N	5 A or 1 A	VS	I, Q, IQ, QI, OFF
WYE	Y	5 A or 1 A	VS	I, OFF
DELTA	Y	5 A or 1 A	VS	I, OFF
WYE	N	0.2 A	VS	V, Q, P, U, VQ, QV, VP, QP, VS, VQS, QVS, VQP, QVP, OFF
DELTA	N	0.2 A	VS	Q, OFF
WYE	Y	0.2 A	VS	Hidden and set to OFF
DELTA	Y	0.2 A	VS	Hidden and set to OFF
WYE	N	5 A or 1 A	3V0	I, V, Q, IV, VI, QV, VQ, IQ, QI, IVQ, IQV, VQI, VIQ, QIV, QVI, OFF
DELTA	N	5 A or 1 A	3V0	I, V, Q, IV, VI, QV, VQ, IQ, QI, IVQ, IQV, VQI, VIQ, QIV, QVI, OFF
WYE	Y	5 A or 1 A	3V0	I, V, IV, VI, OFF
DELTA	Y	5 A or 1 A	3V0	I, V, IV, VI, OFF
WYE	N	0.2 A	3V0	V, Q, P, U, VQ, QV, VP, QP, VS, VQS, QVS, VQP, QVP, OFF
DELTA	N	0.2 A	3V0	V, Q, P, U, VQ, QV, VP, QP, VS, VQS, QVS, VQP, QVP, OFF
WYE	Y	0.2 A	3V0	V, P, U, VP, VS, OFF
DELTA	Y	0.2 A	3V0	V, P, U, VP, VS, OFF

PH DIR 3PH LVL (0.50–10.00 A {5 A nom}, 0.10–2.00 A {1 A nom}) *(Hidden if ELOAD := Y or hidden if VNOM := OFF)* **50PDIRP :=** ______________

FWD DIR Z2 LVL (–128.00 to 128.00 ohm {5 A nom}, –640.00 to 640.00 ohm {1 A nom}) *(Auto-set to Z2R –1/INOM and hidden if EDIR := AUTO; Hidden if VNOM := OFF)* **Z2F :=** ______________

REV DIR Z2 LVL (–128.00 to 128.00 ohm {5 A nom}, –640.00 to 640.00 ohm {1 A nom}) *(Auto-set to MIN [(Z1MAG/2) + (1/INOM), 640/INOM] and hidden if EDIR := AUTO. Hidden if VNOM := OFF)* **Z2R :=** ______________

FWD DIR NSEQ LVL (0.25–5.00 A {5 A nom}, 0.05–1.00 A {1 A nom}) *(Auto-set to 0.10 • INOM and hidden if EDIR := AUTO. Hidden if VNOM := OFF)* **50QFP :=** ______________

REV DIR NSEQ LVL (0.25–5.00 A {5 A nom}, 0.05–1.00 A {1 A nom}) *(Auto-set to 0.05 • INOM and hidden if EDIR := AUTO. Hidden if VNOM := OFF)*	**50QRP :=** ______________
I1 RST FAC I2/I1 (0.02–0.50) *(Auto-set to 0.10 and hidden if EDIR := AUTO; Hidden if VNOM := OFF)*	**a2 :=** ______________
I0 RST FAC I2/I0 (0.10–1.20) *(Auto-set to 0.20 and hidden if EDIR := AUTO; Hidden if VNOM := OFF)*	**k2 :=** ______________
FWD DIR RES LVL (0.05–5.00 A {5 A nom}, 0.01–1.00 A {1 A nom}) *(Auto-set to 0.10 • INOM and hidden if EDIR := AUTO; hidden if EDIR := Y and ORDER does not contain V or I)*	**50GFP :=** ______________
REV DIR RES LVL (0.05–5.00 A {5 A nom}, 0.01–1.00 A {1 A nom}) *(Auto-set to 0.05 • INOM and hidden if EDIR := AUTO; hidden if EDIR := Y and ORDER does not contain V or I)*	**50GRP :=** ______________
RES FACTOR IG/IN (OFF, 0.001–0.1) (*Hidden and forced to OFF if ORDER does not contain I or if EDIR ≠ Y*)	**KGN :=** ______________
MAX TRQ ANG (0.00–85.00 deg) (*Hidden and forced to 0 if KGN := OFF*)	**INMTA :=** ______________
I1 RST FAC I0/I1 (0.001–0.500) *(Auto-set to 0.10 and hidden if EDIR := AUTO; hidden if EDIR := Y and ORDER does not contain V or I)*	**a0 :=** ______________
FWD DIR Z0 LVL (–128.00 to +128.00 ohm {5 A nom}, –640.00 to +640.00 ohm {1 A nom}) **Note:** If EDIR := Y and ORDER does not contain V or S, Z0F is hidden. If EDIR := Y or AUTO and ORDER := U, Z0F is autoset to –0.10 and hidden. If EDIR := AUTO and ORDER contains V or S, Z0F is autoset to MIN [(Z0MAG/2), (640/INOM) – (1/INOM)]. If EDIR := Y and ORDER contains V or S, Z0F is available for user to set.	**Z0F :=** ______________
REV DIR Z0 LVL (–128.00 to +128.00 ohm {5 A nom}, –640.00 to +640.00 ohm {1 A nom}) **Note:** If EDIR :=Y and ORDER does not contain V or S, Z0R is hidden. If EDIR := Y or AUTO and ORDER := U, Z0R is autoset to 0.10 and hidden. If EDIR := AUTO and ORDER contains V or S, Z0R is autoset to MIN [(Z0MAG/2) + (1/INOM), 640/INOM] and hidden. If EDIR :=Y and ORDER contains V or S, Z0R is available for user to set.	**Z0R :=** ______________
ZRO SQ MX TQ ANG (–90.00 to +90.00 Dead band –5 to +5, deg) *(Auto-set to Z0ANG and hidden if EDIR:=AUTO; hidden if EDIR := Y and ORDER does not contain V or S)*	**Z0MTA :=** ______________
FWD DIR LVL ((0.025–25.000) • IN_{NOM} A) (*Hidden if ORDER does not contain S or U*)	**50NFP :=** ______________
REV DIR LVL ((0.025–25.000) • IN_{NOM} A) (*Hidden if ORDER does not contain S or U*)	**50NRP :=** ______________
RES FACTOR (0.001–0.500) *(Hidden if ORDER does not contain S or U)*	**A0n :=** ______________
ENABLE V0 IN DIR (SELOGIC) (*Hidden if EDIR := N*)	**EDIRIV :=** ______________

Wattmetric

(Hidden if EDIR := N or if ORDER does not contain P)

3V0 59 PICKUP (1–430 V)	**59RES :=** ______________
FWD WATT PICKUP (0.001–150.000 W)	**DIRWFP :=** ______________
REV WATT PICKUP (0.001–150.000 W)	**DIRWRP :=** ______________
WATTMETRIC DLY (0.0–18000.0 s)	**DIRWD :=** ______________

Harmonic Blocking

2ND HARM BLOCK (Y, N)	**EHBL2 :=** ______________
2ND HARM PU (5–100%) (*Hidden if EHBL2 := N*)	**HBL2P :=** ______________
2ND HARM PU DLY (0.00–320.00 s) (*Hidden if EHBL2 := N*)	**HBL2PU :=** ______________
2ND HARM DO DLY (0.00–320.00 s) (*Hidden if EHBL2 := N*)	**HBL2DO :=** ______________
2ND HARM TC (SELOGIC) (*Hidden if EHBL2 := N*)	**HBL2TC :=** ______________
5TH HARM BLOCK (Y, N)	**EHBL5 :=** ______________
5TH HARM PU (5–100%) (*Hidden if EHBL5 := N*)	**HBL5P :=** ______________
5TH HARM PU DLY (0.00–320.00 s) (*Hidden if EHBL5 := N*)	**HBL5PU :=** ______________
5TH HARM DO DLY (0.00–320.00 s) (*Hidden if EHBL5 := N*)	**HBL5DO :=** ______________
5TH HARM TC (SELOGIC) (*Hidden if EHBL5 := N*)	**HBL5TC :=** ______________

Load Encroachment

(Hidden if Slot Z = Ax)

LOAD ENCROACH EN (Y, N) *(Hidden and set to N if VNOM := OFF)*	**ELOAD :=** ______________
(The following load encroachment settings are hidden if ELOAD := N	
FWD LD IMPEDANCE (0.10–128.00 ohm {5 A nom}, 0.50 to 640.00 ohm {1 A nom})	**ZLF :=** ______________
POS-FWD LD ANGLE (–90.00 to 90.00 deg) *(PLAF must be greater than or equal to NLAF)*	**PLAF :=** ______________
NEG-FWD LD ANGLE (–90.00 to 90.00 deg) *(PLAF must be greater than or equal to NLAF)*	**NLAF :=** ______________
REV LD IMPEDANCE (0.10–128.00 ohm {5 A nom}, 0.50 to 640.00 ohm {1 A nom})	**ZLR :=** ______________
POS-REV LD ANGLE (90.00–270.00 deg) *(PLAR must be less than or equal to NLAR)*	**PLAR :=** ______________
NEG-REV LD ANGLE (90.00–270.00 deg) *(PLAR must be less than or equal to NLAR)*	**NLAR :=** ______________

High-Impedance Fault (HIF) Detection

(Hidden if firmware option in the MOT is 0, 1, 2, 4, 6, or 7 or if Slot Z = Ax)

HIF EN (Y, N, T)	**EHIF :=** ______________
(The following high-impedance fault detection settings are hidden if EHIF := N)	
HIF DETECTION SENSITIVITY (SELOGIC)	**HIFMODE :=** ______________
HIF EVENT REPORT EXT. TRIGGER (SELOGIC)	**HIFER :=** ______________
BEGIN 24 HOUR INITIAL HIF TUNING (SELOGIC)	**HIFITUNE :=** ______________

RTD

RTD ENABLE (INT, EXT, NONE)	**E49RTD :=** ______________
(All RTD settings are hidden if E49RTD := NONE)	
RTD1 LOCATION (OFF, WDG, BRG, AMB, OTH)	**RTD1LOC :=** ______________
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 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 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 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 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 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 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 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 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 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 and set to OFF if E49RTD := INT)*	**RTD11LOC :=** _______________

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 and set to OFF if E49RTD := INT)*	**RTD12LOC :=** ______________
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 :=** ______________

IEC Thermal Element

IEC THML ELEM (N, 1–3) *(The following IEC thermal settings are hidden if E49IEC := N)*	**E49IEC :=** ______________
AMB TMP SRC (OFF, RTD, RA) (*RTD is unavailable if E49RTD := NONE*)	**TAMB :=** ______________
AMB TMP SRC LOC (1–12 if TAMB := RTD, 1–128 if TAMB := RA) (*Hidden if TAMB := OFF*)	**TAMBLOC :=** ______________
TMP HLTH DO TIME (0.1–900.0 s) (*Hidden if TAMB is not set to RA*)	**THAMBDO :=** ______________
OPERATING QTY (IARMS, IBRMS, ICRMS, IMAX)	**THRO1 :=** ______________
BASIC CURR VALUE (0.1–3.0 pu)	**IBAS1 :=** ______________
CURRENT CORR FAC (1.00–2.00)	**KCONS1 :=** ______________
CURRENT PU (0.05–1.0 pu)	**IEQPU1 :=** ______________
TIME CONS SWI (SELOGIC)	**THST1 :=** ______________
HEAT TIME CONS (1–500 min)	**TCONH11 :=** ______________
COOL TIME CONS (1–500 min)	**TCONC11 :=** ______________
HEAT TIME CONS (1–500 min)	**TCONH12 :=** ______________
COOL TIME CONS (1–500 min)	**TCONC12 :=** ______________
TRIP PU (1–150%)	**THLT1 :=** ______________
ALARM PU (1–100%)	**THLA1 :=** ______________
ALARM DO RATIO (0.01–0.99 pu)	**THLADR1 :=** ______________
TRIP DO RATIO (0.01–0.99 pu)	**THLTDR1 :=** ______________
MAXIMUM TMP (80–300°C)	**TMAX1 :=** ______________
RESET THML (SELOGIC)	**RSTTH1 :=** ______________
OPERATING QTY (IARMS, IBRMS, ICRMS, IMAX) (*Hidden if E49IEC < 2*)	**THRO2 :=** ______________
BASIC CURR VALUE (0.1–3.0 pu) (*Hidden if E49IEC < 2*)	**IBAS2 :=** ______________
CURRENT CORR FAC (1.00–2.00) (*Hidden if E49IEC < 2*)	**KCONS2 :=** ______________
CURRENT PU (0.05–1.00 pu) (*Hidden if E49IEC < 2*)	**IEQPU2 :=** ______________
TIME CONS SWI (SELOGIC) (*Hidden if E49IEC < 2*)	**THST2 :=** ______________
HEAT TIME CONS (1–500 min) (*Hidden if E49IEC < 2)*	**TCONH21 :=** ______________

COOL TIME CONS (1–500 min) (*Hidden if E49IEC < 2*)	**TCONC21 :=** _______________
HEAT TIME CONS (1–500 min) (*Hidden if E49IEC < 2*)	**TCONH22 :=** _______________
COOL TIME CONS (1–500 min) (*Hidden if E49IEC < 2*)	**TCONC22 :=** _______________
TRIP PU (1–150%) (*Hidden if E49IEC < 2*)	**THLT2 :=** _______________
ALARM PU (1–100%) (*Hidden if E49IEC < 2*)	**THLA2 :=** _______________
ALARM DO RATIO (0.01–0.99 pu) (*Hidden if E49IEC < 2*)	**THLADR2 :=** _______________
TRIP DO RATIO (0.01–0.99 pu) (*Hidden if E49IEC < 2*)	**THLTDR2 :=** _______________
MAXIMUM TMP (80–300°C) (*Hidden if E49IEC < 2*)	**TMAX2 :=** _______________
RESET THML (SELOGIC) (*Hidden if E49IEC < 2*)	**RSTTH2 :=** _______________
OPERATING QTY (IARMS, IBRMS, ICRMS, IMAX) (*Hidden if E49IEC < 3*)	**THRO3 :=** _______________
BASIC CURR VALUE (0.1–3.0 pu) (*Hidden if E49IEC < 3*)	**IBAS3 :=** _______________
CURRENT CORR FAC (1.00–2.00) (*Hidden if E49IEC < 3*)	**KCONS3 :=** _______________
CURRENT PU (0.05–1.0 pu) (*Hidden if E49IEC < 3*)	**IEQPU3 :=** _______________
TIME CONS SWI (SELOGIC) (*Hidden if E49IEC < 3*)	**THST3 :=** _______________
HEAT TIME CONS (1–500 min) (*Hidden if E49IEC < 3*)	**TCONH31 :=** _______________
COOL TIME CONS (1–500 min) (*Hidden if E49IEC < 3*)	**TCONC31 :=** _______________
HEAT TIME CONS (1–500 min) (*Hidden if E49IEC < 3*)	**TCONH32 :=** _______________
COOL TIME CONS (1–500 min) (*Hidden if E49IEC < 3*)	**TCONC32 :=** _______________
TRIP PU (1–150%) (*Hidden if E49IEC < 3*)	**THLT3 :=** _______________
ALARM PU (1–100%) (*Hidden if E49IEC < 3*)	**THLA3 :=** _______________
ALARM DO RATIO (0.01–0.99 pu) (*Hidden if E49IEC < 3*)	**THLADR3 :=** _______________
TRIP DO RATIO (0.01–0.99 pu) (*Hidden if E49IEC < 3*)	**THLTDR3 :=** _______________
MAXIMUM TMP (80–300 °C) (*Hidden if E49IEC < 3*)	**TMAX3 :=** _______________
RESET THML (SELOGIC) (*Hidden if E49IEC < 3*)	**RSTTH3 :=** _______________

Undervoltage

(Hidden if Slot Z = Ax)

UV TRIP1 LEVEL (OFF, 2.00–300.00 V) *(Hidden if DELTA_Y := DELTA)*	**27P1P :=** _______________
UV TRIP1 DELAY (0.00–120.00 s) *(Hidden if 27P1P := OFF; or if DELTA_Y := DELTA)*	**27P1D :=** _______________
UV TRIP2 LEVEL (OFF, 2.00–300.00 V) *(Hidden if DELTA_Y := DELTA)*	**27P2P :=** _______________
UV TRIP2 DELAY (0.00–120.00 s) *(Hidden if 27P2P := OFF; hidden if DELTA_Y := DELTA)*	**27P2D :=** _______________
PP UV TRIP1 LEVEL (OFF, 2.00–300.00 V [DELTA_Y := DELTA] or 2.00–520.00 V [DELTA_Y := WYE]) *(Hidden if SINGLEV = Y and DELTA_Y = WYE)*	**27PP1P :=** _______________
PP UV TRIP1 DELAY (0.00–120.00 s) *(Hidden if 27PP1P := OFF)*	**27PP1D :=** _______________
PP UV TRIP2 LEVEL (OFF, 2.00–300.00 V [DELTA_Y = DELTA] or 2.00–520.00 V [DELTA_Y := WYE]) *(Hidden if SINGLEV = Y and DELTA_Y = WYE)*	**27PP2P :=** _______________
PP UV TRIP2 DELAY (0.00–120.00 s) *(Hidden if 27PP2P := OFF)*	**27PP2D :=** _______________
UVS LEVEL 1 (OFF, 2.00–300.00 V) *(Shown if Slot E := 70 or L0)*	**27S1P :=** _______________
UVS DELAY 1 (0.00–120.00 s) *(Hidden if 27S1P := OFF)*	**27S1D :=** _______________
UVS LEVEL 2 (OFF, 2.00–300.00 V) *(Shown if Slot E := 70 or L0)*	**27S2P :=** _______________
UVS DELAY 2 (0.00–120.00 s) *(Hidden if 27S2P := OFF)*	**27S2D :=** _______________

Overvoltage

(Hidden if Slot Z = Ax)

OV TRIP1 LEVEL (OFF, 2.00–300.00 V) *(Hidden if DELTA_Y = DELTA)* **59P1P :=** _______________

OV TRIP1 DELAY (0.00–120.00 s) *(Hidden if 59P1P := OFF or if DELTA_Y = DELTA)* **59P1D :=** _______________

OV TRIP2 LEVEL (OFF, 2.00–300.00 V) *(Hidden if DELTA_Y = DELTA)* **59P2P :=** _______________

OV TRIP2 DELAY (0.00–120.00 s) *(Hidden if 59P2P := OFF or if DELTA_Y = DELTA)* **59P2D :=** _______________

PP OV TRIP1 LEVEL (OFF, 2.00–300.00 V [DELTA_Y := DELTA] or 2.00–520.00 V [DELTA_Y := WYE]) *(Hidden if SINGLEV = Y and DELTA_Y= WYE)* **59PP1P :=** _______________

PP OV TRIP1 DELAY (0.00–120.00 s) *(Hidden if 59PP1P := OFF)* **59PP1D :=** _______________

PP OV TRIP2 LEVEL (OFF, 2.00–300.00 V [DELTA_Y := DELTA] or 2.00–520.00 V [DELTA_Y := WYE]) *(Hidden if SINGLEV := Y and DELTA_Y = WYE)* **59PP2P :=** _______________

PP OV TRIP2 DELAY (0.00–120.00 s) *(Hidden if 59PP2P := OFF)* **59PP2D :=** _______________

ZS OV TRIP1 LVL (OFF, 2.00–300.00 V) *(Hidden if DELTA_Y = DELTA or SINGLEV := Y)* **59G1P :=** _______________

ZS OV TRIP1 DLY (0.00–120.00 s) *(Hidden if 59G1P := OFF; hidden if DELTA_Y = DELTA or SINGLEV := Y)* **59G1D :=** _______________

ZS OV TRIP2 LVL (OFF, 2.00–300.00 V) *(Hidden if DELTA_Y = DELTA or SINGLEV := Y)* **59G2P :=** _______________

ZS OV TRIP2 DLY (0.00–120.00 s) *(Hidden if 59G2P := OFF; hidden if DELTA_Y = DELTA or SINGLEV := Y)* **59G2D :=** _______________

NSQ OV TRIP1 LVL (OFF, 2.00–300.00 V) *(Hidden if SINGLEV = Y)* **59Q1P :=** _______________

NSQ OV TRIP1 DLY (0.00–120.00 s) *(Hidden if 59Q1P := OFF; hidden if SINGLEV = Y)* **59Q1D :=** _______________

NSQ OV TRIP2 LVL (OFF, 2.00–300.00 V) *(Hidden if SINGLEV = Y)* **59Q2P :=** _______________

NSQ OV TRIP2 DLY (0.00–120.00 s) *(Hidden if 59Q2P := OFF; hidden if SINGLEV = Y)* **59Q2D :=** _______________

OVS LEVEL 1 (OFF, 2.00–300.00 V) *(Shown if Slot E = 70 or L0)* **59S1P :=** _______________

OVS DELAY 1 (0.00–120.00 s) *(Hidden if 59S1P := OFF)* **59S1D :=** _______________

OVS LEVEL 2 (OFF, 2.00–300.00 V) *(Shown if Slot E = 70 or L0)* **59S2P :=** _______________

OVS DELAY 2 (0.00–120.00 s) *(Hidden if 59S2P := OFF)* **59S2D :=** _______________

27 Inverse-Time Undervoltage

(Hidden if Slot Z = Ax)

27I ENABLE (Y, N) **E27I1 :=** ______________

(The following 27I1 inverse-time undervoltage settings are hidden if E27I1 := N)

OPERATING QTY (*VS option is hidden if Slot E ≠ 70 or L0*)
See Table SET.3 for range dependencies. **27I1OQ :=** ______________

Table SET.3 Range Dependencies for 27I Operating Quantities

Settings			Operating Quantities									
DELTA_Y	VSCONN	SINGLEV	VAB	VBC	VCA	VA	VB	VC	V1	VS	MINLL	MINLN
DELTA	3V0	N	#	#	#	—	—	—	#	—	#	—
DELTA	3V0	Y	#	—	—	—	—	—	—	—	—	—
DELTA	VS	N	#	#	#	—	—	—	#	#	#	—
DELTA	VS	Y	#	—	—	—	—	—	—	#	—	—
WYE	VS	N	$	$	$	#	#	#	#	#	$	#
WYE	VS	Y	—	—	—	#	—	—	—	#	—	—
WYE	3V0	N	$	$	$	#	#	#	#	—	$	#
WYE	3V0	Y	—	—	—	#	—	—	—	—	—	—

= 2.00–300.00 V $ = 2.00–520.00 V

PICKUP LVL (2.00–300.00 V or 2.00–520.00 V from *Table SET.3*) **27I1P :=** ______________

CURVE (CURVEA, CURVEB, COEF) **27I1CRV :=** ______________

COEFF A (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **27I1CFA :=** ______________

COEFF B (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **27I1CFB :=** ______________

COEFF C (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **27I1CFC :=** ______________

TIME DIAL (0.00–16.00) **27I1TD :=** ______________

RESET TIME (0.00–1.00 s) **27I1TTR :=** ______________

TRQ CONTROL (SELOGIC) **27I1TC :=** ______________

27I ENABLE (Y, N) **E27I2 :=** ______________

(The following 27I2 settings are hidden if E27I2 := N)

OPERATING QTY (*VS option is hidden if Slot E ≠ 70 or L0*)
See Table SET.3 for range dependencies. **27I2OQ :=** ______________

PICKUP LVL (2.00–300.00 V or 2.00–520.00 V from *Table SET.3*) **27I2P :=** ______________

CURVE (CURVEA, CURVEB, COEF) **27I2CRV :=** ______________

COEFF A (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **27I2CFA :=** ______________

COEFF B (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **27I2CFB :=** ______________

COEFF C (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **27I2CFC :=** ______________

TIME DIAL (0.00–16.00) **27I2TD :=** ______________

RESET TIME (0.00–1.00 s) **27I2TTR :=** ______________

TRQ CONTROL (SELOGIC) **27I2TC :=** ______________

59 Inverse-Time Overvoltage

(Hidden if Slot Z = Ax)

59I ENABLE (Y, N) **E59I1 :=** ______________

(The following 59I1 inverse-time overvoltage settings are hidden if E59I1 := N)

OPERATING QTY (*VS option is hidden if Slot E ≠ 70 or L0*)
See Table SET.4 for range dependencies. **59I1OQ :=** ______________

Table SET.4 Range Dependencies for 59I Operating Quantities

Settings			Operating Quantities												
DELTA_Y	**VSCONN**	**SINGLEV**	**VAB**	**VBC**	**VCA**	**VA**	**VB**	**VC**	**VG**	**V1**	**3V2**	**3V0**	**VS**	**MAXLN**	**MAXLN**
DELTA	3V0	N	#	#	#	—	—	—	—	#	#	#	—	#	—
DELTA	3V0	Y	#	—	—	—	—	—	—	—	—	#	—	—	—
DELTA	VS	N	#	#	#	—	—	—	—	#	#	—	#	#	—
DELTA	VS	Y	#	—	—	—	—	—	—	—	—	—	#	—	—
WYE	VS	N	$	$	$	#	#	#	#	#	#	—	#	$	#
WYE	VS	Y	—	—	—	#	—	—	—	—	—	—	#	—	—
WYE	3V0	N	$	$	$	#	#	#	#	#	#	#	—	$	#
WYE	3V0	Y	—	—	—	#	—	—	—	—	—	#	—	—	—
# = 2.00–300.00 V $ = 2.00–520.00 V															

PICKUP LVL (2.00–300.00 V or 2.00–520.00 V from *Table SET.4*) **59I1P :=** ______________

CURVE (CURVEA, CURVEB, COEF) **59I1CR :=** ______________

COEFF A (0.00–6.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **59I1CFA :=** ______________

COEFF B (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **59I1CFB :=** ______________

COEFF C (0.01–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **59I1CFC :=** ______________

TIME DIAL (0.00–16.00) **59I1TD :=** ______________

RESET TIME (0.00–1.00 s) **59I1TTR :=** ______________

TRQ CONTROL (SELogic) **59I1TC :=** ______________

59I ENABLE (Y, N) **E59I2 :=** ______________

(The following 59I2 settings are hidden if E59I2 := N)

OPERATING QTY (*VS option is hidden if Slot E ≠ 70 or L0*)
See Table SET.4 for range dependencies. **59I2OQ :=** ______________

PICKUP LVL (2.00–300.00 V or 2.00–520.00 V from *Table SET.4*) **59I2P :=** ______________

CURVE (CURVEA, CURVEB, COEF) **59I2CRV :=** ______________

COEFF A (0.00–6.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **59I2CFA :=** ______________

COEFF B (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **59I2CFB :=** ______________

COEFF C (0.01–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **59I2CFC :=** ______________

TIME DIAL (0.00–16.00) **59I2TD :=** ______________

RESET TIME (0.00–1.00 s) **59I2TTR :=** ______________

TRQ CONTROL (SELogic) **59I2TC :=** ______________

59I ENABLE (Y, N)	**E59I3 :=** _______________
(The following 59I3 settings are hidden if E59I3 := N)	
OPERATING QTY (*VS option is hidden if Slot E ≠ 70 or L0*) *See Table SET.4 for range dependencies.*	**59I3OQ :=** _______________
PICKUP LVL (2.00–300.00 V or 2.00–520.00 V from *Table SET.4*)	**59I3P :=** _______________
CURVE (CURVEA, CURVEB, COEF)	**59I3CRV :=** _______________
COEFF A (0.00–6.00) *(Hidden if CURVE is set to CURVEA or CURVEB)*	**59I3CFA :=** _______________
COEFF B (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)*	**59I3CFB :=** _______________
COEFF C (0.01–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)*	**59I3CFC :=** _______________
TIME DIAL (0.00–16.00)	**59I3TD :=** _______________
RESET TIME (0.00–1.00 s)	**59I3TTR :=** _______________
TRQ CONTROL	**59I3TC :=** _______________
59I ENABLE (Y, N)	**E59I4 :=** _______________
(The following 59I4 settings are hidden if E59I4 := N)	
OPERATING QTY (*VS option is hidden if Slot E ≠ 70 or L0*) *See Table SET.4 for range dependencies.*	**59I4OQ :=** _______________
PICKUP LVL (2.00–300.00 V or 2.00–520.00 V from *Table SET.4*)	**59I4P :=** _______________
CURVE (CURVEA, CURVEB, COEF)	**59I4CRV :=** _______________
COEFF A (0.00–6.00) *(Hidden if CURVE is set to CURVEA or CURVEB)*	**59I4CFA :=** _______________
COEFF B (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)*	**59I4CFB :=** _______________
COEFF C (0.01–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)*	**59I4CFC :=** _______________
TIME DIAL (0.00–16.00)	**59I4TD :=** _______________
RESET TIME (0.00–1.00 s)	**59I4TTR :=** _______________
TRQ CONTROL (SELOGIC)	**59I4TC :=** _______________

Synchronism Check

(Hidden if Slot Z = Ax, Slot E ≠ 70 or L0, or VSCONN ≠ VS)

SYNCH CHECK (Y, N)	**E25 :=** _______________
(All the following Synchronism Check settings are hidden if E25 := N)	
VS WINDOW LOW (0.00–300.00 V)	**25VLO :=** _______________
VS WINDOW HIGH (0.00–300.00 V)	**25VHI :=** _______________
V RATIO COR FAC (0.50–2.00)	**25RCF :=** _______________
MAX SLIP FREQUENCY (0.05–0.50 Hz)	**25SF :=** _______________
MAX ANGLE 1 (0–80 deg)	**25ANG1 :=** _______________
MAX ANGLE 2 (0–80 deg)	**25ANG2 :=** _______________
SYNCPH PHASE (VA, VB, VC, 0, 30, 60, 90, 120, 150, 180, 210, 240, 270, 300 330 deg lag VA) *(Hidden if DELTA_Y := DELTA)*	**SYNCPH :=** _______________
SYNCPH PHASE (VAB, VBC, VCA, 0, 30, 60, 90, 120, 150, 180, 210, 240, 270, 300, 330 deg lag VAB) *(Hidden if DELTA_Y := WYE)*	**SYNCPH :=** _______________
BRKR CLOSE TIME (OFF, 1–1000 ms)	**TCLOSD :=** _______________
BLK SYNCH CHECK (SELOGIC)	**BSYNCH :=** _______________

Loss-of-Potential

(Hidden if Slot Z = Ax)

LOP BLOCK (SELOGIC) **LOPBLK :=** ______________

Power Factor

(Hidden if Slot Z = Ax)

PF LAG TRIP LEVL (OFF, 0.05–0.99) **55LGTP :=** ______________

PF LD TRIP LEVEL (OFF, 0.05–0.99) **55LDTP :=** ______________

PF TRIP DELAY (1–240 s) *(Hidden if both 55LDTP and 55LGTP := OFF)* **55TD :=** ______________

PF LAG WARN LEVL (OFF, 0.05–0.99) **55LGAP :=** ______________

PF LD WARN LEVEL (OFF, 0.05–0.99) **55LDAP :=** ______________

PF WARN DELAY (1–240 s) *(Hidden if both 55LDAP and 55LGAP := OFF)* **55AD :=** ______________

PF ARMING DELAY (0–5000 s)
(Hidden if all 55LGTP, 55LDTP, 55LGAP, and 55LDAP := OFF) **55DLY :=** ______________

Vector Shift

(Hidden if Slot Z = Ax)

EN VECTOR SHIFT (Y, N) *(Hidden when VNOM := OFF or SINGLEV :=Y)* **E78VS :=** ______________

The following vector shift element settings are hidden if E78VS := N.

VS ANGLE PU THR (2.0–30.0 deg) **78VSAPU :=** ______________

VS VOLT SUPV THR (20.0–100.0 %) **78VS59 :=** ______________

VS BLOCK (SELOGIC) **78VSBL :=** ______________

Frequency

FREQ1 TRIP LEVEL (OFF, 15.00–70.00 Hz) **81D1TP :=** __________

FREQ1 TRIP DELAY (0.00–240.00 s)
(Hidden if 81D1TP := OFF) **81D1TD :=** __________

81D1 TRQCTRL (SELOGIC)
(Hidden if 81D1TP := OFF) **81D1TC :=** __________

FREQ2 TRIP LEVEL (OFF, 15.00–70.00 Hz) **81D2TP :=** __________

FREQ2 TRIP DELAY (0.00–240.00 s)
(Hidden if 81D2TP := OFF) **81D2TD :=** __________

81D2 TRQCTRL (SELOGIC)
(Hidden if 81D2TP := OFF) **81D2TC :=** __________

FREQ3 TRIP LEVEL (OFF, 15.00–70.00 Hz) **81D3TP :=** __________

FREQ3 TRIP DELAY (0.00–240.00 s)
(Hidden if 81D3TP := OFF) **81D3TD :=** __________

81D3 TRQCTRL (SELOGIC)
(Hidden if 81D3TP := OFF) **81D3TC :=** __________

FREQ4 TRIP LEVEL (OFF, 15.00–70.00 Hz) **81D4TP :=** __________

FREQ4 TRIP DELAY (0.00–240.00 s)
(Hidden if 81D4TP := OFF) **81D4TD :=** __________

81D4 TRQCTRL (SELOGIC)
(Hidden if 81D4TP := OFF) **81D4TC :=** __________

FREQ5 TRIP LEVEL (OFF, 15.00–70.00 Hz) **81D5TP :=** __________

FREQ5 TRIP DELAY (0.00–240.00 s)
(Hidden if 81D5TP := OFF) **81D5TD :=** __________

81D5 TRQCTRL (SELOGIC)
(Hidden if 81D5TP := OFF) **81D5TC :=** __________

FREQ6 TRIP LEVEL (OFF, 15.00–70.00 Hz) **81D6TP :=** __________

FREQ6 TRIP DELAY (0.00–240.00 s)
(Hidden if 81D6TP := OFF) **81D6TD :=** __________

81D6 TRQCTRL (SELOGIC)
(Hidden if 81D6TP := OFF) **81D6TC :=** __________

Rate-of-Change of Frequency

(Hidden if Slot Z = Ax)

ENABLE 81R (N, 1–4)	**E81R :=** ______________
(The following rate-of-change-of-frequency settings are hidden if E81R := N)	
81R VOLTAGE SUP (OFF, 12.5–300.0 V)	**81RVSUP :=** ______________
81R CURRENT SUP (OFF, 0.5–10.0 A {5 A nom}, 0.1–2.0 A {1 A nom})	**81RISU P :=** ______________
81R1 TRIP LEVEL (OFF, 0.10–15.00 Hz/s)	**81R1TP :=** ______________
81R1 TREND (INC, DEC, ABS) (*Hidden if 81R1TP := OFF*)	**81R1TRND :=** ______________
81R1 TRIP DELAY (0.10–60.00 s) (*Hidden if 81R1TP := OFF*)	**81R1TD :=** ______________
81R1 DO DELAY (0.00–60.00 s) (*Hidden if 81R1TP := OFF*)	**81R1DO :=** ______________
81R1 TRQ CTRL (SELOGIC) (*Hidden if 81R1TP := OFF*)	**81R1TC :=** ______________
81R2 TRIP LEVEL (OFF, 0.10–15.00 Hz/s) *(Hidden if E81R < 2)*	**81R2TP :=** ______________
81R2 TREND (INC, DEC, ABS) (*Hidden if 81R2TP := OFF*)	**81R2TRND :=** ______________
81R2 TRIP DELAY (0.10–60.00 s) (*Hidden if 81R2TP := OFF*)	**81R2TD :=** ______________
81R2 DO DELAY (0.00–60.00 s) (*Hidden if 81R2TP := OFF*)	**81R2DO :=** ______________
81R2TRQ CTRL (SELOGIC) (*Hidden if 81R2TP := OFF or E81R < 2*)	**81R2TC :=** ______________
81R3 TRIP LEVEL (OFF, 0.10–15.00 Hz/s) *(Hidden if E81R < 3)*	**81R3TP :=** ______________
81R3 TREND (INC, DEC, ABS) (*Hidden if 81R3TP := OFF*)	**81R3TRND :=** ______________
81R3 TRIP DELAY (0.10–60.00 s) (*Hidden if 81R3TP := OFF*)	**81R3TD :=** ______________
81R3 DO DELAY (0.00–60.00 s) (*Hidden if 81R3TP := OFF*)	**81R3DO :=** ______________
81R3 TRQ CTRL (SELOGIC) (*Hidden if 81R3TP := OFF or E81R < 3*)	**81R3TC :=** ______________
81R4 TRIP LEVEL (OFF, 0.10–15.00 Hz/s) *(Hidden if E81R < 4)*	**81R4TP :=** ______________
81R4 TREND (INC, DEC, ABS) (*Hidden if 81R4TP := OFF*)	**81R4TRND :=** ______________
81R4 TRIP DELAY (0.10–60.00 s) (*Hidden if 81R4TP := OFF*)	**81R4TD :=** ______________
81R4 DO DELAY (0.00–60.00 s) (*Hidden if 81R4TP := OFF*)	**81R4DO :=** ______________
81R4 TRQ CTRL (SELOGIC) (*Hidden if 81R4TP := OFF or E81R < 4*)	**81R4TC :=** ______________

Fast Rate-of-Change of Frequency

(Hidden if Slot Z = Ax)

ENABLE 81RF (Y, N)	**E81RF :=** ______________
(The following fast rate-of-change-of-frequency settings are hidden if E81RF := N)	
FREQDIF SETPOINT (0.1–10.0 Hz)	**81RFDFP :=** ______________
DFDT SETPOINT (0.2–15.0 Hz/s)	**81RFRP :=** ______________
81RF PU DELAY (0.10–1.00 s)	**81RFPU :=** ______________
81RF DO DELAY (0.0–1.00 s)	**81RFDO :=** ______________
81RF VOLTAGE BLK (OFF, 2.00–300.00 V [DELTA_Y := DELTA] or 2.00–520.00 V [DELTA_Y := WYE])	**81RFVBLK :=** ______________
81RF CURRENT BLK (OFF, 0.5–100.0 A {5 A nom}, 0.1–20.0 A {1 A nom})	**81RFIBLK :=** ______________
81RF BLOCK (SELOGIC)	**81RFBL :=** ______________
81RF BLOCK DO (0.02–5.00 s)	**81RFBLDO :=** ______________

Demand Metering

ENABLE DEM MTR (THM, ROL)	**EDEM :=** ______________
DEM TIME CONSTNT (5, 10, 15, 30, 60 min)	**DMTC :=** ______________
PH CURR DEM LVL (OFF, 0.50–16.00 A {5 A nom}, 0.10–3.20 A {1 A nom})	**PHDEMP :=** ______________
RES CURR DEM LVL (OFF, 0.50–16.00 A {5 A nom}, 0.10–3.20 A {1 A nom})	**GNDEMP :=** ______________
3I2 CURR DEM LVL (OFF, 0.50–16.00 A {5 A nom}, 0.10–3.20 A {1 A nom})	**3I2DEMP :=** ______________

Power

(Hidden if Slot Z = Ax)

ENABLE PWR ELEM (N, 3P1, 3P2)	**EPWR :=** ______________
(All the following power element settings are hidden if EPWR := N)	
3PH PWR ELEM PU (OFF, 0.2–1300.00 VA {1 A phase CTs}, 1.0–6500.0 VA {5 A phase CTs})	**3PWR1P :=** ______________
PWR ELEM TYPE (+WATTS, –WATTS, +VARS, –VARS) *(Hidden if 3PRW1P := OFF)*	**PWR1T :=** ______________
PWR ELEM DELAY (0.0–240.0 s) *(Hidden if 3PRW1P := OFF)*	**PWR1D :=** ______________
3PH PWR ELEM PU (OFF, 0.2–1300.00 {1 A phase CTs}, 1.0–6500.0 VA {5 A phase CTs}) *(Hidden if EPWR := 3P1)*	**3PWR2P :=** ______________
PWR ELEM TYPE (+WATTS, –WATTS, +VARS, –VARS) *(Hidden if 3PRW2P := OFF or if EPWR := 3P1)*	**PWR2T :=** ______________
PWR ELEM DELAY (0.0–240.0 s) *(Hidden if 3PRW2P := OFF or if EPWR := 3P1)*	**PWR2D :=** ______________

Trip/Close Logic

MIN TRIP TIME (0.0–400.0 s)	**TDURD :=** ______________
CLOSE FAIL DLY (OFF, 0.0–400.0 s)	**CFD :=** ______________
TRIP EQUATION (SELOGIC)	**TR :=** ______________
REMOTE TRIP EQN (SELOGIC)	**REMTRIP :=** ______________
UNLATCH TRIP (SELOGIC)	**ULTRIP :=** ______________
BRKR N/O CONT (SELOGIC)	**52A :=** ______________
BRKR N/C CONT (SELOGIC)	**52B :=** ______________
CLOSE EQUATION (SELOGIC)	**CL :=** ______________
UNLATCH CLOSE (SELOGIC)	**ULCL :=** ______________

Reclosing Control

(Hidden if firmware option in the MOT is 0, 2, 3, or 6)

ENABLE RECLOSER (N, 1–4, C1–C4 shots)	**E79 :=** ______________
(The following reclosing control settings are hidden if E79 := N is selected.)	
OPEN INTERVAL 1 (0.00–3000.00 s) *(Forced to 0 if E79 := N)*	**79OI1 :=** ______________
OPEN INTERVAL 2 (0.00–3000.00 s) *(Hidden and forced to 0 if E79 < 2, or E79 := C1 or N)*	**79OI2 :=** ______________
OPEN INTERVAL 3 (0.00–3000.00 s) *(Hidden and forced to 0 if E79 < 3, or E79 := C1, C2, or N)*	**79OI3 :=** ______________
OPEN INTERVAL 4 (0.00–3000.00 s) *(Hidden and forced to 0 if E79 < 4, or E79 := C1, C2, C3, or N)*	**79OI4 :=** ______________
RST TM FROM RECL (0.00–3000.00 s)	**79RSD :=** ______________

RST TM FROM LO (0.00–3000.00 s)	**79RSLD :=** ______________
RECLS SUPV TIME (OFF, 0.00–3000.00 s) *(Forced to OFF if E79 := N)*	**79CLSD :=** ______________
RECLOSE INITIATE (SELOGIC)	**79RI :=** ______________
RCLS INIT SUPVSN (SELOGIC)	**79RIS :=** ______________
DRIVE-TO-LOCKOUT (SELOGIC)	**79DTL :=** ______________
DRIVE-TO-LSTSHOT (SELOGIC)	**79DLS :=** ______________
SKIP SHOT (SELOGIC)	**79SKP :=** ______________
STALL OPN INTRVL (SELOGIC)	**79STL :=** ______________
BLOCK RESET TMNG (SELOGIC)	**79BRS :=** ______________
SEQ COORDINATION (SELOGIC)	**79SEQ :=** ______________
RCLS SUPERVISION (SELOGIC)	**79CLS :=** ______________

Logic Settings (SET L Command)

SELOGIC Enables

SELOGIC LATCHES (N, 1–32)	**ELAT :=** ______________
SV/TIMERS (N, 1–32)	**ESV :=** ______________
SELOGIC COUNTERS (N, 1–32)	**ESC :=** ______________
MATH VARIABLES (N, 1–32)	**EMV :=** ______________

Latch Bits Equations

SET01 := ____

RST01 := ____

SET02 := ____

RST02 := ____

SET03 := ____

RST03 := ____

SET04 := ____

RST04 := ____

SET05 := ____

RST05 := ____

SET06 := ____

RST06 := ____

SET07 := ____

RST07 := ____

SET08 := ____

RST08 := ____

SET09 := ____

RST09 := ____

SET10 := ____

RST10 := ____

SET11 := ______________________________

RST11 := ______________________________

SET12 := ______________________________

RST12 := ______________________________

SET13 := ______________________________

RST13 := ______________________________

SET14 := ______________________________

RST14 := ______________________________

SET15 := ______________________________

RST15 := ______________________________

SET16 := ______________________________

RST16 := ______________________________

SET17 := ______________________________

RST17 := ______________________________

SET18 := ______________________________

RST18 := ______________________________

SET19 := ______________________________

RST19 := ______________________________

SET20 := ______________________________

RST20 := ______________________________

SET21 := ______________________________

RST21 := ______________________________

SET22 := ______________________________

RST22 := ______________________________

SET23 := ______________________________

RST23 := ______________________________

SET24 := ______________________________

RST24 := ______________________________

SET25 := ______________________________

RST25 := ______________________________

SET26 := ______________________________

RST26 := ______________________________

SET27 := ______________________________

RST27 := ______________________________

SET28 := ______________________________

RST28 := ______________________________

SET29 := ______________________________

RST29 := ______________________________

SET30 := ______________________________

RST30 := ______________________________

SET31 := ______________________________

RST31 := ______________________________

SET32 := ______________________________

RST32 := ______________________________

SV/Timers

SV TIMER PICKUP (0.00–3000.00 s) **SV01PU :=** ___________
SV TIMER DROPOUT (0.00–3000.00 s) **SV01DO :=** ___________

SV INPUT (SELOGIC) **SV01 :=** ______________________________
SV TIMER PICKUP (0.00–3000.00 s) **SV02PU :=** ___________
SV TIMER DROPOUT (0.00–3000.00 s) **SV02DO :=** ___________

SV INPUT (SELOGIC) **SV02 :=** ______________________________
SV TIMER PICKUP (0.00–3000.00 s) **SV03PU :=** ___________
SV TIMER DROPOUT (0.00–3000.00 s) **SV03DO :=** ___________

SV INPUT (SELOGIC) **SV03 :=** ______________________________
SV TIMER PICKUP (0.00–3000.00 s) **SV04PU :=** ___________
SV TIMER DROPOUT (0.00–3000.00 s) **SV04DO :=** ___________

SV INPUT (SELOGIC) **SV04 :=** ______________________________
SV TIMER PICKUP (0.00–3000.00 s) **SV05PU :=** ___________
SV TIMER DROPOUT (0.00–3000.00 s) **SV05DO :=** ___________

SV INPUT (SELOGIC) **SV05 :=** ______________________________
SV TIMER PICKUP (0.00–3000.00 s) **SV06PU :=** ___________
SV TIMER DROPOUT (0.00–3000.00 s) **SV06DO :=** ___________

SV INPUT (SELOGIC) **SV06 :=** ______________________________
SV TIMER PICKUP (0.00–3000.00 s) **SV07PU :=** ___________
SV TIMER DROPOUT (0.00–3000.00 s) **SV07DO :=** ___________

SV INPUT (SELOGIC) **SV07 :=** ______________________________
SV TIMER PICKUP (0.00–3000.00 s) **SV08PU :=** ___________
SV TIMER DROPOUT (0.00–3000.00 s) **SV08DO :=** ___________

SV INPUT (SELOGIC) **SV08 :=** ______________________________
SV TIMER PICKUP (0.00–3000.00 s) **SV09PU :=** ___________
SV TIMER DROPOUT (0.00–3000.00 s) **SV09DO :=** ___________

SV INPUT (SELOGIC) **SV09 :=** ______________________________
SV TIMER PICKUP (0.00–3000.00 s) **SV10PU :=** ___________
SV TIMER DROPOUT (0.00–3000.00 s) **SV10DO :=** ___________

SV INPUT (SELOGIC) **SV10 :=** ______________________________

SV TIMER PICKUP (0.00–3000.00 s)	**SV11PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV11DO :=** ______________
SV INPUT (SELOGIC)	**SV11 :=** ____
SV TIMER PICKUP (0.00–3000.00 s)	**SV12PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV12DO :=** ______________
SV INPUT (SELOGIC)	**SV12 :=** ____
SV TIMER PICKUP (0.00–3000.00 s)	**SV13PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV13DO :=** ______________
SV INPUT (SELOGIC)	**SV13 :=** ____
SV TIMER PICKUP (0.00–3000.00 s)	**SV14PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV14DO :=** ______________
SV INPUT (SELOGIC)	**SV14 :=** ____
SV TIMER PICKUP (0.00–3000.00 s)	**SV15PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV15DO :=** ______________
SV INPUT (SELOGIC)	**SV15 :=** ____
SV TIMER PICKUP (0.00–3000.00 s)	**SV16PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV16DO :=** ______________
SV INPUT (SELOGIC)	**SV16 :=** ____
SV TIMER PICKUP (0.00–3000.00 s)	**SV17PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV17DO :=** ______________
SV INPUT (SELOGIC)	**SV17 :=** ____
SV TIMER PICKUP (0.00–3000.00 s)	**SV18PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV18DO :=** ______________
SV INPUT (SELOGIC)	**SV18 :=** ____
SV TIMER PICKUP (0.00–3000.00 s)	**SV19PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV19DO :=** ______________
SV INPUT (SELOGIC)	**SV19 :=** ____
SV TIMER PICKUP (0.00–3000.00 s)	**SV20PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV20DO :=** ______________
SV INPUT (SELOGIC)	**SV20 :=** ____
SV TIMER PICKUP (0.00–3000.00 s)	**SV21PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV21DO :=** ______________
SV INPUT (SELOGIC)	**SV21 :=** ____
SV TIMER PICKUP (0.00–3000.00 s)	**SV22PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV22DO :=** ______________
SV INPUT (SELOGIC)	**SV22 :=** ____

SV TIMER PICKUP (0.00–3000.00 s) **SV23PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s) **SV23DO :=** ______________

SV INPUT (SELOGIC) **SV23 :=** ____
SV TIMER PICKUP (0.00–3000.00 s) **SV24PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s) **SV24DO :=** ______________

SV INPUT (SELOGIC) **SV24 :=** ____
SV TIMER PICKUP (0.00–3000.00 s) **SV25PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s) **SV25DO :=** ______________

SV INPUT (SELOGIC) **SV25 :=** ____
SV TIMER PICKUP (0.00–3000.00 s) **SV26PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s) **SV26DO :=** ______________

SV INPUT (SELOGIC) **SV26 :=** ____
SV TIMER PICKUP (0.00–3000.00 s) **SV27PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s) **SV27DO :=** ______________

SV INPUT (SELOGIC) **SV27 :=** ____
SV TIMER PICKUP (0.00–3000.00 s) **SV28PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s) **SV28DO :=** ______________

SV INPUT (SELOGIC) **SV28 :=** ____
SV TIMER PICKUP (0.00–3000.00 s) **SV29PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s) **SV29DO :=** ______________

SV INPUT (SELOGIC) **SV29 :=** ____
SV TIMER PICKUP (0.00–3000.00 s) **SV30PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s) **SV30DO :=** ______________

SV INPUT (SELOGIC) **SV30 :=** ____
SV TIMER PICKUP (0.00–3000.00 s) **SV31PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s) **SV31DO :=** ______________

SV INPUT (SELOGIC) **SV31 :=** ____
SV TIMER PICKUP (0.00–3000.00 s) **SV32PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s) **SV32DO :=** ______________
SV INPUT (SELOGIC) **SV32 :=** ____

Counters Equations

SC PRESET VALUE (1–65000) **SC01PV :=** ______________
SC RESET INPUT (SELOGIC) **SC01R :=** ____
SC LOAD PV INPUT (SELOGIC) **SC01LD :=** ____
SC CNT UP INPUT (SELOGIC) **SC01CU :=** ____
SC CNT DN INPUT (SELOGIC) **SC01CD :=** ____

SC PRESET VALUE (1–65000)	**SC02PV :=** ______________
SC RESET INPUT (SELOGIC)	**SC02R :=** ______________
SC LOAD PV INPUT (SELOGIC)	**SC02LD :=** ______________
SC CNT UP INPUT (SELOGIC)	**SC02CU :=** ______________
SC CNT DN INPUT (SELOGIC)	**SC02CD :=** ______________
SC PRESET VALUE (1–65000)	**SC03PV :=** ______________
SC RESET INPUT (SELOGIC)	**SC03R :=** ______________
SC LOAD PV INPUT (SELOGIC)	**SC03LD :=** ______________
SC CNT UP INPUT (SELOGIC)	**SC03CU :=** ______________
SC CNT DN INPUT (SELOGIC)	**SC03CD :=** ______________
SC PRESET VALUE (1–65000)	**SC04PV :=** ______________
SC RESET INPUT (SELOGIC)	**SC04R :=** ______________
SC LOAD PV INPUT (SELOGIC)	**SC04LD :=** ______________
SC CNT UP INPUT (SELOGIC)	**SC04CU :=** ______________
SC CNT DN INPUT (SELOGIC)	**SC04CD :=** ______________
SC PRESET VALUE (1–65000)	**SC05PV :=** ______________
SC RESET INPUT (SELOGIC)	**SC05R :=** ______________
SC LOAD PV INPUT (SELOGIC)	**SC05LD :=** ______________
SC CNT UP INPUT (SELOGIC)	**SC05CU :=** ______________
SC CNT DN INPUT (SELOGIC)	**SC05CD :=** ______________
SC PRESET VALUE (1–65000)	**SC06PV :=** ______________
SC RESET INPUT (SELOGIC)	**SC06R :=** ______________
SC LOAD PV INPUT (SELOGIC)	**SC06LD :=** ______________
SC CNT UP INPUT (SELOGIC)	**SC06CU :=** ______________
SC CNT DN INPUT (SELOGIC)	**SC06CD :=** ______________
SC PRESET VALUE (1–65000)	**SC07PV :=** ______________
SC RESET INPUT (SELOGIC)	**SC07R :=** ______________
SC LOAD PV INPUT (SELOGIC)	**SC07LD :=** ______________
SC CNT UP INPUT (SELOGIC)	**SC07CU :=** ______________
SC CNT DN INPUT (SELOGIC)	**SC07CD :=** ______________
SC PRESET VALUE (1–65000)	**SC08PV :=** ______________
SC RESET INPUT (SELOGIC)	**SC08R :=** ______________
SC LOAD PV INPUT (SELOGIC)	**SC08LD :=** ______________
SC CNT UP INPUT (SELOGIC)	**SC08CU :=** ______________
SC CNT DN INPUT (SELOGIC)	**SC08CD :=** ______________

SC PRESET VALUE (1–65000)	**SC09PV :=** _______________
SC RESET INPUT (SELOGIC)	**SC09R :=** _______________
SC LOAD PV INPUT (SELOGIC)	**SC09LD :=** _______________
SC CNT UP INPUT (SELOGIC)	**SC09CU :=** _______________
SC CNT DN INPUT (SELOGIC)	**SC09CD :=** _______________
SC PRESET VALUE (1–65000)	**SC10PV :=** _______________
SC RESET INPUT (SELOGIC)	**SC10R :=** _______________
SC LOAD PV INPUT (SELOGIC)	**SC10LD :=** _______________
SC CNT UP INPUT (SELOGIC)	**SC10CU :=** _______________
SC CNT DN INPUT (SELOGIC)	**SC10CD :=** _______________
SC PRESET VALUE (1–65000)	**SC11PV :=** _______________
SC RESET INPUT (SELOGIC)	**SC11R :=** _______________
SC LOAD PV INPUT (SELOGIC)	**SC11LD :=** _______________
SC CNT UP INPUT (SELOGIC)	**SC11CU :=** _______________
SC CNT DN INPUT (SELOGIC)	**SC11CD :=** _______________
SC PRESET VALUE (1–65000)	**SC12PV :=** _______________
SC RESET INPUT (SELOGIC)	**SC12R :=** _______________
SC LOAD PV INPUT (SELOGIC)	**SC12LD :=** _______________
SC CNT UP INPUT (SELOGIC)	**SC12CU :=** _______________
SC CNT DN INPUT (SELOGIC)	**SC12CD :=** _______________
SC PRESET VALUE (1–65000)	**SC13PV :=** _______________
SC RESET INPUT (SELOGIC)	**SC13R :=** _______________
SC LOAD PV INPUT (SELOGIC)	**SC13LD :=** _______________
SC CNT UP INPUT (SELOGIC)	**SC13CU :=** _______________
SC CNT DN INPUT (SELOGIC)	**SC13CD :=** _______________
SC PRESET VALUE (1–65000)	**SC14PV :=** _______________
SC RESET INPUT (SELOGIC)	**SC14R :=** _______________
SC LOAD PV INPUT (SELOGIC)	**SC14LD :=** _______________
SC CNT UP INPUT (SELOGIC)	**SC14CU :=** _______________
SC CNT DN INPUT (SELOGIC)	**SC14CD :=** _______________
SC PRESET VALUE (1–65000)	**SC15PV :=** _______________
SC RESET INPUT (SELOGIC)	**SC15R :=** _______________
SC LOAD PV INPUT (SELOGIC)	**SC15LD :=** _______________
SC CNT UP INPUT (SELOGIC)	**SC15CU :=** _______________
SC CNT DN INPUT (SELOGIC)	**SC15CD :=** _______________

SC PRESET VALUE (1–65000)	**SC16PV :=** ______________
SC RESET INPUT (SELOGIC)	**SC16R :=** ______________
SC LOAD PV INPUT (SELOGIC)	**SC16LD :=** ______________
SC CNT UP INPUT (SELOGIC)	**SC16CU :=** ______________
SC CNT DN INPUT (SELOGIC)	**SC16CD :=** ______________
SC PRESET VALUE (1–65000)	**SC17PV :=** ______________
SC RESET INPUT (SELOGIC)	**SC17R :=** ______________
SC LOAD PV INPUT (SELOGIC)	**SC17LD :=** ______________
SC CNT UP INPUT (SELOGIC)	**SC17CU :=** ______________
SC CNT DN INPUT (SELOGIC)	**SC17CD :=** ______________
SC PRESET VALUE (1–65000)	**SC18PV :=** ______________
SC RESET INPUT (SELOGIC)	**SC18R :=** ______________
SC LOAD PV INPUT (SELOGIC)	**SC18LD :=** ______________
SC CNT UP INPUT (SELOGIC)	**SC18CU :=** ______________
SC CNT DN INPUT (SELOGIC)	**SC18CD :=** ______________
SC PRESET VALUE (1–65000)	**SC19PV :=** ______________
SC RESET INPUT (SELOGIC)	**SC19R :=** ______________
SC LOAD PV INPUT (SELOGIC)	**SC19LD :=** ______________
SC CNT UP INPUT (SELOGIC)	**SC19CU :=** ______________
SC CNT DN INPUT (SELOGIC)	**SC19CD :=** ______________
SC PRESET VALUE (1–65000)	**SC20PV :=** ______________
SC RESET INPUT (SELOGIC)	**SC20R :=** ______________
SC LOAD PV INPUT (SELOGIC)	**SC20LD :=** ______________
SC CNT UP INPUT (SELOGIC)	**SC20CU :=** ______________
SC CNT DN INPUT (SELOGIC)	**SC20CD :=** ______________
SC PRESET VALUE (1–65000)	**SC21PV :=** ______________
SC RESET INPUT (SELOGIC)	**SC21R :=** ______________
SC LOAD PV INPUT (SELOGIC)	**SC21LD :=** ______________
SC CNT UP INPUT (SELOGIC)	**SC21CU :=** ______________
SC CNT DN INPUT (SELOGIC)	**SC21CD :=** ______________
SC PRESET VALUE (1–65000)	**SC22PV :=** ______________
SC RESET INPUT (SELOGIC)	**SC22R :=** ______________
SC LOAD PV INPUT (SELOGIC)	**SC22LD :=** ______________
SC CNT UP INPUT (SELOGIC)	**SC22CU :=** ______________
SC CNT DN INPUT (SELOGIC)	**SC22CD :=** ______________

SC PRESET VALUE (1–65000)	**SC23PV :=** _______________
SC RESET INPUT (SELOGIC)	**SC23R :=** _______________
SC LOAD PV INPUT (SELOGIC)	**SC23LD :=** _______________
SC CNT UP INPUT (SELOGIC)	**SC23CU :=** _______________
SC CNT DN INPUT (SELOGIC)	**SC23CD :=** _______________
SC PRESET VALUE (1–65000)	**SC24PV :=** _______________
SC RESET INPUT (SELOGIC)	**SC24R :=** _______________
SC LOAD PV INPUT (SELOGIC)	**SC24LD :=** _______________
SC CNT UP INPUT (SELOGIC)	**SC24CU :=** _______________
SC CNT DN INPUT (SELOGIC)	**SC24CD :=** _______________
SC PRESET VALUE (1–65000)	**SC25PV :=** _______________
SC RESET INPUT (SELOGIC)	**SC25R :=** _______________
SC LOAD PV INPUT (SELOGIC)	**SC25LD :=** _______________
SC CNT UP INPUT (SELOGIC)	**SC25CU :=** _______________
SC CNT DN INPUT (SELOGIC)	**SC25CD :=** _______________
SC PRESET VALUE (1–65000)	**SC26PV :=** _______________
SC RESET INPUT (SELOGIC)	**SC26R :=** _______________
SC LOAD PV INPUT (SELOGIC)	**SC26LD :=** _______________
SC CNT UP INPUT (SELOGIC)	**SC26CU :=** _______________
SC CNT DN INPUT (SELOGIC)	**SC26CD :=** _______________
SC PRESET VALUE (1–65000)	**SC27PV :=** _______________
SC RESET INPUT (SELOGIC)	**SC27R :=** _______________
SC LOAD PV INPUT (SELOGIC)	**SC27LD :=** _______________
SC CNT UP INPUT (SELOGIC)	**SC27CU :=** _______________
SC CNT DN INPUT (SELOGIC)	**SC27CD :=** _______________
SC PRESET VALUE (1–65000)	**SC28PV :=** _______________
SC RESET INPUT (SELOGIC)	**SC28R :=** _______________
SC LOAD PV INPUT (SELOGIC)	**SC28LD :=** _______________
SC CNT UP INPUT (SELOGIC)	**SC28CU :=** _______________
SC CNT DN INPUT (SELOGIC)	**SC28CD :=** _______________
SC PRESET VALUE (1–65000)	**SC29PV :=** _______________
SC RESET INPUT (SELOGIC)	**SC29R :=** _______________
SC LOAD PV INPUT (SELOGIC)	**SC29LD :=** _______________
SC CNT UP INPUT (SELOGIC)	**SC29CU :=** _______________
SC CNT DN INPUT (SELOGIC)	**SC29CD :=** _______________

SC PRESET VALUE (1–65000)		**SC30PV :=** ______________
SC RESET INPUT (SELOGIC)	**SC30R :=**	______________________________
SC LOAD PV INPUT (SELOGIC)	**SC30LD :=**	______________________________
SC CNT UP INPUT (SELOGIC)	**SC30CU :=**	______________________________
SC CNT DN INPUT (SELOGIC)	**SC30CD :=**	______________________________
SC PRESET VALUE (1–65000)		**SC31PV :=** ______________
SC RESET INPUT (SELOGIC)	**SC31R :=**	______________________________
SC LOAD PV INPUT (SELOGIC)	**SC31LD :=**	______________________________
SC CNT UP INPUT (SELOGIC)	**SC31CU :=**	______________________________
SC CNT DN INPUT (SELOGIC)	**SC31CD :=**	______________________________
SC PRESET VALUE (1–65000)		**SC32PV :=** ______________
SC RESET INPUT (SELOGIC)	**SC32R :=**	______________________________
SC LOAD PV INPUT (SELOGIC)	**SC32LD :=**	______________________________
SC CNT UP INPUT (SELOGIC)	**SC32CU :=**	______________________________
SC CNT DN INPUT (SELOGIC)	**SC32CD :=**	______________________________

Math Variables

MV01 := ____

MV02 := ____

MV03 := ____

MV04 := ____

MV05 := ____

MV06 := ____

MV07 := ____

MV08 := ____

MV09 := ____

MV10 := ____

MV11 := ____

MV12 := ____

MV13 := ____

MV14 := ____

MV15 := ____

MV16 := ____

MV17 := ____

MV18 := ____

MV19 := ____

MV20 := ____

MV21 := ____

MV22 := ____

MV23 := ____

MV24 := ____

MV25 := ____

MV26 := ____

MV27 := ____

MV28 := ____

MV29 := ____

MV30 := ____

MV31 := ____

MV32 := ____

Base Output

OUT101 FAIL-SAFE (Y, N) **OUT101FS :=** ______________

OUT101 := ____

OUT102 FAIL-SAFE (Y, N) **OUT102FS :=** ______________

OUT102 := ____

OUT103 FAIL-SAFE (Y, N) **OUT103FS :=** ______________

OUT103 := ____

Slot C Output

Hidden if an output option is not included. The number of outputs depends on the I/O card option.

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 an output option is not included. The number of outputs depends on the I/O card option.

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 an output option is not included. The number of outputs depends on the I/O card option.

OUT501 FAIL-SAFE (Y, N) **OUT501FS :=** ______________

OUT501 := ____

OUT502 FAIL-SAFE (Y, N) **OUT502FS :=** ______________

OUT502 := ____

OUT503 FAIL-SAFE (Y, N) **OUT503FS :=** ______________

OUT503 := ____

OUT504 FAIL-SAFE (Y, N) **OUT504FS :=** ______________

OUT504 := ____

OUT505 FAIL-SAFE (Y, N) **OUT505FS :=** ______________

OUT505 := ____

OUT506 FAIL-SAFE (Y, N) **OUT506FS :=** ______________

OUT506 := ____

OUT507 FAIL-SAFE (Y, N) **OUT507FS :=** ______________

OUT507 := ____

OUT508 FAIL-SAFE (Y, N) **OUT508FS :=** ______________

OUT508 := ____

MIRRORED BITS Transmit SELOGIC Control Equations

(Hidden if PROTO is not MBxx on any of the communications ports)

TMB1A := ____

TMB2A := ____

TMB3A := ____

TMB4A := ____

TMB5A := ____

TMB6A := ____

TMB7A := ____

TMB8A := ____

TMB1B := ____

TMB2B := ____

TMB3B := ____

TMB4B := ____

TMB5B := ____

TMB6B := ____

TMB7B := ____

TMB8B := ____

Global Settings (SET G Command)

General

PHASE ROTATION (ABC, ACB) **PHROT :=** ______________

RATED FREQ. (50, 60 Hz) **FNOM :=** ______________

DATE FORMAT (MDY, YMD, DMY) **DATE_F :=** ______________

MET CUTOFF THRES (Y, N) **METHRES :=** ______________

FAULT CONDITION (SELOGIC) **FAULT :=** ______________

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

Event Messenger Points

(Only the points enabled by EMP are visible.)

MESSENGER POINT MP01 TRIGGER (*OFF, 1 Relay Word bit*) **MPTR01 :=** ______________

MESSENGER POINT MP01 AQ (*None, 1 analog quantity*) **MPAQ01 :=** ______________

MESSENGER POINT MP01 TEXT (*148 characters*) **MPTX01 :=** ______________

MESSENGER POINT MP02 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR02 :=** ______________
MESSENGER POINT MP02 AQ (*None, 1 analog quantity*)	**MPAQ02 :=** ______________
MESSENGER POINT MP02 TEXT (*148 characters*)	**MPTX02 :=** ______________
MESSENGER POINT MP03 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR03 :=** ______________
MESSENGER POINT MP03 AQ (*None, 1 analog quantity*)	**MPAQ03 :=** ______________
MESSENGER POINT MP03 TEXT (*148 characters*)	**MPTX03 :=** ______________
MESSENGER POINT MP04 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR04 :=** ______________
MESSENGER POINT MP04 AQ (*None, 1 analog quantity*)	**MPAQ04 :=** ______________
MESSENGER POINT MP04 TEXT (*148 characters*)	**MPTX04 :=** ______________
MESSENGER POINT MP05 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR05 :=** ______________
MESSENGER POINT MP05 AQ (*None, 1 analog quantity*)	**MPAQ05 :=** ______________
MESSENGER POINT MP05 TEXT (*148 characters*)	**MPTX05 :=** ______________
MESSENGER POINT MP06 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR06 :=** ______________
MESSENGER POINT MP06 AQ (*None, 1 analog quantity*)	**MPAQ06 :=** ______________
MESSENGER POINT MP06 TEXT (*148 characters*)	**MPTX06 :=** ______________
MESSENGER POINT MP07 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR07 :=** ______________
MESSENGER POINT MP07 AQ (*None, 1 analog quantity*)	**MPAQ07 :=** ______________
MESSENGER POINT MP07 TEXT (*148 characters*)	**MPTX07 :=** ______________
MESSENGER POINT MP08 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR08 :=** ______________
MESSENGER POINT MP08 AQ (*None, 1 analog quantity*)	**MPAQ08 :=** ______________
MESSENGER POINT MP08 TEXT (*148 characters*)	**MPTX08 :=** ______________
MESSENGER POINT MP09 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR09 :=** ______________
MESSENGER POINT MP09 AQ (*None, 1 analog quantity*)	**MPAQ09 :=** ______________
MESSENGER POINT MP09 TEXT (*148 characters*)	**MPTX09 :=** ______________
MESSENGER POINT MP10 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR10 :=** ______________
MESSENGER POINT MP10 AQ (*None, 1 analog quantity*)	**MPAQ10 :=** ______________
MESSENGER POINT MP10 TEXT (*148 characters*)	**MPTX10 :=** ______________
MESSENGER POINT MP11 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR11 :=** ______________
MESSENGER POINT MP11 AQ (*None, 1 analog quantity*)	**MPAQ11 :=** ______________
MESSENGER POINT MP11 TEXT (*148 characters*)	**MPTX11 :=** ______________
MESSENGER POINT MP12 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR12 :=** ______________
MESSENGER POINT MP12 AQ (*None, 1 analog quantity*)	**MPAQ12 :=** ______________
MESSENGER POINT MP12 TEXT (*148 characters*)	**MPTX12 :=** ______________
MESSENGER POINT MP13 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR13 :=** ______________
MESSENGER POINT MP13 AQ (*None, 1 analog quantity*)	**MPAQ13 :=** ______________
MESSENGER POINT MP13 TEXT (*148 characters*)	**MPTX13 :=** ______________

MESSENGER POINT MP14 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR14 :=** ______________
MESSENGER POINT MP14 AQ (*None, 1 analog quantity*)	**MPAQ14 :=** ______________
MESSENGER POINT MP14 TEXT (*148 characters*)	**MPTX14 :=** ______________
MESSENGER POINT MP15 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR15 :=** ______________
MESSENGER POINT MP15 AQ (*None, 1 analog quantity*)	**MPAQ15 :=** ______________
MESSENGER POINT MP15 TEXT (*148 characters*)	**MPTX15 :=** ______________
MESSENGER POINT MP16 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR16 :=** ______________
MESSENGER POINT MP16 AQ (*None, 1 analog quantity*)	**MPAQ16 :=** ______________
MESSENGER POINT MP16 TEXT (*148 characters*)	**MPTX16 :=** ______________
MESSENGER POINT MP17 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR17 :=** ______________
MESSENGER POINT MP17 AQ (*None, 1 analog quantity*)	**MPAQ17 :=** ______________
MESSENGER POINT MP17 TEXT (*148 characters*)	**MPTX17 :=** ______________
MESSENGER POINT MP18 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR18 :=** ______________
MESSENGER POINT MP18 AQ (*None, 1 analog quantity*)	**MPAQ18 :=** ______________
MESSENGER POINT MP18 TEXT (*148 characters*)	**MPTX18 :=** ______________
MESSENGER POINT MP19 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR19 :=** ______________
MESSENGER POINT MP19 AQ (*None, 1 analog quantity*)	**MPAQ19 :=** ______________
MESSENGER POINT MP19 TEXT (*148 characters*)	**MPTX19 :=** ______________
MESSENGER POINT MP20 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR20 :=** ______________
MESSENGER POINT MP20 AQ (*None, 1 analog quantity*)	**MPAQ20 :=** ______________
MESSENGER POINT MP20 TEXT (*148 characters*)	**MPTX20 :=** ______________
MESSENGER POINT MP21 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR21 :=** ______________
MESSENGER POINT MP21 AQ (*None, 1 analog quantity*)	**MPAQ21 :=** ______________
MESSENGER POINT MP21 TEXT (*148 characters*)	**MPTX21 :=** ______________
MESSENGER POINT MP22 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR22 :=** ______________
MESSENGER POINT MP22 AQ (*None, 1 analog quantity*)	**MPAQ22 :=** ______________
MESSENGER POINT MP22 TEXT (*148 characters*)	**MPTX22 :=** ______________
MESSENGER POINT MP23 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR23 :=** ______________
MESSENGER POINT MP23 AQ (*None, 1 analog quantity*)	**MPAQ23 :=** ______________
MESSENGER POINT MP23 TEXT (*148 characters*)	**MPTX23 :=** ______________
MESSENGER POINT MP24 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR24 :=** ______________
MESSENGER POINT MP24 AQ (*None, 1 analog quantity*)	**MPAQ24 :=** ______________
MESSENGER POINT MP24 TEXT (*148 characters*)	**MPTX24 :=** ______________
MESSENGER POINT MP25 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR25 :=** ______________
MESSENGER POINT MP25 AQ (*None, 1 analog quantity*)	**MPAQ25 :=** ______________
MESSENGER POINT MP25 TEXT (*148 characters*)	**MPTX25 :=** ______________

MESSENGER POINT MP26 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR26 :=** _______________
MESSENGER POINT MP26 AQ (*None, 1 analog quantity*)	**MPAQ26 :=** _______________
MESSENGER POINT MP26 TEXT (*148 characters*)	**MPTX26 :=** _______________
MESSENGER POINT MP27 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR27 :=** _______________
MESSENGER POINT MP27 AQ (*None, 1 analog quantity*)	**MPAQ27 :=** _______________
MESSENGER POINT MP27 TEXT (*148 characters*)	**MPTX27 :=** _______________
MESSENGER POINT MP28 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR28 :=** _______________
MESSENGER POINT MP28 AQ (*None, 1 analog quantity*)	**MPAQ28 :=** _______________
MESSENGER POINT MP28 TEXT (*148 characters*)	**MPTX28 :=** _______________
MESSENGER POINT MP29 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR29 :=** _______________
MESSENGER POINT MP29 AQ (*None, 1 analog quantity*)	**MPAQ29 :=** _______________
MESSENGER POINT MP29 TEXT (*148 characters*)	**MPTX29 :=** _______________
MESSENGER POINT MP30 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR30 :=** _______________
MESSENGER POINT MP30 AQ (*None, 1 analog quantity*)	**MPAQ30 :=** _______________
MESSENGER POINT MP30 TEXT (*148 characters*)	**MPTX30 :=** _______________
MESSENGER POINT MP31 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR31 :=** _______________
MESSENGER POINT MP31 AQ (*None, 1 analog quantity*)	**MPAQ31 :=** _______________
MESSENGER POINT MP31 TEXT (*148 characters*)	**MPTX31 :=** _______________
MESSENGER POINT MP32 TRIGGER (*OFF, 1 Relay Word bit*)	**MPTR32 :=** _______________
MESSENGER POINT MP32 AQ (*None, 1 analog quantity*)	**MPAQ32 :=** _______________
MESSENGER POINT MP32 TEXT (*148 characters*)	**MPTX32 :=** _______________

Group Selection

GRP CHG DELAY (0–400 s)	**TGR :=** ____
SELECT GROUP1 (SELOGIC)	**SS1 :=** ____
SELECT GROUP2 (SELOGIC)	**SS2 :=** ____
SELECT GROUP3 (SELOGIC)	**SS3 :=** ____
SELECT GROUP4 (SELOGIC)	**SS4 :=** ____

LEA Phase Voltages

(The following LEA phase voltage settings are shown if Slot Z := Lx)

VA RATIO CORRECT (0.500–1.500)	**VARCF :=** _______________
VB RATIO CORRECT (0.500–1.500)	**VBRCF :=** _______________
VC RATIO CORRECT (0.500–1.500)	**VCRCF :=** _______________
VA ANGLE CORRECT (-10.0 to 10.0 deg)	**VAPAC :=** _______________
VB ANGLE CORRECT (-10.0 to 10.0 deg)	**VBPAC :=** _______________
VC ANGLE CORRECT (-10.0 to 10.0 deg)	**VCPAC :=** _______________

LEA Vsync Voltage

(The following LEA Vsync voltage settings are shown if Slot E := L0)

VS RATIO CORRECT (0.500–1.500)	**VSRCF :=** ______________
VS ANGLE CORRECT (-10.0 to 10.0 deg)	**VSPAC :=** ______________

Phasor Measurement (PMU)

EN SYNCHRO PHASOR (Y, N)	**EPMU :=** ______________
(All subsequent PMU 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 if Slot Z := Ax*)	**PHDATAV :=** ______________
VOLT COMP ANGLE (–179.99 to 180.00 deg) (*Hidden if PHDATAV := NA*)	**VCOMP :=** ______________
VS COMP ANGLE (–179.99 to 180.00 deg) *(Hidden if Slot E ≠ 70 or L0 or PHDATAV = NA)*	**VSCOMP :=** ______________
CURRENT DATA SET (I1, ALL, NA)	**PHDATAI :=** ______________
CURRENT COMP ANGLE (–179.99 to 180.00 deg) (*Hidden if PHDATAI := NA*)	**ICOMP :=** ______________
NUM ANALOG (0–4)	**NUMANA :=** ______________
NUM 16-BIT 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 hours; rounded up to quarter)	**UTC_OFF :=** ______________
MONTH TO BEGIN DST (OFF, 1–12)	**DST_BEGM :=** ______________
(The following time and date management settings are hidden if DST_BEGM := OFF)	
WEEK OF THE MONTH TO BEGIN DST ((1–3, L) L = Last week of the month)	**DST_BEGW :=** ______________
DAY OF THE WEEK TO BEGIN DST (SUN, MON, TUE, WED, THU, FRI, SAT)	**DST_BEGD :=** ______________
LOCAL HOUR TO BEGIN DST (0–23)	**DST_BEGH :=** ______________
MONTH TO END DST (1–12)	**DST_ENDM :=** ______________
WEEK OF THE MONTH TO END DST (1–3, L) L = Last week of the month	**DST_ENDW :=** ______________
DAY OF THE WEEK TO END DST (SUN, MON, TUE, WED, THU, FRI, SAT)	**DST_ENDD :=** ______________
LOCAL HOUR TO END DST (0–23)	**DST_ENDH :=** ______________

Breaker Failure

52A INTERLOCK (Y, N)	**52ABF :=** ______________
CURRENT DETECTOR (0.10–10.00 A {5 A nom}, 0.02–2.00 A {1 A nom})	**50BFP :=** ______________
BK FAILURE DELAY (0.00–2.00 s) *(When ATD ≠ OFF, BFD should be <ATD)*	**BFD :=** ______________
AUX TIMER DELAY (OFF, 0.00–2.00 s)	**ATD :=** ______________
BK FAIL INITIATE (SELOGIC)	**BFI :=** ______________

Arc-Flash Protection

(Hidden if Slot E ≠ 7x or L0)

AF PH OC TRP LVL (OFF, 0.50–100.00 A {5 A nom phase}, 0.10–20.00 A {1 A nom phase})	**50PAFP :=** ______________
(The following arc-flash settings are hidden if 50PAFP := OFF	
AF N OC TRP LVL (OFF, 0.50–100.00 A {5 A nom neutral}, 0.10–20.00 A {1 A nom neutral}) (*Hidden if 0.2 A neutral CT*)	**50NAFP :=** ______________
SENSOR 1 TYPE (NONE, POINT, FIBER)	**AFSENS1 :=** ______________
TOL 1 PICKUP (3.0–80.0% {POINT}, 0.6–80.0% {FIBER}) *(Hidden if AFSENS1 := NONE)*	**TOL1P :=** ______________
SENSOR 2 TYPE (NONE, POINT, FIBER)	**AFSENS2 :=** ______________
TOL 2 PICKUP (3.0–80.0% {POINT}, 0.6–80.0% {FIBER}) *(Hidden if AFSENS2 := NONE)*	**TOL2P :=** ______________
SENSOR 3 TYPE (NONE, POINT, FIBER)	**AFSENS3 :=** ______________
TOL 3 PICKUP (3.0–80.0% {POINT}, 0.6–80.0% {FIBER}) *(Hidden if AFSENS3 := NONE)*	**TOL3P :=** ______________
SENSOR 4 TYPE (NONE, POINT, FIBER)	**AFSENS4 :=** ______________
TOL 4 PICKUP (3.0–80.0% {POINT}, 0.6–80.0% {FIBER}) *(Hidden if AFSENS4 := NONE)*	**TOL4P :=** ______________
SENSOR 5 TYPE (None, Point, Fiber) (*Shown if Slot E = 77*)	**AFSENS5 :=** ______________
TOL 5 PICKUP (3.0–80.0% {POINT}, 0.6–80.0% {FIBER}) (*Shown if Slot E = 77*)	**TOL5P :=** ______________
SENSOR 6 TYPE (None, Point, Fiber) (*Shown if Slot E = 77*)	**AFSENS6 :=** ______________
TOL 6 PICKUP (3.0–80.0% {POINT}, 0.6–80.0% {FIBER}) (*Shown if Slot E = 77*)	**TOL6P :=** ______________
SENSOR 7 TYPE (None, Point, Fiber) (*Shown if Slot E = 77*)	**AFSENS7 :=** ______________
TOL 7 PICKUP (3.0–80.0% {POINT}, 0.6–80.0% {FIBER}) (*Shown if Slot E = 77*)	**TOL7P :=** ______________
SENSOR 8 TYPE (None, Point, Fiber) (*Shown if Slot E = 77*)	**AFSENS8 :=** ______________
TOL 8 PICKUP (3.0–80.0% {POINT}, 0.6–80.0% {FIBER}) (*Shown if Slot E = 77*)	**TOL8P :=** ______________
AFD OUTPUT SLOT (101_3, 301_4, 401_4)	**AOUTSLOT :=** ______________

Analog Inputs/Outputs

For the following settings, x is the card position (3, 4, or 5 in Slot C, D, and E, respectively). Settings are hidden if Analog I/O are not included.

AIx01

AI*x*01 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*01NAM :=** _______________
AI*x*01 TYPE (I, V)	**AI*x*01TYP :=** _______________
If 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)	**AI*x*01HW2 :=** _______________
AI*x*01 HI ALARM (OFF, –99999.000 to +99999.000)	**AI*x*01HAL :=** _______________

AIx02

AI*x*02 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*02NAM :=** _______________
AI*x*02 TYPE (I, V)	**AI*x*02TYP :=** _______________
If AI*x*02TYP := I	
AI*x*02 LOW IN VAL (–20.480 to +20.480 mA)	**AI*x*02L :=** _______________
AI*x*02 HI IN VAL (–20.480 to +20.480 mA)	**AI*x*02H :=** _______________
If AI*x*02TYP := V	
AI*x*02 LOW IN VAL (–10.240 to +10.240 V)	**AI*x*02L :=** _______________
AI*x*02 HI IN VAL (–10.240 to +10.240 V)	**AI*x*02H :=** _______________
Note: Set Warn and Alarm to a value between Engr Low and Engr High settings.	
AI*x*02 ENG UNITS (16 characters)	**AI*x*02EU :=** _______________
AI*x*02 EU LOW (–99999.000 to +99999.000)	**AI*x*02EL :=** _______________
AI*x*02 EU HI (–99999.000 to +99999.000)	**AI*x*02EH :=** _______________
AI*x*02 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*02LW1 :=** _______________
AI*x*02 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*02LW2 :=** _______________
AI*x*02 LO ALARM (OFF, –99999.000 to +99999.000)	**AI*x*02LAL :=** _______________
AI*x*02 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*02HW1 :=** _______________
AI*x*02 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*02HW2 :=** _______________
AI*x*02 HI ALARM (OFF, –99999.000 to +99999.000)	**AI*x*02HAL :=** _______________

AIx03

AI*x*03 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*03NAM :=** _______________
AI*x*03 TYPE (I, V)	**AI*x*03TYP :=** _______________
If AI*x*03TYP := I	
AI*x*03 LOW IN VAL (–20.480 to +20.480 mA)	**AI*x*03L :=** _______________
AI*x*03 HI IN VAL (–20.480 to +20.480 mA)	**AI*x*03H :=** _______________
If AI*x*03TYP := V	_______________
AI*x*03 LOW IN VAL (–10.240 to +10.240 V)	**AI*x*03L :=** _______________
AI*x*03 HI IN VAL (–10.240 to +10.240 V)	**AI*x*03H :=** _______________

Note: Set Warn and Alarm to a value between Engr Low and Engr High settings.

AI*x*03 ENG UNITS (16 characters)	**AI*x*03EU :=** _______________
AI*x*03 EU LOW (–99999.000 to +99999.000)	**AI*x*03EL :=** _______________
AI*x*03 EU HI (–99999.000 to +99999.000)	**AI*x*03EH :=** _______________
AI*x*03 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*03LW1 :=** _______________
AI*x*03 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*03LW2 :=** _______________
AI*x*03 LO ALARM (OFF, –99999.000 to +99999.000)	**AI*x*03LAL :=** _______________
AI*x*03 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*03HW1 :=** _______________
AI*x*03 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*03HW2 :=** _______________
AI*x*03 HI ALARM (OFF, –99999.000 to +99999.000)	**AI*x*03HAL :=** _______________

AIx04

AI*x*04 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*04NAM :=** _______________
AI*x*04 TYPE (I, V)	**AI*x*04TYP :=** _______________
If AI*x*04TYP := I	
AI*x*04 LOW IN VAL (–20.480 to +20.480 mA)	**AI*x*04L :=** _______________
AI*x*04 HI IN VAL (–20.480 to +20.480 mA)	**AI*x*04H :=** _______________
If AI*x*04TYP := V	
AI*x*04 LOW IN VAL (–10.240 to +10.240 V)	**AI*x*04L :=** _______________
AI*x*04 HI IN VAL (–10.240 to +10.240 V)	**AI*x*04H :=** _______________

Note: Set Warn and Alarm to a value between Engr Low and Engr High settings.

AI*x*04 ENG UNITS (16 characters)	**AI*x*04EU :=** _______________
AI*x*04 EU LOW (–99999.000 to +99999.000)	**AI*x*04EL :=** _______________
AI*x*04 EU HI (–99999.000 to +99999.000)	**AI*x*04EH :=** _______________
AI*x*04 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*04LW1 :=** _______________
AI*x*04 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*04LW2 :=** _______________
AI*x*04 LO ALARM (OFF, –99999.000 to +99999.000)	**AI*x*04LAL :=** _______________
AI*x*04 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*04HW1 :=** _______________
AI*x*04 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*04HW2 :=** _______________
AI*x*04 HI ALARM (OFF, –99999.000 to +99999.000)	**AI*x*04HAL :=** _______________

AIx05

AI*x*05 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*05NAM :=** _______________
AI*x*05 TYPE (I, V)	**AI*x*05TYP :=** _______________
If AI*x*05TYP := I	
AI*x*05 LOW IN VAL (–20.480 to +20.480 mA)	**AI*x*05L :=** _______________
AI*x*05 HI IN VAL (–20.480 to +20.480 mA)	**AI*x*05H :=** _______________
If AI*x*05TYP := V	
AI*x*05 LOW IN VAL (–10.240 to +10.240 V)	**AI*x*05L :=** _______________
AI*x*05 HI IN VAL (–10.240 to +10.240 V)	**AI*x*05H :=** _______________
Note: Set Warn and Alarm to a value between Engr Low and Engr High settings.	
AI*x*05 ENG UNITS (16 characters)	**AI*x*05EU :=** _______________
AI*x*05 EU LOW (–99999.000 to +99999.000)	**AI*x*05EL :=** _______________
AI*x*05 EU HI (–99999.000 to +99999.000)	**AI*x*05EH :=** _______________
AI*x*05 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*05LW1 :=** _______________
AI*x*05 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*05LW2 :=** _______________
AI*x*05 LO ALARM (OFF, –99999.000 to +99999.000)	**AI*x*05LAL :=** _______________
AI*x*05 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*05HW1 :=** _______________
AI*x*05 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*05HW2 :=** _______________
AI*x*05 HI ALARM (OFF, –99999.000 to +99999.000)	**AI*x*05HAL :=** _______________

AIx06

AI*x*06 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*06NAM :=** _______________
AI*x*06 TYPE (I, V)	**AI*x*06TYP :=** _______________
If AI*x*06TYP := I	
AIx06 LOW IN VAL (–20.480 to +20.480 mA)	**AI*x*06L :=** _______________
AIx06 HI IN VAL (–20.480 to +20.480 mA)	**AI*x*06H :=** _______________
If AI*x*06TYP := V	
AI*x*06 LOW IN VAL (–10.240 to +10.240 V)	**AI*x*06L :=** _______________
AI*x*06 HI IN VAL (–10.240 to +10.240 V)	**AI*x*06H :=** _______________
Note: Set Warn and Alarm to a value between Engr Low and Engr High settings.	
AI*x*06 ENG UNITS (16 characters)	**AI*x*06EU :=** _______________
AI*x*06 EU LOW (–99999.000 to +99999.000)	**AI*x*06EL :=** _______________
AI*x*06 EU HI (–99999.000 to +99999.000)	**AI*x*06EH :=** _______________
AI*x*06 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*06LW1 :=** _______________
AI*x*06 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*06LW2 :=** _______________
AI*x*06 LO ALARM (OFF, –99999.000 to +99999.000)	**AI*x*06LAL :=** _______________
AI*x*06 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*06HW1 :=** _______________
AI*x*06 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*06HW2 :=** _______________
AI*x*06 HI ALARM (OFF, –99999.000 to +99999.000)	**AI*x*06HAL :=** _______________

AIx07

AI*x*07 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*07NAM :=** ______________
AI*x*07 TYPE (I, V)	**AI*x*07TYP :=** ______________
If AI*x*07TYP := I	
AI*x*07 LOW IN VAL (–20.480 to +20.480 mA)	**AI*x*07L :=** ______________
AI*x*07 HI IN VAL (–20.480 to +20.480 mA)	**AI*x*07H :=** ______________
If AI*x*07TYP := V	
AI*x*07 LOW IN VAL (–10.240 to +10.240 V)	**AI*x*07L :=** ______________
AI*x*07 HI IN VAL (–10.240 to +10.240 V)	**AI*x*07H :=** ______________

Note: Set Warn and Alarm to a value between Engr Low and Engr High settings.

AI*x*07 ENG UNITS (16 characters)	**AI*x*07EU :=** ______________
AI*x*07 EU LOW (–99999.000 to +99999.000)	**AI*x*07EL :=** ______________
AI*x*07 EU HI (–99999.000 to +99999.000)	**AI*x*07EH :=** ______________
AI*x*07 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*07LW1 :=** ______________
AI*x*07 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*07LW2 :=** ______________
AI*x*07 LO ALARM (OFF, –99999.000 to +99999.000)	**AI*x*07LAL :=** ______________
AI*x*07 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*07HW1 :=** ______________
AI*x*07 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*07HW2 :=** ______________
AI*x*07 HI ALARM (OFF, –99999.000 to +99999.000)	**AI*x*07HAL :=** ______________

AIx08

AI*x*08 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*08NAM :=** ______________
AI*x*08 TYPE (I, V)	**AI*x*08TYP :=** ______________
If AI*x*08TYP := I	
AI*x*08 LOW IN VAL (–20.480 to +20.480 mA)	**AI*x*08L :=** ______________
AI*x*08 HI IN VAL (–20.480 to +20.480 mA)	**AI*x*08H :=** ______________
If AI*x*08TYP := V	
AI*x*08 LOW IN VAL (–10.240 to +10.240 V)	**AI*x*08L :=** ______________
AI*x*08 HI IN VAL (–10.240 to +10.240 V)	**AI*x*08H :=** ______________

Note: Set Warn and Alarm to a value between Engr Low and Engr High settings.

AI*x*08 ENG UNITS (16 characters)	**AI*x*08EU :=** ______________
AI*x*08 EU LOW (–99999.000 to +99999.000)	**AI*x*08EL :=** ______________
AI*x*08 EU HI (–99999.000 to +99999.000)	**AI*x*08EH :=** ______________
AI*x*08 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*08LW1 :=** ______________
AI*x*08 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*08LW2 :=** ______________
AI*x*08 LO ALARM (OFF, –99999.000 to +99999.000)	**AI*x*08LAL :=** ______________
AI*x*08 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*08HW1 :=** ______________
AI*x*08 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*08HW2 :=** ______________
AI*x*08 HI ALARM (OFF, –99999.000 to +99999.000)	**AI*x*08HAL :=** ______________

AOx01

AO*x*01 ANALOG QTY (Off, 1 analog quantity)	**AO*x*01AQ :=** ________________
AO*x*01 TYPE (I, V)	**AO*x*01TYP :=** ________________
AO*x*01 AQTY LOW (–2147483647 to +2147483647)	**AO*x*01AQL :=** ________________
AO*x*01 AQTY HI (–2147483647 to +2147483647)	**AO*x*01AQH :=** ________________
If 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 :=** ________________

AOx02

AO*x*02 ANALOG QTY (Off, 1 analog quantity)	**AO*x*02AQ :=** ________________
AO*x*02 TYPE (I, V)	**AO*x*02TYP :=** ________________
AO*x*02 AQTY LOW (–2147483647 to +2147483647)	**AO*x*02AQL :=** ________________
AO*x*02 AQTY HI (–2147483647 to +2147483647)	**AO*x*02AQH :=** ________________
If 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 :=** ________________

AOx03

AO*x*03 ANALOG QTY (Off, 1 analog quantity)	**AO*x*03AQ :=** ________________
AO*x*03 TYPE (I, V)	**AO*x*03TYP :=** ________________
AO*x*03 AQTY LOW (–2147483647 to +2147483647)	**AO*x*03AQL :=** ________________
AO*x*03 AQTY HI (–2147483647 to +2147483647)	**AO*x*03AQH :=** ________________
If 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 :=** ________________
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 :=** ________________

AOx04

AO*x*04 ANALOG QTY (Off, 1 analog quantity)	**AO*x*04AQ :=** ________________
AO*x*04 TYPE (I, V)	**AO*x*04TYP :=** ________________
AO*x*04 AQTY LOW (–2147483647 to +2147483647)	**AO*x*04AQL :=** ________________
AO*x*04 AQTY HI (–2147483647 to +2147483647)	**AO*x*04AQH :=** ________________
If 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 :=** ________________

Station DC Battery Monitor

(The following station DC battery monitor settings are hidden if Slot E ≠ 70 or L0)

DC UNDER VOLT PU (OFF, 20.00–300.00 Vdc)	**DCLOP :=** ________________
DC OVER VOLT PU (OFF, 20.00–300.00 Vdc)	**DCHIP :=** ________________

Input Debounce (Base Unit)

IN101 Debounce (AC, 0–65000 ms)	**IN101D :=** ________________
IN102 Debounce (AC, 0–65000 ms)	**IN102D :=** ________________

Input Debounce (Slot C)

(Hidden if an input option is not included)
(AC, 0–65000 ms)

IN301 Debounce	**IN301D :=** ________________	IN308 Debounce	**IN308D :=** ________________
IN302 Debounce	**IN302D :=** ________________	IN309 Debounce	**IN309D :=** ________________
IN303 Debounce	**IN303D :=** ________________	IN310 Debounce	**IN310D :=** ________________
IN304 Debounce	**IN304D :=** ________________	IN311 Debounce	**IN311D :=** ________________
IN305 Debounce	**IN305D :=** ________________	IN312 Debounce	**IN312D :=** ________________
IN306 Debounce	**IN306D :=** ________________	IN313 Debounce	**IN313D :=** ________________
IN307 Debounce	**IN307D :=** ________________	IN314 Debounce	**IN314D :=** ________________

Input Debounce (Slot D)

(Hidden if an input option is not included)
(AC, 0–65000 ms)

IN401 Debounce	**IN401D :=** ________________	IN408 Debounce	**IN408D :=** ________________
IN402 Debounce	**IN402D :=** ________________	IN409 Debounce	**IN409D :=** ________________
IN403 Debounce	**IN403D :=** ________________	IN410 Debounce	**IN410D :=** ________________
IN404 Debounce	**IN404D :=** ________________	IN411 Debounce	**IN411D :=** ________________
IN405 Debounce	**IN405D :=** ________________	IN412 Debounce	**IN412D :=** ________________
IN406 Debounce	**IN406D :=** ________________	IN413 Debounce	**IN413D :=** ________________
IN407 Debounce	**IN407D :=** ________________	IN414 Debounce	**IN414D :=** ________________

Input Debounce (Slot E)

(Hidden if an input option is not included)
(AC, 0–65000 ms)

IN501 Debounce	**IN501D :=** ____________	IN508 Debounce	**IN508D :=** ____________
IN502 Debounce	**IN502D :=** ____________	IN509 Debounce	**IN509D :=** ____________
IN503 Debounce	**IN503D :=** ____________	IN510 Debounce	**IN510D :=** ____________
IN504 Debounce	**IN504D :=** ____________	IN511 Debounce	**IN511D :=** ____________
IN505 Debounce	**IN505D :=** ____________	IN512 Debounce	**IN512D :=** ____________
IN506 Debounce	**IN506D :=** ____________	IN513 Debounce	**IN513D :=** ____________
IN507 Debounce	**IN507D :=** ____________	IN514 Debounce	**IN514D :=** ____________

Breaker Monitor

BREAKER MONITOR (Y, N) **EBMON :=** ____________

(Hidden if EBMON := N)

CL/OPN OPS SETPT 1 (0–65000) **COSP1 :=** ____________

CL/OPN OPS SETPT 2 (0–65000) **COSP2 :=** ____________

CL/OPN OPS SETPT 3 (0–65000) **COSP3 :=** ____________

kA PRI INTERRPTD 1 (0.00–999.00) **KASP1 :=** ____________

kA PRI INTERRPTD 2 (0.00–999.00) **KASP2 :=** ____________

kA PRI INTERRPTD 3 (0.00–999.00) **KASP3 :=** ____________

BRKR MON CONTROL (SELOGIC) **BKMON :=** ____________

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

(Hidden if fiber port is NONE)

IRIG TIME SOURCE (IRIG1, IRIG2) **TIME_SRC :=** ____________

Two-Position Disconnect

DISC 1 N/O CONT (SELOGIC) **89A2P1 :=** ____________

DISC 1 N/C CONT (SELOGIC) **89B2P1 :=** ____________

DISC 1 ALM PU (0.00–300.00 sec) **89A2P1D :=** ____________

DISC 2 N/O CONT (SELOGIC) **89A2P2 :=** ____________

DISC 2 N/C CONT (SELOGIC)	**89B2P2 :=** ______________
DISC 2 ALM PU (0.00–300.00 sec)	**89A2P2D :=** ______________
DISC 3 N/O CONT (SELOGIC)	**89A2P3 :=** ______________
DISC 3 N/C CONT (SELOGIC)	**89B2P3 :=** ______________
DISC 3 ALM PU (0.00–300.00 sec)	**89A2P3D :=** ______________
DISC 4 N/O CONT (SELOGIC)	**89A2P4 :=** ______________
DISC 4 N/C CONT (SELOGIC)	**89B2P4 :=** ______________
DISC 4 ALM PU (0.00–300.00 sec)	**89A2P4D :=** ______________
DISC 5 N/O CONT (SELOGIC)	**89A2P5 :=** ______________
DISC 5 N/C CONT (SELOGIC)	**89B2P5 :=** ______________
DISC 5 ALM PU (0.00–300.00 sec)	**89A2P5D :=** ______________

Control Configuration

ENABLE LOC REM CON (Y, N)	**EN_LRC :=** ______________
LOCAL CONTROL (SELOGIC)	**LOCAL :=** ______________

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

PORT F

ENABLE PORT (Y, N)	**EPORT :=** ______________
PROTOCOL (SEL, MOD, EVMSG, PMU)	**PROTO :=** ______________
MAXIMUM ACCESS LEVEL (1, 2, C)	**MAXACC :=** ______________

Communications

SPEED (300, 1200, 2400, 4800, 9600, 19200, 38400 bps)	**SPEED :=** ______________
DATA BITS (7, 8 bits) *(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 :=** ______________
LANGUAGE (ENGLISH, SPANISH)	**LANG :=** ______________
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 the Ethernet option is not included)
(IP addresses are entered using zzz = 1–126, 128–223; yyy = 0–255; xxx = 0–255; www = 0–255)

ENABLE PORT (Y, N)	**EPORT :=** ______________
IP ADDRESS (zzz.yyy.xxx.www)	**IPADDR :=** ______________

SUBNET MASK (zzz.yyy.xxx.www)	**SUBNETM** := ______________
DEFAULT ROUTER (zzz.yyy.xxx.www) **Note:** Setting DEFRTR = 0.0.0.0 disables the default router.	**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** := ______________
OPERATING MODE (FIXED, FAILOVER, SWITCHED, PRP) *(Hidden unless the redundant Ethernet Port option is ordered)*	**NETMODE** := ______________
FAILOVER TIMEOUT (OFF, 0.10–65.00 s in 0.01-second steps) *(Hidden if not dual redundant Ethernet Port option or if NETMODE is not set to FAILOVER)*	**FTIME** := ______________
PRIMARY NETPORT (A, B) *(Hidden if not dual redundant Ethernet Port option)*	**NETPORT** := ______________
PRP ENTRY TIMEOUT (400–10000 ms) *(Hidden if not dual redundant Ethernet Port option or if NETMODE is not equal to PRP)*	**PRPTOUT** := ______________
PRP DESTINATION ADDR LSB (0–255) *(Hidden if not dual redundant Ethernet Port option or if NETMODE is not equal to PRP)*	**PRPADDR** := ______________
PRP SUPERVISION TX INTERVAL (1–10 s) *(Hidden if not dual redundant Ethernet Port option or if NETMODE is not equal to PRP)*	**PRPINTV** := ______________
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** := ______________
ENABLE TELNET (Y, N)	**ETELNET** := ______________
MAXIMUM ACCESS LEVEL (1, 2, C)	**MAXACC** := ______________
LANGUAGE (ENGLISH, SPANISH)	**LANG** := ______________
TELNET PORT (23, 1025–65534) **Note:** See *Table SET.1* and the note at the end of Port 1 settings.	**TPORT** := ______________
TELNET CONNECT BANNER (254 characters)	**TCBAN** := ______________
TELNET TIME-OUT (1–30 min)	**TIDLE** := ______________
FAST OP MESSAGES (Y, N)	**FASTOP** := ______________

Note: The FAST OP MESSAGES setting only functions when using SEL Fast Operate protocol to operate/set/pulse breaker bits and remote bits. This setting has no effect on the Modbus, DNP, or IEC 61850 protocols.

ENABLE FTP (Y, N)	**EFTPSERV** := ______________
FTP MAXIMUM ACCESS LEVEL (1, 2, C)	**FTPACC** := ______________
FTP USER NAME (20 characters)	**FTPUSER** := ______________
FTP CONNECT BANNER (254 characters)	**FTPCBAN** := ______________
FTP IDLE TIME-OUT (5—255 min)	**FTPIDLE** := ______________
ENABLE IEC 61850 PROTOCOL (Y, N)	**E61850** := ______________
ENABLE IEC 61850 GSE (Y, N) (*Hidden if E61850 := N*)	**EGSE** := ______________
ENABLE MMS FILE SERVICES (Y, N)	**EMMSFS** := ______________
ENABLE MODBUS SESSIONS (0–2)	**EMOD** := ______________
MODBUS MASTER IP ADDRESS (zzz.yyy.xxx.www) *(Hidden if EMOD := 0)*	**MODIP1** := ______________
MODBUS MASTER IP ADDRESS (zzz.yyy.xxx.www) *(Hidden if EMOD := 0 or 1)*	**MODIP2** := ______________

Note: MODIP1 and MODIP2 cannot share an address and must be unique (except when 0.0.0.0, which effectively disables security and allows any master to communicate).

MODBUS TCP PORT 1 (1–65534) *(Hidden if EMOD := 0)*
See *Table SET.1* and the note at the end of Port 1 settings. **MODNUM1 :=** ______________

MODBUS TCP PORT 2 (1–65534) *(Hidden if EMOD := 0 or 1)*
Note: See *Table SET.1* and the note at the end of Port 1 settings. **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 :=** ______________

ENABLE PMU PROCESSING (0–2) **EPMIP :=** ______________

ENABLE DNP SESSIONS (0–5) **EDNP :=** ______________

ENABLE SNTP CLIENT (OFF, UNICAST, MANYCAST, BROADCAST) **ESNTP :=** ______________

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 cannot be set to the same address as IPADDR. IP addresses from 224.0.0.1 through 239.255.255.255 are also valid when PMOTS1 := UDP_S. IP address 255.255.255.255 is also valid when PMOTS1 = UDP_S or TCP.) **PMOIPA1 :=** ______________

PMU OUTPUT 1 TCP/IP PORT NUMBER (1–65534) *(Shown only when EPMIP is not equal to 0 and PMOTS1 is not equal to UDP_S; PMOTCP1 cannot be set to the same number as PMOTCP2)*
Note: See *Table SET.1* and the note at the end of Port 1 settings. **PMOTCP1 :=** ______________

PMU OUTPUT 1 UDP/IP DATA PORT NUMBER (1–65534)
(Shown only when EPMIP is not equal to 0 and PMOTS1 is not equal to 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 cannot be set to the same address as IPADDR. IP addresses from 224.0.0.1 through 239.255.255.255 are also valid when PMOTS2 = UDP_S. IP address 255.255.255.255 is also valid when PMOTS2 = UDP_S or TCP.) **PMOIPA2 :=** ______________

PMU OUTPUT 2 TCP/IP PORT NUMBER (1–65534)
(Shown only when EPMIP := 2 and PMOTS2 is not equal to UDP_S; PMOTCP2 cannot be set to the same number as PMOTCP1)
Note: See *Table SET.1* and the note at the end of Port 1 settings. **PMOTCP2 :=** ______________

PMU OUTPUT 2 UDP/IP DATA PORT NUMBER (1–65534)
(Shown only when EPMIP := 2 and PMOTS2 is not equal to TCP) **PMOUDP2 :=** ______________

DNP3 Protocol

(The following DNP3 settings are hidden if DNP3 is not an option)

ENABLE DNP SESSIONS (0–5) **EDNP :=** ______________

(The following DNP3 settings are hidden if EDNP := 0)

DNP TCP and UDP Port (1–65534)
Note: See *Table SET.1* and the note at the end of Port 1 settings. **DNPNUM :=** ______________

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

Session 1

(The DNP IP address of each session (DNPIP1, DNPIP2, etc.) must be unique)

DNP Master IP Address {zzz.yyy.xxx.www} (15 characters) **DNPIP1 :=** ______________

Transport Protocol (UDP, TCP) **DNPTR1 :=** ______________

UDP Response Port (REQ, 1–65534)	**DNPUDP1 :=** _______________
DNP Address to Report to (0–65519)	**REPADR1 :=** _______________
DNP Map (1–3)	**DNPMAP1 :=** _______________
Analog Input Default Variation (1–6)	**DVARAI1 :=** _______________
Class for Binary Event Data (0–3)	**ECLASSB1 :=** _______________
Class for Counter Event Data (0–3)	**ECLASSC1 :=** _______________
Class for Analog Event Data (0–3)	**ECLASSA1 :=** _______________
Currents Scaling Decimal Places (0–3)	**DECPLA1 :=** _______________
Voltages Scaling Decimal Places (0–3)	**DECPLV1 :=** _______________
Misc Data Scaling Decimal Places (0–3)	**DECPLM1 :=** _______________
Amps Reporting Dead-band Counts (0–32767) *Hidden if ECLASSA1 := 0)*	**ANADBA1 :=** _______________
Volts Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBV1 :=** _______________
Misc Data Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA1 := 0 and ECLASSC1 := 0)*	**ANADBM1 :=** _______________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ1 :=** _______________
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO1 :=** _______________
Seconds to send Data Link Heartbeat (0–7200) *(Hidden if DNPTR1 := UDP)*	**DNPINA1 :=** _______________
Event Message Confirm Time-Out (1–50 s)	**ETIMEO1 :=** _______________
Enable Unsolicited Reporting (Y, N) *(Hidden if ECLASSA1 := 0, ECLASSB1 := 0, ECLASSC1 := 0, and ECLASSV1 := 0)*	**UNSOL1 :=** _______________
Enable Unsolicited Reporting at Power-Up (Y, N) *(Hidden if UNSOL1 := N)*	**PUNSOL1 :=** _______________
Number of Events to Transmit On (1–200) *(Hidden if UNSOL1 := N)*	**NUMEVE1 :=** _______________
Oldest Event to Tx On (0.0–99999.0 s) *(Hidden if UNSOL1 := N)*	**AGEEVE1 :=** _______________
Unsolicited Message Max Retry Attempts (2–10) *(Hidden if UNSOL1 := N)*	**URETRY1 :=** _______________
Unsolicited Message Offline Time-Out (1–5000 s) *Hidden if UNSOL1 := N)*	**UTIMEO1 :=** _______________

Session 2

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

DNP Master IP Address {zzz.yyy.xxx.www} (15 characters)	**DNPIP2 :=** _______________
Transport Protocol (UDP, TCP)	**DNPTR2 :=** _______________
UDP Response Port (REQ, 1–65534)	**DNPUDP2 :=** _______________
DNP Address to Report to (0–65519)	**REPADR2 :=** _______________
DNP Map (1–3)	**DNPMAP2 :=** _______________
Analog Input Default Variation (1–6)	**DVARAI2 :=** _______________
Class for Binary Event Data (0–3)	**ECLASSB2 :=** _______________
Class for Counter Event Data (0–3)	**ECLASSC2 :=** _______________
Class for Analog Event Data (0–3)	**ECLASSA2 :=** _______________
Currents Scaling Decimal Places (0–3)	**DECPLA2 :=** _______________
Voltages Scaling Decimal Places (0–3)	**DECPLV2 :=** _______________
Misc Data Scaling Decimal Places (0–3)	**DECPLM2 :=** _______________
Amps Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA2 := 0)*	**ANADBA2 :=** _______________
Volts Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA2 := 0)*	**ANADBV2 :=** _______________

Misc Data Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA2 := 0 and ECLASSC2 := 0)*	**ANADBM2 :=** _______________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ2 :=** _______________
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO2 :=** _______________
Seconds to send Data Link Heartbeat (0–7200) *(Hidden if DNPTR2 := UDP)*	**DNPINA2 :=** _______________
Event Message Confirm Time-Out (1–50 s)	**ETIMEO2 :=** _______________
Enable Unsolicited Reporting (Y, N) *(Hidden if ECLASSA2 := 0, ECLASSB2 := 0, ECLASSC2 := 0, and ECLASSV2 := 0)*	**UNSOL2 :=** _______________
Enable Unsolicited Reporting at Power-Up (Y, N) *(Hidden if UNSOL2 := N)*	**PUNSOL2 :=** _______________
Number of Events to Transmit On (1–200) *(Hidden if UNSOL2 := N)*	**NUMEVE2 :=** _______________
Oldest Event to Tx On (0.0–99999.0 s) *(Hidden if UNSOL2 := N)*	**AGEEVE2 :=** _______________
Unsolicited Message Max Retry Attempts (2–10) *(Hidden if UNSOL2 := N)*	**URETRY2 :=** _______________
Unsolicited Message Offline Time-Out (1–5000 s) *(Hidden if UNSOL2 := N)*	**UTIMEO2 :=** _______________

Session 3

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

DNP Master IP Address {zzz.yyy.xxx.www} (15 characters)	**DNPIP3 :=** _______________
Transport Protocol (UDP, TCP)	**DNPTR3 :=** _______________
UDP Response Port (REQ, 1–65534)	**DNPUDP3 :=** _______________
DNP Address to Report to (0–65519)	**REPADR3 :=** _______________
DNP Map (1–3)	**DNPMAP3 :=** _______________
Analog Input Default Variation (1–6)	**DVARAI3 :=** _______________
Class for Binary Event Data (0–3)	**ECLASSB3 :=** _______________
Class for Counter Event Data (0–3)	**ECLASSC3 :=** _______________
Class for Analog 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 :=** _______________

Session 4

(All Session 4 settings are hidden if EDNP < 4)

DNP Master IP Address {zzz.yyy.xxx.www} (15 characters)	**DNPIP4 :=** ______________
Transport Protocol (UDP, TCP)	**DNPTR4 :=** ______________
UDP Response Port (REQ, 1–65534)	**DNPUDP4 :=** ______________
DNP Address to Report to (0–65519)	**REPADR4 :=** ______________
DNP Map (1–3)	**DNPMAP4 :=** ______________
Analog Input Default Variation (1–6)	**DVARAI4 :=** ______________
Class for Binary Event Data (0–3)	**ECLASSB4 :=** ______________
Class for Counter Event Data (0–3)	**ECLASSC4 :=** ______________
Class for Analog Event Data (0–3)	**ECLASSA4 :=** ______________
Currents Scaling Decimal Places (0–3)	**DECPLA4 :=** ______________
Voltages Scaling Decimal Places (0–3)	**DECPLV4 :=** ______________
Misc Data Scaling Decimal Places (0–3)	**DECPLM4 :=** ______________
Amps Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA4 := 0)*	**ANADBA4 :=** ______________
Volts Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA4 := 0)*	**ANADBV4 :=** ______________
Misc Data Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA4 := 0 and ECLASSC4 := 0)*	**ANADBM4 :=** ______________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ4 :=** ______________
Seconds to Select/Operate Time-Out (0.0–40.0)	**STIMEO4 :=** ______________
Seconds to send Data Link Heartbeat (0–7200) *(Hidden if DNPTR4 := UDP)*	**DNPINA4 :=** ______________
Event Message Confirm Time-Out (1–50 s)	**ETIMEO4 :=** ______________
Enable Unsolicited Reporting (Y, N) *(Hidden if ECLASSA4 := 0, ECLASSB4 := 0, ECLASSC4 := 0, and ECLASSV4 := 0)*	**UNSOL4 :=** ______________
Enable Unsolicited Reporting at Power-Up (Y, N) *(Hidden if UNSOL4 := N)*	**PUNSOL4 :=** ______________
Number of Events to Transmit On (1–200) *(Hidden if UNSOL4 := N)*	**NUMEVE4 :=** ______________
Oldest Event to Tx On (0.0–99999.0 s) *(Hidden if UNSOL4 := N)*	**AGEEVE4 :=** ______________
Unsolicited Message Max Retry Attempts (2–10) *(Hidden if UNSOL4 := N)*	**URETRY4 :=** ______________
Unsolicited Message Offline Time-Out (1–5000 s) *(Hidden if UNSOL4 := N)*	**UTIMEO4 :=** ______________

Session 5

(All Session 5 settings are hidden if EDNP < 5)

DNP Master IP Address {zzz.yyy.xxx.www} (15 characters)	**DNPIP5 :=** ______________
Transport Protocol (UDP, TCP)	**DNPTR5 :=** ______________
UDP Response Port (REQ, 1–65534)	**DNPUDP5 :=** ______________
DNP Address to Report to (0–65519)	**REPADR5 :=** ______________
DNP Map (1–3)	**DNPMAP5 :=** ______________
Analog Input Default Variation (1–6)	**DVARAI5 :=** ______________
Class for Binary Event Data (0–3)	**ECLASSB5 :=** ______________
Class for Counter Event Data (0–3)	**ECLASSC5 :=** ______________
Class for Analog Event Data (0–3)	**ECLASSA5 :=** ______________
Currents Scaling Decimal Places (0–3)	**DECPLA5 :=** ______________
Voltages Scaling Decimal Places (0–3)	**DECPLV5 :=** ______________

Misc Data Scaling Decimal Places (0–3)	**DECPLM5 :=** ______________
Amps Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA5 := 0)*	**ANADBA5 :=** ______________
Volts Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA5 := 0)*	**ANADBV5 :=** ______________
Misc Data Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA5 := 0 and ECLASSC5 := 0)*	**ANADBM5 :=** ______________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ5 :=** ______________
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO5 :=** ______________
Seconds to send Data Link Heartbeat (0–7200) *(Hidden if DNPTR5 := UDP)*	**DNPINA5 :=** ______________
Event Message Confirm Time-Out (1–50 s)	**ETIMEO5 :=** ______________
Enable Unsolicited Reporting (Y, N) *(Hidden if ECLASSA5 := 0, ECLASSB5 := 0, ECLASSC5 := 0, and ECLASSV5 := 0)*	**UNSOL5 :=** ______________
Enable Unsolicited Reporting at Power-Up (Y, N) *(Hidden if UNSOL5 := N)*	**PUNSOL5 :=** ______________
Number of Events to Transmit On (1–200) *(Hidden if UNSOL5 := N)*	**NUMEVE5 :=** ______________
Oldest Event to Tx On (0.0–99999.0 s) *(Hidden if UNSOL5 := N)*	**AGEEVE5 :=** ______________
Unsolicited Message Max Retry Attempts (2–10) *(Hidden if UNSOL5 := N)*	**URETRY5 :=** ______________
Unsolicited Message Offline Time-Out (1–5000 s) *(Hidden if UNSOL5 := N)*	**UTIMEO5 :=** ______________

SNTP Client Protocol Settings

ENABLE SNTP CLIENT (OFF, UNICAST, MANYCAST, BROADCAST)	**ESNTP :=** ______________
Make the following setting when ESNTP := OFF.	
PRIMARY SERVER IP ADDRESS (zzz.yyy.xxx.www) **Note:** To accept updates from any server when ESNTP = BROADCAST, set SNTPPSIP to 0.0.0.0; only IP addresses in the range 224.0.0.1 through 239.255.255.255 are valid when ESNTP = MANYCAST.	**SNTPPSIP :=** ______________
Make the following settings when ESNTP := UNICAST.	
BACKUP SERVER IP ADDRESS (zzz.yyy.xxx.www)	**SNTPBSIP :=** ______________
SNTP IP (LOCAL) PORT NUMBER (1–65534) **Note:** See *Table SET.1* and the note at the end of Port 1 settings.	**SNTPPORT :=** ______________
SNTP UPDATE RATE (15–3600 s)	**SNTPRATE :=** ______________
Make the following setting when ESNTP := UNICAST or MANYCAST.	
SNTP TIMEOUT (5–20 s) **Note:** SNTPTO must be less than setting SNTPRATE.	**SNTPTO :=** ______________

Port Number Settings Must be Unique

When making the SEL-751 Port 1 settings, port number settings cannot be used for more than one protocol. The relay checks all of the settings shown in *Table SET.1* before saving the changes. If a port number is used more than once, or if it matches any of the fixed port numbers (20, 21, 23, 102, 502), the relay displays an error message and returns to the first setting that is in error or that contains a duplicate value.

Table SET.5 Port Number Settings That Must be Unique

Setting	Name	Setting Required When
TPORT	Telnet Port	Always
MODNUM1[a]	Modbus TCP Port 1	EMOD > 0
MODNUM2[a]	Modbus TCP Port 2	EMOD > 1
PMOTCP1	PMU Output 1 TCP/IP (Local) Port Number	PMOTS1 := TCP, UDP_T, or UDP_U
PMOTCP2	PMU Output 2 TCP/IP (Local) Port Number	PMOTS2 := TCP, UDP_T, or UDP_U
DNPNUM	DNPTCP and UDP Port	EDNP > 0
SNTPPORT	SNTPIP (Local) Port Number	ESNTP ≠ OFF

[a] MODNUM1 and MODNUM2 settings can have the same port number. The relay displays an error message if this number matches the port numbers of the other protocols.

PORT 2

(All of the following Port 2 settings are hidden if the relay is ordered without the Port 2 option. See the SEL-751 MOT for details.)
(Fiber-Optic Serial Port in Slot B; the following setting are autoset and hidden if E49RTD := EXT)

ENABLE PORT (Y, N) **EPORT := _______________**

PROTOCOL (SEL, DNP, MOD, EVMSG, PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB, 103) **PROTO := _______________**

MAXIMUM ACCESS LEVEL (1, 2, C) **MAXACC := _______________**

Communications

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

DATA BITS (7, 8 bits) *(Hidden if PROTO := MOD, DNP, PMU, EVMSG, 103, 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, 103, or MB_)* **T_OUT := _______________**

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

LANGUAGE (ENGLISH, SPANISH) **LANG := _______________**

SEND AUTOMESSAGE (Y, N) *(Hidden if PROTO := MOD, DNP, PMU, EVMSG, 103, or MB_)* **AUTO := _______________**

FAST OP MESSAGES (Y, N) *(Hidden if PROTO := MOD, DNP, PMU, EVMSG, 103, or MB_)* **FASTOP := _______________**

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 :=** ______________
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 :=** ____________
MB Channel Bad Pickup (1–10000 ppm)	**CBADPU :=** ____________
MB Receive Default State (8 characters)	**RXDFLT :=** ____________
RMB1 Pickup Debounce Messages (1–8)	**RMB1PU :=** ____________
RMB1 Dropout Debounce Messages (1–8)	**RMB1DO :=** ____________
RMB2 Pickup Debounce Messages (1–8)	**RMB2PU :=** ____________
RMB2 Dropout Debounce Messages (1–8)	**RMB2DO :=** ____________
RMB3 Pickup Debounce Messages (1–8)	**RMB3PU :=** ____________
RMB3 Dropout Debounce Messages (1–8)	**RMB3DO :=** ____________
RMB4 Pickup Debounce Messages (1–8)	**RMB4PU :=** ____________
RMB4 Dropout Debounce Messages (1–8)	**RMB4DO :=** ____________
RMB5 Pickup Debounce Messages (1–8)	**RMB5PU :=** ____________
RMB5 Dropout Debounce Messages (1–8)	**RMB5DO :=** ____________
RMB6 Pickup Debounce Messages (1–8)	**RMB6PU :=** ____________
RMB6 Dropout Debounce Messages (1–8)	**RMB6DO :=** ____________
RMB7 Pickup Debounce Messages (1–8)	**RMB7PU :=** ____________
RMB7 Dropout Debounce Messages (1–8)	**RMB7DO :=** ____________

RMB8 Pickup Debounce Messages (1–8) **RMB8PU :=** _____________

RMB8 Dropout Debounce Messages (1–8) **RMB8DO :=** _____________

IEC 60870-5-103 Protocol

(Hidden unless serial port with PROTO := 103)

103 DEVICE ADDRESS (0–254)	**103ADDR :=** _____________
CYCLIC DATA REPORTING PERIOD (1–3600 s)	**103CYC :=** _____________
ACCUMULATOR REPORTING PERIOD (OFF, 1–3600 s)	**103ACYC :=** _____________
ACCUMULATOR REPORTING TRIGGER (1 Relay Word Bit)	**103ATRI :=** _____________
ENABLE TIME SYNCHRONIZATION (Y, N)	**103TIME :=** _____________

PORT 3

(EIA-232/485 Port in Slot B)

ENABLE PORT (Y, N)	**EPORT :=** _____________
PROTOCOL (SEL, DNP, MOD, EVMSG, PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB, 103)	**PROTO :=** _____________
MAXIMUM ACCESS LEVEL (1, 2, C)	**MAXACC :=** _____________

Communications

SPEED (300, 1200, 2400, 4800, 9600, 19200, 38400 bps)	**SPEED :=** _____________
DATA BITS (7, 8 bits) *(Hidden if PROTO := DNP, PMU, MOD, EVMSG, 103, or MB_)*	**BITS :=** _____________
PARITY (O, E, N) *(Hidden if PROTO := EVMSG, PMU, or MB_)*	**PARITY :=** _____________
STOP BITS (1, 2 bits) *(Hidden if PROTO := MOD, EVMSG, or MB_)*	**STOP :=** _____________
PORT TIME-OUT (0–30 min) *(Hidden if PROTO := MOD, PMU, EVMSG, 103, or MB_)*	**T_OUT :=** _____________
HDWR HANDSHAKING (Y, N) *(Hidden if COMMINF := 485 or PROTO := MOD, DNP, EVMSG, or MB_)*	**RTSCTS :=** _____________
LANGUAGE (ENGLISH, SPANISH)	**LANG :=** _____________
SEND AUTOMESSAGE (Y, N) *(Hidden if PROTO := MOD, DNP, PMU, EVMSG, 103, or MB_)*	**AUTO :=** _____________
FAST OP MESSAGES (Y, N) *(Hidden if PROTO := MOD, DNP, PMU, EVMSG, 103, or MB_)*	**FASTOP :=** _____________
MINIMUM SECONDS FROM DCD TO TX (0.00–1.00 s) *(Hidden if PROTO is not equal to DNP)*	**MINDLY :=** _____________
MAXIMUM SECONDS FROM DCD TO TX (0.0–1.00 s) *(Hidden if PROTO is not equal to DNP)*	**MAXDLY :=** _____________
SETTLE TIME FROM RTS ON TO TX (OFF, 0.00–30.00 s) *(Hidden if PROTO is not equal to DNP or 103)*	**PREDLY :=** _____________
SETTLE TIME FROM TX TO RTS OFF (0.00–30.00 s) *(Hidden if PROTO is not equal to DNP or 103)*	**PSTDLY :=** _____________

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 :=** ______________
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 :=** ______________

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 :=** ____________

MB Channel Bad Pickup (1–10000 ppm) **CBADPU :=** ____________

MB Receive Default State (8 characters) **RXDFLT :=** ____________

RMB1 Pickup Debounce Messages (1–8) **RMB1PU :=** ____________

RMB1 Dropout Debounce Messages (1–8) **RMB1DO :=** ____________

RMB2 Pickup Debounce Messages (1–8) **RMB2PU :=** ____________

RMB2 Dropout Debounce Messages (1–8) **RMB2DO :=** ____________

RMB3 Pickup Debounce Messages (1–8) **RMB3PU :=** ____________

RMB3 Dropout Debounce Messages (1–8) **RMB3DO :=** ____________

RMB4 Pickup Debounce Messages (1–8) **RMB4PU :=** ____________

RMB4 Dropout Debounce Messages (1–8) **RMB4DO :=** ____________

RMB5 Pickup Debounce Messages (1–8) **RMB5PU :=** ____________

RMB5 Dropout Debounce Messages (1–8) **RMB5DO :=** ____________

RMB6 Pickup Debounce Messages (1–8) **RMB6PU :=** ____________

RMB6 Dropout Debounce Messages (1–8) **RMB6DO :=** ____________

RMB7 Pickup Debounce Messages (1–8) **RMB7PU :=** ____________

RMB7 Dropout Debounce Messages (1–8) **RMB7DO :=** ____________

RMB8 Pickup Debounce Messages (1–8) **RMB8PU :=** ____________

RMB8 Dropout Debounce Messages (1–8) **RMB8DO :=** ____________

IEC 60870-5-103 Protocol

(Hidden unless serial port with PROTO := 103)

103 DEVICE ADDRESS (0–254) **103ADDR :=** ____________

CYCLIC DATA REPORTING PERIOD (1–3600 s) **103CYC :=** ____________

ACCUMULATOR REPORTING PERIOD (OFF, 1–3600 s) **103ACYC :=** ____________

ACCUMULATOR REPORTING TRIGGER (1 Relay Word Bit) **103ATRI :=** ____________

ENABLE TIME SYNCHRONIZATION (Y, N) **103TIME :=** ____________

PORT 4

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

ENABLE PORT (Y, N) **EPORT :=** ____________

PROTOCOL (SEL, DNP, MOD, DNET, EVMSG, PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB, 103) **PROTO :=** ____________

MAXIMUM ACCESS LEVEL (1, 2, C) **MAXACC :=** ____________

Interface Select

(Hidden if PROTO := DNET)

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

Communications

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

DATA BITS (7, 8 bits) *(Hidden if PROTO := DNP, MOD, PMU, EVMSG, MB_, 103, or DNET)* **BITS :=** _______________

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

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

PORT TIME-OUT (0–30 min) *(Hidden if PROTO := MOD, EVMSG, MB_, PMU, 103, or DNET)* **T_OUT :=** _______________

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

LANGUAGE (ENGLISH, SPANISH) **LANG :=** _______________

SEND AUTOMESSAGE (Y, N) *(Hidden if PROTO := DNP, MOD, EVMSG, MB_, PMU, 103, or DNET)* **AUTO :=** _______________

FAST OP MESSAGES (Y, N) *(Hidden if PROTO := DNP, MOD, EVMSG, MB_, PMU, 103, or DNET)* **FASTOP :=** _______________

MINIMUM SECONDS FROM DCD TO TX (0.00–1.00 s) *(Hidden if PROTO is not equal to DNP)* **MINDLY :=** _______________

MAXIMUM SECONDS FROM DCD TO TX (0.0–1.00 s) *(Hidden if PROTO is not equal to DNP)* **MAXDLY :=** _______________

SETTLE TIME FROM RTS ON TO TX (OFF, 0.00–30.00 s) *(Hidden if PROTO is not equal to DNP or 103)* **PREDLY :=** _______________

SETTLE TIME FROM TX TO RTS OFF (0.00–30.00 s) *(Hidden if PROTO is not equal to DNP or 103)* **PSTDLY :=** _______________

Modbus

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

DNP3 Protocol

(Hidden if PROTO := SEL, EVMSG, MB_, PMU, DNET or MOD)

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

DNP Address to Report to (0–65519) **REPADR1 :=** _______________

DNP Map (1–3) **DNPMAP1 :=** _______________

Analog Input Default Variation (1–6) **DVARAI1 :=** _______________

Class for Binary Event Data (0–3) **ECLASSB1 :=** _______________

Class for Counter Event Data (0–3) **ECLASSC1 :=** _______________

Class for Analog Event Data (0–3) **ECLASSA1 :=** _______________

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

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

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

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

Volts Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA1 := 0)* **ANADBV1 :=** _______________

Misc Data Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA1 := 0 and ECLASSC1 := 0)* **ANADBM1 :=** _______________

Minutes for Request Interval (I, M, 1–32767) **TIMERQ1 :=** _______________

Seconds to Select/Operate Time-Out (0.0–30.0) **STIMEO1 :=** _______________

Data Link Retries (0–15) **DRETRY1 :=** _______________

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

Modem Protocol

(For DNP3 session and 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 :=** _______________
MB Channel Bad Pickup (1–10000 ppm)	**CBADPU :=** _______________
MB Receive Default State (8 characters)	**RXDFLT :=** _______________
RMB1 Pickup Debounce Messages (1–8)	**RMB1PU :=** _______________
RMB1 Dropout Debounce Messages (1–8)	**RMB1DO :=** _______________
RMB2 Pickup Debounce Messages (1–8)	**RMB2PU :=** _______________
RMB2 Dropout Debounce Messages (1–8)	**RMB2DO :=** _______________
RMB3 Pickup Debounce Messages (1–8)	**RMB3PU :=** _______________
RMB3 Dropout Debounce Messages (1–8)	**RMB3DO :=** _______________
RMB4 Pickup Debounce Messages (1–8)	**RMB4PU :=** _______________
RMB4 Dropout Debounce Messages (1–8)	**RMB4DO :=** _______________
RMB5 Pickup Debounce Messages (1–8)	**RMB5PU :=** _______________
RMB5 Dropout Debounce Messages (1–8)	**RMB5DO :=** _______________
RMB6 Pickup Debounce Messages (1–8)	**RMB6PU :=** _______________
RMB6 Dropout Debounce Messages (1–8)	**RMB6DO :=** _______________
RMB7 Pickup Debounce Messages (1–8)	**RMB7PU :=** _______________
RMB7 Dropout Debounce Messages (1–8)	**RMB7DO :=** _______________

RMB8 Pickup Debounce Messages (1–8) **RMB8PU** := _______________

RMB8 Dropout Debounce Messages (1–8) **RMB8DO** := _______________

IEC 60870-5-103 Protocol

(Hidden unless serial port with PROTO := 103)

103 DEVICE ADDRESS (0–254)	**103ADDR** := _______________
CYCLIC DATA REPORTING PERIOD (1–3600 s)	**103CYC** := _______________
ACCUMULATOR REPORTING PERIOD (OFF, 1–3600 s)	**103ACYC** := _______________
ACCUMULATOR REPORTING TRIGGER (1 Relay Word Bit)	**103ATRI** := _______________
ENABLE TIME SYNCHRONIZATION (Y, N)	**103TIME** := _______________

Front-Panel Settings (SET F Command)

General

DISPLY PTS ENABL (N, 1–32) *(Hidden and forced to N if the front-panel MOT option is A)*	**EDP** := _______________
LOCAL BITS ENABL (N, 1–32)	**ELB** := _______________
LCD TIMEOUT (OFF, 1–30 min) *(Hidden and forced to OFF if the front-panel MOT option is A)*	**FP_TO** := _______________
LCD CONTRAST (1–8) *(Hidden if the front-panel MOT option is A)*	**FP_CONT** := _______________
FP AUTOMESSAGES (OVERRIDE, ROTATING) *(Hidden if the front-panel MOT option is A)*	**FP_AUTO** := _______________
CLOSE RESET LEDS (Y, N)	**RSTLED** := _______________
ENA_LED COLOR (R = Red, G = Green, A = Amber) *(Hidden if the front-panel MOT option is A)*	**LEDENAC** := _______________
TRIP_LED COLOR (R = Red, G = Green, A = Amber)	**LEDTRPC** := _______________
MAXIMUM ACCESS LEVEL (1, 2) *(Hidden if the front-panel MOT option is A)*	**MAXACC** := _______________

Target LED

(R = Red, G = Green, A = Amber)

TRIP LATCH T_LED (Y, N)	**T01LEDL** := _______________
TARGET T_LED ASSERTED COLOR (R, G, A)	**T01LEDC** := _______________
LED1 EQUATION (SELOGIC)	**T01_LED** := _______________
TRIP LATCH T_LED (Y, N)	**T02LEDL** := _______________
TARGET T_LED ASSERTED COLOR (R, G, A)	**T02LEDC** := _______________
LED2 EQUATION (SELOGIC)	**T02_LED** := _______________
TRIP LATCH T_LED (Y, N)	**T03LEDL** := _______________
TARGET T_LED ASSERTED COLOR (R, G, A)	**T03LEDC** := _______________
LED3 EQUATION (SELOGIC)	**T03_LED** := _______________
TRIP LATCH T_LED (Y, N)	**T04LEDL** := _______________

TARGET T_LED ASSERTED COLOR (R, G, A)	**T04LEDC :=** _______________
LED4 EQUATION (SELOGIC)	**T04_LED :=** _______________
TRIP LATCH T_LED (Y, N)	**T05LEDL :=** _______________
TARGET T_LED ASSERTED COLOR (R, G, A)	**T05LEDC :=** _______________
LED5 EQUATION (SELOGIC)	**T05_LED :=** _______________
TRIP LATCH T_LED (Y, N)	**T06LEDL :=** _______________
TARGET T_LED ASSERTED COLOR (R, G, A)	**T06LEDC :=** _______________
LED6 EQUATION (SELOGIC)	**T06_LED :=** _______________

Operator Control LED

(Asserted/deasserted color choices: R = Red, G = Green, A = Amber, O = Off. Asserted and deasserted colors must be different)

PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB1ALEDC :=** _______________
PB1A_LED EQUATION (SELOGIC)	**PB1A_LED :=** _______________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB1BLEDC :=** _______________
PB1B_LED EQUATION (SELOGIC)	**PB1B_LED :=** _______________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB2ALEDC :=** _______________
PB2A_LED EQUATION (SELOGIC)	**PB2A_LED :=** _______________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB2BLEDC :=** _______________
PB2B_LED EQUATION (SELOGIC)	**PB2B_LED :=** _______________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB3ALEDC :=** _______________
PB3A_LED EQUATION (SELOGIC)	**PB3A_LED :=** _______________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB3BLEDC :=** _______________
PB3B_LED EQUATION (SELOGIC)	**PB3B_LED :=** _______________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB4ALEDC :=** _______________
PB4A_LED EQUATION (SELOGIC)	**PB4A_LED :=** _______________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB4BLEDC :=** _______________
PB4B_LED EQUATION (SELOGIC)	**PB4B_LED :=** _______________

(The following operator control LED settings are hidden if the front-panel MOT option is 1.)

PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB5ALEDC :=** _______________
PB5A_LED EQUATION (SELOGIC)	**PB5A_LED :=** _______________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB5BLEDC :=** _______________
PB5B_LED EQUATION (SELOGIC)	**PB5B_LED :=** _______________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB6ALEDC :=** _______________
PB6A_LED EQUATION (SELOGIC)	**PB6A_LED :=** _______________

PB_LED ASSERTED/DEASSERTED COLORS
(AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO) **PB6BLEDC :=** ______________

PB6B_LED EQUATION (SELOGIC) **PB6B_LED :=** ______________

PB_LED ASSERTED/DEASSERTED COLORS
(AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO) **PB7ALEDC :=** ______________

PB7A_LED EQUATION (SELOGIC) **PB7A_LED :=** ______________

PB_LED ASSERTED/DEASSERTED COLORS
(AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO) **PB7BLEDC :=** ______________

PB7B_LED EQUATION (SELOGIC) **PB7B_LED :=** ______________

PB_LED ASSERTED/DEASSERTED COLORS
(AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO) **PB8ALEDC :=** ______________

PB8A_LED EQUATION (SELOGIC) **PB8A_LED :=** ______________

PB_LED ASSERTED/DEASSERTED COLORS
(AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO) **PB8BLEDC :=** ______________

PB8B_LED EQUATION (SELOGIC) **PB8B_LED :=** ______________

Display Points

(The following display point settings are hidden if the front-panel MOT option is A)
Display Point Settings (maximum 60 characters):
(Boolean): Relay Word Bit Name, "Alias", "Set String", "Clear String"
(Analog): Analog Quantity Name, "User Text and Formatting"

DP01 := ______________________________

DP02 := ______________________________

DP03 := ______________________________

DP04 := ______________________________

DP05 := ______________________________

DP06 := ______________________________

DP07 := ______________________________

DP08 := ______________________________

DP09 := ______________________________

DP10 := ______________________________

DP11 := ______________________________

DP12 := ______________________________

DP13 := ______________________________

DP14 := ______________________________

DP15 := ______________________________

DP16 := ______________________________

DP17 := ______________________________

DP18 := ______________________________

DP19 := ______________________________

DP20 := ______________________________

DP21 := ______________________________

DP22 := ______________________________

DP23 := ______________________________

DP24 := ______________________________

DP25 := ____________________

DP26 := ____________________

DP27 := ____________________

DP28 := ____________________

DP29 := ____________________

DP30 := ____________________

DP31 := ____________________

DP32 := ____________________

Local Bits Labels

LB_NAME (14 characters); CLEAR LB_ LABEL, SET LB_ LABEL, and PULSE LB_ LABEL (7 characters)

LB_NAME **NLB01 :=** __________
CLEAR LB_ LABEL **CLB01 :=** __________
SET LB_ LABEL **SLB01 :=** __________
PULSE LB_ LABEL **PLB01 :=** __________

LB_NAME **NLB02 :=** __________
CLEAR LB_ LABEL **CLB02 :=** __________
SET LB_ LABEL **SLB02 :=** __________
PULSE LB_ LABEL **PLB02 :=** __________

LB_NAME **NLB03 :=** __________
CLEAR LB_ LABEL **CLB03 :=** __________
SET LB_ LABEL **SLB03 :=** __________
PULSE LB_ LABEL **PLB03 :=** __________

LB_NAME **NLB04 :=** __________
CLEAR LB_ LABEL **CLB04 :=** __________
SET LB_ LABEL **SLB04 :=** __________
PULSE LB_ LABEL **PLB04 :=** __________

LB_NAME **NLB05 :=** __________
CLEAR LB_ LABEL **CLB05 :=** __________
SET LB_ LABEL **SLB05 :=** __________
PULSE LB_ LABEL **PLB05 :=** __________

LB_NAME **NLB06 :=** __________
CLEAR LB_ LABEL **CLB06 :=** __________
SET LB_ LABEL **SLB06 :=** __________
PULSE LB_ LABEL **PLB06 :=** __________

LB_NAME **NLB07 :=** __________
CLEAR LB_ LABEL **CLB07 :=** __________
SET LB_ LABEL **SLB07 :=** __________
PULSE LB_ LABEL **PLB07 :=** __________

LB_NAME **NLB08 :=** __________
CLEAR LB_ LABEL **CLB08 :=** __________
SET LB_ LABEL **SLB08 :=** __________
PULSE LB_ LABEL **PLB08 :=** __________

LB_NAME **NLB09 :=** __________
CLEAR LB_ LABEL **CLB09 :=** __________
SET LB_ LABEL **SLB09 :=** __________
PULSE LB_ LABEL **PLB09 :=** __________

LB_NAME **NLB10 :=** __________
CLEAR LB_ LABEL **CLB10 :=** __________
SET LB_ LABEL **SLB10 :=** __________
PULSE LB_ LABEL **PLB10 :=** __________

LB_NAME **NLB11 :=** __________
CLEAR LB_ LABEL **CLB11 :=** __________
SET LB_ LABEL **SLB11 :=** __________
PULSE LB_ LABEL **PLB11 :=** __________

LB_NAME **NLB12 :=** __________
CLEAR LB_ LABEL **CLB12 :=** __________
SET LB_ LABEL **SLB12 :=** __________
PULSE LB_ LABEL **PLB12 :=** __________

LB_NAME **NLB13 :=** __________
CLEAR LB_ LABEL **CLB13 :=** __________
SET LB_ LABEL **SLB13 :=** __________
PULSE LB_ LABEL **PLB13 :=** __________

LB_NAME **NLB14 :=** __________
CLEAR LB_ LABEL **CLB14 :=** __________
SET LB_ LABEL **SLB14 :=** __________
PULSE LB_ LABEL **PLB14 :=** __________

LB_NAME	**NLB15 :=**	________________
CLEAR LB_ LABEL	**CLB15 :=**	________________
SET LB_ LABEL	**SLB15 :=**	________________
PULSE LB_ LABEL	**PLB15 :=**	________________
LB_NAME	**NLB16 :=**	________________
CLEAR LB_ LABEL	**CLB16 :=**	________________
SET LB_ LABEL	**SLB16 :=**	________________
PULSE LB_ LABEL	**PLB16 :=**	________________
LB_NAME	**NLB17 :=**	________________
CLEAR LB_ LABEL	**CLB17 :=**	________________
SET LB_ LABEL	**SLB17 :=**	________________
PULSE LB_ LABEL	**PLB17 :=**	________________
LB_NAME	**NLB18 :=**	________________
CLEAR LB_ LABEL	**CLB18 :=**	________________
SET LB_ LABEL	**SLB18 :=**	________________
PULSE LB_ LABEL	**PLB18 :=**	________________
LB_NAME	**NLB19 :=**	________________
CLEAR LB_ LABEL	**CLB19 :=**	________________
SET LB_ LABEL	**SLB19 :=**	________________
PULSE LB_ LABEL	**PLB19 :=**	________________
LB_NAME	**NLB20 :=**	________________
CLEAR LB_ LABEL	**CLB20 :=**	________________
SET LB_ LABEL	**SLB20 :=**	________________
PULSE LB_ LABEL	**PLB20 :=**	________________
LB_NAME	**NLB21 :=**	________________
CLEAR LB_ LABEL	**CLB21 :=**	________________
SET LB_ LABEL	**SLB21 :=**	________________
PULSE LB_ LABEL	**PLB21 :=**	________________
LB_NAME	**NLB22 :=**	________________
CLEAR LB_ LABEL	**CLB22 :=**	________________
SET LB_ LABEL	**SLB22 :=**	________________
PULSE LB_ LABEL	**PLB22 :=**	________________
LB_NAME	**NLB23 :=**	________________
CLEAR LB_ LABEL	**CLB23 :=**	________________
SET LB_ LABEL	**SLB23 :=**	________________
PULSE LB_ LABEL	**PLB23 :=**	________________
LB_NAME	**NLB24 :=**	________________
CLEAR LB_ LABEL	**CLB24 :=**	________________
SET LB_ LABEL	**SLB24 :=**	________________
PULSE LB_ LABEL	**PLB24 :=**	________________
LB_NAME	**NLB25 :=**	________________
CLEAR LB_ LABEL	**CLB25 :=**	________________
SET LB_ LABEL	**SLB25 :=**	________________
PULSE LB_ LABEL	**PLB25 :=**	________________
LB_NAME	**NLB26 :=**	________________
CLEAR LB_ LABEL	**CLB26 :=**	________________
SET LB_ LABEL	**SLB26 :=**	________________
PULSE LB_ LABEL	**PLB26 :=**	________________
LB_NAME	**NLB27 :=**	________________
CLEAR LB_ LABEL	**CLB27 :=**	________________
SET LB_ LABEL	**SLB27 :=**	________________
PULSE LB_ LABEL	**PLB27 :=**	________________
LB_NAME	**NLB28 :=**	________________
CLEAR LB_ LABEL	**CLB28 :=**	________________
SET LB_ LABEL	**SLB28 :=**	________________
PULSE LB_ LABEL	**PLB28 :=**	________________
LB_NAME	**NLB29 :=**	________________
CLEAR LB_ LABEL	**CLB29 :=**	________________
SET LB_ LABEL	**SLB29 :=**	________________
PULSE LB_ LABEL	**PLB29 :=**	________________
LB_NAME	**NLB30 :=**	________________
CLEAR LB_ LABEL	**CLB30 :=**	________________
SET LB_ LABEL	**SLB30 :=**	________________
PULSE LB_ LABEL	**PLB30 :=**	________________
LB_NAME	**NLB31 :=**	________________
CLEAR LB_ LABEL	**CLB31 :=**	________________
SET LB_ LABEL	**SLB31 :=**	________________
PULSE LB_ LABEL	**PLB31 :=**	________________
LB_NAME	**NLB32 :=**	________________
CLEAR LB_ LABEL	**CLB32 :=**	________________
SET LB_ LABEL	**SLB32 :=**	________________
PULSE LB_ LABEL	**PLB32 :=**	________________

Touchscreen Settings

(Shown if the front-panel MOT option is A)
(Note: The Touchscreen settings category is only available in QuickSet, with the exception of the settings FPTO, FPDUR, and FPBAB, which are also available to set via the touchscreen display.)

Touchscreen Configuration

DISPLAY HOME SCREEN (Refer to *Table 8.17* for setting range)	**FPHOME :=** ______________
DISPLAY TIME-OUT (1–30 min)	**FPTO :=** ______________
ROTATING DISPLAY TRANSITION TIME (3–15 sec)	**FPDUR :=** ______________
BACKLIGHT ACTIVE BRIGHTNESS (1–10)	**FPBAB :=** ______________

Rotating Display

(Refer to Table 8.17 for the setting range)

ROTATING DISPLAY 01	**FPRD01 :=** ______________
ROTATING DISPLAY 02	**FPRD02 :=** ______________
ROTATING DISPLAY 03	**FPRD03 :=** ______________
ROTATING DISPLAY 04	**FPRD04 :=** ______________
ROTATING DISPLAY 05	**FPRD05 :=** ______________
ROTATING DISPLAY 06	**FPRD06 :=** ______________
ROTATING DISPLAY 07	**FPRD07 :=** ______________
ROTATING DISPLAY 08	**FPRD08 :=** ______________
ROTATING DISPLAY 09	**FPRD09 :=** ______________
ROTATING DISPLAY 10	**FPRD10 :=** ______________
ROTATING DISPLAY 11	**FPRD11 :=** ______________
ROTATING DISPLAY 12	**FPRD12 :=** ______________
ROTATING DISPLAY 13	**FPRD13 :=** ______________
ROTATING DISPLAY 14	**FPRD14 :=** ______________
ROTATING DISPLAY 15	**FPRD15 :=** ______________
ROTATING DISPLAY 16	**FPRD16 :=** ______________

Pushbuttons

(OFF, refer to Table 8.17 for the setting range)

PUSHBUTTON 01 HMI SCREEN	**FPPB01 :=** ______________
PUSHBUTTON 02 HMI SCREEN	**FPPB02 :=** ______________
PUSHBUTTON 03 HMI SCREEN	**FPPB03 :=** ______________
PUSHBUTTON 04 HMI SCREEN	**FPPB04 :=** ______________
PUSHBUTTON 05 HMI SCREEN	**FPPB05 :=** ______________
PUSHBUTTON 06 HMI SCREEN	**FPPB06 :=** ______________
PUSHBUTTON 07 HMI SCREEN	**FPPB07 :=** ______________
PUSHBUTTON 08 HMI SCREEN	**FPPB08 :=** ______________

Bay Control Breaker

BREAKER TRIP TYPE (3)	**BK01TTY :=** ______________
BREAKER MODE (CONTROL, MONITOR)	**BK01MOD :=** ______________
BREAKER CLOSE STATUS (Relay Word bit)	**BK01CS :=** ______________
BREAKER OPEN STATUS (Relay Word bit)	**BK01OS :=** ______________
BREAKER ALARM STATUS (Relay Word bit)	**BK01AS :=** ______________
BREAKER HMI CLOSE COMMAND (Relay Word bit)	**BK01CLC :=** ______________
BREAKER HMI OPEN COMMAND (Relay Word bit)	**BK01OPC :=** ______________

Bay Control Disconnect

TWO-POSITION DISCONNECT MODE (MONITOR)	**2D01MOD :=** ______________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS01CS :=** ______________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS01OS :=** ______________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS01AS :=** ______________
TWO-POSITION DISCONNECT MODE (MONITOR)	**2D02MOD :=** ______________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS02CS :=** ______________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS02OS :=** ______________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS02AS :=** ______________
TWO-POSITION DISCONNECT MODE (MONITOR)	**2D03MOD :=** ______________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS03CS :=** ______________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS03OS :=** ______________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS03AS :=** ______________
TWO-POSITION DISCONNECT MODE (MONITOR)	**2D04MOD :=** ______________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS04CS :=** ______________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS04OS :=** ______________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS04AS :=** ______________
TWO-POSITION DISCONNECT MODE (MONITOR)	**2D05MOD :=** ______________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS05CS :=** ______________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS05OS :=** ______________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS05AS :=** ______________

Analog Label

ANALOG QUANTITY	**ALAB01 :=** ______________
ANALOG QUANTITY	**ALAB02 :=** ______________
ANALOG QUANTITY	**ALAB03 :=** ______________
ANALOG QUANTITY	**ALAB04 :=** ______________
ANALOG QUANTITY	**ALAB05 :=** ______________
ANALOG QUANTITY	**ALAB06 :=** ______________
ANALOG QUANTITY	**ALAB07 :=** ______________
ANALOG QUANTITY	**ALAB08 :=** ______________
ANALOG QUANTITY	**ALAB09 :=** ______________

ANALOG QUANTITY	**ALAB10 :=** ______________
ANALOG QUANTITY	**ALAB11 :=** ______________
ANALOG QUANTITY	**ALAB12 :=** ______________
ANALOG QUANTITY	**ALAB13 :=** ______________
ANALOG QUANTITY	**ALAB14 :=** ______________
ANALOG QUANTITY	**ALAB15 :=** ______________
ANALOG QUANTITY	**ALAB16 :=** ______________
ANALOG QUANTITY	**ALAB17 :=** ______________
ANALOG QUANTITY	**ALAB18 :=** ______________
ANALOG QUANTITY	**ALAB19 :=** ______________
ANALOG QUANTITY	**ALAB20 :=** ______________
ANALOG QUANTITY	**ALAB21 :=** ______________
ANALOG QUANTITY	**ALAB22 :=** ______________
ANALOG QUANTITY	**ALAB23 :=** ______________
ANALOG QUANTITY	**ALAB24 :=** ______________
ANALOG QUANTITY	**ALAB25 :=** ______________
ANALOG QUANTITY	**ALAB26 :=** ______________
ANALOG QUANTITY	**ALAB27 :=** ______________
ANALOG QUANTITY	**ALAB28 :=** ______________
ANALOG QUANTITY	**ALAB29 :=** ______________
ANALOG QUANTITY	**ALAB30 :=** ______________
ANALOG QUANTITY	**ALAB31 :=** ______________
ANALOG QUANTITY	**ALAB32 :=** ______________

Digital Label

RELAY WORD BIT	**DLAB01 :=** ______________
RELAY WORD BIT	**DLAB02 :=** ______________
RELAY WORD BIT	**DLAB03 :=** ______________
RELAY WORD BIT	**DLAB04 :=** ______________
RELAY WORD BIT	**DLAB05 :=** ______________
RELAY WORD BIT	**DLAB06 :=** ______________
RELAY WORD BIT	**DLAB07 :=** ______________
RELAY WORD BIT	**DLAB08 :=** ______________
RELAY WORD BIT	**DLAB09 :=** ______________
RELAY WORD BIT	**DLAB10 :=** ______________
RELAY WORD BIT	**DLAB11 :=** ______________
RELAY WORD BIT	**DLAB12 :=** ______________
RELAY WORD BIT	**DLAB13 :=** ______________
RELAY WORD BIT	**DLAB14 :=** ______________
RELAY WORD BIT	**DLAB15 :=** ______________
RELAY WORD BIT	**DLAB16 :=** ______________

RELAY WORD BIT	**DLAB17 :=** _______________
RELAY WORD BIT	**DLAB18 :=** _______________
RELAY WORD BIT	**DLAB19 :=** _______________
RELAY WORD BIT	**DLAB20 :=** _______________
RELAY WORD BIT	**DLAB21 :=** _______________
RELAY WORD BIT	**DLAB22 :=** _______________
RELAY WORD BIT	**DLAB23 :=** _______________
RELAY WORD BIT	**DLAB24 :=** _______________
RELAY WORD BIT	**DLAB25 :=** _______________
RELAY WORD BIT	**DLAB26 :=** _______________
RELAY WORD BIT	**DLAB27 :=** _______________
RELAY WORD BIT	**DLAB28 :=** _______________
RELAY WORD BIT	**DLAB29 :=** _______________
RELAY WORD BIT	**DLAB30 :=** _______________
RELAY WORD BIT	**DLAB31 :=** _______________
RELAY WORD BIT	**DLAB32 :=** _______________

Report Settings (SET R Command)

SER Chatter Criteria

Auto-Removal Enable (Y, N)	**ESERDEL :=** _______________
Number of Counts (2–20 counts)	**SRDLCNT :=** _______________
Removal Time (0.1–90.0 s)	**SRDLTIM :=** _______________

SER Trigger Lists

SERn = As many as 24 Relay Word elements separated by spaces or commas. Use NA to disable the setting.

SER1 := ____

SER2 := ____

SER3 := ____

SER4 := ____

Relay Word Bit Aliases

ALIASn= 'RW Bit'(space)'Alias'(space)'Asserted Text'(space)'Deasserted Text'. Alias, Asserted, and Deasserted text strings can be as many as 15 characters long. Use NA to disable setting.

Enable ALIAS (N, 1–20)	**EALIAS :=** ____________________________________
ALIAS1	**ALIAS1 :=** ____________________________________
ALIAS2	**ALIAS2 :=** ____________________________________
ALIAS3	**ALIAS3 :=** ____________________________________
ALIAS4	**ALIAS4 :=** ____________________________________
ALIAS5	**ALIAS5 :=** ____________________________________
ALIAS6	**ALIAS6 :=** ____________________________________
ALIAS7	**ALIAS7 :=** ____________________________________

ALIAS8	**ALIAS8 :=** ________________
ALIAS 9	**ALIAS9 :=** ________________
ALIAS10	**ALIAS10 :=** ________________
ALIAS11	**ALIAS11 :=** ________________
ALIAS12	**ALIAS12 :=** ________________
ALIAS13	**ALIAS13 :=** ________________
ALIAS14	**ALIAS14 :=** ________________
ALIAS15	**ALIAS15 :=** ________________
ALIAS16	**ALIAS16 :=** ________________
ALIAS17	**ALIAS17 :=** ________________
ALIAS18	**ALIAS18 :=** ________________
ALIAS19	**ALIAS19 :=** ________________
ALIAS20	**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 :=** ________________

HIF Event Reporting

(Hidden if the AST option is not included in the MOT.)

HIF EVENT LENGTH (2, 5, 10, 20 min)	**HIFLER :=** ________________

Fast Message Read Settings

FMRnNAM = Any valid string. (No spaces allowed; should be different from other FMRxNAM)
FMRn = As many as 24 analog quantities separated by spaces or commas. (Analog quantities listed here will be included in the Fast Message read request)
Use NA to disable setting.

FMR1 Name (9 characters)	**FMR1NAM :=** ________________
Fast Message Read FMR1 (24 analog quantities)	**FMR1 :=** ________________
FMR2 Name (9 characters)	**FMR2NAM :=** ________________
Fast Message Read FMR2 (24 analog quantities)	**FMR2 :=** ________________
FMR3 Name (9 characters)	**FMR3NAM :=** ________________
Fast Message Read FMR3 (24 analog quantities)	**FMR3 :=** ________________
FMR4 Name (9 characters)	**FMR4NAM :=** ________________
Fast Message Read FMR4 (24 analog quantities)	**FMR4 :=** ________________

Fast Message Remote Analog Settings

Remote Analog Value Type (I, F, L), I = Integer, F = Float, L = Long

RA01TYPE := ________________
RA02TYPE := ________________
RA03TYPE := ________________
RA04TYPE := ________________
RA05TYPE := ________________
RA06TYPE := ________________
RA07TYPE := ________________
RA08TYPE := ________________
RA09TYPE := ________________
RA10TYPE := ________________
RA11TYPE := ________________
RA12TYPE := ________________
RA13TYPE := ________________
RA14TYPE := ________________
RA15TYPE := ________________
RA16TYPE := ________________
RA17TYPE := ________________
RA18TYPE := ________________
RA19TYPE := ________________
RA20TYPE := ________________
RA21TYPE := ________________
RA22TYPE := ________________
RA23TYPE := ________________
RA24TYPE := ________________
RA25TYPE := ________________
RA26TYPE := ________________
RA27TYPE := ________________
RA28TYPE := ________________
RA29TYPE := ________________
RA30TYPE := ________________
RA31TYPE := ________________
RA32TYPE := ________________

Load Profile

LDP LIST (NA, As many as 17 analog quantities) **LDLIST :=** ____________
LDP ACQ RATE (5, 10, 15, 30, 60 min) **LDAR :=** ____________

Modbus Map Settings (SET M Command)

Modbus User Map

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

MOD_001 := ________________
MOD_002 := ________________
MOD_003 := ________________
MOD_004 := ________________
MOD_005 := ________________
MOD_006 := ________________
MOD_007 := ________________
MOD_008 := ________________
MOD_009 := ________________
MOD_010 := ________________
MOD_011 := ________________
MOD_012 := ________________
MOD_013 := ________________
MOD_014 := ________________
MOD_015 := ________________
MOD_016 := ________________
MOD_017 := ________________
MOD_018 := ________________
MOD_019 := ________________
MOD_020 := ________________
MOD_021 := ________________
MOD_022 := ________________
MOD_023 := ________________
MOD_024 := ________________
MOD_025 := ________________
MOD_026 := ________________

MOD_027 := ______________________________
MOD_028 := ______________________________
MOD_029 := ______________________________
MOD_030 := ______________________________
MOD_031 := ______________________________
MOD_032 := ______________________________
MOD_033 := ______________________________
MOD_034 := ______________________________
MOD_035 := ______________________________
MOD_036 := ______________________________
MOD_037 := ______________________________
MOD_038 := ______________________________
MOD_039 := ______________________________
MOD_040 := ______________________________
MOD_041 := ______________________________
MOD_042 := ______________________________
MOD_043 := ______________________________
MOD_044 := ______________________________
MOD_045 := ______________________________
MOD_046 := ______________________________
MOD_047 := ______________________________
MOD_048 := ______________________________
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MOD_070 := ______________________________
MOD_071 := ______________________________
MOD_072 := ______________________________
MOD_073 := ______________________________
MOD_074 := ______________________________
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MOD_076 := ______________________________
MOD_077 := ______________________________
MOD_078 := ______________________________
MOD_079 := ______________________________
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MOD_081 := ______________________________
MOD_082 := ______________________________
MOD_083 := ______________________________
MOD_084 := ______________________________
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MOD_086 := ______________________________
MOD_087 := ______________________________
MOD_088 := ______________________________
MOD_089 := ______________________________
MOD_090 := ______________________________
MOD_091 := ______________________________
MOD_092 := ______________________________
MOD_093 := ______________________________
MOD_094 := ______________________________
MOD_095 := ______________________________
MOD_096 := ______________________________
MOD_097 := ______________________________
MOD_098 := ______________________________
MOD_099 := ______________________________
MOD_100 := ______________________________
MOD_101 := ______________________________
MOD_102 := ______________________________
MOD_103 := ______________________________
MOD_104 := ______________________________
MOD_105 := ______________________________
MOD_106 := ______________________________
MOD_107 := ______________________________
MOD_108 := ______________________________

MOD_109 := ______________________________

MOD_110 := ______________________________

MOD_111 := ______________________________

MOD_112 := ______________________________

MOD_113 := ______________________________

MOD_114 := ______________________________

MOD_115 := ______________________________

MOD_116 := ______________________________

MOD_117 := ______________________________

MOD_118 := ______________________________

MOD_119 := ______________________________

MOD_120 := ______________________________

MOD_121 := ______________________________

MOD_122 := ______________________________

MOD_123 := ______________________________

MOD_124 := ______________________________

MOD_125 := ______________________________

DNP3 Map Settings (SET DNP n Command)

(Hidden if the DNP option is not included)

*Use the **SET DNP n** command with n = 1, 2, or 3 to create as many as three DNP User Maps. Refer to Appendix D: DNP3 Communications for details. This is DNP Map 1 (DNP Map 2 and DNP Map 3 tables are identical to DNP Map 1 table).*

Binary Input Map

DNP Binary Input Label Name (10 characters)

BI_01 := ______________________________

BI_02 := ______________________________

BI_03 := ______________________________

BI_04 := ______________________________

BI_05 := ______________________________

BI_06 := ______________________________

BI_07 := ______________________________

BI_08 := ______________________________

BI_09 := ______________________________

BI_10 := ______________________________

BI_11 := ______________________________

BI_12 := ______________________________

BI_13 := ______________________________

BI_14 := ______________________________

BI_15 := ______________________________

BI_16 := ______________________________

BI_17 := ______________________________

BI_18 := ______________________________

BI_19 := ______________________________

BI_20 := ______________________________

BI_21 := ______________________________

BI_22 := ______________________________

BI_23 := ______________________________

BI_24 := ______________________________

BI_25 := ______________________________

BI_26 := ______________________________

BI_27 := ______________________________

BI_28 := ______________________________

BI_29 := ______________________________

BI_30 := ______________________________

BI_31 := ______________________________

BI_32 := ______________________________

BI_33 := ______________________________

BI_34 := ________________
BI_35 := ________________
BI_36 := ________________
BI_37 := ________________
BI_38 := ________________
BI_39 := ________________
BI_40 := ________________
BI_41 := ________________
BI_42 := ________________
BI_43 := ________________
BI_44 := ________________
BI_45 := ________________
BI_46 := ________________
BI_47 := ________________
BI_48 := ________________
BI_49 := ________________
BI_50 := ________________
BI_51 := ________________
BI_52 := ________________
BI_53 := ________________
BI_54 := ________________
BI_55 := ________________
BI_56 := ________________
BI_57 := ________________
BI_58 := ________________
BI_59 := ________________
BI_60 := ________________
BI_61 := ________________
BI_62 := ________________
BI_63 := ________________
BI_64 := ________________
BI_65 := ________________
BI_66 := ________________
BI_67 := ________________
BI_68 := ________________
BI_69 := ________________
BI_70 := ________________
BI_71 := ________________
BI_72 := ________________
BI_73 := ________________
BI_74 := ________________
BI_75 := ________________
BI_76 := ________________
BI_77 := ________________
BI_78 := ________________
BI_79 := ________________
BI_80 := ________________
BI_81 := ________________
BI_82 := ________________
BI_83 := ________________
BI_84 := ________________
BI_85 := ________________
BI_86 := ________________
BI_87 := ________________
BI_88 := ________________
BI_89 := ________________
BI_90 := ________________
BI_91 := ________________
BI_92 := ________________
BI_93 := ________________
BI_94 := ________________
BI_95 := ________________
BI_96 := ________________
BI_97 := ________________
BI_98 := ________________
BI_99 := ________________

Binary Output Map

DNP Binary Output Label Name (10 characters)

BO_00 := ____________________

BO_01 := ____________________

BO_02 := ____________________

BO_03 := ____________________

BO_04 := ____________________

BO_05 := ____________________

BO_06 := ____________________

BO_07 := ____________________

BO_08 := ____________________

BO_09 := ____________________

BO_10 := ____________________

BO_11 := ____________________

BO_12 := ____________________

BO_13 := ____________________

BO_14 := ____________________

BO_15 := ____________________

BO_16 := ____________________

BO_17 := ____________________

BO_18 := ____________________

BO_19 := ____________________

BO_20 := ____________________

BO_21 := ____________________

BO_22 := ____________________

BO_23 := ____________________

BO_24 := ____________________

BO_25 := ____________________

BO_26 := ____________________

BO_27 := ____________________

BO_28 := ____________________

BO_29 := ____________________

BO_30 := ____________________

BO_31 := ____________________

Analog Input Map

DNP Analog Input Label Name (24 characters)

AI_00 := ____________________

AI_01 := ____________________

AI_02 := ____________________

AI_03 := ____________________

AI_04 := ____________________

AI_05 := ____________________

AI_06 := ____________________

AI_07 := ____________________

AI_08 := ____________________

AI_09 := ____________________

AI_10 := ____________________

AI_11 := ____________________

AI_12 := ____________________

AI_13 := ____________________

AI_14 := ____________________

AI_15 := ____________________

AI_16 := ____________________

AI_17 := ____________________

AI_18 := ____________________

AI_19 := ____________________

AI_20 := ____________________

AI_21 := ____________________

AI_22 := ____________________

AI_23 := ____________________

AI_24 := ____________________

AI_25 := ____________________

AI_26 := ____________________

AI_27 := ____________________

AI_28 := ____________________

AI_29 := ____________________

AI_30 := ____________________

AI_31 := ____________________

AI_32 := ____________________

AI_33 := ____________________

AI_34 := ____________________

AI_35 := ____________________

AI_36 := ____________________

AI_37 := ____________________

AI_38 := ____________________

AI_39 := ________________________________
AI_40 := ________________________________
AI_41 := ________________________________
AI_42 := ________________________________
AI_43 := ________________________________
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AI_48 := ________________________________
AI_49 := ________________________________
AI_50 := ________________________________
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AI_75 := ________________________________
AI_76 := ________________________________
AI_77 := ________________________________
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AI_79 := ________________________________
AI_80 := ________________________________
AI_81 := ________________________________
AI_82 := ________________________________
AI_83 := ________________________________
AI_84 := ________________________________
AI_85 := ________________________________
AI_86 := ________________________________
AI_87 := ________________________________
AI_88 := ________________________________
AI_89 := ________________________________
AI_90 := ________________________________
AI_91 := ________________________________
AI_92 := ________________________________
AI_93 := ________________________________
AI_94 := ________________________________
AI_95 := ________________________________
AI_96 := ________________________________
AI_97 := ________________________________
AI_98 := ________________________________
AI_99 := ________________________________

Analog Output Map

DNP Analog Output Label Name (6 characters)

AO_00 := ________________
AO_01 := ________________
AO_02 := ________________
AO_03 := ________________
AO_04 := ________________
AO_05 := ________________
AO_06 := ________________
AO_07 := ________________
AO_08 := ________________
AO_09 := ________________
AO_10 := ________________
AO_11 := ________________
AO_12 := ________________
AO_13 := ________________
AO_14 := ________________
AO_15 := ________________
AO_16 := ________________
AO_17 := ________________
AO_18 := ________________
AO_19 := ________________
AO_20 := ________________
AO_21 := ________________
AO_22 := ________________
AO_23 := ________________
AO_24 := ________________
AO_25 := ________________
AO_26 := ________________
AO_27 := ________________
AO_28 := ________________
AO_29 := ________________
AO_30 := ________________
AO_31 := ________________

Counter Map

DNP Counter Label Name (11 characters)

CO_00 := ________________
CO_01 := ________________
CO_02 := ________________
CO_03 := ________________
CO_04 := ________________
CO_05 := ________________
CO_06 := ________________
CO_07 := ________________
CO_08 := ________________
CO_09 := ________________
CO_10 := ________________
CO_11 := ________________
CO_12 := ________________
CO_13 := ________________
CO_14 := ________________
CO_15 := ________________
CO_16 := ________________
CO_17 := ________________
CO_18 := ________________
CO_19 := ________________
CO_20 := ________________
CO_21 := ________________
CO_22 := ________________
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CO_24 := ________________
CO_25 := ________________
CO_26 := ________________
CO_27 := ________________
CO_28 := ________________
CO_29 := ________________
CO_30 := ________________
CO_31 := ________________

IEC 60870-5-103 Map Settings (SET I Command)

(Hidden if the IEC 60870-5-103 option is not included)
Use the SET I command to input the map required for the IEC 60870-5-103 protocol.

Binary Input Map

103BI00 := ________________________________
103BI01 := ________________________________
103BI02 := ________________________________
103BI03 := ________________________________
103BI04 := ________________________________
103BI05 := ________________________________
103BI06 := ________________________________
103BI07 := ________________________________
103BI08 := ________________________________
103BI09 := ________________________________
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103BI12 := ________________________________
103BI13 := ________________________________
103BI14 := ________________________________
103BI15 := ________________________________
103BI16 := ________________________________
103BI17 := ________________________________
103BI18 := ________________________________
103BI19 := ________________________________
103BI20 := ________________________________
103BI21 := ________________________________
103BI22 := ________________________________
103BI23 := ________________________________
103BI24 := ________________________________
103BI25 := ________________________________
103BI26 := ________________________________
103BI27 := ________________________________
103BI28 := ________________________________
103BI29 := ________________________________
103BI30 := ________________________________
103BI31 := ________________________________
103BI32 := ________________________________
103BI33 := ________________________________
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103BI39 := ________________________________
103BI40 := ________________________________
103BI41 := ________________________________
103BI42 := ________________________________
103BI43 := ________________________________
103BI44 := ________________________________
103BI45 := ________________________________
103BI46 := ________________________________
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103BI72 := ______________________________

103BI73 := ______________________________

103BI74 := ______________________________

103BI75 := ______________________________

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103BI78 := ______________________________

103BI79 := ______________________________

103BI80 := ______________________________

103BI81 := ______________________________

103BI82 := ______________________________

103BI83 := ______________________________

103BI84 := ______________________________

103BI85 := ______________________________

103BI86 := ______________________________

103BI87 := ______________________________

103BI88 := ______________________________

103BI89 := ______________________________

103BI90 := ______________________________

103BI91 := ______________________________

103BI92 := ______________________________

103BI93 := ______________________________

103BI94 := ______________________________

103BI95 := ______________________________

103BI96 := ______________________________

103BI97 := ______________________________

103BI98 := ______________________________

103BI99 := ______________________________

Binary Target Map

103BT00 := ______________________________

103BT01 := ______________________________

103BT02 := ______________________________

103BT03 := ______________________________

103BT04 := ______________________________

103BT05 := ______________________________

103BT06 := ______________________________

103BT07 := ______________________________

Fault Analog Map

103FA00 := ______________________________

103FA01 := ______________________________

103FA02 := ______________________________

103FA03 := ______________________________

103FA04 := ______________________________

103FA05 := ______________________________

103FA06 := ______________________________

103FA07 := ______________________________

103FA08 := ________________________________

103FA09 := ________________________________

103FA10 := ________________________________

103FA11 := ________________________________

103FA12 := ________________________________

103FA13 := ________________________________

103FA14 := ________________________________

103FA15 := ________________________________

103FA16 := ________________________________

103FA17 := ________________________________

103FA18 := ________________________________

103FA19 := ________________________________

103FA20 := ________________________________

103FA21 := ________________________________

103FA22 := ________________________________

103FA23 := ________________________________

103FA24 := ________________________________

103FA25 := ________________________________

103FA26 := ________________________________

103FA27 := ________________________________

103FA28 := ________________________________

103FA29 := ________________________________

103FA30 := ________________________________

103FA31 := ________________________________

Binary Control Map

103BO00 := ________________________________

103BO01 := ________________________________

103BO02 := ________________________________

103BO03 := ________________________________

103BO04 := ________________________________

103BO05 := ________________________________

103BO06 := ________________________________

103BO07 := ________________________________

103BO08 := ________________________________

103BO09 := ________________________________

103BO10 := ________________________________

103BO11 := ________________________________

103BO12 := ________________________________

103BO13 := ________________________________

103BO14 := ________________________________

103BO15 := ________________________________

103BO16 := ________________________________

103BO17 := ________________________________

103BO18 := ________________________________

103BO19 := ________________________________

103BO20 := ________________________________

103BO21 := ________________________________

103BO22 := ________________________________

103BO23 := ________________________________

103BO24 := ________________________________

103BO25 := ________________________________

103BO26 := ________________________________

103BO27 := ________________________________

103BO28 := ________________________________

103BO29 := ________________________________

103BO30 := ________________________________

103BO31 := ________________________________

Measurand Map

3MLB000 := ________________________________

3MLB001 := ________________________________

3MLB002 := ________________________________

3MLB003 := ________________________________

3MLB004 := ________________________________

3MLB005 := ________________________________

3MLB006 := ________________________________

3MLB007 := ________________________________

3MLB008 := ________________________________

3MLB009 := ________________________________

3MLB010 := ________________________________

3MLB011 := ________________________________

3MLB012 := ________________________________

3MLB013 := ________________________________

3MLB014 := ________________________________

3MLB015 := ________________________________

3MLB016 := ________________________________

3MLB017 := ________________________________

3MLB018 := ________________________________

3MLB019 := ________________________________

3MLB020 := ________________________________

3MLB021 := ________________________________

3MLB022 := ________________________________

3MLB023 := ________________________________

3MLB024 := ________________________________

3MLB025 := ________________________________

3MLB026 := ________________________________

3MLB027 := ________________________________

3MLB028 := ________________________________

3MLB029 := ________________________________

3MLB030 := ________________________________

3MLB031 := ________________________________

3MLB032 := ________________________________

3MLB033 := ________________________________

3MLB034 := ________________________________

3MLB035 := ________________________________

3MLB036 := ________________________________

3MLB037 := ________________________________

3MLB038 := ________________________________

3MLB039 := ________________________________

3MLB040 := ________________________________

3MLB041 := ________________________________

3MLB042 := ________________________________

3MLB043 := ________________________________

3MLB044 := ________________________________

3MLB045 := ________________________________

3MLB046 := ________________________________

3MLB047 := ________________________________

3MLB048 := ________________________________

3MLB049 := ________________________________

3MLB050 := ________________________________

Section 7
Communications

Overview

A communications interface and protocol are necessary for communicating with the SEL-751 Feeder Protection 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, data, or perform control functions.

Communications Interfaces

The SEL-751 physical interfaces are shown in *Table 7.1*. Several optional SEL devices are available to provide alternative physical interfaces, including EIA-485, EIA-232 fiber-optic serial port, copper or fiber Ethernet port, single or dual redundant.

Table 7.1 SEL-751 Communications Port Interfaces

	Communications Port Interfaces	Location	Feature
PORT F	EIA-232	Front	Standard
PORT 1	Option 1: 10/100BASE-T Ethernet (RJ45 connector) Option 2: Dual, redundant 10/100 BASE-T Ethernet (Port 1A, Port 1B) Option 3: 100BASE-FX Ethernet (LC connector) Option 4: Dual, redundant 100BASE-FX Ethernet (Port 1A, Port 1B)	Rear	Ordering Option
PORT 2 [a]	Multimode Fiber-Optic Serial (ST connector)	Rear	Ordering Option
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 from the optional external SEL-2600 RTD Module. Refer to the SEL-2600 RTD Module Instruction Manual for information on the fiber-optic interface.
[b] Refer to Appendix H: 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-751. 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 as far as 15 m (50 ft) in low noise environments. Use the optional EIA-485 port for communications distances as far as 1200 m (4000 ft) maximum distance (to achieve this performance, ensure proper line termination at the receiver).

To connect a PC serial port to the relay front-panel serial port and enter relay commands, you need the following:

- ➤ A personal computer equipped with one available EIA-232 serial port
- ➤ A communications cable to connect the computer serial port to the relay serial ports
- ➤ Terminal emulation software to control the computer serial port
- ➤ An SEL-751 Relay

Some of the SEL devices available for integration or communications system robustness are included in the following list:

- ➤ SEL communications processors (SEL-2032, SEL-2030, SEL-2020), SEL-3530 RTAC Real-Time Automation Controller
- ➤ SEL-2800 series fiber-optic transceivers
- ➤ SEL-2890 Ethernet Transceiver
- ➤ SEL-3010 Event Messenger
- ➤ SEL-2505 Remote I/O Module (with SEL-2812 compatible ST fiber-optic port) for connection to relay fiber-optic serial Port 2, or use SEL-2505 with EIA-232 (DB-9) serial port to connect to EIA-232 Port 3 on the relay

A variety of terminal emulation programs on personal computers can communicate with the relay. For the best display, use VT-100 terminal emulation or the closest variation.

The default settings for all EIA-232 serial ports are as follows:

Baud Rate = 9600
Data Bits = 8
Parity = N
Stop Bits = 1

To change the port settings, use the **SET P** command (see *Section 6: Settings*) or the front-panel. *Section 8: Front-Panel Operations* provides details on making settings with the front panel.

Hardware Flow Control

All EIA-232 serial ports support RTS/CTS hardware handshaking (hardware flow control). To enable hardware handshaking, use the **SET P** command or front-panel PORT submenu to set RTSCTS = Y. Disable hardware handshaking by setting RTSCTS := N.

- ➤ If RTSCTS := N, the relay permanently asserts the RTS line.
- ➤ If RTSCTS := Y, the relay deasserts RTS when it is unable to receive characters.
- ➤ If RTSCTS := Y, the relay does not send characters until the CTS input is asserted.

Fiber-Optic Serial Port

Use the optional fiber-optic port (Port 2) for safety and communications distances as far as 1 km. For communications distances as far as 4 km, use an SEL-2812 transceiver on Port 3. Although Port 2 and the SEL-2812 are compatible, Port 2 is less sensitive than the SEL-2812, which limits the distance to 1 km. This port can receive the RTD measurement information from the optional external SEL-2600 RTD Module.

Ethernet Port

Use the Ethernet port for interfacing with an Ethernet network environment. SEL-751 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 the primary to the backup network if the relay detects a failure in the primary network. The basic concept in the Parallel Redundancy Protocol (PRP) mode of operation is that the Ethernet network and all traffic are fully duplicated with the two copies operating in parallel. The purpose of the protocol is to provide seamless recovery from any single Ethernet network failure. In addition to failover and PRP modes, the unit can operate in a “fixed connection (to netport) mode” or in a “switched mode” (as an unmanaged switch).

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.

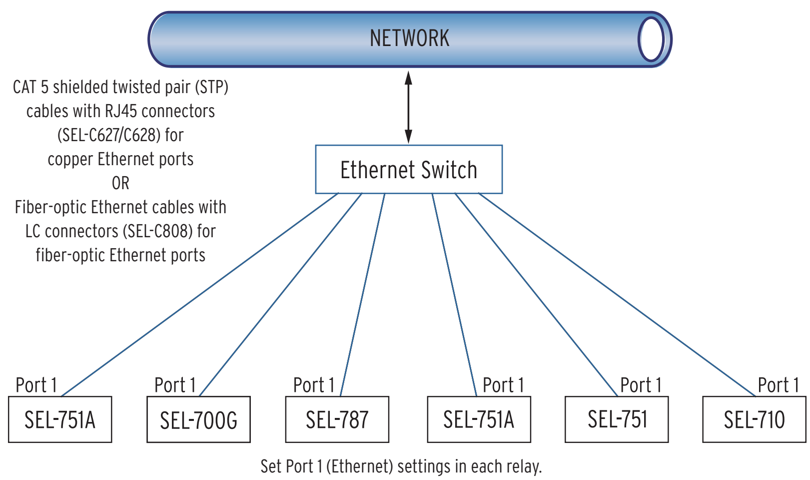


Figure 7.1 Simple Ethernet Network Configuration

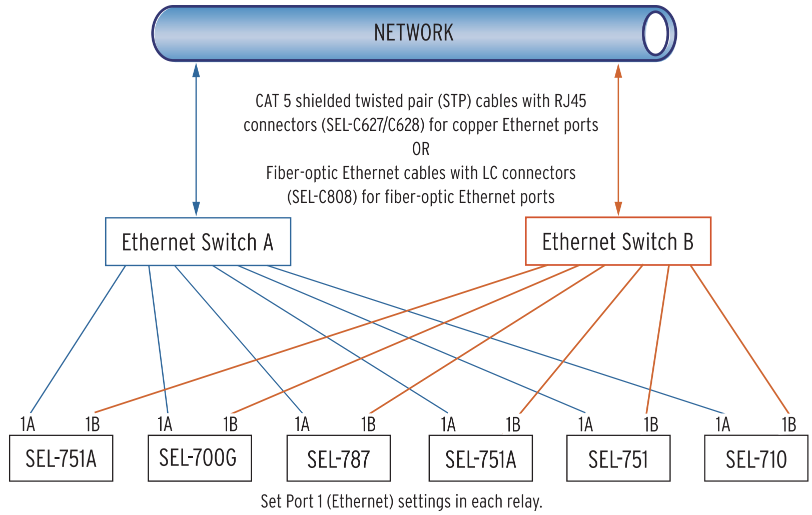


Figure 7.2 Ethernet Network Configuration With Dual Redundant Connections (Failover Mode)

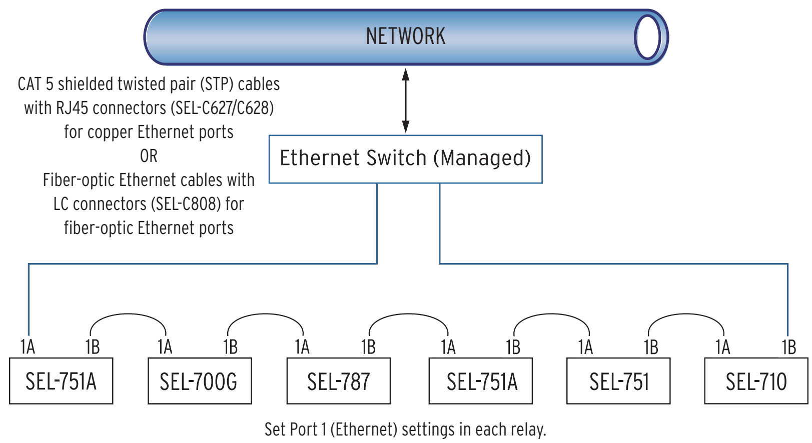


Figure 7.3 Ethernet Network Configuration With Ring Structure (Switched Mode)

Dual Network Port Operation

The SEL-751 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.

Step 1. Set NETMODE to FAILOVER.

Step 2. Set FTIME to the desired network port failover time (0.10–65.00 seconds or OFF).

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

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.

On startup, the relay communicates via NETPORT (primary port) selected. If the SEL-751 detects a link failure on the primary port, it activates the standby port after the failover time, FTIME, elapses. If the link status on the primary link returns to normal before the failover time expires, the failover timer resets and uninterrupted operation continues on the primary network port.

Setting FTIME = OFF allows fast port switching (with no intentional delay). Fast port switching can occur within one processing interval (typically 4 ms to 5 ms) and can help with IEC 61850 GOOSE performance.

After failover, while communicating via standby port, the SEL-751 checks the primary link periodically and continues checking until it detects a normal link status. The relay continues to communicate via the standby port even after the primary port returns to normal. The relay reevaluates the port of choice for communication upon a change of settings, at failure of the standby port, or upon 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. All the messages received on one network port that are not addressed to the relay are transmitted out of the other port without any modifications. In this mode, the relay ignores the NETPORT setting.

Fixed Connection Mode

If you have a single network and want to use only one network port, or if you have both ports connected but want to force usage of only one port for various reasons, set NETMODE to FIXED and set NETPORT to the port you want to use. Only the selected network port operates, and the other port is disabled.

PRP Connection Mode

Parallel Redundancy Protocol (PRP) is part of an IEC standard for high availability automation networks (IEC 62439-3). The purpose of the protocol is to provide seamless recovery from any single Ethernet network failure.

The basic concept is that the Ethernet network and all traffic are fully duplicated with the two copies operating in parallel.

Make the following settings for Port 1 to configure the relay for PRP mode.

- NETMODE = PRP
- PRPTOUT = desired timeout for PRP frame entry
- PRPADDR = PRP destination MAC address LSB (least significant byte of “01-15-4E-00-01-*XX*,” converted to decimal and entered as 0–255)
- PRPINTV = desired supervision frame transmit interval

When NETMODE is not set to PRP, the following settings are hidden.

Table 7.2 PRP Settings

Setting Name	Range	Units	Default Value	Setting Description
PRPTOUT	400–10000	ms	500	PRP Entry Timeout
PRPADDR	0–255		0	The multicast MAC address of PRP supervision frames is 01-15-4E-00-01-*XX* where *XX* is specified by this setting in decimal notation as 0–255
PRPINTV	1–10	seconds	2	PRP Supervision TX Interval

Autonegotiation, Speed, and Duplex Mode

Single or dual copper Ethernet ports can autonegotiate to determine the link speed and duplex mode. Accomplish this by setting the NETASPD and NETBSPD (network speed) to AUTO. You can also set single or dual copper ports to specific speeds so that you can apply them in networks with older switch devices. However, the relay ignores the speed settings for fiber Ethernet ports. The relay hardware fixes the single and dual fiber Ethernet ports to work at 100 Mbps and full duplex mode.

NETPORT Selection

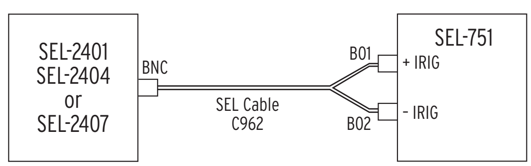
The NETPORT setting gives you the option of selecting the primary port of communication in failover or fixed communications modes.

IRIG-B

The SEL-751 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.

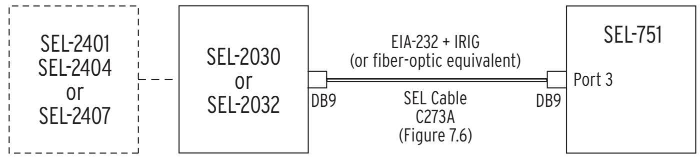
You cannot bring IRIG-B via Port 2 or 3 if you use the **B01–B02** input.

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)

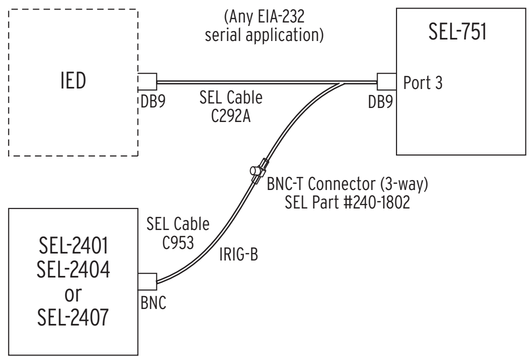
Connect to an SEL communications processor with SEL Cable C273R to bring IRIG-B input with the EIA-232 port. Refer to *Figure 7.5* for a connection diagram. Refer to *Figure 7.6* on how to connect an SEL time source (SEL-2401, SEL-2404, SEL-2407) for IRIG-B input to Port 3.



You cannot use **B01–B02** input or Port 2 if you use Port 3.

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)



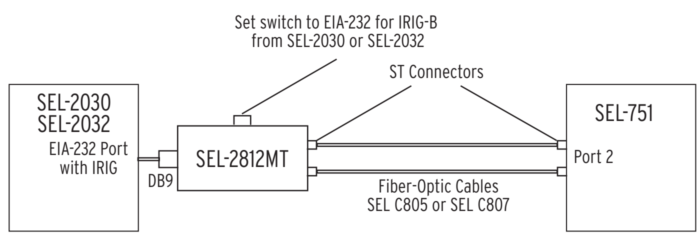
You cannot use **B01–B02** input or Port 2 if you use Port 3.

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

Figure 7.6 IRIG-B Input Via EIA-232 Port 3 (SEL-2401/2404/2407 Time Source)

Option 3: Port 2 (Fiber-Optic Serial Port)

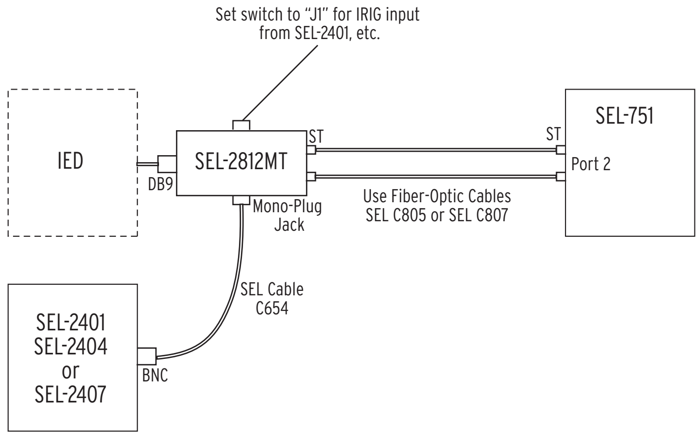
You can use the optional fiber-optic serial Port 2 to bring IRIG-B input to the relay as shown in *Figure 7.7* and *Figure 7.8*.



You cannot use **B01–B02** input or Port 3 input if you use Port 2 for IRIG-B 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)



You cannot use **B01–B02** input or Port 3 input if you use Port 2 for IRIG-B 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 power is available on Pin 1 only on EIA-232 Port 3 and EIA-232 Port 4.

Connect Your PC to the Relay

The front port of the SEL-751 is a standard female 9-pin connector with pin numbering shown in *Figure 7.9*. The pinout assignments for this port are shown in *Table 7.3*. You can connect to a standard 9-pin computer port with SEL Cable C234R; wiring for this cable is shown in *Figure 7.10*. SEL Cable C234R and other cables are available from SEL. Use the SEL-5801 Cable Selector Software to select an appropriate cable for another application. This software is available for free download from the SEL website at selinc.com.

For best performance, SEL Cable C234R should not be more than 15 m (50 ft) long. For long-distance communications and for electrical isolation of communications ports, use the SEL family of fiber-optic transceivers. Contact SEL for more details on these devices.

Port Connector and Communications Cables

Figure 7.9 shows the front-panel EIA-232 serial port (**PORT F**) DB-9 connector pinout for the SEL-751.

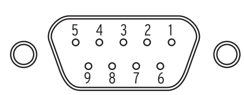


Figure 7.9 EIA-232 DB-9 Connector Pin Numbers

Table 7.3 shows the pin functions for the EIA-232 and EIA-485 serial ports.

Table 7.3 EIA-232/EIA-485 Serial Port Pin Functions (Sheet 1 of 2)

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

Table 7.3 EIA-232/EIA-485 Serial Port Pin Functions (Sheet 2 of 2)

Pin[a]	PORT 3 EIA-232	PORT 3 EIA-485[a]	PORT 4C EIA-232	PORT 4A EIA-485[a]	PORT F EIA-232
6	IRIG–		N/C		N/C
7	RTS		RTS		RTS
8	CTS		CTS		CTS
9	GND		GND		GND

[a] For EIA-485, the pin numbers represent relay terminals _01 through _05.

NOTE: Serial communications cables that are used in the SEL-751 relays for the MIRRORED BITS protocol should have the R designation at the end of the SEL cable number instead of an A; for example, use SEL Cable C234R instead of SEL Cable C234A.

The following cable diagrams show several types of EIA-232 serial communications cables that connect the SEL-751 to other devices. These and other cables are available from SEL. Contact the factory for more information.

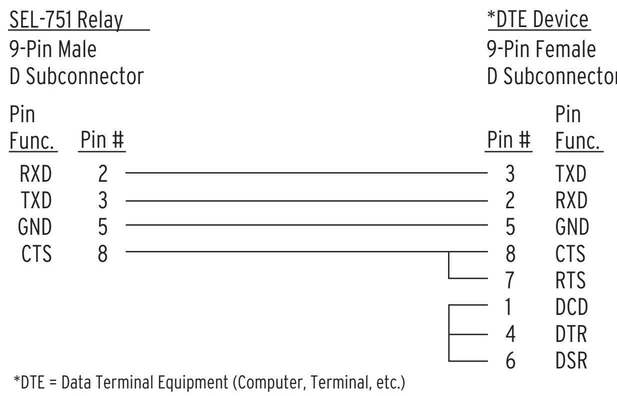


Figure 7.10 SEL Cable C234A—SEL-751 to DTE Device

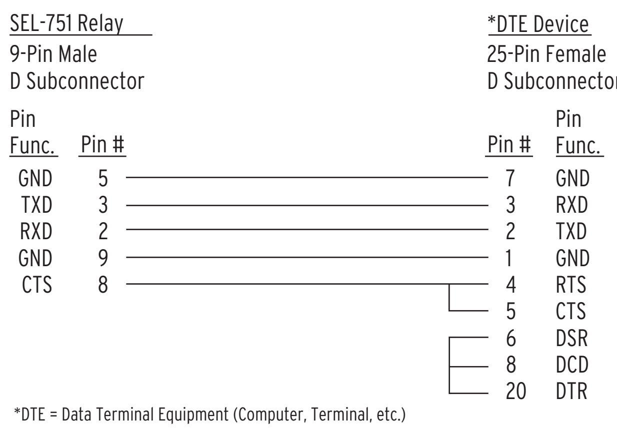


Figure 7.11 SEL Cable C227A—SEL-751 to DTE Device

SEL-751 Relay 9-Pin Male D Subconnector Pin Func.	Pin #	Pin #	**DCE Device 25-Pin Female D Subconnector Pin Func.
GND	5	7	GND
TXD	3	2	TXD (IN)
RTS	7	20	DTR (IN)
RXD	2	3	RXD (OUT)
CTS	8	8	CD (OUT)
GND	9	1	GND

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

Figure 7.12 SEL Cable C222—SEL-751 to Modem

SEL Communications Processor 9-Pin Male D Subconnector Pin Func.	Pin #	Pin #	SEL-751 Relay 9-Pin Male D Subconnector Pin Func.
RXD	2	3	TXD
TXD	3	2	RXD
GND	5	5	GND
RTS	7	8	CTS
CTS	8	7	RTS

Figure 7.13 SEL Cable C272A—SEL-751 to SEL Communications Processor Without IRIG-B Signal

SEL Communications Processor 9-Pin Male D Subconnector Pin Func.	Pin #	Pin #	SEL-751 Relay 9-Pin Male D Subconnector Pin Func.
RXD	2	3	TXD
TXD	3	2	RXD
IRIG+	4	4	IRIG+
GND	5	5	GND
IRIG-	6	6	IRIG-
RTS	7	8	CTS
CTS	8	7	RTS

Figure 7.14 SEL Cable C273A—SEL-751 to SEL Communications Processor With IRIG-B Signal

SEL-751 Relay DTE* 9-Pin Male D Subconnector Pin Func.	Pin #	Pin #	SEL-3010 Event Messenger DCE** 9-Pin Male D Subconnector Pin Func.
DCD***	1	1	+5 Vdc (IN)
RXD	2	2	RXD (OUT)
TXD	3	3	TXD (IN)
	4	4	Not Used
GND	5	5	GND
	6	6	Not Used
RTS	7	7	RTS (IN)
CTS	8	8	CTS (OUT)
GND	9	9	GND

*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-751 to SEL-3010

Communications Protocols

Although the SEL-751 supports a wide range of protocols, not all protocols are available on all ports. In addition, not all hardware options support all protocols.

Be sure to select the correct hardware to support a particular protocol. For example, if Modbus TCP is necessary for your application, be sure to order the Ethernet option for **PORT 1**. *Table 7.4* shows the ports and the protocols available on each port.

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

Table 7.4 Protocols Supported on the Various Ports

PORT	Supported Protocol
PORT F	SEL ASCII and Compressed ASCII Protocols, SELBOOT, File Transfer Protocol, Modbus RTU Slave, C37.118 Protocol (synchrophasor data), and Event Messenger
PORT 1[a]	Modbus TCP/IP, FTP, TCP/IP, IEC 61850, DNP3 LAN/WAN, SNTP, and Telnet TCP/IP (SEL ASCII, Compressed ASCII, SEL Fast Meter, SEL Fast Operate, SEL Fast SER, SEL Fast Message, and C37.118 Protocol (synchrophasor data)
PORT 2	SEL ASCII and Compressed ASCII Protocols, SEL Fast Meter, SEL Fast Operate, SEL Fast SER, SEL Fast Message, SEL Settings File Transfer, SEL MIRRORED BITS, DNP3, IEC 60870-5-103, Modbus RTU Slave, C37.118 Protocol (synchrophasor data), and Event Messenger
PORT 3	All the protocols supported by PORT 2
PORT 4	All the protocols supported by PORT 2 and DeviceNet

[a] PORT 1 concurrently supports two Modbus, five DNP3 LAN/WAN, two FTP, two Telnet, one SNTP, two C37.118 Protocol (synchrophasor data), and seven IEC 61850 sessions.

SEL Communications Protocols

SEL ASCII

This protocol is described in *SEL ASCII Protocol and Commands on page 7.16*.

SEL Compressed ASCII

This protocol provides compressed versions of some of the ASCII commands. The compressed commands are described in *SEL ASCII Protocol and Commands*, and the protocol is described in *Appendix C: SEL Communications Processors*.

SEL Fast Meter

This protocol supports binary messages to transfer metering and digital element messages. Compressed ASCII commands that support Fast Meter are described in *SEL ASCII Protocol and Commands*, and the protocol is described in *Appendix C: SEL Communications Processors*.

SEL Fast Operate

This protocol supports binary messages to transfer operation messages. The protocol is described in *Appendix C: SEL Communications Processors*.

SEL Fast Message

This protocol uses binary messages to receive/transmit data from/to an SEL communications processor. The protocol is described in *Appendix C: SEL Communications Processors*.

SEL Fast SER

This protocol is used to receive binary Sequential Events Record unsolicited responses. The protocol is described in *Appendix C: SEL Communications Processors*.

SEL Event Messenger

This is an SEL ASCII protocol with 8 data bits, no parity, and 1 stop bit for transmitting data to the SEL-3010 Event Messenger. You can change only the communications speed to match the settings in the SEL-3010.

Other Supported Protocols

MIRRORED BITS Protocol

The SEL-751 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-751 provides C37.118 protocol (synchrophasor data) support at all of the serial ports F, 2, 3, or 4. Additionally, Port 1 allows two sessions of the C37.118 protocol, which is described in *Appendix I: Synchrophasors*.

Modbus RTU Protocol

The SEL-751 provides Modbus RTU support. Modbus is an optional protocol described in *Appendix E: Modbus RTU Communications*.

DNP3 (Distributed Network Protocol)

The SEL-751 provides DNP3 protocol support if the option is selected. The DNP3 protocol is described in *Appendix D: DNP3 Communications*.

DeviceNet Protocol

The SEL-751 provides DeviceNet support. DeviceNet is an optional protocol described in *Appendix H: DeviceNet Communications*.

IEC 60870-5-103 Protocol

The SEL-751 provides IEC 60870-5-103 protocol support if the option is selected. The protocol is available on Ports 2, 3, and 4. All ports operate using the same map settings. The IEC 60870-5-103 protocol is described in *Appendix G: IEC 60870-5-103 Communications*.

Ethernet Protocols

As with other communications interfaces, you must choose a data exchange protocol that operates over the Ethernet network link to exchange data. The relay supports FTP, Telnet, Ping, Modbus/TCP, DNP3 LAN/WAN, C37.118, 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.

File Transfer Protocol (FTP) and MMS File Transfer

FTP is a standard protocol for exchanging files between computers over a TCP/IP network. The SEL-751 operates as an FTP server, presenting files to FTP clients. To create an FTP session, you need the FTP username and password. The default username and password are FTPUSER and TAIL, respectively. The SEL-751 supports two FTP sessions at a time. Requests to establish additional FTP sessions are denied.

Manufacturing Messaging Specification (MMS) is used in IEC 61850 applications and provides services for the transfer of real-time data, including files, within a substation LAN.

File Structure

The file structure is organized as a directory and subdirectory tree similar to that used by Windows and other common operating systems. See *Virtual File Interface on page 7.58* for information on available files.

File dates within the last 12 months are displayed with month, day, hour, and minutes. Dates older than twelve months have the year, month, and day. The times are UTC.

Access Control

To log in to the FTP server, enter the value of the Port 1 setting FTPUSER as the user name in your FTP application. Enter the Port 1 setting FTPACC level password as the password in your FTP application. Note that FTP does not encrypt passwords before sending them to the server.

MMS is enabled when Port 1 setting E61850 is set to Y. No authentication is required. MMS File Transfer is enabled when setting EMMSFS is set to Y. If MMS Authentication is enabled via the CID file, then an authenticated connection must be established via MMS for MMS file transfer to take place.

Using FTP and MMS

A free FTP application is included with most web browser software and PC operating systems. You can also obtain free or inexpensive FTP applications from the Internet. Once you have retrieved the necessary files, be sure to close the FTP connection using the disconnect function of your FTP application or completely closing the application. Failure to do so can cause the FTP connection to remain open, which blocks subsequent connection attempts until FTPIDLE time expires. See *Appendix F: IEC 61850 Communications* for information about using MMS.

Telnet Server

Use the Telnet session (TPORT default setting is Port 23) to connect to the relay to use the protocols, which are described in more detail below:

- SEL ASCII
- Compressed ASCII
- Fast Meter
- Fast Operate

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

The relay supports IEC 61850 protocol, including GOOSE, as described in *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 IRIG-B time code signal, even if SNTP is configured in the relay and an NTP server is available. If the IRIG-B source is disconnected (if both TSOK and IRIGOK deassert) then the relay synchronizes the internal time-of-day clock to the NTP server, if available. In this way, an NTP server acts either as the primary time source or as a backup time source to the more accurate IRIG-B time source.

Creating an NTP Server

Three SEL application notes, available from the SEL website, describe how to create an NTP server.

- *AN2009-10: Using an SEL-2401, SEL-2404, or SEL-2407 to Serve NTP Via the SEL-3530 RTAC*
- *AN2009-38: Using SEL Satellite-Synchronized Clocks With the SEL-3332 or SEL-3351 to Output NTP*
- *AN2010-03: Using an SEL-2401, SEL-2404, or SEL-2407 to Create a Stratum 1 Linux NTP Server*

Configuring SNTP Client in the Relay

To enable SNTP in the relay, make Port 1 setting ESNTP = UNICAST, MANYCAST, or BROADCAST. *Table 7.5* shows each setting associated with SNTP.

Table 7.5 Settings Associated With SNTP

Setting	Range	Description
ESNTP	UNICAST, MANYCAST, BROADCAST	Selects the mode of operation of SNTP. See descriptions in *SNTP Operation Modes on page 7.15*.
SNTPPSIP	Valid IP Address	Selects primary NTP server when ENSTP = UNICAST, or broadcast address when ESNTP = MANYCAST or BROADCAST.
SNTPPSIB	Valid IP Address	Selects backup NTP server when ESNTP = UNICAST.
SNTPPORT	1–65534	Ethernet port used by SNTP. Leave at default value unless otherwise necessary.
SNTPRATE	15–3600 s	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 waits for an NTP broadcast when ENSTP = BROADCAST.
SNTPTO	5–20 s	Determines the time the relay waits 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 listens for and synchronizes to any broadcasting NTP server. If setting SNTPPSIP is set to a specific IP address while setting ESNTP = BROADCAST, then the relay listens for and synchronizes to only NTP server broadcasts from that address. When synchronized, the relay asserts Relay Word bit TSNTPP. Relay Word bit TNSTPP deasserts if the relay does not receive a valid broadcast within five seconds after the period defined by setting SNTPRATE.

SNTP Accuracy Considerations

The accuracy of the SNTP server and the networking environment limit SNTP time synchronization accuracy. You can achieve the highest degree of SNTP time synchronization by minimizing the number of switches and routers between the SNTP server and the SEL-751. You can also use network monitoring software to ensure that average and worst-case network bandwidth use is moderate.

When installed on a network configured with one Ethernet switch between the SEL-751 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-751.

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 should terminate at the end of the message in progress when the relay receives XOFF. It can resume 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 7.6* lists these messages.

Table 7.6 Serial Port Automatic Messages

Condition	Description
Power Up	The relay sends a message containing the present date and time, relay and terminal identifiers, and the Access Level 0 prompt when the relay is turned on.
Event Trigger	The relay sends an event summary each time an event report is triggered. See *Section 10: Analyzing Events*.
Self-Test Warning or Failure	The SEL-751 sends a status report each time it detects a self-test warning or failure condition. See *STATUS Command (Relay Self-Test Status) on page 7.51*.

Access Levels

You can issue commands to the SEL-751 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-751 Relay Command Summary* at the end of this manual. You can access these commands only from the corresponding access level, as shown in the *SEL-751 Relay Command Summary*. The access levels are:

- Access Level 0 (the lowest access level)
- Access Level 1
- Access Level 2 (the highest access level)
- Access Level C (restricted access level, should be used under direction of SEL only)

The EPORT and MAXACC settings provide users with access controls for the corresponding port. Setting EPORT to N disables the port and hides the remaining port settings. The MAXACC setting selects the highest access level for the port.

Access Level 0

Once serial port communication is established with the SEL-751, 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-751 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-751 to Access Level 1. See *Access Commands (ACCESS, 2ACCESS, and CAL) on page 7.20* for more detail.

Access Level 1

When the SEL-751 is in Access Level 1, the relay sends the following prompt:

```
=>
```

See the *SEL-751 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-751 sends the prompt:

```
=>>
```

See the *SEL-751 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 for use exclusively by the SEL factory and SEL field service personnel to diagnose troublesome installations. A list of commands available 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 (see *SEL-751 Relay Command Summary*). Enter the **CAL** command at the Access Level 2 prompt:

```
=>>CAL <Enter>
```

Command Summary

The *SEL-751 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 that SEL communications processors require.
- ➤ 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-751 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 7.7 lists the header items and their definitions.

Table 7.7 Command Response Header Definitions

Item	Definition
`[RID Setting]`:	This is the RID (Relay Identifier) setting. The relay ships with the default setting `RID = 751`; see *ID Settings on page 4.3*.
`[TID Setting]`:	This is the TID (Terminal Identifier) setting. The relay ships with the default setting `TID = FEEDER 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 (event), when it is the time the event occurred.
`Time Source`:	This is internal if no time-code input is attached and 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 7.8*) provide entry to the multiple access levels. Different commands are available at the different access levels, as shown in the *SEL-751 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 7.17* for a discussion of placing the relay in an access level.

Table 7.8 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 CAL.	2

Password Requirements

You must enter passwords unless they are disabled. See *PASSWORD Command (Change Passwords)* 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: ? <Enter>
```

The relay is shipped with the default Access Level 1 password shown in *PASSWORD Command (Change Passwords) on page 7.44*. 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 that 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. You can get to Access Level C from Access Level 2 with the **CAL** command. 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.

AFT Command (Arc-Flash Detection Channels Self-Test)

Use the **AFT** command (Access Level 2) to initiate a self-test of the arc-flash detection channels 1 to 8. This test requires that the relay has the SELECT 2 AVI/4 AFDI card or 8 AFDI card in Slot E and the external fiber-optic connections are complete. The test checks the integrity of the arc-flash detection system. *Figure 7.16* shows an example of the **AFT** command response with a 2 AVI/4 AFDI card in Slot E. Refer to *Section 11: Testing and Troubleshooting* for details on the arc-flash self-tests.

```
=>>AFT <Enter>

Arc Flash Diagnostic in progress . . . . . . . . . . . . .

SEL-751                                 Date: 12/09/2010    Time: 09:20:13
FEEDER RELAY                             Time Source: Internal

Channel #   Sensor  Test Light Limits  Measured      Sensor      Excess Ambient
            Type     Min(%)   Max(%)   Test Light(%) Diagnostic  Light

AF Input 1  Fiber    10.00    100.00   31.94         Pass        OK
AF Input 2  Fiber    10.00    100.00   27.08         Pass        OK
AF Input 3  None     ---.--   ---.--   ---.--        ---         ---
AF Input 4  Point    0.10     79.00    2.27          Pass        OK

=>>
```

Figure 7.16 AFT Command Response

The relay asserts the AFALARM Relay Word bit when the sensor diagnostics fail or the relay detects excessive ambient light. Sensor diagnostics failure is indicated by the assertion of the AFS*n*DIAG Relay Word bits and excessive ambient light is indicated by the assertion of the AFS*n*EL Relay Word bits, where $n = 1$ to 8. The relay asserts the AFS*n*EL Relay Word bits when the corresponding TOL*n* Relay Word bits stay asserted continuously for 10 seconds.

ANALOG Command

Use the **ANA** command to test an analog output by temporarily assigning a value to an analog output channel (see *Table 7.9* for the command description and 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 during the time specified

Table 7.9 ANALOG Command

Command	Description	Access Level
ANA *c p t*	Temporarily assigns a value to an analog output channel.	2
Parameters		
c	Parameter *c* is the analog channel (either the channel name, e.g., A0301, or the channel number, e.g., 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 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, assume that the analog output signal type is 4–20 mA, and that you 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
```

BRE Command (Breaker Monitor Data)

Use the **BRE** command to view the breaker monitor report. See *Breaker Monitor on page 5.19* for further details on the breaker monitor.

```
=>BRE <Enter>

SEL-751                                 Date: 12/04/2010   Time: 14:26:57
FEEDER RELAY                             Time Source: External

Trip Counters

Rly Trips (counts)      32
Ext Trips (counts)       0

Cumulative Interrupted Currents

                 IA     IB     IC
Rly Trips (kA)  538.1  483.6  485.5
Ext Trips (kA)    0.0    0.0    0.0


Breaker Contact Wear

           A    B    C
Wear (%)   48   37   36

LAST RESET  11/25/2010 11:16:21

=>
```

Figure 7.17 Breaker Monitor Report

BRE Command (Preload/Reset Breaker Wear)

The **BRE W** command only saves new settings after the `Save Changes (Y/N)?` message. If you make a data entry error while using the **BRE W** command, the values echoed after the `Invalid format, changes not saved` message are the previous BRE values, unchanged by the aborted **BRE W** attempt.

```
=>>BRE W <Enter>

Breaker Wear Percent Preload

Relay (or Internal) Trip Counter (0-65000)    =     0     ? 14  <Enter>

Internal Current (0.0-999999 kA)      IA      = 0.0      ? 32.4  <Enter>
                                      IB      = 0.0      ? 18.6  <Enter>
                                      IC      = 0.0      ? 22.6  <Enter>

External Trip Counter (0-65000)               =     0     ? 2  <Enter>

External Current (0.0-999999 kA)      IA      = 0.0      ? 0.8  <Enter>
                                      IB      = 0.0      ? 0.6  <Enter>
                                      IC      = 0.0      ? 0.7  <Enter>

Percent Wear (0-100%)                 A-phase =   0       ? 22  <Enter>
                                      B-phase =   0       ? 28  <Enter>
                                      C-phase =   0       ? 25  <Enter>


Last Reset                            Date    = 12/04/2010 ? 12/04/2010 <Enter>

                                      Time    = 14:27:10  ? 17:50:12  <Enter>

Save changes (Y,N)? Y <Enter>

=>>
```

Figure 7.18 Breaker Wear Report

Use the **BRE R** command to reset the breaker monitor:

```
=>>BRE R <Enter>

Reset Breaker Wear (Y,N)? y
Clearing Complete

=>>LAST RESET 02/03/2011 05:41:07
```

Figure 7.19 Breaker Reset Response

See *Breaker Monitor on page 5.19* for further details on the breaker monitor.

CEV Command

The SEL-751 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. Additionally, the compressed event report has the arc-flash detector light measurements.

CEV HIF (High-Impedance Fault) Command

The SEL-751 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 **CEV HIF** command to display Compressed ASCII HIF event reports.

The relay generates compressed event reports to display analog data, and the state of related Relay Word bits from the odd and non-harmonic HIF fault detection algorithm and load reduction. The relay provides user-programmable event report triggering conditions. An event report is triggered for all conditions listed in the **SUM HIF** command. When an event report is triggered for any of these conditions, the SEL-751 asserts Relay Word bit HIFREC, which stays asserted until the HIF event report has finished collecting. The relay does not generate additional event reports for triggering conditions that follow the initial triggering condition and are within the same report.

The number of event reports the relay shall be able to store depends on the HIFLER setting at the rate of 1 sample/2 cycles. For example, if the HIFLER setting is 10 minutes, then the relay should be able to store at least four back-to-back event reports. *Figure 7.20* shows an example of the **CEV HIF** command response.

```
=>>CEV HIF <Enter>

"FID","0143"
"FID=SEL-751-X381-V0-Z007002-D20161207","08B6"
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","0ACA"
12,19,2016,11,46,46,594,"04A2"
"REC_NUM","NUM_CH_A","NUM_CH_D","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","PRIM_VAL","14ED"
1,33,48,0.5000,0.5000,10800,"YES","06AB"
"IARMS(A)","IBRMS(A)","ICRMS(A)","SDIA(A)","SDIB(A)","SDIC(A)","SDIAREF(A)","SDIBREF(A)","SDICREF(A)","dA(A)","dB(A)","dC(A)
   ","ISMA(A)","ISMB(A)","ISMC(A)","ISMAREF(A)","ISMBREF(A)","ISMCREF(A)","DLT_T1A(A)","DLT_T1B(A)","DLT_T1C(A)","T7CNTA",
   "T7CNTB","T7CNTC","T8CNTA","T8CNTB","T8CNTC","SW1AL","SW1AH","SW1BL","SW1BH","SW1CL","SW1CH","TRIG","HIA1_A HIA1_B
   HIA1_C HIF1_A HIF1_B HIF1_C NTUNE_A NTUNE_B NTUNE_C 3PH_A 3PH_B 3PH_C DL2CLRA DL2CLRB DL2CLRC ITUNE_A ITUNE_B ITUNE_C
   DIA_DIS DIB_DIS DIC_DIS DVA_DIS DVB_DIS DVC_DIS HIA2_A HIA2_B HIA2_C FRZCLRA FRZCLRB FRZCLRC DUPA DUPB DUPC HIF2_A HIF2_B
   HIF2_C LRA LRB LRC DDNA DDNB DDNC 3PH_CLR LR3 HIFER HIFMODE 3PH_EVE HIFREC","A55A"
621.0,621.0,621.0,102.7,128.3,115.5,121.9,121.9,121.9,24.9,50.5,51.3,51.3,57.8,51.3,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0
   ,0,0, ,"038000000000","1B6E"
621.0,621.0,621.0,128.3,128.3,109.1,121.9,121.9,121.9,24.9,50.5,51.3,44.9,57.8,64.2,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0
   ,0,0, ,"038000000000","1B7C"
621.0,621.0,621.0,128.3,121.9,141.2,121.9,121.9,121.9,24.9,50.5,51.3,44.9,57.8,51.3,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0
   ,0,0, ,"038000000000","1B75"
621.0,621.0,621.0,128.3,134.8,134.8,121.9,121.9,121.9,24.9,50.5,51.3,51.3,57.8,44.9,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0
   ,0,0, ,"038000000000","1B80"
621.0,621.0,621.0,121.9,134.8,134.8,121.9,121.9,121.9,24.9,50.5,51.3,51.3,70.6,51.3,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0
   ,0,0, ,"038000000000","1B70"
622.0,620.0,621.0,128.3,128.3,134.8,121.9,128.3,128.3,24.9,50.5,51.3,44.9,57.8,57.8,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0
   ,0,0, ,"038000000000","1B8B"
621.0,621.0,621.0,128.3,121.9,128.3,121.9,121.9,128.3,24.9,50.5,51.3,44.9,57.8,57.8,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0
   ,0,0, ,"038000000000","1B87"
621.0,621.0,621.0,128.3,115.5,128.3,121.9,121.9,128.3,24.9,50.5,51.3,51.3,57.8,51.3,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0
   ,0,0, ,"038000000000","1B73"
621.0,621.0,621.0,115.5,128.3,141.2,121.9,121.9,128.3,24.9,50.5,51.3,51.3,57.8,51.3,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0
   ,0,0, ,"038000000000","1B6D"
621.0,621.0,621.0,134.8,128.3,121.9,121.9,121.9,128.3,24.9,50.5,51.3,57.8,57.8,57.8,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0
   ,0,0, ,"038000000000","1B8C"
621.0,621.0,621.0,134.8,115.5,147.6,121.9,121.9,128.3,24.9,50.5,51.3,51.3,64.2,57.8,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0
   ,0,0, ,"038000000000","1B7C"
621.0,621.0,620.0,128.3,109.1,128.3,121.9,121.9,128.3,24.9,50.5,51.3,44.9,77.0,51.3,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0
   ,0,0, ,"038000000000","1B73"
621.0,621.0,621.0,141.2,128.3,134.8,121.9,121.9,128.3,24.9,50.5,51.3,32.1,57.8,51.3,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0
   ,0,0, ,"038000000000","1B6E"
621.0,621.0,621.0,115.5,121.9,102.7,121.9,121.9,128.3,24.9,50.5,51.3,57.8,57.8,57.8,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0
   ,0,0, ,"038000000000","1B84"
621.0,621.0,621.0,109.1,115.5,121.9,121.9,121.9,128.3,24.9,50.5,51.3,64.2,64.2,51.3,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0
   ,0,0, ,"038000000000","1B6A"
621.0,621.0,621.0,121.9,109.1,109.1,121.9,121.9,128.3,24.9,50.5,51.3,44.9,64.2,64.2,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0
   ,0,0, ,"038000000000","1B71"
621.0,621.0,621.0,109.1,121.9,134.8,121.9,121.9,128.3,24.9,50.5,51.3,32.1,70.6,51.3,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0
   ,0,0, ,"038000000000","1B69"
621.0,621.0,621.0,96.3,121.9,109.1,121.9,121.9,121.9,24.9,50.5,51.3,44.9,64.2,57.8,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0,
   0,0, ,"038000000000","1B4F"
621.0,621.0,621.0,141.2,128.3,128.3,121.9,121.9,121.9,24.9,50.5,51.3,44.9,70.6,51.3,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0
   ,0,0, ,"038000000000","1B6F"
621.0,621.0,621.0,115.5,121.9,115.5,121.9,121.9,121.9,24.9,50.5,51.3,38.5,51.3,44.9,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0
   ,0,0, ,"038000000000","1B73"
621.0,621.0,621.0,109.1,121.9,128.3,121.9,121.9,121.9,24.9,50.5,51.3,44.9,57.8,51.3,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0
   ,0,0, ,"038000000000","1B78"
621.0,621.0,621.0,141.2,121.9,134.8,121.9,121.9,128.3,24.9,50.5,51.3,44.9,70.6,64.2,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0
   ,0,0, ,"038000000000","1B74"
621.0,621.0,621.0,134.8,128.3,121.9,121.9,121.9,128.3,24.9,50.5,51.3,38.5,64.2,57.8,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0
   ,0,0, ,"038000000000","1B80"
621.0,621.0,621.0,128.3,134.8,121.9,121.9,121.9,128.3,24.9,50.5,51.3,51.3,51.3,57.8,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0
   ,0,0, ,"038000000000","1B76"
621.0,621.0,621.0,115.5,102.7,128.3,121.9,121.9,128.3,24.9,50.5,51.3,51.3,57.8,57.8,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0
   ,0,0, ,"038000000000","1B7A"
```

Figure 7.20 CEV HIF Command Response

```
621.0,621.0,621.0,128.3,115.5,128.3,121.9,121.9,128.3,24.9,50.5,51.3,51.3,51.3,57.8,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0,0
    ,0,0, ,"038000000000","1B73"
621.0,621.0,621.0,115.5,121.9,134.8,121.9,121.9,128.3,24.9,50.5,51.3,44.9,64.2,51.3,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0,0
    ,0,0, ,"038000000000","1B74"
621.0,621.0,621.0,121.9,115.5,147.6,121.9,121.9,128.3,24.9,50.5,51.3,51.3,57.8,64.2,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0,0
    ,0,0, ,"038000000000","1B79"
621.0,621.0,621.0,134.8,128.3,121.9,121.9,121.9,128.3,24.9,50.5,51.3,44.9,70.6,44.9,51.3,57.8,57.8,0,0,0,0,0,0,0,0,0,0,0,0,0
    ,0,0, ,"038000000000","1B7F"

=>>
```

Figure 7.20 CEV HIF Command Response (Continued)

CLOSE Command (Close Breaker)

The **CLO** (**CLOSE**) command asserts Relay Word bit CC for 1/4 cycle when it is executed. Relay Word bit CC can then be programmed into the CL SELOGIC control equation to assert the CLOSE Relay Word bit, which in turn asserts an output contact (e.g., OUT102 = CLOSE) to close a circuit breaker (see *Table 4.69* and *Figure 4.80* for factory-default setting CL and close logic).

To issue the **CLO** command, enter the following.

```
=>>CLO <Enter>

Close Breaker (Y,N)? Y <Enter>

=>>
```

Typing **N <Enter>** after the previous prompt aborts the command.

The main board breaker jumper (see *Table 2.17*) supervises the **CLO** command. If the breaker jumper is not in place (breaker jumper = OFF), the relay does not execute the **CLO** command and responds with the following.

```
=>>CLO <Enter>

Command Aborted: No Breaker Jumper

=>>
```

When setting EN_LRC := Y (see *Table 9.4*), the Relay Word bit LOCAL supervises the **CLO** command. If the LOCAL bit is asserted (LOCAL = 1), the relay does not execute the **CLO** command and responds with the following:

```
=>>CLO <Enter>

Command Aborted: Device in Local Control

=>>
```

The Relay Word bit LOCAL is determined by the LOCAL SELOGIC control equation (see *Table 9.4*).

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 J: MIRRORED BITS Communications*. The summary report includes information on the status of Relay Word bits ROKA and ROKB that indicates if received data are valid.

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
- Resynchronization
- Data error
- Loopback
- Underrun

Table 7.10 COM Command

Command	Description	Access Level
COM S A or **COM S B**	Returns a summary report of the last 255 records in the communications buffer for either MIRRORED BITS communications Channel A or Channel B when only one channel is enabled.	1
COM A	Returns a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.	1
COM B	Returns a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.	1
COM L A	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.	1
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 k*	Sets a remote bit to set, clear, or pulse.	2
Parameters		
nn	a number from 01 to 32, representing RB01 through RB32.	
k	S, C, or P	

Table 7.12 Three Remote Bit States

Subcommand	Description	Access Level
S	Sets remote bit (ON position)	2
C	Clears remote bit (OFF position)	2
P	Pulses 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]	Copies 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 1 overwrite the settings in Group 3.

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*	Displays 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. 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.

Table 7.15 Date Command

Command	Description	Access Level
DATE	Displays the internal clock date.	1
DATE *mm/dd/yyyy, yyyy/mm/dd,* or ***dd/mm/yyyy***	Sets the internal clock date (DATE_F set to MDY, YMD, or DMY).	1

Separate the month, day, and year parameters with spaces, commas, slashes, colons, and semicolons. Set the year in 4-digit form (for dates 2000–2099). Global setting DATE_F sets the date format.

ETH Command

The **ETH** command (Access Level 1) can be used to display the Ethernet port (Port 1) status as shown in *Figure 7.21* for the redundant fiber-optic (FX) Ethernet **Port 1A** and **Port 1B** configuration. The copper Ethernet port is labeled as TX. The response is similar for relays with the single Ethernet port option.

Different Ethernet configurations and different NETMODE settings result in slightly different information being displayed, as shown in the following figures.

```
=>>ETH <Enter>

SEL-751                                  Date: 07/10/2015   Time: 20:16:05.914
FEEDER RELAY                             Time Source: External

NETMODE: PRP

             LINK   SPEED  DUPLEX MEDIA
PORT 1A      Up     100M   Full   TX
PORT 1B      Up     100M   Full   TX

IP Port:

MAC: 00-30-A7-01-02-04
IP ADDRESS: 10.10.52.221
SUBNET MASK: 255.255.255.0
DEFAULT GATEWAY: 10.10.52.1

         PACKETS                BYTES              ERRORS
      SENT      RCVD         SENT        RCVD      SENT    RCVD
      5098      1000       645526       88876         0       0

=>>
```

Figure 7.21 Ethernet Port (PORT 1) Status Report When NETMODE := PRP

```
=>>ETH <Enter>

SEL-751                                  Date: 07/10/2015   Time: 20:18:11.791
FEEDER RELAY                             Time Source: External

NETMODE: FIXED

 PRIMARY PORT:  PORT 1A
 ACTIVE PORT:   PORT 1A

             LINK   SPEED  DUPLEX MEDIA
PORT 1A      Up     100M   Full   TX

IP Port:

MAC: 00-30-A7-01-02-04
IP ADDRESS: 10.10.52.221
SUBNET MASK: 255.255.255.0
DEFAULT GATEWAY: 10.10.52.1

         PACKETS                BYTES              ERRORS
      SENT      RCVD         SENT        RCVD      SENT    RCVD
       143       107        14652        7861         0       0

=>>
```

Figure 7.22 Ethernet Port (PORT 1) Status Report When NETMODE := FIXED

```
=>>ETH <Enter>

SEL-751                                          Date: 10/25/2016   Time: 10:59:25.558
FEEDER RELAY                                     Time Source: Internal

NETMODE: FAILOVER

PRIMARY PORT:  1A
ACTIVE PORT:   1A

                LINK   SPEED  DUPLEX MEDIA
PORT 1A         Up     100M   Full   TX
PORT 1B         Down   --     --     TX


IP Port:

MAC: 00-30-A7-67-32-10
IP ADDRESS: 10.10.52.244
SUBNET MASK: 255.255.255.0
DEFAULT GATEWAY: 10.10.52.1

           PACKETS                BYTES              ERRORS
       SENT      RCVD         SENT       RCVD      SENT    RCVD
         36        72         2660       5081         0       0

GOOSE Port:

MAC: 00-30-A7-78-10-20

           PACKETS                BYTES              ERRORS
       SENT      RCVD         SENT       RCVD      SENT    RCVD
          0         0            0          0         0       0

=>>
```

Figure 7.23 Ethernet Port (PORT 1) Status Report When NETMODE := FAILOVER, E61850 := Y, and EGSE := Y

NOTE: Relays with older CPU cards can be upgraded to firmware versions R112 or higher, but the relay will not have the GOOSE performance improvements (i.e., a GOOSE port with a dedicated MAC address).

```
=>>ETH <Enter>

SEL-751                                          Date: 07/10/2015   Time: 20:21:34.698
FEEDER RELAY                                     Time Source: External

NETMODE: SWITCHED

                LINK   SPEED  DUPLEX MEDIA
PORT 1A         Up     100M   Full   TX
PORT 1B         Up     100M   Full   TX

IP Port:

MAC: 00-30-A7-01-02-04
IP ADDRESS: 10.10.52.221
SUBNET MASK: 255.255.255.0
DEFAULT GATEWAY: 10.10.52.1

           PACKETS                BYTES              ERRORS
       SENT      RCVD         SENT       RCVD      SENT    RCVD
         93        74         8537       5096         0       0

=>>
```

Figure 7.24 Ethernet Port (PORT 1) Status Report When NETMODE := SWITCHED

The command response for the single Ethernet port option is as shown in *Figure 7.25*.

```
=>>ETH <Enter>

SEL-751                                 Date: 06/05/2010   Time: 10:41:44
FEEDER RELAY                             Time Source: Internal

 MAC: 00-30-A7-00-75-6A
 IP ADDRESS: 192.168.1.2
 SUBNET MASK: 255.255.255.0
 DEFAULT GATEWAY: 192.168.1.1

             LINK   SPEED  DUPLEX   MEDIA
PORT 1A      Up     100M    Full      TX

=>>
```

Figure 7.25 Ethernet Port (PORT 1) Status Report for the Single Ethernet Port Option

EVENT Command (Event Reports)

Use the **EVE** command (see *Table 7.16*) to view event reports. See *Section 10: Analyzing Events* for further details on retrieving and analyzing event reports. See the *HISTORY Command on page 7.37* for details on clearing event reports.

Table 7.16 EVENT Command (Event Reports)

Command	Description	Access Level
EVE *n*	Returns the *n* event report with 4-samples/cycle data.	1
EVE *n* R	Returns the *n* event report with raw (unfiltered) 16 samples/cycle analog data and 4 samples/cycle digital data.	1
Parameter		
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.	

FILE Command

The **FIL** command (see *Table 7.17*) is intended to be 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. The **FIL** command is supported if you connect over serial or Ethernet ports.

Table 7.17 FILE Command

Command	Description	Access Level
FIL DIR	Returns a list of files.	1
FIL READ *filename*	Transfers settings file *filename* from the relay to the PC.	1
FIL WRITE *filename*	Transfers settings file *filename* from the PC to the relay.	2
FIL SHOW *filename*	Displays contents of the file *filename*.	1

GOOSE Command

Use the **GOOSE** command to display transmit and receive GOOSE messaging and statistics information, which you can use for troubleshooting. The **GOOSE** command variants and options are shown in *Table 7.18*.

Table 7.18 GOOSE Command Variants

Command Variant	Description	Access Level
GOOSE	Displays GOOSE information.	1
GOOSE *k*	Displays GOOSE information *k* times.	1
GOOSE S	Displays a list of GOOSE subscriptions with their ID.	1
GOOSE S *n*	Displays GOOSE statistics for subscription ID *n*.	1
GOOSE S ALL	Displays GOOSE statistics for all subscriptions.	1
GOOSE S *n* L	Displays GOOSE statistics for subscription ID *n* including error history.	1
GOOSE S ALL L	Displays GOOSE statistics for all subscriptions including error history.	1
GOOSE S *n* C	Clears GOOSE statistics for subscription ID *n*.	1
GOOSE S ALL C	Clears GOOSE statistics for all subscriptions.	1

The information displayed for each GOOSE IED is described in the following table.

Information Field	Description
`Transmit GOOSE Control Reference`	This field represents the GOOSE control reference information that includes the IED name, ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and GSEControl name (GSE Control Block Name) (e.g., SEL_351S_1CFG/LLN0GOGooseDSet13).
`Receive GOOSE Control Reference`	This field represents the goCbRef (GOOSE Control Block Reference) information that includes the iedName (IED name), ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and cbName (GSE Control Block Name) (e.g., SEL_351S_1CFG/LLN0GOGooseDSet13).
`MultiCastAddr` (Multicast Address)	This hexadecimal field represents the GOOSE multicast address.
`Ptag`	This three-bit decimal field represents the priority tag value, where spaces are used if the priority tag is unknown.
`Vlan`	This 12-bit decimal field represents the virtual LAN (Local Area Network) value, where spaces are used if the virtual LAN is unknown.
`StNum` (State Number)	This hexadecimal field represents the state number that increments with each state change.
`SqNum` (Sequence Number)	This hexadecimal field represents the sequence number that increments with each retransmitted GOOSE message sent.
`TTL` (Time to Live)	This field contains the time (in ms) before the next message is expected.

Information Field	Description
Code	When appropriate, this text field contains warning or error condition text that is abbreviated as follows: **Code Abbreviation** — **Explanation** OUT OF SEQUENC — Out of sequence error CONF REV MISMA — Configuration Revision mismatch NEED COMMISSIO — Needs Commissioning TEST MODE — Test Mode MSG CORRUPTED — Message Corrupted TTL EXPIRED — Time to live expired
Transmit Data Set Reference	This field represents the DataSetReference (Data Set Reference) that includes the IED name, LN0 lnClass (Logical Node Class), and GSEControl datSet (Data Set Name) (e.g., SEL_351S_1CFG/LLN0$DSet13).
Receive Data Set Reference	This field represents the datSetRef (Data Set Reference) that includes the iedName (IED name), ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and datSet (Data Set Name) (e.g., SEL_351S_1CFG/LLN0$DSet13).
Ctrl Ref/ ControlBlockReference	This is the GOOSE control block reference. It is a concatenation of the logical device name, LLN0 (logical node containing the control block), GO (functional constraint), and the GSEControl name. (e.g. SEL_351S_1CFG/LLN0GOGooseDSet13)
AppID	This is the application identifier as a decimal number.
From	This is the date and time the current statistics collection started.
To	This is the date and time the GOOSE statistics command was executed.
Accumulated downtime duration	This represents the total amount of time a subscription was in an error state. The duration is displayed in the format: hhhh:mm:ss.zzz.
Maximum downtime duration	This represents the maximum amount of time a subscription was continuously in error state. The duration is displayed in the format: hhhh:mm:ss.zzz.
Date & time maximum downtime began	This is the date and time the recorded maximum downtime started.
Number of messages received out-of-sequence (OOS)	This represents the total number of messages received with either the state number and/or sequence number out-of-sequence. This includes cases where more than one instance of a message is received within a single relay processing interval. In this case, the most recent message is processed and the others are discarded.
Number of time-to-live (TTL) violations detected	This represents the total number of times a message was not received within the expected period/interval.
Number of messages incorrectly encoded or corrupted	This represents the total number of messages that were identified with this subscription but were either incorrectly encoded or encoded with a wrong dataset.
Number of messages lost due to receive overflow	This represents the total number of messages that were not processed because memory resources were exhausted. This includes cases where more than one instance of a message is received within a single relay processing interval. In this case, the most recent message is processed and the others are discarded.
Calculated max. sequential messages lost due to OOS	This represents the maximum estimated number of messages that were missed after receiving a message with a higher state or sequence number than expected.
Calculated number of messages lost due to OOS	This represents the total of all estimated number of messages lost due to state or sequence number skip in received messages.

An example response to the **GOOSE** command is shown in *Figure 7.26*.

```
=>GOOSE <Enter>

GOOSE Transmit Status

 MultiCastAddr   Ptag:Vlan AppID  StNum      SqNum      TTL    Code
-----------------------------------------------------------------------------
SEL_751_1CFG/LLN0$GO$GPub01
 01-0C-CD-01-00-09 4:1     4105   1          117        228
 Data Set: SEL_751_1CFG/LLN0$GPDSet01

SEL_751_1CFG/LLN0$GO$NewGOOSEMessage
 01-0C-CD-01-00-3E 4:1     62     1          117        227
 Data Set: SEL_751_1CFG/LLN0$GPDSet01

SEL_751_1CFG/LLN0$GO$NewGOOSEMessage1
 01-0C-CD-01-00-3F 4:1     63     1          117        226
 Data Set: SEL_751_1CFG/LLN0$GPDSet01

SEL_751_1CFG/LLN0$GO$NewGOOSEMessage2
 01-0C-CD-01-00-40 4:1     64     1          117        214
 Data Set: SEL_751_1CFG/LLN0$GPDSet01

SEL_751_1CFG/LLN0$GO$NewGOOSEMessage3
 01-0C-CD-01-00-41 4:1     65     1          117        213
 Data Set: SEL_751_1CFG/LLN0$GPDSet01

SEL_751_1CFG/LLN0$GO$NewGOOSEMessage4
 01-0C-CD-01-00-42 4:1     66     1          117        213
 Data Set: SEL_751_1CFG/LLN0$GPDSet01

SEL_751_1CFG/LLN0$GO$NewGOOSEMessage5
 01-0C-CD-01-00-43 4:1     67     1          117        205
 Data Set: SEL_751_1CFG/LLN0$GPDSet01

SEL_751_1CFG/LLN0$GO$NewGOOSEMessage6
 01-0C-CD-01-00-44 4:1     68     1          117        206
 Data Set: SEL_751_1CFG/LLN0$GPDSet01


GOOSE Receive Status

 MultiCastAddr   Ptag:Vlan AppID  StNum      SqNum      TTL    Code
-----------------------------------------------------------------------------
SEL_451_1CFG/LLN0$GO$GooseDSet15
 01-0C-CD-01-00-14  :      4116   1          2079182    2000
 Data Set: SEL_451_1CFG/LLN0$DSet15

SEL_351S_1CFG/LLN0$GO$GPub01
 01-0C-CD-01-00-12  :      4114   1          2084274    2000
 Data Set: SEL_351S_1CFG/LLN0$GPDSet01

SEL_700G_1CFG/LLN0$GO$GPub01
 01-0C-CD-01-00-0A  :      4106   2          2075069    2000
 Data Set: SEL_700G_1CFG/LLN0$GPDSet01

SEL_710d5_1CFG/LLN0$GO$GPub01
 01-0C-CD-01-00-18  :      4120   2          2075091    2000
 Data Set: SEL_710d5_1CFG/LLN0$GPDSet01

SEL_710_1CFG/LLN0$GO$GooseDSet13
 01-0C-CD-01-00-08  :      4104   2          2030049    2000
 Data Set: SEL_710_1CFG/LLN0$DSet13

SEL_710_2CFG/LLN0$GO$GPub01
 01-0C-CD-01-00-13  :      19     2          2075484    2000
 Data Set: SEL_710_2CFG/LLN0$GPDSet01
```

Figure 7.26 GOOSE Command Response

```
=>>GOO S 1 L

 SubsID 1
----------------------------------------------------------------------------
 Ctrl Ref: SEL_451_1CFG/LLN0$GO$GooseDSet15
 AppID   : 4116
 From    : 03/06/2017 18:54:16.255  To: 03/06/2017 18:57:39.950

 Accumulated downtime duration                      : 0000:00:00.000
 Maximum downtime duration                          : 0000:00:00.000
 Date & time maximum downtime began                 :
 Number of messages received out-of-sequence(OOS)   : 0
 Number of time-to-live(TTL) violations detected    : 0
 Number of messages incorrectly encoded or corrupted: 0
 Number of messages lost due to receive overflow    : 0
 Calculated max. sequential messages lost due to OOS: 0
 Calculated number of messages lost due to OOS      : 0

 #    Date        Time          Duration        Failure


=>>
```

Figure 7.26 GOOSE Command Response (Continued)

GROUP Command

Use the **GROUP** command (see *Table 7.19*) to display the active settings group or try to force an active settings group change.

Table 7.19 GROUP Command

Command	Description	Access Level
GROUP	Displays the active settings group.	1
GROUP *n*	Changes the active group to Group *n*.	2
Parameter		
n	Parameter n indicates group numbers 1–4.	

When you change the active group, the relay responds with a confirmation prompt: `Are you sure (Y/N)?` Answer **Y <Enter>** to change the active group. The relay asserts the Relay Word bit SALARM for one second when you change the active group.

If any of the SELOGIC control equations SS1–SS3 are set when you issue the **GROUP *n*** command, the group change fails. The relay responds: `Command Unavailable: Active setting group SELOGIC equations have priority over the GROUP command`.

HELP Command

The **HELP** command (see *Table 7.20*) 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 7.20 HELP Command

Command	Description	Access Level
HELP	Displays a list of each command available at the present access level with a one-line description.	1
HELP *command*	Displays information on the command ***command***.	1

HISTORY Command

Use the **HIS** command (see *Table 7.21*) to view a list of one-line descriptions of relay events or clear the list (and corresponding event reports) from nonvolatile memory. For more information on event reports, see *Section 10: Analyzing Events*.

Table 7.21 HISTORY Command

Command	Description	Access Level
HIS	Returns event histories with the oldest at the bottom of the list and the most recent at the top of the list.	1
HIS *n*	Returns event histories with the oldest at the bottom of the list and the most recent at the top of the list, beginning at event *n*.	1
HIS C or **R**	Clears/resets the event history and all corresponding event reports from nonvolatile memory.	1

HIS HIF Command

The **HIS HIF** command displays a quick synopsis of the last 100 high-impedance fault (HIF) events that the relay has captured. The rows in the **HIS HIF** report contain the event reference number, date, time, event type, location, maximum current, active group, and targets. See *High-Impedance Fault Event History on page 10.33* for the **HIS HIF** report format. Use the **HIS HIF** command to list one-line descriptions of relay events. You can list **HIF** event histories by number or by date. This command is only available when the relay supports **HIF** detection.

Table 7.22 HIS HIF Command

Command	Description	Access Level
HIS HIF	Returns HIF event histories with the oldest at the bottom of the list and the most recent at the top of the list.	1
HIS HIF *n*	Returns the n most recent HIF event histories with the oldest at the bottom of the list and the most recent at the top of the list.	1
HIS HIF C or **R**	Clears/resets the HIF events reports but retains the event history.	1
HIS HIF CA or **RA**	Clears/resets the HIF event history and all the corresponding event reports from the nonvolatile memory.	1
Parameter		
n	Indicates a record number. The most recent event has record number one (1).	

HIS C and HIS R Command

The **HIS C** and **HIS R** commands clear/reset the history data and corresponding high-resolution/event report data on the present port. The relay prompts, `Clear all event reports. Are you sure (Y/N)?` when you issue the **HIS C** and **HIS R** commands. If you answer `Y <Enter>`, the relay clears all **HIF** event reports.

HSG Command

When the SEL-751 is ordered with the Arc Sense technology (AST) option for the high-impedance fault (HIF) detection, the relay provides high-impedance fault histogram data with the **HSG** (histogram) command. The **HSG** command displays 100 long-term and 100 short-term histogram counter values of the Phases A, B, and C current odd-harmonic content (ISM) plus the learned limits for the histograms.

Table 7.23 HSG Command

Command	Description	Access Level
HSG	Displays high-impedance fault (HIF) histogram data.	1
NOTE:		
LT HIS A, LT HIS B, LT HIS C	Long-term histogram counter values of the Phases A, B, and C current odd-harmonic content (ISM).	
ST HIS A, ST HIS B, ST HIS C	Short-term histogram counter values of the Phases A, B, and C current odd-harmonic content (ISM).	
HISLIMA, HISLIMB, HISLIMC	Learned histogram thresholds for Phases A, B, and C.	
Mean	Mean values of short- and long-term histograms for Phases A, B, and C.	
Std	Standard deviations for the short- and long-term standard deviations for the short- and long-term histograms for Phases A, B, and C.	
NFA, NFB, NFC	Pickup thresholds of decision timers for Phases A, B, and C.	

Figure 7.27 shows the **HSG** command response.

```
=>>HSG <Enter>

SEL-751                                  Date: 04/11/2011   Time: 16:07:15.933
FEEDER RELAY                             Time Source: Internal

Counter#   LT HIS A   ST HIS A   LT HIS B   ST HIS B   LT HIS C   ST HIS C
1          0          0          0          0          0          0
2          0          0          0          0          0          0
3          0          0          0          0          0          0
.          .          .          .          .          .          .
.          .          .          .          .          .          .
.          .          .          .          .          .          .
98         0          0          0          0          0          0
99         0          0          0          0          0          0
100        0          0          0          0          0          0

Mean       0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
std.       0.0000     0.0000     0.0000     0.0000     0.0000     0.0000

           HISLIMA    HISLIMB    HISLIMC    NFA        NFB        NFC
           0.0000     0.0000     0.0000     99999.0000 99999.0000 99999.0000


=>>
```

Figure 7.27 HSG Command Response

The purpose of the Statistics function is to learn the effects of feeder normal loads on the detection quantity ISM. The function keeps two histogram counters, each has 100 units.

HIF odd-harmonic decision function generates HIF alarms if the difference between two histograms is statistically substantial (determined by using their means and standard deviations). When the difference between the two histograms is not substantial, the long-term histogram is updated through an

IIR filtering process from the short-term histogram. The long-term histogram therefore adapts to the feeder ambient load conditions and increases the overall HIF detection security.

IDENTIFICATION Command

Use the **ID** command (see *Table 7.24*) to extract device identification codes.

Table 7.24 IDENTIFICATION Command

Command	Description	Access Level
ID	Returns a list of device identification codes.	0

INI HIF Command

The **INI HIF** command (see *Table 7.25*) is used to restart the 24 -hour tuning process used in high-impedance fault detection. This command is only available when the relay supports **HIF** detection and **EHIF** is not set to N. If you issue the **INI HIF** commands, the relay prompts, `Initiate HIF 24-hour tuning (Y/N)?` If you answer `Y <Enter>`, the relay initiates the tuning process.

Table 7.25 INI HIF Command

Command	Description	Access Level
INI HIF	Initiates the 24 -hour tuning process used in high-impedance fault detection.	2

IRIG Command

Use the **IRIG** command to direct the relay to read the demodulated IRIG-B time code at the serial port or IRIG-B input (see *Table 7.26*).

Table 7.26 IRI Command

Command	Description	Access Level
IRIG	Forces synchronization of internal control clock to IRIG-B time-code input.	1

To force the relay to synchronize to IRIG-B, enter the following command:

```
=>IRI <Enter>
```

If the relay successfully synchronizes to IRIG-B, it sends the following header and access level prompt:

```
SEL-751                  Date: 12/10/2010 Time: 08:56:03.190
FEEDER RELAY             Time Source: external
=>
```

If no IRIG-B code is present at the serial port input or if the code cannot be read successfully, the relay responds with `IRIG-B DATA ERROR`.

If an IRIG-B signal is present, the relay synchronizes its internal clock with IRIG-B. It is not necessary to issue the **IRIG** command to synchronize the relay clock with IRIG-B. Use the **IRIG** command to determine if the relay is properly reading the IRIG-B signal.

LDP Command (Load Profile Report)

Use the **LDP** commands (see *Table 7.27*) to view and manage the Load Profile report (see *Figure 5.14*). If there is no stored data and an **LDP** command is issued, the relay responds with `No data available`.

Table 7.27 LDP Commands

Command	Description	Access Level
LDP *row1 row2* **LDP *date1 date2***	Displays 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	Clears the load profile report from nonvolatile memory.	1
Parameters		
row1 row2	Append *row1* to return a chronological progression of the first *row1* rows. Append *row1* and *row2* to return all rows between *row1* and *row2*, beginning with *row1* and ending with *row2*. Enter the smaller number first to display a numeric progression of rows through the report. Enter the larger number first to display a reverse numeric progression of rows.	
date1 date2	Append *date1* to return all rows with this date. Append *date1* and *date2* to return all rows between *date1* and date beginning with *date1* and ending with *date2*. Enter the oldest date first to display a chronological progression through the report. Enter the newest date first to display a reverse chronological progression. Date entries are dependent on the date format setting DATE_F.	

L_D Command (Load Firmware)

Use the **L_D** command (see *Table 7.28*) to load firmware. See *Appendix A: Firmware, ICD, and Manual Versions* for information on changes to the firmware and instruction manual. See *Appendix B: Firmware Upgrade Instructions* for further details on downloading firmware. Only download firmware to the front port.

Table 7.28 L_D Command (Load Firmware)

Command	Description	Access Level
L_D	Downloads firmware to the control.	2

LOG HIF (High-Impedance Fault) Command

When the SEL-751 is ordered with the Arc Sense technology (AST) option for the high-impedance fault detection, the relay provides high-impedance fault detection progress data with the **LOG HIF** (**LOG H** command) report.

The **LOG HIF** command displays the progress of HIF detection in percentage of their final pickup, the update of each entry is adaptive based on HIF detection outputs. This command is available only when enable setting EHIF is set to Y and Relay Word bit ITUNE_*x* (where *x* is A,B, or C) is deasserted (tuning process has been completed).

Table 7.29 LOG HIF Command

Command	Description	Access Level
LOG HIF *nnn*	Displays the progress of high-impedance fault (HIF) detection.	1

NOTE:

- Odd-harmonic alarm and fault values ALG.1 A, ALG.1 B, and ALG.1 C for Phases A, B, and C in percent of preset alarm and fault thresholds.
- Non-harmonic alarm and fault values ALG.2 A, ALG.2 B, and ALG.2 C for Phases A, B, and C in percent of preset alarm and fault thresholds.
- HI1 and HI2 are the digital outputs of the odd-harmonic and non-harmonic alarm and fault detection logic. The HIF odd-harmonic alarm and fault output bits under HI1 are HIA1_A, HIA1_B, HIA1_C, and HIF1_A, HIF1_B, HIF1_C, respectively and the HIF non-harmonic alarm and fault output bits under HI2 are HIA2_A, HIA2_B, HIA2_C, and HIF2_A, HIF2_B, HIF2_C, respectively. These Relay Word bits assert when the corresponding percentage values reach 100%.

Figure 7.28 provides an example of **LOG H** (HIF) command report.

```
=>>LOG HIF <Enter>

SEL-751                                   Date: 04/11/2011   Time: 16:07:15.933
FEEDER RELAY                              Time Source: Internal

Date       Time       Percent ALG.1A ALG.1B ALG.1C ALG.2A ALG.2B ALG.2C HI1 HI2
03/28/2011 14:47:48.327 ALARM   0.00   0.00   0.00 100.00   5.00   5.00 000 000
                        FAULT   0.00   0.00   0.00 100.00 100.00 100.00 000 000


Date       Time       Percent ALG.1A ALG.1B ALG.1C ALG.2A ALG.2B ALG.2C HI1 HI2
03/28/2011 14:47:51.342 ALARM   0.00   0.00   0.00 100.00   5.00   5.00 000 000
                        FAULT   0.00   0.00   0.00 100.00 100.00  33.33 000 000


Date       Time       Percent ALG.1A ALG.1B ALG.1C ALG.2A ALG.2B ALG.2C HI1 HI2
03/28/2011 14:47:52.338 ALARM   0.00   0.00   0.00 100.00   5.00   5.00 000 000
                        FAULT   0.00   0.00   0.00 100.00 100.00  33.33 000 000

=>>
```

Figure 7.28 LOG H (HIF) Command Response

LOOPBACK Command

Use the **LOO** command (see *Table 7.30*) for testing the MIRRORED BITS communications channel for proper communication. For more information on MIRRORED BITS, see *Appendix J: MIRRORED BITS Communications*.

Table 7.30 LOO Command

Command	Description	Access Level
LOO	Enables loopback testing of MIRRORED BITS channels.	2
LOO A	Enables loopback on MIRRORED BITS Channel A for the next 5 minutes.	2
LOO B	Enables loopback on MIRRORED BITS Channel B for the next 5 minutes.	2

With the transmitter of the communications channel physically looped back to the receiver, the MIRRORED BITS addressing is wrong and ROK is 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 loopback mode on that channel for five minutes, while the inputs are forced to the default values.

```
=>>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) 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

NOTE: Relays with older CPU cards can be upgraded to firmware versions R112 or higher, but the relay will not have the GOOSE performance improvements (i.e., a GOOSE port with a dedicated MAC address).

Use the **MAC** command to display the MAC addresses of PORT 1, as shown in the following.

```
=>>MAC <Enter>

Port 1 (IP) MAC Address:      00-30-A7-67-32-10
Port 1 (GOOSE) MAC Address:   00-30-A7-78-10-20

=>>
```

MET Command (Metering Data)

The **MET** command (see *Table 7.31* and *Table 7.32*) provides access to the relay metering data.

Table 7.31 Meter Command

Command	Description	Access Level
MET *c n*	Displays metering data.	1
MET *c* R	Resets metering data.	1
Parameters		
c	Parameter for identifying meter class.	
n	Parameter used to specify number of times (1–32767) to repeat the meter response.	

Table 7.32 Meter Class

c	Meter Class
F (or **MET**)	Fundamental Metering
E[a]	Energy Metering
M[a]	Maximum/Minimum Metering
RMS	RMS Metering
T	Thermal and RTD Metering
AI	Analog Input (transducer) Metering
DE[a]	Demand Metering
PE[a]	Peak Demand Metering
PM	Synchrophasor Metering
L	Light Metering for Arc-Flash Detection (AFD)
MV	SELOGIC Math Variable Metering
RA	Remote Analog Metering
HIF	High-Impedance Fault (HIF) Metering

[a] Reset Metering Available.

For more information on metering and example responses for each meter class, see *Section 5: Metering and Monitoring*.

On issuing the **MET *c* R** command for resetting metering quantities in class *c*, the relay responds: `Reset Metering Quantities (Y,N)?` Upon confirming (pressing **Y**), the metering quantities are reset and the relay responds with `Reset Complete`.

OPEN Command (Open Breaker)

The **OPE** (OPEN) command asserts Relay Word bit OC for 1/4 cycle when it is executed. Relay Word bit OC can then be programmed into the TR SELOGIC control equation to assert the TRIP Relay Word bit, which in turn asserts an output contact (e.g., OUT103 = TRIP) to open a circuit breaker (see *Table 4.52* and *Figure 4.34* for factory-default setting TR and trip logic).

To issue the **OPE** command, enter the following.

```
=>>OPE <Enter>

Open Breaker (Y,N)? Y <Enter>

=>>
```

Typing **N <Enter>** after the previous prompt aborts the command.

The main board breaker jumper (see *Table 2.17*) supervises the **OPE** command. 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 <Enter>

Command Aborted: No Breaker Jumper

=>>
```

When setting EN_LRC := Y, the Relay Word bit LOCAL supervises the **OPE** command (see *Table 9.4*). If the LOCAL bit is asserted (LOCAL = 1), the relay does not execute the **OPE** command and responds with the following:

```
=>>OPE <Enter>

Command Aborted: Device in Local Control

=>>
```

The Relay Word bit LOCAL is determined by the LOCAL SELOGIC control equation (see *Table 9.4*).

PASSWORD Command (Change Passwords)

Use the **PAS** command (see *Table 7.33*) to change existing passwords.

Table 7.33 PASSWORD Command

Command	Description	Access Level
PAS *level*	Changes password for Access Level *level*.	2, C
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 7.34*.

Table 7.34 Factory-Default Passwords for Access Levels 1, 2, and C

Access Level	Factory-Default Password
1	OTTER
2	TAIL
C	CLARKE

To change the password for Access Level 1 to #Ot3579!ijd7, enter the following command sequence:

```
=>>PAS 1 <Enter>
Old PW: ? ***** <Enter>
New PW: ? *********** <Enter>
Confirm PW: ? *********** <Enter>
Password Changed
=>>
```

Similarly, use **PAS 2** to change Level 2 passwords and **PAS C** to change Level C passwords.

Table 7.35 Valid Password Characters

Alpha	A B C D E F G H I J K L M N O P Q R S T U V W X Y Z a b c d e f g h i j k l m n o p q r s t u v w x y z
Numeric	0 1 2 3 4 5 6 7 8 9
Special	! " # $ % & ' ( ) * + , - . / : ; < = > ? @ [\ ] ^ _ ` {	} ~

Passwords can contain as many as 12 characters. Upper- and lowercase letters are treated as different characters. Strong passwords consist of 12 characters, with at least one special character or digit and mixed-case sensitivity, but do not form a name, date, acronym, or word. Passwords formed in this manner are less susceptible to password guessing and automated attacks.

Examples of valid, distinct, and strong passwords are as follows:

- #0t3579!ijd7
- (Ih2dcs)36dn
- $A24.68&,mvj
- *4u-Iwg+?lf-

PING Command

When you are setting up or testing substation networks, it is helpful to determine if the network is connected properly and if the other devices are powered up and configured properly. The **PING** command (Access Level 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 7.29*.

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 7.29 PING Command Response

PULSE Command

NOTE: The **PULSE** command is available when the breaker control jumper on the mainboard is in the ENABLED position.

Use the **PULSE** command (see *Table 7.36*) to pulse any of the relay control outputs for a specified time. This function aids you in relay testing and commissioning. When a **PUL** command is issued, the selected contact closes or opens depending on the output contact type (a or b). The **PUL** command energizes the coil and has no effect if the coil is already energized. The control outputs are **OUT*nnn***, where ***nnn*** represents 101–103 (standard), 301–304 (optional), 401–404 (optional), or 501–504 (optional).

Table 7.36 PUL OUT*nnn* Command

Command	Description	Access Level
PUL OUT*nnn*	Pulses output OUT*nnn* for 1 second.	2
PUL OUT*nnn s*	Pulses output OUT*nnn* for *s* seconds.	2
Parameters		
nnn	A control output number	
s	Time in seconds, with a range of 1–30	

QUIT Command

Use the **QUIT** command (see *Table 7.37*) to revert to Access Level 0.

Table 7.37 QUIT Command

Command	Description	Access Level
QUIT	Goes to Access Level 0.	0

Access Level 0 is the lowest access level; the SEL-751 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 7.38*) to restore factory-default settings.

Table 7.38 R_S Command (Restore Factory-Defaults)

Command	Description	Access Level
R_S	Restores 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 7.39*) to view and manage the Sequential Events Recorder report. See *Section 10: Analyzing Events* for further details on SER reports. If there is no SER report row stored, the relay responds with `No Data Available`.

Table 7.39 SER Command (Sequential Events Recorder Report)

Command	Description	Access Level
SER	Displays a chronological progression of all available SER rows (as many as 1024 rows). Row 1 is the most recently triggered row and row 1024 is the oldest.	1
SER C or **R**	Clears/resets the SER records.	1
Parameter		
row1	Append *row1* to return a chronological progression of the first *row1* rows. For example, use **SER 5** to return the first five rows.	
row1 row2	Append *row1* and *row2* to return all rows between *row1* and *row2*, beginning with row1 and ending with *row2*. Enter the smaller number first to display a numeric progression of rows through the report. Enter the larger number first to display a reverse numeric progression of rows. For example, use **SER 1 10** to return the first 10 rows in numeric order or **SER 10 1** to return these same items in reverse numeric order.	
date1	Append *date1* to return all rows with this date. For example, use **SER 1/1/2003** to return all records for January 1, 2003.	
date1 date2	Append *date1* and *date2* to return all rows between date1 and date beginning with *date1* and ending with *date2*. Enter the oldest date first to display a chronological progression through the report. Enter the newest date first to display a reverse chronological progression. Date entries are dependent on the date format setting DATE_F. For example, use **SER 1/5/2003 1/7/2003** to return all records for January 5, 6, and 7, 2003	

SER D Command

The **SER D** command shows a list of SER items that the relay has automatically removed. These are "chattering" elements. You can automatically remove chattering SER elements in the SER Chatter Criteria category of the Report settings; the enable setting is ESERDEL. See *Section 4: Protection and Logic Functions*, *Report Settings (SET R Command)* for more information on SER automatic deletion and reinsertion.

Table 7.40 SER D Command

Command	Description	Access Level
SER D	Lists chattering SER elements that the relay is removing from the SER records.	1

If you issue the **SER D** command and you have not enabled automatic removal of chattering SER elements (Report setting ESERDEL), the relay responds, `Automatic removal of chattering SER elements not enabled`.

SET Command (Change Settings)

The **SET** command is for viewing or changing the relay settings (see *Table 7.41*).

Table 7.41 SET Command (Change Settings)

Command	Description	Access Level
SET *n s* TERSE	Sets the relay settings, beginning at the first setting for Group *n* (*n* = 1, 2, 3, or 4).	2
SET L *n s* TERSE	Sets general logic settings for Group *n* (*n* = 1, 2, 3, or 4).	2
SET G *s* TERSE	Sets global settings.	2
SET P *n s* TERSE	Sets 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	Sets report settings such as Sequential Events Recorder (SER) and Event Report (ER) settings.	2
SET F *s* TERSE	Sets front-panel settings.	2
SET I TERSE	Sets IEC 60870-5-103 settings.	2
SET M *s* TERSE	Sets Modbus User Map settings.	2
SET DNP *m s* TERSE	Sets DNP Map *m* settings (*m* = 1, 2, or 3).	2
Parameter		
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 7.42*.

Table 7.42 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 7.43* for the **SHOW** command settings and for the command format.

Table 7.43 SHOW Command (Show/View Settings)

Command	Description	Access Level
SHO *n s*	Shows relay settings for Group *n* (*n* = 1, 2, 3, or 4).	1
SHO L *n s*	Shows general logic settings for Group *n* (*n* = 1, 2, 3, or 4).	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 I	Shows IEC 60870-5-103 settings	1
SHO M *s*	Shows Modbus User Map settings.	1
SHO DNP *m s*	Shows DNP Map *m* settings (*m* = 1, 2, or 3).	1
Parameter		
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>

Group 1
Relay Settings

ID Settings
RID      := SEL-751
TID      := FEEDER RELAY

Config Settings
CTR      := 120          CTRN     := 120          PTR      := 180.00
PTRS     := 180.00       DELTA_Y  := DELTA        VSCONN   := VS
SINGLEV  := N            VNOM     := 120.00

Line Parameter Settings
Z1MAG    := 2.14         Z1ANG    := 68.86        Z0MAG    := 6.38
Z0ANG    := 72.47        Z0SMAG   := 0.36         Z0SANG   := 84.61
LL       := 4.84

Fault Locator
EFLOC    := N

Max Ph Overcurr
50P1P    := 10.00        50P1D    := 0.00
50P1TC   := 1
50P2P    := 10.00        50P2D    := 0.00
50P2TC   := 1
50P3P    := 10.00        50P3D    := 0.00
50P3TC   := 1
50P4P    := 10.00        50P4D    := 0.00
50P4TC   := 1

Neutral Overcurr
50N1P    := OFF          50N2P    := OFF          50N3P    := OFF
50N4P    := OFF

Residual Overcurr
50G1P    := OFF          50G2P    := OFF          50G3P    := OFF
50G4P    := OFF
```

Figure 7.30 SHOW Command Example

```
Neg Seq Overcurr
50Q1P    := OFF          50Q2P    := OFF          50Q3P    := OFF
50Q4P    := OFF

Phase TOC
51AP     := 6.00         51AC     := U3           51ATD    := 3.00
51ARS    := N            51ACT    := 0.00         51AMR    := 0.00
51ATC    := 1
51BP     := 6.00         51BC     := U3           51BTD    := 3.00
51BRS    := N            51BCT    := 0.00         51BMR    := 0.00
51BTC    := 1
51CP     := 6.00         51CC     := U3           51CTD    := 3.00
51CRS    := N            51CCT    := 0.00         51CMR    := 0.00
51CTC    := 1

Maximum Ph TOC
51P1P    := 6.00         51P1C    := U3           51P1TD   := 3.00
51P1RS   := N            51P1CT   := 0.00         51P1MR   := 0.00
51P1TC   := 1
51P2P    := 6.00         51P2C    := U3           51P2TD   := 3.00
51P2RS   := N            51P2CT   := 0.00         51P2MR   := 0.00
51P2TC   := 1

Negative Seq TOC
51QP     := 6.00         51QC     := U3           51QTD    := 3.00
51QRS    := N            51QCT    := 0.00         51QMR    := 0.00
51QTC    := 1

Neutral TOC
51N1P    := OFF          51N2P    := OFF

Residual TOC
51G1P    := 0.50         51G1C    := U3           51G1TD   := 1.50
51G1RS   := N            51G1CT   := 0.00         51G1MR   := 0.00
51G1TC   := 1
51G2P    := 0.50         51G2C    := U3           51G2TD   := 1.50
51G2RS   := N            51G2CT   := 0.00         51G2MR   := 0.00
51G2TC   := 1

Directional Set
EDIR     := N

Harmonic Blocking Set
EHBL2    := N            EHBL5    := N

Load Encroach Set
ELOAD    := N

High Impedance Fault Settings
EHIF     := N
RTD Settings
E49RTD   := NONE

Thermal Settings
E49IEC   := N


Undervoltage Set
27PP1P   := OFF          27PP2P   := OFF          27S1P    := OFF
27S2P    := OFF

Overvoltage Set
59PP1P   := OFF          59PP2P   := OFF          59Q1P    := OFF
59Q2P    := OFF          59S1P    := OFF          59S2P    := OFF

27 Inverse Time
E27I1    := N            E27I2    := N

59 Inverse Time
E59I1    := N            E59I2    := N            E59I3    := N
E59I4    := N

SyncCheck Set
E25      := N

LOP Setting
LOPBLK   := 0

Power Factor Set
55LGTP   := OFF          55LDTP   := OFF          55LGAP   := OFF
55LDAP   := OFF
```

Figure 7.30 SHOW Command Example (Continued)

```
Vector Shift Set
E78VS    := N

Freq Settings
81D1TP   := OFF           81D2TP   := OFF           81D3TP   := OFF
81D4TP   := OFF           81D5TP   := OFF           81D6TP   := OFF

Rate of Frequency Set
E81R     := N

Fast Rate of Frequency Set
E81RF    := N

Demand Mtr Set
EDEM     := THM           DMTC     := 5             PHDEMP   := 5.00
GNDEMP   := 1.00          3I2DEMP  := 1.00

Power Elements
EPWR     := N

Trip/Close Logic
TDURD    := 0.5           CFD      := 1.0
TR       := ORED50T OR ORED51T OR ORED81T OR REMTRIP OR OC OR SV04T
REMTRIP  := 0
ULTRIP   := NOT ( 51P1P OR 51G1P OR 51N1P OR 52A )
52A      := 0
CL       := SV03T AND LT02 OR CC
ULCL     := 0

Reclosing Control
E79      := N

=>>
```

Figure 7.30 SHOW Command Example (Continued)

STATUS Command (Relay Self-Test Status)

The **STA** command (see *Table 7.44*) displays the status report.

Table 7.44 STATUS Command (Relay Self-Test Status)

Command	Description	Access Level
STA *n*	Displays the relay self-test information *n* times (*n* = 1–32767). Defaults to 1 if *n* is not specified.	1
STA S	Displays the memory and execution utilization for the SELOGIC control equations.	1
STA C or **R**	Reboots the relay and clear self-test warning and failure status results.	2

Refer to *Section 11: Testing and Troubleshooting* for self-test thresholds and corrective actions, as well as hardware configuration conflict resolution. *Table 7.45* shows the status report definitions and message formats for each test.

Table 7.45 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
FPGA	FPGA programming unsuccessful, or FPGA failed	OK/FAIL
GPSB	General purpose serial bus	OK/FAIL

Table 7.45 STATUS Command Report and Definitions (Sheet 2 of 2)

STATUS Report Designator	Definition	Message Format
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 (Refer to *Figure 1.4* and *Figure 1.5* for examples of **STATUS** command responses)	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 (current/voltage)	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, IB, IC, IN)	DC offset in hardware circuits of current channels	OK/WARN
Voltage Offset (VA, VB, VC, VS)	DC offset in hardware circuits of voltage channels	OK/WARN

Figure 7.31 shows the typical relay output for the **STATUS S** command, showing available SELOGIC control equation capability.

NOTE: The **STA S** report gives the available SELOGIC capacity of the relay. In the example, Execution 84% means 84% of execution capacity is still available.

```
=>STA S <Enter>

SEL-751                                 Date: 08/05/2015   Time: 15:26:39.570
FEEDER RELAY                            Time Source: External

Part Number  751501A103X70850630
Global (%)    79
FP (%)        75
Report (%)    91

                 GROUP 1  GROUP 2  GROUP 3  GROUP 4
Execution (%)    84       84       84       84
Group (%)        85       85       85       85
Logic (%)        89       89       89       89

=>>
```

Figure 7.31 Typical Relay Output for STATUS S Command

SUMMARY Command

The **SUM** command (see *Table 7.46*) displays an event summary in a readable format.

Table 7.46 SUMMARY Command

Command	Description	Access Level
SUM ***n***	Displays the latest event summary. Use *n* to display particular event summary.	1
SUM C or **R**	Clears 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 (e.g., A-phase 51 Trip).

SUMMARY HIF Command

Use the **SUM HIF** command (see *Table 7.47*) to view the HIF event summary reports in the relay memory. This command is only available when the relay supports HIF detection.

Table 7.47 SUM HIF Command

Command	Description	Access Level
SUM HIF	Returns the most recent HIF event summary.	1
SUM HIF ***n***	Returns an event summary for HIF event *n*.	1
Parameter		
n	Indicates the record number; see the *HIS HIF Command* (HIF event history report).	

TARGET Command (Display Relay Word Bit Status)

The **TAR** command (see *Table 7.48*) displays the status of front-panel target LEDs or Relay Word bit, whether these LEDs or Relay Word bits are asserted or deasserted.

NOTE: The **TARGET R** command cannot reset the latched targets if a TRIP condition is present.

Table 7.48 TARGET Command (Display Relay Word Bit Status)

Command	Description	Access Level
TAR ***name k*** **TAR** ***n*** **TAR** ***n k***	Displays Relay Word Row 0 or the last displayed target row when used without parameters.	1
TAR R	Clears the front-panel tripping targets. Unlatches the trip logic for testing purposes (see *Figure 8.2*). Shows Relay Word Row 0.	1
Parameter		
name	Displays the Relay Word row with Relay Word bit name.	
n	Shows Relay Word row number *n*.	
k	Repeats *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 7.49*. All Relay Word rows are described in *Table K.1* and *Table K.2*.

Relay Word bits are used in SELOGIC control equations. See *Appendix K: Relay Word Bits*.

The **TAR** command does not remap the front-panel target LEDs, as is done in some previous SEL relays.

Table 7.49 Front-Panel LEDs and the TAR 0 Command

LEDs	7	6	5	4	3	2	1	0
TAR 0	ENABLED	TRIP_LED	TLED_01	TLED_02	TLED_03	TLED_04	TLED_05	TLED_06

TEST DB Command

Use the **TEST DB** command to temporarily force the relay to send fixed analog and/or digital values over communications interfaces for protocol testing.

Table 7.50 TEST DB Commands

Command	Description	Access Level
TEST DB	Displays the present status of digital and analog overrides.	2
TEST DB A *name value*	Forces the protocol analog element *name* to override *value*.	2
TEST DB D *name value*	Forces the protocol digital element *name* to override *value*.	2
TEST DB *name* OFF	Clears (analog or digital) override for element *name*.	2
TEST DB A OFF	Clears all analog overrides.	2
TEST DB D OFF	Clears all digital overrides	2
TEST DB OFF	Clears all analog and digital overrides.	2

⚠**WARNING**
To reduce the chance of a false operating decision when using the **TEST DB** command, ensure that protocol master device(s) flag the data as "forced or test data". One possible method is to monitor the TESTDB Relay Word bit.

The **TEST DB** command provides a method to override Relay Word bits or analog values to aid testing of communications interfaces. The command overrides values in the communications interfaces (ASCII, SEL Fast Message, DNP, Modbus, IEC 60870-5-103, and IEC 61850) only. The actual values used by the relay for protection and control are not changed. However, remote devices may use these analog and digital signals to make control decisions. Ensure that remote devices are properly configured to receive the overridden data before using the **TEST DB** command.

To override analog data in a communications interface, enter the following from Access Level 2 or higher:

```
=>>TEST DB A name value <Enter>
```

NOTE: When using the **TEST DB** command to generate values for Fast Meter testing, you may need to override all current and voltage angles (IA_ANG, VA_ANG, etc.) to ensure the expected phase relationship.

NOTE: When using the **TEST DB** command, specifying a negative value may yield an unexpected display in some instances.

where *value* is a numerical value and *name* is an analog label from *Table L.1*, Analog Quantities, with an "x" in the DNP, Modbus, Fast Meter, IEC 60870-5-103, or IEC 61850 column. For example, the **TEST DB** command can be used to force the value of the A-phase current magnitude transmitted to a remote device to 100 amperes:

```
=>>TEST DB A IA_MAG 100 <Enter>
```

To override digital data in an SEL ASCII, SEL Fast Message, Modbus, DNP, IEC 60870-5-103, or IEC 61850 communications interface, enter the following from Access Level 2 or higher:

```
=>>TEST DB D name value <Enter>
```

where *name* is a Relay Word bit (see *Table K.1*) and *value* is 1 or 0. For example, if Relay Word bit 51P1T := logical 0, the **TEST DB** command can be used effectively to test the communications interface by forcing the communicated status of this Relay Word bit to logical 1:

```
=>>TEST DB D 51P1T 1 <Enter>
```

Values listed in the SER triggers SER1, SER2, SER3, and SER4 cannot be overridden.

When the relay is not in Test Mode, the relay responds to either the digital or analog override request with the following message:

```
WARNING:  TEST MODE is not a regular operation.
Communication outputs of the device will be overridden by simulated values.

Are you sure (Y/N)? Y <Enter>
```

The relay responds:

```
Test Mode Active.  Use Test DB OFF command to exit Test Mode.
Override Added
```

Relay Word bit TESTDB will also assert to indicate that Test Mode is active. If the relay is already in the test mode (overrides are already active), the relay responds:

```
Override Added
```

The **TEST DB** command alone displays the present status of digital and analog overrides. An example **TEST DB** response after two analogs follows:

```
=>>TEST DB <Enter>

SEL-751                          Date: 02/02/09    Time: 16:24:38.764
FEEDER RELAY                     Time Source: Internal

NAME          OVERRIDE VALUE
IA_MAG             100.0000
FREQ                60.0000

=>>
```

Individual overrides are cleared using the **TEST DB** command with the OFF parameter:

```
=>>TEST DB D or A name OFF <Enter>
```

Entering **TEST DB A OFF** clears all analog overrides and **TEST DB D OFF** clears all digital overrides. Entering **TEST DB OFF** without any parameters clears all overrides. When there are no overrides, the relay automatically exits the Test Mode and clears all overrides if no **TEST DB** commands are entered for 30 minutes.

THE Command (Preload or Reset Thermal Data)

The **THE** command allows the user to enter a starting thermal capacity or to reset the thermal capacity for the IEC thermal elements, depending on the included input parameters (see *Table 7.51*).

Table 7.51 THE Command (Preload or Reset Thermal Capacity)

Command	Description	Access Level
THE P	Preloads the thermal capacity used for the thermal element (see *Figure 7.32*)	2
THE R	Resets the thermal capacity used for the thermal element	2

```
=>>THE P <Enter>
Load preset thermal level for the 49 thermal element:
Element 1 = <THRL1>?.34
Element 2 = <THRL2>?.23
Element 3 = <THRL3>?.67
Thermal Level Value Preloaded
=>>
```

Figure 7.32 THE Command Example

TIME Command (View/Change Time)

The **TIME** command (see *Table 7.52*) returns information about the SEL-751 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 7.52 TIME Command (View/Change Time)

Command	Description	Access Level
TIME	Displays the present internal clock time.	1
TIME *hh*	Sets the internal clock to *hh*.	1
TIME *hh:mm*	Sets the internal clock to *hh:mm*.	1
TIME *hh:mm:ss*	Sets the internal clock to *hh:mm:ss*.	1

Use the **TIME** ***hh: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-751 responds with `Invalid Time`.

TRIGGER Command (Trigger Event Report)

Use the **TRI** command (see *Table 7.53*) to trigger the SEL-751 to record data for high-resolution oscillography and event reports.

Table 7.53 TRIGGER Command (Trigger Event Report)

Command	Description	Access Level
TRI	Triggers an event report data capture.	1

When you issue the **TRI** command, the SEL-751 responds with `Triggered`. If the event did not trigger within one second, the relay responds with `Did not trigger`. See *Section 10: Analyzing Events* for further details on event reports.

TRIGGER HIF Command

Use the **TRI HIF** command (see *Table 7.54*) to trigger the SEL-751 to record data for high-impedance fault event reports. This command is only available when the relay supports HIF detection and EHIF is not set to N. When you issue the **TRI HIF** command, the relay responds, `triggered`. If the event did not trigger within 1 second, the relay responds, `did not trigger`.

Table 7.54 TRIGGER HIF Command

Command	Description	Access Level
TRI HIF	Triggers an HIF compressed event report data capture.	1

VEC Command (Show Diagnostic Information)

Issue the **VEC** command under the direction of SEL. The information contained in a vector report is formatted for SEL in-house use only. Your SEL application engineer or the factory may request a **VEC** command capture to help diagnose a relay or system problem.

Table 7.55 VEC Command

Command	Description	Access Level
VEC D	Displays the diagnostic vector report.	2
VEC E	Displays the exception vector report.	2

Language Support

All of the ASCII commands can be displayed in multiple languages (English or Spanish). When you set the port setting LANG (see *Table 4.83*) to either ENGLISH or SPANISH, the SEL-751 displays the ASCII commands in the corresponding language. See the *SEL-751 Relay Command Summary* for a list of the commands.

Virtual File Interface

You can retrieve and send data as files through the relay virtual file interface. Devices with embedded computers can also use the virtual file interface. Send and receive files using the following three protocols:

1. File Transfer Protocol (FTP)- Ethernet Port only
2. MMS File Transfer - Ethernet Port only
3. Ymodem - Serial or Ethernet Ports

FTP and MMS File Structure

The Ethernet File Transfer Protocol (FTP) and the IEC-61850 Manufacturing Messaging Specification (MMS) have a two-level file structure. Files are available at the root level and subdirectories. *Table 7.56* shows the directories and their contents.

Table 7.56 FTP and MMS Virtual File Structure

Directory	Contents
/ (Root)	CFG.TXT[a] file, CFG.XML file, ERR.TXT file and SET_61850.CID and the SETTINGS, REPORTS, EVENTS, COMTRADE[b], and HMI directories
/SETTINGS[a]	Relay settings
/REPORTS	SER, LDP, circuit breaker, and history reports
/EVENTS	CEV, COMTRADE, HIF, and history reports
/COMTRADE[b]	COMTRADE events
/HMI[c]	Touchscreen settings (SET_HMI.zds and CDP.zds) and diagnostics (HMI_ALL.zip)

[a] Only available in FTP file structure.
[b] The COMTRADE directory is only available in MMS file structure.
[c] Available only in the SEL-751 touchscreen display model.

Root Directory

The root directory (/) contains files and subdirectories as shown in *Table 7.56*.

CFG.TXT File (Read-Only). The CFG.TXT file contains general configuration information about the relay and each settings class. External support software retrieves the CFG.TXT file to interact automatically with the relay. Calibration settings are included only when the file is read at Access Level C.

```
[INFO]
RELAYTYPE=SEL-751
FID=SEL-751-X308P-V0-Z006002-D20151111
BFID=
PARTNO=7515010BC6C0C86087X
[CLASSES]
PF,"Port F"
P3,"Port 3"
P1,"Port 1"
G,"Global"
1,"Group 1"
2,"Group 2"
3,"Group 3"
4,"Group 4"
C,"Class C"
L1,"Logic 1"
L2,"Logic 2"
L3,"Logic 3"
L4,"Logic 4"
```

Figure 7.33 CFG.TXT File (Sheet 1 of 2)

```
M,"Modbus User Map"
R,"Report"
F,"Front Panel"
D1,"DNP Map 1 Settings"
D2,"DNP Map 2 Settings"
D3,"DNP Map 3 Settings"
I,"IEC 60870-5-103 Map"
```

Figure 7.33 CFG.TXT File (Sheet 2 of 2)

CFG.XML File (Read-Only). Present only in units with the Ethernet option, the CFG.XML file is supplementary to the CFG.TXT file. The CFG.XML file describes the IED configuration and any options such as the Ethernet port, and includes firmware identification, settings class names, and configuration file information.

ERR.TXT (Read-Only) and SET_61850.CID File. Present if ordered with the IEC 61850 protocol option. The ERR.TXT file contents is based on the most recent SET_61850.CID file written to the relay. If there were no errors, the file is empty. If errors occurred, the relay logs these errors in the ERR.TXT file. The SET_61850.CID file contains the IEC 61850 configured IED description in XML. ACSELERATOR Architect SEL-5032 Software generates and then downloads this file to the relay. See Appendix F: IEC 61850 Communications for more information.

Settings Directory (Only Available for FTP)

You can access the relay settings through files in the SETTINGS directory. We recommend that you use support software to access the settings files, rather than directly accessing them via other means. External settings support software reads settings from all of these files to perform its functions. The relay only allows you to write to the individual SET_cn files, where c is the settings class code and n is the settings instance. Except for the SET_61850 CID file, changing settings with external support software involves the following steps:

Step 1. The PC software reads the CFG.TXT and SET_ALL.TXT files from the relay.

Step 2. You modify the settings at the PC. For each settings class that you modify, the software sends a SET_cn.TXT file to the relay.

Step 3. The PC software reads the ERR.TXT file. If it is not empty, the relay detects errors in the SET_cn.TXT file.

Step 4. For any detected errors, modify the settings and send the settings until the relay accepts your settings.

Step 5. Repeat Step 2-Step 4 for each settings class that you want to modify.

Step 6. Test and commission the relay.

SET_ALL.TXT File (Read-Only). The SET_ALL.TXT file contains the settings for all of the settings classes in the relay. Calibration settings are included only when the file is read at Access Level C.

SET_cn.TXT Files (Read and Write). There is a file for each instance of each setting class. Table 7.57 summarizes the settings files. The settings class is designated by c, and the settings instance number is designated by n.

ERR.TXT (Read-Only). The ERR.TXT file contents are based on the most recent SET_cn.TXT file written to the relay. If there were no errors, the file is empty. If errors occurred, the relay logs these errors in the ERR.TXT file.

Table 7.57 Settings Directory Files

File Name	Settings Description
SET_n.TXT	Group; n in range 1-4
SET_Dn.TXT	DNP3 Map; n in range 1-3
SET_F.TXT	Front panel
SET_G.TXT	Global
SET_I.TXT	60870 Map
SET_Ln.TXT	Logic; n in range 1-4
SET_M.TXT	Modbus Map
SET_Pn.TXT	Port; n in range 1, 2, 3, 4, F
SET_R.TXT	Report
SET_ALL.TXT	All instances of all settings classes
ERR.TXT	Error log for most recently written settings file

Reports Directory (Read-Only)

Use the REPORTS directory to retrieve files that contain the reports shown in *Table 7.58*. Note that the relay provides a report file that contains the latest information each time you request the file. Each time you request a report, the relay stores its corresponding command response in the designated text file.

Table 7.58 Reports Directory Files

File Name	Description	Equivalent Command Response
BRE.TXT	Breaker Report	BRE
CHISTORY.TXT	Compressed ASCII History Report	CHI
CHISTORY_HIF.TXT[a]	Compressed HIF ASCII History Report	CHI HIF
HISTORY.TXT	History Report	HIS
HISTORY_HIF.TXT[a]	HIF History Report	HIS HIF
CLDP.TXT	Compressed Load Profile Data	CLDP
LDP.TXT	Load Profile Data	LDP
CSER. TXT	Compressed Sequence of Events	CSER
SER. TXT	Sequence of Events	SER

[a] Available only when ordered with Arc Sense technology (High-Impedance Fault Detection).

Events Directory (Read-Only)

The relay provides history, event reports, and oscillography files in the EVENTS directory as shown in *Table 7.59*.

Event reports are available in the following formats:

- SEL Compressed ASCII
- Binary COMTRADE format (IEEE C37.111-1999)

The size of each event report file is determined by the LER setting in effect at the time the event is triggered.

Compressed SEL ASCII event report files are generated, when requested, by storing the appropriate command response shown in *Table 7.59*.

Oscillography files are generated at the time the event is triggered (see *Event Reporting on page 10.2*). Higher resolution oscillography is available with SEL Compressed ASCII 32 sample/cycle raw event reports and binary COMTRADE files.

COMTRADE event files are available to read as a batch. See *Batch File Access on page 7.63*.

Table 7.59 Event Directory Files

File Name	Description	Equivalent Command Response
CHISTORY.TXT[a]	Compressed ASCII History Report	CHI
CHISTORY_HIF.TXT[a, b]	Compressed HIF ASCII History Report	CHI HIF
HISTORY. TXT[a]	History Report	HIS
HISTORY_HIF.TXT[a, c]	HIF History Report	HIS HIF
C4_nnnnn.CEV	Compressed 4-samples/cycle ASCII filtered event report; event ID number = nnnnn	CEV nnnnn
CHF_nnnnn.CEV[c]	Compressed HIF ASCII event report	CEV HIF nnnnn
CR_nnnnn.CEV	Compressed 128-samples/cycle ASCII raw event report; event ID number = nnnnn	CEV R nnnnn
HF_nnnnn.CFG[b, c]	HIF COMTRADE configuration file; event ID number = nnnnn	N/A
HF_nnnnn.DAT[b, c]	HIF COMTRADE binary data file; event ID number = nnnnn	N/A
HF_nnnnn.HDR[b, c]	HIF COMTRADE header file; event ID number = nnnnn	N/A
HR_nnnnn.CFG[c]	COMTRADE configuration file; event ID number = nnnnn	N/A
HR_nnnnn.DAT[c]	COMTRADE binary data file; event ID number = nnnnn	N/A
HR_nnnnn.HDR[c]	COMTRADE header file; event ID number = nnnnn	N/A

[a] Also available in the Reports director for convenience.
[b] Available in the units ordered with Arc Sense technology (High-Impedance Fault Detection).
[c] Also available in the COMTRADE directory for MMS only.

HR_nnnnn.* (Read-Only)

The three files HR_nnnnn.CFG, HR_nnnnn.DAT, and HR_nnnnn.HDR shown in *Table 7.59* are used to create an event report that conforms to the COMTRADE standard. The event is an unfiltered (raw) 32 samples/cycle event. The field, nnnnn, corresponds to the unique event identification number displayed by the HIS command. For details on event reports see *Section 10: Analyzing Events*.

HF_nnnnn.* (Read-Only)

The three files HF_nnnnn.CFG, HF_nnnnn.DAT, and HF_nnnnn.HDR shown in *Table 7.59* are used to create a high-impedance event report that conforms to the COMTRADE standard. The field, nnnnn, corresponds to the unique event identification number displayed by the HIS HIF command. For details on event reports see *Section 10: Analyzing Events*.

COMTRADE Directory (Available Only for MMS)

When using MMS file transfer, conveniently retrieve all of the COMTRADE files from the COMTRADE directory. Note that the COMTRADE files are also available in the Events directory. Refer to *Table 7.59* for all the files available in the COMTRADE directory.

HMI Directory (Read and Write)

Use the HMI directory to retrieve the diagnostic information and the setting files that apply to the touchscreen. Refer to *Table 7.56* for all the files available in the HMI directory.

Ymodem File Structure

All the files available (see *Table 7.60*) for Ymodem protocol are in the root directory. See *FILE Command on page 7.32* for a response to the FIL DIR command.

Table 7.60 Files Available for Ymodem Protocol (Sheet 1 of 2)

File Name	Description	Read Access Level	Write Access Level
CFG.TXT	See *Root Directory on page 7.58*	1, 2, C	N/A
ERR.TXT	See *Settings Directory (Only Available for FTP) on page 7.59*	1, 2, C	N/A
SET_ALL.TXT[a]	See *Settings Directory (Only Available for FTP) on page 7.59*	1, 2, C	N/A
SET_n.TXT	See *Settings Directory (Only Available for FTP) on page 7.59*	1, 2, C	2, C
SET_C.TXT[a]	See *Settings Directory (Only Available for FTP) on page 7.59*	C	C
SET_Dn.TXT	See *Settings Directory (Only Available for FTP) on page 7.59*	1, 2, C	2, C
SET_F.TXT	See *Settings Directory (Only Available for FTP) on page 7.59*	1, 2, C	2, C
SET_G.TXT	See *Settings Directory (Only Available for FTP) on page 7.59*	1, 2, C	2, C
SET_I.TXT	See *Settings Directory (Only Available for FTP) on page 7.59*	1, 2, C	2, C
SET_Ln.TXT	See *Settings Directory (Only Available for FTP) on page 7.59*	1, 2, C	2, C
SET_M.TXT	See *Settings Directory (Only Available for FTP) on page 7.59*	1, 2, C	2, C
SET_Pn.TXT	See *Settings Directory (Only Available for FTP) on page 7.59*	1, 2, C	2, C
SET_R.TXT	See *Settings Directory (Only Available for FTP) on page 7.59*	1, 2, C	2, C
C4_nnnnn.CEV	See *Events Directory (Read-Only) on page 7.60*	1, 2, C	N/A
CHF_nnnnn.CEV	See *Events Directory (Read-Only) on page 7.60*	1, 2, C	N/A
CR_nnnnn.CEV	See *Events Directory (Read-Only) on page 7.60*	1, 2, C	N/A
HF_nnnnn.CFG	See *Events Directory (Read-Only) on page 7.60*	1, 2, C	N/A
HF_nnnnn.DAT	See *Events Directory (Read-Only) on page 7.60*	1, 2, C	N/A
HF_nnnnn.HDR	See *Events Directory (Read-Only) on page 7.60*	1, 2, C	N/A
HR_nnnnn.CFG	See *Events Directory (Read-Only) on page 7.60*	1, 2, C	N/A
HR_nnnnn.DAT	See *Events Directory (Read-Only) on page 7.60*	1, 2, C	N/A
HR_nnnnn.HDR	See *Events Directory (Read-Only) on page 7.60*	1, 2, C	N/A
BRE.TXT	See *Reports Directory (Read-Only) on page 7.60*	1, 2, C	N/A
CHISTORY.TXT	See *Reports Directory (Read-Only) on page 7.60*	1, 2, C	N/A
CHISTORY_HIF.TXT	See *Reports Directory (Read-Only) on page 7.60*	1, 2, C	N/A
HISTORY.TXT	See *Reports Directory (Read-Only) on page 7.60*	1, 2, C	N/A
HISTORY_HIF.TXT	See *Reports Directory (Read-Only) on page 7.60*	1, 2, C	N/A

Table 7.60 Files Available for Ymodem Protocol (Sheet 2 of 2)

File Name	Description	Read Access Level	Write Access Level
CLDP.TXT	See *Reports Directory (Read-Only) on page 7.60*	1, 2, C	N/A
LDP.TXT	See *Reports Directory (Read-Only) on page 7.60*	1, 2, C	N/A
CSER.TXT	See *Reports Directory (Read-Only) on page 7.60*	1, 2, C	N/A
SER.TXT	See *Reports Directory (Read-Only) on page 7.60*	1, 2, C	N/A
SET_HMI.zds	See *HMI Directory (Read and Write) on page 7.62*	1, 2, C	2, C
CDP.zds	See *HMI Directory (Read and Write) on page 7.62*	1, 2, C	2, C
HMI_ALL.zip	See *HMI Directory (Read and Write) on page 7.62*	1, 2, C	N/A

[a] Calibration settings are included only when accessed at Access Level C.

Batch File Access

Files can be accessed as a batch by using the supported wild card character, *.

FTP and MMS Wild Card Usage

Table 7.61 shows examples using supported wild cards. Note that these wild cards may be appended to a directory path (e.g., /specified_directory/*.txt).

Table 7.61 FTP and MMS Wildcard Usage Examples

Usage	Description	Example	Note
*xyz	Lists all files and/or subdirectories in a specified directory whose name (including extension) ends with xyz.	/*.TXT	List all files with the .TXT extension.
abc*	Lists all files and/or subdirectories in a specified directory whose name begins with abc.	/SETTINGS/SET*	List all settings files that start with SET.
mno	Lists all files and/or subdirectories in a specified directory whose name contains mno.	/EVENTS/*_100*	List all events that contain _100 in the ID number.

Ymodem Wild Card Usage

NOTE: Ymodem protocol does not support wild cards for settings files.

Event, report, and diagnostic files can also be accessed as a batch using wild cards.

Table 7.62 Ymodem Wildcard Usage Examples

Usage	Description	Example	Note
*xyz	Lists all files that end with xyz.	FILE DIR HIS*.TXT	Lists all of the metering files (HISTORY.TXT, HIF_HISTORY.TXT)
abc*	Lists all files whose name begins with abc.	FILE READ HR_10007*	Retrieves all of the three files for the COMTRADE event 10007 (HR_10007.CFG, HR_10007.DAT, and HR_10007.HDR)

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Section 8

Front-Panel Operations

Overview

The SEL-751 Feeder Protection Relay front panel makes feeder data collection and control quick and efficient. Use the front panel to analyze operating information, view and change relay settings, and perform control functions. You can order the SEL-751 in three different front-panel options, as shown in *Table 1.4* and *Figure 8.1*. The display comes with a two-line display (2 x 16 characters) front panel and eight control pushbuttons. You can also order the SEL-751 with a two-line display front panel and four control pushbuttons or with a touchscreen display (5-inch, color, 800 x 480 pixels) and eight control pushbuttons. You can use the front-panel to accomplish the following activities:

- ➤ Read metering
- ➤ Inspect targets
- ➤ Access settings
- ➤ Control relay operations
- ➤ View diagnostics

Figure 8.1 SEL-751 Front-Panel Models

The two-line display and the touchscreen display front-panel models are similar in all aspects except the display and navigation scheme. The touchscreen display model offers additional features with respect to monitoring, control, and device status that are discussed in *Touchscreen*

Display Front Panel. The function of operation and target LEDs and the TARGET RESET and control pushbuttons are similar in all three front-panel variations.

This section includes the following:

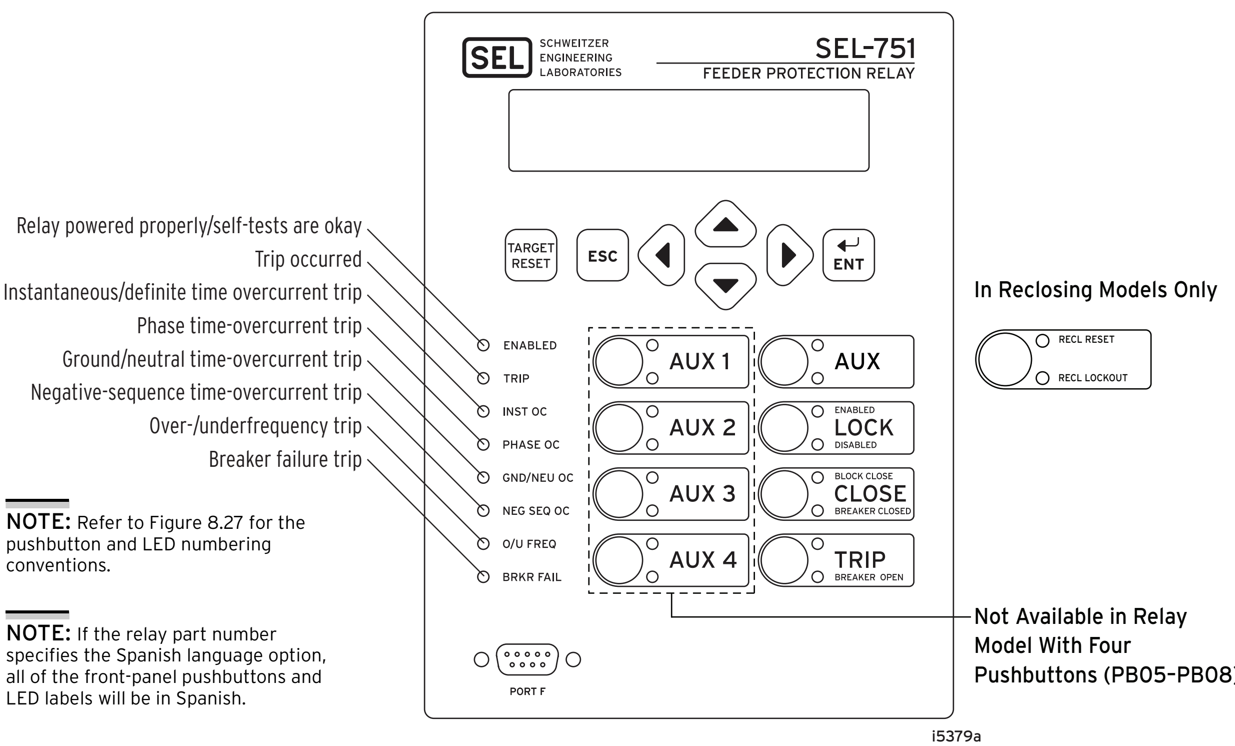
- *Two-Line Display Front Panel on page 8.2*. Discusses the navigation scheme in the two-line display models, the operation of target LEDs, and programming of the control pushbuttons.
- *Touchscreen Display Front Panel on page 8.18*. Discusses the navigation scheme and the display screens in the touchscreen display model.

Two-Line Display Front Panel

Front-Panel Layout

Figure 8.2 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.



NOTE: Refer to Figure 8.27 for the pushbutton and LED numbering conventions.

NOTE: If the relay part number specifies the Spanish language option, all of the front-panel pushbuttons and LED labels will be in Spanish.

Figure 8.2 Front-Panel Overview

NOTE: The reduced SEL-751 model with four pushbuttons does not support AUX 1 through AUX4 (i.e., PB05 through PB08).

You can use the following features of the versatile SEL-751 front-panel to customize it to your needs:

- ➤ Rotating display on the HMI
- ➤ Programmable tricolor target LEDs
- ➤ Programmable tricolor pushbutton LEDs
- ➤ Slide-in configurable front-panel labels to change the identification of target LEDs, pushbuttons, pushbutton LEDs and their operation.

Two-Line Display 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-751 displays a contrast adjustment box. Pressing the **Right Arrow** pushbutton increases the contrast. Pressing the **Left Arrow** pushbutton decreases the screen contrast. When you are finished adjusting the screen contrast, press the **ENT** pushbutton; this process is a shortcut for changing the LCD contrast setting FP_CONT in the front-panel settings.

Front-Panel Automatic Messages

The relay displays automatic messages that override the rotating display under the conditions described in *Table 8.1*. Relay failure has the highest priority, followed by trip and alarm when the front-panel setting FP_AUTO := OVERRIDE.

If the front-panel setting FP_AUTO := ROTATING, then the rotating display messages continue and any TRIP or ALARM message is added to the rotation. Relay failure still overrides the rotating display.

Table 8.1 Front-Panel Automatic Messages (FP_AUTO := OVERRIDE)

Condition	Front-Panel Message
Relay detecting any failure	Displays the type of latest failure (see *Section 11: Testing and Troubleshooting*).
Relay trip has occurred	Displays the type or cause of the trip. Refer to *Table 10.1* for a list of trip display messages.
Relay alarm condition has occurred	Displays the type of alarm. The **TRIP** LED is also flashing during an alarm condition. See *Table 8.3* for a list of the alarm conditions.

Front-Panel Security

Front-Panel Access Levels

The SEL-751 front panel typically operates at Access Level 1 and provides viewing of relay measurements and settings. Some activities, such as editing settings and controlling output contacts, are restricted to those operators who know the Access Level 2 passwords.

In the figures that follow, restricted activities are indicated by the padlock symbol.

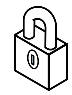


Figure 8.3 Access Level Security Padlock Symbol

Before you can perform a front-panel menu activity that is marked with the padlock symbol, you must enter the correct Access Level 2 password. After you have correctly entered the password, you can perform other Access Level 2 activities without reentering the password.

Access Level 2 Password Entry

When you try to perform an Access Level 2 activity, the relay determines whether you have entered the correct Access Level 2 password since the front-panel inactivity timer expired. If you have not, the relay displays the screen shown in *Figure 8.4* for you to enter the password.

```
Password=
Del Clr Accept
A B C D E F G H
I J K L M N O P
Q R S T U V W X
Y Z . . . . . .
a b c d e f g h
i j k l m n o p
q r s t u v w x
y z . . . . . .
0 1 2 3 4 5 6 7
8 9 . . . . . .
! " # $ % & ' (
) * + , - . / :
; < = > ? @ [ \
] ^ _ ` { | } ~
```

Figure 8.4 Password Entry Screen

See *PASSWORD Command (Change Passwords) on page 7.44* for the list of default passwords and for more information on changing passwords.

Front-Panel Timeout

To help prevent unauthorized access to password-protected functions, the SEL-751 provides 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-751 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 8.5*) to maneuver within the front-panel menu structure, described in detail throughout the remainder of this section. *Table 8.2* describes the function of each front-panel pushbutton.

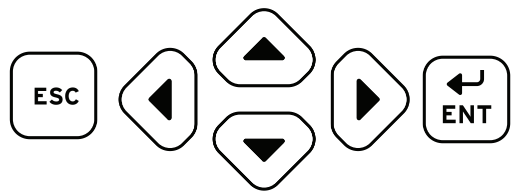


Figure 8.5 Front-Panel Pushbuttons

Table 8.2 Front-Panel Pushbutton Functions

Pushbutton	Function
Up Arrow	Move up within a menu or data list. While editing a setting value, increase the value of the underlined digit.
Down Arrow	Move down within a menu or data list. While editing a setting value, decrease the value of the underlined digit.
Left Arrow	Move the cursor to the left.
Right Arrow	Move the cursor to the right.
ESC	Escape from the present 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-751 automatically scrolls information that requires more space than provided by a 16-character LCD line. Use the **Left Arrow** and **Right Arrow** pushbuttons to suspend automatic scrolling and enable manual scrolling of this information.

MAIN Menu. *Figure 8.6* shows the `MAIN` menu screen. Using the **Up Arrow** or **Down Arrow** and **ENT** pushbuttons, you can navigate to specific menu item in the `MAIN` menu. Each menu item is explained in detail in the following paragraphs.

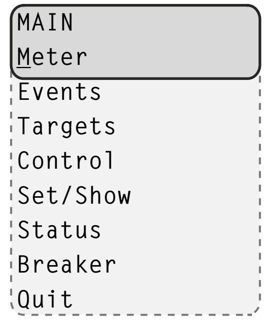


Figure 8.6 Main Menu

Meter Menu. Select the `Meter` menu item from the `MAIN` menu as shown in *Figure 8.7* to view metering data. The `Meter` menu has menu items for viewing different types of metering data like Fundamental, rms, Thermal, etc. Select the type of metering and view the data by using the **Up Arrow** or **Down Arrow** pushbuttons. See *Metering on page 5.2* for a description of the available data fields.

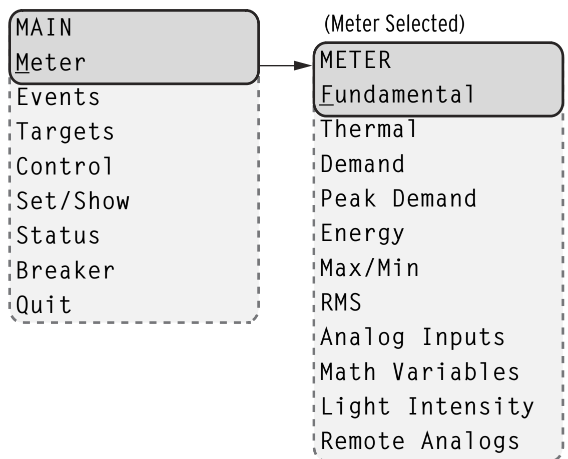


Figure 8.7 MAIN Menu and METER Submenu

For viewing Energy (or Max/Min) metering data, select the `Energy` (or `Max/Min`) menu item from the `METER` menu and select the `Display` menu item as shown in *Figure 8.8*.

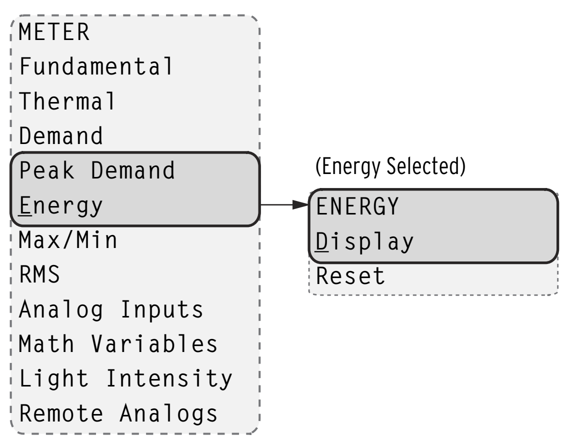


Figure 8.8 METER Menu and ENERGY Submenu

You can reset Energy (or Max/Min, Demand, Peak Demand) metering data from the front-panel HMI by selecting the `Reset` menu item in the `Energy` (or `Max/Min, Demand`, `Peak Demand`) menu. After selecting `Reset` and confirming the reset, the relay displays as shown in *Figure 8.9*.

```
Reset Complete
```

Figure 8.9 Relay Response When Energy (or Max/Min, Demand, Peak Demand) Metering Is Reset

Assume that the relay configuration contains no analog input cards. In response to a request for analog data (selecting `Analog Inputs`), the device displays the message as shown in *Figure 8.10*.

```
No Analog Input
Cards Present
```

Figure 8.10 Relay Response When No Analog Cards Are Installed

Assume that the math variables are not enabled. In response to a request for math variable data (selecting `Math Variables`), the device displays the message as shown in *Figure 8.11*.

```
No Math
Variables
Enabled (see EMV
Setting)
```

Figure 8.11 Relay Response When No Math Variables Enabled

Events Menu. Select the `Events` menu item from the `MAIN` menu as shown in *Figure 8.12*. `EVENTS` menu has `Display` and `Clear` as menu items. Select `Display` to view events and `Clear` to delete all the events data.

```
MAIN                (Events Selected)
Meter
Events      ---->   EVENTS
Targets             Display
Control             Clear
Set/Show
Status
Breaker
Quit
```

Figure 8.12 MAIN Menu and EVENTS Submenu

Figure 8.13 shows the DISPLAY menu when Display is selected from the EVENTS menu with events in the order of occurrence starting with the most recent. You can select an event from the DISPLAY menu and navigate through the event data.

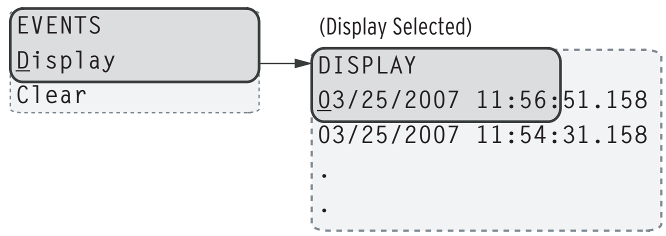


Figure 8.13 EVENTS Menu and DISPLAY Submenu

When Display is selected and no event data are available, the relay displays as shown in *Figure 8.14*.

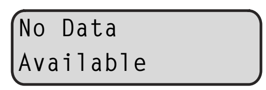


Figure 8.14 Relay Response When No Event Data Available

When you select Clear from the EVENTS menu and confirm the selection, the relay displays the response shown in *Figure 8.15* after it clears the events data.

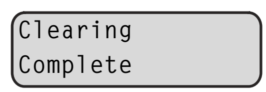


Figure 8.15 Relay Response When Events Are Cleared

Targets Menu. Select the Targets menu item on the MAIN menu as shown in *Figure 8.16* to view the binary state of the target rows. Each target row has eight Relay Word bits as shown in *Table K.1*.

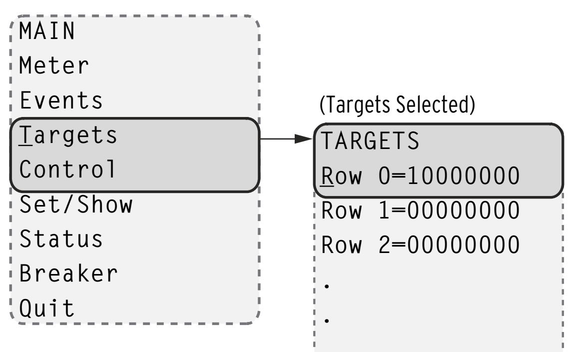


Figure 8.16 MAIN Menu and TARGETS Submenu

Select the target row to display two consecutive Relay Word bits with name and binary state as shown in *Figure 8.17*.

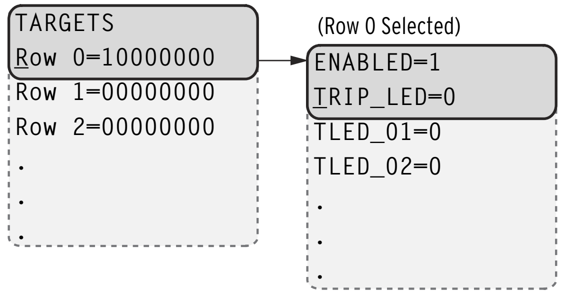


Figure 8.17 TARGETS Menu Navigation

Control Menu . Select the `Control` menu item on the `MAIN` menu as shown in *Figure 8.18* to go to the `CONTROL` menu.

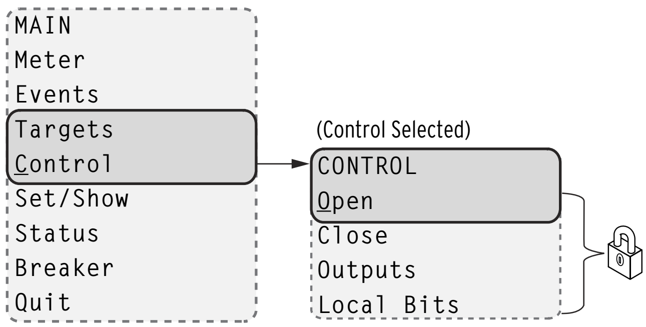


Figure 8.18 MAIN Menu and CONTROL Submenu

The `CONTROL` menu has `Open`, `Close`, `Outputs`, and `Local Bits` as menu items.

Select the `Open` menu item to assert Relay Word bit OC that opens the breaker via the TR SELOGIC control equation (see *Table 4.48* for the TR equation and *Table K.2* for the definition of the OC bit). Note that this requires Level 2 access.

Select the `Close` menu item to assert Relay Word bit CC that closes the breaker via the CL SELOGIC control equation (see *Figure 4.80*). Note that this requires Level 2 access.

Breaker control through the front panel is supervised by the position of the breaker jumper (refer to *Table 2.17*), the status of the LOCAL bit when EN_LRC := Y, and the access level (requires 2AC). When the local/remote supervision setting EN_LRC := Y and LOCAL := 0, control of the OC and CC bits from the front panel is blocked. When EN_LRC := N, breaker control from the front panel is always allowed. For the settings related to the local/remote control function, refer to *Local/Remote Breaker Control* in *Section 9: Bay Control*.

Select the `Outputs` menu item from the `CONTROL` menu as shown in *Figure 8.19* to test (pulse) SEL-751 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 the breaker jumper to be enabled, Level 2 access, and reconfirmation.

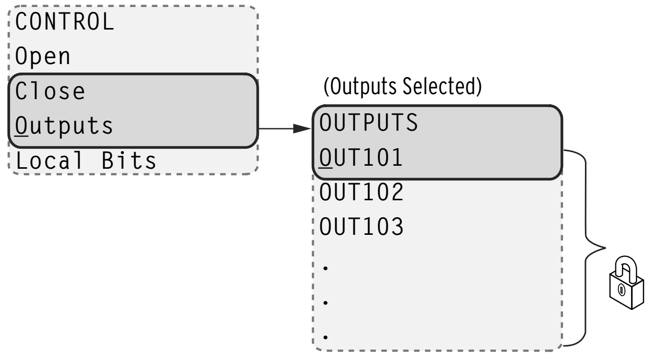


Figure 8.19 CONTROL Menu and OUTPUTS Submenu

Select the `Local Bits` menu item from the `CONTROL` menu for local control action. Local bits take the place of traditional panel switches and perform isolation, open, close, or pulse operations.

With the settings as per the example in *Section 4* (see *Local Bits on page 4.201* for more information), local bit 1 replaces a supervisory switch. *Figure 8.20* shows the screens in closing the supervisory switch. In this operation, local bit LB01 is deasserted (SUPER SW = OPEN). It then changes to asserted (SUPER SW = CLOSE) as shown in the final screen of *Figure 8.20*.

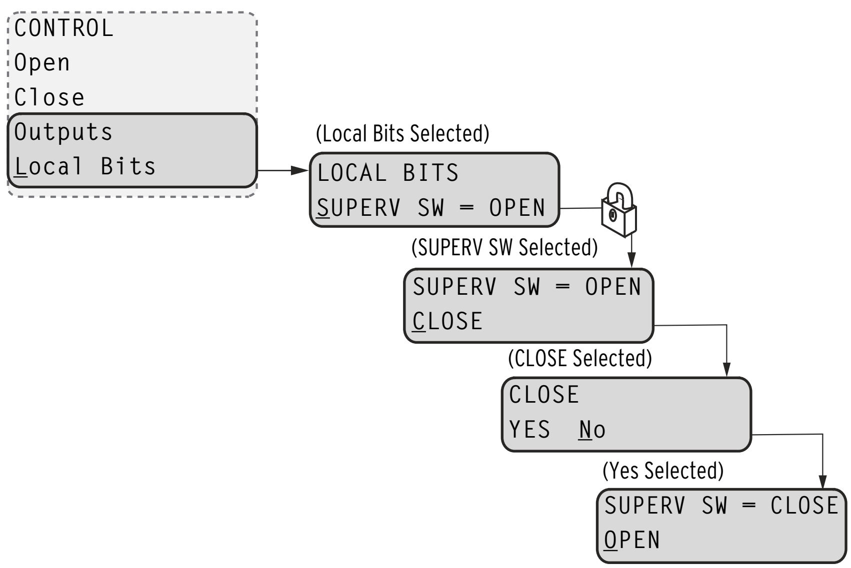


Figure 8.20 CONTROL Menu and LOCAL BITS Submenu

Set/Show Menu. Select the Set/Show menu item on the MAIN menu. Use the Set/Show menu to view or modify the settings (Global, Group, and Port), Active Group, Date, and Time. Note that modifying the settings requires Level 2 access.

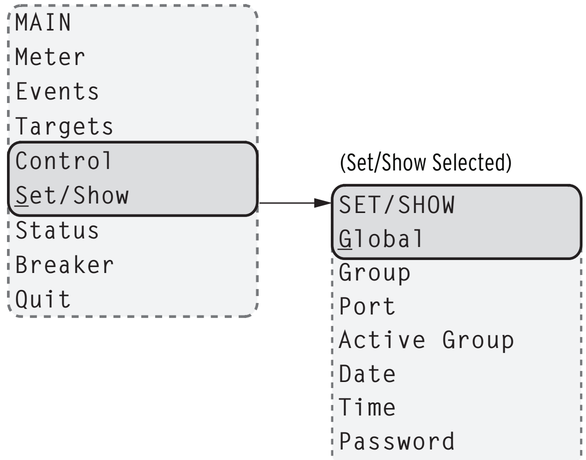


Figure 8.21 MAIN Menu and SET/SHOW Submenu

Each settings class (Global, Group, and Port) includes headings that create subgroups of associated settings as shown in the following illustration. Select the heading that contains the setting of interest, and then navigate to the particular setting. View or edit the setting by pressing the **ENT** pushbutton. For text settings, use the four navigation pushbuttons to scroll through the available alphanumeric and special character settings matrix. For numeric settings, use the **Left Arrow** and **Right Arrow** pushbuttons to select the digit to change and the **Up Arrow** and **Down Arrow** pushbuttons to change the value. Press the **ENT** pushbutton to enter the new setting.

You can also make settings changes by using ACSELERATOR QuickSet SEL-5030 Software or ASCII **SET** commands via a communications port.

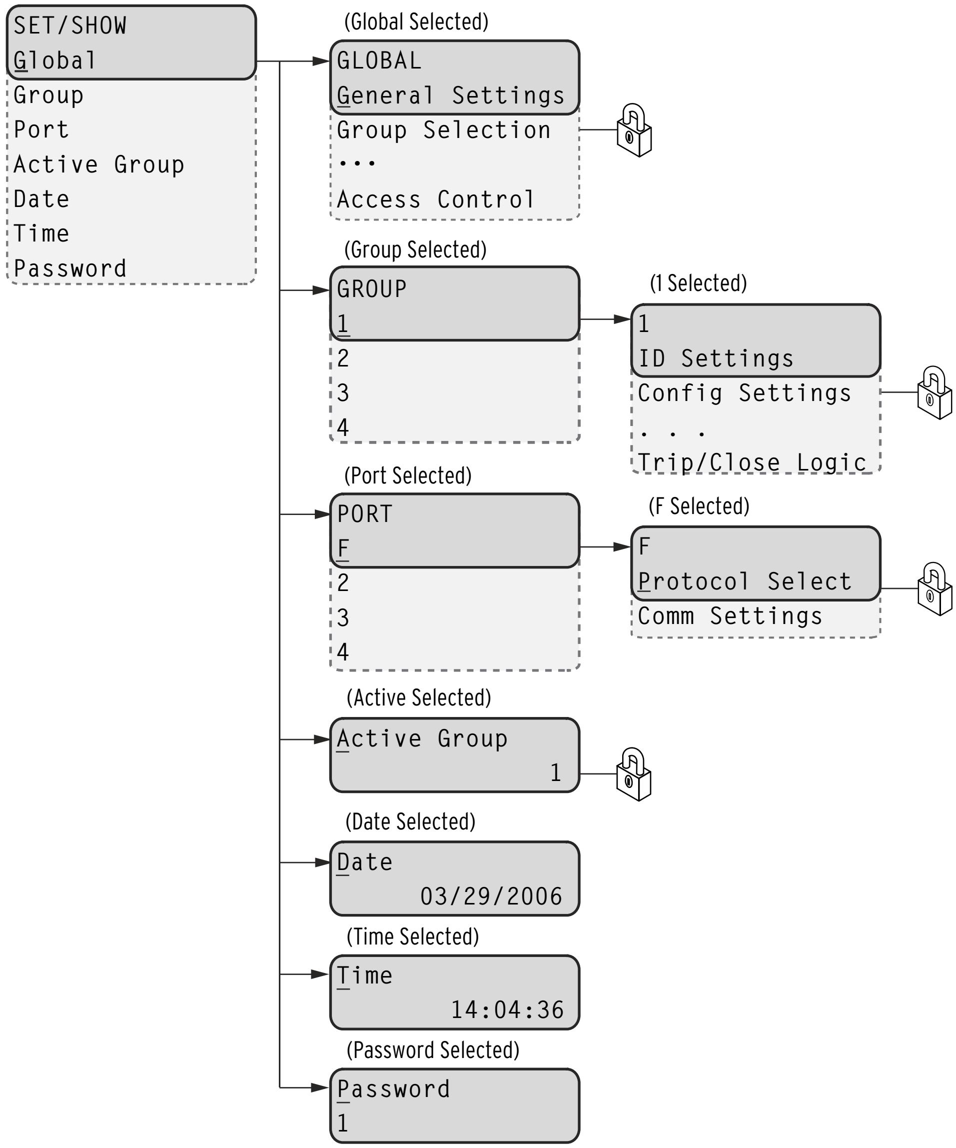


Figure 8.22 SET/SHOW Menu

Status Menu. Select the `Status` menu item on the `MAIN` menu as shown in *Figure 8.23* to access `Relay Status` data and `Reboot Relay`. See *STATUS Command (Relay Self-Test Status) on page 7.51* for the **STATUS** data field description.

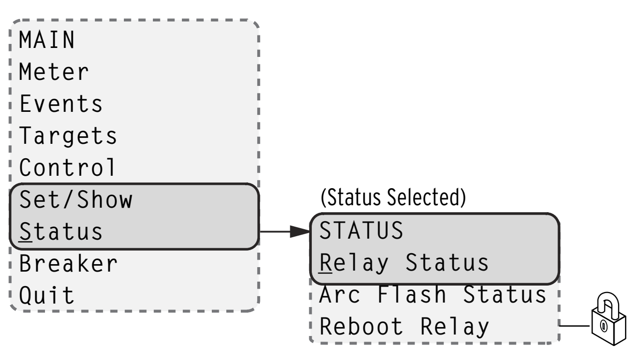


Figure 8.23 MAIN Menu and Status Submenu

Breaker Menu. Select the `Breaker` menu item on the `MAIN` menu as shown in *Figure 8.24* to access `Breaker Monitor` data or `Reset` the data. See *Breaker Monitor on page 5.19*, in *Section 5: Metering and Monitoring* for a detailed description.

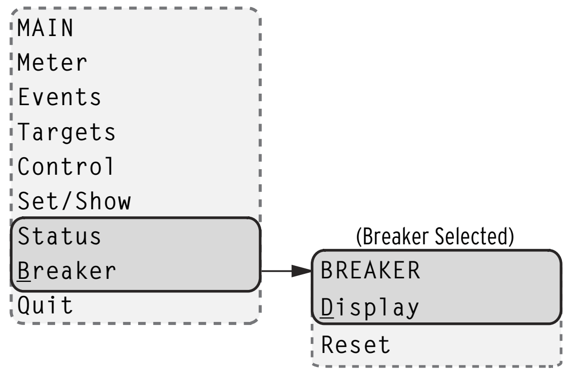


Figure 8.24 MAIN Menu and Breaker Submenu

Language Support

All of the HMI messages can be displayed in multiple languages (English or Spanish). The relay part number determines which language is displayed on the HMI. The HMI can display either ENGLISH or SPANISH. See the *SEL-751 Relay Command Summary* for a list of the commands.

Operation and Target LEDs

Programmable LEDs

The SEL-751 provides quick confirmation of relay conditions via operation and target LEDs. *Figure 8.25* shows this region with factory-default text on the front-panel configurable labels. See *Target LED Settings on page 4.203* for the SELOGIC control equations and the tricolor LED color selection settings.

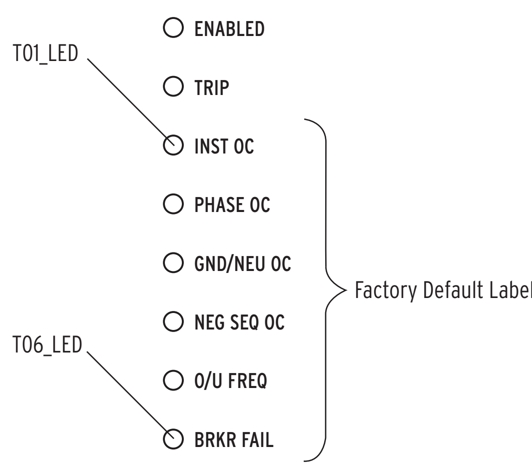


Figure 8.25 Factory Default Front-Panel LEDs

You can reprogram all of these indicators except the ENABLED and TRIP LEDs to reflect operating conditions other than the factory-default programming described in this subsection.

NOTE: The target LEDs are restored to their previous state after the relay is turned off and then turned back on.

Settings T0*n*_LED are SELOGIC control equations that work with the corresponding T0*n*LEDL latch settings to illuminate the LEDs shown in *Figure 8.25*. Use settings T0nLEDC to select the LED color (R–red, G–green, A–amber). Parameter *n* is a number from 1 through 6 that indicates each LED. If the latch setting (T0*n*LEDL) for a certain LED is set to N, then the LED follows the status of the corresponding control equation (T0*n*_LED). When the equation asserts, the LED illuminates, and when the equation deasserts, the LED extinguishes. If the latch setting is set to Y, the LED only asserts if a trip condition occurs and the T0*n*_LED equation is asserted at the time of the trip. At this point, the LED latches in. You can reset this LED by using the TARGET RESET pushbutton or the **TAR R** command, as long as the target conditions are absent. For a concise listing of the default programming on the front-panel LEDs, see *Table 4.98*.

The SEL-751 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) is provided when the SEL-751 is ordered.

The ENABLED LED indicates that the relay is powered correctly, is functional, and has no self-test failures. Trip events illuminate the TRIP LED. The prominent location of the TRIP LED in the top target area aids in recognizing trip events quickly.

The TRIP LED has an additional function that notifies you of warning conditions. When the TRIP LED is flashing, the warning conditions in *Table 8.3* are active when you set the corresponding relay element. For Relay Word bit definitions, see *Appendix K: Relay Word Bits*.

Table 8.3 Possible Warning Conditions (Flashing TRIP LED)

Warning Message	Relay Word Bit Logic Condition
Arc Flash Status Warning	AFALARM
Power Factor Warning	55A
RTD Warning	WDGALRM+BRGALRM+AMBALRM+OTHALRM
RTD Failure	RTDFLT
Comm Loss Warning	COMMLOSS
Comm Idle Warning	COMMIDLE

TARGET RESET Pushbutton

Target Reset

For a trip event, the SEL-751 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 8.26 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 4.187* for further information.

Front-Panel Operator Control Pushbuttons

The base SEL-751 features eight operator-controlled pushbuttons, each with two programmable tricolor pushbutton LEDs, for local control as shown in *Figure 8.27*.

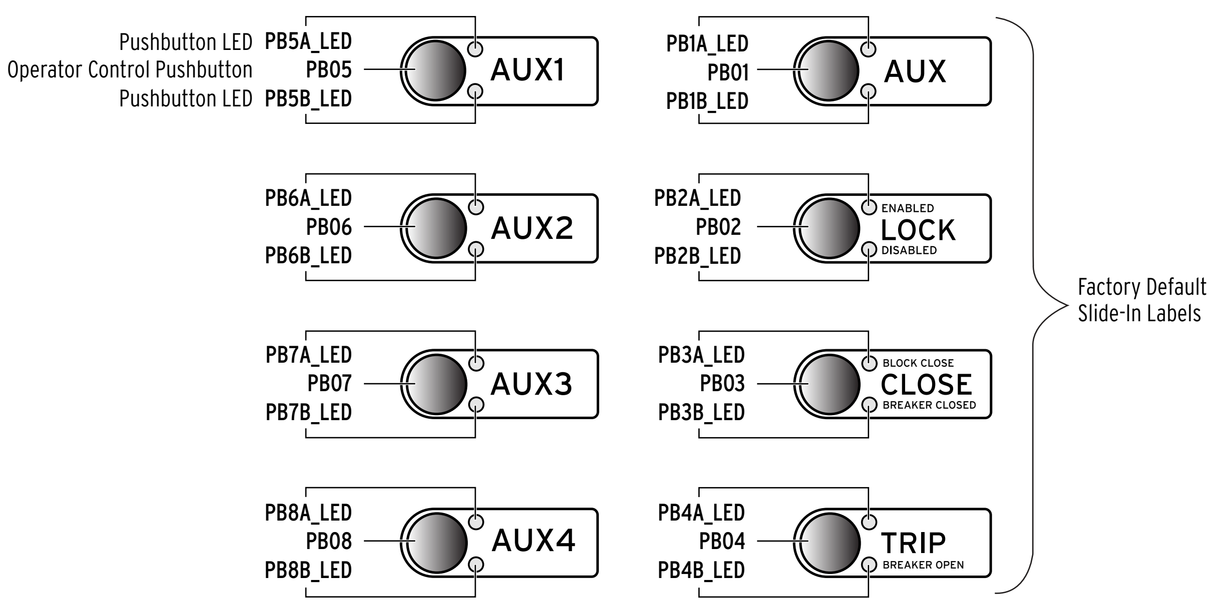


Figure 8.27 Operator Control Pushbuttons and LEDs

NOTE: If the relay part number specifies the Spanish language option, all of the front-panel pushbuttons and LED labels will be in Spanish.

Pressing any one of these eight pushbuttons asserts the corresponding PB*n* (*n* = 01 through 08) Relay Word bit, and the corresponding PB*n*_PUL Relay Word bit. The PB*n* Relay Word bit remains asserted as long as the pushbutton is pressed, but the PB*n*_PUL Relay Word bit asserts only for the initial processing interval, even if the button is still being pressed. Releasing the

NOTE: The reduced SEL-751 model with four pushbuttons does not support AUX1 though AUX4 (i.e., PB05 through PB08).

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 by using the front-panel settings PB*nm*_LED (where *n* = 1 through 8 and *m* = A or B). PB*nm* _LED settings are SELOGIC control equations that, when asserted, illuminate the corresponding LED for as long as the input is asserted. When the input deasserts, the LED also deasserts without latching. Use PB*nm*LEDC settings to select the LED color (R–red, G–green, A–amber) for both the asserted and deasserted state of the LED.

Using SELOGIC control equations, you can readily change the default LED and pushbutton functions. Use the 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-751 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.

Table 8.4 SEL-751 Front-Panel Operator Control Functions (Sheet 1 of 2)

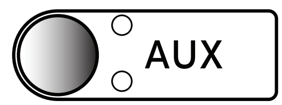
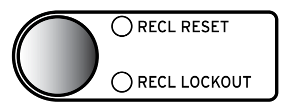
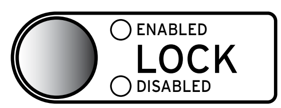
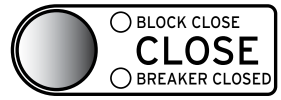
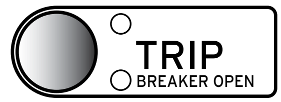
Press the **AUX** operator control pushbutton to enable/disable user-programmed auxiliary control. You can program the corresponding LED to illuminate during the enabled state. **NOTE**: The **AUX** operator control does not perform any function with the factory settings. Also, AUX1 to AUX4 pushbuttons do not perform any function in the factory-default settings. These pushbuttons are available to configure any application you may select.	
For Models With Reclosing Option: The pushbutton is not used in the factory settings, but you can easily program it to perform a user control function. The top LED is programmed to indicate RECL RESET (Relay Word bit 79RS—reclosing relay in RESET state) in the factory settings. The bottom LED is programmed to indicate RECL LOCKOUT (Relay Word bit 79LO—reclosing relay in LOCKOUT state).	
Continually press the **LOCK** operator control pushbutton for three (3) seconds to engage/disengage the lock function (Latch LT02 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 the breaker, but the **TRIP** operator control can still trip the breaker.	

Table 8.4 SEL-751 Front-Panel Operator Control Functions (Sheet 2 of 2)

Press the CLOSE operator control pushbutton to close the breaker. Corresponding BREAKER 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-751 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 corresponding BREAKER 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 breaker (and take the control to the lockout state). Corresponding BREAKER OPEN LED illuminates to indicate 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-751 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 BREAKER 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.	

Touchscreen Display Front Panel

The SEL-751 Feeder Protection Relay can be ordered with an optional touchscreen display (5-inch, color, 800 x 480 pixels). The touchscreen display makes relay data metering, monitoring, and control quick and efficient. The touchscreen display option in the SEL-751 features a straightforward application-driven control structure and includes intuitive and graphical screen designs.

Front-Panel Layout

The touchscreen front panel is the same as the two-line display in regards to the target LEDs, operator control pushbuttons, and the **TARGET RESET** pushbutton. Refer to *Operation and Target LEDs on page 8.13* for a detailed description of these features. In addition, the touchscreen front panel features a **HOME** pushbutton.

Touchscreen Display Human-Machine Interface

This section explains the navigation of the front-panel touchscreen and all the features it supports.

The touchscreen display allows you to:

- View and control bay screens
- Access metering and monitoring data
- Inspect targets
- View event history, summary data, and SER information
- View relay status and configuration
- Control relay operations
- View and edit settings
- Enable the rotating display
- Program control pushbuttons to jump to a specific screen

Figure 8.28 shows the relay touchscreen display components and indicators.

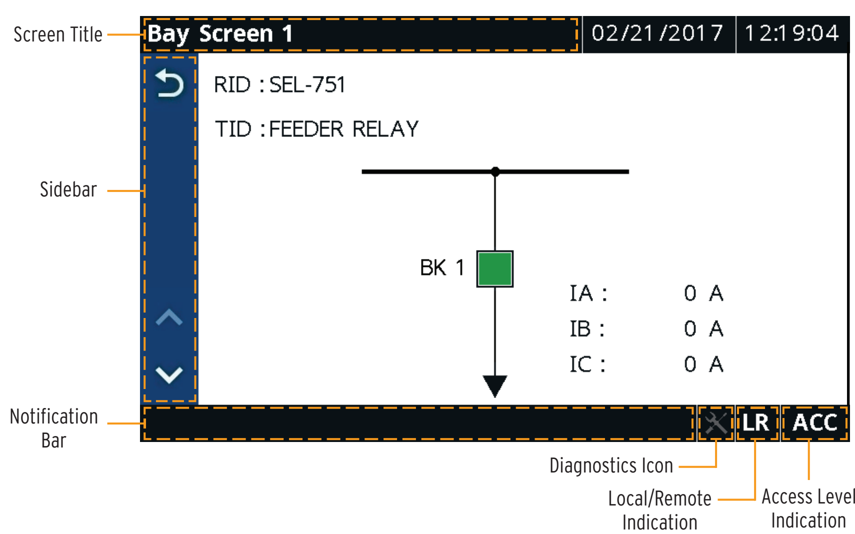
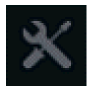


Figure 8.28 Touchscreen Display Components and Indicators

Table 8.5 Touchscreen Display Component and Indicator Descriptions

Display Components and Indicators	Function or Indication
Screen Title	Shows the display name of a screen (see *Figure 8.28*).
Sidebar	Shows the navigation icons (see *Figure 8.28*).
Notification Bar	Shows the notification messages and help text for screens (see *Figure 8.28*).
Diagnostics Icon	ON if there are any warning/diagnostic failures on the unit.
	Normal (no warnings or diagnostic failures present). Icon is OFF.
	Warning. Icon asserts in amber.
	Diagnostic failure. Icon asserts in red.
Local/Remote Indication	Indicates the status of the local/remote control. Refer to *Local/Remote Breaker Control on page 9.3* for more details.
L	When EN_LRC := Y and LOCAL := 1, relay control is in local mode, i.e., OC and CC bits can be processed via the front panel only.
R	When EN_LRC := Y and LOCAL := 0, relay control is in remote mode, i.e., OC and CC bits can be processed via remote sources/protocols only.
LR	When EN_LRC := N, relay control is in local/remote control, i.e., OC and CC bits can be processed from both the front panel and the remote sources/protocols.
Access Level Indication	Indicates the access level that the device is on at the time. Shows ACC if the device is on access level 1 and 2AC if on access level is 2.

Home Pushbutton

Use the **HOME**  pushbutton to wake up the touchscreen after the inactivity timer expires and the screen goes dark. While the default mapping of the **HOME** pushbutton is the **Home** screen (see *Figure 8.29*), you can program the **HOME** pushbutton to jump to any screen. Refer to *Table 8.17* for a list of screens available for the **HOME** pushbutton. Use the FPHOME setting in the **Touchscreen** settings of QuickSet to program a specific screen.

Touchscreen Backlight

Adjustment

You can adjust the touchscreen backlight to suit your viewing angle and lighting conditions. To change the backlight settings, tap the **Settings** folder and then tap the **Touchscreen** application. Use the FPBAB setting to adjust the brightness of the display. The backlight of the display goes dark 60 minutes after the inactivity timer (1–30 min) expires.

Front-Panel Automatic Messages

The relay displays automatic messages that override the present display under the conditions described in *Table 8.6*. Relay failure messages have the highest priority, followed by trip and alarm. When the relay has a trip or alarm condition, the trip and diagnostic messages screen will appear on the display. These messages can also be accessed by tapping the **Trip & Diag. Messages** application in the **Device Info** folder.

Table 8.6 Front-Panel Automatic Messages

Condition	Front-Panel Message
Relay detects any failure	Displays the latest failure type (refer to *Section 11: Testing and Troubleshooting*).
Relay trip occurs	Displays the type or cause of the trip (refer to *Table 10.1* for a list of trip display messages).
Relay alarm condition occurs	Displays the type of alarm. The TRIP LED also flashes during an alarm condition (refer to *Table 8.3* for a list of the warning conditions).

Front-Panel Security

Use the **Access Level** folder on the **Home** screen for login/logout operations.

The SEL-751 front panel typically operates at Access Level 1 and allows you to view relay measurements and settings. Particular activities, such as editing settings and controlling output contacts, are restricted to those operators who know the Access Level 2 password.

When an activity requires Access Level 2, an authentication screen appears on the display, which requires you to enter the 2AC password to proceed further. After you have correctly entered the password, you can perform other Access Level 2 operations without re-entering the password. You will have to re-enter the password if the front-panel inactivity timer, FPTO, expires.

See *PASSWORD Command (Change Passwords) on page 7.44* for the list of default passwords and for more information on changing the passwords.

Front-Panel Timeout

To help prevent unauthorized access to password-protected functions, the SEL-751 provides a front-panel timeout setting, FPTO, in the **Touchscreen** application in the **Settings** folder. The timeout resets each time you press a front-panel pushbutton or tap the display. Once the timeout expires, the access level resets to the ACC access level. You can manually reset the access level by tapping **Logout** in the **Access Level** folder. The backlight of the display goes dark 60 minutes after the inactivity timer (1–30 min) expires.

Touchscreen

Navigating the Touchscreen Folders and Applications

Use the front-panel touchscreen and pushbuttons to access data measured and stored by the relay and to perform relay operations. All relay information and operations are available through the touchscreen via folders, applications, and the buttons in the sidebar. *Table 8.7* describes the functions of the sidebar buttons.

Table 8.7 Sidebar Buttons

Button	Button Name	Function	Button	Button Name	Function
	Up	Pages up in applications with multiple screens; when on the first screen, this button is disabled.		Back	Returns to the preceding screen, e.g., from applications to folders.
	Down	Pages down in applications with multiple screens; when on the last screen, this button is disabled.		Pause	Stops updating the phasors.
	Left	Pages left on the home screen and in folders with multiple screens; this button is hidden if there is no screen to the left.		Play	Updates the phasor values from the relay as the screen refreshes.
	Right	Pages right on the home screen and in folders with multiple screens; this button is hidden if there is no screen to the right.		Refresh	Reloads the data when new data are available.
 0.00	Reset	Resets the accumulating quantities, such as energy, to zero.		Keyboard	Use to edit relay settings.
	Save	Saves the edited settings to the relay.		Search	Search tool (e.g., search for the status of a Relay Word bit).
	Cancel Save	Cancels the setting edits.		Trash	Deletes the records from the report.

The relay wakes up to the screen set in the FPHOME setting, unless the rotating display is enabled. If the rotating display is enabled and the inactivity time has expired, the relay wakes up to the rotating display. Pressing the **HOME** pushbutton a second time returns you to the screen set in the FPHOME setting.

You can navigate the touchscreen by tapping the folders and applications. Tap a folder or an application to view available applications or access an application, respectively. Folders and applications are labeled according to functionality.

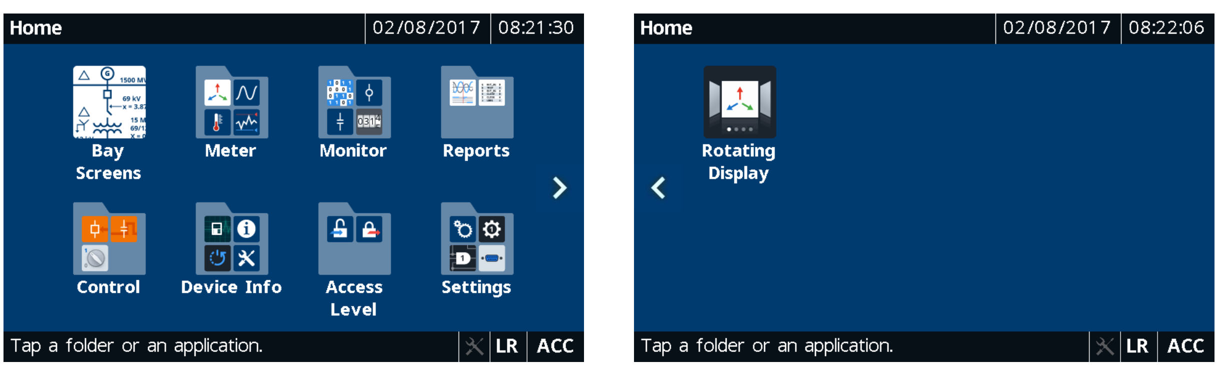


Figure 8.29 Home (Default FPHOME Setting)

Table 8.8 shows a list of folders and applications available on the **Home** screen.

Table 8.8 Home Folders and Applications

Screen Name	Folder or Application Name	Comments
Home	Bay Screens	Always available
	Meter	Always available
	Monitor	Always available
	Reports	Always available
	Control	Always available
	Device Info	Always available
	Access Level	Always available
	Settings	Always available
	Rotating Display	Always available

The applications shown in the folders are based on the part number. For example, if the relay does not support arc flash, the **Light Intensity** and **Arc-Flash Diagnostics** applications are not shown in the **Meter** and **Device Info** folders, respectively.

Descriptions of the folders and applications on the **Home** screen follow.

Bay Screens

NOTE: Five bay screens are always rendered on the touchscreen. Any unused screens are blank.

Tap this application to navigate to as many as five customer-designed screens (Bay Screen 1 through Bay Screen 5, see *Table 8.17*). You can design these screens using ACSELERATOR Bay Screen Builder SEL-5036 Software. Refer to *Section 9: Bay Control* for the procedure to create custom screens.

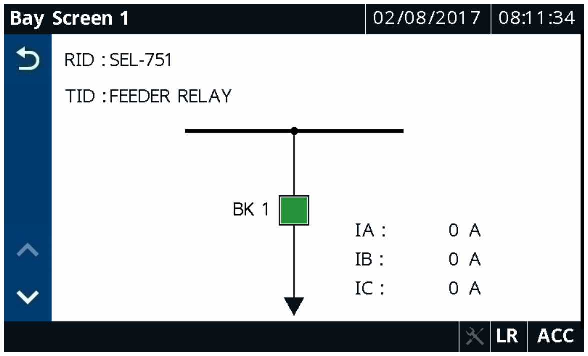


Figure 8.30 Bay Screens Application

Meter

Tapping this folder navigates you to the **Meter** screen, as shown in *Figure 8.31*. This screen lists all of the available metering applications. The applications on the **Meter** screen are part number dependent. Only those metering applications specific to your part number appear on the **Meter** screen. Tapping an application on the **Meter** screen shows you the report for that particular application.

Figure 8.31 Meter Applications

Table 8.9 identifies all the applications available in the **Meter** folder.

Table 8.9 Meter Application Availability

Folder Name	Application Name	Comments[a]
Meter	Phasors	Always available
	Fundamental	Always available
	RMS	Always available
	Energy	Available if the relay supports voltages
	Max/Min	Always available
	Demand	Always available
	Peak Demand	Always available
	Analog Inputs	Shown when (Slot C = 5*x* or 6*x*) or (Slot D = 5*x* or 6*x*) or (Slot E = 5*x* or 6*x*)
	Thermal	Always available
	Math Variables	Always available
	HIF	Shown when HIF is supported, i.e., when the firmware option is 3, 5, or 8
	Remote Analogs	Always available
	Light Intensity	Shown when Slot E = (70 or L0) or 77

[a] Refer to the relay part number.

Figure 8.32 and *Figure 8.33* show typical screens for phasor and fundamental metering.

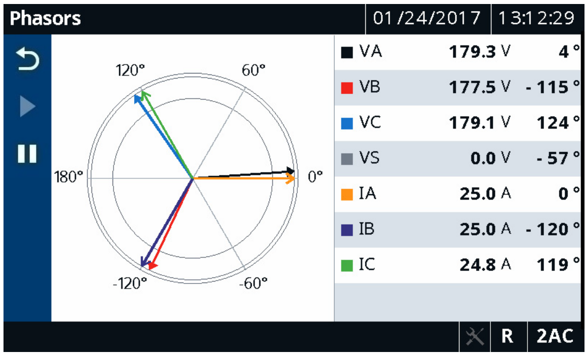


Figure 8.32 Meter Phasors

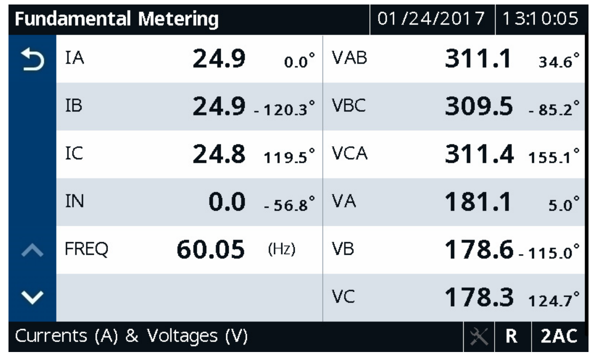


Figure 8.33 Meter Fundamental

A reset feature is provided for the **Energy**, **Max/Min**, **Demand**, and **Peak Demand** applications. Tap the **Reset** button to navigate to the reset confirmation screen. Once you confirm the reset, the data are reset to zero. *Figure 8.34* and *Figure 8.35* show typical screens for energy metering and reset confirmation.

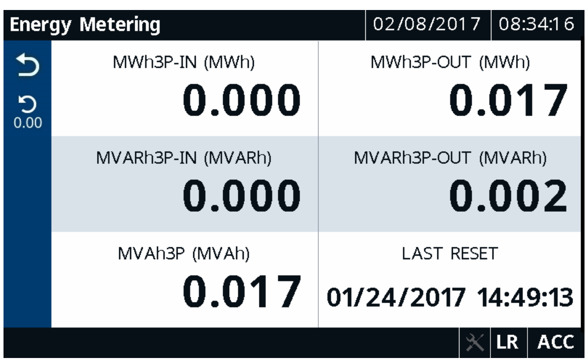


Figure 8.34 Meter Energy

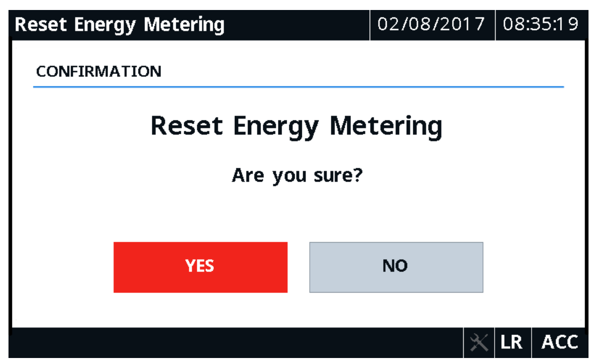


Figure 8.35 Meter Energy Reset

Monitor

Tapping this folder navigates you to the **Monitor** screen, as shown in *Figure 8.36*. Monitor the status of the Relay Word bits (targets), digital outputs, digital inputs, SELogic counters, and breaker wear data using the respective applications (**Relay Word Bits**, **Digital Outputs**, **Digital Inputs**, **SELogic Counters**, and **Breaker Wear**).

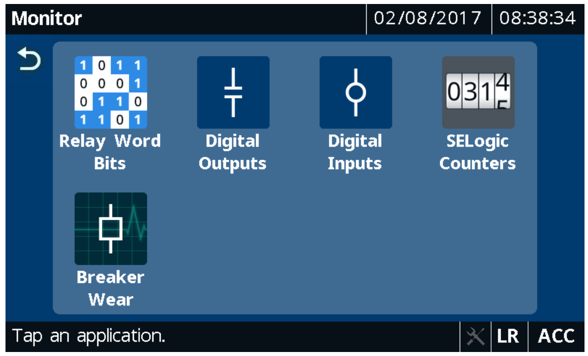


Figure 8.36 Monitor Applications

Table 8.10 identifies all the applications available in the **Monitor** folder.

Table 8.10 Monitor Application Availability

Folder Name	Application Name	Comments
Monitor	Relay Word Bits	Always available
	Digital Outputs	Always available
	Digital Inputs	Always available
	SELOGIC Counters	Always available
	Breaker Wear	Always available

Tap the **Breaker Wear** application to view accumulated breaker wear/ operations. You can reset the accumulated data by tapping the **Reset** button provided in the sidebar of the **Breaker Wear** application. Typical screens for the **Breaker Wear** application follow.

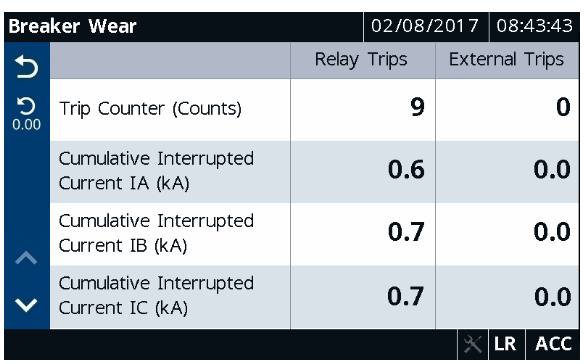


Figure 8.37 Breaker Wear Trips

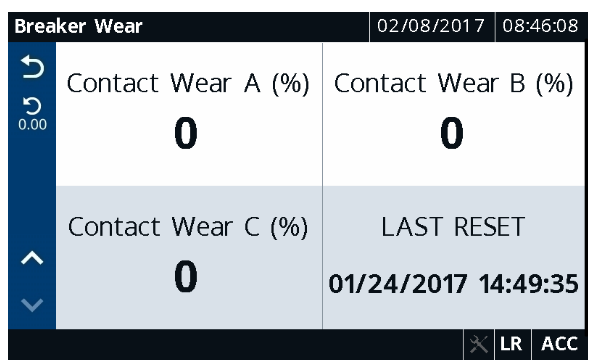


Figure 8.38 Breaker Wear A, B, C, and Last Reset

Monitor the status of the Relay Word bits using the Relay Word Bits screen. Note that asserted Relay Word bits are highlighted in blue. You can use the **Search** button in the **Relay Word Bits** application to view the status of a Relay Word bit. To search for a Relay Word bit, you must enter the full name of the Relay Word bit in the screen **Search Relay Word Bit** SEARCH field. *Figure 8.39* and *Figure 8.40* show typical Relay Word bits monitoring screens.

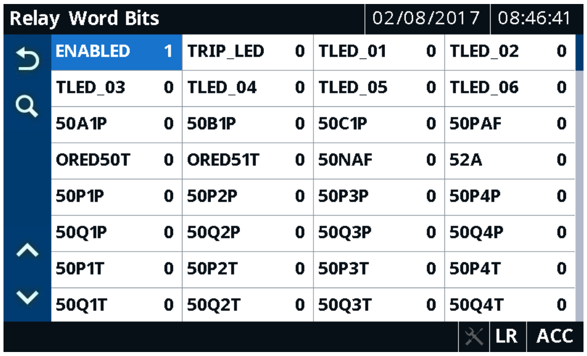


Figure 8.39 Monitor Relay Word Bits

Figure 8.40 Search Relay Word Bits

Reports

Tapping this folder navigates you to the **Reports** screen where you can access the **Events**, **HIF Events** (if available), and **SER** applications. Use these applications to view events, HIF events, and SERs.

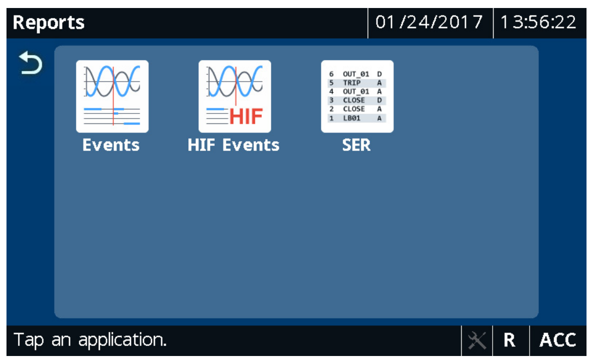


Figure 8.41 Reports Applications

Table 8.11 identifies all the applications available in the **Reports** folder.

Table 8.11 Reports Application Availability

Folder Name	Application Name	Comments[a]
Reports	Events	Always available
	HIF Events	Shown when HIF is supported, i.e., when the firmware option is 3, 5, or 8
	SER	Always available

[a] Refer to the relay part number.

To view the summary of a particular event record, tap the event record on the **Event History** screen. When new records become available while viewing any of the **Reports** screens (**Events**, **HIF Events**, and **SER**), the up and down buttons are disabled and the footer displays a message to refresh the screen. Update the screen using the **Refresh** button. Tapping the **Trash** button on the **Event History**, **HIF Event History**, and **Sequential Events Recorder** screens and confirming the delete action removes the records from the relay. *Figure 8.42* through *Figure 8.44* show typical **Event History**, **Event Summary**, and **Sequential Events Recorder** screens.

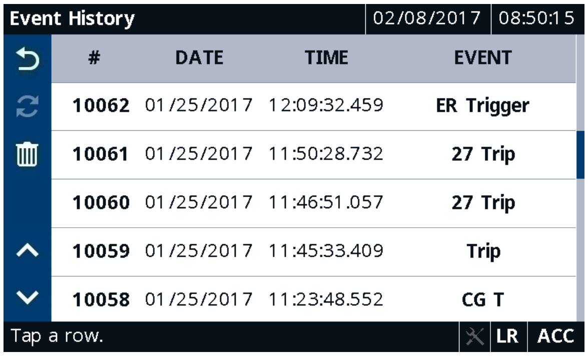


Figure 8.42 Event History

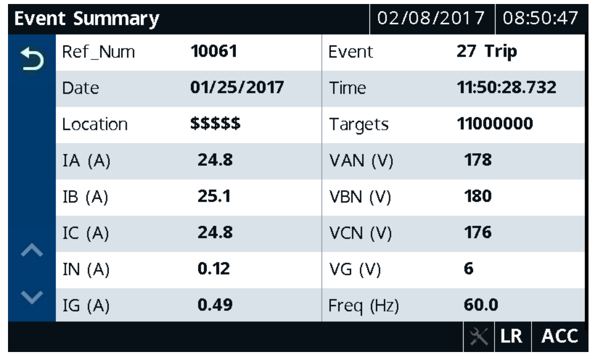


Figure 8.43 Event Summary

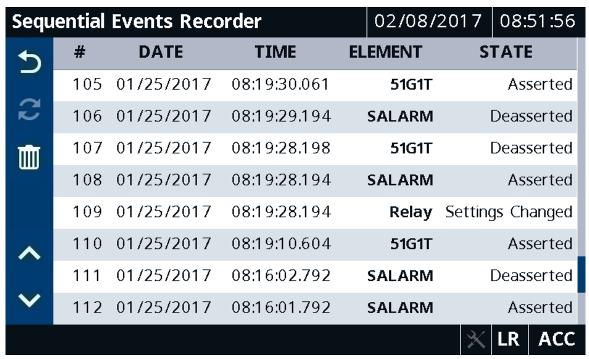


Figure 8.44 Sequential Events Recorder

Control

Tapping this folder navigates you to the **Control** screen, as shown in *Figure 8.45*. Use the **Control** folder applications **Breaker Control**, **Output Pulsing**, and **Local Bits** to perform breaker control operations, pulse output contacts, or control the local bits.

Breaker Control and **Output Pulsing** applications require that the breaker jumper be installed on the main board. Refer to *Password, Breaker Control, and SELBOOT Jumper Selection on page 2.18* for information on the breaker jumper.

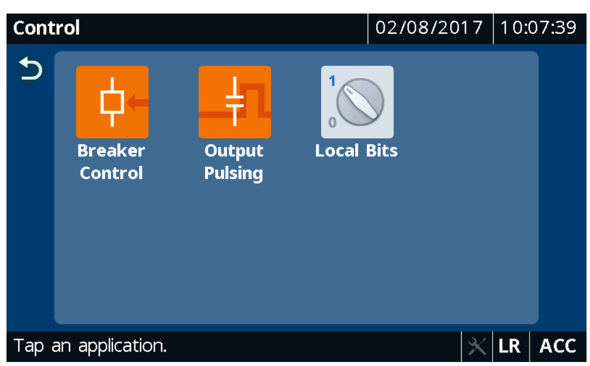


Figure 8.45 Control Applications

Table 8.12 identifies all the applications available in the **Control** folder.

Table 8.12 Control Application Availability

Folder Name	Application Name	Comments
Control	Breaker Control	Always available
	Output Pulsing	Always available
	Local Bits	Always available

To perform breaker control, tap the **Breaker Control** application and then tap and confirm the control action. Breaker control through the touchscreen is supervised by (1) the status of the LOCAL bit when EN_LRC := Y, (2) the position of the breaker jumper, and (3) the access level (requires 2AC). When EN_LRC := N, supervision through the LOCAL bit is ignored, while supervision through the breaker jumper and access level are maintained.

When local/remote supervision setting EN_LRC := Y and LOCAL := 0, the OC and CC bits are not processed from the touchscreen (i.e., breaker control through the touchscreen is blocked). *Figure 8.46* shows a typical breaker control screen. For the settings related to the local/remote control function, refer to *Local/Remote Breaker Control on page 9.3*.

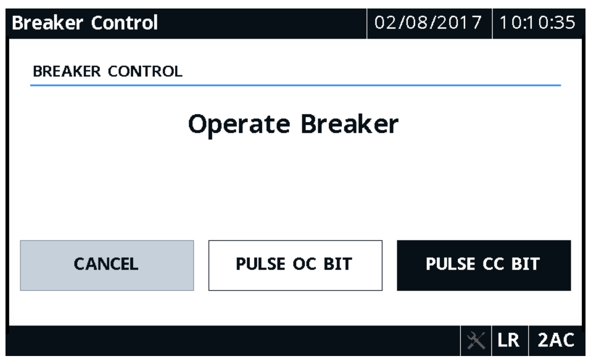


Figure 8.46 Local Bits Confirmation

To pulse a digital output contact, tap the Output Pulsing application. Navigate to the desired output contact screen, tap the desired output, and confirm the control action. The output tile will be highlighted in blue on assertion, as shown in *Figure 8.47*. An output contact cannot be pulsed if it is already asserted. Pulsing the output contact requires that the breaker jumper be installed and that you have Level 2 access.

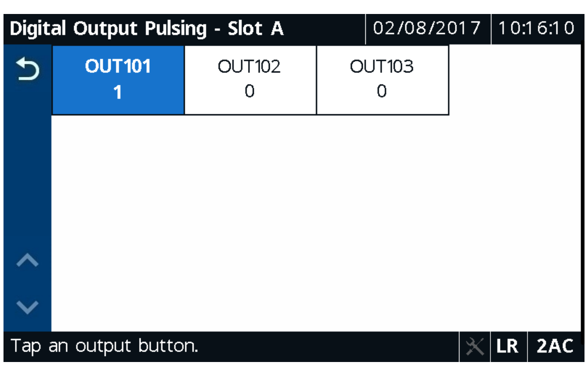


Figure 8.47 Digital Output Pulsing—Slot A

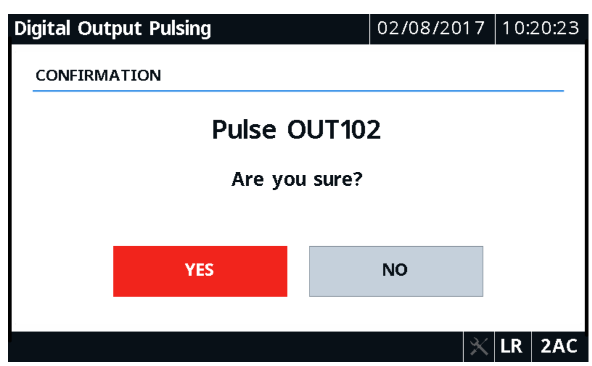


Figure 8.48 Digital Output Pulsing Confirmation

To control the local bits, tap the Local Bits application. You can control the desired local bit by tapping on the corresponding row. Depending on the state, tap and confirm the type of action you would like to perform. *Figure 8.49* through *Figure 8.51* show typical local bits control screens.

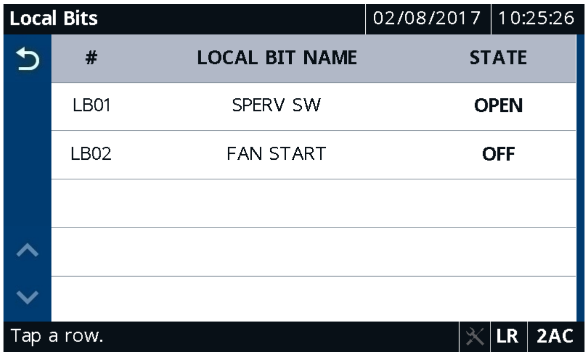


Figure 8.49 Local Bits

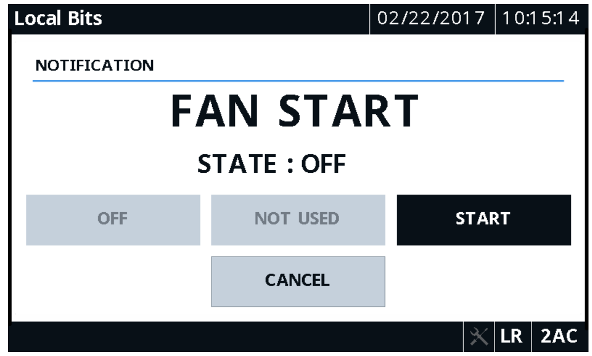


Figure 8.50 Local Bits Notification

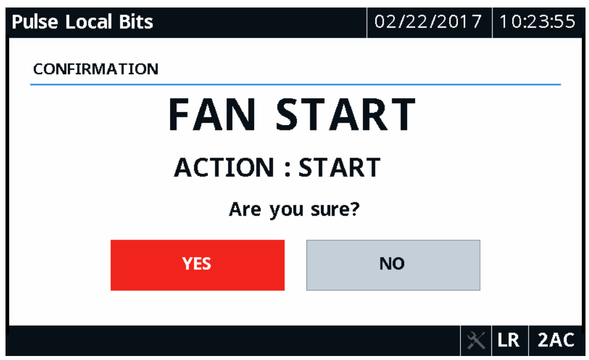


Figure 8.51 Local Bits Confirmation

Device Info

Tapping this folder navigates you to the **Device Info** screen where you can access specific device information applications (**Status**, **Configuration**, **Arc-Flash Diagnostics**, and **Trip & Diag. Messages**) and the **Reboot** application.

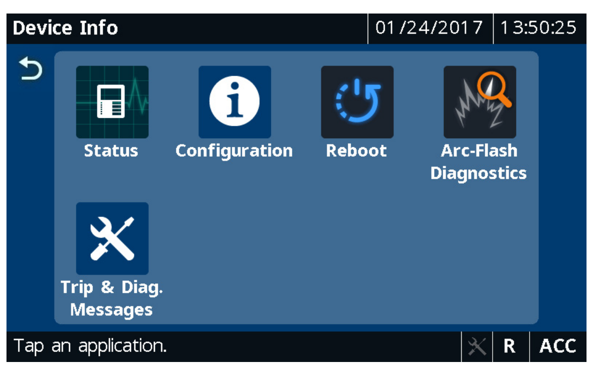


Figure 8.52 Device Info Applications

Table 8.13 identifies all the applications available in the **Device Info** folder.

Table 8.13 Device Info Application Availability

Folder Name	Application Name	Comments[a]
Device Info	Status	Always available
	Configuration	Always available
	Reboot	Always available
	Arc-Flash Diagnostics	Shown when Slot E = (70 or L0) or 77
	Trip & Diag. Messages	Always available

[a] Refer to the relay part number.

Tap the **Status** application to view the relay status, firmware version, part number, etc., as shown in *Figure 8.53*. Use the **Configuration** application to view port information, the jumper positions for the breaker, etc., as shown in *Figure 8.54*. If the relay detects any new card in one of the slots, it disables and directs you to accept the change in configuration, as shown in *Figure 8.55*. *Figure 8.53* through *Figure 8.55* show typical screens for device configuration, device status, and trip and diagnostic messages.

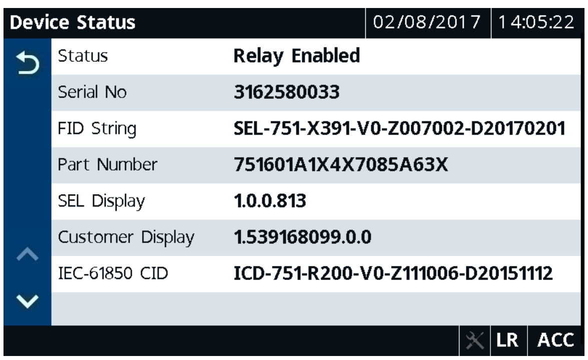


Figure 8.53 Device Status

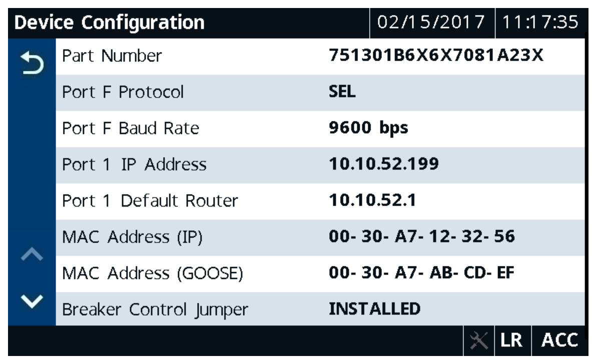


Figure 8.54 Device Configuration

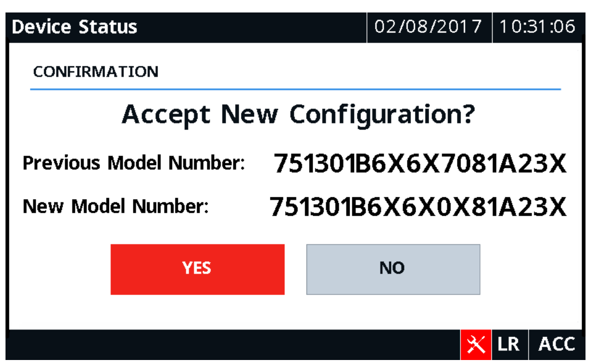


Figure 8.55 Model Number Confirmation

When a diagnostic failure, trip, or warning occurs, the relay displays the diagnostic message on the screen until it is either overridden by the restart of the rotating display or the inactivity timer expires. To view the trip and diagnostic messages, tap the **Trip & Diag. Messages** application in the **Device Info** folder.

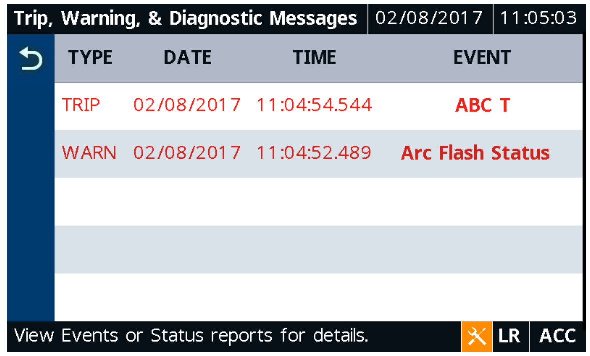


Figure 8.56 Trip and Diagnostic Messages

Tap on the **Arc-Flash Diagnostics** application to run a diagnostic check on the arc-flash sensors. *Figure 8.57* and *Figure 8.58* show typical arc-flash diagnostics screens.

Figure 8.57 Arc-Flash Diagnostics

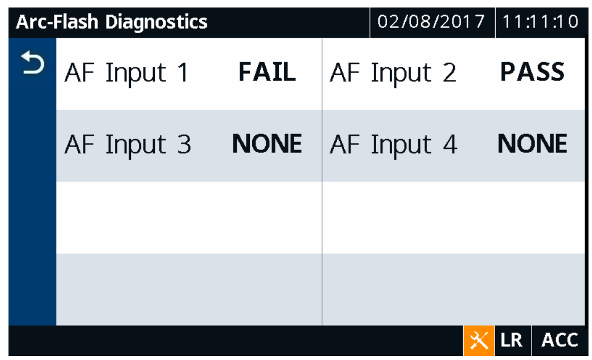


Figure 8.58 Arc-Flash Diagnostics Confirmation

Access Level

Tapping this folder navigates you to the **Access Level** screen where you can either log in to or log out of the 2AC level.

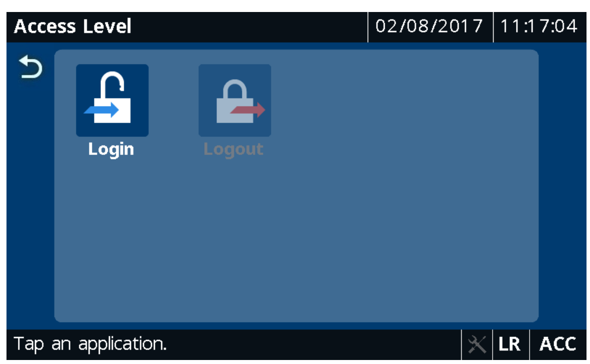


Figure 8.59 Access Level Applications

Table 8.14 identifies all of the applications available in the **Access Level** folder.

Table 8.14 Access Level Application Availability

Folder Name	Application Name	Comments
Access Level	Login	Always available
	Logout	Always available

Note that when a folder requires the 2AC access level and the relay is at ACC, the relay automatically pops up the authentication screen requiring you to enter the password before performing a control operation, editing setting, etc.

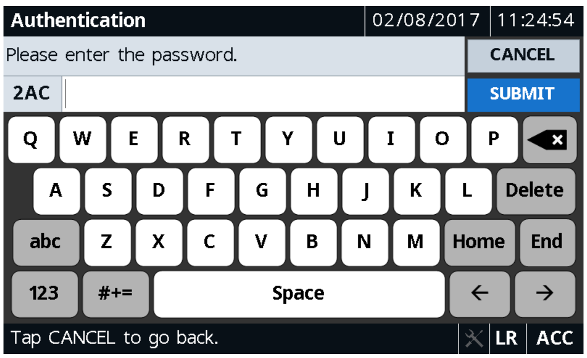


Figure 8.60 Authentication

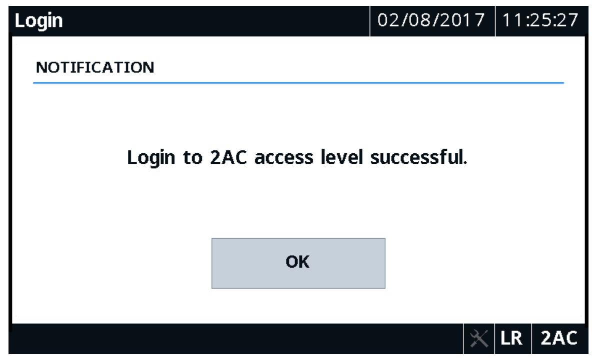


Figure 8.61 Login Confirmation

Settings

Tapping this folder navigates you to the **Settings** screen where you can access settings applications (**Global**, **Touchscreen**) or settings folders (**Port**, **Group**, **Date and Time**) through which you can set or show settings.

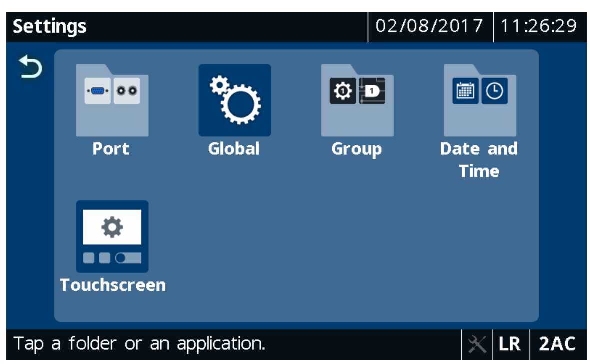


Figure 8.62 Settings Folders and Applications

Table 8.15 identifies all of the folders and applications available in the **Settings** folder.

Table 8.15 Settings Folder and Application Availability

Folder Name	Folder or Application Name	Comments
Settings	Port	Always available
	Global	Always available
	Group	Always available
	Date and Time	Always available
	Touchscreen	Always available

Table 8.16 identifies all the applications available in each folder (**Port**, **Group**, **Date and Time**) in the **Settings** folder.

Table 8.16 Settings Folders Port, Group, and Date and Time Application Availability

Folder Name	Application Name	Comments[a]
Port	Port F	Always available
	Port 1	Shown when Slot B ≠ *x*0*x* or *x*1*x*
	Port 2	Shown when serial fiber port is available and E49RTD ≠ EXT
	Port 3	Always available
	Port 4	Shown when Slot C = A*x* or 0*x*, i.e., Slot C has a comms card or is empty
Group	Set 1	Always available
	Logic 1	Always available
	Set 2	Always available
	Logic 2	Always available
	Set 3	Always available
	Logic 3	Always available
	Set 4	Always available
	Logic 4	Always available
Date and Time	Date	Always available
	Time	Always available

[a] Refer to the relay part number.

Figure 8.63 and *Figure 8.64* show typical port and group settings screens.

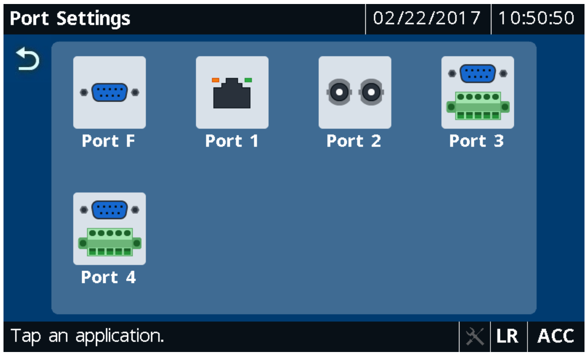


Figure 8.63 Port Settings

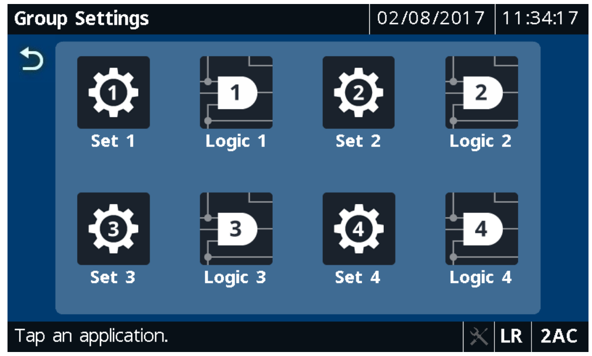


Figure 8.64 Group Settings

To edit a setting, tap on a setting row and enter the 2AC password. If the access level is already at 2AC, the relay does not prompt for password authentication. After entering the value, tap the **Save** button to save your edit, or click the **Cancel Save** button to cancel the edit (see *Table 8.7*). When editing a settings class (e.g., **Set 1** in **Group Settings**), you cannot navigate to another class (e.g., **Logic 1**) without saving or discarding the settings change made in **Set 1**.

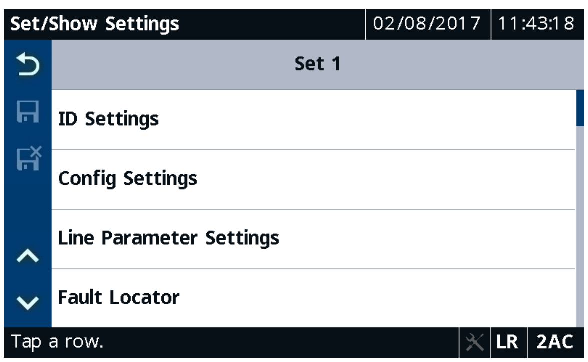


Figure 8.65 Set 1 Settings

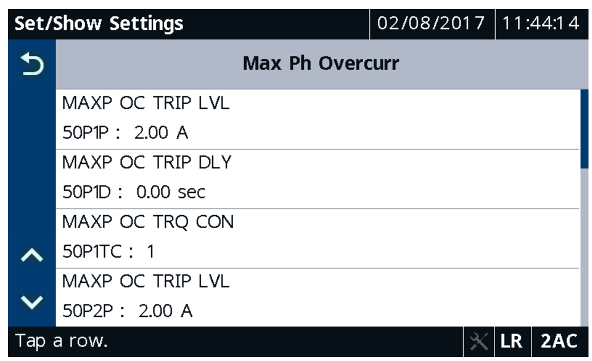


Figure 8.66 Max Phase Overcurrent Settings

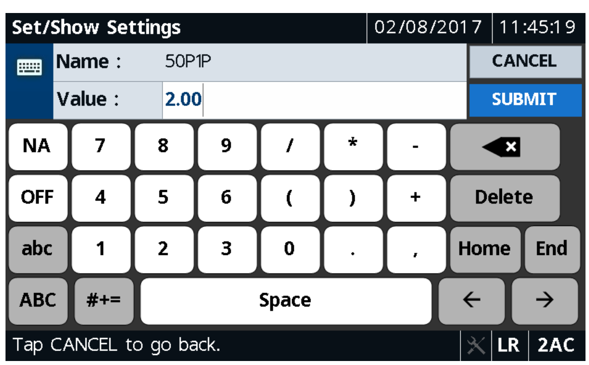


Figure 8.67 Set/Show Settings Edit

You can control the screen brightness, the screen inactivity timer settings, etc., through the **Touchscreen** application.

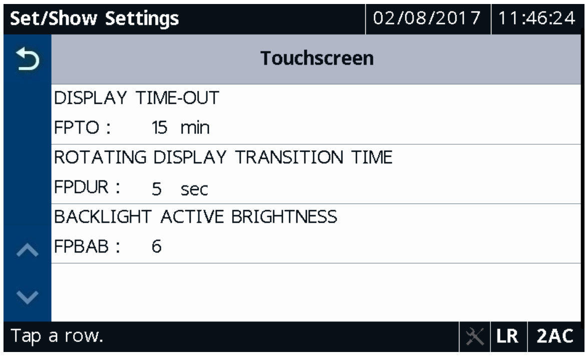


Figure 8.68 Touchscreen Settings

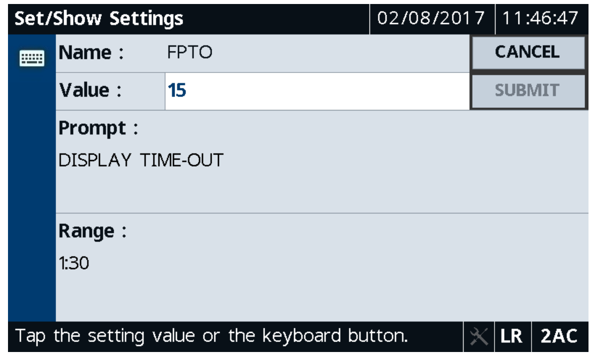


Figure 8.69 Touchscreen Settings Edit

Rotating Display

Tapping this application allows you to start the rotating display. You can pick as many as 16 screens through which the display can rotate after the inactivity timer expires. Refer to *Table 8.17* for all the available quantities on each screen.

Tapping any screen while the display is rotating takes you to that particular screen. You can perform the needed operation and use the **Back** button to return to the **Home** screen.

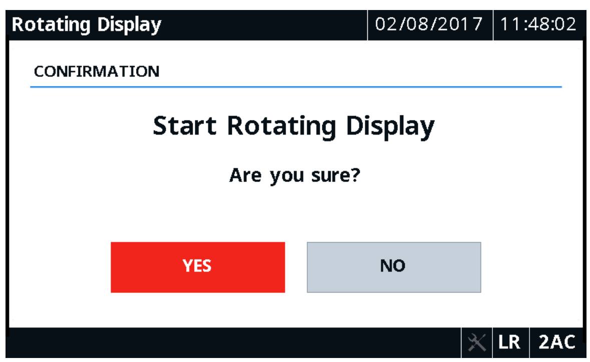


Figure 8.70 Rotating Display

Language Support

All of the HMI messages can be displayed in multiple languages (English or Spanish). The relay part number determines which language is displayed on the HMI. See the *SEL-751 Relay Command Summary* for a list of the commands.

Operation and Target LEDs

Programmable LEDs

The SEL-751 provides quick confirmation of relay conditions via operation and target LEDs. Refer to *Operation and Target LEDs on page 8.13* for details on **ENABLED**, **TRIP**, programmable LEDs and their operation, and possible warning conditions on the relay.

TARGET RESET Pushbutton

Refer to *TARGET RESET Pushbutton on page 8.14* for the operation of the **TARGET RESET** pushbutton, the lamp test, and other target reset options.

Front-Panel Operator Control Pushbuttons

The SEL-751 touchscreen display features eight operator-controlled pushbuttons, each with two programmable tricolor pushbutton LEDs, for local control, as shown in *Table 8.4*. Refer to *Front-Panel Operator Control Pushbuttons on page 8.15* for details on operator control pushbuttons and LEDs and their programming.

You can use the front-panel operator control pushbuttons to jump to a specific screen while using them for LOCK/OPEN/CLOSE operations, etc. You can program the selectable operator pushbutton screen settings under the **Touchscreen** settings category in QuickSet and map the button to a specific screen. For example, PB04, which is used to trip a breaker by default, can be programmed to jump to a bay screen by mapping the pushbutton touchscreen setting FPPB04 to Bay Screen 1. When you press PB04, the display jumps to Bay Screen 1, where you can see a visual confirmation of the TRIP action.

Table 8.17 Screens Available for the Rotating Display, HOME Pushbutton[a], and Programmable Pushbuttons (Sheet 1 of 8)

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
Bay Screens				
		Bay Screen 1		Displays Bay Screen 1
		Bay Screen 2		Displays Bay Screen 2
		Bay Screen 3		Displays Bay Screen 3
		Bay Screen 4		Displays Bay Screen 4
		Bay Screen 5		Displays Bay Screen 5
Meter				
	Phasors			
		Phasor Screen 1	IA_MAG, IA_ANG, IB_MAG, IB_ANG, IC_MAG, IC_ANG	Shown when Slot Z = Ax
		Phasor Screen 2	IA_MAG, IA_ANG, IB_MAG, IB_ANG, IC_MAG, IC_ANG, VAB_MAG, VAB_ANG, VBC_MAG, VBC_ANG, VCA_MAG, VCA_ANG	Shown when (Slot Z ≠ Ax AND DELTA_Y = DELTA) AND (Slot E ≠ 70 or L0)
		Phasor Screen 3	IA_MAG, IA_ANG, IB_MAG, IB_ANG, IC_MAG, IC_ANG, VA_MAG, VA_ANG, VB_MAG, VB_ANG, VC_MAG, VC_ANG	Shown when (Slot Z ≠ Ax AND DELTA_Y = WYE) AND (Slot E ≠ 70 or L0)

Table 8.17 Screens Available for the Rotating Display, HOME Pushbutton[a], and Programmable Pushbuttons (Sheet 2 of 8)

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
		Phasor Screen 4	IA_MAG, IA_ANG, IB_MAG, IB_ANG, IC_MAG, IC_ANG, VAB_MAG, VAB_ANG, VBC_MAG, VBC_ANG, VCA_MAG, VCA_ANG, VS_MAG, VS_ANG	Shown when (Slot Z ≠ Ax AND DELTA_Y = DELTA) AND (Slot E = 70 or L0)
		Phasor Screen 5	IA_MAG, IA_ANG, IB_MAG, IB_ANG, IC_MAG, IC_ANG, VA_MAG, VA_ANG, VB_MAG, VB_ANG, VC_MAG, VC_ANG, VS_MAG, VS_ANG	Shown when (Slot Z ≠ Ax AND DELTA_Y = WYE) AND (Slot E = 70 or L0)
	Fundamental			
		Fundamental Screen 1	IA_MAG, IA_ANG, IB_MAG, IB_ANG, IC_MAG, IC_ANG, IN_MAG, IN_ANG, FREQ, IG_MAG, IG_ANG, I1_MAG, I1_ANG, 3I2, IAV, UBI	Shown when Slot Z = Ax
		Fundamental Screen 2	IA_MAG, IA_ANG, IB_MAG, IB_ANG, IC_MAG, IC_ANG, IN_MAG, IN_ANG, FREQ, VAB_MAG, VAB_ANG, VBC_MAG, VBC_ANG, VCA_MAG, VCA_ANG	Shown when Slot Z ≠ Ax AND DELTA_Y = DELTA
		Fundamental Screen 3	IG_MAG, IG_ANG, I1_MAG, I1_ANG, 3I2, IAV, UBI, V1_MAG, V1_ANG, 3V2, VAVE, UBV	Shown when Slot Z ≠ Ax AND DELTA_Y = DELTA
		Fundamental Screen 4	IA_MAG, IA_ANG, IB_MAG, IB_ANG, IC_MAG, IC_ANG, IN_MAG, IN_ANG, FREQ, VAB_MAG, VAB_ANG, VBC_MAG, VBC_ANG, VCA_MAG, VCA_ANG, VA_MAG, VA_ANG, VB_MAG, VB_ANG, VC_MAG, VC_ANG	Shown when Slot Z ≠ Ax AND DELTA_Y = WYE
		Fundamental Screen 5	IG_MAG, IG_ANG, I1_MAG, I1_ANG, 3I2, IAV, UBI, VG_MAG, VG_ANG, V1_MAG, V1_ANG, 3IV2, VAVE, UBV	Shown when Slot Z ≠ Ax AND DELTA_Y = WYE
		Fundamental Screen 6	P, Q, S, PF	Shown when Slot Z ≠ Ax
		Fundamental Screen 7	PA, QA, SA, PFA, PB, QB, SB, PFB, PC, QC, SC, PFC	Shown when Slot Z ≠ Ax and DELTA_Y = WYE
		Fundamental Screen 8	VS, FREQS, VDC	Shown when Slot E = 70 or L0
	RMS			
		RMS Screen 1	IARMS, IBRMS, ICRMS, INRMS	Shown when Slot Z = Ax
		RMS Screen 2	IARMS, IBRMS, ICRMS, INRMS, VABRMS, VBCRMS, VCARMS	Shown when (Slot Z ≠ Ax AND DELTA_Y = DELTA) AND (Slot E ≠ 70 or L0)

Table 8.17 Screens Available for the Rotating Display, HOME Pushbutton[a], and Programmable Pushbuttons (Sheet 3 of 8)

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
		RMS Screen 3	IARMS, IBRMS, ICRMS, INRMS, VARMS, VBRMS, VCRMS	Shown when (Slot Z ≠ Ax AND DELTA_Y = WYE) AND (Slot E ≠ 70 or L0)
		RMS Screen 4	IARMS, IBRMS, ICRMS, INRMS, VABRMS, VBCRMS, VCARMS, VSRMS	Shown when (Slot Z ≠ Ax AND DELTA_Y = DELTA) AND (Slot E = 70 or L0)
		RMS Screen 5	IARMS, IBRMS, ICRMS, INRMS, VARMS, VBRMS, VCRMS, VSRMS	Shown when (Slot Z ≠ Ax AND DELTA_Y = WYE) AND (Slot E = 70 or L0)
	Max/Min			
		Max/Min Screen 1	IAMX, IAMN, IBMX, IBMN, ICMX, ICMN, INMX, INMN, IGMX, IGMN, VABMX, VABMN, VAMX, VAMN, VBCMX, VBCMN, VBMX, VBMN, VCAMX, VCAMN, VCMX, VCMN, VSMX, VSMN, kW3MX, kW3MN, kVAR3MX, kVAR3MN, kVA3MX, kVA3MN, FREQMX, FREQMN, RTD1MX–RTD12MX, RTD1MN–RTD12MN, AI301MX–AI308MX, AI301MN–AI308MN, AI401MX–AI408MX, AI401MN–AI408MN, AI501MX–AI508MX, AI501MN–AI508MN, MM_LRD	Voltages, RTD, and analog inputs are available only when the part number supports them
		Max/Min Reset Screen	Reset max/min data	Always available
	Energy			
		Energy Screen 1	MWH3PI, MWH3P, MVARH3PI, MVARH3PO, MVAH3P, EM_LRD	Available if the relay supports voltages
		Energy Reset Screen	Reset energy data	
	Demand			
		Demand Screen 1	IAD, IBD, ICD, IGD, 3I2D, DM_LRD	Always available
		Demand Screen 2	KW3DI, KW3DO, KVAR3DI, KVAR3DO, DM_LRD	Shown when (Slot Z ≠ Ax AND DELTA_Y=DELTA) or (Slot Z ≠ Ax AND DELTA_Y = WYE)
		Demand Screen 3	KWADI, KWBDI, KWCDI, KWADO, KWBDO, KWCDO, DM_LRD	Shown when Slot Z ≠ Ax AND DELTA_Y = WYE
		Demand Screen 4	KVARADI, KVARBDI, KVARCDI, KVARADO, KVARBDO, KVARCDO, DM_LRD	Shown when Slot Z ≠ Ax AND DELTA_Y = WYE
		Demand Reset Screen	Reset demand data	Always available

Table 8.17 Screens Available for the Rotating Display, HOME Pushbutton[a], and Programmable Pushbuttons (Sheet 4 of 8)

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
	Peak Demand			
		Peak Demand Screen 1	IAPD, IBPD, ICPD, IGPD, 3I2PD, PM_LRD	Always available
		Peak Demand Screen 2	KW3PDI, KW3PDO, KVAR3PDI, KVAR3PDO, PM_LRD	Shown when (Slot Z ≠ Ax AND DELTA_Y = DELTA) or (Slot Z ≠ Ax AND DELTA_Y = WYE)
		Peak Demand Screen 3	KWAPDI, KWBPDI, KWCPDI, KWAPDO, KWBPDO, KWCPDO, PM_LRD	Shown when Slot Z ≠ Ax AND DELTA_Y = WYE
		Peak Demand Screen 4	KVARAPDI, KVARBPDI, KVARCPDI, KVARAPDO, KVARBPDO, KVARCPDO, PM_LRD	Shown when Slot Z ≠ Ax AND DELTA_Y = WYE
		Peak Demand Reset Screen	Reset peak demand data	Always available
	Analog Inputs			
		Analog Inputs Screen 1	AI301–AI308,AI401–AI408, AI501–AI508	Available if the relay supports analog inputs
	Thermal			
		Thermal Screen 1	RTDWDGMX, RTDBRGMX, RTDAMB, RTDOTHMX	Shown when E49RTD ≠ NONE
		Thermal Screen 2	RTD1– RTD12	Shown when E49RTD ≠ NONE
		Thermal Screen 3	THIEQ1, THTCU1, THTRIP1, THRLS1, THIEQ2, THTCU2, THTRIP2, THRLS2, THIEQ3, THTCU3, THTRIP3, THRLS3	Shown when E49IEC ≠ N
	Math Variables			
		Math Variables Screen 1	MV01–MV32	Shown when EMV ≠ N; shows 12 math variables per page
	HIF			
		HIF Screen 1	ALG.1A Alarm, ALG.1A Fault, ALG.1B Alarm, ALG.1B Fault, ALG.1C Alarm, ALG.1C Fault, ALG.2A Alarm, ALG.2A Fault, ALG.2B Alarm, ALG.2B Fault, ALG.2C Alarm, ALG.2C Fault	Shown when EHIF = Y and ITUNE_X = 0 or EHIF = T and NTUNE_X = 0, X = A, B, C
	Remote Analogs			
		Remote Analogs Screen 1	RA001–RA012	Always available
		Remote Analogs Screen 2	RA013–RA024	Always available
		Remote Analogs Screen 3	RA025–RA036	Always available
		Remote Analogs Screen 4	RA037–RA048	Always available

Table 8.17 Screens Available for the Rotating Display, HOME Pushbutton[a], and Programmable Pushbuttons (Sheet 5 of 8)

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
		Remote Analogs Screen 5	RA049–RA060	Always available
		Remote Analogs Screen 6	RA061–RA072	Always available
		Remote Analogs Screen 7	RA073–RA084	Always available
		Remote Analogs Screen 8	RA085–RA096	Always available
		Remote Analogs Screen 9	RA097–RA108	Always available
		Remote Analogs Screen 10	RA109–RA120	Always available
		Remote Analogs Screen 11	RA121–RA128	Always available
	Light Intensity			
		Light Screen 1	LSENS1, LSENS2, LSENS3, LSENS4	Shown when Slot E = 70 or L0
		Light Screen 2	LSENS1, LSENS2, LSENS3, LSENS4, LSENS5, LSENS6, LSENS7, LSENS8	Shown when Slot E = 77
Monitor				
	Relay Word Bits			
		Relay Word Bits Screen 1	Shows status of all the relay word bits	Shows 32 RWBs per page
	Digital Inputs			
		Digital Inputs Screen 1	IN101, IN102	Slot A inputs (always available)
		Digital Inputs Screen 2	IN301, IN302, IN303, IN304	Shown when Slot C= Dx or 1x or Cx
		Digital Inputs Screen 3	IN301, IN302, IN303	Shown when Slot C = Bx
		Digital Inputs Screen 4	IN301, IN302, IN303, IN304, IN305, IN306, IN307, IN308	Shown when Slot C = 3x
		Digital Inputs Screen 5	IN301, IN302, IN303, IN304, IN305, IN306, IN307, IN308, IN309, IN310, IN311, IN312, IN313, IN314	Shown when Slot C = 4x
		Digital Inputs Screen 6	IN401, IN402, IN403, IN404	Shown when Slot D = Dx or 1x or Cx
		Digital Inputs Screen 7	IN401, IN402, IN403	Shown when Slot D = Bx
		Digital Inputs Screen 8	IN401, IN402, IN403, IN404, IN405, IN406, IN407, IN408	Shown when Slot D = 3x
		Digital Inputs Screen 9	IN401, IN402, IN403, IN404, IN405, IN406, IN407, IN408, IN409, IN410, IN411, IN412, IN413, IN414	Shown when Slot D = 4x
		Digital Inputs Screen 10	IN501, IN502, IN503, IN504	Shown when Slot E = Dx or 1x or Cx
		Digital Inputs Screen 11	IN501, IN502, IN503	Shown when Slot E = Bx

Table 8.17 Screens Available for the Rotating Display, HOME Pushbutton[a], and Programmable Pushbuttons (Sheet 6 of 8)

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
		Digital Inputs Screen 12	IN501, IN502, IN503, IN504, IN505, IN506, IN507, IN508	Shown when Slot E = 3x
		Digital Inputs Screen 13	IN501, IN502, IN503, IN504, IN505, IN506, IN507, IN508, IN509, IN510, IN511, IN512, IN513, IN514	Shown when Slot E = 4x
	Digital Outputs			
		Digital Outputs Screen 1	OUT101, OUT102, OUT103	Slot A outputs (always available)
		Digital Outputs Screen 2	OUT301, OUT302, OUT303, OUT304	Shown when Slot C = Bx or 1x or Cx
		Digital Outputs Screen 3	OUT301, OUT302, OUT303	Shown when Slot C = Dx
		Digital Outputs Screen 4	OUT301, OUT302, OUT303, OUT304, OUT305, OUT306, OUT307, OUT308	Shown when Slot C = 2x
		Digital Outputs Screen 5	OUT401, OUT402, OUT403, OUT404	Shown when Slot D = Bx or 1x or Cx
		Digital Outputs Screen 6	OUT401, OUT402, OUT403	Shown when Slot D = Dx
		Digital Outputs Screen 7	OUT401, OUT402, OUT403, OUT404, OUT405, OUT406, OUT407, OUT408	Shown when Slot D = 2x
		Digital Outputs Screen 8	OUT501, OUT502, OUT503, OUT504	Shown when Slot E = Bx or 1x or Cx
		Digital Outputs Screen 9	OUT501, OUT502, OUT503	Shown when Slot E = Dx
		Digital Outputs Screen 10	OUT501, OUT502, OUT503, OUT504, OUT505, OUT506, OUT507, OUT508	Shown when Slot E = 2x
	SELOGIC Counters			
		SELOGIC Counters Screen 1	SC01–SC32	Shown when ESC ≠ N; shows 12 SELOGIC counters per page
	Breaker Wear			
		Breaker Wear Screen 1	INTT, EXTT, INTIA, INTIB, INTIC, EXTIA, EXTIB, EXTIC	Shown when EBMON = Y
		Breaker Wear Screen 2	WEARA, WEARB, WEARC, BR_LRD	Shown when EBMON = Y
Reports				
	Events			
		Event History Screen 1		Shows the event records in the relay

Table 8.17 Screens Available for the Rotating Display, HOME Pushbutton[a], and Programmable Pushbuttons (Sheet 7 of 8)

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
	HIF Events			
		HIF Event History Screen 1		Shows the HIF event records in the relay when the relay supports AST in the part number
	SER			
		SER Screen 1		Shows the Sequential Event Records (SERs) in the relay
Device Info				
	Status			
		Status Screen 1	Status, serial number, FID string, part number, SEL display, customer display, IEC 61850 CID	Always available
		Status Screen 2	Diagnostic status for the relay cards and power supply rails. CARD_C, CARD_D, CARD_E, CARD_Z, FPGA, GPSB, HMI, RAM, ROM, CR_RAM, NON_VOL, CLOCK, RTD, CID_FILE, +0.9V CHK (V), +1.2V CHK (V), +1.5V CHK (V), +1.8V CHK (V), +2.5V CHK (V), +3.3V CHK (V), +3.75V CHK (V), +5.0V CHK (V), –1.25V CHK (V), –5.0V CHK (V), BATT CHK (V)	Always available
		Status Screen 3	DN_MAC_ID, ASA, DN_RATE, DN_STATUS	Shown if the DeviceNet option is available
		Status Screen 4	OFFSETS: IA, IB, IC, IN, VA, VB, VC, VS	Always available
	Configuration			
		Configuration Screen 1	Part number, Port F protocol, Port F baud rate, Port 1 IP address, Port 1 default router, MAC address (IP), MAC address (GOOSE), breaker control jumper, password bypass jumper, rated frequency, phase rotating, nominal phase CT rating, nominal/neutral CT rating, PT connection, date format	Some of the quantities are part number dependent and will be hidden if the part number does not support them

Table 8.17 Screens Available for the Rotating Display, HOME Pushbutton[a], and Programmable Pushbuttons (Sheet 8 of 8)

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
	Trip & Diag. Messages			
		Trip and Diagnostic Screen 1	Diagnostic failures, trip event types, and warnings	Always available

[a] In addition to the listed screens, the Home screen is available for the HOME pushbutton. By default, the HOME pushbutton is programmed to the Home screen.

Section 9

Bay Control

Overview

The SEL-751 Relay with the touchscreen display option provides you with the ability to design bay configuration screens to meet your system needs. The bay configuration can be displayed as a single-line diagram (SLD) on the touchscreen. You can create as many as five bay screens with one controllable breaker and as many as five monitor-only disconnects. ANSI and IEC symbols, along with analog and digital labels, are available for you to create detailed single-line diagrams of the bay to indicate the status of the breaker and disconnects, bus voltages, and power flow through the breaker. In addition to single-line diagrams, you can design the screens to show the status of various relay elements via Relay Word bits or to show analog quantities for commissioning or day-to-day operations. These screens can be designed with the help of ACSELERATOR Bay Screen Builder SEL-5036 Software in conjunction with ACSELERATOR QuickSet SEL-5030 Software. Note that the bay screen related settings can only be set via QuickSet (setting via an ASCII terminal is not supported).

This section covers all aspects of the SEL-751 Relay bay control.

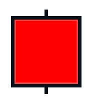
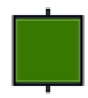
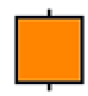
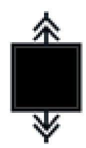
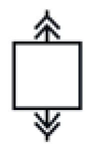
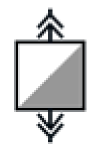
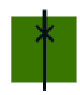
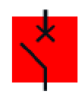
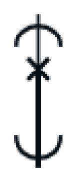
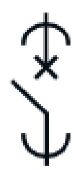
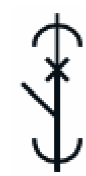
Circuit Breaker Symbol Settings and Status Logic

The SEL-751 supports one breaker that can be controlled and monitored via the bay screen. Use the SELOGIC settings 52A and 52B to map the respective breaker auxiliary contacts to the relay. Because the 52B contact is not always available in all applications, the breaker status logic does not include the 52B contact. The relay uses the 52A Relay Word bit as the status of the breaker in conjunction with the protection elements and trip and close logic. The default setting for 52B is NOT 52A. Map 52A and 52B Relay Word bits to the settings associated with the breaker symbol under the **Bay Control** settings in QuickSet to display the status of the breaker on the bay screen.

Use SELOGIC to create dual-point status of the breaker with breaker alarm indication. Refer to *Table 9.5* for the **Bay Control** breaker settings. Refer to *Bay Control Application Example on page 9.13* for example settings. Refer to *Table 4.52* and *52A and 52B Breaker Status SELOGIC Control Equations on page 4.130* for 52A and 52B settings and descriptions. Refer to *Trip/Close Logic on page 4.128* for more information on the breaker trip and close logic.

Table 9.1 provides typical ANSI and IEC breaker symbols that are supported by Bay Screen Builder. Column 1 identifies the standard (ANSI/IEC) and the type of breaker. Columns 3, 4, and 5 identify closed, open, and alarm states of the breaker image, respectively. Bay Screen Builder allows you to set the breaker color sequence property (identified in Column 2) for each of these states. Select the breaker color sequence based on your system convention. For a complete list of ANSI and IEC circuit breaker symbols available to use with the bay screens, refer to the *ACSELERATOR Bay Screen Builder SEL-5036 Software Instruction Manual*, available in the **Help > Contents** menu of Bay Screen Builder.

Table 9.1 Circuit Breaker Symbols

Type	Breaker Color Sequence	State 1 (Closed)	State 2 (Open)	State 3 (Alarm)
ANSI Breaker	Red, Green, Amber			
ANSI Truck Operated Breaker	Black, White, Grey			
IEC Breaker	Green, Red, Amber			
IEC Truck Operated Breaker	Transparent			

Disconnect Switch Symbol Settings and Status Logic

The SEL-751 supports as many as five monitor-only two-position disconnect switches. The relay firmware does not support the control logic to open and close the disconnects. The disconnect control logic can be programmed with SELOGIC control equations in conjunction with front-panel pushbuttons. Refer to *Table 9.2* for the disconnect settings. The 89A2P*n* and 89B2P*n* (*n* = 1, 2, 3, 4, or 5) SELOGIC control equation settings represent the normally open and normally closed disconnect auxiliary contacts. Typically, these SELOGIC control equation settings are set to SEL-751 inputs that are wired to the corresponding auxiliary contacts. *Figure 9.1* shows the dual-point disconnect status logic. The Relay Word bits 89CL2P*n* and 89OP2P*n* indicate the disconnect switch closed and open states, respectively. 89AL2P*n* indicates the alarm status of the disconnect and asserts when the disconnect switch is in an undetermined state for longer than the 89A2P*n*D timer. Set the 89A2P*n*D timer longer than the expected operation time (undetermined state). Refer to *Table 9.5* for the **Bay Control** disconnect switch settings. Refer to *Bay Control Application Example on page 9.13* for example settings.

Table 9.2 Disconnect Settings[a]

Setting Prompt	Setting Range	Setting Name := Factory Default
DISCONNECT *n* N/O CONTACT	SELOGIC	89A2P*n* := 0
DISCONNECT *n* N/C CONTACT	SELOGIC	89B2P*n* := NOT 89A2P*n*
DISCONNECT *n* ALARM TIMER	0.00–300.00 sec	89A2P*n*D := 5.00

[a] n = 1, 2, 3, 4, or 5

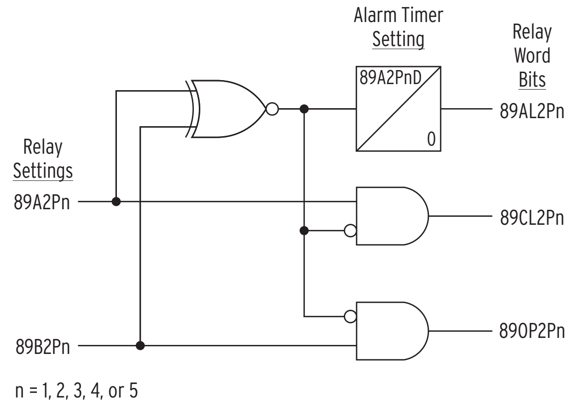
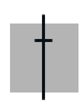
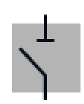


Figure 9.1 Dual-Point Disconnect Status Logic

Table 9.3 provides typical ANSI and IEC disconnect symbols that are available to use in bay screen design. Column 1 identifies the standard (ANSI/IEC) and the type of disconnect. Column 2 identifies the interior color property of the disconnect. Columns 3, 4, and 5 identify closed, open, and alarm states of the disconnect. For a complete list of ANSI and IEC disconnect symbols available to use with the bay screens, refer to the *ACSELERATOR Bay Screen Builder SEL-5036 Software Instruction Manual*.

Table 9.3 Two-Position Disconnect Symbols

Type	Interior Color	State 1 (Closed)	State 2 (Open)	State 3 (Alarm)
ANSI and IEC Disconnect	Gray			
ANSI and IEC Motor-Operated Disconnect	Transparent			

Local/Remote Breaker Control

The SEL-751 supports local/remote breaker control functionality through supervision of the OC and CC breaker control Relay Word bits. The supervision of these breaker control Relay Word bits can be enabled or disabled with the global setting EN_LRC (see *Table 9.4*). To enable local/remote supervision of the breaker control Relay Word bits, set EN_LRC := Y. When EN_LRC := Y, the LOCAL SELOGIC control equation is available.

Table 9.4 Local/Remote Breaker Control Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE LOC REM CON	Y, N	EN_LRC := N
LOCAL CONTROL[a]	SELOGIC	LOCAL := 0

[a] This setting is hidden when EN_LRC := N.

The relay supervises the OC and CC bits based on the EN_LRC setting and the status of the LOCAL Relay Word bit.

- When EN_LRC := Y and LOCAL := 1, the relay processes the OC and CC bits from the front panel (two-line display or touchscreen). The OC and CC bits from remote sources/ protocols (ASCII terminal, SEL Fast Operate, DNP, Modbus, IEC 61850, etc.) are blocked.
- When EN_LRC := Y and LOCAL := 0, the relay processes the OC and CC bits from remote sources/protocols (ASCII terminal, SEL Fast Operate, DNP, Modbus, IEC 61850, etc.). The OC and CC bits from the front panel are blocked (two-line display or touchscreen).
- When EN_LRC := N, the relay processes the OC and CC bits from both the front panel (two-line display or touchscreen) and remote sources/protocols (ASCII terminal, SEL Fast Operate, DNP, Modbus, IEC 61850, etc.).

Enable the local/remote control for proper supervision of breaker control and operator safety. Map the LOCAL SELOGIC control equation to the status of the local/remote switch on the panel, if available. Alternatively, program one of the front-panel pushbuttons and an LED in conjunction with a SELOGIC latch to mimic the local/remote switch and map it to the LOCAL SELOGIC control equation.

When EN_LRC := Y, the status of the local/remote control is indicated on the footer of the touchscreen as "L" for local (LOCAL = 1) and "R" for remote (LOCAL = 0). If you do not intend to use the built-in local/remote function, and prefer to create your own control function using SELOGIC and remote bits, then set EN_LRC := N. In which case, the footer indicates "LR," as shown in *Figure 9.2*, indicating that OC and CC bits are processed from both the touchscreen and remote sources/protocols. Local/remote indication is only available on the SEL-751 touchscreen display model. Refer to *Bay Control Application Example on page 9.13* for example settings.

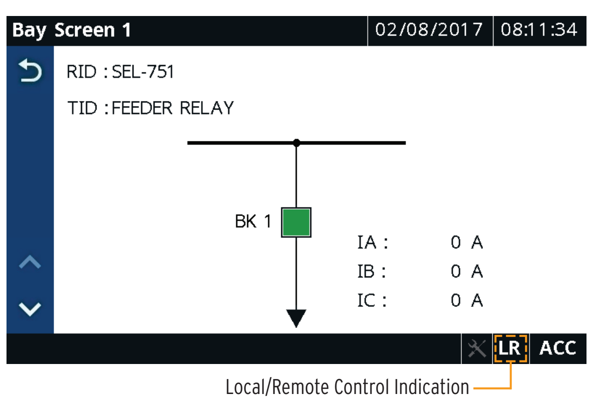


Figure 9.2 Local/Remote Control Mode Indication

Breaker Control Via the Touchscreen

The SEL-751 enables you to control the breaker from the touchscreen or the two-line LCD and through the front-panel operator control pushbuttons. Refer to *Front-Panel Operator Control Pushbuttons on page 8.15* for a discussion on breaker control via the control pushbuttons. Refer to *Control Menu on page 8.9* for instructions on breaker control via the two-line LCD. This section discusses breaker control via touchscreen.

The touchscreen allows you to control the breaker via two applications: **Bay Screens** and **Breaker Control**. The **Bay Screens** application is available on the **Home** screen. Breaker control via the **Bay Screens** application requires you to design a bay control single-line diagram. *Figure 9.3* shows a sample single-line diagram with a controllable breaker, monitor-only disconnects, and analog quantities. For more details on how to design this screen, refer to *Bay Control Application Example*.

You can also control the breaker via the **Breaker Control** application, which is available in the **Control** folder. This application is built-in and is always available for you to perform breaker control. *Figure 9.4* shows the **Breaker Control** application display.

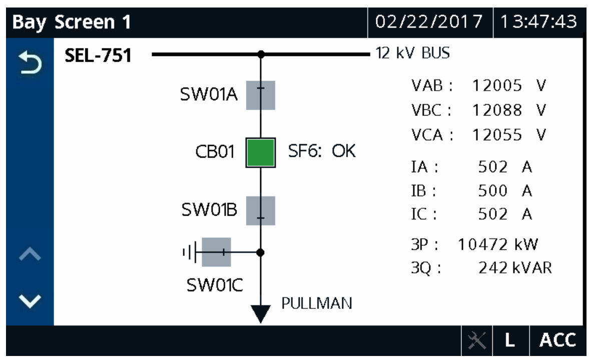


Figure 9.3 Bay Screens Application Display With a Single-Line Diagram

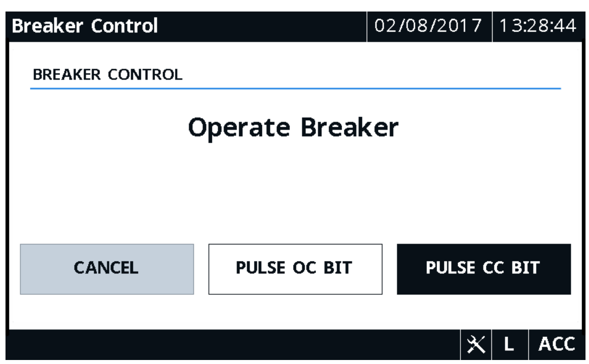


Figure 9.4 Breaker Control Application

The **Bay Screens** and **Breaker Control** applications use the OC and CC bits and require you to program the OC and CC bits into their respective trip (TR) and close (CL) SELOGIC control equations to perform breaker control. For more details on how to program these bits, refer to *Bay Control Application Example*. The relay checks for the following conditions, in the order shown, in both applications. Only when the conditions are satisfied can you perform breaker control.

1. EN_LRC := Y and Relay Word bit LOCAL is asserted. If EN_LRC := N, then this check is ignored.

2. The breaker control jumper on the main board is installed. The Relay Word bit BKJMP stays asserted when the breaker control jumper is installed. Refer to *Password, Breaker Control, and SELBOOT Jumper Selection on page 2.18* for information on the breaker jumper.

3. You are at Access Level 2. The relay prompts for the Access Level 2 password if you are not at Access Level 2.

When the conditions are satisfied, the application pulses the OC or CC bit, respectively, depending on your selection for breaker open or close.

Bay Screens Design Using QuickSet and Bay Screen Builder

QuickSet and Bay Screen Builder provide user-friendly interfaces to set the touchscreen settings. The touchscreen settings are not available for setting via ASCII terminal, unlike the other relay settings. The touchscreen settings are only available if the relay part number is configured with eight pushbuttons and the touchscreen display under **Front-Panel Options** drop down as shown in *Figure 9.5*. *Figure 9.6* shows the **Touchscreen** settings in QuickSet.

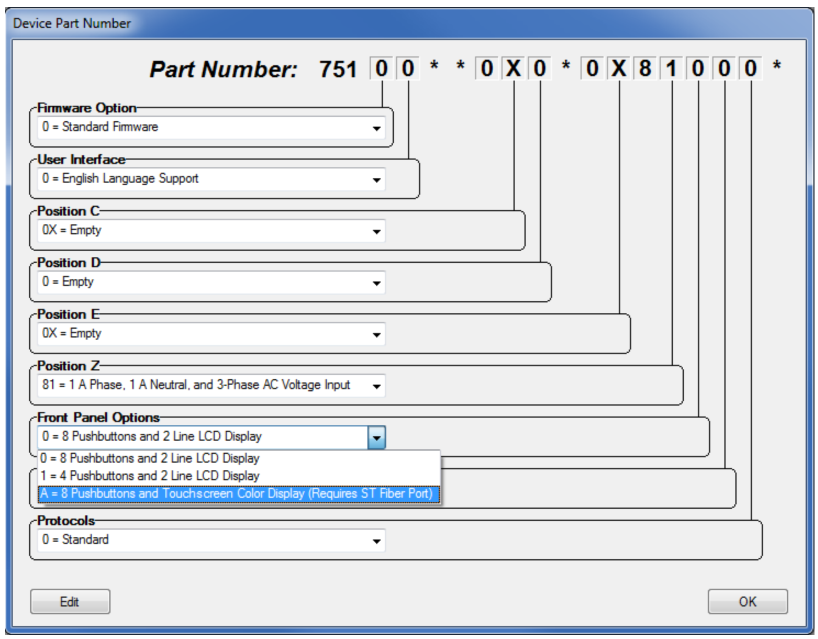


Figure 9.5 QuickSet Front-Panel Options

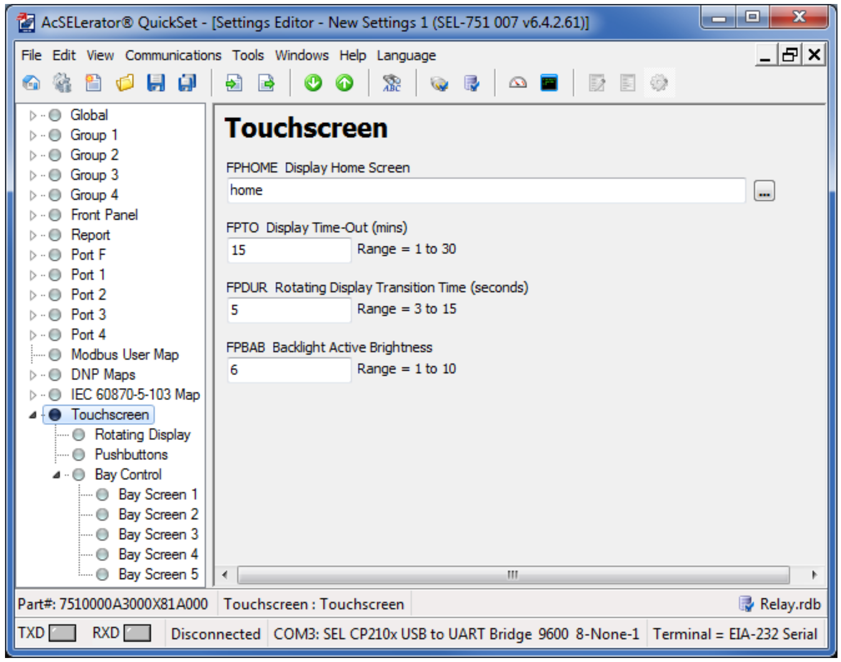


Figure 9.6 QuickSet Touchscreen Settings

NOTE: The touchscreen configuration settings (FPTO, FPDUR, and FPBAB) are available to view and change through the **Touchscreen** application (Figure 8.68) to facilitate field adjustments. Changes made to these settings through the **Touchscreen** application are temporary and the settings are reset to the original QuickSet settings when the relay goes through a power cycle.

Table 9.5 Touchscreen Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
Display Settings		
Display Home Screen	See *Table 8.17*	FPHOME := HOME
Display Time-Out	1–30 min	FPTO := 15
Rotating Display Transition Time	3–15 sec	FPDUR := 5
Backlight Active Brightness	1–10	FPBAB := 6
Rotating Display Screen Settings (kk = 01-16)		
Rotating Display 01	See *Table 8.17*	FPRD01 := Bay Screen 1
Rotating Display *kk*	See *Table 8.17*	FPRD*kk* :=
Pushbutton Settings (nn = 01-08)		
Pushbutton *nn* HMI Screen	OFF, See *Table 8.17*	FPPB*nn* := OFF
Bay Control Breaker Settings		
Breaker Trip Type	3	BK01TTY := 3
Breaker Mode	CONTROL, MONITOR	BK01MOD := MONITOR
Breaker Close Status	Relay Word Bit	BK01CS := 52A
Breaker Open Status	Relay Word Bit	BK01OS := 52B
Breaker Alarm Status	Relay Word Bit	BK01AS := NA
Breaker HMI Close Command	Relay Word Bit	BK01CLC := NA
Breaker HMI Open Command	Relay Word Bit	BK01OPC := NA

Table 9.5 Touchscreen Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
Bay Control Disconnect Switch Settings (nn = 01–05)		
Two-Position Disconnect Mode	MONITOR	2D*nn*MOD := MONITOR
Two-Position Disconnect Close Status	Relay Word Bit	2DS*nn*CS :=
Two-Position Disconnect Open Status	Relay Word Bit	2DS*nn*OS :=
Two-Position Disconnect Alarm Status	Relay Word Bit	2DS*nn*AS :=
Bay Control Analog Label Settings (qq = 01–32)		
Analog Quantity	Analog Quantity	ALAB01 := STRING_RID
Analog Quantity	Analog Quantity	ALAB02 := STRING_TID
Analog Quantity	Analog Quantity	ALAB03 := IA_MAG
Analog Quantity	Analog Quantity	ALAB04 := IB_MAG
Analog Quantity	Analog Quantity	ALAB05 := IC_MAG
Analog Quantity	Analog Quantity	ALAB*qq* :=
Bay Control Digital Label Settings (qq = 01–32)		
Relay Word Bit	Relay Word Bit Name	DLAB*qq* :=

Display Settings

Use these settings to configure the touchscreen. The selection of the **HOME** pushbutton on the front panel takes you to the screen configured as part of the FPHOME setting. By default, FPHOME is set to the **Home** screen, which displays the **Home** screen folders and applications. You can set FPHOME to any screen that you like to view when the **HOME** pushbutton is pressed (see *Table 8.17* for the list of available screens).

To help prevent unauthorized access to password-protected functions, the SEL-751 provides a front-panel timeout setting, FPTO. The timeout resets each time you press a front-panel pushbutton or the screen detects a touch. When the timeout expires, the access level resets to Access Level 1 and switches to the rotating display if at least one screen is configured as part of the rotating display settings, FPRD*kk* (*kk* = 01–16), if not, the display switches to the **Home** screen. The rotating display transition time setting FPDUR defines the duration that each screen is displayed on the rotating display. Set FPDUR to a transition time most suitable to your application.

Use the FPBAB setting to control the backlight active brightness.

Rotating Display Settings

The SEL-751 allows you to configure as many as 16 screens for the rotating display. Configure the settings FPRD*kk* (*kk* = 01–16) to the screens most suitable to your application. Refer to *Table 8.17* for the list of screens available as part of the FPRD*kk* settings.

Pushbutton Settings

The pushbutton settings FPPB*nn* (*nn* = 01–08) allow you to quickly navigate to a specific screen by pressing the programmed pushbutton. Refer to *Table 8.17* for the list of screens available for the FPPB*nn* settings. Note that a given pushbutton can be configured to navigate to a specific screen but can also be used in SELOGIC (e.g., PB08 Relay Word bit). The relay does not prevent you from configuring a pushbutton for two purposes. Make sure to set dual-purpose pushbuttons with care to ensure safe operation.

Bay Control Breaker Settings

Bay control breaker settings are only available if the designed single-line diagram has a breaker symbol. When QuickSet detects a breaker symbol as part of the single-line diagram, it populates the corresponding settings. The SEL-751 supports one three-pole breaker. The setting BK01TTY is forced to 3 by default and is not settable. The breaker on the single-line can be configured as monitor-only or as a controllable breaker. Set BK01MOD = MONITOR if you do not want to allow breaker control via the touchscreen. Set BK01MOD = CONTROL if you want to allow breaker control via the touchscreen. Set BK01CS and BK01OS settings to the corresponding Relay Word bits that indicate the close and open status of the breaker. The relay does not support breaker alarm logic, but it can be programmed using SELOGIC. To display breaker alarm status, set the breaker alarm status setting BK01AS to the corresponding SELOGIC bit. When BK01MOD := CONTROL, both BK01CLC and BK01OPC settings are forced to CC and OC, respectively, and are not settable. Refer to *Bay Control Application Example on page 9.13* for sample breaker settings.

Bay Control Disconnect Switch Settings

The bay control disconnect switch settings are only available if the designed single-line diagram has at least one disconnect symbol. When QuickSet detects one or more disconnect symbols as part of the single-line diagram, it populates the corresponding settings. The SEL-751 supports five monitor-only, two-position disconnects. The setting 2D*nn*MOD (*nn* = 01–05) is forced to MONITOR by default and is not settable. Set 2DS*nn*CS and 2DS*nn*OS settings to the corresponding Relay Word bits that indicate the close and open status of the disconnect. Map the output of the disconnect alarm logic, 89AL2P*n* (see *Figure 9.1*), to the corresponding 2DS*nn*AS setting. Refer to *Bay Control Application Example on page 9.13* for sample disconnect switch settings.

Bay Control Analog Label Settings

The analog label settings are only available if the designed bay screen has at least one analog label. When QuickSet detects one or more analog labels as part of the bay screen, it populates the corresponding settings. The SEL-751 supports as many as 32 analog labels. Set ALAB*qq* (*qq* = 01–32) to display the desired analog quantity on the bay screen. Refer to the display points column of *Table L.1* for the list of analog quantities available to program into analog labels.

Bay Control Digital Label Settings

The digital label settings are only available if the designed bay screen has at least one digital label. When QuickSet detects one or more digital labels as part of the bay screen, it populates the corresponding settings. The SEL-751 supports as many as 32 digital labels. Set DLAB*qq* (*qq* = 01–32) to display the desired Relay Word bits on the bay screen. Refer to *Table K.1* for the list of Relay Word bits available to program into digital labels.

Bay Screen Builder Software

NOTE: Refer to the Product Literature CD for a list of UTF-8 characters that can be rendered on the bay screen in Bay Screen Builder.

The Bay Screen Builder Software provides an intuitive and powerful interface to design bay screens to meet your application needs. This instruction manual provides only a brief overview of the Bay Screen Builder Software. For more details, refer to the *ACSELERATOR Bay Screen Builder SEL-5036 Software Instruction Manual* available from the **Help** > **Contents** menu in Bay Screen Builder or at selinc.com.

Several of the settings identified in *Table 9.5* are available for you to set depending on the symbols chosen for your single-line diagram. *Figure 9.7* shows the layout of Bay Screen Builder and identifies different menus, panes, and information.

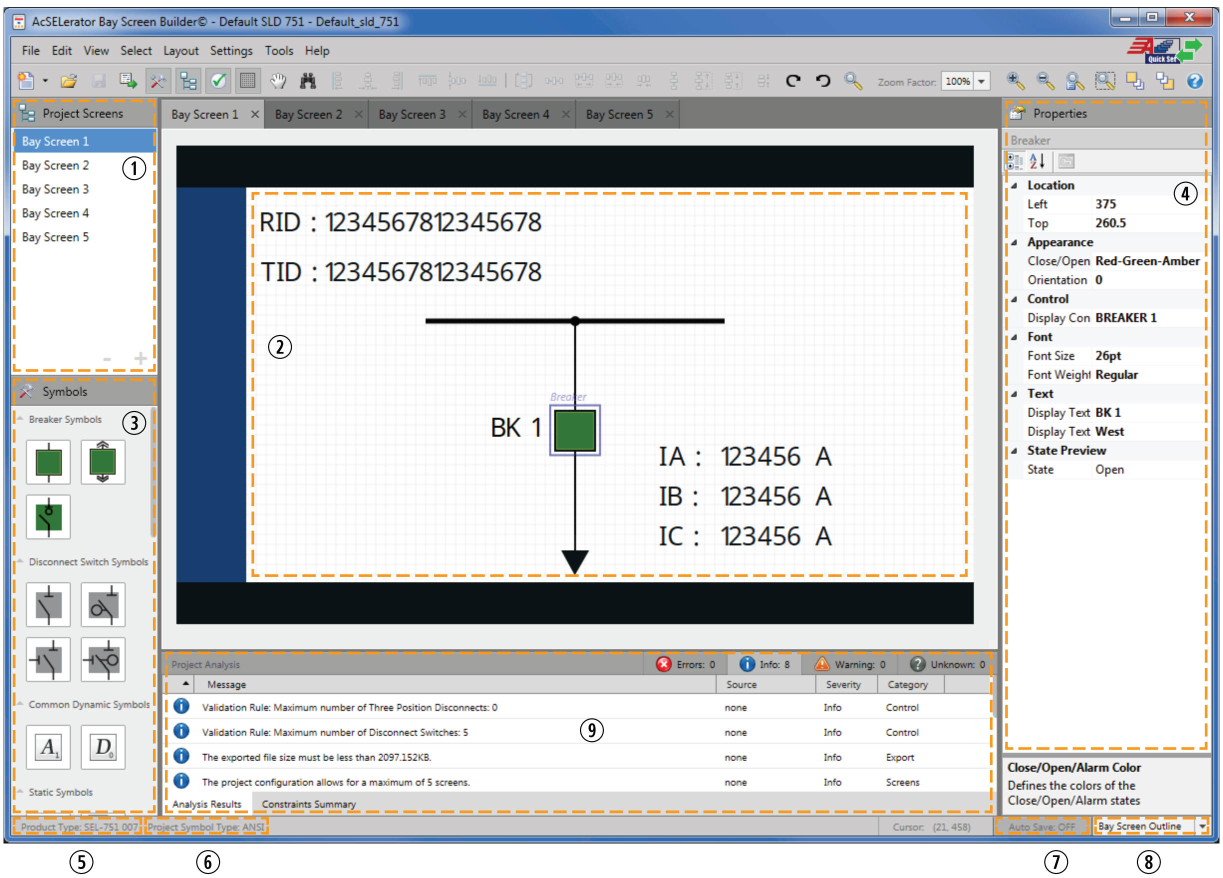


Figure 9.7 Layout of Bay Screen Builder

Descriptions of the different menus, panes, and information in Bay Screen Builder are as follows:

① **Project Screens Pane:** Displays the names of the screens (as many as 5) present in a project. Click a screen name to open the screen, and double-click or right-click a screen name to access additional options for that screen.

② **Screen Area:** Displays the selected project screen and its symbols. Create a single-line diagram or a metering or status screen by dragging and dropping symbols from the **Symbols** pane.

③ **Symbols Pane:** Displays the symbols available for selection. Bay Screen Builder supports several static and a limited number of dynamic ANSI and IEC symbols. Note that for a given project, you can only use either ANSI *or* IEC symbols, not both. While there are no constraints on the number of static symbols, Bay Screen Builder limits the number of dynamic symbols. The following table provides the number of breakers, disconnect switches, analog labels, and digital labels supported in a given project.

Symbols	Number of Supported Symbols per Project
Breakers	1
Disconnects	5
Analog Labels	32
Digital Labels	32

④ **Properties Pane:** Displays the properties of a selected symbol. Edit the symbol properties as needed for your application. For instance, the breaker color sequence property identified in *Table 9.1* can be set via the appearance property of the breaker symbol (refer to *Edit Symbol Properties on page 9.16*). Bay Screen Builder supports UTF-8 character encoding. Refer to the Product Literature CD for a complete list of UTF-8 characters that can be rendered on the touchscreen display.

⑤ **Product Type:** Displays the name of the QuickSet driver version of the product associated with the selected project (e.g., SEL-751 007, as shown in *Figure 9.7*). Select the product type in Bay Screen Builder when you create a new project independent of QuickSet. View **Product Type** though **Settings** > **Project Settings**. If a project is edited via QuickSet, Bay Screen Builder inherits the product type from the QuickSet settings file.

⑥ **Project Symbol Type:** Displays the symbol type (IEC or ANSI) associated with the selected project as shown in *Figure 9.7*. Select the symbol type when you create a new project. If a project is edited via QuickSet, the ANSI symbol type is selected by default.

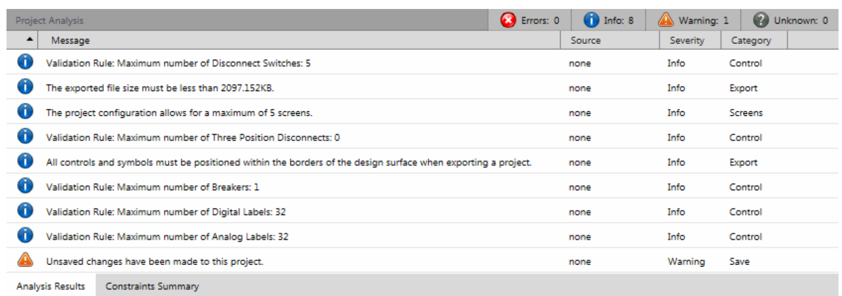
⑦ **Auto Save:** Provides a shortcut for changing the auto save setting for the application. Enable **Auto Save** to allow Bay Screen Builder to automatically save your project periodically. Your auto save setting preference is saved when you exit the application and is applied the next time you launch Bay Screen Builder. You can also set **Auto Save** through **Settings** > **Application Settings** > **File Handling**.

⑧ **Bay Screen Outline:** Displays the drop-down list of symbols on the presently open screen. Click a symbol from the list to make it active. The bay screen outline provides an alternate way to select the symbols and is most useful in cases where symbols are crowded or stacked.

⑨ **Project Analysis Pane:** Displays troubleshooting information/ messages about the project (Errors, Info, Warning, Unknown). The project analysis pane supports two tabs: **Analysis Results** and **Constraints Summary**, as shown in *Figure 9.6* and *Figure 9.7*, respectively.

The **Analysis Results** tab displays details about the error, information, warning, and unknown messages for the project. You can use these messages for troubleshooting. Select a message type button to view the messages for that category. For example, click the **Errors** button to view the error messages for the project. Click a column header to sort by the information in that column (see *Figure 9.8*).

The **Constraints Summary** tab provides information about the rules that apply to the present project. All conditions listed under **Symbol Constraints** must be satisfied for a project to be valid. You can only publish a valid project, but you can save a project with errors (see *Figure 9.9*).



Project Analysis — Errors: 0 — Info: 8 — Warning: 1 — Unknown: 0

Message	Source	Severity	Category
Validation Rule: Maximum number of Disconnect Switches: 5	none	Info	Control
The exported file size must be less than 2097.152KB.	none	Info	Export
The project configuration allows for a maximum of 5 screens.	none	Info	Screens
Validation Rule: Maximum number of Three Position Disconnects: 0	none	Info	Control
All controls and symbols must be positioned within the borders of the design surface when exporting a project.	none	Info	Export
Validation Rule: Maximum number of Breakers: 1	none	Info	Control
Validation Rule: Maximum number of Digital Labels: 32	none	Info	Control
Validation Rule: Maximum number of Analog Labels: 32	none	Info	Control
Unsaved changes have been made to this project.	none	Warning	Save

Analysis Results — Constraints Summary

Figure 9.8 Project Analysis Pane: Analysis Results Tab

NOTE: The **Constraints Summary** tab shows the usage and limits of dynamic symbols for an entire project (all screens). Although not constrained, it is recommended that you limit the dynamic symbols to 32 symbols per screen for faster screen updates.

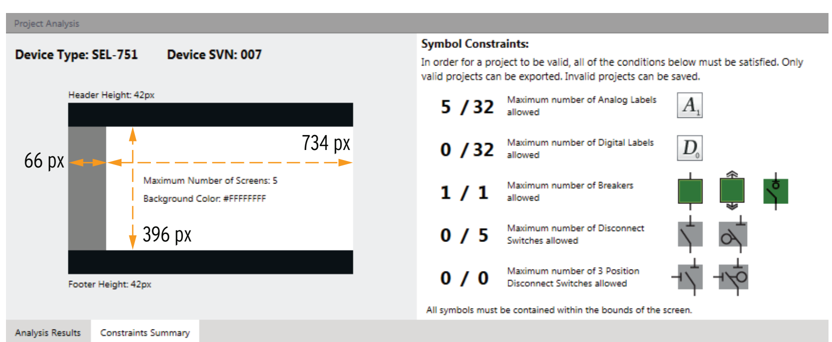


Figure 9.9 Project Analysis Pane: Constraints Summary Tab

You can adjust the size of the panes in the application. If you reconfigure the size of any of these panes, the new size is saved when you exit the application and applies the next time you launch Bay Screen Builder.

Bay Control Application Example

Specific components of bay screens are covered in *Bay Screens Design Using QuickSet and Bay Screen Builder*. This section provides a summarized application example tying all the components together. Refer to the *ACSELERATOR Bay Screen Builder SEL-5036 Software Instruction Manual*, available from the **Help** > **Contents** menu in Bay Screen Builder or at selinc.com, for more specific details regarding bay screen creation and symbol properties.

The SEL-751 supports as many as five custom screens. You can edit the predefined bay screen (Bay Screen 1) and the blank screens (Bay Screen 2, Bay Screen 3, Bay Screen 4, Bay Screen 5) (see *Figure 9.12*). You can also import one of the five predefined bay control single-line diagrams from the instruction manual CD. Refer to *Predefined Bay Control Single-Line Diagrams on page 9.23* for more details.

Consider if you were to create the single-line diagram shown in *Figure 9.10* as part of your application. Use the following step-by-step approach to design the single-line diagram beginning with the predefined bay screen (Bay Screen 1).

Before creating your own diagram, ensure that the number of dynamic symbols in your schematic does not exceed the number allowed by the SEL-751 (see *Figure 9.7* and the symbols pane description).

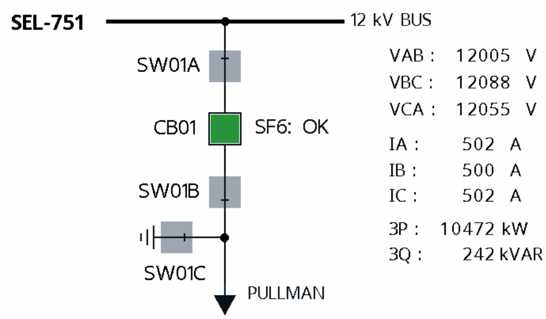


Figure 9.10 Bay Control Single-Line Diagram Schematic

Configure QuickSet for Bay Screen Builder

NOTE: The touchscreen display option is only available for SEL-751 QuickSet drivers 007 and higher.

To use QuickSet and Bay Screen Builder to create bay screens for the SEL-751, your relay must have the touchscreen MOT configuration (an "A" in the 13th place of the part number). When your relay is configured for the touchscreen option, perform the following steps to configure QuickSet to work with Bay Screen Builder.

Step 1. Create an SEL-751 settings file configured for the touchscreen display. Use the **Front-Panel Options** drop down to select the touchscreen option (see *Figure 9.11*).

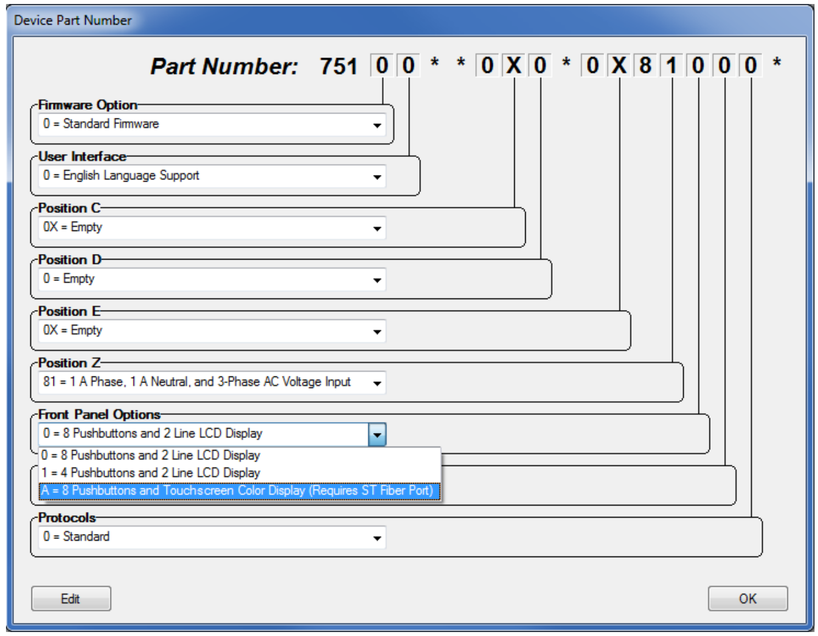


Figure 9.11 Device Part Number Touchscreen Configuration Option

Step 2. Click **OK**.

Step 3. Expand the **Touchscreen** settings class.

Step 4. Click **Bay Control**.

QuickSet displays project management buttons and a project preview that includes a small-scale view of five project screens (one screen with a predefined single-line diagram and four blank screens) and an enlarged view of the predefined single-line diagram, which is selected by default (see *Figure 9.12*).

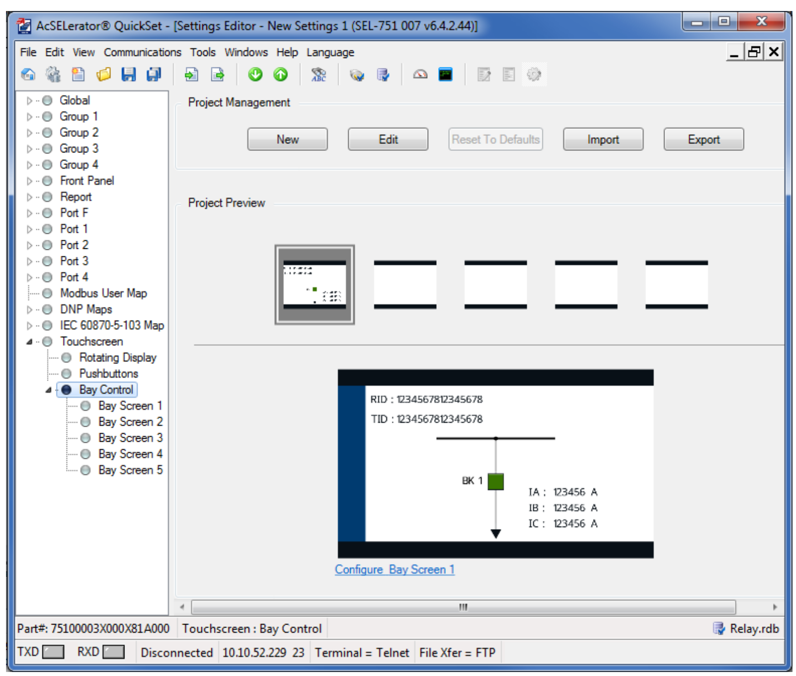


Figure 9.12 QuickSet Bay Control Project Management and Project Preview Display

Build Single-Line Diagrams in Bay Screen Builder

Use Bay Screen Builder to create single-line diagrams to load onto the SEL-751 Relay through QuickSet. To create the single-line diagram shown in *Figure 9.10*, perform the following steps.

Step 1. Select the screen with the predefined single-line diagram shown in *Figure 9.13* as a starting point for your single-line diagram.

Step 2. Click the **Edit** button (*Figure 9.13*) to open the screen with the predefined single-line diagram in Bay Screen Builder.

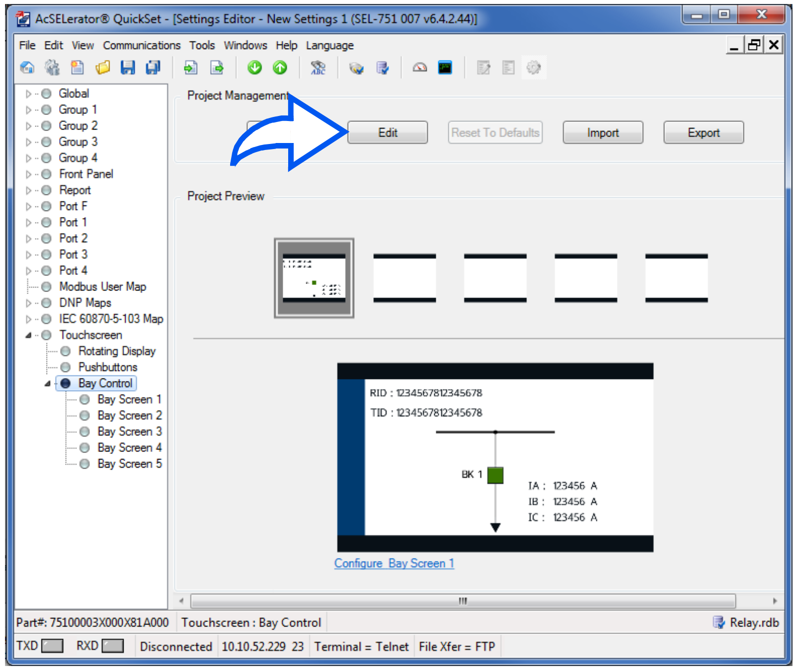


Figure 9.13 Open Single-Line Diagram in Bay Screen Builder

Step 3. Drag-and-drop the additional symbols required for your single-line diagram onto the screen area from the **Symbols** pane (see *Figure 9.14*). Remove the unused labels (RID/TID).

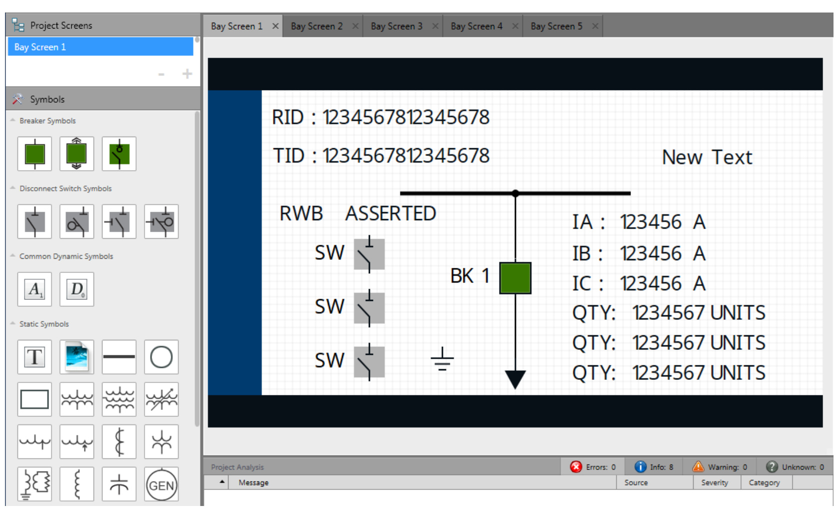
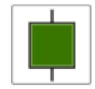
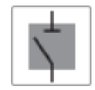
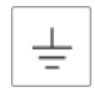
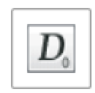
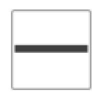


Figure 9.14 Drag-and-Drop Symbols

Table 9.6 lists the number of each symbol required to draw the single-line diagram shown in *Figure 9.10*.

Table 9.6 Symbols Required for the Single-Line Diagram Schematic in Figure 9.10

Symbols Required	Number of Symbols Required	Symbol
Breaker	1	
Disconnect switches	3	
Ground	1	
Analog labels (display voltages, currents, and power)	8	
Digital label (display breaker SF6 gas pressure OK or LOW)	1	
Text boxes (identify the relay, feeder name, nominal bus voltage)	3	
Line (draw the bus and connections)	As Needed	

Edit Symbol Properties

All of the symbols in Bay Screen Builder include editable properties. These properties allow you to customize the symbols to your specific application. These properties appear in the right **Properties** pane of Bay Screen Builder either when you drag a symbol from the left **Symbols** pane and drop it in the screen area or when a symbol in the screen area is selected.

For example, you can use the **Close/Open/Alarm Color** property in the **Appearance** tab of the breaker properties to select a color scheme for your single-line diagram breaker.

Step 1. Select the existing breaker symbol in the predefined single-line diagram to display the breaker symbol properties in the **Properties** pane, as shown in *Figure 9.15*.

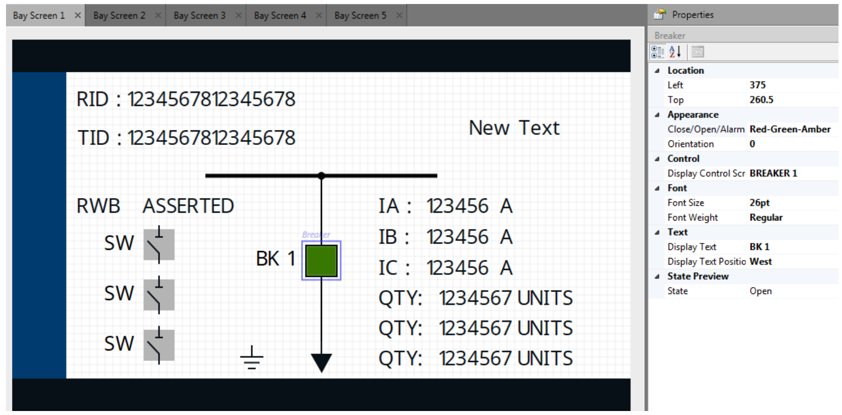


Figure 9.15 Selected Breaker Symbol Settings Displayed in the Properties Pane

Step 2. Select a color option from the drop down menu to edit the **Close/Open/Alarm Color** property in the **Appearance** tab (see *Figure 9.16*).

Table 9.1 lists the available options and breaker appearance in each state based on the selected property.

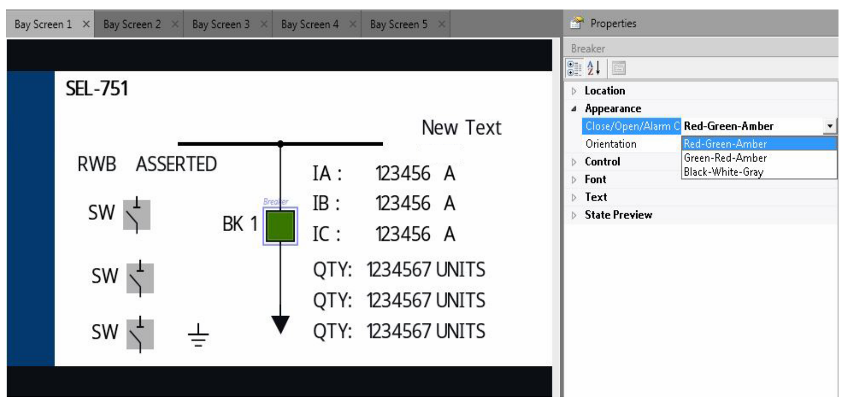


Figure 9.16 Close/Open/Alarm Color Property Drop Down Menu

Step 3. Use the **State Preview** tab to view your breaker close, open, and alarm state color selections.

Step 4. Edit the additional properties as needed for your application.

NOTE: The assignment of breaker Relay Word bits (e.g., 52A, 52B) to breaker symbols, or analog quantities (e.g., VA_MAG) to analog labels, cannot be made in Bay Screen Builder. These assignments can only be made in QuickSet.

Select and edit the disconnect switches, dynamic labels (analog and digital labels), and static symbols, similar to the breaker symbol. Note that some of the symbols have the **Text** tab that can be edited for custom labeling.

In this example, only **Bay Screen 1** has been modified in the project. You can also modify the other screens to add analog/digital labels to monitor the status of the quantities, if necessary. Publish the project using the following process after saving your edits.

Publish Bay Screen Builder Project

When you have completed your single-line diagram in Bay Screen Builder, you are ready to publish your project to QuickSet.

Step 1. Click **Save Project** in the **File** menu to save your project.

Step 2. Click **Publish Package** in the **File** menu to publish your project (see *Figure 9.17*). Bay Screen Builder exports the project into QuickSet.

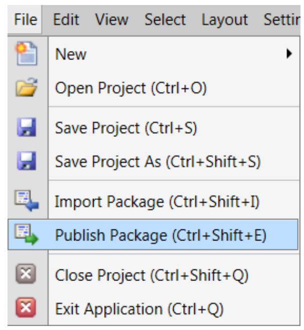


Figure 9.17 Publish Bay Screen Builder Project to QuickSet

Step 3. Allow a few seconds for Bay Screen Builder to publish the project to QuickSet. Respond to the QuickSet prompt, if presented. QuickSet then populates the settings of the updated single-line diagram (see *Figure 9.18*).

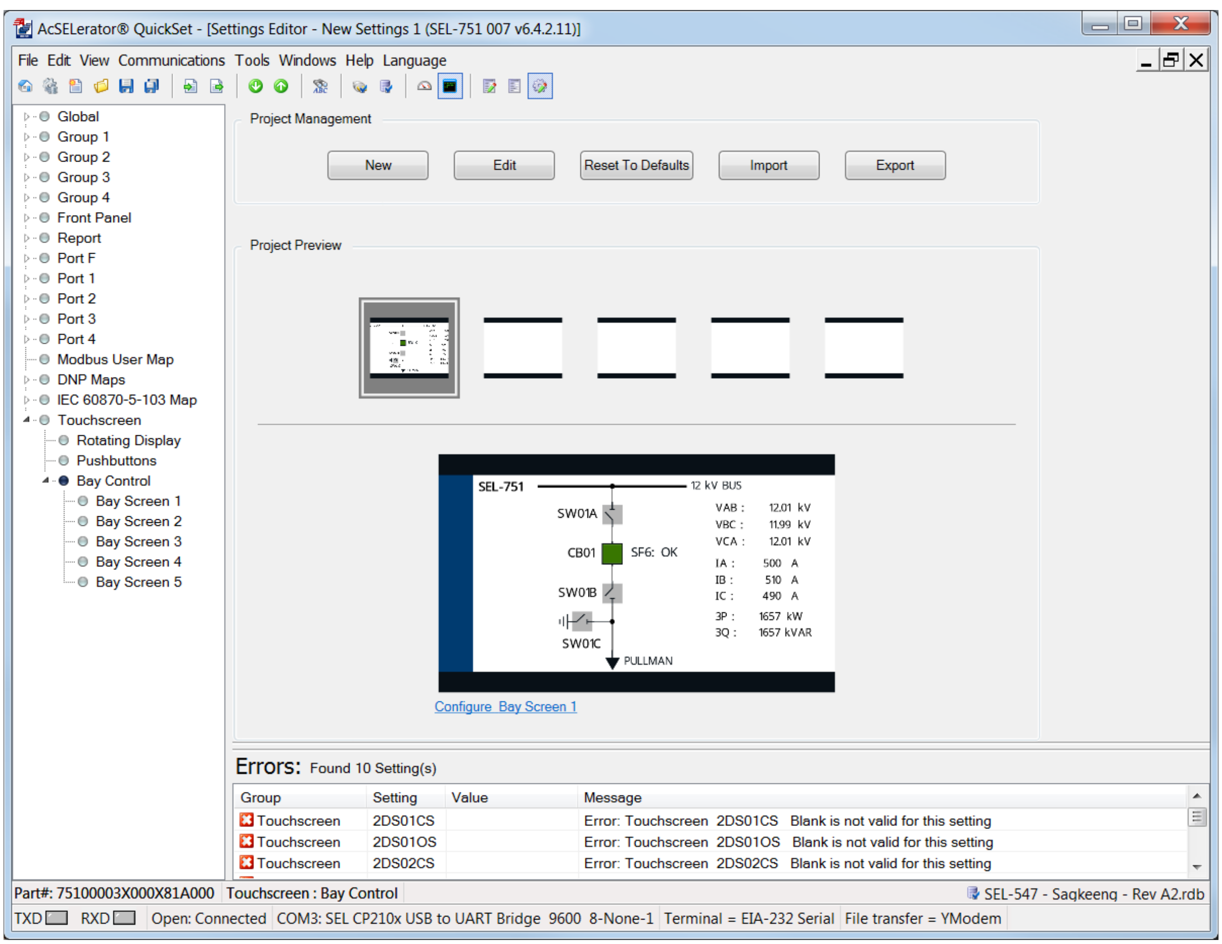


Figure 9.18 QuickSet Updated Single-Line Diagram and Corresponding Settings

Enter QuickSet Settings

The breaker, disconnect, analog and digital label, local/remote, and trip and close settings that follow are the settings applicable to the single-line diagram shown in *Figure 9.10*. Enter the following settings:

Breaker Settings

NOTE: The relay does not support dual-point breaker status (see Bay Control Breaker Settings) and uses the 52A Relay Word bit as the state of the breaker in several of the protection elements, including trip and close logic. If you intend to indicate dual-point status on the bay control single-line diagram, make use of SELOGIC to program this logic similar to the one shown in Figure 9.1.

For *Figure 9.10*, assume the breaker auxiliary contacts 52A and 52B are wired to digital inputs IN101 and IN102, respectively. SELOGIC settings SV01–SV03 are programmed to create dual-point breaker status with alarm to mimic the logic shown in *Figure 9.1*. Breaker settings are included in more than one settings class in QuickSet (**Set 1** and **Logic 1** in **Group**, **Bay Control**). Enter the following settings:

Setting	Example Setting	Comment
Group 1 > Set 1 > Trip and Close Logic		
52A	IN101	
52B	IN102	
Group 1 > Logic 1 > SELOGIC Variables and Timers		
SV01	(52A AND 52B) OR (NOT 52A AND NOT 52B)	(XNOR gate)
SV01PU	0.5	Set pickup time to indicate alarm for undetermined breaker state
SV01DO	0.0	
SV02	NOT SV01 AND 52A	Indicates breaker close status when asserted
SV02PU	0.0	
SV02DO	0.0	
SV03	NOT SV01 AND 52B	Indicates breaker open status when asserted
SV03PU	0.0	
SV03DO	0.0	
Touchscreen > Bay Control > Bay Screen 1		
Breaker Mode	CONTROL	Controllable breaker
Breaker Close Status	SV02T	
Breaker Open Status	SV03T	
Breaker Alarm Status	SV01T	
Breaker HMI Close Command[a]	CC	
Breaker HMI Open Command[a]	OC	

[a] Settings are forced to CC and OC, respectively, and are not available for setting.

Disconnect Switch Settings

For this example, the relay has an 8 DI card in Slot C. Also, the disconnect switch auxiliary contacts 89A and 89B for each of the three disconnect switches are wired to digital inputs IN301, IN302, IN303, IN304, IN305, and IN306. Disconnect settings are included in more than one settings class in QuickSet (**Global**, **Bay Control**). Enter the following settings:

Setting	Example Setting	Comment
Global > Two-Position Disconnect Settings		
89A2P1	IN301	Disconnect 1, A contact
89B2P1	IN302	Disconnect 1, B contact
89A2P2	IN303	Disconnect 2, A contact
89B2P2	IN304	Disconnect 2, B contact
89A2P3	IN305	Disconnect 3, A contact
89B2P3	IN306	Disconnect 3, B contact
Touchscreen > Bay Control > Bay Screen 1		
Two-position disconnect close status	89CL2P1	Switch SW01A
Two-position disconnect open status	89OP2P1	
Two-position disconnect alarm status	89AL2P1	
Two-position disconnect close status	89CL2P2	Switch SW01B
Two-position disconnect open status	89OP2P2	
Two-position disconnect alarm status	89AL2P2	
Two-position disconnect close status	89CL2P3	Switch SW01C
Two-position disconnect open status	89OP2P3	
Two-position disconnect alarm status	89AL2P3	

Analog Label Settings

Enter the following **Bay Control**, **Bay Screen 1** settings:

Setting	Example Setting
VAB	VAB_MAG
VBC	VBC_MAG
VCA	VCA_MAG
IA	IA_MAG
IB	IB_MAG
IC	IC_MAG
3P	P
3Q	Q

Digital Label Settings

In *Figure 9.10*, Breaker SF6 gas pressure alarm is wired to IN307 of the relay.

Enter the following **Bay Control**, **Bay Screen 1** setting:

Setting	Example Setting	Comment
SF6	IN307	SF6 breaker

Local/Remote Control Setting

Figure 9.10 is programmed with the local/remote functionality.

Enter the following **Global**, **Control Configuration** setting:

Setting	Example Setting	Comment
EN_LRC	Y	Enable local/remote control

Application With Handheld Local Remote Breaker Control Switch

Assume that the handheld local remote breaker control switch status is wired to IN308 of the relay. In this particular application, when IN308 is asserted, it implies that the breaker control is in LOCAL mode (or SCADA is cut off).

Enter the following **Global**, **Control Configuration** setting:

Setting	Example Setting	Comment
LOCAL	IN308	Local/remote control selection

Application Without Handheld Local Remote Breaker Control Switch

Assume that no handheld local remote breaker control switch is available. In such case you can program one of the programmable pushbuttons (e.g., PB05) in conjunction with SELOGIC to switch the breaker control between local and remote. Enter the following settings:

Setting	Example Setting	Comment
Group 1 > Logic 1 > SELOGIC Variables and Timers		
ELAT	1	
SET01	PB05_PUL AND NOT LT01	Local when LT01 is asserted
RST01	PB05_PUL AND LT01	Remote when LT01 is deasserted
Front Panel[a]		
PB5ALEDC	GO	
PB5A_LED	LT01	
PB5BLEDC	GO	
PB5B_LED	NOT LT01	
Global > Control Configuration		
LOCAL	LT01	

[a] Use configurable labels to assign PB5A LED to LOCAL and PB5B LED to REMOTE.

Trip and Close Settings

To be able to perform breaker control from the touchscreen or two-line display, program the OC and CC bits in the trip and close SELOGIC control equations, respectively.

Enter the following **Group** settings:

Setting	Example Setting	Comment
TR	ORED50T OR ORED51T OR ORED81T OR REMTRIP OR OC OR SV04T	Trip logic
CL	SV03T AND LT02 OR CC	Close logic

Send all active settings to the relay.

To view the designed bay control single-line diagram on the touchscreen display, perform the following steps:

Step 1. Navigate to the **Home** screen.

Step 2. Select the **Bay Screens** application.

Step 3. Use the **Up** and **Down** arrows to view your screens.

With all the previous settings applied to the relay, you have a bay control single-line diagram that provides the status of the breaker and disconnects and provides you with the ability to perform breaker control via the touchscreen, as shown in *Figure 9.19*. In addition, you have the ability to monitor the voltages at the bus, the flow of currents and power through the breaker, and the status of the breaker SF6 gas pressure.

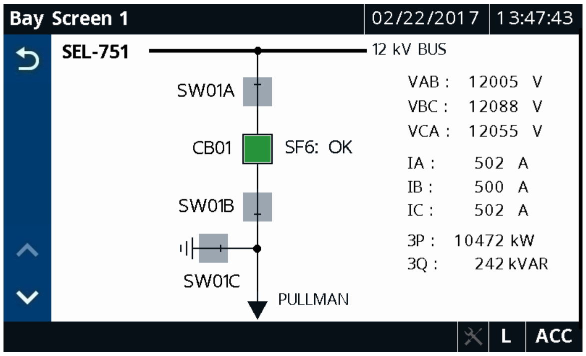


Figure 9.19 Final Bay Screen Builder Rendering

Export/Import Bay Screen Builder Project File

If you plan to use the same Bay Screen Builder project file (*.ldme) across multiple relays, export the file as shown in *Figure 9.20* and save the file to import it to another relay. The *.ldme file does not save the settings associated with the bay control symbols.

Alternately, QuickSet allows you to save the Bay Screen as well as all of the corresponding analog and digital quantities settings (**Tools** > **Settings** > **Export** > **Touchscreen**).

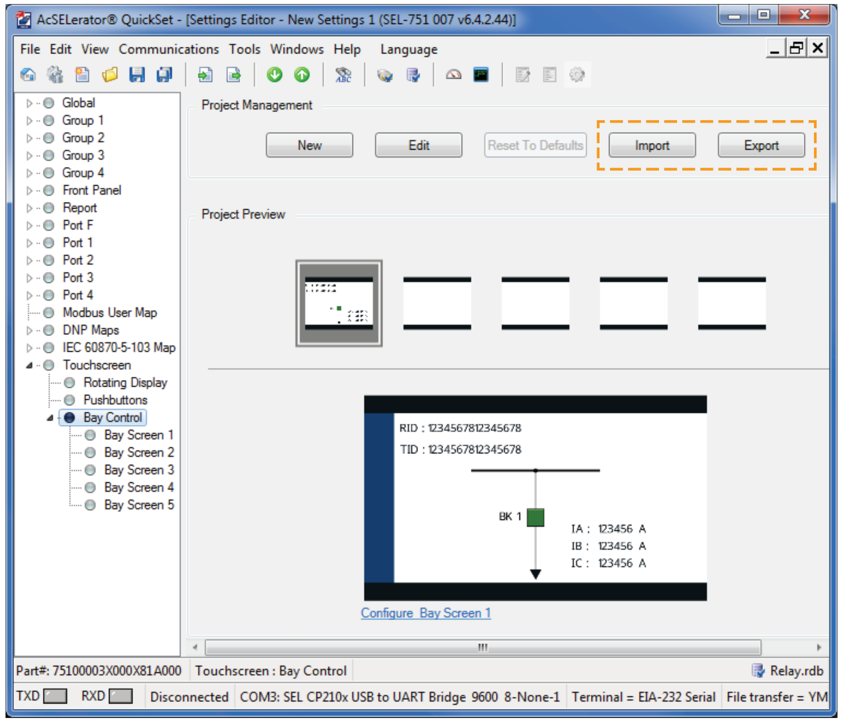


Figure 9.20 Import/Export of the Bay Control Screen in QuickSet

Reset to Defaults

Click **Reset to Defaults** in the QuickSet **Project Management** section to restore the default project in QuickSet.

Predefined Bay Control Single-Line Diagrams

Bay Screen Builder provides the ability to design bay control single-line diagrams. The following predefined single-line diagrams are available on the instruction manual CD. You can use them as is or edit them to fit your specific application. Any one of the following single-line diagrams can be imported into Bay Screen Builder in place of the existing predefined single-line diagram. Use the **Import** button in the **Project Management** area of QuickSet to import one of the screens provided on the instruction manual CD.

All the predefined single-line diagram templates are created with ANSI symbols. To create a single-line diagram with IEC symbols, click the **New** button in QuickSet to start a new Bay Screen Builder project and select IEC as the symbol type.

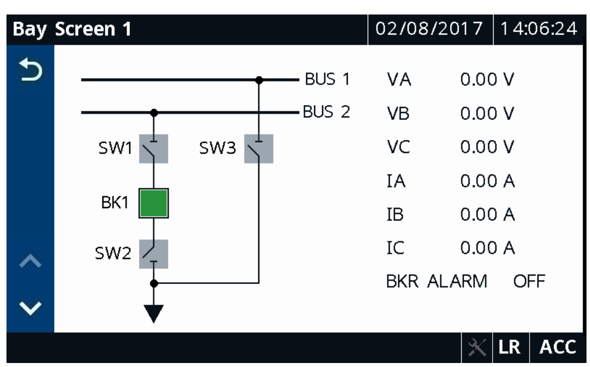


Figure 9.21 Main Bus and Transfer Bus Bay Control Single-Line Diagram

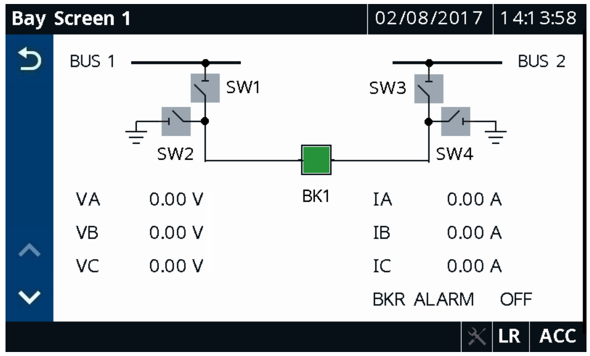


Figure 9.22 Tie Breaker Bay Control Single-Line Diagram

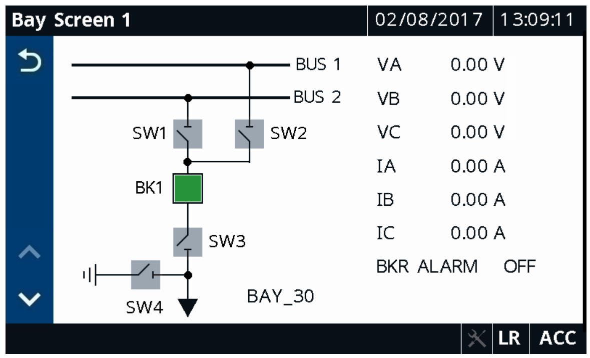


Figure 9.23 Bus 1 and Bus 2 Bay Control Single-Line Diagram

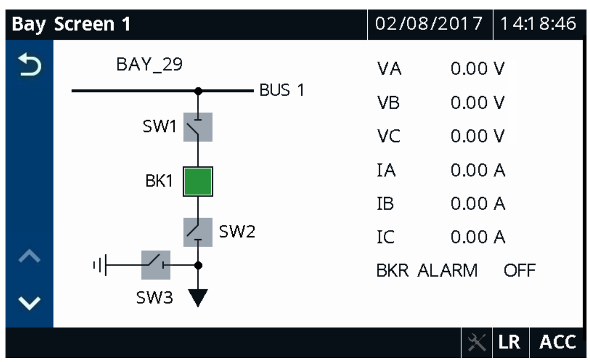


Figure 9.24 Feeder Bay Control Single-Line Diagram

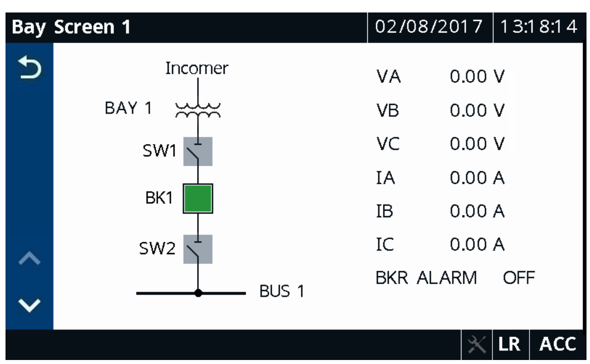


Figure 9.25 Incomer With Step-Down Transformer Bay Control Single-Line Diagram

Section 10
Analyzing Events

Overview

The SEL-751 Feeder Protection Relay provides several tools (listed below) to analyze the cause of relay operations. Use these tools to help diagnose the cause of the relay operation and more quickly restore the protected equipment to service.

- Event Reporting
  - Event Summary Reports
  - Event History Reports
  - Event Reports
- Sequential Events Recorder Report
  - Resolution: 1 ms
  - Accuracy: ±1/4 cycle

All reports are stored in nonvolatile memory, ensuring that a loss of power to the SEL-751 does not result in lost data. The SEL-751 offers four styles of event reports: Standard ASCII (EVE) reports, Compressed ASCII (CEV) reports, Binary COMTRADE reports, and Sequential Event Recorder (SER) reports.

Event Reporting

Analyze events with the following event reporting functions:

- Event Summaries—Enable automatic messaging to allow the relay to send event summaries out a serial port when port setting AUTO := Y. A summary provides a quick overview of an event. You can also retrieve the summaries by using the **SUMMARY** command.
- Event History—The relay keeps an index of stored nonvolatile event reports. Use the **HISTORY** command to obtain this index. The index includes some of the event summary information so that you can identify and retrieve the appropriate event report.
- Event Reports—These detailed reports are stored in nonvolatile memory for later retrieval and detailed analysis.

NOTE: Arc-flash sensor light values and frequency are available only in Compressed ASCII event reports (**CEV** or **CEV R** commands)

NOTE: Models without voltage inputs will not show voltage values in the event reports.

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 K.1*)

- Event summary, including the front-panel target states at the time of tripping, fault type, and fault location.
- Group, Logic, Global, and Report settings (that were in service when the event was recorded)

Compressed Event Reports

The SEL-751 provides Compressed ASCII and COMTRADE 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 and COMTRADE formats. Use the **CHIS** command to display Compressed ASCII event history information. Use the **CSUM** command to display Compressed ASCII event summary information. Use the **CEVENT** command to display Compressed ASCII event reports.

For accurate event report analysis, use the Compressed Event report with raw (unfiltered) data (**CEV R** command). The regular ASCII Event report is useful for a quick check. See *Table C.2* for further information.

Compressed ASCII Event Reports contain *all* of the Relay Word bits. Additionally, the SEL-751 Compressed Event (**CEV** command) report includes analog channels for the % arc-flash sensor light values and frequency measurements that are not available in the regular ASCII Event (**EVE** command) report.

Sequential Events Recorder (SER)

The SER report captures digital element state changes over time. Settings allow as many as 96 Relay Word bits to be monitored, in addition to the automatically generated triggers for relay power up, settings changes, and active setting group changes. State changes are time-tagged to the nearest millisecond. SER information is stored when state changes occur.

SER report data are useful in commissioning tests and during operation for system monitoring and control.

Event Reporting

Length

IMPORTANT: Changing the LER setting clears all events in memory. Be sure to save critical event data prior to changing the LER setting.

The SEL-751 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 six of the most recent 180-cycle, seventeen of the most recent 64-cycle, or as many as seventy of the most recent 15-cycle event reports in nonvolatile memory. Refer to the **SET R** command in *SET Command (Change Settings) on page 7.47* and *Report Settings (SET R Command) on page SET.66*.

Triggering

The SEL-751 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 TR

Refer to *Figure 4.79*. If Relay Word bit TR 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 7.47*). When setting ER detects a logical 0 to logical 1 transition, it generates an event report (if the SEL-751 is not already generating a report that encompasses the new transition). The factory setting is shown in *Event Report Settings on page 4.207*.

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 7.57* for more information on the **TRI** (Trigger Event Report) command.

Event Summaries

IMPORTANT: Clearing the HISTORY report with the **HIS C** or **HIS CA** commands also clears all event data within the SEL-751 event memory.

NOTE: The **HIS CA** command resets the unique event reference number to 10000.

For every triggered event, the relay generates and stores an event summary. The relay stores as many as 70 of the most recent event summaries (if event report length setting LER := 15), as many as 17 (if LER := 64), or as many as 6 (if LER := 180). When the relay stores a new event summary, it discards the oldest event and event summary if the event memory is full. Event summaries contain the following information:

- The relay and terminal identification (RID and TID)
- The event number, unique event reference number, date, time, event type, fault location, and frequency (see *Table 10.1*)
- The primary magnitudes of line, neutral and residual currents
- The primary magnitudes of the line-to-neutral voltages and residual voltage (if DELTA_Y := WYE) or phase-to-phase voltages (if DELTA_Y := DELTA)
- The hottest RTD temperatures

The relay includes the event summary in the event report. The identifiers, date, and time information are at the top of the event report, and the remaining information follows at the end (See *Figure 10.3*). The example event summary in *Figure 10.1* corresponds to the standard 15-cycle event report in *Figure 10.3*.

```
=>>SUM <Enter>

SEL-751                                    Date: 02/03/2015   Time: 10:51:34.267
FEEDER RELAY

Serial No = 000000000000000
FID = SEL-751-X272-V0-Z006002-D20150103                   CID = 2038
EVENT LOGS =  5
REF_NUM = 10016

Event:            BG T
Location              64.2
Targets           11100001
Freq (Hz)             60.0
```

Figure 10.1 Example Event Summary

```
Current Mag
       IA          IB          IC          IN       IG
(A)      2.3         9.3         8.5         0.01     2.97

Voltage Mag
      VAB    VBC    VCA
(V)     72    110     76
```

Figure 10.1 Example Event Summary (Continued)

The relay sends event summaries to all serial ports with setting AUTO := Y each time an event triggers.

Event Logs

The Event Logs field shows the number of events presently stored in the Flash memory of the relay.

Event Reference Number

The Event Reference Number is a unique event identification number assigned to the event. The unique event identification number of any event can be found by issuing the **HIS** command (see ***Viewing the Event History on page 10.8*** for details). The Event Reference Number starts at 10000 and increments with each new event to a maximum of 42767. The Event Reference Number rolls over to 10000 after reaching the next event after event 42767. The Event Reference Number can be reset to 10000 by using the **HIS CA** command.

Event Type

The `Event` field displays the event type. Event types and the logic used to determine event types are shown in *Table 10.1*. The event type designations AG through CAG are only entered in the `Event` field if the fault type is determined successfully.

Table 10.1 Event Types (Sheet 1 of 2)

Event Type	Event Type Logic
Arc Flash Trip	(50PAF + 50NAF) * (TOL1 + TOL2 + TOL3 + TOL4 + TOL5 + TOL6 + TOL7 + TOL8) * TRIP
AG,BG,CG	Single phase-to-ground faults. Appends T if any overcurrent trip asserted.
ABC	Three-phase faults. Appends T if any overcurrent trip asserted.
AB, BC, CA	Phase-to-phase faults. Appends T if any overcurrent trip asserted.
ABG, BCG, CAG	Phase-to-phase-to-ground faults. Appends T if any overcurrent trip asserted.
Phase A1 50 Trip	50A1P * (50P1T + 67P1T) * TRIP[a]
Phase B1 50 Trip	50B1P * (50P1T + 67P1T) * TRIP[a]
Phase C1 50 Trip	50C1P * (50P1T + 67P1T) * TRIP[a]
Phase 50 Trip	(50P1T + 50P2T + 50P3T + 50P4T +67P1T +67P2T +67P3T +67P4T) * TRIP[a]
GND/NEUT 50 Trip	(50N1T + 50N2T + 50N3T + 50N4T + 50G1T + 50G2T + 50G3T + 50G4T + 67G1T + 67G2T + 67G3T + 67G4T + 67N1T + 67N2T + 67N3T + 67N4T) * TRIP[a]
NEG SEQ 50 Trip	(50Q1T + 50Q2T + 50Q3T + 50Q4T+ 67Q1T + 67Q2T + 67Q3T + 67Q4T) * TRIP[a]
Phase A 51 Trip	51AT * TRIP[a]
Phase B 51 Trip	51BT * TRIP[a]
Phase C 51 Trip	51CT * TRIP[a]
Phase 51 Trip	(51P1T + 51P2T) * TRIP[a]

Table 10.1 Event Types (Sheet 2 of 2)

Event Type	Event Type Logic
GND/NEUT 51 Trip	(51N1T + 51N2T + 51G1T + 51G2T) * TRIP[a]
NEG SEQ 51 Trip	(51QT) * TRIP[a]
59 Trip	(59P1T + 59P2T + 59PP1T + 59PP2T + 59G1T + 59G2T + 59Q1T + 59Q2T + 59I1T + 59I2T + 59I3T + 59I4T)* TRIP
55 Trip	55T * TRIP
78 Trip	78VSO * TRIP
Undrfreq 81 Trip	(81D*n*T * TRIP) when 81D*n*TP < FNOM setting, *n* = 1, 2, 3, 4, 5, or 6.
Overfreq 81 Trip	(81D*n*T * TRIP) when 81D*n*TP > FNOM setting, *n* = 1, 2, 3, 4, 5, or 6.
PowerElemnt Trip	(3PWR1T + 3PWR2T) * TRIP
RTD Trip	(WDGTRIP + BRGTRIP + AMBTRIP + OTHTRIP) * TRIP
49 Thermal Trip	(THRLT1 + THRLT2 + THRLT3) * TRIP
Remote Trip	REMTRIP * TRIP
27 Trip	(27P1T + 27P2T+ 27PP1T + 27PP2T + 27I1T + 27I2T) * !LOP * TRIP
RTD Fail Trip	RTDFLT * TRIP
Brk Failure Trip	BFT * TRIP
CommIdleLossTrip	(COMMIDLE + COMMLOSS)*TRIP
Trigger	Trigger command
ER Trigger	ER equation assertion[a]
Trip	TRIP with no known cause

[a] The GFLT bit asserts if any one of the residual overcurrent or residual time-overcurrent Relay Word bits pick up during the event. The NFLT bit asserts if any one of the neutral overcurrent or neutral time-overcurrent Relay Word bits pick up during the event. When PHASE_A, PHASE_B, PHASE_C, or GFLT is set to latch target LEDs, latching can only occur when TRIP occurs after the event trigger and within the event. PHASE_A, PHASE_B, PHASE_C, and GFLT bits assert for a fixed duration of (LER – PRE – 0.75) cycles.

Table 10.2 Phase Involvement Event Type (Sheet 1 of 2)

Type	Condition
ABC	PHASE_A * PHASE_B * PHASE_C * NOT TRIP
AB	PHASE_A * PHASE_B * NOT TRIP
BC	PHASE_B * PHASE_C * NOT TRIP
CA	PHASE_C * PHASE_A * NOT TRIP
ABG	PHASE_A * PHASE_B * GFLT * NOT TRIP
BCG	PHASE_B * PHASE_C * GFLT * NOT TRIP
CAG	PHASE_C * PHASE_A * GFLT * NOT TRIP
AG	PHASE_A * NOT TRIP
BG	PHASE_B * NOT TRIP
CG	PHASE_C * NOT TRIP
ABC T	PHASE_A * PHASE_B * PHASE_C*TRIP
AB T	PHASE_A * PHASE_B * TRIP
BC T	PHASE_B * PHASE_C * TRIP
CA T	PHASE_C * PHASE_A * TRIP
ABG T	PHASE_A * PHASE_B * GFLT * TRIP
BCG T	PHASE_B * PHASE_C * GFLT * TRIP

Table 10.2 Phase Involvement Event Type (Sheet 2 of 2)

Type	Condition
CAG T	PHASE_C * PHASE_A * GFLT * TRIP
AG T	PHASE_A * TRIP
BG T	PHASE_B * TRIP
CG T	PHASE_C * TRIP

The event type logic (PHASE_A, PHASE_B, PHASE_C) uses Relay Word bits FSA, FSB, and FSC to help determine the fault type and to select the appropriate fault location method. The SEL-751 asserts one of the Relay Word bits FSA, FSB, or FSC based on the magnitude and angle difference of negative- and zero-sequence current. The A-, B-, or C-phase naming of the FSA, FSB, and FSC Relay Word bits does not directly translate to assertion of PHASE_A, PHASE_B, PHASE_C. When the relay processes a new EVENT, the status of the FSA, FSB, and FSC Relay Word bits help to determine which phase (PHASE_A, PHASE_B, PHASE_C) to assert.

The event type logic (PHASE_A, PHASE_B, PHASE_C) also uses Relay Word bits NSA, NSB, and NSC to help determine the fault type and to select the appropriate fault location method. The SEL-751 asserts one of the Relay Word bits NSA, NSB, or NSC based on the angle difference of neutral current and positive sequence voltage or the angle difference of the zero-sequence voltage and positive-sequence voltage. The A-, B-, or C-phase naming of the NSA, NSB, and NSC Relay Word bits directly translate to assertion of PHASE_A, PHASE_B, PHASE_C. When the relay processes a new EVENT, the status of the NSA, NSB, and NSC Relay Word bits help to determine which phase (PHASE_A, PHASE_B, PHASE_C) to assert.

If PHASE_A, PHASE_B, or PHASE_C assert, the type in *Table 10.1: Event Types* is replaced by the type in *Table 10.2: Phase Involvement Event Type*.

Fault Location

The relay reports the fault location if the EFLOC setting := Y and the fault locator operates successfully after an event report is generated. If the fault locator does not operate successfully, $$$$$$ is listed in the field. Fault location is based on the line impedance settings Z1MAG, Z1ANG, Z0MAG, and Z0ANG; source impedance settings Z0SMAG and Z0SANG; and corresponding line length setting LL. (See the *Line Parameter Settings on page 4.10*.) Because the fault locating function requires three-phase voltages, the Group setting EFLOC cannot be set to Y when Group setting VNOM := OFF. Similarly, the Group setting EFLOC is hidden and set to N internally when the Group setting SINGLEV := Y.

Fault Detector Elements

The fault locator algorithm uses the overcurrent elements: 50P1P–50P4P, 50N1P–50N4P, 50G1P–50G4P, 50Q1P–50Q4P, 51AP, 51BP, 51CP, 67P1P–67P4P, 67Q1P–67Q4P, 67G1P–67G4P, 67N1T–67N4T, 51P1P, 51P2P, 51N1P, 51N2P, 51G1P, 51G2P, and 51Q as fault detectors. If you set any of these elements to low pickup values for use as load indicators, they can assert during nonfault conditions. In this situation, even though these elements are not being used for tripping the relay, they can still affect the operation of the fault locator, because the start of the disturbance may be unclear.

Fault Locator Operating Window

The SEL-751 uses a 15-cycle subset of the event report data to calculate the event type and fault location. For Global settings LER := 64 or LER :=180, the relay processes the portion of stored data that includes the event report trigger. For LER := 15, the entire event report is available for calculation of the event type and fault location.

It is possible for the event type or fault location to be calculated from a different portion of the event report than expected. For example (with default settings), when the event report is first triggered by overcurrent element pickup (ER), but the trip occurs more than 12 cycles later, the conditions at the time of trip are not considered (unless covered by a new event report).

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 10.3*). 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 current was measured. The currents displayed are as follows:

- Line Currents (IA, IB, IC)
- Neutral Current (IN)
- Residual Current (IG), calculated from IA, IB, IC

The `Voltage Mag` fields display the primary voltage magnitudes at the instant when the maximum current was measured. The voltages displayed are as follows:

- DELTA_Y := WYE
  - Phase-to-Neutral Voltages (VAN, VBN, VCN)
  - Residual Voltage VG, calculated from VA, VB, VC
- DELTA_Y := DELTA
  - Phase-to-Phase Voltages (VAB, VBC, VCA)

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 as follows:

- Winding
- Bearing
- Ambient
- Other

Event History

The event history report gives you a quick look at recent relay activity. The relay labels each new event in reverse chronological order with `1` as the most recent event. See *Figure 10.2* for a sample event history. Use this report to view the events that are presently stored in the SEL-751.

The event history contains the following:

- Standard report header
  - Relay and terminal identification
  - Date and time of report
  - Time source

- Event number, unique event reference number, date, time, event type, and fault location (see *Table 10.1*)
- Maximum feeder current
- Frequency
- Target LED status

```
=>>HIS <Enter>

SEL-751                                  Date: 02/03/2015 Time: 11:22:50.424
FEEDER RELAY                             Time Source: Internal

FID = SEL-751-X272-V0-Z006002-D20150103
   #    REF    DATE         TIME       EVENT   LOCAT  CURRENT   FREQ    TARGETS
   1   10016  02/03/2015  10:51:34.267  BG T   64.23     9.3    60.0   11100001
   2   10015  02/02/2015  16:50:38.619 BCG T   60.43    18.0    60.0   11100001
   3   10014  02/02/2015  16:36:36.604 CAG T   86.77    17.6    60.0   11100001
   4   10013  02/01/2015  16:32:04.924 CAG T   75.44    18.0    59.7   11100001
   5   10012  02/01/2015  16:31:44.917  CG T   68.14    21.5    60.0   11100001
=>>
```

Event Number | Reference Number | Event Type | Location | Maximum Current | Frequency | User-Defined Target LEDs

Figure 10.2 Sample Event History

Viewing the Event History

Access the history report from the communications ports, using the **HIS** command or the analysis menu within ACSELERATOR QuickSet SEL-5030 Software. View and download history reports from Access Level 1 and higher.

Use the **HIS** command from a terminal to obtain the event history. You can specify the number of the most recent events that the relay returns. See *HISTORY Command on page 7.37* for information on the **HIS** command.

Use the front-panel `MAIN > Events > Display` menu to display event history data on the SEL-751 front-panel display.

Use the ACSELERATOR QuickSet software to retrieve the relay event history. View the Relay Event History dialog box via the **Tools** > **Events** > **Get Event Files** menu.

Clearing

Use the **HIS C** command to clear or reset history data from Access Levels 1 and higher. Clear/reset history data at any communications port. This clears all event summaries, history records, and reports. The **HIS C** command does not reset the unique event reference number. This number continues to increment from the present value with each subsequent event. Use the **HIS CA** command to clear all event data and reset the unique event reference number to 10000.

Event Reports

The latest event reports are stored in nonvolatile memory. Each event report includes four sections:

- Analog values of current and voltage
- Digital states of the protection and control elements, including overcurrent, and voltage elements, plus status of digital output and input states
- Event Summary
- Settings in service at the time of event retrieval, consisting of Group, Logic, Global, and Report settings classes

Use the **EVE** command to retrieve the reports. There are several options to customize the report format.

Filtered and Unfiltered Event Reports

The SEL-751 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.

To view the raw inputs to the relay, use the **EVE R** command to select the unfiltered event report. 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.

Event Report Column Definitions

Refer to the example event report in *Figure 10.3* to view event report columns. This example event report displays rows of information each 1/4 cycle. Retrieve this report with the **EVE** command.

The columns contain ac current, ac voltage, input, output, and protection and control element information. Use the serial port **SUM** command (see *SUMMARY Command on page 7.53*) to retrieve event summary reports.

Table 10.3 summarizes the event summary report current and voltage columns. *Table 10.4* summarizes the event summary report output, input, protection, and control element columns.

Table 10.3 Event Report Current and Voltage Columns

Column Heading	Description
IA	Current measured by channel IA (primary A)
IB	Current measured by channel IB (primary A)
IC	Current measured by channel IC (primary A)
IG	Residual current (IA + IB + IC, primary A)
IN	Current measured by channel IN (primary A)
VAN or VAB	Voltage measured by channel VAN or VAB (primary V)
VBN or VBC	Voltage measured by channel VBN or VBC (primary V)
VCN or VCA	Voltage measured by channel VCN or VCA calculated from VAB and VBC (primary V)
VS	Voltage measured by channel VS (terminals VS, NS) (primary V)
VDC	Voltage measured by channel VDC (terminals VBAT+, VBAT–)

Table 10.4 Output, Input, Protection, and Control Element Event Report Columns (Sheet 1 of 2)

Column Heading	Column Symbols	Description
51ABC	.	51 elements in reset state
	A	51AP picked up
	B	51BP picked up
	C	51CP picked up
	a	Both 51AP & 51BP picked up
	b	Both 51BP & 51CP picked up
	c	Both 51CP & 51AP picked up
	3	All three phases picked up
51P	1	51P1P picked up
	2	51P2P picked up
	3	Both 51P1P & 51P2P picked up
51N	1	51N1P picked up
	2	51N2P picked up
	3	Both 51N1P & 51N2P picked up
51G	1	51G1P picked up
	2	51G2P picked up
	3	Both 51G1P & 51G2P picked up
51Q	1	51QP picked up
50P	1	50P1P picked up
	2	50P2P picked up
	3	50P3P picked up
	4	50P4P picked up
	5	Both 50P1P & 50P2P picked up
	6	Both 50P1P & 50P3P picked up
	7	Both 50P1P & 50P4P picked up
	8	Both 50P2P & 50P3P picked up
	9	Both 50P2P & 50P4P picked up
	A	Both 50P3P & 50P4P picked up
	B	50P1P & 50P2P & 50P3P picked up
	C	50P1P & 50P2P & 50P4P picked up
	D	50P1P & 50P3P & 50P4P picked up
	E	50P2P & 50P3P & 50P4P picked up
	F	All four 50P1P & 50P2P & 50P3P & 50P4P picked up
67P	1	67P1P picked up
	2	67P2P picked up
	3	67P3P picked up
	4	67P4P picked up
	5	Both 67P1P & 67P2P picked up
	6	Both 67P1P & 67P3P picked up

Table 10.4 Output, Input, Protection, and Control Element Event Report Columns (Sheet 2 of 2)

Column Heading	Column Symbols	Description
	7	Both 67P1P & 67P4P picked up
	8	Both 67P2P & 67P3P picked up
	9	Both 67P2P & 67P4P picked up
	A	Both 67P3P & 67P4P picked up
	B	67P1P & 67P2P & 67P3P picked up
	C	67P1P & 67P2P & 67P4P picked up
	D	67P1P & 67P3P & 67P4P picked up
	E	67P2P & 67P3P & 67P4P picked up
	F	All four 67P1P & 67P2P & 67P3P & 67P4P picked up
50NQG	N	Any one of 50N1P / 50N2P / 50N3P / 50N4P picked up
	Q	Any one of 50Q1P / 50Q2P / 50Q3P / 50Q4P picked up
	G	Any one of 50G1P / 50G2P / 50G3P / 50G4P picked up
	a	Both 50NxP & 50QyP picked up, x, y = 1–4
	b	Both 50QxP & 50GyP picked up, x, y = 1–4
	c	Both 50GxP & 50NyP picked up, x, y = 1–4
	3	All 50NxP & 50QyP & 50GzP Picked up, x,y,z = 1–4
67QG	Q	Any one of 67Q1P / 67Q2P / 67Q3P / 67Q4P picked up
	G	Any one of 67G1P / 67G2P / 67G3P / 67G4P picked up
	a	Both 67QxP & 67GyP picked up, x, y =1–4
81	1	Any combination 81DxT picked up, x = 1–6
RTD Wdg[a]	w	WDGALRM * !WDGTRIP
	W	WDGTRIP
RTD Brg[a]	b	BRGALRM * !BRGTRIP
	B	BRGTRIP
RTD Oth[a]	o	OTHALRM * !OTHTRIP
	O	OTHTRIP
RTD Amb[a]	a	AMBALRM * !AMBTRIP
	A	AMBTRIP
RTD In[a]	1	RTDIN
In 12	1	IN101 * ! IN102
	2	IN102 * !IN101
	b	IN101 * IN102
Out 12	1	OUT101 * !OUT102
	2	OUT102 * !OUT101
	b	OUT101 * OUT102
Out 3	3	OUT103

[a] These quantities are not displayed when the relay has the voltage card option with VS (synchronized voltage) and VDC (battery voltage) inputs.

Note that the ac values change from plus to minus (–) values in *Figure 10.3*, indicating the sinusoidal nature of the waveforms.

Other figures help in understanding the information available in the event report current columns:

- ➤ *Figure 10.4* shows how event report current column data relate to the actual sampled current waveform and rms current values.
- ➤ *Figure 10.5* shows how you can convert event report current column data to phasor rms current values.

Example 15-Cycle Event Report

The following example of a standard 15-cycle event report in *Figure 10.3* also corresponds to the example SER report in *Figure 10.17*.

In *Figure 10.3*, an arrow (>) in the column following the `VDC` column would identify the "trigger" row. This is the row that corresponds to the `Date` and `Time` values at the top of the event report.

The asterisk (*) in the column following the `VDC` column identifies the row with the maximum phase current. The SEL-751 calculates maximum phase current from the row identified with the asterisk and the row one quarter-cycle previous (see *Figure 10.4* and *Figure 10.5*). These currents are listed at the end of the event report in the event summary. If the trigger row (>) and the maximum phase current row (*) are the same row, the * symbol takes precedence.

Figure 10.4 and *Figure 10.5* look in detail at one cycle of A-phase current (channel IA) identified in *Figure 10.3*. *Figure 10.4* shows how the event report ac current column data relate to the actual sampled waveform and rms values. *Figure 10.5* shows how you can convert the event report current column data to phasor rms values. Voltages processing occurs similarly.

In *Figure 10.4*, note that you can use any two rows of current data from the event report in *Figure 10.3*, 1/4 cycle apart, to calculate rms current values.

```
=>>EVE <Enter>

SEL-751                            Date: 03/11/2015    Time: 14:16:39.043          Date and Time of Event

FEEDER RELAY

Serial Number=000000000000000

FID=SEL-751-X272-V0-Z006002-D20150103       CID=05A2                                Firmware and Checksum Identifier

                                                                 55555 55a8   O     aReplaced with 67 (directional
                                                                 11111 00 1 I u     overcurrent) when setting
                                                                 A      N   n t     EDIR := Y or AUTO
     Currents (A Pri)           Voltages (V Pri)                 B      Q   1 13

 IA     IB     IC     IN     IG     VAB     VBC     VCA        VS VDC CPNGQ PG   2 2   Optional 2 AVI/4 AFDI Card Required

[1]
 -1739    467   1277   -0.0    4.2   -7429   -3317   10679   -7178  48 33... F. . . .3
   449  -1735   1256    0.0  -30.0    7994  -10399    2259    8071  48 33... F. . . .3
  1741   -468  -1279    0.0   -6.0    7421    3323  -10681    7173  48 33... F. . . .3
  -454   1736  -1258    0.0   24.0   -7999   10395   -2255   -8080  48 33... F. . . .3
[2]
 -1742    466   1278   -0.0    1.8   -7418   -3332   10679   -7171  48 33... F. . . .3
   454  -1737   1258   -0.0  -25.2    7999  -10397    2246    8084  48 33... F. . . .3   One Cycle of Data
  1738   -465  -1283    0.0  -10.2    7412    3334  -10685    7162  48 33... F. . . .3
  -456   1736  -1259    0.0   20.4   -8006   10391   -2243   -8087  48 33... F. . . .3

[3]
 -1737    461   1283    0.0    7.2   -7409   -3341   10685   -7160  48 33... F. . . .3
   455  -1737   1258   -0.0  -24.0    8010  -10393    2236    8089  48 33... F. . . .3
  1735   -460  -1284   -0.0   -9.6    7402    3346  -10688    7153  48 33... F. . . .3
  -456   1736  -1259    0.0   20.4   -8015   10388   -2232   -8095  48 33... F. . . .3
```

Figure 10.3 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution

```
[4]
 -1738   460  1282   0.0   3.6  -7402  -3353  10687  -7151  48 33... F. . . .3
   457 -1737  1255  -0.0 -25.2   8015 -10388   2225   8096  48 33... F. . . .3
  1737  -463 -1286  -0.0 -12.0   7396   3357 -10690   7146  48 33... F. . . .3
  -459  1736 -1257   0.0  19.8  -8021  10384  -2219  -8102  48 33... F. . . .3
[5]
 -1737   459  1285  -0.0   6.6  -7393  -3366  10690  -7142  48 33... F. . . .3

   497 -1736  1255  -0.0  15.6   8024 -10384   2212   8104  48*33... F. . . .3     Maximum Phase Current

  1363  -460 -1287   0.0  -384   7385   3368 -10692   7137  48 33.3..F. . . .3

  -346  1738 -1256   0.0   136  -8030  10379  -2209  -8109  48>33.3..F. . . .3     Trigger Row

[6]
 -752.0  458  1286  -0.0   956  -7384  -3377  10690  -7135  48 33.31 F. . . .3
 -941.0-1739  1254  -0.0  -332   8033 -10377   2200   8111  48 33.31 F. . . .3     See Figure 10.4 and Figure 10.5
 -750.3 -458 -1286   0.0 -1163   7376   3379 -10694   7128  48 b3.31 F. . . .3
 -940.7 1738 -1255   0.0   328  -8039  10375  -2198  -8116  48 b3.31 F. . . .3

[7]
  -583   454  1283  -0.0  1154  -7373  -3386  10692  -7126  48 b3.31 F. . . .3
   154 -1737  1253   0.0  -331   8039 -10377   2191   8120  48 b3.31 F. . . .3
   581  -454 -1288   0.0 -1160   7367   3391 -10696   7119  48 b3.31 F. . . .3
  -155  1735 -1252   0.0   327  -8044  10373  -2187  -8127  48 b3.31 F. . . .3
[8]
  -582   453  1289   0.0  1160  -7367  -3400  10696  -7115  48 b3.31 F. . . .3
   154 -1739  1249  -0.0  -337   8048 -10372   2178   8127  48 b3.31 F. . . .3
   580  -452 -1291   0.0 -1163   7358   3404 -10699   7108  48 b3.31 F. . . .3
  -155  1738 -1249   0.0   333  -8055  10368  -2173  -8134  48 b3.31 F. . . .3
[9]
  -584   450  1291  -0.0  1157  -7357  -3411  10699  -7106  48 b3.31 F. . . .3
   156 -1738  1247  -0.0  -335   8059 -10370   2165   8136  48 b3.31 F. . . .3
   581  -451 -1293   0.0 -1163   7351   3413 -10701   7101  48 b3.31 F. . . .3
  -159  1737 -1248   0.0   330  -8064  10366  -2162  -8141  48 b3.31 F. . . .3


[10]
  -582   449  1292  -0.0  1159  -7348  -3422  10699  -7097  48 b3.31 F. . . .3
   156 -1737  1247  -0.0  -334   8064 -10366   2155   8143  48 b3.31 F. . . .3
   580  -450 -1297  -0.0 -1167   7340   3427 -10705   7090  48 b3.31 F. . . .3
  -157  1738 -1248   0.0   333  -8071  10361  -2151  -8150  48 b3.31 F. . . .3
[11]
  -583   449  1296   0.0  1162  -7339  -3434  10705  -7088  48 b3.31 F. . . .3
   156 -1741  1245  -0.0  -340   8073 -10359   2140   8152  48 b3.31 F. . . .3
   581  -448 -1295   0.0 -1162   7333   3438 -10706   7083  48 b3.31 F. . . .3
  -159  1738 -1246   0.0   333  -8078  10355  -2137  -8158  48 b3.31 F. . . .3
[12]
  -583   446  1294  -0.0  1157  -7331  -3445  10706  -7081  48 b3.31 F. . . .3
   156 -1519  1243  -0.0  -121   8080 -10355   2128   8159  48 b3.31 F. . . .3
   581  -276 -1296   0.0  -991   7322   3449 -10708   7074  48 b3.31 F. . . .3
  -158   941 -1243   0.0  -460  -8086  10352  -2124  -8165  48 b3.31 F. . . .3
[13]
  -582   124  1296  -0.0   838  -7319  -3456  10706  -7072  48 b3.31 F. . . .3
   158  -586   981  -0.0   553   8089 -10354   2117   8168  48 C3.31 F. . . .3
   581  -149 -1085   0.0  -652   7313   3461 -10710   7065  48 C3.31 F. . . .3
  -160   585  -569   0.0  -145  -8096  10350  -2111  -8174  48 C3.3. F. . . .3
[14]
  -583   145   651  -0.0   212  -7310  -3469  10710  -7061  48 C3.3. .. . . .3
   158  -585   413  -0.0 -13.8   8096 -10350   2106   8174  48 C3.3. .. . . .3
   581  -146  -436   0.0  -0.6   7304   3472 -10714   7056  48 ..... .. . . .3
  -159   583  -414   0.0   9.6  -8104  10346  -2102  -8181  48 ..... .. . . .3
[15]
  -581   146   435  -0.0   0.0  -7303  -3479  10714  -7052  48 ..... .. . . .3
   157  -584   413  -0.0 -14.4   8107 -10346   2093   8183  48 ..... .. . . .3
   579  -148  -436   0.0  -4.2   7297   3483 -10715   7047  48 ..... .. . . .3
  -158   584  -414   0.0  12.0  -8111  10341  -2088  -8188  48 ..... .. . . ..

Serial No = 000000000000000
FID = SEL-751-X272-V0-Z006002-D20150103        CID = 6803
EVENT LOGS =  5                                REF_NUM = 10023

Event:     BG T
Location   $$$$$$$$
Targets    11001101
Freq (Hz)      60.0

Current Mag
        IA            IB            IC            IN       IG
(A)     119.7         604.3         121.3          0.17   481.61

Voltage Mag
       VAB    VBC    VCA
(V)   17974  18008  31246
```

Figure 10.3 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution (Continued)

```
PHROT   := ABC     FNOM    := 60      DATE_F  := MDY
FAULT   := 50G1P OR 50N1P OR 51P1P OR 51QP OR 50Q1P OR TRIP
EMP     := N       TGR     := 3
SS1     := 1
SS2     := 0
SS3     := 0
SS4     := 0

EPMU    := N
IRIGC   := NONE    UTC_OFF := 0.00    DST_BEGM:= OFF
52ABF   := N       50BFP   := 0.10    BFD     := 0.50    ATD     := OFF
BFI     := R_TRIG TRIP

50PAFP  := OFF     DCLOP   := OFF     DCHIP   := OFF

IN101D  := 10      IN102D  := 10

EBMON   := Y       COSP1   := 10000   COSP2   := 150     COSP3   := 12
KASP1   := 1.20    KASP2   := 8.00    KASP3   := 20.00   BKMON   := TRIP

RSTTRGT := 0
RSTENRGY:= 0
RSTMXMN := 0
RSTDEM  := 0
RSTPKDEM:= 0

DSABLSET:= 0

TIME_SRC:= IRIG1   TIME_SRC:= IRIG1

Group Settings

RID     := SEL-751
TID     := FEEDER RELAY
CTR     := 120     CTRN    := 120     PTR     := 180.00  PTRS    := 180.00
DELTA_Y := DELTA   VSCONN  := VS      SINGLEV := N       VNOM    := 120.00
Z1MAG   := 2.14    Z1ANG   := 68.86   Z0MAG   := 6.38    Z0ANG   := 72.47
Z0SMAG  := 0.36    Z0SANG  := 84.61   LL      := 4.84    EFLOC   := N
50P1P   := 10.00   50P1D   := 0.00    50P1TC  := 1
50P2P   := 10.00   50P2D   := 0.00    50P2TC  := 1
50P3P   := 10.00   50P3D   := 0.00    50P3TC  := 1
50P4P   := 10.00   50P4D   := 0.00    50P4TC  := 1
50N1P   := OFF     50N2P   := OFF     50N3P   := OFF     50N4P   := OFF
50G1P   := OFF     50G2P   := OFF     50G3P   := OFF     50G4P   := OFF
50Q1P   := OFF     50Q2P   := OFF     50Q3P   := OFF     50Q4P   := OFF

51AP    := 6.00
51AC    := U3      51ATD   := 3.00    51ARS   := N
51ACT   := 0.00    51AMR   := 0.00    51ATC   := 1


51BP    := 6.00    51BC    := U3      51BTD   := 3.00    51BRS   := N
51BCT   := 0.00    51BMR   := 0.00    51BTC   := 1


51CP    := 6.00    51CC    := U3      51CTD   := 3.00    51CRS   := N
51CCT   := 0.00    51CMR   := 0.00    51CTC   := 1

51P1P   := 6.00    51P1C   := U3      51P1TD  := 3.00    51P1RS  := N
51P1CT  := 0.00    51P1MR  := 0.00    51P1TC  := 1

51P2P   := 6.00    51P2C   := U3      51P2TD  := 3.00    51P2RS  := N
51P2CT  := 0.00    51P2MR  := 0.00    51P2TC  := 1

51QP    := 6.00    51QC    := U3      51QTD   := 3.00    51QRS   := N
51QCT   := 0.00    51QMR   := 0.00    51QTC   := 1

51N1P   := OFF     51N1C   := U3      51N1TD  := 1.50    51N1RS  := N
51N1CT  := 0.00    51N1MR  := 0.00    51N1TC  := 1

51N2P   := OFF     51N2C   := U3      51N2TD  := 1.50    51N2RS  := N
51N2CT  := 0.00    51N2MR  := 0.00    51N2TC  := 1

51G1P   := 0.50    51G1C   := U3      51G1TD  := 1.50    51G1RS  := N
51G1CT  := 0.00    51G1MR  := 0.00    51G1TC  := 1

51G2P   := 0.50    51G2C   := U3      51G2TD  := 1.50    51G2RS  := N
51G2CT  := 0.00    51G2MR  := 0.00    51G2TC  := 1
```

Figure 10.3 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution (Continued)

```
EHBL2   := N       EHBL5   := N       ELOAD   := N
E49RTD  := NONE
E49IEC  := N
27PP1P  := OFF     27PP2P  := OFF
27S1P   := OFF     27S2P   := OFF

59PP1P  := OFF     59PP2P  := OFF     59Q1P   := OFF     59Q2P   := OFF

59S1P   := OFF     59S2P   := OFF

E27I1   := N       E27I2   := N

E59I1   := N       E59I2   := N       E59I3   := N       E59I4   := N

E25     := N
LOPBLK  := 0

55LGTP  := OFF     55LDTP  := OFF     55LGAP  := OFF     55LDAP  := OFF
E78VS   := N

81D1TP  := OFF
81D2TP  := OFF
81D3TP  := OFF
81D4TP  := OFF
81D5TP  := OFF
81D6TP  := OFF

E81R    := N
E81RF   := N       EDEM    := THM     DMTC    := 5       PHDEMP  := 5.00
GNDEMP  := 1.00    3I2DEMP := 1.00
EPWR    := N
TDURD   := 0.5     CFD     := 1.0
TR      := ORED50T OR ORED51T OR ORED81T OR REMTRIP OR OC OR SV04T
REMTRIP := 0
ULTRIP  := NOT (51P1P OR 51G1P OR 51N1P OR 52A)
52A     := 0
CL      := SV03T AND LT02 OR CC
ULCL    := 0
Report Settings

ESERDEL := N

SER1    := IN101 IN102 51P1T 51G1T 50P1P 50N1T 51N1T PB01 PB02 PB03 PB04
SER2    := CLOSE 52A CC
SER3    := 81D1T 81D2T
SER4    := SALARM

EALIAS  := 4

ALIAS1  :=PB01 FP_AUX1 PICKUP DROPOUT
ALIAS2  :=PB02 FP_LOCK PICKUP DROPOUT
ALIAS3  :=PB03 FP_CLOSE PICKUP DROPOUT
ALIAS4  :=PB04 FP_TRIP PICKUP DROPOUT

ER     := R_TRIG 51P1P OR R_TRIG 51G1P OR R_TRIG 50P1P OR R_TRIG 50G1P OR R_TRIG 51N1P
 OR R_TRIG CF
LER     := 15      PRE     := 5

FMR1NAM := FMR1
FMR1    :=NA
FMR2NAM := FMR2
FMR2    :=NA
FMR3NAM := FMR3
FMR3    :=NA
FMR4NAM := FMR4
FMR4    :=NA
RA01TYPE:= I
RA02TYPE:= I
RA03TYPE:= I
RA04TYPE:= I
RA05TYPE:= I
RA06TYPE:= I
RA07TYPE:= I
RA08TYPE:= I
RA09TYPE:= I
RA10TYPE:= I
RA11TYPE:= I
RA12TYPE:= I
RA13TYPE:= I
RA14TYPE:= I
RA15TYPE:= I
RA16TYPE:= I
RA17TYPE:= I
```

Figure 10.3 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution (Continued)

```
RA18TYPE:= I
RA19TYPE:= I
RA20TYPE:= I
RA21TYPE:= I
RA22TYPE:= I
RA23TYPE:= I

RA24TYPE:= I
RA25TYPE:= I
RA26TYPE:= I
RA27TYPE:= I
RA28TYPE:= I
RA29TYPE:= I
RA30TYPE:= I
RA31TYPE:= I
RA32TYPE:= I

LDLIST  := NA

LDAR    := 15


Logic Settings

ELAT    := 4       ESV     := 5       ESC     := N       EMV     := N

SET01   := NA
RST01   := NA
SET02   := R_TRIG SV02T AND NOT LT02
RST02   := R_TRIG SV02T AND LT02
SET03   := PB03_PUL AND LT02 AND NOT 52A
RST03   := (PB03_PUL OR PB04_PUL OR SV03T) AND LT03
SET04   := PB04_PUL AND 52A
RST04   := (PB03_PUL OR PB04_PUL OR SV04T) AND LT04

SV01PU  := 0.00    SV01DO  := 0.00
SV01    := NA
SV02PU  := 3.00    SV02DO  := 0.00
SV02    := PB02
SV03PU  := 0.00    SV03DO  := 0.00
SV03    := LT03
SV04PU  := 0.00    SV04DO  := 0.00
SV04    := LT04
SV05PU  := 0.25    SV05DO  := 0.25
SV05    := (PB02 OR LT03 OR LT04) AND NOT SV05T

OUT101FS:= Y       OUT101  := HALARM OR SALARM OR AFALARM
OUT102FS:= N       OUT102  := CLOSE
OUT103FS:= N       OUT103  := TRIP

=>>
```

Figure 10.3 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution (Continued)

[a] Replaced with 67 (directional overcurrent) when setting EDIR := Y or AUTO.

Figure 10.4 and *Figure 10.5* look in detail at one cycle of A-phase current (channel IA) identified in *Figure 10.3*. *Figure 10.4* shows how the event report ac current column data relate to the actual sampled waveform and rms values. *Figure 10.5* shows how the event report current column data can be converted to phasor rms values. Voltages are processed similarly.

In *Figure 10.4*, note that you can use any two rows of current data from the event report in *Figure 10.3*, 1/4 cycle apart, to calculate rms current values.

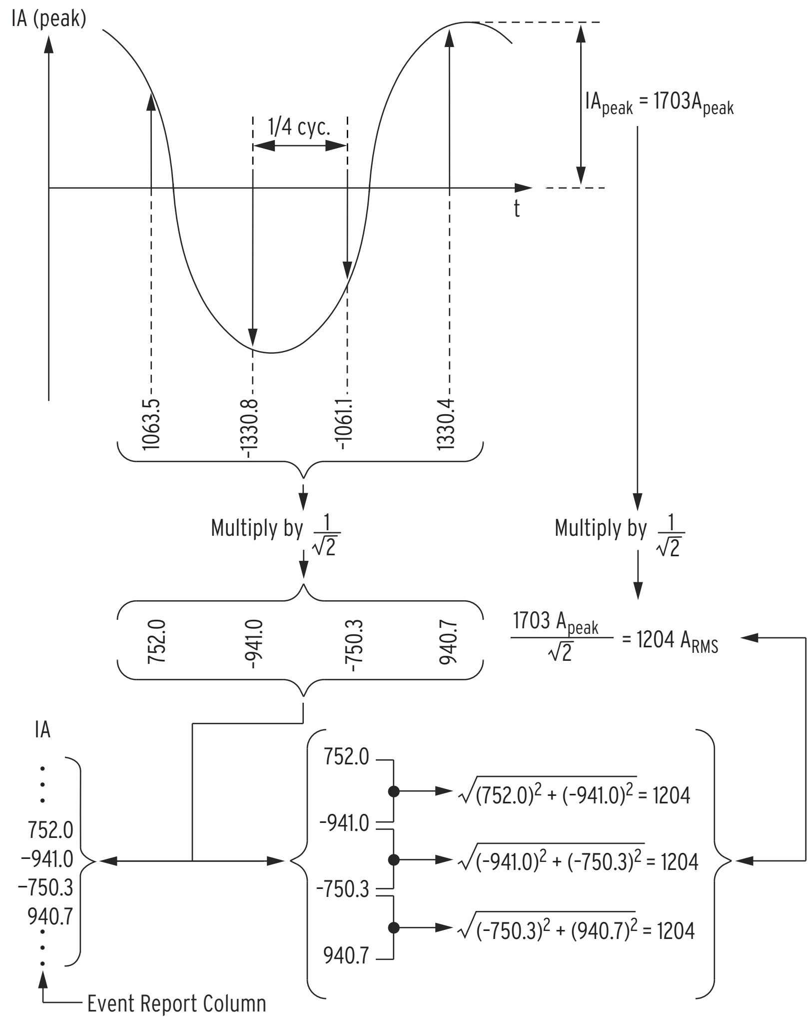


Figure 10.4 Derivation of Event Report Current Values and RMS Current Values From Sampled Current Waveform

In *Figure 10.5*, note that you can use two rows of current data from the event report in *Figure 10.3*, 1/4 cycle apart, to calculate phasor rms current values. In *Figure 10.5*, at the present sample, the phasor rms current value is:

$$IA = 1204\ A\ \angle{-38.6°} \qquad \textbf{Equation 10.1}$$

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

$$1204\ A \bullet \cos(-38.6°) = 940.7\ A \qquad \textbf{Equation 10.2}$$

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 the angle that your calculator reports is correct.

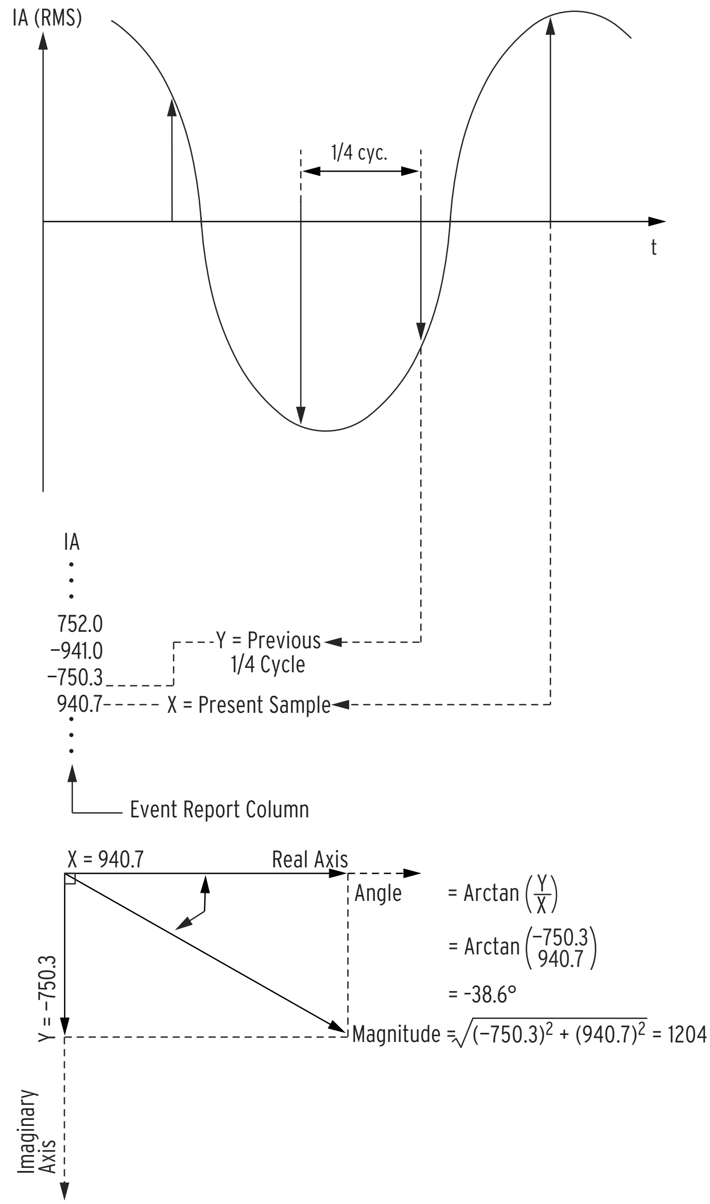


Figure 10.5 Derivation of Phasor RMS Current Values From Event Report Current Values

Retrieving Event Reports Via Ethernet File Transfer

Selected event reports are available as read-only files that can be retrieved using Ethernet File Transfer Protocol (FTP) or Manufacturing Messaging Specification (MMS). MMS is only available in models that support IEC 61850 and only when IEC 61850 and MMS File transfer are enabled (E61850 := Y, EMMSFS := Y). See *File Transfer Protocol (FTP) and MMS File Transfer on page 7.13*, *Virtual File Interface on page 7.58*, and *MMS on page F.4* for additional information.

The Ethernet file server EVENTS folder contains two types of files for each event stored in the relay:

- ➤ Compressed, 4 sample/cycle, filtered event, equivalent to issuing a **CEV** command. These files are named C4.*nnnnn*.cev, where *nnnnn* is the unique event identifier.
- ➤ Compressed, 32 sample/cycle, unfiltered event, equivalent to issuing a **CEV R** command. These files are named CR.*nnnnn*.cev, where *nnnnn* is the unique event identifier.

The date and time displayed for events are from the time of event trigger. The times are UTC.

The EVENTS folder also contains the event history with unique event identification number (equivalent to the **HIS** command) and the compressed event history (equivalent to the **CHIS** command). See *HISTORY Command on page 7.37*. The Event files can also be retrieved with the **FIL** command. See ***FILE Command on page 7.32*** and *CHIS Command on page 10.2* for additional information.

CEVENT

The relay provides a Compressed ASCII event report for SCADA and other automation applications. QuickSet uses Compressed ASCII commands to gather event report data. If you want to view the Compressed ASCII event report data, use a terminal to issue ASCII command **CEV**. A sample of the report appears in *Figure 10.6*; this is a comma-delimited ASCII file. The relay appends a four-digit hex checksum at the end of the line in the Compressed ASCII report.

Items included in the Compressed ASCII event report are similar to the event report, although the relay reports the items in a special order. CEV files (and COMTRADE files) include all Relay Word bits (see *Appendix K: Relay Word Bits*). See *SEL Compressed ASCII Commands on page C.1* for more information on the Compressed ASCII command set.

Report Header

```
=>>CEV <Enter>
"FID","CEV_VER","PART_NUM","SER_NUM","097C"
"FID=SEL-751-R112-V0-Z006002-D20151112","2.0.1","751401B0X0XL087067N","000000000000000","120A"
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","0ACA"
12,14,2016,12,23,52,927,"0496"
```

Summary Labels

```
"REC_NUM","REF_NUM","NUM_CH_A","NUM_CH_D","FREQ","NFREQ","SAM/CYC_A","SAM/
 CYC_D","NUM_OF_CYC","PRIM_VAL","CTR_IA","CTR_IB","CTR_IC","CTR_IN","CTR_IG","PTR_VAB","PTR_VBC","PT
 R_VCA","PTR_VS","EVENT","LOCATION","GROUP","IA(A)","IB(A)","IC(A)","IN(A)","IG(A)","VAB(V)","VBC(V)
 ","VCA(V)","VS(V)","VDC(V)","WDG(C)","BRG(C)","AMB(C)","OTH(C)","5057"
```

Summary Data

```
1,36266,19,1264,60.0,60,4,4,15,"YES",120.00,120.00,120.00,120.00,120.00,180.00,180.00,180.00,4.80,"A
 G T",$$$$,1,1212.2,119.6,122.2,0.00,1089.0,12049.299,12055.252,20960.781,0.152,2.012,"NA","NA","NA"
 ,"NA","2753"
```

Figure 10.6 Sample Compressed ASCII Event Report

```
"IA(A)","IB(A)","IC(A)","IN(A)","IG(A)","VAB(V)","VBC(V)","VCA(V)","VS(V)","VDC(V)","LSENS1(%)","LSE
 NS2(%)","LSENS3(%)","LSENS4(%)","*","*","*","*","FREQ","TRIG","50A1P 50B1P 50C1P 50PAF ORED50T
 ORED51T 50NAF 52A 50P1P 50P2P 50P3P 50P4P 50Q1P 50Q2P 50Q3P 50Q4P 50P1T 50P2T 50P3T 50P4T 50Q1T
 50Q2T 50Q3T 50Q4T 50N1P 50N2P 50N3P 50N4P 50G1P 50G2P 50G3P 50G4P 50N1T 50N2T 50N3T 50N4T 50G1T
 50G2T 50G3T 50G4T 51AP 51BP 51CP 51P1P 51P2P 51N1P 51N2P 51QP 51AT 51BT 51CT 51P1T 51P2T 51N1T 51N2T
 51QT 51AR 51BR 51CR 51P1R 51P2R 51N1R 51N2R 51QR 51G1P 51G1T 51G1R 51G2P 51G2T 51G2R 27P1 27P1T 27P2
 27P2T 59P1 59P1T 59P2 59P2T 3P59 3P27 81D1T 81D2T 81D3T 81D4T 81D5T 81D6T 55A 55T AMBALRM AMBTRIP
 OTHALRM OTHTRIP BKMON * BFI BFT LINKA LINKB PMDOK SALARM WARNING TSOK IRIGOK FAULT COMMIDLE COMMLOSS
 REMTRIP COMMFLT CFGFLT 3PWR1T 3PWR2T LOP PB01 PB02 PB03 PB04 PB05 PB06 PB07 PB08 PB01_PUL PB02_PUL
 PB03_PUL PB04_PUL PB05_PUL PB06_PUL PB07_PUL PB08_PUL IN101 IN102 * * * * * * * * * * * * * * * * *
 * * * * * * * * * * * * * OUT101 OUT102 OUT103 * * ORED81T ORED81RT TRIP * * * * * * * * * * * * *
 * * * * * * * * * * WDGALRM WDGTRIP BRGALRM BRGTRIP RSTENRGY RSTMXMN RSTDEM RSTPKDEM RTDFLT RTDIN
 TRGTR 3PWR1P 3PWR2P DSABLSET RSTTRGT HALARM RTD1A RTD1T RTD2A RTD2T RTD3A RTD3T RTD4A RTD4T RTD5A
 RTD5T RTD6A RTD6T RTD7A RTD7T RTD8A RTD8T RTD9A RTD9T RTD10A RTD10T RTD11A RTD11T RTD12A RTD12T 79RS
 79CY 79LO SH0 SH1 SH2 SH3 SH4 CLOSE CF RCSF OPTMN RSTMN LINKFAIL PASEL PBSEL SG1 SG2 SG3 SG4 * DI_C
 DI_B DI_A CC OC * ER ULTRIP TR FREQTRK PMTRIG DNAUX1 DNAUX2 DNAUX3 DNAUX4 DNAUX5 DNAUX6 DNAUX7 DNAUX8
 DNAUX9 DNAUX10 DNAUX11 RELAY_EN TREA1 TREA2 TREA3 TREA4 PB1A_LED PB1B_LED PB2A_LED PB2B_LED PB3A_LED
 PB3B_LED PB4A_LED PB4B_LED PB5A_LED PB5B_LED PB6A_LED PB6B_LED PB7A_LED PB7B_LED PB8A_LED PB8B_LED
 CL ULCL T01_LED T02_LED T03_LED T04_LED T05_LED T06_LED LB01 LB02 LB03 LB04 LB05 LB06 LB07 LB08 LB09
 LB10 LB11 LB12 LB13 LB14 LB15 LB16 LB17 LB18 LB19 LB20 LB21 LB22 LB23 LB24 LB25 LB26 LB27 LB28 LB29
 LB30 LB31 LB32 RB01 RB02 RB03 RB04 RB05 RB06 RB07 RB08 RB09 RB10 RB11 RB12 RB13 RB14 RB15 RB16 RB17
 RB18 RB19 RB20 RB21 RB22 RB23 RB24 RB25 RB26 RB27 RB28 RB29 RB30 RB31 RB32 SV01 SV02 SV03 SV04 SV05
 SV06 SV07 SV08 SV01T SV02T SV03T SV04T SV05T SV06T SV07T SV08T SV09 SV10 SV11 SV12 SV13 SV14 SV15
 SV16 SV09T SV10T SV11T SV12T SV13T SV14T SV15T SV16T SV17 SV18 SV19 SV20 SV21 SV22 SV23 SV24 SV17T
 SV18T SV19T SV20T SV21T SV22T SV23T SV24T SV25 SV26 SV27 SV28 SV29 SV30 SV31 SV32 SV25T SV26T SV27T
 SV28T SV29T SV30T SV31T SV32T LT01 LT02 LT03 LT04 LT05 LT06 LT07 LT08 LT09 LT10 LT11 LT12 LT13 LT14
 LT15 LT16 LT17 LT18 LT19 LT20 LT21 LT22 LT23 LT24 LT25 LT26 LT27 LT28 LT29 LT30 LT31 LT32 SC01QU
 SC02QU SC03QU SC04QU SC05QU SC06QU SC07QU SC08QU SC01QD SC02QD SC03QD SC04QD SC05QD SC06QD SC07QD
 SC08QD SC09QU SC10QU SC11QU SC12QU SC13QU SC14QU SC15QU SC16QU SC09QD SC10QD SC11QD SC12QD SC13QD
 SC14QD SC15QD SC16QD SC17QU SC18QU SC19QU SC20QU SC21QU SC22QU SC23QU SC24QU SC17QD SC18QD SC19QD
 SC20QD SC21QD SC22QD SC23QD SC24QD SC25QU SC26QU SC27QU SC28QU SC29QU SC30QU SC31QU SC32QU SC25QD
 SC26QD SC27QD SC28QD SC29QD SC30QD SC31QD SC32QD * * * * * * * * * * * * * * * * * * * * * * * * * *
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
 * * * * * * * * * * * * * * * * * * * * * * * * RMB8A RMB7A RMB6A RMB5A RMB4A RMB3A RMB2A RMB1A TMB8A
 TMB7A TMB6A TMB5A TMB4A TMB3A TMB2A TMB1A RMB8B RMB7B RMB6B RMB5B RMB4B RMB3B RMB2B RMB1B TMB8B
 TMB7B TMB6B TMB5B TMB4B TMB3B TMB2B TMB1B LBOKB CBADB RBADB ROKB LBOKA CBADA RBADA ROKA VB001 VB002
 VB003 VB004 VB005 VB006 VB007 VB008 VB009 VB010 VB011 VB012 VB013 VB014 VB015 VB016 VB017 VB018
 VB019 VB020 VB021 VB022 VB023 VB024 VB025 VB026 VB027 VB028 VB029 VB030 VB031 VB032 VB033 VB034
 VB035 VB036 VB037 VB038 VB039 VB040 VB041 VB042 VB043 VB044 VB045 VB046 VB047 VB048 VB049 VB050
 VB051 VB052 VB053 VB054 VB055 VB056 VB057 VB058 VB059 VB060 VB061 VB062 VB063 VB064 VB065 VB066
 VB067 VB068 VB069 VB070 VB071 VB072 VB073 VB074 VB075 VB076 VB077 VB078 VB079 VB080 VB081 VB082
 VB083 VB084 VB085 VB086 VB087 VB088 VB089 VB090 VB091 VB092 VB093 VB094 VB095 VB096 VB097 VB098
 VB099 VB100 VB101 VB102 VB103 VB104 VB105 VB106 VB107 VB108 VB109 VB110 VB111 VB112 VB113 VB114
 VB115 VB116 VB117 VB118 VB119 VB120 VB121 VB122 VB123 VB124 VB125 VB126 VB127 VB128 PHDEM 3I2DEM
 GNDEM * BCWA BCWB BCWC BCW 59VP 59VS AFALARM SF 25A1 25A2 DCHI DCLO 59S1 59S1T 59S2 59S2T 27S1 27S1T
 27S2 27S2T TQUAL8 TQUAL4 TQUAL2 TQUAL1 DST DSTP LPSEC LPSECP FREQFZ * TUTCS TUTC1 TUTC2 TUTC4 TUTC8
 TUTCH 59G1 59G1T 59G2 59G2T 59Q1 59Q1T 59Q2 59Q2T 81R1T 81R2T 81R3T 81R4T AFS1DIAG AFS2DIAG AFS3DIAG
 AFS4DIAG TOL1 TOL2 TOL3 TOL4 AFS1EL AFS2EL AFS3EL AFS4EL 27PP1 27PP1T 27PP2 27PP2T 59PP1 59PP1T
 59PP2 59PP2T 67P1P 67P2P 67P3P 67P4P 67P1T 67P2T 67P3T 67P4T 67Q1P 67Q2P 67Q3P 67Q4P 67Q1T 67Q2T
 67Q3T 67Q4T 67G1P 67G2P 67G3P 67G4P 67G1T 67G2T 67G3T 67G4T 50QF 50QR 50GF 50GR DIRVE DIRQGE DIRIE
 DIRQE FDIRP RDIRP FDIRQ RDIRQ FDIRQG RDIRQG FDIRV RDIRV FDIRI RDIRI DIRPF DIRPR DIRQF DIRQR DIRGF
 DIRGR G1DIR G2DIR G3DIR G4DIR Q1DIR Q2DIR Q3DIR Q4DIR P1DIR P2DIR P3DIR P4DIR 50PDIR 3V0 TSNTPB
 TSNTPP * * * 81RFBLK 81RFT 81RFBL 81RFP 81RFI ZLOAD ZLOUT ZLIN VPOLV PHASE_A PHASE_B PHASE_C GFLT
 INI_HIF * * * HIFER HIFMODE HIFREC 3PH_EVE * HIA1_C HIA1_B HIA1_A * HIA2_C HIA2_B HIA2_A * HIF1_C
 HIF1_B HIF1_A * HIF2_C HIF2_B HIF2_A * NTUNE_C NTUNE_B NTUNE_A * ITUNE_C ITUNE_B ITUNE_A * DIC_DIS
 DIB_DIS DIA_DIS * DVC_DIS DVB_DIS DVA_DIS * DL2CLRC DL2CLRB DL2CLRA * FRZCLRC FRZCLRB FRZCLRA * DUPC
 DUPB DUPA * DDNC DDNB DDNA 3PH_CLR 3PH_C 3PH_B 3PH_A LR3 LRC LRB LRA OREDHIF1 OREDHIF2 * * FSA FSB
 FSC FIDEN * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * TESTDB MATHERR * * AFS5DIAG
 AFS6DIAG AFS7DIAG AFS8DIAG TOL5 TOL6 TOL7 TOL8 AFS5EL AFS6EL AFS7EL AFS8EL THRLA1 THRLA2 THRLA3
 THRLT1 THRLT2 THRLT3 THOVL1 THOVL2 THOVL3 THST1 THST2 THST3 RSTTH1 RSTTH2 RSTTH3 THAMBH 78VSBL 78VSO
 N1DIR N2DIR N3DIR N4DIR * * HBL2T HBL2AT HBL2BT HBL2CT HBL5T HBL5AT HBL5BT HBL5CT UGFWD UGREV * *
 LZFWD LZREV FDIRNI RDIRNI FDIRW RDIRW FDIRC RDIRC * NSA NSB NSC GNDSW 50NF 50NR DIRNE FDIRN RDIRN
 DIRNF DIRNR 67N1P 67N2P 67N3P 67N4P 67N1T 67N2T 67N3T 67N4T 27I1 27I1T 27I1RS * 27I2 27I2T 27I2RS *
 59I1 59I1T 59I1RS * 59I2 59I2T 59I2RS * 59I3 59I3T 59I3RS * 59I4 59I4T 59I4RS * * * * * * * *
 *","E374"
```


Column Labels

Figure 10.6 Sample Compressed ASCII Event Report (Continued)

```
-46.8,119,-72.6,0.0,-0.6,-5153,6714,-1561,0,-0,0.02,0.00,0.26,0.21,0.00,0.00,0.00,0.00,60.00,
,"00000000000000FF2400000000000000000000000000000000000000000000006800A0010290001000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000F000000000000000000000000FFF80010000000000000000000000000000000000
03C000000800000000000","4E43"
-112,14.4,97.8,-0.0,0.6,-10888,-10021,20909,0,-2,0.02,0.01,0.26,0.22,0.00,0.00,0.00,0.00,60.00,
,"00000000000000FF2400000000000000000000000000000000000000000000006800A0010290001000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000F000000000000000000000000FFF80010000000000000000000000000000000000
03C000000800000000000","4EA7"
46.2,-119,72.0,-0.0,-1.2,5166,-6700,1534,-1,3,0.02,0.00,0.25,0.21,0.00,0.00,0.00,0.00,60.00,
,"00000000000000FF2400000000000000000000000000000000000000000000006800A0010290001000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000F000000000000000000000000FFF80010000000000000000000000000000000000
03C000000800000000000","4E09"
111,-15.0,-98.4,0.0,-2.4,10879,10031,-20911,-0,-2,0.01,0.01,0.26,0.22,0.00,0.00,0.00,0.00,60.00,
,"00000000000000FF2400000000000000000000000000000000000000000000006800A0010290001000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000F000000000000000000000000FFF80010000000000000000000000000000000000
03C000000800000000000","4EC6"
```

Event Data (Cycle 1)
The block shown represents four quarter cycles of data.

```
.
.
.

-47.4,119,-71.4,-0.0,0.6,-5261,6613,-1352,0,-2,0.02,0.01,0.25,0.21,0.00,0.00,0.00,0.00,60.00,
,"00000000000000FF2400000000000000000000000000000000000000000000006800A0010290001000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000F000000000000000000000000FFF80010000000000000000000000000000000000
03C000000800000000000","4E3B"
-112,13.8,98.4,-0.0,0.6,-10836,-10085,20921,-0,4,0.02,0.01,0.26,0.21,0.00,0.00,0.00,0.00,60.00,
,"00000000000000FF2400000000000000000000000000000000000000000000006800A0010290001000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000F000000000000000000000000FFF80010000000000000000000000000000000000
03C000000800000000000","4EA5"
75.6,-120,70.8,0.0,26.4,5274,-6601,1327,0,-2,0.02,0.01,0.26,0.20,0.00,0.00,0.00,0.00,60.00,
,"00000000000000FF2400000000000000000000000000000000000000000000006800A0010290001000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000F000000000000000000000000FFF80010000000000000000000000000000000000
03C000000800000000000","4DEB"
```

```
427,-13.8,-99.0,0.0,314,10829,10094,-20923,-
0,4,0.02,0.00,0.26,0.22,0.00,0.00,0.00,0.00,60.00,">","88808000000000FF9000000800000000000000000100
00000000000000000680060010290021000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000F00000000000
000000000000FFF8001000000000000000000000000000000000000003C000000800000000000","4F0B"
```

Event Data
The quarter cycle with the “>” symbol represents the trigger row for the event.

```
-293,119,-72.0,0.0,-246,-5288,6590,-1301,-0,-2,0.02,0.01,0.26,0.21,0.00,0.00,0.00,0.00,60.00,
,"88808000000000FF9000000A0100000000000000210000000000000000000006801700182900210000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000F000000000000000000000000FFF80010000000000070000090000000000000000
03C000000800000000000","4E8F"
-927,13.2,98.4,0.0,-815,-10823,-10100,20923,0,-0,0.02,0.01,0.26,0.21,0.00,0.00,0.00,0.00,60.00,
,"88808000009900669000000801000000000000002100000000000000000000680070018290021000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000F000000000000000000000000FFF80010000000000070000090000000000000000
03C000000000000000000","4ECE"
.
.
.
```

```
-483,119,-70.8,0.0,-435,-5314,6568,-1255,0,-
1,0.02,0.01,0.26,0.21,0.00,0.00,0.00,0.00,60.00,"*","88F0F000009900669000000801000000000000002100000
0000000000000000680070018290021000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
00000000000000000000000000000000000000000000000000000000000000000000000000000000000000F0000000000000
0000000000FFF800190000000000700000900000000000000000003C000000000000000000","4EBE"
```

Event Data
The quarter cycle with the “*” symbol represents the row with the largest measured current for the event. This is the row used for the summary data

```
-1112,13.2,99.0,-0.0,-1000,-10809,-10116,20925,0,-2,0.02,0.01,0.26,0.21,0.00,0.00,0.00,0.00,60.00,
,"88F0F000009900669000000801000000000000002100000000000000000000680070018290021000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000F000000000000000000000000FFF80019000000000070000090000000000000000
03C000000000000000000","4F72"
452,-107,60.0,0.0,405,5324,-6552,1228,-1,3,0.01,0.01,0.25,0.22,0.00,0.00,0.00,0.00,60.00,
,"88808000009900669000000801000000000000002100000000000000000000680070018290021000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000F000000000000000000000000FFF80019000000000070000090000000000000000
03C000000000000000000","4DB6"
760,6.0,-84.6,0.0,682,10802,10127,-20929,0,2,0.02,0.01,0.26,0.21,0.00,0.00,0.00,0.00,60.00,
,"88808000009900669000000801000000000000002100000000000000000000680070018290021000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000F000000000000000000000000FFF80019000000000070000090000000000000000
03C000000000000000000","4E28"
```

Figure 10.6 Sample Compressed ASCII Event Report (Continued)

```
Global Settings

PHROT   := ABC     FNOM    := 60      DATE_F  := MDY
FAULT   := 50G1P OR 50N1P OR 51P1P OR 51QP OR 50Q1P OR TRIP
EMP     := N       TGR     := 3
SS1     := 1
SS2     := 0
SS3     := 0
SS4     := 0
VSRCF   := 1.000   VSPAC   := 0.0
.
.
.
```

Global Settings

```
Group Settings

RID     := SEL-751
TID     := FEEDER RELAY
CTR     := 120     CTRN    := 120     PTR     := 180.00  LEA_S_R := 180.00
LEA_S_SC:= 4.80    DELTA_Y := DELTA   VSCONN  := VS      SINGLEV := N
VNOM    := 120.00
Z1MAG   := 2.14    Z1ANG   := 68.86   Z0MAG   := 6.38    Z0ANG   := 72.47
Z0SMAG  := 0.36    Z0SANG  := 84.61   LL      := 4.84    EFLOC   := N
50P1P   := 2.00    50P1D   := 0.00    50P1TC  := 1
50P2P   := 10.00   50P2D   := 0.00    50P2TC  := 1
50P3P   := 10.00   50P3D   := 0.00    50P3TC  := 1
50P4P   := 10.00   50P4D   := 0.00    50P4TC  := 1
50N1P   := OFF     50N2P   := OFF     50N3P   := OFF     50N4P   := OFF
50G1P   := OFF     50G2P   := OFF     50G3P   := OFF     50G4P   := OFF
50Q1P   := OFF     50Q2P   := OFF     50Q3P   := OFF     50Q4P   := OFF
.
.
.
```

Group Settings

```
Report Settings

ESERDEL := N

SER1    := IN101 IN102 51P1T 51G1T 50P1P 50N1T 51N1T PB01 PB02 PB03 PB04
SER2    := CLOSE 52A CC
SER3    := 81D1T 81D2T
SER4    := SALARM

EALIAS  := 4
.
.
.
```

Report Settings

```
Logic Settings


ELAT    := 4       ESV     := 5       ESC     := N       EMV     := N
.
.
.

=>>
```

Logic Settings

Figure 10.6 Sample Compressed ASCII Event Report (Continued)

The order of the labels in the digital portion of the Column Labels field matches the order of the HEX-ASCII Relay Word. Each numeral in the HEX-ASCII Relay Word reflects the status of four Relay Word bits from the Digital Column Labels field of the Compressed ASCII event report. The HEX-ASCII Relay Word from the trigger cycle from *Figure 10.6*, follows.

```
88808000000000FF90000008000000000000000001000000000000000000006800600102900210
 0000000000000000000000000000000000000000000000000000000000000000000000000000
 0000000000000000000000000000000000000000000000000000000000000000000000000000
 0F00000000000000000000000FFF8001000000000000000000000000000000000003C0000008
 00000000000
```

In this HEX-ASCII Relay Word, the first numeral in the HEX-ASCII Relay Word is an 8. In binary, this is 1000. Mapping the labels to the digital Column Labels yields the following:

50A1P	50B1P	50C1P	50PAF
1	0	0	0

The 50A1P element picked up at the first sample of the trigger cycle row (see *Figure 10.6*)

Viewing Compressed Event (CEV) Reports

The CEV can be viewed in the following ways:

- ACSELERATOR Analytic Assistant SEL-5601 Software
- ACSELERATOR QuickSet SEL-5030 Software via SEL-5601 Software or SYNCHROWAVE Event Software (SEL-5601-2)
- SYNCHROWAVE Event Software (SEL-5601-2)

SEL-5030 Software provides an option to choose between SEL-5601 or SYNCHROWAVE Event (SEL-5601-2) to view the event reports. Navigate to the **Options** menu under **Tools** and select either SEL-5601 or SYNCHROWAVE Event (SEL-5601-2) as the event viewer.

To view the saved events using the SEL-5030 software, click on 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. To view the saved events using SYNCHROWAVE Event Software, click on the **Load Event** function on the right side of the screen.

As shown in *Figure 10.7*, all the ac analog data points shown in a CEV report when viewed with ACSELERATOR Analytic Assistant SEL-5601 or ACSELERATOR QuickSet via SEL-5601 are scaled down by $\sqrt{2}$. SEL recently introduced SYNCHROWAVE Event, also known as SEL-5601-2 Software, for displaying and analyzing relay event reports. The ac analog signals in a CEV report, when viewed using SYNCHROWAVE Event Software, are scaled up by a factor of $\sqrt{2}$ to display the instantaneous magnitudes.

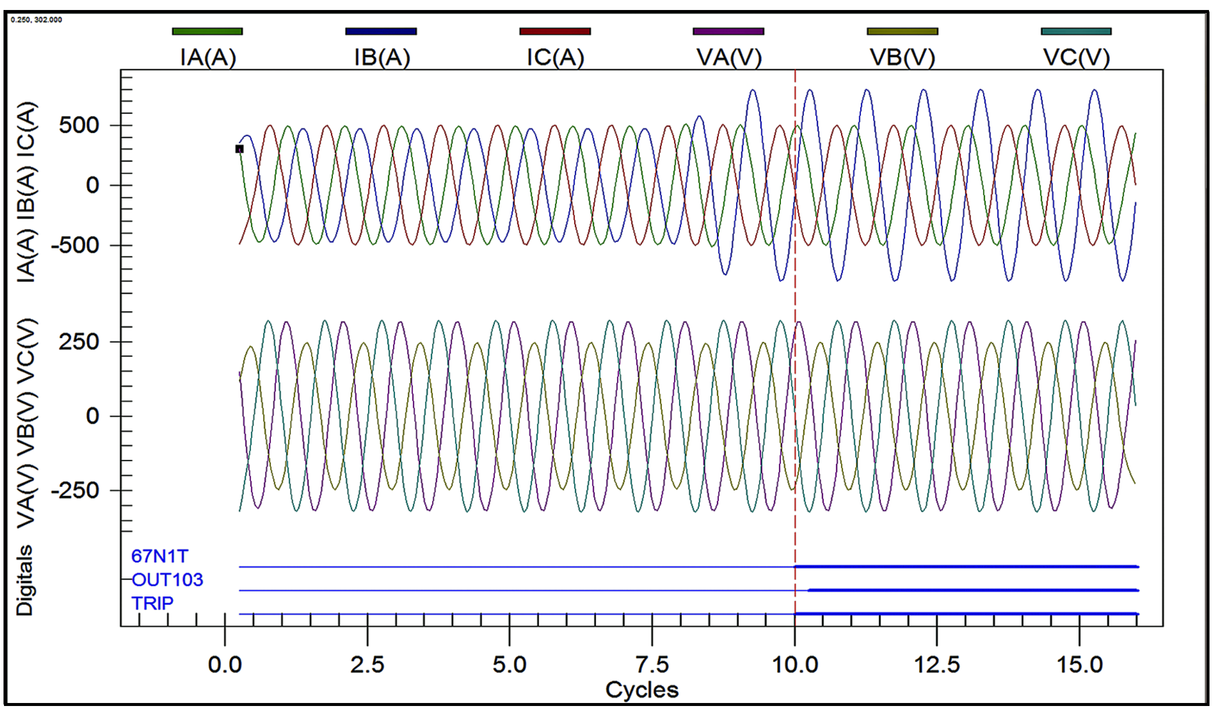


Figure 10.7 Sample CEV Report Viewed With Analytic Assistant or ACSELERATOR QuickSet Via SEL-5601

With ACSELERATOR Analytic Assistant, you have two options for converting CEV reports to COMTRADE, as shown in *Figure 10.8*.

- ➤ Keep COMTRADE Files
- ➤ Use Peak Measurement

Keep COMTRADE Files allows you to convert the CEV report to COMTRADE. **Use Peak Measurement** allows you to scale all the quantities by 1.414 to represent actual instantaneous values for the signals in the converted COMTRADE file.

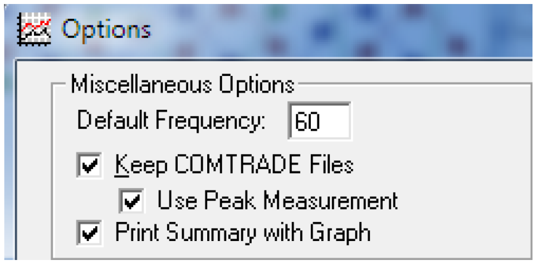


Figure 10.8 Options for Converting CEV Reports to COMTRADE in Analytic Assistant

COMTRADE File Format Event Reports

NOTE: COMTRADE event reports are sampled at 32 samples per cycle, which are equivalent to CEV R event reports.

NOTE: COMTRADE events can be extracted using the **FILE** command (see Section 7: Communications), Ethernet File Transfer Protocol (FTP), or the IEC-61850 Manufacturing Messaging Specification (MMS). To transfer files using MMS, set EMMSFS to Y.

The SEL-751 stores high-resolution raw data oscillography in binary format and uses COMTRADE file types to output these data:

- ➤ .HDR—header file
- ➤ .CFG—configuration file
- ➤ .DAT—high-resolution raw data file

The .HDR file contains summary information about the event in ASCII format. The .CFG file is an ASCII configuration file that describes the layout of the .DAT file. The .DAT file is in binary format and contains the values for each input channel for each sample in the record. These data conform to the IEEE C37.111-1999 COMTRADE standard.

.HDR File

The .HDR file contains the event summary and relay settings information that appears in the event report for the data capture. The settings portion is in a comma-delimited format as illustrated in *Figure 10.9*.

Event Summary Information

```
FID,"SEL-751-X311-V0-Z006002-D20151119"
Event_Report_Type,"UVR"
Serial_Number,"1112345678"
[SUMMARY]
Time_Source,"External"
Event_Logs,"7"
Event_Number,"10004"
Event_Date,"02/11/2015"
Event_Time,"17:44:49.173300"
Event,"Trip*"
Freq,"59.99"
Targets,"11000000"
Fault_IA_Mag(A),"5000.0625"
Fault_IB_Mag(A),"5038.9111"
Fault_IC_Mag(A),"4965.0024"
Fault_IN_Mag(A),"7.0711"
Fault_IG_Mag(A),"150.0000"
Fault_VAB_Mag(V),"669174.4375"
Fault_VBC_Mag(V),"669364.0625"
Fault_VCA_Mag(V),"1164585.8750"
[Fault_Location]
Location,"$$$$$$$$"
[LGEACY_HDR]
SEL-751                                  Date: 11/02/2015   Time: 17:44:49.173
FEEDER RELAY                             Time Source: External
Serial No = 1112345678
FID=SEL-751-X308P-V0-Z006002-D20151111     CID=0000
EVENT LOGS = 7
REF_NUM = 10004
Event:  Trip*
Location:  $$$$$$$$
Freq: 59.99
Targets:  11000000
Current Mag
IA (A) :5000.0625
IB (A) :5038.9111
IC (A) :4965.0024
IN (A) :7.0711
IG (A) :150.0000
Voltage Mag
VAB (V) :669174.4375
VBC (V) :669364.0625
VCA (V) :1164585.8750
```

Relay Settings

```
PHROT   := ABC     FNOM    := 60      DATE_F  := MDY
FAULT   := 50G1P OR 50N1P OR 51P1P OR 51QP OR 50Q1P OR TRIP
EMP     := N       TGR     := 3
SS1     := 1
SS2     := 0
SS3     := 0
SS4     := 0

EPMU    := N
IRIGC   := NONE    UTC_OFF := 0.00    DST_BEGM:= OFF
52ABF   := N       50BFP   := 0.10    BFD     := 0.50    ATD     := OFF
BFI     := R_TRIG TRIP

AO301AQ :=OFF

IN101D  := 10      IN102D  := 10
IN301D  := 10      IN302D  := 10      IN303D  := 10
EBMON   := Y       COSP1   := 10000   COSP2   := 150     COSP3   := 12
KASP1   := 1.20    KASP2   := 8.00    KASP3   := 20.00   BKMON   := TRIP
```

Relay Settings

```
RSTTRGT := 0
RSTENRGY:= 0
RSTMXMN := 0
RSTDEM  := 0
RSTPKDEM:= 0

DSABLSET:= 0

TIME_SRC:= IRIG1   TIME_SRC:= IRIG1
```

Figure 10.9 Sample COMTRADE .HDR Header File

```
Group Settings

RID     := SEL-751
TID     := FEEDER RELAY
CTR     := 1        CTRN    := 1        PTR     := 1.00    DELTA_Y := WYE
SINGLEV := N        VNOM    := OFF


50P1P   := 10.00    50P1D   := 0.00     50P1TC  := 1
50P2P   := 10.00    50P2D   := 0.00     50P2TC  := 1
50P3P   := 10.00    50P3D   := 0.00     50P3TC  := 1
50P4P   := 10.00    50P4D   := 0.00     50P4TC  := 1
50N1P   := OFF      50N2P   := OFF      50N3P   := OFF     50N4P   := OFF
50G1P   := OFF      50G2P   := OFF      50G3P   := OFF     50G4P   := OFF
50Q1P   := OFF      50Q2P   := OFF      50Q3P   := OFF     50Q4P   := OFF

51AP    := 6.00
51AC    := U3       51ATD   := 3.00     51ARS   := N
51ACT   := 0.00     51AMR   := 0.00     51ATC   := 1

51BP    := 6.00     51BC    := U3       51BTD   := 3.00    51BRS   := N
51BCT   := 0.00     51BMR   := 0.00     51BTC   := 1

51CP    := 6.00     51CC    := U3       51CTD   := 3.00    51CRS   := N
51CCT   := 0.00     51CMR   := 0.00     51CTC   := 1

51P1P   := 6.00     51P1C   := U3       51P1TD  := 3.00    51P1RS  := N
51P1CT  := 0.00     51P1MR  := 0.00     51P1TC  := 1

51P2P   := 6.00     51P2C   := U3       51P2TD  := 3.00    51P2RS  := N
51P2CT  := 0.00     51P2MR  := 0.00     51P2TC  := 1

51QP    := 6.00     51QC    := U3       51QTD   := 3.00    51QRS   := N
51QCT   := 0.00     51QMR   := 0.00     51QTC   := 1

51N1P   := OFF      51N2P   := OFF      51G1P   := 0.50    51G1C   := U3
51G1TD  := 1.50     51G1RS  := N
51G1CT  := 0.00     51G1MR  := 0.00     51G1TC  := 1

51G2P   := 0.50     51G2C   := U3       51G2TD  := 1.50    51G2RS  := N
51G2CT  := 0.00     51G2MR  := 0.00     51G2TC  := 1

EDIR    := Y        DIR1    := F        DIR2    := N       DIR3    := N
DIR4    := N        ORDER   := OFF
EDIRIV  := 1

EHBL2   := N        EHBL5   := N
E49RTD  := NONE
E49IEC  := 2
TAMB    := OFF      THRO1   := IARMS    IBAS1   := 1.0     KCONS1  := 1.00
IEQPU1  := 0.05     THST1   := 0
TCONH11 := 60       TCONC11 := 60       TCONH12 := 60      TCONC12 := 60
THLT1   := 100      THLA1   := 50       THLTDR1 := 0.98    THLADR1 := 0.98
TMAX1   := 155      RSTTH1  := 0
THRO2   := IBRMS    IBAS2   := 1.0      KCONS2  := 1.00    IEQPU2  := 0.05
THST2   := 0
TCONH21 := 60       TCONC21 := 60       TCONH22 := 60      TCONC22 := 60
THLT2   := 100      THLA2   := 50       THLTDR2 := 0.98    THLADR2 := 0.98
TMAX2   := 155      RSTTH2  := 0

27P1P   := OFF      27P2P   := OFF

27PP1P  := OFF      27PP2P  := OFF

59P1P   := OFF      59P2P   := OFF
59PP1P  := OFF      59PP2P  := OFF      59G1P   := OFF     59G2P   := OFF
59Q1P   := OFF      59Q2P   := OFF
```

Figure 10.9 Sample COMTRADE .HDR Header File (Continued)

```
E27I1   := N       E27I2   := N

E59I1   := N       E59I2   := N       E59I3   := N       E59I4   := N

LOPBLK  := 0

55LGTP  := OFF     55LDTP  := OFF     55LGAP  := OFF     55LDAP  := OFF
81D1TP  := OFF     81D2TP  := OFF
81D3TP  := OFF
81D4TP  := OFF
81D5TP  := OFF
81D6TP  := OFF
E81R    := N
E81RF   := N       EDEM    := THM     DMTC    := 5       PHDEMP  := 5.00
GNDEMP  := 1.00    3I2DEMP := 1.00
EPWR    := N
TDURD   := 0.5     CFD     := 1.0
TR      := ORED50T OR ORED51T OR ORED81T OR REMTRIP OR OC OR SV04T
REMTRIP := 0
ULTRIP  := NOT (51P1P OR 51G1P OR 51N1P OR 52A)
52A     := 0
CL      := SV03T AND LT02 OR CC
ULCL    := 0

Report Settings

ESERDEL := N

SER1    := IN101 IN102 51P1T 51G1T 50P1P 50N1T 51N1T PB01 PB02 PB03 PB04
SER2    := CLOSE 52A CC
SER3    := 81D1T 81D2T
SER4    := SALARM
EALIAS  := 4

ALIAS1  :=PB01 FP_AUX1 PICKUP DROPOUT
ALIAS2  :=PB02 FP_LOCK PICKUP DROPOUT
ALIAS3  :=PB03 FP_CLOSE PICKUP DROPOUT
ALIAS4  :=PB04 FP_TRIP PICKUP DROPOUT

ER      := R_TRIG 51P1P OR R_TRIG 51G1P OR R_TRIG 50P1P OR R_TRIG 50G1P OR R_TRIG 51N1P
 OR R_TRIG CF
LER     := 15      PRE     := 5

FMR1NAM := FMR1
FMR1    :=NA
FMR2NAM := FMR2
FMR2    :=NA
FMR3NAM := FMR3
FMR3    :=NA
FMR4NAM := FMR4
FMR4    :=NA

RA01TYPE:= I
RA02TYPE:= I
RA03TYPE:= I
RA04TYPE:= I
RA05TYPE:= I
RA06TYPE:= I
RA07TYPE:= I
RA08TYPE:= I
RA09TYPE:= I
RA10TYPE:= I
RA11TYPE:= I
RA12TYPE:= I
RA13TYPE:= I
RA14TYPE:= I
RA15TYPE:= I
RA16TYPE:= I
RA17TYPE:= I
RA18TYPE:= I
RA19TYPE:= I
RA20TYPE:= I
RA21TYPE:= I
RA22TYPE:= I
RA23TYPE:= I
RA24TYPE:= I
RA25TYPE:= I
RA26TYPE:= I
RA27TYPE:= I
RA28TYPE:= I
RA29TYPE:= I
RA30TYPE:= I
RA31TYPE:= I
RA32TYPE:= I
```

Figure 10.9 Sample COMTRADE .HDR Header File (Continued)

```
LDLIST  := NA

LDAR    := 15

Logic Settings
ELAT    := 4       ESV     := 5       ESC     := N       EMV     := N
SET01   := NA
RST01   := NA
SET02   := R_TRIG SV02T AND NOT LT02
RST02   := R_TRIG SV02T AND LT02
SET03   := PB03_PUL AND LT02 AND NOT 52A
RST03   := (PB03_PUL OR PB04_PUL OR SV03T) AND LT03
SET04   := PB04_PUL AND 52A
RST04   := (PB03_PUL OR PB04_PUL OR SV04T) AND LT04

SV01PU  := 0.00    SV01DO  := 0.00
SV01    := NA
SV02PU  := 3.00    SV02DO  := 0.00
SV02    := PB02
SV03PU  := 0.00    SV03DO  := 0.00
SV03    := LT03
SV04PU  := 0.00    SV04DO  := 0.00
SV04    := LT04
SV05PU  := 0.25    SV05DO  := 0.25
SV05    := (PB02 OR LT03 OR LT04) AND NOT SV05T


OUT101FS:= Y       OUT101  := HALARM OR SALARM OR AFALARM
OUT102FS:= N       OUT102  := CLOSE
OUT103FS:= N       OUT103  := TRIP
OUT301FS:= N       OUT301  := 0
OUT302FS:= N       OUT302  := 0
OUT303FS:= N       OUT303  := 0
OUT304FS:= N       OUT304  := 0
```

SAM/CYC_A = 32 SAM/CYC_D = 4	Analog, Digital, and Input Samples per Cycle Data

Figure 10.9 Sample COMTRADE .HDR Header File (Continued)

.CFG File

The .CFG file contains data that is used to reconstruct the input signals to the relay and the status of Relay Word bits during the event report (see *Figure 10.10*). A <CR><LF> follows each line. If control inputs or control outputs are unavailable because of board loading and configuration, the relay does not report these inputs and outputs in the analog and digital sections of the .CFG file.

<RID setting>,FID=SEL-751-Rxxx-V0-Zxxxxxx-Dyyyymmdd,1999	COMTRADE Standard
#T,#A,#D	Total Channels, Analog, Digital
1,IA,A,,A,scale_factor[a],0.0,0,-32767,32767,[CTR],1.0,P 2,IB,B,,A,scale_factor[a],0.0,0,-32767,32767,[CTR],1.0,P 3,IC,C,,A,scale_factor[a],0.0,0,-32767,32767,[CTR],1.0,P 4,IN,,,A,scale_factor[a],0.0,0,-32767,32767,[CTRN],1.0,P 5,IG,,,A,scale_factor[a],0.0,0,-32767,32767,[CTR],1.0,P 6,VA,A,,kV,scale_factor[a],0.0,0,-32767,32767,[PTR],1.0,P 7,VB,B,,kV,scale_factor[a],0.0,0,-32767,32767,[PTR],1.0,P 8,VC,C,,kV,scale_factor[a],0.0,0,-32767,32767,[PTR],1.0,P 9,VS,C,,kV,scale_factor[a],0.0,0,-32767,32767,[PTRS],1.0,P 10,FREQ,,,Hz,0.01,0.0,0,0,12000,1.0,1.0,P 11,VDC,C,,V,scale_factora,0.0,0,-32767,32767,-0.0,1.0,P	Analog Channel Data [a]Scale_factor is the value used to convert the equivalent channel analog data in the DAT file to primary units (A or kV peak-to-peak)
1,rwb_label[b,c],,,0 2,rwb_label[b,c],,,0 . . . nnnn[d],rwb_label[b,c],,,0	Digital (Status) Channel Data [b]rwb_label is replaced with Relay Word bit labels as seen in Table K.1 [c]Place holders denoted by asterisk (*), are labeled as UNUSEDxxx (where xxx is the number of the associated label) [d]nnnn = number of the last Relay Word bit
<NFREQ> 0 0,<# of samples>	
dd/mm/yyyy,hh:mm:ss.ssssss	First Data Point

Figure 10.10 Sample COMTRADE .CFG Configuration File Data (Sheet 1 of 2)

`dd/mm/yyyy,hh:mm:ss.ssssss`	Trigger Point
`BINARY` `<time stamp multiplication factor>`	

Figure 10.10 Sample COMTRADE .CFG Configuration File Data (Sheet 2 of 2)

The configuration file has the following format:

- Relay ID, firmware ID, COMTRADE standard year
- Number and type of channels
- Channel name units and conversion factors
- Digital Relay Word bit names
- System frequency
- Sample rate and number of samples
- Date and time of first data point
- Date and time of trigger point
- Data file type
- Time stamp multiplication factor

.DAT File

The .DAT file follows the COMTRADE binary standard. The format of the binary data files is sample number, time stamp, data value for each analog channel, and digital channel status data for each sample in the file. There are no data separators in the binary file, and the file contains no carriage return/line feed characters. The sequential position of the data in the binary file determines the data translation. Refer to the IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems, IEEE C37.111–1999 for more information. Many software applications can read binary COMTRADE files, including ACSELERATOR Analytic Assistant SEL-5601 Software and ACSELERATOR QuickSet SEL-5030 Software.

Retrieving COMTRADE Event Files

COMTRADE files are available as read-only files that can be retrieved using the **FILE** command and Ymodem file transfer, Ethernet File Transfer Protocol (FTP), or Manufacturing Messaging Specification (MMS). MMS file transfer is only available in models that support IEC 61850 and only when IEC 61850 is enabled (E61850 := Y) and MMS file services is enabled (EMMSFS := Y). See ***FILE Command on page 7.32***, *File Transfer Protocol (FTP) and MMS File Transfer on page 7.13*, and *MMS on page F.4* for additional information.

High-Impedance Fault (HIF) Event Reporting

NOTE: HIF COMTRADE events can be extracted using the **FILE** command (see Section 7: Communications), Ethernet File Transfer Protocol (FTP), or the IEC-61850 Manufacturing Messaging Specification (MMS). To transfer files using MMS, set EMMSFS to Y.

High-impedance fault event information is available when the relay supports HIF detection. The HIF events can be viewed in compressed ASCII or COMTRADE format. The relay stores event information in nonvolatile memory. Report setting HIFLER determines the length of the stored event report. The relay can store approximately 40 minutes of event report data, corresponding to two stored events at the maximum HIFLER setting of 20 minutes, or approximately 20 stored events at the minimum HIFLER setting of two minutes. The length of time reserved within the stored event report for the capture of pretrigger (prefault) data are fixed to 60 seconds (on a 60 Hz system) regardless of the HIFLER setting value. You can view information about a high-impedance fault event in one or more of the following forms:

- HIF event summary
- HIF event history

Event Numbering

Use the **CEV HIF *n*** command to access particular event reports; parameter ***n*** indicates the order of the event report. The most recent event report is record number one (1), the next most recent report is record number two (2), and so on. In addition, events can be accessed by their unique reference number. Reference numbers start at 10000 and increment with each event. When the event report list is cleared, the reference number resets to 10000. *Table 10.5* lists the **CEV HIF** commands.

Table 10.5 CEV HIF Commands

Command	Description
CEV HIF	Returns the most recent compressed HIF event report
CEV HIF *n*	Returns a particular *n* (*n* = record or reference number) compressed HIF event report

High-Impedance Fault Event Summary

You can retrieve a shortened version of stored high-impedance fault event as HIF event summaries. These short-form reports present vital information about a triggered event. See *Figure 10.11* for a sample HIF event summary.

```
=>>SUM HIF <Enter>

SEL-751                                   Date: 03/16/2011   Time: 15:57:17.900
FEEDER RELAY                               Time Source: Internal

Serial No = 000000000000000
FID=SEL-751-X141-V0-Z001001-D20110315
EVENT LOGS = 5
Event: HIF Fault                           HIF Phase: A,B
Downed Conductor: NO                       Freq: 59.99       Breaker: OPEN

Pre-trigger (A):
IARMS        IBRMS        ICRMS
28439.0      0.0          0.0

Post-trigger (A):
-24497.0     0.0          0.0

Pre-trigger (A):
ISMA         ISMB         ISMC         SDIA         SDIB         SDIC
28443.0      0.0          0.0          28440.0      0.0          0.0

Post-trigger (A):
-24493.0     0.0          0.0          -24496.0     0.0          0.0
```

Figure 10.11 Sample HIF Event Summary Report

The event summary contains the following information:

- Standard report header
  - Relay and terminal identification
  - Event date and time
- Event type
- HIF Phase
- Event logs
- Downed Conductor

- System frequency
- Pre-trigger and post-trigger phase currents, sum of difference currents, and total odd harmonic content of currents (from the initial trigger point and the first point of the event report)

Table 10.6 lists event types in fault reporting priority. For example, alarm event types have reporting priority over triggered events. You can trigger events in one of two ways. The **TRI HIF** command triggers an event (see *Triggering on page 10.2* for complete information on the **TRI** command) locally. Report setting HIFER allows you to trigger an event automatically at the assertion of the corresponding Relay Word bit (see *Table 4.28*). You can also program this setting in a manner to aid in simultaneous event triggering in multiple relays.

Table 10.6 HIF Event Types

Event	Event Trigger
HIF ALARM	Assertion of any one of the following Relay Word bits and if no HIF fault has occurred: HIA1_A, HIA1_B, HIA1_C, HIA2_A, HIA2_B, HIA2_C
HIF FAULT	Assertion of any one of the following Relay Word bits: HIF1_A, HIF1_B, HIF1_C, HIF2_A, HIF2_B, HIF2_C
HIF Ext. TRI	Assertion of HIFER SELOGIC variable.
HIF TRI	Execution of the **TRI HIF** command.

Table 10.7 lists HIF phase involvement conditions. Multiple phases can be listed if the relay detects more than one phase involvement. If an HIF fault occurs (HIF*n_x*), alarmed phases are not listed. When an event report is triggered for any of these conditions, Relay Word bit HIFREC is asserted until the HIF event report is finished being collected. The relay does not generate additional event reports for triggering conditions that follow the initial triggering condition and are within the same report.

Table 10.7 HIF Event Phases

Phase	Conditions
A	Assertion of any one of the following Relay Word bits: HIA1_A, HIA2_A, HIF1_A, HIF2_A
B	Assertion of any one of the following Relay Word bits: HIA1_B, HIA2_B, HIF1_B, HIF2_B
C	Assertion of any one of the following Relay Word bits: HIA1_C, HIA2_C, HIF1_C, HIF2_C

When a high-impedance fault is caused by a downed conductor, there can be a load current reduction. Depending on the position of the down conductor and the amount of load dropped, this load reduction event may or may not be detectable back in a substation. The load reduction element is used to detect any load reduction at the time that the relay detects a high-impedance fault. The element is used to report a possible downed conductor event. *Table 10.8* lists HIF downed conductor conditions.

If the HIF1_*x* or HIF2_*x* Relay Word bits have been programmed to alarm, then these alarms can be further secured by ANDing them with the load reduction (LR) bits. A drawback of this approach, however, is that if an event does not lead to enough of a drop in load current, the load reduction logic may not operate (and hence not alarm).

Table 10.8 HIF Downed Conductor

Downed Conductor	Conditions
YES	Assertion of any one of the following Relay Word bits: HIA1_A, HIA1_B, HIA1_C, HIA2_A, HIA2_B, HIA2_C, HIF1_A, HIF1_B, HIF1_C, HIF2_A, HIF2_B, HIF2_C, AND LR*X* (LRA, LRB, LRC) bit asserts where *X* is the same phase as the alarm or fault phase.
NO	When the previous condition is not true.

The system frequency is displayed as measured at the time of trigger to two decimal places. Pretrigger currents are obtained from the first sample in the event report, while post-trigger currents are obtained from the initial trigger sample.

Viewing the HIF Event Summary

Access the history report from the communications ports by using the **HIS HIF** command or the analysis menu within QuickSet. View and download HIF history reports from Access Level 1 and higher.

You can use the **SUM HIF** command to retrieve HIF event summaries by event number. (The relay labels each new event with a unique number as reported in the **HIS HIF** command history report; see *High-Impedance Fault Event History on page 10.33*.) *Table 10.9* lists the **SUM HIF** commands.

Table 10.9 SUM HIF Command

Command	Description
SUM HIF	Return the most recent HIF event summary.
SUM HIF *n*	Return an event summary for HIF event *n*[a].

[a] The parameter n indicates event record number. The most recent event has a record number of one (1).

CSUMMARY HIF

The relay outputs a Compressed ASCII HIF summary report for SCADA and other automation applications. Issue ASCII command **CSU HIF** to view the Compressed ASCII HIF summary report. A sample of the summary report appears in *Figure 10.12*; this is a comma-delimited ASCII file. The relay appends a four digit hex checksum at the end of the lines in the Compressed ASCII report.

Items included in the Compressed ASCII summary report are similar to those included in the summary report, although the relay reports the items in a special order. For the purpose of improving products and services, SEL sometimes changes the items and item order.

See *Compressed Event Reports on page 10.2* for more information on the Compressed ASCII command set.

```
=>>CSUM HIF <Enter>

"FID","0143"
"FID=SEL-751-X141-V0-Z001001-D20110315","08A3"
"REF_NUM","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","0D66"
10033,3,16,2011,15,57,17,900,"0588"
"EVENT","HIF PHASE","DOWNED CONDUCTOR","FREQUENCY","BREAKER","0F5A"
"HIF Fault","A,B","NO",59.99,"OPEN","086B"
"IARMS_PF","IBRMS_PF","ICRMS_PF","IARMS","IBRMS","ICRMS","0E6D"
28439.0,0.0,0.0,-24497.0,0.0,0.0,"063D"
"ISMA_PF","ISMB_PF","ISMC_PF","ISMA","ISMB","ISMC","0C81"
28443.0,0.0,0.0,-24493.0,0.0,0.0,"0634"
"SDIA_PF","SDIB_PF","SDIC_PF","SDIA","SDIB","SDIC","0C4B"
28440.0,0.0,0.0,-24496.0,0.0,0.0,"0634"

Where *_PF  denotes pre-trigger analogs.

=>>
```

Figure 10.12 Sample Compressed ASCII HIF Summary

High-Impedance Fault Event History

The HIF event history gives you a quick look at recent relay activity. See *Figure 10.13* for a sample event history. The HIF event history contains the following:

- Standard report header
  - Relay and terminal identification
  - Date and time of report
- Event reference number
- Event date and time
- Event type
- Downed Conductor
- Settings Group

```
=>>HIS HIF <Enter>

SEL-751                                 Date: 03/17/2011   Time: 09:51:02.729
FEEDER RELAY                             Time Source: Internal

FID=SEL-751-X141-V0-Z001001-D20110315

#          DATE        TIME        EVENT              DOWNED CONDUCTOR   GRP
10012    03/14/2011  10:09:48.011    HIF Fault A,B             YES         1
10011    03/14/2011  10:07:47.950    HIF Fault A,B             NO          1
10010    03/11/2011  14:14:56.033    HIF Fault A,B             NO          1
10009    03/08/2011  16:43:28.151    HIF Ext. TRI              NO          1
10008    03/08/2011  16:39:59.510    HIF Ext. TRI              NO          1

10007    03/08/2011  16:37:58.913    HIF Ext. TRI              NO          1
10006    03/08/2011  14:24:41.643    HIF Ext. TRI              NO          1
10005    03/08/2011  14:19:57.743    HIF Ext. TRI              NO          1
10004    03/08/2011  13:51:03.106    HIF Ext. TRI              NO          1
10003    03/08/2011  13:48:48.230    HIF Ext. TRI              NO          1
10002    03/08/2011  13:47:20.440    HIF Ext. TRI              NO          1
10001    03/08/2011  13:44:20.023    HIF Ext. TRI              NO          1
10000    03/08/2011  13:29:35.196    HIF Ext. TRI              NO          1

=>>
```

Figure 10.13 Sample HIF Event History

The event types and downed conductor status in the event history are determined in the same manner as in the event summary (see *High-Impedance Fault Event Summary on page 10.30*). As shown in *Figure 10.13*, the event history report indicates events stored in relay nonvolatile memory. The relay places a blank row in the history report output; items that are above the blank row are available for viewing (use the **CEV HIF** command). Items that are below the blank row are no longer in relay memory; these events appear in the history report to indicate past power system performance. The relay does not ordinarily modify the numerical or time order in the history report.

Viewing the HIF Event History

Access the history report from the communications ports by using the **HIS HIF** command or the analysis menu within QuickSet. View and download history reports from Access Level 1 and higher.

Use the **HIS HIF** command from a terminal to obtain the event history. You can specify the number of the most recent events that the relay returns.

Table 10.10 HIS HIF Command

Command	Description
HIS HIF	Return event histories with the oldest at the bottom of the list and the most recent at the top of the list.
HIS HIF *k*	Return the *k* most recent event summaries with the oldest at the bottom of the list and the most recent at the top of the list.
HIS HIF C or **R**	Clears the event and the event identifier is unaffected.
HIS HIF CA or **RA**	Clears HIF event and history, also resets the event identifier so that the next event generated has event identifier 10000.

CHISTORY HIF

The SEL-751 provides Compressed ASCII event reports to facilitate event report storage and display. SEL communications processors and the ACSELERATOR Analytic Assistant take advantage of the Compressed ASCII format. Use the **CHIS HIF** command to display Compressed ASCII event history information.

```
=>>CHIS HIF <Enter>
"FID","0143"
"FID=SEL-751-X141-V0-Z001001-D20150315","08A3"
"REC_NUM","REF_NUM","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","EVENT","D
 OWN
ED CONDUCTOR","GRP","184C"
1,10033,3,16,2011,15,57,17,900,"HIF Fault A,B","NO",2,"0B82"
2,10032,3,16,2011,15,53,21,727,"HIF Fault A,B","NO",2,"08EE"
3,10031,3,16,2011,14,29,24,269,"HIF Fault A,B","NO",1,"08F3"
4,10030,3,16,2011,13,57,55,952,"HIF Fault A,B","NO",1,"08F6"
5,10029,3,16,2011,12,41,59,983,"HIF Fault A,B","NO",1,"08FF"
```

Figure 10.14 Sample Compressed HIF History Report

High-Impedance Fault Compressed Event Report

The SEL-751 provides Compressed ASCII event reports to facilitate event report storage and display. SEL communications processors and the ACSELERATOR Analytic Assistant take advantage of the Compressed ASCII format. Use the **CEV HIF** command to display Compressed ASCII HIF event reports.

The relay generates compressed event reports to display analog data, and the state of related Relay Word bits from the odd and nonharmonic HIF fault detection algorithm and load reduction.

The relay provides user-programmable event report triggering conditions. An event report is triggered for all conditions listed in the Summary **HIF** command. When an event report is triggered for any of these conditions, asserts Relay Word bit HIFREC, which stays asserted until the HIF event report has finished collecting. The relay does not generate additional event reports for triggering conditions that follow the initial triggering condition and are within the same report.

The number of event reports the relay shall be able to store depends on the HIFLER setting at the rate of 1 sample every 2 cycles. For example, if the HIFLER setting is 10 minutes, then the relay should be able to store at least four back-to-back event reports. See *Retrieving Event Reports Via Ethernet File Transfer on page 10.18* for details on retrieving compressed events via FTP or MMS File transfer.

High-Impedance Fault COMTRADE File Format Reports

The SEL-751 stores high-impedance fault oscillography in binary format and uses COMTRADE file types to output these data:

- .HDR–header file
- .CFG–configuration file
- .DAT–data file

The .HDR file contains summary information about the event in ASCII format. The .CFG file is an ASCII configuration file that describes the layout of the .DAT file. The .DAT file is in binary format and contains the values for each input channel for each sample in the record. These data conform to the IEEE C37.111-1999 COMTRADE standard.

.HDR File

The .HDR file contains the output of the **HIF** summary command (**SUM HIF**) and settings relevant to the high-impedance fault detection logic as illustrated in *Figure 10.15*.

```
=>>SUM HIF <Enter>
FEEDER 1 Date: 08/03/2012 Time: 08:52:15.854
STATION A Time Source: external
Event Number = 10000
Event: HIF Fault HIF Phase: A,B
Downed Conductor: NO Freq: 59.99
Breaker: CLOSED
Pre-trigger (A):
IARMS IBRMS ICRMS
312.0 238.0 282.0
Post-trigger (A):
312.0 245.0 281.0
Pre-trigger (A):
SDIA SDIB SDIC
236.5 203.5 211.5
Post-trigger (A):
247.0 217.0 224.0
CTR,"1000.0"
HIFLER,"2"
=>>
```

Figure 10.15 Sample HIF COMTRADE .HDR Header File

.CFG File

The .CFG file contains data that are used to reconstruct the captured high-impedance fault data during the event report (see *Figure 10.16*). A **<CR><LF>** follows each line.

<RID>, <FID>, 1999	
##,##A,##D	Total Channels, Analog, Digital

Figure 10.16 Sample HIF COMTRADE .CFG Configuration File Data

```
1,IARMS,A,,A,<scale factor>,0.0,0,-32767,32767,<CTR>,1,P
2,IBRMS,B,,A,<scale factor>,0.0,0,-32767,32767,<CTR>,1,P
3,ICRMS,C,,A,<scale factor>,0.0,0,-32767,32767,<CTR>,1,P
4,SDIA,A,,A,<scale factor>,0.0,0,-32767,32767,<CTR>,1,P
5,SDIB,B,,A,<scale factor>,0.0,0,-32767,32767,<CTR>,1,P
6,SDIC,C,,A,<scale factor>,0.0,0,-32767,32767,<CTR>,1,P
7,SDIAREF,A,,A,<scale factor>,0.0,0,-32767,32767,<CTR>,1,P
8,SDIBREF,B,,A,<scale factor>,0.0,0,-32767,32767,<CTR>,1,P
9,SDICREF,C,,A,<scale factor>,0.0,0,-32767,32767,<CTR>,1,P
10,dA,A,,A,1.000000,0.0,0,-32767,32767,<CTR>,1,P
11,dB,B,,A,1.000000,0.0,0,-32767,32767,<CTR>,1,P
12,dC,C,,A,1.000000,0.0,0,-32767,32767,<CTR>,1,P
```

Analog Channel Data

```
13,T7CNTA,A,,,1,0,0,-32767,32767,1,1,P
14,T7CNTB,B,,,1,0,0,-32767,32767,1,1,P
15,T7CNTC,C,,,1,0,0,-32767,32767,1,1,P
16,T8CNTA,A,,,1,0,0,-32767,32767,1,1,P
17,T8CNTB,B,,,1,0,0,-32767,32767,1,1,P
17,T8CNTB,B,,,1,0,0,-32767,32767,1,1,P
```

Analog Channel Data

```
1,<RWBIT>,,,0
...
##,<RWBIT>,,,0
```

Digital (Status) Channel Data

```
NFREQ
0
0, <last sample number>
```

```
dd/mm/yyyy,hh:mm:ss.ssssss
```

First Data Point

```
dd/mm/yyyy,hh:mm:ss.ssssss
```

Trigger Point

```
BINARY
1
```

Figure 10.16 Sample HIF COMTRADE .CFG Configuration File Data (Continued)

The configuration file has the following format:

- Station name, device identification, COMTRADE standard year
- Number and type of channels
- Channel name units and conversion factors
- HIF digital relay word bit names
- Nominal frequency
- Number of samples
- Date and times of first data point and event trigger

The .CFG file references analog quantities that are particular to high-impedance fault detection. See *High-Impedance Fault Compressed Event Report on page 10.34* for a description of HIF analog and digital values.

.DAT File

The .DAT file follows the COMTRADE binary standard. The format of the binary data files is sample number, time stamp, data value for each analog channel, and digital channel status data for each sample in the file. There are no data separators or carriage return/line feed characters in the binary file. The sequential position of the data in the binary file determines the data translation. Refer to the *IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems, IEEE C37.111-1999* for more information. Many programs read the binary COMTRADE files. These programs include Analytic Assistant. See *Retrieving COMTRADE Event Files on page 10.29* for details on retrieving COMTRADE event files via FIL command, FTP, or MMS File transfer.

Sequential Events Recorder (SER) Report

The SER report captures relay element state changes during 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

Use settings SER1 through SER4 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:

NOTE: A file containing and SER report can be extracted using the **FILE** command (see Section 7: Communications), the Ethernet File Transfer Protocol (FTP), or the IEC-61850 Manufacturing Messaging Specification (MMS). To transfer files using MMS, set EMMSFS to Y.

```
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 4.206* for additional details.

See *SER Command (Sequential Events Recorder Report) on page 7.46* for details on retrieving and clearing SER reports with the **SER** command.

Example SER Report

The example SER report in *Figure 10.17* includes records of events that occurred before the beginning of the event summary report in *Figure 10.3*.

```
=>SER 8 <Enter>

SEL-751                                   Date: 02/28/2007   Time: 16:34:28
FEEDER RELAY                               Time Source: Internal

Serial No = 2007XXXXXXXXXXX
FID = SEL-751-R100-V0-Z001001-D20070410               CID = 5052

#      DATE         TIME              ELEMENT              STATE
8   02/28/2007  13:54:09.602   51P1P                    Asserted
7   02/28/2007  13:54:09.602   51AP                     Asserted
6   02/28/2007  13:54:10.003   51P1T                    Asserted
5   02/28/2007  13:54:10.003   TRIP                     Asserted
4   02/28/2007  13:54:10.219   51P1P                    Deasserted
3   02/28/2007  13:54:10.219   51AP                     Deasserted
2   02/28/2007  13:54:10.236   51P1T                    Deasserted
1   02/28/2007  13:54:10.511   TRIP                     Deasserted
=>
```

Figure 10.17 Example Sequential Events Recorder (SER) Event Report

Section 11
Testing and Troubleshooting

Overview

Relay testing is typically divided into two categories:

- ➤ Tests performed at the time the relay is installed or commissioned
- ➤ Tests performed periodically once the relay is in service

This section provides information on both types of testing for the SEL-751 Feeder Protection Relay. Because the SEL-751 is equipped with extensive self-tests, traditional periodic test procedures can be eliminated or greatly reduced.

Should a problem arise during either commissioning or periodic tests, the section on *Troubleshooting on page 11.16* 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 10: Analyzing Events*.

The relay provides a Sequential Events Recorder (SER) event report that time-tags changes in relay element and input/output contact states. The SER provides a convenient means to verify the pickup/dropout of any element in the relay. The **SER** command is available at the serial ports. See *Section 10: Analyzing Events*.

Use the **TARGET** command to view the state of relay control inputs, relay outputs, and relay elements individually during a test. The **TARGET** command is available at the serial ports and the front panel. See *Section 7: Communications* and *Section 8: Front-Panel Operations*.

Low-Level Test Interface

The SEL-751 has a low-level test interface on the 4 ACI/3 AVI current/voltage card with both the LEA voltage inputs and the regular voltage inputs in Slot Z and on the 2 AVI/4 AFDI voltage card with both the LEA voltage input and the regular voltage input for the VS channel in Slot E. You can test the relay in either of two ways: conventionally, by applying ac signals to the relay inputs or by applying low magnitude ac voltage signals to the test interface on the printed circuit boards.

NOTE: The SEL-RTS Relay Test System consists of the SEL-AMS Adaptive Multichannel Source and SEL-5401 Test System Software.

You can use the SEL-RTS Low-Level Relay Test System to provide signals to test the relay. *Figure 11.1* shows the Test Interface connectors.

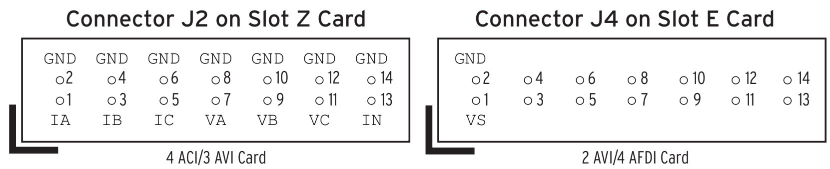


Figure 11.1 Low-Level Test Interface (J2 and J4)

Table 11.1 shows the signal scale factor information used by the AMS Relay Test System SEL-5401 Software for the calibrated inputs.

NOTE: If you use a 4 ACI card in Slot Z, the voltage channels do not apply.

Table 11.1 Resultant Scale Factors for Inputs

Channel Label	Circuit Board & Connector	SEL-5401 Channel No.	Nominal Input	Scale Factor[a] (A/V or V/V)
IA	J2 on Slot Z card	1	5 A/1 A	106.14/21.23
IB	J2 on Slot Z card	2	5 A/1 A	106.14/21.23
IC	J2 on Slot Z card	3	5 A/1 A	106.14/21.23
VA	J2 on Slot Z card	4	300 V/8 V LEA	218.4/5.84
VB	J2 on Slot Z card	5	300 V/8 V LEA	218.4/5.84
VC	J2 on Slot Z card	6	300 V/8 V LEA	218.4/5.84
IN	J2 on Slot Z card	7	5 A/1 A/0.2 A	106.14/21.23/6.86
VS	J4 on Slot E card	8	300 V/8 V LEA	218.4/5.84

[a] Scale Factors for LEA voltage inputs are same as regular PT inputs.

Access the low-level test interface connectors by using the following procedure. Make sure to turn off the relay at the start of *Step 1*. Turn the relay back on after *Step 9*. Refer to the *SEL-RTS Instruction Manual* for additional detail.

⚠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.

Step 1. Remove the control voltage and ac signals from the SEL-751 by opening the appropriate breaker(s) or removing fuses.

Step 2. Loosen the mounting screws and the ground screw on the back and remove the back cover.

Step 3. Remove the 4 ACI/3 AVI board from Slot Z.

Step 4. Locate connector J3 and change four jumpers from Pin CT (normal position) to Pin AMS (low-level test position).

Step 5. Locate connector J2, remove four current jumpers (IA, IB, IC, and IN), and connect low-level signal connector (e.g., ribbon cable connector of SEL-RTS Test System).

Step 6. Insert the 4 ACI/3 AVI board back in its Slot Z.

Step 7. Remove the 2 AVI/4 AFDI board from Slot E.

NOTE: You can use the 14-pin connectors of the SEL-RTS ribbon cable C703. The connectors are not keyed; make sure Pin 1 is connected to the IA/VS channel on the 4 ACI/3 AVI and 2 AVI/4 AFDI boards, respectively.

Step 8. Locate connector J4 and connect low-level signal connector (e.g., ribbon cable 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, DELTA_Y := DELTA, with the low level test interface referenced in *Figure 11.1*, apply the following signals:

- Apply low-level test signal VAB to Pin VA.
- Apply low-level test signal –VBC (equivalent to VCB) to Pin VC.
- Do not apply any signal to pin VB.

Commissioning Tests

SEL performs a complete functional check and calibration of each SEL-751 Relay before it is shipped. This helps to ensure that you receive a relay that operates correctly and accurately. Commissioning tests confirm that the relay is properly connected including the control signal inputs and outputs.

The following connection tests help you enter settings into the SEL-751 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-751, installed and connected according to your protection design
- A PC with serial port, terminal emulation software, and serial communications cable
- *SEL-751 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-751 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.

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

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.

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.

Step 9. If you are connecting an external SEL-2600 RTD Module, perform the following substeps; otherwise, continue with the next step.

a. Connect the fiber-optic cable to the RTD Module fiber-optic output.

b. Plug the relay end of the fiber-optic cable into the relay fiber-optic input (Port 2).

Step 10. Verify the relay ac connections.

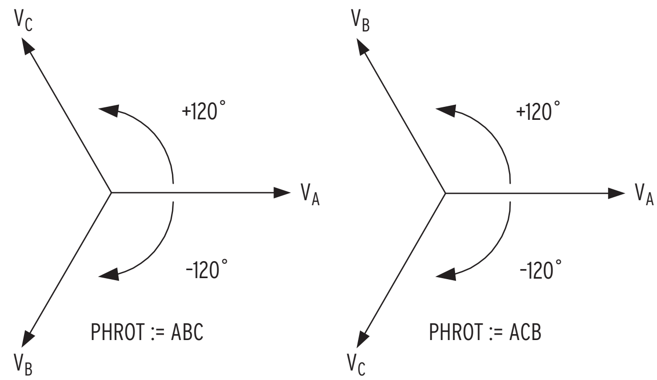
Step 11. Connect the ac test source current or voltage to the appropriate relay terminals.

NOTE: Make sure 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 (DELTA_Y := WYE), set the current and/or voltage phase angles as shown in *Figure 11.2*.

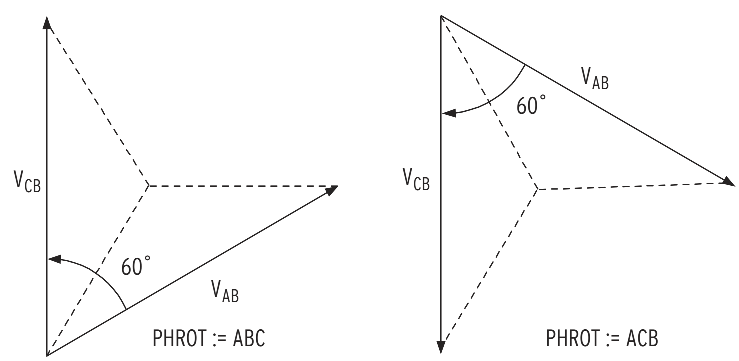
c. If you set the relay to accept delta voltages (DELTA_Y := DELTA), set the current and/or voltage phase angles as shown in *Figure 11.3*.



When setting PHROT := ABC, set angle V_A = angle I_A = 0°
set angle V_B = angle I_B = −120°
set angle V_C = angle I_C = 120°

When setting PHROT := ACB, set angle V_A = angle I_A = 0°
set angle V_B = angle I_B = 120°
set angle V_C = angle I_C = −120°

Figure 11.2 Three-Phase Wye AC Connections



When setting PHROT := ABC, set angle I_A = 0°
set angle I_B = −120°
set angle I_C = 120°
set angle V_{AB} = +30°
set angle V_{CB} = +90°

When setting PHROT := ACB, set angle I_A = 0°
set angle I_B = 120°
set angle I_C = −120°
set angle V_{AB} = −30°
set angle V_{CB} = −90°

Figure 11.3 Three-Phase Open-Delta AC Connections

Step 12. Apply rated current (1 A or 5 A).

Step 13. If the relay is equipped with voltage inputs, apply rated voltage for your application.

Step 14. 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 PTR and CTR settings and the fact that the quantities are displayed in primary units.

Step 15. If you are using a core-balance current transformer, apply a single-phase current to the **IN** terminals. Do not apply voltage.

Step 16. Verify that the relay is measuring the magnitude and phase angle correctly.

The expected magnitude is (applied current) • (CTRN).

Step 17. Verify control input connections. Using the front-panel `MAIN > Targets > Row 17` function, check the control input status in the relay.

As you apply rated voltage to each input, the position in Row 17 corresponding to that input should change from zero (0) to one (1).

Step 18. Verify output contact operation:

Program each of the output contacts you want to test to logical 1. This causes the output contact to close. For example, setting OUT101 = 1 causes the output **OUT101** contact to close.

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 19. Perform any desired protection element tests. Perform only enough tests to prove that the relay operates as intended; exhaustive element performance testing is not necessary for commissioning.

Step 20. Connect the relay for tripping duty.

Step 21. Verify that any settings changed during the tests performed in *Step 18* and *Step 19* are changed back to the correct values for your application.

Step 22. Use the serial port commands in *Table 11.2* to clear the relay data buffers and prepare the relay for operation.

This prevents data generated during commissioning testing from being confused with operational data collected later.

Table 11.2 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 23. When it is safe to do so, energize the feeder.

Step 24. 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 25. 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-751 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 11.4*.

Step 2. Using the front-panel `SET/SHOW` or the serial port **SHO** command, record the CTR and PHROT setting values.

Step 3. Set the phase current angles to apply balanced three-phase currents in accordance with the PHROT setting. Refer to *Figure 11.2*.

Step 4. Set each phase current magnitude equal to the values listed in Column 1 of *Table 11.3*. Use the front panel to view the phase current values. The relay should display the applied current magnitude times the CTR setting.

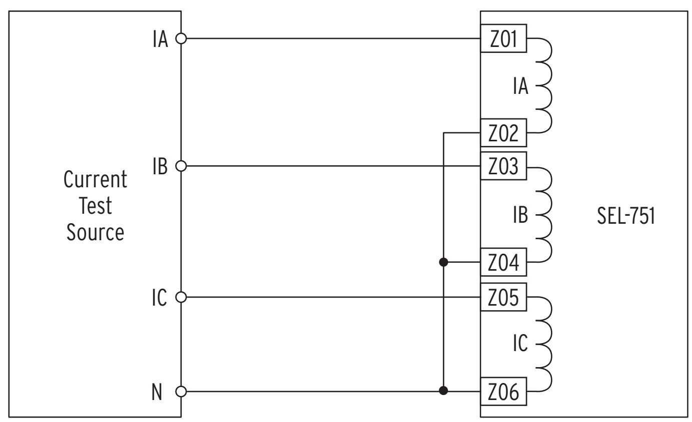


Figure 11.4 Current Source Connections

Table 11.3 Phase Current Measuring Accuracy

|I| Apply (A secondary)[a]	Expected Reading CTR x |I|	A-Phase Reading (A primary)	B-Phase Reading (A primary)	C-Phase Reading (A primary)
0.2 x I_{NOM}				
0.9 x I_{NOM}				
1.6 x I_{NOM}				

[a] I_{NOM} = rated secondary amperes (1 or 5).

Current Unbalance Metering Accuracy

Step 1. Connect the current source to the relay, as shown in *Figure 11.4*.

Step 2. Using the front-panel `SET/SHOW` function or the serial port **SHO** command, record the CTR and PHROT setting values.

Step 3. Set the phase current angles to apply balanced three-phase currents in accordance with the PHROT setting. Refer to *Figure 11.2*.

Step 4. Apply the appropriate magnitude for each phase current, as shown in Column 1 of *Table 11.4*.

Table 11.4 Current Unbalance Measuring Accuracy

|I| Apply (A secondary)	Expected Reading (%)	Actual Reading (%)
$\|IA\| = 0.9 \cdot I_{NOM}$ $\|IB\| = I_{NOM}$ $\|IC\| = I_{NOM}$	7%	
$\|IA\| = 0.75 \cdot I_{NOM}$ $\|IB\| = I_{NOM}$ $\|IC\| = I_{NOM}$	17%	
$\|IA\| = I_{NOM}$ $\|IB\| = 1.2 \cdot I_{NOM}$ $\|IC\| = 1.2 \cdot I_{NOM}$	12%	
$\|IA\| = 0.9 \cdot I_{NOM}$ $\|IB\| = 1.1 \cdot I_{NOM}$ $\|IC\| = 1.1 \cdot I_{NOM}$	13%	

Power and Power Factor Measuring Accuracy

Wye-Connected Voltages

Perform the following steps to test wye-connected voltages:

Step 1. Connect the current source to the relay, as shown in *Figure 11.4*.

Step 2. Connect the voltage source to the relay, as shown in *Figure 11.5*. Make sure that DELTA_Y := WYE.

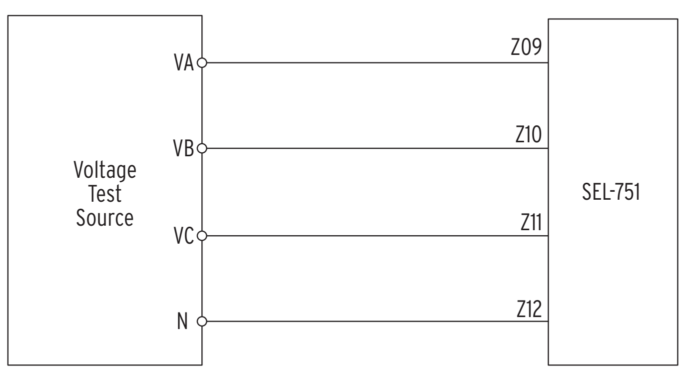


Figure 11.5 Wye Voltage Source Connections

Step 3. Using the front-panel SET/SHOW or the serial port **SHOW** command, record the CTR, PTR, and PHROT setting values.

Step 4. Apply the current and voltage quantities shown in Column 1 of *Table 11.5*.

Values are given for PHROT := ABC and PHROT := ACB.

Step 5. Use the front-panel METER function or the serial port **MET** command to verify the results.

Table 11.5 Power Quantity Accuracy—Wye Voltages

Apply Currents and Voltages	Real Power (kW)	Reactive Power (kVAR)	Power Factor (pf)
PHROT := ABC Ia = 2.5 ∠–26 Ib = 2.5 ∠–146 Ic = 2.5 ∠+94	**Expected:** P = 0.4523 • CTR • PTR	**Expected:** Q = 0.2211 • CTR • PTR	**Expected:** pf = 0.90 lag
Va = 67 ∠0 Vb = 67 ∠–120 Vc = 67 ∠+120	**Measured:**	**Measured:**	**Measured:**
PHROT := ACB Ia = 2.5 ∠–26 Ib = 2.5 ∠+94 Ic = 2.5 ∠–146	**Expected:** P = 0.4523 • CTR • PTR	**Expected:** Q = 0.2211 • CTR • PTR	**Expected:** pf = 0.90 lag
Va = 67 ∠0 Vb = 67 ∠+120 Vc = 67 ∠–120	**Measured:**	**Measured:**	**Measured:**

Delta-Connected Voltages

Perform the following steps to test delta-connected voltages:

Step 1. Connect the current source to the relay, as shown in *Figure 11.4*.

Step 2. Connect the voltage source to the relay, as shown in *Figure 11.6*. Make sure that DELTA_Y := DELTA.

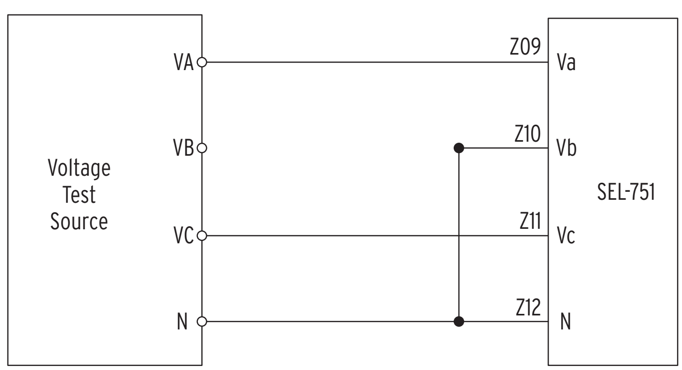


Figure 11.6 Delta Voltage Source Connections

Step 3. Using the front-panel SET/SHOW or the serial port **SHOW** command, record the CTR, PTR, and PHROT setting values.

Step 4. Apply the current and voltage quantities shown in Column 1 of *Table 11.6*.

Values are given for PHROT := ABC and PHROT := ACB.

Step 5. Use the front-panel `METER` or the serial port **MET** command to verify the results.

Table 11.6 Power Quantity Accuracy—Delta Voltages

Apply Currents and Voltages	Real Power (kW)	Reactive Power (kVAR)	Power Factor (pf)
PHROT := ABC Ia = 2.5 ∠–26 Ib = 2.5 ∠–146 Ic = 2.5 ∠+94	**Expected:** P = 0.4677 • CTR • PTR	**Expected:** Q = 0.2286 • CTR • PTR	**Expected** pf = 0.90 lag
VA (Vab) = 120 ∠+30 VC (Vcb) = 120 ∠+90	**Measured:**	**Measured:**	**Measured:**
PHROT := ACB Ia = 2.5 ∠–26 Ib = 2.5 ∠+94 Ic = 2.5 ∠–146	**Expected:** P = 0.4677 • CTR • PTR	**Expected:** Q = 0.2286 • CTR • PTR	**Expected:** pf = 0.90 lag
VA (Vab) = 120 ∠–30 VC (Vcb) = 120 ∠–90	**Measured:**	**Measured:**	**Measured:**

Arc-Flash Protection Tests

Follow the procedures described in *Section 2: Installation* to complete the installation of the Arc-Flash Detection (AFD) fiber-optic sensors in the switchgear equipment to be protected. Make sure the switchgear doors, panels, etc., are closed and in the final operating configuration. This ensures that the ambient light as measured by the sensors is indicative of the normal operating condition. DO NOT ENERGIZE the switchgear for the commissioning tests described in the following text. The relay must have the application settings as necessary, be energized, and be in the ENABLED state. Refer to *Application Guide AG2011-01: Using the* SEL-751 *and* SEL-751*A for Arc-Flash Detection* for more details. The SEL-4520 Arc-Flash Test module provides a convenient way to test the operation of arc-flash detection relays installed in metal-clad and metal-enclosed switchgear. The SEL-4520 is used to test the SEL-751 and SEL-751A Feeder Protection Relays and other arc-flash detection relays that use light and overcurrent to sense an arc-flash event.

Arc-Flash Detection (AFD) System Continuous Self-Testing

The SEL-751 continuously tests (periodic) and monitors all four arc-flash sensor subsystems with the 2 AVI/4 AFDI card and eight arc-flash sensor subsystems with the 8 AFDI card and reports the status. The test period is constant, set to 10 minutes.

1. Point-Sensor AFD Self-Test

   Each point-sensor AFD subsystem on the relay has a Transmit LED channel and a Light Detector channel. The LED periodically sends a light pulse through the transmit fiber cable, which is “coupled” into the receive fiber cable in the point sensor. The light travels back to the light detector on the relay. The relay uses the light measurement by the detector to determine the integrity of the point-sensor AFD loop and report PASS/FAIL status.

2. Clear-Jacketed Fiber Sensor AFD Self-Test

   The clear-jacketed fiber sensor is basically a loop, starting from the Transmit LED and returning to the Light Detector. The relay self-test involves sending a light pulse around the loop

NOTE: The point-sensor diagnostics signal does not affect the response time of the sensor. The clear-jacketed fiber-sensor diagnostics signal can cause a 1 ms delay if the arc-flash event occurs at the same time as the diagnostics test. The clear-jacketed fiber-sensor diagnostic test injects a 1 ms pulse through the fiber once every 10 minutes.

and measuring the light received at the detector. The light measurement by the detector is used to determine the integrity of the clear-jacketed fiber sensor AFD loop and report PASS/FAIL status.

METER LIGHT Report

Use the serial port ASCII command **METER L** and view the METER LIGHT report as shown in *Figure 5.11*.

The report shows the light intensity measurements in percent of full scale (%) for the four AFD channels. This measurement represents the “background” or the “ambient” light in the switchgear areas being monitored for arc-flash. Use this measurement to determine the time-overlight TOL1 to TOL4 settings with a 2 AVI/4 AFDI card and the TOL1–TOL8 settings with an 8 AFDI card for arc-flash protection (refer to *Section 4: Protection and Logic Functions* for details). If there is excessive background light (any of the Relay Word bits AFSnEL picks up) or if there is a diagnostic failure (any of the Relay Word bits AFSnDIAG picks up), the AFALARM Relay Word bit picks up and gives a WARNING on the relay front panel and asserts the ALARM output contact.

Command AFT (Arc-Flash test)

The relay performs the arc-flash self-test periodically as discussed previously. Additionally, by using the serial port ASCII command **AFT**, the relay performs the self-test on demand in all four channels and reports the status of each channel. This same test is also available from the Control Window in the ACSELERATOR QuickSet SEL-5030 Software and the relay front-panel STATUS sub-menu. Refer to *Figure 7.16* for the **AFT** command response example. The response shows the light measurements in percent of full scale and the PASS/FAIL status. The PASS indication means the channel is healthy and ready to detect an arc-flash event. The FAIL indication means the channel in question is not healthy and needs repair and testing when a convenient outage is available for maintenance.

Testing the Arc-Flash Time-Overlight Elements TOL1 to TOL8

Test the TOL elements once the relay has been set, as described in *Section 4: Protection and Logic Functions* for the arc-flash protection elements. You should add the TOL1–TOL4 Relay Word bits with a 2 AVI/4 AFDI card and the TOL1–TOL8 Relay Word bits with a 8 AFDI card Relay Word bits to the **SER** (sequence of events report) settings so that the relay can capture the TOL element assertion and dropout. Apply a bright light source near the light sensor (POINT or FIBER type) in the switchgear cabinet and note that the appropriate TOL element Relay Word bit picks up and drops out as expected.

The arc-flash test can also be captured as a **CEV** event report by triggering the event report with the TOL*n* Relay Word bit. The **CEV R** (raw data) event report should be viewed with the ACSELERATOR Analytic Assistant SEL-5601 Software. You can view the % light intensity analog quantity together with the TOL*n* Relay Word bit to verify the correct operation.

Testing the Arc-Flash Overcurrent Elements 50PAF and 50NAF

These current elements are similar to the 50P and 50N elements, except they use "raw" current input samples and act instantaneously to achieve fast response. You can test these elements similarly to the 50P and 50N elements. You can use the **CEV R** report as described previously to analyze the event.

Testing the Complete Arc-Flash Protection System

It is necessary to verify the complete protection subsystem even though the relay is tested at the factory before shipping as it is a critical protection function. If a synchronized light and current pulse test source is available to simulate an arc, you can use it to exercise the arc-flash protection TOL*n* elements together with the 50PAF or the 50NAF elements. If the relay has been set for the arc-flash protection including the tripping logic, the test could exercise the breaker tripping (unenergized state). You can capture the total event with appropriate event report trigger settings and use the ACSELERATOR Analytic Assistant to view and analyze the **CEV R** (raw data) report. The **CEV R** report shows the analog currents and light channels together with the Relay Word bits so that you can analyze and qualify the response. *Figure 11.7* shows an example event report for a simulated arc-flash incident.

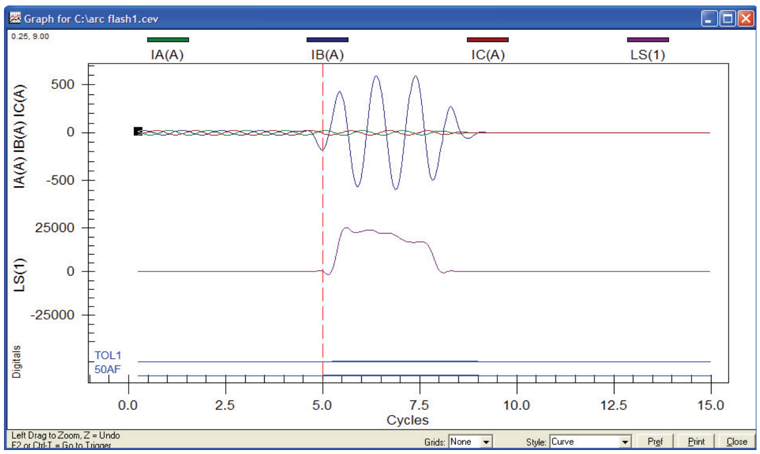


Figure 11.7 CEV R Light Event Capture Example

Periodic Tests (Routine Maintenance)

Because the SEL-751 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-751 does not require specific routine tests, but your operation standards may require some degree of periodic relay verification. If you need or want to perform periodic relay verification, the following checks are recommended.

Table 11.7 Periodic Relay Checks (Sheet 1 of 2)

Test	Description
Relay Status	Use the front-panel STATUS or serial port **STATUS** command to verify that the relay self-tests have not detected any WARN or FAIL conditions.
Arc-Flash Detection (AFD) Status	Use the serial port **AFT** command to verify that the AFD channel self-tests have not detected any FAIL condition in any of the channels.
Meter	Verify that the relay is correctly measuring current and voltage (if included) by comparing the relay meter readings to separate external meters.

Table 11.7 Periodic Relay Checks (Sheet 2 of 2)

Test	Description
Control Input	Using the front-panel `MAIN > Targets > Row 17` function, check the control input status in the relay. As you apply rated voltage to each input, the position in Row 17 corresponding to that input should change from zero (0) to one (1).
Contact Output	Program each of the output contacts you want to test to logical 1. This causes the output contact to close. For example, setting OUT101 := 1 causes the output **OUT101** contact to close. 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-751 runs a variety of self-tests. The relay takes the following corrective actions for out-of-tolerance conditions (see *Table 11.8*):

- Protection Disabled: The relay disables protection and control elements and trip/close logic. All output contacts are de-energized. The ENABLED front-panel LED is extinguished.
- ALARM Output: Two Relay Word bits, HALARM and SALARM, signal self-test problems. SALARM is pulsed for software programmed conditions, such as settings changes, access level changes, three consecutive unsuccessful password entry attempts, active group change, copy command, and password change. HALARM is pulsed for hardware self-test warnings. HALARM is continuously asserted (set to logical 1) for hardware self-test failures. A diagnostic alarm can be configured as explained in *Section 4: Protection and Logic Functions*. In the **Alarm Status** column of *Table 11.8*, Latched indicates that HALARM is continuously asserted, Not Latched indicates that HALARM is pulsed for five seconds, and NA indicates that HALARM is not asserted.
- The relay generates automatic STATUS reports at the serial port for warnings and failures (ports with setting AUTO = Y).
- The relay displays failure messages on the relay front-panel display for failures.
- For certain failures, the relay automatically restarts as many as three times. In many instances, this corrects the failure. The failure message might not be fully displayed before automatic restart occurs. An indication that the relay restarted is recorded in the Sequential Events Recorder (SER).

Use the serial port **STATUS** command or the 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 11.8 Relay Self-Tests (Sheet 1 of 3)

Self-Test	Description	Normal Range	Protection Disabled on Failure	Alarm Status	Auto Message on Failure	Front Panel Message on Failure	Corrective Action
Watchdog Timer	Periodic resetting (1/32 cycle)		Yes	De-energized	No	No	
Main board FPGA (turn on)	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. Contact SEL if failure returns.
Main board FPGA (run time)	Fail on lack of data acquisition interrupts or on detection of a CRC error in the FPGA code		Yes	Latched	Yes	Status Fail FPGA Failure	Automatic restart. Contact SEL if failure returns.
GPSB (back-plane) communications	Fail if GPSB is busy on entry to processing interval		Yes	Latched	Yes	Status Fail GPSB Failure	Automatic restart. Contact SEL if failure returns.
Front-Panel HMI (turn on)	Two-line display: Fail if ID registers do not match or if FPGA programming is unsuccessful Touchscreen display: Automatic diagnostics identify an issue		No	Not Latched	Yes	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
External RAM (turn on)	Performs a read/write test on system RAM		Yes	Latched	No	No	
External RAM (run time)	Performs a read/write test on system RAM		Yes	Latched	Yes	Status Fail RAM Failure	Automatic restart. Contact SEL if failure returns.
Internal RAM (turn on)	Performs a read/write test on system CPU RAM		Yes	Latched	No	No	
Internal RAM (run time)	Performs a read/write test on system CPU RAM		Yes	Latched	Yes	Status Fail RAM Failure	Automatic restart. Contact SEL if failure returns.
Code Flash (turn on)	SELBOOT qualifies code with a checksum		NA	NA	NA	NA	
Data Flash (turn on)	Checksum is computed on critical data		Yes	Latched	Yes	Status Fail Non_Vol Failure	
Data Flash (run time)	Checksum is computed on critical data		Yes	Latched	Yes	Status Fail Non_Vol Failure	
Critical RAM (settings)	Performs a checksum test on the active copy of settings		Yes	Latched	Yes	Status Fail CR_RAM Failure	Automatic restart. Contact SEL if failure returns.
Critical RAM (run time)	Verify instruction matches FLASH image		Yes	Latched	Yes	Status Fail CR_RAM Failure	Automatic restart. Contact SEL if failure returns.
I/O Board Failure	Check if ID register matches part number		Yes	Latched	Yes	Status Fail Card [C|D|E] Failure	
DeviceNet Board Failure	DeviceNet card does not respond in three consecutive 300 ms time out periods		NA	NA	NA	COMMFLT Warning	

Table 11.8 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
Card Z (turn on)	Fail if ID register does not match part number		Yes	Latched	Yes	Status Fail Card Z Fail	
Card Z A/D Offset Warn	Measure dc offset at each input channel	–50 mV to +50 mV	No	Not Latched	No	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
ADCCHK (Slot Z)	A/D reference channel check	<2.375 V or >2.625 V	Yes	Latched	Yes	Status Fail Card Z Fail	Automatic restart. Contact SEL, if failure returns
Card E (turn on)	Fail if ID register does not match part number		Yes	Latched	Yes	Status Fail Card E Fail	
Card E A/D Offset Warn	Measure dc offset at each input channel	–50 to +50 mV	No	Not Latched	No	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
ADCCHK (Slot E)	A/D reference channel check	<2.375 V or >2.625 V	Yes	Latched	Yes	Status Fail Card E Fail	Automatic restart. Contact SEL, if failure returns
+0.9 V Fail	Monitor +0.9 V power supply	0.855 to 0.945 V	Yes	Latched	Yes	Status Fail +0.9 V Failure	
+1.2 V Fail	Monitor +1.2 V power supply	1.152 to 1.248 V	Yes	Latched	Yes	Status Fail +1.2 V Failure	
+1.5 V Fail	Monitor +1.5 V power supply	1.35 to 1.65 V	Yes	Latched	Yes	Status Fail +1.5 V Failure	
+1.8 V Fail	Monitor +1.8 V power supply	1.71 to 1.89 V	Yes	Latched	Yes	Status Fail +1.8 V Failure	
+3.3 V Fail	Monitor +3.3 V power supply	3.07 to 3.53 V	Yes	Latched	Yes	Status Fail +3.3 V Failure	
+5 V Fail	Monitor +5 V power supply	4.65 to 5.35 V	Yes	Latched	Yes	Status Fail +5 V Failure	
+2.5 V Fail	Monitor +2.5 V power supply	2.32 to 2.68 V	Yes	Latched	Yes	Status Fail +2.5 V Failure	
+3.75 V Fail	Monitor +3.75 V power supply	3.48 to 4.02 V	Yes	Latched	Yes	Status Fail +3.75 V Failure	
–1.25 V Fail	Monitor -1.25 V power supply	–1.16 to –1.34 V	Yes	Latched	Yes	Status Fail –1.25 V Failure	
–5 V Fail	Monitor -5 V power supply	–4.65 to –5.35 V	Yes	Latched	Yes	Status Fail –5 V Failure	
Clock Battery	Monitor Clock Battery	2.3 to 3.5 V	No	Not Latched	Yes	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.

Table 11.8 Relay Self-Tests (Sheet 3 of 3)

Self-Test	Description	Normal Range	Protection Disabled on Failure	Alarm Status	Auto Message on Failure	Front Panel Message on Failure	Corrective Action
Clock Chip	Unable to communicate with clock or fails time keeping test		No	Not Latched	Yes	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
Clock Chip RAM	Clock chip static RAM fails		No	Not Latched	Yes	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
External RTD	Fail if no comm, or the external RTD module reports open RTDs, shorted RTDs, a power supply failure		NA	NA	No	RTD Failure	STA C, to clear the warning in the status report. Contact SEL if failure returns.
CID (Configured IED Description) file (access)	Failure to Access/Read CID File		No	NA	No	Status Fail CID File Failure	
Exception Vector	CPU Error		Yes	Latched	NA	Vector nn Relay Disabled	Automatic restart. Contact SEL if failure returns.

Troubleshooting

Table 11.9 Troubleshooting (Sheet 1 of 2)

Symptom/Possible Cause	Diagnosis/Solution
The relay ENABLED front-panel LED is dark.	
Input power is not present or a fuse is blown.	Verify that input power is present. Check fuse continuity.
Self-test failure	View the self-test failure message on the front-panel display.
The relay front-panel display does not show characters.	
The relay front-panel has timed out.	Press the ESC 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 CTR, CTRN, or PTR setting	Verify instrument transformer ratios, connections, and associated settings.
Voltage neutral terminal (N) is not properly grounded.	Verify wiring and connections.

Table 11.9 Troubleshooting (Sheet 2 of 2)

Symptom/Possible Cause	Diagnosis/Solution
The relay does not respond to commands from a device connected to the serial port.	
Cable is not connected.	Verify the cable connections.
Cable is not the correct type.	Verify the cable pinout.
The relay or device is at an incorrect data rate or has another parameter mismatch.	Verify Device software setup.
The relay serial port has received an XOFF, halting communications.	Type **<Ctrl+Q>** to send the relay XON and restart communications.
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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Appendix A
Firmware, ICD, and Manual Versions

Firmware

Determining the Firmware Version

To determine the firmware version, view the status report by using the serial port **STATUS** command or the front panel. The status report displays the Firmware Identification (FID) label.

The firmware version will be either a standard release or a point release. A standard release adds new functionality to the firmware beyond the specifications of the existing version. A point release is reserved for modifying firmware functionality to conform to the specifications of the existing version.

A standard release is identified by a change in the R-number of the device firmware identification (FID) string.

Existing firmware:

FID=SEL-751-**R100**-V0-Z001001-Dxxxxxxxx

Standard release firmware:

FID=SEL-751-**R101**-V0-Z001001-Dxxxxxxxx

A point release is identified by a change in the V-number of the device FID string.

Existing firmware:

FID=SEL-751-R100-**V0**-Z001001-Dxxxxxxxx

Point release firmware:

FID=SEL-751-R100-**V1**-Z001001-Dxxxxxxxx

Table A.1 lists the firmware versions, a description of modifications, and the instruction manual date code that corresponds to the firmware versions. The most recent firmware version is listed first.

Table A.1 R200 Series Firmware Revision History (Sheet 1 of 2)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-751-R200-V4-Z007003-D20170922	Includes all the functions of SEL-751-R200-V3-Z007003-D20170814 with the following additions: ➤ Addressed an issue in the previous firmware that could cause IEC 61850 GI buffered reports to be out of sequence when the number of uncollected reports exceeded 200. ➤ Updated BDP file to 1.0.50751.2004.	20170922
SEL-751-R200-V3-Z007003-D20170814	Includes all the functions of SEL-751-R200-V2-Z007003-D20170315 with the following additions: ➤ Resolved an issue where certain Ethernet traffic could cause diagnostic restarts.	20170814

Table A.1 R200 Series Firmware Revision History (Sheet 2 of 2)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-751-R200-V2-Z007003-D20170315	➤ Added the touchscreen display front-panel option. ➤ Added the four-pushbutton front-panel option. ➤ Added support for an ac currents only (4 ACI) Slot Z card option. ➤ Increased the maximum number of GOOSE subscriptions to 64. ➤ Added a setting, METHRES, in the Global settings category that allows for turning off the squelching of currents and voltages below a certain level. ➤ Increased the maximum allowable value of the VNOM setting from 440 Vrms to 480 Vrms. ➤ Increased the TOL pickup setting to 80% for both the point- and bare-fiber sensors. ➤ Revised the firmware to remove MAXACC front-panel setting for relays with the touchscreen display. ➤ Resolved an issue with the Modbus registers for phase/phase-to-phase max/min voltages that retained a previous value when the DELTA_Y setting was changed. ➤ Revised the LOP threshold from 5 V to 10.5 V (higher than the frequency tracking threshold of 10 V). Added LOPBLK SELOGIC that is tied into seal-in logic to break the seal (reset LOP) under user-defined conditions. ➤ Resolved an issue with LSENS1–LSENS8 analog quantities reading bad values when assigned to math variables with over 50% light applied. ➤ Expanded the range of the TOC element to include a time dial setting of 0.01 for the C curves. ➤ Added support for communications cards without the fiber-optic serial port in Slot B. ➤ Resolved an issue with changing phase angles even though the magnitude/angles of the analog channels were squelched. ➤ Revised the breaker failure setting dependency to allow BFD to be set to 0.0 when ATD := OFF. ➤ Resolved an issue with the analog quantity for frequency getting reset to 0 after a settings change. ➤ Added a decimal point to CEV HIF current-related quantities. ➤ Added disconnect status logic with double point indication to monitor the status of the disconnect switches. ➤ Resolved an issue where the relay does not detect a 4 DI/4 DO card installed in a slot previously occupied by a 14 DI card. ➤ Added Modbus Master IP settings. ➤ Added new SELOGIC control equation HIFITUNE to reinitiate 24-hour tuning.	20170315
SEL-751-R200-V1	➤ SEL-751 R200-V1 was not released. R200-V2 follows R112-V1.	—
SEL-751-R200-V0	➤ SEL-751 R200-V0 was not released. R200-V1 follows R112-V1.	—

Table A.2 R100 Series Firmware Revision History (Sheet 1 of 5)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-751-R112-V3-Z006002-D20170922	Includes all the functions of SEL-751-R112-V2-Z006002-D20170814 with the following additions: ➤ Addressed an issue in the previous firmware that could cause IEC 61850 GI buffered reports to be out of sequence when the number of uncollected reports exceeded 200.	20170922
SEL-751-R112-V2-Z006002-D20170814	Includes all the functions of SEL-751-R112-V1-Z006002-D20160930 with the following additions: ➤ Resolved an issue where certain Ethernet traffic could cause diagnostic restarts. NOTE: When upgrading to the R200 series firmware from the R100 series firmware, make sure to upgrade to firmware version R200-V3 or higher to maintain the Ethernet traffic resolution of this R100 series firmware point release.	20170814
SEL-751-R112-V1-Z006002-D20160930	Includes all the functions of SEL-751-R112-V0-Z006002-D20151112 with the following additions: ➤ Resolved a relay disabling issue when the setting EPMU was set to Y and there was a corrupt IRIG signal. ➤ Resolved an issue where HIF event reports may not get triggered if rising-edge triggered Relay Word bits are used in the HIFER setting. ➤ Resolved an issue causing HIF false alarms in the A-phase channel in the HIF Detection Non-Harmonic Method algorithm. ➤ Modified GOOSE subscription to update data after the messages transition from lower to better quality. ➤ Resolved an issue where the relay was not allowing access to the settings using FTP protocol unless the relay part number included the IEC 61850 protocol option.	20160930
SEL-751-R112-V0-Z006002-D20151112	➤ Enhanced the firmware to add directional control capability to support high-impedance, ungrounded and Petersen coil-grounded systems in relays with the 200 mA CT option. The 200 mA CT can also be used for nondirectional sensitive earth fault (SEF) protection. ➤ Added 8 Vac rms Low-Energy Analog (LEA) ac inputs for system voltages and synchronism-check input. ➤ Added IEC-60870-5-103 protocol. ➤ Added IEC 62439 Parallel Redundancy Protocol (PRP) for models with the dual Ethernet port option. ➤ Increased the number of DNP sessions from 3 to 5. ➤ Updated IEC 61850 protocol implementation to IEC 61850 Edition 2. ➤ Added password authentication and session timeout for MMS services. ➤ Enhanced the CPU card design, including the addition of a GOOSE port with a dedicated MAC address to improve GOOSE processing performance. (Note: Relays with older CPU cards can be upgraded to firmware versions R112 or higher, but the relay will not have the GOOSE performance improvements.) ➤ Added file transfer support in IEC 61850 for CEV events, COMTRADE events, MET reports, SER reports, BRE reports, CID files, and Settings file. ➤ Added the inverse-time over- and undervoltage elements. ➤ Added IEC line/cable thermal overload protection elements to protect the overhead lines and cables against thermal overloads. ➤ Added a vector shift protection function to detect a generator islanding condition based on the phase shift of the voltage waveform.	20151112

Table A.2 R100 Series Firmware Revision History (Sheet 2 of 5)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
	➤ Added Second- and Fifth-Harmonic Current Blocking (Inrush Current Blocking) functionality. ➤ Added fault impedance to the fault location information. ➤ Increased the number of settings groups from 3 to 4. ➤ Added Spanish language support on all communications ports. Also added an ordering option for a relay with Spanish overlay and Spanish front-panel HMI. ➤ Added an ordering option for a 14 digital input card in Slots C, D, and E. ➤ Added an ordering option for an 8 Arc-Flash Input card in Slot E. ➤ Added LOP blocking functionality with the default value for LOPBLK set to 0. ➤ Added OFF to the 50 element, 50PnD, delay setting range. ➤ Added torque-control settings for the frequency (81) and rate-of-change-of-frequency (81R) elements with the default value set to 1. ➤ Added COMTRADE Events support to the relay. ➤ Added a feature in the CEV report to show the part number and serial number of the relay. ➤ Added unique reference numbering system for HIS, CHIS, SUM, CSUM, EVE and CEV reports. ➤ Added OFF to the setting range of failover time setting FTIME to support fast failover switching in dual Ethernet models. ➤ Added the enable port setting EPORT to all the communications ports to enhance port security. ➤ Added the MAXACC setting to the front panel to control limited or full access to the front panel HMI. ➤ Added fault location data to the IEC 61850 ICD file. ➤ Doubled the SELOGIC processing capacity in the relay. ➤ Revised the firmware to add the VSCONN setting allowing the user to choose between VS input (synchronism check element) and external 3V0 input (broken-delta) for use with zero-sequence voltage polarized directional elements and fault location. ➤ Revised the firmware to address an issue with Fast Message that did not report the MIN/MAX analog quantity value correctly. ➤ Resolved an issue that involved phase identification logic where, in some cases, the phase LEDs did not latch correctly when a trip occurred. ➤ Revised the firmware to remove option D from the NETPORT setting. ➤ Modified the firmware to make the MATHERR Relay Word bit visible. ➤ Resolved a synchrophasor voltage magnitude issue for applied voltages of 200 V or higher with the settings combination FNOM := 50, MRATE := 25, PHCOMP := Y, and PMAPP := NARROW. ➤ Revised the firmware to address an issue where the oldest 180-cycle event or HIF event was disappearing from the event history after the relay was power cycled or restarted with STA C. ➤ Modified the prompt for DNP Master IP Address DNPIPn to distinguish them from the device IP Address.	
SEL-751-R111	➤ SEL-751 R111 was not released. R112 follows R110.	—

Table A.2 R100 Series Firmware Revision History (Sheet 3 of 5)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-751-R110-V0-Z005001-D20150410	➤ Lowered the minimum value for definite-time overcurrent elements from 0.5 A to 0.25 A for 5 A relays and from 0.1 A to 0.05 A for 1 A relays. ➤ Expanded the setting range for inverse-time overcurrent elements. Lowered the minimum value from 0.5 A to 0.25 A for 5 A relays and from 0.1 A to 0.05 A for 1 A relays. Increased the maximum value to 24 A from 16 A for 5 A relays and to 4.8 A from 3.20 A for 1 A relays. ➤ Added setting choices C1–C4 to reclose enable setting E79. When C1–C4 options are selected, the reclosing relay does not go to the lockout state upon reclose supervision failure. Instead, the reclosing relay increments the shot counter and starts timing on the next open interval. ➤ Modified the firmware to reset virtual bits when a new CID file is sent to the relay. ➤ Resolved an issue with the relay becoming unresponsive on power-up when the NETPORT setting was set to D in dual Ethernet models with the NETMODE setting set to FIXED or FAILOVER.	20150410
SEL-751-R109-V0-Z004001-D20140402	➤ Increased the maximum event report length to 180 cycles. ➤ Addressed an issue in relays with the optional Arc Sense technology with R106 or R108 firmware that could prevent retrieval of event reports after executing the **CEV HIF** command. ➤ Addressed an issue with setting the IP address of more than one DNP session to 0.0.0.0. The relay now allows only one DNP session with the IP address 0.0.0.0.	20140402
SEL-751-R108-V0-Z003001-D20131218	➤ Fixed LCD display contrast and backlight issues present in firmware revision R106 only. ➤ Fixed Telnet and Modbus/TCP multiple session availability issue present in firmware revision R106 only.	20131218
SEL-751-R106-V0-Z003001-D20131101	➤ Added logical nodes to the IEC 61850 ICD file. ➤ Modified default Dataset and Report Names in the IEC 61850 ICD file. ➤ Corrected an Ethernet Failover Switching issue for dual Ethernet models. ➤ Corrected an issue with the PREDLY setting. RTS is now forced high and CTS is ignored when PERDLY setting is OFF to power certain fiber-optic transceivers. ➤ Corrected an issue with either premature or infinite timeout when a Telnet session is opened without subsequently sending any characters. ➤ Corrected an issue with port timeout when accessing fast protocol data over Telnet without sending any ASCII characters regularly to keep the connection alive. ➤ Corrected an issue with receiving packets from a previous connection on a new Modbus connection when the device is being polled at a rate of 20 ms or faster (polling at high speed). ➤ Improved the security of RTD ALARM and TRIP by adding an approximately 6-second delay to qualify the event. ➤ Corrected an Ethernet issue with the initial Gratuitous ARP request not being sent for as long as five minutes after startup. ➤ Added support for Y-MODEM over Telnet. ➤ Corrected an issue with writing to User Map registers 1–125 with Modbus function code 06. ➤ Corrected an issue with DNP Binary Outputs reported as OFFLINE. ➤ Corrected an issue with angle calculations for analog quantities.	20131101

Table A.2 R100 Series Firmware Revision History (Sheet 4 of 5)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
	➤ Modified to process RSTTRGT SELOGIC equation output on the rising edge. ➤ Corrected an issue with 81RFIBLK = OFF setting. When 81RFIBLK = OFF, the overcurrent blocking scheme should be disabled. ➤ Lowered the minimum value of the VNOM setting range from 100 V to 20 V. ➤ Revised to allow anonymous TCP connection from DNP masters when DNPIP*x* is set to 0.0.0.0. ➤ Changed storage of the latch and local bits from volatile to non-volatile memory.	
SEL-751-R105-V0-Z002001-D20130206	➤ All 50 element time delay setting range upper limits changed to 400 seconds. ➤ Added event fault current data to analog quantities for DNP. ➤ Added new demand power metering and analog quantities. ➤ Corrected an issue with MET PM, where the command used UTC time instead of local time. ➤ Corrected an issue with the HIF HIS report where the report displayed the reference number incorrectly. ➤ Fixed an issue that caused the port settings to not be accepted when the relay settings were downloaded using ACSELERATOR QuickSet SEL-5030 Software. ACSELERATOR QuickSet reported with a message that settings files were not received. ➤ Added a feature in Modbus to always show the latest event data unless another event is selected. ➤ Corrected an issue where the front panel showed a blank page after target resetting the TRIP. ➤ Corrected an issue with the data type “Units_0” in the IEC 61850 ICD file. ➤ Corrected a noise issue when exercising the pulse command of the hybrid outputs. ➤ Resolved an issue that involved phase identification logic where the output was not long enough in duration to latch the phase LEDs when a trip occurred. ➤ Updated the error messages for setting interdependency checks to match the global setting AO*x*0*y*H. ➤ Corrected an issue with the Modbus register for LOCAT (fault location). ➤ Improved synchrophasor algorithm to yield better phasor-based frequency measurements. ➤ Corrected an issue with CEV HIF command in which the command gave the “No Data Available” message when the number of HIF events exceeded the maximum number of events for the given HIFLER setting. ➤ Corrected an issue with the rotating display in which a blank page appeared when the warning message went away. ➤ Modified Real Time Clock (RTC) diagnostics logic to show failure only if the RTC diagnostics fail three consecutive times. ➤ Extended the setting range for the time dial of all the IEC TOC elements to 0.05–1.50.	20130206

Table A.2 R100 Series Firmware Revision History (Sheet 5 of 5)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
	➤ Lowered the minimum value for 51N1P and 51N2P to 0.25 A for 5 A relays and 0.05 A for 1 A relays. ➤ Revised the SELOGIC processing order to run the 52A control equation before running the 79 element control equations to correct a latency issue.	
SEL-751-R103-V0-Z001001-D20111116	➤ Enhanced the firmware to make the serial number visible to IEC 61850 protocol and revised the ICD file to add serial and part number information to PhyNam DO, similar to the 400 series relays. ➤ Corrected issue with rms meter values where in some cases the values would spike for a short time. ➤ Corrected an issue with the MMS error message in response to an IEC 61850 control operation failure. ➤ Revised the units for MIRRORED BITS protocol setting CBADPU to ppm (parts per million). ➤ Corrected an issue where AFD (Arc Flash Detection) outputs 301_2 or 401_2 (setting AOUTSLOT) were processed at a four-millisecond rate rather than a one-millisecond rate. ➤ Corrected an issue with the front panel where two blank lines following the QUIT command resulted in a blank display when selected. ➤ Fixed an issue with ENABLED LED where the LED did not turn off when the relay was disabled.	20111116
SEL-751-R102-V0-Z001001-D20110720	➤ Calibration improvements.	20110720
SEL-751-R101-V0-Z001001-D20110601	➤ Initial version.	20110601

SEL Display Package Versions

The SEL-751 with the touchscreen display option has display packages for the SEL display and default custom display. *Table A.3* lists the display package version, a description of the modifications, and the instruction manual date code that corresponds to the display package versions. The most recent firmware version is listed first. The version number of this firmware is accessible through the **Device Info** folder.

Table A.3 SEL Display Package Revision History

SEL Display Package Version	Revisions	Release Date
1.0.50751.2004	➤ Resolved an issue of occasional loss of touchscreen capability at power up that can occur in some relays.	20170922
1.0.50751.2000	➤ Initial release.	20170315

SEL Display Package and Relay Firmware Compatibility

The display package and the compatible relay firmware versions are listed in *Table A.4*. The version number of the display package is accessible through the **Device Info** folder. Display packages may be compatible with more than one relay firmware version.

Table A.4 SEL Display Package Compatibility With Relay Firmware

SEL Display Package Version	Relay Firmware Versions Supported	Release Date
1.0.50751.2004	R200	20170922
1.0.50751.2000	R200	20170315

DeviceNet and Firmware Versions

The firmware on the DeviceNet interface has two versions, as listed in *Table A.5*. The version number of this firmware is only accessible via the Device Net interface. The SEL-751 needs DeviceNet firmware version 1.005.

Table A.5 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-751 are zipped together on the SEL-751 Product Literature CD (SEL-xxxRxxx.zip). The file can also be downloaded from the SEL website at selinc.com. *Table A.6* lists the compatibility among the EDS files and the various firmware versions of the relay.

Table A.6 EDS File Compatibility

EDS File	Firmware Revisions Supported	Release Date
SEL-751R200.EDS	R200 (with DeviceNet version 1.005)	20170315
SEL-751R101.EDS	R112 (with DeviceNet version 1.005)	20151112
SEL-751R100.EDS	R101, R102, R103, R105, R106, R108, R109, R110 (with DeviceNet version 1.005)	20110601

ICD File

Determining the ICD File Version

To find the ICD revision number in your relay, view the configVersion by using the **ID** command. The configVersion is the last item displayed in the information returned from the **ID** command.

configVersion= ICD-751-R201-V0-Z200006-D20170315

The ICD revision number follows the R (e.g., 201) and the release date follows the D. This revision number is not related to the relay firmware revision number. The configVersion revision displays the ICD file version used to create the CID file that is loaded in the relay.

NOTE: The Z-number representation is implemented with ICD File Revision R103. Previous ICD File Revisions do not provide an informative Z-number.

The configVersion contains other useful information. The Z-number consists of six digits. The first three digits following the Z represent the minimum IED firmware required to be used with the ICD (e.g., 200). The second three digits represent the ICD ClassFileVersion (e.g., 006). The ClassFileVersion increments when there is a major addition or change to the IEC 61850 implementation of the relay.

Table A.7 lists the ICD file versions, a description of modifications, and the instruction manual date code that corresponds to the versions. The most recent version is listed first.

Table A.7 SEL-751 ICD File Revision History (Sheet 1 of 4)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect		Manual Date Code
				File Description	Software Version	
ICD-751-R201-V0-Z200006-D20170315	➤ Increased the maximum number of GOOSE subscriptions to 64. ➤ Added new DCSTSGIO38 (89 Disconnect Status) and PFLLIGGIO39 (Power Factor Lead/Lag Indicator) Logical Nodes and attributes to ANN LDevice. ➤ Added new attributes Ind15 to PROGGIO37 Logical Node to report 52B status ➤ Modified Loc attribute of BK1XCBR1 Logical Node to report Local/Remote Control status ➤ Added new attributes Loc to BKR1CSWI1 Logical Node to report Local/Remote Control status	R200 and higher	006	SEL751 Edition 2, R200 or higher	2.2.14.0 and higher ICD Package version: 2.25.0 and higher	20170315
ICD-751-R200-V0-Z111006-D20151112	➤ Initial ICD file release with Edition 2 support and compatibility. ➤ Updated ClassFileVersion to 006 ➤ Added MMS authentication support. ➤ Made MMS Inactivity Timeout user-configurable with a default value of 900 seconds.	R111and higher	006	SEL751 Edition 2, R111 or higher	2.2.14.0 and higher ICD Package version: 2.18.0 and higher	20151112

Table A.7 SEL-751 ICD File Revision History (Sheet 2 of 4)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect File Description	ACSELERATOR Architect Software Version	Manual Date Code
	➤ Added filehandling service. ➤ Added support to change settings groups with IEC 61850. ➤ Added support for the stSeld attribute in IEC 61850 SBO controls. ➤ Added the LPHD.Sim logical node so the relay will accept GOOSE messages with the test flag asserted. ➤ Increased number of MMS reports to 14. ➤ Increased number of default datasets to 15. ➤ Increased maxAttributes to 800. ➤ Removed maxEntries and maxMappedItems. ➤ Added new TOL1PAFD5, TOL2PAFD6, TOL3PAFD7, TOL4PAFD8, P67N1PTOC14, P67N2PTOC15, P67N3PTOC16, P67N4PTOC17, I1PTUV9, I1PTUV10, I1PTOV12, I1PTOV13, I1PTOV14, I1PTOV15, UGFRDIR1, UGRRDIR1, LZFRDIR1, LZRRDIR1, PWFRDIR1, PWRRDIR1, PIFRDIR1, PIRRDIR1, DIRNFRDIR1, DIRNRRDIR1, FLTRFLO1, FLTRDRE1, and HIFRDRE2 Logical Nodes and attributes to PRO LDevice. ➤ Added new THERMMTHE1 Logical Node and attributes to MET LDevice. ➤ Changed the data sources for negative-sequence current and negative-sequence voltage attributes in METMSQI1 Logical Node ➤ Added new attributes Vsyn and Fs to METMMXU1 Logical Node ➤ Added new attribute Vsyn to RMSMMXU2 Logical Node ➤ Added new attributes MaxVs and MinVs to METMSTA1 Logical Node					

Table A.7 SEL-751 ICD File Revision History (Sheet 3 of 4)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect		Manual Date Code
				File Description	Software Version	
	➤ Added new attributes DmdA.nseq and PkDmdA.nseq to METMDST1 Logical Node ➤ Added new SCGGIO36 and PROGGIO37 Logical Nodes and attributes to ANN LDevice. ➤ Added new attributes Ind09–Ind14 to INCGGIO13, INDGGIO15, and INEGGIO17 Logical Nodes ➤ Added new attributes Ind09–Ind16 to PBLEDGGIO7 Logical Node ➤ Added new attributes Ind05–Ind08 to OUTCGGIO14, OUTDGGIO16, and OUTEGGIO18 Logical Nodes ➤ Added new attributes Ind25–Ind32 to PROGGIO29 Logical Node ➤ Modified Ind01–Ind03 attributes of MISCGGIO34 Logical Node ➤ Added new attributes AnIn05–AnIn08 to LSGGIO35 Logical Node					
ICD-751-R103-V0-Z106004-D20131101	➤ Updated configVersion for new format. ➤ Modified default MMS Report and Dataset names. ➤ Updated all Report Control attributes. ➤ Revised ReportControl rptID attributes to display report name instead of dataset name. ➤ Updated orCat control instances to proprietary node. ➤ Revised dead bands for several Logical Node attributes in MET and ANN LDevices. ➤ Added new OpCntEx attribute to BK1XCBR1 LN. ➤ Modified data types for PF, VA, VAr, and W attributes in METMMXU1 Logical Node.	R106 and higher	004	SEL751 R106 and higher	1.1.145.0 and higher	20131101

Table A.7 SEL-751 ICD File Revision History (Sheet 4 of 4)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect File Description	ACSELERATOR Architect Software Version	Manual Date Code
	➤ Modified data types for MaxA, MinA, MaxPhV, MinPhV, MaxP2PV, and MinP2PV attributes in METMSTA1 Logical Node. ➤ Modified data types for DmdA and PkDmdA attributes in METMDST1 Logical Node. ➤ Revised dataNs attribute of RAGGIO24, RAGGIO25, RAGGIO26, and RAGGIO27 Logical Nodes. ➤ Added new PFRDIR1, PRRDIR1, GFRDIR1, GRRDIR1, QFRDIR1, QRRDIR1, PWR1PDOP1, PWR1PDUP1, PWR2PDOP1, PWR2PDUP1, TOL1PAFD1, TOL2PAFD2, TOL3PAFD3, and TOL4PAFD4 Logical Nodes and attributes to PRO LDevice. ➤ Added new DCZBAT1 and RMSMMXU2 Logical Nodes and attributes to MET LDevice. ➤ Added new BWASCBR1, BWBSCBR2, and BWCSCBR3 Logical Nodes and attributes for Breaker Wear to ANN LDevice. ➤ Added new TRIPGGIO28, PROGGIO29, RCGGIO30, LBGGIO31, MBOKGGIO32, MISCGGIO33, PWRGGIO34, and LSGGIO35 Logical Nodes and attributes to ANN LDevice.					
ICD-751-R102-V0-Z000000-D20121128	➤ Made corrections per KEMA recommendations.	R103–R105	004	SEL751 R105 and earlier	1.1.145.0 and higher	20130206
ICD-751-R101-V0-Z000000-D20111014	➤ Added Serial and Model Number attributes to PhyNam DO.	R103–R105	004[a]	N/A	N/A	20111116
ICD-751-R100-V0-Z000000-D20110623	➤ Initial ICD File Release.	R101–R102	004[a]	N/A	N/A	20110601

[a] These ICD files are no longer supported by nor included with Architect Software.

Instruction Manual

The date code at the bottom of each page of this manual reflects the creation or revision date. *Table A.8* lists the instruction manual release dates and a description of modifications. The most recent instruction manual revisions are listed at the top.

Table A.8 Instruction Manual Revision History (Sheet 1 of 9)

Revision Date	Summary of Revisions
20170927	Appendix A ➤ Updated *Table A.1: R200 Series Firmware Revision History* for firmware version R200-V4. ➤ Updated *Table A.2: R100 Series Firmware Revision History* for firmware version R112-V3.
20170922	Appendix A ➤ Updated *Table A.1: R200 Series Firmware Revision History* for firmware version R200-V4. ➤ Updated *Table A.2: R100 Series Firmware Revision History* for firmware version R112-V3. ➤ Updated *Table A.3: SEL Display Package Revision History* for display package version 1.0.50751.2004. ➤ Updated *Table A.4: SEL Display Package Compatibility With Relay Firmware R100 Series Firmware Revision History* for display package version 1.0.50751.2004.
20170814	Section 4 ➤ Updated *Table 4.32: RTD Resistance Versus Temperature* for the 410°F 100 Platinum value. Appendix A ➤ Updated *Table A.1: R200 Series Firmware Revision History* for firmware version R200-V3. ➤ Updated *Table A.2: R100 Series Firmware Revision History* for firmware version R112-V2.
20170315	Preface ➤ Updated *Manual Overview*, *Safety Information*, including *Hazardous Locations Approvals*, and *General Information*, including *Typographic Conventions*, *Product Labels*, *Wire Sizes and Insulation*, and *Instructions for Cleaning and Decontamination*. ➤ Added *Copyrighted Software*. Section 1 ➤ Updated *Overview* and *Protection Features* and added *Table 1.1: Phase and Neutral Current Ratings Selection for the SEL-751 Models*, *Table 1.2: Current (ACI) and Voltage (AVI) Card Selection for SEL-751 Models*, *Table 1.3: SEL-751 Protection Elements*, and *Table 1.4: SEL-751 Front-Panel Options*. ➤ Updated *Models, Options, and Accessories*; *Checking Relay Status*; and *Specifications*. Section 2 ➤ Updated *Physical Location* and *Relay Mounting*. ➤ Updated *Figure 2.2: Slot Allocation for Different Cards* and *Table 2.2: Communications Ports*. ➤ Added *Current Card (4 ACI)*. ➤ Updated *Table 2.16: Jumper Functions and Default Positions*. ➤ Updated *Installation* for requesting updated product serial number label. ➤ Updated *Figure 2.8: Dual Fiber Ethernet With 2 AVI/4 AFDI Voltage Option With Arc-Flash Detector Inputs, DeviceNet Card, and Fast Hybrid 4 DI/4 DO Card (Relay MOT 751501AA3CA7085030)* through *Figure 2.13: Dual Copper Ethernet, 14 DI Card, 8 DO (Form B) Card, 2 AVI/4 AFDI Card With LEA Vsync, Vbat Inputs, and 4 Arc-Flash Detection Inputs, 4 ACI/3 AVI Card With 5 A Phase, 200 mA Neutral, and Three-Phase LEA Voltage Inputs (8 Vac) (Relay MOT 751501A4A2BL0L70671)* and added *Figure 2.14: Dual 10/100 Base-T Ethernet, EIA-232 Rear Port, Without Single Multimode ST Fiber-Optic Serial Port Rear, With DeviceNet Card, Fast Hybrid 4 DI/4 DO Card, 8 DI Card, and 4 ACI Card (No Voltage Inputs) (Relay MOT 751001AA3CA3AA50F30)*. Section 3 ➤ Updated *Table 3.1: SEL Software Solutions* for ACSELERATOR Bay Screen Builder SEL-5036 Software. ➤ Updated *Table 3.2: ACSELERATOR QuickSet SEL-5030 Software*. ➤ Updated *Figure 3.6: Selection of Drivers*, *Figure 3.7: Update Part Number*, *Figure 3.8: New Setting Screen*, *Figure 3.15: Language Support Options*, and *Figure 3.16: Spanish Settings QuickSet Display*. ➤ Added *Touchscreen Settings and Bay Screen Builder*.

Table A.8 Instruction Manual Revision History (Sheet 2 of 9)

Revision Date	Summary of Revisions
	Section 4 ➤ Updated *Table 4.3: Voltage Configuration Settings*, *VNOM Range Check*, and *Fault Location*. ➤ Updated *Figure 4.2: Instantaneous Overcurrent Element Logic*. ➤ Updated *Table 4.12: A-, B-, and C-Phase Time-Overcurrent Settings*, *Table 4.13: Maximum Phase Time-Overcurrent*, *Table 4.14: Negative-Sequence Time-Overcurrent Settings*, *Table 4.15: Neutral Time-Overcurrent Settings*, and *Table 4.16: Residual Time-Overcurrent Settings*. ➤ Added a note for *Figure 4.38: Positive-Sequence Voltage-Polarized Directional Element for Phase Overcurrent Elements*. ➤ Updated *HIF Detection Settings*; updated *Table 4.28: High-Impedance Fault (HIF) Detections Settings* and *Table 4.29: HIF Relay Word Bits* and added *Example 4.12: HIFITUNE Operation*. ➤ Updated *Second- and Fifth-Harmonic Blocking Logic*, including *Figure 4.58: Three-Phase Second- and Fifth-Harmonic Blocking Logic*. ➤ Updated *Table 4.51: Trip/Close Logic Settings*. ➤ Updated *Loss-of-Potential (LOP) Protection*, including *Figure 4.73: Loss-of-Potential (LOP) Logic*, and added *Table 4.46: Loss-of-Potential (LOP) Setting*. ➤ Updated *52A and 52B Breaker Status SELOGIC Control Equations* and added a notes for disconnect switch status SELOGIC and local/remote breaker control. ➤ Updated *Global Settings (SET G Command)*, *General Settings*, including *Table 4.65: General Global Settings* for METHRES. ➤ Updated *Arc-Flash Time-Overlight Elements (TOL1 through TOL8)*, including *Table 4.73: Arc-Flash Time-Overlight Settings*. ➤ Updated *DC Mode Processing (DC Control Voltage)*, including *Figure 4.109: DC Mode Processing*. ➤ Added *89A and 89B Disconnect Switch Status SELOGIC Control Equations* and *Local/Remote Breaker Control*. ➤ Updated *Port Settings (SET P Command)*, including *Table 4.83: Ethernet Port Settings*. ➤ Added *Port Numbers Must be Unique*. ➤ Added a note on the Port 2 option to *PORT 2*. ➤ Updated *Front-Panel Settings (SET F Command)*, *General Settings*. ➤ Updated *Table 4.90: Display Point and Local Bit Default Settings*, *Table 4.91: LCD Display Settings*, *Table 4.92: Settings That Always, Never, or Conditionally Hide a Display Point*, *Table 4.97: Example Settings and Displays*, *Table 4.98: Target LED Settings*, and *Table 4.99: Pushbutton LED Settings*. ➤ Updated *Local Bits* and *Target LEDs*. ➤ Added *Touchscreen Settings*. Section 5 ➤ Updated *Table 5.1: Measured Fundamental Meter Values*, *Table 5.4: Maximum/Minimum Meter Values*, *Table 5.5: RMS Meter Values*, *Table 5.6: Demand Values*, and *Table 5.7: Synchrophasor Measure Values*. ➤ Updated *Figure 5.2: METER Command Report With Voltage/Arc-Flash Detection 2 AVI/4 AFDI Card in Slot E and 4 ACI/3 AVI Card in Slot Z*. ➤ Updated *Energy Metering*, *Synchrophasor Metering*, and *Small Signal Cutoff for Metering*. Section 6 ➤ Updated *Overview*. ➤ Updated *View/Change Settings With Two-Line Front Panel* and added *View/Change Settings With Touchscreen Front Panel*. ➤ Updated *Settings Sheets*. Section 7 ➤ Updated *Table 7.1: Communications Port Interfaces*. ➤ Updated *Serial (EIA-232 and EIA-485) Port*. ➤ Updated *Fiber-Optic Serial Port* and *Option 3: Port 2 (Fiber-Optic Serial Port)*. ➤ Updated *File Transfer Protocol (FTP) and MMS File Transfer*. ➤ Updated *CEV HIF (High-Impedance Fault Command)* command response. ➤ Updated *CLOSE Command (Close Breaker)*, *OPEN Command (Open Breaker)*, and *GOOSE Command*. ➤ Updated *Table 7.31: Meter Command*, *Table 7.32: Meter Class*, *Table 7.45: STATUS Command Report and Definitions*, *Table 7.52: TIME Command (View/Change Time)*, *Table 7.56: FTP and MMS Virtual File Structure*, and *Table 7.60: Files Available for Ymodem Protocol*. ➤ Updated *SER Command (Sequential Events Recorder Report)* and added *HMI Directory (Read and Write)*.

Table A.8 Instruction Manual Revision History (Sheet 3 of 9)

Revision Date	Summary of Revisions
	Section 8 ➤ Updated *Overview* and *Two-Line Display*, including *Figure 8.1: Front-Panel Overview*. ➤ Added a note for target LEDs to *Programmable LEDs*. ➤ Added *Touchscreen Display Front Panel*. Section 9 ➤ Added *Section 9: Bay Control*. Section 10 ➤ Added a note to *Event Reporting* for SEL-751 models without voltage inputs. ➤ Added *CEVENT*, including *Figure 10.6: Sample Compressed ASCII Event Report*. Section 11 ➤ Updated *Figure 11.6: Delta Voltage Source Connections* and *Table 11.6: Power Quantity Accuracy-Delta Voltages*. ➤ Updated *Self-Test*, including *Table 11.8: Relay Self-Tests*. Appendix A ➤ Updated for firmware version R200-V1. ➤ Added *SEL Display Package Firmware Versions*, including *Table A.2: SEL Display Package Firmware Revision History* and *SEL Display Package and Relay Firmware Compatibility*, including *Table A.3: SEL Display Package Compatibility With Relay Firmware*. Appendix B ➤ Added a note for firmware upgrades in the touchscreen display model. Appendix D ➤ Updated *DNP3 in the SEL-751*, *Data Access*, and *Control Point Operation*. ➤ Updated *Table D.7: Port DNP3 Protocol Settings*. ➤ Added a note for OC and CC bits to *Reference Data Map*. Appendix E ➤ Updated *Overview* and *Table E.7: 02h SEL-751 Inputs*. ➤ Added a note for OC and CC bits to *06h Preset Single Register Command*. ➤ Updated *Table E.33: Modbus Register Labels for Use With SET M Command* and *Table E.34: Modbus Register Map*. Appendix F ➤ Updated *Features* for change in GOOSE message count from 16 to 64. ➤ Updated *Table F.20: Logical Device: PRO (Protection)* and *Table F.21: Logical Device: MET (Metering)*. Appendix I ➤ Updated *Overview*, *Table I.1: PMU Settings in the SEL-751 for C37.118 Protocol in Global Settings*, and *Table I.6: SEL-751 Ethernet Port Settings for Synchrophasors*. ➤ Updated *Synchrophasor Relay Word Bits*, *Protocol Operation*, and *IEEE C37.118 PMU Setting Example*. Appendix J ➤ Updated *Settings* for Port 2. Appendix K ➤ Updated *K.1: SELOGIC Relay Word Bits*. ➤ Updated *K.2: Relay Word Bit Definitions for the SEL-751 Relay*. Appendix L ➤ Updated *Table L.1: Analog Quantities*. Appendix M ➤ Updated *Settings Erasure* for the CAL access level. Glossary ➤ Updated for new features.

Table A.8 Instruction Manual Revision History (Sheet 4 of 9)

Revision Date	Summary of Revisions
	Index ➤ Updated for new features. Command Summary ➤ Updated the command summary lists.
20160930	Preface ➤ Updated the *General Safety Marks* table in *Safety Marks*. ➤ Added *Trademarks*. Section 1 ➤ Updated *Output Contacts* in *Specifications*. Section 4 ➤ Updated *Example 4.4: VNOM Setting Calculation for Standard Voltage Inputs* in *VNOM Range Check*. ➤ Updated *Table 4.25: Overcurrent Elements Controlled by Level Direction Settings DIR1 Through DIR4 (Corresponding Overcurrent Element Figure Numbers in Parentheses)*. ➤ Updated *High-Impedance Fault Detection With Arc Sense Technology* for surface conductivity and current requirements information and added *Figure 4.54: High-Impedance Fault Current Levels Depend on Ground Surface Types*. ➤ Added a note for the HIFER setting (*Table 4.28: High-Impedance Fault (HIF) Detection Settings*) regarding the use of edge-triggered Relay Word bits in the HIFER SELOGIC control equation. ➤ Updated *Figure 4.77: 81R Fast Rate-of-Change-of-Frequency Logic* for the difference in Hz. Section 6 ➤ Corrected SALARM Relay Word bit in *Enter Settings*. Section 7 ➤ Updated *ETH Command* and *Figure 7.23: Ethernet Port (PORT 1) Status Report When NETMODE := FAILOVER, E61850 := Y, and EGSE := Y* for relay responses based on different Ethernet configurations and different NETMODE settings. ➤ Added a note regarding older CPU cards in relays being upgraded to firmware versions R112 or higher and the GOOSE processing performance functionality to *ETH Command*, *MAC Command*, and *Table A.1: Firmware Revision History*. Section 9 ➤ Updated *High-Impedance Fault Event Summary* for HIF1_*x* and HIF2_*x* Relay Word bits and load reduction. ➤ Updated *Table 9.7: HIF Event Phases* for Phase C conditions. Appendix A ➤ Updated for firmware version R112-V1. ➤ Updated the R112-V0 firmware revision history to include the GOOSE performance enhancement. Appendix K ➤ Updated *Table K.2: Relay Word Bit Definitions for the SEL-751 Relay* for AFS1DIAG through AFS4DIAG.
20151112	Preface ➤ Updated *Wire Sizes and Insulation* table for RTD connections. Section 1 ➤ Updated *Standard Protection Features* for *Line/Cable Thermal Elements* per IEC 60255-149 (49), *Second and Fifth Harmonic Blocking Logic*, *Vector Shift Elements for Islanding Detection (78VS)*, *Inverse-Time Over- and Undervoltage (59I/27I)*. ➤ Updated *Models, Options, and Accessories* for 14 DI, 8 AFDI cards, IEC 60870-5-03 communications options and the Spanish language option. ➤ Updated Specifications for I_{NOM} = 200 mA neutral CT, *Low-Energy Analog (LEA) Voltage Inputs*, *IEC Thermal Element (49IEC)*, *Inverse-Time Undervoltage (27I)*, *Inverse-Time Overvoltage* (59I), *Vector Shift (78VS)*. Section 2 ➤ Added terminal designations for 8 AFDI and 14 DI cards and updated the text for the Current/Voltage Card Option (4 ACI/3 AVI) and Voltage/Arc-Flash Detection Inputs Card Option (2 AVI /4 AFDI). ➤ Added rear-panel connections for relays with the new options. ➤ Added new section *Ordering Arc-Flash Fiber Sensors*. ➤ Updated ac/dc control connection diagrams.

Table A.8 Instruction Manual Revision History (Sheet 5 of 9)

Revision Date	Summary of Revisions
	Section 3 ➤ Updated and added Language Support. Section 4 ➤ Updated directional control sections for wattmetric and incremental conductance directional elements (Petersen coil-grounded system), zero-sequence voltage-polarized directional element (ungrounded/high-impedance grounded system). ➤ Added text for *IEC Thermal Elements*, *Low-Energy Analog (LEA) Voltage Inputs*, *Vector Shift Element*, *Second- and Fifth-Harmonic Blocking Logic, Inverse-Time Overvoltage Protection*, and *Inverse-Time Undervoltage Protection*. ➤ Updated Port settings to add PRP operating mode and IEC 60870-5-103 protocol. ➤ Added OFF to the setting range of Failover Timeout setting FTIME. Section 5 ➤ Updated the *Metering and Monitoring* section for LEA voltage inputs. ➤ Updated the *Thermal Metering* section. Setting Sheets ➤ Added settings for LEA voltage inputs, directional control, 27I/59I inverse-time voltage elements, IEC thermal element, and vector shift element. ➤ Added IEC 60870-5-103 and PRP to port settings. Section 7 ➤ Updated AFT command for 8 AFDI Card. ➤ Added Test DB command to command explanations. ➤ Added THE command to preload or reset thermal data. ➤ Added Language support. Section 9 ➤ Added Viewing Compressed Event (CEV) Reports and COMTRADE File Format Event Reports. Section 10 ➤ Updated the section for 8 AFDI card. Appendix A ➤ Updated for firmware version R112. Appendix D ➤ Updated *Table D.7: Port DNP3 Protocol Settings* for 5 DNP sessions. Appendix E ➤ Updated *Table E.34: Modbus Register Map* for the new features. Appendix F ➤ Updated the Logical Nodes description detailed in this manual revision for the SEL-751 006 ICD file. Appendix G ➤ Added IEC-60870-5-103 documentation. Appendix K ➤ Updated *Table K.1: SELOGIC Relay Word Bits* and *Table K.2: Relay Word Bit Definitions for the* SEL-751 *Relay* for the new Relay Word bits. Appendix L ➤ Updated thermal metering, light metering, and fault information in *Table L.1: Analog Quantities*. Appendix M ➤ Added Cybersecurity features documentation. Glossary ➤ Updated for new features. Index ➤ Updated for new features. Command Summary ➤ Updated for new features.

Table A.8 Instruction Manual Revision History (Sheet 6 of 9)

Revision Date	Summary of Revisions
20150410	Section 1 ➤ Added the applied current at which the burden is measured for I_{NOM} = 1 A, 5 A in *Specifications*. ➤ Updated *Processing Specifications and Oscillography.* ➤ Updated the low end of the setting ranges for all overcurrent elements and the high end of the setting ranges for the inverse-time overcurrent elements in *Specifications*. ➤ Updated *Synchrophasor Accuracy* specifications. Section 2 ➤ Added a note on CT circuits to applicable current card descriptions. Section 4 ➤ Updated notes for *Figure 4.1: Instantaneous Overcurrent Element Logic*. ➤ Added a note for *Time-Overcurrent Curves*. ➤ Updated *Zero-Sequence Maximum Torque Angle*. ➤ Updated *Reclose Logic* supervision, adding C1, C2, C3, and C4 choices to the E79 setting. Section 5 ➤ Updated *Load Profiling*. Setting Sheets ➤ Updated the setting ranges for the overcurrent elements. Section 7 ➤ Updated *PULSE Command*. ➤ Updated *AFT Command (Arc-Flash Detection Channels Self-Test)*. Section 10 ➤ Added a note on CT circuits. ➤ Updated *Table 10.8: Relay Self-Tests*. Appendix A ➤ Updated for firmware version R110. ➤ Added *ICD File* section with *Table A.4:* SEL-751 *ICD File Revision History.* Appendix H ➤ Updated *Table H.2: Synchrophasor Order in Data Stream (Voltages and Currents)*. ➤ Added *Table H.9: TQUAL Bits Translation to Time Quality.* Appendix K ➤ Updated *Analog Quantities* for processing of the RMS data.
20150123	Preface ➤ Added *Safety Information* and *General Information*. ➤ Updated the *Product Compliance* label in *Hazardous Locations Approval* and the product labels in *General Information*. Section 1 ➤ Changed the *Certifications* section title to *Compliance* and relocated the section to the beginning of the *Specifications*. ➤ Added the hazardous locations compliance approvals to *Specifications*.
20140402	Preface ➤ Updated the *Product Compliance* label. Section 1 ➤ Updated the *Specifications* for element accuracy and oscillography length. Section 2 ➤ Updated *Card Configuration Procedure*.

Table A.8 Instruction Manual Revision History (Sheet 7 of 9)

Revision Date	Summary of Revisions
	Section 4 ➤ Updated *Figure 4.35: Hybrid Power System with Neutral Ground Resistor*. ➤ Added a note for *Figure 4.50: 81RF Fast Rate-of-Change-of-Frequency Logic* to describe the settings 81RFIBLK := OFF and 81RFVBLK := OFF. ➤ Updated *Table 4.89: Event Report Settings* for event length and LER setting range. The relay now supports event length as high as 180 cycles. Section 6 ➤ Updated the SEL-751 *Settings Sheets* event report length and LER setting range. Section 7 ➤ Updated *Table 7.23: HIS HIF Command* with **HIS HIF C** or **R** and **HIS HIF CA** or **RA** commands. Section 9 ➤ Updated the event storage capability of the SEL-751 in *Event Reporting* and *Event Summaries*. Section 10 ➤ Updated *Table 10.8: Relay Self-Tests*. Appendix A ➤ Updated for firmware version R109. Appendix F ➤ Added a note for *GOOSE* and *ACSELERATOR Architect* regarding GOOSE subscriptions when loading a new CID file. SEL-751 Command Summary ➤ Added **HIS HIF CA** or **RA** command to the list of Access Level 1 commands.
20131218	Section 4 ➤ Updated the setting angle for the ACB phase rotation of the *Delta Connected Voltages* example under *Setting SYNCPH*. ➤ Updated *Figure 4.41: Synchronism-Check Elements*. Appendix A ➤ Updated for firmware version R108.
20131101	Section 1 ➤ Lowered the minimum value of the VNOM setting range from 100 V to 20 V. ➤ Updated the ac current inputs under *AC Current Inputs* and the input voltage range under *Power Supply* in the *Specifications*. ➤ Added Open State Leakage Current for *Fast Hybrid* to the *Specifications*. ➤ Added RTD Trip/Alarm Time Delay to *RTD Protection* category of the *Specifications*. Section 2 ➤ Added a note to *Figure 2.18: Voltage Connections*. ➤ Added a note for fail-safe operation of the fast hybrid output contacts. Section 4 ➤ Lowered the minimum value of the VNOM setting range from 100 V to 20 V. ➤ Updated *Figure 4.51: Trip Logic*. ➤ Added a note for RTD TRIP/WARNING levels. ➤ Added a note for fail-safe operation of the fast hybrid output contacts. Section 7 ➤ Updated the *Fiber-Optic Serial Port* paragraph. ➤ Updated +5 Vdc availability statement in *+5 Vdc Power Supply*. Section 10 ➤ Added a note for clear-jacketed fiber sensor. ➤ Updated the text for SALARM in the ALARM Output bullet of *Self-Test*. Appendix A ➤ Updated for firmware version R106.

Table A.8 Instruction Manual Revision History (Sheet 8 of 9)

Revision Date	Summary of Revisions
	Appendix F ➤ Revised *Table F.7: New Logical Node Extensions*, *Table F.8: Arc-Flash Detection*, and *Table F.9: Thermal Metering Data Logical Node Class Definition*. ➤ Added *Table F.10: Demand Metering Statistics Logical Node Class Definition*, *Table F.11: Circuit Breaker Supervision (Per-Phase) Logical Node Class Definition*, *Table F.12: Compatible Logical Nodes With Extensions*, *Table F.13: Metering Statistics Logical Node Class Definition*, *Table F.14: Circuit Breaker Logical Node Class Definition*, and *Table F.15: Generic Process I/O Logical Node Class Definition*. ➤ Revised *Table F.16: Logical Device: PRO (Protection)*, *Table F.17: Logical Device: MET (Metering)*, *Table F.18: Logical Device: CON (Remote Control)*, *Table F.19: Logical Device: ANN (Annunciation)*, and *Table F.20: Logical Device: CFG (Configuration)*. Appendix J ➤ Updated the definition for the SALARM Relay Word bit.
20130206	Preface ➤ Updated the product labels for the SEL-751. Section 1 ➤ Updated mounting screw size and current/voltage input terminal block information under the *Terminal Connections* category of the *Specifications*. ➤ Updated the time delay setting range for the instantaneous/definite-time overcurrent element. ➤ Updated the pickup and time dial setting ranges for the inverse-time overcurrent elements. Section 4 ➤ Added a note for display points stating that they are updated approximately every two (2) seconds. ➤ Corrected *Table 4.63: Entries for the Four Strings* for set and clear strings. ➤ Updated Note 3 for *Figure 4.1: Instantaneous Overcurrent Element Logic*. ➤ Corrected *Table 4.77: Settings That Always, Never, or Conditionally Hide a Display Point* for the programmable automation controller setting. Section 5 ➤ Update *Table 5.6: Demand Values* with new power demand quantities. ➤ Updated the metering screen captures for demand and peak demand functions. Section 6 Settings Sheets ➤ Revised the hide rules for the 79 element. Section 9 ➤ Updated the footnote for *Table 9.1: Event Types* with the logic of the GFLT Relay Word bit. ➤ Added explanation to determine fault type and fault location in *Event Type*. ➤ Added the *Event Numbering* subsection that explains the procedure for retrieving particular event reports. Appendix A ➤ Updated for firmware version R105. Appendix B ➤ Added instructions for upgrading firmware using ACSELERATOR QuickSet. Appendix E ➤ Revised *Reading History Data Using Modbus*. Appendix J ➤ Updated the Relay Word bit definition for GFLT, PHASE_A, PHASE_B, and PHASE_C. Appendix K ➤ Added new demand and peak demand metering quantities for DNP and Fault date information in *Table K.1: Analog Quantities*. ➤ Added a footnote for Relay Word bits RTD through RTD12 in *Table K.1: Analog Quantities*.
20120903	Preface ➤ Updated product label examples in *Product Labels*. Section 1 ➤ Updated *Specifications*.

Table A.8 Instruction Manual Revision History (Sheet 9 of 9)

Revision Date	Summary of Revisions
20111116	Section 1 ➤ Added *Compression Plug Mounting Ear Screw Tightening Torque* in *Specifications*. ➤ Revised 24/48 Vdc power supply maximum input voltage to 60 Vdc in *Specifications*. ➤ Revised *Channels 1–4 Arc-Flash Detectors (AFDI)* in *Specifications.* Section 2 ➤ Changed “Bare Fiber” to “Clear Fiber” as a result of the new fiber sensor design. Section 4 ➤ Revised *Figure 4.51: Trip Logic* to show target reset when 52A asserts with setting RSTLED = Y. ➤ Changed “Bare Fiber” to “Clear Fiber” as a result of the new fiber sensor design. Section 5 ➤ Updated fundamental and rms metering threshold values in *Small Signal Cutoff for Metering*. Section 6 Setting Sheets ➤ Revised CBADPU setting units to ppm (parts per million). Section 10 ➤ Updated *Table 10.8: Relay Self-Tests* with Corrective Action column. ➤ Changed “Bare Fiber” to “Clear Fiber” as a result of the new fiber sensor design. ➤ Added SEL-4520 Arc Flash Test Module reference in *Arc-Flash Protection Tests*. Appendix A ➤ Updated for firmware version R103. Appendix E ➤ Removed *Modifying Relay Settings Using Modbus*
20110720	Appendix A ➤ Updated for firmware version R102.
20110601	➤ Initial version.

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Appendix B
Firmware Upgrade Instructions

Overview

These instructions guide you through the process of upgrading firmware in the device. The firmware upgrade will be either a standard release or a point release. A standard release adds new functionality to the firmware beyond the specifications of the existing version. A point release is reserved for modifying firmware functionality to conform to the specifications of the existing version.

A standard release is identified by a change in the R-number of the device firmware identification (FID) string.

Existing firmware:

FID=SEL-751-**R100**-V0-Z001001-Dxxxxxxxx

Standard release firmware:

FID=SEL-751-**R101**-V0-Z001001-Dxxxxxxxx

A point release is identified by a change in the V-number of the device FID string.

Existing firmware:

FID=SEL-751-R100-**V0**-Z001001-Dxxxxxxxx

Point release firmware:

FID=SEL-751-R100-**V1**-Z001001-Dxxxxxxxx

These firmware upgrade instructions apply to all SEL-700 series industrial products except the SEL-701 Relay and SEL-734 Meter.

SEL occasionally offers firmware upgrades to improve the performance of your relay. Because SEL-751 relays store firmware in flash memory, changing physical components is not necessary. Upgrade the relay firmware by downloading a file from a personal computer to the relay via the front-panel serial port via ACSELERATOR QuickSet SEL-5030 Software or a terminal emulator as outlined in the following sections. For relays with IEC 61850 option, verify IEC 61850 protocol after the upgrade (see *Protocol Verification for Relays With IEC 61850 Option*).

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-C234A or equivalent, or a null-modem cable)

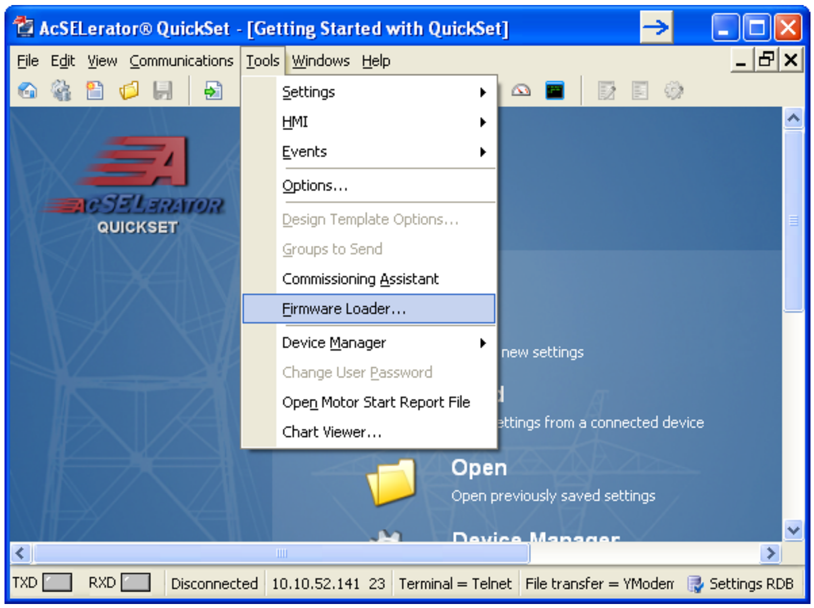
NOTE: Firmware releases are also available as zip files (.z19). Use the zip file for faster download.

➤ Disk containing the firmware upgrade file (for example, r1017xxx.s19 or r1017xxx.z19)

➤ QuickSet Software

Upgrade Firmware Using QuickSet

Select **Tools** > **Firmware Loader** from the QuickSet menu bar to launch a wizard that walks you through the steps to load firmware into your SEL device. Refer to *Section 3: PC Software* for setup and connection procedures for QuickSet.



NOTE: The firmware loader is not supported on Ethernet port connections.

Firmware Loader does not start if:

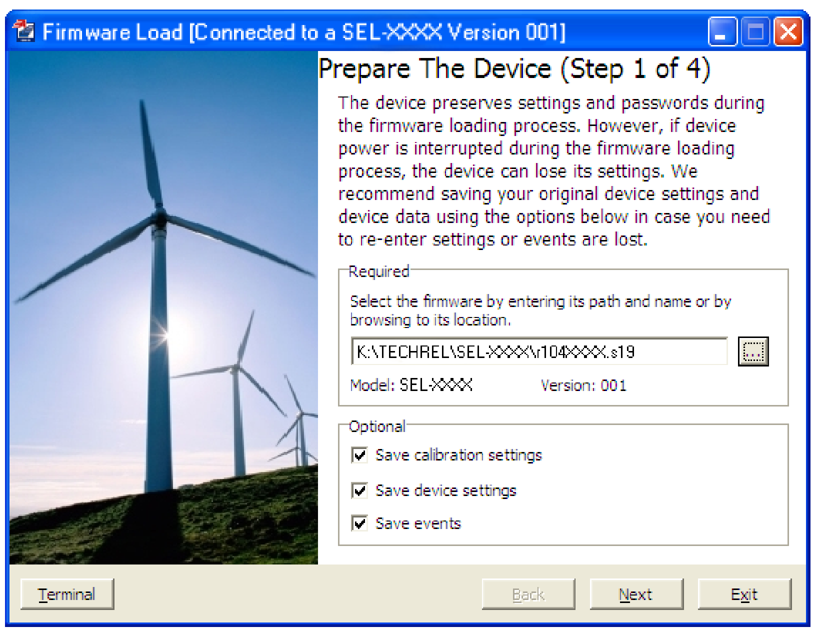
➤ The device is unsupported by QuickSet.

➤ The device is not connected to the computer with a communications cable.

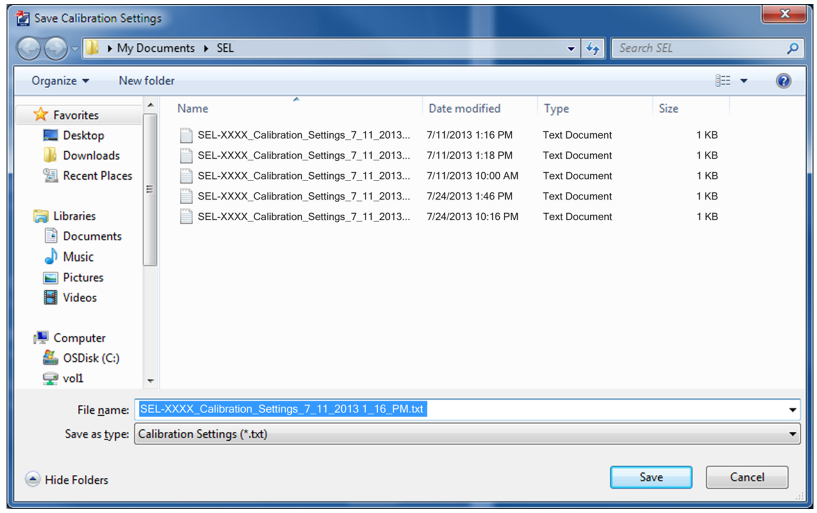
➤ The device is disabled.

Step 1. Prepare the device.

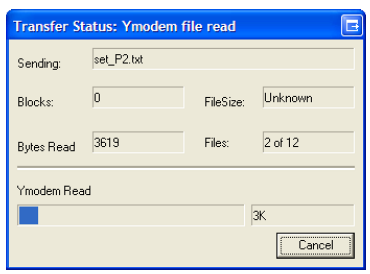
a. Select the firmware to be loaded using the browse control and select **Save calibration settings**, **Save device settings**, and **Save events**. Select **Next** to continue the wizard.

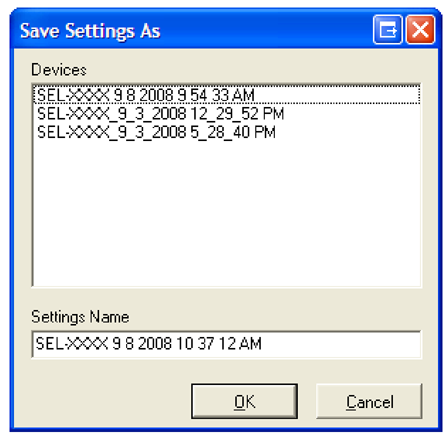


b. Select a file name to save the selected settings or accept the defaults as shown. Click **Save**.



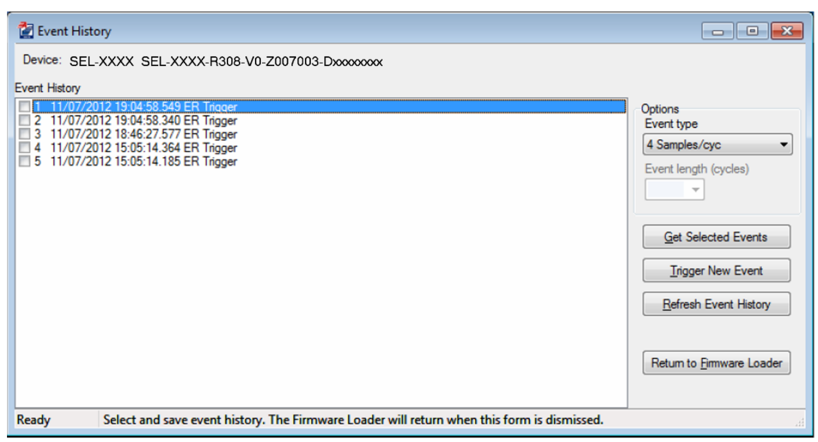
c. The **Transfer Status**: **Ymodem file read** window shows the transfer progress of the settings file. Clicking **Cancel** stops the transfer.
After the device settings are downloaded, select a file name and path to save the settings or accept the default, as shown.





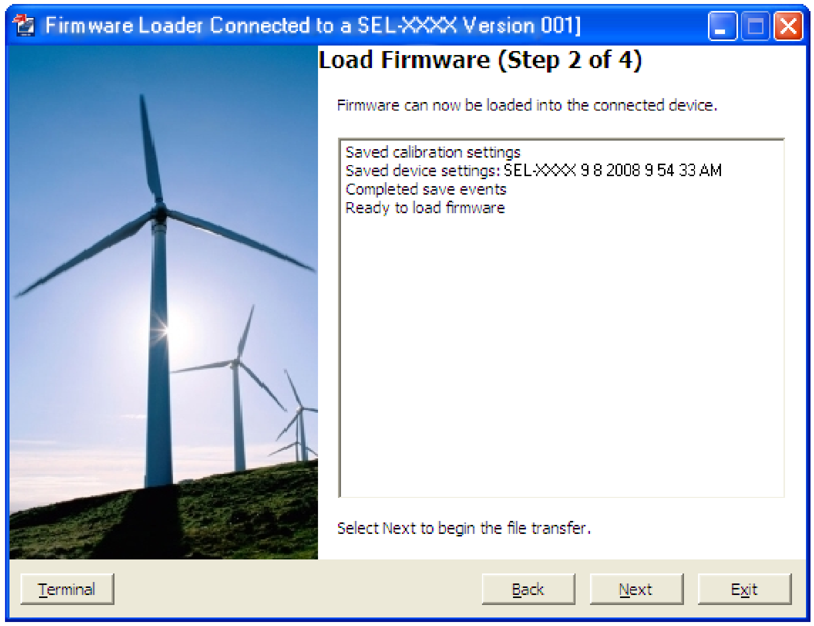
d. Click **Return to Firmware Loader** if this product does not have any event reports.

If there are any event reports to be saved, click the **Get Selected Event** button after selecting the events. After saving them, click the **Return to Firmware Loader** button.



Step 2. Transfer Firmware.

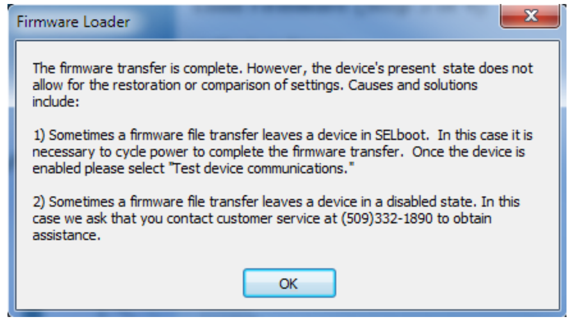
Click **Next** to begin the firmware transfer.



Step 3. Load Firmware.

During this step, the device is put in SELBOOT mode. The transfer speed is maximized and the firmware transfer begins.

NOTE: The following screen can appear if you have one of the two conditions mentioned.



If the relay is disabled, as mentioned in condition number 2, check for the **ENABLED** LED on the front panel of the relay. If the **ENABLED** LED is not illuminated or the front panel displays `STATUS FAIL` or `Non_Vol Failure`, use the following procedure to restore the factory-default settings:

a. Click on the Terminal button on the Firmware Load screen of QuickSet.

b. Set the communications software settings to 9600 bps, 8 data bits, and 1 stop bit.

c. Enter Access Level 2 by issuing the **2AC** command.

d. Issue the **R_S** command to restore the factory-default settings.

e. Enter Access Level 2.

f. Issue the **STATUS** command.

If the **STATUS** report shows option card `FAIL` and `Relay Disabled` and the message:

`Confirm Hardware Config`

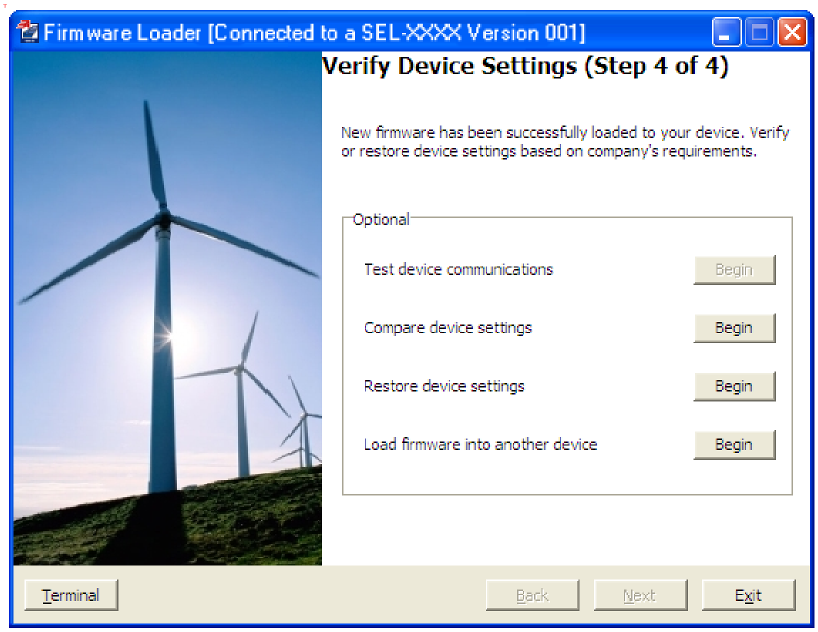
`Accept & Reboot (Y/N)?`

Enter **Y**. This saves the relay calibration settings. The relay responds:

`Config Accepted`

The relay reboots and comes up **ENABLED**.

Step 4. Verify Device.



Select from four verification options, which perform as follows.

Test Device Communications. If the device cannot be restarted, then turn power off and back on to restart it. Once the device is enabled, this option reconnects and reinitializes the device.

Compare Device Settings. This option verifies settings by reading them from the device and comparing them with settings saved to the database.

Restore Device Settings. This option restores settings by writing settings that are saved in the database to the device. Settings are converted automatically, if necessary.

Load Firmware into Another Device. Returns the wizard to *Step 1: Prepare Device* to repeat the firmware-loading process with another device.

Upgrade Firmware Using a Terminal Emulator

The following instructions assume you have a working knowledge of your personal computer terminal emulation software. In particular, you must be able to modify your serial communications parameters (data rate, data bits, parity, etc.), select transfer protocol (Xmodem/CRC or 1k Xmodem/CRC), and transfer files (for example, send and receive binary files).

Step 1. If the relay is in service, open the relay control circuits.

Step 2. Connect the PC to the front-panel serial port and enter Access Level 2.

Step 3. Save the present relay settings.

You can use the PC software (described in the instruction manual PC software section) to save and restore settings easily. Otherwise, use the following steps.

a. Issue the following commands at the ASCII prompt:

SHO, **SHO L**, **SHO G**, **SHO P**, **SHO F**, **SHO R**, **SHO C**, etc.

b. Record all of 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.

NOTE: To save the calibration settings, perform **SHO C** from the terminal by logging into CAL level using the CAL level password. The factory-default password for CAL level is CLARKE.

NOTE: When you are upgrading an SEL-751 with a touchscreen front-panel display, save all of the relay settings, including the touchscreen settings, using QuickSet.

Step 4. Start upgrading the 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 sends the `!>` prompt.

NOTE: Change the baud rate of the relay serial port to 9600 before issuing the **L_D** command to start the upgrade process.

NOTE: If you have difficulty at 115200 bps, choose a slower data transfer rate (e.g., 38400 bps or 57600 bps). Be sure to match the relay and PC data rates.

Step 5. Change the data rate, if necessary.

a. Type **BAU 115200 <Enter>**.

This changes the data rate of the communications port to 115200.

b. Change the data rate of the PC to 115200 to match the relay.

Step 6. Begin the transfer of new firmware to the relay by issuing the **REC** command.

Step 7. Type **Y** to erase the existing firmware or press **<Enter>** to abort.

Step 8. Press any key (for example, **<Enter>**) when the relay sends a prompt.

Step 9. Start the file transfer.

Select the **Send file** option in your communications software. Use the Xmodem protocol and send the file that contains the new firmware (for example, r101xxx.s19 or r101xxx.z19).

The file transfer typically takes less than 15 minutes at 115200 bps, depending on the product. After the transfer is complete, the relay reboots and returns to Access Level 0. *Figure B.1* shows the entire process.

```
=>>L_D <Enter>

Disable relay to receive firmware (Y,N)? Y <Enter>
Are you sure (Y,N)? Y <Enter>
Relay Disabled

BFID=BOOTLDR-R500-V0-Z000000-D20090925
!>BAU 115200 <Enter>
!>REC <Enter>
This command uploads new firmware.
When new firmware is uploaded successfully, IED will erase old firmware,
load new firmware and reboot.

Are you sure you want to erase the existing firmware(Y,N)? Y <Enter>
Press any key to begin transfer and then start transfer at the terminal.<Enter>
Erasing firmware.
Erase successful.
Writing new firmware.
Upload completed successfully. Attempting a restart.
```

Figure B.1 Firmware File Transfer Process

Step 10. The relay illuminates the **ENABLED** front-panel LED if the relay settings were retained through the download.

If the **ENABLED** LED is illuminated, proceed to *Step 11*.

If the **ENABLED** LED is not illuminated or the front panel displays `STATUS FAIL` or `Non_Vol Failure`, use the following procedure to restore the factory-default settings:

a. Set the communications software settings to 9600 bps, 8 data bits, and 1 stop bit.

b. Enter Access Level 2 by issuing the **2AC** command.

c. Issue the **R_S** command to restore the factory-default settings.

The relay then reboots with the factory-default settings.

d. Enter Access Level 2.

e. Issue the **STATUS** command.

If the relay is **ENABLED** go to *Step f*.

If the **STATUS** report shows option card `FAIL` and `Relay Disabled` and the message:

`Confirm Hardware Config`

`Accept & Reboot (Y/N)?`

Enter **Y**. This saves the relay calibration settings.

The relay responds:

`Config Accepted`

The relay reboots and comes up **ENABLED**.

f. Restore relay settings back to the settings saved in *Step 3*.

Step 11. Change the data rate of the PC to match that of the relay prior to *Step 5*, and enter Access Level 2.

Step 12. Issue the **STATUS** command; verify all relay self-test results are OK.

Step 13. Apply current and voltage signals to the relay.

Step 14. Issue the **METER** command; verify that the current and voltage signals are correct.

Step 15. Autoconfigure the SEL-2032, SEL-2030, or 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.

Protocol Verification for Relays With IEC 61850 Option

NOTE: A relay with optional IEC 61850 protocol requires the presence of one valid CID file to enable the protocol. 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 disables the IEC 61850 protocol, because it no longer has a valid configuration. To restart IEC 61850 protocol operation, you must transfer a valid CID file to the relay.

Perform the following steps to verify that the IEC 61850 protocol is still operational after a relay firmware upgrade and if not, re-enable it. This procedure assumes that IEC 61850 was operational with a valid CID file immediately before initiating the relay firmware upgrade.

Step 1. Establish an FTP connection to the relay Ethernet port.

Step 2. Open the ERR.TXT file.

If the ERR.TXT file is empty, the relay found no errors during CID file processing and IEC 61850 should be enabled. Go to *Step 3* if ERR.TXT is empty.

If the ERR.TXT file contains error messages relating to CID file parsing, the relay has disabled the IEC 61850 protocol. Use ACSELERATOR® Architect™ SEL-5032 Software to convert the existing CID file and make it compatible again.

a. Install the Architect software upgrade that supports your required CID file version.

b. Run Architect and open the project that contains the existing CID file for the relay.

c. Download the CID file to the relay.

Step 3. Upon connecting to the relay, Architect detects the upgraded relay firmware and prompts you to allow it to convert the existing CID file to a supported version. Once converted, downloaded, and processed, the valid CID file allows the relay to re-enable the IEC 61850 protocol.

Step 4. In the Telnet session, type **GOO <Enter>**.

Step 5. View the GOOSE status and verify that the transmitted and received messages are as expected.

The relay is now ready for your commissioning procedure.

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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2350 NE Hopkins Court
Pullman, WA 99163-5603 U.S.A.
Tel: +1.509.338.3838
Fax: +1.509.332.7990
Internet: selinc.com
Email: info@selinc.com

Appendix C
SEL Communications Processors

SEL Communications Protocols

The SEL-751 Feeder Protection Relay supports SEL protocols and command sets shown in *Table C.1*.

Table C.1 Supported Serial Command Sets

Command Set	Description
SEL ASCII	Use this protocol to send ASCII commands and receive ASCII responses that are human readable with an appropriate terminal emulation program.
SEL Compressed ASCII	Use this protocol to send ASCII commands and receive Compressed ASCII responses that are comma-delimited for use with spreadsheet and database programs or for use by intelligent electronic devices.
SEL Fast Meter	Use this protocol to send binary commands and receive binary meter and target responses.
SEL Fast Operate	Use this protocol to receive binary control commands.
SEL Fast SER	Use this protocol to receive binary Sequential Events Recorder unsolicited responses.
SEL Fast Message	Use this protocol to write Remote Analog data via unsolicited writes.

SEL ASCII Commands

We originally designed SEL ASCII commands for communication between the relay and a human operator via a keyboard and monitor or a printing terminal. A computer with a serial port can also use the SEL ASCII protocol to communicate with the relay, collect data, and issue commands.

SEL Compressed ASCII Commands

The relay supports a subset of SEL ASCII commands identified as Compressed ASCII commands. Each of these commands results in a comma-delimited message that includes a checksum field. Most spreadsheet and database programs can directly import comma-delimited files. Devices with embedded processors connected to the relay can execute software to parse and interpret comma-delimited messages without expending the customization and maintenance labor necessary to interpret nondelimited messages. The relay calculates a checksum for each line by numerically summing all of the bytes that precede the checksum field in the message. The program that uses the data can detect transmission errors in the message by summing the characters of the received message and comparing this sum to the received checksum.

Most commands are available only in SEL ASCII or Compressed ASCII format. Selected commands have versions in both standard SEL ASCII and Compressed ASCII formats. Compressed ASCII reports generally have fewer characters than conventional SEL ASCII reports because the compressed reports reduce blanks, tabs, and other white space between data fields to a single comma.

Table C.2 lists the Compressed ASCII commands and contents of the command responses.

Table C.2 Compressed ASCII Commands

Command	Response	Access Level
BNAME	ASCII names of Fast Meter status bits	0
CASCII	Configuration data of all Compressed ASCII commands available at access levels > 0	0
CEVENT	Event report	1
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-751 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-751 and use the ASCII data stream for commands and responses.

SEL Fast Meter, Fast Operate, Fast SER, and Unsolicited Write

SEL Fast Meter is a binary message that you solicit with binary commands. Fast Operate is a binary message for control. The relay can also send unsolicited Fast SER messages automatically and receive unsolicited SEL Fast Messages (used in the SEL-751 for Remote Analogs). If the relay is connected to an SEL communications processor, these messages provide the mechanism that the communications processor uses for SCADA or DCS functions that occur simultaneously with ASCII interaction.

SEL Communications Processor

NOTE: If the SEL-751 is connected to any SEL communications processor (SEL-203x or RTAC), the corresponding language port setting must be set to English.

SEL offers SEL communications processors, powerful tools for system integration and automation. The SEL-2030 series and the SEL-2020 communications processors are similar, except that the SEL-2030 series has two slots for network protocol cards. The SEL-3530 Real Time Automation Controller (RTAC) has Ethernet ports as well as serial ports to connect to your SEL relay. These devices provide a single point of contact for integration networks with a star topology, as shown in *Figure C.1*.

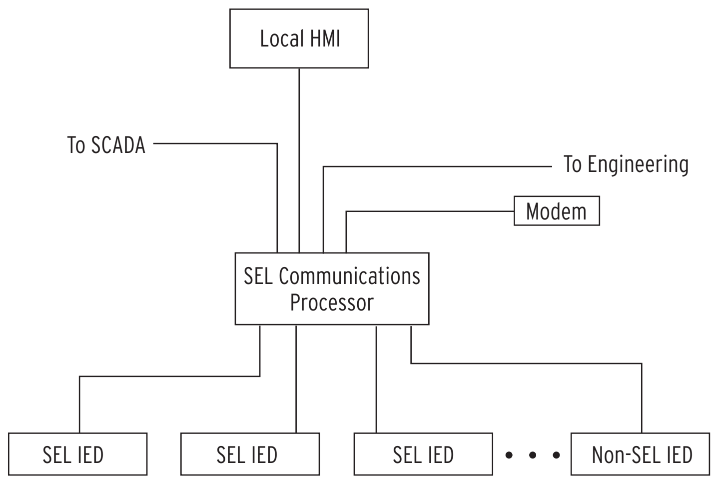


Figure C.1 SEL Communications Processor Star Integration Network

In the star topology network in *Figure C.1*, the SEL communications processor offers the following substation integration functions:

- ➤ Collection of real-time data from SEL and non-SEL IEDs
- ➤ Calculation, concentration, and aggregation of real-time IED data into databases for SCADA, HMI, and other data consumers
- ➤ Access to the IEDs for engineering functions including configuration, report data retrieval, and control through local serial, remote dial-in, and Ethernet network connections
- ➤ Distribution of IRIG-B time synchronization signal to IEDs based on external IRIG-B input, internal clock, or protocol interface
- ➤ Simultaneous collection of SCADA data and engineering connection to SEL IEDs over a single cable
- ➤ Automated dial-out on alarms

The SEL communications processors have 16 serial ports plus a front port. This port configuration does not limit the size of a substation integration project, because you can create a multitiered solution as shown in *Figure C.2*. In this multitiered system, the lower-tier SEL communications processors forward data to the upper-tier SEL communications processor that serves as the central point of access to substation data and substation IEDs.

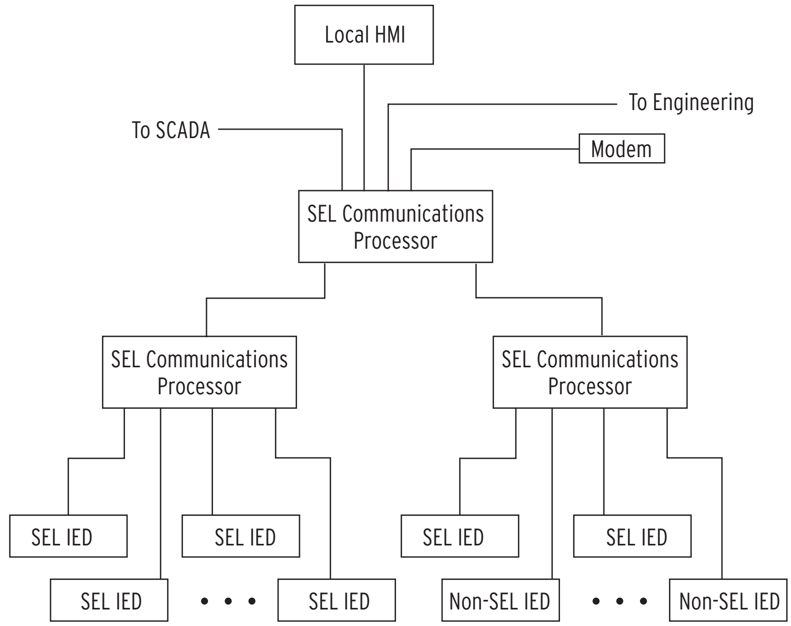


Figure C.2 Multitiered SEL Communications Processor Architecture

You can add additional communications processors to provide redundancy and eliminate possible single points of failure. SEL communications processors provide an integration solution with a reliability comparable to that of SEL relays. In terms of MTBF (mean time between failures), SEL communications processors are 100 to 1000 times more reliable than computer-based and industrial technology-based solutions.

Configuration of an SEL communications processor is different from other general-purpose integration platforms. You can configure SEL communications processors with a system of communication-specific keywords and data movement commands rather than programming in C or another general-purpose computer language. SEL communications processors offer the protocol interfaces listed in *Table C.3*.

Table C.3 SEL Communications Processors Protocol Interfaces

Protocol	Connect to
DNP3 Level 2 Outstation	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-751 and an SEL communications processor is shown in *Figure C.1*. In this architecture, the SEL communications processor collects data from the SEL-751 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); communications overhead is much less for a single data exchange conversation to collect all substation data (from a communications processor) than for many conversations necessary to collect data directly from each individual IED. You can further reduce data latency by connecting any SEL communications processor directly to the SCADA master and eliminating redundant communications processing in the RTU.

The SEL communications processor is responsible for the protocol interface, so you can install, test, and even upgrade the system in the future without disturbing protective relays and other station IEDs. This insulation of the protective devices from the communications interface assists greatly in situations where different departments are responsible for SCADA operation, communication, and protection.

SEL communications processors equipped with an SEL-2701 Ethernet Processor can provide a UCA2 interface to SEL-751 Relays and other serial IEDs. The SEL-751 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).

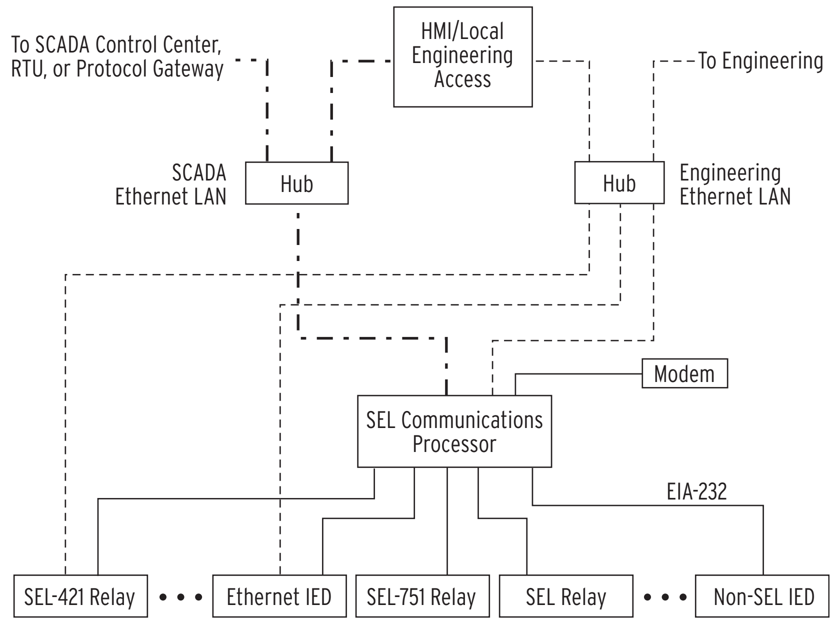


Figure C.3 Enhancing Multidrop Networks With SEL Communications Processors

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-751. The physical configuration used in this example is shown in *Figure C.4*.

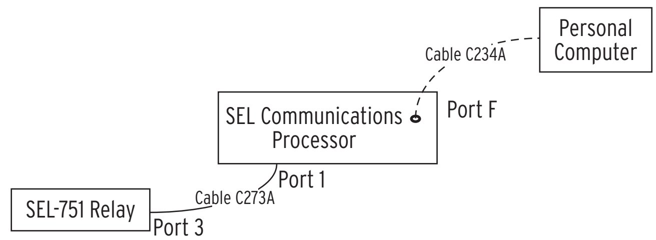


Figure C.4 Example of SEL Relay and SEL Communications Processor Configuration

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-751, 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-751. 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.8 shows the list of meter data 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 With the 2 AVI/ 4 AFD Card Installed

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
IA	200Bh	float
IB	200Dh	float
IC	200Fh	float
IN	2011h	float
IG	2013h	float
UBI	2015h	float
VAB	2017h	float
VBC	2019h	float
VCA	201Bh	float
VS	201Dh	float
UBV	201Fh	float
P	2021h	float
Q	2023h	float
S	2025h	float
PF	2027h	float
FREQ	2029h	float
FREQS	202Bh	float
VDC	202Dh	float

Relay Word Bits Information

Table C.9 lists the Relay Word bit data available in the SEL communications processor TARGET region.

Table C.9 Communications Processor TARGET Region (Sheet 1 of 2)

Address	Relay Word Bits (in Bits 7–0)							
	7	6	5	4	3	2	1	0
2804h	*	*	*	*	*	PWRUP	STSET	*
2805h	See *Table K.1*, Row 0							
2806h	See *Table K.1*, Row 1							
2807h	See *Table K.1*, Row 2							
2808h	See *Table K.1*, Row 3							
2809h	See *Table K.1*, Row 4							

Table C.9 Communications Processor TARGET Region (Sheet 2 of 2)

Address	Relay Word Bits (in Bits 7–0)							
	7	6	5	4	3	2	1	0
280Ah	See *Table K.1*, Row 5							
280Bh	See *Table K.1*, Row 6							
280Ch	See *Table K.1*, Row 7							
280Dh	See *Table K.1*, Row 8							
280Eh	See *Table K.1*, Row 9							
280Fh	See *Table K.1*, Row 10							
2810h	See *Table K.1*, Row 11							
2811h	See *Table K.1*, Row 12							
• • •	• • •							
28A3h	See *Table K.1*, Row 158							

Control Points

The SEL communications processor can automatically pass control messages, called Fast Operate messages, to the SEL-751. You must enable Fast Operate messages by using the FASTOP setting in the SEL-751 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.

NOTE: To use the Fast Operate function, the Breaker jumper must be installed (see Figure 2.7).

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. For example, if you set RB01 on **Port 1** in the SEL communications processor, it automatically sets RB01 in the SEL-751.

Breaker bit BR1 operates differently than remote bits. There is one breaker bit in the SEL-751. For Circuit Breaker 1, when you set BR1, the SEL communications processor sends a message to the SEL-751 that asserts the OC bit for one processing interval. If you clear BR1, the SEL communications processor sends a message to the SEL-751 that asserts the CC bit for one processing interval. OC opens the breaker (via SELOGIC control equation TR) and CC closes the breaker (via SELOGIC control equation CL). See *Figure 4.79* and *Figure 4.80* for the breaker trip and breaker close logic diagrams, respectively.

Demand Data

Table C.10 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.10 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
IAD(A)	300Bh	float
IBD(A)	300Dh	float
ICD(A)	300Fh	float
IGD(A)	3011h	float
3I2D(A)	3013h	float

SEL Communications Processor to SEL-751 Unsolicited Write Remote Analog Example

From the perspective of the SEL-751, Remote Analogs (RA01 through RA32) are specific, pre-allocated memory addresses. These memory addresses are available to accept and store values from remote devices such as an SEL-2032, SEL-2030, or SEL-2020 Communications Processor. Once these values from the remote devices are written into the memory addresses in the SEL-751, you can use these values similar to any other analog quantity in the SEL-751. When using the SEL communications processor to send the Remote Analogs to the SEL-751, we use the Unsolicited Write setting string and send the information by using the SEL Fast Message protocol. This example shows how to configure the Unsolicited Write message in the SEL communications processor to move data stored in the USER region of Port 6 of the SEL communications processor to an SEL-751 connected to Port 3 of the SEL communications processor. We also show how to select the correct Remote Analog data type in the SEL-751 to match the information in the Fast Message.

Although the SEL communications processor caters to static and dynamic data, this example uses static data in the SEL communications processor (entering the Unsolicited Write setting string is the same for static and dynamic data; see the SEL communications processor manual for dynamic data storing techniques). Assume the data are already stored in the USER region of Port 6 in the SEL communications processor. The Unsolicited Write message must be set in the Automatic messages on the SEL communications processor port to which the SEL-751 is connected. Because the SEL-751 is connected to Port 3 of the SEL communications processor, we use the Unsolicited Write Automatic (MESG1) message setting of Port 3 to build the Fast Message string, as shown in *Figure C.5* (see the SEL communications processor manual for in-depth discussions regarding the SEL communications processor Automatic message settings).

Setting the SEL Communications Processor

```
*>>SET A 3 <Enter>

Automatic message settings for Port 3


Save Unsolicited Messages (Y/N)             AUTOBUF = Y     ? <Enter>

Port Startup String
STARTUP ="?"
 ? <Enter>

Enable Automatic Sequential Events Recorder Collection (Y/N)REC_SER = N    ? <Enter>

Block external connections to this port
NOCONN  = NA
 ? <Enter>


Auto-message Settings

How many auto-message sequences (0-12)      MSG_CNT = 0     ? 1 <Enter>

Item 1 trigger D1
ISSUE1  = NA
 ? R1 <Enter>

Item 1 message
MESG1   = ""
 ? \W;06:USER:0000h;20,03:USER:0000h/ <Enter>

Archive Settings

Enable use of archive data items (Y/N)      ARCH_EN = N     ? END <Enter>

AUTOBUF = Y
STARTUP ="?"
REC_SER = N
NOCONN  = NA

MSG_CNT = 1

ISSUE1  = R1
MESG1   = "\W;06:USER:0000h;20,03:USER:0000h/"

ARCH_EN = N

USER    = 0

Save changes (Y/N) ? Y <Enter>

Port 3 Settings Changed

*>>
```

Figure C.5 Unsolicited Write Settings

The Unsolicited Write message string **\W;06:USER:0000h;20,03:USER:0000h/** contains all the information necessary to send the remote analog data to the SEL-751. Following is a discussion on the elements of the Unsolicited Write message string.

- **\W;** indicates this is an Unsolicited Write Message
- **06:User:0000H** indicates where the data are stored in the SEL communications processor (06 is the User regions port number where the data are stored, the beginning of the User region starts at F800H on each port, 0000H indicates what register in the User region to start at).
- **;20** indicates how many 16-bit registers from the SEL communications processor User region to send.
- **,03:USER:** is an SEL communications processor Unsolicited Write message compatibility requirement. 03 is the SEL communications processor port the SEL-751 is connected and the second parameter should always be USER, or F800h.

➤ **0000h/** indicates the first SEL-751 Remote Analog to begin writing to (0000H = RA01 – 003EH = RA32)

➤ The \ and / frames the message.

See the SEL communications processor manual for more information regarding the Unsolicited Write message string.

Following are 16-bit register data that are stored in the User region of Port 6 and sent to the SEL-751 on Port 3. Remember that F800H is synonymous with the start of the USER region in the SEL communications processor. One register stores one Integer and two registers store one Float or Long data type.

```
*>>VIE 6:F800h NR 20 <Enter>

6:F800h

7FFFh 8001h FFFFh 0000h 447Ah 25C3h C47Ah 270Ah
4516h B029h 4516h AFD7h 0001h 7FFFh FFFEh 8001h
FFFFh 6A00h FFFFh 0000h

Starting at register 0000h, the first 4 registers contain 4 Integer data values
7FFFh 8001h FFFFh 0000h

Starting at register 0004h the next 8 registers contain 4 Float data values
447Ah 25C3h C47Ah 270Ah 4516h B029h 4516h AFD7h

Starting at register 000Ch the next 8 registers contain 4 Long data Values.
0001h 7FFFh FFFEh 8001h FFFFh 6A00h FFFFh 0000h

*>>
```

Setting the SEL-751

The SEL-751 interprets Remote Analogs as Integer, Float, or Long data types. For correct remote analog data transfer, the data type sent from the SEL communications processor must match the data type of each of the SEL-751 Remote Analogs. Use the RA*nn*TYPE settings (Report settings) to declare the Remote Analog type (I = Integer, F = Float, L = Long). Assume in our example we need only RA01 through RA12. In this example, we send 4 Integers, 4 Floats, and 4 Longs to the SEL-751. *Figure C.6* shows the correct settings for RA01 through RA13 accordingly, starting at RA01.

```
=>>SET R TERSE <Enter>

Report

SER Chatter Criteria

Auto-Removal EN (N,Y)                          ESERDEL := N         ? <Enter>

SER Trigger Lists
SERn = Up to 24 Device-Word elements separated by spaces or commas.
Use NA to disable setting.


SER Trigger List SER1 (24 Device Word bits)
SER1    := NA
? <Enter>
SER Trigger List SER2 (24 Device Word bits)
SER2    := NA
? <Enter>
SER Trigger List SER3 (24 Device Word bits)
SER3    := NA
? <Enter>
SER Trigger List SER4 (24 Device Word bits)
SER4    := NA
? <Enter>

Event Report Set

Event Trigger (SELogic)
ER      := NA
? <Enter>
Event Length (15,64 cyc)                       LER     := 15        ? <Enter>
Prefault Length (OFF,1-10 cyc)                 PRE     := 4         ? <Enter>

Fast Message Remote Analog Settings

Remote Analog Value Type (I,F,L)               RA01TYPE:= I         ? I <Enter>
Remote Analog Value Type (I,F,L)               RA02TYPE:= I         ? I <Enter>
Remote Analog Value Type (I,F,L)               RA03TYPE:= I         ? I <Enter>
Remote Analog Value Type (I,F,L)               RA04TYPE:= I         ? I <Enter>
Remote Analog Value Type (I,F,L)               RA05TYPE:= I         ? F <Enter>
Remote Analog Value Type (I,F,L)               RA06TYPE:= I         ? F <Enter>
Remote Analog Value Type (I,F,L)               RA07TYPE:= I         ? F <Enter>
Remote Analog Value Type (I,F,L)               RA08TYPE:= I         ? F <Enter>
Remote Analog Value Type (I,F,L)               RA09TYPE:= I         ? L <Enter>
Remote Analog Value Type (I,F,L)               RA10TYPE:= I         ? L <Enter>
Remote Analog Value Type (I,F,L)               RA11TYPE:= I         ? L <Enter>
Remote Analog Value Type (I,F,L)               RA12TYPE:= I         ? L <Enter>
Remote Analog Value Type (I,F,L)               RA13TYPE:= I         ? END <Enter>
Save changes (Y,N)? Y <Enter>
Settings Saved

=>>
```

Figure C.6 Setting Remote Analogs RA01 Through RA13

Now every time the ISSUE1 condition in the Automatic Messages on Port 3 is true, the SEL communications processor sends an Unsolicited Write message to the SEL-751 and populate Remote Analogs 1–12 with the corresponding stored data in the SEL communications processor User region on Port 6.

Execute a **MET RA** or **CME RA** in the SEL-751 to retrieve the Remote Analog data.

Appendix D
DNP3 Communications

Overview

The SEL-751 Feeder Protection Relay provides 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-751 on page D.6*
- *DNP3 Documentation on page D.14*

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 communications 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 communications 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 discussions and examples of specific features of DNP3.

Data Handling

Objects

DNP3 uses a system of data references called objects, defined by the Basic 4 standard object library. Each subset level specification requires a minimum implementation of object types and recommends several optional object types. DNP3 object types, commonly referred to as objects, are specifications for the type of data the object carries. An object can include a single value or more complex data. Some objects serve as shorthand references for special operations, including collections of data, time synchronization, or even all data within the DNP3 device.

If there can be more than one instance of a type of object, then each instance of the object includes an index that makes it unique. For example, each binary status point (Object 1) has an index. If there are 16 binary status points, these points are Object 1, Index 0 through Object 1, Index 15.

Each object also includes multiple versions called variations. For example, Object 1 (binary inputs) has three variations: 0, 1, and 2. You can use variation 0 to request all variations, variation 1 to specify binary input values only, and variation 2 to specify binary input values with status information.

Each DNP3 device has both a list of objects and a map of object indices. The list of objects defines the available objects, variations, and qualifier codes. The map defines the indices for objects that have multiple instances and defines what data or control points correspond with each index.

A master initiates all DNP3 message exchanges except unsolicited data. DNP3 terminology describes all points from the perspective of the master. Binary points for control that move from the master to the outstation are called Binary Outputs, while binary status points within the outstation are called Binary Inputs.

Function Codes

Each DNP3 message includes a function code. Each object has a limited set of function codes that a master can use to manipulate the object. The object listing for the device shows the permitted function codes for each type of object. The most common DNP3 function codes are listed in *Table D.2*.

Table D.2 Selected DNP3 Function Codes

Function Code	Function	Description
1	Read	Request data from the outstation
2	Write	Send data to the outstation
3	Select	First part of a Select Before Operate operation
4	Operate	Second part of a Select Before Operate operation
5	Direct operate	One-step operation with reply
6	Direct operate, no reply	One-step operation with no reply

Qualifier Codes and Ranges

DNP3 masters use qualifier codes and ranges to make requests for specific objects by index. Qualifier codes specify the style of range, and the range specifies the indices of the objects of interest. DNP3 masters use qualifier codes to compose the shortest, most concise message possible when requesting points from a DNP3 outstation.

For example, the qualifier code 01 specifies that the request for points include 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 use special objects, variations, and qualifiers that reduce the message size to send requests with the least number of bytes. 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 communications efficiency. With various trade-offs, each method is less demanding of communications bandwidth than the previous one. For example, unsolicited report-by-exception consumes less communications bandwidth than polled report-by-exception because that method does not require polling messages from the master. To properly evaluate which access method provides optimum performance for your application, you must also consider overall system size and the volume of data communication expected.

Table D.3 DNP3 Access Methods

Access Method	Description
Polled static	Master polls for present value (Class 0) data only
Polled report-by-exception	Master polls frequently for event data and occasionally for Class 0 data
Unsolicited report-by-exception	Outstation devices send unsolicited event data to the master, and the master occasionally polls for Class 0 data
Quiescent	Master never polls and relies on unsolicited reports only

Binary Control Operations

DNP3 masters use Object 12, control device output block, to perform DNP3 binary control operations. The control device output block has both a trip/close selection and a code selection. The trip/close selection allows a single DNP3 index to operate two related control points such as trip and close or raise and lower. Trip/close pair operation is not recommended for new DNP3 devices, but is often included for interoperability with older DNP3 master implementations.

The control device output block code selection specifies either a latch or pulse operation on the point. In many cases, DNP3 outstations have only a limited subset of the possible combinations of the code field. Sometimes, DNP3 outstations assign special operation characteristics to the latch and pulse selections. *Table D.13* describes control point operation for the SEL-751.

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 as a result of data collisions.

DNP3 LAN/WAN Overview

The main process for carrying DNP3 over an Ethernet Network (LAN/WAN) involves encapsulating the DNP3 data link layer data frames within the transport layer frames of the Internet Protocol (IP) suite. This allows the IP stack to deliver the DNP3 data link layer frames to the destination in place of the original DNP3 physical layer.

The DNP User Group Technical Committee has recommended the following guidelines for carrying DNP3 over a network:

NOTE: Link layer confirmations are explicitly disabled for DNP3 LAN/WAN. The IP suite provides a reliable delivery mechanism, which is backed up at the application layer by confirmations when necessary.

- DNP3 shall use the IP suite to transport messages over a LAN/WAN
- Ethernet is the recommended physical link, 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 you need broadcast messages
- The DNP3 protocol stack shall be retained in full
- Link layer confirmations shall be disabled

The Technical Committee has registered a standard port number, 20000, for DNP3 with the Internet Assigned Numbers Authority (IANA). Use this port 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-751

The SEL-751 is a DNP3 Level 2 remote (outstation) device without dual end point.

Data Access

Table D.5 lists DNP3 data access methods along with corresponding SEL-751 settings. You must select a data access method and configure each DNP3 master for polling as specified.

NOTE: Because unsolicited messaging is problematic in most circumstances, SEL recommends using the polled report-by-exception access method to maximize performance and minimize risk of configuration problems.

NOTE: In the settings in Table D.5, the suffix n represents the DNP3 session number from 1 to 5. All settings with the same numerical suffix comprise the complete DNP3 session configuration.

Table D.5 DNP3 Access Methods

Access Method	Master Polling	SEL-751 Settings
Polled static	Class 0	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to 0; UNSOL*n* to No
Polled report-by-exception	Class 0 occasionally, Class 1, 2, 3 frequently	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to the desired event class; UNSOL*n* to No
Unsolicited report-by-exception	Class 0 occasionally, optional Class 1, 2, 3 less frequently; mainly relies on unsolicited messages	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to the desired event class; set UNSOL*n* to Yes and PUNSOL*n* to Yes or No
Quiescent	Class 0, 1, 2, 3 never; relies completely on unsolicited messages	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to the desired event class; set UNSOL*n* and PUNSOL*n* to Yes.

The SEL-751 is an outstation device without dual end point. For a TCP connection, the relay sends out unsolicited messages only if a DNP3 master has already established a session and enabled unsoliticed messaging for that session. However, for a serial/modem/UDP connection, the relay automatically dials out and sends unsolicited messages as defined by the settings.

In both the unsolicited report-by-exception and quiescent polling methods shown in *Table D.5*, you must make a selection for the PUNSOL*n* setting. This setting enables or disables unsolicited data reporting at power up. If your DNP3 master can send a message to enable unsolicited reporting on the SEL-751, 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 acknowledgment messages.

The SEL-751 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.14*). 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-751 does not receive an Application Confirm in response to unsolicited data, it waits for ETIMEO*n* seconds and then repeats the unsolicited message. To prevent clogging of the network with unsolicited data retries, the SEL-751 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-751 pauses UTIMEO*n* seconds and then transmits the unsolicited data again. *Figure D.1* provides an example with URETRY*n* = 2.

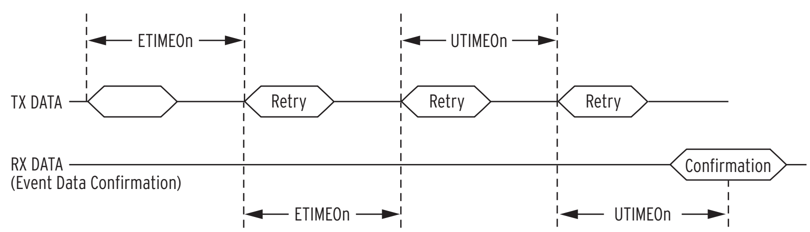


Figure D.1 Application Confirmation Timing With URETRY n = 2

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-751 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-751 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-751 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*).

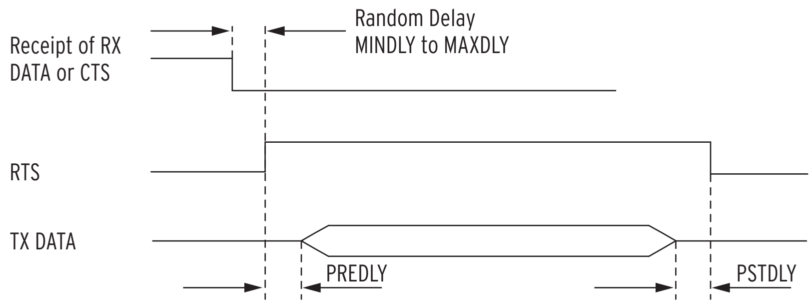


Figure D.2 Message Transmission Timing

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 the data transmission beginning at the same time as the RTS signal assertion.

Event Data

DNP3 event data objects contain change-of-state and time-stamp information that the SEL-751 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-751 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-751 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-751.

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* for a discussion of how to set scaling and dead-band operation on a point-by-point basis. You can modify dead bands for analog inputs 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 by 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 A 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 A) for the device to report a new event value.

The SEL-751 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-751 has the buffer capacities listed in *Table D.6*.

Table D.6 SEL-751 Event Buffer Capacity

Type	Maximum Number of Events
Binary	1024
Analog	100
Counters	32

Binary Controls

The SEL-751 provides more than one way to control individual points. The SEL-751 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-751.

A DNP3 technical bulletin (*Control Relay Output Block Minimum Implementation 9701-002*) recommends that you use one point per Object 12, control block output device. You can use this method to perform Pulse On, Pulse Off, Latch On, and Latch Off operations on selected remote bits.

If your master does not support the single-point-per-index messages or single operation database points, you can use the trip/close operation or use the code field in the DNP3 message to specify operation of the points shown in *Control Point Operation on page D.23*.

Time Synchronization

The accuracy of DNP3 time synchronization is insufficient for most protection and oscillography needs. DNP3 time synchronization provides backup time synchronization in the event the device loses primary synchronization through the IRIG-B input. You can enable time synchronization with the TIMERQ*n* setting and then use Object 50, Variation 1, and Object 52, Variation 2, to set the time via the Session *n* DNP3 master (Object 50, variation 3 for DNP3 LAN/WAN).

By default, the SEL-751 accepts and ignores time set requests (TIMERQ*n* = I for "ignore"). (This mode allows the SEL-751 to use a high accuracy, IRIG time source, but still interoperate with DNP3 masters that send time-synchronization messages.) You can set the SEL-751 to request time synchronization periodically by setting the TIMERQ*n* setting to the desired period. You can also set it to not request, but accept, time synchronization (TIMERQ*n* = M for "master").

Modem Support

The SEL-751 DNP implementation includes modem support for serial ports. Your DNP3 master can dial-in to the SEL-751 and establish a DNP3 connection. The SEL-751 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-751 to other devices.

You can either connect the modem to a computer and configure it before connecting it to the SEL-751, 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-751 to call. The SEL-751 automatically sends the ATDT modem dial command and then the contents of the PH_NUM1 setting when dialing the modem. If PH_NUM2 is set, use the RETRY1 setting to configure the number of times the SEL-751 tries to dial PH_NUM1 before dialing PH_NUM2. Similarly, the RETRY2 setting is the number of attempts the SEL-751 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-751 are shown in *Table D.7*. You can enable DNP3 on Ethernet Port 1 or on any of the serial ports 2 through 4, for a maximum of five 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	0–5	0
DNPNUM[a]	DNP3 TCP and UDP Port	1–65534	20000
DNPADR	Device DNP3 address	0–65519	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 synch requests, but still accepts and applies time synchs from Master; I = Ignores (does not apply) time synchs 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	0
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 when energized; 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

Table D.7 Port DNP3 Protocol Settings (Sheet 2 of 2)

Name	Description	Range	Default
Session 3 Settings			
DNPIP3[a]	IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR3[a]	Transport protocol	UDP, TCP	TCP
. . .			
URETRY3[a,c]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO3[a,c]	Unsolicited messages offline timeout, seconds	1–5000	60
Session 4 Settings			
DNPIP4[a]	IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR4[a]	Transport protocol	UDP, TCP	TCP
. . .			
URETRY4[a,c]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO4[a,c]	Unsolicited messages offline timeout, seconds	1–5000	60
Session 5 Settings			
DNPIP5[a]	IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR5[a]	Transport protocol	UDP, TCP	TCP
. . .			
URETRY5[a,c]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO5[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. Set DNPIPn = 0.0.0.0 to accept connections from any DNP master.
[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 (Sheet 1 of 2)

Name	Description	Range	Default
MODEM	Modem connected to port; all the following settings are hidden if MODEM set to N	Y, N	N
MSTR	Modem startup string	As many as 30 characters	“E0X0&D0S0 = 4”
PH_NUM1	Primary phone number for dial-out	As many as 30 characters	“”
PH_NUM2	Secondary phone number for dial-out	As many as 30 characters	“”

Table D.8 Serial Port DNP3 Modem Settings (Sheet 2 of 2)

Name	Description	Range	Default
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 resulting from 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-751. The list of supported objects conforms to the format laid out in the DNP specifications and includes both supported and unsupported objects for DNP3 implementation Level 2 and higher and unsupported objects for DNP3 implementation Level 2 only. Those that are supported include the function and qualifier codes. The objects that are not supported are shown without any corresponding function and qualifier codes.

Table D.9 SEL-751 DNP Object List (Sheet 1 of 6)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
0	211	Device Attributes—User-specific sets of attributes	1	0	129	0,17
0	212	Device Attributes—Master data set prototypes	1	0	129	0,17
0	213	Device Attributes—Outstation data set prototypes	1	0	129	0,17
0	214	Device Attributes—Master data sets	1	0	129	0,17
0	215	Device Attributes—Outstation data sets	1	0	129	0,17
0	216	Device Attributes—Max binary outputs per request	1	0	129	0,17
0	219	Device Attributes—Support for analog output events	1	0	129	0,17
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

Table D.9 SEL-751 DNP Object List (Sheet 2 of 6)

Obj.	Var.	Description	Request[a] Funct. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Funct. Codes[c]	Response[b] Qual. Codes[d]
0	243	Device Attributes—Device manufacturer’s hardware version	1	0	129	0,17
0	245	Device Attributes—User-assigned location name	1	0	129	0,17
0	246	Device Attributes—User assigned ID code/number	1	0	129	0,17
0	247	Device Attributes—User assigned ID code/number	1	0	129	0,17
0	248	Device Attributes—Device serial number	1	0	129	0,17
0	249	Device Attributes—DNP subset and conformance	1	0	129	0,17
0	250	Device Attributes—Device manufacturer’s product name and model	1	0	129	0,17
0	252	Device Attributes—Device manufacturer's name	1	0	129	0,17
0	254	Device Attributes—Non-specific all attributes request	1	0	129	0,17
0	255	Device Attributes—List of attribute variations	1	0	129	0,17
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-751 DNP Object List (Sheet 3 of 6)

Obj.	Var.	Description	Request[a] Funct. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Funct. Codes[c]	Response[b] Qual. Codes[d]
21	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				
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				

Table D.9 SEL-751 DNP Object List (Sheet 4 of 6)

Obj.	Var.	Description	Request[a] Funct. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Funct. Codes[c]	Response[b] Qual. Codes[d]
31	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 Deadband—All Variations				
34	1[e]	16-Bit Analog Input Reporting Deadband Object	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
34	2	32-Bit Analog Input Reporting Deadband Object	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
34	3	Floating Point Analog Input Reporting Deadband Object	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
40	0	Analog Output Status—All Variations	1	0, 1, 6, 7, 8	129	
40	1	32-Bit Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
40	2[e]	16-Bit Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
40	3	Short Floating Point Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
40	4	Long Floating Point Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
41	0	Analog Output Block—All Variations				
41	1	32-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
41	2[e]	16-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
41	3	Short Floating Point Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
50	0	Time and Date—All Variations				
50	1	Time and Date	1, 2	7, 8 index = 0	129	07, quantity = 1

Table D.9 SEL-751 DNP Object List (Sheet 5 of 6)

Obj.	Var.	Description	Request[a] Funct. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Funct. Codes[c]	Response[b] Qual. Codes[d]
50	2	Time and Date With Interval				
50	3	Time and Date Last Recorded	2	7 quantity = 1	129	
51	0	Time and Date CTO—All Variations				
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	7, quantity = 1
60	0	All Classes of Data	1, 20, 21	6, 7, 8		
60	1	Class 0 Data	1, 20, 21	6, 7, 8		
60	2	Class 1 Data	1	6, 7, 8		
60	3	Class 2 Data	1, 20, 21	6, 7, 8		
60	4	Class 3 Data	1, 20, 21	6, 7, 8		
70	1	File Identifier				
70	2	Authentication Object				
70	3	File Command Object				
70	4	File Command Status Object				
70	5	File Transport Object				
70	6	File Transport Status Object				
70	7	File Descriptor Object				
80	1	Internal Indications	2	0, 1 index = 7		
81	1	Storage Object				
82	1	Device Profile				
83	1	Private Registration Object				
83	2	Private Registration Object Descriptor				
90	1	Application Identifier				
100	1	Short Floating Point				
100	2	Long Floating Point				
100	3	Extended Floating Point				
101	1	Small Packed Binary-Coded Decimal				
101	2	Medium Packed Binary-Coded Decimal				
101	3	Large Packed Binary-Coded Decimal				
110	All	Octet String				
111	All	Octet String Event				
112	All	Virtual Terminal Output Block				

Table D.9 SEL-751 DNP Object List (Sheet 6 of 6)

Obj.	Var.	Description	Request[a] Funct. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Funct. Codes[c]	Response[b] Qual. Codes[d]
113	All	Virtual Terminal Event Data				
N/A		No object required for the following function codes: 13 cold start 14 warm start 23 delay measurement	13, 14, 23			

[a] Supported in requests from master.
[b] May generate in response to master.
[c] Decimal.
[d] Hexadecimal.
[e] Default variation.
[f] Default variation specified by serial port setting DVARAI (or DVARAIn for Ethernet session n [n = 1, 2, 3, 4, or 5]).

Device Profile

The DNP3 Device Profile document, available on the supplied CD or as a download from the SEL website, contains the standard device profile information for the SEL-751.This information is also available in XML format. Please refer to this document for complete information on DNP3 Protocol support in the SEL-751.

Reference Data Map

Table D.10 shows the SEL-751 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-751 to retrieve only the points necessary for your application.

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).

The SEL-751 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: Although the reference maps do not include Relay Word bit labels, you can use these labels for creating custom maps.

Table D.10 DNP3 Reference Data Map (Sheet 1 of 2)

Object	Labels	Description
Binary Inputs		
01, 02	STFAIL	Relay diagnostic failure
	STWARN	Relay diagnostic warning
	STSET.	Relay settings change or restart
	Enabled–TLED_06[a]	Relay Word Elements Target Row 0 (see *Table K.1*)
	50A1P–59I4RS[a]	Relay Word Elements Row 1 to Row 158 (see *Table K.1*)
	PFL	Power Factor Leading for Three-Phase Currents
	0	Logical 0
	1	Logical 1
Binary Outputs		
10,12	RB01–RB32	Remote bits RB01–RB32
10,12	RB01:RB02 RB03:RB04 RB05:RB06 … RB29:RB30 RB31:RB32	Remote bit pairs RB01–RB32

Table D.10 DNP3 Reference Data Map (Sheet 2 of 2)

Object	Labels	Description
10,12	OC	Pulse Open Circuit Breaker command
10,12	CC	Pulse Close Circuit Breaker command
10,12	OC:CC	Open/Close pair for Circuit Breaker
Counters		
20, 22	SC*xx*	SELOGIC Counter Values (*xx* = 01–32)
	GROUP	Active Settings Group
Analog Inputs		
30, 32, 34	IA_MAG–RA128[b,c]	Analog Quantities from *Table L.1* with an “x” in the DNP column
	SER_NUM	Serial Number
	0	Numeric 0
	1	Numeric 1
Analog Outputs		
40, 41	RAxxx	Remote Analogs (RA001 to RA128)
	GROUP	Active Settings Group
	NOOP	No operation, no error

[a] Valid Relay Word bits depend on the relay model.
[b] Valid analog inputs depend on the relay model.
[c] Refer to Default Analog Inputs for default analog input scaling and dead bands.

NOTE: When setting EN_LRC := Y (see Table 9.4), the Relay Word bit LOCAL supervises the CC and OC bits. If the LOCAL bit is asserted (LOCAL = 1), the relay does not set the CC or OC bits. The Relay Word bit LOCAL is determined by the LOCAL SELOGIC control equation (see Table 9.4).

NOTE: All fault information analog inputs contain data from the latest captured event (See Appendix L: Analog Quantities).

Default Data Map

The default data map is an automatically generated subset of the reference map. All data maps are initialized to the default values, based on the SEL-751 part number. *Table D.11* shows the SEL-751 default data map. If the default maps are not appropriate, you can also use the custom DNP mapping commands **SET DNP** and **SHOW DNP** to create the map necessary for your application.

Table D.11 DNP3 Default Data Map (Sheet 1 of 2)

Object	Default Index	Point Label
01, 02	0	ENABLED
	1	TRIP_LED
	2	TLED_01
	3	TLED_02
	4	TLED_03
	5	TLED_04
	6	TLED_05
	7	TLED_06
	8	STFAIL
	9	STSET
	10	IN101
	11	IN102
	12–99	A portion of these binary inputs can have default values as described in *Default Binary Inputs on page D.21*. Outside that scope, they contain the value NA.
10, 12	0–31	RB01–RB32 Remote Bits

Table D.11 DNP3 Default Data Map (Sheet 2 of 2)

Object	Default Index	Point Label
20, 22	0–31	NA
30, 32, 34	0	IA_MAG
	1	IB_MAG
	2	IC_MAG
	3	IG_MAG
	4	IN_MAG
	5	IAV
	6	3I2
	7	FREQ
	8	VAB_MAG
	9	VBC_MAG
	10	VCA_MAG
	11	VAVE
	12	3V2
	13	P
	14	Q
	15	S
	16	PF
	17–99	A portion of these analog inputs can have default values as described in *Default Analog Inputs on page D.21*. Outside that scope, they contain the value NA.
40, 41	0–31	NA

Default Binary Inputs

The SEL-751 dynamically creates the default Binary Input map after you issue an **R_S** command. The SEL-751 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-751 dynamically creates the default Analog Input map after you issue an **R_S** command. The SEL-751 then uses the Part Number to determine the presence of Analog Input cards in slots 3, 4, and 5. If these cards are present, the SEL-751 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.10 includes the supported Object 0 Device Attributes and variations. In response to Object 0 requests, the SEL-751 sends attributes that apply to that particular DNP3 session. Because the SEL-751 supports custom DNP3 maps, these values are likely be different for each session. The SEL-751 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-751” and variation 252 shall contain “SEL”.

Binary Inputs

Binary Inputs (objects 1 & 2) are supported as defined by *Table D.11*. The default variation for both static and event inputs is 2. Only the Read function code (1) is allowed with these objects. All variations are supported. Object 2, variation 3 are responded to, but 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 can be significantly delayed from the time when the original source change occurred 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 RB01–RB32, OC/CC 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-751 supports Control Relay Output Block objects (Object 12,Variation 1). The control relays correspond to the remote bits and other functions as shown previously. Each DNP Control message contains a Trip/Close code (TRIP, CLOSE, or NUL) and an Operation type (PULSE ON, LATCH ON, LATCH OFF, or NUL). The Trip/Close code works with the Operation Type to produce set, clear, and pulse operations.

Control operations differ slightly for single-point controls compared to paired outputs. Paired outputs correspond to the complementary two-output model, and single-point controls follow the complementary latch or activation model. In the complementary two-output model, paired points only support Trip or Close operations, which, when issued, Pulse On the first or second point in the pair, respectively. Latch commands and Pulse operations without a Trip code are not supported. You can cancel an operation in progress 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.

Use of the Status field is exactly as defined. All other fields are ignored. A pulse operation is asserted for a single processing interval. You should exercise caution if sending multiple remote bit pulses in a single message (i.e., point count > 1), because this can result in some of the pulse commands being ignored and the return of an already active status message. The SEL-751 only honors the first ten points in an Object 12, Variation 1 request. Any additional points in the request return the DNP3 status code TOO_MANY_OBJS.

The SEL-751 also supports Pattern Control Blocks (Object 12, Variations 2 and 3) to control multiple binary output points. Variation 2 defines the control type (Trip/Close, Set/Clear, or Pulse) and the range of points to operate. Variation 3 provides a pattern mask that indicates which points in that range should be operated. Object 12, Variations 2 and 3 define the entire control command: the DNP3 master must send both for a successful control. For example, the DNP3 master sends an Object 12, Variation 2 message to request a Trip of the range of indices 0–7. The DNP3 master then sends an Object 12, Variation 3 message with a hexadecimal value of “BB” as the pattern mask (converted to binary notation: 10111011). Read right to left in increasing bit order, the Pattern Block Control command results in a TRIP of indexes 0, 1, 3 to 5, and 7. Multiple binary output point control operations are not guaranteed to occur during the same processing interval.

Control Point Operation

Use the Trip and Close, Latch On/Off and Pulse On operations with Object 12 control relay output block command messages to operate the points shown in *Table D.13*. Pulse operations provide a pulse with duration of one protection processing interval. When setting EN_LRC := Y (see *Table 9.4*), the Relay Word bit LOCAL supervises the CC and OC bits. If the LOCAL bit is asserted (LOCAL = 1), the relay does not set the CC or OC bits. The Relay Word bit LOCAL is determined by the LOCAL SELOGIC control equation (see *Table 9.4*).

Table D.12 SEL-751 Object 12 Control Operations

Label	Close/Pulse On	Trip/Pulse On	Nul/Latch On	Nul/Latch Off	Nul/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
RBxx:RByy	Pulse RByy RB01–RB32	Pulse RBxx RB01–RB32	Pulse RByy RB01–RB32	Pulse RBxx RB01–RB32	Not Supported
OC	Open Circuit Breaker (Pulse OC)	Open Circuit Breaker (Pulse OC)	Open Circuit Breaker (Pulse OC)	No action	Open Circuit Breaker (Pulse OC)
CC	Close Circuit Breaker (Pulse CC)	Close Circuit Breaker (Pulse CC)	Close Circuit Breaker (Pulse CC)	No action	Close Circuit Breaker (Pulse CC)
OC:CC	Close Circuit Breaker (Pulse CC)	Open Circuit Breaker (Pulse OC)	Close Circuit Breaker (Pulse CC)	Open Circuit Breaker (Pulse OC)	Not Supported

Analog Inputs

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).

Analog Inputs (30) and Analog Change Events (32) are supported as defined in *Table D.11*. The DVARAI1 (DVARAI*n* for DNP3 LAN/WAN session *n*) setting defines the default variation for both static and event inputs. Only the Read function code (1) is allowed with these objects. Unless otherwise indicated, analog values are reported in primary units. See *Appendix L: Analog Quantities* for a list of all available analog inputs.

For all currents, the default scaling is the DECPLA setting on magnitudes and scale factor of 100 on angles. The default 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 can be overridden by per-point scaling and dead band. See *Configurable Data Mapping* 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. All events generated during a scan use the time the scan was initiated.

Configurable Data Mapping

One of the most powerful features of the SEL-751 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-751 uses object and point labels, rather than point indices, to streamline the remapping process. This enables you to quickly create a custom map without having to search for each point index in a large reference map.

You can use any of the three available DNP3 maps simultaneously with as many as three unique DNP3 masters. Each map is initially populated with default data points, as described in *Default Data Map on page D.20*. You can remap the points in a default map to create a custom map with as many as the following:

- 100 Binary Inputs (Select from supported Relay Word bits in *Appendix K: Relay Word Bits*)
- 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_LED
BI_02    := TLED_01
BI_03    := TLED_02
…
BI_97    := IN101
BI_98    := IN102
BI_99    := 50P1P

Binary Output Map
BO_00    := RB01
BO_01    := RB02
BO_02    := RB03
…
BO_29    := RB30
BO_30    := RB31
BO_31    := RB32
```

Figure D.3 Sample Response to SHO DNP Command

```
Analog Input Map
AI_00    := IA_MAG
AI_01    := IB_MAG
AI_02    := IC_MAG
…
AI_95    := FREQ
AI_96    := P
AI_97    := Q
AI_98    := S
AI_99    := PF

Analog Output Map
AO_00    := GROUP
AO_01    := RA001
AO_02    := NA
…
AO_29    := NA
AO_30    := RA120
AO_31    := RA128

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 (Continued)

You can also use the **MAP DNP *y s* <Enter>** command to display DNP3 maps, but the parameter y is the port number from 1 to 4. Because Port 1, the Ethernet port, can support multiple DNP3 sessions, it may have a different map assigned to each session selected by parameter *s* for sessions 1 to 5. See *Figure D.4* for an example of a **MAP** command that shows the same map as in *Figure D.3*.

```
=>MAP DNP 11 <Enter>

SEL-751                                    Date: 12/14/2010   Time: 09:33:39
FEEDER RELAY                                Time Source: Internal

Map                          1
Transport                    TCP
Device IP Address            10.201.5.3
Master IP Address            10.200.0.139
Device DNP TCP and UDP Port  20000
Device DNP Address           15
Master DNP Address           0

Binary Inputs
--------------------------------------------------------------------------------
  INDEX  POINT LABEL  EVENT CLASS  SER TIMESTAMP
  0      ENABLED      1            No
  1      TRIP_LED     1            No
  2      TLED_01      1            No
  3      TLED_02      1            No
…
   97    IN101        1            No
   98    IN102        1            No
   99    50P1P        1            No

Binary Outputs
--------------------------------------------------------------------------------
  INDEX  POINT LABEL
  0      RB01
  1      RB02
  2      RB03
…
  29     RB30
  30     RB31
  31     RB32
```

Figure D.4 Port MAP Command

```
Counters
-------------------------------------------------------------------------------
  INDEX  POINT LABEL  EVENT CLASS  DEADBAND
  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
  0      IA_MAG       2                 10.0000  1000
  1      IB_MAG       2                 10.0000  1000
  2      IC_MAG       2                 10.0000  1000
  3      IG_MAG       2                 10.0000  1000
  4      IN_MAG       2                 10.0000  1000
  5      IAV          2                 10.0000  1000
  6      3I2          2                 10.0000  1000

  7      FREQ         2                 1.0000     100
  8      VAB_MAG      2                 10.0000  2000
  9      VBC_MAG      2                 10.0000  2000
  10     VCA_MAG      2                 10.0000  2000
  11     VAVE         2                 10.0000  2000
  12     3V2          2                 10.0000  2000
…
…
  96     P            2                 10.0000  100
  97     Q            2                 10.0000  100
  98     S            2                 10.0000  100
  99     PF           2                 10.0000  100

Analog Outputs
-------------------------------------------------------------------------------
INDEX  POINT LABEL
  0      GROUP
  1      RA001
```

Figure D.4 Port MAP Command (Continued)

You can use the command **SET DNP *x***, where *x* is the map number, to edit or create custom DNP3 data maps. You can also use the ACSELERATOR QuickSet SEL-5030 Software, which is recommended for this purpose.

Scaling factors allow you to overcome the limitations imposed by the integer nature of the default variations of Objects 30 and 32. For example, the device rounds a value of 11.4 A to 11 A. You can use scaling to include decimal point values by multiplying by a number larger than one. If you use 10 as a scaling factor, 11.4 A is 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 by 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 by using standard DNP3 Objects 30 and 32.

You can customize the DNP3 analog input map with per-point scaling, and dead-band settings. Per-point customization is not necessary, but class scaling (DECPLA, DECPLV, and DECPLM) and dead-band (ANADBA, ANADBV, and ANADBM) settings are applied to indices that do not have per-point entries. Unlike per-point scaling described previously, class-level scaling is specified by an integer in the range 0–3 (inclusive), which indicates the number of decimal place shifts. In other words, you should select 0 to multiply by 1, 1 for 10, 2 for 100, or 3 for 1000.

If it is important to maintain tight data coherency (that is, all data read of a certain type 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 currents to be coherent, you should group points IA_MAG, IB_MAG, IC_MAG, IN_MAG, and IG_MAG together in the custom map. If points are not grouped together, they might not come from the same data sample.

The following example describes how to create a custom DNP3 map by point type. The example demonstrates the SEL ASCII command **SET DNP** for each point type, but you can complete the entire configuration without saving changes between point types. To do this, you simply continue entering data and save the entire map at the end. Alternatively, you can use ACSELERATOR QuickSet to simplify custom data map creation.

Consider a case where you want to set the AI points in a map as shown in *Table D.13*.

Table D.13 Sample Custom DNP3 AI Map

Desired Point Index	Description	Label	Scaling	Deadband
0	IA magnitude	IA_MAG	default	default
1	IB magnitude	IB_MAG	default	default
2	IC magnitude	IC_MAG	default	default
3	IN magnitude	IN_MAG	default	default
4	Three-Phase Real Power	P	5	default
5	AB Phase-to-Phase Voltage Magnitude	VAB_MAG	default	default
6	AB Phase-to-Phase Voltage Angle	VAB_ANG	1	15
7	Frequency	FREQ	.01	1

To set these points as part of custom map 1, you can use the command **SET DNP 1 AI_00 TERSE <Enter>** command as shown in *Figure D.5*.

```
=>>SET DNP 1 AI_00 TERSE <Enter>
Analog Input Map

DNP Analog Input Label Name (24 characters)
AI_00   := NA
? > IA_MAG <Enter>

AI_01   := NA
? > IB_MAG <Enter>

AI_02   := NA
? > IC_MAG <Enter>

AI_03   := NA
? > IN_MAG <Enter>

AI_04   := NA
? > P:5 <Enter>

AI_05   := NA
? > VAB_MAG <Enter>

AI_06   := NA
? > VAB_ANG:1:15 <Enter>
```

Figure D.5 Sample Custom DNP3 AI Map Settings

```
AI_07    := NA
? > FREQ:.01:1 <Enter>

AI_08    := NA
? > end <Enter>

Save changes (Y/N) ? Y <Enter>

=>>
```

Figure D.5 Sample Custom DNP3 AI Map Settings (Continued)

You can also use ACSELERATOR QuickSet to enter the previous AI map settings as shown in the screen capture in *Figure D.6*. You can enter scaling and dead-band settings in the same pop-up dialog used to select the AI point, as shown in *Figure D.7*.

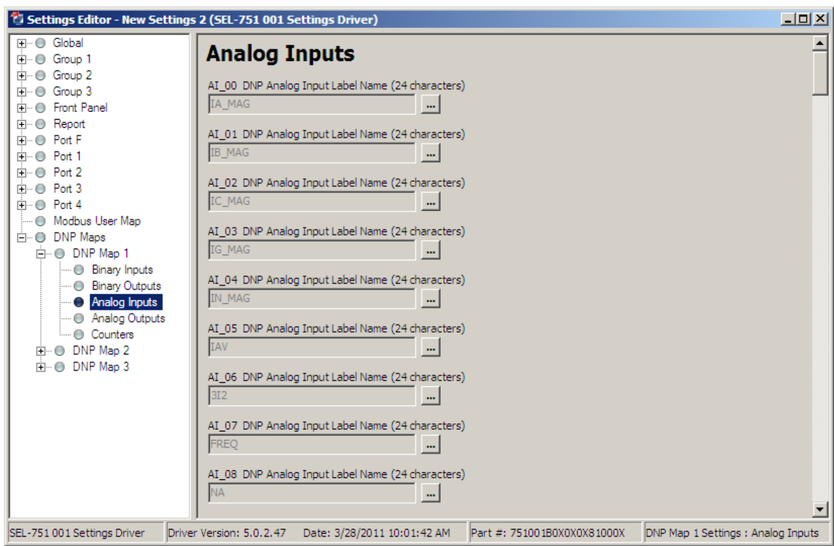


Figure D.6 Analog Input Map Entry in ACSELERATOR QuickSet Software

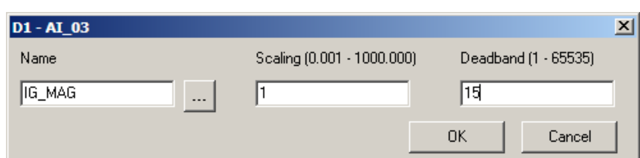


Figure D.7 AI Point Label, Scaling and Deadband in ACSELERATOR QuickSet Software

The **SET DNP x AO_00<Enter>** command allows you to populate the DNP analog output map with any of the 128 Remote Analogs (RA001–RA128) or the GROUP variable (present settings group) as shown in *Figure D.8*.

```
=>>SET DNP 1 AO_00 TERSE <Enter>

DNP Map 1 Settings

Analog Output Map

DNP Analog Output Label Name (6 characters)    AO_00   := NA        ? group
DNP Analog Output Label Name (6 characters)    AO_01   := NA        ? ra001
DNP Analog Output Label Name (6 characters)    AO_02   := NA        ? ra002
DNP Analog Output Label Name (6 characters)    AO_03   := NA        ? ra120
DNP Analog Output Label Name (6 characters)    AO_04   := NA        ? ra128
DNP Analog Output Label Name (6 characters)    AO_05   := NA        ?
DNP Analog Output Label Name (6 characters)    AO_06   := NA        ? end
Save changes (Y,N)? y
Settings Saved

=>>
```

Figure D.8 Sample Custom DNP3 AO Map Settings

You can also use ACSELERATOR QuickSet to enter the AO map settings as shown in the screen capture in *Figure D.9*.

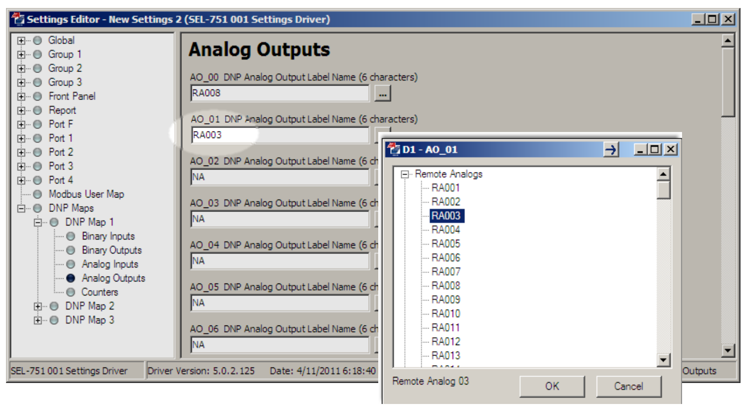


Figure D.9 Analog Output Map Entry in ACSELERATOR QuickSet Software

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.10*. You can populate the custom BO map with any of the 32 remote bits (RB01–RB32). You can define bit pairs in BO maps by including a colon (:) between the bit labels.

```
=>>SET DNP 1 BO_00 TERSE <Enter>
Binary Output Map

DNP Binary Output Label Name (23 characters)
BO_00   := NA
? > RB01 <Enter>

DNP Binary Output Label Name (23 characters)
BO_01   := NA
? > RB02 <Enter>

DNP Binary Output Label Name (23 characters)
BO_02   := NA
? > RB03:RB04 <Enter>

DNP Binary Output Label Name (23 characters)
BO_03   := NA
? > RB05:RB06 <Enter>

DNP Binary Output Label Name (23 characters)
BO_04   := NA
? > end <Enter>

=>>
```

Figure D.10 Sample Custom DNP3 BO Map Settings

You can also use ACSELERATOR QuickSet to enter the BO map settings as shown in the screen capture in *Figure D.11*.

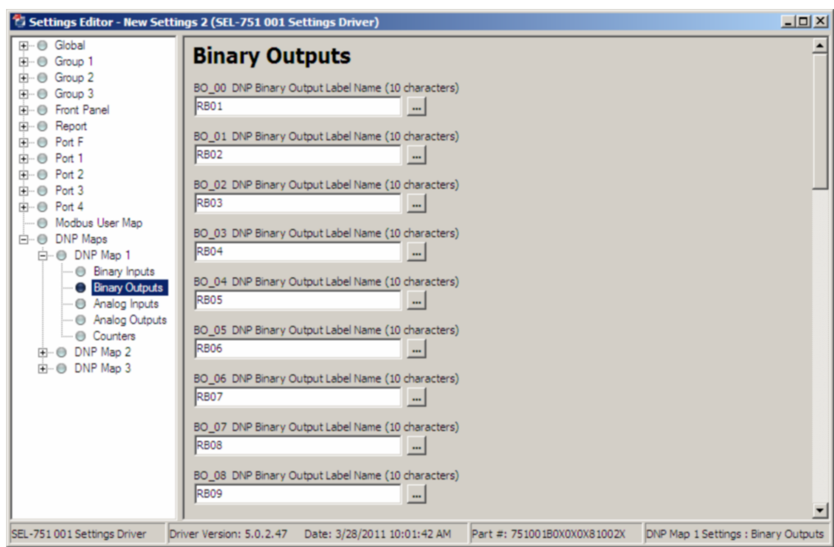


Figure D.11 Binary Output Map Entry in ACSELERATOR QuickSet Software

The binary input (BI) maps are modified in a similar manner, but pairs are not allowed.

Appendix E
Modbus RTU Communications

Overview

This appendix describes Modbus RTU communications features supported by the SEL-751 Feeder Protection 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-751 supports as many as two Modbus TCP sessions. The TCP port number for each session is selected with the Ethernet port settings. The default TCP port number is the Modbus TCP registered port 502. Modbus TCP uses the device IP address as the Modbus identifier and accesses the data in the relay 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 slave device you want. All of the slave devices receive the message, but only the slave device with the matching address responds.

The SEL-751 Modbus communication allows a Modbus master device to do the following:

- Acquire metering, monitoring, and event data from the relay.
- Control SEL-751 output contacts.
- Read the SEL-751 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-751 SLAVEID setting defines the device address. Set this value to a unique number for each device on the Modbus network. For Modbus communication to operate properly, no two slave devices can have the same address.

The cyclical redundancy check detects errors in the received data. If it detects an error, 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-751 supports the Modbus function codes shown in *Table E.2*.

Table E.2 SEL-751 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-751 sends an exception code under the conditions described in *Table E.3*.

Table E.3 SEL-751 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 (i.e., cannot write to a read-only register, cannot write because settings are locked, etc.).
3	Illegal Data Value	The received command contains a value that is out of range.
4	Device Error	The SEL-751 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 (i.e., cannot write to a read-only register, cannot write because settings are locked, etc.).
6	Busy	The device is unable to process the command at this time, because of a busy resource.

In the event that any of the errors listed in *Table E.3* occur, the relay assembles a response message that includes the exception code in the data field. The relay sets the most significant bit in the function code field to indicate to the master that the data field contains an error code, instead of the necessary data.

Cyclical Redundancy Check

The SEL-751 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-751, 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-751 coil addresses start at 0 (e.g., 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

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
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-751 calculates the number of bytes necessary to contain the number of bits requested. If the number of bits requested is not evenly divisible by eight, the device adds one more byte to maintain the balance of bits, padded by zeros to make an even byte. *Table E.14* includes the coil number and lists all possible coils (identified as Outputs and Remote bits) available in the device. Note that the command depends on the device hardware configuration; the device responds only to installed cards.

The relay responses to errors in the query are shown in *Table E.5*.

Table E.5 Responses to 01h Read Discrete Output Coil Query Errors

Error	Error Code Returned	Communications Counter Increments
Invalid bit to read	Illegal Data Address (02h)	Invalid Address
Invalid number of bits to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

02 Read Input Status Command

Use function code 02h to read the On/Off status of the selected bits (inputs), as shown in *Table E.6*. You can read the status of as many as 2000 bits per query. Note that input addresses start at 0 (e.g., 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 (Sheet 1 of 2)

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

Table E.6 02h Read Input Status Command (Sheet 2 of 2)

Bytes	Field
2 bytes	Number of bits to read
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (02h)
1 byte	Bytes of data (*n*)
n bytes	Data
2 bytes	CRC-16

To build the response, the device calculates the number of bytes necessary to contain the number of bits requested. If the number of bits requested is not evenly divisible by eight, the device adds one more byte to maintain the balance of bits, padded by zeroed to make an even byte.

In each row, the input numbers are assigned from the right-most input to the left-most input (i.e., Input 1 is TLED_06 and Input 8 is ENABLED). Input addresses start at 0000 (i.e., 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-751 Inputs

Coil Address (Decimal)	Function Code Supported	Coil Description[a]
0–7	2	Relay Element Status Row 0
8–15	2	Relay Element Status Row 1
16–23	2	Relay Element Status Row 2
• • •	• • •	• • •
1312–1319	2	Relay Element Status Row 164
1320–1327	2	Relay Element Status Row 165
1328–1335	2	Relay Element Status Row 166

[a] The input numbers are assigned from the right-most input to the left-most input in the Relay row as show in the following example.
Address 7 = ENABLED
Address 6 = TRIP
Address 5 = T01_LED
Address 4 = T02_LED
Address 3 = T03_LED
Address 2 = T04_LED
Address 1 = T05_LED
Address 0 = T06_LED

The relay responses to errors in the query are shown in *Table E.8*.

Table E.8 Responses to 02h Read Input Query Errors

Error	Error Code Returned	Communications Counter Increments
Invalid bit to read	Illegal Data Address (02h)	Invalid Address
Invalid number of bits to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

03h Read Holding Register Command

Use function code 03h to read directly from the Modbus Register Map shown in *Table E.34*. You can read a maximum of 125 registers at once with this function code. Most masters use 4X references with this function code. If you are accustomed to 4X references with this function code, for five-digit addressing, add 40001 to the standard database address.

Table E.9 03h Read Holding Register Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (03h)
2 bytes	Starting Register Address
2 bytes	Number of Registers to Read
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (03h)
1 byte	Bytes of data (*n*)
n bytes	Data (2–250)
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table E.10*.

Table E.10 Responses to 03h Read Holding Register Query Errors

Error	Error Code Returned	Communications Counter Increments
Illegal register to read	Illegal Data Address (02h)	Invalid Address
Illegal number of registers to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

04h Read Input Register Command

Use function code 04h to read directly from the Modbus Register Map shown in *Table E.34*. You can read a maximum of 125 registers at once with this function code. Most masters use 3X references with this function code. If you are accustomed to 3X references with this function code, for five-digit addressing, add 30001 to the standard database address.

Table E.11 04h Read Input Register Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (04h)
2 bytes	Starting Register Address
2 bytes	Number of Registers to Read
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (04h)
1 byte	Bytes of data (*n*)
n bytes	Data (2–250)
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table E.12*.

Table E.12 Responses to 04h Read Input Register Query Errors

Error	Error Code Returned	Communications Counter Increments
Illegal register to read	Illegal Data Address (02h)	Invalid Address
Illegal number of registers to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

05h Force Single Coil Command

Use function code 05h to set or clear a coil. In *Table E.13*, the command response is identical to the command request.

Table E.13 05h Force Single Coil Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (05h)
2 bytes	Coil Reference
1 byte	Operation Code (FF for bit set, 00 for bit clear)
1 byte	Placeholder (00)
2 bytes	CRC-16

Table E.14 lists the coil numbers supported by the SEL-751. The physical coils (coils 0–26) are self-resetting. Pulsing a Set remote bit (decimal address 59 through 90) causes the remote bit to be cleared at the end of the pulse.

Table E.14 01h, 05h SEL-751 Output (Sheet 1 of 3)

Coil Address (Decimal)	Function Code Supported	Coil Description
0	01, 05	Pulse OUT101 1 second
1	01, 05	Pulse OUT102 1 second
2	01, 05	Pulse OUT103 1 second
3	01, 05	Pulse OUT301 1 second
4	01, 05	Pulse OUT302 1 second
5	01, 05	Pulse OUT303 1 second
6	01, 05	Pulse OUT304 1 second
7	01, 05	Pulse OUT305 1 second
8	01, 05	Pulse OUT306 1 second
9	01, 05	Pulse OUT307 1 second
10	01, 05	Pulse OUT308 1 second
11	01, 05	Pulse OUT401 1 second
12	01, 05	Pulse OUT402 1 second
13	01, 05	Pulse OUT403 1 second
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

Table E.14 01h, 05h SEL-751 Output (Sheet 2 of 3)

Coil Address (Decimal)	Function Code Supported	Coil Description
38	01, 05	RB12
39	01, 05	RB13
40	01, 05	RB14
41	01, 05	RB15
42	01, 05	RB16
43	01, 05	RB17
44	01, 05	RB18
45	01, 05	RB19
46	01, 05	RB20
47	01, 05	RB21
48	01, 05	RB22
49	01, 05	RB23
50	01, 05	RB24
51	01, 05	RB25
52	01, 05	RB26
53	01, 05	RB27
54	01, 05	RB28
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]

Table E.14 01h, 05h SEL-751 Output (Sheet 3 of 3)

Coil Address (Decimal)	Function Code Supported	Coil Description
76	01, 05	Pulse RB18[a]
77	01, 05	Pulse RB19[a]
78	01, 05	Pulse RB20[a]
79	01, 05	Pulse RB21[a]
80	01, 05	Pulse RB22[a]
81	01, 05	Pulse RB23[a]
82	01, 05	Pulse RB24[a]
83	01, 05	Pulse RB25[a]
84	01, 05	Pulse RB26[a]
85	01, 05	Pulse RB27[a]
86	01, 05	Pulse RB28[a]
87	01, 05	Pulse RB29[a]
88	01, 05	Pulse RB30[a]
89	01, 05	Pulse RB31[a]
90	01, 05	Pulse RB32[a]

[a] Pulsing a Set remote bit will cause the remote bit to be cleared at the end of the pulse (1 SELOGIC Processing Interval).

Coil addresses start at 0000 (i.e., Coil 1 is located at Coil address 0000). If the device is disabled or the breaker jumper is not installed, the device responds with error code 4 (Device Error). In addition to Error Code 4, the device responses to errors in the query are shown in *Table E.15*.

Table E.15 Responses to 05h Force Single Coil Query Errors

Error	Error Code Returned	Communications Counter Increments
Invalid bit (coil)	Illegal Data Address (02h)	Invalid Address
Invalid bit state requested	Illegal Data Value (03h)	Illegal Register
Format Error	Illegal Data Value (03h)	Bad Packet Format

06h Preset Single Register Command

NOTE: When setting EN_LRC := Y (see Table 9.4), the Relay Word bit LOCAL supervises the CC and OC bits. If the LOCAL bit is asserted (LOCAL = 1), the relay does not set the CC or OC bits. The Relay Word bit LOCAL is determined by the LOCAL SELOGIC control equation (see Table 9.4).

The SEL-751 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 you can write by using this function code. If you are accustomed to 4X references with this function code, for six-digit addressing, add 400001 to the standard database addresses. In *Table E.16*, the command response is identical to the command the master required.

Table E.16 06h Preset Single Register Command (Sheet 1 of 2)

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (06h)
2 bytes	Register Address

Table E.16 06h Preset Single Register Command (Sheet 2 of 2)

Bytes	Field
2 bytes	Data
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table E.17*.

Table E.17 Responses to 06h Preset Single Register Query Errors

Error	Error Code Returned	Communications Counter Increments
Illegal register address	Illegal Data Address (02h)	Invalid Address Illegal Write
Illegal register value	Illegal Data Value (03h)	Illegal Write
Format error	Illegal Data Value (03h)	Bad Packet Format

08h Loopback Diagnostic Command

The SEL-751 uses this function to allow a Modbus master to perform a diagnostic test on the Modbus communications channel and relay. When the subfunction field is 0000h, the relay returns a replica of the received message.

Table E.18 08h Loopback Diagnostic Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (08h)
2 bytes	Subfunction (0000h)
2 bytes	Data Field
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (08h)
2 bytes	Subfunction (0000h)
2 bytes	Data Field (identical to data in Master request)
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table E.19*.

Table E.19 Responses to 08h Loopback Diagnostic Query Errors

Error	Error Code Returned	Communications Counter Increments
Illegal subfunction code	Illegal Data Value (03h)	Invalid Function Code/Op Code
Format error	Illegal Data Value (03h)	Bad Packet Format

10h Preset Multiple Registers Command

This function code works much like code 06h, except that it allows you to write multiple registers at once, as many as 100 per operation. If you are accustomed to 4X references with the function code, for six-digit addressing, simply add 400001 to the standard database addresses.

Table E.20 10h Preset Multiple Registers Command

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (10h)
2 bytes	Starting Address
2 bytes	Number of Registers to Write
1 byte	Number of Bytes of Data (*n*)
n bytes	Data
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (10h)
2 bytes	Starting Address
2 bytes	Number of Registers
2 bytes	CRC-16

The relay responses to errors in the query are as follows.

Table E.21 10h Preset Multiple Registers Query Error Messages

Error	Error Code Returned	Communications Counter Increments
Illegal register to set	Illegal Data Address (02h)	Invalid Address Illegal Write
Illegal number of registers to set	Illegal Data Value (03h)	Illegal Register Illegal Write
Incorrect number of bytes in query data region	Illegal Data Value (03h)	Bad Packet Format Illegal Write
Invalid register data value	Illegal Data Value (03h)	Illegal Write

60h Read Parameter Information Command

The SEL-751 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 (Sheet 1 of 2)

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

Table E.22 60h Read Parameter Information 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 (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

Bit	Name	Description
0	RO: Read-only	1 when the setting is read-only
1	H: Hidden	1 when the setting is hidden
2	DBL: 32-bit	1 when the following setting is a fractional value of this setting
3	RA: RAM-only	1 when the setting is not saved in nonvolatile memory
4	RR: Read-only if running	1 when the setting is read-only if in running/operational state
5	P: Power Cycle or Reset	1 when the setting change requires a power cycle or reset
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 (Sheet 1 of 2)

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

Table E.24 60h Read Parameter Conversion Field Definition (Sheet 2 of 2)

Conversion Value	Type	Multiplier	Divisor	Offset	Base
10	Enumeration	1	1	0	1
11	Bit Enumeration	1	1	0	1

Use *Equation E.1* to calculate the actual (not scaled) value of the parameter (setting):

$$\text{value} = \frac{(\text{ParameterValue} + \text{Offset}) \bullet \text{Multiplier} \bullet \text{Base}}{\text{Divisor}}$$

Equation E.1

Use *Equation E.2* to calculate the scaled setting value:

$$\text{value} = \frac{\text{value} \bullet \text{Divisor}}{\text{Multiplier} \bullet \text{Base}} - \text{Offset}$$

Equation E.2

The relay response to errors in the query are shown *Table E.25*.

Table E.25 Responses to 60h Read Parameter Information Query Errors

Error	Error Code Returned	Communications Counter Increments
Illegal parameter to read	Illegal Address (02h)	Invalid Address

61h Read Parameter Text Command

The SEL-751 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 (e.g., Amps)
2 bytes	CRC-16

The relay responses to errors in the query are as follows.

Table E.27 61h Read Parameter Text Query Error Messages

Error	Error Code Returned	Communications Counter Increments
Illegal parameter to read	Illegal Address (02h)	Invalid Address

62h Read Enumeration Text Command

The SEL-751 uses this function to allow a Modbus master to read parameter enumeration or bit enumeration values (setting lists) from the relay. One parameter enumeration is read in each query.

Table E.28 62h Read Enumeration Text Command

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (62h)
2 bytes	Parameter Number
1 byte	Enumeration Index
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (62h)
2 bytes	Parameter Number
1 byte	Enumeration Index
16 bytes	Enumeration Text
2 bytes	CRC-16

The relay responses to errors in the query are as follows.

Table E.29 61h Read Parameter Enumeration Text Query Error Messages

Error	Error Code Returned	Communications Counter Increments
Illegal parameter to read	Illegal Address (02h)	Invalid Address
Illegal enumeration in index	Illegal Data Value (03h)	Illegal Register

7Dh Encapsulated Packet With Control Command

The SEL-751 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 (Sheet 1 of 2)

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)

Table E.30 7Dh Encapsulated Packet With Control Command (Sheet 2 of 2)

Bytes	Field
1 byte	Embedded Modbus Function
n bytes	Optional Data to Support Modbus Function (0–250)
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Status Information (Register 2100h or 2101h based on Bit 3 in Control Command Word)
1 byte	Embedded Modbus Function
n bytes	Optional data to support the Modbus function (0–250)
2 bytes	CRC-16

Table E.31 shows the format of the relay responses to errors in the query.

Table E.31 7Dh Encapsulated Packet Query Errors

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Status Information (Register 2100h or 2101h based on Bit 3 in Control Command Word)
1 byte	Modbus Function with Error Flag
1 bytes	Function Error Code[a]
2 bytes	CRC-16

[a] If the embedded function code is invalid, then an illegal function code is returned here and the illegal function counter is incremented. This error code is returned by the embedded function for all valid embedded functions.

7Eh NOP Command

This function code has no operation. This allows a Modbus master to perform a control operation without any other Modbus command. This is only used inside of the 7Dh when no regular Modbus query is necessary.

Table E.32 7Eh NOP Command

Bytes	Field
An example of a 7D message response using 7E will have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Status Information
1 byte	Function Code (7Eh)
2 bytes	CRC-16

Reading Parameter Information and Value Using Modbus

Through use of Modbus commands, you can read the present value of a parameter as well as parameter name, units, low limit, high limit, scale, and even the enumeration string (if the parameter is an enumeration type). This means that you can use a general user interface to retrieve and display specific parameter details from the relay. Use the **60h**, **61h**, and **62h** commands to retrieve parameter information, and use the **03** command to retrieve values.

Controlling Output Contacts Using Modbus

The SEL-751 includes registers for controlling some of the outputs. See LOGIC COMMAND (2000h), RESET COMMAND (2001h), and registers in the Reset Settings region for the control features supported by the relay. Use Modbus function codes 06h or 10h to write appropriate flags. Remember that when writing to the Logic command register with output contacts, it is not a bit operation. You must write all the bits in that register together to reflect the state you want for each of the outputs.

User-Defined Modbus Data Region and SET M Command

The SEL-751 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. You can also define the user map by writing to user map registers MOD_001 to MOD_125.

To use the user-defined data region, perform the following steps.

Step 1. Define the list of desired quantities (as many as 125). Arrange the quantities in any order that is convenient for you to use.

Step 2. Refer to *Table E.33* for a list of the Modbus label for each quantity.

Step 3. Execute **SET M** command from the command line to map user registers 001 to 125 (MOD_001 to MOD_125) by using the labels in *Table E.33*.

Note that you can also use Modbus protocol to perform this step. 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 quantities you want from addresses 126 through 250 (user map values).

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 1 of 6)

Register Address	Label
280	FPGA
281	GPSB
282	HMI
283	RAM
284	ROM
285	CR_RAM
286	NON_VOL
287	CLKSTS
288	CID_FILE
289	RTD
290	P0P9PS
291	P1P2PS
292	P1P5PS
293	P1P8PS
294	P2P5PS
295	P3P3PS
296	P3P75PS
297	P5PS
298	N1P25PS
299	N5PS
300	CLKBAT
301	CARDC
302	CARDD
303	CARDE
304	CARDZ
305	IASTS
306	IBSTS
307	ICSTS
308	INSTS
309	VASTS
310	VBSTS
311	VCSTS
312	VSSTS
313	RLYSTS
314	SER_NUMH
315	SER_NUML
316–319[a]	
320	IA_MAG
321	IA_ANG
322	IB_MAG
323	IB_ANG
324	IC_MAG
325	IC_ANG
326	IN_MAG
327	IN_ANG
328	IG_MAG
329	IG_ANG
330	I1_MAG
331	I1_ANG
332	IAV
333	3I2
334	UBI
335	VAB_MAG
336	VAB_ANG
337	VBC_MAG
338	VBC_ANG
339	VCA_MAG
340	VCA_ANG
341	VAVE
342	V1_MAG
343	V1_ANG
344	VA_MAG
345	VA_ANG
346	VB_MAG
347	VB_ANG
348	VC_MAG
349	VC_ANG
350	VG_MAG
351	VG_ANG
352	VAVE
353	3V2
354	UBV
355	VS_MAG
356	VS_ANG
357	VDC
358–359[a]	
360	PA
361	QA
362	SA
363	PFA
364	PB
365	QB
366	SB
367	PFB
368	PC
369	QC
370	SC
371	PFC
372	P
373	Q
374	S
375	PF
376	FREQ
377	FREQS
378–379[a]	
380	MWH3PIH
381	MWH3PIL
382	MWH3POH
383	MWH3POL
384	MVRH3PIH
385	MVRH3PIL
386	MVRH3POH
387	MVRH3POL
388	MVAH3PH
389	MVAH3PL
390	ENRGY_S
391	ENRGYMN
392	ENRGY_H
393	ENRGY_D
394	ENRGYMO
395	ENRGY_Y
396–399[a]	
400	RTDWDGMX
401	RTDBRGMX
402	RTDAMB
403	RTDOTHMX
404	RTD1
405	RTD2
406	RTD3
407	RTD4
408	RTD5
409	RTD6
410	RTD7
411	RTD8
412	RTD9
413	RTD10
414	RTD11
415	RTD12
416–419[a]	
420	LSENS1
421	LSENS2
422	LSENS3
423	LSENS4
424	LSENS5
425	LSENS6
426	LSENS7
427	LSENS8
428–429[a]	
430	IARMS
431	IBRMS
432	ICRMS
433	INRMS
434	VARMS
435	VBRMS
436	VCRMS
437	VABRMS
438	VBCRMS
439	VCARMS
440	VSRMS
441–449[a]	
450	IAD
451	IBD
452	ICD
453	IGD
454	3I2D
455	IAPD
456	IBPD
457	ICPD
458	IGPD
459	3I2PD
460	PDEM_R_S
461	PDEM_RMN
462	PDEM_R_H
463	PDEM_R_D
464	PDEM_RMO
465	PDEM_R_Y
466–469[a]	
470	INTT
471	EXTT
472	INTIA
473	EXTIA
474	INTIB
475	EXTIB
476	INTIC
477	EXTIC
478	WEARA
479	WEARB
480	WEARC
481	BRKR_R_S
482	BRKR_RMN
483	BRKR_R_H
484	BRKR_R_D
485	BRKR_RMO
486	BRKR_R_Y
487–489[a]	
490	AI301H
491	AI301L
492	AI302H
493	AI302L
494	AI303H
495	AI303L
496	AI304H
497	AI304L
498	AI305H
499	AI305L
500	AI306H
501	AI306L
502	AI307H
503	AI307L
504	AI308H
505	AI308L
506	AI401H
507	AI401L
508	AI402H
509	AI402L
510	AI403H
511	AI403L
512	AI404H
513	AI404L
514	AI405H
515	AI405L
516	AI406H
517	AI406L
518	AI407H
519	AI407L
520	AI408H
521	AI408L
522	AI501H
523	AI501L
524	AI502H
525	AI502L
526	AI503H
527	AI503L
528	AI504H
529	AI504L
530	AI505H
531	AI505L
532	AI506H
533	AI506L
534	AI507H
535	AI507L
536	AI508H
537	AI508L
538–539[a]	
540	MV01H
541	MV01L
542	MV02H
543	MV02L
544	MV03H
545	MV03L
546	MV04H
547	MV04L
548	MV05H
549	MV05L
550	MV06H
551	MV06L
552	MV07H
553	MV07L
554	MV08H
555	MV08L
556	MV09H
557	MV09L
558	MV10H
559	MV10L
560	MV11H
561	MV11L
562	MV12H
563	MV12L
564	MV13H
565	MV13L

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 2 of 6)

Register Address	Label
566	MV14H
567	MV14L
568	MV15H
569	MV15L
570	MV16H
571	MV16L
572	MV17H
573	MV17L
574	MV18H
575	MV18L
576	MV19H
577	MV19L
578	MV20H
579	MV20L
580	MV21H
581	MV21L
582	MV22H
583	MV22L
584	MV23H
585	MV23L
586	MV24H
587	MV24L
588	MV25H
589	MV25L
590	MV26H
591	MV26L
592	MV27H
593	MV27L
594	MV28H
595	MV28L
596	MV29H
597	MV29L
598	MV30H
599	MV30L
600	MV31H
601	MV31L
602	MV32H
603	MV32L
604	SC01
605	SC02
606	SC03
607	SC04
608	SC05
609	SC06
610	SC07
611	SC08
612	SC09
613	SC10
614	SC11
615	SC12
616	SC13
617	SC14

Register Address	Label
618	SC15
619	SC16
620	SC17
621	SC18
622	SC19
623	SC20
624	SC21
625	SC22
626	SC23
627	SC24
628	SC25
629	SC26
630	SC27
631	SC28
632	SC29
633	SC30
634	SC31
635	SC32
636–639[a]	
640	RA001_H
641	RA001_L
642	RA002_H
643	RA002_L
644	RA003_H
645	RA003_L
646	RA004_H
647	RA004_L
648	RA005_H
649	RA005_L
650	RA006_H
651	RA006_L
652	RA007_H
653	RA007_L
654	RA008_H
655	RA008_L
656	RA009_H
657	RA009_L
658	RA010_H
659	RA010_L
660	RA011_H
661	RA011_L
662	RA012_H
663	RA012_L
664	RA013_H
665	RA013_L
666	RA014_H
667	RA014_L
668	RA015_H
669	RA015_L
670	RA016_H
671	RA016_L
672	RA017_H

Register Address	Label
673	RA017_L
674	RA018_H
675	RA018_L
676	RA019_H
677	RA019_L
678	RA020_H
679	RA020_L
680	RA021_H
681	RA021_L
682	RA022_H
683	RA022_L
684	RA023_H
685	RA023_L
686	RA024_H
687	RA024_L
688	RA025_H
689	RA025_L
690	RA026_H
691	RA026_L
692	RA027_H
693	RA027_L
694	RA028_H
695	RA028_L
696	RA029_H
697	RA029_L
698	RA030_H
699	RA030_L
700	RA031_H
701	RA031_L
702	RA032_H
703	RA032_L
704	RA033_H
705	RA033_L
706	RA034_H
707	RA034_L
708	RA035_H
709	RA035_L
710	RA036_H
711	RA036_L
712	RA037_H
713	RA037_L
714	RA038_H
715	RA038_L
716	RA039_H
717	RA039_L
718	RA040_H
719	RA040_L
720	RA041_H
721	RA041_L
722	RA042_H
723	RA042_L
724	RA043_H

Register Address	Label
725	RA043_L
726	RA044_H
727	RA044_L
728	RA045_H
729	RA045_L
730	RA046_H
731	RA046_L
732	RA047_H
733	RA047_L
734	RA048_H
735	RA048_L
736	RA049_H
737	RA049_L
738	RA050_H
739	RA050_L
740	RA051_H
741	RA051_L
742	RA052_H
743	RA052_L
744	RA053_H
745	RA053_L
746	RA054_H
747	RA054_L
748	RA055_H
749	RA055_L
750	RA056_H
751	RA056_L
752	RA057_H
753	RA057_L
754	RA058_H
755	RA058_L
756	RA059_H
757	RA059_L
758	RA060_H
759	RA060_L
760	RA061_H
761	RA061_L
762	RA062_H
763	RA062_L
764	RA063_H
765	RA063_L
766	RA064_H
767	RA064_L
768	RA065_H
769	RA065_L
770	RA066_H
771	RA066_L
772	RA067_H
773	RA067_L
774	RA068_H
775	RA068_L
776	RA069_H

Register Address	Label
777	RA069_L
778	RA070_H
779	RA070_L
780	RA071_H
781	RA071_L
782	RA072_H
783	RA072_L
784	RA073_H
785	RA073_L
786	RA074_H
787	RA074_L
788	RA075_H
789	RA075_L
790	RA076_H
791	RA076_L
792	RA077_H
793	RA077_L
794	RA078_H
795	RA078_L
796	RA079_H
797	RA079_L
798	RA080_H
799	RA080_L
800	RA081_H
801	RA081_L
802	RA082_H
803	RA082_L
804	RA083_H
805	RA083_L
806	RA084_H
807	RA084_L
808	RA085_H
809	RA085_L
810	RA086_H
811	RA086_L
812	RA087_H
813	RA087_L
814	RA088_H
815	RA088_L
816	RA089_H
817	RA089_L
818	RA090_H
819	RA090_L
820	RA091_H
821	RA091_L
822	RA092_H
823	RA092_L
824	RA093_H
825	RA093_L
826	RA094_H
827	RA094_L
828	RA095_H

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 3 of 6)

Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label
829	RA095_L	881	RA121_L	936	ICN_S	988	VBCX_D	1040	KVAR3PMX
830	RA096_H	882	RA122_H	937	ICNMN	989	VBCXMO	1041	KVR3X_S
831	RA096_L	883	RA122_L	938	ICN_H	990	VBCX_Y	1042	KVR3XMN
832	RA097_H	884	RA123_H	939	ICN_D	991	VBCMN	1043	KVR3X_H
833	RA097_L	885	RA123_L	940	ICNMO	992	VBCN_S	1044	KVR3X_D
834	RA098_H	886	RA124_H	941	ICN_Y	993	VBCNMN	1045	KVR3XMO
835	RA098_L	887	RA124_L	942	INMX	994	VBCN_H	1046	KVR3X_Y
836	RA099_H	888	RA125_H	943	INX_S	995	VBCN_D	1047	KVAR3PMN
837	RA099_L	889	RA125_L	944	INXMN	996	VBCNMO	1048	KVR3N_S
838	RA100_H	890	RA126_H	945	INX_H	997	VBCN_Y	1049	KVR3NMN
839	RA100_L	891	RA126_L	946	INX_D	998	VCAMX	1050	KVR3N_H
840	RA101_H	892	RA127_H	947	INXMO	999	VCAX_S	1051	KVR3N_D
841	RA101_L	893	RA127_L	948	INX_Y	1000	VCAXMN	1052	KVR3NMO
842	RA102_H	894	RA128_H	949	INMN	1001	VCAX_H	1053	KVR3N_Y
843	RA102_L	895	RA128_L	950	INN_S	1002	VCAX_D	1054	KVA3PMX
844	RA103_H	896–899[a]		951	INNMN	1003	VCAXMO	1055	KVA3X_S
845	RA103_L	900	IAMX	952	INN_H	1004	VCAX_Y	1056	KVA3XMN
846	RA104_H	901	IAX_S	953	INN_D	1005	VCAMN	1057	KVA3X_H
847	RA104_L	902	IAXMN	954	INNMO	1006	VCAN_S	1058	KVA3X_D
848	RA105_H	903	IAX_H	955	INN_Y	1007	VCANMN	1059	KVA3XMO
849	RA105_L	904	IAX_D	956	IGMX	1008	VCAN_H	1060	KVA3X_Y
850	RA106_H	905	IAXMO	957	IGX_S	1009	VCAN_D	1061	KVA3PMN
851	RA106_L	906	IAX_Y	958	IGXMN	1010	VCANMO	1062	KVA3N_S
852	RA107_H	907	IAMN	959	IGX_H	1011	VCAN_Y	1063	KVA3NMN
853	RA107_L	908	IAN_S	960	IGX_D	1012	VSMX	1064	KVA3N_H
854	RA108_H	909	IANMN	961	IGXMO	1013	VSX_S	1065	KVA3N_D
855	RA108_L	910	IAN_H	962	IGX_Y	1014	VSXMN	1066	KVA3NMO
856	RA109_H	911	IAN_D	963	IGMN	1015	VSX_H	1067	KVA3N_Y
857	RA109_L	912	IANMO	964	IGN_S	1016	VSX_D	1068	FREQMX
858	RA110_H	913	IAN_Y	965	IGNMN	1017	VSXMO	1069	FREQX_S
859	RA110_L	914	IBMX	966	IGN_H	1018	VSX_Y	1070	FREQXMN
860	RA111_H	915	IBX_S	967	IGN_D	1019	VSMN	1071	FREQX_H
861	RA111_L	916	IBXMN	968	IGNMO	1020	VSN_S	1072	FREQX_D
862	RA112_H	917	IBX_H	969	IGN_Y	1021	VSNMN	1073	FREQXMO
863	RA112_L	918	IBX_D	970	VABMX	1022	VSN_H	1074	FREQX_Y
864	RA113_H	919	IBXMO	971	VABX_S	1023	VSN_D	1075	FREQMN
865	RA113_L	920	IBX_Y	972	VABXMN	1024	VSNMO	1076	FREQN_S
866	RA114_H	921	IBMN	973	VABX_H	1025	VSN_Y	1077	FREQNMN
867	RA114_L	922	IBN_S	974	VABX_D	1026	KW3PMX	1078	FREQN_H
868	RA115_H	923	IBNMN	975	VABXMO	1027	KW3X_S	1079	FREQN_D
869	RA115_L	924	IBN_H	976	VABX_Y	1028	KW3XMN	1080	FREQNMO
870	RA116_H	925	IBN_D	977	VABMN	1029	KW3X_H	1081	FREQN_Y
871	RA116_L	926	IBNMO	978	VABN_S	1030	KW3X_D	1082–1089[a]	
872	RA117_H	927	IBN_Y	979	VABNMN	1031	KW3XMO	1090	RTD1MX
873	RA117_L	928	ICMX	980	VABN_H	1032	KW3X_Y	1091	RTD1X_S
874	RA118_H	929	ICX_S	981	VABN_D	1033	KW3PMN	1092	RTD1XMN
875	RA118_L	930	ICXMN	982	VABNMO	1034	KW3N_S	1093	RTD1X_H
876	RA119_H	931	ICX_H	983	VABN_Y	1035	KW3NMN	1094	RTD1X_D
877	RA119_L	932	ICX_D	984	VBCMX	1036	KW3N_H	1095	RTD1XMO
878	RA120_H	933	ICXMO	985	VBCX_S	1037	KW3N_D	1096	RTD1X_Y
879	RA120_L	934	ICX_Y	986	VBCXMN	1038	KW3NMO	1097	RTD1MN
880	RA121_H	935	ICMN	987	VBCX_H	1039	KW3N_Y	1098	RTD1N_S

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 4 of 6)

Register Address	Label
1099	RTD1NMN
1100	RTD1N_H
1101	RTD1N_D
1102	RTD1NMO
1103	RTD1N_Y
1104	RTD2MX
1105	RTD2X_S
1106	RTD2XMN
1107	RTD2X_H
1108	RTD2X_D
1109	RTD2XMO
1110	RTD2X_Y
1111	RTD2MN
1112	RTD2N_S
1113	RTD2NMN
1114	RTD2N_H
1115	RTD2N_D
1116	RTD2NMO
1117	RTD2N_Y
1118	RTD3MX
1119	RTD3X_S
1120	RTD3XMN
1121	RTD3X_H
1122	RTD3X_D
1123	RTD3XMO
1124	RTD3X_Y
1125	RTD3MN
1126	RTD3N_S
1127	RTD3NMN
1128	RTD3N_H
1129	RTD3N_D
1130	RTD3NMO
1131	RTD3N_Y
1132	RTD4MX
1133	RTD4X_S
1134	RTD4XMN
1135	RTD4X_H
1136	RTD4X_D
1137	RTD4XMO
1138	RTD4X_Y
1139	RTD4MN
1140	RTD4N_S
1141	RTD4NMN
1142	RTD4N_H
1143	RTD4N_D
1144	RTD4NMO
1145	RTD4N_Y
1146	RTD5MX
1147	RTD5X_S
1148	RTD5XMN
1149	RTD5X_H
1150	RTD5X_D
1151	RTD5XMO
1152	RTD5X_Y
1153	RTD5MN
1154	RTD5N_S
1155	RTD5NMN
1156	RTD5N_H
1157	RTD5N_D
1158	RTD5NMO
1159	RTD5N_Y
1160	RTD6MX
1161	RTD6X_S
1162	RTD6XMN
1163	RTD6X_H
1164	RTD6X_D
1165	RTD6XMO
1166	RTD6X_Y
1167	RTD6MN
1168	RTD6N_S
1169	RTD6NMN
1170	RTD6N_H
1171	RTD6N_D
1172	RTD6NMO
1173	RTD6N_Y
1174	RTD7MX
1175	RTD7X_S
1176	RTD7XMN
1177	RTD7X_H
1178	RTD7X_D
1179	RTD7XMO
1180	RTD7X_Y
1181	RTD7MN
1182	RTD7N_S
1183	RTD7NMN
1184	RTD7N_H
1185	RTD7N_D
1186	RTD7NMO
1187	RTD7N_Y
1188	RTD8MX
1189	RTD8X_S
1190	RTD8XMN
1191	RTD8X_H
1192	RTD8X_D
1193	RTD8XMO
1194	RTD8X_Y
1195	RTD8MN
1196	RTD8N_S
1197	RTD8NMN
1198	RTD8N_H
1199	RTD8N_D
1200	RTD8NMO
1201	RTD8N_Y
1202	RTD9MX
1203	RTD9X_S
1204	RTD9XMN
1205	RTD9X_H
1206	RTD9X_D
1207	RTD9XMO
1208	RTD9X_Y
1209	RTD9MN
1210	RTD9N_S
1211	RTD9NMN
1212	RTD9N_H
1213	RTD9N_D
1214	RTD9NMO
1215	RTD9N_Y
1216	RTD10MX
1217	RTD10X_S
1218	RTD10XMN
1219	RTD10X_H
1220	RTD10X_D
1221	RTD10XMO
1222	RTD10X_Y
1223	RTD10MN
1224	RTD10N_S
1225	RTD10NMN
1226	RTD10N_H
1227	RTD10N_D
1228	RTD10NMO
1229	RTD10N_Y
1230	RTD11MX
1231	RTD11X_S
1232	RTD11XMN
1233	RTD11X_H
1234	RTD11X_D
1235	RTD11XMO
1236	RTD11X_Y
1237	RTD11MN
1238	RTD11N_S
1239	RTD11NMN
1240	RTD11N_H
1241	RTD11N_D
1242	RTD11NMO
1243	RTD11N_Y
1244	RTD12MX
1245	RTD12X_S
1246	RTD12XMN
1247	RTD12X_H
1248	RTD12X_D
1249	RTD12XMO
1250	RTD12X_Y
1251	RTD12MN
1252	RTD12N_S
1253	RTD12NMN
1254	RTD12N_H
1255	RTD12N_D
1256	RTD12NMO
1257	RTD12N_Y
1258–1269[a]	
1270	AI301MXH
1271	AI301MXL
1272	AI301X_S
1273	AI301XMN
1274	AI301X_H
1275	AI301X_D
1276	AI301XMO
1277	AI301X_Y
1278	AI301MNH
1279	AI301MNL
1280	AI301N_S
1281	AI301NMN
1282	AI301N_H
1283	AI301N_D
1284	AI301NMO
1285	AI301N_Y
1286	AI302MXH
1287	AI302MXL
1288	AI302X_S
1289	AI302XMN
1290	AI302X_H
1291	AI302X_D
1292	AI302XMO
1293	AI302X_Y
1294	AI302MNH
1295	AI302MNL
1296	AI302N_S
1297	AI302NMN
1298	AI302N_H
1299	AI302N_D
1300	AI302NMO
1301	AI302N_Y
1302	AI303MXH
1303	AI303MXL
1304	AI303X_S
1305	AI303XMN
1306	AI303X_H
1307	AI303X_D
1308	AI303XMO
1309	AI303X_Y
1310	AI303MNH
1311	AI303MNL
1312	AI303N_S
1313	AI303NMN
1314	AI303N_H
1315	AI303N_D
1316	AI303NMO
1317	AI303N_Y
1318	AI304MXH
1319	AI304MXL
1320	AI304X_S
1321	AI304XMN
1322	AI304X_H
1323	AI304X_D
1324	AI304XMO
1325	AI304X_Y
1326	AI304MNH
1327	AI304MNL
1328	AI304N_S
1329	AI304NMN
1330	AI304N_H
1331	AI304N_D
1332	AI304NMO
1333	AI304N_Y
1334	AI305MXH
1335	AI305MXL
1336	AI305X_S
1337	AI305XMN
1338	AI305X_H
1339	AI305X_D
1340	AI305XMO
1341	AI305X_Y
1342	AI305MNH
1343	AI305MNL
1344	AI305N_S
1345	AI305NMN
1346	AI305N_H
1347	AI305N_D
1348	AI305NMO
1349	AI305N_Y
1350	AI306MXH
1351	AI306MXL
1352	AI306X_S
1353	AI306XMN
1354	AI306X_H
1355	AI306X_D
1356	AI306XMO
1357	AI306X_Y
1358	AI306MNH
1359	AI306MNL
1360	AI306N_S
1361	AI306NMN
1362	AI306N_H
1363	AI306N_D
1364	AI306NMO
1365	AI306N_Y
1366	AI307MXH
1367	AI307MXL
1368	AI307X_S
1369	AI307XMN

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 5 of 6)

Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label
1370	AI307X_H	1422	AI402MNH	1474	AI405N_H	1526	AI501MXH	1578	AI504X_H
1371	AI307X_D	1423	AI402MNL	1475	AI405N_D	1527	AI501MXL	1579	AI504X_D
1372	AI307XMO	1424	AI402N_S	1476	AI405NMO	1528	AI501X_S	1580	AI504XMO
1373	AI307X_Y	1425	AI402NMN	1477	AI405N_Y	1529	AI501XMN	1581	AI504X_Y
1374	AI307MNH	1426	AI402N_H	1478	AI406MXH	1530	AI501X_H	1582	AI504MNH
1375	AI307MNL	1427	AI402N_D	1479	AI406MXL	1531	AI501X_D	1583	AI504MNL
1376	AI307N_S	1428	AI402NMO	1480	AI406X_S	1532	AI501XMO	1584	AI504N_S
1377	AI307NMN	1429	AI402N_Y	1481	AI406XMN	1533	AI501X_Y	1585	AI504NMN
1378	AI307N_H	1430	AI403MXH	1482	AI406X_H	1534	AI501MNH	1586	AI504N_H
1379	AI307N_D	1431	AI403MXL	1483	AI406X_D	1535	AI501MNL	1587	AI504N_D
1380	AI307NMO	1432	AI403X_S	1484	AI406XMO	1536	AI501N_S	1588	AI504NMO
1381	AI307N_Y	1433	AI403XMN	1485	AI406X_Y	1537	AI501NMN	1589	AI504N_Y
1382	AI308MXH	1434	AI403X_H	1486	AI406MNH	1538	AI501N_H	1590	AI505MXH
1383	AI308MXL	1435	AI403X_D	1487	AI406MNL	1539	AI501N_D	1591	AI505MXL
1384	AI308X_S	1436	AI403XMO	1488	AI406N_S	1540	AI501NMO	1592	AI505X_S
1385	AI308XMN	1437	AI403X_Y	1489	AI406NMN	1541	AI501N_Y	1593	AI505XMN
1386	AI308X_H	1438	AI403MNH	1490	AI406N_H	1542	AI502MXH	1594	AI505X_H
1387	AI308X_D	1439	AI403MNL	1491	AI406N_D	1543	AI502MXL	1595	AI505X_D
1388	AI308XMO	1440	AI403N_S	1492	AI406NMO	1544	AI502X_S	1596	AI505XMO
1389	AI308X_Y	1441	AI403NMN	1493	AI406N_Y	1545	AI502XMN	1597	AI505X_Y
1390	AI308MNH	1442	AI403N_H	1494	AI407MXH	1546	AI502X_H	1598	AI505MNH
1391	AI308MNL	1443	AI403N_D	1495	AI407MXL	1547	AI502X_D	1599	AI505MNL
1392	AI308N_S	1444	AI403NMO	1496	AI407X_S	1548	AI502XMO	1600	AI505N_S
1393	AI308NMN	1445	AI403N_Y	1497	AI407XMN	1549	AI502X_Y	1601	AI505NMN
1394	AI308N_H	1446	AI403MXH	1498	AI407X_H	1550	AI502MNH	1602	AI505N_H
1395	AI308N_D	1447	AI403MXL	1499	AI407X_D	1551	AI502MNL	1603	AI505N_D
1396	AI308NMO	1448	AI403X_S	1500	AI407XMO	1552	AI502N_S	1604	AI505NMO
1397	AI308N_Y	1449	AI403XMN	1501	AI407X_Y	1553	AI502NMN	1605	AI505N_Y
1398	AI401MXH	1450	AI403X_H	1502	AI407MNH	1554	AI502N_H	1606	AI506MXH
1399	AI401MXL	1451	AI403X_D	1503	AI407MNL	1555	AI502N_D	1607	AI506MXL
1400	AI401X_S	1452	AI403XMO	1504	AI407N_S	1556	AI502NMO	1608	AI506X_S
1401	AI401XMN	1453	AI403X_Y	1505	AI407NMN	1557	AI502N_Y	1609	AI506XMN
1402	AI401X_H	1454	AI404MNH	1506	AI407N_H	1558	AI503MXH	1610	AI506X_H
1403	AI401X_D	1455	AI404MNL	1507	AI407N_D	1559	AI503MXL	1611	AI506X_D
1404	AI401XMO	1456	AI404N_S	1508	AI407NMO	1560	AI503X_S	1612	AI506XMO
1405	AI401X_Y	1457	AI404NMN	1509	AI407N_Y	1561	AI503XMN	1613	AI506X_Y
1406	AI401MNH	1458	AI404N_H	1510	AI408MXH	1562	AI503X_H	1614	AI506MNH
1407	AI401MNL	1459	AI404N_D	1511	AI408MXL	1563	AI503X_D	1615	AI506MNL
1408	AI401N_S	1460	AI404NMO	1512	AI408X_S	1564	AI503XMO	1616	AI506N_S
1409	AI401NMN	1461	AI404N_Y	1513	AI408XMN	1565	AI503X_Y	1617	AI506NMN
1410	AI401N_H	1462	AI405MXH	1514	AI408X_H	1566	AI503MNH	1618	AI506N_H
1411	AI401N_D	1463	AI405MXL	1515	AI408X_D	1567	AI503MNL	1619	AI506N_D
1412	AI401NMO	1464	AI405X_S	1516	AI408XMO	1568	AI503N_S	1620	AI506NMO
1413	AI401N_Y	1465	AI405XMN	1517	AI408X_Y	1569	AI503NMN	1621	AI506N_Y
1414	AI402MXH	1466	AI405X_H	1518	AI408MNH	1570	AI503N_H	1622	AI507MXH
1415	AI402MXL	1467	AI405X_D	1519	AI408MNL	1571	AI503N_D	1623	AI507MXL
1416	AI402X_S	1468	AI405XMO	1520	AI408N_S	1572	AI503NMO	1624	AI507X_S
1417	AI402XMN	1469	AI405X_Y	1521	AI408NMN	1573	AI503N_Y	1625	AI507XMN
1418	AI402X_H	1470	AI405MNH	1522	AI408N_H	1574	AI504MXH	1626	AI507X_H
1419	AI402X_D	1471	AI405MNL	1523	AI408N_D	1575	AI504MXL	1627	AI507X_D
1420	AI402XMO	1472	AI405N_S	1524	AI408NMO	1576	AI504X_S	1628	AI507XMO
1421	AI402X_Y	1473	AI405NMN	1525	AI408N_Y	1577	AI504XMN	1629	AI507X_Y

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 6 of 6)

Register Address	Label
1630	AI507MNH
1631	AI507MNL
1632	AI507N_S
1633	AI507NMN
1634	AI507N_H
1635	AI507N_D
1636	AI507NMO
1637	AI507N_Y
1638	AI508MXH
1639	AI508MXL
1640	AI508X_S
1641	AI508XMN
1642	AI508X_H
1643	AI508X_D
1644	AI508XMO
1645	AI508X_Y
1646	AI508MNH
1647	AI508MNL
1648	AI508N_S
1649	AI508NMN
1650	AI508N_H
1651	AI508N_D
1652	AI508NMO
1653	AI508N_Y
1654	MXMN_R_S
1655	MXMN_RMN
1656	MXMN_R_H
1657	MXMN_R_D
1658	MXMN_RMO
1659	MXMN_R_Y
1660	TERMAL LEVEL 1
1661	TERMAL LEVEL 2
1662	TERMAL LEVEL 3
1663	EQUIV CURRENT 1
1664	EQUIV CURRENT 2
1665	EQUIV CURRENT 3
1666	THERL CAP USE 1
1667	THERL CAP USE 2
1668	THERL CAP USE 3
1669	TIME TO TRIP 1
1670	TIME TO TRIP 2
1671	TIME TO TRIP 3
1672	RELEASE TIME 1
1673	RELEASE TIME 2
1674	RELEASE TIME 3
1675–1689[a]	
1690	FLOC
1691	NUMEVE
1692	EVESEL
1693	EVE_S
1694	EVEMN

Register Address	Label
1695	EVE_H
1696	EVE_D
1697	EVEMO
1698	EVE_Y
1699	EVE_TYPE
1700	EV_LOCAT
1701	EVE_TRGT
1702	EVE_IA
1703	EVE_IB
1704	EVE_IC
1705	EVE_IN
1706	EVE_IG
1707	EVE_VAB
1708	EVE_VBC
1709	EVE_VCA
1710	EVE_VG
1711	EVE_DY
1712	EVE_FREQ
1713	EVE_MAXW
1714	EVE_MAXB
1715	EVE_MAXA
1716	EVE_MAXO
1717	EVE_FZ
1718	EVE_FZFA
1719–1729[a]	
1730	TRIP_LO
1731	TRIP_HI
1732	WARN_LO
1733	WARN_HI
1734–1739[a]	
1740	NUMRCV
1741	NUMOTH
1742	INVADR
1743	BADCRC
1744	UARTERR
1745	ILLFUNC
1746	ILLREG
1747	ILLWR
1748	BADPKTF
1749	BADPKTL
1750–1759[a]	
1760	ROW_0
1761	ROW_1
1762	ROW_2
1763	ROW_3
1764	ROW_4
1765	ROW_5
1766	ROW_6
1767	ROW_7
1768	ROW_8
1769	ROW_9

Register Address	Label
1770	ROW_10
1771	ROW_11
1772	ROW_12
1773	ROW_13
1774	ROW_14
1775	ROW_15
1776	ROW_16
1777	ROW_17
1778	ROW_18
1779	ROW_19
1780	ROW_20
1781	ROW_21
1782	ROW_22
1783	ROW_23
1784	ROW_24
1785	ROW_25
1786	ROW_26
1787	ROW_27
1788	ROW_28
1789	ROW_29
1790	ROW_30
1791	ROW_31
1792	ROW_32
1793	ROW_33
1794	ROW_34
1795	ROW_35
1796	ROW_36
1797	ROW_37
1798	ROW_38
1799	ROW_39
1800	ROW_40
1801	ROW_41
1802	ROW_42
1803	ROW_43
1804	ROW_44
1805	ROW_45
1806	ROW_46
1807	ROW_47
1808	ROW_48
1809	ROW_49
1810	ROW_50
1811	ROW_51
1812	ROW_52
1813	ROW_53
1814	ROW_54
1815	ROW_55
1816	ROW_56
1817	ROW_57
1818	ROW_58
1819	ROW_59
1820	ROW_60

Register Address	Label
1821	ROW_61
1822	ROW_62
1823	ROW_63
1824	ROW_64
1825	ROW_65
1826	ROW_66
1827	ROW_67
1828	ROW_68
1829	ROW_69
1830	ROW_70
1831	ROW_71
1832	ROW_72
1833	ROW_73
1834	ROW_74
1835	ROW_75
1836	ROW_76
1837	ROW_77
1838	ROW_78
1839	ROW_79
1840	ROW_80
1841	ROW_81
1842	ROW_82
1843	ROW_83
1844	ROW_84
1845	ROW_85
1846	ROW_86
1847	ROW_87
1848	ROW_88
1849	ROW_89
1850	ROW_90
1851	ROW_91
1852	ROW_92
1853	ROW_93
1854	ROW_94
1855	ROW_95
1856	ROW_96
1857	ROW_97
1858	ROW_98
1859	ROW_99
1860	ROW_100
1861	ROW_101
1862	ROW_102
1863	ROW_103
1864	ROW_104
1865	ROW_105
1866	ROW_106
1867	ROW_107
1868	ROW_108
1869	ROW_109
1870	ROW_110
1871	ROW_111

Register Address	Label
1872	ROW_112
1873	ROW_113
1874	ROW_114
1875	ROW_115
1876	ROW_116
1877	ROW_117
1878	ROW_118
1879	ROW_119
1880	ROW_120
1881	ROW_121
1882	ROW_122
1883	ROW_123
1884	ROW_124
1885	ROW_125
1886	ROW_126
1887	ROW_127
1888	ROW_128
1889	ROW_129
1890	ROW_130
1891	ROW_131
1892	ROW_132
1893	ROW_133
1894	ROW_134
1895	ROW_135
1896	ROW_136
1897	ROW_137
1898	ROW_138
1899	ROW_139
1900	ROW_140
1901	ROW_141
1902	ROW_142
1903	ROW_143
1904	ROW_144
1905	ROW_145
1906	ROW_146
1907	ROW_147
1908	ROW_148
1909	ROW_149
1910	ROW_150
1911	ROW_151
1912	ROW_152
1913	ROW_153
1914	ROW_154
1915	ROW_155
1916	ROW_156
1917	ROW_157
1918	ROW_158
1919	ROW_159
1920	NA
1921	ROW_160
1922	ROW_161

Register Address	Label
1923	ROW_162
1924	ROW_163
1925	ROW_164
1926	ROW_165
1927	ROW_166
1928–1935[a]	

[a] All the reserved registers between the data areas in the map may also be assigned to the user registers with a label RES_xxxx where xxxx is the register number.

Reading History Data Using Modbus

Through use of 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 1692 (when event number zero is written by accident for the first time, the relay treats selected event number as one). Then read the history of the specific event number you requested from the registers shown in the Historical Data section of the Modbus Register Map (*Table E.34*). After a power cycle, the history data registers show the history data corresponding to the latest event. This information updates dynamically; as whenever there is a new event, the history data registers update automatically with new event data. If specific event number data have been retrieved using a write to the EVENT LOG SEL register, the event data registers stay frozen with that specific event history. These registers return to the free running latest event history data mode when a zero is written to the event selection register from a prior nonzero selection.

Modbus Register Map

NOTE: Certain Modbus quantities are reported as 32-bit numbers; however, Modbus registers are only 16-bit. This results in displaying the Modbus quantities in a LOW and HIGH register. To determine the 32-bit number concatenate the LOW register to the end of the HIGH register. For example, if the HIGH register value is 0x5ADC and the LOW register value is 0xF43B, the resulting 32-bit value is 0x5ADCF43B.

Table E.34 lists the data available in the Modbus interface and their description, range, and scaling information. The table also shows the parameter number for access through use of 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 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
0 (R)	Reserved[c]						100
User Map Register							
1 (R/W)	USER REG #1		280	1935	320	1	101
	•						
	•						
	•						
125 (R/W)	USER REG #125		280	1935	1920	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]						351–360

Table E.34 Modbus Register Map[a] (Sheet 2 of 38)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
Reset Settings								
261	(R/W)	RESET DATA Bit 0 = TRIP (TARGET) 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 Bit 10 = RST BKMON DATA Bits 11–15 = Reserved		0	2047	0	0	361
262–269	(R)	Reserved[c]						362–369
Date/Time Set								
270	(R/W)	SET SEC		0	5999	0	0	370
271	(R/W)	SET MIN		0	59	0	0	371
272	(R/W)	SET HOUR		0	23	0	0	372
273	(R/W)	SET DAY		1	31	1	0	373
274	(R/W)	SET MONTH		1	12	1	0	374
275	(R/W)	SET YEAR		2000	9999	2000	0	375
276–279	(R)	Reserved[c]						376–379
Device Status 0 = OK 1 = WARN 2 = FAIL								
280	(R)	FPGA STATUS		0	2	0	1	380
281	(R)	GPSB STATUS		0	2	0	1	381
282	(R)	HMI STATUS		0	2	0	1	382
283	(R)	RAM STATUS		0	2	0	1	383
284	(R)	ROM STATUS		0	2	0	1	384
285	(R)	CR_RAM STATUS		0	2	0	1	385
286	(R)	NON_VOL STATUS		0	2	0	1	386
287	(R)	CLOCK STATUS		0	2	0	1	387
288	(R)	CID FILE STATUS		0	2	0	1	388
289	(R)	RTD STATUS		0	2	0	1	389
290	(R)	+0.9V STATUS		0	2	0	1	390
291	(R)	+1.2V STATUS		0	2	0	1	391
292	(R)	+1.5V STATUS		0	2	0	1	392
293	(R)	+1.8V STATUS		0	2	0	1	393
294	(R)	+2.5V STATUS		0	2	0	1	394
295	(R)	+3.3V STATUS		0	2	0	1	395
296	(R)	+3.75V STATUS		0	2	0	1	396
297	(R)	+5.0V STATUS		0	2	0	1	397
298	(R)	-1.25V STATUS		0	2	0	1	398
299	(R)	-5.0V STATUS		0	2	0	1	399
300	(R)	CLK_BAT STATUS		0	2	0	1	400
301	(R)	CARD C STATUS		0	2	0	1	401
302	(R)	CARD D STATUS		0	2	0	1	402

Table E.34 Modbus Register Map[a] (Sheet 3 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
303 (R)	CARD E STATUS		0	2	0	1	403
304 (R)	CARD Z STATUS		0	2	0	1	404
305 (R)	IA STATUS		0	2	0	1	405
306 (R)	IB STATUS		0	2	0	1	406
307 (R)	IC STATUS		0	2	0	1	407
308 (R)	IN STATUS		0	2	0	1	408
309 (R)	VA STATUS		0	2	0	1	409
310 (R)	VB STATUS		0	2	0	1	410
311 (R)	VC STATUS		0	2	0	1	411
312 (R)	VS STATUS		0	2	0	1	412
313 (R)	RELAY STATUS 0 = ENABLED 1 = DISABLED		0	1	0	1	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]						416–419
Current Data							
320 (R)	IA CURRENT	A	0	65535	0	1	420
321 (R)	IA ANGLE	deg	-1800	1800	0	0.1	421
322 (R)	IB CURRENT	A	0	65535	0	1	422
323 (R)	IB ANGLE	deg	-1800	1800	0	0.1	423
324 (R)	IC CURRENT	A	0	65535	0	1	424
325 (R)	IC ANGLE	deg	-1800	1800	0	0.1	425
326 (R)	IN CURRENT	A	0	65535	0	1	426
327 (R)	IN ANGLE	deg	-1800	1800	0	0.1	427
328 (R)	IG CURRENT	A	0	65535	0	1	428
329 (R)	IG ANGLE	deg	-1800	1800	0	0.1	429
330 (R)	I1 CURRENT	A	0	65535	0	1	430
331 (R)	I1 ANGLE	deg	-1800	1800	0	0.1	431
332 (R)	AVERAGE CURRENT	A	0	65535	0	1	432
333 (R)	NEG-SEQ CURR 3I2	A	0	65535	0	1	433
334 (R)	CURRENT IMBAL	%	0	1000	0	0.01	434
Voltage Data							
335 (R)	VAB	kV	0	65535	0	0.01	435
336 (R)	VAB ANGLE	deg	-1800	1800	0	0.1	436
337 (R)	VBC	kV	0	65535	0	0.01	437
338 (R)	VBC ANGLE	deg	-1800	1800	0	0.1	438
339 (R)	VCA	kV	0	65535	0	0.01	439
340 (R)	VCA ANGLE	deg	-1800	1800	0	0.1	440
341 (R)	AVERAGE LINE[d]	kV	0	65535	0	0.01	441
342 (R)	V1	kV	0	65535	0	0.01	442
343 (R)	V1 ANGLE	deg	-1800	1800	0	0.1	443
344 (R)	VAN	kV	0	65535	0	0.01	444
345 (R)	VAN ANGLE	deg	-1800	1800	0	0.1	445
346 (R)	VBN	kV	0	65535	0	0.01	446
347 (R)	VBN ANGLE	deg	-1800	1800	0	0.1	447

Table E.34 Modbus Register Map[a] (Sheet 4 of 38)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
348	(R)	VCN	kV	0	65535	0	0.01	448
349	(R)	VCN ANGLE	deg	-1800	1800	0	0.1	449
350	(R)	VG	kV	0	65535	0	0.01	450
351	(R)	VG ANGLE	deg	-1800	1800	0	0.1	451
352	(R)	AVERAGE PHASE[e]	kV	0	65535	0	0.01	452
353	(R)	NEG-SEQ VOLT 3V2	kV	0	65535	0	0.01	453
354	(R)	VOLTAGE IMBAL	%	0	1000	0	0.1	454
355	(R)	VSN	kV	0	65535	0	0.01	455
356	(R)	VSN ANGLE	deg	-1800	1800	0	0.1	456
357	(R)	VDC	V	0	65535	0	0.1	457
358–359	(R)	Reserved[c]						458–459
Power Data								
360	(R)	A REAL POWER	kW	-32768	32767	0	1	460
361	(R)	A REACTIVE POWER	kVAR	-32768	32767	0	1	461
362	(R)	A APPARENT POWER	kVA	-32768	32767	0	1	462
363	(R)	A POWER FACTOR		-100	100	0	0.01	463
364	(R)	B REAL POWER	kW	-32768	32767	0	1	464
365	(R)	B REACTIVE POWER	kVAR	-32768	32767	0	1	465
366	(R)	B APPARENT POWER	kVA	-32768	32767	0	1	466
367	(R)	B POWER FACTOR		-100	100	0	0.01	467
368	(R)	C REAL POWER	kW	-32768	32767	0	1	468
369	(R)	C REACTIVE POWER	kVAR	-32768	32767	0	1	469
370	(R)	C APPARENT POWER	kVA	-32768	32767	0	1	470
371	(R)	C POWER FACTOR		-100	100	0	0.01	471
372	(R)	REAL POWER	kW	-32768	32767	0	1	472
373	(R)	REACTIVE POWER	kVAR	-32768	32767	0	1	473
374	(R)	APPARENT POWER	kVA	-32768	32767	0	1	474
375	(R)	POWER FACTOR		-100	100	0	0.01	475
376	(R)	FREQUENCY	Hz	2000	7000	6000	0.01	476
377	(R)	SYNC FREQUENCY	Hz	2000	7000	6000	0.01	477
378–379	(R)	Reserved[c]						478–479
Energy Data								
380	(R)	MWH3PI HI	MWhr	0	65535	0	0.001	480
381	(R)	MWH3PI LO	MWhr	0	65535	0	0.001	481
382	(R)	MWH3PO HI	MWhr	0	65535	0	0.001	482
383	(R)	MWH3PO LO	MWhr	0	65535	0	0.001	483
384	(R)	MVARH3PI HI	MVRh	0	65535	0	0.001	484
385	(R)	MVARH3PI LO	MVRh	0	65535	0	0.001	485
386	(R)	MVARH3PO HI	MVRh	0	65535	0	0.001	486
387	(R)	MVARH3PO LO	MVRh	0	65535	0	0.001	487
388	(R)	MVAH3P HI	MVAh	0	65535	0	0.001	488
389	(R)	MVAH3P LO	MVAh	0	65535	0	0.001	489
390	(R)	LAST RST TIME-ss		0	5999	0	0.01	490
391	(R)	LAST RST TIME-mm		0	59	0	1	491
392	(R)	LAST RST TIME-hh		0	23	0	1	492

Table E.34 Modbus Register Map[a] (Sheet 5 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
393 (R)	LAST RST DATE-dd		1	31	1	1	493
394 (R)	LAST RST DATE-mm		1	12	1	1	494
395 (R)	LAST RST DATE-yy		2000	9999	2000	1	495
396–399 (R)	Reserved[c]						496–499
RTD Data							
400 (R)	MAX WINDING RTD 7FFFh = Open 8000h = Short 7FFCh = Comm Fail 7FF8h = Stat Fail 7FFEh = Fail 7FF0h = NA	°C	-32768	32767	0	1	500
401 (R)	MAX BEARING RTD	°C	-32768	32767	0	1	501
402 (R)	MAX AMBIENT RTD	°C	-32768	32767	0	1	502
403 (R)	MAX OTHER RTD	°C	-32768	32767	0	1	503
404 (R)	RTD1	°C	-32768	32767	0	1	504
405 (R)	RTD2	°C	-32768	32767	0	1	505
406 (R)	RTD3	°C	-32768	32767	0	1	506
407 (R)	RTD4	°C	-32768	32767	0	1	507
408 (R)	RTD5	°C	-32768	32767	0	1	508
409 (R)	RTD6	°C	-32768	32767	0	1	509
410 (R)	RTD7	°C	-32768	32767	0	1	510
411 (R)	RTD8	°C	-32768	32767	0	1	511
412 (R)	RTD9	°C	-32768	32767	0	1	512
413 (R)	RTD10	°C	-32768	32767	0	1	513
414 (R)	RTD11	°C	-32768	32767	0	1	514
415 (R)	RTD12	°C	-32768	32767	0	1	515
416–419 (R)	Reserved[c]						516–519
Light Meter Data							
420 (R)	LS 1	%	0	1000	0	0.1	520
421 (R)	LS 2	%	0	1000	0	0.1	521
422 (R)	LS 3	%	0	1000	0	0.1	522
423 (R)	LS 4	%	0	1000	0	0.1	523
424 (R)	LS 5	%	0	1000	0	0.1	524
425 (R)	LS 6	%	0	1000	0	0.1	525
426 (R)	LS 7	%	0	1000	0	0.1	526
427 (R)	LS 8	%	0	1000	0	0.1	527
428–429 (R)	Reserved[c]						528–529
RMS Data							
430 (R)	IA RMS	A	0	65535	0	1	530
431 (R)	IB RMS	A	0	65535	0	1	531
432 (R)	IC RMS	A	0	65535	0	1	532
433 (R)	IN RMS	A	0	65535	0	1	533
434 (R)	VA RMS	kV	0	65535	0	0.01	534
435 (R)	VB RMS	kV	0	65535	0	0.01	535
436 (R)	VC RMS	kV	0	65535	0	0.01	536
437 (R)	VAB RMS	kV	0	65535	0	0.01	537

Table E.34 Modbus Register Map[a] (Sheet 6 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
438 (R)	VBC RMS	kV	0	65535	0	0.01	538
439 (R)	VCA RMS	kV	0	65535	0	0.01	539
440 (R)	VS RMS	kV	0	65535	0	0.01	540
441–449 (R)	Reserved[c]						541–549
Demand Data							
450 (R)	IA DEMAND	A	0	65535	0	1	550
451 (R)	IB DEMAND	A	0	65535	0	1	551
452 (R)	IC DEMAND	A	0	65535	0	1	552
453 (R)	IG DEMAND	A	0	65535	0	1	553
454 (R)	3I2 DEMAND	A	0	65535	0	1	554
455 (R)	IA PEAK DEMAND	A	0	65535	0	1	555
456 (R)	IB PEAK DEMAND	A	0	65535	0	1	556
457 (R)	IC PEAK DEMAND	A	0	65535	0	1	557
458 (R)	IG PEAK DEMAND	A	0	65535	0	1	558
459 (R)	3I2 PEAK DEMAND	A	0	65535	0	1	559
460 (R)	PEAKD RST TIM-ss		0	5999	0	0.01	560
461 (R)	PEAKD RST TIM-mm		0	59	0	1	561
462 (R)	PEAKD RST TIM-hh		0	23	0	1	562
463 (R)	PEAKD RST DAT-dd		1	31	1	1	563
464 (R)	PEAKD RST DAT-mm		1	12	1	1	564
465 (R)	PEAKD RST DAT-yy		2000	9999	2000	1	565
466–469 (R)	Reserved[c]						566–569
Breaker Monitor							
470 (R)	RLY TRIPS		0	65535	0	1	570
471 (R)	EXT TRIPS		0	65535	0	1	571
472 (R)	IA RLY	kA	0	65535	0	1	572
473 (R)	IA EXT	kA	0	65535	0	1	573
474 (R)	IB RLY	kA	0	65535	0	1	574
475 (R)	IB EXT	kA	0	65535	0	1	575
476 (R)	IC RLY	kA	0	65535	0	1	576
477 (R)	IC EXT	kA	0	65535	0	1	577
478 (R)	A WEAR	%	0	100	0	1	578
479 (R)	B WEAR	%	0	100	0	1	579
480 (R)	C WEAR	%	0	100	0	1	580
481 (R)	BRKR RST TIM-ss		0	5999	0	1	581
482 (R)	BRKR RST TIM-mm		0	59	0	1	582
483 (R)	BRKR RST TIM-hh		0	23	0	1	583
484 (R)	BRKR RST DAT-dd		1	31	1	1	584
485 (R)	BRKR RST DAT-mm		1	12	1	1	585
486 (R)	BRKR RST DAT-yy		2000	9999	2000	1	586
487–489 (R)	Reserved[c]						587–589
Analog Input Data							
490 (R)	AI301 - HI	EU	-32768	32767	0	0.001	590
491 (R)	AI301 - LO	EU	-32768	32767	0	0.001	591
492 (R)	AI302 - HI	EU	-32768	32767	0	0.001	592

Table E.34 Modbus Register Map[a] (Sheet 7 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
493 (R)	AI302 - LO	EU	-32768	32767	0	0.001	593
494 (R)	AI303 - HI	EU	-32768	32767	0	0.001	594
495 (R)	AI303 - LO	EU	-32768	32767	0	0.001	595
496 (R)	AI304 - HI	EU	-32768	32767	0	0.001	596
497 (R)	AI304 - LO	EU	-32768	32767	0	0.001	597
498 (R)	AI305 - HI	EU	-32768	32767	0	0.001	598
499 (R)	AI305 - LO	EU	-32768	32767	0	0.001	599
500 (R)	AI306 - HI	EU	-32768	32767	0	0.001	600
501 (R)	AI306 - LO	EU	-32768	32767	0	0.001	601
502 (R)	AI307 - HI	EU	-32768	32767	0	0.001	602
503 (R)	AI307 - LO	EU	-32768	32767	0	0.001	603
504 (R)	AI308 - HI	EU	-32768	32767	0	0.001	604
505 (R)	AI308 - LO	EU	-32768	32767	0	0.001	605
506 (R)	AI401 - HI	EU	-32768	32767	0	0.001	606
507 (R)	AI401 - LO	EU	-32768	32767	0	0.001	607
508 (R)	AI402 - HI	EU	-32768	32767	0	0.001	608
509 (R)	AI402 - LO	EU	-32768	32767	0	0.001	609
510 (R)	AI403 - HI	EU	-32768	32767	0	0.001	610
511 (R)	AI403 - LO	EU	-32768	32767	0	0.001	611
512 (R)	AI404 - HI	EU	-32768	32767	0	0.001	612
513 (R)	AI404 - LO	EU	-32768	32767	0	0.001	613
514 (R)	AI405 - HI	EU	-32768	32767	0	0.001	614
515 (R)	AI405 - LO	EU	-32768	32767	0	0.001	615
516 (R)	AI406 - HI	EU	-32768	32767	0	0.001	616
517 (R)	AI406 - LO	EU	-32768	32767	0	0.001	617
518 (R)	AI407 - HI	EU	-32768	32767	0	0.001	618
519 (R)	AI407 - LO	EU	-32768	32767	0	0.001	619
520 (R)	AI408 - HI	EU	-32768	32767	0	0.001	620
521 (R)	AI408 - LO	EU	-32768	32767	0	0.001	621
522 (R)	AI501 - HI	EU	-32768	32767	0	0.001	622
523 (R)	AI501 - LO	EU	-32768	32767	0	0.001	623
524 (R)	AI502 - HI	EU	-32768	32767	0	0.001	624
525 (R)	AI502 - LO	EU	-32768	32767	0	0.001	625
526 (R)	AI503 - HI	EU	-32768	32767	0	0.001	626
527 (R)	AI503 - LO	EU	-32768	32767	0	0.001	627
528 (R)	AI504 - HI	EU	-32768	32767	0	0.001	628
529 (R)	AI504 - LO	EU	-32768	32767	0	0.001	629
530 (R)	AI505 - HI	EU	-32768	32767	0	0.001	630
531 (R)	AI505 - LO	EU	-32768	32767	0	0.001	631
532 (R)	AI506 - HI	EU	-32768	32767	0	0.001	632
533 (R)	AI506 - LO	EU	-32768	32767	0	0.001	633
534 (R)	AI507 - HI	EU	-32768	32767	0	0.001	634
535 (R)	AI507 - LO	EU	-32768	32767	0	0.001	635

Table E.34 Modbus Register Map[a] (Sheet 8 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
536 (R)	AI508 - HI	EU	-32768	32767	0	0.001	636
537 (R)	AI508 - LO	EU	-32768	32767	0	0.001	637
538–539 (R)	Reserved[c]						638–639
Math Variables							
540 (R)	MV01 - HI		-32768	32767	0	0.01	640
541 (R)	MV01 - LO		-32768	32767	0	0.01	641
542 (R)	MV02 - HI		-32768	32767	0	0.01	642
543 (R)	MV02 - LO		-32768	32767	0	0.01	643
544 (R)	MV03 - HI		-32768	32767	0	0.01	644
545 (R)	MV03 - LO		-32768	32767	0	0.01	645
546 (R)	MV04 - HI		-32768	32767	0	0.01	646
547 (R)	MV04 - LO		-32768	32767	0	0.01	647
548 (R)	MV05 - HI		-32768	32767	0	0.01	648
549 (R)	MV05 - LO		-32768	32767	0	0.01	649
550 (R)	MV06 - HI		-32768	32767	0	0.01	650
551 (R)	MV06 - LO		-32768	32767	0	0.01	651
552 (R)	MV07 - HI		-32768	32767	0	0.01	652
553 (R)	MV07 - LO		-32768	32767	0	0.01	653
554 (R)	MV08 - HI		-32768	32767	0	0.01	654
555 (R)	MV08 - LO		-32768	32767	0	0.01	655
556 (R)	MV09 - HI		-32768	32767	0	0.01	656
557 (R)	MV09 - LO		-32768	32767	0	0.01	657
558 (R)	MV10 - HI		-32768	32767	0	0.01	658
559 (R)	MV10 - LO		-32768	32767	0	0.01	659
560 (R)	MV11 - HI		-32768	32767	0	0.01	660
561 (R)	MV11 - LO		-32768	32767	0	0.01	661
562 (R)	MV12 - HI		-32768	32767	0	0.01	662
563 (R)	MV12 - LO		-32768	32767	0	0.01	663
564 (R)	MV13 - HI		-32768	32767	0	0.01	664
565 (R)	MV13 - LO		-32768	32767	0	0.01	665
566 (R)	MV14 - HI		-32768	32767	0	0.01	666
567 (R)	MV14 - LO		-32768	32767	0	0.01	667
568 (R)	MV15 - HI		-32768	32767	0	0.01	668
569 (R)	MV15 - LO		-32768	32767	0	0.01	669
570 (R)	MV16 - HI		-32768	32767	0	0.01	670
571 (R)	MV16 - LO		-32768	32767	0	0.01	671
572 (R)	MV17 - HI		-32768	32767	0	0.01	672
573 (R)	MV17 - LO		-32768	32767	0	0.01	673
574 (R)	MV18 - HI		-32768	32767	0	0.01	674
575 (R)	MV18 - LO		-32768	32767	0	0.01	675
576 (R)	MV19 - HI		-32768	32767	0	0.01	676
577 (R)	MV19 - LO		-32768	32767	0	0.01	677
578 (R)	MV20 - HI		-32768	32767	0	0.01	678
579 (R)	MV20 - LO		-32768	32767	0	0.01	679
580 (R)	MV21 - HI		-32768	32767	0	0.01	680

Table E.34 Modbus Register Map[a] (Sheet 9 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
581 (R)	MV21 - LO		-32768	32767	0	0.01	681
582 (R)	MV22 - HI		-32768	32767	0	0.01	682
583 (R)	MV22 - LO		-32768	32767	0	0.01	683
584 (R)	MV23 - HI		-32768	32767	0	0.01	684
585 (R)	MV23 - LO		-32768	32767	0	0.01	685
586 (R)	MV24 - HI		-32768	32767	0	0.01	686
587 (R)	MV24 - LO		-32768	32767	0	0.01	687
588 (R)	MV25 - HI		-32768	32767	0	0.01	688
589 (R)	MV25 - LO		-32768	32767	0	0.01	689
590 (R)	MV26 - HI		-32768	32767	0	0.01	690
591 (R)	MV26 - LO		-32768	32767	0	0.01	691
592 (R)	MV27 - HI		-32768	32767	0	0.01	692
593 (R)	MV27 - LO		-32768	32767	0	0.01	693
594 (R)	MV28 - HI		-32768	32767	0	0.01	694
595 (R)	MV28 - LO		-32768	32767	0	0.01	695
596 (R)	MV29 - HI		-32768	32767	0	0.01	696
597 (R)	MV29 - LO		-32768	32767	0	0.01	697
598 (R)	MV30 - HI		-32768	32767	0	0.01	698
599 (R)	MV30 - LO		-32768	32767	0	0.01	699
600 (R)	MV31 - HI		-32768	32767	0	0.01	700
601 (R)	MV31 - LO		-32768	32767	0	0.01	701
602 (R)	MV32 - HI		-32768	32767	0	0.01	702
603 (R)	MV32 - LO		-32768	32767	0	0.01	703
Device Counters							
604–635 (R)	COUNTER SC01–COUNTER SC32		0	65000	0	0.01	704–735
636–639 (R)	Reserved[c]						736–739
Remote Analog Data							
640 (R/W)	RA001 (0:UW)		-32768	32767	0	0.01	740
641 (R/W)	RA001 (1:LW)		-32768	32767	0	0.01	741
642 (R/W)	RA002 (0:UW)		-32768	32767	0	0.01	742
643 (R/W)	RA002 (1:LW)		-32768	32767	0	0.01	743
644 (R/W)	RA003 (0:UW)		-32768	32767	0	0.01	744
645 (R/W)	RA003 (1:LW)		-32768	32767	0	0.01	745
646 (R/W)	RA004 (0:UW)		-32768	32767	0	0.01	746
647 (R/W)	RA004 (1:LW)		-32768	32767	0	0.01	747
648 (R/W)	RA005 (0:UW)		-32768	32767	0	0.01	748
649 (R/W)	RA005 (1:LW)		-32768	32767	0	0.01	749
650 (R/W)	RA006 (0:UW)		-32768	32767	0	0.01	750
651 (R/W)	RA006 (1:LW)		-32768	32767	0	0.01	751
652 (R/W)	RA007 (0:UW)		-32768	32767	0	0.01	752
653 (R/W)	RA007 (1:LW)		-32768	32767	0	0.01	753
654 (R/W)	RA008 (0:UW)		-32768	32767	0	0.01	754
655 (R/W)	RA008 (1:LW)		-32768	32767	0	0.01	755
656 (R/W)	RA009 (0:UW)		-32768	32767	0	0.01	756
657 (R/W)	RA009 (1:LW)		-32768	32767	0	0.01	757

Table E.34 Modbus Register Map[a] (Sheet 10 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
658 (R/W)	RA010 (0:UW)		-32768	32767	0	0.01	758
659 (R/W)	RA010 (1:LW)		-32768	32767	0	0.01	759
660 (R/W)	RA011 (0:UW)		-32768	32767	0	0.01	760
661 (R/W)	RA011 (1:LW)		-32768	32767	0	0.01	761
662 (R/W)	RA012 (0:UW)		-32768	32767	0	0.01	762
663 (R/W)	RA012 (1:LW)		-32768	32767	0	0.01	763
664 (R/W)	RA013 (0:UW)		-32768	32767	0	0.01	764
665 (R/W)	RA013 (1:LW)		-32768	32767	0	0.01	765
666 (R/W)	RA014 (0:UW)		-32768	32767	0	0.01	766
667 (R/W)	RA014 (1:LW)		-32768	32767	0	0.01	767
668 (R/W)	RA015 (0:UW)		-32768	32767	0	0.01	768
669 (R/W)	RA015 (1:LW)		-32768	32767	0	0.01	769
670 (R/W)	RA016 (0:UW)		-32768	32767	0	0.01	770
671 (R/W)	RA016 (1:LW)		-32768	32767	0	0.01	771
672 (R/W)	RA017 (0:UW)		-32768	32767	0	0.01	772
673 (R/W)	RA017 (1:LW)		-32768	32767	0	0.01	773
674 (R/W)	RA018 (0:UW)		-32768	32767	0	0.01	774
675 (R/W)	RA018 (1:LW)		-32768	32767	0	0.01	775
676 (R/W)	RA019 (0:UW)		-32768	32767	0	0.01	776
677 (R/W)	RA019 (1:LW)		-32768	32767	0	0.01	777
678 (R/W)	RA020 (0:UW)		-32768	32767	0	0.01	778
679 (R/W)	RA020 (1:LW)		-32768	32767	0	0.01	779
680 (R/W)	RA021 (0:UW)		-32768	32767	0	0.01	780
681 (R/W)	RA021 (1:LW)		-32768	32767	0	0.01	781
682 (R/W)	RA022 (0:UW)		-32768	32767	0	0.01	782
683 (R/W)	RA022 (1:LW)		-32768	32767	0	0.01	783
684 (R/W)	RA023 (0:UW)		-32768	32767	0	0.01	784
685 (R/W)	RA023 (1:LW)		-32768	32767	0	0.01	785
686 (R/W)	RA024 (0:UW)		-32768	32767	0	0.01	786
687 (R/W)	RA024 (1:LW)		-32768	32767	0	0.01	787
688 (R/W)	RA025 (0:UW)		-32768	32767	0	0.01	788
689 (R/W)	RA025 (1:LW)		-32768	32767	0	0.01	789
690 (R/W)	RA026 (0:UW)		-32768	32767	0	0.01	790
691 (R/W)	RA026 (1:LW)		-32768	32767	0	0.01	791
692 (R/W)	RA027 (0:UW)		-32768	32767	0	0.01	792
693 (R/W)	RA027 (1:LW)		-32768	32767	0	0.01	793
694 (R/W)	RA028 (0:UW)		-32768	32767	0	0.01	794
695 (R/W)	RA028 (1:LW)		-32768	32767	0	0.01	795
696 (R/W)	RA029 (0:UW)		-32768	32767	0	0.01	796
697 (R/W)	RA029 (1:LW)		-32768	32767	0	0.01	797
698 (R/W)	RA030 (0:UW)		-32768	32767	0	0.01	798
699 (R/W)	RA030 (1:LW)		-32768	32767	0	0.01	799
700 (R/W)	RA031 (0:UW)		-32768	32767	0	0.01	800
701 (R/W)	RA031 (1:LW)		-32768	32767	0	0.01	801
702 (R/W)	RA032 (0:UW)		-32768	32767	0	0.01	802

Table E.34 Modbus Register Map[a] (Sheet 11 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
703 (R/W)	RA032 (1:LW)		-32768	32767	0	0.01	803
704 (R/W)	RA033 (0:UW)		-32768	32767	0	0.01	804
705 (R/W)	RA033 (1:LW)		-32768	32767	0	0.01	805
706 (R/W)	RA034 (0:UW)		-32768	32767	0	0.01	806
707 (R/W)	RA034 (1:LW)		-32768	32767	0	0.01	807
708 (R/W)	RA035 (0:UW)		-32768	32767	0	0.01	808
709 (R/W)	RA035 (1:LW)		-32768	32767	0	0.01	809
710 (R/W)	RA036 (0:UW)		-32768	32767	0	0.01	810
711 (R/W)	RA036 (1:LW)		-32768	32767	0	0.01	811
712 (R/W)	RA037 (0:UW)		-32768	32767	0	0.01	812
713 (R/W)	RA037 (1:LW)		-32768	32767	0	0.01	813
714 (R/W)	RA038 (0:UW)		-32768	32767	0	0.01	814
715 (R/W)	RA038 (1:LW)		-32768	32767	0	0.01	815
716 (R/W)	RA039 (0:UW)		-32768	32767	0	0.01	816
717 (R/W)	RA039 (1:LW)		-32768	32767	0	0.01	817
718 (R/W)	RA040 (0:UW)		-32768	32767	0	0.01	818
719 (R/W)	RA040 (1:LW)		-32768	32767	0	0.01	819
720 (R/W)	RA041 (0:UW)		-32768	32767	0	0.01	820
721 (R/W)	RA041 (1:LW)		-32768	32767	0	0.01	821
722 (R/W)	RA042 (0:UW)		-32768	32767	0	0.01	822
723 (R/W)	RA042 (1:LW)		-32768	32767	0	0.01	823
724 (R/W)	RA043 (0:UW)		-32768	32767	0	0.01	824
725 (R/W)	RA043 (1:LW)		-32768	32767	0	0.01	825
726 (R/W)	RA044 (0:UW)		-32768	32767	0	0.01	826
727 (R/W)	RA044 (1:LW)		-32768	32767	0	0.01	827
728 (R/W)	RA045 (0:UW)		-32768	32767	0	0.01	828
729 (R/W)	RA045 (1:LW)		-32768	32767	0	0.01	829
730 (R/W)	RA046 (0:UW)		-32768	32767	0	0.01	830
731 (R/W)	RA046 (1:LW)		-32768	32767	0	0.01	831
732 (R/W)	RA047 (0:UW)		-32768	32767	0	0.01	832
733 (R/W)	RA047 (1:LW)		-32768	32767	0	0.01	833
734 (R/W)	RA048 (0:UW)		-32768	32767	0	0.01	834
735 (R/W)	RA048 (1:LW)		-32768	32767	0	0.01	835
736 (R/W)	RA049 (0:UW)		-32768	32767	0	0.01	836
737 (R/W)	RA049 (1:LW)		-32768	32767	0	0.01	837
738 (R/W)	RA050 (0:UW)		-32768	32767	0	0.01	838
739 (R/W)	RA050 (1:LW)		-32768	32767	0	0.01	839
740 (R/W)	RA051 (0:UW)		-32768	32767	0	0.01	840
741 (R/W)	RA051 (1:LW)		-32768	32767	0	0.01	841
742 (R/W)	RA052 (0:UW)		-32768	32767	0	0.01	842
743 (R/W)	RA052 (1:LW)		-32768	32767	0	0.01	843
744 (R/W)	RA053 (0:UW)		-32768	32767	0	0.01	844
745 (R/W)	RA053 (1:LW)		-32768	32767	0	0.01	845
746 (R/W)	RA054 (0:UW)		-32768	32767	0	0.01	846
747 (R/W)	RA054 (1:LW)		-32768	32767	0	0.01	847

Table E.34 Modbus Register Map[a] (Sheet 12 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
748 (R/W)	RA055 (0:UW)		-32768	32767	0	0.01	848
749 (R/W)	RA055 (1:LW)		-32768	32767	0	0.01	849
750 (R/W)	RA056 (0:UW)		-32768	32767	0	0.01	850
751 (R/W)	RA056 (1:LW)		-32768	32767	0	0.01	851
752 (R/W)	RA057 (0:UW)		-32768	32767	0	0.01	852
753 (R/W)	RA057 (1:LW)		-32768	32767	0	0.01	853
754 (R/W)	RA058 (0:UW)		-32768	32767	0	0.01	854
755 (R/W)	RA058 (1:LW)		-32768	32767	0	0.01	855
756 (R/W)	RA059 (0:UW)		-32768	32767	0	0.01	856
757 (R/W)	RA059 (1:LW)		-32768	32767	0	0.01	857
758 (R/W)	RA060 (0:UW)		-32768	32767	0	0.01	858
759 (R/W)	RA060 (1:LW)		-32768	32767	0	0.01	859
760 (R/W)	RA061 (0:UW)		-32768	32767	0	0.01	860
761 (R/W)	RA061 (1:LW)		-32768	32767	0	0.01	861
762 (R/W)	RA062 (0:UW)		-32768	32767	0	0.01	862
763 (R/W)	RA062 (1:LW)		-32768	32767	0	0.01	863
764 (R/W)	RA063 (0:UW)		-32768	32767	0	0.01	864
765 (R/W)	RA063 (1:LW)		-32768	32767	0	0.01	865
766 (R/W)	RA064 (0:UW)		-32768	32767	0	0.01	866
767 (R/W)	RA064 (1:LW)		-32768	32767	0	0.01	867
768 (R/W)	RA065 (0:UW)		-32768	32767	0	0.01	868
769 (R/W)	RA065 (1:LW)		-32768	32767	0	0.01	869
770 (R/W)	RA066 (0:UW)		-32768	32767	0	0.01	870
771 (R/W)	RA066 (1:LW)		-32768	32767	0	0.01	871
772 (R/W)	RA067 (0:UW)		-32768	32767	0	0.01	872
773 (R/W)	RA067 (1:LW)		-32768	32767	0	0.01	873
774 (R/W)	RA068 (0:UW)		-32768	32767	0	0.01	874
775 (R/W)	RA068 (1:LW)		-32768	32767	0	0.01	875
776 (R/W)	RA069 (0:UW)		-32768	32767	0	0.01	876
777 (R/W)	RA069 (1:LW)		-32768	32767	0	0.01	877
778 (R/W)	RA070 (0:UW)		-32768	32767	0	0.01	878
779 (R/W)	RA070 (1:LW)		-32768	32767	0	0.01	879
780 (R/W)	RA071 (0:UW)		-32768	32767	0	0.01	880
781 (R/W)	RA071 (1:LW)		-32768	32767	0	0.01	881
782 (R/W)	RA072 (0:UW)		-32768	32767	0	0.01	882
783 (R/W)	RA072 (1:LW)		-32768	32767	0	0.01	883
784 (R/W)	RA073 (0:UW)		-32768	32767	0	0.01	884
785 (R/W)	RA073 (1:LW)		-32768	32767	0	0.01	885
786 (R/W)	RA074 (0:UW)		-32768	32767	0	0.01	886
787 (R/W)	RA074 (1:LW)		-32768	32767	0	0.01	887
788 (R/W)	RA075 (0:UW)		-32768	32767	0	0.01	888
789 (R/W)	RA075 (1:LW)		-32768	32767	0	0.01	889
790 (R/W)	RA076 (0:UW)		-32768	32767	0	0.01	890
791 (R/W)	RA076 (1:LW)		-32768	32767	0	0.01	891
792 (R/W)	RA077 (0:UW)		-32768	32767	0	0.01	892

Table E.34 Modbus Register Map[a] (Sheet 13 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
793 (R/W)	RA077 (1:LW)		-32768	32767	0	0.01	893
794 (R/W)	RA078 (0:UW)		-32768	32767	0	0.01	894
795 (R/W)	RA078 (1:LW)		-32768	32767	0	0.01	895
796 (R/W)	RA079 (0:UW)		-32768	32767	0	0.01	896
797 (R/W)	RA079 (1:LW)		-32768	32767	0	0.01	897
798 (R/W)	RA080 (0:UW)		-32768	32767	0	0.01	898
799 (R/W)	RA080 (1:LW)		-32768	32767	0	0.01	899
800 (R/W)	RA081 (0:UW)		-32768	32767	0	0.01	900
801 (R/W)	RA081 (1:LW)		-32768	32767	0	0.01	901
802 (R/W)	RA082 (0:UW)		-32768	32767	0	0.01	902
803 (R/W)	RA082 (1:LW)		-32768	32767	0	0.01	903
804 (R/W)	RA083 (0:UW)		-32768	32767	0	0.01	904
805 (R/W)	RA083 (1:LW)		-32768	32767	0	0.01	905
806 (R/W)	RA084 (0:UW)		-32768	32767	0	0.01	906
807 (R/W)	RA084 (1:LW)		-32768	32767	0	0.01	907
808 (R/W)	RA085 (0:UW)		-32768	32767	0	0.01	908
809 (R/W)	RA085 (1:LW)		-32768	32767	0	0.01	909
810 (R/W)	RA086 (0:UW)		-32768	32767	0	0.01	910
811 (R/W)	RA086 (1:LW)		-32768	32767	0	0.01	911
812 (R/W)	RA087 (0:UW)		-32768	32767	0	0.01	912
813 (R/W)	RA087 (1:LW)		-32768	32767	0	0.01	913
814 (R/W)	RA088 (0:UW)		-32768	32767	0	0.01	914
815 (R/W)	RA088 (1:LW)		-32768	32767	0	0.01	915
816 (R/W)	RA089 (0:UW)		-32768	32767	0	0.01	916
817 (R/W)	RA089 (1:LW)		-32768	32767	0	0.01	917
818 (R/W)	RA090 (0:UW)		-32768	32767	0	0.01	918
819 (R/W)	RA090 (1:LW)		-32768	32767	0	0.01	919
820 (R/W)	RA091 (0:UW)		-32768	32767	0	0.01	920
821 (R/W)	RA091 (1:LW)		-32768	32767	0	0.01	921
822 (R/W)	RA092 (0:UW)		-32768	32767	0	0.01	922
823 (R/W)	RA092 (1:LW)		-32768	32767	0	0.01	923
824 (R/W)	RA093 (0:UW)		-32768	32767	0	0.01	924
825 (R/W)	RA093 (1:LW)		-32768	32767	0	0.01	925
826 (R/W)	RA094 (0:UW)		-32768	32767	0	0.01	926
827 (R/W)	RA094 (1:LW)		-32768	32767	0	0.01	927
828 (R/W)	RA095 (0:UW)		-32768	32767	0	0.01	928
829 (R/W)	RA095 (1:LW)		-32768	32767	0	0.01	929
830 (R/W)	RA096 (0:UW)		-32768	32767	0	0.01	930
831 (R/W)	RA096 (1:LW)		-32768	32767	0	0.01	931
832 (R/W)	RA097 (0:UW)		-32768	32767	0	0.01	932
833 (R/W)	RA097 (1:LW)		-32768	32767	0	0.01	933
834 (R/W)	RA098 (0:UW)		-32768	32767	0	0.01	934
835 (R/W)	RA098 (1:LW)		-32768	32767	0	0.01	935
836 (R/W)	RA099 (0:UW)		-32768	32767	0	0.01	936
837 (R/W)	RA099 (1:LW)		-32768	32767	0	0.01	937

Table E.34 Modbus Register Map[a] (Sheet 14 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
838 (R/W)	RA100 (0:UW)		-32768	32767	0	0.01	938
839 (R/W)	RA100 (1:LW)		-32768	32767	0	0.01	939
840 (R/W)	RA101 (0:UW)		-32768	32767	0	0.01	940
841 (R/W)	RA101 (1:LW)		-32768	32767	0	0.01	941
842 (R/W)	RA102 (0:UW)		-32768	32767	0	0.01	942
843 (R/W)	RA102 (1:LW)		-32768	32767	0	0.01	943
844 (R/W)	RA103 (0:UW)		-32768	32767	0	0.01	944
845 (R/W)	RA103 (1:LW)		-32768	32767	0	0.01	945
846 (R/W)	RA104 (0:UW)		-32768	32767	0	0.01	946
847 (R/W)	RA104 (1:LW)		-32768	32767	0	0.01	947
848 (R/W)	RA105 (0:UW)		-32768	32767	0	0.01	948
849 (R/W)	RA105 (1:LW)		-32768	32767	0	0.01	949
850 (R/W)	RA106 (0:UW)		-32768	32767	0	0.01	950
851 (R/W)	RA106 (1:LW)		-32768	32767	0	0.01	951
852 (R/W)	RA107 (0:UW)		-32768	32767	0	0.01	952
853 (R/W)	RA107 (1:LW)		-32768	32767	0	0.01	953
854 (R/W)	RA108 (0:UW)		-32768	32767	0	0.01	954
855 (R/W)	RA108 (1:LW)		-32768	32767	0	0.01	955
856 (R/W)	RA109 (0:UW)		-32768	32767	0	0.01	956
857 (R/W)	RA109 (1:LW)		-32768	32767	0	0.01	957
858 (R/W)	RA110 (0:UW)		-32768	32767	0	0.01	958
859 (R/W)	RA110 (1:LW)		-32768	32767	0	0.01	959
860 (R/W)	RA111 (0:UW)		-32768	32767	0	0.01	960
861 (R/W)	RA111 (1:LW)		-32768	32767	0	0.01	961
862 (R/W)	RA112 (0:UW)		-32768	32767	0	0.01	962
863 (R/W)	RA112 (1:LW)		-32768	32767	0	0.01	963
864 (R/W)	RA113 (0:UW)		-32768	32767	0	0.01	964
865 (R/W)	RA113 (1:LW)		-32768	32767	0	0.01	965
866 (R/W)	RA114 (0:UW)		-32768	32767	0	0.01	966
867 (R/W)	RA114 (1:LW)		-32768	32767	0	0.01	967
868 (R/W)	RA115 (0:UW)		-32768	32767	0	0.01	968
869 (R/W)	RA115 (1:LW)		-32768	32767	0	0.01	969
870 (R/W)	RA116 (0:UW)		-32768	32767	0	0.01	970
871 (R/W)	RA116 (1:LW)		-32768	32767	0	0.01	971
872 (R/W)	RA117 (0:UW)		-32768	32767	0	0.01	972
873 (R/W)	RA117 (1:LW)		-32768	32767	0	0.01	973
874 (R/W)	RA118 (0:UW)		-32768	32767	0	0.01	974
875 (R/W)	RA118 (1:LW)		-32768	32767	0	0.01	975
876 (R/W)	RA119 (0:UW)		-32768	32767	0	0.01	976
877 (R/W)	RA119 (1:LW)		-32768	32767	0	0.01	977
878 (R/W)	RA120 (0:UW)		-32768	32767	0	0.01	978
879 (R/W)	RA120 (1:LW)		-32768	32767	0	0.01	979
880 (R/W)	RA121 (0:UW)		-32768	32767	0	0.01	980
881 (R/W)	RA121 (1:LW)		-32768	32767	0	0.01	981
882 (R/W)	RA122 (0:UW)		-32768	32767	0	0.01	982

Table E.34 Modbus Register Map[a] (Sheet 15 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
883 (R/W)	RA122 (1:LW)		-32768	32767	0	0.01	983
884 (R/W)	RA123 (0:UW)		-32768	32767	0	0.01	984
885 (R/W)	RA123 (1:LW)		-32768	32767	0	0.01	985
886 (R/W)	RA124 (0:UW)		-32768	32767	0	0.01	986
887 (R/W)	RA124 (1:LW)		-32768	32767	0	0.01	987
888 (R/W)	RA125 (0:UW)		-32768	32767	0	0.01	988
889 (R/W)	RA125 (1:LW)		-32768	32767	0	0.01	989
890 (R/W)	RA126 (0:UW)		-32768	32767	0	0.01	990
891 (R/W)	RA126 (1:LW)		-32768	32767	0	0.01	991
892 (R/W)	RA127 (0:UW)		-32768	32767	0	0.01	992
893 (R/W)	RA127 (1:LW)		-32768	32767	0	0.01	993
894 (R/W)	RA128 (0:UW)		-32768	32767	0	0.01	994
895 (R/W)	RA128 (1:LW)		-32768	32767	0	0.01	995
896–899 (R)	Reserved[c]						996–999
MAX/MIN Motor Data							
NOTE: Although Registers 970–1011 labels show phase-to-phase voltages, they represent phase-to-phase voltages when DELTA_Y is set to DELTA and they represent phase voltages when DELTA_Y is set to WYE.							
900 (R)	IA MAX	A	0	65535	0	1	1000
901 (R)	IA MAX TIME ss		0	5999	0	0.01	1001
902 (R)	IA MAX TIME mm		0	59	0	1	1002
903 (R)	IA MAX TIME hh		0	23	0	1	1003
904 (R)	IA MAX DAY dd		1	31	1	1	1004
905 (R)	IA MAX DAY mm		1	12	1	1	1005
906 (R)	IA MAX DAY yy		2000	9999	2000	1	1006
907 (R)	IA MIN	A	0	65535	0	1	1007
908 (R)	IA MIN TIME ss		0	5999	0	0.01	1008
909 (R)	IA MIN TIME mm		0	59	0	1	1009
910 (R)	IA MIN TIME hh		0	23	0	1	1010
911 (R)	IA MIN DAY dd		1	31	1	1	1011
912 (R)	IA MIN DAY mm		1	12	1	1	1012
913 (R)	IA MIN DAY yy		2000	9999	2000	1	1013
914 (R)	IB MAX	A	0	65535	0	1	1014
915 (R)	IB MAX TIME ss		0	5999	0	0.01	1015
916 (R)	IB MAX TIME mm		0	59	0	1	1016
917 (R)	IB MAX TIME hh		0	23	0	1	1017
918 (R)	IB MAX DAY dd		1	31	1	1	1018
919 (R)	IB MAX DAY mm		1	12	1	1	1019
920 (R)	IB MAX DAY yy		2000	9999	2000	1	1020
921 (R)	IB MIN	A	0	65535	0	1	1021
922 (R)	IB MIN TIME ss		0	5999	0	0.01	1022
923 (R)	IB MIN TIME mm		0	59	0	1	1023
924 (R)	IB MIN TIME hh		0	23	0	1	1024
925 (R)	IB MIN DAY dd		1	31	1	1	1025
926 (R)	IB MIN DAY mm		1	12	1	1	1026
927 (R)	IB MIN DAY yy		2000	9999	2000	1	1027

Table E.34 Modbus Register Map[a] (Sheet 16 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
928 (R)	IC MAX	A	0	65535	0	1	1028
929 (R)	IC MAX TIME ss		0	5999	0	0.01	1029
930 (R)	IC MAX TIME mm		0	59	0	1	1030
931 (R)	IC MAX TIME hh		0	23	0	1	1031
932 (R)	IC MAX DAY dd		1	31	1	1	1032
933 (R)	IC MAX DAY mm		1	12	1	1	1033
934 (R)	IC MAX DAY yy		2000	9999	2000	1	1034
935 (R)	IC MIN	A	0	65535	0	1	1035
936 (R)	IC MIN TIME ss		0	5999	0	0.01	1036
937 (R)	IC MIN TIME mm		0	59	0	1	1037
938 (R)	IC MIN TIME hh		0	23	0	1	1038
939 (R)	IC MIN DAY dd		1	31	1	1	1039
940 (R)	IC MIN DAY mm		1	12	1	1	1040
941 (R)	IC MIN DAY yy		2000	9999	2000	1	1041
942 (R)	IN MAX	A	0	65535	0	1	1042
943 (R)	IN MAX TIME ss		0	5999	0	0.01	1043
944 (R)	IN MAX TIME mm		0	59	0	1	1044
945 (R)	IN MAX TIME hh		0	23	0	1	1045
946 (R)	IN MAX DAY dd		1	31	1	1	1046
947 (R)	IN MAX DAY mm		1	12	1	1	1047
948 (R)	IN MAX DAY yy		2000	9999	2000	1	1048
949 (R)	IN MIN	A	0	65535	0	1	1049
950 (R)	IN MIN TIME ss		0	5999	0	0.01	1050
951 (R)	IN MIN TIME mm		0	59	0	1	1051
952 (R)	IN MIN TIME hh		0	23	0	1	1052
953 (R)	IN MIN DAY dd		1	31	1	1	1053
954 (R)	IN MIN DAY mm		1	12	1	1	1054
955 (R)	IN MIN DAY yy		2000	9999	2000	1	1055
956 (R)	IG MAX	A	0	65535	0	1	1056
957 (R)	IG MAX TIME ss		0	5999	0	0.01	1057
958 (R)	IG MAX TIME mm		0	59	0	1	1058
959 (R)	IG MAX TIME hh		0	23	0	1	1059
960 (R)	IG MAX DAY dd		1	31	1	1	1060
961 (R)	IG MAX DAY mm		1	12	1	1	1061
962 (R)	IG MAX DAY yy		2000	9999	2000	1	1062
963 (R)	IG MIN	A	0	65535	0	1	1063
964 (R)	IG MIN TIME ss		0	5999	0	0.01	1064
965 (R)	IG MIN TIME mm		0	59	0	1	1065
966 (R)	IG MIN TIME hh		0	23	0	1	1066
967 (R)	IG MIN DAY dd		1	31	1	1	1067
968 (R)	IG MIN DAY mm		1	12	1	1	1068
969 (R)	IG MIN DAY yy		2000	9999	2000	1	1069
970 (R)	VAB MAX	kV	0	65535	0	0.01	1070
971 (R)	VAB MX TIM ss		0	5999	0	0.01	1071
972 (R)	VAB MX TIM mm		0	59	0	1	1072

Table E.34 Modbus Register Map[a] (Sheet 17 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
973 (R)	VAB MX TIM hh		0	23	0	1	1073
974 (R)	VAB MX DAY dd		1	31	1	1	1074
975 (R)	VAB MX DAY mm		1	12	1	1	1075
976 (R)	VAB MX DAY yy		2000	9999	2000	1	1076
977 (R)	VAB MIN	kV	0	65535	0	0.01	1077
978 (R)	VAB MN TIM ss		0	5999	0	0.01	1078
979 (R)	VAB MN TIM mm		0	59	0	1	1079
980 (R)	VAB MN TIM hh		0	23	0	1	1080
981 (R)	VAB MN DAY dd		1	31	1	1	1081
982 (R)	VAB MN DAY mm		1	12	1	1	1082
983 (R)	VAB MN DAY yy		2000	9999	2000	1	1083
984 (R)	VBC MAX	kV	0	65535	0	0.01	1084
985 (R)	VBC MX TIM ss		0	5999	0	0.01	1085
986 (R)	VBC MX TIM mm		0	59	0	1	1086
987 (R)	VBC MX TIM hh		0	23	0	1	1087
988 (R)	VBC MX DAY dd		1	31	1	1	1088
989 (R)	VBC MX DAY mm		1	12	1	1	1089
990 (R)	VBC MX DAY yy		2000	9999	2000	1	1090
991 (R)	VBC MIN	kV	0	65535	0	0.01	1091
992 (R)	VBC MN TIM ss		0	5999	0	0.01	1092
993 (R)	VBC MN TIM mm		0	59	0	1	1093
994 (R)	VBC MN TIM hh		0	23	0	1	1094
995 (R)	VBC MN DAY dd		1	31	1	1	1095
996 (R)	VBC MN DAY mm		1	12	1	1	1096
997 (R)	VBC MN DAY yy		2000	9999	2000	1	1097
998 (R)	VCA MAX	kV	0	65535	0	0.01	1098
999 (R)	VCA MX TIM ss		0	5999	0	0.01	1099
1000 (R)	VCA MX TIM mm		0	59	0	1	1100
1001 (R)	VCA MX TIM hh		0	23	0	1	1101
1002 (R)	VCA MX DAY dd		1	31	1	1	1102
1003 (R)	VCA MX DAY mm		1	12	1	1	1103
1004 (R)	VCA MX DAY yy		2000	9999	2000	1	1104
1005 (R)	VCA MIN	kV	0	65535	0	0.01	1105
1006 (R)	VCA MN TIM ss		0	5999	0	0.01	1106
1007 (R)	VCA MN TIM mm		0	59	0	1	1107
1008 (R)	VCA MN TIM hh		0	23	0	1	1108
1009 (R)	VCA MN DAY dd		1	31	1	1	1109
1010 (R)	VCA MN DAY mm		1	12	1	1	1110
1011 (R)	VCA MN DAY yy		2000	9999	2000	1	1111
1012 (R)	VS MAX	kV	0	65535	0	0.01	1112
1013 (R)	VS MAX TIME ss		0	5999	0	0.01	1113
1014 (R)	VS MAX TIME mm		0	59	0	1	1114
1015 (R)	VS MAX TIME hh		0	23	0	1	1115
1016 (R)	VS MAX DAY dd		1	31	1	1	1116
1017 (R)	VS MAX DAY mm		1	12	1	1	1117

Table E.34 Modbus Register Map[a] (Sheet 18 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1018 (R)	VS MAX DAY yy		2000	9999	2000	1	1118
1019 (R)	VS MIN	kV	0	65535	0	1	1119
1020 (R)	VS MIN TIME ss		0	5999	0	0.01	1120
1021 (R)	VS MIN TIME mm		0	59	0	1	1121
1022 (R)	VS MIN TIME hh		0	23	0	1	1122
1023 (R)	VS MIN DAY dd		1	31	1	1	1123
1024 (R)	VS MIN DAY mm		1	12	1	1	1124
1025 (R)	VS MIN DAY yy		2000	9999	2000	1	1125
1026 (R)	KW3P MAX	kW	-32768	32767	0	1	1126
1027 (R)	KW3P MX TIM ss		0	5999	0	0.01	1127
1028 (R)	KW3P MX TIM mm		0	59	0	1	1128
1029 (R)	KW3P MX TIM hh		0	23	0	1	1129
1030 (R)	KW3P MX DAY dd		1	31	1	1	1130
1031 (R)	KW3P MX DAY mm		1	12	1	1	1131
1032 (R)	KW3P MX DAY yy		2000	9999	2000	1	1132
1033 (R)	KW3P MIN	kW	-32768	32767	0	1	1133
1034 (R)	KW3P MN TIM ss		0	5999	0	0.01	1134
1035 (R)	KW3P MN TIM mm		0	59	0	1	1135
1036 (R)	KW3P MN TIM hh		0	23	0	1	1136
1037 (R)	KW3P MN DAY dd		1	31	1	1	1137
1038 (R)	KW3P MN DAY mm		1	12	1	1	1138
1039 (R)	KW3P MN DAY yy		2000	9999	2000	1	1139
1040 (R)	KVAR3P MAX	kVAR	-32768	32767	0	1	1140
1041 (R)	KVAR3P MX TIM ss		0	5999	0	0.01	1141
1042 (R)	KVAR3P MX TIM mm		0	59	0	1	1142
1043 (R)	KVAR3P MX TIM hh		0	23	0	1	1143
1044 (R)	KVAR3P MX DAY dd		1	31	1	1	1144
1045 (R)	KVAR3P MX DAY mm		1	12	1	1	1145
1046 (R)	KVAR3P MX DAY yy		2000	9999	2000	1	1146
1047 (R)	KVAR3P MIN	kVAR	-32768	32767	0	1	1147
1048 (R)	KVAR3P MN TIM ss		0	5999	0	0.01	1148
1049 (R)	KVAR3P MN TIM mm		0	59	0	1	1149
1050 (R)	KVAR3P MN TIM hh		0	23	0	1	1150
1051 (R)	KVAR3P MN DAY dd		1	31	1	1	1151
1052 (R)	KVAR3P MN DAY mm		1	12	1	1	1152
1053 (R)	KVAR3P MN DAY yy		2000	9999	2000	1	1153
1054 (R)	KVA3P MAX	kVA	-32768	32767	0	1	1154
1055 (R)	KVA3P MX TIM ss		0	5999	0	0.01	1155
1056 (R)	KVA3P MX TIM mm		0	59	0	1	1156
1057 (R)	KVA3P MX TIM hh		0	23	0	1	1157
1058 (R)	KVA3P MX DAY dd		1	31	1	1	1158
1059 (R)	KVA3P MX DAY mm		1	12	1	1	1159
1060 (R)	KVA3P MX DAY yy		2000	9999	2000	1	1160
1061 (R)	KVA3P MIN	kVA	-32768	32767	0	1	1161
1062 (R)	KVA3P MN TIM ss		0	5999	0	0.01	1162

Table E.34 Modbus Register Map[a] (Sheet 19 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1063 (R)	KVA3P MN TIM mm		0	59	0	1	1163
1064 (R)	KVA3P MN TIM hh		0	23	0	1	1164
1065 (R)	KVA3P MN DAY dd		1	31	1	1	1165
1066 (R)	KVA3P MN DAY mm		1	12	1	1	1166
1067 (R)	KVA3P MN DAY yy		2000	9999	2000	1	1167
1068 (R)	FREQ MAX	Hz	0	65535	0	0.01	1168
1069 (R)	FREQ MX TIM ss		0	5999	0	0.01	1169
1070 (R)	FREQ MX TIM mm		0	59	0	1	1170
1071 (R)	FREQ MX TIM hh		0	23	0	1	1171
1072 (R)	FREQ MX DAY dd		1	31	1	1	1172
1073 (R)	FREQ MX DAY mm		1	12	1	1	1173
1074 (R)	FREQ MX DAY yy		2000	9999	2000	1	1174
1075 (R)	FREQ MIN	Hz	0	65535	0	0.01	1175
1076 (R)	FREQ MN TIM ss		0	5999	0	0.01	1176
1077 (R)	FREQ MN TIM mm		0	59	0	1	1177
1078 (R)	FREQ MN TIM hh		0	23	0	1	1178
1079 (R)	FREQ MN DAY dd		1	31	1	1	1179
1080 (R)	FREQ MN DAY mm		1	12	1	1	1180
1081 (R)	FREQ MN DAY yy		2000	9999	2000	1	1181
1082–1089 (R)	Reserved[c]						1182–1189
MAX/MIN RTD Data							
1090 (R)	RTD1 MAX	°C	-32768	32767	0	1	1190
1091 (R)	RTD1 MX TIM ss		0	5999	0	0.01	1191
1092 (R)	RTD1 MX TIM mm		0	59	0	1	1192
1093 (R)	RTD1 MX TIM hh		0	23	0	1	1193
1094 (R)	RTD1 MX DAY dd		1	31	1	1	1194
1095 (R)	RTD1 MX DAY mm		1	12	1	1	1195
1096 (R)	RTD1 MX DAY yy		2000	9999	2000	1	1196
1097 (R)	RTD1 MIN	°C	-32768	32767	0	1	1197
1098 (R)	RTD1 MN TIM ss		0	5999	0	0.01	1198
1099 (R)	RTD1 MN TIM mm		0	59	0	1	1199
1100 (R)	RTD1 MN TIM hh		0	23	0	1	1200
1101 (R)	RTD1 MN DAY dd		1	31	1	1	1201
1102 (R)	RTD1 MN DAY mm		1	12	1	1	1202
1103 (R)	RTD1 MN DAY yy		2000	9999	2000	1	1203
1104 (R)	RTD2 MAX	°C	-32768	32767	0	1	1204
1105 (R)	RTD2 MX TIM ss		0	5999	0	0.01	1205
1106 (R)	RTD2 MX TIM mm		0	59	0	1	1206
1107 (R)	RTD2 MX TIM hh		0	23	0	1	1207
1108 (R)	RTD2 MX DAY dd		1	31	1	1	1208
1109 (R)	RTD2 MX DAY mm		1	12	1	1	1209
1110 (R)	RTD2 MX DAY yy		2000	9999	2000	1	1210
1111 (R)	RTD2 MIN	°C	-32768	32767	0	1	1211
1112 (R)	RTD2 MN TIM ss		0	5999	0	0.01	1212
1113 (R)	RTD2 MN TIM mm		0	59	0	1	1213

Table E.34 Modbus Register Map[a] (Sheet 20 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1114 (R)	RTD2 MN TIM hh		0	23	0	1	1214
1115 (R)	RTD2 MN DAY dd		1	31	1	1	1215
1116 (R)	RTD2 MN DAY mm		1	12	1	1	1216
1117 (R)	RTD2 MN DAY yy		2000	9999	2000	1	1217
1118 (R)	RTD3 MAX	°C	-32768	32767	0	1	1218
1119 (R)	RTD3 MX TIM ss		0	5999	0	0.01	1219
1120 (R)	RTD3 MX TIM mm		0	59	0	1	1220
1121 (R)	RTD3 MX TIM hh		0	23	0	1	1221
1122 (R)	RTD3 MX DAY dd		1	31	1	1	1222
1123 (R)	RTD3 MX DAY mm		1	12	1	1	1223
1124 (R)	RTD3 MX DAY yy		2000	9999	2000	1	1224
1125 (R)	RTD3 MIN	°C	-32768	32767	0	1	1225
1126 (R)	RTD3 MN TIM ss		0	5999	0	0.01	1226
1127 (R)	RTD3 MN TIM mm		0	59	0	1	1227
1128 (R)	RTD3 MN TIM hh		0	23	0	1	1228
1129 (R)	RTD3 MN DAY dd		1	31	1	1	1229
1130 (R)	RTD3 MN DAY mm		1	12	1	1	1230
1131 (R)	RTD3 MN DAY yy		2000	9999	2000	1	1231
1132 (R)	RTD4 MAX	°C	-32768	32767	0	1	1232
1133 (R)	RTD4 MX TIM ss		0	5999	0	0.01	1233
1134 (R)	RTD4 MX TIM mm		0	59	0	1	1234
1135 (R)	RTD4 MX TIM hh		0	23	0	1	1235
1136 (R)	RTD4 MX DAY dd		1	31	1	1	1236
1137 (R)	RTD4 MX DAY mm		1	12	1	1	1237
1138 (R)	RTD4 MX DAY yy		2000	9999	2000	1	1238
1139 (R)	RTD4 MIN	°C	-32768	32767	0	1	1239
1140 (R)	RTD4 MN TIM ss		0	5999	0	0.01	1240
1141 (R)	RTD4 MN TIM mm		0	59	0	1	1241
1142 (R)	RTD4 MN TIM hh		0	23	0	1	1242
1143 (R)	RTD4 MN DAY dd		1	31	1	1	1243
1144 (R)	RTD4 MN DAY mm		1	12	1	1	1244
1145 (R)	RTD4 MN DAY yy		2000	9999	2000	1	1245
1146 (R)	RTD5 MAX	°C	-32768	32767	0	1	1246
1147 (R)	RTD5 MX TIM ss		0	5999	0	0.01	1247
1148 (R)	RTD5 MX TIM mm		0	59	0	1	1248
1149 (R)	RTD5 MX TIM hh		0	23	0	1	1249
1150 (R)	RTD5 MX DAY dd		1	31	1	1	1250
1151 (R)	RTD5 MX DAY mm		1	12	1	1	1251
1152 (R)	RTD5 MX DAY yy		2000	9999	2000	1	1252
1153 (R)	RTD5 MIN	°C	-32768	32767	0	1	1253
1154 (R)	RTD5 MN TIM ss		0	5999	0	0.01	1254
1155 (R)	RTD5 MN TIM mm		0	59	0	1	1255
1156 (R)	RTD5 MN TIM hh		0	23	0	1	1256
1157 (R)	RTD5 MN DAY dd		1	31	1	1	1257
1158 (R)	RTD5 MN DAY mm		1	12	1	1	1258

Table E.34 Modbus Register Map[a] (Sheet 21 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1159 (R)	RTD5 MN DAY yy		2000	9999	2000	1	1259
1160 (R)	RTD6 MAX	°C	-32768	32767	0	1	1260
1161 (R)	RTD6 MX TIM ss		0	5999	0	0.01	1261
1162 (R)	RTD6 MX TIM mm		0	59	0	1	1262
1163 (R)	RTD6 MX TIM hh		0	23	0	1	1263
1164 (R)	RTD6 MX DAY dd		1	31	1	1	1264
1165 (R)	RTD6 MX DAY mm		1	12	1	1	1265
1166 (R)	RTD6 MX DAY yy		2000	9999	2000	1	1266
1167 (R)	RTD6 MIN	°C	-32768	32767	0	1	1267
1168 (R)	RTD6 MN TIM ss		0	5999	0	0.01	1268
1169 (R)	RTD6 MN TIM mm		0	59	0	1	1269
1170 (R)	RTD6 MN TIM hh		0	23	0	1	1270
1171 (R)	RTD6 MN DAY dd		1	31	1	1	1271
1172 (R)	RTD6 MN DAY mm		1	12	1	1	1272
1173 (R)	RTD6 MN DAY yy		2000	9999	2000	1	1273
1174 (R)	RTD7 MAX	°C	-32768	32767	0	1	1274
1175 (R)	RTD7 MX TIM ss		0	5999	0	0.01	1275
1176 (R)	RTD7 MX TIM mm		0	59	0	1	1276
1177 (R)	RTD7 MX TIM hh		0	23	0	1	1277
1178 (R)	RTD7 MX DAY dd		1	31	1	1	1278
1179 (R)	RTD7 MX DAY mm		1	12	1	1	1279
1180 (R)	RTD7 MX DAY yy		2000	9999	2000	1	1280
1181 (R)	RTD7 MIN	°C	-32768	32767	0	1	1281
1182 (R)	RTD7 MN TIM ss		0	5999	0	0.01	1282
1183 (R)	RTD7 MN TIM mm		0	59	0	1	1283
1184 (R)	RTD7 MN TIM hh		0	23	0	1	1284
1185 (R)	RTD7 MN DAY dd		1	31	1	1	1285
1186 (R)	RTD7 MN DAY mm		1	12	1	1	1286
1187 (R)	RTD7 MN DAY yy		2000	9999	2000	1	1287
1188 (R)	RTD8 MAX	°C	-32768	32767	0	1	1288
1189 (R)	RTD8 MX TIM ss		0	5999	0	0.01	1289
1190 (R)	RTD8 MX TIM mm		0	59	0	1	1290
1191 (R)	RTD8 MX TIM hh		0	23	0	1	1291
1192 (R)	RTD8 MX DAY dd		1	31	1	1	1292
1193 (R)	RTD8 MX DAY mm		1	12	1	1	1293
1194 (R)	RTD8 MX DAY yy		2000	9999	2000	1	1294
1195 (R)	RTD8 MIN	°C	-32768	32767	0	1	1295
1196 (R)	RTD8 MN TIM ss		0	5999	0	0.01	1296
1197 (R)	RTD8 MN TIM mm		0	59	0	1	1297
1198 (R)	RTD8 MN TIM hh		0	23	0	1	1298
1199 (R)	RTD8 MN DAY dd		1	31	1	1	1299
1200 (R)	RTD8 MN DAY mm		1	12	1	1	1300
1201 (R)	RTD8 MN DAY yy		2000	9999	2000	1	1301
1202 (R)	RTD9 MAX	°C	-32768	32767	0	1	1302
1203 (R)	RTD9 MX TIM ss		0	5999	0	0.01	1303

Table E.34 Modbus Register Map[a] (Sheet 22 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1204 (R)	RTD9 MX TIM mm		0	59	0	1	1304
1205 (R)	RTD9 MX TIM hh		0	23	0	1	1305
1206 (R)	RTD9 MX DAY dd		1	31	1	1	1306
1207 (R)	RTD9 MX DAY mm		1	12	1	1	1307
1208 (R)	RTD9 MX DAY yy		2000	9999	2000	1	1308
1209 (R)	RTD9 MIN	°C	-32768	32767	0	1	1309
1210 (R)	RTD9 MN TIM ss		0	5999	0	0.01	1310
1211 (R)	RTD9 MN TIM mm		0	59	0	1	1311
1212 (R)	RTD9 MN TIM hh		0	23	0	1	1312
1213 (R)	RTD9 MN DAY dd		1	31	1	1	1313
1214 (R)	RTD9 MN DAY mm		1	12	1	1	1314
1215 (R)	RTD9 MN DAY yy		2000	9999	2000	1	1315
1216 (R)	RTD10 MAX	°C	-32768	32767	0	1	1316
1217 (R)	RTD10 MX TIM ss		0	5999	0	0.01	1317
1218 (R)	RTD10 MX TIM mm		0	59	0	1	1318
1219 (R)	RTD10 MX TIM hh		0	23	0	1	1319
1220 (R)	RTD10 MX DAY dd		1	31	1	1	1320
1221 (R)	RTD10 MX DAY mm		1	12	1	1	1321
1222 (R)	RTD10 MX DAY yy		2000	9999	2000	1	1322
1223 (R)	RTD10 MIN	°C	-32768	32767	0	1	1323
1224 (R)	RTD10 MN TIM ss		0	5999	0	0.01	1324
1225 (R)	RTD10 MN TIM mm		0	59	0	1	1325
1226 (R)	RTD10 MN TIM hh		0	23	0	1	1326
1227 (R)	RTD10 MN DAY dd		1	31	1	1	1327
1228 (R)	RTD10 MN DAY mm		1	12	1	1	1328
1229 (R)	RTD10 MN DAY yy		2000	9999	2000	1	1329
1230 (R)	RTD11 MAX	°C	-32768	32767	0	1	1330
1231 (R)	RTD11 MX TIM ss		0	5999	0	0.01	1331
1232 (R)	RTD11 MX TIM mm		0	59	0	1	1332
1233 (R)	RTD11 MX TIM hh		0	23	0	1	1333
1234 (R)	RTD11 MX DAY dd		1	31	1	1	1334
1235 (R)	RTD11 MX DAY mm		1	12	1	1	1335
1236 (R)	RTD11 MX DAY yy		2000	9999	2000	1	1336
1237 (R)	RTD11 MIN	°C	-32768	32767	0	1	1337
1238 (R)	RTD11 MN TIM ss		0	5999	0	0.01	1338
1239 (R)	RTD11 MN TIM mm		0	59	0	1	1339
1240 (R)	RTD11 MN TIM hh		0	23	0	1	1340
1241 (R)	RTD11 MN DAY dd		1	31	1	1	1341
1242 (R)	RTD11 MN DAY mm		1	12	1	1	1342
1243 (R)	RTD11 MN DAY yy		2000	9999	2000	1	1343
1244 (R)	RTD12 MAX	°C	-32768	32767	0	1	1344
1245 (R)	RTD12 MX TIM ss		0	5999	0	0.01	1345
1246 (R)	RTD12 MX TIM mm		0	59	0	1	1346
1247 (R)	RTD12 MX TIM hh		0	23	0	1	1347
1248 (R)	RTD12 MX DAY dd		1	31	1	1	1348

Table E.34 Modbus Register Map[a] (Sheet 23 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1249 (R)	RTD12 MX DAY mm		1	12	1	1	1349
1250 (R)	RTD12 MX DAY yy		2000	9999	2000	1	1350
1251 (R)	RTD12 MIN	°C	-32768	32767	0	1	1351
1252 (R)	RTD12 MN TIM ss		0	5999	0	0.01	1352
1253 (R)	RTD12 MN TIM mm		0	59	0	1	1353
1254 (R)	RTD12 MN TIM hh		0	23	0	1	1354
1255 (R)	RTD12 MN DAY dd		1	31	1	1	1355
1256 (R)	RTD12 MN DAY mm		1	12	1	1	1356
1257 (R)	RTD12 MN DAY yy		2000	9999	2000	1	1357
1258–1269 (R)	Reserved						1358–1369
MAX/MIN AI3 Data							
1270 (R)	AI301 MX - HI	EU	-32768	32767	0	0.001	1370
1271 (R)	AI301 MX - LO	EU	-32768	32767	0	0.001	1371
1272 (R)	AI301 MX TIM ss		0	5999	0	0.01	1372
1273 (R)	AI301 MX TIM mm		0	59	0	1	1373
1274 (R)	AI301 MX TIM hh		0	23	0	1	1374
1275 (R)	AI301 MX DAY dd		1	31	1	1	1375
1276 (R)	AI301 MX DAY mm		1	12	1	1	1376
1277 (R)	AI301 MX DAY yy		2000	9999	2000	1	1377
1278 (R)	AI301 MN - HI	EU	-32768	32767	0	0.001	1378
1279 (R)	AI301 MN - LO	EU	-32768	32767	0	0.001	1379
1280 (R)	AI301 MN TIM ss		0	5999	0	0.01	1380
1281 (R)	AI301 MN TIM mm		0	59	0	1	1381
1282 (R)	AI301 MN TIM hh		0	23	0	1	1382
1283 (R)	AI301 MN DAY dd		1	31	1	1	1383
1284 (R)	AI301 MN DAY mm		1	12	1	1	1384
1285 (R)	AI301 MN DAY yy		2000	9999	2000	1	1385
1286 (R)	AI302 MX - HI	EU	-32768	32767	0	0.001	1386
1287 (R)	AI302 MX - LO	EU	-32768	32767	0	0.001	1387
1288 (R)	AI302 MX TIM ss		0	5999	0	0.01	1388
1289 (R)	AI302 MX TIM mm		0	59	0	1	1389
1290 (R)	AI302 MX TIM hh		0	23	0	1	1390
1291 (R)	AI302 MX DAY dd		1	31	1	1	1391
1292 (R)	AI302 MX DAY mm		1	12	1	1	1392
1293 (R)	AI302 MX DAY yy		2000	9999	2000	1	1393
1294 (R)	AI302 MN - HI	EU	-32768	32767	0	0.001	1394
1295 (R)	AI302 MN - LO	EU	-32768	32767	0	0.001	1395
1296 (R)	AI302 MN TIM ss		0	5999	0	0.01	1396
1297 (R)	AI302 MN TIM mm		0	59	0	1	1397
1298 (R)	AI302 MN TIM hh		0	23	0	1	1398
1299 (R)	AI302 MN DAY dd		1	31	1	1	1399
1300 (R)	AI302 MN DAY mm		1	12	1	1	1400
1301 (R)	AI302 MN DAY yy		2000	9999	2000	1	1401
1302 (R)	AI303 MX - HI	EU	-32768	32767	0	0.001	1402
1303 (R)	AI303 MX - LO	EU	-32768	32767	0	0.001	1403

Table E.34 Modbus Register Map[a] (Sheet 24 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1304 (R)	AI303 MX TIM ss		0	5999	0	0.01	1404
1305 (R)	AI303 MX TIM mm		0	59	0	1	1405
1306 (R)	AI303 MX TIM hh		0	23	0	1	1406
1307 (R)	AI303 MX DAY dd		1	31	1	1	1407
1308 (R)	AI303 MX DAY mm		1	12	1	1	1408
1309 (R)	AI303 MX DAY yy		2000	9999	2000	1	1409
1310 (R)	AI303 MN - HI	EU	-32768	32767	0	0.001	1410
1311 (R)	AI303 MN - LO	EU	-32768	32767	0	0.001	1411
1312 (R)	AI303 MN TIM ss		0	5999	0	0.01	1412
1313 (R)	AI303 MN TIM mm		0	59	0	1	1413
1314 (R)	AI303 MN TIM hh		0	23	0	1	1414
1315 (R)	AI303 MN DAY dd		1	31	1	1	1415
1316 (R)	AI303 MN DAY mm		1	12	1	1	1416
1317 (R)	AI303 MN DAY yy		2000	9999	2000	1	1417
1318 (R)	AI304 MX - HI	EU	-32768	32767	0	0.001	1418
1319 (R)	AI304 MX - LO	EU	-32768	32767	0	0.001	1419
1320 (R)	AI304 MX TIM ss		0	5999	0	0.01	1420
1321 (R)	AI304 MX TIM mm		0	59	0	1	1421
1322 (R)	AI304 MX TIM hh		0	23	0	1	1422
1323 (R)	AI304 MX DAY dd		1	31	1	1	1423
1324 (R)	AI304 MX DAY mm		1	12	1	1	1424
1325 (R)	AI304 MX DAY yy		2000	9999	2000	1	1425
1326 (R)	AI304 MN - HI	EU	-32768	32767	0	0.001	1426
1327 (R)	AI304 MN - LO	EU	-32768	32767	0	0.001	1427
1328 (R)	AI304 MN TIM ss		0	5999	0	0.01	1428
1329 (R)	AI304 MN TIM mm		0	59	0	1	1429
1330 (R)	AI304 MN TIM hh		0	23	0	1	1430
1331 (R)	AI304 MN DAY dd		1	31	1	1	1431
1332 (R)	AI304 MN DAY mm		1	12	1	1	1432
1333 (R)	AI304 MN DAY yy		2000	9999	2000	1	1433
1334 (R)	AI305 MX - HI	EU	-32768	32767	0	0.001	1434
1335 (R)	AI305 MX - LO	EU	-32768	32767	0	0.001	1435
1336 (R)	AI305 MX TIM ss		0	5999	0	0.01	1436
1337 (R)	AI305 MX TIM mm		0	59	0	1	1437
1338 (R)	AI305 MX TIM hh		0	23	0	1	1438
1339 (R)	AI305 MX DAY dd		1	31	1	1	1439
1340 (R)	AI305 MX DAY mm		1	12	1	1	1440
1341 (R)	AI305 MX DAY yy		2000	9999	2000	1	1441
1342 (R)	AI305 MN - HI	EU	-32768	32767	0	0.001	1442
1343 (R)	AI305 MN - LO	EU	-32768	32767	0	0.001	1443
1344 (R)	AI305 MN TIM ss		0	5999	0	0.01	1444
1345 (R)	AI305 MN TIM mm		0	59	0	1	1445
1346 (R)	AI305 MN TIM hh		0	23	0	1	1446
1347 (R)	AI305 MN DAY dd		1	31	1	1	1447
1348 (R)	AI305 MN DAY mm		1	12	1	1	1448

Table E.34 Modbus Register Map[a] (Sheet 25 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1349 (R)	AI305 MN DAY yy		2000	9999	2000	1	1449
1350 (R)	AI306 MX - HI	EU	-32768	32767	0	0.001	1450
1351 (R)	AI306 MX - LO	EU	-32768	32767	0	0.001	1451
1352 (R)	AI306 MX TIM ss		0	5999	0	0.01	1452
1353 (R)	AI306 MX TIM mm		0	59	0	1	1453
1354 (R)	AI306 MX TIM hh		0	23	0	1	1454
1355 (R)	AI306 MX DAY dd		1	31	1	1	1455
1356 (R)	AI306 MX DAY mm		1	12	1	1	1456
1357 (R)	AI306 MX DAY yy		2000	9999	2000	1	1457
1358 (R)	AI306 MN - HI	EU	-32768	32767	0	0.001	1458
1359 (R)	AI306 MN - LO	EU	-32768	32767	0	0.001	1459
1360 (R)	AI306 MN TIM ss		0	5999	0	0.01	1460
1361 (R)	AI306 MN TIM mm		0	59	0	1	1461
1362 (R)	AI306 MN TIM hh		0	23	0	1	1462
1363 (R)	AI306 MN DAY dd		1	31	1	1	1463
1364 (R)	AI306 MN DAY mm		1	12	1	1	1464
1365 (R)	AI306 MN DAY yy		2000	9999	2000	1	1465
1366 (R)	AI307 MX - HI	EU	-32768	32767	0	0.001	1466
1367 (R)	AI307 MX - LO	EU	-32768	32767	0	0.001	1467
1368 (R)	AI307 MX TIM ss		0	5999	0	0.01	1468
1369 (R)	AI307 MX TIM mm		0	59	0	1	1469
1370 (R)	AI307 MX TIM hh		0	23	0	1	1470
1371 (R)	AI307 MX DAY dd		1	31	1	1	1471
1372 (R)	AI307 MX DAY mm		1	12	1	1	1472
1373 (R)	AI307 MX DAY yy		2000	9999	2000	1	1473
1374 (R)	AI307 MN - HI	EU	-32768	32767	0	0.001	1474
1375 (R)	AI307 MN - LO	EU	-32768	32767	0	0.001	1475
1376 (R)	AI307 MN TIM ss		0	5999	0	0.01	1476
1377 (R)	AI307 MN TIM mm		0	59	0	1	1477
1378 (R)	AI307 MN TIM hh		0	23	0	1	1478
1379 (R)	AI307 MN DAY dd		1	31	1	1	1479
1380 (R)	AI307 MN DAY mm		1	12	1	1	1480
1381 (R)	AI307 MN DAY yy		2000	9999	2000	1	1481
1382 (R)	AI308 MX - HI	EU	-32768	32767	0	0.001	1482
1383 (R)	AI308 MX - LO	EU	-32768	32767	0	0.001	1483
1384 (R)	AI308 MX TIM ss		0	5999	0	0.01	1484
1385 (R)	AI308 MX TIM mm		0	59	0	1	1485
1386 (R)	AI308 MX TIM hh		0	23	0	1	1486
1387 (R)	AI308 MX DAY dd		1	31	1	1	1487
1388 (R)	AI308 MX DAY mm		1	12	1	1	1488
1389 (R)	AI308 MX DAY yy		2000	9999	2000	1	1489
1390 (R)	AI308 MN - HI	EU	-32768	32767	0	0.001	1490
1391 (R)	AI308 MN - LO	EU	-32768	32767	0	0.001	1491

Table E.34 Modbus Register Map[a] (Sheet 26 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1392 (R)	AI308 MN TIM ss		0	5999	0	0.01	1492
1393 (R)	AI308 MN TIM mm		0	59	0	1	1493
1394 (R)	AI308 MN TIM hh		0	23	0	1	1494
1395 (R)	AI308 MN DAY dd		1	31	1	1	1495
1396 (R)	AI308 MN DAY mm		1	12	1	1	1496
1397 (R)	AI308 MN DAY yy		2000	9999	2000	1	1497
MAX/MIN AI4 Data							
1398 (R)	AI401 MX - HI	EU	-32768	32767	0	0.001	1498
1399 (R)	AI401 MX - LO	EU	-32768	32767	0	0.001	1499
1400 (R)	AI401 MX TIM ss		0	5999	0	0.01	1500
1401 (R)	AI401 MX TIM mm		0	59	0	1	1501
1402 (R)	AI401 MX TIM hh		0	23	0	1	1502
1403 (R)	AI401 MX DAY dd		1	31	1	1	1503
1404 (R)	AI401 MX DAY mm		1	12	1	1	1504
1405 (R)	AI401 MX DAY yy		2000	9999	2000	1	1505
1406 (R)	AI401 MN - HI	EU	-32768	32767	0	0.001	1506
1407 (R)	AI401 MN - LO	EU	-32768	32767	0	0.001	1507
1408 (R)	AI401 MN TIM ss		0	5999	0	0.01	1508
1409 (R)	AI401 MN TIM mm		0	59	0	1	1509
1410 (R)	AI401 MN TIM hh		0	23	0	1	1510
1411 (R)	AI401 MN DAY dd		1	31	1	1	1511
1412 (R)	AI401 MN DAY mm		1	12	1	1	1512
1413 (R)	AI401 MN DAY yy		2000	9999	2000	1	1513
1414 (R)	AI402 MX - HI	EU	-32768	32767	0	0.001	1514
1415 (R)	AI402 MX - LO	EU	-32768	32767	0	0.001	1515
1416 (R)	AI402 MX TIM ss		0	5999	0	0.01	1516
1417 (R)	AI402 MX TIM mm		0	59	0	1	1517
1418 (R)	AI402 MX TIM hh		0	23	0	1	1518
1419 (R)	AI402 MX DAY dd		1	31	1	1	1519
1420 (R)	AI402 MX DAY mm		1	12	1	1	1520
1421 (R)	AI402 MX DAY yy		2000	9999	2000	1	1521
1422 (R)	AI402 MN - HI	EU	-32768	32767	0	0.001	1522
1423 (R)	AI402 MN - LO	EU	-32768	32767	0	0.001	1523
1424 (R)	AI402 MN TIM ss		0	5999	0	0.01	1524
1425 (R)	AI402 MN TIM mm		0	59	0	1	1525
1426 (R)	AI402 MN TIM hh		0	23	0	1	1526
1427 (R)	AI402 MN DAY dd		1	31	1	1	1527
1428 (R)	AI402 MN DAY mm		1	12	1	1	1528
1429 (R)	AI402 MN DAY yy		2000	9999	2000	1	1529
1430 (R)	AI403 MX - HI	EU	-32768	32767	0	0.001	1530
1431 (R)	AI403 MX - LO	EU	-32768	32767	0	0.001	1531
1432 (R)	AI403 MX TIM ss		0	5999	0	0.01	1532
1433 (R)	AI403 MX TIM mm		0	59	0	1	1533
1434 (R)	AI403 MX TIM hh		0	23	0	1	1534

Table E.34 Modbus Register Map[a] (Sheet 27 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1435 (R)	AI403 MX DAY dd		1	31	1	1	1535
1436 (R)	AI403 MX DAY mm		1	12	1	1	1536
1437 (R)	AI403 MX DAY yy		2000	9999	2000	1	1537
1438 (R)	AI403 MN - HI	EU	-32768	32767	0	0.001	1538
1439 (R)	AI403 MN - LO	EU	-32768	32767	0	0.001	1539
1440 (R)	AI403 MN TIM ss		0	5999	0	0.01	1540
1441 (R)	AI403 MN TIM mm		0	59	0	1	1541
1442 (R)	AI403 MN TIM hh		0	23	0	1	1542
1443 (R)	AI403 MN DAY dd		1	31	1	1	1543
1444 (R)	AI403 MN DAY mm		1	12	1	1	1544
1445 (R)	AI403 MN DAY yy		2000	9999	2000	1	1545
1446 (R)	AI404 MX - HI	EU	-32768	32767	0	0.001	1546
1447 (R)	AI404 MX - LO	EU	-32768	32767	0	0.001	1547
1448 (R)	AI404 MX TIM ss		0	5999	0	0.01	1548
1449 (R)	AI404 MX TIM mm		0	59	0	1	1549
1450 (R)	AI404 MX TIM hh		0	23	0	1	1550
1451 (R)	AI404 MX DAY dd		1	31	1	1	1551
1452 (R)	AI404 MX DAY mm		1	12	1	1	1552
1453 (R)	AI404 MX DAY yy		2000	9999	2000	1	1553
1454 (R)	AI404 MN - HI	EU	-32768	32767	0	0.001	1554
1455 (R)	AI404 MN - LO	EU	-32768	32767	0	0.001	1555
1456 (R)	AI404 MN TIM ss		0	5999	0	0.01	1556
1457 (R)	AI404 MN TIM mm		0	59	0	1	1557
1458 (R)	AI404 MN TIM hh		0	23	0	1	1558
1459 (R)	AI404 MN DAY dd		1	31	1	1	1559
1460 (R)	AI404 MN DAY mm		1	12	1	1	1560
1461 (R)	AI404 MN DAY yy		2000	9999	2000	1	1561
1462 (R)	AI405 MX - HI	EU	-32768	32767	0	0.001	1562
1463 (R)	AI405 MX - LO	EU	-32768	32767	0	0.001	1563
1464 (R)	AI405 MX TIM ss		0	5999	0	0.01	1564
1465 (R)	AI405 MX TIM mm		0	59	0	1	1565
1466 (R)	AI405 MX TIM hh		0	23	0	1	1566
1467 (R)	AI405 MX DAY dd		1	31	1	1	1567
1468 (R)	AI405 MX DAY mm		1	12	1	1	1568
1469 (R)	AI405 MX DAY yy		2000	9999	2000	1	1569
1470 (R)	AI405 MN - HI	EU	-32768	32767	0	0.001	1570
1471 (R)	AI405 MN - LO	EU	-32768	32767	0	0.001	1571
1472 (R)	AI405 MN TIM ss		0	5999	0	0.01	1572
1473 (R)	AI405 MN TIM mm		0	59	0	1	1573
1474 (R)	AI405 MN TIM hh		0	23	0	1	1574
1475 (R)	AI405 MN DAY dd		1	31	1	1	1575
1476 (R)	AI405 MN DAY mm		1	12	1	1	1576
1477 (R)	AI405 MN DAY yy		2000	9999	2000	1	1577
1478 (R)	AI406 MX - HI	EU	-32768	32767	0	0.001	1578
1479 (R)	AI406 MX - LO	EU	-32768	32767	0	0.001	1579

Table E.34 Modbus Register Map[a] (Sheet 28 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1480 (R)	AI406 MX TIM ss		0	5999	0	0.01	1580
1481 (R)	AI406 MX TIM mm		0	59	0	1	1581
1482 (R)	AI406 MX TIM hh		0	23	0	1	1582
1483 (R)	AI406 MX DAY dd		1	31	1	1	1583
1484 (R)	AI406 MX DAY mm		1	12	1	1	1584
1485 (R)	AI406 MX DAY yy		2000	9999	2000	1	1585
1486 (R)	AI406 MN - HI	EU	-32768	32767	0	0.001	1586
1487 (R)	AI406 MN - LO	EU	-32768	32767	0	0.001	1587
1488 (R)	AI406 MN TIM ss		0	5999	0	0.01	1588
1489 (R)	AI406 MN TIM mm		0	59	0	1	1589
1490 (R)	AI406 MN TIM hh		0	23	0	1	1590
1491 (R)	AI406 MN DAY dd		1	31	1	1	1591
1492 (R)	AI406 MN DAY mm		1	12	1	1	1592
1493 (R)	AI406 MN DAY yy		2000	9999	2000	1	1593
1494 (R)	AI407 MX - HI	EU	-32768	32767	0	0.001	1594
1495 (R)	AI407 MX - LO	EU	-32768	32767	0	0.001	1595
1496 (R)	AI407 MX TIM ss		0	5999	0	0.01	1596
1497 (R)	AI407 MX TIM mm		0	59	0	1	1597
1498 (R)	AI407 MX TIM hh		0	23	0	1	1598
1499 (R)	AI407 MX DAY dd		1	31	1	1	1599
1500 (R)	AI407 MX DAY mm		1	12	1	1	1600
1501 (R)	AI407 MX DAY yy		2000	9999	2000	1	1601
1502 (R)	AI407 MN - HI	EU	-32768	32767	0	0.001	1602
1503 (R)	AI407 MN - LO	EU	-32768	32767	0	0.001	1603
1504 (R)	AI407 MN TIM ss		0	5999	0	0.01	1604
1505 (R)	AI407 MN TIM mm		0	59	0	1	1605
1506 (R)	AI407 MN TIM hh		0	23	0	1	1606
1507 (R)	AI407 MN DAY dd		1	31	1	1	1607
1508 (R)	AI407 MN DAY mm		1	12	1	1	1608
1509 (R)	AI407 MN DAY yy		2000	9999	2000	1	1609
1510 (R)	AI408 MX - HI	EU	-32768	32767	0	0.001	1610
1511 (R)	AI408 MX - LO	EU	-32768	32767	0	0.001	1611
1512 (R)	AI408 MX TIM ss		0	5999	0	0.01	1612
1513 (R)	AI408 MX TIM mm		0	59	0	1	1613
1514 (R)	AI408 MX TIM hh		0	23	0	1	1614
1515 (R)	AI408 MX DAY dd		1	31	1	1	1615
1516 (R)	AI408 MX DAY mm		1	12	1	1	1616
1517 (R)	AI408 MX DAY yy		2000	9999	2000	1	1617
1518 (R)	AI408 MN - HI	EU	-32768	32767	0	0.001	1618
1519 (R)	AI408 MN - LO	EU	-32768	32767	0	0.001	1619
1520 (R)	AI408 MN TIM ss		0	5999	0	0.01	1620
1521 (R)	AI408 MN TIM mm		0	59	0	1	1621
1522 (R)	AI408 MN TIM hh		0	23	0	1	1622

Table E.34 Modbus Register Map[a] (Sheet 29 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1523 (R)	AI408 MN DAY dd		1	31	1	1	1623
1524 (R)	AI408 MN DAY mm		1	12	1	1	1624
1525 (R)	AI408 MN DAY yy		2000	9999	2000	1	1625
MAX/MIN AI5 Data							
1526 (R)	AI501 MX - HI	EU	-32768	32767	0	0.001	1626
1527 (R)	AI501 MX - LO	EU	-32768	32767	0	0.001	1627
1528 (R)	AI501 MX TIM ss		0	5999	0	0.01	1628
1529 (R)	AI501 MX TIM mm		0	59	0	1	1629
1530 (R)	AI501 MX TIM hh		0	23	0	1	1630
1531 (R)	AI501 MX DAY dd		1	31	1	1	1631
1532 (R)	AI501 MX DAY mm		1	12	1	1	1632
1533 (R)	AI501 MX DAY yy		2000	9999	2000	1	1633
1534 (R)	AI501 MN - HI	EU	-32768	32767	0	0.001	1634
1535 (R)	AI501 MN - LO	EU	-32768	32767	0	0.001	1635
1536 (R)	AI501 MN TIM ss		0	5999	0	0.01	1636
1537 (R)	AI501 MN TIM mm		0	59	0	1	1637
1538 (R)	AI501 MN TIM hh		0	23	0	1	1638
1539 (R)	AI501 MN DAY dd		1	31	1	1	1639
1540 (R)	AI501 MN DAY mm		1	12	1	1	1640
1541 (R)	AI501 MN DAY yy		2000	9999	2000	1	1641
1542 (R)	AI502 MX - HI	EU	-32768	32767	0	0.001	1642
1543 (R)	AI502 MX - LO	EU	-32768	32767	0	0.001	1643
1544 (R)	AI502 MX TIM ss		0	5999	0	0.01	1644
1545 (R)	AI502 MX TIM mm		0	59	0	1	1645
1546 (R)	AI502 MX TIM hh		0	23	0	1	1646
1547 (R)	AI502 MX DAY dd		1	31	1	1	1647
1548 (R)	AI502 MX DAY mm		1	12	1	1	1648
1549 (R)	AI502 MX DAY yy		2000	9999	2000	1	1649
1550 (R)	AI502 MN - HI	EU	-32768	32767	0	0.001	1650
1551 (R)	AI502 MN - LO	EU	-32768	32767	0	0.001	1651
1552 (R)	AI502 MN TIM ss		0	5999	0	0.01	1652
1553 (R)	AI502 MN TIM mm		0	59	0	1	1653
1554 (R)	AI502 MN TIM hh		0	23	0	1	1654
1555 (R)	AI502 MN DAY dd		1	31	1	1	1655
1556 (R)	AI502 MN DAY mm		1	12	1	1	1656
1557 (R)	AI502 MN DAY yy		2000	9999	2000	1	1657
1558 (R)	AI503 MX - HI	EU	-32768	32767	0	0.001	1658
1559 (R)	AI503 MX - LO	EU	-32768	32767	0	0.001	1659
1560 (R)	AI503 MX TIM ss		0	5999	0	0.01	1660
1561 (R)	AI503 MX TIM mm		0	59	0	1	1661
1562 (R)	AI503 MX TIM hh		0	23	0	1	1662
1563 (R)	AI503 MX DAY dd		1	31	1	1	1663
1564 (R)	AI503 MX DAY mm		1	12	1	1	1664
1565 (R)	AI503 MX DAY yy		2000	9999	2000	1	1665
1566 (R)	AI503 MN - HI	EU	-32768	32767	0	0.001	1666

Table E.34 Modbus Register Map[a] (Sheet 30 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1567 (R)	AI503 MN - LO	EU	-32768	32767	0	0.001	1667
1568 (R)	AI503 MN TIM ss		0	5999	0	0.01	1668
1569 (R)	AI503 MN TIM mm		0	59	0	1	1669
1570 (R)	AI503 MN TIM hh		0	23	0	1	1670
1571 (R)	AI503 MN DAY dd		1	31	1	1	1671
1572 (R)	AI503 MN DAY mm		1	12	1	1	1672
1573 (R)	AI503 MN DAY yy		2000	9999	2000	1	1673
1574 (R)	AI504 MX - HI	EU	-32768	32767	0	0.001	1674
1575 (R)	AI504 MX - LO	EU	-32768	32767	0	0.001	1675
1576 (R)	AI504 MX TIM ss		0	5999	0	0.01	1676
1577 (R)	AI504 MX TIM mm		0	59	0	1	1677
1578 (R)	AI504 MX TIM hh		0	23	0	1	1678
1579 (R)	AI504 MX DAY dd		1	31	1	1	1679
1580 (R)	AI504 MX DAY mm		1	12	1	1	1680
1581 (R)	AI504 MX DAY yy		2000	9999	2000	1	1681
1582 (R)	AI504 MN - HI	EU	-32768	32767	0	0.001	1682
1583 (R)	AI504 MN - LO	EU	-32768	32767	0	0.001	1683
1584 (R)	AI504 MN TIM ss		0	5999	0	0.01	1684
1585 (R)	AI504 MN TIM mm		0	59	0	1	1685
1586 (R)	AI504 MN TIM hh		0	23	0	1	1686
1587 (R)	AI504 MN DAY dd		1	31	1	1	1687
1588 (R)	AI504 MN DAY mm		1	12	1	1	1688
1589 (R)	AI504 MN DAY yy		2000	9999	2000	1	1689
1590 (R)	AI505 MX - HI	EU	-32768	32767	0	0.001	1690
1591 (R)	AI505 MX - LO	EU	-32768	32767	0	0.001	1691
1592 (R)	AI505 MX TIM ss		0	5999	0	0.01	1692
1593 (R)	AI505 MX TIM mm		0	59	0	1	1693
1594 (R)	AI505 MX TIM hh		0	23	0	1	1694
1595 (R)	AI505 MX DAY dd		1	31	1	1	1695
1596 (R)	AI505 MX DAY mm		1	12	1	1	1696
1597 (R)	AI505 MX DAY yy		2000	9999	2000	1	1697
1598 (R)	AI505 MN - HI	EU	-32768	32767	0	0.001	1698
1599 (R)	AI505 MN - LO	EU	-32768	32767	0	0.001	1699
1600 (R)	AI505 MN TIM ss		0	5999	0	0.01	1700
1601 (R)	AI505 MN TIM mm		0	59	0	1	1701
1602 (R)	AI505 MN TIM hh		0	23	0	1	1702
1603 (R)	AI505 MN DAY dd		1	31	1	1	1703
1604 (R)	AI505 MN DAY mm		1	12	1	1	1704
1605 (R)	AI505 MN DAY yy		2000	9999	2000	1	1705
1606 (R)	AI506 MX - HI	EU	-32768	32767	0	0.001	1706
1607 (R)	AI506 MX - LO	EU	-32768	32767	0	0.001	1707
1608 (R)	AI506 MX TIM ss		0	5999	0	0.01	1708
1609 (R)	AI506 MX TIM mm		0	59	0	1	1709
1610 (R)	AI506 MX TIM hh		0	23	0	1	1710
1611 (R)	AI506 MX DAY dd		1	31	1	1	1711

Table E.34 Modbus Register Map[a] (Sheet 31 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1612 (R)	AI506 MX DAY mm		1	12	1	1	1712
1613 (R)	AI506 MX DAY yy		2000	9999	2000	1	1713
1614 (R)	AI506 MN - HI	EU	-32768	32767	0	0.001	1714
1615 (R)	AI506 MN - LO	EU	-32768	32767	0	0.001	1715
1616 (R)	AI506 MN TIM ss		0	5999	0	0.01	1716
1617 (R)	AI506 MN TIM mm		0	59	0	1	1717
1618 (R)	AI506 MN TIM hh		0	23	0	1	1718
1619 (R)	AI506 MN DAY dd		1	31	1	1	1719
1620 (R)	AI506 MN DAY mm		1	12	1	1	1720
1621 (R)	AI506 MN DAY yy		2000	9999	2000	1	1721
1622 (R)	AI507 MX - HI	EU	-32768	32767	0	0.001	1722
1623 (R)	AI507 MX - LO	EU	-32768	32767	0	0.001	1723
1624 (R)	AI507 MX TIM ss		0	5999	0	0.01	1724
1625 (R)	AI507 MX TIM mm		0	59	0	1	1725
1626 (R)	AI507 MX TIM hh		0	23	0	1	1726
1627 (R)	AI507 MX DAY dd		1	31	1	1	1727
1628 (R)	AI507 MX DAY mm		1	12	1	1	1728
1629 (R)	AI507 MX DAY yy		2000	9999	2000	1	1729
1630 (R)	AI507 MN - HI	EU	-32768	32767	0	0.001	1730
1631 (R)	AI507 MN - LO	EU	-32768	32767	0	0.001	1731
1632 (R)	AI507 MN TIM ss		0	5999	0	0.01	1732
1633 (R)	AI507 MN TIM mm		0	59	0	1	1733
1634 (R)	AI507 MN TIM hh		0	23	0	1	1734
1635 (R)	AI507 MN DAY dd		1	31	1	1	1735
1636 (R)	AI507 MN DAY mm		1	12	1	1	1736
1637 (R)	AI507 MN DAY yy		2000	9999	2000	1	1737
1638 (R)	AI508 MX - HI	EU	-32768	32767	0	0.001	1738
1639 (R)	AI508 MX - LO	EU	-32768	32767	0	0.001	1739
1640 (R)	AI508 MX TIM ss		0	5999	0	0.01	1740
1641 (R)	AI508 MX TIM mm		0	59	0	1	1741
1642 (R)	AI508 MX TIM hh		0	23	0	1	1742
1643 (R)	AI508 MX DAY dd		1	31	1	1	1743
1644 (R)	AI508 MX DAY mm		1	12	1	1	1744
1645 (R)	AI508 MX DAY yy		2000	9999	2000	1	1745
1646 (R)	AI508 MN - HI	EU	-32768	32767	0	0.001	1746
1647 (R)	AI508 MN - LO	EU	-32768	32767	0	0.001	1747
1648 (R)	AI508 MN TIM ss		0	5999	0	0.01	1748
1649 (R)	AI508 MN TIM mm		0	59	0	1	1749
1650 (R)	AI508 MN TIM hh		0	23	0	1	1750
1651 (R)	AI508 MN DAY dd		1	31	1	1	1751
1652 (R)	AI508 MN DAY mm		1	12	1	1	1752
1653 (R)	AI508 MN DAY yy		2000	9999	2000	1	1753

Table E.34 Modbus Register Map[a] (Sheet 32 of 38)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
MAX/MIN RST Data								
1654	(R)	MX/MN RST TIM-ss		0	5999	0	0.01	1754
1655	(R)	MX/MN RST TIM-mm		0	59	0	1	1755
1656	(R)	MX/MN RST TIM-hh		0	23	0	1	1756
1657	(R)	MX/MN RST DAT-dd		1	31	1	1	1757
1658	(R)	MX/MN RST DAT-mm		1	12	1	1	1758
1659	(R)	MX/MN RST DAT-yy		2000	9999	2000	1	1759
RTD DATA2								
1660	(R)	THERMAL LEVEL 1		0	10000	0	0.01	1760
1661	(R)	THERMAL LEVEL 2		0	10000	0	0.01	1761
1662	(R)	THERMAL LEVEL 3		0	10000	0	0.01	1762
1663	(R)	EQUIV CURRENT 1		0	10000	0	0.01	1763
1664	(R)	EQUIV CURRENT 2		0	10000	0	0.01	1764
1665	(R)	EQUIV CURRENT 3		0	10000	0	0.01	1765
1666	(R)	THERL CAP USE 1	%	0	10000	0	0.1	1766
1667	(R)	THERL CAP USE 2	%	0	10000	0	0.1	1767
1668	(R)	THERL CAP USE 3	%	0	10000	0	0.1	1768
1669	(R)	TIME TO TRIP 1	s	0	9999	0	1	1769
1670	(R)	TIME TO TRIP 2	s	0	9999	0	1	1770
1671	(R)	TIME TO TRIP 3	s	0	9999	0	1	1771
1672	(R)	RELEASE TIME 1	s	0	9999	0	1	1772
1673	(R)	RELEASE TIME 2	s	0	9999	0	1	1773
1674	(R)	RELEASE TIME 3	s	0	9999	0	1	1774
1675–1679	(R)	Reserved[c]						1775–1779
Reserved Area 5								
1680–1689	(R)	Reserved[c]						1760–1789
Fault Location								
NOTE: All Fault Location and Historical Data is updated whenever the event number from the History response (See Section 10: Analyzing Events) is written into the Event Log Select register (Register 1692).								
1690	(R)	FAULT LOCATION		-32768	32767	0	0.1	1790
Historical Data								
1691	(R)	NO. EVENT LOGS		0	100	0	1	1791
1692	(R/W)	EVENT LOG SEL.		0	100	0	0	1792
1693	(R)	EVENT TIME ss		0	5999	0	0.01	1793
1694	(R)	EVENT TIME mm		0	59	0	1	1794
1695	(R)	EVENT TIME hh		0	23	0	1	1795
1696	(R)	EVENT DAY dd		0	31	1	1	1796
1697	(R)	EVENT DAY mm		0	12	1	1	1797
1698	(R)	EVENT DAY yy		0	9999	2000	1	1798

Table E.34 Modbus Register Map[a] (Sheet 33 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1699 (R)	EVENT TYPE		0	55	0	1	1799
	0 = NA 1 = PHASE A1 50 TRIP 2 = PHASE B1 50 TRIP 3 = PHASE C1 50 TRIP 4 = PHASE 50 TRIP 5 = GND/NEUT 50 TRIP 6 = NEG SEQ 50 TRIP 7 = PHASE A 51 TRIP 8 = PHASE B 51 TRIP 9 = PHASE C 51 TRIP 10 = PHASE 51 TRIP 11 = GND/NEUT 51 TRIP 12 = NEG SEQ 51 TRIP 13 = 59 TRIP 14 = 55 TRIP 15 = 81 UF TRIP 16 = 81 OF TRIP 17 = POWERELEMNT TRIP 18 = ARC FLASH TRIP 19 = RTD TRIP 20 = REMOTE TRIP 21 = 27 TRIP 22 = RTD FAIL TRIP 23 = BKR FAILURE TRIP 24 = COMMIDLELOSSTRIP 25 = TRIGGER 26 = ER TRIGGER 27 = TRIP 28 = AG 29 = BG 30 = ABG 31 = CG 32 = CAG 33 = BCG 34 = ABC 35 = AG T 36 = BG T 37 = ABG T 38 = CG T 39 = CAG T 40 = BCG T 41 = ABC T 42 = AG 43 = BG 44 = AB 45 = CG 46 = CA 47 = BC 48 = ABC 49 = AG T 50 = BG T 51 = AB T 52 = CG T 53 = CA T 54 = BC T 55 = ABC T 56 = 78 TRIP 57 = 49 THERMAL TRIP						
1700 (R)	FAULT LOCATION		-32768	32767	0	0.1	1800
1701 (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	1	1801
1702 (R)	EVENT IA	A	0	65535	0	1	1802
1703 (R)	EVENT IB	A	0	65535	0	1	1803
1704 (R)	EVENT IC	A	0	65535	0	1	1804
1705 (R)	EVENT IN	A	0	65535	0	1	1805
1706 (R)	EVENT IG	A	0	65535	0	1	1806
1707 (R)	EVENT VAB/VAN	kV	0	65535	0	0.01	1807
1708 (R)	EVENT VBC/VBN	kV	0	65535	0	0.01	1808
1709 (R)	EVENT VCA/VCN	kV	0	65535	0	0.01	1809
1710 (R)	EVENT VG	kV	0	65535	0	0.01	1810
1711 (R)	EVENT DELTA/WYE 0 = DELTA 1 = WYE		0	1	0	1	1811
1712 (R)	EVENT FREQ	Hz	2000	7000	6000	0.01	1812
1713 (R)	EVNT MAX WDG RTD	°C	-32768	32767	0	1	1813
1714 (R)	EVNT MAX BRG RTD	°C	-32768	32767	0	1	1814
1715 (R)	EVNT MAX AMB RTD	°C	-32768	32767	0	1	1815
1716 (R)	EVNT MAX OTH RTD	°C	-32768	32767	0	1	1816
1717 (R)	FAULT IMP MAG	Ohm	0	65535	0	0.01	1817
1718 (R)	FAULT IMP ANGLE	deg	–18000	18000	0	0.01	1818
1719–1729 (R)	Reserved[c]						1819–1829

Table E.34 Modbus Register Map[a] (Sheet 34 of 38)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
Trip/Warn Data								
The Trip and Warn Status registers bits are “sticky” (once set, they are not cleared until target reset is issued from any interface) when a trip event occurs.								
1730	(R)	TRIP STATUS LO		0	65535	0	1	1830
		Bit 0 = PHASE A1 50	Bit 8 = PHASE B 51					
		Bit 1 = PHASE B1 50	Bit 9 = PHASE C 51					
		Bit 2 = PHASE C1 50	Bit 10 = PHASE 51P1					
		Bit 3 = PHASE 50P1	Bit 11 = GROUND 51G1					
		Bit 4 = GROUND 50G1	Bit 12 = NEUTRAL 51N1					
		Bit 5 = NEUTRAL 50N1	Bit 13 = NEG SEQ 51Q					
		Bit 6 = NEG SEQ 50Q1	Bit 14 = UNDERVOLT 27P1					
		Bit 7 = PHASE A 51	Bit 15 = OVERVOLT 59P1					
1731	(R)	TRIP STATUS HI		0	65535	0	1	1831
		Bit 0 = POWER FACTOR 55	Bit 8 = COMM IDLE					
		Bit 1 = FREQUENCY 81D1	Bit 9 = COMM LOSS					
		Bit 2 = FREQUENCY 81D2	Bit 10 = REMOTE TRIP					
		Bit 3 = RTD-OTHER	Bit 11 = COMM FAULT					
		Bit 4 = RTD-AMBIENT	Bit 12 = CONFIG FAULT					
		Bit 5 = RTD-WIND BEAR	Bit 13 = RESERVED					
		Bit 6 = RTD ERROR	Bit 14 = RESERVED					
		Bit 7 = POWER ELEMENTS	Bit 15 = BREAKER FAIL					
1732	(R)	WARN STATUS LO		0	65535	0	1	1832
		Bit 0 = PHASE 50P2	Bit 8 = NEUTRAL 50N4					
		Bit 1 = PHASE 50P3	Bit 9 = NEG SEQ 50Q2					
		Bit 2 = PHASE 50P4	Bit 10 = NEG SEQ 50Q3					
		Bit 3 = GROUND 50G2	Bit 11 = NEG SEQ 50Q4					
		Bit 4 = GROUND 50G3	Bit 12 = PHASE 51P2					
		Bit 5 = GROUND 50G4	Bit 13 = GROUND 51G2					
		Bit 6 = NEUTRAL 50N2	Bit 14 = NEUTRAL 51N2					
		Bit 7 = NEUTRAL 50N3	Bit 15 = RESERVED					
1733	(R)	WARN STATUS HI		0	65535	0	1	1833
		Bit 0 = POWER FACTOR 55	Bit 8 = FREQUENCY 81D3					
		Bit 1 = SALARM	Bit 9 = FREQUENCY 81D4					
		Bit 2 = WARNING	Bit 10 = RESERVED					
		Bit 3 = RTD-WIND BEAR	Bit 11 = RESERVED					
		Bit 4 = RTD-OTHER	Bit 12 = RESERVED					
		Bit 5 = RTD-AMBIENT	Bit 13 = RESERVED					
		Bit 6 = UNDERVOLT 27P2	Bit 14 = RESERVED					
		Bit 7 = OVERVOLT 59P2	Bit 15 = RESERVED					
1734–1739	(R)	Reserved[c]						1834–1839
Relay Elements								
1740	(R)	NUM MSG RCVD		0	65535	0	1	1840
1741	(R)	NUM OTHER MSG		0	65535	0	1	1841
1742	(R)	INVALID ADDR		0	65535	0	1	1842
1743	(R)	BAD CRC		0	65535	0	1	1843
1744	(R)	UART ERROR		0	65535	0	1	1844
1745	(R)	ILLEGAL FUNCTION		0	65535	0	1	1845
1746	(R)	ILLEGAL REGISTER		0	65535	0	1	1846
1747	(R)	ILLEGAL WRITE		0	65535	0	1	1847
1748	(R)	BAD PKT FORMAT		0	65535	0	1	1848
1749	(R)	BAD PKT LENGTH		0	65535	0	1	1849
1750–1759	(R)	Reserved[c]						1850–1859

Table E.34 Modbus Register Map[a] (Sheet 35 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
Relay Elements							
1760–1919 (R)	ROW 0–ROW 159		0	255	0	1	1860–2019
1920 (R)	Reserved[c]						2020
1921–1927 (R)	ROW 160–ROW ROW 166		0	255	0	1	2021–2027
1928–1935 (R)	Reserved						2028–2035
Control I/O Commands							
2000H (W)	LOGIC COMMAND		0	65535	0	na	
	Bit 0 = Breaker Close (CC Bit) Bit 1 = Breaker Open (OC Bit) Bit 2 = Reserved 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 = Reserved						
2001H (W)	RESET DATA		0	1023	0	na	
	Bit 0 = TRIP (TARGET) 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 Bit 10 = RST BKMON DATA Bits 11–15 = Reserved						
Relay Elements							
2100H (R)	FAST STATUS 0		0	65535	0	na	
	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 = Reserved Bit 15 = Reserved						
2101H (R)	FAST STATUS 1		0	65535	0	na	
	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 = OUT405 Status Bit 13 = OUT406 Status Bit 14 = OUT407 Status Bit 15 = OUT408 Status						
2102H (R)	TRIP STATUS LO					na	
2103H (R)	TRIP STATUS HI					na	
2104H (R)	WARN STATUS LO					na	
2105H (R)	WARN STATUS HI					na	
2106H (R)	AVERAGE CURRENT					na	
2107H (R)	IA CURRENT					na	
2108H (R)	IB CURRENT					na	
2109H (R)	IC CURRENT					na	

Table E.34 Modbus Register Map[a] (Sheet 36 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
210AH (R)	Reserved[c]					na	
210BH (R)	CURRENT IMBAL					na	
210CH (R)	MAX WINDING RTD					na	
210DH (R)	IG CURRENT					na	
210EH (R)	IN CURRENT					na	
210FH (R)	Reserved[c]						
2110H (R)	FAST STATUS 2		0	65535	0	na	
	Bit 0 = IN11/IN301 Status Bit 1 = IN12/IN302 Status Bit 2 = IN13/IN303 Status Bit 3 = IN14/IN304 Status Bit 4 = IN15/IN305 Status Bit 5 = IN16/IN306 Status Bit 6 = IN17/IN307 Status Bit 7 = IN18/IN308 Status	Bit 8 = OUT11/OUT301 Status Bit 9 = OUT12/OUT302 Status Bit 10 = OUT13/OUT303 Status Bit 11 = OUT14/OUT304 Status Bit 12 = OUT305 Status Bit 13 = OUT306 Status Bit 14 = OUT307 Status Bit 15 = OUT308 Status					
2111H (R)	FAST STATUS 3		0	65535	0	na	
	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 = OUT505 Status Bit 9 = OUT506 Status Bit 10 = OUT507 Status Bit 11 = OUT508 Status Bit 12–15 = Reserved					
PAR Group Indices							
3000H (R)	Reserved						
3001H (R)	USER MAP REG		1	125	1		
3002H (R)	USER MAP REG VAL		126	250	126		
3003H (R)	RESERVED AREA1		251	260	251		
3004H (R)	RESET SETTINGS		261	269	261		
3005H (R)	DATE/TIME SET		270	279	270		
3006H (R)	DEVICE STATUS		280	319	280		
3007H (R)	CURRENT DATA		320	334	320		
3008H (R)	VOLTAGE DATA		335	359	335		
3009H (R)	POWER DATA		360	379	360		
300AH (R)	ENERGY DATA		380	399	380		
300BH (R)	RTD DATA		400	419	400		
300CH (R)	LIGHT MTR DATA		420	429	420		
300DH (R)	RMS DATA		430	449	430		
300EH (R)	DEMAND DATA		450	469	450		
300FH (R)	BREAKER MONITOR		470	489	470		
3010H (R)	ANA INP DATA		490	539	490		
3011H (R)	MATH VARIABLES		540	603	540		
3012H (R)	DEVICE COUNTERS		604	639	604		
3013H (R)	REMOTE ANALOGS1		640	767	640		
3014H (R)	REMOTE ANALOGS2		768	895	768		
3015H (R)	RESERVED AREA6		896	899	896		
3016H (R)	MAX/MIN MTR DATA		900	1089	900		

Table E.34 Modbus Register Map[a] (Sheet 37 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
3017H (R)	MAX/MIN RTD DATA		1090	1269	1090		
3018H (R)	MAX/MIN AI3 DATA		1270	1397	1270		
3019H (R)	MAX/MIN AI4 DATA		1398	1525	1398		
301AH (R)	MAX/MIN AI5 DATA		1526	1653	1526		
301BH (R)	MAX/MIN RST DATA		1654	1659	1654		
301CH (R)	RTD DATA2		1660	1679	1660		
301DH (R)	RESERVED AREA5		1680	1689	1680		
301EH (R)	FAULT LOCATION		1690	1690	1690		
301FH (R)	HISTORICAL DATA		1691	1729	1691		
3020H (R)	TRIP/WARN DATA		1730	1739	1730		
3021H (R)	COMM COUNTERS		1740	1759	1740		
3022H (R)	RELAY ELEMENTS		1760	1935	1760		
Product Information							
4000H (R)	VENDOR CODE 865 = SEL		0	65535	865	na	
4001H (R)	PRODUCT CODE		0	65535	107	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	2100	1935	na	
4006H (R)	NUM OF PAR GROUP		1	100	34	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 4–9 = 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–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	

Table E.34 Modbus Register Map[a] (Sheet 38 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
400DH (R)	FIRMWARE BUILD NUM		16400	16400	0	na	
400EH	not used						
400FH (R)	PRODUCT SUPPORT BITS Bit 0 = 2nd IO Card installed Bits 1–15 = Reserved					na	
4010H (R/W)	SETTINGS TIMEOUT	ms	500	65535	750	na	
4011H–4013H	Reserved[c]						
4014H (R)	CONFIGURED BIT Bit 0 = Unit Configured Bits 1–15 = Reserved				0	na	
4015H (R)	Reserved[c]						
4016H (R)	ERROR REGISTER Bit 0–Bit 15 = Reserved		0	65535	0	na	
4017H (R)	ERROR ADDRESS		0	65535	0	na	
4018H–401FH (R)	Reserved[c]						

[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] Read this register only when the PT connection is DELTA.
[e] Read this register only when the PT connection is WYE.

Appendix F
IEC 61850 Communications

Features

NOTE: The SEL-751 supports one CID file, which should be transferred only if a change in the relay configuration is required.

The SEL-751 Relay uses Ethernet and IEC 61850 to support the following features:

- SCADA—Connect as many as seven simultaneous IEC 61850 MMS client sessions. The SEL-751 also supports as many as seven buffered and seven unbuffered report control blocks. See *Table F.22*: *Logical Device: CON (Remote Control)* for Logical Node mapping that enables SCADA control via a Manufacturing Messaging Specification (MMS) browser. Controls support direct control with normal security, direct control with enhanced security, and SBO control with enhanced security control models.
- Peer-to-Peer Real-Time Status and Control—Use GOOSE with as many as 64 incoming (receive) and 8 outgoing (transmit) messages. Virtual bits (VB001–VB128) and Remote Analogs (RA001–RA128) can be mapped from incoming GOOSE messages.
- Configuration—Use FTP client software or ACSELERATOR Architect SEL-5032 Software to transfer the Substation Configuration Language (SCL) Configured IED Description (CID) file to the relay.
- Commissioning and Troubleshooting—Use software such as AX-S4 from Sisco, Inc., to browse the relay logical nodes and verify functionality.

This appendix presents the information you need to use the IEC 61850 features of the SEL-751:

- 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	Communications requirements
IEC 61850-6	Configuration description language for substation IEDs
IEC 61850-7-1	Basic communications structure for substations and feeder equipment—Principles and models
IEC 61850-7-2	Basic communications structure for substations and feeder equipment—Abstract Communication Service Interface (ACSI)
IEC 61850-7-3	Basic communications structure for substations and feeder equipment—Common data classes
IEC 61850-7-4	Basic communications structure for substations and feeder equipment—Compatible logical node (LN) classes and data classes
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 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-751. In addition to IEC 61850, the Ethernet port provides support protocols and data exchange, including FTP and Telnet. Access the SEL-751 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 seven 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. You can use these abstract models to create objects (data items) and services that exist independently of any underlying protocols. These objects are in conformance with the common data class (CDC) specification IEC 61850-7-3, which describes the type and structure of each element within a logical node. CDCs for status, measurements, controllable analogs and statuses, and settings all have unique CDC attributes. Each CDC attribute belongs to a set of functional constraints that groups the attributes into specific categories such as status (ST), description (DC), and substituted value (SV). Functional constraints, CDCs and CDC attributes are used as building blocks for defining Local Nodes.

UCA2 uses GOMSFE (Generic Object Models for Substation and Feeder Equipment) to present data from station IEDs as a series of objects called models or bricks. The IEC working group has incorporated GOMSFE concepts into the standard, with some modifications to terminology; one change was the renaming of bricks to logical nodes. Each logical node represents a group of data (controls, status, measurements, etc.) associated with a particular function. For example, the MMXU logical node (polyphase measurement unit) contains measurement data and other points associated with three-phase metering including voltages and currents. Each IED can contain many functions such as protection, metering, and control. Multiple logical nodes represent the functions in multifunction devices.

You can organize logical nodes into logical devices that are similar to directories on a computer disk. As represented in the IEC 61850 network, each physical device can contain many logical devices, and each logical device can contain many logical nodes. Many relays, meters, and other IEC 61850 devices contain one primary logical device where all models are organized.

IEC 61850 devices are capable of self-description. You do not need to refer to the specifications for the logical nodes, measurements, and other components to request data from another IEC 61850 device. IEC 61850 clients can request and display a list and description of the data available in an IEC 61850 server device. This process is similar to the autoconfiguration process used within

SEL communications processors (SEL-2032 and SEL-2030). Simply run an MMS browser to query devices on an IEC 61850 network and discover what data are available. Self-description also permits extensions to both standard and custom data models. Instead of having to look up data in a profile stored in its database, an IEC 61850 client can simply query an IEC 61850 device and receive a description of all logical devices, logical nodes, and available data.

Unlike other Supervisory Control and Data Acquisition (SCADA) protocols that present data as a list of addresses or indices, IEC 61850 presents data with descriptors in a composite notation made up of components. *Table 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	A-phase
cVal	Data Attribute	Complex value

Data Mapping

Device data are mapped to IEC 61850 logical nodes (LN) according to rules SEL has defined. Refer to IEC 61850-5:2013(E) and IEC 61850-7-4:2010(E) for the mandatory content and usage of these LNs. The SEL-751 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-751. See Logical Nodes for a description of the LNs that make up these Logical Devices.

Table F.3 SEL-751 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.

Settings files, event files and reports are also available through MMS. See *File Transfer Protocol (FTP) and MMS File Transfer on page 7.13*, *Retrieving COMTRADE Event Files on page 10.29*, and *Retrieving Event Reports Via Ethernet File Transfer on page 10.18*.

If MMS authentication is enabled, the device authenticates each MMS association by requiring the client to provide the password authentication parameter with a value that is equal to the 2AC password of the SEL-751.

- ➤ If the correct password authentication parameter is not received, the device returns a not authenticated error code.
- ➤ If the correct password authentication parameter value is received, the device gives a successful association response.

Once an authenticated association is established, the device allows access to all supported MMS services for that association.

GOOSE

The Generic Object Oriented Substation Event (GOOSE) object within IEC 61850 is for high-speed control messaging. IEC 61850 GOOSE automatically broadcasts messages containing status, controls, and measured values onto the network for use by other devices. IEC 61850 GOOSE sends the messages several times, increasing the likelihood that other devices receive the messages.

IEC 61850 GOOSE objects can quickly and conveniently transfer status, controls, and measured values between peers on an IEC 61850 network. Configure SEL devices to respond to GOOSE messages from other network with Architect software. Also, configure outgoing GOOSE messages for SEL devices in Architect. See the Architect online help for more information.

Each IEC 61850 GOOSE sender includes a text identification string (GOOSE Control Block Reference) in each outgoing message and an Ethernet multicast group address. Devices that receive GOOSE messages use the text identification and multicast group to identify and filter incoming GOOSE messages.

NOTE: Virtual bits and remote analogs mapped to GOOSE subscriptions retain their state until they are overwritten, a new CID file is loaded, or the device is restarted. To reset the virtual bits and remote analogs by restarting the device, issue an **STA C** command or remove and then restore power to the device.

Virtual bits (VB001–VB128) are control inputs that you can map to GOOSE receive messages by using the Architect software. See the VB*nnn* bits in *Table F.15* 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-751 virtual bits for controls, you must create SELOGIC control equations to define these operations. The Virtual Bit Logical Nodes only contain Virtual Bit status, and only those Virtual Bits that are assigned to an SER report are able to track bit transitions (via reporting) between LN data update scans.

The relay is capable of receiving analog values via peer-to-peer GOOSE messages. Remote Analogs (RA001–RA128) are analog inputs that you can map to values from incoming GOOSE messages.

File Services

The Ethernet file system allows reading or writing data as files. The file system supports FTP and MMS file transfer. The file system provides:

- ➤ A means for the devices to transfer data as files
- ➤ A hierarchical file structure for the device data

The SEL-751 supports MMS file transfer with or without authentication; the service is intended to support the following:

- CID file download and upload
- Settings Files download and upload
- Retrieval of events, and reports

MMS file services are enabled or disabled via Port 1 settings. See *Virtual File Interface on page 7.58* for details on the files available for MMS file services.

SCL Files

Substation Configuration Language (SCL) is an XML-based configuration language used to support the exchange of database configuration data between different tools, which may come from different manufacturers. There are four types of SCL files:

- IED Capability Description file (.ICD)
- System Specification Description (.SSD) file
- Substation Configuration Description file (.SCD)
- Configured IED Description file (.CID)

The ICD file described the capabilities of an IED, including information on LN and GOOSE support. The SSD file describes the single-line diagram of the substation and the necessary LNs. The SCD file contains information on all IEDs, communications configuration data, and a substation description. The CID file, of which there may be several, describes a single instantiated IED within the project, and includes address information.

Datasets

Datasets are configured using ACSELERATOR Architect and contain data attributes that represent real data values within the SEL-751 device. See Logical Nodes for the logical node tables that list the available data attributes for each logical node and the Relay Word bit mapping for these data attributes. The datasets listed in *Figure F.1* are the defaults for an SEL-751 device. Datasets BRDSet01–BRDSet07 and URDSet01–URDSet07 are preconfigured with common FCDAs to be used for reporting. These datasets can be configured to represent the data you want to monitor. Dataset GPDSet01, which contains breaker status and control data attributes, is used in the default Goose Control Publication.

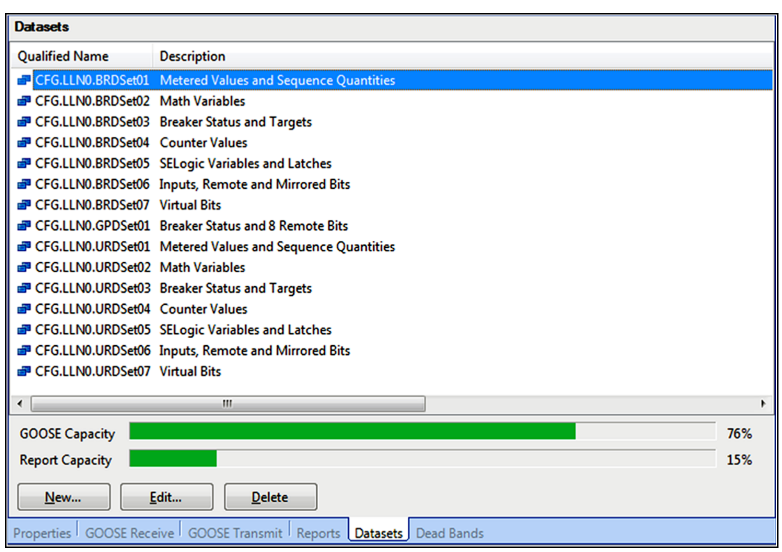


Figure F.1 SEL-751 Datasets

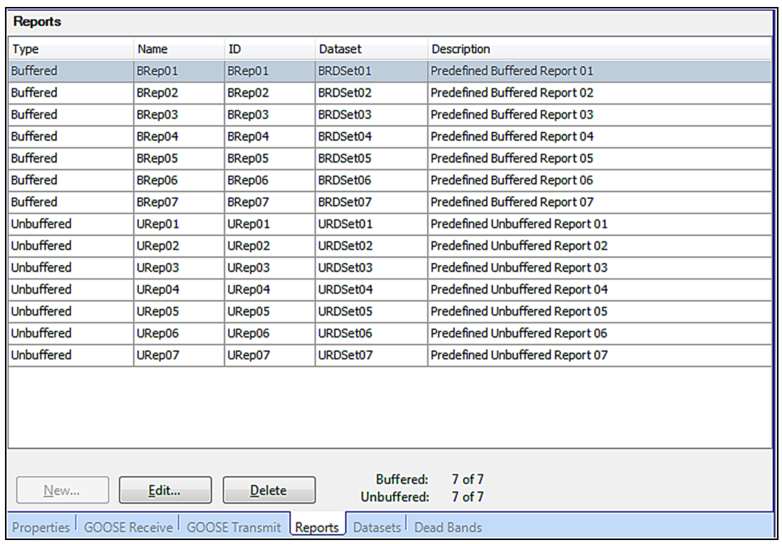
Within Architect, IEC 61850 datasets have two main purposes:

- ➤ GOOSE: You can use predefined or edited datasets, or create new datasets for outgoing GOOSE transmission.
- ➤ Reports: Fourteen predefined datasets (BRDSet01–BRDSet07 and URDSet01–URDSet07) correspond to the default seven buffered and seven unbuffered reports, respectively. Note that you cannot change the number (14) or type of reports (buffered or unbuffered) within Architect. However, you can alter the data attributes that a dataset contains and so define what data an IEC 61850 client receives with a report.
- ➤ MMS: You can use predefined or edited datasets, or create new datasets to be monitored by MMS clients.

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.

Reports

The SEL-751 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.2* are available by default via IEC 61850. There are 14 report control blocks, seven buffered reports and seven unbuffered.


Reports

Type	Name	ID	Dataset	Description
Buffered	BRep01	BRep01	BRDSet01	Predefined Buffered Report 01
Buffered	BRep02	BRep02	BRDSet02	Predefined Buffered Report 02
Buffered	BRep03	BRep03	BRDSet03	Predefined Buffered Report 03
Buffered	BRep04	BRep04	BRDSet04	Predefined Buffered Report 04
Buffered	BRep05	BRep05	BRDSet05	Predefined Buffered Report 05
Buffered	BRep06	BRep06	BRDSet06	Predefined Buffered Report 06
Buffered	BRep07	BRep07	BRDSet07	Predefined Buffered Report 07
Unbuffered	URep01	URep01	URDSet01	Predefined Unbuffered Report 01
Unbuffered	URep02	URep02	URDSet02	Predefined Unbuffered Report 02
Unbuffered	URep03	URep03	URDSet03	Predefined Unbuffered Report 03
Unbuffered	URep04	URep04	URDSet04	Predefined Unbuffered Report 04
Unbuffered	URep05	URep05	URDSet05	Predefined Unbuffered Report 05
Unbuffered	URep06	URep06	URDSet06	Predefined Unbuffered Report 06
Unbuffered	URep07	URep07	URDSet07	Predefined Unbuffered Report 07

Figure F.2 SEL-751 Predefined Reports

For each report control block, there can be just one client association, i.e., only one client can be associated to a report control block (BRCB or URCB) at any given time. The number of reports (14) and the type of reports (buffered or unbuffered) cannot be changed. However, by using Architect, you can reallocate data within each report dataset to present different data attributes for each report beyond the predefined datasets. For buffered reports, connected clients can edit the report parameters shown in *Table F.4*.

Table F.4 Buffered Report Control Block Client Access

RCB Attribute	User changeable (Report Disabled)	User changeable (Report Enabled)	Default Values
RptId	YES		BRep01–BRep07
RptEna	YES	YES	FALSE
OptFlds	YES		seqNum timeStamp dataSet configRef reasonCode dataRef
BufTm	YES		500
TrgOp	YES		dchg qchg
IntgPd	YES		0
GI	YES[a b]	YES[a]	FALSE
PurgeBuf	YES[a]		FALSE
EntryId	YES		0

[a] Exhibits a pulse behavior. Write a one to issue the command. Once command is accepted returns to zero. Always read as zero.
[b] When disabled, a GI is processed and the report buffered if a buffer has been previously established. A buffer is established when the report is enabled for the first time.

Similarly, for unbuffered reports, connected clients can edit the report parameters shown in *Table F.5*.

Table F.5 Unbuffered Report Control Block Client Access

RCB Attribute	User changeable (Report Disabled)	User changeable (Report Enabled)	Default Values
RptId	YES		URep01–URep07
RptEna	YES	YES	FALSE
Resv	YES		FALSE
OptFlds	YES		seqNum timeStamp dataSet configRef reasonCode dataRef
BufTm	YES		250
TrgOps	YES		dchg qchg
IntgPd	YES		0
GI		YES[a]	

[a] Exhibits a pulse behavior. Write a one to issue the command. Once command is accepted, returns to zero. Always read as zero.

For Buffered Reports, only one client can enable the RptEna attribute of the BRCB at a time resulting in a client association for that BRCB. Once enabled, the associated client has exclusive access to the BRCB until the connection is closed or the client disables the RptEna attribute. Once enabled, all unassociated clients have read only access to the BRCB.

For Unbuffered Reports, as many as seven clients can enable the RptEna attribute of the URCB at a time, resulting in multiple client associations for that URCB. Once enabled, each client has independent access to a copy of that URCB. The Resv attribute is writable, however, the SEL-751 does not support reservations. Writing any field of the URCB causes the client to obtain its own copy of the URCB-in essence, acquiring a reservation.

Reports are serviced at a 2 Hz rate. The client can set the IntgPd to any value with a resolution of 1 ms. However, the integrity report is only sent when the period has been detected as having expired. The report service rate of 2 Hz results in a report being sent within 500 ms of expiration of the IntgPd. The new IntgPd begins at the time that the current report is serviced.

Supplemental Software

Examine the data structure and value of the supported IEC 61850 LNs with an MMS browser such as MMS Object Explorer and AX-S4 MMS from Sisco, Inc. The settings necessary to browse an SEL-751 with an MMS browser are as follows:

OSI-PSEL (Presentation Selector)	00000001
OSI-SSEL (Session Selector)	0001
OSI-TSEL (Transport Selector)	0001

Time Stamps and Quality

In addition to the various data values, the two attributes quality and t (time stamp) are available at any time. The relay determines the time stamp when it detects a change in quality or data.

The relay applies a time stamp to all data and quality attributes (Boolean, Bstrings, Analogs, etc.) in the same fashion as when it detects a data or quality change. However, there is a difference in how the relay detects the change between the different attribute types. For points that are assigned as SER points, i.e., programmed in the SER report, the relay detects the change as the receipt of an SER record (which contains the SER time stamp) within the relay.

For all other Booleans or Bstrings, the relay detects the change via the scanner, which compares the last state against the previous state to detect the change. For analogs, the scanner looks at the amount of change relative to the dead band configured for the point to indicate a change and apply the timestamp. In all cases, the relay uses these time stamps for the reporting model.

Functionally Constrained Data Attributes mapped to points assigned to the SER report have 4 ms SER-accurate time stamps for data change events. To ensure that you get SER-quality time stamps for changes to certain points, you must include those points in the SER report. All other FCDAs are scanned for data changes on a 1/2-second interval and have 1/2-second time-stamped accuracy. See the **SET R** command for information on programming the SER report.

The SEL-751 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-751 datasets that contain them. Internal status indicators provide the information necessary for the device to set these attributes.

For example, if the device becomes disabled, as shown via status indications (e.g., an internal self-test failure), the SEL-751 sets the Validity attribute to invalid and the Failure attribute to TRUE. Note that the SEL-751 does not set any of the other quality attributes. These attributes always indicate FALSE (0). See the Architect online help for additional information on GOOSE Quality attributes.

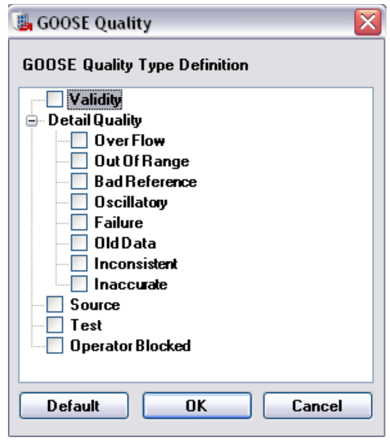


Figure F.3 GOOSE Quality

GOOSE Processing

SEL devices support GOOSE processing as defined by IEC 61850-7-1:2011(E), IEC 61850-7-2:2010(E), and IEC 61850-8-1:2011(E) via the installed Ethernet port. Outgoing GOOSE messages are processed within the following constraints:

- You can define as many as eight outgoing GOOSE messages consisting of any Data Attribute (DA) from any logical node. You can map a single DA to one or more outgoing GOOSE, or one or more times within the same outgoing GOOSE. You can also map a single GOOSE dataset to multiple GOOSE control blocks.
- The relay transmits all configured GOOSE immediately upon successful initialization. If a GOOSE message is not retriggered; then, following the initial transmission, the relay retransmits that GOOSE based on the minimum time and maximum time configured for that GOOSE message. The first transmission occurs immediately on triggering of an element within the GOOSE dataset. The second transmission occurs Min. Time later. The third transmission occurs Min. Time after the second transmission. The fourth transmission occurs twice Min. Time after the third transmission. All subsequent transmissions occur at the Max Time interval. For example, a message with a Min. Time of 4 ms and Max. Time of 1000 ms is transmitted upon triggering, then retransmitted at intervals of 4 ms, 4 ms, 8 ms, and then at 1000 ms indefinitely or until another change triggers a new GOOSE message (See IEC 61850-8-1, Sec. 18.1).
- GOOSE transmission is squelched (silenced) after a permanent (latching) self-test failure.
- Each outgoing GOOSE includes communications parameters (VLAN, Priority, and Multicast Address) and is transmitted entirely in a single network frame.
- The SEL-751 maintains the configuration of outgoing GOOSE through a power cycle and device reset.

Incoming GOOSE messages are processed within the following constraints:

- You can configure the SEL-751 to subscribe to as many as 64 incoming GOOSE messages.

  The SEL-751 recognizes incoming GOOSE messages as valid based on the following content. Any GOOSE message that fails these checks is rejected.

  - Source broadcast MAC address
  - Dataset Reference
  - Application ID
  - GOOSE Control Reference

- Rejection of all DA contained in an incoming GOOSE, based on the accumulation of the following error indications created by inspection of the received GOOSE:

  - **Configuration Mismatch**: the configuration number of the incoming GOOSE changes.
  - **Needs Commissioning**: this Boolean parameter of the incoming GOOSE is true.
  - **Test Mode**: this Boolean parameter of the incoming GOOSE is true.
  - **Decode Error**: the format of the incoming GOOSE is not as configured.

- The SEL-751 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. Configure all other IEC 61850 settings, including subscriptions to incoming GOOSE messages, with Architect.

Table F.6 IEC 61850 Settings

Label	Description	Range	Default
E61850	Enables IEC 61850 protocol	Y, N	N
EGSE[a]	Enables IEC 61850 GSE	Y[b], N	N
EMMSFS[a]	Enables MMS file services	Y[b], N	N

[a] Settings EGSE and EMMSFS are hidden when E61850 is set to N.
[b] Requires that E61850 be set to Y.

ACSELERATOR Architect Software

The Architect Software enables users to design and commission IEC 61850 substations containing SEL IEDs. Users can use Architect to do the following:

- Organize and configure all SEL IEDs in a substation project.
- Configure incoming and outgoing GOOSE messages.
- Edit and create GOOSE datasets.
- Read non-SEL IED Capability Description (ICD) and Configured IED Description (CID) files and determine the available IEC 61850 messaging options.
- Use or edit preconfigured datasets for reports.
- Load IEC 61850 CID files into SEL IEDs.
- Generate ICD and CID files that provide SEL IED descriptions to other manufacturers' tools so they can use SEL GOOSE messages and reporting features.
- Edit dead-band settings for measured values.

Architect provides a graphical user interface (GUI) for users to select, edit, and create IEC 61850 GOOSE messages important for substation protection, coordination, and control schemes. Typically, the user first places icons representing IEDs in a substation container, then edits the outgoing GOOSE messages or creates new ones for each IED. The user can also select incoming GOOSE messages for each IED to receive from any other IEDs in the domain.

Some measured values are reported to IEC 61850 only when the value changes beyond a defined dead-band value. Architect allows a dead band to be changed during the CID file configuration. Check and set the dead-band values for your particular application when configuring the CID file for a device.

Architect has the capability to read other manufacturers' ICD and CID files, enabling the user to map the data seamlessly into SEL IED logic. See the Architect online help for more information.

SEL ICD File Versions

ACSELERATOR Architect version R.1.1.69.0 and later supports multiple ICD file versions for each type of IED in a project. Because relays with different firmware versions may require different CID file versions, users can manage the CID files of all IEDs within a single project.

Please ensure that you work with the appropriate version of ACSELERATOR Architect relative to your current configuration, existing project files, and ultimate goals. If you want the best available IEC 61850 functionality for your SEL relay, obtain the latest version of ACSELERATOR Architect and select the appropriate ICD version(s) for your needs. Architect generates CID files from ICD files, so the ICD file version Architect uses also determines the CID file version generated. Details about the different SEL-751 ICD files can be found in *Table A.7*.

The Logical Nodes description detailed in this manual revision corresponds to the SEL-751 006 ICD file. Information about the previous SEL-751 004 ICD files can be found in the previous manual revisions. Please refer to *Table A.7* to find the manual revision corresponding to the ICD file you are using.

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 the IEC 61850 guidelines.

Table F.7 New Logical Node Extensions

Logical Node	IEC 61850	Description or Comments
Arc Flash Detection	PAFD	This LN shall be used to represent Arc Flash Detection status.
Thermal Measurements (for equipment or ambient temperature readings)	MTHR	This LN shall be used to represent values from RTDs and to calculate thermal capacity and usage mainly used for Thermal Monitoring.
Thermal Metering (IEC Thermal Elements)	MTHE	This LN shall be used to represent IEC Thermal Element Metering values.
Metering Statistics	MSTA	This LN shall be used for power system metering statistics.
Demand Metering Statistics	MDST	This LN shall be used for calculation of demand currents in a three-phase system. This shall not be used for billing purposes.

Table F.8 defines the data class Arc-Flash Detection. This class represents Arc-Flash Detection status.

Table F.8 Arc-Flash Detection Logical Node Class Definition

PAFD Class				
Data Object Name	Common Data Class	Explanation	T[a]	M/O/C/E[b]
LNName		Shall be inherited from Logical-Node Class (see IEC 61850-7-2).		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Status Information				
Str	ACD	Start		E
Op	ACT	Operate	T	E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table F.9 defines the data class Thermal Metering Data. This class is a collection of simultaneous measurements (or evaluations) that represent the RTD thermal metering values. Valid data depend on the presence and configuration of the RTD module(s).

Table F.9 Thermal Metering Data Logical Node Class Definition (Sheet 1 of 2)

MTHR Class				
Data Object Name	Common Data Class	Explanation	T[a]	M/O/C/E[b]
LNName		The name shall be composed of the class name, the LN-Prefix, and the LN-Instance-ID (according to IEC 61850-7-2).		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
EEHealth	INS	External equipment health (RTD Communications Status)		E

Table F.9 Thermal Metering Data Logical Node Class Definition (Sheet 2 of 2)

MTHR Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
Data Objects				
Measured Values				
MaxAmbTmp	MV	Maximum Ambient Temperature		E
MaxBrgTmp	MV	Maximum Bearing Temperature		E
MaxOthTmp	MV	Maximum Other Temperature		E
MaxWdgTmp	MV	Maximum Winding Temperature		E
Tmp	MV	Temperature		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table F.10 defines the data class Thermal Element Metering Data. This class is a collection of simultaneous measurements (or evaluations) that represent the IEC 49 Thermal Element values.

Table F.10 Thermal Element Metering Data Logical Node Class Definition

MTHE Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and LN-Instance-ID (according to IEC 61850-7-2).		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Measured Values				
Thrl1	MV	Operating quantity thermal level memory from Element 1		E
Thrl2	MV	Operating quantity thermal level memory from Element 2		E
Thrl3	MV	Operating quantity thermal level memory from Element 3		E
Thieq1	MV	Operating quantity equivalent current from Element 1		E
Thieq2	MV	Operating quantity equivalent current from Element 2		E
Thieq3	MV	Operating quantity equivalent current from Element 3		E
Thtcu1	MV	Thermal capacity used from Element 1		E
Thtcu2	MV	Thermal capacity used from Element 2		E
Thtcu3	MV	Thermal capacity used from Element 3		E
Thtrip1	MV	Time before thermal element trips from Element 1		E
Thtrip2	MV	Time before thermal element trips from Element 2		E
Thtrip3	MV	Time before thermal element trips from Element 3		E
Thrls1	MV	Time before thermal element releases from Element 1		E
Thrls2	MV	Time before thermal element releases from Element 2		E
Thrls3	MV	Time before thermal element releases from Element 3		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension

Table F.11 defines the data class Metering Statistics. This class is a collection of power system metering statistics.

Table F.11 Metering Statistics Logical Node Class Definition

MSTA Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and LN-Instance-ID (according to IEC 61850-7-2).		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Measured and Metered Values				
AvAmps	MV	Average current		E
AvVolts	MV	Average voltage		E
MaxVA	MV	Maximum apparent power		E
MinVA	MV	Minimum apparent power		E
MaxW	MV	Maximum real power		E
MinW	MV	Minimum real power		E
MaxVAr	MV	Maximum reactive power		E
MinVAr	MV	Minimum reactive power		E
MaxA	WYE	Maximum phase currents		E
MinA	WYE	Minimum phase currents		E
MaxPhV	WYE	Maximum phase-to-ground voltages		E
MinPhV	WYE	Minimum phase-to-ground voltages		E
MaxP2PV	DEL	Maximum phase-to-phase voltages		E
MinP2PV	DEL	Minimum phase-to-phase voltages		E
MaxVs	MV	Maximum synchronism-check voltage		E
MinVs	MV	Minimum synchronism-check voltage		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state

[b] M: Mandatory; O: Optional; C: Conditional; E: Extension

Table F.12 defines the data class Demand Metering Statistics. This class is a collection of demand currents and energy.

Table F.12 Demand Metering Statistics Logical Node Class Definition (Sheet 1 of 2)

MDST Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and the LN-Instance-ID (according to IEC 61850-7-2).		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Measured Values				
DmdA	WYE	Phase Demand Currents		E
DmdAnseq	MV	Negative-Sequence Demand Current		E

Table F.12 Demand Metering Statistics Logical Node Class Definition (Sheet 2 of 2)

MDST Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
PkDmdA	WYE	Peak Demand Currents		E
PkDmdAnseq	MV	Negative-Sequence Peak Demand Current		E
SupWh	BCR	Real energy supply (default supply direction: energy flow towards busbar)		E
SupVArh	BCR	Reactive energy supply (default supply direction: energy flow towards busbar)		E
DmdWh	BCR	Real energy demand (default demand direction: energy flow from busbar away)		E
DmdVArh	BCR	Reactive energy demand (default demand direction: energy flow from busbar away)		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table F.13 Compatible Logical Nodes With Extensions

Logical Node	IEC 61850	Description or comments
Fault Locator	RFLO	This LN is used for fault locator measurement data.
Circuit Breaker	XCBR	This LN is used for circuit breaker status and measurement data.
Measurement	MMXU	This LN is used for power system measurement data.
Generic Process I/O	GGIO	This LN is used for Remote Analog data.
Circuit Breaker Wear Supervision	SCBR	This LN is used for supervision of circuit breakers.

Table F.14 Fault Locator Logical Node Class Definition

RFLO Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and the LN-Instance-ID (according to IEC 61850-7-2).		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Measured and Metered Values				
FltZ	CMV	Fault impedance		M
FltDiskm	MV	Fault distance		O
FltA	WYE	Fault currents		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table F.15 Circuit Breaker Logical Node Class Definition

XCBR Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and the LN-Instance-ID (according to IEC 61850-7-2).		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Status Information				
Loc	SPS	Local control behavior		M
OpCnt	INS	Operation counter		M
OpCntEx	INS	Operation counter—external		E
Measured and Metered Values				
Pos	DPC	Switch position		M
BlkOpn	SPC	Block opening		M
BlkCls	SPC	Block closing		M

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table F.16 Measurement Logical Node Class Definition

MMXU Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and the LN-Instance-ID (according to IEC 61850-7-2).		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Measured and Metered Values				
TotW	MV	Total active power		O
TotVAr	MV	Total reactive power		O
TotVA	MV	Total apparent power		O
TotPF	MV	Average power factor		O
Hz	MV	Frequency		O
PPV	DEL	Phase-to-phase voltages		O
PhV	WYE	Phase-to-ground voltages		O
A	WYE	Phase currents		O
VSyn	CMV	Synchronism-check voltage		E
Fs	MV	Synchronism-check frequency		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table F.17 Measurement Logical Node Class Definition

MMXU Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and the LN-Instance-ID (according to IEC 61850-7-2).		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Measured and Metered Values				
PPV	DEL	Phase-to-phase voltages		O
PhV	WYE	Phase-to-ground voltages		O
A	WYE	Phase currents		O
VSyn	CMV	Synchronism-check voltage		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table F.18 Generic Process I/O Logical Node Class Definition

GGIO Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and the LN-Instance-ID (according to IEC 61850-7-2).		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Measured Values				
AnIn	MV	Analog input		O
Ra	MV	Remote analog		E
Controls				
SPCSO	SPC	Single point controllable status output		O
Status Information				
Ind	SPS	General indication (binary input)		O

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table F.19 Circuit Breaker Supervision (Per-Phase) Logical Node Class Definition (Sheet 1 of 2)

SCBR Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and the LN-Instance-ID (according to IEC 61850-7-2).		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M

Table F.19 Circuit Breaker Supervision (Per-Phase) Logical Node Class Definition (Sheet 2 of 2)

SCBR Class				
Data Objects				
Status Information				
ColOpn	SPS	Open command of trip coil		M
Measured Values				
AbrPrt	MV	Calculated or measured wear (e.g. of main contact), expressed in % where 0% corresponds to new condition		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension

Logical Nodes

The following tables, *Table F.20* through *Table F.24*, show the Logical Nodes (LN) supported in the SEL-751 and the associated Relay Word bits or measured quantities. *Table F.20* shows the LN associated with protection elements defined as Logical Device PRO.

Table F.20 Logical Device: PRO (Protection) (Sheet 1 of 13)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = CO			
BKR1CSWI1	Pos.Oper.ctlVal	CC[a]	Breaker close/open command
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PARTNO	Part number
Functional Constraint = MX[a]			
FLTRFLO1	FltZ.instCVal.mag.f	FZ	Fault impedance magnitude of the most recent fault
FLTRFLO1	FltZ.instCVal.ang.f	FZFA	Fault impedance angle of the most recent fault
FLTRFLO1	FltDiskm.instMag.f	FLOC	Fault location of the most recent fault
FLTRFLO1	FltA.phsA.instCVal.mag.f	FIA	A-phase current of the most recent fault event
FLTRFLO1	FltA.phsB.instCVal.mag.f	FIB	B-phase current of the most recent fault event
FLTRFLO1	FltA.phsC.instCVal.mag.f	FIC	C-phase current of the most recent fault event
FLTRFLO1	FltA.neut.instCVal.mag.f	FIN	Neutral current of the most recent fault event
FLTRFLO1	FltA.res.instCVal.mag.f	FIG	Residual current of the most recent fault event
Functional Constraint = ST			
A55POPF1	Op.general	55A	Power factor alarm
A55POPF1	Str.general	55A	Power factor alarm
A55POPF1	Str.dirGeneral	unknown	Direction undefined
ATPTOC20	Op.general	51AT	A-phase time-overcurrent element trip

Table F.20 Logical Device: PRO (Protection) (Sheet 2 of 13)

Logical Node	Attribute	Data Source	Comment
ATPTOC20	Str.general	51AP	A-phase time-overcurrent element pickup
ATPTOC20	Str.dirGeneral	unknown	Direction unknown due to settings
BFR1RBRF1	OpEx.general	BFT	Breaker failure trip
BFR1RBRF1	Str.general	BFI	Breaker failure initiation
BK1XCBR1	BlkCls.stVal	0	Breaker close blocking not configured by default
BK1XCBR1	BlkOpn.stVal	0	Breaker open blocking not configured by default
BK1XCBR1	CBOpCap.stVal	None	Breaker/Contactor physical operation capabilities not known to relay
BK1XCBR1	Loc.stVal	LOCAL	Breaker/Contactor local control status. Asserted when relay is in Local mode.
BK1XCBR1	OpCnt.stVal	INTT	Internal trip counter
BK1XCBR1	OpCntEx.stVal	EXTT	External trip counter
BK1XCBR1	Pos.stVal	52A?1:2[b]	Breaker position (52A = false, breaker opened; 52A = true, breaker closed)
BKR1CSWI1	OpCls.general	CC	Breaker close control
BKR1CSWI1	OpOpn.general	OC	Breaker open control
BKR1CSWI1	Loc.stVal	LOCAL	Breaker/Contactor local control status. Asserted when relay is in Local mode.
BKR1CSWI1	Pos.stVal	52A?1:2[b]	Breaker position (52A = false, breaker opened; 52A = true, breaker closed)
BTPTOC21	Op.general	51BT	B-phase time-overcurrent element trip
BTPTOC21	Str.general	51BP	B-phase time-overcurrent element pickup
BTPTOC21	Str.dirGeneral	unknown	Direction unknown due to settings
CTPTOC22	Op.general	51CT	C-phase time-overcurrent element trip
CTPTOC22	Str.general	51CP	C-phase time-overcurrent element pickup
CTPTOC22	Str.dirGeneral	unknown	Direction unknown due to settings
D1TPTOF1	Op.general	81D1T	Level 1 trip definite time over-/underfrequency elements
D1TPTOF1	Str.general	81D1T	Level 1 trip definite time over-/underfrequency elements
D1TPTOF1	Str.dirGeneral	unknown	Direction undefined
D2TPTOF2	Op.general	81D2T	Level 2 trip definite time over-/underfrequency elements
D2TPTOF2	Str.general	81D2T	Level 2 trip definite time over-/underfrequency elements
D2TPTOF2	Str.dirGeneral	unknown	Direction undefined
D3TPTOF3	Op.general	81D3T	Level 3 trip definite time over-/underfrequency elements
D3TPTOF3	Str.general	81D3T	Level 3 trip definite time over-/underfrequency elements
D3TPTOF3	Str.dirGeneral	unknown	Direction undefined

Table F.20 Logical Device: PRO (Protection) (Sheet 3 of 13)

Logical Node	Attribute	Data Source	Comment
D4TPTOF4	Op.general	81D4T	Level 4 trip definite time over-/underfrequency elements
D4TPTOF4	Str.general	81D4T	Level 4 trip definite time over-/underfrequency elements
D4TPTOF4	Str.dirGeneral	unknown	Direction undefined
D5TPTOF5	Op.general	81D5T	Level 5 trip definite time over/underfrequency elements
D5TPTOF5	Str.general	81D5T	Level 5 trip definite time over/underfrequency elements
D5TPTOF5	Str.dirGeneral	unknown	Direction undefined
D6TPTOF6	Op.general	81D6T	Level 6 trip definite time over-/underfrequency elements
D6TPTOF6	Str.general	81D6T	Level 6 trip definite time over-/underfrequency elements
D6TPTOF6	Str.dirGeneral	unknown	Direction undefined
DIRNFRDIR1	Dir.general	FDIRN	Forward directional element for low-impedance grounded, Petersen Coil grounded or ungrounded/high-impedance grounded systems
DIRNFRDIR1	Dir.dirGeneral	FDIRN?0:1	Forward directional element for low-impedance grounded, Petersen coil grounded, or ungrounded/high-impedance grounded systems, direction (FDIRN = false, direction unknown; FDIRN = true, direction forward)
DIRNRRDIR1	Dir.general	RDIRN	Reverse directional element for low-impedance grounded, Petersen coil grounded, or ungrounded/high-impedance grounded systems
DIRNRRDIR1	Dir.dirGeneral	RDIRN?0:2	Reverse directional element for low-impedance grounded, Petersen Coil grounded, or ungrounded/high-impedance grounded systems, direction (RDIRN = false, direction unknown; RDIRN = true, direction reverse)
FLTRDRE1	RcdMade.stVal	FLREP	Event report present
FLTRDRE1	FltNum.stVal	FLRNUM	Unique event ID number
HIFRDRE2	RcdMade.stVal	HIFLREP[b]	HIF event present
HIFRDRE2	FltNum.stVal	HIFLRNUM[b]	Unique HIF event ID number
G1TPIOC9	Op.general	50G1T	Level 1 residual ground instantaneous overcurrent element trip
G1TPIOC9	Str.general	50G1P	Level 1 residual ground instantaneous overcurrent element pickup
G1TPIOC9	Str.dirGeneral	unknown	Direction undefined
G1TPTOC17	Op.general	51G1T	Level 1 residual ground time-overcurrent element trip
G1TPTOC17	Str.general	51G1P	Level 1 residual ground time-overcurrent element pickup
G1TPTOC17	Str.dirGeneral	unknown	Direction unknown due to settings
G1TPTOV8	Op.general	59G1T	Level 1 zero-sequence instantaneous overvoltage element trip
G1TPTOV8	Str.general	59G1	Level 1 zero-sequence instantaneous overvoltage element pickup
G1TPTOV8	Str.dirGeneral	unknown	Direction undefined
G2TPIOC10	Op.general	50G2T	Level 2 residual ground instantaneous overcurrent element trip
G2TPIOC10	Str.general	50G2P	Level 2 residual ground instantaneous overcurrent element pickup
G2TPIOC10	Str.dirGeneral	unknown	Direction undefined
G2TPTOC18	Op.general	51G2T	Level 2 residual ground time-overcurrent element trip

Table F.20 Logical Device: PRO (Protection) (Sheet 4 of 13)

Logical Node	Attribute	Data Source	Comment
G2TPTOC18	Str.general	51G2P	Level 2 residual ground time-overcurrent element pickup
G2TPTOC18	Str.dirGeneral	unknown	Direction unknown due to settings
G2TPTOV9	Op.general	59G2T	Zero-sequence instantaneous overvoltage element trip
G2TPTOV9	Str.general	59G2	Zero-sequence instantaneous overvoltage element pickup
G2TPTOV9	Str.dirGeneral	unknown	Direction undefined
G3TPIOC11	Op.general	50G3T	Level 3 residual ground instantaneous overcurrent element trip
G3TPIOC11	Str.general	50G3P	Level 3 residual ground instantaneous overcurrent element pickup
G3TPIOC11	Str.dirGeneral	unknown	Direction undefined
G4TPIOC12	Op.general	50G4T	Level 4 residual ground instantaneous overcurrent element trip
G4TPIOC12	Str.general	50G4P	Level 4 residual ground instantaneous overcurrent element pickup
G4TPIOC12	Str.dirGeneral	unknown	Direction undefined
GFPIOC21	Op.general	50GF	Residual forward direction decision supervision
GFPIOC21	Str.general	50GF	Residual forward direction decision supervision
GFPIOC21	Str.dirGeneral	unknown	Direction undefined
GFRDIR1	Dir.general	DIRGF	Forward directional control routed to residual ground overcurrent elements
GFRDIR1	Dir.dirGeneral	DIRGF?0:1	Forward directional control routed to residual ground overcurrent elements, direction (DIRGF = false, direction unknown; DIRGF = true, direction forward)
GRPIOC22	Op.general	50GR	Residual reverse direction decision supervision
GRPIOC22	Str.general	50GR	Residual reverse direction decision supervision
GRPIOC22	Str.dirGeneral	unknown	Direction undefined
GRRDIR1	Dir.general	DIRGR	Reverse directional control routed to residual ground overcurrent elements
GRRDIR1	Dir.dirGeneral	DIRGR?0:2	Reverse directional control routed to residual ground overcurrent elements, direction (DIRGR = false, direction unknown; DIRGR = true, direction reverse)
HIZPHIZ1	Op.phsA	HIF1_A	A-phase HIF detection
HIZPHIZ1	Op.phsB	HIF1_B	B-phase HIF detection
HIZPHIZ1	Op.phsC	HIF1_C	C-phase HIF detection
HIZPHIZ1	Op.general	OREDHIF1	HIF1_A OR HIF1_B OR HIF1_C
HIZPHIZ1	Str.general	OREDHIF1	HIF1_A OR HIF1_B OR HIF1_C
HIZPHIZ1	Str.dirGeneral	unknown	Direction undefined
HIZPHIZ2	Op.phsA	HIF2_A	A-phase HIF detection
HIZPHIZ2	Op.phsB	HIF2_B	B-phase HIF detection
HIZPHIZ2	Op.phsC	HIF2_C	C-phase HIF detection
HIZPHIZ2	Op.general	OREDHIF2	HIF2_A OR HIF2_B OR HIF2_C

Table F.20 Logical Device: PRO (Protection) (Sheet 5 of 13)

Logical Node	Attribute	Data Source	Comment
HIZPHIZ2	Str.general	OREDHIF2	HIF2_A OR HIF2_B OR HIF2_C
HIZPHIZ2	Str.dirGeneral	unknown	Direction undefined
I1TPTOV12	Op.general	59I1T	Level 1 inverse overvoltage element trip
I1TPTOV12	Str.general	59I1	Level 1 inverse overvoltage element pickup
I1TPTOV12	Str.dirGeneral	unknown	Direction undefined
I1TPTOV13	Op.general	59I2T	Level 2 inverse overvoltage element trip
I1TPTOV13	Str.general	59I2	Level 2 inverse overvoltage element pickup
I1TPTOV13	Str.dirGeneral	unknown	Direction undefined
I1TPTOV14	Op.general	59I3T	Level 3 inverse overvoltage element trip
I1TPTOV14	Str.general	59I3	Level 3 inverse overvoltage element pickup
I1TPTOV14	Str.dirGeneral	unknown	Direction undefined
I1TPTOV15	Op.general	59I4T	Level 4 inverse overvoltage element trip
I1TPTOV15	Str.general	59I4	Level 4 inverse overvoltage element pickup
I1TPTOV15	Str.dirGeneral	unknown	Direction undefined
I1TPTUV10	Op.general	27I2T	Level 2 inverse undervoltage element trip
I1TPTUV10	Str.general	27I2	Level 2 inverse undervoltage element pickup
I1TPTUV10	Str.dirGeneral	unknown	Direction undefined
I1TPTUV9	Op.general	27I1T	Level 1 inverse undervoltage element trip
I1TPTUV9	Str.general	27I1	Level 1 inverse undervoltage element pickup
I1TPTUV9	Str.dirGeneral	unknown	Direction undefined
LOPPTUV5	Op.general	LOP	Loss of potential
LOPPTUV5	Str.general	LOP	Loss of potential
LOPPTUV5	Str.dirGeneral	unknown	Direction undefined
LZFRDIR1	Dir.general	LZFWD	Zero-sequence voltage polarized forward direction detected low impedance control S
LZFRDIR1	Dir.dirGeneral	LZFWD?0:1	Zero-sequence voltage polarized forward direction detected low impedance control S, direction (LZFWD = false, direction unknown; LZFWD = true, direction forward)
LZRRDIR1	Dir.general	LZREV	Zero-sequence voltage polarized reverse direction detected low impedance control S
LZRRDIR1	Dir.dirGeneral	LZREV?0:2	Zero-sequence voltage polarized reverse direction detected low impedance control S, direction (LZREV = false, direction unknown; LZREV = true, direction reverse)
N1TPIOC5	Op.general	50N1T	Level 1 neutral ground instantaneous overcurrent element trip
N1TPIOC5	Str.general	50N1P	Level 1 neutral ground instantaneous overcurrent element pickup
N1TPIOC5	Str.dirGeneral	unknown	Direction undefined

Table F.20 Logical Device: PRO (Protection) (Sheet 6 of 13)

Logical Node	Attribute	Data Source	Comment
N1TPTOC15	Op.general	51N1T	Level 1 neutral ground time-overcurrent element trip
N1TPTOC15	Str.general	51N1P	Level 1 neutral ground time-overcurrent element pickup
N1TPTOC15	Str.dirGeneral	unknown	Direction undefined
N2TPIOC6	Op.general	50N2T	Level 2 neutral ground instantaneous overcurrent element trip
N2TPIOC6	Str.general	50N2P	Level 2 neutral ground instantaneous overcurrent element pickup
N2TPIOC6	Str.dirGeneral	unknown	Direction undefined
N2TPTOC16	Op.general	51N2T	Level 2 neutral ground time-overcurrent element trip
N2TPTOC16	Str.general	51N2P	Level 2 neutral ground time-overcurrent element pickup
N2TPTOC16	Str.dirGeneral	unknown	Direction undefined
N3TPIOC7	Op.general	50N3T	Level 3 neutral ground instantaneous overcurrent element trip
N3TPIOC7	Str.general	50N3P	Level 3 neutral ground instantaneous overcurrent element pickup
N3TPIOC7	Str.dirGeneral	unknown	Direction undefined
N4TPIOC8	Op.general	50N4T	Level 4 neutral ground instantaneous overcurrent element trip
N4TPIOC8	Str.general	50N4P	Level 4 neutral ground instantaneous overcurrent element pickup
N4TPIOC8	Str.dirGeneral	unknown	Direction undefined
NAFPIOC18	Op.general	50NAF	Sample based neutral overcurrent element
NAFPIOC18	Str.general	50NAF	Sample based neutral overcurrent element
NAFPIOC18	Str.dirGeneral	unknown	Direction undefined
P1TPIOC1	Op.general	50P1T	Level 1 phase instantaneous overcurrent element trip
P1TPIOC1	Str.general	50P1P	Level 1 phase instantaneous overcurrent element pickup
P1TPIOC1	Str.dirGeneral	unknown	Direction undefined
P1TPTOC13	Op.general	51P1T	Level 1 maximum phase time-overcurrent element trip
P1TPTOC13	Str.general	51P1P	Level 1 maximum phase time-overcurrent element pickup
P1TPTOC13	Str.dirGeneral	unknown	Direction unknown due to settings
P1TPTOV1	Op.general	59P1T	Level 1 phase overvoltage element trip
P1TPTOV1	Str.general	59P1	Level 1 phase overvoltage element pickup
P1TPTOV1	Str.dirGeneral	unknown	Direction undefined
P1TPTUV1	Op.general	27P1T	Level 1 phase undervoltage element trip
P1TPTUV1	Str.general	27P1	Level 1 phase undervoltage element pickup
P1TPTUV1	Str.dirGeneral	unknown	Direction undefined
P2TPIOC2	Op.general	50P2T	Level 2 phase instantaneous overcurrent element trip
P2TPIOC2	Str.general	50P2P	Level 2 phase instantaneous overcurrent element pickup
P2TPIOC2	Str.dirGeneral	unknown	Direction undefined

Table F.20 Logical Device: PRO (Protection) (Sheet 7 of 13)

Logical Node	Attribute	Data Source	Comment
P2TPTOC14	Op.general	51P2T	Level 2 maximum phase time-overcurrent element trip
P2TPTOC14	Str.general	51P2P	Level 2 maximum phase time-overcurrent element pickup
P2TPTOC14	Str.dirGeneral	unknown	Direction unknown due to settings
P2TPTOV2	Op.general	59P2T	Level 2 phase overvoltage element trip
P2TPTOV2	Str.general	59P2	Level 2 phase overvoltage element pickup
P2TPTOV2	Str.dirGeneral	unknown	Direction undefined
P2TPTUV2	Op.general	27P2T	Level 2 phase undervoltage element trip
P2TPTUV2	Str.general	27P2	Level 2phase undervoltage element pickup
P2TPTUV2	Str.dirGeneral	unknown	Direction undefined
P3PTOV5	Op.general	3P59	Three-phase overvoltage pickup when all 3 phases are above 59P1P
P3PTOV5	Str.general	3P59	Three-phase overvoltage pickup when all 3 phases are above 59P1P
P3PTOV5	Str.dirGeneral	unknown	Direction undefined
P3PTUV6	Op.general	3P27	Three-phase undervoltage pickup when all 3 phases are below 27P1P
P3PTUV6	Str.general	3P27	Three-phase undervoltage pickup when all 3 phases are below 27P1P
P3PTUV6	Str.dirGeneral	unknown	Direction undefined
P3TPIOC3	Op.general	50P3T	Level 3 phase instantaneous overcurrent element trip
P3TPIOC3	Str.general	50P3P	Level 3 phase instantaneous overcurrent element pickup
P3TPIOC3	Str.dirGeneral	unknown	Direction undefined
P4TPIOC4	Op.general	50P4T	Level 4 phase instantaneous overcurrent element trip
P4TPIOC4	Str.general	50P4P	Level 4 phase instantaneous overcurrent element pickup
P4TPIOC4	Str.dirGeneral	unknown	Direction undefined
P67G1PTOC2	Op.general	67G1T	Level 1 residual ground directional overcurrent trip
P67G1PTOC2	Str.general	67G1P	Level 1 residual ground directional overcurrent pickup
P67G1PTOC2	Str.dirGeneral	unknown	Direction unknown due to settings
P67G2PTOC5	Op.general	67G2T	Level 2 residual ground directional overcurrent trip
P67G2PTOC5	Str.general	67G2P	Level 2 residual ground directional overcurrent pickup
P67G2PTOC5	Str.dirGeneral	unknown	Direction unknown due to settings
P67G3PTOC8	Op.general	67G3T	Level 3 residual ground directional overcurrent trip
P67G3PTOC8	Str.general	67G3P	Level 3 residual ground directional overcurrent pickup
P67G3PTOC8	Str.dirGeneral	unknown	Direction unknown due to settings
P67G4PTOC11	Op.general	67G4T	Level 4 residual ground directional overcurrent trip
P67G4PTOC11	Str.general	67G4P	Level 4 residual ground directional overcurrent pickup
P67G4PTOC11	Str.dirGeneral	unknown	Direction unknown due to settings

Table F.20 Logical Device: PRO (Protection) (Sheet 8 of 13)

Logical Node	Attribute	Data Source	Comment
P67N1PTOC14	Op.general	67N1T	Level 1 neutral directional overcurrent trip
P67N1PTOC14	Str.general	67N1P	Level 1 neutral directional overcurrent pickup
P67N1PTOC14	Str.dirGeneral	unknown	Direction unknown due to settings
P67N2PTOC15	Op.general	67N2T	Level 2 neutral directional overcurrent trip
P67N2PTOC15	Str.general	67N2P	Level 2 neutral directional overcurrent pickup
P67N2PTOC15	Str.dirGeneral	unknown	Direction unknown due to settings
P67N3PTOC16	Op.general	67N3T	Level 3 neutral directional overcurrent trip
P67N3PTOC16	Str.general	67N3P	Level 3 neutral directional overcurrent pickup
P67N3PTOC16	Str.dirGeneral	unknown	Direction unknown due to settings
P67N4PTOC17	Op.general	67N4T	Level 4 neutral directional overcurrent trip
P67N4PTOC17	Str.general	67N4P	Level =42 neutral directional overcurrent pickup
P67N4PTOC17	Str.dirGeneral	unknown	Direction unknown due to settings
P67P1PTOC1	Op.general	67P1T	Level 1 phase directional overcurrent trip
P67P1PTOC1	Str.general	67P1P	Level 1 phase directional overcurrent pickup
P67P1PTOC1	Str.dirGeneral	unknown	Direction unknown due to settings
P67P2PTOC4	Op.general	67P2T	Level 2 phase directional overcurrent trip
P67P2PTOC4	Str.general	67P2P	Level 2 phase directional overcurrent pickup
P67P2PTOC4	Str.dirGeneral	unknown	Direction unknown due to settings
P67P3PTOC7	Op.general	67P3T	Level 3 phase directional overcurrent trip
P67P3PTOC7	Str.general	67P3P	Level 3 phase directional overcurrent pickup
P67P3PTOC7	Str.dirGeneral	unknown	Direction unknown due to settings
P67P4PTOC10	Op.general	67P4T	Level 4 phase directional overcurrent trip
P67P4PTOC10	Str.general	67P4P	Level 4 phase directional overcurrent pickup
P67P4PTOC10	Str.dirGeneral	unknown	Direction unknown due to settings
P67Q1PTOC3	Op.general	67Q1T	Level 1 negative-sequence directional overcurrent trip
P67Q1PTOC3	Str.general	67Q1P	Level 1 negative-sequence directional overcurrent pickup
P67Q1PTOC3	Str.dirGeneral	unknown	Direction unknown due to settings
P67Q2PTOC6	Op.general	67Q2T	Level 2 negative-sequence directional overcurrent trip
P67Q2PTOC6	Str.general	67Q2P	Level 2 negative-sequence directional overcurrent pickup
P67Q2PTOC6	Str.dirGeneral	unknown	Direction unknown due to settings
P67Q3PTOC9	Op.general	67Q3T	Level 3 negative-sequence directional overcurrent trip
P67Q3PTOC9	Str.general	67Q3P	Level 3 negative-sequence directional overcurrent pickup
P67Q3PTOC9	Str.dirGeneral	unknown	Direction unknown due to settings

Table F.20 Logical Device: PRO (Protection) (Sheet 9 of 13)

Logical Node	Attribute	Data Source	Comment
P67Q4PTOC12	Op.general	67Q4T	Level 4 negative-sequence directional overcurrent trip
P67Q4PTOC12	Str.general	67Q4P	Level 4 negative-sequence directional overcurrent pickup
P67Q4PTOC12	Str.dirGeneral	unknown	Direction unknown due to settings
PAFPIOC17	Op.general	50PAF	Sample based phase overcurrent element
PAFPIOC17	Str.general	50PAF	Sample based phase overcurrent element
PAFPIOC17	Str.dirGeneral	unknown	Direction undefined
PFRDIR1	Dir.general	DIRPF	Forward directional control routed to phase overcurrent elements
PFRDIR1	Dir.dirGeneral	DIRPF?0:1	Forward directional control routed to phase overcurrent elements, direction (DIRPF = false, direction unknown; DIRPF = true, direction forward)
PIFRDIR1	Dir.general	FDIRC	Forward directional element for Petersen coil incremental conductance
PIFRDIR1	Dir.dirGeneral	FDIRC?0:1	Forward directional element for Petersen coil incremental conductance, direction (FDIRC = false, direction unknown; FDIRC = true, direction forward)
PIRRDIR1	Dir.general	RDIRC	Reverse directional element for Petersen coil incremental conductance
PIRRDIR1	Dir.dirGeneral	RDIRC?0:2	Reverse directional element for Petersen coil incremental conductance, direction (RDIRC = false, direction unknown; RDIRC = true, direction forward)
PP1TPTOV3	Op.general	59PP1T	Level 1 phase-to-phase overvoltage element trip
PP1TPTOV3	Str.general	59PP1	Level 1 phase-to-phase overvoltage element pickup
PP1TPTOV3	Str.dirGeneral	unknown	Direction undefined
PP1TPTUV3	Op.general	27PP1T	Level 1 phase-to-phase undervoltage element trip
PP1TPTUV3	Str.general	27PP1	Level 1 phase-to-phase undervoltage element pickup
PP1TPTUV3	Str.dirGeneral	unknown	Direction undefined
PP2TPTOV4	Op.general	59PP2T	Level 2 phase-to-phase overvoltage element trip
PP2TPTOV4	Str.general	59PP2	Level 2 phase-to-phase overvoltage element pickup
PP2TPTOV4	Str.dirGeneral	unknown	Direction undefined
PP2TPTUV4	Op.general	27PP2T	Level 2 phase-to-phase undervoltage element trip
PP2TPTUV4	Str.general	27PP2	Level 2 phase-to-phase undervoltage element pickup
PP2TPTUV4	Str.dirGeneral	unknown	Direction undefined
PRRDIR1	Dir.general	DIRPR	Reverse directional control routed to phase overcurrent elements
PRRDIR1	Dir.dirGeneral	DIRPR?0:2	Reverse directional control routed to phase overcurrent elements, direction (DIRPR = false, direction unknown; DIRPR = true, direction reverse
PWFRDIR1	Dir.general	FDIRW	Forward directional output for Petersen coil wattmetric element
PWFRDIR1	Dir.dirGeneral	FDIRW?0:1	Forward directional output for Petersen coil wattmetric elements, direction (FDIRW = false, direction unknown; FDIRW = true, direction forward)

Table F.20 Logical Device: PRO (Protection) (Sheet 10 of 13)

Logical Node	Attribute	Data Source	Comment
PWR1PDOP1	Op.general	3PWR1T	Three-Phase Power Element 1 trip
PWR1PDOP1	Str.general	3PWR1P	Three-Phase Power Element 1 pickup
PWR1PDOP1	Str.dirGeneral	unknown	Direction undefined
PWR1PDUP1	Op.general	3PWR1T	Three-Phase Power Element 1 trip
PWR1PDUP1	Str.general	3PWR1P	Three-Phase Power Element 1 pickup
PWR1PDUP1	Str.dirGeneral	unknown	Direction undefined
PWR2PDOP1	Op.general	3PWR2T	Three-Phase Power Element 2 trip
PWR2PDOP1	Str.general	3PWR2P	Three-Phase Power Element 2 pickup
PWR2PDOP1	Str.dirGeneral	unknown	Direction undefined
PWR2PDUP1	Op.general	3PWR2T	Three-Phase Power Element 2 trip
PWR2PDUP1	Str.general	3PWR2P	Three-Phase Power Element 2 pickup
PWR2PDUP1	Str.dirGeneral	unknown	Direction undefined
PWRRDIR1	Dir.general	RDIRW	Reverse directional output for Petersen coil wattmetric element
PWRRDIR1	Dir.dirGeneral	RDIRW?0:1	Reverse directional output for Petersen coil wattmetric element, direction (RDIRW = false, direction unknown; RDIRW = true, direction reverse)
Q1TPIOC13	Op.general	50Q1T	Level 1 negative-sequence instantaneous overcurrent element trip
Q1TPIOC13	Str.general	50Q1P	Level 1 negative-sequence instantaneous overcurrent element pickup
Q1TPIOC13	Str.dirGeneral	unknown	Direction undefined
Q1TPTOV10	Op.general	59Q1T	Negative-sequence instantaneous overvoltage element trip
Q1TPTOV10	Str.general	59Q1	Negative-sequence instantaneous overvoltage element pickup
Q1TPTOV10	Str.dirGeneral	unknown	Direction undefined
Q2TPIOC14	Op.general	50Q2T	Level 2 negative-sequence instantaneous overcurrent element trip
Q2TPIOC14	Str.general	50Q2P	Level 2 negative-sequence instantaneous overcurrent element pickup
Q2TPIOC14	Str.dirGeneral	unknown	Direction undefined
Q2TPTOV11	Op.general	59Q2T	Negative-sequence instantaneous overvoltage element trip
Q2TPTOV11	Str.general	59Q2	Negative-sequence instantaneous overvoltage element pickup
Q2TPTOV11	Str.dirGeneral	unknown	Direction undefined
Q3TPIOC15	Op.general	50Q3T	Level 3 negative-sequence instantaneous overcurrent element trip
Q3TPIOC15	Str.general	50Q3P	Level 3 negative-sequence instantaneous overcurrent element pickup
Q3TPIOC15	Str.dirGeneral	unknown	Direction undefined
Q4TPIOC16	Op.general	50Q4T	Level 4 negative-sequence instantaneous overcurrent element trip
Q4TPIOC16	Str.general	50Q4P	Level 4 negative-sequence instantaneous overcurrent element pickup
Q4TPIOC16	Str.dirGeneral	unknown	Direction undefined

Table F.20 Logical Device: PRO (Protection) (Sheet 11 of 13)

Logical Node	Attribute	Data Source	Comment
QFPIOC19	Op.general	50QF	Negative-sequence forward direction decision supervision
QFPIOC19	Str.general	50QF	Negative-sequence forward direction decision supervision
QFPIOC19	Str.dirGeneral	unknown	Direction undefined
QFRDIR1	Dir.general	DIRQF	Forward directional control routed to negative sequence overcurrent elements
QFRDIR1	Dir.dirGeneral	DIRQF?0:1	Forward directional control routed to negative sequence overcurrent elements, direction (DIRQF = false, direction unknown; DIRQF = true, direction forward)
QRPIOC20	Op.general	50QR	Negative-sequence reverse direction decision supervision
QRPIOC20	Str.general	50QR	Negative-sequence reverse direction decision supervision
QRPIOC20	Str.dirGeneral	unknown	Direction undefined
QRRDIR1	Dir.general	DIRQR	Reverse directional control routed to negative-sequence overcurrent elements
QRRDIR1	Dir.dirGeneral	DIRQR?0:2	Reverse directional control routed to negative-sequence overcurrent elements, direction (DIRQR = false, direction unknown; DIRQR = true, direction reverse
QTPTOC19	Op.general	51QT	Negative-sequence time-overcurrent element trip
QTPTOC19	Str.general	51QP	Negative-sequence time-overcurrent element pickup
QTPTOC19	Str.dirGeneral	unknown	Direction unknown due to settings
R1TPFRC1	Op.general	81R1T	Level 1 rate-of-change-of-frequency element trip
R1TPFRC1	Str.general	81R1T	Level 1 rate-of-change-of-frequency element trip
R1TPFRC1	Str.dirGeneral	unknown	Direction undefined
R2TPFRC2	Op.general	81R2T	Level 2 rate-of-change-of-frequency element trip
R2TPFRC2	Str.general	81R2T	Level 2 rate-of-change-of-frequency element trip
R2TPFRC2	Str.dirGeneral	unknown	Direction undefined
R3TPFRC3	Op.general	81R3T	Level 3 rate-of-change-of-frequency element trip
R3TPFRC3	Str.general	81R3T	Level 3 rate-of-change-of-frequency element trip
R3TPFRC3	Str.dirGeneral	unknown	Direction undefined
R4TPFRC4	Op.general	81R4T	Level 4 rate-of-change-of-frequency element trip
R4TPFRC4	Str.general	81R4T	Level 4 rate-of-change-of-frequency element trip
R4TPFRC4	Str.dirGeneral	unknown	Direction undefined
S1TPTOV6	Op.general	59S1T	Level 1 VS channel overvoltage element with time delay
S1TPTOV6	Str.general	59S1	Level 1 VS channel overvoltage element pickup
S1TPTOV6	Str.dirGeneral	unknown	Direction undefined
S1TPTUV7	Op.general	27S1T	Level 1 VS channel undervoltage element with time delay
S1TPTUV7	Str.general	27S1	Level 1 VS channel undervoltage element pickup
S1TPTUV7	Str.dirGeneral	unknown	Direction undefined

Table F.20 Logical Device: PRO (Protection) (Sheet 12 of 13)

Logical Node	Attribute	Data Source	Comment
S2TPTOV7	Op.general	59S2T	Level 2 VS channel overvoltage element with time delay
S2TPTOV7	Str.general	59S2	Level 2 VS channel overvoltage element pickup
S2TPTOV7	Str.dirGeneral	unknown	Direction undefined
S2TPTUV8	Op.general	27S2T	Level 2 VS channel undervoltage element with time delay
S2TPTUV8	Str.general	27S2	Level 2 VS channel undervoltage element pickup
S2TPTUV8	Str.dirGeneral	unknown	Direction undefined
T55POPF2	Op.general	55T	Power factor trip
T55POPF2	Str.general	55T	Power factor trip
T55POPF2	Str.dirGeneral	unknown	Direction undefined
TOL1PAFD1	Op.general	TOL1[c]	Arc-Flash Light Input 1 element pickup
TOL1PAFD1	Str.general	TOL1[c]	Arc-Flash Light Input 1 element pickup
TOL1PAFD1	Str.dirGeneral	unknown	Direction undefined
TOL2PAFD2	Op.general	TOL2[c]	Arc-Flash Light Input 2 element pickup
TOL2PAFD2	Str.general	TOL2[c]	Arc-Flash Light Input 2 element pickup
TOL2PAFD2	Str.dirGeneral	unknown	Direction undefined
TOL3PAFD3	Op.general	TOL3[c]	Arc-Flash Light Input 3 element pickup
TOL3PAFD3	Str.general	TOL3[c]	Arc-Flash Light Input 3 element pickup
TOL3PAFD3	Str.dirGeneral	unknown	Direction undefined
TOL4PAFD4	Op.general	TOL4[c]	Arc-Flash Light Input 4 element pickup
TOL4PAFD4	Str.general	TOL4[c]	Arc-Flash Light Input 4 element pickup
TOL4PAFD4	Str.dirGeneral	unknown	Direction undefined
TOL5PAFD1	Op.general	TOL5[c]	Arc-Flash Light Input 5 element pickup
TOL5PAFD1	Str.general	TOL5[c]	Arc-Flash Light Input 5 element pickup
TOL5PAFD1	Str.dirGeneral	unknown	Direction undefined
TOL6PAFD2	Op.general	TOL6[c]	Arc-Flash Light Input 6 element pickup
TOL6PAFD2	Str.general	TOL6[c]	Arc-Flash Light Input 6 element pickup
TOL6PAFD2	Str.dirGeneral	unknown	Direction undefined
TOL7PAFD3	Op.general	TOL7[c]	Arc-Flash Light Input 7 element pickup
TOL7PAFD3	Str.general	TOL7[c]	Arc-Flash Light Input 7 element pickup
TOL7PAFD3	Str.dirGeneral	unknown	Direction undefined
TOL8PAFD4	Op.general	TOL8[c]	Arc-Flash Light Input 8 element pickup
TOL8PAFD4	Str.general	TOL8[c]	Arc-Flash Light Input 8 element pickup
TOL8PAFD4	Str.dirGeneral	unknown	Direction undefined

Table F.20 Logical Device: PRO (Protection) (Sheet 13 of 13)

Logical Node	Attribute	Data Source	Comment
TRIPPTRC1	Tr.general	TRIP	Trip logic output
UGFRDIR1	Dir.general	UGFWD	Zero-sequence voltage polarized forward direction detected ungrounded/high Z control U
UGFRDIR1	Dir.dirGeneral	UGFWD?0:1	Zero-sequence voltage polarized forward direction detected ungrounded/high Z control U, direction (UGFWD = false, direction unknown; UGFWD = true, direction forward)
UGRRDIR1	Dir.general	UGREV	Zero-sequence voltage polarized reverse direction detected ungrounded/high Z control U
UGRRDIR1	Dir.dirGeneral	UGREV?0:2	Zero-sequence voltage polarized reverse direction detected ungrounded/high Z control U, direction (UGREV = false, direction unknown; UGREV = true, direction reverse)

[a] MX values contain instantaneous attributes (instMag and instCVal), which are updated whenever the source updates, and other attributes that are only updated when the source goes outside the data source's deadband (mag and cVal). Only instantaneous values are shown in the table.
[b] Valid data depends on HIF firmware option and EHIF setting.
[c] Valid data depends on the installed arc-flash card.

Table F.21 shows the LN associated with measuring elements defined as Logical Device MET.

Table F.21 Logical Device: MET (Metering) (Sheet 1 of 5)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PARTNO	Part number
Functional Constraint = MX[a b]			
DCZBAT1	Vol.instMag.f	VDC	Station dc battery voltage
METMDST1	DmdA.nseq.instCVal.mag.f	3I2D	Negative-sequence current demand
METMDST1	DmdA.phsA.instCVal.mag.f	IAD	A-phase current demand
METMDST1	DmdA.phsB.instCVal.mag.f	IBD	B-phase current demand
METMDST1	DmdA.phsC.instCVal.mag.f	ICD	C-phase current demand
METMDST1	DmdA.res.instCVal.mag.f	IGD	Residual current demand
METMDST1	DmdVArh.actVal	MVARH3PO	Three-phase reactive energy OUT
METMDST1	DmdWh.actVal	MWH3P	Three-phase real energy OUT
METMDST1	PkDmdA.nseq.instCVal.mag.f	3I2PD	Negative-sequence current peak demand
METMDST1	PkDmdA.phsA.instCVal.mag.f	IAPD	A-phase current peak demand
METMDST1	PkDmdA.phsB.instCVal.mag.f	IBPD	B-phase current peak demand
METMDST1	PkDmdA.phsC.instCVal.mag.f	ICPD	C-phase current peak demand
METMDST1	PkDmdA.res.instCVal.mag.f	IGPD	Residual current peak demand
METMDST1	SupVArh.actVal	MVARH3PI	Reactive energy, three-phase IN
METMDST1	SupWh.actVal	MWH3PI	Three-phase real energy IN
METMMXU1	A.phsA.instCVal.ang.f	IA_ANG	Current, A-phase, angle

Table F.21 Logical Device: MET (Metering) (Sheet 2 of 5)

Logical Node	Attribute	Data Source	Comment
METMMXU1	A.phsA.instCVal.mag.f	IA_MAG	Current, A-phase, magnitude
METMMXU1	A.phsB.instCVal.ang.f	IB_ANG	Current, B-phase, angle
METMMXU1	A.phsB.instCVal.mag.f	IB_MAG	Current, B-phase, magnitude
METMMXU1	A.phsC.instCVal.ang.f	IC_ANG	Current, C-phase, angle
METMMXU1	A.phsC.instCVal.mag.f	IC_MAG	Current, C-phase, magnitude
METMMXU1	A.res.instCVal.ang.f	IG_ANG	Current, calculated-residual, angle
METMMXU1	A.res.instCVal.mag.f	IG_MAG	Current, calculated-residual, magnitude
METMMXU1	A.neut.instCVal.ang.f	IN_ANG	Neutral current, angle
METMMXU1	A.neut.instCVal.mag.f	IN_MAG	Neutral current, magnitude
METMMXU1	Hz.instMag.f	FREQ	Frequency
METMMXU1	PF.phsA.instCVal.mag.f	PFA	Power factor, A-phase, magnitude
METMMXU1	PF.phsB.instCVal.mag.f	PFB	Power factor, B-phase, magnitude
METMMXU1	PF.phsC.instCVal.mag.f	PFC	Power factor, C-phase, magnitude
METMMXU1	PhV.phsA.instCVal.ang.f	VA_ANG	Voltage, A-phase-to-neutral, angle
METMMXU1	PhV.phsA.instCVal.mag.f	VA_MAG	Voltage, A-phase-to-neutral, magnitude
METMMXU1	PhV.phsB.instCVal.ang.f	VB_ANG	Voltage, B-phase-to-neutral, angle
METMMXU1	PhV.phsB.instCVal.mag.f	VB_MAG	Voltage, B-phase-to-neutral, magnitude
METMMXU1	PhV.phsC.instCVal.ang.f	VC_ANG	Voltage, C-phase-to-neutral, angle
METMMXU1	PhV.phsC.instCVal.mag.f	VC_MAG	Voltage, C-phase-to-neutral, magnitude
METMMXU1	PhV.res.instCVal.ang.f	VG_ANG	Zero-sequence voltage, angle
METMMXU1	PhV.res.instCVal.mag.f	VG_MAG	Zero-sequence voltage, magnitude
METMMXU1	PPV.phsAB.instCVal.ang.f	VAB_ANG	Voltage, A-to-B-phase, angle
METMMXU1	PPV.phsAB.instCVal.mag.f	VAB_MAG	Voltage, A-to-B-phase, magnitude
METMMXU1	PPV.phsBC.instCVal.ang.f	VBC_ANG	Voltage, B-to-C-phase, angle
METMMXU1	PPV.phsBC.instCVal.mag.f	VBC_MAG	Voltage, B-to-C-phase, magnitude
METMMXU1	PPV.phsCA.instCVal.ang.f	VCA_ANG	Voltage, C-to-A-phase, angle
METMMXU1	PPV.phsCA.instCVal.mag.f	VCA_MAG	Voltage, C-to-A-phase, magnitude
METMMXU1	TotPF.instMag.f	PF	Power factor, three-phase, magnitude
METMMXU1	TotVA.instMag.f	S	Apparent power, three-phase, magnitude
METMMXU1	TotVAr.instMag.f	Q	Reactive power, three-phase, magnitude
METMMXU1	TotW.instMag.f	P	Real power, three-phase, magnitude
METMMXU1	VA.phsA.instCVal.mag.f	SA	Apparent power, A-phase, magnitude
METMMXU1	VA.phsB.instCVal.mag.f	SB	Apparent power, B-phase, magnitude
METMMXU1	VA.phsC.instCVal.mag.f	SC	Apparent power, C-phase, magnitude

Table F.21 Logical Device: MET (Metering) (Sheet 3 of 5)

Logical Node	Attribute	Data Source	Comment
METMMXU1	VAr.phsA.instCVal.mag.f	QA	Reactive power, A-phase, magnitude
METMMXU1	VAr.phsB.instCVal.mag.f	QB	Reactive power, B-phase, magnitude
METMMXU1	VAr.phsC.instCVal.mag.f	QC	Reactive power, C-phase, magnitude
METMMXU1	W.phsA.instCVal.mag.f	PA	Real power, A-phase, magnitude
METMMXU1	W.phsB.instCVal.mag.f	PB	Real power, B-phase, magnitude
METMMXU1	W.phsC.instCVal.mag.f	PC	Real power, C-phase, magnitude
METMMXU1	VSyn.instCVal.ang.f	VS_ANG	Synchronizing voltage angle
METMMXU1	VSyn.instCVal.mag.f	VS_MAG	Synchronizing voltage magnitude
METMMXU1	Fs.instMag.f	FREQS	Synchronizing frequency
METMSQI1	MaxImbA.instMag.f	UBI	Current imbalance
METMSQI1	MaxImbV.instMag.f	UBV	Voltage imbalance
METMSQI1	SeqA.c1.instCVal.ang.f	I1_ANG	Positive-sequence current, angle
METMSQI1	SeqA.c1.instCVal.mag.f	I1_MAG	Positive-sequence current, magnitude
METMSQI1	SeqA.c2.instCVal.ang.f	I2_ANG	Negative-sequence current, angle
METMSQI1	SeqA.c2.instCVal.mag.f	3I2	Negative-sequence current, magnitude
METMSQI1	SeqA.c3.instCVal.ang.f	IG_ANG	Current, calculated-residual, angle
METMSQI1	SeqA.c3.instCVal.mag.f	IG_MAG	Current, calculated-residual, magnitude
METMSQI1	SeqV.c1.instCVal.ang.f	V1_ANG	Positive-sequence voltage, angle
METMSQI1	SeqV.c1.instCVal.mag.f	V1_MAG	Positive-sequence voltage, magnitude
METMSQI1	SeqV.c2.instCVal.ang.f	V2_ANG	Negative-sequence voltage, angle
METMSQI1	SeqV.c2.instCVal.mag.f	3V2	Negative-sequence voltage, magnitude
METMSQI1	SeqV.c3.instCVal.ang.f	VG_ANG	Zero-sequence voltage, angle
METMSQI1	SeqV.c3.instCVal.mag.f	VG_MAG	Zero-sequence voltage, magnitude
METMSTA1	AvAmps.instMag.f	IAV	Current, average current, magnitude
METMSTA1	AvVolts.instMag.f	VAVE	Average voltage, magnitude
METMSTA1	MaxA.phsA.instCVal.mag.f	IAMX	Current, A-phase, maximum magnitude
METMSTA1	MaxA.phsB.instCVal.mag.f	IBMX	Current, B-phase, maximum magnitude
METMSTA1	MaxA.phsC.instCVal.mag.f	ICMX	Current, C-phase, maximum magnitude
METMSTA1	MaxA.res.instCVal.mag.f	IGMX	Current, residual, maximum magnitude
METMSTA1	MaxA.neut.instCVal.mag.f	INMX	Current, neutral, maximum magnitude
METMSTA1	MaxP2PV.phsAB.instCVal.mag.f	VABMX	Voltage, A-to-B-phase, maximum magnitude
METMSTA1	MaxP2PV.phsBC.instCVal.mag.f	VBCMX	Voltage, B-to-C-phase, maximum magnitude
METMSTA1	MaxP2PV.phsCA.instCVal.mag.f	VCAMX	Voltage, C-to-A-phase, maximum magnitude
METMSTA1	MaxPhV.phsA.instCVal.mag.f	VAMX	Voltage, A-phase-to-neutral, maximum magnitude

Table F.21 Logical Device: MET (Metering) (Sheet 4 of 5)

Logical Node	Attribute	Data Source	Comment
METMSTA1	MaxPhV.phsB.instCVal.mag.f	VBMX	Voltage, B-phase-to-neutral, maximum magnitude
METMSTA1	MaxPhV.phsC.instCVal.mag.f	VCMX	Voltage, C-phase-to-neutral, maximum magnitude
METMSTA1	MaxVs.instMag.f	VSMX	Synchronizing voltage, maximum magnitude
METMSTA1	MaxVA.instMag.f	KVA3PMX	Apparent power, three-phase, maximum magnitude
METMSTA1	MaxVAr.instMag.f	KVAR3PMX	Reactive power, three-phase, maximum magnitude
METMSTA1	MaxW.instMag.f	KW3PMX	Real power, three-phase, maximum magnitude
METMSTA1	MinA.phsA.instCVal.mag.f	IAMN	Current, A-phase, minimum magnitude
METMSTA1	MinA.phsB.instCVal.mag.f	IBMN	Current, B-phase, minimum magnitude
METMSTA1	MinA.phsC.instCVal.mag.f	ICMN	Current, C-phase, minimum magnitude
METMSTA1	MinA.res.instCVal.mag.f	IGMN	Current, residual, minimum magnitude
METMSTA1	MinA.neut.instCVal.mag.f	INMN	Current, neutral, minimum magnitude
METMSTA1	MinP2PV.phsAB.instCVal.mag.f	VABMN	Voltage, A-to-B-phase, minimum magnitude
METMSTA1	MinP2PV.phsBC.instCVal.mag.f	VBCMN	Voltage, B-to-C-phase, minimum magnitude
METMSTA1	MinP2PV.phsCA.instCVal.mag.f	VCAMN	Voltage, C-to-A-phase, minimum magnitude
METMSTA1	MinPhV.phsA.instCVal.mag.f	VAMN	Voltage, A-phase-to-neutral, minimum magnitude
METMSTA1	MinPhV.phsB.instCVal.mag.f	VBMN	Voltage, B-phase-to-neutral, minimum magnitude
METMSTA1	MinPhV.phsC.instCVal.mag.f	VCMN	Voltage, C-phase-to-neutral, minimum magnitude
METMSTA1	MinVs.instMag.f	VSMN	Synchronizing voltage, minimum magnitude
METMSTA1	MinVA.instMag.f	KVA3PMN	Apparent power, three-phase, minimum magnitude
METMSTA1	MinVAr.instMag.f	KVAR3PMN	Reactive power, three-phase, minimum magnitude
METMSTA1	MinW.instMag.f	KW3PMN	Real power, three-phase, minimum magnitude
RMSMMXU2	A.phsA.instCVal.mag.f	IARMS	RMS current, A-phase, magnitude
RMSMMXU2	A.phsB.instCVal.mag.f	IBRMS	RMS current, B-phase, magnitude
RMSMMXU2	A.phsC.instCVal.mag.f	ICRMS	RMS current, C-phase, magnitude
RMSMMXU2	A.neut.instCVal.mag.f	INRMS	RMS current, neutral, magnitude
RMSMMXU2	PhV.phsA.instCVal.mag.f	VARMS	RMS voltage, A-phase, magnitude
RMSMMXU2	PhV.phsB.instCVal.mag.f	VBRMS	RMS voltage, B-phase, magnitude
RMSMMXU2	PhV.phsC.instCVal.mag.f	VCRMS	RMS voltage, C-phase, magnitude
RMSMMXU2	PPV.phsAB.instCVal.mag.f	VABRMS	RMS voltage, AB-phase-to-phase, magnitude
RMSMMXU2	PPV.phsBC.instCVal.mag.f	VBCRMS	RMS voltage, BC-phase-to-phase, magnitude
RMSMMXU2	PPV.phsCA.instCVal.mag.f	VCARMS	RMS voltage, CA-phase-to-phase, magnitude
RMSMMXU2	VSyn.instCVal.mag.f	VSRMS	Synchronizing voltage, RMS magnitude
THERMMTHR1	MaxAmbTmp.instMag.f	RTDAMB[c]	Ambient RTD temperature
THERMMTHR1	MaxBrgTmp.instMag.f	RTDBRGMX[c]	Maximum bearing RTD temperature

Table F.21 Logical Device: MET (Metering) (Sheet 5 of 5)

Logical Node	Attribute	Data Source	Comment
THERMMTHR1	MaxOthTmp.instMag.f	RTDOTHMX[c]	Other maximum RTD temperature
THERMMTHR1	MaxWdgTmp.instMag.f	RTDWDGMX[c]	Maximum winding RTD temperature
THERMMTHR1	Tmp01.instMag.f–Tmp12.instMag.f	RTD1–RTD12[c]	RTD1–RTD12 temperature
THERMMTHE1	Thrl1.instMag.f–Thrl3.instMag.f	THRL1–THRL3[d]	Operating quantity thermal level memory from Element 1 to Element 3
THERMMTHE1	Thieq1.instMag.f–Thieq3.instMag.f	THIEQ1–THIEQ3[d]	Operating quantity equivalent current from Element 1 to Element 3
THERMMTHE1	Thtcu1.instMag.f–Thtcu3.instMag.f	THTCU1–THTCU3[d]	Thermal capacity used from Element 1 to Element 3
THERMMTHE1	Thtrip1.instMag.f–Thtrip3.instMag.f	THTRIP1–THTRIP3[d]	Time before thermal element trips from Element 1 to Element 3
THERMMTHE1	Thrls1.instMag.f–Thrls3.instMag.f	THRLS1–THRLS3[d]	Time before thermal element releases from Element 1 to Element 3
Functional Constraint = ST			
DCZBAT1	BatHi.stVal	DCHI	Station dc battery instantaneous overvoltage element
DCZBAT1	BatLo.stVal	DCLO	Station dc battery instantaneous undervoltage element
THERMMTHR1	EEHealth.stVal	RTDFLT?1:3[c]	RTD input or communication status

[a] MX values contain instantaneous attributes (instMag and instCVal), which are updated whenever the source updates, and other attributes that are only updated when the source goes outside the data source's deadband (mag and cVal). Only instantaneous values are shown in the table.
[b] Data validity depends on the relay model and installed card options. Refer to Section 1: Introduction and Specifications for different relay models and available card options. Refer to Section 5: Metering and Monitoring for the model-dependent metering quantities.
[c] Valid data depends on E49RTD and RTD1LOC–RTD12LOC settings.
[d] Valid data depends on the E49IEC setting.

Table F.22 shows the LN associated with control elements defined as Logical Device CON.

Table F.22 Logical Device: CON (Remote Control)

Logical Node	Status	Control	Relay Word Bit	Comment
RBGGIO1	SPCSO01.stVal–SPCSO08.stVal	SPCSO01.Oper.ctlVal–SPCSO08.Oper.ctlVal	RB01–RB08	Remote Bits RB01–RB08
RBGGIO2	SPCSO09.stVal–SPCSO16.stVal	SPCSO09.Oper.ctlVal–SPCSO16.Oper.ctlVal	RB09–RB16	Remote Bits RB09–RB16
RBGGIO3	SPCSO17.stVal–SPCSO24.stVal	SPCSO17.Oper.ctlVal–SPCSO24.Oper.ctlVal	RB17–RB24	Remote Bits RB17–RB24
RBGGIO4	SPCSO25.stVal–SPCSO32.stVal	SPCSO25.Oper.ctlVal–SPCSO32.Oper.ctlVal	RB25–RB32	Remote Bits RB25–RB32

Table F.23 shows the LN associated with annunciation elements defined as Logical Device ANN.

Table F.23 Logical Device: ANN (Annunciation) (Sheet 1 of 7)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PARTNO	Part number
Functional Constraint = MX[a]			
AINCGGIO21	AnIn01.instMag.f–AnIn08.instMag.f	AI301–AI308[b]	Analog inputs (AI301 to AI308)—Slot C
AINDGGIO22	AnIn01.instMag.f–AnIn08.instMag.f	AI401–AI408[b]	Analog inputs (AI401 to AI408)—Slot D
AINEGGIO23	AnIn01.instMag.f–AnIn08.instMag.f	AI501–AI508[b]	Analog inputs (AI501 to AI508)—Slot E
BWASCBR1	AbrPrt.instMag.f	WEARA	Breaker–Contact A wear
BWBSCBR2	AbrPrt.instMag.f	WEARB	Breaker–Contact B wear
BWCSCBR3	AbrPrt.instMag.f	WEARC	Breaker–Contact C wear
LSGGIO35	AnIn01.instMag.f–AnIn08.instMag.f	LSENS1–LSENS8[c]	Arc-flash sensor light (LSENS1–LSENS8)
MVGGIO12	AnIn01.instMag.f–AnIn32.instMag.f	MV01–MV32[d]	Math Variables (MV01 to MV32)
PFLLIGGIO39	AnIn01.instMag.f	PFAL	A-phase power factor lead/lag indicator (1: LEAD, 0: LAG)
PFLLIGGIO39	AnIn02.instMag.f	PFBL	B-phase power factor lead/lag indicator (1: LEAD, 0: LAG)
PFLLIGGIO39	AnIn03.instMag.f	PFCL	C-phase power factor lead/lag indicator (1: LEAD, 0: LAG)
PFLLIGGIO39	AnIn04.instMag.f	PFL	Three-phase power factor lead/lag indicator (1: LEAD, 0: LAG)
PWRGGIO34	AnIn01.instMag.f	KWADI[e]	Real power, A-phase demand IN
PWRGGIO34	AnIn02.instMag.f	KWBDI[e]	Real power, B-phase demand IN
PWRGGIO34	AnIn03.instMag.f	KWCDI[e]	Real power, C-phase demand IN
PWRGGIO34	AnIn04.instMag.f	KW3DI[e]	Real power, three-phase demand IN
PWRGGIO34	AnIn05.instMag.f	KVARADI[e]	Reactive power, A-phase demand IN
PWRGGIO34	AnIn06.instMag.f	KVARBDI[e]	Reactive power, B-phase demand IN
PWRGGIO34	AnIn07.instMag.f	KVARCDI[e]	Reactive power, C-phase demand IN
PWRGGIO34	AnIn08.instMag.f	KVAR3DI[e]	Reactive power, three-phase demand IN
PWRGGIO34	AnIn09.instMag.f	KWADO[e]	Real power, A-phase demand OUT
PWRGGIO34	AnIn10.instMag.f	KWBDO[e]	Real power, B-phase demand OUT
PWRGGIO34	AnIn11.instMag.f	KWCDO[e]	Real power, C-phase demand OUT
PWRGGIO34	AnIn12.instMag.f	KW3DO[e]	Real power, three-phase demand OUT
PWRGGIO34	AnIn13.instMag.f	KVARADO[e]	Reactive power, A-phase demand OUT
PWRGGIO34	AnIn14.instMag.f	KVARBDO[e]	Reactive power, B-phase demand OUT

Table F.23 Logical Device: ANN (Annunciation) (Sheet 2 of 7)

Logical Node	Attribute	Data Source	Comment
PWRGGIO34	AnIn15.instMag.f	KVARCDO[e]	Reactive power, C-phase demand OUT
PWRGGIO34	AnIn16.instMag.f	KVAR3DO[e]	Reactive power, three-phase demand OUT
PWRGGIO34	AnIn17.instMag.f	KWAPDI[e]	Real power, A-phase peak demand IN
PWRGGIO34	AnIn18.instMag.f	KWBPDI[e]	Real power, B-phase peak demand IN
PWRGGIO34	AnIn19.instMag.f	KWCPDI[e]	Real power, C-phase peak demand IN
PWRGGIO34	AnIn20.instMag.f	KW3PDI[e]	Real power, three-phase peak demand IN
PWRGGIO34	AnIn21.instMag.f	KVARAPDI[e]	Reactive power, A-phase peak demand IN
PWRGGIO34	AnIn22.instMag.f	KVARBPDI[e]	Reactive power, B-phase peak demand IN
PWRGGIO34	AnIn23.instMag.f	KVARCPDI[e]	Reactive power, C-phase peak demand IN
PWRGGIO34	AnIn24.instMag.f	KVAR3PDI[e]	Reactive power, three-phase peak demand IN
PWRGGIO34	AnIn25.instMag.f	KWAPDO[e]	Real power, A-phase peak demand OUT
PWRGGIO34	AnIn26.instMag.f	KWBPDO[e]	Real power, B-phase peak demand OUT
PWRGGIO34	AnIn27.instMag.f	KWCPDO[e]	Real power, C-phase peak demand OUT
PWRGGIO34	AnIn28.instMag.f	KW3PDO[e]	Real power, three-phase peak demand OUT
PWRGGIO34	AnIn29.instMag.f	KVARAPDO[e]	Reactive power, A-phase peak demand OUT
PWRGGIO34	AnIn30.instMag.f	KVARBPDO[e]	Reactive power, B-phase peak demand OUT
PWRGGIO34	AnIn31.instMag.f	KVARCPDO[e]	Reactive power, C-phase peak demand OUT
PWRGGIO34	AnIn32.instMag.f	KVAR3PDO[e]	Reactive power, three-phase peak demand OUT
RAGGIO24	Ra001.instMag.f–Ra032.instMag.f	RA001–RA032	Remote analogs (RA001 to RA032)
RAGGIO25	Ra033.instMag.f–Ra064.instMag.f	RA033–RA064	Remote analogs (RA033 to RA064)
RAGGIO26	Ra065.instMag.f–Ra096.instMag.f	RA065–RA096	Remote analogs (RA065 to RA096)
RAGGIO27	Ra097.instMag.f–Ra128.instMag.f	RA097–RA128	Remote analogs (RA097 to RA128)
SCGGIO20	AnIn01.instMag.f–AnIn32.instMag.f	SC01–SC32[f]	SELOGIC counters (SC01 to SC32)
Functional Constraint = ST			
BWASCBR1	ColOpn.stVal	OC	Open breaker
BWBSCBR2	ColOpn.stVal	OC	Open breaker
BWCSCBR3	ColOpn.stVal	OC	Open breaker
DCSTSGGIO38	Ind01.stVal	89A2P1	2-position Disconnect 1 N/O contact
DCSTSGGIO38	Ind02.stVal	89B2P1	2-position Disconnect 1 N/C contact
DCSTSGGIO38	Ind03.stVal	89CL2P1	2-position Disconnect 1 closed
DCSTSGGIO38	Ind04.stVal	89OP2P1	2-position Disconnect 1 open
DCSTSGGIO38	Ind05.stVal	89A2P2	2-position Disconnect 2 N/O contact

Table F.23 Logical Device: ANN (Annunciation) (Sheet 3 of 7)

Logical Node	Attribute	Data Source	Comment
DCSTSGGIO38	Ind06.stVal	89B2P2	2-position Disconnect 2 N/C contact
DCSTSGGIO38	Ind07.stVal	89CL2P2	2-position Disconnect 2 closed
DCSTSGGIO38	Ind08.stVal	89OP2P2	2-position Disconnect 2 open
DCSTSGGIO38	Ind09.stVal	89A2P3	2-position Disconnect 3 N/O contact
DCSTSGGIO38	Ind10.stVal	89B2P3	2-position Disconnect 3 N/C contact
DCSTSGGIO38	Ind11.stVal	89CL2P3	2-position Disconnect 3 closed
DCSTSGGIO38	Ind12.stVal	89OP2P3	2-position Disconnect 3 open
DCSTSGGIO38	Ind13.stVal	89A2P4	2-position Disconnect 4 N/O contact
DCSTSGGIO38	Ind14.stVal	89B2P4	2-position Disconnect 4 N/C contact
DCSTSGGIO38	Ind15.stVal	89CL2P4	2-position Disconnect 4 closed
DCSTSGGIO38	Ind16.stVal	89OP2P4	2-position Disconnect 4 open
DCSTSGGIO38	Ind17.stVal	89A2P5	2-position Disconnect 5 N/O contact
DCSTSGGIO38	Ind18.stVal	89B2P5	2-position Disconnect 5 N/C contact
DCSTSGGIO38	Ind19.stVal	89CL2P5	2-position Disconnect 5 closed
DCSTSGGIO38	Ind20.stVal	89OP2P5	2-position Disconnect 5 open
DCSTSGGIO38	Ind21.stVal	89AL2P1	2-position Disconnect 1 alarm
DCSTSGGIO38	Ind22.stVal	89AL2P2	2-position Disconnect 2 alarm
DCSTSGGIO38	Ind23.stVal	89AL2P3	2-position Disconnect 3 alarm
DCSTSGGIO38	Ind24.stVal	89AL2P4	2-position Disconnect 4 alarm
DCSTSGGIO38	Ind25.stVal	89AL2P5	2-position Disconnect 5 alarm
INAGGIO1	Ind01.stVal–Ind02.stVal	IN101–IN102	Digital inputs (IN101 to IN102)—Slot A
INCGGIO13	Ind01.stVal–Ind14.stVal	IN301–IN314[b]	Digital inputs (IN301 to IN314)—Slot C
INDGGIO15	Ind01.stVal–Ind14.stVal	IN401–IN414[b]	Digital inputs (IN401 to IN414)—Slot D
INEGGIO17	Ind01.stVal–Ind14.stVal	IN501–IN514[b]	Digital inputs (IN501 to IN514)—Slot E
LBGGIO31	Ind01.stVal–Ind32.stVal	LB01–LB32[g]	Local Bits (LB01 to LB32)
LTGGIO5	Ind01.stVal–Ind32.stVal	LT01–LT32[h]	Latch Bits (LT01 to LT32)
MBOKGGIO32	Ind01.stVal	ROKA	Channel A, received data ok
MBOKGGIO32	Ind02.stVal	RBADA	Channel A, outage duration over threshold
MBOKGGIO32	Ind03.stVal	CBADA	Channel A, channel unavailability over threshold
MBOKGGIO32	Ind04.stVal	LBOKA	Channel A, looped back ok
MBOKGGIO32	Ind05.stVal	ROKB	Channel B, received data ok
MBOKGGIO32	Ind06.stVal	RBADB	Channel B, outage duration over threshold
MBOKGGIO32	Ind07.stVal	CBADB	Channel B, channel unavailability over threshold
MBOKGGIO32	Ind08.stVal	LBOKB	Channel B, looped back ok

Table F.23 Logical Device: ANN (Annunciation) (Sheet 4 of 7)

Logical Node	Attribute	Data Source	Comment
MISCGGIO33	Ind01.stVal	FREQFZ	Synchrophasor bit that asserts if the measured frequency > ±20 Hz from nominal
MISCGGIO33	Ind02.stVal	LINK1	Asserted when a valid link is detected on Port 1 in a single ethernet option
MISCGGIO33	Ind03.stVal	MATHERR	SELOGIC math error bit
MISCGGIO33	Ind04.stVal	HALARM	Indication of a diagnostic failure or warning that warrants an ALARM
MISCGGIO33	Ind05.stVal	SALARM	Indication of software or user activity that warrants an ALARM
MISCGGIO33	Ind06.stVal	WARNING	Relay Word WARNING
MISCGGIO33	Ind07.stVal	IRIGOK	IRIG-B time synch input data is valid
MISCGGIO33	Ind08.stVal	TSOK	Time synchronization OK
MISCGGIO33	Ind09.stVal	DST	Daylight-saving time active
MISCGGIO33	Ind10.stVal	LINKA	Asserted when a valid link is detected on Port 1A
MISCGGIO33	Ind11.stVal	LINKB	Asserted when a valid link is detected on Port 1B
MISCGGIO33	Ind12.stVal	LINKFAIL	Asserted when a valid link is not detected on the active port(s)
MISCGGIO33	Ind13.stVal	PASEL	Asserted when Port 1A is active
MISCGGIO33	Ind14.stVal	PBSEL	Asserted when Port 1B is active
MISCGGIO33	Ind15.stVal	COMMLOSS	DeviceNet communication failure
MISCGGIO33	Ind16.stVal	COMMFLT	DeviceNet internal communication failure
MISCGGIO33	Ind17.stVal–Ind32.stVal	0	Reserved for future use
OUTAGGIO2	Ind01.stVal–Ind03.stVal	OUT101–OUT103	Digital outputs (OUT101 to OUT103)—Slot A
OUTCGGIO14	Ind01.stVal–Ind08.stVal	OUT301–OUT308[b]	Digital outputs (OUT301 to OUT308)—Slot C
OUTDGGIO16	Ind01.stVal–Ind08.stVal	OUT401–OUT408[b]	Digital outputs (OUT401 to OUT408)—Slot D
OUTEGGIO18	Ind01.stVal–Ind08.stVal	OUT501–OUT508[b]	Digital outputs (OUT501 to OUT508)—Slot E
PBLEDGGIO7	Ind01.stVal	PB1A_LED	Pushbutton PB1A LED
PBLEDGGIO7	Ind02.stVal	PB1B_LED	Pushbutton PB1B LED
PBLEDGGIO7	Ind03.stVal	PB2A_LED	Pushbutton PB2A LED
PBLEDGGIO7	Ind04.stVal	PB2B_LED	Pushbutton PB2B LED
PBLEDGGIO7	Ind05.stVal	PB3A_LED	Pushbutton PB3A LED
PBLEDGGIO7	Ind06.stVal	PB3B_LED	Pushbutton PB3B LED
PBLEDGGIO7	Ind07.stVal	PB4A_LED	Pushbutton PB4A LED
PBLEDGGIO7	Ind08.stVal	PB4B_LED	Pushbutton PB4B LED
PBLEDGGIO7	Ind09.stVal	PB5A_LED	Pushbutton PB5A LED
PBLEDGGIO7	Ind10.stVal	PB5B_LED	Pushbutton PB5B LED

Table F.23 Logical Device: ANN (Annunciation) (Sheet 5 of 7)

Logical Node	Attribute	Data Source	Comment
PBLEDGGIO7	Ind11.stVal	PB6A_LED	Pushbutton PB6A LED
PBLEDGGIO7	Ind12.stVal	PB6B_LED	Pushbutton PB6B LED
PBLEDGGIO7	Ind13.stVal	PB7A_LED	Pushbutton PB7A LED
PBLEDGGIO7	Ind14.stVal	PB7B_LED	Pushbutton PB7B LED
PBLEDGGIO7	Ind15.stVal	PB8A_LED	Pushbutton PB8A LED
PBLEDGGIO7	Ind16.stVal	PB8B_LED	Pushbutton PB8B LED
PROGGIO29	Ind01.stVal	AFALARM	Arc-flash system integrity alarm
PROGGIO29	Ind02.stVal	FREQTRK	Frequency tracking enable bit
PROGGIO29	Ind03.stVal–Ind06.stVal	AFS1EL–AFS4EL[c]	AF Light Input 1–4 excessive ambient light pickup
PROGGIO29	Ind07.stVal	CLOSE	Close logic output
PROGGIO29	Ind08.stVal	CF	Close condition failure (asserts for 1/4 cycle)
PROGGIO29	Ind09.stVal	RCSF	Reclose supervision failure (asserts for 1/4 cycle)
PROGGIO29	Ind10.stVal	OPTMN	Open interval timer is timing
PROGGIO29	Ind11.stVal	RSTMN	Reset timer is timing
PROGGIO29	Ind12.stVal	PHDEM	Phase current demand pickup
PROGGIO29	Ind13.stVal	3I2DEM	Negative-sequence current demand pickup
PROGGIO29	Ind14.stVal	GNDEM	Zero-sequence current demand pickup
PROGGIO29	Ind15.stVal	59VP	Phase voltage window element (selected phase voltage [VP] between settings 25VLO and 25VHI)
PROGGIO29	Ind16.stVal	59VS	VS channel voltage window element (selected phase voltage [VS] between settings 25VLO and 25VHI)
PROGGIO29	Ind17.stVal	SF	Slip frequency of voltages VP and VS and less than setting 25SF
PROGGIO29	Ind18.stVal	81RFBLK	Fast rate-of-change overall block logic output
PROGGIO29	Ind19.stVal	81RFT	Fast rate-of-change trip output
PROGGIO29	Ind20.stVal	81RFBL	Fast rate-of-change block output SELOGIC
PROGGIO29	Ind21.stVal	81RFP	Fast rate-of-change pickup
PROGGIO29	Ind22.stVal	81RFI	Fast rate-of-change initiate
PROGGIO29	Ind23.stVal	25A1	Level 1 synchronism check element
PROGGIO29	Ind24.stVal	25A2	Level 2 Synchronism check element
PROGGIO29	Ind25.stVal	ZLOAD	Load encroachment element pickup
PROGGIO29	Ind26.stVal	GNDSW	Directional element for low-impedance grounded or ungrounded/high impedance grounded systems is operating on neutral channel (IN) current IN
PROGGIO29	Ind27.stVal	50NF	Forward direction neutral overcurrent threshold exceeded
PROGGIO29	Ind28.stVal	50NR	Reverse direction neutral overcurrent threshold exceeded

Table F.23 Logical Device: ANN (Annunciation) (Sheet 6 of 7)

Logical Node	Attribute	Data Source	Comment
PROGGIO29	Ind29.stVal–Ind32.stVal	AFS5EL–AFS8EL[c]	AF Light Input 5–8 excessive ambient light pickup
PROGGIO37	Ind01.stVal–Ind03.stVal	THRLA1–THRLA3	Thermal Element 1 alarm—Thermal Element 3 alarm
PROGGIO37	Ind04.stVal–Ind06.stVal	THRLT1–THRLT3	Thermal Element 1 trip—Thermal Element 3 trip
PROGGIO37	Ind07.stVal–Ind09.stVal	THOVL1–THOVL3	Thermal Element 1 operating current overload—Thermal Element 3 operating current overload
PROGGIO37	Ind10.stVal	THAMBH	Ambient temperature measurement health
PROGGIO37	Ind11.stVal	78VSBL	Vector shift element block condition
PROGGIO37	Ind12.stVal	78VSO	Vector shift element output
PROGGIO37	Ind13.stVal	HBL2T	Combined-phase second-harmonic block timed out
PROGGIO37	Ind14.stVal	HBL5T	Combined-phase fifth-harmonic block timed out
PROGGIO37	Ind14.stVal	HBL5T	Combined-phase fifth-harmonic block timed out
PROGGIO37	Ind15.stVal	52B	Circuit breaker N/C contact
RCGGIO30	Ind01.stVal	79RS	Reclosing relay in reset state
RCGGIO30	Ind02.stVal	79CY	Reclosing relay in reclose cycle state
RCGGIO30	Ind03.stVal	79LO	Reclosing relay in lockout state
RCGGIO30	Ind04.stVal–Ind08.stVal	SH0–SH4	Reclosing relay shot counter = 0–4
RMBAGGIO8	Ind01.stVal–Ind08.stVal	RMB1A–RMB8A	Receive MIRRORED BITS (RMB1A to RMB8A)
RMBBGGIO10	Ind01.stVal–Ind08.stVal	RMB1B–RMB8B	Receive MIRRORED BITS (RMB1B to RMB8B)
SGGGIO36	Ind01.stVal–Ind04.stVal	SG1–SG4	Setting Group 1 to 4 selection
SVGGIO3	Ind01.stVal–Ind32.stVal	SV01–SV32[i]	SELOGIC Variables (SV01 to SV32)
SVTGGIO4	Ind01.stVal–Ind32.stVal	SV01T–SV32T[i]	SELOGIC Variable timers (SV01T to SV32T)
TLEDGGIO6	Ind01.stVal	ENABLED	ENABLED LED
TLEDGGIO6	Ind02.stVal	TRIP_LED	TRIP LED
TLEDGGIO6	Ind03.stVal–Ind08.stVal	TLED_01–TLED_06	Target LEDs TLED_01 to TLED_06
TMBAGGIO9	Ind01.stVal–Ind08.stVal	TMB1A–TMB8A	Transmit MIRRORED BITS (TMB1A to TMB8A)
TMBBGGIO11	Ind01.stVal–Ind08.stVal	TMB1B–TMB8B	Transmit MIRRORED BITS (TMB1B to TMB8B)
TRIPGGIO28	Ind01.stVal	AMBTRIP	Ambient temperature trip
TRIPGGIO28	Ind02.stVal	BRGTRIP	Bearing temperature trip
TRIPGGIO28	Ind03.stVal	FAULT	Indicates fault condition
TRIPGGIO28	Ind04.stVal	OTHTRIP	Other temperature trip
TRIPGGIO28	Ind05.stVal	REMTRIP	Remote trip
TRIPGGIO28	Ind06.stVal	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
TRIPGGIO28	Ind07.stVal	ULTRIP	Unlatch (auto reset) trip from SELOGIC equation
TRIPGGIO28	Ind08.stVal	WDGTRIP	Winding temperature trip

Table F.23 Logical Device: ANN (Annunciation) (Sheet 7 of 7)

Logical Node	Attribute	Data Source	Comment
TRIPGGIO28	Ind09.stVal–Ind16.stVal	0	Reserved for future use
VBGGIO19	Ind001.stVal–Ind128.stVal	VB001–VB128	Virtual Bits (VB001 to VB128)

[a] MX values contain instantaneous attributes (instMag and instCVal), which are updated whenever the source updates, and other attributes that are only updated when the source goes outside the data source's deadband (mag and cVal). Only instantaneous values are shown in the table.
[b] Active data depends on the optional I/O card installed in the slot.
[c] Active data depends on the optional arc-flash card installed.
[d] Active data depends on the EMV setting.
[e] 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.
[f] Active data depends on the ESC setting.
[g] Active data depends on the ELB setting.
[h] Active data depends on the ELAT setting.
[i] Active data depends on the ESV setting.

Table F.24 Logical Device: CFG (Configuration)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PARTNO	Part number
DevIDLPHD1	PhyNam.serNum	SER_NUM	Serial number
LLN0	NamPlt.swRev	FID	Firmware revision

Protocol Implementation Conformance Statement

The following tables are as shown in the IEC 61850 standard, Part 8-1, Section 24. Note that because the standard explicitly dictates which services and functions must be implemented to achieve conformance, only the optional services and functions are listed.

Table F.25 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.26 PICS for T-Profile Support

Profile		Client	Server	Value/Comment
T1	TCP/IP	N	Y	
T2	OSI	N	N	
T3	GOOSE/GSE	Y	Y	Only GOOSE, Not GSSE
T4	GSSE	N	N	
T5	Time Sync	Y	N	

Refer to the ACSI Conformance statements 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.27* 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.27 MMS Service Supported Conformance (Sheet 1 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
status		YES
getNameList		YES
identify		YES
rename		
read		YES
write		YES
getVariableAccessAttributes		YES
defineNamedVariable		
defineScatteredAccess		
getScatteredAccessAttributes		
deleteVariableAccess		
defineNamedVariableList		
getNamedVariableListAttributes		YES
deleteNamedVariableList		
defineNamedType		
getNamedTypeAttributes		
deleteNamedType		
input		
output		
takeControl		
relinquishControl		
defineSemaphore		
deleteSemaphore		
reportPoolSemaphoreStatus		
reportSemaphoreStatus		
initiateDownloadSequence		
downloadSegment		
terminateDownloadSequence		
initiateUploadSequence		
uploadSegment		
terminateUploadSequence		
requestDomainDownload		
requestDomainUpload		
loadDomainContent		
storeDomainContent		
deleteDomain		

Table F.27 MMS Service Supported Conformance (Sheet 2 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
getDomainAttributes		YES
createProgramInvocation		
deleteProgramInvocation		
start		
stop		
resume		
reset		
kill		
getProgramInvocationAttributes		
obtainFile		
defineEventCondition		
deleteEventCondition		
getEventConditionAttributes		
reportEventConditionStatus		
alterEventConditionMonitoring		
triggerEvent		
defineEventAction		
deleteEventAction		
alterEventEnrollment		
reportEventEnrollmentStatus		
getEventEnrollmentAttributes		
acknowledgeEventNotification		
getAlarmSummary		
getAlarmEnrollmentSummary		
readJournal		
writeJournal		
initializeJournal		
reportJournalStatus		
createJournal		
deleteJournal		
fileOpen		
fileRead		
fileClose		
fileRename		
fileDelete		
fileDirectory		
unsolicitedStatus		
informationReport		YES
eventNotification		
attachToEventCondition		
attachToSemaphore		
conclude		YES
cancel		YES
getDataExchangeAttributes		

Table F.27 MMS Service Supported Conformance (Sheet 3 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
exchangeData		
defineAccessControlList		
getAccessControlListAttributes		
reportAccessControlledObjects		
deleteAccessControlList		
alterAccessControl		
ReconfigureProgramInvocation		

Table F.28 lists specific settings for the MMS parameter Conformance Building Block (CBB).

Table F.28 MMS Parameter CBB

MMS Parameter CBB	Client-CR Supported	Server-CR Supported
STR1		YES
STR2		YES
VNAM		YES
VADR		YES
VALT		YES
TPY		YES
VLIS		YES
CEI		

The following Variable Access conformance statements are listed in the order specified in the IEC 61850 standard, Part 8-1. Generally, only those services whose implementation is not mandatory are shown. Refer to the IEC 61850 standard Part 8-1 for more information.

Table F.29 AlternateAccessSelection Conformance Statement

AlternateAccessSelection	Client-CR Supported	Server-CR Supported
accessSelection		YES
component		YES
index		
indexRange		
allElements		
alternateAccess		YES
selectAccess		YES
component		YES
index		
indexRange		
allElements		

Table F.30 VariableAccessSpecification Conformance Statement

VariableAccessSpecification	Client-CR Supported	Server-CR Supported
listOfVariable		YES
variableSpecification		YES
alternateAccess		YES
variableListName		YES

Table F.31 VariableSpecification Conformance Statement

VariableSpecification	Client-CR Supported	Server-CR Supported
name		YES
address		
variableDescription		
scatteredAccessDescription		
invalidated		

Table F.32 Read Conformance Statement

Read	Client-CR Supported	Server-CR Supported
Request		
specificationWithResult		
variableAccessSpecification		
Response		
variableAccessSpecification		YES
listOfAccessResult		YES

Table F.33 GetVariableAccessAttributes Conformance Statement

GetVariableAccessAttributes	Client-CR Supported	Server-CR Supported
Request		
name		
address		
Response		
mmsDeletable		YES
address		
typeSpecification		YES

Table F.34 DefineNamedVariableList Conformance Statement

DefineVariableAccessAttributes	Client-CR Supported	Server-CR Supported
Request		
variableListName		
listOfVariable		
variableSpecification		
alternateAccess		
Response		

Table F.35 GetNamedVariableListAttributes Conformance Statement

GetNamedVariableListAttributes	Client-CR Supported	Server-CR Supported
Request		
ObjectName		
Response		
mmsDeletable		YES
listOfVariable		YES
variableSpecification		YES
alternateAccess		YES

Table F.36 DeleteNamedVariableList

DeleteNamedVariableList	Client-CR Supported	Server-CR Supported
Request		
Scope		
listOfVariableListName		
domainName		
Response		
numberMatched		
numberDeleted		
DeleteNamedVariableList-Error		

GOOSE Services Conformance Statement

Table F.37 GOOSE Conformance

	Subscriber	Publisher	Value/Comment
GOOSE Services	YES	YES	
SendGOOSEMessage		YES	
GetGoReference			
GetGOOSEElementNumber			
GetGoCBValues		YES	
SetGoCBValues			
GSENotSupported			
GOOSE Control Block (GoCB)		YES	

ACSI Conformance Statements

Table F.38 ACSI Basic Conformance Statement

		Client/Subscriber	Server/Publisher	SEL-751 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.39 ACSI Models Conformance Statement (Sheet 1 of 2)

		Client/Subscriber	Server/Publisher	SEL-751 Support
If Server Side (B11) Supported				
M1	Logical device	c2[a]	c2[a]	YES
M2	Logical node	c3[b]	c3[b]	YES
M3	Data	c4[c]	c4[c]	YES
M4	Data set	c5[d]	c5[d]	YES
M5	Substation	O[e]	O[e]	
M6	Setting group control	O[e]	O[e]	
Reporting				
M7	Buffered report control	O[e]	O[e]	YES
M7-1	sequence-number			YES
M7-2	report-time-stamp			YES
M7-3	reason-for-inclusion			YES
M7-4	data-set-name			YES
M7-5	data-reference			YES
M7-6	buffer-overflow			YES
M7-7	entryID			YES
M7-8	BufTm			YES
M7-9	IntgPd			YES
M7-10	G1			YES
M8	Unbuffered report control	O[e]	O[e]	YES

Table F.39 ACSI Models Conformance Statement (Sheet 2 of 2)

		Client/Subscriber	Server/Publisher	SEL-751 Support
M8-1	sequence-number			YES
M8-2	report-time-stamp			YES
M8-3	reason-for-inclusion			YES
M8-4	data-set-name			YES
M8-5	data-reference			YES
M8-6	BufTm			YES
M8-7	IntgPd			YES
M8-8	GI			YES
Logging				
M9	Log control	O[e]	O[e]	
M9-1	IntgPd	O[e]	O[e]	
M10	Log	O[e]	O[e]	
M11	Control	M[f]	M[f]	YES
If GSE (B31/32) Is Supported				
M12	GOOSE	O[e]	O[e]	YES
M12-1	entryID			YES
M12-2	DataRefInc			YES
M13	GSSE	O[e]	O[e]	
If GSE (B41/42) Is Supported				
M14	Multicast SVC	O[e]	O[e]	
M15	Unicast SVC	O[e]	O[e]	
M16	Time	M[f]	M[f]	
M17	File Transfer	O[e]	O[e]	

[a] c2 shall be "M" if support for LOGICAL-NODE model has been declared.
[b] c3 shall be "M" if support for DATA model has been declared.
[c] c4 shall be "M" if support for DATA-SET, Substitution, Report, Log Control, or Time model has been declared.
[d] c5 shall be "M" if support for Report, GSE, or SV models has been declared.
[e] O = Optional.
[f] M = Mandatory.

Table F.40 ACSI Services Conformance Statement (Sheet 1 of 4)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-751 Support
Server (Clause 6)					
S1	ServerDirectory	TP		M[a]	YES
Application Association (Clause 7)					
S2	Associate		M[a]	M[a]	YES
S3	Abort		M[a]	M[a]	YES
S4	Release		M[a]	M[a]	YES
Logical Device (Clause 8)					
S5	LogicalDeviceDirectory	TP	M[a]	M[a]	YES
Logical Node (Clause 9)					
S6	LogicalNodeDirectory	TP	M[a]	M[a]	YES
S7	GetAllDataValues	TP	O[b]	M[a]	YES

Table F.40 ACSI Services Conformance Statement (Sheet 2 of 4)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-751 Support
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
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]	

Table F.40 ACSI Services Conformance Statement (Sheet 3 of 4)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-751 Support
Generic Substation Event Model (GSE) (Clause 14.3.5.3.4)					
GOOSE-Control-Block					
S35	SendGOOSEMessage	MC	c8[e]	c8[e]	YES
S36	GetReference	TP	O[b]	c9[f]	
S37	GetGOOSEElement				
Number	TP	O[b]	c9[f]		
S38	GetGoCBValues	TP	O[b]	O[b]	YES
S39	SetGoCBValues	TP	O[b]	O[b]	
ONLY					
GSSE-Control-Block					
S40	SendGSSEMessage	MC	c8[e]	c8[e]	
S41	GetReference	TP	O[b]	c9[f]	
S42	GetGSSEElement				
Number	TP	Ob	c9[f]		
S43	GetGsCBValues	TP	O[b]	O[b]	
S44	GetGsCBValues	TP	O[b]	O[b]	
Transmission of Sample Value Model (SVC) (Clause 16)					
Multicast SVC					
S45	SendMSVMessage	MC	c10[g]	c10[g]	
S46	GetMSVCBValues	TP	O[b]	O[b]	
S47	SetMSVCBValues	TP	O[b]	O[b]	
Unicast SVC					
S48	SendUSVMessage	MC	c10[g]	c10[g]	
S49	GetUSVCBValues	TP	O[b]	O[b]	
S50	SetUSVCBValues	TP	O[b]	O[b]	
Control (Clause 16.4.8)					
S51	Select		M[a]	O[b]	
S52	SelectWithValue	TP	Ma	O[b]	YES
S53	Cancel	TP	O[b]	M[a]	YES
S54	Operate	TP	M[a]	M[a]	YES
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)

Table F.40 ACSI Services Conformance Statement (Sheet 4 of 4)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-751 Support
	T2				YES (for IRIG-B)
	T3				YES (for IRIG-B)
	T4				YES (for IRIG-B)
T3	Supported Time Stamp resolution (nearest negative power of 2 in seconds)				7 (10 ms) for SNTP 18 (4 µs) for IRIG-B

[a] M = Mandatory.
[b] O = Optional.
[c] c6 shall declare support for at least one (BRCB or URCB).
[d] c7 shall declare support for at least one (QueryLogByTime or QueryLogAfter).
[e] c8 shall declare support for at least one (SendGOOSEMessage or SendGSSEMessage).
[f] c9 shall declare support if TP association is available.
[g] c10 shall declare support for at least one (SendMSVMessage or SendUSVMessage).

Appendix G
IEC 60870-5-103 Communications

Overview

The SEL-751 Feeder Protection Relay provides the IEC 60870-5-103 interface for direct serial connections to the device.

This section covers the following topics:

- *Introduction to IEC 60870-5-103*
- *IEC 60870-5-103 in the SEL-751*
- *IEC 60870-5-103 Documentation*

Introduction to IEC 60870-5-103

The International Electrotechnical Commission (IEC) 60870-5 is a protocol standard developed by the IEC Technical Committee of teleprotection, telecontrol, and telecommunications for electrical engineering and power system automation. It defines systems used for supervisory control and data acquisition (SCADA), including details related to communications between devices. IEC 60870-5-103 is a companion standard that allows interoperability between devices in a control system and protection equipment. The IEC 60870-5 standard consists of the documents listed in *Table G.1*.

Table G.1 IEC 60870-5 Standard Documents

Document	Description
IEC 60870-5-1	Transmission Frame Formats
IEC 60870-5-2	Data Link Transmission Services
IEC 60870-5-3	General Structure of Application Data
IEC 60870-5-4	Definition and Coding of Information Elements
IEC 60870-5-5	Basic Application Functions
IEC 60870-5-6	Guidelines for Conformance Testing IEC 60870-5 Companion Standards
IEC 60870-5-7	Security extensions to IEC 60870-5-1010 and IEC 60870-5-104 protocols

The IEC 60870-5-103 document contains the information necessary for successful implementation of this protocol. SEL strongly recommends that anyone involved with the design, installation, configuration, or maintenance of IEC 60870-5-103 systems be familiar with the appropriate sections of this document.

IEC 60870-5 was designed for wide-spread telecontrol networks. It is an international standard based on an international accepted and proven enhanced performance architecture (EPA) model (see *Table G.2*). The standard provides a balance between efficiency and reliability while using minimal hardware.

Table G.2 IEC 60870-5 Enhanced Performance Architecture Model

Layer	Layer Type
7	Application
–	–
–	–
–	–
–	–
2	Datalink
1	Physical

Layer seven implementation is described in the IEC 60870-5-3 and IEC 60870-5-4 sections of the standard. Layer two implementation is described in the IEC 60870-5-2 and IEC 60870-5-1 sections of the standard.

The history of IEC 60870-5 spans from 1990 to 2006. *Table G.3* shows the history during this time period. The first five sections are the basic parts of the standard. The next six describe the companion standards, and the last two sections are test procedures of the standard.

Table G.3 History of IEC 60870-5

Section	Description
IEC 60870-5-1	Transmission Frame Formats
IEC 60870-5-2	Data Link Transmission Services
IEC 60870-5-3	General Structure of Application Data
IEC 60870-5-4	Definition and Coding Information Elements
IEC 60870-5-5	Basic Application Functions
IEC 60870-5-101	CS For Basic Telecontrol Tasks
IEC 60870-5-102	CS For Transmission Of Integrated Totals In Electric Power Systems
IEC 60870-5-103	CS for Informative Interface Of Protection Equipment
IEC 60870-5-104	Network Access For TCS101 Using Standard Transport Profiles
IEC 60870-5-101 Ed 2	Addendums Incorporated In Standard
IEC 60870-5-104 Ed 2	Addendums Incorporated In Standard
IEC 60870-5-601	Conformance Test Procedures For TCS 101
IEC 60870-5-604	Conformance Test Procedures For TCS 104

Data Handling

Master/Slave Communication

The IEC 60870-5-103 standard is such that the IED only sends a message when the Master asks for it. Communication is set up by the Master and the Master controls the communication between the Master and the IED.

Interoperability

The method of data exchange in the SEL-751 involves Application Service Data Units (ASDUs) along with application procedures for transmission of standardized data messages (see *Table G.4*). The data are recognized by any IEC 60870-5-103 Master because the application data take the form of an IEC 60870-5-103 data type and pairs with an IEC 60870-5-103 address, resulting in device interoperability.

Table G.4 SEL-751 ASDU Types

ASDU Type	Description
1	Time Tagged Message
2	Time Tagged Message With Relative Time
4	Time Tagged Measurands With Relative Time
5	Identification
6	Time Synchronization
7	General Interrogation Start
8	General Interrogation Termination
9	Measurands II
20	General Command
205	Non-Standard (defined below)

Type Identification	0xCD (205)							
Variable Structure Qualifier	0x81							
Cause of Transmission	0x01							
Device Address	ADDR							
Function Type	FUN							
Information Number	INF							
Information Element Meter value: 29-bit signed integer ER: 0 valid, 1 invalid	2^7	•	•	•	•	•	•	2^0
	2^{15}	•	•	•	•	•	•	2^8
	2^{23}	•	•	•	•	•	•	2^{16}
	0	ER	0	-2^{28}	•	•	•	2^{24}
Four Octet Binary Time	Defined in 60870-5-103, 7.2.6.28							

Table G.5 lists the available category map settings in the SEL-751. When configuring the settings with the command line, categories can be selected by entering “>” or “<”.

Table G.5 IEC 60870-5-103 Category Map Settings

Setting Prompt	Scaling/Nominal Value Range	Information Number Range	Function Type Range	Setting Name
103 Binary Input Label	NA	0–255	0–255	103BI00
103 Binary Input Label	NA	0–255	0–255	103BI01
–	–	–	–	–
–	–	–	–	–
–	–	–	–	–
103 Binary Input Label	NA	0–255	0–255	103BI99
103 Binary Target Label	NA	0–255	0–255	103BT00
103 Binary Target Label	NA	0–255	0–255	103BT01
–	–	–	–	–
–	–	–	–	–
–	–	–	–	–
103 Binary Target Label	NA	0–255	0–255	103BT07
103 Binary Control Label	NA	0–255	0–255	103BO00
103 Binary Control Label	NA	0–255	0–255	103BO01
–	–	–	–	–
–	–	–	–	–
–	–	–	–	–
103 Binary Control Label	NA	0–255	0–255	103BO31
103 Fault Analog Label	0.000–99999	0–255	0–255	103FA00
103 Fault Analog Label	0.000–99999	0–255	0–255	103FA01
–	–	–	–	–
–	–	–	–	–
–	–	–	–	–
103 Fault Analog Label	0.000–99999	0–255	0–255	103FA31
103 Measurand Label	0.001–999999	0–255	0–255	3MLB000
103 Measurand Label	0.001–999999	0–255	0–255	3MLB001
–	–	–	–	–
–	–	–	–	–
–	–	–	–	–
103 Measurand Label	0.001–999999	0–255	0–255	3MLB127
103 Meter Quantity Label	0.000–99999	0–255	0–255	103MQ00
103 Meter Quantity Label	0.000–99999	0–255	0–255	103MQ01
–	–	–	–	–
–	–	–	–	–
–	–	–	–	–
103 Meter Quantity Label	0.000–99999	0–255	0–255	103MQ31

Cause of Transmission

The Cause of Transmission (COT) represents the reason the SEL-751 sends a message to the Master. See *Table G.6* for the possible COTs.

Table G.6 IEC 60870-5-103 Cause Of Transmission

Cause of Transmission	Description
1	Spontaneous Events
2	Cyclic
3	Reset Frame Count Bit (FCB)
4	Reset Communication Unit (CU)
5	Start/Restart
6	Power On
7	Test Mode
8	Time Synchronization
9	Initiation Of General Interrogation
10	Termination Of General Interrogation
12	Remote Operation
20	General Command (Control Direction), Positive Acknowledgment Of Command (Monitor)
21	Negative Acknowledgment Of Command (Monitor)
31	Disturbance Recorder
40–44	Generic Commands And Data

Information Number

The Information Number (INF) is one of the two octets of the information object identifier. See *Table G.7* for the range and description of Information Numbers in IEC 60870-5-103.

Table G.7 IEC 60870-5-103 Information Numbers (Sheet 1 of 2)

Function Type	Description
Monitor Direction	
0–15	System Functions
16–31	Status
32–47	Supervision
48–63	Earth Fault
64–127	Short Circuit
128–143	Auto Reclose
144–159	Measurands
160–239	Not Used
240–255	Generic Functions

Table G.7 IEC 60870-5-103 Information Numbers (Sheet 2 of 2)

Function Type	Description
Control Direction	
0–15	System Functions
16–31	General Commands
32–239	Not Used
240–255	Generic Functions

Function Type

The Function Type (FUN) is the second of the two octets of the information object identifier.

Together, the pair [INF, FUN] distinctly characterizes each point within each data class. *Table G.8* and *Table G.9* give the Standard Function Types and Data Map for the IEC 60870-5-103 standard.

Table G.8 IEC 60870-5-103 Standard Function Types

Function Type	Description
128	Distance protection
160	Overcurrent protection
176	Transformer Differential Protection
192	Line Differential Protection
254	Generic Function Type
255	Global Function Type

Table G.9 IEC 60870-5-103 Data Map (Sheet 1 of 3)

INF	Description	GI	ASDU Type	COT	FUN
System functions in monitor direction					
0[a]	End of general interrogation	–	8	10	255
0[a]	Time synchronization	–	6	8	255
2[a]	Reset FCB	–	5	3	According to main FUN
3[a]	Reset CU	–	5	4	According to main FUN
4[a]	Start/restart	–	5	5	According to main FUN
5[a]	Power on	–	5	6	According to main FUN
Status indications in monitor direction[b]					
16	Auto-recloser active	Yes	1	1,7,9,11,12,20,21	128, 160, 192
17	Teleprotection active	Yes	1	1,7,9,11,12,20,21	128, 160
18	Protection active	Yes	1	1,7,9,11,12,20,21	128, 160, 176, 192
19	LED Reset	–	1	1,7,11,12,20,21	128, 160, 176, 192
20	Monitor direction blocked	Yes	1	9,11	128, 160, 176, 192
21	Test mode	Yes	1	9,11	128, 160, 176, 192
22	Local parameter setting	Yes	1	9,11	128, 160, 176, 192

Table G.9 IEC 60870-5-103 Data Map (Sheet 2 of 3)

INF	Description	GI	ASDU Type	COT	FUN
23	Characteristic 1[c]	Yes	1	1,7,9,11,12,20,21	128
24	Characteristic 2[c]	Yes	1	1,7,9,11,12,20,21	128
25	Characteristic 3[c]	Yes	1	1,7,9,11,12,20,21	128
26	Characteristic 4[c]	Yes	1	1,7,9,11,12,20,21	128
27	Auxiliary input 1[d]	Yes	1	1,7,9,11	128, 160, 176, 192
28	Auxiliary input 2[d]	Yes	1	1,7,9,11	128, 160, 176, 192
29	Auxiliary input 3[d]	Yes	1	1,7,9,11	128, 160, 176, 192
30	Auxiliary input 4[d]	Yes	1	1,7,9,11	128, 160, 176, 192
Supervision indications in monitor direction[b]					
32	Measurand supervision I	Yes	1	1,7,9	128, 160
33	Measurand supervision V	Yes	1	1,7,9	128, 160
35	Phase sequence supervision	Yes	1	1,7,9	128, 160
36	Trip circuit supervision	Yes	1	1,7,9	128, 160, 176, 192
37	I>> back-up operation	Yes	1	1,7,9	128
38	Voltage transformer fuse failure	Yes	1	1,7,9	128, 160
39	Teleprotection disturbed	Yes	1	1,7,9	128, 160, 192
46	Group warning	Yes	1	1,7,9	128, 160, 176, 192
47	Group alarm	Yes	1	1,7,9	128, 160, 176, 192
Earth fault indications in monitor direction[b]					
48	Earth Fault L_1	Yes	1	1,7,9	128, 160
49	Earth Fault L_2	Yes	1	1,7,9	128, 160
50	Earth Fault L_3	Yes	1	1,7,9	128, 160
51	Earth fault forward, i.e., line	Yes	1	1,7,9	128, 160
52	Earth fault reverse, i.e., busbar	Yes	1	1,7,9	128, 160
Fault indications in monitor direction[e]					
64	Start/pick-up L[b]	Yes	2	1,7,9	128, 160, 192
65	Start/pick-up L[c]	Yes	2	1,7,9	128, 160, 192
66	Start/pick-up L[d]	Yes	2	1,7,9	128, 160, 192
67	Start/pick-up N	Yes	2	1,7,9	128, 160, 192
68	General trip	–	2	1,7	128, 160, 176, 192
69	Trip L_1	–	2	1,7	128, 160, 176, 192
70	Trip L_2	–	2	1,7	128, 160, 176, 192
71	Trip L_3	–	2	1,7	128, 160, 176, 192
72	Trip I>> (back-up operation)	–	2	1,7	128, 160, 176, 192
73	Fault Location X in ohms	–	4	1,7	128
74	Fault forward / line	–	2	1,7	128, 160
75	Fault reverse / busbar	–	2	1,7	128, 160
76	Teleprotection signal transmitted	–	2	1,7	128, 160
77	Teleprotection signal received	–	2	1,7	128, 160
78	Zone 1	–	2	1,7	128

Table G.9 IEC 60870-5-103 Data Map (Sheet 3 of 3)

INF	Description	GI	ASDU Type	COT	FUN
79	Zone 2	–	2	1,7	128
80	Zone 3	–	2	1,7	128
81	Zone 4	–	2	1,7	128
82	Zone 5	–	2	1,7	128
83	Zone 6	–	2	1,7	128
84	General start / pick-up	Yes	2	1,7,9	128, 160, 176, 192
85	Breaker failure	–	2	1,7	128, 160
86	Trip measuring system L_1	–	2	1,7	176
87	Trip measuring system L_2	–	2	1,7	176
88	Trip measuring system L_3	–	2	1,7	176
89	Trip measuring system E	–	2	1,7	176
90	Trip I>	–	2	1,7	160
91	Trip I>>	–	2	1,7	160
92	Trip IN>	–	2	1,7	160
93	Trip IN>>	–	2	1,7	160
Auto-recloser indications in monitor direction[b]					
128	Circuit breaker on by Auto-recloser	–	1	1,7	128, 160, 192
129	Circuit breaker on by long-time Auto-recloser	–	1	1,7	128, 160, 192
130	Auto-recloser blocked	Yes	1	1,7,9	128, 160, 192
Measurands in monitor direction					
144	Measurand I	–	3.1	2,7	128, 160
145	Measurands I, V	–	3.2	2,7	128, 160
146	Measurands I, V, P, Q	–	3.3	2,7	128
147	Measurands I_N, V_{EN}	–	3.4	2,7	128, 160
148	Measurands $I_{L1,2,3}$, $V_{L1,2,3}$, P, Q, f	–	9	2,7	128
System functions in control direction					
0[a]	Initiation of General Interrogation		7	9	255
0[a]	Time synchronization		6	8	255
General commands in control direction[f]					
16	Auto-recloser on/off	ON/OFF	20	20	128, 160, 192
65	Teleprotection on/off	ON/OFF	20	20	128, 160
66	Protection on/off	ON/OFF	20	20	128, 160, 176, 192
67	LED Reset	ON	20	20	128, 160, 176, 192
68	Activate characteristic 1[c]	ON	20	20	128
69	Activate characteristic 2[c]		20	20	128
70	Activate characteristic 3[c]		20	20	128
71	Activate characteristic 4[c]		20	20	128

[a] The SEL-751 supports these points at the specified INF and FUN.
[b] Referred to as Binary Data in the SEL-751.
[c] Mapped to settings group indications and control in the SEL-751.
[d] Mapped to device contact inputs in the SEL-751.
[e] Referred to as Binary Targets and other Fault Information in the SEL-751.
[f] Referred to as Binary Controls in the SEL-751.

IEC 60870-5-103 in the SEL-751

The IEC 60870-5-103 protocol settings in the SEL-751 contain five parameters that must be set properly to get the most out of the protocol. These parameters are called 103ADDR, 103CYC, 103ACYC, 103ATRI, and 103TIME. *Table G.10* describes each of these parameters.

Table G.10 SEL-751 IEC 60870-5-103 Port Settings

Parameter	Description	Range/Valid Input
103ADDR	Link layer address of the product	0–254
103CYC	Period at which to report cyclic data (measurands)	1–3600 seconds
103ACYC	Meter quantity period to report type ASDU 205 data	OFF, 1–3600 seconds
103ATRI	Relay Word bit used as a meter quantity reporting trigger for type ASDU 205 data	1 Relay Word bit
103TIME	Time synchronization enable	Y, N

The IEC 60870-5-103 standard in the SEL-751 provides six category types namely, Binary Inputs, Binary Targets, Binary Controls, Measurands, Fault Analogs, and Meter Quantities. Each data point within each class type requires an Information Number and a Function Type. Binary Inputs, Binary Targets, and Binary Controls are defined within the map by a Label Name followed by an Information Number followed by a Function Type. Measurands, Fault Analogs, and Meter Quantities are defined within the map by a Label Name followed by the Scale Factor/Nominal Value followed by the Information Number followed by the Function Type. The Nominal Value pertains only to Measurands and is defined within the following formula.

$$\text{Value seen by Master} = \frac{4096 \bullet \text{Label\_Value}}{2.4 \bullet \text{Nominal\_Value}}$$

Consider for example frequency in the Measurand point (FREQ, 60, 0, 1). Conceptually, when the frequency is 60 Hz, which is 0.4167 of 2.4 • Nominal Value (2.4 • 60 = 144), then the value 0.4167 gets encoded as a 13-bit, fixed-point number that has the same bit-wise representation as the integer that is equal to the Value seen by Master or

$$\frac{4096 \bullet \text{FREQ}}{2.4 \bullet 60\ \text{Hz}}$$

Binary Inputs

In the SEL-751, binary data are reported as ASDU type 1 (Time Tagged Message). Those points, monitored by the SER function of the device, have their changes reported as COT type 1 (Spontaneous Events). The format of a binary input point within the binary input map is “Label, [INF, FUN].” The Label represents any valid binary input point accepted by the SEL-751. The INF parameter is an integer in the range of 0 to 255. Similarly, the FUN parameter is an integer in the range of 0 to 255. The Label can be entered by itself with the SEL-751 choosing default parameters for INF and FUN. The default parameter for INF is an available, unique value that is selected by the SEL-751. The default parameter for FUN is 250.

The [INF, FUN] pair needs to either be entered together or not entered at all. The SEL-751 does not accept only one member of the [INF, FUN] pair. Label, INF, and FUN can all be manually entered. No other combinations are valid with the SEL-751.

Binary Targets

The binary targets are Relay Word bits within the SEL-751 under row zero. They also appear as LEDs on the front panel of the SEL-751. There are eight binary targets in the SEL-751 namely, ENABLED, TRIP_LED, TLED_01, TLED_02, TLED_03, TLED_04, TLED_05, and TLED_06. In the SEL-751, binary targets are reported as ASDU type 2 (Time Tagged Message with Relative Time) with COT type 1 (Spontaneous Events). The format of a binary target point within the binary target map is “Label, [INF, FUN].” Label represents any valid binary target point accepted by the SEL-751. The INF parameter is an integer in the range of 0 to 255. Similarly, the FUN parameter is an integer in the range of 0 to 255. Label can be entered by itself with the SEL-751 choosing default parameters for INF and FUN. The default parameter for INF is an available, unique value that is selected by the SEL-751. The default parameter for FUN is 250.

The [INF, FUN] pair needs to either be entered together or not entered at all. The SEL-751 does not accept only one member of the [INF, FUN] pair. Also, Label, INF, and FUN can all be manually entered. No other combinations are valid with the SEL-751.

Fault Analogs

The fault analogs are analog quantities in the SEL-751 used to describe faults recognized by the relay, such as fault current or fault location. These quantities are listed in *Table G.11*. In the SEL-751, fault analog quantities are reported as ASDU type 4 (Time Tagged Measurands with Relative Time) with COT type 1 (Spontaneous Events). The format of a fault analog point within the fault analog map is “Label, [Scaling, [INF, FUN]].” Label represents any valid fault analog point accepted by the SEL-751. Scaling is the scaling factor applied to the point prior to being sent out of the relay via the protocol. Its range is 0.000 to 99999.000. The INF parameter is an integer in the range of 0 to 255. Similarly, the FUN parameter is an integer in the range of 0 to 255. Label can be entered by itself with the SEL-751 choosing default parameters for Scaling, INF, and FUN. The Label and Scaling values can also be entered together with the SEL-751 choosing default parameters for the INF and FUN. The default parameter for INF is an available, unique value that is selected by the SEL-751. The default parameter for FUN is 250. The default value for Scaling is 1.

The [INF, FUN] pair needs to either be entered together or not entered at all. The SEL-751 does not accept only one member of the [INF, FUN] pair. If the [INF, FUN] pair has been entered, then Scaling must also be entered.

For a single Master/SEL-751 session, the SEL-751 stores as many as three sets of event data into a buffer. If the buffer is full as a result of multiple events with the poll cycle, any new event data is discarded. When the buffered data have been reported (using the first-in first-out (FIFO) principle) to the Master, those data are removed from the buffer to make room for the next event.

Table G.11 SEL-751 Analog Fault Quantities (Sheet 1 of 2)

Analog Fault Quantity	Description
FLOC	Location of the fault event
FIA	A-phase current of the fault event
FIB	B-phase current of the fault event

Table G.11 SEL-751 Analog Fault Quantities (Sheet 2 of 2)

Analog Fault Quantity	Description
FIC	C-phase current of the fault event
FIG	Ground current of the fault event
FIN	Neutral current of the fault event
FFREQ	Frequency of the fault event
FZ	Fault impedance magnitude of the fault event
FZFA	Fault impedance angle of the fault event

Binary Controls

In the SEL-751, two types of controls are permitted under this protocol. They are as follows:

- Latching Single-Point: On/Off operations latch the point to 1 or 0, respectively. The points format is (Label, INF, FUN)
- Pulsing Single-Point: On operation pulses the point or triggers the point. Off has no effect. The point format is (Label, INF, FUN)

When controls are sent to the SEL-751 successfully, the relay responds with ASDU type 1 (Time Tagged Message) and COT type 20 (Positive Acknowledgment on Command) as well as with ASDU type 1 (Time Tagged Message) and COT type 12 (Remote Operation) if the control was sent remotely. The format of a binary control point within the binary control map is "Label, [INF, FUN]." Label represents any valid binary control point accepted by the SEL-751. The INF parameter is an integer in the range of 0 to 255. Similarly, the FUN parameter is an integer in the range of 0 to 255. Label can be entered by itself with the SEL-751 choosing default parameters for INF and FUN. The default parameter for INF is an available, unique value to use that is selected by the SEL-751. The default parameter for FUN is 250.

The [INF, FUN] pair needs to either be entered together or not entered at all. The SEL-751 does not accept only one member of the [INF, FUN] pair. Also, the Label, INF, and FUN can all be manually entered. No other combinations are valid with the SEL-751.

Measurands

In the SEL-751, a measurand is defined as a group of at most 16 analog quantities with the same [INF, FUN] pair. The SEL-751 allows at most 8 measurands even if the measurand map is not completely filled with analog quantities (total of 128). Measurands are refreshed for the Master at the expiration of the 103CYC parameter and sent to the Master, once polled by the Master.

In the SEL-751, measurands are reported as ASDU type 9 (Measurands II) with COT type 2 (Cyclic). The format of an analog quantity within a measurand in the measurand map is "Label, Nominal, [INF, FUN]." Label represents any valid analog quantity accepted by the SEL-751. Nominal is the nominal value applied to the point prior to being sent out of the relay via the protocol. Its range is 0.001 to 999999.000. The INF parameter is an integer in the range of 0 to 255. Similarly, the FUN parameter is an integer in the range of 0 to 255. You are required to enter the Nominal value. The Label and Nominal values can be entered by themselves with the SEL-751 choosing default parameters for INF and FUN. The default parameter for INF is an available, unique value to use that is selected by the SEL-751. The default parameter for FUN is 250.

The [INF, FUN] pair needs to either be entered together or not entered at all. The SEL-751 does not accept only one member of the [INF, FUN] pair. And of course, the Label, Nominal, INF, and FUN can all be manually entered. No other combinations are valid with the SEL-751.

Meter Quantities

The meter quantities are analog quantities in the SEL-751. In the SEL-751, meter quantities are reported as ASDU type 205 (Non-Standard) with COT type 1 (Spontaneous Events). The format of a meter quantity point within the meter quantity map is "Label, [Scaling, [INF, FUN]]." Label represents any valid meter quantity point accepted by the SEL-751. Scaling is the scaling factor applied to the point prior to being sent out of the relay via the protocol. Its range is 0.000 to 99999. The INF parameter is an integer in the range of 0 to 255. Similarly, the FUN parameter is an integer in the range of 0 to 255. Label can be entered by itself with the SEL-751 choosing default parameters for the Scaling, INF, and FUN. Label and Scaling can also be entered together with the SEL-751 choosing default parameters for the INF and FUN. The default parameter for INF is an available, unique value to use that is selected by the SEL-751. The default parameter for FUN is 250. The default value for Scaling is 1.

In any case, the [INF, FUN] pair needs to either be entered together or not entered at all. The SEL-751 does not accept only one member of the [INF, FUN] pair. If the [INF, FUN] pair has been entered, then Scaling must also be entered.

The SEL-751 begins its response within 45 milliseconds of receiving a complete request. The above classes define the IEC 60870-5-103 data map in the SEL-751. The SEL-751 provides for only one IEC 60870-5-103 map. The map consists of 332 definable points. These points include 100 binary input points, 8 binary targets, 32 binary controls, 8 measurands (totaling 128 analog quantities), 32 fault analogs, and 32 meter quantities.

Time Synchronization

The SEL-751 supports time synchronization as indicated with the 103TIME parameter under the device port settings. If the value is set to yes, then the device uses the time provided by the Master when the command is given, as long as the SEL-751 is not connected to an external time source, e.g., IRIG or SNTP. The SEL-751 sets the internal time validity bit to indicate proper reception of the time synchronization command sequence from the Master. The date and time should not be trusted unless the validity bit is set. Time synchronization in the SEL-751 should only be used if IRIG or SNTP sources are not available.

IEC 60870-5-103 Documentation

The *IEC 60870-5-103 Configuration/Interoperability Guide for the* SEL-751 is available on the supplied CD or as a download from the SEL website and contains the standard device profile information for the SEL-751. Please refer to this document for complete information on IEC 60870-5-103 configuration and interoperability in the SEL-751.

Appendix H
DeviceNet Communications

Overview

This appendix describes DeviceNet communications features supported by the SEL-751 Feeder 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-751 to the DeviceNet automation network. The card (see *Figure H.1*) occupies the communications expansion Slot **C** in the relay.

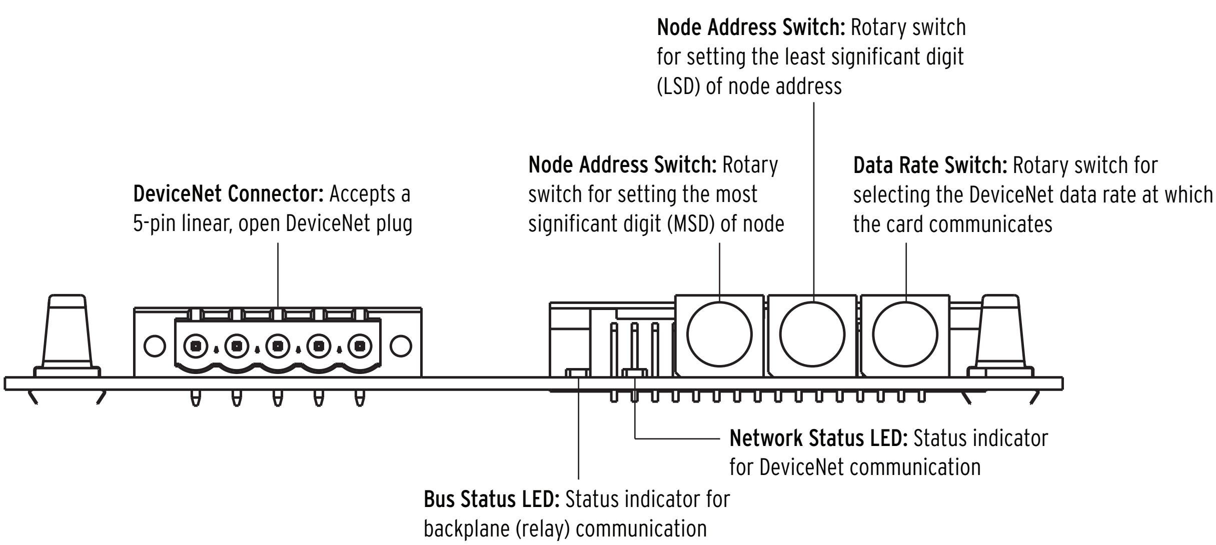


Figure H.1 DeviceNet Card Component Overview

Features

The DeviceNet Card features the following:

- ➤ The card receives the necessary power from the DeviceNet network.
- ➤ Rotary switches let you set the node address and network data rate prior to mounting in the SEL-751 and applying power. Alternatively, you can set the switches to positions that allow for configuration of these settings over the DeviceNet network, using 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-751 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
- ➤ Retrieve and modify relay settings
- ➤ Read and set time
- ➤ Monitor device status, trip/warning status, and I/O status
- ➤ Perform high-speed control
- ➤ Reset trip, target, and accumulated data
- ➤ Retrieve events history

You can configure the DeviceNet interface through the use of address and data transmission rate switches. Indicators on the card at the back of the relay show network status and network activity.

Electronic Data Sheet

The Electronic Data Sheet (EDS) is a specially formatted file that includes configurable parameters for the device and public interfaces to those parameters. The EDS file contains information such as number of parameters; groupings; parameter name; minimum, maximum, and default values; units; data format; and scaling. This information makes possible user-friendly configuration tools (e.g., 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-751, SEL-xxxRxxx.EDS, is located on the SEL-751 Product Literature CD, or can also be downloaded from the SEL website at selinc.com.

Complete specifications for the DeviceNet protocol are available on the Open DeviceNet Vendor's Association (ODVA) website 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 I
Synchrophasors

Overview

The SEL-751 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-751 Relays, to synchronize the gathering of power system data. The accurate clock allows precise event report triggering and other off-line analysis functions. Synchrophasors are still measured if the high-accuracy time source is not connected; however, the data are not time-synchronized to any external reference, as indicated by Relay Word bits TSOK := logical 0 and PMDOK := logical 0.

The SEL-751 Global settings class contains the synchrophasor settings, including the choice of transmitted synchrophasor data set. The Port settings class selects which serial port(s) or Ethernet port you can use for synchrophasor protocol. See *Settings for Synchrophasors on page I.4*.

The SEL-751 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 I.11*.

When synchrophasor measurement is enabled, the SEL-751 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 I.13*.

The value of synchrophasor data increases greatly when you can share the data over a communications network in real time. A synchrophasor protocol is available in the SEL-751 that allows for a centralized device to collect data efficiently from several phasor measurement units (PMUs). Some possible uses of a system-wide synchrophasor system include the following:

- Power-system state measurement
- Generator Model Validation
- Wide-area network protection and control schemes

- ➤ Small-signal analysis
- ➤ Power-system disturbance analysis

The SEL-3373 is a Phasor Data Concentrator (PDC) designed to interface with PMUs, other PDCs, and Synchrophasor Vector Processors (SVPs). The SEL-3373 has two primary functions. The first is to collect and correlate synchrophasor data from multiple PMUs. The second is to then compact and transmit synchrophasor data either to a data historian for post-analysis or to visualization software for real-time viewing of a power system.

The SEL-3378 Synchrophasor Vector Processor (SVP) is a real-time synchrophasor programmable logic controller. Use the SVP to collect synchrophasor messages from relays and phasor measurement units (PMUs). The SVP time-aligns incoming messages, processes these messages with an internal logic engine, and sends control command to external devices to perform user-defined actions. Additionally, the SVP can send calculated or derived data to devices such as other SVPs, phasor data concentrators (PDCs), and monitoring systems.

The SEL-751 supports the protocol portion of the IEEE C37.118, Standard for Synchrophasors for Power Systems. In the SEL-751, this protocol is referred to as C37.118. See *Settings Affect Message Contents on page I.15*.

Synchrophasor Measurement

The phasor measurement unit in the SEL-751 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 I.5*).

The phase angle is measured relative to an absolute time reference, which is represented by a cosine function in *Figure I.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, you can compare the SEL-751 synchrophasor values directly to values from other phasor measurement units that conform to C37.118.

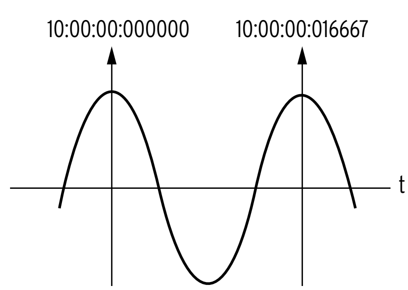

Figure I.1 Phase Reference

The TSOK Relay Word bit asserts when the SEL-751 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 can introduce a time shift in the measured signal. Global settings VCOMP, VSCOMP, and ICOMP, entered in degrees, are added to the measured phasor angles to create the corrected phasor angles, as shown in *Figure I.2*, *Figure I.3*, and *Equation I.1*. The VCOMP, VSCOMP, and ICOMP settings can be positive or negative values. The corrected angles are displayed in the **MET PM** command and transmitted as part of synchrophasor messages.

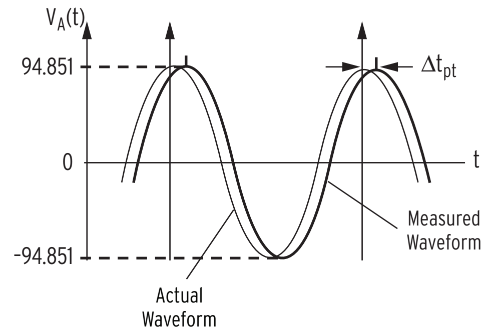

Figure I.2 Waveform at Relay Terminals May Have a Phase Shift

$$\text{Compensation Angle} = \frac{\Delta t_{pt}}{\left(\frac{1}{freq_{nominal}}\right)} \cdot 360^\circ$$
$$= \Delta t_{pt} \cdot freq_{nominal} \cdot 360^\circ$$

Equation I.1

If the time shift on the PT measurement path $\Delta t_{pt} = 0.784$ ms and the nominal frequency, $freq_{nominal} = 60$Hz, use *Equation I.2* to obtain the correction angle:

$$0.784 \cdot 10^{-3} s \cdot 60 s^{-1} \cdot 360^\circ = 16.934^\circ$$

Equation I.2

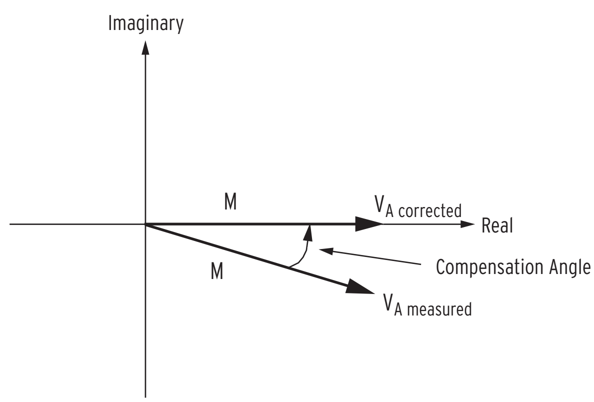

Figure I.3 Correction of Measured Phase Angle

The phasors are rms values scaled in primary units, as determined by Group settings PTR, PTRS (for synchronism-check input), CTR, 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 I.1*. Modify these settings when you want to use the C37.118 synchrophasor protocol.

You must set Global enable setting EPMU to Y before the remaining SEL-751 synchrophasor settings are available. No synchrophasor data collection can take place when EPMU := N.

You must make the serial port settings in *Table I.5* or Ethernet port settings in *Table I.6* to transmit data with a synchrophasor protocol. It is possible to set EPMU := Y without using any ports for synchrophasor protocols. For example, the port **MET PM** ASCII command can still be used.

Table I.1 PMU Settings in the SEL-751 for C37.118 Protocol in Global Settings

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-751 FEEDER1
PMID	PMU Hardware ID (1–65534)	1
PHDATAV	Phasor Data Set, Voltages (V1, ALL, NA)	V1
VCOMP	Voltage Angle Comp Factor (–179.99 to 180.00 deg)	0.00
VSCOMP	VS Voltage Angle Comp Factor (–179.99 to 180.00 deg)	0.00
PHDATAI	Phasor Data Set, Currents (I1, ALL, NA)	I1
ICOMP	Current Angle Comp Factor (–179.99 to 180.00 deg)	0.00
NUMANA	Number of Analog Values (0–4)	0
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)	81D1T OR 81D2T OR 81D3T OR 81D4T
TREA3	Trigger Reason Bit 3 (SELOGIC)	59P1T OR 59P2T[b]
TREA4	Trigger Reason Bit 4 (SELOGIC)	27P1T OR 27P2T[b]
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.
[b] For the SEL-751 model with the currents only option, the default setting is NA.

Certain settings in *Table I.1* are hidden, depending on the status of other settings. For example, if PHDATAI := NA, the ICOMP setting is hidden to limit the number of settings for your synchrophasor application. Definitions for the settings in *Table I.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 I.15* for detailed information.

PMAPP

Selects the type of digital filters used in the synchrophasor algorithm:

- The Narrow Bandwidth setting (N) represents filters with a cutoff frequency approximately ¼ of MRATE. The response in the frequency domain is narrower, and response in the time domain is slower. This method results in synchrophasor data that are free of aliasing signals and well suited for post disturbance analysis.
- The Fast Response setting (F) represents filters with a higher cutoff frequency. The response in frequency domain is wider and the response in the time domain is faster. This method results in synchrophasor data that you can use in synchrophasor applications requiring more speed in tracking system parameters.

PHCOMP

Enables or disables frequency-based compensation for synchrophasors. For most applications, set PHCOMP := Y to activate the algorithm that compensates for the magnitude and angle errors of synchrophasors for frequencies that are off nominal. Use PHCOMP := N if you are concentrating the SEL-751 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, VCOMP, 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 I.15* for detailed information.

- PHDATAV := V1 transmits only positive-sequence voltage, V_1
- PHDATAV := ALL transmit V_1, V_A, V_B, V_C, and V_S (if available). VAB, VBC, VCA are transmitted if DELTA_Y := DELTA.
- PHDATAV := NA does not transmit any voltages

Table I.2 describes the order of synchrophasors inside the data packet.

Table I.2 Synchrophasor Order in Data Stream (Voltages and Currents)

Synchrophasors[a,b,c] Rectangular Real	Synchrophasors[a,b,c] Rectangular Imaginary	Included When Global Settings Are as Follows:
V1	V1	PHDATAV := V1 or ALL
VA	VA	PHDATAV := ALL
VB	VB	
VC	VC	
VS	VS	
I1	I1	PHDATAI := I1 or ALL
IA	IA	PHDATAI := ALL
IB	IB	
IC	IC	
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 CTR, CTRN, PTR, PTRS are used to scale the values.
[c] When PHDATAV := ALL and DELTA_Y := WYE, phase voltages VA, VB, and VC are transmitted. Phase voltages VAB, VBC, and VCAX are transmitted when DELTA_Y := DELTA.

The VCOMP and VSCOMP settings allow correction for any steady-state voltage phase errors (from the potential transformers or wiring characteristics). See *Synchrophasor Measurement on page I.2* for details on this setting.

PHDATAI and ICOMP

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 I.15* 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
- ➤ PHDATAI := NA does not transmit any currents

The ICOMP setting allows correction for any steady-state phase errors (from the current transformers or wiring characteristics). See *Synchrophasor Measurement on page I.2* for details on these settings.

Table I.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.

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 I.15* 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 I.3*.

The format of the user-defined analog data is always floating point, and each value occupies four bytes.

Table I.3 User-Defined Analog Values Selected by the NUMANA Setting

NUMANA Setting	Analog Quantities Sent	Total Number of Bytes Used for Analog Values
0	None	0
1	MV29	4
2	Previous, plus MV30	8
3	Previous, plus MV31	12
4	Previous, plus MV32	16

NUMDSW

Selects the number of user-definable digital status words to be included in the synchrophasor data stream.

This setting is one of seven settings that determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size. See *Communications Bandwidth on page I.15* 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 I.4*.

Table I.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-751 evaluates these equations and places the results in Relay Word bits with the same names: TREA1–TREA4, and PMTRIG.

NOTE: The PM Trigger function is not associated with the SEL-751 Event Report Trigger ER, a SELOGIC control equation in the Report settings class.

The trigger reason equations represent the Trigger Reason bits in the STAT field of the data packet. After the trigger reason bits are set to convey a message, the PMTRIG equation should be asserted for a reasonable amount of time, to allow the synchrophasor processor to read the TREA1–TREA4 fields.

The SEL-751 automatically sets the TREA1–TREA4 or PMTRIG Relay Word bits based on their default SELOGIC control equation. You must program these bits to change their operation.

You can use these bits to send various messages at a low bandwidth via the synchrophasor message stream. You can also use Digital Status Words to send binary information directly, without the need to manage the coding of the trigger reason messages in SELOGIC control equations.

Use these Trigger Reason bits if your synchrophasor system design requires these bits. The SEL-751 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 can adjust the synchrophasor time stamp accordingly.

NOTE: Set IRIGC = C37.118 only when an IRIG-B000 signal is connected to the relay. Set IRIGC = NONE when an IRIG-B002 (standard IRIG) signal is connected.

- 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 I.5*.

Table I.5 SEL-751 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 I.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 I.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 I.6*.

Ethernet port setting EPMIP cannot be set when Global setting EPMU := N. Synchrophasors must be enabled (EPMU := Y) before EPMIP can be set.

Table I.6 SEL-751 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)[c, d]	192.168.1.3
PMOTCP1	PMU Output 1TCP/IP (Local) Port Number (1–65534)[c, d]	4712
PMOUDP1	PMU Output 1 UDP/IP Data (Remote) Port Number (1–65534)[c, e, f]	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)[g]	192.168.1.4
PMOTCP2	PMU Output 2 TCP/IP (Local) Port Number (1–65534)[d, g]	4722
PMOUDP2	PMU Output 2 UDP/IP Data (Remote) Port Number (1–65534)[f, g, h]	4713

[a] Setting is hidden when EPMU := N.
[b] Set EPMIP := 1 or 2 to access other settings and to enable IEEE C37.118 protocol synchrophasors on this port. Setting EPMIP is not available when Global setting EPMU is set to N.
[c] Setting hidden when PMOTS1 := OFF.
[d] Port number must be unique.
[e] Setting hidden when PMOTS1 := TCP.
[f] Port numbers must be unique for PMOUDP1, PMOUDP2, and DNPUDP1–3, if active.
[g] Setting hidden when PMOTS2 := OFF.
[h] Setting hidden when PMOTS2 := TCP.

Definitions for some of the settings in *Table I.6* are discussed further in the following text.

PMOTS1 and PMOTS2

Selects the PMU Output transport scheme for Session 1 and Session 2, respectively.

PMOTSn := TCP. establishes a single, persistent TCP socket for transmitting and receiving synchrophasor messages (both commands and data), as illustrated in *Figure I.4*.

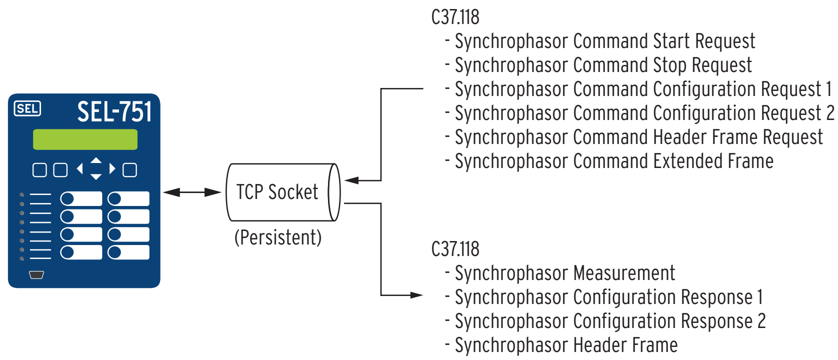

Figure I.4 TCP Connection

PMOTSn := UDP_T. establishes two socket connections. A non-persistent TCP connection is used for receiving synchrophasor command messages as well as synchrophasor configuration and header response messages. A persistent UDP connection is used to transmit synchrophasor data messages. *Figure I.5* depicts the UDP_T connection.

PMOTSn := UDP_U. uses the same connection scheme as the UDP_T except the synchrophasor configuration and header response messages are sent over the UDP connection, as shown in *Figure I.5*.

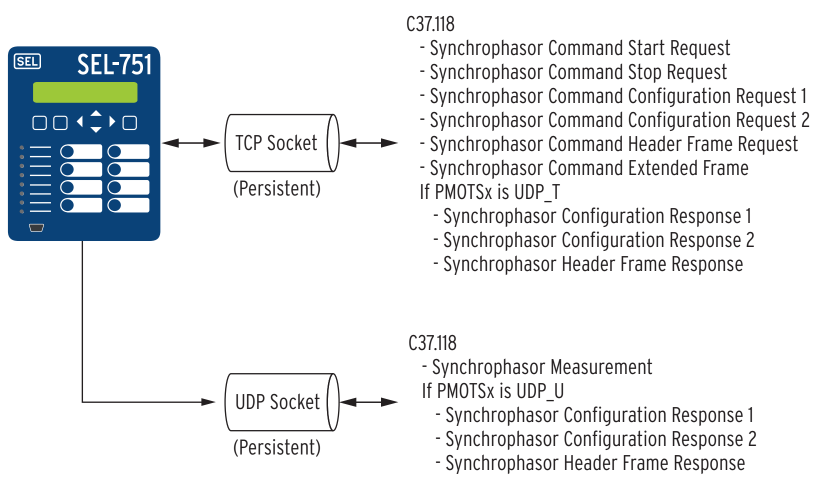

Figure I.5 UDP_T and UDP_U Connections

NOTE: The UDP setting (UDP_T, UDP_U, and UDP_S) allows for both Multicast and Unicast IP addresses.

PMOTSn := UDP_S. establishes a single persistent UDP socket to transmit synchrophasor messages. Synchrophasor data are transmitted whenever new data are read. With this communication scheme, the relay sends a "Synchrophasor Configuration Response 2" once every minute, as shown in *Figure I.6*.

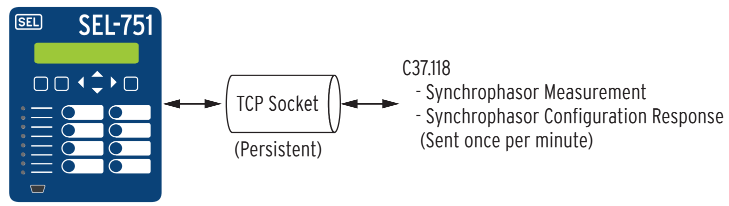

Figure I.6 UDP_S Connection

PMOIPA1 and PMOIPA2

Defines the PMU Output Client IP address for Session 1 and Session 2, respectively.

PMOTCP1 and PMOTCP2

Defines the TCP/IP (Local) port number for Session 1 and Session 2, respectively. The TCP port numbers must all be unique (See *Table M.1*).

PMOUDP1 and PMOUDP2

Defines the UDP/IP (Remote) port number for Session 1 and Session 2, respectively. The UDP port numbers must all be unique (See *Table M.1*).

Synchrophasor Relay Word Bits

Table I.7 and *Table I.8* list the SEL-751 Relay Word bits that are related to synchrophasor measurement. The Synchrophasor Trigger Relay Word bits in *Table I.7* follow the state of the SELOGIC control equations of the same name, listed at the bottom of *Table I.1*. These Relay Word bits are included in the IEEE C37.118 synchrophasor data frame STAT field. See *Table I.4* for standard definitions for these settings.

Table I.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 I.8* indicate the present status of the timekeeping function of the SEL-751.

Table I.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.

The Relay Word bit TSOK provides the indication that the time synchronization is OK. The SEL-751 determines the suitability of the IRIG-B signal for normal accuracy by applying several tests:

- Seconds, minutes, and day fields are in range
- Time from two consecutive messages differs by one second, except for leap second or daylight-saving time transitions
- When IRIGC = C37.118, the signal contains the correct parity bit

The SEL-751 determines the suitability of the IRIG-B signal for high-accuracy timekeeping by applying two additional tests:

NOTE: The jitter measurement for the IRIG signal could take up to 15 seconds to determine. During this time TSOK is not asserted.

- The jitter between positive transitions (rising edges) of the clock signal is less than 500 ns
- The time error information contained in the IRIG-B control field indicates time error is less than 10^{-6} seconds (1 µs)

When IRIGC = NONE, the relay asserts TSOK when only the first test is met. When IRIGC = C37.118 and an appropriate IRIG-B signal is connected, Relay Word bit TSOK only asserts when these two tests are met. The time error information in the IRIG-B control field is mapped to the TQUAL bits in the relay. *Table I.9* provides the information for the TQUAL bits and how they translate to time quality. The values 0 (Locked) and 4 (1 microsecond) indicate that the relay is receiving high-accuracy IRIG.

When the IRIG signal is lost, IRIGOK deasserts. However, TSOK remains asserted for a holdover period as long as 15 seconds. If the IRIG signal is not restored within 15 seconds, TSOK also deasserts.

Table I.9 TQUAL Bits Translation to Time Quality

TQUAL8	TQUAL4	TQUAL2	TQUAL1	Value	Time Quality
0	0	0	0	0	Locked
0	0	0	1	1	1 nanosecond
0	0	1	0	2	10 nanoseconds
0	0	1	1	3	100 nanoseconds
0	1	0	0	4	1 microsecond
0	1	0	1	5	10 microseconds
0	1	1	0	6	100 microseconds
0	1	1	1	7	1 millisecond
1	0	0	0	8	10 milliseconds
1	0	0	1	9	100 milliseconds
1	0	1	0	10	1 second
1	0	1	1	11	10 seconds
1	1	0	0	12	100 seconds
1	1	0	1	13	1 000 seconds
1	1	1	0	14	10 000 seconds
1	1	1	1	15	Fault

The Relay Word bit PMDOK indicates that the phasor measurement data are acceptable and asserts under the following conditions.

For the SEL-751 models with the voltage option:

- The relay is enabled
- EPMU = Y
- IRIGOK = 1
- TSOK = 1
- The synchrophasor filter buffers are fully primed
- The magnitude of the positive-sequence voltage, |V1| > 10 V
- The frequency is 40–70 Hz

For the SEL-751 models with the currents only option:

- The relay is enabled
- EPMU = Y
- IRIGOK = 1
- TSOK = 1
- The synchrophasor filter buffers are fully primed
- The magnitude of the positive-sequence current, $|I1| > 0.1 \cdot I_{NOM}$ (I_{NOM} = 1 A or 5 A)
- The frequency is 40–70 Hz

PMDOK takes 15 seconds to assert when the relay is first powered, after any of the settings in *Table I.1* are changed, or when an IRIG-B time signal is first connected. This is due to the delay in time qualification (TSOK to assert).

View Synchrophasors Using the MET PM Command

You can use the **MET PM** serial port ASCII command to view the SEL-751 synchrophasor measurements. See *MET Command (Metering Data) on page 7.42* 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 and 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 and PHDATAI. The **MET PM** command can function even when no serial ports are sending synchrophasor data—it is unaffected by serial port setting PROTO.

NOTE: To have the MET PM xx:yy:zz response transmitted from a serial port, the corresponding port must have the AUTO setting set to Y (YES).

The **MET PM** command only operates when the SEL-751 is in the IRIG timekeeping mode, as indicated by Relay Word bit TSOK = logical 1.

Figure I.7 shows a sample **MET PM** command response. The synchrophasor data are also available via the **HMI > Meter PM** menu in ACSELERATOR QuickSet, and has a similar format to *Figure I.7*.

You can use the **MET PM *time*** command to direct the SEL-751 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 I.7* occurring just after 14:14:12, with the time stamp 14:14:12.000. See *Section 7: Communications* for complete command options, and error messages.

```
=>MET PM <Enter>

SEL-751                                 Date: 01/07/2010   Time: 20:55:21.000
FEEDER RELAY                            Time Source: External

Time Quality   Maximum time synchronization error:    0.000 (ms)  TSOK = 1

Synchrophasors

                     Phase Voltages             Pos. Sequence Voltage
                 VA        VB        VC                 V1
MAG (V)         134.00    132.21    135.34             134.31
ANG (DEG)       129.22     10.57    -111.89            128.12

                 VS
MAG (V)         123.41
ANG (DEG)       135.00

                     Phase Currents             Pos. Sequence Current
                 IA         IB         IC                I1
MAG (A)          24.50     23.54     22.50              23.51
ANG (DEG)        120.22     1.23   -120.21             120.32

                 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 I.7 Sample MET PM Command Response

C37.118 Synchrophasor Protocol

The SEL-751 complies with IEEE C37.118, Standard for Synchrophasors for Power Systems. The protocol is available on serial ports 2, 3, 4, and F by setting the corresponding port setting PROTO := PMU. In addition, synchrophasor data can be accessed through the Ethernet port when the EPMIP setting is enabled.

This section does not cover the details of the protocol, but highlights some of the important features and options that are available.

Settings Affect Message Contents

The SEL-751 allows several options for transmitting synchrophasor data. These are controlled by Global settings described in *Settings for Synchrophasors on page I.4*. You can select how often to transmit the synchrophasor messages (MRATE) and which synchrophasors to transmit (PHDATAV and PHDATAI). The SEL-751 automatically includes the frequency and rate-of-change-of-frequency in the synchrophasor messages.

The relay can include as many as four user-programmable analog values in the synchrophasor message, as controlled by Global setting NUMANA, and 0 or 16 digital status values, as controlled by Global setting NUMDSW.

The SEL-751 always includes the results of four synchrophasor trigger reason SELOGIC control equations TREA1, TREA2, TREA3, and TREA4, and the trigger SELOGIC control equation result PMTRIG, in the synchrophasor message.

Communications Bandwidth

A phasor measurement unit (PMU) that is configured to transmit a single synchrophasor (positive-sequence voltage, for example) at a message rate of once per second places little burden on the communications channel. As more synchrophasors, analog values, or digital status words are added, or if the message rate is increased, some communications channel restrictions come into play.

The C37.118 synchrophasor message format always includes 18 bytes for the message header and terminal ID, time information, status bits, and CRC value. The selection of synchrophasor data, numeric format, programmable analog, and programmable digital data adds to the byte requirements. You can use *Table I.10* to calculate the number of bytes in a synchrophasor message.

Table I.10 Size of a C37.118 Synchrophasor Message

Item	Possible Number of Quantities	Bytes per Quantity	Number of Bytes	
			Minimum	Maximum
Fixed			18	18
Synchrophasors	0–18	4	0	72
Frequency/DFDT	2 (fixed)	2	4	4
Analog Values	0–4	4	0	16
Digital Status Words	0–1	2	0	2
Total (Minimum and Maximum)			22	112

Table I.11 lists the baud settings available on any SEL-751 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 I.11 Serial Port Bandwidth for Synchrophasors (in Bytes) (Sheet 1 of 2)

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

Table I.11 Serial Port Bandwidth for Synchrophasors (in Bytes) (Sheet 2 of 2)

Global Setting MRATE	Port Setting SPEED								
	300	600	1200	2400	4800	9600	19200	38400	57600
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 I.10* and *Table I.11*, it is clear that the lower SPEED settings are very restrictive.

The smallest practical synchrophasor message would be comprised of one digital status word, and this message would consume 24 bytes (includes frequency and DFDT). This type of message could be sent at any message rate (MRATE = 60) when SPEED := 38400, to MRATE := 5 when SPEED := 2400, and 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-751 only transmits synchrophasor messages over serial ports that have setting PROTO := PMU. The connected device is typically a synchrophasor processor, such as the SEL-3373. The synchrophasor processor controls the PMU functions of the SEL-751, 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-751 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-751 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-751 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 distribution system to use the SEL-751 for feeder protection and 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 bus in each substation
- Three-phase, positive-sequence, and neutral current for each line
- 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-751 for each line, an SEL-2407 Satellite-Synchronized Clock, and an SEL-3373 Phasor Data Concentrator in each substation.

This example covers the PMU settings in the SEL-751 Relays. Some system details:

- The nominal frequency is 60 Hz.
- The bus PTs and wiring have a phase error of 4.20 degrees (lagging) at 60 Hz.
- The breaker CTs and wiring have a phase error of 3.50 degrees (lagging) at 60 Hz.
- The neutral CTs and wiring have a phase error of 3.50 degrees (lagging) at 60 Hz.
- The synchrophasor data use port 3, and the maximum baud allowed is 19200.
- The system designer specifies integer numeric representation for the synchrophasor data, and rectangular coordinates.
- The system designer specifies integer numeric representation for the frequency data.
- The system designer specifies C37.118 synchrophasor response, because the data are being used for system monitoring.

The protection settings are not shown.

The protection engineer performs a bandwidth check, using *Table I.10*, and determines the necessary message size. The system requirements, in order of appearance in *Table I.10*, are as follows:

- 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 I.11*, the engineer verifies that the port baud of 9600 is adequate for the message, at 10 messages per second.

The Protection SELOGIC Variables SV14, SV15, and SV16 are used to transmit the breaker status, loss-of-potential alarm, and frequency measurement status, respectively. Make the Global settings as shown in *Table I.12*.

Table I.12 Example Synchrophasor Global Settings

Setting	Description	Value
FNOM	Nominal System Frequency (50, 60 Hz)	60
EPMU	Enable Synchronized Phasor Measurement (Y, N)	Y
MRATE	Messages per Second (1, 2, 4, 5, 10, 12, 15, 20, 30, 60)	10
PMAPP	PMU Application (F := Fast Response, N := Narrow Bandwidth)	FAST
PHCOMP	Frequency-Based Phasor Compensation (Y, N)	Y
PMSTN	Station Name (16 characters)	SAMPLE1
PMID	PMU Hardware ID (1–65534)	14
PHDATAV	Phasor Data Set, Voltages (V1, ALL, NA)	V1
VCOMP	Phase Voltage Angle Compensation Factor (–179.99 to 180 degrees)	4.20
PHDATAI	Phasor Data Set, Currents (I1, ALL, NA)	ALL
ICOMP	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 I.13 Example Synchrophasor Logic Settings

Logic Setting	Description	Value
TREA1	Trigger Reason Bit 1 (SELOGIC Equation)	NA
TREA2	Trigger Reason Bit 2 (SELOGIC Equation)	NA
TREA3	Trigger Reason Bit 3 (SELOGIC Equation)	NA
TREA4	Trigger Reason Bit 4 (SELOGIC Equation)	NA
PMTRIG	Trigger (SELOGIC Equation)	NA

The three Relay Word bits this example uses must be placed in certain SELOGIC variables. Make the settings in *Table I.14* in all seven setting groups.

Table I.14 Example Synchrophasor SELOGIC Settings

Setting	Value
SV14	52A
SV15	LOP
SV16	FREQTRK

Make the *Table I.15* settings for serial port 3, using the **SET P 3** command.

Table I.15 Example Synchrophasor Port Settings

Setting	Description	Value
PROTO	Protocol (SEL, MOD, DNP, EVMSG, PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB)	PMU
SPEED	Data Speed (300 to 38400)	19200
STOPBIT	Stop Bits (1, 2 bits)	1
RTSCTS	Enable Hardware Handshaking (Y, N)	N

The SEL-751 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-751 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-751 only responds to configuration block request messages when it is in the non-transmitting mode.

Appendix J
Mirrored Bits Communications

Overview

IMPORTANT: Be sure to configure the port before connecting to a Mirrored Bits device. If you connect an unconfigured port to a Mirrored Bits device, the device will appear to be locked up.

NOTE: Complete all of the port settings for a port that you use for Mirrored Bits communications before you connect an external Mirrored Bits communications device. If you connect a Mirrored Bits communications device to a port that is not set for Mirrored Bits communications operation, the port will be continuously busy.

Mirrored Bits is a direct relay-to-relay communications protocol that allows IEDs to exchange information quickly, securely, and with minimal expense. Use Mirrored Bits for functions such as remote control and remote sensing. The SEL-751 Feeder Protection Relay supports two Mirrored Bits communications channels, designated A and B. Use the port setting PROTO to assign one of the Mirrored Bits communications channels to a serial port; PROTO:=MBA for Mirrored Bits communications Channel A or PROTO:=MBB for Mirrored Bits communications Channel B. Mirrored Bits are either Transmit Mirrored Bits (TMB) or Received Mirrored Bits (RMB). Transmit Mirrored Bits include TMB1A–TMB8A (channel A) and TMB1B–TMB8B (channel B). The last letter (A or B) designates with which channel the bits are associated. Received bits include RMB1A–RMB8A and RMB1B–RMB8B. Control the transmit Mirrored Bits in SELogic control equations. Use the received Mirrored Bits as arguments in SELogic control equations. The channel status bits are ROKA, RBADA, CBADA, LBOKA, ROKB, RBADB, CBADB, and LBOKB. You can also use these channel status bits as arguments in SELogic control equations. Use the **COM** command (see *Section 7: Communications*) for additional channel status information.

Because of different applications, the SEL product range supports several variations of the Mirrored Bits communications protocol. Through port settings, you can set the SEL-751 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-751, the Mirrored Bits transmission rate is a function of both the data rate and the power system cycle. At data rates slower than 9600, the SEL-751 transmits Mirrored Bits as fast as possible for the given rate. At rates of 9600 bps and faster, the SEL-751 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-751 automatically enters the self-pacing mode at data rates of 9600, 19200, and 38400. *Table J.1* shows the transmission rates of the Mirrored Bits messages at different data rates.

Table J.1 Number of MIRRORED BITS Messages for Different Data Rates

Rate	Transmission Rate of MIRRORED BITS Packets
2400	15 ms
4800	7.5 ms
9600	4 times per power system cycle (automatic pacing mode)
19200	4 times per power system cycle (automatic pacing mode)
38400	4 times per power system cycle (automatic pacing mode)

Transmitting at longer intervals for data rates faster than 9600 bps 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-751 to match the TX_ID of the remote SEL-751. The SEL-751 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 communications is 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 in the following description and after two consecutive messages pass all of the data checks previously described. After ROK*c* is reasserted, received data may be delayed while passing through the security counters described in the following text.

While ROK*c* is deasserted, the relay does not transfer new RMB data to the pickup-dropout security counters described in the following text. Instead, the relay sends one of the user-definable default values to the security counter inputs. For each RMB*n*, use the RXDFLT setting to determine the default state the MIRRORED BITS should use in place of received data if the relay detects an error condition. The setting is a mask of 1s, 0s, and/or Xs (for RMB1A–RMB8A), where X represents the most recently received valid value. The positions of the 1s and 0s correspond to the respective positions of the MIRRORED BITS in the Relay Word bits (see *Appendix K: Relay Word Bits*). *Table J.2* is an extract of *Appendix K: Relay Word Bits*, showing the positions of the MIRRORED BITS.

Table J.2 Positions of the MIRRORED BITS

Bit/ Row	7	6	5	4	3	2	1	0
92	RMB8A	RMB7A	RMB6A	RMB5A	RMB4A	RMB3A	RMB2A	RMB1A
94	RMB8B	RMB7B	RMB6B	RMB5B	RMB4B	RMB3B	RMB2B	RMB1B

Table J.3 shows an example of the values of the MIRRORED BITS for a RXDFLT setting of 10100111.

Table J.3 MIRRORED BITS Values for a RXDFLT Setting of 10100111

Bit/ Row	7	6	5	4	3	2	1	0
92	1	0	1	0	0	1	1	1

Individual pickup and dropout security counters supervise the movement of each received data bit into the corresponding RMB*n* element. You can set each pickup/dropout security counter from 1 to 8. A setting of 1 causes a security counter to pass every occurrence, while a setting of 8 causes a counter to wait for eight consecutive occurrences in the received data before updating the data bits. The pickup and dropout security count settings are separate. Control the security count settings with the settings RMB*n*PU and RMB*n*DO.

A pickup/dropout security counter operates identically to a pickup/dropout timer, except that the counter uses units of counted received messages instead of time. Select a setting for the security counter in accordance with the transmission rate (see *Table J.1*). For example, when transmitting at 2400 bps, a security counter set to 2 counts delays a bit by about 30 ms. However, when operating at 9600 bps, a setting of 2 counts delays a bit by about 8.5 ms.

You must consider the impact of the security counter settings in the receiving relay to determine the channel timing performance, particularly when two relays of different processing rates are communicating via MIRRORED BITS, such as an SEL-321 and an SEL-751. The SEL-321 processes power system information each 1/8 power system cycle, but, when transmitting at 19200 bps, the SEL-751 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-751 transmits messages at approximately 1/4-cycle processing interval (9600 bps and faster, see *Table J.1*), a counter set to two in the SEL-321 delays a received bit by another approximately 1/2 cycle. However, a security counter in the SEL-751 with a setting of two delays a received bit from the SEL-321 by 1/4 cycle, because the SEL-751 is receiving new MIRRORED BITS messages each 1/8 cycle from the SEL-321.

Channel Synchronization

When an SEL-751 detects a communications error, it deasserts ROKA or ROKB. If an SEL-751 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* (Loop Back OK) asserts and deasserts based on the received data checks (see the *Section 7: Communications* for the ACSII commands).

Channel Monitoring

Based on the results of data checks (described previously), the relay collects information regarding the 255 most recent communications errors. Each record contains at least the following fields:

- DATE—Date when the dropout occurred
- TIME—Time when the dropout occurred
- RECOVERY_DATE—Date when the channel returned to service (if the channel is currently failed, it is displayed and included in the calculations, as if its recovery were to occur at the time the report was requested)
- RECOVERY_TIME—Time when the channel returned to service (if the channel is currently failed, it is displayed and included in the calculations, as if its recovery were to occur at the time the report was requested)
- DURATION—Time elapsed during dropout
- CAUSE—Reason for dropout (see *Message Decoding and Integrity Checks on page J.2*)

There is a single record for each outage, but an outage can evolve. For example, the initial cause could be a data disagreement, but framing errors can extend the outage. If the channel is currently failed, it is displayed and included in the calculations, as if its recovery were to occur at the time the report was requested.

NOTE: Combine error conditions including RBADA, RBADB, CBADA, and CBADB with other alarm conditions by 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 Modem

To use a Pulsar MBT modem, set setting PROTO := MBTA or MBTB (Port settings). Setting PROTO := MBTA or MBTB hides setting SPEED (forces the data rate to 9600 bps), hides setting PARITY (forces parity to a value of 0), hides setting RTSCTS (forces RTSCTS to a value of N), and forces the transmit time to be faster than double the power system cycle. *Table J.4* shows the difference in message transmission periods without use of the Pulsar modem (PROTO ≠ MBTA or MBTB), and with use of the Pulsar MBT modem (PROTO = MBTA or MBTB).

NOTE: You must consider the idle time in calculations of data transfer latency through a Pulsar MBT modem system.

Table J.4 MIRRORED BITS Communications Message Transmission Period

Data Rate	PROTO ≠ MBTA or MBTB	PROTO = MBTA or MBTB
38400	4 times a power system cycle	n/a
19200	4 times a power system cycle	n/a
9600	4 times a power system cycle	2 times a power system cycle
4800	7.5 ms	n/a

The relay sets RTS to a negative voltage at the EIA-232 connector to signify that MIRRORED BITS communications matches this specification.

Settings

Set PROTO = MBA or MB8A to enable the MIRRORED BITS protocol channel A on this port. Set PROTO = MBB or MB8B to enable the MIRRORED BITS protocol channel B on this port. The standard MIRRORED BITS protocols MBA and MBB use a 6-data bit format for data encoding. The MB8 protocols MB8A and MB8B use an 8-data bit format, which allows MIRRORED BITS to operate on communications channels requiring an 8-data bit format. For the remainder of this section, PROTO = MBA is assumed. *Table J.5* shows the MIRRORED BITS protocol port settings, ranges, and default settings for Port F, Port 2, Port 3, and Port 4.

Table J.5 MIRRORED BITS Protocol Settings (Sheet 1 of 2)

Setting Prompt	Setting Description	Factory Default Setting
TXID	MIRRORED BITS ID of This Device (1–4)	2
RXID	MIRRORED BITS ID of Device Receiving From (1–4)	1
RBADPU	Outage Duration to Set RBAD (0–10000 seconds)	60
CBADPU	Channel Unavailability to Set CBAD (1–10000 ppm)	1000
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

Table J.5 MIRRORED BITS Protocol Settings (Sheet 2 of 2)

Setting Prompt	Setting Description	Factory Default Setting
RMB2PU	RMB2 Pickup Debounce Messages (1–8 messages)	1
RMB2DO	RMB2 Dropout Debounce Messages (1–8 messages)	1
RMB3PU	RMB3 Pickup Debounce Messages (1–8 messages)	1
RMB3DO	RMB3 Dropout Debounce Messages (1–8 messages)	1
RMB4PU	RMB4 Pickup Debounce Messages (1–8 messages)	1
RMB4DO	RMB4 Dropout Debounce Messages (1–8 messages)	1
RMB5PU	RMB5 Pickup Debounce Messages (1–8 messages)	1
RMB5DO	RMB5 Dropout Debounce Messages (1–8 messages)	1
RMB6PU	RMB6 Pickup Debounce Messages (1–8 messages)	1
RMB6DO	RMB6 Dropout Debounce Messages (1–8 messages)	1
RMB7PU	RMB7 Pickup Debounce Messages (1–8 messages)	1
RMB7DO	RMB7 Dropout Debounce Messages (1–8 messages)	1
RMB8PU	RMB8 Pickup Debounce Messages (1–8 messages)	1
RMB8DO	RMB8 Dropout Debounce Messages (1–8 messages)	1

Appendix K

Relay Word Bits

Overview

The protection and control element results are represented by Relay Word bits in the SEL-751 Feeder Protection 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 K.1 and *Table K.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 7.53*).

You can use any Relay Word bit (except Row 0) in SELOGIC control equations (see *Section 4: Protection and Logic Functions*) and the Sequential Events Recorder (SER) trigger list settings (see *Section 10: Analyzing Events*).

Table K.1 SELOGIC 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	50A1P	50B1P	50C1P	50PAF	ORED50T	ORED51T	50NAF	52A
2	50P1P	50P2P	50P3P	50P4P	50Q1P	50Q2P	50Q3P	50Q4P
3	50P1T	50P2T	50P3T	50P4T	50Q1T	50Q2T	50Q3T	50Q4T
4	50N1P	50N2P	50N3P	50N4P	50G1P	50G2P	50G3P	50G4P
5	50N1T	50N2T	50N3T	50N4T	50G1T	50G2T	50G3T	50G4T
6	51AP	51BP	51CP	51P1P	51P2P	51N1P	51N2P	51QP
7	51AT	51BT	51CT	51P1T	51P2T	51N1T	51N2T	51QT
8	51AR	51BR	51CR	51P1R	51P2R	51N1R	51N2R	51QR
9	51G1P	51G1T	51G1R	51G2P	51G2T	51G2R	27P1	27P1T
10	27P2	27P2T	59P1	59P1T	59P2	59P2T	3P59	3P27
11	81D1T	81D2T	81D3T	81D4T	81D5T	81D6T	55A	55T
12	AMBALRM	AMBTRIP	OTHALRM	OTHTRIP	BKMON	BKJMP	BFI	BFT
13	LINKA	LINKB	PMDOK	SALARM	WARNING	TSOK	IRIGOK	FAULT
14	COMMIDLE	COMMLOSS	REMTRIP	COMMFLT	CFGFLT	3PWR1T	3PWR2T	LOP
15	PB01	PB02	PB03	PB04	PB05	PB06	PB07	PB08

Table K.1 SELogic Relay Word Bits (Sheet 2 of 5)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
16	PB01_PUL	PB02_PUL	PB03_PUL	PB04_PUL	PB05_PUL	PB06_PUL	PB07_PUL	PB08_PUL
17	IN101	IN102	*	*	*	*	*	*
18	IN301	IN302	IN303	IN304	IN305	IN306	IN307	IN308
19	IN401	IN402	IN403	IN404	IN405	IN406	IN407	IN408
20	IN501	IN502	IN503	IN504	IN505	IN506	IN507	IN508
21	OUT101	OUT102	OUT103	*	*	ORED81T	ORED81RT	TRIP
22	OUT301	OUT302	OUT303	OUT304	OUT305	OUT306	OUT307	OUT308
23	OUT401	OUT402	OUT403	OUT404	OUT405	OUT406	OUT407	OUT408
24	OUT501	OUT502	OUT503	OUT504	OUT505	OUT506	OUT507	OUT508
25	WDGALRM	WDGTRIP	BRGALRM	BRGTRIP	RSTENRGY	RSTMXMN	RSTDEM	RSTPK-DEM
26	RTDFLT	RTDIN	TRGTR	3PWR1P	3PWR2P	DSABLSET	RSTTRGT	HALARM
27	RTD1A	RTD1T	RTD2A	RTD2T	RTD3A	RTD3T	RTD4A	RTD4T
28	RTD5A	RTD5T	RTD6A	RTD6T	RTD7A	RTD7T	RTD8A	RTD8T
29	RTD9A	RTD9T	RTD10A	RTD10T	RTD11A	RTD11T	RTD12A	RTD12T
30	79RS	79CY	79LO	SH0	SH1	SH2	SH3	SH4
31	CLOSE	CF	RCSF	OPTMN	RSTMN	LINKFAIL	PASEL	PBSEL
32	SG1	SG2	SG3	SG4	*	DI_C	DI_B	DI_A
33	CC	OC	*	ER	ULTRIP	TR	FREQTRK	PMTRIG
34	DNAUX1	DNAUX2	DNAUX3	DNAUX4	DNAUX5	DNAUX6	DNAUX7	DNAUX8
35	DNAUX9	DNAUX10	DNAUX11	RELAY_EN	TREA1	TREA2	TREA3	TREA4
36	PB1A_LED	PB1B_LED	PB2A_LED	PB2B_LED	PB3A_LED	PB3B_LED	PB4A_LED	PB4B_LED
37	PB5A_LED	PB5B_LED	PB6A_LED	PB6B_LED	PB7A_LED	PB7B_LED	PB8A_LED	PB8B_LED
38	CL	ULCL	T01_LED	T02_LED	T03_LED	T04_LED	T05_LED	T06_LED
39	LB01	LB02	LB03	LB04	LB05	LB06	LB07	LB08
40	LB09	LB10	LB11	LB12	LB13	LB14	LB15	LB16
41	LB17	LB18	LB19	LB20	LB21	LB22	LB23	LB24
42	LB25	LB26	LB27	LB28	LB29	LB30	LB31	LB32
43	RB01	RB02	RB03	RB04	RB05	RB06	RB07	RB08
44	RB09	RB10	RB11	RB12	RB13	RB14	RB15	RB16
45	RB17	RB18	RB19	RB20	RB21	RB22	RB23	RB24
46	RB25	RB26	RB27	RB28	RB29	RB30	RB31	RB32
47	SV01	SV02	SV03	SV04	SV05	SV06	SV07	SV08
48	SV01T	SV02T	SV03T	SV04T	SV05T	SV06T	SV07T	SV08T
49	SV09	SV10	SV11	SV12	SV13	SV14	SV15	SV16
50	SV09T	SV10T	SV11T	SV12T	SV13T	SV14T	SV15T	SV16T
51	SV17	SV18	SV19	SV20	SV21	SV22	SV23	SV24
52	SV17T	SV18T	SV19T	SV20T	SV21T	SV22T	SV23T	SV24T
53	SV25	SV26	SV27	SV28	SV29	SV30	SV31	SV32
54	SV25T	SV26T	SV27T	SV28T	SV29T	SV30T	SV31T	SV32T

Table K.1 SELOGIC Relay Word Bits (Sheet 3 of 5)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
55	LT01	LT02	LT03	LT04	LT05	LT06	LT07	LT08
56	LT09	LT10	LT11	LT12	LT13	LT14	LT15	LT16
57	LT17	LT18	LT19	LT20	LT21	LT22	LT23	LT24
58	LT25	LT26	LT27	LT28	LT29	LT30	LT31	LT32
59	SC01QU	SC02QU	SC03QU	SC04QU	SC05QU	SC06QU	SC07QU	SC08QU
60	SC01QD	SC02QD	SC03QD	SC04QD	SC05QD	SC06QD	SC07QD	SC08QD
61	SC09QU	SC10QU	SC11QU	SC12QU	SC13QU	SC14QU	SC15QU	SC16QU
62	SC09QD	SC10QD	SC11QD	SC12QD	SC13QD	SC14QD	SC15QD	SC16QD
63	SC17QU	SC18QU	SC19QU	SC20QU	SC21QU	SC22QU	SC23QU	SC24QU
64	SC17QD	SC18QD	SC19QD	SC20QD	SC21QD	SC22QD	SC23QD	SC24QD
65	SC25QU	SC26QU	SC27QU	SC28QU	SC29QU	SC30QU	SC31QU	SC32QU
66	SC25QD	SC26QD	SC27QD	SC28QD	SC29QD	SC30QD	SC31QD	SC32QD
67	AILW1	AILW2	AILAL	*	AIHW1	AIHW2	AIHAL	*
68	AI301LW1	AI301LW2	AI301LAL	*	AI301HW1	AI301HW2	AI301HAL	*
69	AI302LW1	AI302LW2	AI302LAL	*	AI302HW1	AI302HW2	AI302HAL	*
70	AI303LW1	AI303LW2	AI303LAL	*	AI303HW1	AI303HW2	AI303HAL	*
71	AI304LW1	AI304LW2	AI304LAL	*	AI304HW1	AI304HW2	AI304HAL	*
72	AI305LW1	AI305LW2	AI305LAL	*	AI305HW1	AI305HW2	AI305HAL	*
73	AI306LW1	AI306LW2	AI306LAL	*	AI306HW1	AI306HW2	AI306HAL	*
74	AI307LW1	AI307LW2	AI307LAL	*	AI307HW1	AI307HW2	AI307HAL	*
75	AI308LW1	AI308LW2	AI308LAL	*	AI308HW1	AI308HW2	AI308HAL	*
76	AI401LW1	AI401LW2	AI401LAL	*	AI401HW1	AI401HW2	AI401HAL	*
77	AI402LW1	AI402LW2	AI402LAL	*	AI402HW1	AI402HW2	AI402HAL	*
78	AI403LW1	AI403LW2	AI403LAL	*	AI403HW1	AI403HW2	AI403HAL	*
79	AI404LW1	AI404LW2	AI404LAL	*	AI404HW1	AI404HW2	AI404HAL	*
80	AI405LW1	AI405LW2	AI405LAL	*	AI405HW1	AI405HW2	AI405HAL	*
81	AI406LW1	AI406LW2	AI406LAL	*	AI406HW1	AI406HW2	AI406HAL	*
82	AI407LW1	AI407LW2	AI407LAL	*	AI407HW1	AI407HW2	AI407HAL	*
83	AI408LW1	AI408LW2	AI408LAL	*	AI408HW1	AI408HW2	AI408HAL	*
84	AI501LW1	AI501LW2	AI501LAL	*	AI501HW1	AI501HW2	AI501HAL	*
85	AI502LW1	AI502LW2	AI502LAL	*	AI502HW1	AI502HW2	AI502HAL	*
86	AI503LW1	AI503LW2	AI503LAL	*	AI503HW1	AI503HW2	AI503HAL	*
87	AI504LW1	AI504LW2	AI504LAL	*	AI504HW1	AI504HW2	AI504HAL	*
88	AI505LW1	AI505LW2	AI505LAL	*	AI505HW1	AI505HW2	AI505HAL	*
89	AI506LW1	AI506LW2	AI506LAL	*	AI506HW1	AI506HW2	AI506HAL	*
90	AI507LW1	AI507LW2	AI507LAL	*	AI507HW1	AI507HW2	AI507HAL	*
91	AI508LW1	AI508LW2	AI508LAL	*	AI508HW1	AI508HW2	AI508HAL	*
92	RMB8A	RMB7A	RMB6A	RMB5A	RMB4A	RMB3A	RMB2A	RMB1A
93	TMB8A	TMB7A	TMB6A	TMB5A	TMB4A	TMB3A	TMB2A	TMB1A
94	RMB8B	RMB7B	RMB6B	RMB5B	RMB4B	RMB3B	RMB2B	RMB1B

Table K.1 SELogic Relay Word Bits (Sheet 4 of 5)

Bit/Row	Relay Word Bits						
	7	6	5	4	3	2	1	0
95	TMB8B	TMB7B	TMB6B	TMB5B	TMB4B	TMB3B	TMB2B	TMB1B
96	LBOKB	CBADB	RBADB	ROKB	LBOKA	CBADA	RBADA	ROKA
97	VB001	VB002	VB003	VB004	VB005	VB006	VB007	VB008
98	VB009	VB010	VB011	VB012	VB013	VB014	VB015	VB016
99	VB017	VB018	VB019	VB020	VB021	VB022	VB023	VB024
100	VB025	VB026	VB027	VB028	VB029	VB030	VB031	VB032
101	VB033	VB034	VB035	VB036	VB037	VB038	VB039	VB040
102	VB041	VB042	VB043	VB044	VB045	VB046	VB047	VB048
103	VB049	VB050	VB051	VB052	VB053	VB054	VB055	VB056
104	VB057	VB058	VB059	VB060	VB061	VB062	VB063	VB064
105	VB065	VB066	VB067	VB068	VB069	VB070	VB071	VB072
106	VB073	VB074	VB075	VB076	VB077	VB078	VB079	VB080
107	VB081	VB082	VB083	VB084	VB085	VB086	VB087	VB088
108	VB089	VB090	VB091	VB092	VB093	VB094	VB095	VB096
109	VB097	VB098	VB099	VB100	VB101	VB102	VB103	VB104
110	VB105	VB106	VB107	VB108	VB109	VB110	VB111	VB112
111	VB113	VB114	VB115	VB116	VB117	VB118	VB119	VB120
112	VB121	VB122	VB123	VB124	VB125	VB126	VB127	VB128
113	PHDEM	3I2DEM	GNDEM	*	BCWA	BCWB	BCWC	BCW
114	59VP	59VS	AFALARM	SF	25A1	25A2	DCHI	DCLO
115	59S1	59S1T	59S2	59S2T	27S1	27S1T	27S2	27S2T
116	TQUAL8	TQUAL4	TQUAL2	TQUAL1	DST	DSTP	LPSEC	LPSECP
117	FREQFZ	*	TUTCS	TUTC1	TUTC2	TUTC4	TUTC8	TUTCH
118	59G1	59G1T	59G2	59G2T	59Q1	59Q1T	59Q2	59Q2T
119	81R1T	81R2T	81R3T	81R4T	AFS1DIAG	AFS2DIAG	AFS3DIAG	AFS4DIAG
120	TOL1	TOL2	TOL3	TOL4	AFS1EL	AFS2EL	AFS3EL	AFS4EL
121	27PP1	27PP1T	27PP2	27PP2T	59PP1	59PP1T	59PP2	59PP2T
122	67P1P	67P2P	67P3P	67P4P	67P1T	67P2T	67P3T	67P4T
123	67Q1P	67Q2P	67Q3P	67Q4P	67Q1T	67Q2T	67Q3T	67Q4T
124	67G1P	67G2P	67G3P	67G4P	67G1T	67G2T	67G3T	67G4T
125	50QF	50QR	50GF	50GR	DIRVE	DIRQGE	DIRIE	DIRQE
126	FDIRP	RDIRP	FDIRQ	RDIRQ	FDIRQG	RDIRQG	FDIRV	RDIRV
127	FDIRI	RDIRI	DIRPF	DIRPR	DIRQF	DIRQR	DIRGF	DIRGR
128	G1DIR	G2DIR	G3DIR	G4DIR	Q1DIR	Q2DIR	Q3DIR	Q4DIR
129	P1DIR	P2DIR	P3DIR	P4DIR	50PDIR	3V0	TSNTPB	TSNTPP
130	*	*	*	81RFBLK	81RFT	81RFBL	81RFP	81RFI
131	ZLOAD	ZLOUT	ZLIN	VPOLV	PHASE_A	PHASE_B	PHASE_C	GFLT
132	INI_HIF	HIFITUNE	*	*	HIFER	HIFMODE	HIFREC	3PH_EVE
133	*	HIA1_C	HIA1_B	HIA1_A	*	HIA2_C	HIA2_B	HIA2_A
134	*	HIF1_C	HIF1_B	HIF1_A	*	HIF2_C	HIF2_B	HIF2_A

Table K.1 SELogic Relay Word Bits (Sheet 5 of 5)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
135	*	NTUNE_C	NTUNE_B	NTUNE_A	*	ITUNE_C	ITUNE_B	ITUNE_A
136	*	DIC_DIS	DIB_DIS	DIA_DIS	*	DVC_DIS	DVB_DIS	DVA_DIS
137	*	DL2CLRC	DL2CLRB	DL2CLRA	*	FRZCLRC	FRZCLRB	FRZCLRA
138	*	DUPC	DUPB	DUPA	*	DDNC	DDNB	DDNA
139	3PH_CLR	3PH_C	3PH_B	3PH_A	LR3	LRC	LRB	LRA
140	OREDHIF1	OREDHIF2	*	*	FSA	FSB	FSC	FIDEN
141	*	*	*	*	*	*	*	*
142	IN309	IN310	IN311	IN312	IN313	IN314	*	*
143	IN409	IN410	IN411	IN412	IN413	IN414	*	*
144	IN509	IN510	IN511	IN512	IN513	IN514	*	*
145	TESTDB	MATHERR	LINK1	52B	AFS5DIAG	AFS6DIAG	AFS7DIAG	AFS8DIAG
146	TOL5	TOL6	TOL7	TOL8	AFS5EL	AFS6EL	AFS7EL	AFS8EL
147	THRLA1	THRLA2	THRLA3	THRLT1	THRLT2	THRLT3	THOVL1	THOVL2
148	THOVL3	THST1	THST2	THST3	RSTTH1	RSTTH2	RSTTH3	THAMBH
149	78VSBL	78VSO	N1DIR	N2DIR	N3DIR	N4DIR	*	*
150	HBL2T	HBL2AT	HBL2BT	HBL2CT	HBL5T	HBL5AT	HBL5BT	HBL5CT
151	UGFWD	UGREV	LOCAL	ENLRC	LZFWD	LZREV	FDIRNI	RDIRNI
152	FDIRW	RDIRW	FDIRC	RDIRC	*	NSA	NSB	NSC
153	GNDSW	50NF	50NR	DIRNE	FDIRN	RDIRN	DIRNF	DIRNR
154	67N1P	67N2P	67N3P	67N4P	67N1T	67N2T	67N3T	67N4T
155	27I1	27I1T	27I1RS	*	27I2	27I2T	27I2RS	*
156	59I1	59I1T	59I1RS	*	59I2	59I2T	59I2RS	*
157	59I3	59I3T	59I3RS	*	59I4	59I4T	59I4RS	*
158	*	*	*	*	*	*	*	*
159	89A2P1	89B2P1	89CL2P1	89OP2P1	89A2P2	89B2P2	89CL2P2	89OP2P2
160	89A2P3	89B2P3	89CL2P3	89OP2P3	89A2P4	89B2P4	89CL2P4	89OP2P4
161	89A2P5	89B2P5	89CL2P5	89OP2P5	*	*	*	*
162	89AL2P1	89AL2P2	89AL2P3	89AL2P4	89AL2P5	*	*	*
163	*	*	*	*	*	*	*	*
164	*	*	*	*	*	*	*	*
165	*	*	*	*	*	*	*	*
166	*	*	*	*	*	*	*	*

Definitions

Table K.2 Relay Word Bit Definitions for the SEL-751 Relay (Sheet 1 of 17)

Bit	Definition	Row
25A1	Level 1 synchronism check element	114
25A2	Level 2 synchronism check element	114
27I1	Level 1 inverse undervoltage element pickup	155
27I1RS	Level 1 inverse undervoltage element reset	155
27I1T	Level 1 inverse undervoltage element time out	155
27I2	Level 2 inverse undervoltage element pickup	155
27I2RS	Level 2 inverse undervoltage element reset	155
27I2T	Level 2 inverse undervoltage element time out	155
27P1	Level 1 phase undervoltage element pickup	9
27P1T	Level 2 phase undervoltage element trip	9
27P2	Level 2 phase undervoltage element pickup	10
27P2T	Level 2 phase undervoltage element trip	10
27PP1	Level 1 phase-to-phase undervoltage element pickup	121
27PP1T	Level 1 phase-to-phase undervoltage element trip	121
27PP2	Level 2 phase-to-phase undervoltage element pickup	121
27PP2T	Level 2 phase-to-phase undervoltage element trip	121
27S1	Level 1 vs channel undervoltage element pickup	115
27S1T	Level 1 vs channel undervoltage element with time delay	115
27S2	Level 2 vs channel undervoltage element pickup	115
27S2T	Level 1 vs channel undervoltage element with time delay	115
3I2DEM	Negative-sequence current demand pickup	113
3P27	Three-phase undervoltage pickup when all three phases are below 27P1P	10
3P59	Three-phase overvoltage pickup when all three phases are above 59P1P	10
3PH_A	A-phase above three-phase event level	139
3PH_B	B-phase above three-phase event level	139
3PH_C	C-phase above three-phase event level	139
3PH_CLR	Three-phase events cleared	139
3PH_EVE	Three-phase event detection	132
3PWR1P	Three-Phase Power Element 1 pickup	26
3PWR1T	Three-Phase Power Element 1 trip	14
3PWR2P	Three-Phase Power Element 2 pickup	26
3PWR2T	Three-Phase Power Element 2 trip	14

Table K.2 Relay Word Bit Definitions for the SEL-751 Relay (Sheet 2 of 17)

Bit	Definition	Row
3V0	Asserts when VSCONN := 3V0	129
50A1P	Level 1 A-phase instantaneous overcurrent element pickup	1
50B1P	Level 1 B-phase instantaneous overcurrent element pickup	1
50C1P	Level 1 C-phase instantaneous overcurrent element pickup	1
50G1P	Level 1 residual-ground instantaneous overcurrent element pickup	4
50G1T	Level 1 residual-ground instantaneous overcurrent element trip	5
50G2P	Level 2 residual-ground instantaneous overcurrent element pickup	4
50G2T	Level 2 residual-ground instantaneous overcurrent element trip	5
50G3P	Level 3 residual-ground instantaneous overcurrent element pickup	4
50G3T	Level 3 residual-ground instantaneous overcurrent element trip	5
50G4P	Level 4 residual-ground instantaneous overcurrent element pickup	4
50G4T	Level 4 residual-ground instantaneous overcurrent element trip	5
50GF	Forward direction residual-ground overcurrent threshold exceeded	125
50GR	Reverse direction residual-ground overcurrent threshold exceeded	125
50N1P	Level 1 neutral-ground instantaneous overcurrent element pickup	4
50N1T	Level 1 neutral-ground instantaneous overcurrent element trip	5
50N2P	Level 2 neutral-ground instantaneous overcurrent element pickup	4
50N2T	Level 2 neutral-ground instantaneous overcurrent element trip	5
50N3P	Level 3 neutral-ground instantaneous overcurrent element pickup	4
50N3T	Level 3 neutral-ground instantaneous overcurrent element trip	5
50N4P	Level 4 neutral-ground instantaneous overcurrent element pickup	4
50N4T	Level 4 neutral-ground instantaneous overcurrent element trip	5
50NAF	Sample-based neutral overcurrent element pickup	1
50NF	Forward direction neutral overcurrent threshold exceeded	153
50NR	Reverse direction neutral overcurrent threshold exceeded	153
50P1P	Level 1 phase instantaneous overcurrent element pickup	2
50P1T	Level 1 phase instantaneous overcurrent element trip	3
50P2P	Level 2 phase instantaneous overcurrent element pickup	2
50P2T	Level 2 phase instantaneous overcurrent element trip	3
50P3P	Level 3 phase instantaneous overcurrent element pickup	2
50P3T	Level 3 phase instantaneous overcurrent element trip	3
50P4P	Level 4 phase instantaneous overcurrent element pickup	2
50P4T	Level 4 phase instantaneous overcurrent element trip	3
50PAF	Sample based phase overcurrent element pickup	1

Table K.2 Relay Word Bit Definitions for the SEL-751 Relay (Sheet 3 of 17)

Bit	Definition	Row
50PDIR	Three-phase overcurrent threshold exceeded	129
50Q1P	Level 1 negative-sequence instantaneous overcurrent element pickup	2
50Q1T	Level 1 negative-sequence instantaneous overcurrent element trip	3
50Q2P	Level 2 negative-sequence instantaneous overcurrent element pickup	2
50Q2T	Level 2 negative-sequence instantaneous overcurrent element trip	3
50Q3P	Level 3 negative-sequence instantaneous overcurrent element pickup	2
50Q3T	Level 3 negative-sequence instantaneous overcurrent element trip	3
50Q4P	Level 4 negative-sequence instantaneous overcurrent element pickup	2
50Q4T	Level 4 negative-sequence instantaneous overcurrent element trip	3
50QF	Forward direction negative-sequence overcurrent threshold exceeded	125
50QR	Reverse direction negative-sequence overcurrent threshold exceeded	125
51AP	A-phase time-overcurrent element pickup	6
51AR	A-phase time-overcurrent element reset	8
51AT	A-phase time-overcurrent element trip	7
51BP	B-phase time-overcurrent element pickup	6
51BR	B-phase time-overcurrent element reset	8
51BT	B-phase time-overcurrent element trip	7
51CP	C-phase time-overcurrent element pickup	6
51CR	C-phase time-overcurrent element reset	8
51CT	C-phase time-overcurrent element trip	7
51G1P	Level 1 residual-ground time-overcurrent element pickup	9
51G1R	Level 1 residual-ground time-overcurrent element reset	9
51G1T	Level 1 residual-ground time-overcurrent element trip	9
51G2P	Level 2 residual-ground time-overcurrent element pickup	9
51G2R	Level 2 residual-ground time-overcurrent element reset	9
51G2T	Level 2 residual-ground time-overcurrent element trip	9
51N1P	Level 1 neutral-ground time-overcurrent element pickup	6
51N1R	Level 1 neutral-ground time-overcurrent element reset	8
51N1T	Level 1 neutral-ground time-overcurrent element trip	7
51N2P	Level 2 neutral-ground time-overcurrent element pickup	6
51N2R	Level 2 neutral-ground time-overcurrent element reset	8
51N2T	Level 2 neutral-ground time-overcurrent element trip	7
51P1P	Level 1 maximum phase time-overcurrent element pickup	6
51P1R	Level 1 maximum phase time-overcurrent element reset	8

Table K.2 Relay Word Bit Definitions for the SEL-751 Relay (Sheet 4 of 17)

Bit	Definition	Row
51P1T	Level 1 maximum phase time-overcurrent element trip	7
51P2P	Level 2 maximum phase time-overcurrent element pickup	6
51P2R	Level 2 maximum phase time-overcurrent element reset	8
51P2T	Level 2 maximum phase time-overcurrent element trip	7
51QP	Negative-sequence time-overcurrent element pickup	6
51QR	Negative-sequence time-overcurrent element reset	8
51QT	Negative-sequence time-overcurrent element trip	7
52A	Circuit breaker N/O contact	1
52B	Circuit breaker N/C contact	145
55A	Power factor alarm	11
55T	Power factor trip	11
59G1	Level 1 zero-sequence instantaneous overvoltage element pickup	118
59G1T	Level 1 zero-sequence instantaneous overvoltage element trip	118
59G2	Level 2 zero-sequence instantaneous overvoltage element pickup	118
59G2T	Level 2 zero-sequence instantaneous overvoltage element trip	118
59I1	Level 1 inverse overvoltage element pickup	156
59I1RS	Level 1 inverse overvoltage element reset	156
59I1T	Level 1 inverse overvoltage element time out	156
59I2	Level 2 inverse overvoltage element pickup	156
59I2RS	Level 2 inverse overvoltage element reset	156
59I2T	Level 2 inverse overvoltage element time out	156
59I3	Level 3 inverse overvoltage element pickup	157
59I3RS	Level 3 inverse overvoltage element reset	157
59I3T	Level 3 inverse overvoltage element time out	157
59I4	Level 4 inverse overvoltage element pickup	157
59I4RS	Level 4 inverse overvoltage element reset	157
59I4T	Level 4 inverse overvoltage element time out	157
59P1	Level 1 phase overvoltage element pickup	10
59P1T	Level 1 phase overvoltage element trip	10
59P2	Level 2 phase overvoltage element pickup	10
59P2T	Level 2 phase overvoltage element trip	10
59PP1	Level 1 phase-to-phase overvoltage element pickup	121
59PP1T	Level 1 phase-to-phase overvoltage element trip	121
59PP2	Level 2 phase-to-phase overvoltage element pickup	121

Table K.2 Relay Word Bit Definitions for the SEL-751 Relay (Sheet 5 of 17)

Bit	Definition	Row
59PP2T	Level 2 phase-to-phase overvoltage element trip	121
59Q1	Level 1 negative-sequence instantaneous overvoltage element pickup	118
59Q1T	Level 1 negative-sequence instantaneous overvoltage element trip	118
59Q2	Level 2 negative-sequence instantaneous overvoltage element pickup	118
59Q2T	Level 2 negative-sequence instantaneous overvoltage element trip	118
59S1	Level 1 VS channel overvoltage element pickup	115
59S1T	Level 1 VS channel overvoltage element trip	115
59S2	Level 2 VS channel overvoltage element pickup	115
59S2T	Level 2 VS channel overvoltage element trip	115
59VP	Phase voltage window element (selected phase voltage [VP] between settings 25VLO and 25VHI)	114
59VS	VS channel voltage window element (selected phase voltage [VS] between settings 25VLO and 25VHI)	114
67G1P	Level 1 residual-ground directional overcurrent pickup	124
67G1T	Level 1 residual-ground directional overcurrent trip	124
67G2P	Level 2 residual-ground directional overcurrent pickup	124
67G2T	Level 2 residual-ground directional overcurrent trip	124
67G3P	Level 3 residual-ground directional overcurrent pickup	124
67G3T	Level 3 residual-ground directional overcurrent trip	124
67G4P	Level 4 residual-ground directional overcurrent pickup	124
67G4T	Level 4 residual-ground directional overcurrent trip	124
67N1P	Level 1 neutral directional overcurrent pickup	154
67N1T	Level 1 neutral directional overcurrent trip	154
67N2P	Level 2 neutral directional overcurrent pickup	154
67N2T	Level 2 neutral directional overcurrent trip	154
67N3P	Level 3 neutral directional overcurrent pickup	154
67N3T	Level 3 residual-ground directional overcurrent trip	154
67N4P	Level 4 neutral directional overcurrent pickup	154
67N4T	Level 4 residual-ground directional overcurrent trip	154
67P1P	Level 1 phase directional overcurrent pickup	122
67P1T	Level 1 phase directional overcurrent trip	122
67P2P	Level 2 phase directional overcurrent pickup	122
67P2T	Level 2 phase directional overcurrent trip	122
67P3P	Level 3 phase directional overcurrent pickup	122
67P3T	Level 3 phase directional overcurrent trip	122

Table K.2 Relay Word Bit Definitions for the SEL-751 Relay (Sheet 6 of 17)

Bit	Definition	Row
67P4P	Level 4 phase directional overcurrent pickup	122
67P4T	Level 4 phase directional overcurrent trip	122
67Q1P	Level 1 negative-sequence directional overcurrent pickup	123
67Q1T	Level 1 negative-sequence directional overcurrent trip	123
67Q2P	Level 2 negative-sequence directional overcurrent pickup	123
67Q2T	Level 2 negative-sequence directional overcurrent trip	123
67Q3P	Level 3 negative-sequence directional overcurrent pickup	123
67Q3T	Level 3 negative-sequence directional overcurrent trip	123
67Q4P	Level 4 negative-sequence directional overcurrent pickup	123
67Q4T	Level 4 negative-sequence directional overcurrent trip	123
78VSBL	Vector shift element block condition	149
78VSO	Vector shift element output	149
79CY	Reclosing relay in reclose cycle state	30
79LO	Reclosing relay in lockout state	30
79RS	Reclosing relay in reset state	30
81D1T	Level 1 definite-time over- and underfrequency trip	11
81D2T	Level 2 definite-time over- and underfrequency trip	11
81D3T	Level 3 definite-time over- and underfrequency trip	11
81D4T	Level 4 definite-time over- and underfrequency trip	11
81D5T	Level 5 definite-time over- and underfrequency trip	11
81D6T	Level 6 definite-time over- and underfrequency trip	11
81R1T	Level 1 rate-of-change-of-frequency element trip	119
81R2T	Level 2 rate-of-change-of-frequency element trip	119
81R3T	Level 3 rate-of-change-of-frequency element trip	119
81R4T	Level 4 rate-of-change-of-frequency element trip	119
81RFBL	Fast rate-of-change-of-frequency block output SELOGIC	130
81RFBLK	Fast rate-of-change-of-frequency overall block logic output	130
81RFI	Fast rate-of-change-of-frequency initiate	130
81RFP	Fast rate-of-change-of-frequency pickup	130
81RFT	Fast rate-of-change-of-frequency trip output	130
89A2P1	2 position disconnect 1 N/O contact	159
89A2P2	2 position disconnect 2 N/O contact	159
89A2P3	2 position disconnect 3 N/O contact	160
89A2P4	2 position disconnect 4 N/O contact	160

Table K.2 Relay Word Bit Definitions for the SEL-751 Relay (Sheet 7 of 17)

Bit	Definition	Row
89A2P5	2 position disconnect 5 N/O contact	161
89AL2P1	2 position disconnect 1 alarm	162
89AL2P2	2 position disconnect 2 alarm	162
89AL2P3	2 position disconnect 3 alarm	162
89AL2P4	2 position disconnect 4 alarm	162
89AL2P5	2 position disconnect 5 alarm	162
89B2P1	2 position disconnect 1 N/C contact	159
89B2P2	2 position disconnect 2 N/C contact	159
89B2P3	2 position disconnect 3 N/C contact	160
89B2P4	2 position disconnect 4 N/C contact	160
89B2P5	2 position disconnect 5 N/C contact	161
89CL2P1	2 position disconnect 1 closed	159
89CL2P2	2 position disconnect 2 closed	159
89CL2P3	2 position disconnect 3 closed	160
89CL2P4	2 position disconnect 4 closed	160
89CL2P5	2 position disconnect 5 closed	161
89OP2P1	2 position disconnect 1 open	159
89OP2P2	2 position disconnect 2 open	159
89OP2P3	2 position disconnect 3 open	160
89OP2P4	2 position disconnect 4 open	160
89OP2P5	2 position disconnect 5 open	161
AFALARM	Arc-flash system integrity alarm, logical OR of all AF diagnostics and excessive light bits (AFS*n*DIAG & AFS*n*SEL)	114
AFS1DIAG–AFS4DIAG	AF light input 1–4 diagnostic failure	119
AFS5DIAG–AFS8DIAG	AF light input 5–8 diagnostic failure	145
AFS1EL–AFS4EL	AF light input 1–4 excessive ambient light pickup for long time	120
AFS5EL–AFS8EL	AF light input 5–8 excessive ambient light pickup for long time	146
AI*nnn*HAL	Analog inputs 301–508 warnings/alarms (where *nnn* = 301–508) high alarm limit	68–91
AI*nnn*HW1	Analog inputs 301–508 warnings/alarms (where *nnn* = 301–508) high warning, Level 1	68–91
AI*nnn*HW2	Analog inputs 301–508 warnings/alarms (where *nnn* = 301–508) high warning, Level 2	68–91
AI*nnn*LAL	Analog inputs 301–508 warnings/alarms (where *nnn* = 301–508) low alarm limit	68–91
AI*nnn*LW1	Analog inputs 301–508 warnings/alarms (where *nnn* = 301–508) low warning, Level 1	68–91
AI*nnn*LW2	Analog inputs 301–508 warnings/alarms (where *nnn* = 301–508) low warning, Level 2	68–91
AIHAL	Analog inputs high alarm limit. If any AI*xxx*HAL = 1, then AIHAL = 1.	67
AIHW1	Analog inputs high warning, Level 1. If any AI*xxx*HW1 = 1, then AIHW1 = 1.	67

Table K.2 Relay Word Bit Definitions for the SEL-751 Relay (Sheet 8 of 17)

Bit	Definition	Row
AIHW2	Analog inputs high warning, Level 2. If any AI*xxx*HW2 = 1, then AIHW2 = 1.	67
AILAL	Analog inputs low alarm limit. If any AI*xxx*LAL = 1, then AILAL = 1.	67
AILW1	Analog inputs low warning, Level 1. If any AI*xxx*LW1 = 1, then AILW1 = 1.	67
AILW2	Analog inputs low warning, Level 2. If any AI*xxx*LW2 = 1, then AILW2 = 1.	67
AMBALRM	Ambient temperature alarm. AMBALRM asserts if the healthy ambient RTD temperature exceeds its alarm set point.	12
AMBTRIP	Ambient temperature trip. AMBTRIP asserts when the healthy ambient RTD temperature exceeds its trip set point.	12
BCW	BCWA + BCWB + BCWC	113
BCWA	A-phase breaker contact wear has reached the 100 percent wear level	113
BCWB	B-phase breaker contact wear has reached the 100 percent wear level	113
BCWC	C-phase breaker contact wear has reached the 100 percent wear level	113
BFI	Breaker failure initiation. Asserts when the SELOGIC control equation BFI results in a logical 1. Use to indicate that the breaker failure logic has started.	12
BFT	Asserts when the relay issues a breaker failure trip.	12
BKJMP	Asserts if breaker control jumper is installed on main board	12
BKMON	Breaker monitor initiation	12
BRGALRM	Bearing temperature alarm BRGALRM asserts when any healthy bearing RTD temperature exceeds its alarm set point	25
BRGTRIP	Bearing temperature trip BRGTRIP asserts when one or two (when EBRGV = Y) healthy bearing RTD temperatures exceed their trip set points	25
CBADA	Channel A, channel unavailability over threshold	96
CBADB	Channel B, channel unavailability over threshold	96
CC	Close command	33
CF	Close condition failure (asserts for ¼ cycle)	31
CFGFLT	Asserts on failed settings interdependency check during Modbus settings change	14
CL	CL Close SELOGIC equation	38
CLOSE	Initiates closing action when asserted	31
COMMFLT	Time-out of internal communication between CPU board and DeviceNet board	14
COMMIDLE	DeviceNet card in programming mode	14
COMMLOSS	DeviceNet communication failure	14
DCHI	Station dc battery instantaneous overvoltage element	114
DCLO	Station dc battery instantaneous undervoltage element	114
DDNA	A-phase tuning threshold decrease	138
DDNB	B-phase tuning threshold decrease	138
DDNC	C-phase tuning threshold decrease	138
DI_A	A-phase distortion index	32

Table K.2 Relay Word Bit Definitions for the SEL-751 Relay (Sheet 9 of 17)

Bit	Definition	Row
DI_B	B-phase distortion index	32
DI_C	C-phase distortion index	32
DIA_DIS	A-phase large difference current disturbance	136
DIB_DIS	B-phase large difference current disturbance	136
DIC_DIS	C-phase large difference current disturbance	136
DIRGF	Forward directional control routed to residual overcurrent elements	127
DIRGR	Reverse directional control routed to residual overcurrent elements	127
DIRIE	Internal enable for channel in current-polarized directional element	125
DIRNE	Internal enable for directional elements for low-impedance grounded, Petersen coil-grounded, or ungrounded/high-impedance grounded systems	153
DIRNF	Forward directional control routed to neutral-ground overcurrent elements	153
DIRNR	Reverse directional control routed to neutral-ground overcurrent elements	153
DIRPF	Forward directional control routed to phase overcurrent elements	127
DIRPR	Reverse directional control routed to phase overcurrent elements	127
DIRQE	Internal enable for negative-sequence voltage-polarized directional element	125
DIRQF	Forward directional control routed to negative-sequence overcurrent elements	127
DIRQGE	Internal enable for negative-sequence voltage-polarized directional element	125
DIRQR	Reverse directional control routed to negative-sequence overcurrent elements	127
DIRVE	Internal enable for zero-sequence voltage-polarized directional element	125
DL2CLRA	A-phase decision logic clear	137
DL2CLRB	B-phase decision logic clear	137
DL2CLRC	C-phase decision logic clear	137
DNAUX1–DNAUX8	DeviceNet/Modbus AUX1–AUX8 assert bits	34
DNAUX9–DNAUX11	DeviceNet/Modbus AUX9–AUX11 assert bits	35
DSABLSET	SELOGIC equation: do not allow settings changes from front-panel interface when asserted	26
DST	Daylight-saving time	116
DSTP	Daylight-saving time pending	116
DUPA	A-phase tuning threshold increase	138
DUPB	B-phase tuning threshold increase	138
DUPC	C-phase tuning threshold increase	138
DVA_DIS	A-phase difference voltage disturbance	136
DVB_DIS	B-phase difference voltage disturbance	136
DVC_DIS	C-phase difference voltage disturbance	136
ENABLED	Enable LED	0
ENLRC	Asserts when Local/Remote control is enable by EN_LRC :=Y	151

Table K.2 Relay Word Bit Definitions for the SEL-751 Relay (Sheet 10 of 17)

Bit	Definition	Row
ER	Event report trigger SELOGIC control equation	33
FAULT	Indicates fault condition. Asserts when SELOGIC control equation FAULT result is logical 1.	13
FDIRC	Forward directional element for Petersen coil incremental conductance	152
FDIRI	Forward channel in current-polarized directional element	127
FDIRN	Forward directional element for low-impedance grounded, Petersen coil-grounded, or ungrounded/high-impedance grounded systems	153
FDIRNI	ORed forward directional logic	151
FDIRP	Forward positive-sequence voltage-polarized directional element	126
FDIRQ	Forward negative-sequence voltage-polarized directional element	126
FDIRQG	Forward negative-sequence voltage-polarized directional element	126
FDIRV	Forward zero-sequence voltage-polarized directional element	126
FDIRW	Forward directional output for Petersen coil wattmetric element	152
FIDEN	Fault identification logic enabled	140
FREQFZ	Synchrophasor bit that asserts if the measured frequency > ±20 Hz from nominal	117
FREQTRK	Frequency tracking enable bit—tracking enabled when bit is asserted	33
FRZCLRA	A-phase average freeze and trending clear condition	137
FRZCLRB	B-phase average freeze and trending clear condition	137
FRZCLRC	C-phase average freeze and trending clear condition	137
FSA	A-phase fault selection	140
FSB	B-phase fault selection	140
FSC	C-phase fault selection	140
G1DIR	Directional control for elements 67G1P, 51G1P, and 51G2P	128
G2DIR	Directional control for element 67G2P	128
G3DIR	Directional control for element 67G3P	128
G4DIR	Directional control for element 67G4P	128
GFLT	Ground fault (pulse for (LER – PRE – 0.75) cycles)	131
GNDEM	Zero-sequence current demand pickup	113
GNDSW	Directional element for low-impedance grounded or ungrounded/high-impedance grounded systems is operating on neutral channel (IN) current	153
HALARM	Diagnostics failure	26
HBL2AT	A-phase second-harmonic block timed out	150
HBL2BT	B-phase second-harmonic block timed out	150
HBL2CT	C-phase second-harmonic block timed out	150
HBL2T	Combined-phase second-harmonic block timed out	150
HBL5AT	A-phase fifth-harmonic block timed out	150

Table K.2 Relay Word Bit Definitions for the SEL-751 Relay (Sheet 11 of 17)

Bit	Definition	Row
HBL5BT	B-phase fifth-harmonic block timed out	150
HBL5CT	C-phase fifth-harmonic block timed out	150
HBL5T	Combined-phase fifth-harmonic block timed out	150
HIA1_A	A-phase HIF alarm	133
HIA1_B	B-phase HIF alarm	133
HIA1_C	C-phase HIF alarm	133
HIA2_A	A-phase HIF alarm	133
HIA2_B	B-phase HIF alarm	133
HIA2_C	C-phase HIF alarm	133
HIF1_A	A-phase HIF detection	134
HIF1_B	B-phase HIF detection	134
HIF1_C	C-phase HIF detection	134
HIF2_A	A-phase HIF detection	134
HIF2_B	B-phase HIF detection	134
HIF2_C	C-phase HIF detection	134
HIFER	HIF event report external trigger SELOGIC setting	132
HIFITUNE	Begin 24-hour initial HIF tuning	134
HIFMODE	HIF detection sensitivity SELOGIC setting	132
HIFREC	HIF event report triggered and is being collected	132
IN101–IN102	Contact inputs IN101 and IN102	17
IN301–IN308	Contact inputs IN301–IN308 (available only with optional I/O module)	18
IN309–IN314	Contact inputs IN309–IN314 (available only with optional 14 DI I/O module)	142
IN401–IN408	Contact inputs IN401–IN408 (available only with optional I/O module)	19
IN409–IN414	Contact inputs IN409–IN414 (available only with optional 14 DI I/O module)	143
IN501–IN508	Contact inputs IN501–IN508 (available only with optional I/O module)	20
IN509–IN514	Contact inputs IN509–IN514 (available only with optional 14 DI I/O module)	144
INI_HIF	Begin 24-hour initial tuning (HIF detection)	132
IRIGOK	IRIG-B time-synchronized input data are valid	13
ITUNE_A	A-phase initial tuning	135
ITUNE_B	B-phase initial tuning	135
ITUNE_C	C-phase initial tuning	135
LB01–LB08	Local bits 1–8	39
LB09–LB16	Local bits 9–16	40
LB17–LB24	Local bits 17–24	41

Table K.2 Relay Word Bit Definitions for the SEL-751 Relay (Sheet 12 of 17)

Bit	Definition	Row
LB25–LB32	Local bits 25–32	42
LBOKA	Channel A, looped back ok	96
LBOKB	Channel B, looped back ok	96
LINK1	Asserted when a valid link is detected on Port 1	145
LINKA	Asserts when Ethernet Port 1A detects link	13
LINKB	Asserts when Ethernet Port 1B detects link	13
LINKFAIL	Failure of active Ethernet port link	31
LOCAL	Asserts when relay control configuration is in LOCAL mode	151
LOP	Loss-of-potential	14
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.	116
LPSECP	Leap second pending	116
LR3	Three-phase load reduction event	139
LRA	A-phase load reduction in	139
LRB	B-phase load reduction in	139
LRC	C-phase load reduction in	139
LT01–LT08	Latch bits 1–8	55
LT09–LT16	Latch bits 9–16	56
LT17–LT24	Latch bits 17–24	57
LT25–LT32	Latch bits 25–32	58
LZFWD	Zero-sequence voltage-polarized forward direction detected low impedance controls	151
LZREV	Zero-sequence voltage-polarized reverse direction detected low impedance controls	151
MATHERR	SELOGIC math error bit asserted for divide-by-zero, etc., in SELOGIC math functions	145
N1DIR	Directional control for elements 67N1P, 51N1P, 51N2P	149
N2DIR	Directional control for element 67N2P	149
N3DIR	Directional control for element 67N3P	149
N4DIR	Directional control for element 67N4P	149
NSA	A-phase fault identification logic output. Used in fault-type target logic for Petersen coil-grounded and ungrounded/high-impedance grounded systems.	152
NSB	B-phase fault identification logic output. Used in fault-type target logic for Petersen coil-grounded and ungrounded/high-impedance grounded systems.	152
NSC	C-phase fault identification logic output. Used in fault-type target logic for Petersen coil-grounded and ungrounded/high-impedance grounded systems.	152
NTUNE_A	A-phase normal tuning	135
NTUNE_B	B-phase normal tuning	135
NTUNE_C	C-phase normal tuning	135
OC	Open command	33

Table K.2 Relay Word Bit Definitions for the SEL-751 Relay (Sheet 13 of 17)

Bit	Definition	Row
OPTMN	Open interval timer is timing	31
ORED50T	Logical OR of all the instantaneous overcurrent elements tripped outputs	1
ORED51T	Logical OR of all the time overcurrent elements tripped outputs	1
ORED81RT	ORed frequency rate-of-change element	21
ORED81T	ORed, over- and underfrequency element	21
OREDHIF1	HIF1_A or HIF1_B or HIF1_C	140
OREDHIF2	HIF2_A or HIF2_B or HIF2_C	140
OTHALRM	Other temperature alarm. OTHALRM asserts when any healthy other RTD temperature exceeds its alarm set point.	12
OTHTRIP	Other temperature trip. OTHTRIP asserts when one or more healthy other RTD temperatures exceed their trip set points.	12
OUT101–OUT103	Control equation for contact outputs OUT101–OUT103	21
OUT301–OUT308	Control equation for contact outputs OUT301–OUT308 (available only with optional I/O module)	22
OUT401–OUT408	Control equation for contact outputs OUT401–OUT408 (available only with optional I/O module)	23
OUT501–OUT508	Control equation for contact outputs OUT501–OUT508 (available only with optional I/O module)	24
P1DIR	Directional control for elements 67P1P, 51P1P, and 51P2P	129
P2DIR	Directional control for element 67P2P	129
P3DIR	Directional control for element 67P3P	129
P4DIR	Directional control for element 67P4P	129
PASEL	Ethernet Port A is active	31
PB01–PB08	Front-panel pushbutton 1–8 bit (asserted when PB01–PB08 is pressed)	15
PB01_PUL–PB08_PUL	Front-panel pushbutton 1–8 pulse bit (asserted for one processing interval when PB01–PB08 is pressed)	16
PB1A_LED–PB4A_LED	SELOGIC control equation: drives LED PB1A–LED PB4A	36
PB1B_LED–PB4B_LED	SELOGIC control equation: drives LED PB1B–LED PB4B	36
PB5A_LED–PB8A_LED	SELOGIC control equation: drives LED PB5A–LED PB8A	37
PB5B_LED–PB8B_LED	SELOGIC control equation: drives LED PB5B–LED PB8B	37
PBSEL	Ethernet Port B is active	31
PHASE_A	A-phase involved in the fault (pulse for (LER – PRE – 0.75) cycles)	131
PHASE_B	B-phase involved in the fault (pulse for (LER – PRE – 0.75) cycles)	131
PHASE_C	C-phase involved in the fault (pulse for (LER – PRE – 0.75) cycles)	131
PHDEM	C-phase current demand pickup	113
PMDOK	Assert if data acquisition system is operating correctly	13
PMTRIG	Trigger for synchrophasors	33

Table K.2 Relay Word Bit Definitions for the SEL-751 Relay (Sheet 14 of 17)

Bit	Definition	Row
Q1DIR	Directional control for element 67Q1P and 51QP	128
Q2DIR	Directional control for element 67Q2P	128
Q3DIR	Directional control for element 67Q3P	128
Q4DIR	Directional control for element 67Q4P	128
RB01–RB08	Remote bits 1–8	43
RB09–RB16	Remote bits 9–16	44
RB17–RB24	Remote bits 17–24	45
RB25–RB32	Remote bits 25–32	46
RBADA	Channel A, outage duration over threshold	96
RBADB	Channel B, outage duration over threshold	96
RCSF	Reclose supervision failure (asserts for ¼ cycle)	31
RDIRC	Forward directional element for Petersen coil incremental conductance	152
RDIRI	Reverse channel IN current-polarized directional element	127
RDIRN	Reverse directional element for low-impedance grounded Petersen coil-grounded or ungrounded/high-impedance grounded systems	153
RDIRNI	ORed reverse directional logic	151
RDIRP	Reverse positive-sequence voltage-polarized directional element	126
RDIRQ	Reverse negative-sequence voltage-polarized directional element	126
RDIRQG	Reverse negative-sequence voltage-polarized directional element	126
RDIRV	Reverse zero-sequence voltage-polarized directional element	126
RDIRW	Reverse directional output for Petersen coil wattmetric element	152
RELAY_EN	Relay data quality flag	35
REMTRIP	Remote trip	14
RMB1A–RMB8A	Channel A receive MIRRORED BITS RMB1A through RMB8A	92
RMB1B–RMB8B	Channel B receive MIRRORED BITS RMB1B through RMB8B	94
ROKA	Channel A, received data ok	96
ROKB	Channel B, received data ok	96
RSTDEM	Reset demand meter	25
RSTENRGY	Reset energy metering. Asserts when the SELOGIC control equation RSTENRG result is logical 1.	25
RSTMN	Reset timer is timing	31
RSTMXMN	Reset Max/Min metering. Asserts when the SELOGIC control equation RSTMXMN result is logical 1.	25
RSTPKDEM	Reset peak demand meter	25
RSTTH1	Thermal Element 1 reset	148
RSTTH2	Thermal Element 2 reset	148

Table K.2 Relay Word Bit Definitions for the SEL-751 Relay (Sheet 15 of 17)

Bit	Definition	Row
RSTTH3	Thermal Element 3 reset	148
RSTTRGT	SELOGIC control equation: reset trip logic and targets when asserted	26
RTD1A–RTD4A RTD1T–RTD4T	RTD1 through RTD4: alarms and trips	27
RTD5A–RTD8A RTD5T–RTD8T	RTD5 through RTD8: alarms and trips	28
RTD9A–RTD12A RTD9T–RTD12T	RTD9 through RTD12: alarms and trips	29
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	26
RTDIN	Indicates status of contact connected to SEL-2600A RTD module	26
SALARM	Software alarms: invalid password, changing access levels, settings changes	13
SC01QD–SC07QD	SELOGIC counters 01 through 08 asserted when counter = 0	60
SC01QU–SC08QU	SELOGIC counters 01 through 08 asserted when counter = preset value	59
SC09QD–SC16QD	SELOGIC counters 09 through 16 asserted when counter = 0	62
SC09QU–SC16QU	SELOGIC counters 09 through 16 asserted when counter = preset value	61
SC17QD–SC24QD	SELOGIC counters 17 through 24 asserted when counter = 0	64
SC17QU–SC24QU	SELOGIC counters 17 through 24 asserted when counter = preset value	63
SC25QD–SC32QD	SELOGIC counters 25 through 32 asserted when counter = 0	66
SC25QU–SC32QU	SELOGIC counters 25 through 32 asserted when counter = preset value	65
SF	Asserts when frequency difference (slip frequency) of voltages VP and VS is less than the maximum slip frequency setting 25SF	114
SG1	Asserts when Setting Group 1 is active	32
SG2	Asserts when Setting Group 2 is active	32
SG3	Asserts when Setting Group 3 is active	32
SG4	Asserts when Setting Group 4 is active	32
SH0	Reclosing relay shot counter = 0	30
SH1	Reclosing relay shot counter = 1	30
SH2	Reclosing relay shot counter = 2	30
SH3	Reclosing relay shot counter = 3	30
SH4	Reclosing relay shot counter = 4	30
SV01–SV08	SELOGIC control equation variables SV01 through SV08	47
SV01T–SV08T	SELOGIC control equation variable SV01T through SV08T with settable pickup and dropout time delay	48
SV09–SV16	SELOGIC control equation variables SV09 through SV16	49
SV09T–SV16T	SELOGIC control equation variable SV09T through SV16T with settable pickup and dropout time delay	50
SV17–SV24	SELOGIC control equation variables SV17 through SV24	51

Table K.2 Relay Word Bit Definitions for the SEL-751 Relay (Sheet 16 of 17)

Bit	Definition	Row
SV17T–SV24T	SELOGIC control equation variable SV17T through SV24T with settable pickup and dropout time delay	52
SV25–SV32	SELOGIC control equation variables SV25 through SV32	53
SV25T–SV32T	SELOGIC control equation variable SV25T through SV32T with settable pickup and dropout time delay	54
T01_LED–T06_LED	SELOGIC control equation: drives T01_LED–T06_LED	38
TESTDB	Command TESTDB (asserts when analog and digital values reported via Modbus, IEC 61850, or Fast Meter protocol may be overridden)	145
THAMBH	Ambient temperature measurement health	148
THOVL1	Thermal Element 1 operating current overload	147
THOVL2	Thermal Element 2 operating current overload	147
THOVL3	Thermal Element 3 operating current overload	148
THRLA1	Thermal Element 1 alarm	147
THRLA2	Thermal Element 2 alarm	147
THRLA3	Thermal Element 3 alarm	147
THRLT1	Thermal Element 1 trip	147
THRLT2	Thermal Element 2 trip	147
THRLT3	Thermal Element 3 trip	147
THST1	Thermal Element 1 time constant state switch	148
THST2	Thermal Element 2 time constant state switch	148
THST3	Thermal Element 3 time constant state switch	148
TLED_01–TLED_06	Target LED 1–Target LED 6	0
TMB1A–TMB8A	Channel A transmit MIRRORED BITS TMB1A through TMB8A	93
TMB1B–TMB8B	Channel B transmit MIRRORED BITS TMB1B through TMB8B	95
TOL1–TOL4	Arc-flash light input 1–4 element pickups	120
TOL5–TOL8	Arc-flash light input 5–8 element pickups	146
TQUAL1	Time quality bit, add 1 when asserted	116
TQUAL2	Time quality bit, add 2 when asserted	116
TQUAL4	Time quality bit, add 4 when asserted	116
TQUAL8	Time quality bit, add 8 when asserted	116
TR	Trip SELOGIC control equation (also has been referred to as TRIPEQ)	33
TREA1–TREA4	Trigger reason bits 1–4 for synchrophasors	35
TRGTR	Target reset. Asserts for one quarter-cycle when you execute a front-panel, serial port target reset command, or Modbus target reset.	26
TRIP	Breaker trip	21
TRIP_LED	TRIP LED	0
TSNTPB	SNTP secondary server is active	129

Table K.2 Relay Word Bit Definitions for the SEL-751 Relay (Sheet 17 of 17)

Bit	Definition	Row
TSOK	Assert if current time source accuracy is sufficient for synchronized phasor measurements	13
TUTC1	Offset hours from UTC time, binary, add 1 if asserted	117
TUTC2	Offset hours from UTC time, binary, add 2 if asserted	117
TUTC4	Offset hours from UTC time, binary, add 4 if asserted	117
TUTC8	Offset hours from UTC time, binary, add 8 if asserted	117
TUTCH	Offset half-hour from UTC time, binary, add 0.5 if asserted	117
TUTCS	Offset hours sign from UTC time, subtract the UTC offset if TUTCS is asserted; otherwise, add	117
UGFWD	Zero-sequence voltage-polarized forward direction detected ungrounded/high Z control U	151
UGREV	Zero-sequence voltage-polarized reverse direction detected ungrounded/high Z control U	151
ULCL	Unlatch Close SELOGIC control equation state	38
ULTRIP	Unlatch Trip SELOGIC control equation state	33
VB*xxx*	Virtual bits used for incoming GOOSE messages (*xxx* = 1–128)	97–112
VPOLV	Positive-sequence polarization voltage valid	131
WARNING	Warning bit asserts for possible warning conditions as shown in *Table 8.3*. These conditions also trigger a flashing TRIP LED.	13
WDGALRM	Winding temperature alarm WDGALRM asserts when any healthy winding RTD temperature exceeds its alarm set point	25
WDGTRIP	Winding temperature trip WDGTRIP asserts when one or two (when EWDGV = Y) healthy winding RTD temperatures exceed their trip set points	25
ZLIN	Load encroachment “load in” element	131
ZLOAD	Load encroachment element pickup	131
ZLOUT	Load encroachment “load out” element	131

Appendix L
Analog Quantities

The SEL-751 Feeder Protection Relay contains several analog quantities that you can use for more than one function. The actual analog quantities available depend on the part number of the relay you use. Analog quantities are typically generated and used by a primary function, such as metering, and 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 control equations are processed every 25 ms and may not be suitable for fast-response control and protection applications.

Table L.1 lists analog quantities that you can use in the following specific functions (indicated with an x):

- Display points (see *Section 8: Front-Panel Operations*)
- SELOGIC control equations (see *Section 4: Protection and Logic Functions*)
- Load profile recorder (see *Section 5: Metering and Monitoring*)
- DNP (see *Appendix D: DNP3 Communications*)
- Fast Message Read
- IEC 60870-5-103 (see *Appendix G: IEC 60870-5-103 Communications*)
- Modbus (see *Appendix E: Modbus RTU Communications*)
- Fast Meter (see *Appendix C: SEL Communications Processors*)
- IEC 61850 (see *Appendix F: IEC 61850 Communications*)

Table L.1 Analog Quantities (Sheet 1 of 8)

Name	Description	Units	Display Points	SELOGIC	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103	Modbus	Fast Meter	IEC 61850
Fundamental Instantaneous Metering									
IA_MAG	A-phase line current	A pri	x	x	x	x	x	x	x
IA_ANG	Angle of the A-phase line current	degrees	x	x	x	x	x		x
IB_MAG	B-phase line current	A pri	x	x	x	x	x	x	x
IB_ANG	Angle of the B-phase line current	degrees	x	x	x	x	x		x
IC_MAG	C-phase line current	A pri	x	x	x	x	x	x	x
IC_ANG	Angle of the C-phase line current	degrees	x	x	x	x	x		x
IN_MAG	Neutral current	A pri	x	x	x	x	x	x	x

Table L.1 Analog Quantities (Sheet 2 of 8)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103	Modbus	Fast Meter	IEC 61850
IN_ANG	Angle of the neutral current	degrees	x	x	x	x	x		x
IG_MAG	Calculated-residual current	A pri	x	x	x	x	x	x	x
IG_ANG	Angle of the calculated-residual current	degrees	x	x	x	x	x		x
IAV	Average line current	A pri	x	x	x	x	x		x
3I2	Negative-sequence current	A pri	x	x	x	x	x		x
UBI	Current unbalance	%	x	x	x	x	x	x	x
VA_MAG	A-phase-to-neutral voltage	V pri	x	x	x	x	x		x
VA_ANG	Angle of the A-phase-to-neutral voltage	degrees	x	x	x	x	x		x
VB_MAG	B-phase-to-neutral voltage	V pri	x	x	x	x	x		x
VB_ANG	Angle of the B-phase-to-neutral voltage	degrees	x	x	x	x	x		x
VC_MAG	C-phase-to-neutral voltage	V pri	x	x	x	x	x		x
VC_ANG	Angle of the C-phase-to-neutral voltage	degrees	x	x	x	x	x		x
VAB_MAG	A-to-B-phase voltage	V pri	x	x	x	x	x	x	x
VAB_ANG	Angle of the A-to-B-phase voltage	degrees	x	x	x	x	x		x
VBC_MAG	B-to-C-phase voltage	V pri	x	x	x	x	x	x	x
VBC_ANG	Angle of the B-to-C-phase voltage	degrees	x	x	x	x	x		x
VCA_MAG	C-to-A-phase voltage	V pri	x	x	x	x	x	x	x
VCA_ANG	Angle of the C-to-A-phase voltage	degrees	x	x	x	x	x		x
VG_MAG	Zero-sequence voltage	V pri	x	x	x	x	x		x
VG_ANG	Angle of the zero-sequence voltage	degrees	x	x	x	x	x		x
VS_MAG	Sync. voltage	V pri	x	x	x	x	x	x	x
VS_ANG	Angle of the sync. voltage	degrees	x	x	x	x	x		x
VAVE	Average voltage	V pri	x	x	x	x	x		x
3V2	Negative-sequence voltage	V pri	x	x	x	x	x		x
UBV	Voltage unbalance	%	x	x	x	x	x	x	x
SA	A-phase apparent power	kVA pri	x	x	x	x	x		x
SB	B-phase apparent power	kVA pri	x	x	x	x	x		x
SC	C-phase apparent power	kVA pri	x	x	x	x	x		x
S	Three-phase apparent power	kVA pri	x	x	x	x	x	x	x
PA	A-phase real power	kW pri	x	x	x	x	x		x
PB	B-phase real power	kW pri	x	x	x	x	x		x
PC	C-phase real power	kW pri	x	x	x	x	x		x
P	Three-phase real power	kW pri	x	x	x	x	x	x	x
QA	A-phase reactive power	kVAR pri	x	x	x	x	x		x
QB	B-phase reactive power	kVAR pri	x	x	x	x	x		x
QC	C-phase reactive power	kVAR pri	x	x	x	x	x		x
Q	Three-phase reactive power	kVAR pri	x	x	x	x	x	x	x
PFA	A-phase power factor		x	x	x	x	x		x
PFB	B-phase power factor		x	x	x	x	x		x
PFC	C-phase power factor		x	x	x	x	x		x
PF	Three-phase power factor		x	x	x	x	x	x	x
FREQ[a]	Frequency	Hz	x	x	x	x	x	x	x
FREQS[a]	Synch frequency	Hz	x	x	x	x	x	x	x

Table L.1 Analog Quantities (Sheet 3 of 8)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103	Modbus	Fast Meter	IEC 61850
DFDT	Frequency rate-of-change	Hz/sec.	x	x					x
VDC	Station dc battery voltage	Vdc	x	x	x	x	x	x	x
I1_MAG	Positive-sequence current	A pri	x	x	x	x	x		x
I1_ANG	Angle of positive-sequence current	degrees	x	x		x	x		x
V1_MAG	Positive-sequence voltage	V pri	x	x	x	x	x		x
V1_ANG	Angle of positive-sequence voltage	degrees	x	x		x	x		x
Fault Information									

Note 1: When a fault location is undefined, the relay will report -999.9 for FLOC and FZ in all protocols except MODBUS, where FZ will be 6553.5. When a fault location is undefined, the relay will report 0 for FZFA in all protocols except MODBUS, where FZFA will be 180.00.

Note 2: The fault location is a unit less quantity and depends on the units used for entering LL. IEC 61850/DNP/60870 assume the location is in km.

Note 3: The fault location analogs are reported as part of Event History data in Modbus and have different labels.

Note 4: If the relay is restarted (cold start), Event Report information will be reset until a new Event Record is generated.

Note 5: All fault location analogs contain data from the latest event except for the fault location analogs used in MODBUS. The fault location analogs in the MODBUS map contain the data from the event selected by writing the event number from the History response (See Section 10: Analyzing Events) into the Event Log Select register (See Appendix E: Modbus RTU Communications).

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103	Modbus	Fast Meter	IEC 61850
FLOC[1, 2, 3]	Fault location of the most recent fault; for IEC 60870 fault analogs, fault location of fault event		x	x		x	x		x
FIA[3]	A-phase current of the most recent fault event; for IEC 60870 fault analogs, A-phase current of fault event	A pri	x	x		x	x		x
FIB[3]	B-phase current of the most recent fault event; for IEC 60870 fault analogs, B-phase current of fault event	A pri	x	x		x	x		x
FIC[3]	C-phase current of the most recent fault event; for IEC 60870 fault analogs, C-phase current of fault event	A pri	x	x		x	x		x
FIG[3]	Ground current of the most recent fault event; for IEC 60870 fault analogs, ground current of fault event	A pri	x	x		x	x		x
FIN[3]	Neutral fault current of the most recent fault event; for IEC 60870 fault analogs, neutral current of fault event	A pri	x	x		x	x		x
FFREQ[3]	Frequency of the most recent fault; for IEC 60870 fault analogs, frequency of fault event	Hz	x	x		x	x		x
FZ[1, 3]	Fault impedance magnitude of the most recent fault; for IEC 60870, fault impedance magnitude of the fault event	ohm s	x	x		x	x		x
FZFA[1, 3]	Fault impedance angle of the most recent fault; for IEC 60870, fault impedance angle of the fault event	degrees	x	x		x	x		x
FLRNUM[4]	Unique Identification number of the latest event								x
FLREP[4]	Event Report Present (shall be 1 when an event report is present, and 0 otherwise								x
HIFLRNUM[4]	Unique Identification number of the latest HIF event								x
HIFLREP[4]	HIF Event Report Present (shall be 1 when an HIF event report is present, and 0 otherwise)								x

Table L.1 Analog Quantities (Sheet 4 of 8)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103	Modbus	Fast Meter	IEC 61850
Light Metering									
LSENS1	Arc-flash sensor 1 light	%	x	x	x	x	x		x
LSENS2	Arc-flash sensor 2 light	%	x	x	x	x	x		x
LSENS3	Arc-flash sensor 3 light	%	x	x	x	x	x		x
LSENS4	Arc-flash sensor 4 light	%	x	x	x	x	x		x
LSENS5	Arc-flash sensor 5 light	%	x	x	x	x	x		x
LSENS6	Arc-flash sensor 6 light	%	x	x	x	x	x		x
LSENS7	Arc-flash sensor 7 light	%	x	x	x	x	x		x
LSENS8	Arc-flash sensor 8 light	%	x	x	x	x	x		x
Thermal Metering Note 6: RTD open is equivalent to +32767 and RTD short is equivalent to –32768 when RTDs are monitored via LDP.									
RTDWDGMX	Maximum winding RTD temperature	°C	x	x		x	x		x
RTDBRGMX	Maximum bearing RTD temperature	°C	x	x		x	x		x
RTDAMB	Ambient RTD temperature	°C	x	x		x	x		x
RTDOTHMX	Other maximum RTD temperature	°C	x	x		x	x		x
RTD1 to RTD12[6]	RTD1 temperature to RTD12 temperature	°C	x	x	x	x	x		x
THRL1 to THRL3	Operating quantity thermal level memory from element 1 to element 3	pu	x	x	x	x	x		x
THIEQ1 to THIEQ3	Operating quantity equivalent current from element 1 to element 3	pu	x	x	x	x	x		x
THTCU1 to THTCU3	Thermal capacity used from element 1 to element 3	%	x	x	x	x	x		x
THTRIP1 to THTRIP3	Time before thermal element trips from element 1 to element 3	s	x	x	x	x	x		x
THRLS1 to THRLS3	Time before thermal element releases from element 1 to element 3	s	x	x	x	x	x		x
Analog Input Metering									
AI301 to AI308	Analog inputs for an analog card in Slot C		x	x	x	x	x		x
AI401 to AI408	Analog inputs for an analog card in Slot D		x	x	x	x	x		x
AI501 to AI508	Analog inputs for an analog card in Slot E		x	x	x	x	x		x
Energy Metering Note 7: This Analog Quantity is not available for FMR.									
EM_LRDH	Energy last reset date/time high word					x[7]			
EM_LRDM	Energy last reset date/time middle word					x[7]			
EM_LRDL	Energy last reset date/time low word					x[7]			
MWH3PI	Three-phase real energy IN	MWh pri	x	x	x	x	x		x
MWH3PO	Three-phase real energy OUT	MWh pri	x	x	x	x	x		x
MVARH3PI	Three-phase reactive energy IN	MVARh pri	x	x	x	x	x		x
MVARH3PO	Three-phase reactive energy OUT	MVARh pri	x	x	x	x	x		x
MVAH3P	Three-phase apparent energy	MVAh pri	x	x	x	x	x		x

Table L.1 Analog Quantities (Sheet 5 of 8)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103	Modbus	Fast Meter	IEC 61850
Maximum/Minimum Metering Note 8: For each of the maximum or minimum analog quantities, the corresponding time stamp is also reported in Modbus. In addition, the time when Max/Min data was last reset is also reported in Modbus (the actual labels used in the Modbus Map are not MM_LRDH, MM_LRDM, MM_LRDL). Note 9: EU is Engineering Units.									
MM_LRDH[8]	Max/min last reset date/time high word					x[7]			
MM_LRDM[8]	Max/min last reset date/time middle word					x[7]			
MM_LRDL[8]	Max/min last reset date/time low word					x[7]			
IAMX	A-phase maximum current	A pri	x	x	x	x	x		x
IBMX	B-phase maximum current	A pri	x	x	x	x	x		x
ICMX	C-phase maximum current	A pri	x	x	x	x	x		x
INMX	Neutral maximum current	A pri	x	x	x	x	x		x
IGMX	Calculated residual maximum current	A pri	x	x	x	x	x		x
IAMN	A-phase minimum current	A pri	x	x	x	x	x		x
IBMN	B-phase minimum current	A pri	x	x	x	x	x		x
ICMN	C-phase minimum current	A pri	x	x	x	x	x		x
INMN	Neutral minimum current	A pri	x	x	x	x	x		x
IGMN	Calculated residual minimum current	A pri	x	x	x	x	x		x
VABMX	A-to-B-phase maximum voltage	V pri	x	x	x	x	x		x
VBCMX	B-to-C-phase maximum voltage	V pri	x	x	x	x	x		x
VCAMX	C-to-A-phase maximum voltage	V pri	x	x	x	x	x		x
VAMX	A-phase maximum voltage	V pri	x	x	x	x	x		x
VBMX	B-phase, maximum voltage	V pri	x	x	x	x	x		x
VCMX	C-phase maximum voltage	V pri	x	x	x	x	x		x
VSMX	Vsync maximum voltage	V pri	x	x		x			
VABMN	A-to-B-phase minimum voltage	V pri	x	x	x	x	x		x
VBCMN	B-to-C-phase minimum voltage	V pri	x	x	x	x	x		x
VCAMN	C-to-A-phase minimum voltage	V pri	x	x	x	x	x		x
VAMN	A-phase minimum voltage	V pri	x	x	x	x	x		x
VBMN	B-phase minimum voltage	V pri	x	x	x	x	x		x
VCMN	C-phase minimum voltage	V pri	x	x	x	x	x		x
VSMN	Vsync minimum voltage	V pri	x	x		x	x		x
KVA3PMX	Three-phase maximum apparent power	kVA pri	x	x	x	x	x		x
KW3PMX	Three-phase maximum real power	kW pri	x	x	x	x	x		x
KVAR3PMX	Three-phase maximum reactive power	kVAR pri	x	x	x	x	x		x
KVA3PMN	Three-phase minimum apparent power	kVA pri	x	x	x	x	x		x
KW3PMN	Three-phase minimum real power	kW pri	x	x	x	x	x		x
KVAR3PMN	Three-phase minimum reactive power	kVAR pri	x	x	x	x	x		x
FREQMX	Maximum frequency	Hz	x	x	x	x	x		x
FREQMN	Minimum frequency	Hz	x	x	x	x	x		x
RTD1MX to RTD12MX	RTD1 maximum to RTD12 maximum	°C	x	x	x	x	x		x
RTD1MN to RTD12MN	RTD1 minimum to RTD12 minimum	°C	x	x	x	x	x		x
AI301MX to AI308MX	Analog transducer input 301–308 maximum	EU[9]	x	x	x	x	x		x
AI301MN to AI308MN	Analog transducer input 301–308 minimum	EU[9]	x	x	x	x	x		x
AI401MX to AI408MX	Analog transducer input 401–408 maximum	EU[9]	x	x	x	x	x		x

Table L.1 Analog Quantities (Sheet 6 of 8)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103	Modbus	Fast Meter	IEC 61850
AI401MN to AI408MN	Analog transducer input 401–408 minimum	EU[9]	x	x	x	x	x		x
AI501MX to AI508MX	Analog transducer input 501–508 maximum	EU[9]	x	x	x	x	x		x
AI501MN to AI508MN	Analog transducer input 501–508 minimum	EU[9]	x	x	x	x	x		x
RMS Metering									
IARMS	A-phase rms current	A pri	x	x	x	x	x		x
IBRMS	B-phase rms current	A pri	x	x	x	x	x		x
ICRMS	C-phase rms current	A pri	x	x	x	x	x		x
INRMS	Neutral rms current	A pri	x	x	x	x	x		x
VARMS	A-phase rms voltage	V pri	x	x	x	x	x		x
VBRMS	B-phase rms voltage	V pri	x	x	x	x	x		x
VCRMS	C-phase rms voltage	V pri	x	x	x	x	x		x
VSRMS	Vsync rms voltage	V pri	x	x	x	x	x		x
VABRMS	A-to-B-phase rms voltage	V pri	x	x	x	x	x		x
VBCRMS	B-to-C-phase rms voltage	V pri	x	x	x	x	x		x
VCARMS	C-to-A-phase rms voltage	V pri	x	x	x	x	x		x
Demand Metering									
IAD	A-phase current demand	A pri	x	x		x	x	x	x
IBD	B-phase current demand	A pri	x	x		x	x	x	x
ICD	C-phase current demand	A pri	x	x		x	x	x	x
IGD	Residual current demand	A pri	x	x		x	x	x	x
3I2D	Negative-sequence current demand	A pri	x	x		x	x	x	x
KWADI	Real power, A-phase demand IN	kW pri	x	x		x			x
KWBDI	Real power, B-phase demand IN	kW pri	x	x		x			x
KWCDI	Real power, C-phase demand IN	kW pri	x	x		x			x
KW3DI	Real power, three-phase demand IN	kW pri	x	x		x			x
KVARADI	Reactive power, A-phase demand IN	kVAR pri	x	x		x			x
KVARBDI	Reactive power, B-phase demand IN	kVAR pri	x	x		x			x
KVARCDI	Reactive power, C-phase demand IN	kVAR pri	x	x		x			x
KVAR3DI	Reactive power, three-phase demand IN	kVAR pri	x	x		x			x
KWADO	Real-power, A-phase demand OUT	kW pri	x	x		x			x
KWBDO	Real power, B-phase demand OUT	kW pri	x	x		x			x
KWCDO	Real power, C-phase demand OUT	kW pri	x	x		x			x
KW3DO	Real power, three-phase demand OUT	kW pri	x	x		x			x
KVARADO	Reactive power, A-phase demand OUT	kVAR pri	x	x		x			x
KVARBDO	Reactive power, B-phase demand OUT	kVAR pri	x	x		x			x
KVARCDO	Reactive power, C-phase demand OUT	kVAR pri	x	x		x			x
KVAR3DO	Reactive power, three-phase demand OUT	kVAR pri	x	x		x			x
Peak Demand Metering Note10: In addition to the peak demand data, the time when the peak demand data were last reset is also reported in Modbus (the actual labels used in the Modbus Map are not PM_LRDH, PM_LRDM, PM_LRDL).									
PM_LRDH[10]	Peak demand last reset date/time high word					x[7]			
PM_LRDM[10]	Peak demand last reset date/time middle word					x[7]			
PM_LRDL[10]	Peak demand last reset date/time low word					x[7]			

Table L.1 Analog Quantities (Sheet 7 of 8)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103	Modbus	Fast Meter	IEC 61850
IAPD	A-phase current peak demand	A pri	x	x		x	x	x	x
IBPD	B-phase current peak demand	A pri	x	x		x	x	x	x
ICPD	C-phase current peak demand	A pri	x	x		x	x	x	x
IGPD	Residual current peak demand	A pri	x	x		x	x	x	x
3I2PD	Negative-sequence current peak demand	A pri	x	x		x	x	x	x
KWAPDI	Real power, A-phase peak demand IN	kW pri	x	x		x			x
KWBPDI	Real power, B-phase peak demand IN	kW pri	x	x		x			x
KWCPDI	Real power, C-phase peak demand IN	kW pri	x	x		x			x
KW3PDI	Real power, three-phase peak demand IN	kW pri	x	x		x			x
KVARAPDI	Reactive power, A-phase peak demand IN	kVAR pri	x	x		x			x
KVARBPDI	Reactive power, B-phase peak demand IN	kVAR pri	x	x		x			x
KVARCPDI	Reactive power, C-phase peak demand IN	kVAR pri	x	x		x			x
KVAR3PDI	Reactive power, three-phase peak demand IN	kVAR pri	x	x		x			x
KWAPDO	Real power, A-phase peak demand OUT	kW pri	x	x		x			x
KWBPDO	Real power, B-phase peak demand OUT	kW pri	x	x		x			x
KWCPDO	Real power, C-phase peak demand OUT	kW pri	x	x		x			x
KW3PDO	Real power, three-phase peak demand OUT	kW pri	x	x		x			x
KVARAPDO	Reactive power, A-phase peak demand OUT	kVAR pri	x	x		x			x
KVARBPDO	Reactive power, B-phase peak demand OUT	kVAR pri	x	x		x			x
KVARCPDO	Reactive power, C-phase peak demand OUT	kVAR pri	x	x		x			x
KVAR3PDO	Reactive power, three-phase peak demand OUT	kVAR pri	x	x		x			x
Breaker Monitoring									
INTT	Internal trips—counter		x	x	x	x	x		x
INTIA	Accumulated current—internal trips, A-phase	kA pri	x	x	x	x	x		x
INTIB	Accumulated current—internal trips, B-phase	kA pri	x	x	x	x	x		x
INTIC	Accumulated current—internal trips, C-phase	kA pri	x	x	x	x	x		x
EXTT	External trips—counter		x	x	x	x	x		x
EXTIA	Accumulated current—external trips, A-phase	kA pri	x	x	x	x	x		x
EXTIB	Accumulated current—external trips, B-phase	kA pri	x	x	x	x	x		x
EXTIC	Accumulated current—external trips, C-phase	kA pri	x	x	x	x	x		x
WEARA	Breaker wear, A-phase	%	x	x	x	x	x		x
WEARB	Breaker wear, B-phase	%	x	x	x	x	x		x
WEARC	Breaker wear, C-phase	%	x	x	x	x	x		x
AST/HIF (High-Impedance Fault)									
SDIA	A-phase total inter-harmonic content	A pri		x					
SDIB	B-phase total inter-harmonic content	A pri		x					
SDIC	C-phase total inter-harmonic content	A pri		x					
SDIAREF	A-phase reference total inter-harmonic content	A pri		x					
SDIBREF	B-phase reference total inter-harmonic content	A pri		x					
SDICREF	C-phase reference total inter-harmonic content	A pri		x					
ISMA	A-phase total odd-harmonic content	A pri		x					
ISMB	B-phase total odd-harmonic content	A pri		x					
ISMC	C-phase total odd-harmonic content	A pri		x					

Table L.1 Analog Quantities (Sheet 8 of 8)

Name	Description	Units	Display Points	SELOGIC	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103	Modbus	Fast Meter	IEC 61850
ISMAREF	A-phase reference total odd-harmonic content	A pri		x					
ISMBREF	B-phase reference total odd-harmonic content	A pri		x					
ISMCREF	C-phase reference total odd-harmonic content	A pri		x					
Date/Time Note11: DATE and TIME are also available as DNP Object 50									
DATE	Present date		x				x	x	
TIME	Present time		x				x	x	
YEAR	Year number (0000–9999)			x			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 Note12: RID and TID are only available as display point settings (DP01 to DP32) in the two-line display model Note13: STRING_RID and STRING_TID are only available as analog label quantities for the bay screen in the touchscreen display model									
RID[12]	Relay identifier		x						
TID[12]	Terminal identifier		x						
STRING_RID[13]	Relay identifier (Bay Screen)		x						
STRING_TID[13]	Terminal identifier (Bay Screen)		x						
Serial Number Note14: SER_NUM is available for use with display points in the two-line display model, but is not available for use with analog labels in the touchscreen display model.									
SER_NUM[7, 14]	Serial number of the relay		x			x	x		x
Setting Group									
GROUP	Active setting group number		x	x	x	x			x
Math Variables									
MV01 to MV32	Math variable 01 to math variable 32		x	x	x	x	x		x
SELOGIC Counters Note15: Also available as DNP counter object.									
SC01 to SC32	SELOGIC counter 01 to SELOGIC counter 32		x	x	x	x	x		x
Remote Analogs Note16: FM refers to Fast Message support for Remote Analogs. Remote Analogs can be written by issuing an unsolicited Fast Message Write command.									
RA001 to RA128	Remote analog 001 to remote analog 128		x	x	x	x	x	x[16]	x

[a] FREQ and FREQS are set equal to the FNOM setting following a settings change.

Appendix M
Cybersecurity Features

The SEL-751 provides a number of features to help meet cybersecurity design requirements.

Access Control

The SEL-751 has a number of mechanisms for managing electronic access. These include ways to limit access, provide user authentication, and monitor electronic and physical access.

Physical Port Controls

Each physical serial port and the Ethernet port can be individually disabled using the EPORT setting. By default, all of the ports are enabled. It is good security practice to disable unused ports.

IP Ports

When using Ethernet, there are a number of IP ports available within the SEL-751. Many of these IP port numbers are configurable. All IP ports can be disabled. *Table M.1* describes each of these.

Table M.1 IP Port Numbers

IP Port Default	Port Selection Setting	Network Protocol	Default Port State	Port Enable Setting	Purpose
21	--	TCP	Disabled	EFTPSERV	FTP protocol access for file transfer of settings and reports
23	TPORT	TCP	Disabled	ETELNET	Telnet access for general engineering terminal access
102	--	TCP	Disabled	E61850	IEC 61850 MMS for SCADA functionality
123	SNTPPORT	UDP	Disabled	ESNTP	SNTP time synchronization
502	MODNUM1/ MODNUM2	TCP	Disabled	EMOD	MODBUS for SCADA functionality
4712/ 4713	PMOTCP1/ PMOUDP1	TCP/UDP	Disabled	PMOTS1	Synchrophasor data output, session 1
4722/ 4713	PMOTCP2/ PMOUDP2	TCP/UDP	Disabled	PMOTS2	Synchrophasor data output, session 2
20000	DNPNUM	TCP/UDP	Disabled	EDNP	DNP for SCADA functionality

See *PORT 1 on page 4.189* and *Ethernet Port on page 7.3* for more information on these settings.

Authentication and Authorization

The SEL-751 supports four levels of access, as described in *Access Levels on page 7.17*. Refer to this section to learn how each level is accessed and how to change passwords. It is good security practice to change the default passwords of each access level and to use a unique password for each level.

The MAXACC setting limits the level of access for each port. This permits you to operate under the principle of “least privilege”, restricting ports to the levels necessary for the functions performed on those ports.

The SEL-751 supports strong passwords with as many as 12 characters, using any printable character, allowing users to select complex passwords if they so choose. SEL recommends that passwords have a minimum of 8 characters and include at least one of each of the following: lowercase letter, uppercase letter, number, and special character.

Ethernet protocols Telnet and FTP require the proper passwords to gain access to level-protected functions. Ethernet protocol MMS requires a password to gain access if MMS Authentication is enabled via the CID file. See *Section 7: Communications* for more information on access restrictions for the Ethernet protocols.

Monitoring and Logging

The SEL-751 provides Relay Word bits that are useful for monitoring relay access:

- SALARM—Pulses for approximately one second whenever a user gains access to Level 1 or higher, when an incorrect password is entered when attempting to access Level 1 or higher, or when a setting is changed.
- PASEL, PBSEL—Asserted while the Ethernet port(s) is active.
- LINK1, LINKA, LINKB—Asserted while the link is active on the Ethernet port(s). Loss of a link can be an indication that an Ethernet cable has been disconnected.
- LINKFAIL—Asserted if link is lost on the active IP port (ports 1A or 1B).

These bits can be mapped for SCADA monitoring via DNP3, IEC 61850, Modbus, or SEL Fast Message. They also may be added to the SER for later analysis or assigned to output contacts for alarm purposes.

The SEL-751 SER is a useful tool for capturing a variety of relay events. In addition to capturing state changes of user selected Relay Word bits, it captures all power-ups, settings changes, and group switches. See *Sequential Events Recorder (SER) Report on page 10.37* for more information about SER.

Physical Access Security

Physical security of cybersecurity assets is a common concern. SEL-751 relays can be installed within a control house that provides physical security. Other times, relays are installed in breakers or enclosures within the switchyard. The SEL-751 provides tools to help manage physical security, especially when the unit is installed in the switch yard.

You can monitor physical ingress by wiring a door sensor to one of the SEL-751 contact inputs. This input can then be mapped for SCADA monitoring or added to the SER log so that you can monitor when physical access to the relay occurs.

It is also possible to wire an electronic latch to an SEL-751 contact output. You could then map this output for SCADA control.

Configuration Management

Many users are concerned about managing the configuration of their relays. The SEL-751 provides mechanisms to help users manage relay configuration.

All settings changes are logged to the SER log. Analysis of this log indicates if any unauthorized settings changes occurred. The SALARM Relay Word bit also indicates changes in the relay configuration by pulsing for approximately one second when any of the following occur:

- Settings are changed or saved
- A password changes
- The relay switches settings groups

See *Self-Test on page 11.13* for more information regarding the Relay Word bit SALARM.

Malware Protection

The SEL-751 has inherent and continuous monitoring for Malware. For a full description of this, see selinc.com/mitigating_malware/.

Security Vulnerabilities

If SEL finds a security vulnerability with the SEL-751, it will be disclosed using our standard security notification process. For a full description of this process, see selinc.com/support/security-notifications/.

Settings Erasure

It is often desirable to erase the settings from the relay when it is removed from service. You can completely erase all the configuration settings from the SEL-751 using this procedure:

Step 1. Go to CAL access level. See *Access Levels on page 7.17*.

Step 2. Execute the **R_S** command.

Step 3. Allow the relay to restart.

NOTE: Do not erase the settings when sending the relay to the factory for service. SEL needs to be able to see how the relay was configured to properly diagnose any problems.

Once this procedure is complete, all internal instances of user settings and passwords will be erased. Do not do this when sending in the relay for service at the factory. SEL needs to see how the relay was configured in order to properly diagnose many problems.

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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 motor cooling air at the cooling air inlet. 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:

25	Synchronism-Check Element
27	Undervoltage Element
27I	Inverse-Time Undervoltage Element
32	Directional Power Element
49	Thermal Element
49IEC	IEC Line/Cable Thermal Element
50	Instantaneous Overcurrent Element
51	Inverse-Time Overcurrent Element
52	AC Circuit Breaker
55	Power Factor Element
59	Overvoltage Element
59I	Inverse-Time Overvoltage Element
60	Loss-of-Potential Element
67	Directional Overcurrent Element
78VS	Vector Shift Element
79	Reclosing Control Logic
81	Frequency Element
81R	Rate-of-Change-of-Frequency Element
81RF	Fast Rate-of-Change-of-Frequency 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.

Arc-Flash Detection

The sensing of an arc-flash condition by detection of light and overcurrent by the relay.

Clear-Jacketed Fiber Sensor—The fiber optic loop sensor used for arc-flash detection.

Point Sensor—The fiber-optic cable sensor with a light diffuser on the end and used for arc-flash detection.

Arc-Flash Protection (Relay) An action performed by the relay to minimize the arc-flash hazard.

Arc-Flash Hazard A dangerous condition associated with the release of energy caused by an electric arc.

ASCII Abbreviation for American Standard Code for Information Interchange. Defines a standard way to communicate text characters between two electronic devices. The SEL-751 Feeder Protection Relay uses ASCII text characters to communicate through the relay front- and rear-panel EIA-232 serial ports.

Assert To activate; to fulfill the logic or electrical requirements necessary to operate a device. To apply a short-circuit or closed contact to an SEL-751 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.

AST Arc Sense technology used for the high-impedance fault (HIF) detection elements.

Bay Screen Builder SEL-5036 Software An intuitive and powerful interface to design bay screens to meet application needs.

Best Choice Ground Directional Element Logic An SEL logic that determines the directional element that the relay uses for ground faults.

Breaker Auxiliary Contact A spare electrical contact associated with a circuit breaker that opens or closes to indicate the breaker position. A Form A breaker auxiliary contact (ANSI Standard Device Number 52A) closes when the breaker is closed, opens when the breaker is open. A Form B breaker auxiliary contact (ANSI Standard Device Number 52B) opens when the breaker is closed and closes when the breaker is open.

C37.118 C37.118 IEEE Standard for Synchrophasors for Power Systems.

Checksum A numeric identifier of the firmware in the relay. Calculated by the result of a mathematic sum of the relay code.

CID Abbreviation for Checksum Identifier. The checksum of the specific firmware installed in the relay.

CID File IEC 61850 Configured IED Description file. XML file that contains the configuration for a specific IED.

COMTRADE Abbreviation for Common Format for Transient Data Exchange. The SEL-751 supports the IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems, IEEE C37.111–1999.

Contiguous Items in sequence; the second immediately following the first.

CR_RAM Abbreviation for Critical RAM. Refers to the area of relay random-access memory (RAM) where the relay stores mission-critical data.

CRC-16 Abbreviation for Cyclical Redundancy Check-16. A mathematical algorithm applied to a block of digital information to produce a unique, identifying number. Used to ensure that the information was received without data corruption.

CT Abbreviation for current transformer.

Current Unbalance The SEL-751 calculates the magnitudes of the measured phase currents, calculates the average of those magnitudes, determines the magnitude with the largest deviation from average. It then calculates the difference between the magnitude average and magnitude of the phase with the largest deviation from the average. Finally, the relay calculates the percent unbalance current by dividing the difference value by the CT nominal current or by the average magnitude, whichever is larger.

Deassert To deactivate; to remove the logic or electrical requirements necessary to operate a device. To remove a short-circuit or closed contact from an SEL-751 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.

Directional Supervision The relay uses directional elements to determine whether protective elements operate based on the direction of a fault relative to the relay.

DNP (Distributed Network Protocol) Manufacturer-developed, hardware-independent communications protocol.

EEPROM Abbreviation for Electrically Erasable Programmable Read-Only Memory. Nonvolatile memory where relay settings, event reports, SER records, and other nonvolatile data are stored.

Ethernet A network physical and data link layer defined by IEEE 802.2 and IEEE 802.3.

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.

FTP File transfer protocol.

Fundamental Frequency The component of the measured electrical signal for which frequency is equal to the normal electrical system frequency, usually 50 or 60 Hz. Generally used to differentiate between the normal system frequency and any harmonic frequencies present.

Fundamental Meter Type of meter data presented by the SEL-751 that includes the present values measured at the relay ac inputs. The word “Fundamental” is used to indicate that the values are Fundamental Frequency values and do not include harmonics.

GOOSE IEC 61850 Generic Object Oriented Substation Event. GOOSE objects can quickly and conveniently transfer status, controls, and measured values among peers on an IEC 61850 network.

Ground Directional Element Priority The order the relay uses to select directional elements to provide ground directional decisions; relay setting ORDER.

HIF High-impedance ground fault such as a downed conductor.

IA, IB, IC Measured A-, B-, and C-phase currents.

ICD File IEC 61850 IED Capability Description file. An XML file that describes IED capabilities, including information on logical node and GOOSE support.

IEC 60870-5-103 Standard protocol developed by the IEC Technical Committee of teleprotection, telecontrol, and telecommunications for electrical engineering and power system automation. It defines systems used for supervisory control and data acquisition (SCADA), including details related to communications between devices.

IEC 61850 Standard protocol for real-time exchange of data between databases in multi-vendor devices.

IG Residual current, calculated from the sum of the phase currents. In normal, balanced operation, this current is very small or zero. When a ground fault occurs, this current can be large.

IN Neutral current measured by the relay IN input. The IN input is typically connected to the secondary winding of a window-CT for ground fault detection on resistance-grounded systems.

IP Address An identifier for a computer or device on a TCP/IP network. Networks using the TCP/IP protocol route messages based on the IP address of the destination. The format of an IP address is a 32-bit numeric address written as four numbers separated by periods. Each number can be zero to 255. For example, 1.160.10.240 could be an IP address.

IRIG-B A time code input that the relay can use to set the internal relay clock.

LCD Abbreviation for Liquid Crystal Display. Used as the relay front-panel alphanumeric display.

LED Abbreviation for Light-Emitting Diode. Used as indicator lamps on the relay front panel.

LEA Inputs Low-energy analog inputs. LEA voltage inputs are suitable for C37.92 compliant high-impedance sensors, such as capacitive voltage dividers and resistive voltage dividers.

Logical Node In IEC 61850, the smallest part of a function that exchanges data. A logical node (LN) is an object defined by its data and methods. Each logical node represents a group of data (controls, status, measurements, etc.) associated with a particular function.

Load Encroachment The load-encroachment feature allows setting of phase overcurrent elements independent of load levels.

Loss-of-Potential Loss of one or more phase voltage inputs to the relay.

MAC Address The Media Access Control (hardware) address of a device connected to a shared network medium, most often used with Ethernet networks.

MMS Manufacturing Messaging Specification, a data exchange protocol used by IEC 61850.

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 Rotation
The sequence of voltage or current phasors in a multi-phase electrical system. In an ABC phase rotation system, the B-phase voltage lags the A-phase voltage by 120 degrees, and the C-phase voltage lags B-phase voltage by 120 degrees. In an ACB phase rotation system, the C-phase voltage lags the A-phase voltage by 120°, and the B-phase voltage lags the C-phase voltage by 120 degrees.

Pickup Time
The time measured from the application of an input signal until the output signal asserts. The time can be settable, as in the case of a logic variable timer, or can be a result of the characteristics of an element algorithm, as in the case of an overcurrent element pickup time.

Pinout
The definition or assignment of each electrical connection at an interface. Typically refers to a cable, connector, or jumper.

Power, P
Real part of the complex power (S) expressed in units of Watts (W), kilowatts (kW), or megawatts (MW).

Power Factor
The cosine of the angle by which phase current lags phase voltage in an ac electrical circuit. Power factor equals 1.0 for power flowing to a resistive load.

Power, Q
Reactive part of the complex power (S) expressed in units of Vars (W), kilovars (kVar), or megavars (MVar).

Protection and Control Processing
Processing interval is four times per power system cycle (except for math variables and analog quantities, which are processed every 25 ms).

PT
Abbreviation for potential transformer. Also referred to as a voltage transformer or VT.

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.

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-751 (and the SEL-2600 RTD Module) can measure the resistance of the RTD, and thus determine the temperature at the RTD location. Typically embedded in the motor windings or attached to the races of bearings.

Self-Test A function that verifies the correct operation of a critical device subsystem and indicates if the relay has detected an out-of-tolerance condition. The SEL-751 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.

Synchrophasors The word synchrophasor is derived from two words: synchronized phasor. Synchrophasor measurement refers to the concept of providing measurements taken on a synchronized schedule in multiple locations. A high-accuracy clock, commonly a Global Positioning System (GPS) receiver such as the SEL-2407 Satellite-Synchronized Clock, makes synchrophasor measurement possible.

Terminal Emulation Software Personal computer (PC) software that you can use to send and receive ASCII text messages via the PC serial port.

Transducer Device that converts the input to the device to an analog output quantity of either current (±1, 2.5, 5, 10 and 20 mA, or 4–20 ma), or voltage (±1, 2.5, 5, or 10 V).

Underfrequency Element A protection element that causes the relay to trip when the measured electrical system frequency is less than a settable frequency.

VA, VB, VC Measured A-, B-, and C-phase-to-neutral voltages.

VAB, VBC, VCA Measured or calculated phase-to-phase voltages.

VG Residual voltage calculated from the sum of the three phase-to-neutral voltages, if connected.

VS Measured phase-to-neutral or phase-to-phase synchronism-check voltage.

VT Abbreviation for voltage transformer. Also referred to as a potential transformer or PT.

Vector Shift Element The element is based on detecting phase shift (vector shift) in the three-phase voltages caused by islanding of a generator and a subsequent sudden increase of loading on the generator.

Wye As used in this instruction manual, a phase-to-neutral connection of voltage transformers for electrical measuring purposes. Three voltage transformers are used with one primary lead of the first transformer connected to A-phase and the other lead connected to ground. The second and third voltage transformers are connected to measure the voltage from B-phase and C-phase-to-ground, respectively. This connection is frequently called “four-wire wye,” alluding to the three phase leads plus the neutral lead.

Z-Number That portion of the relay RID string that identifies the proper ACSELERATOR QuickSet SEL-5030 software relay driver version when creating or editing relay settings files.

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SEL-751 Relay Command Summary

The following table lists the front serial port ASCII commands associated with particular activities. The commands are shown in uppercase letters, but you can also enter these with lowercase letters. Commands can be initiated with the three initial letters of the command. Refer to *SEL ASCII Protocol and Commands* for additional details and capabilities of each command.

La siguiente tabla muestra los comandos ASCII del puerto serie frontal asociados con diferentes actividades. Los comandos se pueden usar en mayúsculas o minúsculas. Los comandos se pueden ejecutar usando las primeras tres letras del nombre. Por más detalles consulte la guía *SEL ASCII Protocol and Commands*.

Serial Port Command	Command Description
Access Level 0 Commands	
ACC	Goes to Access Level 1.
ID	Relay identification code.
QUIT	Goes to Access Level 0.
Access Level 1 Commands	
2AC	Goes to Access Level 2.
BRE	Displays breaker monitor data (trips, interrupted current, wear).
CEV *n*	Shows compressed event report number *n*, at 1/4-cycle resolution. If *n* is omitted, the most recent compressed event report is displayed.
CEV *n* R	Shows compressed raw event report number *n*, at 1/32-cycle resolution. If *n* is omitted, the most recent compressed event report is displayed.
CEV HIF *n*	Shows compressed HIF (high-impedance fault) event record or reference number *n*, at 2-cycle resolution. If is *n* omitted, the most recent compressed event report is displayed.
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.

Comando del Puerto Serial	Descripción del Comando
Comandos del Nivel de Acceso 0	
ACC	Ir a Nivel de Acceso 1.
ID	Código de identificación del relé.
SAL	Ir al Nivel de Acceso 0.
Comandos de Nivel de Acceso 1	
2AC	Ir a Nivel de Acceso 2.
INT	Mostrar información sobre disparos, corriente interrumpida, desgaste.
CEV *n*	Mostrar el reporte comprimido de evento número *n*, resolución de 1/4 de ciclo.
CEV *n* R	Agregue R para mostrar el reporte de evento comprimido sin filtro, resolución 1/32 de ciclo. Si no se especifica *n* se muestra el evento comprimido mas reciente.
CEV HIF *n*	Mostrar el reporte comprimido HIF (high-impedance fault) de evento número *n*, una muestra cada 2 ciclos. Si no se especifica *n* se muestra el evento comprimido mas reciente.
COM A	Presentar un resumen de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS Canal A.
COM B	Presentar un resumen de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS Canal B.
COM C	Borra todos los registros de comunicaciones. Si los dos canales MIRRORED BITS están habilitados, suprimiendo el especificador de canales (A o B) se borran los dos canales.
COM C A	Borra todos los registros de comunicaciones del Canal A.
COM C B	Borra todos los registros de comunicaciones del Canal B.
COM L	Anexa un informe detallado al informe de síntesis de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS.

Serial Port Command	Command Description
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.
DATE	Shows the date.
DATE *dd/mm/yyyy*	Sets the date in DMY format if DATE_F setting is DMY.
DATE *mm/dd/yyyy*	Sets the date in MDY format if DATE_F setting is MDY.
DATE *yyyy/mm/dd*	Sets the 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 *n* R	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.
FIL READ *filename*	Transfers settings file *filename* from the relay to the PC.
FIL SHOW *filename*	*Filename* displays contents of the file filename.
GOOSE *k*	Displays transmit and receive GOOSE messaging information. Enter number *k* to scroll the GOOSE data *k* times on the screen.
GROUP	Displays active group setting.
HELP	Displays a short description of selected commands.
HIS *n*	Shows summary of *n* latest event reports, where *n* = 1 is the most recent entry. If *n* is omitted, all of the event report summaries are displayed.
HIS C or **R**	Clears or resets history buffer.
HIS HIF *n*	Shows summary of as many as the last *n* HIF events the relay has captured. If *n* is omitted, all of the event summaries are displayed.
HIS HIF C or **R**	Clears or resets all HIF event data, but retains the event history.

Comando del Puerto Serial	Descripción del Comando
COM L A	Anexa un informe detallado al informe de síntesis de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS del Canal A.
COM L B	Anexa un informe detallado al informe de síntesis de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS del Canal B.
COM S	Muestra un resumen de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS.
COU *n*	Muestra el estado actualizado de los contadores del dispositivo. *n* = repite el informe *n* veces, con ½ segundos entre cada informe.
FEC	Ver fecha.
FEC *dd/mm/yyyy*	Si DATE_F es igual a DMY, ingrese fecha en formato Día Mes Año
FEC *mm/dd/yyyy*	Si DATE_F es MDA, ingrese fecha en formato Mes Día Año.
FEC *yyyy/mm/dd*	Si DATE_F es AMD, ingrese fecha en formato Año Mes Día.
ETH	Mostrar el estado del puerto de Ethernet.
EVE *n*	Mostrar el reporte de evento estándar número *n*, con 4 muestras por ciclo. Omitiendo *n*, se muestra el informe más reciente.
EVE *n* R	Muestra el evento número n (32 muestras analógicas y 4 muestras digitales por ciclo)
FIL DIR	Mostrar lista de archivos.
FIL READ *filename*	Transferir el archivo de configuración *filename* del relé a la computadora.
FIL SHOW *filename*	Muestra el contenido del archivo *filename*.
GOOSE *k*	Mostrar información de transmisión y recepción de mensajes GOOSE. Ingresar el numero *k* para mostrar los datos GOOSE *k* veces en la pantalla.
GRUPO	Mostrar el grupo de ajustes activo.
AYU	Mostrar una descripción corta de los comandos elegidos.
HIS *n*	Mostrar el resumen de los últimos *n* informes de eventos, donde *n* = 1 es la entrada más reciente. Si *n* es no está especificado, muestra todos los resúmenes de reportes de eventos.
HIS D o **R**	Borrar la historia de eventos.
HIS HIF *n*	Muestra el resumen de los últimos *n* reportes de evento HIF. Si no se especifica n, se muestran todos los resúmenes de eventos
HIS HIF D o **R**	Borrar (D) o reiniciar (R) todos los datos HIF, pero mantiene el historial de eventos.

Serial Port Command	Command Description
HIS HIF CA or **RA**	Clears or resets the HIF event history and all the corresponding event reports from the nonvolatile memory.
HSG	Displays 100 long-term and 100 short-term histogram counter values of the three phases (data for high-impedance fault (HIF) detection).
IRIG	Forces synchronization of internal control clock to IRIG-B time-code input.
LDP ***row1 row2***	Displays load profile report rows from *row1* to *row2*, starting with *row1*. If *row2* is omitted, displays the first *row1* rows.
LDP ***date1 date2***	Displays load profile report rows from *date1* to *date2*, starting with *date1*.
LDP C	Clears signal profile data.
LOG HIF ***nnn***	Displays the progress log (*nnn* entries, as many as 500) of HIF (high-impedance fault) detection as a percentage of their final pickup. If *nnn* is not specified, all (as many as 500) entries are displayed.
MAC	Displays the MAC address of the Ethernet port (PORT 1).
MET or **MET F**	Displays fundamental instantaneous metering data.
MET AI	Displays analog input (transducer) data.
MET DE	Displays demand metering data in primary amperes.
MET E	Displays energy metering data.
MET HIF	Displays the progress of HIF (high-impedance fault) detection in percentage of their final pickup values.
MET L	Displays arc-flash detector (AFD) light input (relay requires the arc-flash detection (AFD) option with a 2 AVI /4 AFDI card or 8 AFDI card in Slot E).
MET M	Display minimum and maximum metering data.
MET MV	Displays SELOGIC math variable data.
MET PE	Displays peak demand metering data in primary amperes.
MET PM	Displays synchrophasor metering data.
MET RA	Displays remote analog metering data.
MET RD	Resets demand metering values.
MET RE	Resets energy metering data.
MET RM	Resets minimum and maximum metering data.
MET RMS	Displays rms metering data.
MET RP	Resets demand and peak demand metering values.

Comando del Puerto Serial	Descripción del Comando
HIS HIF DT o **RT**	Borrar o reiniciar el historial de eventos HIF de memoria no volátil.
HSG	Muestra 100 histogramas de largo plazo y 100 histogramas de corto plazo para las tres fases. (datos para detección de fallas de alta impedancia HIF).
IRIG	Forzar la sincronización del reloj interno a IRIG-B.
LDP ***row1 row2***	Mostrar los datos de perfil carga entra las filas *row1* y *row2*. Si se omite *row2*, muestra las primeras *row1* columnas.
LDP ***date1 date2***	Mostrar los datos de perfil carga entra las filas *date1* y *date2*.
LDP D	Borrar los datos de perfil de la señal.
LOG HIF ***nnn***	Muestra reporte de progreso (*nnn* entradas, *nnn*<500) HIF en porcentaje del valor final de disparo. Si no se especifica nnn, se muestran todos los registros (hasta 500).
MAC	Mostrar la dirección MAC del puerto de Ethernet (PUERTO 1).
MED o **MED F**	Mostrar los datos de medición fundamentales.
MED EA	Mostrar los datos de entrada analógica.
MED DE	Mostrar los datos de demanda de medición en amperes primarios.
MED E	Mostrar los datos de medición de energía.
MED HIF	Muestra reporte de progreso HIF en porcentaje del valor final de disparo.
MED L	Muestra la entrada de luz de los sensores AFD (arco de voltaje). Requiere sensores AFD tarjeta 2AVI/4 AFDI o 8 ADFI en Slot E.
MED M	Mostrar datos de medición mínimos y máximos.
MED V	Mostrar variables matemáticas SELOGIC.
MED PE	Mostrar los datos de demanda de medición pico en amperes primarios.
MED PM	Mostrar fasores sincronizados.
MED RA	Mostrar datos analogicos de medición remota.
MED RD	Reiniciar mediciones de demanda.
MED RE	Reiniciar los datos de medición de energía.
MED RM	Reiniciar los datos de medición mínima y máxima.
MED RMS	Mostrar los datos de medición rms.
MED RP	Reiniciar los valores de medición de demanda pico.

Serial Port Command	Command Description
MET T	Displays RTD and thermal 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 ***date1***	Displays all SER records made on date *date1*.
SER ***date1 date2***	Displays all SER records made from dates *date2* to *date1*, inclusive, starting with *date2*.
SER ***row1***	Displays the *row1* most recent SER records starting with record *row1*.
SER ***row1 row2***	Displays SER records *row2* to *row1*, starting with *row2*.
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,* where *n* = 1, 2, 3, or 4. If *n* is not specified, default is the active settings group.
SHO DNP ***m***	Displays the DNP data map settings for Map *m*, where *m* = 1, 2, or 3.
SHO F	Displays the front-panel settings.
SHO G	Displays the global settings.
SHO I	Displays the IEC 60870-5-103 map settings.
SHO L ***n***	Displays the general logic settings for group *n*, where *n* = 1, 2, 3, or 4. If *n* is not specified, default is the active settings group.
SHO M	Displays the Modbus User Map settings.
SHO P ***n***	Displays the port settings, where *n* specifies Port 1, 2, 3, 4, or F; *n* defaults to the active port if not listed.
SHO R	Displays the report settings.
STA ***n***	Displays the relay self-test status *n* (1–32727) times. If *n* is omitted, *n* defaults to 1.
STA S	Displays the SELOGIC usage status report.
SUM ***n***	Displays event summary *n*. If *n* is omitted, displays the most recent event summary.
SUM HIF ***n***	Displays HIF (high-impedance fault) event summary *n*. If *n* is omitted, displays the most recent HIF event summary.
SUM C or **R**	Resets the event summary buffer.

Comando del Puerto Serial	Descripción del Comando
MED T	Mostrar los datos de medición RTD y termicos
PING ***x.x.x.x t***	Determinar si el puerto Ethernet esta funcionando y configurado adecuadamente. *x.x.x.x* es la dirección IP. *t* es el intervalo entre PINGs, *t* es ajustable entre 2 y 255 segundos. Por omisión, *t* = 1 segundo. Oprima Q para detener.
SER	Mostrar toda la información en el Registrador de Eventos Secuenciales (SER).
SER ***date1***	Mostar todos las registros SER del día *date1*.
SER ***date1 date2***	Mostrar todos los registros SER creados entre los días *date2* al *date1*, comenzando con *date2*.
SER ***row1***	Mostrar los *n* registros SER más recientes comenzando con el archivo *row1*.
SER ***row1 row2***	Mostrar los registros SER del *row2* al *row1*, comenzando con *row2*.
SER D o **R**	Borrar los datos SER.
SER B	Muestra ítems removidos del SER. Útil cuando la supresión automática de SER esta activada.
MOS ***n***	Mostrar ajustes del grupo *n* del relé (*n* = 1, 2, 3 o 4). Por omisión, muestra grupo de ajustes 1.
MOS DNP ***m***	Mostrar ajustes de mapa de datos DNP para el Mapa *m* (*m* = 1, 2 o 3).
MOS F	Mostrar ajustes del panel frontal.
MOS G	Mostrar ajustes globales.
MOS I	Mostrar mapa de ajustes IEC 60870-5-103.
MOS L ***n***	Mostrar la lógica de configuración general del grupo *n* del relé (*n* = 1, 2, 3 o 4). Por omisión, muestra grupo de ajustes 1.
MOS M	Mostrar ajustes del Mapa del Usuario Modbus.
MOS P ***n***	Mostrar configuraciones de puerto, donde *n* especifica el puerto (1, 2, 3, 4 o F); por defecto muestra ajustes del puerto activo.
MOS R	Mostrar configuración de reportes.
EST ***n***	Muestar resultados de autotest *n* veces. Por omisión, *n* = 1.
EST S	Mostrar reporte de utilización SELOGIC.
SUM ***n***	Muestra un resumen del evento *n*.
SUM HIF ***n***	Muestra un resumen del evento HIF número *n*. Muestra el resumen de event HIF mas reciente si se omite *n*.
SUM C o **R**	Borrar el buffer de resúmenes de evento.

Serial Port Command	Command Description
TAR	Displays the default target row or the most recently viewed target row.
TAR ***n***	Displays target row *n*.
TAR ***n k***	Displays target row *n*. Repeats display of row *n* for repeat count *k*.
TAR ***name***	Displays the target row with target name in the row.
TAR ***name k***	Displays the target row with target name in the row. Repeats display of this row for repeat count *k*.
TAR R	Resets any latched targets and the most recently viewed target row.
TIME	Displays the time.
TIME ***hh***	Sets the time by entering **TIM** followed by hours, as shown (24-hour clock).
TIME ***hh:mm***	Sets the time by entering **TIM** followed by hours and minutes, as shown (24-hour clock).
TIME ***hh:mm:ss***	Sets the time by entering **TIM** followed by hours, minutes, and seconds, as shown (24-hour clock).
TRI	Triggers an event report data capture.
TRI HIF	Triggers an HIF event report data capture
Access Level 2 Commands	
AFT	Tests arc-flash detector channels.
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 R	Resets the breaker data.
BRE W	Preloads the breaker data.
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	Closes the circuit breaker.
CON RB*nn k*	Selects a remote bit to set, clear, or pulse where *nn* is a number from 01 to 32, representing RB01 through RB32. *k* is S, C, or P for Set, Clear, or Pulse.
COPY ***m n***	Copies the relay and logic settings from Group *m* to Group *n*.
FIL WRITE ***filename***	Transfers settings file *filename* from the PC to the relay.

Comando del Puerto Serial	Descripción del Comando
BAN	Mostrar la fila de banderas por defecto o la última fila de banderas mostrada.
BAN ***n***	Mostrar la fila de banderas *n*.
BAN ***n k***	Mostrar la fila de banderas *n k* veces.
BAN ***name***	Mostrar la fila de banderas que contiene la bandera name.
BAN ***name k***	Mostrar la fila de banderas que contiene la bandera name *k* veces.
BAN R	Resetea todas las banderas selladas y la fila de banderas mostrada mas recientemente.
HOR	Ver hora.
HOR ***hh***	Configurar la hora ingresando **HOR** seguido por horas como se muestra (relog 24 horas).
HOR ***hh:mm***	Configurar la hora ingresando **HOR** seguido por horas y minutos como se muestra (relog 24 horas).
HOR ***hh:mm:ss***	Configurar la hora ingresando **HOR** seguido por horas, minutos y segundos como se muestra (relog 24 horas).
TRI	Disparar la captura de un reporte de evento.
TRI HIF	Disparar la captura de un reporte de evento de HIF.
Comandos del Nivel de Acceso 2	
AFT	AFT Probar detectores arc-flash en canales.
ANA ***c p t***	Probar el canal de salida analógica donde *c* es el nombre o el número del canal, *p* es el porcentaje de escala completa, o las letras “R” o “r” para indicar el modo de rampa y *t* para indicar la duración de la prueba en minutos decimales.
INT R	Reiniciar datos del interruptor.
INT W	Precargar datos del interruptor.
CAL	Ingresar al Nivel de Acceso C. Si el jumper de acceso en la tarjeta principal no está en su lugar, el relé pedirá la contraseña de Acceso del Nivel C. El Nivel de Acceso C está reservado para uso exclusivo de SEL.
CER	Cerrar el interruptor.
CON RB*nn k*	Seleccionar un bit remoto para activar, desactivar o pulsar donde *nn* es un número del 01 al 32, representando desde RB01 hasta RB32. *k* es A, D o P para Activar, Deactivar o Pulsar.
COPY ***m n***	Copiar configuración del relé y la configuración lógica del grupo *m* al grupo *n*.
FIL WRITE ***filename***	Transferir el archivo de configuración *filename* de la computadora al relé.

Serial Port Command	Command Description
GROUP *n*	Changes the active group to Group *n* (where *n* = 1, 2, 3, or 4).
INI HIF	Restarts the 24-hour tuning process used in high-impedance fault detection.
L_D	Loads new firmware.
LOO	Enables loopback testing of MIRRORED BITS channels.
LOO A	Enables loopback on MIRRORED BITS Channel A for the next 5 minutes.
LOO B	Enables loopback on MIRRORED BITS Channel B for the next 5 minutes.
LOO R	Disables the loopback on both channels and returns the device to normal operation.
LOO *xx* DATA	Enables loopback mode for *xx* minutes and allows the loopback data to modify the RMB values.
OPE	Opens the circuit breaker.
PARTNO	Allows for updates to the part number after the relay hardware configuration has been changed.
PAS 1	Changes the Access Level 1 password.
PAS 2	Changes the Access Level 2 password.
PUL OUT*nnn*	Pulse output contact *nnn*.
PUL OUT*nnn s*	Pulses Output Contact *nnn,* where *nnn* = OUT101…, for *s* (1 to 30, default is 1) seconds.
R_S	Restores the factory-default settings and passwords and reboots the relay; available only after a firmware upgrade.
SET *n*	Modifies the relay settings for group *n*, where *n* = 1, 2, 3, or 4. If *n* is not specified, default is the active settings group.
SET *name*	For all **SET** commands, jump ahead to a specific setting by entering the setting name, e.g., 50P1P.
SET DNP *n*	Modifies the DNP data map settings for map *n*, where *n* = 1, 2, or 3.
SET F	Modifies the front-panel settings.
SET G	Modifies the global settings.
SET I	Modifies the IEC 60870-5-103 settings.
SET L *n*	Modifies the SELOGIC variable and timer settings for group *n*, where *n* = 1, 2, 3, or 4. If *n* is not specified, default is the active settings group.
SET M	Modifies the Modbus User Map settings.

Comando del Puerto Serial	Descripción del Comando
GRUPO *n*	Usar Grupo de configuraciones *n*, donde *n* = 1, 2, 3 o 4.
INI HIF	INI HIF Reinicia el proceso de sintonización HIF (24Hrs).
L_D	Cargar un firmware nuevo.
LOO	Habilitar loopback de los canales MIRRORED BITS.
LOO A	Habilitar loopback en Canal MIRRORED BITS A por los siguientes 5 minutos.
LOO B	Habilitar prueba loopback en Canal MIRRORED BITS B por los siguientes 5 minutos.
LOO R	Deshabilita loopback en canales MB A y B.
LOO *xx* DATA	Habilita loopback for xx minutos y permite modificar valores RMB.
ABR	Abrir el interruptor.
PARTNO	Cambia el número de parte del relé use despues de cambiar una tarjeta del relé.
PAS 1	Cambiar la contraseña del Nivel de Acceso 1.
PAS 2	Cambiar la contraseña del Nivel de Acceso 2.
PUL OUT*nnn*	Pulsar el contacto de salida *nnn*.
PUL OUT*nnn s*	Pulsar el contacto de salida *nnn* (*nnn* = OUT101…) por *s* (de 1 a 30, el numero predeterminado es 1) segundos.
R_S	Resetea el relé usando ajustes y passwords por defacto y despuės reinicia el relé. Disponible solamente después de una actualización de firmware.
AJU *n*	Modificar el grupo *n* de ajustes del relé, donden *n* =1, 2, 3 o 4. Si no se especifica n, se modifica el grupo activo.
AJU *name*	Para todos los comandos **SET**, adeléntese a un ajuste ingresando el nombre del ajuste, por ejemplo, 50P11P.
AJU DNP *n*	Modificar la configuración del mapa de datos DNP para el mapa *n*, donde *n* = 1, 2 o 3.
AJU F	Modificar la configuración del panel frontal.
AJU G	Modificar las ajustes globales.
AJU I	Modificar ajustes IEC 60870-5-103.
AJU L *n*	Modifica ajustes SELOGIC, laches, variables lógicas (SV) y matemáticas (MV) en el grupo de ajustes n. Si no se especifica n, se modifica el grupo activo.
AJU M	Modificar las configuración del Mapa del Usuario Modbus.

Serial Port Command	Command Description
SET P *n*	Modifies the port *n* settings, where *n* = 1, 2, 3, 4, or F. If not specified, the default is the active port.
SET R	Modifies the report settings.
SET … TERSE	For all **SET** commands, **TERSE** disables the automatic **SHO** command after the settings entry.
STA C or **R**	Clears the self-test status and restarts the relay.
TEST DB	Displays the present status of digital and analog overrides.
THE P	Loads the preset value of thermal capacity used in the IEC line/cable thermal element.
THE R	Resets the calculated thermal capacity used in the IEC line/cable thermal element.
VEC D	Displays the diagnostic vector report.
VEC E	Displays the exception vector report.
Access Level CAL Commands	
PAS C	Changes the Access Level C password.

Comando del Puerto Serial	Descripción del Comando
AJU P *n*	Modificar la configuración del puerto *n*, donde *n* = 1, 2, 3, 4 o F. Si *n* no está especificado, el puerto predeterminado es el puerto activo.
AJU R	Modificar la configuración de reportes.
AJU...TERSO	Para todos los comandos **AJU**, **TERSO** desactiva los comandos automáticos **MOS** después de modificar las configuraciones.
EST C o **R**	Salir del modo de diagnostico automático y reiniciar el relé.
TEST DB	Mostrar el estado actual de variable digitales y analógicas con valores forzados.
THE P	Cargar valores predeterminados de capacidad térmica en el elemento térmico IEC de líneas y cables.
THE R	Reinicia la capacidad térmica calculada usada en el elemento térmico IEC de líneas y cables.
VEC D	Mostar reporte standard de reinicio del relé.
VEC E	Mostar reporte de reinicio del relé.
Comandos del Nivel del Acceso C	
PAS C	Cambiar la contraseña del Nivel de Acceso C.

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SEL-751 Relay Command Summary

The following table lists the front serial port ASCII commands associated with particular activities. The commands are shown in uppercase letters, but you can also enter these with lowercase letters. Commands can be initiated with the three initial letters of the command. Refer to *SEL ASCII Protocol and Commands* for additional details and capabilities of each command.

La siguiente tabla muestra los comandos ASCII del puerto serie frontal asociados con diferentes actividades. Los comandos se pueden usar en mayúsculas o minúsculas. Los comandos se pueden ejecutar usando las primeras tres letras del nombre. Por más detalles consulte la guía *SEL ASCII Protocol and Commands*.

Serial Port Command	Command Description
Access Level 0 Commands	
ACC	Goes to Access Level 1.
ID	Relay identification code.
QUIT	Goes to Access Level 0.
Access Level 1 Commands	
2AC	Goes to Access Level 2.
BRE	Displays breaker monitor data (trips, interrupted current, wear).
CEV *n*	Shows compressed event report number *n*, at 1/4-cycle resolution. If *n* is omitted, the most recent compressed event report is displayed.
CEV *n* R	Shows compressed raw event report number *n*, at 1/32-cycle resolution. If *n* is omitted, the most recent compressed event report is displayed.
CEV HIF *n*	Shows compressed HIF (high-impedance fault) event record or reference number *n*, at 2-cycle resolution. If is *n* omitted, the most recent compressed event report is displayed.
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.

Comando del Puerto Serial	Descripción del Comando
Comandos del Nivel de Acceso 0	
ACC	Ir a Nivel de Acceso 1.
ID	Código de identificación del relé.
SAL	Ir al Nivel de Acceso 0.
Comandos de Nivel de Acceso 1	
2AC	Ir a Nivel de Acceso 2.
INT	Mostrar información sobre disparos, corriente interrumpida, desgaste.
CEV *n*	Mostrar el reporte comprimido de evento número *n*, resolución de 1/4 de ciclo.
CEV *n* R	Agregue R para mostrar el reporte de evento comprimido sin filtro, resolución 1/32 de ciclo. Si no se especifica *n* se muestra el evento comprimido mas reciente.
CEV HIF *n*	Mostrar el reporte comprimido HIF (high-impedance fault) de evento número *n*, una muestra cada 2 ciclos. Si no se especifica *n* se muestra el evento comprimido mas reciente.
COM A	Presentar un resumen de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS Canal A.
COM B	Presentar un resumen de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS Canal B.
COM C	Borra todos los registros de comunicaciones. Si los dos canales MIRRORED BITS están habilitados, suprimiendo el especificador de canales (A o B) se borran los dos canales.
COM C A	Borra todos los registros de comunicaciones del Canal A.
COM C B	Borra todos los registros de comunicaciones del Canal B.
COM L	Anexa un informe detallado al informe de síntesis de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS.

Serial Port Command	Command Description
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.
DATE	Shows the date.
DATE *dd/mm/yyyy*	Sets the date in DMY format if DATE_F setting is DMY.
DATE *mm/dd/yyyy*	Sets the date in MDY format if DATE_F setting is MDY.
DATE *yyyy/mm/dd*	Sets the 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 *n* R	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.
FIL READ *filename*	Transfers settings file *filename* from the relay to the PC.
FIL SHOW *filename*	*Filename* displays contents of the file filename.
GOOSE *k*	Displays transmit and receive GOOSE messaging information. Enter number *k* to scroll the GOOSE data *k* times on the screen.
GROUP	Displays active group setting.
HELP	Displays a short description of selected commands.
HIS *n*	Shows summary of *n* latest event reports, where *n* = 1 is the most recent entry. If *n* is omitted, all of the event report summaries are displayed.
HIS C or **R**	Clears or resets history buffer.
HIS HIF *n*	Shows summary of as many as the last *n* HIF events the relay has captured. If *n* is omitted, all of the event summaries are displayed.
HIS HIF C or **R**	Clears or resets all HIF event data, but retains the event history.

Comando del Puerto Serial	Descripción del Comando
COM L A	Anexa un informe detallado al informe de síntesis de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS del Canal A.
COM L B	Anexa un informe detallado al informe de síntesis de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS del Canal B.
COM S	Muestra un resumen de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS.
COU *n*	Muestra el estado actualizado de los contadores del dispositivo. *n* = repite el informe *n* veces, con ½ segundos entre cada informe.
FEC	Ver fecha.
FEC *dd/mm/yyyy*	Si DATE_F es igual a DMY, ingrese fecha en formato Día Mes Año
FEC *mm/dd/yyyy*	Si DATE_F es MDA, ingrese fecha en formato Mes Día Año.
FEC *yyyy/mm/dd*	Si DATE_F es AMD, ingrese fecha en formato Año Mes Día.
ETH	Mostrar el estado del puerto de Ethernet.
EVE *n*	Mostrar el reporte de evento estándar número *n*, con 4 muestras por ciclo. Omitiendo *n*, se muestra el informe más reciente.
EVE *n* R	Muestra el evento número n (32 muestras analógicas y 4 muestras digitales por ciclo)
FIL DIR	Mostrar lista de archivos.
FIL READ *filename*	Transferir el archivo de configuración *filename* del relé a la computadora.
FIL SHOW *filename*	Muestra el contenido del archivo *filename*.
GOOSE *k*	Mostrar información de transmisión y recepción de mensajes GOOSE. Ingresar el numero *k* para mostrar los datos GOOSE *k* veces en la pantalla.
GRUPO	Mostrar el grupo de ajustes activo.
AYU	Mostrar una descripción corta de los comandos elegidos.
HIS *n*	Mostrar el resumen de los últimos *n* informes de eventos, donde *n* = 1 es la entrada más reciente. Si *n* es no está especificado, muestra todos los resúmenes de reportes de eventos.
HIS D o **R**	Borrar la historia de eventos.
HIS HIF *n*	Muestra el resumen de los últimos *n* reportes de evento HIF. Si no se especifica n, se muestran todos los resúmenes de eventos
HIS HIF D o **R**	Borrar (D) o reiniciar (R) todos los datos HIF, pero mantiene el historial de eventos.

Serial Port Command	Command Description
HIS HIF CA or **RA**	Clears or resets the HIF event history and all the corresponding event reports from the nonvolatile memory.
HSG	Displays 100 long-term and 100 short-term histogram counter values of the three phases (data for high-impedance fault (HIF) detection).
IRIG	Forces synchronization of internal control clock to IRIG-B time-code input.
LDP ***row1 row2***	Displays load profile report rows from *row1* to *row2*, starting with *row1*. If *row2* is omitted, displays the first *row1* rows.
LDP ***date1 date2***	Displays load profile report rows from *date1* to *date2*, starting with *date1*.
LDP C	Clears signal profile data.
LOG HIF ***nnn***	Displays the progress log (*nnn* entries, as many as 500) of HIF (high-impedance fault) detection as a percentage of their final pickup. If *nnn* is not specified, all (as many as 500) entries are displayed.
MAC	Displays the MAC address of the Ethernet port (PORT 1).
MET or **MET F**	Displays fundamental instantaneous metering data.
MET AI	Displays analog input (transducer) data.
MET DE	Displays demand metering data in primary amperes.
MET E	Displays energy metering data.
MET HIF	Displays the progress of HIF (high-impedance fault) detection in percentage of their final pickup values.
MET L	Displays arc-flash detector (AFD) light input (relay requires the arc-flash detection (AFD) option with a 2 AVI /4 AFDI card or 8 AFDI card in Slot E).
MET M	Display minimum and maximum metering data.
MET MV	Displays SELOGIC math variable data.
MET PE	Displays peak demand metering data in primary amperes.
MET PM	Displays synchrophasor metering data.
MET RA	Displays remote analog metering data.
MET RD	Resets demand metering values.
MET RE	Resets energy metering data.
MET RM	Resets minimum and maximum metering data.
MET RMS	Displays rms metering data.
MET RP	Resets demand and peak demand metering values.

Comando del Puerto Serial	Descripción del Comando
HIS HIF DT o **RT**	Borrar o reiniciar el historial de eventos HIF de memoria no volátil.
HSG	Muestra 100 histogramas de largo plazo y 100 histogramas de corto plazo para las tres fases. (datos para detección de fallas de alta impedancia HIF).
IRIG	Forzar la sincronización del reloj interno a IRIG-B.
LDP ***row1 row2***	Mostrar los datos de perfil carga entra las filas *row1* y *row2*. Si se omite *row2*, muestra las primeras *row1* columnas.
LDP ***date1 date2***	Mostrar los datos de perfil carga entra las filas *date1* y *date2*.
LDP D	Borrar los datos de perfil de la señal.
LOG HIF ***nnn***	Muestra reporte de progreso (*nnn* entradas, *nnn*<500) HIF en porcentaje del valor final de disparo. Si no se especifica nnn, se muestran todos los registros (hasta 500).
MAC	Mostrar la dirección MAC del puerto de Ethernet (PUERTO 1).
MED o **MED F**	Mostrar los datos de medición fundamentales.
MED EA	Mostrar los datos de entrada analógica.
MED DE	Mostrar los datos de demanda de medición en amperes primarios.
MED E	Mostrar los datos de medición de energía.
MED HIF	Muestra reporte de progreso HIF en porcentaje del valor final de disparo.
MED L	Muestra la entrada de luz de los sensores AFD (arco de voltaje). Requiere sensores AFD tarjeta 2AVI/4 AFDI o 8 ADFI en Slot E.
MED M	Mostrar datos de medición mínimos y máximos.
MED V	Mostrar variables matemáticas SELOGIC.
MED PE	Mostrar los datos de demanda de medición pico en amperes primarios.
MED PM	Mostrar fasores sincronizados.
MED RA	Mostrar datos analogicos de medición remota.
MED RD	Reiniciar mediciones de demanda.
MED RE	Reiniciar los datos de medición de energía.
MED RM	Reiniciar los datos de medición mínima y máxima.
MED RMS	Mostrar los datos de medición rms.
MED RP	Reiniciar los valores de medición de demanda pico.

Serial Port Command	Command Description
MET T	Displays RTD and thermal 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 ***date1***	Displays all SER records made on date *date1*.
SER ***date1 date2***	Displays all SER records made from dates *date2* to *date1*, inclusive, starting with *date2*.
SER ***row1***	Displays the *row1* most recent SER records starting with record *row1*.
SER ***row1 row2***	Displays SER records *row2* to *row1*, starting with *row2*.
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,* where *n* = 1, 2, 3, or 4. If *n* is not specified, default is the active settings group.
SHO DNP ***m***	Displays the DNP data map settings for Map *m*, where *m* = 1, 2, or 3.
SHO F	Displays the front-panel settings.
SHO G	Displays the global settings.
SHO I	Displays the IEC 60870-5-103 map settings.
SHO L ***n***	Displays the general logic settings for group *n*, where *n* = 1, 2, 3, or 4. If *n* is not specified, default is the active settings group.
SHO M	Displays the Modbus User Map settings.
SHO P ***n***	Displays the port settings, where *n* specifies Port 1, 2, 3, 4, or F; *n* defaults to the active port if not listed.
SHO R	Displays the report settings.
STA ***n***	Displays the relay self-test status *n* (1–32727) times. If *n* is omitted, *n* defaults to 1.
STA S	Displays the SELOGIC usage status report.
SUM ***n***	Displays event summary *n*. If *n* is omitted, displays the most recent event summary.
SUM HIF ***n***	Displays HIF (high-impedance fault) event summary *n*. If *n* is omitted, displays the most recent HIF event summary.
SUM C or **R**	Resets the event summary buffer.

Comando del Puerto Serial	Descripción del Comando
MED T	Mostrar los datos de medición RTD y termicos
PING ***x.x.x.x t***	Determinar si el puerto Ethernet esta funcionando y configurado adecuadamente. *x.x.x.x* es la dirección IP. *t* es el intervalo entre PINGs, *t* es ajustable entre 2 y 255 segundos. Por omisión, *t* = 1 segundo. Oprima Q para detener.
SER	Mostrar toda la información en el Registrador de Eventos Secuenciales (SER).
SER ***date1***	Mostar todos las registros SER del día *date1*.
SER ***date1 date2***	Mostrar todos los registros SER creados entre los días *date2* al *date1*, comenzando con *date2*.
SER ***row1***	Mostrar los *n* registros SER más recientes comenzando con el archivo *row1*.
SER ***row1 row2***	Mostrar los registros SER del *row2* al *row1*, comenzando con *row2*.
SER D o **R**	Borrar los datos SER.
SER B	Muestra ítems removidos del SER. Útil cuando la supresión automática de SER esta activada.
MOS ***n***	Mostrar ajustes del grupo *n* del relé (*n* = 1, 2, 3 o 4). Por omisión, muestra grupo de ajustes 1.
MOS DNP ***m***	Mostrar ajustes de mapa de datos DNP para el Mapa *m* (*m* = 1, 2 o 3).
MOS F	Mostrar ajustes del panel frontal.
MOS G	Mostrar ajustes globales.
MOS I	Mostrar mapa de ajustes IEC 60870-5-103.
MOS L ***n***	Mostrar la lógica de configuración general del grupo *n* del relé (*n* = 1, 2, 3 o 4). Por omisión, muestra grupo de ajustes 1.
MOS M	Mostrar ajustes del Mapa del Usuario Modbus.
MOS P ***n***	Mostrar configuraciones de puerto, donde *n* especifica el puerto (1, 2, 3, 4 o F); por defecto muestra ajustes del puerto activo.
MOS R	Mostrar configuración de reportes.
EST ***n***	Muestar resultados de autotest *n* veces. Por omisión, *n* = 1.
EST S	Mostrar reporte de utilización SELOGIC.
SUM ***n***	Muestra un resumen del evento *n*.
SUM HIF ***n***	Muestra un resumen del evento HIF número *n*. Muestra el resumen de event HIF mas reciente si se omite *n*.
SUM C o **R**	Borrar el buffer de resúmenes de evento.

Serial Port Command	Command Description
TAR	Displays the default target row or the most recently viewed target row.
TAR *n*	Displays target row *n*.
TAR *n k*	Displays target row *n*. Repeats display of row *n* for repeat count *k*.
TAR *name*	Displays the target row with target name in the row.
TAR *name k*	Displays the target row with target name in the row. Repeats display of this row for repeat count *k*.
TAR R	Resets any latched targets and the most recently viewed target row.
TIME	Displays the time.
TIME *hh*	Sets the time by entering **TIM** followed by hours, as shown (24-hour clock).
TIME *hh:mm*	Sets the time by entering **TIM** followed by hours and minutes, as shown (24-hour clock).
TIME *hh:mm:ss*	Sets the time by entering **TIM** followed by hours, minutes, and seconds, as shown (24-hour clock).
TRI	Triggers an event report data capture.
TRI HIF	Triggers an HIF event report data capture
Access Level 2 Commands	
AFT	Tests arc-flash detector channels.
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 R	Resets the breaker data.
BRE W	Preloads the breaker data.
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	Closes the circuit breaker.
CON RB*nn k*	Selects a remote bit to set, clear, or pulse where *nn* is a number from 01 to 32, representing RB01 through RB32. *k* is S, C, or P for Set, Clear, or Pulse.
COPY *m n*	Copies the relay and logic settings from Group *m* to Group *n*.
FIL WRITE *filename*	Transfers settings file *filename* from the PC to the relay.

Comando del Puerto Serial	Descripción del Comando
BAN	Mostrar la fila de banderas por defecto o la última fila de banderas mostrada.
BAN *n*	Mostrar la fila de banderas *n*.
BAN *n k*	Mostrar la fila de banderas *n k* veces.
BAN *name*	Mostrar la fila de banderas que contiene la bandera name.
BAN *name k*	Mostrar la fila de banderas que contiene la bandera name *k* veces.
BAN R	Resetea todas las banderas selladas y la fila de banderas mostrada mas recientemente.
HOR	Ver hora.
HOR *hh*	Configurar la hora ingresando **HOR** seguido por horas como se muestra (relog 24 horas).
HOR *hh:mm*	Configurar la hora ingresando **HOR** seguido por horas y minutos como se muestra (relog 24 horas).
HOR *hh:mm:ss*	Configurar la hora ingresando **HOR** seguido por horas, minutos y segundos como se muestra (relog 24 horas).
TRI	Disparar la captura de un reporte de evento.
TRI HIF	Disparar la captura de un reporte de evento de HIF.
Comandos del Nivel de Acceso 2	
AFT	AFT Probar detectores arc-flash en canales.
ANA *c p t*	Probar el canal de salida analógica donde *c* es el nombre o el número del canal, *p* es el porcentaje de escala completa, o las letras “R” o “r” para indicar el modo de rampa y *t* para indicar la duración de la prueba en minutos decimales.
INT R	Reiniciar datos del interruptor.
INT W	Precargar datos del interruptor.
CAL	Ingresar al Nivel de Acceso C. Si el jumper de acceso en la tarjeta principal no está en su lugar, el relé pedirá la contraseña de Acceso del Nivel C. El Nivel de Acceso C está reservado para uso exclusivo de SEL.
CER	Cerrar el interruptor.
CON RB*nn k*	Seleccionar un bit remoto para activar, desactivar o pulsar donde *nn* es un número del 01 al 32, representando desde RB01 hasta RB32. *k* es A, D o P para Activar, Deactivar o Pulsar.
COPY *m n*	Copiar configuración del relé y la configuración lógica del grupo *m* al grupo *n*.
FIL WRITE *filename*	Transferir el archivo de configuración *filename* de la computadora al relé.

Serial Port Command	Command Description
GROUP *n*	Changes the active group to Group *n* (where *n* = 1, 2, 3, or 4).
INI HIF	Restarts the 24-hour tuning process used in high-impedance fault detection.
L_D	Loads new firmware.
LOO	Enables loopback testing of MIRRORED BITS channels.
LOO A	Enables loopback on MIRRORED BITS Channel A for the next 5 minutes.
LOO B	Enables loopback on MIRRORED BITS Channel B for the next 5 minutes.
LOO R	Disables the loopback on both channels and returns the device to normal operation.
LOO *xx* DATA	Enables loopback mode for *xx* minutes and allows the loopback data to modify the RMB values.
OPE	Opens the circuit breaker.
PARTNO	Allows for updates to the part number after the relay hardware configuration has been changed.
PAS 1	Changes the Access Level 1 password.
PAS 2	Changes the Access Level 2 password.
PUL OUT*nnn*	Pulse output contact *nnn*.
PUL OUT*nnn s*	Pulses Output Contact *nnn,* where *nnn* = OUT101…, for *s* (1 to 30, default is 1) seconds.
R_S	Restores the factory-default settings and passwords and reboots the relay; available only after a firmware upgrade.
SET *n*	Modifies the relay settings for group *n*, where *n* = 1, 2, 3, or 4. If *n* is not specified, default is the active settings group.
SET *name*	For all **SET** commands, jump ahead to a specific setting by entering the setting name, e.g., 50P1P.
SET DNP *n*	Modifies the DNP data map settings for map *n*, where *n* = 1, 2, or 3.
SET F	Modifies the front-panel settings.
SET G	Modifies the global settings.
SET I	Modifies the IEC 60870-5-103 settings.
SET L *n*	Modifies the SELOGIC variable and timer settings for group *n*, where *n* = 1, 2, 3, or 4. If *n* is not specified, default is the active settings group.
SET M	Modifies the Modbus User Map settings.

Comando del Puerto Serial	Descripción del Comando
GRUPO *n*	Usar Grupo de configuraciones *n*, donde *n* = 1, 2, 3 o 4.
INI HIF	INI HIF Reinicia el proceso de sintonización HIF (24Hrs).
L_D	Cargar un firmware nuevo.
LOO	Habilitar loopback de los canales MIRRORED BITS.
LOO A	Habilitar loopback en Canal MIRRORED BITS A por los siguientes 5 minutos.
LOO B	Habilitar prueba loopback en Canal MIRRORED BITS B por los siguientes 5 minutos.
LOO R	Deshabilita loopback en canales MB A y B.
LOO *xx* DATA	Habilita loopback for xx minutos y permite modificar valores RMB.
ABR	Abrir el interruptor.
PARTNO	Cambia el número de parte del relé use despues de cambiar una tarjeta del relé.
PAS 1	Cambiar la contraseña del Nivel de Acceso 1.
PAS 2	Cambiar la contraseña del Nivel de Acceso 2.
PUL OUT*nnn*	Pulsar el contacto de salida *nnn*.
PUL OUT*nnn s*	Pulsar el contacto de salida *nnn* (*nnn* = OUT101…) por *s* (de 1 a 30, el numero predeterminado es 1) segundos.
R_S	Resetea el relé usando ajustes y passwords por defacto y después reinicia el relé. Disponible solamente después de una actualización de firmware.
AJU *n*	Modificar el grupo *n* de ajustes del relé, donden *n* =1, 2, 3 o 4. Si no se especifica n, se modifica el grupo activo.
AJU *name*	Para todos los comandos **SET**, adeléntese a un ajuste ingresando el nombre del ajuste, por ejemplo, 50P11P.
AJU DNP *n*	Modificar la configuración del mapa de datos DNP para el mapa *n*, donde *n* = 1, 2 o 3.
AJU F	Modificar la configuración del panel frontal.
AJU G	Modificar las ajustes globales.
AJU I	Modificar ajustes IEC 60870-5-103.
AJU L *n*	Modifica ajustes SELOGIC, laches, variables lógicas (SV) y matemáticas (MV) en el grupo de ajustes n. Si no se especifica n, se modifica el grupo activo.
AJU M	Modificar las configuración del Mapa del Usuario Modbus.

Serial Port Command	Command Description
SET P *n*	Modifies the port *n* settings, where *n* = 1, 2, 3, 4, or F. If not specified, the default is the active port.
SET R	Modifies the report settings.
SET … TERSE	For all **SET** commands, **TERSE** disables the automatic **SHO** command after the settings entry.
STA C or **R**	Clears the self-test status and restarts the relay.
TEST DB	Displays the present status of digital and analog overrides.
THE P	Loads the preset value of thermal capacity used in the IEC line/cable thermal element.
THE R	Resets the calculated thermal capacity used in the IEC line/cable thermal element.
VEC D	Displays the diagnostic vector report.
VEC E	Displays the exception vector report.
Access Level CAL Commands	
PAS C	Changes the Access Level C password.

Comando del Puerto Serial	Descripción del Comando
AJU P *n*	Modificar la configuración del puerto *n*, donde *n* = 1, 2, 3, 4 o F. Si *n* no está especificado, el puerto predeterminado es el puerto activo.
AJU R	Modificar la configuración de reportes.
AJU...TERSO	Para todos los comandos **AJU**, **TERSO** desactiva los comandos automáticos **MOS** después de modificar las configuraciones.
EST C o **R**	Salir del modo de diagnostico automático y reiniciar el relé.
TEST DB	Mostrar el estado actual de variable digitales y analógicas con valores forzados.
THE P	Cargar valores predeterminados de capacidad térmica en el elemento térmico IEC de líneas y cables.
THE R	Reinicia la capacidad térmica calculada usada en el elemento térmico IEC de líneas y cables.
VEC D	Mostar reporte standard de reinicio del relé.
VEC E	Mostar reporte de reinicio del relé.
Comandos del Nivel del Acceso C	
PAS C	Cambiar la contraseña del Nivel de Acceso C.

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