SEL-751
Feeder Protection Relay

Instruction Manual

20241231

SEL SCHWEITZER ENGINEERING LABORATORIES

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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, safety information, 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 Interface. Describes the built-in web server and its features, including settings, metering and monitoring, reports, and firmware upgrade. Also describes the features, installation methods, and types of help available with the ACSELERATOR QuickSet SEL-5030 Software.

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

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

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

Section 7: Communications. Describes how to connect the SEL-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 relay 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 Communications. Describes the Modbus protocol support provided by the SEL-751.

Appendix F: EtherNet/IP Communications. Describes the EtherNet/IP support provided by the SEL-751.

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

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

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

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

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

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

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

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

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

Safety Information

Dangers, Warnings, and Cautions

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

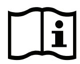
⚠DANGER
Indicates an imminently hazardous situation that, if not avoided, **will** result in death or serious injury.

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

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

Safety Symbols

The following symbols are often marked on SEL products.

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

Safety Marks

The following statements apply to this device.

General Safety Marks

⚠CAUTION There is danger of explosion if the battery is incorrectly replaced. Replace only with Panasonic no. BR1632A or equivalent recommended by manufacturer. See Owner's Manual for safety instructions. The battery used in this device may present a fire or chemical burn hazard if mistreated. Do not recharge, disassemble, heat above 100°C or incinerate. Dispose of used batteries according to the manufacturer’s instructions. Keep battery out of reach of children.	**⚠ATTENTION** Une pile remplacée incorrectement pose des risques d’explosion. Remplacez seulement avec un Panasonic no. BR1632A ou un produit équivalent recommandé par le fabricant. Voir le guide d’utilisateur pour les instructions de sécurité. La pile utilisée dans cet appareil peut présenter un risque d’incendie ou de brûlure chimique si vous en faites mauvais usage. Ne pas recharger, démonter, chauffer à plus de 100°C ou incinérer. Éliminez les vieilles piles suivant les instructions du fabricant. Gardez la pile hors de la portée des enfants.
⚠CAUTION 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.	**⚠ATTENTION** Pour assurer la sécurité et le bon fonctionnement, il faut vérifier les classements d’équipement ainsi que les instructions d’installation et d’opération avant la mise en service ou l’entretien de l’équipement. Il faut vérifier l’intégrité de toute connexion de conducteur de protection avant de réaliser d’autres actions. L’utilisateur est responsable d’assurer l’installation, l’opération et l’utilisation de l’équipement pour la fonction prévue et de la manière indiquée dans ce manuel. Une mauvaise utilisation pourrait diminuer toute protection de sécurité fournie par l'équipement.
For use in Pollution Degree 2 environment.	Pour l'utilisation dans un environnement de Degré de Pollution 2.
Per UL compliance, ambient air temperature shall not exceed 50°C (122°F).	Conforme à la norme UL, la température de l'air ambiant ne doit pas dépasser 50°C (122°F).
For use on a flat surface of a Type 1 enclosure.	Destiné à l'utilisation sur une surface plane d'un boîtier de Type 1.
Terminal Ratings Wire Material Use 75°C (167°F) copper conductors only. Tightening Torque 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: 0.18–0.25 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 : 0,18–0,25 Nm (1,6–2,2 livres-pouce)

Hazardous Locations Safety Marks

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

Compliance Approvals

Hazardous Locations Approvals

The SEL-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 T3C in the maximum surrounding air temperature of 50°C.

The SEL-751 shall be installed in an indoor or outdoor (extended) locked enclosure that provides a degree of protection to personnel against access to hazardous parts. In either environment, the relay shall be protected from direct sunlight, precipitation, and full wind pressure.

To comply with the requirements of the European ATEX standard for hazardous location, the SEL-751 shall be installed in an ATEX-certified enclosure with a tool-removable door or cover that provides a degree of protection not less than IP54, in accordance with EN 60079-0. The enclosure shall be limited to the surrounding air temperature range of –20°C ≤ Ta ≤ +50°C. The enclosure should be certified to these requirements or be tested for compliance as part of the complete assembly. The enclosure must be marked "WARNING—Do not open when an explosive atmosphere is present."

Other Safety Marks (Sheet 1 of 2)

⚠DANGER Disconnect or de-energize all external connections before opening this device. Contact with hazardous voltages and currents inside this device can cause electrical shock resulting in injury or death.	⚠DANGER Débrancher tous les raccordements externes avant d'ouvrir cet appareil. Tout contact avec des tensions ou courants internes à l'appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.
⚠DANGER Contact with instrument terminals can cause electrical shock that can result in injury or death.	⚠DANGER Tout contact avec les bornes de l'appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.
⚠WARNING Use of this equipment in a manner other than specified in this manual can impair operator safety safeguards provided by this equipment.	⚠AVERTISSEMENT L'utilisation de cet appareil suivant des procédures différentes de celles indiquées dans ce manuel peut désarmer les dispositifs de protection d'opérateur normalement actifs sur cet équipement.
⚠WARNING Have only qualified personnel service this equipment. If you are not qualified to service this equipment, you can injure yourself or others, or cause equipment damage.	⚠AVERTISSEMENT Seules des personnes qualifiées peuvent travailler sur cet appareil. Si vous n'êtes pas qualifiés pour ce travail, vous pourriez vous blesser avec d'autres personnes ou endommager l'équipement.
⚠WARNING Always isolate the relay control circuits before performing any modifications to the relay.	⚠AVERTISSEMENT Il faut toujours isoler les circuits de commande du relais avant d'apporter des modifications au relais.

Other Safety Marks (Sheet 2 of 2)

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

General Information

Typographic Conventions

There are many ways to communicate with the SEL-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 QuickSet.

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

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

Trademarks

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

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

acSELerator Architect®	SEL-2407®
acSELerator QuickSet®	SELogic®
Arc Sense™	Synchrowave®
Best Choice Ground Directional Element®	synchroWAVe®
Mirrored Bits®	time-overlight®

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.

LED Emitter

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

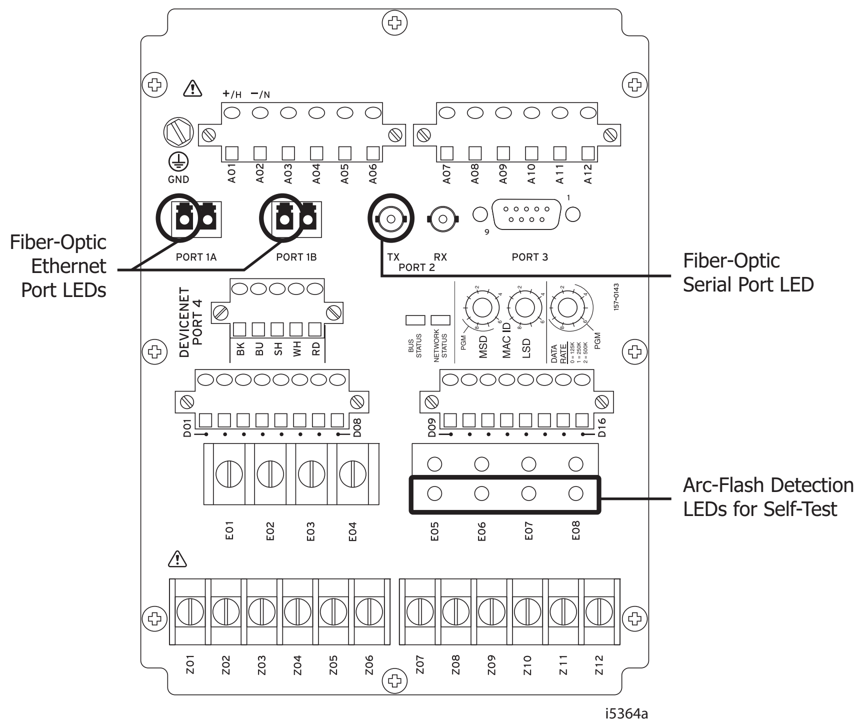
⚠CAUTION
Looking into optical connections, fiber ends, or bulkhead connections can result in hazardous radiation exposure.

The following table shows LED information specific to the SEL-751 (see *Figure 2.12* 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 2.12* 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]	As high as 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	As high as ±10% of nominal voltage
Overvoltage	Category II
Pollution	Degree 2
Atmospheric pressure	80 to 110 kPa

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

Wire Sizes and Insulation

NOTE: Make sure to select an appropriate lug size that is compatible with the SEL relay terminal block. While terminal blocks can accept wire sizes as large as 10 AWG, all SEL qualification testing of terminal blocks is performed with ring or fork terminals for wire sizes as high as 12 AWG.

For standard wiring connections, use 105°C-rated wiring. Wire sizes for grounding (earthing), current, voltage, and contact connections are dictated by the terminal blocks and expected load currents. You can use the following table as a guide in selecting wire sizes. Refer to the application note *Wiring SEL-2400, SEL-2200, and SEL-700 Series Devices* (AN2014-08) for wiring and termination guidance. Strip the wires 8 mm (0.31 in) for installation and termination.

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

[a] See Table 2.21: 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 Support

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

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Section 1
Introduction and Specifications

Overview

The SEL-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, and directional control-based protection, as well as high-impedance fault and broken conductor detection 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), with the number “7” (for LEA phase voltage sensor RJ45 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 Model Options Table (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).

When selected with the “7L” MOT option, the Slot Z card comes with a 4 ACI and 3 AVI LEA card. The card supports three current channels, three Rogowski coil or low-power current inputs, and one 200 mA neutral input. It additionally supports three LEA voltage sensor inputs. Refer to *Section 4: Protection and Logic Functions* for settings and examples related to LEA connections. The current and voltage channels accept an RJ45 connector input and the 200 mA neutral channel accepts a terminal block input, as shown in *Figure 1.1*.

Figure 1.1 Slot Z LEA Card With Rogowski Coil Connection for Current Input

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 Model Options Table (MOT). For example, “70” in the MOT for Slot E indicates a SELECT 2 AVI/4 AFDI card with Vsync (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
Rogowski Coil or Low-Power Current Transformer Input Phase, 200 mA Neutral	L

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

Table 1.2 Current (ACI) and Voltage (AVI) Card Selection Options 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 AC Currents Only	4 ACI (A1, A2, A3, A5, A6, A7)	IA, IB, IC, IN	None (0X)	None
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
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 Detection 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 With LEA Voltage Sensor Inputs, Rogowski Coil or Low-Power Current Inputs, 200 mA Neutral Inputs, and 7 Digital Inputs	4 ACI/3 AVI (7L)	IA, IB, IC, IN, VA, VB, VC	2 AVI/7 DI (LA, LB, LC, LD, LG, LH)	VS, VBAT, 7DI

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 Card (Current Only Model) With 1 A or 5 A Neutral Channel	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/ 3 AVI LEA Card With 200 mA Neutral Channel
50P	Max. Phase Overcurrent	X	X	X	X
67P	Max. Phase Overcurrent With Directional Control		X[a]	X[b]	X[b]
50Q	Neg.-Seq. Overcurrent	X	X	X	X
67Q	Neg.-Seq. Overcurrent With Directional Control		X[a]	X[b]	X[b]
50G	Residual Overcurrent	X	X	X	X
67G	Residual Overcurrent With Directional Control		X[a]	X[b]	X[b]
50N	Neutral Overcurrent	X	X	X	X
67N	Neutral Overcurrent With Directional Control			X[b]	X[b]
50INC	Incipient Cable Fault Detection	X	X	X	X

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

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

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

Protection Element		Slot Z 4 ACI Card (Current Only Model) With 1 A or 5 A Neutral Channel	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/ 3 AVI LEA Card With 200 mA Neutral Channel
BCD	Broken Conductor Detection		X[d,e]	X[d,e]	X[d,e]
CLPU	Cold Load Pickup Element	X	X	X	X
97FM	Frequency Magnitude Element		X	X	X

[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 with the 2 AVI/4 AFDI or 2 AVI/7 DI card in Slot E.
[d] Available as ordering options.
[e] Available only for models with Arc-Sense Technology.

Front-Panel Options

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

[a] For ordering options, refer to the SEL-751 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 Recorder (SER)
- ➤ Compatibility with SEL-3010 Event Messenger
- ➤ A complete suite of accurate metering functions
- ➤ Breaker wear monitoring
- ➤ Load profile report
- ➤ HIF compressed event report (option)
- ➤ 97FM elements for frequency component detection

Communications and Control Features

- ➤ EIA-232, front-panel port
- ➤ EIA-232, EIA-485, single or dual, copper or fiber-optic Ethernet, and fiber-optic rear-panel EIA-232 ports
- ➤ Built-in web server
- ➤ IRIG-B time-code input

- Modbus RTU slave, Modbus TCP/IP, Simple Network Time Protocol (SNTP), Precision Time Protocol (PTP), DNP3 serial, DNP3 LAN/WAN, Ethernet FTP, Telnet, MIRRORED BITS, Event Messenger, IEC 61850 Edition 2.1, IEC 60870-5-103, DeviceNet, EtherNet/IP, Synchrophasors with C37.118-2005 Protocol, Parallel Redundancy Protocol (PRP), and Rapid Spanning Tree Protocol (RSTP)
- SEL ASCII, Compressed ASCII, Fast Meter, Fast Operate, Fast SER, and Fast Message Protocols
- Programmable Boolean and math operators, logic functions, and analog compare

Language Support

- The standard relay front-panel overlay is in English; a Spanish overlay is available as an ordering option. Text displayed on the HMI display will correspond to the ENGLISH or SPANISH ordering option.
- All of the ASCII 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.
- The web server reports can be displayed in English or Spanish by setting the Ethernet Port 1 setting LANG to either ENGLISH or SPANISH.

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 at selinc.com on the SEL-751 product page under Documentation > Ordering Information. Options and accessories are as follows:

SEL-751 Base Unit

- Front panel with two-line display or with touchscreen display
  - Four 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
- Three expansion slots for optional cards (Slots **C**, **D**, **E**)
- Four ac current inputs (1 A/5 A/200 mA neutral only) (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 C37.118-2005

- Breaker wear monitoring

Options

- Firmware options
  - Autoreclosing control
  - Directional control for overcurrent elements (solid or low-impedance grounded systems only)
  - Advanced directional control for overcurrent elements (low-impedance grounded systems; ungrounded, high-impedance grounded systems; and Petersen coil-grounded systems—requires 200 mA neutral CT)
  - HIF detection using Arc Sense technology
- Current/Voltage input options (see *Table 1.1* and *Table 1.2*)
- 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
- 2 AVI/7 DI card option with
  - Synchronism-check voltage input (300 V or 8 V LEA)
  - DC station battery monitor
  - 7 digital 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/Fiber-optic EIA-232/Ethernet ports (single/dual, copper or fiber-optic)
  - SNTP
  - FTP
  - PTP (firmware-based for FAILOVER and FIXED modes and hardware-based for PRP)
  - PRP
  - RSTP
  - Modbus TCP/IP
  - IEC 61850 Edition 2.1
  - IEC 60870-5-103
  - EtherNet/IP
  - DNP3 serial and LAN/WAN
  - DeviceNet (**Note:** This option has been discontinued and is no longer available as of September 25, 2017.)

- 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 62.5/200 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 Euro Connector Kit
- Ring Terminal Kit for all connections to the relay
- Dust Protection Kit
- Relay Wire Termination Kits—See *Application Note AN2014-08*.
- IP terminal block covers

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

Applications

The SEL-751 Feeder Protection Relay has many power system protection, monitoring, and control applications. *Figure 1.2* 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.

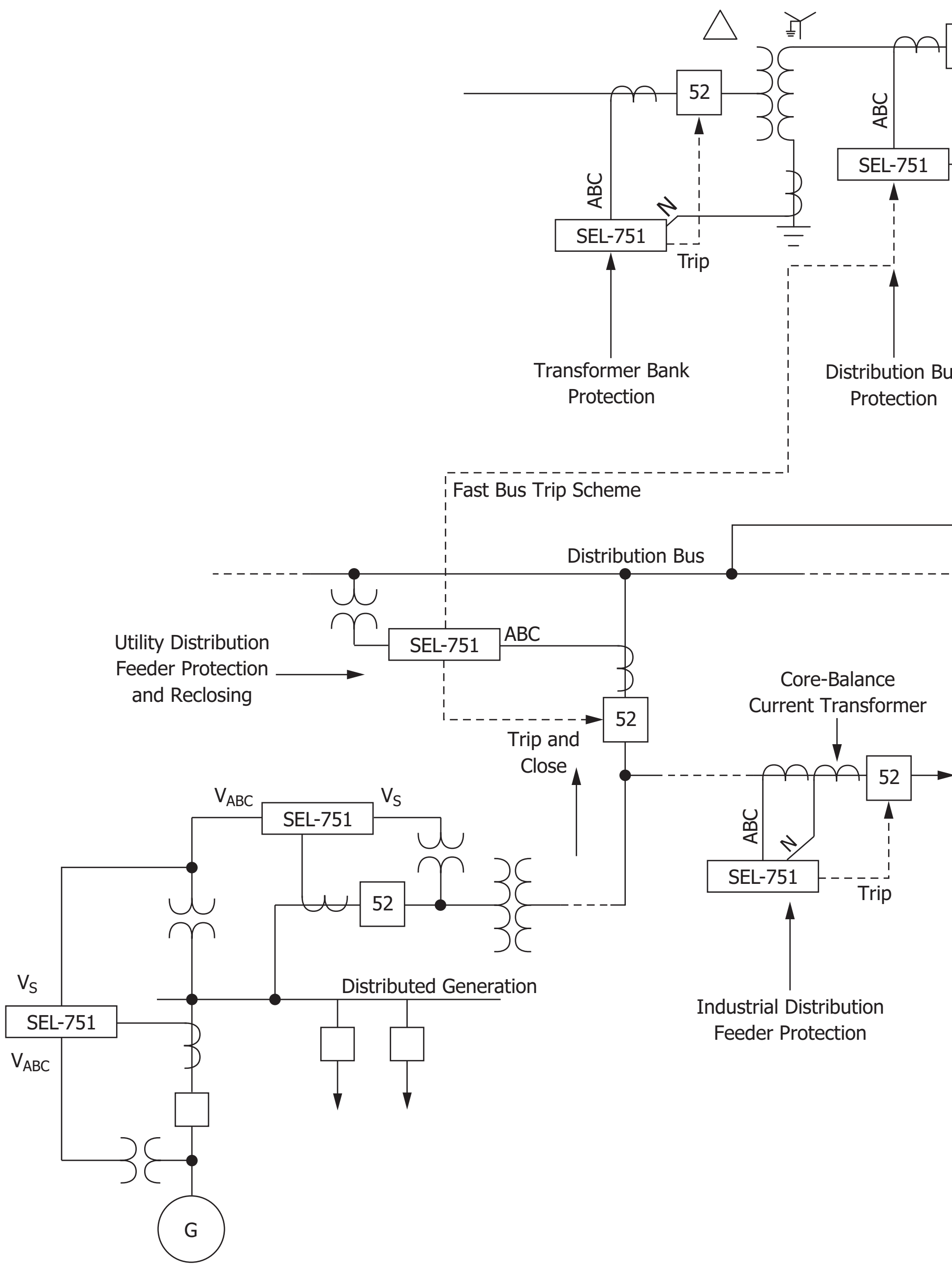

Figure 1.2 SEL-751 Feeder Protection Relay Applied Throughout the Power System

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
- HIF detection and protection for feeders

Figure 1.3 shows typical current connections. Refer to *Section 2: Installation* for additional applications and the related connection diagrams.

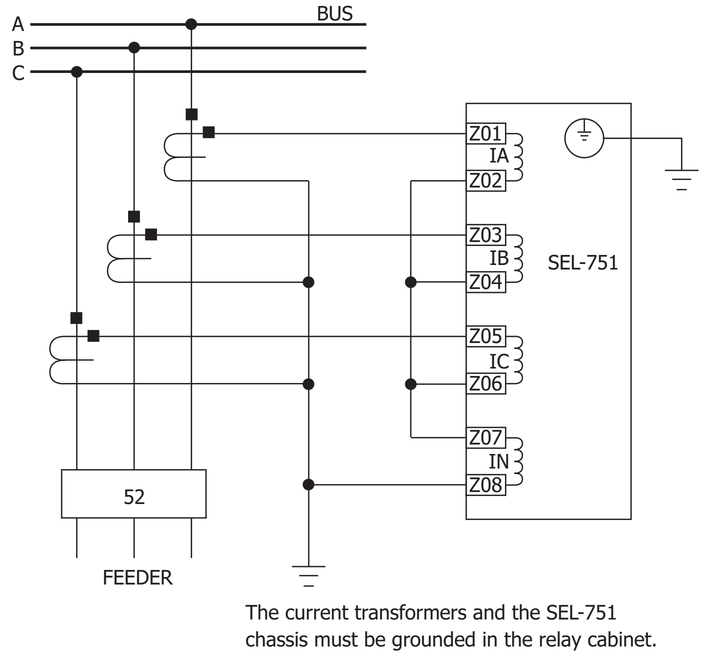

Figure 1.3 Typical Current Connections

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 the 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 2.27*.
- ➤ 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-C234A Cable (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 1.4*. 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 1.4 Response Header

Step 7. Type **ACC <Enter>** and the appropriate password (see *Table 7.45* for factory-default passwords) to go to Access Level 1.

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

Checking the 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 1.5*.

```
=>>STA <Enter>

=>STA

SEL-751                                   Date: 01/02/2000   Time: 21:28:32.222
FEEDER RELAY                              Time Source: Internal

Serial Num = 3221230120     FID = SEL-751-X607-V0-Z100001-D20230202
CID = 230A                  PART NUM = 751001BBX9X0X86A00X

SELF TESTS (W=Warn)
  FPGA  GPSB  HMI   RAM   ROM   CR_RAM  NON_VOL  CLOCK  +0.675V  +0.675VD
  OK    OK    OK    OK    OK    OK      OK       OK     0.68     0.68

  +1.0V  +1.1V  +1.35V  +1.8V  +3.3V  +3.75V  +5.0V  -1.25V  -5.0V  BATT
  1.01   1.09   1.34    1.79   3.35   3.78    5.06   -1.25   -4.98  2.99

Option Cards
  CARD_C  CARD_D  CARD_E  CARD_Z
  OK      OK      OK      OK

Offsets
   IA    IB    IC    IN    VA    VB    VC
  0     0     0     0     0     0     0

  Relay Enabled

=>>
```

Figure 1.5 STA Command Response

If a communications card with the DeviceNet protocol is present, the status report depicted in *Figure 1.6* applies. If a communications card with Modbus RTU protocol is present, the status report depicted in *Figure 1.5* applies.

```
=>STA <Enter>

SEL-751                                   Date: 01/02/2000   Time: 21:28:32.222
FEEDER RELAY                              Time Source: Internal

Serial Num = 3221230120     FID = SEL-751-X607-V0-Z100001-D20230202
CID = 230A                  PART NUM = 751001BBX9X0X86A00X

SELF TESTS (W=Warn)
  FPGA  GPSB  HMI   RAM   ROM   CR_RAM  NON_VOL  CLOCK  +0.675V  +0.675VD
  OK    OK    OK    OK    OK    OK      OK       OK     0.68     0.68

  +1.0V  +1.1V  +1.35V  +1.8V  +3.3V  +3.75V  +5.0V  -1.25V  -5.0V  BATT
  1.01   1.09   1.34    1.79   3.35   3.78    5.06   -1.25   -4.98  2.99

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
  0     0     0     0     0     0     0

  Relay Enabled

=>
```

Figure 1.6 STA Command Response—Communications Card/DeviceNet Protocol

Table 7.61 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 1.6*) 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.

CE Mark

RCM Mark

UKCA Mark

Normal Locations

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.

Hazardous Locations

UL Certified for Hazardous Locations to U.S. and Canadian standards CL 1, DIV 2; GP A, B, C, D; T3C, maximum surrounding air temperature of 50°C (File E470448)

EU

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

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

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

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

General

AC Current Input

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

Measurement Category:	II

Phase and Neutral Currents

I_{NOM} = 5 A

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

I_{NOM} = 1 A

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

I_{NOM} = 200 mA

Continuous Rating:	4 A
A/D Measurement Limit:	8.4 A peak (6 Arms symmetrical)
Saturation Current Rating:	Linear to 4 A symmetrical
1-Second Thermal:	500 A
Burden (per phase):	<0.01 VA @ 0.2 A

Rogowski Coil-Based AC Current Inputs—Phase Currents

Continuous Rating:	30 Vrms
Nominal Input Voltage:	65 mV to 4.16 Vrms
Number of Gain Ranges:	6
Full Scale Voltage:	4, 8, 16, 32, 64, 128 Vrms
A/D Measurement Limit:	±185 V_{peak}
10-Second Thermal:	200 Vac
Input Impedance:	2 MΩ‖50 pF
Standard Compliance:	IEC 61869-6 IEC 61869-13

Low-Power Current Transformer (LPCT) Inputs—Phase Currents

Continuous Rating:	4 Vrms
Nominal Input Voltage:	16 mV to 260 mVrms
Number of Gain Ranges:	4
Full Scale Voltage:	1, 2, 4, 8 Vrms
A/D Measurement Limit:	±11.3 V_{peak}
10-Second Thermal:	200 Vac
Input Impedance:	2 MΩ‖50 pF
Standard Compliance:	IEC 61869-6 IEC 61869-13

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 (phase-to-neutral)
10-Second Thermal:	600 Vac (phase-to-neutral)
A/D Measurement Limit:	315 Vrms

	Burden	Input Impedance (Per Phase)	Input Impedance (Phase-to-Phase)
Vphase	0.008 VA @ 120 Vac	2 MΩ	4 MΩ
Vbat/Vs	0.003 VA @ 120 Vac	5 MΩ	

Low-Energy Analog (LEA) Voltage Inputs (Euro Connector Input)

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)
Input Impedance:	2 MΩ single-ended (phase-to-neutral) 4 MΩ differential (phase-to-phase)

Low-Energy Analog Voltage Sensor Inputs (RJ45 Input)

Continuous Rating:	8 Vrms
Nominal Input Voltage:	0.5–6.8 Vrms
Full-Scale Voltage:	8 Vrms
A/D Measurement Limit:	±12 V_{peak} @ 60 Hz
10-Second Thermal:	200 Vac
Input Impedance:	2 MΩ‖50 pF
Standard Compliance:	IEC 61869-6 IEC 61869-13

Power Supply

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

High-Voltage Supply

Rated Supply Voltage:	110–240 Vac, 50/60 Hz 110–250 Vdc
Input Voltage Range (Design Range):	85–264 Vac 85–300 Vdc
Power Consumption:	<55 VA (ac) <25 W (dc)
Interruptions:	50 ms @ 125 Vac/Vdc 100 ms @ 250 Vac/Vdc

Low-Voltage Supply

Rated Supply Voltage:	24–48 Vdc
Input Voltage Range (Design Range):	19.2–60.0 Vdc
Power Consumption:	<25 W (dc)
Interruptions:	10 ms @ 24 Vdc 50 ms @ 48 Vdc

Fuse Ratings

Low-Voltage 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

High-Voltage Power Supply Fuse

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

Output Contacts

General

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

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

Standard Contacts

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

DC Output Ratings

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

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

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

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

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

AC Output Ratings

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

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

Utilization Category:	AC-15

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

Voltage Protection Across Open Contacts:	270 Vac, 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-Second Thermal:	50 A
Open State Leakage Current:	<500 µA
MOV Protection (maximum voltage):	250 Vac/330 Vdc

Pickup Time:	<50 µs, resistive load
Dropout Time:	<8 ms, resistive load

Breaking Capacity (10,000 Operations):

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

Cyclic Capacity (4 Cycles in 1 Second, Followed by 2 Minutes Idle for Thermal Dissipation):

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

AC Output Ratings

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

Optoisolated Control Inputs

When Used With DC Control Signals

Pickup/Dropout Time:	Depends on the input debounce settings
250 V:	ON for 200.0–312.5 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

Pickup Time:	2 ms
Dropout Time:	16 ms
250 V:	ON for 170.6–312.5 Vac OFF below 106 Vac
220 V:	ON for 150.2–275 Vac OFF below 93.3 Vac
125 V:	ON for 85–156.2 Vac OFF below 53 Vac
110 V:	ON for 75.1–137.5 Vac OFF below 46.6 Vac
48 V:	ON for 32.8–60 Vac OFF below 20.3 Vac
24 V:	ON for 14–30 Vac OFF below 5 Vac

Current Draw at Nominal DC Voltage:	2 mA (at 220–250 V) 4 mA (at 48–125 V) 10 mA (at 24 V)
Rated Impulse Withstand Voltage (U_{imp}):	4000 V

Analog Output (Optional)

	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
SNTP Accuracy:	±1 ms (in an ideal network)
PTP Accuracy:	±1 ms for firmware-based PTP ±250 ns for hardware-based PTP
Unsynchronized Clock Drift Relay Powered:	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)

EIA-232 Multimode Fiber-Optic Port (Optional)

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 RTU and TCP/IP, DNP3 serial and LAN/WAN, FTP, Telnet, SNTP, PTP, IEC 61850 Edition 2.1, IEC 60870-5-103, EtherNet/IP, PRP, IEEE 802.1Q-2014 RSTP, MIRRORED BITS, EVMSG, IEEE C37.118-2005 (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: The front-panel display is impaired for temperatures below –20°C and above +70°C.

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

Operating Environment

Insulation Class:	1
Pollution Degree:	2
Overvoltage Category:	II
Atmospheric Pressure:	80–110 kPa
Relative Humidity:	5%–95%, noncondensing
Maximum Altitude Without Derating (Consult the Factory for Higher Altitude Derating):	2000 m

Dimensions

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

Weight

2.7 kg (6.0 lb)

Relay Mounting Screw (#8-32) Tightening Torque

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

Terminal Connections

Terminal Block

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

Terminal Block Tightening Torque

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

Compression Plug Tightening Torque

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

Compression Plug Mounting Ear Screw Tightening Torque

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

RTD Compression Plug Tightening Torque

Maximum:	0.25 Nm (2.2 in-lb)

Product Standards

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

Type Tests

Environmental Tests

Enclosure Protection:	IEC 60529:2001 + CRDG:2003 IP65 enclosed in panel (2-line display models) IP54 enclosed in panel (touchscreen models) IP50 for terminals enclosed in the dust-protection assembly (protection against solid foreign objects only) (SEL Part #915900170). The 10°C temperature derating applies to the temperature specifications of the relay. IP10 for terminals and the relay rear panel IP20 for terminals and the relay rear panel with optional terminal block cover

Note: If rear terminals are accessible during normal use, the product must be mounted in a locked enclosure or restricted area accessible by trained maintenance or operation personnel only.

Vibration Resistance:	IEC 60255-21-1:1988 IEC 60255-27:2013, Section 10.6.2.1 Endurance: Class 2 Response: Class 2
Shock Resistance:	IEC 60255-21-2:1988 IEC 60255-27:2013, Section 10.6.2.2 IEC 60255-27:2013, Section 10.6.2.3 Withstand: Class 1 Response: Class 2 Bump: Class 1
Seismic (Quake Response):	IEC 60255-21-3:1993 IEC 60255-27:2013, Section 10.6.2.4 Response: Class 2
Cold:	IEC 60068-2-1:2007 IEC 60255-27:2013, Section 10.6.1.2 IEC 60255-27:2013, Section 10.6.1.4 –40°C, 16 hours
Dry Heat:	IEC 60068-2-2:2007 IEC 60255-27:2013, Section 10.6.1.1 IEC 60255-27:2013, Section 10.6.1.3 85°C, 16 hours
Damp Heat, Steady State:	IEC 60068-2-78:2001 IEC 60255-27:2013, Section 10.6.1.5 40°C, 93% relative humidity, 10 days
Damp Heat, Cyclic:	IEC 60068-2-30:2001 IEC 60255-27:2013, Section 10.6.1.6 25° to 55°C, 95% relative humidity, 6 cycles
Change of Temperature:	IEC 60068-2-14:2009 IEC 60255-1:2010, Section 6.12.3.5 –40° to +85°C, ramp rate 1°C/min, 5 cycles

Dielectric Strength and Impulse Tests

Dielectric (Hi-Pot):	IEC 60255-27:2013, Section 10.6.4.3 IEEE C37.90-2005 1.0 kVac on analog outputs, Ethernet ports, Port 3, IRIG 2.0 kVac on analog inputs 2.5 kVac on contact I/O 3.6 kVdc on power supply, current, and voltage inputs
Impulse:	IEC 60255-27:2013, Section 10.6.4.2 0.5 J, 5 kV on power supply, contact I/O, ac current, and voltage inputs 0.5 J, 1 kV on Port 3, RTD, and IRIG ports 0.5 J, 530 V on analog outputs IEEE C37.90:2005 0.5 J, 5 kV 0.5 J, 530 V on analog outputs

RFI and Interference Tests

Electrostatic Discharge Immunity:	IEC 61000-4-2:2008 IEC 60255-26:2013; Section 7.2.3 IEEE C37.90.3:2001 Severity Level 4 8 kV contact discharge 15 kV air discharge
Radiated RF Immunity:	IEC 61000-4-3:2010 IEC 60255-26:2013; Section 7.2.4 10 V/m IEEE C37.90.2-2004 20 V/m
Fast Transient, Burst Immunity[a]:	IEC 61000-4-4:2011 IEC 60255-26:2013; Section 7.2.5 4 kV @ 5.0 kHz 2 kV @ 5.0 kHz for comm. ports
Surge Immunity[a]:	IEC 61000-4-5:2005 IEC 60255-26:2013; Section 7.2.7 2 kV line-to-line 4 kV line-to-earth

Surge Withstand Capability Immunity[a]:	EN 61000-4-18:2010 IEC 60255-26:2013; Section 7.2.6 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 Comm. ports, IRIG, and PTC ports Zone B, 2 kV line-to-earth LEA ports compliant with IEC 61869-13 tested to 1 kV, 1 MHz common mode
Conducted RF Immunity:	IEC 61000-4-6:2008 IEC 60255-26:2013; Section 7.2.8 10 Vrms
Magnetic Field Immunity:	IEC 61000-4-8:2009 IEC 60255-26:2013, Section 7.2.10 Severity Level: 1000 A/m for 3 seconds 100 A/m for 1 minute; 50/60 Hz IEC 61000-4-9: 2001 Severity Level: 1000 A/m IEC 61000-4-10:2001 Severity Level: 100 A/m (100 kHz and 1 MHz)
Power Supply Immunity:	IEC 61000-4-11:2004 IEC 61000-4-17:1999 IEC 61000-4-29:2000 IEC 60255-26:2013, Section 7.2.11 IEC 60255-26:2013, Section 7.2.12 IEC 60255-26:2013, Section 7.2.13

EMC Emissions

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

Processing Specifications and Oscillography

AC Voltage and Current Inputs:	32 samples per power system cycle
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
Phase Discontinuity Detection:	Processing rate is once every 2 power system cycles
Cold Load Pickup:	Processing rate is once every 2 power system cycles
Broken Conductor Detection:	Processing rate is once every 2 power system cycles
Processing Rate:	Once every 2 power system cycles

Oscillography

Length:	15, 64, 180, or 300 cycles
Sampling Rate:	32 samples per cycle unfiltered 4 samples per cycle filtered
Trigger:	Programmable with Boolean expression
Format:	ASCII and Compressed ASCII Binary COMTRADE (32 samples per cycle unfiltered)

Note: Binary COMTRADE format as per IEEE C37.111-2013, IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems.

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):	±1 ms

Functional Requirements

Over- and Undercurrent Protection:	IEC 60255-151:2009
Over- and Undervoltage Protection:	IEC 60255-127:2010
Frequency Protection:	IEC 60255-181:2019

Relay Elements

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

Supported and Effective 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 models:	0.010–4.000 A, 0.001 A steps (50N)
Accuracy:	±3% of setting plus ±0.02 • I_{NOM} A secondary (steady state) ±5% of setting plus ±0.02 • I_{NOM} A secondary (transient) ±6% of setting plus ±0.02 • I_{NOM} A secondary (transient for 50Q)
Time Delay:	0.00–400.00 seconds, 0.01 seconds steps
Accuracy:	±0.5% plus ±0.25 cycle
Pickup/Dropout Time:	<1.75 cycles (with fast hybrid output contacts)
Reset Ratio:	95% for setting ≥0.1 • I_{NOM} 90% for setting <0.1 • I_{NOM}
Transient Overreach:	<15% for X/R = 10–120
Overshoot Time:	5 ms

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)

Supported Setting Range, A Secondary:

5 A models:	0.25–24.00 A, 0.01 A steps
1 A models:	0.05–4.8 A, 0.01 A steps
200 mA models:	10–960 mA, 0.01 mA steps (51N)

Effective Setting Range (IEC), A Secondary:

5 A models:	0.5–5.165 A, 0.01 A steps
1 A models:	0.1–1.03 A, 0.01 A steps
200 mA models:	10–206 mA, 0.01 mA steps (51N)
Lowest Value of Input Energizing Quantity for which the Relay is Guaranteed to Operate (G_T):	1.20 • setting
Threshold at which the Relay Switches from Dependent Time Operation to Independent Time Operation (G_D):	>30 • setting
Accuracy:	±5% of setting plus ±0.02 • I_{NOM} A secondary (steady state pickup)

Time Dial

U.S./IEEE:	0.50–15.00, 0.01 steps
IEC:	0.01–1.50, 0.01 steps
Accuracy (Operate Time):	±1.5 cycles, ±4% between 2 and 30 multiples of pickup (within A/D measurement limit)
Accuracy (Reset Time):	±1.5 cycles, ±4% between 0.5 and 0 multiples of pickup
Reset Ratio:	95% for setting ≥ 0.1 • I_{NOM} 90% for setting < 0.1 • I_{NOM}
Transient Overreach:	<15% for X/R = 10–120
Overshoot Time:	5–30 ms

Breaker Failure Instantaneous Overcurrent

Pickup Setting Range, A Secondary:

5 A models:	0.10–10.00 A, 0.01 A steps
1 A models:	0.02–2.00 A, 0.01 A steps
Accuracy:	±3% of setting plus ±0.02 • I_{NOM} A secondary (steady state)
Time Delay:	0.00–2.00 seconds, 0.01 second steps
Pickup/Dropout Time:	<1.5 cycles

IEC Thermal Element (49IEC)

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

Undervoltage (27P, 27PP, 27S)

Supported and Effective Setting Range:	OFF, 2.00–300.00 V, 0.01 V steps (phase elements, phase-to-phase elements with delta inputs or synchronism voltage input) OFF, 2.00–520.00 V, 0.01 V steps (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
Accuracy:	±0.5% plus ±0.25 cycle
Pickup/Dropout Time:	<1.75 cycles (with fast hybrid output contacts)
Reset Ratio:	106% for setting ≤ 10 V 101% for setting > 10 V
Overshoot:	35 ms

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

Supported and Effective Setting Range:	OFF, 2.00–300.00 V, 0.01 V steps (phase elements, phase-to-phase elements with delta inputs or synchronism voltage input) OFF, 2.00–520.00 V, 0.01 V steps (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
Accuracy:	±0.5% plus ±0.25 cycle
Pickup/Dropout Time:	<1.75 cycles (with fast hybrid output contacts)
Reset Ratio:	96% for setting ≤ 10 V 99% for setting > 10 V
Overshoot:	35 ms

Incipient Cable Fault (50INC)

Pickup Setting Range, A Secondary:	OFF, 0.50–50.00 A (phase), 0.01-A steps for 5 A OFF, 0.10–10.00 A (phase), 0.01-A steps for 1 A
Accuracy:	±5% of setting A secondary
Pickup time:	<1/2 cycle

Inverse-Time Undervoltage (27I)

Supported and Effective Setting Range:	OFF, 2.00–300.00 V, 0.01 V steps (phase elements, positive-sequence elements, phase-to-phase elements with delta inputs or synchronism-check voltage input) OFF, 2.00–520.00 V, 0.01 V steps (phase-to-phase elements with wye inputs)
Accuracy:	±1% of setting plus ±0.5 V
Pickup/Dropout Time:	<1.75 cycles (with fast hybrid output contacts)

Time Dial:	0.00–16.00 s
Accuracy:	±1.5 cyc plus ±4% between 0.95 and 0.1 multiples of pickup
Reset Ratio:	103% for setting ≤ 10 V 102% for setting > 10 V
Overshoot Time:	5–30 ms

Inverse-Time Overvoltage (59I)

Supported and Effective Setting Range:	OFF, 2.00–300.00 V, 0.01 V steps (phase elements, sequence elements, or phase-to-phase elements with delta inputs or synchronism voltage input) OFF, 2.00–520.00 V, 0.01 V steps (phase-to-phase elements with wye inputs)
Accuracy:	±1% of setting plus ±0.5 V
Time Dial:	0.00–16.00 s, 0.01 s steps
Accuracy:	±1.5 cyc plus ±4% between 1.05 and 5.5 multiples of pickup
Pickup/Dropout Time:	<1.75 cycles (with fast hybrid output contacts)
Reset Ratio:	96% for setting ≤ 10 V 99% for setting > 10 V
Overshoot Time:	5–30 ms

Harmonic Blocking

Pickup Range (% of fundamental):	5%–100%
Pickup Accuracy (A secondary):	
5 A models:	±5% plus ±0.10 A of harmonic current
1 A models:	±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°, 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, Three-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:	0.00–400.00 seconds, 0.01-second steps
Accuracy:	±0.5% plus ±0.25 cycle
Pickup/Dropout Time:	<5.5 cycles (with fast hybrid output contacts)
Reset Hysteresis:	<0.02 Hz

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
Accuracy:	±0.5% plus ±0.25 cycle

Synchronism Check (25)

Pickup Range, Secondary Voltage:	0.00–300.00 V
Pickup Accuracy, Secondary Voltage:	±1% plus ±0.5 V (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

Pickup Setting Range

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

Accuracy

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

Phase Discontinuity Detection

Pickup Setting Range:	0.01–1.00 pu, 0.01 steps
Accuracy:	±5% of setting above 0.15 pu
Processing rate:	Once every 2 power system cycles

Broken Conductor Detection

Sensitivity (Minimum Line Charging Current Required for Broken Conductor Detection):	15 mA secondary for 5 A 3 mA secondary for 1 A
Minimum Operating Time (After the Conductor Breaks and Series Arc Extinguishes):	4 cycles
Maximum Operating Time (After the Condcutor Breaks and Series Arc Extinguishes):	8 cycles
Time Delay for Zone 2:	OFF, 0–600 cycles, 1-cycle steps
Timer Accuracy:	±2 cycles
Processing Rate:	Once every 2 power system cycles

Cold-Load Pickup

Pickup Setting Range:	0–500 minutes, 1-minute steps
Accuracy:	0.5% ±2 cycles
Processing rate:	Once every 2 power system cycles

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 Ω 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 Fault/Alarm/Trip Time Delay:	Approx. 12 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 C37.118-2005 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 C37.118-2005 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)

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

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Section 2
Installation

Overview

The first steps in applying the SEL-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

The SEL-751 is EN 60255-27 certified at Installation/Overvoltage Category II and Pollution Degree 2. This allows mounting of the relay in weather protected locations not temperature controlled that do not exceed the temperature and humidity ratings for the relay. The SEL-751 is required to be mounted in an indoor or outdoor (extended) locked enclosure that provides a degree of protection to personnel against access to hazardous parts. In either environment, the relay shall be protected from direct sunlight, precipitation, and full wind pressure.

You can place the relay in extreme temperature and humidity locations. (See *Operating Temperature* and *Operating Environment on page 1.17*.) For EN 60255-27 certification, the SEL-751 rating is 2000 m (6562 ft) above mean sea level.

To comply with the requirements of the European ATEX standard for hazardous locations, the SEL-751 shall be installed in an ATEX-certified enclosure with a tool-removable door or cover that provides a degree of protection not less than IP54, in accordance with EN 60079-0. The enclosure shall be limited to the surrounding air temperature range of –20°C ≤ Ta ≤ +50°C. The enclosure should be certified to these requirements or be tested for compliance as part of the complete assembly. The enclosure must be marked “WARNING—Do not open when an explosive atmosphere is present.” In North America, the relay is approved for Hazardous Locations Class I, Division 2, Groups A, B, C, and D, and temperature class T3C with a maximum surrounding air temperature of 50°C.

Relay Mounting

To flush mount the SEL-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 IP 65 when the two-line display model is enclosed in a panel and rated IP54 when the touchscreen display model is enclosed in a panel.

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

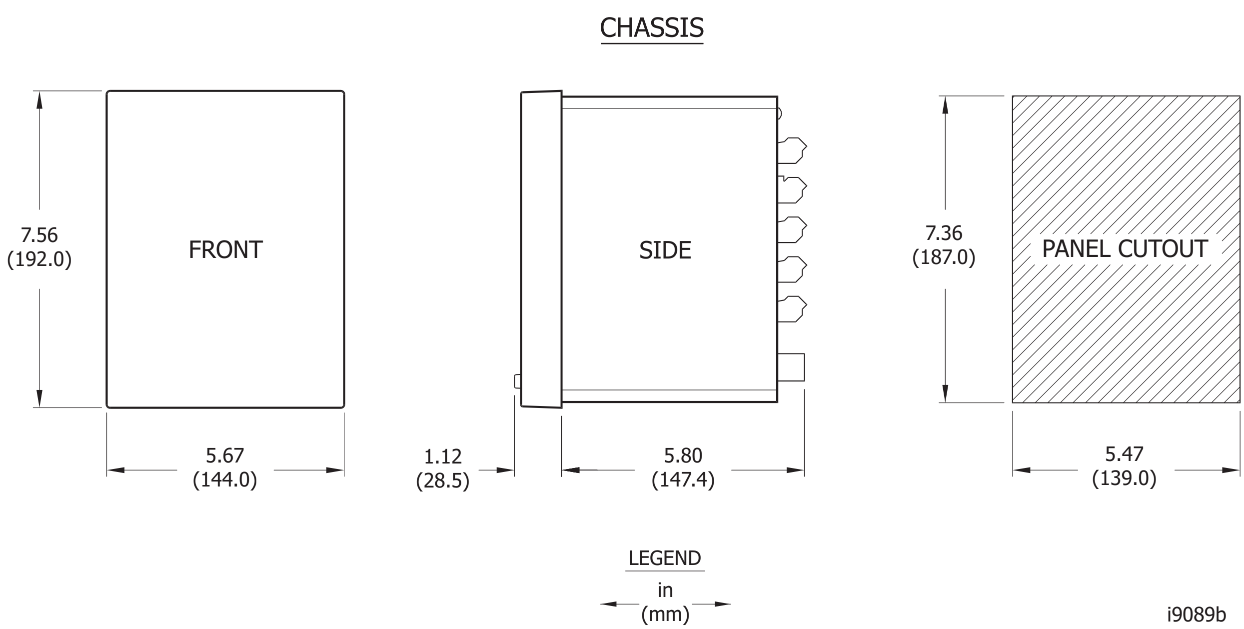


Figure 2.1 Relay Panel-Mount Dimensions

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

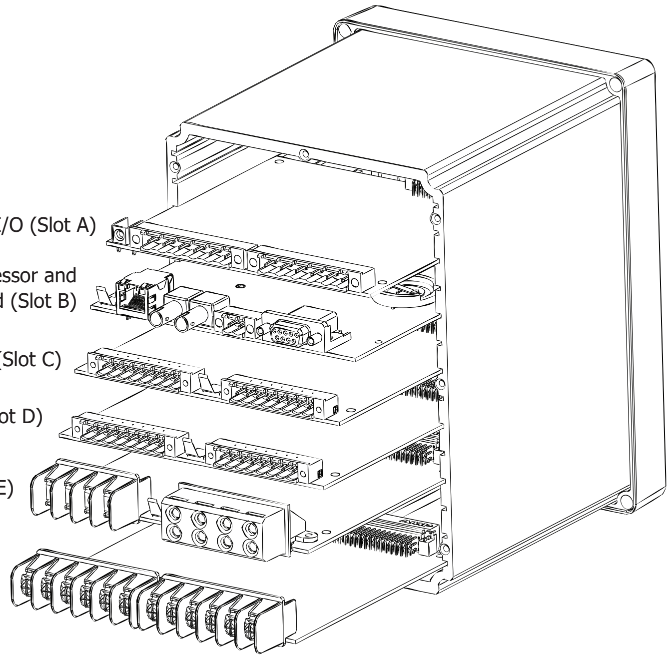
I/O Configuration

Your SEL-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.

The SEL-751 comes with an orange Euro connector on the Slot **A** card for the 24–48 Vdc low-voltage power supply and **C**, **D**, or **E** slots with the 24–48 Vdc/Vac digital input options. Relays manufactured after May 18, 2022, will be provided with an orange Euro connector for the low-voltage power supply and digital inputs. Refer to *Figure 2.19* and *Figure 2.21* for orange Euro connector examples.

The SEL-751 comes with 90-degree connectors as of July 21, 2023, on the Slot D board when the relay is configured with an arc-flash detection inputs card. Arc-flash detection cards can only be placed in Slot E.

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)		3 (e.g., IN301)	4 (e.g., OUT401)	5 (e.g., AI501)	
Description	Power supply and I/O card[a]	CPU/comm. card[b]	Comm. or input/ output[c] card	Input/output[c] or RTD card	Input/output[c] or voltage/arc-flash card	4 ACI/3 AVI card in base unit
Card Type						
SELECT EIA-232/485			●			
SELECT DeviceNet			●			
SELECT 3 DI/4 DO/1 AO (one card per relay)			●	●	●	
SELECT 4 DI/4 DO			●	●	●	
SELECT 4 DI/3 DO (1 Form B, 2 Form C)			●	●	●	
SELECT 8 DI			●	●	●	
SELECT 8 DO			●	●	●	
SELECT 8 AI			●	●	●	
SELECT 14 DI			●	●	●	
SELECT 4 AI/4 AO (one card per relay)			●	●	●	
SELECT 10 RTD				●		
SELECT 2 AVI/4 AFDI (MOT…x70x…)					●	
SELECT 2 AVI/4 AFDI (MOT…xL0x…)					●	

	Rear-Panel Slot					
	A	B	C	D	E	Z
Software Reference	1 (e.g., OUT101)		3 (e.g., IN301)	4 (e.g., OUT401)	5 (e.g., AI501)	
Description	Power supply and I/O card[a]	CPU/comm. card[b]	Comm. or input/output[c] card	Input/output[c] or RTD card	Input/output[c] or voltage/arc-flash card	4 ACI/3 AVI card in base unit
Card Type						
SELECT 2 AVI/7 DI (MOT…x7Xx…) where X = A to H					●	
SELECT 2 AVI/7 DI (MOT…xLXx…) where X = A to H					●	
SELECT 8 AFDI (MOT…x77x…)					●	
SELECT 4 ACI/3 AVI (MOT…x81/82/83/85/86/87x…)						●
SELECT 4 ACI/3 AVI (MOT…xL1/L2/L3/L5/L6/L7x…)						●
SELECT 4 ACI/3 AVI LEA (MOT…x7Lx…)						●
SELECT 4 ACI (MOT...xA1/A2/A3/A5/A6/A7x...)						●

[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)

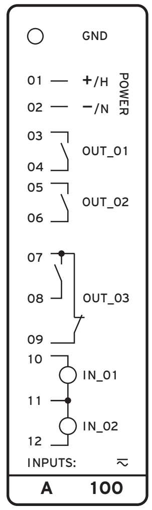
Select appropriate power supply option for the application:

- ➤ High Voltage: 110–240 Vac, 110–250 Vdc, 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 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:

- C37.118 (Synchrophasor Data)
- Modbus TCP/IP
- EtherNet/IP
- DNP3 LAN/WAN
- IEC 61850

- Simple Network Time Protocol (SNTP)
- Precision Time Protocol (PTP)
- 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 (Slot C)

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

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

- **Port 4A**, an isolated EIA-485 serial port interface
- **Port 4C**, 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 Card (4 ACI)

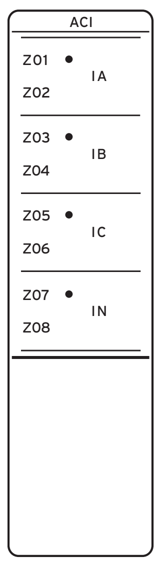
⚠WARNING
Before working on a CT circuit, first apply a short to the secondary winding of the CT.

MOT…xA1x…(1 A phase, 1 A neutral CTs), or **…xA5x…**(5 A phase, 5 A neutral CTs), or **…xA2x…**(1 A phase, 5 A neutral CTs), or **…xA6x…** (5 A phase, 1 A neutral CTs) or **…xA3x…**(1 A phase, 200 mA neutral CTs), or **…xA7x…**(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 CT.

The 4 ACI current card inputs terminal designation for the card is as shown in *Table 2.4*.

NOTE: Terminals Z09–Z12 on the 4 ACI card are not functional.

Table 2.4 Current Inputs (4 ACI) Card Terminal Designations

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

Current/Voltage Card (4 ACI/3 AVI)

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

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

MOT…x81x…(1 A phase, 1 A neutral CTs), or **…x85x…**(5 A phase, 5 A neutral CTs), or **…x82x…**(1 A phase, 5 A neutral CTs), or **…x86x…** (5 A phase, 1 A neutral CTs) 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.

MOT…x7Lx… Rogowski coil or LPCT phase, 200 mA neutral CTs and LEA voltage sensor inputs. Supported in Slot Z of the SEL-751, this card has current inputs for three-phase Rogowski coil or LPCTs, neutral current CTs, and LEA voltage sensor 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 2.5*.

Table 2.5 Current/Voltage Inputs (4 ACI/3 AVI) Card Terminal Designations

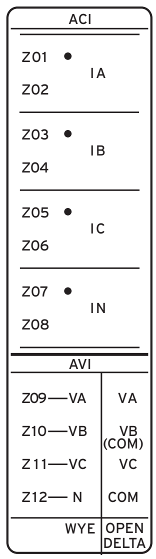
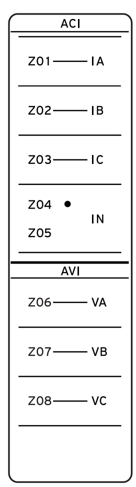
Side-Panel Connections Label	Terminal Number	Description
	Z01	IA, A-Phase current input
	Z02	
	Z03	IB, B-Phase current input
	Z04	
	Z05	IC, C-Phase current input
	Z06	
	Z07	IN, Neutral current input
	Z08	
	Z09	VA, A-Phase voltage input
	Z10	VB, B-Phase voltage input
	Z11	VC, C-Phase voltage input
	Z12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

Table 2.6 Current/Voltage Inputs (4 ACI/3 AVI) LEA Card Terminal Designations

Side-Panel Connections Label	Terminal Number	Description
	Z01	IA, A-phase current input
	Z02	IB, B-phase current input
	Z03	IC, C-phase current input
	Z04	IN, neutral current input
	Z05	
	Z06	VA, A-phase voltage input
	Z07	VB, B-phase voltage input
	Z08	VC, C-phase voltage input

The pinout assignments for RJ45 connector are in accordance with IEC 61869-10 and IEC 61869-11, as shown in *Table 2.7*.

Table 2.7 RJ45 Pinout Assignments for Current/Voltage Inputs (4 ACI/3 AVI) LPCT/Rogowski Coil and LEA Card

RJ45 Connector Pins	1	2	3	4	5	6	7	8
Passive LPVT							a[a]	n[a]
Passive LPCT/ Rogowski Coil	S1[b]	S2[b]						

[a] See Figure 2.3.
[b] See Figure 2.4.

Figure 2.3 and *Figure 2.4* show typical terminal markings for the passive LPVT and the LPCT/Rogowski coil, as shown in *Table 2.7*.

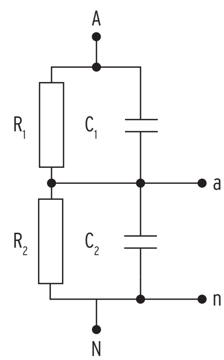


Figure 2.3 Terminal Markings for Passive LPVT

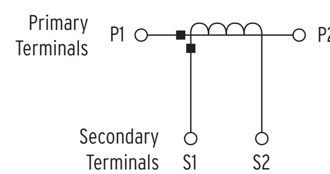


Figure 2.4 Terminal Markings for Passive LPCT

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

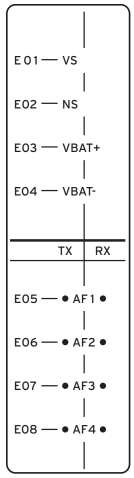
⚠WARNING
Voltage measurement circuits have high input impedance and will respond to stray signals when left open (disconnected). Always isolate the relay control circuit before opening the voltage input test switches or performing work on the voltage circuit.

MOT…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 2.8*.

Table 2.8 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, return 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

NOTE: Relays manufactured after July 21, 2023, configured with an arc-flash card come with 90-degree connectors on the Slot D board.

Voltage/Digital Inputs Card (2 AVI/7 DI)

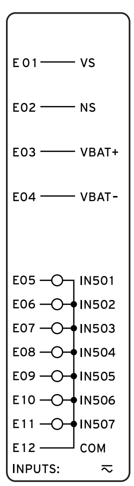
MOT...x7Ax..., MOT...x7Bx..., MOT...x7Cx..., MOT...x7Dx..., MOT...x7Gx..., or MOT...x7Hx... Supported only in Slot E of the SEL-751, this card has 300 Vac synchronism-check voltage input (VS), station dc battery monitor input (VBAT), and 7 digital inputs (IN501 to IN507).

MOT...xLAx..., MOT...xLBx..., MOT...xLCx..., MOT...xLDx..., MOT...xLGx..., or MOT...xLHx... Supported only in Slot E of the SEL-751, this card has 8 Vac LEA synchronism-check voltage input (VS), station dc battery monitor input (VBAT), and 7 digital inputs (IN501 to IN507).

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

The terminal designations for both are shown in *Table 2.9*.

Table 2.9 Voltage/Digital Inputs (2 AVI/7 DI) Card Terminal Designations

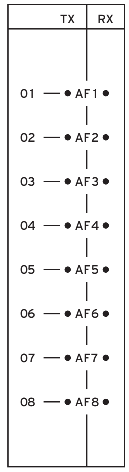
Side-Panel Connections Label	Terminal Number	Description
	E01	VS, synchronism-check voltage input
	E02	NS, return connection for synchronism-check voltage input
	E03	VBAT+ station battery (positive) voltage input
	E04	VBAT– station battery (negative) voltage input
	E05	IN501, drives IN501 element
	E06	IN502, drives IN502 element
	E07	IN503, drives IN503 element
	E08	IN504, drives IN504 element
	E09	IN505, drives IN505 element
	E10	IN506, drives IN506 element
	E11	IN507, drives IN507 element
	E12	COM

Eight Arc-Flash Detection Inputs (8 AFDI)

MOT…x77x… Supported only in Slot **E** of the SEL-751, this card has eight arc-flash fiber-optic transmit and receive inputs (AF1–AF8). *Table 2.10* shows the terminal designations.

NOTE: Relays manufactured after July 21, 2023, configured with an arc-flash card come with 90-degree connectors on the Slot D board.

Table 2.10 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

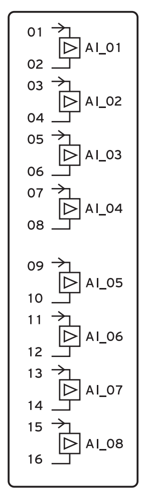
Analog Inputs Card (8 AI)

Supported in any nonbase unit slot (Slot **C** through Slot **E**), this card has eight analog inputs. *Table 2.11* shows the terminal designation.

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

NOTE: The requirements of IEC 60255-26 and IEC 60255-27 are met for connection lengths less than 10 m for analog inputs and outputs.

Table 2.11 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 if the card is installed in Slot C, D, or E, respectively.

Analog Input/Output Card (4 AI/4 AO)

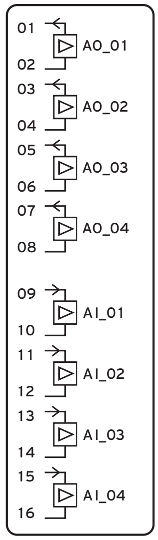
NOTE: Analog inputs cannot provide loop power. Each analog output is self powered and has an isolated power supply.

NOTE: Analog outputs are isolated from each other.

NOTE: The requirements of IEC 60255-26 and IEC 60255-27 are met for connection lengths less than 10 meters for analog inputs and outputs.

Supported in any one of the nonbase unit slots (Slot **C** through Slot **E**), this card has four analog inputs and four analog outputs. *Table 2.12* shows the terminal designations.

Table 2.12 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 if the card is installed in Slot C, D, or E, respectively.

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

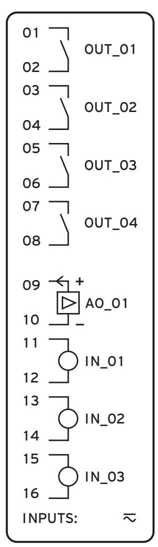
NOTE: Analog output is self powered and has an isolated power supply.

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

NOTE: The requirements of IEC 60255-26 and IEC 60255-27 are met for connection lengths less than 10 meters for analog inputs and outputs.

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 2.13* shows the terminal designations.

Table 2.13 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 if the card is installed in Slot C, D, or E, respectively.

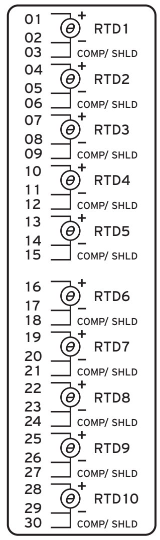
RTD Card (10 RTD)

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

NOTE: Use passive resistors to simulate temperatures to test the RTD inputs. Use of an RTD simulator can damage the relay.

Supported in Slot D only, this card has 10 three-wire RTD inputs. *Table 2.14* shows the terminal designations.

Table 2.14 RTD (10 RTD) Card Terminal Designations

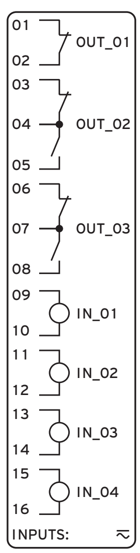


Side-Panel Connections Label	Terminal Number	Description
(see diagram above)	01	RTD01 (+)
	02	RTD01 (–)
	03	RTD01 Comp/Shield
	04	RTD02 (+)
	05	RTD02 (–)
	06	RTD02 Comp/Shield
	07	RTD03 (+)
	08	RTD03 (–)
	09	RTD03 Comp/Shield
	•	•
	•	•
	•	•
	28	RTD10 (+)
	29	RTD10 (–)
	30	RTD10 Comp/Shield

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) and two Form C digital output contacts. *Table 2.15* shows the terminal designations.

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



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

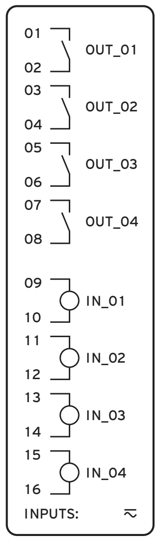
[a] x=3, 4, or 5 if the card is installed in Slot C, D, or E, respectively.

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 (all normally open). Optionally, the outputs can be fast hybrid (high-speed, high-current interrupting) outputs. *Table 2.16* shows the terminal designations.

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

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



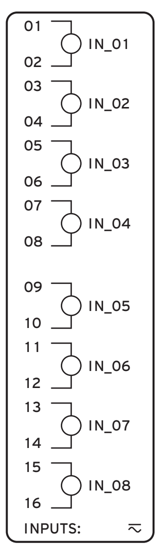
Side-Panel Connections Label	Terminal Number	Description[a]
	01, 02	OUTx01, driven by OUTx01 SELOGIC control equation
	03, 04	OUTx02, driven by OUTx02 SELOGIC control equation
	05, 06	OUTx03, driven by OUTx03 SELOGIC control equation
	07, 08	OUTx04, driven by OUTx04 SELOGIC control equation
	09, 10	INx01, drives INx01 element
	11, 12	INx02, drives INx02 element
	13, 14	INx03, drives INx03 element
	15, 16	INx04, drives INx04 element

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

I/O Card (8 DI)

Supported in any nonbase unit slot (Slot **C** through Slot **E**), this card has eight digital inputs. *Table 2.17* shows the terminal designations.

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



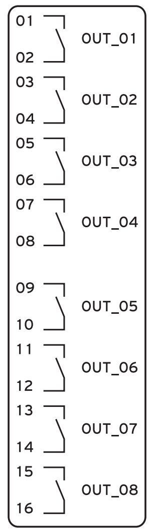
Side-Panel Connections Label	Terminal Number	Description[a]
	01, 02	INx01, drives INx01 element
	03, 04	INx02, drives INx02 element
	05, 06	INx03, drives INx03 element
	07, 08	INx04, drives INx04 element
	09, 10	INx05, drives INx05 element
	11, 12	INx06, drives INx06 element
	13, 14	INx07, drives INx07 element
	15, 16	INx08, drives INx08 element

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

I/O Card (8 DO)

Supported in any nonbase unit slot (Slot **C** through Slot **E**), this card has eight digital outputs. *Table 2.18* shows the terminal designations.

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

Side-Panel Connections Label	Terminal Number	Description[a]
	01, 02	OUT*x*01, driven by 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

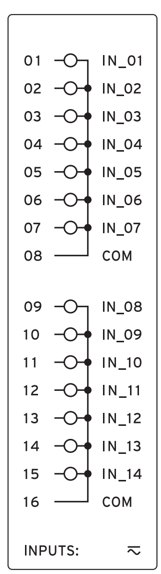
[a] x = 3, 4, or 5 if the card is installed in Slot C, D, or E, respectively.

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 2.19* shows the terminal designations.

Table 2.19 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 if the card is installed in Slot C, D, or E, respectively.

Card Configuration Procedure

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

The SEL-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 cards are available for the SEL-751 in Slots **C**, **D**, and **E**. Optional communications cards are available only for Slot **C**, an RTD card is available only for Slot **D**, 1 A/5 A CT combinations for voltage/current and current only cards are available only on Slot **Z**, and voltage only cards are available only for Slot **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 an array of applications. Choose the combination of cards most suited for your application.

Swapping Optional I/O Cards

When an I/O card is moved from one slot to a different slot, the associated settings for the slot the card is moved from are lost. For example, if a 4 DI/4 DO card is installed in Slot **D**, the SELOGIC control equation settings OUT401–OUT404 are available. If OUT401 = IN101 AND 51P1T, and the card is moved to a different slot, then the OUT401 setting is lost. This is true for all the digital and analog I/O cards.

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

The SEL-751 can be upgraded by adding as many as three cards.

Installation

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

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

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

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

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

Step 3. Disconnect all the connection plugs.

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

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

Step 6. Insert the card in the correct slot.

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

Step 7. Before reattaching the rear cover, check for and remove any foreign material that may remain inside the SEL-751 case.

Step 8. Carefully reattach the rear cover.

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

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

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

```
STATUS FAIL
X Card Failure
```

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

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

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

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

The front panel displays the following:

```
STATUS
Relay Status
```

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

The front panel displays the following:

```
Serial Num
000000000000000000000000
```

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

The front panel displays the following:

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

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

The front panel displays the following:

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

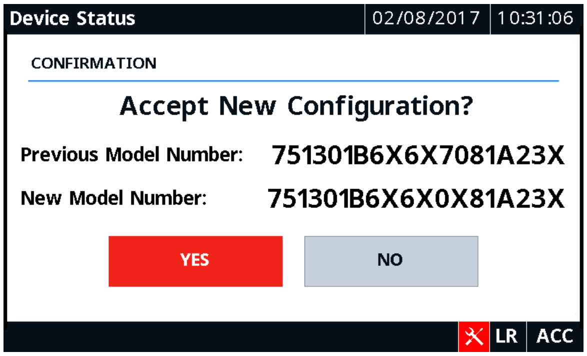
Step 18. Select **Yes** and press the **ENT** pushbutton.

The front panel displays the following:

```
Config Accepted
Enter to Reboot
```

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

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



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

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

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

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

Slot B CPU Card Replacement

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

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

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

Step 1. Turn off the power to the relay.

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

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

Step 4. Remove the rear panel.

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

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

Step 7. Apply new side stickers to the relay.

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

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

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

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

The default password for Access Level C is CLARKE.

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

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

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

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

Slot A Power Supply Card

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

Analog Input (AI) Voltage/Current Jumper Selection

Figure 2.5 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.

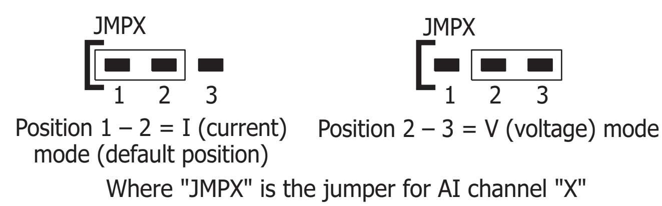


Figure 2.5 Circuit Board of Analog I/O Board, Showing Jumper Selection

Analog Output (AO) Voltage/Current Jumper Selection

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

Figure 2.6 shows the locations of JMP1 through JMP4 on an analog output board. You can select each of the four analog output channels as either a current analog output or a voltage analog output.

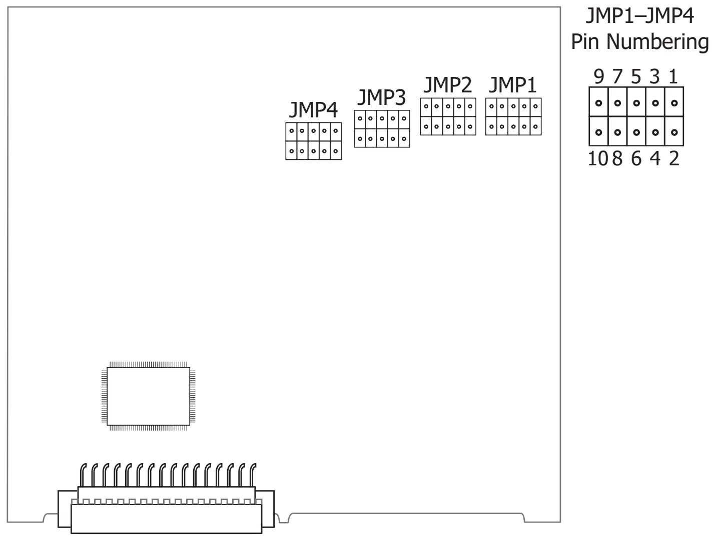


Figure 2.6 JMP1 Through JMP4 Locations on 4 AI/4 AO Board

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 2.7* shows JMP4 selected as a current analog output. The current analog output selection is the default setting for JMP1 through JMP4. *Figure 2.8* shows JMP1 selected as a voltage analog output.

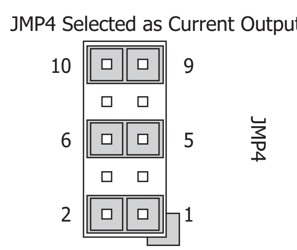


Figure 2.7 Current Output Jumpers

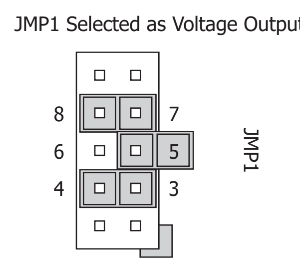


Figure 2.8 Voltage Output Jumpers

Password, Breaker Control, and SELBOOT Jumper Selection

Figure 2.9 shows the major components of the Slot **B** card in the base unit. Notice the three sets of pins labeled A, B, and C.

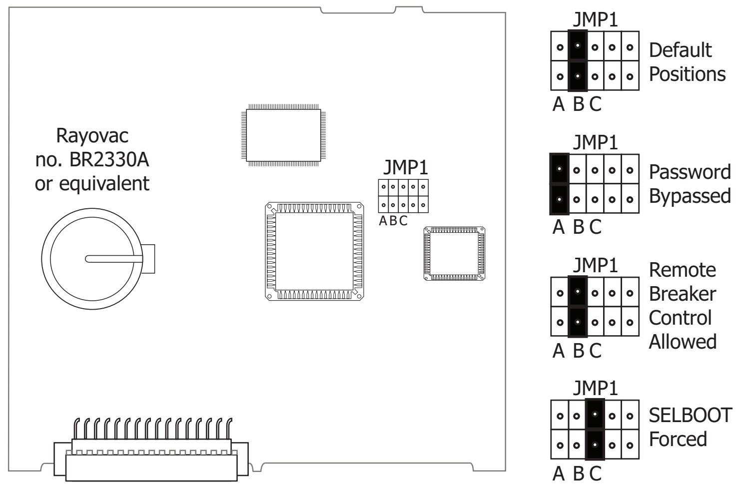


Figure 2.9 Card Layout for Relay With Firmware Versions Prior to R400-V0

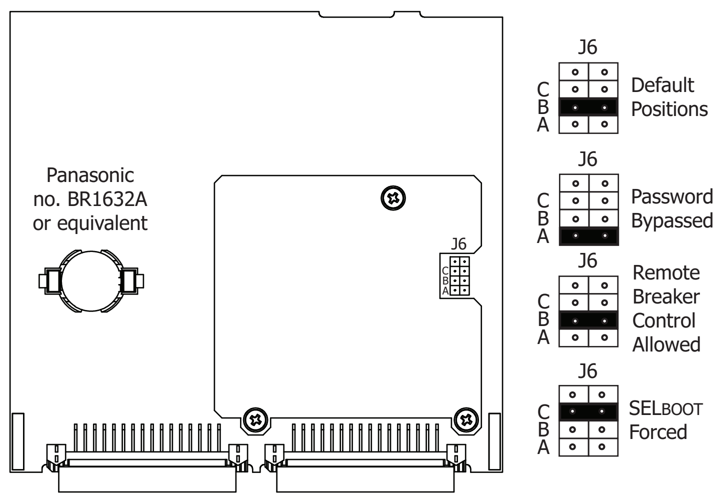


Figure 2.10 Card Layout for Relay With Firmware Versions R400-V0 or Higher

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 2.9* (SELBOOT Forced). After the relay is forced to SELBOOT, you can only communicate with it via the front-panel port.

To gain access to the Level 1, 2, or C command levels without passwords, place the jumper in Position A, as shown in *Figure 2.9* (Password Bypassed). Note that you can only access command levels without passwords to the access level set for the MAXACC setting for the port through which you are communicating. Although you can gain access to Level 2 and Level C without passwords, the alarm contact still closes momentarily when accessing Level 2 and Level C. See *Table 2.20* for the functions of the three sets of pins and their jumper default positions.

Table 2.20 Jumper Functions and Default Positions

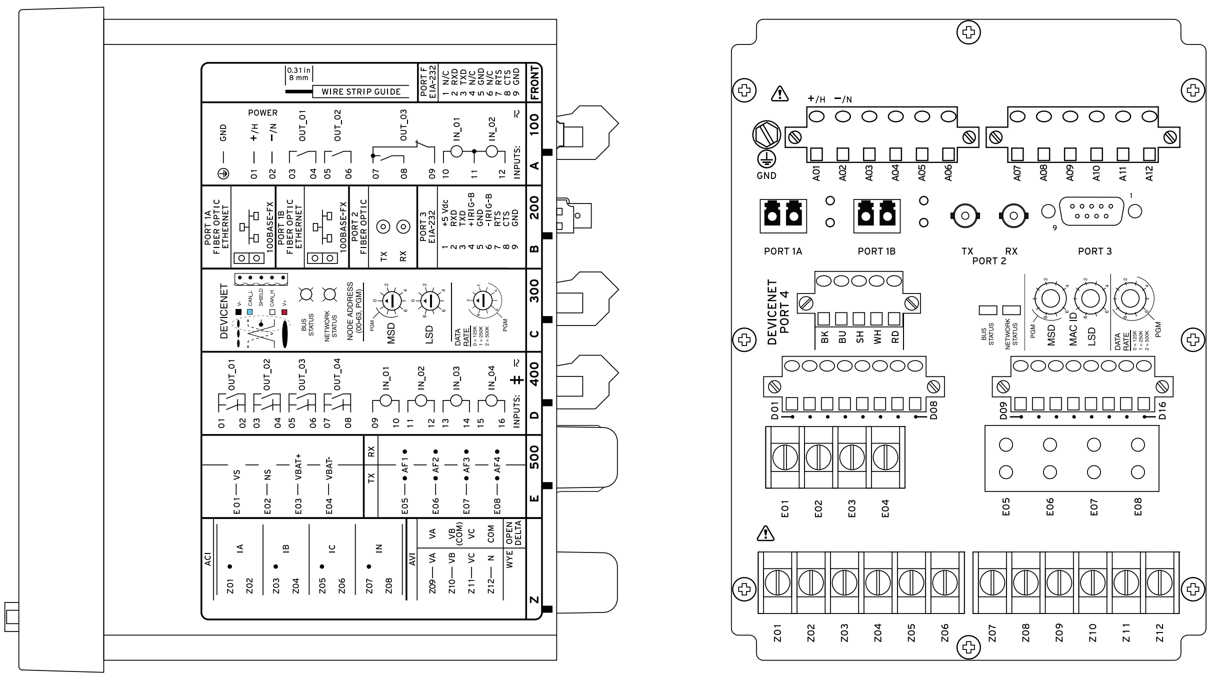
Pins	Jumper Default Position	Description
A	Not bypassed (requires password)	Password bypass
B	On (breaker control enabled)	Enable breaker control[a]
C	Not bypassed (not forced SELBOOT)	SELBOOT Forced

[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

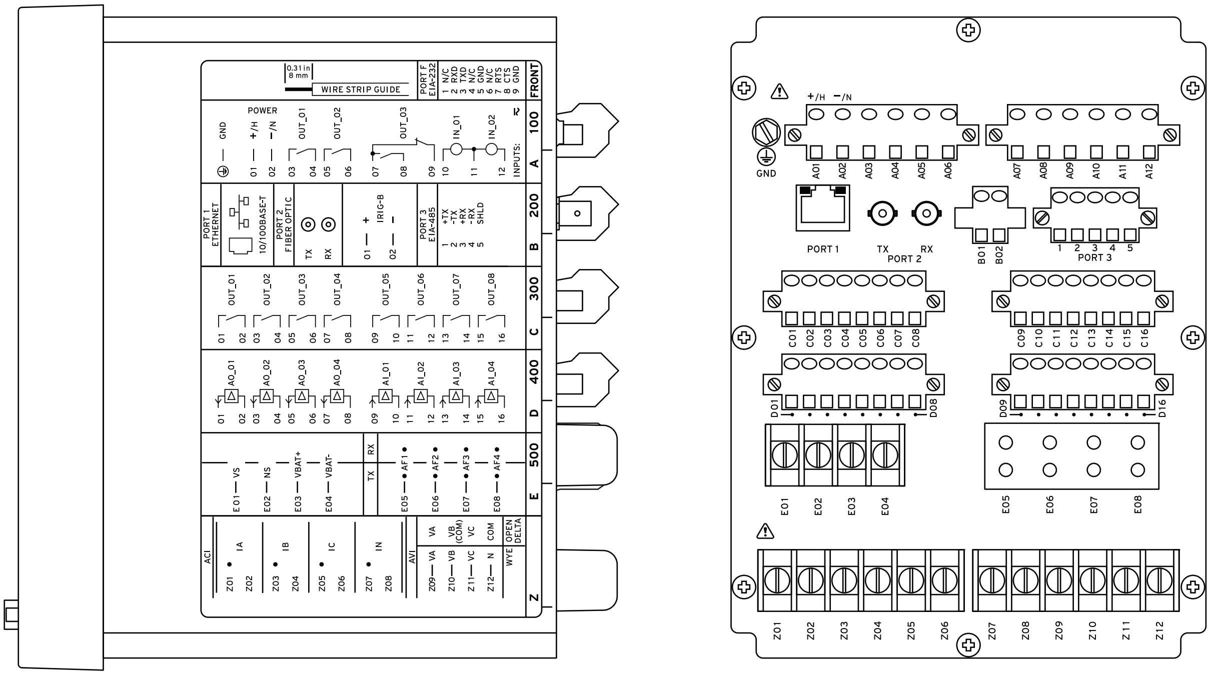
The physical layout of the connectors on the side-panel and rear-panel diagrams of seven sample configurations of the SEL-751 are shown in *Figure 2.11* through *Figure 2.17*.



‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

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

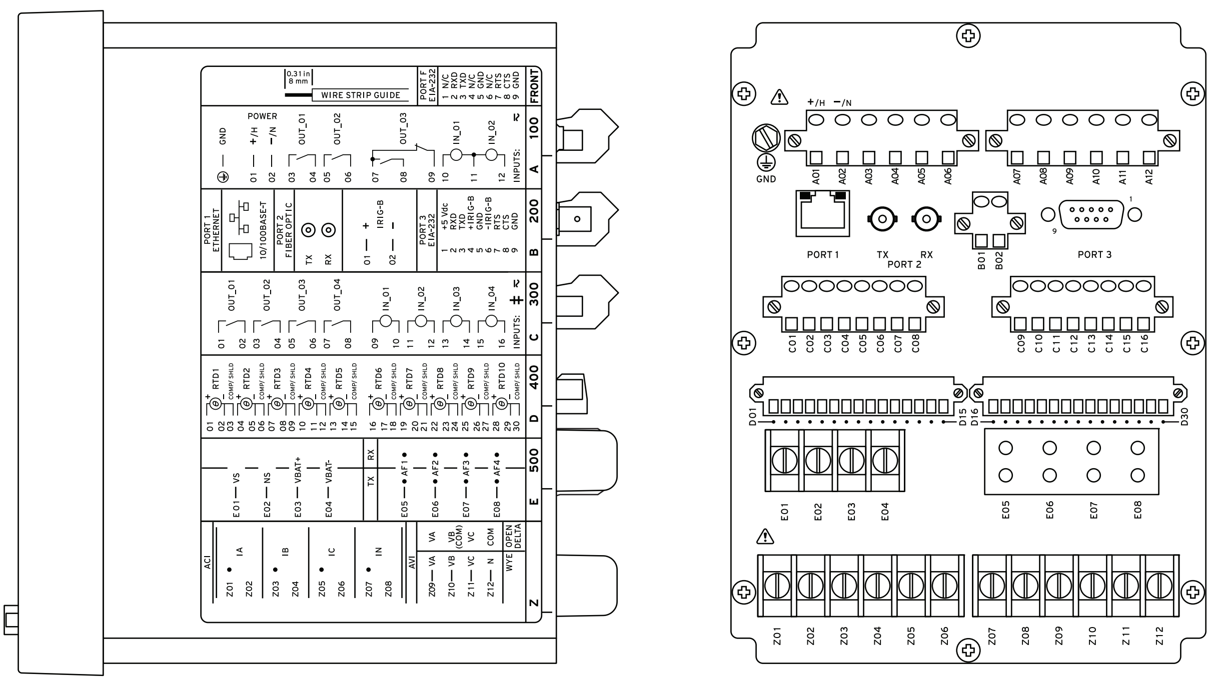
Figure 2.11 Dual Fiber Ethernet With 2 AVI/4 AFDI Voltage Option With Arc-Flash Detector Inputs, DeviceNet Card, and Fast Hybrid 4 DI/4 DO Card (Relay MOT 751501AA3CA70850830)



‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

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

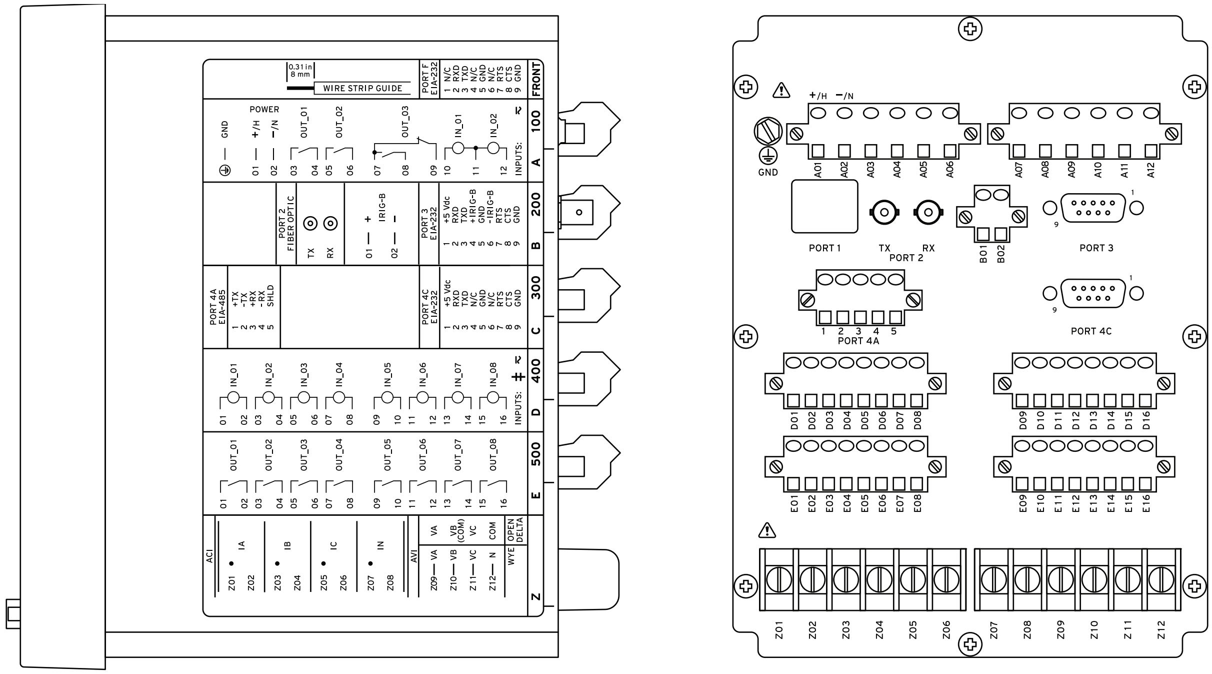
Figure 2.12 Single Copper Ethernet, EIA-485 Communication, 8 DO (Form A) Card, 4 AI/4 AO Card, and 2 AVI/4 AFDI Voltage Option With Arc-Flash Detector Inputs (Relay MOT 751201A2A6X70810320)



‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

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

Figure 2.13 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)

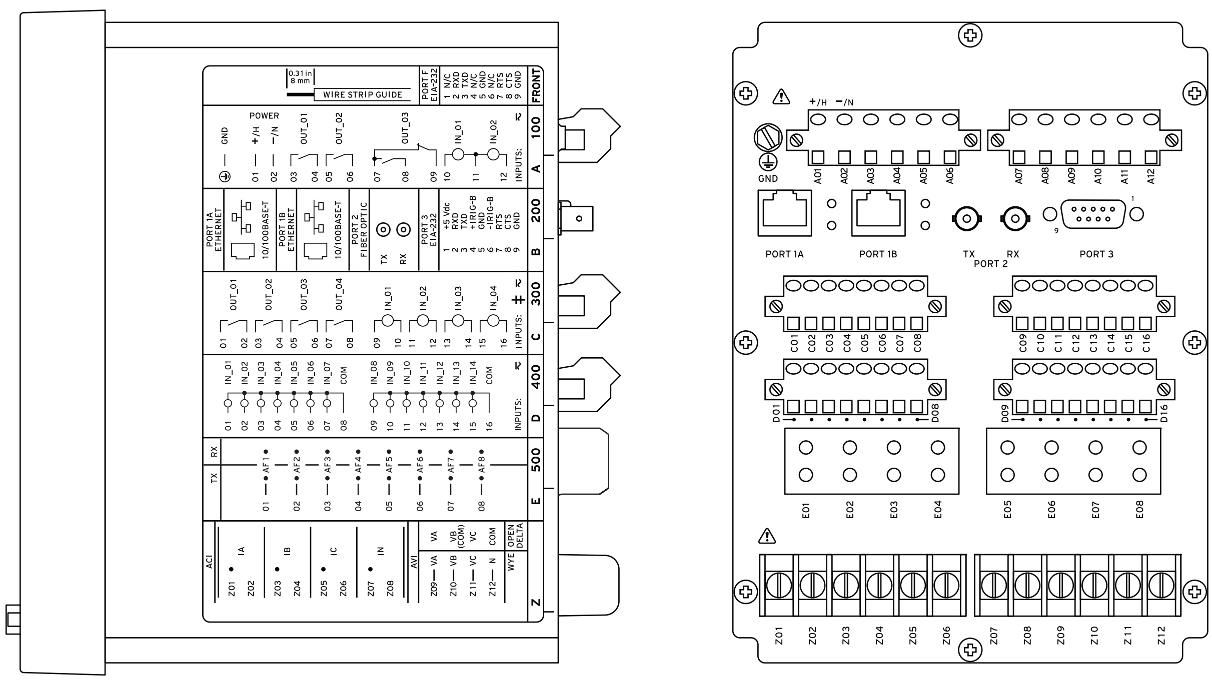


‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(A) Side-Panel Input and Output Designations

(B) Rear-Panel Layout

Figure 2.14 No Ethernet, EIA-232 Serial Communications, EIA-232/EIA-485 Communications Card, 8 DI Card, and 8 DO Card (Form A) (Relay MOT 751401AA03A2A850000)

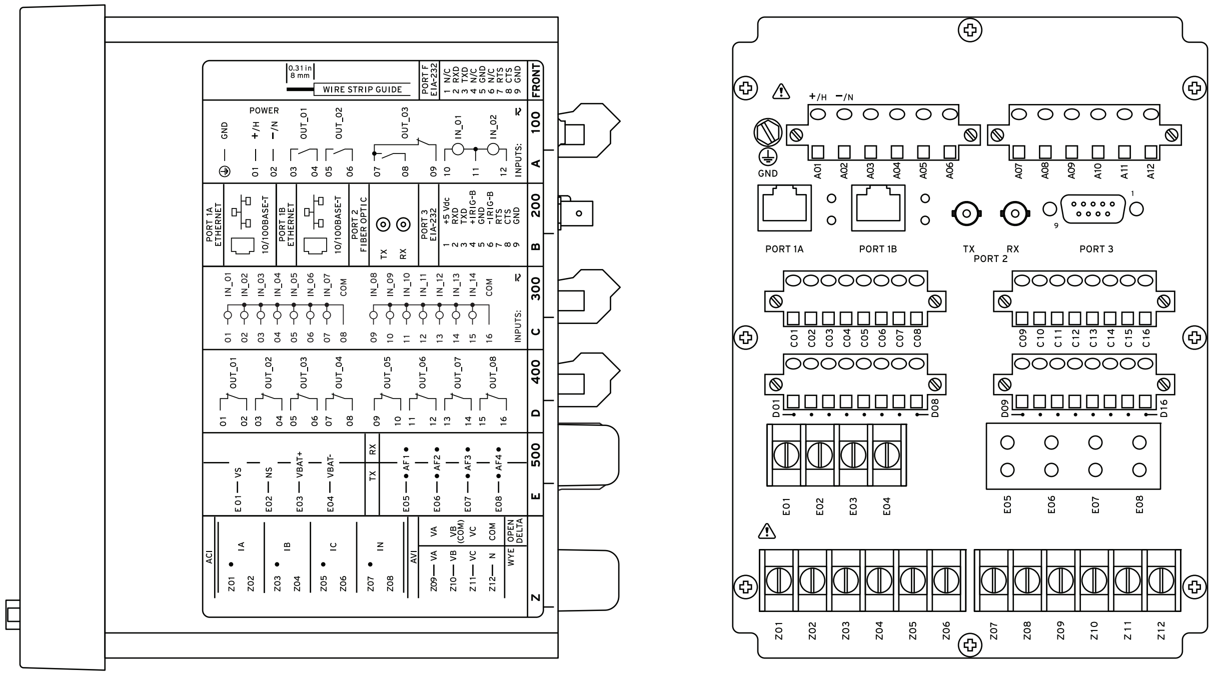


‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(A) Side-Panel Input and Output Designations

(B) Rear-Panel Layout

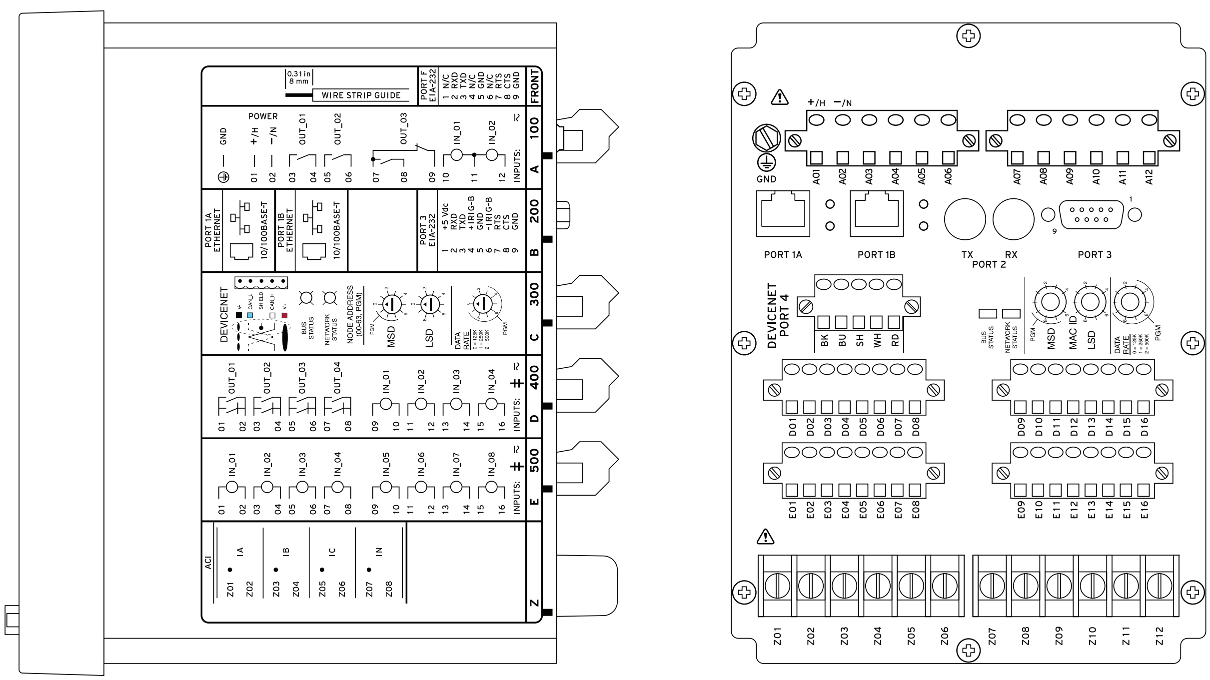
Figure 2.15 Dual Copper Ethernet, 4 DI/4 DO Card, 14 DI Card, 8 AFDI With Arc-Flash Detector Inputs, 4 ACI/3 AVI Card With 5 A Phase, 200 mA Neutral, and Three-Phase AC Voltage Inputs (300 Vac) (Relay MOT 7515S1A1A4A77870671)



‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

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

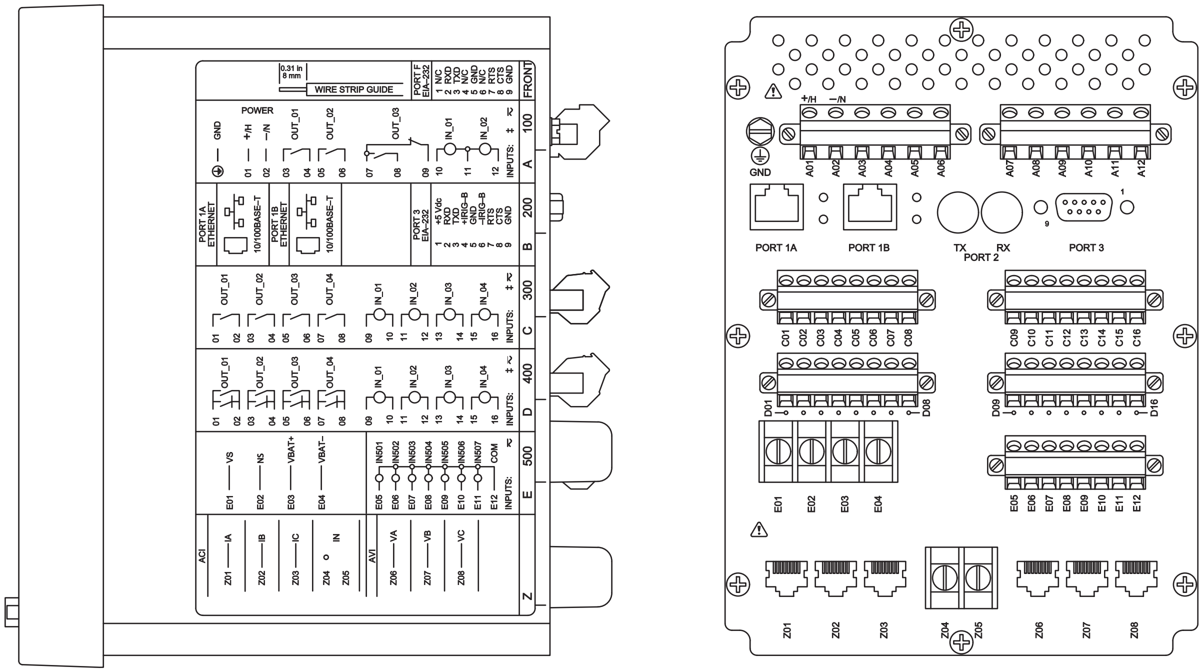
Figure 2.16 Dual Copper Ethernet, 14 DI Card, 8 DO (Form B) Card, 2 AVI/4 AFDI Card With LEA Vsync, Vbat Inputs, and 4 Arc-Flash Detection Inputs, 4 ACI/3 AVI Card With 5 A Phase, 200 mA Neutral, and Three-Phase LEA Voltage Inputs (8 Vac) (Relay MOT 751501A4A2BL0L70671)



‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

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

Figure 2.17 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)



‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(A) Side-Panel Input and Output Designations

(B) Rear-Panel Layout

Figure 2.18 Dual 10/100 Base-T Ethernet, EIA-232 Rear Port, 4 DI/4 DO Card, Fast Hybrid 4 DI/4 DO Card, LEA Vsync/Vbat (300 Vdc) 7 DI Card, and 4 ACI/3 AVI LEA Card (Relay MOT 751001A1ACALA7LAF30)

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 1.15* for complete power input specifications). The **POWER** terminals are isolated from chassis ground. Use 14 AWG (2.1 mm^2) to 16 AWG (1.3 mm^2) size wire to connect to the **POWER** terminals.

The SEL-751 comes with an orange Euro connector on the Slot A card for the 24–48 Vdc low-voltage power supply option. *Figure 2.19* shows the orange Euro connector with the 24–48 Vdc power supply rating.

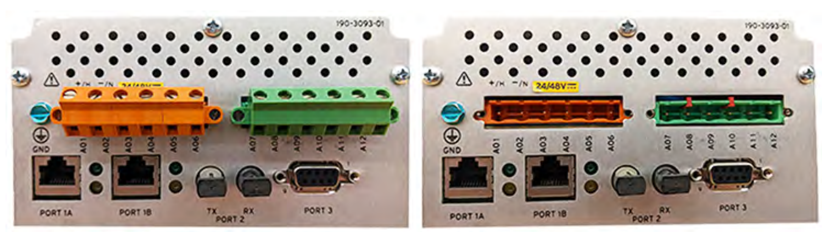


Figure 2.19 Slot A Euro Connector

For compliance with IEC 60947-1 and IEC 60947-3, place a suitable external switch or circuit breaker in the power leads for the SEL-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, 300 V.

Operational power is internally fused by a power supply fuse. See *Field Serviceability on page 2.58* 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) to 18 AWG (0.8 mm^2) wire less than 2 m (6.6 ft) in length for the ground connection.

The relay IN input can be connected to the ground CT, as shown in *Figure 2.36*. Connecting the IN input residually requires you to select a relatively high overcurrent element pickup setting to avoid tripping due to false residual current caused by CT saturation.

The IN connection shown in *Figure 2.36* is preferred and provides for a lower ratio flux-balance CT that avoids saturation and provides greater ground fault sensitivity.

When you use a ground CT, its placement is critical and depends on the type of cable used to connect the load to the source. As *Figure 2.20* shows, using unshielded cable requires that the CT be placed between the neutral connection to ground and the load, with the neutral lead included in the CT window. With shielded cable, the shield connection to ground must pass through the CT window.

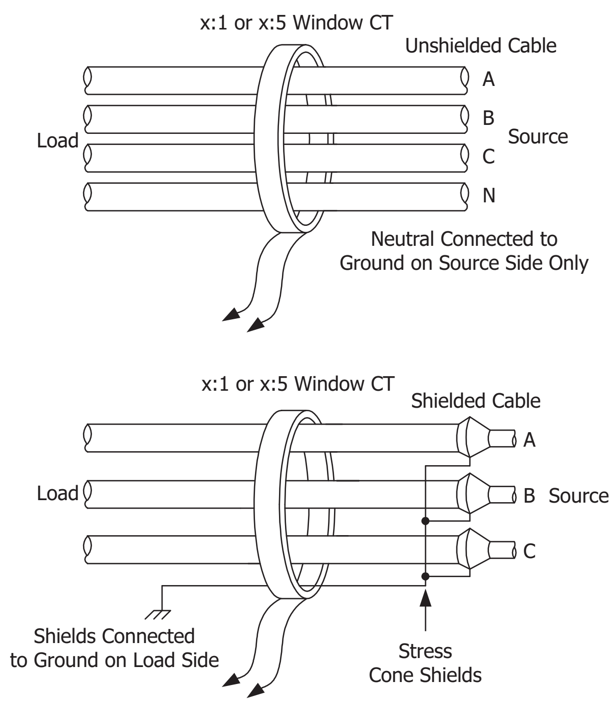


Figure 2.20 Ground CT Placement

Serial Ports

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

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

Communication ports are typically wired using a shielded, twisted pair cable. When used in locations with high magnetic fields, such as generating stations or metal clad switchgear, the shield should be grounded on one end (preferably close to the relay). For installations with a high probability of a lightning surge, the shield should be grounded on both ends. Alternatively, a double-shielded cable can be used with the outer shield grounded on both ends and the inner shield grounded close to the relay.

For connecting devices at distances farther than 100 ft, 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 IRIG-B accepts a demodulated time signal to synchronize the internal clock with an external source. Three options for IRIG-B signal input are given, but only one should be used at a time. You can use the IRIG-B (**B01** and **B02**) inputs, an SEL communications processor via EIA-232 serial **Port 3**, or fiber-optic serial **Port 2**. The available communications processors are the SEL-2032, SEL-2030, SEL-2020, and the SEL-2100 Logic Processor. You can also use the SEL-3530 Real-Time Automation Controller (RTAC) to provide an IRIG-B input.

The models with fiber-optic Ethernet and dual copper Ethernet do not have the terminals **B01** and **B02** for IRIG-B but have IRIG-B input via EIA-232 **Port 3**. The third option for IRIG-B is via fiber-optic serial **Port 2**. Use an SEL-2812MT Transceiver to connect to the SEL-2030 or SEL-2032 and bring the IRIG-B signal with the EIA-232 input. Use a fiber-optic cable pair with ST connectors (C805, C807, or C808) to connect to **Port 2** on the SEL-700G. Refer to *Section 7: Communications* for IRIG-B connection examples and for details about using an SEL-2401/2407/2488 as a time source.

IRIG ports are typically wired using a coaxial or shielded, twisted pair cable. When used in locations with high magnetic field, such as generating stations or metal clad switchgear, the shield should be grounded on one end (preferably at the signal source [GPS clock or similar]). For installations with a high probability of a lightning surge, the shield should be grounded on both ends. When necessary, a SEL-2812-based fiber-optic transceiver can be used instead.

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 Connections

When the relay is ordered with the 24 Vdc/Vac or 48 Vdc/Vac input voltage option, the digital inputs come with the orange Euro connector on the slot. *Figure 2.21* shows the orange Euro connector for the 3 DI/4 DO/1 AO digital inputs option on Slot C.

Figure 2.21 Slot C Euro Connector

I/O Diagram

A more functional representation of two of the control (I/O) connections is shown in *Figure 2.22* and *Figure 2.23*.

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

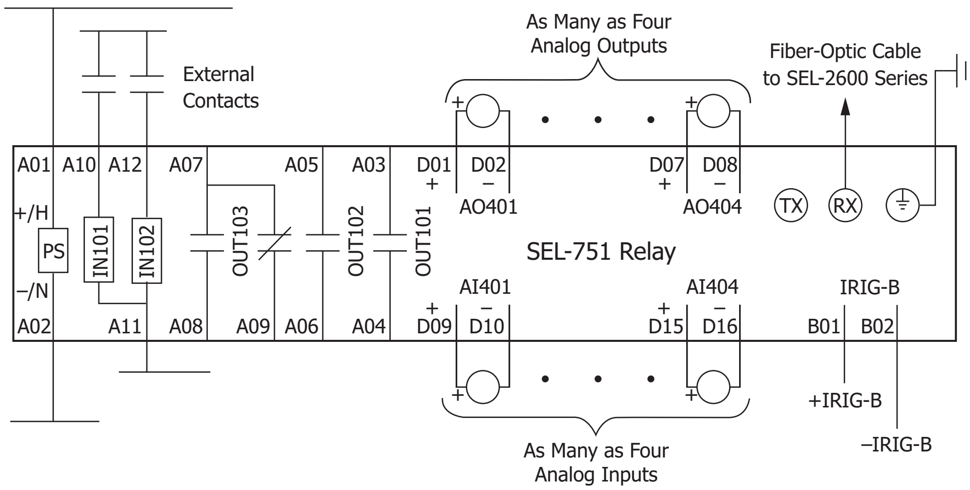
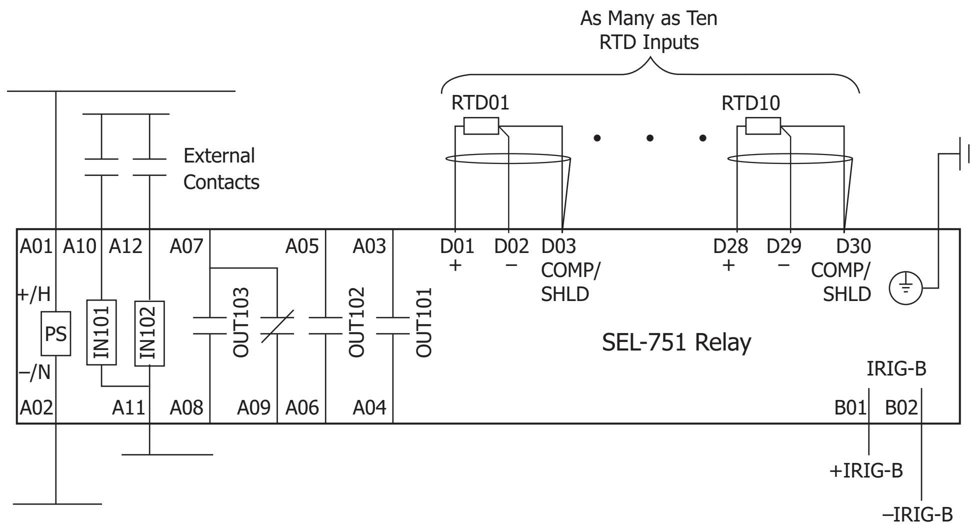


Figure 2.22 Control I/O Connections—4 AI/4 AO Option in Slot D and Fiber-Optic Port in Slot B

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



- The chassis ground connector located on the rear-panel card Slot A must always be connected to the local ground mat.
- Power supply rating (110–240 Vac, 110–250 Vdc or 24–48 Vdc) depends on the relay part number.
- Optoisolated Inputs IN101 and IN102 are standard and are located on the card in Slot A.
- All optoisolated inputs are single-rated: 24, 48, 110, 125, 220, or 250 Vac/Vdc. Standard Inputs IN101/102 can have a different rating then 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 um fiber-optic cable is necessary for connecting to an SEL-2600 RTD Module. This fiber-optic cable should be 1000 meters or shorter.

Figure 2.23 Control I/O Connections—Internal RTD Option in Slot D

RTD Wiring

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

Table 2.21 shows the maximum cable lengths for the RTD connections that satisfy the 25-ohm limit required for connecting to SEL devices.

Table 2.21 Typical Maximum RTD Lead Length

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

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

RTD wiring recommendations:

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

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

Analog Output Wiring

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

Connect the two terminals of the analog output as shown in *Figure 2.24*. 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.

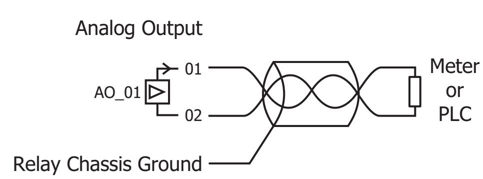


Figure 2.24 Analog Output Wiring Example

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

Figure 2.25 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.

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).

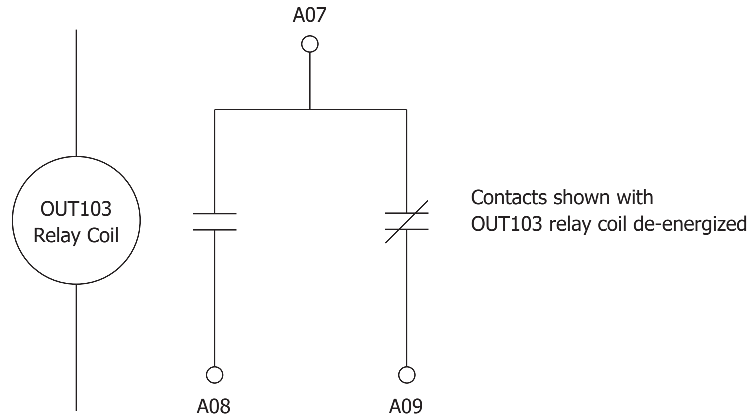


Figure 2.25 Output OUT103 Relay Output Contact Configuration

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

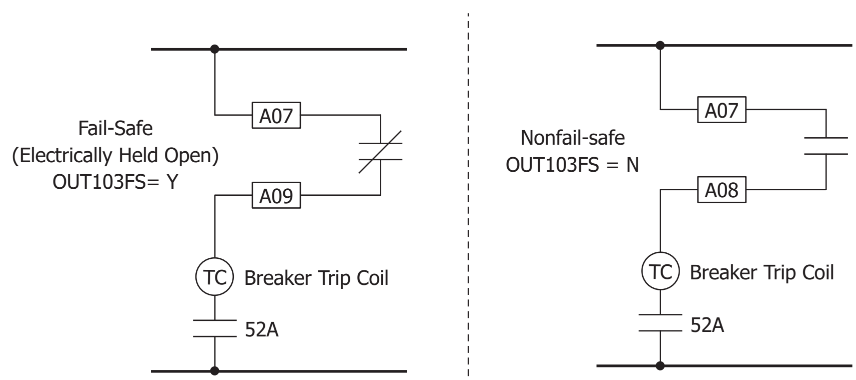


Figure 2.26 Breaker Trip Coil Connections With OUT103FS := Y and OUT103FS := N

High-Speed, High-Current Interrupting DC Tripping Outputs

High-speed outputs are optimized for direct tripping of power circuit breakers. They operate in less than 50 µs, work with dc trip coil circuits, are polarity insensitive and capable of making 30 A, and can interrupt 10 A with an 8 ms dropout time. High-speed outputs are implemented as hybrid circuits, each of which consists of the parallel combination of a high-current, solid-state switch and an electromechanical bypass relay. Avoid using high-speed outputs to drive highly sensitive, high-input-resistance electronic inputs (e.g., <2 mA electronic circuits) unless such inputs are connected in parallel with a low-resistance load (e.g., a breaker trip coil).

Avoid connecting multiple high-speed outputs in parallel when driving highly sensitive electronic inputs. Keep wiring short, and use fiber-based MIRRORED BITS communications to bridge longer distances.

Voltage Connections

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

With the voltage inputs option, 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 2.27* and *Figure 2.28* 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 2.28 (a): Direct Connection*, *Figure 2.28 (b)*: *Wye-Wye VT Connections With LEA Inputs*, or *Figure 2.28 (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 2.28 (d)–Figure 2.28 (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 2.28 (e)* and *Figure 2.28 (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.

Figure 2.28 (b) shows LEA inputs, which support only wye-wye connections. Refer to *Under- and Overvoltage Functions on page 4.122* and *LEA Ratio and Angle Correction Factors (Global Settings) on page 4.11* for the LEA settings and ratio correction factor calculations.

Figure 2.28 (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 *Figure 2.28 (e)* and *Figure 2.28 (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.

When the Global setting EDCMON := N, terminals E03 and E04 can be used to input a broken delta (3V0) or a line to ground or a phase-to-phase voltage from a feeder to the VBAT+/VBAT– input on the relay with VBAT– terminal grounded. Typical application includes over- and undervoltage supervision (27N/59N) beyond a wye-delta transformer (see *Figure 2.31*). An example broken delta connection is shown in *Figure 2.28 (g)*.

When a VBAT input is present and the Global setting EDCMON is set to N, you can use the VBAT channel as an ac voltage input with the under- and overvoltage functions (27N/59N). This voltage input may be used as a second 3V0 input to the relay. The VBAT channel 3V0 is independent of the 3V0 from the VS channel and cannot be used in directional elements. The Global setting EDCMON := N disables the dc under- and overvoltage elements. See *Figure 2.28* and *Figure 2.31* for example connections and *Under- and Overvoltage Functions* for the 27N and 59N element logic.

Some installations do not have all three voltage phases available to connect to the relay as shown in *Figure 2.27 (a)* to *Figure 2.27 (f)*. In such cases set DELTA_Y to WYE or DELTA according and set SINGLEV := Y. Individual phase voltage can be selected using the SING_VIN setting. Based on the

DELTA_Y setting, the relay allows phase-to-neutral or phase-to-phase voltage selections for the SING_VIN setting. In those cases the relay will disable some of the voltage-based functions as specified in *Table 4.5*.

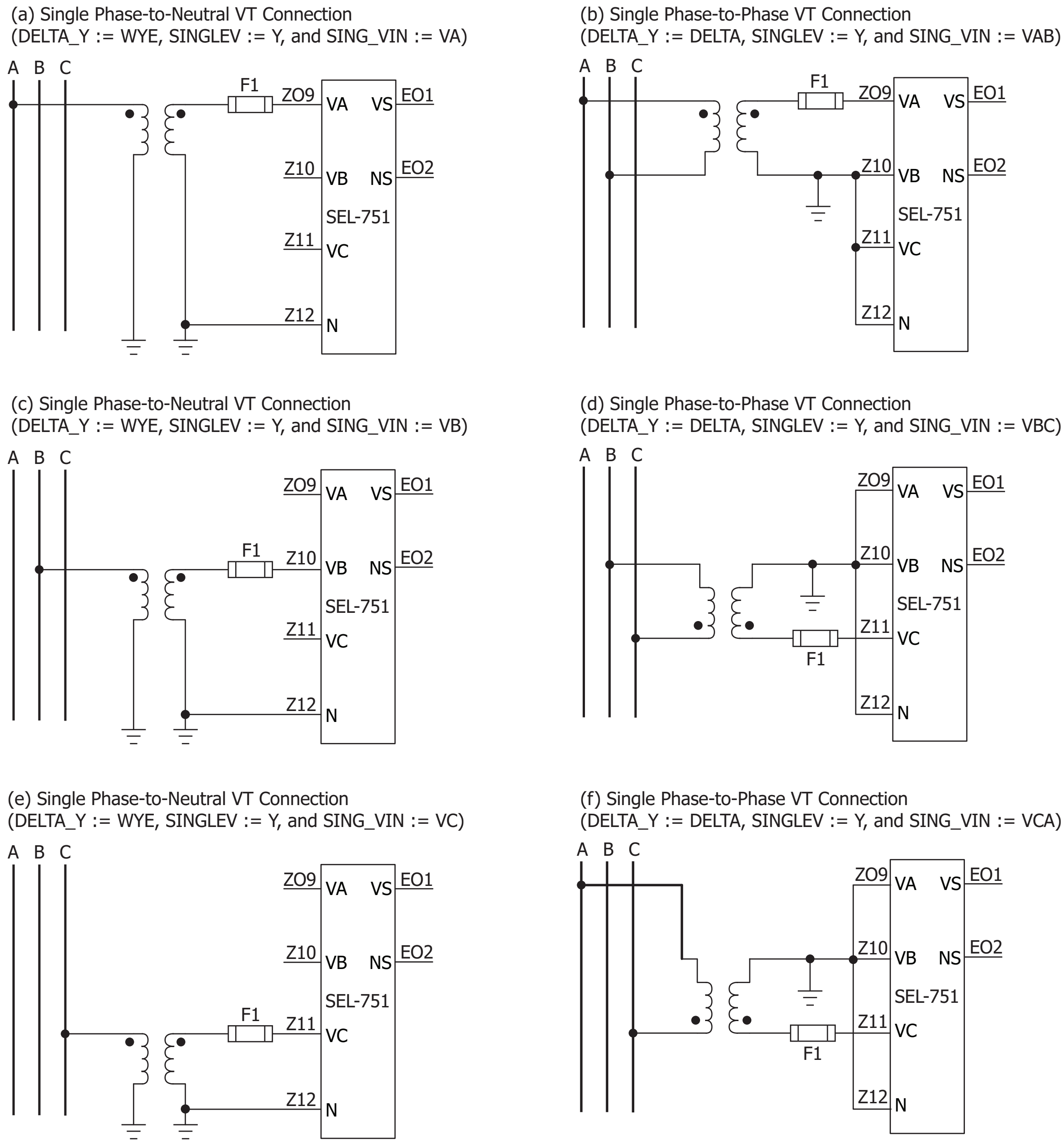


Figure 2.27 Single-Phase Voltage Connections

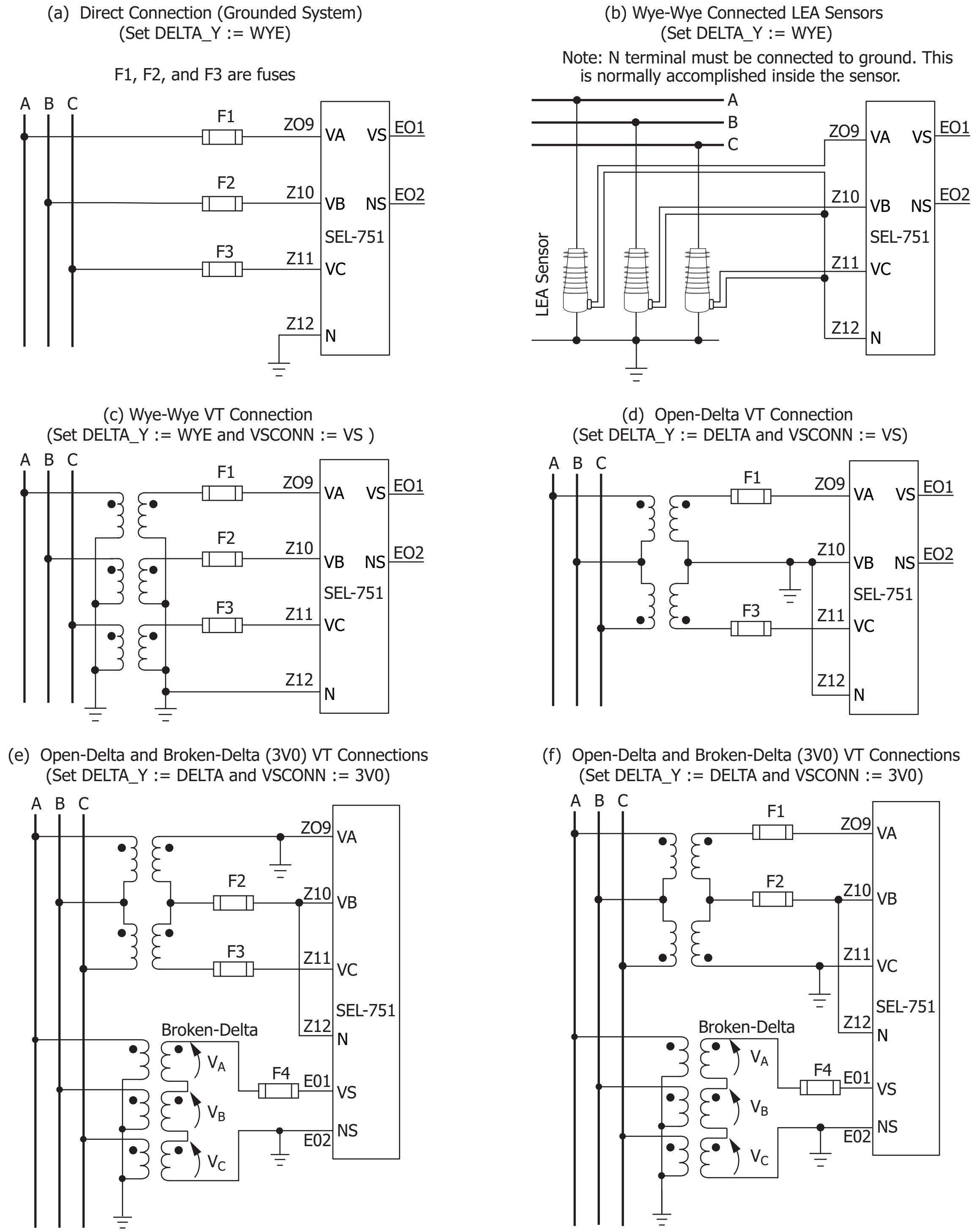


Figure 2.28 Voltage Connections

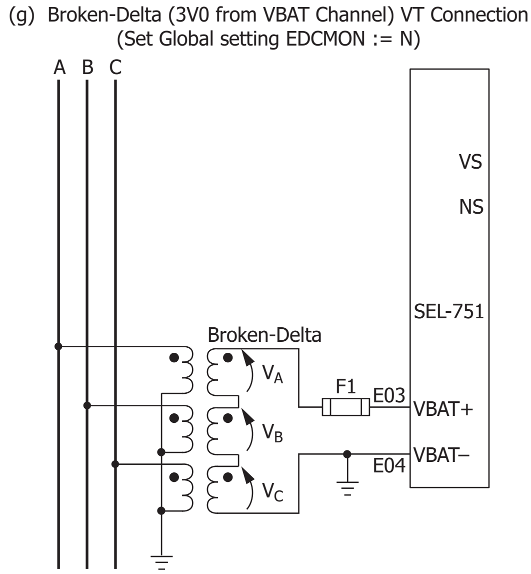


Figure 2.28 Voltage Connections (Continued)

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 2.28* (*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 2.28 (d)*, *Figure 2.28 (e)* or *Figure 2.28 (f))*, the correct PTR setting is 108.44.

Single-phase voltage connections follow the same rationale. Refer to *Figure 2.27 (a)* to *Figure 2.27 (f)*. For example, with a single-phase voltage connection (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 2.28 (e)* or *Figure 2.28 (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.

The relay setting PTRN is the overall potential ratio from the broken-delta voltage source or a line-to-ground or a phase-to-phase voltage from a feeder to the relay VBAT+/VBAT– voltage inputs. The setting PTRN is only available when the Global setting EDCMON := N. When the setting EDCMON := Y, the setting PTRN is set to 1 and hidden.

Settings PTR, PTRS, and PTRN 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 4.5*, 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 or SELECT 2 AVI/7 DI voltage/digital inputs card in Slot E. The Global setting EDCMON := N disables the station dc battery monitor elements. Refer to *Section 5: Metering and Monitoring* for details on the station dc battery monitor function and settings.

AC/DC Connections and Applications

Figure 2.29 shows typical phase and neutral current connections for a feeder application. *Figure 2.30* through *Figure 2.39* show ac/dc connection diagrams for various applications. See *Figure 2.27* and *Figure 2.28* for other voltage connections.

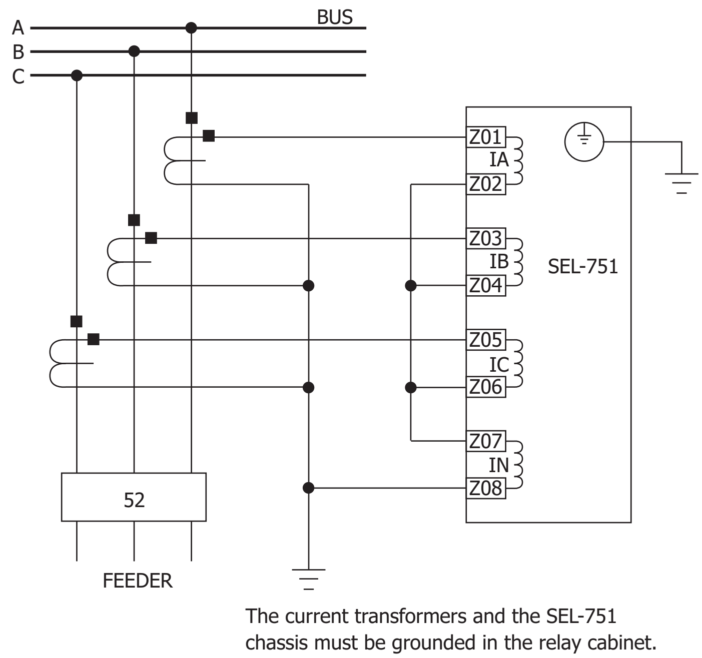
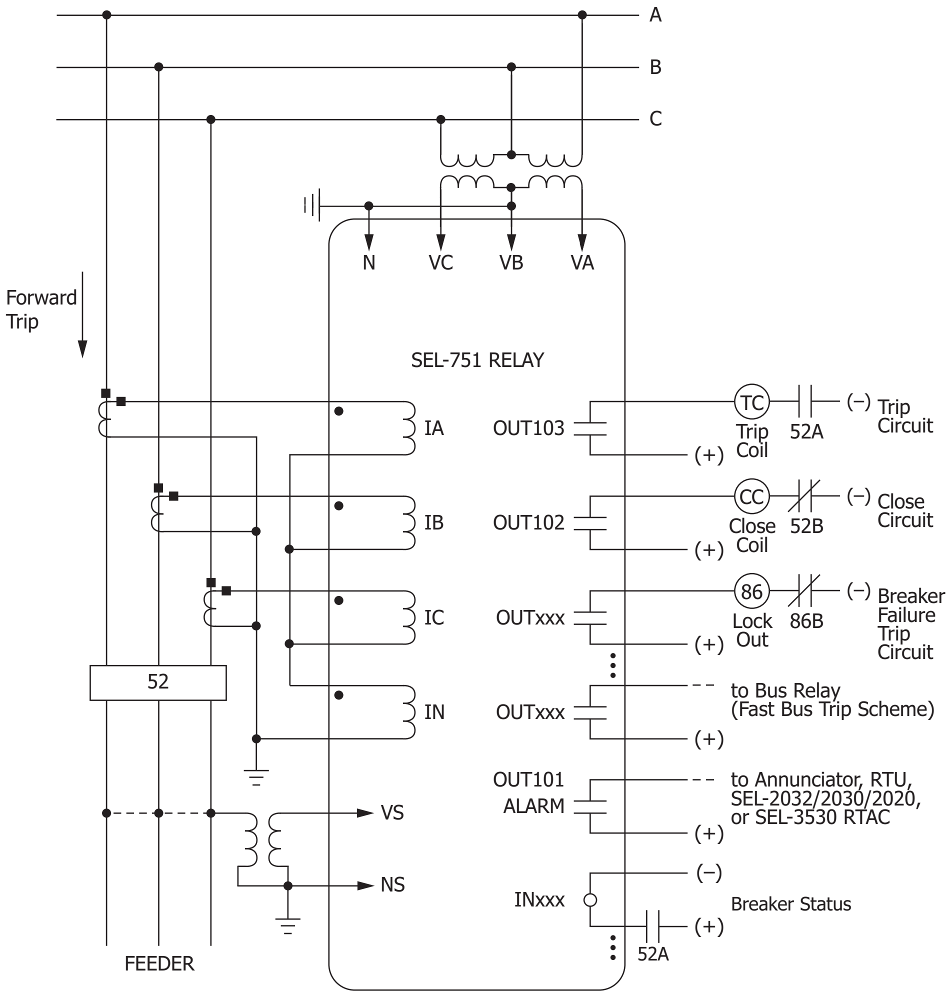


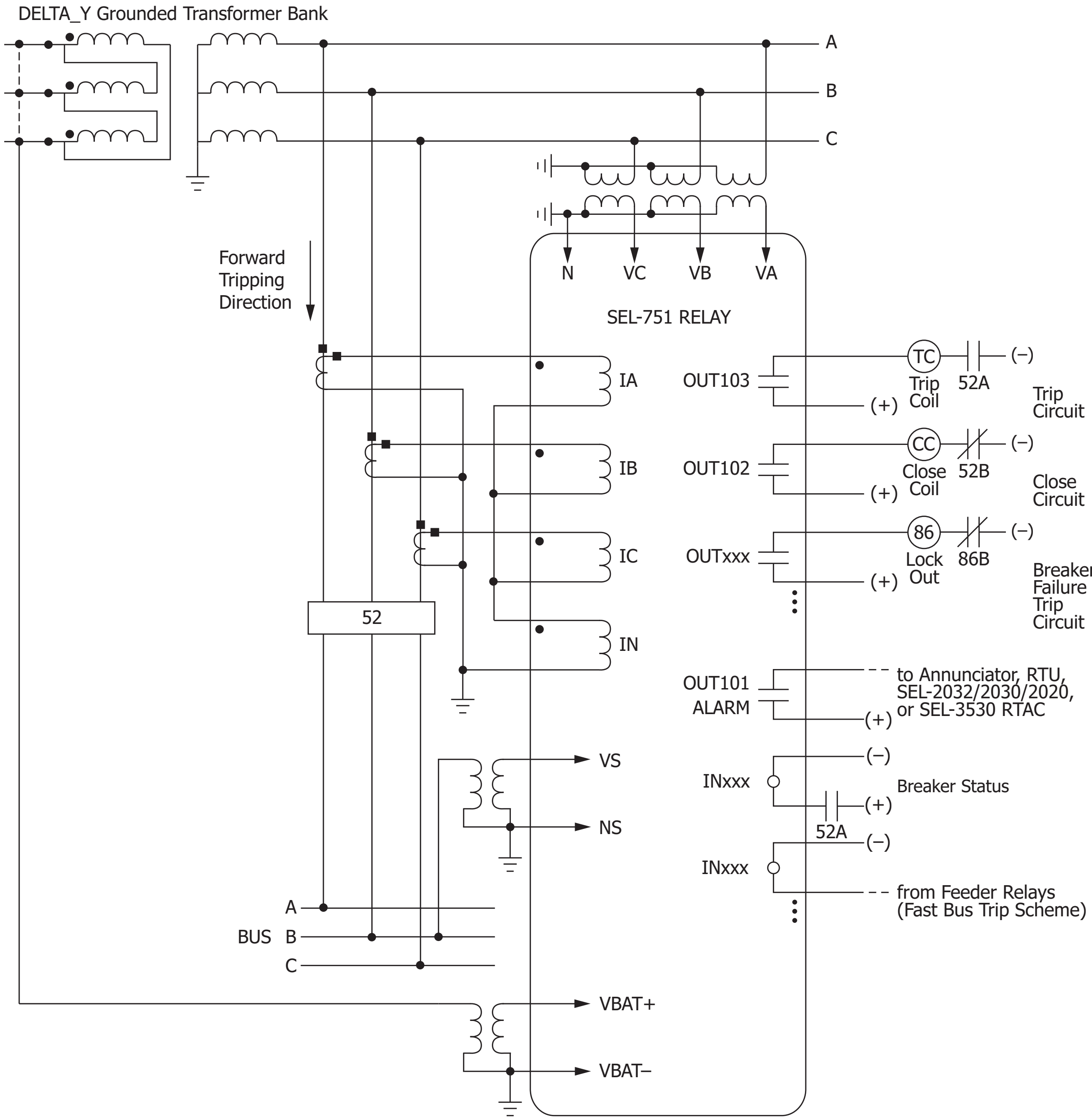
Figure 2.29 Typical Current Connections



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 2.30 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 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.

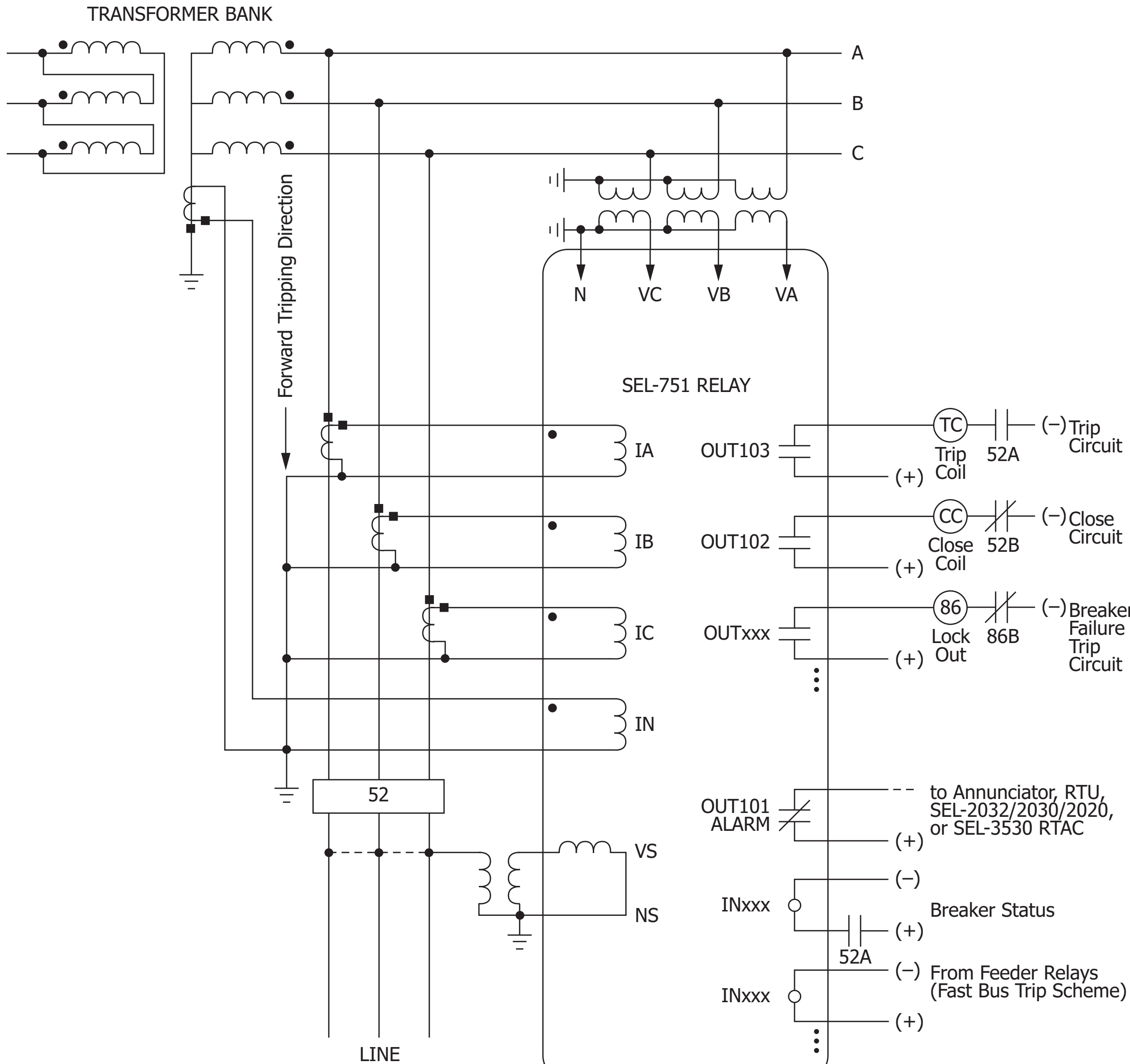
The voltage channel VBAT does not need to be connected. Here, it is shown connected for use in the 27N/59N voltage elements with the Global setting EDCMON := N. See *Figure 2.28 (g)* for a broken delta 3V0 from VBAT channel connection. The Global setting EDCMON := N disables the dc under- and overvoltage 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.

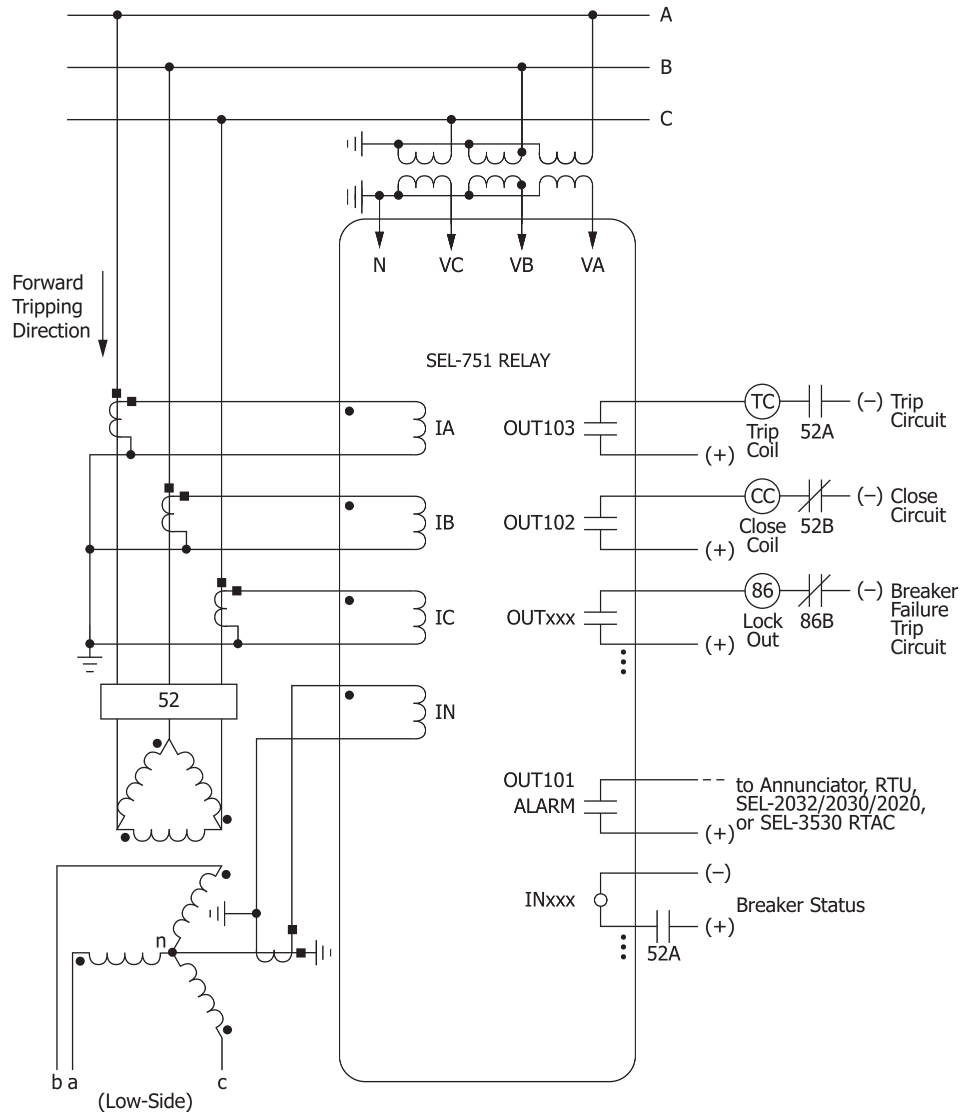
Figure 2.31 SEL-751 Provides Overcurrent Protection for a Distribution Bus (Includes Fast Bus Trip Scheme) (Wye-Connected PTs)



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 2.28 (d and e) 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 2.32 Transmission Line Directional Overcurrent Protection and Reclosing With Current-Polarization Source Connected to Channel IN (Wye-Connected PTs)

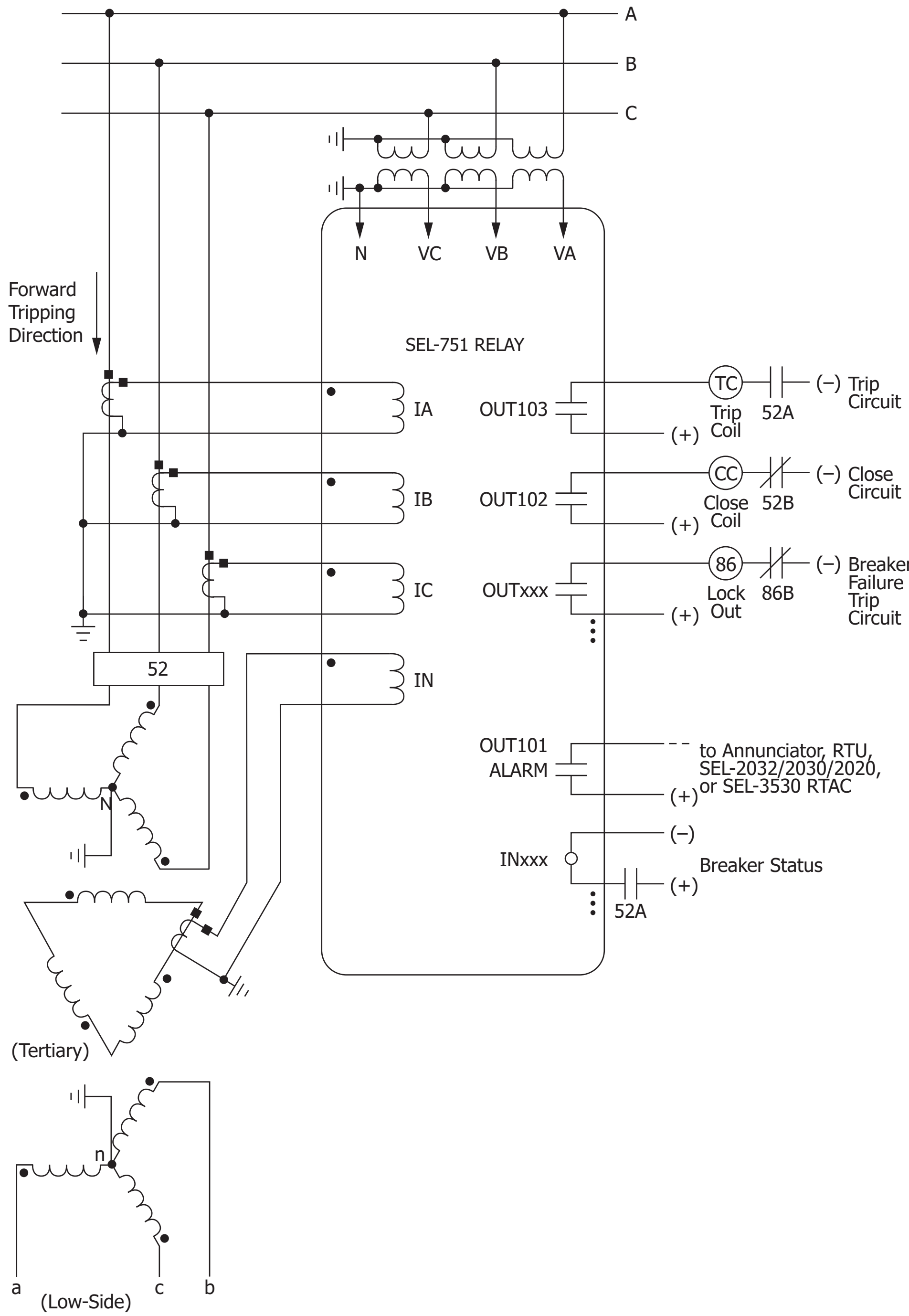


Voltages are necessary for voltage elements, synchronism-check elements, voltage-polarized directional elements, fault location, and metering (e.g., voltage, KW, KVAR). INxxx and OUTxxx indicate user-configurable optional digital inputs and outputs.

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 1.14. See neutral ground overcurrent element pickup specifications in Table 4.10 and Table 4.17.

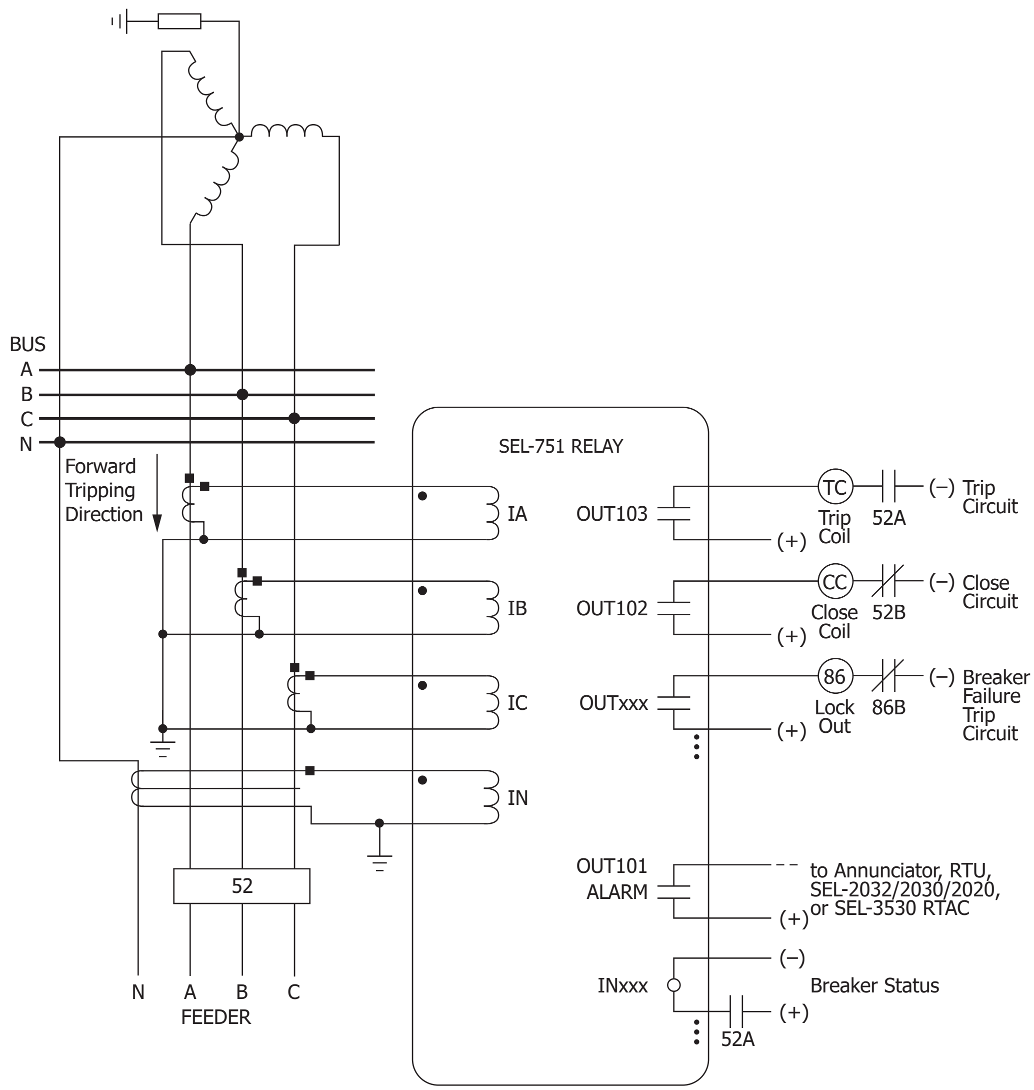
Figure 2.33 SEL-751 Provides Overcurrent Protection for a Delta-Wye Transformer Bank (Wye-Connected PTs)



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



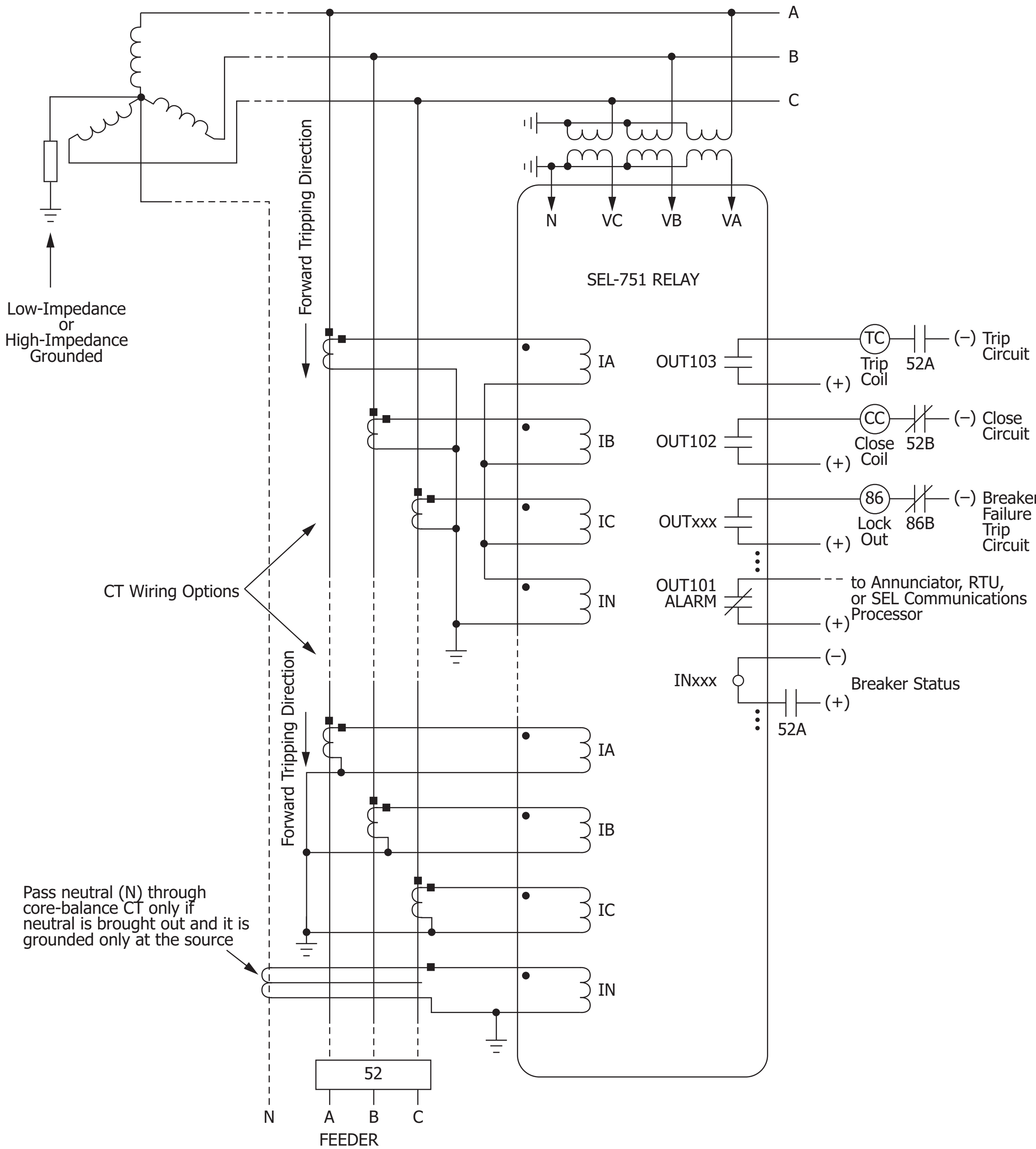
A core-balance current transformer is often referred to as a zero-sequence, ground fault, or window current transformer.

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

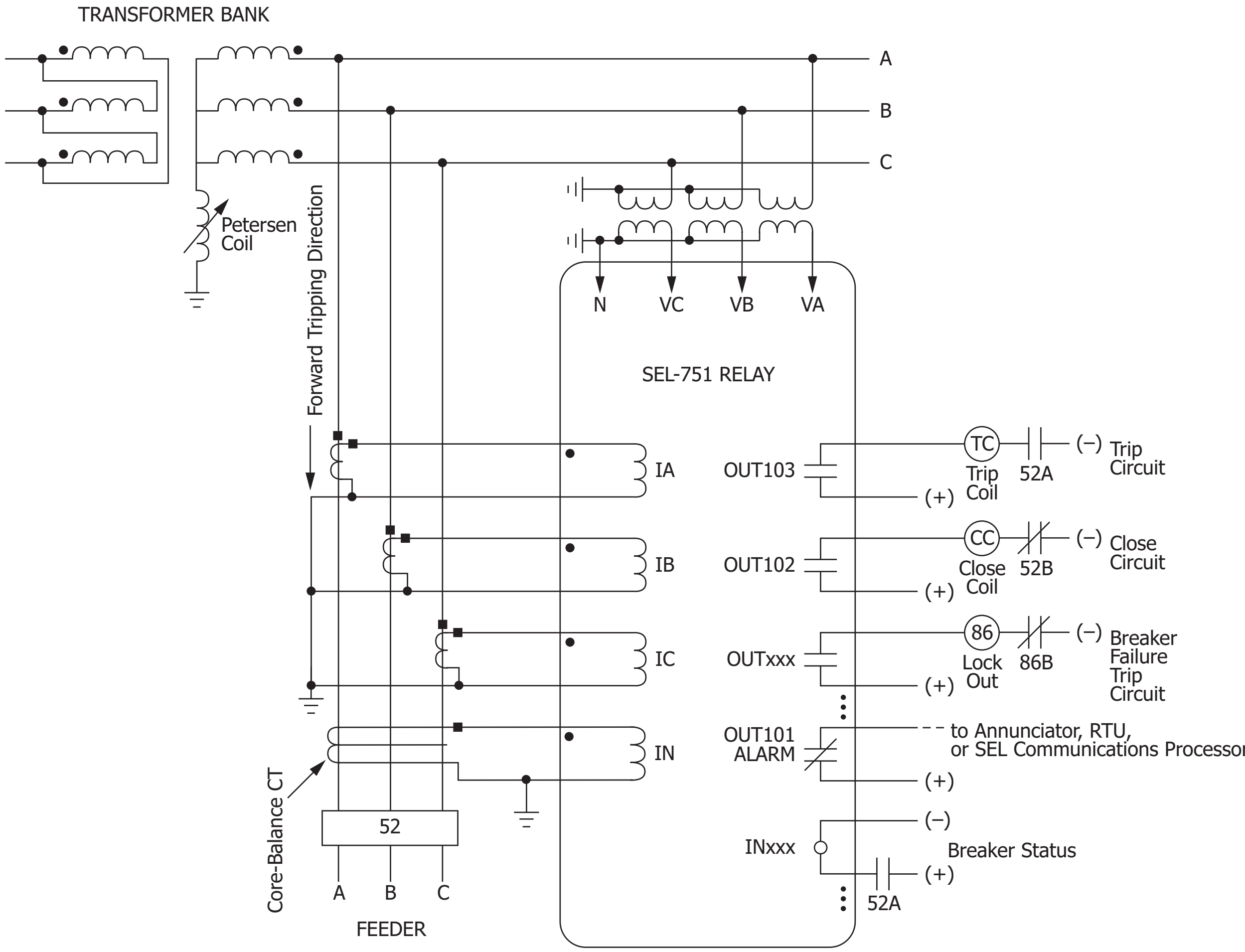


A core-balance current transformer is often referred to as a zero-sequence, ground fault, or window current transformer.

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 4.23–Table 4.25). Nondirectional sensitive earth fault (SEF) protection is also available.

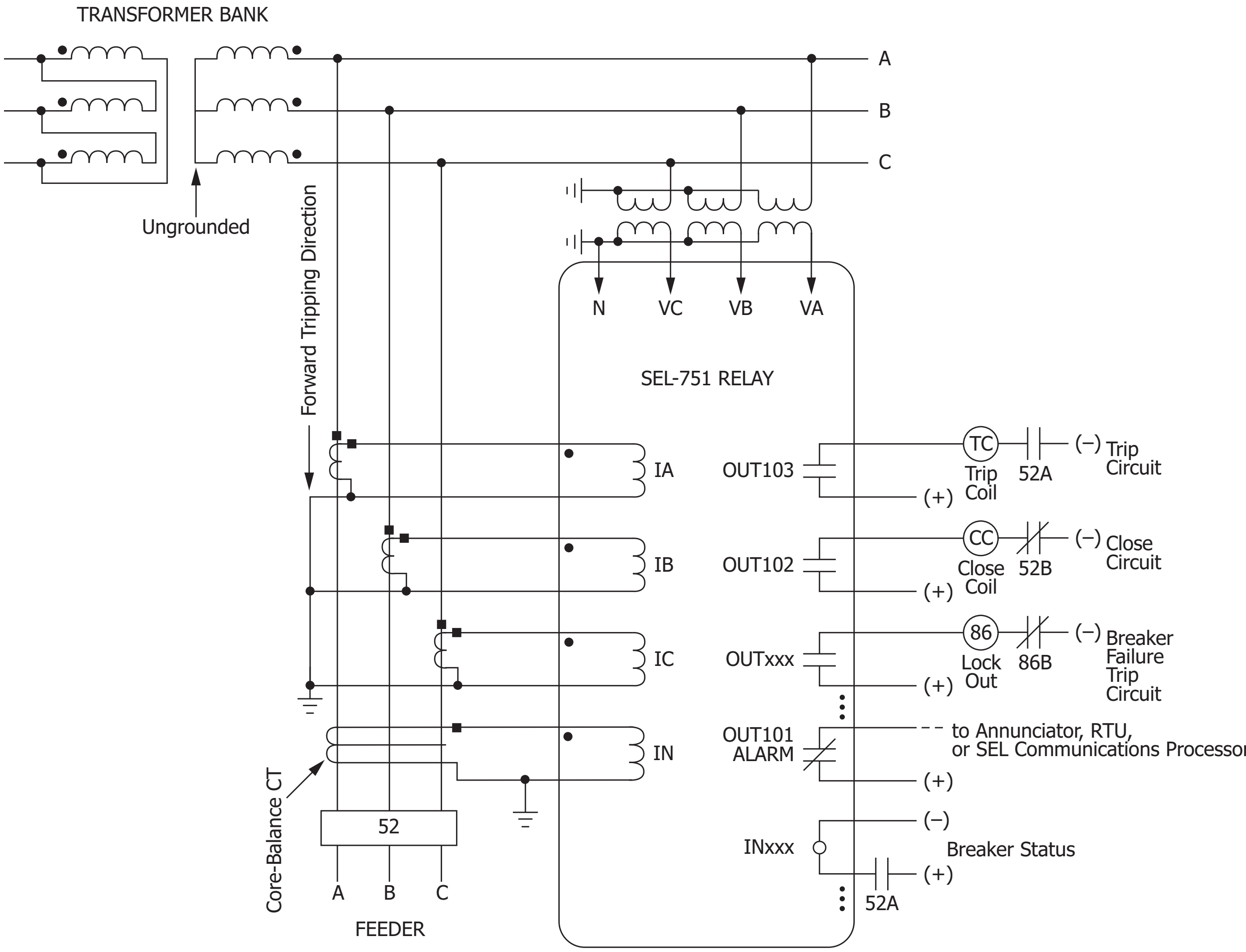
Figure 2.36 SEL-751 Provides Overcurrent Protection for a High-Impedance or Low-Impedance Grounded System (Wye-Connected PTs)



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 4.23–Table 4.25). Nondirectional sensitive earth fault (SEF) protection is also available.

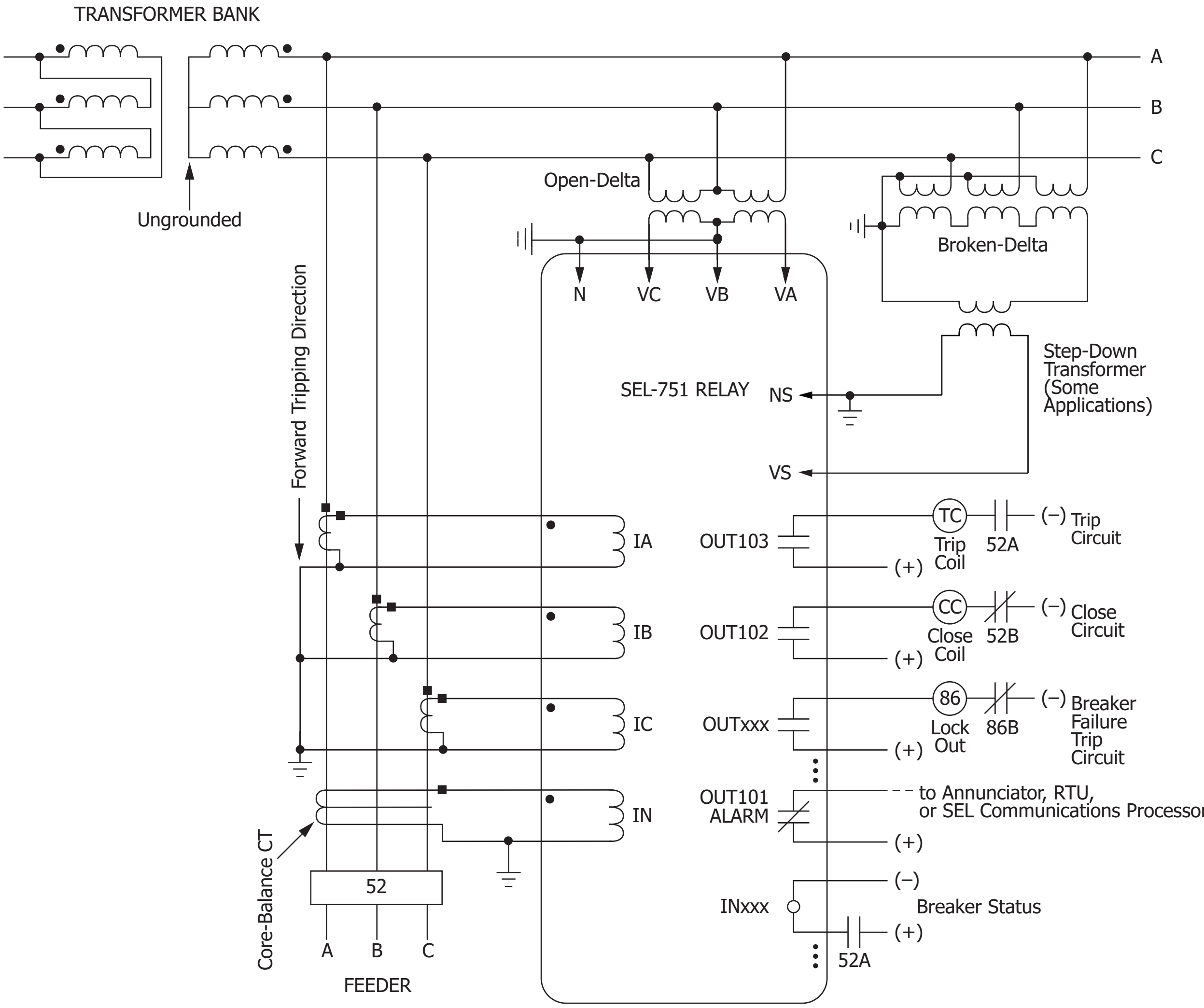
Figure 2.37 SEL-751 Provides Overcurrent Protection for a Petersen Coil-Grounded System (Wye-Connected PTs)



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 4.23–Table 4.25). Nondirectional sensitive earth fault (SEF) protection is also available.

Figure 2.38 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 4.23–Table 4.25). 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 2.39 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 2.40 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 2.13* 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 2.15* 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 2.40 SEL-751 With an Arc-Flash Option Card and 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 2.41* shows an example of a typical black-jacketed fiber installation.

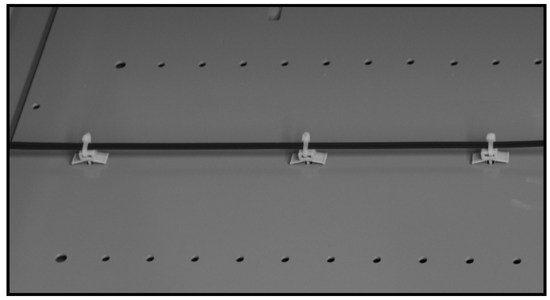


Figure 2.41 Black-Jacketed Fiber installation Example

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 2.40*.

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 2.42* shows a schematic diagram of the point-sensor assembly.

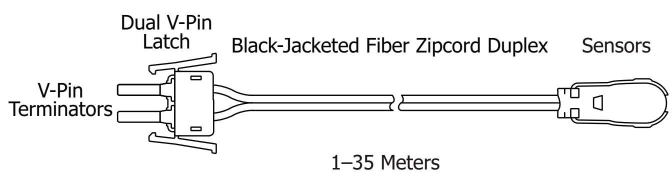


Figure 2.42 Point-Sensor Assembly

There is a standard point sensor or a window point sensor available for the point-sensor assembly.

The standard point sensor is optimized for mounting inside the switchgear compartment. *Figure 2.45* shows the standard point-sensor dimensions.

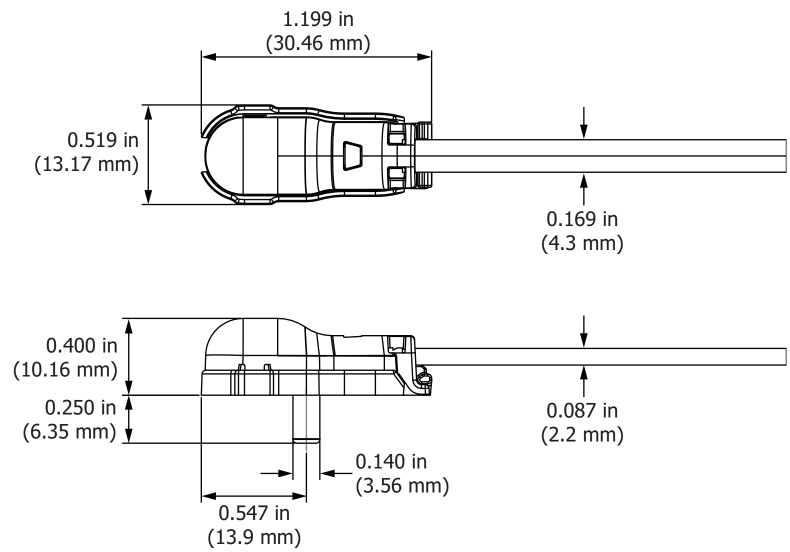
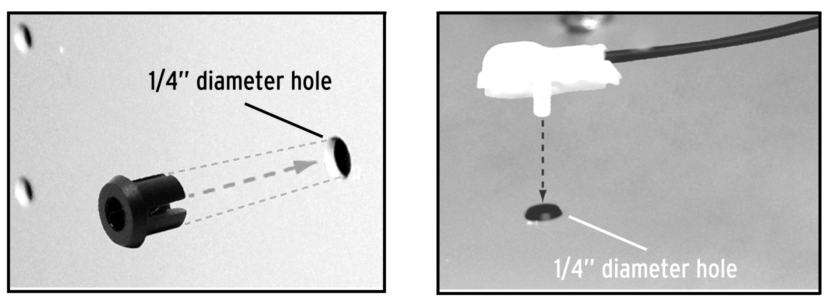


Figure 2.43 Standard Point-Sensor Dimensions

The sensor is mounted flush on the switchgear cabinet wall, using a standard 1/4-inch hole. Mounting steps are shown in *Figure 2.44*.



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

Figure 2.44 Standard Point-Sensor Installation

The window point sensor is optimized for mounting outside switchgear, motor control centers, or breaker cabinets to detect an arc flash inside the enclosure. *Figure 2.45* shows the window point-sensor dimensions.

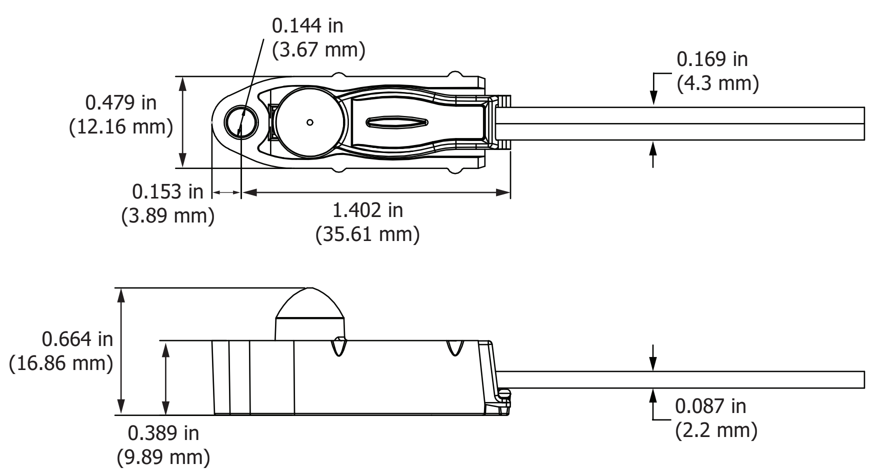


Figure 2.45 Window Point-Sensor Dimensions

The window point sensor requires two holes to be drilled on the enclosure as shown in *Figure 2.46*. The sensor must be mounted from the outside and secured in the correct position to the switchgear by using the self-tapping screws provided.

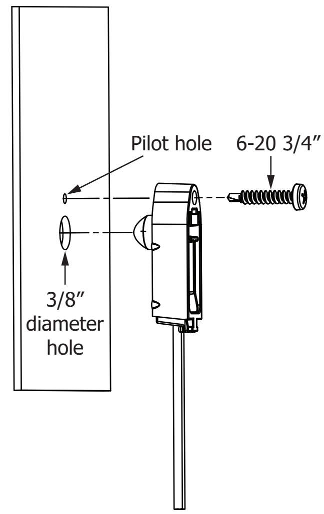


Figure 2.46 Window Point-Sensor Installation

The point sensor is omnidirectional with a slight loss of sensitivity at the fiber entry point. *Figure 2.47* through *Figure 2.49* 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.

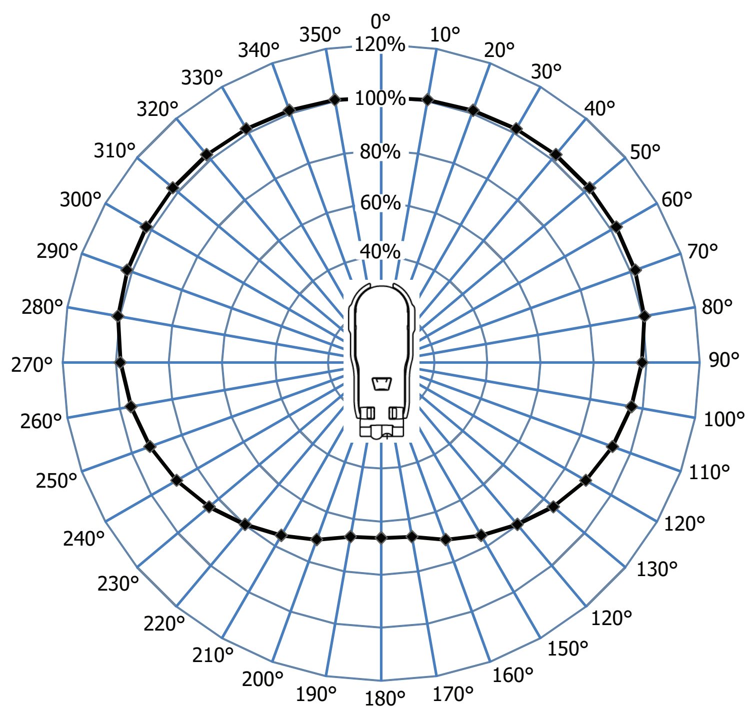


Figure 2.47 Point-Sensor Directivity (0–360° Around the Mounting Plane)

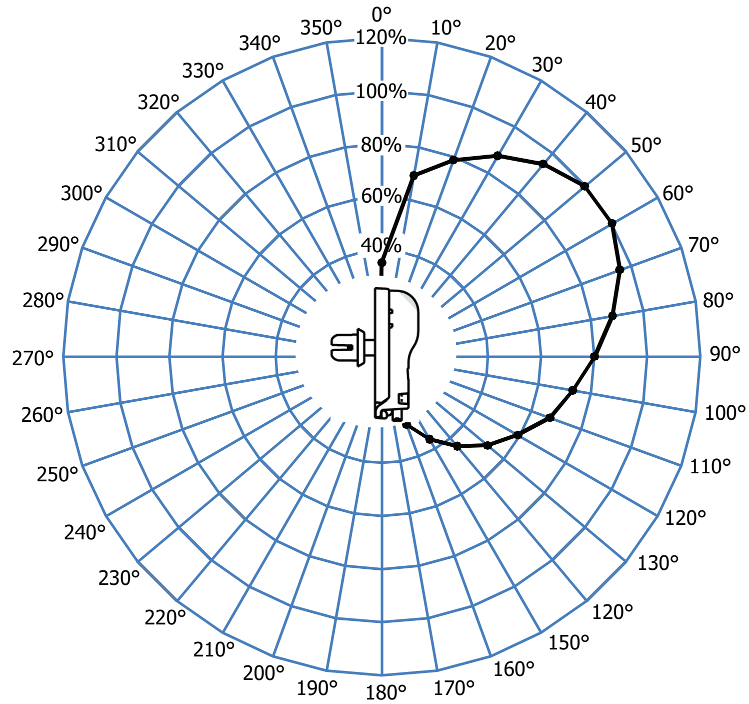


Figure 2.48 Point-Sensor Directivity (Front to Back, Above the Mounting Plane)

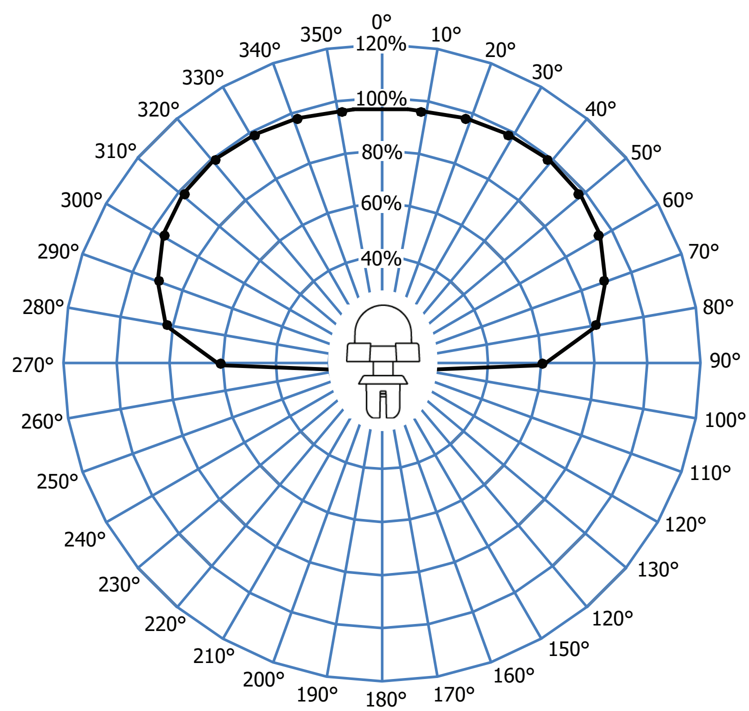
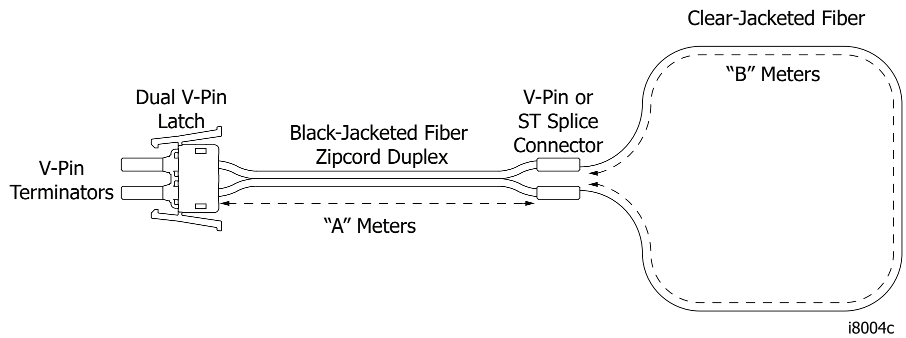


Figure 2.49 Point-Sensor Directivity (Left to Right, Above the Mounting Plane)

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 2.50* shows a schematic diagram of the clear-jacketed fiber sensor. *Figure 2.51* 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 2.50 Clear-Jacketed Fiber Sensor Assembly

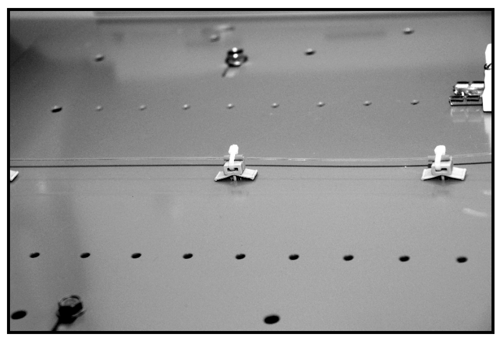


Figure 2.51 Clear-Jacketed Fiber Sensor Mounting Example

A clear-jacketed fiber sensor consists of the major components shown in *Figure 2.52*. 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 2.53*. The ST connector option is generally superior because of positive locking.

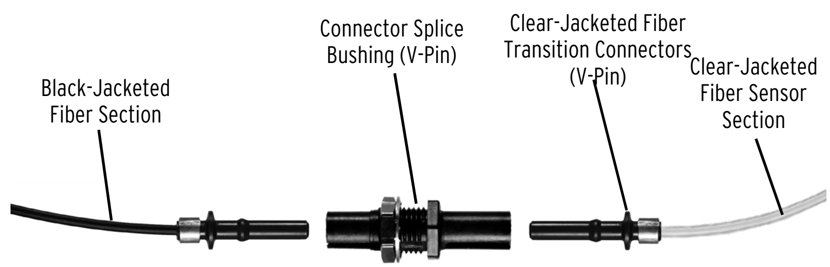
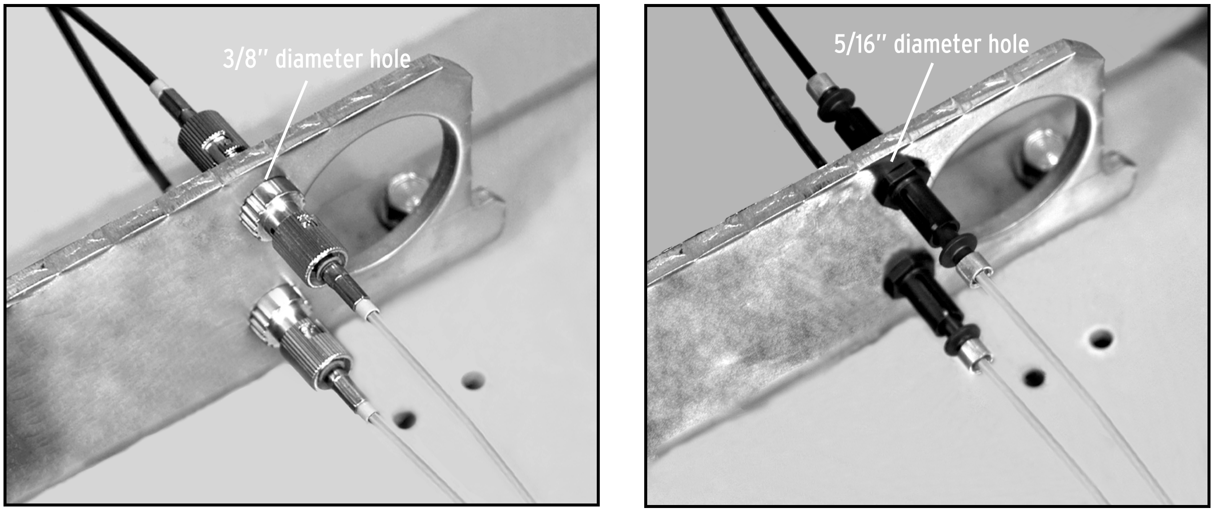


Figure 2.52 Clear-Jacketed Fiber Sensor Components (V-Pin Style)

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 2.53*.



ST Connection (3/8″ diameter hole)

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

Figure 2.53 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.

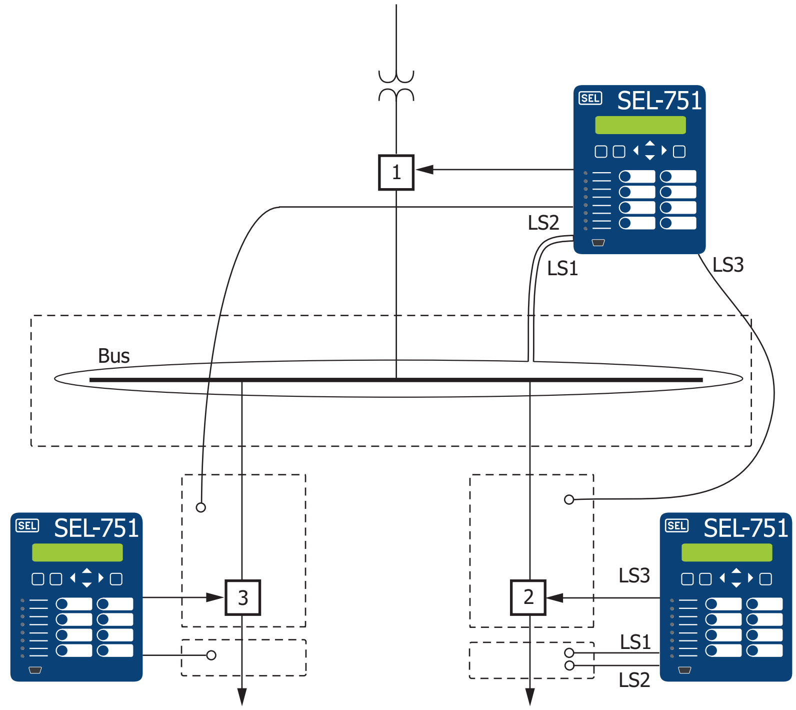
Application Example

⚠CAUTION
Before placing the arc-flash protection system in service, first make sure all the sensors are correctly installed, and then execute the **AFT** command to initiate a self-test.

Figure 2.54 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 2.54* 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 2.54*). 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 2.54 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 2.22* are typical values.

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.

Table 2.22 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.

Table 2.23 SEL-C804 and SEL-C814 Arc-Flash Detection Cable Specifications (Sheet 1 of 2)

Specifications	Cable	
	Black Jacket, Zipcord	Clear Jacket, Simplex
Operating Temperature	–40° to +85°C	–55° to +85°C
Core Material	PMMA	PMMA
Cladding Material	Fluorinated Polymer	Fluorinated Polymer

Table 2.23 SEL-C804 and SEL-C814 Arc-Flash Detection Cable Specifications (Sheet 2 of 2)

Specifications	Cable	
	Black Jacket, Zipcord	Clear Jacket, Simplex
Core Diameter	980 µm	980 µm
Cladding Diameter	1000 µm	1000 µm
Jacket Material	PVC	Polyethylene
Outer Cable Diameter	2.2 mm x 4.3 mm (0.087 in x 0.17 in)	2.20 mm (0.087 in)
Weight/Unit Length	11 g/m (0.008 lb/ft)	4 g/m (0.003 lb/ft)
Maximum Cable Pull Tension	140 N (9.6 lb/ft)	70 N (4.8 lb/ft)
Maximum Connector Pull Tension	43.8 N (3.0 lb/ft)	43.8 N (3.0 lb/ft)
Minimum Bend Radius	25 mm (0.98 in)	25 mm (0.98 in)
Attenuation (Loss)	0.175 dB/m	0.175 dB/m

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 2.55*.

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

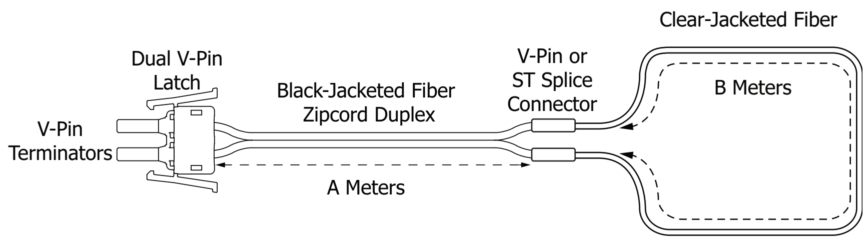


Figure 2.55 Bare-Fiber Sensor Assembly With Two Splices

This example shows a point sensor with an **A** dimension of 30 m, as shown in *Figure 2.56*.

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

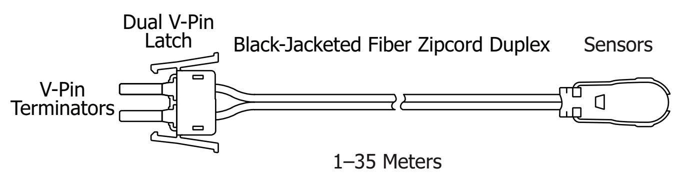


Figure 2.56 Point Sensor Assembly

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 2.57*, 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

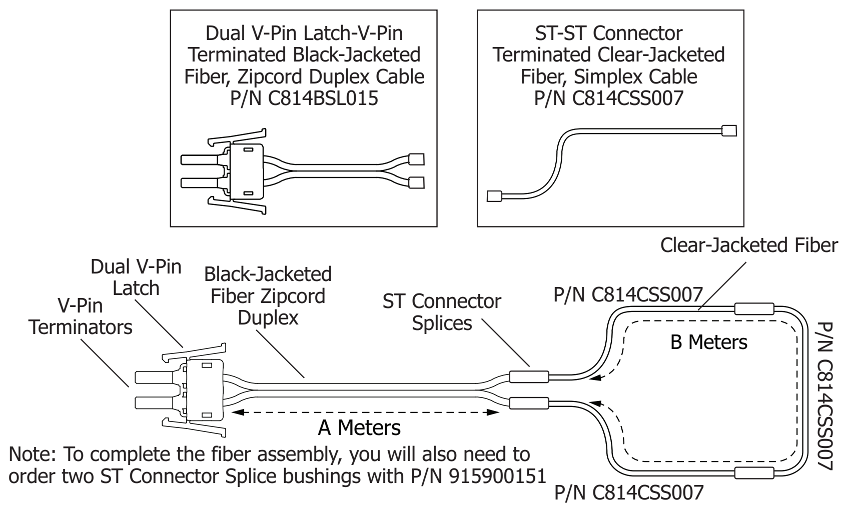
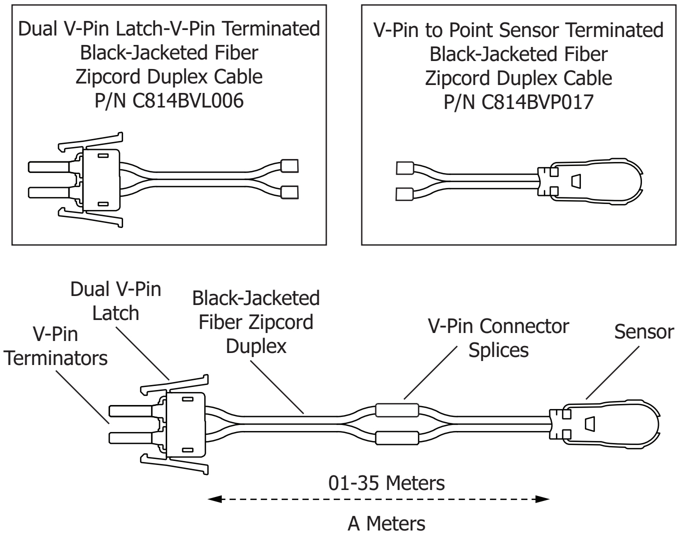


Figure 2.57 Bare-Fiber Sensor Assembly With Two Additional ST Splice Connectors

This example of a point sensor with two V-pin connectors, as shown in *Figure 2.58*, shows the part numbers generated using an SEL-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 2.58 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, Panasonic no. BR1632A 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 Panasonic no. BR1632A 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 Interface

Overview

The SEL-751 Feeder Protection Relay can communicate with your computer in three different ways.

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

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

- The web server requires a web browser (Microsoft Internet Explorer, Mozilla Firefox, Google Chrome, etc.) and an Ethernet cable. The relay must have the Ethernet port option. Refer to *Web Server* for functional details and capabilities.
- The SEL software solution requires downloading ACSELERATOR QuickSet SEL-5030 Software (via Compass) to your computer. Communication to the relay is accomplished through a serial or Ethernet port. Refer to *QuickSet Software on page 3.10* for functional details and capabilities.
- The ASCII command line requires PC-based terminal emulation software (HyperTerminal, Tera Term, etc.), a serial or Ethernet port, and a serial or Ethernet cable to connect to the relay. Refer to *Section 7: Communications* for ASCII commands and supported functions.

Web Server

Connection and Login to Web Server

The web server provides a GUI for the relay without loading any software on your PC. The GUI is contained in the relay firmware. To connect to the web server of the SEL-751, the relay and your PC must be connected to the same Ethernet network. The network can be of any size, from a company-wide network to a direct-connect from your PC to the relay. The connection from the relay is through the Ethernet port of the relay (Port 1). To start communicating with the relay, you must enter a valid IP address (SET P 1 IPADDR) and valid default router (SET P 1 DEFRTR) via a relay serial port. Be sure to obtain the IP address and default router from your IT resource to avoid network conflicts (e.g., duplicate IP addresses).

The SEL-751 comes pre-loaded with settings that enable you to communicate with the relay over a simple network. The network consists of connecting the SEL-751 (via Port 1) directly to the Ethernet port of your computer. Connect to Ethernet Port 1 of the relay by using a standard RJ45 connector for the copper port and an LC connector for the fiber-optic port. This connection requires that the computer not be connected to any other network (see *Figure 3.1*).

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

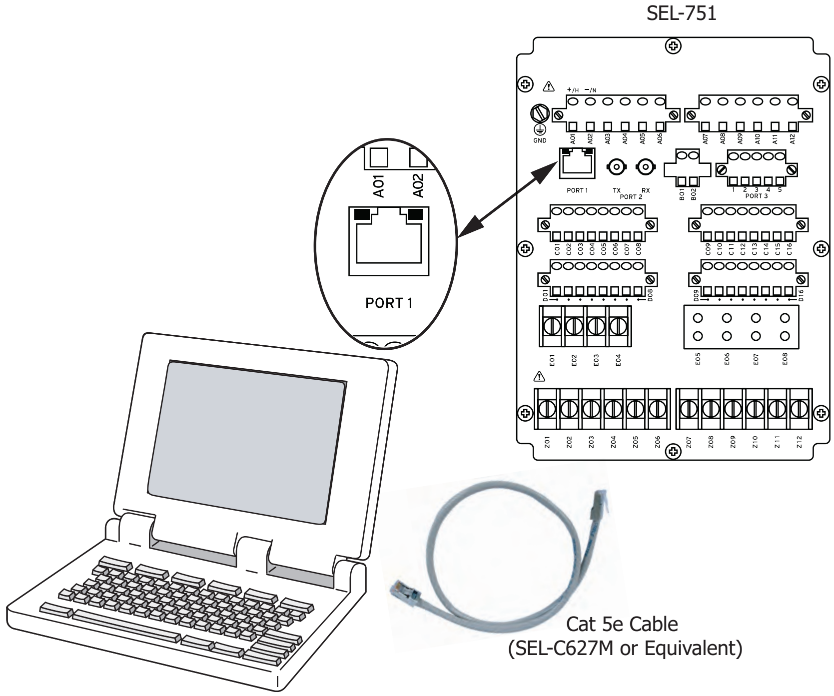


Figure 3.1 Direct Connection of an SEL-751 to a Computer

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

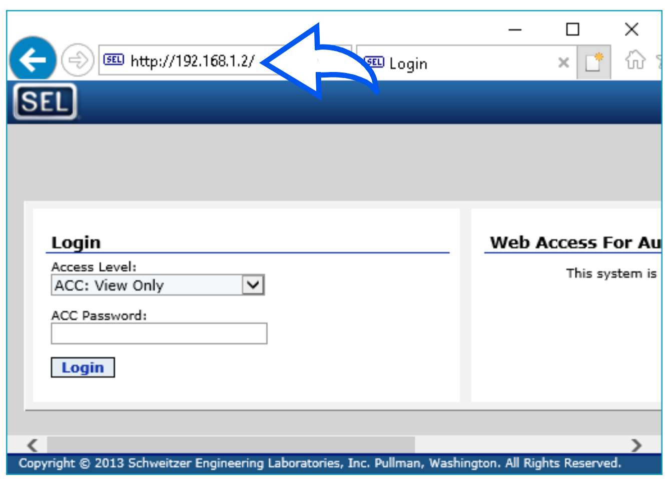


Figure 3.2 Login Page of Web Server for an SEL-751

The Login page of the web server allows you to access either Access Level 1 (ACC) or Access Level 2 (2AC). The menu item you select under Access Level determines the access level at which you enter the web server (see *Figure 3.3*). For factory-default passwords, refer to *Table 7.45*.

Meter, Reports, Communications, Relay Status, and Settings (show only) require Access Level 1 or 2. System requires Access Level 2. The reports shown in each category are based on the part number and settings. For example, if the relay does not support arc flash, the Meter Light report is not available.

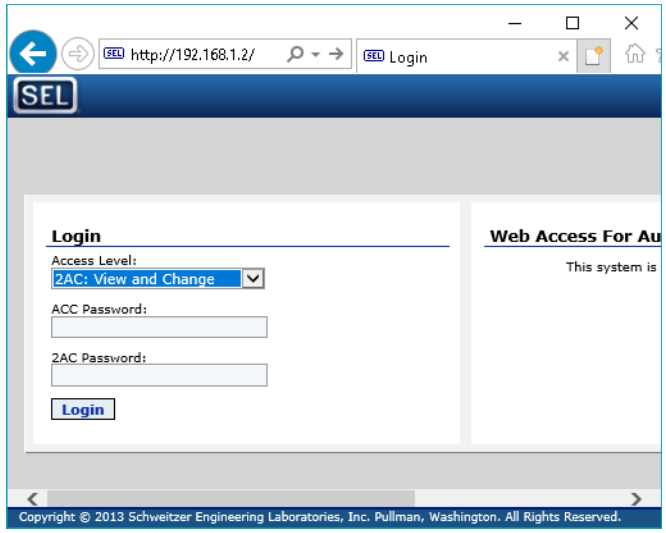


Figure 3.3 Select Access Level 2 From the Web Server Login

Meter

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

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

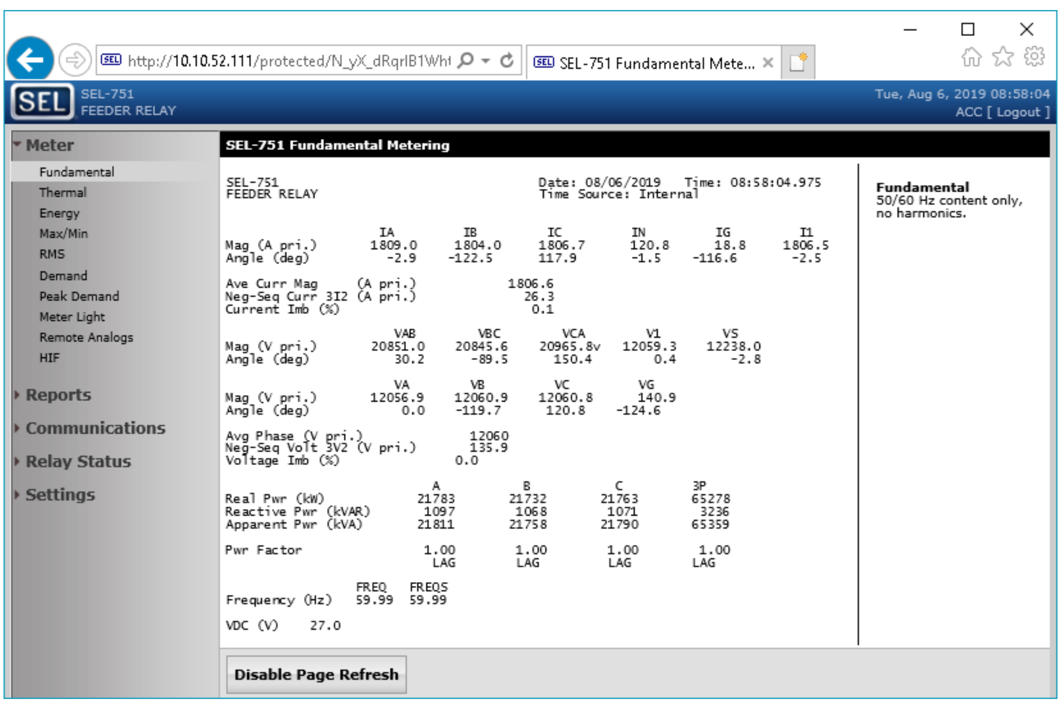


Figure 3.4 Fundamental Meter Report Webpage

Reports

The SEL-751 collects and stores a variety of data and statistics from the power system. These data are stored and reported through a series of reports. Located on the navigation pane, the Report menu lists each of the reports stored in the relay (Event Reports, HIF Event Reports, Sequential Events Recorder, Load Profile, and Breaker Monitor). When you select a report from the Reports menu, its corresponding report is displayed.

Event Reports

Event reports stored in the SEL-751 can be exported in three different formats (binary COMTRADE, raw CEV, or filtered CEV). When you select **Event Reports**, a list of all the event reports presently stored in the relay is shown (see *Figure 3.5*).

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

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

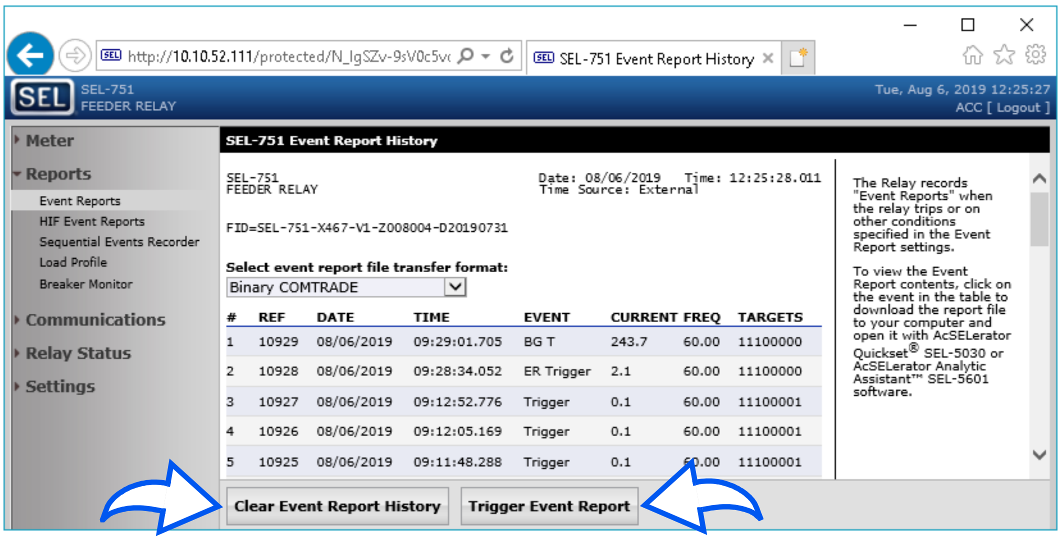


Figure 3.5 Event Report Webpage

HIF Event Reports

When the SEL-751 is ordered with the Arc Sense technology (AST) option for high-impedance fault (HIF) detection, the relay provides HIF reports. When you select **HIF Event Reports** from the Reports menu, a list of the HIF event reports available in the relay is shown. In addition to retrieving events, the HIF Event Reports page allows you to clear all the HIF events stored in the relay or to trigger an event.

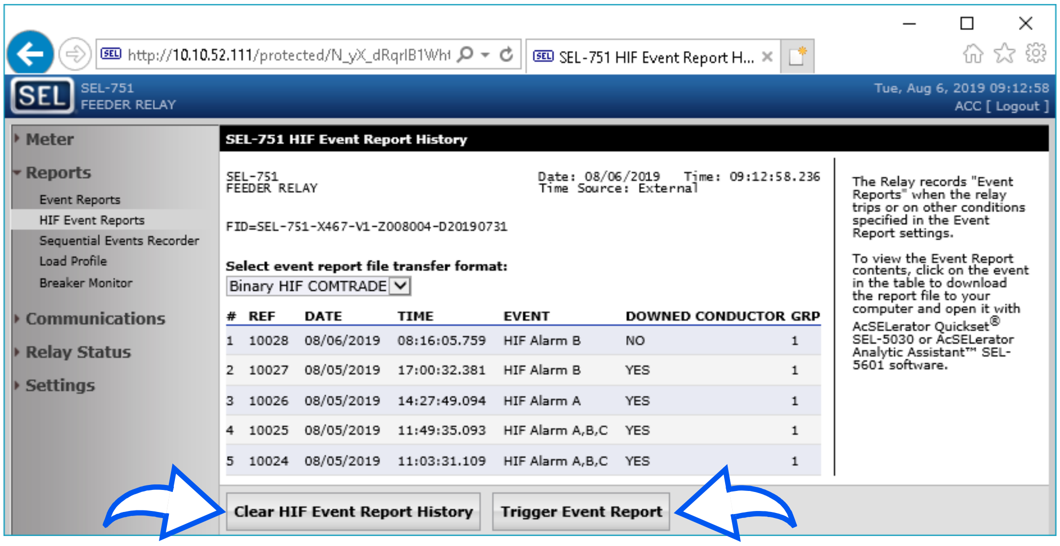


Figure 3.6 HIF Event Report Webpage

Sequential Events Recorder

In addition to event reports, the SEL-751 collects and stores time-stamped data for assertion and deassertion of the Relay Word bits. These data are captured in the Sequential Events Recorder (SER) and can be exported through the web server.

When you select **Sequential Events Recorder**, a list of all the SER records presently stored in the relay displays (see *Figure 3.7*). The SER report stored in the SEL-751 can be downloaded or cleared by clicking the appropriate button at the bottom of the webpage.

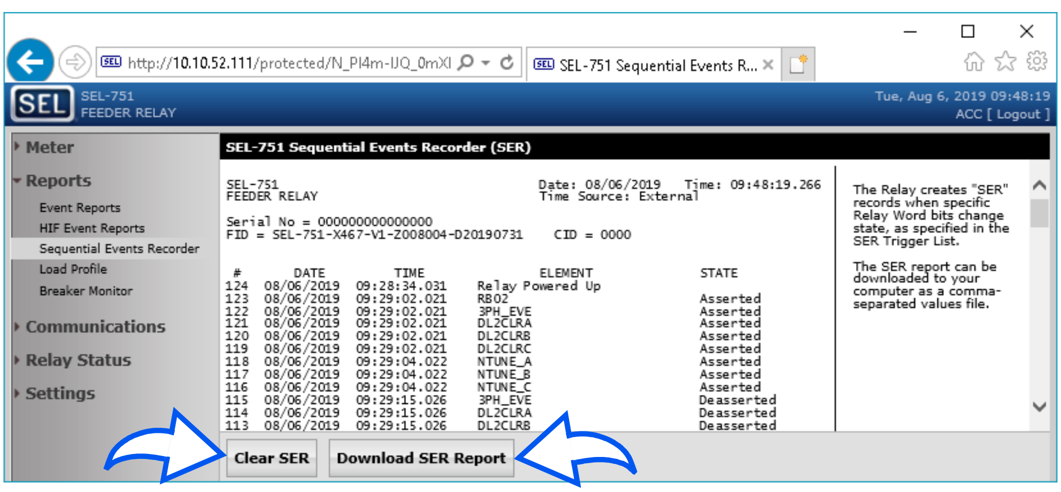


Figure 3.7 Sequential Events Recorder Report Webpage

Load Profile

The SEL-751 collects and stores time-stamped data of the analog quantities. These data are reported in the load profile report. When you select **Load Profile**, a list of all the load profile records presently stored in the relay displays (see *Figure 3.8*). You can export or clear the load profile report stored in the SEL-751 by using the two buttons at the bottom of the display window.

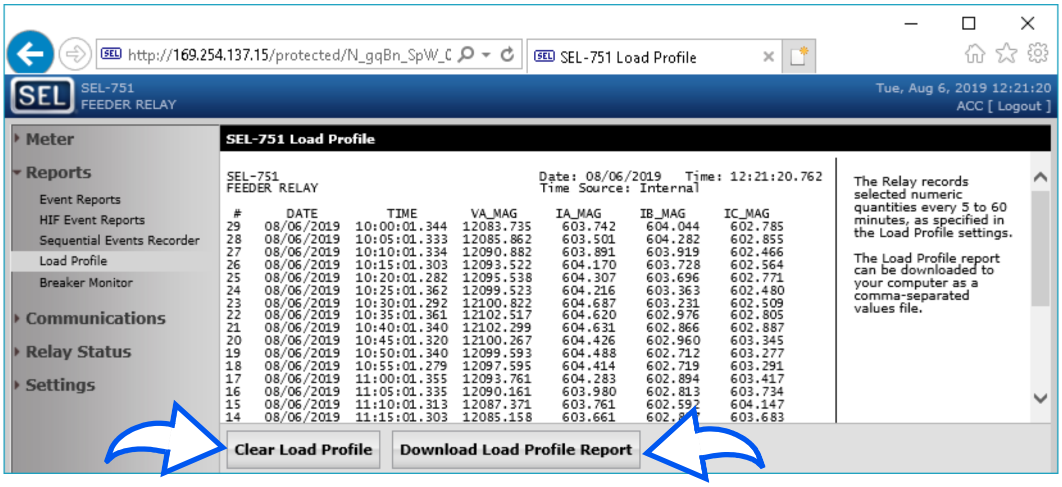


Figure 3.8 Load Profile Webpage

Breaker Monitor Report

The breaker monitor in the SEL-751 helps in scheduling circuit breaker maintenance (see *Breaker Monitor*). When you select **Breaker Monitor**, the breaker monitor report presently stored in the relay displays (see *Figure 3.9*). The breaker monitor report stored in the SEL-751 can be downloaded with the Download Breaker Monitor Report button.

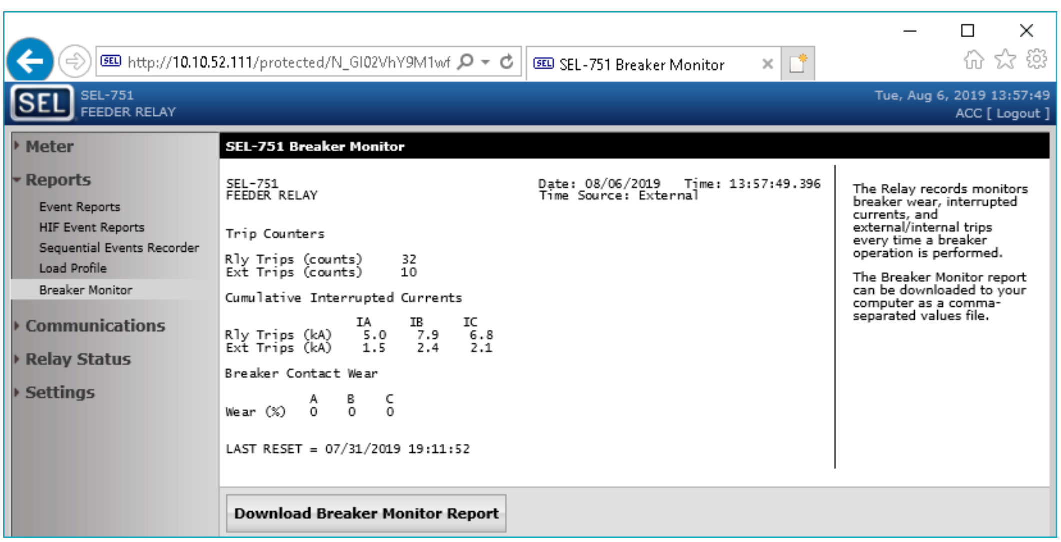


Figure 3.9 Breaker Wear Monitor Webpage

Communications

You can view the Ethernet port configuration details, including the MAC address of the relay, by clicking **Communications** > **Ethernet** (see *Figure 3.10*). Click **Clear Ethernet Statistics** to clear PACKETS, BYTES, and ERRORS data. Refer to *Section 7: Communications* for additional details on the Ethernet command.

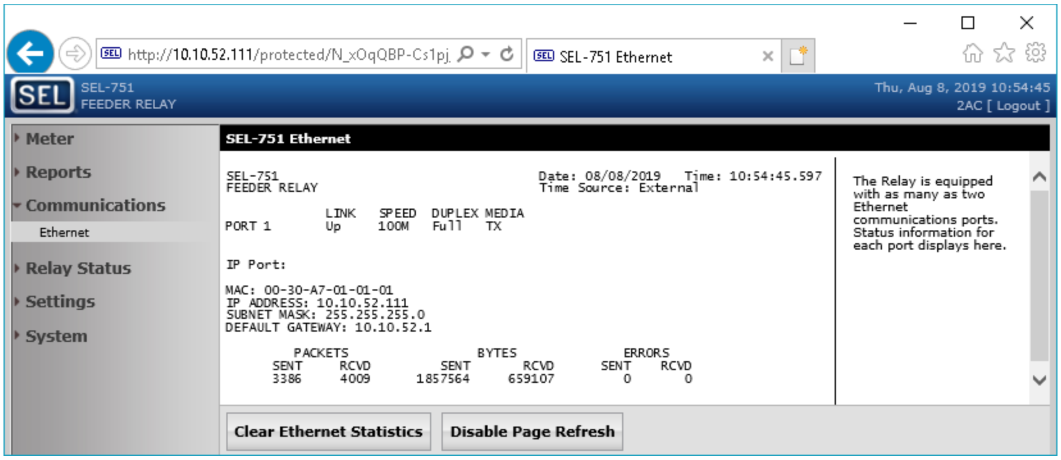


Figure 3.10 MAC Address

Relay Status

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

Self-Tests

The SEL-751 has continual diagnostics that verify the status of the relay hardware. The results of these diagnostics can be viewed by selecting **Relay Status** > **Self-Tests** in the navigation pane. When you select **Relay Status** > **Self-Tests**, the status of the relay, including the serial number, part number, and self-tests results, are displayed (see *Figure 3.11*).

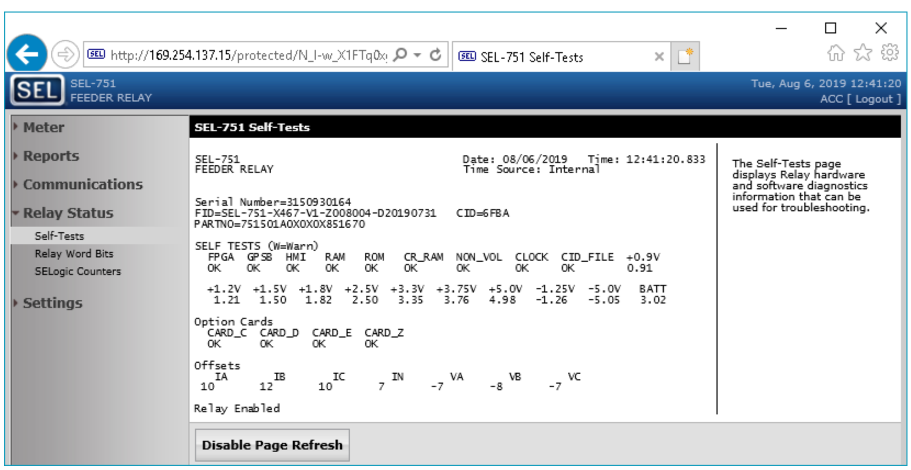
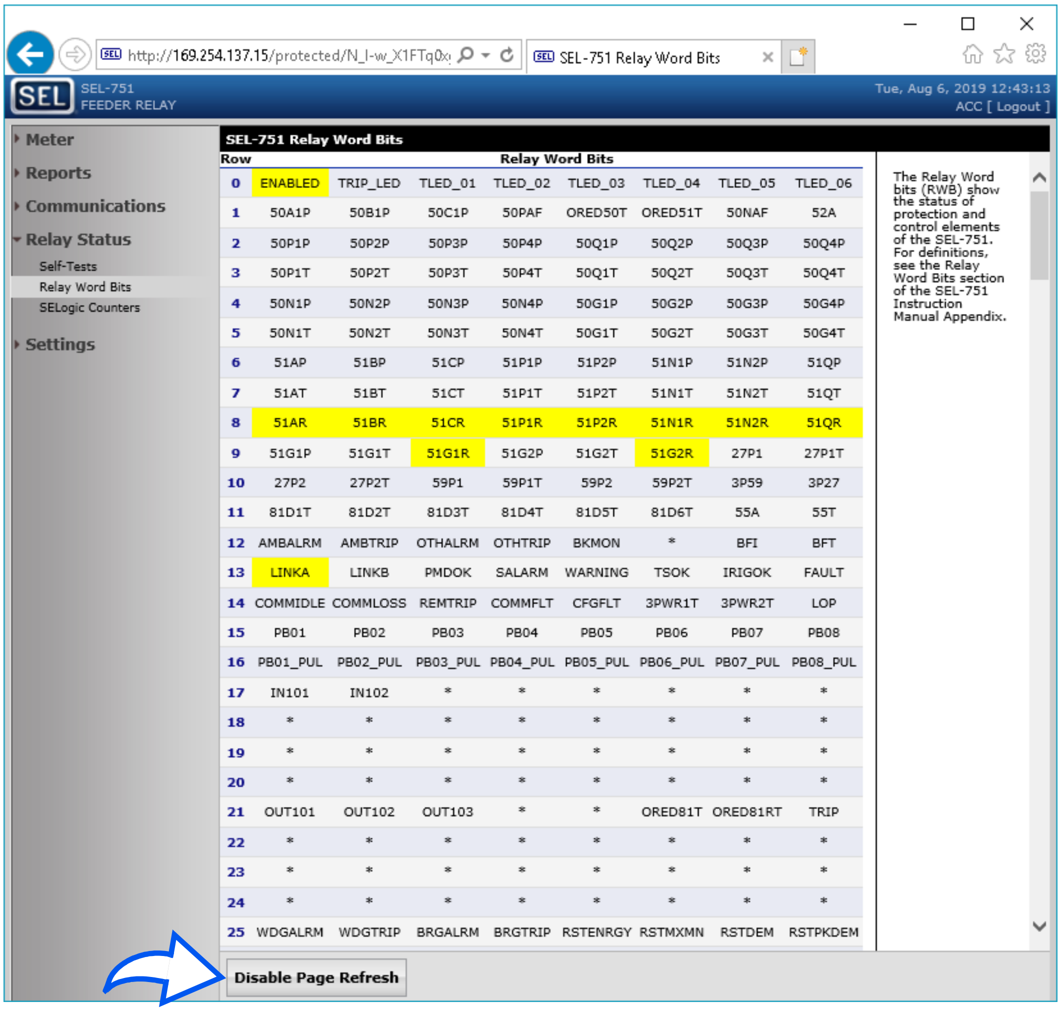


Figure 3.11 Self-Tests Webpage

Relay Word Bits

The web server can display the present state of the Relay Word bits of the relay. Select **Relay Word Bits** to display the state of all the Relay Word bits (see *Figure 3.12*). Relay Word bits shown in yellow are asserted. This webpage is updated automatically; you can disable the automatic updates by clicking **Disable Page Refresh**. Scroll up or down to view the remaining Relay Word bits not visible on the screen.



Row	Relay Word Bits							
0	ENABLED	TRIP_LED	TLED_01	TLED_02	TLED_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	*	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
16	PB01_PUL	PB02_PUL	PB03_PUL	PB04_PUL	PB05_PUL	PB06_PUL	PB07_PUL	PB08_PUL
17	IN101	IN102	*	*	*	*	*	*
18	*	*	*	*	*	*	*	*
19	*	*	*	*	*	*	*	*
20	*	*	*	*	*	*	*	*
21	OUT101	OUT102	OUT103	*	*	ORED81T	ORED81RT	TRIP
22	*	*	*	*	*	*	*	*
23	*	*	*	*	*	*	*	*
24	*	*	*	*	*	*	*	*
25	WDGALRM	WDGTRIP	BRGALRM	BRGTRIP	RSTENRGY	RSTMXMN	RSTDEM	RSTPKDEM

Figure 3.12 Relay Word Bits Webpage

SELogic Counters

When you select **Relay Status** > **SELogic Counters**, the count of each of the enabled SELogic counters displays (see *Figure 3.13*). A counter is only displayed when it is enabled.

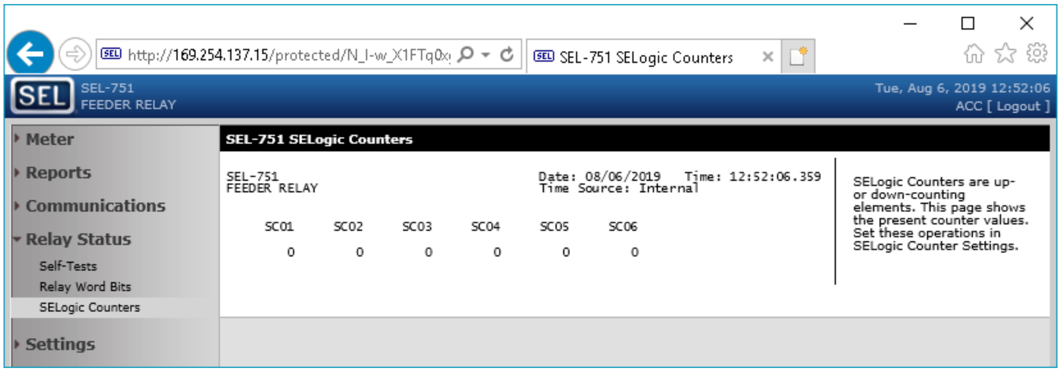


Figure 3.13 SELogic Counters Webpage

Settings

When you select **Settings** on the navigation pane, a list of all the available settings classes in the SEL-751 displays. Select a class of settings to view each of the settings in that class (Group, Logic, Global, Report, etc.). *Figure 3.14* shows the Group 1 settings class of Settings.

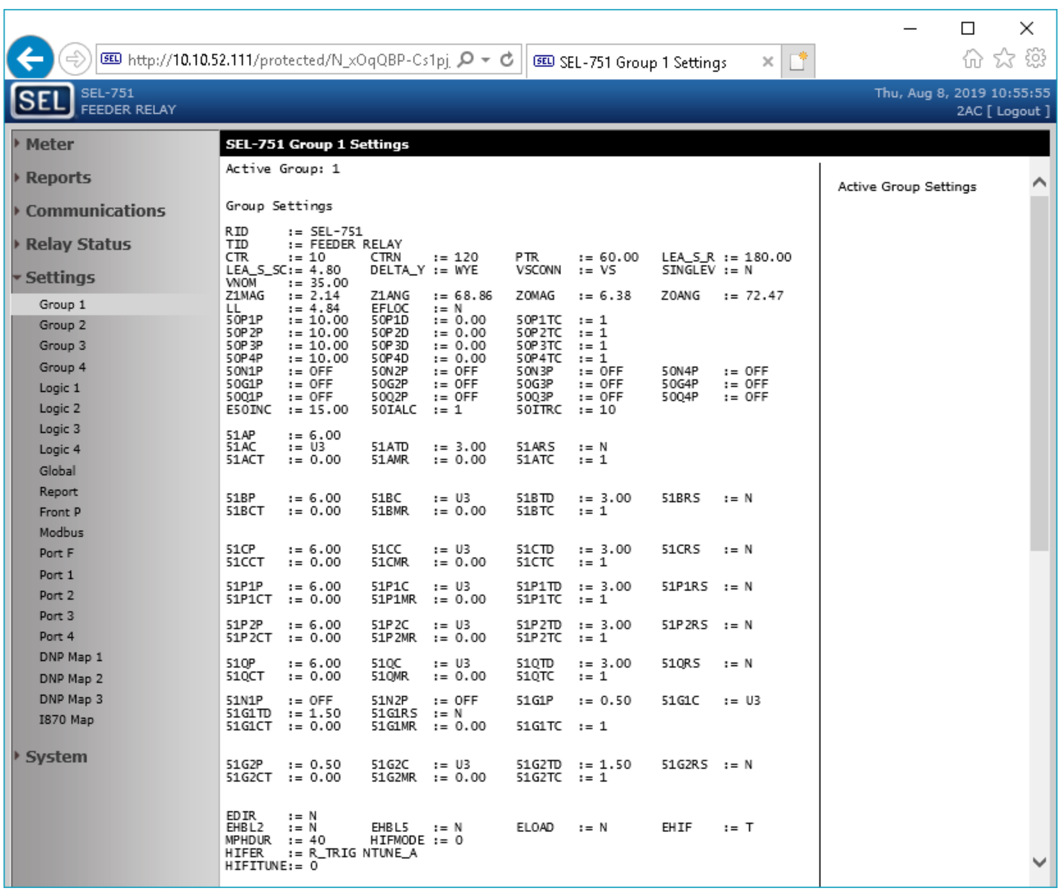


Figure 3.14 Group 1 Settings Webpage

System

File Management

The web server offers a convenient method for upgrading the relay firmware (Access Level 2). Select **System** > **File Management** (on the navigation pane) to upgrade your relay firmware (see *Figure 3.15*).

When preparing to upgrade the relay firmware you must first download the new relay firmware. The firmware is designated with a .zds extension. Click **Browse** to navigate to and select the firmware you want to send to the relay, and click **Upgrade Firmware** to start the upgrade process (see *Figure 3.15*). See *Appendix B: Firmware Upgrade Instructions* for the complete firmware upgrade procedure.

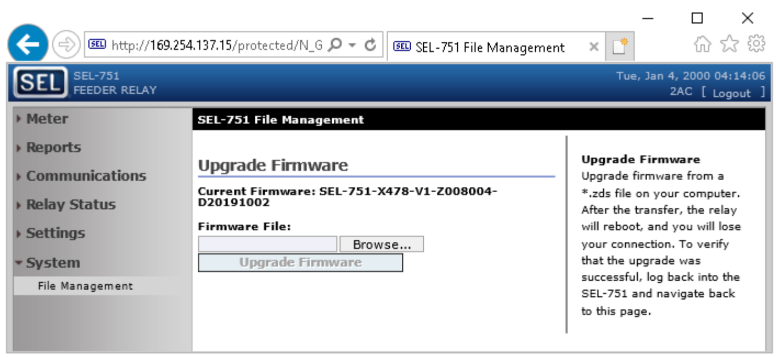


Figure 3.15 Upgrade Relay Firmware From the File Management Webpage

Language Support

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

QuickSet Software

This section describes how to get started with the SEL-751 and QuickSet. SEL provides many PC software solutions (applications) to support the SEL-751 and other SEL devices. *Table 3.1* lists SEL-751 software solutions.

Table 3.1 SEL Software Solutions (Sheet 1 of 2)

Part Number	Product Name	Description
SEL-5030	ACSELERATOR QuickSet SEL-5030 Software	See *Table 3.2*
SEL-5032	ACSELERATOR Architect SEL-5032 Software	Configures IEC 61850 communications
SEL-5036	ACSELERATOR Bay Screen Builder SEL-5036 Software	Designs and manages bay screens in conjunction with SEL-5030 for the SEL-751 with color touchscreen display
SEL-5040	ACSELERATOR Report Server SEL-5040 Software	Automatically retrieves, files, and summarizes reports
SEL-5601-2	SEL-5601-2 SYNCHROWAVE Event Software	Plots COMTRADE and SEL Compressed ASCII format event report oscillography; performs custom calculations on analog, digital, and complex quantities; and analyzes the Impedance Plane for distance element (mho) operation, the Alpha Plane for differential element (78L) operation, and the Bewley Lattice for traveling-wave data

Table 3.1 SEL Software Solutions (Sheet 2 of 2)

Part Number	Product Name	Description
SEL-5702	SEL-5702 Synchrowave Operations Software	Supports a variety of power system operations and analytics applications with high-resolution time-series data, real-time analytics, and GIS locations information to improve operator situational awareness.
SEL-5703	SEL-5703 Synchrowave Monitoring	Provides power system situational awareness by translating data into visual information; displays and analyzes time-synchronized synchrophasor data and relay event reports
SEL-5801	SEL-5801 Cable Selector	Selects the proper SEL cables for your application

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 QuickSet Applications

Application	Description
Rules-Based Settings Editor	Provides online or offline device settings that include interdependency checks. Use this feature to create and manage settings for multiple devices in a database.
HMI	Provides a summary view of device operation. Use this feature to simplify commissioning testing.
Design Templates[a]	Allows you to customize 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 Bay Screen Builder for SEL-751 relays with the color touchscreen display.
Setting Database Management	QuickSet uses a database to manage the settings of multiple devices.
Terminal	Provides a direct connection to the SEL device. Use this feature to ensure proper 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 your PC.

Step 2. Apply power to the SEL-751.

Step 3. Start 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 with the relay.

Step 1. Select **Communications** from the QuickSet main menu bar, as shown in *Figure 3.16*.

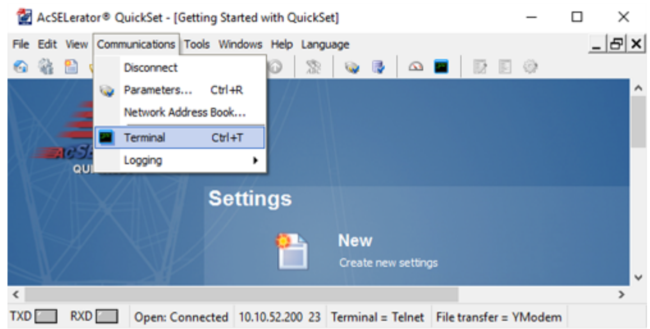


Figure 3.16 Communications Parameter Menu Selection

Step 2. Select the **Parameters** submenu to display the screen shown in *Figure 3.17*.

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 3.18*.

For the SEL-751, always select FTP as the file transfer option.

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

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

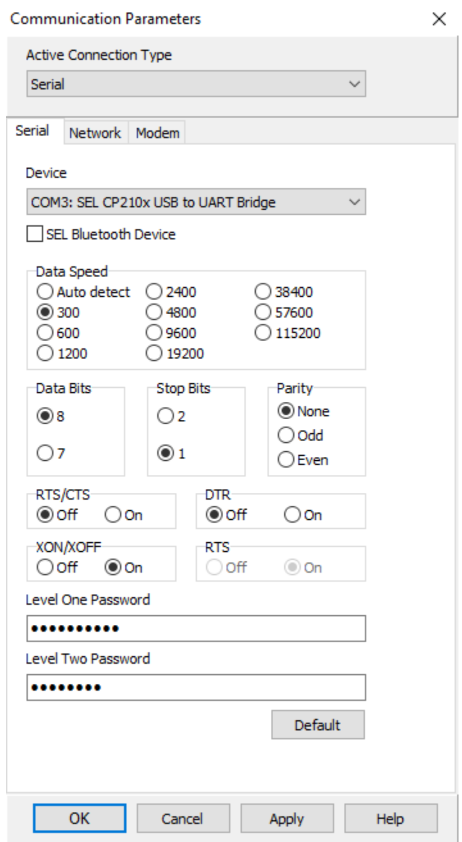


Figure 3.17 Serial Port Communication Parameters Dialog Box

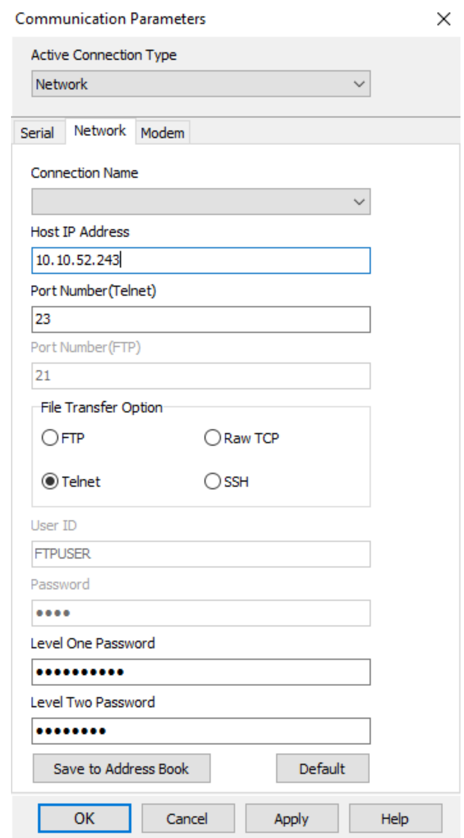


Figure 3.18 Network Communication Parameters Dialog Box

Terminal

Terminal Window

Select **Communications > Terminal** on the main menu bar (see *Figure 3.19*) to open the terminal window.

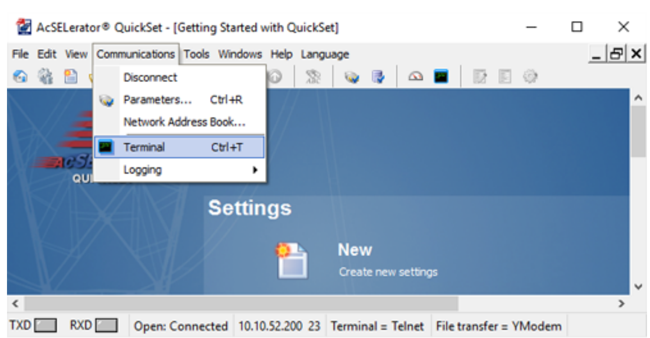


Figure 3.19 Communications Terminal Menu Selection

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 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 **Communications > Logging > Terminal Logging**, and specify a file at the prompt. QuickSet records communications events and errors in this file. Click **Communications > Logging > Connection Log** to view the log. Clear the log by selecting **Communications > Logging > Clear Connection Log**.

Driver and Part Number

After clicking **Communications > Terminal**, access the relay at Access Level 1. Issue the **ID** command to receive an identification report, as shown in *Figure 3.20*.

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 3.20 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 driver version is discussed in more detail in *Settings Editor on page 3.18*. 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.6*. 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 CDP was created and downloaded to the relay via QuickSet.

Settings Database Management and Driver

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

Database Manager

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

Settings Database

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

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

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

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

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

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

Copy/Move Settings Between Databases

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

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

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

a. Highlight a device or setting in Settings Database A.

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

Step 4. Reverse this process to move or copy 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 a new database:

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

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

Step 3. Click **OK**.

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

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

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 3.15*.

Settings

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 menu. QuickSet shows all of the settings categories in the settings tree view. The settings tree view remains constant whether settings categories are enabled or disabled.

Settings Menu

QuickSet uses a database to store and manage SEL relay settings. Each unique relay has its own settings records. Use the **File** menu to open (**Open)** an existing record, create and open a new (**New)** record, or read (**Read)** relay settings from a connected SEL-751 and then create and open a new record. Click **Tools** > **Settings** > **Convert** to convert and open an existing record in the settings editor.

Table 3.3 File/Tools Menus

Menus	Description
<<, >>	Use these navigation menu buttons to move from one category to the next
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

To make SEL-751 settings with the settings editor, click **File** > **New** on the main menu bar and select the SEL-751 and the latest driver version (00*X*) on the Settings Editor Selection screen, as shown in *Figure 3.21*.

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

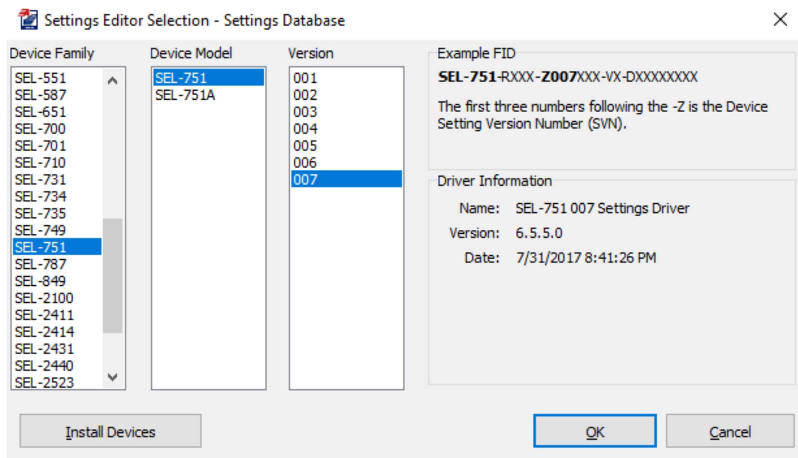


Figure 3.21 Driver Selection

After the relay model and settings driver selection, QuickSet presents the Device Part Number dialog box. Use this dialog box to configure the settings editor to produce settings for a relay with options determined by the part number, as shown in *Figure 3.22*. Click **OK** when finished.

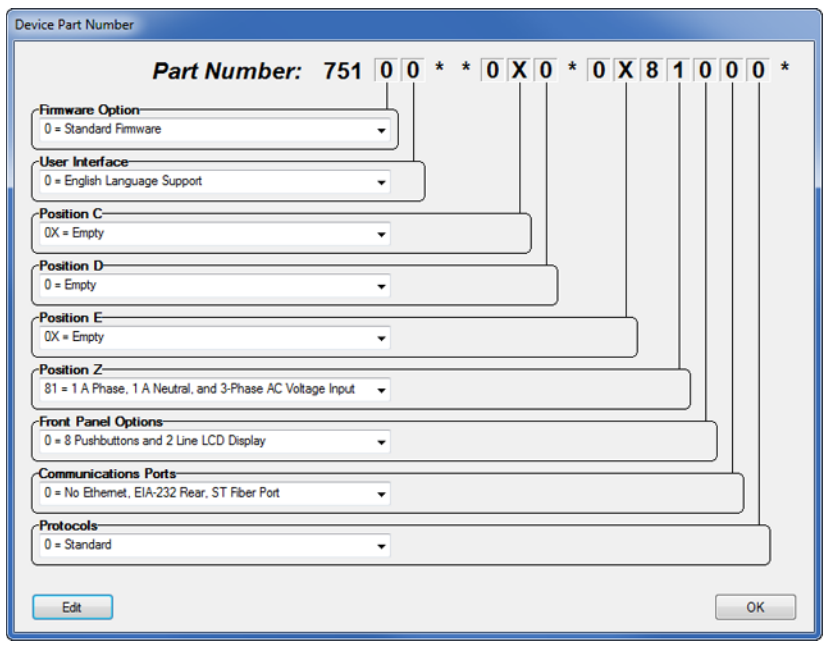


Figure 3.22 Update Part Number

Figure 3.23 shows the Settings Editor screen. Check the driver version number in the title bar of the Settings Editor screen. Compare the QuickSet 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.

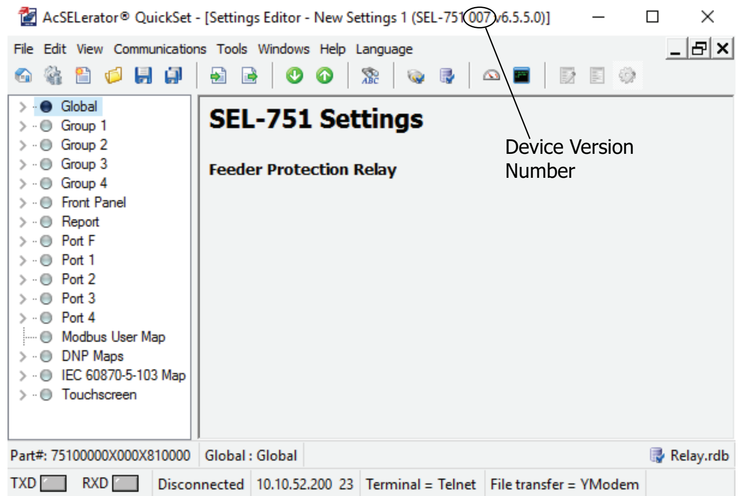


Figure 3.23 New Settings Screen

File > Open

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

File > Read

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

Tools > Settings > Convert

Use the **Convert** menu item (**Tools > Settings**) 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

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

Enter Settings

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

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

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

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

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

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

Expression Builder

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

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

Access Expression Builder. Use the ellipsis button that follows the setting text boxes in the settings editor to create an expression, as shown in *Figure 3.24*.

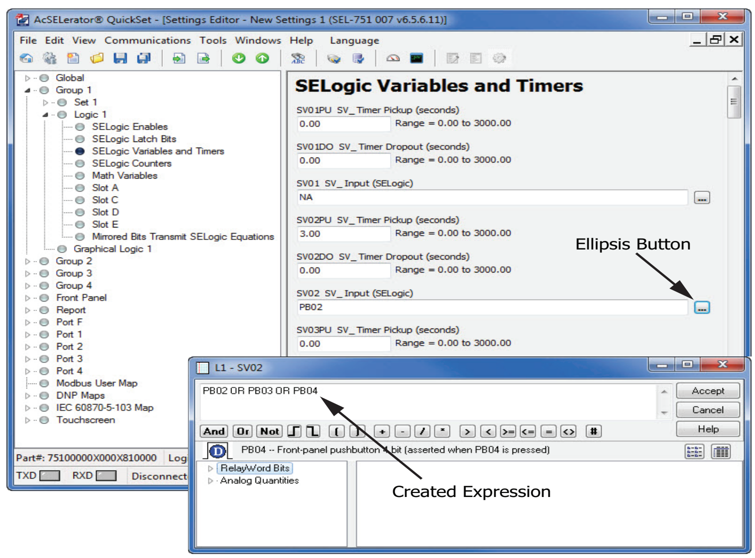


Figure 3.24 Expression Created With Expression Builder

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

Touchscreen Settings and Bay Screen Builder

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

File > Save

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

File > Send

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

Edit > Part Number

Use this menu item to change the part number.

Text Files

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

Event Analysis

QuickSet has integrated analysis tools that help you retrieve information about relay operations quickly and easily. Use the event information that the SEL-751 stores to evaluate the performance of a system (select **Tools > Events > Get Event Files**). *Figure 3.25* shows the event retrieval screen.

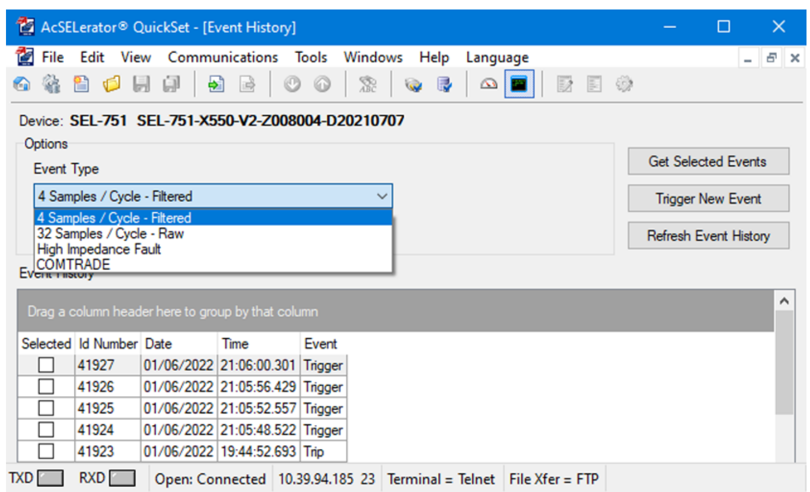


Figure 3.25 Retrieve Events Screen

You can retrieve event files stored in the relay and transfer these files to a computer. For information on the types of event files and data capture, see *Section 10: Analyzing Events*. To download event files from the device, click **Tools > Events > Get Event Files**. The Event History dialog box appears, as shown in *Figure 3.25*.

View Event History

NOTE: HIF events are only available with the Arc Sense technology (AST) option. HIF events can take as long as an hour to download (at 38400 bps). Increase the data rate before downloading.

The SEL-751 is capable of capturing three types of events (4 samples/cycle filtered, 32 samples/cycle raw, and high-impedance fault). These events can be captured in either compressed ASCII (.cev) or COMTRADE format. QuickSet allows you to download the .cev events. Use the Event Type drop-down shown in *Figure 3.25* to select the event type. For information on how to download COMTRADE events from the relay, see *Section 10: Analyzing Events*, *Retrieving COMTRADE Event Files*.

Get Event

Highlight the event you want to view (see *Figure 3.25*), select the event type from the Event Type drop down menu (4 samples or 32 samples), and click **Get Selected Event**. QuickSet then queries where to save the file on your computer, as shown in *Figure 3.26*.

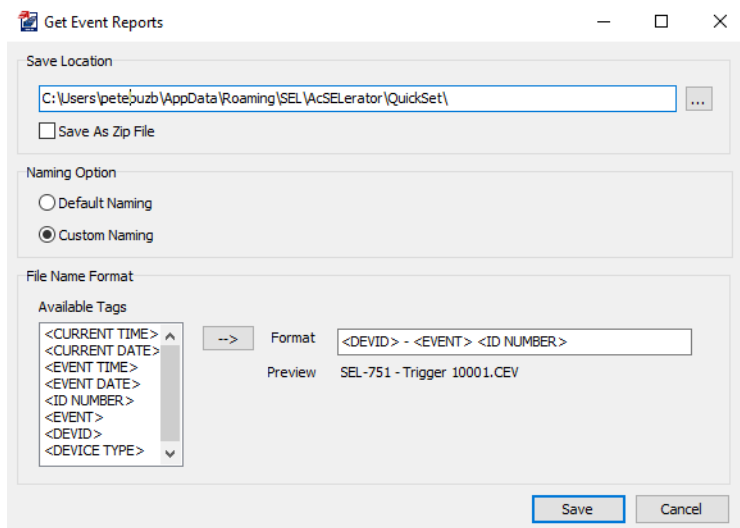


Figure 3.26 Save the Retrieved Event

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

View Event Files

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

Meter and Control

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

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

Device Overview

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

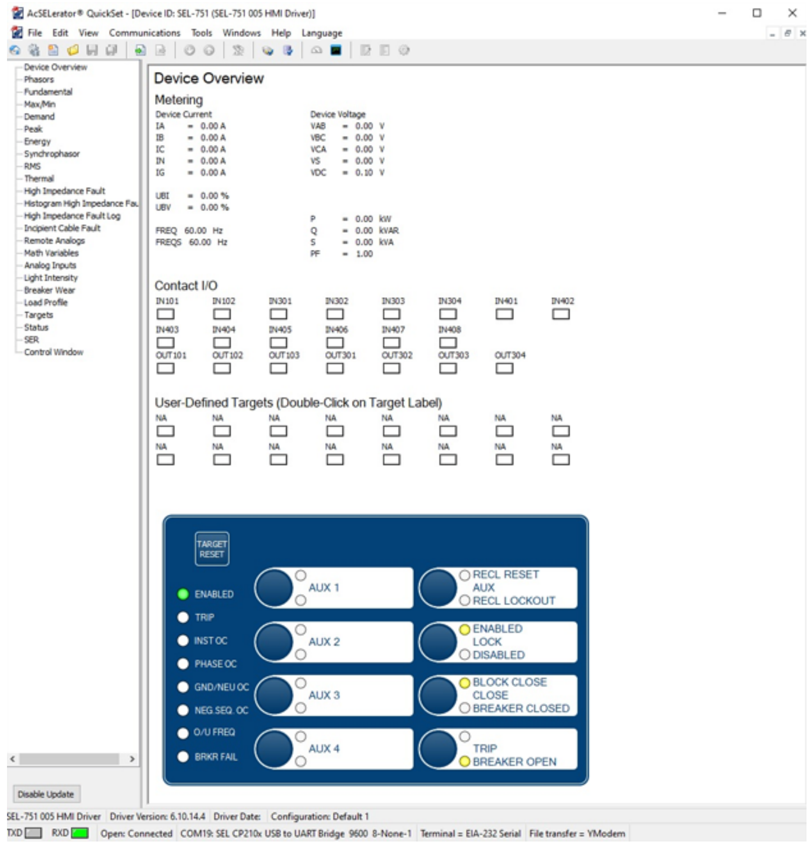


Figure 3.27 Device Overview Screen

You can assign any Relay Word bit to the 16 user-defined target LEDs. To change the present assignment, double-click on the text above the square you want to change. After double-clicking on the text, a box with available Relay Word bits appears in the lower left corner of the screen. Select the appropriate Relay Word bit, and click 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 assignments. 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 (RB02 = 1), the Relay Word bit is asserted. 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 3.28 shows the control screen. From here, you can reset metering data; clear the Event History, SER, MIRRORED BITS report, or LDP; or trigger events. You can also reset the targets, synchronize with IRIG, or set the time and date. If supported, you can run arc-flash sensor diagnostic tests.

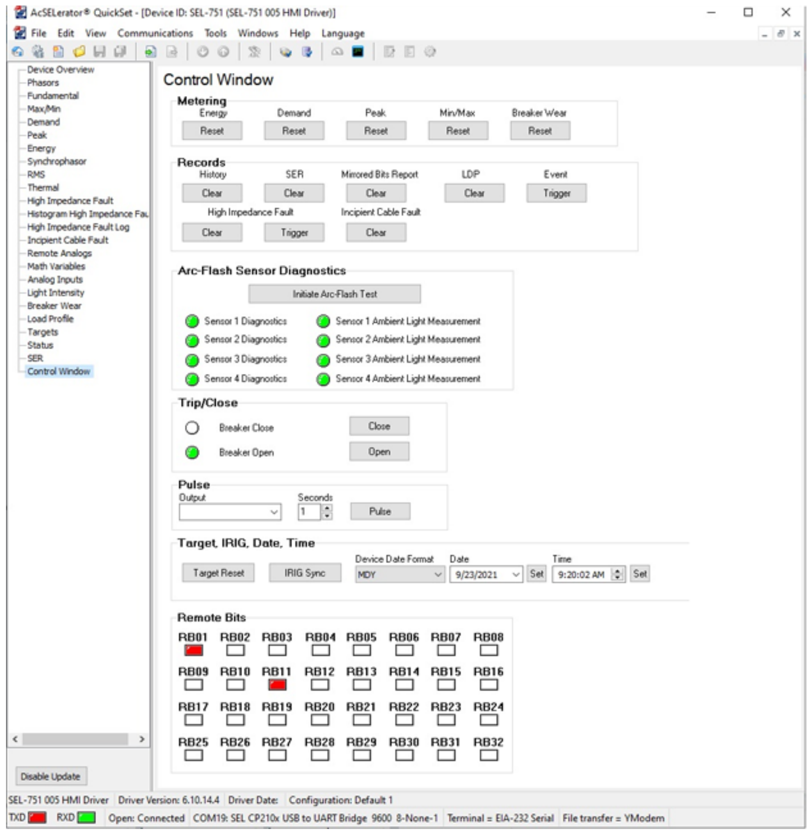


Figure 3.28 Control Screen

To control the Remote bits, click on the appropriate square, then select the operation from the box shown in *Figure 3.29*.

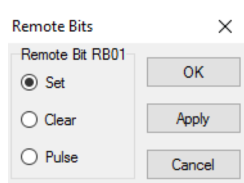


Figure 3.29 Remote Operation Selection

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 **Language** to choose from English, Spanish, French, or Chinese, as seen in *Figure 3.30*. Selecting any of these choices converts the menu items in QuickSet to the selected language.

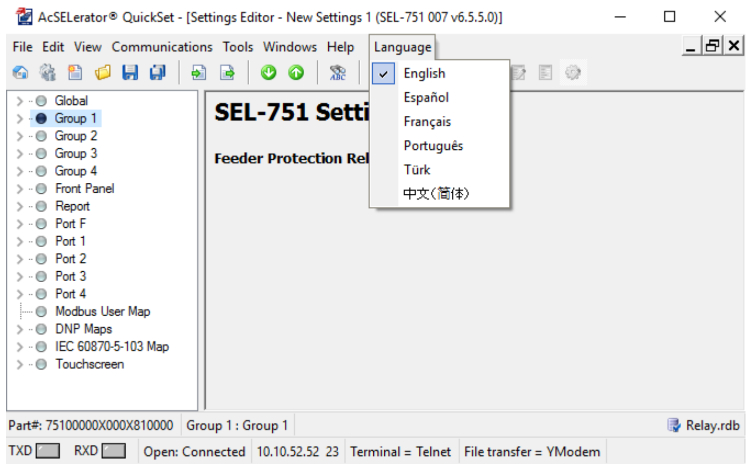


Figure 3.30 Language Support Options

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 3.31*.

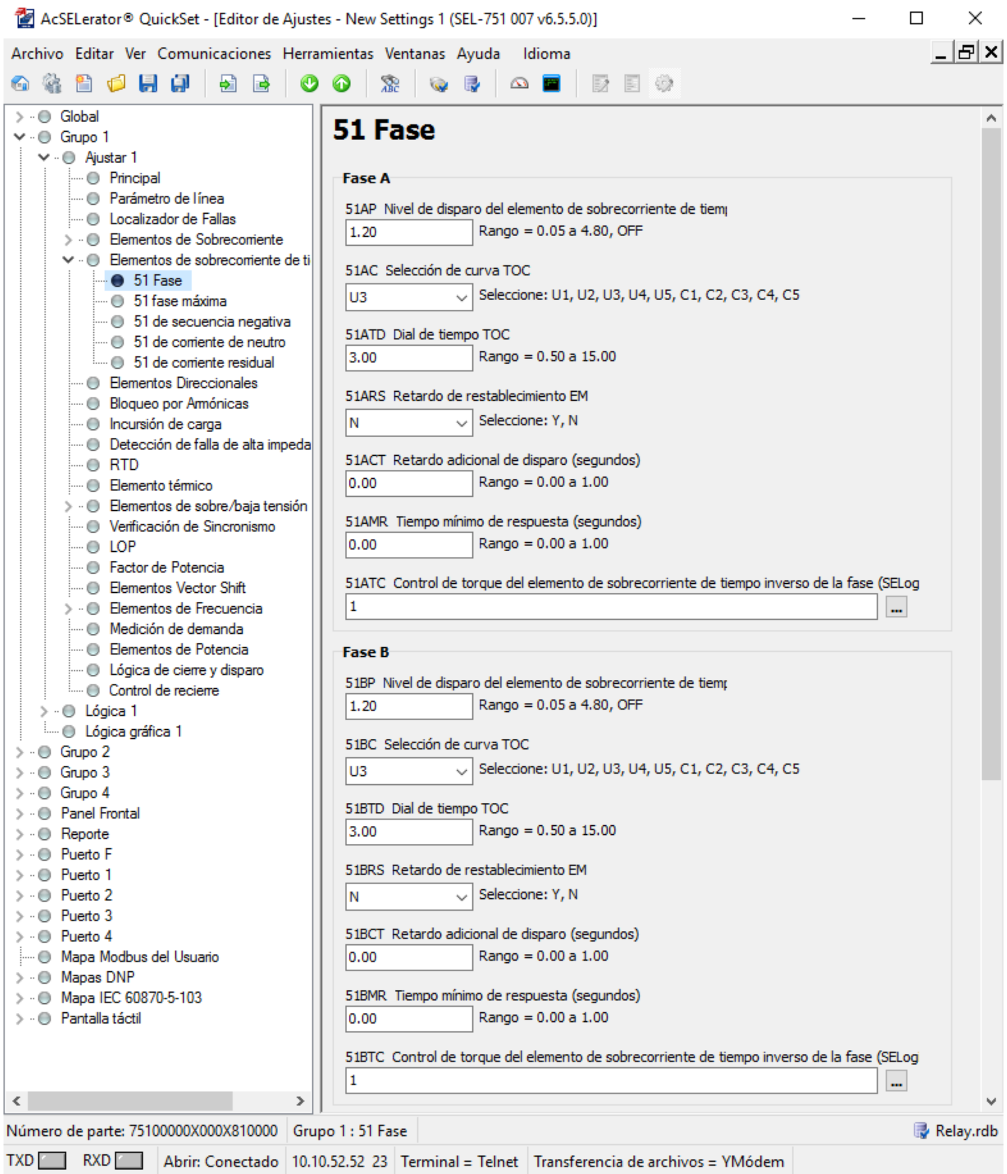


Figure 3.31 Spanish Settings QuickSet Display

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 3.32*.

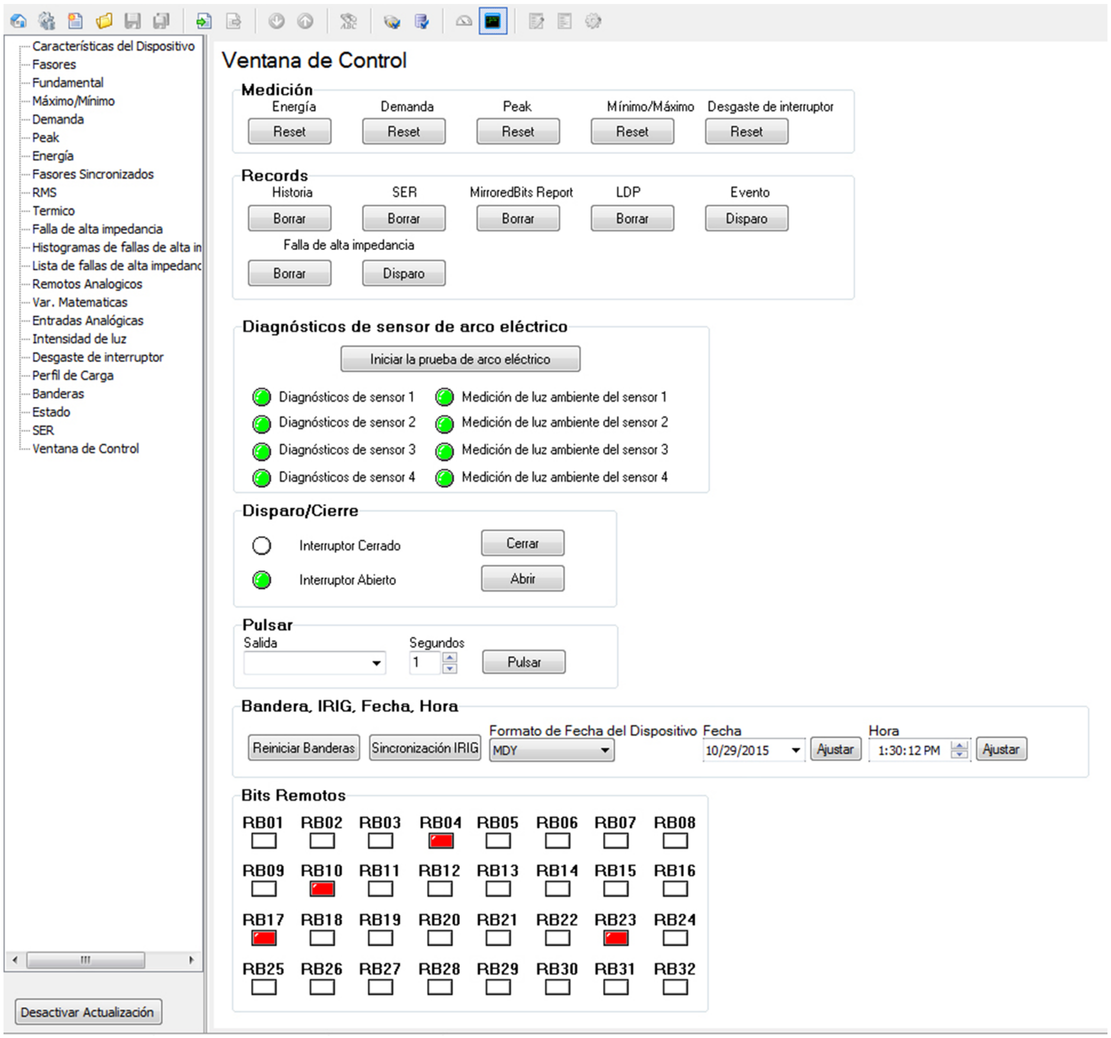


Figure 3.32 Spanish Control Window (Ventana de Control) Display

QuickSet Help

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

Table 3.4 QuickSet Help

Help	Description
General QuickSet	Select **Help** from the main menu bar.
SEL-751 Settings	Select **Settings Help** from the **Help** menu bar while the **Settings Editor** is open.

Section 4

Protection and Logic Functions

Overview

NOTE: Each SEL-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) Sensor Inputs. Describes the low-energy analog current and voltage sensors.

VNOM Range Check. Identifies the VNOM range for DELTA and WYE connected PT configurations.

Line Parameter Settings. Lists the line parameter settings for use with fault location and direction elements.

Fault Location. Describes the fault location settings.

Overcurrent Elements. Lists the settings and describes the logic associated with overcurrent elements.

Incipient Cable Fault. Describes the logic and settings to detect multiple self-clearing, short-duration overcurrent events in a cable.

Time-Overcurrent Elements. Lists the settings and time-overcurrent curves and describes the logic associated with the elements.

Directional Control. Lists the settings to configure the directional elements. Describes the operating characteristics, logic, and the configuration of directional settings for directional control of the overcurrent elements.

Load-Encroachment Logic. Lists the settings to configure load-encroachment logic. Describes the operating characteristics and logic of the load-encroachment function and provides application examples.

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

Phase Discontinuity Detection (PDD) Element. Lists the settings and describes the logic associated with the phase discontinuity element.

Broken Conductor Detection (BCD) Element. Lists the settings used to configure the broken conductor element, describes the operating characteristics and logic, and provides application examples.

Cold-Load Pickup (CLPU) Element. Lists the settings used to configure the cold load pickup element, describes the operating characteristics and logic, and provides application examples.

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.

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

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

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

Power Elements. Lists the settings and describes the logic associated with power elements.

Power Factor Elements. Lists the settings and describes the logic 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 and describes the logic associated with over- and underfrequency elements.

Rate-of-Change-of-Frequency (81R) Protection. Lists the settings and describes the logic associated with rate-of-change-of-frequency elements.

Fast Rate-of-Change-of-Frequency (81RF) Protection. Lists the settings and describes the logic associated with fast rate-of-change-of-frequency elements.

Detecting Frequency Components With the 97FM Element. Lists the settings and describes the logic associated with the 97FM element.

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.

General Settings. Lists the Global system settings, such as phase rotation, nominal frequency, date format, etc.

Event Messenger Points. Describes the configuration of event messenger points.

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

LEA Ratio Correction Settings. Lists settings for the LEA ratio and angle correction for phase voltage, synchronism voltage, and current inputs.

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

Time and Date Management Settings. Lists settings for time and date management, describes the configuration of the settings, and lists the supported protocols.

Breaker Failure Settings. 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.

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

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

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

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

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

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

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

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

Touchscreen Settings. The touchscreen settings apply to relays that support the color touchscreen display. (The settings are supported in ACSELERATOR QuickSet SEL-5030 Software only.)

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 I.1).

You can enter the settings by using the front-panel SET RELAY function (see *Section 8: Front-Panel Operations*), the serial port (see *Section 7: Communications*), the EIA-485 port (see *Appendix E: Modbus 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 or low-energy analog current sensor ratios and connections
- Voltage transformer or low-energy analog (LEA) voltage sensor ratios and connections, if used
- Type and location of resistance temperature detectors (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
COMPANY NAME	5 Characters	CONAM := CONAM

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. Use the CONAM setting to include the abbreviated name of your company.

Configuration Settings

The relay can be ordered with either conventional or LEA secondary current input cards. The secondary-to-primary ratio settings configure the relay to accurately scale measured values and report the primary quantities. The CTR and CTRN settings are applicable and available for setting when the relay is ordered with conventional current inputs (1 A or 5 A).

Table 4.2 CT Configuration Settings for 1 A/5 A Slot Z CT Card

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

Calculate the phase and neutral current CT ratios by dividing the primary rating by the secondary rating.

EXAMPLE 4.1 Phase CT Ratio Setting Calculation

Consider an application where the phase CT rating is 100:5 A.
Set CTR := 100/5 := 20.

The CS_TYPE, IPR, USR, INOM, FDR_CURR and ILEA_SC settings are applicable to the relay with LEA current inputs. Set the current sensor type to RCOIL or LPCT using the CS_TYPE setting. Obtain the rated primary current (IPR) and rated sensor voltage (USR) from the LEA sensor. Set the rated feeder current (FDR_CURR) setting to the load current in the feeder or the nominal primary current of a conventional CT that would otherwise be used. Choose the nominal relay current (INOM) as would be used for a conventional CT. The ILEA_SC setting is autocalculated by the relay and is not available for setting. ILEA_SC is derived as the ratio of feeder current to nominal current, ILEA_SC = FDR_CURR/INOM. Refer to *LEA Current Inputs* for additional details.

Table 4.3 CT Configuration Settings for LEA Slot Z CT Card

Setting Prompt	Setting Range	Setting Name := Factory Default
CURR SENSOR TYPE	RCOIL, LPCT	CS_TYPE := RCOIL
RATED PRI CURR	1–6000 A primary	IPR := 100
RATED SENS VOLT	10.0–1000.0 mV @ FNOM[a]	USR := 180.0
NOMINAL CURRENT	1 A[b]	INOM := 1
RATED FEEDER CUR	1–6000 A primary	FDR_CURR := 100
PHASE ILEA SCALE	1.00–6000.00[c]	ILEA_SC := 100.00

[a] The setting range is 10.0–1000.0 mV and default USR := 22.5 mV for CS_TYPE := LPCT.
[b] INOM is part number dependent for conventional CT inputs (1 A or 5 A). The INOM setting is forced to 1 A for LEA current sensor inputs.
[c] Autocalculated and used to scale the primary currents to an equivalent secondary current used for the pickup thresholds.

Table 4.4 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—conventional voltage inputs rated for 300 Vac or LEA voltage inputs rated for 8 Vac. Refer to *Figure 2.28* for different voltage connections.

Table 4.4 Voltage Configuration Settings

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

[a] Autocalculated.
[b] Shown if Global setting EDCMON := N, else is set to 1 and hidden.
[c] The line voltage setting range is 20.00–480.00 if DELTA_Y := WYE.
[d] The setting range is VA, VB, VC if DELTA_Y := WYE.

The PTR and PTRS settings are applicable and available for setting when the relay is ordered with conventional 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 *LEA Voltage Inputs*. The DELTA_Y, VSCONN, VNOM, SINGLEV, and SING_VIN 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. Set the VBAT channel PT ratio setting (PTRN) equal to the VT ratio of the VBAT input when measuring ac voltages.

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. 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 and select the appropriate input from SING_VIN, as shown in *Figure 2.27*. Be sure to set DELTA_Y equal to WYE for a phase-to-neutral input or DELTA_Y equal to DELTA for a phase-to-phase 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 voltage-sequence components 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 metering.
- **Event Reports.** When you use one voltage, the unmeasured voltages are reported as zero.

Table 4.5 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.
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, AUTO, or AUTO2)		
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.

Table 4.5 Effect on Group Settings When SINGLEV := Y (Sheet 2 of 2)

Group Setting	Change	Reason
Identifier Settings		
27I*n*OQ (*n* = 1, 2)	Refer to *Table SET.3: Range Dependencies for 27I Operating Quantities*	
59I*n*OQ (*n* = 1, 2, 3, 4)	Refer to *Table SET.4: Range Dependencies for 59I Operating Quantities*	
Vector Shift Settings		
E78VS	Hidden	Element enable requires three-phase voltages

Low-Energy Analog (LEA) Sensor Inputs

LEA sensors for measurement of primary voltages and currents are gaining popularity owing to their excellent linearity and wide dynamic range characteristics, reduced size, reduced weight, and enhanced personnel safety. Typically, Rogowski coils and low-power CTs (LPCT) are used for current measurements, and low-power VTs (LPVT) are used for voltage measurements. The SEL-751 offers different card options for receiving signals from these sensors. Refer to the SEL-751 Model Option Table for all the variants available.

LEA Current Inputs

The SEL-751 can be ordered with either a conventional 4 ACI card or an LEA input card. The LEA input card supports three LEA-based voltage inputs, three LEA-based current inputs, and a conventional sensitive neutral current input (IN), as shown in *Figure 1.1*. The LEA input card complies with LEA specifications defined in the IEC 61869-13 standard. The card is compatible with low-power instrument transformers that comply with IEC 61869-10 and IEC 61869-11 standards and supports sensors having outputs compliant with the IEEE C37.92 standard.

The current channels of an LEA input card support two types of sensors: LPCTs and Rogowski coils. LPCTs are conventional CTs equipped with an internal shunt resistor that generates an output voltage proportional to the primary current. A Rogowski coil produces an output voltage proportional to the rate of change of the primary current. When operating in the Rogowski coil mode, the SEL-751 uses an internal hardware integrator to produce a signal proportional to the primary current.

Considerations for Selecting Rogowski Coil/LPCT

Rogowski coils and LPCT sensors support an exceptionally wide dynamic range that may be 20 or more times wider than the conventional CT; in practice, this means that a single 100 A sensor may be able to protect circuits with loads going as high as 2,000 A. Voltage output produced by such a sensor may easily exceed 100 V during the fault. To accommodate the wide range of applications made possible by the low-energy sensors, the SEL-751 adjusts its current-channel gain, allowing the relay to support Rogowski coil sensors with output between 4–128 V full scale rms during the fault. The SEL-751 is designed to measure as much as 30 times the nominal feeder current without clipping. The choice of Rogowski coil and feeder current should be made such that calculated clipping voltage is within 4–128 Vrms range for Rogowski coils and 1–8 Vrms for LPCTs. Refer to *Example 4.4* for calculation of clipping voltages for the Rogowski coils and *Example 4.5* for calculation of the clipping voltages for the LPCT-based sensors.

EXAMPLE 4.4 Clipping Voltage Calculation for Rogowski Coil

Assume a Rogowski coil sensor with the following data and relay settings:

FNOM = 60 Hz
CS_TYPE = RCOIL
IPR = 100 A
USR = 180 mV at 60 Hz
INOM = 1 A
FDR_CURR = 800 A
ILEA_SC = 800/1 = 800, is autocalculated
Sensor output voltage at 800 A = 180 mV/100 • 800 = 1.44 Vrms
Clipping Voltage = 1.44 Vrms • 30 = 43.2 Vrms

EXAMPLE 4.5 Clipping Voltage Calculation for LPCT

Assume an LPCT sensor with the following data:

CS_TYPE = LPCT
IPR = 100 A
USR = 22.5 mV
INOM = 1 A
FDR_CURR = 800 A
ILEA_SC = 800/1 = 800, is saved in CTR (autocalculated)
Sensor output voltage at 800 A = 22.5 mV/100 • 800 = 180 mVrms
Clipping Voltage = 180.0 mV • 30 = 5.4 Vrms

Secondary Current Calculation for LEA Current Inputs

Relays with LEA current inputs calculate a secondary current equivalent to that measured by conventional current input cards. This secondary current is equal to the primary current divided by the scaling factor ILEA_SC, which is autocalculated by the relay as ILEA_SC = FDR_CURR/INOM.

Example 4.6 explains the conversion of an overcurrent element pickup setting from a conventional 4 ACI card to an equivalent setting for the LEA input card.

EXAMPLE 4.6 Additional Setting Conversion

Consider an application with a conventional CT card with a 1200/5 = 240 CT ratio and a pickup setting for an instantaneous overcurrent element of 50P1P = 15 A secondary. The equivalent 50P1P setting for an LEA current input card (Rogowski coil or LPCT sensor) can be calculated as below.

First convert 50P1P setting to primary amperes, $I_{primary}$ = 15 * 240 = 3600 A primary.

Calculate 50P1P settings in secondary amperes for each of the LEA CT cards as shown in the table below.

The corresponding 50P1P settings in both conventional and LEA relays will pick up for the same primary current.

Settings/Calculations	Rogowski Coil	LPCT
IPR	80 A	100 A
USR	180 mV @ 60 Hz	22.5 mV
FDR_CURR	1500	1000
INOM	1	1
ILEA_SC	1500 (autocalculated)	1000 (autocalculated)
50P1P = $I_{primary}$/ILEA_SC	3600/1500 = 2.4 A secondary	3600/1000 = 3.6 A secondary

LEA Voltage Inputs

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

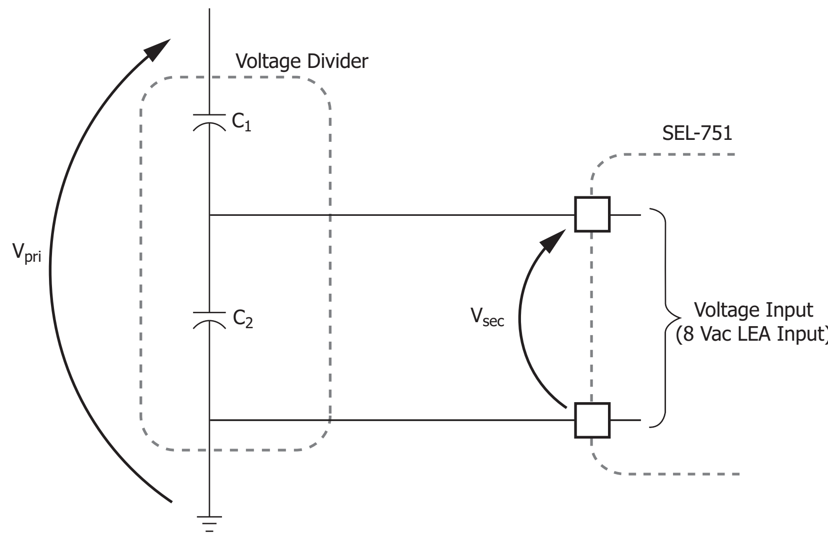


Figure 4.1 Low-Energy Analog Voltage Sensor (Capacitive Voltage Divider)

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

Irrespective of the voltage input option, conventional (300 Vac) or LEA (8 Vac), all the voltage-related settings are based at 300 V. For example, the 59 element pickup range for conventional 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 4.7*. 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 4.7 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 inputs, Global settings VARCF, VBRCF, VCRCF, VSRCF, IARCF, IBRCF, ICRCF, VAPAC, VBPAC, VCPAC, VSPAC, IAPAC, IBPAC, and ICPAC are applied to the respective voltage and current inputs, **VA**, **VB**, **VC**, **VS**, **IA**, **IB**, and **IC**. These normalized secondary voltages and currents are used throughout the SEL-751. Refer to *Table 4.81* through *Table 4.83* under Global Settings for these settings.

Ratio Correction Factors (RCF) for LEA Inputs

The ratio correction factor (RCF) settings minimize the magnitude error by compensating for the irregularities (on a per-phase basis) introduced by LEA sensors. 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.

Similarly, the RCF value for current sensors is defined as follows:

$$RCF = \frac{\text{True ratio}}{\text{Marked ratio}} = \left(\frac{I_{Pri}}{\text{Sensor output voltage}}\right) \Big/ \left(\frac{IPR}{USR}\right)$$

Equation 4.2

where:

I_{Pri} = Test primary current passing through the Rogowski coil or low-power CT

Sensor output voltage	=	Resultant voltage generated at the terminals of the sensor
IPR and USR	=	Sensitivity parameters of the sensor used

The marked LEA sensor ratio of the voltage divider or transformation ratio for the Rogowski coil sensor 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 4.8*. 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

Similar conclusions can be drawn for Rogowski coil and LPCT current sensors.

EXAMPLE 4.8 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 *Example 4.8*. 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 as follows:

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 LEA Inputs

Use the VAPAC, VBPAC, VCPAC, and VSPAC voltage phase-angle correction Global settings for the voltage inputs **VA**, **VB**, **VC**, and **VS**, respectively. Use the IAPAC, IBPAC and ICPAC current phase-angle correction Global settings for the current inputs **IA**, **IB**, and **IC**, respectively. These settings compensate for the phase error caused by the LEA sensor 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.

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. Limit the VNOM setting to 250 V (l-l) for ungrounded systems and to 480 V (l-l) for solidly grounded systems when using WYE-connected PTs. In an ungrounded system, when there is a line-to-ground fault, the terminal voltages can increase by a factor of as much as 1.73.

EXAMPLE 4.9 VNOM Setting Calculation for Conventional 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 *LEA Voltage Inputs*.

EXAMPLE 4.10 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 4.6 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

Line Parameter Settings

Table 4.7 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 4.52*, 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. The relay uses line charging current-based fault location subjected to a broken conductor event. For more information, refer to *Broken Conductor Fault Locating on page 4.106*.

Table 4.8 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 4.9* through *Table 4.12* 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 4.9 Maximum Phase Overcurrent Settings (Sheet 1 of 2)

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

Table 4.9 Maximum Phase Overcurrent Settings (Sheet 2 of 2)

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]	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]	50P4 := 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 or equal to 8 • I_{NOM}, 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 4.111.

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 or equal to 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.

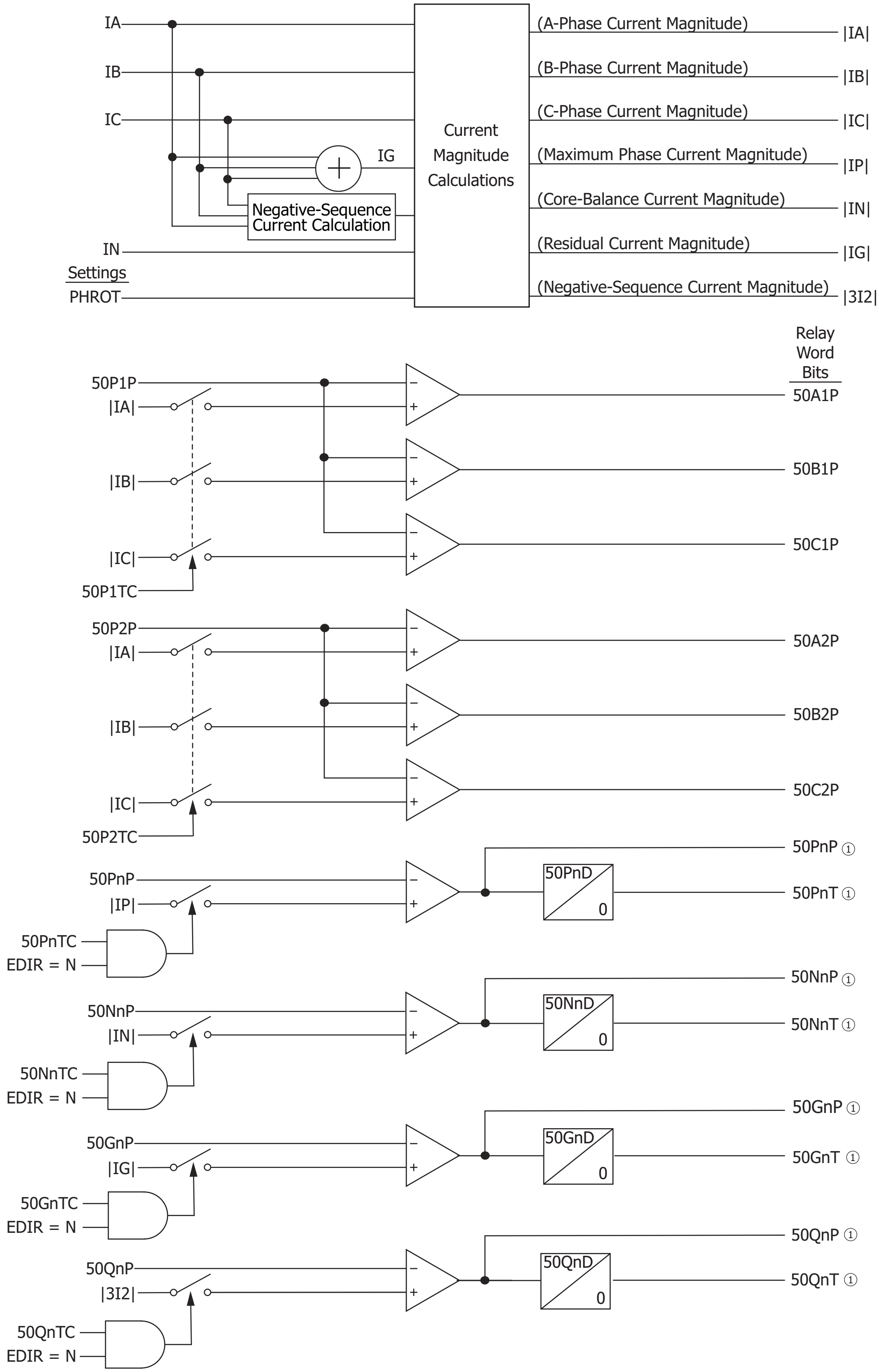
NOTE: When a switch or breaker closes, the three poles may not close at the same time, creating a momentary current unbalance condition. To override this condition use an overcurrent trip delay (for example, 50NnD := 0.05 s).

Table 4.10 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] 0.010–4.000 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] 0.010–4.000 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] 0.010–4.000 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] 0.010–4.000 A[c]	50N4P := OFF
NEUT OC TRIP DLY	OFF, 0.00–400.00 sec	50N4D := 0.50
NEUT OC TRQ CON	SELOGIC	50N4TC := 1

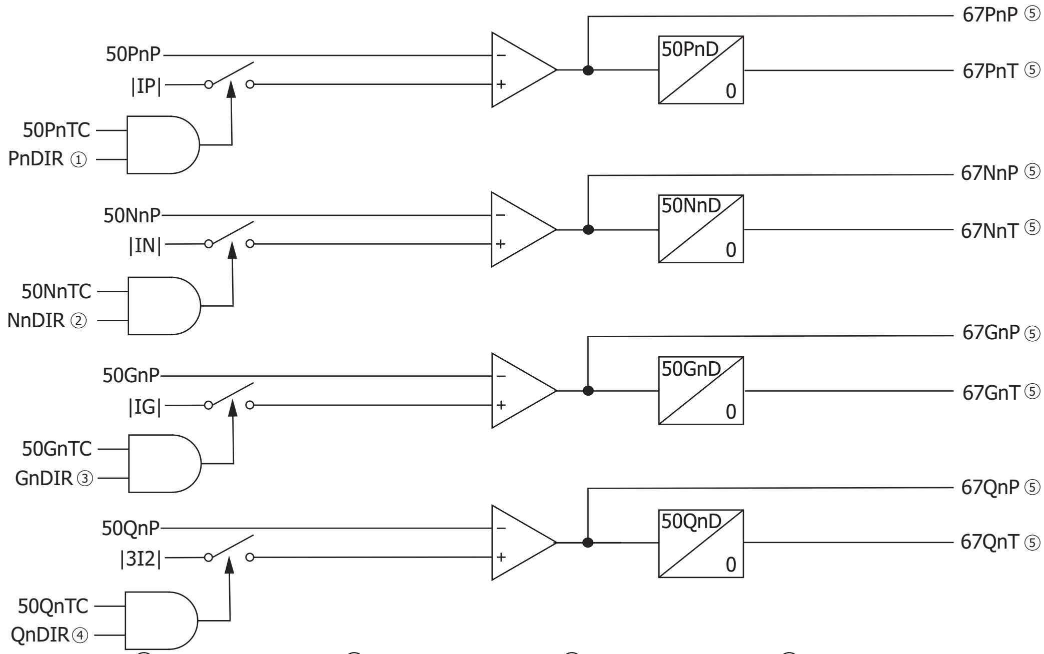
[a] For I_{NOM} = 5 A.
[b] For I_{NOM} = 1 A.
[c] For I_{NOM} = 0.2 A.

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 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).

Figure 4.2 Instantaneous Overcurrent Element Logic Without Directional Control



① From *Figure 4.47*; ② From *Figure 4.41*; ③ From *Figure 4.40*; ④ From *Figure 4.46*; ⑤ Residual Current Magnitude |IG| 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, AUTO, or AUTO2	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, EDIR is automatically set to N and hidden.

Figure 4.3 Instantaneous Overcurrent Element Logic With Directional Control Enabled

When a core-balance CT is connected to the relay **IN** input, as in *Figure 2.35*, 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.

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 Residual Overcurrent Settings (Sheet 1 of 2)

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

Table 4.11 Residual Overcurrent Settings (Sheet 2 of 2)

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]	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.

Table 4.12 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, 0.00–400.00 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, 0.00–400.00 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, 0.00–400.00 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, 0.00–400.00 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 (e.g., 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 4.4 and *Figure 4.5* 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 4.4 is not valid for conditions with a saturated CT, where the resultant current to the relay is nonsinusoidal.

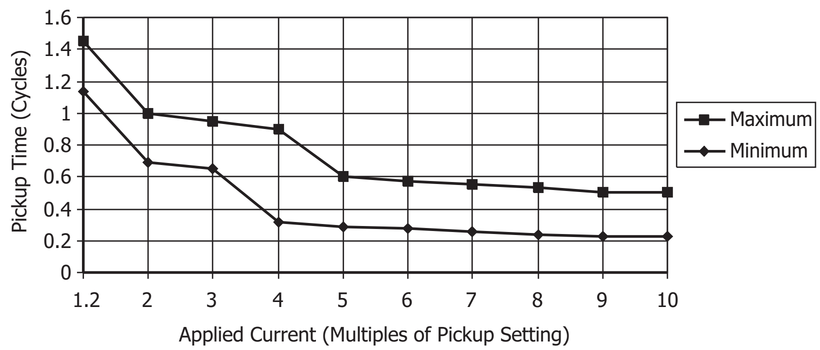


Figure 4.4 Instantaneous Overcurrent Element Pickup Time Curve

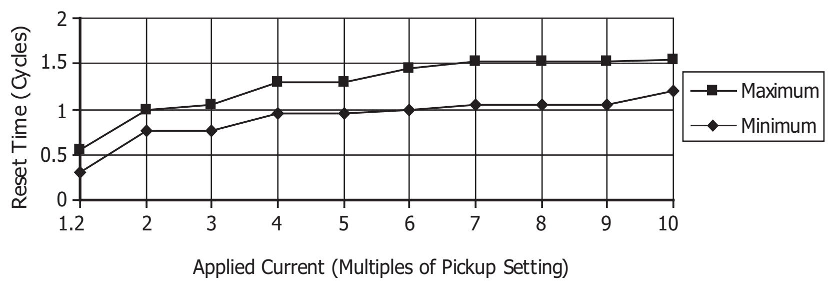


Figure 4.5 Instantaneous Overcurrent Element Reset Time Curve

Incipient Cable Fault

The incipient cable fault element is used to detect self-clearing, half- to one-cycle overcurrent events. This type of event is most common in cable splices and are indicative of an impending fault. As the frequency of the events increases, the likelihood of a permanent fault increases, and preventative maintenance should be scheduled.

NOTE: 50INC event report data stored in the relay are lost if the element is turned OFF.

The setting E50INC is chosen as per the overcurrent threshold for the phase channels. The relay scales the threshold 50INCTH for the neutral channel such that the phase and neutral elements pick up for the same primary current according to the following equations:

50INCTH = E50INC for phase currents

50INCTH = E50INC • CTR/CTRN for neutral current

When 50INTC (defined by a SELOGIC equation) is asserted, the logic, as detailed in *Figure 4.7*, is processed. If two consecutive raw samples of current (IA, IB, IC, or IN) are higher than the user-defined threshold, it asserts the respective 50INC*x* (*x* = A, B, C, N) Relay Word bit. The 32-sample dropout on timer T1 is to ensure that the rising edge of timer T2 only occurs once for a detection of current above the threshold, so subsequent half-cycles above the threshold do not reset the window defined by 50INC*x*. The dropout of timer T2 defines the window to count an incipient cable fault, which includes up to a full cycle for detection plus the time required to verify that the overcurrent has self-cleared. Timer T3 is the verification that the overcurrent has cleared by requiring that no sample in the last cycle is above the threshold. If the overcurrent clears within two cycles, an event is recorded in the history report and the counter is incremented. If 50INTC is deasserted, the logic is not processed and the timers are cleared, but the counters are not cleared. The incipient fault cable phase, total number of events on each phase, and time stamps of the 64 most recent events are stored in the report (see *Figure 4.6*), which is displayed with the **HIS 50INC** command (see *Table 7.32*). To reset the counter and the event report, issue the **HIS 50INC C** command.

Alternatively, the 50INCRST setting can be defined as a SELOGIC equation. The counters are reset and HIS 50INC events are cleared on the rising edge of 50INCRST.

```
=>>HIS 50INC <Enter>

SEL-751                                   Date: 28/12/2021   Time: 13:42:25.378
FEEDER RELAY                              Time Source: Internal


FID=SEL-751-X543-V0-Z009005-D20211203

#     DATE        TIME         CNTA   CNTB   CNTC   CNTN   INCF PHASE
1     26/12/2021 19:00:12.882  1      0      0      0        A
2     26/12/2021 19:04:12.224  1      1      0      0        B
3     26/12/2021 19:04:13.407  1      1      1      0        C
4     27/12/2021 09:18:11.074  2      1      1      0        A
5     27/12/2021 12:47:59.811  3      1      1      0        A
6     27/12/2021 12:48:00.699  3      2      1      0        B
7     27/12/2021 12:48:01.353  3      2      2      0        C
8     27/12/2021 12:48:06.951  4      2      2      0        A

LAST RESET =  24/12/2021 19:06:28.232
```

Figure 4.6 HIS 50INC Report Response

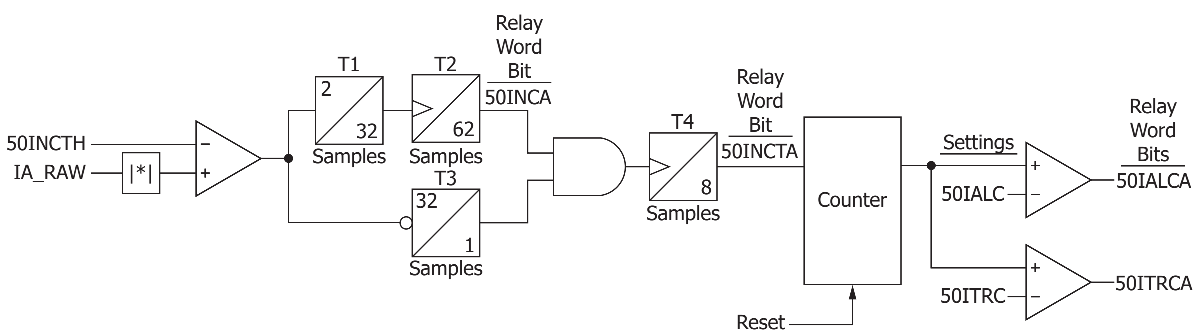


Figure 4.7 Incipient Cable Fault Logic

The logic provides a threshold for alarm via 50IALC and a threshold for tripping via 50ITRC, depending on the number of detected events. These have corresponding Relay Word bits, 50IALC*x* and 50ITRC*x* (*x* = A, B, C, N), for each phase when the count on that phase is higher than the respective threshold.

Table 4.13 Incipient Cable Fault Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
50INC PU LVL	OFF, 0.50–50.00 A peak[a], 0.10–10.00 A peak[b]	E50INC := 15.00 E50INC := 3.00
50INC WARN COUNT	1–100	50IALC := 1
50INC TRIP COUNT	1–100	50ITRC := 10
50INC TORQUE CONTROL	SELOGIC	50INTC := 1
50INC RESET	SELOGIC	50INCRST := 0

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

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 4.14* through *Table 4.18* for available settings.

You can select from five U.S., five IEC, and three IEEE inverse characteristics. *Table 4.20* and *Table 4.22* show equations for the curves and *Figure 4.13* through *Figure 4.25* 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 4.14 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, E1, E2, E3	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, E1, E2, E3	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, E1, E2, E3	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 4.8*.

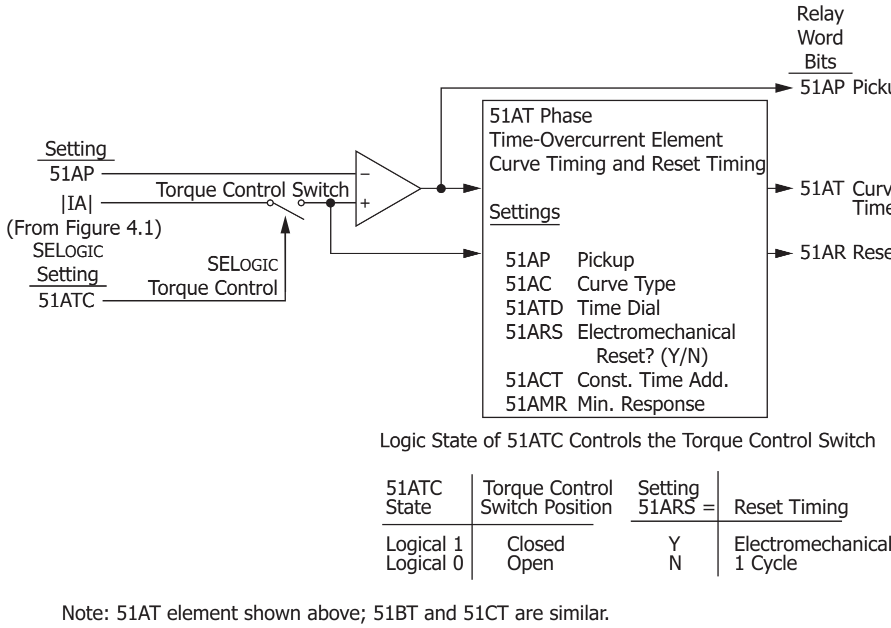


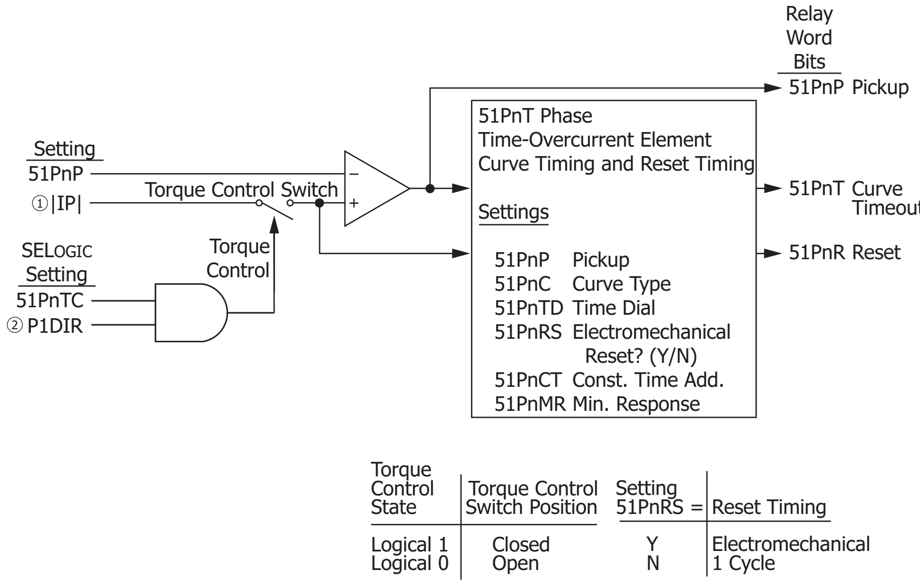
Figure 4.8 Phase Time-Overcurrent Elements 51AT, 51BT, and 51CT

Table 4.15 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, E1, E2, E3	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, E1, E2, E3	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 4.9*.



n = 1 or 2.

① From Figure 4.2; ② To Figure 4.47.

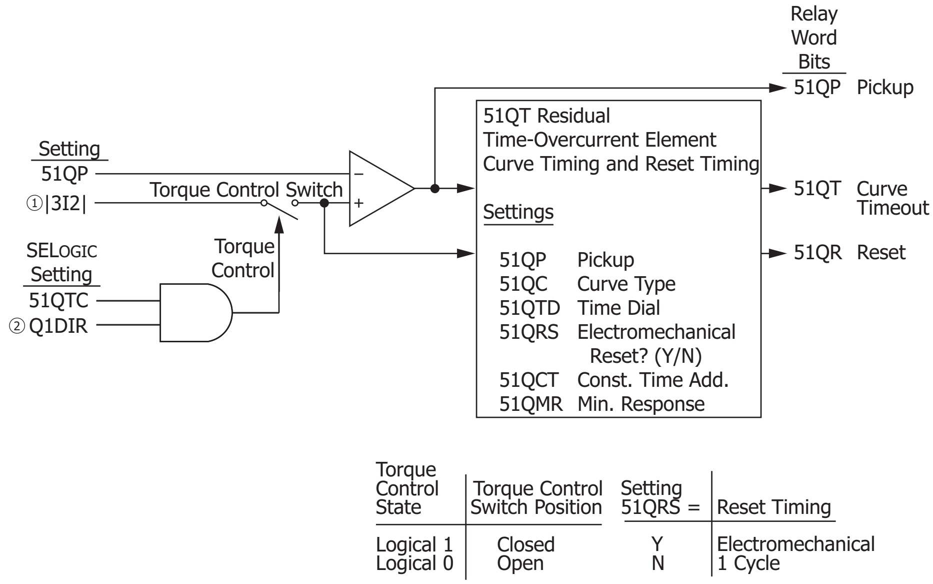
Figure 4.9 Maximum Phase Time-Overcurrent Elements 51P1T and 51P2T

Table 4.16 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, E1, E2, E3	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 4.10*.



① From Figure 4.2; ② Figure 4.46.

Figure 4.10 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 4.17 Neutral Time-Overcurrent Settings (Sheet 1 of 2)

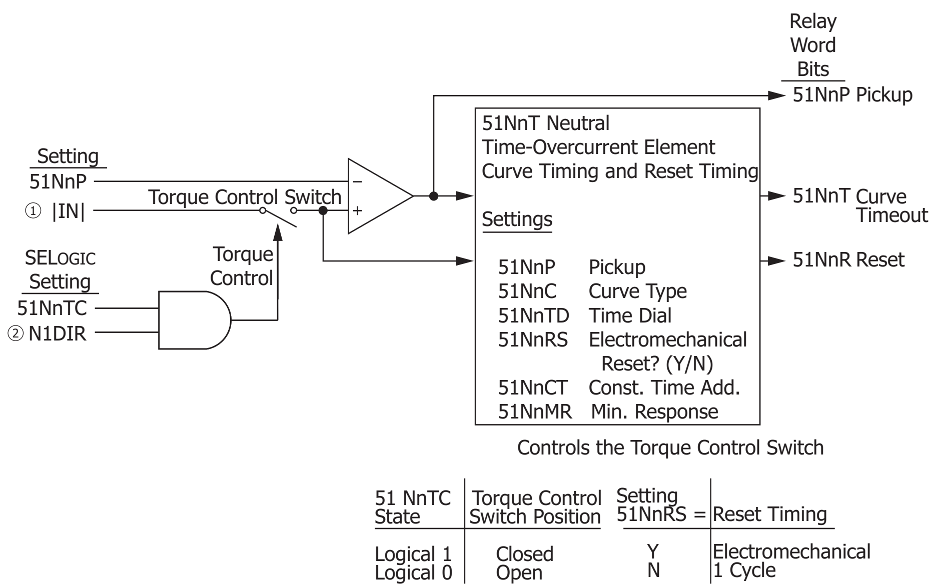
Setting Prompt	Setting Range	Setting Name := Factory Default
TOC TRIP LVL	OFF, 0.25–24.00 A[a], 0.05–4.80 A[b] 10.00–960.00 mA[c]	51N1P := OFF
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5, E1, E2, E3	51N1C := U3
TOC TIME DIAL	0.50–15.00[d] 0.01–1.50[e]	51N1TD := 1.50
EM RESET DELAY	Y, N	51N1RS := 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, E1, E2, E3	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 4.17 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 4.11*.



n = 1 or 2

① From Figure 4.2; ② Figure 4.41

Figure 4.11 Neutral Time-Overcurrent Elements 51N1T and 51N2T

Table 4.18 Residual Time-Overcurrent Settings (Sheet 1 of 2)

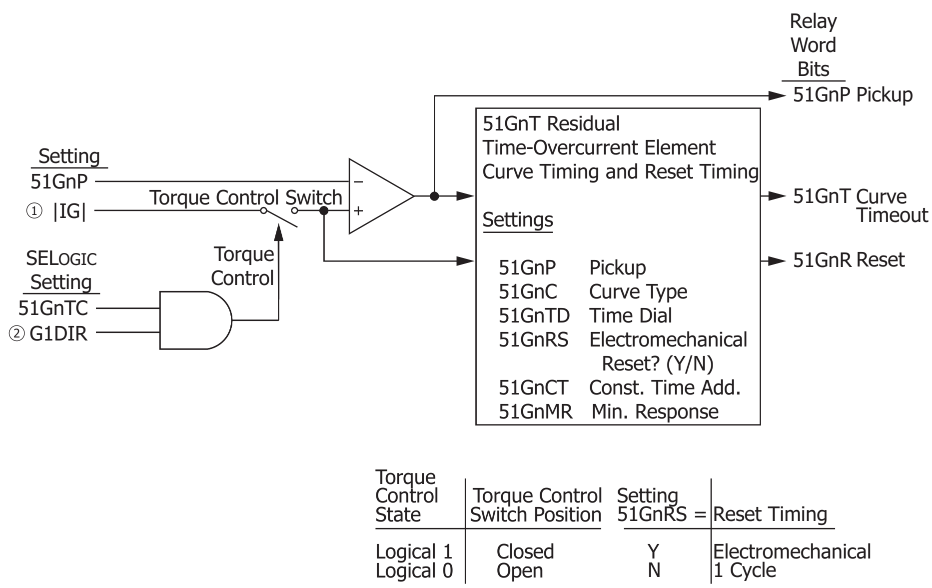
Setting Prompt	Setting Range	Setting Name := Factory Default
TOC TRIP LVL	OFF, 0.25–24.00 A[a], 0.05–4.80 A[b]	51G1P := 0.50 51G1P := 0.10
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5, E1, E2, E3	51G1C := U3
TOC TIME DIAL	0.50–15.00[c], 0.01–1.50[d]	51G1TD := 1.50
EM RESET DELAY	Y, N	51G1RS := 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

Table 4.18 Residual Time-Overcurrent Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5, E1, E2, E3	51G2C := U3
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 4.12*.



n = 1 or 2

① From Figure 4.2; ② From Figure 4.40

Figure 4.12 Residual Time-Overcurrent Elements 51G1T and 51G2T

Time-Overcurrent Curves

NOTE: The operating time (t_p) equations in *Table 4.20* through *Table 4.22* use M = 30 when the applied multiple of pickup current is above 30 and global setting 51SAT := Y, which results in the flattening of the curves shown in *Figure 4.13* through *Figure 4.25*. Setting 51SAT := N allows the tp equations to use a value of M > 30.

The following information describes the curve timing for the curve and time dial settings made for the time-overcurrent elements (see *Figure 4.8* through *Figure 4.12*). The U.S., IEC, and IEEE time-overcurrent relay curves are shown in *Figure 4.13* through *Figure 4.25*.

Table 4.19 Time-Current Curves

Curve	Notes and Compliance	Chart
U.S. Curves		
U1 (Moderately Inverse)	Similar to IEEE C37.112 Moderately Inverse and IEC 60255-151 Type D, if used with appropriate time-dial setting.	*Figure 4.13*
U2 (Inverse)		*Figure 4.14*
U3 (Very Inverse)	Similar to IEEE C37.112 Very Inverse and IEC 60255-151 Type E, if used with appropriate time-dial setting.	*Figure 4.15*
U4 (Extremely Inverse)	Similar to IEEE C37.112 Extremely Inverse and IEC 60255-151 Type F, if used with appropriate time-dial setting.	*Figure 4.16*
U5 (Short-Time Inverse)		*Figure 4.17*
IEC Curves		
C1 (Standard Inverse)	IEC 60255-151 Type A	*Figure 4.18*
C2 (Very Inverse)	IEC 60255-151 Type B	*Figure 4.19*
C3 (Extremely Inverse)	IEC 60255-151 Type C	*Figure 4.20*
C4 (Long-Time Inverse)		*Figure 4.21*
C5 (Short-Time Inverse)		*Figure 4.22*
IEEE Curves		
E1 (Moderately Inverse)	IEEE C37.112 Moderately Inverse IEC 60255-151 Type D	*Figure 4.23*
E2 (Very Inverse)	IEEE C37.112 Very Inverse IEC 60255-151 Type E	*Figure 4.24*
E3 (Extremely Inverse)	IEEE C37.112 Extremely Inverse IEC 60255-151 Type F	*Figure 4.25*

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 4.20 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 4.13*
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 4.14*
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 4.15*
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 4.16*
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 4.17*

where:
t_p = operating time in seconds (see *Note on page 4.28*)
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 4.21 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 4.18*
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 4.19*
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 4.20*
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 4.21*
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 4.22*

where:
t_p = operating time in seconds (see *Note on page 4.28*)
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 4.22 Equations Associated With IEEE Curves

Curve Type	Operating Time	Reset Time	Figure
E1 (Moderately Inverse)	$t_p = TD \bullet \left(0.1140 + \frac{0.0515}{M^{0.02} - 1}\right)$	$t_r = TD \bullet \left(\frac{4.85}{1 - M^2}\right)$	*Figure 4.23*
E2 (Very Inverse)	$t_p = TD \bullet \left(0.491 + \frac{19.61}{M^2 - 1}\right)$	$t_r = TD \bullet \left(\frac{21.6}{1 - M^2}\right)$	*Figure 4.24*
E3 (Extremely Inverse)	$t_p = TD \bullet \left(0.1217 + \frac{28.2}{M^2 - 1}\right)$	$t_r = TD \bullet \left(\frac{29.1}{1 - M^2}\right)$	*Figure 4.25*

where:
t_p = operating time in seconds (see *Note on page 4.28*)
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]

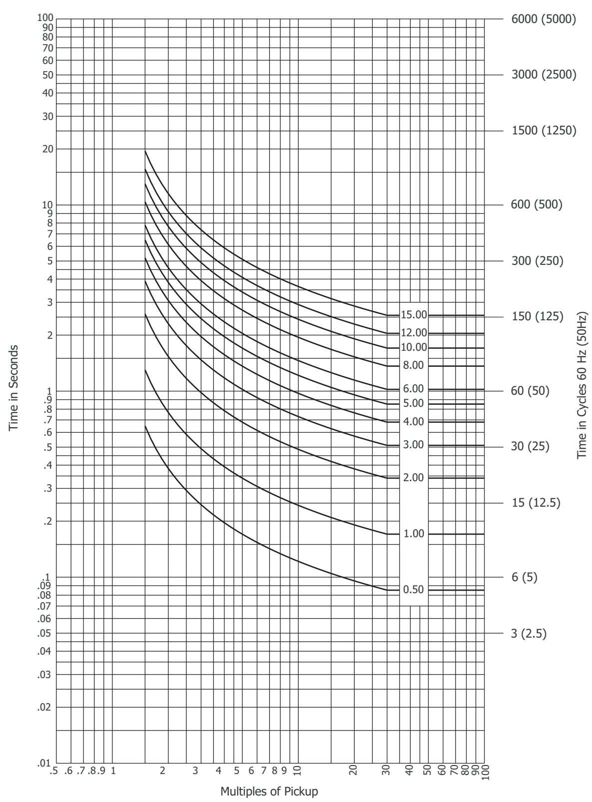


Figure 4.13 U.S. Moderately Inverse Curve: U1

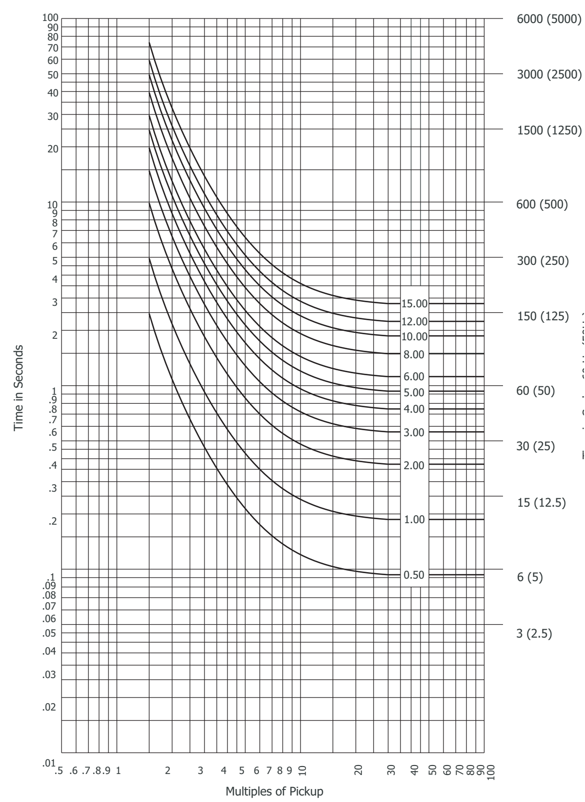


Figure 4.14 U.S. Inverse Curve: U2

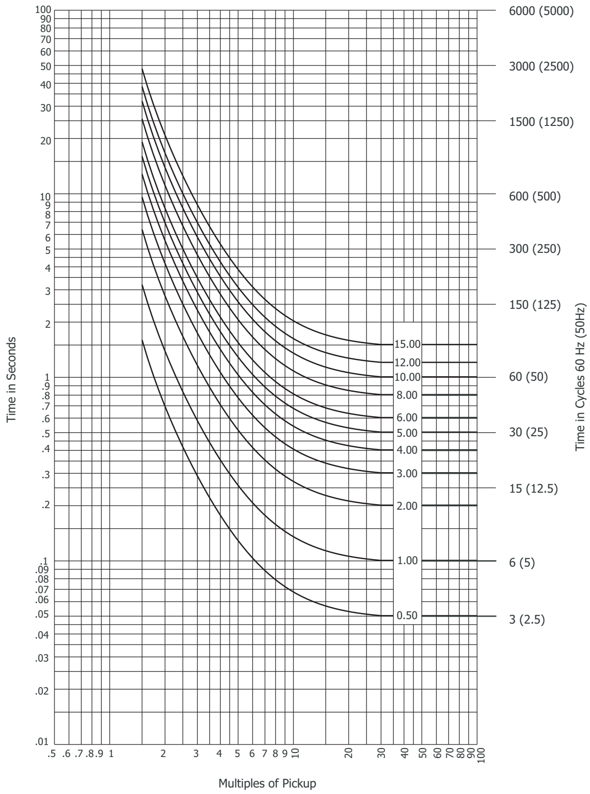


Figure 4.15 U.S. Very Inverse Curve: U3

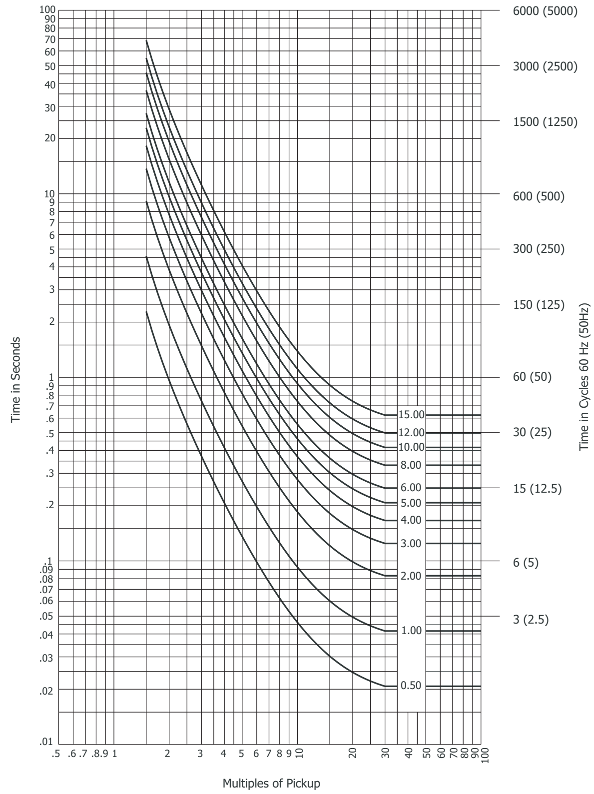


Figure 4.16 U.S. Extremely Inverse Curve: U4

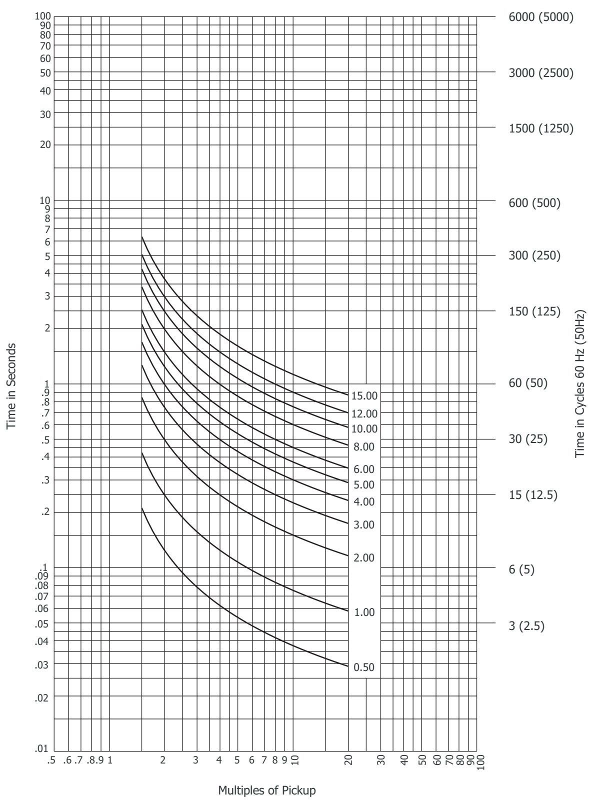


Figure 4.17 U.S. Short-Time Inverse Curve: U5

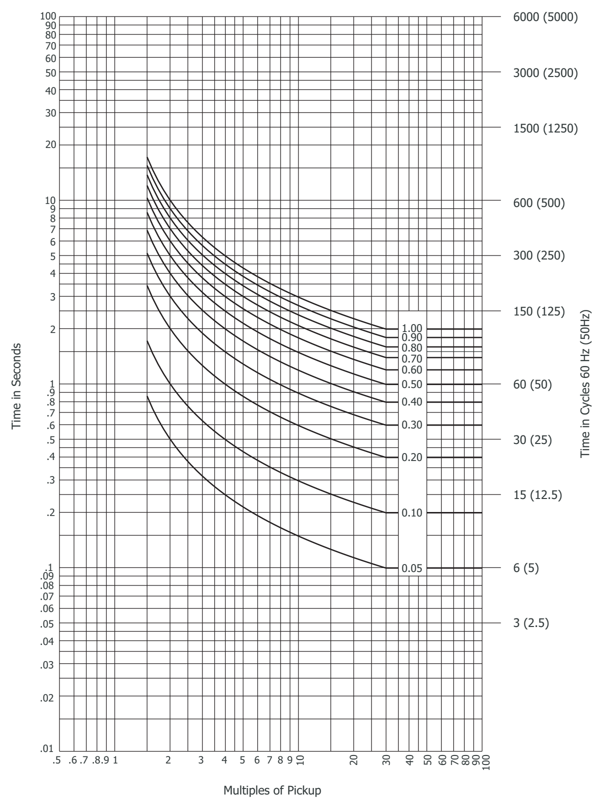


Figure 4.18 IEC Class A Curve (Standard Inverse): C1

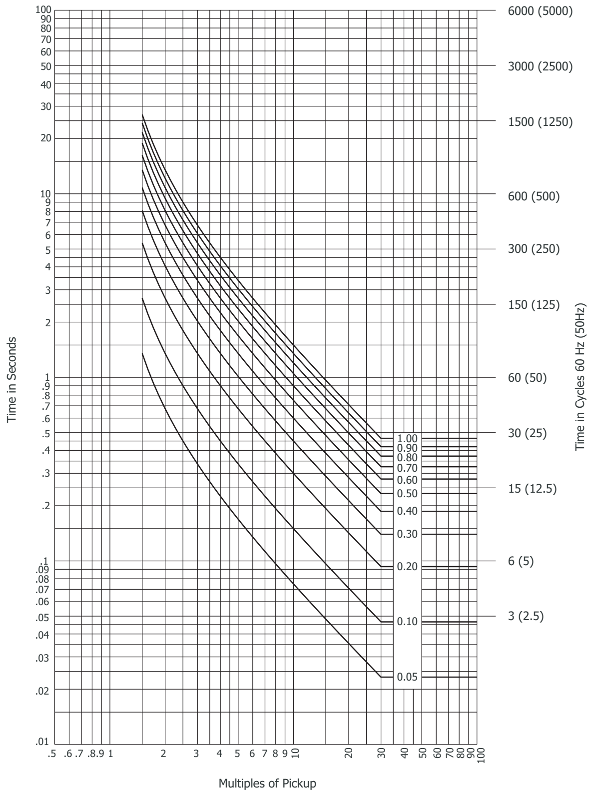


Figure 4.19 IEC Class B Curve (Very Inverse): C2

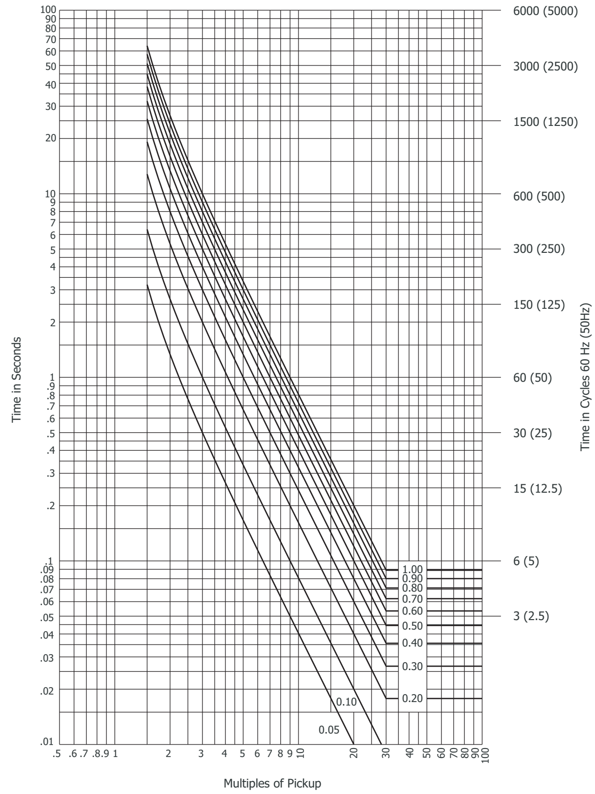


Figure 4.20 IEC Class C Curve (Extremely Inverse): C3

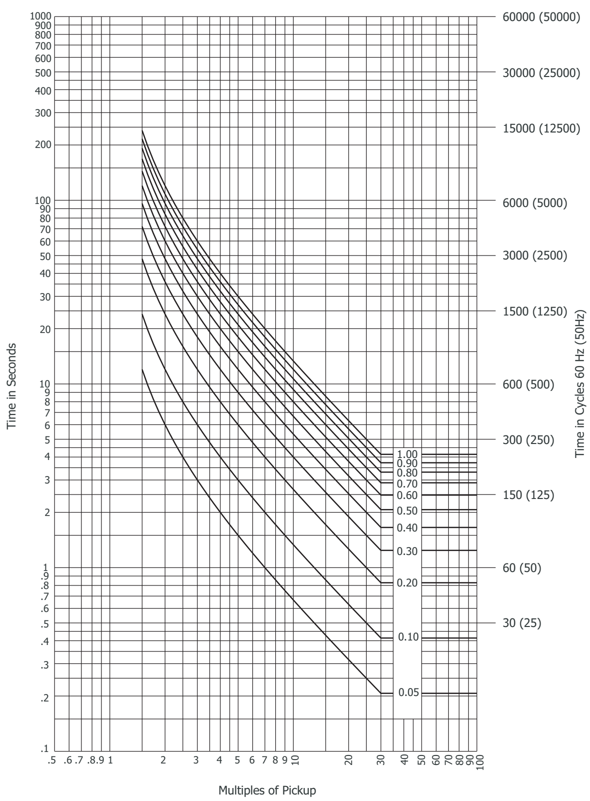


Figure 4.21 IEC Long-Time Inverse Curve: C4

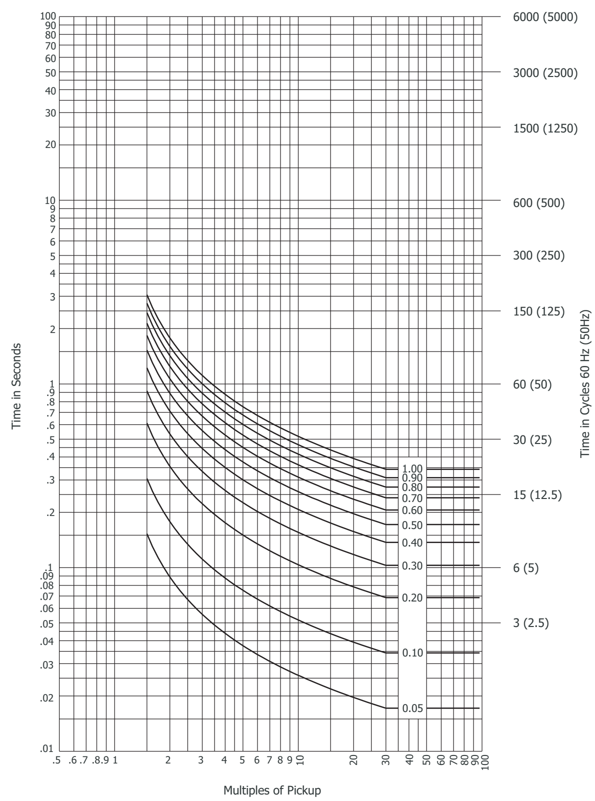


Figure 4.22 IEC Short-Time Inverse Curve: C5

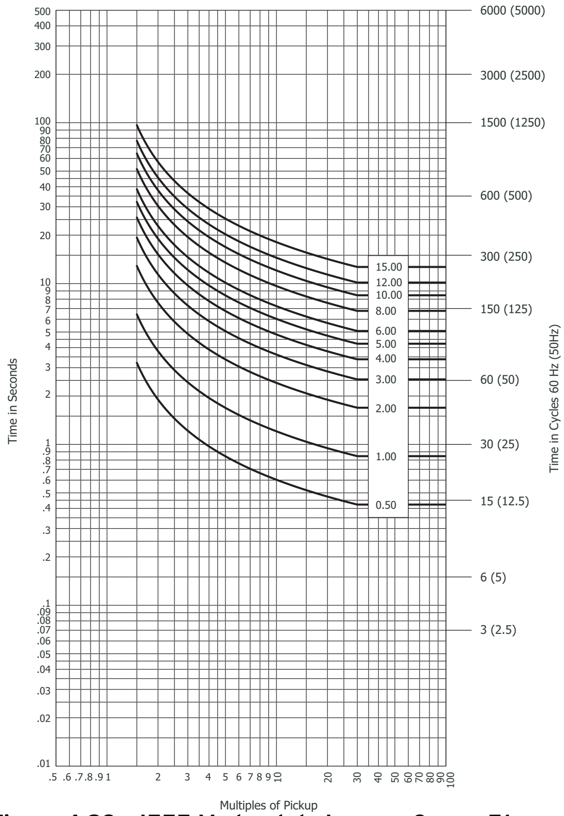


Figure 4.23 IEEE Moderately Inverse Curve: E1

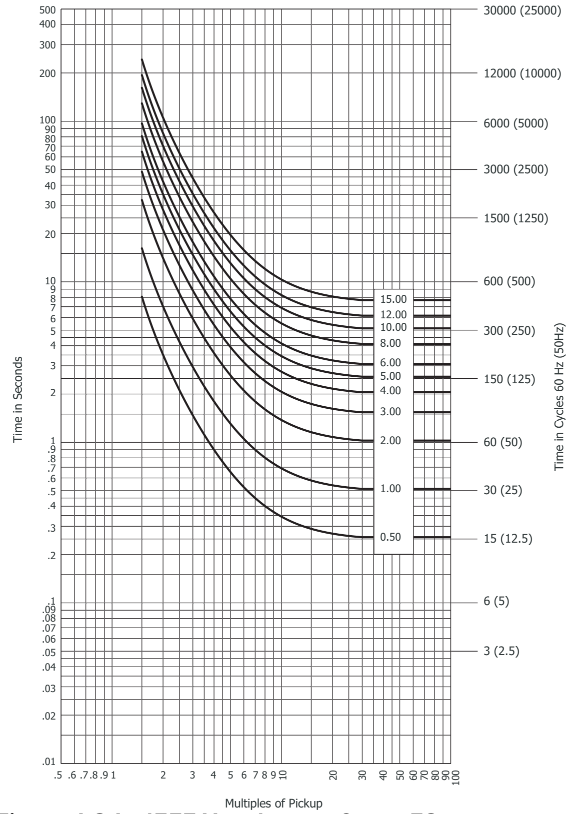


Figure 4.24 IEEE Very Inverse Curve: E2

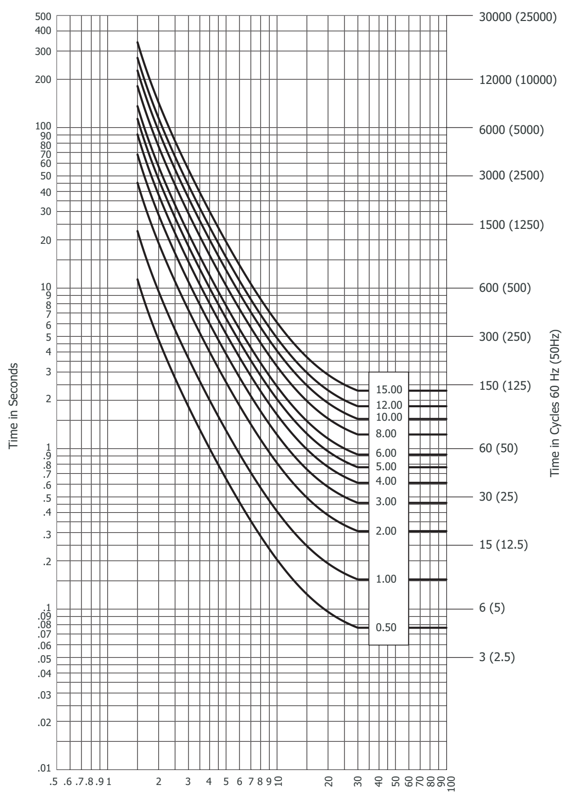


Figure 4.25 IEEE Extremely Inverse Curve: E3

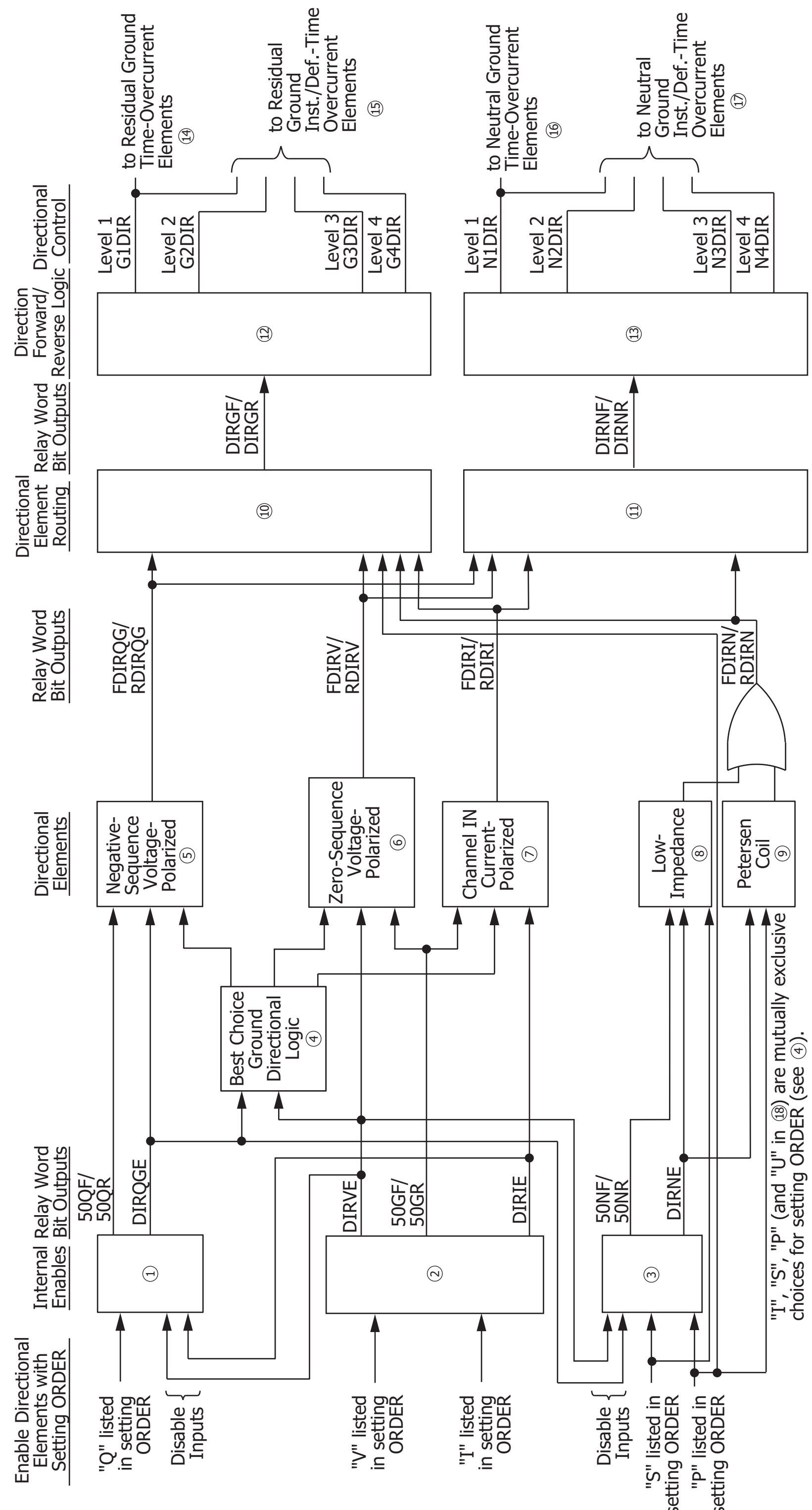
Directional Control

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 4.63*.

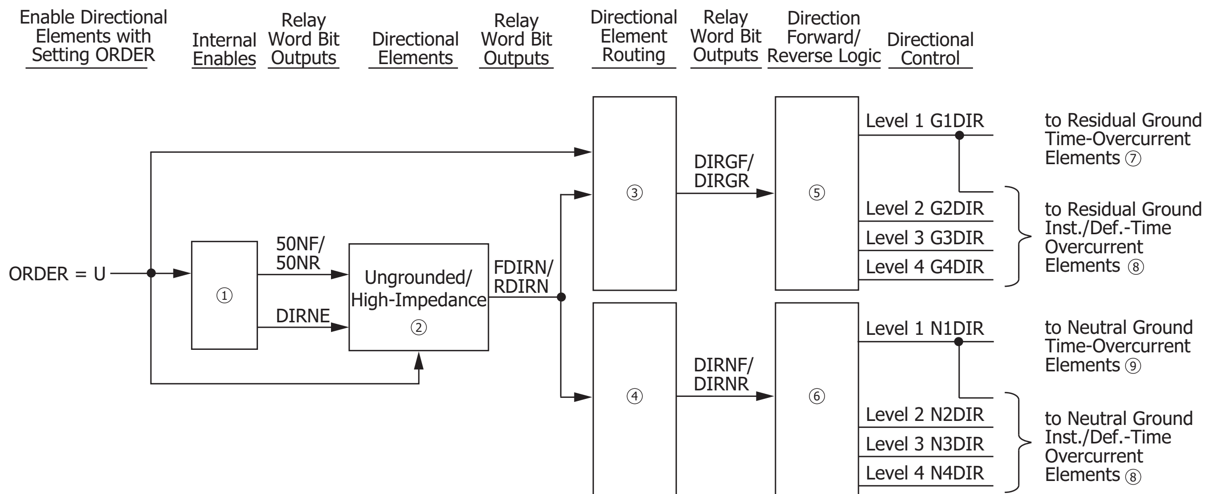
Six directional elements are available to control the neutral ground and residual ground overcurrent elements. Not all are available simultaneously. These six directional elements are:

- 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 4.29; ② Figure 4.30; ③ Figure 4.31; ④ Table 4.23 and Table 4.24;
⑤Figure 4.32; ⑥ Figure 4.33; ⑦ Figure 4.34; ⑧ Figure 4.35; ⑨ Figure 4.36;
⑩ Figure 4.38; ⑪ Figure 4.39; ⑫ Figure 4.40; ⑬ Figure 4.41; ⑭ Figure 4.12;
⑮ Figure 4.2; ⑯ Figure 4.11; ⑰ Figure 4.2; ⑱ Figure 4.27.

Figure 4.26 General Logic Flow of Directional Control for Neutral Ground and Residual Ground Overcurrent Elements (Excluding Ungrounded/High-Impedance Grounded Systems)



① Figure 4.31; ② Figure 4.37; ③ Figure 4.38; ④ Figure 4.39; ⑤ Figure 4.40; ⑥ Figure 4.41; ⑦ Residual Time-Overcurrent Elements 51G1T and 51G2T; ⑧ Figure 4.2; ⑨ Figure 4.11; ⑩ Figure 4.12.

Figure 4.27 General Logic Flow of Directional Control for Neutral Ground and Residual Ground Overcurrent Elements (Ungrounded/High-Impedance Grounded Systems; ORDER := U)

Table 4.23 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 4.29*, *Figure 4.32*	All models (not dependent on neutral channel [IN])
V	Zero-sequence voltage-polarized	DIRVE	*Figure 4.30*, *Figure 4.33*	
I	Channel IN current polarized	DIRIE	*Figure 2.32*, *Figure 4.30*, *Figure 4.34*	Models with a 1 A or 5 A nominal neutral channel (IN)
S[a]	Zero-sequence voltage-polarized (Low-impedance)	DIRNE (Low-impedance)	*Figure 2.35*, *Figure 4.31*, *Figure 4.35*	Models with a 0.2 A nominal neutral channel (IN) and advanced directional MOT option
P[a]	Wattmetric and incremental conductance (Petersen coil)	DIRNE (Petersen coil)	*Figure 2.37*, *Figure 4.31*, *Figure 4.36*	
U[a]	Zero-sequence voltage-polarized (Ungrounded/high-impedance)	DIRNE (Ungrounded/high-impedance)	*Figure 2.35*, *Figure 2.36*, *Figure 2.38*, *Figure 4.31*, *Figure 4.37*	

[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 4.24 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] and advanced directional MOT option
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 4.25 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 4.23 and Table 4.24.
[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 4.26 and *Figure 4.27* 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 4.26* and *Figure 4.27* that setting ORDER enables the directional elements. Setting ORDER can be set with the elements listed and defined in *Table 4.23*, subject to the setting combination constraints in *Table 4.24*. Note that *Table 4.23* and *Table 4.24* 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 or AUTO2.

Table 4.25 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 4.23* through *Table 4.25*), setting EDIR (directional control enable) can only be set to N. Refer to *Figure 2.27* and *Figure 2.28* 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 4.23* through *Table 4.25* (and lower left-hand corner of *Figure 4.26*) 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 4.23*, *Figure 4.26*, and *Figure 4.27*) 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 4.63*.

Internal Enables

Refer to *Figure 4.26*, *Figure 4.27*, *Figure 4.29*, *Figure 4.30*, and *Figure 4.31*.

Table 4.23 lists the internal enables and their correspondence to the ground directional elements.

Note that *Figure 4.29* has extra internal enable DIRQE, which is used in the directional element logic that controls negative-sequence and phase overcurrent elements (see *Figure 4.42*).

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 4.29*, *Figure 4.30*, and *Figure 4.31*), unless VSCONN = 3V0. In that case, the directional-element enables in *Figure 4.30* and *Figure 4.31* are not affected by LOP.

The channel IN current-polarized directional element (with corresponding internal enable DIRIE; *Figure 4.30*) does not use voltage in making direction decisions, thus a loss-of-potential condition does not disable the element. Refer to *Figure 4.90* 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 4.63*.

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 4.31* (and *Figure 4.35* and *Figure 4.37*) 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 4.28*, 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.

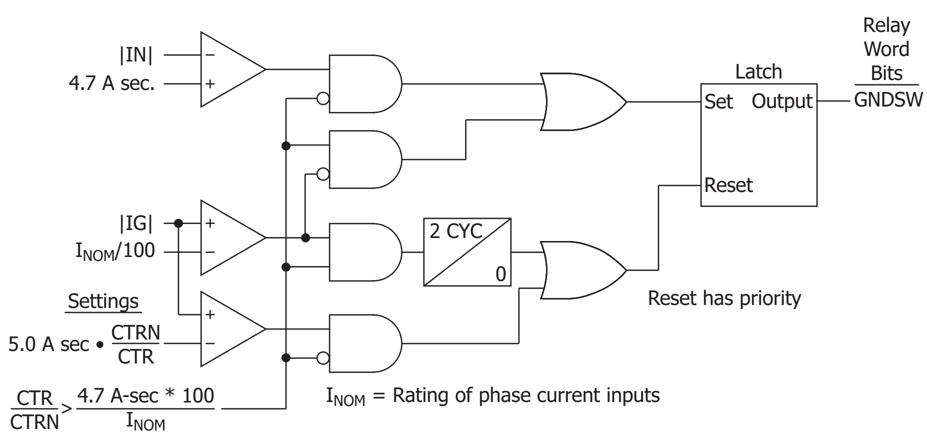


Figure 4.28 Logic for Relay Word Bit GNDSW

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 4.30* 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 4.31* (and *Figure 4.35* and *Figure 4.37*) 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 4.31*, *Figure 4.35*, and *Figure 4.37* also has an effect on zero-sequence impedance settings Z0F and Z0R (see *Figure 4.35* and *Figure 4.37*). 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 4.35* and *Figure 4.37*, 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 4.31*, *Figure 4.35*, and *Figure 4.37* 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 4.33* and *Figure 4.35* through *Figure 4.37*) 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 2.28: 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 4.24 is the embodiment of the Best Choice Ground Directional Element logic. Note in *Table 4.24* 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 4.26 shows no control emanating from the Best Choice Ground Directional Element logic to the directional elements corresponding to S or P (*Figure 4.35*, and *Figure 4.36*, 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 4.31*. If neither DIRQGE nor DIRVE are asserted (and thus their corresponding directional elements are not enabled), then the internal enable logic of *Figure 4.31* 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 4.26*, *Figure 4.27*, and *Figure 4.32* through *Figure 4.37*. The Best Choice Ground Directional Element logic in *Table 4.24* determines which directional element will run.

Note in *Figure 4.36* 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, Héctor 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 4.26*, *Figure 4.27*, *Figure 4.38*, and *Figure 4.39*. 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 4.40* and *Figure 4.41*.

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 4.38* and DIRNF in *Figure 4.39*) asserts to logical 1, thus, enabling the residual ground (*Figure 4.40*) and neutral ground (*Figure 4.41*) 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 Group 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 4.38* and *Figure 4.39*. 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 4.40*, 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 4.90* and accompanying text for more information on loss-of-potential.

Direction Forward/Reverse Logic

Refer to *Figure 4.26*, *Figure 4.27*, *Figure 4.40*, and *Figure 4.41*.

The forward (Relay Word bit DIRGF in *Figure 4.40* and DIRNF in *Figure 4.41*) and reverse (Relay Word bit DIRGR in *Figure 4.40* and DIRNR in *Figure 4.41*) 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 4.31 shows the overcurrent elements that are controlled by each level direction setting. Note in *Table 4.31* that all the time-overcurrent elements (51_T elements) are controlled by the DIR1 level direction setting.

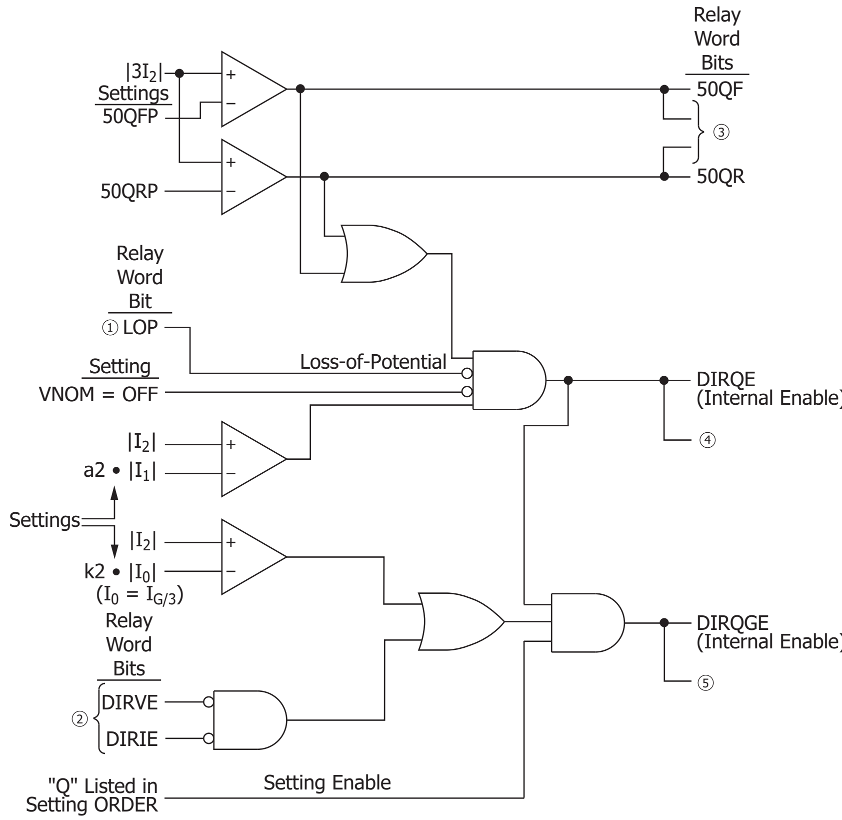
If a level direction setting (e.g., DIR1) is set:

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.

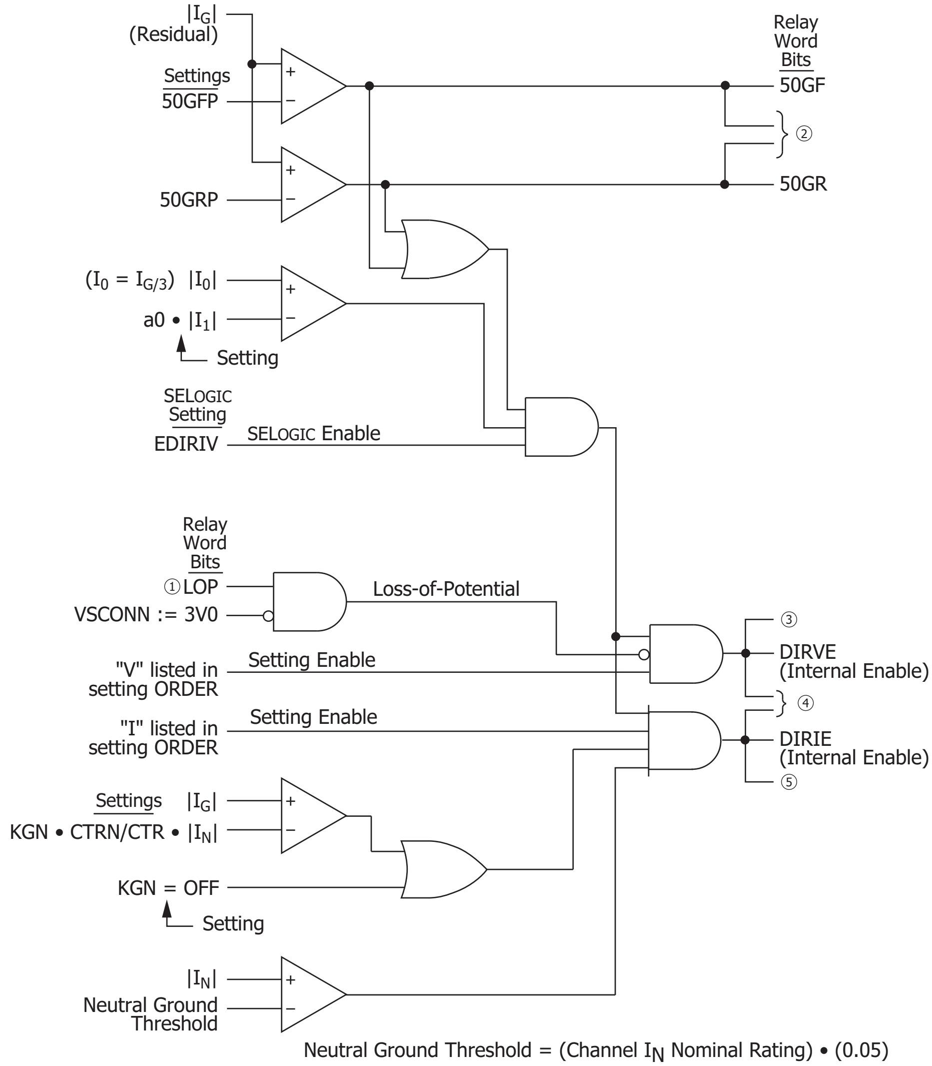
See the beginning of *Directional Control Settings on page 4.63* for a discussion of the operation of level direction settings DIR1 through DIR4 when the directional control enable setting EDIR is set to EDIR := N.

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



① From Figure 4.90; ② From Figure 4.30; ③ to Figure 4.32 and Figure 4.43;
④ to Figure 4.43 and Figure 4.44; ⑤ to Figure 4.31, Table 4.23, and Table 4.24.

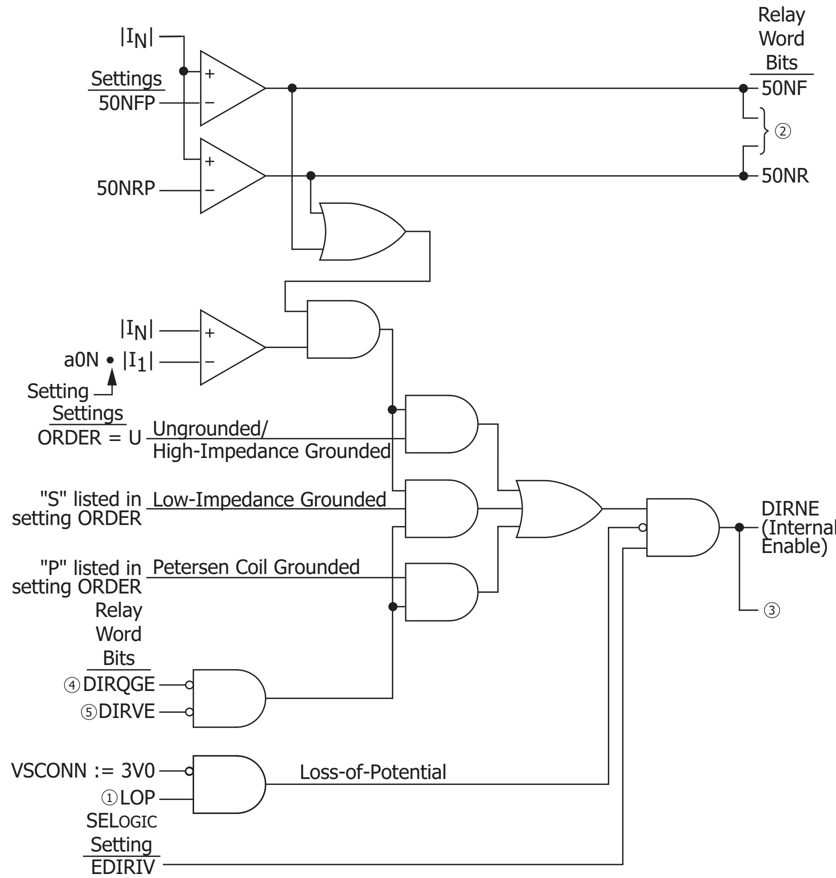
Figure 4.29 Internal Enables (DIRQE and DIRQGE) Logic for Negative-Sequence Voltage-Polarized Directional Elements



① From Figure 4.90; ② to Figure 4.33 and Figure 4.34; ③ to Figure 4.31 and Figure 4.33; ④ to Figure 4.29, Figure 4.38, Figure 4.39, Table 4.23, and Table 4.24; ⑤ to Figure 4.34.

Figure 4.30 Internal Enables (DIRVE and DIRIE) Logic for Zero-Sequence Voltage-Polarized and Channel IN Current-Polarized Directional Elements

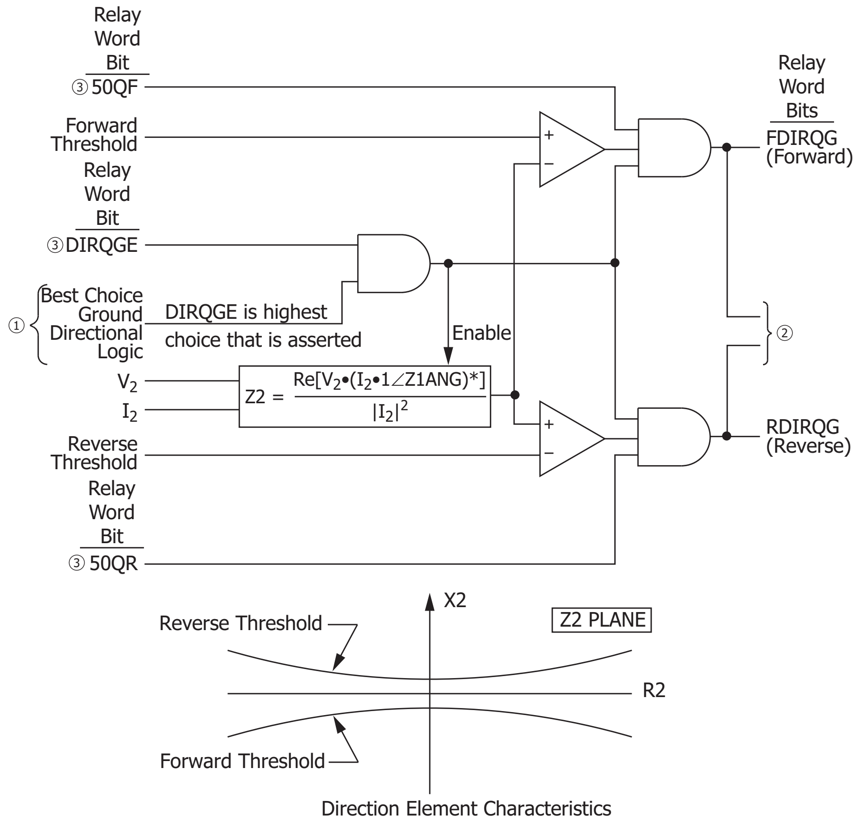
NOTE: Residual ground current I_G is used in place of neutral current I_N under certain circumstances. See Switch Between I_N and I_G for Low-Impedance Grounded and Ungrounded/High-Impedance Grounded Systems on page 4.40.



① From Figure 4.90; ② to Figure 4.35 and Figure 4.37; ③ to Figure 4.26, Figure 4.27, Figure 4.35, Figure 4.36, Figure 4.37, Table 4.23, and Table 4.24; ④ from Figure 4.29; ⑤ from Figure 4.30.

Figure 4.31 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 4.87* for information on using SELOGIC setting EDIRIV.



Forward Threshold:

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

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

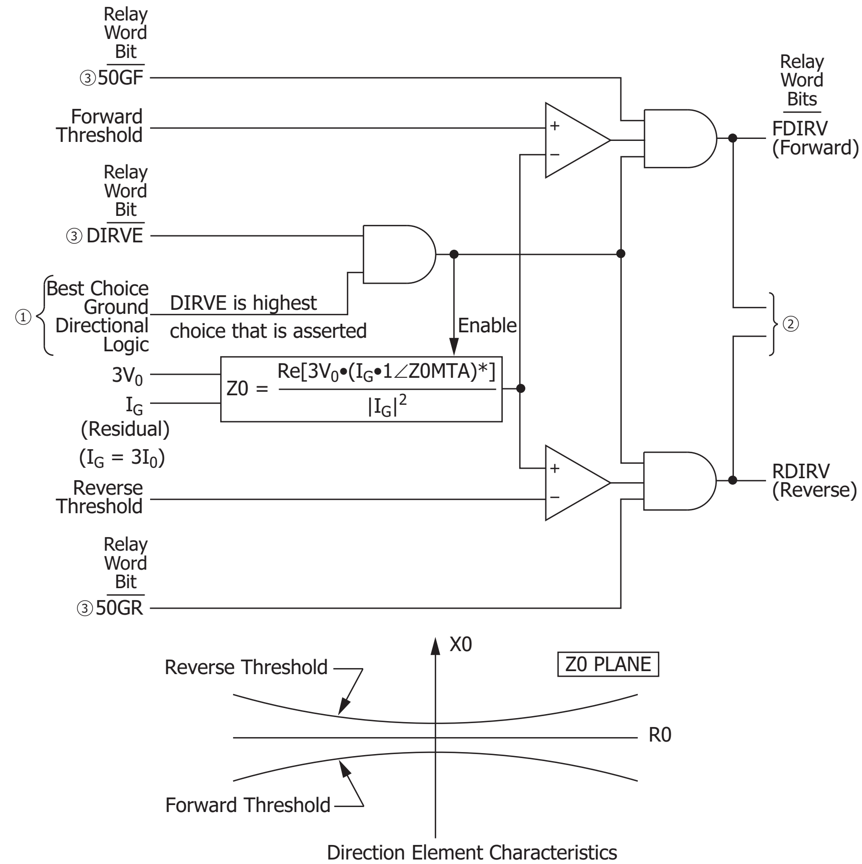
Reverse Threshold:

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

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

① From Table 4.24; ② to Figure 4.38 and Figure 4.39; ③ from Figure 4.29.

Figure 4.32 Negative-Sequence Voltage-Polarized Directional Element for Neutral Ground and Residual Ground Overcurrent Elements



Forward Threshold:

If Z0F Setting ≤ 0, Forward Threshold = $0.75 \bullet Z0F - 0.25 \bullet \left|\frac{V_0}{I_0}\right|$

If Z0F Setting > 0, Forward Threshold = $1.25 \bullet Z0F - 0.25 \bullet \left|\frac{V_0}{I_0}\right|$

Reverse Threshold:

If Z0R Setting ≥ 0, Reverse Threshold = $0.75 \bullet Z0R + 0.25 \bullet \left|\frac{V_0}{I_0}\right|$

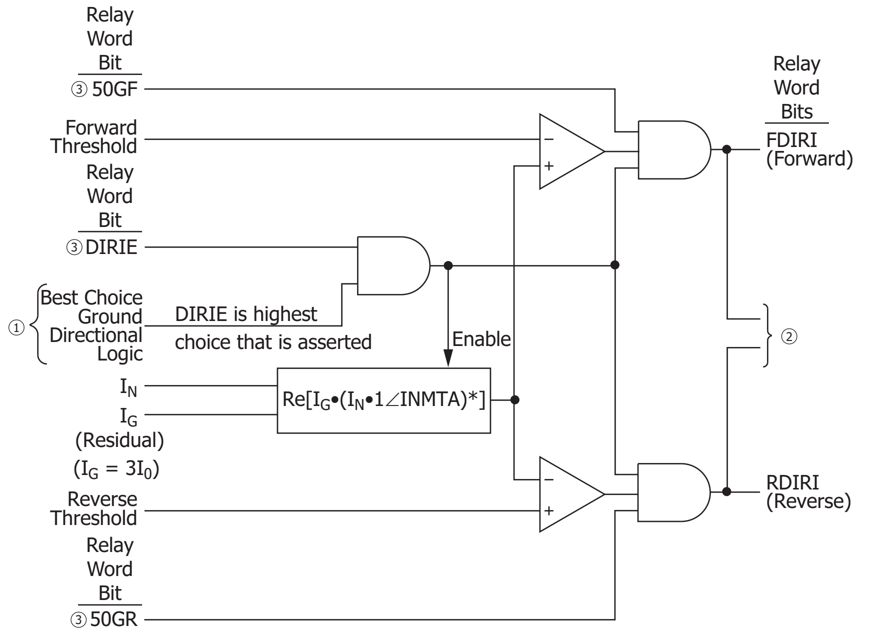
If Z0R Setting < 0, Reverse Threshold = $1.25 \bullet Z0R + 0.25 \bullet \left|\frac{V_0}{I_0}\right|$

① From Table 4.24; ② to Figure 4.38 and Figure 4.39; ③ from Figure 4.30.

Figure 4.33 Zero-Sequence Voltage-Polarized Directional Element

The 3V0 input to *Figure 4.33* 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 4.42*.

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) • $(0.05)^2$

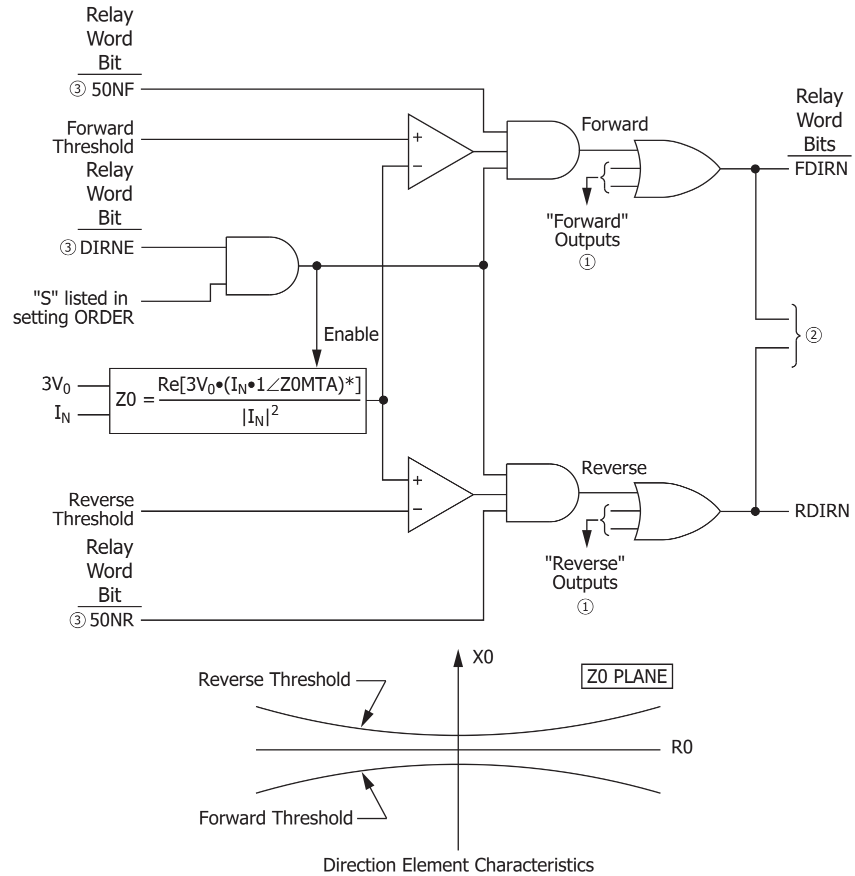
Reverse Threshold:

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

① From Table 4.24; ② to Figure 4.38 and Figure 4.39; ③ from Figure 4.30.

Figure 4.34 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 4.40



Forward Threshold:

If Z0F Setting ≤ 0, Forward Threshold $= 0.75 \bullet \text{Z0F} - 0.25 \bullet \left|\frac{3V_0}{I_N}\right|$

If Z0F Setting > 0, Forward Threshold $= 1.25 \bullet \text{Z0F} - 0.25 \bullet \left|\frac{3V_0}{I_N}\right|$

Reverse Threshold:

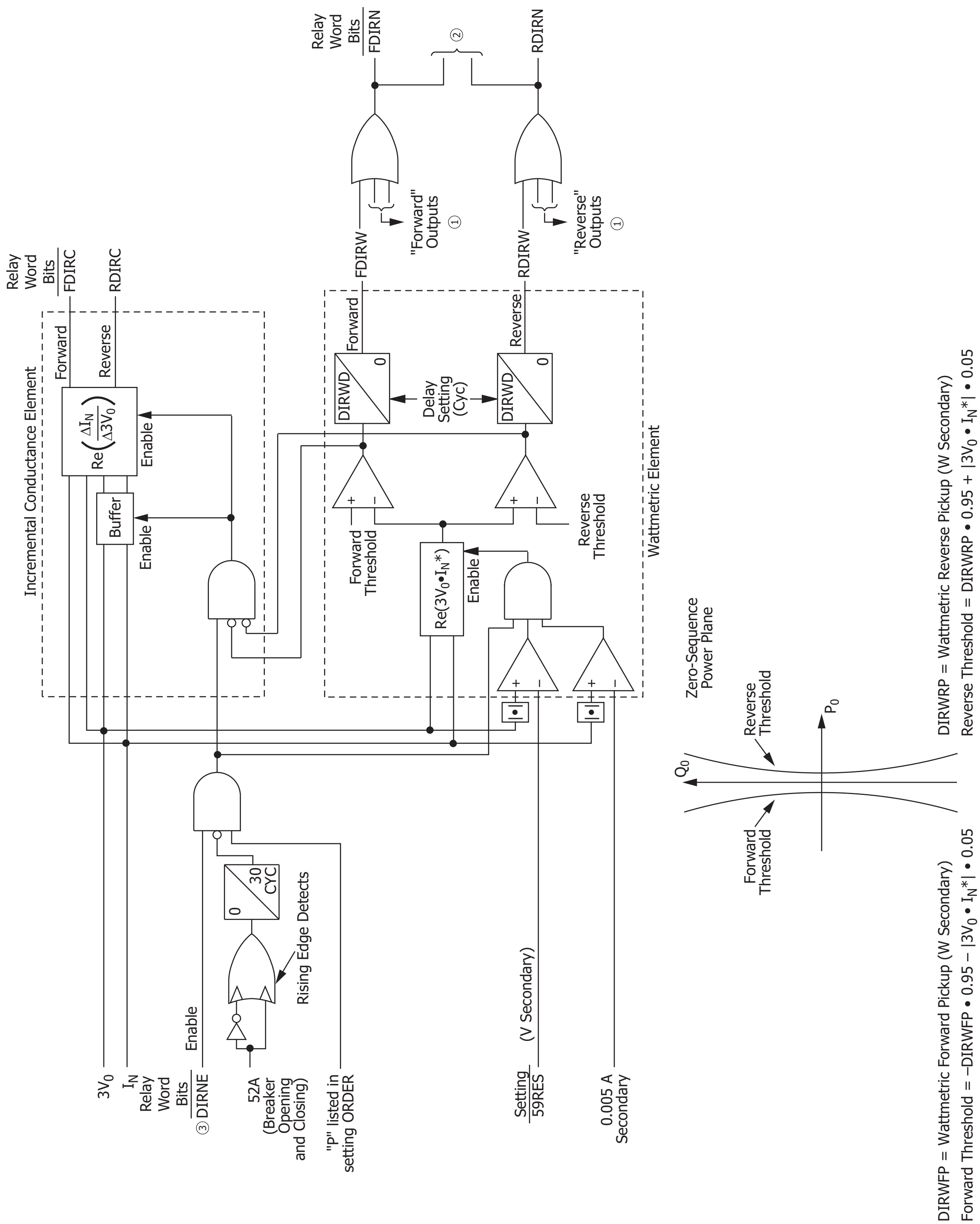
If Z0R Setting ≥ 0, Reverse Threshold $= 0.75 \bullet \text{Z0R} + 0.25 \bullet \left|\frac{3V_0}{I_N}\right|$

If Z0R Setting < 0, Reverse Threshold $= 1.25 \bullet \text{Z0R} + 0.25 \bullet \left|\frac{3V_0}{I_N}\right|$

① From Figure 4.36 and Figure 4.37; ② to Figure 4.38 and Figure 4.39;
③ from Figure 4.31.

Figure 4.35 Zero-Sequence Voltage-Polarized Directional Element (Low-Impedance Grounded Systems)

The 3V0 input to *Figure 4.35* 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 4.42*.

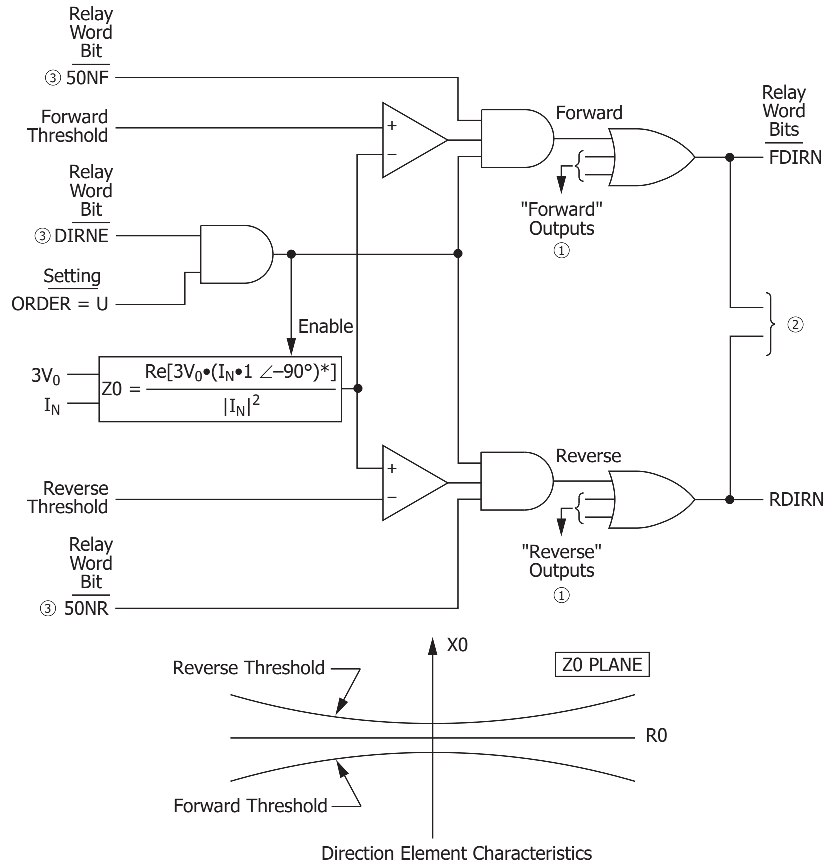


① From Figure 4.35 and Figure 4.37; ② to Figure 4.38 and Figure 4.39; ③ from Figure 4.31.

Figure 4.36 Wattmetric and Incremental Conductance Directional Elements (Petersen Coil-Grounded Systems)

The 3V0 input to *Figure 4.36* 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 4.42*.

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 4.40



Forward Threshold:

$$Z0F = -0.10,\ \text{Forward Threshold} = 0.75 \bullet Z0F - 0.25 \bullet \left|\frac{3V_0}{I_N}\right|$$

Reverse Threshold:

$$Z0R = 0.10,\ \text{Reverse Threshold} = 0.75 \bullet Z0R + 0.25 \bullet \left|\frac{3V_0}{I_N}\right|$$

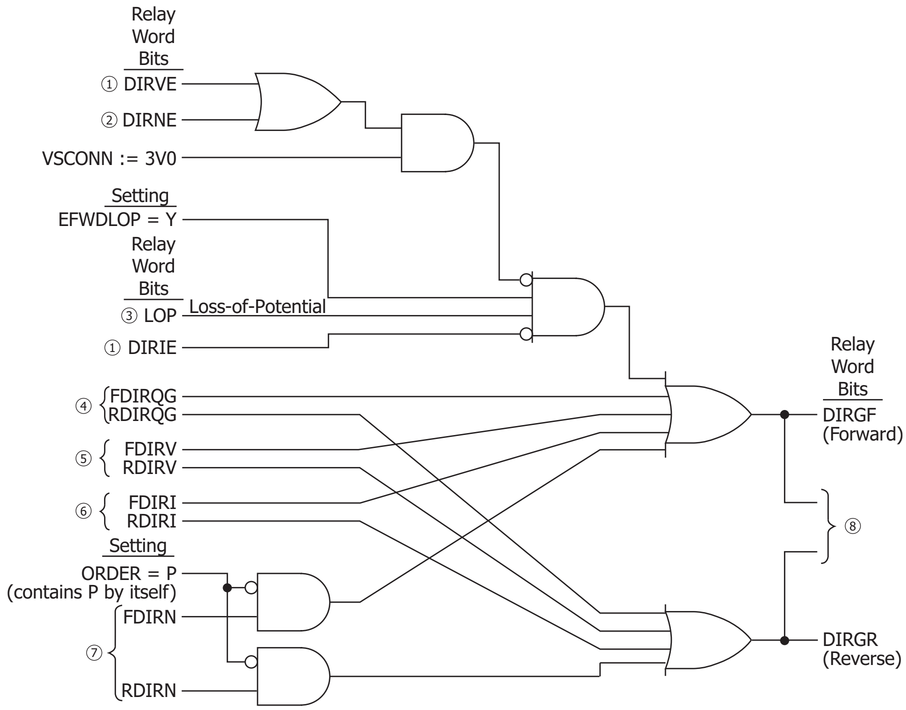
For setting ORDER = U, settings Z0F and Z0R are set internally, as shown above, and hidden.

Note: 1 ∠–90° = One Ohm at –90° Angle

① From Figure 4.35 and Figure 4.36; ② to Figure 4.38 and Figure 4.39;
③ from Figure 4.31.

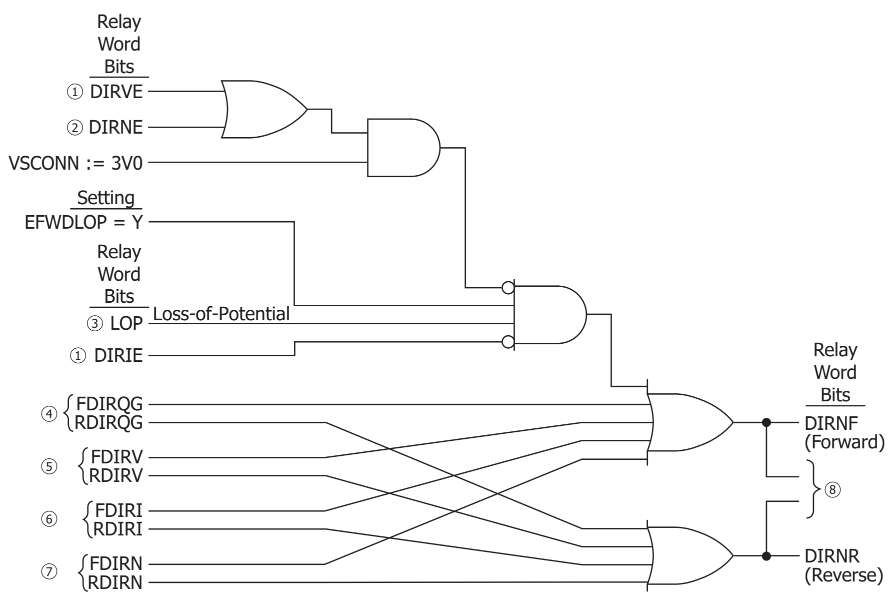
Figure 4.37 Zero-Sequence Voltage-Polarized Directional Element (Ungrounded/High-Impedance Grounded Systems)

The 3V0 input to *Figure 4.37* 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 4.42*.



① From Figure 4.30; ② from Figure 4.31; ③ from Figure 4.90; ④ from Figure 4.32; ⑤ from Figure 4.33; ⑥ from Figure 4.34; ⑦ from Figure 4.35, Figure 4.36, or Figure 4.37; ⑧ to Figure 4.40.

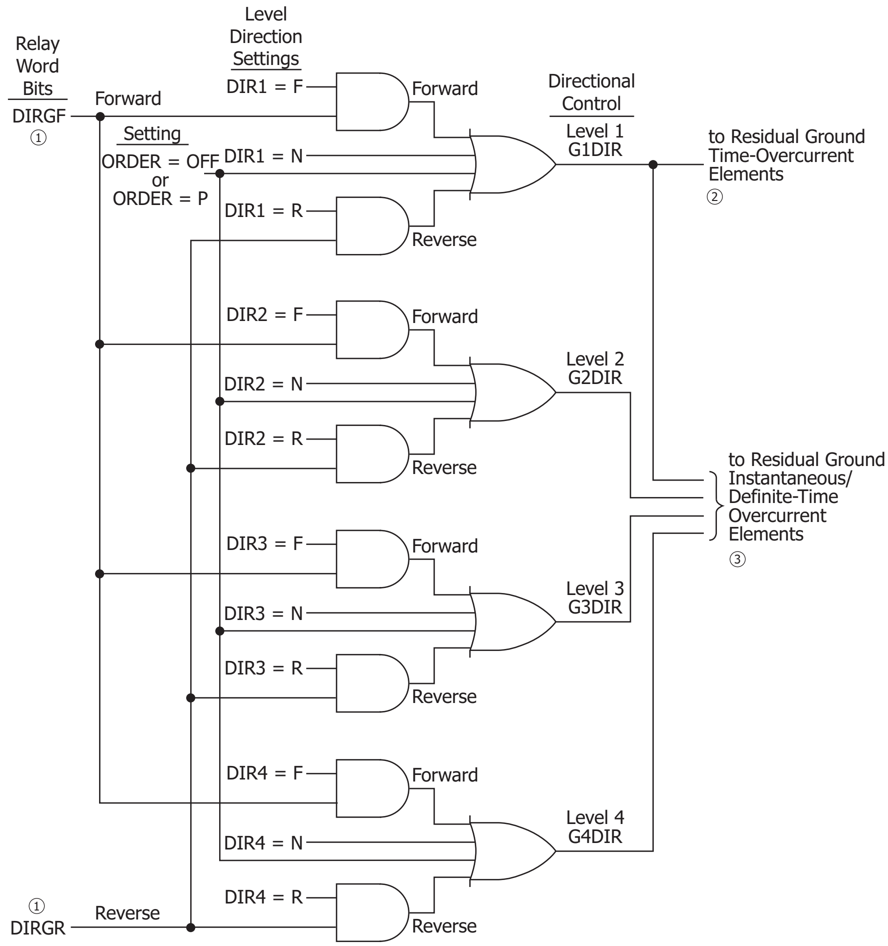
Figure 4.38 Routing of Directional Elements to Residual Ground Overcurrent Elements



① From Figure 4.30; ② from Figure 4.31; ③ from Figure 4.90; ④ from Figure 4.32; ⑤ from Figure 4.33; ⑥ from Figure 4.34; ⑦ from Figure 4.35, Figure 4.36, or Figure 4.37; ⑧ to Figure 4.41.

Figure 4.39 Routing of Directional Elements to Neutral Ground Overcurrent Elements

The 3V0 input to *Figure 4.36* 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 4.42*.



① From Figure 4.38; ② Figure 4.12; ③ Figure 4.2.

Figure 4.40 Direction Forward/Reverse Logic for Residual Ground Overcurrent Elements

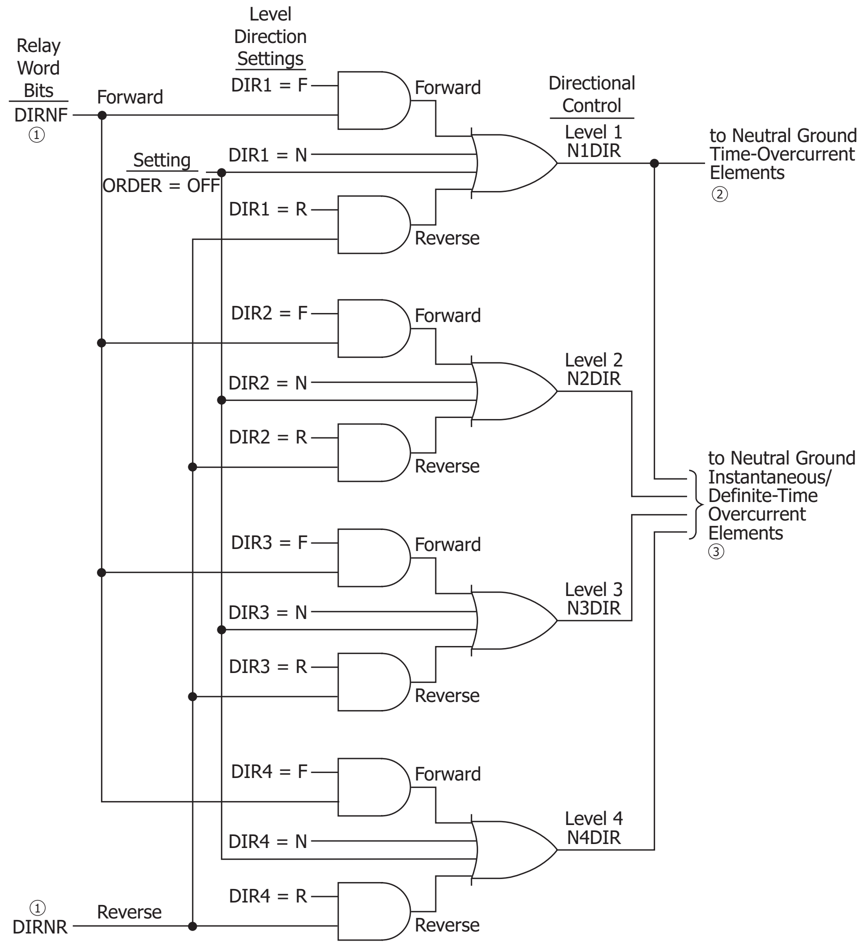


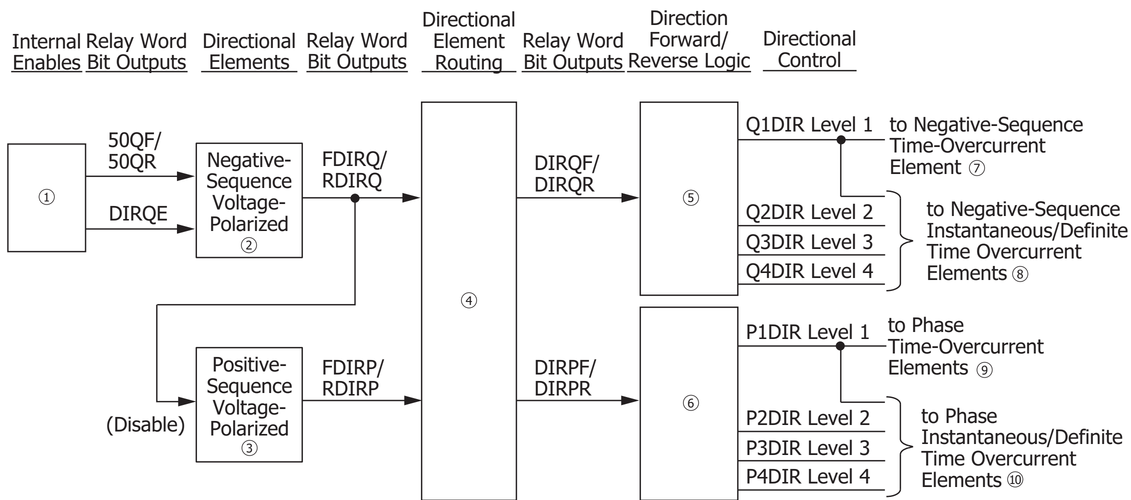
Figure 4.41 Direction Forward/Reverse Logic for Neutral Ground Overcurrent Elements

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 4.63*.

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 4.42* 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 4.29* and *Figure 4.44*.



① Figure 4.29; ② Figure 4.43; ③ Figure 4.44; ④ Figure 4.45; ⑤ Figure 4.46; ⑥ Figure 4.47; ⑦ Figure 4.10;
⑧ Figure 4.2; ⑨ Figure 4.9; ⑩ Figure 4.2.

Figure 4.42 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 4.29* and *Figure 4.42*.

The internal enable DIRQE corresponds to the negative-sequence voltage-polarized directional element.

Note that *Figure 4.29* 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 4.26*).

The settings involved with internal enable DIRQE in *Figure 4.29* (e.g., settings a2, k2) are explained in *Directional Control Settings on page 4.63*.

Directional Elements

Refer to *Figure 4.42*, *Figure 4.43*, and *Figure 4.44*.

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 4.29* and *Figure 4.44*).

Refer to *Figure 4.90* and accompanying text for more information on loss-of-potential.

Note in *Figure 4.42* and *Figure 4.44* 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 4.44* 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 4.10*).

Directional Element Routing

Refer to *Figure 4.42* and *Figure 4.45*.

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 4.46* and *Figure 4.47*.

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 4.29* and *Figure 4.44*), 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 4.90* and accompanying text for more information on loss-of-potential.

Direction Forward/Reverse Logic

Refer to *Figure 4.42*, *Figure 4.46*, and *Figure 4.47*.

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 4.31 shows the overcurrent elements that are controlled by each level direction setting. Note in *Table 4.31* 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)

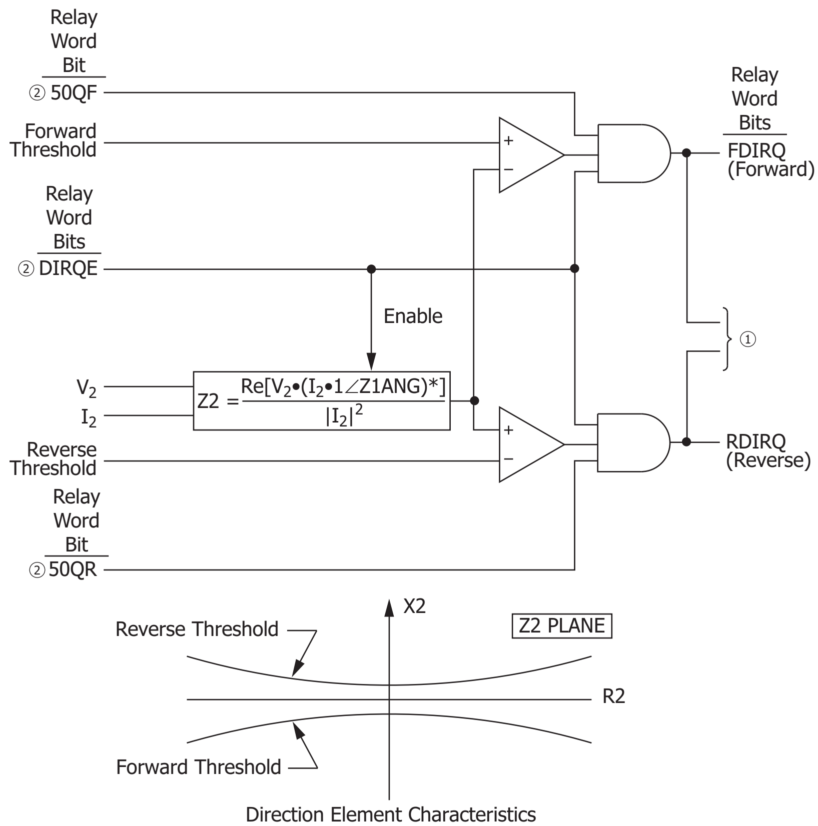
then the corresponding Level 1 directional control outputs in *Figure 4.46* and *Figure 4.47* assert to logical 1. The referenced Level 1 overcurrent elements in *Figure 4.46* and *Figure 4.47* are then not controlled by the directional control logic.

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 4.46* and *Figure 4.47* 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 4.63* 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 4.87* describes how to avoid this limitation for special cases.



Forward Threshold:

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

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

Reverse Threshold:

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

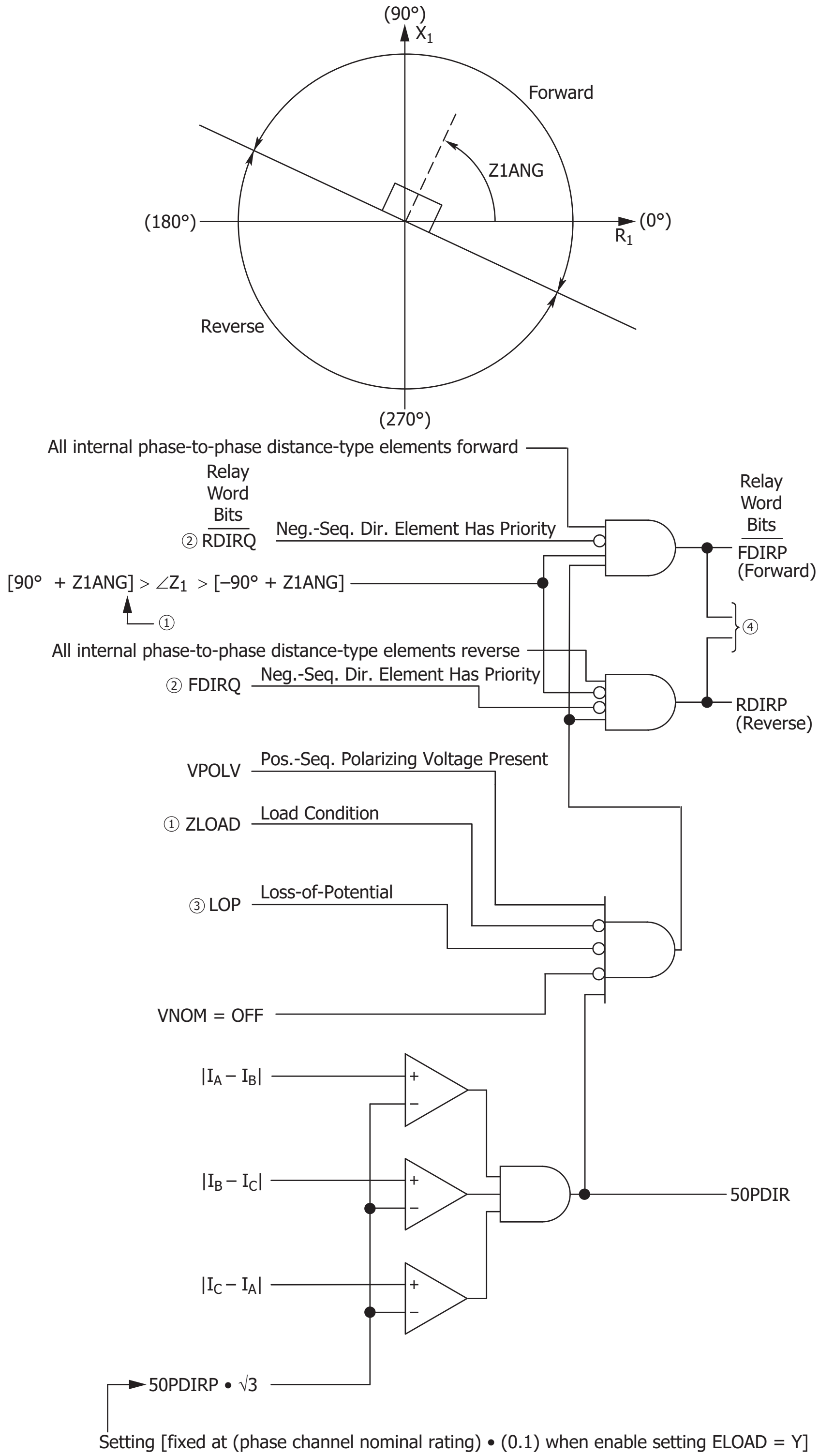
If Z2R Setting < 0, Reverse Threshold $= 1.25 \bullet Z2R + 0.25 \bullet \left|\frac{V_2}{I_2}\right|$

① To Figure 4.44 and Figure 4.45; ② from Figure 4.29.

Figure 4.43 Negative-Sequence Voltage-Polarized Directional Element for Negative-Sequence and Phase Overcurrent Elements

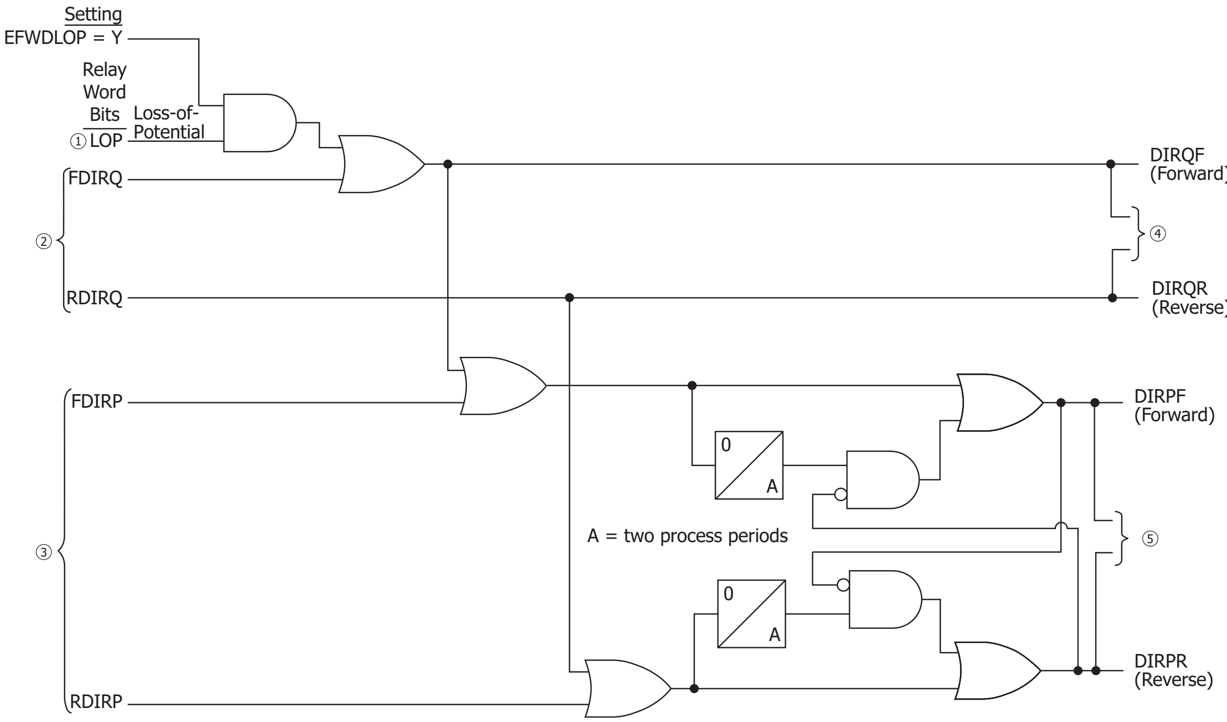
NOTE: The positive-sequence voltage-polarized directional element uses positive-sequence memory voltage as the polarizing voltage.

NOTE: There are two modes: slow (normal conditions) and fast charge (when voltages are restored). The respective time constants are 21 quarter cycles (~5 cycles) and 3 quarter cycles.



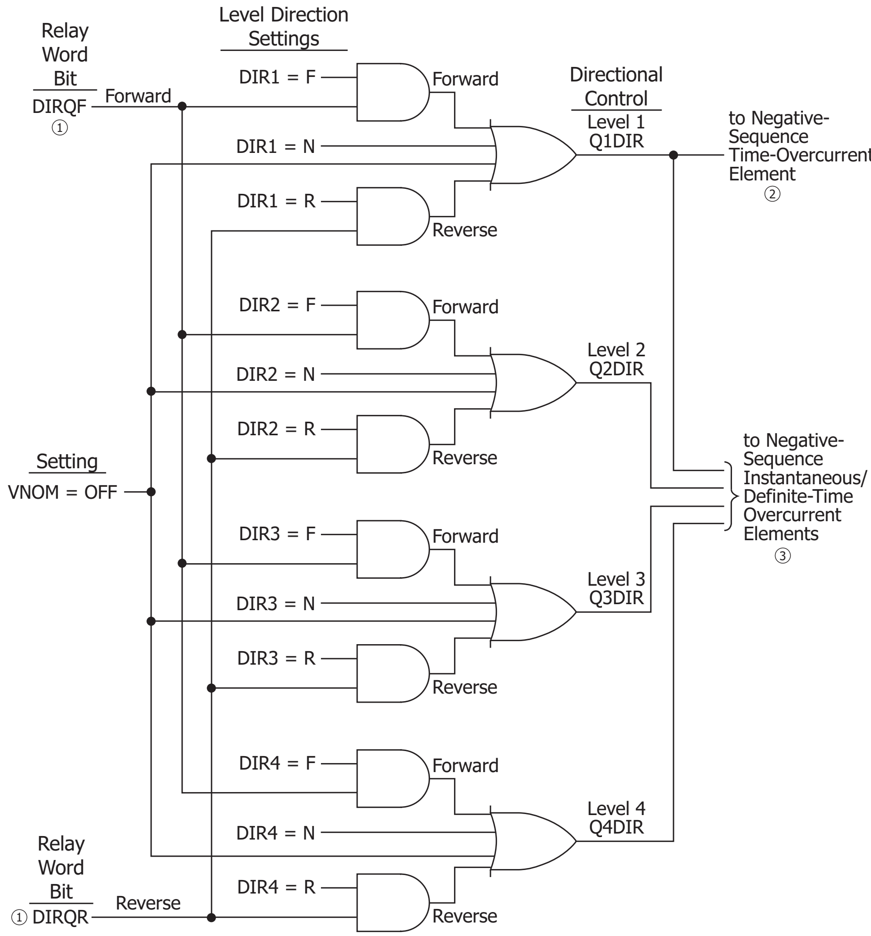
① From Figure 4.60; ② from Figure 4.43; ③ from Figure 4.90; ④ to Figure 4.45.

Figure 4.44 Positive-Sequence Voltage-Polarized Directional Element for Phase Overcurrent Elements



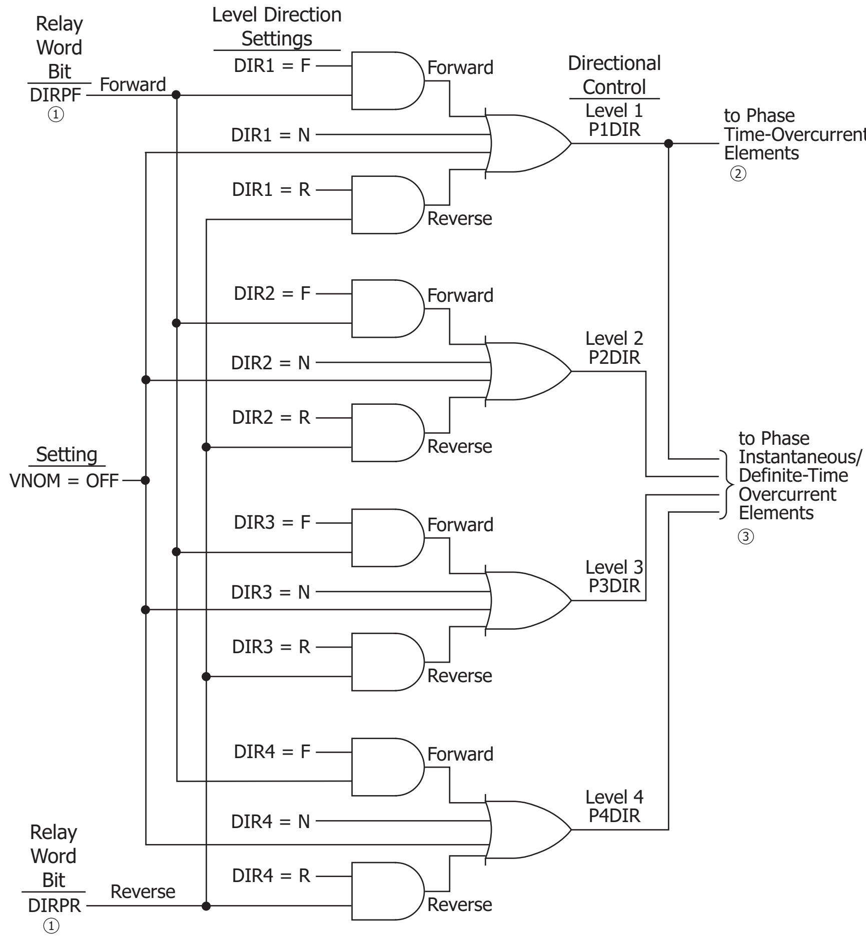
① From Figure 4.90; ② from Figure 4.43; ③ from Figure 4.44; ④ to Figure 4.46; ⑤ to Figure 4.47.

Figure 4.45 Routing of Directional Elements to Negative-Sequence and Phase Overcurrent Elements



① From Figure 4.45; ② Figure 4.10; ③ Figure 4.2.

Figure 4.46 Direction Forward/Reverse Logic for Negative-Sequence Overcurrent Elements



① From Figure 4.45; ② Figure 4.9; ③ Figure 4.2.

Figure 4.47 Direction Forward/Reverse Logic for Phase Overcurrent Elements

Directional Control Settings

Table 4.26 and *Table 4.27* show all the directional element settings. The Wattmetric element settings for Petersen coil-grounded systems are shown in *Table 4.27*.

Table 4.26 Directional Control Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
DIR CONTROL ENBL	Y, AUTO, AUTO2, 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]

Table 4.26 Directional Control Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
REV DIR Z2 LVL	–128.00 to 128.00 ohm [c]	Z2R := 0.06[c]
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 4.25 and Table SET.2 on page SET.7 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 4.27 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	0.00–18000.00 sec	DIRWD := 0.50

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 4.40*, *Figure 4.41*, *Figure 4.46*, and *Figure 4.47* assert to logical 1. The overcurrent elements referenced in *Figure 4.40*, *Figure 4.41*, *Figure 4.46*, and *Figure 4.47* 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 4.25*.

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

NOTE: Use caution when setting EDIR := AUTO, as it is not appropriate for all applications. Systems with a strong negative-sequence source (i.e., equivalent negative-sequence impedance of less than 2.5/INOM in ohms) can use EDIR := AUTO. The EDIR := AUTO2 settings in *Table 4.29* provide equal or better protection than EDIR := AUTO for most systems.

If the directional control enable setting EDIR is set:

EDIR := **AUTO**

then the following directional control settings are calculated and set automatically (*Table 4.28*).

Table 4.28 Ground Directional Element Settings AUTO Calculations

Setting	Equation
50QFP	0.10 • INOM
50QRP	0.05 • INOM
Z2F	0.5 • Z1MAG
Z2R	Z2F + 1/INOM
a2	0.10
k2	0.20
50GFP	0.10 • INOM
50GRP	0.05 • INOM
Z0F	0.5 • Z0MAG[a]
Z0R	Z0F + 1/INOM[a]
a0	0.10
Z0MTA	Z0ANG

[a] These equations apply when ORDER is not set equal to U. Refer to *Z0F and Z0R Set Automatically*.

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.

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 2.29*. 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.

Setting EDIR := AUTO2 will set the directional control settings as shown in *Table 4.29*. It is best to use AUTO2 if any of the following apply:

- ➤ The negative-sequence impedance of the source is greater than 2.5/INOM in ohms.
- ➤ The line impedance is unknown.
- ➤ A non-fault condition occurs, such as a switching transformer energization, causing the negative-sequence voltage to be approximately zero.

Table 4.29 Ground Directional Element Settings AUTO2 Calculations

Setting	Equation
50QFP	0.10 • INOM
50QRP	0.05 • INOM
Z2F	–1.5/INOM
Z2R	1.5/INOM
a2	0.10
k2	0.20
50GFP	0.10 • INOM
50GRP	0.05 • INOM
Z0F	–1.5/INOM
Z0R	1.5/INOM
a0	0.10
Z0MTA	Z0ANG

The remaining directional control settings are *not* set automatically if setting EDIR := AUTO or AUTO2. They have to be set by the user, whether setting EDIR := AUTO, AUTO2, 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 4.30 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 4.31 shows the overcurrent elements that are controlled by each level direction setting. Note in *Table 4.31* that all the time-overcurrent elements (51_T elements) are controlled by the DIR1 level direction setting. *Figure 4.40*, *Figure 4.41*, *Figure 4.46*, and *Figure 4.47* show the logic implementation of the control listed in *Table 4.31*.

Table 4.31 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 4.9*) 51P1T (*Figure 4.9*) 51P2P (*Figure 4.9*) 51P2T (*Figure 4.9*)	67N1P (*Figure 4.2*) 67N1T (*Figure 4.2*) 51N1P (*Figure 4.11*) 51N1T (*Figure 4.11*) 51N2P (*Figure 4.11*) 51N2T (*Figure 4.11*)	67G1P (*Figure 4.2*) 67G1T (*Figure 4.2*) 51G1P (*Figure 4.12*) 51G1T (*Figure 4.12*) 51G2P (*Figure 4.12*) 51G2T (*Figure 4.12*)	67Q1P (*Figure 4.2*) 67Q1T (*Figure 4.2*) 51QP (*Figure 4.10*) 51QT (*Figure 4.10*)
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 (*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 4.87* 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 4.23*, subject to the setting combination constraints in *Table 4.24* and *Table 4.25*. Note that *Table 4.23* and *Table 4.24* also list directional element availability per model (according to the neutral channel [IN] rating). *Table 4.25* 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 4.32*) 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 4.29*), then the second listed directional element (V = zero-sequence voltage-polarized directional element; see *Figure 4.33*) 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 4.30*), then the third listed directional element (S = zero-sequence voltage-polarized directional element [low-impedance]; see *Figure 4.35*) 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 4.31*), 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 4.40* and *Figure 4.41*).

If setting:

ORDER = **V**

then the zero-sequence voltage-polarized directional element (V = zero-sequence voltage-polarized directional element; see *Figure 4.33*) 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 4.30*), 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 4.40* and *Figure 4.41*).

If setting:

ORDER = **OFF**

then all of the ground directional elements are inoperable. Note in *Figure 4.40* and *Figure 4.41* that setting ORDER := OFF effectively makes the neutral ground and residual ground overcurrent elements nondirectional (the directional control outputs of *Figure 4.40* and *Figure 4.41* are continuously asserted to logical 1).

Petersen Coil Considerations for Setting ORDER

Note in *Figure 4.40* 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 4.41*) are the elements that detect the ground fault, not the residual-ground overcurrent elements (referenced in *Figure 4.40*). The residual ground overcurrent elements (including forward and reverse fault detectors 50GF and 50GR, respectively; see *Figure 4.30*) 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 4.24*). Then, the residual ground elements (*Figure 4.40*) 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 4.44*).

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 4.32* and *Figure 4.43*).

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.

Z2F and Z2R Set Automatically

NOTE: If Z2F or Z2R exceeds the setting range, the quantity is set to the upper limit of the setting range.

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 4.50 and *Figure 4.51* 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 4.29*). 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 4.29*). 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 4.29*.

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 for the negative-sequence voltage-polarized directional elements to be enabled ($|I_2| > 0.1 \cdot |I_1|$).

k2—Zero-Sequence Current Restraint Factor, I_2/I_0. Note the internal enable logic outputs in *Figure 4.29*:

- 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 for the DIRQGE internal enable (and following negative-sequence voltage-polarized directional element in *Figure 4.32*) to be enabled:

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

Equation 4.3

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 4.4

If both of the internal enables (DIRVE and DIRIE) are deasserted, then factor k2 is ignored as a logic enable for the DIRQGE internal enable. This effectively puts fewer restrictions on the operation of the negative-sequence voltage-polarized directional element.

- 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

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 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.
0GRP—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 4.30*). 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 4.30*). 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 4.69*** 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 4.34 shows the logic for the current polarized directional element for ground faults. Traditional elements of this type use the directional characteristics shown in *Figure 4.48*, 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.

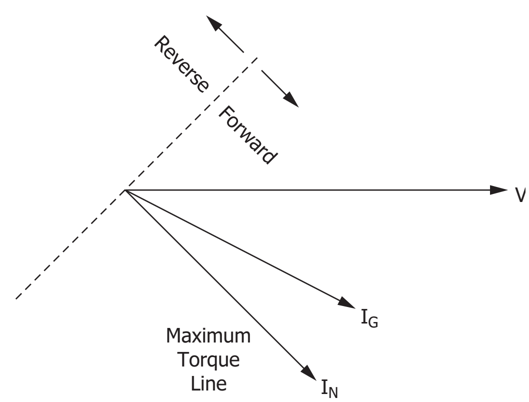


Figure 4.48 Traditional Channel IN Current-Polarized Directional Element

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 4.49*.

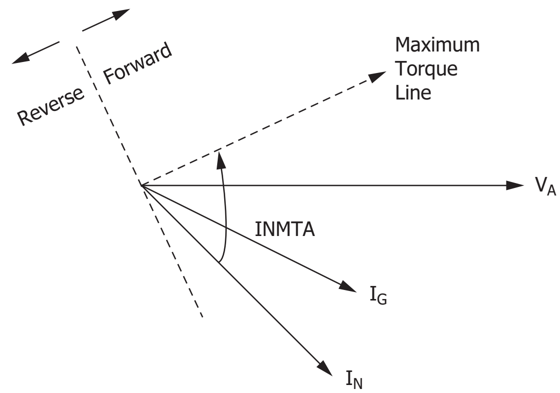


Figure 4.49 Current-Polarized Directional Element Characteristic When INMTA ≠ 0.00

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 4.48*). 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 4.30*). 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 4.49*).

See the technical paper *Selecting Directional Elements for Impedance-Grounded Distribution Systems* by Ronald Lavorin, Daqing Hou, Héctor 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 4.30*.

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 4.5

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 for the zero-sequence voltage-polarized and channel IN current-polarized directional elements to be enabled ($|I_0| > 0.1 \cdot |I_1|$).

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 4.33* and *Figure 4.35*).

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.

Z0F and Z0R Set Automatically

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 4.35, and Figure 4.37, 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 4.40.

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 4.37*), the following settings are made internally and hidden:

Z0F = **–0.10 Ω secondary**

Z0R = **0.10 Ω secondary**

Deriving Z0F and Z0R Settings

Figure 4.50 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 4.50* 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 4.51a*, with resultant Z0F and Z0R settings as in *Figure 4.51b*. The zero-sequence line angle noted in *Figure 4.51a* (∠Z0MTA) is the same angle found in *Figure 4.33* and *Figure 4.35* (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 4.50* and *Figure 4.51* just provide a theoretical background.

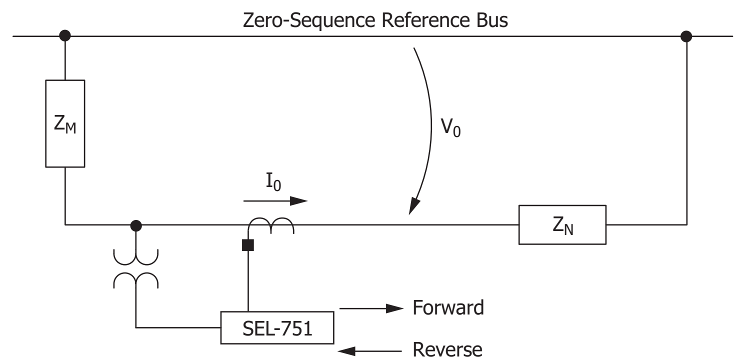


Figure 4.50 Zero-Sequence Impedance Network and Relay Polarity

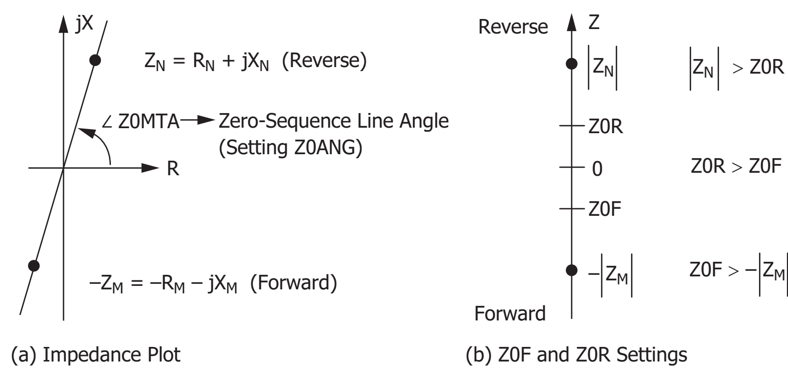


Figure 4.51 Zero-Sequence Impedance Plot for Solidly-Grounded, Mostly Inductive System

Z0MTA—Zero-Sequence Maximum Torque Angle. The Z0MTA setting is at the heart of the zero-sequence voltage-polarized directional element of *Figure 4.33*. 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"

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.

Otherwise, Z0MTA is hidden and of no consequence. Z0MTA can be set one of two ways:

- 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 4.50* and *Figure 4.51*[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 4.52* 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)

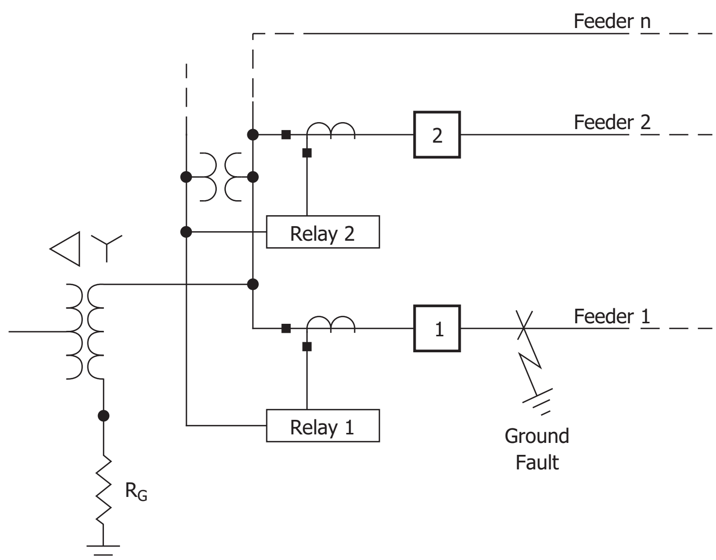


Figure 4.52 Low-Impedance Grounded Distribution System With a Ground Fault on Feeder 1

A grounding bank is installed if low-impedance grounding is desired at a substation and the transformer bank is to remain ungrounded. *Figure 4.52* 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 4.53 shows the resultant zero-sequence impedance network for the ground fault on Feeder 1 in *Figure 4.52*. V_0 in *Figure 4.53* is the zero-sequence voltage seen by all the relays connected to the distribution substation bus three-phase voltage.

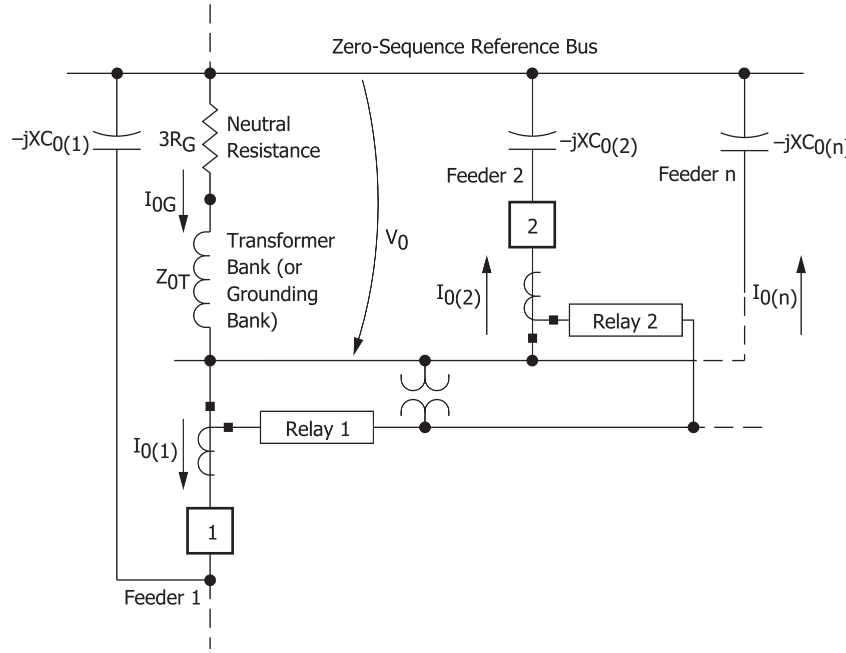


Figure 4.53 Zero-Sequence Impedance Network for Low-Impedance Grounded Distribution System With a Ground Fault on Feeder 1

Impedance definitions for *Figure 4.53*:

- $-jXC_{0(1)}$ = 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 4.53*:

- $I_{0(1)}$ = 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 4.52* (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 4.54 plots the increase in zero-sequence current I_{0G} resulting from decreasing neutral resistance R_G.

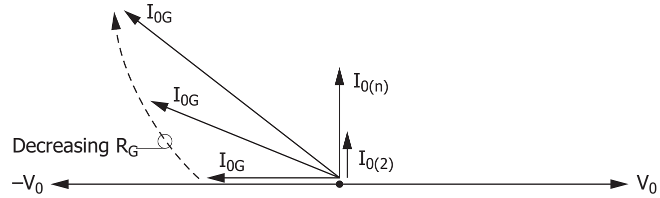


Figure 4.54 Decreasing Neutral Resistance R_G Results in Increasing Zero-Sequence Current I_{OG}

Vectorially add currents $I_{0(2)}$ and $I_{0(n)}$ to I_{0G} (per direction in *Figure 4.53*):

$$I_{0(1)} = I_{0G} - I_{0(2)} - I_{0(n)}$$

Figure 4.55 plots the increase in zero-sequence current $I_{0(1)}$ (seen by Relay 1) resulting from decreasing neutral resistance R_G.

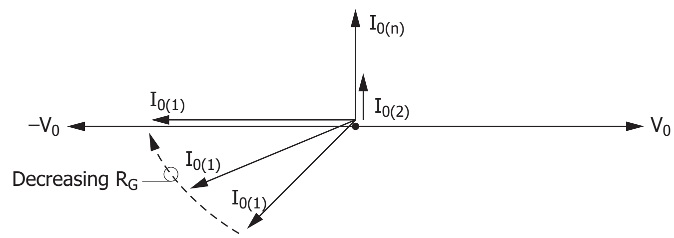


Figure 4.55 Decreasing Neutral Resistance R_G Results in Increasing Zero-Sequence Current $I_{O(1)}$ (Seen by Relay 1)

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 4.30 and Figure 4.33) 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.

In *Figure 4.55*, 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 4.55*. 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 4.55* are converted (using polarity and impedances in *Figure 4.53*) to the apparent zero-sequence impedances that the respective relays see, as plotted in *Figure 4.56*:

- ➤ 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

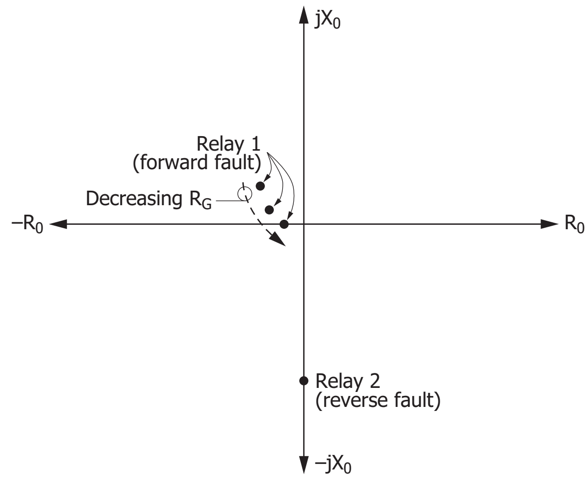


Figure 4.56 Zero-Sequence Impedance Plots for Ground Fault on Low-Impedance Grounded Distribution System

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 4.56* 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 4.56* 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 4.56* appear asymmetric, especially when compared to *Figure 4.51*(a) for a solidly grounded system with sources at each end. The Z0MTA setting in *Figure 4.51*(a) would (by inspection) be approximately 75 degrees.

Contrastingly, the Z0MTA setting for *Figure 4.56* 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 4.57* 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 4.30* and *Figure 4.33*).

All these settings, zero-sequence voltage, and zero-sequence current converge on the zero-sequence voltage-polarized directional element in *Figure 4.33* (and its preceding enable logic in *Figure 4.30*) to produce the directional characteristic in *Figure 4.57*.

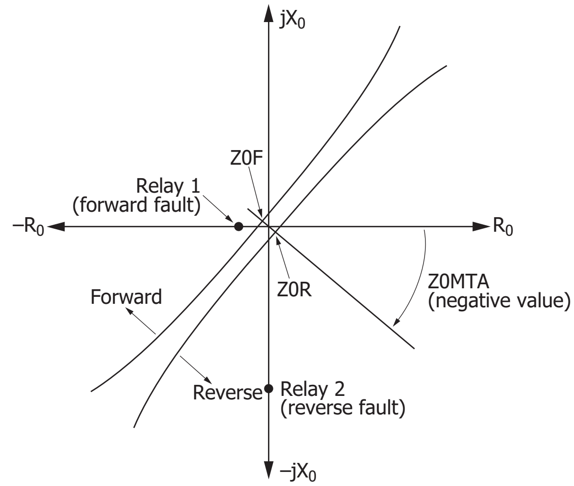


Figure 4.57 Z0MTA Setting Provides Forward/Reverse Ground Fault Discrimination in a Low-Impedance Grounded Distribution System

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 4.40, settings 50NFP and 50NRP are applied to Figure 4.31, Figure 4.35, and Figure 4.37, 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 4.31*). 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 4.31*). 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 4.31*. The following comparison is made as part of internal enable DIRNE (for low-impedance grounded and ungrounded/high-impedance grounded systems):

$|I_N| > a0N \cdot |I_1|$

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 2.36*, *Figure 2.38*, and *Figure 2.39*).

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:

$a0N = (3I_0 \text{ pri.}/I_1 \text{ pri.}) \cdot (CTR/CTRN)$

$3I_0$ 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 4.36*).

The $3V_0$ input to *Figure 4.36* may come either from a calculation or from a direct measurement, as described in *Zero-Sequence Voltage Sources on page 4.42*. 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 4.84* 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 4.36* may come either from a calculation or from a direct measurement, as described in *Zero-Sequence Voltage Sources on page 4.42*. 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 4.84* 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 2.37*). With such a connection:

$$I_N = 3I_0$$

In *Figure 2.37*, 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 2.37* (refer to the relay and feeder shown in *Figure 2.37* as Relay 1 and Feeder 1, respectively; other feeders on the same bus, though not shown in *Figure 2.37*, are then Relay 2/Feeder 2, etc.). In the zero-sequence network view in *Figure 4.58*, 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 4.58* 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.

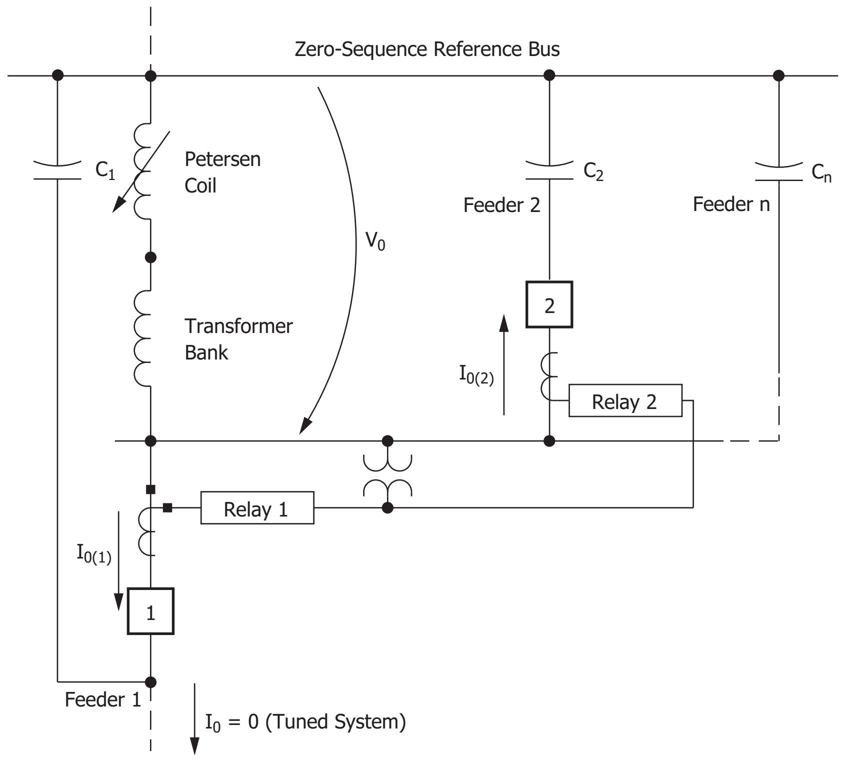


Figure 4.58 Zero-Sequence Impedance Network for Ground Fault on Feeder 1

Figure 4.59 shows the zero-sequence vector relationships described above for *Figure 4.58* (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 2.37*). The vectors shown in *Figure 4.59* 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 4.59*. This system resistance provides the "real power component" with which the wattmetric directional element (*Figure 4.36*) 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.

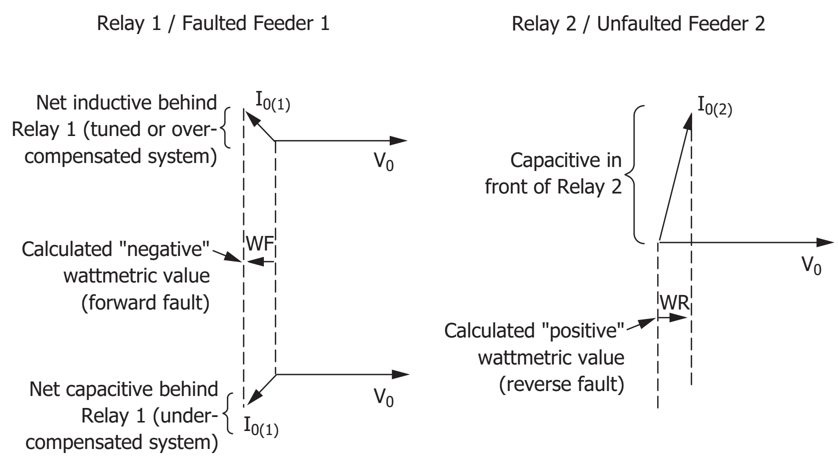


Figure 4.59 Wattmetric Element Operation for Ground Fault on Feeder 1

The sum of settings DIRWFP and DIRWRP must be 0.1 watts secondary or greater:

DIRWFP + DIRWRP ≥ 0.1 watts secondary

In *Figure 4.59*, 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 4.36*).

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 2.37*, 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 2.35*, 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 4.32*. 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:

$$\begin{aligned} DIRWFP &= \text{W secondary (VS and IN base)} \bullet \frac{PTRS}{PTR} \\ &= \text{25 W} \bullet \frac{96}{60} = \text{40.000 W secondary (VA, VB, VC, and IN base)} \end{aligned}$$

$$\begin{aligned} DIRWRP &= \text{W secondary (VS and IN base)} \bullet \frac{PTRS}{PTR} \\ &= \text{10.417 W} \bullet \frac{96}{60} \\ &= \text{16.667 W secondary (VA, VB, VC, and IN base)} \end{aligned}$$

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 4.32 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 4.30* and *Figure 4.31*.

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. 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.

EDIRIV := **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 4.31* shows the overcurrent elements that are controlled by each level direction setting. Note in *Table 4.31* that all the time-overcurrent elements (51_T elements) are controlled by the DIR1 level direction setting. See *Figure 4.40*, *Figure 4.41*, *Figure 4.46*, and *Figure 4.47*.

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 4.40*, *Figure 4.41*, *Figure 4.46*, and *Figure 4.47*)

50P1TC = **DIRPF** (direction forward; see *Figure 4.2*)

50G1TC = **DIRGF** (direction forward; see *Figure 4.2*)

51P1TC = **DIRPF** (direction forward; see *Figure 4.9*)

51N1TC = **1** (nondirectional; see *Figure 4.11*)

51G1TC = **DIRGF** (direction forward; see *Figure 4.12*)

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 4.60*) and settings are enabled/disabled with setting ELOAD. If the Group setting VNOM := OFF, then ELOAD is not available. See *Table 4.4* 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 4.33 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.

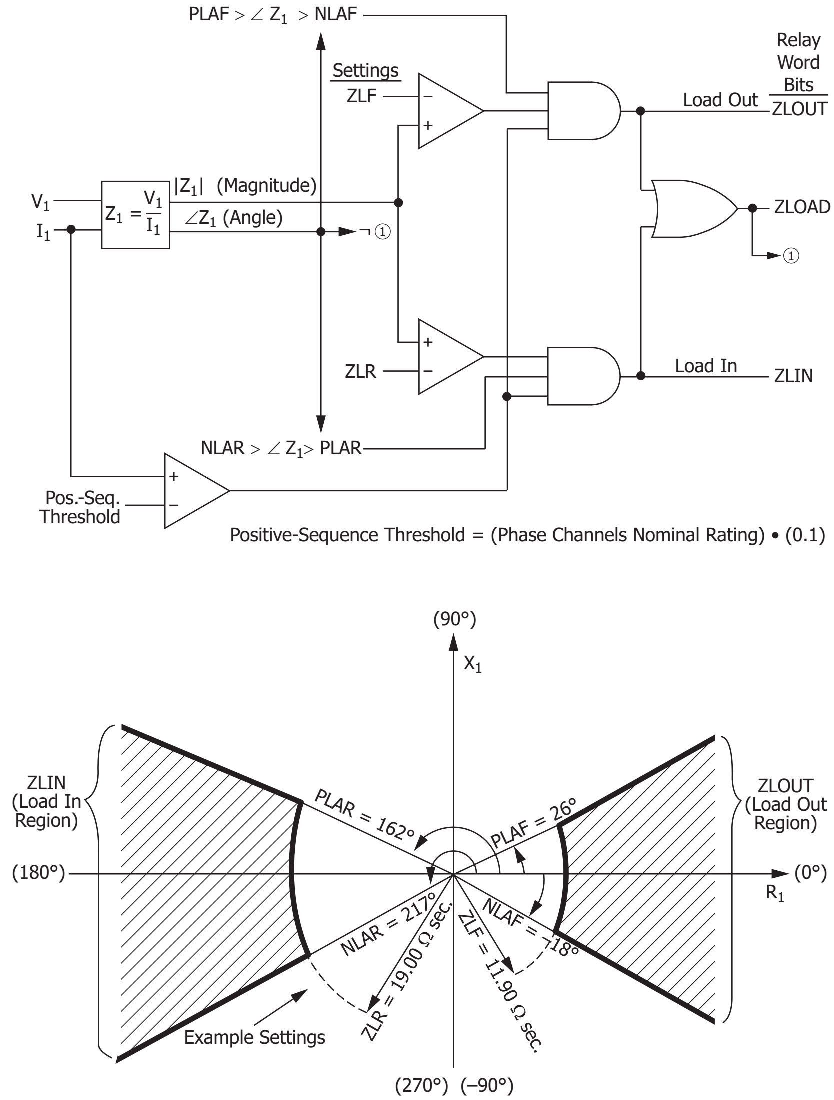
Note that a positive-sequence impedance calculation (Z_1) is made in the load-encroachment logic in *Figure 4.60*. Load is largely a balanced condition, so apparent positive-sequence impedance is a good load measure. The load-encroachment logic operates only if the positive-sequence current (I_1) is greater than the positive-sequence threshold defined in *Figure 4.60*. 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 4.44

Figure 4.60 Load-Encroachment Logic

Load-Encroachment Examples

EXAMPLE 4.11 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 4.12 Convert Maximum Loads to Equivalent Secondary Impedances

Start with maximum forward load:

800 MVA • (1/3) = 267 MVA per phase

230 kV • (1/√ 3) = 132.8 kV line-to-neutral

267 MVA • (1/132.8 kV) • (1000kV/MV) = 2010 A primary

2010 A primary • (1/CT ratio) = 2010 A primary • (1/400) = 5.03 A secondary

132.8 kV • (1000 V/kV) = 132800 V primary

132800 V primary • (1/PT ratio) = 132800 V primary • (1/2000) = 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 4.13 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 flashovers 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 fault currents that are quite small. The HIF current of multigrounded 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 4.61*. 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.

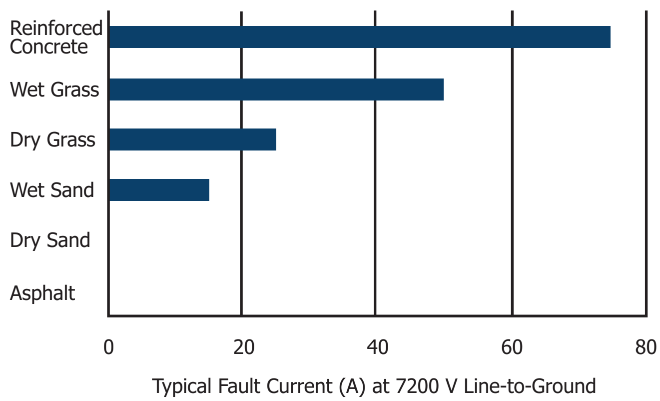


Figure 4.61 HIF Current Levels Depend on Ground Surface Type

HIF detection with Arc Sense technology (AST) is available in select SEL-751 models. The part number indicates whether or not the relay supports HIF detection.

The AST is an HIF detection function mainly for four-wire multi-grounded distribution systems, where the system dynamic single-phase loads make the system standing residual current large and unpredictable, meaning that the traditional residual overcurrent elements are not effective for HIF detections.

The AST can be applied to three-wire distribution systems with different grounding schemes, including solidly grounded or low-impedance grounded systems. However, because all loads on three-wire systems are connected by phase-to-phase or three-phase connections, the system standing residual current only comes from the asymmetry of the power apparatus, and it is rather small but stable. A sensitively set traditional residual overcurrent element provides a good coverage for high-impedance faults on these three-wire systems. You can use a time delay for the security under inrush, switching, system paralleling conditions, or time coordination with downstream protective devices.

NOTE: HIF detection 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.

HIF detection is based on the odd-harmonics and interharmonic components present in the current signal. HIF detection requires the current to be at least two percent of the nominal load current.

The HIF detection method shown in *Figure 4.62* 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 0.02 • I_{NOM} load current is needed for successful tuning.)
- ➤ Decision logic to differentiate an HIF condition from other system conditions, such as switching operations and noisy loads.

NOTE: Power lines that employ certain communication or metering technologies, which affect the line currents by inducing interharmonic components of the line frequencies, may interfere with AST and may lead to false assertions. Use the setting MPHDUR to secure against such interference.

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 SDI reference 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 decision logic is used 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.

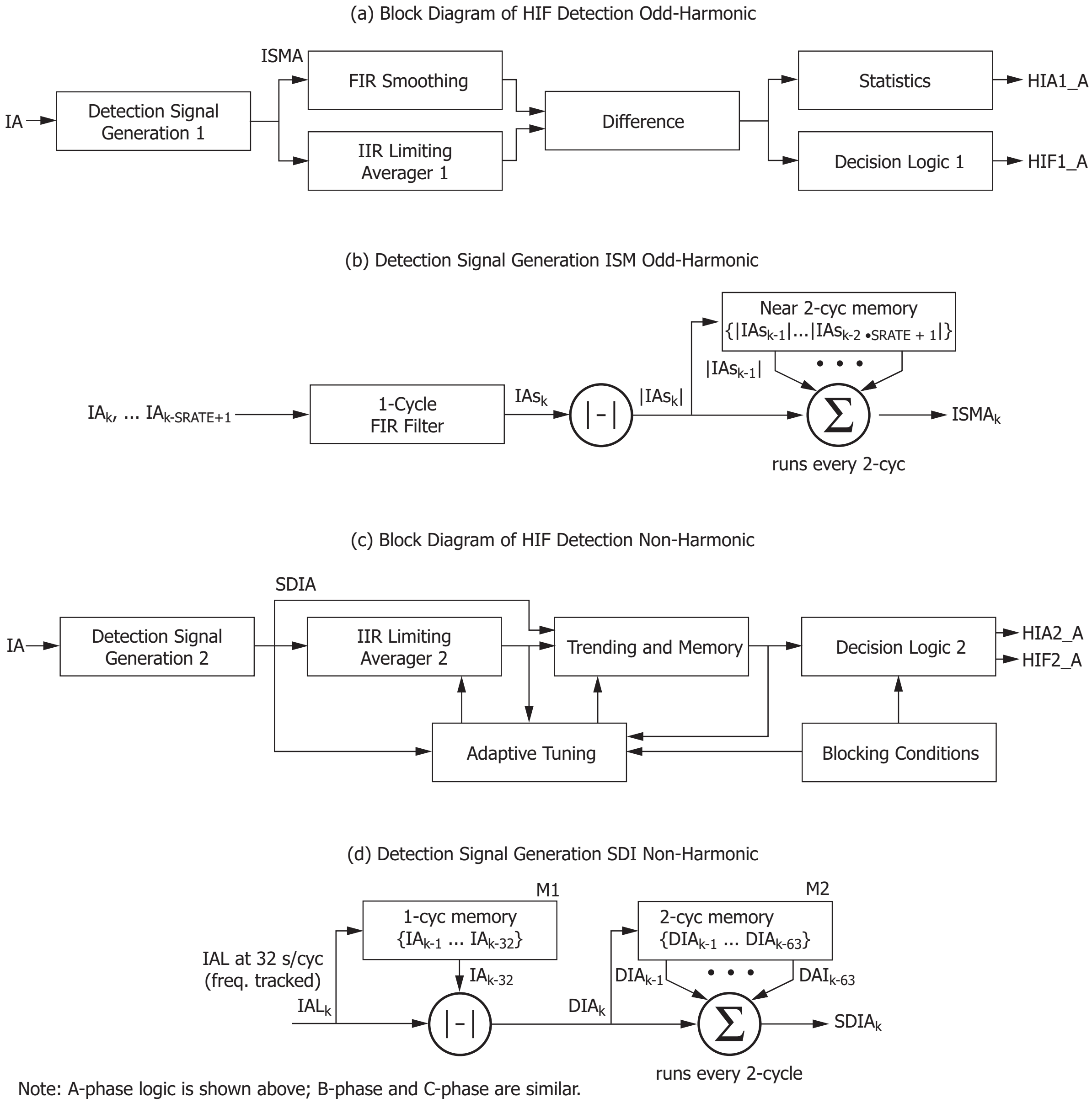


Figure 4.62 HIF Detection Block Diagram

HIF Detection Settings

NOTE: It is recommended to use EHIF := Y for field tests and follow the initial tuning process.

Table 4.34 lists the relay settings corresponding to HIF detection. HIF 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. The tuning process is interrupted by a change in the EHIF setting value, a change in the FNOM setting value, a loss of load current, the assertion of FRZCLR*x* (where *x* = A, B, C) when a large voltage or current disturbance is detected on any of the phases, or the assertion of the HIFFRZ Relay Word bit.

Once interrupted, the initial tuning restarts the next time the relay detects load current greater than the LOWITHR setting. 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. The relay enters the normal tuning mode where it continues to tune to the present power system conditions. When the relay is in normal tuning mode, Relay Word bits NTUNE_A, NTUNE_B, and/or NTUNE_C are asserted if current greater than the LOWITHR is detected on that particular phase. If the relay does not detect load current greater than LOWITHR while in normal tuning mode, the relay stops tuning and retains the long-term reference value for four hours, which prevents the relay from re-tuning following a short system disturbance. The programmable SELOGIC control equation HIFFRZ can be used to retain the learned reference quantities indefinitely. If a line is de-energized for more than four hours and the SELOGIC control equation HIFFRZ is not asserted, 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 for the HIF 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.

Interharmonics can be introduced into line currents when certain metering technologies, such as a two-way automatic communication system (TWACS), are used on power lines. Set the HIF setting MPHDUR to the longest time observed between interharmonic activity on multiple phases (due to any such metering technology). Adjust this setting only if it is known that such metering technologies exist on an electric system.

NOTE: A minimum of 0.02 • I_{NOM} load current is expected for successful tuning of the HIF detection algorithm.

HIF 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.

Table 4.34 HIF Detection Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
HIF EN	Y, N, T	EHIF := N
HIF MULTI PH EVNT DURATION WNDW	OFF, 30–600 sec	MPHDUR := OFF
TUNING AND DETECTION CURR THRES	0.02–0.10[a] 0.1–0.5[b]	LOWITHR := 0.05 LOWITHR := 0.25
HIF DETECTION SENSITIVITY	SELOGIC	HIFMODE := 0
FREEZE HIF DETECTION ALGORITHM	SELOGIC	HIFFRZ := TRIP
HIF EVENT REPORT EXT. TRIGGER[c]	SELOGIC	HIFER := 0
BEGIN 24 HOUR INITIAL HIF TUNING	SELOGIC	HIFITUNE := 0

[a] When INOM = 1 A.
[b] When INOM = 5 A.
[c] SEL recommends that you use edge-triggered Relay Word bits in the HIFER SELOGIC control equation; otherwise, there may be issues when triggering multiple reports if the HIFER SELOGIC control 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 4.14 HIFMODE Programming and Operation

As detailed previously, assertion of the HIFMODE SELOGIC control equation controls the sensitivity of the HIF detection algorithm. Field experience suggests that downed conductor events that lead to HIFs 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 an HIF. It is during this time that it would be desirable to increase the sensitivity of the HIF 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. (Note that the factory-default setting for 79RI [reclose initiate] = TRIP.)

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 TRIP # (in reclose cycle state)

EXAMPLE 4.15 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 TRIP asserts the output for SV Timer 16. The timer stays asserted for the duration of the dropout setting, which in this example is 30 minutes. During this 30 minutes, the timer assertion maintains the assertion of HIFMODE, ensuring 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 4.35*. You can use Relay word bits in custom logic programming to indicate HIF 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 4.35 HIF Relay Word Bits

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	HIFFRZ, 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
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
Phase interharmonics incremental change is greater than the tuned detection margin	SW1A, SW1B, SW1C

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 10.31*, *High-Impedance Fault Compressed Event Report on page 10.35*, and *Figure 7.25*, *Figure 5.15: MET H (HIF) Command Response*, *Figure 7.36: LOG H (HIF) Command Response*, and *Figure 7.34: HSG Command Response* for more information.

Phase Discontinuity Detection (PDD) Element

The PDD element in the SEL-751 uses current unbalance to detect an open conductor. The PDD logic can correctly identify broken conductors only in cases that result in an open phase condition for at least eight power system cycles.

PDD Settings

Table 4.36 Phase Discontinuity Detection Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
EN PH DISC DET	Y, N	EPDDET := N
PD DET TRQ CTRL	SELOGIC	PDDTC := NOT(50P1P OR 50P2P OR 50P3P OR 50P4P OR 51AP OR 51BP OR 51CP OR 51P1P OR 51P2P OR 67P1P OR 67P2P OR 67P3P OR 67P4P)
PD UNB THR	0.01–1.00 pu	PDUBTHR := 0.15

The PDD logic (see *Figure 4.63*) and settings are enabled/disabled with the enable phase discontinuity detection setting EPDDET.

The PDD element can be torque controlled using the PDDTC SELOGIC control equation (see *Figure 4.65*). For example, when PDDTC := IN101, the PDD element outputs (PDDET*p*; *p* = A, B, C) are operational only if IN101 is asserted.

The setting PDUBTHR is the phase discontinuity unbalance threshold. The relay-calculated negative-to-positive-sequence current ratio is compared with this threshold to detect a phase discontinuity condition (see *Figure 4.64*). In most single-phase open conditions, the negative-to-positive-sequence current ratio is greater than 0.15. If the ratio is greater than 0.15 during normal operation, set PDUBTHR to a higher value with extra margin.

PDD Logic

The PDD logic consists of three sub-logics:

NOTE: The PDD logic is processed once every two power system cycles.

- ➤ Phase discontinuity enable logic (see *Figure 4.63*). This logic enables the PDD function.
- ➤ Phase discontinuity current unbalance detection logic (see *Figure 4.64*). This logic identifies current unbalance caused by phase discontinuity.
- ➤ PDD logic (see *Figure 4.65*). This logic is supervised by the PDEN, PDIUBD, and PDDTC Relay Word bits. If all the Relay Word bits are asserted, a phase discontinuity condition is declared in the phase that has the lowest current magnitude.

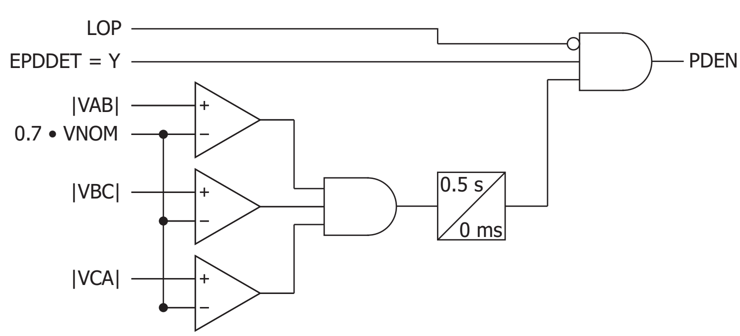


Figure 4.63 Phase Discontinuity Enable Logic

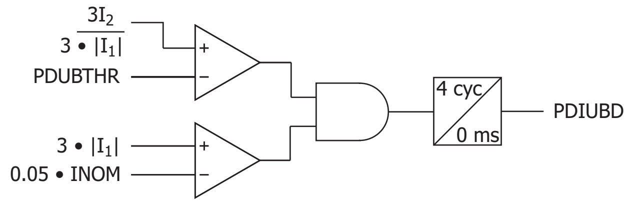


Figure 4.64 Phase Discontinuity Current Unbalance Logic

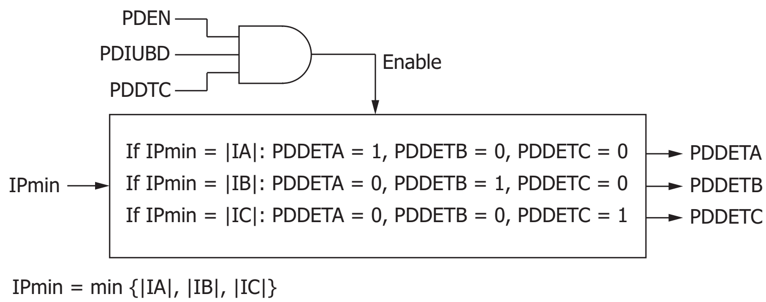


Figure 4.65 Phase Discontinuity Detection Logic

This logic primarily detects phase discontinuity based on the negative-to-positive current ratio. Typically, during a single-phase open condition, the negative-to-positive-sequence current ratio is higher than 0.15. However, the range of this ratio is not unique to phase discontinuity events. This ratio may be very sensitive under low-load conditions. In such cases, the ratio can be as low as 0.1. For double-phase open conditions, the ratio can be close to 1. Therefore, special care needs to be taken when setting PDUBTHR.

Detecting open conductors with current unbalance is not considered highly secure because the negative-to-positive-sequence current ratio can have a finite value due to unbalance faults, uneven loading, load change in one of the phases, or an open phase condition beyond the protected line. Therefore, SEL recommends using the output of PDD logic as an alarm for supervision.

For more information on phase discontinuity detection via current unbalance, refer to the technical paper, “Detecting and Locating Broken Conductor Faults on High-Voltage Lines to Prevent Autoreclosing Onto Permanent Faults,” available at selinc.com.

Broken Conductor Detection (BCD) Element

This section provides an overview of the broken conductor detection (BCD) function that uses the charging current of the line to determine a broken conductor condition in overhead lines in transmission and sub-transmission systems. The BCD element is a firmware option. The BCD element requires wye-connected VTs (see the DELTA_Y setting in *Configuration Settings on page 4.5*).

NOTE: The BCD element is a firmware option.

NOTE: The BCD element is available only with WYE-connected VTs (DELTA := WYE).

The BCD function is designed to detect a broken conductor before it converts into a shunt fault for single-conductor line configurations. The BCD element prevents a shunt fault and may block autoreclose attempts on a permanent fault. The BCD element helps to mitigate possible hazards, such as a fire. Note, however, that even if the broken conductor phase breakers are tripped before the broken conductor segment contacts the ground path, the conductor still has stored energy that can initiate a fire after it touches the ground. The BCD logic can correctly identify broken conductors only in cases where an open phase condition lasts for at least eight power system cycles. In the case of a bundled conductor line configuration, the logic cannot detect a broken conductor unless all the conductors of a single phase break.

The BCD element can only be applied to overhead lines with charging current greater than 0.3 percent of INOM. The BCD element can be applied to two-terminal overhead lines, hybrid lines, and tapped or multiterminal lines. The BCD element is not applicable to lines with shunt reactors connected to the line or its buses. Apply care when configuring the BCD element for lines with leading power factor loads. If the line is expected to carry leading power factor loads (power factor angle 90° ±20°), contact SEL for more information on how to configure the element.

Table 4.37 Broken Conductor Detection Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
EN BRK CND DET	Y, N	EBCDET := N
BCD LN LENTH	0.10–999.00	BCLL := 100.00
POS SEQ LN SUS	FM, 0.045–250.00 mS[a] FM, 0.009–50.000 mS[b]	BCB1 := FM
AVG NOM CH CR	15.0–16600.0 mA[a] 3.0–3320.0 mA[b]	BCCIM := 421.3[a] BCCIM := 84.3[b]
BC ZONE 1 REACH	OFF, 0.10–1.50 pu	BCZ1R := 0.80
BC ZONE 2 REACH	OFF, 0.10–1.50 pu	BCZ2R := 1.20
ZONE 2 PKUP DEL	OFF, 0–600 cyc	BCZ2D := OFF
BC DET TRQ CTRL	SELOGIC	BCDTC := BCZ1A OR BCZ1B OR BCZ1C
L CH CR TRQ CTRL	SELOGIC	BCLCITC := 0
BCFL TRQ CTRL	SELOGIC	BCFLTC := NOT(50P1P OR 50P2P OR 50P3P OR 50P4P OR 51AP OR 51BP OR 51CP OR 51P1P OR 51P2P OR 67P1P OR 67P2P OR 67P3P OR 67P4P)
BC UNB THR	0.01–1.00 pu	BCUBTHR := 0.15

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

The BCD logic (see *Figure 4.66–Figure 4.69*) and settings (see *Table 4.37*) are enabled/disabled with the enable broken conductor detection element setting EBCDET. If the Group setting DELTA_Y := DELTA, then EBCDET is not available.

The BCLL setting refers to the line length that is expected to be covered with the BCD function. This setting value has no defined unit. You can set the line length for BCD in miles, kilometers, ohms, etc. For single- or parallel-line configurations, BCLL equals the total length of the line. For multiterminal or tapped lines, BCLL equals the total length of the line including the length of the taps. For hybrid lines, BCLL equals the line length from the relay to the point of intersection of overhead line and underground cable.

The BCB1 setting (positive-sequence line susceptance for BCD) can be a numeric value or FM (field measurements). When BCB1 is set as FM, you must also set BCCIM, which is the average nominal phase charging current magnitude corresponding to BCLL. Set BCB1 as a numeric value equal to the positive-sequence line susceptance that corresponds to the line length for broken conductor detection (BCLL) in secondary mS (milliSiemens, S = A/V). You can obtain the required susceptance value from an EMTP (electromagnetic transient program) or other related software packages.

Typically, these software require parameters for calculating the line susceptance that are not well known to the user. This can lead to errors in the calculated line susceptance values. SEL, therefore, recommends setting BCB1 to FM. Apply care when you convert the line susceptance from primary to secondary. Note that the primary susceptance value is divided by the ratio of CTR to PTR to get equivalent secondary susceptance.

For lines that have charging current less than 0.75% of INOM, SEL highly recommends setting BCB1 to FM. Note that for such lines, the broken conductor detection can only be set when both of the following are true:

1. The relay in the field measures charging currents in a way that they can be differentiated from noise.
2. The BCCIM setting is at least 0.3% of INOM (mA).

The BCCIM setting refers to the average charging current magnitude of the three phases that correspond to the BCLL calculated at nominal voltage in secondary mA. The value of BCCIM is dependent on BCB1. If BCB1 is set to FM, the value for BCCIM can be obtained from energizing the line while keeping the remote terminals open.

From the relay measurements, calculate the average values of the secondary phase currents (I_{AVG}, mA) and secondary phase voltages (V_{AVG}, V) and use either *Equation 4.6* or *Equation 4.7* to get the value of BCCIM.

If the minimum value of the charging current magnitudes among three phases (in mA) is less than 0.95 • I_{AVG} (in mA), then use *Equation 4.6* to calculate the value of the setting BCCIM.

$$BCCIM = 0.95 \bullet \frac{I_{AVG}}{V_{AVG}} \bullet \frac{VNOM}{\sqrt{3}} \text{ [mA]}$$ **Equation 4.6**

Otherwise, use *Equation 4.7* to calculate the value of the setting BCCIM.

$$BCCIM = \frac{I_{AVG}}{V_{AVG}} \bullet \frac{VNOM}{\sqrt{3}} \text{ [mA]}$$ **Equation 4.7**

If BCB1 is not set to FM, the value of the setting BCCIM is internally calculated by the relay as follows:

$$BCCIM = BCB1 \bullet \frac{VNOM}{\sqrt{3}} \text{ [mA]}$$ **Equation 4.8**

Irrespective of whether *Equation 4.6*, *Equation 4.7*, or *Equation 4.8* is used to calculate the value of BCCIM, it should be at least 0.3 percent of INOM (mA) to configure the BCD function.

The BCZ1R setting refers to the reach of Zone 1 that covers the BCD function. Zone 1 is designed to be an instantaneous protection zone, so there is no user-defined delay setting for this zone. The setting value of Zone 1 depends on the line configuration. SEL recommends the following values for BCZ1R:

➤ For a single-line configuration, set BCZ1R to 0.8 pu.

- For a parallel-line configuration, set BCZ1R to 0.7 pu. Here, BCZ1R is slightly reduced to account for the impact of zero-sequence mutual coupling on the estimated broken conductor fault location.
- For lines with a charging current of 0.30% INOM ≤ BCCIM • 10^{-3} < 0.75% INOM, set BCZ1R to 0.5 pu. Here, BCZ1R is reduced to account for the current magnitude error at low currents.
- For multiterminal or tapped lines, set BCZ1R to the corresponding line length from the relay to the tap point, with some extra margin.
- For hybrid transmission lines, the setting value of BCZ1R can be the same as the single- or parallel-line configuration value.

For multiterminal or tapped lines, if the conductor breaks within Zone 1 but beyond the tap point, the relay may not detect a broken conductor because, in such a situation, the relay can measure both the charging current until the broken conductor location and the load currents of the tap loads. If BCZ1R is set to OFF, the Zone 1 paths in the *Main Broken Conductor Detection Logic* (see *Figure 4.67*) and *Low-Charging Current Logic* (see *Figure 4.68*) are disabled for all three phases.

The BCZ2R setting refers to the reach of Zone 2 that covers the BCD function. The intention of setting BCZ2R is to cover the remote terminal with some extra margin for a single or parallel line configuration. For multiterminal or tapped lines, BCZ2R is set to protect all of the remote terminals with some extra margin. For hybrid transmission lines, BCZ2R is set to cover the overhead section of the line with some extra margin. SEL recommends setting BCZ2R to 1.2 pu for any line configuration, where 1.2 pu corresponds to 1.2 • BCLL (1.2 times line length for BCD) and should always be greater than the setting BCZ1R. For lines having a charging current of 0.30% INOM ≤ BCCIMx10^{-3} < 0.75% INOM, set BCZ2R to 1.5 pu. If BCZ2R is set to OFF, the Zone 2 paths in the *Main Broken Conductor Detection Logic* (see *Figure 4.67*), *Low-Charging Current Logic* (see *Figure 4.68*), and *Broken Conductor Alarm Logic* (see *Figure 4.69*) for all three phases are disabled.

The BCZ2D setting is the pickup delay in power system cycles for asserting the internal broken conductor detected bit (BCIDET*p*) for broken conductors beyond Zone 1 but within Zone 2. An appropriate pickup delay should be able to distinguish between a remote broken conductor event and an event in which a remote pole opens spuriously due to a breaker failure. SEL recommends setting BCZ2D to 0 when all the remote terminals have three-pole tripping breakers. If you set BCZ2D to OFF, its timer output deasserts, which means the internal broken conductor detection beyond Zone 1 is blocked.

The BCDTC setting is a user-defined SELOGIC equation that can be used to control the final broken conductor detection bit (BCDET*p*) in the *Main Broken Conductor Detection Logic* (see *Figure 4.67*). For example, when BCDTC := BCZ1A OR BCZ1B OR BCZ1C, the BCDET*p* element is only operational if at least one of the BCZ1*p* bits is asserted.

The BCLCITC setting is a user-defined SELOGIC control equation that you can use to control the detection of a broken conductor that has low charging currents (less than 0.75 percent of INOM) as a broken conductor event or an alarm. You can set BCLCITC to either 1 (true) or 0 (false). If it is set to 1 (true), broken conductors that have a charging current magnitude less than 0.75 percent of INOM are asserted as broken conductor events, which can be used to initiate tripping of the line. In contrast, if BCLCITC is set to 0 (false), broken conductors that have a charging current magnitude less than 0.75

percent of INOM are asserted as alarms that can be used for supervision. If the line is not expected to carry low-inductive loading (less than 1.5 percent of INOM), SEL recommends setting BCLCITC to 1. Otherwise, it should be set to 0.

The BCFLTC setting (broken conductor fault location torque control) can be used to torque-control the broken conductor fault location calculation BCFL. If BCFLTC := 0 during an event, then BCFL is not calculated.

The BCUBTHR setting is the broken conductor unbalance threshold. Relay-calculated negative-to-positive-sequence current ratio is compared with this threshold to detect a broken conductor for some of the low-loading cases when there is no significant angle change in the current of the broken conductor phase (see *Figure 4.69*).

The BCD logic is designed to be executed on a per-phase basis. It can be viewed as a combination of the following logics:

- Enable logic (see *Figure 4.66*)
- Main broken conductor detection logic (see *Figure 4.67*)
- Low-charging current logic (see *Figure 4.68*)
- Broken conductor alarm logic (see *Figure 4.69*)

Enable Logic

This logic enables the BCD function.

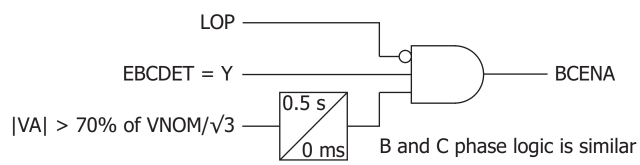


Figure 4.66 Broken Conductor Detection Enable Logic

Main Broken Conductor Detection Logic

This logic is defined as the *main logic* because it is intended to detect broken conductors. The main logic asserts broken conductor detection when all the following conditions are satisfied.

- The relay measures average magnitude of the Phase *p* current to be greater than 0.75% of INOM.
- The relay measures average magnitude of the Phase *p* current to be less than 1.5 times the BCCIM setting. This is indicated by the BCI*p*MS Relay Word bits.
- The steady-state current leads the corresponding Phase *p* voltage by 90° with a 20° allowable tolerance. Analog quantity BCIV*p*A, which gives the averaged angle difference between Phase *p* current and its respective phase voltage, is used for this purpose. BCI*p*AS asserts when BCIV*p*A falls between 70° and 110°.
- The Phase *p* current angle undergoes significant incremental change (greater than 15°) over a period of 300 ms while BCI*p*AS is asserted. This condition is indicated by BCI*p*IAS, which is determined by using the analog quantities BCIV*p*AP and BCIV*p*A. Here, BCIV*p*AP gives the averaged angle difference between Phase *p* current and its respective phase voltage 300 ms before the present processing interval. The supervision of incremental angle change helps secure the

broken conductor algorithm during low-loading and low-load pickup conditions where the phase currents may lead the corresponding phase voltages by approximately 90°.

- ➤ The relay measures significant loading current ($3 \bullet |I_1|_{AVG} >$ 5% of INOM). This check helps in distinguishing between close-in broken conductor events and cases where the lines are energized from the remote end, have their poles closed, and carry zero current because of no load.
- ➤ Broken conductor location is estimated within user-defined Zone 1 (BCZ1R) or Zone 2 (BCZ2R) reaches.
- ➤ One of the phases has its internal broken conductor detection bit (either of BCIDET*p*) asserted for more than four power system cycles, while the internal broken conductor detection bits of the other two phases remain deasserted. The four power system cycles pickup delay to assert the final broken conductor detected bit (BCDET*p*) and the two power system cycles dropout delay to block BCDET*p*. The delays are set up this way to account for security and (remote) breaker pole scatter time.
- ➤ Broken conductor detected torque control SELOGIC (BCDTC) is TRUE.

The average magnitudes and angle differences used in the logics are the 2-cycle (8-sample) averages of instantaneous magnitudes.

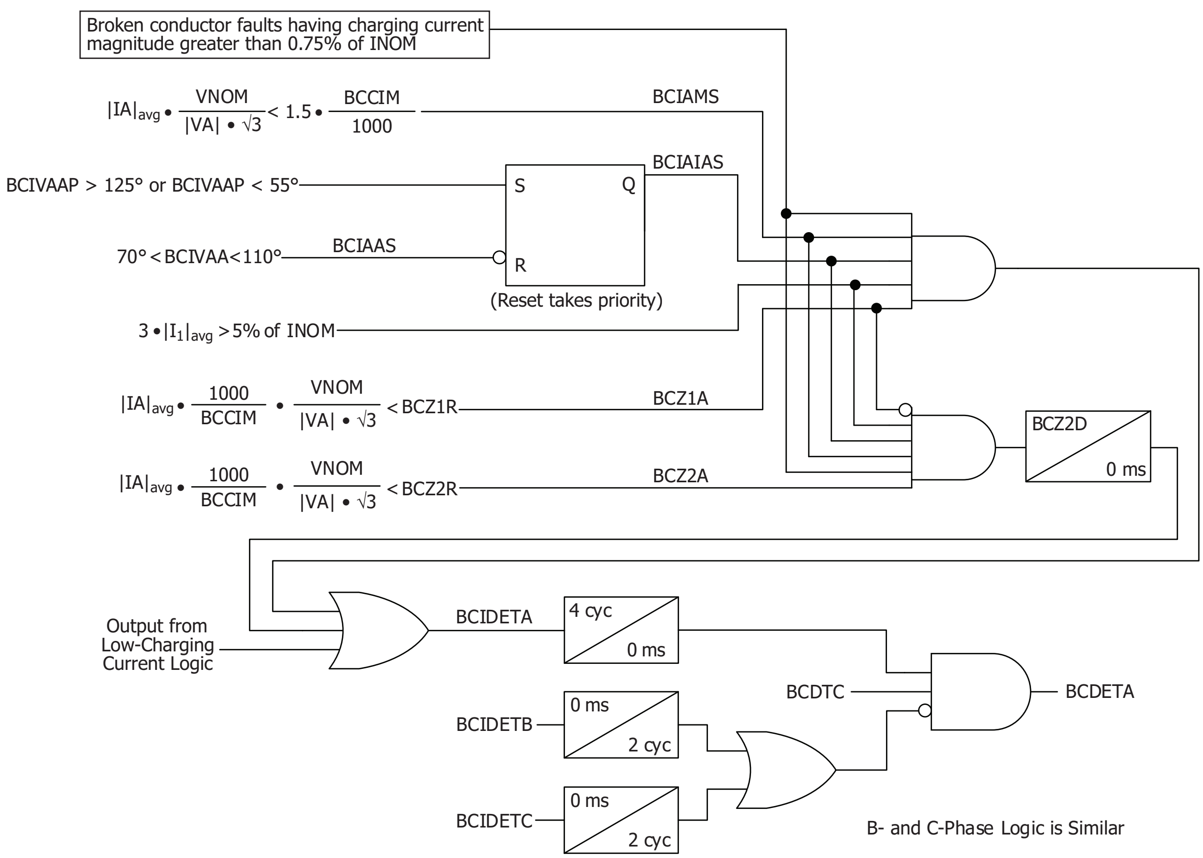


Figure 4.67 Main Broken Conductor Detection Logic

Low-Charging Current Logic

This logic detects broken conductors that have low-charging current magnitudes (less than 0.75% of INOM). For close-in broken conductors or broken conductors in lines that have low-charging currents corresponding to its entire length, you expect the relay to measure low-charging current magnitudes. The *Main Broken Conductor Detection Logic* disables in low-charging current conditions because of the unreliable current angle measurements. The low-charging current logic bypasses the angle checks and instead requires the following conditions to be satisfied:

- ➤ The circuit breaker poles are closed to distinguish between pole-open conditions and close-in broken conductors using the 52A settings.
- ➤ The relay measures significant loading current ($3 \cdot |I_1|_{AVG} >$ 5% of INOM).
- ➤ The relay measures the magnitude of the phase current to be less than 0.75% of INOM and the relay setting BCCIM.

Detecting broken conductors with charging current magnitudes of less than 0.75 percent of INOM is not considered highly secure because the angle checks are bypassed. This introduces a possible security risk and a chance of misoperation when using the output of low-charging current logic for tripping. This is especially true when the line is carrying low-reactive load current resulting in a current magnitude less than 0.75 percent of INOM. To improve the security of the low charging current logic when BCLCITC is set to 1 (True) and subjected to unbalance faults, consider including 'NOT FAULT' in the broken conductor detected torque control (BCDTC) setting.

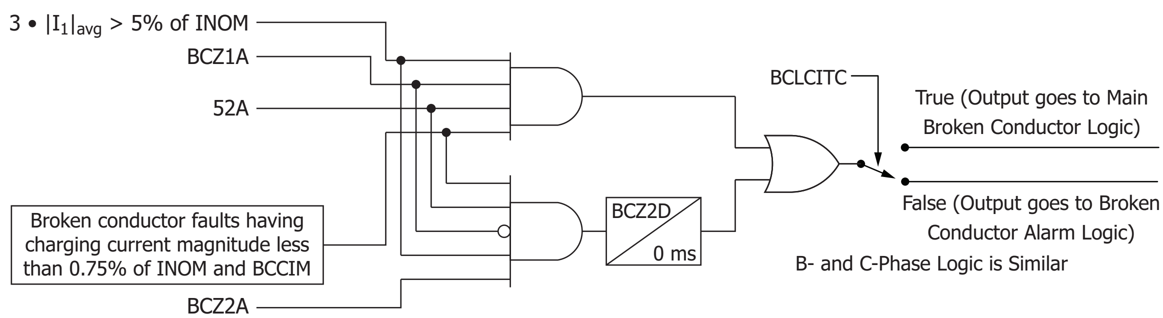


Figure 4.68 Low-Charging Current Logic

The broken conductor detection function may overreach in either of the following conditions:

- ➤ When there is only one line connected behind the local bus and broken conductor occurs on that line.
- ➤ When there is only one line connected beyond the remote bus and broken conductor occurs on that line.

Broken Conductor Alarm Logic

For some low-loading cases, if the conductor breaks, there might not be a significant angle change in the current of the broken conductor phase. Moreover, it is possible for the broken conductor current magnitude to be greater than 0.75 percent of INOM. For such scenarios, the *Main Broken Conductor Detection Logic* and the *Low-Charging Current Logic* cannot detect a broken conductor. Therefore, another approach monitors either the ratio of the magnitudes of the negative-sequence currents to the positive-sequence currents or the assertion of broken conductor Zone 1 before it asserts a broken conductor alarm.

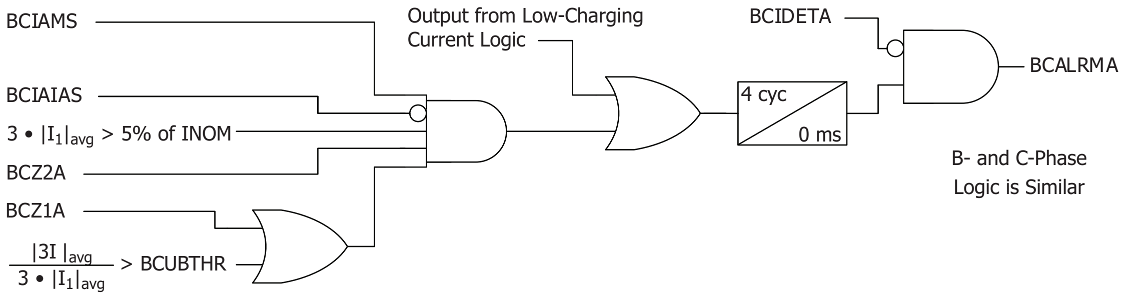


Figure 4.69 Broken Conductor Alarm Logic

Note that the output of the Broken Conductor Alarm Logic does not declare a broken conductor event, but rather only asserts as a broken conductor alarm. This is because the output of the Broken Conductor Alarm Logic may assert without an actual broken conductor during low-loading conditions with a small load change in one of the phases. The broken conductor detection and alarm bits are complementary to each other. Therefore, if a broken conductor is reliably detected in Phase A, BCIDETA blocks the output of the corresponding phase alarm logic (BCALRMA).

Broken Conductor Fault Locating

This section explains the broken conductor fault locating method using the line charging current. In general, the broken conductor fault locating expression (BCFL) is given by *Equation 4.9*:

$$BCFL = \frac{I_{Ph}}{BCCIM} \bullet 1000 \bullet \frac{VNOM \bullet \mathrm{BCLL}/V_{Ph}}{\sqrt{3}}$$ **Equation 4.9**

where:

I_{Ph} = charging current of the broken conductor phase in A secondary
V_{Ph} = voltage of the broken conductor phase in V secondary

The broken conductor fault locating expression is directly proportional to the charging current of the broken conductor phase, which is the ratio of the measured charging current of the broken conductor phase to the total charging current of the line, times the line length. For the broken conductor fault locating method, the relay uses data stored in the event report to compute distance to the broken conductor. The relay calculates distance to the broken conductor upon satisfaction of all five of the following conditions:

- The fault locator is enabled (setting EFLOC := Y).
- The broken conductor detection element is enabled (EBCDET = Y).
- Charging current of the broken conductor phase is greater than 0.3% of INOM.
- The event data contain a rising edge of any broken conductor detection bits (BCDETA, BCDETB, or BCDETC).
- BCFLTC is true during the whole event.

Typical error in the BCFL is 10 percent of reported BCFL or 2 miles, whichever is greater. This error is defined for broken conductor events that have a broken conductor current magnitude (in secondary) greater than 25 mA (for both 1 A and 5 A INOM relays) and a line length for broken conductor detection less than 200 miles.

Single-Line Configuration BCD Application Example

The settings configuration of a BCD element depends on the line configuration. An example of a single-line configuration for an INOM = 5 A relay follows. This example assumes the line has three-pole tripping breakers and that the application is intended to protect Zone 1. All currents and voltages in this example are in secondary values.

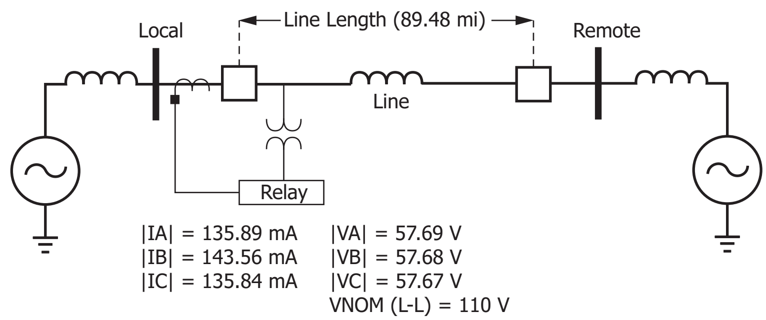


Figure 4.70 Single-Line Configuration Example

Step 1. Enable the broken conductor detection element by setting EBCDET = Y.

Step 2. Set BCLL = 89.48.

Step 3. Set BCB1 = FM to use field measurements for BCCIM.

Step 4. Calculate BCCIM from the relay measurements. In this example I_{AVG} = 138.43 mA and V_{AVG} = 57.68 V (phase voltage). Therefore,

$$BCCIM = \frac{I_{AVG}}{V_{AVG}} \bullet \frac{VNOM}{\sqrt{3}} = 152.42 \text{ mA}$$

Since the calculated BCCIM is greater than 0.3 percent of INOM in mA, the BCD feature can be applied.

Step 5. Set BCZ1R = 0.8 pu and BCZ2R = 1.2 pu for the single-line configuration.

Step 6. Set BCZ2D = 0. SEL recommends setting BCZ2D to 0 when all the remote terminals have three-pole tripping breakers.

Step 7. Set BCDTC = BCZ1A OR BCZ1B OR BCZ1C for Zone 1 protection.

If you wish to protect both Zone 1 and 2, then set BCDTC to 1 (true) if all the remote terminals of the line have three-pole tripping breakers.

Step 8. Set BCLCITC to 1 if the line is not expected to carry low inductive loading (less than 1% of INOM). Otherwise, it should be set to 0.

Step 9. Set BCFLTC to NOT(50P1P OR 50P2P OR 50P3P OR 50P4P OR 51AP OR 51BP OR 51CP OR 51P1P OR 51P2P OR 67P1P OR 67P2P OR 67P3P OR 67P4P) to block the BCFL calculation if any overcurrent element picks up.

BCFLTC can be set per your preference to enable/disable the fault location calculation via broken conductor detection. If a broken conductor fault converts into a shunt fault, more reliable fault locating could be obtained by FLOC (see *Fault Location* and *Section 10: Analyzing Events*).

Step 10. Set BCUBTHR to 0.15.

Step 11. Set EFLOC = Y to allow the relay to report the estimated broken conductor location (see *Fault Location*).

The BCD element has the capability to detect a broken conductor before it touches the ground and creates a shunt fault. The broken conductor detected bits (BCDET*p*) may, therefore, be used to trip the breakers before possible occurrence of a shunt fault. Further, any attempt to reclose the breakers on a permanent fault may also be blocked.

If the reclosing control is enabled in the relay, consider having the following in the recloser drive to lockout (79DTL) SELOGIC.

➤ Broken conductor detected Relay Word bits (BCDETA OR BCDETB OR BCDETC)

➤ Direct trip signal received from one of the remote terminals that is based on BCD protection

Refer to SEL application guide “Application Considerations for the Broken Conductor Detection Element” (AG2021-03) for more information on the broken conductor application examples and testing considerations.

Cold-Load Pickup (CLPU) Element

CLPU is the phenomenon of drawing excessive amounts of current by the loads in a distribution network when it is re-energized after an outage. This cold load starting current could be greater than the normal load currents and could be falsely identified as an overcurrent fault by the relay. The CLPU element identifies possible cold loading events in a distribution line after an outage by providing two Relay Word bits (CLPU1 and CLPU2, see *Figure 4.71*) that can be used to torque-control overcurrent elements to prevent unwanted tripping.

CLPU Settings

Table 4.38 CLPU Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
EN CLPU	Y, N	ECLPU := N
CL START	SELOGIC	CLSTRT := NOT 52A OR 27PP1T
MIN CLO TIME	0–500 min	CLOTM := 10
EXT CLO TIME	OFF, 0–500 min	CLOTE := OFF
CL REC DEL	0–500 min	CLRTD := 10
CL REC IMAG	OFF, 0.25–100.00 A[a], 0.05–20.00 A[b]	CLRIM := 10.00[a] CLRIM := 2.00[b]

Table 4.38 CLPU Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
CL REC CRNT DEL	1–500 min	CLRCTD := 1
CL RESET	SELOGIC	CLRST := 0

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

Table 4.38 presents the settings associated with the CLPU element. The ECLPU setting enables the CLPU settings and the logic (see *Figure 4.71*).

The CLSTRT SELOGIC control equation can be configured to identify an outage before a cold loading takes place. By default, the logic identifies a possible outage by asserting Relay Word bit CLSTRT if the local breaker is open or if the line-to-line voltage drops below a certain value (see *Example 4.16*). If CLSTRT is deasserted, then the logic assumes the outage has been cleared and feeder is re-energized.

If the outage identified by CLSTRT lasts for longer than the user-defined CLOTM time, the logic declares it as a cold load outage by asserting the CLPU1 Relay Word bit.

You can enable the second CLPU Relay Word bit by setting CLOTE to a value higher than CLOTM. When the outage lasts for longer than the CLOTE time, the logic declares a long-term cold load outage by asserting the CLPU2 Relay Word bit.

You can define a fixed operating time for the CLPU bits by using the setting CLRTD. Once configured, the CLPU bits are disabled CLRTD time after the feeder is energized. This setting allows you to disable the CLPU bits if the cold loading current does not return to the normal load current (or a safe operating current) within an acceptable time.

The setting CLRIM defines the safe operating current magnitude to disable the CLPU bits. When the maximum phase current magnitude drops below this threshold and remains below the threshold for longer than CLRCTD time, the logic deasserts CLPU1 and CLPU2. The CLRCTD setting delays the CLPU reset for a set number of minutes after the maximum phase current magnitude drops below the CLRIM threshold.

User can also reset the CLPU bits using the CLRST SELOGIC control equation.

CLPU Logic

Figure 4.71 shows the CLPU logic. Relay Word bit CLSTRT indicates a possible outage when asserted and a healthy feeder when deasserted. The logic provides two Relay Word bits, CLPU1 and CLPU2, that can be used in the instantaneous/time overcurrent element torque control equations to enable new trip level settings for the cold loading period. These Relay Word bits can also be used to disable any element in the SEL-751 during the cold loading period through the corresponding torque control settings. Cold load recovery time, which is the time taken by the distribution system to return to normal operating currents, depends on the outage time. The longer the outage, the longer the cold load recovery time. Therefore, the two CLPU bits allow you to enable two different levels of overcurrent elements based on the expected or predicted outage time. CLPU1 shall be used for short-term outages when the outage duration is greater than the user defined CLOTM time setting. CLPU2 shall be used for long-term outages when the outage time is over the user defined CLOTE time setting (CLOTE > CLOTM). Once asserted, CLPU1 and CLPU2 bits are latched until the reset command received either after CLRTD timer expires or current drops below CLRIM and CLRCTD timer expires or manual reset through CLRST SELOGIC control equation. The reset path through the CLRTD timer and the CLRCTD timer are supervised by the CLSTRT and CLPU1 Relay Word bits.

The CLPU logic is processed once every 2 power system cycles. A momentary assertion must be conditioned to be at least 2 cycles in duration. A rising-edge operator (R_TRIG) should not be used in the SELOGIC settings.

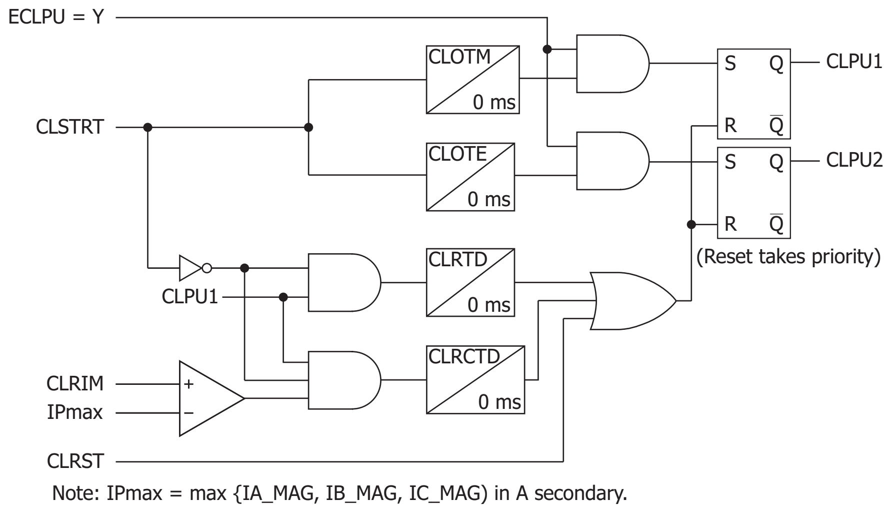


Figure 4.71 CLPU Logic

EXAMPLE 4.16 Cold-Load Pickup Setting

In this example we are going to identify a possible outage using breaker status and an undervoltage element. Both CLPU1 and CLPU2 will be configured to enable two levels of instantaneous overcurrent elements for the CLPU period (50P2P and 50P3P). The example settings for INOM = 5 A are as follows:

ECLPU := Y
CLOTM := 10
CLOTE := 60
CLRTD := 180
CLRIM := 15
CLRCTD := 2
CLRST := RB01

First enable the CLPU element by setting ECLPU := Y.

Suppose we want to identify an outage either if the breaker poles get open or when the secondary line voltages drop below 2 V for 0.5 s. Configure an undervoltage element and CLSTRT as follows:

27PP1P := 2
27PP1D := 0.5
CLSTRT := NOT 52A OR 27PP1T

CLSTRT will deassert and indicates the feeder is healthy when both 52A asserted and 27PP1T are deasserted.

CLOTM is selected to enable the CLPU1 and consequently 50P2P if the outage time is greater than 10 min. If the outage lasts for more than an hour, then 50P2P should be disabled and 50P3P should be enabled via CLPU2. Hence, CLOTE is set to 60.

The maximum operating time of the CLPU overcurrent levels are chosen to be 3 hours and hence CLRTD is set to 180. After CLSTRT deasserts and if the current does not return to the safe value within 3 hours, then CLPU will be disabled.

CLRIM is selected as 15, which is the safe operating current to disable the CLPU overcurrent levels. CLRCTD is set to 2 so that currents must be below 15 A secondary for more than 2 minutes to disable CLPU overcurrent levels.

Manual reset of the CLPU bits is enabled through Remote Bit RB01.

Configure the instantaneous overcurrent elements for the CLPU as follows. 50P2P and 50P3P are set to 3 times and 6 times of the normal pickup value respectively.

50P2P := 45
50P2TC := CLPU1 AND NOT CLPU2
50P3P := 90
50P3TC := CLPU2

Use NOT CLPU1 in all the other instantaneous/time overcurrent element torque-control SELogic control equations to disable those during the cold loading; e.g., 50P1TC := NOT CLPU1, 50G1TC := NOT CLPU1, and 51P1TC := NOT CLPU1.

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 4.72* and *Figure 4.73*, 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 can be used to detect and prevent an over-excitation condition. 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 4.72*) 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.

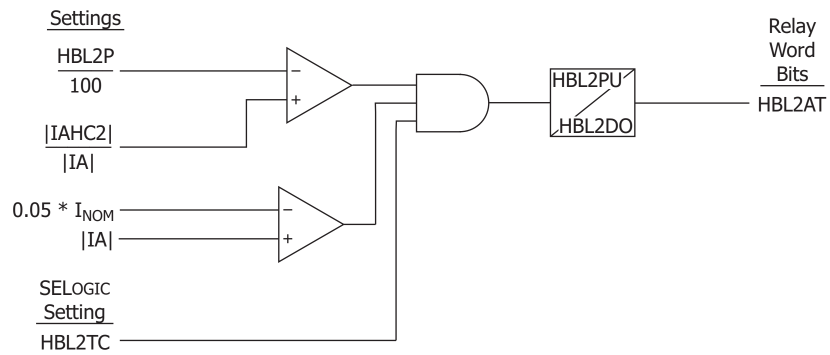


Figure 4.72 A-Phase Second-Harmonic Blocking

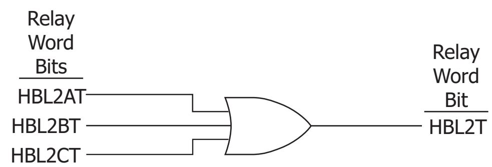


Figure 4.73 Three-Phase Second- and Fifth-Harmonic Blocking Logic

Table 4.39 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 4.17 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 := **NOT HBL2T**

50P2TC := **1**

TR := **...OR 67P1T OR 67P2T OR...**

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 4.18 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 := **...OR 51P1T * NOT HBL2T OR 51AT OR 51BT OR 51CT OR...**

ER := **...OR R_TRIG 51P1P OR R_TRIG 51P1T OR...**

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 4.19 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 := **NOT HBL2T OR 50P3**

51ATC := **1**

51BTC := **1**

51CTC := **1**

TR := **...OR 51PT OR 51AT OR 51BT OR 51CT OR...**

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 4.9, 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 detectors (RTD) card option (select E49RTD := INT), the SEL-751 offers several protection and monitoring functions, settings for which are described in *Table 4.40*. See *Figure 2.22* 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 4.40 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 4.40 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

NOTE: An open condition for an RTD is detected if the temperature is greater than 250°C and a short condition is detected if the temperature is less then –50°C.

NOTE: To improve security, RTD FAULT, ALARM, and TRIP indicators are delayed by approximately 12 seconds.

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 4.20*.

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. Refer to *Application Guide AG2016-10: How to Identify a Faulty RTD Connected to an SEL-700 Series Relay* to determine if an RTD connected to an SEL-751 is faulty. *Table 4.41* lists the RTD resistance versus temperature for the four supported RTD types.

Table 4.41 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

Table 4.41 RTD Resistance Versus Temperature (Sheet 2 of 2)

Temp (°F)	Temp (°C)	100 Platinum	120 Nickel	100 Nickel	10 Copper
176	80.00	130.89	182.84	148.30	12.12
194	90.00	134.70	191.64	154.90	12.51
212	100.00	138.50	200.64	161.80	12.90
230	110.00	142.29	209.85	168.80	13.28
248	120.00	146.06	219.29	176.00	13.67
266	130.00	149.83	228.96	183.30	14.06
284	140.00	153.58	238.85	190.90	14.44
302	150.00	157.32	248.95	198.70	14.83
320	160.00	161.05	259.30	206.60	15.22
338	170.00	164.77	269.91	214.80	15.61
356	180.00	168.47	280.77	223.20	16.00
374	190.00	172.17	291.96	231.80	16.39
392	200.00	175.85	303.46	240.70	16.78
410	210.00	179.53	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 4.42*.

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:

$$\text{If } THIEQ \geq IEQPU$$

$$THRL_t = (THRL_{t-1}) \bullet \left(\frac{TCONH[x]}{TCONH[x] + \Delta t}\right) + \left(\frac{THIEQ_t}{IMC}\right)^2 \bullet \left(\frac{\Delta t}{TCONH[x] + \Delta t}\right) \bullet FAMB$$

Equation 4.10

If $THIEQ < IEQPU$

$$THRL_t = (THRL_{t-1}) \bullet \left(\frac{TCONC[x]}{TCONC[x] + \Delta t}\right)$$

Equation 4.11

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 4.10* and *Equation 4.11*.

$THIEQ$ = 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 4.10*, *Equation 4.11*, and *Equation 4.16*.

$TCONC[x]$ = 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 4.10*, *Equation 4.11*, and *Equation 4.17*

$FAMB$ = 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 4.12*.

$$THIEQ = \frac{THRO}{I_{NOM}}$$

Equation 4.12

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 4.13*:

$$IMC = KCONS \bullet IBAS$$

Equation 4.13

where:

$KCONS$ = User-selectable current correction constant

$IBAS$ = Basic current value in per unit

Lastly, the relay computes the ambient temperature factor, FAMB, according to *Equation 4.14*:

$$FAMB = \frac{TMAX - 40°C}{TMAX - TAMB}$$ **Equation 4.14**

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 4.15*.

$$THTCU_t = \frac{THRL_t}{(THLT/100)} \bullet 100$$ **Equation 4.15**

If $FAMB \bullet [THIEQ_t/IMC]^2 > THLT/100$, the relay calculates the time before trip using *Equation 4.16*. 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 4.16**

If $FAMB \bullet [THIEQ_t/IMC]^2 \le THLT/100$, the relay reports 9999 seconds.

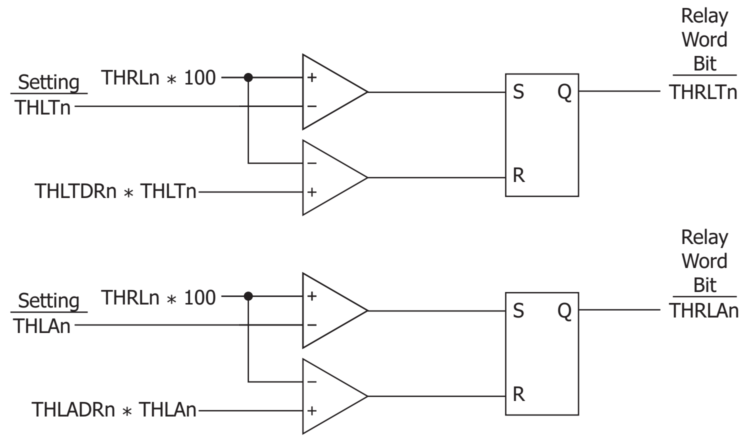
If the thermal lockout Relay Word bit THRLT is asserted and THIEQ < IEQPU, the relay calculates the time to release the thermal element using *Equation 4.17*.

$$THRLS_t = TCONC[x] \bullet \ln\left(\frac{THRL_t}{THLTDR \bullet THLT/100}\right)$$ **Equation 4.17**

Otherwise, the relay does not calculate the time to lockout release.

Thermal Element Logic

Figure 4.74 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 4.74 Thermal Alarm and Trip Logic

When considering settings levels for the thermal elements alarming and tripping functions, note from *Equation 4.10* that the relay calculates the steady state thermal level as shown in *Equation 4.18*:

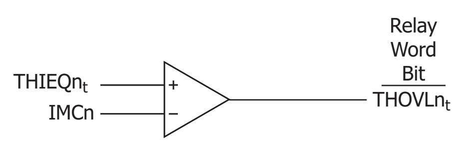
$$THRL_{SS} = \left(\frac{THIEQ}{IMC}\right)^2 \bullet FAMB$$

Equation 4.18

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 4.75 shows the logic for thermal element current overload.



n = 1, 2, or 3.

Figure 4.75 Thermal Element Current Overload Logic

Thermal Element Settings

See *Table 4.42* 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 4.14*. 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 4.14*. 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 4.14*). 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 4.42 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 4.42 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 2.27* or *Figure 2.28*, 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 2.27* or *Figure 2.28*, 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 2.28*. 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 2.28*. When a synchronism voltage input is present (e.g., **VS** input shown in *Figure 2.28*) the SEL-751 provides two levels of VS under- and overvoltage elements. You can use these elements to control the reclosing logic described later. When a VBAT input is present and the Global setting EDCMON is set to N, the SEL-751 provides two levels of VBAT channel under- and overvoltage elements (27N and 59N). The Global setting EDCMON := N disables the dc under- and overvoltage elements.

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 4.76* and *Figure 4.77* 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 4.43 Undervoltage Function (Sheet 1 of 2)

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 := 5.00
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 := 5.00

Table 4.43 Undervoltage Function (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
UVBAT LEVEL 1	OFF, 2.00–300.00 V	27N1P := OFF
UVBAT DELAY 1	0.00–120.00 sec	27N1D := 0.50
UVBAT LEVEL 2	OFF, 2.00–300.00 V	27N2P := OFF
UVBAT DELAY 2	0.00–120.00 sec	27N2D := 5.00

[a] Setting range shown is for DELTA_Y := DELTA.
[b] Setting range shown is for DELTA_Y := WYE.

Table 4.44 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
OVS LEVEL 1	Off, 2.00–300.00 V	59S1P := OFF
OVS DELAY 1	0.00–120.00 sec	59S1D := 0.50
OVS LEVEL 2	Off, 2.00–300.00 V	59S2P := OFF
OVS DELAY 2	0.00–120.00 sec	59S2D := 0.50
OVBAT LEVEL 1	OFF, 2.00–300.00 V	59N1P := OFF
OVBAT DELAY 1	0.00–120.00 sec	59N1D := 0.50
OVBAT LEVEL 2	OFF, 2.00–300.00 V	59N2P := OFF
OVBAT DELAY 2	0.00–120.00 sec	59N2D :=5.00

[a] Setting range shown is for DELTA_Y := DELTA.
[b] Setting range shown is for DELTA_Y := WYE.

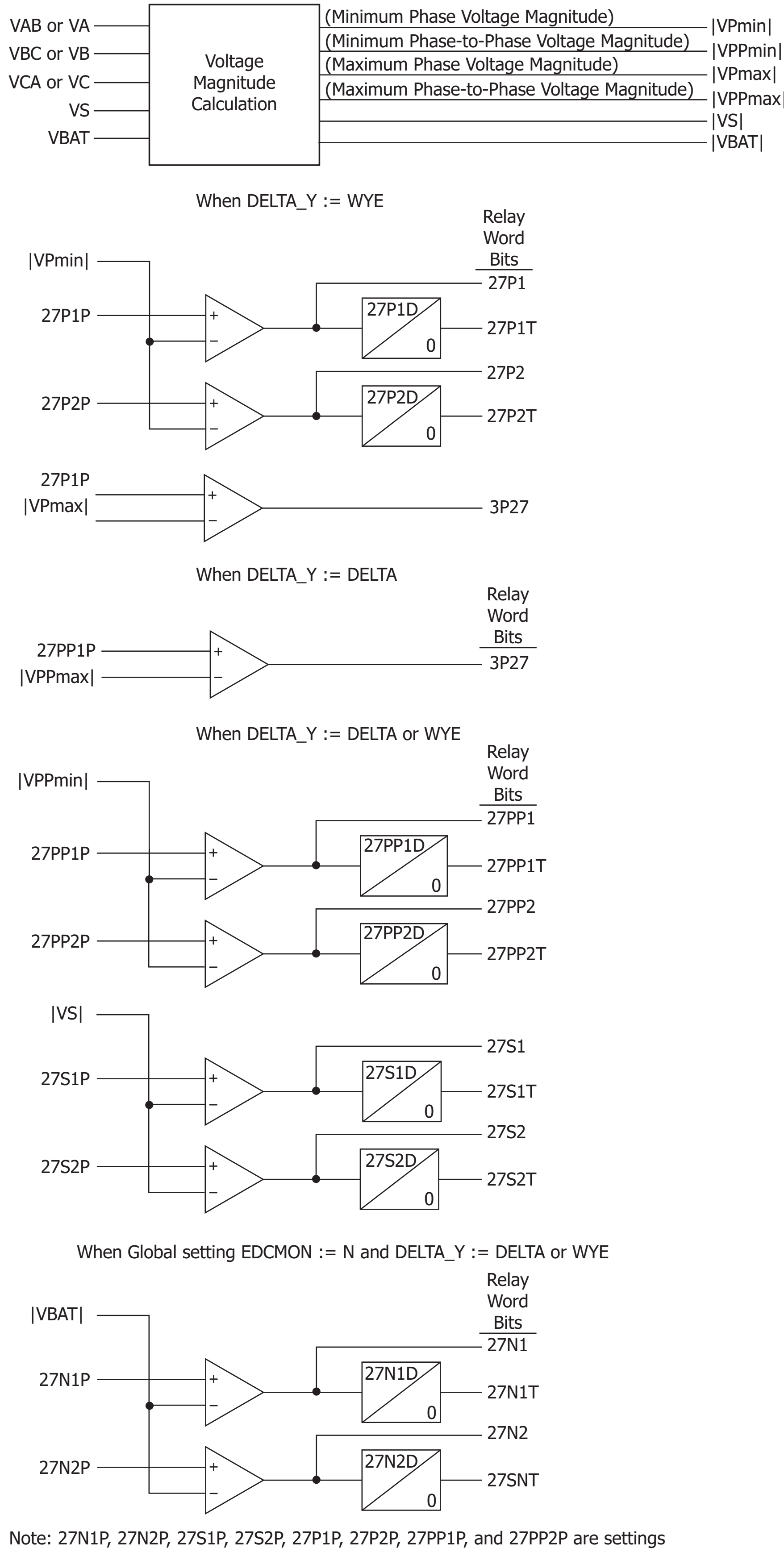


Figure 4.76 Undervoltage Element Logic

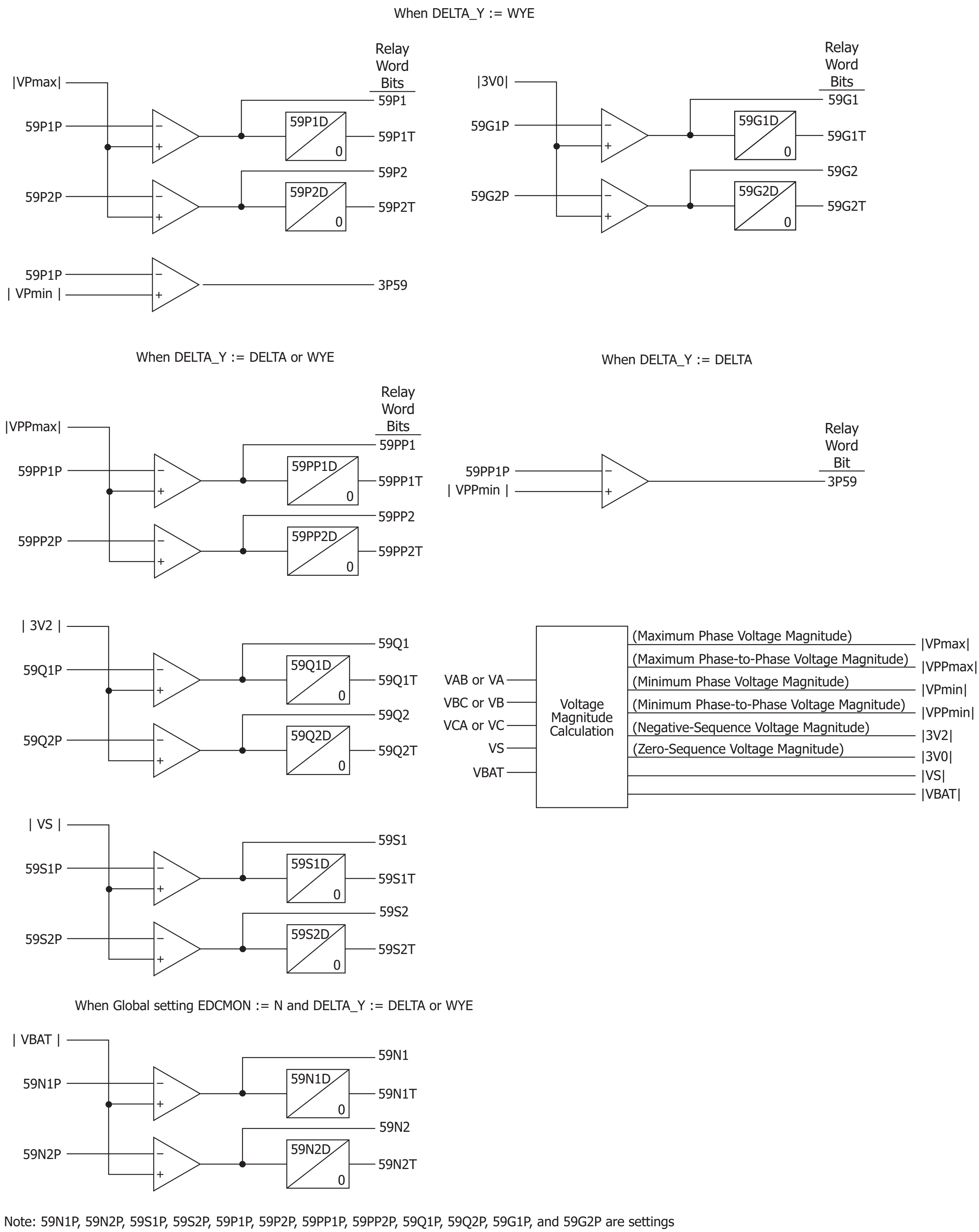


Figure 4.77 Overvoltage Element Logic

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 4.45*.

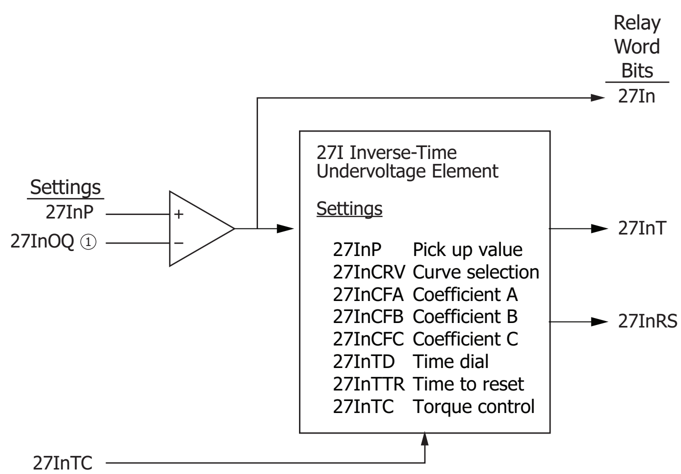
Table 4.45 Operating Quantities for the 27I Element

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
If SINGLEV = Y, VA = VB = VC and VAB = VBC = VCA
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 4.78 shows the inputs, settings and outputs of the inverse-time undervoltage element.



n = 1 or 2. ① Refer to Table 4.45.

Figure 4.78 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 4.19*.

$$TTT_n = 27InTD \bullet \left(27InCFB + \frac{27InCFA}{\left(1 - \frac{27InOQ}{27InP}\right)^{27InCFC}} \right)$$

Equation 4.19

The settings used are listed in *Table 4.46*.

Table 4.46 Inverse-Time Undervoltage Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
27I ENABLE	Y, N	E27I*n* := N
OPERATING QTY	Refer to *Table 4.45*	27I*n*OQ := VAB
PICKUP LVL	Refer to *Table 4.45*	27I*n*P := 120.00
CURVE	CURVEA, CURVEB, COEF	27I*n*CRV := CURVEA
COEFF A	0.00–3.00	27I*n*CFA := 1
COEFF B	0.00–3.00	27I*n*CFB := 0
COEFF C	0.01–3.00	27I*n*CFC := 1
TIME DIAL	0.00–16.00	27I*n*TD := 1.00
RESET TIME	0.00–1.00 sec	27I*n*TTR := 0.01
TRQ CONTROL	SELOGIC	27I*n*TC := 1

The SEL-751 provides three curve options for each of the 27I elements, settable via the 27I*n*CRV setting—CURVEA, CURVEB, and COEF (user programmable curve). CURVEA is compliant with IEC 60255-127 and is the IEC standard curve as shown in *Figure 4.79*. CURVEB is a non-standard curve as shown in *Figure 4.79*. The curve option COEF is the user programmable curve. Set the coefficient related settings 27I*n*CFA, 27I*n*CFB and 27I*n*CFC to realize the curve that meets your application needs. *Table 4.47* shows the parameters of the three curves. Note that when 27I*n*CRV is set to CURVEA or CURVEB the coefficient related settings 27I*n*CFA, 27I*n*CFB and 27I*n*CFC are forced to the values shown in *Table 4.47* and hidden.

Table 4.47 Specification Of Inverse-Time Undervoltage Protection Element

Curve Description	Curve Defining Constants		
	27InCFA	27InCFB	27InCFC
Curve A	1	0	1
Curve B	0.98	1.28	2.171
Programmable Curve	0.00–3.00	0.00–3.00	0.01–3.00
n = 1 or 2.			

When the operating quantity exceeds the pickup level, 27I*n*P, then the output remains deasserted. If the operating quantity exceeds the pickup level for the reset time setting, 27I*n*TTR, then the time integrator resets to 0.

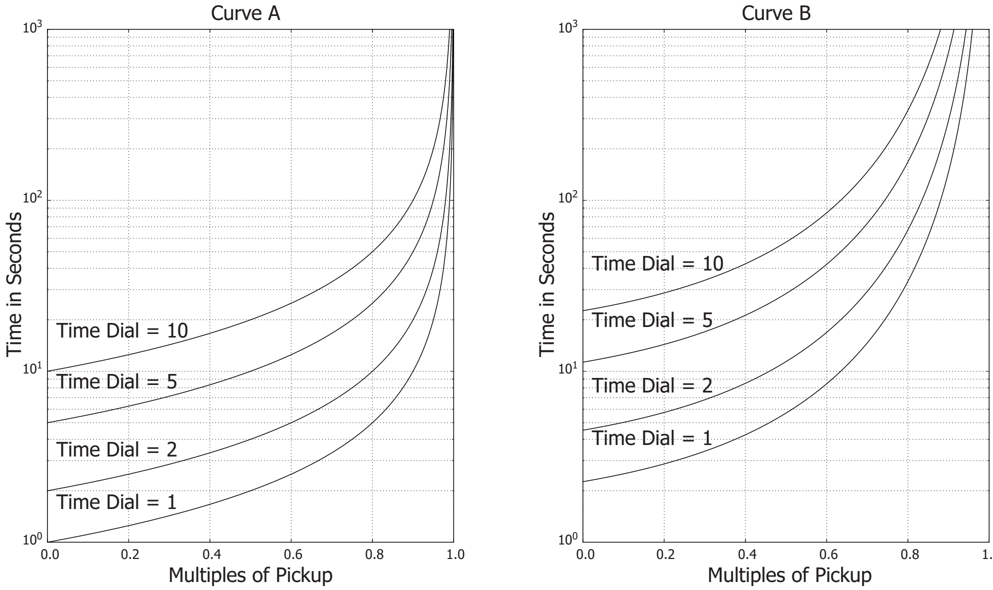


Figure 4.79 Inverse Time-Undervoltage Element Curves

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 4.48*.

Table 4.48 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	—	—	—	#	—	—	—	—	—	#	—	—	—

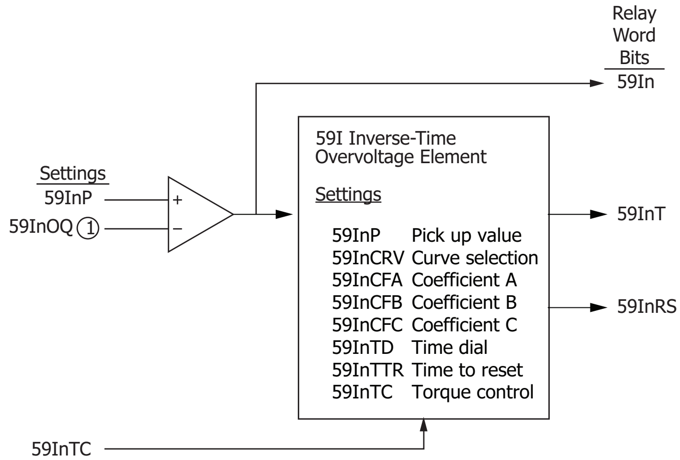
= 2.00–300.00 V $ = 2.00–520.00 V — Operating quantity is not available

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
If SINGLEV = Y, VA = VB = VC and VAB = VBC = VCA
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 4.80 shows the inputs, settings and outputs of the inverse-time overvoltage element.



n = 1, 2, 3, or 4. ① Refer to *Table 4.48*.

Figure 4.80 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 4.20*.

$$TTT_n = 59InTD \bullet \left(59InCFB + \frac{59InCFA}{\left(\frac{59InOQ}{59InP}\right)^{59InCFC} - 1} \right)$$

Equation 4.20

The settings used are listed in *Table 4.49*.

Table 4.49 Inverse-Time Overvoltage Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
59I ENABLE	Y, N	E59I*n* := N
OPERATING QTY	Refer to *Table 4.48*	59I*n*OQ := VAB
PICKUP LVL	Refer to *Table 4.48*	59I*n*P := 120.00
CURVE	CURVEA, CURVEB, CURVEC, COEF	59I*n*CRV := CURVEA
COEFF A	0.00–6.00	59I*n*CFA := 3.88
COEFF B	0.00–3.00	59I*n*CFB := 0.96
COEFF C	0.01–3.00	59I*n*CFC := 2.00
TIME DIAL	0.00–16.00	59I*n*TD := 1.00
RESET TIME	0.00–1.00 sec	59I*n*TTR := 0.01
TRQ CONTROL	SELOGIC	59I*n*TC := 1

The SEL-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 4.81*.

The curve option COEF is the user-programmable curve. Set the coefficient related settings 59I*n*CFA, 59I*n*CFB, and 59I*n*CFC to realize the curve that meets your application needs. *Table 4.50* shows the parameters of the three curves. Note that when 59I*n*CRV is set to CURVEA, CURVEB, or CURVEC the coefficient related settings 59I*n*CFA, 59I*n*CFB, and 59I*n*CFC are forced to the values shown in *Table 4.50* and hidden.

Table 4.50 Specification of Inverse-Time Overvoltage Protection Element

Curve Description	Curve Defining Constants		
	59InCFA	59InCFB	59InCFC
Curve A	3.88	0.96	2
Curve B	5.64	0.24	2
Curve C	0.14	0	0.02
Programmable Curve	0.00–6.00	0.00–3.00	0.01–3.00

n = 1, 2, 3, or 4.

When the operating quantity remains lower than the pickup level, 59I*n*P, then the output remains deasserted. If the operating quantity gets lower than the pickup level for the reset time setting, 59I*n*TTR, then the time integrator resets to 0.

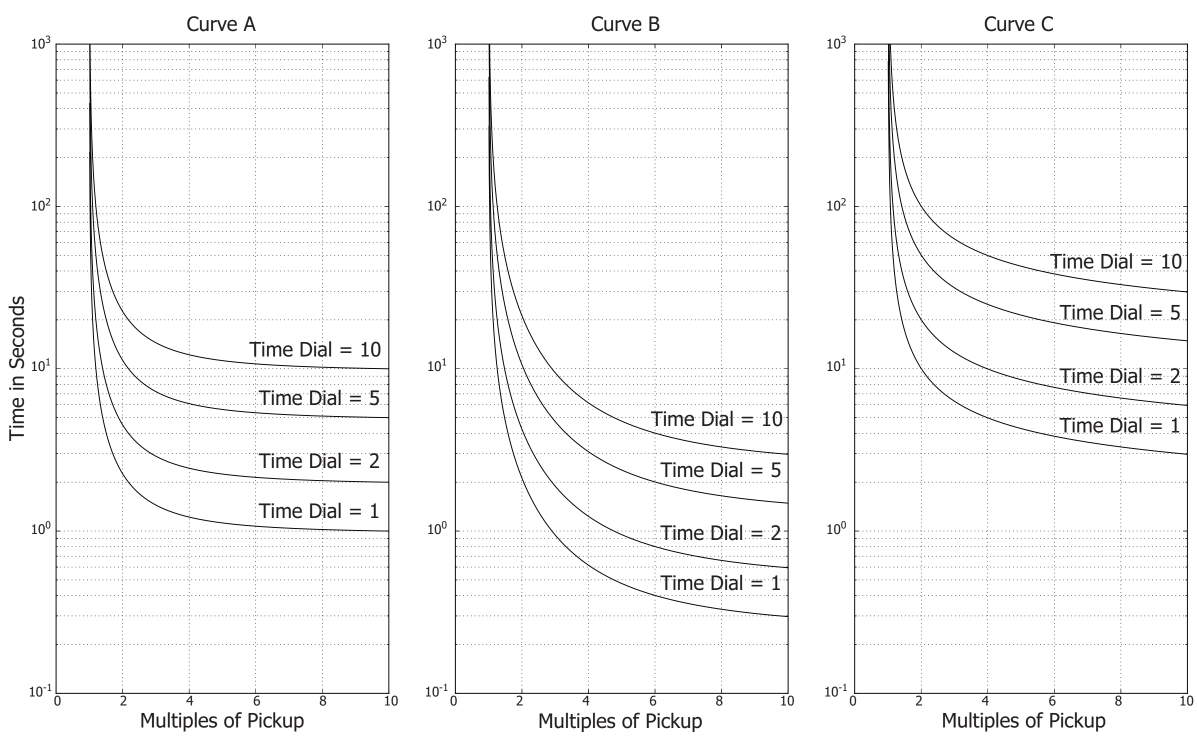


Figure 4.81 Inverse Time-Overvoltage Element Curves

Synchronism-Check Elements

NOTE: The synchronism-check element is only available when VSCONN := VS.

Figure 2.30, and *Figure 2.31* 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**, **VC**, **VAB**, **VBC**, or **VCA** 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 4.82* and *Figure 4.83*). 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 4.83*. 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 4.83*. 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.

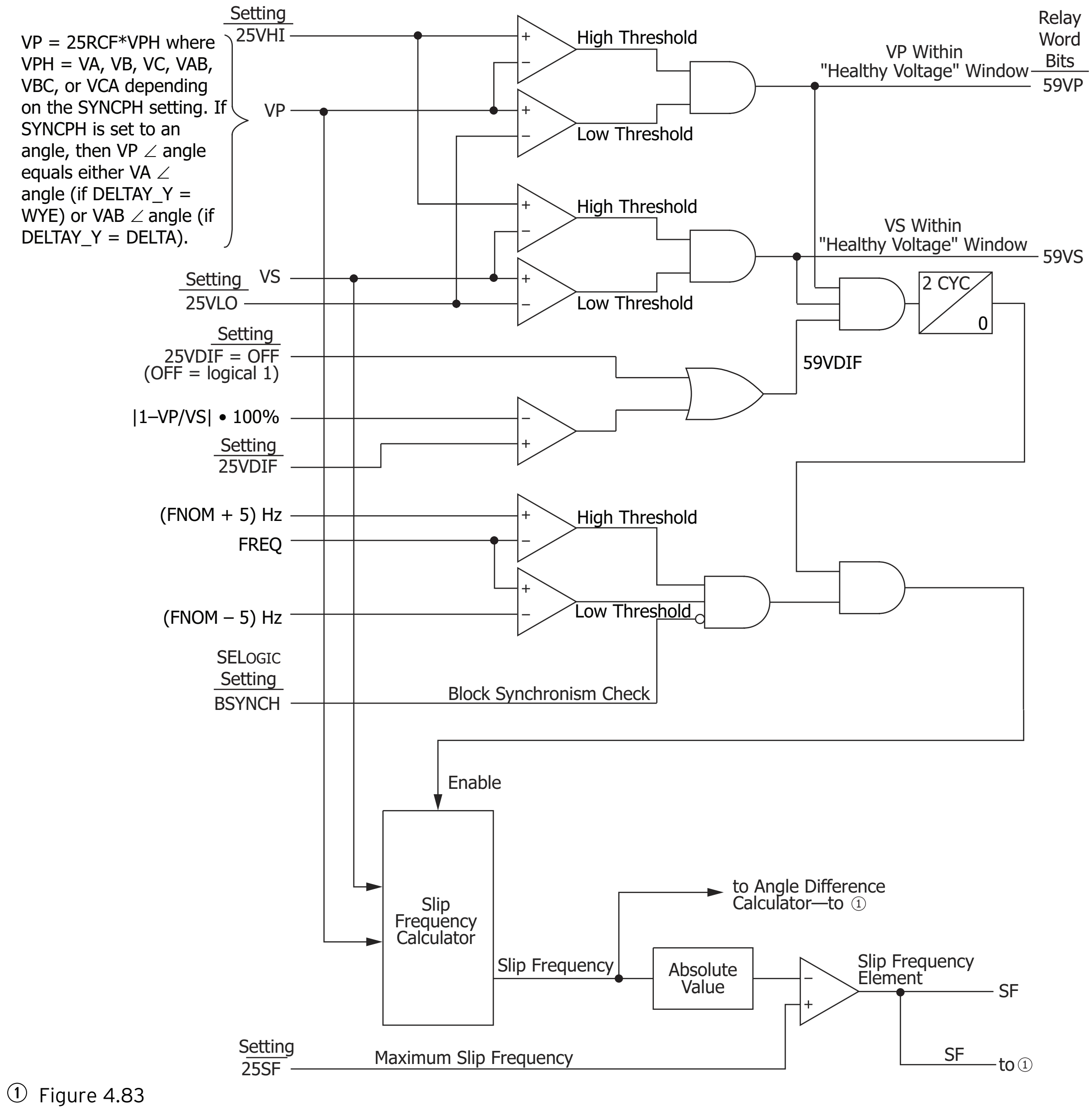
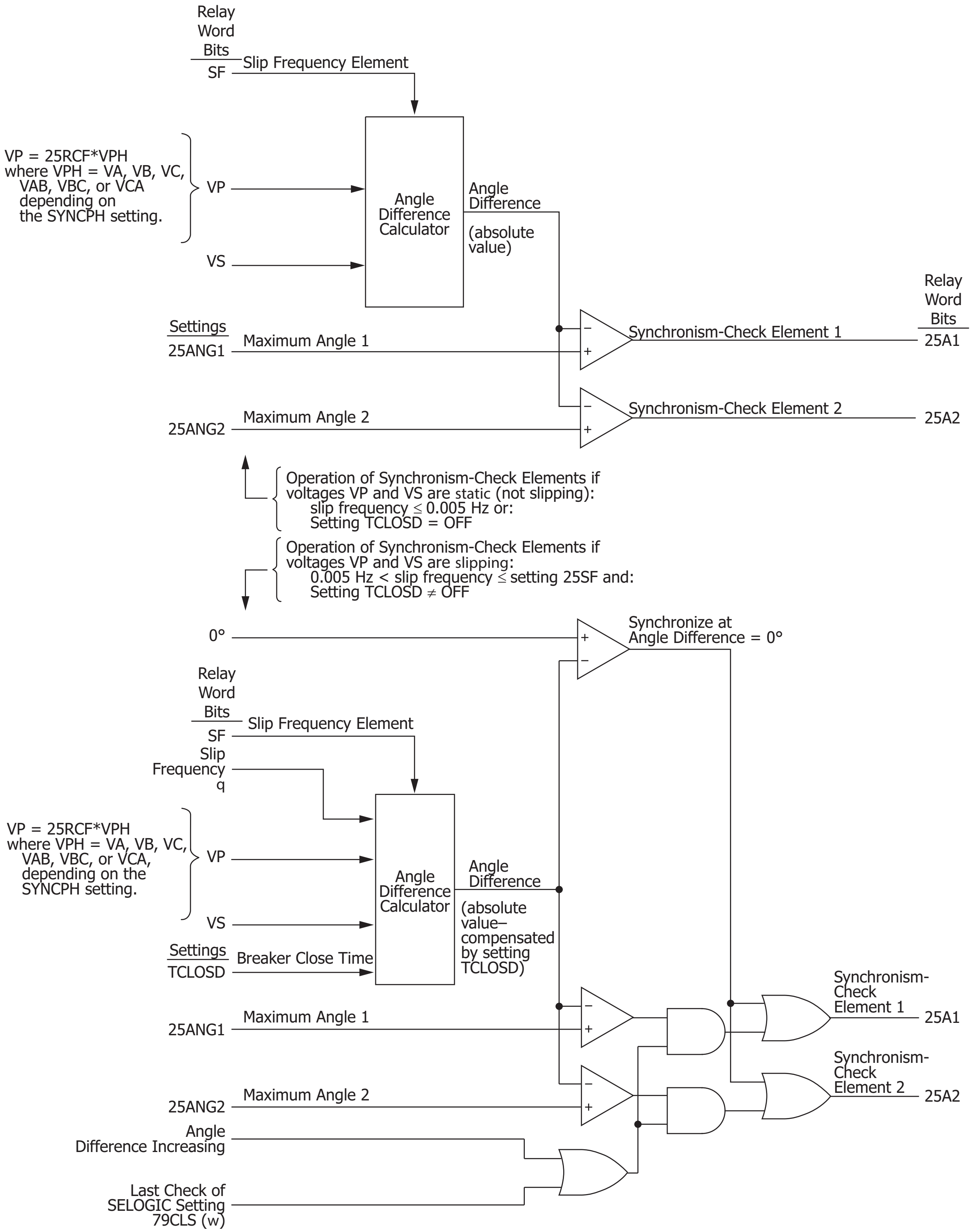


Figure 4.82 Synchronism-Check Voltage Window and Slip Frequency Elements



① From Figure 4.82; ② see Figure 4.104.

Figure 4.83 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, VC, VAB, VBC, or VCA (wye connected PTs) or VAB, VBC, or VCA (delta-connected PTs). This happens in applications where voltage input **VS** is connected

- Phase-to-neutral when using a delta-connected relay
- Beyond a delta-wye transformer

For such applications requiring **VS** to be at a constant phase angle difference from any of the possible synchronizing voltages (VA, VB, or VC; VAB, VBC, or VCA), an angle setting is made with the SYNCPH setting (see *Table 4.51* and *Setting SYNCPH on page 4.134*).

NOTE: The synchronism-check element is only available when VSCONN := VS.

Table 4.51 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
MAX VOLTAGE DIFF	OFF, 1.0–15.0%	25VDIF := OFF
V RATIO COR FAC	0.25–4.00	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, VAB, VBC, VCA 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
DEAD LINE VOLT	2.00–300.00 V	27LP := 25.00
LIVE LINE VOLT	2.00–300.00 V	59LP := 90.00
DEAD BUS VOLT	2.00–300.00 V	27BP := 25.00
LIVE BUS VOLT	2.00–300.00 V	59BP := 90.00

[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 4.83*). For situations where VS cannot be in phase with VA, VB, VC, VAB, VBC, or VCA, the angle setting choices (0, 30, …, 300, or 330 degrees) are referenced to VA.

Delta-Connected Voltages

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).

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 to meet the "healthy voltage" criteria (settings 25VHI and 25VLO—see *Figure 4.82*). 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 2.30 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 2.30* 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**, **VC**, **VAB**, **VBC**, or **VCA *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 2.30*).

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 4.82* and *Figure 4.83*.

Voltage Window

Refer to *Figure 4.82*. 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 4.82*. The synchronism-check element slip frequency calculator runs if both voltages VP and VS are healthy (59VP and 59VS asserted to logical 1), the percentage difference between VP and VS is less than the setting 25VDIF (59VDIF asserted to logical 1), and the SELOGIC control equation setting BSYNCH (Block Synchronism Check) is deasserted (= logical 0). You can disable the voltage difference supervision by setting 25VDIF := OFF. 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 4.103*)

In addition, you can block synchronism-check operation when the relay is tripping:

BSYNCH := **... OR TRIP**

Slip Frequency Calculator

Refer to *Figure 4.82*. The synchronism-check element Slip Frequency Calculator in *Figure 4.82* runs if voltages VP and VS are healthy (59VP and 59VS asserted to logical 1), the percentage difference between VP and VS is less than the setting 25VDIF (59VDIF 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 4.82*, 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 slip cycles/second • (360°/slip cycle) • 1 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 4.83* 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 4.83*. 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:

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:

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 4.83*. 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 4.84*). The Angle Difference Calculator calculates the Angle Difference between voltages VP and VS, compensated with the breaker close time:

Angle Difference = $|(\angle VP - \angle VS) + [(fP - fS) \cdot TCLOSD \cdot (1 / 1000) \cdot (360°/\text{slip cycle})]|$

Angle Difference Example (Voltages VP and VS are “Slipping”).

Refer to bottom of *Figure 4.83*. 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:

Angle Difference = $|(\angle VP - \angle VS) + [(fP - fS) \cdot TCLOSD \cdot (1 / 1000) \cdot (360°/\text{slip cycle})]|$

NOTE: The angle compensation in Figure 4.84 appears much greater than 3.6 degrees. Figure 4.84 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°|

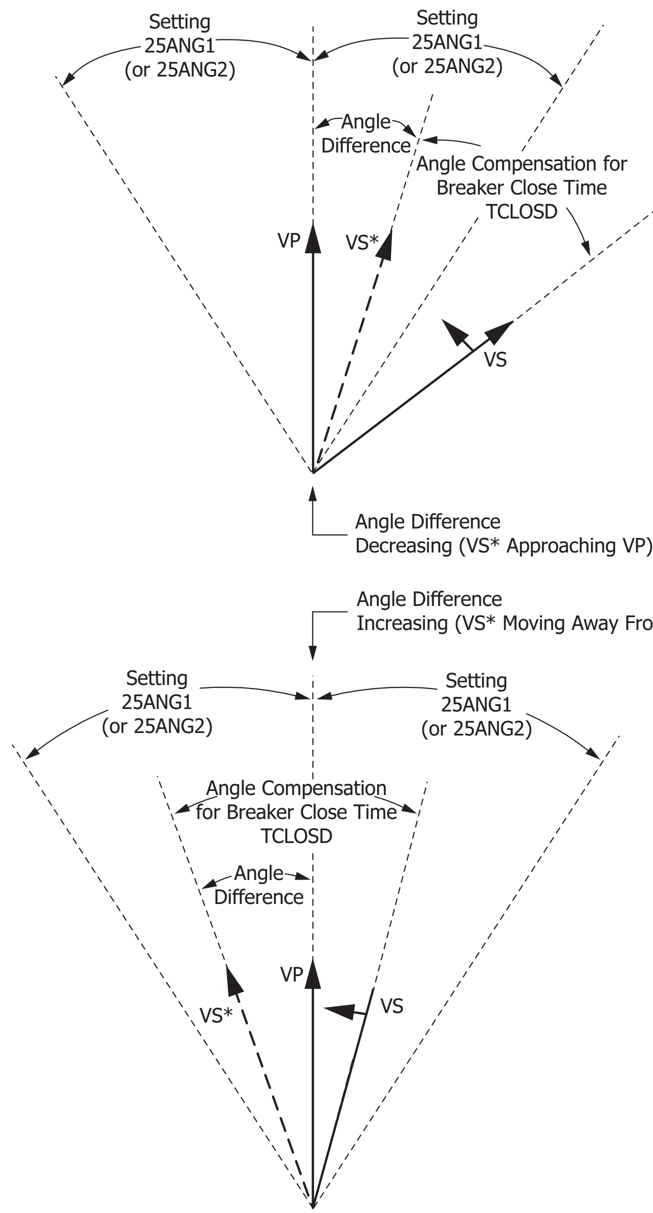


Figure 4.84 Angle Difference Between VP and VS Compensated by Breaker Close Time (fP < fS and VP Shown as Reference in This Example)

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 4.84*.

The top of *Figure 4.84* 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 4.84* 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 4.83*) 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 4.83*.

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 4.83*. 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 4.84* 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 4.84* 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 4.164*.

   Refer to the bottom of *Figure 4.104*. 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 4.105*).

   Refer to the top of *Figure 4.104*. 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 4.84*. 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 4.83* 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 4.103*. Element 25A2 operates similarly.

Synchronism-Check Applications for Automatic Reclosing and Manual Closing

Refer to *Trip/Close Logic on page 4.160* and *Reclose Supervision Logic on page 4.164*.

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 4.104*)

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 4.103*)

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 4.103* for logic output).

Manual Closing Voltage Check

Voltage checks can be used to supervise manual closing. The SEL-751 provides three manual closing voltage check conditions:

- ➤ Dead line–live bus (DLLB)
- ➤ Dead line–dead bus (DLDB)
- ➤ Live line–dead bus (LLDB)

You can use the settings 27LP, 59LP, 27BP, and 59BP to define voltage levels to identify dead line, live line, dead bus, and live bus (see *Table 4.51*). See *Figure 4.85* for the logic.

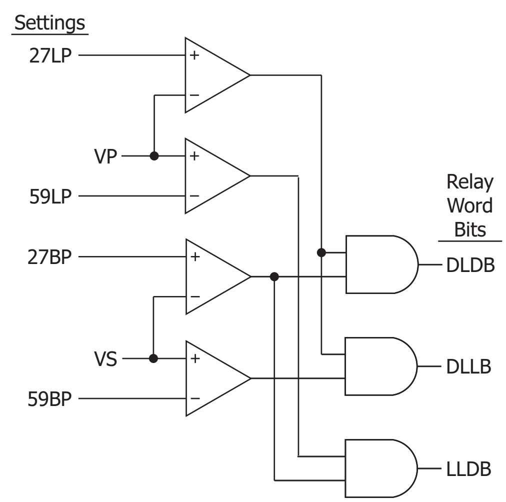


Figure 4.85 Manual Closing Voltage Check Element Logic

Use the DLDB, DLLB, and LLDB Relay Word bits to supervise manual closing. For example, presume that manual closing of Breaker BK1 in *Figure 4.86* should not be allowed if the respective bus is dead (dead line/dead bus or live line/dead bus condition). Suppose we use IN301 to initiate a manual close:

IN301 := NOT(DLDB OR LLDB) AND (...)

CL := IN301 AND (...)

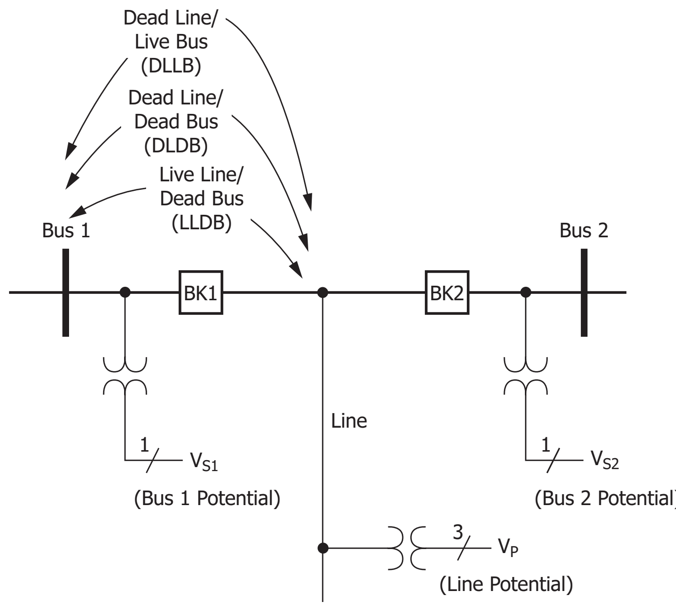


Figure 4.86 Manual Closing Voltage Check Element Application

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 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.

With SELOGIC control equations, the power elements provide a wide variety of protection and control applications. Typical applications include the following:

- Overpower and/or underpower protection/control
- Reverse power protection/control
- VAR control for capacitor banks

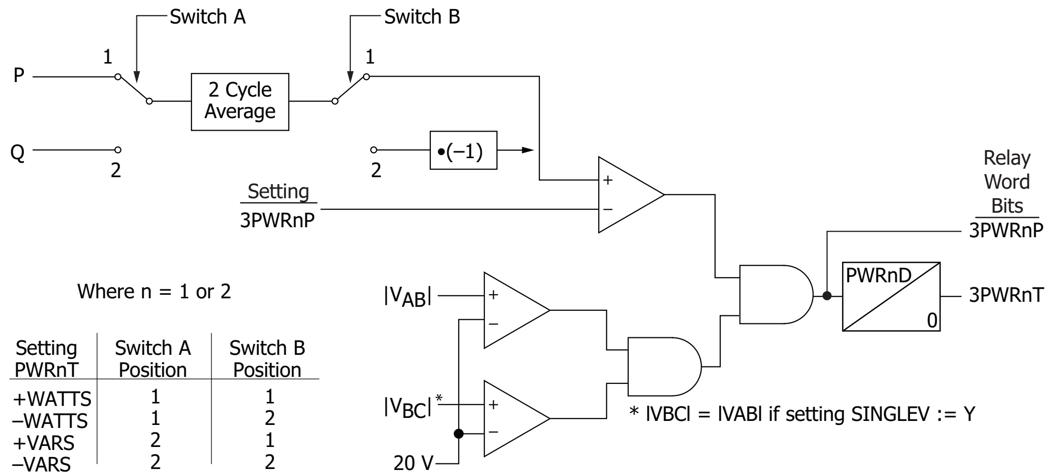
Table 4.52 Power Element Settings

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
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 4.87* shows the power element logic diagram and *Figure 4.88* shows the operation in the Real/Reactive power plane.



Setting PWRnT	Switch A Position	Switch B Position
+WATTS	1	1
−WATTS	1	2
+VARS	2	1
−VARS	2	2

Figure 4.87 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 4.87*. 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.

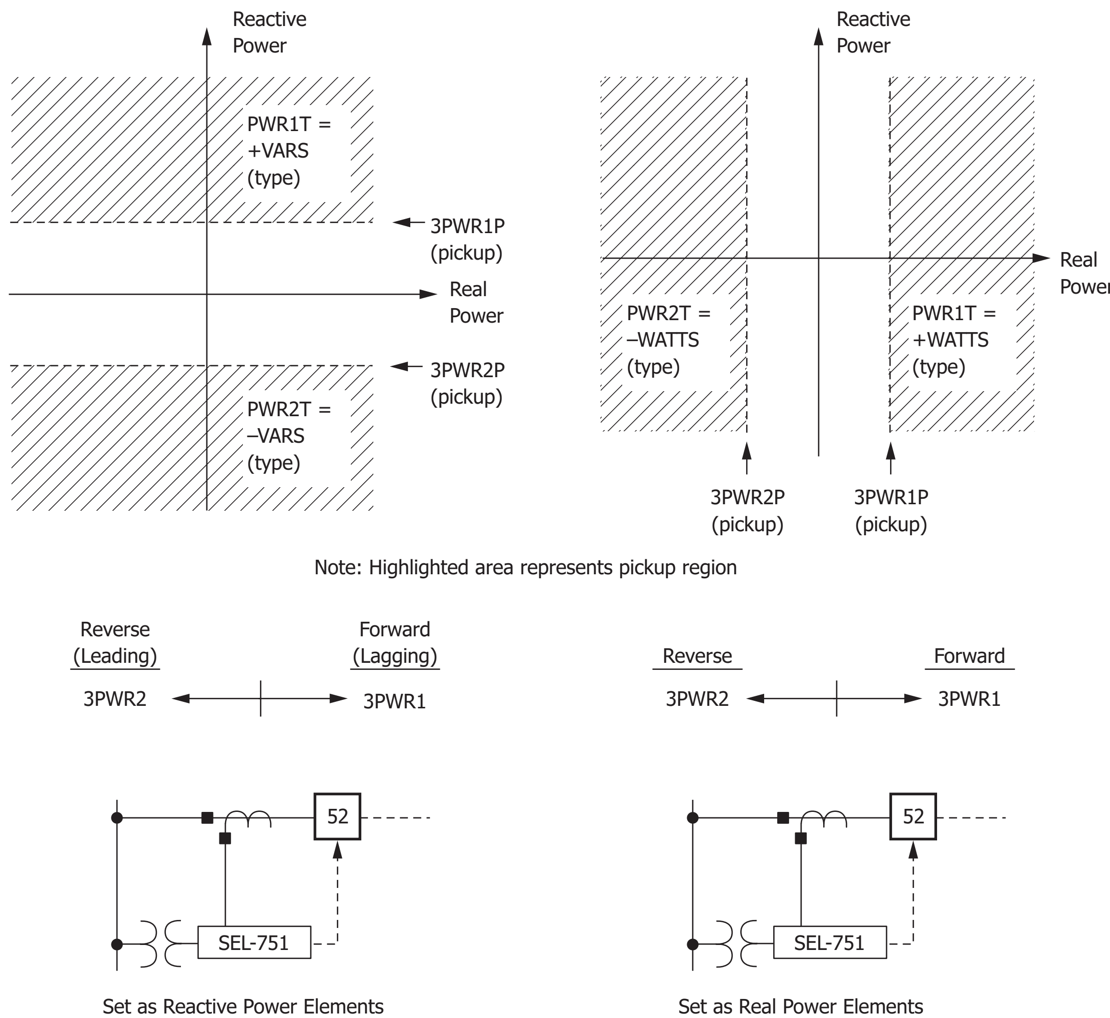


Figure 4.88 Power Elements Operation in the Real/Reactive Power Plane

Power Factor Elements

NOTE: The 55 element uses a power factor that is derived from 8-cycle averaged quantities.

Table 4.53 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 4.89* 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.

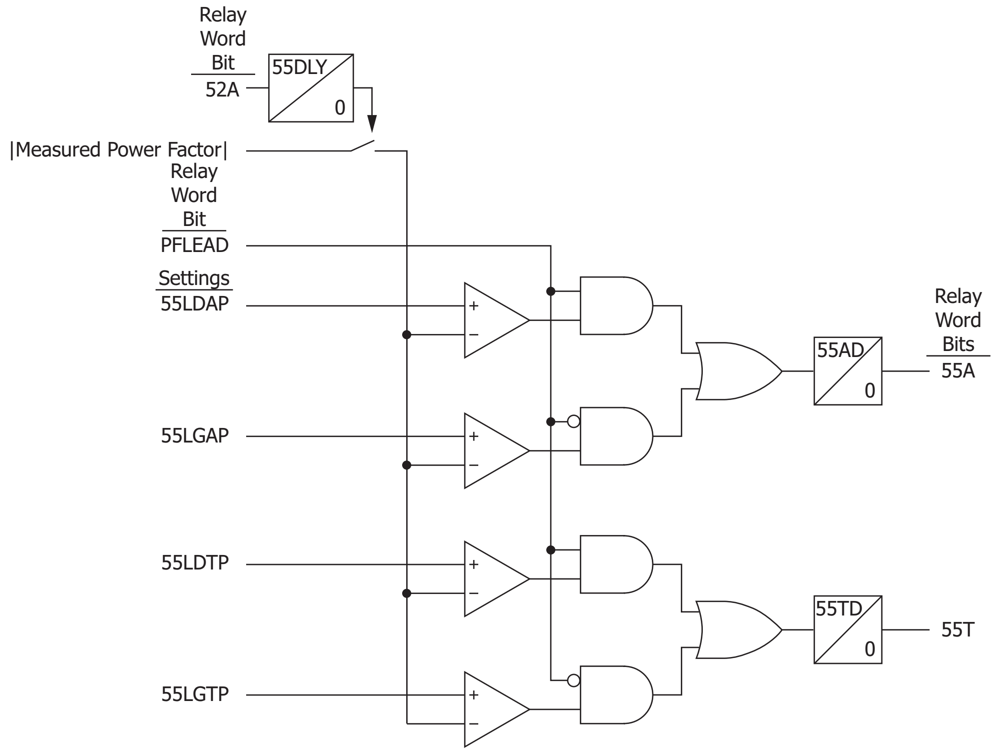


Figure 4.89 Power Factor Elements Logic

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 4.90* 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 state of the LOP Relay Word bit is stored in non-volatile memory. If the relay loses power, the state of the LOP Relay Word bit is retained. The relay resets the LOP Relay Word bit when the conditions of the RESET input of the latch are met, as shown in *Figure 4.90*.

Settings

The LOP function is always active unless blocked by the corresponding SELOGIC control equation, LOPBLK (see *Table 4.54* for the setting and *Figure 4.90* 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 4.20*).

Table 4.54 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 4.20*). 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 4.20 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.

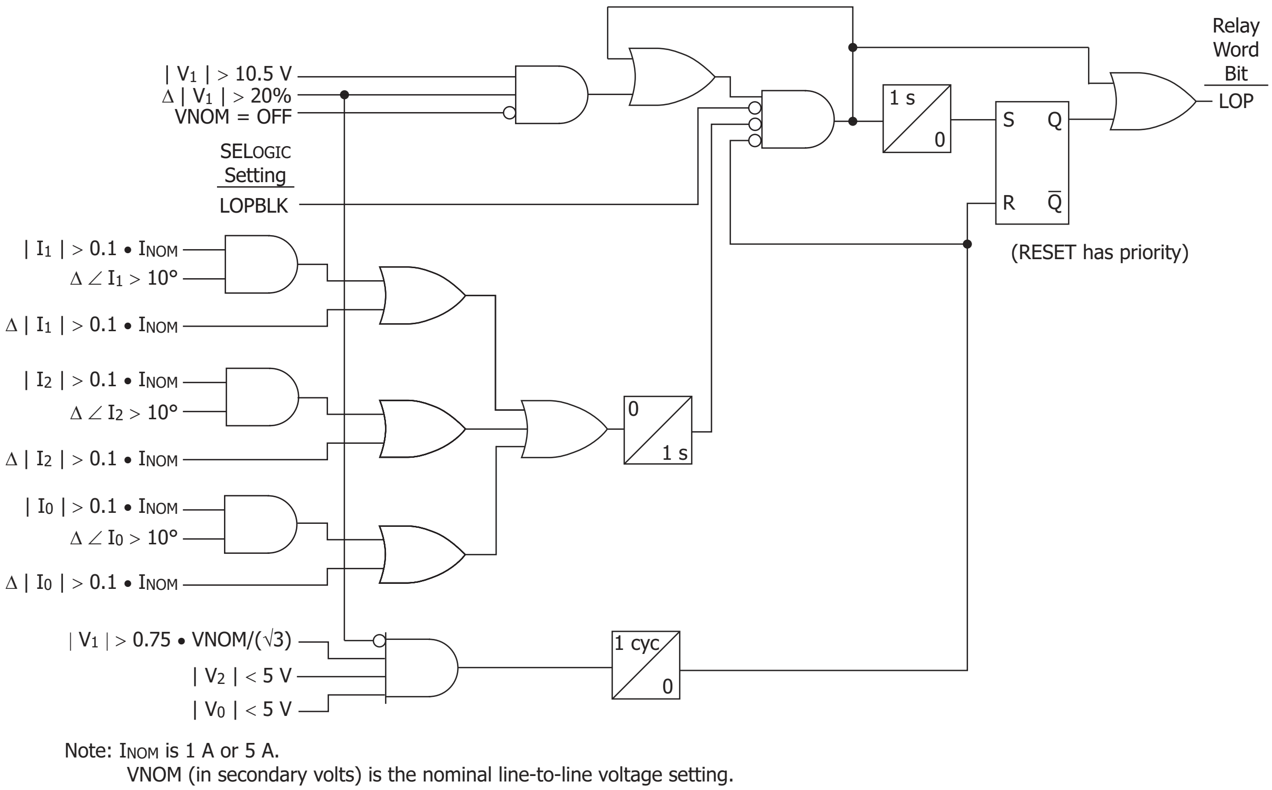


Figure 4.90 Loss-of-Potential (LOP) Logic

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 4.91* 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

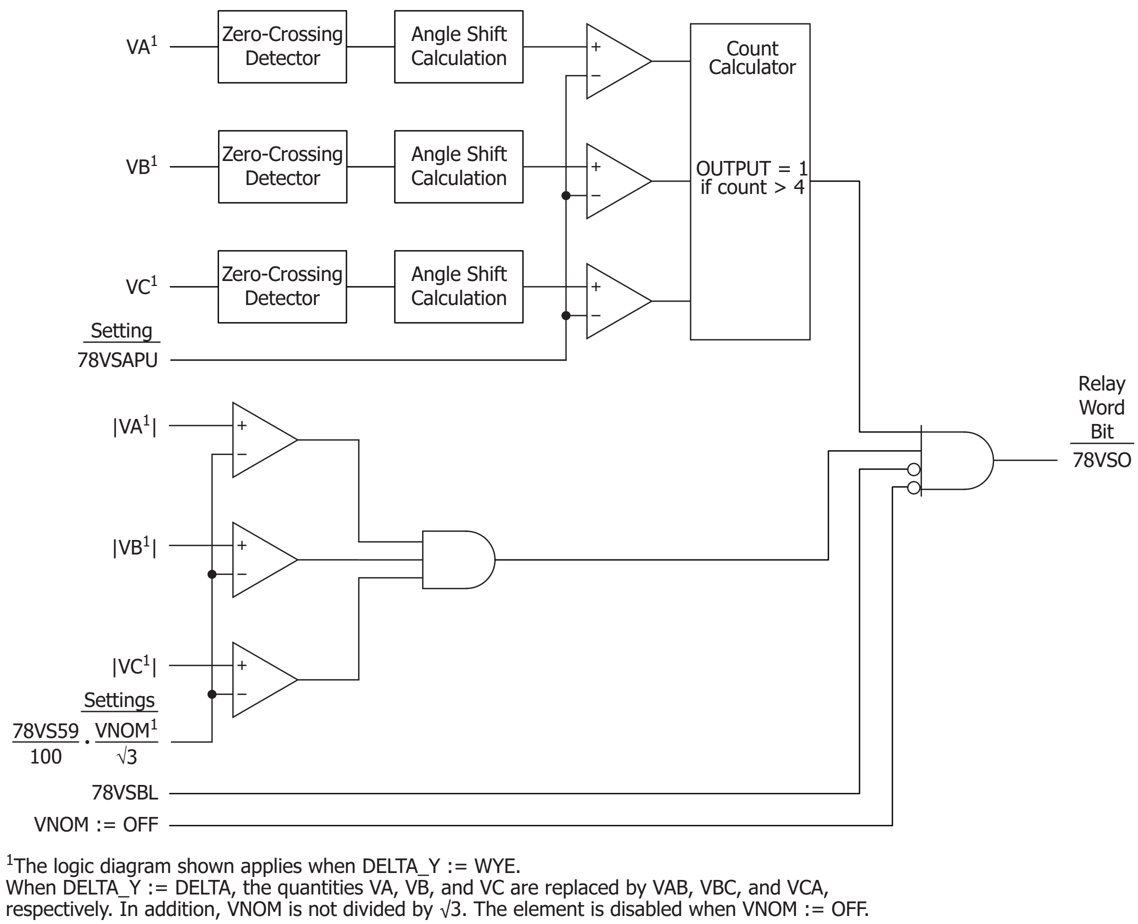


Figure 4.91 Logic Diagram of the Vector Shift Element

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 4.55* 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 4.55 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

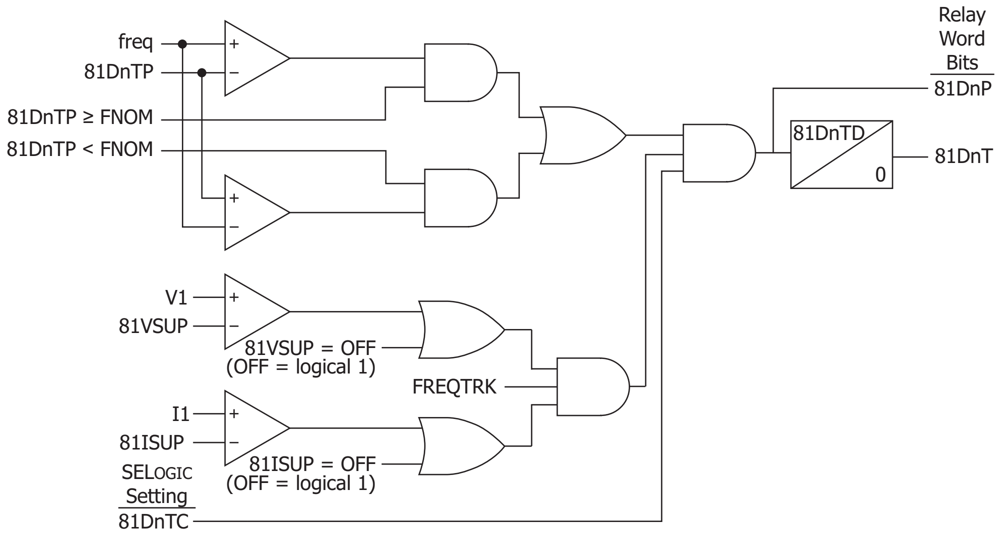
NOTE: The relay measures system frequency for these elements with the positive-sequence voltage if the voltage input is present and the applied positive-sequence voltage is greater than 10 volts. Otherwise, the relay uses positive-sequence current as long as the minimum magnitude is 0.1 • (Nominal CT Rating). The measured frequency is set to nominal frequency setting (FNOM) if the signal is below the minimum level.

The SEL-751 provides six trip over- or underfrequency elements with independent level and time-delay settings. *Table 4.56* 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 4.92* shows the logic diagram for the frequency elements.

Table 4.56 Frequency Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
81 VOLTAGE SUP	OFF, 12.5–300.0 V	81VSUP := OFF
81 CURRENT SUP	OFF, 0.4–2.0 A[a] OFF, 2.0–10.0 A[b]	81ISUP := OFF
FREQ1 TRIP LEVEL	OFF, 15.00–70.00 Hz	81D1TP := OFF
FREQ1 TRIP DELAY[c]	0.00–400.00 sec	81D1TD := 1.00
81D1 TRQCTRL	SELOGIC	81D1TC := 1
FREQ2 TRIP LEVEL	OFF, 15.00–70.00 Hz	81D2TP := OFF
FREQ2 TRIP DELAY[c]	0.00–400.00 sec	81D2TD := 1.00
81D2 TRQCTRL	SELOGIC	81D2TC := 1
FREQ3 TRIP LEVEL	OFF, 15.00–70.00 Hz	81D3TP := OFF
FREQ3 TRIP DELAY[c]	0.00–400.00 sec	81D3TD := 1.00
81D3 TRQCTRL	SELOGIC	81D3TC := 1
FREQ4 TRIP LEVEL	OFF, 15.00–70.00 Hz	81D4TP := OFF
FREQ4 TRIP DELAY[c]	0.00–400.00 sec	81D4TD := 1.00
81D4 TRQCTRL	SELOGIC	81D4TC := 1
FREQ5 TRIP LEVEL	OFF, 15.00–70.00 Hz	81D5TP := OFF
FREQ5 TRIP DELAY[c]	0.00–400.00 sec	81D5TD := 1.00
81D5 TRQCTRL	SELOGIC	81D5TC := 1
FREQ6 TRIP LEVEL	OFF, 15.00–70.00 Hz	81D6TP := OFF
FREQ6 TRIP DELAY[c]	0.00–400.00 sec	81D6TD := 1.00
81D6 TRQCTRL	SELOGIC	81D6TC := 1

[a] Setting range when INOM = 1 A.
[b] Setting range when INOM = 5 A.
[c] Frequency element time delays are best set for at least three cycles at the lowest 81U pickup setting. 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
81DnP = Over- and Underfrequency Element Pickup Relay Word Bit
81DnT = Definite-Time Delayed Over- and Underfrequency Element Trip Relay Word Bit
FREQTRK = Relay Is Tracking Frequency
81DnTC = SELOGIC Setting for Torque Control of Frequency Element

Not shown in the figure, Relay Word bit ORED81T is asserted if any of the 81DnT Relay Word bits are asserted (n = 1–6).

Figure 4.92 Over- and Underfrequency Element Logic

You can use the 81VSUP and 81ISUP group settings to enable voltage and/or current supervision of the element. A minimum positive-sequence voltage and/or current is necessary for the operation of the 81 element when the levels are specified by the 81VSUP and 81ISUP settings, respectively. Set 81VSUP := OFF if no voltage supervision is necessary and 81ISUP := OFF if no current supervision is necessary. In any case, the element is also supervised by Relay Word bit FREQTRK, which ensures that the relay is tracking and measuring the system frequency.

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 4.57* shows the settings available for the elements.

Table 4.57 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

Table 4.57 Rate-of-Change-of-Frequency Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
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
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 4.93* 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). The frequency measurement used by the 81R element is available in the COMTRADE event report as FREQ_81R. *Table 4.58* shows the time windows for different trip level settings. Additionally, the Relay Word bit ORED81RT := 81R1T OR 81R2T OR 81R3T OR 81R4T.

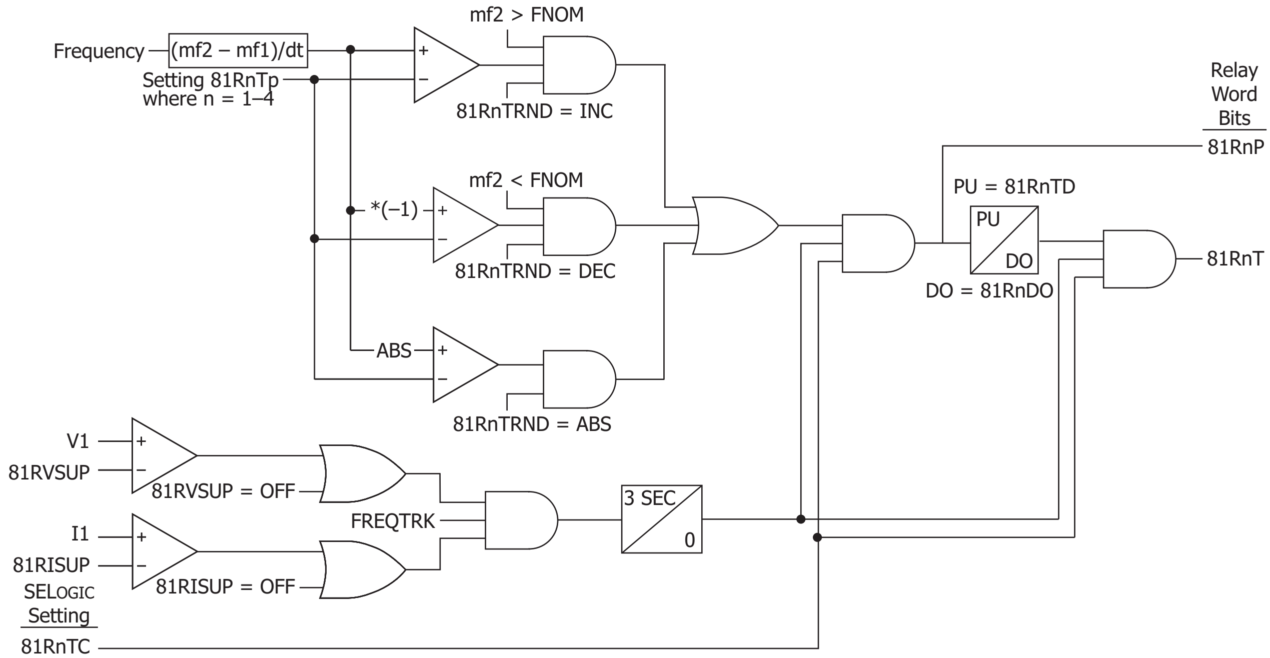


Figure 4.93 81R Frequency Rate-of-Change Scheme Logic

Table 4.58 Time Window Versus 81RnTP Setting

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
0.32–0.29	24
0.28–0.26	27
< 0.25	30

NOTE: The specified 81R accuracy is valid from 15.00 Hz/sec to 0.23 Hz/sec.

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 81RVSUP and 81RISUP 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 4.94*) 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 4.59*).

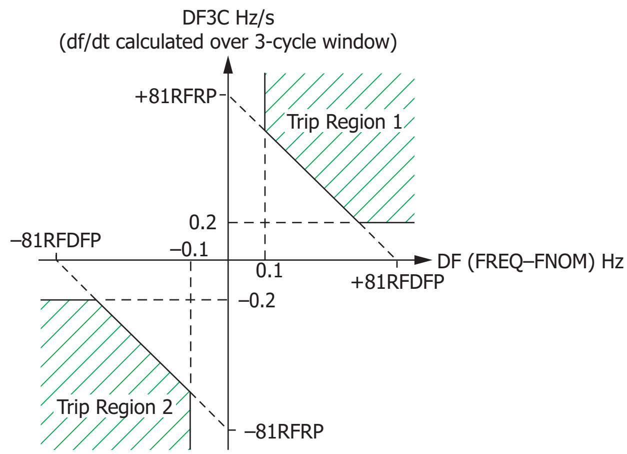


Figure 4.94 81RF Characteristics

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 4.59 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] OFF, 2–520 V[b]	81RFVBLK := OFF 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 4.95 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.

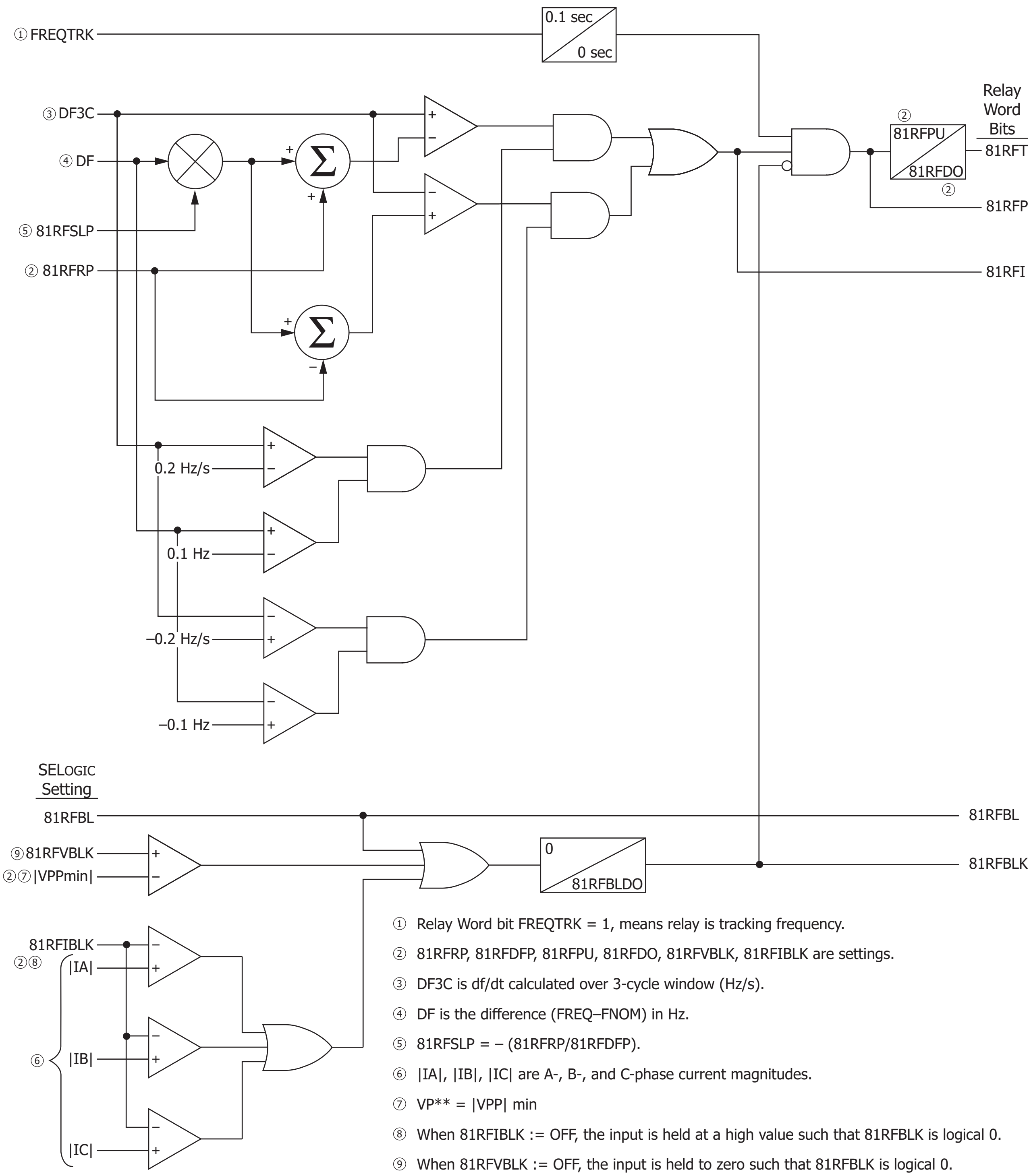


Figure 4.95 81RF Fast Rate-of-Change-of-Frequency Logic

Detecting Frequency Components With the 97FM Element

The 97FM elements monitor the magnitude of a user-selected frequency component in different analog signals (see *Table 4.60*) by evaluating an individual term of the discrete Fourier transform (DFT). The SEL-751 relay with the voltage option provides ten of these elements.

Table 4.60 Operating Quantities and Associated Sampling Rates

97FMxOQ	Operating Quantity	FNOM = 60		FNOM = 50	
		Delta T	Max 97FMxFS Setting	Delta T	Max 97FMxFS Setting
VA[a]	Raw VA	1/(32 FNOM) = 1/1920	960 Hz	1/(32 FNOM) = 1/1600	800 Hz
VB[a]	Raw VB	1/(32 FNOM) = 1/1920	960 Hz	1/(32 FNOM) = 1/1600	800 Hz
VC[a]	Raw VC	1/(32 FNOM) = 1/1920	960 Hz	1/(32 FNOM) = 1/1600	800 Hz
VAB[b]	Raw VAB	1/(32 FNOM) = 1/1920	960 Hz	1/(32 FNOM) = 1/1600	800 Hz
VBC[b]	Raw VBC	1/(32 FNOM) = 1/1920	960 Hz	1/(32 FNOM) = 1/1600	800 Hz
VCA[b]	Raw VCA	1/(32 FNOM) = 1/1920	960 Hz	1/(32 FNOM) = 1/1600	800 Hz
IA	Raw IA	1/(32 FNOM) = 1/1920	960 Hz	1/(32 FNOM) = 1/1600	800 Hz
IB	Raw IB	1/(32 FNOM) = 1/1920	960 Hz	1/(32 FNOM) = 1/1600	800 Hz
IC	Raw IC	1/(32 FNOM) = 1/1920	960 Hz	1/(32 FNOM) = 1/1600	800 Hz
P	Three-phase active power	1/(4 FNOM) = 1/240	60 Hz	1/(4 FNOM) = 1/200	50 Hz
Q	Three-phase reactive power	1/(4 FNOM) = 1/240	60 Hz	1/(4 FNOM) = 1/200	50 Hz
S	Three-phase apparent power	1/(4 FNOM) = 1/240	60 Hz	1/(4 FNOM) = 1/200	50 Hz
FREQ	Frequency	3/FNOM = 1/20	10 Hz	3/FNOM = 3/50	8 Hz

[a] Available if DELTA_Y := WYE.
[b] Available if DELTA_Y := DELTA.

The 97FM element may be configured in three different operating modes: SU_EU (secondary or engineering units) mode, seen in *Figure 4.96*, in which the magnitude of the selected quantity at the selected frequency is compared to a threshold in the corresponding secondary or engineering units; dB_DC mode, seen in *Figure 4.97*, in which the magnitude of the selected component is obtained in dB of the dc component of the same signal; and finally, dB_FN mode, also seen in *Figure 4.97*, in which the magnitude of the selected component is obtained in dB of the fundamental component. The 97FM*x*PT setting is used to choose the operating mode.

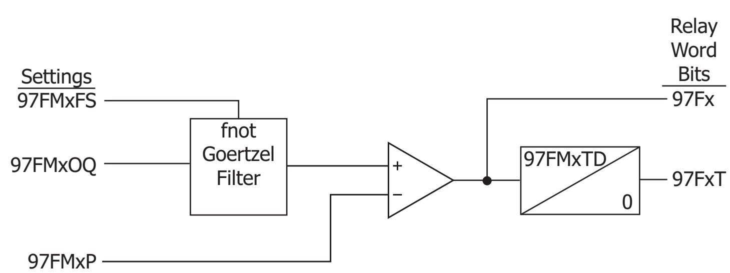
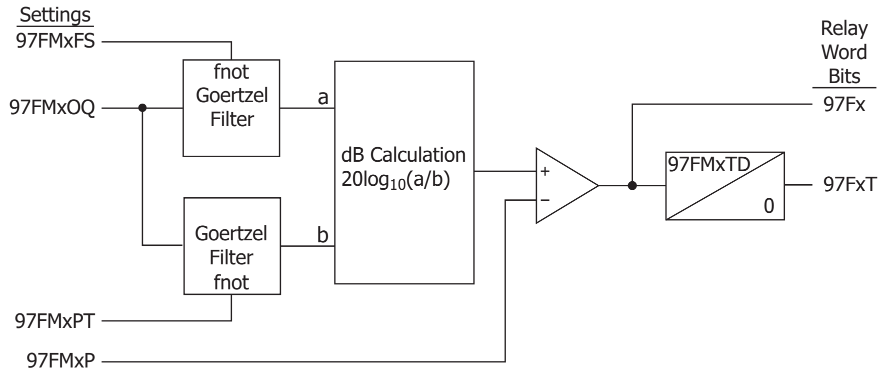


Figure 4.96 SU_EU Operating Mode (97FMxPT = SU_EU)



97FMxPT has two modes in this diagram: dB_DC and dB_FN.

Figure 4.97 dB_DC (97FM*x*PT = dB_BC) and dB_FN (97FM*x*PT = dB_FN) Operating Modes

When the 97FM*x* analog quantity exceeds the corresponding threshold 97FM*x*P, the element asserts the 97F*x* Relay Word bit and the time-delayed 97F*x*T Relay Word bit. These Relay Word bits may be directly monitored in the SER report. In some applications, these Relay Word bits may repeatedly assert and de-assert, cluttering the SER report. To avoid this, use the 97FM*x*ER timer. While 97FM*x*ERT is deasserted, the 97FM*x* element generates a report every time that 97F*x*T asserts, as shown in *Figure 4.98*.

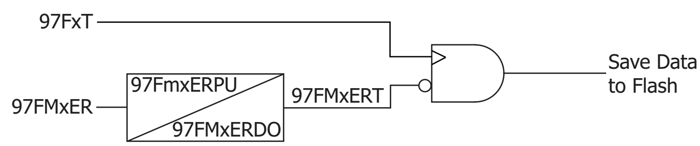


Figure 4.98 97FM*x*ER Timer Logic

You can use the **HIS FMR** command to access these reports. *Figure 4.99* details the data included in the reports.

```
=>>HIS FMR 10 <Enter>

SEL-751                                    Date: 04/16/2019   Time: 16:47:59.217
FEEDER RELAY                               Time Source: External

#     DATE        TIME          97FMx       97FMxOQ  97FMxFS  97FMxFR  97FMxPT
1    04/16/2019  16:47:54.211    0.17         Q        1.00     0.5      DB_DC
2    04/16/2019  16:47:48.200    15.85        Q        1.00     0.5      DB_DC
3    04/16/2019  16:47:36.205    6.53         Q        1.00     0.5      DB_DC
4    04/16/2019  16:47:20.200    4.01         Q        1.00     0.5      DB_DC
5    04/16/2019  16:46:58.184    43.34        Q        1.00     0.5      DB_DC
6    04/16/2019  16:46:54.174    4.89         Q        1.00     0.5      DB_DC
7    04/16/2019  16:46:46.183    21.89        Q        1.00     0.5      DB_DC
8    04/16/2019  16:46:42.178    21.31        Q        1.00     0.5      DB_DC
9    04/16/2019  16:46:38.168    1.04         Q        1.00     0.5      DB_DC
10   04/16/2019  16:46:28.178    5.62         Q        1.00     0.5      DB_DC
```

Figure 4.99 HIS FMR Command Response

Frequency Resolution

The 97*x*FM element uses a windowed Goertzel filter to isolate the desired frequency component. The capacity of this filter to reject off frequencies is shown in *Figure 4.100*.

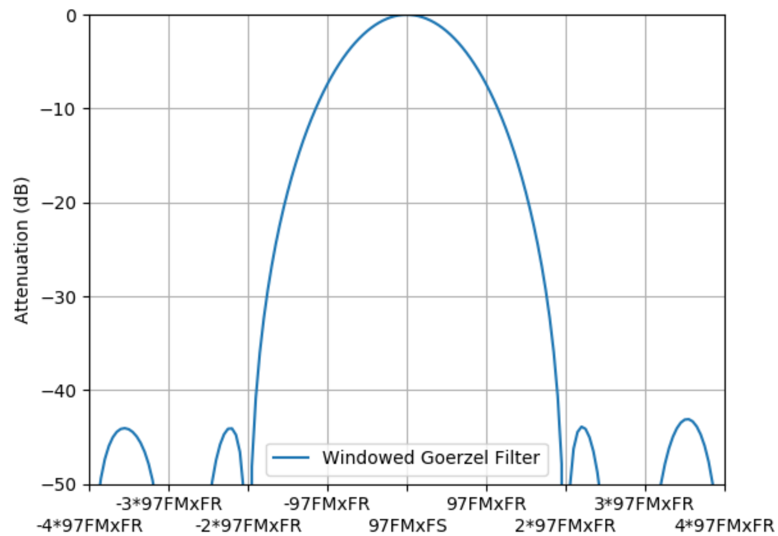


Figure 4.100 Filter Frequency Response

Frequency Tracking

The relay tracks the fundamental frequency by adjusting the sampling rate by a factor equal to FREQ / FNOM. As the sampling rate changes, the effective pickup frequency of the 97FM element also moves by the same factor. Use the following equation to find the effective pickup frequency of the 97FM element:

$$\text{Effective Pickup Frequency} = \frac{FREQ \bullet \text{97FMxFS}}{FNOM}$$

Table 4.61 Frequency Magnitude Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Default Value
97FM ENABLE	Y, N	E97FM*x* := N
OPERATING QTTY	IA, IB, IC, VAB[a], VBC[a], VCA[a], VA[b], VB[b], VC[b], P, Q, S, FREQ	97FM*x*OQ := P
FREQ SETPOINT	0.00–960.00 Hz (for analogs and FNOM = 60) 0.00–800.00 Hz (for analogs and FNOM = 50) 0.00–60.00 Hz (for P, Q, S, and FNOM = 60) 0.00–50.00 Hz (for P, Q, S, and FNOM = 50) 0.00–10.00 Hz (for FREQ and FNOM = 60) 0.00–8.00 Hz (for FREQ and FNOM = 50)	97FM*x*FS := 20
PICKUP TYPE	SU_EU, DB_FN (for currents and voltages) SU_EU, DB_DC (for P, Q, S, and FREQ)	97FM*x*PT := SU_EU
FREQ RESOLUTION	0.1, 0.5, 1, 5, 10, 20 Hz	97FM*x*FR := 1
PICKUP LEVEL	0.00–11250000.00 kVar (for Q) 0.00–11250000.00 kVA (for S) 0.00–11250000.00 kW (for P) 0.00–2 • I_{NOM} A sec (for I) 0.00–300.00 V sec (for V) 0.00–70.00 Hz (for FREQ) –60.00–0.00 (for dB)	97FM*x*P := 0.00
TIME DELAY	0.0–6000.0 sec	97FM*x*TD := 0.0

Table 4.61 Frequency Magnitude Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Default Value
TRQ CONTROL	SELOGIC	97FM*x*TC := 1
EVENT TIMER	SELOGIC	97FM*x*ER := 0
PICKUP TIMER	0–30000 min	97FM*x*PU := 0
DROPOUT TIMER	0–30000 min	97FM*x*DO := 600

[a] Shown if DELTA_Y := DELTA.
[b] Shown if DELTA_Y := WYE.

Monitoring Sub-Synchronous Resonance and Load Variations

To detect low-frequency power oscillation resulting from sub-synchronous resonance or load oscillations, set a 97FM element as follows. If the frequency of the oscillation is known to be 1 Hz and the magnitude is 10 kW, set the 97FM element according to *Table 4.62*.

Table 4.62 97FM Element Settings for an Oscillation With 1 Hz Frequency and 10 kW Magnitude

Setting Name	Value
E97FM1	Y
97FM1OQ	P
97FM1FS	1 Hz
97FM1PT	SU_EU
97FM1FR	1 Hz
97FM1P	5 kW
97FM1TD	10 s
97FM1TC	1
97FM1ER	97F1T
97FM1PU	0 min
97FM1DO	60 min

With these settings, the element will save, at most, one event per hour.

Trip/Close Logic

NOTE: The factory-default assignment of Relay Word bit TRIP is output OUT103. See Table 4.77 for the output contacts settings.

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 4.101* illustrates the tripping logic.

Table 4.63 Trip/Close Logic Settings (Sheet 1 of 2)

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
MANUAL TRIP EQN	SV	MTR := 0

NOTE: The factory-default assignment of Relay Word bit TRIP is output OUT103. See Table 4.77 for the output contacts settings.

Table 4.63 Trip/Close Logic Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
UNLATCH TRIP	SV	ULTRIP := NOT (51P1P OR 51G1P OR 51N1P OR 52A)
UNLATCH MTRIP	SV	ULMTRIP := NOT 52A OR TRGTR
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

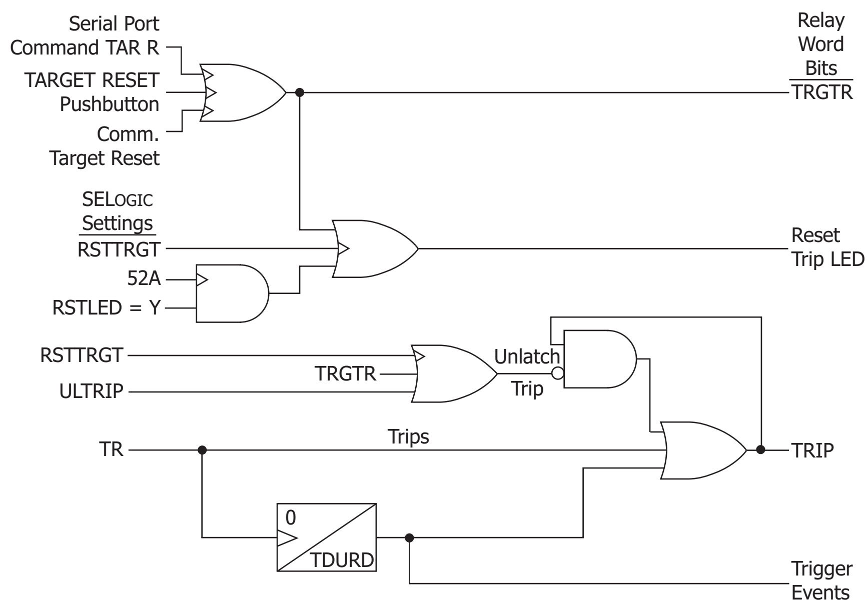


Figure 4.101 Trip Logic

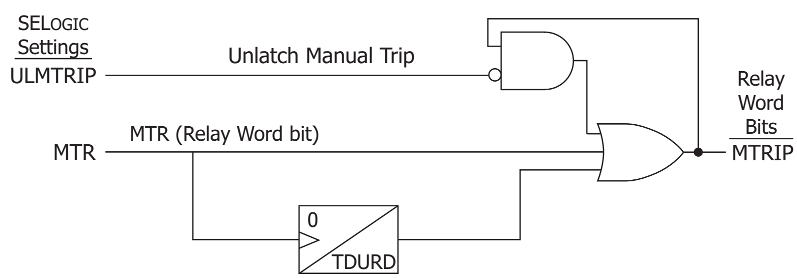


Figure 4.102 Manual Trip Logic

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

NOTE: The outputs in the SEL-751 are not designed to interrupt the trip coil current. An auxiliary contact with adequate current interrupting capacity must clear the trip coil current before the output of the SEL-751 opens. Failure to observe this safeguard could result in damage to the SEL-751 output contacts. Avoid programming Relay Word bit TR or MTR in the output equation to directly trip the breaker. Instead, use Relay Word bit TRIP or MTRIP, which stays asserted for at least the duration of the TDURD setting or until TRIP or MTRIP is unlatched, whichever is longer.

NOTE: You can create your own custom logic using SELogic variables and map those variables to the TR or MTR 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 4.63* 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 2.30*).

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: The factory-default setting ULTRIP provides an automatic reset of the trip when the breaker opens or 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 settings and logic, refer to Disconnect Control Settings. For the touchscreen relay option, refer to Table 9.5 for typical disconnect symbols. For the settings related to bay control disconnect symbols, refer to Table 9.7 and the corresponding descriptions.

NOTE: For the settings related to the local/remote breaker control function, refer to Local/Remote Control on page 9.7. For breaker control via the front panel pushbuttons, refer to Front-Panel Operator Control Pushbuttons on page 8.16. 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/Disconnect Control Via Touchscreen on page 9.8.

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, and to reduce to 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).

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 with the touchscreen display option additionally provides the ability to design detailed single-line diagrams and display the breaker and disconnect statuses. Refer to *Table 9.1* for typical circuit breaker symbols available for display on the bay screens. For settings related to bay control breaker symbols, refer to *Table 9.7* and the corresponding description.

Manual Trip Logic

The SEL-751 also has additional logic for manually tripping the circuit breakers. Use SELOGIC control equation MTR to trip the circuit breakers manually by adding the MTRIP Relay Word bit to the corresponding trip output contact. For example, with the default settings, you can add MTRIP to OUT103 as:

OUT103 := TRIP OR MTRIP

Use SELOGIC control equation ULMTRIP to unlatch manual trips for the circuit breaker. The manual trip logic is shown in *Figure 4.102*.

With default settings in the SEL 751, the manual trips are routed through the protection trip logic TR equation (OC and SV04T). As a result, the manual trips result in the latching of the TRIP target LED. Additionally, by default, the TRIP Relay Word bit is used to initiate a breaker failure (see BFI in *Breaker Failure Settings).* If you do not want to latch the TRIP target LED or initiate BFI for a manual trip, you can remove manual trip specific Relay Word bits from the TR equation and use them in the manual trip logic MTR equation.

CL Close SELOGIC Control Equation

NOTE: The close logic does not work with the reclosing model relays if the 52A setting is set to 0 or evaluates to 0, even if setting E79 = N.

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 4.104*).

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 2.30* 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.

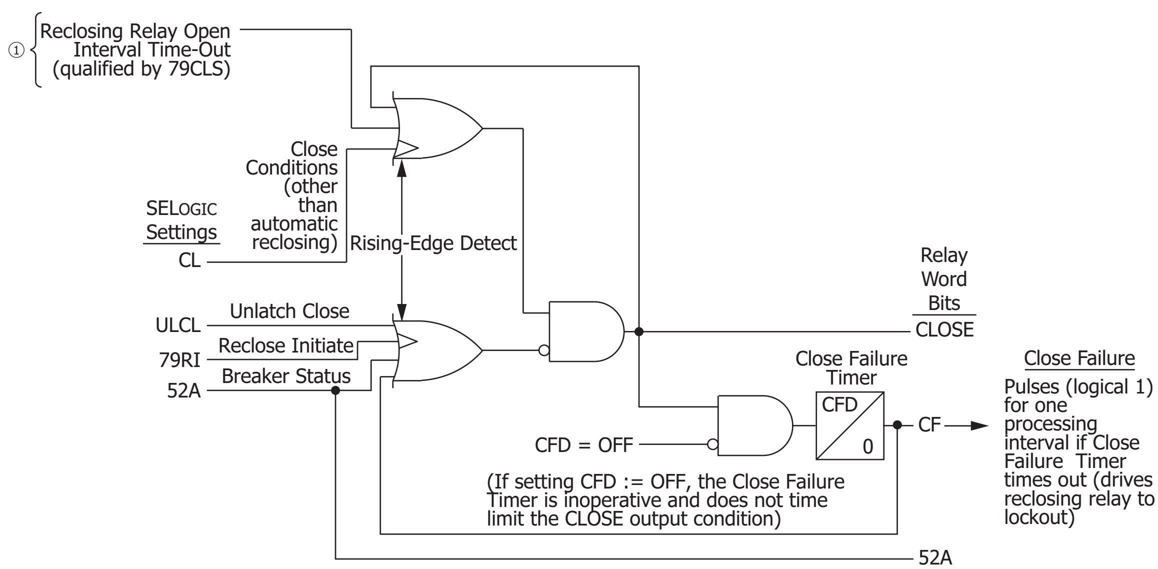
Reclose Supervision Logic

NOTE: The close logic does not work with the reclosing model relays if the 52A setting is set to 0 or evaluates to 0, even if setting E79 = N.

Note that one of the inputs into the close logic in *Figure 4.103* is:

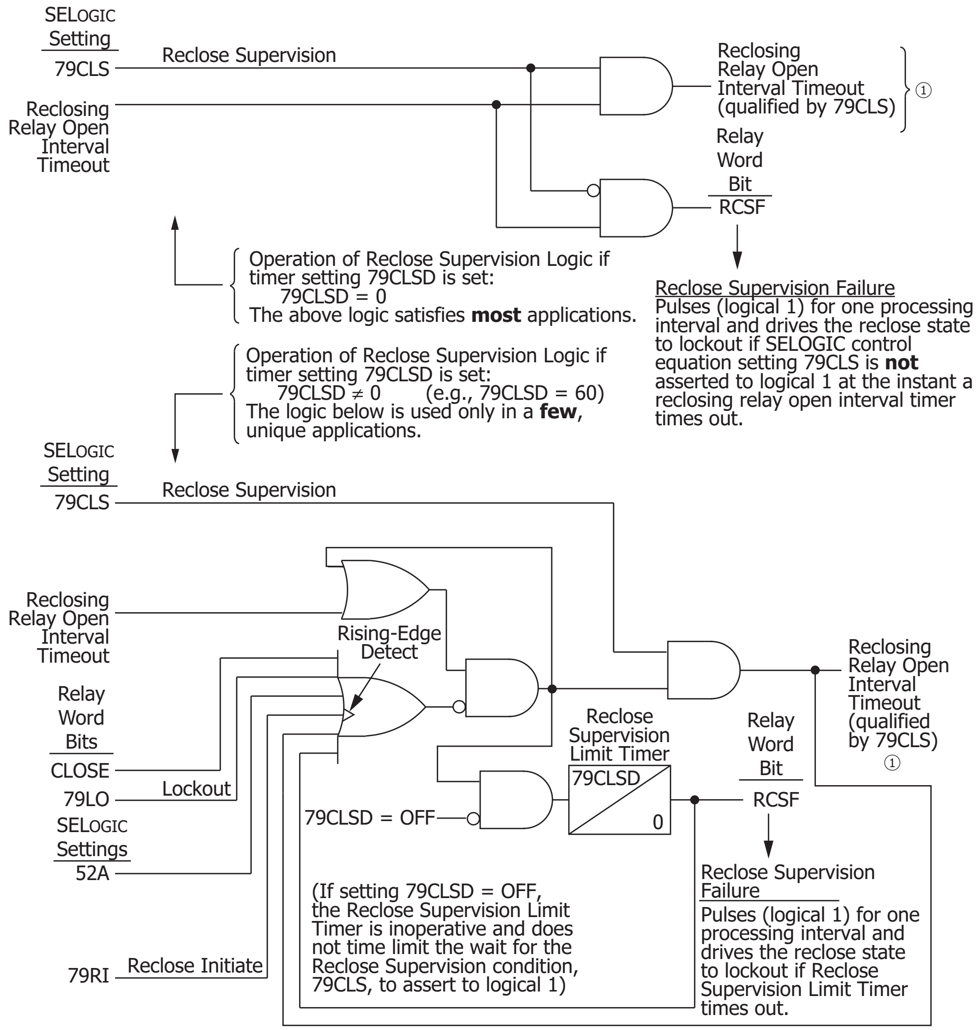
Reclosing Relay Open Interval Time-Out (qualified by 79CLS)

This input into the close logic in *Figure 4.103* is the indication that a reclosing relay open interval has timed out (see *Figure 4.105*), 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 4.103* is an output of the reclose supervision logic in the following *Figure 4.104*.



① From Figure 4.104

Figure 4.103 Close Logic



① To Figure 4.103

Figure 4.104 Reclose Supervision Logic (Following Open Interval Time-Out)

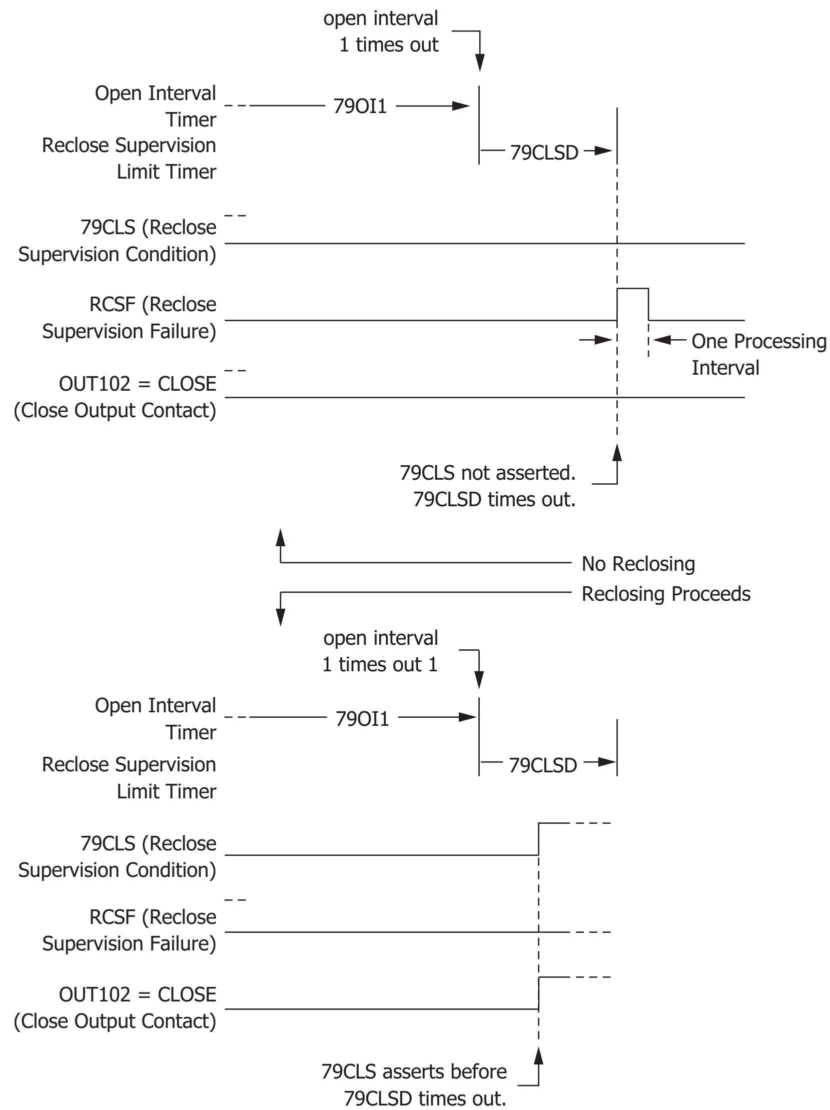


Figure 4.105 Reclose Supervision Limit Timer Operation

Settings and General Operation

Figure 4.104 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 4.65* for Recloser Control settings.

For Most Applications

Refer to the top of *Figure 4.104*.

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 4.104* 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 4.104* 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 4.109* and *Table 4.66*), the reclosing relay is then driven to the lockout state.

See *Example 4.21*.

For a Few, Unique Applications

Refer to the bottom of *Figure 4.104* and *Figure 4.105*.

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 4.104* 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 4.103* 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 4.104* is explained in more detail in the following text.

Set Reclose Supervision Logic.

Refer to the bottom of *Figure 4.104*. If *all* the following are true:

- The close logic output CLOSE (also see *Figure 4.103*) 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 4.104*. Then, when 79CLS asserts to logical 1, the sealed-in reclosing relay open interval time-out condition propagates through *Figure 4.92* and on to the close logic in *Figure 4.103*.

Unlatch Reclose Supervision Logic.

Refer to the bottom of *Figure 4.104*. 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 4.104*) 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 4.103*. See *Example 4.22*.

EXAMPLE 4.21 Settings Example 1

Refer to the top of Figure 4.104 and Figure 4.106.

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.

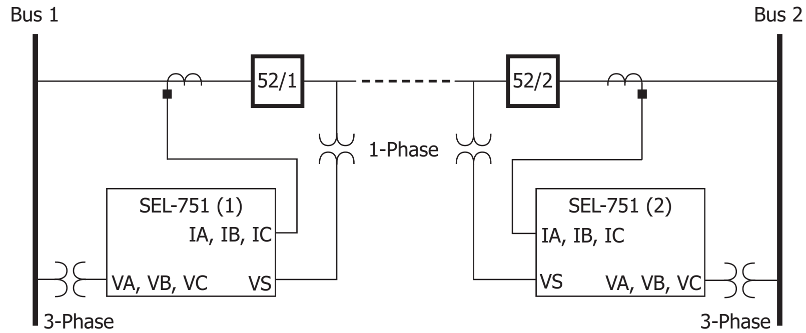


Figure 4.106 SEL-751 Relays Installed at Both Ends of a Transmission Line in a High-Speed Reclose Scheme

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 4.180*.

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 4.103*). Note the built-in 2-cycle qualification of the synchronism-check voltages shown in *Figure 4.82*.

EXAMPLE 4.22 Settings Example 2

Refer to subsection Synchronism-Check Elements on page 4.131. Also refer to Figure 4.105 and Figure 4.106.

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 4.139, 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 4.109 and Table 4.66), the reclosing relay is then driven to the lockout state.

Reclose Logic

Note that input:

Reclosing Relay Open Interval Time-Out

in *Figure 4.104* is the logic input that is qualified by SELOGIC control equation setting 79CLS, and then propagated on to the close logic in *Figure 4.103* 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 4.104*. 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 4.174*) 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 4.164*).

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 4.107 explains in general the different states of the reclosing relay and its operation.

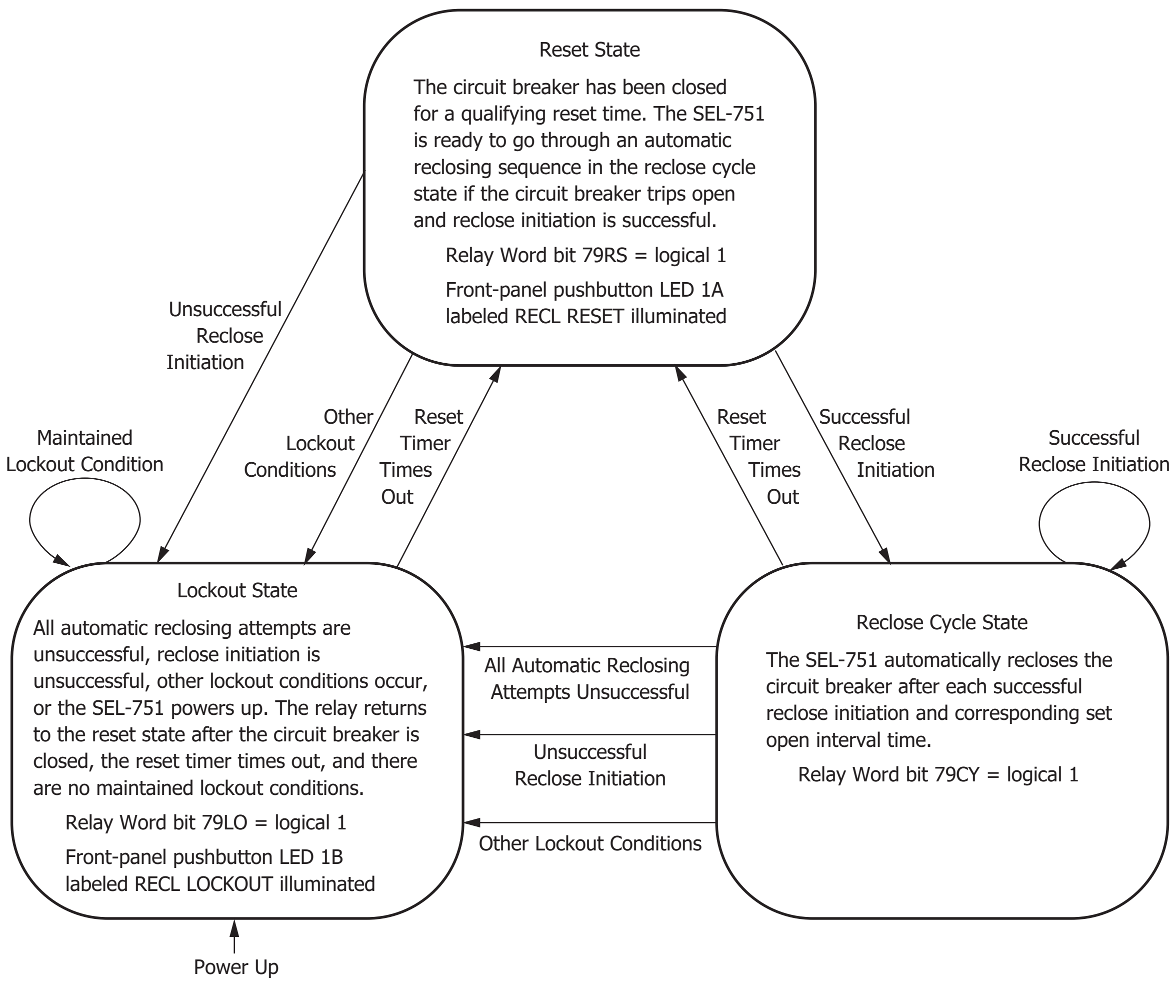


Figure 4.107 Reclosing Relay States and General Operation

Table 4.64 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 4.64*) 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 4.105*).
- 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 4.177*).
- 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 4.179*].
- The close failure timer (setting CFD) times out (see *Figure 4.103*).
- 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 4.104*** and top of *Figure 4.105*) 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 7.64* for more information on the **OPEN** command. Also, see *Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, Respectively) on page 4.179*.

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 4.64*).
- 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 4.103*) 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 4.65*.

Table 4.65 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 4.65*, 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 4.65*, 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 4.108*.

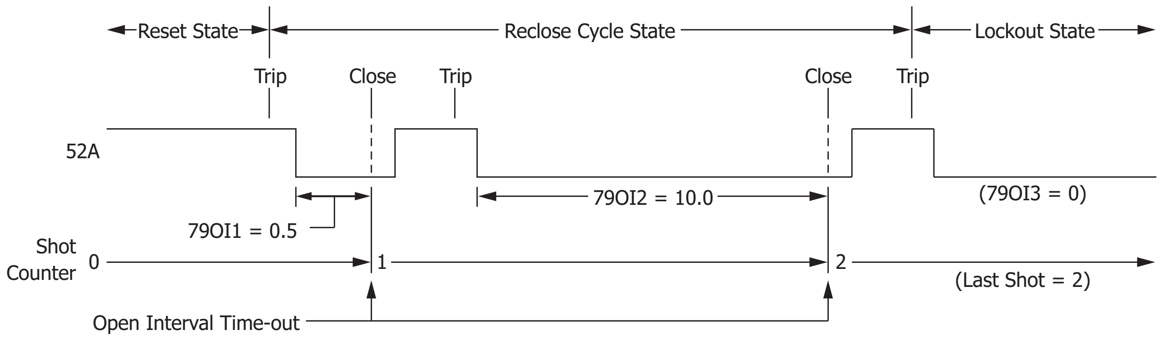


Figure 4.108 Reclosing Sequence From Reset to Lockout With Example Settings

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 4.180*).

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 7.79* 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 4.160* 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 4.183*) 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 4.103*).

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 4.173*).

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 4.182*).

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 4.180*).

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 4.182*.

Reclosing Relay Shot Counter

Refer to *Figure 4.108*. 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 4.175*). The shot counter resets back to shot = 0 when the reclosing relay returns to the Reset State.

Table 4.66 Shot Counter Correspondence to Relay Word Bits and Open Interval Times (Sheet 1 of 2)

Shot	Corresponding Relay Word Bit	Corresponding Open Interval
0	SH0	79OI1
1	SH1	79OI2

Table 4.66 Shot Counter Correspondence to Relay Word Bits and Open Interval Times (Sheet 2 of 2)

Shot	Corresponding Relay Word Bit	Corresponding Open Interval
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 4.183*).

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) 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 4.23 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 autoreclose cycle 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 autoreclose 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 4.24 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 4.101).

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 4.103 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 autoreclose 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 4.24*, 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 4.179*).
- ➤ Reclose initiation is by the breaker contact opening (e.g., 79RI := NOT 52A—refer to *Additional Settings Example on page 4.177*).

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 4.176*).

EXAMPLE 4.25 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 4.64.

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 4.26 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 4.66*). 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 4.172*).

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 4.66*). 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 4.172*).

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 4.176*).

EXAMPLE 4.27 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 4.28 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 4.67 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 4.67, 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 4.29 Additional Settings Example 2

If you use the SEL-751 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 4.109.

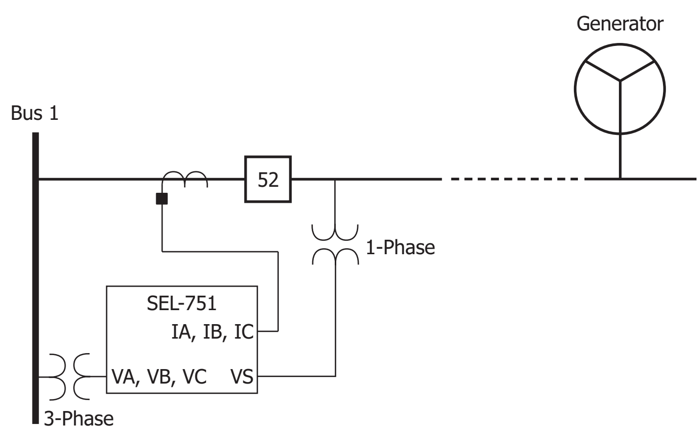


Figure 4.109 Reclose Blocking for Islanded Generator

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 4.30 Additional Settings Example 3

Refer to Figure 4.106 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 4.176*).

EXAMPLE 4.31 Factory Settings Example

The reset timing is blocked if Relay Word bit TRIP is asserted, regardless of the reclosing relay state:

79BRS := **TRIP**

EXAMPLE 4.32 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 4.107 and Table 4.64).

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 4.33 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.

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 4.110*) 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 4.183* and *Additional Settings Example 2 on page 4.185*.

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 4.182*).

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 4.34 Factory Settings Example

Sequence coordination is not enabled in the factory settings:

79SEQ := **0**

EXAMPLE 4.35 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 4.110 and Figure 4.111.

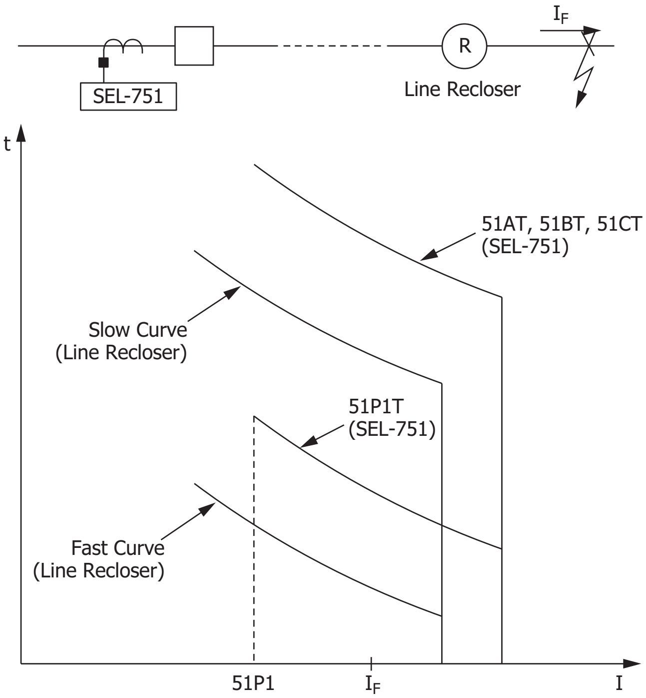
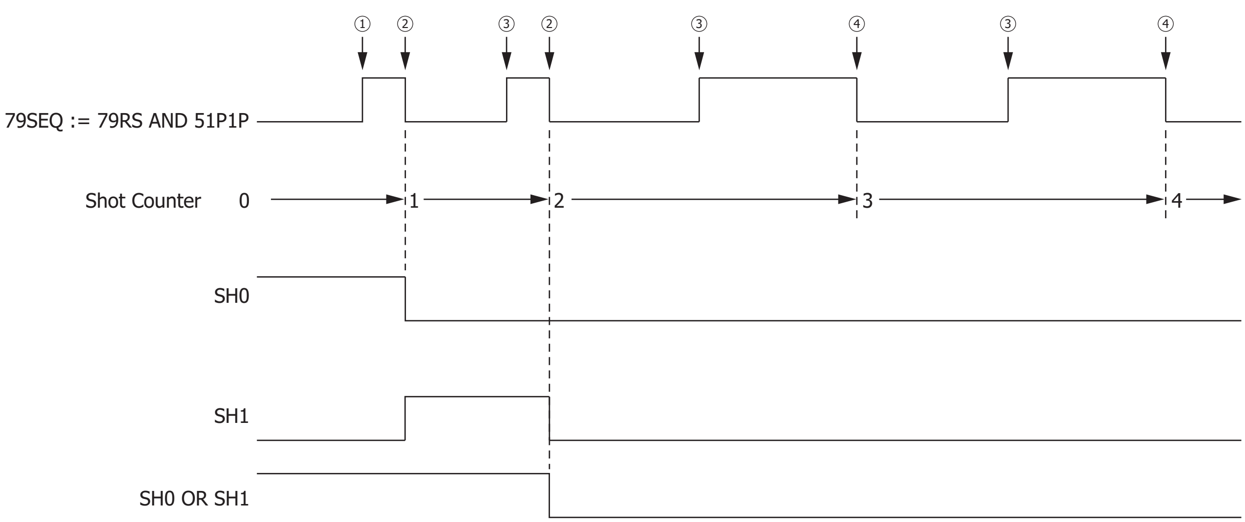


Figure 4.110 Sequence Coordination Between the SEL-751 and a Line Recloser

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 4.111 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 4.110), 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

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.

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**

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 4.36 Additional Settings Example 2

Review preceding Example 1.

Assume that the line recloser in Figure 4.110 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 4.65 and Figure 4.108). 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 4.111). 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**

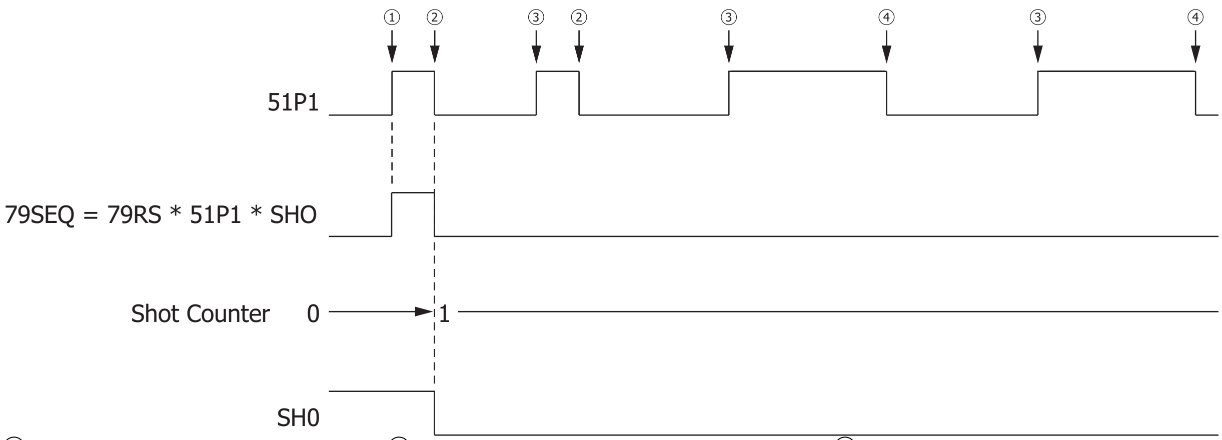
Refer to Figure 4.112.

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 4.110), 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 SHO 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 4.112 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 4.112.

Reclose Supervision Setting (79CLS)

See *Reclose Supervision Logic on page 4.164*.

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 4.68 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 4.68 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 4.113*.

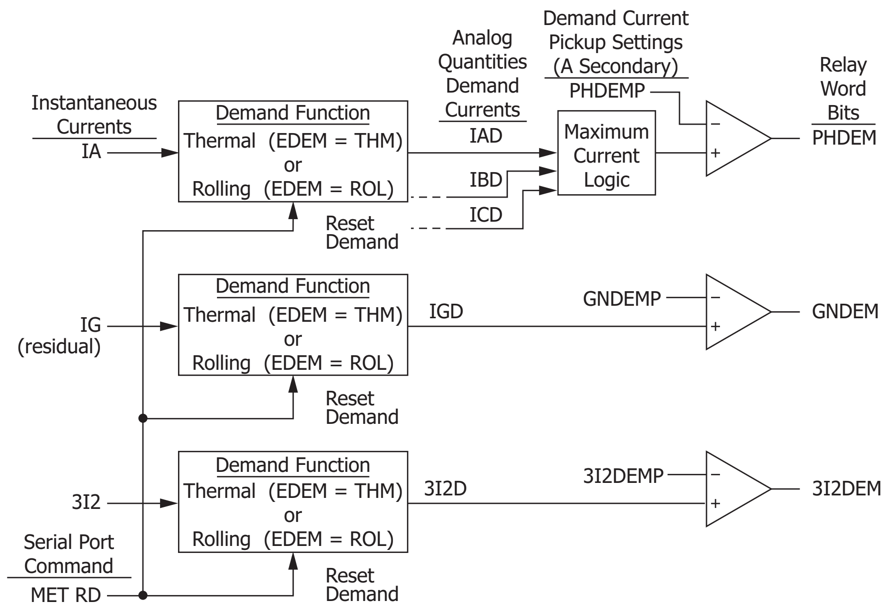


Figure 4.113 Demand Current Logic Outputs

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 4.114* 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”).

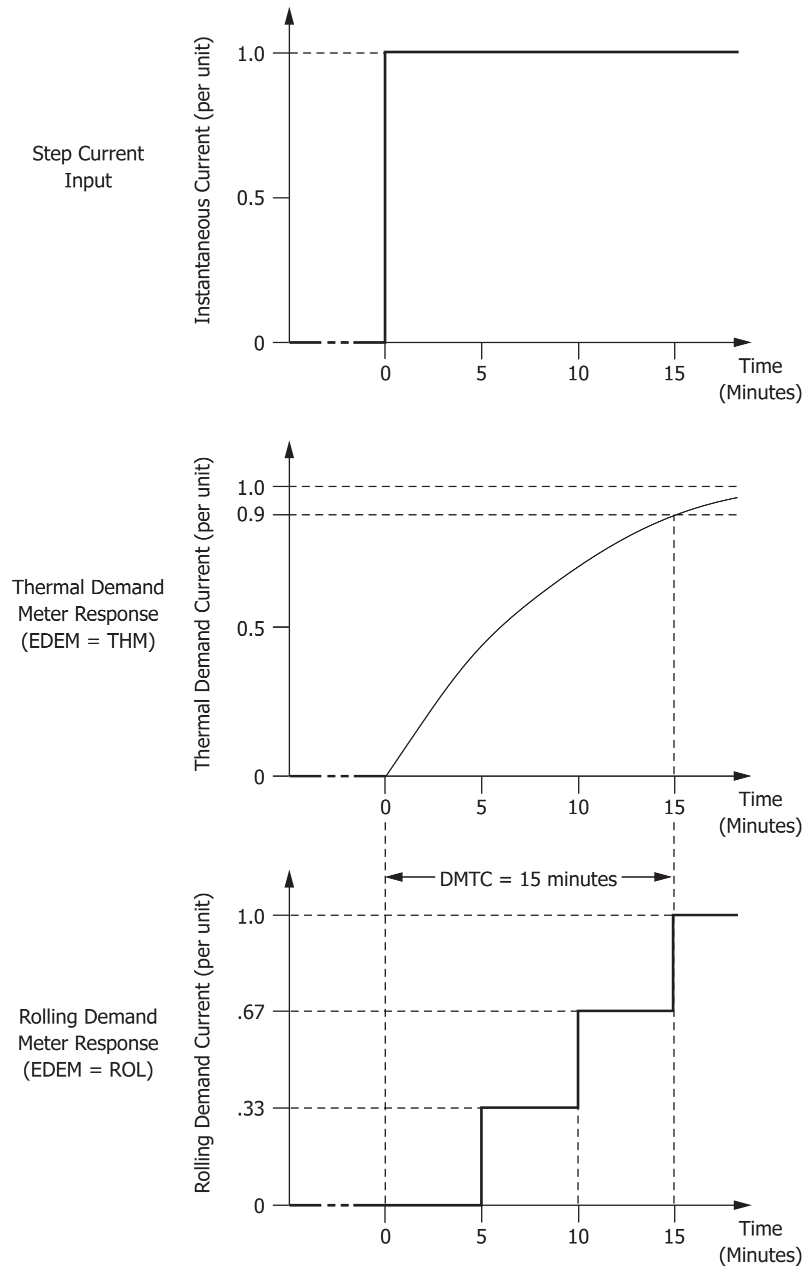


Figure 4.114 Response of Thermal and Rolling Demand Meters to a Step Input (Setting DMTC = 15 minutes)

Thermal Demand Meter Response

The response of the thermal demand meter in *Figure 4.114* (middle) to the step current input (top) is analogous to the series RC circuit in *Figure 4.115*.

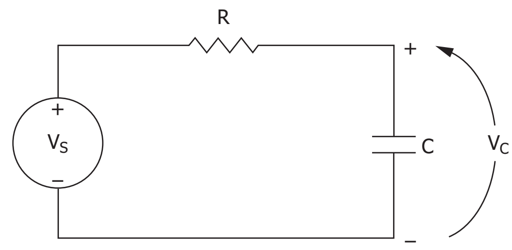


Figure 4.115 Voltage VS Applied to Series RC Circuit

In the analogy:

Voltage VS in *Figure 4.115* corresponds to the step current input in *Figure 4.114* (top).

Voltage VC across the capacitor in *Figure 4.115* corresponds to the response of the thermal demand meter in *Figure 4.114* (middle).

If voltage VS in *Figure 4.115* has been at zero (VS = 0.0 per unit) for some time, voltage VC across the capacitor in *Figure 4.115* 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 4.113* (middle) to the step current input (top).

In general, as voltage VC across the capacitor in *Figure 4.115* 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 4.68*). Note that in *Figure 4.114*, 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 4.114* (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 4.68*). Note in *Figure 4.114*, 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 4.114* 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 4.114* (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 4.69 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.

NOTE: Upon relay initial turn on, Port 1 setting changes, or Logic setting changes, you may have to wait as long as two minutes before an additional setting change can occur. Note that the relay is functional with protection enabled as soon as the **ENABLED** LED comes on (approximately 5–10 seconds from turn on).

Table 4.69 Enable Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
SELOGIC Latches	N, 1–64	ELAT := 4
SV/Timers	N, 1–64	ESV := 5
SELOGIC Counters	N, 1–64	ESC := N
Math Variables[a]	N, 1–64	EMV := N

[a] If a math variable is set equal to NA (e.g., MV01 := NA), it is treated as 0.

Latch Bits

Latch control switches (latch bits are the outputs of these switches) replace traditional latching devices. Traditional latching devices maintain output contact state. The SEL-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 4.116*). 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).

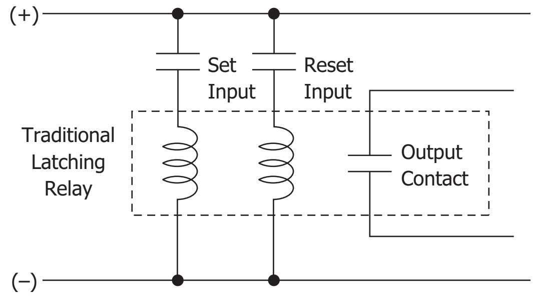


Figure 4.116 Schematic Diagram of a Traditional Latching Device

Sixty-four latch control switches in the SEL-751 provide latching device functionality. *Figure 4.117* shows the logic diagram of a latch switch. The output of the latch control switch is a Relay Word bit LT*n* (*n* = 01–64), called a latch bit.

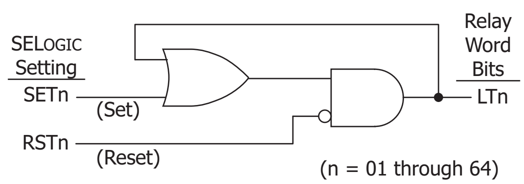


Figure 4.117 Logic Diagram of a Latch Switch

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 64 latches. *Table 4.70* shows the **SET** and **RESET** default settings for Latch 1 through Latch 4. The remaining latches are all set to NA.

Table 4.70 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
⋮	⋮	⋮
SET64	SELOGIC	SET64 := NA
RST64	SELOGIC	RST64 := NA

Latch Bits: Nonvolatile State

Power Loss

The states of the latch bits (LT01–LT64) 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 LT64) are retained, as in the preceding *Power Loss on page 4.193* explanation. If the individual settings change causes a change in SELOGIC control equation settings SET*n* or RST*n* (*n* = 1 through 64), 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 4.118*. Timers SV01T through SV64T in *Figure 4.118* 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 64).

NOTE: Any SELOGIC control equation that contains a Relay Word bit/analog quantity that gets hidden because of a setting change or a configuration change will show up as a `BAD SELOGIC EQUATION`.

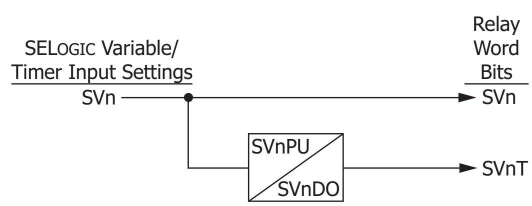


Figure 4.118 SELOGIC Control Equation Variable/Timers SV01/SV01T–SV64T

You can enter as many as 15 elements per SELOGIC control equation, including a total of 14 elements in parentheses (see *Table 4.72* 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 4.72*. Math SELOGIC control equation settings operate on numerical values, using one or more of the Mathematical operators listed in *Table 4.72*. 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 4.37* for an explanation on improving the accuracy of the math operations by managing the processing order.

EXAMPLE 4.37 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 • 100,000) 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 4.37 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.

NOTE: Math variables are reset to zero if the relay loses power because the math variables are stored in volatile memory.

The executed result of a math SELOGIC control equation is stored in a math variable. The storage format of the math variable is a 32-bit fixed point signed integer; 24 bits represent the integer portion, 7 bits represent the fractional portion, and one bit represents the sign. The smallest and largest values a math variable can represent are –16777215.99 and +16777215.99, respectively. If the executed result exceeds these limits, it will be clipped at the limit value. For example, when the MV01 := executed result is –16777219.00, MV01 will be –16777215.99. Similarly, when the MV02 := executed result is +16777238.00, MV02 will be +16777215.99. Because there are only 7 bits available for the fractional portion, the result of multiplication and division with decimals will have lower accuracy than one would expect with a floating point processor. As illustrated by the results of in *Table 4.71*, the results vary from 20 percent at the smallest end of the fractional values to 0.2 percent at the largest. Using scaling factors where possible is recommended to avoid the error introduced by the fixed point processor when multiplying and dividing fractional numbers.

Table 4.71 Math Variable Fractional Multiplication Results (Sheet 1 of 2)

MV01 := 0.01 • 10	Result = 0.08	Error = 20%
MV01 := 0.05 • 10	Result = 0.47	Error = 6.0%
MV01 := 0.10 • 10	Result = 1.02	Error = 2.0%

Table 4.71 Math Variable Fractional Multiplication Results (Sheet 2 of 2)

MV01 := 0.50 • 10	Result = 5.00	Error = 0.0%
MV01 := 0.99 • 10	Result = 9.92	Error = 0.2%

Comments can be added to both Boolean and math SELOGIC control equations by inserting a # symbol. Everything following the # symbol in a SELOGIC control equation is treated as a comment. See *Table 4.73* 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 4.72 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 4.119*.

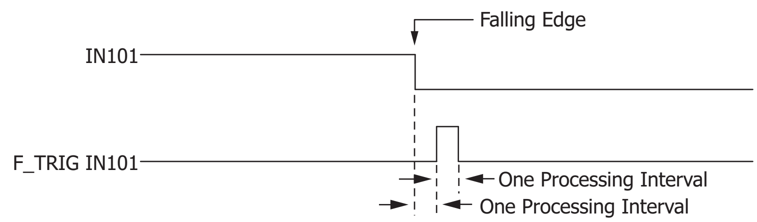


Figure 4.119 Result of Falling-Edge Operator on a Deasserting Input

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

Table 4.73 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* = 01–64) reset to logical 0 after power restoration or a settings change. *Figure 4.120* 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)**

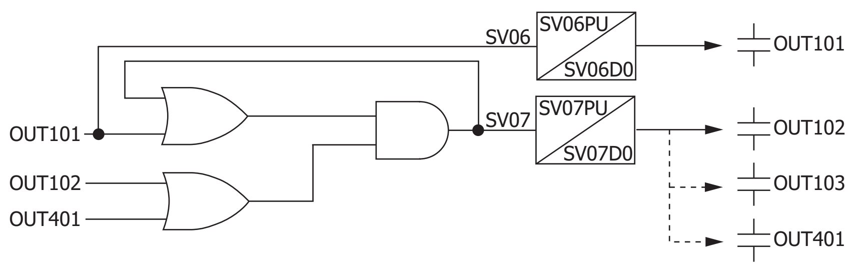


Figure 4.120 Example Use of SELOGIC Variables/Timers

SV/Timers Settings

The SEL-751 includes 64 SELOGIC variables. *Table 4.74* shows the pickup, dropout, and equation settings for SV/Timers.

Table 4.74 SELOGIC Variable Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
SV TIMER PICKUP	0.00–3000.00 sec	SV01PU := 0.00
SV TIMER DROPOUT	0.00–3000.00 sec	SV01DO := 0.00
SV INPUT	SELOGIC	SV01 := NA
SV TIMER PICKUP	0.00–3000.00 sec	SV02PU := 3.00
SV TIMER DROPOUT	0.00–3000.00 sec	SV02DO := 0.00
SV INPUT	SELOGIC	SV02 := PB02
SV TIMER PICKUP	0.00–3000.00 sec	SV03PU := 0.00
SV TIMER DROPOUT	0.00–3000.00 sec	SV03DO := 0.00
SV INPUT	SELOGIC	SV03 := LT03
SV TIMER PICKUP	0.00–3000.00 sec	SV04PU := 0.00
SV TIMER DROPOUT	0.00–3000.00 sec	SV04DO := 0.00
SV INPUT	SELOGIC	SV04 := LT04

Table 4.74 SELOGIC Variable Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
SV TIMER PICKUP	0.00–3000.00 sec	SV05PU := 0.25
SV TIMER DROPOUT	0.00–3000.00 sec	SV05DO := 0.25
SV INPUT	SELOGIC	SV05 := (PB02 OR LT03 OR LT04) AND NOT SV05T
• • •	• • •	• • •
SV TIMER PICKUP	0.00–3000.00 sec	SV64PU := 0.00
SV TIMER DROPOUT	0.00–3000.00 sec	SV64DO := 0.00
SV INPUT	SELOGIC	SV64 := NA

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: The SEL-751 tracks the frequency using either voltage or current. When tracking the frequency, the processing interval varies with the frequency.

NOTE: If setting SCnnCD is set to NA, the entire counter nn is disabled.

NOTE: If setting SCnnCU is set to NA, the counter counts downwards only.

NOTE: SELOGIC counters are reset to zero if the relay loses power because the counters are stored in volatile memory.

SELOGIC counters are up- or down-counting elements, updated every processing interval.

Each counter element consists of one count setting, four control inputs, two digital outputs, and one analog output. *Figure 4.121* shows Counter 01, the first of 64 counters available in the device.

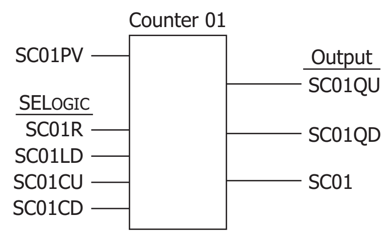


Figure 4.121 Counter 01

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 4.75* describes the counter inputs and outputs, and *Table 4.76* shows the order of precedence of the control inputs.

Table 4.75 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).

Table 4.75 Counter Input/Output Description (Sheet 2 of 2)

Name	Type	Description
SC*nn*R	Active High Input	Reset counter to zero (follows SELOGIC setting)
SC*nn*QU	Active High Output	This Q Up output asserts when the Preset Value (maximum count) is reached (SC*n* = SC*n*PV, *n* = 01 to 64).
SC*nn*QD	Active High Output	This Q Down output asserts when the counter is equal to zero (SC*n* = 0, *n* = 01 to 64).
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 4.76 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 4.122 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.

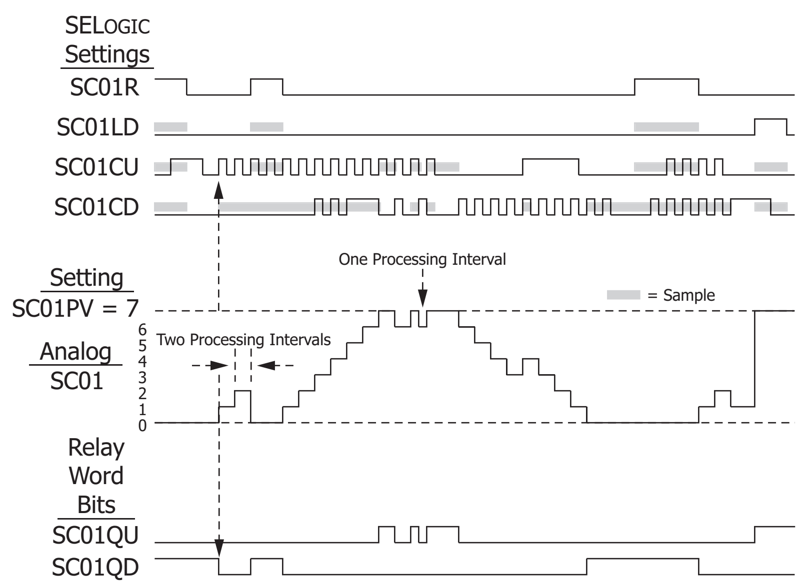


Figure 4.122 Example of the Effects of the Input Precedence

The shaded areas illustrate the precedence of the inputs:

- When SC01R is asserted, the SC01LD input is ignored.
- When SC01R or SC01LD is asserted, rising edges on the SC01CU or SC01CD inputs are ignored.

- When input SC01CU has a rising edge, a rising edge on SC01CD is ignored (unless SC01 is already at the maximum value SC01PV (= 7), in which case SC01CU is ignored, and the SC01CD is processed). An example of this exception appears in the previous diagram, just before the “one processing interval” notation.

A maintained logical 1 state on the SC01CU or SC01CD inputs is ignored (after the rising edge is processed). A rising edge received on the SC01CU or SC01CD inputs is ignored when the SC01R or SC01LD inputs are asserted.

A maintained logical 1 on the SC01CU or SC01CD inputs does not get treated as a rising edge when the SC01R or SC01LD input deasserts. The same operating principles apply for all of the counters: SC01–SC*mm*, where *mm* = the number of enabled counters.

Output Contacts

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: Eight digital outputs for Slot **C** (OUT301–OUT308) are shown. The outputs for Slot **D** (OUT401–OUT408) and Slot **E** (OUT501–OUT508) have similar settings.

Table 4.77 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
OUT301 FAIL-SAFE	Y, N	OUT301FS := N
OUT301	SELOGIC	OUT301 := 0
OUT302 FAIL-SAFE	Y, N	OUT302FS := N
OUT302	SELOGIC	OUT302 := 0
OUT303 FAIL-SAFE	Y, N	OUT303FS := N
OUT303	SELOGIC	OUT303 := 0
OUT304 FAIL-SAFE	Y, N	OUT304FS := N
OUT304	SELOGIC	OUT304 := 0
OUT305 FAIL-SAFE	Y, N	OUT305FS := N
OUT305	SELOGIC	OUT305 := 0
OUT306 FAIL-SAFE	Y, N	OUT306FS := N
OUT306	SELOGIC	OUT306 := 0
OUT307 FAIL-SAFE	Y, N	OUT307FS := N
OUT307	SELOGIC	OUT307 := 0
OUT308 FAIL-SAFE	Y, N	OUT308FS := N
OUT308	SELOGIC	OUT308 := 0

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 2.22* and *Figure 2.23*.

When TRIP output fail-safe is enabled and the **TRIP** contact is appropriately connected (see *Figure 2.26*), 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 4.78 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
51 CURVE SAT	Y, N	51SAT := 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.

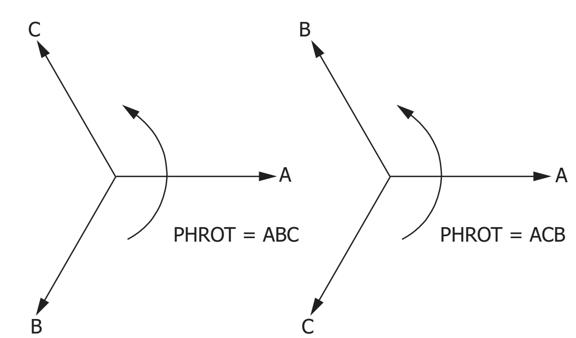


Figure 4.123 Phase Rotation Setting

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 Cutoff for Metering on page 5.14* for more details.

Setting 51SAT := N allows the operating time (tp) curves in *Table 4.20* through *Table 4.22* to use a value of M > 30.

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 4.79 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 4.38*).

EXAMPLE 4.38 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 4.39 Setting MPTXxx With a Specified Location of Analog Quantity

MPTX01 := THE LOAD CURRENT IS %.2f AMPERES

MPAQ01 value = 157.44

Formatted message out when triggered: THE LOAD CURRENT IS 157.44 AMPERES

MPTX01 := THE LOAD CURRENT IS %d AMPERES

MPAQ01 value = 157.44

Formatted message out when triggered: THE LOAD CURRENT IS 157 AMPERES

Multiple Settings Groups

SEL-751 relays have four independent settings groups. Each settings group has complete relay settings and protection SELOGIC settings. The active settings group can be:

- Viewed on the front-panel two-line LCD using the **MAIN** > **Set/Show** > **Active Group** menus, as shown in *Figure 8.21*.
- Viewed using the SEL ASCII serial port **GROUP** command, as described in *Table 7.30*.
- Selected using the SEL ASCII serial port **GROUP *n*** command, as described in *Table 7.30*.
- Selected using SELOGIC control equation settings SS1 through SS4, as shown in *Table 4.80*.

If SELOGIC control equations SS1–SS4 are defined and evaluate to logical 1, they have priority over the **GROUP *n*** command to select the active settings group. If the SELOGIC control equations are defined but evaluate to logical 0, or if they are not defined, the **GROUP *n*** command can be used to select the active settings group.

Active Settings Group Indication

Only one settings group can be active at a time. Relay Word bits SG1 through SG4 indicate the active settings group. For example, if settings Group 3 is the active settings group, Relay Word bit SG3 is asserted to logical 1 and Relay Word bits SG1, SG2, and SG4 are deasserted to logical 0.

Active Settings Group Selection Via SELOGIC Control Equations

The Global settings class contains the SELOGIC control equation settings SS1–SS4, as shown in *Table 4.80*.

Table 4.80 Settings 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

As an example of how these settings operate, assume that the active settings group is settings Group 3. The corresponding Relay Word bit, SG3, is asserted to logical 1 to indicate that settings Group 3 is the active settings group.

When settings Group 3 is the active settings group, setting SS3 has priority. If setting SS3 is asserted to logical 1, settings Group 3 remains the active settings group, regardless of the activity of settings SS1, SS2, or SS4. If settings SS1 through SS4 all deassert to logical 0, settings Group 3 remains the active settings group.

If the active settings Group 3 SELOGIC control equation SS3 deasserts to logical 0 and one of the other settings (e.g., SS1) asserts to logical 1, the relay switches the active settings group from settings Group 3 to one of the other settings groups (e.g., settings Group 1) after the qualifying time setting TGR (Global setting).

In this example, if multiple SS*n* assert after SS3 deasserts to logical 0, the order of switching follows the first SS*n* that is set in a priority order of 1 through 4.

Active Settings Group Changes

The relay is disabled for less than one second while it processes the active settings group change. Relay elements, timers, and logic are reset, unless otherwise indicated in the specific logic description. For example, local bit (LB01–LB32), remote bit (RB01–RB64), and latch bit (LT01–LT64) states are retained during an active settings group change. The output contacts do not change state until the relay enables in the new settings group and the SELOGIC control equations are processed to determine the output contact status for the new group. After a group change, an automatic message is shown on the front panel and sent to any serial port that has setting AUTO := Y.

Active Setting: Nonvolatile State

Power Loss

The active settings group is retained if power to the relay is lost and then restored. If a settings group is active (e.g., settings Group 3) when power is lost, the same settings group is active when power is restored.

Settings Change

If individual settings are changed for the active settings group or one of the other settings groups, the active settings group is retained, much like in the preceding explanation. If individual settings are changed for a settings group other than the active settings group, there is no interruption of the active settings group, so the relay is not momentarily disabled. If the individual settings change causes a change in one or more SELOGIC control equation settings SS1–SS4, the active settings group can be changed, subject to the newly enabled SS1–SS4 settings.

LEA Ratio Correction Settings

Table 4.81 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 4.82 LEA Ratio and Phase Correction Settings for Phase Current

Setting Prompt	Setting Range	Setting Name := Factory Default
IA RATIO CORRECT	0.900–1.100	IARCF := 1.000
IB RATIO CORRECT	0.900–1.100	IBRCF := 1.000
IC RATIO CORRECT	0.900–1.100	ICRCF := 1.000
IA ANGLE CORRECT	–10.0 to 10.0 deg	IAPAC := 0.0
IB ANGLE CORRECT	–10.0 to 10.0 deg	IBPAC := 0.0
IC ANGLE CORRECT	–10.0 to 10.0 deg	ICPAC := 0.0

Table 4.83 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, VSRCF, IARCF, IBRCF, and ICRCF—compensate for irregularities (on a per-phase basis) of voltage and current LEA inputs. The LEA phase correction (PAC) settings—VAPAC, VBPAC, VCPAC, VSPAC, IAPAC, IBPAC, and ICPAC—compensate for the phase shift on the corresponding channels bringing the voltages and currents to the SEL-751. Refer to *Ratio Correction Factors (RCF) for LEA Inputs on page 4.11* for the discussion on the RCF and PAC settings. Note that the PAC setting does not affect the synchrophasors or the related metering (MET PM) or the raw signals in the COMTRADE event report. For phase angle correction of the synchrophasor data, use the synchrophasor compensation factor settings VCOMP, VSCOMP, and ICOMP. Refer to *Settings for Synchrophasors on page K.4* for more information on synchrophasor compensation factors.

Synchrophasor Measurement

The SEL-751 provides Phasor Measurement Control Unit (PMCU) capabilities when connected to an IRIG-B time source. See *Appendix K: Synchrophasors* for the description and *Table K.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 K: Synchrophasors* for the description and *Table K.1* for the settings. For SNTP applications, refer to *Simple Network Time Protocol (SNTP) on page 7.16*. For PTP applications, refer to *Precision Time Protocol (PTP) on page 7.19*. For time update from a DNP Master, see *Time Synchronization on page D.9*.

Table 4.84 shows the time and date management settings that are available in the Global settings.

Table 4.84 Time and Date Management Settings

Setting Description	Setting Range	Setting Name := Factory Default
IRIG-B CONTROL BITS DEFINITION	NONE, C37.118	IRIGC := NONE
OFFSET FROM UTC	–24.00 to 24.00 hours, rounds up to nearest 0.25 hour	UTC_OFF := 0.00
MONTH TO BEGIN DST	OFF, 1–12	DST_BEGM := OFF
WEEK OF THE MONTH TO BEGIN DST	1–3, L	DST_BEGW := 2
DAY OF THE WEEK TO BEGIN DST	SUN, MON, TUE, WED, THU, FRI, SAT, SUN	DST_BEGD := SUN
LOCAL HOUR TO BEGIN DST	0–23	DST_BEGH := 2
MONTH TO END DST	1–12	DST_ENDM := 11
WEEK OF THE MONTH TO END DST	1–3, L	DST_ENDW := 1
DAY OF THE WEEK TO END DST	SUN, MON, TUE, WED, THU, FRI, SAT, SUN	DST_ENDD := SUN
LOCAL HOUR TO END DST	0–23	DST_ENDH := 2

IRIGC

IRIGC defines whether IEEE C37.118 control bit extensions are in use. Control bit extensions contain information such as leap second, UTC, daylight-saving time (DST), 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 7.16* for a description and *Table 7.5* for the settings.

Precision Time Protocol (PTP)

The SEL-751 Port 1 (Ethernet port) supports PTP. See *Precision Time Protocol (PTP) on page 7.19* for a description and *Table 7.7* for the settings.

PTP Timekeeping

Using PTP, the SEL-751 can only be synchronized by a grandmaster clock on the PTP timescale, not an arbitrary (ARB) timescale. With the ARB timescale, the epoch is set by an administrative procedure and can change at any time during normal operation. The PTP timescale uses the PTP epoch of January 1, 1970 00:00:00 International Atomic Time (TAI), which corresponds to December 31, 1969 23:59:51.999918 UTC. The unit of time is the SI second and accounts for leap seconds. As of June 2016, TAI is 37 seconds ahead of UTC.

When the SEL-751 is synced to a PTP master and the UTC offset information from the PTP master is valid, the PTP master tells the SEL-751 when to go into daylight-saving time (DST) and when to exit DST. The PTP master also provides the UTC offset at this time. Otherwise, the SEL-751 uses the internal values for DST and UTC offset.

The offset between TAI and UTC is included in the PTP Announce message, along with a flag that indicates whether or not the offset is valid. The SEL-751 uses the offset sent by the Grand Master (GM) clock to determine UTC regardless of validity. Because of this, all SEL devices and other slave devices that share this behavior (that are synchronized with the GM) retain relational accuracy with each other even if, in certain cases, the GM is incorrect in relation to UTC.

The Announce message may also include the current TAI to Local offset value (required in the Power, C37.238 profile). In accordance with IEEE 1588-2008 16.3.3.4, this value must include the TAI to UTC offset to reflect local time at the node, or slave device. If the SEL-751 receives a TAI to Local offset value that does not include the TAI to UTC offset, it may incorrectly calculate UTC and Local time. Also, if the Announce message does not include the TAI to Local offset value, the SEL-751 uses its configured Time and Date Management Settings (UTC_OFF and DST_BEGM) to calculate local time. This is one reason that the SEL-751 Time and Date Management Settings must match the settings in the GM clock. Otherwise, devices that are synchronized may have issues with time-alignment.

SEL-751 relays only synchronize to clocks that serve TAI and they do not support PTP in SWITCHED NETMODE. Additionally, the maximum synchronization interval that SEL-751 relays support is 16 seconds.

PTP must be enabled in the Port 1 settings (EPTP := Y). The SEL-751 must be connected to a network containing an appropriate PTP master and all intervening switches must be IEEE 1588-aware. For SEL-751 relays, PTP is only available on Ethernet Ports 1A and 1B. See *Precision Time Protocol (PTP) on page 7.19* for more information on configuring the relay and the Ethernet network for PTP.

PTP Over PRP Networks

In SEL-751 relays, PTP over PRP is based on a best master clock algorithm. After the relay synchronizes with a specific port, the relay does not switch to the alternate time until its present source deviates from it by at least 250 ns. The relay does not switch to alternative time if the current time source has 250 ns accuracy or better.

Breaker Failure Settings

NOTE: The SEL-751 does not support subsidence current detection. Apply caution when using very low 50BFG setting values.

Table 4.85 Breaker Failure Settings

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
RES CUR DETECTOR	OFF, 0.25–10.00 A[b]	50BFG := OFF
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
BF SEAL-IN DELAY	OFF, 0.00–2.00 sec	BFISID := 0.00
BF RETRIP DELAY	OFF, 0.00–2.00 sec	BFRTD := 0.05
BF TRIP EQUATION	SELOGIC	BFTR := 0
BF UNLATCH EQN	SELOGIC	BFULTR := 0

[a] Setting ranges and default values shown are for 5 A nominal CT rating. Divide by 5 for 1 A CTs.
[b] Setting ranges 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 4.124*). In the default breaker failure logic, assertion of Relay Word bit TRIP starts the BFD timer if any of the phase currents remain greater than the 50BFP setting. If any of the phase currents remain greater than the threshold (50BFP) for longer than the BFD delay setting, Relay Word bit BFT asserts. Use the BFT Relay Word bit to operate a contact output to trip appropriate backup breakers.

For added security against inadvertent breaker failure initiations (e.g. wiring or testing errors), program BFRTD to a setting other than OFF. BFRTD (Breaker Failure Retrip Delay) begins timing when BFI and one of the supervisory elements, 50BF, 50BFG (if enabled), or 52A (if enabled), or the aux timer (if configured) asserts. Relay Word bit BFRT asserts when BFRTD times out. Account for any added delay to BFRTD in the BFD setting. Program BFRT in the TR SELOGIC control equation to issue a retrip to the breaker.

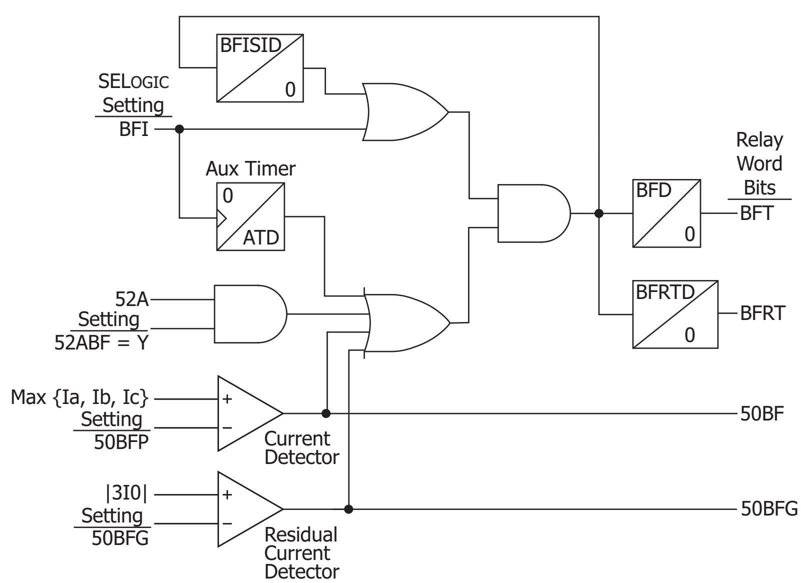


Figure 4.124 Breaker Failure Logic

Changing the BFI or the 52ABF, ATD, 50BFP, 50BFG, BFISID, or BFRTD settings will modify the default breaker failure logic.

- ➤ Set BFI in conjunction with BFISID per your application needs. If breaker failure initiation is not desired on manual trip, set BFI to the protective element Relay Word bits used in the TR SELOGIC equation (e.g., BFI := 50P1T OR 51P1T OR...).
- ➤ Set BFISID := 0 to achieve immediate seal-in, especially when breaker failure is initiated on the rising edge of the input (e.g. BFI := R_TRIG TRIP). To bias your application towards security, set BFISID to the desired delay or OFF with BFI set to the actual input instead of the rising edge (e.g., BFI := TRIP).
- ➤ Set 50BFG to operate the breaker failure logic on residual ground current check, in addition to phase current checks. This can be used in applications when a weak source drives a fault.
- ➤ Set 52ABF := Y for applications where the fault currents for protective trips are too low for the current detector to operate.
- ➤ Aux timer (ATD) can be used to start the BFD timer for dual breaker applications where the current detector may not operate on the initiation of the logic due to distribution of the fault current between the breakers. If used, the ATD timer must be set longer than the normal clearing time of the adjacent breaker to allow the current to redistribute to this breaker after the adjacent breaker opens. For secure operation, set the ATD timer shorter than the BFD timer.
- ➤ BFRTD may be set to provide a security time delay for a retrip attempt of the breaker.

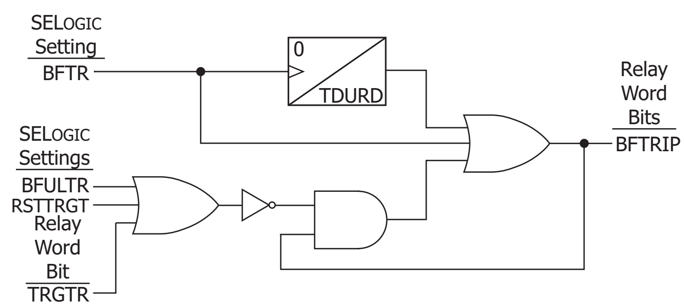


Figure 4.125 Breaker Failure Trip Logic

Include Relay Word bit BFT in the SELOGIC control equation BFTR (breaker failure trip equation), if you want to use the breaker failure trip logic shown in *Figure 4.125*. When BFTR evaluates to logical 1, Relay Word bit BFTRIP asserts and seals in. Include BFTRIP in a contact output equation to trip backup breakers via an auxiliary tripping relay, or use multiple contact outputs to direct trip adjacent breakers to clear the zone. For example,

OUT406 = BFTRIP

Relay Word bit TRGTR and SELOGIC control equations BFULTR and RSTTRGT reset BFTRIP. The minimum trip duration of BFTRIP is controlled by Group setting TDURD. See *Trip/Close Logic on page 4.160* for a description of minimum trip duration timers, trip unlatch conditions, and operation of Relay Word bit TRGTR.

The breaker failure logic does not automatically trigger an event report. Modify the SELOGIC event report trigger equation ER to trigger an event when a breaker failure trip occurs. For example:

ER = R_TRIG 51P1P OR R_TRIG 51G1P OR R_TRIG BFTRIP OR…

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 4.86 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.

NOTE: The 50NAFP setting is not available with the 0.2 A neutral channel option.

Table 4.86 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).

The arc-flash overcurrent elements use raw A/D converter samples, and process them 16 times per cycle. Individual samples are compared with the setting threshold as shown in *Figure 4.126*, 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.

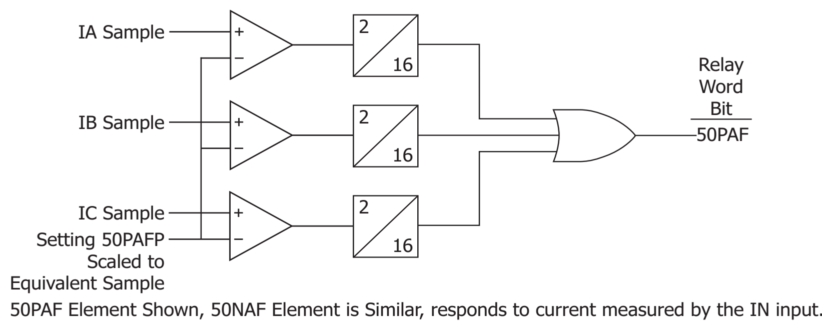


Figure 4.126 Arc-Flash Instantaneous Overcurrent Element Logic

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 4.87* 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 4.88*. 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 4.87 Arc-Flash Time-Overlight Settings (Sheet 1 of 2)

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

Table 4.87 Arc-Flash Time-Overlight Settings (Sheet 2 of 2)

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

NOTE: The AOUTSLOT setting is meant to be used with elements that are processed at 1/16 of a power system cycle. If elements processed at 1/4 of the power system cycle are assigned to an output equation and the corresponding output is selected in the AOUTSLOT setting, the element will chatter in the SER.

The default processing interval in the SEL-751 is 1/4 of the power system cycle. However, to obtain faster arc-flash protection, you can select as many as 4 outputs to be processed every 1/16 of a power system cycle. Use the setting AOUTSLOT to select these outputs. For instance, if Slot **C** 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 4.127* shows the TOL element logic diagram. The Relay Word bits corresponding to these OUT*xxx* SELOGIC control equations, along with all of the TOL, 50PAF, and 50NAF bits, are processed at 1/16 of a power system cycle for the SER.

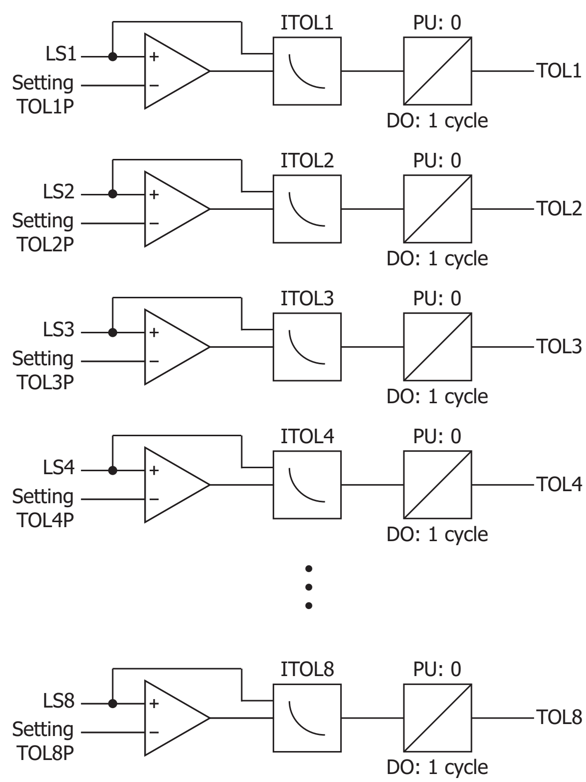


Figure 4.127 Inverse Time-Overlight Element Logic

Figure 4.128 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 1/4 of a power system cycle.

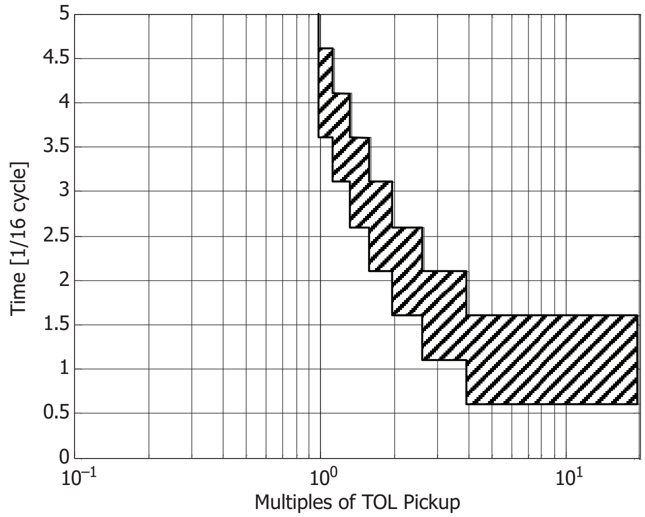


Figure 4.128 TOL Element Inverse Curve Characteristic

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 4.88*. 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 4.88 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 4.126* and *Figure 4.127*) are: 50PAF, 50NAF, TOL1, TOL2, TOL3, TOL4, TOL5, TOL6, TOL7 and TOL8.

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).

As described earlier, you select as many as four 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 4.77*, 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 4.63* and *Figure 4.101* 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 4.40 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 **C** 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 4.41 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 **C** 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 4.129*. Variable *x* displays the slot position (**3** through **5**), and variable *y* displays the transducer (analog) input number (1 through 4 or 8).

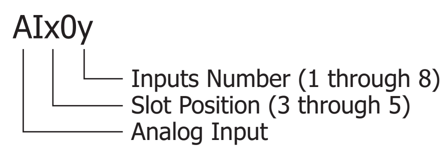


Figure 4.129 Analog Input Card Adaptive Name

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 **C**. 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 2.5* 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 4.89 summarizes the steps and describes the settings we carry out in this example.

Table 4.89 Summary of Steps

	Step	Activity	Terse Description
General	1	SET G AI301NAM	Access settings for INPUT 1
	2	TX_TEMP	Enter a Tag name
	3	I	Select type of analog input; “I” for current
Transducer High/Low Output	4	4	Enter transducer low output (LOW IN VAL)
	5	20	Enter transducer high output (HI IN VAL)
Level	6	Degrees C	Enter Engineering unit
	7	–50	Enter Engineering unit value LOW
	8	150	Enter Engineering unit value HIGH
Low Warning/ Alarm	9	OFF	Enter LOW WARNING 1 value
	10	OFF	Enter LOW WARNING 2 value
	11	OFF	Enter LOW ALARM value
High Warning/ Alarm	12	65	Enter HIGH WARNING 1 value
	13	95	Enter HIGH WARNING 2 value
	14	105	Enter HIGH ALARM value

NOTE: The AIxOyNAM setting cannot accept the following and issues the Invalid Element message:
- Analog Quantities
- Duplicate Names
- Other AI Names

Because the analog card is in Slot **C**, type **SET G AI301NAM <Enter>** to go directly to the setting for Slot **C**, 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 4.130*. 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      ? 105 <Enter>
AI 302 Settings
AI302 TAG NAME (8 characters)
AI302NAM:= AI302
? END  <Enter>
Save changes (Y,N)? Y <Enter>
Settings Saved
=>>
```

Figure 4.130 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 4.90 shows the setting prompt, setting range, and factory-default settings for an analog input card in Slot **C**. 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 4.90 Analog Input Card Settings in Slot C

Setting Prompt	Setting Range	Setting Name := Factory Default
AI301 TAG NAME	8 characters 0–9, A–Z, _	AI301NAM := AI301
AI301 TYPE	I, V	AI301TYP := I
AI301 LOW IN VAL	–20.480 to +20.480 mA	AI301L := 4.000
AI301 HI IN VAL	–20.480 to +20.480 mA	AI301H := 20.000
AI301 LOW IN VAL	–10.240 to +10.240 V	AI301L := 0.000[a]
AI301 HI IN VAL	–10.240 to +10.240 V	AI301H := 10.000[a]
AI301 ENG UNITS	16 characters	AI301EU := mA
AI301 EU LOW	–99999.000 to +99999.000	AI301EL := 4.000
AI301 EU HI	–99999.000 to +99999.000	AI301EH := 20.000
AI301 LO WARN 1	OFF, –99999.000 to +99999.000	AI301LW1 := OFF
AI301 LO WARN 2	OFF, –99999.000 to +99999.000	AI301LW1 := OFF
AI301 LO ALARM	OFF, –99999.000 to +99999.000	AI301LAL := OFF
AI301 HI WARN 1	OFF, –99999.000 to +99999.000	AI301HW1 := OFF
AI301 HI WARN 2	OFF, –99999.000 to +99999.000	AI301HW2 := OFF
AI301 HI ALARM	OFF, –99999.000 to +99999.000	AI301HAL := OFF

[a] Voltage setting range for a voltage transducer, 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 4.131* shows the *x* and *y* variable allocation for the analog output card.

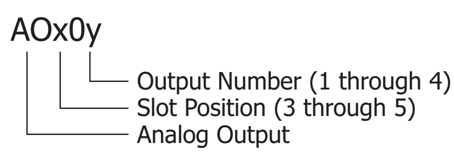


Figure 4.131 Analog Output Number Allocation

For an analog input/output card in Slot C, setting AO301AQ identifies the analog quantity we assign to Analog Output 1 (when set to OFF, the device hides all associated AO*x*0*y* settings and no value appears on the output). You can assign any of the analog quantities listed in *Appendix M: Analog Quantities*.

Table 4.91 shows the setting prompt, setting range, and factory-default settings for an analog card in Slot C.

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 4.91 Analog Output Card Settings in Slot C (Sheet 1 of 2)

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

Table 4.91 Analog Output Card Settings in Slot C (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
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 4.42 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 M: 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 4.132*. Note that the AO301 channel has to be configured as a "current analog output" channel (refer to *Figure 2.6* through *Figure 2.8*).

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 4.132 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 5.18* 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 4.133 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 4.133*, 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).

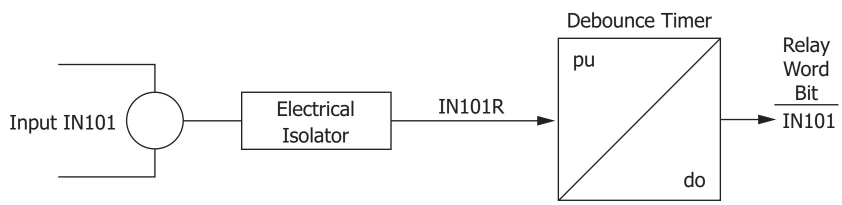


Figure 4.133 DC Mode Processing

AC Mode Processing (AC Control Voltage)

Figure 4.134 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.

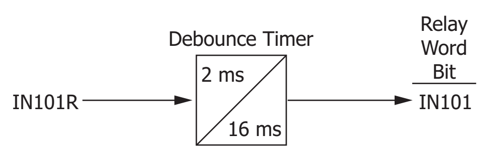


Figure 4.134 AC Mode Processing

Figure 4.135 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 4.135*). If IN101R deasserts (points marked 2 in *Figure 4.135*) 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.

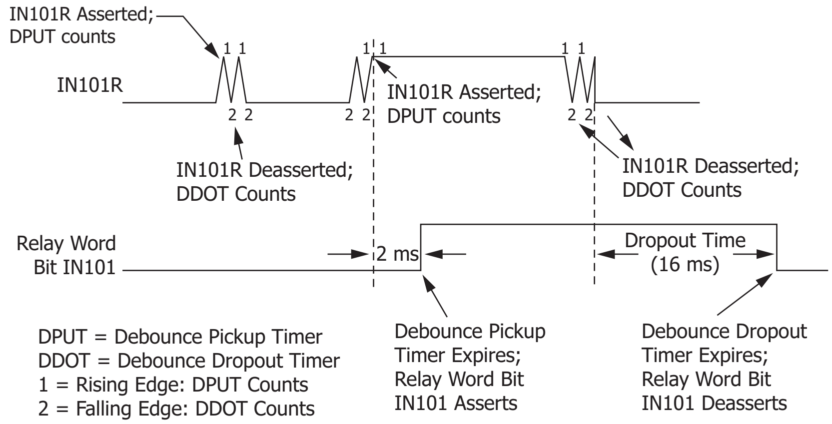


Figure 4.135 Timing Diagram for Debounce Timer Operation When Operating in AC Mode

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 4.92 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 4.92 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 4.101* 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 4.113* for the demand current logic diagram.

Table 4.93 Data Reset Settings (Sheet 1 of 2)

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

Table 4.93 Data Reset Settings (Sheet 2 of 2)

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

Access Control

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

NOTE: Do not set the maximum access level setting MAXACC := ACC on all ports at the same time when you are using the DSABLSET setting. This locks you out from editing settings.

The DSABLSET setting defines conditions for disabling all setting changes from the front-panel interface. To disable setting changes from the front-panel interface, assign 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 4.94* shows the prompt, range, and factory-default name for this setting.

Table 4.94 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 4.95* 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 2.28* and *IRIG-B on page 7.8* for additional information.

Table 4.95 Time Synchronization Source Setting

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

Disconnect Control Settings

The SEL-751 supports control of as many as eight two-position and two three-position disconnects. For the disconnect settings and logic, refer to *Disconnect Control Settings on page 9.2*. The SEL-751 with the touchscreen display also provides you with the ability to design detailed single-line diagrams and display the breaker and disconnect statuses. Refer to *Table 9.5* for typical disconnect symbols available for display on the bay screens. For the settings related to bay control disconnect symbols, refer to *Table 9.7* and the corresponding description.

Local/Remote Control

The SEL-751 supports local/remote control of breakers and disconnects. For the settings related to the local/remote control function, refer to *Local/Remote Control on page 9.7*. For breaker control via front-panel pushbuttons, refer to *Front-Panel Operator Control Pushbuttons on page 8.16*. 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/Disconnect Control Via Touchscreen on page 9.8*.

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 4.96* through *Table 4.101* for the port settings. See the appropriate appendix for additional information on communications protocols (DNP3, Modbus, EtherNet/IP, IEC 61850, IEC 60870-5-103, DeviceNet, MIRRORED BITS, and Synchrophasors).

The EPORT and MAXACC settings provide you with access controls for the corresponding port. Setting EPORT to N disables the port and hides the remaining port settings. The MAXACC setting selects the highest access level for the port.

PORT F

Table 4.96 Front-Panel Serial Port Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PORT	Y, N	EPORT := Y
PROTOCOL	SEL, MOD, EVMSG[a], PMU	PROTO := SEL
MAXIMUM ACCESS LEVEL	1, 2, C	MAXACC := 2
SPEED	300–38400 bps	SPEED := 9600
DATA BITS	7, 8 bits	BITS := 8
PARITY	O, E, N	PARITY := N
STOP BITS	1, 2 bits	STOP := 1
PORT TIME-OUT	0–30 min	T_OUT := 5
HDWR HANDSHAKING	Y, N	RTSCTS := N
LANGUAGE	ENGLISH, SPANISH	LANG := ENGLISH
SEND AUTOMESSAGE	Y, N	AUTO := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

[a] When PROTO := EVMSG, the relay uses the settings BITS = 8, PARITY = N, and STOP = 1, regardless of any user-entered settings.

PORT 1

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

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 other protocols.

Table 4.97 Ethernet Port Settings (Sheet 1 of 3)

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PORT	Y, N	EPORT := Y
ENABLE ETHERNET FIRMWARE UPGRADE	Y, N	EETHFWU := N
IP ADDRESS	zzz.yyy.xxx.www	IPADDR := 192.168.1.2
SUBNET MASK	15 characters	SUBNETM := 255.255.255.0
DEFAULT ROUTER	15 characters	DEFRTR := 192.168.1.1
ENABLE TCP KEEP-ALIVE	(Y, N)	ETCPKA := Y
TCP KEEP-ALIVE IDLE RANGE	1–20 sec	KAIDLE := 10

Table 4.97 Ethernet Port Settings (Sheet 2 of 3)

Setting Prompt	Setting Range	Setting Name := Factory Default
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 TIMEOUT	1–30 min	TIDLE := 15
FAST OP MESSAGES	Y, N	FASTOP := N
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 61850 MODE/BEHAVIOR CONTROL	Y, N	E850MBC := N
ENABLE GOOSE TX IN OFF MODE	Y, N	EOFFMTX := N
ENABLE MODBUS SESSIONS	0–2	EMOD := 0
MODBUS MASTER IP ADDRESS	zzz.yyy.xxx.www[a]	MODIP1 := 0.0.0.0
MODBUS MASTER IP ADDRESS	zzz.yyy.xxx.www[a]	MODIP2 := 0.0.0.0
MODBUS TCP PORT 1	1–65534	MODNUM1 := 502
MODBUS TCP PORT 2	1–65534	MODNUM2 := 502
MODBUS TIMEOUT 1	15–900 sec	MTIMEO1 := 15
MODBUS TIMEOUT 2	15–900 sec	MTIMEO2 := 15
ENABLE HTTP SERVER	Y, N	EHTTP :=Y

NOTE: The Telnet LANG setting also applies to the web server interface.

Table 4.97 Ethernet Port Settings (Sheet 3 of 3)

Setting Prompt	Setting Range	Setting Name := Factory Default
HTTP MAXIMUM ACCESS LEVEL	1, 2	HTTPACC := 2
TCP/IP PORT	1–65535	HTTPPORT := 80
HTTP CONNECT BANNER	254 ASCII printable characters	HTTPBAN := This system is for the use of authorized personnel only
HTTP WEB SERVER TIMEOUT	1–60 min	HTTPIDLE := 10
ENABLE RSTP	Y, N	ERSTP := N
BRIDGE PRIORITY[b]	0–61440	BRDGPRI := 49152
PORTA PRIORITY[b]	0–240	PORTAPRI := 128
PORTB PRIORITY[b]	0–240	PORTBPRI := 128
ENA FIXGOOSE PUB	0–1	EFGTX := 0
ENA FIXGOOSE SUB	0–4	EFGRX := 0
ENABLE PMU PROCESSING[c]	0–2	EPMIP := 0
ENABLE DNP SESSIONS[d]	0–5	EDNP := 0
ENABLE SNTP CLIENT[e]	OFF, UNICAST, MANYCAST, BROADCAST	ESNTP := OFF
ENABLE PTP[f]	Y, N	EPTP := N
ENABLE ETHERNET/IP[g]	Y, N	EEIP := N

[a] MODIP1 and MODIP2 cannot share an address and must be unique (except when 0.0.0.0, which effectively disables security and allows any master to communicate).
[b] The bridge priority and port priority settings should be in increments of 4096 and 16, respectively.
[c] See Appendix K: Synchrophasors for a complete list of synchrophasor settings and their descriptions.
[d] See Table D.7 for a complete list of the DNP3 session settings.
[e] See Table 7.5 for a complete list of SNTP settings and their descriptions.
[f] See Table 7.7 for a complete list of PTP settings and their descriptions.
[g] See Table F.22 for a complete list of EtherNet/IP 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 4.98* 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 4.98 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
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

Table 4.98 Port Number Settings That Must be Unique (Sheet 2 of 2)

Setting	Name	Setting Required When
SNTPPORT	SNTPIP (Local) Port Number	ESNTP ≠ OFF
EPTP	Enable PTP	PTPPRO = DEFAULT and PTPTR = UDP (Ports 319 and 320 are reserved)
EEIP	Enable EtherNet/IP	EEIP ≠ N (Ports 2222 and 44818 are reserved)

[a] MODNUM1 and MODNUM2 can have the same port number. The relay displays an error message if this number matches with the port numbers of 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 H: IEC 60870-5-103 Communications for more information on IEC 60870-5-103.

NOTE: All port settings are hidden if the relay is ordered without the Port 2 option. See the SEL-751 MOT for details.

Table 4.99 Fiber-Optic Serial Port Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PORT	Y, N	EPORT := Y
PROTOCOL	SEL, DNP, MOD, EVMSG[a], PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB, 103	PROTO := SEL
MAXIMUM ACCESS LEVEL	1, 2, C	MAXACC := 2
SPEED	300–38400 bps	SPEED := 9600
DATA BITS	7, 8 bits	BITS := 8
PARITY	O, E, N	PARITY := N
STOP BITS	1, 2 bits	STOP := 1
PORT TIME-OUT	0–30 min	T_OUT := 5
LANGUAGE	ENGLISH, SPANISH	LANG := ENGLISH
SEND AUTOMES-SAGE	Y, N	AUTO := N
FAST OP MESSAGES	Y, N	FASTOP := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

[a] When PROTO := EVMSG, the relay uses the settings BITS = 8, PARITY = N, and STOP = 1, regardless of any user-entered settings.

PORT 3

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 H: IEC 60870-5-103 Communications for more information on IEC 60870-5-103.

Table 4.100 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[a], PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB, 103	PROTO := SEL
MAXIMUM ACCESS LEVEL	1, 2, C	MAXACC := 2
SPEED	300–38400 bps	SPEED := 9600
DATA BITS	7, 8 bits	BITS := 8
PARITY	O, E, N	PARITY := N
STOP BITS	1, 2 bits	STOP := 1
PORT TIMEOUT	0–30 min	T_OUT := 5
HDWR HANDSHAKING	Y, N	RTSCTS := N

Table 4.100 Rear-Panel Serial Port (EIA-232) Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
LANGUAGE	ENGLISH, SPANISH	LANG := ENGLISH
SEND AUTOMESSAGE	Y, N	AUTO := N
FAST OP MESSAGES	Y, N	FASTOP := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

[a] When PROTO := EVMSG, the relay uses the settings BITS = 8, PARITY = N, and STOP = 1, regardless of any user-entered settings.

PORT 4

Table 4.101 Rear-Panel Serial Port (EIA-232/EIA-485) Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PORT	Y, N	EPORT := Y
PROTOCOL	SEL, MOD, DNET, DNP, EVMSG[a], PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB, 103	PROTO := SEL
MAXIMUM ACCESS LEVEL	1, 2, C	MAXACC := 2
COMM INTERFACE	232, 485	COMMINF := 232
SPEED	300–38400 bps	SPEED := 9600
DATA BITS	7, 8 bits	BITS := 8
PARITY	O, E, N	PARITY := N
STOP BITS	1, 2 bits	STOP := 1
PORT TIMEOUT	0–30 min	T_OUT := 5
HDWR HANDSHAKING	Y, N	RTSCTS := N
LANGUAGE	ENGLISH, SPANISH	LANG := ENGLISH
SEND AUTOMESSAGE	Y, N	AUTO := N
FAST OP MESSAGES	Y, N	FASTOP := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

[a] When PROTO := EVMSG, the relay uses the settings BITS = 8, PARITY = N, and STOP = 1, regardless of any user-entered settings.

NOTE: For additional settings when PROTO := MBxx, see Table J.5 as well as MIRRORED BITS Transmit SELOGIC Control Equations.

For additional settings when PROTO := DNP, see Table D.7 for a complete list of the DNP3 session settings.

Refer to Appendix H: IEC 60870-5-103 Communications for more information on IEC 60870-5-103.

Set the speed, data bits, parity, and stop bits settings to match the serial port configuration of the equipment that is communicating with the serial port.

After Port Timeout minutes of inactivity on a serial port at Access Level 2, the port automatically returns to Access Level 0. This security feature helps prevent unauthorized access to the relay settings if the relay is accidentally left in Access Level 2. If you do not want the port to time out, set Port Timeout equal to 0 minutes.

For detailed information on communications protocols, refer to *Appendix C: SEL Communications Processors*, *Appendix D: DNP3 Communications*, *Appendix E: Modbus Communications*, *Appendix F: EtherNet/IP Communications*, *Appendix G: IEC 61850 Communications*, *Appendix H: IEC 60870-5-103 Communications*, *Appendix I: DeviceNet Communications*, *Appendix J: MIRRORED BITS Communications*, and *Appendix K: Synchrophasors*.

Use the MBT option if you are using a Pulsar MBT9600 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, 2, 3, and 4, when PROTO := SEL, use the LANG setting to communicate with the relay in English or Spanish. On Port 1, when ETELNET := Y, use the LANG setting to communicate with the relay in English or Spanish. Refer to the *SEL-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 4.102* shows the additional settings, which can be set only at the rear on the DeviceNet card. Once the relay detects the DeviceNet card, all **Port 4** settings are hidden. Refer to *Appendix I: DeviceNet Communications* for details on DeviceNet.

Table 4.102 Rear-Panel DeviceNet Port Settings

Setting Name	Setting Range
MAC_ID	0–63
ASA	8 Hex characters assigned by factory
DN_Rate	125, 250, 500 kbps

Front-Panel Settings (SET F Command)

The SEL-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 9.7* for the touchscreen display settings. The touchscreen display settings are not settable via the **SET F** command.

General Settings

Local bits provide control from the front panel (local bits), and display points show selected information on the LCD. However, you need to first enable the appropriate number of local bits and display points necessary for your application. When your SEL-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 4.103 Display Point and Local Bit Default Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
DISPLAY PTS ENABL[a]	N, 1–32	EDP := 4
LOCAL BITS ENABL	N, 1–32	ELB := 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 LCD. The FP_CONT setting is not available in the touchscreen display model.

Use the front-panel automessage setting FP_AUTO to define the display of Trip/Warning messages. Set FP_AUTO either to OVERRIDE or ROTATING for when the relay triggers a Trip/Warning message. Choosing OVERRIDE will have the Trip/Warning message override the rotating display, while choosing ROTATING will add the Trip/Warning message to the rotating display. Refer to *Table 9.7* for the equivalent touchscreen display settings. Note that the FP_AUTO setting is not available in the touchscreen display model. The touchscreen display provides settings that allow you to choose from a wide range of screens, including custom screens, to display as part of the rotating display. The touchscreen automatically flashes a screen that overrides the rotating display in the case of trip or diagnostic failures. Refer to *Section 8: Front-Panel Operations* for more information on trip and diagnostic messages.

Set RSTLED := Y to automatically reset the latched LEDs when the breaker or contactor closes.

The MAXACC setting (under Front-Panel Settings) 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 the settings. If MAXACC is set to 2, the front panel allows breaker control and read/write access to the settings.

NOTE: All Target LED settings can be found in Table 4.112.

Table 4.104 LCD Settings

Setting Prompt	Range	Setting Name := Factory Default
LCD TIMEOUT[a]	OFF, 1–30; min	FP_TO := 15
LCD CONTRAST[a]	1–16	FP_CONT := 10
FP AUTOMESSAGES[a]	OVERRIDE, ROTAT-ING	FP_AUTO := OVER-RIDE
CLOSE RESET LEDS	Y, N	RSTLED := Y
MAXIMUM ACCESS LEVEL[a]	1, 2	MAXACC := 2

[a] These settings are not supported in the touchscreen display model.

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. 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.

Table 4.105 Front-Panel Display Point Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
DISPLAY POINT DP01	60 characters	DP01 := RID
DISPLAY POINT DP02	60 characters	DP02 := TID
DISPLAY POINT DP03	60 characters	DP03 := IAV, “AVE CURR [5] A”
DISPLAY POINT DP04	60 characters	DP04 := IG_MAG, “GND CURR {5} A”
DISPLAY POINT DP05	60 characters	DP05 :=
• • •	• • •	• • •
DISPLAY POINT DP32	60 characters	DP32 :=

Boolean Display Point Entry Composition

Boolean information is the status of Relay Word bits (see *Appendix L: Relay Word Bits*). In general, the legal syntax for Boolean display points consists of the following four fields or strings, separated by commas:

Relay Word Bit Name, “Alias”, “Set String”, “Clear String”.

where:

Name = Relay Word bit name (IN101, for example). All binary quantities occupy one line on the front-panel display (all analog quantities occupy two lines).

Alias = A more descriptive name for the Relay Word bit (such as TRANSFORMER 3), or the analog quantity (such as TEMPERATURE).

Set String = State what should be displayed on the LCD when the Relay Word bit is asserted (CLOSED, for example)

Clear String = State what should be displayed on the LCD when the Relay Word bit is deasserted (OPEN, for example)

Any or all of Alias, Set String, or Clear String can be empty. Although the relay accepts an empty setting Name as valid, a display point with an empty Name setting is always hidden (see 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 4.106* 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 4.106* shows examples of settings that always, never, or conditionally hide a display point.

Table 4.106 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 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 4.107 Entries for the Four Strings

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

Figure 4.136 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 4.136 Display Point Settings

Figure 4.137 shows the display when both HV and LV breakers are open (both IN101 and IN102 deasserted). *Figure 4.138* shows the display when the HV breaker is closed, and the LV breaker is open (IN101 asserted, but IN102 still deasserted).

Figure 4.137 Front-Panel Display—Both HV and LV Breakers Open

Figure 4.138 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 4.139*.

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 4.140*.

```
TRFR 1 HV BRKR:= CLOSED
TRFR 1 LV BRKR:= CLOSED
```

Figure 4.139 Front-Panel Display—Both HV and LV Breakers Closed

```
TRFR 1 LV BRKR:= CLOSED
```

Figure 4.140 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 4.141*.

```
TRFR 1 HV BRKR:=
TRFR 1 LV BRKR:= CLOSED
```

Figure 4.141 Front-Panel Display—HV Breaker Open, LV Breaker Closed

Name Only

Table 4.108 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 4.108 Binary Entry in the Name String Only

Name	Alias	Set String	Clear String
IN101	—	—	—

Figure 4.142 shows the front-panel display for the entry in *Table 4.108*. Input IN101 is deasserted in this display (`IN101=0`), but changes to `IN101=1` when Input IN101 asserts.

```
IN101=0
```

Figure 4.142 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 4.109* shows an entry in the Name string only (leaving the User Text and Formatting string void) with the following syntax:

Table 4.109 Analog Entry in the Name String Only

Name	Alias	Set String	Clear String
AI301	—	—	—

Figure 4.143 shows the front-panel display for the entry in *Table 4.109*. Using the **SET F** command, select DP01. Set DP01 as follows:

```
DP01    := RID, "{16}"
 ? AI301 <Enter>
```

Figure 4.143 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 4.110* 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 4.110 Entry in the Name String and the Alias Strings

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

Figure 4.144 shows the front-panel display for the entry in *Table 4.110*. Input IN101 is deasserted in this display (0), and the display changes to `INPUT IN101=1` when Input IN101 asserts.

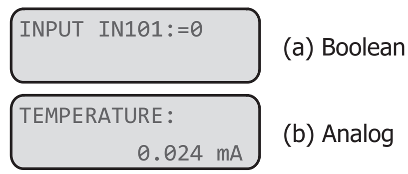


Figure 4.144 Front-Panel Display for an Entry in (a) Boolean Name and Alias Strings and (b) Analog Name and User Text and Formatting Strings

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 4.145*.

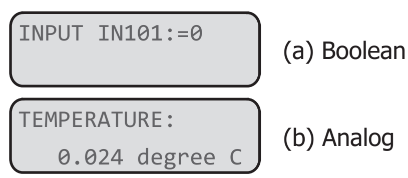


Figure 4.145 Front-Panel Display for an Entry in (a) Boolean Name and Alias Strings and (b) Analog Name, User Text and Formatting Strings, and Engineering Units

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

Table 4.111 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 := 1234.0
AI301,"TEMP = {5}"	TEMP := 1234
AI301,"TEMP = {4.2,0.001} C"	TEMP := 1.23 C
AI301,"TEMP HV HS1 = {4,1000}"	TEMP HV HS1 := 1234000
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 4.146* 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 4.146 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 4.147*.

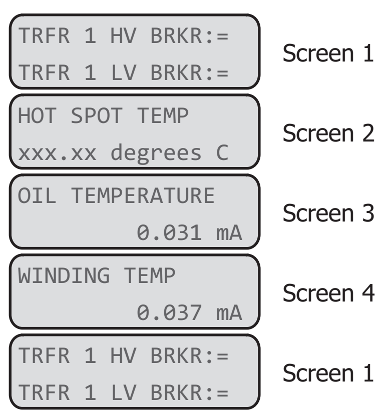


Figure 4.147 Rotating Display

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 4.148* 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 4.148 Adding Two Local Bits

Target LED Settings

The SEL-751 offers the following types of LEDs. See *Figure 8.2* and *Figure 8.31* for the programmable LED locations:

- One **ENABLED** and one **TRIP** tricolored target LED
- Six tricolored programmable target LEDs
- Sixteen tricolored programmable pushbutton LEDs

You can program all 22 LEDs 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 models. For touchscreen display relays, the illuminated color of the **ENABLED** LED is fixed at green.

NOTE: If the LED latch setting (T*n*LEDL) 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 only if a TRIP condition occurs and the T*n*_LED equation asserts at the time of the trip. To reset these latched LEDs, the TRIP condition should no longer exist and one of the following takes place:

- Pressing **TARGET RESET** on the front panel.
- Issuing the serial port command **TAR R**.
- The assertion of the SELOGIC control equation RSTTRGT.

With 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 4.112 shows the target LED settings. The factory-default settings shown match the as-shipped front-panel overlay (see *Figure 8.2*). You can change the settings to suit your application. See *Section 8: Front-Panel Operations* for slide-in labels for custom LED designations.

Table 4.112 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

Table 4.112 Target LED Settings (Sheet 2 of 2)

Setting Prompt	Setting Range[a]	Setting Name := Factory Default
TARGET T_LED ASSERTED COLOR	R, G, A	T03LEDC := R
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 4.113* shows the setting prompts, settings ranges, and default settings for the LEDs.

Table 4.113 shows the setting prompts, the settings ranges, and the default settings for the LEDs. The factory-default settings shown match the as-shipped front-panel overlay (see *Figure 8.2*). You can change the settings to suit your application. See *Section 8: Front-Panel Operations* for slide-in labels for custom LED designations.

Table 4.113 Pushbutton LED Settings[a] (Sheet 1 of 3)

Setting Prompt	Setting Range[b]	Setting Name := Factory Default
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB1ALEDC := AO
PB1A_LED EQUATION	SELOGIC	PB1A_LED := 79RS
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB1BLEDC := AO
PB1B_LED EQUATION	SELOGIC	PB1B_LED := 79LO
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB2ALEDC := AO
PB2A_LED EQUATION	SELOGIC	PB2A_LED := NOT LT02 OR SV02 AND NOT SV02T AND SV05T

Table 4.113 Pushbutton LED Settings[a] (Sheet 2 of 3)

Setting Prompt	Setting Range[b]	Setting Name := Factory Default
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB2BLEDC := AO
PB2B_LED EQUATION	SELogic	PB2B_LED := LT02 OR SV02 AND NOT SV02T AND SV05T
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB3ALEDC := AO
PB3A_LED EQUATION	SELogic	PB3A_LED := NOT LT02 AND NOT 52A
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB3BLEDC := AO
PB3B_LED EQUATION	SELogic	PB3B_LED := 52A OR SV03 AND NOT SV03T AND SV05T
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB4ALEDC := AO
PB4A_LED EQUATION	SELogic	PB4A_LED := 0
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB4BLEDC := AO
PB4B_LED EQUATION	SELogic	PB4B_LED := NOT 52A OR SV04 AND NOT SV04T AND SV05T
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB5ALEDC := AO
PB5A_LED EQUATION	SELogic	PB5A_LED := 0
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB5BLEDC := AO
PB5B_LED EQUATION	SELogic	PB5B_LED := 0
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB6ALEDC := AO
PB6A_LED EQUATION	SELogic	PB6A_LED := 0
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB6BLEDC := AO
PB6B_LED EQUATION	SELogic	PB6B_LED := 0
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB7ALEDC := AO
PB7A_LED EQUATION	SELogic	PB7A_LED := 0
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB7BLEDC := AO
PB7B_LED EQUATION	SELogic	PB7B_LED := 0
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB8ALEDC := AO
PB8A_LED EQUATION	SELogic	PB8A_LED := 0

Table 4.113 Pushbutton LED Settings[a] (Sheet 3 of 3)

Setting Prompt	Setting Range[b]	Setting Name := Factory Default
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB8BLEDC := AO
PB8B_LED EQUATION	SELOGIC	PB8B_LED := 0

[a] The pushbutton LED settings, PB5A/PB5B–PB8A/PB8B, are hidden 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 4.115* (see *Appendix L: Relay Word Bits* for more information).

SER Chatter Criteria

The SER includes an automatic deletion and reinsertion function to prevent overfilling of the SER buffer with chattering information. Each processing interval the relay checks the Relay Word bits in the four SER reports for any changes of state (except the Relay Word bits corresponding to the digital inputs and arc-flash elements [TOL*x*, 50*x*AF, and OUT*xxx*, selected through the setting AOUTSLOT] that have 1/16 of the power system cycle SER-accurate time-stamps). 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 4.114* shows the auto-removal settings.

Table 4.114 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 4.115* shows the settings prompt and default settings for the four SER trigger equations.

Table 4.115 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 4.116 Enable Alias Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Enable ALIAS Settings (N, 1–64)	N, 1–64	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 64 unique aliases, as defined by the Enable Alias Settings (EALIAS) setting. Factory default alias settings are shown in *Table 4.117*.

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 L.1* for the complete list of Relay Word bits. Use as many as 15 characters to define the alias, asserted text, and deasserted text strings. You can use capital letters (A–Z), numbers (0–9), and the underscore character (_) within each string. Do not attempt to use a space within a string because the relay interprets a space as the break between two strings. If you want to clear a string, simply type **NA**.

Table 4.117 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–ALIAS64	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 4.118 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, 300 cyc	LER := 15
PREFAULT LENGTH	1–175 cyc[a]	PRE := 5

[a] The range shown is for LER := 180. The generalized range is 1 - (LER-5) cyc.

Event reports can be 15 cycles, 64 cycles, 180 cycles, or 300 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 forty 15-cycle event reports, twenty 64-cycle event reports, eight 180-cycle event reports, or five 300-cycle event reports.

HIF Event Report Settings

Table 4.119 HIF Event Report Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
HIF EVENT LENGTH	3, 5, 10, 20 min	HIFLER := 10
PRE HIF LENGTH	1–19 min[a]	HIFPRE := 1

[a] The range shown is for HIFLER := 20. The generalized range is 1–(HIFLER–1) min. The setting resolution is 1 min.

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 M: 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 4.120 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 D Command)

Table 4.121 shows the available settings. See *Appendix D: DNP3 Communications* for additional details.

Table 4.121 DNP Map Settings[a]

Setting Prompt	Setting Range	Setting Name := Factory Default
DNP Binary Input Label Name	10 characters	BI_00 := ENABLED
DNP Binary Input Label Name	10 characters	BI_01 := TRIP_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
• • •	• • •	
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 4.122 shows the available settings. See *Appendix E: Modbus Communications* for additional details.

Table 4.122 User Map Register Settings[a]

Setting Prompt	Setting Range	Setting Name := Factory Default
USER REG#1	NA, 1 Modbus Register Label	MOD_001 :=
• • •	• • •	• • •
USER REG#125	NA, 1 Modbus Register Label	MOD_125 :=

[a] See Appendix E: Modbus Communications for a complete list of the Modbus Register Labels and factory-default settings.

EtherNet/IP Assembly Map Settings (SET E Command)

Table 4.123 shows the available assembly map settings. See *Appendix F: EtherNet/IP Communications* for additional details.

Table 4.123 EtherNet/IP Assembly Map (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
Input Assembly (IA) Binary		
EIP Input Assembly Binary Label Name	10 characters	IAB_00 := NA
• • •	• • •	• • •
EIP Input Assembly Binary Label Name	10 characters	IAB_99 := NA
Input Assembly (IA) Analog		
EIP Input Assembly Analog Label Name	10 characters	IAA_00 := NOOP
EIP Input Assembly Analog Label Name	10 characters	IAA_01 := NA
• • •	• • •	• • •
EIP Input Assembly Analog Label Name	10 characters	IAA_99 := NA
Output Assembly (OA) Binary		
EIP Output Assembly Binary Label Name	10 characters	OAB_00 := NA
• • •	• • •	• • •
EIP Output Assembly Binary Label Name	10 characters	OAB_31 := NA

Table 4.123 EtherNet/IP Assembly Map (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
Output Assembly (OA) Analog		
EIP Output Assembly Analog Label Name	10 characters	OAA_00 := NOOP
EIP Output Assembly Analog Label Name	10 characters	OAA_01 := NA
• • •	• • •	• • •
EIP Output Assembly Analog Label Name	10 characters	OAA_31 := NA

Touchscreen Settings

The touchscreen settings apply to relays that support the color touchscreen display and are discussed in *Section 9: Bay Control* (see *Table 9.7*).

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
- Web server via Ethernet port
- EIA-232 serial ports (by using SEL ASCII text commands or ACSELERATOR QuickSet SEL-5030 Software)
- Telnet via Ethernet port
- Modbus via EIA-232 port or EIA-485 port
- Modbus TCP via Ethernet port
- EtherNet/IP 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 2.1 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 and the 2 AVI/7 DI voltage/7 digital inputs 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 5.18* 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*.

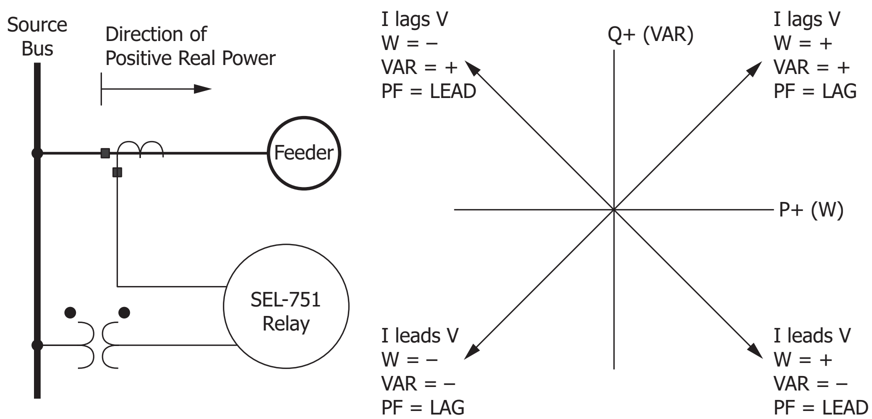


Figure 5.1 Complex Power Measurement Conventions

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
- High-impedance fault (HIF) metering (HIF 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...) or Sync-Check and DC Station Battery Voltages and 7 Digital Inputs Option (2 AVI/7 DI Card MOT...7X/LX...); where X = A to H	VS (synchronism-check voltage) magnitude (V primary) and phase angle (deg) Synchronism-check voltage frequency FREQS (Hz) VDC (if Global setting EDCMON := Y: station battery voltage (Vdc), else VBAT channel voltage (V primary))

[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 M: 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, VAB < 0.34 V (for delta-connected PT) 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     120.800    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 7.42*).

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.

NOTE: Energy values rollover after 99999.999 MVAh and reset to 0.

- ➤ 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

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 or Voltage/ 7 Digital Inputs 2 AVI/7 DI 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 64 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 64) 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 64 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 or Voltage/7 Digital Inputs 2 AVI/7 DI 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.

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 4.186* 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 are 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 (not local time).

The **METER PM** command only operates when the SEL-751 is in the IRIG or hardware-based PTP timekeeping mode, as indicated by Relay Word bit TSOK = logical 1. *Table 5.7* shows the measured values for the **METER PM** command. *Figure K.7* in *Appendix K: Synchrophasors* shows a sample **METER PM** command response. You can use the **METER PM XX: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 K.7*, occurring just after 14:14:12, with the time stamp 14:14:12.000. Refer to *Appendix K: Synchrophasors* for further details on synchrophasor measurements, settings, C37.118 protocol, etc.

Table 5.7 Synchrophasor Measured Values

Relay Option	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

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 HIF detection, the relay provides HIF 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 HIF Metering Measured Values

Relay Option	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 4.78*) 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 4.245*). Choose which analog quantities you want to monitor from the analog quantities listed in *Appendix M: Analog Quantities*. Set these quantities into the LDLIST load profile list report setting.

The relay memory can hold data for 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
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

LDP data are also available as a read-only file that can be retrieved using Ethernet FTP or MMS. MMS is only available in models that support IEC 61850 and only when IEC 61850 and MMS file transfer are enabled (E61850 := Y, EMMSFS := Y). See *File Transfer Protocol (FTP) and MMS File Transfer on page 7.15*, *Virtual File Interface on page 7.83*, and *MMS on page G.5* for additional information.

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 or voltage/7 digital inputs 2 AVI/7 DI 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 (EDCMON, DCLOP, and DCHIP) are available via the **SET G** command (see *Table 5.9* and *Global Settings (SET G Command) on page SET.47*).

DC Under- and Overvoltage Elements

Table 5.9 Station DC Battery Monitor Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
EN DC BAT MON	Y, N	EDCMON := Y
DC UNDER VOLT PU	(OFF, 20.00–300.00) Vdc	DCLOP := OFF
DC OVER VOLT PU	(OFF, 20.00–300.00) Vdc	DCHIP := OFF

Set the EDCMON setting equal to Y to enable the station dc battery monitor elements. The station dc battery monitor compares the measured station battery voltage (Vdc) to the undervoltage (low) and overvoltage (high) pickups DCLOP and DCHIP (refer to *Figure 5.17*). 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 250 V. 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 1.14* for the various power supply specifications. The power supply rating is located on the serial number sticker on the relay side panel.

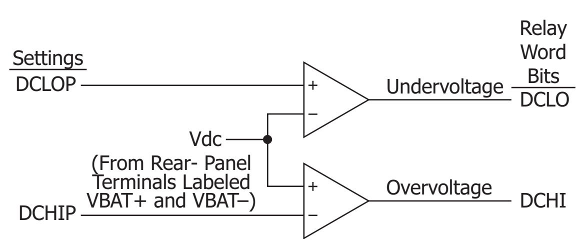


Figure 5.17 DC Under- and Overvoltage Elements

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.

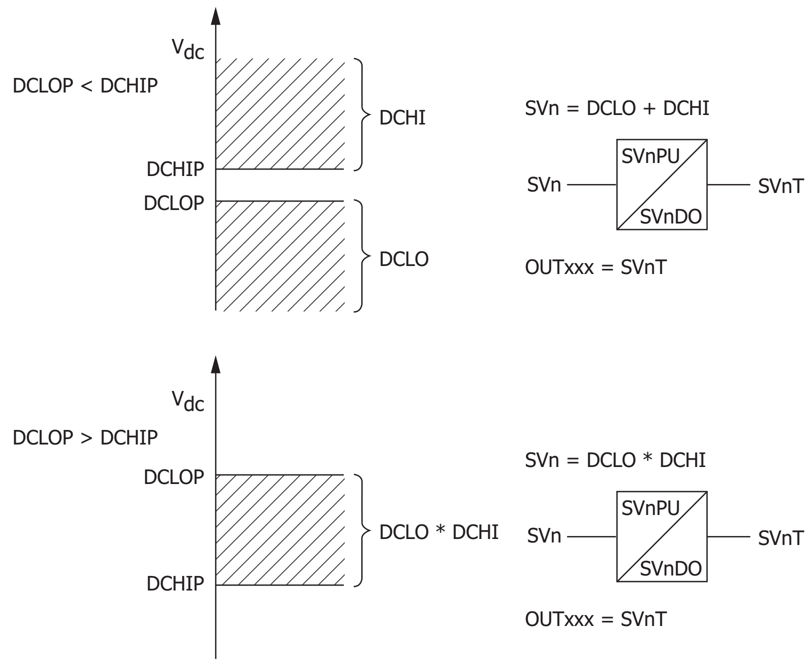


Figure 5.18 Create DC Voltage Elements With SELOGIC Control Equations

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 the 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 4.101*). 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 4.103*)

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 7.36* and *BRE Command (Preload/Reset Breaker Wear) on page 7.36*.

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**	KASP1 = **1.20**
COSP2 = **150**	KASP2 = **8.00**
COSP3 = **12**	KASP3 = **20.00**

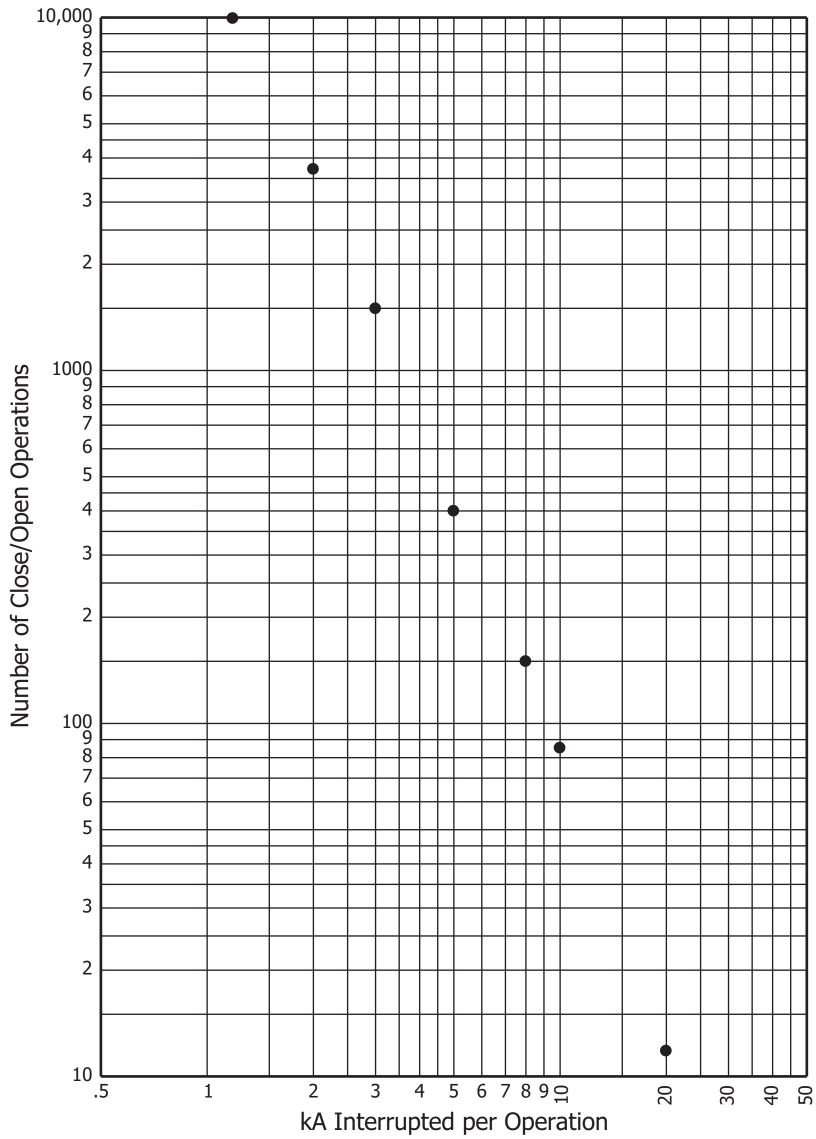


Figure 5.19 Plotted Breaker Maintenance Points for a 25 kV Circuit Breaker

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*.

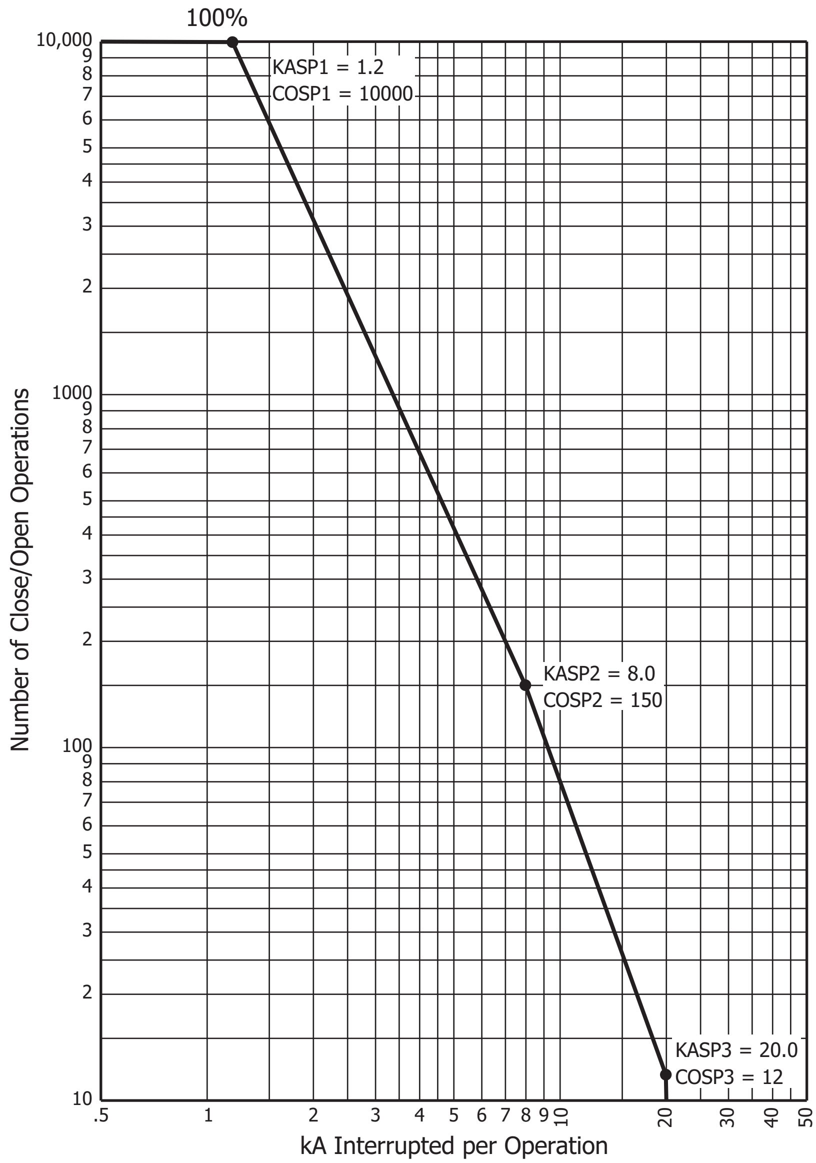


Figure 5.20 SEL-751 Breaker Maintenance Curve for a 25 kV Circuit Breaker

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 7.36*).

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 4.101*)

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 5.28* 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 Close and Operate Times

The breaker close time for electromechanical contacts (BRKCLTM) is calculated as the time between the rising edge of the CLOSE Relay Word bit and the rising edge of the 52A Relay Word bit, as shown in *Figure 5.22*. The breaker close time for fast-hybrid contacts (BRKCLTH) is calculated by subtracting 5 ms from BRKCLTM.

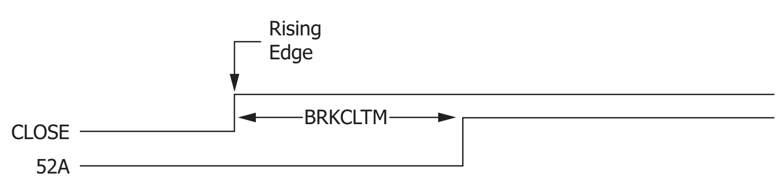


Figure 5.22 Logic Diagram to Calculate BRKCLTM

The breaker operate time for electromechanical contacts (BRKOPTM) is calculated as the time between assertion of the BKMON Relay Word bit to the deassertion of the 52A Relay Word bit, as shown in *Figure 5.23*. The breaker operate time for fast-hybrid contacts (BRKOPTH) is calculated by subtracting 5 ms from BRKOPTM.

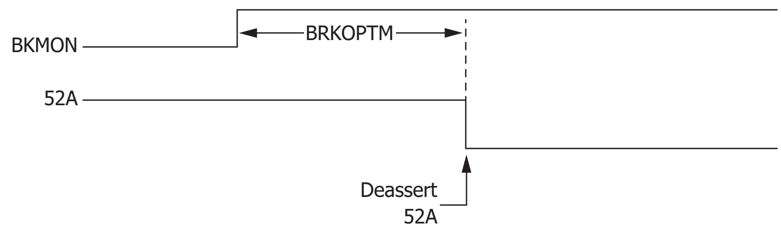


Figure 5.23 Logic Diagram to Calculate BRKOPTM

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 5.24–Figure 5.27*. 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 5.24–Figure 5.27*) that the interrupted current in a given figure is the same magnitude for all the interruptions (e.g., in *Figure 5.25*, 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 5.24*. 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.

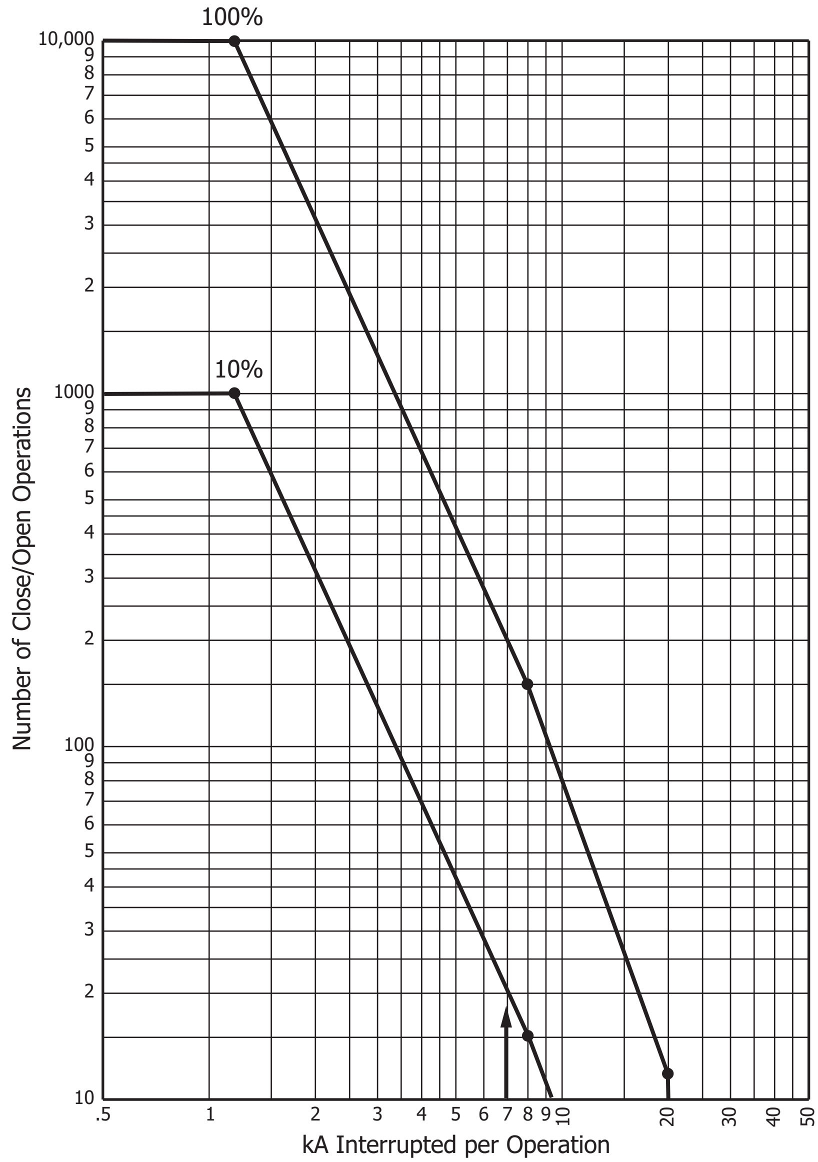


Figure 5.24 Breaker Monitor Accumulates 10 Percent Wear

10 Percent to 25 Percent Breaker Wear

Refer to *Figure 5.25*. 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.

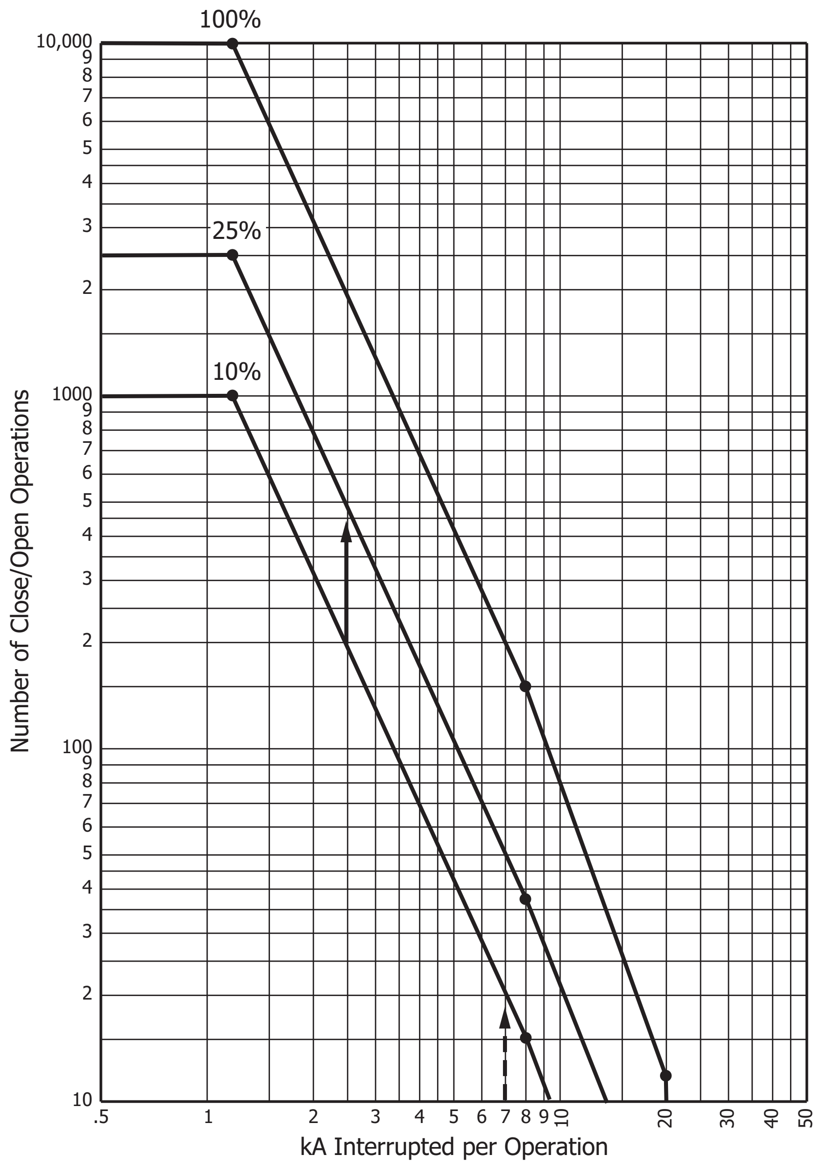


Figure 5.25 Breaker Monitor Accumulates 25 Percent Wear

25 Percent to 50 Percent Breaker Wear

Refer to *Figure 5.26*. 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.

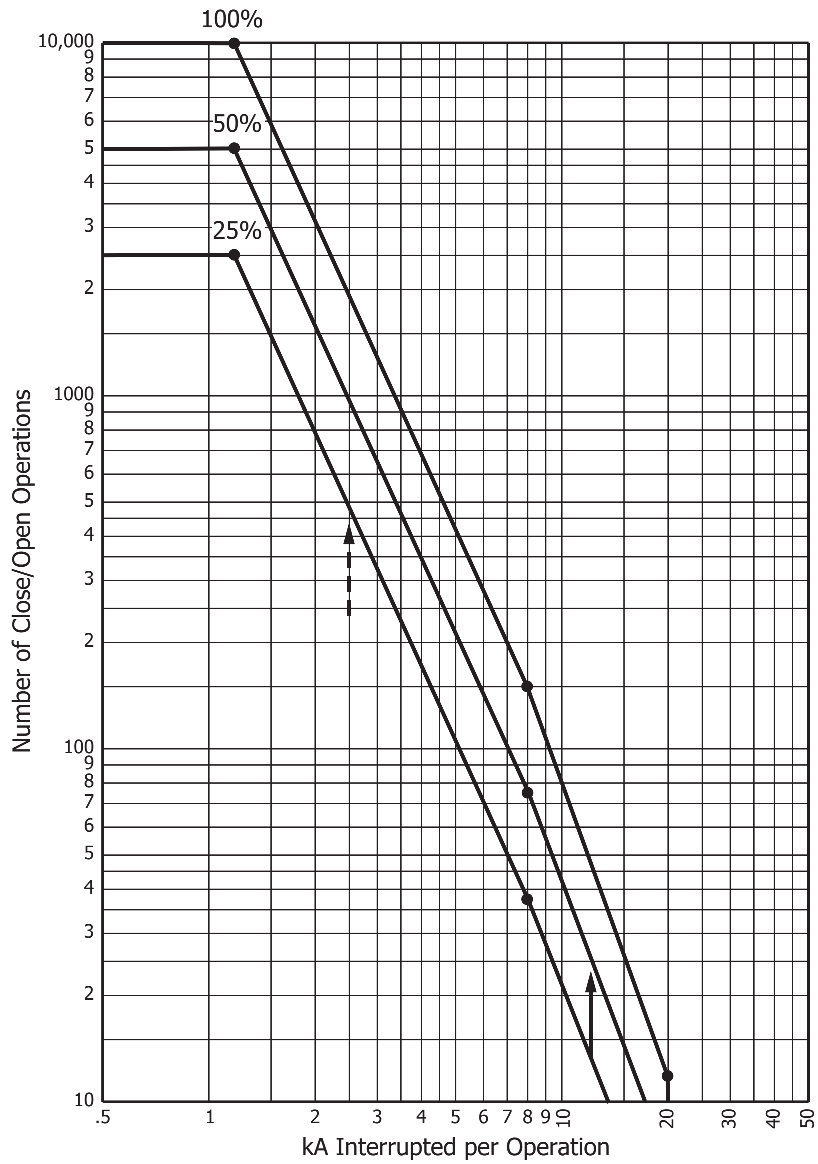


Figure 5.26 Breaker Monitor Accumulates 50 Percent Wear

50 Percent to 100 Percent Breaker Wear

Refer to *Figure 5.27*. The current value changes from 12.0 kA to 1.5 kA. The 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.

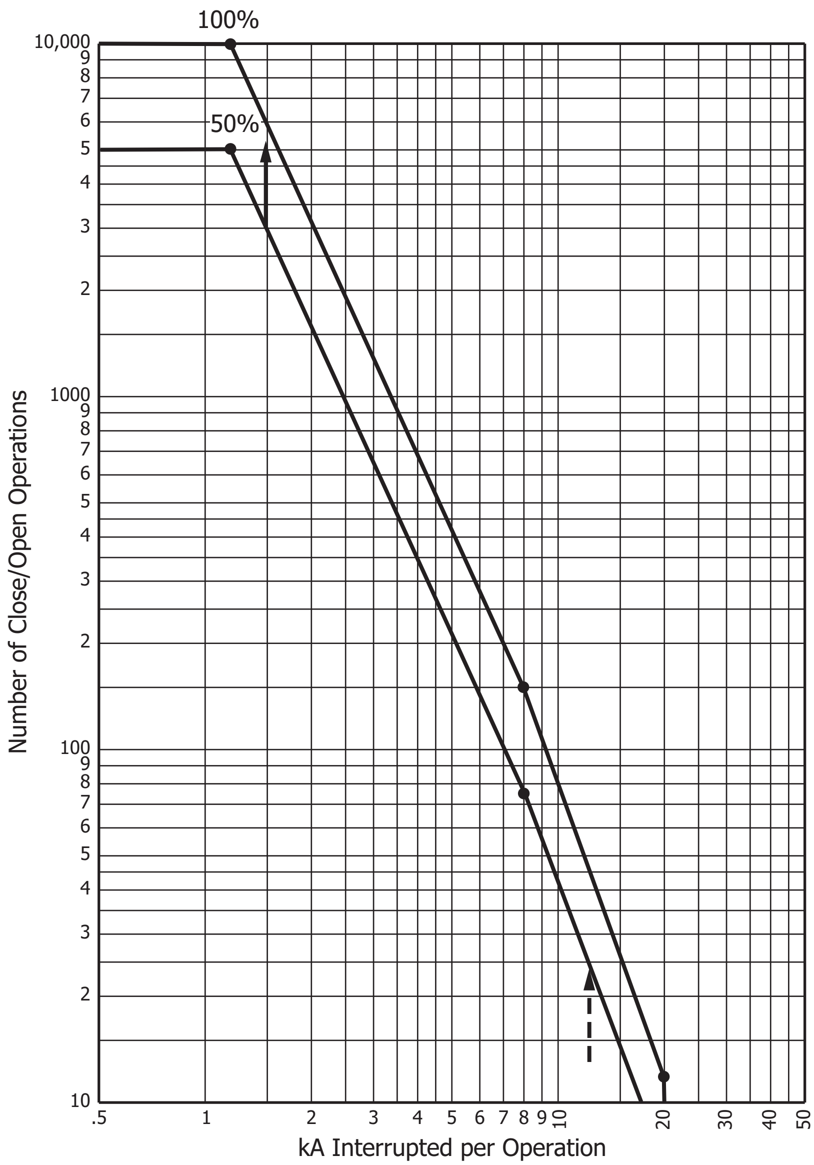


Figure 5.27 Breaker Monitor Accumulates 100 Percent Wear

Breaker Monitor Output

When the breaker maintenance curve for a particular phase (A, B, or C) reaches the 100 percent wear level (see *Figure 5.27*), 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.

Breaker wear data are also available as a read-only file that can be retrieved using Ethernet FTP or MMS. MMS is only available in models that support IEC 61850 and only when IEC 61850 and MMS file transfer are enabled

(E61850 := Y, EMMSFS := Y). See *File Transfer Protocol (FTP) and MMS File Transfer on page 7.15*, *Virtual File Interface on page 7.83*, and *MMS on page G.5* for additional information.

Determination of Relay-Initiated Trips and Externally Initiated Trips

See *Section 7: Communications*. Note in the **BRE** command response that the accumulated number of trips and accumulated interrupted current are separated into two groups of data: those generated by relay-initiated trips (Rly Trips) and those generated by externally initiated trips (Ext Trips). The categorization of these data is determined by the status of the TRIP 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 relay must determine whether to accumulate this current and trip count information under relay-initiated trips or externally initiated trips.

To make this determination, the relay checks the status of the TRIP Relay Word bit at the instant BKMON newly asserts (TRIP is the logic output of *Figure 4.101 on page 4.161*). 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 5.27*).

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 5.28. 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.

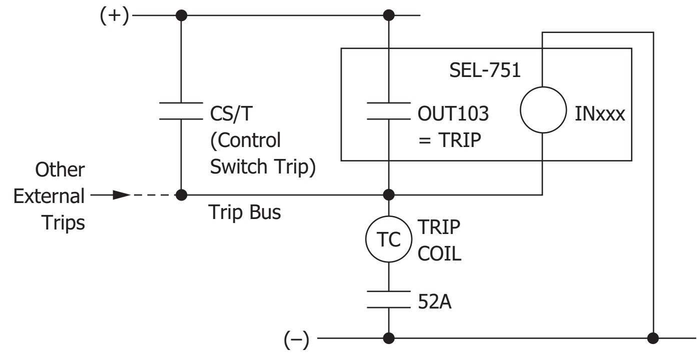


Figure 5.28 Input INxxx Connected to Trip Bus for Breaker Monitor Initiation

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

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

The SEL-751 Feeder Protection Relay stores the settings you enter in nonvolatile memory. Settings are divided into the following ten setting classes:

1. Group *n* (where *n* = 1, 2, 3, or 4)
2. Logic Group *n* (where *n* = 1, 2, 3, or 4)
3. Global
4. Port *p* (where *p* = F, 1 [Ethernet], 2, 3, or 4)
5. Front Panel
6. Report
7. Modbus
8. EtherNet/IP
9. DNP3
10. IEC 60870-5-103
11. Touchscreen (this setting class is only available for models with the color touchscreen display)

Some setting classes have multiple instances. In the previous list, there are five port setting instances, one for each port. Settings can be viewed or set in several ways, as shown in *Table 6.1*.

Table 6.1 Methods of Accessing Settings[a]

	Web Server[b]	Serial Port Commands[c]	Front-Panel HMI Set/Show Menu[d]	ACSELERATOR QuickSet SEL-5030 (PC Software)[b]
Display Settings	All settings	All settings (**SHO** command)	Global, Group, and Port settings	All settings
Change Settings	Not available	All settings (**SET** command)	Global, Group, and Port settings	All settings

[a] These settings access methods do not apply to the touchscreen settings.
[b] Refer to Section 3: PC Interface for detailed information.
[c] Refer to Section 7: Communications for detailed information on setup and use of the serial communications port and Ethernet port.
[d] Refer to Section 8: Front-Panel Operations for detailed information on the front-panel layout, menus and screens, and operator control pushbuttons.

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

Two-Line Front Panel

You can use the pushbuttons on the front panel to view/change settings. See *Section 8: Front-Panel Operations* for the operating details of the front panel.

Enter the front-panel menu by pushing the **ESC** pushbutton. 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.

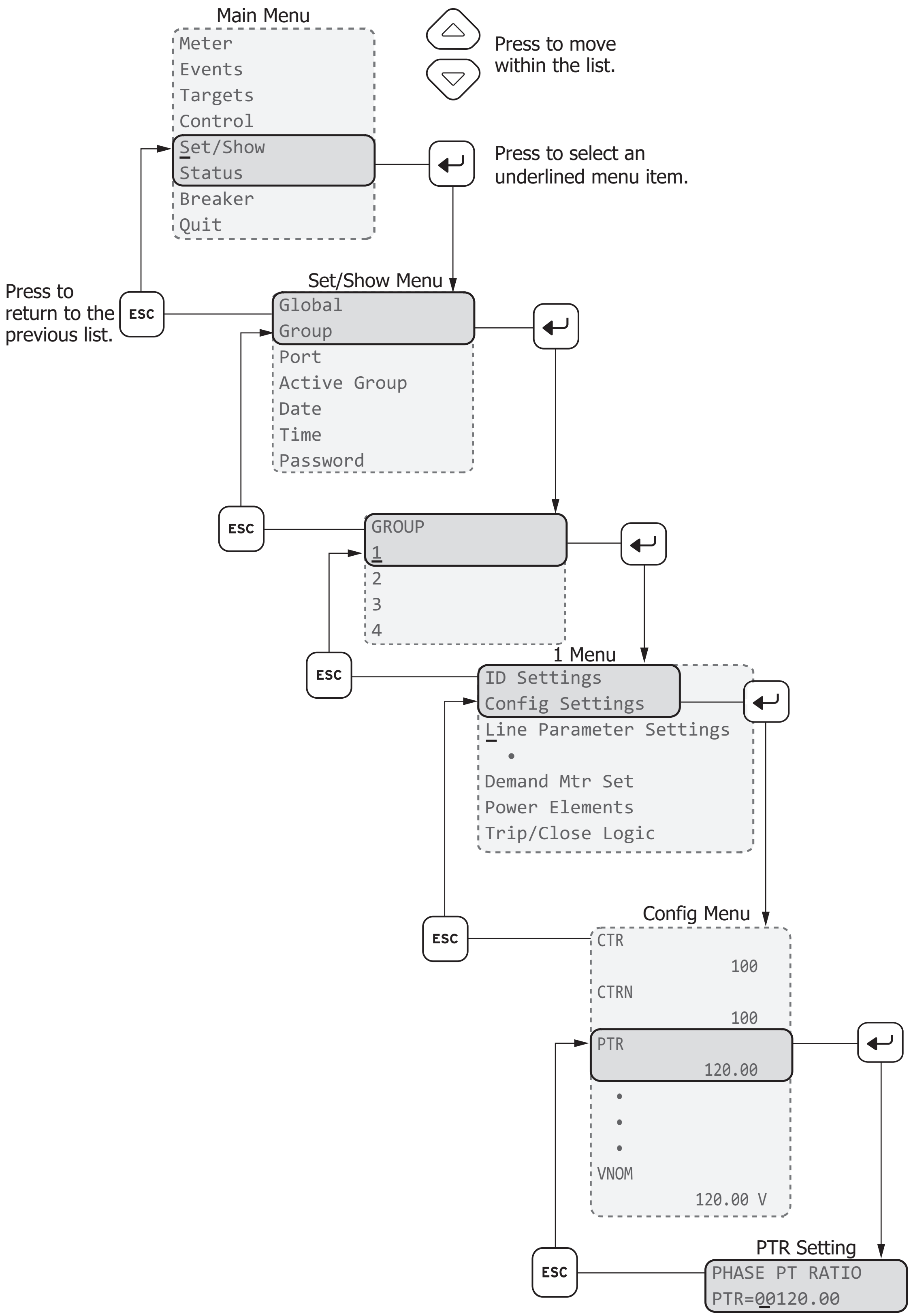


Figure 6.1 Front-Panel Setting Entry Example

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.

Communications Port

Refer to *Section 7: Communications* for information on how to set up and access the relay serial or Ethernet port with a personal computer and how to use ASCII commands to communicate with the relay.

View Settings

Use the **SHOW** command to view relay settings. The **SHOW** command is available from Access Level 1 and Access Level 2. *Table 6.2* lists the **SHOW** command options.

Table 6.2 SHOW Command Options

Command	Description
SHO *n*	Show relay group settings: *n* specifies the settings group (1, 2, 3, or 4); *n* defaults to the active settings group if not listed.
SHO L *n*	Show logic settings: *n* specifies the settings group (1, 2, 3, or 4); *n* defaults to the active settings group if not listed.
SHO G	Show global configuration settings.
SHO P *n*	Show serial port settings for Port *n* (*n* = F, 1, 2, 3, or 4).
SHO F	Show front-panel display and LED settings.
SHO R	Show Sequential Events Recorder (SER) and Event Report settings.
SHO M	Show Modbus map settings.
SHO E	Show EtherNet/IP assembly map settings.
SHO D	Show DNP3 map settings.
SHO I	Show IEC 60870-5-103 map settings.

You can append a setting name to each of the commands to specify the setting to display (e.g., **SHO 50P1P** displays the 50P1P setting).

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*	Group	Protection elements, timers, etc., for settings Group *n* (1, 2, 3, or 4).
SET L *n*	Logic	SELOGIC control equations for settings Group *n* (1, 2, 3, or 4).
SET G	Global	Global configuration settings including Event Messenger, optoisolated input debounce timers, etc.
SET P *n*	Port	Serial port settings for serial Port *n* (1, 2, 3, 4, or F).
SET F	Front Panel	Front-panel display and LED settings.

Table 6.3 SET Command Options (Sheet 2 of 2)

Command	Settings Type	Description
SET R	Reports	SER and Event Report settings.
SET M	Modbus	Modbus user map settings.
SET E	EtherNet/IP	EtherNet/IP assembly 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 1, 2, 3, or 4 when *n* = G or L for group settings; *m* defaults to 1 if the parameter is left blank.
	is F, 1, 2, 3, or 4 when *n* = P for port settings; *m* defaults to the active port if the parameter is left blank.
s	is the name of the specific setting you want to jump to and begin setting. If *s* is not entered, the relay starts at the first setting (e.g., enter **50P1P** to start at the phase overcurrent trip level setting).
TERSE	instructs the relay to skip the settings display after the last setting. Use this parameter to speed up the **SET** command. If you want to review the settings before saving, do not use the **TERSE** option.

Web Server

Refer to *Section 3: PC Interface* for information on how to set up communication and how to access the relay on an Ethernet port with a personal computer.

View Settings

Once communication with the relay is established through the web server, the home page screen appears in your browser window. Click **Settings** on the navigation pane to view all the available settings classes, as shown in *Figure 6.2*. You can only view SEL-751 settings through the web server, even at Access Level 2. Click on a settings class to view its settings.

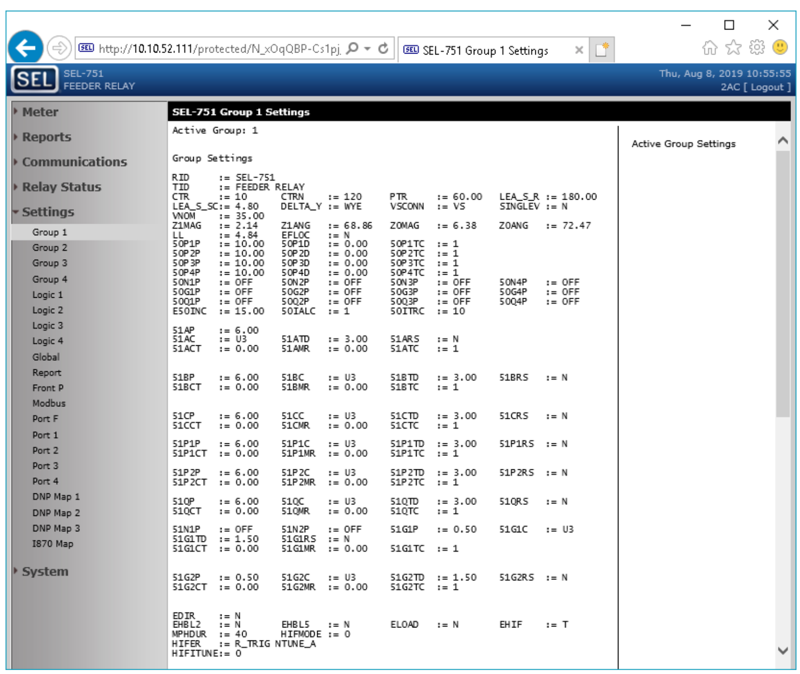


Figure 6.2 Logic 1 Settings Webpage

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 `Save changes (Y, N)?` 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.

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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** := ______________

COMPANY NAME (5 Characters) **CONAM** := ______________

Configuration

PHASE CT RATIO (1–5000) *(Shown if Slot Z ≠ 7L)* **CTR** := ______________

CURR SENSOR TYPE (RCOIL, LPCT) *(Shown if Slot Z = 7L)* **CS_TYPE** := ______________

RATED PRI CURR (1–6000 A pri) *(Shown if Slot Z = 7L)* **IPR** := ______________

RATED SENS VOLT (10.0–1000.0 mV at FNOM {if CS_TYPE = RCOIL}, 10.0–1000.0 mV {if CS_TYPE = LPCT}) *(Shown if Slot Z = 7L)* **USR** := ______________

NOMINAL CURRENT (1 A) *(Shown if Slot Z = 7L)* **INOM** := ______________

RATED FEEDER CUR (1–6000 A pri) *(Shown if Slot Z = 7L)* **FDR_CURR** := ______________

PHASE ILEA SCALE (1.00–6000.00 [autocalculated]) *(Shown if Slot Z = 7L)* **ILEA_SC** := ______________

NEUTRAL CT RATIO (1–5000) **CTRN** := ______________

PHASE PT RATIO (1.00–10000.00) *(Shown if Slot Z = 8x)* **PTR** := ______________

PHASE LPVT RATIO (37.50–500000.00) *(Shown if Slot Z = Lx or 7L)* **LEA_R** := ______________

PHASE LPVT SCALE (1.00–13333.33 [autocalculated]) *(Shown if Slot Z = Lx or 7L)* **LEA_SC** := ______________

SYNCV PT RATIO (1.00–10000.00) (*Shown if Slot E = 70 or 7A–7H*) **PTRS** := ______________

SYNCV LPVT RATIO (37.50–500000.00) (*Shown if Slot E = L0 or LA–LH*) **LEA_S_R** := ______________

SYNCV LPVT SCALE (1.00–13333.33 [autocalculated]) *(Shown if Slot E = L0 or LA–LH)* **LEA_S_SC** := ______________

VBAT CH PT RATIO (1.00–10000.00) *(Shown if Slot E = (7x or Lx, where x = 0, A, B, C, D, G, H) and EDCMON := N)* **PTRN** := ______________

XFMR CONNECTION (WYE, DELTA) *(Shown if Slot Z = 81–87, L1–L7, or 7L)* **DELTA_Y** := ______________

VS CONNECTION (VS, 3V0) (*Shown if Slot E = 70, 7A–7H, L0, or LA–LH)* **VSCONN** := ______________

EN SINGLEV (Y, N) *(Shown if Slot Z ≠ Ax)* **SINGLEV** := ______________

SINGLE V INPUT (VA, VB, VC {if DELTA_Y := WYE}, VAB, VBC, VCA {if DELTA_Y := DELTA}) *(Hidden if SINGLEV = N)*	**SING_VIN :=** ________
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}), 0.010–4.000 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}, 0.010–4.000 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}, 0.010–4.000 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}, 0.010–4.000 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, 0.00–400.00 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, 0.00–400.00 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, 0.00–400.00 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, 0.00–400.00 s) *(Hidden if 50Q4P := OFF)* **50Q4D** := ______________

NSEQ OC TRQ CON (SELOGIC) *(Hidden if 50Q4P := OFF)* **50Q4TC** := ______________

Incipient Cable Fault

50INC PU LVL (OFF, 0.01–10.00 • INOM A) **E50INC** := ______________

50INC WARN COUNT (1–100) *(Hidden if E50INC := OFF)*	**50IALC** := _______________
50INC TRIP COUNT (1–100) *(Hidden if E50INC := OFF)*	**50ITRC** := _______________
50INC TRQ CON (SELOGIC) *(Hidden if E50INC := OFF)*	**50INTC** := _______________
50INC RESET (SELOGIC) *(Hidden if E50INC := OFF)*	**50INCRST** := _______________

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, E1, E2, E3) *(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, E1, E2, E3) (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, E1, E2, E3) *(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, E1, E2, E3) *(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, E1, E2, E3) *(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, E1, E2, E3) *(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, E1, E2, E3) *(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, E1, E2, E3) *(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, E1, E2, E3) *(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, E1, E2, E3) *(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, AUTO2, 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 and AUTO2 are 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	INnom	VSCONN	Advanced Firmware Feature (MOT Option)	Range
WYE	N	5 A, 1 A	VS	Directional (MOT Option = 2, 4, or 5)	I, V, Q, IV, VI, QV, VQ, IQ, QI, IVQ, IQV, VQI, VIQ, QIV, QVI, OFF
DELTA	N	5 A, 1 A	VS	Directional (MOT Option = 2, 4, or 5)	I, Q, IQ, QI, OFF
WYE	Y	5 A, 1 A	VS	Directional (MOT Option = 2, 4, or 5)	I, OFF
DELTA	Y	5 A, 1 A	VS	Directional (MOT Option = 2, 4, or 5)	I, OFF
WYE	N	0.2 A	VS	Directional (MOT Option = 2, 4, or 5)	V, Q, VQ, QV, OFF
DELTA	N	0.2 A	VS	Directional (MOT Option = 2, 4, or 5)	Q, OFF
WYE	Y	0.2 A	VS	Directional (MOT Option = 2, 4, or 5)	Hidden and set to OFF
DELTA	Y	0.2 A	VS	Directional (MOT Option = 2, 4, or 5)	Hidden and set to OFF
WYE	N	5 A, 1 A	3V0	Directional (MOT Option = 2, 4, or 5)	I, V, Q, IV, VI, QV, VQ, IQ, QI, IVQ, IQV, VQI, VIQ, QIV, QVI, OFF
DELTA	N	5 A, 1 A	3V0	Directional (MOT Option = 2, 4, or 5)	I, V, Q, IV, VI, QV, VQ, IQ, QI, IVQ, IQV, VQI, VIQ, QIV, QVI, OFF
WYE	Y	5 A, 1 A	3V0	Directional (MOT Option = 2, 4, or 5)	I, V, IV, VI, OFF
DELTA	Y	5 A, 1 A	3V0	Directional (MOT Option = 2, 4, or 5)	V, I, VI, IV, OFF
WYE	N	0.2A	3V0	Directional (MOT Option = 2, 4, or 5)	V,Q,VQ,QV,OFF
DELTA	N	0.2 A	3V0	Directional (MOT Option = 2, 4, or 5)	V, Q, VQ, QV, OFF
WYE	Y	0.2 A	3V0	Directional (MOT Option = 2, 4, or 5)	V, OFF
DELTA	Y	0.2 A	3V0	Directional (MOT Option = 2, 4, or 5)	V, OFF
WYE	N	0.2 A	VS	Advanced Directional (MOT Option = 6, 7, or 8)	V, Q, P, U, VQ, QV, VP, QP, VS, VQS, QVS, VQP, QVP, OFF
DELTA	N	0.2 A	VS	Advanced Directional (MOT Option = 6, 7, or 8)	Q, OFF
WYE	Y	0.2 A	VS	Advanced Directional (MOT Option = 6, 7, or 8)	Hidden and set to OFF
DELTA	Y	0.2 A	VS	Advanced Directional (MOT Option = 6, 7, or 8)	Hidden and set to OFF
WYE	N	0.2 A	3V0	Advanced Directional (MOT Option = 6, 7, or 8)	V, Q, P, U, VQ, QV, VP, QP, VS, VQS, QVS, VQP, QVP, OFF
DELTA	N	0.2 A	3V0	Advanced Directional (MOT Option = 6, 7, or 8)	V, Q, P, U, VQ, QV, VP, QP, VS, VQS, QVS, VQP, QVP, OFF
WYE	Y	0.2 A	3V0	Advanced Directional (MOT Option = 6, 7, or 8)	V, P, U, VP, VS, OFF
DELTA	Y	0.2 A	3V0	Advanced Directional (MOT Option = 6, 7, or 8)	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/I_{NOM} and hidden if EDIR := AUTO; auto-set to –1.5/INOM and hidden if EDIR := AUTO2. 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/I_{NOM}), 640/I_{NOM}] and hidden if EDIR := AUTO; auto-set to 1.5/INOM and hidden if EDIR := AUTO2. 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 • I_{NOM} and hidden if EDIR := AUTO or AUTO2. 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 • I_{NOM} and hidden if EDIR := AUTO or AUTO2. Hidden if VNOM := OFF)* **50QRP :=** ______________

I1 RST FAC I2/I1 (0.02–0.50) *(Auto-set to 0.10 and hidden if EDIR := AUTO or AUTO2; hidden if VNOM := OFF)* **a2 :=** ______________

I0 RST FAC I2/I0 (0.10–1.20) *(Auto-set to 0.20 and hidden if EDIR := AUTO or AUTO2; 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 • I_{NOM} and hidden if EDIR := AUTO or AUTO2; 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 • I_{NOM} and hidden if EDIR := AUTO or AUTO2; 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 or AUTO2; 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), $(640/I_{NOM}) – (1/I_{NOM})$].
If EDIR := AUTO2, Z0F is autoset to –1.5/INOM and hidden.
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) + $(1/I_{NOM})$, $640/I_{NOM}$] and hidden.
If EDIR := AUTO2, Z0R is autoset to 1.5/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 Deadband –5.00 to +5.00 deg) *(Auto-set to Z0ANG and hidden if EDIR:=AUTO or AUTO2; 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 (0.00–18000.00 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 HIF detection settings are hidden if EHIF := N)	
HIF MULTI PH EVNT DURATION WNDW (OFF, 30–600 sec)	**MPHDUR** := ______________
TUNING AND DETECTION CURR THRES (0.02–0.10 A {1A nom}, 0.10–0.50 A {5 A nom})	**LOWITHR** := ______________
HIF DETECTION SENSITIVITY (SELOGIC)	**HIFMODE** := ______________
FREEZE HIF DETECTION ALGORITHM (SELOGIC)	**HIFFRZ** := ______________
HIF EVENT REPORT EXT. TRIGGER (SELOGIC)	**HIFER** := ______________
BEGIN 24 HOUR INITIAL HIF TUNING (SELOGIC)	**HIFITUNE** := ______________

Phase Discontinuity Detection

EN PH DISC DET (Y, N)	**EPDDET** := ______________
(The following phase discontinuity detection settings are hidden if EPDDET := N)	
PD DET TRQ CTRL (SELOGIC)	**PDDTC** := ______________
PD UNB THR (0.01–1.00 pu)	**PDUBTHR** := ______________

Broken Conductor Detection

(Hidden if firmware option in the MOT is 0, 1, 2, 4, 6, or 7)

EN BRK CND DET (Y, N)	**EBCDET** := ______________
(The following broken conductor detection settings are hidden if EBCDET := N)	
BCD LN LENTH (0.10–999.00)	**BCLL** := ______________

POS SEQ LN SUS (FM, 0.045–250.000 {5 A nom}, 0.009–50.000 {1 A nom})	**BCBI** := ______________
AVG NOM CH CR (15.0–16600.0 {5 A nom}, 3.0–3320.0 {1 A nom}) *(BCCIM is hidden if BCB1 is not FM)*	**BCCIM** := ______________
BC ZONE 1 REACH (OFF, 0.10–1.50 pu) *(BCZ1R must be less than BCZ2R)*	**BCZ1R** := ______________
BC ZONE 2 REACH (OFF, 0.10–1.50 pu) *(BCZ2R must be greater than BCZ1R)*	**BCZ2R** := ______________
ZONE 2 PKUP DEL (OFF, 0–600 cyc) *(BCZ2D is hidden if BCZ2R is OFF)*	**BCZ2D** := ______________
BC DET TRQ CTRL (SELOGIC)	**BCDTC** := ______________
L CH CR TRQ CTRL (SELOGIC)	**BCLCITC** := ______________
BCFL TRQ CTRL (SELOGIC)	**BCFLTC** := ______________
BC UNB THR (0.01–1.00 pu)	**BCUBTHR** := ______________

Cold Load Pickup

EN CLPU (Y, N)	**ECLPU** := ______________
(The following cold load pickup settings are hidden if ECLPU := N)	
CL START (SELOGIC)	**CLSTRT** := ______________
MIN CLO TIME (0–500 min)	**CLOTM** := ______________
EXT CLO TIME (OFF, 0–500 min)	**CLOTE** := ______________
CL REC DEL (0–500 min)	**CLRTD** := ______________
CL REC IMAG (OFF, 0.25–100.00 A {5 A nom}, 0.05–20.00 A {1 A nom})	**CLRIM** := ______________
CL REC CRNT DEL (1–500 min)	**CLRCTD** := ______________
CL RESET (SELOGIC)	**CLRST** := ______________

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 := 7x or Lx, where x = 0, A, B, C, D, G, H)*	**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 := 7x or Lx, where x = 0, A, B, C, D, G, H)*	**27S2P** := ________
UVS DELAY 2 (0.00–120.00 s) *(Hidden if 27S2P := OFF)*	**27S2D** := ________
UVBAT LEVEL 1 (OFF, 2.00–300.00 V) *(Shown if Slot E = (7x or Lx, where x = 0, A, B, C, D, G, H) and EDCMON := N)*	**27N1P** := ________
UVBAT DELAY 1 (0.00–120.00 s) *(Hidden if 27N1P := OFF)*	**27N1D** := ________
UVBAT LEVEL 2 (OFF, 2.00–300.00 V) *(Shown if Slot E = (7x or Lx, where x = 0, A, B, C, D, G, H) and EDCMON := N)*	**27N2P** := ________
UVBAT DELAY 2 (0.00–120.00 s) *(Hidden if 27N2P := OFF)*	**27N2D** := ________

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 = 7x or Lx, where x = 0, A, B, C, D, G, H)*	**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 = 7x or Lx, where x = 0, A, B, C, D, G, H)*	**59S2P :=** _______________
OVS DELAY 2 (0.00–120.00 s) *(Hidden if 59S2P := OFF)*	**59S2D :=** _______________
OVBAT LEVEL 1 (OFF, 2.00–300.00 V) *(Shown if Slot E = (7x or Lx, where x = 0, A, B, C, D, G, H) and EDCMON := N)*	**59N1P :=** _______________
OVBAT DELAY 1 (0.00–120.00 s) *(Hidden if 59N1P := OFF)*	**59N1D :=** _______________
OVBAT LEVEL 2 (OFF, 2.00–300.00 V) *(Shown if Slot E = (7x or Lx, where x = 0, A, B, C, D, G, H) and EDCMON := N)*	**59N2P :=** _______________
OVBAT DELAY 2 (0.00–120.00 s) *(Hidden if 59N2P := OFF)*	**59N2D :=** _______________

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

(Shown if VSCONN = VS and Slot E = 70, L0, 7A–7H, LA–LH)

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 :=** ______________
MAX VOLTAGE DIFF (OFF, 1.0–15.0%)	**25VDIF :=** ______________
V RATIO COR FAC (0.25–4.00)	**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, VAB, VBC, VCA, 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 :=** ______________

DEAD LINE VOLT (2.00–300.00 V)	**27LP** := ______________
LIVE LINE VOLT (2.00–300.00 V)	**59LP** := ______________
DEAD BUS VOLT (2.00–300.00 V)	**27BP** := ______________
LIVE BUS VOLT (2.00–300.00 V)	**59BP** := ______________

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

81 VOLTAGE SUP (OFF, 12.5–300.0 V)	**81VSUP** := __________
81 CURRENT SUP (OFF, 2.0–10.0 A {5 A nom}, 0.4–2.0 A {1 A nom})	**81ISUP** := __________
FREQ1 TRIP LEVEL (OFF, 15.00–70.00 Hz)	**81D1TP** := __________
FREQ1 TRIP DELAY (0.00–400.00 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 (0.00–400.00 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 (0.00–400.00 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 (0.00–400.00 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
(0.00–400.00 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
(0.00–400.00 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** := ______________

97 Frequency Magnitude

(Hidden if Slot Z = Ax)

97FM ENABLE (Y, N)	**E97FM1** := ______________
OPERATING QTTY (IA, IB, IC, VAB, VBC, VCA, P, Q, S, FREQ [DELTA_Y = DELTA] or IA, IB, IC, VA, VB, VC, P, Q, S, FREQ [DELTA_Y = WYE])	**97FM1OQ** := ______________
FREQ SETPOINT (0.00–960.00 Hz for analogs and FNOM = 60; 0.00–800.00 Hz for analogs and FNOM = 50; 0.00–60.00 Hz for P, Q, S, and FNOM = 60; 0.00–50.00 Hz for P, Q, S, and FNOM = 50; 0.00–10.00 Hz for FREQ and FNOM = 60; 0.00–8.00 Hz for FREQ and FNOM = 50)	**97FM1FS** := ______________
PICKUP TYPE (SU_EU, DB_FN for currents and voltages; SU_EU, DB_DC for P, Q, S, and FREQ)	**97FM1PT** := ______________
FREQUENCY RESOLUTION (0.1, 0.5, 1, 5, 10, 20 Hz)	**97FM1FR** := ______________
PICKUP LEVEL (97FMxPT = SU_EU [0.00–11250000.00 kVAR for Q; 0.00–11250000.00 kVA for S; 0.00–11250000.00 kW for P; 0.00, 0.01, ..., 2 • INOM for I; 0.00–300.00 for V; 0.00–70.00 Hz for FREQ or –60.00 to 0.00 for DB_FN or DB_DC])	**97FM1P** := ______________
TIME DELAY (0.0–6000.0 sec)	**97FM1TD** := ______________
TRQ CONTROL (SELOGIC)	**97FM1TC** := ______________
EVENT TIMER (SELOGIC)	**97FM1ER** := ______________
PICKUP TIMER (0–30000 min)	**97FM1PU** := ______________
DROPOUT TIMER (0–30000 min)	**97FM1DO** := ______________
97FM ENABLE (Y, N)	**E97FM2** := ______________
OPERATING QTTY (IA, IB, IC, VAB, VBC, VCA, P, Q, S, FREQ [DELTA_Y = DELTA] or IA, IB, IC, VA, VB, VC, P, Q, S, FREQ [DELTA_Y = WYE])	**97FM2OQ** := ______________
FREQ SETPOINT (0.00–960.00 Hz for analogs and FNOM = 60; 0.00–800.00 Hz for analogs and FNOM = 50; 0.00–60.00 Hz for P, Q, S, and FNOM = 60; 0.00–50.00 Hz for P, Q, S, and FNOM = 50; 0.00–10.00 Hz for FREQ and FNOM = 60; 0.00–8.00 Hz for FREQ and FNOM = 50)	**97FM2FS** := ______________
PICKUP TYPE (SU_EU, DB_FN for currents and voltages; SU_EU, DB_DC for P, Q, S, and FREQ)	**97FM2PT** := ______________
FREQUENCY RESOLUTION (0.1, 0.5, 1, 5, 10, 20 Hz)	**97FM2FR** := ______________

PICKUP LEVEL (97FMxPT = SU_EU [0.00–11250000.00 kVAR for Q; 0.00–11250000.00 kVA for S; 0.00–11250000.00 kW for P; 0.00, 0.01, ..., 2 • INOM for I; 0.00–300.00 for V; 0.00–70.00 Hz for FREQ or –60.00 to 0.00 for DB_FN or DB_DC])	**97FM2P** := _______________
TIME DELAY (0.0–6000.0 sec)	**97FM2TD** := _______________
TRQ CONTROL (SELOGIC)	**97FM2TC** := _______________
EVENT TIMER (SELOGIC)	**97FM2ER** := _______________
PICKUP TIMER (0–30000 min)	**97FM2PU** := _______________
DROPOUT TIMER (0–30000 min)	**97FM2DO** := _______________
97FM ENABLE (Y, N)	**E97FM3** := _______________
OPERATING QTTY (IA, IB, IC, VAB, VBC, VCA, P, Q, S, FREQ [DELTA_Y = DELTA] or IA, IB, IC, VA, VB, VC, P, Q, S, FREQ [DELTA_Y = WYE])	**97FM3OQ** := _______________
FREQ SETPOINT (0.00–960.00 Hz for analogs and FNOM = 60; 0.00–800.00 Hz for analogs and FNOM = 50; 0.00–60.00 Hz for P, Q, S, and FNOM = 60; 0.00–50.00 Hz for P, Q, S, and FNOM = 50; 0.00–10.00 Hz for FREQ and FNOM = 60; 0.00–8.00 Hz for FREQ and FNOM = 50)	**97FM3FS** := _______________
PICKUP TYPE (SU_EU, DB_FN for currents and voltages; SU_EU, DB_DC for P, Q, S, and FREQ)	**97FM3PT** := _______________
FREQUENCY RESOLUTION (0.1, 0.5, 1, 5, 10, 20 Hz)	**97FM3FR** := _______________
PICKUP LEVEL (97FMxPT = SU_EU [0.00–11250000.00 kVAR for Q; 0.00–11250000.00 kVA for S; 0.00–11250000.00 kW for P; 0.00, 0.01, ..., 2 • INOM for I; 0.00–300.00 for V; 0.00–70.00 Hz for FREQ or –60.00 to 0.00 for DB_FN or DB_DC])	**97FM3P** := _______________
TIME DELAY (0.0–6000.0 sec)	**97FM3TD** := _______________
TRQ CONTROL (SELOGIC)	**97FM3TC** := _______________
EVENT TIMER (SELOGIC)	**97FM3ER** := _______________
PICKUP TIMER (0–30000 min)	**97FM3PU** := _______________
DROPOUT TIMER (0–30000 min)	**97FM3DO** := _______________
97FM ENABLE (Y, N)	**E97FM4** := _______________
OPERATING QTTY (IA, IB, IC, VAB, VBC, VCA, P, Q, S, FREQ [DELTA_Y = DELTA] or IA, IB, IC, VA, VB, VC, P, Q, S, FREQ [DELTA_Y = WYE])	**97FM4OQ** := _______________
FREQ SETPOINT (0.00–960.00 Hz for analogs and FNOM = 60; 0.00–800.00 Hz for analogs and FNOM = 50; 0.00–60.00 Hz for P, Q, S, and FNOM = 60; 0.00–50.00 Hz for P, Q, S, and FNOM = 50; 0.00–10.00 Hz for FREQ and FNOM = 60; 0.00–8.00 Hz for FREQ and FNOM = 50)	**97FM4FS** := _______________
PICKUP TYPE (SU_EU, DB_FN for currents and voltages; SU_EU, DB_DC for P, Q, S, and FREQ)	**97FM4PT** := _______________
FREQUENCY RESOLUTION (0.1, 0.5, 1, 5, 10, 20 Hz)	**97FM4FR** := _______________
PICKUP LEVEL (97FMxPT = SU_EU [0.00–11250000.00 kVAR for Q; 0.00–11250000.00 kVA for S; 0.00–11250000.00 kW for P; 0.00, 0.01, ..., 2 • INOM for I; 0.00–300.00 for V; 0.00–70.00 Hz for FREQ or –60.00 to 0.00 for DB_FN or DB_DC])	**97FM4P** := _______________
TIME DELAY (0.0–6000.0 sec)	**97FM4TD** := _______________
TRQ CONTROL (SELOGIC)	**97FM4TC** := _______________
EVENT TIMER (SELOGIC)	**97FM4ER** := _______________
PICKUP TIMER (0–30000 min)	**97FM4PU** := _______________
DROPOUT TIMER (0–30000 min)	**97FM4DO** := _______________

97FM ENABLE (Y, N)	**E97FM5 :=** ______________
OPERATING QTTY (IA, IB, IC, VAB, VBC, VCA, P, Q, S, FREQ [DELTA_Y = DELTA] or IA, IB, IC, VA, VB, VC, P, Q, S, FREQ [DELTA_Y = WYE])	**97FM5OQ :=** ______________
FREQ SETPOINT (0.00–960.00 Hz for analogs and FNOM = 60; 0.00–800.00 Hz for analogs and FNOM = 50; 0.00–60.00 Hz for P, Q, S, and FNOM = 60; 0.00–50.00 Hz for P, Q, S, and FNOM = 50; 0.00–10.00 Hz for FREQ and FNOM = 60; 0.00–8.00 Hz for FREQ and FNOM = 50)	**97FM5FS :=** ______________
PICKUP TYPE (SU_EU, DB_FN for currents and voltages; SU_EU, DB_DC for P, Q, S, and FREQ)	**97FM5PT :=** ______________
FREQUENCY RESOLUTION (0.1, 0.5, 1, 5, 10, 20 Hz)	**97FM5FR :=** ______________
PICKUP LEVEL (97FMxPT = SU_EU [0.00–11250000.00 kVAR for Q; 0.00–11250000.00 kVA for S; 0.00–11250000.00 kW for P; 0.00, 0.01, ..., 2 • INOM for I; 0.00–300.00 for V; 0.00–70.00 Hz for FREQ or –60.00 to 0.00 for DB_FN or DB_DC])	**97FM5P :=** ______________
TIME DELAY (0.0–6000.0 sec)	**97FM5TD :=** ______________
TRQ CONTROL (SELOGIC)	**97FM5TC :=** ______________
EVENT TIMER (SELOGIC)	**97FM5ER :=** ______________
PICKUP TIMER (0–30000 min)	**97FM5PU :=** ______________
DROPOUT TIMER (0–30000 min)	**97FM5DO :=** ______________
97FM ENABLE (Y, N)	**E97FM6 :=** ______________
OPERATING QTTY (IA, IB, IC, VAB, VBC, VCA, P, Q, S, FREQ [DELTA_Y = DELTA] or IA, IB, IC, VA, VB, VC, P, Q, S, FREQ [DELTA_Y = WYE])	**97FM6OQ :=** ______________
FREQ SETPOINT (0.00–960.00 Hz for analogs and FNOM = 60; 0.00–800.00 Hz for analogs and FNOM = 50; 0.00–60.00 Hz for P, Q, S, and FNOM = 60; 0.00–50.00 Hz for P, Q, S, and FNOM = 50; 0.00–10.00 Hz for FREQ and FNOM = 60; 0.00–8.00 Hz for FREQ and FNOM = 50)	**97FM6FS :=** ______________
PICKUP TYPE (SU_EU, DB_FN for currents and voltages; SU_EU, DB_DC for P, Q, S, and FREQ)	**97FM6PT :=** ______________
FREQUENCY RESOLUTION (0.1, 0.5, 1, 5, 10, 20 Hz)	**97FM6FR :=** ______________
PICKUP LEVEL (97FMxPT = SU_EU [0.00–11250000.00 kVAR for Q; 0.00–11250000.00 kVA for S; 0.00–11250000.00 kW for P; 0.00, 0.01, ..., 2 • INOM for I; 0.00–300.00 for V; 0.00–70.00 Hz for FREQ or –60.00 to 0.00 for DB_FN or DB_DC])	**97FM6P :=** ______________
TIME DELAY (0.0–6000.0 sec)	**97FM6TD :=** ______________
TRQ CONTROL (SELOGIC)	**97FM6TC :=** ______________
EVENT TIMER (SELOGIC)	**97FM6ER :=** ______________
PICKUP TIMER (0–30000 min)	**97FM6PU :=** ______________
DROPOUT TIMER (0–30000 min)	**97FM6DO :=** ______________
97FM ENABLE (Y, N)	**E97FM7 :=** ______________
OPERATING QTTY (IA, IB, IC, VAB, VBC, VCA, P, Q, S, FREQ [DELTA_Y = DELTA] or IA, IB, IC, VA, VB, VC, P, Q, S, FREQ [DELTA_Y = WYE])	**97FM7OQ :=** ______________
FREQ SETPOINT (0.00–960.00 Hz for analogs and FNOM = 60; 0.00–800.00 Hz for analogs and FNOM = 50; 0.00–60.00 Hz for P, Q, S, and FNOM = 60; 0.00–50.00 Hz for P, Q, S, and FNOM = 50; 0.00–10.00 Hz for FREQ and FNOM = 60; 0.00–8.00 Hz for FREQ and FNOM = 50)	**97FM7FS :=** ______________
PICKUP TYPE (SU_EU, DB_FN for currents and voltages; SU_EU, DB_DC for P, Q, S, and FREQ)	**97FM7PT :=** ______________

FREQUENCY RESOLUTION (0.1, 0.5, 1, 5, 10, 20 Hz)	97FM7FR := ______________
PICKUP LEVEL (97FMxPT = SU_EU [0.00–11250000.00 kVAR for Q; 0.00–11250000.00 kVA for S; 0.00–11250000.00 kW for P; 0.00, 0.01, ..., 2 • INOM for I; 0.00–300.00 for V; 0.00–70.00 Hz for FREQ or –60.00 to 0.00 for DB_FN or DB_DC])	97FM7P := ______________
TIME DELAY (0.0–6000.0 sec)	97FM7TD := ______________
TRQ CONTROL (SELOGIC)	97FM7TC := ______________
EVENT TIMER (SELOGIC)	97FM7ER := ______________
PICKUP TIMER (0–30000 min)	97FM7PU := ______________
DROPOUT TIMER (0–30000 min)	97FM7DO := ______________
97FM ENABLE (Y, N)	E97FM8 := ______________
OPERATING QTTY (IA, IB, IC, VAB, VBC, VCA, P, Q, S, FREQ [DELTA_Y = DELTA] or IA, IB, IC, VA, VB, VC, P, Q, S, FREQ [DELTA_Y = WYE])	97FM8OQ := ______________
FREQ SETPOINT (0.00–960.00 Hz for analogs and FNOM = 60; 0.00–800.00 Hz for analogs and FNOM = 50; 0.00–60.00 Hz for P, Q, S, and FNOM = 60; 0.00–50.00 Hz for P, Q, S, and FNOM = 50; 0.00–10.00 Hz for FREQ and FNOM = 60; 0.00–8.00 Hz for FREQ and FNOM = 50)	97FM8FS := ______________
PICKUP TYPE (SU_EU, DB_FN for currents and voltages; SU_EU, DB_DC for P, Q, S, and FREQ)	97FM8PT := ______________
FREQUENCY RESOLUTION (0.1, 0.5, 1, 5, 10, 20 Hz)	97FM8FR := ______________
PICKUP LEVEL (97FMxPT = SU_EU [0.00–11250000.00 kVAR for Q; 0.00–11250000.00 kVA for S; 0.00–11250000.00 kW for P; 0.00, 0.01, ..., 2 • INOM for I; 0.00–300.00 for V; 0.00–70.00 Hz for FREQ or –60.00 to 0.00 for DB_FN or DB_DC])	97FM8P := ______________
TIME DELAY (0.0–6000.0 sec)	97FM8TD := ______________
TRQ CONTROL (SELOGIC)	97FM8TC := ______________
EVENT TIMER (SELOGIC)	97FM8ER := ______________
PICKUP TIMER (0–30000 min)	97FM8PU := ______________
DROPOUT TIMER (0–30000 min)	97FM8DO := ______________
97FM ENABLE (Y, N)	E97FM9 := ______________
OPERATING QTTY (IA, IB, IC, VAB, VBC, VCA, P, Q, S, FREQ [DELTA_Y = DELTA] or IA, IB, IC, VA, VB, VC, P, Q, S, FREQ [DELTA_Y = WYE])	97FM9OQ := ______________
FREQ SETPOINT (0.00–960.00 Hz for analogs and FNOM = 60; 0.00–800.00 Hz for analogs and FNOM = 50; 0.00–60.00 Hz for P, Q, S, and FNOM = 60; 0.00–50.00 Hz for P, Q, S, and FNOM = 50; 0.00–10.00 Hz for FREQ and FNOM = 60; 0.00–8.00 Hz for FREQ and FNOM = 50)	97FM9FS := ______________
PICKUP TYPE (SU_EU, DB_FN for currents and voltages; SU_EU, DB_DC for P, Q, S, and FREQ)	97FM9PT := ______________
FREQUENCY RESOLUTION (0.1, 0.5, 1, 5, 10, 20 Hz)	97FM9FR := ______________
PICKUP LEVEL (97FMxPT = SU_EU [0.00–11250000.00 kVAR for Q; 0.00–11250000.00 kVA for S; 0.00–11250000.00 kW for P; 0.00, 0.01, ..., 2 • INOM for I; 0.00–300.00 for V; 0.00–70.00 Hz for FREQ or –60.00 to 0.00 for DB_FN or DB_DC])	97FM9P := ______________
TIME DELAY (0.0–6000.0 sec)	97FM9TD := ______________
TRQ CONTROL (SELOGIC)	97FM9TC := ______________
EVENT TIMER (SELOGIC)	97FM9ER := ______________
PICKUP TIMER (0–30000 min)	97FM9PU := ______________

DROPOUT TIMER (0–30000 min)	**97FM9DO** := ______________
97FM ENABLE (Y, N)	**E97FM0** := ______________
OPERATING QTTY (IA, IB, IC, VAB, VBC, VCA, P, Q, S, FREQ [DELTA_Y = DELTA] or IA, IB, IC, VA, VB, VC, P, Q, S, FREQ [DELTA_Y = WYE])	**97FM0OQ** := ______________
FREQ SETPOINT (0.00–960.00 Hz for analogs and FNOM = 60; 0.00–800.00 Hz for analogs and FNOM = 50; 0.00–60.00 Hz for P, Q, S, and FNOM = 60; 0.00–50.00 Hz for P, Q, S, and FNOM = 50; 0.00–10.00 Hz for FREQ and FNOM = 60; 0.00–8.00 Hz for FREQ and FNOM = 50)	**97FM0PT** := ______________
PICKUP TYPE (SU_EU, DB_FN for currents and voltages; SU_EU, DB_DC for P, Q, S, and FREQ)	**97FM0PT** := ______________
FREQUENCY RESOLUTION (0.1, 0.5, 1, 5, 10, 20 Hz)	**97FM0FR** := ______________
PICKUP LEVEL (97FMxPT = SU_EU [0.00–11250000.00 kVAR for Q; 0.00–11250000.00 kVA for S; 0.00–11250000.00 kW for P; 0.00, 0.01, ..., 2 • INOM for I; 0.00–300.00 for V; 0.00–70.00 Hz for FREQ or –60.00 to 0.00 for DB_FN or DB_DC])	**97FM0P** := ______________
TIME DELAY (0.0–6000.0 sec)	**97FM0TD** := ______________
TRQ CONTROL (SELOGIC)	**97FM0TC** := ______________
EVENT TIMER (SELOGIC)	**97FM0ER** := ______________
PICKUP TIMER (0–30000 min)	**97FM0PU** := ______________
DROPOUT TIMER (0–30000 min)	**97FM0DO** := ______________

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** := ______________
MANUAL TRIP EQN (SELOGIC)	**MTR** := ______________
UNLATCH TRIP (SELOGIC)	**ULTRIP** := ______________
UNLATCH MTRIP (SELOGIC)	**ULMTRIP** := ______________
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, 1–64)	**ELAT** := ______________
SV/TIMERS (N, 1–64)	**ESV** := ______________
SELOGIC COUNTERS (N, 1–64)	**ESC** := ______________
MATH VARIABLES (N, 1–64)	**EMV** := ______________

Latch Bits Equations

SET01 := ____________________

RST01 := ____________________

SET02 := ____________________

RST02 := ____________________

SET03 := ____________________

RST03 := ____________________

SET04 := ____________________

RST04 := ____________________

SET05 := ____________________

RST05 := ____________________

SET06 := ____________________

RST06 := ____________________

SET07 := ____________________

RST07 := ____________________

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SET59 := ________________

RST59 := ________________

SET60 := ________________

RST60 := ________________

SET61 := ________________

RST61 := ________________

SET62 := ______________________________
RST62 := ______________________________
SET63 := ______________________________
RST63 := ______________________________
SET64 := ______________________________
RST64 := ______________________________

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 :=	
SV TIMER PICKUP (0.00–3000.00 s)		SV33PU :=
SV TIMER DROPOUT (0.00–3000.00 s)		SV33DO :=
SV INPUT (SELOGIC)	SV33 :=	
SV TIMER PICKUP (0.00–3000.00 s)		SV34PU :=
SV TIMER DROPOUT (0.00–3000.00 s)		SV34DO :=

SV INPUT (SELOGIC) **SV34 :=** ______________________________
SV TIMER PICKUP (0.00–3000.00 s) **SV35PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s) **SV35DO :=** ______________

SV INPUT (SELOGIC) **SV35 :=** ______________________________
SV TIMER PICKUP (0.00–3000.00 s) **SV36PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s) **SV36DO :=** ______________

SV INPUT (SELOGIC) **SV36 :=** ______________________________
SV TIMER PICKUP (0.00–3000.00 s) **SV37PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s) **SV37DO :=** ______________

SV INPUT (SELOGIC) **SV37 :=** ______________________________
SV TIMER PICKUP (0.00–3000.00 s) **SV38PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s) **SV38DO :=** ______________

SV INPUT (SELOGIC) **SV38 :=** ______________________________
SV TIMER PICKUP (0.00–3000.00 s) **SV39PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s) **SV39DO :=** ______________

SV INPUT (SELOGIC) **SV39 :=** ______________________________
SV TIMER PICKUP (0.00–3000.00 s) **SV40PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s) **SV40DO :=** ______________

SV INPUT (SELOGIC) **SV40 :=** ______________________________
SV TIMER PICKUP (0.00–3000.00 s) **SV41PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s) **SV41DO :=** ______________

SV INPUT (SELOGIC) **SV41 :=** ______________________________
SV TIMER PICKUP (0.00–3000.00 s) **SV42PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s) **SV42DO :=** ______________

SV INPUT (SELOGIC) **SV42 :=** ______________________________
SV TIMER PICKUP (0.00–3000.00 s) **SV43PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s) **SV43DO :=** ______________

SV INPUT (SELOGIC) **SV43 :=** ______________________________
SV TIMER PICKUP (0.00–3000.00 s) **SV44PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s) **SV44DO :=** ______________

SV INPUT (SELOGIC) **SV44 :=** ______________________________
SV TIMER PICKUP (0.00–3000.00 s) **SV45PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s) **SV45DO :=** ______________

SV INPUT (SELOGIC) **SV45 :=** ______________________________
SV TIMER PICKUP (0.00–3000.00 s) **SV46PU :=** ______________
SV TIMER DROPOUT (0.00–3000.00 s) **SV46DO :=** ______________

SV INPUT (SELOGIC)	**SV46 :=** ______
SV TIMER PICKUP (0.00–3000.00 s)	**SV47PU :=** ______
SV TIMER DROPOUT (0.00–3000.00 s)	**SV47DO :=** ______
SV INPUT (SELOGIC)	**SV47 :=** ______
SV TIMER PICKUP (0.00–3000.00 s)	**SV48PU :=** ______
SV TIMER DROPOUT (0.00–3000.00 s)	**SV48DO :=** ______
SV INPUT (SELOGIC)	**SV48 :=** ______
SV TIMER PICKUP (0.00–3000.00 s)	**SV49PU :=** ______
SV TIMER DROPOUT (0.00–3000.00 s)	**SV49DO :=** ______
SV INPUT (SELOGIC)	**SV49 :=** ______
SV TIMER PICKUP (0.00–3000.00 s)	**SV50PU :=** ______
SV TIMER DROPOUT (0.00–3000.00 s)	**SV50DO :=** ______
SV INPUT (SELOGIC)	**SV50 :=** ______
SV TIMER PICKUP (0.00–3000.00 s)	**SV51PU :=** ______
SV TIMER DROPOUT (0.00–3000.00 s)	**SV51DO :=** ______
SV INPUT (SELOGIC)	**SV51 :=** ______
SV TIMER PICKUP (0.00–3000.00 s)	**SV52PU :=** ______
SV TIMER DROPOUT (0.00–3000.00 s)	**SV52DO :=** ______
SV INPUT (SELOGIC)	**SV52 :=** ______
SV TIMER PICKUP (0.00–3000.00 s)	**SV53PU :=** ______
SV TIMER DROPOUT (0.00–3000.00 s)	**SV53DO :=** ______
SV INPUT (SELOGIC)	**SV53 :=** ______
SV TIMER PICKUP (0.00–3000.00 s)	**SV54PU :=** ______
SV TIMER DROPOUT (0.00–3000.00 s)	**SV54DO :=** ______
SV INPUT (SELOGIC)	**SV54 :=** ______
SV TIMER PICKUP (0.00–3000.00 s)	**SV55PU :=** ______
SV TIMER DROPOUT (0.00–3000.00 s)	**SV55DO :=** ______
SV INPUT (SELOGIC)	**SV55 :=** ______
SV TIMER PICKUP (0.00–3000.00 s)	**SV56PU :=** ______
SV TIMER DROPOUT (0.00–3000.00 s)	**SV56DO :=** ______
SV INPUT (SELOGIC)	**SV56 :=** ______
SV TIMER PICKUP (0.00–3000.00 s)	**SV57PU :=** ______
SV TIMER DROPOUT (0.00–3000.00 s)	**SV57DO :=** ______
SV INPUT (SELOGIC)	**SV57 :=** ______
SV TIMER PICKUP (0.00–3000.00 s)	**SV58PU :=** ______
SV TIMER DROPOUT (0.00–3000.00 s)	**SV58DO :=** ______

SV INPUT (SELOGIC) **SV58 :=** ____________

SV TIMER PICKUP (0.00–3000.00 s) **SV59PU :=** ____________

SV TIMER DROPOUT (0.00–3000.00 s) **SV59DO :=** ____________

SV INPUT (SELOGIC) **SV59 :=** ____________

SV TIMER PICKUP (0.00–3000.00 s) **SV60PU :=** ____________

SV TIMER DROPOUT (0.00–3000.00 s) **SV60DO :=** ____________

SV INPUT (SELOGIC) **SV60 :=** ____________

SV TIMER PICKUP (0.00–3000.00 s) **SV61PU :=** ____________

SV TIMER DROPOUT (0.00–3000.00 s) **SV61DO :=** ____________

SV INPUT (SELOGIC) **SV61 :=** ____________

SV TIMER PICKUP (0.00–3000.00 s) **SV62PU :=** ____________

SV TIMER DROPOUT (0.00–3000.00 s) **SV62DO :=** ____________

SV INPUT (SELOGIC) **SV62 :=** ____________

SV TIMER PICKUP (0.00–3000.00 s) **SV63PU :=** ____________

SV TIMER DROPOUT (0.00–3000.00 s) **SV63DO :=** ____________

SV INPUT (SELOGIC) **SV63 :=** ____________

SV TIMER PICKUP (0.00–3000.00 s) **SV64PU :=** ____________

SV TIMER DROPOUT (0.00–3000.00 s) **SV64DO :=** ____________

SV INPUT (SELOGIC) **SV64 :=** ____________

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 :=** ______________
SC PRESET VALUE (1–65000)	**SC33PV :=** ______________
SC RESET INPUT (SELOGIC)	**SC33R :=** ______________
SC LOAD PV INPUT (SELOGIC)	**SC33LD :=** ______________

SC CNT UP INPUT (SELOGIC)	**SC33CU** := ________________
SC CNT DN INPUT (SELOGIC)	**SC33CD** := ________________
SC PRESET VALUE (1–65000)	**SC34PV** := ______
SC RESET INPUT (SELOGIC)	**SC34R** := ________________
SC LOAD PV INPUT (SELOGIC)	**SC34LD** := ________________
SC CNT UP INPUT (SELOGIC)	**SC34CU** := ________________
SC CNT DN INPUT (SELOGIC)	**SC34CD** := ________________
SC PRESET VALUE (1–65000)	**SC35PV** := ______
SC RESET INPUT (SELOGIC)	**SC35R** := ________________
SC LOAD PV INPUT (SELOGIC)	**SC35LD** := ________________
SC CNT UP INPUT (SELOGIC)	**SC35CU** := ________________
SC CNT DN INPUT (SELOGIC)	**SC35CD** := ________________
SC PRESET VALUE (1–65000)	**SC36PV** := ______
SC RESET INPUT (SELOGIC)	**SC36R** := ________________
SC LOAD PV INPUT (SELOGIC)	**SC36LD** := ________________
SC CNT UP INPUT (SELOGIC)	**SC36CU** := ________________
SC CNT DN INPUT (SELOGIC)	**SC36CD** := ________________
SC PRESET VALUE (1–65000)	**SC37PV** := ______
SC RESET INPUT (SELOGIC)	**SC37R** := ________________
SC LOAD PV INPUT (SELOGIC)	**SC37LD** := ________________
SC CNT UP INPUT (SELOGIC)	**SC37CU** := ________________
SC CNT DN INPUT (SELOGIC)	**SC37CD** := ________________
SC PRESET VALUE (1–65000)	**SC38PV** := ______
SC RESET INPUT (SELOGIC)	**SC38R** := ________________
SC LOAD PV INPUT (SELOGIC)	**SC38LD** := ________________
SC CNT UP INPUT (SELOGIC)	**SC38CU** := ________________
SC CNT DN INPUT (SELOGIC)	**SC38CD** := ________________
SC PRESET VALUE (1–65000)	**SC39PV** := ______
SC RESET INPUT (SELOGIC)	**SC39R** := ________________
SC LOAD PV INPUT (SELOGIC)	**SC39LD** := ________________
SC CNT UP INPUT (SELOGIC)	**SC39CU** := ________________
SC CNT DN INPUT (SELOGIC)	**SC39CD** := ________________
SC PRESET VALUE (1–65000)	**SC40PV** := ______
SC RESET INPUT (SELOGIC)	**SC40R** := ________________
SC LOAD PV INPUT (SELOGIC)	**SC40LD** := ________________
SC CNT UP INPUT (SELOGIC)	**SC40CU** := ________________
SC CNT DN INPUT (SELOGIC)	**SC40CD** := ________________

SC PRESET VALUE (1–65000) **SC41PV :=** ______________
SC RESET INPUT (SELOGIC) **SC41R :=** ______________
SC LOAD PV INPUT (SELOGIC) **SC41LD :=** ______________
SC CNT UP INPUT (SELOGIC) **SC41CU :=** ______________
SC CNT DN INPUT (SELOGIC) **SC41CD :=** ______________

SC PRESET VALUE (1–65000) **SC42PV :=** ______________
SC RESET INPUT (SELOGIC) **SC42R :=** ______________
SC LOAD PV INPUT (SELOGIC) **SC42LD :=** ______________
SC CNT UP INPUT (SELOGIC) **SC42CU :=** ______________
SC CNT DN INPUT (SELOGIC) **SC42CD :=** ______________

SC PRESET VALUE (1–65000) **SC43PV :=** ______________
SC RESET INPUT (SELOGIC) **SC43R :=** ______________
SC LOAD PV INPUT (SELOGIC) **SC43LD :=** ______________
SC CNT UP INPUT (SELOGIC) **SC43CU :=** ______________
SC CNT DN INPUT (SELOGIC) **SC43CD :=** ______________

SC PRESET VALUE (1–65000) **SC44PV :=** ______________
SC RESET INPUT (SELOGIC) **SC44R :=** ______________
SC LOAD PV INPUT (SELOGIC) **SC44LD :=** ______________
SC CNT UP INPUT (SELOGIC) **SC44CU :=** ______________
SC CNT DN INPUT (SELOGIC) **SC44CD :=** ______________

SC PRESET VALUE (1–65000) **SC45PV :=** ______________
SC RESET INPUT (SELOGIC) **SC45R :=** ______________
SC LOAD PV INPUT (SELOGIC) **SC45LD :=** ______________
SC CNT UP INPUT (SELOGIC) **SC45CU :=** ______________
SC CNT DN INPUT (SELOGIC) **SC45CD :=** ______________

SC PRESET VALUE (1–65000) **SC46PV :=** ______________
SC RESET INPUT (SELOGIC) **SC46R :=** ______________
SC LOAD PV INPUT (SELOGIC) **SC46LD :=** ______________
SC CNT UP INPUT (SELOGIC) **SC46CU :=** ______________
SC CNT DN INPUT (SELOGIC) **SC46CD :=** ______________

SC PRESET VALUE (1–65000) **SC47PV :=** ______________
SC RESET INPUT (SELOGIC) **SC47R :=** ______________
SC LOAD PV INPUT (SELOGIC) **SC47LD :=** ______________
SC CNT UP INPUT (SELOGIC) **SC47CU :=** ______________
SC CNT DN INPUT (SELOGIC) **SC47CD :=** ______________

SC PRESET VALUE (1–65000)	**SC48PV :=** ______________
SC RESET INPUT (SELOGIC)	**SC48R :=** ______________
SC LOAD PV INPUT (SELOGIC)	**SC48LD :=** ______________
SC CNT UP INPUT (SELOGIC)	**SC48CU :=** ______________
SC CNT DN INPUT (SELOGIC)	**SC48CD :=** ______________
SC PRESET VALUE (1–65000)	**SC49PV :=** ______________
SC RESET INPUT (SELOGIC)	**SC49R :=** ______________
SC LOAD PV INPUT (SELOGIC)	**SC49LD :=** ______________
SC CNT UP INPUT (SELOGIC)	**SC49CU :=** ______________
SC CNT DN INPUT (SELOGIC)	**SC49CD :=** ______________
SC PRESET VALUE (1–65000)	**SC50PV :=** ______________
SC RESET INPUT (SELOGIC)	**SC50R :=** ______________
SC LOAD PV INPUT (SELOGIC)	**SC50LD :=** ______________
SC CNT UP INPUT (SELOGIC)	**SC50CU :=** ______________
SC CNT DN INPUT (SELOGIC)	**SC50CD :=** ______________
SC PRESET VALUE (1–65000)	**SC51PV :=** ______________
SC RESET INPUT (SELOGIC)	**SC51R :=** ______________
SC LOAD PV INPUT (SELOGIC)	**SC51LD :=** ______________
SC CNT UP INPUT (SELOGIC)	**SC51CU :=** ______________
SC CNT DN INPUT (SELOGIC)	**SC51CD :=** ______________
SC PRESET VALUE (1–65000)	**SC52V :=** ______________
SC RESET INPUT (SELOGIC)	**SC52R :=** ______________
SC LOAD PV INPUT (SELOGIC)	**SC52LD :=** ______________
SC CNT UP INPUT (SELOGIC)	**SC52CU :=** ______________
SC CNT DN INPUT (SELOGIC)	**SC52CD :=** ______________
SC PRESET VALUE (1–65000)	**SC53PV :=** ______________
SC RESET INPUT (SELOGIC)	**SC53R :=** ______________
SC LOAD PV INPUT (SELOGIC)	**SC53LD :=** ______________
SC CNT UP INPUT (SELOGIC)	**SC53CU :=** ______________
SC CNT DN INPUT (SELOGIC)	**SC53CD :=** ______________
SC PRESET VALUE (1–65000)	**SC54PV :=** ______________
SC RESET INPUT (SELOGIC)	**SC54R :=** ______________
SC LOAD PV INPUT (SELOGIC)	**SC54LD :=** ______________
SC CNT UP INPUT (SELOGIC)	**SC54CU :=** ______________
SC CNT DN INPUT (SELOGIC)	**SC54CD :=** ______________

SC PRESET VALUE (1–65000) **SC55PV :=** ______________
SC RESET INPUT (SELOGIC) **SC55R :=** ______________
SC LOAD PV INPUT (SELOGIC) **SC55LD :=** ______________
SC CNT UP INPUT (SELOGIC) **SC55CU :=** ______________
SC CNT DN INPUT (SELOGIC) **SC55CD :=** ______________

SC PRESET VALUE (1–65000) **SC56PV :=** ______________
SC RESET INPUT (SELOGIC) **SC56R :=** ______________
SC LOAD PV INPUT (SELOGIC) **SC56LD :=** ______________
SC CNT UP INPUT (SELOGIC) **SC56CU :=** ______________
SC CNT DN INPUT (SELOGIC) **SC56CD :=** ______________

SC PRESET VALUE (1–65000) **SC57PV :=** ______________
SC RESET INPUT (SELOGIC) **SC57R :=** ______________
SC LOAD PV INPUT (SELOGIC) **SC57LD :=** ______________
SC CNT UP INPUT (SELOGIC) **SC57CU :=** ______________
SC CNT DN INPUT (SELOGIC) **SC57CD :=** ______________

SC PRESET VALUE (1–65000) **SC58PV :=** ______________
SC RESET INPUT (SELOGIC) **SC58R :=** ______________
SC LOAD PV INPUT (SELOGIC) **SC58LD :=** ______________
SC CNT UP INPUT (SELOGIC) **SC58CU :=** ______________
SC CNT DN INPUT (SELOGIC) **SC58CD :=** ______________

SC PRESET VALUE (1–65000) **SC59PV :=** ______________
SC RESET INPUT (SELOGIC) **SC59R :=** ______________
SC LOAD PV INPUT (SELOGIC) **SC59LD :=** ______________
SC CNT UP INPUT (SELOGIC) **SC59CU :=** ______________
SC CNT DN INPUT (SELOGIC) **SC59CD :=** ______________

SC PRESET VALUE (1–65000) **SC60PV :=** ______________
SC RESET INPUT (SELOGIC) **SC60R :=** ______________
SC LOAD PV INPUT (SELOGIC) **SC60LD :=** ______________
SC CNT UP INPUT (SELOGIC) **SC60CU :=** ______________
SC CNT DN INPUT (SELOGIC) **SC60CD :=** ______________

SC PRESET VALUE (1–65000) **SC61PV :=** ______________
SC RESET INPUT (SELOGIC) **SC61R :=** ______________
SC LOAD PV INPUT (SELOGIC) **SC61LD :=** ______________
SC CNT UP INPUT (SELOGIC) **SC61CU :=** ______________
SC CNT DN INPUT (SELOGIC) **SC61CD :=** ______________

SC PRESET VALUE (1–65000) **SC62PV :=** ______________
SC RESET INPUT (SELOGIC) **SC62R :=** ______________
SC LOAD PV INPUT (SELOGIC) **SC62LD :=** ______________
SC CNT UP INPUT (SELOGIC) **SC62CU :=** ______________
SC CNT DN INPUT (SELOGIC) **SC62CD :=** ______________

SC PRESET VALUE (1–65000) **SC63PV :=** ______________
SC RESET INPUT (SELOGIC) **SC63R :=** ______________
SC LOAD PV INPUT (SELOGIC) **SC63LD :=** ______________
SC CNT UP INPUT (SELOGIC) **SC63CU :=** ______________
SC CNT DN INPUT (SELOGIC) **SC63CD :=** ______________

SC PRESET VALUE (1–65000) **SC64PV :=** ______________
SC RESET INPUT (SELOGIC) **SC64R :=** ______________
SC LOAD PV INPUT (SELOGIC) **SC64LD :=** ______________
SC CNT UP INPUT (SELOGIC) **SC64CU :=** ______________
SC CNT DN INPUT (SELOGIC) **SC64CD :=** ______________

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 := ____________________
MV33 := ____________________
MV34 := ____________________
MV35 := ____________________
MV36 := ____________________
MV37 := ____________________
MV38 := ____________________
MV39 := ____________________
MV40 := ____________________
MV41 := ____________________
MV42 := ____________________
MV43 := ____________________
MV44 := ____________________
MV45 := ____________________
MV46 := ____________________
MV47 := ____________________
MV48 := ____________________
MV49 := ____________________
MV50 := ____________________
MV51 := ____________________
MV52 := ____________________
MV53 := ____________________
MV54 := ____________________
MV55 := ____________________
MV56 := ____________________
MV57 := ____________________
MV58 := ____________________
MV59 := ____________________
MV60 := ____________________
MV61 := ____________________
MV62 := ____________________
MV63 := ____________________
MV64 := ____________________

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** := ______________
51 CURVE SAT (Y, N)	**51SAT** := ______________
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 or 7L)

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 Phase Currents

(The following LEA phase current settings are shown if Slot Z = 7L)

IA RATIO CORRECT (0.900–1.100)	**IARCF :=** ______________
IB RATIO CORRECT (0.900–1.100)	**IBRCF :=** ______________
IC RATIO CORRECT (0.900–1.100)	**ICRCF :=** ______________
IA ANGLE CORRECT (–10.0 to 10.0 deg)	**IAPAC :=** ______________
IB ANGLE CORRECT (–10.0 to 10.0 deg)	**IBPAC :=** ______________
IC ANGLE CORRECT (–10.0 to 10.0 deg)	**ICPAC :=** ______________

LEA Vsync Voltage

(The following LEA Vsync voltage settings are shown if Slot E = L0, LA–LH)

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** := ______________
RES CUR DETECTOR (OFF, 0.25–10.00 A {5 A nom}, 0.05–2.00 A {1 A nom})	**50BFG** := ______________
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** := ______________

BF SEAL-IN DELAY (OFF, 0.00–2.00 sec) **BFISID** := ______________

BF RETRIP DELAY (OFF, 0.00–2.00 sec) **BFRTD** := ______________

BF TRIP EQUATION (SELOGIC) **BFTR** := ______________

BF UNLATCH EQN (SELOGIC) **BFULTR** := ______________

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** := ______________

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 or if 50PAFP := OFF*) **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 ≠ 7x or Lx, where x = 0, A, B, C, D, G, H)

EN DC BAT MON (Y, N) **EDCMON := ________________**

DC UNDER VOLT PU (OFF, 20.00–300.00 Vdc) *(Hidden if EDCMON := N)* **DCLOP := ________________**

DC OVER VOLT PU (OFF, 20.00–300.00 Vdc) *(Hidden if EDCMON := N)* **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 :=** ________________	IN304 Debounce	**IN304D :=** ________________
IN302 Debounce	**IN302D :=** ________________	IN305 Debounce	**IN305D :=** ________________
IN303 Debounce	**IN303D :=** ________________	IN306 Debounce	**IN306D :=** ________________

IN307 Debounce	**IN307D** := ________	IN311 Debounce	**IN311D** := ________
IN308 Debounce	**IN308D** := ________	IN312 Debounce	**IN312D** := ________
IN309 Debounce	**IN309D** := ________	IN313 Debounce	**IN313D** := ________
IN310 Debounce	**IN310D** := ________	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

EN 2P DISC (N, 1–8)	**89EN2P** :=	______
2P DISC 1 NAME (16 characters)	**89NM2P1** :=	______
DISC 1 N/O CONT (SELOGIC)	**89A2P1** :=	______
DISC 1 N/C CONT (SELOGIC)	**89B2P1** :=	______
DISC 1 ALM PU (0.00–300.00 sec)	**89A2P1D** :=	______
DISC 1 SEALIN (0.00–300.00 sec)	**89S2P1D** :=	______
DISC 1 IMMOBI (0.00–300.00 sec)	**89I2P1D** :=	______
DISC 1 CL CONT (SELOGIC)	**89RC2P1** :=	______
DISC 1 CL BLK (SELOGIC)	**89CB2P1** :=	______
DISC 1 CL RST (SELOGIC)	**89CR2P1** :=	______
DISC 1 CL IM RS (SELOGIC)	**89CT2P1** :=	______
DISC 1 OP CONT (SELOGIC)	**89RO2P1** :=	______
DISC 1 OP BLK (SELOGIC)	**89OB2P1** :=	______
DISC 1 OP RST (SELOGIC)	**89OR2P1** :=	______
DISC 1 OP IM RS (SELOGIC)	**89OT2P1** :=	______
2P DISC 2 NAME (16 characters)	**89NM2P2** :=	______
DISC 2 N/O CONT (SELOGIC)	**89A2P2** :=	______
DISC 2 N/C CONT (SELOGIC)	**89B2P2** :=	______
DISC 2 ALM PU (0.00–300.00 sec)	**89A2P2D** :=	______
DISC 2 SEALIN (0.00–300.00 sec)	**89S2P2D** :=	______
DISC 2 IMMOBI (0.00–300.00 sec)	**89I2P2D** :=	______
DISC 2 CL CONT (SELOGIC)	**89RC2P2** :=	______
DISC 2 CL BLK (SELOGIC)	**89CB2P2** :=	______
DISC 2 CL RST (SELOGIC)	**89CR2P2** :=	______
DISC 2 CL IM RS (SELOGIC)	**89CT2P2** :=	______
DISC 2 OP CONT (SELOGIC)	**89RO2P2** :=	______

DISC 2 OP BLK (SELOGIC)	**89OB2P2** := ______________
DISC 2 OP RST (SELOGIC)	**89OR2P2** := ______________
DISC 2 OP IM RS (SELOGIC)	**89OT2P2** := ______________
2P DISC 3 NAME (16 characters)	**89NM2P3** := ______________
DISC 3 N/O CONT (SELOGIC)	**89A2P3** := ______________
DISC 3 N/C CONT (SELOGIC)	**89B2P3** := ______________
DISC 3 ALM PU (0.00–300.00 sec)	**89A2P3D** := ______________
DISC 3 SEALIN (0.00–300.00 sec)	**89S2P3D** := ______________
DISC 3 IMMOBI (0.00–300.00 sec)	**89I2P3D** := ______________
DISC 3 CL CONT (SELOGIC)	**89RC2P3** := ______________
DISC 3 CL BLK (SELOGIC)	**89CB2P3** := ______________
DISC 3 CL RST (SELOGIC)	**89CR2P3** := ______________
DISC 3 CL IM RS (SELOGIC)	**89CT2P3** := ______________
DISC 3 OP CONT (SELOGIC)	**89RO2P3** := ______________
DISC 3 OP BLK (SELOGIC)	**89OB2P3** := ______________
DISC 3 OP RST (SELOGIC)	**89OR2P3** := ______________
DISC 3 OP IM RS (SELOGIC)	**89OT2P3** := ______________
2P DISC 4 NAME (16 characters)	**89NM2P4** := ______________
DISC 4 N/O CONT (SELOGIC)	**89A2P4** := ______________
DISC 4 N/C CONT (SELOGIC)	**89B2P4** := ______________
DISC 4 ALM PU (0.00–300.00 sec)	**89A2P4D** := ______________
DISC 4 SEALIN (0.00–300.00 sec)	**89S2P4D** := ______________
DISC 4 IMMOBI (0.00–300.00 sec)	**89I2P4D** := ______________
DISC 4 CL CONT (SELOGIC)	**89RC2P4** := ______________
DISC 4 CL BLK (SELOGIC)	**89CB2P4** := ______________
DISC 4 CL RST (SELOGIC)	**89CR2P4** := ______________
DISC 4 CL IM RS (SELOGIC)	**89CT2P4** := ______________
DISC 4 OP CONT (SELOGIC)	**89RO2P4** := ______________
DISC 4 OP BLK (SELOGIC)	**89OB2P4** := ______________
DISC 4 OP RST (SELOGIC)	**89OR2P4** := ______________
DISC 4 OP IM RS (SELOGIC)	**89OT2P4** := ______________
2P DISC 5 NAME (16 characters)	**89NM2P5** := ______________
DISC 5 N/O CONT (SELOGIC)	**89A2P5** := ______________
DISC 5 N/C CONT (SELOGIC)	**89B2P5** := ______________
DISC 5 ALM PU (0.00–300.00 sec)	**89A2P5D** := ______________
DISC 5 SEALIN (0.00–300.00 sec)	**89S2P5D** := ______________
DISC 5 IMMOBI (0.00–300.00 sec)	**89I2P5D** := ______________
DISC 5 CL CONT (SELOGIC)	**89RC2P5** := ______________
DISC 5 CL BLK (SELOGIC)	**89CB2P5** := ______________
DISC 5 CL RST (SELOGIC)	**89CR2P5** := ______________
DISC 5 CL IM RS (SELOGIC)	**89CT2P5** := ______________

DISC 5 OP CONT (SELOGIC)	**89RO2P5 :=** _______________
DISC 5 OP BLK (SELOGIC)	**89OB2P5 :=** _______________
DISC 5 OP RST (SELOGIC)	**89OR2P5 :=** _______________
DISC 5 OP IM RS (SELOGIC)	**89OT2P5 :=** _______________
2P DISC 6 NAME (16 characters)	**89NM2P6 :=** _______________
DISC 6 N/O CONT (SELOGIC)	**89A2P6 :=** _______________
DISC 6 N/C CONT (SELOGIC)	**89B2P6 :=** _______________
DISC 6 ALM PU (0.00–300.00 sec)	**89A2P6D :=** _______________
DISC 6 SEALIN (0.00–300.00 sec)	**89S2P6D :=** _______________
DISC 6 IMMOBI (0.00–300.00 sec)	**89I2P6D :=** _______________
DISC 6 CL CONT (SELOGIC)	**89RC2P6 :=** _______________
DISC 6 CL BLK (SELOGIC)	**89CB2P6 :=** _______________
DISC 6 CL RST (SELOGIC)	**89CR2P6 :=** _______________
DISC 6 CL IM RS (SELOGIC)	**89CT2P6 :=** _______________
DISC 6 OP CONT (SELOGIC)	**89RO2P6 :=** _______________
DISC 6 OP BLK (SELOGIC)	**89OB2P6 :=** _______________
DISC 6 OP RST (SELOGIC)	**89OR2P6 :=** _______________
DISC 6 OP IM RS (SELOGIC)	**89OT2P6 :=** _______________
2P DISC 7 NAME (16 characters)	**89NM2P7 :=** _______________
DISC 7 N/O CONT (SELOGIC)	**89A2P7 :=** _______________
DISC 1 N/C CONT (SELOGIC)	**89B2P7 :=** _______________
DISC 7 ALM PU (0.00–300.00 sec)	**89A2P7D :=** _______________
DISC 7 SEALIN (0.00–300.00 sec)	**89S2P7D :=** _______________
DISC 7 IMMOBI (0.00–300.00 sec)	**89I2P7D :=** _______________
DISC 7 CL CONT (SELOGIC)	**89RC2P7 :=** _______________
DISC 7 CL BLK (SELOGIC)	**89CB2P7 :=** _______________
DISC 7 CL RST (SELOGIC)	**89CR2P7 :=** _______________
DISC 7 CL IM RS (SELOGIC)	**89CT2P7 :=** _______________
DISC 7 OP CONT (SELOGIC)	**89RO2P7 :=** _______________
DISC 7 OP BLK (SELOGIC)	**89OB2P7 :=** _______________
DISC 7 OP RST (SELOGIC)	**89OR2P7 :=** _______________
DISC 7 OP IM RS (SELOGIC)	**89OT2P7 :=** _______________
2P DISC 8 NAME (16 characters)	**89NM2P8 :=** _______________
DISC 8 N/O CONT (SELOGIC)	**89A2P8 :=** _______________
DISC 8 N/C CONT (SELOGIC)	**89B2P8 :=** _______________
DISC 8 ALM PU (0.00–300.00 sec)	**89A2P8D :=** _______________
DISC 8 SEALIN (0.00–300.00 sec)	**89S2P8D :=** _______________
DISC 8 IMMOBI (0.00–300.00 sec)	**89I2P8D :=** _______________
DISC 8 CL CONT (SELOGIC)	**89RC2P8 :=** _______________
DISC 8 CL BLK (SELOGIC)	**89CB2P8 :=** _______________
DISC 8 CL RST (SELOGIC)	**89CR2P8 :=** _______________

DISC 8 CL IM RS (SELOGIC)	**89CT2P8 :=** ______________
DISC 8 OP CONT (SELOGIC)	**89RO2P8 :=** ______________
DISC 8 OP BLK (SELOGIC)	**89OB2P8 :=** ______________
DISC 8 OP RST (SELOGIC)	**89OR2P8 :=** ______________
DISC 8 OP IM RS (SELOGIC)	**89OT2P8 :=** ______________

Three-Position Disconnect

EN 3P DISC (N, 1–2)	**89EN3P :=** ______________
3P DISC 1 NAME (16 characters)	**89NM3P1 :=** ______________
3P DISC 1 MODE (CONTROL, MONITOR)	**89MD3P1 :=** ______________
3P DISC 2 NAME (16 characters)	**89NM3P2 :=** ______________
3P DISC 2 MODE (CONTROL, MONITOR)	**89MD3P2 :=** ______________

In-Line Disconnect

LDISC 1 N/O CONT (SELOGIC)	**89A3PL1 :=** ______________
LDISC 1 N/C CONT (SELOGIC)	**89B3PL1 :=** ______________
LDISC 1 ALM PU CONT (0.00–300.00 sec)	**89A3PL1D :=** ______________
LDISC 1 SEALIN (0.00–300.00 sec)	**89S3PL1D :=** ______________
LDISC 1 IMMOBI (0.00–300.00 sec)	**89I3PL1D :=** ______________
LDISC 1 CL CONT (SELOGIC)	**89RC3PL1 :=** ______________
LDISC 1 CL BLK (SELOGIC)	**89CB3PL1 :=** ______________
LDISC 1 CL RST (SELOGIC)	**89CR3PL1 :=** ______________
LDISC 1 CL IM RS (SELOGIC)	**89CT3PL1 :=** ______________
LDISC 1 OP CONT (SELOGIC)	**89RO3PL1 :=** ______________
LDISC 1 OP BLK (SELOGIC)	**89OB3PL1 :=** ______________
LDISC 1 OP RST (SELOGIC)	**89OR3PL1 :=** ______________
LDISC 1 OP IM RS (SELOGIC)	**89OT3PL1 :=** ______________
LDISC 2 N/O CONT (SELOGIC)	**89A3PL2 :=** ______________
LDISC 2 N/C CONT (SELOGIC)	**89B3PL2 :=** ______________
LDISC 2 ALM PU CONT (0.00–300.00 sec)	**89A3PL2D :=** ______________
LDISC 2 SEALIN (0.00–300.00 sec)	**89S3PL2D :=** ______________
LDISC 2 IMMOBI (0.00–300.00 sec)	**89I3PL2D :=** ______________
LDISC 2 CL CONT (SELOGIC)	**89RC3PL2 :=** ______________
LDISC 2 CL BLK (SELOGIC)	**89CB3PL2 :=** ______________
LDISC 2 CL RST (SELOGIC)	**89CR3PL2 :=** ______________
LDISC 2 CL IM RS (SELOGIC)	**89CT3PL2 :=** ______________
LDISC 2 OP CONT (SELOGIC)	**89RO3PL2 :=** ______________
LDISC 2 OP BLK (SELOGIC)	**89OB3PL2 :=** ______________
LDISC 2 OP RST (SELOGIC)	**89OR3PL2 :=** ______________
LDISC 2 OP IM RS (SELOGIC)	**89OT3PL2 :=** ______________

Earthing Disconnect

EDISC 1 N/O CONT (SELOGIC)	**89A3PE1** := ______________
EDISC 1 N/C CONT (SELOGIC)	**89B3PE1** := ______________
EDISC 1 ALM PU CONT (0.00–300.00 sec)	**89A3PE1D** := ______________
EDISC 1 SEALIN (0.00–300.00 sec)	**89S3PE1D** := ______________
EDISC 1 IMMOBI (0.00–300.00 sec)	**89I3PE1D** := ______________
EDISC 1 CL CONT (SELOGIC)	**89RC3PE1** := ______________
EDISC 1 CL BLK (SELOGIC)	**89CB3PE1** := ______________
EDISC 1 CL RST (SELOGIC)	**89CR3PE1** := ______________
EDISC 1 CL IM RS (SELOGIC)	**89CT3PE1** := ______________
EDISC 1 OP CONT (SELOGIC)	**89RO3PE1** := ______________
EDISC 1 OP BLK (SELOGIC)	**89OB3PE1** := ______________
EDISC 1 OP RST (SELOGIC)	**89OR3PE1** := ______________
EDISC 1 OP IM RS (SELOGIC)	**89OT3PE1** := ______________
EDISC 2 N/O CONT (SELOGIC)	**89A3PE2** := ______________
EDISC 2 N/C CONT (SELOGIC)	**89B3PE2** := ______________
EDISC 2 ALM PU CONT (0.00–300.00 sec)	**89A3PE2D** := ______________
EDISC 2 SEALIN (0.00–300.00 sec)	**89S3PE2D** := ______________
EDISC 2 IMMOBI (0.00–300.00 sec)	**89I3PE2D** := ______________
EDISC 2 CL CONT (SELOGIC)	**89RC3PE2** := ______________
EDISC 2 CL BLK (SELOGIC)	**89CB3PE2** := ______________
EDISC 2 CL RST (SELOGIC)	**89CR3PE2** := ______________
EDISC 2 CL IM RS (SELOGIC)	**89CT3PE2** := ______________
EDISC 2 OP CONT (SELOGIC)	**89RO3PE2** := ______________
EDISC 2 OP BLK (SELOGIC)	**89OB3PE2** := ______________
EDISC 2 OP RST (SELOGIC)	**89OR3PE2** := ______________
EDISC 2 OP IM RS (SELOGIC)	**89OT3PE2** := ______________

Control Configuration

ENABLE LOC REM CON (Y, N)	**EN_LRC** := ______________
LOCAL CONTROL (SELOGIC)	**LOCAL** := ______________

IEC 61850 Mode Control

(Hidden when IEC 61850 is not supported)

CONTROL FOR IEC 61850 BLOCKED MODE (SELOGIC)	**SC850BM** := ______________
CONTROL FOR IEC 61850 TEST MODE (SELOGIC)	**SC850TM** := ______________

IEC 61850 Simulation Mode

(Hidden when IEC 61850 is not supported)

SELOGIC CONTROL FOR IEC 61850 SIMULATION MODE (SELOGIC) *(Hidden if E61850 := N and EFGRX := 0)*	**SC850SM** := ______________

IEC 61850 Local Remote

(Hidden when IEC 61850 is not supported)

SELOGIC CONTROL FOR CONTROL AUTHORITY AT STATION LEVEL (SELOGIC) **SC850LS :=** ______________

SELOGIC CONTROL FOR CONTROL AUTHORITY AT LOCAL/BAY LEVEL (SELOGIC) **LOC :=** ______________

SELOGIC CONTROL FOR MULTILEVEL MODE OF CONTROL AUTHORITY (SELOGIC) **MLTLEV :=** ______________

IEC 61850 Breaker CILO

(Hidden when IEC 61850 is not supported)

SELOGIC CONTROL FOR BREAKER OPEN SUPERVISION (SELOGIC) **SCBK1BO :=** ______________

SELOGIC CONTROL FOR BREAKER CLOSE SUPERVISION (SELOGIC) **SCBK1BC :=** ______________

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 and forced to 0)* **T_OUT :=** ______________

HDWR HANDSHAKING (Y, N) *(Hidden if PROTO := MOD or EVMSG and forced to N)* **RTSCTS :=** ______________

LANGUAGE (ENGLISH, SPANISH) **LANG :=** ______________

SEND AUTOMESSAGE (Y, N) *(Hidden if PROTO := MOD, EVMSG, or PMU and forced to N)* **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 :=** ______________

ENABLE ETHERNET FIRMWARE UPGRADE (Y, N) **EETHFWU :=** ______________

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 sec) (*Hidden if ETCPKA := N*)	**KAIDLE** := _______________
TCP KEEP-ALIVE INTERVAL RANGE (1–20 sec) (*Hidden if ETCPKA := N*)	**KAINTV** := _______________
TCP KEEP-ALIVE COUNT RANGE (1–20) (*Hidden if ETCPKA := N*)	**KACNT** := _______________
OPERATING MODE (FIXED, FAILOVER, SWITCHED, PRP) *(Hidden when dual redundant Ethernet Port option is not included)*	**NETMODE** := _______________
FAILOVER TIMEOUT (OFF, 0.10–65.00 s in 0.01-second steps) *(Hidden when dual redundant Ethernet Port option is not included or if NETMODE is not set to FAILOVER)*	**FTIME** := _______________
PRIMARY NETPORT (A, B) *(Hidden when dual redundant Ethernet Port option is not included)*	**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 when dual redundant Ethernet Port option is not included or if NETMODE is not equal to PRP)*	**PRPADDR** := _______________
PRP SUPERVISION TX INTERVAL (1–10 sec) *(Hidden when dual redundant Ethernet Port option is not included or if NETMODE is not equal to PRP)*	**PRPINTV** := _______________
NETWRK PORTA SPD (AUTO, 10, 100 Mbps) *(Hidden when dual redundant Ethernet Port option is not included)*	**NETASPD** := _______________
NETWRK PORTB SPD (AUTO, 10, 100 Mbps) *(Hidden when dual redundant Ethernet Port option is not included)*	**NETBSPD** := _______________
ENABLE TELNET (Y, N)	**ETELNET** := _______________
MAXIMUM ACCESS LEVEL (1, 2, C)	**MAXACC** := _______________
LANGUAGE (ENGLISH, SPANISH)	**LANG** := _______________
TELNET PORT (23, 1025–65534) **Note:** See *Table SET.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 other 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) *(Hidden and forced to N when IEC 61850 is not supported)*	**E61850** := _______________
ENABLE IEC 61850 GSE (Y, N) (*Hidden and forced to N if E61850 := N*)	**EGSE** := _______________
ENABLE MMS FILE SERVICES (Y, N)	**EMMSFS** := _______________
ENABLE 61850 MODE/BEHAVIOR CONTROL (Y, N)	**E850MBC** := _______________
ENABLE GOOSE TX IN OFF MODE (Y, N)	**EOFFMTX** := _______________
ENABLE MODBUS SESSIONS (0–2)	**EMOD** := _______________
MODBUS MASTER IP ADDRESS (zzz.yyy.xxx.www) *(Hidden if EMOD := 0)*	**MODIP1** := _______________
MODBUS MASTER IP ADDRESS (zzz.yyy.xxx.www) *(Hidden if EMOD := 0 or 1)*	**MODIP2** := _______________

Note: MODIP1 and MODIP2 cannot share an address and must be unique (except when 0.0.0.0, which effectively disables security and allows any master to communicate).

MODBUS TCP 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 HTTP SERVER (Y, N)	**EHTTP :=** ______________
HTTP MAXIMUM ACCESS LEVEL (1, 2) *(Hidden when EHTTP := N)*	**HTTPACC :=** ______________
HTTP SERVER TCP/IP PORT NUMBER (1–65534) *(Hidden when EHTTP := N)* See *Table SET.1* and the note at the end of Port 1 settings.	**HTTPPORT :=** ______________
HTTP CONNECT BANNER (254 ASCII printable characters) *(Hidden when EHTTP := N)*	**HTTPBAN :=** ______________
HTTP WEB SERVER TIMEOUT (1–60 min) *(Hidden when EHTTP := N)*	**HTTPIDLE :=** ______________
ENABLE RSTP (Y, N) *(Hidden when the dual Ethernet port option is not included or if NETMODE ≠ SWITCHED)*	**ERSTP :=** ______________
BRIDGE PRIORITY (0–61440) *(Hidden if ERSTP := N; input must be in increments of 4096)*	**BRDGPRI :=** ______________
PORTA PRIORITY (0–240) *(Hidden if ERSTP := N; input must be in increments of 16)*	**PORTAPRI :=** ______________
PORTB PRIORITY (0–240) *(Hidden if ERSTP := N; input must be in increments of 16)*	**PORTBPRI :=** ______________

Fixed GOOSE Publication Configuration

(The following settings are hidden when IEC 61850 is not supported)

ENA FIXGOOSE PUB (0–1)	**EFGTX :=** ______________
TX1 MSG DEST MAC (5 characters, *mm–nn*)	**FG1TXMAC :=** ______________
FG1 TX MIN (4–60000 ms)	**FG1TXMIN :=** ______________
FG1 TX MAX (4–60000 ms)	**FG1TXMAX :=** ______________
FG1 TX APPID (0–255)	**FG1TXAID :=** ______________
FG1 TX VLAN ID (0–255)	**FG1TXVID :=** ______________
FG1 TX VLAN PRIO (0–7)	**FG1TXVPR :=** ______________
FG1 TXBIN01 (8 characters, valid Relay Word bit)	**TXBIN01 :=** ______________
FG1 TXBIN02 (8 characters, valid Relay Word bit)	**TXBIN02 :=** ______________
FG1 TXBIN03 (8 characters, valid Relay Word bit)	**TXBIN03 :=** ______________
FG1 TXBIN04 (8 characters, valid Relay Word bit)	**TXBIN04 :=** ______________
FG1 TXBIN05 (8 characters, valid Relay Word bit)	**TXBIN05 :=** ______________
FG1 TXBIN06 (8 characters, valid Relay Word bit)	**TXBIN06 :=** ______________
FG1 TXBIN07 (8 characters, valid Relay Word bit)	**TXBIN07 :=** ______________
FG1 TXBIN08 (8 characters, valid Relay Word bit)	**TXBIN08 :=** ______________
FG1 TXANA01 (8 characters, valid analog quantity)	**TXANA01 :=** ______________
FG1 TXANA02 (8 characters, valid analog quantity)	**TXANA02 :=** ______________

FG1 TXANA03 (8 characters, valid analog quantity) **TXANA03 :=** ______________

FG1 TXANA04 (8 characters, valid analog quantity) **TXANA04 :=** ______________

FG1 TXANA05 (8 characters, valid analog quantity) **TXANA05 :=** ______________

FG1 TXANA06 (8 characters, valid analog quantity) **TXANA06 :=** ______________

FG1 TXANA07 (8 characters, valid analog quantity) **TXANA07 :=** ______________

FG1 TXANA08 (8 characters, valid analog quantity) **TXANA08 :=** ______________

Fixed GOOSE Subscription Configuration

(The following settings are hidden when IEC 61850 is not supported)

ENA FIXGOOSE SUB (0–4) **EFGRX :=** ______________

RXx MSG DEST MAC (5 characters, *mm–nn*) (*x* = 1–4) **FG*x*RXMAC :=** ______________

SEL Synchrophasor Protocol Settings

(The following synchrophasor protocol settings are hidden if Global setting EPMU := N)

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

Note: The DNP IP address of each session (DNPIP1, DNPIP2, etc.) must be unique.

DNP Master IP Address {zzz.yyy.xxx.www} (15 characters)	**DNPIP1** := ______________
Transport Protocol (UDP, TCP)	**DNPTR1** := ______________
UDP Response Port (REQ, 1–65534)	**DNPUDP1** := ______________
DNP Address to Report to (0–65519)	**REPADR1** := ______________
DNP Map (1–3)	**DNPMAP1** := ______________
Analog Input Default Variation (1–6) *(Only applies to objects 30 and 32)*	**DVARAI1** := ______________
Class for Binary Event Data (0–3)	**ECLASSB1** := ______________
Class for Counter Event Data (0–3)	**ECLASSC1** := ______________
Class for Analog Event Data (0–3)	**ECLASSA1** := ______________
Currents Scaling Decimal Places (0–3)	**DECPLA1** := ______________
Voltages Scaling Decimal Places (0–3)	**DECPLV1** := ______________
Misc Data Scaling Decimal Places (0–3)	**DECPLM1** := ______________
Amps Reporting Deadband Counts (0–32767) *Hidden if ECLASSA1 := 0)*	**ANADBA1** := ______________
Volts Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBV1** := ______________
Misc Data Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0 and ECLASSC1 := 0)*	**ANADBM1** := ______________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ1** := ______________
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO1** := ______________
Seconds to send Data Link Heartbeat (0–7200) *(Hidden if DNPTR1 := UDP)*	**DNPINA1** := ______________
Event Message Confirm Time-Out (1–50 sec)	**ETIMEO1** := ______________
Enable Unsolicited Reporting (Y, N) *(Hidden and forced to N if ECLASSA1 := 0, ECLASSB1 := 0, ECLASSC1 := 0, and ECLASSV1 := 0)* *(All subsequent settings are hidden and forced to N if UNSOL1 := N)*	**UNSOL1** := ______________
Enable Unsolicited Reporting at Power-Up (Y, N)	**PUNSOL1** := ______________
Number of Events to Transmit On (1–200)	**NUMEVE1** := ______________
Oldest Event to Tx On (0.0–99999.0 sec)	**AGEEVE1** := ______________
Unsolicited Message Max Retry Attempts (2–10)	**URETRY1** := ______________
Unsolicited Message Offline Time-Out (1–5000 sec)	**UTIMEO1** := ______________

Session 2

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

DNP Master IP Address {zzz.yyy.xxx.www} (15 characters)	**DNPIP2** := ______________
Transport Protocol (UDP, TCP)	**DNPTR2** := ______________
UDP Response Port (REQ, 1–65534)	**DNPUDP2** := ______________
DNP Address to Report to (0–65519)	**REPADR2** := ______________
DNP Map (1–3)	**DNPMAP2** := ______________
Analog Input Default Variation (1–6)	**DVARAI2** := ______________
Class for Binary Event Data (0–3)	**ECLASSB2** := ______________
Class for Counter Event Data (0–3)	**ECLASSC2** := ______________
Class for Analog 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 Deadband Counts (0–32767) *(Hidden if ECLASSA2 := 0)*	**ANADBA2** := ______________
Volts Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA2 := 0)*	**ANADBV2** := ______________
Misc Data Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA2 := 0 and ECLASSC2 := 0)*	**ANADBM2** := ______________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ2** := ______________
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO2** := ______________
Seconds to send Data Link Heartbeat (0–7200) *(Hidden if DNPTR2 := UDP)*	**DNPINA2** := ______________
Event Message Confirm Time-Out (1–50 sec)	**ETIMEO2** := ______________
Enable Unsolicited Reporting (Y, N) *(Hidden and forced to N if ECLASSA2 := 0, ECLASSB2 := 0, ECLASSC2 := 0, and ECLASSV2 := 0)* *(All subsequent settings are hidden and forced to N if UNSOL2 := N)*	**UNSOL2** := ______________
Enable Unsolicited Reporting at Power-Up (Y, N)	**PUNSOL2** := ______________
Number of Events to Transmit On (1–200)	**NUMEVE2** := ______________
Oldest Event to Tx On (0.0–99999.0 sec)	**AGEEVE2** := ______________
Unsolicited Message Max Retry Attempts (2–10)	**URETRY2** := ______________
Unsolicited Message Offline Time-Out (1–5000 sec)	**UTIMEO2** := ______________

Session 3

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

DNP Master IP Address {zzz.yyy.xxx.www} (15 characters)	**DNPIP3** := ______________
Transport Protocol (UDP, TCP)	**DNPTR3** := ______________
UDP Response Port (REQ, 1–65534)	**DNPUDP3** := ______________
DNP Address to Report to (0–65519)	**REPADR3** := ______________
DNP Map (1–3)	**DNPMAP3** := ______________
Analog Input Default Variation (1–6)	**DVARAI3** := ______________
Class for Binary Event Data (0–3)	**ECLASSB3** := ______________
Class for Counter Event Data (0–3)	**ECLASSC3** := ______________
Class for Analog 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 Deadband Counts (0–32767) *(Hidden if ECLASSA3 := 0)*	**ANADBA3** := ______________
Volts Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA3 := 0)*	**ANADBV3** := ______________
Misc Data Reporting Deadband 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 sec)	**ETIMEO3** := ______________
Enable Unsolicited Reporting (Y, N) *(Hidden and forced to N if ECLASSA3 := 0, ECLASSB3 := 0, ECLASSC3 := 0, and ECLASSV3 := 0)* *(All subsequent settings are hidden and forced to N if UNSOL3 := N)*	**UNSOL3** := ______________

Enable Unsolicited Reporting at Power-Up (Y, N)	**PUNSOL3 :=** ______________
Number of Events to Transmit On (1–200)	**NUMEVE3 :=** ______________
Oldest Event to Tx On (0.0–99999.0 sec)	**AGEEVE3 :=** ______________
Unsolicited Message Max Retry Attempts (2–10)	**URETRY3 :=** ______________
Unsolicited Message Offline Time-Out (1–5000 sec)	**UTIMEO3 :=** ______________

Session 4

(All Session 4 settings are hidden if EDNP < 4)

DNP Master IP Address {zzz.yyy.xxx.www} (15 characters)	**DNPIP4 :=** ______________
Transport Protocol (UDP, TCP)	**DNPTR4 :=** ______________
UDP Response Port (REQ, 1–65534)	**DNPUDP4 :=** ______________
DNP Address to Report to (0–65519)	**REPADR4 :=** ______________
DNP Map (1–3)	**DNPMAP4 :=** ______________
Analog Input Default Variation (1–6)	**DVARAI4 :=** ______________
Class for Binary Event Data (0–3)	**ECLASSB4 :=** ______________
Class for Counter Event Data (0–3)	**ECLASSC4 :=** ______________
Class for Analog 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 Deadband Counts (0–32767) *(Hidden if ECLASSA4 := 0)*	**ANADBA4 :=** ______________
Volts Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA4 := 0)*	**ANADBV4 :=** ______________
Misc Data Reporting Deadband 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 sec)	**ETIMEO4 :=** ______________
Enable Unsolicited Reporting (Y, N) *(Hidden and forced to N if ECLASSA4 := 0, ECLASSB4 := 0, ECLASSC4 := 0, and ECLASSV4 := 0)* *(All subsequent settings are hidden and forced to N if UNSOL4 := N)*	**UNSOL4 :=** ______________
Enable Unsolicited Reporting at Power-Up (Y, N)	**PUNSOL4 :=** ______________
Number of Events to Transmit On (1–200)	**NUMEVE4 :=** ______________
Oldest Event to Tx On (0.0–99999.0 sec)	**AGEEVE4 :=** ______________
Unsolicited Message Max Retry Attempts (2–10)	**URETRY4 :=** ______________
Unsolicited Message Offline Time-Out (1–5000 sec)	**UTIMEO4 :=** ______________

Session 5

(All Session 5 settings are hidden if EDNP < 5)

DNP Master IP Address {zzz.yyy.xxx.www} (15 characters)	**DNPIP5 :=** ______________
Transport Protocol (UDP, TCP)	**DNPTR5 :=** ______________
UDP Response Port (REQ, 1–65534)	**DNPUDP5 :=** ______________
DNP Address to Report to (0–65519)	**REPADR5 :=** ______________

DNP Map (1–3)	**DNPMAP5 :=** ______________
Analog Input Default Variation (1–6)	**DVARAI5 :=** ______________
Class for Binary Event Data (0–3)	**ECLASSB5 :=** ______________
Class for Counter Event Data (0–3)	**ECLASSC5 :=** ______________
Class for Analog 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 Deadband Counts (0–32767) *(Hidden if ECLASSA5 := 0)*	**ANADBA5 :=** ______________
Volts Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA5 := 0)*	**ANADBV5 :=** ______________
Misc Data Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA5 := 0 and ECLASSC5 := 0)*	**ANADBM5 :=** ______________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ5 :=** ______________
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO5 :=** ______________
Seconds to send Data Link Heartbeat (0–7200) *(Hidden if DNPTR5 := UDP)*	**DNPINA5 :=** ______________
Event Message Confirm Time-Out (1–50 sec)	**ETIMEO5 :=** ______________
Enable Unsolicited Reporting (Y, N) *(Hidden and forced to N if ECLASSA5 := 0, ECLASSB5 := 0, ECLASSC5 := 0, and ECLASSV5 := 0)* *(All subsequent settings are hidden and forced to N if UNSOL5 := N)*	**UNSOL5 :=** ______________
Enable Unsolicited Reporting at Power-Up (Y, N)	**PUNSOL5 :=** ______________
Number of Events to Transmit On (1–200)	**NUMEVE5 :=** ______________
Oldest Event to Tx On (0.0–99999.0 sec)	**AGEEVE5 :=** ______________
Unsolicited Message Max Retry Attempts (2–10)	**URETRY5 :=** ______________
Unsolicited Message Offline Time-Out (1–5000 sec)	**UTIMEO5 :=** ______________

SNTP Client Protocol Settings

ENABLE SNTP CLIENT (OFF, UNICAST, MANYCAST, BROADCAST)	**ESNTP :=** ______________
(All subsequent category settings are hidden if 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) *(Hidden if ESNTP ≠ UNICAST)*	**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 sec)	**SNTPRATE :=** ______________
Make the following setting when ESNTP := UNICAST or MANYCAST.	
SNTP TIMEOUT (5–20 sec) *(Hidden and forced to 5 if ESNTP := BROADCAST)* **Note:** SNTPTO must be less than setting SNTPRATE.	**SNTPTO :=** ______________

PTP Settings

ENABLE PTP (Y, N) *(All subsequent category settings are hidden if EPTP := N)* *(Hidden and forced to N if NETMODE := SWITCHED)*	**EPTP** := ______________
PTP PROFILE (DEFAULT, C37.238) *(Hidden and forced to C37.238 if NETMODE := PRP)*	**PTPPRO** := ______________
PTP TRANSPORT MECHANISM (UDP, LAYER2) *(Hidden and forced to LAYER2 if PTPPRO := C37.238 or if NETMODE := PRP)*	**PTPTR** := ______________
PTP DOMAIN NUMBER (0–255)	**DOMNUM** := ______________
PTP PATH DELAY MECHANISM (P2P, E2E, OFF) *(Hidden and forced to P2P if PTPPRO := C37.238 or if NETMODE := PRP)*	**PTHDLY** := ______________
PEER DELAY REQUEST INTERVAL (1, 2, 4, 8, 16, 32, 64 seconds) *(Hidden if PTHDLY ≠ P2P, PTPPRO ≠ C37.238, and NETMODE ≠ PRP)*	**PDINT** := ______________
PTP NUMBER OF ACCEPTABLE MASTERS (OFF, 1–5)	**AMNUM** := ______________
PTP ACCEPTABLE MASTER *n* IP (zzz.yyy.xxx.www) *(Hidden if n > AMNUM or if AMNUM := OFF or if PTPTR := LAYER2 or if NETMODE := PRP or if PTPPRO := C37.238)*	**AMIP*n*** := ______________
PTP ACCEPTABLE MASTER *n* MAC (xx:xx:xx:xx:xx:xx) *(Hidden if AMNUM := OFF or if NETMODE ≠ PRP and if PTPTR ≠ LAYER2 and if PTPPRO ≠ C37.238)*	**AMMAC*n*** := ______________
PTP ALTERNATE PRIORITY1 FOR MASTER *n* (0–255) *(Hidden if n > AMNUM or if AMNUM := OFF)*	**ALTPRI*n*** := ______________
PTP VLAN IDENTIFIER (1–4094) *(Hidden if NETMODE ≠ PRP and PTPPRO ≠ C37.238)*	**PVLAN** := ______________
PTP VLAN PRIORITY (0–7) *(Hidden if NETMODE ≠ PRP and PTPPRO ≠ C37.238)*	**PVLANPR** := ______________

EtherNet/IP Settings

ENABLE ETHERNET/IP (Y, N)	**EEIP** := ______________
CONFIGURATION ID (0–255)	**CONFIGID** := ______________
MAJOR EDS REVISION (1–255)	**MAJOREDS** := ______________
MINOR EDS REVISION (1–255)	**MINOREDS** := ______________
NUMBER OF IP ADDRESSES FOR EIP SCANNER (OFF, 1–8) *(OFF allows anonymous clients)*	**NUMIP** := ______________
IP ADDRESS (zzz.yyy.xxx.www) *(Hidden if NUMIP := OFF; n > NUMIP)* *(Note: EIPIPn settings shall not be equal to the value of the IPADDR setting. EIPIP1, EIPIP2, EIPIP3, ..., EIPIP8 must be unique.)*	**EIPIP*n*** := ______________
NUMBER OF IO CONNECTIONS (1–6)	**NUMCONN** := ______________
APPLICATION TYPE (EXCLUSIVE_OWNER, INPUT_ONLY) *(Note: At most three exclusive owner types shall be allowed.)*	**APPTYP*n*** := ______________
INPUT ASSEMBLY (IA1, IA2, IA3, OA1, OA2, OA3)	**INASSM*n*** := ______________
OUTPUT ASSEMBLY (OA1, OA2, OA3) *(Hidden if APPTYPn := INPUT_ONLY)*	**OUTASSM*n*** := ______________

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
EPTP	Enable PTP	PTPPRO = DEFAULT and PTPTR = UDP (Ports 319 and 320 are reserved)
EEIP	Enable EtherNet/IP	EEIP ≠ N (Ports 2222 and 44818 are reserved)

[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_ and forced to 0)* **T_OUT :=** ______________

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

LANGUAGE (ENGLISH, SPANISH) **LANG :=** ______________

SEND AUTOMESSAGE (Y, N) *(Hidden if PROTO := MOD, DNP, PMU, EVMSG, 103, or MB_ and forced to N)* **AUTO :=** ______________

FAST OP MESSAGES (Y, N) *(Hidden if PROTO := MOD, DNP, PMU, EVMSG, 103, or MB_ and forced to N)* **FASTOP :=** ______________

Modbus

MODBUS SLAVE ID (1–247) *(Hidden if PROTO := SEL, EVMSG, MB_, 103, or DNP)* **SLAVEID :=** ______________

DNP3 Protocol

(Hidden if PROTO := SEL, EVMSG, MB_, PMU, 103, or MOD)

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

DNP Address to Report to (0–65519) **REPADR1 :=** ______________

DNP Map (1–3)	**DNPMAP1 :=** ______________
Analog Input Default Variation (1–6)	**DVARAI1 :=** ______________
Class for Binary Event Data (0–3)	**ECLASSB1 :=** ______________
Class for Counter Event Data (0–3)	**ECLASSC1 :=** ______________
Class for Analog Event Data (0–3)	**ECLASSA1 :=** ______________
Currents Scaling Decimal Places (0–3)	**DECPLA1 :=** ______________
Voltages Scaling Decimal Places (0–3)	**DECPLV1 :=** ______________
Misc Data Scaling Decimal Places (0–3)	**DECPLM1 :=** ______________
Amps Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBA1 :=** ______________
Volts Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBV1 :=** ______________
Misc Data Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0 and ECLASSC1 := 0)*	**ANADBM1 :=** ______________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ1 :=** ______________
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO1 :=** ______________
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 sec)	**ETIMEO1 :=** ______________
Enable Unsolicited Reporting (Y, N) *(Hidden and forced to N if ECLASSA1 := 0, ECLASSB1 := 0 and ECLASSC1 := 0)* *(All subsequent settings are hidden and forced to N if UNSOL1 := N)*	**UNSOL1 :=** ______________
Enable Unsolicited Reporting at Power-Up (Y, N)	**PUNSOL1 :=** ______________
Number of Events to Transmit On (1–200)	**NUMEVE1 :=** ______________
Oldest Event to Tx On (0.0–99999.0 sec)	**AGEEVE1 :=** ______________
Unsolicited Message Max Retry Attempts (2–10)	**URETRY1 :=** ______________
Unsolicited Message Offline Time-Out (1–5000 sec)	**UTIMEO1 :=** ______________

MIRRORED BITS Protocol

(All subsequent settings are hidden if PROTO := SEL, DNP, PMU, EVMSG, 103, or MOD)

MB Transmit Identifier (1-4)	**TXID :=** ______________
MB Receive Identifier (1-4)	**RXID :=** ______________
MB RX Bad Pickup Time (0–10000 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 sec) **103CYC :=** ____________

ACCUMULATOR REPORTING PERIOD (OFF, 1–3600 sec) **103ACYC :=** ____________

ACCUMULATOR REPORTING TRIGGER (1 Relay Word Bit) **103ATRI :=** ____________

ENABLE TIME SYNCHRONIZATION (Y, N) **103TIME :=** ____________

PORT 3

(EIA-232/485 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_ and forced to 0)* **T_OUT :=** ____________

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

LANGUAGE (ENGLISH, SPANISH) **LANG :=** ____________

SEND AUTOMESSAGE (Y, N) *(Hidden if PROTO := MOD, DNP, PMU, EVMSG, 103, or MB_ and forced to N)* **AUTO :=** ____________

FAST OP MESSAGES (Y, N) *(Hidden if PROTO := MOD, DNP, PMU, EVMSG, 103, or MB_ and forced to N)* **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, 103, DNP, or MB_)*	**SLAVEID :=** ______________

DNP3 Protocol

(Hidden if PROTO := SEL, EVMSG, MB_, PMU, 103, or MOD.)

DNP Address (0–65519)	**DNPADR :=** ______________
DNP Address to Report to (0–65519)	**REPADR1 :=** ______________
DNP Map (1–3)	**DNPMAP1 :=** ______________
Analog Input Default Variation (1–6)	**DVARAI1 :=** ______________
Class for Binary Event Data (0–3)	**ECLASSB1 :=** ______________
Class for Counter Event Data (0–3)	**ECLASSC1 :=** ______________
Class for Analog Event Data (0–3)	**ECLASSA1 :=** ______________
Currents Scaling Decimal Places (0–3)	**DECPLA1 :=** ______________
Voltages Scaling Decimal Places (0–3)	**DECPLV1 :=** ______________
Misc Data Scaling Decimal Places (0–3)	**DECPLM1 :=** ______________
Amps Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBA1 :=** ______________
Volts Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBV1 :=** ______________
Misc Data Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0 and ECLASSC1 := 0)*	**ANADBM1 :=** ______________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ1 :=** ______________
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO1 :=** ______________
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 sec)	**ETIMEO1 :=** ______________
Enable Unsolicited Reporting (Y, N) *(Hidden and forced to N if ECLASSA1 := 0, ECLASSB1 := 0, and ECLASSC1 := 0)* *(All subsequent settings are hidden and forced to N when UNSOL1 := N)*	**UNSOL1 :=** ______________
Enable Unsolicited Reporting at Power-Up (Y, N)	**PUNSOL1 :=** ______________
Number of Events to Transmit On (1–200)	**NUMEVE1 :=** ______________
Oldest Event to Tx On (0.0–99999.0 sec)	**AGEEVE1 :=** ______________
Unsolicited Message Max Retry Attempts (2–10)	**URETRY1 :=** ______________
Unsolicited Message Offline Time-Out (1–5000 sec)	**UTIMEO1 :=** ______________

Modem Protocol

(For DNP3 session and EIA-232 port only)

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

Time Between Dial-Out Attempts (5–3600 sec)	**MDRET :=** ______________

Mirrored Bits Protocol

(Hidden if PROTO := SEL, DNP, PMU, EVMSG, 103, or MOD)

MB Transmit Identifier (1-4)	**TXID :=** ______________
MB Receive Identifier (1-4)	**RXID :=** ______________
MB RX Bad Pickup Time (0–10000 sec)	**RBADPU :=** ______________
MB Channel Bad Pickup (1–10000 ppm)	**CBADPU :=** ______________
MB Receive Default State (8 characters)	**RXDFLT :=** ______________
RMB1 Pickup Debounce Messages (1–8)	**RMB1PU :=** ______________
RMB1 Dropout Debounce Messages (1–8)	**RMB1DO :=** ______________
RMB2 Pickup Debounce Messages (1–8)	**RMB2PU :=** ______________
RMB2 Dropout Debounce Messages (1–8)	**RMB2DO :=** ______________
RMB3 Pickup Debounce Messages (1–8)	**RMB3PU :=** ______________
RMB3 Dropout Debounce Messages (1–8)	**RMB3DO :=** ______________
RMB4 Pickup Debounce Messages (1–8)	**RMB4PU :=** ______________
RMB4 Dropout Debounce Messages (1–8)	**RMB4DO :=** ______________
RMB5 Pickup Debounce Messages (1–8)	**RMB5PU :=** ______________
RMB5 Dropout Debounce Messages (1–8)	**RMB5DO :=** ______________
RMB6 Pickup Debounce Messages (1–8)	**RMB6PU :=** ______________
RMB6 Dropout Debounce Messages (1–8)	**RMB6DO :=** ______________
RMB7 Pickup Debounce Messages (1–8)	**RMB7PU :=** ______________
RMB7 Dropout Debounce Messages (1–8)	**RMB7DO :=** ______________
RMB8 Pickup Debounce Messages (1–8)	**RMB8PU :=** ______________
RMB8 Dropout Debounce Messages (1–8)	**RMB8DO :=** ______________

IEC 60870-5-103 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_ and forced to 0)*	**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 and forced to N)*	**RTSCTS** := _______
LANGUAGE (ENGLISH, SPANISH)	**LANG** := _______
SEND AUTOMESSAGE (Y, N) *(Hidden if PROTO := DNP, MOD, EVMSG, MB_, PMU, 103, or DNET and forced to N)*	**AUTO** := _______
FAST OP MESSAGES (Y, N) *(Hidden if PROTO := DNP, MOD, EVMSG, MB_, PMU, 103, or DNET and forced to N)*	**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_, 103, or DNET)*	**SLAVEID** := _______

DNP3 Protocol

(Hidden if PROTO := SEL, EVMSG, MB_, PMU, DNET, 103, or MOD)

DNP Address (0–65519)	**DNPADR** := _______
DNP Address to Report to (0–65519)	**REPADR1** := _______
DNP Map (1–3)	**DNPMAP1** := _______
Analog Input Default Variation (1–6)	**DVARAI1** := _______
Class for Binary Event Data (0–3)	**ECLASSB1** := _______
Class for Counter Event Data (0–3)	**ECLASSC1** := _______
Class for Analog Event Data (0–3)	**ECLASSA1** := _______
Currents Scaling Decimal Places (0–3)	**DECPLA1** := _______
Voltages Scaling Decimal Places (0–3)	**DECPLV1** := _______
Misc Data Scaling Decimal Places (0–3)	**DECPLM1** := _______
Amps Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBA1** := _______
Volts Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBV1** := _______
Misc Data Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0 and ECLASSC1 := 0)*	**ANADBM1** := _______
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ1** := _______
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO1** := _______
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 sec) **ETIMEO1 :=** ______________

Enable Unsolicited Reporting (Y, N) *(Hidden and forced to N if ECLASSA1 := 0, ECLASSB1 := 0, ECLASSC1 := 0, and ECLASSV1 := 0)* *(All subsequent settings are hidden and forced to N when UNSOL1 := N)* **UNSOL1 :=** ______________

Enable Unsolicited Reporting at Power-Up (Y, N) **PUNSOL1 :=** ______________

Number of Events to Transmit On (1–200) **NUMEVE1 :=** ______________

Oldest Event to Tx On (0.0–99999.0 sec) **AGEEVE1 :=** ______________

Unsolicited Message Max Retry Attempts (2–10) **URETRY1 :=** ______________

Unsolicited Message Offline Time-Out (1–5000 sec) **UTIMEO1 :=** ______________

Modem Protocol

(For DNP3 session and EIA-232 port only)

Modem Connected to Port (Y, N) **MODEM :=** ______________

Modem Startup String (30 characters) **MSTR :=** ______________

Phone Number for Dial-Out (30 characters) **PH_NUM1 :=** ______________

Phone Number for Dial-Out (30 characters) **PH_NUM2 :=** ______________

Retry Attempts for Phone 1 Dial-Out (1–20) **RETRY1 :=** ______________

Retry Attempts for Phone 2 Dial-Out (1–20) **RETRY2 :=** ______________

Time to Attempt Dial (5–300 sec) **MDTIME :=** ______________

Time Between Dial-Out Attempts (5–3600 sec) **MDRET :=** ______________

MIRRORED BITS Protocol

(Hidden if PROTO := SEL, EVMSG, DNP, PMU, DNET, 103, or MOD)

MB Transmit Identifier (1–4) **TXID :=** ______________

MB Receive Identifier (1–4) **RXID :=** ______________

MB RX Bad Pickup Time (0–10000 sec) **RBADPU :=** ______________

MB Channel Bad Pickup (1–10000 ppm) **CBADPU :=** ______________

MB Receive Default State (8 characters) **RXDFLT :=** ______________

RMB1 Pickup Debounce Messages (1–8) **RMB1PU :=** ______________

RMB1 Dropout Debounce Messages (1–8) **RMB1DO :=** ______________

RMB2 Pickup Debounce Messages (1–8) **RMB2PU :=** ______________

RMB2 Dropout Debounce Messages (1–8) **RMB2DO :=** ______________

RMB3 Pickup Debounce Messages (1–8) **RMB3PU :=** ______________

RMB3 Dropout Debounce Messages (1–8) **RMB3DO :=** ______________

RMB4 Pickup Debounce Messages (1–8) **RMB4PU :=** ______________

RMB4 Dropout Debounce Messages (1–8) **RMB4DO :=** ______________

RMB5 Pickup Debounce Messages (1–8) **RMB5PU :=** ______________

RMB5 Dropout Debounce Messages (1–8) **RMB5DO :=** ______________

RMB6 Pickup Debounce Messages (1–8) **RMB6PU :=** ______________

RMB6 Dropout Debounce Messages (1–8) **RMB6DO :=** ______________

RMB7 Pickup Debounce Messages (1–8) **RMB7PU :=** ______________

RMB7 Dropout Debounce Messages (1–8) **RMB7DO :=** ______________

RMB8 Pickup Debounce Messages (1–8) **RMB8PU :=** ______________

RMB8 Dropout Debounce Messages (1–8) **RMB8DO :=** ______________

IEC 60870-5-103 Protocol

(Hidden unless serial port with PROTO := 103)

103 DEVICE ADDRESS (0–254)	**103ADDR** := ______________
CYCLIC DATA REPORTING PERIOD (1–3600 sec)	**103CYC** := ______________
ACCUMULATOR REPORTING PERIOD (OFF, 1–3600 sec)	**103ACYC** := ______________
ACCUMULATOR REPORTING TRIGGER (1 Relay Word Bit)	**103ATRI** := ______________
ENABLE TIME SYNCHRONIZATION (Y, N)	**103TIME** := ______________

Front-Panel Settings (SET F Command)

General

DISPLY PTS ENABL (N, 1–32) *(Hidden and forced to N if the front-panel MOT option is A/B)*	**EDP** := ______________
LOCAL BITS ENABL (N, 1–32)	**ELB** := ______________
LCD TIMEOUT (OFF, 1–30 min) *(Hidden and forced to OFF if the front-panel MOT option is A/B)*	**FP_TO** := ______________
LCD CONTRAST (1–8) *(Hidden if the front-panel MOT option is A/B)*	**FP_CONT** := ______________
FP AUTOMESSAGES (OVERRIDE, ROTATING) *(Hidden if the front-panel MOT option is A/B)*	**FP_AUTO** := ______________
CLOSE RESET LEDS (Y, N)	**RSTLED** := ______________
ENA_LED COLOR (R = Red, G = Green, A = Amber) *(Hidden if the front-panel MOT option is A/B)*	**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/B)*	**MAXACC** := ______________

Target LED

(R = Red, G = Green, A = Amber)

TRIP LATCH T_LED (Y, N)	**T01LEDL** := ______________
TARGET T_LED ASSERTED COLOR (R, G, A)	**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

(The pushbutton LED settings, PB5A/PB5B–PB8A/PB8B, are hidden for relay models with four pushbuttons)
(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/B)

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/B)
Display Point Settings (maximum 60 characters):
(Boolean): Relay Word Bit Name, "Alias", "Set String", "Clear String"
(Analog): Analog Quantity Name, "User Text and Formatting"

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/B)
(Note: The Touchscreen settings category is only available in QuickSet, with the exception of the settings FPTO, FPDUR, and FPBAB, which are also available to set via the touchscreen display.)

Touchscreen Configuration

DISPLAY HOME SCREEN (Refer to *Table 8.17* 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

(The pushbutton settings, FPPB04–FPPB08, are hidden for relay models with front panel MOT option B)
(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 Two-Position Disconnect

TWO-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**2D01MOD** := ______________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS01CS** := ______________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS01OS** := ______________
TWO-POSITION DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**2DS01IS** := ______________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS01AS** := ______________
TWO-POSITION DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**2DS01CL** := ______________
TWO-POSITION DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**2DS01OP** := ______________
TWO-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**2D02MOD** := ______________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS02CS** := ______________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS02OS** := ______________
TWO-POSITION DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**2DS02IS** := ______________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS02AS** := ______________
TWO-POSITION DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**2DS02CL** := ______________
TWO-POSITION DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**2DS02OP** := ______________
TWO-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**2D03MOD** := ______________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS03CS** := ______________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS03OS** := ______________
TWO-POSITION DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**2DS03IS** := ______________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS03AS** := ______________
TWO-POSITION DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**2DS03CL** := ______________
TWO-POSITION DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**2DS03OP** := ______________
TWO-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**2D04MOD** := ______________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS04CS** := ______________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS04OS** := ______________
TWO-POSITION DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**2DS04IS** := ______________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS04AS** := ______________
TWO-POSITION DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**2DS04CL** := ______________
TWO-POSITION DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**2DS04OP** := ______________
TWO-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**2D05MOD** := ______________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS05CS** := ______________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS05OS** := ______________

TWO-POSITION DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**2DS05IS** := ______________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS05AS** := ______________
TWO-POSITION DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**2DS05CL** := ______________
TWO-POSITION DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**2DS05OP** := ______________
TWO-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**2D06MOD** := ______________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS06CS** := ______________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS06OS** := ______________
TWO-POSITION DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**2DS06IS** := ______________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS06AS** := ______________
TWO-POSITION DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**2DS06CL** := ______________
TWO-POSITION DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**2DS06OP** := ______________
TWO-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**2D07MOD** := ______________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS07CS** := ______________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS07OS** := ______________
TWO-POSITION DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**2DS07IS** := ______________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS07AS** := ______________
TWO-POSITION DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**2DS07CL** := ______________
TWO-POSITION DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**2DS07OP** := ______________
TWO-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**2D08MOD** := ______________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS08CS** := ______________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS08OS** := ______________
TWO-POSITION DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**2DS08IS** := ______________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS08AS** := ______________
TWO-POSITION DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**2DS08CL** := ______________
TWO-POSITION DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**2DS08OP** := ______________

Bay Control Three-Position Disconnect

THREE-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**3D01MOD** := ______________
THREE-POSITION IN-LINE DISCONNECT CLOSE STATUS (Relay Word bit)	**3ID01CS** := ______________
THREE-POSITION IN-LINE DISCONNECT OPEN STATUS (Relay Word bit)	**3ID01OS** := ______________
THREE-POSITION IN-LINE DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**3ID01IS** := ______________
THREE-POSITION IN-LINE DISCONNECT ALARM STATUS (Relay Word bit)	**3ID01AS** := ______________
THREE-POSITION IN-LINE DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**3ID01CL** := ______________
THREE-POSITION IN-LINE DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**3ID01OP** := ______________
THREE-POSITION EARTHING DISCONNECT CLOSE STATUS (Relay Word bit)	**3ED01CS** := ______________
THREE-POSITION EARTHING DISCONNECT OPEN STATUS (Relay Word bit)	**3ED01OS** := ______________
THREE-POSITION EARTHING DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**3ED01IS** := ______________
THREE-POSITION EARTHING DISCONNECT ALARM STATUS (Relay Word bit)	**3ED01AS** := ______________

THREE-POSITION EARTHING DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**3ED01CL** := ______________
THREE-POSITION EARTHING DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**3ED01OP** := ______________
THREE-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**3D02MOD** := ______________
THREE-POSITION IN-LINE DISCONNECT CLOSE STATUS (Relay Word bit)	**3ID02CS** := ______________
THREE-POSITION IN-LINE DISCONNECT OPEN STATUS (Relay Word bit)	**3ID02OS** := ______________
THREE-POSITION IN-LINE DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**3ID02IS** := ______________
THREE-POSITION IN-LINE DISCONNECT ALARM STATUS (Relay Word bit)	**3ID02AS** := ______________
THREE-POSITION IN-LINE DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**3ID02CL** := ______________
THREE-POSITION IN-LINE DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**3ID02OP** := ______________
THREE-POSITION EARTHING DISCONNECT CLOSE STATUS (Relay Word bit)	**3ED02CS** := ______________
THREE-POSITION EARTHING DISCONNECT OPEN STATUS (Relay Word bit)	**3ED02OS** := ______________
THREE-POSITION EARTHING DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**3ED02IS** := ______________
THREE-POSITION EARTHING DISCONNECT ALARM STATUS (Relay Word bit)	**3ED02AS** := ______________
THREE-POSITION EARTHING DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**3ED02CL** := ______________
THREE-POSITION EARTHING DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**3ED02OP** := ______________

Analog Label

ANALOG QUANTITY	**ALAB01** := ______________
ANALOG QUANTITY	**ALAB02** := ______________
ANALOG QUANTITY	**ALAB03** := ______________
ANALOG QUANTITY	**ALAB04** := ______________
ANALOG QUANTITY	**ALAB05** := ______________
ANALOG QUANTITY	**ALAB06** := ______________
ANALOG QUANTITY	**ALAB07** := ______________
ANALOG QUANTITY	**ALAB08** := ______________
ANALOG QUANTITY	**ALAB09** := ______________
ANALOG QUANTITY	**ALAB10** := ______________
ANALOG QUANTITY	**ALAB11** := ______________
ANALOG QUANTITY	**ALAB12** := ______________
ANALOG QUANTITY	**ALAB13** := ______________
ANALOG QUANTITY	**ALAB14** := ______________
ANALOG QUANTITY	**ALAB15** := ______________
ANALOG QUANTITY	**ALAB16** := ______________
ANALOG QUANTITY	**ALAB17** := ______________
ANALOG QUANTITY	**ALAB18** := ______________
ANALOG QUANTITY	**ALAB19** := ______________

ANALOG QUANTITY	**ALAB20 :=** ______________
ANALOG QUANTITY	**ALAB21 :=** ______________
ANALOG QUANTITY	**ALAB22 :=** ______________
ANALOG QUANTITY	**ALAB23 :=** ______________
ANALOG QUANTITY	**ALAB24 :=** ______________
ANALOG QUANTITY	**ALAB25 :=** ______________
ANALOG QUANTITY	**ALAB26 :=** ______________
ANALOG QUANTITY	**ALAB27 :=** ______________
ANALOG QUANTITY	**ALAB28 :=** ______________
ANALOG QUANTITY	**ALAB29 :=** ______________
ANALOG QUANTITY	**ALAB30 :=** ______________
ANALOG QUANTITY	**ALAB31 :=** ______________
ANALOG QUANTITY	**ALAB32 :=** ______________

Digital Label

RELAY WORD BIT	**DLAB01 :=** ______________
RELAY WORD BIT	**DLAB02 :=** ______________
RELAY WORD BIT	**DLAB03 :=** ______________
RELAY WORD BIT	**DLAB04 :=** ______________
RELAY WORD BIT	**DLAB05 :=** ______________
RELAY WORD BIT	**DLAB06 :=** ______________
RELAY WORD BIT	**DLAB07 :=** ______________
RELAY WORD BIT	**DLAB08 :=** ______________
RELAY WORD BIT	**DLAB09 :=** ______________
RELAY WORD BIT	**DLAB10 :=** ______________
RELAY WORD BIT	**DLAB11 :=** ______________
RELAY WORD BIT	**DLAB12 :=** ______________
RELAY WORD BIT	**DLAB13 :=** ______________
RELAY WORD BIT	**DLAB14 :=** ______________
RELAY WORD BIT	**DLAB15 :=** ______________
RELAY WORD BIT	**DLAB16 :=** ______________
RELAY WORD BIT	**DLAB17 :=** ______________
RELAY WORD BIT	**DLAB18 :=** ______________
RELAY WORD BIT	**DLAB19 :=** ______________
RELAY WORD BIT	**DLAB20 :=** ______________
RELAY WORD BIT	**DLAB21 :=** ______________
RELAY WORD BIT	**DLAB22 :=** ______________
RELAY WORD BIT	**DLAB23 :=** ______________
RELAY WORD BIT	**DLAB24 :=** ______________
RELAY WORD BIT	**DLAB25 :=** ______________
RELAY WORD BIT	**DLAB26 :=** ______________

RELAY WORD BIT	**DLAB27 :=** ______________
RELAY WORD BIT	**DLAB28 :=** ______________
RELAY WORD BIT	**DLAB29 :=** ______________
RELAY WORD BIT	**DLAB30 :=** ______________
RELAY WORD BIT	**DLAB31 :=** ______________
RELAY WORD BIT	**DLAB32 :=** ______________

Report Settings (SET R Command)

SER Chatter Criteria

Auto-Removal Enable (Y, N)	**ESERDEL :=** ______________
Number of Counts (2–20 counts) *(Hidden if ESERDEL := N)*	**SRDLCNT :=** ______________
Removal Time (0.1–90.0 sec) *(Hidden if ESERDEL := N)*	**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, 1–64) **EALIAS :=** ____

(All subsequent ALIAS settings are hidden if EALIAS := N)

ALIAS1	**ALIAS1 :=** ____
ALIAS2	**ALIAS2 :=** ____
ALIAS3	**ALIAS3 :=** ____
ALIAS4	**ALIAS4 :=** ____
ALIAS5	**ALIAS5 :=** ____
ALIAS6	**ALIAS6 :=** ____
ALIAS7	**ALIAS7 :=** ____
ALIAS8	**ALIAS8 :=** ____
ALIAS9	**ALIAS9 :=** ____
ALIAS10	**ALIAS10 :=** ____
ALIAS11	**ALIAS11 :=** ____
ALIAS12	**ALIAS12 :=** ____
ALIAS13	**ALIAS13 :=** ____
ALIAS14	**ALIAS14 :=** ____
ALIAS15	**ALIAS15 :=** ____
ALIAS16	**ALIAS16 :=** ____

ALIAS17	**ALIAS17 :=** ____________
ALIAS18	**ALIAS18 :=** ____________
ALIAS19	**ALIAS19 :=** ____________
ALIAS20	**ALIAS20 :=** ____________
ALIAS21	**ALIAS21 :=** ____________
ALIAS22	**ALIAS22 :=** ____________
ALIAS23	**ALIAS23 :=** ____________
ALIAS24	**ALIAS24 :=** ____________
ALIAS25	**ALIAS25 :=** ____________
ALIAS26	**ALIAS26 :=** ____________
ALIAS27	**ALIAS27 :=** ____________
ALIAS28	**ALIAS28 :=** ____________
ALIAS29	**ALIAS29 :=** ____________
ALIAS30	**ALIAS30 :=** ____________
ALIAS31	**ALIAS31 :=** ____________
ALIAS32	**ALIAS32 :=** ____________
ALIAS33	**ALIAS33 :=** ____________
ALIAS34	**ALIAS34 :=** ____________
ALIAS35	**ALIAS35 :=** ____________
ALIAS36	**ALIAS36 :=** ____________
ALIAS37	**ALIAS37 :=** ____________
ALIAS38	**ALIAS38 :=** ____________
ALIAS39	**ALIAS39 :=** ____________
ALIAS40	**ALIAS40 :=** ____________
ALIAS41	**ALIAS41 :=** ____________
ALIAS42	**ALIAS42 :=** ____________
ALIAS43	**ALIAS43 :=** ____________
ALIAS44	**ALIAS44 :=** ____________
ALIAS45	**ALIAS45 :=** ____________
ALIAS46	**ALIAS46 :=** ____________
ALIAS47	**ALIAS47 :=** ____________
ALIAS48	**ALIAS48 :=** ____________
ALIAS49	**ALIAS49 :=** ____________
ALIAS50	**ALIAS50 :=** ____________
ALIAS51	**ALIAS51 :=** ____________
ALIAS52	**ALIAS52 :=** ____________
ALIAS53	**ALIAS53 :=** ____________
ALIAS54	**ALIAS54 :=** ____________
ALIAS55	**ALIAS55 :=** ____________
ALIAS56	**ALIAS56 :=** ____________
ALIAS57	**ALIAS57 :=** ____________

ALIAS58	**ALIAS58 :=** ________________
ALIAS59	**ALIAS59 :=** ________________
ALIAS60	**ALIAS60 :=** ________________
ALIAS61	**ALIAS61 :=** ________________
ALIAS62	**ALIAS62 :=** ________________
ALIAS63	**ALIAS63 :=** ________________
ALIAS64	**ALIAS64 :=** ________________

Event Report

EVENT TRIGGER (SELOGIC)	**ER :=** ________________
EVENT LENGTH (15, 64, 180, 300 cyc)	**LER :=** ________________
PREFAULT LENGTH (1–10 cyc {if LER := 15}, 1–59 cyc {if LER := 64}, 1–175 cyc {if LER := 180}, 1–295 cyc {if LER := 300})	**PRE :=** ________________

HIF Event Reporting

(Hidden if the AST option is not included in the MOT.)

HIF EVENT LENGTH (3, 5, 10, 20 min)	**HIFLER :=** ________________
PRE HIF LENGTH (1–2 minutes {if HIFLER := 3}, 1–4 minutes {if HIFLER := 5}, 1–9 minutes {if HIFLER := 10}, 1–19 minutes {if HIFLER := 20})	**HIFPRE :=** ________________

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 := ________________	**RA08TYPE :=** ________________
RA02TYPE := ________________	**RA09TYPE :=** ________________
RA03TYPE := ________________	**RA10TYPE :=** ________________
RA04TYPE := ________________	**RA11TYPE :=** ________________
RA05TYPE := ________________	**RA12TYPE :=** ________________
RA06TYPE := ________________	**RA13TYPE :=** ________________
RA07TYPE := ________________	**RA14TYPE :=** ________________

RA15TYPE := ____________	RA24TYPE := ____________
RA16TYPE := ____________	RA25TYPE := ____________
RA17TYPE := ____________	RA26TYPE := ____________
RA18TYPE := ____________	RA27TYPE := ____________
RA19TYPE := ____________	RA28TYPE := ____________
RA20TYPE := ____________	RA29TYPE := ____________
RA21TYPE := ____________	RA30TYPE := ____________
RA22TYPE := ____________	RA31TYPE := ____________
RA23TYPE := ____________	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 Communications for additional details)
(User Map Register Label Name (8 characters))

MOD_001 := ____________	MOD_021 := ____________
MOD_002 := ____________	MOD_022 := ____________
MOD_003 := ____________	MOD_023 := ____________
MOD_004 := ____________	MOD_024 := ____________
MOD_005 := ____________	MOD_025 := ____________
MOD_006 := ____________	MOD_026 := ____________
MOD_007 := ____________	MOD_027 := ____________
MOD_008 := ____________	MOD_028 := ____________
MOD_009 := ____________	MOD_029 := ____________
MOD_010 := ____________	MOD_030 := ____________
MOD_011 := ____________	MOD_031 := ____________
MOD_012 := ____________	MOD_032 := ____________
MOD_013 := ____________	MOD_033 := ____________
MOD_014 := ____________	MOD_034 := ____________
MOD_015 := ____________	MOD_035 := ____________
MOD_016 := ____________	MOD_036 := ____________
MOD_017 := ____________	MOD_037 := ____________
MOD_018 := ____________	MOD_038 := ____________
MOD_019 := ____________	MOD_039 := ____________
MOD_020 := ____________	MOD_040 := ____________

MOD_041 := ________________
MOD_042 := ________________
MOD_043 := ________________
MOD_044 := ________________
MOD_045 := ________________
MOD_046 := ________________
MOD_047 := ________________
MOD_048 := ________________
MOD_049 := ________________
MOD_050 := ________________
MOD_051 := ________________
MOD_052 := ________________
MOD_053 := ________________
MOD_054 := ________________
MOD_055 := ________________
MOD_056 := ________________
MOD_057 := ________________
MOD_058 := ________________
MOD_059 := ________________
MOD_060 := ________________
MOD_061 := ________________
MOD_062 := ________________
MOD_063 := ________________
MOD_064 := ________________
MOD_065 := ________________
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MOD_068 := ________________
MOD_069 := ________________
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MOD_073 := ________________
MOD_074 := ________________
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MOD_076 := ________________
MOD_077 := ________________
MOD_078 := ________________
MOD_079 := ________________
MOD_080 := ________________
MOD_081 := ________________
MOD_082 := ________________
MOD_083 := ________________
MOD_084 := ________________
MOD_085 := ________________
MOD_086 := ________________
MOD_087 := ________________
MOD_088 := ________________
MOD_089 := ________________
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 := ______________________

EtherNet/IP Assembly Map Settings (SET E Command)

EtherNet/IP Assembly Map

(See Appendix F: EtherNet/IP Communications for additional details)
(EtherNet/IP Assembly Map settings are hidden if EtherNet/IP is not included)
(Use SET E n command where n = 1, 2, or 3 to create as many as three EtherNet/IP Assembly Maps
(This is EtherNet/IP Assembly Map 1 (EtherNet/IP Assembly Map 2 and EtherNet/IP Assembly Map 3 are identical to EtherNet/IP Assembly Map 1)

Input Assembly (IA) Binary

IAB_00 := ______________________
IAB_01 := ______________________
IAB_02 := ______________________
IAB_03 := ______________________
IAB_04 := ______________________
IAB_05 := ______________________
IAB_06 := ______________________
IAB_07 := ______________________
IAB_08 := ______________________
IAB_09 := ______________________
IAB_10 := ______________________
IAB_11 := ______________________
IAB_12 := ______________________
IAB_13 := ______________________
IAB_14 := ______________________
IAB_15 := ______________________
IAB_16 := ______________________
IAB_17 := ______________________
IAB_18 := ______________________
IAB_19 := ______________________
IAB_20 := ______________________
IAB_21 := ______________________
IAB_22 := ______________________
IAB_23 := ______________________
IAB_24 := ______________________
IAB_25 := ______________________
IAB_26 := ______________________
IAB_27 := ______________________
IAB_28 := ______________________
IAB_29 := ______________________
IAB_30 := ______________________
IAB_31 := ______________________
IAB_32 := ______________________
IAB_33 := ______________________
IAB_34 := ______________________
IAB_35 := ______________________
IAB_36 := ______________________
IAB_37 := ______________________
IAB_38 := ______________________
IAB_39 := ______________________
IAB_40 := ______________________
IAB_41 := ______________________
IAB_42 := ______________________
IAB_43 := ______________________
IAB_44 := ______________________
IAB_45 := ______________________
IAB_46 := ______________________
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IAB_95 := ______________________

IAB_96 := ______________________

IAB_97 := ______________________

IAB_98 := ______________________

IAB_99 := ______________________

Input Assembly (IA) Analog

IAA_00 := ______________________

IAA_01 := ______________________

IAA_02 := ______________________

IAA_03 := ______________________

IAA_04 := ______________________

IAA_05 := ______________________

IAA_06 := ______________________

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IAA_10 := ______________________

IAA_11 := ______________________

IAA_12 := ______________________

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IAA_16 := ______________________

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IAA_20 := ______________________

IAA_21 := ______________________

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IAA_91 := ________________

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IAA_93 := ________________

IAA_94 := ________________

IAA_95 := ________________

IAA_96 := ________________

IAA_97 := ________________

IAA_98 := ________________

IAA_99 := ________________

Output Assembly (OA) Binary

OAB_00 := ________________

OAB_01 := ________________

OAB_02 := ________________

OAB_03 := ________________

OAB_04 := ________________

OAB_05 := ________________

OAB_06 := ________________

OAB_07 := ________________

OAB_08 := ________________

OAB_09 := ________________

OAB_10 := ________________

OAB_11 := ________________

OAB_12 := ________________

OAB_13 := ________________

OAB_14 := ________________

OAB_15 := ________________

OAB_16 := ________________

OAB_17 := ________________

OAB_18 := ________________

OAB_19 := ________________

OAB_20 := ________________

OAB_21 := ________________

OAB_22 := ________________

OAB_23 := ________________

OAB_24 := ________________

OAB_25 := ________________

OAB_26 := ________________

OAB_27 := ________________

OAB_28 := ________________

OAB_29 := ________________

OAB_30 := ________________

OAB_31 := ________________

Output Assembly (OA) Analog

OAA_00 := ________________

OAA_01 := ________________

OAA_02 := ________________

OAA_03 := ________________

OAA_04 := ________________

OAA_05 := ________________

OAA_06 := ________________

OAA_07 := ________________

OAA_08 := ________________

OAA_09 := ________________

OAA_10 := ________________

OAA_11 := ________________

OAA_12 := ________________

OAA_13 := ________________

OAA_14 := ________________

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OAA_16 := ________________

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OAA_25 := ________________

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OAA_27 := ________________

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OAA_29 := ________________

OAA_30 := ________________

OAA_31 := ________________

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_00 := ____________________
BI_01 := ____________________
BI_02 := ____________________
BI_03 := ____________________
BI_04 := ____________________
BI_05 := ____________________
BI_06 := ____________________
BI_07 := ____________________
BI_08 := ____________________
BI_09 := ____________________
BI_10 := ____________________
BI_11 := ____________________
BI_12 := ____________________
BI_13 := ____________________
BI_14 := ____________________
BI_15 := ____________________
BI_16 := ____________________
BI_17 := ____________________
BI_18 := ____________________
BI_19 := ____________________
BI_20 := ____________________
BI_21 := ____________________
BI_22 := ____________________
BI_23 := ____________________
BI_24 := ____________________
BI_25 := ____________________
BI_26 := ____________________
BI_27 := ____________________
BI_28 := ____________________
BI_29 := ____________________
BI_30 := ____________________
BI_31 := ____________________
BI_32 := ____________________
BI_33 := ____________________
BI_34 := ____________________
BI_35 := ____________________
BI_36 := ____________________
BI_37 := ____________________
BI_38 := ____________________
BI_39 := ____________________
BI_40 := ____________________
BI_41 := ____________________
BI_42 := ____________________
BI_43 := ____________________
BI_44 := ____________________
BI_45 := ____________________
BI_46 := ____________________
BI_47 := ____________________
BI_48 := ____________________
BI_49 := ____________________
BI_50 := ____________________
BI_51 := ____________________
BI_52 := ____________________
BI_53 := ____________________
BI_54 := ____________________
BI_55 := ____________________
BI_56 := ____________________
BI_57 := ____________________
BI_58 := ____________________
BI_59 := ____________________
BI_60 := ____________________
BI_61 := ____________________
BI_62 := ____________________
BI_63 := ____________________
BI_64 := ____________________
BI_65 := ____________________
BI_66 := ____________________
BI_67 := ____________________
BI_68 := ____________________
BI_69 := ____________________

BI_70 := ________________________

BI_71 := ________________________

BI_72 := ________________________

BI_73 := ________________________

BI_74 := ________________________

BI_75 := ________________________

BI_76 := ________________________

BI_77 := ________________________

BI_78 := ________________________

BI_79 := ________________________

BI_80 := ________________________

BI_81 := ________________________

BI_82 := ________________________

BI_83 := ________________________

BI_84 := ________________________

BI_85 := ________________________

BI_86 := ________________________

BI_87 := ________________________

BI_88 := ________________________

BI_89 := ________________________

BI_90 := ________________________

BI_91 := ________________________

BI_92 := ________________________

BI_93 := ________________________

BI_94 := ________________________

BI_95 := ________________________

BI_96 := ________________________

BI_97 := ________________________

BI_98 := ________________________

BI_99 := ________________________

Binary Output Map

DNP Binary Output Label Name (10 characters)

BO_00 := ________________________

BO_01 := ________________________

BO_02 := ________________________

BO_03 := ________________________

BO_04 := ________________________

BO_05 := ________________________

BO_06 := ________________________

BO_07 := ________________________

BO_08 := ________________________

BO_09 := ________________________

BO_10 := ________________________

BO_11 := ________________________

BO_12 := ________________________

BO_13 := ________________________

BO_14 := ________________________

BO_15 := ________________________

BO_16 := ________________________

BO_17 := ________________________

BO_18 := ________________________

BO_19 := ________________________

BO_20 := ________________________

BO_21 := ________________________

BO_22 := ________________________

BO_23 := ________________________

BO_24 := ________________________

BO_25 := ________________________

BO_26 := ________________________

BO_27 := ________________________

BO_28 := ________________________

BO_29 := ________________________

BO_30 := ________________________

BO_31 := ________________________

Analog Input Map

DNP Analog Input Label Name (24 characters)

AI_00 := ________________________

AI_01 := ________________________

AI_02 := ________________________

AI_03 := ________________________

AI_04 := ________________________

AI_05 := ________________________

AI_06 := ________________________
AI_07 := ________________________
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AI_36 := ________________________
AI_37 := ________________________
AI_38 := ________________________
AI_39 := ________________________
AI_40 := ________________________
AI_41 := ________________________
AI_42 := ________________________
AI_43 := ________________________
AI_44 := ________________________
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AI_46 := ________________________
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AI_49 := ________________________
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AI_56 := ________________________
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AI_58 := ________________________
AI_59 := ________________________
AI_60 := ________________________
AI_61 := ________________________
AI_62 := ________________________
AI_63 := ________________________
AI_64 := ________________________
AI_65 := ________________________
AI_66 := ________________________
AI_67 := ________________________
AI_68 := ________________________
AI_69 := ________________________
AI_70 := ________________________
AI_71 := ________________________
AI_72 := ________________________
AI_73 := ________________________
AI_74 := ________________________
AI_75 := ________________________
AI_76 := ________________________
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AI_95 := ________________________________
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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 := ________________________________
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CO_21 := ________________________________
CO_22 := ________________________________
CO_23 := ________________________________

CO_24 := ________________________

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CO_27 := ________________________

CO_28 := ________________________

CO_29 := ________________________

CO_30 := ________________________

CO_31 := ________________________

IEC 60870-5-103 Map Settings (SET I Command)

(Hidden if the IEC 60870-5-103 option is not included)
Use the SET I command to input the map required for the IEC 60870-5-103 protocol.

Binary Input Map

103BI00 := ________________________

103BI01 := ________________________

103BI02 := ________________________

103BI03 := ________________________

103BI04 := ________________________

103BI05 := ________________________

103BI06 := ________________________

103BI07 := ________________________

103BI08 := ________________________

103BI09 := ________________________

103BI10 := ________________________

103BI11 := ________________________

103BI12 := ________________________

103BI13 := ________________________

103BI14 := ________________________

103BI15 := ________________________

103BI16 := ________________________

103BI17 := ________________________

103BI18 := ________________________

103BI19 := ________________________

103BI20 := ________________________

103BI21 := ________________________

103BI22 := ________________________

103BI23 := ________________________

103BI24 := ________________________

103BI25 := ________________________

103BI26 := ________________________

103BI27 := ________________________

103BI28 := ________________________

103BI29 := ________________________

103BI30 := ________________________

103BI31 := ________________________

103BI32 := ________________________

103BI33 := ________________________

103BI34 := ________________________

103BI35 := ________________________

103BI36 := ________________________

103BI37 := ________________________

103BI38 := ________________________

103BI39 := ________________________

103BI40 := ________________________

103BI41 := ________________________

103BI42 := ________________________

103BI43 := ________________________

103BI44 := ________________________

103BI45 := ________________________

103BI46 := ________________________

103BI47 := ________________________

103BI48 := ________________________

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103BI67 := ________________
103BI68 := ________________
103BI69 := ________________
103BI70 := ________________
103BI71 := ________________
103BI72 := ________________
103BI73 := ________________
103BI74 := ________________
103BI75 := ________________
103BI76 := ________________
103BI77 := ________________
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 := ________________
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103FA20 := ________________
103FA21 := ________________

103FA22 := ______________________________

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103FA24 := ______________________________

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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 I: DeviceNet Communications for information on the DeviceNet communications card.

Be sure to evaluate the installation and communications necessary to integrate with existing devices before ordering your SEL-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 (49 ft) in low noise environments. Use the optional EIA-485 port for communications distances as far as 1200 m (3937 ft) maximum distance (to achieve this performance, ensure proper line termination at the receiver).

To connect a PC serial port to the relay front-panel serial port and enter relay commands, you need the following:

- A personal computer equipped with one available EIA-232 serial port
- A communications cable to connect the computer serial port to the relay serial ports
- Terminal emulation software to control the computer serial port
- An SEL-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 Real-Time Automation Controller (RTAC)
- SEL-2800 series fiber-optic transceivers
- SEL-2890 Ethernet Transceiver
- SEL-3010 Event Messenger
- SEL-2505 Remote I/O Module (with SEL-2812 compatible ST fiber-optic port) for connection to relay fiber-optic serial Port 2, or use SEL-2505 with EIA-232 (DB-9) serial port to connect to EIA-232 Port 3 on the relay

A variety of terminal emulation programs on personal computers can communicate with the relay. For the best display, use VT-100 terminal emulation or the closest variation.

The default settings for all EIA-232 serial ports are as follows:

Data Rate = 9600
Data Bits = 8
Parity = N
Stop Bits = 1

To change the port settings, use the **SET P** command (see *Section 6: Settings*) or the front-panel. *Section 8: Front-Panel Operations* provides details on making settings with the front panel.

Hardware Flow Control

All EIA-232 serial ports support RTS/CTS hardware handshaking (hardware flow control). To enable hardware handshaking, use the **SET P** command or front-panel PORT submenu to set RTSCTS := Y. Disable hardware handshaking by setting RTSCTS := N.

- If RTSCTS := N, the relay permanently asserts the RTS line.
- If RTSCTS := Y, the relay deasserts RTS when it is unable to receive characters.
- If RTSCTS := Y, the relay does not send characters until the CTS input is asserted.

Fiber-Optic Serial Port

Use the optional fiber-optic port (Port 2) for safety and communications distances as far as 1 km. 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.

Telnet or Web Server

NOTE: Telnet and the web server work with other NETMODE settings also, but NETMODE = SWITCHED is easiest to begin communication. The relay hides setting NETMODE when equipped with a single Ethernet port.

Factory-default settings for the Ethernet ports disable all Ethernet protocols except Telnet, HTTP, and PING. Command **SET P 1** accesses settings for both Ethernet ports on the SEL-751: Port 1A and Port 1B. See Ethernet port settings in *Table 4.97 on page 4.225* for a sample of the **SET P 1** command with factory-default settings. Use the **SET P 1** command to make the following settings:

- IPADDR := IP address assign by network administrator
- DEFRTR := Default router IP address assigned by network administrator
- NETMODE := SWITCHED (available with dual Ethernet ports)
- ETELNET := Y
- EHTTP := Y

Leave all other settings at their default values.

Connect an Ethernet cable between your PC or a network switch and any Ethernet port on the relay. Verify that the amber link LED illuminates on the connected relay port. Many computers and most Ethernet switches support autocrossover, so nearly any Cat 5 Ethernet cable with RJ45 connectors, such as an SEL-C627 cable will work. When the computer does not support autocrossover, use a crossover cable, such as an SEL-C628 cable. If your relay is equipped with dual Ethernet ports, connect to either port. Use a Telnet application or ACSELERATOR QuickSet SEL-5030 Software on the host PC to communicate with the relay. To terminate a Telnet session, use the **EXIT** command from any access level.

In addition, you can communicate with the relay through your web browser. Launch a web browser and enter address http://IPADDR for unsecure HTTP communication, where IPADDR is the Port 1 IPADDR setting. To terminate the session, close the web browser (see *Section 3: PC Interface* for more details).

Ethernet Port

Use the Ethernet port for interfacing with an Ethernet network environment. SEL-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).

You should carefully design your Ethernet network to maximize reliability, minimize system administrator efforts, and provide adequate security. SEL recommends that you work with a networking professional to design your substation Ethernet network.

Several settings control how the relay with the optional Ethernet card operates on an Ethernet network. These settings include IP addressing information, network port failover options, and network speed.

Use the network configuration settings shown in *Table 4.97* to configure the relay for operation on an IP network and to set other parameters affecting the physical Ethernet network interface operation.

Figure 7.1 shows an example of a simple Ethernet network configuration, *Figure 7.2* shows an example of an Ethernet network configuration with dual redundant connections, and *Figure 7.3* shows an example of an Ethernet network configuration with ring structure.

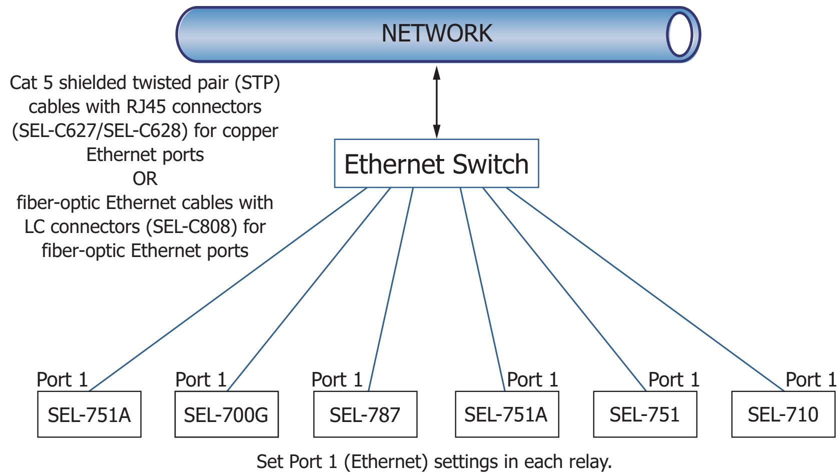


Figure 7.1 Simple Ethernet Network Configuration

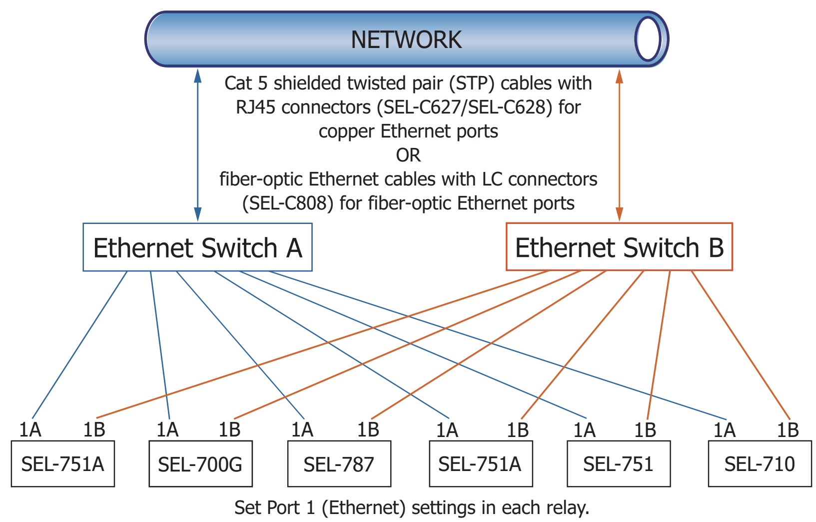


Figure 7.2 Ethernet Network Configuration With Dual Redundant Connections (Failover Mode)

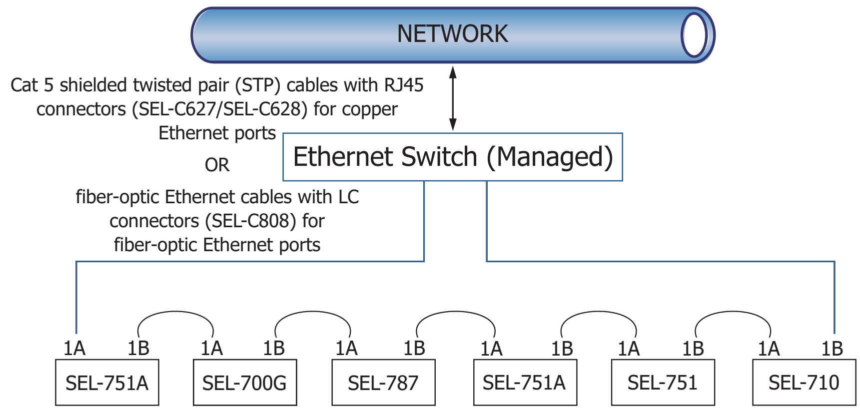


Figure 7.3 Ethernet Network Configuration With Ring Structure (Switched Mode)

Dual Network Port Operation

The SEL-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.

NOTE: If you change settings for the host port in the relay and the standby network port is active, the relay resets and returns to operation on the primary port.

Step 1. Set NETMODE to FAILOVER.

Step 2. Set FTIME to the desired network port failover time (0.10–65.00 seconds or OFF).

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

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.

Switched Mode

If you have a network configuration where you want to use the relay as an unmanaged or managed switch, set NETMODE to SWITCHED. Set ERSTP := Y to use it as a managed switch. In SWITCHED mode, both links are enabled. The relay responds to the messages it receives on either port. All the messages received on one network port that are not addressed to the relay are transmitted out of the other port without any modifications. In this mode, the relay ignores the NETPORT setting.

SWITCHED mode is often used to connect several relays to each other, creating a network of relays, then connecting at least two relays to a managed switch for redundancy. This configuration is popular because it reduces cost and reduces the number of devices in a network without sacrificing redundancy. Basically, each relay has a redundant path to the network. Refer to *Figure 7.3*.

There are compromises to be made in this configuration, however. When connecting cables between multiple switches in an Ethernet network, physical loops (rings) may occur that cause traffic storms, total bandwidth consumption, and other improper functioning. As a result, a subset of the relays in this configuration can seem unresponsive for extended periods of time.

For example, in *Figure 7.3*, imagine that a DNP master is receiving DNP UDP unsolicited messages from the relays. When a link is broken, it can sometimes take as long as 5 minutes for communications to be restored. For a similar network involving IEC 61850 GOOSE and a broken link, the restoration time can be greater than 5 seconds. The relay offers Rapid Spanning Tree Protocol (RSTP) mode to improve restoration times in such configurations. With RSTP enabled, the expected restoration time of the before-mentioned GOOSE network is around 100 ms.

RSTP protocol controls active paths in an Ethernet network to avoid loops and enable a level of redundancy. All Port 1 protocols are supported when RSTP is enabled. Refer to *Rapid Spanning Tree Protocol (RSTP) on page 7.21* for additional details.

Fixed Connection Mode

If you have a single network and want to use only one network port, or if you have both ports connected but want to force usage of only one port for various reasons, set NETMODE to FIXED and set NETPORT to the port you want to use. Only the selected network port operates, and the other port is disabled.

PRP Connection Mode

Parallel Redundancy Protocol (PRP) is part of an IEC standard for high availability automation networks (IEC 62439-3). The purpose of the protocol is to provide seamless recovery from any single Ethernet network failure.

The basic concept is that the Ethernet network and all traffic are fully duplicated with the two copies operating in parallel.

Make the following settings for Port 1 to configure the relay for PRP mode.

- ➤ NETMODE = PRP
- ➤ PRPTOUT = desired timeout for PRP frame entry

- ➤ PRPADDR = PRP destination MAC address LSB (least significant byte of "01-15-4E-00-01-*XX*," converted to decimal and entered as 0–255)
- ➤ PRPINTV = desired supervision frame transmit interval

When NETMODE is not set to PRP, the following settings are hidden.

Table 7.2 PRP Settings

Setting Prompt	Setting Description	Setting Range	Setting Name := Factory Default
PRP ENTRY TIMEOUT	PRP Entry Timeout	400–10000 ms	PRPTOUT := 500
PRP DESTINATION ADDR LSB	The multicast MAC address of PRP supervision frames is 01-15-4E-00-01-*XX* where *XX* is specified by this setting in decimal notation as 0–255	0–255	PRPADDR := 0
PRP SUPERVISION TX INTERVAL	PRP Supervision TX Interval	1–10 s	PRPINTV := 2

Autonegotiation, Speed, and Duplex Mode

NOTE: Firmware versions R401-V0 and higher do not support half 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.

Network Storm Detection

In an Ethernet network, a storm of messages can occur when an incorrect network configuration causes network loops. These network storms can disrupt relay communication. To detect such storms, the relay periodically checks the number of received messages over the Ethernet ports. When the relay receives an excessive amount of Ethernet traffic, the relay asserts the STORMDET (storm detect) Relay Word bit and stops processing Ethernet messages. However, the Bridge Protocol Data Units (BPDUs) are processed irrespective of the state of the STORMDET Relay Word bit.

NETPORT Selection

The NETPORT setting gives you the option of selecting the primary port of communication in failover or fixed communications modes.

TCP Keep Alive

NOTE: The ETCPKA setting applies to all TCP traffic on Ethernet ports, including Telnet, FTP, IEC 61850, MMS, and C37.118 (PMU). TCP Keep Alive is enabled with default KAIDLE, KAINTV, and KACNT settings for C37.118 (PMU) sessions even when ETCPKA = N.

The ETCPKA setting, along with the KAIDLE, KAINTV, and KACNT settings, can be used to verify that the computer at the remote end of a TCP connection is still available. If ETCPKA is enabled and the relay does not transmit any TCP data within the interval specified by the KAIDLE setting, the relay sends a keep-alive packet to the remote computer. If the relay does not receive a response from the remote computer within the time specified by KAINTV, the keep-alive packet is re-transmitted as many as KACNT times.

After this count is reached, the relay considers the remote device no longer available, so the relay terminates the connection without waiting for the idle timer (TIDLE or FTPIDLE) to expire.

The relay monitors MMS inactivity to identify and disconnect MMS clients that have stopped communicating. You can set it from 0 to 4,200,000 seconds via the IED Properties MMS Settings in ACSELERATOR Architect SEL-5032 Software. The MMS inactivity default value is either 120 seconds or 900 seconds, depending on the relay firmware version. Setting this value to 0 disables the MMS inactivity timer. If enabled, the relay starts a timer for an MMS session after it receives an MMS request from the client on that session. It resets the timer whenever it receives a new MMS request from that client. When the timer runs out, the relay disconnects the MMS session, making it available for other MMS clients.

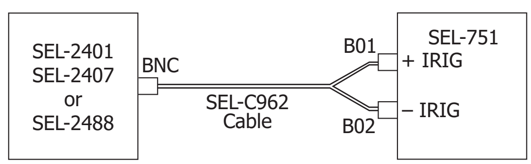
This feature was implemented in addition to the TCP keep-alive timer to specifically handle MMS clients that do not disconnect properly. As there are a limited number of MMS sessions available, this ensures that misbehaving MMS clients do not take up multiple MMS sessions. Note that the MMS inactivity time-out can still disconnect an MMS session even if the relay receives TCP keep-alive messages from that MMS client.

IRIG-B

The SEL-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 a 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.

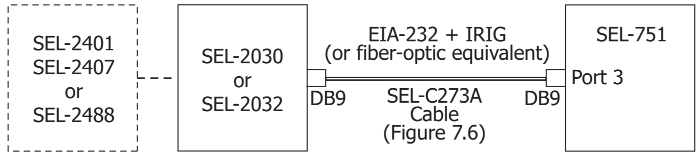
You cannot bring IRIG-B via Port 2 or 3 if you use the **B01–B02** input.

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)

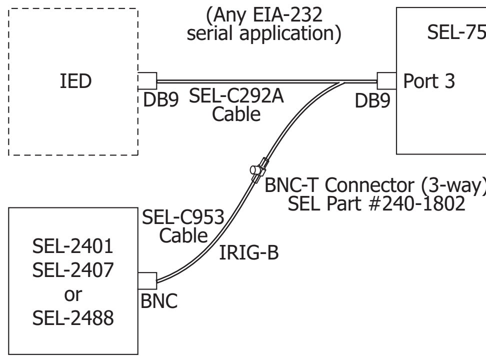
Connect to an SEL communications processor with an SEL-C273R Cable to bring IRIG-B input with the EIA-232 port. Refer to *Figure 7.5* for a connection diagram. Refer to *Figure 7.6* on how to connect an SEL time source (SEL-2401, SEL-2407, SEL-2488) for IRIG-B input to Port 3.



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)



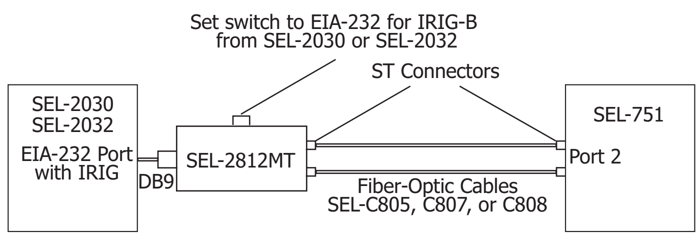
You cannot use B01–B02 input or Port 2 if you use Port 3.

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

Figure 7.6 IRIG-B Input Via EIA-232 Port 3 (SEL-2401/2407/2488 Time Source)

Option 3: Port 2 (Fiber-Optic Serial Port)

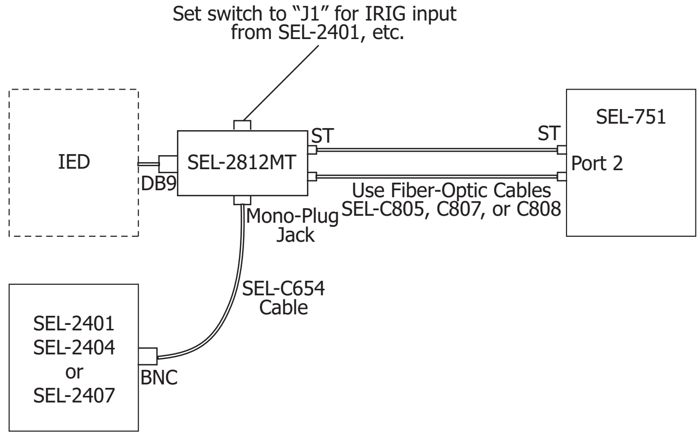
You can use the optional fiber-optic serial Port 2 to bring IRIG-B input to the relay as shown in *Figure 7.7* and *Figure 7.8*.



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-2401/2407/2488 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 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-C234R Cable; wiring for this cable is shown in *Figure 7.10*. SEL-C234R Cable and other cables are available from SEL. Use the SEL-5801 Cable Selector Software to select an appropriate cable for another application. This software is available for free download from the SEL website at selinc.com.

For best performance, SEL-C234R Cable should not be more than 15 m (49 ft) long. For long-distance communications and for electrical isolation of communications ports, use the SEL family of fiber-optic transceivers. Contact SEL for more details on these devices.

Port Connector and Communications Cables

Figure 7.9 shows the front-panel EIA-232 serial port (**PORT F**) DB-9 connector pinout for the SEL-751.

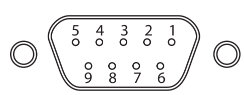


Figure 7.9 EIA-232 DB-9 Connector Pin Numbers

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 an SEL-C234**R** Cable instead of an SEL-C234**A** Cable. The SEL-C234**R** Cable is double-shielded and provides better data integrity compared to the SEL-C234**A** Cable.

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.

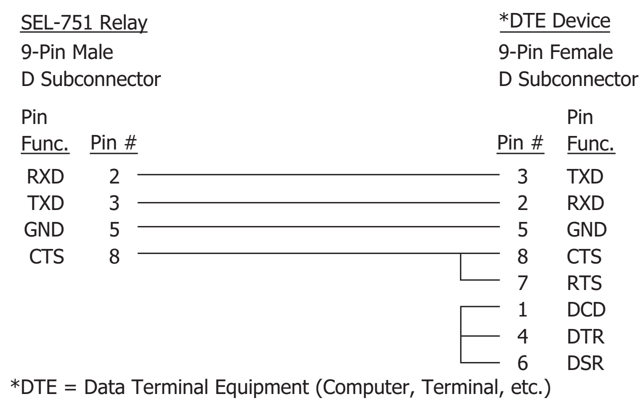


Figure 7.10 SEL-C234A Cable—SEL-751 to DTE Device

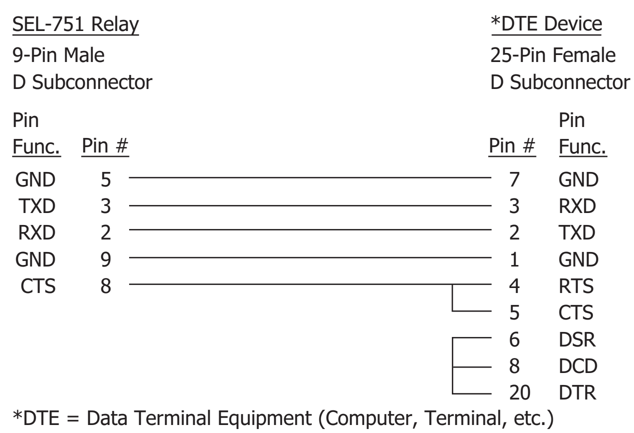


Figure 7.11 SEL-C227A Cable—SEL-751 to DTE Device

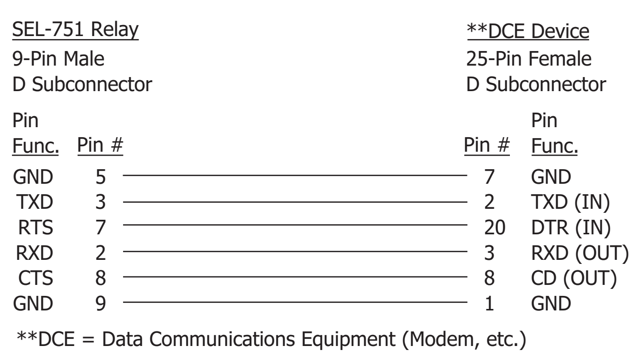


Figure 7.12 SEL-C222 Cable—SEL-751 to Modem

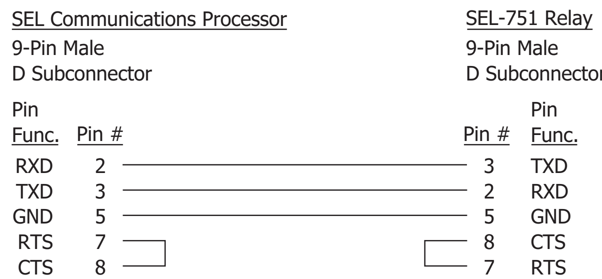


Figure 7.13 SEL-C272A Cable—SEL-751 to SEL Communications Processor (Without IRIG-B Signal)

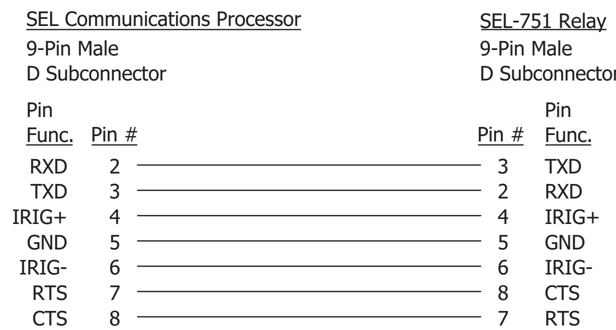


Figure 7.14 SEL-C273A Cable—SEL-751 to SEL Communications Processor (With IRIG-B Signal)

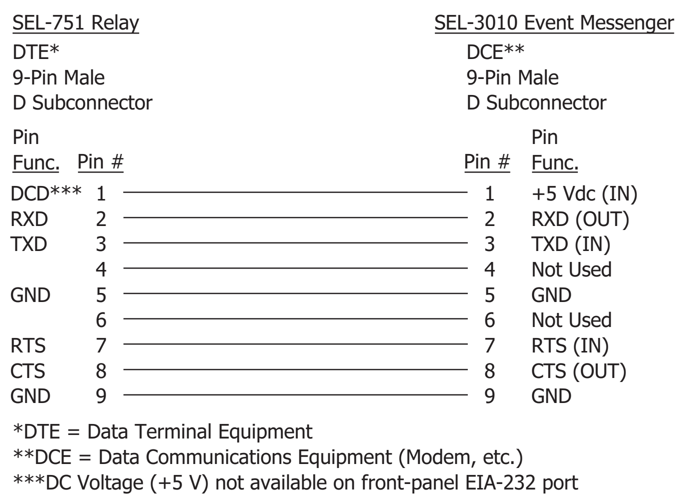


Figure 7.15 SEL-C387 Cable—SEL-751 to SEL-3010

Communications Protocols

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 (FTP), Modbus RTU Slave, C37.118 Protocol (synchrophasor data), and Event Messenger
PORT 1[a]	Modbus TCP/IP, FTP, IEC 61850, DNP3 LAN/WAN, SNTP, EtherNet/IP, PTP, and Telnet (SEL ASCII, Compressed ASCII, SEL Fast Meter, SEL Fast Operate, SEL Fast SER, SEL Fast Message, web server (HTTP), C37.118 Protocol (synchrophasor data), PRP, and RSTP
PORT 2	SEL ASCII and Compressed ASCII Protocols, SEL Fast Meter, SEL Fast Operate, SEL Fast SER, SEL Fast Message, 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, one PTP, two C37.118 protocol (synchrophasor data), and seven IEC 61850 sessions, as well as two EIP I/O connections and six EIP message connections.

SEL Communications Protocols

SEL ASCII

This protocol is described in *SEL ASCII Protocol and Commands on page 7.26*.

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. The MIRRORED BITS protocol is described in *Appendix J: MIRRORED BITS Communications*.

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 K: Synchrophasors*.

Modbus RTU Protocol

The SEL-751 provides Modbus RTU support. Modbus is an optional protocol described in *Appendix E: Modbus Communications*.

Distributed Network Protocol (DNP3)

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 I: 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 H: IEC 60870-5-103 Communications*.

Ethernet Protocols

As with other communications interfaces, you must choose a data exchange protocol that operates over the Ethernet network link to exchange data. The relay supports FTP, Telnet, Ping, Modbus/TCP, HTTP, DNP3 LAN/WAN, C37.118, 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 message 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 7.83* for information on available files.

File dates within the last 12 months are displayed with month, day, hour, and minutes. Dates older than twelve months have the year, month, and day. The times are UTC.

Access Control

To log in to the FTP server, enter the value of the Port 1 setting FTPUSER as the user name in your FTP application. Enter the Port 1 setting FTPACC level password as the password in your FTP application. Note that FTP does not encrypt passwords before sending them to the server.

MMS is enabled when the Port 1 setting E61850 is set to Y. No authentication is required. MMS File Transfer is enabled when setting EMMSFS is set to Y. If MMS Authentication is enabled via the CID file, then an authenticated connection must be established via MMS for MMS file transfer to take place.

Using FTP and MMS

A free FTP application is included with most web browser software and PC operating systems. You can also obtain free or inexpensive FTP applications from the Internet. Once you have retrieved the necessary files, be sure to close the FTP connection using the disconnect function of your FTP application or completely closing the application. Failure to do so can cause the FTP connection to remain open, which blocks subsequent connection attempts until FTPIDLE time expires. See *Appendix G: IEC 61850 Communications* for information about using MMS.

Telnet Server

Use the Telnet session (TPORT default setting is Port 23) to connect to the relay to use the protocols, which are described in more detail below:

- SEL ASCII
- Compressed ASCII
- Fast Meter
- Fast Operate
- Fast SER

NOTE: Use the **QUIT** command prior to closing the Telnet-to-Host session to set the relay to Access Level 0. Otherwise, the relay remains at an elevated access level until TIDLE expires.

Telnet is a terminal connection across a TCP/IP network that operates in a manner very similar to a direct serial port connection to one of the relay ports. As with FTP, Telnet is a part of TCP/IP. A free Telnet application is included with most computer operating systems, or you can obtain low-cost or free Telnet applications on the Internet.

Ping Server

Ping is an application based on ICMP over an IP network. A free Ping application is included with most computer operating systems. Use a Ping client with the relay Ping server to verify that your network configuration is correct.

C37.118 Protocol

The SEL-751 provides C37.118 protocol (synchrophasor data) support at serial Ports F, 2, 3, or 4. Additionally, Port 1 allows two C37.118 protocol sessions. The C37.118 protocol is described in *Appendix K: Synchrophasors*.

IEC 61850

Use as many as seven sessions of MMS over a TCP network to exchange data with the relay. Use GOOSE to do real-time data exchange with as many as 64 incoming messages and 8 outgoing messages. For more details on the IEC 61850 protocol, see *Appendix G: IEC 61850 Communications*.

Simple Network Time Protocol (SNTP)

When the Port 1 (Ethernet port) setting ESNTP is ON, 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 and hardware-based PTP. The relay can use SNTP as a less accurate primary time source or as a backup time source to the higher accuracy IRIG-B time source and hardware-based PTP.

SNTP as Primary or Backup Time Source

If IRIG-B and PTP time sources are connected and Relay Word bit TSOK, IRIGOK, or PTP_OK/PTPSYNC asserts, then the relay synchronizes the internal time-of-day clock to the incoming IRIG-B time code signal or PTP packet from the network, even if SNTP is configured in the relay and an NTP server is available. If the IRIG-B and PTP sources are disconnected, then the relay synchronizes the internal time-of-day clock to the NTP server, if available. In this way, an NTP server acts as either the primary time source or as the backup time source to the more accurate 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 Prompt	Setting Range	Setting Name := Factory Default	Description
ENABLE SNTP CLIENT	OFF, UNICAST, MANYCAST, BROADCAST	ESNTP := OFF	Selects the mode of operation of SNTP. See descriptions in *SNTP Operation Modes on page 7.17*.
PRIMARY SERVER IP ADDRESS	Valid IP Address	SNTPPSIP := 192.168.1.1	Selects primary NTP server when ESNTP = UNICAST, or broadcast address when ESNTP = MANYCAST or BROADCAST.
BACKUP SERVER IP ADDRESS	Valid IP Address	SNTPPSIB := 192.168.1.1	Selects backup NTP server when ESNTP = UNICAST.
SNTP IP (LOCAL) PORT NUMBER	1–65534	SNTPPORT := 123	Ethernet port used by SNTP. Leave at default value unless otherwise necessary.
SNTP UPDATE RATE	15–3600 seconds	SNTPRATE := 60	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 ESNTP = BROADCAST.
SNTP TIMEOUT	5–20 seconds	SNTPTO := 5	Determines the time the relay waits for the NTP master to respond when ESNTP = 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.

Embedded Web Server (HTTP)

When Port 1 setting EHTTP := Y, the relay serves webpages displaying settings, metering, status reports, event files, etc. The relay embedded web server has been optimized and tested to work with the most popular web browsers, but it should also work with any standard web browser. As many as three users can access the embedded web server simultaneously. To begin using the embedded read-only web server, launch your web browser, and browse to http://IPADDR, where IPADDR is the Port 1 setting IPADDR.

Log in using your username and password to view or export various reports, view settings, monitor communications or relay status, or upgrade firmware (Access Level 2 only).

To log out of the web server, either close the web browser window or click **Logout** in the banner bar near the top of the webpage. For more information on the web server, see *Section 3: PC Interface*.

Table 7.6 lists the HTTP settings that are available for configuring the web server.

Table 7.6 HTTP Server Configuration

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE HTTP SERVER	Y, N	EHTTP := Y
HTTP MAXIMUM ACCESS LEVEL	1, 2	HTTPACC := 2
TCP/IP PORT	1–65535	HTTPPORT := 80
HTTP CONNECT BANNER	254 ASCII printable characters	HTTPBAN := This system is for the use of authorized personnel only.
HTTP WEB SERVER TIMEOUT	1–60 min	HTTPIDLE := 10

Precision Time Protocol (PTP)

Configuring PTP in the Relay

The SEL-751 supports hardware-based PTP if NETMODE := PRP. If NETMODE := FAILOVER or FIXED mode, the SEL-751 supports firmware-based PTP. If the EPTP setting is available and set to Y, then the SEL-751 supports PTP Version 2 (PTPv2) as a slave-only clock as defined by IEEE 1588-2008 on Ports 1A and 1B. *Table 7.7* shows the settings associated with PTP.

Table 7.7 Settings Associated With PTP

Setting Prompt	Setting Range	Setting Name := Factory Default	Description
ENABLE PTP	Y, N	EPTP := N	When set to Y, the device becomes a slave PTP clock
PTP PROFILE	DEFAULT, C37.238	PTPPRO := DEFAULT	Sets the PTP profile
PTP TRANSPORT MECHANISM	UDP, LAYER2	PTPTR := UDP	Transport mechanism for PTP messages
PTP DOMAIN NUMBER	0–255	DOMNUM := 0	PTP domain number of the clock
PTP PATH DELAY MECHANISM	P2P, E2E, OFF	PTHDLY := E2E	Path delay measurement method to be used on the PTP network
PEER DELAY REQUEST INTERVAL	1, 2, 4, 8, 16, 32, 64 sec	PDINT := 1	Duration of time between transmissions of peer delay request messages
PTP NUMBER OF ACCEPTABLE MASTERS	1–5, OFF	AMNUM := OFF	Number of acceptable PTP masters
PTP ACCEPTABLE MASTER *n*[a] IP	*zzz.yyy.xxx.www*	AMIP*n* := 192.168.1.12*n*	Acceptable master IP addresses
PTP ACCEPTABLE MASTER *n*[a] MAC	*xx:xx:xx:xx:xx:xx*	AMMAC*n* := 00-30-A7-00-00-0*m*[b]	Acceptable master MAC addresses
PTP ALTERNATE PRIORITY1 FOR MASTER *n*[a]	0–255	ALTPRI*n* := 0	If the acceptable master table option is enabled and this setting value is not zero, the Priority 1 value received in the Announce message from the specified master will be replaced by this value and used in the Best Master Clock Algorithm (BCMA)
PTP VLAN IDENTIFIER	1–4094	PVLAN := 1	VLAN ID for a C37.238 Ethernet frame
PTP VLAN PRIORITY	0–7	PVLANPR := 4	VLAN priority for a C37.238 Ethernet frame

[a] n = 1–5.
[b] m = A–E.

To achieve the best accuracy, it is necessary to have one or more PTP master clocks and that all intervening equipment (e.g., Ethernet switches) be IEEE 1588-aware (i.e., all intervening network devices need to be transparent or boundary clocks).

In PTP, a clock that provides time to other devices, typically based on GPS input, is a master clock. The intervening switches are transparent clocks. You can connect networks together and pass time from one network to another using boundary clocks. Transparent and boundary clocks are important because they provide time correction in the PTP messages that pass through them, whereas devices that are not IEEE 1588-aware do not provide this correction. Because it is possible for a network to have multiple master clocks, PTP clocks implement algorithms to select the best available clock. The one selected for use by an end device is the grandmaster clock. You can learn more about configuring a PTP network in these application guides:

- "Using the SEL-2488 to Provide IEEE 1588 Version 2 Grandmaster Functionality in a Redundant Network Topology" (AN2015-07)
- "Using the SEL-2488 to Provide IEEE 1588 Version 2 Grandmaster Functionality to Isolated Ethernet Networks" (AN2015-06)

To configure PTP, update the Port 1 PTP settings as described in *Table 7.7*. By default, PTP is disabled in the SEL-751. Set EPTP to Y to enable PTP and to make the other PTP settings available.

PTP implementation in the SEL-751 supports both one-step and two-step clocks. A one-step clock provides time information using a single event message. A two-step clock provides time information using the combination of an event message and a subsequent general message.

Within PTP, there are multiple clock profiles available. A profile defines the set of PTP features available in a specific application domain. SEL-751 relays support two profiles: Default and Power (C37.238-2011).

The Default profile has many optional features and is intended to address common applications. The Default profile supports both UDP or Layer 2 (802.3) Ethernet transport, and can use either the end-to-end (E2E) or the peer-to-peer (P2P) delay mechanism. Grandmaster clocks can send Announce, Sync, and Delay request messages over a wide range of intervals. A Default profile network can consist of boundary clocks or transparent clocks anywhere between the grandmaster and the end devices. The only performance requirement for the Default profile is that a master clock must maintain frequency accuracy to within 0.01 percent.

The Power profile has minimal optional features to facilitate interoperability and performance predictability. The Power profile is only supported on Layer 2 networks and exclusively uses the peer-to-peer delay mechanism. All messages must be sent at 1-second intervals, have 802.1Q VLAN tags, and include grandmaster ID and (maximum) inaccuracy fields in the Announce message. Transparent clocks are mandatory in a Power profile network and boundary clocks are not allowed. Select the profile by using the PTPPRO setting.

PTP defines a logical grouping of clocks in a network as a clock domain. This allows a logical separation between clocks that participate in different application domains to coexist on the same network. Domains are identified by domain numbers. The domain number for the SEL-751 is selected using the DOMNUM setting. Set DOMNUM to match the domain number configured in the master clocks to which the SEL-751 should synchronize.

The SEL-751 supports transport of PTP messages over UDP or Layer 2 (Ethernet). Use the PTPTR setting to select the PTP transport mechanism. This needs to match the transport mechanism used in the master clocks. Only Layer 2 is available with the Power profile. If operating in a UDP network, PTP operates on Ports 319 or 320. Except for peer delay messages, the SEL-751 sets the time allowed to live (TTL) value in the UDP/IP header of PTP messages to 64. This allows you to use routers across a WAN to synchronize the SEL-751 PTP master. High-accuracy synchronization may not be achievable across the WAN, so it is left to you to determine if the accuracy meets the needs of your application.

When using the Power profile, use the VLAN identifier and priority settings, PVLAN and PVLANPR, to set the VLAN ID and priority, respectively, of the Ethernet frames. Be sure to set PVLAN unique from other VLANs used within the SEL-751.

PTP defines two methods for calculating and correcting the communications path delay between the SEL-751 and the master clock: end-to-end (Delay Request Response) and peer-to-peer (Peer Delay Request Response). The end-to-end mechanism calculates the total path delay between the SEL-751 and the master clock.

The peer-to-peer mechanism calculates the total path delay in a piecemeal fashion between each device in the path. Peer-to-peer is the more accurate method and is recommended for use with the SEL-751. Only the peer-to-peer mechanism is available for the Power profile. The SEL-751 periodically initiates path delay calculations. Use the PTHDLY and PDINT settings to configure the path delay method and the path delay request rate. If PTHDLY is set to OFF, then the SEL-751 will not calculate and correct for path delay.

By default, the SEL-751 synchronizes to any clock on the network that it evaluates to be the best clock based on the BMCA. Use the settings to specify a list of master (grandmaster or boundary) clocks to which the SEL-751 may synchronize. The SEL-751 will not synchronize to any master clock that is not in the list. It is recommended to use this feature for additional security. The AMNUM setting selects the number of master clocks you list. The default value is OFF, which means the SEL-751 synchronizes to any master clock on the network. If AMNUM is set to a value other than OFF, the number of allowable masters must be identified in accordance with the PTP transport chosen, i.e., MAC address for 802.3 or IP address for UDP transport.

If the PTP transport (PTPTR) is set to UDP, use the AMIP*n* settings to specify the IP addresses of the clocks to which the SEL-751 is permitted to synchronize. If PTP transport is set to Layer 2, use the AMMAC*n* settings to specify the MAC addresses of the clocks to which the SEL-751 is permitted to synchronize.

If the ALTPRI*n* (Alternate Priority1 for Master *n*) setting value is positive, the ALTPRI*n* value replaces the Priority1 value in the received Announce message before the SEL-751 applies the BMCA. The ALTPRI*n* values reprioritize the master clocks locally.

EtherNet/Industrial Protocol (IP)

EtherNet/IP is an industrial protocol that uses standard Ethernet and TCP/IP technology to transport Common Industrial Protocol (CIP) packets. You can enable EtherNet/IP on Port 1 for a maximum of eight simultaneous CIP connections. Of these eight simultaneous connections, you can have as many as two Class 1 (I/O) connections and as many as six combined Class 3 messages and Unconnected Message Manager (UCMM) messages.
When configuring EIP on Port 1, you can create as many as six Class 1 (I/O) connection configurations. Of these six, only two can be used simultaneously. Of the remaining six available connection configurations, as many as three can be Exclusive Owner connection configurations. The remaining connection configurations must be Input Only connection configurations. EtherNet/IP is described in detail in *Appendix F: EtherNet/IP Communications*.

Rapid Spanning Tree Protocol (RSTP)

RSTP is a protocol and is a distributed algorithm that is defined in the IEEE 802.1Q-2014 standard. Devices communicate RSTP through packets called Bridge Protocol Data Units (BPDUs) that travel between adjacent RSTP-enabled devices. These frames allow the devices to determine the root bridge in the network, as well as defines the state and role of each port of devices connected in the RSTP network.

Table 7.8 and *Table 7.9* list the various roles and states supported by the SEL-751. Use the **RSTP** command to view the assigned state and role of a port. The relay keeps a log of the states and roles in the Sequential Events Recorder (SER) report.

Table 7.8 RSTP Roles Supported in the SEL-751

Roles	Definition
Root Port	A port with the shortest path[a] to the root bridge. All STP and RSTP capable bridges must have exactly one except the root bridge, which cannot have any.
Designated Port	The port that connects a LAN to its designated bridge.
Alternate Port	Represents the best alternative path to the root bridge. This path is different than using the root port. The alternative port moves to the forwarding state if there is a failure on the designated port for the segment.
Backup Port	Represents a redundant path to a segment where another port on the bridge already connects.
Disabled	The port is disabled during the role initialization or it is disabled due to a link or hardware failure.

[a] This is not always the shortest path. The settings in the network define the path costs, so the root port is the one with the smallest path costs to the root switch. There may be a physically shorter path, but because of the path costs of the other devices, a longer path to the root may be used.

Table 7.9 RSTP States Supported in the SEL-751

States	Definition
Forwarding	A port receiving and transmitting message frames and BPDUs.
Learning	A port receiving and transmitting BPDUs; this port does not receive or transmit message frames.
Discarding	A port receiving BPDUs; this port does not receive or transmit message frames.

NOTE: Exercise caution when disabling RSTP (ERSTP := N) in a relay connected in a switched network because doing so could introduce network loops.

There are three RSTP settings available to set on Port 1 after RSTP is enabled. They include the bridge priority (BRDGPRI), which is used to help determine the root bridge in the network, and the port priorities (PORTAPRI and PORTBPRI) for Ports 1A and 1B, which are used to help determine the root port of the device. See *Table 7.53* for more information regarding these settings.

Example of a Simple Topology

The simplest example of a loop is a network of devices connected in a ring (*Figure 7.16*). Devices connected in a ring topology allow traffic to go from one port on one device to another port on another device in either direction around the ring, as the two green lines show in *Figure 7.16* between Devices 1 and 6.

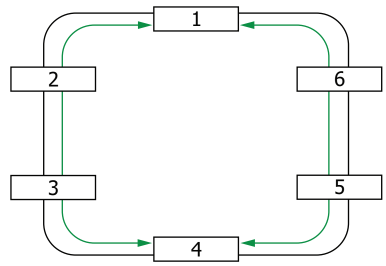


Figure 7.16 Physical Ring Without Loop Mitigation

Disabling the link between Devices 3 and 4 forces traffic to follow a single path across the network (as the green line in *Figure 7.17* shows). The process of disabling links to logically remove loops from the network is called convergence because the devices use RSTP to converge the network into a stable configuration without any loops.

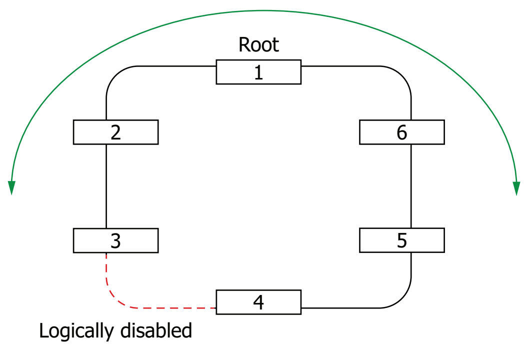


Figure 7.17 Network Convergence With Logically Disabled Link

The logically disabled connections remain physically present and can be quickly enabled by RSTP to provide an alternative path for the network traffic in the event of a physical network failure. For example, if the link between Devices 2 and 3 were to fail, traffic would be disrupted on the network, as indicated by the dashed green line in *Figure 7.18*. Devices 2 and 3 would respond by using RSTP and BPDUs to inform the other devices in the network that an event occurred. The rapid spanning tree algorithm (RSTA) in each network device would then use BPDUs over RSTP to communicate with their respective connected devices, in turn, and eventually the logically disabled link between Devices 3 and 4 would be re-enabled, as shown in *Figure 7.19*.

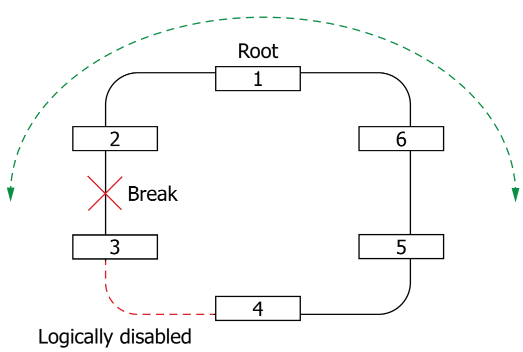


Figure 7.18 Physical Link Failure Between Devices

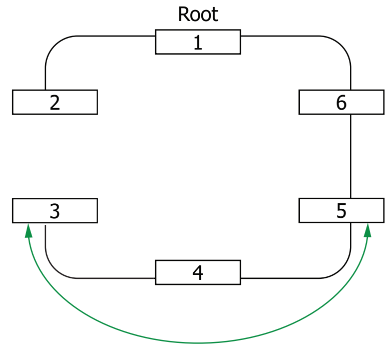


Figure 7.19 Network Convergence

As the green line in *Figure 7.19* shows, traffic can still flow between Devices 3 and 5 but now it is through a different path. The process of re-enabling disabled links to allow traffic to flow and heal the network is called reconvergence. *Figure 7.3* shows a typical network diagram using SEL-751 in a switched network with ERSTP := Y. During this change in the network, traffic is temporarily disrupted. Refer to SEL application guide "Understanding RSTP and Choosing the Best Network Topology" (AG2017-21) at selinc.com for additional information on RSTP.

RSTP Performance Measurement

Figure 7.20 shows a convergence example involving a ring network where both SEL-2730M switches and all seven SEL-700 series relays are configured with default RSTP settings. In this example, there is a transmitting device connected to the North SEL-2730M switch and a receiving device connected to the South SEL-2730M switch.

As a result of the devices being configured with default RSTP settings, the network converges to break the loop at Relay 14. This configuration results in the port for Relay 14 to be in discarding state (indicated by "D"). In this state, traffic flows from the North SEL-2730M switch to the South SEL-2730M switch by passing through Link L1.

For this example, consider a link-down event occurring at Link L1. A link-down event is when the cable that connects two devices is physically broken (indicated by the slash). After this link-down event, the network takes approximately 150 ms to reconverge such that the discarding port on Relay 14 transitions into a forwarding state. This allows traffic to flow from the North SEL-2730M switch to the South SEL-2730M switch by passing through all seven relays.

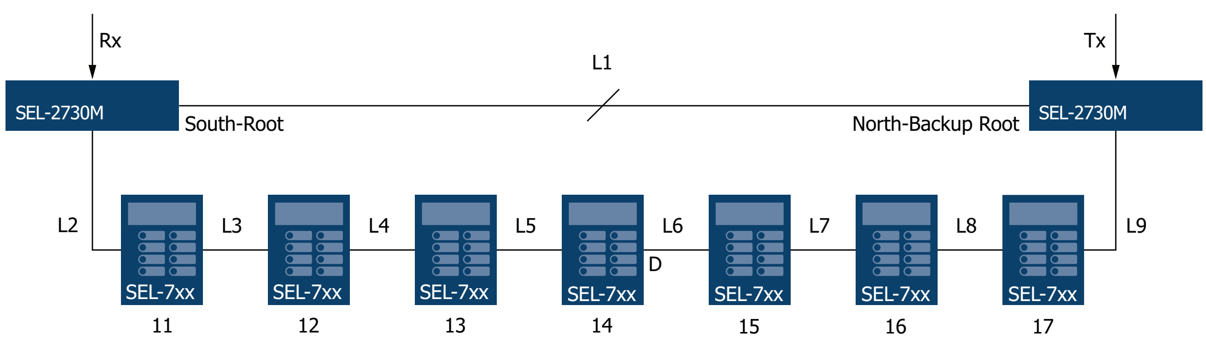


Figure 7.20 Link-Down Event at Link L1

If additional relays are added to this example network, then the reconvergence time will increase by approximately 20 ms per additional relay.

SEL-700 series relays are configured with a Max Age value of 40. This means that a network with SEL-700 series RSTP devices should be created with the understanding that the maximum number of hops from the root in the network should not exceed 40.

To understand the importance of enabling RSTP in an SEL-700 series relay ring network in comparison to leaving it disabled, refer to the SEL application guide “Maintaining Switched-Mode Relay Responsiveness in an RSTP Network” (AG2019-15).

SEL ASCII Protocol and Commands

Message Format

SEL ASCII protocol is designed for manual and automatic communication. All commands the relay receives must be of the following form:

```
<command><CR>  or  <command><CRLF>
```

NOTE: The **<Enter>** key on most keyboards is configured to send the ASCII character 13 (**<Ctrl+M>**) for a carriage return. This manual instructs you to press the **<Enter>** key after commands to send the proper ASCII code to the SEL-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 7.10* lists these messages.

Table 7.10 Serial Port Automatic Messages

Condition	Description
Power Up	The relay sends a message containing the present date and time, relay and terminal identifiers, and the Access Level 0 prompt when the relay is turned on.
Event Trigger	The relay sends an event summary each time an event report is triggered. See *Section 10: Analyzing Events*.
Self-Test Warning or Failure	The SEL-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 7.77*.

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 you with access controls for the corresponding port. Setting EPORT to N disables the port and hides the remaining port settings. The MAXACC setting selects the highest access level for the port.

Access Level 0

Once serial port communication is established with the SEL-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 7.30* 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

Access Level C is for use exclusively by the SEL factory and SEL field service personnel to diagnose troublesome installations. Do not enter Access Level C except as directed by SEL.

The **CAL** command allows the relay to go to Access Level C (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 7.11 lists the header items and their definitions.

Table 7.11 Command Response Header Definitions

Item	Definition
`[RID Setting]`:	This is the RID (Relay Identifier) setting. The relay ships with the default setting `RID = 751`; see *ID Settings on page 4.4*.
`[TID Setting]`:	This is the TID (Terminal Identifier) setting. The relay ships with the default setting `TID = FEEDER RELAY`; see *ID Settings on page 4.4*.
`Date`:	This is the date when the command response was given, except for relay response to the **EVE** command (event), when it is the date the event occurred. You can modify the date display format (Month/Day/Year, Year/Month/Day, or Day/Month/Year) by changing the DATE_F relay setting.
`Time`:	This is the time when the command response was given, except for relay response to the **EVE** command (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 7.12*) 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 7.27* for a discussion of placing the relay in an access level.

Table 7.12 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 7.65*. 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.

89CLOSE Command (Close Disconnect)

The **89C** command (see *Table 7.13*) is used to close a 2-position disconnect, or the respective in-line or earthing disconnect of a 3-position disconnect. The **89C *m*** command asserts Relay Word bit 89CC2P*m* for 1/4 cycle when executed, while the **89C *n m*** command asserts Relay Word bit 89CC3P*nm* for 1/4 cycle when executed. See *Figure 9.2* for how these Relay Word bits are used in the disconnect close control logic.

Table 7.13 89CLOSE Command

Command	Description	Access Level
89CLOSE *m*	Closes Two-Position Disconnect *m*, where *m* = 1 to 8.	2
89CLOSE *n m*	Closes Three-Position Disconnect *m*, where *m* = 1 or 2 and *n* = L or E for in-line or earthing disconnect.	2

To issue the **89C 1** command, enter the following.

```
=>>89C 1 <Enter>
Close 2P1 Y/N ? Y <Enter>
Are you sure (Y/N)? Y <Enter>
Operation In Progress.......
Disconnect Closed

=>>
```

Typing **N <Enter>** after either of the prompts aborts the command.

Following a successful issuance of the command, the relay displays `Operation In Progress`.... While 89IP2P*m*/89IP3P*nm* is asserted and the respective Relay Word bits 89OP2P*m*/89OP3P*nm*, 89CL2P*m*/89CL3P*nm*, and 89AL2P*m*/89AL3P*nm* are deasserted, a dot (.) is appended to the message every half second to show progress. While the operation is in progress, communications are unavailable on the port where the **89C** command was executed. If none of the Relay Word bits assert within 60 seconds, the relay exits the **89C** command. Following the in-progress state, the Relay Word bit that asserts determines the subsequent status message displayed in the terminal (`Disconnect Open` if 89OP2P*m*/89OP3P*nm* is asserted, `Disconnect Closed` if 89CL2P*m*/89CL3P*nm* is asserted, or `Status Undetermined - Check Wiring` if 89AL2P*m*/89AL3P*nm* is asserted). See *Disconnect Control Settings on page 9.2*.

The **89C** command is supervised by the main board breaker control jumper (see *Table 2.20*). If the breaker control jumper is not in place (breaker control jumper = OFF), the relay does not execute the **89C** command and responds with the following:

```
=>>89CLOSE L 1 <Enter>

Command Aborted: No Breaker Jumper

=>>
```

When setting EN_LRC := Y (see *Table 9.6*), the Relay Word bit LOCAL supervises the **89C** command. If the LOCAL bit is asserted (LOCAL = 1), the relay does not execute the **89C** command from the ASCII terminal and responds with the following:

```
=>>89C L 1 <Enter>

Command Aborted: Device in Local Control

=>>
```

The Relay Word bit LOCAL is determined by the LOCAL SELOGIC control equation (see *Table 9.6*).

89OPEN Command (Open Disconnect)

The **89O** command (see *Table 7.14*) is used to open a 2-position disconnect, or the respective in-line or earthing disconnect of a 3-position disconnect. The **89O *m*** command asserts Relay Word bit 89OC2P*m* for 1/4 cycle when executed, while the **89O *n m*** command asserts Relay Word bit 89OC3P*nm* for 1/4 cycle when executed. See *Figure 9.3* for how these Relay Word bits are used in the disconnect open control logic.

Table 7.14 89OPEN Command

Command	Description	Access Level
89OPEN *m*	Opens Two-Position Disconnect *m*, where *m* = 1 to 8.	2
89OPEN *n m*	Opens Three-Position Disconnect *m*, where *m* = 1 or 2 and *n* = L or E for in-line or earthing disconnect.	2

To issue the **89O 1** command, enter the following:

```
=>>89O 1 <Enter>
Open 2P1 Y/N ? Y <Enter>
Are you sure (Y/N)? Y <Enter>
Operation In Progress.......
Disconnect Open

=>>
```

Typing **N <Enter>** after either of the prompts aborts the command.

Following a successful issuance of the command, the relay displays `Operation In Progress`.... While 89IP2P*m*/89IP3P*nm* is asserted and the respective Relay Word bits 89OP2P*m*/89OP3P*nm*, 89CL2P*m*/89CL3P*nm*, and 89AL2P*m*/89AL3P*nm* are deasserted, a dot (.) is appended to the message every half second to show progress. While the operation is in progress, communications are unavailable on the port where the **89O** command was executed. If none of the Relay Word bits assert within 60 seconds, the relay exits the **89O** command. Following the in-progress state, the Relay Word bit that asserts determines the subsequent status message displayed in the terminal (`Disconnect Open` if 89OP2P*m*/89OP3P*nm* is asserted, `Disconnect Closed` if 89CL2P*m*/89CL3P*nm* is asserted, or `Status Undetermined - Check Wiring` if 89AL2P*m*/89AL3P*nm* is asserted). See *Disconnect Control Settings on page 9.2*.

The **89O** command is supervised by the main board breaker control jumper (see *Table 2.20*). If the breaker control jumper is not in place (breaker control jumper = OFF), the relay does not execute the **89O** command and responds with the following:

```
=>>89OPEN L 1 <Enter>

Command Aborted: No Breaker Jumper

=>>
```

When setting EN_LRC := Y (see *Table 9.6*), the Relay Word bit LOCAL supervises the **89O** command. If the LOCAL bit is asserted (LOCAL = 1), the relay does not execute the **89O** command and responds with the following:

```
=>>89O L 1 <Enter>

Command Aborted: Device in Local Control

=>>
```

The Relay Word bit LOCAL is determined by the LOCAL SELOGIC control equation (see *Table 9.6*).

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 7.21* 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 7.21 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 7.15* 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 7.15 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 5.18* 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 7.22 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 7.23 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 7.24 Breaker Reset Response

See *Breaker Monitor on page 5.18* 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 SEL-5601-2 SYNCHROWAVE Event Software take advantage of the Compressed ASCII format. Use the **CHIS** command to display Compressed ASCII event history information. Use the **CSUM** command to display Compressed ASCII event summary information. Use the **CEVENT *n*** (**CEV *n***) command to display Compressed ASCII event reports. Parameter *n* indicates the event number. The events can be accessed by the event record number or by their unique reference number. The most recent event report is record number one (1), the next most recent report is record number two (2), and so on. Reference numbers start at 10000 and increment by 1 with each event. When the event report list is cleared, the reference number resets to 10000. See *Table C.2* for further information. Compressed ASCII Event Reports contain all of the Relay Word bits. The **CEV *n* R** command 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 SYNCHROWAVE Event 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 7.25* shows an example of the **CEV HIF** command response.

```
=>>CEV HIF <Enter>

"FID","0143"
"FID=SEL-751-X512-V2-Z008004-D20201217","08B3"
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","0ACA"
12,24,2020,11,35,52,637,"0492"
"REC_NUM","NUM_CH_A","NUM_CH_D","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","PRIM_VAL","14ED"
3,33,64,0.5000,0.5000,10800,"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 MPH_EVE HIFMODE 3PH_EVE HIFREC SW1A SW1B SW1C HIFER RESRV1 RESRV2 RESRV3
    RESRV4 RESRV5 RESRV6 RESRV7 RESRV8 RESRV9 RESRV10 RESRV11 RESRV12","C2B0"

38.0,40.0,39.0,163.6,160.4,170.0,150.8,150.8,154.0,25.7,26.5,21.7,48.1,48.1,51.3,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,0,0,0,0,
    0, ,"0001C00000000000","1BAD"
38.0,40.0,39.0,154.0,150.8,138.0,150.8,150.8,150.8,25.7,26.5,21.7,51.3,48.1,41.7,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000000","1C1C"
38.0,40.0,39.0,157.2,157.2,144.4,150.8,150.8,150.8,25.7,26.5,21.7,51.3,48.1,48.1,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000000","1C24"
38.0,40.0,39.0,144.4,147.6,147.6,150.8,150.8,150.8,25.7,26.5,21.7,41.7,44.9,38.5,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000000","1C34"
38.0,40.0,39.0,150.8,154.0,160.4,150.8,150.8,150.8,25.7,26.5,21.7,48.1,48.1,48.1,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000000","1C20"
39.0,40.0,39.0,160.4,150.8,150.8,150.8,150.8,150.8,25.7,26.5,21.7,48.1,51.3,44.9,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000000","1C25"
38.0,40.0,39.0,157.2,170.0,157.2,150.8,150.8,150.8,25.7,26.5,21.7,51.3,51.3,51.3,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000000","1C17"
39.0,40.0,39.0,163.6,160.4,157.2,150.8,150.8,154.0,25.7,26.5,21.7,51.3,44.9,54.5,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000000","1C25"
38.0,40.0,39.0,157.2,144.4,150.8,150.8,150.8,150.8,25.7,26.5,21.7,48.1,48.1,44.9,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000100","1C2C"
39.0,40.0,39.0,160.4,150.8,160.4,150.8,150.8,154.0,25.7,26.5,21.7,48.1,44.9,54.5,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000000","1C23"
39.0,40.0,39.0,144.4,147.6,157.2,150.8,150.8,154.0,25.7,26.5,21.7,41.7,41.7,48.1,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000000","1C26"
```

Figure 7.25 CEV HIF Command Response

```
38.0,40.0,39.0,157.2,170.0,150.8,150.8,154.0,154.0,25.7,26.5,21.7,54.5,54.5,48.1,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000000","1C1C"
38.0,40.0,39.0,163.6,150.8,160.4,150.8,154.0,154.0,25.7,26.5,21.7,48.1,48.1,51.3,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000000","1C1A"
39.0,40.0,39.0,154.0,150.8,150.8,150.8,150.8,154.0,25.7,26.5,21.7,51.3,48.1,44.9,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000000","1C20"
38.0,40.0,39.0,160.4,150.8,144.4,154.0,150.8,154.0,25.7,26.5,21.7,48.1,48.1,48.1,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000000","1C1B"
38.0,40.0,39.0,157.2,150.8,147.6,154.0,150.8,150.8,25.7,26.5,21.7,48.1,48.1,44.9,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000000","1C2C"
38.0,40.0,39.0,147.6,150.8,150.8,154.0,150.8,150.8,25.7,26.5,21.7,41.7,41.7,51.3,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000000","1C21"
38.0,40.0,39.0,147.6,150.8,144.4,150.8,150.8,150.8,25.7,26.5,21.7,44.9,48.1,48.1,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000000","1C2E"
38.0,40.0,39.0,150.8,150.8,163.6,150.8,150.8,154.0,25.7,26.5,21.7,48.1,48.1,51.3,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000000","1C21"
38.0,41.0,39.0,150.8,166.8,144.4,150.8,154.0,150.8,25.7,26.5,21.7,48.1,54.5,51.3,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000000","1C27"
39.0,41.0,39.0,157.2,160.4,157.2,150.8,154.0,154.0,25.7,26.5,21.7,48.1,44.9,48.1,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000000","1C24"
38.0,40.0,39.0,150.8,157.2,154.0,150.8,154.0,154.0,25.7,26.5,21.7,48.1,51.3,41.7,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000000","1C17"
38.0,41.0,39.0,150.8,150.8,147.6,150.8,154.0,150.8,25.7,26.5,21.7,48.1,44.9,48.1,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000000","1C2C"
38.0,41.0,39.0,154.0,144.4,160.4,150.8,154.0,154.0,25.7,26.5,21.7,44.9,48.1,51.3,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000000","1C18"
39.0,40.0,39.0,160.4,157.2,150.8,154.0,154.0,154.0,25.7,26.5,21.7,48.1,44.9,44.9,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000000","1C22"
38.0,40.0,38.0,141.2,157.2,157.2,150.8,154.0,154.0,25.7,26.5,21.7,44.9,44.9,48.1,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000000","1C22"
38.0,40.0,39.0,154.0,141.2,150.8,150.8,154.0,154.0,25.7,26.5,21.7,54.5,44.9,48.1,44.9,44.9,44.9,2,2,2,0,0,0,0,0,0,128,0,0,0,
    0,0, ,"0001C00000000000","1C1A"
.
.
.
=>>
```

Figure 7.25 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 4.84* and *Figure 4.103* 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 2.20*) 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 9.6*), 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 9.6*).

COM PTP Command

The **COM PTP** command provides a report of the PTP data sets maintained by the device as well as statistics for the measured time offsets with the parent (master) clock. The PTP data sets contain information about the state, identity, and configuration of the local, parent, and grandmaster clocks in addition to properties of the time being distributed by the grandmaster clock.

Table 7.16 COM PTP Command

Command	Description	Access Level
COM PTP	Displays the PTP data sets and offset statistics for the active PTP slave port or for the last active PTP slave port.	1
COM PTP C or **R**	Clears or resets the PTP offset statistics for all ports.	1

If the EPTP setting is set to No, and the **COM PTP** command (with or without any parameters) is sent to the relay, the relay responds with:

```
=>COM PTP <Enter>

PTP not enabled
```

If a temporary resource shortage exists, a settings change is in progress, or the PTP component is not yet initialized, and the **COM PTP** command is sent to the relay, the relay responds with:

```
=>COM PTP <Enter>

Command is not available
```

If EPTP is enabled and the **COM PTP C** or **R** command is sent to the SEL-751, the SEL-751 responds with:

```
=>COM PTP C <Enter>

Clear PTP offset statistics?
Are you sure? Y N
```

If you select **Y**, the relay responds with `Clearing Complete`. If **N** is selected, the relay responds with `Command Canceled`. If anything else is selected, the relay responds with `Command Canceled`.

If a **COM PTP C** or **R** is sent to the SEL-751 and the PTP component is enabled but not yet initialized, the SEL-751 responds with:

```
=>COM PTP R <Enter>

Command is not available
```

The SEL-751 Relay saves the date and time when the PTP offset statistics are cleared. The format of the offset clearing date matches the DATE_F Global setting. The statistic clearing date and time is the time of the last user reset via an ASCII command, the last Port 1 settings change, or the last power up. The time stamp of the most recent event is displayed.

An example response to the **COM PTP** command when PTP is available is shown in *Figure 7.26*.

```
=>>COM PTP <Enter>

SEL-751                                 Date: 05/13/2019   Time: 10:01:41.976
FEEDER RELAY                             Time Source: External


PTP offset statistics previously cleared on 05/09/2019 09:32:18 (UTC)


Settings Data Set
  PTP Profile : Default
  Transport Mechanism : UDP
  Path Delay : P2P



Default Data Set
  Two Step : true
  Clock Identity : 00 30 A7 FF FE 12 32 22
  Number of Ports : 1
  Clock Quality
    Clock Class : 255
    Clock Accuracy : 254
    Offset Log Variance : 0
  Priority1 : 255
  Priority2 : 255
  Domain Number : 0
  Slave Only : true



Current Data Set
  Steps Removed : 1


Parent Data Set
  Parent Port Identity
  Clock Identity : 00 30 A7 FF FE 0B 29 91
    Port Number : 1
  Grandmaster Clock Identity : 00 30 A7 FF FE 0B 29 91
  Grandmaster Clock Quality
    Clock Class : Synchronized with PTP timescale 6
    Clock Accuracy : Within 100 ns
    Offset Log Variance : 18887
  Grandmaster Priority1 : 128
  Grandmaster Priority2 : 128
```

Figure 7.26 COM PTP Command Response When PTP is Available

```
Time Properties Data Set
  Current UTC Offset : 37
  Current UTC Offset Valid : true
  Leap59 : false
  Leap61 : false
  Time Traceable : true
  Frequency Traceable : true
  PTP Timescale : true
  Time Source : GPS
  Local Time Offset
    Offset Valid : true
    Name : UTC-07:00
    Current Offset : -25237 s
    Jump Seconds : -3600 s
    Time of Next Jump : 1572771637 s


Port Data Set
  Port Identity
    Clock Identity : 00 30 A7 FF FE 12 32 22
    Port Number : 1
  Port State : SLAVE
  Log Pdelay Request Interval : 0
  Peer Mean Path Delay : 0 ns
  Announce Receipt Timeout : 4 intervals
  Path Delay Mechanism : P2P
  Failed to Receive Response : true
  Received Multiple Pdelay Responses : false
  Reason for Non-synchronization :
  Port status : A, ACTIVE

=>>
```

Figure 7.26 COM PTP Command Response When PTP is Available (Continued)

A description of each PTP data set displayed in *Figure 7.27* is provided in *Table 7.17*.

Table 7.17 PTP Data Set Descriptions (Sheet 1 of 5)

Type of Data Set	Information Field	Description
Settings	PTP Profile	This value is the same as PTPPRO.
	Transport Mechanism	This value is the same as PTPTR.
	Path Delay	This value is the same as PTHDLY.
Default	Two Step	For the default data, this is set to TRUE. A two-step clock provides time information using the combination of an event message and a subsequent general message. A one-step clock provides times information using a single event message.
	Clock Identity	This is an 8-octet number that uniquely identifies the clock on the network. It is derived from the Ethernet MAC address.
	Number of Ports	This is the number of Ethernet ports used to communicate PTP messages. It is always 1 for SEL-751 Relays.
	Clock Quality	This contains information about clock class, accuracy, and variance for the SEL-751 Relay.
	Priority1	This is the first priority for the SEL-751 Relay used in the default BMCA. It is always set to 255.
	Priority2	This is the second priority for the SEL-751 Relay used in the default BMCA. It is always set to 255.
	Domain Number	This value is the same as DOMNUM. It is the PTP domain number that the clock is part of.
	Slave Only	This is always TRUE for SEL-751 Relays.
Current	Steps Removed	This is the number of communications paths between the SEL-751 Relay and the grandmaster clock. A communication path is the link between a master and a slave port. Hence, links to transparent clocks do not count as separate paths. The values range from 1–65535.

Table 7.17 PTP Data Set Descriptions (Sheet 2 of 5)

Type of Data Set	Information Field	Description
Parent	Parent Port Identity	This contains the clock identity and port number of the adjacent clock to which the SEL-751 clock is synchronized. The port number identifies the specific port on the adjacent clock from which the SEL-751 clock is receiving PTP messages.
	Grandmaster Clock Identity	This is the clock identity of the grandmaster clock that the SEL-751 is synchronized to.
	Grandmaster Clock Quality	This contains the class, accuracy, and variance of the grandmaster clock.
	Grandmaster Clock Class	This field displays an ASCII message based on the received clock class code described as follows:

Code (decimal)	Message
68–122, 133–170, 216–232	Profile specific value
6	Synchronized with PTP timescale
7	Holdover with PTP timescale
13	Synchronized with ARB timescale
14	Holdover with ARB timescale
52	Holdover degrade A with PTP timescale
58	Holdover degrade A with ARB timescale
187	Holdover degrade B with PTP timescale
193	Holdover degrade B with ARB timescale
248	Default
255	Slave only
All other codes	Reserved with decimal code value (xxx)

Table 7.17 PTP Data Set Descriptions (Sheet 3 of 5)

<table>
<tr><th>Type of Data Set</th><th>Information Field</th><th>Description</th></tr>
<tr><td></td><td>Grandmaster Clock Accuracy</td><td>This field displays an ASCII message based on the received clock accuracy enumeration value described as follows:
<table>
<tr><th>Value (Hex)</th><th>Message</th></tr>
<tr><td>20</td><td>Within 25 ns</td></tr>
<tr><td>21</td><td>Within 100 ns</td></tr>
<tr><td>22</td><td>Within 250 ns</td></tr>
<tr><td>23</td><td>Within 1 μs</td></tr>
<tr><td>24</td><td>Within 2.5 μs</td></tr>
<tr><td>25</td><td>Within 10 μs</td></tr>
<tr><td>26</td><td>Within 25 μs</td></tr>
<tr><td>27</td><td>Within 100 μs</td></tr>
<tr><td>28</td><td>Within 250 μs</td></tr>
<tr><td>29</td><td>Within 1 ms</td></tr>
<tr><td>2A</td><td>Within 2.5 ms</td></tr>
<tr><td>2B</td><td>Within 10 ms</td></tr>
<tr><td>2C</td><td>Within 25 ms</td></tr>
<tr><td>2D</td><td>Within 100 ms</td></tr>
<tr><td>2E</td><td>Within 250 ms</td></tr>
<tr><td>2F</td><td>Within 1 s</td></tr>
<tr><td>30</td><td>Within 10 s</td></tr>
<tr><td>31</td><td>Greater than 10 s</td></tr>
<tr><td>80–FD</td><td>Profile specific value (0xyy)</td></tr>
<tr><td>FE</td><td>Unknown</td></tr>
<tr><td>All other codes</td><td>Reserved (0xyy)</td></tr>
</table></td></tr>
<tr><td></td><td>Grandmaster Priority1</td><td>This is the priority1 value set in the grandmaster clock. If the setting ALTPRIn > 0, its value is used as the reported priority1 value for Grandmaster n. The expected value is between 0 to 255.</td></tr>
<tr><td></td><td>Grandmaster Priority2</td><td>This is the priority2 value set in the grandmaster clock. The expected value is between 0–255.</td></tr>
<tr><td></td><td>C37.238 TLV Information</td><td>This is the C37.238 TLV information received. It is valid only in the Power profile. In the case of the Default profile, this section is hidden.</td></tr>
<tr><td>Time Properties</td><td>Current UTC Offset</td><td>This is the current number of leap seconds between TAI and UTC.</td></tr>
<tr><td></td><td>Current UTC Offset Valid</td><td>This attribute is TRUE if the current UTC Offset is valid and should be used. Otherwise, it is FALSE.</td></tr>
<tr><td></td><td>Leap59</td><td>This is set to TRUE if there is an impending leap second removal, i.e., the last minute of the current day contains 59 seconds.</td></tr>
<tr><td></td><td>Leap61</td><td>This is set to TRUE if there is an impending leap second insertion, i.e., the last minute of the current day contains 61 seconds.</td></tr>
<tr><td></td><td>Time Traceable</td><td>This indicates if the time being served is traceable to UTC reference time.</td></tr>
<tr><td></td><td>Frequency Traceable</td><td>This indicates if the frequency being distributed is traceable to a primary source.</td></tr>
</table>

Table 7.17 PTP Data Set Descriptions (Sheet 4 of 5)

Type of Data Set	Information Field	Description
	PTP Timescale	This is TRUE if the time being served uses the PTP/UTC timescale. Otherwise, it is FALSE.
	Time Source	This shows the source of the time being distributed based on the value of the timeSource enumeration as show in the following table.
	Local Time Offset	This is the offset of local time from UTC and information about impending change in the offset.
Port	Port Identity	This contains the clock ID and port number of the SEL-751 Relay on the PTP network.
	Port State	This is the synchronization state of the SEL-751 Relay: LISTENING, SLAVE, UNCALIBRATED, or FAULTY. The relay is synchronized if the state is SLAVE.
	Log Delay Request Interval	If the end-to-end delay mechanism is enabled, then this is the logarithm to base 2 of the delay request intervals (in seconds) received from the master clock. If the peer-to-peer (P2P) delay mechanism is enabled, these data are hidden. Also, these data are hidden when the delay mechanism is set to OFF.
	Log Pdelay Request Interval	If the peer-to-peer (P2P) delay mechanism is enabled, this is the logarithm to base 2 of the configured peer delay request intervals (PDINT). If the end-to-end delay mechanism is enabled, these data are hidden. Also, these data are hidden when the delay mechanism is set to OFF.
	Peer Mean Path Delay	If the peer-to-peer (P2P) delay mechanism is enabled, this is the measured mean peer delay on the SEL-751 Relay. If the peer-to-peer (P2P) delay mechanism is not selected (PTHDLY ≠ P2P), these data are hidden.
	Announcement Receipt Timeout	This value is always 4 announce intervals.
	Path Delay Mechanism	This is the same value as PTHDLY.
	Failed to Receive Response	The value is TRUE if no response is received after 5 consecutive Delay or Pdelay Requests from the port. Otherwise, the value is FALSE. These data are hidden if PTHDLY = OFF.
	Received Multiple Pdelay Responses	This is set to TRUE if a response is received from more than one clock to a Pdelay request from the SEL-751. The port state will transition to FAULTY when this happens. The value is reset to FALSE when only one clock responds to Pdelay requests from the SEL-751. These data are hidden if PTHDLY ≠ P2P.

Time Source codes (nested table):

Code (decimal)	Message
10	ATOMIC_CLOCK
20	GPS
30	TERRESTRIAL_RADIO
40	PTP
50	NTP
60	HAND_SET
90	OTHER
A0	INTERNAL_OSCILLATOR
F0–FE	PROFILE SPECIFIC VALUE (0xyy)
All other codes	RESERVED (0xyy)

Table 7.17 PTP Data Set Descriptions (Sheet 5 of 5)

<table>
<tr><th>Type of Data Set</th><th>Information Field</th><th>Description</th></tr>
<tr><td></td><td>Reason for Nonsynchronization</td><td>If the SEL-751 Relay is failing to synchronize, this will provide one of the following reasons for the failure: incorrect domain number, clock not in the acceptable master table, or missing TLV in Announce messages. Otherwise, the string is empty.
<table>
<tr><th>#</th><th>Reason for Nonsynchronization Display Strings</th></tr>
<tr><td>1</td><td>Received Announce message for a different domain: <domain number></td></tr>
<tr><td>2</td><td>Received Announce message from an unacceptable master: <MAC or IP address></td></tr>
<tr><td>3</td><td>Required TLV is missing or incorrectly formatted by clock <clock id></td></tr>
</table></td></tr>
<tr><td></td><td>Port Status</td><td>This displays the Port 1A and 1B time synchronization status. If the port is not synchronized to a PTP master, NA is displayed. If a port is in the SLAVE state and it is chosen as a master, ACTIVE is displayed.
Additional port status indications are available via Relay Word bits PTPA, PTPB, PASEL, and PBSEL. When Ethernet Port 1A is active, PASEL asserts. Similarly, when Ethernet Port 1B is active, PBSEL asserts. If the operating mode of Port 1 of the relay is PRP, then PTPA asserts if PTP is enabled and the relay is receiving PTP messages on Port 1A. Similarly, in PRP mode, PTPB asserts if PTP is enabled and the relay is receiving PTP messages on Port 1B.</td></tr>
</table>

COMMUNICATIONS Command

The **COM *x*** command (see *Table 7.18*) displays communications statistics for the Mirrored Bits communications channels. For more information on Mirrored Bits communications, see *Appendix J: Mirrored Bits Communications*. The summary report includes information on the 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 7.18 COM Command (Sheet 1 of 2)

Command	Description	Access Level
COM S A or **COM S B**	Returns a summary report of the last 255 records in the communications buffer for either Mirrored Bits communications Channel A or Channel B when only one channel is enabled.	1
COM A	Returns a summary report of the last 255 records in the communications buffer for Mirrored Bits communications Channel A.	1
COM B	Returns a summary report of the last 255 records in the communications buffer for Mirrored Bits communications Channel B.	1

Table 7.18 COM Command (Sheet 2 of 2)

Command	Description	Access Level
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 7.19*) to control remote bits (Relay Word bits RB01–RB64). 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 7.19*.

Table 7.19 CONTROL Command

Command	Description	Access Level
CON RB*nn k*	Sets a remote bit to set, clear, or pulse.	2
Subcommand		
S	Set remote bit (ON position)	2
C	Clear remote bit (OFF position)	2
P	Pulse remote bit for 1/4 cycle (MOMENTARY position)	2
Parameters		
nn	A number from 01 to 64, representing RB01 through RB64	
k	S, C, or P	

For example, use the following command to set Remote Bit RB05:

```
=>>CON RB05 S <Enter>
```

COPY Command

Use the **COPY *j k*** command (see *Table 7.20*) to copy the settings of 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 4.

Table 7.20 COPY Command

Command	Description	Access Level
COPY *j k*	Copies settings in Group *j* to settings in Group *k*.	2
Parameters		
j	1, 2, 3, or 4.	
k	1, 2, 3, or 4.	

For example, when you enter the **COPY 1 3** command, the relay responds, `Are you sure (Y/N)?` Answer **Y <Enter>** (for yes) to complete copying. The settings in Group 1 overwrite the settings in Group 3.

COUNTER Command (Counter Values)

The device generates the values of the 64 counters in response to the **COU** command (see *Table 7.21*).

Table 7.21 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 7.22*) 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 7.22 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 7.27* 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 7.27 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 7.28 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
```

Figure 7.29 Ethernet Port (PORT 1) Status Report When NETMODE := FAILOVER, E61850 := Y, and EGSE := Y

```
         PACKETS                BYTES              ERRORS
      SENT     RCVD         SENT       RCVD      SENT    RCVD
        36       72         2660       5081         0       0

=>>
```

Figure 7.29 Ethernet Port (PORT 1) Status Report When NETMODE := FAILOVER, E61850 := Y, and EGSE := Y (Continued)

```
=>>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 7.30 Ethernet Port (PORT 1) Status Report When NETMODE := SWITCHED

The command response for the single Ethernet port option is as shown in *Figure 7.31*.

```
=>>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 7.31 Ethernet Port (PORT 1) Status Report for the Single Ethernet Port Option

EVENT Command (Event Reports)

Use the **EVE** command (see *Table 7.23*) to view event reports. See *Section 10: Analyzing Events* for further details on retrieving and analyzing event reports. See the *HISTORY Command on page 7.58* for details on clearing event reports.

Table 7.23 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) 32 samples/cycle analog data and 4 samples/cycle digital data.	1
Parameter		
n	Indicates a record or event reference number. The most recent event has a record number of 1 and increments by 1 with each event, whereas the event reference number is a unique number that starts at 10000 and increments by 1 with each event (see *Event Reference Number on page 10.4* for details). If *n* is not specified, the relay displays the latest event report by default.	

FILE Command

The **FIL** command (see *Table 7.24*) 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 7.24 FILE Command

Command	Description	Access Level
FIL DIR	Returns a list of files.	1
FIL READ *filename*	Transfers settings file *filename* from the relay to the PC.	1
FIL WRITE *filename*	Transfers settings file *filename* from the PC to the relay.	2
FIL SHOW *filename*	Displays contents of the file *filename*.	1

FGS (Fixed GOOSE) Command

Use the **FGS** command to display transmit and receive Fixed GOOSE messaging and statistics information, which you can use for troubleshooting. The **FGS** command variants and options are shown in *Table 7.25*.

Table 7.25 FGS Command Varients (Sheet 1 of 2)

Command Variant	Description	Access Level
FGS	Displays Fixed GOOSE information.	1
FGS *k*	Displays Fixed GOOSE information *k* times.	1
FGS S	Displays a list of Fixed GOOSE subscriptions with their ID.	1
FGS S *n*	Displays a list of Fixed GOOSE statistics for subscription ID *n*.	1
FGS S ALL	Displays Fixed GOOSE statistics for all subscriptions.	1

Table 7.25 FGS Command Varients (Sheet 2 of 2)

Command Variant	Description	Access Level
FGS S *n* L	Displays Fixed GOOSE statistics for subscription ID *n* including error history.	1
FGS S ALL L	Displays Fixed GOOSE statistics for all subscriptions including error history.	1
FGS S *n* C	Clears Fixed GOOSE statistics for subscription ID *n*.	1
FGS S ALL C	Clears Fixed GOOSE statistics for all subscriptions.	1

The information displayed for Fixed GOOSE is described in *Table 7.26*.

Table 7.26 Fixed GOOSE Description

Information Field	Description
`MultiCastAddr` (Multicast Address)	This hexadecimal field represents the GOOSE multicast address.
`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.
`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 MSG CORRUPTED — Message corrupted TTL EXPIRED — Time to live expired HOST DISABLED — Optional code for when the host is disabled or becomes unresponsive after the **TEST FGS** command has been issued
`SubsID`	This is the identifier for the subscription.
`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 data set.

Table 7.26 Fixed GOOSE Description

Information Field	Description
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.

Figure 7.32 shows an example response to the **FGS** command.

```
=>FGS <Enter>
Fixed GOOSE Transmit Status
 MultiCastAddr   StNum      SqNum      TTL    Code
-----------------------------------------------------------------------------
 01-0C-CD-FF-00-01 2          55         957


Fixed GOOSE Receive Status
 MultiCastAddr   StNum      SqNum      TTL    Code
-----------------------------------------------------------------------------
 01-0C-CD-FF-00-02  2          9          2000
 01-0C-CD-FF-00-03  0          0          0
 01-0C-CD-FF-00-04  0          0          0
 01-0C-CD-FF-00-05  0          0          0

=>FGS S 1 L <Enter>
 SubsID 001   01-0C-CD-FF-00-02
-----------------------------------------------------------------------------
From: 11/28/2023 11:10:19.623
To: 11/28/2023 11:14:21.130
 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 7.32 FGS Command Response

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 7.27*.

Table 7.27 GOOSE Command Variants (Sheet 1 of 2)

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

Table 7.27 GOOSE Command Variants (Sheet 2 of 2)

Command Variant	Description	Access Level
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.

Table 7.28 GOOSE IED Description (Sheet 1 of 2)

Information Field	Description
`Transmit GOOSE Control Reference`	This field represents the GOOSE control reference information that includes the IED name, ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and GSEControl name (GSE Control Block Name) (e.g., SEL_351S_1CFG/LLN0GOGooseDSet13).
`Receive GOOSE Control Reference`	This field represents the goCbRef (GOOSE Control Block Reference) information that includes the iedName (IED name), ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and cbName (GSE Control Block Name) (e.g., SEL_351S_1CFG/LLN0GOGooseDSet13).
`MultiCastAddr` (Multicast Address)	This hexadecimal field represents the GOOSE multicast address.
`Ptag`	This three-bit decimal field represents the priority tag value, where spaces are used if the priority tag is unknown.
`Vlan`	This 12-bit decimal field represents the virtual LAN (Local Area Network) value, where spaces are used if the virtual LAN is unknown.
`StNum` (State Number)	This hexadecimal field represents the state number that increments with each state change.
`SqNum` (Sequence Number)	This hexadecimal field represents the sequence number that increments with each retransmitted GOOSE message sent.
`TTL` (Time to Live)	This field contains the time (in ms) before the next message is expected.
`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 GSECon-trol 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.

Table 7.28 GOOSE IED Description (Sheet 2 of 2)

Information Field	Description
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 data set.
Number of messages lost due to receive overflow	This represents the total number of messages that were not processed because memory resources were exhausted. This includes cases where more than one instance of a message is received within a single relay processing interval. In this case, the most recent message is processed and the others are discarded.
Calculated max. sequential messages lost due to OOS	This represents the maximum estimated number of messages that were missed after receiving a message with a higher state or sequence number than expected.
Calculated number of messages lost due to OOS	This represents the total of all estimated number of messages lost due to state or sequence number skip in received messages.

Table 7.29 Warning and Error Codes for GOOSE Subscriptions

Code	Enumeration[a]	Definition	Error/Warning
–	0	No errors present.	–
HOST DISABLED	1	Optional code for when the subscribing device is disabled or becomes unresponsive after the **GOOSE** command has been issued.	Error
CONF REV MISMA	2	Configuration revision mismatch. Displayed when the value of the configuration revision number in the received GOOSE message does not match with the value of the configuration revision number present in the CID file.	Error
NEED COMMISSIO	3	Needs commissioning. Displayed when the received GOOSE message has NdsCom = true.	Error
MSG CORRUPTED	4	Message corrupted. Displayed when a received GOOSE message does not meet the proper format or is corrupted.	Error
TTL EXPIRED	5	Time-to-live expired.	Error
OUT OF SEQUENC	6	Out-of-sequence (OOS) error. This error is present when the StNum or SqNum value between received GOOSE messages is not sequential.	Warning
INVALID QUAL	7	Invalid date quality received.	Warning

[a] Enumerations are used to communicate GOOSE error codes in the LGOS logical node.

Figure 7.33 shows an example response to the **GOOSE** command.

```
=>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 7.33 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 7.33 GOOSE Command Response (Continued)

GROUP Command

Use the **GROUP** command (see *Table 7.30*) to display the active settings group or try to force an active settings group change.

Table 7.30 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 7.31*) gives a list of commands available at the present access level. You can also get a description of any particular command; type **HELP** followed by the name of the command for help on each command.

Table 7.31 HELP Command

Command	Description	Access Level
HELP	Displays a list of each command available at the present access level with a one-line description.	1
HELP *command*	Displays information on the command *command*.	1

HISTORY Command

Use the **HIS** command (see *Table 7.32*) to view a list of one-line descriptions of relay events or clear the list (and corresponding event reports) from nonvolatile memory. For more information on event reports, see *Section 10: Analyzing Events*.

Table 7.32 HISTORY Command

Command	Description	Access Level
HIS	Returns event histories with the oldest at the bottom of the list and the most recent at the top of the list.	1
HIS [50INC] ***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 [50INC] C or **R**	Clears/resets the event history and all corresponding event reports from nonvolatile memory.	1
HIS CA or **RA**	Clears/resets the event history and all corresponding event reports from nonvolatile memory and resets the unique reference number to 10000.	1
Parameter		
50INC	Returns event history for the incipient cable fault detection element. If 50INC is not specified, the relay displays histories for the standard event report.	

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 10.34* 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 7.33 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 and the unique reference number.	1
HIS HIF CA or **RA**	Clears/resets the HIF event history and all the corresponding event reports from the nonvolatile memory and resets the unique reference number to 10000.	1
Parameter		
n	Indicates a record number. The most recent event has record number one (1).	

HSG Command

When the SEL-751 is ordered with the Arc Sense technology (AST) option for the HIF detection, the relay provides HIF 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 7.34 HSG Command

Command	Description	Access Level
HSG	Displays 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 7.34 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 7.34 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.

ID Command

Use the **ID** command (see *Table 7.35*) to extract device identification codes, as shown in *Figure 7.35*. You can use the information in the SPECIAL field in the **ID** command response to determine the hardware and firmware compatibility of the relay. Contact SEL technical support before you downgrade the relay firmware.

Table 7.35 ID Command

Command	Description	Access Level
ID	Returns a list of device identification codes.	0

```
=ID <Enter>

"FID=SEL-751-R301-V2-Z009005-D20220607","08AF"
"BFID=SLBT7XX-R601-V0-Z000000-D20211116","094D"
"CID=E754","0262"
"DEVID=SEL-751","03C7"
"DEVCODE=77","0315"
"PARTNO=751301ABA1X7085B361","06AF"
"CONFIG=111112010","041B"
"SPECIAL=00","030E"
"SEL DISPLAY PACKAGE=3.0.50751.3012","0888"
"CUSTOMER DISPLAY PACKAGE=3.709393047","099C"
```

Figure 7.35 ID Command Response

INI HIF Command

The **INI HIF** command (see *Table 7.36*) is used to restart the 24 -hour tuning process used in HIF 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 7.36 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 7.37*).

Table 7.37 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.

L_D Command (Load Firmware)

Use the **L_D** command (see *Table 7.38*) 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 7.38 L_D Command (Load Firmware)

Command	Description	Access Level
L_D	Loads new firmware.	2

LDP Command (Load Profile Report)

Use the **LDP** commands (see *Table 7.39*) 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 7.39 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.	

LOG HIF (High-Impedance Fault) Command

When the SEL-751 is ordered with the Arc Sense technology (AST) option for the HIF detection, the relay provides HIF 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 7.40 LOG HIF Command

Command	Description	Access Level
LOG HIF *nnn*	Displays the progress of 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 7.36 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 7.36 LOG H (HIF) Command Response

LOOPBACK Command

Use the **LOO** command (see *Table 7.41*) for testing the MIRRORED BITS communications channel for proper communication. For more information on MIRRORED BITS, see *Appendix J: MIRRORED BITS Communications*.

Table 7.41 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 firmware versions R112-V0 to R301-V2 support two MAC addresses (IP and GOOSE).

Use the **MAC** command to display the MAC address of **PORT 1**, as shown in the following.

```
=>>MAC <Enter>

Port 1 (IP) MAC Address:      00-30-A7-67-32-10

=>>
```

METER Command (Metering Data)

The **MET** command (see *Table 7.42* and *Table 7.43*) provides access to the relay metering data.

Table 7.42 MET 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 7.43 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	HIF Metering

[a] Reset command available.

For more information on metering and example responses for each meter class, see *Section 5: Metering and Monitoring*.

On issuing the **MET *c* R** command for resetting metering quantities in class *c*, the relay responds: `Reset Metering Quantities (Y,N)?` Upon confirming (pressing **Y**), the metering quantities are reset and the relay responds with `Reset Complete`.

OPEN 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 4.63* and *Figure 4.40* 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 2.20*) 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 9.6*). 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 9.6*).

PASSWORD Command (Change Passwords)

Use the **PAS** command (see *Table 7.44*) to change existing passwords.

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.

Table 7.44 PASSWORD Command

Command	Description	Access Level
PAS *level*	Changes password for Access Level *level*.	2, C
Parameter		
level	Represents the relay Access Level 1, 2, or C.	

The factory-default passwords are as shown in *Table 7.45*.

Table 7.45 Factory-Default Passwords for Access Levels 1, 2, and C

Access Level	Factory-Default Password
1	OTTER
2	TAIL
C	CLARKE

To change the password for Access Level 1 to #Ot3579!ijd7, enter the following command sequence:

```
=>>PAS 1 <Enter>
New PW: ? *********** <Enter>
Confirm PW: ? *********** <Enter>
Password Changed
=>>
```

Similarly, use **PAS 2** to change Level 2 passwords and **PAS C** to change Level C passwords.

Table 7.46 Valid Password Characters

<table>
<tr><td>Alpha</td><td>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</td></tr>
<tr><td>Numeric</td><td>0 1 2 3 4 5 6 7 8 9</td></tr>
<tr><td>Special</td><td>! " # $ % & ' ( ) * + , - . / : ; < = > ? @ [\ ] ^ _ ` { | } ~</td></tr>
</table>

Passwords can contain as many as 12 characters. Upper- and lowercase letters are treated as different characters. Strong passwords consist of 12 characters, with at least one special character or digit and mixed-case sensitivity, but do not form a name, date, acronym, or word. Passwords formed in this manner are less susceptible to password guessing and automated attacks.

Examples of valid, distinct, and strong passwords are as follows:

- #0t3579!ijd7
- (Ih2dcs)36dn
- $A24.68&,mvj
- *4u-Iwg+?lf-

PING Command

When you are setting up or testing substation networks, it is helpful to determine if the network is connected properly and if the other devices are powered up and configured properly. The **PING** command (Access Level 1) allows 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 and configured correctly. A typical **PING** command response is shown in *Figure 7.37*.

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 7.37 PING Command Response

PRP Command

Use the **PRP** command (see *Table 7.47*) to display the PRP node table and statistics when PRP is enabled. The PRP node table gives information about what the relay has observed from other devices on the network, and the statistics table gives overall statistics about what the relay has sent and received from the network.

NOTE: This command is only available in firmware versions R401-V0 and higher.

Table 7.47 PRP Command

Command	Description	Access Level
PRP	Displays the PRP node table and statistics.	1

Table 7.48 describes the node table information displayed in the output of the **PRP** command. *Table 7.49* describes the statistics information displayed in the output of the **PRP** command.

Table 7.48 PRP Command Node Table Definitions

Information Field	Description
MAC ADDRESS	Displays as many as 128 connected device MAC addresses that are connected to the relay[a]
TYPE	Reveals the device type based on received PRP supervison frames It will display one of the following types for each displayed MAC address SAN A: If the single-access node (non-PRP) supported device is connected to Port 1A SAN B: If the single-access node (non-PRP) supported device is connected to Port 1B SAN A B: If the relay has received frames on both Port 1A and 1B and has not received a PRP supervision frame, then it is viewed as a single access node on both ports DANP: Dual access node if the relay has received PRP supervision frames from the device
TIME LAST SEEN SUPERVISION FRAME (TlsSup)	Displays the time in seconds since the last PRP supervision frame was received from the device
PORT	Describes which port the following statistics are describing
RECEIVE SUPERVISION FRAME (RxSup)	Displays the total number of received PRP supervision frames from the device
RECEIVE	Displays total received frames on respective ports of the relay
TIME LAST SEEN NON-SUPERVISION FRAME (TlsRx)	Displays the time in seconds since the last non-PRP supervision frame was seen

[a] Device times out and is removed from the node table after 60 seconds.

Table 7.49 PRP Command Statistics Definitions

Information Field	Description
LINK REDUDANCY ENTITY (LRE)	Displays the statistics label for Port A, Port B, and the host; the host label displays the combined statistics of Ports A and B
PORT 1A TRANSMIT	Total PRP frames sent from Port 1A
PORT 1B TRANSMIT	Total PRP frames sent from Port 1B
HOST TRANSMIT	Total frames sent out from either port excluding PRP supervision frames
PORT 1A RECEIVE	Total PRP frames received on Port 1A
PORT 1B RECEIVE	Total PRP frames received on Port 1B
HOST RECEIVE	Total PRP frames received to the host excluding duplicate rejections
PORT 1A WRONG LAN	Total LAN B PRP frames received on Port 1A[a]
PORT 1B WRONG LAN	Total LAN A PRP frames received on Port 1B[a]
HOST WRONG LAN	Always zero
PORT 1A ERRORS	Number of errors detected on Port 1A
PORT 1B ERRORS	Number of errors detected on Port 1B
HOST ERRORS	Always zero
PORT 1A/1B UNIQUE	Always zero
HOST UNIQUE	Number of frames detected for which no duplicate frames were detected before the time-out period
PORT 1A/1B DUPLICATE	Always zero
HOST DUPLICATE	Number of frames detected for which exactly one duplicate was detected before the time-out period[b]
PORT 1A/1B MULTIPLE	Always zero
HOST MULTIPLE	Number of frames detected for which more than one duplicate was detected before the timeout period[b]
PORT 1A OWN RECEIVE	Number of frames received on Port 1A that contain the MAC address of the relay as the source address
PORT 1B OWN RECEIVE	Number of frames received on Port 1B that contain the MAC address of the relay as the source address

[a] Wrong LAN duplicate frames are considered non-PRP frames, but the relay does not discard them. If WRONGLAN is incrementing, it indicates at least one of the devices on the network is on the wrong LAN, and the frames from that device are not being properly discarded as duplicate frames.
[b] All duplicate and multiple PRP frames are discarded.

Table 7.38 shows an example response to the **PRP** command.

```
=>PRP <Enter>

SEL-751                                         Date: 12/08/2023   Time: 10:00:50.020
FEEDER RELAY                                    Time Source: Internal


Node Table

        MacAddress     Type  TlsSup[s]   Port     RxSup        Rx  TlsRx[s]
-----------------  -------  ---------   -----  --------  --------  --------
00-30-a7-11-11-50   DANP       0.26      A           22     48504    327.75
                                         B          143     47339    655.03
ac-1a-3d-94-af-bb   SAN A      0.00      A            0      4310      0.00
                                         B            0         0    655.03
Statistics

LRE            Tx        Rx WrongLan   Errors   Unique  Duplic.    Multi    OwnRx
-------- -------- -------- -------- -------- -------- -------- -------- --------
A           50860    48705        0        0        0        0        0        0
B           50860    47536        0        0        0        0        0        0
HOST          413   103158        0        0       45      330        0
```

Figure 7.38 PRP 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 7.50*) 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), 301–308 (optional), 401–408 (optional), or 501–508 (optional). For example, OUTPUT301 refer to Output 01 in Slot C.

Table 7.50 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 7.51*) to revert to Access Level 0.

Table 7.51 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).

RSTP Command

Use the **RSTP** command (see *Table 7.52*) to display the RSTP statistics and the present RSTP configuration when RSTP is enabled.

Table 7.52 RSTP Command

Command	Description	Access Level
RSTP	Displays the RSTP statistics and the present RSTP configuration.	1

Table 7.53 describes the information displayed in the output of the **RSTP** command.

Table 7.53 RSTP Command Definitions (Sheet 1 of 2)

Information Field	Description
ROOT BRIDGE	Reveals the role of the relay in the RSTP configuration. It will either display YES or NO.
BRIDGE ID	Displays the Bridge ID of the relay, which consists of the bridge priority (in decimal format) and the MAC address of the relay.
ROOT BRIDGE ID	Displays the Bridge ID of the root bridge, which consists of the bridge priority (in decimal format) and the MAC address of the root bridge.
ROOT PORT	Displays the port number (i.e., Port 1A or Port 1B) that is forwarding towards the root bridge when the relay is a designated bridge. If the relay is the root bridge, this displays NA.
TIME SINCE TOPOLOGY CHANGE	Displays the number of seconds since the last topology change occurred.
BRIDGE PRIORITY	Determines the root bridge. The bridge with the lowest value becomes the root bridge. It can be set under the Port 1 settings.
HELLO TIME	Interval in which the relay sends BPDUs. It is fixed at 2 seconds.
MAX AGE	Maximum number of hops before a BPDU is discarded. It is fixed at 40.
FORWARD DELAY	The time that the relay must spend in the listening and learning states before transitioning to forwarding. It is fixed at 21 seconds. This is only used when the relay is in STP compatibility mode.
PORT 1A PROTOCOL	Displays either STP or RSTP.
PORT 1B PROTOCOL	Displays either STP or RSTP.
PORT 1A STATE	The state of Port 1A.
PORT 1B STATE	The state of Port 1B.
PORT 1A ROLE	The role of Port 1A.
PORT 1B ROLE	The role of Port 1B.
PORT 1A PRIORITY	Determines which port the device selects as a root port when there is a tie between two ports. The port with the lower value will become the root port. It can be set under the Port 1 settings.
PORT 1B PRIORITY	Determines which port the device selects as a root port when there is a tie between two ports. The port with the lower value will become the root port. It can be set under the Port 1 settings.
PORT 1A PATH COST	Helps determine which path the device selects to a root bridge. The device selects paths with the lowest overall cost first. It is fixed at 200000.
PORT 1B PATH COST	Helps determine which path the device selects to a root bridge. The device selects paths with the lowest overall cost first. It is fixed at 200000.
PORT 1A EDGE PORT	If YES, Port 1A is an edge port. If NO, it is not.

Table 7.53 RSTP Command Definitions (Sheet 2 of 2)

Information Field	Description
PORT 1B EDGE PORT	If YES, Port 1B is an edge port. If NO, it is not.
PORT 1A BPDU COUNT	Displays the number of BPDUs received on Port 1A.
PORT 1B BPDU COUNT	Displays the number of BPDUs received on Port 1B.

Figure 7.39 shows an example response to the **RSTP** command.

```
=>RSTP <Enter>

SEL-751                                 Date: 08/26/2022   Time: 10:55:23.711
FEEDER RELAY                            Time Source: External


RSTP Communication Statistics:

Root Bridge: NO
Bridge Id: 28672-0030A71BF353
Root Bridge Id: 20480-0030A71C931C
Root Port: 1B
Time Since Topology Change: 154111 sec
Bridge Priority: 28672;   Hello Time:  2 sec
Max Age: 40;   Forward Delay:  21 sec

PORT PROTOCOL  STATE       ROLE    PRIORITY  PATHCOST EDGE #BPDU-RCVD
 1A   RSTP   Discarding   Disabled    128    200000   False    553073
 1B   RSTP   Forwarding   Rootport    128    200000   False     77077

=>
```

Figure 7.39 RSTP Command Response

R_S Command (Restore Factory Defaults)

NOTE: In firmware versions R301-V1 and higher, the relay firmware retains the IP address, subnet mask, and default router settings after an **R_S** command is issued.

Use the **R_S** command (see *Table 7.54*) to restore factory-default settings.

Table 7.54 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 7.55*) 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 7.55 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
Parameters		
row1	Append *row1* to return a chronological progression of the first *row1* rows. For example, use **SER 5** to return the first five rows.	
row1 row2	Append *row1* and *row2* to return all rows between *row1* and *row2*, beginning with row1 and ending with *row2*. Enter the smaller number first to display a numeric progression of rows through the report. Enter the larger number first to display a reverse numeric progression of rows. For example, use **SER 1 10** to return the first 10 rows in numeric order or **SER 10 1** to return these same items in reverse numeric order.	
date1	Append *date1* to return all rows with this date. For example, use **SER 1/1/2003** to return all records for January 1, 2003.	
date1 date2	Append *date1* and *date2* to return all rows between date1 and date beginning with *date1* and ending with *date2*. Enter the oldest date first to display a chronological progression through the report. Enter the newest date first to display a reverse chronological progression. Date entries are dependent on the date format setting DATE_F. For example, use **SER 1/5/2003 1/7/2003** to return all records for January 5, 6, and 7, 2003	

SER D Command

The **SER D** command shows a list of SER items that the relay has automatically removed. These are "chattering" elements. You can automatically remove chattering SER elements in the SER Chatter Criteria category of the Report settings; the enable setting is ESERDEL. See *Section 4: Protection and Logic Functions*, *Report Settings (SET R Command)* for more information on SER automatic deletion and reinsertion.

Table 7.56 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 7.57*).

Table 7.57 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 E *m s* TERSE	Sets the EtherNet/IP Assembly Map *m* settings (*m* = 1, 2, or 3).	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 7.58*.

Table 7.58 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 7.59* for the **SHOW** command settings and for the command format.

Table 7.59 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 E *m s*	Shows the EtherNet/IP Assembly Map *m* settings (*m* = 1, 2, or 3).	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
```

Figure 7.40 SHOW Command Example

```
Config Settings
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

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

Neg Seq Overcurr
50Q1P    := OFF          50Q2P    := OFF          50Q3P    := OFF
50Q4P    := OFF

Incipient Fault 50
E50INC   := 15.00        50IALC   := 1            50ITRC   := 10

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
```

Figure 7.40 SHOW Command Example (Continued)

```
Harmonic Blocking Set
EHBL2    := N             EHBL5    := N

Load Encroach Set
ELOAD    := N

Phase Discontinuity Detection Settings
EPDDET   := N

Cold Load Pickup
ECLPU    := 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

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
52B      := NOT 52A
CL       := SV03T AND LT02 OR CC
ULCL     := 0

Reclosing Control
E79 := N

=>
```

Figure 7.40 SHOW Command Example (Continued)

STATUS Command (Relay Self-Test Status)

The **STA** command (see *Table 7.60*) displays the status report.

Table 7.60 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 7.61* shows the status report definitions and message formats for each test.

Table 7.61 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
HMI	Front-panel FPGA programming unsuccessful, or front-panel FPGA failed	OK/WARN
RAM	Volatile memory integrity	OK/FAIL
ROM	Firmware integrity	OK/FAIL
CR_RAM	Integrity of settings in RAM and code that runs in RAM	OK/FAIL
Non_Vol	Integrity of data stored in nonvolatile memory	OK/FAIL
Clock	Clock functionality	OK/WARN
RTD	Integrity of RTD module/communications	OK/FAIL
CID_FILE	Configured IED description file	OK/FAIL
x.x V	Power supply status (Refer to *Figure 1.5* and *Figure 1.6* 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

Table 7.61 STATUS Command Report and Definitions (Sheet 2 of 2)

STATUS Report Designator	Definition	Message Format
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)	Measurement of dc offset in hardware circuits of current channels	Measurement of dc offset/WARN
Voltage Offset (VA, VB, VC, VS)	Measurement of dc offset in hardware circuits of voltage channels	Measurement of dc offset/WARN

Figure 7.41 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 7.41 Typical Relay Output for STATUS S Command

SUMMARY Command

The **SUM** command (see *Table 7.62*) displays an event summary in a readable format.

Table 7.62 SUMMARY Command

Command	Description	Access Level
SUM *n*	Displays the latest event summary. Use *n* to display particular event summary (where *n* is either Event Record or Reference number).	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 7.63*) to view the HIF event summary reports in the relay memory. This command is only available when the relay supports HIF detection.

Table 7.63 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 7.64*) displays the status of front-panel target LEDs or Relay Word bit, whether these LEDs or Relay Word bits are asserted or deasserted.

Table 7.64 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).	

NOTE: The **TARGET R** command cannot reset the latched targets if a TRIP condition is present.

The elements are represented as Relay Word bits and are listed in rows of eight, called Relay Word rows. The first four rows, representing the front-panel operation and target LEDs, correspond to *Table 7.65*. All Relay Word rows are described in *Table L.1* and *Table L.2*.

Relay Word bits are used in SELOGIC control equations. See *Appendix L: Relay Word Bits*.

The **TAR** command does not remap the front-panel target LEDs, as is done in some previous SEL relays.

Table 7.65 Front-Panel LEDs and the TAR 0 Command

LEDs	7	6	5	4	3	2	1	0
TAR 0	ENABLED	TRIP_LED	TLED_01	TLED_02	TLED_03	TLED_04	TLED_05	TLED_06

TEST DB Command

Use the **TEST DB** command to temporarily force the relay to send fixed analog and/or digital values over communications interfaces for protocol testing.

If the relay is enabled to control IEC 61850 Mode/Behavior, then the **TEST DB** command can only be used when the relay is in On mode. The **TEST DB** command cannot be used in any other mode. If the **TEST DB** command is active while the relay is in On mode, a change of mode will deactivate the **TEST DB** command.

Table 7.66 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.

NOTE: The **TEST DB** command does not support digital points for the SEL Fast Message protocol.

The **TEST DB** command provides a method to override Relay Word bits or analog values to aid in the testing and commissioning of communications interfaces only and should not be used on an energized system. The command overrides values in the communications interfaces (ASCII, SEL Fast Message, DNP3, Modbus, EtherNet/IP, 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.

R1*xx* firmware versions use a previous version of the **TEST DB** command that aids in the testing and commissioning of the IEC 61850 protocol only. Note that the **TEST DB** command supported by R1*xx* firmware versions provides a method to override Relay Word Bits only and should not be used on an energized system. If used on an energized system it can lead to unwanted operations, including a potential trip.

NOTE: When using the **TEST DB** command to generate values for Fast Meter testing, you may need to override all current and voltage angles (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.

To override analog data in a communications interface, enter the following from Access Level 2 or higher:

```
=>>TEST DB A name value <Enter>
```

where *value* is a numerical value and *name* is an analog label from *Table M.1*, Analog Quantities, with an "x" in the DNP, Modbus, EtherNet/IP, Fast Meter, IEC 60870-5-103, or IEC 61850 column. For example, the **TEST DB** command can be used to force the value of the A-phase current magnitude transmitted to a remote device to 100 amperes.

```
=>>TEST DB A IA_MAG 100 <Enter>
```

To override digital data in an SEL ASCII, Modbus, EtherNet/IP, DNP, IEC 60870-5-103, or IEC 61850 communications interface, enter the following from Access Level 2 or higher:

```
=>>TEST DB D name value <Enter>
```

where *name* is a Relay Word bit (see *Table L.1*) and *value* is 1 or 0. For example, if Relay Word bit 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.

THERMAL 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 7.67*).

Table 7.67 THE Command (Preload or Reset Thermal Capacity)

Command	Description	Access Level
THE P	Preloads the thermal capacity used for the thermal element (see *Figure 7.42*)	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 7.42 THE Command Example

TIME Command (View/Change Time)

The **TIME** command (see *Table 7.68*) 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 7.68 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 7.69*) to trigger the SEL-751 to record data for high-resolution oscillography and event reports.

Table 7.69 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 7.70*) to trigger the SEL-751 to record data for HIF 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 7.70 TRIGGER HIF Command

Command	Description	Access Level
TRI HIF	Triggers an HIF compressed event report data capture.	1

VECTOR 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 7.71 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 4.96*) 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. When using serial ports of virtual terminal links, use the **FILE DIR** command to access the file interface.

Send and receive files using the following three protocols:

Protocol	Port Availability
FTP	Ethernet only
MMS	Ethernet only
Ymodem	Serial and Ethernet

FTP and MMS File Structure

The Ethernet FTP and the IEC 61850 MMS have a two-level file structure. Files are available at the root level and in subdirectories. *Table 7.72* shows the directories and their contents.

Table 7.72 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, BRE, and HIS reports
/EVENTS	CEV, COMTRADE, HIF, and HIS reports
/COMTRADE[b]	COMTRADE events
/HMI[c]	Touchscreen settings (SET_HMI.zds and CDP.zds) and diagnostics (HMI_ALL.zip)

[a] Only available in the FTP file structure.
[b] The COMTRADE directory is only available in the 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 7.72*.

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"
```

Figure 7.43 CFG.TXT File

```
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"
M,"Modbus User Map"
R,"Report"
F,"Front Panel"
D1,"DNP Map 1 Settings"
D2,"DNP Map 2 Settings"
D3,"DNP Map 3 Settings"
I,"IEC 60870-5-103 Map"
E1,"EtherNet/IP Assembly Map 1 Settings"
E2,"EtherNet/IP Assembly Map 2 Settings"
E3,"EtherNet/IP Assembly Map 3 Settings"
```

Figure 7.43 CFG.TXT File (Continued)

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. Architect generates and then downloads this file to the relay. See *Appendix G: IEC 61850 Communications* for more information.

Settings Directory (Available for FTP and MMS)

You can access the relay settings through files in the SETTINGS directory. It is recommended that you use support software to access the settings files, rather than directly accessing them via other means. External settings support software reads settings from all of these files to perform its functions. The relay only allows you to write to the individual SET_*cn* files, where *c* is the settings class code and *n* is the settings instance. Except for the SET_61850 CID file, changing settings with external support software involves the following steps:

Step 1. Read the CFG.TXT and the SET_ALL.TXT files from the relay using a support software.

Step 2. Modify the settings for each settings class and send the corresponding SET_*cn*.TXT file to the relay using the support software.

Step 3. Read the ERR.TXT file from the relay. If the ERR.TXT file is empty, the relay detected no errors in the SET_*cn*.TXT file and it is accepted.

Step 4. For any detected errors, fix the SET_*cn*.TXT file as indicated by the ERR.TXT file and send the SET_*cn*.TXT file to the relay.

Step 5. Repeat *Step 2* to *Step 4* for each setting class that you want to modify.

Step 6. After all setting changes are complete, test and commission the relay.

SET_ALL.TXT File (Read-Only). The SET_ALL.TXT file contains the settings for all of the settings classes in the relay. Calibration settings are included only when the file is read at Access Level C.

SET_cn.TXT Files (Read and Write). There is a file for each instance of each setting class. *Table 7.73* 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 7.73 Settings Directory Files

File Name	Settings Description
SET_*n*.TXT	Group; *n* in range 1–4
SET_D*n*.TXT	DNP3 Map; *n* in range 1–3
SET_F.TXT	Front panel
SET_G.TXT	Global
SET_I.TXT	60870 Map
SET_L*n*.TXT	Logic; *n* in range 1–4
SET_M.TXT	Modbus Map
SET_E*n*.TXT	EtherNet/IP Assembly Map; *n* in range 1–3
SET_P*n*.TXT	Port; *n* in range 1, 2, 3, 4, F
SET_R.TXT	Report
SET_ALL.TXT	All instances of all settings classes
ERR.TXT	Error log for most recently written settings file

Reports Directory (Read-Only) (Available for FTP and MMS)

Use the REPORTS directory to retrieve files that contain the reports shown in *Table 7.74*. 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 7.74 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 (HIF detection).

Events Directory (Read-Only) (Available for FTP and MMS)

The relay provides history, event reports, and oscillography files in the EVENTS directory as shown in *Table 7.76*.

Event reports are available in the following formats:

- SEL Compressed ASCII
- Binary COMTRADE format (IEEE C37.111-2013)

The file names for the C37.111-2013 COMTRADE and COMTRADE HIF event files have the following format:

yymmdd,hhMMssmmm,0t,aaaaa,bbbbb,ccccc,ddd,nnnnn.ext

Table 7.75 C37.111-2013 COMTRADE Event File Names

Variable	Description
yy	The last two digits of the year
mm	The month (01 to 12)
dd	The day (01 to 31)
hh	The hour (00 to 23)
MM	The minute (00 to 59)
ss	The second (00 to 59)
mmm	The millisecond (000 to 999)
0t	Indicates that the time stamp is the event trigger time with a UTC offset of 0
aaaaa	The last five characters of the TID setting (after removing spaces)
bbbbb	The last five characters of the RID setting (after removing spaces)
ccccc	The CONAM setting
ddd	Event record type, time-domain report (TDR) for event reports, high-impedance fault (HF) for HIF event reports
nnnnn	The unique serial number associated with the event file
ext	CFG (indicating configuration file) or DAT (indicating data file) or HDR (indicating header file)

The *yymmdd* and *hhMMss* values are based on the SOC (second of century) of the first triggered data point as specified in the COMTRADE C37.111 standard.

Spaces and characters **? " / \ < > * | : ; [ ] $ % { }** are not supported in the TID or RID used in the C37.111-2013 filenames, and the relay will automatically remove them.

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 7.76*.

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 7.90*.

Table 7.76 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 32-samples/cycle ASCII raw event report; event ID number = *nnnnn*	**CEV R *nnnnn***
yymmdd,hhMMssmmm, 0t,aaaaa,bbbbb,ccccc,HF, nnnnn.CFG[b, c]	HIF COMTRADE configuration file; event ID number = *nnnnn*	N/A
yymmdd,hhMMssmmm, 0t,aaaaa,bbbbb,ccccc,HF, nnnnn.DAT[b, c]	HIF COMTRADE binary data file; event ID number = *nnnnn*	N/A
yymmdd,hhMMssmmm, 0t,aaaaa,bbbbb,ccccc,HF, nnnnn.HDR[b, c]	HIF COMTRADE header file; event ID number = *nnnnn*	N/A
yymmdd,hhMMssmmm, 0t,aaaaa,bbbbb,ccccc,TDR, nnnnn.CFG[c]	COMTRADE configuration file; event ID number = *nnnnn*	N/A
yymmdd,hhMMssmmm, 0t,aaaaa,bbbbb,ccccc,TDR, nnnnn.DAT[c]	COMTRADE binary data file; event ID number = *nnnnn*	N/A
yymmdd,hhMMssmmm, 0t,aaaaa,bbbbb,ccccc,TDR, nnnnn.HDR[c]	COMTRADE header file; event ID number = *nnnnn*	N/A

[a] Also available in the Reports directory for convenience.
[b] Available in the units ordered with Arc Sense technology (HIF detection).
[c] Also available in the COMTRADE directory for MMS only.

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 7.76* 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 7.72* for all the files available in the HMI directory.

Ymodem File Structure

All the files available (see *Table 7.77*) for Ymodem protocol are in the root directory. See *FILE Command on page 7.51* for a response to the **FIL DIR** command.

Table 7.77 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 7.84*	1, 2, C	N/A
ERR.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.85*	1, 2, C	N/A
SET_ALL.TXT[a]	See *Settings Directory (Available for FTP and MMS) on page 7.85*	1, 2, C	N/A
SET_*n*.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.85*	1, 2, C	2, C
SET_C.TXT[a]	See *Settings Directory (Available for FTP and MMS) on page 7.85*	C	C
SET_D*n*.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.85*	1, 2, C	2, C
SET_F.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.85*	1, 2, C	2, C
SET_G.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.85*	1, 2, C	2, C
SET_I.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.85*	1, 2, C	2, C
SET_L*n*.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.85*	1, 2, C	2, C
SET_M.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.85*	1, 2, C	2, C
SET_P*n*.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.85*	1, 2, C	2, C
SET_R.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.85*	1, 2, C	2, C
C4_*nnnnn*.CEV	See *Events Directory (Read-Only) (Available for FTP and MMS) on page 7.87*	1, 2, C	N/A
CHF_*nnnnn*.CEV	See *Events Directory (Read-Only) (Available for FTP and MMS) on page 7.87*	1, 2, C	N/A
CR_*nnnnn*.CEV	See *Events Directory (Read-Only) (Available for FTP and MMS) on page 7.87*	1, 2, C	N/A
yymmdd,hhMMssmmm, 0t,aaaaa,bbbbb,ccccc,HF, nnnnn.CFG	See *Events Directory (Read-Only) (Available for FTP and MMS) on page 7.87*	1, 2, C	N/A
yymmdd,hhMMssmmm, 0t,aaaaa,bbbbb,ccccc,HF, nnnnn.DAT	See *Events Directory (Read-Only) (Available for FTP and MMS) on page 7.87*	1, 2, C	N/A
yymmdd,hhMMssmmm, 0t,aaaaa,bbbbb,ccccc,HF, nnnnn.HDR	See *Events Directory (Read-Only) (Available for FTP and MMS) on page 7.87*	1, 2, C	N/A
yymmdd,hhMMssmmm, 0t,aaaaa,bbbbb,ccccc,TDR, nnnnn.CFG	See *Events Directory (Read-Only) (Available for FTP and MMS) on page 7.87*	1, 2, C	N/A
yymmdd,hhMMssmmm, 0t,aaaaa,bbbbb,ccccc,TDR, nnnnn.DAT	See *Events Directory (Read-Only) (Available for FTP and MMS) on page 7.87*	1, 2, C	N/A
yymmdd,hhMMssmmm, 0t,aaaaa,bbbbb,ccccc,TDR, nnnnn.HDR	See *Events Directory (Read-Only) (Available for FTP and MMS) on page 7.87*	1, 2, C	N/A
BRE.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.86*	1, 2, C	N/A
CHISTORY.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.86*	1, 2, C	N/A
CHISTORY_HIF.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.86*	1, 2, C	N/A
HISTORY.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.86*	1, 2, C	N/A

Table 7.77 Files Available for Ymodem Protocol (Sheet 2 of 2)

File Name	Description	Read Access Level	Write Access Level
HISTORY_HIF.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.86*	1, 2, C	N/A
CLDP.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.86*	1, 2, C	N/A
LDP.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.86*	1, 2, C	N/A
CSER.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.86*	1, 2, C	N/A
SER.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.86*	1, 2, C	N/A
SET_HMI.zds	See *HMI Directory (Read and Write) on page 7.88*	1, 2, C	2, C
CDP.zds	See *HMI Directory (Read and Write) on page 7.88*	1, 2, C	2, C
HMI_ALL.zip	See *HMI Directory (Read and Write) on page 7.88*	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 7.78 shows examples using supported wild cards. Note that these wild cards may be appended to a directory path (e.g., /specified_directory/*.txt).

Table 7.78 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 7.79 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 yymmdd, hhMMssmmm, 0t,aaaaa,bbbbb,ccccc,HF,nnnnn*	Retrieves all of the three files for the COMTRADE event nnnnn (CFG, DAT, and 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. You can order the SEL-751 in four 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 character) front panel and four or eight control pushbuttons. You can also order the SEL-751 with a touchscreen display (5-inch, color, 800 x 480 pixels) and four or eight control pushbuttons. Use any one of the front panels to analyze operating information, view and change relay settings, and perform control functions. You can use the front-panel to accomplish the following activities:

➤ Read metering

➤ Inspect targets

➤ Access settings

➤ Control relay operations

➤ View diagnostics

Figure 8.1 SEL-751 Front-Panel Options

The two-line display and the touchscreen display front-panel models are similar in all aspects except the display and navigation scheme. The touchscreen display model offers additional features with respect to monitoring, control, and device status that are discussed in *Touchscreen Display Front Panel*. The function of operation and target LEDs and the **TARGET RESET** and control pushbuttons are similar in all four 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 8.19*. 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:

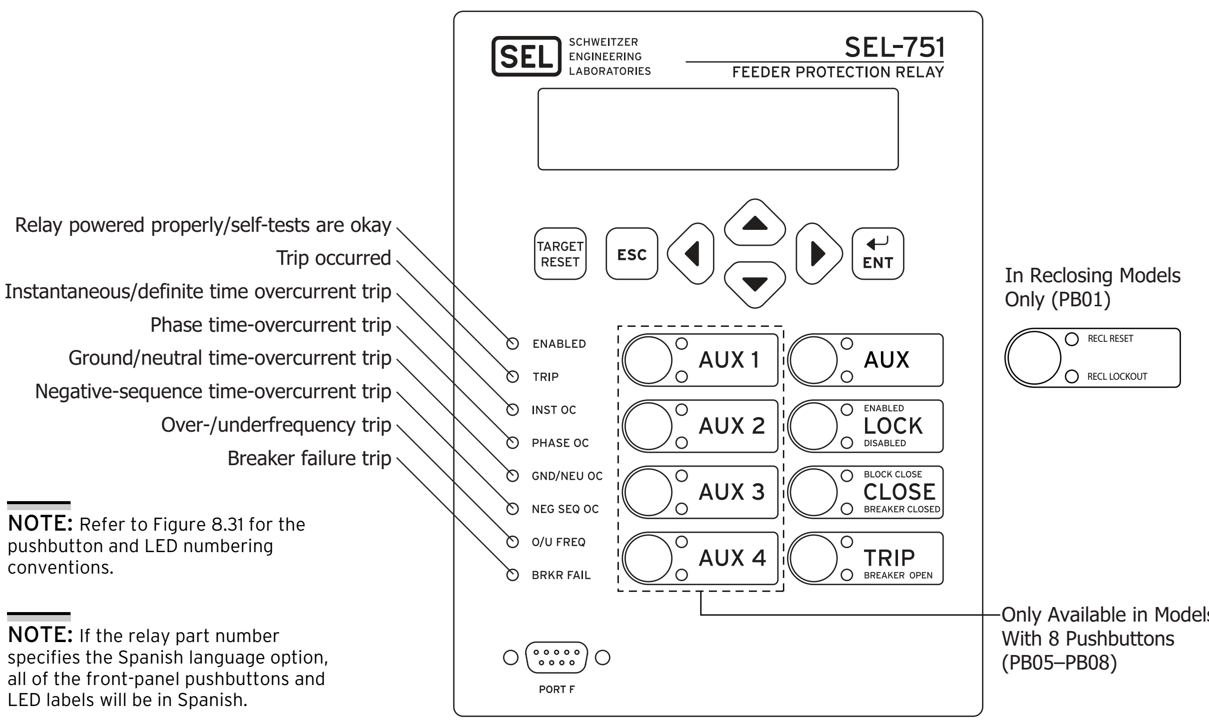
➤ Human-Machine Interface (HMI)

➤ **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 8.31 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 HMI

Contrast

NOTE: See the Preface for an explanation of typographic conventions used to describe menus, the front-panel display, and the front-panel pushbuttons.

NOTE: The two-line display updates every second.

You can adjust the LCD screen contrast to suit your viewing angle and lighting conditions. To change screen contrast, press and hold the **ESC** pushbutton for two seconds. The SEL-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.

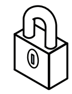


Figure 8.3 Access Level Security Padlock Symbol

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 7.65* 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. 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.

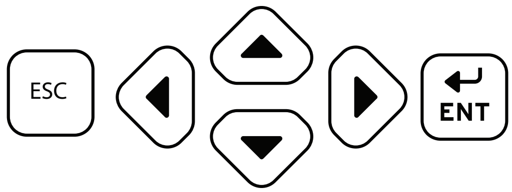
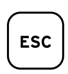


Figure 8.5 Front-Panel Pushbuttons

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.

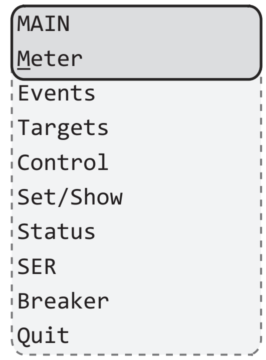


Figure 8.6 MAIN Menu

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.

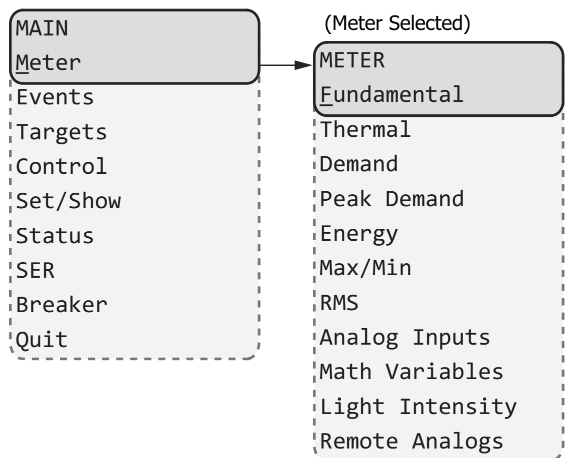


Figure 8.7 MAIN Menu and METER Submenu

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*.

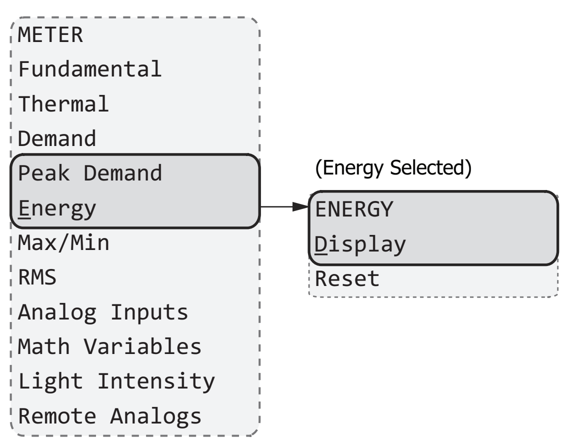


Figure 8.8 METER Menu and ENERGY Submenu

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*.

Figure 8.9 Relay Response When Energy (or Max/Min, Demand, Peak Demand) Metering Is Reset

Assume that the relay configuration contains no analog input cards. In response to a request for analog data (selecting `Analog Inputs`), the device displays the message as shown in *Figure 8.10*.

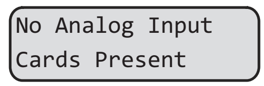


Figure 8.10 Relay Response When No Analog Cards Are Installed

Assume that the math variables are not enabled. In response to a request for math variable data (selecting `Math Variables`), the device displays the message as shown in *Figure 8.11*.

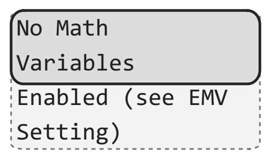


Figure 8.11 Relay Response When No Math Variables Enabled

Events Menu. Select the `Events` menu item from the `MAIN` menu as shown in *Figure 8.12*. `EVENTS` menu has `Display` and `Clear` as menu items. Select `Display` to view events and `Clear` to delete all the events data.

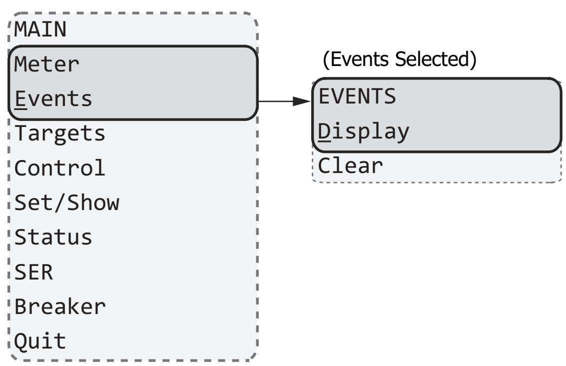


Figure 8.12 MAIN Menu and EVENTS Submenu

Figure 8.13 shows the DISPLAY menu when Display is selected from the EVENTS menu with events in the order of occurrence starting with the most recent. You can select an event from the DISPLAY menu and navigate through the event data.

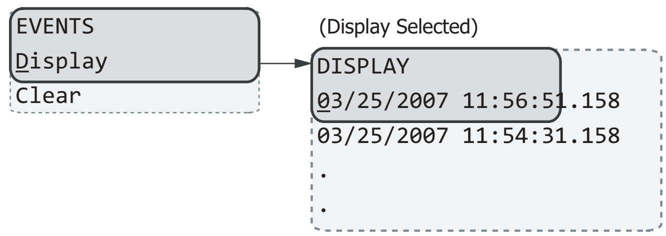


Figure 8.13 EVENTS Menu and DISPLAY Submenu

When Display is selected and no event data are available, the relay displays as shown in *Figure 8.14*.

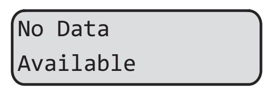


Figure 8.14 Relay Response When No Event Data Are Available

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 L.1*.

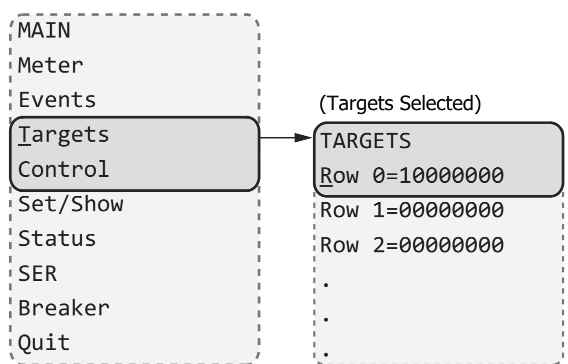


Figure 8.16 MAIN Menu and TARGETS Submenu

Select the target row to display two consecutive Relay Word bits with name and binary state as shown in *Figure 8.17*.

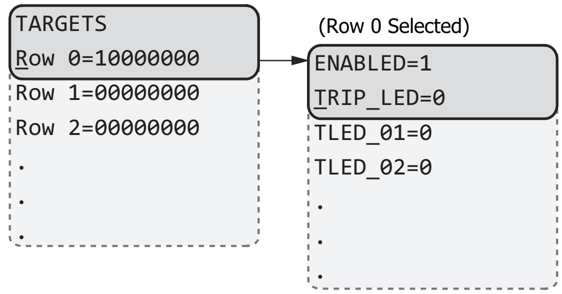


Figure 8.17 TARGETS Menu Navigation

Control Menu. Select the `Control` menu item on the `MAIN` menu as shown in *Figure 8.18* to go to the `CONTROL` menu.

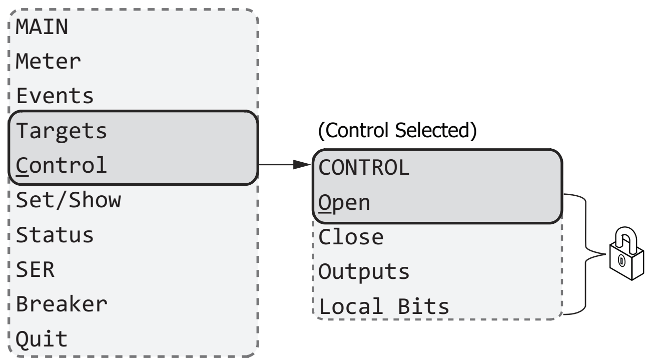


Figure 8.18 MAIN Menu and CONTROL Submenu

The `CONTROL` menu has `Open`, `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 4.56* for the TR equation and *Table L.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 4.103*). 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 2.20*), the status of the LOCAL bit when EN_LRC := Y, and the access level (requires Access Level 2). 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 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.

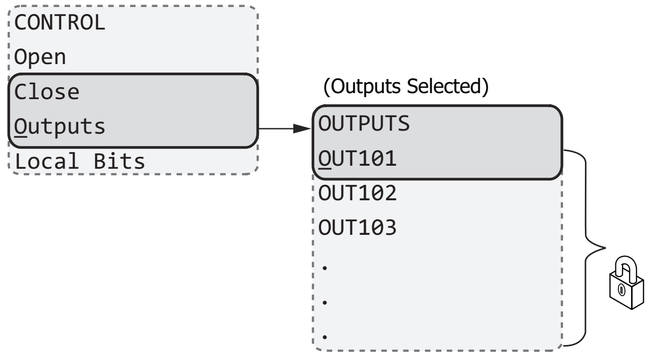


Figure 8.19 CONTROL Menu and OUTPUTS Submenu

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 4.238* 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*.

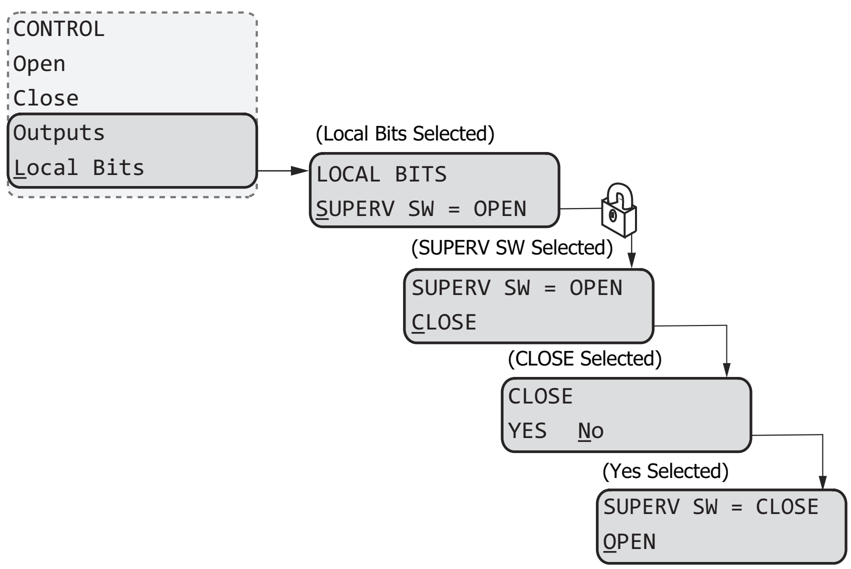


Figure 8.20 CONTROL Menu and LOCAL BITS Submenu

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.

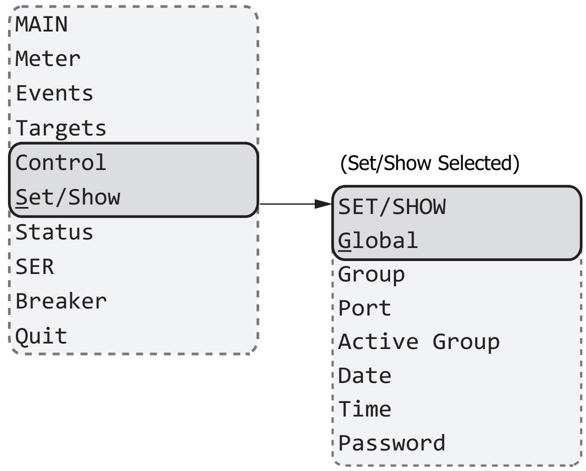


Figure 8.21 MAIN Menu and SET/SHOW Submenu

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.

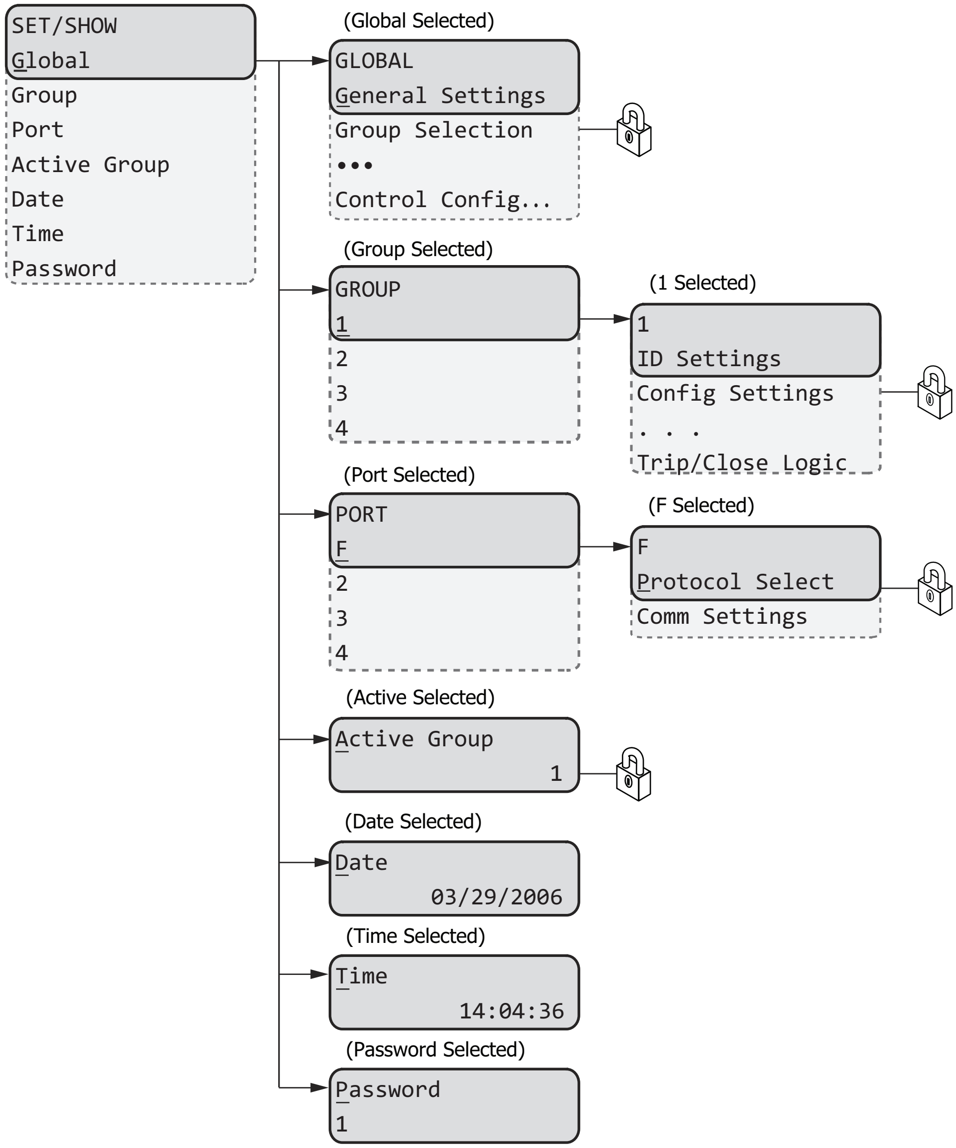


Figure 8.22 SET/SHOW Menu

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 7.77* for the **STATUS** data field description.

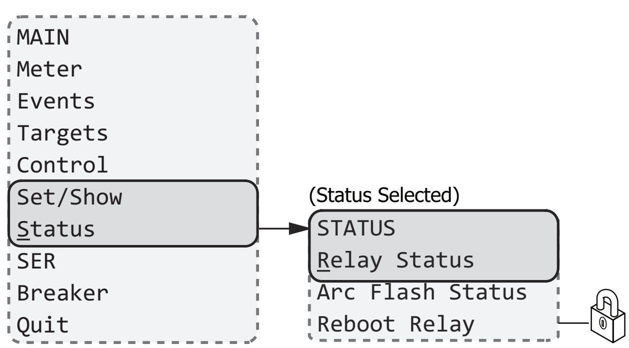


Figure 8.23 MAIN Menu and STATUS Submenu

Sequential Events Recorder (SER) Menu. Select the SER menu item on the MAIN menu as shown in *Figure 8.24* to display or clear the SER report.

```
MAIN
Meter
Events
Targets
Control
Set/Show
Status                (Status Selected)
SER         ------->  SER
Breaker               Display
Quit                  Clear
```

Figure 8.24 MAIN Menu and SER Submenu

Figure 8.25 shows the SER report when Display is selected from the SER menu with the relay element state changes in order of occurrence starting with the most recent. The first row displays the index number of the state change and its time stamp. The second row displays the date of the state change, the relay element, and the relay element state. Relay elements with aliases greater than eight characters are truncated. The relay element state equals 1 for asserted or 0 for deasserted. See *Section 10: Analyzing Events* for additional details on analyzing SER reports.

```
SER
Display  ------->  1  11:10:27.561
Clear              10/18 52A     0
                   2  11:10:27.490
                   10/18 TRIP    1
                   •
                   •
                   •
```

Figure 8.25 SER Menu and Display Submenu

When Display is selected and no SER report rows are stored, the relay displays the response shown in *Figure 8.26*.

```
No Data
Available
```

Figure 8.26 Relay Response When No SER Data Are Available

When you select Clear from the SER menu and confirm the selection, the relay displays the response shown in *Figure 8.27* after it clears the SER data.

```
Clearing
Complete
```

Figure 8.27 Relay Response When SER Report Is Cleared

Breaker Menu. Select the Breaker menu item on the MAIN menu as shown in *Figure 8.28* to access Breaker Monitor data or Reset the data. See *Breaker Monitor on page 5.18*, in *Section 5: Metering and Monitoring* for a detailed description.

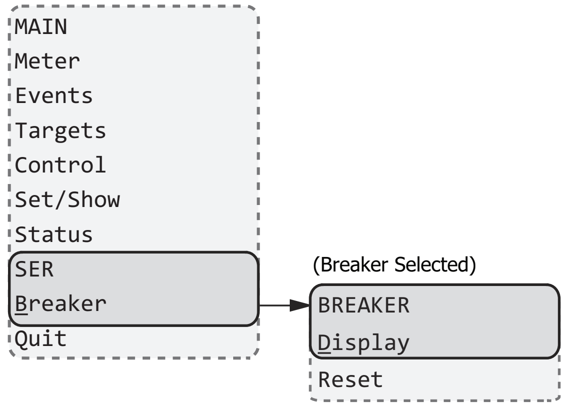


Figure 8.28 MAIN Menu and BREAKER Submenu

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 8.29* shows this region with factory-default text on the front-panel configurable labels. See *Target LED Settings on page 4.240* for the SELOGIC control equations and the tricolor LED color selection settings. The Relay Word bits associated with the target LEDs are TLED_01 to TLED_06.

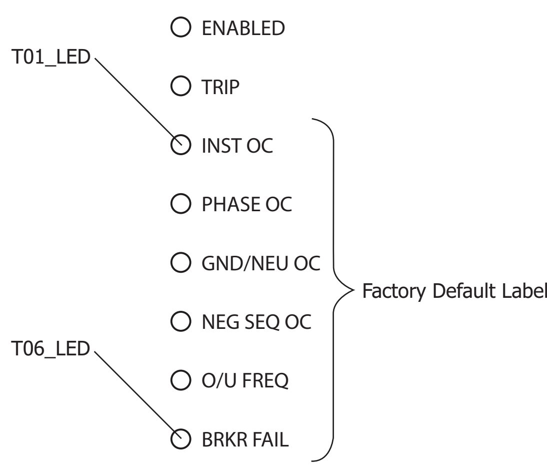


Figure 8.29 Factory Default Front-Panel LEDs

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.

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 8.29*. Use settings T0nLEDC to select the LED color (R–red, G–green,

NOTE: The target LEDs are restored to their previous state after the relay is turned off and then turned back on.

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 asserts if a trip condition occurs and the T0*n*_LED equation is asserted within two cycles of the trip assertion. 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 4.112*.

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 L: 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 8.30 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 7.64* 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 4.223* for further information.

Front-Panel Operator Control Pushbuttons

The base SEL-751 features four operator-controlled pushbuttons, PB01–PB04, each with two programmable tricolor pushbutton LEDs, for local control as shown in *Figure 8.31*. PB05–PB08 are available as an ordering option.

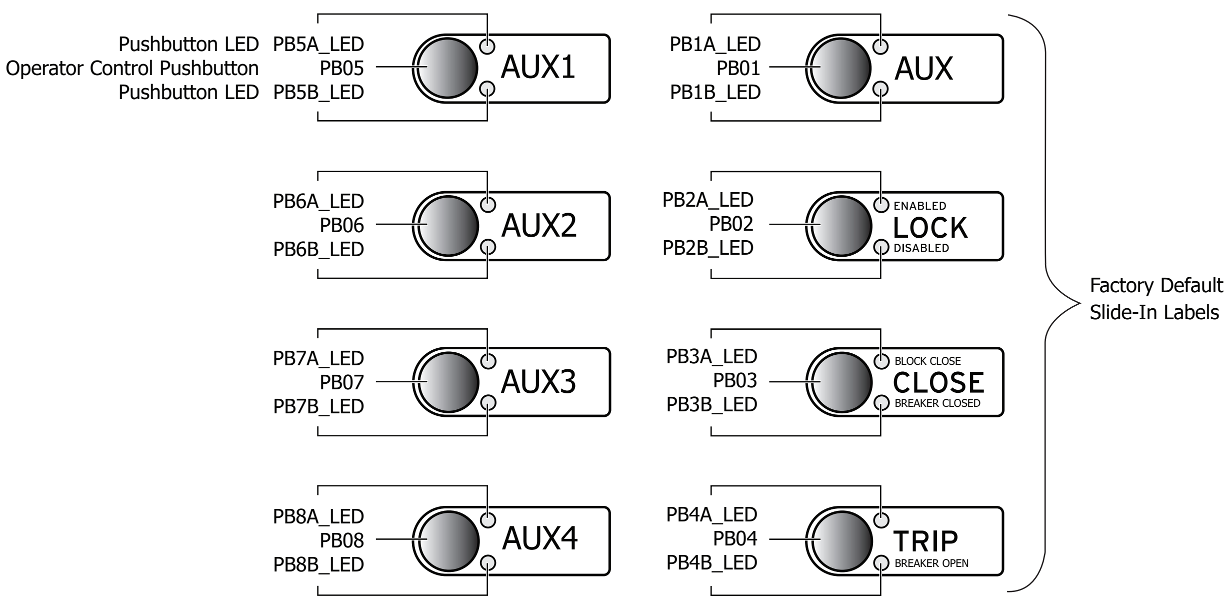


Figure 8.31 Operator Control Pushbuttons and LEDs

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 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. Word processor templates for printing slide-in labels are available at selinc.com. 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)

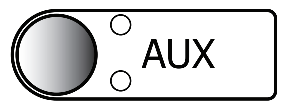
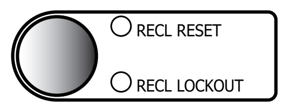
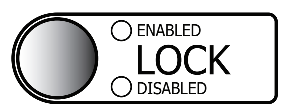
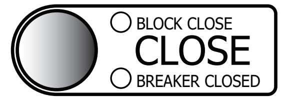
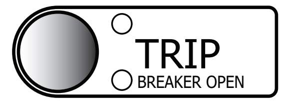
Press the **AUX** operator control pushbutton to enable/disable user-programmed auxiliary control. You can program the corresponding LED to illuminate during the enabled state. **NOTE**: The **AUX** operator control does not perform any function with the factory settings. Also, AUX1 to AUX4 pushbuttons 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 4.67* 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 4.67* 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 8.14* for a detailed description of these features. In addition, the touchscreen front panel features a **HOME**  pushbutton.

Touchscreen Display HMI

NOTE: The touchscreen display updates every 250 ms.

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 8.32 shows the relay touchscreen display components and indicators.

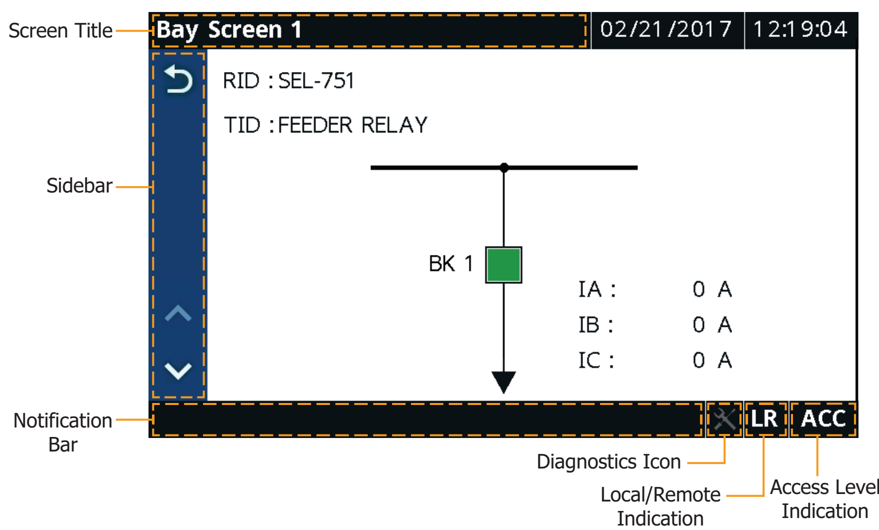
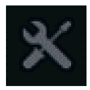


Figure 8.32 Touchscreen Display Components and Indicators

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 8.32*).
Sidebar	Shows the navigation icons (see *Figure 8.32*).
Notification Bar	Shows the notification messages and help text for screens (see *Figure 8.32*).
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 Control on page 9.7* for more details.
L	When EN_LRC := Y and LOCAL := 1, relay control is in local mode, i.e., OC 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 the device is on Access Level 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 8.33*), 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

Touchscreen displays have an LED backlight that you can adjust to suit your viewing angle and lighting conditions. To change the backlight settings, tap the **Settings** folder and then tap the **Touchscreen** application. Use the FPBAB setting to adjust the brightness of the display.

Front-Panel Automatic Messages

The relay displays automatic messages that override the present display under the conditions described in *Table 8.6*. 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 Access Level 2 password to proceed further. After you have correctly entered the password, you can perform other Access Level 2 operations without re-entering the password. You will have to re-enter the password if the front-panel inactivity timer, FPTO, expires.

See *PASSWORD Command (Change Passwords) on page 7.65* 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.

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.	TRIG	Trigger Event	Triggers an event.
	Down	Pages down in applications with multiple screens; when on the last screen, this button is disabled.		Back	Returns to the preceding screen, e.g., from applications to folders.
	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.		Pause	Stops updating the phasors.
	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.		Play	Updates the phasor values from the relay as the screen refreshes.
0.00	Reset	Resets the accumulating quantities, such as energy, to zero.		Refresh	Reloads the data when new data are available.
	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.

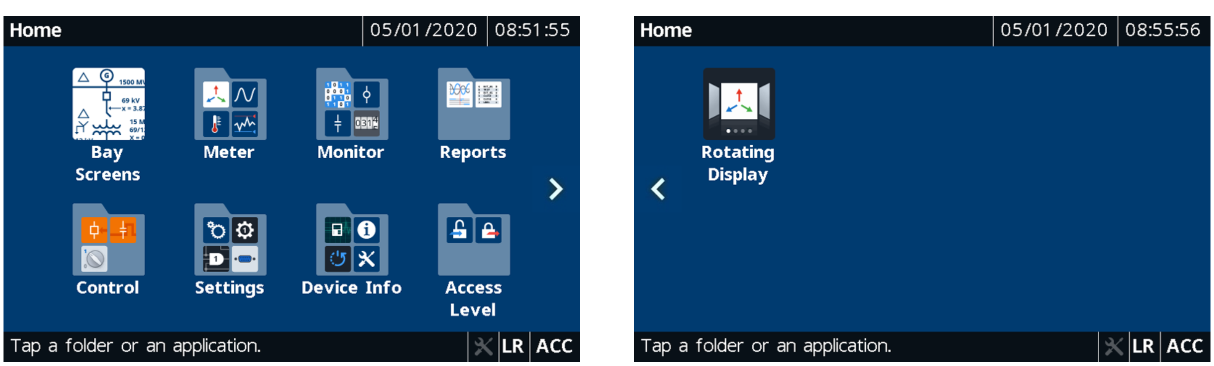


Figure 8.33 Home (Default FPHOME Setting)

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
	Settings	Always available
	Device Info	Always available
	Access Level	Always available
	Rotating Display	Always available

The applications shown in the folders are based on the part number. For example, if the relay does not 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.

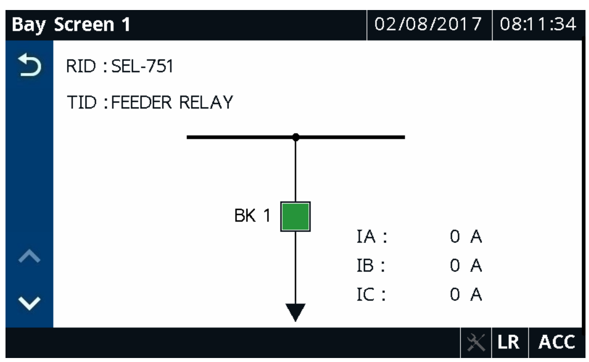


Figure 8.34 Bay Screens Application

Meter

Tapping this folder navigates you to the Meter screen, as shown in *Figure 8.35*. 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.

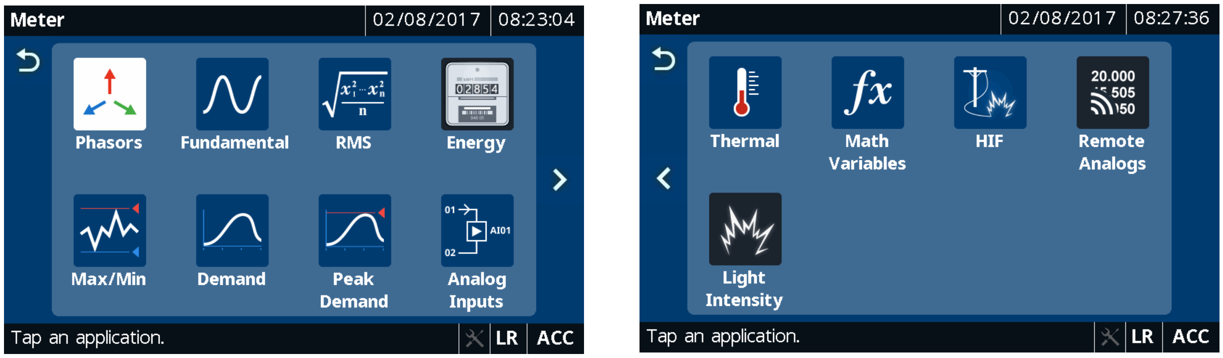


Figure 8.35 Meter Applications

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 8.36 and *Figure 8.37* show typical screens for phasor and fundamental metering.

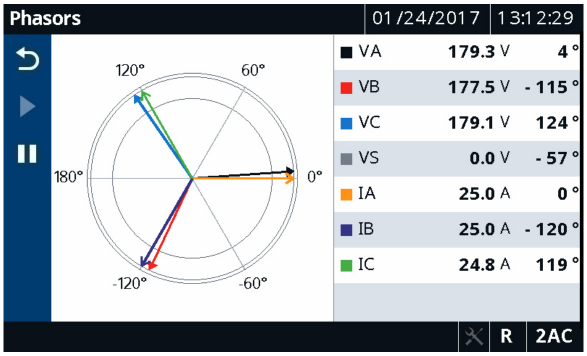


Figure 8.36 Meter Phasors

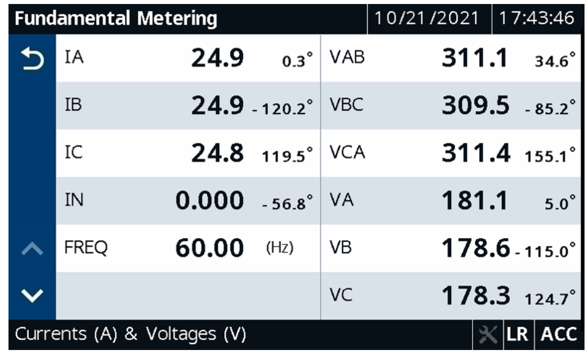


Figure 8.37 Meter Fundamental

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 8.38* and *Figure 8.39* show typical screens for energy metering and reset confirmation.

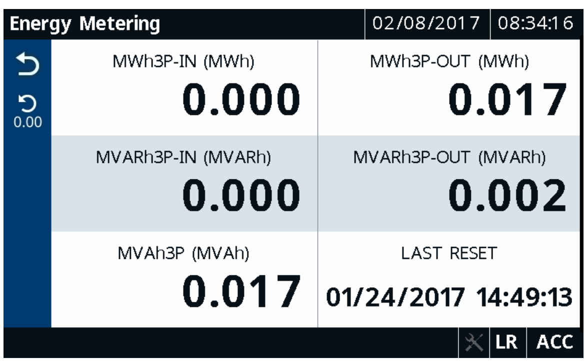


Figure 8.38 Meter Energy

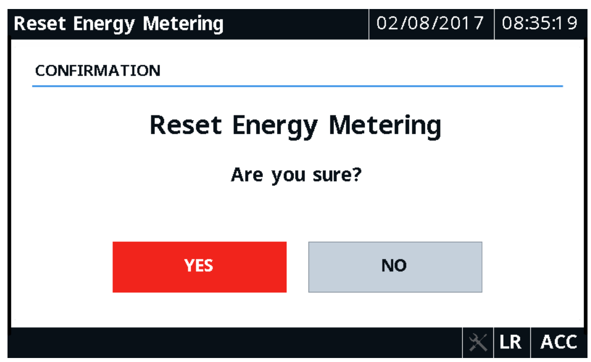


Figure 8.39 Meter Energy Reset

Monitor

Tapping this folder navigates you to the Monitor screen, as shown in *Figure 8.40*. 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).

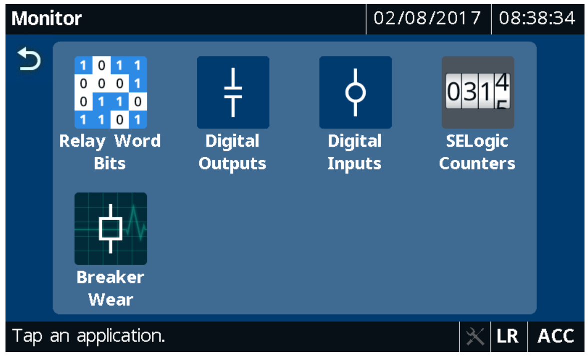


Figure 8.40 Monitor Applications

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.

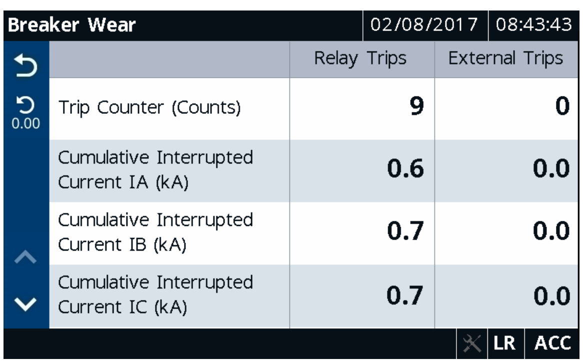


Figure 8.41 Breaker Wear Trips

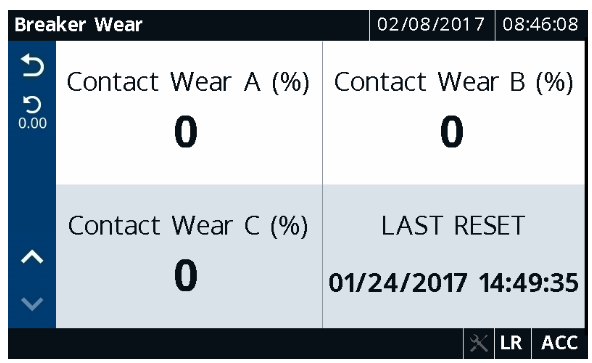


Figure 8.42 Breaker Wear A, B, C, and Last Reset

Use the Relay Word Bits screen to monitor the status of the Relay Word bits. 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 8.43* and *Figure 8.44* show typical Relay Word bits monitoring screens.

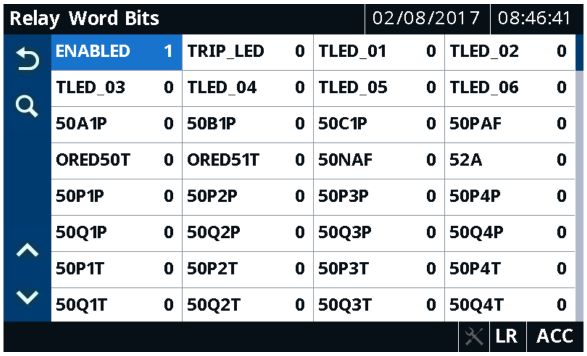


Figure 8.43 Monitor Relay Word Bits

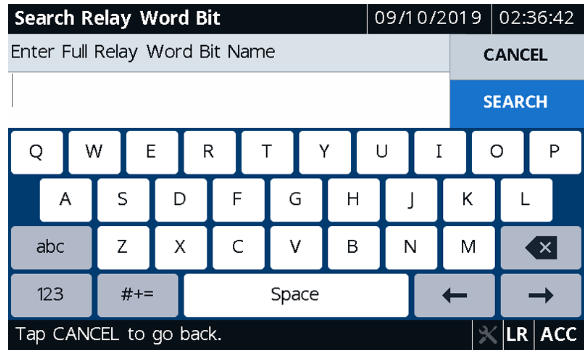


Figure 8.44 Search Relay Word Bits

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.

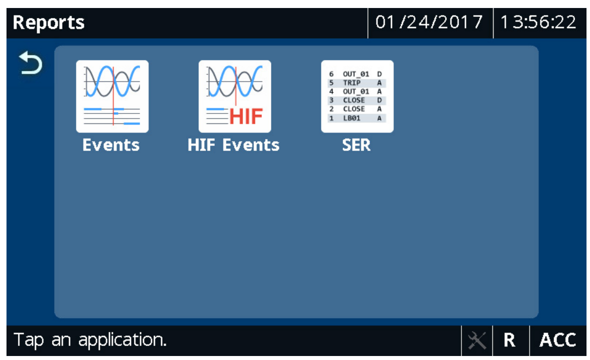


Figure 8.45 Reports Applications

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. You can also trigger an event from the Event History screen using the **Trigger Event** button. 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 8.46* through *Figure 8.48* show typical Event History, Event Summary, and Sequential Events Recorder screens.

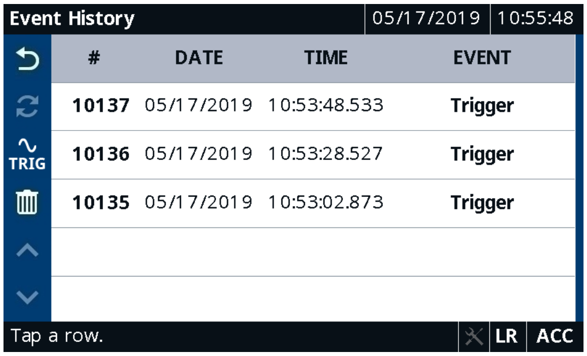


Figure 8.46 Event History

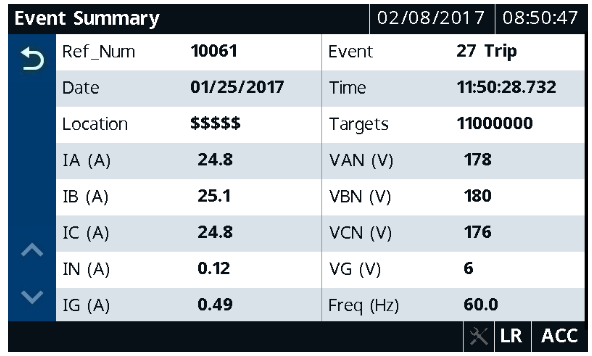


Figure 8.47 Event Summary

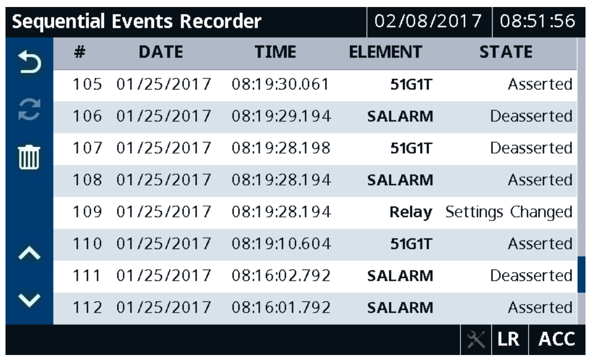


Figure 8.48 Sequential Events Recorder

Control

Tapping this folder navigates you to the Control screen, as shown in *Figure 8.49*. Use the Control folder applications Breaker Control, Output Pulsing, and Local Bits to perform breaker control operations, pulse output contacts, or control the local bits.

Breaker Control and Output Pulsing applications require that the breaker jumper be installed on the main board. Refer to *Password, Breaker Control, and SELBOOT Jumper Selection on page 2.21* for information on the breaker jumper.

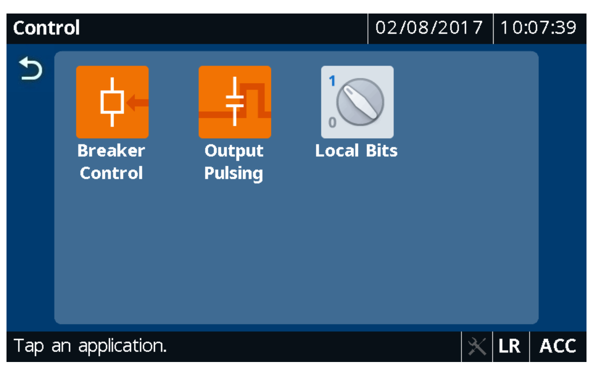


Figure 8.49 Control Applications

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 Access Level 2). 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 8.50* shows a typical breaker control screen. For the settings related to the local/remote control function, refer to *Local/Remote Control on page 9.7*.

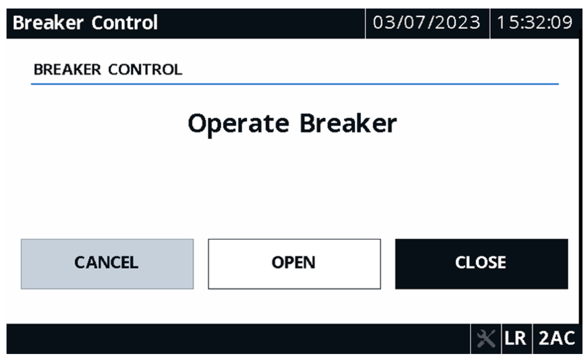


Figure 8.50 Local Bits Confirmation

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 8.51*. 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.

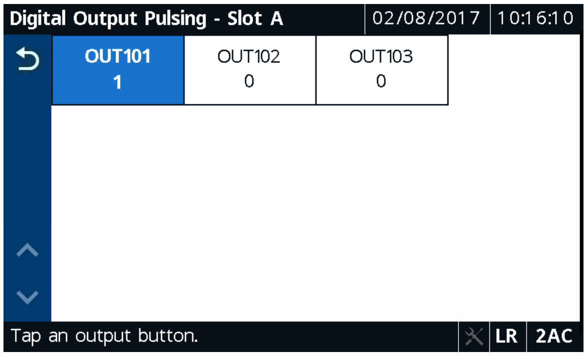


Figure 8.51 Digital Output Pulsing—Slot A

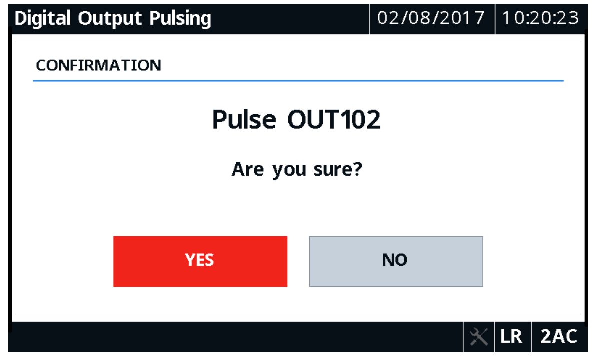


Figure 8.52 Digital Output Pulsing Confirmation

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 8.53* through *Figure 8.55* show typical local bits control screens.

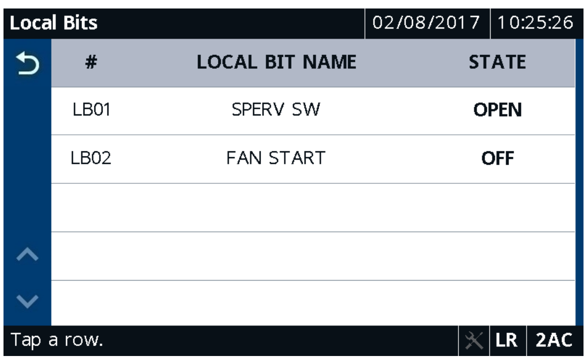


Figure 8.53 Local Bits

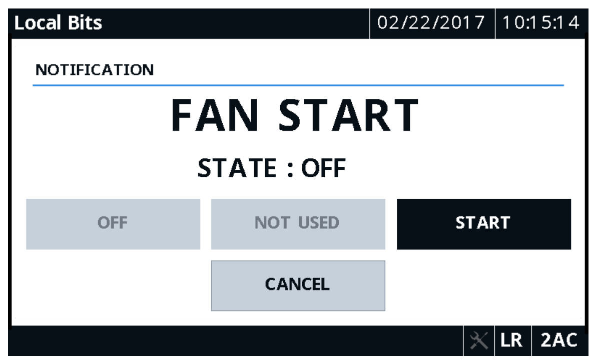


Figure 8.54 Local Bits Notification

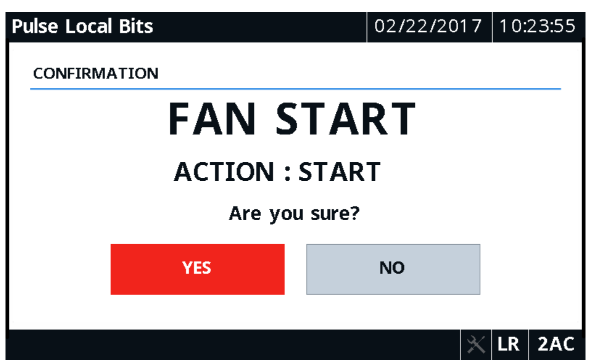


Figure 8.55 Local Bits Confirmation

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.

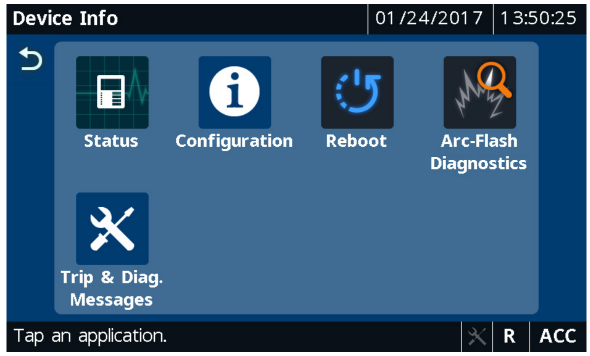


Figure 8.56 Device Info Applications

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 8.57*. Use the **Configuration** application to view port information, the jumper positions for the breaker, etc., as shown in *Figure 8.58*. 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 8.59*. *Figure 8.57* through *Figure 8.59* show typical screens for device configuration, device status, and trip and diagnostic messages.

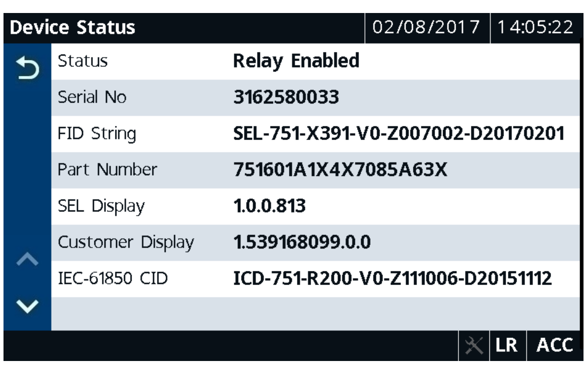


Figure 8.57 Device Status

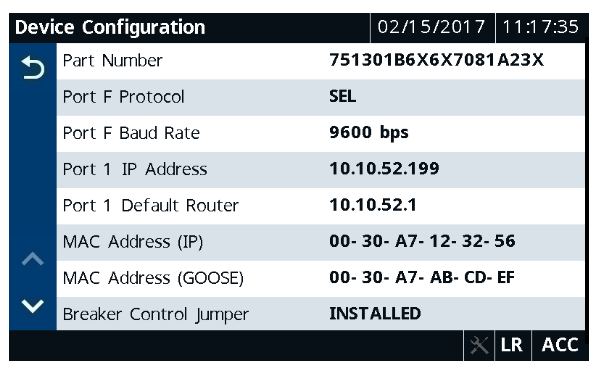


Figure 8.58 Device Configuration

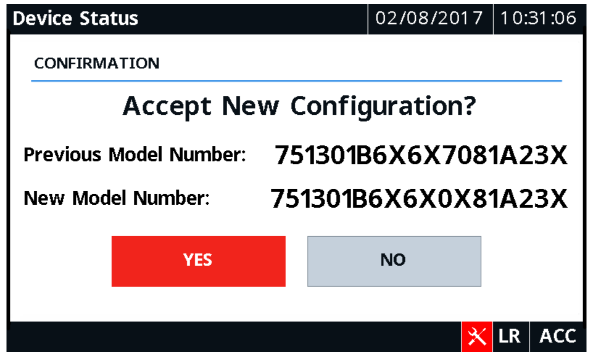


Figure 8.59 Model Number Confirmation

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.

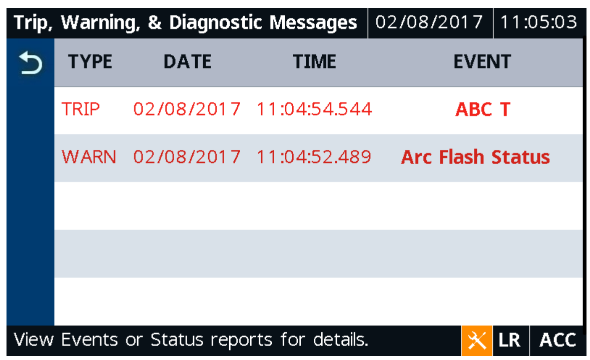


Figure 8.60 Trip and Diagnostic Messages

Tap on the **Arc-Flash Diagnostics** application to run a diagnostic check on the arc-flash sensors. *Figure 8.61* and *Figure 8.62* show typical arc-flash diagnostics screens.

Figure 8.61 Arc-Flash Diagnostics

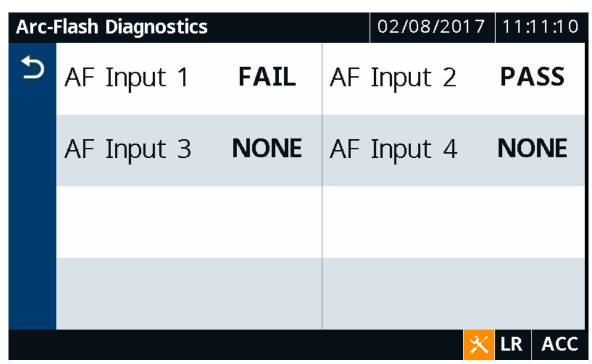


Figure 8.62 Arc-Flash Diagnostics Confirmation

Access Level

Tapping this folder navigates you to the Access Level screen where you can either log in to or log out of Access Level 2.

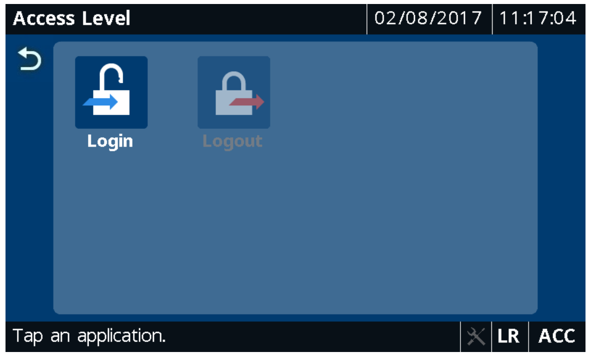


Figure 8.63 Access Level Applications

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 Access Level 2 and the relay is at Access Level 1, the relay automatically pops up the authentication screen requiring you to enter the password before performing a control operation, editing setting, etc.

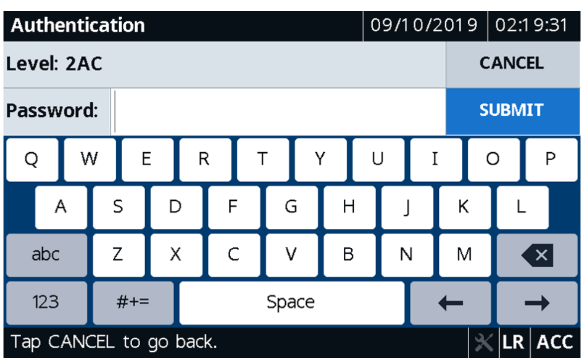


Figure 8.64 Authentication

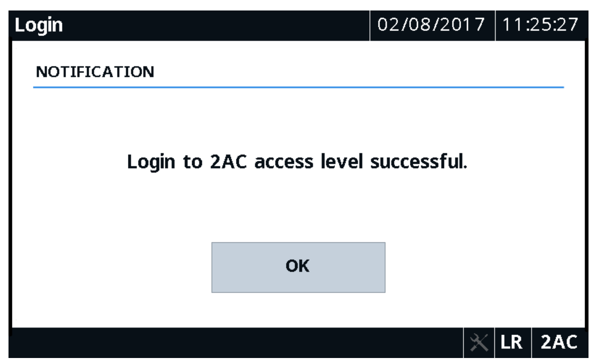


Figure 8.65 Login Confirmation

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.

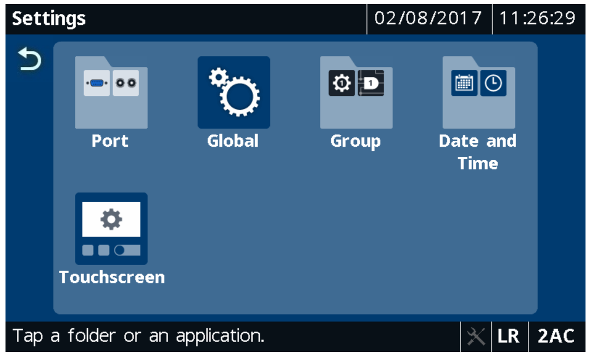


Figure 8.66 Settings Folders and Applications

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 8.67 and *Figure 8.68* show typical port and group settings screens.

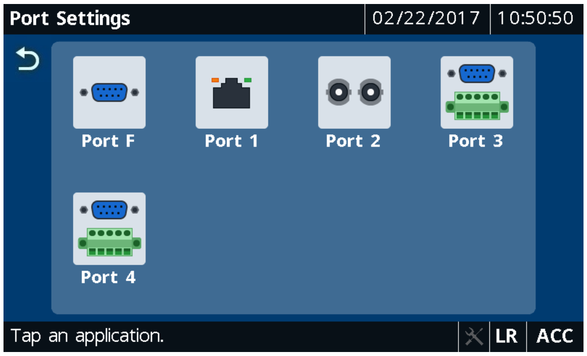


Figure 8.67 Port Settings

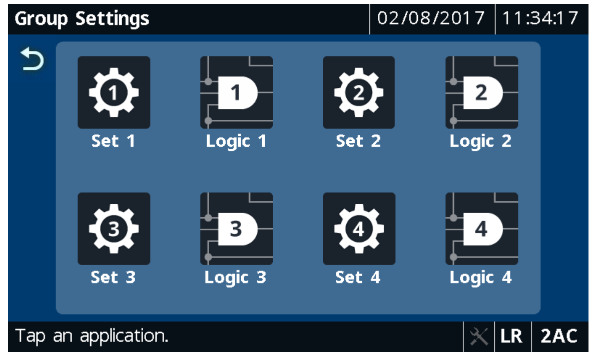


Figure 8.68 Group Settings

To edit a setting, tap on a setting row and enter the Access Level 2 password. If the access level is already at Access Level 2, 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.

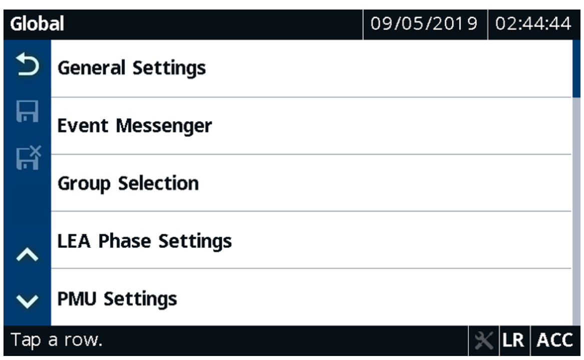


Figure 8.69 Global Settings

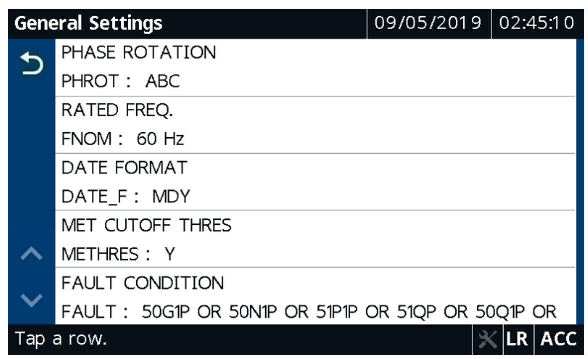


Figure 8.70 General Settings

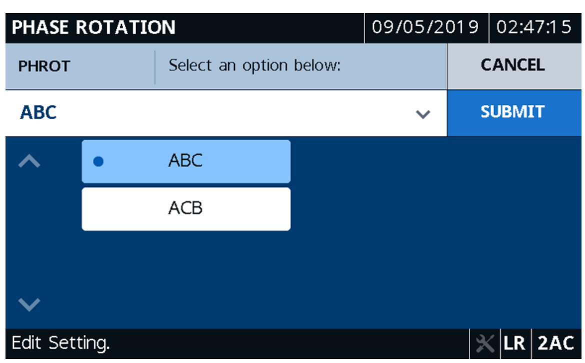


Figure 8.71 Set/Show Settings Edit

You can control the screen brightness, the screen inactivity timer settings, etc., through the Touchscreen application.

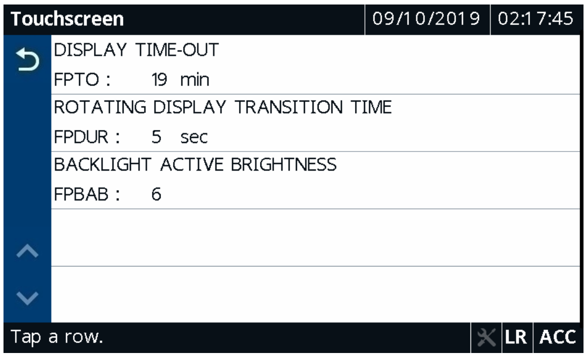


Figure 8.72 Touchscreen Settings

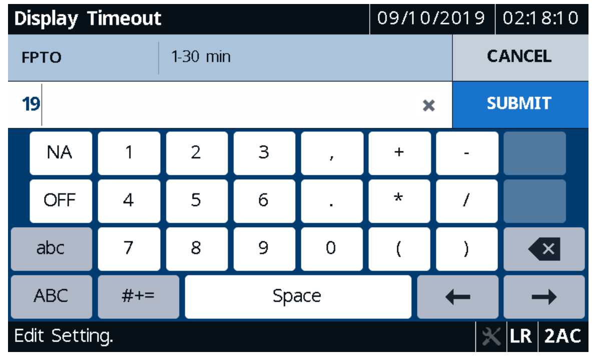


Figure 8.73 Touchscreen Settings Edit

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.

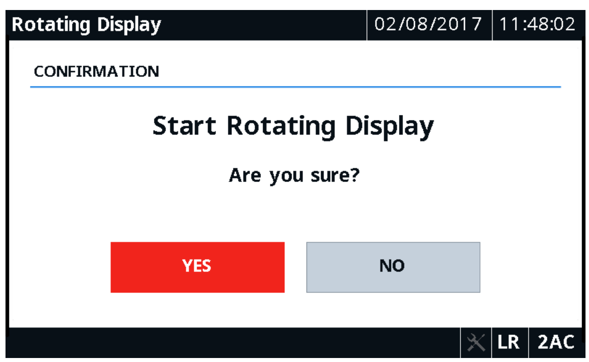


Figure 8.74 Rotating Display

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 8.14* 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 8.15* 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 four operator-controlled pushbuttons, PB01–PB04, each with two programmable tricolor pushbutton LEDs, for local control, as shown in *Table 8.4*. PB05–PB08 are available as ordering options. Refer to *Front-Panel Operator Control Pushbuttons on page 8.16* 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 = Lx OR 8x OR 7x) AND (DELTA_Y = DELTA) AND (Slot E ≠ 7y OR Ly); where y = 0, A to H
		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 = Lx OR 8x OR 7x) AND (DELTA_Y = WYE) AND (Slot E ≠ 7y OR Ly); where y = 0, A to H

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 = Lx OR 8x OR 7x) AND (DELTA_Y = DELTA) AND (Slot E = 7y OR Ly); where y = 0, A to H
		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 = Lx OR 8x OR 7x) AND (DELTA_Y = WYE) AND (Slot E = 7y OR Ly); where y = 0, A to H
	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 = 7x OR Lx AND Slot E ≠ 77) AND (Slot Z = 8x OR Lx OR 7x)

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			
		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 = Lx OR 8x OR 7x) AND (DELTA_Y = DELTA) AND (Slot E ≠ 7y OR Ly); where y = 0, A to H
		RMS Screen 3	IARMS, IBRMS, ICRMS, INRMS, VARMS, VBRMS, VCRMS	Shown when (Slot Z = Lx OR 8x OR 7x) AND (DELTA_Y = WYE) AND (Slot E ≠ 7y OR Ly); where y = 0, A to H
		RMS Screen 4	IARMS, IBRMS, ICRMS, INRMS, VABRMS, VBCRMS, VCARMS, VSRMS	Shown when (Slot Z = Lx OR 8x OR 7x) AND (DELTA_Y = DELTA) AND (Slot E = 7y OR Ly); where y = 0, A to H
		RMS Screen 5	IARMS, IBRMS, ICRMS, INRMS, VARMS, VBRMS, VCRMS, VSRMS	Shown when (Slot Z = Lx OR 8x OR 7x) AND (DELTA_Y = WYE) AND (Slot E = 7y OR Ly); where y = 0, A to H
	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, FRE-QMX, 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	

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
	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
	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–MV64	Shown when EMV ≠ N; shows 12 math variables per page

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
	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
		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

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 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
		Digital Inputs Screen 12	IN501, IN502, IN503, IN504, IN505, IN506, IN507, IN508	Shown when Slot E = 3x, 7A, 7B, 7C, 7D, 7G, 7H, LA, LB, LC, LD, LG, or LH IN508 is only available 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–SC64	Shown when ESC ≠ N; shows 12 SELOGIC counters per page

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
	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
	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, +0.675V CHK (V), +0.675VD CHK (V), +1V CHK (V), +1.1V CHK (V), +1.35V CHK (V), +1.8V 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

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
	Configuration			
		Configuration Screen 1	Part number, Port F protocol, Port F baud rate, Port 1 IP address, Port 1 default router, MAC address (IP), 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
	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 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. The relay supports the control of as many as eight two-position disconnects and as many as two three-position disconnects. ANSI and IEC symbols, along with analog and digital labels, are available for you to create detailed single-line diagrams of the bay to indicate the status of the breaker and disconnects, bus voltages, and power flow through the breaker. In addition to single-line diagrams, you can design the screens to show the status of various relay elements via Relay Word bits or to show analog quantities for commissioning or day-to-day operations. These screens can be designed with the help of ACSELERATOR Bay Screen Builder SEL-5036 Software in conjunction with ACSELERATOR QuickSet SEL-5030 Software. Note that the bay screen related settings can only be set via QuickSet (setting via an ASCII terminal is not supported).

This section covers all aspects of the SEL-751 bay control.

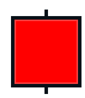
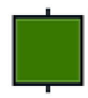
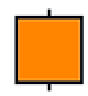
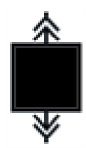
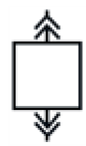
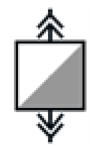
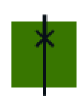
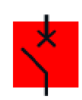
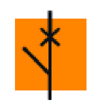
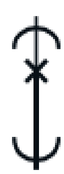
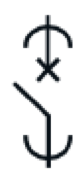
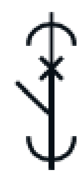
Circuit Breaker Symbol Settings and Status Logic

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 9.7* for the Bay Control breaker settings. Refer to *Bay Control Application Example on page 9.18* for example settings. Refer to *Table 4.63* and *52A and 52B Breaker Status SELOGIC Control Equations on page 4.163* for 52A and 52B settings and descriptions. Refer to *Trip/Close Logic on page 4.160* for more information on the breaker trip and close logic.

Table 9.1 provides typical ANSI and IEC breaker symbols that are supported by Bay Screen Builder. Column 1 identifies the standard (ANSI/IEC) and the type of breaker. Columns 3, 4, and 5 identify closed, open, and alarm states of the breaker image, respectively. Bay Screen Builder allows you to set the breaker color sequence property (identified in Column 2) for each of these states. Select the breaker color sequence based on your system convention. For a complete list of ANSI and IEC circuit breaker symbols available to use with the bay screens, refer to the *ACSELERATOR Bay Screen Builder SEL-5036 Software Instruction Manual*, available in the **Help > Contents** menu of Bay Screen Builder.

Table 9.1 Circuit Breaker Symbols

Type	Breaker Color Sequence	State 1 (Closed)	State 2 (Open)	State 3 (Alarm)
ANSI Breaker	Red, Green, Amber			
ANSI Truck Operated Breaker	Black, White, Grey			
IEC Breaker	Green, Red, Amber			
IEC Truck Operated Breaker	Transparent			

Disconnect Control Settings

The SEL-751 supports control of as many as eight two-position and two three-position disconnects. Refer to *Table 9.2* and *Table 9.3* for the two- and three-position disconnect settings. The following description applies to both the two- and three-position disconnects enabled by the 89EN2P and 89EN3P settings, respectively. Generic setting names are used in the following description. For example, the label setting for two-position Disconnect 1 (89NM2P1) is represented by 89NM*km*, where *k* is the disconnect type (*k* = 2P, 3PL, or 3PE) and *m* is the disconnect number (*m* = 1–8 if *k* = 2P and *m* = 1–2 if *k* = 3PL or 3PE).

Use the 89NM*km* setting and a maximum of 16 characters to name the disconnect. The 89A*km* and 89B*km* SELOGIC control equation settings represent the normally open and normally closed disconnect auxiliary contacts. Typically, these SELOGIC control equation settings are set to SEL-751 inputs that are wired to the corresponding auxiliary contacts. *Figure 9.1* shows the dual-point disconnect status logic. Relay Word bits 89CL*km* and 89OP*km* indicate whether the disconnect is in a fully closed or fully opened state, respectively. The alarm bit 89AL*km* indicates the alarm status of the disconnect and asserts when the disconnect is in an undetermined state for longer than the 89A*km*D time setting. The 89AL*km* alarm bit also asserts if the disconnect fails to start a close or open operation after a successful command is issued. Set the 89A*km*D timer to a value longer than the longest expected operation time (undetermined state).

Table 9.2 Two-Position Disconnect Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
EN 2P DISC	N, 1–8	89EN2P := 8
Disconnect m[a]		
2P DISC *m* NAME	16 characters	89NM2P*m* := 2P*m*
DIS *m* N/O CONT	SELOGIC	89A2P*m* := 0
DIS *m* N/C CONT	SELOGIC	89B2P*m* := NOT 89A2P*m*
DIS *m* ALM PU	0.00–300.00 sec	89A2P*m*D := 5.00
DIS *m* SEALIN	OFF, 0.00–300.00 sec	89S2P*m*D := 4.67
DIS *m* IMMOBI	OFF, 0.00–300.00 sec	89I2P*m*D := 0.33
DIS *m* CL CONT	SELOGIC	89RC2P*m* := 89CC2P*m*
DIS *m* CL BLK	SELOGIC	89CB2P*m* := 89AL2P*m*
DIS *m* CL RST	SELOGIC	89CR2P*m* := 89CL2P*m* OR 89CS2P*m* OR 89ALP2*m*
DIS *m* CL IM RS	SELOGIC	89CT2P*m* := NOT 89OP2P*m*
DIS *m* OP CONT	SELOGIC	89RO2P*m* := 89OCP*m*
DIS *m* OP BLK	SELOGIC	89OB2P*m* := 89AL2P*m*
DIS *m* OP RST	SELOGIC	89OR2P*m* := 89OP2P*m* OR 89OS2P*m* OR 89AL2P*m*
DIS *m* OP IM RS	SELOGIC	89OT2P*m* := NOT 89CL2P *m*

[a] The value of m can be set to any number between 1 and the value of setting 89EN2P.

Table 9.3 Three-Position Disconnect Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
EN 3P DISC	N, 1–2	89EN3P := N
Disconnect m[a]		
3P DISC *m* NAME	16 characters	89NM3P*m* := 3P*m*
In-Line Disconnect		
LDIS *m* N/O CONT	SELOGIC	89A3PL*m* := 0
LDIS *m* N/C CONT	SELOGIC	89B3PL*m* := NOT 89A3PL*m*
LDIS *m* ALM PU	0.00–300.00 sec	89A3PL*m*D := 5.00
LDIS *m* SEALIN	OFF, 0.00–300.00 sec	89S3PL*m*D := 4.67
LDIS *m* IMMOBI	OFF, 0.00–300.00 sec	89I3PL*m*D := 0.33
LDIS *m* CL CONT	SELOGIC	89RC3PL*m* := 89CC3PL*m*
LDIS *m* CL BLK	SELOGIC	89CB3PL*m* := 89CL3PE*m* OR 89AL3PL*m* OR 89AL3PE*m*

Table 9.3 Three-Position Disconnect Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
LDIS *m* CL RST	SELOGIC	89CR3PL*m* := 89CL3PL*m* OR 89CS3PL*m* OR 89AL3PL*m*
LDIS *m* CL IM RS	SELOGIC	89CT3PL*m* := NOT 89OP3PL*m*
LDIS *m* OP CONT	SELOGIC	89RO3PL*m* := 89OC3PL*m*
LDIS *m* OP BLK	SELOGIC	89OB3PL*m* := 89CL3PE*m* OR 89AL3PL*m* OR 89AL3PE*m*
LDIS *m* OP RST	SELOGIC	89OR3PL*m* := 89OP3PL*m* OR 89OS3PL*m* OR 89AL3PL*m*
LDIS *m* OP IM RS	SELOGIC	89OT3PL*m* := NOT 89CL3PL*m*
Earthing Disconnect		
EDIS *m* N/O CONT	SELOGIC	89A3P*m* := 0
EDIS *m* N/C CONT	SELOGIC	89B3P*m* := NOT 89A3PE*m*
EDIS *m* ALM PU	0.00–300.00 sec	89A3PE*m*D := 5.00
EDIS *m* SEALIN	OFF, 0.00–300.00 sec	89S3PE*m*D := 4.67
EDIS *m* IMMOBI	OFF, 0.00–300.00 sec	89I3PE*m*D := 0.33
EDIS *m* CL CONT	SELOGIC	89RC3PE*m* := 89CC3PE*m*
EDIS *m* CL BLK	SELOGIC	89CB3PE*m* := 89CL3PL*m* OR 89AL3PL*m* OR 89AL3PE*m*
EDIS *m* CL RST	SELOGIC	89CR3PE*m* := 89CL3PE*m* OR 89CS3PE*m* OR 89AL3PE*m*
EDIS *m* CL IM RS	SELOGIC	89CT3PE*m* := NOT 89OP3PE*m*
EDIS *m* OP CONT	SELOGIC	89RO3PE*m* := 89OC3PE*m*
EDIS *m* OP BLK	SELOGIC	89OB3PE*m* := 89CL3PL*m* OR 89AL3PL*m* OR 89AL3PE*m*
EDIS *m* OP RST	SELOGIC	89OR3PE*m* := 89OP3PE*m* OR 89OS3PE*m* OR 89AL3PE*m*
EDIS *m* OP IM RS	SELOGIC	89OT3PE*m* := NOT 89CE3PL*m*

[a] The value of m can be set to any number between 1 and the value of setting 89EN3P.

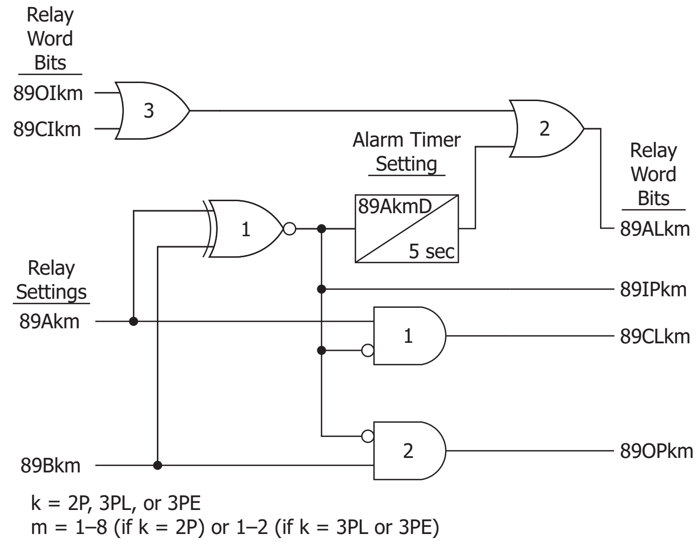


Figure 9.1 Dual-Point Disconnect Status Logic

The close and open logics shown in *Figure 9.2* and *Figure 9.3* are primarily for control of motor-operated disconnects. The settings and control described are not intended for manually operated disconnects and can be ignored. The description of close and open control logics apply to all two- and three-position motor-operated disconnects that are enabled.

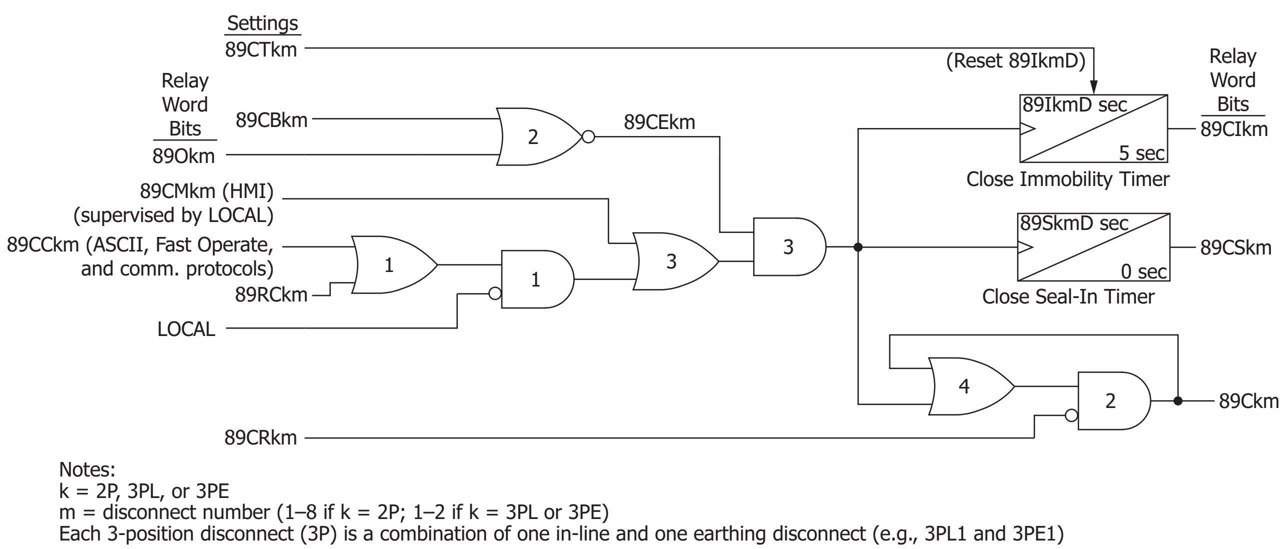


Figure 9.2 Disconnect Close Logic

Close control action of a disconnect can be initiated via the Bay Screens application on the touchscreen HMI (Relay Word bit 89CM*km*) or via remote means, including communications protocols (Relay Word bit 89CC*km*) or SELOGIC control equation settings (89RC*km*). Close control from the HMI requires that local control be enabled (Relay Word bit LOCAL asserted). When Relay Word bit LOCAL is asserted, remote close control is blocked. Use the 89CB*km* SELOGIC control equation setting to block both local and remote control, if required. The logic automatically seals in a successful close signal (Relay Word bit 89C*km*) until the user-defined reset Relay Word bit 89CR*km* asserts. By default, the relay uses the seal-in timer output to avoid a premature reset of the close signal. An immobility timer detects if the disconnect remains in the fully open position for longer than the 89I*km*D time setting after the close signal is issued (89C*km* asserts) by asserting Relay Word bit 89CI*km*.

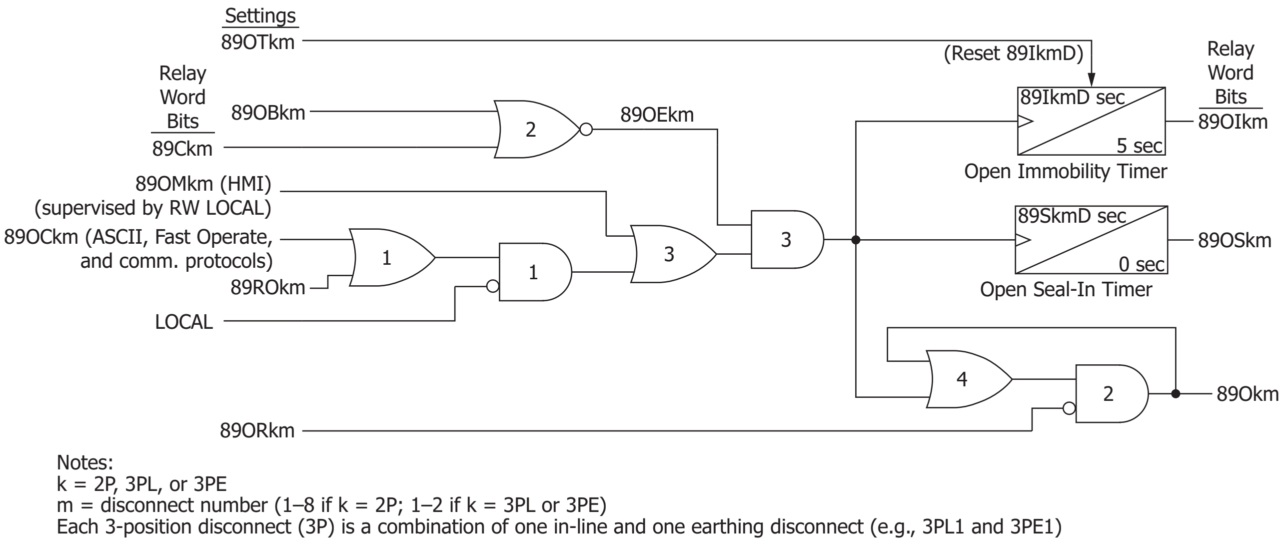


Figure 9.3 Disconnect Open Logic

Similarly, an open control action of a disconnect can be initiated via the Bay Screens application on the touchscreen HMI (Relay Word bit 89OM*km*) or via remote means, including communications protocols (Relay Word bit 89OC*km*) or SELOGIC settings (89RO*km*). Open control from the HMI requires that local control be enabled (Relay Word bit LOCAL asserted). When Relay Word bit LOCAL is asserted, remote close is blocked. Use the 89OB*km* SELOGIC control equation setting to block both local and remote control, if required. The logic automatically seals in a successful open signal (Relay Word bit 89O*km*) until the user-defined reset Relay Word bit 89OR*km* asserts. By default, the relay uses the seal-in timer output to avoid a premature reset of the open signal. An immobility timer detects if the disconnect remains in the fully closed position for longer than the 89I*km*D time setting after the open signal is issued (89O*km* asserts) by asserting Relay Word bit 89OI*km*.

Table 9.4 Disconnect Control Setting Guidelines

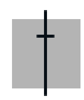
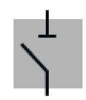
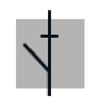
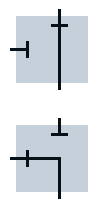
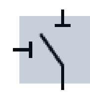
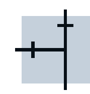
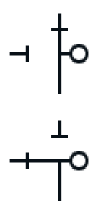
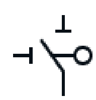
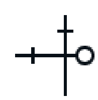
Setting	Remarks
89EN*k*	Enable required number of two- and three-position disconnects
89NM*km*	Label each disconnect with a unique name
89A*km*	SELOGIC control equation for normally open auxiliary contact of the disconnect
89B*km*	SELOGIC control equation for normally closed auxiliary contact of the disconnect
89A*km*D	Operate alarm delay; set longer than the highest expected operate time of the disconnect
89S*km*D	Seal-in delay; set longer than the highest expected operate time of the motor-operated disconnect

The factory-default values of all the other settings should be suitable for most applications, however, they must be reviewed and edited for specific requirements.

Refer to *Table 9.5* for the bay control disconnect settings. Refer to *Bay Control Application Example on page 9.18* for example settings.

Table 9.5 provides typical ANSI and IEC disconnect symbols that are available to use in bay screen design. Column 1 identifies the standard (ANSI/IEC) and the type of disconnect. Column 2 identifies the interior color property of the disconnect. Columns 3, 4, and 5 identify closed, open, and alarm states of the disconnect. For a complete list of ANSI and IEC disconnect symbols available to use with the bay screens, refer to the *ACSELERATOR Bay Screen Builder SEL-5036 Software Instruction Manual*.

Table 9.5 Two- and Three-Position Disconnect Symbols

Type	Interior Color	State 1 (Closed)	State 2 (Open)	State 3 (Alarm)
ANSI and IEC Disconnect (Two-Position)	Gray			
ANSI and IEC Motor-Operated Disconnect (Two-Position)	Transparent			
ANSI and IEC Disconnect (Three-Position)	Gray			
ANSI and IEC Motor-Operated Disconnect (Three-Position)	Transparent			

Local/Remote Control

The Local/Remote Control function and associated settings are common and apply to breakers and disconnects. The SEL-751 supports the local/remote breaker control functionality through supervision of the OC and CC breaker control Relay Word bits and the local/remote disconnect control functionality through supervision of the disconnect open and close control logic (see *Figure 9.2* and *Figure 9.3*). The supervision can be enabled or disabled with Global setting EN_LRC (see *Table 9.6*). To enable local/remote supervision of the breaker and disconnect, set EN_LRC := Y. When EN_LRC := Y, the LOCAL SELOGIC control equation is available.

Table 9.6 Local/Remote Control Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE LOC REM CON	Y, N	EN_LRC := N
LOCAL CONTROL[a]	SELOGIC	LOCAL := 0

[a] This setting is hidden when EN_LRC := N.

The relay controls the status of the LOCAL Relay Word bit based on the EN_LRC setting.

- When EN_LRC := Y and LOCAL := 1, the relay processes the open and close commands from the front panel (two-line display or touchscreen). The commands from remote sources/protocols (ASCII terminal, SEL Fast Operate, DNP, Modbus, EtherNet/IP, IEC 61850, etc.) are blocked.
- When EN_LRC := Y and LOCAL := 0, the relay processes the open and close commands from remote sources/protocols (ASCII terminal, SEL Fast Operate, DNP, Modbus, EtherNet/IP, IEC 61850, etc.). The commands from the front panel are blocked (two-line display or touchscreen).
- When EN_LRC := N, the relay processes the open and close commands from both the front panel (two-line display or touchscreen) and remote sources/protocols (ASCII terminal, SEL Fast Operate, DNP, Modbus, EtherNet/IP, IEC 61850, etc.).

Enable local/remote control for proper supervision of breaker/disconnect 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 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, set EN_LRC := N. When EN_LRC := N, "LR," as shown in *Figure 9.4*, indicates 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 9.18* for example settings.

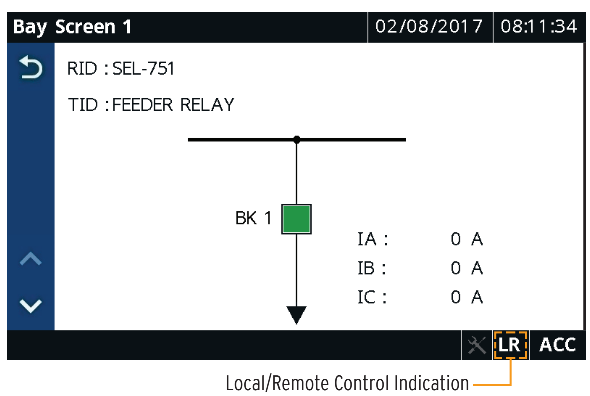


Figure 9.4 Local/Remote Control Mode Indication

Breaker/Disconnect Control Via Touchscreen

The SEL-751 enables you to control breakers from the touchscreen or two-line LCD and disconnects from the touchscreen. Breakers and disconnects can also be controlled through the front-panel operator control pushbuttons. Refer to *Front-Panel Operator Control Pushbuttons on page 8.16* for a discussion on breaker/disconnect 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 and disconnect control via touchscreen.

The touchscreen allows you to control the breaker via two applications: Bay Screens and Breaker Control; however, only the Bay Screens application allows you to control the disconnect switches. The Bay Screens application is available on the Home screen. Breaker and disconnect control via the Bay Screens application requires you to design a bay control single-line diagram. *Figure 9.5* shows a sample single-line diagram with a controllable breaker, disconnects, and analog quantities. For details on how to design a bay screen, refer to *Bay Control Application Example*.

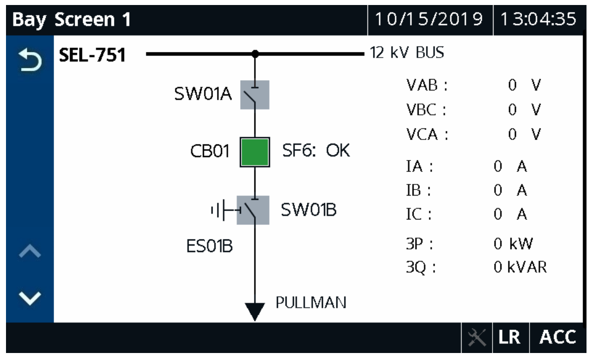


Figure 9.5 Bay Screens Application Display With a Single-Line Diagram

You can also control the breaker via the Breaker Control application, which is available in the Control folder. This application is built-in and is always available for you to perform breaker control. *Figure 9.6* shows the Breaker Control application display.

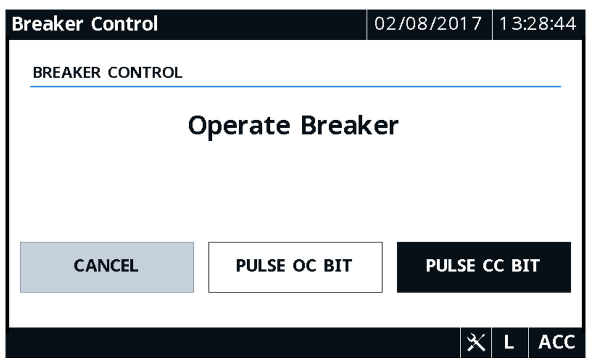


Figure 9.6 Breaker Control Application

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 details on how to program these bits, refer to *Bay Control Application Example*. Also, the Bay Screens application uses the 89OM*km* and 89CM*km* bits to perform disconnect control (see *Figure 9.2* and *Figure 9.3* for details). The relay checks for the following conditions, in the order shown, in both applications. Only when the conditions are satisfied can you perform breaker and/or disconnect control.

1. EN_LRC := Y and Relay Word bit LOCAL is asserted. If EN_LRC := N, then this check is ignored.

2. The breaker control jumper on the main board is installed. The Relay Word bit BKJMP stays asserted when the breaker control jumper is installed. Refer to *Password, Breaker Control, and*

SELBOOT Jumper Selection on page 2.21 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 four or eight pushbuttons and the touchscreen display under the Front-Panel Options drop down as shown in *Figure 9.7*. *Figure 9.8* shows the Touchscreen settings in QuickSet.

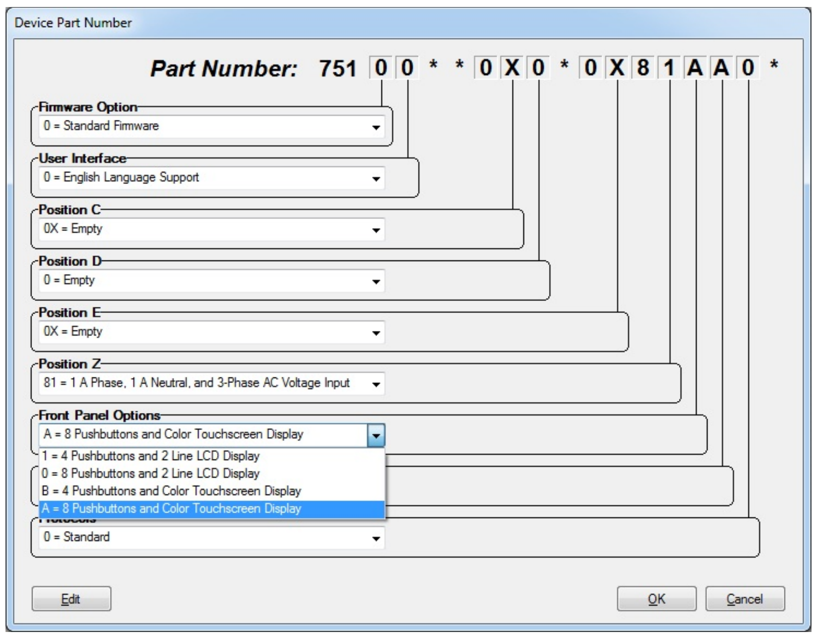


Figure 9.7 QuickSet Front-Panel Options

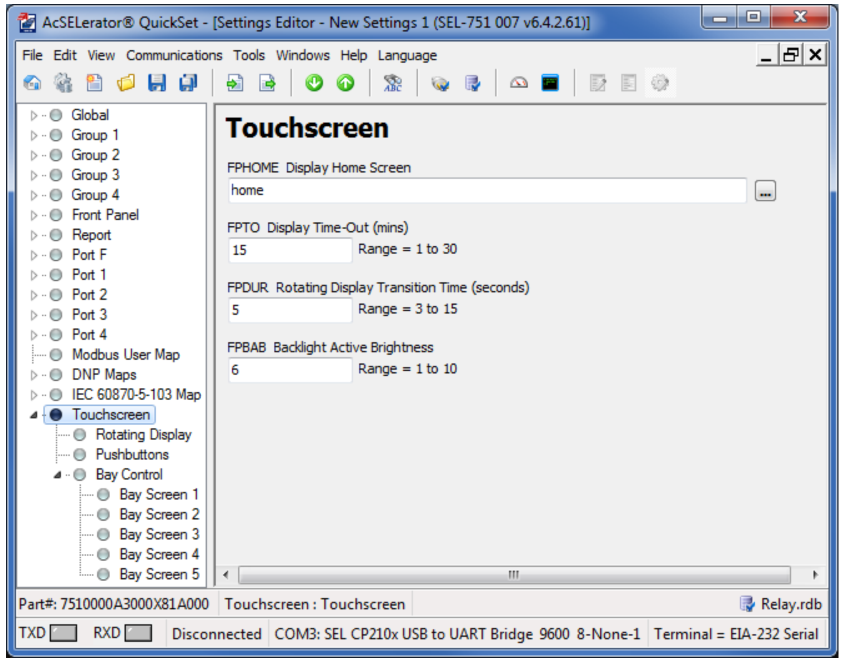


Figure 9.8 QuickSet Touchscreen Settings

Table 9.7 Touchscreen Settings (Sheet 1 of 3)

Setting Prompt	**Setting Range**	**Setting Name := Factory Default**
Display Settings		
Display Home Screen	See *Table 8.17*	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 = 01–04 or 01–08 depending on the ordering option selected)		
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

NOTE: The settings in Table 9.7 are populated under each of the custom screens (sld1–sld5) based on the dynamic symbols you choose.

Table 9.7 Touchscreen Settings (Sheet 2 of 3)

Setting Prompt	Setting Range	Setting Name := Factory Default
Bay Control Two-Position Disconnect Settings (m = 1–8)		
Two-Position Disconnect Close Status	Relay Word bit	2DS*m*CS :=
Two-Position Disconnect Open Status	Relay Word Bit	2DS*m*OS :=
Two-Position Disconnect In-Progress Status	Relay Word Bit	2DS*m*IS := NA
Two-Position Disconnect Alarm Status	Relay Word Bit	2DS*m*AS := NA
Two-Position Disconnect HMI Close Command	89CM2P1–89CM2P16	2DS*m*CL := NA
Two-Position Disconnect HMI Open Command	89OM2P1–89OM2P16	2DS*m*OP := NA
Bay Control Three-Position Disconnect Settings (m = 1–2)		
Three-Position In-Line Disconnect Close Status	Relay Word bit	3ID*m*CS :=
Three-Position In-Line Disconnect Open Status	Relay Word Bit	3ID*m*OS :=
Three-Position In-Line Disconnect In-Progress Status	Relay Word Bit	3ID*m*IS := NA
Three-Position In-Line Disconnect Alarm Status	Relay Word Bit	3ID*m*AS := NA
Three-Position In-Line Disconnect HMI Close Command	89CM3PL1–89CM3PL2	3ID*m*CL := NA
Three-Position In-Line Disconnect HMI Open Command	89OM3PL1–89OM3PL2	3ID*m*OP := NA
Three-Position Earthing Disconnect Close Status	Relay Word Bit	3ED*m*CS :=
Three-Position Earthing Disconnect Open Status	Relay Word Bit	3ED*m*OS :=
Three-Position Earthing Disconnect In-Progress Status	Relay Word Bit	3ED*m*IS := NA
Three-Position Earthing Disconnect Alarm Status	Relay Word Bit	3ED*m*AS := NA
Three-Position Earthing Disconnect HMI Close Command	89CM3PE1–89CM3PE2	3ED*m*CL := NA
Three-Position Earthing Disconnect HMI Open Command	89OM3PE1–89OM3PE2	3ED*m*OP := NA
Bay Control Analog Label Settings (qq = 01–32)		
Analog Quantity	Analog Quantity	ALAB01 := STRING_RID
Analog Quantity	Analog Quantity	ALAB02 := STRING_TID
Analog Quantity	Analog Quantity	ALAB03 := IA_MAG

Table 9.7 Touchscreen Settings (Sheet 3 of 3)

Setting Prompt	Setting Range	Setting Name := Factory Default
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. Pressing 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* = 01–04 or 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., PB01 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 controllable. 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 9.18* for sample breaker settings.

Bay Control Disconnect Settings

The bay control disconnect settings are only available if the designed single-line diagram has at least one disconnect symbol. When QuickSet detects one or more disconnect symbols as part of the single-line diagram, it populates the corresponding settings. The SEL-751 supports eight two-position and two three-position disconnects. Set the DS*n*CS and DS*n*OS settings to the corresponding Relay Word bits that indicate the closed and open status of the disconnect. Map the output of the disconnect alarm logic, 89AL*km* (see *Figure 9.1*), to the corresponding DS*n*AS setting. A successful close or open command from the HMI asserts the corresponding 89CM*km* or 89OM*km* Relay Word bit used in *Figure 9.2* and *Figure 9.3*, respectively. Refer to *Bay Control Application Example on page 9.18* for example disconnect settings.

Bay Control Analog Label Settings

The analog label settings are only available if the designed bay screen has at least one analog label. When QuickSet detects one or more analog labels as part of the bay screen, it populates the corresponding settings. The SEL-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 M.1* for the list of analog quantities available to program into analog labels.

Bay Control Digital Label Settings

The digital label settings are only available if the designed bay screen has at least one digital label. When QuickSet detects one or more digital labels as part of the bay screen, it populates the corresponding settings. The SEL-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 L.1* for the list of Relay Word bits available to program into digital labels.

Bay Screen Builder Software

NOTE: A complete list of UTF-8 characters that can be rendered on the touchscreen display is available at selinc.com on the applicable product page.

The Bay Screen Builder Software provides an intuitive and powerful interface to design bay screens to meet your application needs. This instruction manual provides only a brief overview of the Bay Screen Builder Software. For more details, refer to the *ACSELERATOR Bay Screen Builder SEL-5036 Software Instruction Manual* available from the **Help** > **Contents** menu in Bay Screen Builder or at selinc.com.

Several of the settings identified in *Table 9.7* are available for you to set depending on the symbols chosen for your single-line diagram. *Figure 9.9* shows the layout of Bay Screen Builder and identifies different menus, panes, and information.

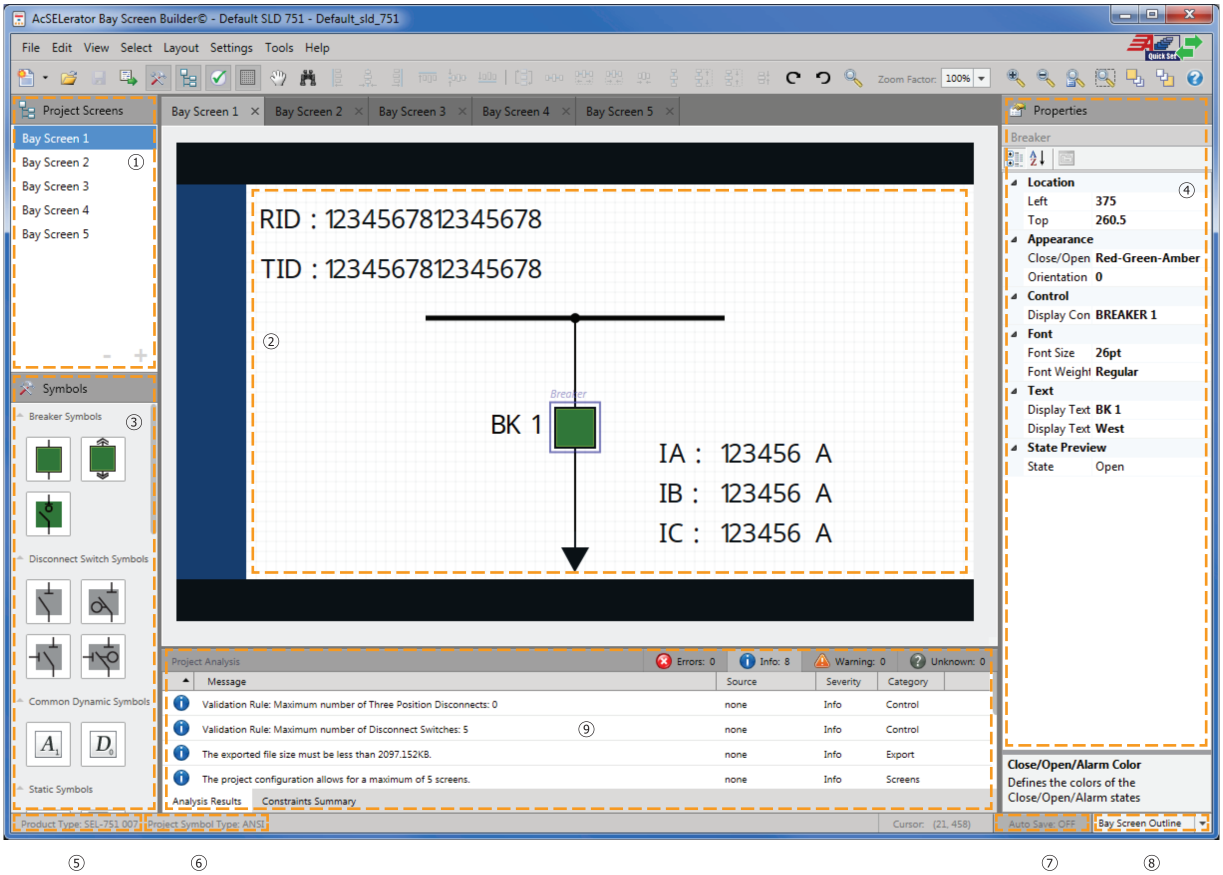


Figure 9.9 Layout of Bay Screen Builder

Descriptions of the different menus, panes, and information in Bay Screen Builder are as follows:

① **Project Screens Pane:** Displays the names of the screens (as many as 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, disconnects, analog labels, and digital labels supported in a given project.

Symbols	Number of Supported Symbols per Project
Breakers	1
Two-Position Disconnects	8
Three-Position Disconnects	2
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 9.21*). Bay Screen Builder supports UTF-8 character encoding. A complete list of UTF-8 characters that can be rendered on the touchscreen display is available at selinc.com on the applicable product page.

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 9.9*). 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. You can export the project file with a different QuickSet driver version using **File** > **Export Package As**.

⑥ **Project Symbol Type:** Displays the symbol type (IEC or ANSI) associated with the selected project as shown in *Figure 9.9*. Select the symbol type when you create a new project. If a project is edited via QuickSet, the ANSI symbol type is selected by default.

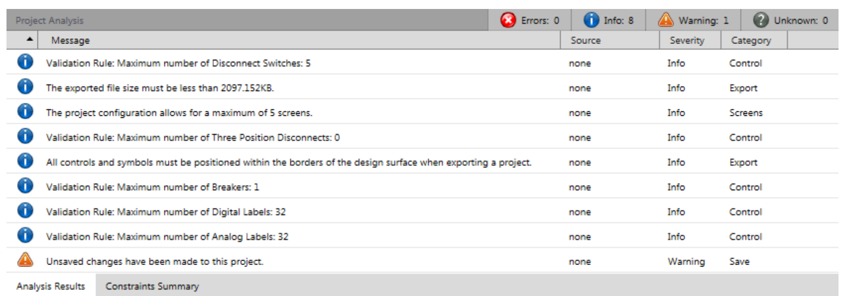
⑦ **Auto Save:** Provides a shortcut for changing the auto save setting for the application. Enable **Auto Save** to allow Bay Screen Builder to automatically save your project periodically. Your auto save setting preference is saved when you exit the application and is applied the next time you launch Bay Screen Builder. You can also set **Auto Save** through **Settings** > **Application Settings** > **File Handling**.

⑧ **Bay Screen Outline:** Displays the drop-down list of symbols on the presently open screen. Click a symbol from the list to make it active. The bay screen outline provides an alternate way to select the symbols and is most useful in cases where symbols are crowded or stacked.

⑨ **Project Analysis Pane:** Displays troubleshooting information/ messages about the project (Errors, Info, Warning, Unknown). The project analysis pane supports two tabs: Analysis Results and Constraints Summary, as shown in *Figure 9.8* and *Figure 9.9*, 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 9.10*).

The **Constraints Summary** tab provides information about the rules that apply to the present project. All conditions listed under Symbol Constraints must be satisfied for a project to be valid. You can only publish a valid project, but you can save a project with errors (see *Figure 9.11*).


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 9.10 Project Analysis Pane: Analysis Results Tab

NOTE: The Constraints Summary tab shows the usage and limits of dynamic symbols for an entire project (all screens). Although not constrained, it is recommended that you limit the dynamic symbols to 32 symbols per screen for faster screen updates.

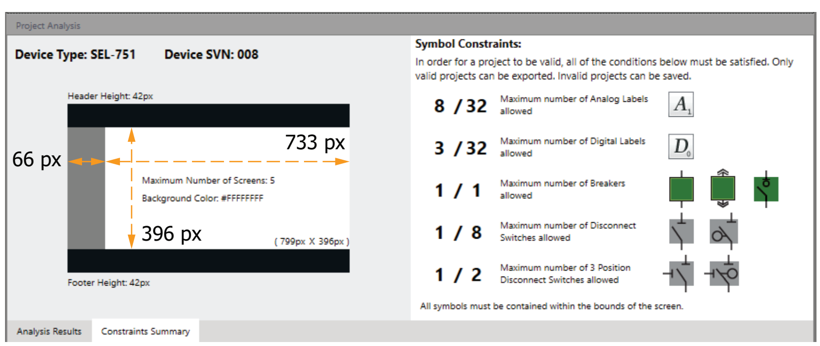


Figure 9.11 Project Analysis Pane: Constraints Summary Tab

You can adjust the size of the panes in the application. If you reconfigure the size of any of these panes, the new size is saved when you exit the application and applies the next time you launch Bay Screen Builder.

Bay Control Application Example

Specific components of bay screens are covered in *Bay Screens Design Using QuickSet and Bay Screen Builder*. This section provides a summarized application example tying all the components together. Refer to the *ACSELERATOR Bay Screen Builder SEL-5036 Software Instruction Manual*, available from the **Help** > **Contents** menu in Bay Screen Builder or at selinc.com, for more specific details regarding bay screen creation and symbol properties.

The SEL-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 9.14*). You can also download one of the five predefined bay control single-line diagrams available at selinc.com. Refer to *Predefined Bay Control Single-Line Diagrams on page 9.28* for more details.

Consider if you were to create the single-line diagram shown in *Figure 9.12* as part of your application. Use the following step-by-step approach to design the single-line diagram beginning with the predefined bay screen (Bay Screen 1).

Before creating your own diagram, ensure that the number of dynamic symbols in your schematic does not exceed the number allowed by the SEL-751 (see *Figure 9.9* and the symbols pane description).

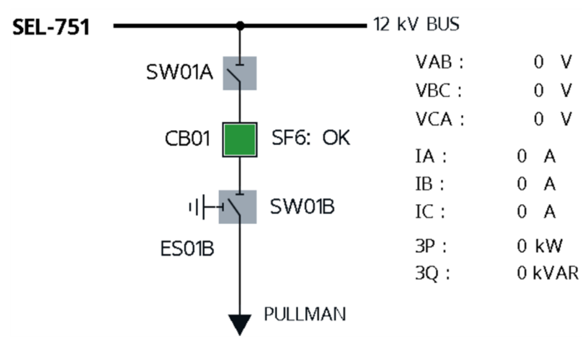


Figure 9.12 Bay Control Single-Line Diagram Schematic

Configure QuickSet for Bay Screen Builder

NOTE: The touchscreen display option is only available for SEL-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” or “B” 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 9.13*).

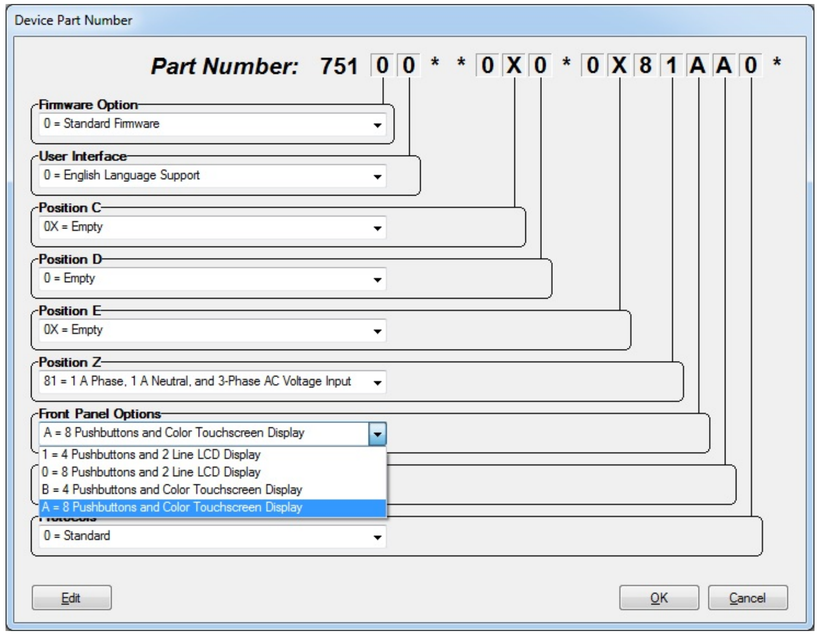


Figure 9.13 Device Part Number Touchscreen Configuration Option

Step 2. Click **OK**.

Step 3. Expand the Touchscreen settings class.

Step 4. Click **Bay Control**.

QuickSet displays project management buttons and a project preview that includes a small-scale view of five project screens (one screen with a predefined single-line diagram and four blank screens) and an enlarged view of the predefined single-line diagram, which is selected by default (see *Figure 9.14*).

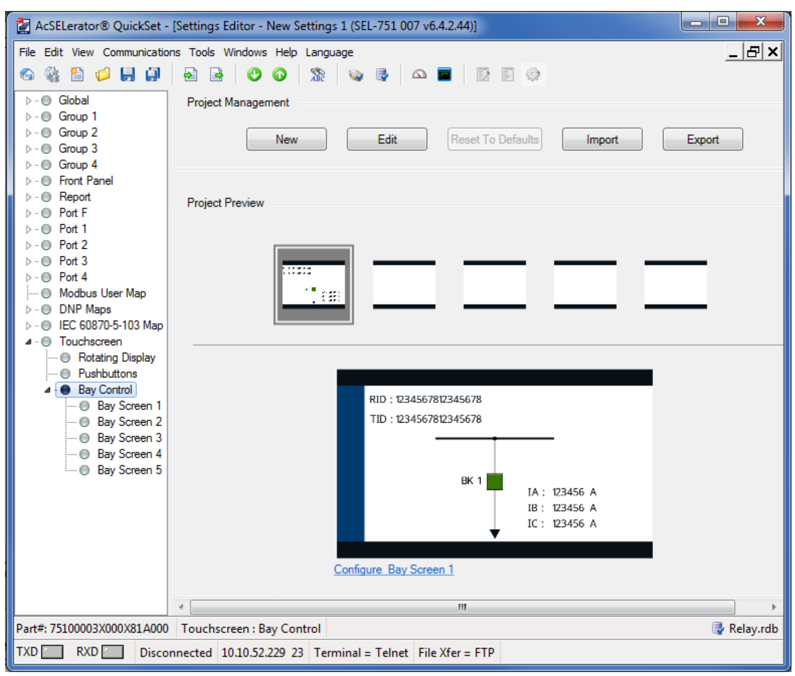


Figure 9.14 QuickSet Bay Control Project Management and Project Preview Display

Build Single-Line Diagrams in Bay Screen Builder

Use Bay Screen Builder to create single-line diagrams to load onto the SEL-751 through QuickSet. To create the single-line diagram shown in *Figure 9.12*, perform the following steps.

Step 1. Select the screen with the default single-line diagram shown in *Figure 9.15* as a starting point for your single-line diagram.

Step 2. Click **Edit** (*Figure 9.15*) to open the screen with the default single-line diagram in Bay Screen Builder.

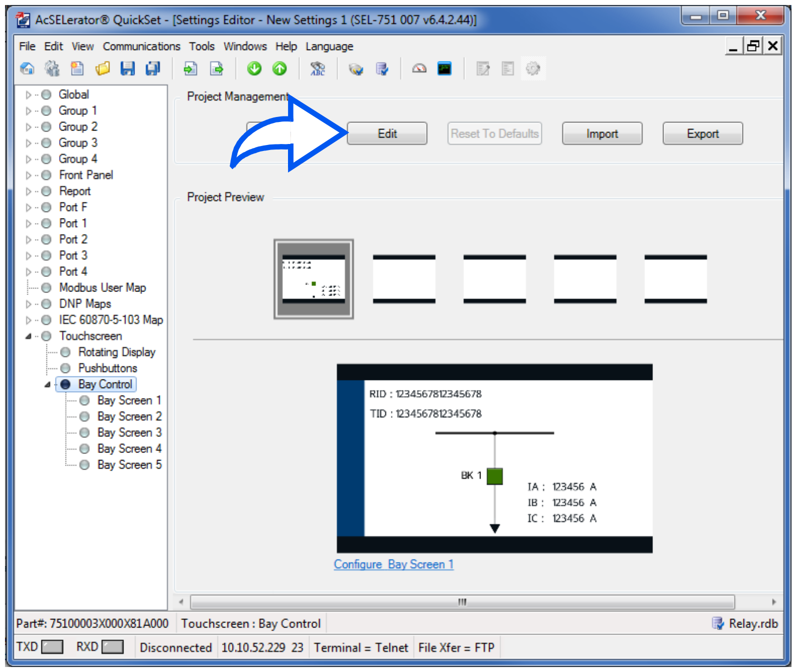


Figure 9.15 Open Single-Line Diagram in Bay Screen Builder

Step 3. Drag-and-drop the additional symbols required for your single-line diagram onto the screen area from the Symbols pane (see *Figure 9.16*). Remove the unused labels (RID/TID).

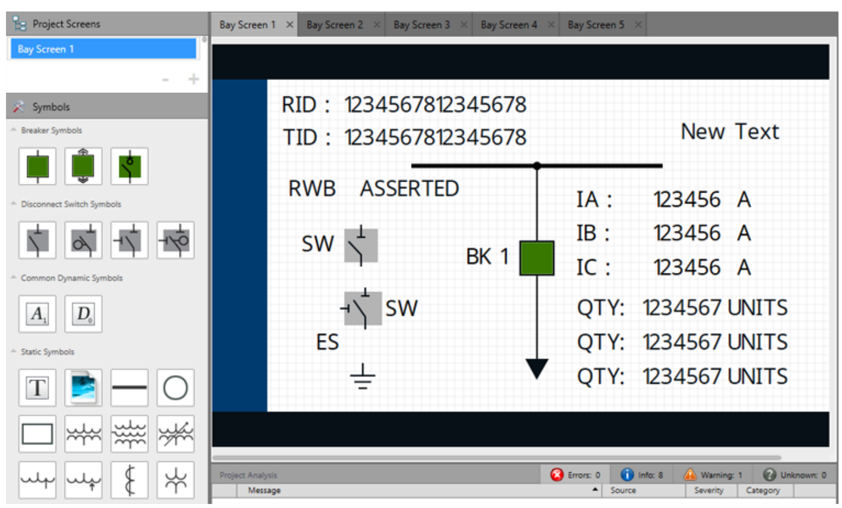
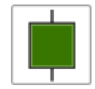
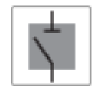
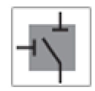
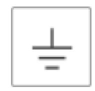
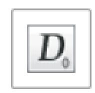
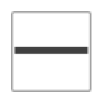


Figure 9.16 Drag-and-Drop Symbols

Table 9.8 lists the number of each symbol required to draw the single-line diagram shown in *Figure 9.12*.

Table 9.8 Symbols Required for the Single-Line Diagram Schematic in Figure 9.12

Symbols Required	Number of Symbols Required	Symbol
Breaker	1	
Two-position disconnects	1	
Three-position disconnects	1	
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 9.17*.

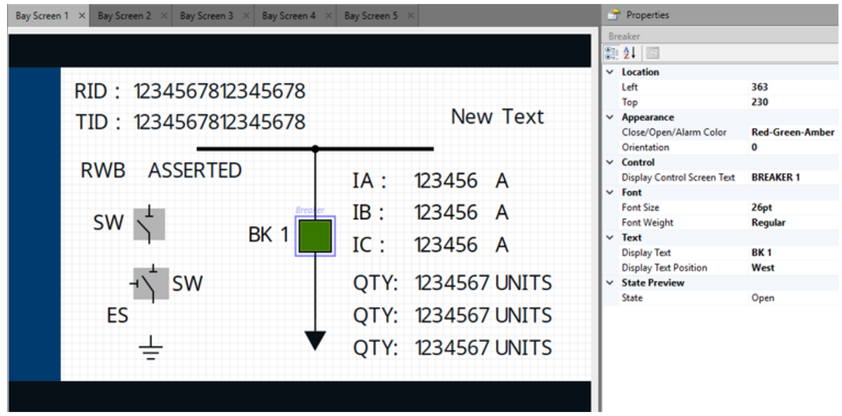


Figure 9.17 Selected Breaker Symbol Settings Displayed in the Properties Pane

Step 2. Select a color option from the drop down menu to edit the Close/Open/Alarm Color property in the Appearance tab (see *Figure 9.18*).

Table 9.1 lists the available options and breaker appearance in each state based on the selected property.

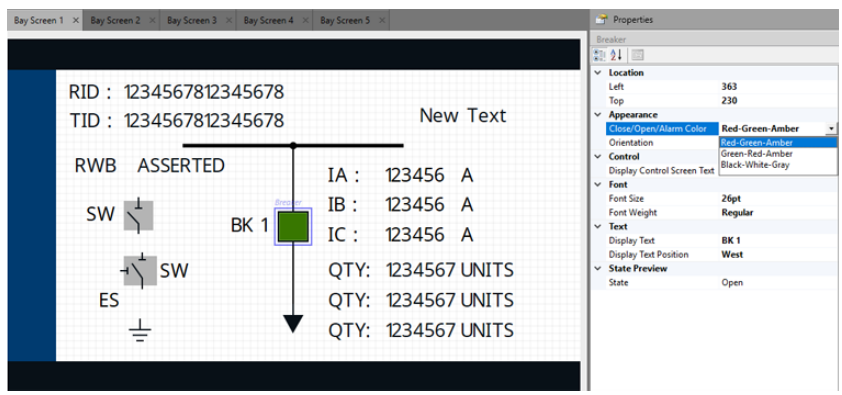


Figure 9.18 Close/Open/Alarm Color Property Drop Down Menu

Step 3. Use the State Preview tab to view your breaker close, open, and alarm state color selections.

Step 4. Edit the additional properties as needed for your application.

NOTE: If sufficient width is not provided for the value field of the analog label, the label is rendered as "$$$$$."

NOTE: The assignment of breaker Relay Word bits (e.g., 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 disconnects, dynamic labels (analog and digital labels), and static symbols, similar to the breaker symbol. Note that some of the symbols have the Text tab that can be edited for custom labeling.

In this example, only Bay Screen 1 has been modified in the project. You can also modify the other screens to add analog/digital labels to monitor the status of the quantities, if necessary. Publish the project using the following process after saving your edits.

Publish Bay Screen Builder Project

When you have completed your single-line diagram in Bay Screen Builder, you are ready to publish your project to QuickSet.

Step 1. Click **File** > **Save Project** to save your project.

Step 2. Click **File** > **Publish Package** to publish your project (see *Figure 9.19*). Bay Screen Builder exports the project into QuickSet.

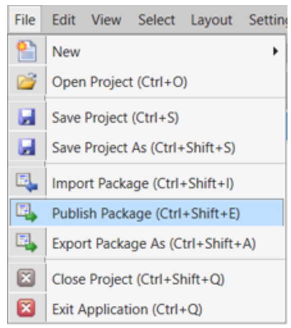


Figure 9.19 Publish Bay Screen Builder Project to QuickSet

Step 3. Allow a few seconds for Bay Screen Builder to publish the project to QuickSet. Respond to the QuickSet prompt, if presented. QuickSet then populates the settings of the updated single-line diagram (see *Figure 9.20*).

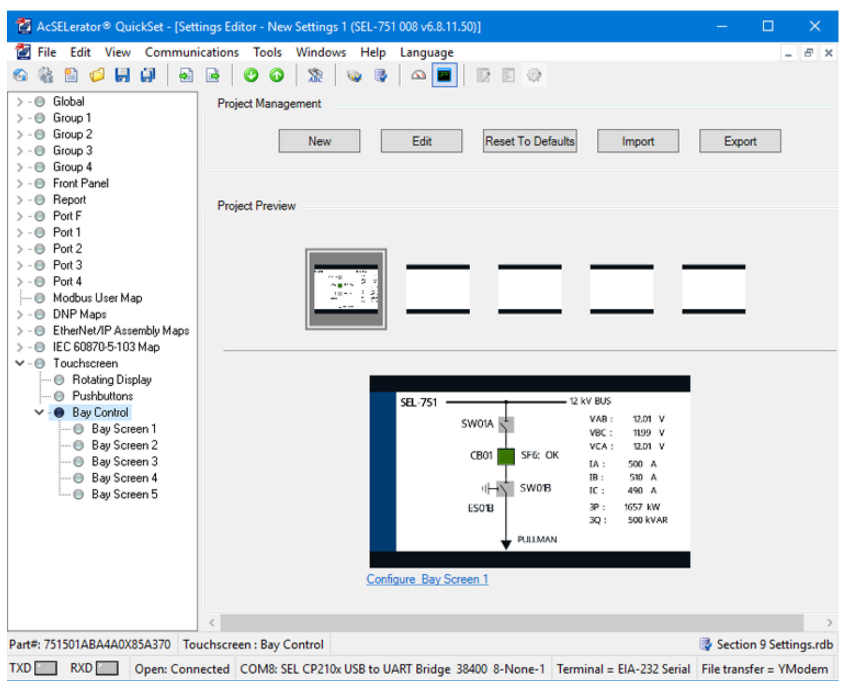


Figure 9.20 QuickSet Updated Single-Line Diagram and Corresponding Settings

Enter QuickSet Settings

The breaker, disconnect, analog and digital label, local/remote, and trip and close settings that follow are the settings applicable to the single-line diagram shown in *Figure 9.12*. Enter the following settings.

Breaker Settings

NOTE: The relay does not support dual-point breaker status (see Bay Control Breaker Settings) and uses the 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 9.12*, 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 Settings

For this example, the relay has an 8 DI card in Slot C. Also, the disconnect auxiliary contacts 89A and 89B for the two disconnects are wired to digital inputs IN301, IN302, IN303, IN304, IN305, and IN306. Disconnect settings other than those specified in the table are set to the factory-default values. Refer to *Table 9.2* for all the disconnect setting prompts and factory-default values. Disconnect settings are included in more than one settings class in QuickSet (Global, Bay Control). Enter the following settings:

NOTE: For three-position disconnects, the relay has one setting, 89NM3Pm, to name the disconnect. You can name the in-line and earthing disconnects separately through the Bay Screens application.

Setting	Example Setting	Comment
Global > Two-Position Disconnect Settings		
89NM2P1	SW01A	Disconnect 1, name
89A2P1	IN301	Disconnect 1, A contact
89B2P1	IN302	Disconnect 1, B contact
Global > Three-Position Disconnect Settings		
89NM3P1	SW01B	Disconnect 1, name
89A3PL1	IN303	In-Line Disconnect 1, A contact
89B3PL1	IN304	In-Line Disconnect 1, B contact
89A3PE1	IN305	Earthing Disconnect 1, A contact
89B3PE1	IN306	Earthing Disconnect 1, B contact
Touchscreen > Bay Control > Bay Screen 1		
Two-position disconnect close status	89CL2P1	Disconnect SW01A
Two-position disconnect open status	89OP2P1	
Two-position disconnect alarm status	89AL2P1	
Two-position disconnect in-progress status	89IP2P1	
Two-position disconnect HMI close command	89CM2P1	
Two-position disconnect HMI open command	89OM2P1	
Three-position in-line disconnect close status	89CL3PL1	Disconnect SW01B
Three-position in-line disconnect open status	89OP3PL1	
Three-position in-line disconnect alarm status	89AL3PL1	
Three-position in-line disconnect in-progress status	89IP3PL1	
Three-position in-line disconnect HMI close command	89CM3PL1	
Three-position in-line disconnect HMI open command	89OM3PL1	
Three-position earthing disconnect close status	89CL3PE1	Disconnect ES01B
Three-position earthing disconnect open status	89OP3PE1	
Three-position earthing disconnect alarm status	89AL3PE1	
Three-position earthing disconnect in-progress status	89IP3PE1	
Three-position earthing disconnect HMI close command	89CM3PE1	
Three-position earthing disconnect HMI open command	89OM3PE1	

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 9.12*, 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 9.12 is programmed with the local/remote functionality.

Enter the following Global, Control Configuration setting:

Setting	Example Setting	Comment
EN_LRC	Y	Enable local/remote control

Application With Handheld Local Remote Breaker Control Switch

Assume that the handheld local remote breaker control switch status is wired to IN308 of the relay. In this particular application, when IN308 is asserted, it implies that the breaker control is in LOCAL mode (or SCADA is cut off).

Enter the following Global, Control Configuration setting:

Setting	Example Setting	Comment
LOCAL	IN308	Local/remote control selection

Application Without Handheld Local Remote Breaker Control Switch

Assume that no handheld local remote breaker control switch is available. In such case you can program one of the programmable pushbuttons (in touchscreen model with 8 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 9.21*. 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.

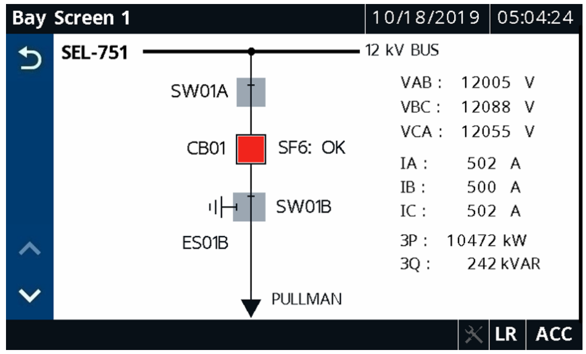


Figure 9.21 Final Bay Screen Builder Rendering

Export/Import Bay Screen Builder Project File

If you plan to use the same Bay Screen Builder project file (*.ldme) across multiple relays, export the file as shown in *Figure 9.22* and save the file to import it to another relay. The *.ldme file does not save the settings associated with the bay control symbols.

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**).

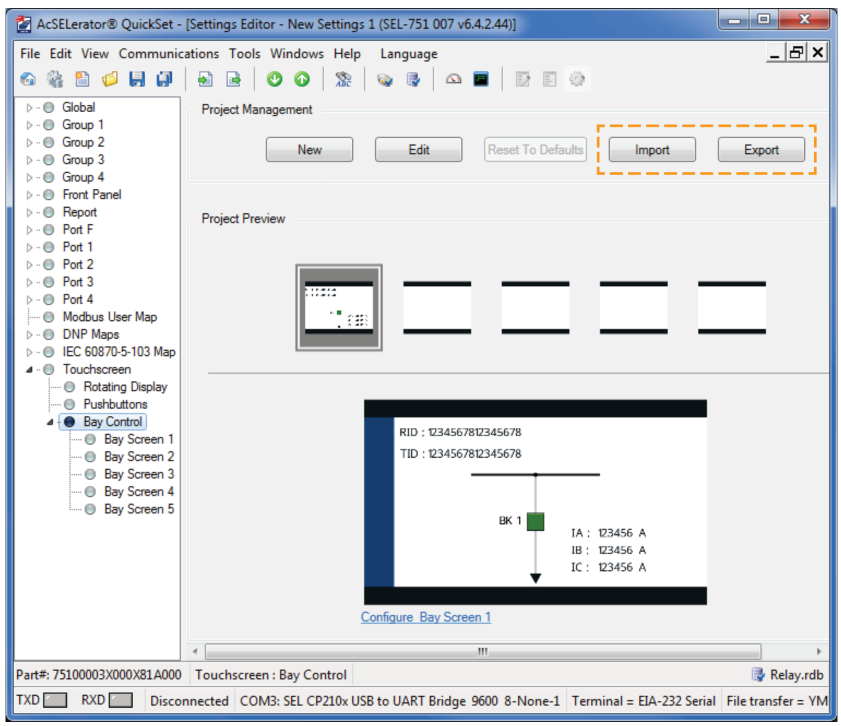


Figure 9.22 Import/Export of the Bay Control Screen in QuickSet

Reset to Defaults

Click **Reset to Defaults** in the QuickSet Project Management section to restore the default project in QuickSet.

Predefined Bay Control Single-Line Diagrams

Bay Screen Builder provides the ability to design bay control single-line diagrams. The following predefined single-line diagrams are available at selinc.com. 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 at selinc.com.

ANSI and IEC

The predefined single-line diagrams are provided at selinc.com as .ldme files. Each of the following single-line diagrams is provided as an ANSI and an IEC single-line diagram:

- Main Bus and Transfer Bus
- Tie Breaker
- Bus 1 and Bus 2
- Feeder
- Incomer With Step-Down Transformer

Figure 9.23 shows the ANSI predefined bay control single-line diagram for a main bus and transfer bus application.

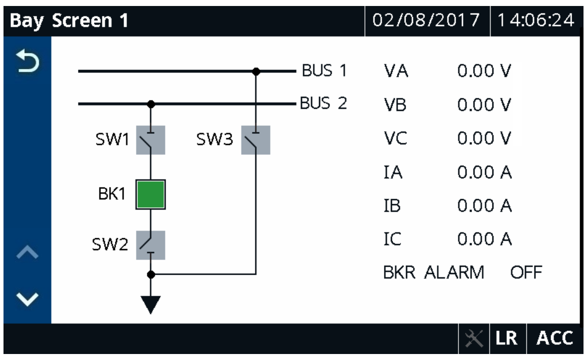


Figure 9.23 ANSI Main Bus and Transfer Bus

Figure 9.24 shows the IEC predefined bay control single-line diagram for a main bus and transfer bus application.

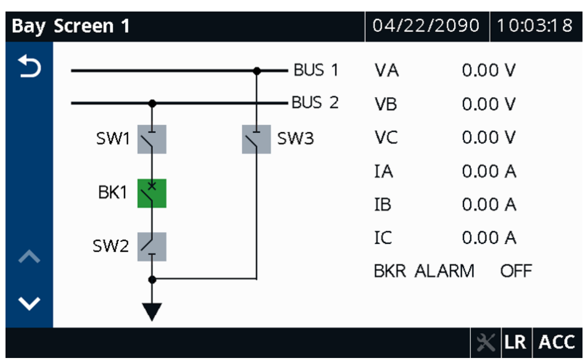


Figure 9.24 IEC Main Bus and Transfer Bus

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 ms

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 types of event reports: Standard ASCII (EVE) reports, Compressed ASCII (CEV) reports, Binary COMTRADE reports, and Sequential Event Recorder (SER) reports.

Event Reporting

Analyze events with the following event reporting functions:

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.

- 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.

Each time an event occurs, a new summary, history record, and report are created. Event report information includes:

- Date and time of the event
- Individual sample analog inputs (currents and voltages)
- Digital states of selected Relay Word bits (listed in *Table L.1*)

- Event summary, including the front-panel target states at the time of tripping, fault type, and fault location.
- Group, Logic, Global, and Report settings (that were in service when the event was triggered)
- Relay part number and serial number to identify the relay model type

Compressed Event Reports

The SEL-751 provides Compressed ASCII and COMTRADE event reports to facilitate event report storage and display. SEL communications processors and the SEL-5601-2 SYNCHROWAVE Event Software take advantage of the Compressed ASCII and COMTRADE formats. Use the **CHIS** command to display Compressed ASCII event history information. Use the **CSUM** command to display Compressed ASCII event summary information. Use the **CEVENT** command to display Compressed ASCII event reports.

For accurate event report analysis, use the Compressed Event report with raw (unfiltered) data (**CEV R** command). The regular ASCII Event report is useful for a quick check. See *Table C.2* for further information.

Compressed ASCII Event Reports contain *all* of the Relay Word bits. 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, 180, or 300 cycles. Prefault length is 1–10 cycles for LER = 15, 1–59 cycles for LER = 64, 1–175 cycles for LER = 180, and 1–295 cycles for LER = 300. 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 five of the most recent 300-cycle, eight of the most recent 180-cycle, twenty of the most recent 64-cycle, or as many as forty of the most recent 15-cycle event reports in nonvolatile memory. Refer to the **SET R** command in *SET Command (Change Settings) on page 7.73* and *Report Settings (SET R Command) on page SET.90*.

Triggering

The SEL-751 triggers (generates) an event report when any of the following occur:

- Relay Word bit TR 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 4.101*. 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 7.73*). 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 4.245*.

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 7.82* for more information on the **TRI** (Trigger Event Report) command.

Event Summaries

IMPORTANT: Clearing the history report with the **HIS C** or **HIS CA** command clears all event data within the SEL-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 44 of the most recent event summaries (if event report length setting LER := 15), as many as 21 (if LER := 64), as many as 8 (if LER := 180), or as many as 4 (if LER := 300). 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)
- Event number, unique event reference number, date, time, event type (see *Table 10.1*), fault location, and frequency
- Primary magnitudes of line, neutral, and residual currents
- Primary magnitudes of the line-to-neutral voltages and residual voltage (if DELTA_Y := WYE) or phase-to-phase voltages (if DELTA_Y := DELTA); if SINGLE := Y and DELTA_Y := WYE, voltages reported are $\sqrt{3}$ times measured value of SING_VIN setting
- The hottest RTD temperatures, SEL-2600 RTD Module or internal RTD card option necessary

The relay includes the event summary in the event report. The identifiers, date, and time information are at the top of the event report, and the remaining information follows at the end (see *Figure 10.3*). The example event summary in *Figure 10.1* corresponds to the standard 15-cycle event report in *Figure 10.3*.

```
=>>SUM <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

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

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 10.9*** for details). The Event Reference Number starts at 10000 and increments with each new event to a maximum of 42767. The Event Reference Number rolls over to 10000 after reaching the next event after event 42767. The Event Reference Number can be reset to 10000 by using the **HIS CA** command.

Event Type

The `Event` field displays the event type. Event types and the logic used to determine event types are shown in order of priority in *Table 10.1*. 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 A2 50 Trip	50A2P * (50P2T + 67P2T) * TRIP[a]

Table 10.1 Event Types (Sheet 2 of 2)

Event Type	Event Type Logic
Phase B2 50 Trip	50B2P * (50P2T + 67P2T) * TRIP[a]
Phase C2 50 Trip	50C2P * (50P2T + 67P2T) * 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]
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 + BFTRIP) * TRIP
CommIdleLossTrip	(COMMIDLE + COMMLOSS) * TRIP
Broken Cond A	BCDETA * TRIP
Broken Cond B	BCDETB * TRIP
Broken Cond C	BCDETC * TRIP
Phase Discont A	PDDETA * TRIP
Phase Discont B	PDDETB * TRIP
Phase Discont C	PDDETC * TRIP
Phase A INC Trip	50INCTA * TRIP
Phase B INC Trip	50INCTB * TRIP
Phase C INC Trip	50INCTC * TRIP
Neutral INC Trip	50INCTN * TRIP
Trigger	Trigger command
ER Trigger	ER equation assertion[a]
Trip	TRIP with no known cause
Trip*	Upon cycling power on the relay if the **TRIP** LED is latched and no active TRIP exists

[a] The GFLT bit asserts if any one of the residual or neutral overcurrent or residual 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

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
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 locating 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.

If FSA, FSB, or FSC Relay Word bits are not asserted, the relay further evaluates the event type based on the negative-sequence current magnitude. If |I2| < 0.2 * |I1|, Phase_A, Phase_B, and Phase_C Relay Word bits are asserted. The SELOGIC control equation FAULT has to be picked up for three-phase fault indication. If |I2| <0.2 * |I1| condition is not satisfied, the relay evaluates the fault type based on the magnitude of maximum phase-to-phase current IPPmax to assert the combination of PHASE_A or PHASE_B or PHASE_C Relay word bits.

Phase_A and Phase_B are asserted if current IAB = IPPmax.

Phase_B and Phase_C are asserted if current IBC = IPPmax.

Phase_C and Phase_A are asserted if current ICA = IPPmax.

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 locating 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 any ground or neutral Relay Word bits are asserted, the relay sets the GFLT Relay Word bit.

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 setting EFLOC := 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 *Line Parameter Settings on page 4.14*). 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. The relay uses line charging current-based fault location subjected to a broken conductor event. For more information, refer to *Broken Conductor Fault Locating on page 4.106*.

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 Report settings LER := 64, LER := 180, or LER := 300, 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 cosine-filtered phase current during an event. The instant the maximum cosine-filtered phase current occurs is marked by an asterisk (*) in the event report (see *Figure 10.3*). This row of data corresponds to the analogs shown in the summary report for the event. Furthermore, the relay looks at DI_A, DI_B, and DI_C Relay Word bits to determine if the peak detector is active at the trigger point (>) of the event. If active, it will show the peak detector output current in the summary report appended with “pk” string for the corresponding phase current instead of the maximum cosine-filtered phase current identified by the asterisk (*).

The `Current Mag` fields display the primary current magnitudes at the instant when the maximum 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 (see *Table 10.1*), and fault location
- Maximum feeder current
- Frequency
- Target LED status

```
==>>HIS <Enter>

SEL-751                                  Date: 12/26/2023   Time: 14:07:23.358
FEEDER RELAY                             Time Source: Internal


FID=SEL-751-X658-V0-Z101100-D20231219
```

Figure 10.2 Sample Event History

#	REF	DATE	TIME11:07:50.605	EVENT	LOCAT	CURRENT	FREQ	TARGETS
1	10007	12/26/2023	11:07:48.466	Phase 51 Trip	100.3	123.5	60.0	11010000
2	10006	12/26/2023	11:07:46.320	Phase 50 Trip	21.1	7834.3	60.0	11110000
3	10005	12/26/2023	11:07:44.169	59 Trip	14.7	10.4	60.0	11000000
4	10004	12/26/2023	11:07:42.023	Trigger	67.5	761.3	60.0	10000000
5	10003	12/26/2023	11:07:39.860	Remote Trip	89.4	2300.8	60.0	11000000
6	10002	12/26/2023	11:07:37.704	NEG SEQ 51 Trip	34.5	8563.1	60.0	11000100
7	10001	12/26/2023		UndrFreq 81 Trip	10.1	345.2	60.0	11000010
Event Number				Event Type	Fault Location	Maximum Current	Frequency	User-Defined Target LEDs

Figure 10.2 Sample Event History (Continued)

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 7.58* 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 (includes relay serial number in Compressed ASCII event reports)
- Settings in service at the time of event triggering, consisting of Group, Logic, Global, and Report settings classes

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 7.78*) 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 VBAT (terminals VBAT+, VBAT–)

Table 10.4 Output, Input, Protection, and Control Element Event Report Columns (Sheet 1 of 3)

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

Table 10.4 Output, Input, Protection, and Control Element Event Report Columns (Sheet 2 of 3)

Column Heading	Column Symbols	Description
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
	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

Table 10.4 Output, Input, Protection, and Control Element Event Report Columns (Sheet 3 of 3)

Column Heading	Column Symbols	Description
	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 10.16*.

In *Figure 10.3*, an arrow (>) in the column following the `VDC` column identifies 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.

```
=>>EVE <Enter>

SEL-751                                  Date: 03/11/2015    Time: 14:16:39.043
FEEDER RELAY

Serial Number=000000000000000

FID=SEL-751-X272-V0-Z006002-D20150103       CID=05A2

                                                            55555 55[a]8   0
                                                            11111 00 1 I u
                                                            A      N   n t
       Currents (A Pri)           Voltages (V Pri)          B      Q   1 13
IA     IB     IC     IN     IG     VAB    VBC    VCA        VS VDC CPNGQ PG   2 2

[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
  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
[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
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
[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
 -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
```

Annotations (right of the report, top to bottom):

- Data and Time of Event
- Firmware and Checksum Identifier
- [a]Replaced with 67 (directional overcurrent) when setting EDIR := Y or AUTO
- Optional 2 AVI/4 AFDI or 4 AVI/7 DI Card Required
- One Cycle of Data
- Maximum Phase Current
- Trigger Row
- See Figure 10.4 and Figure 10.5

Figure 10.3 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution

```
[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
```

```
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
```

Figure 10.3 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution (Continued)

```
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
```

```
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
```

Figure 10.3 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution (Continued)

```
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

LDLIST  := NA

LDAR    := 15
```

Figure 10.3 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution (Continued)

```
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)

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.

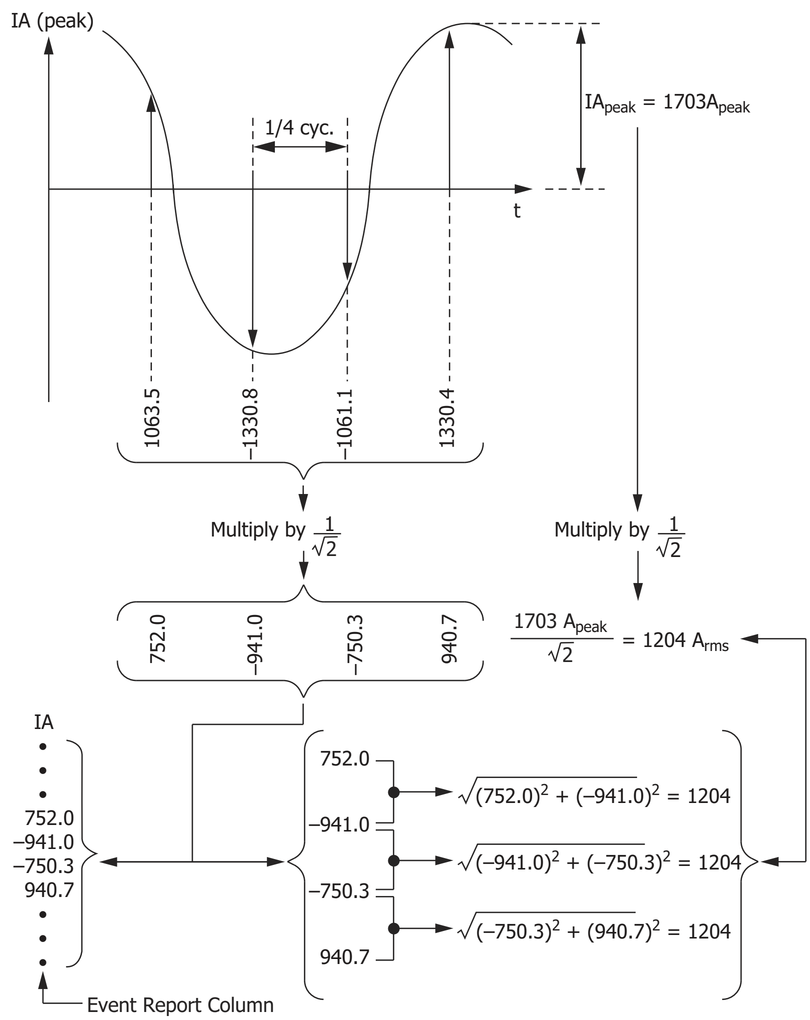


Figure 10.4 Derivation of Event Report Current Values and RMS Current Values From Sampled Current Waveform

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:

$$\mathrm{IA} = 1204\ \mathrm{A}\ \angle{-38.6^\circ} \qquad \textbf{Equation 10.1}$$

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

$$1204\ \mathrm{A} \bullet \cos(-38.6^\circ) = 940.7\ \mathrm{A} \qquad \textbf{Equation 10.2}$$

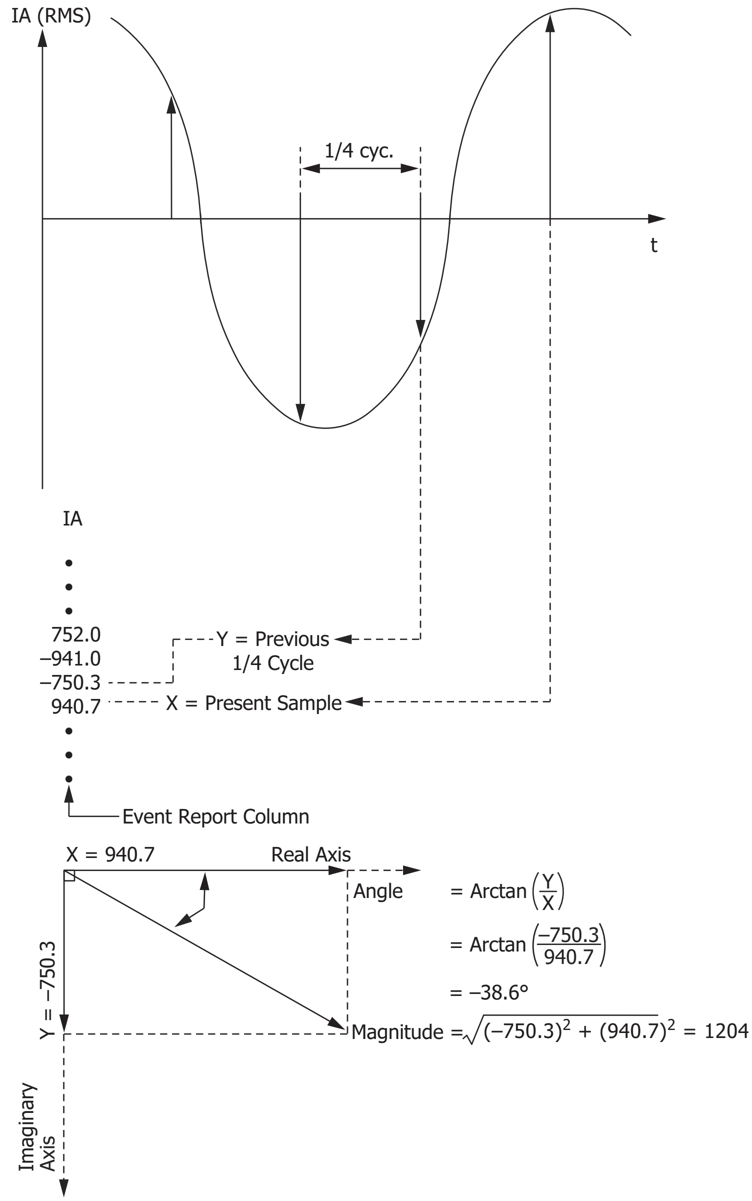


Figure 10.5 Derivation of Phasor RMS Current Values From Event Report Current Values

NOTE: The arctan function of many calculators and computing programs does not return the correct angle for the second and third quadrants (when X is negative). When in doubt, graph the X and Y quantities to confirm that the angle that your calculator reports is correct.

Retrieving Event Reports Via Ethernet File Transfer

Selected event reports are available as read-only files that can be retrieved using Ethernet File Transfer Protocol (FTP) or manufacturing message specification (MMS). MMS is only available in models that support IEC 61850 and only when IEC 61850 and MMS File transfer are enabled (E61850 := Y, EMMSFS := Y). See *File Transfer Protocol (FTP) and MMS File Transfer on page 7.15*, *Virtual File Interface on page 7.83*, and *MMS on page G.5* for additional information.

The Ethernet file server EVENTS folder contains two types of files for each event stored in the relay:

- ➤ Compressed, 4 sample/cycle, filtered event, equivalent to issuing a **CEV** command. These files are named C4.*nnnnn*.cev, where *nnnnn* is the unique event identifier.
- ➤ Compressed, 32 sample/cycle, unfiltered event, equivalent to issuing a **CEV R** command. These files are named CR.*nnnnn*.cev, where *nnnnn* is the unique event identifier.

The date and time displayed for events are from the time of event trigger. The times are UTC.

The EVENTS folder also contains the event history with unique event identification number (equivalent to the **HIS** command) and the compressed event history (equivalent to the **CHIS** command). See *HISTORY Command on page 7.58*. The Event files can also be retrieved with the **FIL** command. See *FILE Command on page 7.51* 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 L: Relay Word Bits*). See *SEL Compressed ASCII Commands on page C.1* for more information on the Compressed ASCII command set.

=>>**CEV <Enter>** "FID","CEV_VER","PART_NUM","SER_NUM","097C" "FID=SEL-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"	Report Header
"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","PTR_V CA","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 Labels
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,"AG 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","27 53"	Summary Data

Figure 10.6 Sample Compressed ASCII Event Report

```
"IA(A)","IB(A)","IC(A)","IN(A)","IG(A)","VAB(V)","VBC(V)","VCA(V)","*","*","*","*","*","*","*","*","*","*"
    ,"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 PFLEAD BFI BFT * * 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 * * * * * * IN301
    IN302 IN303 IN304 * * * * * * * * * * * * * * * * * * * OUT101 OUT102 OUT103 * * ORED81T ORED81RT TRIP
    OUT301 OUT302 OUT303 OUT304 * * * * * * * * * * * * * * * * * * * * * 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
    * * SG1 SG2 SG3 SG4 * DI_C DI_B DI_A CC OC BKJMP 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 RB33 RB34 RB35 RB36 RB37 RB38 RB39 RB40 RB41 RB42 RB43 RB44 RB45 RB46
    RB47 RB48 RB49 RB50 RB51 RB52 RB53 RB54 RB55 RB56 RB57 RB58 RB59 RB60 RB61 RB62 RB63 RB64 SV33 SV34 SV35
    SV36 SV37 SV38 SV39 SV40 SV33T SV34T SV35T SV36T SV37T SV38T SV39T SV40T SV41 SV42 SV43 SV44 SV45 SV46
    SV47 SV48 SV41T SV42T SV43T SV44T SV45T SV46T SV47T SV48T SV49 SV50 SV51 SV52 SV53 SV54 SV55 SV56 SV49T
    SV50T SV51T SV52T SV53T SV54T SV55T SV56T SV57 SV58 SV59 SV60 SV61 SV62 SV63 SV64 SV57T SV58T SV59T
    SV60T SV61T SV62T SV63T SV64T LT33 LT34 LT35 LT36 LT37 LT38 LT39 LT40 LT41 LT42 LT43 LT44 LT45 LT46 LT47
    LT48 LT49 LT50 LT51 LT52 LT53 LT54 LT55 LT56 LT57 LT58 LT59 LT60 LT61 LT62 LT63 LT64 PHDEM 3I2DEM GNDEM
    59VDIF 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 * * * * * * * * * * * * 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
```


Column Labels


```
-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,
    ,"00000000000000FF240000000000000000000000000000000000000000000006800A0010290001000000000000000000000000
    00000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
    0000000000000000000000000000F000000000000000000000000FFF80010000000000000000000000000000000000003C000000
    800000000000","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,
    ,"00000000000000FF240000000000000000000000000000000000000000000006800A0010290001000000000000000000000000
    00000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
    0000000000000000000000000000F000000000000000000000000FFF80010000000000000000000000000000000000003C000000
    800000000000","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,
    ,"00000000000000FF240000000000000000000000000000000000000000000006800A0010290001000000000000000000000000
    00000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
    0000000000000000000000000000F000000000000000000000000FFF80010000000000000000000000000000000000003C000000
    800000000000","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,
    ,"00000000000000FF240000000000000000000000000000000000000000000006800A0010290001000000000000000000000000
    00000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
    0000000000000000000000000000F000000000000000000000000FFF80010000000000000000000000000000000000003C000000
    800000000000","4EC6"
.
.
.
```


Event Data (Cycle 1)
The block shown represents four quarter cycles of data.

Figure 10.6 Sample Compressed ASCII Event Report (Continued)

```
-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,
    ,"00000000000000FF240000000000000000000000000000000000000000000006800A0010290001000000000000000000000000
    000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
    0000000000000000000000000000F00000000000000000000000FFF800100000000000000000000000000000000000003C000000
    800000000000","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,
    ,"00000000000000FF240000000000000000000000000000000000000000000006800A0010290001000000000000000000000000
    000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
    0000000000000000000000000000F00000000000000000000000FFF800100000000000000000000000000000000000003C000000
    800000000000","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,
    ,"00000000000000FF240000000000000000000000000000000000000000000006800A0010290001000000000000000000000000
    000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
    0000000000000000000000000000F00000000000000000000000FFF800100000000000000000000000000000000000003C000000
    800000000000","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,">","88808000000000FF9000000800000000000000000100000
    00000000000000680060010290021000000000000000000000000000000000000000000000000000000000000000000000000
    000000000000000000000000000000000000000000000000000000000000000000000000000000000F00000000000000000000
    000FFF800100000000000000000000000000000000000003C0000008000000000000","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,
    ,"88808000000000FF9000000A010000000000000021000000000000000000000680170018290021000000000000000000000000
    000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
    0000000000000000000000000000F00000000000000000000000FFF8001000000000000700000900000000000000003C000000
    800000000000","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,
    ,"88808000009900669000000801000000000000000021000000000000000000000680070018290021000000000000000000000000
    000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
    0000000000000000000000000000F00000000000000000000000FFF8001000000000000700000900000000000000003C000000
    000000000000","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,"*","88F0F000009900669000000801000000000000000021 0000000
    000000000000680070018290021000000000000000000000000000000000000000000000000000000000000000000000000000
    0000000000000000000000000000000000000000000000000000000000000000000000000000000F0000000000000000000000
    0FFF80019000000000007000009000000000000000003C000000000000000000","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,
    ,"88F0F000009900669000000801000000000000000021000000000000000000000680070018290021000000000000000000000000
    000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
    0000000000000000000000000000F00000000000000000000000FFF80019000000000007000009000000000000000003C000000
    000000000000","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,
    ,"88808000009900669000000801000000000000000021000000000000000000000680070018290021000000000000000000000000
    000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
    0000000000000000000000000000F00000000000000000000000FFF80019000000000007000009000000000000000003C000000
    000000000000","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,
    ,"88808000009900669000000801000000000000000021000000000000000000000680070018290021000000000000000000000000
    000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
    0000000000000000000000000000F00000000000000000000000FFF80019000000000007000009000000000000000003C000000
    000000000000","4E28"
```

```
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

Figure 10.6 Sample Compressed ASCII Event Report (Continued)

```
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.

```
88808000000000FF9000000800000000000000000100000000000000000068006001029002100000000
    000000000000000000000000000000000000000000000000000000000000000000000000000000
    0000000000000000000000000000000000000000000000000000000000000000000F0000000000
    0000000000000FFF8001000000000000000000000000000000000003C00000080000000000
```

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 QuickSet SEL-5030 Software via SYNCHROWAVE Event (SEL-5601-2)
- ➤ SYNCHROWAVE Event (SEL-5601-2)

Using the SEL-5030 software, navigate to the **Options** menu under **Tools** and select SYNCHROWAVE Event (SEL-5601-2) as the event viewer.

To view the saved events using the SEL-5030 software, click **Tools > Events** to view an event with SYNCHROWAVE Event and select the event you want to view (QuickSet remembers the location where you stored the previous event record). You can view multiple events by clicking on **Local Event > Add New Event** in the SYNCHROWAVE Event software.

As shown in *Figure 10.7*, all the analog and digital data can be viewed with SYNCHROWAVE Event (SEL-5601-2) or QuickSet via SYNCHROWAVE Event (SEL-5601-2). The Export Event feature allows you to export the CEV report in COMTRADE format. The Export Data feature also allows you to export the CEV report in comma-separated values (CSV) format.

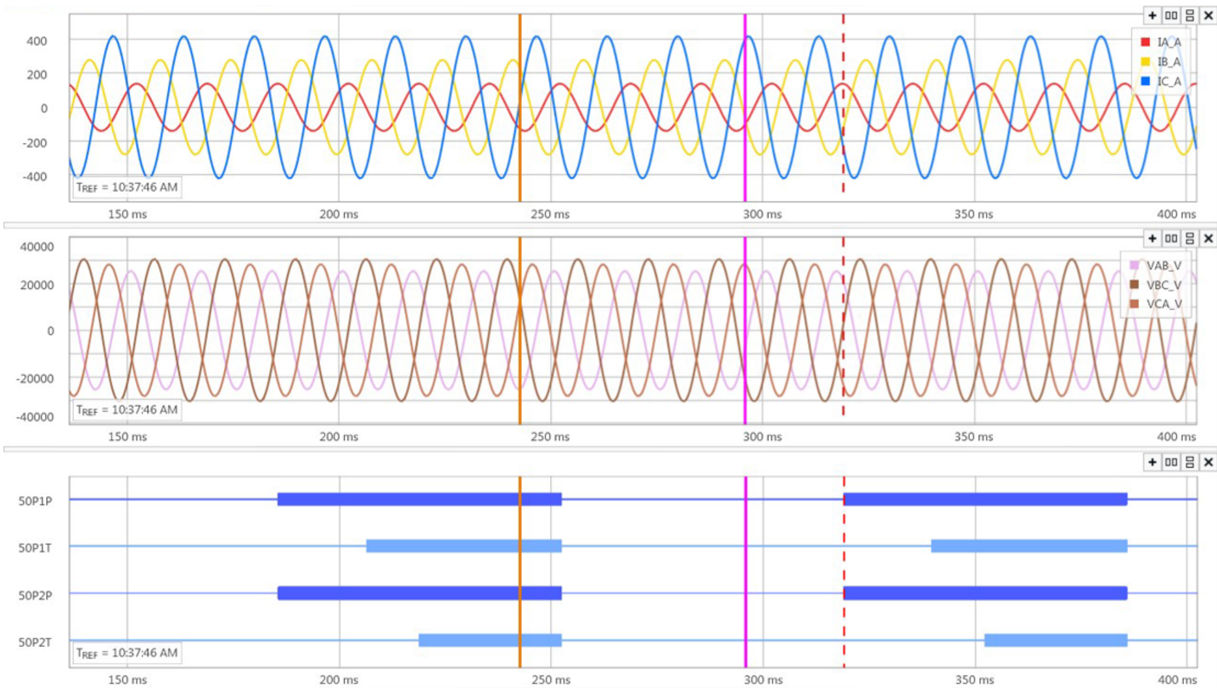


Figure 10.7 Sample CEV Report Viewed With SYNCHROWAVE Event

With SYNCHROWAVE Event, you have six options for converting CEV reports to COMTRADE.

- COMTRADE 1999 ASCII
- COMTRADE 1999 Binary
- COMTRADE 2013 ASCII
- COMTRADE 2013 Binary
- COMTRADE 2013 Binary32
- COMTRADE 2013 Float32

COMTRADE File Format Event Reports

NOTE: COMTRADE event reports are sampled at 32 samples per cycle, which are equivalent to CEV R event reports.

NOTE: COMTRADE events can be extracted using the **FILE** command (see Section 7: Communications), Ethernet File Transfer Protocol (FTP), or IEC 61850 Manufacturing Message 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 C37.111-2013 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 10.8*.

Event Summary Information

```
FID,"SEL-751-X615-V0-Z100100-D20230301"
Event_Report_Type,"UVR"
Part_Number,"751501B4XDX2X85A27X"
Serial_Number,"3221230120"

[Summary]
Time_Source,"Internal"
Event_Logs,"1"
Event_Number,"10027"
Event_Date,"06/03/2023"
Event_Time,"14:56:55.672000"
Event,"Trip"
Freq,"60.00"
Targets,"11000000"
IA (A),"5000.0625"
IB (A),"5038.9111"
IC (A),"4965.0024"
IN (A),"7.0711"
IG (A),"150.0000"
VAB (A),"669174.4375"
VBC (A),"669364.0625"
VCA (A),"1164585.8750"

[Fault_Location]
Location,"$$$$$$$$"
[Settings]

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

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
```

Figure 10.8 Sample COMTRADE .HDR Header File

```
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     := 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 10.8 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 10.8 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 10.8 Sample COMTRADE .HDR Header File (Continued)

.CFG File

The .CFG file contains data that is used to reconstruct the input signals to the relay and the status of Relay Word bits during the event report (see *Figure 10.9*). A <CR><LF> follows each line. If control inputs or control outputs are unavailable because of board loading and configuration, the relay does not report these inputs and outputs in the analog and digital sections of the .CFG file.

<RID setting>,FID=SEL-751-Rxxx-Vx-Zxxxxxx-Dyyyymmdd,2013	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,VDC,,,V,scale_factor[a],0.0,0,-32767,32767,1.0[b],1.0,P 11,FREQ,,,Hz,0.01,0.0,0,0,12000,1.0,1.0,P 12,FREQ_81R,,,Hz,0.01,0.0,0,0,12000,1.0,1.0,P	Analog Channel Data [a]Scale_factor is the value used to convert the equivalent channel analog data in the DAT file to primary units (A or kV peak-to-peak) [b]This factor depends on the Global setting EDCMON at the time the report is triggered. If EDCMON := Y, factor equals 1.0, else [PTRN].
1,rwb_label[c,d],,,0 2,rwb_label[c,d],,,0 . . . nnnn[e],rwb_label[c,d],,,0	Digital (Status) Channel Data [c]rwb_label is replaced with Relay Word bit labels as seen in Table L.1 [d]Place holders denoted by asterisk (*), are labeled as UNUSEDxxx (where xxx is the number of the associated label) [e]nnnn = number of the last Relay Word bit
<NFREQ> 0 0,<# of samples>	
dd/mm/yyyy,hh:mm:ss.ssssss	First Data Point
dd/mm/yyyy,hh:mm:ss.ssssss	Trigger Point
BINARY <time stamp multiplication factor> <time code, local code> <time quality indicator code, leap second indicator>	

Figure 10.9 Sample COMTRADE .CFG Configuration File Data

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
- Time code and time quality indicator code

.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 C37.111-2013 for more information. Many software applications can read binary COMTRADE files, including SYNCHROWAVE Event and QuickSet.

Retrieving COMTRADE Event Files

COMTRADE files are available as read-only files that can be retrieved using the **FILE** command and Ymodem file transfer, Ethernet FTP, web server (EHTTP := Y), or 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 7.51*, *File Transfer Protocol (FTP) and MMS File Transfer on page 7.15*, and *MMS on page G.5* for additional information.

High-Impedance Fault (HIF) Event Reporting

NOTE: HIF COMTRADE events can be extracted using the **FILE** command (see Section 7: Communications and File Transfer Protocol (FTP) and MMS File Transfer on page 7.15). To transfer files using MMS, set EMMSFS to Y.

HIF 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. You can select the event report length (HIFLER) and prefault length (HIFPRE) in the SEL-751. Event report length is 3, 5, 10, or 20 minutes. Prefault length is 1–2 minutes for HIFLER := 3, 1–4 minutes for HIFLER := 5, 1–9 minutes for HIFLER := 10 minutes, and 1–19 minutes for HIFLER := 20. Prefault length is the first part of the total event report length and precedes the event report triggering point. Changing the HIFPRE setting has no effect on the stored reports. 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 13 stored events at the minimum HIFLER setting of three minutes. You can view information about an HIF event in 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 HIF events as HIF event summaries. These short-form reports present vital information about a triggered event. See *Figure 10.10* 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 10.10 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 4.34*). You can also program this setting in a manner to aid in simultaneous event triggering in multiple relays.

Table 10.6 HIF Event Types (Sheet 1 of 2)

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

Table 10.6 HIF Event Types (Sheet 2 of 2)

Event	Event Trigger
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 an HIF is caused by a downed conductor, there can be a load current reduction. Depending on the position of the downed 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 an HIF. 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 10.34*.) *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 10.11*; 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 10.11 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 10.12* 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 10.12 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 10.31*). As shown in *Figure 10.12*, 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 SYNCHROWAVE Event 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","DOWN
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 10.13 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 SYNCHROWAVE Event 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 10.19* for details on retrieving compressed events via FTP or MMS File transfer.

High-Impedance Fault COMTRADE File Format Reports

The SEL-751 stores HIF 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 C37.111-2013 COMTRADE standard.

.HDR File

The .HDR file contains the output of the HIF summary command (**SUM HIF**), **HSG** command, and the relay settings as illustrated in *Figure 10.14*.

```
FID,"SEL-751-X640-V0-Z101100-D20230818"
Event_Report_Type,"HIF"
Serial_Number,"000000000000000"

[Summary]
Time_Source,"Internal"
Event_Logs,"2"
Event_Number,"10001"
Event_Date,"25/08/2023"
Event_Time,"13:22:55.613300"
Event,"HIF Fault"
HIF_Phase,"C"
Downed_Conductor,"NO"
Freq,"49.99"
Breaker,"OPEN"
Prefault_IARMS(A),"0.0000"
Prefault_IBRMS(A),,"0.0000"
Prefault_ICRMS(A),"4.0000"
Prefault_ISMA(A),"0.1604"
Prefault_ISMB(A),"0.1604"
Prefault_ISMC(A),"95.7734"
Prefault_SDIA(A),"0.8021"
Prefault_SDIB(A),"0.9625"
Prefault_SDIC(A),"0.9625"
Postfault_IARMS(A),"0.0000"
Postfault_IBRMS(A),,"0.0000"
Postfault_ICRMS(A),"4.0000"
Postfault_ISMA(A),"0.1069"
Postfault_ISMB(A),"0.1604"
Postfault_ISMC(A),"87.3779"
Postfault_SDIA(A),"0.8021"
Postfault_SDIB(A),"0.7486"
Postfault_SDIC(A),"1.1764"


SAM/CYC_A = 0.5
[Settings]

Global Settings
.
.
.

Group Settings
.
.
.

Report Settings
.
.
.
```

Figure 10.14 Sample HIF COMTRADE .HDR Header File

```
Logic Settings
.
.
.

Configuration Settings
.
.
.


Hsg Report

SEL-751                                  Date: 08/25/2023   Time: 14:27:04.207
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
4          0          0          0          0          0          0
5          0          0          0          0          0          0
6          0          0          0          0          0          0
7          0          0          0          0          0          0
8          0          0          0          0          1          0
9          0          0          0          0          0          0
10         0          0          0          0          0          0
11         0          0          0          0          0          0
12         0          0          0          0          0          0
13         0          0          0          0          0          0
14         0          0          0          0          0          0
15         0          0          0          0          0          0
16         0          0          0          0          0          0
17         0          0          0          0          0          0
18         0          0          0          0          0          0
19         0          0          0          0          2          0
20         0          0          0          0          0          0
21         0          0          0          0          0          0
22         0          0          0          0          3          0
23         0          0          0          0          2          0
24         0          0          0          0          1          0
25         0          0          0          0          0          0
26         0          0          0          0          0          0
27         0          0          0          0          1          0
28         0          0          0          0          1          0
29         0          0          0          0          1          0
30         0          0          0          0          0          0
31         0          0          0          0          0          0
32         0          0          0          0          2          0
33         0          0          0          0          0          0
34         0          0          0          0          0          0
35         0          0          0          0          0          0
.          .          .          .          .          .          .
.          .          .          .          .          .          .
.          .          .          .          .          .          .
95         0          0          0          0          0          0
96         0          0          0          0          0          0
97         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
           2.4999     2.4999     2.4999     99999.0000 99999.0000 99999.0000
```

Figure 10.14 Sample HIF COMTRADE .HDR Header File (Continued)

.CFG File

The .CFG file contains data that are used to reconstruct the captured high-impedance fault data during the event report (see *Figure 10.15*). A **<CR><LF>** follows each line.

```
<RID>, <FID>, 2013
```

```
##,##A,##D
```

Total Channels, Analog, Digital

```
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
<time stamp multiplication factor>
<time code, local code>
<time quality indicator code, leap second indicator>
```

Figure 10.15 Sample HIF COMTRADE .CFG Configuration File Data

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
- Time code and time quality indicator code

The .CFG file references analog quantities that are particular to high-impedance fault detection. See *High-Impedance Fault Compressed Event Report on page 10.35* 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 C37.111-2013* for more information. Many programs read the binary COMTRADE files. These programs include SYNCHROWAVE Event. See *Retrieving COMTRADE Event Files on page 10.30* 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 over an extended period. SER report data are useful in commissioning tests and root-cause analysis studies. SER information is stored when state changes occur. The report records the most recent 1024 state changes if a relay element is listed in the SER trigger equations.

SER Triggering

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 and File Transfer Protocol (FTP) and MMS File Transfer on page 7.15). 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 64 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 4.244* for additional details.

Retrieving and Clearing SER Reports

The SER report is available as a read-only file that can be retrieved using Ethernet File Transfer Protocol (FTP) or Manufacturing Message Specification (MMS). MMS is only available in models that support IEC 61850 and only when IEC 61850 and MMS file transfer are enabled (E61850 := Y, EMMSFS := Y). See *File Transfer Protocol (FTP) and MMS File Transfer on page 7.15*, *Virtual File Interface on page 7.83*, and *MMS on page G.5* for additional information.

See *SER Command (Sequential Events Recorder Report) on page 7.71* for details on retrieving and clearing SER reports with the **SER** command.

Example SER Report

The example SER report in *Figure 10.16* 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 10.16 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, 180, or 300-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*. Similar results can be achieved using the web server. See *Section 3: PC Interface*.

Low-Level Test Interface

NOTE: The SEL-751 with the three-phase Rogowski coil or low-power current transformer (RJ45 inputs), 200 mA neutral/three-phase LEA voltage sensor (RJ45 inputs) model option is not supported on the SEL low-level relay test system (RTS).

NOTE: The SEL RTS consists of the SEL-AMS (Adaptive Multichannel Source) and SEL-5401 Test System Software.

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.

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.

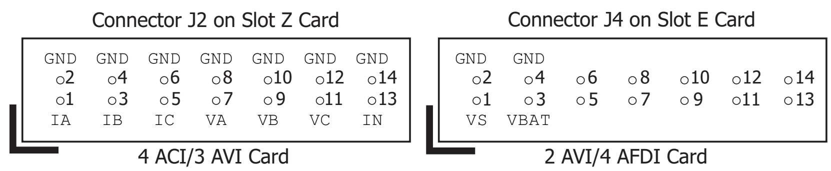


Figure 11.1 Low-Level Test Interface (J2 and J4)

Table 11.1 shows the signal scale factor information used by the AMS Relay Test System SEL-5401 Software for the calibrated inputs.

Table 11.1 Resultant Scale Factors for Inputs

Channel Label	Circuit Board & Connector	SEL-5401 Channel No.	Nominal Input	Scale Factor (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
VBAT[a]	J4 on Slot E card	9	270 V	196.07

[a] This is available if the Global setting EDCMON := N.

NOTE: If you use a 4 ACI card in Slot Z, the voltage channels do not apply.

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 VA.
- Apply low-level test signal –VBC (equivalent to VCB) to pin VC.
- Do not apply any signal to pin VB.

When simulating a delta PT connection with the low-level test interface and SINGLEV := Y, apply the signals as follows:

- If SING_VIN = VAB, apply low-level test signal VAB to pin VA.
- If SING_VIN = VBC, apply low-level test signal –VBC to pin VC.
- If SING_VIN = VCA, apply low-level test signal VCA to pin VC.

Commissioning Tests

SEL performs a complete functional check and calibration of each SEL-751 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-C234A Cable 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.

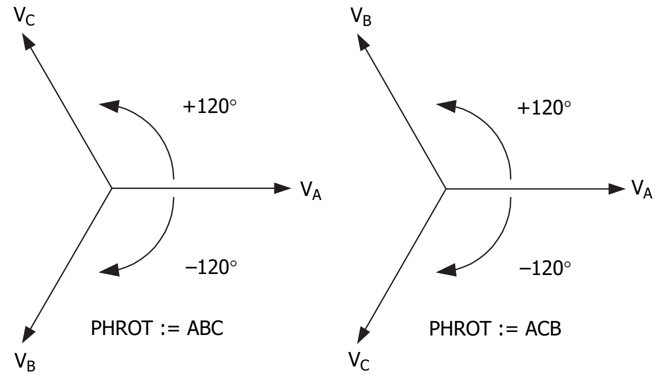
Step 11. Connect the ac test source current or voltage to the appropriate relay terminals.

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*.

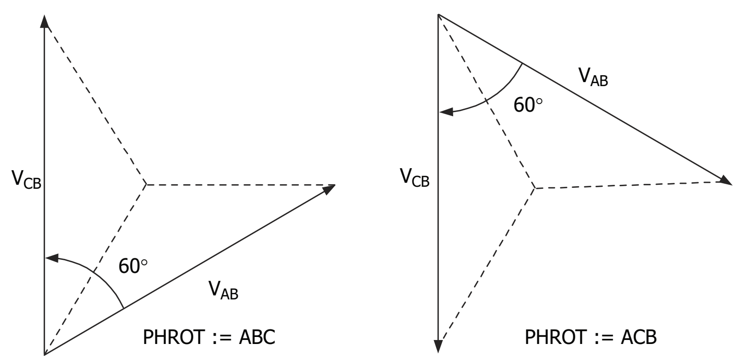
c. If you set the relay to accept delta voltages (DELTA_Y := DELTA), set the current and/or voltage phase angles as shown in *Figure 11.3*.



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.

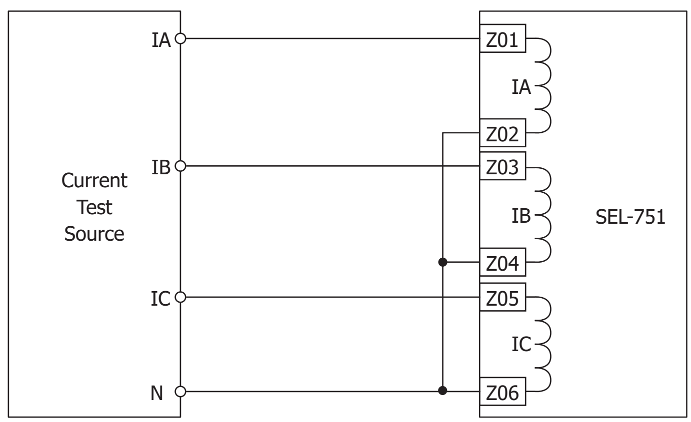


Figure 11.4 Current Source Connections

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 (%)
$\lvert IA\rvert = 0.9 \cdot I_{NOM}$ $\lvert IB\rvert = I_{NOM}$ $\lvert IC\rvert = I_{NOM}$	7%	
$\lvert IA\rvert = 0.75 \cdot I_{NOM}$ $\lvert IB\rvert = I_{NOM}$ $\lvert IC\rvert = I_{NOM}$	17%	
$\lvert IA\rvert = I_{NOM}$ $\lvert IB\rvert = 1.2 \cdot I_{NOM}$ $\lvert IC\rvert = 1.2 \cdot I_{NOM}$	12%	
$\lvert IA\rvert = 0.9 \cdot I_{NOM}$ $\lvert IB\rvert = 1.1 \cdot I_{NOM}$ $\lvert IC\rvert = 1.1 \cdot I_{NOM}$	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.

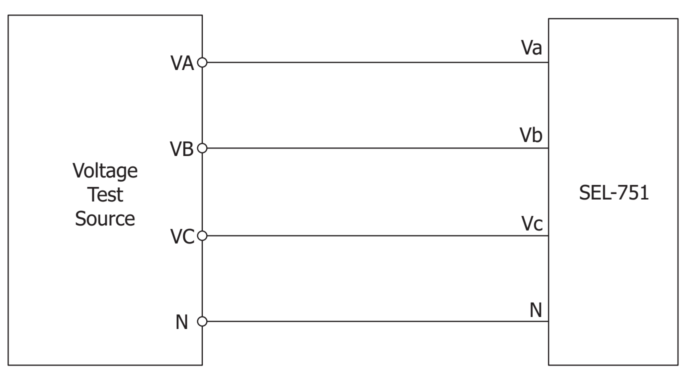


Figure 11.5 Wye Voltage Source Connections

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.

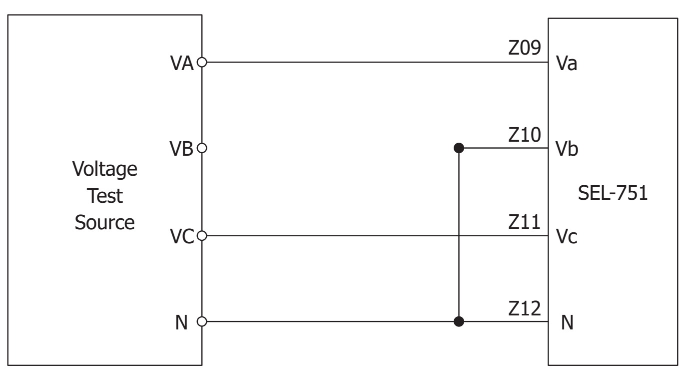


Figure 11.6 Delta Voltage Source Connections

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 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.

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.

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 7.21* 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 SEL-5601-2 SYNCHROWAVE Event 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

⚠CAUTION
Before placing the arc-flash protection system in service, first make sure all the sensors are correctly installed, and then execute the **AFT** command to initiate a self-test.

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 SYNCHROWAVE Event 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.

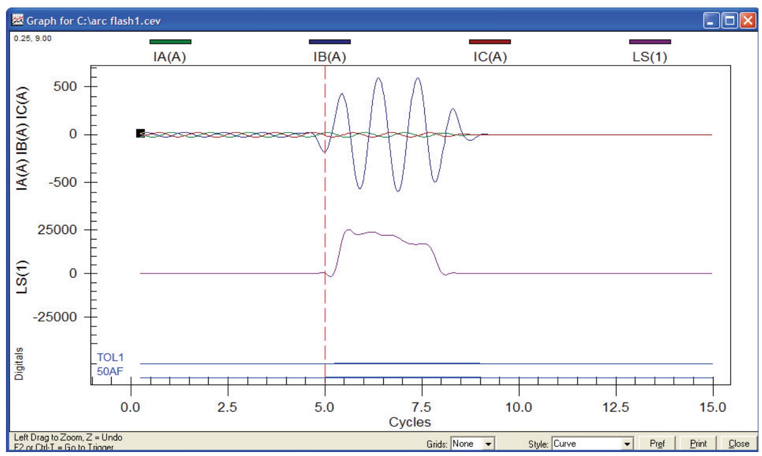


Figure 11.7 CEV R Light Event Capture Example

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

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.
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.

NOTE: Refer to Access Commands (ACCESS, 2ACCESS, and CAL) for more information on when SALARM is pulsed for access level changes and unsuccessful password entry attempts.

- 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, unsuccessful password entry attempts, firmware upgrade attempts via Ethernet, 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).

NOTE: "W" in the STA response refers to warning of the corresponding quantity.

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 main board field-programmable gate array does not accept program, the version number is incorrect, or if field programmable date array checksum is not correct		Yes	Latched	Yes	Status Fail FPGA Failure	Automatic restart. Contact SEL if failure returns.
Main board FPGA (run time)	FPGA SEU detected an uncorrectable error		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	

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
DeviceNet Board Failure	DeviceNet card does not respond in three consecutive 300 ms time out periods		NA	NA	NA	COMMFLT Warning	
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
PGA Failure (Slot Z)	A/D reference channel check for 4 ACI/ 3 AVI LEA card	<1.0625 V or >1.4375 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
+0.675 V Fail[a]	Monitor +0.675 V power supply	0.608 to 0.743 V	Yes	Latched	Yes	Status Fail +0.675 V Failure	
+0.675 VD Fail[a]	Monitor +0.675 VD power supply	0.608 to 0.743 V	Yes	Latched	Yes	Status Fail +0.675 V Failure	
+1.0 V Fail[a]	Monitor +1.0 V power supply	0.9 to 1.1 V	Yes	Latched	Yes	Status Fail +1.0 V Failure	
+1.1 V Fail[a]	Monitor +1.1 V power supply	0.99 to 1.21 V	Yes	Latched	Yes	Status Fail +1.1 V Failure	
+1.35 V Fail[a]	Monitor +1.35 V power supply	1.215 to 1.485 V	Yes	Latched	Yes	Status Fail +1.35 V Failure	
+1.8 V Fail[a]	Monitor +1.8 V power supply	1.62 to 1.98 V	Yes	Latched	Yes	Status Fail +1.8 V Failure	
+3.3 V Fail[a]	Monitor +3.3 V power supply	2.97 to 3.63 V	Yes	Latched	Yes	Status Fail +3.3 V Failure	
+3.75 V Fail[a]	Monitor +3.75 V power supply	3.00 to 4.50 V	Yes	Latched	Yes	Status Fail +3.75 V Failure	
+5.0 V Fail[a]	Monitor +5 V power supply	4.25 to 5.75 V	Yes	Latched	Yes	Status Fail +5.0 V Failure	
–1.25 V Fail[a]	Monitor -1.25 V power supply	–1.1 to –1.5 V	Yes	Latched	Yes	Status Fail –1.25 V Failure	

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
–5 V Fail[a]	Monitor -5 V power supply	–2.0 to –10.0 V	Yes	Latched	Yes	Status Fail –5 V Failure	
Clock Battery	Monitor Clock Battery	2.3 to 10.0 V	No	Not Latched	Yes	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
Clock Chip	Unable to communicate with clock or fails time keeping test		No	Not Latched	Yes	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
Clock Chip RAM	Clock chip static RAM fails		No	Not Latched	Yes	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
External/Internal RTD	Fails if the internal RTD card or the external RTD reports that at least one enabled RTD input is open or shorted, if there is no communication, or if there is a power supply failure for the external RTD module		NA	NA	No	RTD Failure	STA C, to clear the warning in the status report. Contact SEL if failure returns.
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.

[a] In firmware versions prior to R400-V0, the power supply voltage self-tests are different from what is shown. Use the STATUS command to view self-tests applicable to your firmware.

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/HOME pushbutton to activate the display.
The relay is de-energized.	Verify input power and fuse continuity.
The relay does not accurately measure voltages or currents.	
Wiring error	Verify input wiring.

Table 11.9 Troubleshooting (Sheet 2 of 2)

Symptom/Possible Cause	Diagnosis/Solution
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.
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.

Technical Support

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

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Appendix A
Firmware, ICD, and Manual Versions

Firmware

Determining the Firmware Version

To determine the firmware version, view the status report by using the serial port **STATUS** command or the front panel. The status report displays the firmware identification (FID) string.

The firmware version will be either a standard release or a point release. A standard release adds new functionality to the firmware beyond the specifications of the existing version. A point release is reserved for modifying firmware functionality to conform to the specifications of the existing version.

A standard release is identified by a change in the R-number of the device firmware identification (FID) string.

Existing firmware:

FID=SEL-751-**R100**-V0-Z001001-D*xxxxxxxx*

Standard release firmware:

FID=SEL-751-**R101**-V0-Z001001-D*xxxxxxxx*

A point release is identified by a change in the V-number of the device FID string.

Existing firmware:

FID=SEL-751-R100-**V0**-Z001001-D*xxxxxxxx*

Point release firmware:

FID=SEL-751-R100-**V1**-Z001001-D*xxxxxxxx*

The date code is after the D. For example, the following is firmware version number R100, date code June 1, 2011.

FID=SEL-751-R100-V0-Z001001-**D20110601**

Table A.1, *Table A.2*, *Table A.3*, and *Table A.4* list the firmware versions, a description of modifications, and the instruction manual date code that corresponds to the firmware versions of each series of firmware. The most recent firmware version is listed first.

Starting with revisions published after March 1, 2022, changes that address security vulnerabilities are marked with “[Cybersecurity]”. Other improvements to cybersecurity functionality that should be evaluated for potential cybersecurity importance are marked with “[Cybersecurity Enhancement]”.

Table A.1 R400 Series Firmware Revision History (Sheet 1 of 7)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-751-R402-V0-Z102100-D20241231	➤ [Cybersecurity] Resolved an issue where the MMS server did not lock the user out after three failed password attempts within one minute. ➤ Updated IEC 61850 protocol implementation to IEC 61850 Edition 2.1. ➤ Improved processing of pulsed remote bits by adding support for pulse configuration attributes cmdQual, onDur, offDur, and numPls according to IEC 61850-7-3. ➤ Added support to provide the IEC 61850 library version (LIB61850ID) to the LPHD logical node. ➤ Added the RREC logical node to support autoreclose functionality. ➤ Added support for indexed unbuffered and buffered MMS reports. ➤ Added support to allow the relay to accept GOOSE data with questionable or invalid validity. ➤ Added support for the sAddr attribute to replace the esel:datasrc attribute in ICD files to improve compatibility with third-party system configuration tools. ➤ Added support for deadband configuration, including the dbRef, dbAngRef, zeroDbRef, and zeroDb attributes, according to IEC 61850-7-3 Edition 2.1. ➤ Modified the firmware to update the settings group control block (SGCB) and the LTRK logical node's last activation time-stamp attribute for group switches not initiated by MMS and for changes to the active group settings. ➤ Improved support for IEC 61850 Edition 1 MMS clients. ➤ Added message quality and IEC 61850 simulation mode capability to Fixed GOOSE messages. ➤ Added the STORMDET Relay Word bit to indicate a network storm. ➤ Added Sequential Events Recorder (SER) functionality to the two-line display models. ➤ Lowered the minimum setting range for the breaker failure residual current setting (50BFG) from 10 percent to 5 percent of I_{NOM}. ➤ Enhanced the firmware by adding an LEA clipping voltage-dependency check. ➤ Enhanced the firmware to always set the nominal current INOM setting to 1 A for relay models with the LEA option. ➤ Resolved an issue with the output contact state in Blocked, Test/Blocked, and Off modes. ➤ Resolved an issue with the reporting of the quality data attribute in IEC 61850 OFF mode. ➤ Resolved an issue with the leap second addition for the SNTP protocol. ➤ Resolved an issue with the LPSEC Relay Word bit. ➤ Resolved an issue with the simulation mode LPHDSIM Relay Word bit. ➤ Resolved an issue with the calculation of the negative-sequence current (3I2) quantity used in the negative-sequence time-overcurrent (51Q) element. ➤ Resolved an issue with the processing of multicast and broadcast messages in failover mode.	20241231

Table A.1 R400 Series Firmware Revision History (Sheet 2 of 7)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-751-R401-V3-Z101100-D20241231	Includes all the functions of SEL-751-R401-V2-Z101100-D20241031 with the following additions: ➤ [Cybersecurity] Resolved an issue where the MMS server did not lock the user out after three failed password attempts within one minute. ➤ Resolved an issue with the output contact state in Blocked, Test/Blocked, and Off modes. ➤ Resolved an issue with the reporting of the quality data attribute in IEC 61850 OFF mode. ➤ Resolved an issue with the LPSEC Relay Word bit. ➤ Resolved an issue with the simulation mode LPHDSIM Relay Word bit. ➤ Resolved an issue with the calculation of the negative-sequence current (3I2) quantity used in the negative-sequence time-overcurrent (51Q) element. ➤ Resolved an issue with the processing of multicast and broadcast messages in failover mode.	20241231
SEL-751-R401-V2-Z101100-D20241031	Includes all the functions of SEL-751-R401-V1-Z101100-D20240930 with the following additions: ➤ Modified the TEST DB functionality to override Relay Word bits that are in the Sequential Events Recorder (SER). ➤ Resolved an issue where the relay would incorrectly process a SELOGIC equation that used the NOT operator in combination with either the R_TRIG or F_TRIG operator. ➤ Resolved an issue where changing the DELTA_Y setting did not retain the SYNCPH setting. ➤ Resolved an issue where the breaker monitor report could be incorrect if no currents are applied while the breaker opens.	20241031
SEL-751-R401-V1-Z101100-D20240930	Includes all the functions of SEL-751-R401-V0-Z101100-D20240308 with the following additions: ➤ Resolved an issue where performing certain operations including, but not limited to, using HMI pushbuttons, accessing the relay via communications ports, and viewing or modifying settings could cause a diagnostic restart of the relay. ➤ Resolved an issue where the IN_MAG and IN_ANG analog quantities, when used in SELOGIC control equations, used the wrong minimum current threshold for relays with a 200 mA neutral channel I_{NOM} when METHRES was set to Y. ➤ Resolved an issue where the BRKCLTM, BRKCLTH, BRKOPTM, and BRKOPTH analog quantities were inaccurate for external breaker operation. ➤ Resolved an issue where an arc-flash test would fail when the relay was put in IEC 61850 Blocked or Test/Blocked mode. ➤ Resolved an issue where entering a special character for a settings value via the terminal session may cause the device to interpret the setting as 0.	20240930
SEL-751-R401-V0-Z101100-D20240308	➤ [Cybersecurity] Resolved an issue where a Bridge Protocol Data Unit (BPDU) packet of invalid size could cause the relay to perform a diagnostic restart. ➤ [Cybersecurity] Removed advanced diagnostic commands from Access Level C. ➤ [Cybersecurity] Resolved an issue where the SALARM Relay Word bit did not pulse for an incorrect password entered via the touchscreen.	20240308

Table A.1 R400 Series Firmware Revision History (Sheet 3 of 7)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ [Cybersecurity] Improved the security of the web server. ➤ Added the ability to use the VBAT channel as an ac voltage input with the under- and overvoltage functions (27N/59N). ➤ Added the ability to configure line and bus voltage checks for manual closing in synchronism-check applications. ➤ Added the ability to enable voltage difference supervision for the synchronism-check element. ➤ Added support for hardware-based IEEE 1588-2008 Precision Time Protocol (PTP) time synchronization in Parallel Redundancy Protocol (PRP) mode. ➤ Added the ability to measure up to the A/D saturation limit for all the time-overcurrent elements. ➤ Added the AUTO2 option to the directional control enable setting. ➤ Added a SELOGIC control equation to manually trip the breaker and another SELOGIC control equation to unlatch the manual trip. ➤ Added voltage and current supervision settings to the frequency elements. ➤ Added the residual current (3I0) supervision setting to the breaker failure logic. Also added the RSTTRGT Relay Word bit to the breaker failure trip reset logic. ➤ Added the 97FM elements to monitor the magnitudes of user-selected frequency components in different analog signals. ➤ Added the ability to capture event reports as long as 300 cycles. ➤ Added the frequency measurements used by the 81R element (FREQ_81R) to the COMTRADE event report. ➤ Added the ability to monitor individual phases for the 50P2 element. ➤ Added SELOGIC settings SCBK1BO and SCBK1BC for the IEC 61850 breaker control interlocking (CILO) logical node. ➤ Increased the number of MMS buffered and unbuffered reports to as many as twelve. ➤ Improved the Fixed GOOSE communications by adding an algorithm to detect and reject out-of-sequence messages. ➤ Added the **PRP** command to display the PRP node table and statistics when PRP is enabled. ➤ Added the HIF histogram data (HSG command response) and setting to the HDR file of the HIF COMTRADE event report. ➤ Added the ability to configure the prefault length (HIFPRE setting) for HIF event reports. ➤ Added logic in the HIF detection algorithm such that if a disturbance is detected on any one of the phases, adaptive tuning, trending, and memory functions in all three phases are frozen. ➤ Added the user-configurable SELOGIC setting, HIFRZ, to freeze HIF tuning (HIFFRZ asserted) so that small disturbances do not impact the tuning process. ➤ Added the LOWITHR setting to configure the minimum current threshold required for HIF tuning. ➤ Improved the dependability of the HIF element when a fault current appears in all three phases through coupling.	

Table A.1 R400 Series Firmware Revision History (Sheet 4 of 7)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Improved the accuracy of the data time stamp in the COMTRADE event report. ➤ Improved the resolution of the frequency measurement in the COMTRADE event report. ➤ Expanded the phasor measurement data acceptable criteria for voltage models. ➤ Increased the resolution of the directional element wattmetric delay setting, DIRWD, to two decimal places. ➤ Expanded the range of the voltage ratio correction factor setting, 25RCF, for the synchronism-check element. ➤ Improved the performance of the relay in Switched mode during a network storm. ➤ Resolved an issue where the relay restarted when the navigation buttons in the Status application were pressed on the touchscreen display. ➤ Resolved an issue where the Ethernet port would lock up upon a Port 1 setting change when RSTP was enabled. ➤ Resolved an issue for the single copper Ethernet port models when the network port speed setting NETWRK PORTA SPD was set to 10 Mbps or 100 Mbps. Only firmware versions R400-V0 and R400-V1 are affected. ➤ Resolved an issue in the HIF2 (nonharmonic/interharmonic) adaptive tuning logic that affected the calculation of the sum-of-difference current (SDI) reference and trending and memory function output. ➤ Resolved an issue where the 89 Relay Word bits were not accepted in the DNP binary output settings when set in pairs. ➤ Resolved an issue where the synchrophasor data frames could be dropped when used in a UDP_S transport scheme. ➤ Resolved an issue where the synchrophasor configuration frames were not transmitted every one minute when used in a UDP_S transport scheme. This issue affects firmware versions R400-V0 and higher. ➤ Resolved an issue where the IRIGOK Relay Word bit deasserted momentarily with repeated trip triggering. ➤ Resolved an issue where the breaker monitor Relay Word bits BCW and BCW*x* (*x* = A, B, C), remained asserted even after the breaker monitor setting EBMON was disabled. ➤ Resolved an issue where the GOOSE messages did not use the correct MAC address after the MAC address was updated. ➤ Resolved an issue where the three-phase overvoltage pickup Relay Word bit 3P59 never asserted. ➤ Resolved an issue where the individual phase overcurrent pick up Relay Word bits 50A1P, 50B1P, and 50C1P did not assert when the set point was greater than 8 times the nominal current. This issue affects firmware versions R400-V0 and higher. ➤ Resolved an issue where the Trip/Warn Modbus Registers 1730–1733 did not report the correct values. This issue affects firmware versions R400-V0 and higher. ➤ Resolved an issue where the serial number was reported incorrectly via Modbus.	

Table A.1 R400 Series Firmware Revision History (Sheet 5 of 7)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Updated the firmware to store the state of the loss of potential (LOP) Relay Word bit in nonvolatile memory. ➤ Resolved an issue where the relay could experience a NON VOL failure under certain conditions.	
SEL-751-R400-V5-Z100100-D20241231	Includes all the functions of SEL-751-R400-V4-Z100100-D20241031 with the following additions: ➤ [Cybersecurity] Resolved an issue where the MMS server did not lock the user out after three failed password attempts within one minute. ➤ Resolved an issue with the output contact state in Blocked, Test/Blocked, and Off modes. ➤ Resolved an issue with the reporting of the quality attribute in IEC 61850 OFF mode. ➤ Resolved an issue with the LPSEC Relay Word bit. ➤ Resolved and issue with the simulation mode LPHDSIM Relay Word bit. ➤ Resolved an issue with the calculation of the negative-sequence current (3I2) quantity used in the negative-sequence time-overcurrent (51Q) element. ➤ Resolved an issue with the SEL display package version. ➤ Resolved an issue with the processing of multicast and broadcast messages in failover mode.	20241231
SEL-751-R400-V4-Z100100-D20241031	Includes all the functions of SEL-751-R400-V3-Z100100-D20240930 with the following additions: ➤ Modified the TEST DB functionality to override Relay Word bits that are in the Sequential Events Recorder (SER). ➤ Resolved an issue where changing the DELTA_Y setting did not retain the SYNCPH setting. ➤ Resolved an issue where the breaker monitor report could be incorrect if no currents are applied while the breaker opens.	20241031
SEL-751-R400-V3-Z100100-D20240930	Includes all the functions of SEL-751-R400-V2-Z100100-D20240308 with the following additions: ➤ Resolved an issue where performing certain operations including, but not limited to, using HMI pushbuttons, accessing the relay via communications ports, and viewing or modifying settings could cause a diagnostic restart of the relay. ➤ Resolved an issue where the IN_MAG and IN_ANG analog quantities, when used in SELOGIC control equations, used the wrong minimum current threshold for relays with a 200 mA neutral channel I_{NOM} when METHRES was set to Y. ➤ Resolved an issue where the BRKCLTM, BRKCLTH, BRKOPTM, and BRKOPTH analog quantities were inaccurate for external breaker operation. ➤ Resolved an issue where an arc-flash test would fail when the relay was put in IEC 61850 Blocked or Test/Blocked mode. ➤ Resolved an issue where entering a special character for a settings value via the terminal session may cause the device to interpret the setting as 0.	20240930

Table A.1 R400 Series Firmware Revision History (Sheet 6 of 7)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-751-R400-V2-Z100100-D20240308	Includes all the functions of SEL-751-R400-V1-Z100100-D20230607 with the following additions: ➤ [Cybersecurity] Resolved an issue where a Bridge Protocol Data Unit (BPDU) packet of invalid size could cause the relay to perform a diagnostic restart. ➤ [Cybersecurity] Removed advanced diagnostic commands from Access Level C. ➤ [Cybersecurity] Resolved an issue where the SALARM Relay Word bit did not pulse for an incorrect password entered via the touchscreen. ➤ [Cybersecurity] Improved the security of the web server. ➤ Added the frequency measurements used by the 81R element (FREQ_81R) to the COMTRADE event report. ➤ Added logic in the HIF detection algorithm such that if a system disturbance is detected on any one of the phases, adaptive tuning, trending, and memory functions in all three phases are frozen. ➤ Improved the accuracy of the data time stamp in the COMTRADE event report. ➤ Improved the resolution of the frequency measurement in the COMTRADE event report. ➤ Expanded the phasor measurement data acceptable criteria for voltage models. ➤ Improved the performance of the relay in Switched mode during a network storm. ➤ Resolved an issue where the relay restarted when the navigation buttons in the Status application were pressed on the touchscreen display. ➤ Resolved an issue where the Ethernet port would lock up upon a Port 1 setting change when RSTP was enabled. ➤ Resolved an issue for the single copper Ethernet port models when the network port speed setting NETWRK PORTA SPD was set to 10 Mbps or 100 Mbps. Only firmware versions R400-V0 and R400-V1 are affected. ➤ Resolved an issue in the HIF2 (nonharmonic/interharmonic) adaptive tuning logic that affected the calculation of the sum-of-difference current (SDI) reference and trending and memory function output. ➤ Resolved an issue where the 89 Relay Word bits were not accepted in the DNP binary output settings when set in pairs. ➤ Resolved an issue where the synchrophasor data frames could be dropped when used in a UDP_S transport scheme. ➤ Resolved an issue where the synchrophasor configuration frames were not transmitted every one minute when used in a UDP_S transport scheme. This issue affects firmware versions R400-V0 and higher. ➤ Resolved an issue where the IRIGOK Relay Word bit deasserted momentarily with repeated trip triggering. ➤ Resolved an issue where the breaker monitor Relay Word bits BCW and BCW*x* (*x* = A, B, C) remained asserted even after the breaker monitor setting EBMON was disabled. ➤ Resolved an issue where the GOOSE messages did not use the correct MAC address after the MAC address was updated. ➤ Resolved an issue where the three-phase overvoltage pickup Relay Word bit 3P59 never asserted.	20240308

Table A.1 R400 Series Firmware Revision History (Sheet 7 of 7)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Resolved an issue where the individual phase overcurrent pick up Relay Word bits 50A1P, 50B1P, and 50C1P did not assert when the set point was greater than 8 times the nominal current. This issue affects firmware versions R400-V0 and higher. ➤ Resolved an issue where the Trip/Warn Modbus Registers 1730–1733 did not report the correct values. This issue affects firmware versions R400-V0 and higher. ➤ Resolved an issue where the serial number was reported incorrectly via Modbus. ➤ Resolved an issue where the relay could experience a NON VOL failure under certain conditions. **NOTE:** We recommend that you save all the events stored in the relay before upgrading from any previous firmware version to firmware version R400-V2 or higher. Clear the event history buffer after the firmware upgrade.	
SEL-751-R400-V1-Z100100-D20230607	Includes all the functions of SEL-751-R400-V0-Z100100-D20230315 with the following additions: ➤ Resolved an issue where Remote Bit RB08 could incorrectly assert when the synchronism-check element was enabled (E25 := Y).	20230607
SEL-751-R400-V0-Z100100-D20230315	➤ Added firmware support for a new processor component. Previous firmware versions cannot be upgraded to R400. ➤ Added Fixed GOOSE communications capability for models that support IEC 61850 protocol. ➤ Added support for IEEE moderately inverse, very inverse, and extremely inverse curves (E1, E2, E3) for the time-overcurrent elements per IEEE C37.112. ➤ Increased SELOGIC capability to support 64 of each of the following: latch bits, counters, math variables, timers, and remote bits. ➤ Increased the number of virtual bits to 256. ➤ Added the over-/underfrequency element pickup Relay Word bit 81D*n*P (*n* = 1–6) and the rate-of-change-of-frequency element pickup Relay Word bits 81R*n*P (*n* = 1–4). ➤ Added support for IEEE C37.111-2013 COMTRADE event format. ➤ Improved the Sequential Events Recorder (SER) time-stamp accuracy to ±1 ms.	20230315

Table A.2 R300 Series Firmware Revision History (Sheet 1 of 8)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-751-R302-V6-Z010005-D20241231	Includes all the functions of SEL-751-R302-V5-Z010005-D20240930 with the following additions: ➤ [Cybersecurity] Resolved an issue where the MMS server did not lock the user out after three failed password attempts within one minute. ➤ Resolved and issue with the reporting of the quality data attribute in IEC 61850 OFF mode. ➤ Resolved an issue with the LPSEC Relay Word bit. ➤ Resolved an issue with the simulation mode LPHDSIM Relay Word bit.	20241231

Table A.2 R300 Series Firmware Revision History (Sheet 2 of 8)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-751-R302-V5-Z010005-D20240930	Includes all the functions of SEL-751-R302-V4-Z010005-D20240329 with the following additions: ➤ Resolved an issue where the IN_MAG and IN_ANG analog quantities, when used in SELOGIC control equations, used the wrong minimum current threshold for relays with a 200 mA neutral channel I_{NOM} when METHRES was set to Y. ➤ Resolved an issue where the BRKCLTM, BRKCLTH, BRKOPTM, and BRKOPTH analog quantities were inaccurate for external breaker operation. ➤ Improved the performance of the relay Switched mode during a network storm. ➤ Resolved an issue where an arc-flash test would fail when the relay was put in IEC 61850 Blocked or Test/Blocked mode. ➤ Resolved an issue where Port 1B became occasionally unresponsive after changing the NETMODE setting value from SWITCHED to PRP. ➤ Resolved an issue where entering a special character for a settings value via the terminal session may cause the device to interpret the setting as 0.	20240930
SEL-751-R302-V4-Z010005-D20240329	Includes all the functions of SEL-751-R302-V3-Z010005-D20240122 with the following addition: ➤ Resolved an issue with the processing of the math variables.	20240329
SEL-751-R302-V3-Z010005-D20240122	Includes all the functions of SEL-751-R302-V2-Z010005-D20230428 with the following additions: ➤ [Cybersecurity] Resolved an issue where a Bridge Protocol Data Unit (BPDU) packet of invalid size could cause the relay to perform a diagnostic restart. ➤ [Cybersecurity] Removed advanced diagnostic commands from Access Level C. ➤ [Cybersecurity] Resolved an issue where the SALARM Relay Word bit did not pulse for an incorrect password entered via the touchscreen. ➤ [Cybersecurity] Improved the security of the web server. ➤ Added the frequency measurements used by the 81R element (FREQ_81R) to the COMTRADE event report. ➤ Added logic in the HIF detection algorithm such that if a system disturbance is detected on any one of the phases, adaptive tuning, trending and memory functions in all three phases are frozen. ➤ Improved the accuracy of the data time stamp in the COMTRADE event report. ➤ Improved the resolution of the frequency measurement in the COMTRADE event report. ➤ Expanded the phasor measurement data acceptable criteria for voltage models. ➤ Resolved an issue where the relay failed to synchronize with the SNTP server when RSTP was enabled. This issue affects firmware version R302-V0 only. ➤ Resolved an issue where the synchrophasor data frames could be dropped when used in a UDP_S transport scheme. ➤ Resolved an issue where the PTP time of the relay did not include leap seconds that have occurred since 1970.	20240308

Table A.2 R300 Series Firmware Revision History (Sheet 3 of 8)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Resolved an issue where the target LEDs were not being latched. ➤ Resolved an issue where the relay could experience a NON VOL failure under certain conditions.	
SEL-751-R302-V2-Z010005-D20230428	Includes all the functions of SEL-751-R302-V1-Z010005-D20230315 with the following additions: ➤ Resolved an issue with the frequency measurement algorithm at higher frequencies (greater than 68 Hz). The measured frequency was outside the specified accuracy of 0.01 Hz, which could result in incorrect operation of the overfrequency and rate-of-change-of-frequency (81R) elements. Only R3*xx* firmware versions are affected.	20230428
SEL-751-R302-V1-Z010005-D20230315	Includes all the functions of SEL-751-R302-V0-Z010005-D20220826 with the following additions: ➤ Resolved an issue where Precision Time Protocol (PTP) was not able to synchronize the time if the PTP transport mechanism setting PTPTR was set equal to LAYER2. Only firmware version R302-V0 is affected.	20230315
SEL-751-R302-V0-Z010005-D20220826	➤ [Cybersecurity] Resolved a rare, low-risk issue where deliberately crafted Ethernet traffic could cause the relay to perform a diagnostic restart. ➤ [Cybersecurity] Updated a third-party networking software component, which removes low-risk security vulnerabilities that could result in temporary loss of Ethernet communications. ➤ Added support for IEEE 802.1Q-2014 Rapid Spanning Tree Protocol (RSTP) for models with the dual Ethernet port option. ➤ Added support for the IEC 61850 Local/Remote control feature defined in the IEC 61850-7-4. ➤ Added support for the IEC 61850 functional naming feature. ➤ Added SELOGIC variable SC850SM for IEC 61850 simulation mode. ➤ Increased the number of Relay Word bit aliases to 32. ➤ Improved performance to allow touchscreen operation after a firmware downgrade. ➤ Enhanced firmware to add diagnostic improvements. ➤ Resolved an issue where the relay failed to evaluate analog quantity I850MOD when mapped to a SELOGIC control equation. ➤ Resolved an issue where the relay incorrectly retained all the port settings instead of only the IP address, subnet mask, and default router settings for Port 1 during a firmware upgrade from any previous R3*xx* firmware revision.	20220826
SEL-751-R301-V5-Z009005-D20230428	Includes all the functions of SEL-751-R301-V4-Z009005-D20220826 with the following additions: ➤ Resolved an issue with the frequency measurement algorithm at higher frequencies (greater than 68 Hz). The measured frequency was outside the specified accuracy of 0.01 Hz, which could result in incorrect operation of the overfrequency and rate-of-change-of-frequency (81R) elements. Only R3*xx* firmware versions are affected.	20230428
SEL-751-R301-V4-Z009005-D20220826	Includes all the functions of SEL-751-R301-V3-Z009005-D20220719 with the following additions: ➤ Improved performance to allow touchscreen operation after a firmware downgrade. ➤ Enhanced firmware to add diagnostic improvements.	20220826

Table A.2 R300 Series Firmware Revision History (Sheet 4 of 8)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-751-R301-V3-Z009005-D20220719	Includes all the functions of SEL-751-R301-V2-Z009005-D20220607 with the following addition: ➤ Resolved an issue in relays with a conventional 4 ACI or 4 ACI/3 AVI card where the arc flash (50PAF) and incipient cable fault (50INC) elements incorrectly operated after a power cycle or restarted after an **STA C** command. Only firmware versions R301-V0, R301-V1, and R301-V2 are affected.	20220719
SEL-751-R301-V2-Z009005-D20220607	Includes all the functions of SEL-751-R301-V1-Z009005-D20220308 with the following additions: ➤ Added firmware support for new hardware component suppliers. ➤ Resolved an issue with the arc-flash diagnostics. Only firmware versions R301-V0 and R301-V1 are affected. ➤ Resolved an issue that caused the touchscreen to incorrectly display "Resend the Touchscreen settings." ➤ Resolved an issue with the calculation of the total interharmonic content reference quantities (SDIAREF, SDIBREF, SDICREF) used in the Arc Sense technology (AST) function that can cause the AST element to operate slower or faster than expected. ➤ Resolved an issue with the operation of the fast hybrid output contact in arc-flash models when the corresponding outputs are used in the AOUTSLOT setting. Only firmware versions R301-V0 and R301-V1 are affected.	20220607
SEL-751-R301-V1-Z009005-D20220308	Includes all the functions of SEL-751-R301-V0-Z009005-D20220107 with the following additions: ➤ [Cybersecurity] Resolved an issue where GOOSE receive messages would no longer be processed during or after a GOOSE data storm on the network. ➤ Enhanced the relay firmware to retain the IP address, subnet mask, and default router settings during a firmware upgrade from any previous R3*xx* firmware revision.	20220308
SEL-751-R301-V0-Z009005-D20220107	➤ Added an ordering option for the 4 ACI/3 AVI low-energy analog (LEA) card in Slot Z. ➤ Added an ordering option for the 2 AVI/7 DI card in Slot E. ➤ Added the broken conductor detection (BCD) logic to detect and locate a single conductor break before it converts to a shunt fault. ➤ Added the phase discontinuity detection (PDD) element. ➤ Added the cold load pickup (CLPU) element. ➤ Enhanced the incipient cable fault detection logic to monitor the neutral current input. Also added SELOGIC control equations for torque control (50INTC) and element reset (50INCRST). ➤ Added support for single-phase voltage inputs with setting SING_VIN to allow for individual phase-to-phase or phase-to-neutral voltage selection. ➤ Added the ability to select phase-to-phase voltages for the synchronism check element when used with wye-connected PTs. ➤ Added the IEC 61850 blocked-by-interlocking control error response. ➤ Added analog quantities for breaker operate times for opening and closing the breaker. ➤ Increased the resolution of the neutral current channel IN from one to three decimal places in the fundamental metering report.	20220107

Table A.2 R300 Series Firmware Revision History (Sheet 5 of 8)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Provided Relay Word bits SW1A, SW1B, SW1C, and HIFER to enhance operational awareness of the Arc Sense technology (AST) logic. ➤ Increased the resolution of the 50N*n*P (*n* = 1, 2) settings from two to three decimal places for the 200 mA neutral CT option. ➤ Added the PFLEAD Relay Word bit to indicate power factor lead/lag. ➤ Resolved an issue where the relay always remained in IEC 61850 ON mode after the **R_S** command was issued, independent of the selected IEC 61850 mode/behavior.	
SEL-751-R300-V9-Z008004-D20230428	Includes all the functions of SEL-751-R300-V8-Z008004-D20220826 with the following additions: ➤ Resolved an issue with the frequency measurement algorithm at higher frequencies (greater than 68 Hz). The measured frequency was outside the specified accuracy of 0.01 Hz, which could result in incorrect operation of the overfrequency and rate-of-change-of-frequency (81R) elements. Only R3*xx* firmware versions are affected.	20230428
SEL-751-R300-V8-Z008004-D20220826	Includes all the functions of SEL-751-R300-V7-Z008004-D20220607 with the following additions: ➤ Improved performance to allow touchscreen operation after a firmware downgrade. ➤ Enhanced firmware to add diagnostic improvements.	20220826
SEL-751-R300-V7-Z008004-D20220607	Includes all the functions of SEL-751-R300-V6-Z008004-D20220225 with the following additions: ➤ Added firmware support for new hardware component suppliers. ➤ Resolved an issue that caused the touchscreen to incorrectly display "Resend the Touchscreen settings." ➤ Resolved an issue with the calculation of the total interharmonic content reference quantities (SDIAREF, SDIBREF, SDICREF) used in the Arc Sense technology (AST) function that can cause the AST element to operate slower or faster than expected. ➤ Resolved an issue where the relay always remained in IEC 61850 ON mode after issuing the **R_S** command independent of the selected IEC 61850 mode/behavior.	20220607
SEL-751-R300-V6-Z008004-D20220225	Includes all the functions of SEL-751-R300-V5-Z008004-D20220225 with the following addition: ➤ Resolved an issue where Ethernet/IP communication stopped after approximately 25 days.	20220225
SEL-751-R300-V5-Z008004-D20220225	Includes all the functions of SEL-751-R300-V4-Z008004-D20211116 with the following addition: ➤ [Cybersecurity] Resolved an issue where GOOSE receive messages would no longer be processed during or after a GOOSE data storm on the network.	20220225
SEL-751-R300-V4-Z008004-D20211116	Includes all the functions of SEL-751-R300-V3-Z008004-D20210104 with the following additions: ➤ Revised the firmware to allow replacement of the field-programmable gate array (FPGA) part. ➤ Enhanced the high-impedance fault (HIF) detection algorithm to ride-through de-energization of the line. ➤ Resolved an issue where a large number of file read operations could lead to a data retrieval error. ➤ Resolved an issue where the station battery voltage (Vbat) was reported incorrectly for voltages higher than 328 V.	20211116

Table A.2 R300 Series Firmware Revision History (Sheet 6 of 8)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Resolved an issue where the OC and CC control points would incorrectly pulse for the Nul/Latch Off control operation via DNP3 protocol. ➤ Resolved an issue where the status of IN305–IN308, OUT305–OUT308, OUT405–OUT408, and OUT505–OUT508 in the Fast Status Modbus registers were reported incorrectly. ➤ Resolved an issue where the GFLT Relay Word bit did not assert for all neutral ground faults. ➤ Resolved an issue with the OR logic of the OREDHIF1 and OREDHIF2 Relay Word bits.	
SEL-751-R300-V3-Z008004-D20210104	Includes all the functions of SEL-751-R300-V2-Z008004-D20200921 with the following additions: ➤ Resolved a rare issue where Telnet traffic could cause a diagnostic restart of the relay. ➤ Resolved an issue in touchscreen relay models where repeated triggering of the TRIP/WARN messages resulted in the relay becoming disabled. ➤ Resolved an issue where the **CAS** command response was corrupted after a setting change. This issue interfered with real-time automation controller (RTAC) event collection.	20210104
SEL-751-R300-V2-Z008004-D20200921	Includes all the functions of SEL-751-R300-V1-Z008004-D20200603 with the following additions: ➤ Resolved an issue with the EPORT setting for the Ethernet Port. ➤ Resolved an issue where the **HIS 50INC C** command did not reset the alarm and trip Relay Word bits for the incipient cable fault logic. ➤ Resolved an issue where relay models that included the low-energy analog (LEA) option did not report the **DNA** command response correctly. This issue interfered with ACSELERATOR QuickSet and ACSELERATOR RTAC communications. ➤ Resolved an issue where the Enable EtherNet/IP setting (EEIP) was not available in certain models. ➤ Resolved an issue in the relay where Modbus Register addresses did not match the Modbus Register Map.	20200921
SEL-751-R300-V1-Z008004-D20200603	Includes all the functions of SEL-751-R300-V0-Z008004-D20200331 with the following addition: ➤ Resolved an issue in relays with the two-line display and eight pushbutton HMI option where, after upgrading to R300-V0, the HMI self-test status displayed as WARN. Only relays manufactured after September 15, 2018 are affected.	20200603
SEL-751-R300-V0-Z008004-D20200331	➤ Added support for zipped and digitally signed (.zds) firmware files. These files requires the SELBOOT firmware version to be upgraded to R600 first. Firmware files with the .s19 and .z19 extensions cannot be sent to relays with SELBOOT firmware R600. ➤ Added the ability to upgrade relay firmware remotely over an Ethernet network. ➤ Added web server capability to relays equipped with Ethernet. ➤ Increased the number of two-position disconnects to eight and added control support to all two-position disconnects. ➤ Added two three-position disconnects with control support. ➤ Added support for IEEE 1588-2008 firmware-based Precision Time Protocol (PTP) for time synchronization.	20200331

Table A.2 R300 Series Firmware Revision History (Sheet 7 of 8)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Added IEC 61850 Test Mode with standard operating modes, including On, Blocked, Test, Test/Blocked, and Off. ➤ Added the EtherNet/IP communications option for relays equipped with Ethernet. ➤ Added the incipient cable fault detection (50INC) element. ➤ Improved the security of the Arc Sense technology (AST) logic in the firmware to support metering applications that use two-way automatic communication systems (TWACSs). ➤ Improved Sequential Events Recorder (SER) time-stamp accuracy for digital inputs and arc-flash elements (50PAF, 50NAF, TOL, and digital outputs) to 1 ms. ➤ Improved event reports to include settings at the time of the event. ➤ Improved the performance of the directional element logic during evolving faults. ➤ Enhanced the breaker failure logic by adding the settable breaker failure seal-in delay setting, BFISID. This setting supports schemes that seal-in without a delay or schemes biased towards security that use a pickup delay prior to seal-in or do not use a seal-in. Also added retrip and separate breaker failure trip logic. ➤ Added predefined IEC bay control single-line diagrams (SLDs) for touchscreen applications to the product literature CD. ➤ Added the ability to trigger event reports from the Event History application on the touchscreen display. ➤ Improved the security of the resistance temperature detector (RTD) FAULT, ALARM, and TRIP indicators by adding an approximately 12-second delay to filter RTD measurements distorted by electrical noise. ➤ Increased the upper limit of the frequency trip delay setting 81D*n*TD (*n* = 1 to 4) from 240.00 to 400.00 seconds. ➤ Added the 81D5T and 81D6T elements to the WARN STATUS HI Modbus register. ➤ Added the breaker fail element to the TRIP STATUS HI Modbus register. ➤ Added the RTDA and RTDT Relay Word bits for each RTD. ➤ Resolved an issue where the vector shift (78VS) element may not operate for islanding conditions preceded by a fault close to the relay. ➤ Resolved an issue where the reference period calculation gets frozen under certain system conditions after the 78VSO Relay Word bit asserts for the first time. This can result in the 78VSO Relay Word bit staying asserted even after the system reverts to normal operating conditions. ➤ Resolved an issue in which the power factor element did not correctly operate when real power was negative. ➤ Resolved an issue where the 52A Relay Word bit could occasionally deassert for one processing interval (4 ms) during group switching. ➤ Resolved an issue where the advanced directional elements (S, P, U) were available on the 200 mA neutral CT with the selection of the regular directional firmware feature. The advanced directional element is an optional, priced firmware feature. Firmware versions R112-V0 and higher are affected by this issue.	

Table A.2 R300 Series Firmware Revision History (Sheet 8 of 8)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Revised the firmware to remove the ability to configure TCP native keep-alive settings for DNP3 because the DNP3 standard requires the use of a DNP specific TCP keep-alive mechanism, which can be configured using the DNPINA setting. ➤ Resolved an issue in which the relay continued to send Fast Sequential Events Recorder (SER) data to the real-time automation controller (RTAC) after the relay acknowledged an RTAC disable command. ➤ Addressed an issue with event type mismatch between the CHI and CEV commands that resulted in RTACs being unable to collect events with event type strings longer than 14 characters. ➤ Resolved an issue where the state of Target LED (TLED) data points were not correctly reported in GOOSE messages. ➤ Resolved an issue where the Global access control setting DSABLSET did not disable editing settings via the touchscreen interface when DSABLSET := Y. ➤ Resolved an issue where the analog quantities for rms voltages were not correctly reported when SINGLEV = Y. ➤ Resolved an issue in the touchscreen models in which the power factor lead/lag label shown on the fundamental metering screen was not updating when setting SINGLEV = Y. ➤ Resolved an issue in the touchscreen models where editing the DNP3 setting, TIMERQ, resulted in an unresponsive screen until the Home pushbutton was pressed. ➤ Resolved an issue where the COMTRADE events included event data four times. Firmware versions R112-V0 and higher are affected by this issue. ➤ Modified firmware to increment the state number (stNum) in GOOSE messages for any change of the quality attribute.	

Table A.3 R200 Series Firmware Revision History (Sheet 1 of 5)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-751-R202-V5-Z007003-D20220826	Includes all the functions of SEL-751-R202-V4-Z007003-D20220607 with the following addition: ➤ Enhanced firmware to add diagnostic improvements.	20220826
SEL-751-R202-V4-Z007003-D20220607	Includes all the functions of SEL-751-R202-V3-Z007003-D20220225 with the following addition: ➤ Added firmware support for new hardware component suppliers.	20220607
SEL-751-R202-V3-Z007003-D20220225	Includes all the functions of SEL-751-R202-V2-Z007003-D20211116 with the following addition: ➤ [Cybersecurity] Resolved an issue where GOOSE receive messages would no longer be processed during or after a GOOSE data storm on the network.	20220225
SEL-751-R202-V2-Z007003-D20211116	Includes all the functions of SEL-751-R202-V1-Z007003-D20210104 with the following additions: ➤ Revised the firmware to allow replacement of the field-programmable gate array (FPGA) part. ➤ Enhanced the high-impedance fault (HIF) detection algorithm to ride through de-energization of the line. ➤ Resolved an issue where a large number of file read operations could lead to a data retrieval error.	20211116

Table A.3 R200 Series Firmware Revision History (Sheet 2 of 5)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Resolved an issue where the station battery voltage (Vbat) was reported incorrectly for voltages higher than 328 V. ➤ Resolved an issue where the OC and CC control points would incorrectly pulse for the Nul/Latch Off control operation via DNP3 protocol. ➤ Resolved an issue where the status of IN305–IN308, OUT305–OUT308, OUT405–OUT408, and OUT505–OUT508 in the Fast Status Modbus registers were reported incorrectly. ➤ Resolved an issue where the GFLT Relay Word bit did not assert for all neutral ground faults. ➤ Resolved an issue with the OR logic of the OREDHIF1 and OREDHIF2 Relay Word bits.	
SEL-751-R202-V1-Z007003-D20210104	Includes all the functions of SEL-751-R202-V0-Z007003-D20200331 with the following additions: ➤ Resolved a rare issue where Telnet traffic could cause a diagnostic restart of the relay. ➤ Resolved an issue in touchscreen relay models where repeated triggering of the TRIP/WARN messages resulted in the relay becoming disabled. ➤ Resolved an issue where the **CAS** command response was corrupted after a setting change. This issue interfered with real-time automation controller (RTAC) event collection.	20210104
SEL-751-R202-V0-Z007003-D20200331	➤ Improved the performance of the directional element logic during evolving faults. ➤ Resolved an issue where the vector shift (78VS) element may not operate for islanding conditions preceded by a close-in fault. ➤ Resolved an issue where the reference period calculation gets frozen under certain system conditions after the 78VSO Relay Word bit asserts for the first time. This can result in the 78VSO Relay Word bit staying asserted even after the system reverts to normal operating conditions. ➤ Resolved an issue in which the power factor element did not correctly operate when real power was negative. ➤ Resolved an issue where the 52A Relay Word bit could occasionally deassert for one processing interval (4 ms) during group switching. ➤ Resolved an issue in which the relay continued to send Fast SER data to the RTAC even after the relay acknowledged an RTAC disable command. ➤ Addressed a mismatch between the event type strings for the CHI and CEV commands. Due to the mismatch, SEL RTACs were not able to collect events with event type strings longer than 14 characters from the relay. ➤ Resolved an issue where the Target LED (TLED) data point were not correctly reported in GOOSE messages. ➤ Resolved an issue in the touchscreen models where editing the DNP3 setting, TIMERQ, resulted in an unresponsive screen until the Home pushbutton was pressed. ➤ Resolved an issue where the relay enabled 1/2 cycle before the front-end analogs settled down, leading to nuisance events on relay power up. This issue affects firmware version R201-V1 only.	20200331

Table A.3 R200 Series Firmware Revision History (Sheet 3 of 5)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-751-R201-V1-Z007003-D20180921	Includes all the functions of SEL-751-R201-V0-Z007003-D20180420 with the following additions: ➤ Expanded the TCP keep-alive settings to all TCP protocols, including Telnet, FTP, DNP3, MMS, and IEEE C37.118 (PMU), so that keep alive can be turned off or configured as desired. ➤ Resolved an issue where the relay failed to resend IEC 61850 MMS reports upon power cycling once good quality data was available. ➤ Resolved an issue where the internally-enabled, negative-sequence, voltage-polarized directional element, DIRQE, incorrectly blocked positive-sequence, voltage-polarized directional elements from asserting. ➤ Resolved an issue with losing the MAC address when upgrading certain units in the field from R110 or earlier to R112-V0–R113-V0 or R200-V2–R201-V0. ➤ Resolved an issue in R201-V0 where clearing the event history from the touchscreen did not clear the event history buffer and resulted in the TRGTR Relay Word bit being pulsed continuously until the relay was restarted. ➤ Resolved an issue with the PULSE/CON PULSE/TEST DO command on any output blocking the processing of all the remaining outputs for the duration of the pulse. ➤ Resolved an issue where RTD values were not accepted in the Modbus map. ➤ Resolved an issue in R201-V0 where the Port 1 Modbus settings EMOD, MODNUM*n*, and MTIMEO*n* showed a redundant OFF in the ranges.	20180921
SEL-751-R201-V0-Z007003-D20180420	➤ Resolved an issue where the CHIS report displayed an incorrect value for fault location. ➤ Increased the resolution of neutral current channel IN from one to three decimal points in CEV/EVE reports. ➤ Resolved an issue with the editing of Ethernet DNP settings and Modbus settings from the touchscreen front panel. ➤ Resolved an issue with editing settings with interdependencies from the touchscreen front panel that could lead to mismatched settings and/or incomplete hiding of the settings display. For example, editing 50P1P to OFF from the touchscreen relay would not hide the other settings in the category. ➤ Updated BDP file to 1.0.50751.2010.	20180420
SEL-751-R200-V4-Z007003-D20170922	Includes all the functions of SEL-751-R200-V3-Z007003-D20170814 with the following additions: ➤ Added support for a four pushbutton touchscreen relay configuration option in the model option table (MOT). ➤ Added support for a touchscreen relay configuration option without a fiber-optic serial port in the MOT.	20171206
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

Table A.3 R200 Series Firmware Revision History (Sheet 4 of 5)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-751-R200-V3-Z007003-D20170814	Includes all the functions of SEL-751-R200-V2-Z007003-D20170315 with the following addition: ➤ Resolved an issue where certain Ethernet traffic could cause diagnostic restarts.	20170814
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

Table A.3 R200 Series Firmware Revision History (Sheet 5 of 5)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Modified the General Purpose Serial Bus (GPSB) diagnostics logic to show a failure only if the GPSB diagnostics fail three consecutive times within a 24-hour period. ➤ Resolved an issue where the synchrophasor protocol was missing data packets and configuration frame packets. This issue has been resolved in R200-V2.	
SEL-751-R200-V1	➤ SEL-751 R200-V1 was not released.	—
SEL-751-R200-V0	➤ SEL-751 R200-V0 was not released.	—

Table A.4 R100 Series Firmware Revision History (Sheet 1 of 6)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-751-R113-V2-Z006002-D20220225	Includes all the functions of SEL-751-R113-V1-Z006002-D20180921 with the following addition: ➤ [Cybersecurity] Resolved an issue where GOOSE receive messages would no longer be processed during or after a GOOSE data storm on the network.	20220225
SEL-751-R113-V1-Z006002-D20180921	➤ Expanded the TCP keep-alive settings to all TCP protocols, including Telnet, FTP, DNP3, MMS, and IEEE C37.118 (PMU), so that keep alive can be turned off or configured as desired. ➤ Resolved an issue where the relay failed to resend IEC 61850 MMS reports upon power cycling once good quality data was available. ➤ Resolved an issue where the internally-enabled, negative-sequence, voltage-polarized directional element, DIRQE, incorrectly blocked positive-sequence, voltage-polarized directional elements from asserting. ➤ Resolved an issue with losing the MAC address when upgrading certain units in the field from R110 or earlier to R112-V0–R113-V0 or R200-V2–R201-V0. ➤ Resolved an issue with the PULSE/CON PULSE/TEST DO command on any output blocking the processing of all the remaining outputs for the duration of the pulse. ➤ Resolved an issue where RTD values were not accepted in the Modbus map. 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.	20180921
SEL-751-R113-V0-Z006002-D20180420	➤ Resolved an issue where the CHIS report displayed an incorrect value for fault location. ➤ Increased the resolution of neutral current channel IN from 1 to 3 decimal points in CEV/EVE reports. 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.	20180420

Table A.4 R100 Series Firmware Revision History (Sheet 2 of 6)

Firmware Identification (FID) String	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 addition: ➤ 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. 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.	20170922
SEL-751-R112-V2-Z006002-D20170814	Includes all the functions of SEL-751-R112-V1-Z006002-D20160930 with the following addition: ➤ 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.	20151112

Table A.4 R100 Series Firmware Revision History (Sheet 3 of 6)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ 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. ➤ 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 Telnet access setting ETELNET and FTP access setting EFTPSERV to Ethernet Port 1. ➤ 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.	

Table A.4 R100 Series Firmware Revision History (Sheet 4 of 6)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Modified the prompt for DNP Master IP Address DNPIPn to distinguish them from the device IP Address. ➤ Added the TEST DB command to support relay testing. ➤ Resolved an overflow issue in the impedance calculation (Z0) for the zero-sequence voltage-polarized directional element. Firmware versions R103 to R110 are affected.	
SEL-751-R111	➤ SEL-751 R111 was not released.	—
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.	20131101

Table A.4 R100 Series Firmware Revision History (Sheet 5 of 6)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ 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. ➤ 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 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.	20130206

Table A.4 R100 Series Firmware Revision History (Sheet 6 of 6)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ 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. ➤ 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

SELBOOT Firmware Version and Relay Firmware Compatibility

The SELBOOT version and the compatible relay firmware versions are listed in *Table A.5*. The SELBOOT firmware R600 ensures that the relay firmware upgrade file is digitally signed by SEL using a secure hash algorithm and that the file has been provided by SEL and that its contents have not been altered. R300-V0 or higher firmware requires that the SELBOOT firmware be upgraded to R600.

Table A.5 SELBOOT Firmware Revision History (Sheet 1 of 2)

Boot Firmware Identification Number	Summary of Revisions	Firmware Version Supported	Release Date
SLBTIND-R101-V0-Z000000-D20230609	➤ Improved the relay start up time (ENABLED LED ON).	R4*xx* and higher	20230609
SLBTIND-R100-V0-Z000000-D20230315	➤ Revised the SELBOOT firmware to support a new CPU board.	R4*xx* and higher	20230315
SLBT7XX-R602-V0-Z000000-D20220826	➤ Improved the restart performance of the SELBOOT firmware.	R3*xx*	20220826
SLBT7XX-R601-V0-Z000000-D20211116	➤ Revised the SELBOOT firmware to allow replacement of the field-programmable gate array (FPGA) part.	R3*xx*	20211116

Table A.5 SELBOOT Firmware Revision History (Sheet 2 of 2)

Boot Firmware Identification Number	Summary of Revisions	Firmware Version Supported	Release Date
SLBT7XX-R600-V0-Z000000-D20200331	➤ The new SELBOOT supports zipped and digitally signed (.zds) firmware files.	R3*xx*	20200331
BOOTLDR-R502-V0-Z000000-D20211116	➤ Revised the SELBOOT firmware to allow replacement of the field-programmable gate array (FPGA) part.	R1*xx*, R2*xx*	20211116
BOOTLDR-R501-V0-Z000000-D20140402	➤ Changed RAM integrated circuit.	R1*xx*, R2*xx*	20140402
BOOTLDR-R500-V0-Z000000-D20110601	➤ Initial version.	R100 to R108	20110601

SEL Display Package Versions

The SEL-751 with the touchscreen display option has display packages for the SEL display and default custom display. The SEL display package is embedded in the relay firmware. *Table A.6* 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.6 SEL Display Package Revision History (Sheet 1 of 2)

SEL Display Package Version	Revisions	Release Date
3.0.50751.3024	➤ Resolved an issue where the touchscreen relay displayed the Light Intensity and Arc-Flash Diagnostics icons for models that did not include the arc-flash option.	20240308
3.0.50751.3020	➤ Improved performance to allow touchscreen operation during a firmware downgrade.	20220826
3.0.50751.3012	➤ Added firmware support for new hardware component suppliers.	20220607
3.0.50751.3010	➤ Updated the Fundamental, RMS, and Phasors applications for 4 ACI/3 AVI low-energy analog (LEA) card in Slot Z. ➤ Updated the Digital Inputs application for the new Vsync/Vbat/7 digital input (2 AVI/7 DI) cards in Slot E. ➤ Increased the resolution of the neutral current channel IN from one to three decimal places in the Fundamental application.	20220107
3.0.50751.3007	➤ Added firmware support for new hardware component suppliers.	20220607
3.0.50751.3004	➤ Added support for new hardware component suppliers. ➤ Modified the color touchscreen backlight brightness for more consistent dimming while in standby mode. ➤ Improved the performance of the touchscreen display in rotating display mode. ➤ Resolved an issue where the backlight could flicker during power up.	20211116
3.0.50751.3000	➤ Updated the keyboard layout on the touchscreen display for ease of data entry. ➤ Added pick list feature for settings that have a fixed list in the setting range. ➤ Added the ability to keep the backlight of the touchscreen display always on after the inactivity timer expires. Relays shipped after May 21, 2020 will support this feature.	20200331
1.0.50751.2022	➤ Added support for new hardware component suppliers.	20211116
1.0.50751.2010	➤ Resolved an issue of slow HMI display startup that can occur in some relays.	20180420

Table A.6 SEL Display Package Revision History (Sheet 2 of 2)

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.7*. The SEL display package is embedded in the relay firmware. 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.7 SEL Display Package Compatibility With Relay Firmware

SEL Display Package Version	Relay Firmware Versions Supported	Release Date
3.0.50751.3024	R302-V4, R400-V2, R401-V0, and R402-V0	20240308
3.0.50751.3020	R300-V8, R300-V9, R301-V4, R301-V5, R302-V0 to R302-V3, R400-V0, and R400-V1	20220826
3.0.50751.3012	R301-V2 or higher	20220607
3.0.50751.3010	R301-V0 or higher	20220107
3.0.50751.3007	R300-V7 or higher	20220607
3.0.50751.3004	R300-V4 or higher	20211116
3.0.50751.3000	R300-V0 or higher	20200331
1.0.50751.2022	R202-V2 or higher	20211116
1.0.50751.2010	R201-V0 or higher	20180420
1.0.50751.2004	R200-V4 or higher	20170922
1.0.50751.2000	R200-V2 or higher	20170315

DeviceNet and Firmware Versions

The firmware on the DeviceNet interface has one version, as listed in *Table A.8*. 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.8 DeviceNet Card Version

DeviceNet Card Software Version	Revisions	Release Date
Major Rev: 1, Minor Rev: 5 (Rev 1.005)	Reads product code, DeviceNet card parameter descriptions, etc., from the relay.	20080407

The Electronic Data Sheet (EDS) file is not updated every time a firmware release is made. A new EDS file is released only when there is a change in the Modbus/DeviceNet parameters. The EDS file and an ICON file for the SEL-751 are zipped together (SEL-*xxx*R*xxx*.zip) and can be downloaded from the SEL website at selinc.com.

Table A.9 lists the compatibility among the EDS files and the various firmware versions of the relay.

Table A.9 EDS File Compatibility

EDS File	Firmware Revisions Supported	Release Date
SEL-751R400.EDS	R400, R401, R402	20230315
SEL-751R300.EDS	R300, R301, R302	20200331
SEL-751R200.EDS	R200, R201, R202	20170315
SEL-751R101.EDS	R112, R113	20151112
SEL-751R100.EDS	R101, R102, R103, R105, R106, R108, R109, R110	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.10 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.10 SEL-751 ICD File Revision History (Sheet 1 of 10)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect File Description	Manual Date Code
ICD-751-R402-V0-Z402010-D20241231	➤ Initial ICD file release with Edition 2.1 support and compatibility. ➤ Updated ClassFileVersion to 010. ➤ Added pulse configuration attributes cmdQual, onDur, offDur, and numPls according to IEC 61850-7-3 Edition 2.1.	R402-V0 and higher	010	SEL-751 Edition 2.1, R402 or higher	20241231

Table A.10 SEL-751 ICD File Revision History (Sheet 2 of 10)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect File Description	Manual Date Code
	➤ Added deadband data attributes dbRef, dbAngRef, zeroDbRef, and zeroDb according to IEC 61850-7-3 Edition 2.1. ➤ Added attributes valImport and valKind according to IEC 61850-6 for compatibility with third-party system configuration tools. ➤ Added the BK179RREC1 logical node to support breaker autoreclose functionality. ➤ Extended the LPHD logical node to include the IEC 61850 library version (SelLibId). ➤ Added LocKey data object support and modified the data source mapping for Loc and LocSta. ➤ Added support for the sAddr attribute to replace esel:datasrc attribute in ICD files to improve compatibility with third-party system configuration tools. ➤ Removed logical devices MVGGIO12 and SCGGIO20 and added logical devices MVGGIO1, MVGGIO2, SCGGIO1, and SCGGIO2. ➤ Added data object FGRXQ in logical nodes FGRX*n*GGIO (*n* = 1–4) to report FG*n*RQ Relay Word bit. ➤ Modified data source of Loc data object of XSWI and XCBR logical nodes from OREDLOC to LOCAL. ➤ Conformance-related changes.				

Table A.10 SEL-751 ICD File Revision History (Sheet 3 of 10)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect File Description	Manual Date Code
ICD-751-R401-V0-Z401009-D20240308	➤ Updated ClassFileVersion to 009. ➤ Increased number of MMS reports to 24. ➤ Increased number of default datasets to 32. ➤ Conformance related changes. ➤ Modified Pos attribute in BK1XCBR1 logical node to report 52A|52B breaker status. ➤ Modified EnaOpn and EnaCls datasource in BKR1CILO1 logical node. ➤ Removed GOLCCH2 logical node and replaced IPLCCH1 logical node with ETHLCCH1.	R401-V0 and higher	009	SEL-751 Edition 2, R401 or higher	20240308
ICD-751-R400-V0-Z400006-D20230315	➤ Added over- and underfrequency protection element pickup Relay Word bits to D1TPTOF1, D2TPTOF2, D3TPTOF3, D4TPTOF4, D5TPTOF5, and D6TPTOF6 logical nodes. ➤ Added rate-of-change-of-frequency protection element pickup Relay Word bits to R1TPFRC1, R2TPFRC2, R3TPFRC3, and R4TPFRC4 logical nodes. ➤ Added RBGGIO5, RBGGIO6, RBGGIO7, and RBGGIO8 logical nodes to support 64 remote bits to CON logical device. ➤ Added PRBGGIO5, PRBGGIO6, PRBGGIO7, and PRBGGIO8 logical nodes to support pulsing of 64 remote bits to CON logical device.	R400-V0 and higher	006	SEL-751 Edition 2, R400 or higher	20230315

Table A.10 SEL-751 ICD File Revision History (Sheet 4 of 10)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect File Description	Manual Date Code
	➤ Added new attributes Ind33–Ind 64 to SVGGIO3 logical node to support 64 SELOGIC variables. ➤ Added new attributes Ind33–Ind64 to SVTGGIO4 logical node to support 64 SELOGIC variables. ➤ Added new attributes Ind33–Ind64 to LTGGIO5 logical node to support 64 latch bits. ➤ Added new attributes AnIn33–AnIn64 to MVGGIO12 logical node to support 64 math variables. ➤ Added VBGGIO2 logical node to ANN logical device to support 256 virtual bits. ➤ Added new attributes AnIn33–AnIn64 to SCGGIO20 to support 64 SELOGIC counters.				
ICD-751-R204-V0-Z302006-D20220826	➤ Added system logical nodes LGOS, LTIM, LTMS, and LCCH. ➤ Added the IEC 61850 LTRK logical node for service tracking. ➤ Added the IEC 61850 feature for simulation mode. ➤ Added support for the IEC 61850 Local/Remote control feature defined in the IEC 61850-7-4 standard. Control messages need to include the orCat value associated with the active control authority. ➤ Added support for the IEC 61850 Functional naming feature. ➤ Added PRBGGIO logical nodes to support pulsing remote bits.	R302-V0 and higher	006	SEL-751 Edition 2, R302 or higher	20220826

Table A.10 SEL-751 ICD File Revision History (Sheet 5 of 10)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect File Description	Manual Date Code
ICD-751-R203-V0-Z301006-D20220107	➤ Added the blocked-by-interlocking AddCause to the control error response when an operation fails due to a control interlocking (CILO) check. ➤ Added the new BKR1CILO1 logical node and attributes to the PRO logical device for breaker control and status. ➤ Added the new EMCSCBR1 and FHCSCBR1 logical nodes and attributes to the ANN logical device for breaker monitoring analogs. ➤ Modified Pos attribute of BKR1CSWI1 Logical node to report 52A|52B breaker status.	R301 and higher	006	SEL-751 Edition 2, R301 or higher	20220107
ICD-751-R202-V0-Z300006-D20200331	➤ Added the ability to control mode and behavior through an MMS write to the LPHD logical node mode data object (Mod. ctlVal) in logical device CFG. ➤ Added new DC1CSWI1–DC12CSWI12, DC1CILO1–DC12CILO12, and DC1XSWI1–DC12XSWI12 Logical Nodes and attributes to PRO LDevice for Disconnect Control and Status. ➤ Added new SYN1RSYN1 and SYN2RSYN2, Logical Nodes and attributes to PRO LDevice for Synchronism Check element status.	R300 and higher	006	SEL-751 Edition 2, R300 or higher	20200331

Table A.10 SEL-751 ICD File Revision History (Sheet 6 of 10)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect File Description	Manual Date Code
	➤ Replaced AbrPrt attribute with AccAbr attribute in BWASCBR1, BWBSCBR2, and BWCSCBR3 Logical Nodes to conform with the IEC61850 standard for SCBR Logical Node.				
ICD-751-R201-V0-Z200006-D20170315	➤ Increased 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	SEL-751 Edition 2, R200 or 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. ➤ Added filehandling service. ➤ Added support to change settings groups with IEC 61850. ➤ Added support for the stSeld attribute in IEC 61850 SBO controls.	R111 and higher	006	SEL-751 Edition 2, R111 or higher	20151112

Table A.10 SEL-751 ICD File Revision History (Sheet 7 of 10)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect File Description	Manual Date Code
	➤ 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.				

Table A.10 SEL-751 ICD File Revision History (Sheet 8 of 10)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect File Description	Manual Date Code
	➤ Added new attribute Vsyn to RMSMMXU2 Logical Node. ➤ Added new attributes MaxVs, and MinVs to METMSTA1 Logical Node. ➤ 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.	R106 and higher	004	SEL-751 R106 and above	20131101

Table A.10 SEL-751 ICD File Revision History (Sheet 9 of 10)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	acSELerator Architect File Description	Manual Date Code
	➤ Corrected ReportControl rptID attributes to display report name instead of dataset name. ➤ Updated orCat control instances to proprietary node. ➤ Corrected deadbands 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. ➤ 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. ➤ Corrected 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.				

Table A.10 SEL-751 ICD File Revision History (Sheet 10 of 10)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect File Description	Manual Date Code
	➤ 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	SEL-751 R105 and earlier	20130206
ICD-751-R101-V0-Z000000-D20111014	➤ Added Serial and Model Number attributes to PhyNam DO.	R103–R105	004[a]	N/A	20111116
ICD-751-R100-V0-Z000000-D20110623	➤ Initial ICD File Release.	R101–R102	004[a]	N/A	20110601

[a] These ICD files are no longer supported and are not included with the Architect software.

Instruction Manual

The date code at the bottom of each page of this manual reflects the creation or revision date. *Table A.11* lists the instruction manual versions and revision descriptions. The most recent instruction manual is listed first.

Table A.11 Instruction Manual Revision History (Sheet 1 of 25)

Date Code	Summary of Revisions
20241231	Section 4 ➤ Updated *Table 4.3: CT Configuration Settings for LEA Slot Z CT Card*. ➤ Updated *Example 4.4: Clipping Voltage Calculation for Rogowski Coil* and *Example 4.6: Additional Setting Conversion*. ➤ Updated *Secondary Current Calculation for LEA Current Inputs*. ➤ Updated *LEA Ratio Correction Settings*. ➤ Updated *Table 4.85: Breaker Failure Settings*. Setting Sheets ➤ Updated *Configuration Settings*, *Breaker Failure*, and *IEC 61850 Simulation Mode*. Section 7 ➤ Added *Network Storm Detection*.

Table A.11 Instruction Manual Revision History (Sheet 2 of 25)

Date Code	Summary of Revisions
	Section 8 ➤ Updated *Figure 8.6: Main Menu*, *Figure 8.7: MAIN Menu and METER Submenu*, *Figure 8.12: MAIN Menu and EVENTS Submenu*, *Figure 8.16: MAIN Menu and TARGETS Submenu*, *Figure 8.18: MAIN Menu and CONTROL Submenu*, *Figure 8.21: MAIN Menu and SET/SHOW Submenu*, *Figure 8.23: MAIN Menu and STATUS Submenu*, and *Figure 8.24: MAIN Menu and BREAKER Submenu*. ➤ Added *Sequential Events Recorder (SER) Menu*, including *Figure 8.24: MAIN Menu and SER Submenu* through *Figure 8.27: Relay Response When SER Report Is Cleared*. Appendix A ➤ Updated for firmware versions R402-V0, R401-V3, R400-V5, and R302-V6. ➤ Updated *Table A.7: SEL Display Package Compatibility With Relay Firmware*. ➤ Updated *Table A.9: EDS File Compatibility*. Appendix G ➤ Updated for changes related to IEC 61850 Edition 2.1. Appendix L ➤ Updated *Table L.1: SELOGIC Relay Word Bits* and *Table L.2: Relay Word Bit Definitions for the SEL-751*.
20241031	Section 8 ➤ Updated *Front Panel Operator Control Pushbuttons* for changes related to the discontinuation of the Product Literature CD. Section 9 ➤ Updated *Bay Screen Builder Software* and *Bay Control Application Example* for changes related to the discontinuation of the Product Literature CD. Appendix A ➤ Updated for firmware versions R401-V2 and R400-V4. ➤ Updated *DeviceNet and Firmware Versions* for changes related to the discontinuation of the Product Literature CD. Appendix B ➤ Updated *Required Equipment* for changes related to the discontinuation of the Product Literature CD. ➤ Updated *Upgrade the SELBOOT Firmware Loader Using a Terminal Emulator* for changes related to the discontinuation of the firmware CD. Appendix D ➤ Updated *Device Profile* for changes related to the discontinuation of the Product Literature CD. Appendix H ➤ Updated *IEC 60870-5-103 Documentation* for changes related to the discontinuation of the Product Literature CD. Appendix I ➤ Updated *Electronic Data Sheet* for changes related to the discontinuation of the Product Literature CD.
20240930	Preface ➤ Updated *General Safety Marks* for UL compliance language. Section 1 ➤ Updated *Communication and Control Features*, *SEL-751 Base Unit*, *Accessories*, and *Specifications*. Section 2 ➤ Updated *Physical Location*. ➤ Updated *I/O Configuration* for arc-flash detection inputs card-related changes. ➤ Updated *IRIG-B Time-Code Input*.

Table A.11 Instruction Manual Revision History (Sheet 3 of 25)

Date Code	Summary of Revisions
	Section 4 ➤ Updated *Table 4.9: Maximum Phase Overcurrent Settings* through *Table 4.14: A-, B-, and C-Phase Time-Overcurrent Settings*, as well as *Table 4.17: Neutral Time-Overcurrent Settings*. ➤ Added a note to *Figure 4.44: Positive-Sequence Voltage-Polarized Directional Element for Phase Overcurrent Elements*. ➤ Updated *High-Impedance Fault Detection With Arc Sense Technology*. ➤ Updated *Table 4.38: CLPU Settings*. ➤ Added a note to *Table 4.58: Time Window Versus 81RnTP Setting*. ➤ Updated *Breaker Failure Settings*. ➤ Updated *Table 4.86: Arc-Flash Overcurrent Settings*. Section 7 ➤ Updated *Figure 7.4: IRIG-B Input (Relay Terminals B01–B02)* through *Figure 7.6: IRIG-B Input Via EIA-232 Port 3 (SEL-2401/2407/2488 Time Source)*, as well as *Figure 7.8: IRIG-B Input Via Fiber-Optic EIA-232 Port 2 (SEL-2401/2407/2488 Time Source)*. Section 9 ➤ Updated *Overview*. Section 10 ➤ Updated *Event Reporting*. Appendix A ➤ Updated for firmware versions R401-V1, R400-V3, and R302-V5. ➤ Added note "Resolved an issue where the relay could experience a NON VOL failure under certain conditions" to firmware versions R401-V0, R400-V2, and R302-V3. ➤ Updated *Table A.3: R200 Series Firmware Revision History* with a revision in FID String SEL-751-R200-V2-Z007003-D20170315. Appendix G ➤ Updated *Table G.7: Control Authority Settings*.
20240329	Preface ➤ Updated *Compliance Approvals*, *Hazardous Locations Approvals*. ➤ Updated Trademarks. Section 3 ➤ Updated *Table 3.1: SEL Software Solutions*. Appendix A ➤ Updated for firmware versions R302-V4. Appendix K ➤ Updated *Overview*.
20240308	Section 1 ➤ Updated *Table 1.3: SEL-751 Protection Elements*. ➤ Updated *Monitoring Features*, *Options*, and *Accessories*. ➤ Updated *Figure 1.5: STA Command Response*. ➤ Updated *Specifications*. Section 2 ➤ Updated *Voltage Connections*, including *Figure 2.28: Voltage Connections*. ➤ Updated *Potential Transformer Ratios and PT Nominal Secondary Voltage Settings* and *Station DC Battery Monitor*. ➤ Updated *Figure 2.31: SEL-751 Provides Overcurrent Protection for a Distribution Bus (Includes Fast Bus Trip Scheme) (Wye-Connected PTs)*.

Table A.11 Instruction Manual Revision History (Sheet 4 of 25)

Date Code	Summary of Revisions
	Section 4 ➤ Updated *Configuration Settings*, including *Table 4.4: Voltage Configuration Settings* and *Table 4.5: Effect on Group Settings When SINGLEV := Y*. ➤ Updated *Figure 4.2: Instantaneous Overcurrent Element Logic Without Directional Control*, *Figure 4.3: Instantaneous Overcurrent Element Logic With Directional Control Enabled*, and *Figure 4.11: Neutral Time-Overcurrent Elements 51N1T and 51N2T*. ➤ Updated *Table 4.26: Directional Control Settings* and *Table 4.27: Wattmetric Settings*. ➤ Updated *Settings Made Automatically*, including *Table 4.28: Ground Directional Element Settings AUTO Calculations*. ➤ Updated *High-Impedance Fault Detection With Arc Sense Technology*, including *Table 4.34: HIF Detection Settings* and *Table 4.35: HIF Relay Word Bits*. ➤ Updated *Under- and Overvoltage Functions*, including *Table 4.43: Undervoltage Function*, *Table 4.44: Overvoltage Function*, *Figure 4.76: Undervoltage Element Logic*, and *Figure 4.77: Overvoltage Element Logic*. ➤ Updated *Figure 4.82: Synchronism-Check Voltage Window* and *Slip Frequency Elements*. ➤ Updated *Table 4.51: Synchronism-Check Settings*. ➤ Updated *Block Synchronism-Check Conditions* and *Slip Frequency Calculator*. ➤ Added *Manual Closing Voltage Check*. ➤ Updated *Loss-of-Potential (LOP) Protection*. ➤ Updated *Table 4.56: Frequency Settings*. ➤ Updated *Frequency Protection*, including *Figure 4.92: Over- and Underfrequency Element Logic*. ➤ Updated *Rate-of-Change-of-Frequency (81R) Protection*. ➤ Added *Detecting Frequency Components With the 97FM Element*. ➤ Updated *Trip/Close Logic*, including *Table 4.63: Trip/Close Logic Settings*. ➤ Added *Manual Trip Logic*, including *Figure 4.102: Manual Trip Logic*. ➤ Updated *Table 4.78: General Global Settings*. ➤ Updated *General Settings* and *PTP Over PRP Networks*. ➤ Updated *Breaker Failure Settings*, including *Table 4.85: Breaker Failure Settings*, *Figure 4.124: Breaker Failure Logic*, and *Figure 4.125: Breaker Failure Trip Logic*. ➤ Updated *Table 4.111: Example Settings and Displays*. ➤ Updated *Event Report Settings*, including *Table 4.118: Event Report Settings*. ➤ Updated *HIF Event Report Settings*, *Table 4.119: HIF Event Report Settings*. Section 5 ➤ Updated *DC Under- and Overvoltage Elements*, including *Table 5.9: Station DC Battery Monitor Settings*. Settings Sheets ➤ Updated *Configuration*. ➤ Updated *Directional Control*, including *Table SET.1: Range Dependencies for the EDIR Setting*. ➤ Updated *Wattmetric*, *High-Impedance Fault (HIF) Detection*, *Undervoltage*, *Overvoltage*, *Synchronism Check*, *Frequency*, *Trip/Close Logic*, *General*, *Breaker Failure*, *Station DC Battery Monitor*, *Two-Position Disconnect*, and *HIF Event Reporting*. ➤ Added *97 Frequency Magnitude* and *IEC 61850 Breaker CILO*. ➤ Updated *Event Report* and *HIF Event Reporting*. Section 7 ➤ Updated *Simple Network Time Protocol (SNTP)* and *SNTP as Primary Backup Time Source*. ➤ Updated *Precision Time Protocol*, *Configuring PTP in the Relay*. ➤ Added *FGS (Fixed GOOSE) Command* and *PRP Command*. Section 10 ➤ Updated *Event Reporting*, *Length* and *Event Summaries*. ➤ Updated *Table 10.1: Event Types*, *Figure 10.2: Sample Event History*, *Table 10.3: Event Report Current and Voltage Columns*, *Figure 10.6: Sample Compressed ASCII Event Report*, and *Figure 10.9: Sample COMTRADE .CFG Configuration File Data*. ➤ Updated *High-Impedance Fault (HIF) Event Reporting*. ➤ Updated *Figure 10.14: Sample HIF COMTRADE .HDR Header File*.

Table A.11 Instruction Manual Revision History (Sheet 5 of 25)

Date Code	Summary of Revisions
	Section 11 ➤ Updated *Testing Tools*, *Serial Port Commands*. ➤ Updated *Figure 11.1: Low-Level Test Interface (J2 and J4)* and *Table 11.1: Resultant Scale Factors for Inputs*. Appendix A ➤ Updated for firmware versions R302-V3, R400-V2, and R401-V0. ➤ Updated the R400-V0 IEEE C37.111-2013 COMTRADE event format entry. ➤ Updated for display package version 3.0.50751.3024. ➤ Updated for ICD file version R401-V0. Appendix D ➤ Updated *Time Synchronization*. Appendix E ➤ Updated *Table E.33: Modbus Register Labels for Use With SEL M Command*, *Table E.35: Modbus Map*, and *Table E.37: Trigger Conditions for the Trip/Warn Status Register Bits*. Appendix G ➤ Updated *Features*. ➤ Updated *Datasets*, including *Figure G.3: SEL-751 Datasets*. ➤ Updated *Reports*, including *Figure G.4: SEL-751 Predefined Reports*, *Table G.4: Buffered Report Control Block Client Access*, and *Table G.5: Unbuffered Report Control Block Client Access*. ➤ Updated *Optional Control Configurations*, *Control Interlocking*, and *Fixed GOOSE*. ➤ Updated *Table G.39: Logical Device: PRO (Protection)*, *Table G.40: Logical Device: MET (Metering)*, and *Table G.43: Logical Device: CFG (Configuration)*. Appendix K ➤ Updated *Overview* and *Synchrophasor Measurement*. ➤ Updated *Time Quality of the IRIG Source*, including *Table K.9: Time Synchronization Relay Word Bits*. ➤ Updated *Ethernet Port Settings for IEEE C37.118 Synchrophasors*, and added *Table K.7: SEL-751 Ethernet Port Settings for PTP Synchrophasors*. Appendix L ➤ Updated *Table L.1: SELOGIC Relay Word Bits* and *Table L.2: Relay Word Bit Definitions for the SEL-751*. Appendix M ➤ Updated *Table M.1: Analog Quantities*.
20230607	Appendix A ➤ Updated for firmware revision R400-V1.
20230428	Appendix A ➤ Updated for firmware revisions R300-V9, R301-V5, and R302-V2.
20230315	Preface ➤ Updated *Safety Marks*. Section 1 ➤ Updated *Figure 1.5: STA Command Response–No Communications Card or EIA-232/EIA-485 Communications Card* and *Figure 1.6: STA Command Response–Communications Card/DeviceNet Protocol*. ➤ Updated *Specifications*. Section 2 ➤ Updated *Physical Location*, *Password, Breaker Control, and SELBOOT Jumper Selection*, *Serial Ports*, *IRIG-B*, and *Time-Code Input*.

Table A.11 Instruction Manual Revision History (Sheet 6 of 25)

Date Code	Summary of Revisions
	Section 4 ➤ Updated *ID Settings*, including *Table 4.1: Identifier Settings*. ➤ Updated *Overcurrent Elements* for the peak detector threshold. ➤ Updated *Time-Overcurrent Elements* for the IEEE curves. ➤ Added *Table 4.19: Time-Current Curves* and *Figure 4.23: IEEE Moderately Inverse Curve: E1* through *Figure 4.25: IEEE Extremely Inverse Curve: E3*. ➤ Updated *Figure 4.90: Over- and Underfrequency Element Logic* and *Figure 4.91: 81R Frequency Rate-of-Change Scheme Logic*. ➤ Updated *Table 4.64: Enable Settings*. ➤ Updated *Latch Bits*, including *Table 4.65: Latch Bits Equation Settings*. ➤ Updated *SELOGIC Control Equation Variables/Timers*. ➤ Updated *Table 4.69: SELOGIC Variable Settings*. ➤ Updated *Counter Variables*, including *Table 4.68: Counter Input/Output Description*. ➤ Updated *PORT 1*, *Table 4.91: Ethernet Port Settings*. ➤ Updated *Relay Word Bit Aliases*, including *Table 4.111: Enable Alias Settings*. ➤ Updated *Math Variable Metering*. Settings Sheets ➤ Updated *Identifier*, *Phase-Time Overcurrent*, *Maximum Phase Time-Overcurrent*, *Negative-Sequence Time-Overcurrent*, *Neutral Time-Overcurrent*, *Residual Time-Overcurrent*, *SELOGIC Enables*, *Latch Bits Equations*, *SV/Timers*, *Counters Equations*, *Math Variables*, and *Relay Word Bit Aliases*. ➤ Added *Fixed GOOSE Publications Configuration* and *Fixed GOOSE Subscription Configuration*. Section 7 ➤ Updated *CONTROL Command (Control Remote Bit)*, *COUNTER Command (Counter Values)*, *MAC Command*, *R_S Command (Restore Factory Defaults)*, and *Events Directory (Read Only) (Available for FTP and MMS)*. ➤ Updated *Table 7.71: Event Directory Files*, *Table 7.72: Files Available for Ymodem Protocol*, and *Table 7.74: Ymodem Wildcard Usage Examples*. Section 8 ➤ Updated *Figure 8.46: Local Bits Confirmation* and *Table 8.17: Screens Available for the Rotating Display, HOME Pushbutton, and Programmable Pushbuttons*. Section 10 ➤ Updated *Figure 10.6: Sample Compressed ASCII Event Report*, *Figure 10.8: Sample COMTRADE .HDR Header File*, *Figure 10.9: Sample COMTRADE .CFG File Data*, and *Figure 10.15: Sample HIF COMTRADE .CFG Configuration File Data*. Section 11 ➤ Updated *Table 11.8: Relay Self-Tests*. Appendix A ➤ Updated for firmware revisions R302-V1 and R400-V0, SELBOOT firmware revision R100-V0, and ICD file revision R400-V0. Appendix B ➤ Updated *Table B.1: Firmware Upgrade Methods*. Appendix D ➤ Updated *D.10: DNP3 Reference Data Map*, *Table D.11: DNP3 Default Data Map*, and *Table D.12: SEL-751 Object 12 Control Operations*. Appendix E ➤ Updated *Table E.7: 02h SEL-751 Inputs*, *Table E.14: 01h, 05h SEL-751 Output*, *Table E.33: Modbus Register Labels for Use With SET M Command*, and *Table E.35: Modbus Map*. ➤ Added *Table E.34: Modbus Register Labels for Use With SET M Command in Firmware Versions Prior to R400*. Appendix G ➤ Added *Fixed GOOSE*. ➤ Updated *Table G.22: IEC 61850 Settings*, *Table G.39: Logical Device: PRO (Protection)*, *Table G.41: Logical Device: CON (Remote Control)*, and *Table G.42: Logical Device: ANN (Annunciation)*.

Table A.11 Instruction Manual Revision History (Sheet 7 of 25)

Date Code	Summary of Revisions
	Appendix L ➤ Updated *Table L.1: SELOGIC Relay Word Bits* and *Table L.2: Relay Word Bit Definitions for the SEL-751*. Appendix M ➤ Updated *Table M.1: Analog Quantities*. Appendix N ➤ Added a note regarding the **R_S** command and retention of the IP address, subnet mask, and default router settings in firmware versions R301-V1 and higher. Command Summary ➤ Added **COM S A** and **COM S B**.
20220826	Preface ➤ Updated *Wire Sizes and Insulation*. Section 1 ➤ Updated *Specifications*, including *Compliance*, *Communications Protocols*, *Dielectric Strength and Impulse Tests*, and *EMC Emissions*. Section 2 ➤ Updated *I/O Configuration*, *Power Connections*, and *Grounding (Earthing) Connections*. ➤ Added *I/O Connections*. ➤ Updated *Point-Sensor Installation*. Section 4 ➤ Updated *Figure 4.85: Loss-of-Potential (LOP) Logic* and *Table 4.90: Ethernet Port Settings*. ➤ Updated *Relay Word Bit Aliases*. Settings Sheets ➤ Added *61850 Simulation Mode* and *61850 Local Remote*. ➤ Updated *PORT 1* for the RSTP settings. ➤ Updated *Relay Word Bit Aliases*. Section 7 ➤ Updated *Table 7.4: Protocols Supported on the Various Ports*. ➤ Added *Switched Mode* and *Rapid Spanning Tree Protocol (RSTP)*. ➤ Added *Table 7.27: Warning and Error Codes for GOOSE Subscriptions*. ➤ Updated *ID Command* and added *RSTP Command*. Appendix A ➤ Updated for firmware versions R202-V5, R300-V8, R301-V4, and R302-V0. ➤ Updated *Table A.4: SELBOOT Firmware Revision History* for R602-V0. ➤ Updated *Table A.5: SEL Display Package Revision History* and *Table A.6: SEL Display Package Compatibility With Relay Firmware* for 3.0.50751.3020. ➤ Updated *Table A.9: SEL-751 ICD File Revision History* for R204-V0. Appendix B ➤ Updated *Table B.1: Firmware Upgrade Methods*. ➤ Added *Upgrade the SELBOOT Firmware Loader Using a Terminal Emulator*. Appendix G ➤ Added *Functional Naming*, *Local Remote Control Authority*, and *Service Tracking*. ➤ Updated *Simulation Mode*. ➤ Updated *Table G.23: New Logical Node Extensions* and added *Table G.29: LCCH Physical Communication Channel Supervision*, *Table G.30: LGOS GOOSE Subscription*, and *Table G.31: LTMS Time Master Supervision*. ➤ Updated *Table G.39: Logical Device: PRO (Protection)*, *Table G.40: Logical Device: MET (Metering)*, *Table G.41: Logical Device: CON (Remote Control)*, *Table G.42: Logical Device: ANN (Annunciation)*, and *Table G.43: Logical Device: CFG (Configuration)*. Appendix L ➤ Updated *Table L.1: SELOGIC Relay Word Bits* and *Table L.2: Relay Word Bit Definitions for the SEL-751*.

Table A.11 Instruction Manual Revision History (Sheet 8 of 25)

Date Code	Summary of Revisions
	Glossary ➤ Added RSTP. Command Summary ➤ Added the **RSTP** command.
20220719	Appendix A ➤ Updated for firmware version R301-V3.
20220607	Appendix A ➤ Updated for firmware versions R202-V4, R300-V7, and R301-V2. ➤ Updated for SEL display package versions 3.0.50751.3007 and 3.0.50751.3012. ➤ Updated *Table A.6: SEL Display Package Compatibility With Relay Firmware*.
20220308	Appendix A ➤ Updated *Table A.1: R300 Series Firmware Revision History* for the R301-V1 firmware revision.
20220225	Appendix A ➤ Updated *Table A.1: R300 Series Firmware Revision History* for the R300-V5 and R300-V6 firmware revisions. ➤ Updated *Table A.2: R200 Series Firmware Revision History* for the R202-V3 firmware revision. ➤ Updated *Table A.3: R100 Series Firmware Revision History* for the R113-V2 firmware revision.
20220107	Section 1 ➤ Updated *Overview* and *Features*, *Protection Features*, including *Table 1.1: Phase and Neutral Current Ratings Selection for the SEL-751 Models*, *Table 1.2: Current (ACI) and Voltage (AVI) Card Selection Options for SEL-751 Models*, and *Table 1.3: SEL-751 Protection Elements*. ➤ Added *Figure 1.1: Slot Z LEA Card With Rogowski Coil Connection for Current Input*. ➤ Updated *Specifications*. Section 2 ➤ Updated *Figure 2.2: Slot Allocations for Different Cards*. ➤ Updated *Current/Voltage Card (4 ACI/3 AVI)* and added *Voltage/Digital Inputs Card (2 AVI/7 DI)*. ➤ Added *Figure 2.17: Dual 10/100 Base-T Ethernet, EIA-232 Rear Port, 4 DI/4 DO Card, Fast Hybrid4 DI/ 4 DO Card, Vsync/Vbat 7 DI Card, and 4 ACI/3 AVI LEA Card (Relay MOT 751001A1ACALA7LAF30)*. ➤ Updated *Figure 2.23: Single-Phase Voltage Connections*. Section 3 ➤ Updated *Figure 3.25: Retrieve Events Screen*, *Figure 3.27: Device Overview Screen*, and *Figure 3.28: Control Screen*. Section 4 ➤ Updated *Configuration Settings,* including *Table 4.4: Voltage Configuration Settings* and *Fault Location*. ➤ Added *Low-Energy Analog (LEA) Sensor Inputs* and *Low-Energy Analog (LEA) Voltage Inputs*. ➤ Updated *Table 4.10: Neutral Overcurrent Settings.* ➤ Updated *Figure 4.2: Instantaneous Overcurrent Element Logic without Directional Control* and added *Figure 4.3: Instantaneous Overcurrent Element Logic with Directional Control Enabled*. ➤ Updated *Incipient Cable Fault*, including *Figure 4.7: Incipient Cable Fault Logic* and *Table 4.13: Incipient Cable Fault Settings*. ➤ Updated *Table 4.31: HIF Relay Word Bits*. ➤ Added *Phase Discontinuity Detection (PDD) Element*, *Broken Conductor Detection (BCD) Element*, and *Cold-Load Pickup (CLPU) Element*. ➤ Updated *Table 4.41: Operating Quantities for the 27I Element* and *Table 4.44: Operating Quantities for the 59I Element*. ➤ Updated *Synchronism-Check Elements*. Section 5 ➤ Updated *Table 5.1: Measured Fundamental Meter Values*, *Table 5.4: Maximum/Minimum Meter Values*, *Table 5.5: RMS Meter Values*. ➤ Added *Breaker Close and Operate Times*.

Table A.11 Instruction Manual Revision History (Sheet 9 of 25)

Date Code	Summary of Revisions
	Settings Sheets ➤ Updated *Neutral Overcurrent*. ➤ Updated *Configuration*, *Incipient Cable Fault*, and *Synchronism Check*. ➤ Added phase discontinuity detection (PDD), broken conductor detection (BCD), and cold-load pickup (CLPU) settings. Section 7 ➤ Updated *Figure 7.20: CEV HIF Command Response*. ➤ Updated *Figure 7.31: SHOW Command Example*. Section 8 ➤ Updated *Table 8.17: Screens Available for the Rotating Display, HOME Pushbutton, and Programmable Pushbuttons*. Section 10 ➤ Updated *Table 10.1: Event Types*. ➤ Updated *Fault Location*. ➤ Updated *Figure 10.14: Sample HIF COMTRADE .HDR Header File*. Section 11 ➤ Updated *Low-Level Test Interface*. ➤ Updated *Table 11.8: Relay Self-Tests*. Appendix A ➤ Updated *Table A.1: R300 Series Firmware Revision History* for relay firmware version R301-V0. ➤ Updated *Table A.5: SEL Display Package Revision History* for 3.0.50751.3010. ➤ Updated *Table A.6: SEL Display Package Compatibility With Relay Firmware* for 3.0.50751.3010. ➤ Updated *Table A.9: SEL-751 ICD File Revision History* for R203-V0. Appendix C ➤ Updated *SEl Communications Processor Example*. Appendix E ➤ Updated *Table E.34: Modbus Map*. Appendix G ➤ Added *Control Interlocking*, including *Figure G.4: CSWI Logical Node Direct Operate Command Request*. ➤ Updated *Table G.6: AddCause Descriptions* and *Table G.31: Logical Device: PRO (Protection)*. Appendix L ➤ Updated *Table L.1: SELOGIC Relay Word Bits.* ➤ Updated *Table L.2: Relay Word Bit Definitions for the SEL-751.* Appendix M ➤ Updated *Table M.1: Analog Quantities*. Glossary ➤ Added Broken Conductor Detection (BCD), Cold-Load Pickup (CLPU), Low-Power Current Transformer (LPCT), Low-Power Voltage Transformer (LPVT), Phase Discontinuity Detection (PDD), and Rogowski Coil. Command Summary ➤ Added **HIS 50INC** command.
20211116	Section 1 ➤ Updated *RFI and Interference Tests* conducted and radiated emissions. Appendix A ➤ Updated *Table A.1: R300 Series Firmware Revision History* for relay firmware version R300-V4. ➤ Updated *Table A.2: R200 Series Firmware Revision History* for relay firmware version R202-V2. ➤ Updated *Table A.4: SELBOOT Firmware Revision History* for SELboot firmware versions R601 and R502. ➤ Updated *Table A.5: SEL Display Package Revision History* for display packages 1.0.50751.2022 and 3.0.50751.3004. ➤ Updated *Table A.6: SEL Display Package Compatibility With Relay Firmware*.

Table A.11 Instruction Manual Revision History (Sheet 10 of 25)

Date Code	Summary of Revisions
20210104	Appendix A ➤ Updated *Table A.1: R300 Series Firmware Revision History* for relay firmware version R300-V3. ➤ Updated *Table A.2: R200 Series Firmware Revision History* for relay firmware version R202-V1.
20200921	Appendix A ➤ Updated *Table A.1: R300 Series Firmware Revision History* for relay firmware version R300-V2. ➤ Added an entry for relay firmware version R112-V0 to *Table A.3: R100 Series Firmware Revision History*.
20200603	Appendix A ➤ Updated *Table A.1: R300 Series Firmware Revision History* for relay firmware version R300-V1.
20200331	Preface ➤ Updated *Manual Overview*. ➤ Updated *Safety Information*, including *Compliance Approvals*. ➤ Updated *General Information*, including *Product Labels*. Section 1 ➤ Updated *Table 1.3: SEL-751 Protection Elements* for 50INC, incipient cable fault. ➤ Updated *Features* and *Specifications*. Section 2 ➤ Updated *Physical Location*. ➤ Added notes for IEC 60255-26 and IEC 60255-27 requirements. ➤ Updated *Communications Ports (Slot B)* and *RTD Card (10 RTD)*. ➤ Updated *Point Sensor Installation* for *Figure 2.36: Point-Sensor Dimensions*. Section 3 ➤ Updated *Overview* for the built-in web server. ➤ Added *Web Server*. ➤ Updated *Table 3.1: SEL Software Solutions*, *Figure 3.25: Retrieve Events Screen*, and *Figure 3.26: Save the Retrieved Event*. Section 4 ➤ Updated *Overview* and *Group Settings (SET Command)*. ➤ Added *Incipient Cable Fault*. ➤ Updated *Table 4.21: Best Choice Ground Directional Element Logic* for the advanced directional MOT option. ➤ Updated *Figure 4.39: Routing of Directional Element to Negative-Sequence and Phase Overcurrent Elements*. ➤ Updated *HIF Detection Settings* for two-way automatic communication systems (TWACSs). ➤ Updated *RTD Trip/Warning Levels*. ➤ Updated *Frequency Protection*, including *Table 4.49: Frequency Settings* for trip delay ranges. ➤ Updated *Trip/Close Logic*. ➤ Added *Multiple Setting Groups*. ➤ Added *Precision Time Protocol (PTP)* and *PTP Timekeeping* to *Time and Date Management Settings*. ➤ Updated *Breaker Failure Settings*. ➤ Updated *Disconnect Control Settings* and *Local/Remote Control*. ➤ Updated *Table 4.86: Ethernet Port Settings* for PTP, IEC 61850 mode/behavior, and HTTP settings. ➤ Added a note to *PORT 1* regarding the Telnet LANG setting and the web server interface. ➤ Updated *Table 4.87: Port Number Settings That Must be Unique*. ➤ Added *EtherNet/IP Assembly Map Settings (SET E Command)*. Section 6 ➤ Updated *Overview*, *Table 6.1: Methods of Accessing Settings*, *Table 6.2: SHOW Command Options*, and *Table 6.3: SET Command Options*. ➤ Added *Web Server*.

Table A.11 Instruction Manual Revision History (Sheet 11 of 25)

Date Code	Summary of Revisions
	Settings Sheets ➤ Added *Incipient Cable Fault*. ➤ Updated *Table SET.2: Range Dependencies for the ORDER Setting* for advanced directional. ➤ Updated *Frequency* and *Breaker Failure*. ➤ Added *Two-Position Disconnect*, *Three-Position Disconnect*, *IEC 61850 Mode Control*, *PTP Settings*, and *EtherNet/IP Settings*. ➤ Added HTTP settings to *PORT 1*. ➤ Updated *Table SET.5: Port Number Settings That Must be Unique*. ➤ Updated *Bay Control Two-Position Disconnect* and added *Bay Control Three-Position Disconnect*. ➤ Added *EtherNet/IP Assembly Map Settings (SET E Command)*. Section 7 ➤ Added *Telnet or Web Server* and *Embedded Web Server (HTTP)*. ➤ Updated *Ethernet Port* and added *TCP Keep Alive*. ➤ Updated *Table 7.4: Protocols Supported on the Various Ports*, *Table 7.5: Settings Associated With SNTP*, and *Table 7.7: Settings Associated With PTP*. ➤ Updated *Ethernet Protocols* for *EtherNet/Industrial Protocol (IP)*. ➤ Added *Precision Time Protocol (PTP)*, *COM PTP Command*, *89CLOSE (Close Disconnect)*, and *89OPEN (Open Disconnect)*. ➤ Updated *Table 7.47: SET command (Change Settings)* and *Table 7.49: SHOW Command (Show/View Settings) for EtherNet/IP*. ➤ Updated *TEST DB Command*. ➤ Updated *Virtual File Interface*, including *Table 7.62: FTP and MMS Virtual File Structure*, *Figure 7.34: CFG.TXT File*, and *Table 7.63: Settings Directory Files*. Section 8 ➤ Added notes for display update rates to *Contrast* and *Touchscreen Display HMI*. ➤ Updated *Table 8.7: Sidebar Buttons* and *Reports* for the Trigger Event button. ➤ Updated *Figure 8.40: Search Relay Word Bits*, *Figure 8.42: Event History*, *Figure 8.60: Authentication*, *Figure 8.65: Global Settings*, *Figure 8.66: General Settings*, *Figure 8.67: Set/Show Settings Edit*, *Figure 8.68: Touchscreen Settings*, and *Figure 8.69: Touchscreen Settings Edit*. Section 9 ➤ Updated *Disconnect Control Settings* and *Table 9.2: Two-Position Disconnect Settings* and added *Table 9.3: Three-Position Disconnect Settings*. ➤ Updated *Figure 9.1: Dual-Point Disconnect Status Logic*. ➤ Added *Figure 9.2: Disconnect Close Logic*, *Figure 9.3: Disconnect Open Logic*, and *Table 9.4: Disconnect Control Setting Guidelines*. ➤ Updated *Table 9.5: Two- and Three-Position Disconnect Symbols* and *Local/Remote Control*. ➤ Updated *Breaker/Disconnect Control Via Touchscreen*, *Table 9.7: Touchscreen Settings,* and *Bay Control Disconnect Switch Settings*. ➤ Updated *Figure 9.5: Bay Screens Application Display With a Single-Line Diagram* and *Table 9.8: Symbols Required for the Single-Line Diagram Schematic in Figure 9.12*. ➤ Updated *Figure 9.12: Bay Control Single-Line Diagram Schematic*, *Figure 9.16: Drag-and-Drop Symbols*, *Figure 9.17: Selected Breaker Symbol Settings Displayed in the Properties Pane*, *Figure 9.18: Close/Open/ Alarm Color Property Drop Down Menu*, *Figure 9.20: QuickSet Updated Single-Line Diagram and Corresponding Settings*, *Figure 9.21: Final Bay Screen Builder Rendering*, and *Figure 9.24: IEC Main Bus and Transfer Bus*. ➤ Updated *Disconnect Settings*. Section 10 ➤ Updated *Length*, *Event Summaries*, *Viewing Compressed Event (CEV) Reports*, including *Figure 10.7: Sample CEV Report Viewed With SYNCHROWAVE Event*, and *Analyzing Events*, in *Event Reporting*.

Table A.11 Instruction Manual Revision History (Sheet 12 of 25)

Date Code	Summary of Revisions
	Appendix A ➤ Added *Table A.1: R300 Series Firmware Revision History* for relay firmware version R300-V0. ➤ Updated *Table A.2: R200 Series Firmware Revision History* for relay firmware version R202-V0. ➤ Added *SELBOOT Firmware Version and Relay Firmware Compatibility*, including *Table A.4: SELBOOT Firmware Revision History*. ➤ Updated *Table A.5: SEL Display Package Revision History*, *Table A.6: SEL Display Package Compatibility With Relay Firmware*, *Table A.8: EDS File Compatibility*, *Table A.9: SEL ICD File Revision History*. Appendix B ➤ Added *Table B.1: Firmware Upgrade Methods* and updated *Required Equipment*. ➤ Added *Digitally Signed Firmware Files*, *Ethernet Firmware Upgrades*, *Special Instructions for Upgrading to R300 Series Firmware*, *Upgrade the Firmware Using the Web Server*, *Upgrade the Firmware Using File Transfer Protocol*, and *Upgrade the Firmware Via Terminal Emulator Using the FILE Command Over Telnet*. ➤ Updated *Upgrade Firmware Using QuickSet*. Appendix D ➤ Updated *Table D.7: Port DNP3 Protocol Settings* and *Table D.12: SEL-787 Object 12 Control Operations*. ➤ Updated *Reference Data Map*, including *Table D.10: DNP3 Reference Data Map*. ➤ Updated *Figure D.4: Port MAP Command*. Appendix E ➤ Updated to *Table E.33: Modbus Register Labels for Use With SET M Command*, *Table E.34: Modbus Register Map*, and *Table E.35: Trigger Conditions for Trip/Warn Status Register Bits*. Appendix F ➤ Added *EtherNet/IP Communications.* Appendix G ➤ Added *IEC 61850 Mode/Behavior*. ➤ Updated *Table G.17: IEC 61850 Settings*. ➤ Updated *Mode*, *Behavior*, and *Health* in *Logical Nodes.* ➤ Updated *Table G.23: Demand Metering Statistics Logical Node Class Definition*. ➤ Updated *Table G.31: Logical Device: PRO (Protection)*, *Table G.32: Logical Device: MET (Metering)*, *Table G.33: Logical Device: CON (Remote Control)*, *Table G.34: Logical Device: ANN (Annunciation)*, and *Table G.35: Logical Device: CFG (Configuration)*. Appendix L ➤ Updated *Table L.1: SELOGIC Relay Word Bits* and *Table L.2: Relay Word Bit Definitions for the SEL-751 Relay*. Appendix M ➤ Updated *Table M.1: Analog Quantities*. Appendix N ➤ Added port numbers for PTP, web server, and EtherNet/IP to *Table N.1: IP Port Numbers*. ➤ Added *Firmware Hash Verification* and *Vulnerability Notification Process*. Command Summary ➤ Updated access level commands ACC and 2AC and SER command descriptions. ➤ Added 89C and 89O commands.
20181207	Section 1 ➤ Updated *Features* and *Models, Options, and Accessories* to remove references to multiple Model Options Tables.
20180921	Preface ➤ Updated *Safety Marks*, *General Safety Marks* and *Hazardous Locations Safety Marks*. ➤ Updated *Compliance Approvals*, including the product compliance label. ➤ Updated the product labels for the power supply range and power consumption. Section 1 ➤ Updated *Options*. ➤ Updated *Specifications*, *Compliance* for hazardous locations and ATEX. ➤ Updated *Specifications*, *General* for *AC Voltage Input*, *Power Supply*, *Output Contacts*, *Operating Temperature*, *Operating Environment*, and *Terminal Connections*.

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Date Code	Summary of Revisions
	Section 2 ➤ Updated *Relay Placement*, *Physical Location* for hazardous locations and ATEX. ➤ Updated *Figure 2.2: Slot Allocations for Different Cards*. ➤ Added a note to *Analog Inputs/Outputs Card (4 AI/4 AO)* on analog output isolation. ➤ Updated *Card Configuration Procedure* for the touchscreen display models. ➤ Added a caution for the arc-flash protection system self-test to *Application Example*. Section 3 ➤ Updated *Figure 3.7: Update Part Number*. Section 4 ➤ Updated *VNOM Range Check*. ➤ Added a note to *SELogic Control Equation Variables/Timers* for Relay Word bits or analog quantities that get hidden due to a setting or configuration change. ➤ Updated *Table 4.84: Front-Panel Serial Port Settings*, *Table 4.87: Fiber-Optic Serial Port Settings*, *Table 4.88: Rear-Panel Serial Port (EIA-232) Settings*, and *Table 4.89: Rear-Panel Serial Port (EIA-232/EIA-485) Settings* for a note on the EVMSG protocol. Section 5 ➤ Updated *Load Profiling* for the availability of LDP data in a read-only file. ➤ Updated *View or Reset Breaker Monitor Information*, *Via Front Panel* for the availability of breaker wear data in a read-only file. Section 7 ➤ Updated *Ethernet Port* for recommendations for Ethernet network configurations. ➤ Added *TCP Keep Alive* to *Dual Network Port Operation*. Section 9 ➤ Updated *Figure 9.3: Bay Screens Application Display With a Single-Line Diagram*, *Figure 9.9: Project Analysis Pane: Constraints Summary Tab*, *Figure 9.10: Bay Control Single-Line Diagram Schematic*, *Figure 9.19: Final Bay Screen Builder Rendering*. ➤ Added a note to *Build Single-Line Diagrams in Bay Screen Builder*, *Edit Symbol Properties* for analog labels. Section 10 ➤ Updated *Table 10.1 Event Types* for Trip*. ➤ Updated *Retrieving and Clearing SER Reports* for the availability of SER data in a read-only file. Section 11 ➤ Added a caution for the arc-flash protection system self-test to *Testing the Complete Arc-Flash Protection System*. Appendix A ➤ Updated *Table A.1: R200 Series Firmware Revision History* for the R201-V1 firmware revision. ➤ Updated *Table A.2: R100 Series Firmware Revision History* for the R113-V1 firmware revision. Appendix E ➤ Updated *Table E.34: Modbus Register Map*. Appendix F ➤ Updated the note on the CID file. ➤ Updated *IEC 61850 Introduction*. ➤ Added *Control*, *Control Requests*, and *Simulation Mode*. ➤ Added a note to *Architect Software* for GOOSE message APPIDs. ➤ Added *Mode*, *Behavior*, *Health*, and *NamPlt* to *Logical Nodes*. ➤ Added *SEL Nameplate Data* and *Potential Client and Automation Application Issues With Edition 2 Upgrades*. Appendix H ➤ Added a note for DeviceNet. Appendix L ➤ Updated *Table L.1: Analog Quantities*.

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Date Code	Summary of Revisions
20180420	Preface ➤ Updated *Other Safety Marks*. ➤ Updated *Typographic Conventions*, *Environmental Conditions and Voltage Information*, and *Wire Sizes and Insulation*. Section 1 ➤ Updated *General* and *Type Tests* in *Specifications*. Section 2 ➤ Updated *Physical Location* and *Relay Mounting*. ➤ Updated *Figure 2.2: Slot Allocations for Different Cards*. ➤ Updated *Communications Ports (Slot B)*, *Communications Card (Slot C)*, *Current Card (4 ACI)*, *Analog Inputs Card (8 AI)*, and *I/O Card (4 DI/3 DO)*. ➤ Updated *Card Configuration Procedure*. ➤ Updated *Figure 2.4: JMP2 Through JMP4 Locations on 4AI/4 AO Board.* ➤ Updated *Ground (Earthing) Connections*. ➤ Updated *IRIG-B Time-Code Input* and *Serial Ports*. ➤ Updated *Table 2.18: Typical Maximum RTD Lead Length*. ➤ Updated *Fail-Safe/Nonfail-Safe Tripping*, including *Figure 2.19: Breaker Trip Coil Connections With OUT103FS := Y and OUT103FS := N*. ➤ Updated *Figure 2.25: Transmission Line Directional Overcurrent Protection and Reclosing With Current-Polarization Source Connected to Channel IN (Wye-Connected PTs)*. Section 4 ➤ Updated *Overview* for *Touchscreen Settings*. ➤ Updated *High-Impedance Fault Detection With Arc-Sense Technology* with interharmonic components note. ➤ Updated *Loss-of-Potential (LOP) Protection*, including *Figure 4.73: Loss-of-Potential (LOP) Logic*. ➤ Added a note for math variables to *Table 4.58: Enable Settings*. ➤ Updated *SELOGIC Control Equation Operators*. ➤ Updated *Table 4.63: SELOGIC Variable Settings* and *Table 4.66: Control Output Equations and Contact Behavior Settings*. ➤ Updated *PORT 1* with notes for TCP Keep-Alive and FAST OP MESSAGES. ➤ Updated *PORT 3* and *PORT 4*. ➤ Updated *Target LED Settings*, including *Table 4.100: Target LED Settings* and *Table 4.101: Pushbutton LED Settings*. Section 5 ➤ Updated *Determination of Relay-Initiated Trips and Externally Initiated Trips*. Section 6 ➤ Added note regarding relay settings changes following turn on or Port 1 or Logic settings changes. Settings Sheets ➤ Updated *Arc-Flash Protection* and *Port 1*. Section 7 ➤ Updated *Serial (EIA-232 and EIA-485) Port*. ➤ Updated *Other Support Protocols*, *MIRRORED BITS Protocol*. ➤ Updated *Ethernet Protocols*, *Telnet Server*, *Ping Server*, and *IEC 61850*, and added *C37.118 Protocol*. ➤ Updated *Table 7.11: CONTROL Command*, *Table 7.15: EVENT Command (Event Report)*, *Table 7.21: HISTORY Command*, and *Table 7.22: HIS HIF Command*. ➤ Updated *COPY Command*, including *Table 7.12: COPY Command*. ➤ Updated *PASSWORD Command*, *PING Command*, and *PULSE Command*. ➤ Updated *Table 7.45: STATUS Command Report and Definitions*. ➤ Updated *TEST DB Command*. ➤ Updated *Virtual File Interface*. ➤ Updated *Table 7.56: FTP and MMS Virtual File Structure* and *Table 7.59: Event Directory Files*. Section 8 ➤ Updated *Overview*, including *Figure 8.1: SEL-751 Front-Panel Options*.

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Date Code	Summary of Revisions
	Section 10 ➤ Updated *Event Reporting* and *Triggering*. ➤ Updated *Table 10.1: Event Types* and *Currents, Voltages, and RTD Temperatures*. ➤ Updated *Event Reports* and *Examples 15-Cycle Event Report*. Section 11 ➤ Updated *Figure 11.5: Wye Voltage Source Connections*. ➤ Updated *Self-Test*, including *Table 11.8: Relay Self-Tests*. ➤ Updated *Table 11.9: Troubleshooting*. Appendix A ➤ Updated *Firmware*. ➤ Updated *Table A.1: R200 Series Firmware Revision History* for the R201 firmware revision. ➤ Updated *Table A.2: R100 Series Firmware Revision History* for the R113 firmware revision. ➤ Updated *Table A.3: SEL Display Package Revision History* for the 1.0.50751.2010 display package. ➤ Updated *Table A.4: SEL Display Package Compatibility With Relay Firmware* for the 1.0.50751.2010 display package and the R201 firmware revision. ➤ Updated *Table A.6: EDS File Compatibility* for the R201 firmware revision. Appendix C ➤ Updated *Setting the SEL Communications Processor*. Appendix D ➤ Updated *Table D.2: Selected DNP3 Function Codes*, *Table D.7: Port DNP3 Protocol Settings*, *Table D.8: Serial Port DNP3 Modem Settings*, and *Table D.12: SEL-751 Object 12 Control Operations*. ➤ Updated *Figure D.6: Analog Input Map Entry in ACSELERATOR QuickSet Software* through *Figure D.11: Binary Output Map Entry in ACSELERATOR QuickSet Software*. Appendix E ➤ Updated *Table E.34: Modbus Register Map*. Appendix K ➤ Updated *Table K.2: Relay Word Bit Definitions for the SEL-751 Relay*. Appendix M ➤ Updated *Monitoring* and *Logging*. Glossary ➤ Updated for terms. Index ➤ Updated for terms. Command Summary ➤ Updated for commands.
20171206	Preface ➤ Updated *Safety Marks*. ➤ Updated *Trademarks*. Section 1 ➤ Updated *Table 1.4: SEL-751 Front-Panel Options.* ➤ Updated *Models, Options, and Accessories*. ➤ Updated *Specifications*. Section 2 ➤ Updated *Current Card (4 ACI)*. ➤ Updated *Installation*. ➤ Added *RTD Wiring*. ➤ Added *High-Speed, High-Current Interrupting DC Tripping Outputs*. ➤ Updated *Figure 2.21: Voltage Connections.*

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Date Code	Summary of Revisions
	Section 3 ➤ Updated *Table 3.1: SEL Software Solutions*. ➤ Updated *Communications*. ➤ Updated *Event Analysis*. ➤ Updated *File > New*. ➤ Updated *Using Expression Builder*. Section 4 ➤ Updated *VNOM Range Check*. ➤ Updated *Counter Variables*. ➤ Updated *Table 4.88: Rear-Panel Serial Port (EA-232/EA-485) Settings*. ➤ Added *Table 4.92: Front-Panel Display Point Settings*. Settings Sheets ➤ Updated *SET PORT p (p = F, 1, 2, 3, or 4) Command*. ➤ Updated *Operator Control LED*. ➤ Updated *Pushbuttons*. ➤ Updated *SER Chatter Criteria.* ➤ Updated *Relay Word Bit Aliases*. Section 7 ➤ Updated *CEV Command*. ➤ Updated *Virtual File Interface*. ➤ Updated *Settings Directory*. ➤ Updated *Table 7.46: SUMMARY Command*. Section 8 ➤ Updated *Figure 8.1: SEL-751 Front-Panel Models*. ➤ Updated *Front-Panel Operator Control Pushbuttons*. Section 10 ➤ Updated *Triggering*. ➤ Updated *Viewing Compressed Event (CEV) Reports*. ➤ Updated *Figure 10.2: Sample Event History*. Appendix A ➤ Updated *Table A.1: R200 Series Firmware Revision History* for the R201 firmware revision. ➤ Updated *Table A.2: R100 Series Firmware Revision History* for the R113 firmware revision. ➤ Updated *Table A.3: SEL Display Package Revision History* for the 1.0.50751.2010 display package. ➤ Updated *Table A.4: SEL Display Package Compatibility With Relay Firmware* for the 1.0.50751.2010 display package and the R201 firmware revision. ➤ Updated *Table A.6: EDS File Compatibility* for the R201 firmware revision. Appendix D ➤ Updated *Table D.10: DNP3 Reference Data Map*. Appendix E ➤ Updated *Table E.34: Modbus Register Map* Appendix I ➤ Updated *Table I.14: Example Synchrophasor SELOGIC Settings.* Appendix K ➤ Updated *Table K.2: Relay Word Bit Definitions for the SEL-751 Relay.*
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.

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Date Code	Summary of Revisions
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*. 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*.

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Date Code	Summary of Revisions
	➤ 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 note 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)*. 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*.

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Date Code	Summary of Revisions
	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. 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*.

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Date Code	Summary of Revisions
	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. Section 3 ➤ Updated and added Language Support.

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Date Code	Summary of Revisions
	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.11 Instruction Manual Revision History (Sheet 22 of 25)

Date Code	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.11 Instruction Manual Revision History (Sheet 23 of 25)

Date Code	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.11 Instruction Manual Revision History (Sheet 24 of 25)

Date Code	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.11 Instruction Manual Revision History (Sheet 25 of 25)

Date Code	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.

Appendix B
Firmware Upgrade Instructions

Overview

These instructions guide you through the process of upgrading the 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-D*xxxxxxxx*

Standard release firmware:

FID=SEL-751-**R101**-V0-Z001001-D*xxxxxxxx*

A point release is identified by a change in the V-number of the device FID string.

Existing firmware:

FID=SEL-751-R100-**V0**-Z001001-D*xxxxxxxx*

Point release firmware:

FID=SEL-751-R100-**V1**-Z001001-D*xxxxxxxx*

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 unnecessary. Upgrade the relay firmware by downloading a file from a personal computer to the relay via the Ethernet port through the web server, FTP, or Telnet. You can also use the front-panel serial port through ACSELERATOR QuickSet SEL-5030 Software or a terminal emulator, as outlined in the following sections. For relays with the IEC 61850 option, verify the IEC 61850 protocol after the upgrade (see *Protocol Verification for Relays With IEC 61850 Option*).

Table B.1 details the available firmware upgrade methods. Available methods depend on your existing firmware and the firmware version to which you are upgrading.

Table B.1 Firmware Upgrade Methods

Existing Firmware	Upgrade Version	SELBOOT Upgrade Required?	Firmware Upgrade Methods Supported	
			Serial	Ethernet
R1*xx*	R2*xx*	NA	Terminal emulator QuickSet	—
R1*xx* or R2*xx*	R3*xx*	Yes (R600 or higher)	Terminal emulator[a]	—
R3*xx*	R3*xx*[b]	No	Terminal emulator QuickSet	Web server FTP FILE command Terminal emulator
R1*xx* or R2*xx* or R3*xx*	R4*xx*[c]	NA	Firmware upgrade not supported	

[a] When upgrading from R1xx or R2xx to R3xx, you must first perform the Special Instructions for Upgrading to R300 Series Firmware and then follow the Upgrade the Firmware Using a Terminal Emulator instructions to upgrade your relay firmware.
[b] In firmware versions R301-V1 and higher, the relay firmware retains the IP address, subnet mask, and default router settings during a firmware upgrade from any previous R3xx firmware version.
[c] R4xx and higher firmware versions support new hardware components. An upgrade to R4xx firmware from any previous firmware version requires a Slot B CPU card manufactured after April 14, 2023.

Required Equipment

Gather the following equipment before starting this firmware upgrade:

- PC
- Terminal emulation software that supports Xmodem/CRC or 1k Xmodem/CRC protocol
- Serial communications cable (SEL-C234A or equivalent, or a null-modem cable) or Ethernet cable
- Firmware upgrade file (e.g., r*xxx*-v*x*751.s19, r*xxx*-v*x*751.z19, or r*xxx*-v*x*751.zds)
- QuickSet software

Digitally Signed Firmware Files

The SEL-751 supports digitally signed firmware files for firmware versions R300 and higher. These firmware files are compressed to reduce file transfer times and are digitally signed by SEL using a secure hash algorithm. The signature ensures that the file has been provided by SEL and that its contents have not been altered. Once the firmware is uploaded to the relay, the signature of the firmware is verified with a public key number that is stored on the relay from the factory. If the relay cannot verify the signature, it rejects the file.

The name of the digitally signed firmware file is of the form r*xxx*-v*x*751.zds, where r*xxx*-v*x* is the firmware revision number, 751 indicates the relay type, and .zds is the file extension reserved for digitally signed files. Firmware files with the .s19 or .z19 extension are not available for firmware versions R300 and higher.

Ethernet Firmware Upgrades

NOTE: The relay pulses the SALARM bit and writes an entry to the relay SER log whenever a firmware upgrade is attempted over Ethernet. Monitoring the SALARM bit and reviewing the SER log can help identify possible unauthorized firmware upgrade attempts.

You can upgrade firmware over an Ethernet connection by sending the .zds firmware upgrade files via File Transfer Protocol (FTP), HTTP, or Telnet protocols to a relay running SELBOOT version R600 or newer and a relay firmware version identified in *Table B.1*. FTP, HTTP, and Telnet are plain text protocols and do not inherently support message encryption (e.g., relay passwords, etc.). Because of this, SEL strongly recommends you use a security gateway between your relay and your network that provides encrypted communications along with SEL Software Defined Networking (SDN) technology to harden your network cybersecurity.

Special Instructions for Upgrading to R300 Series Firmware

The SELBOOT firmware in relays shipped with firmware versions earlier than R300 must be upgraded before you can use digitally signed firmware files. The SELBOOT firmware can be upgraded from version R500, R501, or R502 to version R601 by uploading a special SELBOOT Loader firmware to the relay.

The following instructions assume you have a working knowledge of your PC terminal emulation software.

NOTE: Make sure that the relay and SELBOOT firmware revisions are compatible. Refer to Firmware, ICD, and Manual Versions in this manual. If needed, upgrade the SELBOOT firmware prior to upgrading the relay firmware.

NOTE: To save the calibration settings, perform **SHO C** from the terminal by logging into Access Level C using the Access Level C password. The factory-default password for Access Level C is CLARKE.

NOTE: When you are upgrading an SEL-751 with a touchscreen front-panel display, save all of the relay settings, including the touchscreen settings, using QuickSet.

NOTE: Change the data rate of the relay serial port to 9600 before issuing the **L_D** command to start the upgrade process.

Step 1. If the relay is in service, open the relay control circuits.

Step 2. Connect the PC to the front-panel serial port and enter Access Level 2.

Step 3. Save the present relay settings.

You can use the PC software (see *Section 3: PC Interface*) to save and restore settings, or you can use the following steps:

a. Issue the following commands at the ASCII prompt: **SHO**, **SHO L**, **SHO G**, **SHO P**, **SHO F**, **SHO R**, **SHO C**, etc.

b. Record all the settings for possible reentry after the firmware upgrade.

We recommend that you save all data, including events, stored in the relay before the upgrade.

Step 4. Change the data rate of the communications software to 9600 bps and press **<Enter>**.

Step 5. Download the SELBOOT Loader firmware to the relay.

a. Issue the **L_D** command.

b. Type **Y <Enter>** at the following prompt:

```
Disable relay to receive firmware (Y/N)?
```

c. Type **Y <Enter>** at the following prompt:

```
Are you sure (Y,N)?
```

The relay sends the `!>` prompt.

Step 6. Issue the **REC** command to receive the new firmware.

Step 7. Type **Y** to confirm that the existing SELBOOT and relay firmwares can be erased.

Step 8. Press any key (e.g., **<Enter>**) when the relay sends a prompt.

Step 9. Use the Xmodem protocol to send the special SELBOOT Loader firmware (e.g., slbtldr_r6017*xx*.s19) to the relay. The special SELBOOT Loader firmware erases the existing SELBOOT and relay firmwares and loads SELBOOT firmware version SLBT7XX-R601-V0-Z000000-D20211116.

The file transfer typically takes less than 5 minutes at 9600 bps, depending on the product. After the transfer is complete, the relay reboots and displays the SELBOOT `!>` prompt. After the SELBOOT upgrade is complete, upgrade your relay firmware by using a terminal emulator (see *Upgrade the Firmware Using a*

Terminal Emulator). It is not necessary to save the relay settings and other data again during the firmware upgrade process if you saved them before upgrading SELBOOT. Proceed to *Step 5* in *Upgrade the Firmware Using a Terminal Emulator*.

Figure B.1 shows the entire special SELBOOT upgrade process.

```
=>>L_D <Enter>
Disable relay to receive firmware (Y,N)? Y <Enter>
Are you sure (Y,N)? Y <Enter>
Relay Disabled


BFID=BOOTLDR-R501-V0-Z000000-D20140224
!>REC <Enter>
This command uploads new firmware.
When new firmware is uploaded successfully, IED will erase old firmware,
load new firmware and reboot.

Are you sure you want to erase the existing firmware(Y,N)? Y <Enter>
Press any key to begin transfer and then start transfer at the terminal.
Erasing firmware.
Erase successful.
Writing new firmware.
Upload completed successfully. Attempting a restart.

Upgrading SELBoot


 Preparing S Record...

 Validating S Record...


* * * * * * * * * W A R N I N G * * * * * * * * *

 Do not turn off or cycle power to the relay or it may
 become inoperative and require factory repair!!!

  Performing this operation will require firmware
      to be downloaded to relay after reboot.

 * * * * * * * * * * * * * * * * * * * * * * * * *

 Removing Old SELBoot...

 Writing New SELBoot...

 Removing SELBoot Loader

 SELBoot Loader cleared... Resetting Relay!!!


BFID=SLBT7XX-R601-V0-Z000000-D20211116
!>
```

Figure B.1 Special SELBOOT Upgrade Process

Upgrade the SELBOOT Firmware Loader Using a Terminal Emulator

NOTE: Make sure the relay and SELBOOT firmware revisions are compatible. Refer to Appendix A: Firmware, ICD, and Manual Versions in this manual. If needed, upgrade the SELBOOT firmware prior to upgrading the relay firmware.

The process for upgrading SELBOOT is similar to *Upgrade the Firmware Using a Terminal Emulator on page B.6*. To determine if SELBOOT must be updated, do the following:

Step 1. Establish communication between the relay and a personal computer.

Step 2. From the computer, type **ID <Enter>**.

The relay responds with the following:

```
=ID <Enter>

"FID=SEL-751-R301-V2-Z009005-D20220607","08AF"
"BFID=SLBT7XX-R601-V0-Z000000-D20211116","094D"
"CID=E754","0262"
"DEVID=SEL-751","03C7"
"DEVCODE=77","0315"
"PARTNO=751301ABA1X7085B361","06AF"
"CONFIG=111112010","041B"
"SPECIAL=00","030E"
"SEL DISPLAY PACKAGE=3.0.50751.3012","0888"
"CUSTOMER DISPLAY PACKAGE=3.709393047","099C"
```

Step 3. Locate the Boot Firmware Identifier String (BFID).

Step 4. Find the SELBOOT revision number in the BFID (R*xxx*). Compare the revision number with the revision numbers listed in *Table A.5* to determine if it is necessary to upgrade SELBOOT. If an upgrade is necessary, follow the process mentioned below. Otherwise, upgrade the relay firmware using one of the methods mentioned later in the section.

Step 5. To upgrade SELBOOT, obtain the new SELBOOT file (r*xxx*7*xx*.zds) by contacting SEL technical support. Follow the instructions under *Upgrade the Firmware Using a Terminal Emulator on page B.6*. In *Step 6*, replace the **REC** command with **REC BOOT** and follow the prompts.

Step 6. When the relay prompts: `Press any key to begin transfer and then start transfer at the terminal`, press **<Enter>** and select the SELBOOT file.

Step 7. When the SELBOOT upgrade is successful, the relay prompts:

```
Erasing SELboot. Writing SELboot.

SELboot upload completed successfully.
Restarting SELboot.
```

Change the data rate of the communications software to 9600 bps and press **<Enter>**.

Step 8. Type **EXI <Enter>** at the SELBOOT `!>` prompt to exit SELBOOT. The relay should display the = prompt.

If the relay does not return the SELBOOT `!>` prompt within two minutes after displaying `Restarting SELboot`, cycle the relay power. The relay should restart and display the = prompt.

Once the SELBOOT upgrade is complete, select a firmware upgrade method as discussed later in the section. It is not necessary to save the relay settings and other data gain if you did this before upgrading SELBOOT.

Upgrade the Firmware Using a Terminal Emulator

NOTE: Make sure that the relay and SELBOOT firmware revisions are compatible. Refer to Firmware, ICD, and Manual Versions in this manual. If needed, upgrade the SELBOOT firmware prior to upgrading the relay firmware.

NOTE: To save the calibration settings, perform **SHO C** from the terminal by logging into Access Level C using the Access Level C password. The factory-default password for Access Level C is CLARKE.

NOTE: When you are upgrading an SEL-751 with a touchscreen front-panel display, save all of the relay settings, including the touchscreen settings, using QuickSet.

NOTE: Change the data rate of the relay serial port to 9600 bps before issuing the **L_D** command to start the upgrade process.

NOTE: If you have difficulty at 115200 bps, choose a slower data transfer rate (e.g., 38400 bps or 57600 bps). Be sure to match the relay and PC data rates.

The following instructions assume you have a working knowledge of your PC terminal emulation software.

Step 1. If the relay is in service, open the relay control circuits.

Step 2. Connect the PC to the front-panel serial port and enter Access Level 2.

Step 3. Save the present relay settings.

You can use the PC software (see *Section 3: PC Interface*) to save and restore settings, or you can use the following steps:

a. Issue the following commands at the ASCII prompt: **SHO**, **SHO L**, **SHO G**, **SHO P**, **SHO F**, **SHO R**, **SHO C**, etc.

b. Record all the settings for possible re-entry after the firmware upgrade.

We recommend that you save all stored data in the relay, including events, before the upgrade.

Step 4. Start upgrading the firmware.

a. Issue the **L_D** command.

b. Type **Y <Enter>** at the following prompt:

```
Disable relay to receive firmware (Y/N)?
```

c. Type **Y <Enter>** at the following prompt:

```
Are you sure (Y,N)?
```

The relay sends the `!>` prompt.

Step 5. Change the data rate, if necessary.

a. Type **BAU 115200 <Enter>**.

This changes the data rate of the communications port to 115200 bps.

b. Change the data rate of the PC to 115200 bps to match the relay.

Step 6. Issue the **REC** command to receive the new firmware.

Step 7. Type **Y** to confirm that the existing firmware can be erased.

Step 8. Press any key (e.g., **<Enter>**) when the relay sends a prompt.

Step 9. Start the file transfer.

Use the Xmodem protocol to send the file that contains the new firmware (e.g., r*xxx*-v*x*751.s19, r*xxx*-v*x*751.z19, or r*xxx*-v*x*751.zds).

Firmware files for firmware versions R1*xx* and R2*xx* have .s19 or .z19 extensions. Firmware files for firmware versions R300 or higher have .zds extensions. Firmware files with .s19 or .z19 extensions are not available for firmware versions R300 and higher.

The file transfer typically takes less than 15 minutes at 115200 bps, depending on the product. After the transfer is complete, the relay reboots and returns to Access Level 0.

Figure B.2 shows the entire upgrade process.

```
=>>L_D <Enter>

Disable relay to receive firmware (Y,N)? Y <Enter>
Are you sure (Y,N)? Y <Enter>
Relay Disabled

BFID=SLBT7XX-R600-V0-Z000000-D20200331
!>BAU 115200 <Enter>
!>REC <Enter>
This command uploads new firmware.
When new firmware is uploaded successfully, IED will erase old firmware,
load new firmware and reboot.

Are you sure you want to erase the existing firmware(Y,N)? Y <Enter>
Press any key to begin transfer and then start transfer at the terminal. <Enter>
Erasing firmware.
Erase successful.
Writing new firmware.
Upload completed successfully. Attempting a restart.
```

Figure B.2 Firmware File Transfer Process

Step 10. The relay front-panel **ENABLED** LED illuminates if the relay settings are retained through the download.

If the **ENABLED** LED is illuminated, proceed to *Step 11*.

If the **ENABLED** LED is not illuminated or the front panel displays `STATUS FAIL Non_Vol Failure`, use the following procedure to restore the factory-default settings:

a. Set the communications software settings to 9600 bps, 8 data bits, and 1 stop bit.

b. Enter Access Level 2 by issuing the **2AC** command.

c. Issue the **R_S** command to restore the factory-default settings.

The relay then reboots with the factory-default settings.

d. Enter Access Level 2.

e. Issue the **STATUS** command.

If the relay is enabled, go to *Step f*.

If the STATUS report shows option card `FAIL` and `Relay Disabled` and the message:

`Confirm Hardware Config`

`Accept & Reboot (Y/N)?`

Enter **Y**. This saves the relay calibration settings.

The relay responds:

`Config Accepted`

The relay reboots and comes up enabled.

f. Restore relay settings back to the settings saved in *Step 3*.

Step 11. Change the data rate of the PC to match that of the relay prior to *Step 4*, and enter Access Level 2.

Step 12. Issue the **STATUS** command; verify all relay self-test results are OK.

Step 13. Apply current and voltage signals to the relay.

Step 14. Issue the **METER** command; verify that the current and voltage signals are correct.

Step 15. Autoconfigure the SEL communications processor port if you have a communications processor connected.

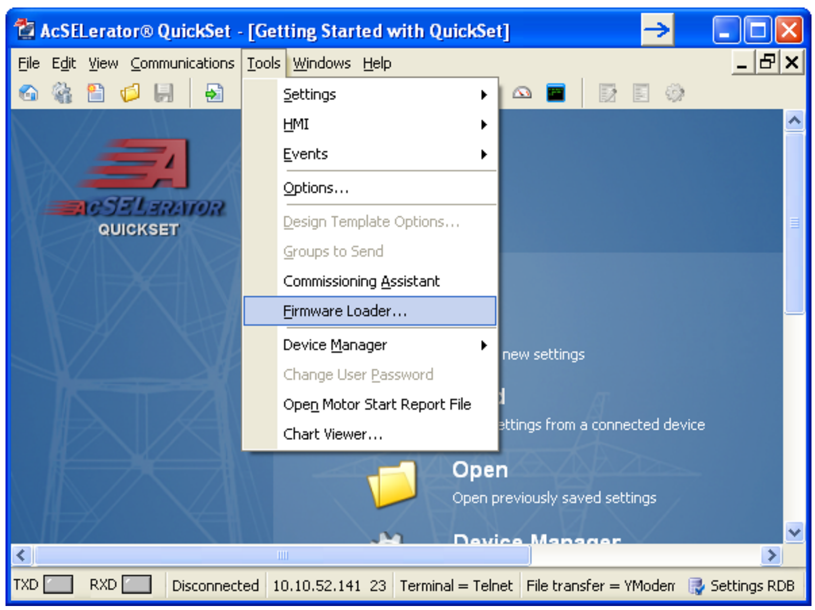
This step re-establishes automatic data collection between the SEL communications processor and the SEL relay. Failure to perform this step can result in automatic data collection failure when cycling communications processor power.

Upgrade the Firmware Using QuickSet

Select **Tools** > **Firmware Loader** from the QuickSet menu bar to launch a wizard that walks you through the steps to load firmware into your SEL device. Refer to *Section 3: PC Interface* for setup and connection procedures for QuickSet.

NOTE: The firmware loader is not supported on Ethernet port connections.

NOTE: In instances where SELBOOT needs to be upgraded, QuickSet cannot be used to upgrade the relay firmware. Use a terminal emulator to upgrade SELBOOT and then upgrade the relay firmware.



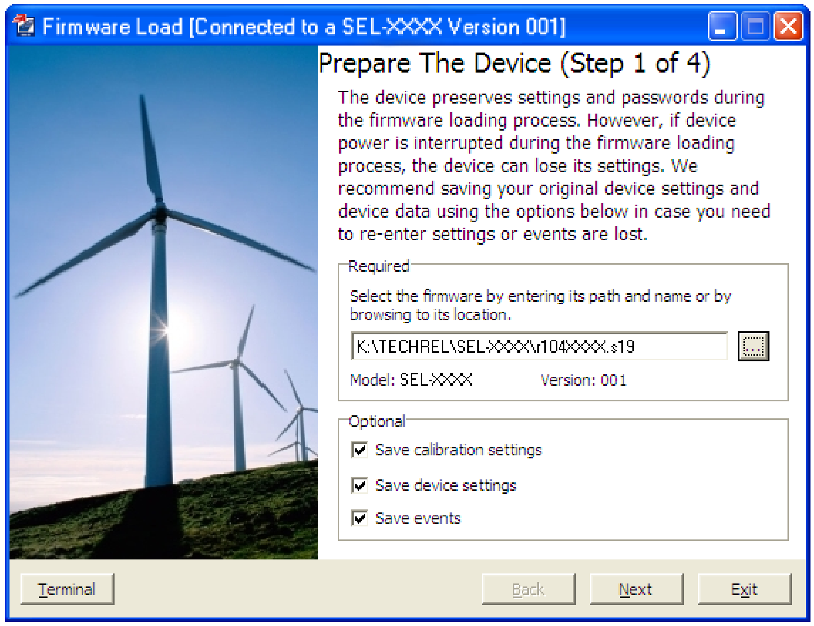
Firmware Loader does not start if:

- ➤ The device is unsupported by QuickSet.
- ➤ The device is not connected to the computer with a communications cable.
- ➤ The device is disabled.

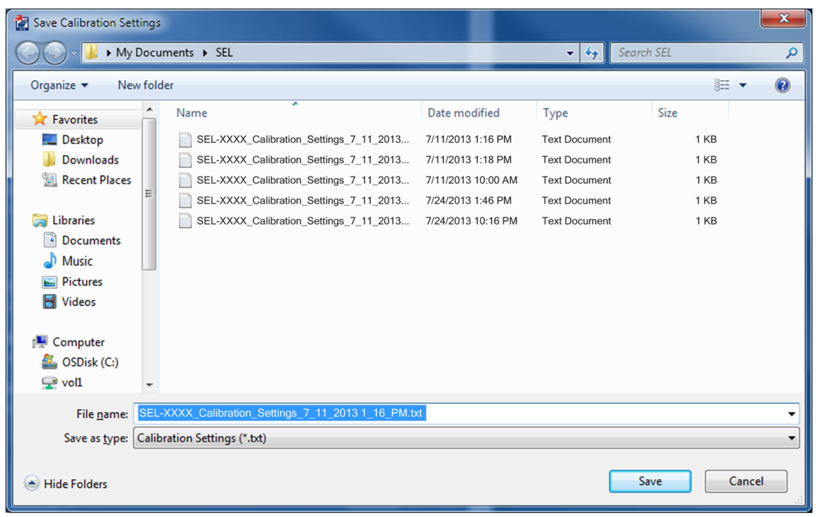
Step 1. If the relay is in service, open the relay control circuits.

Step 2. Prepare the device.

a. Select the firmware to be loaded using the browse control and select **Save calibration settings**, **Save device settings**, and **Save events**. Select **Next** to continue the wizard.

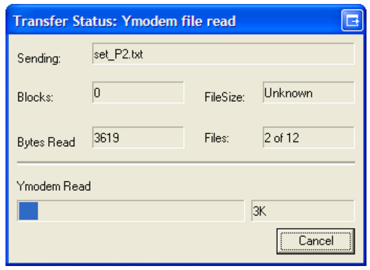


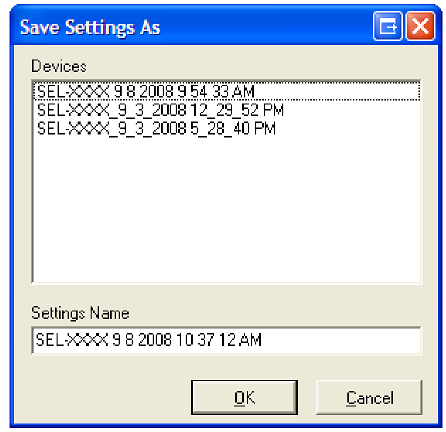
b. Select a file name to save the selected settings or accept the defaults as shown. Click **Save**.



c. The **Transfer Status**: **Ymodem file read** window shows the transfer progress of the settings file.

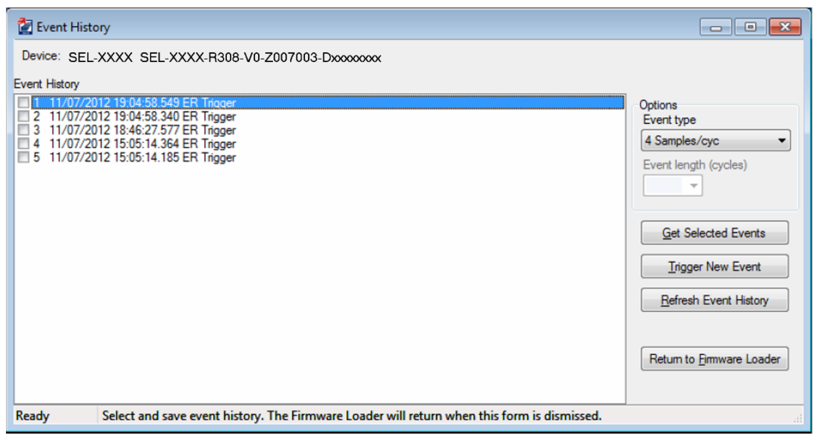
After the device settings are downloaded, select a file name and path to save the settings or accept the default, as shown.





d. Click **Return to Firmware Loader** if this device does not have any event reports.

If there are any event reports to be saved, select the events and click the **Get Selected Event**. After saving them, click **Return to Firmware Loader**.



Step 3. Transfer firmware.

Click **Next** to begin the firmware transfer.

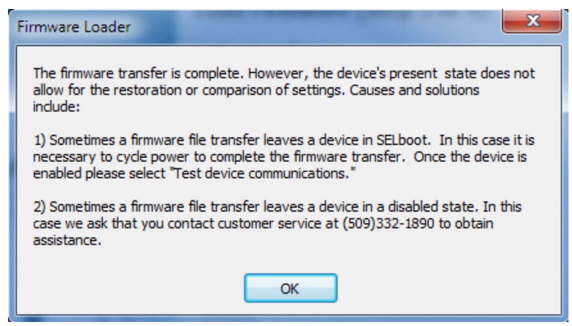
Step 4. Load firmware.

During this step, the device is put in SELBOOT mode. The transfer speed is maximized and the firmware transfer begins.

Step 5. Click **Next** to complete the firmware upgrade.

NOTE: The following screen appears if you have one of the two conditions mentioned.

If the relay is disabled as a result of a settings mismatch between a previous firmware version and a new firmware version, check the **ENABLED** LED on the front panel of the relay. If the **ENABLED** LED is not illuminated or the front panel displays `STATUS FAIL Non_Vol Failure` on the two-line display model, or a settings mismatch notification screen on the touchscreen model, use the following procedure to restore the factory-default settings:



a. Click on the Terminal button on the Firmware Load screen of QuickSet.

b. Set the communications software settings to 9600 bps, 8 data bits, and 1 stop bit.

c. Enter Access Level 2 by issuing the **2AC** command.

d. Issue the **R_S** command to restore the factory-default settings.

The relay reboots and comes up enabled.

Note that the port settings will be restored to the default settings due to the **R_S** command.

If the relay is still disabled, use the following procedure:

e. Enter Access Level 2.

f. Issue the **STATUS** command.

If the STATUS report shows option card `FAIL` and `Relay Disabled` and the message:

`Confirm Hardware Config`

`Accept & Reboot (Y/N)?`

Enter **Y**.

This saves the relay calibration settings. The relay responds:

`Config Accepted`

The relay reboots and comes up enabled.

Step 6. Verify device settings.

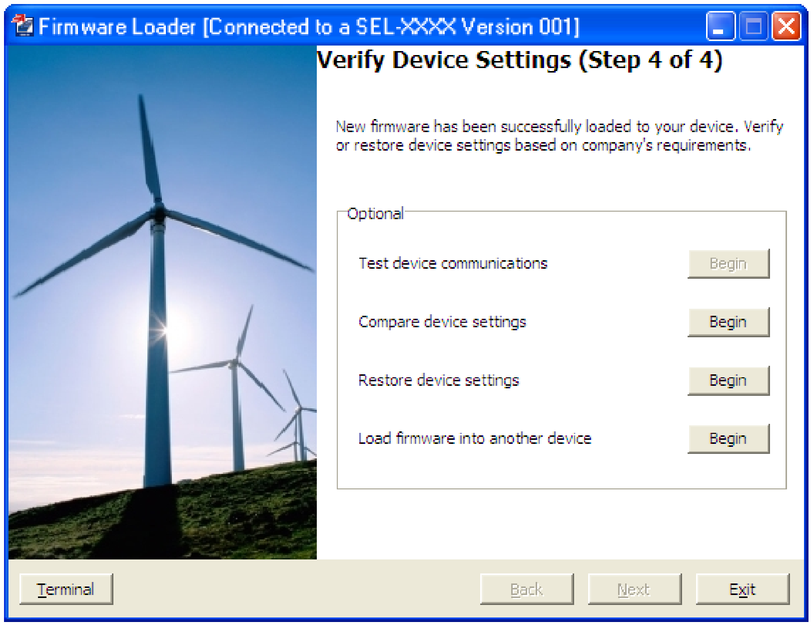
Select from four verification options, which perform as follows.

Test Device Communications. If the device cannot be restarted, then turn power off and back on to restart it. Once the device is enabled, this option reconnects and reinitializes the device.

Compare Device Settings. This option verifies settings by reading them from the device and comparing them with settings saved to the database.

Restore Device Settings. This option restores settings by writing settings that are saved in the database to the device. Settings are converted automatically, if necessary.

Load Firmware into Another Device. Returns the wizard to *Step 2*: *Prepare Device* to repeat the firmware-loading process with another device.



Upgrade the Firmware Using the Web Server

NOTE: The relay pulses the SALARM bit and writes an entry to the relay SER log whenever a firmware upgrade is attempted over Ethernet. Monitoring the SALARM bit and reviewing the SER log can help identify possible unauthorized firmware upgrade attempts.

The web server offers a convenient method for upgrading the relay firmware. Located on the left navigation pane of the screen, the System menu contains the File Management category that allows you to upgrade firmware in the relay. To upgrade the firmware using the web server, the firmware in your relay must be R300 or higher. The firmware is designated with a .zds extension. Refer to *Section 3: PC Interface* for connecting and logging in to the SEL-751 web server using the Ethernet port.

To upgrade relay firmware using the web server, set the Port 1 settings HTTPACC := 2 and EETHFWU := Y. If EETHFWU is set to N, you cannot upgrade the firmware over Ethernet, regardless of the HTTPACC setting.

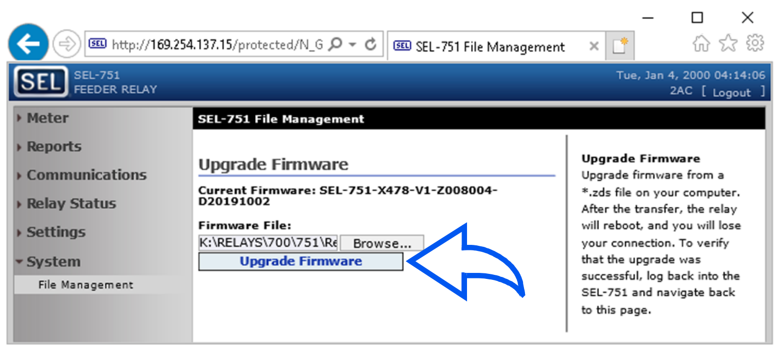
Step 1. In QuickSet, save the current relay settings and other data.

Step 2. Proceed with the firmware upgrade process by performing the following steps:

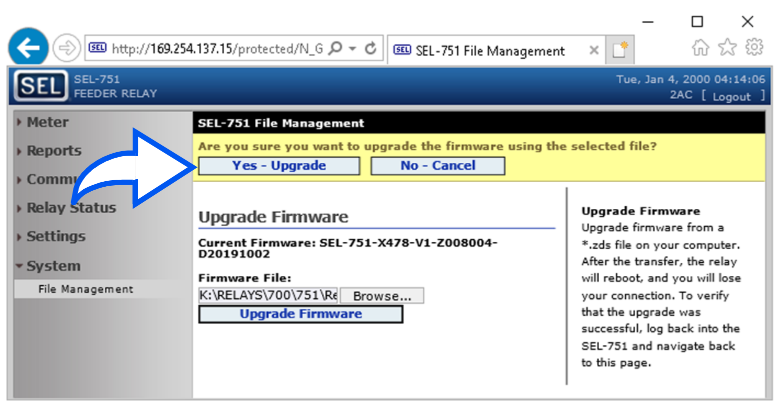
a. Click **System > File Management** from the left navigation pane of the webpage.

b. Click **Browse** to select the firmware you want to send to the relay.

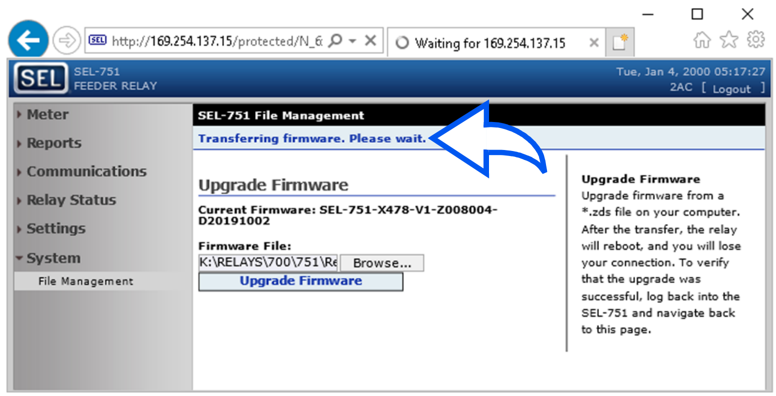
c. Click **Upgrade Firmware** to start the upgrade process.



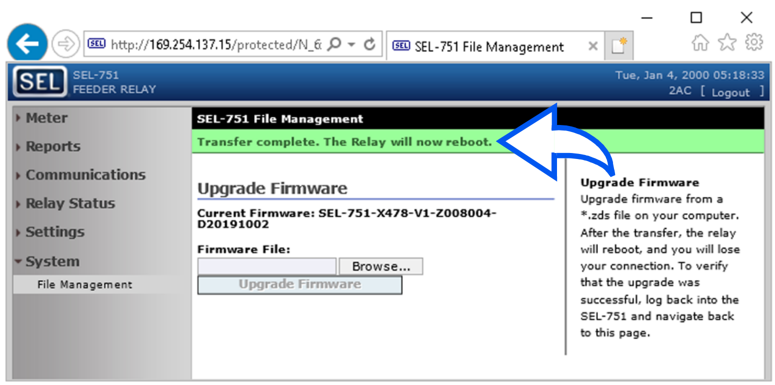
Step 3. Click **Yes - Upgrade** if you want to upgrade using the file selected.



Once the upgrade process is in progress, the relay acknowledges the transfer with the message, **Transferring firmware. Please wait**.



After the relay finishes the firmware transfer, an acknowledgment message appears and the relay reboots.



NOTE: After the relay reboots, if the **ENABLED** LED is not illuminated or if the front panel displays STATUS FAIL Non_Vol Failure on the two-line display model, or a settings mismatch notification screen on the touchscreen model, then open a terminal emulator using the serial port and use the following procedure to restore the factory-default settings. Refer to Upgrade the Firmware Using a Terminal Emulator for terminal emulator setup and connections.

a. Set the communications software settings to 9600 bps, 8 data bits, and 1 stop bit.

b. Enter Access Level 2 by issuing the **2AC** command.

c. Issue the **R_S** command to restore the factory default.

The relay reboots and comes up enabled.

Note that the port settings will be restored to the factory-default settings due to the **R_S** command.

If the relay is still disabled, use the following procedure:

d. Enter Access Level 2.

e. Issue the **STATUS** command.

If the STATUS report shows option card `FAIL` and `Relay Disabled` and the message:

```
Confirm Hardware Config
Accept & Reboot (Y/N)?
```

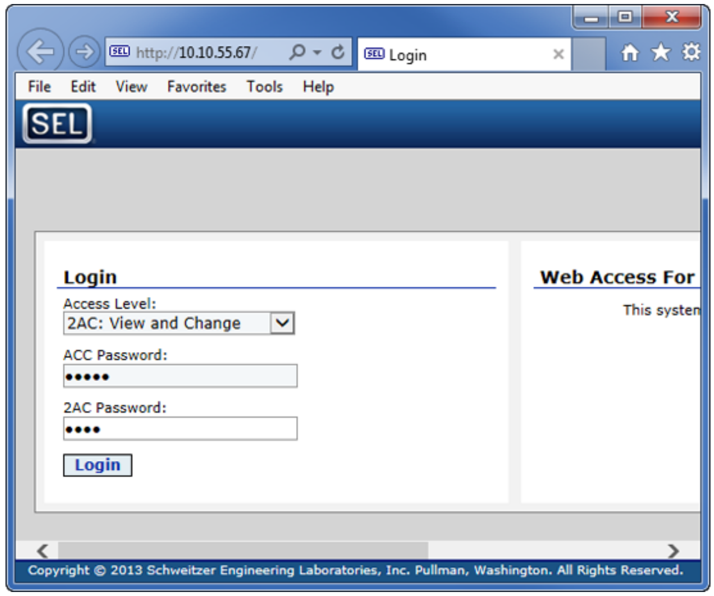
Enter **Y**.

This saves the relay calibration settings. The relay responds:

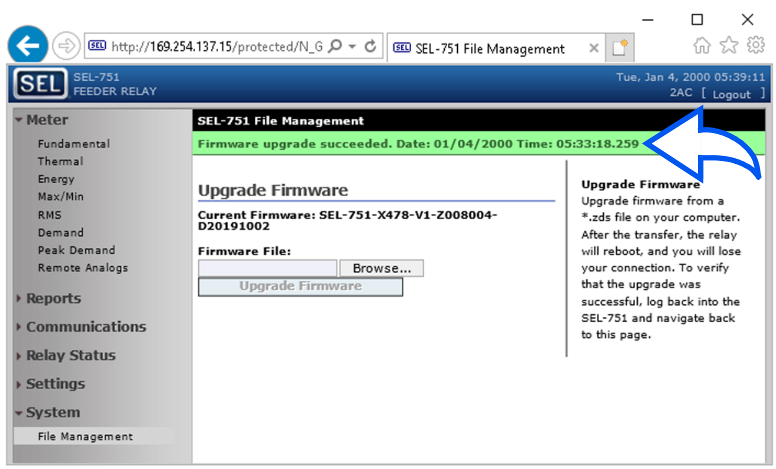
```
Config accepted
```

The relay reboots and comes up enabled.

Step 4. After the relay reboots, the Login screen appears on the web server. Log in to the relay to verify completion of the firmware upgrade process.



An acknowledgment message appears that verifies a successful firmware upgrade.



Step 5. Check that the relay firmware version matches the version that was used for the upgrade and that the relay is enabled.

Click on **Relay Status** > **Self-Tests** to view the status report.

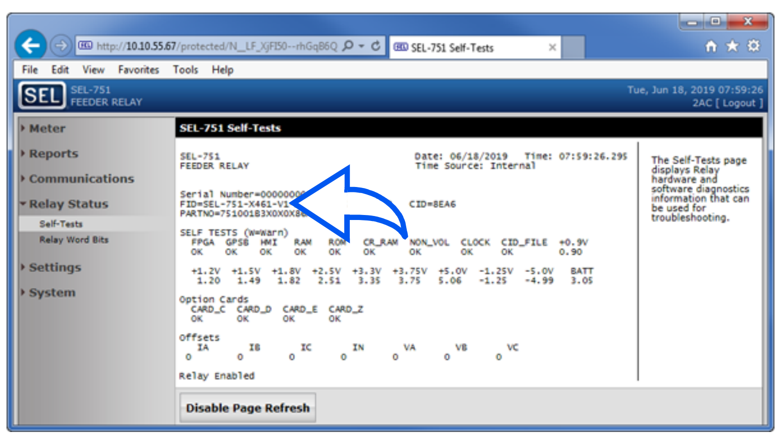


Table B.2 shows messages displayed in the web browser and the message meaning.

Table B.2 Ethernet Firmware Upgrade User Messages

User Message	Relay Condition
Firmware upgrade succeeded.	The previous firmware upgrade with a .zds file was successful.
Invalid upgrade file.	The .zds file was not successfully received or validated by the relay.
Upgrade in progress on another interface.	A firmware upgrade is presently being performed through another connection.
Errors during Upgrade File Transfer.	Upgrade failed due to errors during file transfer.

Upgrade the Firmware Using File Transfer Protocol

NOTE: Make sure that the relay and SELBOOT firmware revisions are compatible. Refer to Firmware, ICD, and Manual Versions in this manual. If needed, upgrade the SELBOOT firmware prior to upgrading the relay firmware.

NOTE: The relay pulses the SALARM bit and writes an entry to the relay SER log whenever a firmware upgrade is attempted over Ethernet. Monitoring the SALARM bit and reviewing the SER log can help identify possible unauthorized firmware upgrade attempts.

To upgrade firmware using File Transfer Protocol (FTP), the firmware in your relay must be R300 or higher. The firmware is designated with a .zds extension.

To upgrade relay firmware using FTP, set the Port 1 settings FTPACC := 2 or C and EETHFWU := Y. If EETHFWU is set to N, you cannot upgrade the firmware over Ethernet, regardless of the FTPACC setting.

The following instructions assume you have a working knowledge of the Windows command prompt.

Step 1. If the relay is in service, open the relay control circuits.

Step 2. Connect the PC to the Ethernet port and enter Access Level 2.

Step 3. Save the present relay settings.

You can use the PC software (see *Section 3: PC Interface*) to save and restore settings, or you can use the following steps:

a. Issue the following commands at the ASCII prompt: **SHO**, **SHO L**, **SHO G**, **SHO P**, **SHO F**, **SHO R**, **SHO C**, etc.

b. Record all the settings for possible re-entry after the firmware upgrade.

We recommend that you save all stored data in the relay, including events, before the upgrade.

NOTE: To save the calibration settings, perform **SHO C** from the terminal by logging into Access Level C using the Access Level C password. The factory-default password for Access Level C is CLARKE.

NOTE: When you are upgrading an SEL-751 with a touchscreen front-panel display, save all of the relay settings, including the touchscreen settings, using QuickSet.

NOTE: File name RELAY.zds is not case sensitive.

Step 4. Rename the r*xxx*-v*x*751.zds file as RELAY.zds.

Step 5. Create an FTP session to connect to the relay using the relay IP address.

Step 6. Enter your FTP username and password.

Step 7. Issue the **CD UPGRADE** command to switch the present relay directory to the UPGRADE directory.

Step 8. Issue the **PUT RELAY.ZDS** command to place the RELAY.zds file in the UPGRADE directory and to send the file to the relay.

When the download is complete, the relay reboots and comes up enabled.

During this upgrade process, you will lose the FTP connection, and you must reestablish the FTP connection after the upgrade is complete. Then navigate to the relay UPGRADE directory and review the ERR.txt file for any error messages. If the firmware upgraded properly, no errors occurred during the upgrade process and the file is empty. If messages are contained within the file, see *Table B.2* for the error message and a description.

Figure B.3 shows the entire upgrade process via Windows command prompt.

```
Microsoft Windows [Version 10.0.17763.805]
(c) 2018 Microsoft Corporation. All rights reserved.

Y:\>FTP 10.39.94.180 <Enter>
Connected to 10.39.94.180.
220 FTP SERVER
550 NOOP requested action not taken.
User (10.39.94.180:(none)): xxxxxx <Enter>
331 User name okay, need password.
Password: xxxxxx <Enter>
230 User logged in, proceed.
ftp> CD UPGRADE <Enter>
250 CWD  requested file action okay, completed.
ftp> PUT RELAY.ZDS <Enter>
200 PORT Command okay.
150 File status okay; about to open data connection.
Connection closed by remote host.
ftp>
```

Figure B.3 Firmware Upgrade Via FTP

Upgrade the Firmware Via Terminal Emulator Using the FILE Command Over Telnet

NOTE: Make sure that the relay and SELBOOT firmware revisions are compatible. Refer to Firmware, ICD, and Manual Versions in this manual. If needed, upgrade the SELBOOT firmware prior to upgrading the relay firmware.

NOTE: The relay pulses the SALARM bit and writes an entry to the relay SER log whenever a firmware upgrade is attempted over Ethernet. Monitoring the SALARM bit and reviewing the SER log can help identify possible unauthorized firmware upgrade attempts.

To upgrade firmware using the **FILE** command over Telnet, the firmware in your relay must be R300 or higher. The firmware is designated with a .zds extension.

To upgrade relay firmware using the **FILE** command over Ethernet, set the Port 1 settings MAXACC := 2 or C and EETHFWU := Y. If EETHFWU is set to N, you cannot upgrade the firmware over Ethernet, regardless of the MAXACC setting.

The following procedure assumes that you have a working knowledge of the software being used to upgrade the firmware via **FILE** command.

Step 1. If the relay is in service, open the relay control circuits.

Step 2. Connect the PC to the Ethernet port and enter Access Level 2.

Step 3. Save the present relay settings.

NOTE: To save the calibration settings, perform **SHO C** from the terminal by logging into Access Level C using the Access Level C password. The factory-default password for Access Level C is CLARKE.

NOTE: When you are upgrading an SEL-751 with a touchscreen front-panel display, save all of the relay settings, including the touchscreen settings, using QuickSet.

You can use the PC software (see *Section 3: PC Interface*) to save and restore settings, or you can use the following steps:

a. Issue the following commands at the ASCII prompt: **SHO**, **SHO L**, **SHO G**, **SHO P**, **SHO F**, **SHO R**, **SHO C**, etc.

b. Record all the settings for possible re-entry after the firmware upgrade.

We recommend that you save all stored data in the relay, including events, before the upgrade.

NOTE: File name RELAY.zds is not case sensitive.

Step 4. Rename the r*xxx*-v*x*751.zds file as RELAY.zds.

Step 5. Save the RELAY.zds file to a directory.

Step 6. Update the active directory to be the directory where the RELAY.zds file is saved.

Step 7. Issue the **FILE WRITE RELAY.ZDS** command to the relay.

Step 8. Send the RELAY.zds file to the relay via Ymodem transfer.

When the upgrade is complete, the relay reboots and comes up enabled.

During this upgrade process, you will lose the Telnet connection, and you must reestablish the Telnet connection after the upgrade is complete. Then navigate to the relay UPGRADE directory and review the ERR.txt file for any error messages. If the firmware upgraded properly, no errors occurred during the upgrade process and the file is empty. If messages are contained within the file, see *Table B.2* for the error message and a description.

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.

Technical Support

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

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

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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
CBRE	Breaker monitor	1
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*.

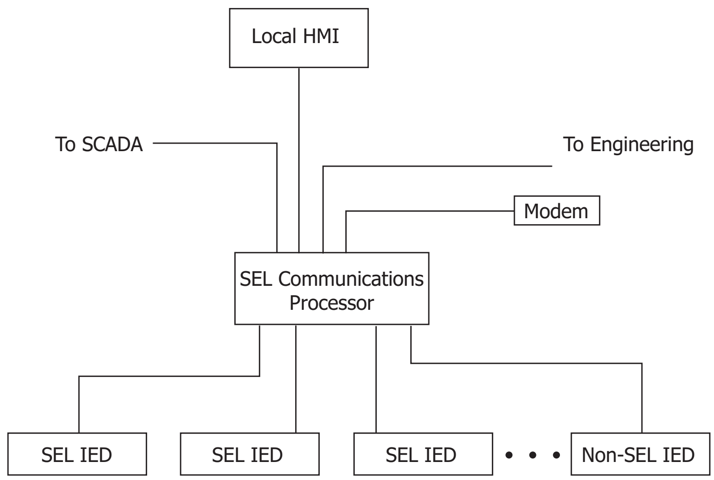


Figure C.1 SEL Communications Processor Star Integration Network

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.

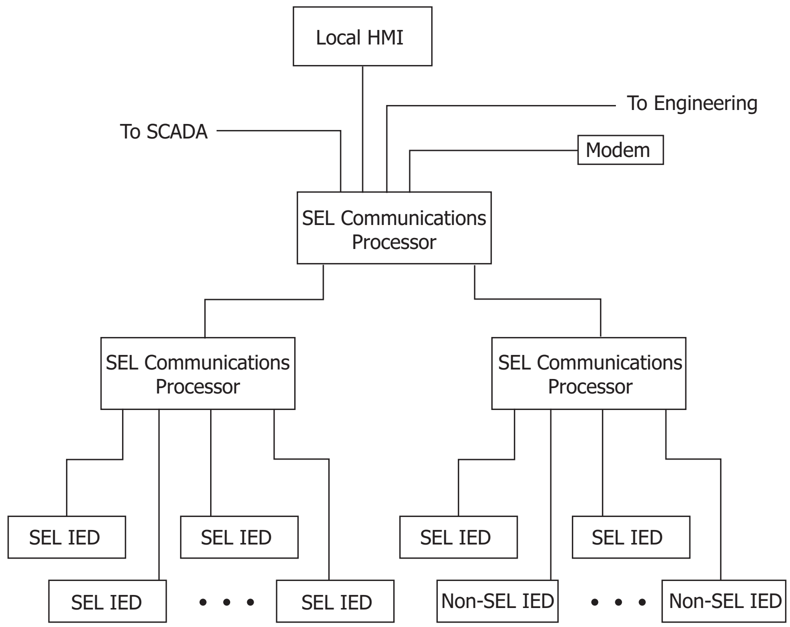


Figure C.2 Multitiered SEL Communications Processor Architecture

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 (Sheet 1 of 2)

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

Table C.3 SEL Communications Processors Protocol Interfaces (Sheet 2 of 2)

Protocol	Connect to
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.

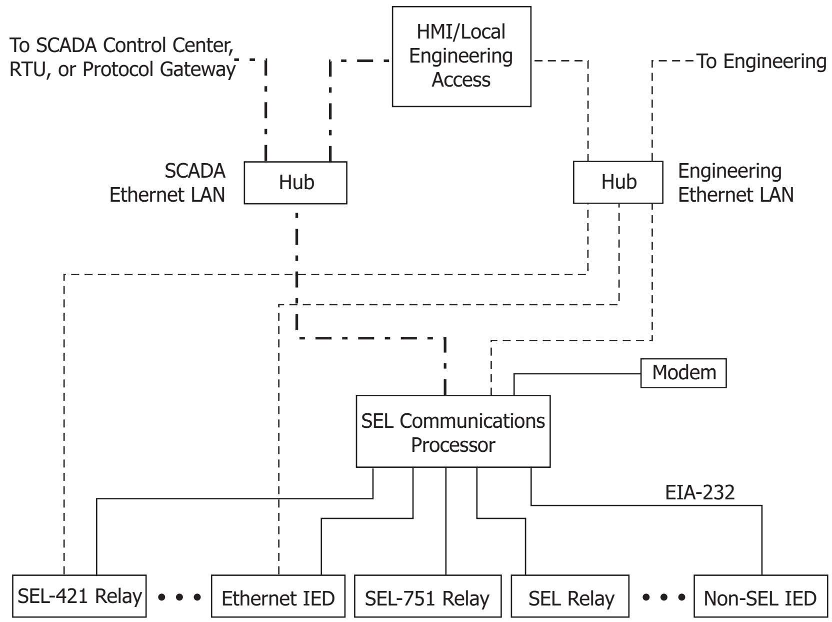


Figure C.3 Enhancing Multidrop Networks With SEL Communications Processors

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*. In this example, the communications processor is an RTAC that is connected to the SEL-751 by using SEL Protocol via ACSELERATOR RTAC software. For more information regarding the RTAC and ACSELERATOR RTAC software, refer to selinc.com.

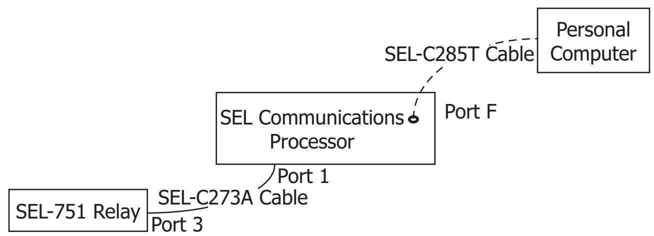


Figure C.4 Example of SEL Relay and SEL Communications Processor Configuration

Table C.4 shows the Port 1 settings for the RTAC.

Table C.4 RTAC Port 1 Settings (Sheet 1 of 2)

Setting	Range	Value
Communications		
SERIAL COMMUNICATIONS PORT	The number of ports depends on the RTAC MOT	Com_01
SERIAL COMMUNICATIONS PORT TYPE	EIA-232, EIA-485/EIA-422	EIA232
BAUD RATE	Auto-Baud, 300, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200	115200
DATA BITS	8	8
PARITY BIT	None	None
STOP BIT	1	1
RTS_CTS	True, False	False
XON/XOFF	True, False	True
LEVEL 1 PASSWORD	0–32 characters	**********
LEVEL 2 PASSWORD	0–32 characters	**********
ENABLE PASSWORD MONITOR	True, False	False
POLL CASCII RETRIES	0–255	3
POLL CASCII INACTIVITY TIMEOUT	100–65535 ms	8000
POLL BINARY RETRIES	0–255	3
POLL BINARY INACTIVITY TIMEOUT	<min>–65535 ms	2500

Table C.4 RTAC Port 1 Settings (Sheet 2 of 2)

Setting	Range	Value
SLOW POLL MODE MULTIPLIER	1–65535	5
TRANSMIT FAST UNSOLICITED WRITE MESSAGING ON STARTUP	True, False	False
Date-Time		
UTC OFFSET	–720 to 840 minutes	0
DST ENABLED	True, False	True
Event		
ENABLE EVENT COLLECTION	True, False	False
ENABLE COMTRADE COLLECTION	True, False	False
LIST OF EVENT TYPES TO BE COLLECTED		HR
SEL		
VIRTUAL PORT NUMBER	1–254	1

After these settings are configured to align with the Port 3 settings of the SEL-751, the RTAC will autoconfigure the connection. Refer to *Figure C.5* to see what a healthy connection looks like after autoconfiguration is complete. Note that ENO and EN are TRUE and that Offline is FALSE.

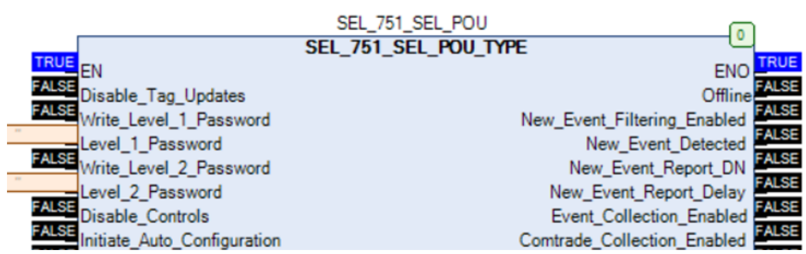


Figure C.5 Healthy Communications Between an RTAC and an SEL-751

Data Collection

In this example, the RTAC is configured to collect data from the SEL-751 via SEL Protocol, using the list in *Table C.5*.

Table C.5 RTAC Data Collection Automessages

Message Name	Message Type	Command	Poll Period
History	Compressed ASCII	CHI	0
Load Data	Compressed ASCII	CLDP	0
SER	Compressed ASCII	CSE	0
Status	Compressed ASCII	CST	0
Demand Meter	Fast Meter	D2	0
Meter	Fast Meter	D1	1000
Peak Meter	Fast Meter	D3	0

You have the ability to set the poll period for each of the commands in *Table C.5*.

Control Points

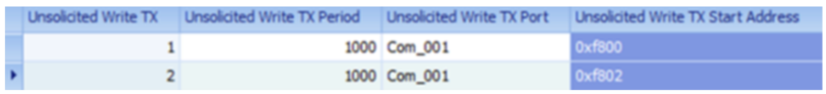
The RTAC can automatically pass control messages, called Fast Operate messages, to the SEL-751. You must enable Fast Operate messages by using the FASTOP setting in the SEL-751 port settings for the port connected to the SEL communications processor.

NOTE: To use the Fast Operate function, the Breaker jumper must be installed (see Figure 2.9).

When you enable Fast Operate functions, the SEL communications processor automatically sends messages to the relay for changes in remote bits RB01–RB64 on the corresponding SEL communications processor port.

SEL Communications Processor to SEL-751 Unsolicited Write Remote Analog Example

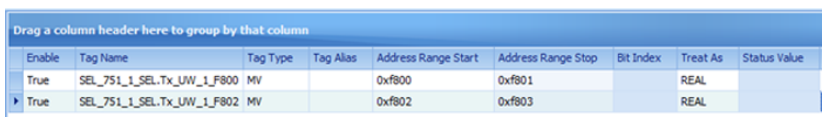
There are two settings that must be configured in the RTAC if you need to write to remote analogs in the SEL-751. In this example, the required settings to write to RA001 and RA002 are provided. The first set of settings is under the Tx UW Messages tab (*Figure C.6*).



Unsolicited Write TX	Unsolicited Write TX Period	Unsolicited Write TX Port	Unsolicited Write TX Start Address
1	1000	Com_001	0xf800
2	1000	Com_001	0xf802

Figure C.6 Unsolicited Write Remote Analogs Tx UW Messages Settings

In the settings, note the unsolicited write Tx starting addresses. After these two settings are properly configured, Tx UW Message 1 must be configured (*Figure C.7*). Note the Tag Types being MV and the Datatype being REAL. Use a similar setup to write to all of the remote analogs.



Drag a column header here to group by that column

Enable	Tag Name	Tag Type	Tag Alias	Address Range Start	Address Range Stop	Bit Index	Treat As	Status Value
True	SEL_751_1_SEL.Tx_UW_1_F800	MV		0xf800	0xf801		REAL	
True	SEL_751_1_SEL.Tx_UW_1_F802	MV		0xf802	0xf803		REAL	

Figure C.7 Tag Type and Datatype for RA001-RA128

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 communication requirements	Meters, simple IEDs
2	Moderately complex: monitoring and metering devices and multifunction devices that contain more data	Protective relays, RTUs
3	Sophisticated: devices with great amounts of data or complex communication requirements	Large RTUs, SCADA masters
4	Enhanced: additional data types and functionality for more complex requirements	Large RTUs, SCADA masters

Each level is a proper superset of the previous lower-numbered level. A higher-level device can act as a master to a lower-level device, but can only use the data types and functions implemented in the lower level device. For example, a typical SCADA master is a Level 3 device and can use Level 2 (or lower) functions to poll a Level 2 (or lower) device for Level 2 (or lower) data. Similarly, a lower-level device can poll a higher-level device, but the lower level device can only access the features and data available to its level.

In addition to the eight-volume DNP3 specification, the protocol is further refined by conformance requirements, optional features, and a series of technical bulletins. The technical bulletins supplement the specifications with 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 includes a start address and a stop address. Each of these two addresses uses two bytes. An example request using qualifier code 01 might have the four hexadecimal byte range field, 00h 04h 00h 10h, which specifies points in the range 4 to 16.

Access Methods

DNP3 has many features that help obtain maximum possible message efficiency. DNP3 masters send requests with the least number of bytes by using special objects, variations, and qualifiers that reduce the message size. Other features eliminate the continual exchange of static (unchanging) data values. These features optimize use of bandwidth and maximize performance over a connection of any speed.

DNP3 event data collection eliminates the need to use bandwidth to transmit values that have not changed. Event data are time-stamped records that show when observed measurements changed. For binary points, the remote device (DNP3 outstation) logs changes from logical 1 to logical 0 and from logical 0 to logical 1. For analog points, the outstation device logs changes that exceed a deadband. DNP3 outstation devices collect event data in a buffer that either the master can request or the device can send to the master without a request message. Data sent from the outstation to the master without a polling request are called unsolicited data.

DNP3 data fit into one of four event classes: 0, 1, 2, or 3. Class 0 is reserved for reading the present value data (static data). Classes 1, 2, and 3 are event data classes. The meaning of Classes 1 to 3 is arbitrary and defined by the application at hand. With outstations that contain great amounts of data or in large systems, the three event classes provide a framework for prioritizing different types of data. For example, you can poll once a minute for Class 1 data, once an hour for Class 2 data, and once a day for Class 3 data.

DNP3 also supports static polling: simple polling of the present value of data points within the outstation. By combining event data, unsolicited polling, and static polling, you can operate your system in one of the four access methods shown in *Table D.3*.

The access methods listed in *Table D.3* are listed in order of increasing 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.12* 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 Open System Interconnection (OSI) 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 IP suite. This allows the IP stack to deliver the DNP3 data link layer frames to the destination in place of the original DNP3 physical layer.

The DNP User Group Technical Committee has recommended the following guidelines for carrying DNP3 over a network:

NOTE: Link layer confirmations are explicitly disabled for DNP3 LAN/WAN. The IP suite provides a reliable delivery mechanism, which is backed up at the application layer by confirmations when necessary.

- DNP3 shall use the IP suite to transport messages over a LAN/WAN
- Ethernet is the recommended physical link, although you can use others
- TCP must be used for WANs
- TCP is strongly recommended for LANs
- UDP 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 unsolicited 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.

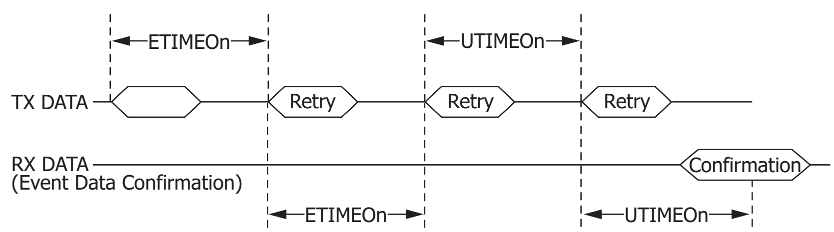


Figure D.1 Application Confirmation Timing With URETRY n = 2

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 between the end of carrier detection and the start of data transmission (see *Figure D.2*).

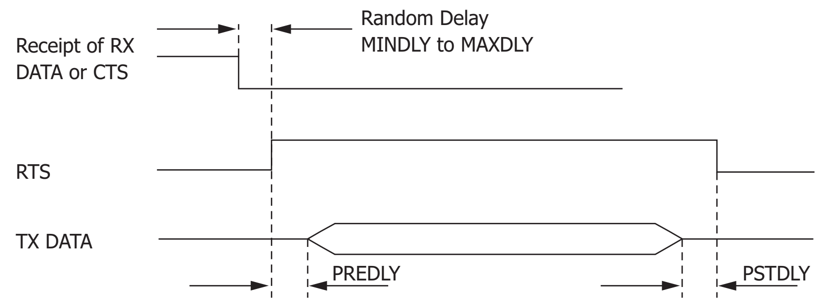


Figure D.2 Message Transmission Timing

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 twice 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 deadband and scaling operation on analog points shown in *Table D.7*. You can either:

- ➤ set and use default deadband and scaling according to data type, or
- ➤ use a custom data map to select deadbands on a point-by-point basis.

See *DNP3 Documentation* for a discussion of how to set scaling and deadband operation on a point-by-point basis. You can modify deadbands for analog inputs at run-time by writing to Object 34.

The settings ANADBA*n*, ANADBV*n*, and ANADBM*n* control default deadband operation for each type of analog data. Because DNP3 Objects 30 and 32 use integer data, you must use scaling to send digits after the decimal point and avoid rounding to a simple integer value.

With no scaling, the value of 12.632 would be sent as 12. With a scaling setting of 1, the value transmitted is 126. With a scaling setting of 3, the value transmitted is 12632. You must make certain that the maximum value does not exceed 32767 if you are polling the default 16-bit variations for Objects 30 and 32, but you can send some decimal values 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 deadbands 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.12* 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.24*.

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 or PTP 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”).

The SEL-751 prioritizes its time synchronization sources. These time sources fall under one of two categories. The first category is called primary time sources and the second category is called secondary time sources. IRIG-B, PTP, and SNTP are primary time sources. All other time sources, such as DNP, IEC 60870-5-103, Modbus, and serial port **TIME** and **DATE** commands, are secondary time sources.

If NETMODE := PRP and a PTP time source is available, the SEL-751 synchronizes its time with that time source regardless of what other time sources are available. If PTP is not available and IRIG-B is, the SEL-751 synchronizes its time with the IRIG time source even if other time sources are available. For other NETMODE settings (NETMODE ≠ PRP), if an IRIG-B time source is available, the SEL-751 synchronizes its time with that time source regardless of what other time sources are available. If an IRIG-B time source is not available and PTP is (firmware-based PTP), the SEL-751 synchronizes its time with that PTP time source even if other time sources are available. For all the NETMODE settings, if IRIG-B and PTP are not available but SNTP is, the SEL-751 synchronizes its time with that SNTP time source even if other time sources are available. Finally, if IRIG-B, PTP, and SNTP are not available, the SEL-751 synchronizes with the remaining time sources that could be available. They include DNP, IEC 60870-5-103, Modbus, or serial port **TIME** and **DATE** commands. These four time sources take on the same priority. At any given time, the relay will synchronize with the one that most recently established synchronization with the relay. In summary, time synchronization prioritization starts with PTP (when NETMODE := PRP) and is followed by IRIG-B, PTP, SNTP, DNP, IEC 60870-5-103, Modbus, or serial port **TIME** and **DATE** commands.

Note that when an IRIG-B time source is available and IRIGC := NONE, any remaining time source that is available can be used to update the year only. If IRIGC := C37.118, IRIG-B also updates the year.

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.

NOTE: To enable hardware handshaking, set the modem settings for the selected port equal to Y if you are using a Null modem cable for DNP protocol implementation.

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 3)

Name	Description	Range	Default
EDNP[a]	Enable DNP3 Sessions	0–5	0
DNPNUM[a]	DNP3 TCP and UDP Port	1–65534	20000
DNPADR	Device DNP3 address	0–65519	0
Session 1 Settings			
DNPIP1[b]	DNP Master IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR1[a]	Transport protocol	UDP, TCP	TCP
DNPUDP1[a]	UDP response port	REQ, 1–65534	20000
REPADR1	DNP3 address of the Master to send messages to	0–65519	1
DNPMAP1	DNP3 Session Custom Map	1–3	1
DVARAI1	Analog Input Default Variation	1–6	4
ECLASSB1	Class for binary event data, 0 disables	0–3	1
ECLASSC1	Class for counter event data, 0 disables	0–3	0
ECLASSA1	Class for analog event data, 0 disables	0–3	2
DECPLA1	Decimal places scaling for Current data	0–3	1
DECPLV1	Decimal places scaling for Voltage data	0–3	1
DECPLM1	Decimal places scaling for Miscellaneous data	0–3	1
ANADBA1	Analog reporting deadband for current; hidden if ECLASSA1 set to 0	0–32767	100
ANADBV1	Analog reporting deadband for voltages; hidden if ECLASSA1 set to 0	0–32767	100
ANADBM1	Analog reporting deadband for miscellaneous analogs; hidden if ECLASSA and ECLASSC set to 0	0–32767	100
TIMERQ1	Time-set request interval, minutes (M = Disables time 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[c]	Send Data Link Heartbeat, seconds; hidden if DNPTR1 set to UDP	0.0–7200	120
DRETRY1[d]	Data link retries	0–15	0

Table D.7 Port DNP3 Protocol Settings (Sheet 2 of 3)

Name	Description	Range	Default
DTIMEO1[d]	Data link time-out, seconds; hidden if DRETRY1 set to 0	0.0–5.0	1
ETIMEO1	Event message confirm time-out, seconds	1–50	5
UNSOL1	Enable unsolicited reporting; hidden and set to N if ECLASSB1, ECLASSC1, and ECLASSA1 set to 0	Y, N	N
PUNSOL1	Enable unsolicited reporting at turn on; hidden and set to N if UNSOL1 set to N	Y, N	N
NUMEVE1[e]	Number of events to transmit on	1–200	10
AGEEVE1[e]	Oldest event to transmit on, seconds	0.0–99999.0	2.0
URETRY1[e]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO1[e]	Unsolicited messages offline timeout, seconds	1–5000	60
Session 2 Settings			
DNPIP2[b]	DNP Master IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR2[a]	Transport protocol	UDP, TCP	TCP
. . .			
URETRY2[a,e]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO2[a,e]	Unsolicited messages offline timeout, seconds	1–5000	60
Session 3 Settings			
DNPIP3[b]	IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR3[a]	Transport protocol	UDP, TCP	TCP
. . .			
URETRY3[a,e]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO3[a,e]	Unsolicited messages offline timeout, seconds	1–5000	60
Session 4 Settings			
DNPIP4[b]	IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR4[a]	Transport protocol	UDP, TCP	TCP
. . .			
URETRY4[a,e]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO4[a,e]	Unsolicited messages offline timeout, seconds	1–5000	60
Session 5 Settings			
DNPIP5[b]	IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR5[a]	Transport protocol	UDP, TCP	TCP
. . .			
URETRY5[a,e]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO5[a,e]	Unsolicited messages offline timeout, seconds	1–5000	60
Serial Port Settings			
MINDLY[d]	Minimum delay from DCD to TX, seconds	0.00–1.00	0.05
MAXDLY[d]	Maximum delay from DCD to TX, seconds	0.00–1.00	0.10

Table D.7 Port DNP3 Protocol Settings (Sheet 3 of 3)

Name	Description	Range	Default
PREDLY[d]	Settle time from RTS on to TX; Off disables PSTDLY	OFF, 0.00–30.00	0.00
PSTDLY[d]	Settle time from TX to RTS off; hidden if PREDLY set to Off	0.00–30.00	0.00

[a] Available only on Ethernet ports.
[b] Set DNPIPn = 0.0.0.0 to accept connections from any DNP master.
[c] DNPINAn (n = 1–5) allows you to set the wait time to detect a bad TCP connection. The relay closes the unused TCP connection after the DNPINAn response timeout. It is recommended that you set this value to be less than 20 seconds. Disabling DNPINAn violates the DNP3 standard and should only be done for testing.
[d] Available only on serial ports.
[e] Hidden if UNSOLn set to N.

The modem settings in *Table D.8* are only available for DNP3 serial port sessions.

Table D.8 Serial Port DNP3 Modem Settings

Name	Description	Range	Default
MODEM	Modem connected to port; all 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	“”
RETRY1	Retry attempts for primary dial out; hidden and unused if PH_NUM2 set to “”	1–20	5
RETRY2	Retry attempts for secondary dial out; hidden and unused if PH_NUM2 set to “”	1–20	5
MDTIME	Time from initiating call to failure because of no connection, seconds	5–300	60
MDRET	Time between dial-out attempts	5–3600	120

DNP3 Documentation

Object List

Table D.9 lists the objects and variations with supported function codes and qualifier codes available in the SEL-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] Funct. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Funct. Codes[c]	Response[b] Qual. Codes[d]
0	211	Device Attributes—User-specific sets of attributes	1	0	129	0,17
0	212	Device Attributes—Master data set prototypes	1	0	129	0,17
0	213	Device Attributes—Outstation data set prototypes	1	0	129	0,17
0	214	Device Attributes—Master data sets	1	0	129	0,17
0	215	Device Attributes—Outstation data sets	1	0	129	0,17
0	216	Device Attributes—Max binary outputs per request	1	0	129	0,17
0	219	Device Attributes—Support for analog output events	1	0	129	0,17
0	220	Device Attributes—Max analog output index	1	0	129	0,17
0	221	Device Attributes—Number of analog outputs	1	0	129	0,17
0	222	Device Attributes—Support for binary output events	1	0	129	0,17
0	223	Device Attributes—Max binary output index	1	0	129	0,17
0	224	Device Attributes—Number of binary outputs	1	0	129	0,17
0	225	Device Attributes—Support for frozen counter events	1	0	129	0,17
0	226	Device Attributes—Support for frozen counters	1	0	129	0,17
0	227	Device Attributes—Support for counter events	1	0	129	0,17
0	228	Device Attributes—Max counter index	1	0	129	0,17
0	229	Device Attributes—Number of counters	1	0	129	0,17
0	230	Device Attributes—Support for frozen analog inputs	1	0	129	0,17
0	231	Device Attributes—Support for analog input events	1	0	129	0,17
0	232	Device Attributes—Max analog input index	1	0	129	0,17
0	233	Device Attributes—Number of analog inputs	1	0	129	0,17
0	234	Device Attributes—Support for double-bit events	1	0	129	0,17
0	235	Device Attributes—Max double-bit binary index	1	0	129	0,17
0	236	Device Attributes—Number of double-bit binaries	1	0	129	0,17
0	237	Device Attributes—Support for binary input events	1	0	129	0,17
0	238	Device Attributes—Max binary input index	1	0	129	0,17
0	239	Device Attributes—Number of binary inputs	1	0	129	0,17
0	240	Device Attributes—Max transmit fragment size	1	0	129	0,17
0	241	Device Attributes—Max receive fragment size	1	0	129	0,17
0	242	Device Attributes—Device manufacturer's software version	1	0	129	0,17

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				

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	4	16-Bit Frozen Delta Counter				
21	5	32-Bit Frozen Counter With Time of Freeze				
21	6	16-Bit Frozen Counter With Time of Freeze				
21	7	32-Bit Frozen Delta Counter With Time of Freeze				
21	8	16-Bit Frozen Delta Counter With Time of Freeze				
21	9	32-Bit Frozen Counter Without Flag				
21	10	16-Bit Frozen Counter Without Flag				
21	11	32-Bit Frozen Delta Counter Without Flag				
21	12	16-Bit Frozen Delta Counter Without Flag				
22	0	Counter Change Event—All Variations	1	6, 7, 8		
22	1	32-Bit Counter Change Event Without Time	1	6, 7, 8	129	17, 28
22	2[e]	16-Bit Counter Change Event Without Time	1	6, 7, 8	129, 130	17, 28
22	3	32-Bit Delta Counter Change Event Without Time				
22	4	16-Bit Delta Counter Change Event Without Time				
22	5	32-Bit Counter Change Event With Time	1	6, 7, 8	129	17, 28
22	6	16-Bit Counter Change Event With Time	1	6, 7, 8	129	17, 28
22	7	32-Bit Delta Counter Change Event With Time				
22	8	16-Bit Delta Counter Change Event With Time				
23	0	Frozen Counter Event—All Variations				
23	1	32-Bit Frozen Counter Event Without Time				
23	2	16-Bit Frozen Counter Event Without Time				
23	3	32-Bit Frozen Delta Counter Event Without Time				
23	4	16-Bit Frozen Delta Counter Event Without Time				
23	5	32-Bit Frozen Counter Event With Time				
23	6	16-Bit Frozen Counter Event With Time				
23	7	32-Bit Delta Counter Change Event With Time				
23	8	16-Bit Delta Counter Change Event With Time				
30[f]	0	Analog Input—All Variations	1	0, 1, 6, 7, 8, 17, 28		
30[f]	1	32-Bit Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[f]	2	16-Bit Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[f]	3	32-Bit Analog Input Without Flag	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[f]	4	16-Bit Analog Input Without Flag	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[f]	5	Short Floating Point Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[f]	6	Long Floating Point Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
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				

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	5	32-Bit Frozen Analog Input Without Flag				
31	6	16-Bit Frozen Analog Input Without Flag				
31	7	Short Floating Point Frozen Analog Input				
31	8	Long Floating Point Frozen Analog Input				
32[f]	0	Analog Change Event—All Variations	1	6, 7, 8		
32[f]	1	32-Bit Analog Change Event Without Time	1	6, 7, 8	129	17, 28
32[f]	2	16-Bit Analog Change Event Without Time	1	6, 7, 8	129, 130	17, 28
32[f]	3	32-Bit Analog Change Event With Time	1	6, 7, 8	129	17, 28
32[f]	4	16-Bit Analog Change Event With Time	1	6, 7, 8	129	17, 28
32[f]	5	Short Floating Point Analog Change Event	1	6, 7, 8	129	17, 28
32[f]	6	Long Floating Point Analog Change Event	1	6, 7, 8	129	17, 28
32[f]	7	Short Floating Point Analog Change Event With Time	1	6, 7, 8	129	17, 28
32[f]	8	Long Floating Point Analog Change Event With Time	1	6, 7, 8	129	17, 28
33	0	Frozen Analog Event—All Variations				
33	1	32-Bit Frozen Analog Event Without Time				
33	2	16-Bit Frozen Analog Event Without Time				
33	3	32-Bit Frozen Analog Event With Time				
33	4	16-Bit Frozen Analog Event With Time				
33	5	Short Floating Point Frozen Analog Event				
33	6	Long Floating Point Frozen Analog Event				
33	7	Short Floating Point Frozen Analog Event With Time				
33	8	Long Floating Point Frozen Analog Event With Time				
34	0	Analog 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

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	0	Time and Date—All Variations				
50	1	Time and Date	1, 2	7, 8 index = 0	129	07, quantity = 1
50	2	Time and Date With Interval				
50	3	Time and Date Last Recorded	2	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 (dnp_*rxxx*751.zip), available 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: Deadband changes via Object 34 are not stored in nonvolatile memory. Make sure to reissue the Object 34 deadband changes you want to retain after changing DNP port settings, issuing an **STA C** command, or cold starting the relay (power-cycle).

NOTE: Although the reference maps do not include Relay Word bit labels, you can use these labels for creating custom maps.

The SEL-751 scales analog values by the indicated settings or fixed scaling indicated in the description. Analog deadbands for event reporting use the indicated settings, or ANADBM if you have not specified a setting.

Table D.10 DNP3 Reference Data Map (Sheet 1 of 3)

Object	Labels	Description
Binary Inputs		
01, 02	STFAIL	Relay diagnostic failure (HALARM is latched)
	STWARN	Relay diagnostic warning (HALARM is pulsed)
	STSET	Relay settings change or restart
	Enabled–TLED_06[a]	Relay Word Elements Target Row 0 (see *Table L.1*)
	50A1P–SC850BM[a]	Relay Word Elements Row 1 to Row 158 (see *Table L.1*)
	PFL	Power factor leading for three-phase currents
	0	Logical 0
	1	Logical 1
Binary Outputs		
10,12	RB01–RB64	Remote bits RB01–RB64
10,12	RB01:RB02 RB03:RB04 RB05:RB06 … RB61:RB62 RB63:RB64	Remote bit pairs RB01–RB64

Table D.10 DNP3 Reference Data Map (Sheet 2 of 3)

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
10, 12	89OC2P1–89OC2P8	Pulse Open 2-Position Disconnects 1–8 command
10, 12	89CC2P1–89CC2P8	Pulse Close 2-Position Disconnects 1–8 command
10,12	89OC2P1:89CC2P1 89OC2P2:89CC2P2 … 89OC2P8:89CC2P8	Open/Close Pair for 2-Position Disconnects 1–8
10, 12	89OC3PL1	Pulse Open 3-Position In-Line Disconnect 1 command
10, 12	89CC3PL1	Pulse Close 3-Position In-Line Disconnect 1 command
10,12	89OC3PL1:89CC3PL1	Open/Close pair for 3-Position In-Line Disconnect 1
10, 12	89OC3PL2	Pulse Open 3-Position In-Line Disconnect 2 command
10, 12	89CC3PL2	Pulse Close 3-Position In-Line Disconnect 2 command
10,12	89OC3PL2:89CC3PL2	Open/Close pair for 3-Position In-Line Disconnect 2
10, 12	89OC3PE1	Pulse Open 3-Position Earthing Disconnect 1 command
10, 12	89CC3PE1	Pulse Close 3-Position Earthing Disconnect 1 command
10,12	89OC3PE1:89CC3PE1	Open/Close pair for 3-Position Earthing Disconnect 1
10, 12	89OC3PE2	Pulse Open 3-Position Earthing Disconnect 2 command
10, 12	89CC3PE2	Pulse Close 3-Position Earthing Disconnect 2 command
10,12	89OC3PE2:89CC3PE2	Open/Close pair for 3-Position Earthing Disconnect 2
Counters		
20, 22	SC*xx*	SELOGIC counter values (*xx* = 01–64)
	GROUP	Active settings group
Analog Inputs		
30, 32, 34	IA_MAG–RA128[b,c]	Analog quantities from *Table M.1* with an “x” in the DNP column
	SER_NUM	Serial number
	0	Numeric 0
	1	Numeric 1

NOTE: When the setting EN_LRC := Y (see Table 9.6), the Relay Word bit LOCAL supervises the CC and OC, 89CC2Pm and 89OC2Pm (m = 1–8), and 89CC3Pnm and 89OC3Pnm (m = 1–2, n = L or E) bits. To set the binaries, the relay should be in remote control mode (i.e., LOCAL = 0). The Relay Word bit LOCAL is determined by the LOCAL SELOGIC control equation (see Table 9.6).

NOTE: All fault information analog inputs contain data from the latest captured event (see Appendix M: Analog Quantities).

Table D.10 DNP3 Reference Data Map (Sheet 3 of 3)

Object	Labels	Description
Analog Outputs		
40, 41	RA*xxx*	Remote analogs (RA001 to RA128)
	GROUP	Active settings group
	NOOP	No operation, no error

[a] Valid Relay Word bits depend on the relay model.
[b] Valid analog inputs depend on the relay model.
[c] Refer to Default Analog Inputs for default analog input scaling and deadbands.

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.22*. Outside that scope, they contain the value NA.
10, 12	0–31	RB01–RB32 remote bits
20, 22	0–31	NA
30, 32, 34	0	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

Table D.11 DNP3 Default Data Map (Sheet 2 of 2)

Object	Default Index	Point Label
	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.22*. 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: Deadband changes via Object 34 are not stored in nonvolatile memory. Make sure to reissue the Object 34 deadband changes you want to retain after changing DNP port settings, issuing an **STA C** command, or cold starting the relay (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 present, each analog input point label, AI*x*0*y* (where *x* is the slot and *y* is the point number), is added to the default map in numerical order.

Device Attributes (Object 0)

Table D.9 includes the supported Object 0 device attributes and variations. In response to Object 0 requests, the SEL-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 and 2) are supported as defined by *Table D.11*. The default variation for both static and event inputs is 2. Only the Read function code (1) is allowed with these objects. All variations are supported. Object 2, Variation 3 are responded to, but contain no data.

Binary inputs are scanned approximately twice per second to generate events. When time is reported with these event objects, it is the time at which the scanner observed the bit change. This 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 and EtherNet/IP. For example, STWARN and STFAIL are derived from the diagnostic task data. Another binary input, STSET, is derived from the SER and carries the time stamp of actual occurrence. Static reads of this input always show 0.

Binary Outputs

Binary output status (Object 10, Variation 2) is supported. Static reads of points RB01–RB64, OC/CC, 89OC2P*m*/89CC2P*m* (where *m* = 1 to 8), or 89OC3P*nm*/89CC3P*nm* (where *n* = L or E and *m* = 1 or 2) respond with the online bit set and the state of the requested bit. Reads from control-only binary output points respond with the online 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 10 points in an Object 12, Variation 1 request. Any additional points in the request return the DNP3 status code TOO_MANY_OBJS.

The SEL-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.12*. Pulse operations provide a pulse with duration of one protection processing interval. When setting EN_LRC := Y (see *Table 9.6*), the Relay Word bit LOCAL supervises the CC and OC, 89CC2P*m* and 89OC2P*m* (*m* = 1–8), and 89CC3P*nm* and 89OC3P*nm* (*m* = 1–2, *n* = L or E) 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 9.6*).

Table D.12 SEL-751 Object 12 Control Operations (Sheet 1 of 2)

Label	Close/Pulse On	Trip/Pulse On	Nul/Latch On	Nul/Latch Off	Nul/Pulse On
RB01–RB64	Pulse Remote Bit RB01–RB64	Pulse Remote Bit RB01–RB64	Set Remote Bit RB01–RB64	Clear Remote Bit RB01–RB64	Pulse Remote Bit RB01–RB64
RB*xx*:RB*yy*	Pulse RB*yy* RB01–RB64	Pulse RB*xx* RB01–RB64	Pulse RB*yy* RB01–RB64	Pulse RB*xx* RB01–RB64	Pulse RB*yy* RB01–RB64
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)	Close Circuit Breaker (Pulse CC)
89OC2P1–89OC2P8	Open 2-Position Disconnect (Pulse 89OC2P1–89OC2P8)	Open 2-Position Disconnect (Pulse 89OC2P1–89OC2P8)	Open 2-Position Disconnect (Pulse 89OC2P1–89OC2P8)	No Action	Open 2-Position Disconnect (Pulse 89OC2P1–89OC2P8)
89CC2P1–89CC2P8	Close 2-Position Disconnect (Pulse 89CC2P1–89CC2P8)	Close 2-Position Disconnect (Pulse 89CC2P1–89CC2P8)	Close 2-Position Disconnect (Pulse 89CC2P1–89CC2P8)	No Action	Close 2-Position Disconnect (Pulse 89CC2P1–89CC2P8)
89OC2P*m*: 89CC2P*m*	Close 2-Position Disconnect (Pulse 89CC2P1–89CC2P8)	Open 2-Position Disconnect (Pulse 89OC2P1–89OC2P8)	Close 2-Position Disconnect (Pulse 89CC2P1–89CC2P8)	Open 2-Position Disconnect (Pulse 89OC2P1–89OC2P8)	Close 2-Position Disconnect (Pulse 89CC2P1–89CC2P8)
89OC3PL1	Open 3-Position In-Line Disconnect (Pulse 89OC3PL1)	Open 3-Position In-Line Disconnect (Pulse 89OC3PL1)	Open 3-Position In-Line Disconnect (Pulse 89OC3PL1)	No Action	Open 3-Position In-Line Disconnect (Pulse 89OC3PL1)
89CC3PL1	Close 3-Position In-Line Disconnect (Pulse 89CC3PL1)	Close 3-Position In-Line Disconnect (Pulse 89CC3PL1)	Close 3-Position In-Line Disconnect (Pulse 89CC3PL1)	No Action	Close 3-Position In-Line Disconnect (Pulse 89CC3PL1)
89OC3PL1: 89CC3PL1	Close 3-Position In-Line Disconnect (Pulse 89CC3PL1)	Open 3-Position In-Line Disconnect (Pulse 89OC3PL1)	Close 3-Position In-Line Disconnect (Pulse 89CC3PL1)	Open 3-Position In-Line Disconnect (Pulse 89OC3PL1)	Close 3-Position In-Line Disconnect (Pulse 89CC3PL1)
89OC3PL2	Open 3-Position In-Line Disconnect (Pulse 89OC3PL2)	Open 3-Position In-Line Disconnect (Pulse 89OC3PL2)	Open 3-Position In-Line Disconnect (Pulse 89OC3PL2)	No Action	Open 3-Position In-Line Disconnect (Pulse 89OC3PL2)
89CC3PL2	Close 3-Position In-Line Disconnect (Pulse 89CC3PL2)	Close 3-Position In-Line Disconnect (Pulse 89CC3PL2)	Close 3-Position In-Line Disconnect (Pulse 89CC3PL2)	No Action	Close 3-Position In-Line Disconnect (Pulse 89CC3PL2)

Table D.12 SEL-751 Object 12 Control Operations (Sheet 2 of 2)

Label	Close/Pulse On	Trip/Pulse On	Nul/Latch On	Nul/Latch Off	Nul/Pulse On
89OC3PL2: 89CC3PL2	Close 3-Position In-Line Disconnect (Pulse 89CC3PL2)	Open 3-Position In-Line Disconnect (Pulse 89OC3PL2)	Close 3-Position In-Line Disconnect (Pulse 89CC3PL2)	Open 3-Position In-Line Disconnect (Pulse 89OC3PL2)	Close 3-Position In-Line Disconnect (Pulse 89CC3PL2)
89OC3PE1	Open 3-Position Earthing Disconnect (Pulse 89OC3PE1)	Open 3-Position Earthing Disconnect (Pulse 89OC3PE1)	Open 3-Position Earthing Disconnect (Pulse 89OC3PE1)	No Action	Open 3-Position Earthing Disconnect (Pulse 89OC3PE1)
89CC3PE1	Close 3-Position Earthing Disconnect (Pulse 89CC3PE1)	Close 3-Position Earthing Disconnect (Pulse 89CC3PE1)	Close 3-Position Earthing Disconnect (Pulse 89CC3PE1)	No Action	Close 3-Position Earthing Disconnect (Pulse 89CC3PE1)
89OC3PE1: 89CC3PE1	Close 3-Position Earthing Disconnect (Pulse 89CC3PE1)	Open 3-Position Earthing Disconnect (Pulse 89OC3PE1)	Close 3-Position Earthing Disconnect (Pulse 89CC3PE1)	Open 3-Position Earthing Disconnect (Pulse 89OC3PE1)	Close 3-Position Earthing Disconnect (Pulse 89CC3PE1)
89OC3PE2	Open 3-Position Earthing Disconnect (Pulse 89OC3PE2)	Open 3-Position Earthing Disconnect (Pulse 89OC3PE2)	Open 3-Position Earthing Disconnect (Pulse 89OC3PE2)	No Action	Open 3-Position Earthing Disconnect (Pulse 89OC3PE2)
89CC3PE2	Close 3-Position Earthing Disconnect (Pulse 89CC3PE2)	Close 3-Position Earthing Disconnect (Pulse 89CC3PE2)	Close 3-Position Earthing Disconnect (Pulse 89CC3PE2)	No Action	Close 3-Position Earthing Disconnect (Pulse 89CC3PE2)
89OC3PE2: 89CC3PE2	Close 3-Position Earthing Disconnect (Pulse 89CC3PE2)	Open 3-Position Earthing Disconnect (Pulse 89OC3PE2)	Close 3-Position Earthing Disconnect (Pulse 89CC3PE2)	Open 3-Position Earthing Disconnect (Pulse 89OC3PE2)	Close 3-Position Earthing Disconnect (Pulse 89CC3PE2)

Analog Inputs

Analog Inputs (30) and Analog Change Events (32) are supported as defined in *Table D.9* and *Table D.10*. The DVARAI1 (DVARAI*n* for DNP3 LAN/WAN Session *n*) setting defines the default variation for both static and event inputs. Only the Read function code (1) is allowed with these objects. Unless otherwise indicated, analog values are reported in primary units. See *Appendix M: Analog Quantities* for a list of all available analog inputs.

NOTE: Deadband changes via Object 34 are not stored in nonvolatile memory. Make sure to reissue the Object 34 deadband changes you want to retain after changing DNP port settings, issuing an **STA C** command, or cold starting the relay (power-cycle).

For all currents, the default scaling is the DECPLA setting on magnitudes and scale factor of 100 on angles. The default deadband for currents is ANADBV on magnitudes and ANADBM on angles. For all voltages, the default scaling is the DECPLV setting on magnitudes and scale factor of 100 on angles. The default deadband for voltages is ANADBV on magnitudes and ANADBM on angles. For all Powers and Energies, the default scaling is the DECPLM setting and default deadband is ANADBM. For all other quantities, the default scaling is 1 and default deadband is ANADBM.

Default scaling and deadbands can be overridden by per-point scaling and deadband. See *Configurable Data Mapping* for more information. Deadbands for analog inputs can also be modified by writing to Object 34.

A deadband check is done after any scaling has been applied. Event class messages are generated whenever an input changes beyond the value given by the appropriate deadband setting. The voltage and current phase angles only generate an event if, in addition to their deadband check, the corresponding magnitude changes beyond its own deadband. Analog inputs are scanned approximately twice per second. All events generated during a scan use the time the scan was initiated.

Configurable Data Mapping

One of the most powerful features of the SEL-751 implementation is the ability to remap DNP3 data and, for analog values, specify per-point scaling and deadbands. Remapping is the process of selecting data from the reference map and organizing it into a data subset optimized for your application. The SEL-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.21*. You can remap the points in a default map to create a custom map with as many as:

- 100 Binary Inputs
- 32 Binary Outputs
- 100 Analog Inputs
- 32 Analog Outputs
- 32 Counters

You can use the **SHOW DNP *x* <Enter>** command to view the DNP3 data map settings, where *x* is the DNP3 map number from 1 to 3. See *Figure D.3* for an example display of Map 1.

```
=>>SHO DNP 1 <Enter>

DNP Map 1 Settings

Binary Input Map
BI_00    := ENABLED
BI_01    := TRIP_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

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    := RA002
…
AO_29    := RA029
AO_30    := RA030
AO_31    := RA031
```

Figure D.3 Sample Response to SHO DNP Command

```
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 DNP** command.

```
=>MAP DNP 1 1 <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


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
```

Figure D.4 Port MAP Command

```
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
  2      RA002
  ...
  ...
  30    RA030
  31    RA031
```

Figure D.4 Port MAP Command (Continued)

You can use the command **SET DNP *x***, where *x* is the map number, to edit or create custom DNP3 data maps. You can also use 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 deadband settings. Per-point customization is not necessary, but class scaling (DECPLA, DECPLV, and DECPLM) and deadband (ANADBA, ANADBV, and ANADBM) settings are applied to indices that do not have per-point entries. Unlike per-point scaling described previously, class-level scaling is specified by an integer in the range 0–3 (inclusive), which indicates the number of decimal place shifts. In other words, 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 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>


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

You can also use QuickSet to enter the previous AI map settings as shown in the screen capture in *Figure D.6*. You can enter scaling and deadband settings in the same pop-up dialog used to select the AI point, as shown in *Figure D.7*.

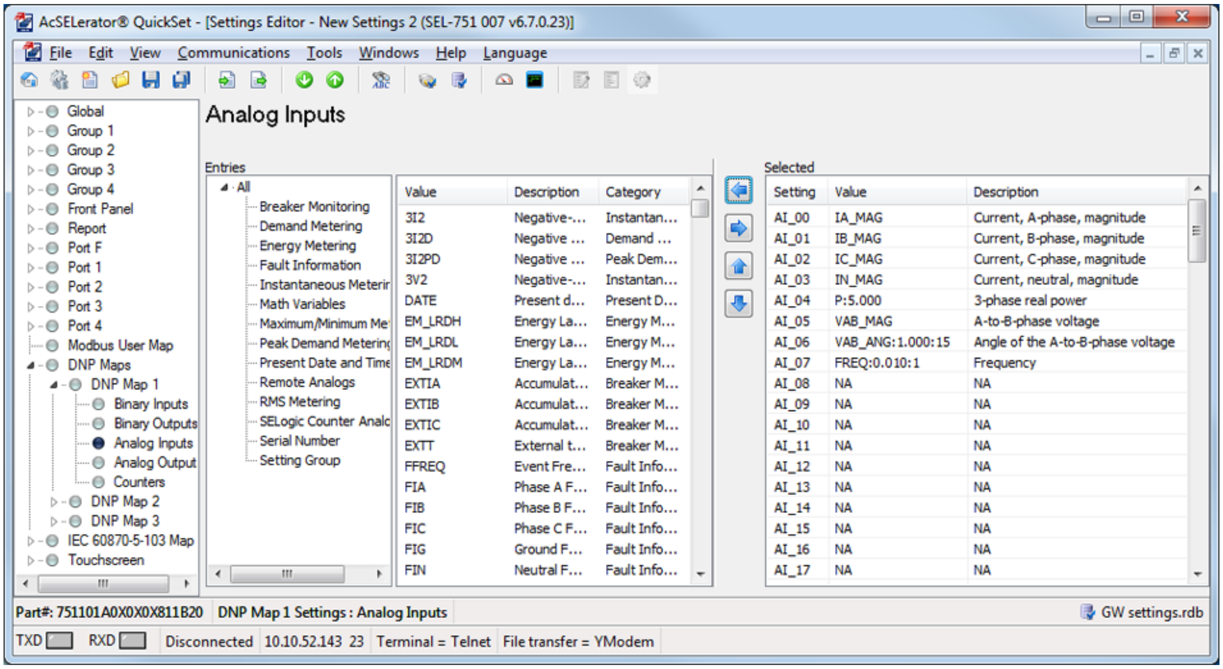


Figure D.6 Analog Input Map Entry in QuickSet Software

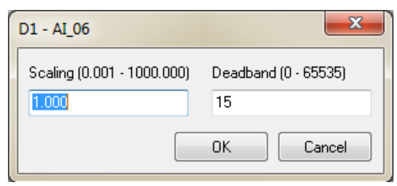


Figure D.7 AI Point Scaling and Deadband in QuickSet Software

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 QuickSet to enter the AO map settings, as shown in *Figure D.9*.

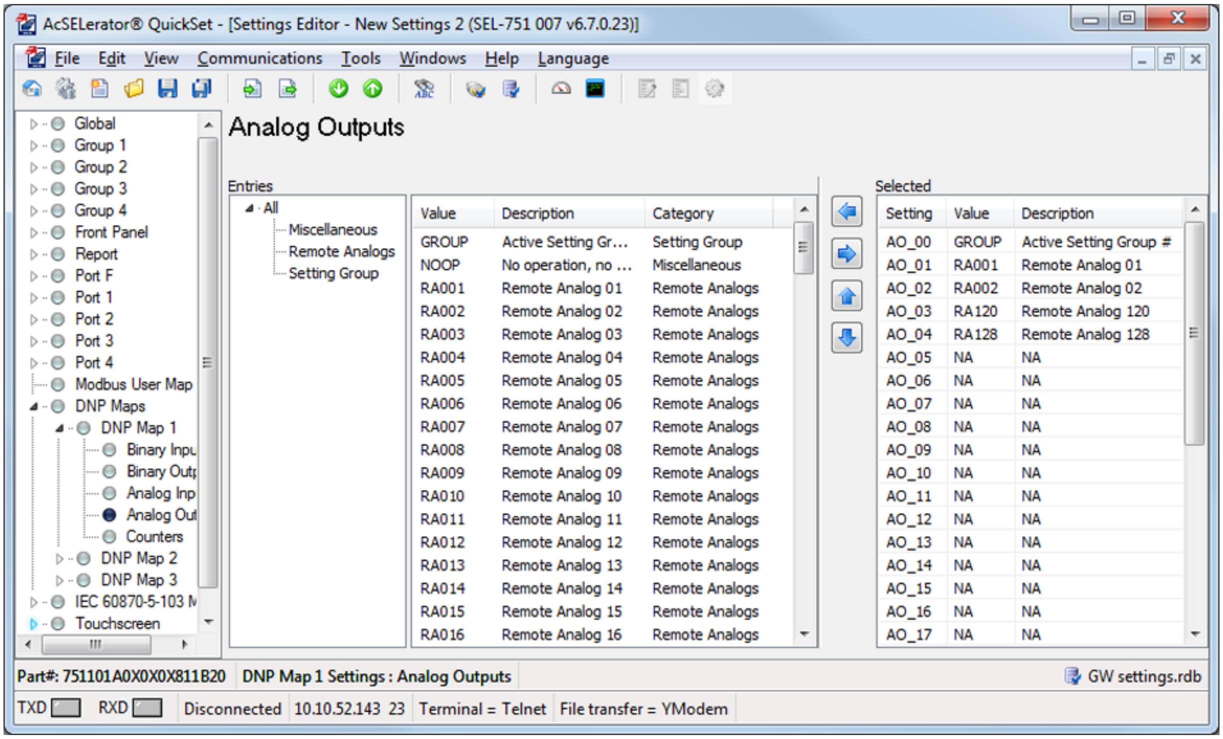


Figure D.9 Analog Output Map Entry in QuickSet Software

The **SET DNP *x* CO_00 <Enter>** command allows you to populate the DNP counter map with per-point deadbands. Entering these settings is similar to defining the analog input map settings.

You can use the command **SET DNP *x* BO_00 TERSE <Enter>** to change the binary output Map *x* as shown in *Figure D.10*. You can populate the custom BO map with any of the 64 remote bits (RB01–RB64). You can define bit pairs in BO maps by including a colon (:) between the bit labels.

```
=>>SET DNP 1 BO_00 TERSE <Enter>
Binary Output Map

DNP Binary Output Label Name (23 characters)
BO_00    := NA
? > RB01 <Enter>

DNP Binary Output Label Name (23 characters)
BO_01    := NA
? > RB02 <Enter>

DNP Binary Output Label Name (23 characters)
BO_02    := NA
? > RB03:RB04 <Enter>

DNP Binary Output Label Name (23 characters)
BO_03    := NA
? > RB05:RB06 <Enter>

DNP Binary Output Label Name (23 characters)
BO_04    := NA
? > end <Enter>

=>>
```

Figure D.10 Sample Custom DNP3 BO Map Settings

You can also use QuickSet to enter the BO map settings as shown in the screen capture in *Figure D.11*.

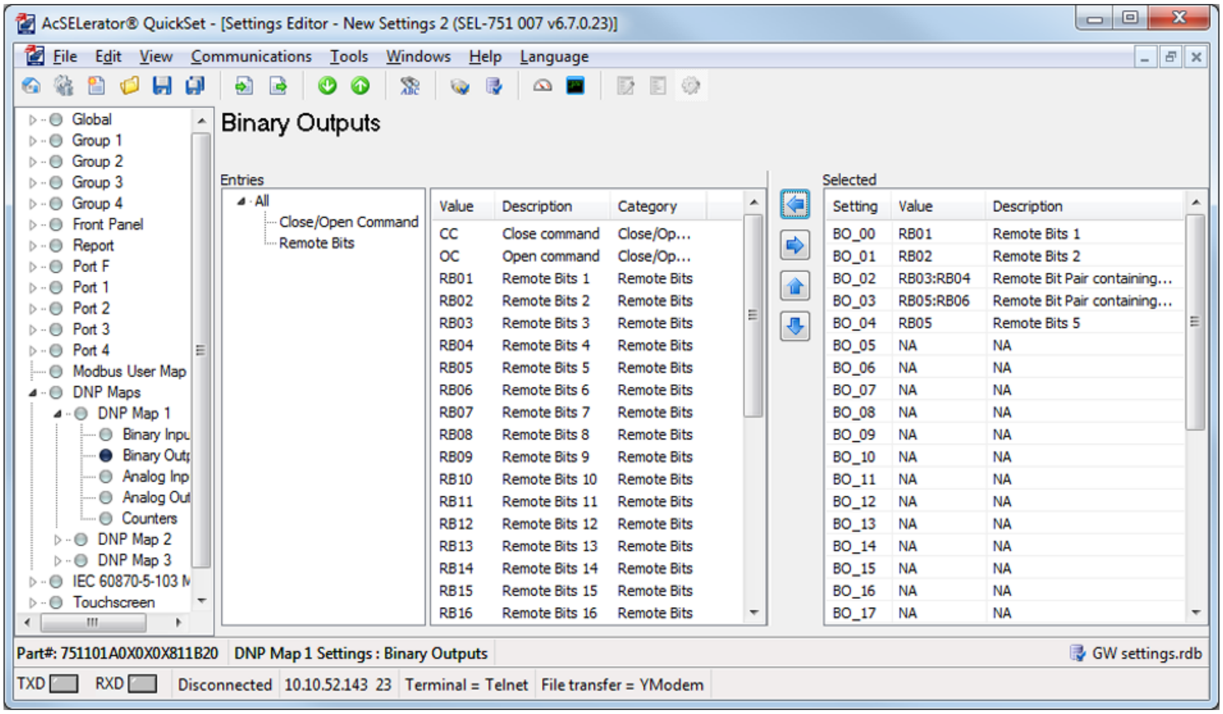


Figure D.11 Binary Output Map Entry in QuickSet Software

The binary input (BI) maps are modified in a similar manner, but pairs are not allowed.

Appendix E
Modbus Communications

Overview

This appendix describes Modbus RTU communications features supported by the SEL-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
• • •	• • •	• • •
2256–2263	2	Relay Element Status Row 282
2264–2271	2	Relay Element Status Row 283
2272–2279	2	Relay Element Status Row 284

[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.35*. 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.35*. 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 5)

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 5)

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 5)

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]
91	01, 05	RB33
92	01, 05	RB34
93	01, 05	RB35
94	01, 05	RB36
95	01, 05	RB37
96	01, 05	RB38
97	01, 05	RB39
98	01, 05	RB40
99	01, 05	RB41
100	01, 05	RB42
101	01, 05	RB43
102	01, 05	RB44
103	01, 05	RB45
104	01, 05	RB46
105	01, 05	RB47
106	01, 05	RB48
107	01, 05	RB49
108	01, 05	RB50
109	01, 05	RB51
110	01, 05	RB52
111	01, 05	RB53
112	01, 05	RB54
113	01, 05	RB55

Table E.14 01h, 05h SEL-751 Output (Sheet 4 of 5)

Coil Address (Decimal)	Function Code Supported	Coil Description
114	01, 05	RB56
115	01, 05	RB57
116	01, 05	RB58
117	01, 05	RB59
118	01, 05	RB60
119	01, 05	RB61
120	01, 05	RB62
121	01, 05	RB63
122	01, 05	RB64
123	01, 05	Pulse RB33[a]
124	01, 05	Pulse RB34[a]
125	01, 05	Pulse RB35[a]
126	01, 05	Pulse RB36[a]
127	01, 05	Pulse RB37[a]
128	01, 05	Pulse RB38[a]
129	01, 05	Pulse RB39[a]
130	01, 05	Pulse RB40[a]
131	01, 05	Pulse RB41[a]
132	01, 05	Pulse RB42[a]
133	01, 05	Pulse RB43[a]
134	01, 05	Pulse RB44[a]
135	01, 05	Pulse RB45[a]
136	01, 05	Pulse RB46[a]
137	01, 05	Pulse RB47[a]
138	01, 05	Pulse RB48[a]
139	01, 05	Pulse RB49[a]
140	01, 05	Pulse RB50[a]
141	01, 05	Pulse RB51[a]
142	01, 05	Pulse RB52[a]
143	01, 05	Pulse RB53[a]
144	01, 05	Pulse RB54[a]
145	01, 05	Pulse RB55[a]
146	01, 05	Pulse RB56[a]
147	01, 05	Pulse RB57[a]
148	01, 05	Pulse RB58[a]
149	01, 05	Pulse RB59[a]
150	01, 05	Pulse RB60[a]
151	01, 05	Pulse RB61[a]

Table E.14 01h, 05h SEL-751 Output (Sheet 5 of 5)

Coil Address (Decimal)	Function Code Supported	Coil Description
152	01, 05	Pulse RB62[a]
153	01, 05	Pulse RB63[a]
154	01, 05	Pulse RB64[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 the setting EN_LRC := Y (see Table 9.6), the Relay Word bit LOCAL supervises the CC and OC, 89CC2Pm and 89OC2Pm (m = 1–8), and 89CC3Pnm and 89OC3Pnm (m = 1–2, n = L or E) bits. To set the binaries, the relay should be in remote control mode (i.e., LOCAL = 0). The Relay Word bit LOCAL is determined by the LOCAL SELOGIC control equation (see Table 9.6).

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.35* 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

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (06h)
2 bytes	Register Address
2 bytes	Data
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table E.17*.

Table E.17 Responses to 06h Preset Single Register Query Errors

Error	Error Code Returned	Communications Counter Increments
Illegal register address	Illegal Data Address (02h)	Invalid Address Illegal Write
Illegal register value	Illegal Data Value (03h)	Illegal Write
Format error	Illegal Data Value (03h)	Bad Packet Format

08h Loopback Diagnostic Command

The SEL-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 (Sheet 1 of 2)

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (10h)
2 bytes	Starting Address
2 bytes	Number of Registers to Write
1 byte	Number of Bytes of Data (*n*)
n bytes	Data
2 bytes	CRC-16
A successful response from the slave will have the following format:	

Table E.20 10h Preset Multiple Registers Command (Sheet 2 of 2)

Bytes	Field
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

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (60h)
2 bytes	Parameter Number
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (60h)
2 bytes	Parameter Number
1 byte	Parameter Descriptor
1 byte	Parameter Conversion
2 bytes	Parameter Minimum Settable Value
2 bytes	Parameter Maximum Settable Value
2 bytes	Parameter Default Value
2 bytes	CRC-16

The Parameter Descriptor field is defined in *Table E.23*.

Table E.23 60h Read Parameter Descriptor Field Definition

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

Conversion Value	Type	Multiplier	Divisor	Offset	Base
0	Boolean	1	1	0	1
1	Unsigned Integer	1	1	0	1
2	Unsigned Integer	1	10	0	1
3	Unsigned Integer	1	100	0	1
4	Unsigned Integer	1	1000	0	1
5	Hexadecimal	1	1	0	1
6	Integer	1	1	0	1
7	Integer	1	10	0	1
8	Integer	1	100	0	1
9	Integer	1	1000	0	1
10	Enumeration	1	1	0	1
11	Bit Enumeration	1	1	0	1

Use *Equation E.1* to calculate the actual (not scaled) value of the parameter (setting):

$$\text{value} = \frac{(\text{ParameterValue} + \text{Offset}) \bullet \text{Multiplier} \bullet \text{Base}}{\text{Divisor}}$$

Equation E.1

Use *Equation E.2* to calculate the scaled setting value:

$$\text{value} = \frac{\text{value} \bullet \text{Divisor}}{\text{Multiplier} \bullet \text{Base}} - \text{Offset}$$

Equation E.2

The relay response to errors in the query are shown *Table E.25*.

Table E.25 Responses to 60h Read Parameter Information Query Errors

Error	Error Code Returned	Communications Counter Increments
Illegal parameter to read	Illegal Address (02h)	Invalid Address

61h Read Parameter Text Command

The SEL-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 (Sheet 1 of 2)

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

Table E.28 62h Read Enumeration Text 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 (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

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Control Command (same as write to 2000h)
1 byte	Embedded Modbus Function
n bytes	Optional Data to Support Modbus Function (0–250)
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Status Information (Register 2100h or 2101h based on Bit 3 in Control Command Word)
1 byte	Embedded Modbus Function
n bytes	Optional data to support the Modbus function (0–250)
2 bytes	CRC-16

Table E.31 shows the format of the relay responses to errors in the query.

Table E.31 7Dh Encapsulated Packet Query Errors

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Status Information (Register 2100h or 2101h based on Bit 3 in Control Command Word)
1 byte	Modbus Function with Error Flag
1 bytes	Function Error Code[a]
2 bytes	CRC-16

[a] If the embedded function code is invalid, then an illegal function code is returned here and the illegal function counter is incremented. This error code is returned by the embedded function for all valid embedded functions.

7Eh NOP Command

This function code has no operation. This allows a Modbus master to perform a control operation without any other Modbus command. This is only used inside of the 7Dh when no regular Modbus query is necessary.

Table E.32 7Eh NOP Command

Bytes	Field
An example of a 7D message response using 7E will have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Status Information
1 byte	Function Code (7Eh)
2 bytes	CRC-16

Reading Parameter Information and Value Using Modbus

Through use of Modbus commands, you can read the present value of a parameter as well as parameter name, units, low limit, high limit, scale, and even the enumeration string (if the parameter is an enumeration type). This means that you can use a general user interface to retrieve and display specific parameter details from the relay. Use the **60h**, **61h**, and **62h** commands to retrieve parameter information, and use the **03** command to retrieve values.

Controlling Output Contacts Using Modbus

The SEL-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. For more information on the Modbus labels, refer to the respective register in the Modbus map (*Table E.35*).

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 9)

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	P0P675PS
291	P0P675DD
292	Reserved
293	P1P8PS
294	Reserved
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	P1PS
317	P1P1PS
318	P1P35PS
319	P15PS
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	Reserved
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	Reserved
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	Reserved
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	Reserved
420	LSENS1
421	LSENS2
422	LSENS3
423	LSENS4
424	LSENS5
425	LSENS6
426	LSENS7
427	LSENS8
428–429	Reserved
430	IARMS
431	IBRMS
432	ICRMS
433	INRMS
434	VARMS
435	VBRMS
436	VCRMS
437	VABRMS
438	VBCRMS
439	VCARMS
440	VSRMS
441–449	Reserved
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	Reserved
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	Reserved
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

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 2 of 9)

Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label
527	AI503L	573	MV17L	618	SC15	666	RA014_H	711	RA036_L
528	AI504H	574	MV18H	619	SC16	667	RA014_L	712	RA037_H
529	AI504L	575	MV18L	620	SC17	668	RA015_H	713	RA037_L
530	AI505H	576	MV19H	621	SC18	669	RA015_L	714	RA038_H
531	AI505L	577	MV19L	622	SC19	670	RA016_H	715	RA038_L
532	AI506H	578	MV20H	623	SC20	671	RA016_L	716	RA039_H
533	AI506L	579	MV20L	624	SC21	672	RA017_H	717	RA039_L
534	AI507H	580	MV21H	625	SC22	673	RA017_L	718	RA040_H
535	AI507L	581	MV21L	626	SC23	674	RA018_H	719	RA040_L
536	AI508H	582	MV22H	627	SC24	675	RA018_L	720	RA041_H
537	AI508L	583	MV22L	628	SC25	676	RA019_H	721	RA041_L
538–539	Reserved	584	MV23H	629	SC26	677	RA019_L	722	RA042_H
540	MV01H	585	MV23L	630	SC27	678	RA020_H	723	RA042_L
541	MV01L	586	MV24H	631	SC28	679	RA020_L	724	RA043_H
542	MV02H	587	MV24L	632	SC29	680	RA021_H	725	RA043_L
543	MV02L	588	MV25H	633	SC30	681	RA021_L	726	RA044_H
544	MV03H	589	MV25L	634	SC31	682	RA022_H	727	RA044_L
545	MV03L	590	MV26H	635	SC32	683	RA022_L	728	RA045_H
546	MV04H	591	MV26L	636–639	Reserved	684	RA023_H	729	RA045_L
547	MV04L	592	MV27H	640	RA001_H	685	RA023_L	730	RA046_H
548	MV05H	593	MV27L	641	RA001_L	686	RA024_H	731	RA046_L
549	MV05L	594	MV28H	642	RA002_H	687	RA024_L	732	RA047_H
550	MV06H	595	MV28L	643	RA002_L	688	RA025_H	733	RA047_L
551	MV06L	596	MV29H	644	RA003_H	689	RA025_L	734	RA048_H
552	MV07H	597	MV29L	645	RA003_L	690	RA026_H	735	RA048_L
553	MV07L	598	MV30H	646	RA004_H	691	RA026_L	736	RA049_H
554	MV08H	599	MV30L	647	RA004_L	692	RA027_H	737	RA049_L
555	MV08L	600	MV31H	648	RA005_H	693	RA027_L	738	RA050_H
556	MV09H	601	MV31L	649	RA005_L	694	RA028_H	739	RA050_L
557	MV09L	602	MV32H	650	RA006_H	695	RA028_L	740	RA051_H
558	MV10H	603	MV32L	651	RA006_L	696	RA029_H	741	RA051_L
559	MV10L	604	SC01	652	RA007_H	697	RA029_L	742	RA052_H
560	MV11H	605	SC02	653	RA007_L	698	RA030_H	743	RA052_L
561	MV11L	606	SC03	654	RA008_H	699	RA030_L	744	RA053_H
562	MV12H	607	SC04	655	RA008_L	700	RA031_H	745	RA053_L
563	MV12L	608	SC05	656	RA009_H	701	RA031_L	746	RA054_H
564	MV13H	609	SC06	657	RA009_L	702	RA032_H	747	RA054_L
565	MV13L	610	SC07	658	RA010_H	703	RA032_L	748	RA055_H
566	MV14H	611	SC08	659	RA010_L	704	RA033_H	749	RA055_L
567	MV14L	612	SC09	660	RA011_H	705	RA033_L	750	RA056_H
568	MV15H	613	SC10	661	RA011_L	706	RA034_H	751	RA056_L
569	MV15L	614	SC11	662	RA012_H	707	RA034_L	752	RA057_H
570	MV16H	615	SC12	663	RA012_L	708	RA035_H	753	RA057_L
571	MV16L	616	SC13	664	RA013_H	709	RA035_L	754	RA058_H
572	MV17H	617	SC14	665	RA013_L	710	RA036_H	755	RA058_L

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 3 of 9)

Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label
756	RA059_H	801	RA081_L	846	RA104_H	891	RA126_L	936	ICN_S
757	RA059_L	802	RA082_H	847	RA104_L	892	RA127_H	937	ICNMN
758	RA060_H	803	RA082_L	848	RA105_H	893	RA127_L	938	ICN_H
759	RA060_L	804	RA083_H	849	RA105_L	894	RA128_H	939	ICN_D
760	RA061_H	805	RA083_L	850	RA106_H	895	RA128_L	940	ICNMO
761	RA061_L	806	RA084_H	851	RA106_L	896	BRKCLTM	941	ICN_Y
762	RA062_H	807	RA084_L	852	RA107_H	897	BRKCLTH	942	INMX
763	RA062_L	808	RA085_H	853	RA107_L	898	BRKOPTM	943	INX_S
764	RA063_H	809	RA085_L	854	RA108_H	899	BRKOPTH	944	INXMN
765	RA063_L	810	RA086_H	855	RA108_L	900	IAMX	945	INX_H
766	RA064_H	811	RA086_L	856	RA109_H	901	IAX_S	946	INX_D
767	RA064_L	812	RA087_H	857	RA109_L	902	IAXMN	947	INXMO
768	RA065_H	813	RA087_L	858	RA110_H	903	IAX_H	948	INX_Y
769	RA065_L	814	RA088_H	859	RA110_L	904	IAX_D	949	INMN
770	RA066_H	815	RA088_L	860	RA111_H	905	IAXMO	950	INN_S
771	RA066_L	816	RA089_H	861	RA111_L	906	IAX_Y	951	INNMN
772	RA067_H	817	RA089_L	862	RA112_H	907	IAMN	952	INN_H
773	RA067_L	818	RA090_H	863	RA112_L	908	IAN_S	953	INN_D
774	RA068_H	819	RA090_L	864	RA113_H	909	IANMN	954	INNMO
775	RA068_L	820	RA091_H	865	RA113_L	910	IAN_H	955	INN_Y
776	RA069_H	821	RA091_L	866	RA114_H	911	IAN_D	956	IGMX
777	RA069_L	822	RA092_H	867	RA114_L	912	IANMO	957	IGX_S
778	RA070_H	823	RA092_L	868	RA115_H	913	IAN_Y	958	IGXMN
779	RA070_L	824	RA093_H	869	RA115_L	914	IBMX	959	IGX_H
780	RA071_H	825	RA093_L	870	RA116_H	915	IBX_S	960	IGX_D
781	RA071_L	826	RA094_H	871	RA116_L	916	IBXMN	961	IGXMO
782	RA072_H	827	RA094_L	872	RA117_H	917	IBX_H	962	IGX_Y
783	RA072_L	828	RA095_H	873	RA117_L	918	IBX_D	963	IGMN
784	RA073_H	829	RA095_L	874	RA118_H	919	IBXMO	964	IGN_S
785	RA073_L	830	RA096_H	875	RA118_L	920	IBX_Y	965	IGNMN
786	RA074_H	831	RA096_L	876	RA119_H	921	IBMN	966	IGN_H
787	RA074_L	832	RA097_H	877	RA119_L	922	IBN_S	967	IGN_D
788	RA075_H	833	RA097_L	878	RA120_H	923	IBNMN	968	IGNMO
789	RA075_L	834	RA098_H	879	RA120_L	924	IBN_H	969	IGN_Y
790	RA076_H	835	RA098_L	880	RA121_H	925	IBN_D	970	VABMX[a]
791	RA076_L	836	RA099_H	881	RA121_L	926	IBNMO	971	VABX_S[a]
792	RA077_H	837	RA099_L	882	RA122_H	927	IBN_Y	972	VABXMN[a]
793	RA077_L	838	RA100_H	883	RA122_L	928	ICMX	973	VABX_H[a]
794	RA078_H	839	RA100_L	884	RA123_H	929	ICX_S	974	VABX_D[a]
795	RA078_L	840	RA101_H	885	RA123_L	930	ICXMN	975	VABXMO[a]
796	RA079_H	841	RA101_L	886	RA124_H	931	ICX_H	976	VABX_Y[a]
797	RA079_L	842	RA102_H	887	RA124_L	932	ICX_D	977	VABMN[a]
798	RA080_H	843	RA102_L	888	RA125_H	933	ICXMO	978	VABN_S[a]
799	RA080_L	844	RA103_H	889	RA125_L	934	ICX_Y	979	VABNMN[a]
800	RA081_H	845	RA103_L	890	RA126_H	935	ICMN		

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 4 of 9)

Register Address	Label
980	VABN_H[a]
981	VABN_D[a]
982	VABNMO[a]
983	VABN_Y[a]
984	VBCMX[a]
985	VBCX_S[a]
986	VBCXMN[a]
987	VBCX_H[a]
988	VBCX_D[a]
989	VBCXMO[a]
990	VBCX_Y[a]
991	VBCMN[a]
992	VBCN_S[a]
993	VBCNMN[a]
994	VBCN_H[a]
995	VBCN_D[a]
996	VBCNMO[a]
997	VBCN_Y[a]
998	VCAMX[a]
999	VCAX_S[a]
1000	VCAXMN[a]
1001	VCAX_H[a]
1002	VCAX_D[a]
1003	VCAXMO[a]
1004	VCAX_Y[a]
1005	VCAMN[a]
1006	VCAN_S[a]
1007	VCANMN[a]
1008	VCAN_H[a]
1009	VCAN_D[a]
1010	VCANMO[a]
1011	VCAN_Y[a]
1012	VSMX
1013	VSX_S
1014	VSXMN
1015	VSX_H
1016	VSX_D
1017	VSXMO
1018	VSX_Y
1019	VSMN
1020	VSN_S
1021	VSNMN
1022	VSN_H
1023	VSN_D
1024	VSNMO
1025	VSN_Y
1026	KW3PMX
1027	KW3X_S
1028	KW3XMN
1029	KW3X_H
1030	KW3X_D
1031	KW3XMO
1032	KW3X_Y
1033	KW3PMN
1034	KW3N_S
1035	KW3NMN
1036	KW3N_H
1037	KW3N_D
1038	KW3NMO
1039	KW3N_Y
1040	KVAR3PMX
1041	KVR3X_S
1042	KVR3XMN
1043	KVR3X_H
1044	KVR3X_D
1045	KVR3XMO
1046	KVR3X_Y
1047	KVAR3PMN
1048	KVR3N_S
1049	KVR3NMN
1050	KVR3N_H
1051	KVR3N_D
1052	KVR3NMO
1053	KVR3N_Y
1054	KVA3PMX
1055	KVA3X_S
1056	KVA3XMN
1057	KVA3X_H
1058	KVA3X_D
1059	KVA3XMO
1060	KVA3X_Y
1061	KVA3PMN
1062	KVA3N_S
1063	KVA3NMN
1064	KVA3N_H
1065	KVA3N_D
1066	KVA3NMO
1067	KVA3N_Y
1068	FREQMX
1069	FREQX_S
1070	FREQXMN
1071	FREQX_H
1072	FREQX_D
1073	FREQXMO
1074	FREQX_Y
1075	FREQMN
1076	FREQN_S
1077	FREQNMN
1078	FREQN_H
1079	FREQN_D
1080	FREQNMO
1081	FREQN_Y
1082–1089	Reserved
1090	RTD1MX
1091	RTD1X_S
1092	RTD1XMN
1093	RTD1X_H
1094	RTD1X_D
1095	RTD1XMO
1096	RTD1X_Y
1097	RTD1MN
1098	RTD1N_S
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

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 5 of 9)

Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label
1209	RTD9MN	1254	RTD12N_H	1310	AI303MNH	1355	AI306X_D	1400	AI401X_S
1210	RTD9N_S	1255	RTD12N_D	1311	AI303MNL	1356	AI306XMO	1401	AI401XMN
1211	RTD9NMN	1256	RTD12NMO	1312	AI303N_S	1357	AI306X_Y	1402	AI401X_H
1212	RTD9N_H	1257	RTD12N_Y	1313	AI303NMN	1358	AI306MNH	1403	AI401X_D
1213	RTD9N_D	1258-1269	Reserved	1314	AI303N_H	1359	AI306MNL	1404	AI401XMO
1214	RTD9NMO	1270	AI301MXH	1315	AI303N_D	1360	AI306N_S	1405	AI401X_Y
1215	RTD9N_Y	1271	AI301MXL	1316	AI303NMO	1361	AI306NMN	1406	AI401MNH
1216	RTD10MX	1272	AI301X_S	1317	AI303N_Y	1362	AI306N_H	1407	AI401MNL
1217	RTD10X_S	1273	AI301XMN	1318	AI304MXH	1363	AI306N_D	1408	AI401N_S
1218	RTD10XMN	1274	AI301X_H	1319	AI304MXL	1364	AI306NMO	1409	AI401NMN
1219	RTD10X_H	1275	AI301X_D	1320	AI304X_S	1365	AI306N_Y	1410	AI401N_H
1220	RTD10X_D	1276	AI301XMO	1321	AI304XMN	1366	AI307MXH	1411	AI401N_D
1221	RTD10XMO	1277	AI301X_Y	1322	AI304X_H	1367	AI307MXL	1412	AI401NMO
1222	RTD10X_Y	1278	AI301MNH	1323	AI304X_D	1368	AI307X_S	1413	AI401N_Y
1223	RTD10MN	1279	AI301MNL	1324	AI304XMO	1369	AI307XMN	1414	AI402MXH
1224	RTD10N_S	1280	AI301N_S	1325	AI304X_Y	1370	AI307X_H	1415	AI402MXL
1225	RTD10NMN	1281	AI301NMN	1326	AI304MNH	1371	AI307X_D	1416	AI402X_S
1226	RTD10N_H	1282	AI301N_H	1327	AI304MNL	1372	AI307XMO	1417	AI402XMN
1227	RTD10N_D	1283	AI301N_D	1328	AI304N_S	1373	AI307X_Y	1418	AI402X_H
1228	RTD10NMO	1284	AI301NMO	1329	AI304NMN	1374	AI307MNH	1419	AI402X_D
1229	RTD10N_Y	1285	AI301N_Y	1330	AI304N_H	1375	AI307MNL	1420	AI402XMO
1230	RTD11MX	1286	AI302MXH	1331	AI304N_D	1376	AI307N_S	1421	AI402X_Y
1231	RTD11X_S	1287	AI302MXL	1332	AI304NMO	1377	AI307NMN	1422	AI402MNH
1232	RTD11XMN	1288	AI302X_S	1333	AI304N_Y	1378	AI307N_H	1423	AI402MNL
1233	RTD11X_H	1289	AI302XMN	1334	AI305MXH	1379	AI307N_D	1424	AI402N_S
1234	RTD11X_D	1290	AI302X_H	1335	AI305MXL	1380	AI307NMO	1425	AI402NMN
1235	RTD11XMO	1291	AI302X_D	1336	AI305X_S	1381	AI307N_Y	1426	AI402N_H
1236	RTD11X_Y	1292	AI302XMO	1337	AI305XMN	1382	AI308MXH	1427	AI402N_D
1237	RTD11MN	1293	AI302X_Y	1338	AI305X_H	1383	AI308MXL	1428	AI402NMO
1238	RTD11N_S	1294	AI302MNH	1339	AI305X_D	1384	AI308X_S	1429	AI402N_Y
1239	RTD11NMN	1295	AI302MNL	1340	AI305XMO	1385	AI308XMN	1430	AI403MXH
1240	RTD11N_H	1296	AI302N_S	1341	AI305X_Y	1386	AI308X_H	1431	AI403MXL
1241	RTD11N_D	1297	AI302NMN	1342	AI305MNH	1387	AI308X_D	1432	AI403X_S
1242	RTD11NMO	1298	AI302N_H	1343	AI305MNL	1388	AI308XMO	1433	AI403XMN
1243	RTD11N_Y	1299	AI302N_D	1344	AI305N_S	1389	AI308X_Y	1434	AI403X_H
1244	RTD12MX	1300	AI302NMO	1345	AI305NMN	1390	AI308MNH	1435	AI403X_D
1245	RTD12X_S	1301	AI302N_Y	1346	AI305N_H	1391	AI308MNL	1436	AI403XMO
1246	RTD12XMN	1302	AI303MXH	1347	AI305N_D	1392	AI308N_S	1437	AI403X_Y
1247	RTD12X_H	1303	AI303MXL	1348	AI305NMO	1393	AI308NMN	1438	AI403MNH
1248	RTD12X_D	1304	AI303X_S	1349	AI305N_Y	1394	AI308N_H	1439	AI403MNL
1249	RTD12XMO	1305	AI303XMN	1350	AI306MXH	1395	AI308N_D	1440	AI403N_S
1250	RTD12X_Y	1306	AI303X_H	1351	AI306MXL	1396	AI308NMO	1441	AI403NMN
1251	RTD12MN	1307	AI303X_D	1352	AI306X_S	1397	AI308N_Y	1442	AI403N_H
1252	RTD12N_S	1308	AI303XMO	1353	AI306XMN	1398	AI401MXH	1443	AI403N_D
1253	RTD12NMN	1309	AI303X_Y	1354	AI306X_H	1399	AI401MXL	1444	AI403NMO

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 6 of 9)

Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label
1445	AI403N_Y	1490	AI406N_H	1535	AI501MNL	1580	AI504XMO	1625	AI507XMN
1446	AI403MXH	1491	AI406N_D	1536	AI501N_S	1581	AI504X_Y	1626	AI507X_H
1447	AI403MXL	1492	AI406NMO	1537	AI501NMN	1582	AI504MNH	1627	AI507X_D
1448	AI403X_S	1493	AI406N_Y	1538	AI501N_H	1583	AI504MNL	1628	AI507XMO
1449	AI403XMN	1494	AI407MXH	1539	AI501N_D	1584	AI504N_S	1629	AI507X_Y
1450	AI403X_H	1495	AI407MXL	1540	AI501NMO	1585	AI504NMN	1630	AI507MNH
1451	AI403X_D	1496	AI407X_S	1541	AI501N_Y	1586	AI504N_H	1631	AI507MNL
1452	AI403XMO	1497	AI407XMN	1542	AI502MXH	1587	AI504N_D	1632	AI507N_S
1453	AI403X_Y	1498	AI407X_H	1543	AI502MXL	1588	AI504NMO	1633	AI507NMN
1454	AI404MNH	1499	AI407X_D	1544	AI502X_S	1589	AI504N_Y	1634	AI507N_H
1455	AI404MNL	1500	AI407XMO	1545	AI502XMN	1590	AI505MXH	1635	AI507N_D
1456	AI404N_S	1501	AI407X_Y	1546	AI502X_H	1591	AI505MXL	1636	AI507NMO
1457	AI404NMN	1502	AI407MNH	1547	AI502X_D	1592	AI505X_S	1637	AI507N_Y
1458	AI404N_H	1503	AI407MNL	1548	AI502XMO	1593	AI505XMN	1638	AI508MXH
1459	AI404N_D	1504	AI407N_S	1549	AI502X_Y	1594	AI505X_H	1639	AI508MXL
1460	AI404NMO	1505	AI407NMN	1550	AI502MNH	1595	AI505X_D	1640	AI508X_S
1461	AI404N_Y	1506	AI407N_H	1551	AI502MNL	1596	AI505XMO	1641	AI508XMN
1462	AI405MXH	1507	AI407N_D	1552	AI502N_S	1597	AI505X_Y	1642	AI508X_H
1463	AI405MXL	1508	AI407NMO	1553	AI502NMN	1598	AI505MNH	1643	AI508X_D
1464	AI405X_S	1509	AI407N_Y	1554	AI502N_H	1599	AI505MNL	1644	AI508XMO
1465	AI405XMN	1510	AI408MXH	1555	AI502N_D	1600	AI505N_S	1645	AI508X_Y
1466	AI405X_H	1511	AI408MXL	1556	AI502NMO	1601	AI505NMN	1646	AI508MNH
1467	AI405X_D	1512	AI408X_S	1557	AI502N_Y	1602	AI505N_H	1647	AI508MNL
1468	AI405XMO	1513	AI408XMN	1558	AI503MXH	1603	AI505N_D	1648	AI508N_S
1469	AI405X_Y	1514	AI408X_H	1559	AI503MXL	1604	AI505NMO	1649	AI508NMN
1470	AI405MNH	1515	AI408X_D	1560	AI503X_S	1605	AI505N_Y	1650	AI508N_H
1471	AI405MNL	1516	AI408XMO	1561	AI503XMN	1606	AI506MXH	1651	AI508N_D
1472	AI405N_S	1517	AI408X_Y	1562	AI503X_H	1607	AI506MXL	1652	AI508NMO
1473	AI405NMN	1518	AI408MNH	1563	AI503X_D	1608	AI506X_S	1653	AI508N_Y
1474	AI405N_H	1519	AI408MNL	1564	AI503XMO	1609	AI506XMN	1654	MXMN_R_S
1475	AI405N_D	1520	AI408N_S	1565	AI503X_Y	1610	AI506X_H	1655	MXMN_RMN
1476	AI405NMO	1521	AI408NMN	1566	AI503MNH	1611	AI506X_D	1656	MXMN_R_H
1477	AI405N_Y	1522	AI408N_H	1567	AI503MNL	1612	AI506XMO	1657	MXMN_R_D
1478	AI406MXH	1523	AI408N_D	1568	AI503N_S	1613	AI506X_Y	1658	MXMN_RMO
1479	AI406MXL	1524	AI408NMO	1569	AI503NMN	1614	AI506MNH	1659	MXMN_R_Y
1480	AI406X_S	1525	AI408N_Y	1570	AI503N_H	1615	AI506MNL	1660	THRL1
1481	AI406XMN	1526	AI501MXH	1571	AI503N_D	1616	AI506N_S	1661	THRL2
1482	AI406X_H	1527	AI501MXL	1572	AI503NMO	1617	AI506NMN	1662	THRL3
1483	AI406X_D	1528	AI501X_S	1573	AI503N_Y	1618	AI506N_H	1663	THIEQ1
1484	AI406XMO	1529	AI501XMN	1574	AI504MXH	1619	AI506N_D	1664	THIEQ2
1485	AI406X_Y	1530	AI501X_H	1575	AI504MXL	1620	AI506NMO	1665	THIEQ3
1486	AI406MNH	1531	AI501X_D	1576	AI504X_S	1621	AI506N_Y	1666	THTCU1
1487	AI406MNL	1532	AI501XMO	1577	AI504XMN	1622	AI507MXH	1667	THTCU2
1488	AI406N_S	1533	AI501X_Y	1578	AI504X_H	1623	AI507MXL	1668	THTCU3
1489	AI406NMN	1534	AI501MNH	1579	AI504X_D	1624	AI507X_S	1669	THTRIP1

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 7 of 9)

Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label
1670	THTRIP2	1744	UARTERR	1798	ROW_38	1843	ROW_83	1888	ROW_128
1671	THTRIP3	1745	ILLFUNC	1799	ROW_39	1844	ROW_84	1889	ROW_129
1672	THRLS1	1746	ILLREG	1800	ROW_40	1845	ROW_85	1890	ROW_130
1673	THRLS2	1747	ILLWR	1801	ROW_41	1846	ROW_86	1891	ROW_131
1674	THRLS3	1748	BADPKTF	1802	ROW_42	1847	ROW_87	1892	ROW_132
1675–1689	Reserved	1749	BADPKTL	1803	ROW_43	1848	ROW_88	1893	ROW_133
1690	FLOC	1750–1759	Reserved	1804	ROW_44	1849	ROW_89	1894	ROW_134
1691	NUMEVE	1760	ROW_0	1805	ROW_45	1850	ROW_90	1895	ROW_135
1692	EVESEL	1761	ROW_1	1806	ROW_46	1851	ROW_91	1896	ROW_136
1693	EVE_S	1762	ROW_2	1807	ROW_47	1852	ROW_92	1897	ROW_137
1694	EVEMN	1763	ROW_3	1808	ROW_48	1853	ROW_93	1898	ROW_138
1695	EVE_H	1764	ROW_4	1809	ROW_49	1854	ROW_94	1899	ROW_139
1696	EVE_D	1765	ROW_5	1810	ROW_50	1855	ROW_95	1900	ROW_140
1697	EVEMO	1766	ROW_6	1811	ROW_51	1856	ROW_96	1901	ROW_141
1698	EVE_Y	1767	ROW_7	1812	ROW_52	1857	ROW_97	1902	ROW_142
1699	EVE_TYPE	1768	ROW_8	1813	ROW_53	1858	ROW_98	1903	ROW_143
1700	EV_LOCAT	1769	ROW_9	1814	ROW_54	1859	ROW_99	1904	ROW_144
1701	EVE_TRGT	1770	ROW_10	1815	ROW_55	1860	ROW_100	1905	ROW_145
1702	EVE_IA	1771	ROW_11	1816	ROW_56	1861	ROW_101	1906	ROW_146
1703	EVE_IB	1772	ROW_12	1817	ROW_57	1862	ROW_102	1907	ROW_147
1704	EVE_IC	1773	ROW_13	1818	ROW_58	1863	ROW_103	1908	ROW_148
1705	EVE_IN	1774	ROW_14	1819	ROW_59	1864	ROW_104	1909	ROW_149
1706	EVE_IG	1775	ROW_15	1820	ROW_60	1865	ROW_105	1910	ROW_150
1707	EVE_VAB	1776	ROW_16	1821	ROW_61	1866	ROW_106	1911	ROW_151
1708	EVE_VBC	1777	ROW_17	1822	ROW_62	1867	ROW_107	1912	ROW_152
1709	EVE_VCA	1778	ROW_18	1823	ROW_63	1868	ROW_108	1913	ROW_153
1710	EVE_VG	1779	ROW_19	1824	ROW_64	1869	ROW_109	1914	ROW_154
1711	EVE_DY	1780	ROW_20	1825	ROW_65	1870	ROW_110	1915	ROW_155
1712	EVE_FREQ	1781	ROW_21	1826	ROW_66	1871	ROW_111	1916	ROW_156
1713	EVE_MAXW	1782	ROW_22	1827	ROW_67	1872	ROW_112	1917	ROW_157
1714	EVE_MAXB	1783	ROW_23	1828	ROW_68	1873	ROW_113	1918	ROW_158
1715	EVE_MAXA	1784	ROW_24	1829	ROW_69	1874	ROW_114	1919	ROW_159
1716	EVE_MAXO	1785	ROW_25	1830	ROW_70	1875	ROW_115	1920	NA
1717	EVE_FZ	1786	ROW_26	1831	ROW_71	1876	ROW_116	1921	ROW_160
1718	EVE_FZFA	1787	ROW_27	1832	ROW_72	1877	ROW_117	1922	ROW_161
1719–1729	Reserved	1788	ROW_28	1833	ROW_73	1878	ROW_118	1923	ROW_162
1730	TRIP_LO	1789	ROW_29	1834	ROW_74	1879	ROW_119	1924	ROW_163
1731	TRIP_HI	1790	ROW_30	1835	ROW_75	1880	ROW_120	1925	ROW_164
1732	WARN_LO	1791	ROW_31	1836	ROW_76	1881	ROW_121	1926	ROW_165
1733	WARN_HI	1792	ROW_32	1837	ROW_77	1882	ROW_122	1927	ROW_166
1734–1739	Reserved	1793	ROW_33	1838	ROW_78	1883	ROW_123	1928	ROW_167
1740	NUMRCV	1794	ROW_34	1839	ROW_79	1884	ROW_124	1929	ROW_168
1741	NUMOTH	1795	ROW_35	1840	ROW_80	1885	ROW_125	1930	ROW_169
1742	INVADR	1796	ROW_36	1841	ROW_81	1886	ROW_126	1931	ROW_170
1743	BADCRC	1797	ROW_37	1842	ROW_82	1887	ROW_127	1932	ROW_171

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 8 of 9)

Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label
1933	ROW_172	1978	ROW_217	2022	ROW_261	2319	MV42L	2363	MV64L
1934	ROW_173	1979	ROW_218	2023	ROW_262	2320	MV43H	2364–2373	Reserved
1935	ROW_174	1980	ROW_219	2024	ROW_263	2321	MV43L	2374	SC33
1936	ROW_175	1981	ROW_220	2025	ROW_264	2322	MV44H	2375	SC34
1937	ROW_176	1982	ROW_221	2026	ROW_265	2323	MV44L	2376	SC35
1938	ROW_177	1983	ROW_222	2027	ROW_266	2324	MV45H	2377	SC36
1939	ROW_178	1984	ROW_223	2028	ROW_267	2325	MV45L	2378	SC37
1940	ROW_179	1985	ROW_224	2029	ROW_268	2326	MV46H	2379	SC38
1941	ROW_180	1986	ROW_225	2030	ROW_269	2327	MV46L	2380	SC39
1942	ROW_181	1987	ROW_226	2031	ROW_270	2328	MV47H	2381	SC40
1943	ROW_182	1988	ROW_227	2032	ROW_271	2329	MV47L	2382	SC41
1944	ROW_183	1989	ROW_228	2033	ROW_272	2330	MV48H	2383	SC42
1945	ROW_184	1990	ROW_229	2034	ROW_273	2331	MV48L	2384	SC43
1946	ROW_185	1991	ROW_230	2035	ROW_274	2332	MV49H	2385	SC44
1947	ROW_186	1992	ROW_231	2036	ROW_275	2333	MV49L	2386	SC45
1948	ROW_187	1993	ROW_232	2037	ROW_276	2334	MV50H	2387	SC46
1949	ROW_188	1994	ROW_233	2038	ROW_277	2335	MV50L	2388	SC47
1950	ROW_189	1995	ROW_234	2039	ROW_278	2336	MV51H	2389	SC48
1951	ROW_190	1996	ROW_235	2040	ROW_279	2337	MV51L	2390	SC49
1952	ROW_191	1997	ROW_236	2041	ROW_280	2338	MV52H	2391	SC50
1953	ROW_192	1998	ROW_237	2042	ROW_281	2339	MV52L	2392	SC51
1954	ROW_193	1999	ROW_238	2043	ROW_282	2340	MV53H	2393	SC52
1955	ROW_194	2000	ROW_239	2044	ROW_283	2341	MV53L	2394	SC53
1956	ROW_195	2001	ROW_240	2045	ROW_284	2342	MV54H	2395	SC54
1957	ROW_196	2002	ROW_241	2046–2299	Reserved	2343	MV54L	2396	SC55
1958	ROW_197	2003	ROW_242	2300	MV33H	2344	MV55H	2397	SC56
1959	ROW_198	2004	ROW_243	2301	MV33L	2345	MV55L	2398	SC57
1960	ROW_199	2005	ROW_244	2302	MV34H	2346	MV56H	2399	SC58
1961	ROW_200	2006	ROW_245	2303	MV34L	2347	MV56L	2400	SC59
1962	ROW_201	2007	ROW_246	2304	MV35H	2348	MV57H	2401	SC60
1963	ROW_202	2008	ROW_247	2305	MV35L	2349	MV57L	2402	SC61
1964	ROW_203	2009	ROW_248	2306	MV36H	2350	MV58H	2403	SC62
1965	ROW_204	2010	ROW_249	2307	MV36L	2351	MV58L	2404	SC63
1966	ROW_205	2011	ROW_250	2308	MV37H	2352	MV59H	2405	SC64
1967	ROW_206	2012	ROW_251	2309	MV37L	2353	MV59L	2406–2415	Reserved
1968	ROW_207	2013	ROW_252	2310	MV38H	2354	MV60H	2416	FG1RA01H
1969	ROW_208	2014	ROW_253	2311	MV38L	2355	MV60L	2417	FG1RA01L
1970	ROW_209	2015	ROW_254	2312	MV39H	2356	MV61H	2418	FG1RA02H
1971	ROW_210	2016	ROW_255	2313	MV39L	2357	MV61L	2419	FG1RA02L
1972	ROW_211	2017	ROW_256	2314	MV40H	2358	MV62H	2420	FG1RA03H
1973	ROW_212	2018	ROW_257	2315	MV40L	2359	MV62L	2421	FG1RA03L
1974	ROW_213	2019	ROW_258	2316	MV41H	2360	MV63H	2422	FG1RA04H
1975	ROW_214	2020	ROW_259	2317	MV41L	2361	MV63L	2423	FG1RA04L
1976	ROW_215	2021	ROW_260	2318	MV42H	2362	MV64H	2424	FG1RA05H
1977	ROW_216								

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 9 of 9)

Register Address	Label	Register Address	Label
2425	FG1RA05L	2463	FG3RA08L
2426	FG1RA06H	2464	FG4RA01H
2427	FG1RA06L	2465	FG4RA01L
2428	FG1RA07H	2466	FG4RA02H
2429	FG1RA07L	2467	FG4RA02L
2430	FG1RA08H	2468	FG4RA03H
2431	FG1RA08L	2469	FG4RA03L
2432	FG2RA01H	2470	FG4RA04H
2433	FG2RA01L	2471	FG4RA04L
2434	FG2RA02H	2472	FG4RA05H
2435	FG2RA02L	2473	FG4RA05L
2436	FG2RA03H	2474	FG4RA06H
2437	FG2RA03L	2475	FG4RA06L
2438	FG2RA04H	2476	FG4RA07H
2439	FG2RA04L	2477	FG4RA07L
2440	FG2RA05H	2478	FG4RA08H
2441	FG2RA05L	2479	FG4RA08L
2442	FG2RA06H	2480–2499	Reserved
2443	FG2RA06L	2500	97FM1_H
2444	FG2RA07H	2501	97FM1_L
2445	FG2RA07L	2502	97FM2_H
2446	FG2RA08H	2503	97FM2_L
2447	FG2RA08L	2504	97FM3_H
2448	FG3RA01H	2505	97FM3_L
2449	FG3RA01L	2506	97FM4_H
2450	FG3RA02H	2507	97FM4_L
2451	FG3RA02L	2508	97FM5_H
2452	FG3RA03H	2509	97FM5_L
2453	FG3RA03L	2510	97FM6_H
2454	FG3RA04H	2511	97FM6_L
2455	FG3RA04L	2512	97FM7_H
2456	FG3RA05H	2513	97FM7_L
2457	FG3RA05L	2514	97FM8_H
2458	FG3RA06H	2515	97FM8_L
2459	FG3RA06L	2516	97FM9_H
2460	FG3RA07H	2517	97FM9_L
2461	FG3RA07L	2518	97FM0_H
2462	FG3RA08H	2519	97FM0_L

[a] Registers report corresponding phase-to-phase values when the setting DELTA_Y = DELTA and phase-to-neutral values when the setting DELTA_Y = WYE.

Table E.34 Modbus Register Labels for Use With SET M Command in Firmware Versions Prior to R400

Register Address	Label
290	P0P9PS
291	P1P2PS
292	P1P5PS
293	P1P8PS
294	P2P5PS
295	P3P3PS
296	P3P75PS
297	P5PS
298	N1P25PS
299	N5PS
316–319	Reserved

Reading History Data Using Modbus

Through use of the Modbus Register Map (*Table E.35*), 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 a zero is written to the register, the relay will return event number one). Then read the history of the specific event number you requested from the registers shown in the Historical Data section of the Modbus Register Map (*Table E.35*). 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.35 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.35 Modbus Map[a] (Sheet 1 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
0 (R)	Reserved[d]						100
User Map Register							
1 (R/W)	USER REG #1		280	1981	320	1	101
	• • •						
125 (R/W)	USER REG #125		280	1981	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[d]						351–360
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		361
262–269 (R)	Reserved[d]						362–369
Date/Time Set							
270 (R/W)	SET SEC		0	5999	0	0.01	370
271 (R/W)	SET MIN		0	59	0	1	371
272 (R/W)	SET HOUR		0	23	0	1	372
273 (R/W)	SET DAY		1	31	1	1	373
274 (R/W)	SET MONTH		1	12	1	1	374
275 (R/W)	SET YEAR		2000	9999	2000	1	375
276–279 (R)	Reserved[d]						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

Table E.35 Modbus Map[a] (Sheet 2 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
289 (R)	RTD STATUS		0	2	0	1	389
290 (R)	+0.675V STATUS[e]		0	2	0	1	390
291 (R)	+0.675VD STATUS[e]		0	2	0	1	391
292 (R)	Reserved[d, e]		0	2	0	1	392
293 (R)	+1.8V STATUS[e]		0	2	0	1	393
294 (R)	Reserved[d, e]		0	2	0	1	394
295 (R)	+3.3V STATUS[e]		0	2	0	1	395
296 (R)	+3.75V STATUS[e]		0	2	0	1	396
297 (R)	+5.0V STATUS[e]		0	2	0	1	397
298 (R)	-1.25V STATUS[e]		0	2	0	1	398
299 (R)	-5.0V STATUS[e]		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
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 (R)	+1.0 V STATUS[e]		0	2	0	1	416
317 (R)	+1.1 V STATUS[e]		0	2	0	1	417
318 (R)	+1.35 V STATUS[e]		0	2	0	1	418
319 (R)	+15.0 V STATUS[e]		0	2	0	1	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

Table E.35 Modbus Map[a] (Sheet 3 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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[f]	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
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[g]	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[d]						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

Table E.35 Modbus Map[a] (Sheet 4 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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[d]						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
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[d]						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[d]						516–519
Light Meter Data							
420 (R)	LS 1	%	0	1000	0	0.1	520

Table E.35 Modbus Map[a] (Sheet 5 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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[d]						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[g]	kV	0	65535	0	0.01	534
435 (R)	VB RMS[g]	kV	0	65535	0	0.01	535
436 (R)	VC RMS[g]	kV	0	65535	0	0.01	536
437 (R)	VAB RMS[f]	kV	0	65535	0	0.01	537
438 (R)	VBC RMS[f]	kV	0	65535	0	0.01	538
439 (R)	VCA RMS[f]	kV	0	65535	0	0.01	539
440 (R)	VS RMS	kV	0	65535	0	0.01	540
441–449 (R)	Reserved[d]						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[d]						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

Table E.35 Modbus Map[a] (Sheet 6 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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[d]						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
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

Table E.35 Modbus Map[a] (Sheet 7 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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
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[d]						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

Table E.35 Modbus Map[a] (Sheet 8 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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
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	1	704–735
636–639 (R)	Reserved[d]						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

Table E.35 Modbus Map[a] (Sheet 9 of 42)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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
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

Table E.35 Modbus Map[a] (Sheet 10 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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
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

Table E.35 Modbus Map[a] (Sheet 11 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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
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

Table E.35 Modbus Map[a] (Sheet 12 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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
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

Table E.35 Modbus Map[a] (Sheet 13 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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
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

Table E.35 Modbus Map[a] (Sheet 14 of 42)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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
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	(R)	BRKR CLO TIM ELE	ms	–1	30000	–1	1	—
897	(R)	BRKR CLO TIM HYB	ms	–1	30000	–1	1	—
898	(R)	BRKR OPE TIM ELE	ms	–1	30000	–1	1	—
899	(R)	BRKR OPE TIM HYB	ms	–1	30000	–1	1	—
MAX/MIN 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

Table E.35 Modbus Map[a] (Sheet 15 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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
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

Table E.35 Modbus Map[a] (Sheet 16 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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
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

Table E.35 Modbus Map[a] (Sheet 17 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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
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

Table E.35 Modbus Map[a] (Sheet 18 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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
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[d]						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

Table E.35 Modbus Map[a] (Sheet 19 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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
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

Table E.35 Modbus Map[a] (Sheet 20 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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
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

Table E.35 Modbus Map[a] (Sheet 21 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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
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

Table E.35 Modbus Map[a] (Sheet 22 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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
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

Table E.35 Modbus Map[a] (Sheet 23 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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
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

Table E.35 Modbus Map[a] (Sheet 24 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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
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

Table E.35 Modbus Map[a] (Sheet 25 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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
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

Table E.35 Modbus Map[a] (Sheet 26 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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
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

Table E.35 Modbus Map[a] (Sheet 27 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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
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

Table E.35 Modbus Map[a] (Sheet 28 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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
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

Table E.35 Modbus Map[a] (Sheet 29 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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
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

Table E.35 Modbus Map[a] (Sheet 30 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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
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

Table E.35 Modbus Map[a] (Sheet 31 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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
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

Table E.35 Modbus Map[a] (Sheet 32 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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[d]						1775–1779
Reserved Area 5							
1680–1689 (R)	Reserved[d]						1760–1789
Fault Location							
NOTE: 1: 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); 2: When a fault location is undefined, registers 1690/1700, 1717, and 1718 will report –999.9, 6553.5, and 180.0, respectively; 3: The fault location is also reported as part of Historical Data (Register 1700) and has a different label from Register 1690.							
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	1	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
1699 (R)	EVENT TYPE 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 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 58 = BROKEN COND A 59 = BROKEN COND B 60 = BROKEN COND C 61 = PHASE DISCONT A 62 = PHASE DISCONT B 63 = PHASE DISCONT C 64 = PHASE A INC TRIP 65 = PHASE B INC TRIP 66 = PHASE C INC TRIP 67 = NEUTRAL INC TRIP 68 = PHASE A2 50 TRIP 69 = PHASE B2 50 TRIP 70 = PHASE C2 50 TRIP		0	70	0	1	1799
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		0	255	0	1	1801

Table E.35 Modbus Map[a] (Sheet 33 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
	Bit 6 = TRIP_LED Bit 7 = ENABLED						
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[d]						1819–1829
Trip/Warn Data							
The Trip/Warn Status register bits are momentarily set as long as a trip/warn condition exists (see *Table E.37* for the trigger conditions). When a trip event occurs, the elements are latched to the rising edge of the TRIP Relay Word bit and they are not cleared until a target reset is issued from any interface.							
1730 (R)	TRIP STATUS LO Bit 0 = PHASE A1 50 Bit 1 = PHASE B1 50 Bit 2 = PHASE C1 50 Bit 3 = PHASE 50P1 Bit 4 = GROUND 50G1 Bit 5 = NEUTRAL 50N1 Bit 6 = NEG SEQ 50Q1 Bit 7 = PHASE A 51 Bit 8 = PHASE B 51 Bit 9 = PHASE C 51 Bit 10 = PHASE 51P1 Bit 11 = GROUND 51G1 Bit 12 = NEUTRAL 51N1 Bit 13 = NEG SEQ 51Q Bit 14 = UNDERVOLT 27P1 Bit 15 = OVERVOLT 59P1		0	65535	0	1	1830
1731 (R)	TRIP STATUS HI Bit 0 = POWER FACTOR 55 Bit 1 = FREQUENCY 81D1 Bit 2 = FREQUENCY 81D2 Bit 3 = RTD-OTHER Bit 4 = RTD-AMBIENT Bit 5 = RTD-WIND BEAR Bit 6 = RTD ERROR Bit 7 = POWER ELEMENTS Bit 8 = COMM IDLE Bit 9 = COMM LOSS Bit 10 = REMOTE TRIP Bit 11 = COMM FAULT Bit 12 = CONFIG FAULT Bit 13 = RESERVED Bit 14 = RESERVED Bit 15 = BREAKER FAIL		0	65535	0	1	1831

Table E.35 Modbus Map[a] (Sheet 34 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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 = FREQUENCY 81D5 Bit 3 = RTD-WIND BEAR / Bit 11 = FREQUENCY 81D6 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 (R)	TRIP STATUS1 LO		0	65535	0	1	1834
	Bit 0 = POWER FACTOR 55 Bit 1 = SALARM Bit 2 = WARNING Bit 3–Bit 15 = Reserved						
1735–1739 (R)	Reserved[d]						1835–1839
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[d]						1850–1859
Relay Elements							
1760–1919 (R)	ROW 0–ROW 159		0	255	0	1	1860–2019
1920 (R)	Reserved[d]						2020
1921–1973 (R)	ROW 160–ROW ROW 212		0	255	0	1	2021–2073
1974 – 2045 (R)	ROW 213–ROW 284		0	255	0	1	2074–2145
2046 – 2299 (R)	Reserved						2146–2399
Math Variables							
2300 (R)	MV33 – HI		–32768	32767	0	0.01	2400
2301 (R)	MV33 – LO		–32768	32767	0	0.01	2401
2302 (R)	MV34 – HI		–32768	32767	0	0.01	2402
2303 (R)	MV34 – LO		–32768	32767	0	0.01	2403
2304 (R)	MV35 – HI		–32768	32767	0	0.01	2404
2305 (R)	MV35 – LO		–32768	32767	0	0.01	2405

Table E.35 Modbus Map[a] (Sheet 35 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
2306 (R)	MV36 – HI		–32768	32767	0	0.01	2406
2307 (R)	MV36 – LO		–32768	32767	0	0.01	2407
2308 (R)	MV37 – HI		–32768	32767	0	0.01	2408
2309 (R)	MV37 – LO		–32768	32767	0	0.01	2409
2310 (R)	MV38 – HI		–32768	32767	0	0.01	2410
2311 (R)	MV38 – LO		–32768	32767	0	0.01	2411
2312 (R)	MV39 – HI		–32768	32767	0	0.01	2412
2313 (R)	MV39 – LO		–32768	32767	0	0.01	2413
2314 (R)	MV40 – HI		–32768	32767	0	0.01	2414
2315 (R)	MV40 – LO		–32768	32767	0	0.01	2415
2316 (R)	MV41 – HI		–32768	32767	0	0.01	2416
2317 (R)	MV41 – LO		–32768	32767	0	0.01	2417
2318 (R)	MV42 – HI		–32768	32767	0	0.01	2418
2319 (R)	MV42 – LO		–32768	32767	0	0.01	2419
2320 (R)	MV43 – HI		–32768	32767	0	0.01	2420
2321 (R)	MV43 – LO		–32768	32767	0	0.01	2421
2322 (R)	MV44 – HI		–32768	32767	0	0.01	2422
2323 (R)	MV44 – LO		–32768	32767	0	0.01	2423
2324 (R)	MV45 – HI		–32768	32767	0	0.01	2424
2325 (R)	MV45 – LO		–32768	32767	0	0.01	2425
2326 (R)	MV46 – HI		–32768	32767	0	0.01	2426
2327 (R)	MV46 – LO		–32768	32767	0	0.01	2427
2328 (R)	MV47 – HI		–32768	32767	0	0.01	2428
2329 (R)	MV47 – LO		–32768	32767	0	0.01	2429
2330 (R)	MV48 – HI		–32768	32767	0	0.01	2430
2331 (R)	MV48 – LO		–32768	32767	0	0.01	2431
2332 (R)	MV49 – HI		–32768	32767	0	0.01	2432
2333 (R)	MV49 – LO		–32768	32767	0	0.01	2433
2334 (R)	MV50 – HI		–32768	32767	0	0.01	2434
2335 (R)	MV50 – LO		–32768	32767	0	0.01	2435
2336 (R)	MV51 – HI		–32768	32767	0	0.01	2436
2337 (R)	MV51 – LO		–32768	32767	0	0.01	2437
2338 (R)	MV52 – HI		–32768	32767	0	0.01	2438
2339 (R)	MV52 – LO		–32768	32767	0	0.01	2439
2340 (R)	MV53 – HI		–32768	32767	0	0.01	2440
2341 (R)	MV53 – LO		–32768	32767	0	0.01	2441
2342 (R)	MV54 – HI		–32768	32767	0	0.01	2442
2343 (R)	MV54 – LO		–32768	32767	0	0.01	2443
2344 (R)	MV55 – HI		–32768	32767	0	0.01	2444
2345 (R)	MV55 – LO		–32768	32767	0	0.01	2445
2346 (R)	MV56 – HI		–32768	32767	0	0.01	2446
2347 (R)	MV56 – LO		–32768	32767	0	0.01	2447
2348 (R)	MV57 – HI		–32768	32767	0	0.01	2448
2349 (R)	MV57 – LO		–32768	32767	0	0.01	2449
2350 (R)	MV58 – HI		–32768	32767	0	0.01	2450

Table E.35 Modbus Map[a] (Sheet 36 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
2351 (R)	MV58 – LO		–32768	32767	0	0.01	2451
2352 (R)	MV59 – HI		–32768	32767	0	0.01	2452
2353 (R)	MV59 – LO		–32768	32767	0	0.01	2453
2354 (R)	MV60 – HI		–32768	32767	0	0.01	2454
2355 (R)	MV60 – LO		–32768	32767	0	0.01	2455
2356 (R)	MV61 – HI		–32768	32767	0	0.01	2456
2357 (R)	MV61 – LO		–32768	32767	0	0.01	2457
2358 (R)	MV62 – HI		–32768	32767	0	0.01	2458
2359 (R)	MV62 – LO		–32768	32767	0	0.01	2459
2360 (R)	MV63 – HI		–32768	32767	0	0.01	2460
2361 (R)	MV63 – LO		–32768	32767	0	0.01	2461
2362 (R)	MV64 – HI		–32768	32767	0	0.01	2462
2363 (R)	MV64 – LO		–32768	32767	0	0.01	2463
2364 – 2373 (R)	Reserved						2464–2473
Device Counters							
2374 – 2405 (R)	COUNTER SC33–COUNTER SC64		0	65000	0	1	2474–2505
2406 – 2415 (R)	Reserved						2506–2515
Fixed GOOSE Analogs							
2416 (R)	FG1 RCV ANA01-H		–32768	32767	0	0.01	2516
2417 (R)	FG1 RCV ANA01-L		–32768	32767	0	0.01	2517
2418 (R)	FG1 RCV ANA02-H		–32768	32767	0	0.01	2518
2419 (R)	FG1 RCV ANA02-L		–32768	32767	0	0.01	2519
2420 (R)	FG1 RCV ANA03-H		–32768	32767	0	0.01	2520
2421 (R)	FG1 RCV ANA03-L		–32768	32767	0	0.01	2521
2422 (R)	FG1 RCV ANA04-H		–32768	32767	0	0.01	2522
2423 (R)	FG1 RCV ANA04-L		–32768	32767	0	0.01	2523
2424 (R)	FG1 RCV ANA05-H		–32768	32767	0	0.01	2524
2425 (R)	FG1 RCV ANA05-L		–32768	32767	0	0.01	2525
2426 (R)	FG1 RCV ANA06-H		–32768	32767	0	0.01	2526
2427 (R)	FG1 RCV ANA06-L		–32768	32767	0	0.01	2527
2428 (R)	FG1 RCV ANA07-H		–32768	32767	0	0.01	2528
2429 (R)	FG1 RCV ANA07-L		–32768	32767	0	0.01	2529
2430 (R)	FG1 RCV ANA08-H		–32768	32767	0	0.01	2530
2431 (R)	FG1 RCV ANA08-L		–32768	32767	0	0.01	2531
2432 (R)	FG2 RCV ANA01-H		–32768	32767	0	0.01	2532
2433 (R)	FG2 RCV ANA01-L		–32768	32767	0	0.01	2533
2434 (R)	FG2 RCV ANA02-H		–32768	32767	0	0.01	2534
2435 (R)	FG2 RCV ANA02-L		–32768	32767	0	0.01	2535
2436 (R)	FG2 RCV ANA03-H		–32768	32767	0	0.01	2536
2437 (R)	FG2 RCV ANA03-L		–32768	32767	0	0.01	2537
2438 (R)	FG2 RCV ANA04-H		–32768	32767	0	0.01	2538
2439 (R)	FG2 RCV ANA04-L		–32768	32767	0	0.01	2539
2440 (R)	FG2 RCV ANA05-H		–32768	32767	0	0.01	2540
2441 (R)	FG2 RCV ANA05-L		–32768	32767	0	0.01	2541
2442 (R)	FG2 RCV ANA06-H		–32768	32767	0	0.01	2542

Table E.35 Modbus Map[a] (Sheet 37 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
2443 (R)	FG2 RCV ANA06-L		–32768	32767	0	0.01	2543
2444 (R)	FG2 RCV ANA07-H		–32768	32767	0	0.01	2544
2445 (R)	FG2 RCV ANA07-L		–32768	32767	0	0.01	2545
2446 (R)	FG2 RCV ANA08-H		–32768	32767	0	0.01	2546
2447 (R)	FG2 RCV ANA08-L		–32768	32767	0	0.01	2547
2448 (R)	FG3 RCV ANA01-H		–32768	32767	0	0.01	2548
2449 (R)	FG3 RCV ANA01-L		–32768	32767	0	0.01	2549
2450 (R)	FG3 RCV ANA02-H		–32768	32767	0	0.01	2550
2451 (R)	FG3 RCV ANA02-L		–32768	32767	0	0.01	2551
2452 (R)	FG3 RCV ANA03-H		–32768	32767	0	0.01	2552
2453 (R)	FG3 RCV ANA03-L		–32768	32767	0	0.01	2553
2454 (R)	FG3 RCV ANA04-H		–32768	32767	0	0.01	2554
2455 (R)	FG3 RCV ANA04-L		–32768	32767	0	0.01	2555
2456 (R)	FG3 RCV ANA05-H		–32768	32767	0	0.01	2556
2457 (R)	FG3 RCV ANA05-L		–32768	32767	0	0.01	2557
2458 (R)	FG3 RCV ANA06-H		–32768	32767	0	0.01	2558
2459 (R)	FG3 RCV ANA06-L		–32768	32767	0	0.01	2559
2460 (R)	FG3 RCV ANA07-H		–32768	32767	0	0.01	2560
2461 (R)	FG3 RCV ANA07-L		–32768	32767	0	0.01	2561
2462 (R)	FG3 RCV ANA08-H		–32768	32767	0	0.01	2562
2463 (R)	FG3 RCV ANA08-L		–32768	32767	0	0.01	2563
2464 (R)	FG4 RCV ANA01-H		–32768	32767	0	0.01	2564
2465 (R)	FG4 RCV ANA01-L		–32768	32767	0	0.01	2565
2466 (R)	FG4 RCV ANA02-H		–32768	32767	0	0.01	2566
2467 (R)	FG4 RCV ANA02-L		–32768	32767	0	0.01	2567
2468 (R)	FG4 RCV ANA03-H		–32768	32767	0	0.01	2568
2469 (R)	FG4 RCV ANA03-L		–32768	32767	0	0.01	2569
2470 (R)	FG4 RCV ANA04-H		–32768	32767	0	0.01	2570
2471 (R)	FG4 RCV ANA04-L		–32768	32767	0	0.01	2571
2472 (R)	FG4 RCV ANA05-H		–32768	32767	0	0.01	2572
2473 (R)	FG4 RCV ANA05-L		–32768	32767	0	0.01	2573
2474 (R)	FG4 RCV ANA06-H		–32768	32767	0	0.01	2574
2475 (R)	FG4 RCV ANA06-L		–32768	32767	0	0.01	2575
2476 (R)	FG4 RCV ANA07-H		–32768	32767	0	0.01	2576
2477 (R)	FG4 RCV ANA07-L		–32768	32767	0	0.01	2577
2478 (R)	FG4 RCV ANA08-H		–32768	32767	0	0.01	2578
2479 (R)	FG4 RCV ANA08-L		–32768	32767	0	0.01	2579
2480 – 2499 (R)	Reserved						2580–2599
97FM Element							
2500 (R)	97FM1 - HI		–32768	32767	0	0.01	2600
2501 (R)	97FM1 - LO		–32768	32767	0	0.01	2601
2502 (R)	97FM2 - HI		–32768	32767	0	0.01	2602
2503 (R)	97FM2 - LO		–32768	32767	0	0.01	2603
2504 (R)	97FM3 - HI		–32768	32767	0	0.01	2604
2505 (R)	97FM3 - LO		–32768	32767	0	0.01	2605

Table E.35 Modbus Map[a] (Sheet 38 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
2506 (R)	97FM4 - HI		–32768	32767	0	0.01	2606
2507 (R)	97FM4 - LO		–32768	32767	0	0.01	2607
2508 (R)	97FM5 - HI		–32768	32767	0	0.01	2608
2509 (R)	97FM5 - LO		–32768	32767	0	0.01	2609
2510 (R)	97FM6 - HI		–32768	32767	0	0.01	2610
2511 (R)	97FM6 - LO		–32768	32767	0	0.01	2611
2512 (R)	97FM7 - HI		–32768	32767	0	0.01	2612
2513 (R)	97FM7 - LO		–32768	32767	0	0.01	2613
2514 (R)	97FM8 - HI		–32768	32767	0	0.01	2614
2515 (R)	97FM8 - LO		–32768	32767	0	0.01	2615
2516 (R)	97FM9 - HI		–32768	32767	0	0.01	2616
2517 (R)	97FM9 - LO		–32768	32767	0	0.01	2617
2518 (R)	97FM0 - HI		–32768	32767	0	0.01	2618
2519 (R)	97FM0 - LO		–32768	32767	0	0.01	2619
Control I/O Commands							
2000H (Hex) (W)	LOGIC COMMAND 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		0	65535	0	na	
2001H (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	1023	0	na	
2002H (W)	LOGIC COMMAND Bit 0 = CLOSE 3-POSITION IN-LINE DISCONNECT 1 Bit 1 = OPEN 3-POSITION IN-LINE DISCONNECT 1 Bit 2 = CLOSE 3-POSITION EARTHING DISCONNECT 1 Bit 3 = OPEN 3-POSITION EARTHING DISCONNECT 1 Bit 4 = CLOSE 3-POSITION IN-LINE DISCONNECT 2 Bit 5 = OPEN 3-POSITION IN-LINE DISCONNECT 2 Bit 6 = CLOSE 3-POSITION EARTHING DISCONNECT 2 Bit 7 = OPEN 3-POSITION EARTHING DISCONNECT 2 Bit 8 = CLOSE 2-POSITION DISCONNECT 1 Bit 9 = OPEN 2-POSITION DISCONNECT 1 Bit 10 = CLOSE 2-POSITION DISCONNECT 2 Bit 11 = OPEN 2-POSITION DISCONNECT 2 Bit 12 = CLOSE 2-POSITION DISCONNECT 3 Bit 13 = OPEN 2-POSITION DISCONNECT 3 Bit 14 = CLOSE 2-POSITION DISCONNECT 4 Bit 15 = OPEN 2-POSITION DISCONNECT 4		0	255	0	na	

Table E.35 Modbus Map[a] (Sheet 39 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
2003H (W)	LOGIC COMMAND Bit 0 = 2 POS DISCONNECT 5 CLOSE Bit 1 = 2 POS DISCONNECT 5 OPEN Bit 2 = 2 POS DISCONNECT 6 CLOSE Bit 3 = 2 POS DISCONNECT 6 OPEN Bit 4 = 2 POS DISCONNECT 7 CLOSE Bit 5 = 2 POS DISCONNECT 7 OPEN Bit 6 = 2 POS DISCONNECT 8 CLOSE Bit 7 = 2 POS DISCONNECT 8 OPEN Bit 8–Bit15 = Reserved		0	255	0	na	
Relay Elements							
2100H (R)	FAST STATUS 0 Bit 0 = Faulted/Trip Bit 1 = Warning Bit 2 = IN101 Status Bit 3 = IN102 Status Bit 4 = IN401 Status Bit 5 = IN402 Status Bit 6 = IN403 Status Bit 7 = Reserved Bit 8 = OUT101 Status Bit 9 = OUT102 Status Bit 10 = OUT401 Status Bit 11 = OUT402 Status Bit 12 = OUT403 Status Bit 13 = OUT404 Status Bit 14 = Reserved Bit 15 = Reserved		0	65535	0	na	
2101H (R)	FAST STATUS 1 Bit 0 = Enabled Bit 1 = Reserved Bit 2 = IN404 Status Bit 3 = IN501 Status Bit 4 = IN502 Status Bit 5 = IN503 Status Bit 6 = IN504 Status Bit 7 = Reserved Bit 8 = OUT501 Status Bit 9 = OUT502 Status Bit 10 = OUT503 Status Bit 11 = OUT504 Status Bit 12 = OUT405 Status Bit 13 = OUT406 Status Bit 14 = OUT407 Status Bit 15 = OUT408 Status		0	65535	0	na	
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	
210AH (R)	Reserved[d]					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[d]						

Table E.35 Modbus Map[a] (Sheet 40 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
2110H (R)	FAST STATUS 2		0	65535	0	na	
	Bit 0 = IN301 Status; Bit 8 = OUT301 Status						
	Bit 1 = IN302 Status; Bit 9 = OUT302 Status						
	Bit 2 = IN303 Status; Bit 10 = OUT303 Status						
	Bit 3 = IN304 Status; Bit 11 = OUT304 Status						
	Bit 4 = IN305 Status; Bit 12 = OUT305 Status						
	Bit 5 = IN306 Status; Bit 13 = OUT306 Status						
	Bit 6 = IN307 Status; Bit 14 = OUT307 Status						
	Bit 7 = IN308 Status; Bit 15 = OUT308 Status						
2111H (R)	FAST STATUS 3		0	65535	0	na	
	Bit 0 = IN405 Status; Bit 8 = OUT505 Status						
	Bit 1 = IN406 Status; Bit 9 = OUT506 Status						
	Bit 2 = IN407 Status; Bit 10 = OUT507 Status						
	Bit 3 = IN408 Status; Bit 11 = OUT508 Status						
	Bit 4 = IN505 Status; Bit 12–15 = Reserved						
	Bit 5 = IN506 Status						
	Bit 6 = IN507 Status						
	Bit 7 = IN508 Status						
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)	BREAKER MON TIME		896	899	896		
3016H (R)	MAX/MIN MTR DATA		900	1089	900		
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		

Table E.35 Modbus Map[a] (Sheet 41 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
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	1981	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	1981	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	
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[d]						

Table E.35 Modbus Map[a] (Sheet 42 of 42)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Numbers
4014H (R)	CONFIGURED BIT Bit 0 = Unit Configured Bits 1–15 = Reserved				0	na	
4015H (R)	Reserved[d]						
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[d]						

[a] All addresses in this table refer to the register addresses in the Modbus packet.
[b] Registers labeled (R/W) are read-write registers. Registers labeled (W) are write-only registers. Registers labeled (R) are read-only registers.
[c] Register value * Multiplier = System value as seen by the relay. For example, if the register 321 (IA angle) reads 300 in decimal, then the system value is 30 deg (Multiplier = 0.1).
[d] Reserved addresses return 0.
[e] In firmware versions prior to R400-V0, the power supply voltage self-tests are different from what is shown. Refer to *Table E.36* for the correct Modbus register addresses for these self-tests.
[f] Read this register only when the PT connection is DELTA.
[g] Read this register only when the PT connection is WYE.

Table E.36 Modbus Addresses for the Self-Test Registers in Firmware Versions Prior to R400

Modbus Register Address[a]		Name/Enums	Units	Min	Max	Default	Multiplier[b]	DeviceNet Parameter Numbers
290	(R)	+0.9 V STATUS		0	2	0	1	390
291	(R)	+1.2 V STATUS		0	2	0	1	391
292	(R)	+1.5 V STATUS		0	2	0	1	392
293	(R)	+1.8 V STATUS		0	2	0	1	393
294	(R)	+2.5 V STATUS		0	2	0	1	394
295	(R)	+3.3 V STATUS		0	2	0	1	395
296	(R)	+3.75 V STATUS		0	2	0	1	396
297	(R)	+5.0 V STATUS		0	2	0	1	397
298	(R)	–1.25 V STATUS		0	2	0	1	398
299	(R)	–5.0 V STATUS		0	2	0	1	399
316–319	(R)	Reserved[c]						

[a] Registers labeled (R/W) are read-write registers. Registers labeled (W) are write-only registers. Registers labeled (R) are read-only registers.
[b] Register value * Multiplier = System value as seen by the relay. For example, if register 321 (IA angle) reads 300 in decimal, then the system value is 30 deg (Multiplier = 0.1).
[c] Reserved addresses return 0.

Table E.37 Trigger Conditions for the Trip/Warn Status Register Bits (Sheet 1 of 2)

Register #	Bit #	Description	Trigger Condition
1730	—	TRIP STATUS LO	—
	Bit 0	PHASE A1 50	50A1P
	Bit 1	PHASE B1 50	50B1P
	Bit 2	PHASE C1 50	50C1P
	Bit 3	PHASE 50P1	50P1T
	Bit 4	GROUND 50G1	50G1T
	Bit 5	NEUTRAL 50N1	50N1T
	Bit 6	NEG SEQ 50Q1	50Q1T
	Bit 7	PHASE A 51	51AT
	Bit 8	PHASE B 51	51BT
	Bit 9	PHASE C 51	51CT
	Bit 10	PHASE 51P1	51P1T
	Bit 11	GROUND 51G1	51G1T
	Bit 12	NEUTRAL 51N1	51N1T
	Bit 13	NEG SEQ 51Q	51QT
	Bit 14	UNDERVOLT 27P1	27P1T
	Bit 15	OVERVOLT 59P1	59P1T
1731	—	TRIP STATUS HI	—
	Bit 0	POWER FACTOR 55	55T
	Bit 1	FREQUENCY 81D1	81D1T
	Bit 2	FREQUENCY 81D2	81D2T
	Bit 3	RTD-OTHER	OTHTRIP
	Bit 4	RTD-AMBIENT	AMBTRIP
	Bit 5	RTD-WIND BEAR	RTDT
	Bit 6	RTD ERROR	RTDFLT
	Bit 7	POWER ELEMENTS	3PWR1T OR 3 PWR2T
	Bit 8	COMM IDLE	COMMIDLE
	Bit 9	COMM LOSS	COMMLOSS
	Bit 10	REMOTE TRIP	REMTRIP
	Bit 11	COMM FAULT	COMMFLT
	Bit 12	CONFIG FAULT	ALARMCR
	Bit 13	RESERVED	—
	Bit 14	RESERVED	—
	Bit 15	BREAKER FAIL	BFT OR BFTRIP

Table E.37 Trigger Conditions for the Trip/Warn Status Register Bits (Sheet 2 of 2)

Register #	Bit #	Description	Trigger Condition
1732	—	WARN STATUS LO	—
	Bit 0	PHASE 50P2	50P2T
	Bit 1	PHASE 50P3	50P3T
	Bit 2	PHASE 50P4	50P4T
	Bit 3	GROUND 50G2	50G2T
	Bit 4	GROUND 50G3	50G3T
	Bit 5	GROUND 50G4	50G4T
	Bit 6	NEUTRAL 50N2	50N2T
	Bit 7	NEUTRAL 50N3	50N3T
	Bit 8	NEUTRAL 50N4	50N4T
	Bit 9	NEG SEQ 50Q2	50Q2T
	Bit 10	NEG SEQ 50Q3	50Q3T
	Bit 11	NEG SEQ 50Q4	50Q4T
	Bit 12	PHASE 51P2	51P2T
	Bit 13	GROUND 51G2	51G2T
	Bit 14	NEUTRAL 51N2	51N2T
	Bit 15	RESERVED	—
1733	—	WARN STATUS HI	—
	Bit 0	POWER FACTOR 55	55A
	Bit 1	SALARM	SALARM
	Bit 2	WARNING	WARNING
	Bit 3	RTD-WIND BEAR	RTDA
	Bit 4	RTD-OTHER	OTHALRM
	Bit 5	RTD-AMBIENT	AMBALRM
	Bit 6	UNDERVOLT 27P2	27P2T
	Bit 7	OVERVOLT 59P2	59P2T
	Bit 8	FREQUENCY 81D3	81D3T
	Bit 9	FREQUENCY 81D4	81D4T
	Bit 10–15	RESERVED	—
1734	—	TRIP STATUS 1 LO	—
	Bit 0	PHASE A2 50	50A2P
	Bit 1	PHASE B2 50	50B2P
	Bit 2	PHASE C2 50	50C2P
	Bit 3–15	RESERVED	—

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Appendix F
EtherNet/IP Communications

Overview

EtherNet/IP, or Ethernet/Industrial Protocol, is an industrial protocol that uses standard Ethernet and TCP/IP technology to transport Common Industrial Protocol (CIP) packets.

The SEL-751 Feeder Protection Relay supports EtherNet/IP. This section discusses general specifications for EtherNet/IP implementation, as well as the CIP data model, the allocation of the CIP connections, the EtherNet/IP Port 1 settings, and the Electronic Data Sheet (EDS) file in the SEL-751.

The SEL-751 supports two ways of exchanging data via EtherNet/IP.

➤ **Implicit Message Adapter.** The I/O data are mapped into Assembly object instances. The SEL-751 exchanges these I/O data via EtherNet/IP Implicit Class 1 connections with a remote EtherNet/IP Scanner device using UDP packets.

➤ **Explicit Message Server.** The I/O data are mapped into Assembly object instances. The SEL-751 responds to generic TCP EtherNet/IP Explicit message requests initiated by a remote EtherNet/IP Client device.

For more information on EtherNet/IP, visit www.odva.org.

Specifications

Table F.1 EtherNet/IP Specifications (Sheet 1 of 2)

EtherNet/IP Services
Implicit Message Adapter (Class 1)
Explicit Message Server (Class 3 and unconnected)
CIP Model—Implemented Objects
Identity Object
Message Router Object
Assembly Object
Connection Manager Object
File Object
TCP/IP Interface Object
Ethernet Link Object
Vendor Specific Object

Table F.1 EtherNet/IP Specifications (Sheet 2 of 2)

Implicit Message Adapter	
Number of Connections	As many as eight (two Class 1 connections and six Class 3/unconnected connections)
Class 1 Connection Types	Unicast Multicast
Class 1 Connection Transport Types	Exclusive Owner Input Only Listen Only
Class 1 Connection Trigger Types	Cyclic Change of State
Input Only Heartbeat Connection Point	238
Listen Only Heartbeat Connection Point	237

CIP Data Model

Profile

Table F.2 CIP Data Model Profile

Class Name	Class ID	Number of Instances
Identity Object	0x01	1
Message Router Object	0x02	1
Assembly Object	0x04	Determined by the user/based on the application
Connection Manager Object	0x06	1
File Object	0x37	2
TCP/IP Interface Object	0xF5	1
Ethernet Link Object	0xF6	See *Ethernet Link Object (0xF6)*
Vendor Specific Object	0x64	1

Identity Object (0x01)

Instances Implemented

The SEL-751 supports one instance (Instance ID = 1) of the Identity Object.

Table F.3 Identity Object List of Attributes (Sheet 1 of 2)

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	1	The revision of this CIP Object
2	Max Instance	GET	UINT	1	The maximum Identity Object Instance ID
3	Number of Instances	GET	UINT	1	Total number of Identity Objects
4	Optional Attribute List	GET	[UINT, Array of UINT]	[1, [21]]	[Number of Optional Instance Attributes, List of Optional Instance Attributes]

Table F.3 Identity Object List of Attributes (Sheet 2 of 2)

Attribute ID	Name	Access	Data Type	Default	Description
6	Maximum ID Number Class Attributes	GET	UINT	7	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	21	Maximum Instance Attribute ID
Instance Attributes					
1	Vendor ID	GET	UINT	865	
2	Device Type	GET	UINT	0x2B	
3	Product Code	GET	UINT		The most significant byte is the Device Code (DEVCODE as found in the **ID** command of the SEL-751) and its least significant byte is the user-configurable Configuration ID as provided in the Ethernet port settings
4	[Major Revision, Minor Revision]	GET	[USINT, USINT]	[1,1]	
5	Status	GET	WORD		Refer to *Table F.4*
6	Serial Number	GET	UDINT		The low-order 32 bits of the MAC address of the Ethernet port
7	Product Name	GET	STRING		The existing default product name (the default RID string) of the SEL-751 plus the value of the user-configurable Configuration ID as provided in the Ethernet port settings. The general format is, "<Default RID>-<Configuration ID>".
21	Catalog Number	GET	STRING		The existing default product name (the default RID string) of the SEL-751 plus the value of the user-configurable Configuration ID as provided in the Ethernet port settings. The general format is, "<Default RID>-<Configuration ID>".

Table F.4 Status WORD Bits Descriptions

Bit Number[a]	Name	Description
0	Owned	TRUE, if at least one scanner has established an Exclusive Owner Class 1 connection to the SEL-751. FALSE, if the SEL-751 has no active Exclusive Owner connections to a scanner.
2	Configured	Always TRUE.
4 to 7	Extended Device Status	Hexadecimal value: 2: A Class 1 connection has timed out. 3: No Class 1 connection has been established. 6: At least one Class 1 connection is active. 7: In any other case.
11	Major Unrecoverable Fault	TRUE if the product is disabled due to an unrecoverable fault; otherwise, it is FALSE.

[a] The Status WORD bits not listed in this table are always set to FALSE.

Table F.5 Identity Object Supported Services

Service Code	Service Name	Class	Instance	Description
0x01	Get Attributes All	Yes	Yes	Returns a list of all of the values of the attributes.
0x05	Reset	No	Yes	Restarts the EtherNet/IP service in the SEL-751. Only reset type 0 is allowed.
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.

Message Router Object (0x02)

Table F.6 Message Router Object List of Attributes

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	1	The revision of this CIP Object
2	Max Instance	GET	UINT	1	The maximum Message Router Object Instance ID
3	Number of Instances	GET	UINT	1	Total number of Message Router Object Instances
4	Optional Attribute List	GET	[UINT, Array of UINT]	[3,[1,2,3]]	[Number of Optional Instance Attributes, List of Optional Instance Attributes]
5	Optional Service List	GET	[UINT, Array of UINT]	[1,[10]]	Number of Optional Service Codes followed by the List of Optional Service Codes
6	Maximum ID Number Class Attributes	GET	UINT	7	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	3	Maximum Instance Attribute ID
Instance Attributes					
1	Class List	GET	[UINT, Array of UINT]		Implemented object list
2	Maximum Connections	GET	UINT		Maximum number of connections supported
3	Number of Connections	GET	UINT		Number of connections currently used

Table F.7 Message Router Supported Services

Service Code	Service Name	Class	Instance	Description
0x01	Get Attribute All	Yes	Yes	Returns a list of all of the attributes.
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.
0x0A	Multiple Service Packet	No	Yes	

Assembly Object (0x04)

Instances Implemented

The SEL-751 settings define the number of Assembly Object Instances based on the number and type of connections configured and the data content of each instance. Each assembly is as large as 500 bytes in size. The SEL-751 supports a total of six assemblies (three Input Assemblies and three Output Assemblies).

Table F.8 Assembly Object List of Attributes

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	2	The revision of this CIP Object
2	Max Instance	GET		Determined by the settings	The maximum Assembly Object Instance ID defined by the user
3	Number of Instances	GET		Determined by the settings	Total number of Assembly Object instances defined by the user
4	Optional Attribute List	GET	[UINT, Array of UINT]	[1,[4]]	[Number of Optional Instance Attributes, List of Optional Instance Attributes]
6	Maximum ID Number Class Attributes	GET	UINT	7	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	4	Maximum Instance Attribute ID
Instance Attributes					
1	Number of Members	GET	UINT		Number of Assembly Members defined by the user
2	Member List	GET	Array of [UINT, UINT, EPATH]		Only 500 bytes are allowed
3	Data	GET, SET	Array of Bytes		Data map defined with **SET E 1**, **2**, or **3**
4	Size	GET	UINT		Number of bytes in Instance Attribute 3

Table F.9 Assembly Object Supported Services

Service Code	Service Name	Class	Instance	Description
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.
0x10	Set Attribute Single	No	Yes	Sets the value of a specific attribute.
0x18	Get Member	No	Yes	Returns the value of a member of the data attribute.
0x19	Set Member	No	Yes	Modifies the value of a member of the data attribute.

Connection Manager Object (0x06)

Table F.10 Connection Manager Object List of Attributes

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	1	The revision of this CIP Object
2	Max Instance	GET	UINT		The maximum Connection Manager Object Instance ID
3	Number of Instances	GET	UINT		Total number of Connection Manager Object Instances
4	Optional Attribute List	GET	[UINT, Array of UINT]	[8,[1,2,3,4,5,6,7,8]]	[Number of Optional Instance Attributes, List of Optional Instance Attributes]
6	Maximum ID Number Class Attributes	GET	UINT	7	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	8	Maximum Instance Attribute ID
Instance Attributes					
1	Open Requests	GET/SET	UINT		Number of FWD Open service requests received
2	Open Format Rejects	GET/SET	UINT		Number of FWD Open service requests rejected because of bad format
3	Open Resource Rejects	GET/SET	UINT		Number of FWD Open service requests rejected because of lack of resources
4	Open Other Rejects	GET/SET	UINT		Number of FWD Open service requests rejected for reasons other than bad format or lack or resources
5	Close Requests	GET/SET	UINT		Number of FWD Close service requests received
6	Close Format Rejects	GET/SET	UINT		Number of FWD Close service requests rejected because of bad format
7	Close Other Rejects	GET/SET	UINT		Number of FWD Open service requests rejected for reasons other than bad format
8	Connection Timeouts	GET/SET	UINT		Number of connection timeouts

Table F.11 Connection Manager Object Supported Services (Sheet 1 of 2)

Service Code	Service Name	Class	Instance	Description
0x01	Get Attribute All	Yes	Yes	Returns a list of all of the attributes.
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.
0x10	Set Attribute Single	No	Yes	Sets the value of a specific attribute.
0x02	Set Attribute All	No	Yes	Sets the value of all attributes.
0x54	Forward Open	No	Yes	Establishes a CIP connection.
0x4E	Forward Close	No	Yes	Closes a CIP connection.

Table F.11 Connection Manager Object Supported Services (Sheet 2 of 2)

Service Code	Service Name	Class	Instance	Description
0x5B	Large Forward Open	No	Yes	Establishes a CIP connection that allows a large connection size.
0x5A	Get Connection Owner	No	Yes	Returns data about the connection that owns the object.

File Object (0x37)

The File Object stores the EDS and icon files. The EDS file is generated by the SEL-751 based on the EtherNet/IP Port 1 settings and the SET E 1, 2, or 3 settings. The relay can retrieve the file using the File Object services. You cannot write an EDS file to the relay using the File Object services.

The SEL-751 implements two instances of the File Object:

➤ Instance 0xC8 returns an uncompressed version of the EDS file with an embedded icon.

➤ Instance 0xC9 returns a compressed version of the icon file.

Table F.12 File Object List of Attributes (Sheet 1 of 2)

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	1	The revision of this CIP Object
2	Max Instance	GET	UINT	201	
3	Number of Instances	GET	UINT	2	
6	Maximum ID Number Class Attributes	GET	UINT	32	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	11	Maximum Instance Attribute ID
32	Directory	GET	[UINT, STRINGI, STRINGI] [UINT, STRINGI, STRINGI]	[0xC8,(ENG)‘EDS and Icon Files’, (ENG)‘EDS.txt’] [0xC9, (ENG)‘Related EDS and Icon Files’, (ENG) ‘EDSCollection.gz’]	List of all File Object instance and file names present in the SEL-751 and the associated instance numbers
0xC8 Instance Attributes					
1	State	GET	USINT	2	
2	Instance Name	GET	STRINGI	(ENG)‘EDS and Icon Files’	
3	File Format Version	GET	UINT	1	
4	File Name	GET	STRINGI	(ENG)‘EDS.txt’	
5	File Revision	GET	[USINT, USINT]		[Major EDS revision Ethernet port setting, Minor EDS revision Ethernet port setting]
6	File Size	GET	UDINT		Size of the EDS file in bytes
7	File Checksum	GET	UINT		Checksum of the EDS file (2s complement of the 16-bit sum of all octets in the file)
8	Invocation Method	GET	USINT	255	

Table F.12 File Object List of Attributes (Sheet 2 of 2)

Attribute ID	Name	Access	Data Type	Default	Description
9	File Save Parameters	GET	USINT	0	
10	File Access Rule	GET	USINT	1	
11	File Encoding Format	GET	USINT	0	
0xC9 Instance Attributes					
1	State	GET	USINT	2	
2	Instance Name	GET	STRINGI	(ENG)‘Related EDS and Icon Files’	
3	File Format Version	GET	UINT	1	
4	File Name	GET	STRINGI	(ENG)‘EDSCollection.gz’	
5	File Revision	GET	[USINT, USINT]	[1,1]	[Major Revision, Minor Revision]
6	File Size	GET	UDINT		Size of the loaded file in bytes
7	File Checksum	GET	UINT		Checksum of the EDSCollection file (2s complement of the 16-bit sum of all octets in the file)
8	Invocation Method	GET	USINT	255	
9	File Save Parameters	GET	USINT	0	
10	File Access Rule	GET	USINT	1	
11	File Encoding Format	GET	USINT	1	

Table F.13 File Object Supported Services

Service Code	Service Name	Class	Instance	Description
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.
0x4B	Initiate Upload	No	Yes	
0x4F	Upload Transfer	No	Yes	

TCP/IP Interface Object (0xF5)

Instances Implemented

The number of instances of the TCP/IP Interface Object is always 1, regardless of whether the CPU card contains a single Ethernet port or a dual Ethernet port.

Table F.14 TCP/IP Interface Object List of Attributes (Sheet 1 of 3)

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	4	The revision of this CIP Object
2	Max Instance	GET	UINT	1	The maximum TCP/IP Object Instance ID
3	Number of Instances	GET	UINT	1	Total number of TCP/IP Object Instances

Table F.14 TCP/IP Interface Object List of Attributes (Sheet 2 of 3)

Attribute ID	Name	Access	Data Type	Default	Description
4	Optional Attribute List	GET	[UINT, Array of UINT]	[4,[8,9,16,17]]	[Number of Optional Instance Attributes, List of Optional Instance Attributes]
6	Maximum ID Number Class Attributes	GET	UINT	7	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	17	Maximum Instance Attribute ID
Instance Attributes					
1	Status	GET	DWORD	2	
2	Configuration Capability	GET	DWORD	32	Any change in the configuration will be updated when the server is restarted
3	Configuration Control	GET	DWORD	0	IP addresses must be configured statically. DHCP and DNS are not supported.
4	Physical Link Object	GET	[UINT, EPATH]		[Path size, Path to the corresponding Ethernet link object instance] For a dual Ethernet port CPU card, the value is 00 00 (path size of 0). For a single Ethernet port CPU card, the value is 02 00 20 F6 24 01, where 02 00 is the path size (number of 16-bit words), 20 is the 8-bit class segment type, F6 is the Ethernet Link Object class, 24 is the 8-bit instance segment type, and 01 is Instance 1.
5	Interface Configuration	GET	[UDINT, UDINT, UDINT, UDINT, UDINT, STRING]		[IP address, Network mask, Gateway address, 0, 0, null]
6	Host Name	GET	STRING		When converted to ASCII, this displays, "[Product Name]-[Serial Number]". This attribute cannot be set by the scanner.
8	TTL Value	GET/SET	USINT	1	The scanner can set this attribute
9	Mcast Config	GET/SET	[USINT, USINT, UINT, UDINT]	[Alloc control, Reserved, Num Mcast, Mcast Start Address]	The scanner can set this attribute only if the control is 01 00. 1st and 2nd Byte: This represents the control. When the value is 00 00, the scanner cannot change the number of multicast connections nor the Mcast Start Address. To change these, all eight bytes must be written at once, e.g., 01 00 *xx xx yy yy yy yy*. 3rd and 4th Byte: Number of multicast connections supported by the product in little endian order. 02 00 is the default value. The maximum number of multicast connections supported is 2. 5th–8th Byte: Mcast Start Address according to the default algorithm specified in Section 3-5.3 of Volume 2 of the standard.
13	Encapsulation Inactivity Timeout	GET/SET	UINT	120	The scanner can set this value

Table F.14 TCP/IP Interface Object List of Attributes (Sheet 3 of 3)

Attribute ID	Name	Access	Data Type	Default	Description
16	Active TCP Connections	GET	UINT	1	
17	Non-CIP Encapsulation Messages per Second	GET	UDINT	0	

Table F.15 TCP/IP Interface Object Supported Services

Service Code	Service Name	Class	Instance	Description
0x01	Get Attribute All	Yes	Yes	Returns a list of all of the attributes.
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.
0x10	Set Attribute Single	No	Yes	Sets the value of a specific attribute.

Ethernet Link Object (0xF6)

Instances Implemented

The number of instances of the Ethernet Link Object depends on whether the CPU card contains a single Ethernet port or a dual Ethernet port. The value will be 1 for a single Ethernet port and 2 for a dual Ethernet port.

Table F.16 Ethernet Link Object List of Attributes

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	4	The revision of this CIP Object
2	Max Instance	GET	UINT		The maximum Ethernet Link Object Instance ID
3	Number of Instances	GET	UINT		Total number of Ethernet Link Object Instances
4	Optional Attribute List	GET	[UINT, Array of UINT]	[1,[10]]	[Number of Optional Instance Attributes, List of Optional Instance Attributes]
6	Maximum ID Number Class Attributes	GET	UINT	7	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	11	Maximum Instance Attribute ID
Instance Attributes					
1	Interface Speed	GET	UINT		Speed (MBPS) in use on the corresponding interface
2	Interface Flags	GET	DWORD		See *Table F.17*
3	Physical Address	GET	USINT[6]		MAC address of the corresponding interface
10	Interface Label	GET	STRING		SEL-751 interface name, e.g., “PORT 1”
11	Interface Capability	GET	[DWORD, USINT]		[Capability bits, Array Element Count]

Table F.17 Interface Flags Bits Descriptions

Bit Number	Name	Description
0	Link Status	0: The Ethernet interface link is inactive. 1: The link is active.
1	Half/Full Duplex	0: The interface is running half duplex. 1: The interface is running full duplex.
2–4	Negotiation Status	Octal unsigned value: 0: Auto negotiation in progress. 1: Auto negotiation and speed detection failed. Using default values. 2: Auto negotiation failed, but detected speed. 3: Successfully negotiated speed and duplex. 4: Auto negotiation not attempted.
5	Manual Setting Requires Reset	Set to 1.

Table F.18 Ethernet Link Object Supported Services

Service Code	Service Name	Class	Instance	Description
0x01	Get Attribute All	Yes	Yes	Returns a list of all of the attributes.
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.

Vendor Specific Object (0x64)

Instances Implemented

The SEL-751 supports one instance (Instance ID = 1) of the Vendor Specific Object.

Table F.19 Vendor Specific Object List of Attributes

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	1	The revision of this CIP Object
2	Max Instance	GET	UINT	1	The maximum Vendor Specific Object Instance ID
3	Number of Instances	GET	UINT	1	Total number of Vendor Specific Object Instances
Instance Attributes					
100	Enabled[a]	GET	BOOL		Relay Enabled Status
101	Trip	GET	BOOL		Protection Trip

[a] This attribute reflects the value of the Relay Word bit indicating Enabled status of the SEL-751.

Table F.20 Vendor Specific Object Supported Services

Service Code	Service Name	Class	Instance	Description
0x01	Get Attribute All	Yes	Yes	Returns a list of all of the attributes.
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.

CIP Connections and Corresponding Assembly Map

The SEL-751 supports as many as eight simultaneous CIP connections. Of the eight simultaneous connections, as many as two of them can be Class 1 (I/O) connections and as many as six of them can be a combination of Class 3 messages and Unconnected Message Manager (UCMM) messages. Class 3 connections are created internally by the SEL-751 when the appropriate connection is made by the EtherNet/IP scanner.

When configuring EtherNet/IP (EIP) on Port 1, you can create as many as six Class 1 (I/O) connection configurations. Of these six, only two can be used simultaneously. Of the six available connection configurations, as many as three can be Exclusive Owner connection configurations. The remaining number of connection configurations must be Input Only connection configurations.

An Exclusive Owner connection configuration contains both a Target to Originator (T->O, data flows from the SEL-751 to the scanner) connection and an Originator to Target (O->T, data flows from the scanner to the SEL-751) connection. An Input Only connection configuration contains a (T->O) connection only. For every distinct (T->O) connection, the SEL-751 automatically creates a Listen Only connection configuration. Listen Only connection configurations do not count against the six Class 1 (I/O) connection configurations. For the SEL-751, the types of supported connections are shown in *Table F.21*.

The flow of data is represented via assemblies. Input Assemblies 100, 102, and 104 are always associated with (T->O) connections and Output Assemblies 101, 103, and 105 are always associated with (O->T) connections. Note that these Output Assemblies can also be associated with (T->O) connections. The Input Assemblies can contain both binary input (from *Table L.1*) and analog input (from *Table M.1*) data. The Output Assemblies can contain both binary output and analog output data. Input Assembly 100 and Output Assembly 101 consist of data that can be chosen by setting the EtherNet/IP Assembly Map 1 settings using the **SET E 1** command. Similarly, Input Assembly 102 and Output Assembly 103 consist of data that can be chosen by setting the EtherNet/IP Assembly Map 2 settings using the **SET E 2** command. Input Assembly 104 and Output Assembly 105 consist of data that can be chosen by setting the EtherNet/IP Assembly Map 3 settings using the **SET E 3** command. Each of these assembly maps contains 100 binary input points, 100 analog input points, 32 binary output points, and 32 analog output points. It is important to note that the binary output points can take on the value of any remote bit (SET/CLEAR) or any 89OC/89CC bit (SET by the scanner and pulsed by the SEL-751 outside of the EIP library) within the SEL-751. The OC and CC bits are also allowed (SET by the scanner and pulsed by the SEL-751 outside of the EIP library). To pulse OC and CC in the EtherNet/IP Output Assembly Binary Map, you must pulse the CC bit only. When you write a 1, it pulses CC and when you write a 0, it pulses OC. The analog output points can take on the value of NOOP (writing to this point reports no errors and modifies no internal values). All the remote analogs and the active settings group are controllable.

Both the EIP settings on Port 1 and the configured assembly maps are used by the SEL-751 to create the Electronic Data Sheet (EDS) file. Only the SEL-751 can create and modify the EDS file. Refer to the *Electronic Data Sheet File* for more information.

Table F.21 Class 1 Connection Support

Class 1 Connections	Supported Connections
Input Only	Point-to-point Point to-multicast Multicast-to-point Multicast-to-multicast
Listen Only	Point-to-point Point to-multicast Multicast-to-point Multicast-to-multicast
Exclusive Owner	Point-to-point Point to-multicast Multicast-to-point Multicast-to-multicast

EtherNet/IP Settings

Table F.22 shows the EtherNet/IP Port 1 settings in the SEL-751.

Table F.22 Port 1 EtherNet/IP Protocol Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE ETHERNET/IP	Y, N	EEIP := N
CONFIGURATION ID	0–255	CONFIGID := 0
MAJOR EDS REVISION	1–255	MAJOREDS := 1
MINOR EDS REVISION	1–255	MINOREDS := 1
NUMBER OF IP ADDRESSES FOR EIP SCANNER	OFF, 1–8	NUMIP := 1
IP ADDRESS *zzz.yyy.xxx.www*	*zzz*: 1–126, 128–223 *yyy*: 0–255 *xxx*: 0–255 *www*: 0–255	EIPIP1 := 192.168.1.151 EIPIP2 := 192.168.1.152 EIPIP3 := 192.168.1.153 EIPIP4 := 192.168.1.154 EIPIP5 := 192.168.1.155 EIPIP6 := 192.168.1.156 EIPIP7 := 192.168.1.157 EIPIP8 := 192.168.1.158
NUMBER OF I/O CONNECTIONS	1–6	NUMCONN := 1
APPLICATION TYPE	EXCLUSIVE_OWNER, INPUT_ONLY	APPTYP*n* := INPUT_ONLY
INPUT ASSEMBLY	IA1, IA2, IA3, OA1, OA2, OA3	INASSM*n* := IA1
OUTPUT ASSEMBLY	OA1, OA2, OA3	OUTASSM*n* := OA1

Electronic Data Sheet File

EtherNet/IP uses an EDS file to define the interface between the EIP library and the scanner. The scanner uses this information to determine what objects, attributes, and services are supported by the SEL-751.

In the SEL-751, the EDS file consists of the following sections:

- *File Description Section, [File]*
- *Device Description Section, [Device]*
- *Device Classification Section, [Device Classification]*
- *Parameters Section, [Params]*
- *Assembly Section, [Assembly]*
- *Connections Section, [Connection Manager]*
- *Vendor Specific Object Section*
- *Capacity Section, [Capacity]*
- *Ethernet Link Class, [Ethernet Link Class]*

File Description Section, [File]

The File Description Section of the EDS file contains the entries listed in *Table F.23*.

Table F.23 File Description Section Entries

Name	Keyword	Value
File Description Text	DescText	Contains the product specific name <Prod Name> as specified by the product. It is of the format "<Prod Name> EtherNet/IP Adapter EDS File".
File Creation Date	CreateDate	UTC date value that is hard-coded to match the R-release date of the firmware.
File Creation Time	CreateTime	UTC time value that is hard-coded to match the R-release time of the firmware.
Last Modification Date	ModDate	UTC data value that is determined when the EDS file is generated.
Last Modification Time	ModTime	UTC time value that is determined when the EDS file is generated.
EDS Revision	Revision	The format is MAJOREDS.MINOREDS, where MAJOREDS and MINOREDS are populated by the correspondingly named parameters in the Port 1 settings.

Device Description Section, [Device]

The Device Description Section of the EDS file contains the entries listed in *Table F.24*.

Table F.24 Device Description Section Entries (Sheet 1 of 2)

Name	Keyword	Value
Vendor ID	VendCode	SEL Vendor ID number, 865
Vendor Name	VendName	"Schweitzer Engineering Laboratories"
Device Type	ProdType	43

Table F.24 Device Description Section Entries (Sheet 2 of 2)

Name	Keyword	Value
Device Type String	ProdTypeStr	"Generic Device Type"
Product Code	ProdCode	The number derived from the Device Code (DEVCODE as found in the **ID** command of the SEL-751) and Configuration ID as provided in the Ethernet port settings
Major Revision	MajRev	The Major Revision is assigned internally by the SEL-751
Minor Revision	MinRev	The Minor Revision is assigned internally by the SEL-751
Product Name	ProdName	Takes on the existing default product name (the default RID string in a two-line display model or the default STRING RID in a touch-screen display model) of the SEL-751 plus the value of the user-configurable Configuration ID as provided in the Port 1 settings. The general format is "<Default RID>-<Configuration ID>".
Catalog Number	Catalog	Takes on the existing default product name (the default RID string in a two-line display model or the default STRING RID in a touch-screen display model) of the SEL-751 plus the value of the user-configurable Configuration ID as provided in the Port 1 settings. The general format is "<Default RID>-<Configuration ID>".
Icon File Name	Icon	SEL751.ICO
Icon Contents	IconContents	Uncompressed content of characters

Device Classification Section, [Device Classification]

The Device Classification Section of the EDS file contains the entry listed in *Table F.25*.

Table F.25 Device Classification Section Entry

Name	Keyword	Value
Device Classification	Class1	"EtherNetIP"

Parameters Section, [Params]

Each parameter entry is named as *ParamN,* where *N* is a sequential number starting from 1 and ending at the maximum number of parameter object instances as defined in the corresponding assembly map.

All parameters of the EDS file are defined for ParamN in *Table F.26*.

Table F.26 Parameters of the EDS File (Sheet 1 of 2)

Label	Value
Reserved	0
Path Size, Path	Left empty
Descriptor	0x0000

Table F.26 Parameters of the EDS File (Sheet 2 of 2)

Label	Value
Data Type	Digitals: BOOL (0xC1) 1 Byte (0 or 1) Analogs: SINT (0xC2) Signed 1 Byte Integer, USINT (0xC6) Unsigned 1 Byte Integer, INT (0xC3) Signed 2 Byte Integer, UINT (0xC7) Unsigned 2 Byte Integer, DINT (0xC4) Signed 4 Byte Integer, UDINT (0xC8) Unsigned 4 Byte Integer, REAL (0xCA) 4 Byte Float, LREAL (0xCB) 8 Byte Float, LINT (0xC5) Signed 8 Byte Integer, or ULINT (0xC9) Unsigned 8 Byte Integer
Data Size (Bytes)	See previous
Name	Takes on the label name as defined in the corresponding assembly map. Names are unique.
Units	The value is “” for digitals. The value is determined internally by the SEL-751 for analogs.
Help String	“”
Min, max, default data values	It is 0,1,0 for digitals and ,,0, for analogs
Mult, div, base, offset scaling	It is ,,,, for all instances
Mult, div, base, offset links	It is ,,,, for all instances
Decimal places	0

RPI Parameter

The Requested Packet Interval (RPI) parameter entry falls immediately after the last parameter object instance as defined previously. This RPI parameter entry, Param(N+1), follows the structure detailed in *Table F.27*.

Table F.27 RPI Parameter Structure

Label	Value
Reserved	0
Path Size, Path	,,
Descriptor	0x0004
Data Type	0xC8
Data Size (Bytes)	4
Name	“RPI Range”
Units	“ms”
Help String	“This parameter limits the range of the RPI value”
Min, max, default data values	100000,,1000000
Mult, div, base, offset scaling	1,1000,1,0
Mult, div, base, offset links	,,,,
Decimal Places	1

Assembly Section, [Assembly]

The Assembly Section of the EDS file contains the entries listed in *Table F.28* for all of the available assemblies in the product.

Table F.28 Assembly Section Entries

Label	Value
Name	*Name* reflects the name of the Assembly type and instance, e.g., Input Assembly 1, Output Assembly 1, Input Assembly 2, etc.
Path	Set to "20 04 24 *InstID* 30 03" where *InstID* is the hexadecimal representation of the Assembly instance ID number.
Size	*Size_Bytes* reflects the total size in bytes of the mapped parameters in the Assembly instance.
Descriptor	0x0000
Reserved	Left empty
Member Size	Each mapped parameter in the corresponding Assembly instance is included in the EDS file using the following format: Member Size, Member Reference, Member Size, Member Reference, ... Member Size, Member Reference *MemberSize* reflects the data size for each parameter mapped in the corresponding Assembly instance in bits.
Member Reference	*MemberReference* reflects the name of each parameter entry "ParamN" (where N is the parameter instance) mapped in the corresponding Assembly instance.

Connections Section, [Connection Manager]

The Connections Section of the EDS file contains the entries listed in *Table F.29*, *Table F.30*, and *Table F.31*.

Table F.29 Input Only Connection Entries (Sheet 1 of 2)

Field	Value
Trigger and transport	0x02030002
Connection parameters	0x44640305
O->T RPI	Left empty
O->T size	0
O->T format	Left empty
T->O RPI	Set to "*ParamN*" where *N* is the parameter entry that defines the RPI for the device.
T->O size	Left empty
T->O format	*Input_Assem* is set to "*AssemN*" where *N* is the configured input assembly for the connection point.
Connection name string	*Connection_Name* contains "INPUT ONLY" as part of the string. All names are enumerated, e.g., "INPUT ONLY 1", etc.

Table F.29 Input Only Connection Entries (Sheet 2 of 2)

Field	Value
Help string	""
Path	Set to "20 04 2C EE 2C *In*" where *In* is the hexadecimal representation of the configured input assembly instance ID number.

Table F.30 Listen Only Connection Entries

Field	Value
Trigger and transport	0x01030002
Connection parameters	0x44640305
O->T RPI	Left empty
O->T size	0
O->T format	Left empty
T->O RPI	Set to "*ParamN*" where N is the parameter entry that defines the RPI for the device.
T->O size	Left empty
T->O format	*Input_Assem* is set to "*AssemN*" where *N* is the configured input assembly for the connection point.
Connection name string	*Connection_Name* contains "LISTEN ONLY" as part of the string. All names shall be enumerated, e.g., "LISTEN ONLY 1", etc.
Help string	""
Path	Set to "20 04 2C ED 2C *In*" where *In* is the hexadecimal representation of the configured input assembly instance ID number.

Table F.31 Exclusive Owner Connection Entries (Sheet 1 of 2)

Field	Value
Trigger and transport	0x04030002
Connection parameters	0x44640405
O->T RPI	Set to *"ParamN*" where *N* is the parameter entry that defines the RPI for the device.
O->T size	Left empty
O->T format	*Output_Assem* is set to *"AssemN*" where *N* is the configured output assembly for the connection point.
T->O RPI	Set to *"ParamN*" where N is the parameter entry that defines the RPI for the device.
T->O size	Left empty
T->O format	*Input_Assem* is set to *"AssemN*" where *N* is the configured input assembly for the connection point.
Connection name string	*Connection_Name* contains "EXCLUSIVE OWNER" as part of the string. All names are enumerated, e.g., "EXCLUSIVE OWNER 1", etc.

Table F.31 Exclusive Owner Connection Entries (Sheet 2 of 2)

Field	Value
Help string	“”
Path	“20 04 2C *Out* 2C *In*” where *Out* is the hexadecimal representation of the configured output assembly instance ID number and *In* is the hexadecimal representation of the configured input assembly instance ID number.

Vendor Specific Object Section

The Vendor Specific Object Section of the EDS file contains the entries listed in *Table F.32*.

Table F.32 Vendor Specific Object Section Entries

Label	Value
Revision	1
Maximum Instance Number	1
Number of Static Instances	1
Maximum Number of Dynamic Instances	0
Object Name	“Relay Status”
Object Class Code	0x64

Capacity Section, [Capacity]

The Capacity Section of the EDS file contains the entries listed in *Table F.33*.

Table F.33 Capacity Section Entries

Keyword	Value
MaxIOConnections	2
MaxMsgConnections	6

Ethernet Link Class, [Ethernet Link Class]

The Ethernet Link Class Section of the EDS file contains the entries listed in *Table F.34*.

Table F.34 Ethernet Link Class (Sheet 1 of 2)

Keyword	Value
Revision	4
Object_Name	"Ethernet Link Object"
Object_Class_Code	0xF6
MaxInst	It is 2 if a dual Ethernet port CPU card is used. It is 1 if a single Ethernet port CPU card is used.
Number_Of_Static_Instances	It is 2 if a dual Ethernet port CPU card is used. It is 1 if a single Ethernet port CPU card is used.
Max_Number_Of_Dynamic_Instances	0

Table F.34 Ethernet Link Class (Sheet 2 of 2)

Keyword	Value
InterfaceLabel1	It is “PORT 1” if a single Ethernet port CPU card is used. It is “PORT 1A” if a dual Ethernet port CPU card is used.
InterfaceLabel2	Does not exist if a single Ethernet port CPU card is used. It is “PORT 1B” if a dual Ethernet port CPU card is used.

Appendix G
IEC 61850 Communications

Features

The SEL-751 uses Ethernet and IEC 61850 to support the following features:

- **SCADA**—Connect as many as seven simultaneous IEC 61850 Manufacturing Message Specification (MMS) client sessions. The SEL-751 also supports association-based (non-indexed) reports and indexed reports. See *Table G.43* for Logical Node mapping that enables SCADA control via an MMS browser. Controls support direct control with normal security, direct control with enhanced security, and select before operate (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–VB256) and Remote Analogs (RA001–RA128) can be mapped from incoming GOOSE messages. Use Fixed GOOSE with 4 incoming (receive) messages and 1 outgoing (transmit) message. Relay Word bits FG*n*RB*x* and analog quantities FG*n*RA*x* (where *n* = 1–4 and *x* = 01–08) maps the received Fixed GOOSE messages.
- **Configuration**—Use FTP client software or ACSELERATOR Architect SEL-5032 Software to transfer the Substation Configuration Language (SCL) Configured IED Description (CID) file to the relay.
- **Commissioning and Troubleshooting**—Use software such as AX-S4 from Sisco, Inc., to browse the relay logical nodes and verify functionality.

NOTE: The SEL-751 ships with a default CID file installed that supports basic IEC 61850 functionality. A new CID file should be loaded if a change in the relay configuration is required. If an invalid CID file is transferred, the relay will reject the file and revert to the previous valid CID file.

This appendix presents the information you need to use the IEC 61850 features of the SEL-751:

- *IEC 61850 Introduction*
- *IEC 61850 Operation*
- *IEC 61850 Configuration*
- *Logical Nodes*
- *Protocol Implementation Conformance Statement*
- *ACSI Conformance Statements*

IEC 61850 Introduction

In the early 1990s, the Electric Power Research Institute (EPRI) and the Institute of Electrical and Electronics Engineers, Inc. (IEEE) began to define a Utility Communications Architecture (UCA). They initially focused on inter-control center and substation-to-control center communications and produced the Inter-Control Center Communications Protocol (ICCP) specification. This specification, later adopted by the IEC as 60870-6 TASE.2, became the standard protocol for real-time exchange of data between databases.

In 1994, EPRI and IEEE began work on UCA 2.0 for Field Devices (simply referred to as UCA2). In 1997, they combined efforts with Technical Committee 57 of the IEC to create a common international standard. Their joint efforts created the current IEC 61850 standard.

The IEC 61850 standard, a superset of UCA2, contains most of the UCA2 specification, plus additional functionality. The standard describes client/server and peer-to-peer communications, substation design and configuration, testing, and project standards. The IEC 61850 standard consists of the parts listed in *Table G.1*. The original parts were first published between 2001 and 2004, and they are often referred to as IEC 61850 Edition 1 (Ed1). Selected parts of these standards were updated in 2011 and tagged as Edition 2 (Ed2). The current edition, Edition 2, Amendment 1 (Ed2.1), was published in 2020. The SEL-751 is compliant with Ed2.1.

It is possible and even likely that an installation will have a mixture of devices that conform to different editions. The standard supports backwards compatibility, i.e., Ed2 devices can send and receive messages to and from Ed1 devices. However, there are important considerations to be made when adding Ed2 or Ed2.1 devices to an existing Ed1 system. Refer to *Potential Client and Automation Application Issues With Edition 2 and 2.1 Upgrades on page G.88* for more information.

Table G.1 IEC 61850 Document Set (Sheet 1 of 2)

IEC 61850 Sections	Definitions
IEC 61850-1	Introduction and overview
IEC 61850-2	Glossary
IEC 61850-3	General requirements
IEC 61850-4	System and project management
IEC 61850-5	Communications requirements
IEC 61850-6	Configuration description language for substation IEDs
IEC 61850-7-1	Basic communications structure for substations and feeder equipment—Principles and models
IEC 61850-7-2	Basic communications structure for substations and feeder equipment—Abstract Communication Service Interface (ACSI)
IEC 61850-7-3	Basic communications structure for substations and feeder equipment—Common data classes (CDCs)
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 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

Table G.1 IEC 61850 Document Set (Sheet 2 of 2)

IEC 61850 Sections	Definitions
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 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 the 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 services 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 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 logical nodes.

UCA2 uses GOMSFE (Generic Object Models for Substation and Feeder Equipment) to present data from station IEDs as a series of objects called models or bricks. The IEC working group has incorporated GOMSFE concepts into the standard, with some modifications to terminology; one change was the renaming of bricks to logical nodes. Each logical node represents a group of data (controls, status, measurements, etc.) associated with a particular function. For example, the MMXU logical node (polyphase measurement unit) contains measurement data and other points associated with three-phase metering, including voltages and currents. Each IED can contain many functions such as protection, metering, and control. Multiple logical nodes represent the functions in multifunction devices.

You can organize logical nodes into logical devices that are similar to directories on a computer disk. As represented in the IEC 61850 network, each physical device can contain many logical devices, and each logical device can contain many logical nodes. Many relays, meters, and other IEC 61850 devices contain one primary logical device where all models are organized.

IEC 61850 devices are capable of self-description. You do not need to refer to the specifications for the logical nodes, measurements, and other components to request data from another IEC 61850 device. IEC 61850 clients can request and display a list and description of the data available in an IEC 61850 server device. This process is similar to the autoconfiguration process used within SEL communications processors (SEL-2032 and SEL-2030). Simply run an MMS browser to query devices on an IEC 61850 network and discover what data are available. Self-description also permits extensions to both standard and custom data models. Instead of having to look up data in a profile stored in its database, an IEC 61850 client can simply query an IEC 61850 device and receive a description of all logical devices, logical nodes, and available data.

Unlike other Supervisory Control and Data Acquisition (SCADA) protocols that present data as a list of addresses or indices, IEC 61850 presents data with descriptors in a composite notation made up of components. *Table G.2* shows how the A-phase current expressed as MMXUAphsA$cVal is broken down into its component parts.

Table G.2 Example IEC 61850 Descriptor Components

Components		Description
MMXU	Logical Node	Polyphase measurement unit
A	Data Object	Phase-to-ground amperes
PhsA	Sub-Data Object	A-phase
cVal	Data Attribute	Complex value

Data Mapping

Device data are mapped to IEC 61850 logical nodes (LN) according to rules 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 G.3* for descriptions of the logical devices in an SEL-751. See *Logical Nodes on page G.34* for a description of the LNs that make up these logical devices.

Table G.3 SEL-751 Logical Devices

Logical Device	Description
ANN	Annunciator elements—alarms and status values
CFG	Configuration elements—data sets and report control blocks
CON	Control elements—remote bits
MET	Metering or measurement elements—currents, voltages, power, etc.
PRO	Protection elements—protection functions and breaker control

Functional Naming

Substation design typically starts with a one-line diagram and progresses down to the assignment of functions to IEDs. In this top-down approach, the functions are identified and named independently from the IEDs to which they are assigned.

NOTE: Functional naming is not supported by all MMS clients and GOOSE subscribers. Verify support for this feature before configuring functional names in a publishing IED.

Because a logical device is a grouping of logical nodes that perform a certain high-level function at a substation, the associated name often indicates the assigned function. The functional naming feature allows users to name a logical device based on the function it provides independent of the name of the IED to which the function is assigned. The alternative is product naming, which prepends the IED name to the logical device instance to create the logical device name. The functional name is used on the communications interface for all references to data in the logical device.

The SEL-751 supports functional naming of logical devices. You can add functional names in Architect for relays that support Ed2 or higher. To enable it in Architect, navigate to **Edit** > **Project Settings** and select the **Enable functional name editing on Server Model tab of supporting IEDs** check box, as shown in *Figure G.1*.

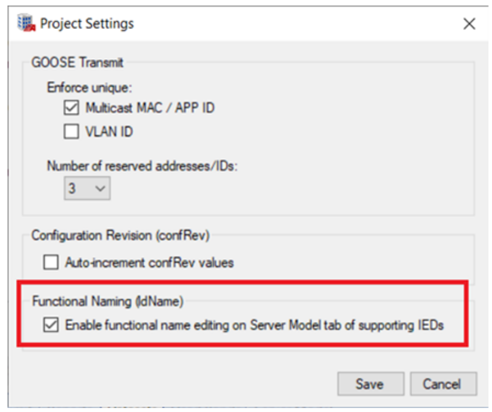


Figure G.1 Enable Functional Naming in Architect

To provide functional names to the logical devices, navigate to the Server Model tab for the IED. Because data sets and control blocks are in the CFG logical device, any functional name given to the CFG logical device instance is used in data set references, control block references, and published GOOSE messages, as shown in *Figure G.2*. The IED Server Model also allows the user to change the default logical node prefix and instance values.

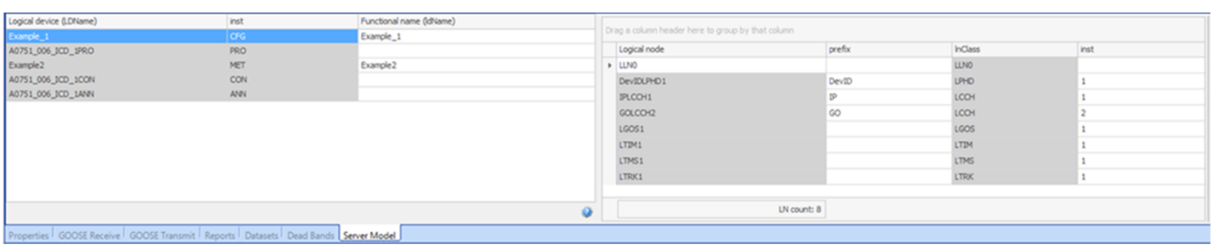


Figure G.2 Server Model View in Architect

MMS

MMS provides services for the application-layer transfer of real-time data within a substation LAN. MMS was developed as a network independent data exchange protocol for industrial networks in the 1980s and standardized as ISO 9506.

In theory, you can map IEC 61850 to any protocol. However, it can be unwieldy and quite complicated to map objects and services to a protocol that only provides access to simple data points via registers or index numbers. MMS supports complex named objects and flexible services that enable mapping to IEC 61850 in a straightforward manner. This was why the UCA users group used MMS for UCA from the start and why 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 7.15*, *Retrieving COMTRADE Event Files on page 10.30*, and *Retrieving Event Reports Via Ethernet File Transfer on page 10.19*.

If MMS authentication is enabled, the device authenticates each MMS association by requiring the client to provide the password authentication parameter with a value that is equal to the Access Level 2 password of the SEL-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.

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 the Port 1 settings. See *Virtual File Interface on page 7.83* 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 (.ICD) file
- ➤ System Specification Description (.SSD) file
- ➤ Substation Configuration Description (.SCD) file
- ➤ Configured IED Description (.CID) file

The ICD file describes 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.

Data Sets

Data sets are configured using Architect and contain data attributes that represent real data values within the SEL-751 device. See *Logical Nodes on page G.34* 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 data sets listed in *Figure G.3* are the defaults for an SEL-751 device. Data sets BRDSet01–BRDSet07 and URDSet01–URDSet07 are preconfigured with common FCDAs to be used for reporting. These data sets can be configured to represent the data you want to monitor. Data set GPDSet01, which contains breaker status and control data attributes, is used in the default Goose Control Publication.

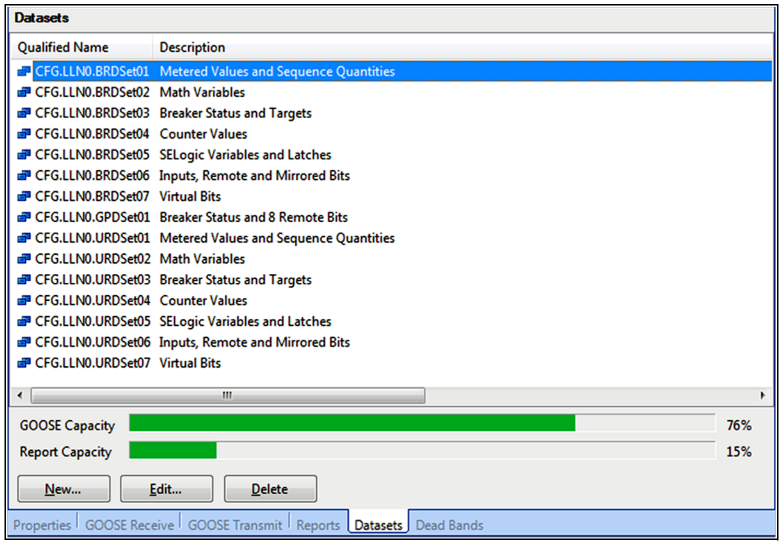


Figure G.3 SEL-751 Data Sets

Within Architect, IEC 61850 data sets have two main purposes:

- GOOSE: You can use predefined or edited data sets, or create new data sets for outgoing GOOSE transmission.
- Reports: Fourteen predefined data sets (BRDSet01–BRDSet07 and URDSet01–URDSet07) correspond to the default seven buffered and seven unbuffered reports, respectively.

  You can alter the data attributes that a data set contains within Architect and so define what data an IEC 61850 client receives with a report.

  However, the number of URCB instances (84) and BRCB instances (12) and the type of reports (buffered or unbuffered) cannot be changed.
- MMS: You can use predefined or edited data sets, or create new data sets to be monitored by MMS clients.

NOTE: Do not edit the data set names used in reports. Changing or deleting any of those data set names will cause a failure in generating the corresponding report.

Reports

IEC 61850 provides two classes of reporting services, unbuffered and buffered, that a client can use to receive event data from a server. The unbuffered report service provides event data on a best-effort basis only while the client is connected. In contrast, the buffered report service keeps an internal buffer of events, which ensures that clients can receive a sequence of events even after reconnecting following a lost connection. The relay supports unbuffered and buffered report control blocks in the report model as defined in IEC 61850-8-1:2020.

IEC 61850 servers can deliver the same event data to multiple clients. IEC 61850 Ed1 proposed two different approaches that a server could use to accomplish this: association-based (non-indexed) reports and indexed reports. As of Ed2.1, SEL-751 relays support both methods. The relay supports as many as 24 report control blocks (12 each of unbuffered and buffered reports). Reports can either be configured as association-based reports or indexed reports. Configuring a mix of association-based reports and indexed reports is not allowed, and such a configuration will be rejected by the IED. SEL devices with ClassFileVersion 009 or lower support only association-based reports. Devices that are ClassFileVersion 010 support association-based reports as well as indexed reports.

ICD files with ClassFileVersion 009 or lower only support dynamic report reservations. Writing to ResvTms of the buffered report control block (BRCB) or Resv of the unbuffered report control block (URCB) causes the client to dynamically obtain a reservation. ICD files with ClassFileVersion 010 support both preconfigured report reservations and dynamic reservations.

Reports are serviced at a 2 Hz rate. The client can set 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 the expiration of IntgPd. A new IntgPd begins at the time that the current report is serviced.

When configuring unbuffered and buffered reports that contain only analog values, a data change report is only triggered when there is a change in the magnitude value in excess of the deadband setting. When you are configuring unbuffered and buffered reports that contain a combination of digital and analog values, any digital value change triggers a data change report, which contains the current value of the analogs in the report at the time of the trigger.

Unbuffered Reports

By using Architect, you can define if the URCB should be association-based or indexed. You can allocate data within each report data set to present different data attributes for each report. For unbuffered reports, connected clients may edit the report parameters shown in *Table G.4*.

Table G.4 Unbuffered Report Control Block Client Access (Sheet 1 of 2)

RCB Attribute	User Changeable[a] (Report Disabled)	User Changeable (Report Enabled)	Default Values
RptId	YES		URep01–URep12
RptEna	YES	YES	FALSE
Resv	YES		Non-indexed reports: Resv = FALSE for all URCB instances if none is preconfigured for any client. Resv = TRUE for all URCB instances if one or more are preconfigured for a client. Indexed reports: Resv = FALSE for the specific URCB instance if it is not preconfig-ured for any client. Resv = TRUE for the specific URCB instance if it is preconfigured for a client.
OptFlds	YES		seqNum timeStamp dataSet reasonCode
BufTm	YES		250
TrgOp	YES		dchg qchg period
IntgPd	YES		0

Table G.4 Unbuffered Report Control Block Client Access (Sheet 2 of 2)

RCB Attribute	User Changeable[a] (Report Disabled)	User Changeable (Report Enabled)	Default Values
GI		YES[b]	FALSE
Owner			For non-indexed reports: The client's IP address for all URCB instances if the ReportControl has a single preconfigured client and its IP address can be found in the SCL. Otherwise, the default value shall be NULL. NULL if the URCB instance is not preconfigured. For indexed reports: For a specific URCB instance, the IP address of the preconfigured client in the SCL or NULL if not found. NULL if the URCB instance is not preconfigured.

[a] The report must be actively reserved by setting Resv to 1 before the attribute values can be changed.
[b] Exhibits a pulse behavior. Write a one to issue the command. Once command is accepted, returns to zero. Always read as zero.

Resv indicates report reservation for unbuffered reports. Clients must actively reserve the URCB by setting Resv to 1 before the report can be enabled. This is applicable to preconfigured SCL clients as well. A successful write to Resv results in the Owner attribute being updated to the IP address of the client that performed the write operation. When the MMS client disables the URCB by setting RptEna to FALSE and actively unreserves it by setting Resv to 0, the report is immediately available for write operations.

Association-Based (Non-Indexed) URCBs

In association-based URCBs, the relay provides a unique URCB instance for each client association. Each client sees a different instance, although all instances have the same URCB name. This results in multiple client associations for that URCB. Once enabled, each client has independent access to an instance of that URCB. The server automatically ensures that a URCB instance is available to each client. SEL first offered association-based URCB support in the IEC 61850 Ed1 release of the relay.

The relay supports 12 association-based URCBs and 7 simultaneous clients, resulting in a total of 84 URCB instances, since each client views a different instance.

Indexed URCBs

In indexed URCBs, the server provides multiple URCB instances with all instances visible to all clients. Because all clients can see all instances, each instance must have a unique name. The report name is appended with a two-digit number *nn*, where *nn* ranges from 01 to the maximum number of instances supported for that control block. This allows a client to view all instances of a report control block, unlike association-based reports, where each client can only view the instance to which the report control block is connected. Clients can reserve an instance by using the URCB Resv attribute. To prevent conflicts between clients, Ed2 introduced the concept of preconfigured reservations.

The relay added support for as many as 84 indexed URCB instances as part of its IEC 61850 Ed2.1 release of the relay.

Each report control block has seven instances available to connect to when a URCB is configured as indexed. For example, if UrcbA is configured as indexed, a client can connect to any one of the instances named UrcbA*xx*, where *xx* = 01–07.

Buffered Reports

By using Architect, you can define if the BRCB should be association-based or indexed. You can allocate data within each report data set to present different data attributes for each report. For buffered reports, connected clients may edit the report parameters shown in *Table G.5*.

Table G.5 Buffered Report Control Block Client Access

RCB Attribute	User Changeable[a] (Report Disabled)	User Changeable (Report Enabled)	Default Values
RptId	YES		BRep01–BRep07
RptEna	YES	YES	FALSE
OptFlds	YES		seqNum timeStamp dataSet reasonCode entryID bufOvfl
BufTm	YES		500
TrgOps	YES		dchg qchg period
IntgPd	YES		0
GI	YES[b, c]	YES[b]	0
PurgeBuf	YES[b]		FALSE
EntryId	YES		0
ResvTms	YES		ResvTms = 0 if the BRCB instance is not preconfigured ResvTms = –1 if the BRCB instance is preconfigured for a specific client in the SCL
Owner			For a specific BRCB instance, the IP address of the preconfigured client in the SCL or NULL if not found NULL if the BRCB instance is not preconfigured

[a] The report must be actively reserved by setting ResvTms > 0 before the attribute values can be changed.
[b] Exhibits a pulse behavior. Write a one to issue the command. Once command is accepted, returns to zero. Always read as zero.
[c] When disabled, a GI will be processed and the report buffered if a buffer has been previously established. Buffered reports begin buffering at startup.

ResvTms is an indication of the report reservation time for buffered reports. Clients must actively reserve the BRCB by setting ResvTms to a value greater than 0 before the report can be enabled. This is applicable to preconfigured SCL clients as well. A successful write to ResvTms results in the Owner attribute being updated to the IP address of the client that performed the write operation. When the MMS client disables the BRCB by setting RptEna to FALSE and actively unreserves it by setting ResvTms to 0, the report is immediately available for write operations. After the ResvTms duration elapses, ResvTms reverts to 0 for dynamic associations, indicating the control block is available to other clients.

Association-Based (Non-Indexed) BRCBs

When a BRCB is configured as association-based or non-indexed, only one client can enable the BRCB at a time, which results 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 BRCB is unreserved. Once enabled by a client, all unassociated clients have read-only access to the

BRCB. For example, if an association-based BRCB is named BrcbA, a client can connect to the report with the name BrcbA. SEL first offered association-based BRCB support in the IEC 61850 Ed1 release of the relay.

Indexed BRCBs

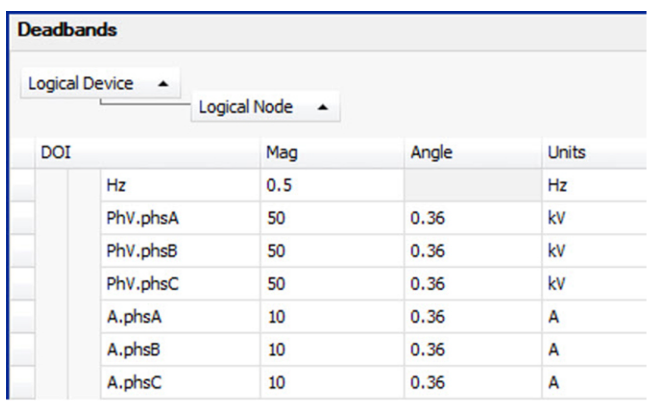
In indexed BRCBs, the server provides multiple BRCB instances with all instances visible to all clients. The report name is appended with a two-digit number *nn*, where *nn* ranges from 01 to the maximum number of instances supported for that control block. This allows a client to view all instances of a report control block. Clients can reserve an instance by using the BRCB ResvTms attribute.

The relay supports 12 indexed BRCB instances as part of the IEC 61850 Ed2.1 release of the relay. Only one instance of the report control block is available to connect to when a BRCB is configured as indexed. For example, if BrcbA is configured as indexed in Architect, a client connects to the report with the name BrcbA01.

Deadband Configuration and Functionality

Analog values of the MV, CMV, APC, and BAC CDCs defined in IEC 61850-7-3 have associated deadbands that determine when the analog values should be updated. The MV and CMV analog objects contain attributes that reflect the instantaneous value of the magnitude, instMag, and the value of the magnitude, mag, which is updated based on the deadband calculation.

Deadband calculations in Ed1 and Ed2 use a percent multiplier and the maximum range. The percent multiplier, a number between 0 and 100,000, is multiplied by 0.001 percent to determine the percentage of the maximum range to use as a deadband. Architect handles these calculations in the background, enabling users to configure the deadbands using nominal values. *Figure G.4* displays the view from the Deadband tab in Architect for both Edition 1 and Edition 2 implementations.


Deadbands

Logical Device

Logical Node

DOI	Mag	Angle	Units
Hz	0.5		Hz
PhV.phsA	50	0.36	kV
PhV.phsB	50	0.36	kV
PhV.phsC	50	0.36	kV
A.phsA	10	0.36	A
A.phsB	10	0.36	A
A.phsC	10	0.36	A

Figure G.4 Deadbands View in Architect for ClassFileVersion Less Than 010

Ed2.1 introduced deadband-related attributes dbRef, dbAngRef, zeroDb, and zeroDbRef to explicitly expose deadband behavior. The attribute dbRef may have a value of 0, which means the value db shall be used as the percentage of the last transmitted value in units of 0.001 percent. This is appropriate for currents and voltages. If the dbRef value is greater than 0, it means db represents the percentage of the dbRef in units of 0.001 percent and is appropriate for values with constant or small-changing values, e.g., frequency. Attribute zeroDb is the configuration parameter used to calculate the range around zero where the deadbanded value mag is forced to zero. The value of zeroDb shall represent the percentage of zeroDbRef in units of 0.001 percent.

For ICD files with ClassFileVersion 010, use Architect to view and configure the deadbands for analog values. The configuration values for the parameters shown previously are editable, and Architect displays the resulting deadband value.

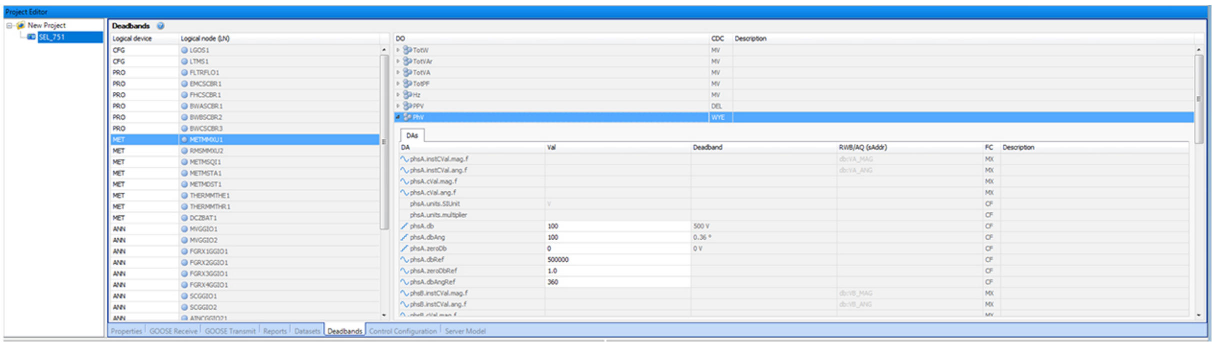


Figure G.5 Deadbands View in Architect for ClassFileVersion 010

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 quality (q) and time-stamp (t) attributes are available at any time. The relay determines the time stamp when it detects a change in quality or data.

The relay applies a time stamp to all data and quality attributes (Boolean, Bstrings, analogs, etc.) in the same fashion as when it detects a data or quality change. However, there is a difference in how the relay detects the change between the different attribute types. For points that are assigned as SER points, i.e., programmed in the SER report, the relay detects the change as the receipt of an SER record (which contains the SER time stamp) within the relay.

For all other Booleans or Bstrings, the relay detects the change via the scanner, which compares the last state against the previous state to detect the change. For analogs, the scanner looks at the amount of change relative to the deadband configured for the point to indicate a change and applies the timestamp. In all cases, the relay uses these time stamps for the reporting model.

Functionally Constrained Data Attributes (FCDAs) mapped to points assigned to the SER report have time stamps accurate to within 1/4 cycle processing interval for data change events (the Relay Word bits corresponding to the digital inputs and arc-flash elements [TOL*x*, 50*x*AF, and OUT*xxx*, selected through the setting AOUTSLOT] have 1/16 of the power system cycle SER-accurate time stamps). 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 *SER Trigger Lists on page 4.244* 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 G.6* shows the GOOSE quality attributes available to devices that subscribe to GOOSE messages from SEL-751 data sets 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.

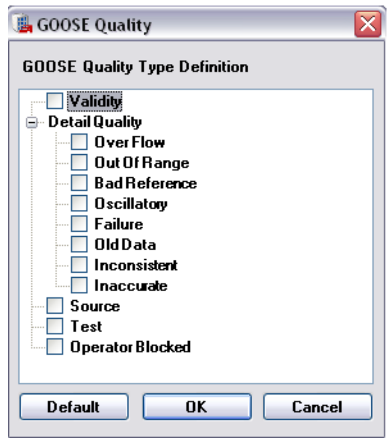


Figure G.6 GOOSE Quality

Control

IEC 61850 Controls

An IEC 61850 server may allow a client to manipulate data related to its outputs, external devices, or internal functions. This is accomplished by the IEC 61850 control model, which provides services to execute control commands. The control models are defined in IEC 61850-7-2 and the mapping to the MMS application protocol is defined in IEC 61850-8-1. The former describes control functionality while the latter maps the IEC 61850 control primitives to MMS. The SEL-751 supports four different control models for all controllable CDCs defined in IEC 61850-7-3:

- Status only
- Direct with normal security
- Direct with enhanced security
- SBO with enhanced security

The one control model selected during initial IED configuration in Architect is applied throughout the CID file. This control mode applies to all controls in the IED. For CID files created from an ICD file with ClassFileVersion 010, the Architect tool allows you to modify the control model on a per-control basis if a different control model is required other than the one selected during initial IED configuration. Firmware that supports Ed2.1 and ClassFileVersion 010 supports pulsing of the SPC and DPC control models as defined in IEC 61850-7-3 by configuring pulseConfig attributes cmdQual, onDur, offDur, and numPls.

Direct Control Models

The direct control models provide the simplest means to initiate actions on the server. In these models, the client issues a control request via MMS, and the server validates the request. Once validated, the server attempts to act upon the request. Note that if multiple clients try to perform control actions, the server does nothing to prevent the simultaneous control actions.

SBO Control Model

The SBO control model supports the Select or SelectWithValue Service and can be used to prevent multiple clients from performing simultaneous control actions. In this mode, a client has to “reserve” the control object by sending a “select” control command. Once an object is selected, only the client that made the selection is allowed to perform control actions on it. If that client does not send a valid operate request for the object by the time the ten-second selection timer runs out, the object becomes available for selection again. The relay supports as many as ten pending control object selections at any time.

NOTE: When an IED is configured with the SBO with Enhanced Security control model, the sboTimeout attribute of the controllable CDCs in the CID file is set to ten seconds. The time-out is not configurable via Architect.

The attribute stSeld (selected status) of the controllable CDC is set to TRUE when a client successfully selects the control object. The attribute is reset to FALSE when either the control (operate) command is successfully executed, an error occurs, or no operate command is received within the select time-out period. The stSeld attribute may trigger a report just like any data attribute with trigger option.

Security in Control Models

“Security” in the control model context refers to additional supervision of the status value by the control object. The “enhanced security” models report additional error information on failed operations to the requesting client than the models with “normal security.” Enhanced security control models also provide a command termination report indicating if the control actually reached the new state as commanded within a configurable time-out period.

NOTE: The maximum time required for a control operation to be completed should be less than the configured time-out period to avoid erroneous command termination reports indicating failure.

The time-out period between the execution of a control and the generation of a command termination report indicating failure has a default value of 1 s and is configurable via the CID file. This time-out is not configurable via Architect.

Optional Control Configurations

The SEL-751 relays support the pulse configuration option as specified in Clause 6.7 of IEC 61850-7-3. For those relays that are not Ed2.1 or are ClassFileVersion 010 or lower, some control logical nodes are available that pulse the control for one processing interval.

Controls that may be configured for pulse operations, such as the SPCSO data objects in the RBGGIO logical nodes, contain a pulseConfig constructed data attribute type.

The cmdQual data attribute of an SPC or DPC control defines whether the control is persistent or pulsed. If cmdQual = 0, the control object pulses when the command is written to, according to the onDur, offDur, and numPls attributes. *Figure G.7* shows an example of how onDur, offDur, and numPls are used when the control is pulsed. If cmdQual = 1, the control object asserts if ctlVal is true and deasserts if ctlVal is false. If cmdQual = 0 (pulse), onDur = 0, and offDur = 0, the control object pulses for one processing interval.

NOTE: The accuracy with which the control object pulses is within a processing interval of the relay.

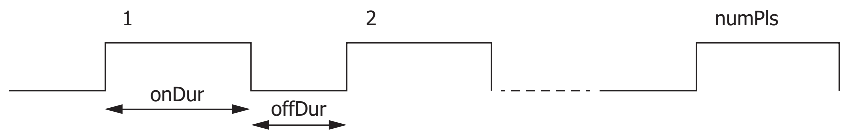


Figure G.7 onDur, offDur, and numPls Attributes of Control Pulse

Use Architect to configure a control to pulse by selecting a controllable data object (such as a remote bit), selecting the Control Configuration tab, and setting the pulseConfig.cmdQual to pulse (see *Figure G.8*). Setting pulseConfig.cmdQual to pulse allows changes to the onDur, offDur, and numPls attributes.

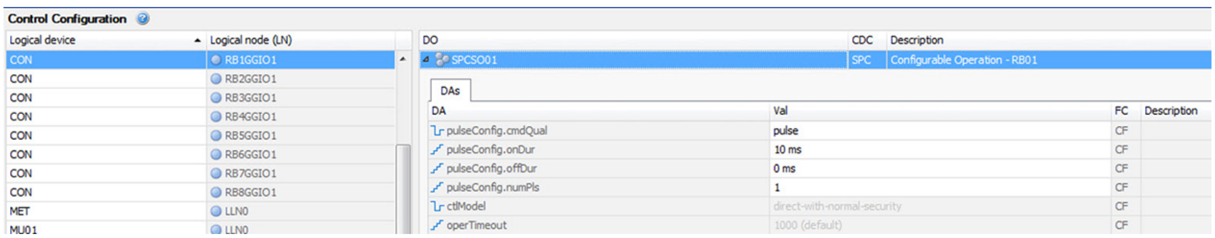


Figure G.8 Control Configuration View in Architect

Control Interlocking

NOTE: The InRef1 and InRef2 data objects in the CSWI logical node must include a reference to the CILO EnaOpn and EnaCls data objects, respectively, to get a "Blocked-by-interlocking" AddCause.

The SEL-751 relay uses control interlocking to supervise the open and close control commands from MMS clients. The relay accomplishes this by checking the CSWI logical node control object against an associated CILO logical node data object. The CILO logical node has two data objects: Enable Open (EnaOpn) and Enable Close (EnaCls). When the associated CILO logical node EnaCls and EnaOpn data objects are not asserted, the relay blocks the control operation and sends the AddCause "Blocked-by-interlocking" to the MMS client.

Program SELOGIC setting SCBK1BO to supervise opening and SCBK1BC to supervise closing of the circuit breaker/contactor. Use settings 89CB*km* and 89OB*km* (*k* = 2P, 3PL, or 3PE; *m* = switch number [1–8 if *k* = 2P; 1–2 if *k* = 3PL or 3PE]) to supervise closing and opening of the 2- or 3-position disconnect switches, respectively.

Figure G.9 shows how the relay responds to a CSWI logical node write command request from the MMS client when IEC 61850 control interlocking is applied.

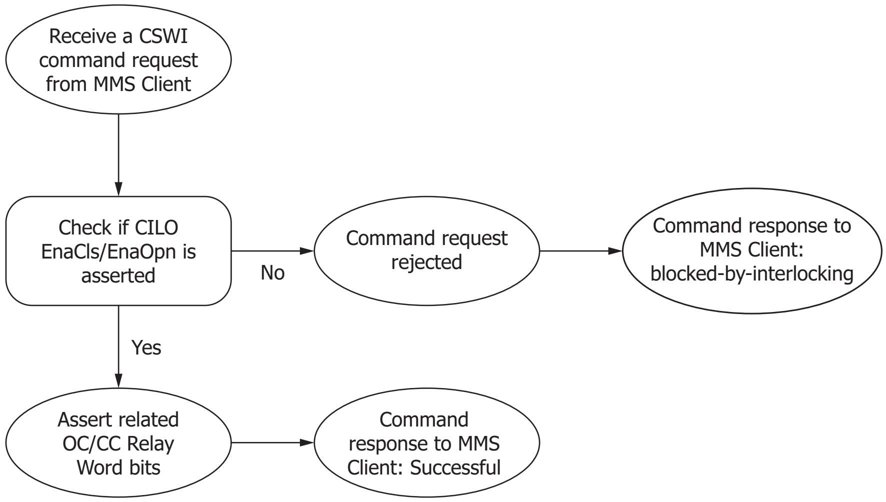


Figure G.9 CSWI Logical Node Direct Operate Command Request

Local/Remote Control Authority

NOTE: The lnRef3 data object in the CSWI logical node must include a reference to the XCBR/XSWI Loc data object to get a "Blocked-by-switching-hierarchy" AddCause.

Control commands at a substation originate from one of three levels: remote (network control center) level, station level, or bay level. Under certain operational conditions (e.g., during maintenance), it may be necessary to block control commands from one or more of these levels. The local/remote control feature allows you to enable or disable control authority at any of the three levels. The level at which a control command originates is determined by the value of the origin.orCat (originator category) attribute in the command (see *Table G.6*).

Table G.6 Originator Categories

Originator Category	Value
Not-supported	0
Bay-control	1
Station-control	2
Remote-control	3
Automatic-bay	4
Automatic-station	5
Automatic-remote	6
Maintenance	7
Process	8

The SEL-751 supports the local/remote control feature defined in IEC 61850-7-4. The feature is supported at the IED level and logical node level with identical and configurable attributes in the LLN0 logical node in each logical device and in the CSWI logical nodes. *Table G.7* describes the attributes and their data sources in various logical nodes.

Table G.7 Control Authority Attributes

Logical Node	Attribute	Data Source	Description
LLN0	Loc.stVal	LOC	Control authority of the IED at local (bay) level
	LocKey.stVal	NOOP	Physical key or toggle switch indication for switching IED in local mode
	LocSta.stVal	LOCSTA	Control authority of the IED at station level
	MltLev.setVal	MLTLEV	Multi-level control authority
CSWI	Loc.stVal	LOC	Control authority of the switch controller at local (bay) level
	LocKey.stVal	NOOP	Physical key or toggle switch indication for switching switch controller LN in local mode
	LocSta.stVal	LOCSTA	Control authority of the switch controller at station level
XCBR/XSWI	Loc.stVal	LOCAL	Switchgear local/remote status
	LocKey.stVal	NOOP	Physical key or toggle switch indication for switchgear local mode

You can control the Relay Word bits LOC, LOCSTA, and MLTLEV through SELOGIC control equations. LOCSTA is set to True when the SELOGIC control equation SC850LS asserts and set to False when SC850LS deasserts. LOCSTA may also be controlled through MMS, but if it is set to True through SELOGIC control equations, it cannot be set to False through MMS.

The IED-level local/remote behavior can be changed using the following methods:

- ➤ The value of the LOC Relay Word bit is changed through a SELOGIC control equation.
- ➤ If the system is equipped with a physical key or a toggle switch for controlling the local/remote status of the entire IED, the data source of CFG.LLN0.LocKey.stVal can be configured to indicate the binary input to which the physical key is wired.

Similarly, the switchgear local/remote behavior can be changed using the following methods:

- ➤ The value of the LOCAL Relay Word bit is changed through a SELOGIC control equation. The assertion of the LOCAL Relay Word bit changes the XCBR and XSWI logical nodes to local mode. This blocks all control commands to the associated CSWI logical nodes.
- ➤ If a switchgear has a physical local/remote control switch, the data source of XCBR.LocKey.stVal can be configured to indicate the binary input to which the physical key is wired.

The MLTLEV SELOGIC control equation allows you to define whether multiple levels of control authority are allowed. If MLTLEV is FALSE, only one level of control authority is allowed to control the switchgear, as shown in *Table G.8*.

Table G.8 Control Authority Settings[a]—MLTLEV Set to FALSE

Switchgear Local/ Remote Behavior	Local Control Behavior	Control Authority at Station Level	orCat Value		
XCBR.Loc XSWI.Loc	CSWI.Loc	CSWI.LocSta	Bay (1 or 4)	Station (2 or 5)	Remote (3 or 6)
T	X	X	NA	NA	NA
F	T	X	AA	NA	NA
F	F	T	NA	AA	NA
F	F	F	NA	NA	AA

[a] T = True (asserted)
F = False (deasserted)
X = Do not care (true or false)
AA = Command is allowed
NA = Command is not allowed

If MLTLEV is TRUE, multiple levels of control authority are allowed to control the switchgear, as shown in *Table G.9*.

Table G.9 Control Authority Settings[a]—MLTLEV Set to True

Switchgear Local/ Remote Behavior	Local Control Behavior	Control Authority at Station Level	orCat Value		
XCBR.Loc XSWI.Loc	CSWI.Loc	CSWI.LocSta	Bay (1 or 4)	Station (2 or 5)	Remote (3 or 6)
T	X	X	NA	NA	NA
F	T	X	AA	NA	NA
F	F	T	AA	AA	NA
F	F	F	AA	AA	AA

[a] T = True (asserted)
F = False (deasserted)
X = Do not care (true or false)
AA = Command is allowed
NA = Command is not allowed

Control Requests

IEC 61850 control services are implemented by reading and writing to pseudovariables in the relay in response to MMS requests. Similar to how client requests are generated and mapped to MMS read or write service requests, server actions are also mapped to internal commands, read and write actions, and MMS information report messages. In the case of an unsuccessful control request, the relay sends the appropriate response PDU indicating that there was a problem and an MMS information report that contains more detailed information about the problem that occurred.

When writing controls, the client must select and write the entire Oper, SBOw, or Cancel structure to the relay. See *Figure G.10* for the attributes of the CON logical device and the ST and CO functional constraints (FC) of LN RBGGIO1 used for control of RB01 through RB08.

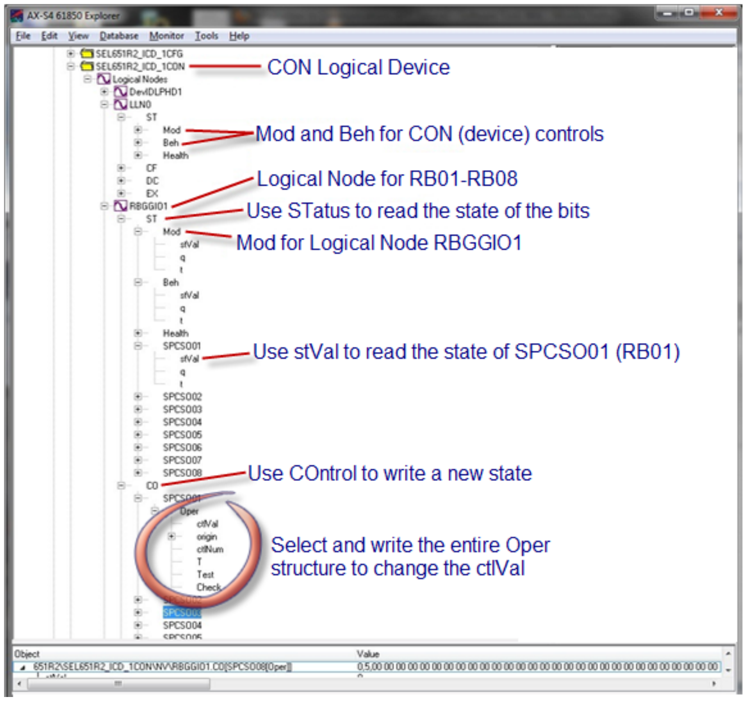


Figure G.10 MMS Client View of the CON Logical Device

Control Error Messages

If a control request results in an error condition, the relay responds with an AddCause value in an MMS information report. See Clause 20.5.2.9 of IEC 61850-7-2 for additional information on the AddCause values. The SEL-751 supports the AddCause values in *Table G.10* as part of the LastApplError information report.

Table G.10 AddCause Descriptions (Sheet 1 of 2)

AddCause Enumeration	AddCause Description	Error Condition
0	Unknown	No other AddCause value defined within this section applies
2	Blocked-by-switching-hierarchy	Logical node is set to local mode, i.e. Loc.stVal = true
3	Select-failed	Originator category not allowed to issue control commands or SelectWithValue operation fails
4	Invalid-position	For controls with enhanced security, an AddCause of “Invalid-position” (4) will be sent if the control status changes to an unexpected value. If no control status change is detected after the operate time-out period, an AddCause of “Time-limitover” (16) will be sent.
5	Position-reached	Control status is already at the desired state
6	Parameter-change-in-execution	Control object is already selected by the client, and 1. Logical node is set to local mode i.e., Loc.stVal = true, or 2. Originator category not hallowed to issue control commands
8	Blocked-by-mode	Mode of logical device or node is not ON

Table G.10 AddCause Descriptions (Sheet 2 of 2)

AddCause Enumeration	AddCause Description	Error Condition
10	Blocked-by-interlocking	Control operation of switch device failed due to interlock check
12	Command-already-in-execution	Execution of a previous control is not completed
13	Blocked-by-health	Health of logical device or node is not OK
16	Time-limit-over	CommandTermination gives a negative response. (The control failed to reach its intended state prior to time-out.)
18	Object-not-selected	Cancel operation fails

Any AddCause value not specified above is not supported. Control CDC data attributes that are associated with unsupported AddCause values and are not part of a control structure are accepted but ignored. For example, the attribute CmdBlk.stVal, which is associated with the AddCause value “blocked-by-command” and is not part of a SBOw, Oper, or Cancel structure, will be ignored.

Group Switch Via MMS

The group switch feature in IEC 61850 is primarily a convenience feature for users so that they can institute a settings group switch from an IEC 61850 client without having to revert to the command line or some other tool. However, this has great potential for integration with IEC 61850 SCADA systems that would be able to control setting groups through IEC 61850 MMS.

The IEC 61850 specification outlines a method for switching the current settings group to another preconfigured settings group. The setting group control block, or SGCB, contains the SettingControl element that enables settings group control. An SEL-751 CID file that supports the group switch functionality only contains one SGCB. The SGCB contains the number of settings groups in the relay and may also contain the current active setting group, ActSG. Note that if the CID file contains a value for ActSG, it is ignored and the relay uses the actual active setting group value for ActSG at the time of CID file download.

When the IEC 61850 functions of the relay are enabled, the selectActiveSG service allows an MMS client to request that the relay change the active setting group. The MMS client can request a group switch by writing a valid setting group number to ActSG. The relay updates the ActSG value under the following conditions:

- ➤ The value written to ActSG is valid and not the current active group
- ➤ There is no group switch in progress
- ➤ The setting of the active group was successful

Note that if the value written to ActSG is the same as the current group, the relay will not attempt to switch settings groups. Please refer to *Multiple Settings Groups on page 4.204* for more information on setting group selection.

Service Tracking

The IEC 61850 standard defines many services to be provided by an IED (server). These services include control services, reporting services, logging services, and group switch control services. IEC 61850 Ed2 defines the service tracking feature to allow these services to be reported or logged, whether they succeed or fail.

The SEL-751 supports the service tracking feature for control commands, report control block edits, and group switch selection. You can report these services.

Tracking of these services is enabled by data objects in the service tracking logical node LTRK. *Table G.11* lists the service tracking data objects. Their data attributes mirror those in the service request or in the control block that was the target of the service request.

Table G.11 Service Tracking Data Objects

Data Object	CDC	Description
SpcTrk	CTS	Tracks control service requests targeted at a controllable single-point object
DpcTrk	CTS	Tracks control service requests targeted at a controllable double-point object
EncTrk	CTS	Tracks control service requests targeted at a controllable enumerated status object
UrcbTrk	UTS	Tracks unbuffered report control block edits
BrcbTrk	BTS	Tracks buffered report control block edits
SgcbTrk	STS	Tracks active settings group selection

Refer to *Table G.45* for information regarding the available attributes in each tracking data object.

Each tracking data object includes the data attributes objRef, serviceType, and errorCode. The attribute objRef provides the reference to the control object or control block instance that was the target of the service request. The attribute serviceType provides an enumerated value for the specific service requested or executed. *Table G.12* defines the service type enumerations.

Table G.12 IEC 61850 Service Type Enumeration (Sheet 1 of 2)

Service Type	Service Name	Description
16	SelectActiveSG	Active settings group switch request
24	SetBRCBValues	Write request on one or more of the following buffered report control block attributes: RptID, RptEna, OptFlds, BufTm, TrgOps, IntgPd, PurgeBuf, EntryID, GI, or ResvTms
26	SetURCBValues	Write request on one or more of the following unbuffered report control block attributes: RptID, RptEna, OptFlds, BufTm, TrgOps, IntgPd, Resv, or GI
44	SelectWithValue	Select control request
45	Cancel	Cancel control request
46	Operate	Operate control request

Table G.12 IEC 61850 Service Type Enumeration (Sheet 2 of 2)

Service Type	Service Name	Description
47	CommandTermination	Control processing completed on a control object configured with enhanced security control model
54	InternalChange	Report control block has been automatically disabled, i.e., RptEna is set to False after a loss of association with the client

The attribute errorCode provides the error code that indicates whether the service was successful or unsuccessful. *Table G.13* lists the codes and the corresponding ACSI errors.

Table G.13 IEC 61850 ACSI Service Error

Error Code	ACSI Error
0	no-error
1	instance-not-available
3	access-violation
5	parameter-value-inappropriate
6	parameter-value-inconsistent
7	class-not-supported
8	instance-locked-by-other-client
10	type-conflict
11	failed-due-to-communications-constraint
12	failed-due-to-server-constraint

When creating data sets to track the services through information reporting, it is important to include the tracking data objects as a whole object (FCD—functionally constrained data), and not as individual data attributes (FCDA—functional constrained data attribute). Only the objRef attribute has a trigger option (dupd—data update) and can trigger a report. The dupd trigger option must also be enabled in the report control block that is reporting changes in the tracking data objects.

GOOSE

The Generic Object Oriented Substation Event (GOOSE) object within IEC 61850 is for high-speed control messaging. IEC 61850 GOOSE automatically broadcasts messages containing status, controls, and measured values onto the network for use by other devices. IEC 61850 GOOSE sends the messages several times, increasing the likelihood that other devices receive the messages.

IEC 61850 GOOSE objects can quickly and conveniently transfer status, controls, and measured values between peers on an IEC 61850 network. Configure SEL devices to respond to GOOSE messages from other network devices 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–VB256) are control inputs that you can map to GOOSE receive messages by using the Architect software. See the VB*nnn* bits in *Table G.36* 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.

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 data set 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 message 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 data set. The second transmission occurs Min. Time later. The third transmission occurs Min. Time after the second transmission. The fourth transmission occurs twice Min. Time after the third transmission. All subsequent transmissions occur at the Max. Time interval. For example, a message with a Min. Time of 4 ms and Max. Time of 1000 ms is transmitted upon triggering, then retransmitted at intervals of 4 ms, 4 ms, 8 ms, and then at 1000 ms indefinitely or until another change triggers a new GOOSE message (see IEC 61850-8-1, Sec. 18.1). The default Min. Time value is 8 ms. This is also the suggested Min. Time value.
- GOOSE transmission is squelched (silenced) after a permanent (latching) self-test failure.
- Each outgoing GOOSE message 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 messages 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
  - Data Set Reference
  - Application ID
  - GOOSE Control Reference
- Rejection of all DA contained in an incoming GOOSE message, based on the accumulation of the following error indications created by inspection of the received GOOSE message:
  - **Configuration Mismatch**: the configuration number of the incoming GOOSE message changes.
  - **Needs Commissioning**: this Boolean parameter of the incoming GOOSE message is true.
  - **Decode Error**: the format of the incoming GOOSE message is not as configured.
- Rejection of all DAs with quality indicating test if the subscriber is On or Blocked mode.
- Upon a transition of Mod/Beh, the received GOOSE messages are evaluated to determine if the messages will be processed or not according to IEC 61850-7-4 Appendix A.
- 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

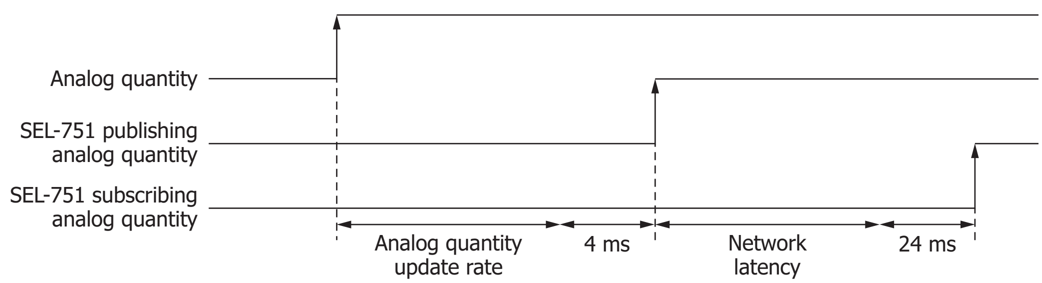
Link-layered priority tagging and virtual LAN is supported as described in Annex C of IEC 61850-8-1:2004(E).

Fixed GOOSE

Fixed GOOSE is a simple and fast peer-to-peer communication method that uses the fixed length GOOSE format described in Annex A of IEC 61850-8-1:2011/A1:2020. The SEL-751 supports one outgoing (transmit) Fixed GOOSE message and four incoming (receive) Fixed GOOSE messages. Each Fixed GOOSE message can contain as many as eight analogs and eight digitals. Various settings required to configure Fixed GOOSE messages are shown in *Table G.24*.

To enable Fixed GOOSE publications, set EFGTX equal to 1. The TXBIN*x* and TXANA*x* (where *x* = 01–08) settings allow you to configure the list of digitals and analogs to be transmitted. If an analog or digital is not configured in the settings, its value is reported as 0. Fixed GOOSE messages are triggered when there are changes in the values of transmit data configured in the settings. The first transmission occurs immediately following a change in the values of the configured Fixed GOOSE data set. The second transmission occurs FG1TXMIN later. The third transmission occurs FG1TXMIN after the second. The fourth transmission occurs twice FG1TXMIN after the third. All subsequent transmissions occur until the FG1TXMAX interval. Each Fixed GOOSE message contains the configured APP ID, VLAN ID, and priority defined by the settings FG1TXAID, FG1TXVID, and FG1TXVPR. The number of Fixed GOOSE messages that can be subscribed to is defined by EFGRX. Use the FG*n*RXMAC (where *n* = 1–4) and FG1TXMAC settings to set the subscription and publication MAC addresses, respectively. It is expected that the MAC addresses be changed in the settings from the defaults based on the user's system configuration.

Relay Word bits FG*n*RB*x* and analog quantities FG*n*RA*x* (where *n* = 1–4 and *x* = 01–08) map the received Fixed GOOSE message data based on the number of Fixed GOOSE messages. Relay Word bits FG*n*RQ (*n* = 1–4) are Fixed GOOSE quality bits that assert when the respective subscribed Fixed GOOSE message is corrupted or has not arrived within the time-to-live. The SEL-751 transmits Fixed GOOSE messages within 4 ms of the data transition and updates digitals within 4 ms and analogs within 24 ms of message reception. *Figure G.11* illustrates the inherent delays in the analog quantity update when communicated via Fixed GOOSE. The SEL-751 processes and updates analogs at their defined rates. Selection of the analog quantity for publication determines the analog quantity update rate. See *Appendix M: Analog Quantities* for more information on analog quantity update rates. See *FGS (Fixed GOOSE) Command on page 7.51* for more information on Fixed GOOSE communication statistics.



Note: Network latency not-to-scale.

Note: Binary Fixed GOOSE data have similar time delays to those illustrated in the figure, except that binary data are evaluated at every processing interval (4 ms) and do not have analog quantity update rate delays.

Figure G.11 Timing Diagram for Analog Quantity Communicated Via Fixed GOOSE

Simulation Mode

NOTE: Fixed GOOSE simulation is available in relays with firmware versions R402-V0 and higher.

The SEL-751 can be configured to operate in simulation mode. In this mode, the SEL-751 continues to process normal GOOSE messages and Fixed GOOSE messages until a simulated GOOSE message or a Fixed GOOSE message is received for a subscription. Once a simulated GOOSE or Fixed GOOSE message is received, only simulated GOOSE or Fixed GOOSE messages are processed for that subscription. Simulation mode only terminates when LPHDSIM is returned to FALSE. When the relay is not in simulation mode, only normal GOOSE or Fixed GOOSE messages are processed for all subscriptions. You can place the SEL-751 in simulation mode by setting LPHDSIM (CFG.DevIDLPHD1.Sim.stVal) to true via MMS messaging.

Alternatively, you can use SELOGIC variable SC850SM to set LPHDSIM. The rising edge of SC850SM sets LPHDSIM, and the falling edge of SC850SM clears LPHDSIM. When you use SC850SM to enter simulation mode, the relay rejects MMS attempts to enter or exit simulation mode until SC850SM deasserts.

IEC 61850 Mode/Behavior

The IEC 61850-7-4:2010 standard defines the behavior of the different modes to facilitate testing. The different modes are only available in IEDs with IEC 61850 Edition 2 or higher.

SEL-751 relays support the following modes:

- On
- Blocked
- Test
- Test/Blocked
- Off

IEC 61850 Behavior is determined by the logical device mode and its logical node mode according to the IEC 61850 standard. For SEL-751 relays, the selected IEC 61850 Mode/Behavior applies to the entire IED, including all the logical devices and all the logical nodes. The behavior of the IED is always the same as the selected mode. *Table G.14* describes the available services based on the mode/behavior of the IED.

Table G.14 IEC 61850 Services Based on Mode/Behavior

Mode	MMS	GOOSE Publication and Subscription
On	Available	Available
Blocked	Available	Available
Test	Available	Available
Test/Blocked	Available	Available
Off	No services[a]	Publication[b]

[a] All MMS control requests to change the mode with Test = false will be processed.
[b] GOOSE publication in Off mode is disabled if EOFFMTX = N.

The analog quantity I850MOD is an enumerated number that corresponds to mode and behavior as shown in *Table G.15*. You can view the value of this analog quantity by assigning it to a math variable.

Table G.15 Analog Quantity I850MOD Status Based on the Selected IEC 61850 Mode/Behavior

I850MOD	IEC 61850 Mode/Behavior
1	On
2	Blocked
3	Test
4	Test/Blocked
5	Off
0	Not Supported

Mode/Behavior Control

Enable Mode/Behavior Control

IEC 61850 Mode/Behavior, by default, is disabled in SEL-751 relays. To enable IEC 61850 Mode/Behavior, you must set the Port 1 setting E61850 equal to Y. To enable IEC 61850 Mode/Behavior Control, you must set Port setting E850MBC equal to Y and the CID file setting controllableModeSupported to True. You can set the controllableModeSupported setting by selecting **Enable control of IEC 61850 Mode/Behavior** when adding an IED to an Architect project, as shown in *Figure G.12*.

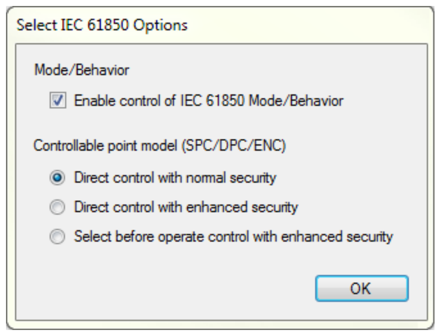


Figure G.12 Set controllableModeSupported = True

Enhanced Secure Mode Control

Relay setting E850MBC and CID file setting controllableModeSupported provide security to prevent accidental switching into an unplanned IEC 61850 Mode/Behavior during normal operations. For example, following IED testing, a technician can disable unplanned switching of IEC 61850 Mode/Behavior by setting E850MBC to N after switching the relay back to On mode.

Change Mode Via MMS or SELogic

If IEC 61850 Mode/Behavior is set as controllable, you can control the IEC 61850 Mode/Behavior via MMS writes to the LLN0 logical node mode data object (Mod.ctlVal) in logical device CFG. Note that Mod.ctVal in other logical devices does not accept MMS writes. See *Table G.16* for the list of writable values.

Table G.16 IEC 61850 Mode/Behavior List of Writable Values

Write Values to Mod.ctVal in Logical Device CFG	Selected IEC 61850 Mode/Behavior
1	On
2	Blocked
3	Test
4	Test/Blocked
5	Off

You can also control IEC 61850 Mode/Behavior through use of the **SET G** command with protection SELogic variables SC850TM and SC850BM on the left side of the SELogic control equations. These variables are the SELogic controls for the Test and Blocked modes, respectively.

Table G.17 IEC 61850 Mode/Behavior Evaluated States of SC850TM and SC850BM

SC850TM	SC850BM	Selected IEC 61850 Mode/Behavior
0	0	See note[a]
1	0	Test
0	1	Blocked
1	1	Test/Blocked
See note[b]	See note[b]	Off

[a] The SELOGIC controls have higher priority than MMS clients in controlling the Test and Blocked modes. When SC850TM and SC850BM both evaluate to 0 (false), IEC 61850 Mode/Behavior control is available to MMS clients. If either SC850TM or SC850BM evaluates to 1 (true), SELOGIC determines the IEC 61850 Mode/Behavior of the IED regardless of MMS control values.

[b] You cannot control Off mode by using SC850TM and SC850BM. When an MMS client causes the IED to be in Off mode, the SELOGIC controls are disabled and SC850TM and SC850BM are not evaluated.

EXAMPLE G.1 Change Mode Via SELOGIC

In this example, Pushbuttons PB01 and PB02 control SC850TM. Pushbuttons PB03 and PB04 control SC850BM. If you press PB01, the relay enters Test mode. If you press PB03, the relay transitions from Test mode into Test/Blocked mode. Press PB02 and PB04 to reset Test and Blocked modes, respectively.

```
=>>SHO L <Enter>

Latch Bits Eqns
SET01    := PB01
RST01    := PB02
SET02    := PB03
RST02    := PB04
```

```
=>>SHO G <Enter>

IEC 61850 Mode/Behavior Configuration
SC850BM    := LT02
SC850TM    := LT01
```

Regardless of mode (On, Blocked, Test, Test/Blocked, Off), the Mod, Beh, and Health quality bitstring will always be quality.validity = Good, quality.failure = False, and quality.test = False. This behavior is not the same when using the **TEST DB** command. The **TEST DB** command behavior is independent of this.

Incoming Messages Processing

IEC 61850 incoming data processing is jointly determined by quality validity, test, and operatorBlocked. SEL-751 relays, by default, check if the quality operatorBlocked equals False; if not, the relays treat the messages as invalid. You can disable the default check by changing the quality mask of GOOSE subscriptions. *Figure G.13* illustrates the default quality check for GOOSE subscription in SEL-751 relays.

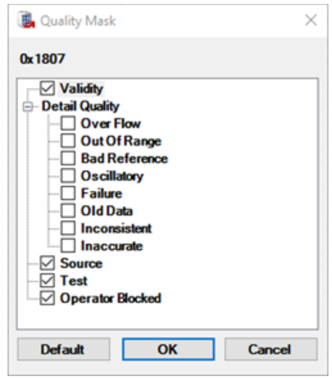


Figure G.13 Default Quality Check on GOOSE Subscription if Quality is Present

Relay Operation for Different IEC 61850 Modes/Behaviors

Mode: On

In On mode, the relay operates as normal; it reports IEC 61850 Mode/Behavior status as On and processes all inputs and outputs as normal. If the quality of the subscribed GOOSE messages satisfies the GOOSE processing (see *GOOSE Processing on page G.23*), the relay processes the received GOOSE messages as valid. *Table G.18* and *Table G.19* illustrate how the relay handles incoming and outgoing messages while in On mode.

Table G.18 IEC 61850 Incoming Message Handling in On Mode

IEC 61850 Messages	Incoming Message With Quality Test Bit Set to False (0)	Incoming Message With Quality Test Bit Set to True (1)
MMS	Processed	Processed as invalid
GOOSE	Processed	Processed as invalid

Table G.19 IEC 61850 Outgoing Message Handling in On Mode

IEC 61850 Messages	Outgoing Message Quality Test Bit Status
MMS	False
GOOSE	False

Figure G.14 illustrates the On Mode/Behavior.

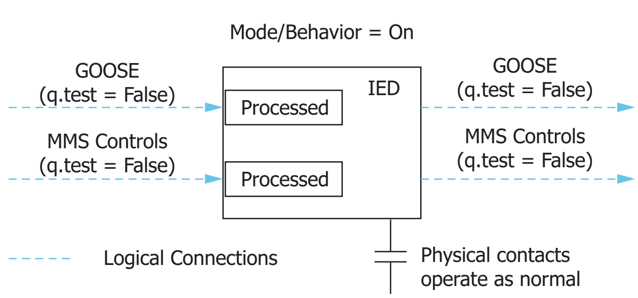


Figure G.14 Relay Operations in On Mode

Mode: Blocked

Blocked mode is similar to On mode, but in Blocked mode, none of the physical contact outputs are operated. However, it does continue to operate control bits, such as remote bits and output contact bits. *Figure G.15* illustrates the Blocked Mode/Behavior.

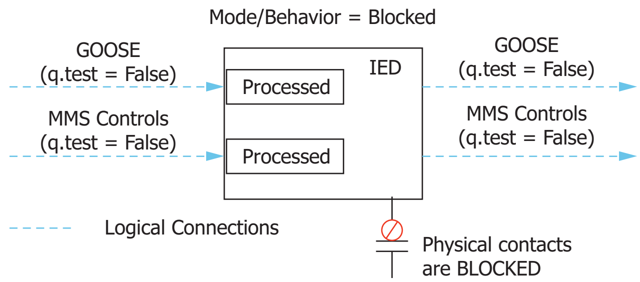


Figure G.15 Relay Operations in Blocked Mode

Mode: Test

In Test mode, the relay processes valid incoming test signals or normal messages and operates physical contact outputs, if triggered. In this Mode/Behavior, outgoing MMS and GOOSE messages have the quality test bit set to True if the quality test bit is present. If the quality of the subscribed GOOSE messages satisfies the user-defined quality type definition (regardless of whether the quality test bit is set to True or False—see *GOOSE Processing on page G.23*), the relay processes the received GOOSE messages as valid. *Table G.20* and *Table G.21* illustrate how the relay handles incoming and outgoing messages while in Test mode.

Table G.20 IEC 61850 Incoming Message Handling in Test Mode

IEC 61850 Messages	Incoming Message With Quality Test Bit Set to False (0)	Incoming Message With Quality Test Bit Set to True (1)
MMS	Not Processed	Processed
GOOSE	Processed	Processed

Table G.21 IEC 61850 Outgoing Message Handling in Test Mode

IEC 61850 Messages	Outgoing Message Quality Test Bit Status
MMS	True
GOOSE	True

Figure G.16 illustrates the Test Mode/Behavior.

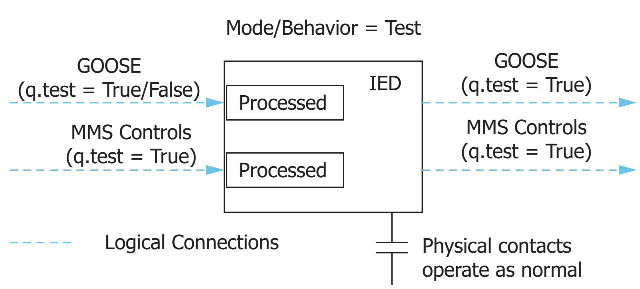


Figure G.16 Relay Operations in Test Mode

Mode: Test/Blocked

In Test/Blocked mode, the relay processes valid incoming test signals or normal messages but blocks any physical contact outputs from operating. In this Mode/Behavior, outgoing MMS and GOOSE messages have the quality test bit set to True if the quality test bit is present. If the quality of the subscribed GOOSE messages satisfies the user-defined quality type definition (regardless of whether the quality test bit is set to True or False— see *GOOSE Processing on page G.23*), the relay processes the received GOOSE messages as valid.

Figure G.17 illustrates the Test/Blocked Mode/Behavior.

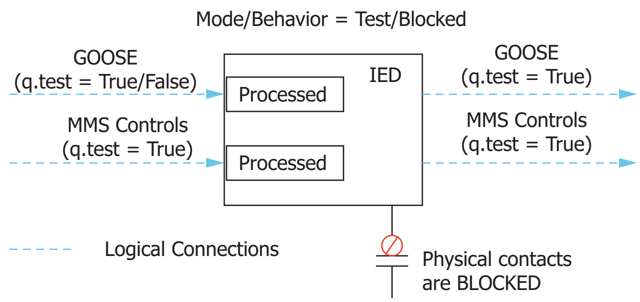


Figure G.17 Relay Operations in Test/Blocked Mode

Mode: Off

In Off mode, the relay no longer processes incoming GOOSE messages. The relay processes MMS control requests to change the IEC 61850 Mode/Behavior if the quality Test bit is set to False. In this mode, the relay is in a disabled state and it no longer trips any physical contact outputs. The Relay Word bit ENABLED is set to False. The device processes MMS control requests to change the active mode of IEC 61850 Mode/Behavior if the quality test bit of the control is set to False. If EOFFMTX is set to Y, the relay continues to transmit GOOSE messages with the quality test bit set to False (0) and the validity set to Invalid (01) if the quality bit is present in the messages. If EOFFMTX is set to N, the relay does not transmit GOOSE messages in this mode. *Table G.22* and *Table G.23* describe how the relay handles incoming and outgoing messages while in Off mode.

Table G.22 IEC 61850 Incoming Message Handling in Off Mode

IEC 61850 Messages	Incoming Message With Quality Test Bit Set to False (0)	Incoming Messages With Quality Test Bit Set to True (1)
MMS	Relay Only Processes Messages to Control the Mode	Not Processed
GOOSE	Not Processed	Not Processed

Table G.23 IEC 61850 Outgoing Message Handling in Off Mode

IEC 61850 Messages	Outgoing Message Quality Validity Bit Status
MMS	Invalid
GOOSE	Invalid

Figure G.18 illustrates the Off Mode/Behavior.

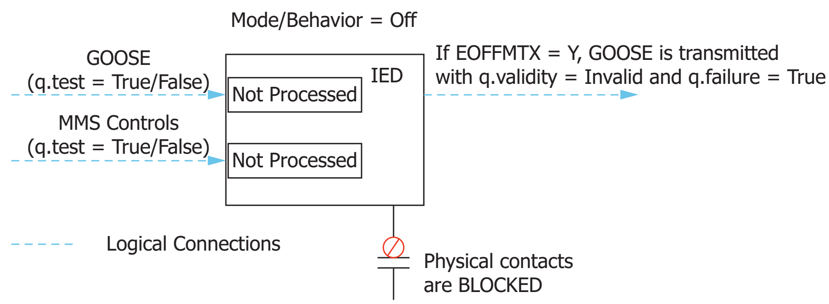


Figure G.18 Relay Operations in Off Mode

IEC 61850 Configuration

Settings

Table G.24 lists IEC 61850 settings. IEC 61850 settings are only available if your device includes the optional IEC 61850 protocol. Configure all other IEC 61850 settings, including subscriptions to incoming GOOSE messages, with Architect.

Table G.24 IEC 61850 Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE IEC 61850 PROTOCOL	Y, N	E61850 := N
ENABLE IEC 61850 GSE[a]	Y[b], N	EGSE := N
ENABLE MMS FILE SERVICES[a]	Y[b], N	EMMSFS := N
ENABLE IEC 61850 MODE/BEHAVIOR CONTROL	Y, N	E850MBC := N
ENABLE GOOSE TX IN OFF MODE	Y, N	EOFFMTX := N
ENA FIXGOOSE PUB	0–1	EFGTX := 0
TX1 MSG DEST MAC	*mm–nn* *mm*: 00–FF *nn*: 00–FF	FG1TXMAC := 00–01
FG1 TX MIN	4–60000 ms	FG1TXMIN := 4
FG1 TX MAX	4–60000 ms	FG1TXMAX := 1000
FG1 TX APPID	0–255	FG1TXAID := 1
FG1 TX VLANID	0–255	FG1TXVID := 1
FG1 TX VLAN PRIO	0–7	FG1TXVPR := 4
ENA FIXGOOSE SUB	0–4	EFGRX := 0
RX*k*[c] MSG DEST MAC	*mm–nn* *mm*: 00–FF *nn*: 00–FF	FG*k*RXMAC := 00–01

[a] Settings EGSE and EMMSFS are hidden when E61850 is set to N.
[b] Requires that E61850 be set to Y.
[c] k = 1–4.

Fixed GOOSE Transmit Digitals

Enter as many as eight Relay Word bits. The Fixed GOOSE transmit digital entries are text-edit mode settings. Default Relay Word bits are TRIP, 50P1T, 50G1T, 50N1T, 51P1T, 51G1T, 51N1T, and 52A. If a Fixed GOOSE transmit digital is set equal to NA (e.g., TXBIN08 = NA), it is treated as a 0.

Fixed GOOSE Transmit Analogs

Enter as many as eight analog quantities. The Fixed GOOSE transmit analog entries are text-edit mode settings. Default analog quantities are IA_MAG, IB_MAG, IC_MAG, IAV, IG_MAG, IN_MAG, 3I2, and FREQ. If a Fixed GOOSE transmit analog is set equal to NA (e.g., TXANA08 = NA), it is treated as a 0.

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 data sets.
- 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 data sets for reports.
- Load IEC 61850 CID files into SEL IEDs.
- Generate ICD and CID files that provide SEL IED descriptions to other manufacturers' tools so they can use SEL GOOSE messages and reporting features.
- Edit deadband settings for measured values.

NOTE: Other manufacturers' ICD and CID files must have IEC 61850 outgoing GOOSE messages with Application IDs (APPIDs) of exactly four characters and VLAN IDs of exactly three characters so that the relay can successfully subscribe to them. If you attempt to configure a relay to subscribe to a GOOSE message that does not meet this criteria, the relay will reject the CID file upon download. Edit other manufacturers' ICD and CID files prior to importing them into Architect by adding leading zeros to the APPID and VLAN ID of outgoing GOOSE messages, as necessary.

Architect provides a graphical user interface (GUI) for users to select, edit, and create IEC 61850 GOOSE messages important for substation protection, coordination, and control schemes. Typically, the user first places icons representing IEDs in a substation container, then edits the outgoing GOOSE messages or creates new ones for each IED. The user can also select incoming GOOSE messages for each IED to receive from any other IEDs in the domain.

Some measured values are reported to IEC 61850 only when the value changes beyond a defined deadband value. Architect allows a deadband to be changed during the CID file configuration. Check and set the deadband values for your particular application when configuring the CID file for a device.

Architect can read ICD and CID files from other manufacturers, enabling the user to map the data seamlessly into SEL IED logic. See the Architect online help for more information.

SEL ICD File Versions

Architect version R.1.1.69.0 and later supports multiple ICD file versions for each type of IED in a project. Because relays with different firmware versions may require different CID file versions, users can manage the CID files of all IEDs within a single project.

Ensure that you work with the appropriate version of Architect relative to your current configuration, existing project files, and ultimate goals. If you want the best available IEC 61850 functionality for your SEL relay, obtain the latest version of Architect and select the appropriate ICD version(s) for your needs. Architect generates CID files from ICD files, so the ICD file version Architect uses also determines the CID file version generated. Details about the different SEL-751 ICD files can be found in *Table A.10*.

The logical nodes description detailed in this manual revision corresponds to the SEL-751 010 ICD file. Information about the previous SEL-751 004 ICD files can be found in the previous manual revisions. Please refer to *Table A.10* to find the manual revision corresponding to the ICD file you are using.

Logical Nodes

Each logical device (LD) has a set of common data objects at the top level LLN0. These represent the current state of the device, as well as some informational data. These data objects are: Mod (Mode), Beh (Behavior), Health, and NamPlt. See the following sections for a brief description of each object.

Mode

The SEL-700 series relays include at the top-level LLN0 within each LD the following enumerations for Mod.stVal:

Mod.stVal Enumeration	Description
1	On
2	Blocked
3	Test
4	Test/Blocked
5	Off
0	IEC 61850 Mode/Behavior disabled

NOTE: Relays that have ICD files with ClassFileVersion 010 always report Mod.stVal = 1 (On mode) for all LD.LLN0 except CFG.LLN0.

The top-level logical node of each LD also includes the following Mod attributes:

Mod.q represents quality.

Mod.t represents time stamps.

Mod.stVal represents the current Mode/Behavior.

You can control IEC 61850 Mode/Behavior via LLN0COMod$Oper in your CFG logical device.

Behavior

The SEL-700 series relays' LNs include the following enumerations for Beh stVal:

Beh stVal Enumeration	Description
1	On
2	Blocked
3	Test
4	Test/Blocked
5	Off
0	IEC 61850 Mode/Behavior disabled

Logical nodes also include the following Beh attributes:

Beh q and **Beh t** according to the *Time Stamps and Quality* section.

Health

The SEL-700 series relays include at the top-level LLN0 within the CFG LD (CFG.LLN0) the following enumerations for Health stVal:

Health stVal Enumeration	Health stVal Value	Description
1	OK	RELAY_EN Relay Word bit = 1
3	Alarm	RELAY_EN Relay Word bit = 0

CFG.LLN0 also includes the following Health attributes:

Health q and **Health t** according to the *Time Stamps and Quality* section.

NamPlt

The top-level LLN0 of each LD includes the following NamPlt attributes:

- ➤ NamPlt vendor which is set to “SEL”.
- ➤ NamPlt swRev which contains the relay FID string value.
- ➤ NamPlt d, which is the LD description.

IEC 61850 Library ID Checksum

The LPHD logical node in the CFG logical device contains information about the physical device, such as the physical device nameplate information. SEL extended this logical node to include an object that provides an identifier for the version of the IEC 61850 component firmware in the device. This object, LPHD.SelLibID, contains a checksum derived from the IEC 61850 library version and is the same value across different devices with the same underlying code. The value is also available in the LIB61850ID field of the *ID Command*.

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 G.25 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.
Physical Communication Channel Supervision	LCCH	This LN is used for supervision of physical communication channels
GOOSE Subscription	LGOS	This LN is used for GOOSE subscription statistics
Time Master Supervision	LTMS	This LN is used for time synchronization master supervision

Table G.26 defines the data class Arc-Flash Detection. This class represents Arc-Flash Detection status.

Table G.26 Arc-Flash Detection Logical Node Class Definition

PAFD Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/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; E: Extension.

Table G.27 defines the data class Thermal Metering Data. This class is a collection of simultaneous measurements (or evaluations) that represent the RTD thermal metering values. Valid data depend on the presence and configuration of the RTD module(s).

Table G.27 Thermal Metering Data Logical Node Class Definition

MTHR Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/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
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; E: Extension.

Table G.28 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 G.28 Thermal Element Metering Data Logical Node Class Definition

MTHE Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/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; E: Extension

Table G.29 defines the data class Metering Statistics. This class is a collection of power system metering statistics.

Table G.29 Metering Statistics Logical Node Class Definition

MSTA Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/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		O
AvVolts	MV	Average voltage		O
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; E: Extension

Table G.30 defines the data class Demand Metering Statistics. This class is a collection of demand currents and energy.

Table G.30 Demand Metering Statistics Logical Node Class Definition

MDST Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/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
PkDmdA	WYE	Peak Demand Currents		E
PkDmdAnseq	MV	Negative-Sequence Peak Demand Current		E
SupWh	BCR[c]	Real energy supply (default supply direction: energy flow towards busbar)		E
SupVArh	BCR[c]	Reactive energy supply (default supply direction: energy flow towards busbar)		E
DmdWh	BCR[c]	Real energy demand (default demand direction: energy flow from busbar away)		E
DmdVArh	BCR[c]	Reactive energy demand (default demand direction: energy flow from busbar away)		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; E: Extension.
[c] For IEC 61850 Edition 1 relays, this data object is defined as MV CDC.

Table G.31 LCCH Physical Communication Channel Supervision (Sheet 1 of 2)

LCCH Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and LN-Instance-ID according to IEC 61850-7-2, Clause 22.		
Data Objects				
Common Logical Node Information				
Beh	ENS	Behavior		M
NamPlt	LPL	Name plate		O

Table G.31 LCCH Physical Communication Channel Supervision (Sheet 2 of 2)

LCCH Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/E[b]**
Status Information				
ChLiv	SPS	Physical channel status		M
RedChLiv	SPS	Physical channel status of redundant channel		M
FerCh	INS	Frame error rate on this channel		O
RedFerCh	INS	Frame error rate on redundant channel		O
Measured and Metered Values				
RxCnt	BCR	Number of received messages		O
RedRxCnt	BCR	Number of received messages on redundant channel		O
TxCnt	BCR	Number of sent messages		O
Controls				
RsStat	SPC	Reset device statistics		E
Settings				
NetMod	ENG	Network mode		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; E: Extension.

Table G.32 LGOS GOOSE Subscription (Sheet 1 of 2)

LGOS Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and LN-Instance-ID according to IEC 61850-7-2, Clause 22		
Data Objects				
Common Logical Node Information				
Beh	ENS	Behavior		M
NamPlt	LPL	Name plate		O
Status Information				
NdsCom	SPS	Subscription needs commissioning		O
St	SPS	Status of the subscription		M
SimSt	SPS	Status showing that Sim messages are received and accepted		O
LastStNum	INS	Last state number received		O
LastSqNum	INS	Last sequence number received		E
LastTal	INS	Last time-allowed-to-live received		E
ConfRevNum	INS	Expected configuration revision number		O

Table G.32 LGOS GOOSE Subscription (Sheet 2 of 2)

LGOS Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/E[b]**
RxConfRevNum	INS	Configuration revision number of the received messages		O
ErrSt	ENS	Current error status of the subscription		E
OosCnt	INS	Number of out-of-sequence (OOS) errors		E
TalCnt	INS	Number of time-allowed-to-live violations		E
DecErrCnt	INS	Number of messages that failed decoding		E
BufOvflCnt	INS	Number of messages lost due to buffer overflow		E
MsgLosCnt	INS	Number of messages lost due to OOS errors (estimated)		E
MaxMsgLos	INS	Max. number of sequential messages lost due to OOS error (estimated)		E
InvQualCnt	INS	Number of mapped incoming GOOSE data with invalid quantity		E
Measured and Metered Values				
TotDwnTm	MV	Total downtime in seconds		E
MaxDwnTm	MV	Maximum continuous downtime in seconds		E
Controls				
RsStat	SPC	Reset/clear statistics		E
Settings				
GoCBRef	ORG	Reference to the subscribed GOOSE control block		O
DatSet	ORG	Configured data set reference		E
GoID	VSG	Configured GOOSE ID		E
Addr	VSG	Configured multicast MAC address		E
VlanID	ING	Configured VLAN ID		E
VlanPri	ING	Configured VLAD priority		E
AppID	ING	Configured APPID		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; E: Extension.

Table G.33 LTMS Time Master Supervision (Sheet 1 of 2)

LTMS Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and LN-Instance-ID according to IEC 61850-7-2, Clause 22		

Table G.33 LTMS Time Master Supervision (Sheet 2 of 2)

LTMS Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/E[b]**
Data Objects				
Common Logical Node Information				
Beh	ENS	Behavior		M
NamPlt	LPL	Name plate		O
Status Information				
TmAcc	INS	Number of significant bits in fraction of second in the time accuracy part of the time stamp		O
TmSrc	VSS	Current time source identity		M
TmSrcTyp	ENS	Type of the clock source		M
TmSyn	ENS	Actual time synchronization applied		O
TmSynLkd	ENS	Locked status of clock synchronization		O
Measured and Metered Values				
TmTosPer	MV	Duration, in milliseconds, between two consecutive top-of-second points on the synchronized time		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; E: Extension.

Table G.34 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.
Physical Device	LPHD	This LN is used to represent information about the physical device.

Table G.35 Fault Locator Logical Node Class Definition (Sheet 1 of 2)

RFLO Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/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 G.35 Fault Locator Logical Node Class Definition (Sheet 2 of 2)

RFLO Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/E[b]**
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; E: Extension.

Table G.36 Circuit Breaker Logical Node Class Definition

XCBR Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/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
CBOpCap	ENS	Circuit breaker operating capability		O
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; E: Extension.

Table G.37 Measurement Logical Node Class Definition

MMXU Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/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
W	WYE	Phase active power		O
VAr	WYE	Phase reactive power		O
VA	WYE	Phase apparent power		O
PF	WYE	Phase power factor		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; E: Extension.

Table G.38 Measurement Logical Node Class Definition (Sheet 1 of 2)

MMXU Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/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

Table G.38 Measurement Logical Node Class Definition (Sheet 2 of 2)

MMXU Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/E[b]**
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; E: Extension.

Table G.39 Generic Process I/O Logical Node Class Definition

GGIO Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/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
FGRXQ	SPS	Fixed GOOSE message received quality bit		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; E: Extension.

Table G.40 Physical Device Logical Node Class Definition(Sheet 1 of 2)

LPHD Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/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

Table G.40 Physical Device Logical Node Class Definition(Sheet 2 of 2)

LPHD Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/E[b]**
Data Objects				
Descriptions				
PhyNam	ENS	Physical device name plate		M
Status Information				
PhyHealth	ENS	Reflects the state of the physical device related hardware and software		M
Proxy	SPS	Reflects if the physical device is a proxy		M
SelLibId	VSD	IEC 61850 library ID checksum		E
Controls				
Sim	SPC	Simulation mode		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; E: Extension

Device Logical Nodes

The following tables, *Table G.41* through *Table G.45*, show the Logical Nodes (LN) supported in the SEL-751 and the associated Relay Word bits or measured quantities.

Table G.41 shows the LN associated with protection elements defined as Logical Device PRO.

Table G.41 Logical Device: PRO (Protection) (Sheet 1 of 17)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = CO			
BKR1CSWI1	Pos.Oper.ctlVal	CC:OC[a]	Breaker close/open command
DC1CSWI1	Pos.Oper.ctlVal	89CC2P1: 89OC2P1[a]	Two-Position Disconnect 1 close/open command
DC2CSWI2	Pos.Oper.ctlVal	89CC2P2: 89OC2P2[a]	Two-Position Disconnect 2 close/open command
DC3CSWI3	Pos.Oper.ctlVal	89CC2P3: 89OC2P3[a]	Two-position Disconnect 3 close/open command
DC4CSWI4	Pos.Oper.ctlVal	89CC2P4: 89OC2P4[a]	Two-position Disconnect 4 close/open command
DC5CSWI5	Pos.Oper.ctlVal	89CC2P5: 89OC2P5[a]	Two-position Disconnect 5 close/open command
DC6CSWI6	Pos.Oper.ctlVal	89CC2P6: 89OC2P6[a]	Two-position Disconnect 6 close/open command
DC7CSWI7	Pos.Oper.ctlVal	89CC2P7: 89OC2P7[a]	Two-position Disconnect 7 close/open command
DC8CSWI8	Pos.Oper.ctlVal	89CC2P8: 89OC2P8[a]	Two-position Disconnect 8 close/open command
DC9CSWI9	Pos.Oper.ctlVal	89CC3PL1: 89OC3PL1[a]	Three-position In-Line Disconnect 1 close/open command
DC10CSWI10	Pos.Oper.ctlVal	89CC3PL2: 89OC3PL2[a]	Three-position In-Line Disconnect 2 close/open command

Table G.41 Logical Device: PRO (Protection) (Sheet 2 of 17)

Logical Node	Attribute	Data Source	Comment
DC11CSWI11	Pos.Oper.ctlVal	89CC3PE1: 89OC3PE1[a]	Three-position Earthing Disconnect 1 close/open command
DC12CSWI12	Pos.Oper.ctlVal	89CC3PE2: 89OC3PE2[a]	Three-position Earthing Disconnect 2 close/open command
Functional Constraint = MX[b]			
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
ATPTOC20	Str.general	51AP	A-phase time-overcurrent element pickup
ATPTOC20	Str.dirGeneral	unknown	Direction unknown due to settings
BK179RREC1	TrBeh.stVal	THREE POLE TRIPPING	Trip behavior kind (three-pole)
BK179RREC1	Rec3PhCnt1	F3PSHOT[c]	Three-pole trip (TP) shot counter
BK179RREC1	AutoRecSt	RECST[c]	Reclosing state—1: Ready, 2: In Progress, 12: Not Ready
BK179RREC1	OpCls	CLOSE	Supervised **CLOSE** command
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	Asserted when relay control configuration is in Local mode
BK1XCBR1	LocKey.stVal	NOOP	No operation, no error
BK1XCBR1	OpCnt.stVal	INTT	Internal trip counter
BK1XCBR1	OpCntEx.stVal	EXTT	External trip counter
BK1XCBR1	Pos.stVal	52A?1:2[d]	Breaker position (52A = false, breaker opened; 52A = true, breaker closed)
BKR1CILO1	EnaCls.stVal	BKENC1	Supervise the close operation of Breaker BKR1
BKR1CSWI1	OpCls.general	CC	Breaker close control
BKR1CSWI1	OpOpn.general	OC	Breaker open control
BKR1CSWI1	Loc.stVal	LOC	Control authority at local/bay level
BKR1CSWI1	LocKey.stVal	NOOP	No operation, no error
BKR1CSWI1	LocSta.stVal	LOCSTA	Control authority at station level

Table G.41 Logical Device: PRO (Protection) (Sheet 3 of 17)

Logical Node	Attribute	Data Source	Comment
BKR1CSWI1	Pos.stVal	52A|52B?0:1:2:3[d]	Breaker close/open status
BKR1CILO1	EnaOpn.stVal	BKENO1	Supervise the open operation of Breaker BKR1
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 definite-time over-/underfrequency trip
D1TPTOF1	Str.general	81D1P	Level 1 definite-time over-/underfrequency pickup
D1TPTOF1	Str.dirGeneral	unknown	Direction undefined
D2TPTOF2	Op.general	81D2T	Level 2 definite-time over-/underfrequency trip
D2TPTOF2	Str.general	81D2P	Level 2 definite-time over-/underfrequency pickup
D2TPTOF2	Str.dirGeneral	unknown	Direction undefined
D3TPTOF3	Op.general	81D3T	Level 3 definite-time over-/underfrequency trip
D3TPTOF3	Str.general	81D3P	Level 3 definite-time over-/underfrequency pickup
D3TPTOF3	Str.dirGeneral	unknown	Direction undefined
D4TPTOF4	Op.general	81D4T	Level 4 definite-time over-/underfrequency trip
D4TPTOF4	Str.general	81D4P	Level 4 definite-time over-/underfrequency pickup
D4TPTOF4	Str.dirGeneral	unknown	Direction undefined
D5TPTOF5	Op.general	81D5T	Level 5 definite-time over/underfrequency trip
D5TPTOF5	Str.general	81D5P	Level 5 definite-time over/underfrequency pickup
D5TPTOF5	Str.dirGeneral	unknown	Direction undefined
D6TPTOF6	Op.general	81D6T	Level 6 definite-time over-/underfrequency trip
D6TPTOF6	Str.general	81D6P	Level 6 definite-time over-/underfrequency pickup
D6TPTOF6	Str.dirGeneral	unknown	Direction undefined
DC1CILO1	EnaCls.stVal	89CE2P1	Two-Position Disconnect 1 close enabled
DC1CILO1	EnaOpn.stVal	89OE2P1	Two-Position Disconnect 1 open enabled
DC2CILO2	EnaCls.stVal	89CE2P2	Two-Position Disconnect 2 close enabled
DC2CILO2	EnaOpn.stVal	89OE2P2	Two-Position Disconnect 2 open enabled
DC3CILO3	EnaCls.stVal	89CE2P3	Two-Position Disconnect 3 close enabled
DC3CILO3	EnaOpn.stVal	89OE2P3	Two-Position Disconnect 3 open enabled
DC4CILO4	EnaCls.stVal	89CE2P4	Two-Position Disconnect 4 close enabled
DC4CILO4	EnaOpn.stVal	89OE2P4	Two-Position Disconnect 4 open enabled
DC5CILO5	EnaCls.stVal	89CE2P5	Two-Position Disconnect 5 close enabled
DC5CILO5	EnaOpn.stVal	89OE2P5	Two-Position Disconnect 5 open enabled
DC6CILO6	EnaCls.stVal	89CE2P6	Two-Position Disconnect 6 close enabled
DC6CILO6	EnaOpn.stVal	89OE2P6	Two-Position Disconnect 6 open enabled
DC7CILO7	EnaCls.stVal	89CE2P7	Two-Position Disconnect 7 close enabled
DC7CILO7	EnaOpn.stVal	89OE2P7	Two-Position Disconnect 7 open enabled
DC8CILO8	EnaCls.stVal	89CE2P8	Two-Position Disconnect 8 close enabled

Table G.41 Logical Device: PRO (Protection) (Sheet 4 of 17)

Logical Node	Attribute	Data Source	Comment
DC8CILO8	EnaOpn.stVal	89OE2P8	Two-Position Disconnect 8 open enabled
DC9CILO9	EnaCls.stVal	89CE3PL1	Three-Position In-Line Disconnect 1 close enabled
DC9CILO9	EnaOpn.stVal	89OE3PL1	Three-Position In-Line Disconnect 1 open enabled
DC10CILO10	EnaCls.stVal	89CE3PL2	Three-Position In-Line Disconnect 2 close enabled
DC10CILO10	EnaOpn.stVal	89OE3PL2	Three-Position In-Line Disconnect 2 open enabled
DC11CILO11	EnaCls.stVal	89CE3PE1	Three-Position Earthing Disconnect 1 close enabled
DC11CILO11	EnaOpn.stVal	89OE3PE1	Three-Position Earthing Disconnect 1 open enabled
DC12CILO12	EnaCls.stVal	89CE3PE2	Three-Position Earthing Disconnect 2 close enabled
DC12CILO12	EnaOpn.stVal	89OE3PE2	Three-Position Earthing Disconnect 2 open enabled
DC1CSWI1	OpCls.general	89C2P1	Two-Position Disconnect 1 closed
DC1CSWI1	OpOpn.general	89O2P1	Two-Position Disconnect 1 open
DC1CSWI1	Loc.stVal	LOC	Control authority at local/bay level
DC1CSWI1	LocKey.stVal	NOOP	No operation, no error
DC1CSWI1	LocSta.stVal	LOCSTA	Control authority at station level
DC1CSWI1	Pos.stVal	89CL2P1|89OP2P1?0:1:2:3[e]	Two-Position Disconnect 1 close/open status
DC2CSWI2	OpCls.general	89C2P2	Two-Position Disconnect 2 closed
DC2CSWI2	OpOpn.general	89O2P2	Two-Position Disconnect 2 open
DC2CSWI2	Loc.stVal	LOC	Control authority at local/bay level
DC2CSWI2	LocKey.stVal	NOOP	No operation, no error
DC2CSWI2	LocSta.stVal	LOCSTA	Control authority at station level
DC2CSWI2	Pos.stVal	89CL2P2|89OP2P2?0:1:2:3[e]	Two-Position Disconnect 2 close/open status
DC3CSWI3	OpCls.general	89C2P3	Two-Position Disconnect 3 closed
DC3CSWI3	OpOpn.general	89O2P3	Two-Position Disconnect 3 open
DC3CSWI3	Loc.stVal	LOC	Control authority at local/bay level
DC3CSWI3	LocKey.stVal	NOOP	No operation, no error
DC3CSWI3	LocSta.stVal	LOCSTA	Control authority at station level
DC3CSWI3	Pos.stVal	89CL2P3|89OP2P3?0:1:2:3[e]	Two-Position Disconnect 3 close/open status
DC4CSWI4	OpCls.general	89C2P4	Two-Position Disconnect 4 closed
DC4CSWI4	OpOpn.general	89O2P4	Two-Position Disconnect 4 open
DC4CSWI4	Loc.stVal	LOC	Control authority at local/bay level
DC4CSWI4	LocKey.stVal	NOOP	No operation, no error
DC4CSWI4	LocSta.stVal	LOCSTA	Control authority at station level
DC4CSWI4	Pos.stVal	89CL2P4|89OP2P4?0:1:2:3[e]	Two-Position Disconnect 4 close/open status
DC5CSWI5	OpCls.general	89C2P5	Two-Position Disconnect 5 closed
DC5CSWI5	OpOpn.general	89O2P5	Two-Position Disconnect 5 open
DC5CSWI5	Loc.stVal	LOC	Control authority at local/bay level
DC5CSWI5	LocKey.stVal	NOOP	No operation, no error
DC5CSWI5	LocSta.stVal	LOCSTA	Control authority at station level

Table G.41 Logical Device: PRO (Protection) (Sheet 5 of 17)

Logical Node	Attribute	Data Source	Comment
DC5CSWI5	Pos.stVal	89CL2P5|89OP2P5?0:1:2:3[e]	Two-Position Disconnect 5 close/open status
DC6CSWI6	OpCls.general	89C2P6	Two-Position Disconnect 6 closed
DC6CSWI6	OpOpn.general	89O2P6	Two-Position Disconnect 6 open
DC6CSWI6	Loc.stVal	LOC	Control authority at local/bay level
DC6CSWI6	LocKey.stVal	NOOP	No operation, no error
DC6CSWI6	LocSta.stVal	LOCSTA	Control authority at station level
DC6CSWI6	Pos.stVal	89CL2P6|89OP2P6?0:1:2:3[e]	Two-Position Disconnect 6 close/open status
DC7CSWI7	OpCls.general	89C2P7	Two-Position Disconnect 7 closed
DC7CSWI7	OpOpn.general	89O2P7	Two-Position Disconnect 7 open
DC7CSWI7	Loc.stVal	LOC	Control authority at local/bay level
DC7CSWI7	LocKey.stVal	NOOP	No operation, no error
DC7CSWI7	LocSta.stVal	LOCSTA	Control authority at station level
DC7CSWI7	Pos.stVal	89CL2P7|89OP2P7?0:1:2:3[e]	Two-Position Disconnect 7 close/open status
DC8CSWI8	OpCls.general	89O2P8	Two-Position Disconnect 8 closed
DC8CSWI8	OpOpn.general	89C2P8	Two-Position Disconnect 8 open
DC8CSWI8	Loc.stVal	LOC	Control authority at local/bay level
DC8CSWI8	LocKey.stVal	NOOP	No operation, no error
DC8CSWI8	LocSta.stVal	LOCSTA	Control authority at station level
DC8CSWI8	Pos.stVal	89CL2P8|89OP2P8?0:1:2:3[e]	Two-Position Disconnect 8 close/open status
DC9CSWI9	OpCls.general	89C3PL1	Three-Position In-Line Disconnect 1 closed
DC9CSWI9	OpOpn.general	89O3PL1	Three-Position In-Line Disconnect 1 open
DC9CSWI9	Loc.stVal	LOC	Control authority at local/bay level
DC9CSWI9	LocKey.stVal	NOOP	No operation, no error
DC9CSWI9	LocSta.stVal	LOCSTA	Control authority at station level
DC9CSWI9	Pos.stVal	89CL3PL1|89OP3PL1?0:1:2:3[e]	Three-Position In-Line Disconnect 1 close/open status
DC10CSWI10	OpCls.general	89C3PL2	Three-Position In-Line Disconnect 2 closed
DC10CSWI10	OpOpn.general	89O3PL2	Three-Position In-Line Disconnect 2 open
DC10CSWI10	Loc.stVal	LOC	Control authority at local/bay level
DC10CSWI10	LocKey.stVal	NOOP	No operation, no error
DC10CSWI10	LocSta.stVal	LOCSTA	Control authority at station level
DC10CSWI10	Pos.stVal	89CL3PL2|89OP3PL2?0:1:2:3[e]	Three-Position In-Line Disconnect 2 close/open status
DC11CSWI11	OpCls.general	89C3PE1	Three-Position Earthing Disconnect 1 closed
DC11CSWI11	OpOpn.general	89O3PE1	Three-Position Earthing Disconnect 1 open
DC11CSWI11	Loc.stVal	LOC	Control authority at local/bay level
DC11CSWI11	LocKey.stVal	NOOP	No operation, no error
DC11CSWI11	LocSta.stVal	LOCSTA	Control authority at station level

Table G.41 Logical Device: PRO (Protection) (Sheet 6 of 17)

Logical Node	Attribute	Data Source	Comment
DC11CSWI11	Pos.stVal	89CL3PE1|89OP3PE1?0:1:2:3[e]	Three-Position Earthing Disconnect 1 close/open status
DC12CSWI12	OpCls.general	89C3PE2	Three-Position Earthing Disconnect 2 closed
DC12CSWI12	OpOpn.general	89O3PE2	Three-Position Earthing Disconnect 2 open
DC12CSWI12	Loc.stVal	LOC	Control authority at local/bay level
DC12CSWI12	LocKey.stVal	NOOP	No operation, no error
DC12CSWI12	LocSta.stVal	LOCSTA	Control authority at station level
DC12CSWI12	Pos.stVal	89CL3PE2|89OP3PE2?0:1:2:3[e]	Three-Position Earthing Disconnect 2 close/open status
DC1XSWI1	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC1XSWI1	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC1XSWI1	Loc.stVal	LOCAL	Asserted when relay control configuration is in Local mode
DC1XSWI1	LocKey.stVal	NOOP	No operation, no error
DC1XSWI1	OpCnt.stVal	0	
DC1XSWI1	Pos.stVal	89CL2P1?1:2[d]	Disconnect 1 position
DC1XSWI1	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC1XSWI1	SwTyp.stVal	Disconnector	Disconnect type
DC2XSWI2	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC2XSWI2	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC2XSWI2	Loc.stVal	LOCAL	Asserted when relay control configuration is in Local mode
DC2XSWI2	LocKey.stVal	NOOP	No operation, no error
DC2XSWI2	OpCnt.stVal	0	
DC2XSWI2	Pos.stVal	89CL2P2?1:2[d]	Disconnect 2 position
DC2XSWI2	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC2XSWI2	SwTyp.stVal	Disconnector	Disconnect type
DC3XSWI3	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC3XSWI3	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC3XSWI3	Loc.stVal	LOCAL	Asserted when relay control configuration is in Local mode
DC3XSWI3	LocKey.stVal	NOOP	No operation, no error
DC3XSWI3	OpCnt.stVal	0	
DC3XSWI3	Pos.stVal	89CL2P3?1:2[d]	Disconnect 3 position
DC3XSWI3	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC3XSWI3	SwTyp.stVal	Disconnector	Disconnect type
DC4XSWI4	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC4XSWI4	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC4XSWI4	Loc.stVal	LOCAL	Asserted when relay control configuration is in Local mode
DC4XSWI4	LocKey.stVal	NOOP	No operation, no error
DC4XSWI4	OpCnt.stVal	0	
DC4XSWI4	Pos.stVal	89CL2P4?1:2[d]	Disconnect 4 position
DC4XSWI4	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC4XSWI4	SwTyp.stVal	Disconnector	Disconnect type

Table G.41 Logical Device: PRO (Protection) (Sheet 7 of 17)

Logical Node	Attribute	Data Source	Comment
DC5XSWI5	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC5XSWI5	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC5XSWI5	Loc.stVal	LOCAL	Asserted when relay control configuration is in Local mode
DC5XSWI5	LocKey.stVal	NOOP	No operation, no error
DC5XSWI5	OpCnt.stVal	0	
DC5XSWI5	Pos.stVal	89CL2P5?1:2[d]	Disconnect 5 position
DC5XSWI5	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC5XSWI5	SwTyp.stVal	Disconnector	Disconnect type
DC6XSWI6	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC6XSWI6	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC6XSWI6	Loc.stVal	LOCAL	Asserted when relay control configuration is in Local mode
DC6XSWI6	LocKey.stVal	NOOP	No operation, no error
DC6XSWI6	OpCnt.stVal	0	
DC6XSWI6	Pos.stVal	89CL2P6?1:2[d]	Disconnect 6 position
DC6XSWI6	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC6XSWI6	SwTyp.stVal	Disconnector	Disconnect type
DC7XSWI7	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC7XSWI7	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC7XSWI7	Loc.stVal	LOCAL	Asserted when relay control configuration is in Local mode
DC7XSWI7	LocKey.stVal	NOOP	No operation, no error
DC7XSWI7	OpCnt.stVal	0	
DC7XSWI7	Pos.stVal	89CL2P7?1:2[d]	Disconnect 7 position
DC7XSWI7	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC7XSWI7	SwTyp.stVal	Disconnector	Disconnect type
DC8XSWI8	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC8XSWI8	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC8XSWI8	Loc.stVal	LOCAL	Asserted when relay control configuration is in Local mode
DC8XSWI8	LocKey.stVal	NOOP	No operation, no error
DC8XSWI8	OpCnt.stVal	0	
DC8XSWI8	Pos.stVal	89CL2P8?1:2[d]	Disconnect 8 position
DC8XSWI8	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC8XSWI8	SwTyp.stVal	Disconnector	Disconnect type
DC9XSWI9	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC9XSWI9	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC9XSWI9	Loc.stVal	LOCAL	Asserted when relay control configuration is in Local mode
DC9XSWI9	LocKey.stVal	NOOP	No operation, no error
DC9XSWI9	OpCnt.stVal	0	
DC9XSWI9	Pos.stVal	89CL3PL1?1:2[d]	In-Line Disconnect 1 position
DC9XSWI9	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC9XSWI9	SwTyp.stVal	Disconnector	Disconnect type

Table G.41 Logical Device: PRO (Protection) (Sheet 8 of 17)

Logical Node	Attribute	Data Source	Comment
DC10XSWI10	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC10XSWI10	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC10XSWI10	Loc.stVal	LOCAL	Asserted when relay control configuration is in Local mode
DC10XSWI10	LocKey.stVal	NOOP	No operation, no error
DC10XSWI10	OpCnt.stVal	0	
DC10XSWI10	Pos.stVal	89CL3PL2?1:2[d]	In-Line Disconnect 2 position
DC10XSWI10	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC10XSWI10	SwTyp.stVal	Disconnector	Disconnect type
DC11XSWI11	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC11XSWI11	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC11XSWI11	Loc.stVal	LOCAL	Asserted when relay control configuration is in Local mode
DC11XSWI11	LocKey.stVal	NOOP	No operation, no error
DC11XSWI11	OpCnt.stVal	0	
DC11XSWI11	Pos.stVal	89CL3PE1?1:2[d]	Earthing Disconnect 1 position
DC11XSWI11	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC11XSWI11	SwTyp.stVal	Disconnector	Disconnect type
DC12XSWI12	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC12XSWI12	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC12XSWI12	Loc.stVal	LOCAL	Asserted when relay control configuration is in Local mode
DC12XSWI12	LocKey.stVal	NOOP	No operation, no error
DC12XSWI12	OpCnt.stVal	0	
DC12XSWI12	Pos.stVal	89CL3PE2?1:2[d]	Earthing Disconnect 2 position
DC12XSWI12	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC12XSWI12	SwTyp.stVal	Disconnector	Disconnect type
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[f]	HIF event present
HIFRDRE2	FltNum.stVal	HIFLRNUM[f]	Unique HIF event ID number
G1TPIOC9	Op.general	50G1T	Level 1 residual ground instantaneous overcurrent element trip

Table G.41 Logical Device: PRO (Protection) (Sheet 9 of 17)

Logical Node	Attribute	Data Source	Comment
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
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

Table G.41 Logical Device: PRO (Protection) (Sheet 10 of 17)

Logical Node	Attribute	Data Source	Comment
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
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
LLN0	Loc.stVal	LOC	Control authority at local (bay) level
LLN0	LocKey.stVal	NOOP	No operation, no error
LLN0	LocSta.stVal	LOCSTA	Control authority at station level
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

Table G.41 Logical Device: PRO (Protection) (Sheet 11 of 17)

Logical Node	Attribute	Data Source	Comment
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
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
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

Table G.41 Logical Device: PRO (Protection) (Sheet 12 of 17)

Logical Node	Attribute	Data Source	Comment
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 2 phase 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
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

Table G.41 Logical Device: PRO (Protection) (Sheet 13 of 17)

Logical Node	Attribute	Data Source	Comment
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
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

Table G.41 Logical Device: PRO (Protection) (Sheet 14 of 17)

Logical Node	Attribute	Data Source	Comment
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)
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

Table G.41 Logical Device: PRO (Protection) (Sheet 15 of 17)

Logical Node	Attribute	Data Source	Comment
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
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	81R1P	Level 1 rate-of-change-of-frequency element pickup
R1TPFRC1	Str.dirGeneral	unknown	Direction undefined
R2TPFRC2	Op.general	81R2T	Level 2 rate-of-change-of-frequency element trip
R2TPFRC2	Str.general	81R2P	Level 2 rate-of-change-of-frequency element pickup
R2TPFRC2	Str.dirGeneral	unknown	Direction undefined
R3TPFRC3	Op.general	81R3T	Level 3 rate-of-change-of-frequency element trip
R3TPFRC3	Str.general	81R3P	Level 3 rate-of-change-of-frequency element pickup

Table G.41 Logical Device: PRO (Protection) (Sheet 16 of 17)

Logical Node	Attribute	Data Source	Comment
R3TPFRC3	Str.dirGeneral	unknown	Direction undefined
R4TPFRC4	Op.general	81R4T	Level 4 rate-of-change-of-frequency element trip
R4TPFRC4	Str.general	81R4P	Level 4 rate-of-change-of-frequency element pickup
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
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
SYN1RSYN1	Rel.stVal	25A1	Level 1 synchronism check element
SYN1RSYN1	HzInd.stVal	SF	Slip frequency of voltages VP and VS and less than setting 25SF
SYN2RSYN2	Rel.stVal	25A2	Level 2 synchronism check element
SYN2RSYN2	HzInd.stVal	SF	Slip frequency of voltages VP and VS and less than setting 25SF
T55POPF2	Op.general	55T	Power factor trip
T55POPF2	Str.general	55T	Power factor trip
T55POPF2	Str.dirGeneral	unknown	Direction undefined
TOL1PAFD1	Op.general	TOL1[g]	Arc-Flash Light Input 1 element pickup
TOL1PAFD1	Str.general	TOL1[g]	Arc-Flash Light Input 1 element pickup
TOL1PAFD1	Str.dirGeneral	unknown	Direction undefined
TOL2PAFD2	Op.general	TOL2[g]	Arc-Flash Light Input 2 element pickup
TOL2PAFD2	Str.general	TOL2[g]	Arc-Flash Light Input 2 element pickup
TOL2PAFD2	Str.dirGeneral	unknown	Direction undefined
TOL3PAFD3	Op.general	TOL3[g]	Arc-Flash Light Input 3 element pickup
TOL3PAFD3	Str.general	TOL3[g]	Arc-Flash Light Input 3 element pickup
TOL3PAFD3	Str.dirGeneral	unknown	Direction undefined
TOL4PAFD4	Op.general	TOL4[g]	Arc-Flash Light Input 4 element pickup
TOL4PAFD4	Str.general	TOL4[g]	Arc-Flash Light Input 4 element pickup
TOL4PAFD4	Str.dirGeneral	unknown	Direction undefined
TOL5PAFD1	Op.general	TOL5[g]	Arc-Flash Light Input 5 element pickup
TOL5PAFD1	Str.general	TOL5[g]	Arc-Flash Light Input 5 element pickup
TOL5PAFD1	Str.dirGeneral	unknown	Direction undefined
TOL6PAFD2	Op.general	TOL6[g]	Arc-Flash Light Input 6 element pickup
TOL6PAFD2	Str.general	TOL6[g]	Arc-Flash Light Input 6 element pickup
TOL6PAFD2	Str.dirGeneral	unknown	Direction undefined

Table G.41 Logical Device: PRO (Protection) (Sheet 17 of 17)

Logical Node	Attribute	Data Source	Comment
TOL7PAFD3	Op.general	TOL7[g]	Arc-Flash Light Input 7 element pickup
TOL7PAFD3	Str.general	TOL7[g]	Arc-Flash Light Input 7 element pickup
TOL7PAFD3	Str.dirGeneral	unknown	Direction undefined
TOL8PAFD4	Op.general	TOL8[g]	Arc-Flash Light Input 8 element pickup
TOL8PAFD4	Str.general	TOL8[g]	Arc-Flash Light Input 8 element pickup
TOL8PAFD4	Str.dirGeneral	unknown	Direction undefined
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)
Functional Constraint = SP			
LLN0	GrRef.setSrcRef	IdName	Functional name
LLN0	MltLev.setVal	MLTLEV	Multilevel mode of control authority

[a] Writing a 0 to Pos.Oper.ctlVal will cause the open control bit to assert and writing any other value will cause the close control bit to assert.
[b] 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 the instantaneous values are shown in the table.
[c] Internal data source that is not available to the user.
[d] If the breaker/disconnect is closed, value = 10(2). If the breaker/disconnect is open, value = 01(1).
[e] If the disconnect is closed, value = 10(2). If the disconnect is open, value = 01(1). Value = 00(0) indicates an in progress or intermediate state. Value = 11(3) indicates an alarm state.
[f] Valid data depend on HIF firmware option and EHIF setting.
[g] Valid data depend on the installed arc-flash card.

Table G.42 shows the LN associated with measuring elements defined as Logical Device MET.

Table G.42 Logical Device: MET (Metering) (Sheet 1 of 5)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = MX[a b]			
DCZBAT1	Vol.instMag.f	VDC	If Global setting EDCMON := Y, station dc battery voltage, else VBAT channel ac voltage magnitude
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	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

Table G.42 Logical Device: MET (Metering) (Sheet 2 of 5)

Logical Node	Attribute	Data Source	Comment
METMDST1	PkDmdA.res.instCVal.mag.f	IGPD	Residual current peak demand
METMMXU1	A.phsA.instCVal.ang.f	IA_ANG	Current, A-phase, angle
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
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

Table G.42 Logical Device: MET (Metering) (Sheet 3 of 5)

Logical Node	Attribute	Data Source	Comment
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
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

Table G.42 Logical Device: MET (Metering) (Sheet 4 of 5)

Logical Node	Attribute	Data Source	Comment
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[c]	RMS voltage, A-phase, magnitude
RMSMMXU2	PhV.phsB.instCVal.mag.f	VBRMS[c]	RMS voltage, B-phase, magnitude
RMSMMXU2	PhV.phsC.instCVal.mag.f	VCRMS[c]	RMS voltage, C-phase, magnitude
RMSMMXU2	PPV.phsAB.instCVal.mag.f	VABRMS[c]	RMS voltage, AB-phase-to-phase, magnitude
RMSMMXU2	PPV.phsBC.instCVal.mag.f	VBCRMS[c]	RMS voltage, BC-phase-to-phase, magnitude
RMSMMXU2	PPV.phsCA.instCVal.mag.f	VCARMS[c]	RMS voltage, CA-phase-to-phase, magnitude
RMSMMXU2	VSyn.instCVal.mag.f	VSRMS	Synchronizing voltage, RMS magnitude
THERMMTHR1	MaxAmbTmp.instMag.f	RTDAMB[d]	Ambient RTD temperature
THERMMTHR1	MaxBrgTmp.instMag.f	RTDBRGMX[d]	Maximum bearing RTD temperature
THERMMTHR1	MaxOthTmp.instMag.f	RTDOTHMX[d]	Other maximum RTD temperature
THERMMTHR1	MaxWdgTmp.instMag.f	RTDWDGMX[d]	Maximum winding RTD temperature
THERMMTHR1	Tmp01.instMag.f–Tmp12.instMag.f	RTD1–RTD12[d]	RTD1–RTD12 temperature
THERMMTHE1	Thrl1.instMag.f–Thrl3.instMag.f	THRL1–THRL3[e]	Operating quantity thermal level memory from Element 1 to Element 3
THERMMTHE1	Thieq1.instMag.f–Thieq3.instMag.f	THIEQ1–THIEQ3[e]	Operating quantity equivalent current from Element 1 to Element 3
THERMMTHE1	Thtcu1.instMag.f–Thtcu3.instMag.f	THTCU1–THTCU3[e]	Thermal capacity used from Element 1 to Element 3
THERMMTHE1	Thtrip1.instMag.f–Thtrip3.instMag.f	THTRIP1–THTRIP3[e]	Time before thermal element trips from Element 1 to Element 3
THERMMTHE1	Thrls1.instMag.f–Thrls3.instMag.f	THRLS1–THRLS3[e]	Time before thermal element releases from Element 1 to Element 3
Functional Constraint = ST			
LLN0	Loc.stVal	LOC	Control authority at local (bay) level
LLN0	LocKey.stVal	NOOP	No operation, no error
LLN0	LocSta.stVal	LOCSTA	Control authority at station level
DCZBAT1	BatHi.stVal	DCHI	Station dc battery instantaneous overvoltage element
DCZBAT1	BatLo.stVal	DCLO	Station dc battery instantaneous undervoltage element
METMDST1[f]	DmdVArh.actVal	MVARH3PO	Three-phase reactive energy OUT

Table G.42 Logical Device: MET (Metering) (Sheet 5 of 5)

Logical Node	Attribute	Data Source	Comment
METMDST1[f]	DmdWh.actVal	MWH3PO	Three-phase real energy OUT
METMDST1[f]	SupVArh.actVal	MVARH3PI	Reactive energy, three-phase IN
METMDST1[f]	SupWh.actVal	MWH3PI	Three-phase real energy IN
THERMMTHR1	EEHealth.stVal	RTDFLT?1:3[d]	RTD input or communication status
Functional Constraint = SP			
LLN0	GrRef.setSrcRef	IdName	Functional name
LLN0	MltLev.setVal	MLTLEV	Multilevel mode of control authority

[a] MX values contain instantaneous attributes (instMag and instCVal), which are updated whenever the source updates, and other attributes 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] If DELTA_Y := WYE, only VARMS, VBRMS, and VCRMS are calculated. If DELTA_Y := DELTA, only VABRMS, VBCRMS, and VCARMS are calculated.
[d] Valid data depend on E49RTD and RTD1LOC–RTD12LOC settings.
[e] Valid data depend on the E49IEC setting.
[f] For IEC 61850 Edition 1 relays, this quantity is located under Functional Constraint MX.

Table G.43 shows the LN associated with control elements defined as Logical Device CON.

Table G.43 Logical Device: CON (Remote Control)

Logical Node	Status	Control	Relay Word Bit	Comment
Functional Constraint = CO				
RBGGIO1	SPCSO01.stVal–SPCSO08.stVal	SPCSO01.Oper.ctlVal–SPCSO08.Oper.ctlVal	RB01–RB08	Remote Bits RB01–RB08
RBGGIO2	SPCSO09.stVal–SPCSO16.stVal	SPCSO09.Oper.ctlVal–SPCSO16.Oper.ctlVal	RB09–RB16	Remote Bits RB09–RB16
RBGGIO3	SPCSO17.stVal–SPCSO24.stVal	SPCSO17.Oper.ctlVal–SPCSO24.Oper.ctlVal	RB17–RB24	Remote Bits RB17–RB24
RBGGIO4	SPCSO25.stVal–SPCSO32.stVal	SPCSO25.Oper.ctlVal–SPCSO32.Oper.ctlVal	RB25–RB32	Remote Bits RB25–RB32
RBGGIO5	SPCSO33.stVal–SPCSO40.stVal	SPCSO33.Oper.ctlVal–SPCSO40.Oper.ctlVal	RB33–RB40	Remote Bits RB33–RB40
RBGGIO6	SPCSO41.stVal–SPCSO48.stVal	SPCSO41.Oper.ctlVal–SPCSO48.Oper.ctlVal	RB41–RB48	Remote Bits RB41–RB48
RBGGIO7	SPCSO49.stVal–SPCSO56.stVal	SPCSO49.Oper.ctlVal–SPCSO56.Oper.ctlVal	RB49–RB56	Remote Bits RB49–RB56
RBGGIO8	SPCSO57.stVal–SPCSO64.stVal	SPCSO57.Oper.ctlVal–SPCSO64.Oper.ctlVal	RB57–RB64	Remote Bits RB57–RB64
Functional Constraint = ST				
LLN0	Loc.stVal	—	LOC	Control authority at local (bay) level
LLN0	LocKey.stVal	—	NOOP	No operation, no error
LLN0	LocSta.stVal	LocSta.Oper.ctlVal	LOCSTA	Control authority at station level
Functional Constraint = SP				
LLN0	GrRef.setSrcRef	—	IdName	Functional name
LLN0	MltLev.setVal	—	MLTLEV	Multilevel mode of control authority

Table G.44 shows the LN associated with annunciation elements defined as Logical Device ANN.

Table G.44 Logical Device: ANN (Annunciation) (Sheet 1 of 6)

Logical Node	Attribute	Data Source	Comment
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	AccmAbr.instMag.f	WEARA	Breaker–Contact A wear
BWBSCBR2	AccmAbr.instMag.f	WEARB	Breaker–Contact B wear
BWCSCBR3	AccmAbr.instMag.f	WEARC	Breaker–Contact C wear
EMCSCBR1	AuxSwTmOpn.instMag.f	BRKOPTM	Latest breaker open time of the electromechanical contact
EMCSCBR1	AuxSwTmCls.instMag.f	BRKCLTM	Latest breaker close time of the electromechanical contact
FGRX1GGIO1	AnIn01.instMag.f–AnIn08.instMag.f	FG1RA01–FG1RA08	Fixed GOOSE Subscription 1 analogs
FGRX2GGIO1	AnIn01.instMag.f–AnIn08.instMag.f	FG2RA01–FG2RA08	Fixed GOOSE Subscription 2 analogs
FGRX3GGIO1	AnIn01.instMag.f–AnIn08.instMag.f	FG3RA01–FG3RA08	Fixed GOOSE Subscription 3 analogs
FGRX4GGIO1	AnIn01.instMag.f–AnIn08.instMag.f	FG4RA01–FG4RA08	Fixed GOOSE Subscription 4 analogs
FHCSCBR1	AuxSwTmOpn.instMag.f	BRKOPTH	Latest breaker open time of the fast-hybrid contact
FHCSCBR1	AuxSwTmCls.instMag.f	BRKCLTH	Latest breaker close time of the fast-hybrid contact
LSGGIO35	AnIn01.instMag.f–AnIn08.instMag.f	LSENS1–LSENS8[c]	Arc-flash sensor light (LSENS1–LSENS8)
MVGGIO1	AnIn01.instMag.f–AnIn32.instMag.f	MV01–MV32[d]	Math Variables (MV01 to MV32)
MVGGIO2	AnIn33.instMag.f–AnIn64.instMag.f	MV33–MV64[d]	Math Variables (MV33 to MV64)
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

Table G.44 Logical Device: ANN (Annunciation) (Sheet 2 of 6)

Logical Node	Attribute	Data Source	Comment
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
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)
SCGGIO1	AnIn01.instMag.f–AnIn32.instMag.f	SC01–SC32[f]	SELOGIC counters (SC01 to SC32)
SCGGIO2	AnIn33.instMag.f–AnIn64.instMag.f	SC33–SC64[f]	SELOGIC counters (SC33 to SC64)
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 G.44 Logical Device: ANN (Annunciation) (Sheet 3 of 6)

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
FGRX1GGIO1	FGRXQ.stVal	FG1RQ	Fixed GOOSE Message 1 received quality bit
FGRX1GGIO1	Ind01.stVal–Ind08.stVal	FG1RB01–FG1RB08	Fixed GOOSE Subscription 1 digitals
FGRX2GGIO1	FGRXQ.stVal	FG2RQ	Fixed GOOSE Message 2 received quality bit
FGRX2GGIO1	Ind01.stVal–Ind08.stVal	FG2RB01–FG2RB08	Fixed GOOSE Subscription 2 digitals
FGRX3GGIO1	FGRXQ.stVal	FG3RQ	Fixed GOOSE Message 3 received quality bit
FGRX3GGIO1	Ind01.stVal–Ind08.stVal	FG3RB01–FG3RB08	Fixed GOOSE Subscription 3 digitals
FGRX4GGIO1	FGRXQ.stVal	FG4RQ	Fixed GOOSE Message 4 received quality bit
FGRX4GGIO1	Ind01.stVal–Ind08.stVal	FG4RB01–FG4RB08	Fixed GOOSE Subscription 4 digitals
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
LLN0	Loc.stVal	LOC	Control authority at local (bay) level
LLN0	LocKey.stVal	NOOP	No operation, no error
LLN0	LocSta.stVal	LOCSTA	Control authority at station level
LBGGIO31	Ind01.stVal–Ind32.stVal	LB01–LB32[g]	Local Bits (LB01 to LB32)
LTGGIO5	Ind01.stVal–Ind64.stVal	LT01–LT64[h]	Latch Bits (LT01 to LT64)
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

Table G.44 Logical Device: ANN (Annunciation) (Sheet 4 of 6)

Logical Node	Attribute	Data Source	Comment
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
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
PBLEDGGIO7	Ind11.stVal	PB6A_LED	Pushbutton PB6A LED
PBLEDGGIO7	Ind12.stVal	PB6B_LED	Pushbutton PB6B LED
PBLEDGGIO7	Ind13.stVal	PB7A_LED	Pushbutton PB7A LED

Table G.44 Logical Device: ANN (Annunciation) (Sheet 5 of 6)

Logical Node	Attribute	Data Source	Comment
PBLEDGGIO7	Ind14.stVal	PB7B_LED	Pushbutton PB7B LED
PBLEDGGIO7	Ind15.stVal	PB8A_LED	Pushbutton PB8A LED
PBLEDGGIO7	Ind16.stVal	PB8B_LED	Pushbutton PB8B LED
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
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

Table G.44 Logical Device: ANN (Annunciation) (Sheet 6 of 6)

Logical Node	Attribute	Data Source	Comment
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–Ind64.stVal	SV01–SV64[i]	SELOGIC Variables (SV01 to SV64)
SVTGGIO4	Ind01.stVal–Ind64.stVal	SV01T–SV64T[i]	SELOGIC Variable timers (SV01T to SV64T)
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 control equation
TRIPGGIO28	Ind08.stVal	WDGTRIP	Winding temperature trip
TRIPGGIO28	Ind09.stVal–Ind16.stVal	0	Reserved for future use
VBGGIO19	Ind001.stVal–Ind128.stVal	VB001–VB128	Virtual bits (VB001 to VB128)
VBGGIO2	Ind129.stVal–Ind256.stVal	VB129–VB256	Virtual bits (VB129 to VB256)
Functional Constraint = SP			
LLN0	GrRef.setSrcRef	IdName	Functional name
LLN0	MltLev.setVal	MLTLEV	Multilevel mode of control authority

[a] MX values contain instantaneous attributes (instMag and instCVal), which are updated whenever the source updates, and other attributes 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 depend on the optional I/O card installed in the slot.
[c] Active data depend on the optional arc-flash card installed.
[d] Active data depend 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 depend on the ESC setting.
[g] Active data depend on the ELB setting.
[h] Active data depend on the ELAT setting.
[i] Active data depend on the ESV setting.

Table G.45 Logical Device: CFG (Configuration) (Sheet 1 of 5)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = CO			
DevIDLPHD1	Sim.Oper.ctlVal	LPHDSIM	IEC 61850 logical node for physical device simulation
GOLCCH2	RsStat.Oper.ctlVal	GORST[a]	Reset statistics for GOOSE traffic
IPLCCH1	RsStat.Oper.ctlVal	IPRST[a]	Reset statistics for general IP traffic (excluding GOOSE traffic)
LLN0	LocSta.Oper.ctlVal	SC850LS	SELOGIC control for control authority at station level
LLN0	Mod.Oper.ctlVal[b]	I60MOD[c]	IEC 61850 mode/behavior control
LGOS*n*[d]	RsStat.Oper.ctlVal	GRST*n*[e]	Reset GOOSE statistics for Message *n*
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PARTNO	Part number
DevIDLPHD1	PhyNam.serNum	SER_NUM	Serial number
DevIDLPHD1	SelLibId.val	[e]	IEC 61850 library ID checksum
LLN0	NamPlt.swRev	FID	Firmware revision
Functional Constraint = ST			
DevIDLPHD1	Sim.stVal	LPHDSIM	IEC 61850 logical node for physical device simulation
DevIDLPHD1	PhyHealth.stVal	RELAY_EN	Relay enabled
ETHLCCH1	ChLiv.stVal	IPCH[a]	Status of primary ETH channel
ETHLCCH1	RedChLiv.stVal	IPRCH[a]	Status of redundant ETH channel.
ETHLCCH1	RxCnt.actVal	IPRX[a]	Number of frames received over the primary ETH channel
ETHLCCH1	RedRxCnt.actVal	IPRRX[a]	Number of frames received over the redundant ETH channel.
ETHLCCH1	TxCnt.actVal	IPTX[a]	Number of frames transmitted on both primary and redundant ETH channels
ETHLCCH1	FerCh.stVal	IPFER[a]	Frame error rate on the primary ETH channel
ETHLCCH1	RedFerCh.stVal	IPRFER[a]	Frame error rate on the redundant ETH channel.
ETHLCCH1	RsStat.stVal	IPRST[a]	Status of statistics reset for general ETH traffic
LLN0	Mod.stVal	I60MOD[c]	IEC 61850 mode/behavior status
LLN0	Health.stVal	RELAY_EN	Relay enabled
LLN0	Loc.stVal	LOC	Control authority at local (bay) level
LLN0	LocKey.stVal	NOOP	No operation, no error
LLN0	LocSta.stVal	LOCSTA	Control authority at station level
LGOS*n*[d]	NdsCom.stVal	GNCM*n*[e]	Subscription needs commissioning for GOOSE Message *n*. True if ConfRevNum does not match RxConfRevNum
LGOS*n*[d]	St.stVal	GST*n*[e]	Status of the subscription (True = active, False = not active) for GOOSE Message *n*
LGOS*n*[d]	SimSt.stVal	GSIM*n*[e]	Status showing that simulation messages are received and accepted for GOOSE Message *n*
LGOS*n*[d]	LastStNum.stVal	GLST*n*[e]	Last state number received (StNum) for GOOSE Message *n*
LGOS*n*[d]	LastSqNum.stVal	GLSQ*n*[e]	Last sequence number received (SqNum) for GOOSE Message *n*
LGOS*n*[d]	LastTal.stVal	GTAL*n*[e]	Last time-allowed-to-live received (TTL) for GOOSE Message *n*
LGOS*n*[d]	ConfRevNum.stVal	[f]	Expected configuration revision number for GOOSE Message *n*
LGOS*n*[d]	RxConfRevNum.stVal	GCNF*n*[e]	Received configuration revision number for GOOSE Message *n*
LGOS*n*[d]	ErrSt.stVal[g]	GERR*n*[e]	Error status of the subscription for GOOSE Message *n*

Table G.45 Logical Device: CFG (Configuration) (Sheet 2 of 5)

Logical Node	Attribute	Data Source	Comment
LGOS*n*[d]	OosCnt.stVal	GOOS*n*[e]	Number of out-of-sequence (OOS) errors for GOOSE Message *n*
LGOS*n*[d]	TalCnt.stVal	GTLC*n*[e]	Number of time-allowed-to-live violations for GOOSE Message *n*
LGOS*n*[d]	DecErrCnt.stVal	GDER*n*[e]	Number of messages that failed decoding for GOOSE Message *n*
LGOS*n*[d]	BufOvflCnt.stVal	GBFO*n*[e]	Number of messages lost because of buffer overflow for GOOSE Message *n*
LGOS*n*[d]	MsgLosCnt.stVal	GMSL*n*[e]	Number of messages lost due to OOS errors (estimated) for GOOSE Message *n*
LGOS*n*[d]	MaxMsgLos.stVal	GMXM*n*[e]	Maximum number of sequential messages lost because of OOS error (estimated) for GOOSE Message *n*
LGOS*n*[d]	InvQualCnt.stVal	GIDQ*n*[e]	Number of mapped data with invalid quality for GOOSE Message *n*
LGOS*n*[d]	RsStat.stVal	GRST*n*[e]	Status of statistics reset for GOOSE messages
LTIM	TmDT.stVal	TMDT[a]	Indicates daylight-saving time is currently in effect at the IED location
LTMS	TmAcc.stVal	TSACC[a]	Number of significant bits in the FractionOfSecond (an attribute of TimeStamp) 18: 4 µs accuracy (2^{-18}) 10: 1 ms accuracy (2^{-10}) 7: 10 ms accuracy (2^{-7}) 31: Unknown accuracy
LTMS	TmSrc.stVal	TSSRC[a]	Time-source identity If TmSrcTyp is PTP: For ICD files with ClassFileVersion 010, TmSrc indicates the grandmaster clock identity according to IEC/IEEE 61588:2021 For ICD files with a ClassFileVersion earlier than 010, TmsSrc indicates the timeSource enumeration according to IEEE 1588-2008 If TmSrcTyp is SNTP: TmSrc indicates the IP address of the SNTP server For all other values of TmSrcTyp, TmSrc is set to NA
LTMS	TmTosPer.stVal	TSTYPE[a]	Type of the clock source as defined by Relay Word bits Time.SNTP_PriSrvr, Time.SNTP_BackupSrvr, Time.SyncOk, and Time.IRIG_Ok 1: Unknown 2: SNTP 3: PTP 4: IRIG-B
LTMS	TmSyn.stVal	TSSYN[a]	Traceability of the reference time to which the IED is synchronized 3: GlobalAreaClock—TmSrcTyp is PTP with grandmaster clock class of 6, TmSrcTyp is IRIG-B with IRIGC = C37.118, or TmSrcTyp is SNTP 2: LocalAreaClock—TmSrcTyp is PTP with grandmaster clock other than 6 (Future), or TmSrcTyp is IRIG-B with IRIGC ≠ C37.118 1: InternalClock—TmSrcTyp is unknown
LTMS	TmSynLkd.stVal	TSSYNLK[a]	Status of clock synchronization: 1: Locked 2: Unlocked for 0–10 seconds 3: Unlocked for 10–100 seconds 4: Unlocked for 100–1000 seconds 5: Unlocked for more than 1000 seconds
Functional Constraint = MX			
LGOS*n*[d]	TotDwnTm.instMag.f	GDWT*n*[e]	Total downtime in seconds for GOOSE Message *n*
LGOS*n*[d]	MaxDwnTm.instMag.f	GMXD*n*[e]	Maximum continuous downtime in seconds for GOOSE Message *n*

Table G.45 Logical Device: CFG (Configuration) (Sheet 3 of 5)

Logical Node	Attribute	Data Source	Comment
LTMS	TmTosPer.instMag.f	TSPER[a]	Duration, in milliseconds, between two consecutive top-of-second points on the synchronized time; TmTosPer is set to 0 for time sources other than high-accuracy PTP or IRIG-B
Functional Constraint = SP			
ETHLCCH1	NetMod.setVal	NETMODE	Port 1 network operating mode setting 1: Fixed 2: Failover 3: Switched 4: PRP
LGOS*n*[d]	GoCBRef.setSrcRef	[f]	Configured GOOSE control block reference for GOOSE Message *n*
LGOS*n*[d]	DatSet.setSrcRef	[f]	Configured data set reference for GOOSE Message *n*
LGOS*n*[d]	GoID.setVal	[f]	Configured ID for GOOSE Message *n*
LGOS*n*[d]	Addr.setVal	[f]	Configured multicast MAC address for GOOSE Message *n*
LGOS*n*[d]	VlanID.setVal	[f]	Configured VLAN ID for GOOSE Message *n*
LGOS*n*[d]	VlanPri.setVal	[f]	Configured VLAN priority for GOOSE Message *n*
LGOS*n*[d]	AppID.setVal	[f]	Configured APPID for GOOSE Message *n*
LLN0	MtlLev.setVal	MLTLEV	Multilevel mode of control authority
LTIM	TmOfsTmm.setVal	TMOFFS[a]	Offset of local time from UTC in minutes
LTIM	TmUseDT.setVal	TMUSEDT[a]	Set to True if daylight-saving time is enabled
LTIM	TmChgDT.setTm	TMCHGDT[a]	Local time of next change to daylight-saving time
LTIM	TmChgST.setTm	TMCHGST[a]	Local time of next change to standard time
Functional Constraint = SR			
LTRK1	SpcTrk.objRef	[h]	ACSI reference to the SPC object targeted in the request
LTRK1	SpcTrk.serviceType	[h, i]	Type of service requested or executed
LTRK1	SpcTrk.errorCode	[h, j]	ACSI service error status
LTRK1	SpcTrk.ctlVal	[h]	Control value in the request
LTRK1	SpcTrk.ctlNum	[h]	Control number in the request
LTRK1	SpcTrk.origin.orCat	[h]	Originator category value in the request
LTRK1	SpcTrk.origin.orIdent	[h]	Originator identity value in the request
LTRK1	SpcTrk.T	[h]	Time-stamp value in the request
LTRK1	SpcTrk.Test	[h]	Test value in the request
LTRK1	SpcTrk.Check	[h]	Check condition value in the request
LTRK1	SpcTrk.respAddCause	[h]	AddCause value returned in the response
LTRK1	DpcTrk.objRef	[h]	ACSI reference to the DPC object targeted in the request
LTRK1	DpcTrk.serviceType	[h, i]	Type of service requested or executed
LTRK1	DpcTrk.errorCode	[h, j]	ACSI service error status
LTRK1	DpcTrk.ctlVal	[h]	Control value in the request
LTRK1	DpcTrk.ctlNum	[h]	Control number in the request
LTRK1	DpcTrk.origin.orCat	[h]	Originator category value in the request
LTRK1	DpcTrk.origin.orIdent	[h]	Originator identity value in the request
LTRK1	DpcTrk.T	[h]	Time-stamp value in the request
LTRK1	DpcTrk.Test	[h]	Test value in the request
LTRK1	DpcTrk.Check	[h]	Check condition value in the request

Table G.45 Logical Device: CFG (Configuration) (Sheet 4 of 5)

Logical Node	Attribute	Data Source	Comment
LTRK1	DpcTrk.respAddCause	h	AddCause value returned in the response
LTRK1	EncTrk.objRef	h	ACSI reference to the ENC object targeted in the request
LTRK1	EncTrk.serviceType	h, i	Type of service requested or executed
LTRK1	EncTrk.errorCode	h, j	ACSI service error status
LTRK1	EncTrk.ctlVal	h	Control value in the request
LTRK1	EncTrk.ctlNum	h	Control number in the request
LTRK1	EncTrk.origin.orCat	h	Originator category value in the request
LTRK1	EncTrk.origin.orIdent	h	Originator identity value in the request
LTRK1	EncTrk.T	h	Time-stamp value in the request
LTRK1	EncTrk.Test	h	Test value in the request
LTRK1	EncTrk.Check	h	Check condition value in the request
LTRK1	EncTrk.respAddCause	h	AddCause value returned in the response
LTRK1	BrcbTrk.objRef	h	ACSI reference of the BRCB object targeted in the request
LTRK1	BrcbTrk.serviceType	h, i	Type of service requested or executed
LTRK1	BrcbTrk.errorCode	h, j	ACSI service error status
LTRK1	BrcbTrk.rptID	h	RptID attribute value in the request or target BRCB object
LTRK1	BrcbTrk.rptEna	h	RptEna attribute value in the request or target BRCB object
LTRK1	BrcbTrk.datSet	h	DatSet attribute value in the target BRCB object
LTRK1	BrcbTrk.confRev	h	ConfRev attribute value in the target BRCB object
LTRK1	BrcbTrk.optFlds	h	OptFlds attribute value in the request or target BRCB object
LTRK1	BrcbTrk.bufTm	h	BufTm attribute value in the request or target BRCB object
LTRK1	BrcbTrk.sqNum	h	SqNum attribute value in the target BRCB object
LTRK1	BrcbTrk.trgOps	h	TrgOps attribute value in the request or target BRCB object
LTRK1	BrcbTrk.intgPd	h	IntgPd attribute value in the request or target BRCB object
LTRK1	BrcbTrk.gi	h	GI attribute value in the request or target BRCB object
LTRK1	BrcbTrk.purgeBuf	h	PurgeBuf attribute value in the request or target BRCB object
LTRK1	BrcbTrk.entryID	h	EntryID attribute value in the request or target BRCB object
LTRK1	BrcbTrk.timeOfEntry	h	TimeOfEntry attribute value in the request or target BRCB object
LTRK1	BrcbTrk.resvTms	h	resvTms attribute value in the request or target BRCB object
LTRK1	BrcbTrk.owner	h	Owner attribute value in the request or target BRCB object
LTRK1	UrcbTrk.objRef	h	ACSI reference of the URCB object targeted in the request
LTRK1	UrcbTrk.serviceType	h, i	Type of service requested or executed
LTRK1	UrcbTrk.errorCode	h, j	ACSI service error status
LTRK1	UrcbTrk.rptID	h	RptID attribute value in the request or target URCB object
LTRK1	UrcbTrk.rptEna	h	RptEna attribute value in the request or target URCB object
LTRK1	UrcbTrk.resv	h	Resv attribute value in the request or target URCB object
LTRK1	UrcbTrk.datSet	h	DatSet attribute value in the target URCB object
LTRK1	UrcbTrk.confRev	h	ConfRev attribute value in the target URCB object
LTRK1	UrcbTrk.optFlds	h	OptFlds attrbute value in the request or target URCB object
LTRK1	UrcbTrk.bufTm	h	BufTm attribute value in the request or target URCB object
LTRK1	UrcbTrk.sqNum	h	SqNum attribute value in the target URCB object

Table G.45 Logical Device: CFG (Configuration) (Sheet 5 of 5)

Logical Node	Attribute	Data Source	Comment
LTRK1	UrcbTrk.trgOps	h	TrgOps attribute value in the request or target URCB object
LTRK1	UrcbTrk.intgPd	h	IntgPd attribute value in the request or target URCB object
LTRK1	UrcbTrk.gi	h	GI attribute value in the request or target URCB object
LTRK1	UrcbTrk.owner	h	Owner attribute value in the request or target URCB object
LTRK1	SgcbTrk.objRef	h	ACSI reference of the SGCB object targeted in the request
LTRK1	SgcbTrk.serviceType	h, i	Type of service requested (SelectActiveSG)
LTRK1	SgcbTrk.errorCode	h, j	ACSI service error status
LTRK1	SgcbTrk.numOfSG	h	NumOfSG attribute value in the target SGCB object
LTRK1	SgcbTrk.actSG	h	ActSG attribute value in the request
LTRK1	SgcbTrk.editSG	h	EditSG attribute value in the target SGCB object (0)
LTRK1	SgcbTrk.cnfEdit	h	CnfEdit attribute value in the target SGCB object (FALSE)
LTRK1	SgcbTrk.lActTm	h, k	LActTm attribute value in the target SGCB object after activation of the settings group via MMS or non-MMS means

[a] Internal data source and not available to the user.
[b] MMS controls to Mod.Oper are only accepted if IEC 61850 Mode/Behavior is enabled on the relay. Refer to Mode/Behavior Control on page G.27 for more details.
[c] I60MOD is an internal data source derived from the I850MOD analog quantity and is not available to the user.
[d] Where n = 1–16, corresponding to the first 16 GOOSE message subscriptions.
[e] Internal data source not available to the user. See GOOSE on page G.22 for more information.
[f] Data source defined in the IEC 61850 Configured IED Description (CID) file.
[g] Refer to Table 7.27 for a description of each enumeration.
[h] The value depends on the ACSI service type requested, the target object, and the error status.
[i] Refer to Table G.12 for the IEC 61850 service type enumeration.
[j] Refer to Table G.13 for the IEC 61850 ACSI service error.
[k] The LActTm attribute also updates if a setting in the active setting group is changed.

SEL Nameplate Data

The CID file contains information that describes the physical device attributes according to IEC 61850 standards. The LN0 logical node of each logical device contains the Nameplate DOI (instantiated data object) with the data shown in *Table G.46*.

Table G.46 SEL Nameplate Data

Data Attribute	Value
vendor	“SEL”
swRev	Contents of FID string from **ID** command
configRev	Always 0
IdNs	IEC 61850-7-4:2007B

Protocol Implementation Conformance Statement

The following tables are as shown in the IEC 61850 standard, Part 8-1, Section 24. Note that because the standard explicitly dictates which services and functions must be implemented to achieve conformance, only the optional services and functions are listed.

Table G.47 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 G.48 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 MMS stack provides the basis for many IEC 61850 protocol services. *Table G.49* 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 G.49 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		

Table G.49 MMS Service Supported Conformance (Sheet 2 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
output		
takeControl		
relinquishControl		
defineSemaphore		
deleteSemaphore		
reportPoolSemaphoreStatus		
reportSemaphoreStatus		
initiateDownloadSequence		
downloadSegment		
terminateDownloadSequence		
initiateUploadSequence		
uploadSegment		
terminateUploadSequence		
requestDomainDownload		
requestDomainUpload		
loadDomainContent		
storeDomainContent		
deleteDomain		
getDomainAttributes		YES
createProgramInvocation		
deleteProgramInvocation		
start		
stop		
resume		
reset		
kill		
getProgramInvocationAttributes		
obtainFile		YES
defineEventCondition		
deleteEventCondition		
getEventConditionAttributes		
reportEventConditionStatus		
alterEventConditionMonitoring		
triggerEvent		
defineEventAction		
deleteEventAction		
alterEventEnrollment		
reportEventEnrollmentStatus		
getEventEnrollmentAttributes		
acknowledgeEventNotification		
getAlarmSummary		

Table G.49 MMS Service Supported Conformance (Sheet 3 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
getAlarmEnrollmentSummary		
readJournal		
writeJournal		
initializeJournal		
reportJournalStatus		
createJournal		
deleteJournal		
fileOpen		YES
fileRead		YES
fileClose		YES
fileRename		
fileDelete		YES
fileDirectory		YES
unsolicitedStatus		
informationReport		YES
eventNotification		
attachToEventCondition		
attachToSemaphore		
conclude		YES
cancel		YES
getDataExchangeAttributes		
exchangeData		
defineAccessControlList		
getAccessControlListAttributes		
reportAccessControlledObjects		
deleteAccessControlList		
alterAccessControl		
ReconfigureProgramInvocation		

Table G.50 lists specific settings for the MMS parameter Conformance Building Block (CBB).

Table G.50 MMS Parameter CBB

MMS Parameter CBB	Client-CR Supported	Server-CR Supported
STR1		YES
STR2		YES
VNAM		YES
VADR		YES
VALT		YES
TPY		YES
VLIS		YES
CEI		

The following Variable Access conformance statements are listed in the order specified in the IEC 61850 standard, Part 8-1. Generally, only those services whose implementation is not mandatory are shown. Refer to the IEC 61850 standard Part 8-1 for more information.

Table G.51 AlternateAccessSelection Conformance Statement

AlternateAccessSelection	Client-CR Supported	Server-CR Supported
accessSelection		YES
component		YES
index		
indexRange		
allElements		
alternateAccess		YES
selectAccess		YES
component		YES
index		
indexRange		
allElements		

Table G.52 VariableAccessSpecification Conformance Statement

VariableAccessSpecification	Client-CR Supported	Server-CR Supported
listOfVariable		YES
variableSpecification		YES
alternateAccess		YES
variableListName		YES

Table G.53 VariableSpecification Conformance Statement

VariableSpecification	Client-CR Supported	Server-CR Supported
name		YES
address		
variableDescription		
scatteredAccessDescription		
invalidated		

Table G.54 Read Conformance Statement

Read	Client-CR Supported	Server-CR Supported
Request		
specificationWithResult		
variableAccessSpecification		
Response		
variableAccessSpecification		YES
listOfAccessResult		YES

Table G.55 GetVariableAccessAttributes Conformance Statement

GetVariableAccessAttributes	Client-CR Supported	Server-CR Supported
Request		
name		
address		
Response		
mmsDeletable		YES
address		
typeSpecification		YES

Table G.56 DefineNamedVariableList Conformance Statement

DefineVariableAccessAttributes	Client-CR Supported	Server-CR Supported
Request		
variableListName		
listOfVariable		
variableSpecification		
alternateAccess		
Response		

Table G.57 GetNamedVariableListAttributes Conformance Statement

GetNamedVariableListAttributes	Client-CR Supported	Server-CR Supported
Request		
ObjectName		
Response		
mmsDeletable		YES
listOfVariable		YES
variableSpecification		YES
alternateAccess		YES

Table G.58 DeleteNamedVariableList

DeleteNamedVariableList	Client-CR Supported	Server-CR Supported
Request		
Scope		
listOfVariableListName		
domainName		
Response		
numberMatched		
numberDeleted		
DeleteNamedVariableList-Error		

GOOSE Services Conformance Statement

Table G.59 GOOSE Conformance

	Subscriber	Publisher	Value/Comment
GOOSE Services	YES	YES	
SendGOOSEMessage		YES	
GetGoReference			
GetGOOSEElementNumber			
GetGoCBValues		YES	
SetGoCBValues			
GSENotSupported			
GOOSE Control Block (GoCB)		YES	

ACSI Conformance Statements

Table G.60 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 G.61 ACSI Models Conformance Statement (Sheet 1 of 3)

		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]	YES

Table G.61 ACSI Models Conformance Statement (Sheet 2 of 3)

		Client/Subscriber	Server/Publisher	SEL-751 Support
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
M7-11	conf-revision			YES
M8	Unbuffered report control	O^e	O^e	YES
M8-1	sequence-number			YES
M8-2	report-time-stamp			YES
M8-3	reason-for-inclusion			YES
M8-4	data-set-name			YES
M8-5	data-reference			YES
M8-6	BufTm			YES
M8-7	IntgPd			YES
M8-8	GI			YES
M8-9	conf-revision			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
M17	File transfer	O^e	O^e	YES
M18	Application Association	c3	c3	YES
M19	GOOSE Control Block	O	O	YES
M20	Sampled Value Control Block	O	O	
If GSE (B31/32) Is Supported				
M12	GOOSE	O^e	O^e	YES
M12-1	entryID			YES
M12-2	DataReflnc			YES
M13	GSSE	O^e	O^e	

Table G.61 ACSI Models Conformance Statement (Sheet 3 of 3)

		Client/Subscriber	Server/Publisher	SEL-751 Support
If GSE (B41/42) Is Supported				
M14	Multicast SVC	O[e]	O[e]	
M15	Unicast SVC	O[e]	O[e]	
For All IEDs				
M16	Time	M[f]	M[f]	YES[g]

[a] c2 shall be "M" if support for LOGICAL-NODE model has been declared.
[b] c3 shall be "M" if support for DATA model has been declared.
[c] c4 shall be "M" if support for DATA-SET, Substitution, Report, Log Control, or Time model has been declared.
[d] c5 shall be "M" if support for Report, GSE, or SV models has been declared.
[e] O = Optional.
[f] M = Mandatory.
[g] Time source with required accuracy shall be available. Only the Time Master is an SNTP (Mode 4 response) time server. All other Client/Server devices are SNTP (Mode 3 request) clients.

Table G.62 ACSI Services Conformance Statement (Sheet 1 of 3)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-751 Support
Server (Clause 6)					
S1	ServerDirectory	TP		M[a]	YES
Application Association (Clause 7)					
S2-1	Associate_Request	TP	M	O	NO
S2-2	Associate_Response		O	M	YES
S3-1	Abort_Request	TP	c11[b]	M	YES
S3-2	Abort_Processing		M	M	YES
S4-1	Release_Request		c11[b]	O	NO
S4-2	Release_Reponse	TP	M	M	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[c]	M[a]	YES
Data (Clause 10)					
S8	GetDataValues	TP	M[a]	M[a]	YES
S9	SetDataValues	TP	O[c]	O[c]	
S10	GetDataDirectory	TP	O[c]	M[a]	YES
S11	GetDataDefinition	TP	O[c]	M[a]	YES
Data Set (Clause 11)					
S12	GetDataSetValues	TP	O[c]	M[a]	YES
S13	SetDataSetValues	TP	O[c]	O[c]	
S14	CreateDataSet	TP	O[c]	O[c]	
S15	DeleteDataSet	TP	O[c]	O[c]	
S16	GetDataSetDirectory	TP	O[c]	O[c]	YES
Substitution (Clause 12)					
S17	SetDataValues	TP	M[a]	M[a]	

Table G.62 ACSI Services Conformance Statement (Sheet 2 of 3)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-751 Support
Setting Group Control (Clause 13)					
S18	SelectActiveSG	TP	O[c]	O[c]	YES
S19	SelectEditSG	TP	O[c]	O[c]	
S20	SetSGvalues	TP	O[c]	O[c]	
S21	ConfirmEditSGVal	TP	O[c]	O[c]	
S22	GetSGValues	TP	O[c]	O[c]	
S23	GetSGCBValues	TP	O[c]	O[c]	
S24	Report	TP	c6[d]	c6[d]	YES
S24-1	data-change (dchg)				YES
S24-2	qchg-change (qchg)				YES
S24-3	data-update (dupd)				YES
S25	GetBRCBValues	TP	c6[d]	c6[d]	YES
S26	SetBRCBValues	TP	c6[d]	c6[d]	YES
Unbuffered Report Control Block (URCB)					
S27	Report	TP	c6[d]	c6[d]	YES
S27-1	data-change (dchg)				YES
S27-2	qchg-change (qchg)				YES
S27-3	data-update (dupd)				YES
S28	GetURCBValues	TP	c6[d]	c6[d]	YES
S29	SetURCBValues	TP	c6[d]	c6[d]	YES
Logging (Clause 14)					
Log Control Block					
S30	GetLCBValues	TP	M[a]	M[a]	
S31	SetLCBValues	TP	O[c]	M[a]	
LOG					
S32	QueryLogByTime	TP	c7[e]	M[a]	
S33	QueryLogByEntry	TP	c7[e]	M[a]	
S34	GetLogStatusValues	TP	M[a]	M[a]	
Generic Substation Event Model (GSE) (Clause 14.3.5.3.4)					
GOOSE-Control-Block					
S35	SendGOOSEMessage	MC	c8[f]	c8[f]	YES
S36	GetReference	TP	O[c]	c9[g]	
S37	GetGOOSEElementNumber	TP	O[c]	c9[g]	
S38	GetGoCBValues	TP	O[c]	O[c]	YES
S39	SetGoCBValues	TP	O[c]	O[c]	
GSSE-Control-Block					
S40	SendGSSEMessage	MC	c8[f]	c8[f]	
S41	GetReference	TP	O[c]	c9[g]	
S42	GetGSSEElementNumber	TP	O[c]	c9[g]	
S43	GetGsCBValues	TP	O[c]	O[c]	

Table G.62 ACSI Services Conformance Statement (Sheet 3 of 3)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-751 Support
S44	GetGsCBValues	TP	O[c]	O[c]	
Transmission of Sample Value Model (SVC) (Clause 16)					
Multicast SVC					
S45	SendMSVMessage	MC	c10[h]	c10[h]	
S46	GetMSVCBValues	TP	O[c]	O[c]	
S47	SetMSVCBValues	TP	O[c]	O[c]	
Unicast SVC					
S48	SendUSVMessage	MC	c10[h]	c10[h]	
S49	GetUSVCBValues	TP	O[c]	O[c]	
S50	SetUSVCBValues	TP	O[c]	O[c]	
Control (Clause 16.4.8)					
S51	Select		M[a]	O[c]	
S52	SelectWithValue	TP	Ma	O[c]	YES
S53	Cancel	TP	O[c]	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[c]	O[c]	
File Transfer (Clause 20)					
S57	GetFile	TP	O[c]	M[a]	YES
S58	SetFile	TP	O[c]	O[c]	YES
S59	DeleteFile	TP	O[c]	O[c]	
S60	GetFileAttributeValues	TP	O[c]	M[a]	YES
S61	GetServerDirectory (FILESYSTEM)	TP	M[a]	M[a]	YES
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				10 (1 ms) for SNTP 18 (4 µs) for IRIG-B
	T1				YES (for IRIG-B)
	T2				YES (for IRIG-B)
	T3				YES (for IRIG-B)
	T4				YES (for IRIG-B)
T3	Supported Time Stamp resolution (nearest negative power of 2 in seconds)				10 (1 ms) for SNTP 18 (4 µs) for IRIG-B

[a] M = Mandatory.
[b] Either the abort or the release request shall be supported by the client. Additionally, the client must understand the abort request delivered by the server.
[c] O = Optional.
[d] c6 shall declare support for at least one (BRCB or URCB).
[e] c7 shall declare support for at least one (QueryLogByTime or QueryLogAfter).
[f] c8 shall declare support for at least one (SendGOOSEMessage or SendGSSEMessage).
[g] c9 shall declare support if TP association is available.
[h] c10 shall declare support for at least one (SendMSVMessage or SendUSVMessage).

Potential Client and Automation Application Issues With Edition 2 and 2.1 Upgrades

The following are issues that IEC 61850 Edition 1 (Ed1)-based client or automation applications may experience with IEC 61850 Edition 2 (Ed2) and Edition 2.1 (Ed2.1) ICD and firmware changes. However, such issues may be resolved by reconfiguring the client or automation application or worked around by restoring the Ed1 (CID) configuration. None of these should prevent a client application from dynamically discovering the data in the IED as long as the application adheres to the specification of the standard. Note that upgrading to Ed2 firmware will not break existing Ed1 configurations (CID files) in the field, nor require loading an Ed2 version of the CID file.

Unexpected Error Messages

Some MMS and control errors have been changed in Ed2. Hence, the firmware now issues only the Ed2-compliant errors. Clients or automation applications that rely on the Ed1-compliant errors will not function correctly. You can resolve this by reconfiguring the client or automation application to accept Ed2-compliant errors.

Missing or Unknown Data Objects and Attributes

Ed2 has changed some data object and attribute names, as well as the data types of some attributes. Ed2 also prohibits the use of proprietary CDCs. See *Logical Nodes on page G.34* and the logical nodes tables in each product specific manual to determine the Ed2 names. This may cause the failure of clients or automation applications that rely on the Ed1 names. You can also resolve this by reconfiguring the client or automation application to accept the Ed2 names.

Unable to Find Operate Time-Out

A proprietary method was used to specify the operate time-out of control objects in the CID files. A client or automation application that relies on this proprietary method will fail to find the operate time-out in the CID file. You can also resolve this by reconfiguring the client or automation application to accept the Ed2 control object operate time-outs.

Unexpected Control Block Data Attribute Type

The string type data attributes in control blocks (RptID, DatSet, etc.) have been changed from a maximum length of 65 to 129 characters, i.e., VisString65 to VisString129. Some clients and automation applications might see this as an error when the type is reported in the MMS GetVariableAccessAttributes response. You can resolve this by reconfiguring the client or automation application.

Unexpected Reports

Ed2 requires report buffering to start when the device is turned on, unlike in the Ed1 implementation where report buffering started after the first report enable. If a client or automation application relies on the Ed1 behavior, it might fail or indicate an error if the IED sends buffered reports immediately after the first enable. You can resolve this by reconfiguring the client or automation application.

Failure to Reselect a Control Object Before the Time-Out

In Ed1, if a client reselected a control object before the select-before-operate time-out expired, the reselection would succeed and cause the selected timeout to restart. According to Ed2, this reselection is supposed to fail. Ed1-based clients or automation applications that rely on successful reselection might operate incorrectly. You can resolve this by reconfiguring the client or automation application.

Test Control Commands Fail Immediately

In Ed1, if the test attribute was set in a control command structure, the relay would accept the command but perform no action on the target control object. With enhanced control models, the IED would eventually report an operate timeout error after the operate time-out expired. However, in Ed2, any such test commands will fail immediately with an error indicating that the command is blocked because the IED is not in the appropriate mode. Clients or automation applications that depend on the Ed1 behavior might fail. You can resolve this by reconfiguring the client or automation application.

No Reports

Ed2 specifies that no reports are to be generated for a deadbanded attribute if the deadband is set to 0. Previously in Ed1, a deadband of 0 would cause the relay to generate reports for any change in the instantaneous value. Ed1-based clients or automation applications might not operate correctly because of the lack of reports. You can resolve this by reconfiguring the client or automation application.

Known Interoperability Issues Between Ed2.1 and Ed2

For unbuffered and buffered reporting, the client reserves the RCB first before changing the configuration of the RCB and enabling it. Otherwise, if not reserved, the server refuses the configuration and enable request. SEL recommends that you update each client system to Ed2.1 when an Ed2.1 server device is used.

Changes to Data Modeling in Ed2.1

Some logical nodes and data objects have been extended and updated in Ed2.1. The logical nodes and objects present in the default ICD files for SEL devices may have changed for Ed2.1.

The name space for data modeling in Ed2.1 has been changed from IEC 61850-7-4:2007A to IEC 61850-7-4:2007B.

Changes Related to Communication Services in Ed2.1

The changes for communication services in Ed2.1 include:

- Setting Group
  - SGCB.LActTm updates when the active setting group has changed via non-IEC 61850 means or if a setting has changed in the active setting group.
- Unbuffered Reporting
  - When a URCB instance is pre-assigned to a specific client, the Resv attribute is TRUE. The client must always set Resv = TRUE before the report can be enabled.
- Buffered Reporting
  - When a BRCB instance is pre-assigned to a specific client, the ResvTms attribute is –1. The client must set ResvTms to a value greater than 0 before the report can be enabled.

Backward Compatibility With Ed1 Devices

In some cases, updating Ed1 client applications or server devices in an existing IEC 61850 system may not be feasible. While Ed2 or Ed2.1 devices are generally backwards compatible, it might be preferable to use an Ed1 ICD file in a device that supports Ed2 or Ed2.1.

Ed1 subscriber devices cannot interpret the simulation bit or Mode/Behavior in a GOOSE message, which could lead to a misoperation. Therefore, caution and thorough testing are essential in mixed edition systems.

Architect Flexible Server Model (FSM)

Architect provides an interface to build custom ICD files for Ed2.1 devices that have ICD files with ClassFileVersion 010. SEL devices have a default ICD file available in Architect, but it may be necessary to add IEC 61850 optional objects to the default logical nodes or to add additional logical nodes based on an application.

You may need to customize the SCL server model of a device to model functions configured in SELOGIC control equations, and then make them available through MMS or GOOSE. Various functions such as automatic tap changer control, gas alarm for GIS, etc., may be configured in SELOGIC programming but require specific customization to implement in IEC 61850.

For example, the SIML logical node models insulation medium supervision (liquid). Transformers or tap changers use oil as an insulator and sensors or measuring devices may be wired into contact inputs on the relay. Because the connection of these sensors into a device is application-specific, they are not included in the default ICD file. The FSM provides an interface to add and customize the SIML logical node.

Begin by adding a device to the Project Editor in Architect by selecting an existing ICD file (ClassFileVersion 010). Select the Server Model tab to view the logical devices, logical nodes, and data objects that exist in the default ICD file, as shown in *Figure G.19*. Although logical nodes may be added to an existing logical device, SEL recommends that you add a new logical device for customized logical nodes. If SEL releases new logical nodes or features in the future, the merge operation between default and customized files is less prone to inadvertent removal of the customized logical nodes.

The default ICD file in this example contains five logical devices: CFG, PRO, MET, CON, and ANN. To add a logical device, select the **+ Add LDevice** button in the logical device pane. Provide an instance name for the new logical device. The new logical device is named XFMR, as shown in *Figure G.21*.

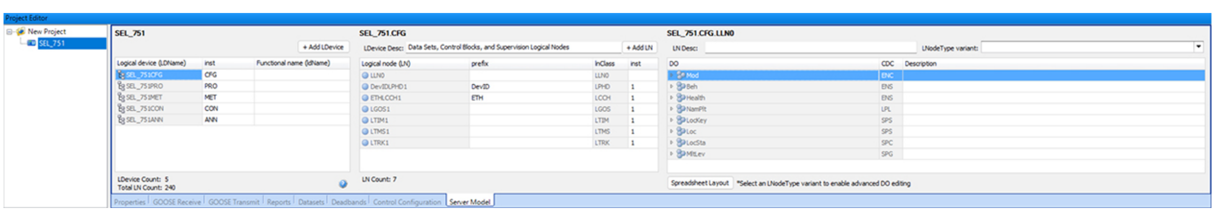


Figure G.19 Server Model View in Architect

Every logical device contains an LLN0 or common logical node that provides common information. To add another logical node, either right-click in the logical node pane or select the **+ Add LN** button. This opens a pop-up window that contains a list of logical nodes that are present in the Architect Library. There may be more than one variant of each logical node, where each variant may have different data objects included. In this case, there is only one SIML logical node, which will be added to this file (see *Figure G.20*).

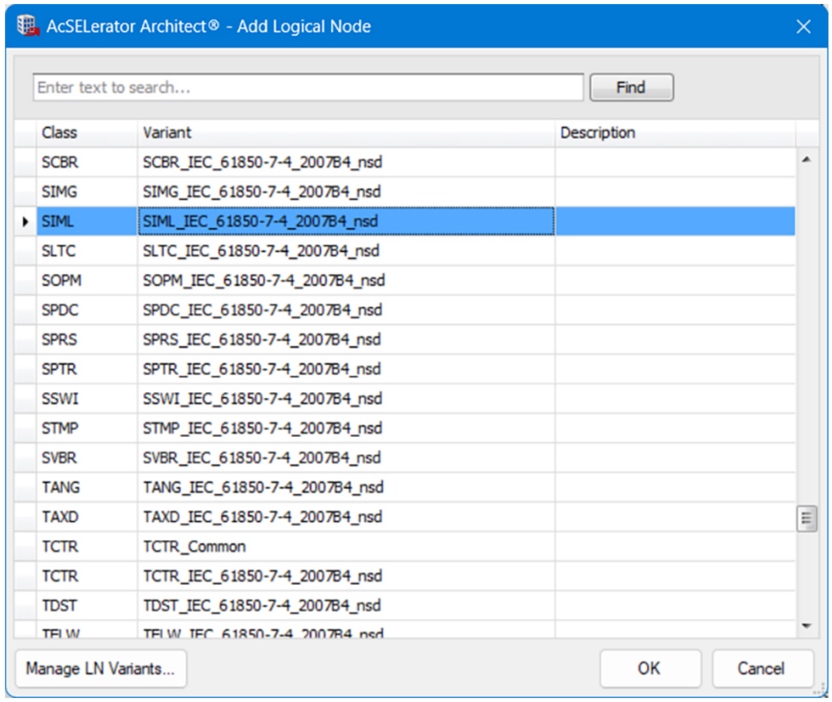


Figure G.20 Add Logical Node SIML

Once the logical node is added to the logical device, select the logical node, which will display the data objects available in the data object pane (see *Figure G.21*). Add the TmpAlm and GasInsAlm objects by selecting the box to the left of the attribute name. Each object conforms to a particular CDC defined for that object in the IEC 61850 standard. In this example, both TmpAlm and GasInsAlm are single point status (SPS) data objects.

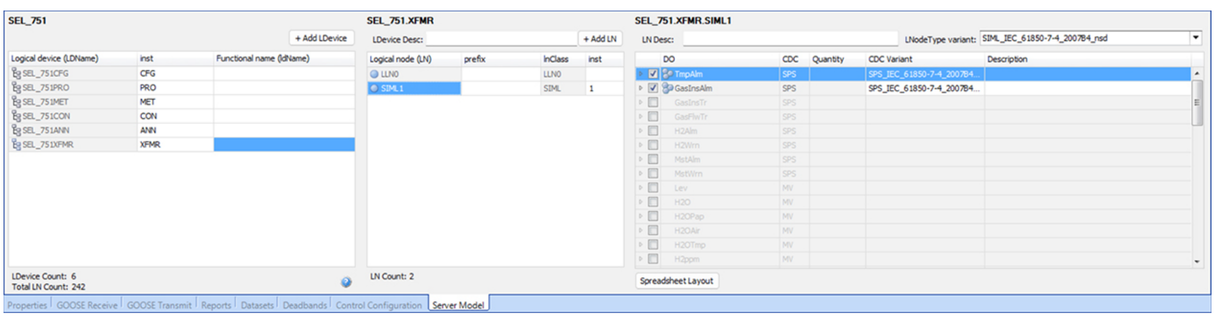


Figure G.21 Server Model View With XFMR Logical Device and SIML Logical Node With Available Data Objects

Each object contains a list of attributes. The TmpAlm object, when expanded, lists the associated attributes. In this example, the temperature alarm is wired to IN306 on Slot C, which is represented by Relay Word bit IN306. The association between the TmpAlm.stVal (status value) and IN306 must be made by entering the Relay Word bit name following the db prompt in the RWB/AQ column, as shown in *Figure G.22*.

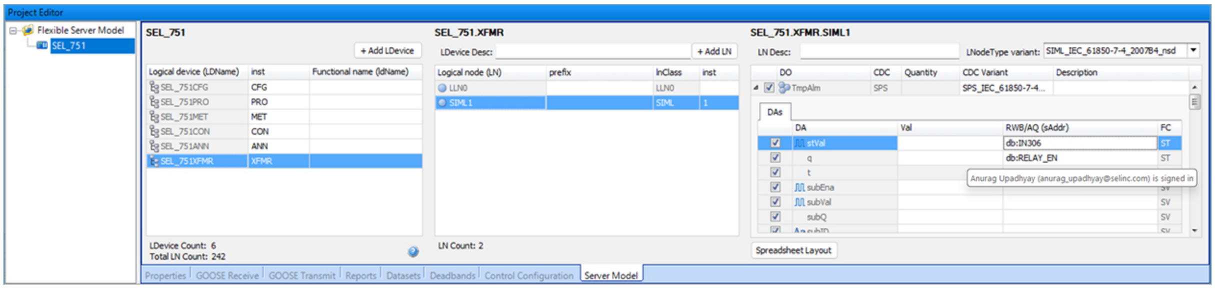


Figure G.22 TmpAlm Attributes

The same procedure is followed to configure the gas insulation alarm (GasInsAlm.stVal), which is wired to IN307 on Slot C and is represented by the Relay Word bit IN307, as shown in *Figure G.23*.

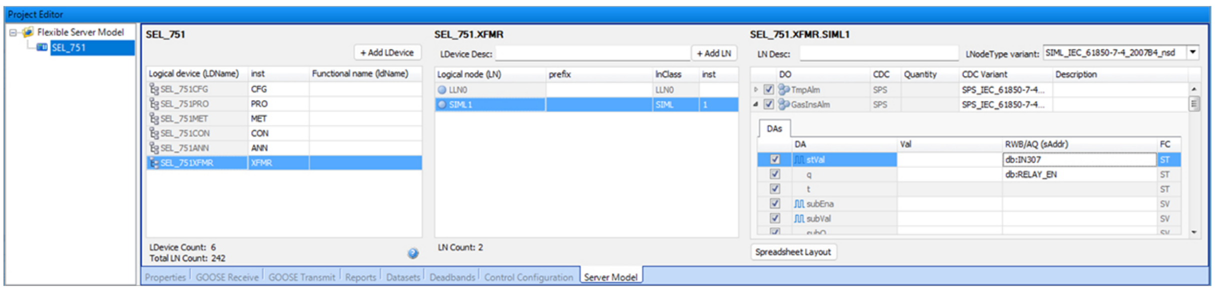


Figure G.23 GasInsAlm Attributes

If desired, other logical nodes may be added to the new XFMR logical device. Save the configuration of the project and device. The new logical node objects and attributes are available for adding to data sets that may be sent in a GOOSE message or added to a report, as shown in *Figure G.24*.

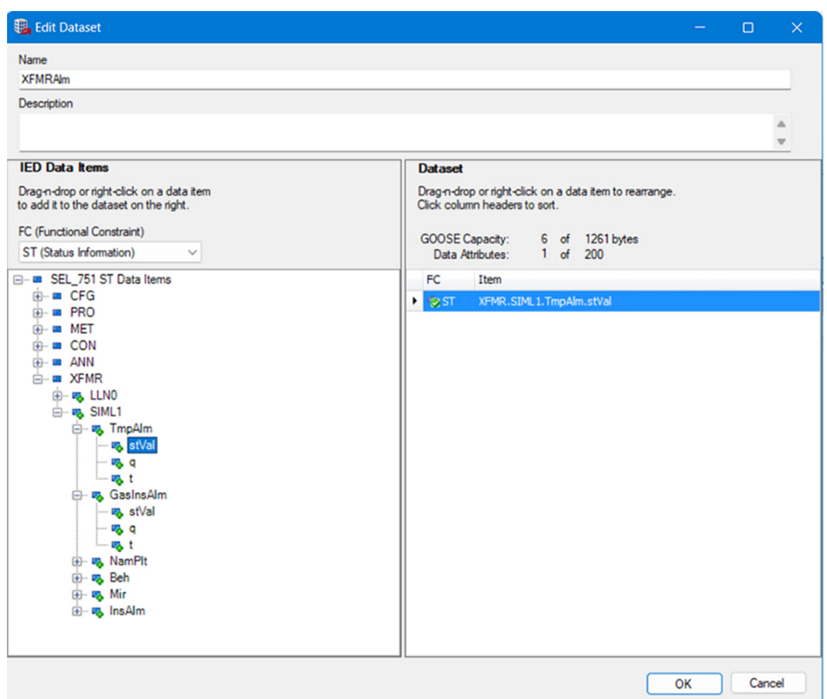


Figure G.24 Creation of Data Set Using XFMR Logical Device

Appendix H
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 H.1*.

Table H.1 IEC 60870-5 Standard Documents

Document	Description
IEC 60870-5-1	Transmission Frame Formats
IEC 60870-5-2	Data Link Transmission Services
IEC 60870-5-3	General Structure of Application Data
IEC 60870-5-4	Definition and Coding of Information Elements
IEC 60870-5-5	Basic Application Functions
IEC 60870-5-6	Guidelines for Conformance Testing IEC 60870-5 Companion Standards
IEC 60870-5-7	Security extensions to IEC 60870-5-1010 and IEC 60870-5-104 protocols

The IEC 60870-5-103 document contains the information necessary for successful implementation of this protocol. SEL strongly recommends that anyone involved with the design, installation, configuration, or maintenance of IEC 60870-5-103 systems be familiar with the appropriate sections of this document.

IEC 60870-5 was designed for wide-spread telecontrol networks. It is an international standard based on an international accepted and proven enhanced performance architecture (EPA) model (see *Table H.2*). The standard provides a balance between efficiency and reliability while using minimal hardware.

Table H.2 IEC 60870-5 Enhanced Performance Architecture Model

Layer	Layer Type
7	Application
–	–
–	–
–	–
–	–
2	Datalink
1	Physical

Layer 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 H.3* shows the history during this time period. The first five sections are the basic parts of the standard. The next six describe the companion standards, and the last two sections are test procedures of the standard.

Table H.3 History of IEC 60870-5

Section	Description
IEC 60870-5-1	Transmission Frame Formats
IEC 60870-5-2	Data Link Transmission Services
IEC 60870-5-3	General Structure of Application Data
IEC 60870-5-4	Definition and Coding Information Elements
IEC 60870-5-5	Basic Application Functions
IEC 60870-5-101	CS For Basic Telecontrol Tasks
IEC 60870-5-102	CS For Transmission Of Integrated Totals In Electric Power Systems
IEC 60870-5-103	CS for Informative Interface Of Protection Equipment
IEC 60870-5-104	Network Access For TCS101 Using Standard Transport Profiles
IEC 60870-5-101 Ed 2	Addendums Incorporated In Standard
IEC 60870-5-104 Ed 2	Addendums Incorporated In Standard
IEC 60870-5-601	Conformance Test Procedures For TCS 101
IEC 60870-5-604	Conformance Test Procedures For TCS 104

Data Handling

Master/Slave Communication

The IEC 60870-5-103 standard is such that the IED only sends a message when the Master asks for it. Communication is set up by the Master and the Master controls the communication between the Master and the IED.

Interoperability

The method of data exchange in the SEL-751 involves Application Service Data Units (ASDUs) along with application procedures for transmission of standardized data messages (see *Table H.4*). The data are recognized by any IEC 60870-5-103 Master because the application data take the form of an IEC 60870-5-103 data type and pairs with an IEC 60870-5-103 address, resulting in device interoperability.

Table H.4 SEL-751 ASDU Types

<table>
<tr><th>ASDU Type</th><th>Description</th></tr>
<tr><td>1</td><td>Time Tagged Message</td></tr>
<tr><td>2</td><td>Time Tagged Message With Relative Time</td></tr>
<tr><td>4</td><td>Time Tagged Measurands With Relative Time</td></tr>
<tr><td>5</td><td>Identification</td></tr>
<tr><td>6</td><td>Time Synchronization</td></tr>
<tr><td>7</td><td>General Interrogation Start</td></tr>
<tr><td>8</td><td>General Interrogation Termination</td></tr>
<tr><td>9</td><td>Measurands II</td></tr>
<tr><td>20</td><td>General Command</td></tr>
<tr><td>205</td><td>Non-Standard (defined below)
<table>
<tr><td>Type Identification</td><td colspan="8">0xCD (205)</td></tr>
<tr><td>Variable Structure Qualifier</td><td colspan="8">0x81</td></tr>
<tr><td>Cause of Transmission</td><td colspan="8">0x01</td></tr>
<tr><td>Device Address</td><td colspan="8">ADDR</td></tr>
<tr><td>Function Type</td><td colspan="8">FUN</td></tr>
<tr><td>Information Number</td><td colspan="8">INF</td></tr>
<tr><td rowspan="4">Information Element Meter value: 29-bit signed integer
ER: 0 valid, 1 invalid</td><td>2^7</td><td>•</td><td>•</td><td>•</td><td>•</td><td>•</td><td>•</td><td>2^0</td></tr>
<tr><td>2^{15}</td><td>•</td><td>•</td><td>•</td><td>•</td><td>•</td><td>•</td><td>2^8</td></tr>
<tr><td>2^{23}</td><td>•</td><td>•</td><td>•</td><td>•</td><td>•</td><td>•</td><td>2^{16}</td></tr>
<tr><td>0</td><td>ER</td><td>0</td><td>-2^{28}</td><td>•</td><td>•</td><td>•</td><td>2^{24}</td></tr>
<tr><td>Four Octet Binary Time</td><td colspan="8">Defined in 60870-5-103, 7.2.6.28</td></tr>
</table>
</td></tr>
</table>

Table H.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 H.5 IEC 60870-5-103 Category Map Settings

Setting Prompt	Scaling/Nominal Value Range	Information Number Range	Function Type Range	Setting Name
103 Binary Input Label	NA	0–255	0–255	103BI00
103 Binary Input Label	NA	0–255	0–255	103BI01
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
103 Binary Input Label	NA	0–255	0–255	103BI99
103 Binary Target Label	NA	0–255	0–255	103BT00
103 Binary Target Label	NA	0–255	0–255	103BT01
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
103 Binary Target Label	NA	0–255	0–255	103BT07
103 Binary Control Label	NA	0–255	0–255	103BO00
103 Binary Control Label	NA	0–255	0–255	103BO01
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
103 Binary Control Label	NA	0–255	0–255	103BO31
103 Fault Analog Label	0.000–99999	0–255	0–255	103FA00
103 Fault Analog Label	0.000–99999	0–255	0–255	103FA01
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
103 Fault Analog Label	0.000–99999	0–255	0–255	103FA31
103 Measurand Label	0.001–999999	0–255	0–255	3MLB000
103 Measurand Label	0.001–999999	0–255	0–255	3MLB001
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
103 Measurand Label	0.001–999999	0–255	0–255	3MLB127
103 Meter Quantity Label	0.000–99999	0–255	0–255	103MQ00
103 Meter Quantity Label	0.000–99999	0–255	0–255	103MQ01
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
103 Meter Quantity Label	0.000–99999	0–255	0–255	103MQ31

Cause of Transmission

The Cause of Transmission (COT) represents the reason the SEL-751 sends a message to the Master. See *Table H.6* for the possible COTs.

Table H.6 IEC 60870-5-103 Cause Of Transmission

Cause of Transmission	Description
1	Spontaneous Events
2	Cyclic
3	Reset Frame Count Bit (FCB)
4	Reset Communication Unit (CU)
5	Start/Restart
6	Power On
7	Test Mode
8	Time Synchronization
9	Initiation Of General Interrogation
10	Termination Of General Interrogation
12	Remote Operation
20	General Command (Control Direction), Positive Acknowledgment Of Command (Monitor)
21	Negative Acknowledgment Of Command (Monitor)
31	Disturbance Recorder
40–44	Generic Commands And Data

Information Number

The Information Number (INF) is one of the two octets of the information object identifier. See *Table H.7* for the range and description of Information Numbers in IEC 60870-5-103.

Table H.7 IEC 60870-5-103 Information Numbers (Sheet 1 of 2)

Function Type	Description
Monitor Direction	
0–15	System Functions
16–31	Status
32–47	Supervision
48–63	Earth Fault
64–127	Short Circuit
128–143	Auto Reclose
144–159	Measurands
160–239	Not Used
240–255	Generic Functions

Table H.7 IEC 60870-5-103 Information Numbers (Sheet 2 of 2)

Function Type	Description
Control Direction	
0–15	System Functions
16–31	General Commands
32–239	Not Used
240–255	Generic Functions

Function Type

The Function Type (FUN) is the second of the two octets of the information object identifier.

Together, the pair [INF, FUN] distinctly characterizes each point within each data class. *Table H.8* and *Table H.9* give the Standard Function Types and Data Map for the IEC 60870-5-103 standard.

Table H.8 IEC 60870-5-103 Standard Function Types

Function Type	Description
128	Distance protection
160	Overcurrent protection
176	Transformer Differential Protection
192	Line Differential Protection
254	Generic Function Type
255	Global Function Type

Table H.9 IEC 60870-5-103 Data Map (Sheet 1 of 3)

INF	Description	GI	ASDU Type	COT	FUN
System functions in monitor direction					
0[a]	End of general interrogation	–	8	10	255
0[a]	Time synchronization	–	6	8	255
2[a]	Reset FCB	–	5	3	According to main FUN
3[a]	Reset CU	–	5	4	According to main FUN
4[a]	Start/restart	–	5	5	According to main FUN
5[a]	Power on	–	5	6	According to main FUN
Status indications in monitor direction[b]					
16	Autorecloser active	Yes	1	1,7,9,11,12,20,21	128, 160, 192
17	Teleprotection active	Yes	1	1,7,9,11,12,20,21	128, 160
18	Protection active	Yes	1	1,7,9,11,12,20,21	128, 160, 176, 192
19	LED Reset	–	1	1,7,11,12,20,21	128, 160, 176, 192
20	Monitor direction blocked	Yes	1	9,11	128, 160, 176, 192
21	Test mode	Yes	1	9,11	128, 160, 176, 192
22	Local parameter setting	Yes	1	9,11	128, 160, 176, 192

Table H.9 IEC 60870-5-103 Data Map (Sheet 2 of 3)

INF	Description	GI	ASDU Type	COT	FUN
23	Characteristic 1[c]	Yes	1	1,7,9,11,12,20,21	128
24	Characteristic 2[c]	Yes	1	1,7,9,11,12,20,21	128
25	Characteristic 3[c]	Yes	1	1,7,9,11,12,20,21	128
26	Characteristic 4[c]	Yes	1	1,7,9,11,12,20,21	128
27	Auxiliary input 1[d]	Yes	1	1,7,9,11	128, 160, 176, 192
28	Auxiliary input 2[d]	Yes	1	1,7,9,11	128, 160, 176, 192
29	Auxiliary input 3[d]	Yes	1	1,7,9,11	128, 160, 176, 192
30	Auxiliary input 4[d]	Yes	1	1,7,9,11	128, 160, 176, 192
Supervision indications in monitor direction[b]					
32	Measurand supervision I	Yes	1	1,7,9	128, 160
33	Measurand supervision V	Yes	1	1,7,9	128, 160
35	Phase sequence supervision	Yes	1	1,7,9	128, 160
36	Trip circuit supervision	Yes	1	1,7,9	128, 160, 176, 192
37	I>> back-up operation	Yes	1	1,7,9	128
38	Voltage transformer fuse failure	Yes	1	1,7,9	128, 160
39	Teleprotection disturbed	Yes	1	1,7,9	128, 160, 192
46	Group warning	Yes	1	1,7,9	128, 160, 176, 192
47	Group alarm	Yes	1	1,7,9	128, 160, 176, 192
Earth fault indications in monitor direction[b]					
48	Earth Fault L_1	Yes	1	1,7,9	128, 160
49	Earth Fault L_2	Yes	1	1,7,9	128, 160
50	Earth Fault L_3	Yes	1	1,7,9	128, 160
51	Earth fault forward, i.e., line	Yes	1	1,7,9	128, 160
52	Earth fault reverse, i.e., busbar	Yes	1	1,7,9	128, 160
Fault indications in monitor direction[e]					
64	Start/pick-up L[b]	Yes	2	1,7,9	128, 160, 192
65	Start/pick-up L[c]	Yes	2	1,7,9	128, 160, 192
66	Start/pick-up L[d]	Yes	2	1,7,9	128, 160, 192
67	Start/pick-up N	Yes	2	1,7,9	128, 160, 192
68	General trip	–	2	1,7	128, 160, 176, 192
69	Trip L_1	–	2	1,7	128, 160, 176, 192
70	Trip L_2	–	2	1,7	128, 160, 176, 192
71	Trip L_3	–	2	1,7	128, 160, 176, 192
72	Trip I>> (back-up operation)	–	2	1,7	128, 160, 176, 192
73	Fault Location X in ohms	–	4	1,7	128
74	Fault forward / line	–	2	1,7	128, 160
75	Fault reverse / busbar	–	2	1,7	128, 160
76	Teleprotection signal transmitted	–	2	1,7	128, 160
77	Teleprotection signal received	–	2	1,7	128, 160
78	Zone 1	–	2	1,7	128

Table H.9 IEC 60870-5-103 Data Map (Sheet 3 of 3)

INF	Description	GI	ASDU Type	COT	FUN
79	Zone 2	–	2	1,7	128
80	Zone 3	–	2	1,7	128
81	Zone 4	–	2	1,7	128
82	Zone 5	–	2	1,7	128
83	Zone 6	–	2	1,7	128
84	General start / pick-up	Yes	2	1,7,9	128, 160, 176, 192
85	Breaker failure	–	2	1,7	128, 160
86	Trip measuring system L_1	–	2	1,7	176
87	Trip measuring system L_2	–	2	1,7	176
88	Trip measuring system L_3	–	2	1,7	176
89	Trip measuring system E	–	2	1,7	176
90	Trip I>	–	2	1,7	160
91	Trip I>>	–	2	1,7	160
92	Trip IN>	–	2	1,7	160
93	Trip IN>>	–	2	1,7	160
Autorecloser indications in monitor direction[b]					
128	Circuit breaker on by autorecloser	–	1	1,7	128, 160, 192
129	Circuit breaker on by long-time autorecloser	–	1	1,7	128, 160, 192
130	Autorecloser 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	Autorecloser 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 H.10* describes each of these parameters.

Table H.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 H.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 H.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 H.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, PTP, 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, PTP, 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 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 I
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

NOTE: The DeviceNet option has been discontinued and is no longer available as of September 25, 2017.

The DeviceNet Card is an optional accessory that enables connection of the SEL-751 to the DeviceNet automation network. The card (see *Figure I.1*) occupies the communications expansion Slot **C** in the relay.

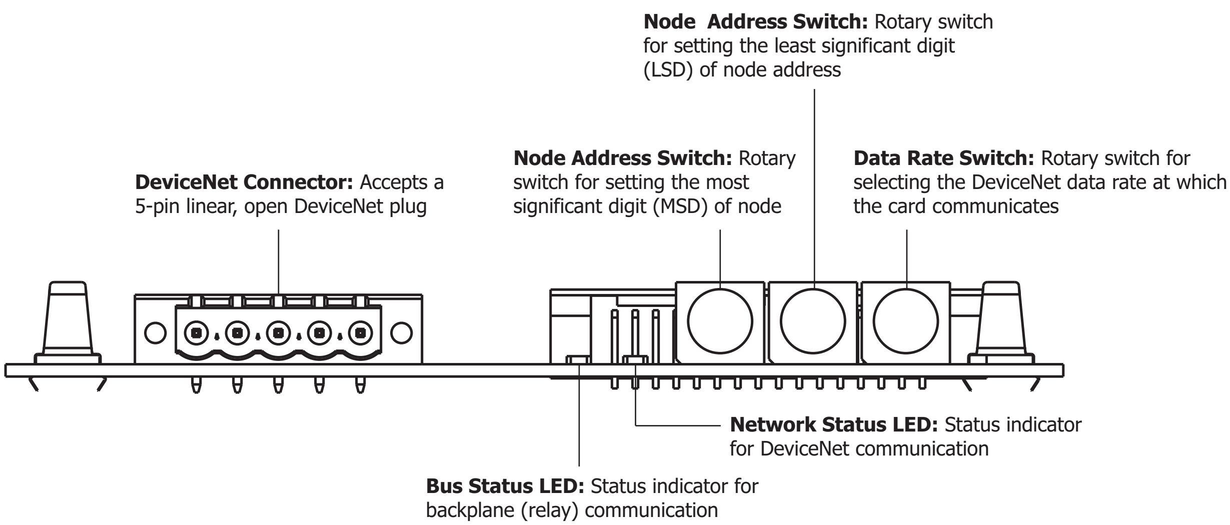


Figure I.1 DeviceNet Card Component Overview

Features

The DeviceNet Card features the following:

- The card receives the necessary power from the DeviceNet network.
- Rotary switches let you set the node address and network data rate prior to mounting in the SEL-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 rear 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
- 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.35*) 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.35*. The parameter numbers are offset by a count of 100 from the register numbers.

The EDS file for the SEL-751, SEL-*xxx*R*xxx*.EDS, is located on 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 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

Data 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)

NOTE: Exercise caution when applying a MIRRORED BITS channel to relays that protect systems which may not be synchronized, because the automatic pacing modes operate under the assumption that both relays are protecting systems of similar frequency. To maintain MIRRORED BITS channel dependability for this application, it is best to use a data rate of either 2400 or 4800.

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). The relay clears the ROK*c* bit when it detects any of the following conditions.

- 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 described below, and after two consecutive messages pass all of the data checks previously described. After ROK*c* is reasserted, received data can be delayed while passing through the security counters described in the following paragraph.

While ROK*c* is deasserted, the relay does not transfer new RMB data to the pickup-dropout security counters described below. Instead, the relay sends one of the user-definable default values to the security counter inputs. For each RMB*n*, use the RXDFLT setting to determine the default state the MIRRORED BITS should use in place of received data if an error condition is detected. The setting is a mask of 1s, 0s, and/or Xs (for RMB1A–RMB8A), where X represents the most recently received valid value. The positions of the 1s and 0s correspond to the respective positions of the MIRRORED BITS in the Relay Word bits (see *Appendix L: Relay Word Bits*). *Table J.2* is an extract of *Appendix L: Relay Word Bits*, showing the positions of the MIRRORED BITS.

Table J.2 Positions of the MIRRORED BITS

Bit/ Row	7	6	5	4	3	2	1	0
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 ASCII 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 *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. *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
Synchrophasors

Overview

The SEL-751 provides phasor measurement unit (PMU) capabilities when connected to an IRIG-B time source or a hardware-based PTP 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 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 offline 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 K.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 K.12*.

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 K.14*.

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 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 (SEL-5702 Synchrowave Operations Software or SEL-5703 Synchrowave Monitoring Software) for real-time viewing of a power system.

Synchrowave Operations quickly translates power system data into visual information. It is a powerful, yet easy-to-use solution for displaying and analyzing real-time streaming data, archived data, and relay event data, and provides a time-synchronized wide-area view of your system. Synchrowave Monitoring includes Event Viewer, providing engineers and operators with the ability to view PMU data and perform event analysis by viewing relay event reports directly from Synchrowave Monitoring.

The SEL-3378 Synchrophasor Vector Processor (SVP) is a real-time synchrophasor programmable logic controller. Use the SVP to collect synchrophasor messages from relays and 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 K.15*.

Synchrophasor Measurement

The PMU in the SEL-751 measures voltages and currents on a constant-time basis. These samples are time-stamped with the IRIG or PTP time source. The relay then filters the measured samples according to Global setting PMAPP := Fast or Narrow (see *PMAPP on page K.5*).

The phase angle is measured relative to an absolute time reference, which is represented by a cosine function in *Figure K.1*. The time-of-day is shown for the two time marks. The reference is consistent with the phase reference defined in the C37.118 standard. During steady-state conditions, you can compare the SEL-751 synchrophasor values directly to values from other PMUs that conform to C37.118.

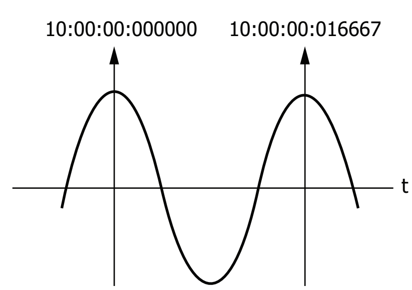

Figure K.1 Phase Reference

The TSOK Relay Word bit asserts when the SEL-751 has determined that the IRIG-B or PTP 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 K.2*, *Figure K.3*, and *Equation K.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.

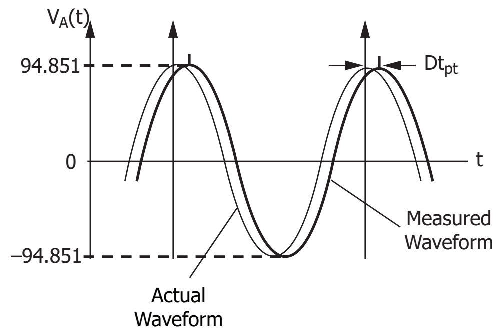

Figure K.2 Waveform at Relay Terminals May Have a Phase Shift

$$\text{Compensation Angle} = \frac{\Delta t_{pt}}{\left(\frac{1}{freq_{nominal}}\right)} \cdot 360^\circ = \Delta t_{pt} \cdot freq_{nominal} \cdot 360^\circ$$

Equation K.1

If the time shift on the PT measurement path Δt_{pt} = 0.784 ms and the nominal frequency, $freq_{nominal}$ = 60Hz, use *Equation K.2* to obtain the correction angle:

$$0.784 \cdot 10^{-3} s \cdot 60 s^{-1} \cdot 360^\circ = 16.934^\circ$$

Equation K.2

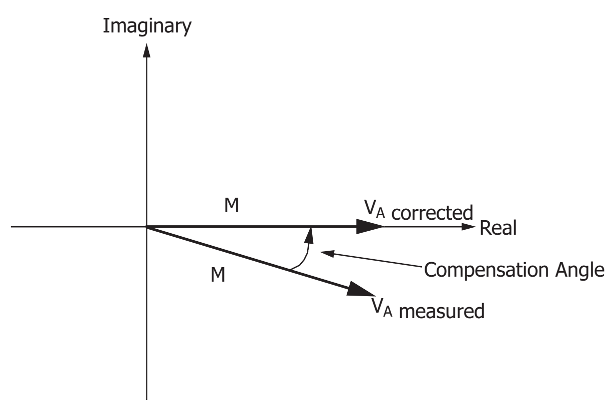

Figure K.3 Correction of Measured Phase Angle

The phasors are rms values scaled in primary units, as determined by Group settings PTR, PTRS (for synchronism-check input), CTR, and CTRN.

Because the sampling reference is based on the GPS clock (IRIG/PTP 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 PMU settings are listed in *Table K.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 K.5* or Ethernet port settings in *Table K.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 K.1 PMU Settings in the SEL-751 for C37.118 Protocol in Global Settings (Sheet 1 of 2)

Setting	Description	Default
EPMU	Enable Synchronized Phasor Measurement (Y, N)	N[a]
MRATE	Messages per Second (1, 2, 5, 10, 25, or 50 when NFREQ := 50) (1, 2, 4, 5, 10, 12, 15, 20, 30, or 60 when NFREQ := 60)	10
PMAPP	PMU Application (Fast := Fast Response, Narrow := Narrow Bandwidth)	NARROW
PHCOMP	Frequency-Based Phasor Compensation (Y, N)	Y
PMSTN	Station Name (16 characters)	SEL-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]

Table K.1 PMU Settings in the SEL-751 for C37.118 Protocol in Global Settings (Sheet 2 of 2)

Setting	Description	Default
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 K.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 K.1* are as follows.

MRATE

Selects the message rate in messages per second for synchrophasor data streaming on serial ports.

Choose the MRATE setting that suits the needs of your PMU application. This setting is one of seven settings that determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size. See *Communications Bandwidth on page K.16* 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 K.16* 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 K.2 describes the order of synchrophasors inside the data packet.

Table K.2 Synchrophasor Order in Data Stream (Voltages and Currents)

Synchrophasors[a b c] Rectangular Real	Synchrophasors[a b c] Rectangular Imaginary	Included When Global Settings Are as Follows:
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 K.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 K.16* 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 K.2* for details on these settings.

Table K.2 describes the order of synchrophasors inside the data packet. Synchrophasors are transmitted in the order indicated from the top to the bottom of the table. Real values are transmitted first and imaginary values are transmitted second.

Synchrophasors are only transmitted if specified to be included by the PHDATAV and PHDATAI settings. For example, if PHDATAV := ALL and PHDATAI := I1, selected phase voltages are transmitted first (see PHVOLT setting), followed by VS input voltage, positive-sequence voltage, and positive-sequence current.

NUMANA

Selects the number of user-definable analog values to be included in the synchrophasor data stream.

This setting is one of seven settings that determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size. See *Communications Bandwidth on page K.16* for detailed information.

The choices for this setting depend on the synchrophasor system design.

- ➤ Setting NUMANA := 0 sends no user-definable analog values.
- ➤ Setting NUMANA := 1–4 sends the user-definable analog values, as listed in *Table K.3*.

The format of the user-defined analog data is always floating point, and each value occupies four bytes.

Table K.3 User-Defined Analog Values Selected by the NUMANA Setting

NUMANA Setting	Analog Quantities Sent	Total Number of Bytes Used for Analog Values
0	None	0
1	MV29	4
2	Previous, plus MV30	8
3	Previous, plus MV31	12
4	Previous, plus MV32	16

NUMDSW

Selects the number of user-definable digital status words to be included in the synchrophasor data stream.

This setting is one of seven settings that determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size. See *Communications Bandwidth on page K.16* for detailed information.

The choices for this setting depend on the synchrophasor system design. The inclusion of binary data can help indicate breaker status or other operational data to the synchrophasor processor.

- ➤ Setting NUMDSW := 0 sends no user-definable binary status words.
- ➤ Setting NUMDSW := 1 sends the user-definable binary status words, as listed in *Table K.4*.

Table K.4 User-Defined Digital Status Words Selected by the NUMDSW Setting

NUMDSW Setting	Digital Status Words Sent	Total Number of Bytes Used for Digital Values
0	None	0
1	[SV32, SV31…SV17]	2

TREA1, TREA2, TREA3, TREA4, and PMTRIG

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, daylight-saving time (DST), 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 K.5*.

Table K.5 SEL-751 Serial Port Settings for Synchrophasors (Sheet 1 of 2)

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

Table K.5 SEL-751 Serial Port Settings for Synchrophasors (Sheet 2 of 2)

Setting	Description	Default
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 K.5*, do not include the settings BITS and PARITY; these two settings are internally fixed as BITS := 8, PARITY := N.

Serial port setting PROTO cannot be set to PMU (see *Table K.5*) when Global setting EPMU := N. Synchrophasors must be enabled (EPMU := Y) before PROTO can be set to PMU.

If you use a computer terminal session or ACSELERATOR QuickSet® SEL-5030 Software connected to a serial port, and then set that same serial port PROTO setting to PMU, you lose the ability to communicate with the relay through ASCII commands. If this happens, either connect via another serial port (that has PROTO := SEL) or use the front-panel HMI SET/SHOW screen to change the port PROTO setting back to SEL.

Ethernet Port Settings for IEEE C37.118 Synchrophasors

IEEE C37.118-compliant synchrophasors are available via serial or Ethernet port. The associated IEEE C37.118-compliant Ethernet port settings are shown in *Table K.6*. If the time source is PTP, use the additional settings shown in *Table K.7*.

For IEEE C37. 118-compliant and PTP-compliant synchrophasors, Ethernet port setting EPMIP cannot be set when Global setting EPMU := N. Synchrophasors must be enabled (EPMU := Y) before EPMIP can be set.

Table K.6 SEL-751 Ethernet Port Settings for IEEE C37.118 Synchrophasors (Sheet 1 of 2)

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

Table K.6 SEL-751 Ethernet Port Settings for IEEE C37.118 Synchrophasors (Sheet 2 of 2)

Setting	Description	Default
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.

Table K.7 SEL-751 Ethernet Port Settings for PTP-Compliant Synchrophasors

Setting	Description	Default
NETMODE[a]	Operating Mode (FIXED, FAILOVER, SWITCHED, PRP)	FAILOVER
EPTP[b]	ENABLE PTP (Y, N)	N
DOMNUM	PTP Domain Number (0-255)	0
PDINT	Peer Delay Request Interval (1,2, 4, 8, 16, 32, 64 seconds)	1
AMNUM	PTP Number of Acceptable Masters (OFF,1-5)	OFF
PVLAN	PTP VLAN Identifier (1-4094)	1
PVLANPR	PTP VLAN Priority (0-7)	4

[a] NETMODE shall be set to PRP to support synchrophasors.
[b] EPTP shall be set to Y to support synchrophasors using PTP.

Definitions for some of the settings in *Table K.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

This setting establishes a single, persistent TCP socket for transmitting and receiving synchrophasor messages (both commands and data), as illustrated in *Figure K.4*.

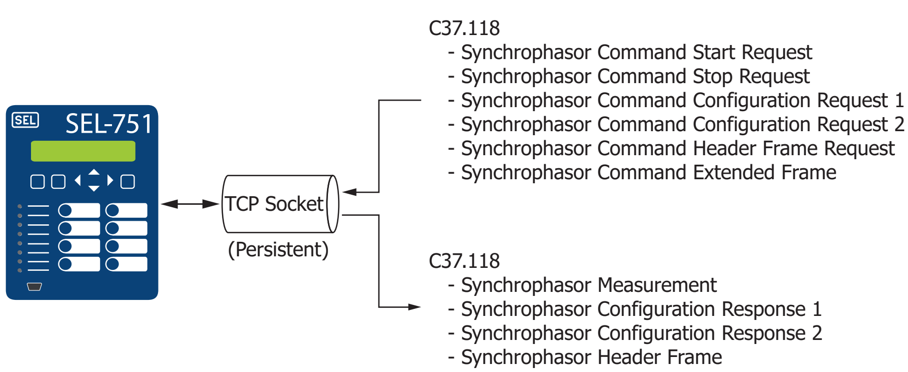

Figure K.4 TCP Connection

PMOTSn := UDP_T

This setting establishes two socket connections. A non-persistent TCP connection is used for receiving synchrophasor command messages as well as synchrophasor configuration and header response messages. A persistent UDP connection is used to transmit synchrophasor data messages. *Figure K.5* depicts the UDP_T connection.

PMOTSn := UDP_U

This setting uses the same connection scheme as the UDP_T except the synchrophasor configuration and header response messages are sent over the UDP connection, as shown in *Figure K.5*.

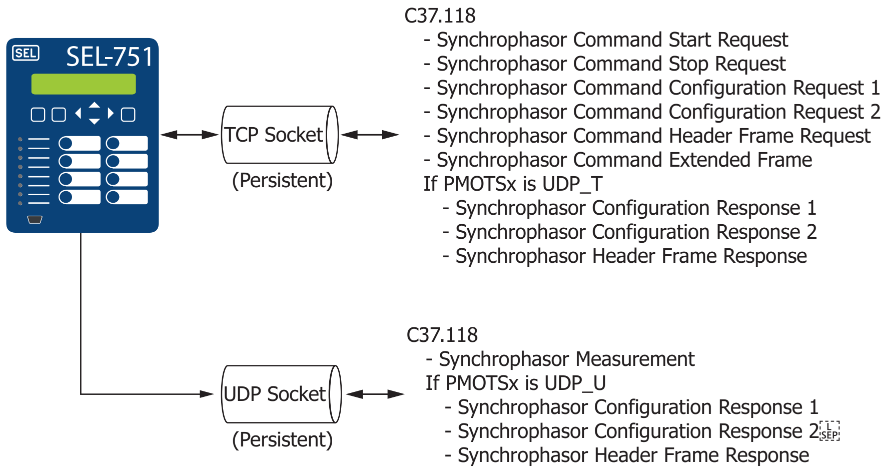

Figure K.5 UDP_T and UDP_U Connections

PMOTSn := UDP_S

NOTE: The UDP setting (UDP_T, UDP_U, and UDP_S) allows for both Multicast and Unicast IP addresses.

This setting establishes a single persistent UDP socket to transmit synchrophasor messages. Synchrophasor data are transmitted whenever new data are read. With this communication scheme, the relay sends a “Synchrophasor Configuration Response 2” once every minute, as shown in *Figure K.6*.

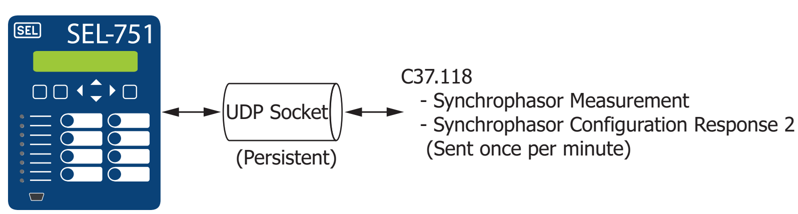

Figure K.6 UDP_S Connection

PMOIPA1 and PMOIPA2

Defines the PMU Output Client IP address for Session 1 and Session 2, respectively.

PMOTCP1 and PMOTCP2

Defines the TCP/IP (Local) port number for Session 1 and Session 2, respectively. The TCP port numbers must all be unique (see *Table N.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 N.1*).

Synchrophasor Relay Word Bits

Table K.8 and *Table K.9* list the SEL-751 Relay Word bits that are related to synchrophasor measurement. The Synchrophasor Trigger Relay Word bits in *Table K.8* follow the state of the SELOGIC control equations of the same name, listed at the bottom of *Table K.1*. These Relay Word bits are included in the IEEE C37.118 synchrophasor data frame STAT field. See *Table K.4* for standard definitions for these settings.

Table K.8 Synchrophasor Trigger Relay Word Bits

Name	Description
PMTRIG	Trigger (SELOGIC)
TREA4	Trigger Reason Bit 4 (SELOGIC)
TREA3	Trigger Reason Bit 3 (SELOGIC)
TREA2	Trigger Reason Bit 2 (SELOGIC)
TREA1	Trigger Reason Bit 1 (SELOGIC)

Time Quality of the IRIG-B or PTP Time Source

The time synchronization Relay Word bits in *Table K.9* indicate the present status of the timekeeping function of the SEL-751.

Table K.9 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 or hardware-based PTP time source of sufficient accuracy for synchrophasor measurement.
PMDOK	Phasor Measurement Data OK.
PTP_TIM	Asserts if a valid PTP time source is detected.
PTP_OK	Asserts if the PTP time is within the local offset (4 ms for firmware-based PTP and 250 ns for hardware-based PTP).
PTPSYNC	Asserts if the relay is using PTP time to do time sync.
PTPA	Asserts when PTP is enabled in PRP mode and the relay is receiving PTP messages on Port 1A.
PTPB	Asserts when PTP is enabled in PRP mode and the relay is receiving PTP messages on Port 1B.

The Relay Word bit TSOK provides the indication that the time synchronization is OK. The SEL-751 determines the suitability of the IRIG-B or PTP 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 DST transitions
- ➤ When IRIGC = C37.118, the signal contains the correct parity bit
- ➤ If hardware-based PTP is available, TSOK will assert; if only firmware-based PTP is available, TSOK will not assert

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)

For the IRIG time source, 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. For hardware-based PTP, when Relay Word bits PTP_TIM, PTP_OK, and PTPSYNC assert, the TSOK bit asserts. The time error information in the IRIG-B control field is mapped to the TQUAL bits in the relay. *Table K.10* 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 time.

For the IRIG time source, when the IRIG signal is lost, IRIGOK deasserts. For the PTP time source, when the PTP time source is lost, the PTP_TIM, PTP_OK, and PTPSYNC Relay Word bits deassert. For both scenarios, the TSOK Relay Word bit remains asserted for a holdover period as long as 15 seconds. If the IRIG or PTP signal is not restored within 15 seconds, TSOK also deasserts.

Table K.10 TQUAL Bits Translation to Time Quality

TQUAL8	TQUAL4	TQUAL2	TQUAL1	Value	Time Quality
0	0	0	0	0	Locked
0	0	0	1	1	1 nanosecond
0	0	1	0	2	10 nanoseconds
0	0	1	1	3	100 nanoseconds
0	1	0	0	4	1 microsecond
0	1	0	1	5	10 microseconds
0	1	1	0	6	100 microseconds
0	1	1	1	7	1 millisecond
1	0	0	0	8	10 milliseconds
1	0	0	1	9	100 milliseconds
1	0	1	0	10	1 second
1	0	1	1	11	10 seconds
1	1	0	0	12	100 seconds
1	1	0	1	13	1000 seconds
1	1	1	0	14	10000 seconds
1	1	1	1	15	Fault

The Relay Word bit PMDOK indicates that the phasor measurement data are acceptable and asserts under the following conditions.

For the SEL-751 models with the voltage option:

- ➤ The relay is enabled
- ➤ EPMU = Y
- ➤ TSOK = 1

- The synchrophasor filter buffers are fully primed
- The magnitude of the positive-sequence voltage, |V1| > 10 V, or the magnitude of the positive-sequence current, |I1| > 0.1 • INOM (INOM = 1 A or 5 A)
- The frequency is 40–70 Hz

For the SEL-751 models with the currents only option:

- The relay is enabled
- EPMU = Y
- TSOK = 1
- The synchrophasor filter buffers are fully primed
- The magnitude of the positive-sequence current, |I1| > 0.1 • 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 K.1* are changed, or when an IRIG-B or PTP 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 *METER Command (Metering Data) on page 7.64* 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 PMU(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 K.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 K.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 K.7* occurring just after 14:14:12, with the time stamp 14:14:12.000. See *Section 7: Communications* for complete command options and error messages.

```
=>MET PM <Enter>

SEL-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 K.7 Sample MET PM Command Response

IEEE 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 K.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 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 K.11* to calculate the number of bytes in a synchrophasor message.

Table K.11 Size of a C37.118 Synchrophasor Message

Item	Possible Number of Quantities	Bytes per Quantity	Number of Bytes	
			Minimum	Maximum
Fixed			18	18
Synchrophasors	0–18	4	0	72
Frequency/DFDT	2 (fixed)	2	4	4
Analog Values	0–4	4	0	16
Digital Status Words	0–1	2	0	2
		Total (Minimum and Maximum)	22	112

Table K.12 lists the 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 K.12 Serial Port Bandwidth for Synchrophasors (in Bytes)

Global Setting MRATE	Port Setting SPEED								
	300	600	1200	2400	4800	9600	19200	38400	57600
1	21	42	85	170	340	680	1360	2720	4080
2		21	42	85	170	340	680	1360	2040
4 (60 Hz only)			21	42	85	170	340	680	1020
5				34	68	136	272	544	816
10					34	68	136	272	408
12 (60 Hz only)					28	56	113	226	340
15 (60 Hz only)					21	45	90	181	272
20 (60 Hz only)						34	68	136	204
25 (50 Hz only)						27	54	108	163
30 (60 Hz only)						22	45	90	136
50 (50 Hz only)							27	54	81
60 (60 Hz only)							22	45	68

Referring to *Table K.11* and *Table K.12*, it is clear that the lower SPEED settings are very restrictive.

The smallest practical synchrophasor message would be comprised of one digital status word, and this message would consume 24 bytes (includes frequency and DFDT). This type of message could be sent at any message rate (MRATE = 60) when SPEED := 38400, 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 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 K.11*, and determines the necessary message size. The system requirements, in order of appearance in *Table K.11*, are as follows:

- Six synchrophasors, in integer representation
- Integer representation for the frequency data
- Three digital status bits, which require one status word

The message size is 18 + 6 • 4 + 2 • 2 + 1 • 2 = 48 bytes. Using *Table K.12*, the engineer verifies that the port 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 K.13*.

Table K.13 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 K.14 Example Synchrophasor Logic Settings

Logic Setting	Description	Value
TREA1	Trigger Reason Bit 1 (SELOGIC control equation)	NA
TREA2	Trigger Reason Bit 2 (SELOGIC control equation)	NA
TREA3	Trigger Reason Bit 3 (SELOGIC control equation)	NA
TREA4	Trigger Reason Bit 4 (SELOGIC control equation)	NA
PMTRIG	Trigger (SELOGIC control equation)	NA

The three Relay Word bits this example uses must be placed in certain SELOGIC variables. Make the settings in *Table K.15* in all setting groups.

Table K.15 Example Synchrophasor SELOGIC Settings

Setting	Value
SV30	52A
SV31	LOP
SV32	FREQTRK

Make the *Table K.16* settings for serial Port 3, using the **SET P 3** command.

Table K.16 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

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Appendix L
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 L.1 and *Table L.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 7.79*).

You can use any Relay Word bit (except Row 0) in SELOGIC control equations (see *Section 4: Protection and Logic Functions*) and the Sequential Events Recorder (SER) trigger list settings (see *Section 10: Analyzing Events*).

Table L.1 SELOGIC Relay Word Bits (Sheet 1 of 8)

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	PFLEAD	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 L.1 SELogic Relay Word Bits (Sheet 2 of 8)

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	a	a	a	a	a	a
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	a	a	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	RSTPKDEM
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	a	DI_C	DI_B	DI_A
33	CC	OC	BKJMP	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
55	LT01	LT02	LT03	LT04	LT05	LT06	LT07	LT08

Table L.1 SELOGIC Relay Word Bits (Sheet 3 of 8)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
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	[a]	AIHW1	AIHW2	AIHAL	[a]
68	AI301LW1	AI301LW2	AI301LAL	[a]	AI301HW1	AI301HW2	AI301HAL	[a]
69	AI302LW1	AI302LW2	AI302LAL	[a]	AI302HW1	AI302HW2	AI302HAL	[a]
70	AI303LW1	AI303LW2	AI303LAL	[a]	AI303HW1	AI303HW2	AI303HAL	[a]
71	AI304LW1	AI304LW2	AI304LAL	[a]	AI304HW1	AI304HW2	AI304HAL	[a]
72	AI305LW1	AI305LW2	AI305LAL	[a]	AI305HW1	AI305HW2	AI305HAL	[a]
73	AI306LW1	AI306LW2	AI306LAL	[a]	AI306HW1	AI306HW2	AI306HAL	[a]
74	AI307LW1	AI307LW2	AI307LAL	[a]	AI307HW1	AI307HW2	AI307HAL	[a]
75	AI308LW1	AI308LW2	AI308LAL	[a]	AI308HW1	AI308HW2	AI308HAL	[a]
76	AI401LW1	AI401LW2	AI401LAL	[a]	AI401HW1	AI401HW2	AI401HAL	[a]
77	AI402LW1	AI402LW2	AI402LAL	[a]	AI402HW1	AI402HW2	AI402HAL	[a]
78	AI403LW1	AI403LW2	AI403LAL	[a]	AI403HW1	AI403HW2	AI403HAL	[a]
79	AI404LW1	AI404LW2	AI404LAL	[a]	AI404HW1	AI404HW2	AI404HAL	[a]
80	AI405LW1	AI405LW2	AI405LAL	[a]	AI405HW1	AI405HW2	AI405HAL	[a]
81	AI406LW1	AI406LW2	AI406LAL	[a]	AI406HW1	AI406HW2	AI406HAL	[a]
82	AI407LW1	AI407LW2	AI407LAL	[a]	AI407HW1	AI407HW2	AI407HAL	[a]
83	AI408LW1	AI408LW2	AI408LAL	[a]	AI408HW1	AI408HW2	AI408HAL	[a]
84	AI501LW1	AI501LW2	AI501LAL	[a]	AI501HW1	AI501HW2	AI501HAL	[a]
85	AI502LW1	AI502LW2	AI502LAL	[a]	AI502HW1	AI502HW2	AI502HAL	[a]
86	AI503LW1	AI503LW2	AI503LAL	[a]	AI503HW1	AI503HW2	AI503HAL	[a]
87	AI504LW1	AI504LW2	AI504LAL	[a]	AI504HW1	AI504HW2	AI504HAL	[a]
88	AI505LW1	AI505LW2	AI505LAL	[a]	AI505HW1	AI505HW2	AI505HAL	[a]
89	AI506LW1	AI506LW2	AI506LAL	[a]	AI506HW1	AI506HW2	AI506HAL	[a]
90	AI507LW1	AI507LW2	AI507LAL	[a]	AI507HW1	AI507HW2	AI507HAL	[a]
91	AI508LW1	AI508LW2	AI508LAL	[a]	AI508HW1	AI508HW2	AI508HAL	[a]
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
95	TMB8B	TMB7B	TMB6B	TMB5B	TMB4B	TMB3B	TMB2B	TMB1B

Table L.1 SELOGIC Relay Word Bits (Sheet 4 of 8)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
96	LBOKB	CBADB	RBADB	ROKB	LBOKA	CBADA	RBADA	ROKA
97[b]	RB33	RB34	RB35	RB36	RB37	RB38	RB39	RB40
98	RB41	RB42	RB43	RB44	RB45	RB46	RB47	RB48
99	RB49	RB50	RB51	RB52	RB53	RB54	RB55	RB56
100	RB57	RB58	RB59	RB60	RB61	RB62	RB63	RB64
101	SV33	SV34	SV35	SV36	SV37	SV38	SV39	SV40
102	SV33T	SV34T	SV35T	SV36T	SV37T	SV38T	SV39T	SV40T
103	SV41	SV42	SV43	SV44	SV45	SV46	SV47	SV48
104	SV41T	SV42T	SV43T	SV44T	SV45T	SV46T	SV47T	SV48T
105	SV49	SV50	SV51	SV52	SV53	SV54	SV55	SV56
106	SV49T	SV50T	SV51T	SV52T	SV53T	SV54T	SV55T	SV56T
107	SV57	SV58	SV59	SV60	SV61	SV62	SV63	SV64
108	SV57T	SV58T	SV59T	SV60T	SV61T	SV62T	SV63T	SV64T
109	LT33	LT34	LT35	LT36	LT37	LT38	LT39	LT40
110	LT41	LT42	LT43	LT44	LT45	LT46	LT47	LT48
111	LT49	LT50	LT51	LT52	LT53	LT54	LT55	LT56
112	LT57	LT58	LT59	LT60	LT61	LT62	LT63	LT64
113	PHDEM	3I2DEM	GNDEM	59VDIF	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	[a]	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	MTR	MTRIP	ULMTRIP	81RFBLK	81RFT	81RFBL	81RFP	81RFI
131	ZLOAD	ZLOUT	ZLIN	VPOLV	PHASE_A	PHASE_B	PHASE_C	GFLT
132	INI_HIF	HIFITUNE	HIFFRZ	MPH_EVE	HIFER	HIFMODE	HIFREC	3PH_EVE
133	[a]	HIA1_C	HIA1_B	HIA1_A	[a]	HIA2_C	HIA2_B	HIA2_A
134	[a]	HIF1_C	HIF1_B	HIF1_A	[a]	HIF2_C	HIF2_B	HIF2_A
135	[a]	NTUNE_C	NTUNE_B	NTUNE_A	[a]	ITUNE_C	ITUNE_B	ITUNE_A

Table L.1 SELogic Relay Word Bits (Sheet 5 of 8)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
136	[a]	DIC_DIS	DIB_DIS	DIA_DIS	[a]	DVC_DIS	DVB_DIS	DVA_DIS
137	[a]	DL2CLRC	DL2CLRB	DL2CLRA	[a]	FRZCLRC	FRZCLRB	FRZCLRA
138	[a]	DUPC	DUPB	DUPA	[a]	DDNC	DDNB	DDNA
139	3PH_CLR	3PH_C	3PH_B	3PH_A	LR3	LRC	LRB	LRA
140	OREDHIF1	OREDHIF2	RTDT	RTDA	FSA	FSB	FSC	FIDEN
141	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
142	IN309	IN310	IN311	IN312	IN313	IN314	[a]	[a]
143	IN409	IN410	IN411	IN412	IN413	IN414	[a]	[a]
144	IN509	IN510	IN511	IN512	IN513	IN514	[a]	[a]
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	[a]	[a]
150	HBL2T	HBL2AT	HBL2BT	HBL2CT	HBL5T	HBL5AT	HBL5BT	HBL5CT
151	UGFWD	UGREV	LOCAL	ENLRC	LZFWD	LZREV	FDIRNI	RDIRNI
152	FDIRW	RDIRW	FDIRC	RDIRC	[a]	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	[a]	27I2	27I2T	27I2RS	[a]
156	59I1	59I1T	59I1RS	[a]	59I2	59I2T	59I2RS	[a]
157	59I3	59I3T	59I3RS	[a]	59I4	59I4T	59I4RS	[a]
158	BFRT	50BF	BFTRIP	50BFG	DLDB	DLLB	LLDB	[a]
159	89A2P1	89B2P1	89CL2P1	89OP2P1	89A2P2	89B2P2	89CL2P2	89OP2P2
160	89A2P3	89B2P3	89CL2P3	89OP2P3	89A2P4	89B2P4	89CL2P4	89OP2P4
161	89A2P5	89B2P5	89CL2P5	89OP2P5	[a]	[a]	[a]	[a]
162	89AL2P1	89AL2P2	89AL2P3	89AL2P4	89AL2P5	[a]	[a]	[a]
163	50ITRCC	50ITRCB	50ITRCA	50IALCC	50IALCB	50IALCA	50ITRCN	50IALCN
164	50INCTC	50INCTB	50INCTA	50INCC	50INCB	50INCA	50INCTN	50INCN
165	27N1	27N1T	27N2	27N2T	59N1	59N1T	59N2	59N2T
166	PTP_TIM	PTP_OK	PTPSYNC	PTPA	PTPB	50A2P	50B2P	50C2P
167	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
168	89O2P1	89OS2P1	89OI2P1	89OE2P1	89C2P1	89CS2P1	89CI2P1	89CE2P1
169	89O2P2	89OS2P2	89OI2P2	89OE2P2	89C2P2	89CS2P2	89CI2P2	89CE2P2
170	89O2P3	89OS2P3	89OI2P3	89OE2P3	89C2P3	89CS2P3	89CI2P3	89CE2P3
171	89O2P4	89OS2P4	89OI2P4	89OE2P4	89C2P4	89CS2P4	89CI2P4	89CE2P4
172	89O2P5	89OS2P5	89OI2P5	89OE2P5	89C2P5	89CS2P5	89CI2P5	89CE2P5
173	89O2P6	89OS2P6	89OI2P6	89OE2P6	89C2P6	89CS2P6	89CI2P6	89CE2P6
174	89O2P7	89OS2P7	89OI2P7	89OE2P7	89C2P7	89CS2P7	89CI2P7	89CE2P7
175	89O2P8	89OS2P8	89OI2P8	89OE2P8	89C2P8	89CS2P8	89CI2P8	89CE2P8

Table L.1 SELOGIC Relay Word Bits (Sheet 6 of 8)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
176	89OC2P1	89RO2P1	89OM2P1	a	89CC2P1	89RC2P1	89CM2P1	a
177	89OC2P2	89RO2P2	89OM2P2	a	89CC2P2	89RC2P2	89CM2P2	a
178	89OC2P3	89RO2P3	89OM2P3	a	89CC2P3	89RC2P3	89CM2P3	a
179	89OC2P4	89RO2P4	89OM2P4	a	89CC2P4	89RC2P4	89CM2P4	a
180	89OC2P5	89RO2P5	89OM2P5	a	89CC2P5	89RC2P5	89CM2P5	a
181	89OC2P6	89RO2P6	89OM2P6	a	89CC2P6	89RC2P6	89CM2P6	a
182	89OC2P7	89RO2P7	89OM2P7	a	89CC2P7	89RC2P7	89CM2P7	a
183	89OC2P8	89RO2P8	89OM2P8	a	89CC2P8	89RC2P8	89CM2P8	a
184	89OC3PL1	89RO3PL1	89OM3PL1	a	89CC3PL1	89RC3PL1	89CM3PL1	a
185	89OC3PE1	89RO3PE1	89OM3PE1	a	89CC3PE1	89RC3PE1	89CM3PE1	a
186	89OC3PL2	89RO3PL2	89OM3PL2	a	89CC3PL2	89RC3PL2	89CM3PL2	a
187	89OC3PE2	89RO3PE2	89OM3PE2	a	89CC3PE2	89RC3PE2	89CM3PE2	a
188	a	a	a	a	a	a	a	a
189	a	a	a	a	a	a	a	a
190	a	a	a	a	a	a	a	a
191	a	a	a	a	a	a	a	a
192	89IP2P1	89IP2P2	89IP2P3	89IP2P4	89IP2P5	89IP2P6	89IP2P7	89IP2P8
193	89A3PL1	89B3PL1	89CL3PL1	89OP3PL1	89AL3PL1	89IP3PL1	89AL	a
194	89A3PE1	89B3PE1	89CL3PE1	89OP3PE1	89AL3PE1	89IP3PE1	89IP	a
195	89A3PL2	89B3PL2	89CL3PL2	89OP3PL2	89AL3PL2	89IP3PL2	a	a
196	89A3PE2	89B3PE2	89CL3PE2	89OP3PE2	89AL3PE2	89IP3PE2	a	a
197	89O3PL1	89OS3PL1	89OI3PL1	89OE3PL1	89C3PL1	89CS3PL1	89CI3PL1	89CE3PL1
198	89O3PE1	89OS3PE1	89OI3PE1	89OE3PE1	89C3PE1	89CS3PE1	89CI3PE1	89CE3PE1
199	89O3PL2	89OS3PL2	89OI3PL2	89OE3PL2	89C3PL2	89CS3PL2	89CI3PL2	89CE3PL2
200	89O3PE2	89OS3PE2	89OI3PE2	89OE3PE2	89C3PE2	89CS3PE2	89CI3PE2	89CE3PE2
201	89A2P6	89B2P6	89CL2P6	89OP2P6	89A2P7	89B2P7	89CL2P7	89OP2P7
202	89A2P8	89B2P8	89CL2P8	89OP2P8	a	89AL2P6	89AL2P7	89AL2P8
203	PDEN	PDIUBD	PDDETA	PDDETB	PDDETC	CLPU1	CLPU2	CLSTRT
204	a	a	BCDETA	BCDETB	BCDETC	BCFLTC	a	a
205	BCENA	BCENB	BCENC	BCIAMS	BCIBMS	BCICMS	a	a
206	BCIAAS	BCIBAS	BCICAS	BCIAIAS	BCIBIAS	BCICIAS	a	a
207	BCZ1A	BCZ1B	BCZ1C	BCZ2A	BCZ2B	BCZ2C	a	a
208	BCIDETA	BCIDETB	BCIDETC	BCALRMA	BCALRMB	BCALRMC	a	a
209	LPHDSIM	a	a	a	SCBK1BC	SCBK1BO	BKENC1	BKENO1
210	SC850TM	SC850BM	SC850SM	SC850LS	LOC	MLTLEV	LOCSTA	OREDLOC
211	a	a	a	a	a	a	a	a
212	SW1C	SW1B	SW1A	a	a	a	a	a
213	VB001	VB002	VB003	VB004	VB005	VB006	VB007	VB008
214	VB009	VB010	VB011	VB012	VB013	VB014	VB015	VB016
215	VB017	VB018	VB019	VB020	VB021	VB022	VB023	VB024

Table L.1 SELogic Relay Word Bits (Sheet 7 of 8)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
216	VB025	VB026	VB027	VB028	VB029	VB030	VB031	VB032
217	VB033	VB034	VB035	VB036	VB037	VB038	VB039	VB040
218	VB041	VB042	VB043	VB044	VB045	VB046	VB047	VB048
219	VB049	VB050	VB051	VB052	VB053	VB054	VB055	VB056
220	VB057	VB058	VB059	VB060	VB061	VB062	VB063	VB064
221	VB065	VB066	VB067	VB068	VB069	VB070	VB071	VB072
222	VB073	VB074	VB075	VB076	VB077	VB078	VB079	VB080
223	VB081	VB082	VB083	VB084	VB085	VB086	VB087	VB088
224	VB089	VB090	VB091	VB092	VB093	VB094	VB095	VB096
225	VB097	VB098	VB099	VB100	VB101	VB102	VB103	VB104
226	VB105	VB106	VB107	VB108	VB109	VB110	VB111	VB112
227	VB113	VB114	VB115	VB116	VB117	VB118	VB119	VB120
228	VB121	VB122	VB123	VB124	VB125	VB126	VB127	VB128
229	VB129	VB130	VB131	VB132	VB133	VB134	VB135	VB136
230	VB137	VB138	VB139	VB140	VB141	VB142	VB143	VB144
231	VB145	VB146	VB147	VB148	VB149	VB150	VB151	VB152
232	VB153	VB154	VB155	VB156	VB157	VB158	VB159	VB160
233	VB161	VB162	VB163	VB164	VB165	VB166	VB167	VB168
234	VB169	VB170	VB171	VB172	VB173	VB174	VB175	VB176
235	VB177	VB178	VB179	VB180	VB181	VB182	VB183	VB184
236	VB185	VB186	VB187	VB188	VB189	VB190	VB191	VB192
237	VB193	VB194	VB195	VB196	VB197	VB198	VB199	VB200
238	VB201	VB202	VB203	VB204	VB205	VB206	VB207	VB208
239	VB209	VB210	VB211	VB212	VB213	VB214	VB215	VB216
240	VB217	VB218	VB219	VB220	VB221	VB222	VB223	VB224
241	VB225	VB226	VB227	VB228	VB229	VB230	VB231	VB232
242	VB233	VB234	VB235	VB236	VB237	VB238	VB239	VB240
243	VB241	VB242	VB243	VB244	VB245	VB246	VB247	VB248
244	VB249	VB250	VB251	VB252	VB253	VB254	VB255	VB256
245	SC33QU	SC34QU	SC35QU	SC36QU	SC37QU	SC38QU	SC39QU	SC40QU
246	SC33QD	SC34QD	SC35QD	SC36QD	SC37QD	SC38QD	SC39QD	SC40QD
247	SC41QU	SC42QU	SC43QU	SC44QU	SC45QU	SC46QU	SC47QU	SC48QU
248	SC41QD	SC42QD	SC43QD	SC44QD	SC45QD	SC46QD	SC47QD	SC48QD
249	SC49QU	SC50QU	SC51QU	SC52QU	SC53QU	SC54QU	SC55QU	SC56QU
250	SC49QD	SC50QD	SC51QD	SC52QD	SC53QD	SC54QD	SC55QD	SC56QD
251	SC57QU	SC58QU	SC59QU	SC60QU	SC61QU	SC62QU	SC63QU	SC64QU
252	SC57QD	SC58QD	SC59QD	SC60QD	SC61QD	SC62QD	SC63QD	SC64QD
253	81D1P	81D2P	81D3P	81D4P	81D5P	81D6P	[a]	[a]
254	81R1P	81R2P	81R3P	81R4P	[a]	[a]	[a]	[a]
255	FG1RB01	FG1RB02	FG1RB03	FG1RB04	FG1RB05	FG1RB06	FG1RB07	FG1RB08

Table L.1 SELogic Relay Word Bits (Sheet 8 of 8)

Bit/Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
256	FG2RB01	FG2RB02	FG2RB03	FG2RB04	FG2RB05	FG2RB06	FG2RB07	FG2RB08
257	FG3RB01	FG3RB02	FG3RB03	FG3RB04	FG3RB05	FG3RB06	FG3RB07	FG3RB08
258	FG4RB01	FG4RB02	FG4RB03	FG4RB04	FG4RB05	FG4RB06	FG4RB07	FG4RB08
259	97F1	97F1T	97FM1ER	97FM1ERT	97F2	97F2T	97FM2ER	97FM2ERT
260	97F3	97F3T	97FM3ER	97FM3ERT	97F4	97F4T	97FM4ER	97FM4ERT
261	97F5	97F5T	97FM5ER	97FM5ERT	97F6	97F6T	97FM6ER	97FM6ERT
262	97F7	97F7T	97FM7ER	97FM7ERT	97F8	97F8T	97FM8ER	97FM8ERT
263	97F9	97F9T	97FM9ER	97FM9ERT	97F0	97F0T	97FM0ER	97FM0ERT
264	STORMDET	[a]	[a]	[a]	[a]	[a]	[a]	[a]
265	FG1RQ	FG2RQ	FG3RQ	FG4RQ	[a]	[a]	[a]	[a]

[a] Reserved for future use.
[b] In firmware versions prior to R400, Rows 97–112 were occupied by Virtual Bits VB001 (Row 97, Bit 7) to VB128 (Row 112, Bit 0). Each row showed the status of 8 virtual bits.

Definitions

Table L.2 Relay Word Bit Definitions for the SEL-751 (Sheet 1 of 25)

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
27N1	Level 1 VBAT channel undervoltage element pickup	211
27N1T	Level 1 VBAT channel undervoltage element trip	211
27N2	Level 2 VBAT channel undervoltage element pickup	211
27N2T	Level 2 VBAT channel undervoltage element trip	211
27P1	Level 1 phase undervoltage element pickup	9
27P1T	Level 1 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

Table L.2 Relay Word Bit Definitions for the SEL-751 (Sheet 2 of 25)

Bit	Definition	Row
27S1T	Level 1 VS channel undervoltage element with time delay	115
27S2	Level 2 VS channel undervoltage element pickup	115
27S2T	Level 2 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
3V0	Asserts when VSCONN := 3V0	129
50A1P	Level 1 A-phase instantaneous overcurrent element pickup	1
50A2P	Level 2 A-phase instantaneous overcurrent element pickup	166
50B1P	Level 1 B-phase instantaneous overcurrent element pickup	1
50B2P	Level 2 B-phase instantaneous overcurrent element pickup	166
50BF	Breaker failure current detector	158
50BFG	Breaker failure residual current detector	158
50C1P	Level 1 C-phase instantaneous overcurrent element pickup	1
50C2P	Level 2 C-phase instantaneous overcurrent element pickup	166
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
50IALCA	Counter alarm level Phase A	163
50IALCB	Counter alarm level Phase B	163
50IALCC	Counter alarm level Phase C	163
50INCA	Element pickup Phase A	164
50INCB	Element pickup Phase B	164
50INCC	Element pickup Phase C	164
50INCTA	Element time out Phase A, self clearing	164

Table L.2 Relay Word Bit Definitions for the SEL-751 (Sheet 3 of 25)

Bit	Definition	Row
50INCTB	Element time out Phase B, self clearing	164
50INCTC	Element time out Phase C, self clearing	164
50ITRCA	Counter trip level Phase A	163
50ITRCB	Counter trip level Phase B	163
50ITRCC	Counter trip level Phase C	163
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
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

Table L.2 Relay Word Bit Definitions for the SEL-751 (Sheet 4 of 25)

Bit	Definition	Row
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
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

Table L.2 Relay Word Bit Definitions for the SEL-751 (Sheet 5 of 25)

Bit	Definition	Row
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
59N1	Level 1 VBAT channel overvoltage element pickup	211
59N1T	Level 1 VBAT channel overvoltage element trip	211
59N2	Level 2 VBAT channel overvoltage element pickup	211
59N2T	Level 2 VBAT channel overvoltage element trip	211
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
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
59VDIF	Phase and VS voltage difference within acceptable bounds	113
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

Table L.2 Relay Word Bit Definitions for the SEL-751 (Sheet 6 of 25)

Bit	Definition	Row
67N3T	Level 3 neutral directional overcurrent trip	154
67N4P	Level 4 neutral directional overcurrent pickup	154
67N4T	Level 4 neutral 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
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
81D1P	Level 1 definite-time over- and underfrequency pickup	253
81D2P	Level 2 definite-time over- and underfrequency pickup	253
81D3P	Level 3 definite-time over- and underfrequency pickup	253
81D4P	Level 4 definite-time over- and underfrequency pickup	253
81D5P	Level 5 definite-time over- and underfrequency pickup	253
81D6P	Level 6 definite-time over- and underfrequency pickup	253
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
81R1P	Level 1 rate-of-change-of-frequency element pickup	254
81R2P	Level 2 rate-of-change-of-frequency element pickup	254
81R3P	Level 3 rate-of-change-of-frequency element pickup	254
81R4P	Level 4 rate-of-change-of-frequency element pickup	254
81R1T	Level 1 rate-of-change-of-frequency element trip	119

Table L.2 Relay Word Bit Definitions for the SEL-751 (Sheet 7 of 25)

Bit	Definition	Row
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	Two-Position Disconnect 1 N/O contact	159
89A2P2	Two-Position Disconnect 2 N/O contact	159
89A2P3	Two-Position Disconnect 3 N/O contact	160
89A2P4	Two-Position Disconnect 4 N/O contact	160
89A2P5	Two-Position Disconnect 5 N/O contact	161
89A2P6	Two-Position Disconnect 6 N/O contact	201
89A2P7	Two-Position Disconnect 7 N/O contact	201
89A2P8	Two-Position Disconnect 8 N/O contact	202
89A3PE1	Three-Position Earthing Disconnect 1 N/O auxiliary contact	194
89A3PE2	Three-Position Earthing Disconnect 2 N/O auxiliary contact	196
89A3PL1	Three-Position In-Line Disconnect 1 N/O auxiliary contact	193
89A3PL2	Three-Position In-Line Disconnect 2 N/O auxiliary contact	195
89AL	Any two- or three-position disconnect in alarm	195
89AL2P1	Two-Position Disconnect 1 alarm	162
89AL2P2	Two-Position Disconnect 2 alarm	162
89AL2P3	Two-Position Disconnect 3 alarm	162
89AL2P4	Two-Position Disconnect 4 alarm	162
89AL2P5	Two-Position Disconnect 5 alarm	162
89AL2P6	Two-Position Disconnect 6 alarm	202
89AL2P7	Two-Position Disconnect 7 alarm	202
89AL2P8	Two-Position Disconnect 8 alarm	202
89AL3PE1	Three-Position Earthing Disconnect 1 alarm	194
89AL3PE2	Three-Position Earthing Disconnect 2 alarm	196
89AL3PL1	Three-Position In-Line Disconnect 1 alarm	193
89AL3PL2	Three-Position In-Line Disconnect 2 alarm	195
89B2P1	Two-Position Disconnect 1 N/C contact	159
89B2P2	Two-Position Disconnect 2 N/C contact	159
89B2P3	Two-Position Disconnect 3 N/C contact	160
89B2P4	Two-Position Disconnect 4 N/C contact	160
89B2P5	Two-Position Disconnect 5 N/C contact	161
89B2P6	Two-Position Disconnect 6 N/C contact	201
89B2P7	Two-Position Disconnect 7 N/C contact	201
89B2P8	Two-Position Disconnect 8 N/C contact	202

Table L.2 Relay Word Bit Definitions for the SEL-751 (Sheet 8 of 25)

Bit	Definition	Row
89B3PE1	Three-Position Earthing Disconnect 1 N/C auxiliary contact	194
89B3PE2	Three-Position Earthing Disconnect 2 N/C auxiliary contact	196
89B3PL1	Three-Position In-Line Disconnect 1 N/C auxiliary contact	193
89B3PL2	Three-Position In-Line Disconnect 2 N/C auxiliary contact	195
89C2P1	Two-Position Disconnect 1 close output	168
89C2P2	Two-Position Disconnect 2 close output	169
89C2P3	Two-Position Disconnect 3 close output	170
89C2P4	Two-Position Disconnect 4 close output	171
89C2P5	Two-Position Disconnect 5 close output	172
89C2P6	Two-Position Disconnect 6 close output	173
89C2P7	Two-Position Disconnect 7 close output	174
89C2P8	Two-Position Disconnect 8 close output	175
89C3PE1	Three-Position Earthing Disconnect 1 close output	198
89C3PE2	Three-Position Earthing Disconnect 2 close output	200
89C3PL1	Three-Position In-Line Disconnect 1 close output	197
89C3PL2	Three-Position In-Line Disconnect 2 close output	199
89CC2P1	Two-Position Disconnect 1 close command for control via communication protocols	176
89CC2P2	Two-Position Disconnect 2 close command for control via communication protocols	177
89CC2P3	Two-Position Disconnect 3 close command for control via communication protocols	178
89CC2P4	Two-Position Disconnect 4 close command for control via communication protocols	179
89CC2P5	Two-Position Disconnect 5 close command for control via communication protocols	180
89CC2P6	Two-Position Disconnect 6 close command for control via communication protocols	181
89CC2P7	Two-Position Disconnect 7 close command for control via communication protocols	182
89CC2P8	Two-Position Disconnect 8 close command for control via communication protocols	183
89CC3PE1	Three-Position Earthing Disconnect 1 close command for control via communication protocols	185
89CC3PE2	Three-Position Earthing Disconnect 2 close command for control via communication protocols	187
89CC3PL1	Three-Position In-Line Disconnect 1 close command for control via communication protocols	184
89CC3PL2	Three-Position In-Line Disconnect 2 close command for control via communication protocols	186
89CE2P1	Two-Position Disconnect 1 close enable	168
89CE2P2	Two-Position Disconnect 2 close enable	169
89CE2P3	Two-Position Disconnect 3 close enable	170
89CE2P4	Two-Position Disconnect 4 close enable	171
89CE2P5	Two-Position Disconnect 5 close enable	172
89CE2P6	Two-Position Disconnect 6 close enable	173
89CE2P7	Two-Position Disconnect 7 close enable	174
89CE2P8	Two-Position Disconnect 8 close enable	175
89CE3PE1	Three-Position Earthing Disconnect 1 close enable	198
89CE3PE2	Three-Position Earthing Disconnect 2 close enable	200

Table L.2 Relay Word Bit Definitions for the SEL-751 (Sheet 9 of 25)

Bit	Definition	Row
89CE3PL1	Three-Position In-Line Disconnect 1 close enable	197
89CE3PL2	Three-Position In-Line Disconnect 2 close enable	199
89CI2P1	Two-Position Disconnect 1 close immobility timer timed out	168
89CI2P2	Two-Position Disconnect 2 close immobility timer timed out	169
89CI2P3	Two-Position Disconnect 3 close immobility timer timed out	170
89CI2P4	Two-Position Disconnect 4 close immobility timer timed out	171
89CI2P5	Two-Position Disconnect 5 close immobility timer timed out	172
89CI2P6	Two-Position Disconnect 6 close immobility timer timed out	173
89CI2P7	Two-Position Disconnect 7 close immobility timer timed out	174
89CI2P8	Two-Position Disconnect 8 close immobility timer timed out	175
89CI3PE1	Three-Position Earthing Disconnect 1 close immobility timer timed out	198
89CI3PE2	Three-Position Earthing Disconnect 2 close immobility timer timed out	200
89CI3PL1	Three-Position In-Line Disconnect 1 close immobility timer timed out	197
89CI3PL2	Three-Position In-Line Disconnect 2 close immobility timer timed out	199
89CL2P1	Two-Position Disconnect 1 closed	159
89CL2P2	Two-Position Disconnect 2 closed	159
89CL2P3	Two-Position Disconnect 3 closed	160
89CL2P4	Two-Position Disconnect 4 closed	160
89CL2P5	Two-Position Disconnect 5 closed	161
89CL2P6	Two-Position Disconnect 6 closed	201
89CL2P7	Two-Position Disconnect 7 closed	201
89CL2P8	Two-Position Disconnect 8 closed	202
89CL3PE1	Three-Position Earthing Disconnect 1 closed	194
89CL3PE2	Three-Position Earthing Disconnect 2 closed	196
89CL3PL1	Three-Position In-Line Disconnect 1 closed	193
89CL3PL2	Three-Position In-Line Disconnect 2 closed	195
89CM2P1	Two-Position Disconnect 1 close command for control via front panel HMI	176
89CM2P2	Two-Position Disconnect 2 close command for control via front panel HMI	177
89CM2P3	Two-Position Disconnect 3 close command for control via front panel HMI	178
89CM2P4	Two-Position Disconnect 4 close command for control via front panel HMI	179
89CM2P5	Two-Position Disconnect 5 close command for control via front panel HMI	180
89CM2P6	Two-Position Disconnect 6 close command for control via front panel HMI	181
89CM2P7	Two-Position Disconnect 7 close command for control via front panel HMI	182
89CM2P8	Two-Position Disconnect 8 close command for control via front panel HMI	183
89CM3PE1	Three-Position Earthing Disconnect 1 close command for control via front panel HMI	185
89CM3PE2	Three-Position Earthing Disconnect 2 close command for control via front panel HMI	187
89CM3PL1	Three-Position In-Line Disconnect 1 close command for control via front panel HMI	184
89CM3PL2	Three-Position In-Line Disconnect 2 close command for control via front panel HMI	186
89CS2P1	Two-Position Disconnect 1 close seal-in timer timed out	168
89CS2P2	Two-Position Disconnect 2 close seal-in timer timed out	169
89CS2P3	Two-Position Disconnect 3 close seal-in timer timed out	170

Table L.2 Relay Word Bit Definitions for the SEL-751 (Sheet 10 of 25)

Bit	Definition	Row
89CS2P4	Two-Position Disconnect 4 close seal-in timer timed out	171
89CS2P5	Two-Position Disconnect 5 close seal-in timer timed out	172
89CS2P6	Two-Position Disconnect 6 close seal-in timer timed out	173
89CS2P7	Two-Position Disconnect 7 close seal-in timer timed out	174
89CS2P8	Two-Position Disconnect 8 close seal-in timer timed out	175
89CS3PE1	Three-Position Earthing Disconnect 1 close seal-in timer timed out	198
89CS3PE2	Three-Position Earthing Disconnect 2 close seal-in timer timed out	200
89CS3PL1	Three-Position In-Line Disconnect 1 close seal-in timer timed out	197
89CS3PL2	Three-Position In-Line Disconnect 2 close seal-in timer timed out	199
89IP	Any two- or three-position disconnect operation in-progress	194
89IP2P1	Two-Position Disconnect 1 operation in-progress	192
89IP2P2	Two-Position Disconnect 2 operation in-progress	192
89IP2P3	Two-Position Disconnect 3 operation in-progress	192
89IP2P4	Two-Position Disconnect 4 operation in-progress	192
89IP2P5	Two-Position Disconnect 5 operation in-progress	192
89IP2P6	Two-Position Disconnect 6 operation in-progress	192
89IP2P7	Two-Position Disconnect 7 operation in-progress	192
89IP2P8	Two-Position Disconnect 8 operation in-progress	192
89IP3PE1	Three-Position Earthing Disconnect 1 operation in-progress	194
89IP3PE2	Three-Position Earthing Disconnect 2 operation in-progress	196
89IP3PL1	Three-Position In-Line Disconnect 1 operation in-progress	193
89IP3PL2	Three-Position In-Line Disconnect 2 operation in-progress	195
89O2P1	Two-Position Disconnect 1 open output	168
89O2P2	Two-Position Disconnect 2 open output	169
89O2P3	Two-Position Disconnect 3 open output	170
89O2P4	Two-Position Disconnect 4 open output	171
89O2P5	Two-Position Disconnect 5 open output	172
89O2P6	Two-Position Disconnect 6 open output	173
89O2P7	Two-Position Disconnect 7 open output	174
89O2P8	Two-Position Disconnect 8 open output	175
89O3PE1	Three-Position Earthing Disconnect 1 open output	198
89O3PE2	Three-Position Earthing Disconnect 2 open output	200
89O3PL1	Three-Position In-Line Disconnect 1 open output	197
89O3PL2	Three-Position In-Line Disconnect 2 open output	199
89OC2P1	Two-Position Disconnect 1 open command for control via communication protocols	176
89OC2P2	Two-Position Disconnect 2 open command for control via communication protocols	177
89OC2P3	Two-Position Disconnect 3 open command for control via communication protocols	178
89OC2P4	Two-Position Disconnect 4 open command for control via communication protocols	179
89OC2P5	Two-Position Disconnect 5 open command for control via communication protocols	180
89OC2P6	Two-Position Disconnect 6 open command for control via communication protocols	181
89OC2P7	Two-Position Disconnect 7 open command for control via communication protocols	182

Table L.2 Relay Word Bit Definitions for the SEL-751 (Sheet 11 of 25)

Bit	Definition	Row
89OC2P8	Two-Position Disconnect 8 open command for control via communication protocols	183
89OC3PE1	Three-Position Earthing Disconnect 1 open command for control via communication protocols	185
89OC3PE2	Three-Position Earthing Disconnect 2 open command for control via communication protocols	187
89OC3PL1	Three-Position In-Line Disconnect 1 open command for control via communication protocols	184
89OC3PL2	Three-Position In-Line Disconnect 2 open command for control via communication protocols	186
89OE2P1	Two-Position Disconnect 1 open enable	168
89OE2P2	Two-Position Disconnect 2 open enable	169
89OE2P3	Two-Position Disconnect 3 open enable	170
89OE2P4	Two-Position Disconnect 4 open enable	171
89OE2P5	Two-Position Disconnect 5 open enable	172
89OE2P6	Two-Position Disconnect 6 open enable	173
89OE2P7	Two-Position Disconnect 7 open enable	174
89OE2P8	Two-Position Disconnect 8 open enable	175
89OE3PE1	Three-Position Earthing Disconnect 1 open enable	198
89OE3PE2	Three-Position Earthing Disconnect 2 open enable	200
89OE3PL1	Three-Position In-Line Disconnect 1 open enable	197
89OE3PL2	Three-Position In-Line Disconnect 2 open enable	199
89OI2P1	Two-Position Disconnect 1 open immobility timer timed out	168
89OI2P2	Two-Position Disconnect 2 open immobility timer timed out	169
89OI2P3	Two-Position Disconnect 3 open immobility timer timed out	170
89OI2P4	Two-Position Disconnect 4 open immobility timer timed out	171
89OI2P5	Two-Position Disconnect 5 open immobility timer timed out	172
89OI2P6	Two-Position Disconnect 6 open immobility timer timed out	173
89OI2P7	Two-Position Disconnect 7 open immobility timer timed out	174
89OI2P8	Two-Position Disconnect 8 open immobility timer timed out	175
89OI3PE1	Three-Position Earthing Disconnect 1 open immobility timer timed out	198
89OI3PE2	Three-Position Earthing Disconnect 2 open immobility timer timed out	200
89OI3PL1	Three-Position In-Line Disconnect 1 open immobility timer timed out	197
89OI3PL2	Three-Position In-Line Disconnect 2 open immobility timer timed out	199
89OM2P1	Two-Position Disconnect 1 open command for control via front panel HMI	176
89OM2P2	Two-Position Disconnect 2 open command for control via front panel HMI	177
89OM2P3	Two-Position Disconnect 3 open command for control via front panel HMI	178
89OM2P4	Two-Position Disconnect 4 open command for control via front panel HMI	179
89OM2P5	Two-Position Disconnect 5 open command for control via front panel HMI	180
89OM2P6	Two-Position Disconnect 6 open command for control via front panel HMI	181
89OM2P7	Two-Position Disconnect 7 open command for control via front panel HMI	182
89OM2P8	Two-Position Disconnect 8 open command for control via front panel HMI	183
89OM3PE1	Three-Position Earthing Disconnect 1 open command for control via front panel HMI	185

Table L.2 Relay Word Bit Definitions for the SEL-751 (Sheet 12 of 25)

Bit	Definition	Row
89OM3PE2	Three-Position Earthing Disconnect 2 open command for control via front panel HMI	187
89OM3PL1	Three-Position In-Line Disconnect 1 open command for control via front panel HMI	184
89OM3PL2	Three-Position In-Line Disconnect 2 open command for control via front panel HMI	186
89OP2P1	Two-Position Disconnect 1 open	159
89OP2P2	Two-Position Disconnect 2 open	159
89OP2P3	Two-Position Disconnect 3 open	160
89OP2P4	Two-Position Disconnect 4 open	160
89OP2P5	Two-Position Disconnect 5 open	161
89OP2P6	Two-Position Disconnect 6 open	201
89OP2P7	Two-Position Disconnect 7 open	201
89OP2P8	Two-Position Disconnect 8 open	202
89OP3PE1	Three-Position Earthing Disconnect 1 open	194
89OP3PE2	Three-Position Earthing Disconnect 2 open	196
89OP3PL1	Three-Position In-Line Disconnect 1 open	193
89OP3PL2	Three-Position In-Line Disconnect 2 open	195
89OS2P1	Two-Position Disconnect 1 open seal-in timer timed out	168
89OS2P2	Two-Position Disconnect 2 open seal-in timer timed out	169
89OS2P3	Two-Position Disconnect 3 open seal-in timer timed out	170
89OS2P4	Two-Position Disconnect 4 open seal-in timer timed out	171
89OS2P5	Two-Position Disconnect 5 open seal-in timer timed out	172
89OS2P6	Two-Position Disconnect 6 open seal-in timer timed out	173
89OS2P7	Two-Position Disconnect 7 open seal-in timer timed out	174
89OS2P8	Two-Position Disconnect 8 open seal-in timer timed out	175
89OS3PE1	Three-Position Earthing Disconnect 1 open seal-in timer timed out	198
89OS3PE2	Three-Position Earthing Disconnect 2 open seal-in timer timed out	200
89OS3PL1	Three-Position In-Line Disconnect 1 open seal-in timer timed out	197
89OS3PL2	Three-Position In-Line Disconnect 2 open seal-in timer timed out	199
89RC2P1	Two-Position Disconnect 1 remote close control SELOGIC control equation	176
89RC2P2	Two-Position Disconnect 2 remote close control SELOGIC control equation	177
89RC2P3	Two-Position Disconnect 3 remote close control SELOGIC control equation	178
89RC2P4	Two-Position Disconnect 4 remote close control SELOGIC control equation	179
89RC2P5	Two-Position Disconnect 5 remote close control SELOGIC control equation	180
89RC2P6	Two-Position Disconnect 6 remote close control SELOGIC control equation	181
89RC2P7	Two-Position Disconnect 7 remote close control SELOGIC control equation	182
89RC2P8	Two-Position Disconnect 8 remote close control SELOGIC control equation	183
89RC3PE1	Three-Position Earthing Disconnect 1 remote close control SELOGIC control equation	185
89RC3PE2	Three-Position Earthing Disconnect 2 remote close control SELOGIC control equation	187
89RC3PL1	Three-Position In-Line Disconnect 1 remote close control SELOGIC control equation	184
89RC3PL2	Three-Position In-Line Disconnect 2 remote close control SELOGIC control equation	186
89RO2P1	Two-Position Disconnect 1 remote open control SELOGIC control equation	176
89RO2P2	Two-Position Disconnect 2 remote open control SELOGIC control equation	177

Table L.2 Relay Word Bit Definitions for the SEL-751 (Sheet 13 of 25)

Bit	Definition	Row
89RO2P3	Two-Position Disconnect 3 remote open control SELOGIC control equation	178
89RO2P4	Two-Position Disconnect 4 remote open control SELOGIC control equation	179
89RO2P5	Two-Position Disconnect 5 remote open control SELOGIC control equation	180
89RO2P6	Two-Position Disconnect 6 remote open control SELOGIC control equation	181
89RO2P7	Two-Position Disconnect 7 remote open control SELOGIC control equation	182
89RO2P8	Two-Position Disconnect 8 remote open control SELOGIC control equation	183
89RO3PE1	Three-Position Earthing Disconnect 1 remote open control SELOGIC control equation	185
89RO3PE2	Three-Position Earthing Disconnect 2 remote open control SELOGIC control equation	187
89RO3PL1	Three-Position In-Line Disconnect 1 remote open control SELOGIC control equation	184
89RO3PL2	Three-Position In-Line Disconnect 2 remote open control SELOGIC control equation	186
97F1	Frequency component magnitude element pick up	259
97F1T	Frequency component magnitude element time out	259
97FM1ER	Event report timer pick up	259
97FM1ERT	Event report timer time out	259
97F2	Frequency component magnitude element pick up	259
97F2T	Frequency component magnitude element time out	259
97FM2ER	Event report timer pick up	259
97FM2ERT	Event report timer time out	259
97F3	Frequency component magnitude element pick up	260
97F3T	Frequency component magnitude element time out	260
97FM3ER	Event report timer pick up	260
97FM3ERT	Event report timer time out	260
97F4	Frequency component magnitude element pick up	260
97F4T	Frequency component magnitude element time out	260
97FM4ER	Event report timer pick up	260
97FM4ERT	Event report timer time out	260
97F5	Frequency component magnitude element pick up	261
97F5T	Frequency component magnitude element time out	261
97FM5ER	Event report timer pick up	261
97FM5ERT	Event report timer time out	261
97F6	Frequency component magnitude element pick up	261
97F6T	Frequency component magnitude element time out	261
97FM6ER	Event report timer pick up	261
97FM6ERT	Event report timer time out	261
97F7	Frequency component magnitude element pick up	262
97F7T	Frequency component magnitude element time out	262
97FM7ER	Event report timer pick up	262
97FM7ERT	Event report timer time out	262
97F8	Frequency component magnitude element pick up	262
97F8T	Frequency component magnitude element time out	262
97FM8ER	Event report timer pick up	262

Table L.2 Relay Word Bit Definitions for the SEL-751 (Sheet 14 of 25)

Bit	Definition	Row
97FM8ERT	Event report timer time out	262
97F9	Frequency component magnitude element pick up	263
97F9T	Frequency component magnitude element time out	263
97FM9ER	Event report timer pick up	263
97FM9ERT	Event report timer time out	263
97F0	Frequency component magnitude element pick up	263
97F0T	Frequency component magnitude element time out	263
97FM0ER	Event report timer pick up	263
97FM0ERT	Event report timer time out	263
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
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
BCALRMA	Broken conductor alarm for Phase A	208
BCALRMB	Broken conductor alarm for Phase B	208
BCALRMC	Broken conductor alarm for Phase C	208
BCDETA	Broken conductor detected in Phase A	204
BCDETB	Broken conductor detected in Phase B	204
BCDETC	Broken conductor detected in Phase C	204
BCENA	Broken conductor detection algorithm enabled for Phase A	205
BCENB	Broken conductor detection algorithm enabled for Phase B	205
BCENC	Broken conductor detection algorithm enabled for Phase C	205
BCFLTC	Broken conductor fault location torque control	204
BCIAAS	Broken conductor Phase A current angle supervision satisfied	206

Table L.2 Relay Word Bit Definitions for the SEL-751 (Sheet 15 of 25)

Bit	Definition	Row
BCIAIAS	Broken conductor Phase A current incremental angle supervision satisfied	206
BCIAMS	Broken conductor Phase A current magnitude supervision satisfied	205
BCIBAS	Broken conductor Phase B current angle supervision satisfied	206
BCIBIAS	Broken conductor Phase B current incremental angle supervision satisfied	206
BCIBMS	Broken conductor Phase B current magnitude supervision satisfied	205
BCICAS	Broken conductor Phase C current angle supervision satisfied	206
BCICIAS	Broken conductor Phase C current incremental angle supervision satisfied	206
BCICMS	Broken conductor Phase C current magnitude supervision satisfied	205
BCIDETA	Broken conductor internal detection for Phase A	208
BCIDETB	Broken conductor internal detection for Phase B	208
BCIDETC	Broken conductor internal detection for Phase C	208
BCW	BCWA + BCWB + BCWC	113
BCWA	A-phase breaker contact wear has reached the 100% wear level	113
BCWB	B-phase breaker contact wear has reached the 100% wear level	113
BCWC	C-phase breaker contact wear has reached the 100% wear level	113
BCZ1A	Broken conductor detected in Zone 1 for Phase A	207
BCZ1B	Broken conductor detected in Zone 1 for Phase B	207
BCZ1C	Broken conductor detected in Zone 1 for Phase C	207
BCZ2A	Broken conductor detected in Zone 2 for Phase A	207
BCZ2B	Broken conductor detected in Zone 2 for Phase B	207
BCZ2C	Broken conductor detected in Zone 2 for Phase C	207
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
BFRT	Breaker failure retrip	158
BFT	Asserts when the relay issues a breaker failure trip	12
BFTRIP	Breaker failure trip logic output	158
BKJMP	Asserts if breaker control jumper is installed on main board	33
BKENC1	SELOGIC control for breaker close interlocking supervision	209
BKENO1	SELOGIC control for breaker open interlocking supervision	209
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 1/4 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
CLPU1	Cold Load Pickup 1 enabled	203

Table L.2 Relay Word Bit Definitions for the SEL-751 (Sheet 16 of 25)

Bit	Definition	Row
CLPU2	Cold Load Pickup 2 enabled	203
CLSTRT	Cold load start	203
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
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
DLDB	Dead line dead bus	158
DLLB	Dead line live bus	158
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

Table L.2 Relay Word Bit Definitions for the SEL-751 (Sheet 17 of 25)

Bit	Definition	Row
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
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
FG1RB01–FG1RB08	Fixed GOOSE Message 1 Bits 01–08 asserted	255
FG2RB01–FG2RB08	Fixed GOOSE Message 2 Bits 01–08 asserted	256
FG3RB01–FG3RB08	Fixed GOOSE Message 3 Bits 01–08 asserted	257
FG4RB01–FG4RB08	Fixed GOOSE Message 4 Bits 01–08 asserted	258
FG1RQ–FG4RQ	Fixed GOOSE Message 1–4 received quality bit	265
FIDEN	Fault identification logic enabled	140
FREQFZ	Synchrophasor bit that asserts if the measured frequency > ±20 Hz from nominal	117
FREQTRK	Frequency tracking	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

Table L.2 Relay Word Bit Definitions for the SEL-751 (Sheet 18 of 25)

Bit	Definition	Row
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
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
HIFFRZ	SELOGIC control equation to freeze tuning	132
HIFITUNE	Begin 24-hour initial HIF tuning	132
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
LB25–LB32	Local Bits 25–32	42

Table L.2 Relay Word Bit Definitions for the SEL-751 (Sheet 19 of 25)

Bit	Definition	Row
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 (only available with the single Ethernet port option)	145
LINKA	Asserts when Ethernet Port 1A detects link (only available with the dual Ethernet port option)	13
LINKB	Asserts when Ethernet Port 1B detects link (only available with the dual Ethernet port option)	13
LINKFAIL	Failure of active Ethernet port link	31
LLDB	Live line dead bus	158
LOC	SELOGIC control for control authority at local/bay level	210
LOCAL	Asserts when relay control configuration is in LOCAL mode	151
LOCSTA	Control authority at station level	210
LOP	Loss-of-potential	14
LPHDSIM	IEC 61850 simulation mode; asserts when simulation mode is set	209
LPSEC	While LPSECP is asserted, add leap second if LPSEC = 0, and delete leap second if LPSEC = 1	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
LT33–LT40	Latch bits 33–40	109
LT41–LT48	Latch bits 41–48	110
LT49–LT56	Latch bits 49–56	111
LT57–LT64	Latch bits 57–64	112
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
MLTLEV	SELOGIC control for multilevel mode of control authority	210
MPH_EVE	Multi-phase event detection	132
MTR	Manual trip SELOGIC control equation state	130
MTRIP	Manual breaker trip	130
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

Table L.2 Relay Word Bit Definitions for the SEL-751 (Sheet 20 of 25)

Bit	Definition	Row
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
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
OREDLOC	Logical OR of LOC and LOCAL Relay Word bits	210
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 (only available with the dual Ethernet port option)	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 (only available with the dual Ethernet port option)	31
PDEN	Phase discontinuity detection algorithm enabled	203
PDDETA	Phase discontinuity detected in Phase A	203

Table L.2 Relay Word Bit Definitions for the SEL-751 (Sheet 21 of 25)

Bit	Definition	Row
PDDETB	Phase discontinuity detected in Phase B	203
PDDETC	Phase discontinuity detected in Phase C	203
PDIUBD	Phase discontinuity current unbalance detected	203
PFLEAD	Three-phase power factor lead indication	12
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	Phase current demand pickup	113
PMDOK	Assert if data acquisition system is operating correctly	13
PMTRIG	Trigger for synchrophasors	33
PTP_OK	Asserts if PTP time is within the 4 ms local offset (firmware-based PTP) or within the 250 ns local offset (hardware-based PTP)	166
PTP_TIM	Asserts if a valid PTP time source is detected	166
PTPA	Asserts when PTP is enabled in PRP mode and the relay is receiving PTP messages on Port 1A	166
PTPB	Asserts when PTP is enabled in PRP mode and the relay is receiving PTP messages on Port 1B	166
PTPSYNC	Asserts if the relay is using PTP time to do time sync	166
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
RB33–RB40	Remote Bits 33–40	97
RB41–RB48	Remote Bits 41–48	98
RB49–RB56	Remote Bits 49–56	99
RB57–RB64	Remote Bits 57–64	100
RBADA	Channel A, outage duration over threshold	96
RBADB	Channel B, outage duration over threshold	96
RCSF	Reclose supervision failure (asserts for 1/4 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

Table L.2 Relay Word Bit Definitions for the SEL-751 (Sheet 22 of 25)

Bit	Definition	Row
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
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
RTDA	Winding/Bearing RTD overtemperature alarm	140
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
RTDT	Winding/Bearing RTD overtemperature trip	140
SALARM	Software alarms: invalid password, changing access levels, settings changes, active group change, **COPY** command, and password change	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
SC33QD–SC40QD	SELOGIC Counters 33 through 40 asserted when counter = 0	246
SC33QU–SC40QU	SELOGIC Counters 33 through 40 asserted when counter = preset value	245
SC41QD–SC48QD	SELOGIC Counters 41 through 48 asserted when counter = 0	248
SC41QU–SC48QU	SELOGIC Counters 41 through 48 asserted when counter = preset value	247

Table L.2 Relay Word Bit Definitions for the SEL-751 (Sheet 23 of 25)

Bit	Definition	Row
SC49QD–SC56QD	SELOGIC Counters 49 through 56 asserted when counter = 0	250
SC49QU–SC56QU	SELOGIC Counters 49 through 56 asserted when counter = preset value	249
SC57QD–SC64QD	SELOGIC Counters 57 through 64 asserted when counter = 0	252
SC57QU–SC64QU	SELOGIC Counters 57 through 64 asserted when counter = preset value	251
SC850BM	SELOGIC control for IEC 61850 Block Mode	210
SC850BM	SELOGIC control for IEC 61850 Block Mode	210
SC850TM	SELOGIC control for IEC 61850 Test Mode	210
SC850SM	SELOGIC control for IEC 61850 Simulation Mode	210
SC850LS	SELOGIC control for control authority at station level	210
SCBK1BC	SELOGIC control for breaker close interlocking supervision equation	209
SCBK1BO	SELOGIC control for breaker open interlocking supervision equation	209
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
STORMDET	Asserts if a network storm has been detected	264
SV01–SV08	SELOGIC Control Equation Variables SV01 through SV08	47
SV01T–SV08T	SELOGIC Control Equation Variables SV01T through SV08T with settable pickup and drop-out time delay	48
SV09–SV16	SELOGIC Control Equation Variables SV09 through SV16	49
SV09T–SV16T	SELOGIC Control Equation Variables SV09T through SV16T with settable pickup and drop-out time delay	50
SV17–SV24	SELOGIC Control Equation Variables SV17 through SV24	51
SV17T–SV24T	SELOGIC Control Equation Variables SV17T through SV24T with settable pickup and drop-out time delay	52
SV25–SV32	SELOGIC Control Equation Variables SV25 through SV32	53
SV25T–SV32T	SELOGIC Control Equation Variables SV25T through SV32T with settable pickup and drop-out time delay	54
SV33–SV40	SELOGIC Control Equation Variables SV33 through SV40	101
SV33T–SV40T	SELOGIC Control Equation Variables SV33T through SV40T with settable pickup and drop-out time delay	102
SV41–SV48	SELOGIC Control Equation Variables SV41 through SV48	103
SV41T–SV48T	SELOGIC Control Equation Variables SV41T through SV48T with settable pickup and drop-out time delay	104
SV49–SV56	SELOGIC Control Equation Variables SV49 through SV56	105
SV49T–SV56T	SELOGIC Control Equation Variables SV49T through SV56T with settable pickup and drop-out time delay	106

Table L.2 Relay Word Bit Definitions for the SEL-751 (Sheet 24 of 25)

Bit	Definition	Row
SV57–SV64	SELOGIC Control Equation Variables SV57 through SV64	107
SV57T–SV64T	SELOGIC Control Equation Variables SV57T through SV64T with settable pickup and dropout time delay	108
SW1A	Asserts when the A-phase interharmonics incremental change is greater than the tuned detection margin	212
SW1B	Asserts when the B-phase interharmonics incremental change is greater than the tuned detection margin	212
SW1C	Asserts when the C-phase interharmonics incremental change is greater than the tuned detection margin	212
T01_LED–T06_LED	SELOGIC control equation: drives T01_LED–T06_LED	38
TESTDB	Command **TEST DB** (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
TSNTPP	SNTP primary server is active	129
TSOK	Assert if current time source accuracy is sufficient for synchronized phasor measurements	13

Table L.2 Relay Word Bit Definitions for the SEL-751 (Sheet 25 of 25)

Bit	Definition	Row
TUTC1	Offset hours from UTC, binary, add 1 if asserted	117
TUTC2	Offset hours from UTC, binary, add 2 if asserted	117
TUTC4	Offset hours from UTC, binary, add 4 if asserted	117
TUTC8	Offset hours from UTC, binary, add 8 if asserted	117
TUTCH	Offset half-hour from UTC, binary, add 0.5 if asserted	117
TUTCS	Offset hours sign from UTC, 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
ULMTRIP	Unlatch manual trip SELOGIC control equation state	130
ULTRIP	Unlatch Trip SELOGIC control equation state	33
VB*xxx*	Virtual bits used for incoming GOOSE messages (*xxx* = 1–256)	213–244
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 M
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. Analog quantities for rms data are determined through the use of data averaged over the previous 8 cycles.

Table M.1 lists analog quantities that you can use in the following specific functions:

- Display points (see *Section 8: Front-Panel Operations*)
- SELOGIC control equations (see *Section 4: Protection and Logic Functions*)
- Load profile recorder (see *Section 5: Metering and Monitoring*)
- DNP (see *Appendix D: DNP3 Communications*)
- Fast Message Read (FMR)
- IEC 60870-5-103 (see *Appendix H: IEC 60870-5-103 Communications*)
- EtherNet/IP (see *Appendix F: EtherNet/IP Communications*)
- Modbus (see *Appendix E: Modbus Communications*)
- Fast Meter (see *Appendix C: SEL Communications Processors*)
- IEC 61850 (see *Appendix G: IEC 61850 Communications*)

Table M.1 Analog Quantities (Sheet 1 of 10)

Name	Description	Units	Display Points	SELOGIC	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/EtherNet/IP	Modbus[a]	Fast Meter	IEC 61850[b]
Fundamental Instantaneous Metering Note 1: FREQ and FREQS are set equal to the FNOM setting following a settings change. Note 2: Value of the VDC analog quantity depends on the Global setting EDCMON. If EDCMON = Y, VDC contains station dc battery voltage (Vdc), else VBAT channel AC voltage (V primary).									
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

Table M.1 Analog Quantities (Sheet 2 of 10)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/EtherNet/IP	Modbus[a]	Fast Meter	IEC 61850[b]
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
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

Table M.1 Analog Quantities (Sheet 3 of 10)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/EtherNet/IP	Modbus[a]	Fast Meter	IEC 61850[b]
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[1]	Frequency	Hz	x	x	x	x	x	x	x
FREQS[1]	Sync frequency	Hz	x	x	x	x	x	x	x
DFDT	Frequency rate-of-change	Hz/sec	x	x					x
VDC[2]	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 3: 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 4: 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 5: The fault location analogs are reported as part of Event History data in Modbus and have different labels. Note 6: If the relay is restarted (cold start), Event Report information will be reset until a new Event Record is generated. Note 7: 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 Communications).									
FLOC[3, 4, 5]	Fault location of the most recent fault; for IEC 60870 fault analogs, fault location of fault event		x	x		x	x		x
FIA[5]	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[5]	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[5]	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[5]	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[5]	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[5]	Frequency of the most recent fault; for IEC 60870 fault analogs, frequency of fault event	Hz	x	x		x	x		x
FZ[3, 5]	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[3, 5]	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[6]	Unique Identification number of the latest event								x

Table M.1 Analog Quantities (Sheet 4 of 10)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/EtherNet/IP	Modbus[a]	Fast Meter	IEC 61850[b]
FLREP[6]	Event Report Present (shall be 1 when an event report is present, and 0 otherwise								x
HIFLRNUM[6]	Unique Identification number of the latest HIF event								x
HIFLREP[6]	HIF Event Report Present (shall be 1 when an HIF event report is present, and 0 otherwise								x
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 8: RTD open is equivalent to +32767 and RTD short is equivalent to –32768 when RTDs are monitored via LDP. Note 9: Use caution when assigning RTD analog quantities to SELogic control equations or math variables because the conditions RTD open, short, comm fail, stat fail, fail, and NA will be reported as +32767, –32768, +32764, +32760, +32766, and +32752, respectively.									
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[8,9]	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 10: This Analog Quantity is not available for FMR.									
EM_LRDH	Energy last reset date/time high word					x[10]			
EM_LRDM	Energy last reset date/time middle word					x[10]			
EM_LRDL	Energy last reset date/time low word					x[10]			

Table M.1 Analog Quantities (Sheet 5 of 10)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/EtherNet/IP	Modbus[a]	Fast Meter	IEC 61850[b]
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		
Maximum/Minimum Metering Note 11: 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 12: EU is Engineering Units. Note 13: Upon reset, the maximum and minimum metering quantities read +16777216 for MN and –16777216 for MX.									
MM_LRDH[11]	Max/min last reset date/time high word					x[10]			
MM_LRDM[11]	Max/min last reset date/time middle word					x[10]			
MM_LRDL[11]	Max/min last reset date/time low word					x[10]			
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	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

Table M.1 Analog Quantities (Sheet 6 of 10)

Name	Description	Units	Display Points	SELOGIC	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/EtherNet/IP	Modbus[a]	Fast Meter	IEC 61850[b]
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[12]	x	x	x	x	x		x
AI301MN to AI308MN	Analog Transducer Input 301–308 minimum	EU[12]	x	x	x	x	x		x
AI401MX to AI408MX	Analog Transducer Input 401–408 maximum	EU[12]	x	x	x	x	x		x
AI401MN to AI408MN	Analog Transducer Input 401–408 minimum	EU[12]	x	x	x	x	x		x
AI501MX to AI508MX	Analog Transducer Input 501–508 maximum	EU[12]	x	x	x	x	x		x
AI501MN to AI508MN	Analog Transducer Input 501–508 minimum	EU[12]	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

Table M.1 Analog Quantities (Sheet 7 of 10)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/EtherNet/IP	Modbus[a]	Fast Meter	IEC 61850[b]
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 Note 14: 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[14]	Peak demand last reset date/time high word					x[10]			
PM_LRDM[14]	Peak demand last reset date/time middle word					x[10]			
PM_LRDL[14]	Peak demand last reset date/time low word					x[10]			
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

Table M.1 Analog Quantities (Sheet 8 of 10)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/EtherNet/IP	Modbus[a]	Fast Meter	IEC 61850[b]
BRKCLTM	Latest breaker close time of the electromechanical contact	ms	x	x	x	x	x		x
BRKCLTH	Latest breaker close time of the fast-hybrid contact	ms	x	x	x	x	x		x
BRKOPTM	Latest breaker operate time of the electromechanical contact	ms	x	x	x	x	x		x
BRKOPTH	Latest breaker operate time of the fast-hybrid contact	ms	x	x	x	x	x		x
AST/HIF (High-Impedance Fault)									
SDIA	A-phase total interharmonic content	A pri		x					
SDIB	B-phase total interharmonic content	A pri		x					
SDIC	C-phase total interharmonic content	A pri		x					
SDIAREF	A-phase reference total interharmonic content	A pri		x					
SDIBREF	B-phase reference total interharmonic content	A pri		x					
SDICREF	C-phase reference total interharmonic 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					
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 Note 15: 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 Note 16: RID and TID are only available as display point settings (DP01 to DP32) in the two-line display model. Note 17: STRING_RID and STRING_TID are only available as analog label quantities for the bay screen in the touchscreen display model.									
RID[16]	Relay identifier		x						
TID[16]	Terminal identifier		x						
STRING_RID[17]	Relay identifier (Bay Screen)		x						
STRING_TID[17]	Terminal identifier (Bay Screen)		x						
Serial Number Note 18: 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[10, 18]	Serial number of the relay		x			x	x		x

Table M.1 Analog Quantities (Sheet 9 of 10)

Name	Description	Units	Display Points	SELOGIC	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/EtherNet/IP	Modbus[a]	Fast Meter	IEC 61850[b]
Setting Group									
GROUP	Active setting group number		x	x	x	x			x
Math Variables									
MV01 to MV64	Math Variable 01 to Math Variable 64		x	x	x	x	x		x
SELOGIC Counters Note 19: Also available as DNP counter object.									
SC01 to SC64[19]	SELOGIC Counter 01 to SELOGIC Counter 64		x	x	x	x	x		x
Remote Analogs Note 20: 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[20]	x
IEC 61850 Test Mode									
I850MOD	IEC 61850 Test Mode status			x					x
Broken Conductor Detection Note 21: When fault location is undefined, the relay will report –999.99 for BCFL.									
BCIVAA	2-cycle (8-sample) averaged angle difference between A-phase current and its respective phase voltage	degrees (±180°)		x					
BCIVBA	2-cycle (8-sample) averaged angle difference between B-phase current and its respective phase voltage	degrees (±180°)		x					
BCIVCA	2-cycle (8-sample) averaged angle difference between C-phase current and its respective phase voltage	degrees (±180°)		x					
BCIVAAP	2-cycle (8-sample) averaged angle difference between A-phase current and its respective phase voltage, 300 ms before present processing interval	degrees (±180°)		x					
BCIVBAP	2-cycle (8-sample) averaged angle difference between B-phase current and its respective phase voltage, 300 ms before present processing interval	degrees (±180°)		x					
BCIVCAP	2-cycle (8-sample) averaged angle difference between C-phase current and its respective phase voltage, 300 ms before present processing interval	degrees (±180°)		x					
BCFL[21]	Filtered broken conductor fault location			x					
Fixed GOOSE Analogs									
FG1RA01 to FG1RA08	Fixed GOOSE Receive Msg 1 Analogs 01 to 08		x	x	x	x	x		x
FG2RA01 to FG2RA08	Fixed GOOSE Receive Msg 2 Analogs 01 to 08		x	x	x	x	x		x
FG3RA01 to FG3RA08	Fixed GOOSE Receive Msg 3 Analogs 01 to 08		x	x	x	x	x		x
FG4RA01 to FG4RA08	Fixed GOOSE Receive Msg 4 Analogs 01 to 08		x	x	x	x	x		x

Table M.1 Analog Quantities (Sheet 10 of 10)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/EtherNet/IP	Modbus[a]	Fast Meter	IEC 61850[b]
97FM Element									
97FM0 to 97FM9	Magnitude of selected frequency component for elements 0–9		x	x	x	x	x		

[a] Modbus register labels may be different from the corresponding analog quantity labels. See Appendix E: Modbus Communications for more information.
[b] IEC 61850 data object labels may be different from the corresponding analog quantity labels. See Appendix G: IEC 61850 Communications for more information.

Appendix N
Cybersecurity Features

The SEL-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 N.1* describes each of these.

Table N.1 IP Port Numbers

IP Port Default	Port Selection Setting	Network Protocol	Default Port State	Port Enable Setting	Purpose
21	--	TCP	Enabled	EFTPSERV	FTP protocol access for file transfer of settings and reports
23	TPORT	TCP	Enabled	ETELNET	Telnet access for general engineering terminal access
80	HTTPPORT	TCP	Enabled	EHTTP	Web server access to various relay information
102	--	TCP	Disabled	E61850	IEC 61850 MMS for SCADA functionality
123	SNTPPORT	UDP	Disabled	ESNTP	SNTP time synchronization
319/320	--	UDP	Disabled	EPTP[a]	PTP time synchronization
502	MODNUM1/ MODNUM2	TCP	Disabled	EMOD	MODBUS for SCADA functionality
2222/ 44818	--	TCP/UDP	Disabled	EEIP	EtherNet/IP for SCADA functionality
4712/ 4713	PMOTCP1/ PMOUDP1	TCP/UDP	Disabled	PMOTS1	Synchrophasor data output, Session 1
4722/ 4713	PMOTCP2/ PMOUDP2	TCP/UDP	Disabled	PMOTS2	Synchrophasor data output, Session 2
20000	DNPNUM	TCP/UDP	Disabled	EDNP	DNP for SCADA functionality

[a] When PTPPRO = DEFAULT and PTPTR = UDP.

See *PORT 1 on page 4.225* 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 7.27*. 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 2 or higher, when an incorrect password is entered or when a setting is changed.
- PASEL, PBSEL—Asserted while the Ethernet port(s) is active.
- LINK1, LINKA, LINKB—Asserted while the link is active on the Ethernet port(s). Loss of a link can be an indication that an Ethernet cable has been disconnected.
- LINKFAIL—Asserted if link is lost on the active IP port (Ports 1A or 1B).

NOTE: Refer to Access Commands (ACCESS, 2ACCESS, and CAL) for more information on when SALARM is pulsed for access level changes and unsuccessful password entry attempts.

These bits can be mapped for SCADA monitoring via DNP3, IEC 61850, Modbus, EtherNet/IP, or SEL Fast Message. They also may be added to the SER for later analysis or assigned to output contacts for alarm purposes.

The SEL-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 10.39* for more information about SER.

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/.

Firmware Hash Verification

This device supports digitally signed firmware upgrades. SEL uses the SHA-256 secure hash algorithm to compress and digitally sign firmware upgrade files. The signature ensures that the file has been provided by SEL and that its contents have not been altered. When the file is uploaded to the relay, the signature is verified using a public key stored on the relay. If the relay cannot verify the signature, it rejects the file. See *Appendix B: Firmware Upgrade Instructions* for more information on firmware upgrades.

Operating System/ Firmware

SEL-751 relays are embedded devices that do not allow additional software to be installed. SEL-751 relays include a self-test that continually checks running code against the known good baseline version of code in nonvolatile memory. This process is outlined in more detail in the document titled *The SEL Process for Mitigating Malware Risk to Embedded Devices* located at selinc.com/mitigating_malware/. SEL-751 relays run in an embedded environment for which there is no commercial anti-virus software available.

Software/Firmware Verification

SEL-751 relays have the ability to install firmware updates in the field. Authenticity and integrity of firmware updates can be verified by using the *Firmware Hash* page at selinc.com/products/firmware/.

Physical Access Security

Physical security of cybersecurity assets is a common concern. Typically, relays are installed within a control enclosure that provides physical security. Other times, they are installed in boxes within the switchyard. The relay provides some tools that may be useful for managing physical security, especially when the unit is installed in the switchyard.

You can monitor physical ingress by wiring a door sensor to one of the relay contact inputs. This input can then be mapped for SCADA monitoring or added to the SER log so that you can detect when physical access to the relay occurs.

It is also possible to wire an electronic latch to a relay contact output. You could then map this input for SCADA control.

Vulnerability Notification Process

Security Vulnerability Process

SEL provides security disclosure alerts to customers, and SEL instruction manuals document all releases. SEL security vulnerability disclosures are described in *The SEL Process for Disclosing Security Vulnerabilities* at selinc.com.

Emailed Security Notification

You can sign up to receive email notifications when SEL releases security vulnerability notices and service bulletins at selinc.com/support/security-notifications/.

Settings Erasure

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 many problems.

NOTE: In firmware versions R301-V1 and higher, the relay firmware retains the IP address, subnet mask, and default router settings after an **R_S** command is issue.

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 Access Level C. See *Access Levels on page 7.27*.

Step 2. Execute the **R_S** command.

Step 3. Allow the relay to restart.

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 to properly diagnose many problems.

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 Hazard A dangerous condition associated with the release of energy caused by an electric arc.

Arc-Flash Protection (Relay) An action performed by the relay to minimize the arc-flash hazard.

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.

Broken Conductor Detection (BCD) An element that reliably detects and estimates the location of broken conductors.

C37.118 IEEE C37.118 Standard for Synchrophasors for Power Systems.

C37.238 IEEE C37.238 Standard Profile for Use of IEEE 1588 Precision Time Protocol in Power System Applications.

Checksum A numeric identifier of the firmware in the relay. Calculated by the result of a mathematic sum of the relay code.

CID Abbreviation for Checksum Identifier. The checksum of the specific firmware installed in the relay.

CID File IEC 61850 Configured IED Description file. An XML file that contains the configuration for a specific IED.

Cold Load Pickup (CLPU) The phenomenon that takes places when a distribution circuit is re-energized following an extended outage of that circuit.

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 C37.111-2013.

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.”

Directional Supervision The relay uses directional elements to determine whether protective elements operate based on the direction of a fault relative to the relay.

Distributed Network Protocol (DNP) Manufacturer-developed, hardware-independent communications protocol.

Dropout Time The time measured from the removal of an input signal until the output signal deasserts. The time can be settable, as in the case of a logic variable timer, or can be a result of the characteristics of an element algorithm, as in the case of an overcurrent element dropout time.

Ethernet A network physical and data link layer defined by IEEE 802.2 and IEEE 802.3.

EtherNet/IP An Ethernet-based protocol that provides ease of integration for industrial automation applications and provides access to metering data, protection elements, targets, and contact I/O.

Event History A quick look at recent relay activity that includes a standard report header; event number, date, time, and type; maximum fault phase current; and targets.

Event Report A text-based collection of data stored by the relay in response to a triggering condition, such as a fault or command. The data show relay measurements before and after the trigger, in addition to the states of protection elements, relay inputs, and relay outputs each processing interval. After an electrical system fault, use event reports to analyze relay and system performance.

Event Summary A shortened version of stored event reports. An event summary includes items such as event date and time, event type, fault voltages, currents, etc. The relay sends an event report summary (if auto messaging is enabled) to the relay serial port a few seconds after an event.

Fail-Safe Refers to an output contact that is energized during normal relay operation and de-energized when relay power is removed or if the relay fails.

Fast Meter, Fast Operate Binary serial port commands that the relay recognizes at the relay front-and rear-panel EIA-232 serial ports. These commands and the responses from the relay make relay data collection by a communications processor faster and more efficient than transfer of the same data through use of formatted ASCII text commands and responses.

FID Relay firmware identification string. Lists the relay model, firmware version and date code, and other information that uniquely identifies the firmware installed in a particular relay.

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.

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.

LED Abbreviation for light-emitting diode. Used as indicator lamps on the relay front panel.

Load Encroachment The load-encroachment feature allows setting of phase overcurrent elements independent of load levels.

Logical Node In IEC 61850, the smallest part of a function that exchanges data. A logical node (LN) is an object defined by its data and methods. Each logical node represents a group of data (controls, status, measurements, etc.) associated with a particular function.

Loss-of-Potential Loss of one or more phase voltage inputs to the relay.

Low-Power Current Transformer (LPCT) A current sensor with a direct voltage output in conformity with the IEC 61869-10 standard.

Low-Power Voltage Transformer (LPVT) A voltage sensor with a resistive or capacitive divider and voltage output in conformity with the IEC 61869-11 standard.

MAC Address The Media Access Control (hardware) address of a device connected to a shared network medium, most often used with Ethernet networks.

MIRRORED BITS Protocol for direct relay-to-relay communications.

MMS Manufacturing Message Specification, a data exchange protocol used by IEC 61850.

NEMA Abbreviation for National Electrical Manufacturers Association.

Neutral Overcurrent Element A protection element that causes the relay to trip when the neutral current magnitude (measured by the IN input) exceeds a user-settable value. Used to detect and trip in response to ground faults.

Nominal Frequency Normal electrical system frequency, usually 50 or 60 Hz.

Nonfail-Safe Refers to an output contact that is not energized during normal relay operation. When referred to a trip output contact, the protected equipment remains in operation unprotected when relay power is removed or if the relay fails.

Nonvolatile Memory Relay memory that is able to correctly maintain data it is storing even when the relay is de-energized.

Overfrequency Element A protection element that causes the relay to trip when the measured electrical system frequency exceeds a settable frequency.

Phase Discontinuity Detection (PDD) The PDD element that detects an open conductor.

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 degrees, and the B-phase voltage lags the C-phase voltage by 120 degrees.

Pickup Time The time measured from the application of an input signal until the output signal asserts. The time can be settable, as in the case of a logic variable timer, or can be a result of the characteristics of an element algorithm, as in the case of an overcurrent element pickup time.

Pinout The definition or assignment of each electrical connection at an interface. Typically refers to a cable, connector, or jumper.

Power, P Real part of the complex power (S) expressed in units of watts (W), kilowatts (kW), or megawatts (MW).

Power Factor The cosine of the angle by which phase current lags phase voltage in an ac electrical circuit. Power factor equals 1.0 for power flowing to a resistive load.

Power, Q Reactive part of the complex power (S) expressed in units of Vars (Var), kilovars (kVar), or megavars (MVar).

Protection and Control Processing Processing interval is four times per power system cycle (except for math variables and analog quantities, which are processed every 25 ms).

PT Abbreviation for potential transformer. Also referred to as a voltage transformer or VT.

PRP Parallel Redundancy Protocol provides seamless recovery from any single Ethernet network failure in a dual redundant Ethernet network, in accordance with IEC 62439-3.

PTP Precision Time Protocol, as defined in IEEE 1588 for high-accuracy clock synchronization.

RAM Abbreviation for random-access memory. Volatile memory where the relay stores intermediate calculation results, Relay Word bits, and other data that are updated every processing interval.

Rate-of-Change-of-Frequency Element A protection element that causes the relay to trip when the measured electrical system rate-of-change of frequency exceeds a settable rate.

Relay Word The collection of relay element and logic results. Each element or result is represented by a unique identifier, known as a Relay Word bit.

Relay Word Bit A single relay element or logic result that the relay updates once each processing interval. A Relay Word bit can be equal to either logical 1 or logical 0. Logical 1 represents a true logic condition, picked up element, or asserted contact input or contact output. Logical 0 represents a false logic condition, dropped out element, or deasserted contact input or contact output. You can use Relay Word bits in SELOGIC control equations to control relay tripping, event triggering, and output contacts, as well as other functions.

Remote Bit A Relay Word bit for which state is controlled by serial port commands, including the **CONTROL** command, binary Fast Operate command, or Modbus® command.

Residual Current The sum of the measured phase currents. In normal, balanced operation, this current is very small or zero. When a ground fault occurs, this current can be large.

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.

Rogowski Coil An air-core coil around a current-carrying conductor that generates a voltage proportional to the rate of change of current. An integrator is used to derive current from the output of the Rogowski coil.

ROM Abbreviation for read-only memory. Nonvolatile memory where the relay firmware is stored.

RSTP Abbreviation for Rapid Spanning Tree Protocol. RSTP provides an improved failover response in switched mode dual redundant Ethernet networks in accordance with IEEE 802.1D-2004.

RTD Abbreviation for Resistance Temperature Detector. An RTD is made of a metal having a precisely known resistance and temperature coefficient of resistance. The SEL-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.

VBAT Measured station dc battery voltage.

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. If the main board access jumper is not in place, the relay prompts for the entry of the Access Level 1 password.
ID	Relay identification code.
QUIT	Goes to Access Level 0.
Access Level 1 Commands	
2AC	Goes to Access Level 2. If the main board access jumper is not in place, the relay prompts for the entry of the Access Level 2 password.
BRE	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 high-impedance fault (HIF) 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 of the communications records. If both MIRRORED BITS channels are enabled, omitting the channel specifier (A or B) clears both channels.

Comando del Puerto Serial	Descripción del Comando
Comandos del Nivel de Acceso 0	
ACC	Ir a Nivel de Acceso 1. Si el jumper de acceso en la tarjeta principal no está en su lugar, el relé pedirá la contraseña de Acceso del Nivel 1.
ID	Código de identificación del relé.
SAL	Ir al Nivel de Acceso 0.
Comandos de Nivel de Acceso 1	
2AC	Ir a Nivel de Acceso 2. Si el jumper de acceso en la tarjeta principal no está en su lugar, el relé pedirá la contraseña de Acceso del Nivel 2.
INT	Muestra información sobre disparos, corriente interrumpida, desgaste.
CEV *n*	Muestra 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*	Muestra el reporte comprimido de fallas de alta impedancia (HIF) 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.

Serial Port Command	Command Description
COM C A	Clears all communications records for Channel A.
COM C B	Clears all communications records for Channel B.
COM L A	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.
COM L B	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.
COM PTP	Displays the PTP data sets and offset statistics for the active PTP slave port or for the last active PTP slave port.
COM PTP C or **R**	Clears or resets the PTP offset statistics.
COM S A	Returns a summary report of the last 255 records in the MIRRORED BITS communications buffer for MIRRORED BITS Channel A.
COM S B	Returns a summary report of the last 255 records in the MIRRORED BITS communications buffer for MIRRORED BITS Channel B.
COU *n*	Shows current state of device counters. *n* = repeat the report *n* times, with a 1/2 second delay between each report.
DATE	Shows the date.
DATE *dd/mm/yyyy*	Sets 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 the contents of the corresponding file.

Comando del Puerto Serial	Descripción del Comando
COM C A	Borra todos los registros de comunicaciones del Canal A.
COM C B	Borra todos los registros de comunicaciones del Canal B.
COM L A	Anexa un informe detallado al reporte 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 reporte de síntesis de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS del Canal B.
COM PTP	Muestra datos PTP y estadísticas de compensación para el puerto PTP activo, o para el ultimo puerto PTP activo.
COM PTP C o **R**	Borra las estadísticas de compensación PTP.
COM S A	Muestra un resumen de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS del Canal A.
COM S B	Muestra un resumen de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS del Canal B.
COU *n*	Muestra el estado actualizado de los contadores del dispositivo. *n* = repite el informe *n* veces, con ½ segundos entre cada reporte.
FEC	Ver fecha.
FEC *dd/mm/aaaa*	Si DATE_F es igual a DMA, ingrese fecha en formato Día Mes Año
FEC *mm/dd/aaaa*	Si DATE_F es MDA, ingrese fecha en formato Mes Día Año.
FEC *aaaa/mm/dd*	Si DATE_F es AMD, ingrese fecha en formato Año Mes Día.
ETH	Muestra el estado del puerto de Ethernet.
EVE *n*	Muestra 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	Muestra 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*.

Serial Port Command	Command Description
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 50INC	Displays incipient fault event histories with the oldest at the bottom of the list and the most recent at the top.
HIS C or **R**	Clears or resets the 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.
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 HIF detection).
IRIG	Forces synchronization of internal control clock to IRIG-B time-code input.
LDP	Displays signal profile data.
LDP *row1 row2*	Displays load profile report rows from *row1* to *row2*, starting with *row1*. If *row2* is omitted, displays the first *row1* rows.
LDP *date1 date2*	Displays load profile report rows from *date1* to *date2*, starting with *date1*.
LDP C	Clears load profile data.
LOG HIF *nnn*	Displays the progress log (*nnn* entries, as many as 500) of HIF 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 metering data.
MET *k*	Displays fundamental metering data *k* times, where *k* is between 1 and 32767.
MET AI	Displays analog input (transducer) data.

Comando del Puerto Serial	Descripción del Comando
GOOSE *k*	Muestra información de transmisión y recepción de mensajes GOOSE. Ingresar el numero *k* para mostrar los datos GOOSE *k* veces en la pantalla.
GRUPO	Muestra el grupo de ajustes activo.
AYUDA	Muestra una descripción corta de los comandos elegidos.
HIS *n*	Muestra 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 50INC	Muestra lista de eventos de fallas incipientes. Ordenados por fecha, con el evento más reciente arriba.
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.
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 HIF).
IRIG	Forzar la sincronización del reloj interno a IRIG-B.
LDP	Muestra los datos de perfil carga.
LDP *row1 row2*	Muestra los datos de perfil carga entra las filas *row1* y *row2*. Si se omite *row2*, muestra las primeras *row1* columnas.
LDP *date1 date2*	Muestra los datos de perfil carga entra las filas *date1* y *date2*.
LDP D	Borra datos de perfil de carga.
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	Muestra la dirección MAC del puerto de Ethernet (PUERTO 1).
MED o **MED F**	Muestra los datos de medición fundamentales.
MED *k*	Muestra los datos de medición fundamentales *k* veces, donde *k* entre 1 y 32767.
MED EA	Muestra los datos de entrada analógica.

Serial Port Command	Command Description
MET DE	Displays demand metering data in primary amperes.
MET E	Displays energy metering data.
MET HIF	Displays the progress of HIF 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.
MET T	Displays RTD and thermal metering data.
PING *x.x.x.x t*	Determines if Ethernet port is functioning and configured properly. *x.x.x.x* is the IP address and *t* is the PING interval settable from 2 to 255 seconds. Default *t* is 1 second. Press Q to stop.
RSTP	Displays RSTP statistics and the present RSTP configuration of Port 1.
SER	Displays the entire Sequential Events Recorder (SER) report.
SER *date1*	Displays all the rows in the SER report recorded on the specified date (see **DATE** command for date format).
SER *date1 date2*	Displays all the rows in the SER report recorded between dates *date1* and *date2*, inclusive.
SER *row1*	Displays the latest *row1* rows in the SER report (*row1* = 1–1024, where 1 is the most recent entry).
SER *row1 row2*	Displays rows *row1–row2* in the SER report.
SER C or **R**	Clears SER data.

Comando del Puerto Serial	Descripción del Comando
MED DE	Muestra los datos de demanda de medición en amperes primarios.
MED E	Muestra 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 2 AVI/4 AFDI o 8 ADFI en Slot E.
MED M	Muestra datos de medición mínimos y máximos.
MED V	Muestra datos de variables matemáticas SELOGIC.
MED PE	Muestra los datos de demanda de medición pico en amperes primarios.
MED PM	Muestra fasores sincronizados.
MED RA	Muestra 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	Muestra los datos de medición rms.
MED RP	Reiniciar los valores de medición de demanda pico.
MED T	Muestra 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.
RSTP	Muestra estadisticas y configuracion RSTP actual.
SER	Muestra el reporte completo del Registrador de Eventos Secuenciales (SER).
SER *date1*	Muestra todas las filas en el reporte SER del día *date1* (vea el comando **FECHA** por el formato de fecha).
SER *date1 date2*	Muestra todas las filas en el reporte SER entre el día *date1* y el día *date2* (vea el comando **FECHA** por el formato de fecha).
SER *row1*	Muestra las ultimas *row1* filas en el reporte SER (*row1* = 1–1024, 1 es la fila más reciente).
SER *row1 row2*	Muestra las filas entre *row1–row2*.
SER D o **R**	Borrar los datos SER.

Serial Port Command	Command Description
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 E *m*	Displays EtherNet/IP assembly map settings for Map *m* (*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	Displays the relay self-test status.
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 event summary *n*. If *n* is omitted, displays the most recent HIF event summary.
SUM C or **R**	Resets the event summary buffer.
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 **TIME** followed by hours, as shown (24-hour clock).

Comando del Puerto Serial	Descripción del Comando
SER B	Muestra ítems removidos del SER. Útil cuando la supresión automática de SER esta activada.
MOS *n*	Muestra ajustes del grupo *n* del relé (*n* = 1, 2, 3 o 4). Por omisión, muestra grupo de ajustes 1.
MOS DNP *m*	Muestra ajustes de mapa de datos DNP para el Mapa *m* (*m* = 1, 2 o 3).
MOS E *m*	Muestra ajustes EtherNet/IP del mapa número *m* (*m* = 1, 2, 3).
MOS F	Muestra ajustes del panel frontal.
MOS G	Muestra ajustes globales.
MOS I	Muestra mapa de ajustes IEC 60870-5-103.
MOS L *n*	Muestra 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	Muestra ajustes del mapa del usuario Modbus.
MOS P *n*	Muestra configuraciones de puerto, donde *n* especifica el puerto (1, 2, 3, 4 o F); por defecto muestra ajustes del puerto activo.
MOS R	Muestra configuración de reportes.
EST	Muestra resultados de autotest.
EST S	Muestra 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.
BAN	Muestra la fila de banderas por defecto o la última fila de banderas mostrada.
BAN *n*	Muestra la fila de banderas *n*.
BAN *n k*	Muestra la fila de banderas *n k* veces.
BAN *name*	Muestra la fila de banderas que contiene la bandera name.
BAN *name k*	Muestra la fila de banderas que contiene la bandera name *k* veces.
BAN R	Resetea todas las banderas selladas y la fila de banderas mostrada mas recientemente.
HORA	Ver hora.
HORA *hh*	Configurar la hora ingresando **HORA** seguido por horas como se muestra (relog 24 horas).

Serial Port Command	Command Description
TIME *hh:mm*	Sets the time by entering **TIME** followed by hours and minutes, as shown (24-hour clock).
TIME *hh:mm:ss*	Sets the time by entering **TIME** 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	
89C *m*	Closes 2-position Disconnect *m*, where *m* = 1–8.
89O *m*	Opens 2-position Disconnect *m*, where *m* = 1–8.
89C *n m*	Closes Three-Position Disconnect *m*, where *m* = 1 or 2 and *n* = L or E (in-line or earthing disconnect).
89O *n m*	Opens Two-Position Disconnect *m*, where *m* = 1 or 2 and *n* = L or E (in-line or earthing disconnect).
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 64, representing RB01 through RB64. *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.
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 HIF detection.
L_D	Loads new firmware.

Comando del Puerto Serial	Descripción del Comando
HORA *hh:mm*	Configurar la hora ingresando **HORA** seguido por horas y minutos como se muestra (relog 24 horas).
HORA *hh:mm:ss*	Configurar la hora ingresando **HORA** seguido por horas, minutos y segundos como se muestra (relog 24 horas).
TRI	Disparar la captura de un reporte de evento.
TRI HIF	Disparar la captura de un reporte de evento de HIF.
Comandos del Nivel de Acceso 2	
89C *m*	Cierra el seccionador de 2-posiciones *m*, donde *m* = 1–8.
89A *m*	Abre el seccionador de 2-posiciones *m*, donde *m* = 1–8.
89C *n m*	Cierra el seccionador de 3-posiciones *m*, donde *m* = 1 o 2 y n = L o E (en-línea o tierra).
89A *n m*	Abre el seccionador de 3-posiciones *m*, donde *m* = 1 o 2 y n = L o E (en-línea o tierra).
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 64, representando desde RB01 hasta RB64. *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.
GRUPO *n*	Usar Grupo de configuraciones *n*, donde *n* = 1, 2, 3 o 4.
INI HIF	Reinicia el proceso de sintonización HIF (24 hrs).
L_D	Cargar un firmware nuevo.

Serial Port Command	Command Description
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 E *m*	Modifies EtherNet/IP assembly map settings for Map *m* (*m* = 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
LOO	Habilitar loopback de los canales MIRRORED BITS.
LOO A	Habilitar loopback en Canal MIRRORED BITS A por los siguientes 5 minutos.
LOO B	Habilitar loopback en Canal MIRRORED BITS B por los siguientes 5 minutos.
LOO R	Deshabilita loopback en canales MB A y B.
LOO *xx* DATA	Habilita loopback for *xx* minutos y permite modificar valores RMB.
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**, adelántese a un ajuste ingresando el nombre del ajuste, por ejemplo, 50P1P.
AJU DNP *n*	Modificar la configuración del mapa de datos DNP para el Mapa *n*, donde *n* = 1, 2 o 3.
AJU E *m*	Modificar ajustes EtherNet/IP del mapa número *m* (*m* = 1, 2, or 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 C 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	Muestra 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	Muestra reporte standard de reinicio del relé.
VEC E	Muestra reporte de reinicio del relé.
Comandos del Nivel del Acceso C	
PAS C	Cambiar la contraseña del Nivel de Acceso C.

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. If the main board access jumper is not in place, the relay prompts for the entry of the Access Level 1 password.
ID	Relay identification code.
QUIT	Goes to Access Level 0.
Access Level 1 Commands	
2AC	Goes to Access Level 2. If the main board access jumper is not in place, the relay prompts for the entry of the Access Level 2 password.
BRE	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 high-impedance fault (HIF) 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 of the communications records. If both MIRRORED BITS channels are enabled, omitting the channel specifier (A or B) clears both channels.

Comando del Puerto Serial	Descripción del Comando
Comandos del Nivel de Acceso 0	
ACC	Ir a Nivel de Acceso 1. Si el jumper de acceso en la tarjeta principal no está en su lugar, el relé pedirá la contraseña de Acceso del Nivel 1.
ID	Código de identificación del relé.
SAL	Ir al Nivel de Acceso 0.
Comandos de Nivel de Acceso 1	
2AC	Ir a Nivel de Acceso 2. Si el jumper de acceso en la tarjeta principal no está en su lugar, el relé pedirá la contraseña de Acceso del Nivel 2.
INT	Muestra información sobre disparos, corriente interrumpida, desgaste.
CEV *n*	Muestra 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*	Muestra el reporte comprimido de fallas de alta impedancia (HIF) 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.

Serial Port Command	Command Description
COM C A	Clears all communications records for Channel A.
COM C B	Clears all communications records for Channel B.
COM L A	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.
COM L B	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.
COM PTP	Displays the PTP data sets and offset statistics for the active PTP slave port or for the last active PTP slave port.
COM PTP C or **R**	Clears or resets the PTP offset statistics.
COM S A	Returns a summary report of the last 255 records in the MIRRORED BITS communications buffer for MIRRORED BITS Channel A.
COM S B	Returns a summary report of the last 255 records in the MIRRORED BITS communications buffer for MIRRORED BITS Channel B.
COU *n*	Shows current state of device counters. *n* = repeat the report *n* times, with a 1/2 second delay between each report.
DATE	Shows the date.
DATE *dd/mm/yyyy*	Sets 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 the contents of the corresponding file.

Comando del Puerto Serial	Descripción del Comando
COM C A	Borra todos los registros de comunicaciones del Canal A.
COM C B	Borra todos los registros de comunicaciones del Canal B.
COM L A	Anexa un informe detallado al reporte 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 reporte de síntesis de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS del Canal B.
COM PTP	Muestra datos PTP y estadísticas de compensación para el puerto PTP activo, o para el ultimo puerto PTP activo.
COM PTP C o **R**	Borra las estadísticas de compensación PTP.
COM S A	Muestra un resumen de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS del Canal A.
COM S B	Muestra un resumen de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS del Canal B.
COU *n*	Muestra el estado actualizado de los contadores del dispositivo. *n* = repite el informe *n* veces, con ½ segundos entre cada reporte.
FEC	Ver fecha.
FEC *dd/mm/aaaa*	Si DATE_F es igual a DMA, ingrese fecha en formato Día Mes Año
FEC *mm/dd/aaaa*	Si DATE_F es MDA, ingrese fecha en formato Mes Día Año.
FEC *aaaa/mm/dd*	Si DATE_F es AMD, ingrese fecha en formato Año Mes Día.
ETH	Muestra el estado del puerto de Ethernet.
EVE *n*	Muestra 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	Muestra 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*.

Serial Port Command	Command Description
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 50INC	Displays incipient fault event histories with the oldest at the bottom of the list and the most recent at the top.
HIS C or **R**	Clears or resets the 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.
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 HIF detection).
IRIG	Forces synchronization of internal control clock to IRIG-B time-code input.
LDP	Displays signal profile data.
LDP *row1 row2*	Displays load profile report rows from *row1* to *row2*, starting with *row1*. If *row2* is omitted, displays the first *row1* rows.
LDP *date1 date2*	Displays load profile report rows from *date1* to *date2*, starting with *date1*.
LDP C	Clears load profile data.
LOG HIF *nnn*	Displays the progress log (*nnn* entries, as many as 500) of HIF 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 metering data.
MET *k*	Displays fundamental metering data *k* times, where *k* is between 1 and 32767.
MET AI	Displays analog input (transducer) data.

Comando del Puerto Serial	Descripción del Comando
GOOSE *k*	Muestra información de transmisión y recepción de mensajes GOOSE. Ingresar el numero *k* para mostrar los datos GOOSE *k* veces en la pantalla.
GRUPO	Muestra el grupo de ajustes activo.
AYUDA	Muestra una descripción corta de los comandos elegidos.
HIS *n*	Muestra 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 50INC	Muestra lista de eventos de fallas incipientes. Ordenados por fecha, con el evento más reciente arriba.
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.
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 HIF).
IRIG	Forzar la sincronización del reloj interno a IRIG-B.
LDP	Muestra los datos de perfil carga.
LDP *row1 row2*	Muestra los datos de perfil carga entra las filas *row1* y *row2*. Si se omite *row2*, muestra las primeras *row1* columnas.
LDP *date1 date2*	Muestra los datos de perfil carga entra las filas *date1* y *date2*.
LDP D	Borra datos de perfil de carga.
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	Muestra la dirección MAC del puerto de Ethernet (PUERTO 1).
MED o **MED F**	Muestra los datos de medición fundamentales.
MED *k*	Muestra los datos de medición fundamentales *k* veces, donde *k* entre 1 y 32767.
MED EA	Muestra los datos de entrada analógica.

Serial Port Command	Command Description
MET DE	Displays demand metering data in primary amperes.
MET E	Displays energy metering data.
MET HIF	Displays the progress of HIF 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.
MET T	Displays RTD and thermal metering data.
PING *x.x.x.x t*	Determines if Ethernet port is functioning and configured properly. *x.x.x.x* is the IP address and *t* is the PING interval settable from 2 to 255 seconds. Default *t* is 1 second. Press Q to stop.
RSTP	Displays RSTP statistics and the present RSTP configuration of Port 1.
SER	Displays the entire Sequential Events Recorder (SER) report.
SER *date1*	Displays all the rows in the SER report recorded on the specified date (see **DATE** command for date format).
SER *date1 date2*	Displays all the rows in the SER report recorded between dates *date1* and *date2*, inclusive.
SER *row1*	Displays the latest *row1* rows in the SER report (*row1* = 1–1024, where 1 is the most recent entry).
SER *row1 row2*	Displays rows *row1–row2* in the SER report.
SER C or **R**	Clears SER data.

Comando del Puerto Serial	Descripción del Comando
MED DE	Muestra los datos de demanda de medición en amperes primarios.
MED E	Muestra 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 2 AVI/4 AFDI o 8 ADFI en Slot E.
MED M	Muestra datos de medición mínimos y máximos.
MED V	Muestra datos de variables matemáticas SELOGIC.
MED PE	Muestra los datos de demanda de medición pico en amperes primarios.
MED PM	Muestra fasores sincronizados.
MED RA	Muestra 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	Muestra los datos de medición rms.
MED RP	Reiniciar los valores de medición de demanda pico.
MED T	Muestra 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.
RSTP	Muestra estadisticas y configuracion RSTP actual.
SER	Muestra el reporte completo del Registrador de Eventos Secuenciales (SER).
SER *date1*	Muestra todas las filas en el reporte SER del día *date1* (vea el comando **FECHA** por el formato de fecha).
SER *date1 date2*	Muestra todas las filas en el reporte SER entre el día *date1* y el día *date2* (vea el comando **FECHA** por el formato de fecha).
SER *row1*	Muestra las ultimas *row1* filas en el reporte SER (*row1* = 1–1024, 1 es la fila más reciente).
SER *row1 row2*	Muestra las filas entre *row1–row2*.
SER D o **R**	Borrar los datos SER.

Serial Port Command	Command Description
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 E *m*	Displays EtherNet/IP assembly map settings for Map *m* (*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	Displays the relay self-test status.
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 event summary *n*. If *n* is omitted, displays the most recent HIF event summary.
SUM C or **R**	Resets the event summary buffer.
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 **TIME** followed by hours, as shown (24-hour clock).

Comando del Puerto Serial	Descripción del Comando
SER B	Muestra ítems removidos del SER. Útil cuando la supresión automática de SER esta activada.
MOS *n*	Muestra ajustes del grupo *n* del relé (*n* = 1, 2, 3 o 4). Por omisión, muestra grupo de ajustes 1.
MOS DNP *m*	Muestra ajustes de mapa de datos DNP para el Mapa *m* (*m* = 1, 2 o 3).
MOS E *m*	Muestra ajustes EtherNet/IP del mapa número *m* (*m* = 1, 2, 3).
MOS F	Muestra ajustes del panel frontal.
MOS G	Muestra ajustes globales.
MOS I	Muestra mapa de ajustes IEC 60870-5-103.
MOS L *n*	Muestra 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	Muestra ajustes del mapa del usuario Modbus.
MOS P *n*	Muestra configuraciones de puerto, donde *n* especifica el puerto (1, 2, 3, 4 o F); por defecto muestra ajustes del puerto activo.
MOS R	Muestra configuración de reportes.
EST	Muestra resultados de autotest.
EST S	Muestra 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.
BAN	Muestra la fila de banderas por defecto o la última fila de banderas mostrada.
BAN *n*	Muestra la fila de banderas *n*.
BAN *n k*	Muestra la fila de banderas *n k* veces.
BAN *name*	Muestra la fila de banderas que contiene la bandera name.
BAN *name k*	Muestra la fila de banderas que contiene la bandera name *k* veces.
BAN R	Resetea todas las banderas selladas y la fila de banderas mostrada mas recientemente.
HORA	Ver hora.
HORA *hh*	Configurar la hora ingresando **HORA** seguido por horas como se muestra (relog 24 horas).

Serial Port Command	Command Description
TIME *hh:mm*	Sets the time by entering **TIME** followed by hours and minutes, as shown (24-hour clock).
TIME *hh:mm:ss*	Sets the time by entering **TIME** 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	
89C *m*	Closes 2-position Disconnect *m*, where *m* = 1–8.
89O *m*	Opens 2-position Disconnect *m*, where *m* = 1–8.
89C *n m*	Closes Three-Position Disconnect *m*, where *m* = 1 or 2 and *n* = L or E (in-line or earthing disconnect).
89O *n m*	Opens Two-Position Disconnect *m*, where *m* = 1 or 2 and *n* = L or E (in-line or earthing disconnect).
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 64, representing RB01 through RB64. *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.
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 HIF detection.
L_D	Loads new firmware.

Comando del Puerto Serial	Descripción del Comando
HORA *hh:mm*	Configurar la hora ingresando **HORA** seguido por horas y minutos como se muestra (relog 24 horas).
HORA *hh:mm:ss*	Configurar la hora ingresando **HORA** seguido por horas, minutos y segundos como se muestra (relog 24 horas).
TRI	Disparar la captura de un reporte de evento.
TRI HIF	Disparar la captura de un reporte de evento de HIF.
Comandos del Nivel de Acceso 2	
89C *m*	Cierra el seccionador de 2-posiciones *m*, donde *m* = 1–8.
89A *m*	Abre el seccionador de 2-posiciones *m*, donde *m* = 1–8.
89C *n m*	Cierra el seccionador de 3-posiciones *m*, donde *m* = 1 o 2 y n = L o E (en-línea o tierra).
89A *n m*	Abre el seccionador de 3-posiciones *m*, donde *m* = 1 o 2 y n = L o E (en-línea o tierra).
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 64, representando desde RB01 hasta RB64. *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.
GRUPO *n*	Usar Grupo de configuraciones *n*, donde *n* = 1, 2, 3 o 4.
INI HIF	Reinicia el proceso de sintonización HIF (24 hrs).
L_D	Cargar un firmware nuevo.

Serial Port Command	Command Description
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 E *m*	Modifies EtherNet/IP assembly map settings for Map *m* (*m* = 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
LOO	Habilitar loopback de los canales MIRRORED BITS.
LOO A	Habilitar loopback en Canal MIRRORED BITS A por los siguientes 5 minutos.
LOO B	Habilitar loopback en Canal MIRRORED BITS B por los siguientes 5 minutos.
LOO R	Deshabilita loopback en canales MB A y B.
LOO *xx* DATA	Habilita loopback for *xx* minutos y permite modificar valores RMB.
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**, adelántese a un ajuste ingresando el nombre del ajuste, por ejemplo, 50P1P.
AJU DNP *n*	Modificar la configuración del mapa de datos DNP para el Mapa *n*, donde *n* = 1, 2 o 3.
AJU E *m*	Modificar ajustes EtherNet/IP del mapa número *m* (*m* = 1, 2, or 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	Comando del Puerto Serial	Descripción del Comando
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.	**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.
SET R	Modifies the report settings.	**AJU R**	Modificar la configuración de reportes.
SET … TERSE	For all **SET** commands, **TERSE** disables the automatic **SHO** command after the settings entry.	**AJU … TERSO**	Para todos los comandos **AJU**, **TERSO** desactiva los comandos automáticos **MOS** después de modificar las configuraciones.
STA C or **R**	Clears the self-test status and restarts the relay.	**EST C** o **R**	Salir del modo de diagnostico automático y reiniciar el relé.
TEST DB	Displays the present status of digital and analog overrides.	**TEST DB**	Muestra el estado actual de variable digitales y analógicas con valores forzados.
THE P	Loads the preset value of thermal capacity used in the IEC line/cable thermal element.	**THE P**	Cargar valores predeterminados de capacidad térmica en el elemento térmico IEC de líneas y cables.
THE R	Resets the calculated thermal capacity used in the IEC line/cable thermal element.	**THE R**	Reinicia la capacidad térmica calculada usada en el elemento térmico IEC de líneas y cables.
VEC D	Displays the diagnostic vector report.	**VEC D**	Muestra reporte standard de reinicio del relé.
VEC E	Displays the exception vector report.	**VEC E**	Muestra reporte de reinicio del relé.
Access Level C Commands		Comandos del Nivel del Acceso C	
PAS C	Changes the Access Level C password.	**PAS C**	Cambiar la contraseña del Nivel de Acceso C.