SEL-751

Feeder Protection Relay

Instruction Manual

20150123

SEL SCHWEITZER ENGINEERING LABORATORIES, INC.

PM751-01

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Preface

Manual Overview

The SEL-751 Feeder Protection Relay Instruction Manual describes common aspects of feeder relay application and use. It includes the necessary information to install, set, test, and operate the relay.

An overview of each manual section and topics follows:

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

Section 1: Introduction and Specifications. Describes the basic features and functions of the SEL-751; lists the relay specifications.

Section 2: Installation. Describes how to mount and wire the SEL-751; illustrates wiring connections for various applications.

Section 3: PC Software. Describes the features, installation methods, and types of help available with the ACSELERATOR QuickSet® SEL-5030 Software.

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

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

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

Section 7: Communications. Describes how to connect the SEL-751 to a PC for communication; shows serial port pinouts; lists and defines serial port commands. Describes the communications port interfaces and protocols supported by the relay for serial and Ethernet.

Section 8: Front-Panel Operations. Explains the features and use of the front panel, including front-panel command menu, default displays, and automatic messages.

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

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

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

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

Appendix C: SEL Communications Processors. Provides examples of how to use the SEL-751 with SEL communications processors for total substation automation solutions.

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

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

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

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

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

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

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

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

SEL-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:

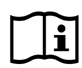
⚠DANGER
Indicates an imminently hazardous situation that, if not avoided, **will** result in death or serious injury.

⚠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

For use in Pollution Degree 2 environment.	Pour l'utilisation dans un environnement de Degré de Pollution 2.
Ambient air temperature shall not exceed 50°C (122°F).	La température ambiante de l'air ne doit pas dépasser 50°C (122°F).
For use on a flat surface of a Type 12 enclosure.	Pour l'utilisation sur une surface plane d'un boîtier de Type 12.
Terminal Ratings Wire Material Use 75°C (167°F) copper conductors only. Tightening Torque CT Terminal Blocks: 0.9–1.4 Nm (8–12 in-lb) Compression Plug: 0.5–1.0 Nm (4.4–8.8 in-lbs) Compression Plug Mounting Ear Screw: 0.18–0.025 Nm (1.6–2.2 in-lbs)	Valeurs nominales des bornes Matériau de fil Utiliser seulement conducteurs en cuivre 75°C (167°F). Couple de serrage CT borniers: 0,9–1,4 Nm (8–12 livres-pouce) Fiche à compression: 0,5–1,0 Nm (4,4–8,8 livres-pouce) Vis à oreille de montage de la fiche à compression: 0,18–0,025 Nm (1,6–2,2 livres-pouce)

Hazardous Locations Safety Marks

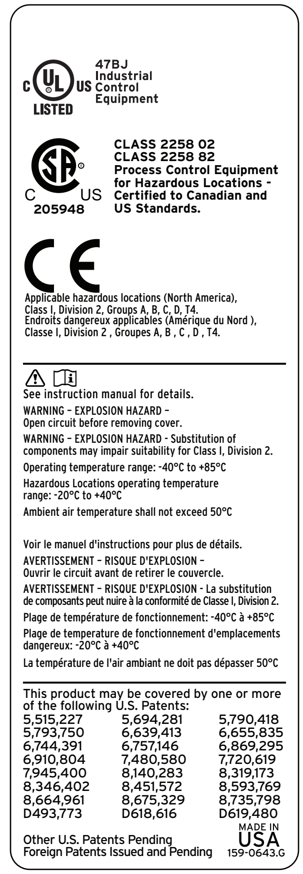
⚠WARNING – EXPLOSION HAZARD Open circuit before removing cover.	⚠AVERTISSEMENT – DANGER D'EXPLOSION Ouvrir le circuit avant de déposer le couvercle.
⚠WARNING – EXPLOSION HAZARD Substitution of components may impair suitability for Class I, Division 2.	⚠AVERTISSEMENT – DANGER D'EXPLOSION La substitution de composants peut détériorer la conformité à Classe I, Division 2.
Operating Temperature Range: –40°C to +85°C (–40°F to +185°F).	Plage de température de fonctionnement: –40°C à +85°C (–40°F à +185°F).
Hazardous Locations Operating Temperature Range: –20°C to +40°C (–4°F to +104°F).	Emplacements Plage de température de fonctionnement d'emplacements dangereux: –20°C à +40°C (–4°F à +104°F).

Hazardous Locations Approvals

The SEL-751 complies with UL 1604, CSA 22.2 No. 213 and EN 60079-15. In North America, the relay is approved for Class I, Division 2, Groups A, B, C, D, and T4 in the –40°C to +70°C temperature range.

To comply with the requirements of the European ATEX standard for hazardous locations, the SEL-751 must be installed in an enclosure that meets the requirements of an Ex n enclosure rated IP54 or better. The enclosure should be certified to these requirements or be tested for compliance as part of the complete assembly.

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



Hazardous Locations Compliance Label for the SEL-751

Other Safety Marks (Sheet 1 of 2)

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

Other Safety Marks (Sheet 2 of 2)

⚠WARNING Do not perform any procedures or adjustments that this instruction manual does not describe.	⚠AVERTISSEMENT Ne pas appliquer une procédure ou un ajustement qui n'est pas décrit explicitement dans ce manuel d'instruction.
⚠WARNING During installation, maintenance, or testing of the optical ports, use only test equipment qualified for Class 1 laser products.	⚠AVERTISSEMENT Durant l'installation, la maintenance ou le test des ports optiques, utilisez exclusivement des équipements de test homologués comme produits de type laser de Classe 1.
⚠WARNING Overtightening the mounting nuts may permanently damage the relay chassis.	⚠AVERTISSEMENT Une pression excessive sur les écroux de montage peut endommager de façon permanente le chassis du relais.
⚠WARNING To install an option card, the relay must be de-energized and then reenergized. When reenergized, the relay will reboot. Therefore, deenergize 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'équipementprotégé avant d'installer la carte à option pour empêcher des dégats à l'équipement
⚠WARNING Before working on a CT circuit, first apply a short to the secondary winding of the CT.	⚠AVERTISSEMENT Avant de travailler sur un circuit TC, placez d'abord un court-circuit sur l'enroulement secondaire du TC.
⚠CAUTION Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.	⚠ATTENTION Les composants de cet équipement sont sensibles aux décharges électrostatiques (DES). Des dommages permanents non-décelables peuvent résulter de l'absence de précautions contre les DES. Raccordez-vous correctement à la terre, ainsi que la surface de travail et l'appareil avant d'en retirer un panneau. Si vous n'êtes pas équipés pour travailler avec ce type de composants, contacter SEL afin de retourner l'appareil pour un service en usine.
⚠CAUTION There is danger of explosion if the battery is incorrectly replaced. Replace only with Ray-O-Vac® no. BR2335 or equivalent recommended by manufacturer. See Owner's Manual for safety instructions. The battery used in this device may present a fire or chemical burn hazard if mistreated. Do not recharge, disassemble, heat above 100°C or incinerate. Dispose of used batteries according to the manufacturer's instructions. Keep battery out of reach of children.	⚠ATTENTION Une pile remplacée incorrectement pose des risques d'explosion. Remplacez seulement avec un Ray-O-Vac® no BR2335 ou un produit équivalent recommandé par le fabricant. Voir le guide d'utilisateur pour les instructions de sécurité. La pile utilisée dans cet appareil peut présenter un risque d'incendie ou de brûlure chimique si vous en faites mauvais usage. Ne pas recharger, démonter, chauffer à plus de 100°C ou incinérer. Éliminez les vieilles piles suivant les instructions du fabricant. Gardez la pile hors de la portée des enfants.
⚠CAUTION 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 front-panel menus and pushbuttons.
- ➤ Using ACSELERATOR QuickSet.

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

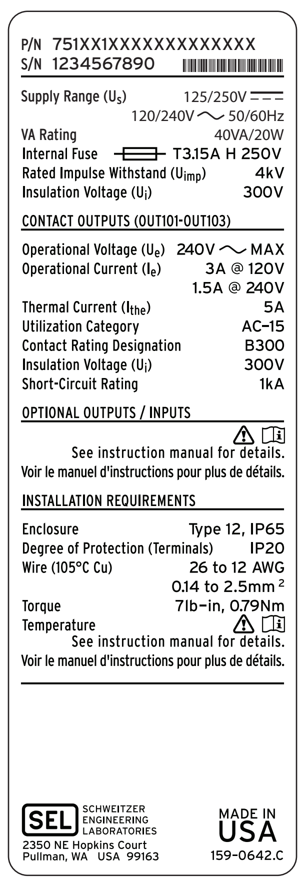
Example	Description
STATUS	Commands typed at a command line interface on a PC.
<Enter>	Single keystroke on a PC keyboard.
<Ctrl+D>	Multiple/combination keystroke on a PC keyboard.
Start > Settings	PC dialog boxes and menu selections. The > character indicates submenus.
CLOSE	Relay front-panel pushbuttons.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

Examples

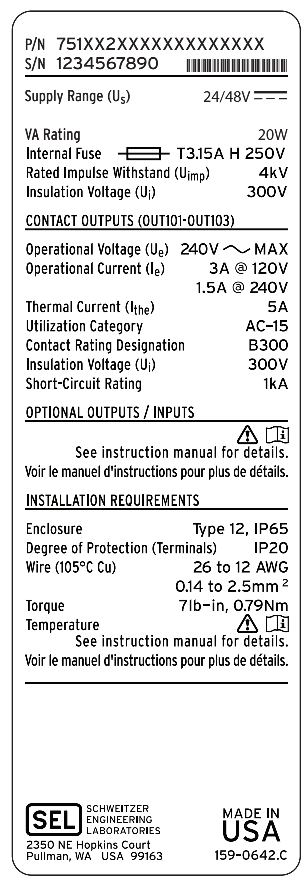
This instruction manual uses several example illustrations and instructions to explain how to effectively operate the SEL-751. These examples are for demonstration purposes only; the firmware identification information or settings values included in these examples may not necessarily match those in the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

Product Labels

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



(for high-voltage supply)



(for low-voltage supply)

LED Emitter

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

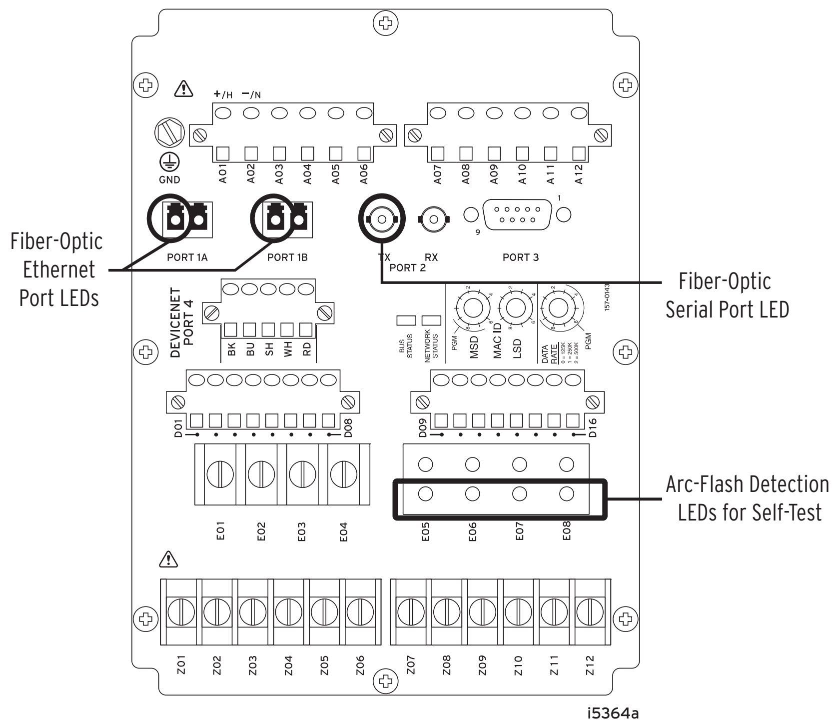
⚠CAUTION
Looking into optical connections, fiber ends, or bulkhead connections can result in hazardous radiation exposure.

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

SEL-751 LED Information

Item	Fiber-Optic Ethernet Port 1 (1A, 1B)	Port 2	Arc-Flash Channel 1–4
Mode	Multimode	Multimode	Multimode
Wavelength	1300 nm	820 nm	640 nm
Source	LED	LED	LED
Connector type	LC	ST	V-pin
Typical Output power	–15.7 dBm	–16 dBm	-12 dBm

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



SEL-751 LED Locations

LED Safety Warnings and Precautions

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

Environmental Conditions and Voltage Information

The following table lists important environmental and voltage information.

Condition	Range/Description
Indoor/outdoor use	Indoor
Altitude[a]	To 2000 m
Temperature	
IEC Performance Rating (per IEC/EN 60068-2-1 and IEC/EN 60068-2-2)	–40 to +85°C
Relative humidity	5 to 95%
Main supply voltage fluctuations	To ±10% of Nominal voltage
Overvoltage	Category II
Pollution	Degree 2
Atmospheric pressure	80 to 110 kPa

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

Wire Sizes and Insulation

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

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

Instructions for Cleaning and Decontamination

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

Technical Assistance

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

Obtain technical assistance from the following address:

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

Section 1
Introduction and Specifications

Overview

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

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

Features

Standard Protection Features

- Phase Instantaneous Overcurrent (50P)
- Ground (Residual) Instantaneous Overcurrent (50G)
- Neutral Instantaneous Overcurrent (50N)
- Negative-Sequence Overcurrent (50Q)
- Phase Time Overcurrent (51P)
- Ground (Residual) Time Overcurrent (51G)
- Neutral Time Overcurrent (51N)
- Negative-Sequence Time Overcurrent (51Q)
- Undervoltage (27P, 27PP)
- Overvoltage (59P, 59PP, 59G, 59Q)
- Under- and Over-Frequency (81)
- Rate of Change of Frequency (81R)
- Fast Rate-of-Change of Frequency (81RF) for Aurora Mitigation
- Directional Power (32)
- Power Factor (55)
- Loss-of-Potential (60 LOP)
- Load Encroachment
- Fault Locator and Faulted Phase Indication
- Breaker Failure Protection
- Breaker Wear Monitor

Optional Protection Features

- Autoreclosing Control (79)
- Directional Control for 50P, 50G, 50Q, 51P, 51G, 51Q
- High-Impedance Fault Detection (HIF)
- Arc-Flash Protection
- Synchronism Check (25)
  - Synchronism-Check Undervoltage (27S)
  - Synchronism-Check Overvoltage (59S)
- Station DC Battery Monitor
- RTD-Based Protection: Monitor as many as ten (10) RTDs when you use an internal RTD card, or monitor as many as twelve (12) when you use an external SEL-2600 RTD Module with the ST® option. There are separate Trip and Warn settings for each RTD.

Monitoring Features

- Event Summaries that contain relay ID, date and time, trip cause, and current/voltage magnitudes
- Event Reports including filtered and raw analog data
- Sequential Events Record (SER)
- Compatibility with SEL-3010 Event Messenger
- A complete suite of accurate metering functions
- Breaker Wear Monitoring
- Load Profile Report
- High-Impedance Fault (HIF) Compressed Event Report (option)

Communications and Control

- EIA-232, front-panel port
- EIA-232, EIA-485, single or dual, copper or fiber-optic Ethernet, and fiber-optic rear panel EIA-232 ports.
- IRIG-B time-code input
- Modbus® RTU slave, Modbus TCP/IP, Simple Network Time Protocol (SNTP), DNP3 serial, DNP3 LAN/WAN, Ethernet FTP, Telnet, MIRRORED BITS®, Event Messenger, IEC 61850, DeviceNet, File Transfer Protocols, and Synchrophasors with C37.118 Protocol
- SEL ASCII, Compressed ASCII, Fast Meter, Fast Operate, Fast SER, and Fast Message Protocols
- Programmable Boolean and math operators, logic functions, and analog compare

Models, Options, and Accessories

Models

Complete ordering information is not provided in this instruction manual. See the latest SEL-751 Model Option Table at www.selinc.com, under SEL Literature, Ordering Information (Model Option Tables). Options and accessories are as follows:

SEL-751 Base Unit

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

Options

- Firmware options
  - Autoreclosing Control
  - Directional Control for Overcurrent Elements
  - High-impedance fault detection (HIF) using Arc Sense™ technology
- 2 AVI/4 AFDI card option with
  - Synchronism-check voltage input
  - DC station battery monitor
  - Four arc-flash detector inputs
- Input/output (I/O) option
  - Additional digital I/O
  - Additional analog I/O
  - 10 RTD inputs

- Communications options (protocol/ports)
  - EIA-485/EIA-232/Ethernet ports (single/dual, copper or fiber-optic)
  - Simple Network Time protocol (SNTP)
  - Modbus TCP/IP protocol
  - DeviceNet
  - IEC 61850 communications
  - DNP3 serial and LAN/WAN

Accessories

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

- External RTD protection
  - SEL-2600 RTD Module (with ST® option only)
  - A simplex 62.5/125 µm fiber-optic cable with ST connector for connecting the external RTD module to the SEL-751
- Remote I/O with SEL-2505 Remote I/O Module SEL-2812 compatible (ST option only)
- SEL-C804 Multimode Fiber-Optic Arc-Flash Detection (AFD) Sensors and Accessories
- SEL-751 Configurable Labels
- Rack-Mounting Kits
  - For one relay
  - For two relays
  - For one relay and a test switch
- Wall-Mounting Kits
- Bezels for Retrofit
- Replacement Rear Connector Kit
- Dust Protection Kit

For all SEL-751 mounting accessories for competitor products, including adapter plates, visit http://www2.selinc.com/mounting_selector/.

Applications

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

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

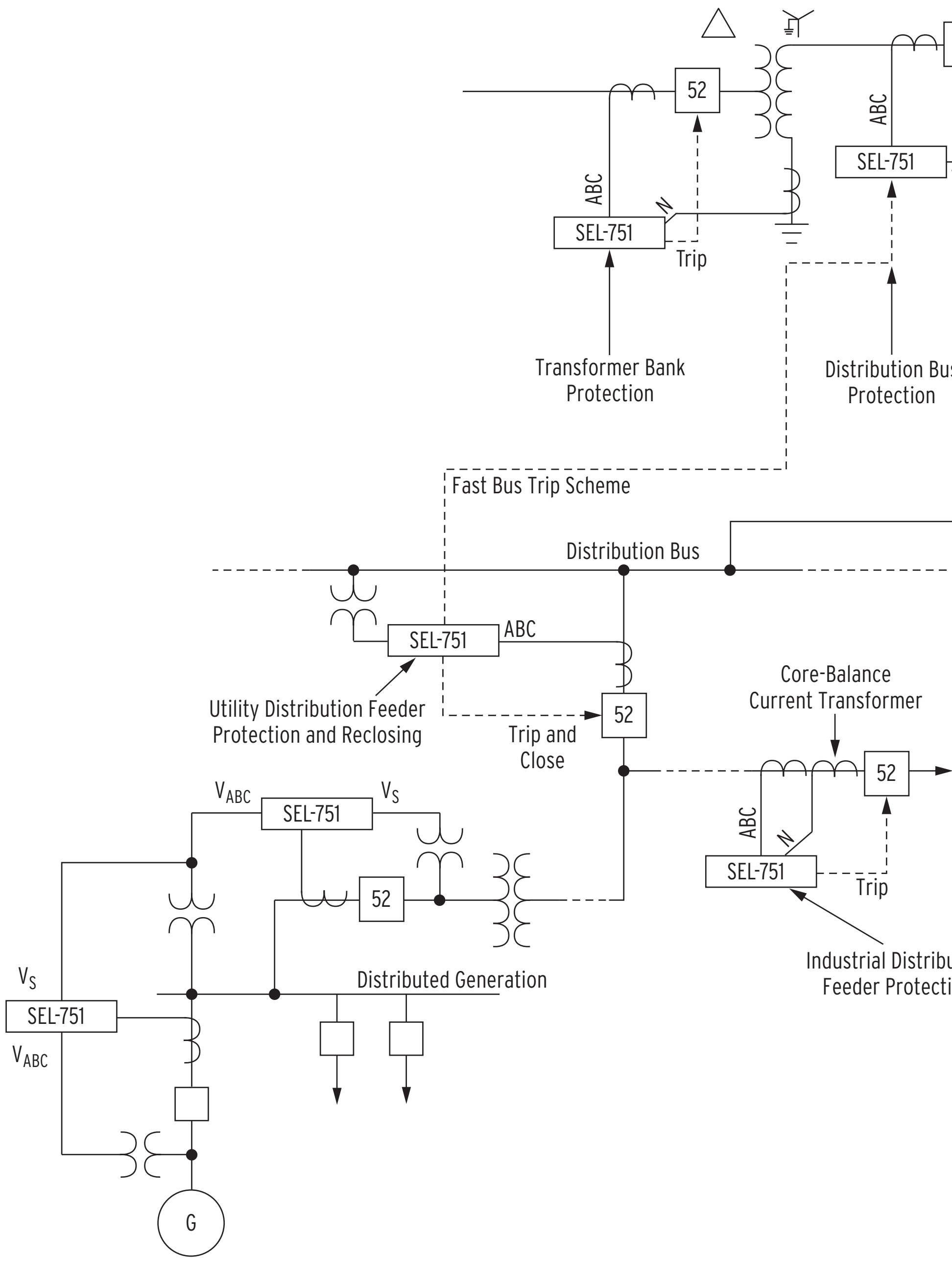


Figure 1.1 SEL-751 Feeder Protection Relay Applied Throughout the Power System

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

- With internal or external RTD module for thermal protection
- With Arc-Flash detection and protection
- High-impedance fault (HIF) detection and protection for feeders

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

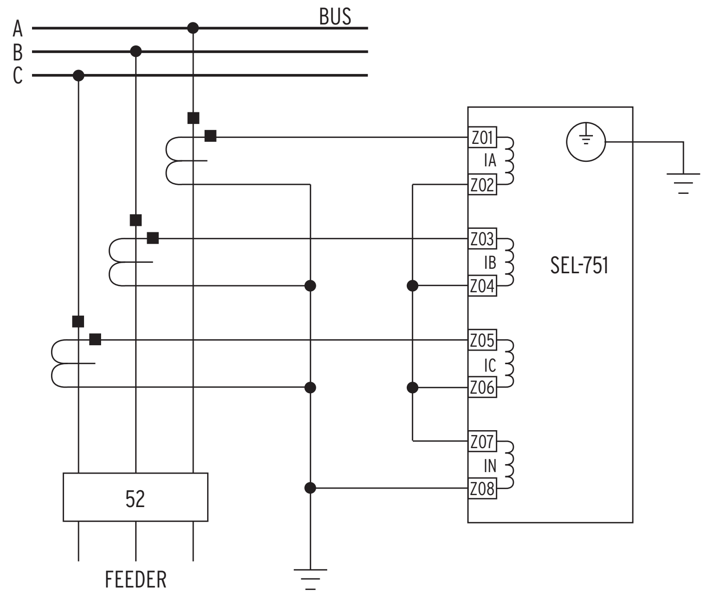


Figure 1.2 Typical Current Connections

Getting Started

Understanding basic relay operation principles and methods will help you use the SEL-751 effectively. This section presents the fundamental knowledge you need to operate the SEL-751, organized by task. These tasks help you become familiar with the relay and include the following:

- ➤ Powering the relay
- ➤ Establishing communication
- ➤ Checking relay status
- ➤ Setting the date and time

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

Powering the Relay

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

- ➤ Observe proper polarity, as indicated by the **+/H** (terminal **A01**) and the **–/N** (terminal **A02**) on the power connections.
- ➤ Connect the ground lead; see *Grounding (Earthing) Connections on page 2.18*.
- ➤ Once connected to power, the relay does an internal self-check and the **ENABLED** LED illuminates.

Establishing Communication

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

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

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

Step 3. Start the PC terminal emulation program.

Step 4. Set the PC terminal emulation program to the communications port settings listed in the Default Value column of *Table 1.1*. 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 1.1*.

Table 1.1 SEL-751 Serial Port Settings

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

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

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

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

Figure 1.3 Response Header

Step 7. Type **ACC <Enter>** and the appropriate password (see *Table 7.33* for factory default passwords) to go to Access Level 1.

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

Checking Relay Status

Use the **STA** serial port command to view the SEL-751 operational status. Analog channel dc offset and monitored component status are listed in the status report depicted in *Figure 1.4*.

```
=>>STA <Enter>

SEL-751                                   Date: 03/11/2011   Time: 18:02:57.722
FEEDER RELAY                              Time Source: Internal

Serial Num = 000000000000000
FID = SEL-751-X139-V0-Z001001-D20110309                CID = 05A2
PART NUM = 751501B0XCA70860230

SELF TESTS (W=Warn)
  FPGA  GPSB  HMI   RAM   ROM   CR_RAM  NON_VOL  CLOCK  CID_FILE  +0.9V  +1.2V
  OK    OK    OK    OK    OK    OK      OK       OK     OK        0.90   1.20

  +1.5V  +1.8V  +2.5V  +3.3V  +3.75V  +5.0V  -1.25V  -5.0V   BATT
  1.50   1.80   2.51   3.35   3.77    4.98   -1.26   -5.03   3.06

Option Cards
  CARD_C  CARD_D  CARD_E  CARD_Z
  OK      OK      OK      OK

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

  Relay Enabled
=>>
```

Figure 1.4 STA Command Response—No Communications Card or EIA-232/ EIA-485 Communications Card

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

```
=>STA <Enter>

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

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

SELF TESTS (W=Warn)
  FPGA  GPSB  HMI   RAM   ROM   CR_RAM  NON_VOL  CLOCK  CID_FILE  +0.9V  +1.2V
  OK    OK    OK    OK    OK    OK      OK       OK     OK        0.90   1.20

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

Option Cards
  CARD_C  CARD_D  CARD_E  CARD_Z
  OK      OK      OK      OK

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

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

  Relay Enabled
=>
```

Figure 1.5 STA Command Response—Communications Card/DeviceNet Protocol

Table 7.44 provides the definition of each status report designator and *Table 10.8* shows all the self-tests performed by the relay. The beginning of the status report printout (see *Figure 1.5*) contains the relay serial number, firmware identification string (FID), and checksum string (CID). These strings uniquely identify the relay and the version of the operating firmware.

Setting the Date and Time

DAT (**Date** Command)

Viewing the Date

Type **DAT <Enter>** at the prompt to view the date stored in the SEL-751. If the date stored in the relay is July 29, 2010, and the DATE_F setting is MDY, the relay will reply:

```
7/29/2010
```

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

```
2010/7/29
```

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

```
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 will reply with the stored time. For example

```
13:52:44
```

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

Changing the Time

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

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

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

Specifications

Compliance

ISO 9001:2008 Certified

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

* 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.

CE:	CE Mark–EMC Directive Low Voltage Directive IEC 61010-1:2001 IEC 60947-1 IEC 60947-4-1 IEC 60947-5-1
Hazardous Locations Approvals:	Complies with UL 1604, ISA 12.12.01, CSA 22.2 No. 213, and EN 60079-15 (Class I, Division 2).

General

AC Current Input

Phase and Neutral Currents

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

I_{NOM} = 5 A

Continuous Rating:	15 A, linear to 100 A symmetrical
1 Second Thermal:	500 A
Burden (per phase):	< 0.1 VA

I_{NOM} = 1 A

Continuous Rating:	3 A, linear to 20 A symmetrical
1 Second Thermal:	100 A
Burden (per phase):	< 0.01 VA
Measurement Category:	II

AC Voltage Inputs

V_{NOM} (L-L) Setting Range:	20–250 V (if DELTA_Y := DELTA) 20–440 V (if DELTA_Y := WYE)
Rated Continuous Voltage:	300 Vac
10 Second Thermal:	600 Vac
Burden:	< 0.1 VA
Input Impedance:	4 MΩ differential (phase-phase) 7 MΩ common mode (phase-chassis)

Power Supply

125/250 Vdc or 120/240 Vac

Rated Supply Voltage:	110–240 Vac, 50/60 Hz 110–250 Vdc
Input Voltage Range:	85–264 Vac 85–300 Vdc
Power Consumption:	< 40 VA (ac) < 20 W (dc)
Interruptions:	50 ms @ 125 Vac/Vdc 100 ms @ 250 Vac/Vdc

24/48 Vdc

Rated Supply Voltage:	24–48 Vdc
Input Voltage Range:	19.2–60.0 Vdc
Power Consumption:	<20 W (dc)
Interruptions:	10 ms @ 24 Vdc 50 ms @ 48 Vdc

Output Contacts

General

OUT103 is Form C Trip output, all other outputs are Form A, except for the SELECT 4 DI /3 DO card, which supports one Form-B and two Form-C outputs and SELECT 8DO card, which supports Form-A and Form-B outputs.

Mechanical Durability:	100,000 no load operations
Pickup/Dropout Time:	≤8 ms (coil energization to contact closure)

DC Output Ratings

Rated Operational Voltage:	250 Vdc
Rated Voltage Range:	19.2–275 Vdc
Rated Insulation Voltage:	300 Vdc
Make:	30 A @ 250 Vdc per IEEE C37.90
Continuous Carry:	6 A @ 70°C 4 A @ 85°C
Thermal:	50 A for 1 s
Contact Protection:	360 Vdc, 40 J MOV protection across open contacts

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

24 Vdc	.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
Utilization Category:	AC-15 (control of electromagnetic loads > 72 VA)
Contact Rating Designation:	B300 (B = 5 A, 300 = rated insulation voltage)
Voltage Protection Across Open Contacts:	270 Vac, 40 J
Rated Operational Current (I_e):	3 A @ 120 Vac 1.5 A @ 240 Vac
Conventional Enclosed Thermal Current (I_{the}) Rating:	5 A
Rated Frequency:	50/60 ±5 Hz
Electrical Durability Make VA Rating:	3600 VA, cos ϕ = 0.3
Electrical Durability Break VA Rating:	360 VA, cos ϕ = 0.3

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

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

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

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

Break Capacity (10000 Operations):

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

Cyclic Capacity (4 cycles in 1 second, followed by 2 minutes idle for thermal dissipation):

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

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

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

Optoisolated Control Inputs

When Used With DC Control Signals

250 V:	ON for 200–312.5 Vdc OFF below 150 Vdc
220 V:	ON for 176–275 Vdc OFF below 132 Vdc
125 V:	ON for 100–156.2 Vdc OFF below 75 Vdc
110 V:	ON for 88–137.5 Vdc OFF below 66 Vdc
48 V:	ON for 38.4–60 Vdc OFF below 28.8 Vdc
24 V:	ON for 15–30 Vdc OFF for <5 Vdc

When Used With AC Control Signals

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

Analog Output (Optional)

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

Analog Inputs (Optional)

Maximum Input Range:	±20 mA ±10 V Operational range set by user
Input Impedance:	200 Ω (current mode) >10 kΩ (voltage mode)
Accuracy at 25°C:	
With User Calibration:	0.05% of full scale (current mode) 0.025% of full scale (voltage mode)
Without User Calibration:	Better than 0.5% of full scale at 25°C
Accuracy Variation With Temperature:	±0.015% per °C of full-scale (±20 mA or ±10 V)

Arc-Flash Detectors (Optional)

Multimode fiber-optic receiver/transmitter pair

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

Frequency and Phase Rotation

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

Time-Code Input

Format:	Demodulated IRIG-B
On (1) State:	V_{ih} ≥2.2 V
Off (0) State:	V_{il} ≤0.8 V
Input Impedance:	2 kΩ
Synchronization Accuracy Internal Clock:	±1 µs
Synchrophasor Reports (e.g., **MET PM**):	±10 µs
All other reports:	±5 ms
Simple Network Time Protocol (SNTP) Accuracy Internal Clock:	±5 ms
Unsynchronized Clock Drift 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 (RJ-45 connector)
Single/Dual 100BASE-FX (LC connector)

Multimode Fiber-Optic Port

Location:	Front Panel
Data Speed:	300–38400 bps

Fiber-Optic Ports Characteristics

Port 1 (or 1A, 1B) Ethernet

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

Port 2 Serial

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

Channels 1-4 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 dB/m
Black-Jacketed Fiber Typical Loss:	–0.17 dB/m
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 dB/m
Clear-Jacketed Fiber Typical Loss:	–0.17 dB/m
ST or V-Pin Connector Splice Loss:	–2.00 dB
Approximate Range:	As much as 70 m

Optional Communications Cards

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

Communications Protocols

SEL, Modbus, DNP3, FTP, TCP/IP, Telnet, SNTP, IEC 61850, MIRRORED BITS, EVMSG, C37.118 (synchrophasors) and DeviceNet.

Operating Temperature

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

Note: Not applicable to UL applications.
Note: LCD contrast is impaired for temperatures below –20°C and above 70°C.

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

Operating Environment

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

Relay Mounting Screw (#8-32) Tightening Torque

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

Terminal Connections

Terminal Block

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

Terminal Block Tightening Torque

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

Compression Plug Tightening Torque

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

Compression Plug Mounting Ear Screw Tightening Torque

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

Type Tests

Environmental Tests

Enclosure Protection:	IEC 60529:2001 + CRDG:2003 IP65 enclosed in panel IP20 for terminals IP54 rated terminal dust protection assembly (SEL Part #915900170). 10°C temperature derating applies to the temperature specifications of the relay.
Vibration Resistance:	IEC 60068-2-6:2007 3 G, 10–150 Hz IEC 60255-21-1:1988, Class 1 IEC 60255-21-3:1993, Class 2
Shock Resistance:	IEC 60255-21-2:1988, Class 1
Cold:	IEC 60068-2-1:2007 –40°C, 16 hours
Damp Heat, Steady State:	IEC 60068-2-78:2001 40°C, 93% relative humidity, 4 days
Damp Heat, Cyclic:	IEC 60068-2-30:2005 25–55°C, 6 cycles, 95% relative humidity
Dry Heat:	IEC 60068-2-2:2007 85°C, 16 hours

Dielectric Strength and Impulse Tests

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

RFI and Interference Tests

EMC Immunity

Electrostatic Discharge Immunity:	IEC 61000-4-2:2008 IEC 60255-22-2:2008 Severity Level 4 8 kV contact discharge 15 kV air discharge
Radiated RF Immunity:	IEC 61000-4-3:2010 IEC 60255-22-3:2007 10 V/m IEEE C37.90.2-2004 35 V/m
Digital Radio Telephone RF Immunity:	ENV 50204:1995
Fast Transient, Burst Immunity:	IEC 61000-4-4:2011 IEC 60255-22-4:2008 4 kV @ 5.0 kHz 2 kV @ 5.0 kHz for comm. ports
Surge Immunity:	IEC 61000-4-5:2005 IEC 60255-22-5:2008 2 kV line-to-line 4 kV line-to-earth
Surge Withstand Capability Immunity:	IEC 60255-22-1:2007 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
Conducted RF Immunity:	IEC 61000-4-6:2008 IEC 60255-22-6: 2001 10 Vrms
Magnetic Field Immunity:	IEC 61000-4-8:2009 1000 A/m for 3 seconds 100 A/m for 1 minute IEC 61000-4-9: 2001 1000 A/m
Power Supply Immunity:	IEC 60255-11:2008

EMC Emissions

Conducted Emissions:	EN 55011:1998, Class A IEC 60255-25:2000
Radiated Emissions:	EN 55011:1998, Class A IEC 60255-25:2000

Electromagnetic Compatibility

Product Specific:	EN 50263:1999

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)
Arc Flash Processing:	Arc Flash light is sampled 32 times per cycle. Arc Flash current, light, and 2 fast hybrid outputs are processed 16 times per cycle.

Oscillography

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

Sequential Events Recorder

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

Relay Elements

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

Pickup Setting Range, A Secondary:	
5 A models:	0.50–100.00 A, 0.01 A steps
1 A models:	0.10–20.00 A, 0.01 A steps
Accuracy:	±3% plus ±0.02 • I_{NOM} A secondary (Steady State) ±5% plus ±0.02 • I_{NOM} A secondary (Transient) ±6% plus ±0.02 • I_{NOM} A secondary (Transient for 50Q)
Time Delay:	0.00–400.00 seconds, 0.01 seconds steps 0.1–400.0 seconds, 0.1 second steps (50Q)
Pickup/Dropout Time:	<1.5 cycles

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

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

Arc-Flash Time-Overlight (TOL1–TOL4)

Pickup Setting Range, % of Full Scale:	3.0–20.0% (Point Sensor) 0.6–4.0% (Fiber Sensor)
Pickup/Dropout Time:	2–5 ms/1 cycle

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

Pickup Setting Range, A Secondary:	
5 A models:	0.50–16.00 A, 0.01 A steps 0.25–16.00 A, 0.01 A steps (51N)
1 A models:	0.10–3.20 A, 0.01 A steps 0.05–16.00 A, 0.01 A steps (51N)
Accuracy:	±5% of setting plus ±0.02 • I_{NOM} A secondary (Steady State pickup)
Time Dial	
US:	0.50–15.00, 0.01 steps
IEC:	0.05–1.50, 0.01 steps
Accuracy:	±1.5 cycles, plus ±4% between 2 and 30 multiples of pickup (within rated range of current)

Undervoltage (27P, 27PP, 27S)

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

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

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

Power Elements (32)

Instantaneous/Definite Time, 3 Phase Elements Type:	+W, –W, +VAR, –VAR
Pickup Setting Range, VA Secondary:	
5 A models:	1.0–6500.0 VA, 0.1 VA steps
1 A models:	0.2–1300.0 VA, 0.1 VA steps
Accuracy:	±0.10 A • (L-L voltage secondary) plus ±5% of setting at unity power factor for power elements and zero power factor for reactive power elements (5 A nominal) ±0.02 A • (L-L voltage secondary) plus ±5% of setting at unity power factor for power elements and zero power factor for reactive power elements (1 A nominal)
Time Delay:	0.0–240.0 seconds, 0.1 second steps
Pickup/Dropout Time:	<10 cycles

Power Factor (55)

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

Frequency (81)

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

Rate-of-Change of Frequency (81R)

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

Synchronism Check (25)

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

Load-Encroachment Detection

Setting Range

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

Accuracy

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

Station Battery Voltage Monitor

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

Timers

Setting Range:	Various
Accuracy:	±0.5% of setting plus ±1/4 cycle

RTD Protection

Setting Range:	Off, 1–250°C
Accuracy:	±2°C
RTD Open-Circuit Detection:	>250°C
RTD Short-Circuit Detection:	<–50°C
RTD Types:	PT100, NI100, NI120, CU10
RTD Lead Resistance:	25 ohm max. per lead
Update Rate:	<3 s
Noise Immunity on RTD Inputs:	As high as 1.4 Vac (peak) at 50 Hz or greater frequency
RTD Trip/Alarm Time Delay:	Approx. 6 s

Metering

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

Phase Currents:	±1% of reading, ±1° (±2.5° at 0.2–0.5 A for relays with I_{NOM} = 1 A)
3-Phase Average Current:	±1% of reading
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)
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
3-Phase Average Line-to-Line Voltage:	±1% of reading for voltages within 24–264 V
Line-to-Ground Voltages:	±1% of reading, ±1° for voltages within 24–264 V
3-Phase Average Line-to-Ground Voltages:	±1% of reading for voltages within 24–264 V
Voltage Imbalance (%):	±2% of reading
V1 Positive-Sequence Voltage:	±2% of reading for voltages within 24–264 V
3V2 Negative-Sequence Voltage:	±2% of reading for voltages within 24–264 V
Real 3-Phase Power (kW):	±3% of reading for 0.10 < pf < 1.00
Reactive 3-Phase Power (kVAR):	±3% of reading for 0.00 < pf < 0.90
Apparent 3-Phase Power (kVA):	±3% of reading
Power Factor:	±2% of reading
RTD Temperatures:	±2°C

Energy Meter

Accumulators:	Separate IN and OUT accumulators updated once per second, transferred to non-volatile 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 Data Rate in Messages per Second

IEEE C37.118 Protocol:	60 (nominal 60 Hz system) 50 (nominal 50 Hz system)
IEEE C37.118 Accuracy:	Level 1 at maximum message rate when phasor has the same frequency as phase A voltage
Current Range:	(0.4–2) • I_{NOM} (I_{NOM} = 1 A or 5 A)
Frequency Range:	±5 Hz of nominal (50 or 60 Hz)
Voltage Range:	24 V–264 V
Phase Angle Range:	–179.99° to 180°

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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

You can mount the SEL-751 in a sheltered indoor environment (a building or an enclosed cabinet) that does not exceed the temperature and humidity ratings for the relay. The relay is IEC EN61010-1 rated at Installation/Overvoltage Category II and Pollution Degree 2. This rating allows mounting of the relay indoors or in an outdoor (extended) enclosure where the relay is protected against exposure to direct sunlight, precipitation, and full wind pressure, but neither temperature nor humidity are controlled.

You can place the relay in extreme temperature and humidity locations. (See *Operating Temperature* and *Operating Environment on page 1.12*.) For EN 61010 certification, the SEL-751 rating is 2000 m (6560 feet) above mean sea level.

To comply with the requirements of the European ATEX standard for hazardous locations, the SEL-751 must be installed in an enclosure that meets the requirements of an Ex n enclosure rated IP54 or better. The enclosure should be certified to these requirements or be tested for compliance as part of the complete assembly. In North America, the relay is approved for Class 1, Division 2, Groups A, B, C, D, and T4 hazardous locations.

Relay Mounting

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

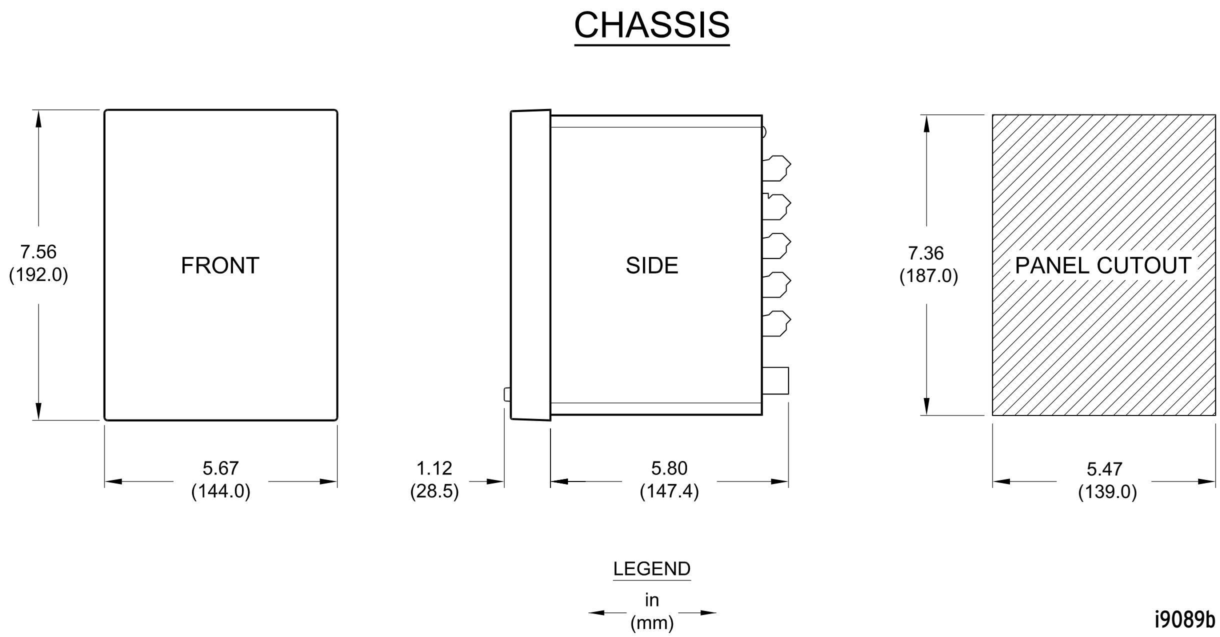


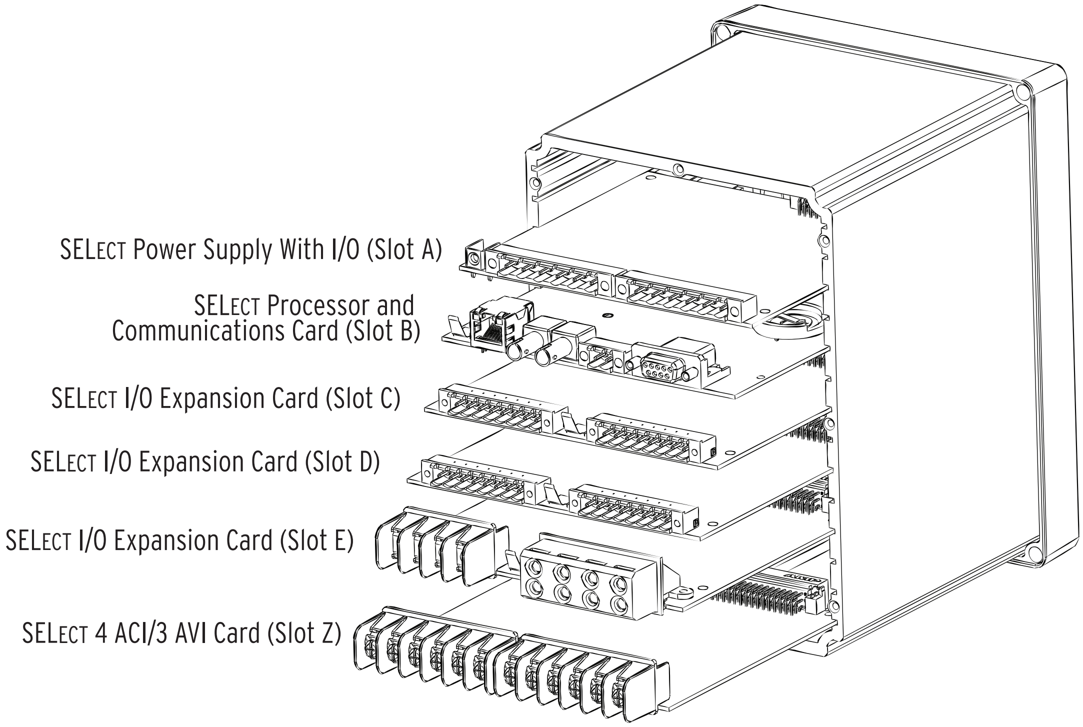
Figure 2.1 Relay Panel-Mount Dimensions

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.

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



	Rear-Panel Slot					
	A	**B**	**C**	**D**	**E**	**Z**
Software Reference	1 (e.g., OUT101)	n/a	3 (e.g., IN301)	4 (e.g., OUT401)	5 (e.g., AI501)	n/a
Description	Power supply and I/O card[a]	CPU/comm. card[b]	Comm. or input/output[c] card	Input/output[c] or RTD card	Input/output[c] or voltage/arc-flash card	4 ACI/3 AVI card in base unit
Card Type						
SELECT EIA-232/485			•	n/a	n/a	n/a
SELECT DeviceNet			•	n/a	n/a	n/a
SELECT 3 DI/4 DO/1 AO (one card per relay)			•	•	•	n/a
SELECT 4 DI/4 DO			•	•	•	n/a
SELECT 4 DI/3 DO (1 Form B, 2 Form C)			•	•	•	n/a
SELECT 8 DI			•	•	•	n/a
SELECT 8 DO			•	•	•	n/a
SELECT 8AI			•	•	•	n/a
SELECT 4 AI/4 AO (one card per relay)			•	•	•	n/a
SELECT 10 RTD			n/a	•	n/a	n/a
SELECT 2 AVI/4 AFDI (MOT … x70x…)			n/a	n/a	•	n/a
SELECT 4 ACI/3 AVI (MOT...x81/82/85/86x...)			n/a	n/a	n/a	•

[a] Power supply, two inputs, and three outputs.
[b] IRIG-B, EIA-232/485, fiber-optic serial and/or Ethernet ports (the IRIG-B input option is available on terminals B01, B02 for all models except models with fiber-optic Ethernet port (P1) and dual copper Ethernet port (P1) 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).

Figure 2.2 Slot Allocations for Different Cards

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

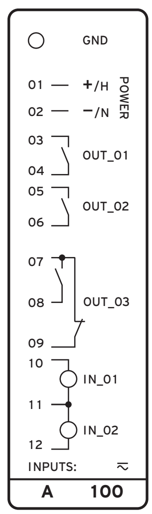
Select appropriate power supply option for the application:

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

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

Table 2.1 Power Supply Card Inputs Terminal Designation



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

Base-Unit Communications Ports (Slot B)

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

Table 2.2 Communications Ports

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

- Modbus TCP/IP
- DNP3 LAN/WAN
- IEC 61850
- Simple Network Time Protocol (SNTP)
- FTP
- Telnet

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

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

Communications Card

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

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

Select either EIA-232 or EIA-485 functionality through 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

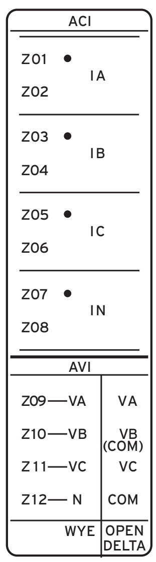
- SEL Fast Meter
- SEL Fast Operate
- SEL Fast SER
- SEL Fast Message Unsolicited Write
- SEL Settings File Transfer
- SEL MIRRORED BITS (MBA, MBB, MB8A, MB8B, MBTB, MBTA)
- Event Messenger
- DNP3 Slave Level 2
- C37.118 (Synchrophasor Data)

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

MOT...x81x... (1 A phase, 1 A neutral CTs), or ...x85x...(5 A phase, 5 A neutral CTs), or ...x82x... (1 A phase, 5 A neutral CTs), or ...x86x...(5 A phase, 1 A neutral CTs). Supported in Slot Z of the SEL-751, this card has current inputs for three-phase CTs, neutral current CTs and voltage inputs for three-phase (wye or delta) PTs.

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

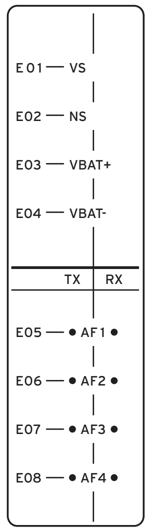
Table 2.4 4 ACI/3 AVI Current/Voltage Card Inputs Terminal Designation

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

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

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

Table 2.5 2 AVI/4 AFDI Voltage/Arc-Flash Detection Card Inputs Terminal Designation

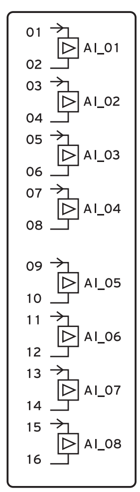


Side-Panel Connections Label	Terminal Number	Description
	E01	VS, synchronism-check voltage input
	E02	NS, common connection for synchronism-check voltage input
	E03	VBAT+ station battery (positive) voltage input
	E04	VBAT- station battery (negative) voltage input
	E05	AF1 Channel TX and RX Inputs
	E06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

Analog Input Card (8 AI)

Supported in any nonbase unit slot (Slot C through Slot E), this card has eight analog inputs. *Table 2.6* shows the terminal allocation.

Table 2.6 Eight Analog Input (8 AI) Card Terminal Allocation



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

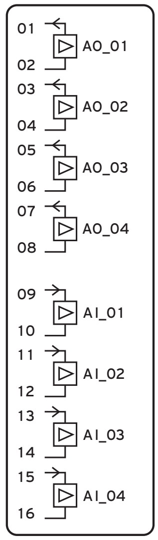
[a] x = 3, 4, or 5 (e.g., AI410, AI402, etc., if the card was installed in Slot D).

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.

Supported in any one of the nonbase unit slots (Slot **C** through Slot **E**), this card has four analog inputs and four analog outputs (**AO**). *Table 2.7* shows the terminal allocation.

Table 2.7 Four Analog Input/Four Analog Output (4 AI/4 AO) Card Terminal Allocation

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

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

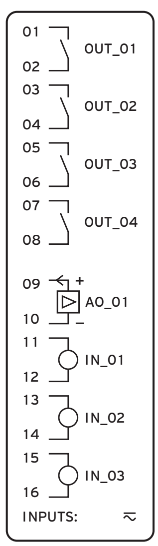
I/O Input Card (3 DI/4 DO/1 AO)

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

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

Supported in one nonbase unit slot (Slot **C**, **D**, or **E**), this card has three digital inputs, four digital outputs, and one analog output. *Table 2.8* shows the terminal allocation.

Table 2.8 I/O (3 DI/4 DO/1 AO) Card Terminal Allocation

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

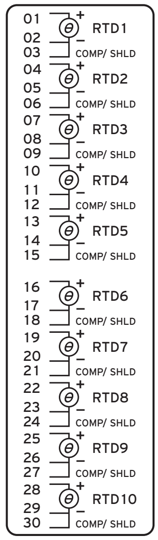
[a] x=3, 4, or 5 (for example, OUT401, OUT402, etc., if the card was installed in Slot D).

RTD Card (10 RTD)

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

Supported in Slot **D** only, this card has 10 three-wire RTD inputs. *Table 2.9* shows the terminal allocation.

Table 2.9 RTD (10 RTD) Card Terminal Allocation

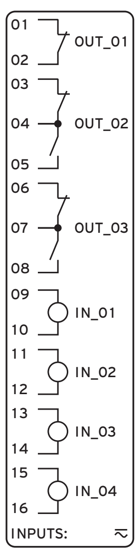


Side-Panel Connections Label	Terminal Number	Description
(see diagram above)	01	RTD01 (+)
	02	RTD01 (-)
	03	RTD01 Comp/Shield
	04	RTD02 (+)
	05	RTD02 (-)
	06	RTD02 Comp/Shield
	07	RTD03 (+)
	08	RTD03 (-)
	09	RTD03 Comp/Shield
	•	•
	•	•
	•	•
	28	RTD10 (+)
	29	RTD10 (-)
	30	RTD10 Comp/Shield

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 contact output) and two Form-C digital output contacts. *Table 2.10* shows the terminal allocation.

Table 2.10 Four Digital Inputs, One Form-B Digital Output, Two Form-C Digital Outputs (4 DI/3 DO) Card Terminal Allocation



Side-Panel Connections Label	Terminal Number	Description[a]
(see diagram above)	01, 02	OUT*x*01, driven by OUTx01 SELOGIC control equation
	03, 04, 05	OUT*x*02, driven by OUTx02 SELOGIC control equation
	06, 07, 08	OUT*x*03, driven by OUTx03 SELOGIC control equation
	09, 10	IN*x*01, drives IN*x*01 element
	11, 12	IN*x*02, drives IN*x*02 element
	13, 14	IN*x*03, drives IN*x*03 element
	15, 16	IN*x*04, drives IN*x*04 element

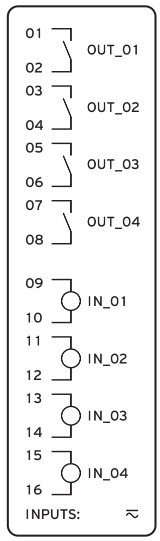
[a] x = 3, 4, or 5 (e.g., OUT401, OUT402, etc. if the card was installed in Slot D).

I/O Card (4 DI/4 DO)

Supported in any nonbase unit slot (Slot C through Slot E), this card has four digital inputs and four outputs. The four outputs are either all normally open contact outputs or all fast hybrid (high-speed, high-current interrupting) outputs. *Table 2.11* shows the terminal allocation.

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

Table 2.11 Four Digital Input/Four Digital Output (4 DI/4 DO) Card Terminal Allocation

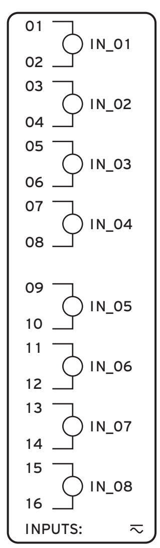
Side-Panel Connections Label	Terminal Number	Description[a]
	01, 02	OUT*x*01, driven by OUTx01 SELOGIC control equation
	03, 04	OUT*x*02, driven by OUTx02 SELOGIC control equation
	05, 06	OUT*x*03, driven by OUTx03 SELOGIC control equation
	07, 08	OUT*x*04, driven by OUTx04 SELOGIC control equation
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

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

I/O Card (8 DI)

Supported in any nonbase unit slot (Slot C through Slot E), this card has eight digital inputs. *Table 2.12* shows the terminal allocation.

Table 2.12 Eight Digital Input (8 DI) Card Terminal Allocation

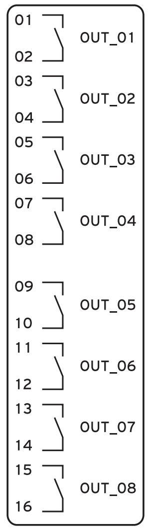
Side-Panel Connections Label	Terminal Number	Description[a]
	01, 02	IN*x*01, drives IN*x*01 element
	03, 04	IN*x*02, drives IN*x*02 element
	05, 06	IN*x*03, drives IN*x*03 element
	07, 08	IN*x*04, drives IN*x*04 element
	09, 10	IN*x*05, drives IN*x*05 element
	11, 12	IN*x*06, drives IN*x*06 element
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

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

I/O Card (8DO)

Supported in any nonbase unit slot (Slot **C** through Slot **E**), this card has eight digital outputs. *Table 2.13* shows the terminal allocation.

Table 2.13 Eight Digital Output (8 DO) Card Terminal Allocation

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

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

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).

Card Configuration Procedure

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

The SEL-751 offers flexibility in tailoring I/O to your specific application. The SEL-751 has six rear-panel slots, labeled as Slots A, B, C, D, E, and Z. Slots A, B, and Z are base unit slots, each associated with a specific function. Optional digital/analog I/O, communication, RTD, arc-flash detectors, and voltage/current cards are available for the SEL-751 in Slots C, D, and E. *Figure 2.2* shows the slot allocations for the cards. Because installations differ substantially, the SEL-751 offers a variety of card configurations that provide options for the many diverse applications. Choose the combination of option cards most suited for your application.

Swapping Optional I/O Boards

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

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

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

Installation

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

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

Step 2. Disconnect all the connection plugs.

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

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

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

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

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

Step 7. Carefully reattach the rear cover.

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

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

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

```
STATUS FAIL
X Card Failure
```

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

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

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

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

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

The front panel displays the following:

```
STATUS
Relay Status
```

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

The front panel displays the following:

```
Serial Num
000000000000000000000000
```

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

The front panel displays the following:

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

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

The front panel displays the following:

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

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

The front panel displays the following:

```
Config Accepted
Enter to Reboot
```

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

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

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

```
PART NUM = 751001B5X1X7086020X
```

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

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

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

Slot B CPU Board Replacement

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

Step 1. Turn off the power to the relay.

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

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

Step 4. Remove the rear panel.

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

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

Step 7. Apply new side stickers to the relay.

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

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

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

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

The CAL level default password is CLARKE.

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

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

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

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

Slot A Power Supply Card

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

Analog Input Card Voltage/Current Jumper Selection

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

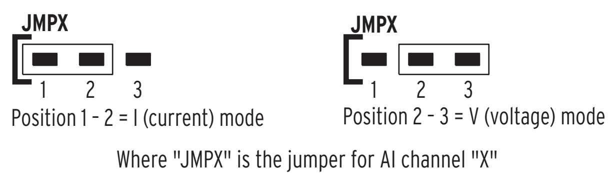


Figure 2.3 Circuit Board of Analog I/O Board, Showing Jumper Selection

Analog Output (AO) Configuration Jumper

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

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

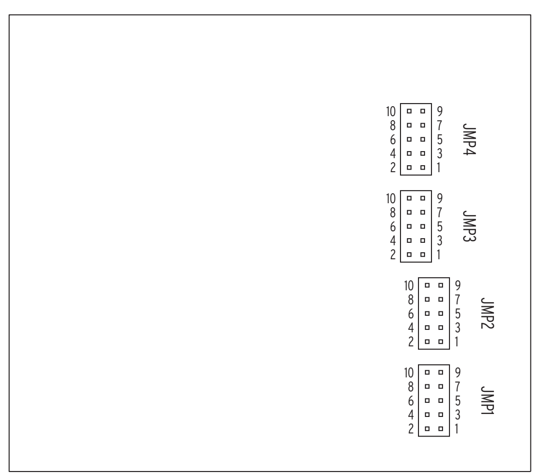


Figure 2.4 JMP1 Through JMP4 Locations on 4 AI/4 AO Board

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

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

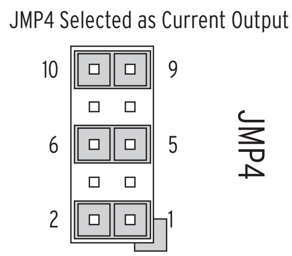


Figure 2.5 Current Output Jumpers

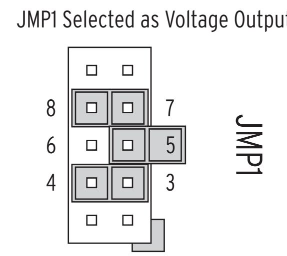


Figure 2.6 Voltage Output Jumpers

Password, Breaker Control, and SELBOOT Jumper Selection

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

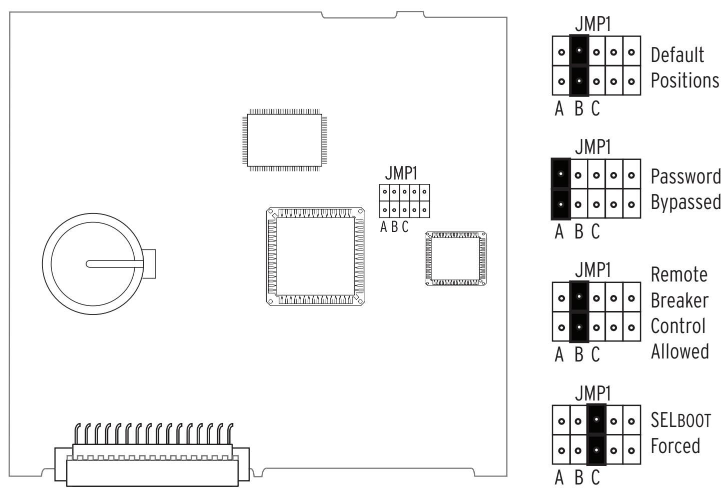


Figure 2.7 Pins for Password, Breaker Control, and SELBOOT Jumper

Pins labeled A bypass the password requirement, pins labeled B enable breaker control, and pins labeled C force the relay to the SEL operating system called SELBOOT. In the unlikely event that the SEL-751 experiences an internal failure, communication with the relay may be compromised. Forcing the relay to SELBOOT provides you with a way to download new firmware. To force the relay to SELBOOT, place the jumper in position C, as shown in *Figure 2.7* (SELBOOT Forced). After the relay is forced to SELBOOT, you can only communicate with it via the front-panel port.

To gain access to Level 1 and Level 2 command levels without passwords, place the jumper in position A, as shown in *Figure 2.7* (Password Bypassed). Although you gain access to Level 2 without a password, the alarm contact still closes momentarily when accessing Level 2. See *Table 2.14* for the functions of the three sets of pins and their jumper default positions.

Table 2.14 Jumper Functions and Default Positions

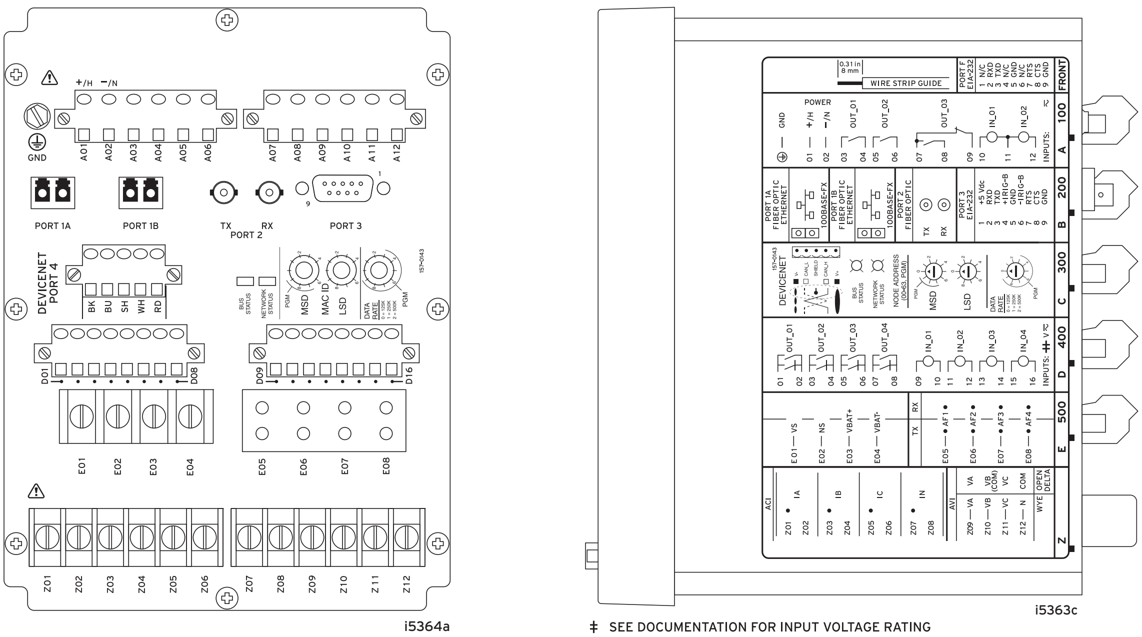
Pins	Jumper Default Position	Description
A	Not bypassed (requires password)	Password bypass
B	On (breaker control enabled)	Enable breaker control[a]
C	Not bypassed (not forced SELBOOT)	Forced SELBOOT

[a] Enable/disable serial port, front panel, and Fast Operate commands for breaker control.

Rear-Panel Connections

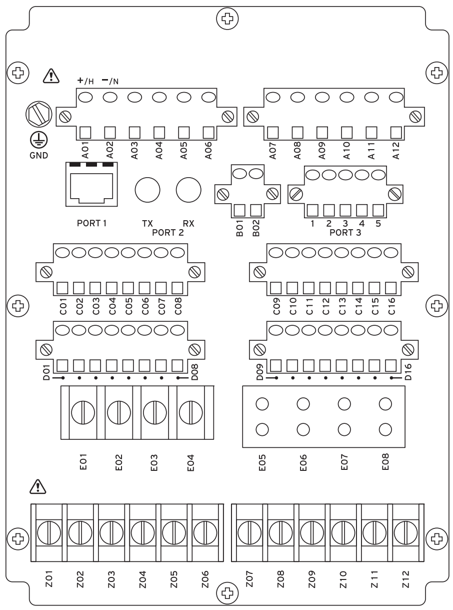
Rear-Panel and Side-Panel Diagrams

The physical layout of the connectors on the rear-panel and side-panel diagrams of three sample configurations of the SEL-751 are shown in *Figure 2.8*, *Figure 2.9*, *Figure 2.10*, and *Figure 2.11*.



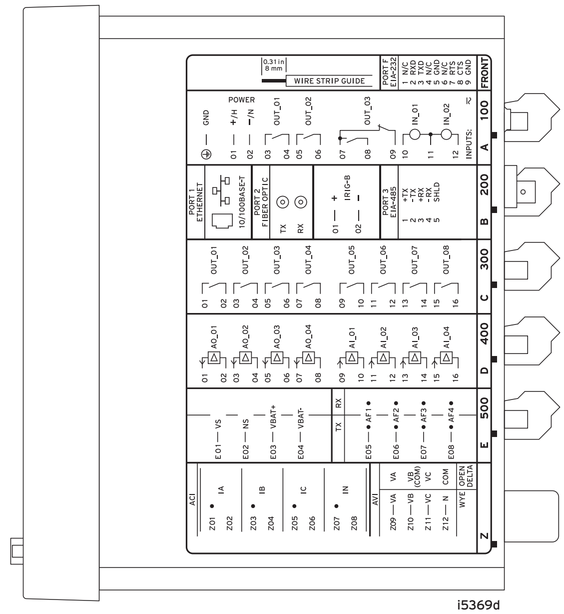
(A) Rear-Panel Layout (B) Side-Panel Input and Output Designations

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



i5370a

(A) Rear-Panel Layout

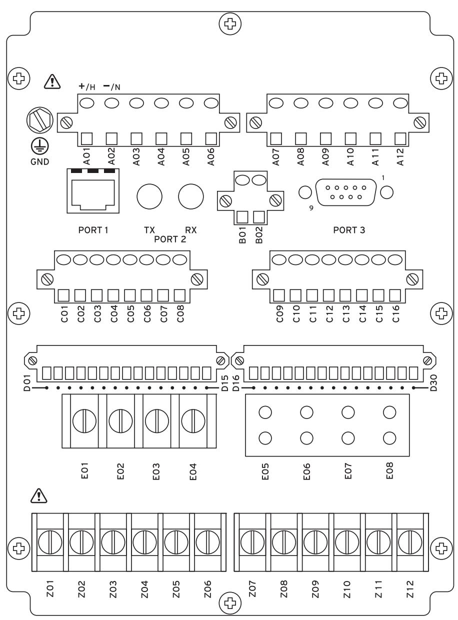


i5369d

‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

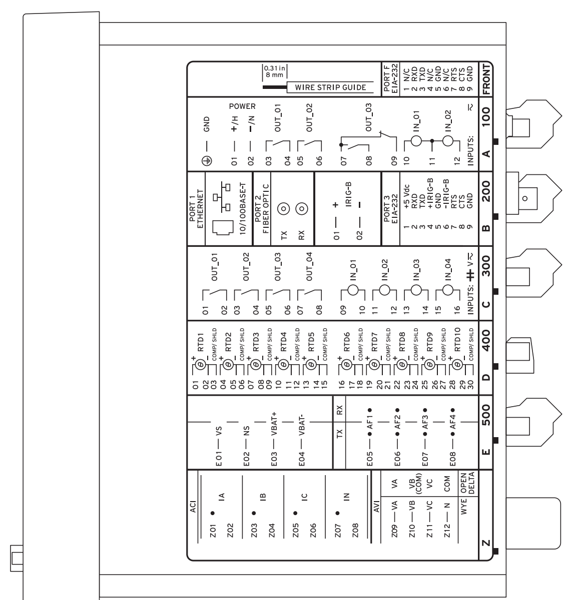
(B) Side-Panel Input and Output Designations

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



i5366a

(A) Rear-Panel Layout

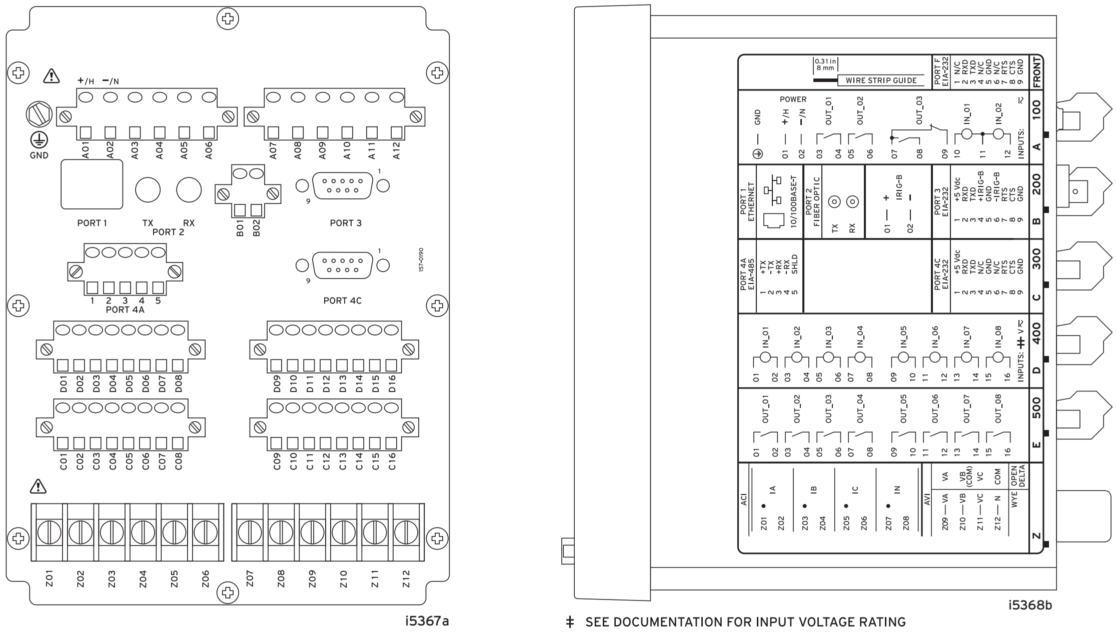


i5365c

‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(B) Side-Panel Input and Output Designations

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



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

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

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

For compliance with IEC 60947-1 and IEC 60947-3, place a suitable external switch or circuit breaker in the power leads for the SEL-751; this device should interrupt both the hot (**+/H**) and neutral (**-/N**) power leads. The maximum current rating for the power disconnect circuit breaker or optional overcurrent device (fuse) should be 20 A.

Operational power is internally fused by a power supply fuse. See *Field Serviceability on page 2.36* for details. Be sure to use fuses that comply with IEC 60127-2.

Grounding (Earthing) Connections

You must connect the ground terminal labeled **GND** on the rear panel to a rack frame or switchgear ground for proper safety and performance. Use 14 AWG (2.1 mm^2) wire less than 2 m (6.6 feet) in length for the ground connection.

Serial Ports

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

The serial port EIA-485 plug-in connector accepts wire size AWG 24 through AWG 12. Strip the wires 8 mm (0.31 inches) and install with a small slotted-tip screwdriver. All EIA-232 ports accept 9-pin D-subminiature male connectors.

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

IRIG-B Time-Code Input

The SEL-751 accepts a demodulated IRIG-B time signal to synchronize the internal clock with an external source. Three options for IRIG-B signal input are given, but you should use only one at a time. You can use IRIG-B (**B01** and **B02**) inputs or an SEL communications processor via EIA-232 serial **Port 3**. The available communications processors are the SEL-2032, SEL-2030, SEL-2020, and the SEL-2100 Logic Processor. You can also use the SEL-3530 Real-Time Automation Controller (RTAC) to provide IRIG-B input.

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

Ethernet Port

The SEL-751 can be ordered with an optional single/dual 10/100BASE-T or 100BASE-FX Ethernet port. Connect to Port 1 of the device by using a standard RJ-45 connector for the copper port and an LC connector for the fiber-optic port.

Fiber-Optic Serial Port

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

I/O Diagram

A more functional representation of two of the control (I/O) connections is shown in *Figure 2.12* and *Figure 2.13*.

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

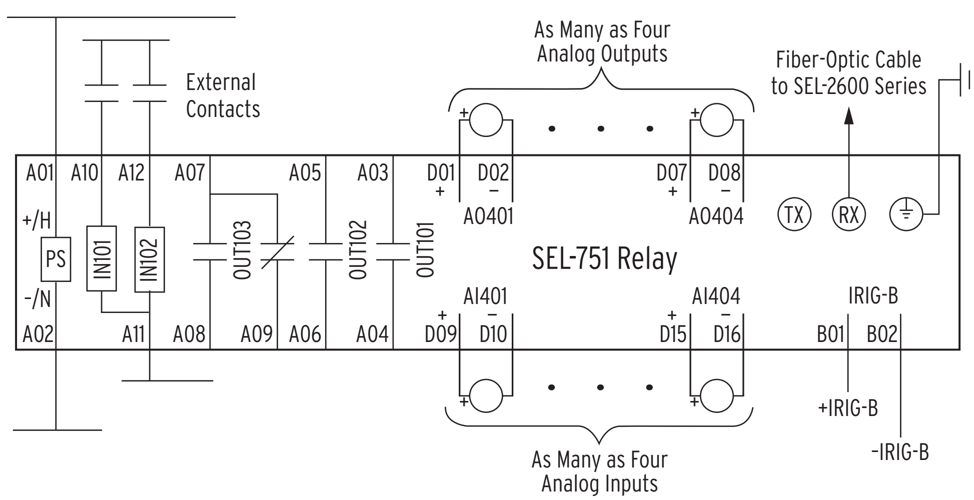


Figure 2.12 Control I/O Connections—4 AI/4 AO Option in Slot D and Fiber-Optic Port in Slot B

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

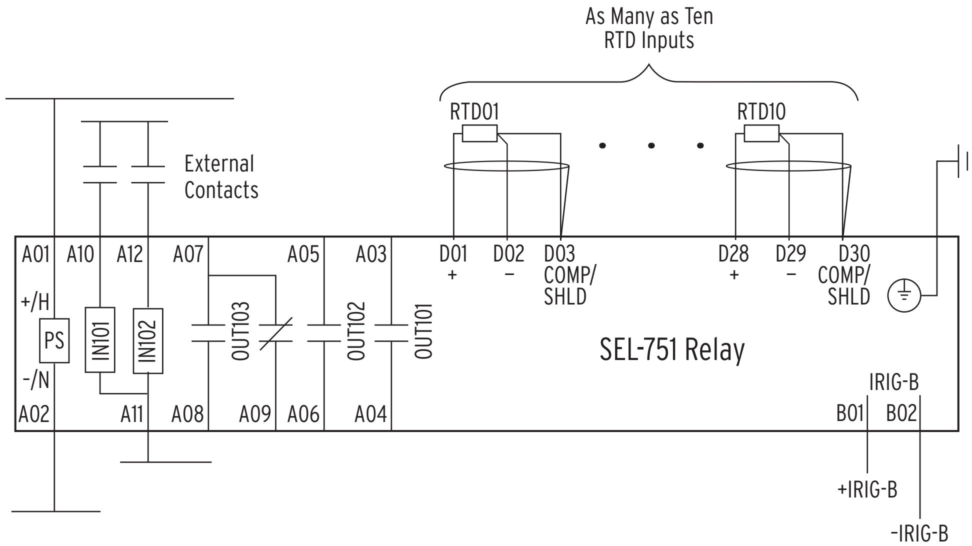


Figure 2.13 Control I/O Connections—Internal RTD Option in Slot D

Notes:

- The chassis ground connector located on the rear-panel card Slot A must always be connected to the local ground mat.
- Power supply rating (110–240 Vac, 110–250 Vdc or 24–48 Vdc) depends on relay part number.
- Optoisolated inputs IN101 and IN102 are standard and located on the card in Slot **A**.
- All optoisolated inputs are single-rated: 24, 48, 110, 125, 220, or 250 Vac/Vdc. Standard inputs IN101/102 can have a different rating than the optional IN401/402/403/404 (not shown).
- Output contacts OUT101, OUT102, and OUT103 are standard and are located on the card in Slot **A**.
- The analog (transducer) outputs shown are located on the optional I/O expansion card in Slot D.
- The fiber-optic serial port is located on the card in Slot **B**. A Simplex 62.5/125 µm fiber-optic cable is necessary for connecting to an SEL-2600 Series RTD Module. This fiber-optic cable should be 1000 meters or shorter.

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

Table 2.15 shows the maximum cable lengths for the RTD connections.

Table 2.15 Typical Maximum RTD Lead Length

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

AC/DC Control Connection Diagrams

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

Fail-Safe/Nonfail-Safe Tripping

NOTE: When using fast hybrid output contacts, do not use the FAILSAFE mode for these outputs.

Figure 2.14 shows the output **OUT103** relay coil and Form C contact. When the relay coil is de-energized, the contact between **A07** and **A08** is open while the contact between **A07** and **A09** is closed.

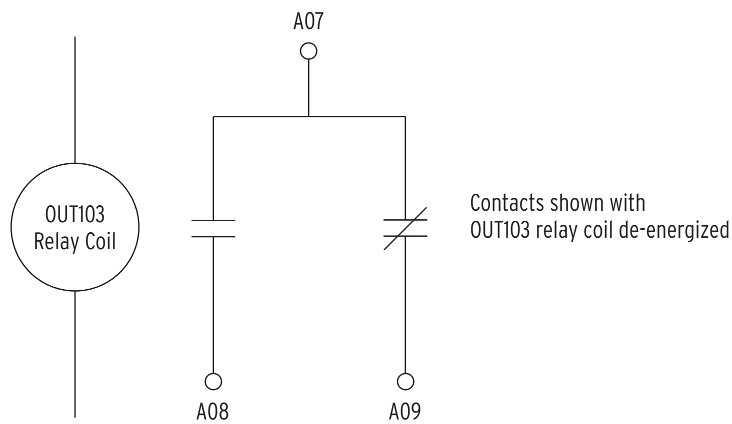


Figure 2.14 Output OUT103 Relay Output Contact Configuration

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

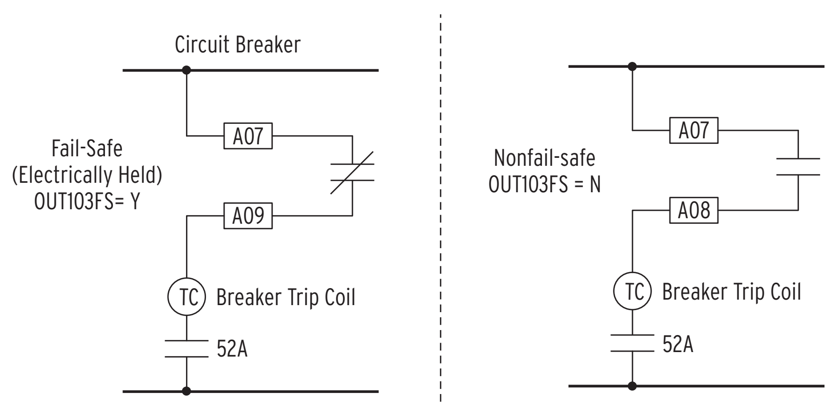


Figure 2.15 OUT103 Contact Fail-Safe and Nonfail-Safe Options

Voltage Connections

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, use an open-delta VT connection, or use a single-phase VT. *Figure 2.16* and *Figure 2.17* show the methods of connecting single-phase and three-phase voltages.

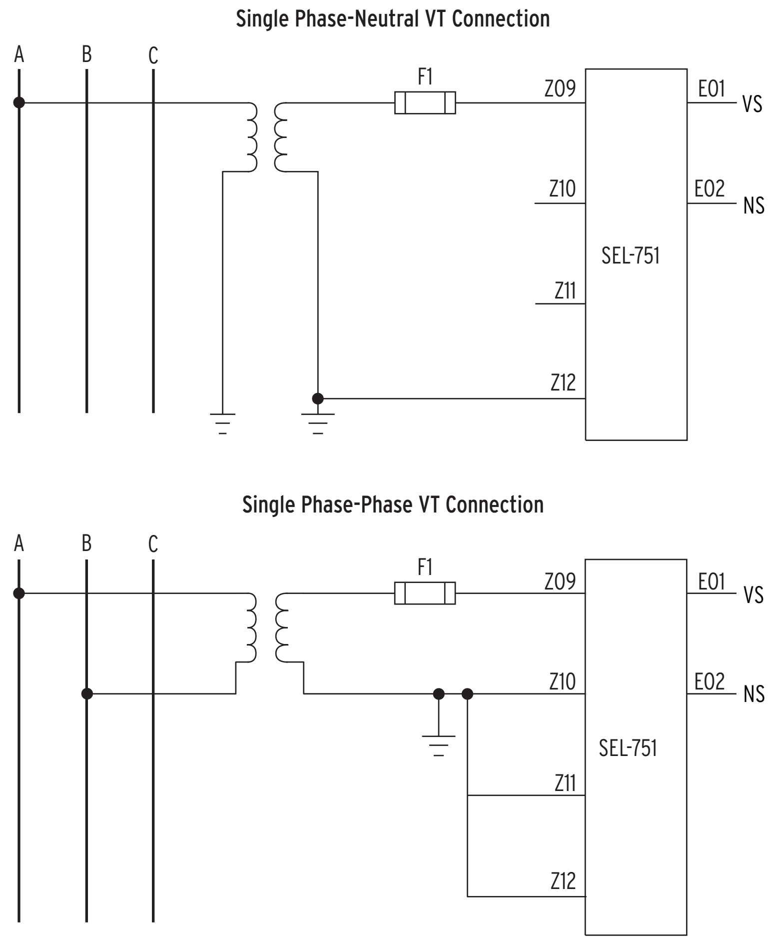
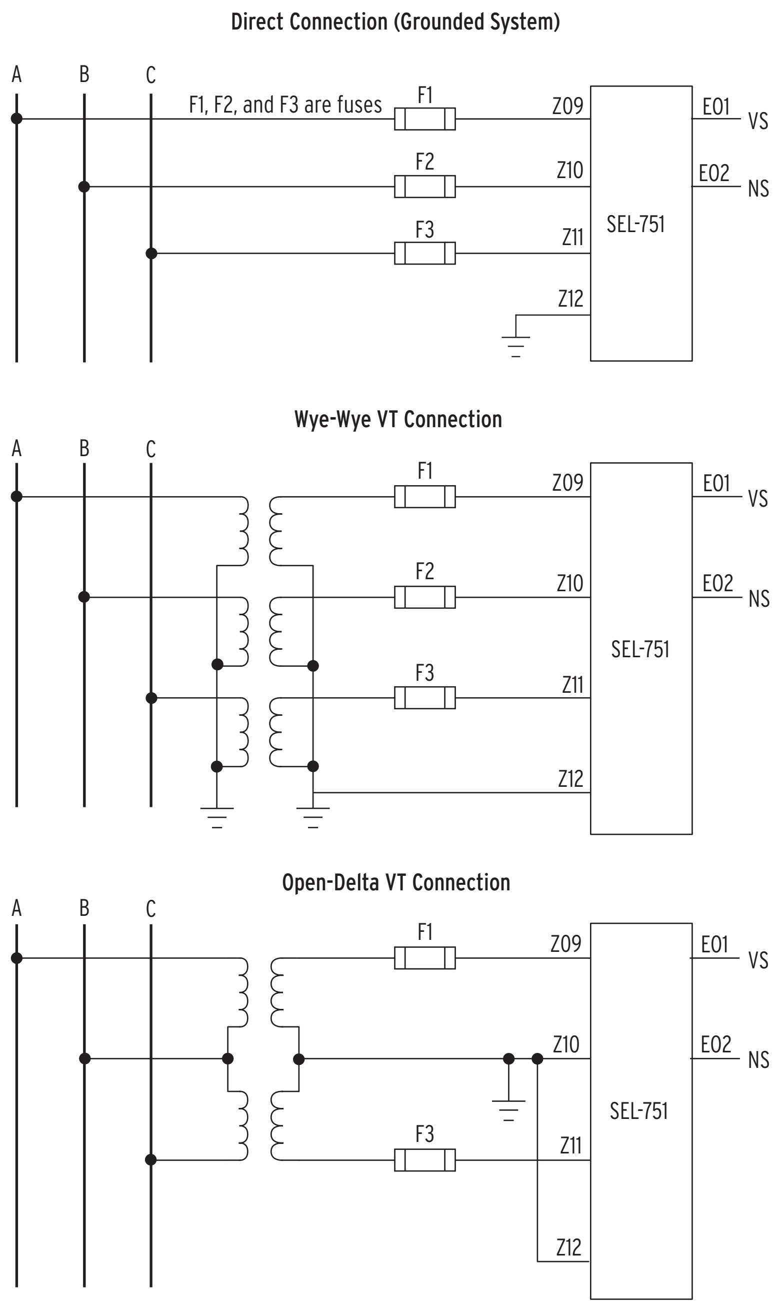


Figure 2.16 Single-Phase Voltage Connections



Note: This figure shows grounding Phase B (E02). You can choose to ground Phase A or Phase C instead of Phase B, provided all other connections remain as shown.

Figure 2.17 Voltage Connections

Station DC Battery Monitor

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

AC/DC Connections and Applications

Figure 2.18 shows typical phase and neutral current connections for a feeder application. *Figure 2.19* through *Figure 2.23* show ac/dc connection diagrams for various applications, however, wye-connected PTs are shown. See *Figure 2.16* and *Figure 2.17* for other voltage connections.

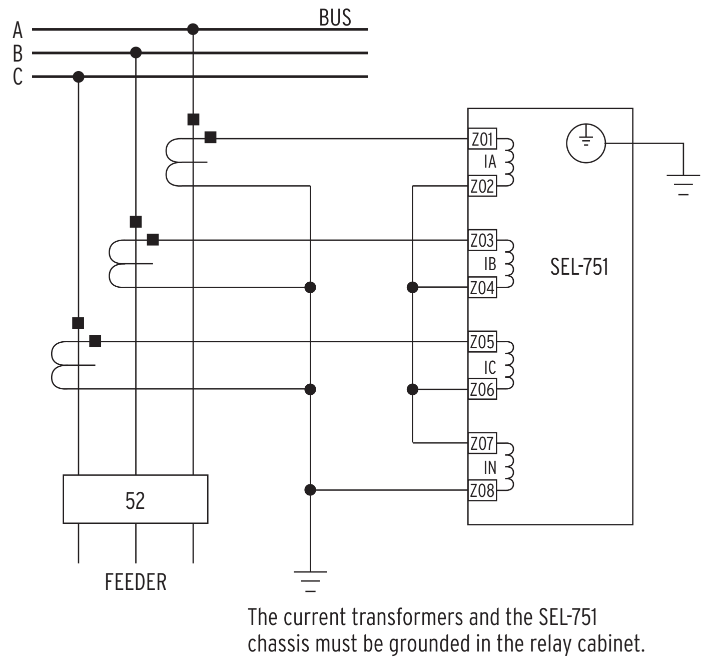
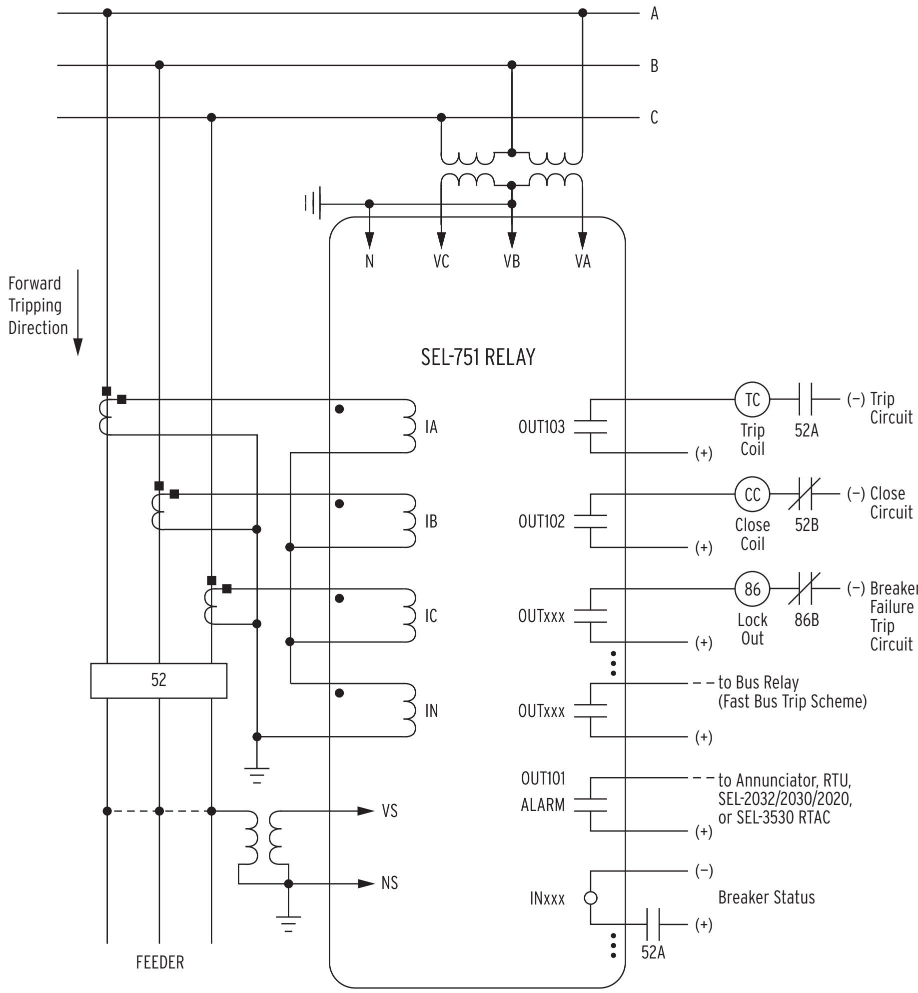


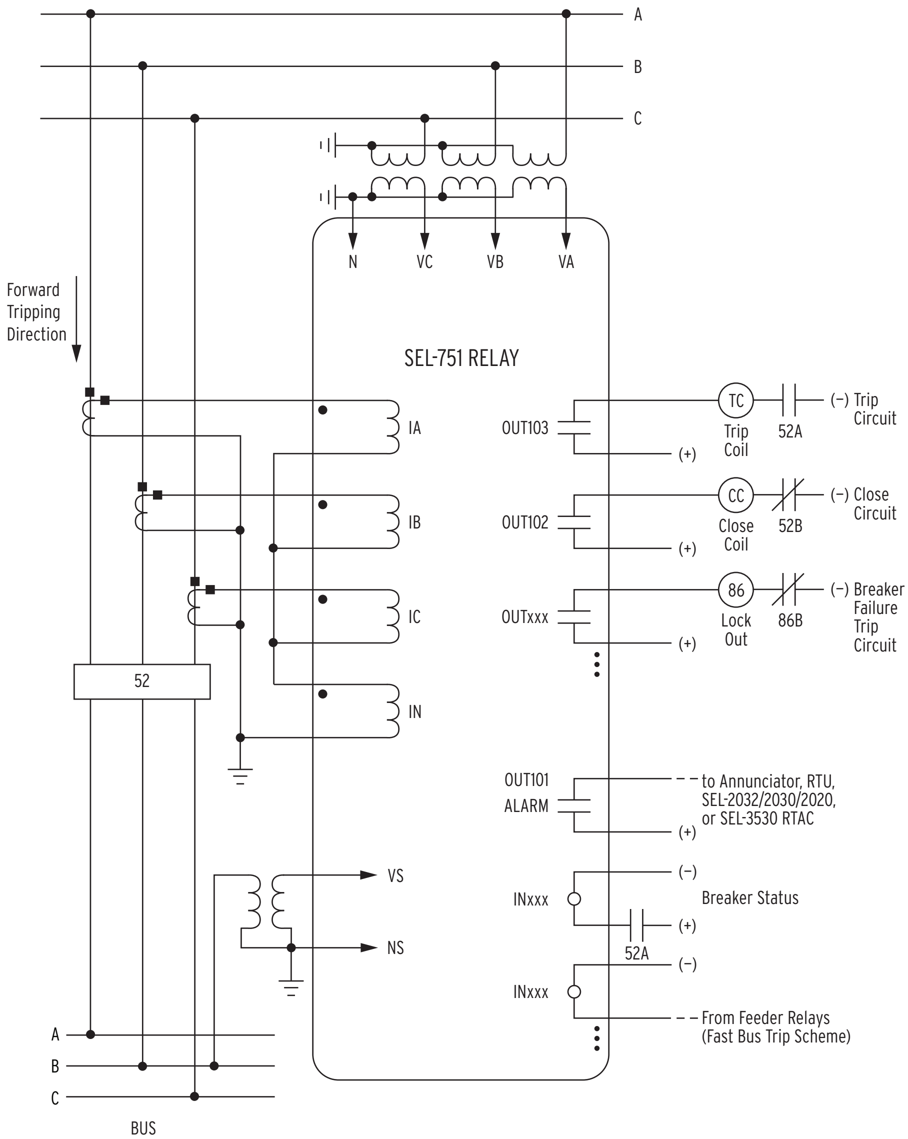
Figure 2.18 Typical Current Connections



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 for use in voltage and synchronism-check elements and voltage metering. You can use the VS voltage channel for other voltage inputs such as 3VO from a broken delta PT connection as long as you take care to disable the synchronism-check elements. INxxx and OUTxxx indicate user-configurable optional digital inputs and outputs.

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



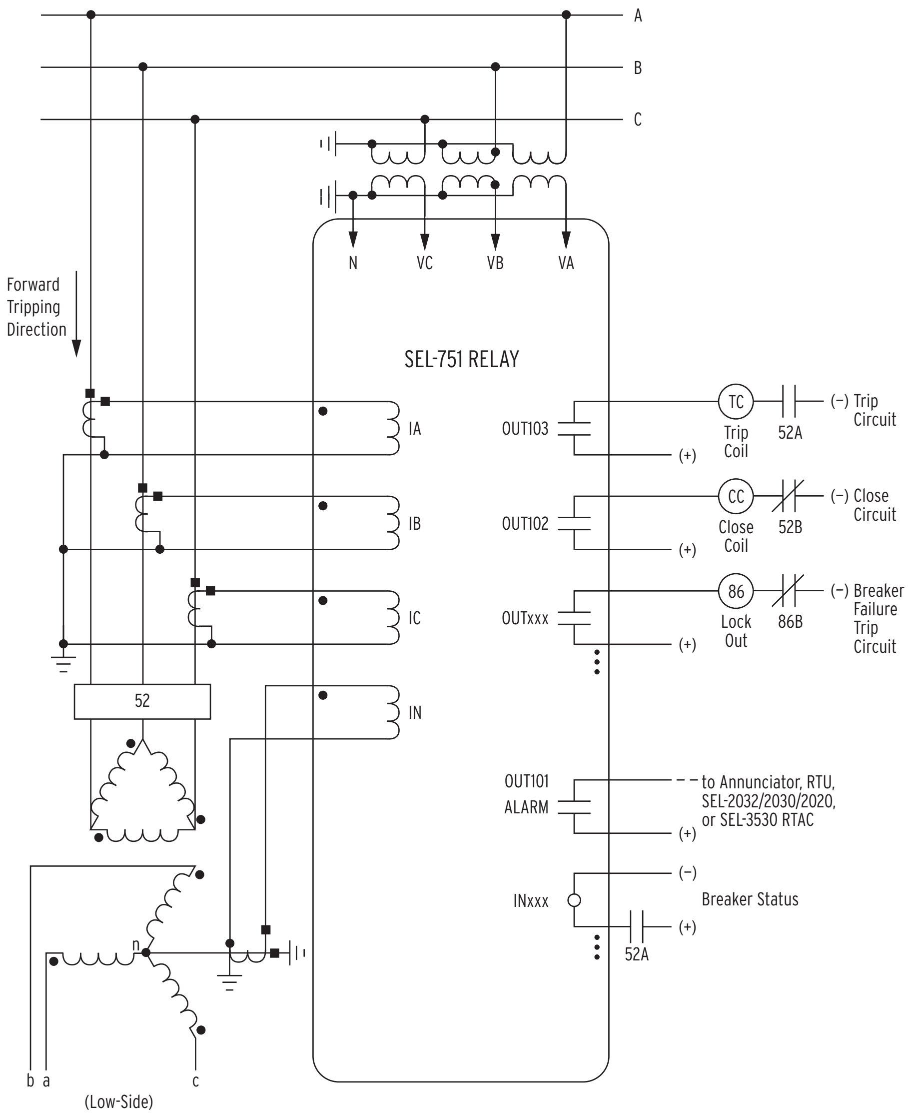
The fast bus trip scheme is often referred to as a reverse-interlocking or zone-interlocking scheme.

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 for use in voltage and synchronism-check elements and voltage metering. You can use VS voltage channel for other voltage inputs such as 3VO from a broken delta PT connection as long as you take care to disable the synchronism-check elements. INxxx and OUTxxx indicate user-configurable optional digital inputs and outputs.

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).

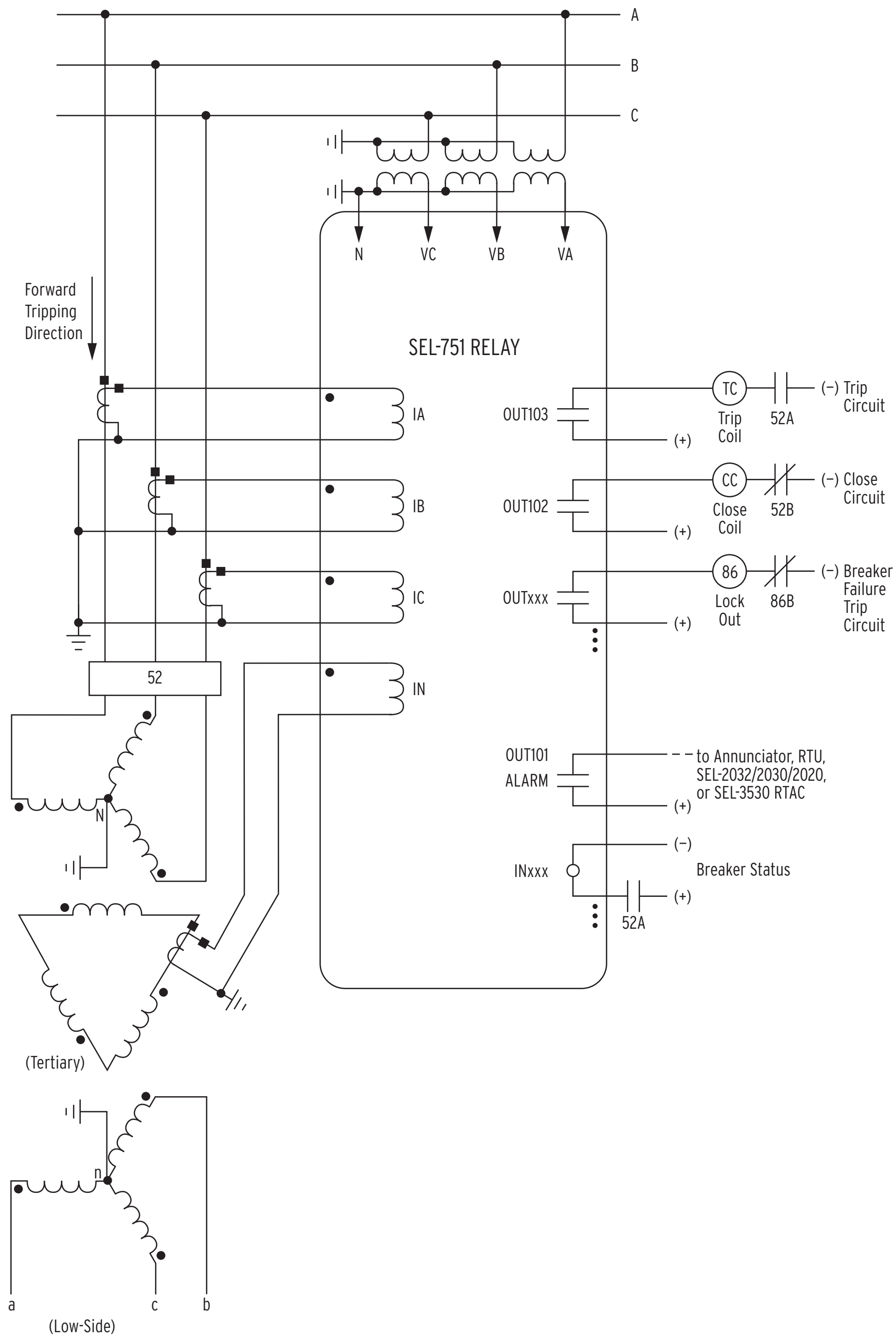
Figure 2.20 SEL-751 Provides Overcurrent Protection for a Distribution Bus (Includes Fast Bus Trip Scheme) (Wye-Connected PTs)



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).

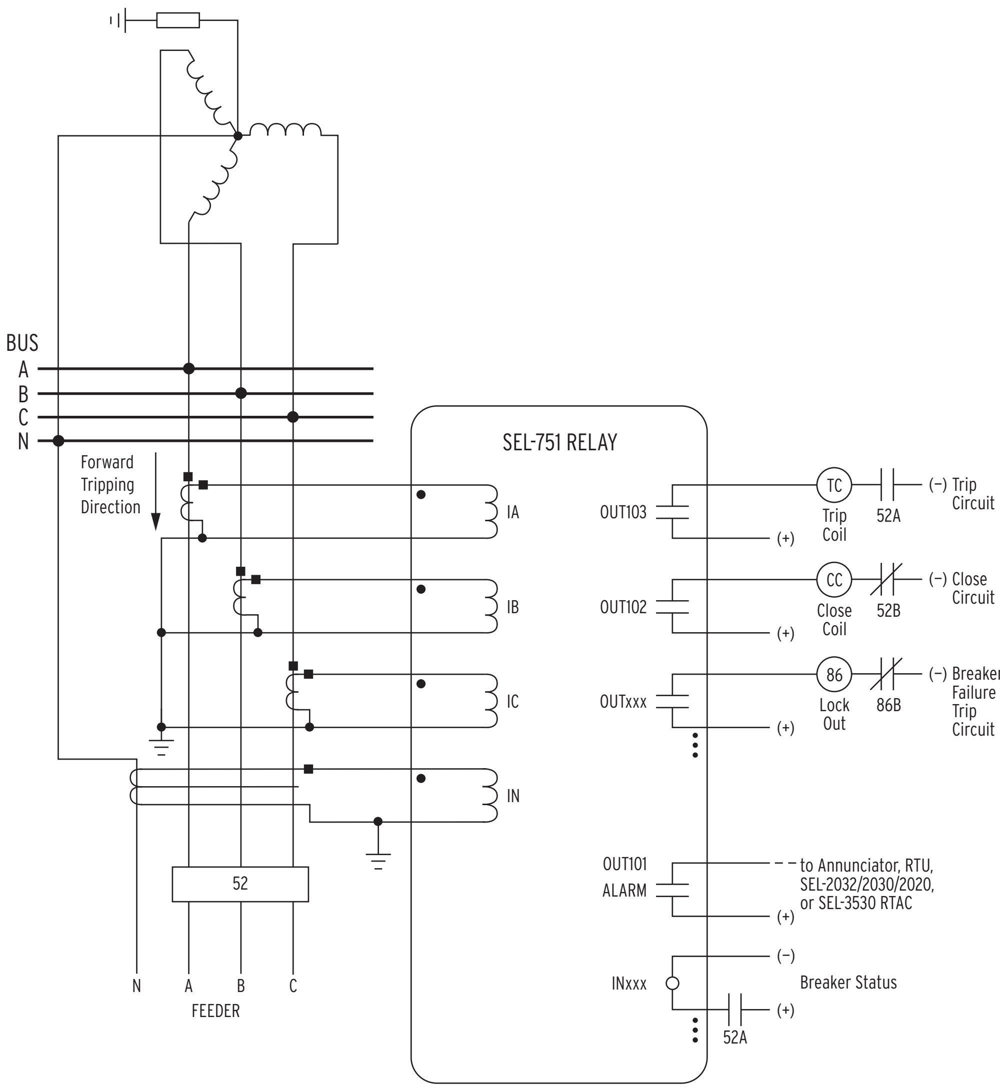
Figure 2.21 SEL-751 Provides Overcurrent Protection for a Delta-Wye Transformer Bank (Wye-Connected PTs)



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 2.22 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 2.23 SEL-751 Provides Overcurrent Protection for an Industrial Distribution Feeder (Core-Balance Current Transformer Connected to Channel IN)

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 10: 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 2.24 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 2.11* 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 2.24 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 will vary 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 2.25* shows an example of a typical black-jacketed fiber installation.

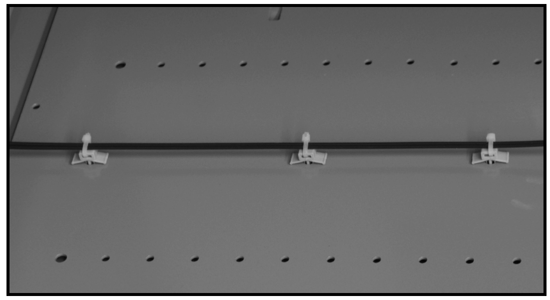


Figure 2.25 Black-Jacketed Fiber installation Example

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 2.24*.

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

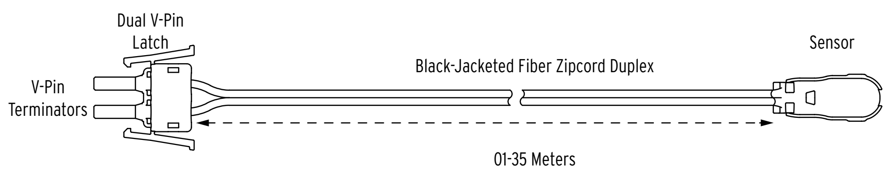
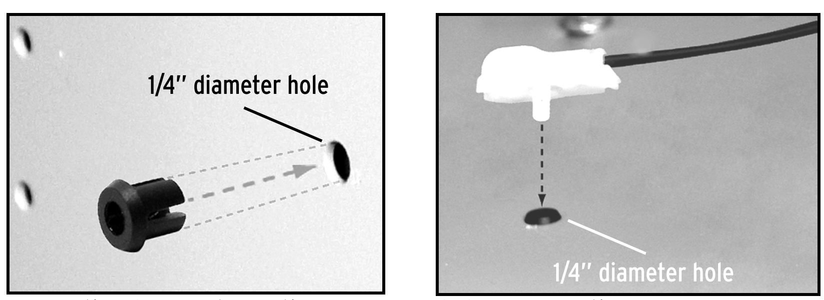


Figure 2.26 Point-Sensor Assembly

The sensor is mounted flush on the switchgear cabinet wall, using a standard 1/4-inch hole. Mounting steps are shown in *Figure 2.27*.



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

Figure 2.27 Point-Sensor Installation

The point sensor is omnidirectional with a slight loss of sensitivity at the fiber entry point. *Figure 2.28* through *Figure 2.30* 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.

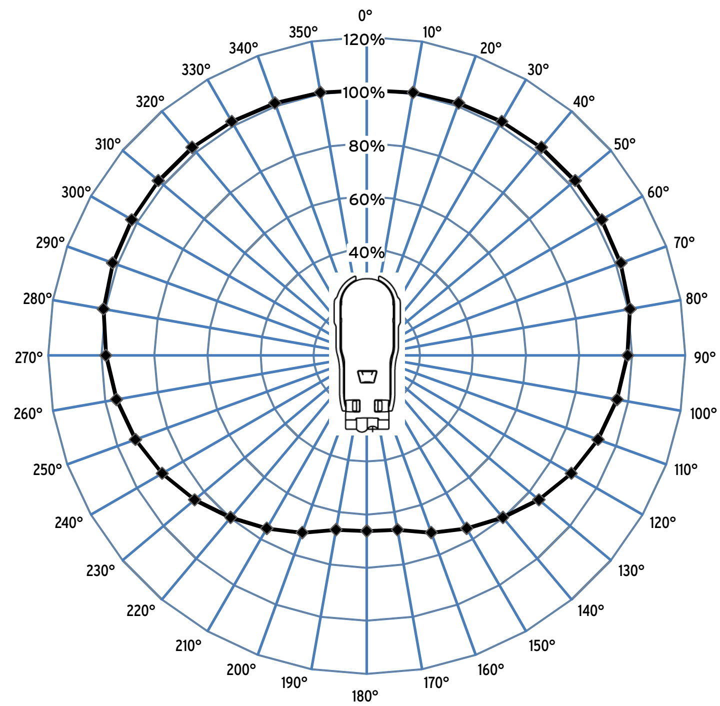


Figure 2.28 Point-Sensor Directivity (0–360° Around the Mounting Plane)

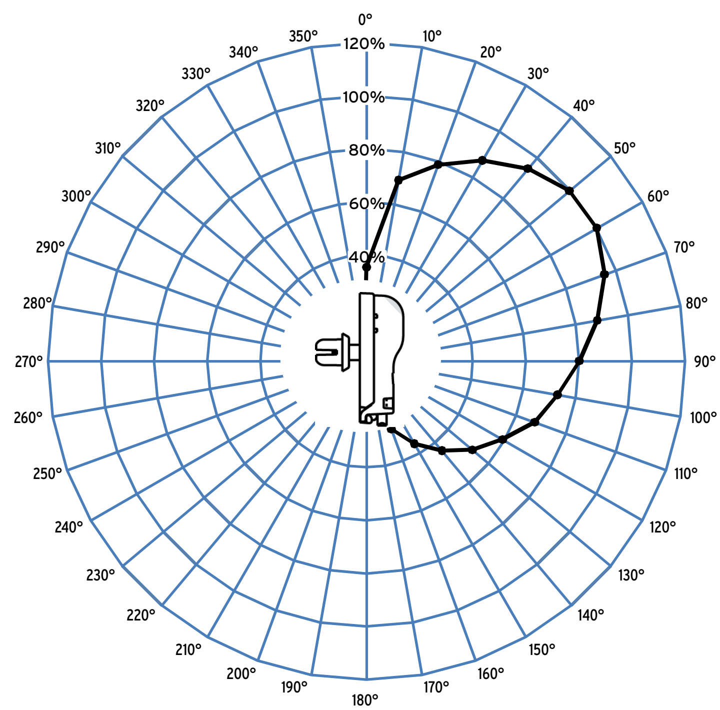


Figure 2.29 Point-Sensor Directivity (Front to Back, Above the Mounting Plane)

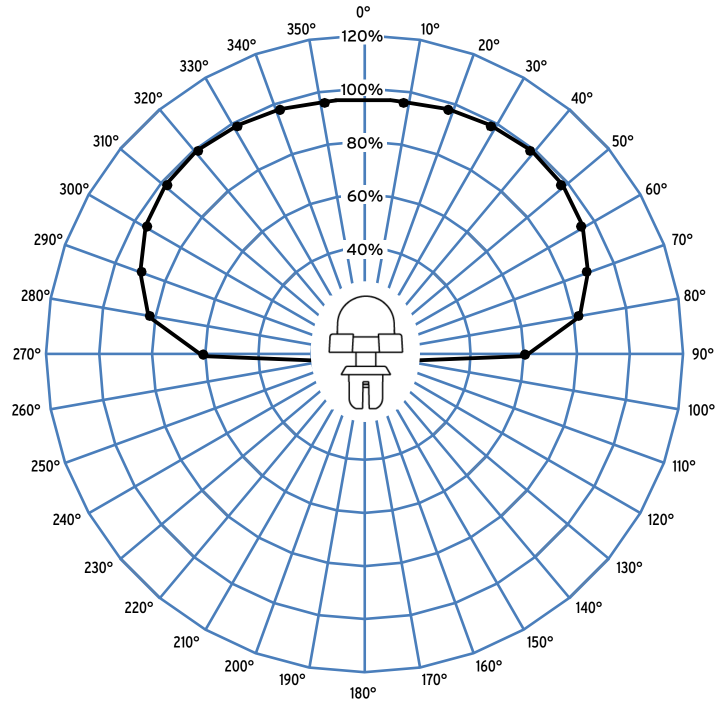
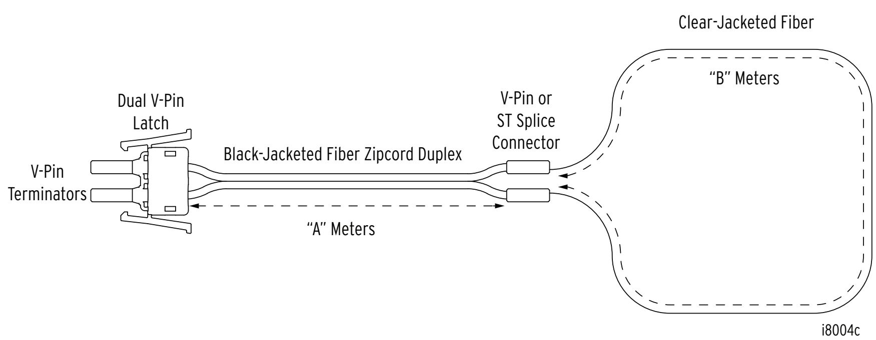


Figure 2.30 Point-Sensor Directivity (Left to Right, Above the Mounting Plane)

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 2.31* shows a schematic diagram of the clear-jacketed fiber sensor. *Figure 2.32* 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 2.31 Clear-Jacketed Fiber Sensor Assembly

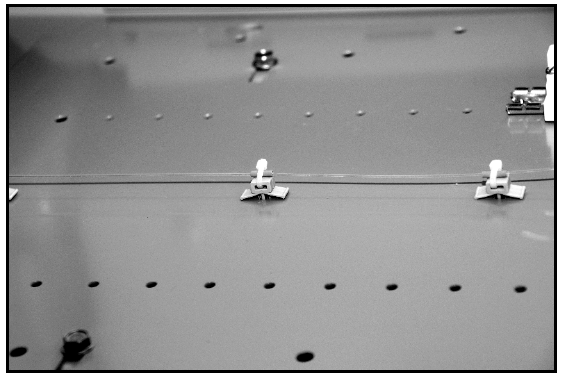


Figure 2.32 Clear-Jacketed Fiber Sensor Mounting Example

A clear-jacketed fiber sensor consists of the major components shown in *Figure 2.33*. 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 2.34*. The ST® connector option is generally superior because of positive locking.

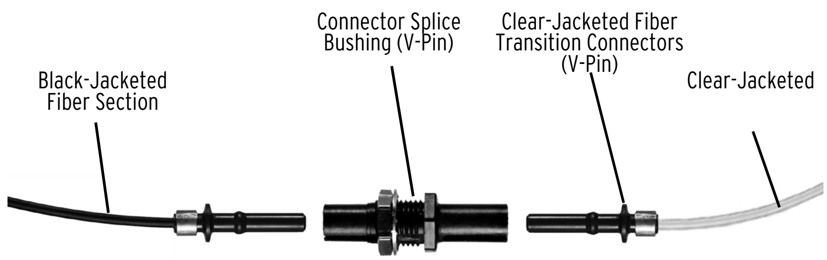
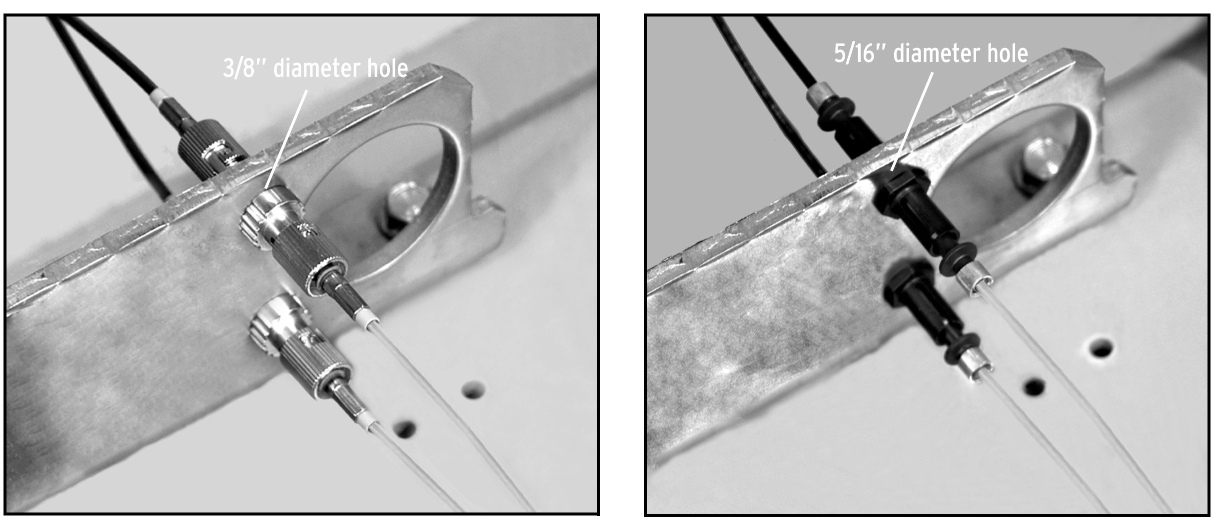


Figure 2.33 Clear-Jacketed Fiber Sensor Components (V-Pin Style)

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 2.34*.



ST Connection (3/8″ diameter hole)

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

Figure 2.34 Clear-Jacketed Fiber Sensor Showing Transition From Clear- to Black-Jacketed Fiber Section

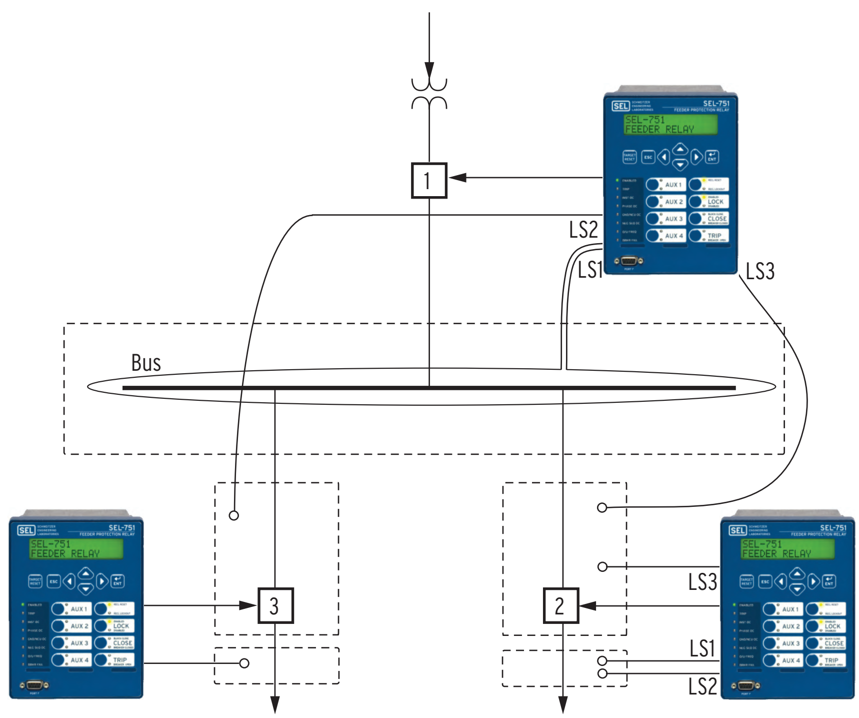
The clear-jacketed fiber loop should be returned through the same general area as the forward path, providing dual opportunity to sense the same arc-flash event. This approach ensures that the maximum distance between the relay and the light-producing event remains below 35 m, irrespective of the SEL-751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

Application Example

Figure 2.35 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 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 2.35*). 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 2.35 Switchgear Application Example

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 10: Testing and Troubleshooting* for detailed testing and troubleshooting information.

The only two components that can be replaced in the field are the power supply fuse and the real-time clock battery. A lithium battery powers the clock (date and time) if the external power source is lost or removed. The battery is a 3 V lithium coin cell, Ray-O-Vac® BR2335 or equivalent. At room temperature (25°C), the battery 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 four rear-panel screws and the relay rear panel.

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

Step 4. Locate the fuse on the board.

Step 5. Remove the fuse from the fuse holder.

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

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

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

Real-Time Clock Battery Replacement

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

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

Step 1. De-energize the relay.

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

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

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

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

Properly dispose of the old battery.

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

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

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

Step 9. Set the relay date and time.

Section 3
PC Software

Overview

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

Table 3.1 SEL Software Solutions

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

This section describes how to get started with the SEL-751 and ACSELERATOR QuickSet SEL-5030 Software. ACSELERATOR 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 ACSELERATOR QuickSet applications provided for the SEL-751.

Table 3.2 ACSELERATOR QuickSet SEL-5030 Software

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.
Setting Database Management	ACSELERATOR 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 ACSELERATOR QuickSet and device-specific ACSELERATOR QuickSet context help.

[a] Available only in licensed versions of ACSELERATOR QuickSet.

Setup

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

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

Step 2. Apply power to the SEL-751.

Step 3. Start ACSELERATOR QuickSet.

Communications

ACSELERATOR 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 ACSELERATOR QuickSet to communicate effectively with the relay.

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

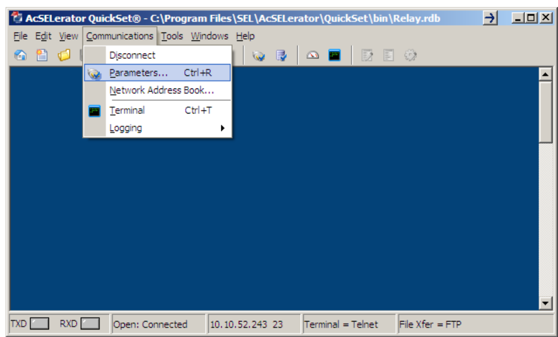


Figure 3.1 Serial Port Communications Dialog Box

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

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

Step 4. Configure ACSELERATOR QuickSet to match the SEL-751 default settings by entering Access Level 1 and Access Level 2 passwords in the respective text boxes.

Step 5. For network communications, select **Network** from the Active Connection Type drop-down menu and enter the network parameters as shown in *Figure 3.3*.

For the SEL-751, always select FTP as the File Transfer Option.

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

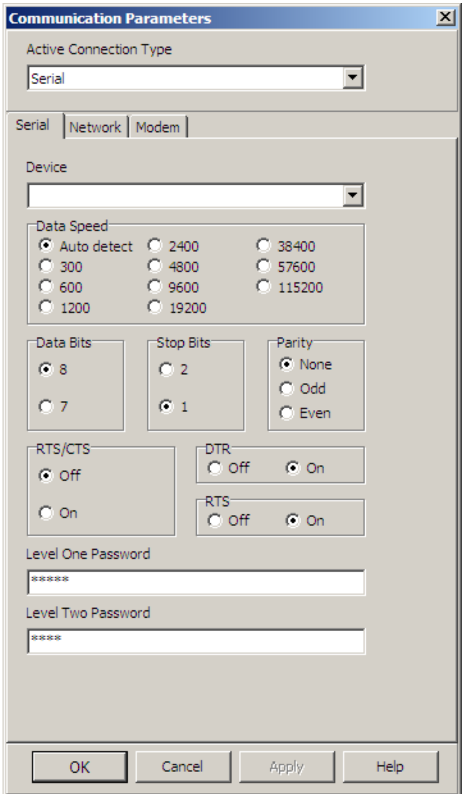


Figure 3.2 Serial Port Communication Parameters Dialog Box

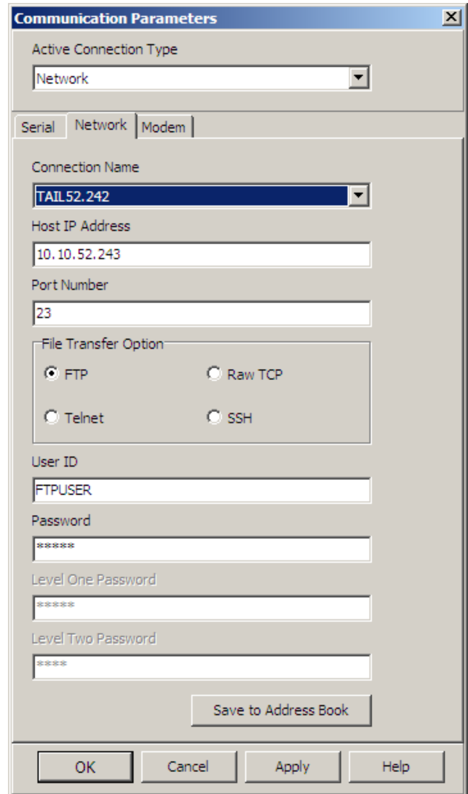


Figure 3.3 Network Communication Parameters Dialog Box

Terminal

Terminal Window

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

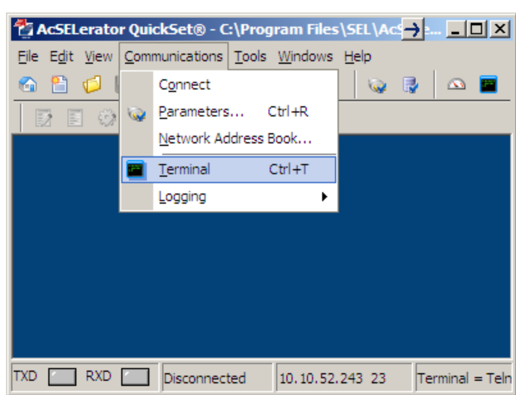


Figure 3.4 Tools Menu

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

Verify proper communications with the relay by opening a terminal window, pressing **<Enter>** a few times, and verifying that a prompt is received. If a prompt is not received, verify proper setup.

Terminal Logging

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

Drivers and Part Number

After clicking **Communications > Terminal**, access the relay at Access Level 1. Issue the **ID** command to receive an identification report, as shown in *Figure 3.5*.

```
=ID <Enter>
"FID=SEL-751-R100-V0-Z001001-D20110504","08EE"
"BFID=BOOTLDR-R500-V0-Z000000-D20090925","0952"
"CID=9B42","025E"
"DEVID=SEL-751","0408"
"DEVCODE=77","0316"
"PARTNO=75101B6X3X7183021X","06D9"
"CONFIG=11251201","03F0"
"iedName =TEMPLATE","05DC"
"type =SEL_751","04B0"
"configVersion =ICD-751-R100-V0-Z001001-D20070326","0D75"
=
```

Figure 3.5 Device Response to the ID Command

Locate and record the Z-number (Z001001) in the FID string. The first portion of the Z-number (Z001…) determines the ACSELERATOR QuickSet relay settings driver version when you are creating or editing relay settings files. The use of the Device Editor driver version will be discussed in more detail later in this section—see *Settings Editor (Editor Mode) on page 3.8*. Compare the part number (`PARTNO=7510XXXXXXXXXXXXXX`) with the Model Option Table (MOT) to ensure the correct relay configuration.

Settings Database Management and Drivers

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

Active Database

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

Database Manager

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

Settings Database

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

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

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

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

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

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

Copy/Move Settings Between Databases

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

Step 2. Click the **Open B** option button to open a relay database.

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

a. Highlight a device or setting in the **A** database,

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

Step 4. Reverse this process to take devices from the **B** database to the **A** database. **Copy** creates an identical device that appears in both databases. **Move** removes the device from one database and places the device in another database.

Create a New Database, Copy an Existing Database

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

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

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

Step 3. Click **OK**.

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

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

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

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

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

Settings

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

Settings Editor

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 ACSELERATOR QuickSet menus. ACSELERATOR QuickSet shows all of the settings categories in the settings tree view. The settings tree view remains constant whether settings categories are enabled or disabled. However, any disabled settings are dimmed when accessed by clicking an item in the tree view.

Settings Menu

ACSELERATOR QuickSet uses a database to store and manage SEL relay settings. Each unique relay has its own record of settings. Use the **File** menu to **Open** an existing record, create and open a **New** record, or **Read** relay settings from a connected SEL-751 and then create and open a new record. Use **Tools** menu to **Convert** and open an existing record. The record will be opened in the **Setting Editor** as a **Setting Form** (template) or in **Editor Mode**.

Table 3.3 File/Tools Menus

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

File > New

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

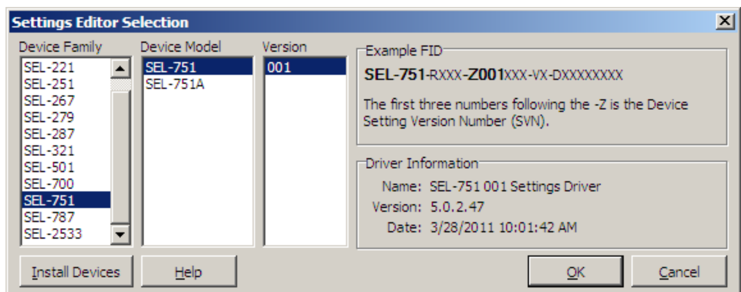


Figure 3.6 Selection of Drivers

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

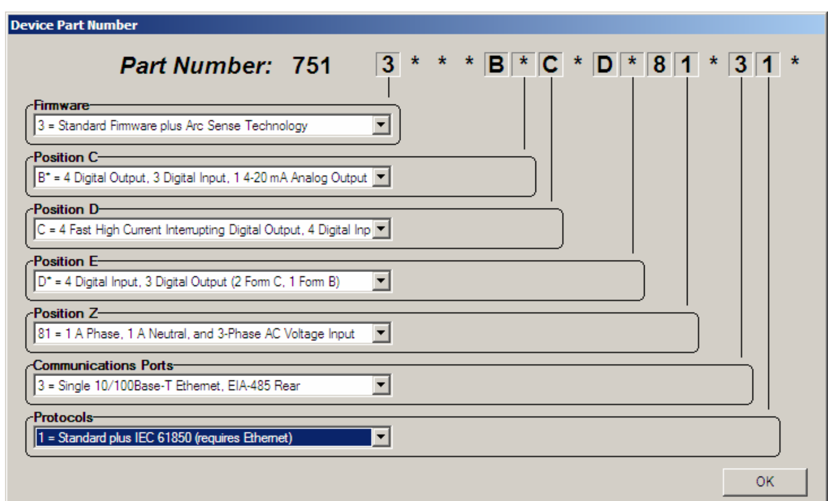


Figure 3.7 Update Part Number

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

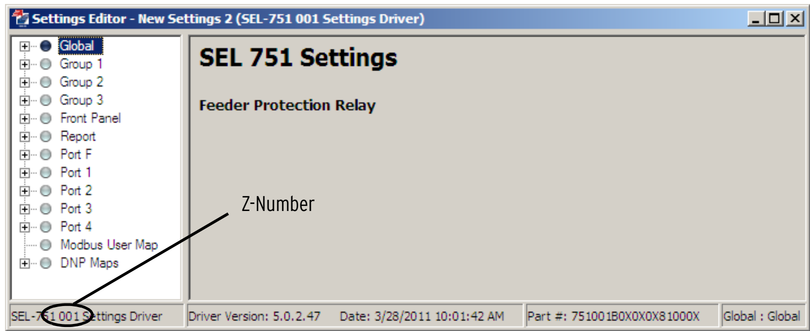


Figure 3.8 New Setting Screen

File > Open

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

File > Read

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

Tools > Settings > Convert

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

Settings Editor (Editor Mode)

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

Entering Settings

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

Step 1. Click the **+** marks and the buttons in the **Settings Tree View** to expand and select the settings you want to change.

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

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

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

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

Expression Builder

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

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

Access the Expression Builder

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

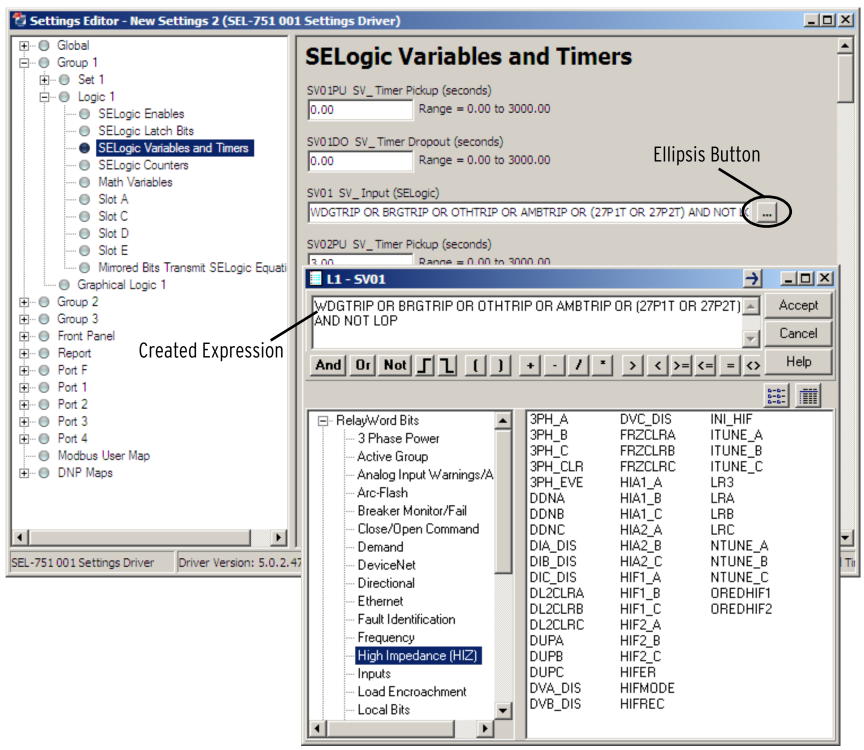


Figure 3.9 Expressions Created With Expression Builder

Expression Builder Organization

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

Using the Expression Builder

Use the right side of the equation (RVALUE) to select broad categories of device elements, analog quantities, counters, timers, latches, and logic variables. Select a category in the RVALUE tree view, and the **Expression**

Builder displays all operands for that category in the list box at the bottom right side. Directly underneath the right side of the equation, choose operators to include in the RVALUE. These operators include basic logic, rising- and falling-edge triggers, expression compares, and comments.

File > Save

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

File > Send

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

Edit > Part Number

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

Text Files

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

Event Analysis

ACSELERATOR QuickSet has integrated analysis tools that help you retrieve information about relay operations quickly and easily. Use the event information that the SEL-751 stores to evaluate the performance of a system (select **Tools > Events > Get Event Files**). *Figure 3.10* shows composite screens for retrieving events.

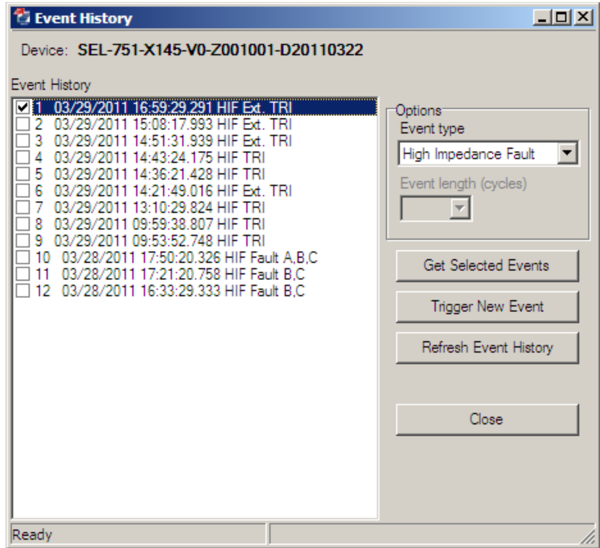


Figure 3.10 Composite Screens for Retrieving Events

Event Waveforms

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

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

View Event History

You can retrieve event files stored in the relay and transfer these files to a computer. For information on the types of event files and data capture, see *Section 9: Analyzing Events*. To download event files from the device, click **Tools > Events > Get Event Files**. The **Event History** dialog box appears, as shown in *Figure 3.10*.

The SEL-751 is capable of capturing three types of events (4 samples/cycle filtered, 32 samples/cycle raw, and high-impedance fault). The drop down menu under Event Type allows the selection of which type to retrieve.

Get Event

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

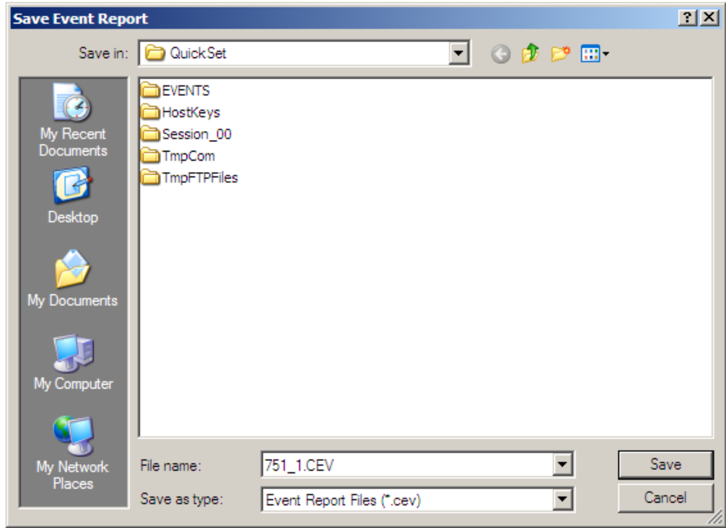


Figure 3.11 Saving the Retrieved Event

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

View Event Files

To view the saved events, you need the SEL-5601 software package. Use the **View Event Files** function from the **Tools > Events** menu to select the event you want to view (ACSELERATOR QuickSet remembers the location where you stored the previous event record). Use **View Combined Event Files** to simultaneously view as many as three separate events.

Meter and Control

Click on **Tools > HMI > HMI** to bring up the screen shown in *Figure 3.12*. The HMI tree view shows all the functions available from the HMI function. Unlike the self-configuration of the device, the HMI tree remains the same regardless of the type of cards installed. For example, if no Analog Input card is installed, the Analog Input function is still available, but the device responds as follows:

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

Device Overview

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

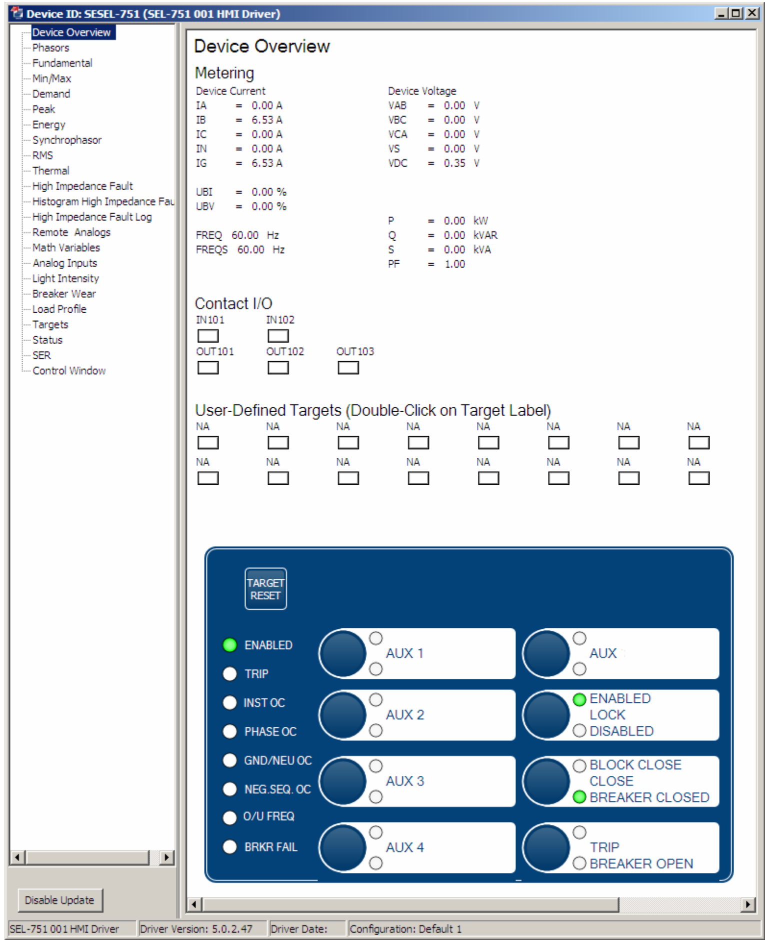


Figure 3.12 Device Overview Screen

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

The front-panel LEDs display the status of the 24 front-panel LEDs. Use the front-panel settings to change the front-panel LED assignment. The **Fundamental**, **Min/Max**, **Energy**, etc., screens display the corresponding values.

Click on the **Targets** button to view the status of all the Relay Word bits. When a Relay Word bit has a value of 1 (ENABLED = 1), the Relay Word bit is asserted. Similarly, when a Relay Word bit has a value of 0 (RB02 = 0), the Relay Word bit is deasserted.

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

Figure 3.13 shows the control screen. From here you can reset metering data clear the Event History, SER, MIRRORED BITS report, LDP, or trigger events. You can also reset the targets, synchronize with IRIG, and set the time and date. If supported, you can run arc-flash sensor diagnostic tests.

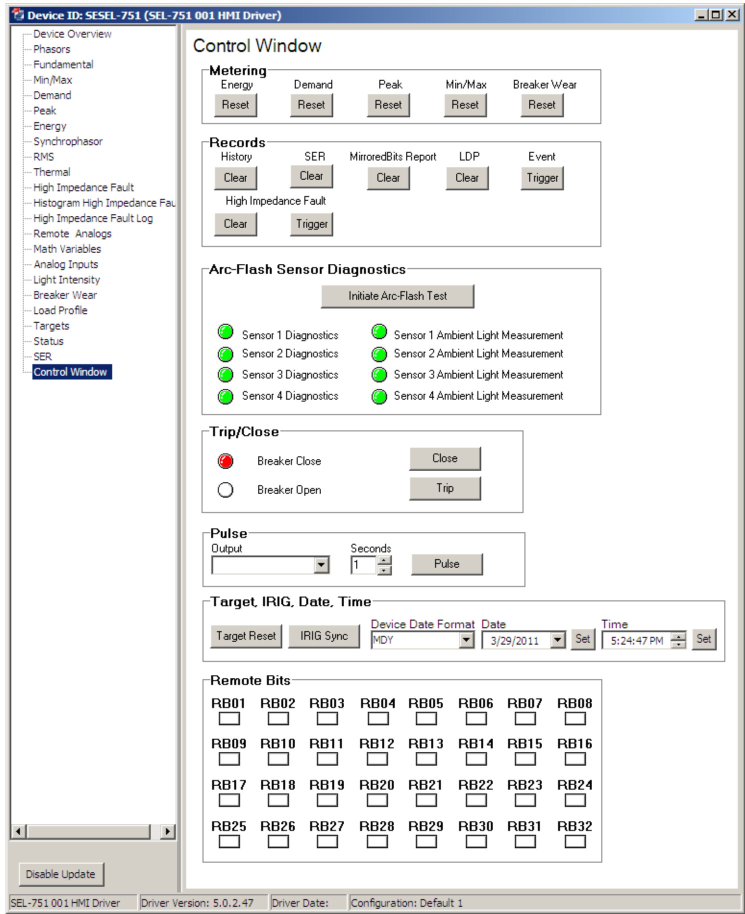


Figure 3.13 Control Screen

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

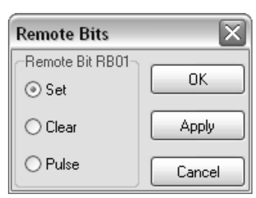


Figure 3.14 Remote Operation Selection

ACSELERATOR QuickSet Help

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

Table 3.4 ACSELERATOR QuickSet Help

Help	Description
General ACSELERATOR QuickSet	Select **Help** from the main menu bar
SEL-751 Settings	Select **Settings Help** from the **Help** menu bar while the **Settings Editor** is open.
Database Manager	Select **Help** from the bottom of the **Database Manager** window

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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 will need to know about the protected equipment before calculating the relay settings.

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

Current-Based Protection. Lists settings for protection elements included in all models of the SEL-751, including the overcurrent elements.

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

Voltage-Based Protection. Lists settings associated with undervoltage, overvoltage, power factor, synchronism-check elements, fault locator, load-encroachment, and directional element.

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

High-Impedance Fault Detection. Lists settings associated with high-impedance fault detection.

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 settings associated with demand metering.

Logic Settings (SET L Command). Lists settings associated with latches, timers, and output contacts.

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

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

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

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

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

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

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

Breaker Monitor. Lists settings and describes the breaker monitor function that you can use for scheduling circuit breaker maintenance.

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

Data Reset. Lists 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.

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

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

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

DNP Map Settings (Set DNP n Command, n = 1, 2, or 3). Shows DNP user map register settings.

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

See *Section 6: Settings* for the 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 G.1).

You can enter the settings by using the front-panel `SET RELAY` function (see *Section 8: Front-Panel Operations*), the serial port (see *Section 7: Communications*), the EIA-485 port (see *Appendix E: Modbus RTU Communications*), or the Ethernet port (see *Section 7: Communications*).

Application Data

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

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

Group Settings (SET Command)

ID Settings

All models of the SEL-751 have the identifier settings described in *Table 4.1*.

Table 4.1 Identifier Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
UNIT ID LINE 1	16 Characters	RID := SEL-751
UNIT ID LINE 2	16 Characters	TID := FEEDER RELAY

The SEL-751 prints the Relay and Terminal Identifier strings at the top of the responses to serial port commands to identify messages from individual relays.

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

Configuration Settings

Table 4.2 CT Configuration Settings

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

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

EXAMPLE 4.1 Phase CT Ratio Setting Calculation

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

Table 4.3 shows the voltage settings.

Table 4.3 Voltage Configuration Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PHASE PT RATIO	1.00–10000.00	PTR := 180
SYNCV PT RATIO	1.00–10000.00	PTRS :=180
XFMR CONNECTION	WYE, DELTA	DELTA_Y := DELTA
LINE VOLTAGE	OFF, 20–250 V[a]	VNOM := 120
SINGLE V INPUT	Y, N	SINGLEV := N

[a] The line voltage setting range is 20–440 if DELTA_Y := WYE.

These settings configure the relay voltage inputs to correctly measure and scale the voltage signals. Set the phase PT ratio (PTR) setting equal to the VT ratio. The synchronism-check voltage input **VS** is an optional single phase-neutral or phase-phase voltage input. Set the synchronism-check voltage input PT ratio (PTRS) setting equal to the VT ratio of the **VS** input.

EXAMPLE 4.2 Phase VT Ratio Setting Calculations

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

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

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

In applications where only a single voltage is available, set SINGLEV equal to Y. As shown in *Figure 2.16*, the single voltage must be connected to the A-phase input, but it can be an A-N or an A-B voltage. Be sure to set DELTA_Y equal to WYE for an A-N input or DELTA_Y equal to DELTA for an A-B input voltage.

When you set SINGLEV equal to Y, the relay performance changes in the following ways:

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

Table 4.4 Effect on Group Settings When SINGLEV = Y

Group Setting	Change	Reason
Identifier Settings		
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		
ELOAD, EFLOC	Forced to N and hidden	These functions require three-phase voltage.
Directional Element Settings (available when EDIR = Y)		
ORDER	Q, V removed from setting range	Associated directional element requires three-phase voltage.
50PDIRP, Z2F, Z2R, a2, k2, 50QFP, 50QRP	Hidden	Associated voltage elements require three-phase voltage.
59Q1P, 59Q2P	Forced to OFF and hidden	These functions require three-phase voltage.

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, 20–440 V (l-l).

Note that the VNOM setting is always in line-to-line voltage, even when set for a wye configuration. You should be careful to use a solidly-grounded wye system for VNOM inputs greater than 250 V (l-l) to avoid a 1.73 increase in terminal voltages from a line-to-ground fault.

Table 4.5 Main Relay Functions That Change With VNOM = OFF

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

Line Parameter Settings

Table 4.6 Line Parameter Settings

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

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

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

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

If the protected line belongs to a hybrid power system, such as shown in *Figure 4.35*, 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)

Current-Based Protection

Overcurrent Elements

Four levels of instantaneous/definite-time elements are available for phase, neutral, residual, and negative-sequence overcurrent as shown in *Table 4.7* through *Table 4.10* and in *Figure 4.1*.

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

Table 4.7 Maximum Phase Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
MAXP OC TRIP LVL	OFF, 0.50–100.00 A[a] 0.10–20.00 A[b]	50P1P := 10.00 50P1P := 2.00
MAXP OC TRIP DLY	0.00–400.00 sec	50P1D := 0.00
MAXP OC TRQ CON	SELOGIC	50P1TC := 1
MAXP OC TRIP LVL	OFF, 0.50–100.00 A[a] 0.10–20.00 A[b]	50P2P := 10.00 50P2P := 2.00
MAXP OC TRIP DLY	0.00–400.00 sec	50P2D := 0.00
MAXP OC TRQ CON	SELOGIC	50P2TC := 1
MAXP OC TRIP LVL	OFF, 0.50–100.00 A[a] 0.10–20.00 A[b]	50P3P := 10.00 50P3P := 2.00
MAXP OC TRIP DLY	0.00–400.00 sec	50P3D := 0.00
MAXP OC TRQ CON	SELOGIC	50P3TC := 1
MAXP OC TRIP LVL	OFF, 0.50–100.00 A[a] 0.10–20.00 A[b]	50P4P := 10.00 50P4P := 2.00
MAXP OC TRIP DLY	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.

The phase instantaneous overcurrent elements (50P1 through 50P4; see *Figure 4.1*) normally operate by using the output of the one cycle cosine-filtered phase current. During severe CT saturation, the cosine-filtered phase current magnitude can be substantially reduced because of the high harmonic content and reduced magnitude of the distorted secondary waveform. If the overcurrent element relied only on the output of the cosine-filtered secondary current, the operation of any high-set instantaneous overcurrent element might be severely delayed and jeopardized. For any phase instantaneous overcurrent element in the SEL-751 that is set greater than eight times the relay current input rating (40 A in a 5 A relay), the overcurrent element also operates on the output of a bipolar peak detector if the current waveform is highly distorted, as is the case with severe CT saturation. This ensures fast operation of the 50P*n* phase overcurrent elements even with severe CT saturation.

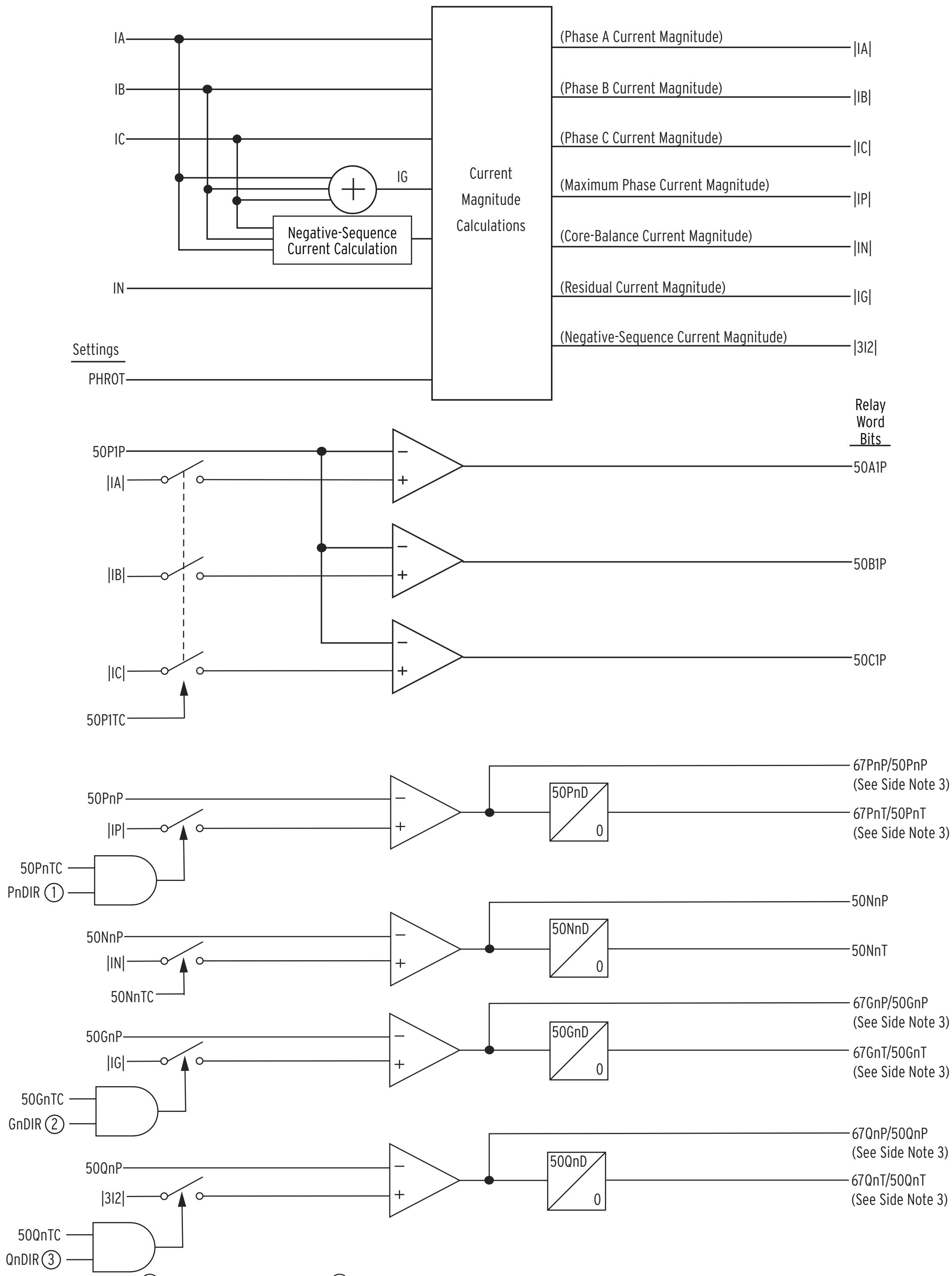
When the harmonic distortion index exceeds the fixed threshold, which indicates severe CT saturation, the phase overcurrent elements operate on the output of the peak detector. When the harmonic distortion index is below the fixed threshold, the phase overcurrent elements operate on the output of the cosine filter.

Table 4.8 Neutral Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
NEUT OC TRIP LVL	OFF, 0.50–100.00 A[a] 0.10–20.00 A[b]	50N1P := OFF
NEUT OC TRIP DLY	0.00–400.00 sec	50N1D := 0.50
NEUT OC TRQ CON	SELOGIC	50N1TC := 1
NEUT OC TRIP LVL	OFF, 0.50–100.00 A[a] 0.10–20.00 A[b]	50N2P := OFF
NEUT OC TRIP DLY	0.00–400.00 sec	50N2D := 0.50
NEUT OC TRQ CON	SELOGIC	50N2TC := 1
NEUT OC TRIP LVL	OFF, 0.50–100.00 A[a] 0.10–20.00 A[b]	50N3P := OFF
NEUT OC TRIP DLY	0.00–400.00 sec	50N3D := 0.50
NEUT OC TRQ CON	SELOGIC	50N3TC := 1
NEUT OC TRIP LVL	OFF, 0.50–100.00 A[a] 0.10–20.00 A[b]	50N4P := OFF
NEUT OC TRIP DLY	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.

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



① To Figure 4.32 ② From Figure 4.26 ③ From Figure 4.31

In Figure , Residual Current Magnitude IIGI is calculated residual current. Not shown in the figure, Relay Word Bit ORED50T is asserted if any of the 50PnT, 50NnT, 50GnT, 50QnT, 67PnT, 67QnT or 67GnT Relay Word Bits are asserted (n = 1 to 4).

- When EDIR := N, use 50PnT, 50QnT, and 50GnT as 67PnT, 67QnT, and 67GnT are non-functional.
- When EDIR := Y, use 67PnT, 67QnT, and 67GnT as 50PnT, 50QnT, and 50GnT are non-functional.
- When the directional control option is not ordered, EDIR is automatically set to N and hidden. Use 50PnT, 50QnT, and 50GnT as 67PnT, 67QnT, and 67GnT are non functional.

Figure 4.1 Instantaneous Overcurrent Element Logic

When a core-balance CT is connected to the relay **IN** input, as in *Figure 2.23*, use the neutral overcurrent element to detect the ground faults. Calculate the trip level settings based on the available ground fault current and the core-balance CT ratio.

Table 4.9 Residual Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
RES OC TRIP LVL	OFF, 0.50–100.00 A [a] 0.10–20.00 A [b]	50G1P := OFF
RES OC TRIP DLY	0.00–400.00 sec	50G1D := 0.50
RES OC TRQ CON	SELOGIC	50G1TC := 1
RES OC TRIP LVL	OFF, 0.50–100.00 A [a] 0.10–20.00 A [b]	50G2P := OFF
RES OC TRIP DLY	0.00–400.00 sec	50G2D := 0.50
RES OC TRQ CON	SELOGIC	50G2TC := 1
RES OC TRIP LVL	OFF, 0.50–100.00 A [a] 0.10–20.00 A [b]	50G3P := OFF
RES OC TRIP DLY	0.00–400.00 sec	50G3D := 0.50
RES OC TRQ CON	SELOGIC	50G3TC := 1
RES OC TRIP LVL	OFF, 0.50–100.00 A [a] 0.10–20.00 A [b]	50G4P := OFF
RES OC TRIP DLY	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 4.10 Negative-Sequence Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
NSEQ OC TRIP LVL	OFF, 0.50–100.00 A [a] 0.10–20.00 A [b]	50Q1P := OFF
NSEQ OC TRIP DLY	0.1–400.0 sec	50Q1D := 0.2
NSEQ OC TRQ CON	SELOGIC	50Q1TC := 1
NSEQ OC TRIP LVL	OFF, 0.50–100.00 A [a] 0.10–20.00 A [b]	50Q2P := OFF
NSEQ OC TRIP DLY	0.1–400.0 sec	50Q2D := 0.2
NSEQ OC TRQ CON	SELOGIC	50Q2TC := 1
NSEQ OC TRIP LVL	OFF, 0.50–100.00 A [a] 0.10–20.00 A [b]	50Q3P := OFF
NSEQ OC TRIP DLY	0.1–400.0 sec	50Q3D := 0.2
NSEQ OC TRQ CON	SELOGIC	50Q3TC := 1
NSEQ OC TRIP LVL	OFF, 0.50–100.00 A [a] 0.10–20.00 A [b]	50Q4P := OFF
NSEQ OC TRIP DLY	0.1–400.0 sec	50Q4D := 0.2
NSEQ OC TRQ CON	SELOGIC	50Q4TC := 1

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

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

Pickup and Reset Time Curves

Figure 4.2 and *Figure 4.3* 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 4.2 is not valid for conditions with a saturated CT, where the resultant current to the relay is nonsinusoidal.

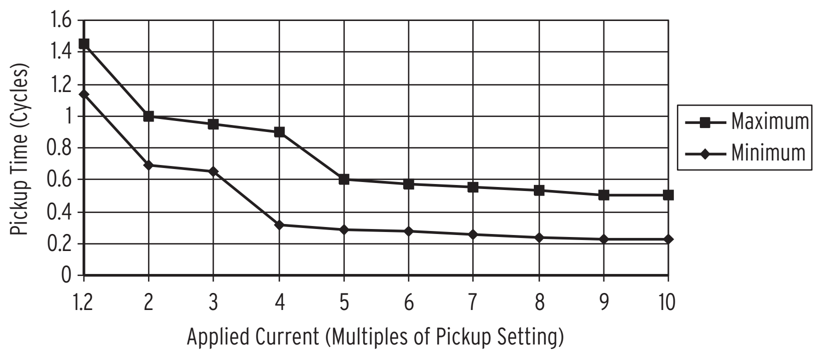


Figure 4.2 Instantaneous Overcurrent Element Pickup Time Curve

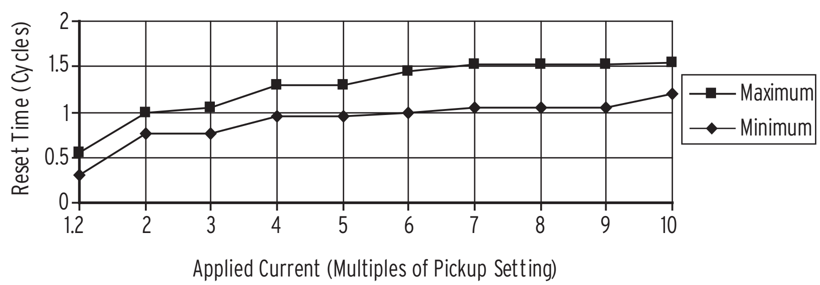


Figure 4.3 Instantaneous Overcurrent Element Reset Time Curve

Time-Overcurrent Elements

One level of inverse time element is available for phase A, B, C, and negative-sequence overcurrent. Also, two levels of inverse time elements are available for maximum phase, neutral, and residual overcurrent. See *Table 4.11* through *Table 4.15* for available settings.

You can select from five U.S. and five IEC inverse characteristics. *Table 4.14* and *Table 4.15* show equations for the curves and *Figure 4.9* through *Figure 4.18* 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.

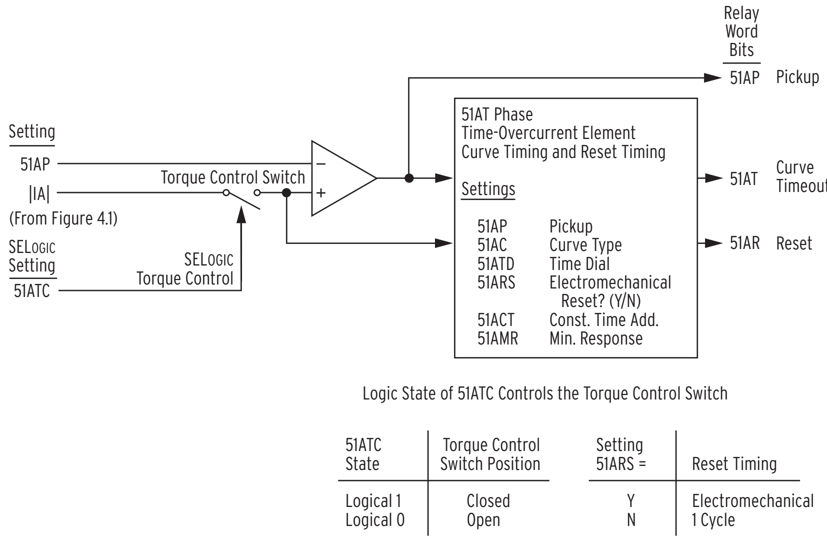
Each element can be torque controlled through use of appropriate SELOGIC control equations (e.g., when 51P1TC := IN401 the 51P1 element will be operational only if IN401 is asserted).

Table 4.11 Phase A, B, and C Time-Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
TOC TRIP LVL	OFF, 0.50–16.00 A[a], 0.10–3.20 A[b]	51AP := 6.00 51AP := 1.2
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51AC := U3
TOC TIME DIAL	0.50–15.00[c], 0.05–1.50[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, 0.50–16.00 A[a], 0.10–3.20 A[b]	51BP := 6.00 51BP := 1.2
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51BC := U3
TOC TIME DIAL	0.50–15.00[c], 0.05–1.50[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, 0.50–16.00 A[a], 0.10–3.20 A[b]	51CP := 6.00 51CP := 1.2
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51CC := U3
TOC TIME DIAL51_C	0.50–15.00[c], 0.05–1.50[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 4.4*.



Note: 51AT element shown above; 51BT and 51CT are similar.

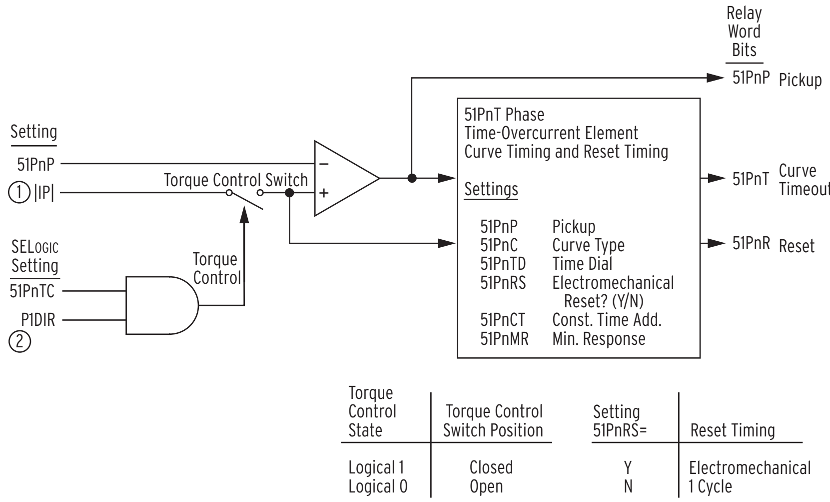
Figure 4.4 Phase Time-Overcurrent Elements 51AT, 51BT, and 51CT

Table 4.12 Maximum Phase Time-Overcurrent

Setting Prompt	Setting Range	Setting Name := Factory Default
TOC TRIP LVL	OFF, 0.50–16.00 A[a], 0.10–3.20 A[b]	51P1P := 6.00 51P1P := 1.2
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51P1C := U3
TOC TIME DIAL	0.50–15.00[c], 0.05–1.50[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, 0.50–16.00 A[a], 0.10–3.20 A[b]	51P2P := 6.00 51P2P := 1.2
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51P2C := U3
TOC TIME DIAL	0.50–15.00[c], 0.05–1.50[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 4.5*.



n = 1, 2.
① From Figure 4.1 ② To Figure 4.32

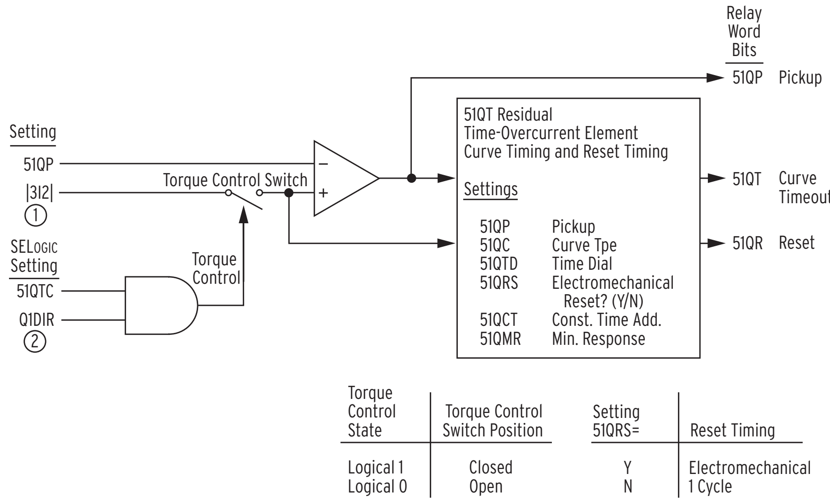
Figure 4.5 Maximum Phase Time-Overcurrent Elements 51P1T and 51P2T

Table 4.13 Negative-Sequence Time-Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
TOC TRIP LVL	OFF, 0.50–16.00 A[a], 0.10–3.20 A[b]	51QP := 6.00 51QP := 1.2
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51QC := U3
TOC TIME DIAL	0.50–15.00[c], 0.05–1.50[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 4.6*.



① From Figure 4.1 ② Figure 4.31

Figure 4.6 Negative-Sequence Time-Overcurrent Element 51QT

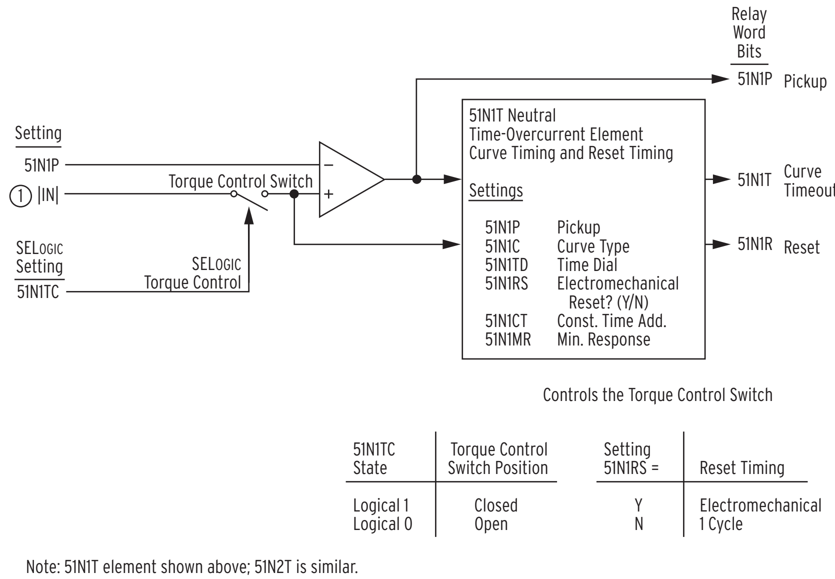
False negative-sequence current can transiently appear when a circuit breaker is closed and balanced load current suddenly appears. To avoid tripping for this transient condition, do not use a time-dial setting that results in curve times slower than three cycles.

Table 4.14 Neutral Time-Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
TOC TRIP LVL	OFF, 0.25–16.00 A[a] 0.05–3.20 A[b]	51N1P := OFF
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51N1C := U3
TOC TIME DIAL	0.50–15.00[c] 0.05–1.50[d]	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, 0.25–16.00 A[a] 0.05–3.20 A[b]	51N2P := OFF
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51N2C := U3
TOC TIME DIAL	0.50–15.00[c] 0.05–1.50[d]	51N2TD := 1.50
EM RESET DELAY	Y, N	51N2RS := N
CONST TIME ADDER	0.00–1.00 sec	51N2CT := 0.00
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 51_C := U_.
[d] For 51_C := C_.

The neutral time-overcurrent elements, 51N1T and 51N2T, respond to neutral channel current IN as shown *Figure 4.7*.



① From Figure 4.1

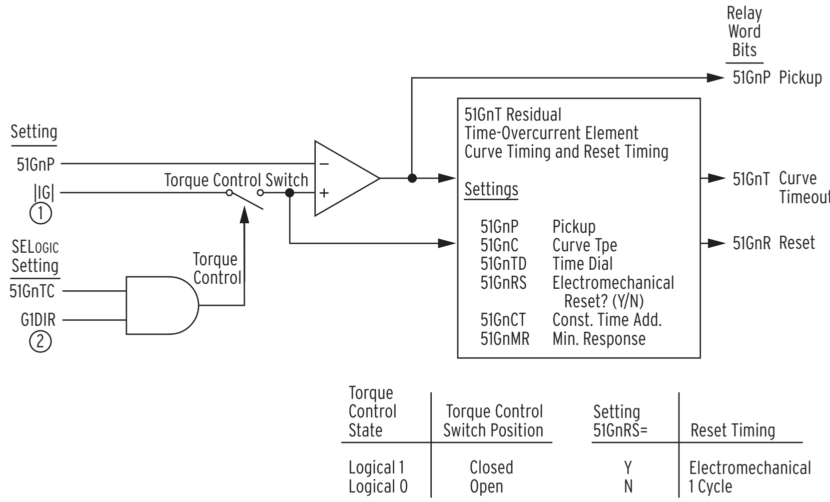
Figure 4.7 Neutral Time-Overcurrent Elements 51N1T and 51N2T

Table 4.15 Residual Time-Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
TOC TRIP LVL	OFF, 0.50–16.00 A[a], 0.10–3.20 A[b]	51G1P := 0.50 51G1P := 0.10
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51G1C := U3
TOC TIME DIAL	0.50–15.00[c], 0.05–1.50[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, 0.50–16.00 A[a], 0.10–3.20 A[b]	51G2P := 0.50 51G2P := 0.10
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51G2C := U3
TOC TIME DIAL	0.50–15.00[c], 0.05–1.50[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 4.8*.



n = 1, 2
① From Figure 4.1 ② From Figure 4.26

Figure 4.8 Residual Time-Overcurrent Elements 51G1T and 51G2T

Time-Overcurrent Curves

The following information describes the curve timing for the curve and time dial settings made for the time-overcurrent elements (see *Figure 4.4* through *Figure 4.8*). The U.S. and IEC time-overcurrent relay curves are shown in *Figure 4.9* through *Figure 4.18*. Curves U1, U2, and U3 (*Figure 4.9* through *Figure 4.11*) conform to IEEE C37.112-1996 IEEE Standard Inverse-Time Characteristic Equations for Overcurrent Relays.

Relay Word Bit ORED51T

Relay Word bit ORED51T is asserted if any of the Relay Word bits 51AT, 51BT, 51CT, 51PIT, 51P2T, 51N1T, 51N2T, 51G1T, 51G2T, or 51QT are asserted.

Table 4.16 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 4.9*
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 4.10*
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 4.11*
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 4.12*
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 4.13*

where:
t_p = operating time in seconds
t_r = electromechanical induction—disk emulation reset time in seconds (if you select electromechanical reset setting)
TD = time-dial setting
M = applied multiples of pickup current [for operating time (t_p), M>1; for reset time (t_r), M≤1]

Table 4.17 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 4.14*
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 4.15*
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 4.16*
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 4.17*
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 4.18*

where:
t_p = operating time in seconds
t_r = electromechanical induction—disk emulation reset time in seconds (if you select electromechanical reset setting)
TD = time-dial setting
M = applied multiples of pickup current [for operating time (t_p), M>1; for reset time (t_r), M≤1]

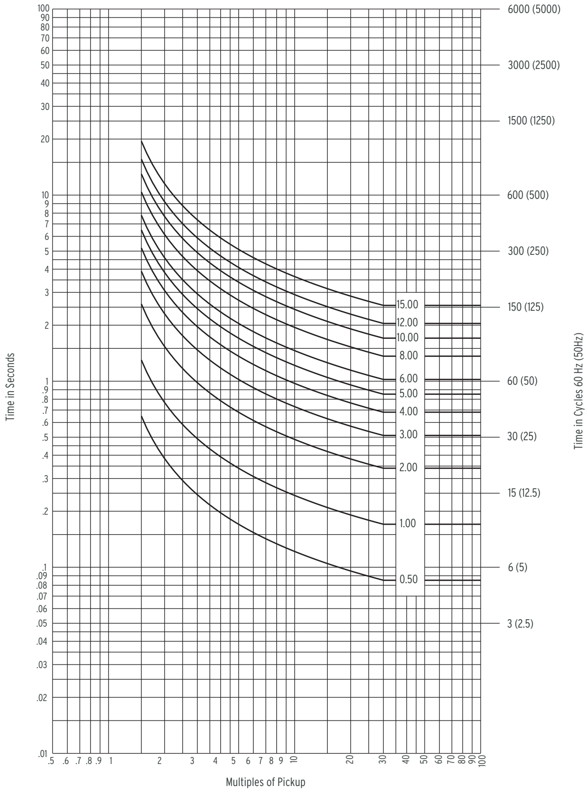


Figure 4.9 U.S. Moderately Inverse Curve: U1

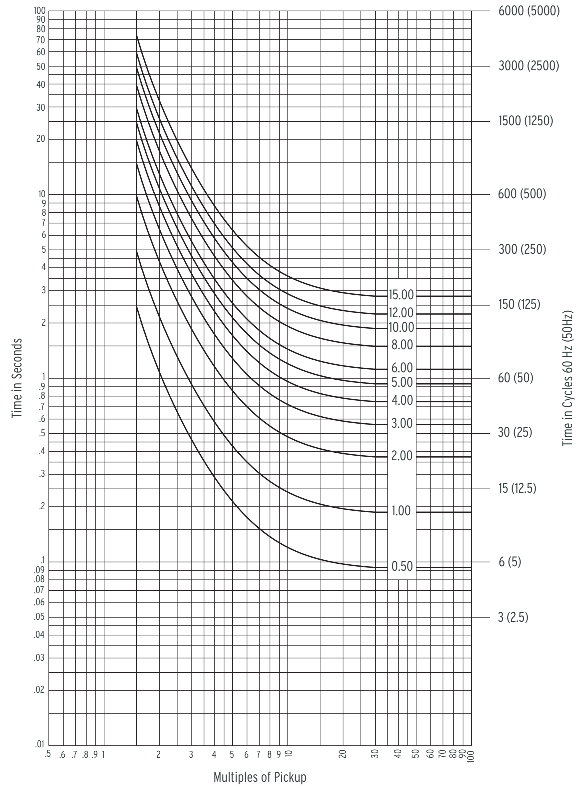


Figure 4.10 U.S. Inverse Curve: U2

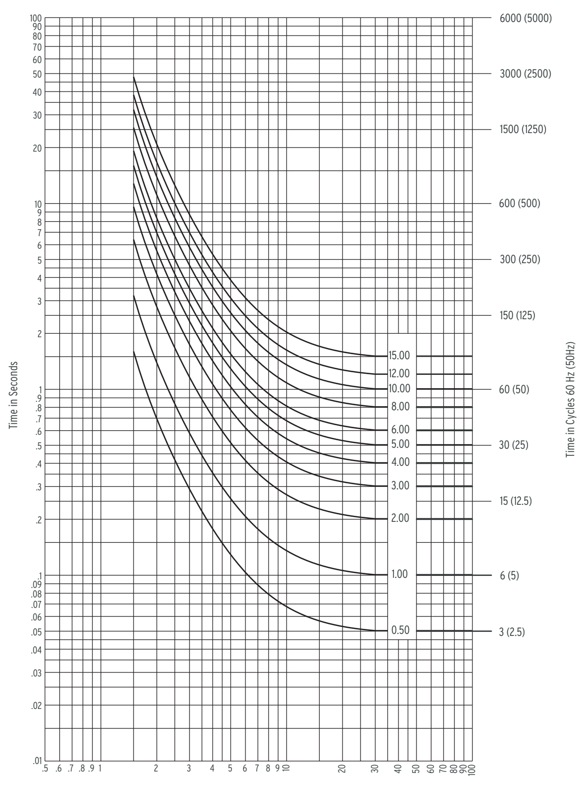


Figure 4.11 U.S. Very Inverse Curve: U3

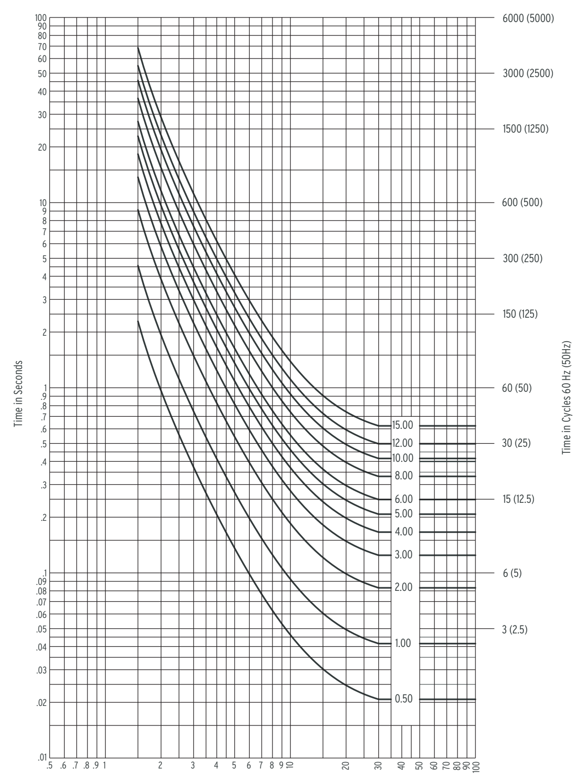


Figure 4.12 U.S. Extremely Inverse Curve: U4

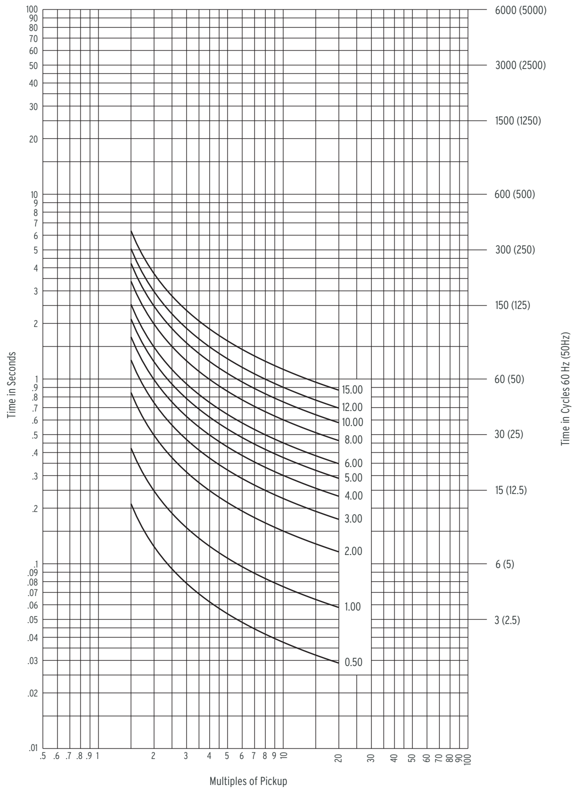


Figure 4.13 U.S. Short-Time Inverse Curve: U5

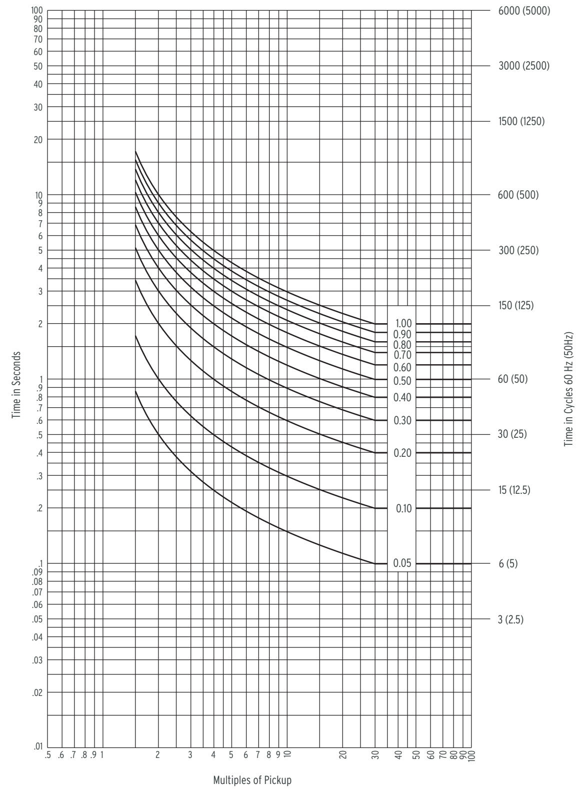


Figure 4.14 IEC Class A Curve (Standard Inverse): C1

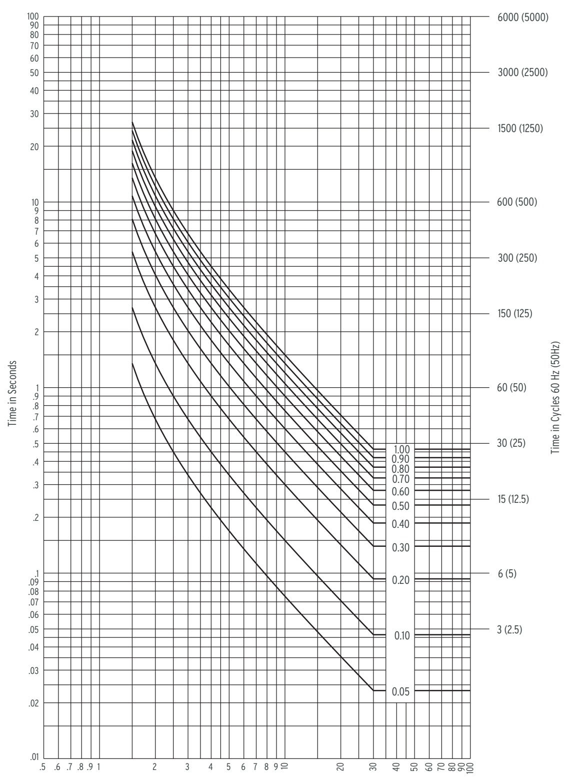


Figure 4.15 IEC Class B Curve (Very Inverse): C2

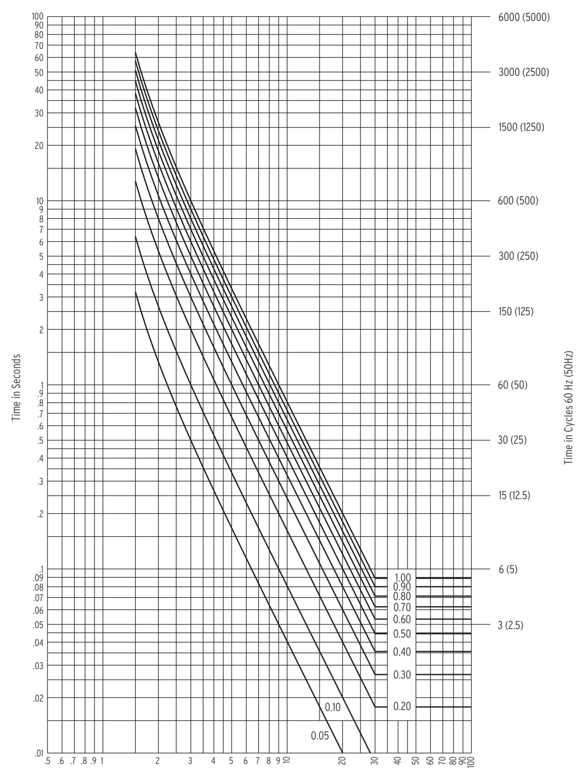


Figure 4.16 IEC Class C Curve (Extremely Inverse): C3

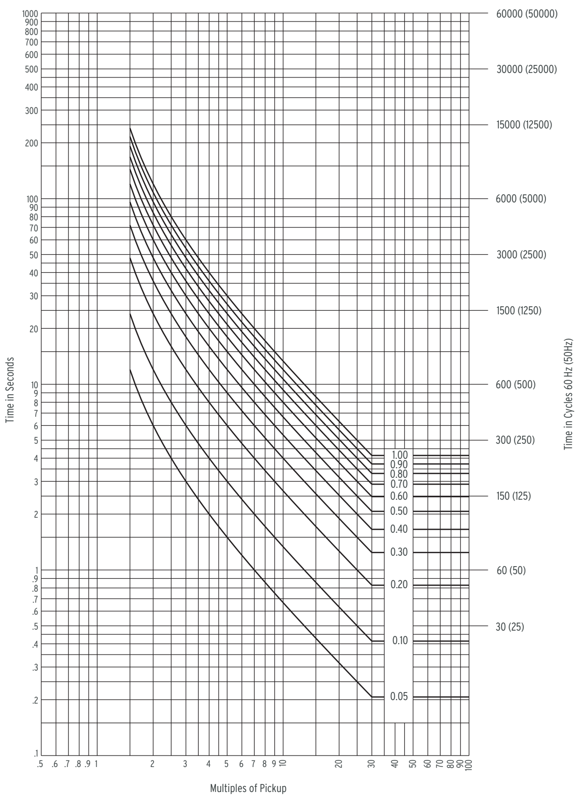


Figure 4.17 IEC Long-Time Inverse Curve: C4

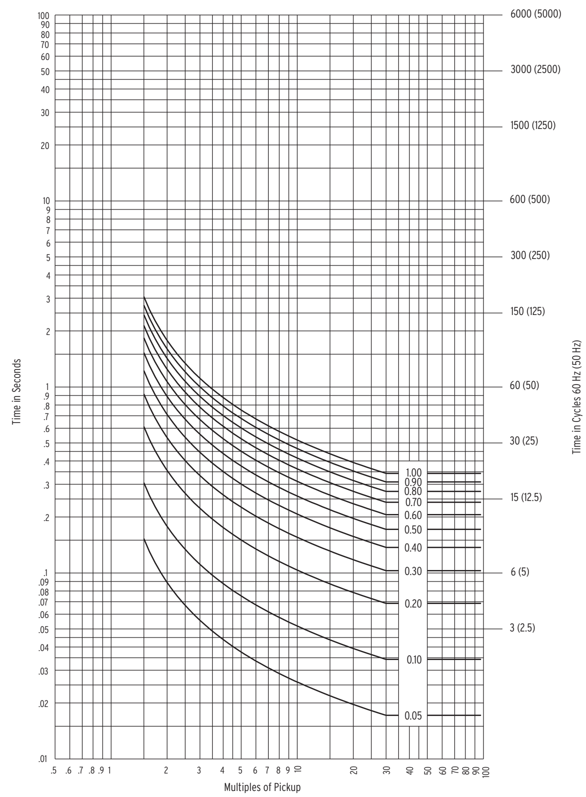


Figure 4.18 IEC Short-Time Inverse Curve: C5

Directional Elements

The directional control for overcurrent elements is enabled by setting EDIR to Y or AUTO. The EDIR setting and other directional control settings are described in *Directional Control Settings on page 4.36*.

Directional Control for Residual Overcurrent Elements

Three directional elements are available to control the residual ground overcurrent elements. Not all are available simultaneously. These three directional elements are:

- ➤ Negative-sequence voltage-polarized directional element
- ➤ Zero-sequence voltage-polarized directional element
- ➤ Channel IN current-polarized directional element

Figure 4.19 gives an overview of how these directional elements are enabled and routed to control the residual ground overcurrent elements. Note in *Figure 4.19* that the ORDER setting enables the directional elements. ORDER can be set with the elements listed and defined in *Table 4.18*.

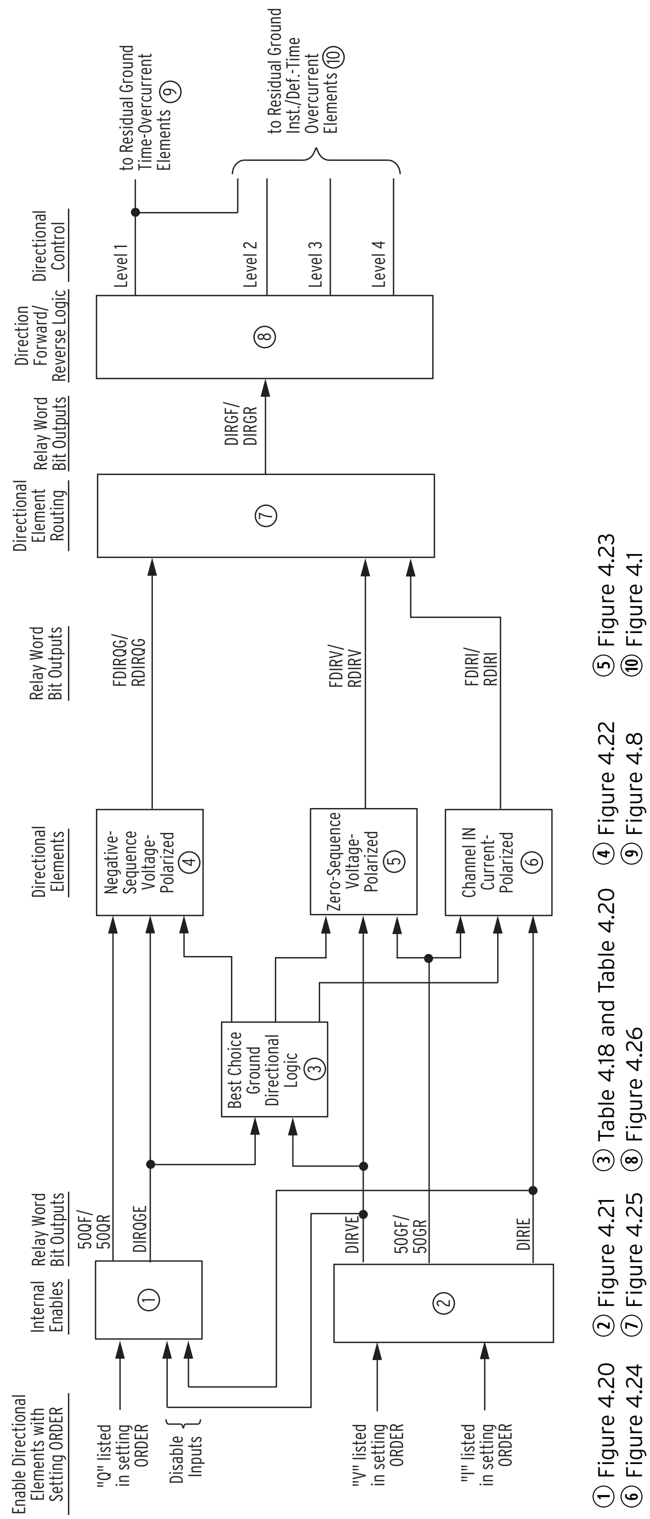


Figure 4.19 General Logic Flow of Directional Control for Residual Ground Overcurrent Elements

Table 4.18 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 4.20*, *Figure 4.22*	All models with the directional control option
V	Zero-sequence voltage-polarized	DIRVE	*Figure 4.21*, *Figure 4.23*	
I	Channel IN current polarized	DIRIE	*Figure 4.21*, *Figure 4.24*	

The order in which these directional elements are listed in setting ORDER determines the priority in which they operate to provide Best Choice Ground Directional Element® logic control. See the discussion on setting ORDER in the *Directional Control Settings on page 4.36*.

Table 4.19 shows the availability of the ground directional elements for the voltage transformer setting DELTA_Y.

Table 4.19 Ground Directional Element Availability by Voltage Transformer Connections

Element Designation in ORDER Setting	DELTA_Y := WYE	DELTA_Y := DELTA
Q	Yes	Yes
V	Yes	No
I	Yes	Yes

Internal Enables. Refer to *Figure 4.20* and *Figure 4.21*. See *Table 4.18* for the internal enables and their correspondence to the ground directional elements.

Note that *Figure 4.20* has extra internal enable DIRQE, which you would use in the directional element logic that controls negative-sequence and phase overcurrent elements (see *Figure 4.27*).

Additionally, note that if a loss-of-potential condition occurs (Relay Word bit LOP asserts) all the internal enables (except for DIRIE) are disabled (see *Figure 4.20* and *Figure 4.21*). The channel IN current polarized directional element (with corresponding internal enabled DIRIE) does not use voltage in making direction decisions, thus a loss-of-potential condition does not disable the element. Refer to *Figure 4.21* and accompanying text for more information on loss-of-potential.

The settings involved with the internal enables (for example, settings a2, k2, a0) are explained in *Directional Control Settings on page 4.36*.

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

Table 4.20 is the embodiment of the Best Choice Ground Directional Element logic (refer to *Figure 4.22*, *Figure 4.23*, and *Figure 4.24*). The Best Choice Ground Directional Element logic determines which directional element runs.

Table 4.20 Best Choice Ground Directional Element Logic

ORDER Setting Combinations	Resultant ground directional element preference (indicated below with corresponding internal enables; run element that corresponds to highest choice internal enable that is asserted)			ORDER Setting Combination Availability
	1st Choice	2nd Choice	3rd Choice	
OFF	No ground directional elements enabled			All models
Q	DIRQGE			
QV	DIRQGE	DIRVE		
V	DIRVE			
VQ	DIRVE	DIRQGE		
I	DIRIE			
IQ	DIRIE	DIRQGE		
IQV	DIRIE	DIRQGE	DIRVE	
IV	DIRIE	DIRVE		
IVQ	DIRIE	DIRVE	DIRQGE	
QI	DIRQGE	DIRIE		
QIV	DIRQGE	DIRIE	DIRVE	
QVI	DIRQGE	DIRVE	DIRIE	
VI	DIRVE	DIRIE		
VIQ	DIRVE	DIRIE	DIRQGE	
VQI	DIRVE	DIRQGE	DIRIE	

Directional Element Routing. Refer to *Figure 4.25*.

The directional element outputs are routed to the forward and reverse (Relay Word bits DIRGF and DIRGR, respectively) logic points and then on to the direction forward/reverse logic in *Figure 4.26*.

Loss of Potential. Note that if a loss-of-potential condition occurs (Relay Word bit LOP asserts) and internal enable DIRIE is not asserted, then the forward logic point (Relay Word bit DIRGF in *Figure 4.25*) asserts to logical 1, thus enabling the residual ground (*Figure 4.26*) 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 *Internal Enables*, 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 4.46* and accompanying text for more information on loss-of-potential.

Direction Forward/Reverse Logic. Refer to *Figure 4.26*. The forward (Relay Word bit DIRGF in *Figure 4.26*) and reverse (Relay Word bit DIRGR in *Figure 4.26*) logic points are routed to the different levels of overcurrent protection by the level direction settings DIR1 and DIR4.

Table 4.23 shows the overcurrent elements that are controlled by each level direction setting. Note in *Table 4.23* that all the time-overcurrent elements (51_T elements) are controlled by the DIR1 level direction setting.

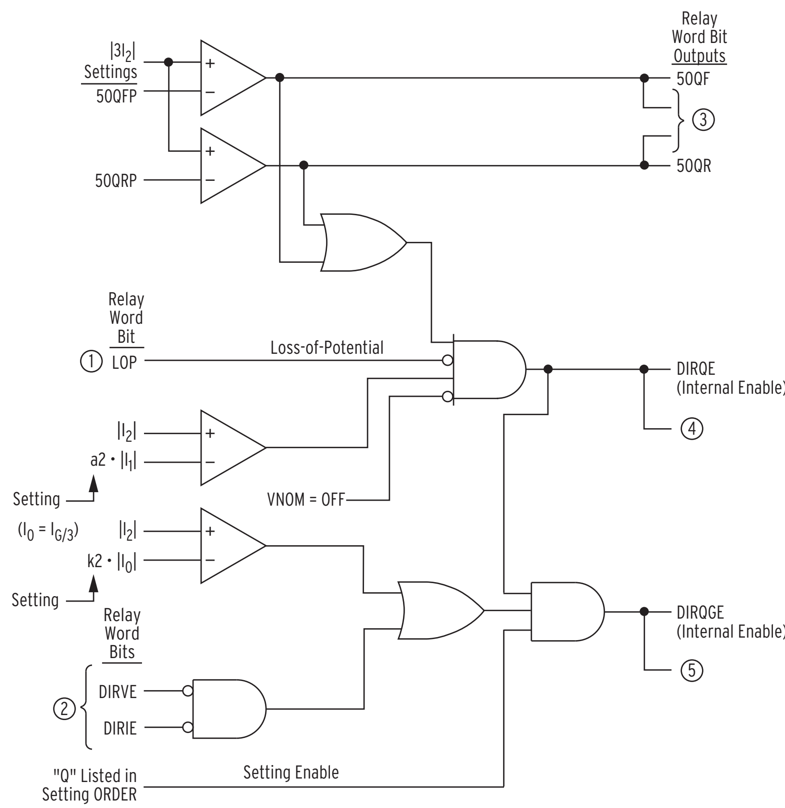
If a level direction setting (for example, DIR1) is set as follows,

DIR1 := **N** (nondirectional)

then the corresponding Level 1 directional control outputs in *Figure 4.26* assert to logical 1. The referenced Level 1 overcurrent elements in *Figure 4.26* are then not controlled by the directional control logic.

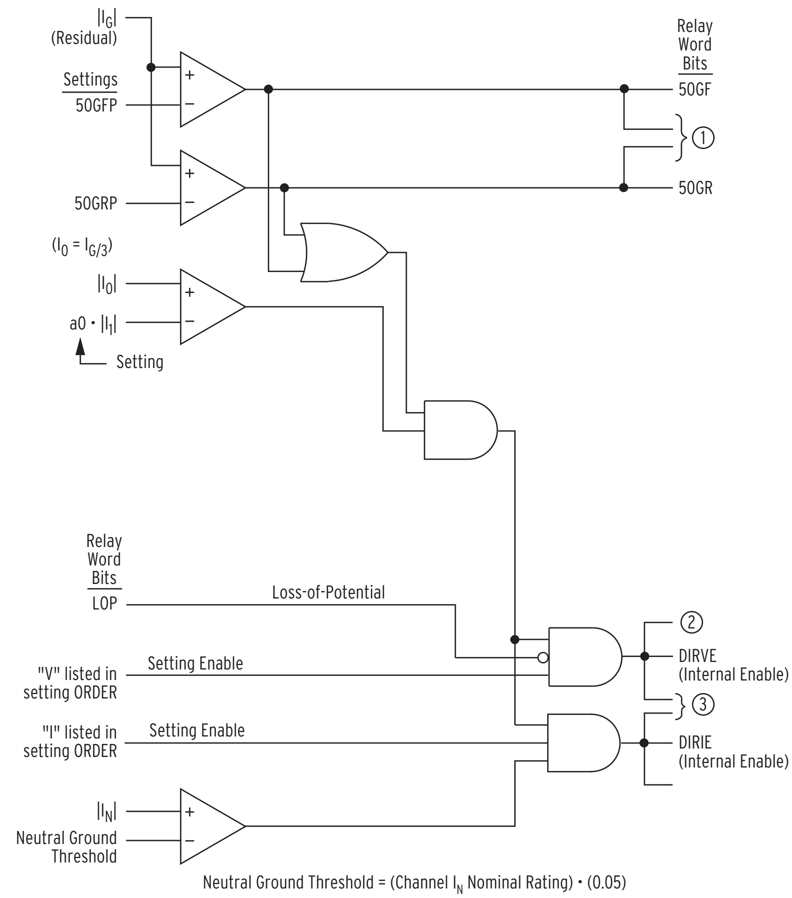
See the beginning of *Directional Control Settings on page 4.36* for a discussion on the operation of level direction settings DIR1–DIR4 when the directional control enable setting EDIR is set to EDIR := N.

In some applications, level direction settings DIR1–DIR4 are not flexible enough in assigning the necessary direction for certain overcurrent elements. *Directional Control Provided by Torque Control Settings on page 4.44* describes how to avoid this limitation for special cases.



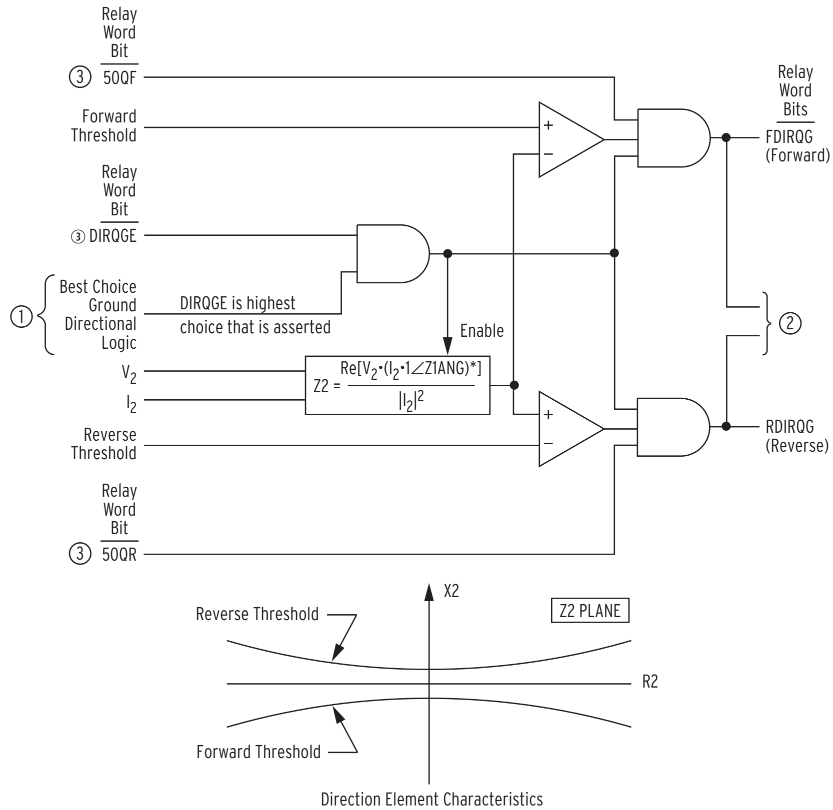
① From Figure 4.46 ② From Figure 4.21 ③ To Figure 4.22 and Figure 4.28
④ To Figure 4.28 ⑤ To Figure 4.22, and Table 4.20

Figure 4.20 Internal Enables (DIRQE and DIRQGE) Logic for Negative-Sequence Voltage-Polarized Directional Elements



① To Figure 4.23 and Figure 4.24 ② To Figure 4.23 ③ To Figure 4.20, Table 4.18, and Table 4.20

Figure 4.21 Internal Enables (DIRVE and DIRIE) Logic for Zero-Sequence Voltage-Polarized and Channel IN Current-Polarized Directional Elements



Forward Threshold:

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

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

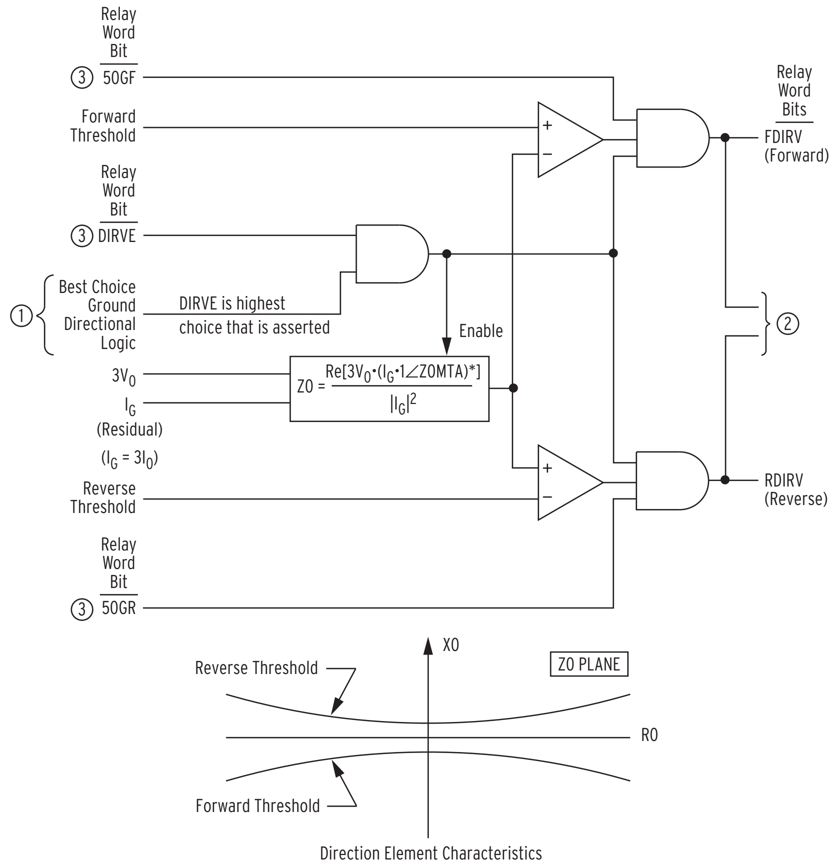
Reverse Threshold:

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

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

① From Table 4.20 ② To Figure 4.25 ③ From Figure 4.20

Figure 4.22 Negative-Sequence Voltage-Polarized Directional Element for Residual Ground Overcurrent Elements



<u>Forward Threshold:</u>

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

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

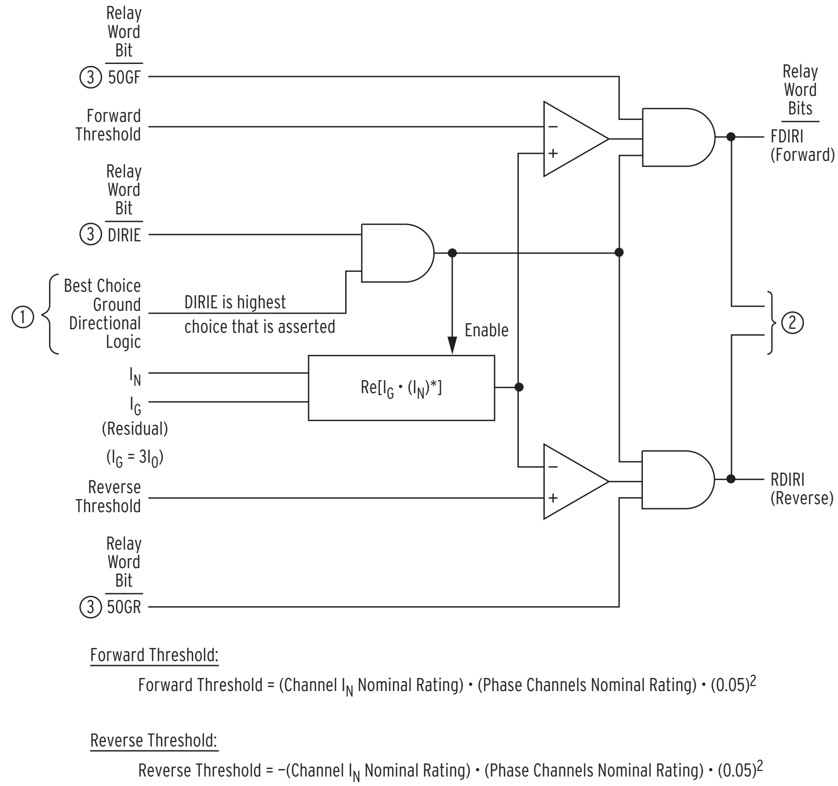
<u>Reverse Threshold:</u>

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

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

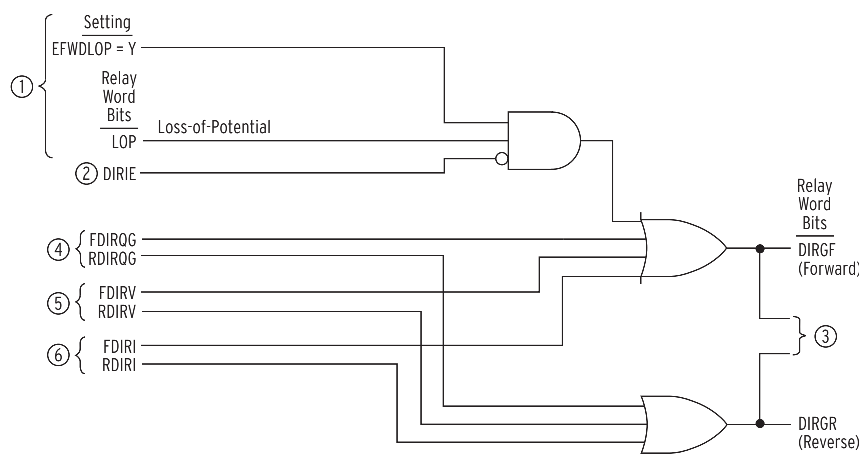
① From Table 4.20 ② To Figure 4.25 ③ From Figure 4.21

Figure 4.23 Zero-Sequence Voltage-Polarized Directional Element



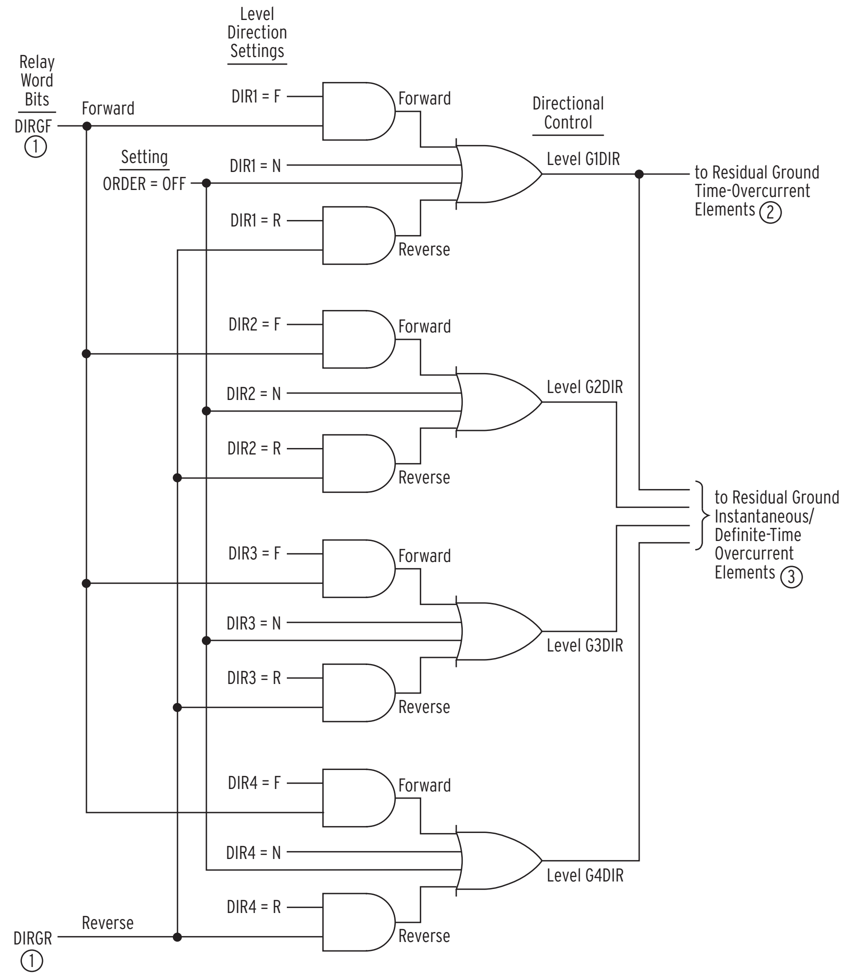
① From Table 4.20 ② To Figure 4.25 ③ From Figure 4.21

Figure 4.24 Channel IN Current-Polarized Directional Element



① From Figure 4.46 ② From Figure 4.21 ③ From Figure 4.26
④ From Figure 4.22 ⑤ From Figure 4.23 ⑥ To Figure 4.24

Figure 4.25 Routing of Directional Elements to Residual Ground Overcurrent Elements



① From Figure 4.25 ② Figure 4.8 ③ Figure 4.1

Figure 4.26 Direction Forward/Reverse Logic for Residual 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 4.36*.

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 4.27* gives an overview of how the negative-sequence voltage-polarized and positive-sequence voltage-polarized directional elements are enabled and routed to control the negative-sequence and phase overcurrent elements.

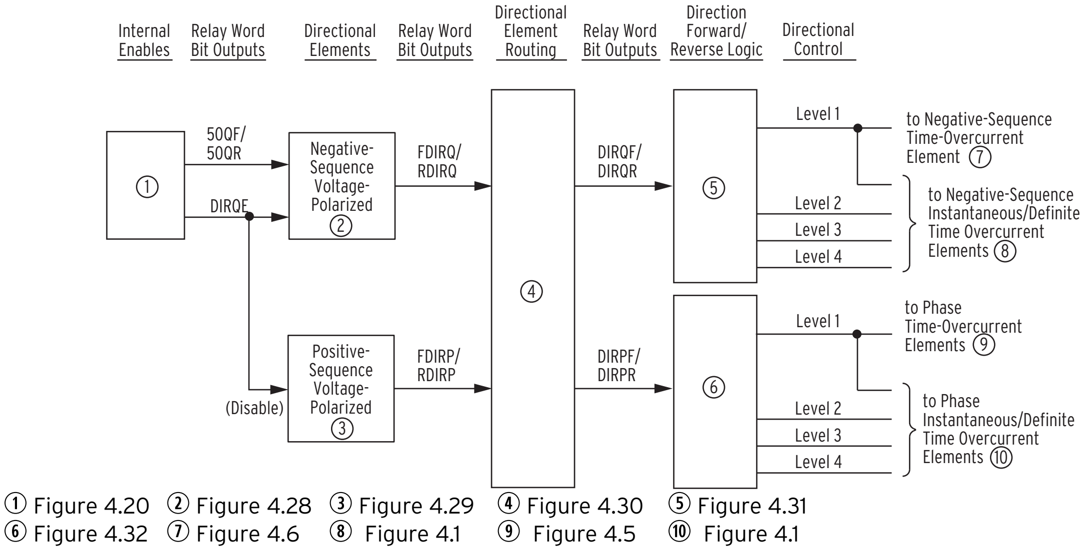


Figure 4.27 General Logic Flow of Directional Control for Negative-Sequence and Phase Overcurrent Elements

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 a pickup setting less than forward load can operate for some remote, unbalanced, reverse faults. If possible, overcurrent element pickup settings should be set greater than the current expected for load in either direction. If this is not possible, refer to the technical paper, *Use of Directional Elements at the Utility-Industrial Interface*, by Dave Costello, Greg Bow, and Martin Moon, which is available on the SEL website, or by contacting SEL for assistance.

Internal Enables. Refer to *Figure 4.20* and *Figure 4.21*.

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

Note that *Figure 4.20* has extra internal enable DIRQGE, which you would use in the directional element logic that controls the residual ground overcurrent elements (see *Figure 4.19*).

The settings involved with internal enable DIRQE in *Figure 4.20* (for example, settings a2, k2) are explained in *Directional Control Settings on page 4.36*.

Directional Elements. Refer to *Figure 4.27*, *Figure 4.31*, and *Figure 4.29*.

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 4.20* and *Figure 4.29*).

Refer to *Figure 4.46* and accompanying text for more information on loss-of-potential.

Note in *Figure 4.27* and *Figure 4.29* that the assertion of internal enable DIRQE (for the negative-sequence voltage-polarized directional element) disables the positive-sequence voltage-polarized directional element. The negative-sequence voltage-polarized directional element has priority over the positive-sequence voltage-polarized directional element in controlling the phase overcurrent elements. The negative-sequence voltage-polarized directional element operates for unbalanced faults, while the positive-sequence voltage-polarized directional element operates for three-phase faults.

Note also in *Figure 4.29* 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 4.18*).

Directional Element Routing. Refer to *Figure 4.27* and *Figure 4.30*.

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 4.31* and *Figure 4.32*.

Loss-of-Potential. If a loss-of-potential condition occurs (Relay Word bit LOP asserts), then the forward logic points (Relay Word bits DIRQF and DIRPF) assert to logical 1, thus enabling the negative-sequence and phase overcurrent elements that are set direction forward (with settings DIR1 = F, DIR2 = F, etc.). These direction forward overcurrent elements effectively become nondirectional and provide overcurrent protection during a loss-of-potential condition.

As detailed previously (in *Figure 4.20* and *Figure 4.29*), 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 4.46* and accompanying text for more information on loss-of-potential.

Direction Forward/Reverse Logic. Refer to *Figure 4.27*, *Figure 4.31*, and *Figure 4.32*.

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–DIR4.

Table 4.23 shows the overcurrent elements that are controlled by each level direction setting. Note in *Table 4.23* that all the time-overcurrent elements (51_T elements) are controlled by the DIR1 level direction setting.

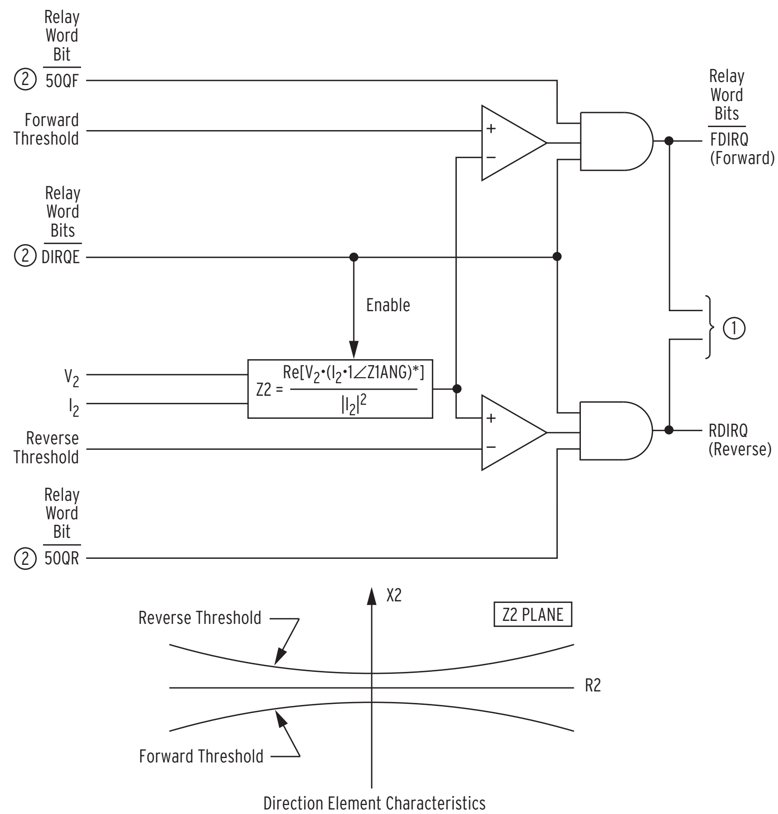
If a level direction setting (for example, DIR1) is set:

DIR1 := **N** (nondirectional)

then the corresponding Level 1 directional control outputs in *Figure 4.31* and *Figure 4.32* assert to logical 1. The referenced Level 1 overcurrent elements in *Figure 4.31* and *Figure 4.32* are then not controlled by the directional control logic.

See *Directional Control Settings on page 4.36* for a discussion of the operation of level direction settings DIR1–DIR4 when the directional control enable setting EDIR is set to EDIR := N.

In some applications, level direction settings DIR1–DIR4 are not flexible enough in assigning the necessary direction for certain overcurrent elements. *Directional Control Provided by Torque Control Settings on page 4.44* describes how to avoid this limitation for special cases.



Forward Threshold:

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

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

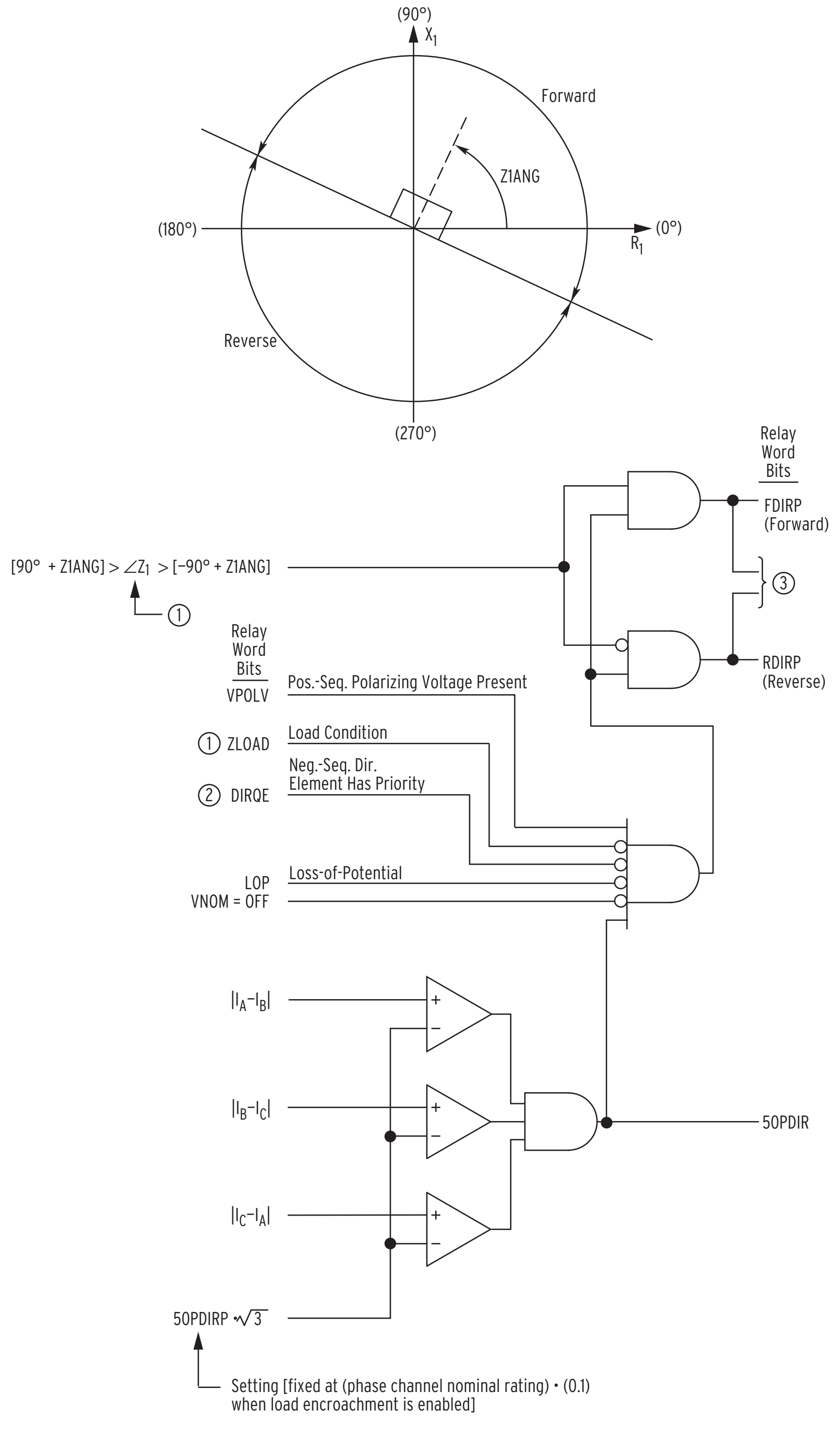
Reverse Threshold:

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

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

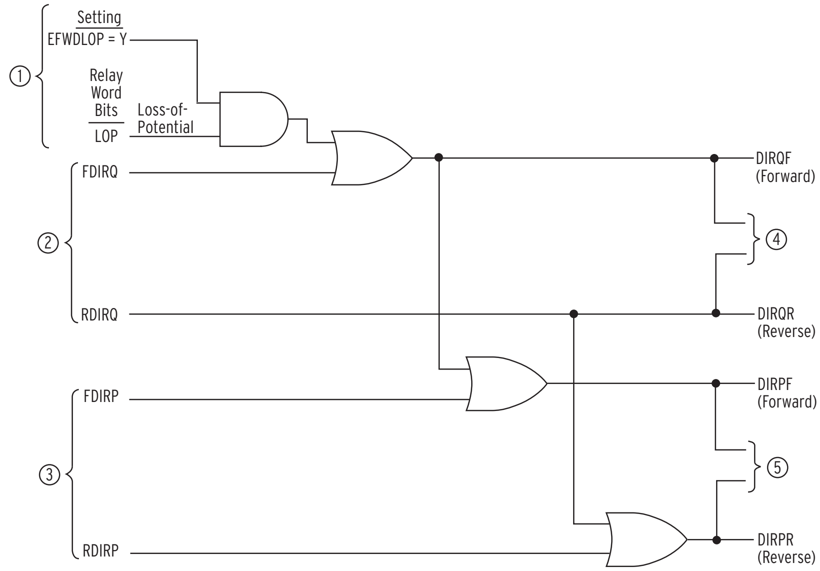
① To Figure 4.30 ② From Figure 4.20

Figure 4.28 Negative-Sequence Voltage-Polarized Directional Element for Negative-Sequence and Phase Overcurrent Elements



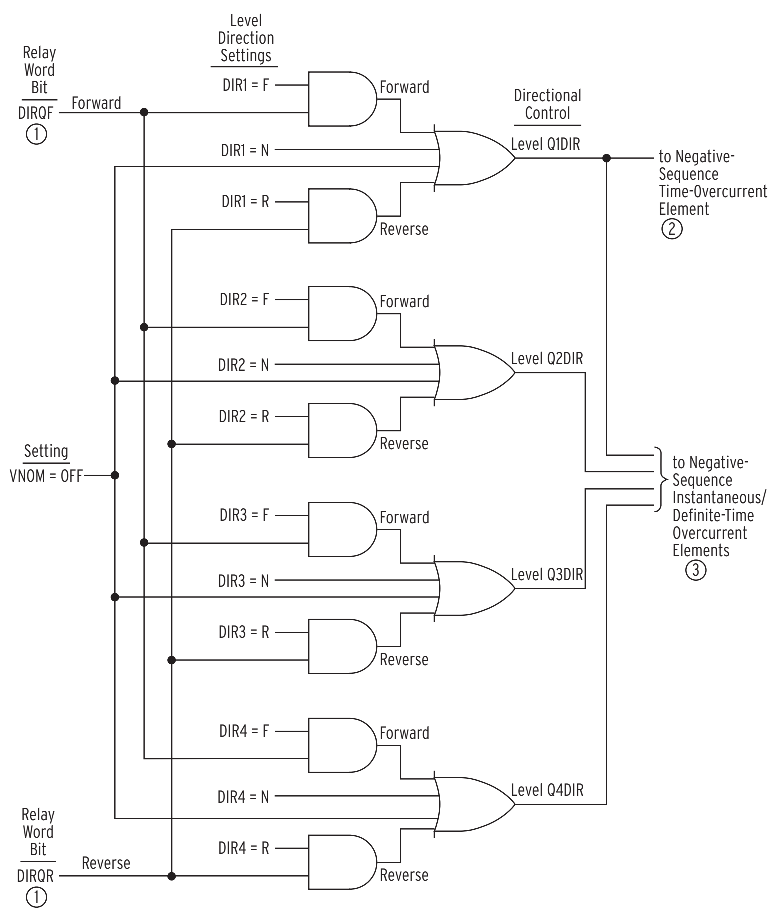
① To Figure 4.36 ② From Figure 4.20 ③ To Figure 4.30

Figure 4.29 Positive-Sequence Voltage-Polarized Directional Element for Phase Overcurrent Elements



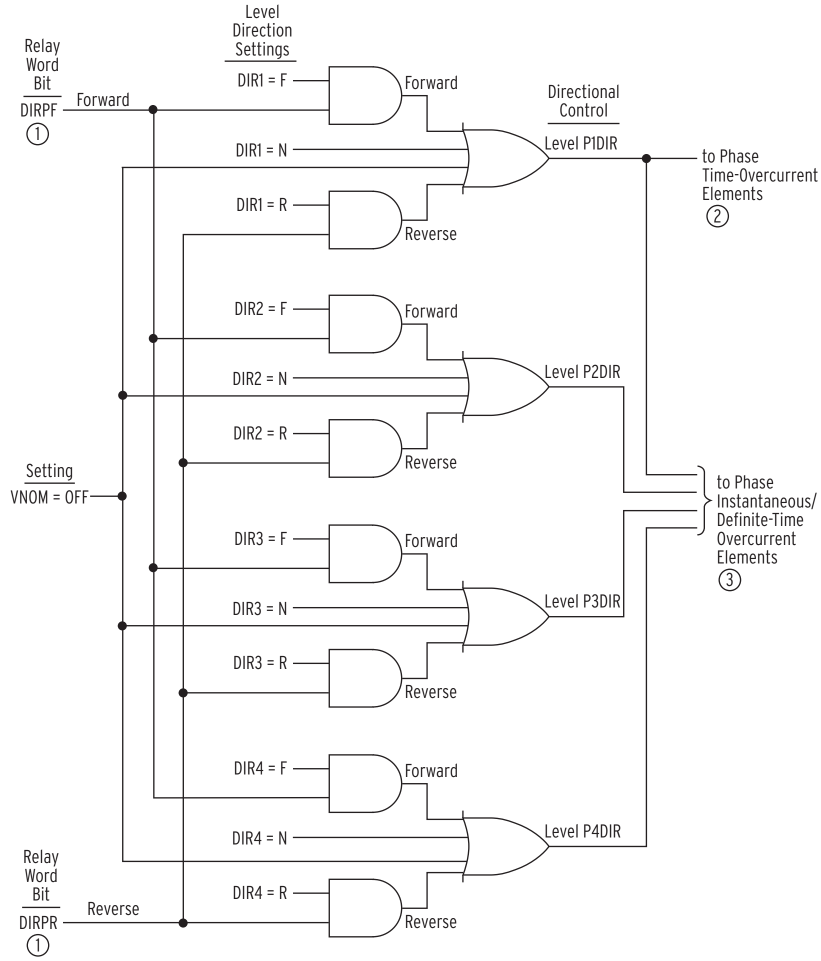
① From Figure 4.46 ② From Figure 4.28 ③ From Figure 4.29
④ To Figure 4.31 ⑤ To Figure 4.32

Figure 4.30 Routing of Directional Elements to Negative-Sequence and Phase Overcurrent Elements



① From Figure 4.30 ② Figure 4.6 ③ Figure 4.1

Figure 4.31 Direction Forward/Reverse Logic for Negative-Sequence Overcurrent Elements



① From Figure 4.30 ② Figure 4.5 ③ Figure 4.1

Figure 4.32 Direction Forward/Reverse Logic for Phase Overcurrent Elements

Directional Control Settings

The directional control for overcurrent elements is enabled by making directional control enable setting EDIR. Setting EDIR has setting choices:

Y	Enable directional control
N	Disable directional control
AUTO	Enable directional control and set many of the directional element settings automatically

If directional control enable setting EDIR := N, directional control is disabled and no directional control settings are made. All level direction settings are set internally as:

DIR1 := N	(no directional control for Level 1 overcurrent elements)
DIR2 := N	(no directional control for Level 2 overcurrent elements)
DIR3 := N	(no directional control for Level 3 overcurrent elements)
DIR4 := N	(no directional control for Level 4 overcurrent elements)

Table 4.21 Directional Element Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
DIR CONTROL ENBL	Y, AUTO, N	EDIR := N
FWD DIR ON LOP	Y, N	EFWDLOP := Y
DIR CONTROL LVL1	F, R, N	DIR1 := N
DIR CONTROL LVL2	F, R, N	DIR2 := N
DIR CONTROL LVL3	F, R, N	DIR3 := N
DIR CONTROL LVL4	F, R, N	DIR4 := N
GND DIR PRIORITY	Q, V, I, OFF[a]	ORDER := OFF
PH DIR 3PH LVL	0.50–10.00 A[c]	50PDIRP := 3.00[c]
FWD DIR Z2 LVL	–128.00 to 128.00 ohm[b]	Z2F := –0.06[b]
REV DIR Z2 LVL	–128.00 to 128.00 ohm[b]	Z2R := 0.06[b]
FWD DIR NSEQ LVL	0.25–5.00 A[c]	50QFP := 0.50[c]
REV DIR NSEQ LVL	0.25–5.00 A[c]	50QRP := 0.25[c]
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[c]	50GFP := 0.50[c]
REV DIR RES LVL	0.05–5.00 A[c]	50GRP := 0.25[c]
I1 RST FAC I0/I1	0.02–0.50	a0 := 0.10
FWD DIR Z0 LVL	–128.00 to 128.00 ohm[b]	Z0F := –0.06[b]
REV DIR Z0 LVL	–128.00 to 128.00 ohm[b]	Z0R := 0.06[b]
ZRO SQ MX TQ ANG-	–90.00 to –5.00 and 5.00 to 90.00 deg	ZM0TA := 72.47

[a] Choice V is available when DELTA_Y := WYE. All combinations of available Q, V, and I are allowed.
[b] Setting ranges and default Amp values shown are for 5 A nominal CT rating. Multiply by 5 for 1 A CTs.
[c] Setting ranges and default Amp values shown are for 5 A nominal CT rating. Divide by 5 for 1 A CTs.

With the previous settings, the directional control outputs in *Figure 4.26*, *Figure 4.31*, and *Figure 4.32* assert to logical 1. The overcurrent elements referenced in *Figure 4.26*, *Figure 4.31*, and *Figure 4.32* are then not controlled by the directional control logic.

Settings Made Automatically. If the directional control enable setting EDIR is set:

EDIR := **AUTO**

then the following directional control settings are calculated and set automatically:

Z2F, Z2R, 50QFP, 50QRP, a2, k2, 50GFP, 50GRP, a0, Z0F, Z0R, and Z0MTA

If EDIR := AUTO, then Z0MTA is set equal to Z0ANG and Z0MTA is hidden.

Once these settings are calculated automatically, they can only be modified if you go back and change the directional control enable setting to EDIR = Y.

The remaining directional control settings are *not* set automatically if setting EDIR := AUTO. You must set these, whether setting EDIR := AUTO or Y. These settings are:

DIR1–DIR4, ORDER, and 50PDIRP

All these settings are explained in detail in the remainder of this subsection.

You would not use all of these directional control settings (set automatically or by you) in every application. The following are directional control settings that are hidden/not made for particular conditions:

Table 4.22 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 I

Settings.

DIR1–DIR4 Overcurrent Element Direction Settings. *Table 4.23* shows the overcurrent elements that are controlled by each level direction setting. Note in *Table 4.23* that all the time-overcurrent elements (51_T elements) are controlled by the DIR1 level direction setting. *Figure 4.26*, *Figure 4.31*, and *Figure 4.32* show the logic implementation of the control listed in *Table 4.23*.

Table 4.23 Overcurrent Elements Controlled by Level Direction Settings DIR1–DIR4

Level Direction Settings	Phase	Residual Ground	Negative-Sequence
DIR1	67P1P 67P1T 51P1T 51P2T	67G1P 67G1T 51G1T 51G2T	67Q1P 67Q1T 51QT
DIR2	67P2P 67P2T	67G2P 67G2T	67Q2P 67Q2T
DIR3	67P3P 67P3T	67G3P 67G3T	67Q3P 67Q3T
DIR4	67P4P 67P4T	67G4P 67G4T	67Q4P 67Q4T

In some applications, the level direction settings DIR1–DIR4 are not flexible enough in assigning the necessary direction for certain overcurrent elements. *Directional Control Provided by Torque Control Settings on page 4.44* 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 4.18*, subject to the setting combination constraints in *Table 4.19* and *Table 4.20*. *Table 4.19* lists the ground directional element availability resulting from the voltage transformer connections.

The *order* in which the directional elements are listed in setting ORDER determines the priority in which these elements operate to provide Best Choice Ground Directional Element logic control.

EXAMPLE 4.3 For example, if setting ORDER := QV

then the first listed directional element (Q = negative-sequence voltage-polarized directional element; see *Figure 4.22*) is the first priority directional element to provide directional control for the residual ground overcurrent elements.

If the negative-sequence voltage-polarized directional element is not operable (that is, it does not have sufficient operating quantity as indicated by its internal enable, DIRQGE, not being asserted; see *Figure 4.20*), then the second listed directional element (V = zero-sequence voltage-polarized directional element; see *Figure 4.23*) provides directional control for the residual ground overcurrent elements.

If the zero-sequence voltage-polarized directional element is not operable (that is, it does not have sufficient operating quantity as indicated by its internal enable, DIRVE, not being asserted (see *Figure 4.21*), then no directional control is available. The residual ground overcurrent elements do not operate, even though these elements are designated with the DIR*n* (*n* = 1–4) settings to be directionally controlled (see *Figure 4.26* and *Figure 4.27*).

EXAMPLE 4.4 Another example, if setting ORDER := V

then the zero-sequence voltage-polarized directional element (V = zero-sequence voltage-polarized directional element; see *Figure 4.23*) provides directional control for the residual ground overcurrent elements at all times (assuming it has sufficient operating quantity). If there is not sufficient operating quantity during an event (that is, internal enable DIRVE is not asserted; see *Figure 4.21*), then no directional control is available. The residual ground overcurrent elements do not operate, even though these elements are designated with the DIR*n* (*n* = 1–4) settings to be directionally controlled (see *Figure 4.26* and *Figure 4.19*).

If setting:

ORDER := OFF

then all of the ground directional elements are inoperable. Note in *Figure 4.26* and *Figure 4.27* that setting ORDER := OFF effectively makes the residual ground overcurrent elements nondirectional (the directional control outputs of *Figure 4.26* and *Figure 4.27* are continuously asserted to logical 1).

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 4.29*).

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)

0.1 A secondary (1 A nominal phase current inputs)

Z2F/Z2R—Forward/Reverse Directional Z2 Thresholds. Use Z2F and Z2R to calculate the forward and reverse thresholds, respectively, for the negative-sequence voltage-polarized directional elements (see *Figure 4.22* and *Figure 4.31*).

If enable setting EDIR = Y, you calculate and enter the settings Z2F and Z2R (negative-sequence impedance values), but setting Z2R must be greater in value than setting Z2F by 0.1 Ω secondary.

If enable setting EDIR = AUTO, the relay uses the positive-sequence line impedance magnitude setting Z1MAG as follows to calculate the settings Z2F and Z2R (negative-sequence impedance values) automatically:

Z2F = **Z1MAG/2** (Ω secondary)

Z2R = **Z1MAG/2 +** *z* (Ω secondary; *z* listed in *Table 4.24*)

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

Table 4.24 z Constant for Z2R Setting

Relay Configuration	z (Ω Secondary)
5 A nominal current	0.2
1 A nominal current	1.0

Figure 4.33 and *Figure 4.34* and supporting text concern the zero-sequence impedance network, the relay polarity, and the derivation of settings Z0F and Z0R. The same general approach outlined for deriving settings Z0F and Z0R can also be applied to deriving settings Z2F and Z2R in the negative-sequence impedance network, although the preceding method of automatically making the settings Z2F and Z2R usually suffices.

50QFP/50QRP—Forward/Reverse Directional Negative-Sequence Current Pickup. The 50QFP setting ($3I_2$ current value) is the pickup for the forward fault detector 50QF of the negative-sequence voltage-polarized directional elements (see *Figure 4.20*). Ideally, the setting is greater than normal load unbalance and less than the least expected negative-sequence current magnitude for unbalanced forward faults.

The 50QRP setting ($3I_2$ current value) is the pickup for the reverse fault detector 50QR of the negative-sequence voltage-polarized directional elements (see *Figure 4.20*). Ideally, the setting is greater than normal load unbalance and less than the least expected negative-sequence current magnitude for unbalanced reverse faults.

If enable setting EDIR = AUTO, the settings 50QFP and 50QRP are set automatically at:

50QFP = 0.50 A secondary (5 A nominal phase current inputs, **IA**, **IB**, **IC**)

50QRP = 0.25 A secondary (5 A nominal phase current inputs, **IA**, **IB**, **IC**)

50QFP = 0.10 A secondary (1 A nominal phase current inputs, **IA**, **IB**, **IC**)

50QRP = 0.05 A secondary (1 A nominal phase current inputs, **IA**, **IB**, **IC**)

a2—Positive-Sequence Current Restraint Factor, I_2/I_1. The a2 factor (refer to *Figure 4.20*) increases the security of the negative-sequence voltage-polarized directional elements. It keeps the elements from operating for negative-sequence current (system unbalance), which circulates as a result of line asymmetries, CT saturation during three-phase faults, etc.

If enable setting EDIR := AUTO, setting a2 is set automatically at a2 = **0.1**

For setting a2 = 0.1, the negative-sequence current (I_2) magnitude has to be greater than 1/10 of the positive-sequence current (I_1) magnitude in order for the negative-sequence voltage-polarized directional elements to be enabled ($|I_2| > 0.1 \bullet |I_1|$).

k2—Zero-Sequence Current Restraint Factor, I_2/I_0. Note the internal enable logic outputs in *Figure 4.20*:

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 4.22*) to be enabled:

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

This check ensures that the relay uses the most robust analog quantities in making directional decisions for the residual ground overcurrent elements.

The zero-sequence current (I_0), referred to in the previous application of the k2 factor, is from the residual current (I_G), which is derived from phase currents I_A, I_B, and I_C:

$$I_0 = I_G/3 \qquad 3I_0 = I_G = I_A + I_B + I_C$$

If both of the internal enables:

DIRVE	internal enable for the zero-sequence voltage-polarized directional element that controls the residual ground overcurrent elements
DIRIE	internal enable for the channel IN current-polarized directional element that controls the residual ground overcurrent elements

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.

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 that at least one of the internal enables DIRVE or DIRIE is asserted.

50GFP/50GRP—Forward/Reverse Directional Residual Ground Current Pickup. If setting ORDER does not contain V or I (no zero-sequence voltage-polarized or channel IN current-polarized directional elements are enabled), then settings 50GFP and 50GRP are not made or displayed.

The 50GFP setting ($3I_0$ current value) is the pickup for the forward fault detector 50GF of the zero-sequence voltage-polarized and channel IN current-polarized directional elements (see *Figure 4.21*). Ideally, this setting is greater than normal load unbalance and less than the least expected zero-sequence current magnitude for unbalanced forward faults.

The 50GRP setting ($3I_0$ current value) is the pickup for the reverse fault detector 50GR of the zero-sequence voltage-polarized and channel IN current-polarized directional elements (see *Figure 4.21*). Ideally, this setting is greater than normal load unbalance and less than the least expected zero-sequence current magnitude for unbalanced reverse faults.

If enable setting EDIR := AUTO, the settings 50GFP and 50GRP are set automatically at:

50GFP = 0.50 A secondary (5 A nominal phase current inputs, **IA**, **IB**, **IC**)

50GRP = 0.25 A secondary (5 A nominal phase current inputs, **IA**, **IB**, **IC**)

50GFP = 0.10 A secondary (1 A nominal phase current inputs, **IA**, **IB**, **IC**)

50GRP = 0.05 A secondary (1 A nominal phase current inputs, **IA**, **IB**, **IC**)

a0—Positive-Sequence Current Restraint Factor, I_0/I_1. If setting ORDER does not contain V or I (no zero-sequence voltage-polarized or channel **IN** current-polarized directional elements are enabled), then setting a0 is not made or displayed.

Refer to *Figure 4.21*. The a0 factor increases the security of the zero-sequence voltage-polarized and channel **IN** current-polarized directional elements. This factor keeps the elements from operating for zero-sequence current (system unbalance), which circulates as a result of line asymmetries, CT saturation during three-phase faults, etc.

The zero-sequence current (I_0), referred to in the application of the a0 factor, is from the residual current (I_G), which is derived from phase currents I_A, I_B, and I_C:

$$I_0 = I_G/3 \qquad 3I_0 = I_G = I_A + I_B + I_C$$

If enable setting EDIR := AUTO, setting a0 is set automatically at a0 := **0.1**

For setting a0 := 0.1, the zero-sequence current (I_0) magnitude has to be greater than 1/10 of the positive-sequence current (I_1) magnitude in order for the zero-sequence voltage-polarized and channel **IN** current-polarized directional elements to be enabled ($|I_0| > 0.1 \cdot |I_1|$).

Z0F/Z0R—Forward/Reverse Directional Z0 Threshold. If the preceding setting ORDER does not contain V (no zero-sequence, voltage-polarized directional element is enabled), then there is no need to make the settings Z0F and Z0R. The relay also does not display these settings.

Use Z0F and Z0R to calculate the forward and reverse thresholds, respectively, for the zero-sequence voltage-polarized directional elements (see *Figure 4.23*).

If enable setting EDIR := Y, you calculate and enter settings Z0F and Z0R (zero-sequence impedance values), but setting Z0R must be greater in value than setting Z0F by 0.1 Ω secondary.

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.

If enable setting EDIR = AUTO, the relay calculates the settings Z0F and Z0R (zero-sequence impedance values) automatically, using the zero-sequence line impedance magnitude setting Z0MAG as follows:

Z0F = Z0MAG/2 (Ω Secondary)

Z0R = Z0MAG/2 + *z* (Ω Secondary; *z* listed in *Table 4.25*)

Table 4.25 z Constant for Z0R Setting

Relay Configuration	z (Ω Secondary)
5 A nominal current	0.2
1 A nominal current	1.0

Deriving Z0F and Z0R Settings. *Figure 4.33* 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 4.33* is a solidly-grounded system (mostly inductive; presume uniform system angle) with load-connected line to neutral, the impedance plot (in the R + jX plane) would appear as in *Figure 4.34a*, with resultant Z0F and Z0R settings as in *Figure 4.34b*. The zero-sequence line angle noted in *Figure 4.34a* (∠Z0MTA) is the same angle found in *Figure 4.23* (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 4.33* and *Figure 4.34* just provide a theoretical background.

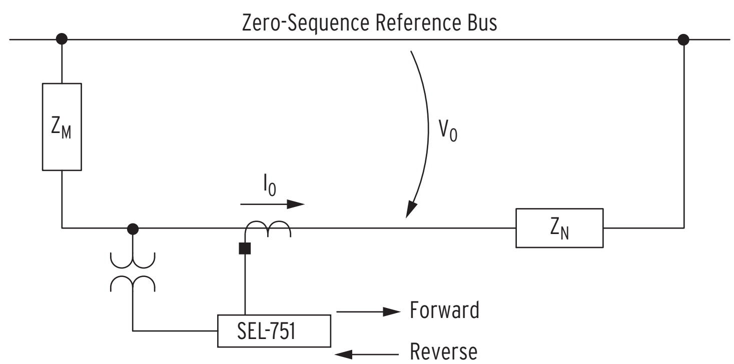


Figure 4.33 Zero-Sequence Impedance Network and Relay Polarity

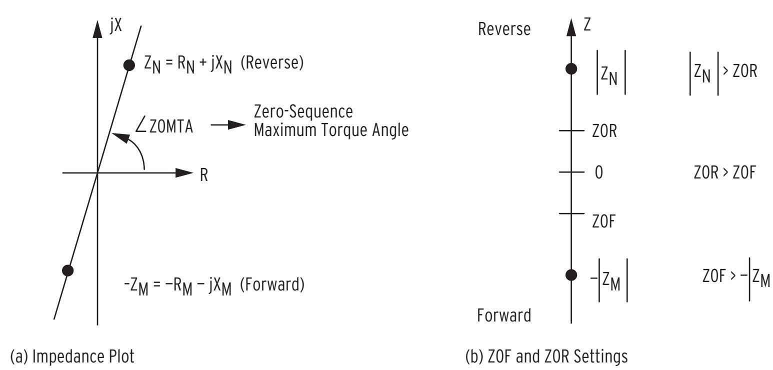


Figure 4.34 Zero-Sequence Impedance Plot for Solidly-Grounded, Mostly Inductive System

Z0MTA—Zero-Sequence Maximum Torque Angle. If enable setting EDIR := Y and ORDER contains a V, you should set setting Z0MTA. You must set Z0MTA to compensate for the neutral ground resistor and you would use it in the Best Choice Ground Directional Element logic to make proper forward and reverse fault determination (see *Figure 4.35*).

If enable setting EDIR := AUTO, then Z0MTA is set equal to Z0ANG and Z0MTA is hidden.

If the protected line belongs to a hybrid power system, such as shown in *Figure 4.35*, then for proper directional decision, Z0ANG does not equal Z0MTA and EDIR does not equal AUTO. You must set Z0MTA to compensate for the neutral ground resistor and you would use it in the Best Choice Ground Directional Element logic to make proper forward and reverse fault determination.

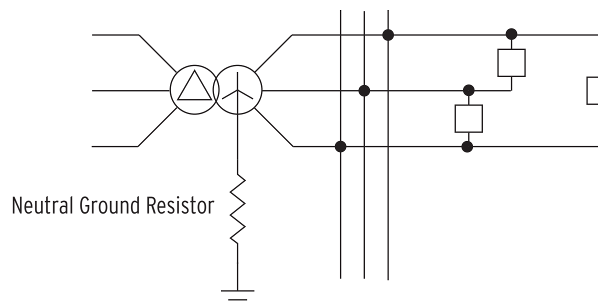


Figure 4.35 Hybrid Power System With Neutral Ground Resistor

Directional Control Provided by Torque Control Settings. For most applications, you would use the level direction settings DIR1–DIR4 to set overcurrent elements direction forward, reverse, or nondirectional. *Table 4.23* shows the overcurrent elements that are controlled by each level direction setting. Note in *Table 4.23* that all the time-overcurrent elements (51_T elements) are controlled by the DIR1 level direction setting. See *Figure 4.26*, *Figure 4.31*, and *Figure 4.32*.

Suppose that you need to set the Level 1 overcurrent elements as follows:

67P1T	direction forward
67G1T	direction forward
51P1T	direction reverse
51G1T	nondirectional

To accomplish this, you would “turn off” the DIR1 setting, and use the corresponding SELOGIC control equation torque control settings for the previous overcurrent elements to make the elements directional (forward or reverse) or nondirectional. The necessary settings are:

DIR1 := **N** (“turned off”; see *Figure 4.26*, *Figure 4.31*, and *Figure 4.32*)
50P1TC := **DIRPF** (direction forward)
50G1TC := **DIRGF** (direction forward)
51P1TC := **DIRPR** (direction reverse)
51G1TC := **1** (nondirectional)

This is just one example of using SELOGIC control equation torque control settings to make overcurrent elements directional (forward or reverse) or nondirectional. This example shows only Level 1 overcurrent elements (controlled by level direction setting DIR1). The same setting principles apply to the other levels as well. Many variations are possible.

Load-Encroachment Logic

The load-encroachment feature allows certain elements (system backup, phase directional, etc.) to be set without regard for load levels. For example, to obtain necessary system backup sensitivity, 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 4.26 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.

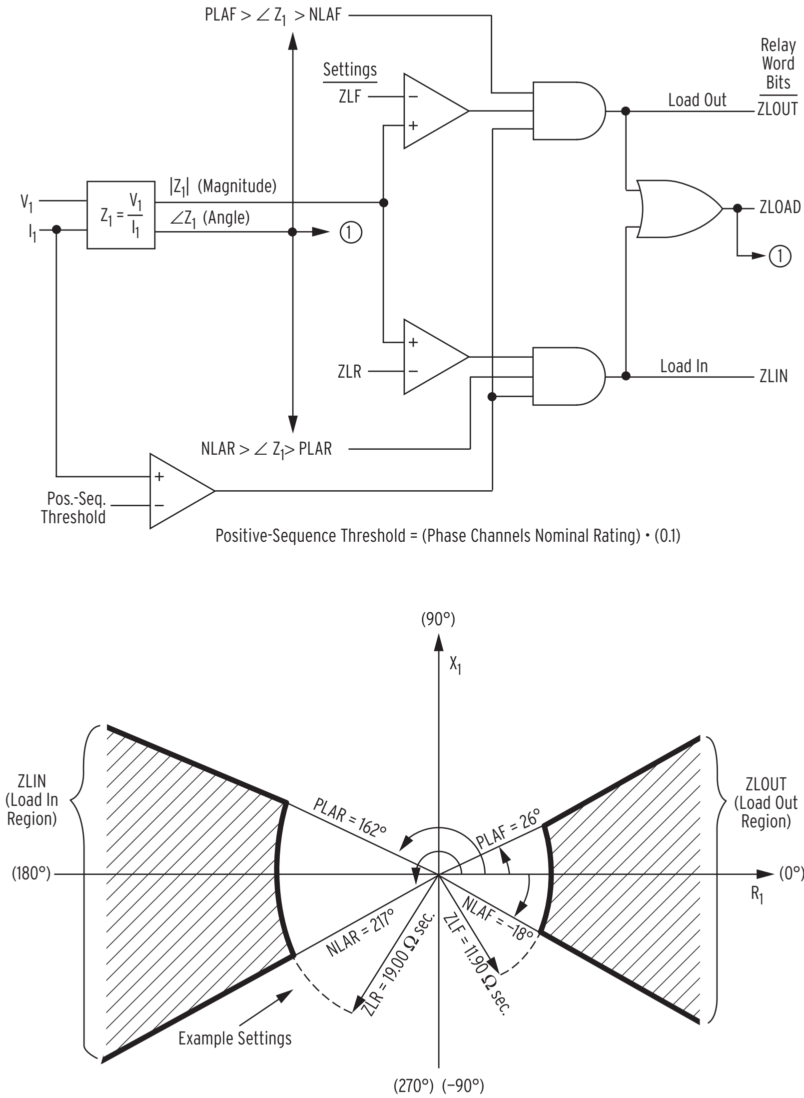
Note that a positive-sequence impedance calculation (Z_1) is made in the load-encroachment logic in *Figure 4.36*. Load is largely a balanced condition, so apparent positive-sequence impedance is a good load measure. The load-encroachment logic operates only if the positive-sequence current (I_1) is greater than the positive-sequence threshold defined in *Figure 4.36*. 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 4.29

Figure 4.36 Load-Encroachment Logic

EXAMPLE 4.5 Load-Encroachment Setting Example

Example system conditions:
Nominal Line-Line Voltage: 230 kV
Maximum Forward Load: 800 MVA
Maximum Reverse Load: 500 MVA
Power Factor (Forward Load): 0.90 lag to 0.95 lead
Power Factor (Reverse Load): 0.80 lag to 0.95 lead
CT ratio: 2000/5 = 400
PT ratio: 134000/67 = 2000

The PTs are connected line-to-neutral.

Convert Maximum Loads to Equivalent Secondary Impedances

Start with maximum forward load:
800 MVA • (1/3) 267 MVA per phase
230 kV • (1/√ 3) = 132.8 kV line-to-neutral
267 MVA • (1/132.8 kV) • (1000kV/MV) = 2010 A primary

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

132.8 kV • (1000 V/kV) = 132800 V primary

132800 V primary • (1/PT ratio) = 132800 V primary • (1 V secondary/2000 V primary) = 66.4 V secondary

Now, calculate the equivalent secondary impedance:

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

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

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

Again, for the maximum forward load:

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

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

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

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:

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

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

NOTE: Detecting high-impedance faults has challenged utilities and researchers for years, especially in situations where a fault occurs on asphalt or dry sand or generates little or virtually no fault current. As is commonly known, not all HIFs are detectable. Detecting HIFs potentially reduces the risks associated with these faults. The SEL HIF detection method increases the likelihood that an HIF will be detected.

High-impedance faults (HIF) are short-circuit faults with fault currents smaller than those a traditional overcurrent protective relay can detect. The main causes of HIFs are tree branches touching a phase conductor failing or dirty insulators that cause flashovers between a phase conductor and the ground or downed conductors. Almost all HIFs involve the ground directly or indirectly.

Staged downed-conductor fault tests in North America indicate that downed conductor HIFs generate quite small fault currents. 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.

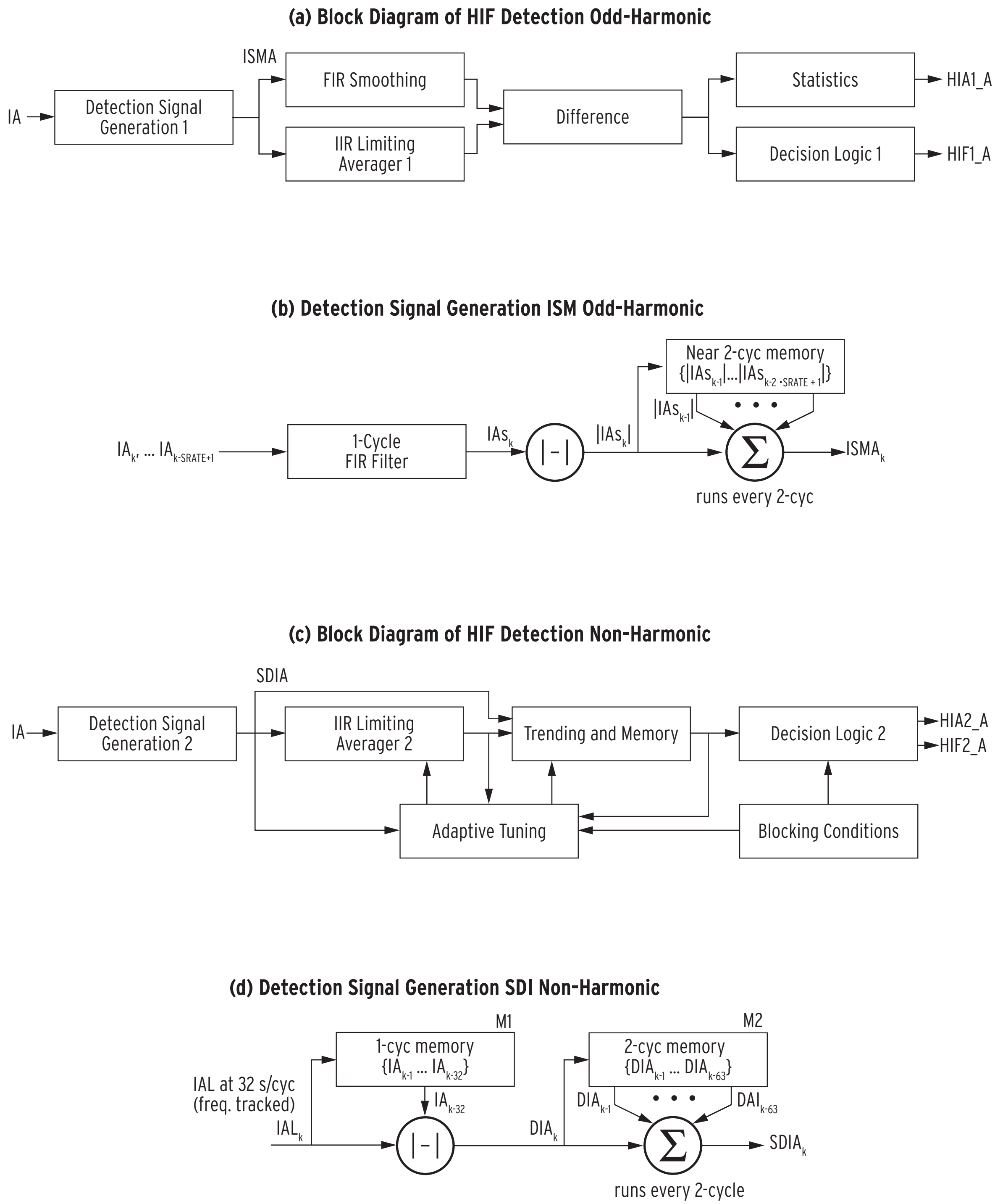
High-impedance fault detection is available in select SEL-751 models. The part number indicates whether or not the relay supports high-impedance fault detection.

The high-impedance fault (HIF) detection method shown in *Figure 4.37* incorporates the following key elements:

- An informative quantity that reveals HIF signatures as much as possible without being affected by loads and other system operation conditions.
- A running average of the quantity that provides a stable prefault reference.
- An adaptive tuning feature that learns and tunes out feeder ambient load conditions. (Note: A minimum of 0.05 • I_{NOM} load current is expected for successful tuning.)
- Decision logic to differentiate an HIF condition from other system conditions such as switching operations and noisy loads.

The HIF detection element derives a Sum of Difference current (SDI) that represents the total non-harmonic contents of the phase currents to detect a HIF signature. An averaging filter generates a stable reference of SDI and adapts to the ambient conditions of feeder loads. In turn, an adapted detection threshold is established based on the trends of the measured SDI and you would use decision logic to separate normal trending from the existence of a HIF on the distribution system. The SEL technical paper, *Detection of High-Impedance Faults in Power Distribution Systems* by Daqing Hou, details additional information about this HIF detection method.

Additional HIF detection logic measures the total odd-harmonic content (ISM), maintains long-term and short-term histograms of ISM, and generates HIF alarms by comparing the difference between two histograms. When the difference between the two histograms is not substantial, the long-term histogram is updated through an IIR filtering process from the short-term histogram. The long-term histogram therefore adapts to the feeder ambient load conditions and increases the overall HIF detection security.



Note: A-phase logic is shown above; B-phase and C-phase are similar.

Figure 4.37 Block Diagram of HIF Detection

HIF Detection Settings

NOTE: It is recommended to use EHIF := Y for field tests and follow the initial tuning process.

Table 4.27 lists the relay settings corresponding to high-impedance fault detection. High-impedance fault detection is enabled by group setting EHIF := Y or T. When EHIF is set to Y, the detection algorithm begins calculating a running average of the applicable algorithm quantity to provide a stable prefault reference. This initial tuning will assert Relay Word bits

ITUNE_*x* (where *x* = A, B, C). This process takes 24 hours but is interrupted by a change in the EHIF setting value, a change in the FNOM setting value, a loss of load current, or a relay trip condition.

Once interrupted, the initial tuning will restart the next time the relay detects load current. It can be restarted if necessary with the **INI HIF** command. See **INI HIF** for more information on the **INI HIF** command. After the initial tuning process, the relay will retain the learned value for four hours. If a line is de-energized for more than four hours, the relay will restart the initial tuning process upon the re-energization of the line. When EHIF is set to T, the detection algorithm bypasses the 24 -hour tuning process and is available immediately for testing purposes. The relay must be tracking frequency in order for the high-impedance fault detection algorithm to work; if the relay is not tracking frequency, the algorithm is disabled.

High-impedance fault detection sensitivity is controlled by the group SELOGIC control equation setting HIFMODE. Assertion of this logic equation sets Relay Word bit HIFMODE and increases the sensitivity of the detection algorithm.

Table 4.27 High-Impedance Fault (HIF) Detection Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
HIF EN	Y, N, T	EHIF := N
HIF DETECTION SENSITIVITY	SELOGIC Equation	HIFMODE := 0
HIF EVENT REPORT EXT. TRIGGER	SELOGIC Equation	HIFER := 0

EXAMPLE 4.6 HIFMODE Programming and Operation

As detailed previously, assertion of the HIFMODE SELOGIC control equation controls the sensitivity of the high-impedance fault detection algorithm. Field experience may suggest that downed conductor events that lead to high-impedance faults might occur more frequently during periods of storm activity. Furthermore, conductor configuration could make it likely that a downed conductor might initially create a high-current fault by making temporary contact with another conductor. This fault would be detected and cleared; disappearing upon a successful autoreclosure. The downed conductor would then be creating a high-impedance fault. It is during this time that it would be desirable to increase the sensitivity of the high-impedance fault detection algorithm. For example, a successful reclosure Relay Word bit could trigger a timer input. The dropout period of the timer is set to the period of time that is desired for increased detection sensitivity.

Enter the following Group Settings:

EHIF := Y

HIFMODE := SV16T AND 52A

Enter the following Logic Settings:

SV16PU := 0.00 # Pickup set to 0.00 sec

SV16DO := 1800 # Dropout set to 30.0 minutes on a 60 Hz system

SV16 := R_TRIG 79RI # (in reclose cycle state)

While the recloser is timing towards the reset state after a successful reclosure Relay Word bit 79RI asserts the output for SV Timer 16. The timer stays asserted for the duration of the dropout setting, which is 30 minutes in this example. During this 30 minutes, the timer assertion maintains the assertion of HIFMODE, assuring a window of time for increased sensitivity of the HIF detection algorithm.

Group SELOGIC control equation setting HIFER allows for the automatic triggering of HIF detection event reports. Assertion of HIFER will set Relay Word bit HIFREC and trigger an event report.

HIF Detection Logical Outputs

The SEL-751 indicates HIF detection through the Relay Word Bit outputs detailed in *Table 4.28*. You can use Relay word bits in custom logic programming to indicate high-impedance fault detection activity.

Table 4.28 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

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 9.18*, *High-Impedance Fault Compressed Event Report on page 9.22*, and *Figure 7.20*, *Figure 5.15: MET H (HIF) Command Response*, *Figure 7.25: LOG H (HIF) Command Response*, and *Figure 7.24: HSG Command Response* for more information.

RTD-Based Protection

RTD Input Function

When you connect an SEL-2600 RTD Module (select E49RTD := EXT) or order the internal RTD card option (select E49RTD := INT), the SEL-751 offers several protection and monitoring functions, settings for which are described in *Table 4.29*. See *Figure 2.12* 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 4.29 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 4.29 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 will not be replaced, set the RTD location for that input equal to OFF.
- ➤ For RTDs embedded in motor stator windings, set the RTD location equal to WDG.
- ➤ For inputs connected to RTDs measuring bearing race temperature, set the RTD location equal to BRG.
- ➤ For the input connected to an RTD measuring ambient motor cooling air temperature, set the RTD location equal to AMB. Only one ambient temperature RTD is allowed.
- ➤ For inputs connected to monitor temperatures of another apparatus, set the RTD location equal to OTH.

If an RTD location setting is equal to OFF, the relay does not request that an RTD type setting be entered for that input.

RTD Type

The four available RTD types for setting RTD*n*TY are:

- ➤ 100-ohm platinum (PT100)
- ➤ 100-ohm nickel (NI100)
- ➤ 120-ohm nickel (NI120)
- ➤ 10-ohm copper (CU10)

RTD Trip/Warning Levels

The SEL-751 provides temperature warnings and trips through use of the RTD temperature measurements and the warning and trip temperature settings, ALTMP*n* and TRTMP*n*, in *Table 4.16*.

NOTE: To improve security, RTD ALARM and TRIP are delayed by approximately 6 seconds.

The relay issues a winding temperature warning if any of the healthy winding RTDs (RTD location setting equals WDG) indicate a temperature greater than the relay RTD warning temperature setting. The relay issues a winding temperature trip if one or two of the healthy winding RTDs indicate a temperature greater than their RTD trip temperature settings. Two winding RTDs must indicate excessive temperature when the winding trip voting setting EWDGV equals Y. Only one excessive temperature indication is necessary if the winding trip voting is not enabled. The bearing trip voting, EBRGV, works similarly.

The warning and trip temperature settings for bearing, ambient, and other RTD types function similarly, except that trip voting is not available for ambient and other RTDs.

To disable any of the temperature warning or trip functions, set the appropriate temperature setting to OFF.

Only healthy RTDs can contribute temperatures to the warning and trip functions. The relay includes specific logic to indicate if RTD leads are shorted or open.

Figure 4.17 lists the RTD resistance versus temperature for the four supported RTD types.

Table 4.30 RTD Resistance Versus Temperature

Temp (°F)	Temp (°C)	100 Platinum	120 Nickel	100 Nickel	10 Copper
–58	–50.00	80.31	86.17	74.30	7.10
–40	–40.00	84.27	92.76	79.10	7.49
–22	–30.00	88.22	99.41	84.20	7.88
–4	–20.00	92.16	106.15	89.30	8.26
14	–10.00	96.09	113.00	94.60	8.65
32	0.00	100.00	120.00	100.00	9.04
50	10.00	103.90	127.17	105.60	9.42
68	20.00	107.79	134.52	111.20	9.81
86	30.00	111.67	142.06	117.10	10.19
104	40.00	115.54	149.79	123.00	10.58
122	50.00	119.39	157.74	129.10	10.97
140	60.00	123.24	165.90	135.30	11.35
158	70.00	127.07	174.25	141.70	11.74
176	80.00	130.89	182.84	148.30	12.12
194	90.00	134.70	191.64	154.90	12.51
212	100.00	138.50	200.64	161.80	12.90
230	110.00	142.29	209.85	168.80	13.28
248	120.00	146.06	219.29	176.00	13.67
266	130.00	149.83	228.96	183.30	14.06
284	140.00	153.58	238.85	190.90	14.44
302	150.00	157.32	248.95	198.70	14.83
320	160.00	161.05	259.30	206.60	15.22
338	170.00	164.77	269.91	214.80	15.61
356	180.00	168.47	280.77	223.20	16.00
374	190.00	172.17	291.96	231.80	16.39
392	200.00	175.85	303.46	240.70	16.78
410	210.00	179.15	315.31	249.80	17.17
428	220.00	183.17	327.54	259.20	17.56
446	230.00	186.82	340.14	268.90	17.95
464	240.00	190.45	353.14	278.90	18.34
482	250.00	194.08	366.53	289.10	18.73

Voltage-Based Protection

Undervoltage Function

Table 4.31 Undervoltage Function

Setting Prompt	Setting Range	Setting Name := Factory Default
UV TRIP1 LEVEL	OFF, 2.0–300.0 V	27P1P := OFF
UV TRIP1 DELAY	0.0–120.0 sec	27P1D := 0.5
UV TRIP2 LEVEL	OFF, 2.0–300.0 V	27P2P := OFF
UV TRIP2 DELAY	0.0–120.0 sec	27P2D := 5.0
PP UV TRIP1 LEVEL	OFF, 2.0–300.0 V[a]	27PP1P := OFF
PP UV TRIP1 LEVEL	OFF, 2.0–520.0 V[b]	27PP1P := OFF
PP UV TRIP1 DELAY	0.0–120.0 sec	27PP1D := 0.5
PP UV TRIP2 LEVEL	OFF, 2.0–300.0 V[a]	27PP2P := OFF
PP UV TRIP2 LEVEL	OFF, 2.0–520.0 V[b]	27PP2P := OFF
PP UV TRIP2 DELAY	0.0–120.0 sec	27PP2D := 0.5
UVS LEVEL 1	OFF, 2.0–300.0 V	27S1P := OFF
UVS DELAY 1	0.0–120.0 sec	27S1D := 0.5
UVS LEVEL 2	OFF, 2.0–300.0 V	27S2P := OFF
UVS DELAY 2	0.0–120.0 sec	27S2D := 0.5

[a] Setting range shown is for DELTA_Y := DELTA.
[b] Setting range shown is for DELTA_Y := WYE.

Overvoltage Function

Table 4.32 Overvoltage Function (Sheet 1 of 2)

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

Table 4.32 Overvoltage Function (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
NSQ OV TRIP1 DLY	0.00–120.00 sec	59Q1D := 0.50
NSQ OV TRIP2 LVL	Off, 2.00–300.00 V	59Q2P := OFF
NSQ OV TRIP2 DLY	0.00–120.00 sec	59Q2D := 5.00
UVS LEVEL 1	Off, 2.00–300.00 V	59S1P := OFF
UVS DELAY 1	0.00–120.00 sec	59S1D := 0.50
UVS LEVEL 2	Off, 2.00–300.00 V	59S2P := OFF
UVS DELAY 2	0.00–120.00 sec	59S2D := 0.50

[a] Setting range shown is for DELTA_Y := DELTA.
[b] Setting range shown is for DELTA_Y := WYE.

When you connect the SEL-751 voltage inputs to phase-to-phase connected VTs (single-phase or three-phase), as in *Figure 2.16* or *Figure 2.17*, 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 2.16* or *Figure 2.17*, the relay provides two levels of phase-to-neutral, phase-to-phase overvoltage and undervoltage elements. When a synchronism voltage input is present (e.g., VS input shown in *Figure 2.17*) the SEL-751 provides two levels of VS under- and overvoltage elements. You can use these elements to control reclosing logic described later.

Each of the elements has an associated time delay, except the three-phase under- and overvoltage elements, 3P27 and 3P59. You can use these elements as you choose for tripping and warning. *Figure 4.38* and *Figure 4.39* show the logic diagrams for the undervoltage and overvoltage elements, respectively. To disable any of these elements, set the level settings equal to OFF.

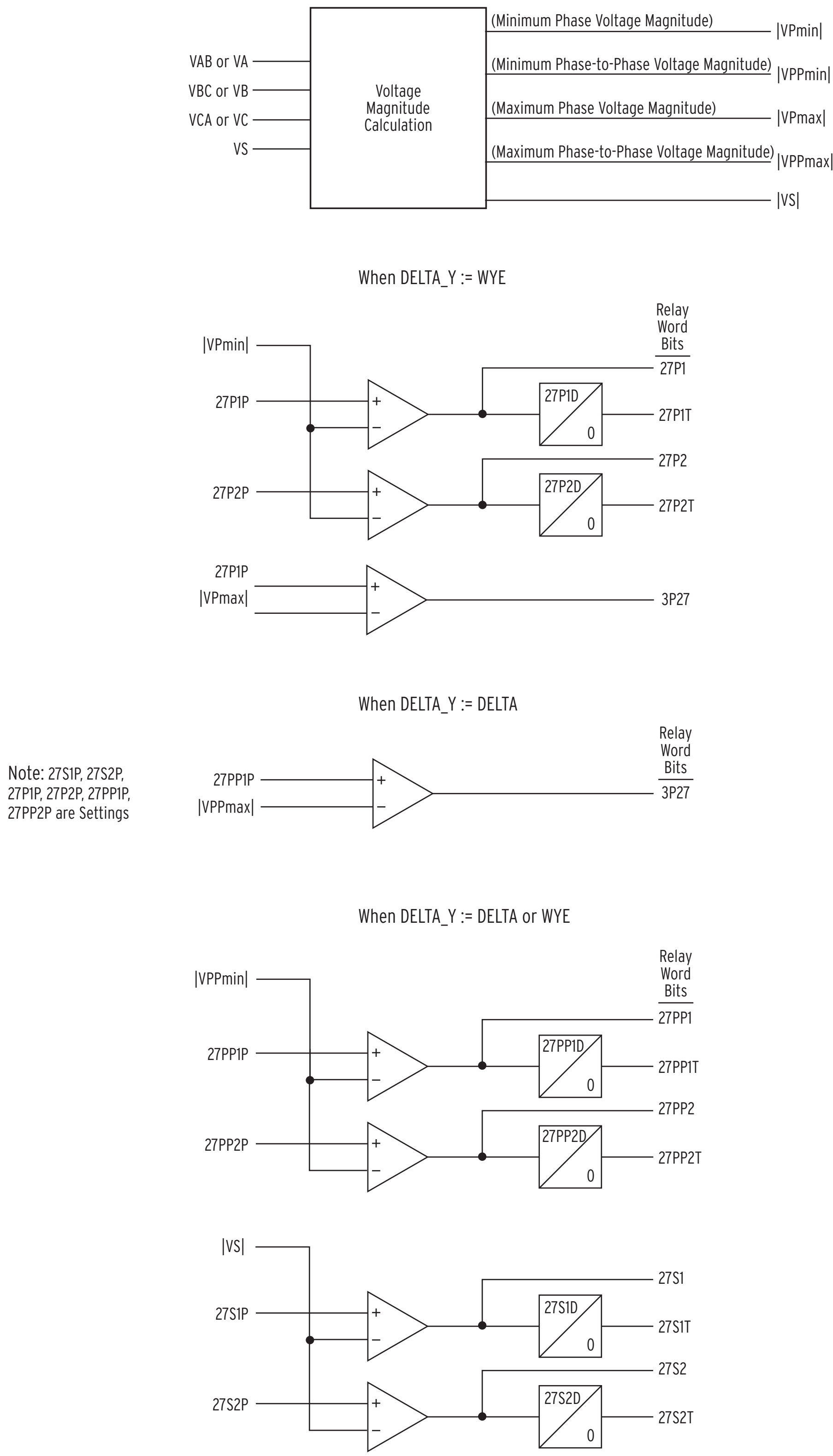


Figure 4.38 Undervoltage Element Logic

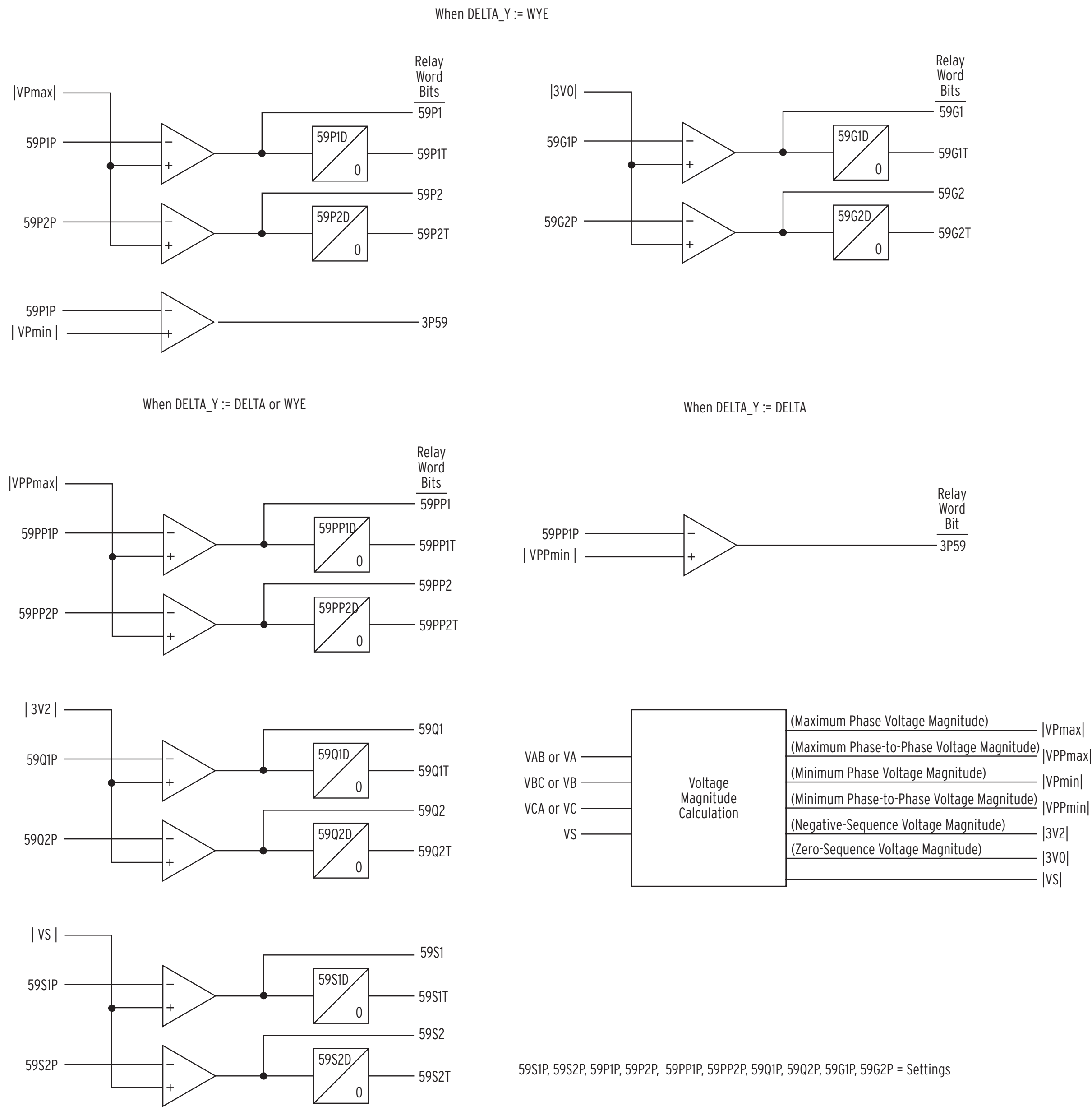


Figure 4.39 Overvoltage Element Logic

Synchronism-Check Elements

Figure 2.19, and *Figure 2.20* show examples where synchronism check can be applied. Synchronism-check voltage input **VS** is connected to one side of the circuit breaker, on any phase you want. The other synchronizing phase (**VA**, **VB**, or **VC** voltage inputs) on the other side of the circuit breaker is setting selected.

The two synchronism-check elements use the same voltage window (to assure healthy voltage), frequency window (FNOM ±5 Hz), and slip frequency settings (see *Figure 4.40* and *Figure 4.41*). 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 4.41*. 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 4.41*. 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.

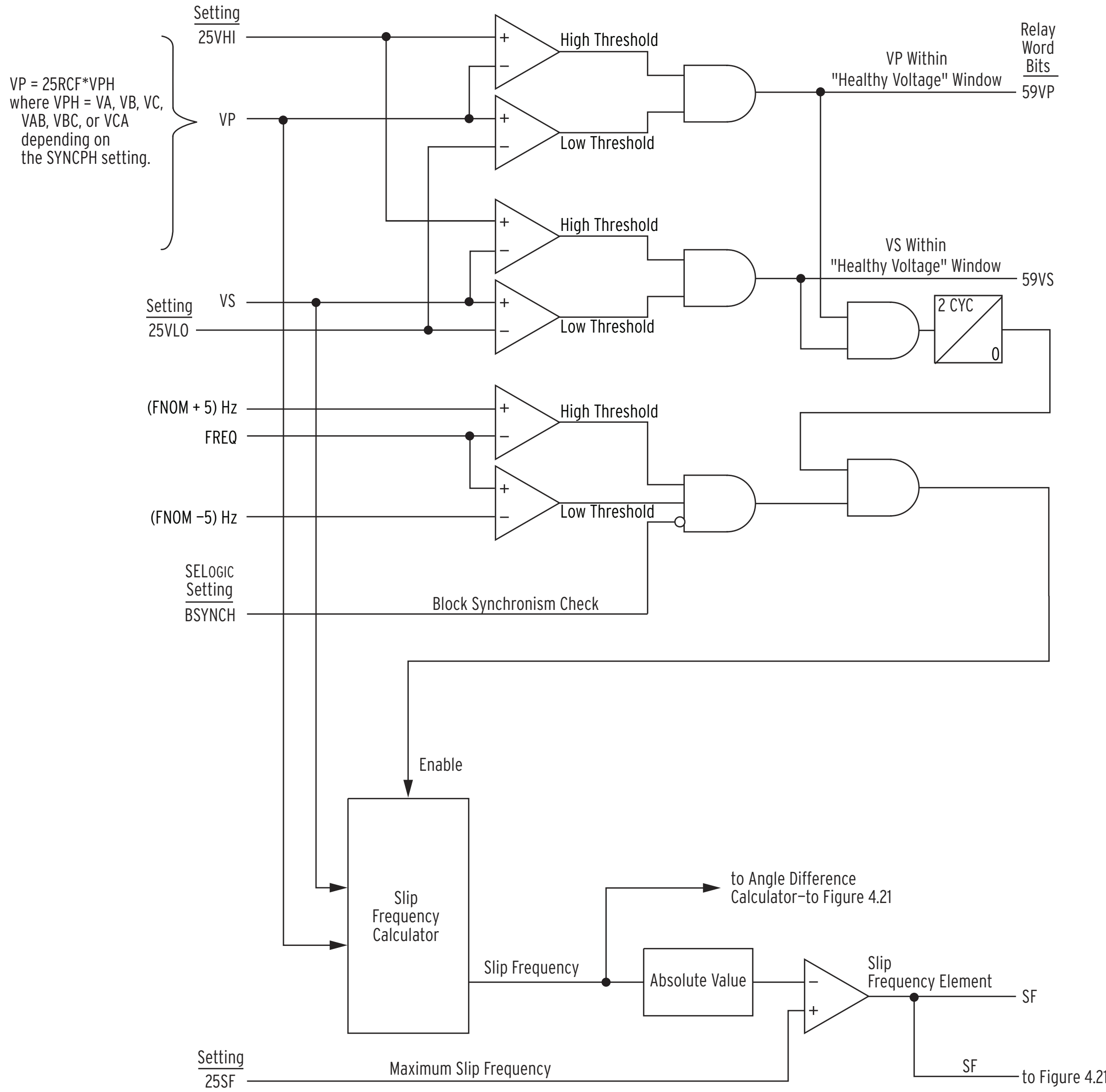
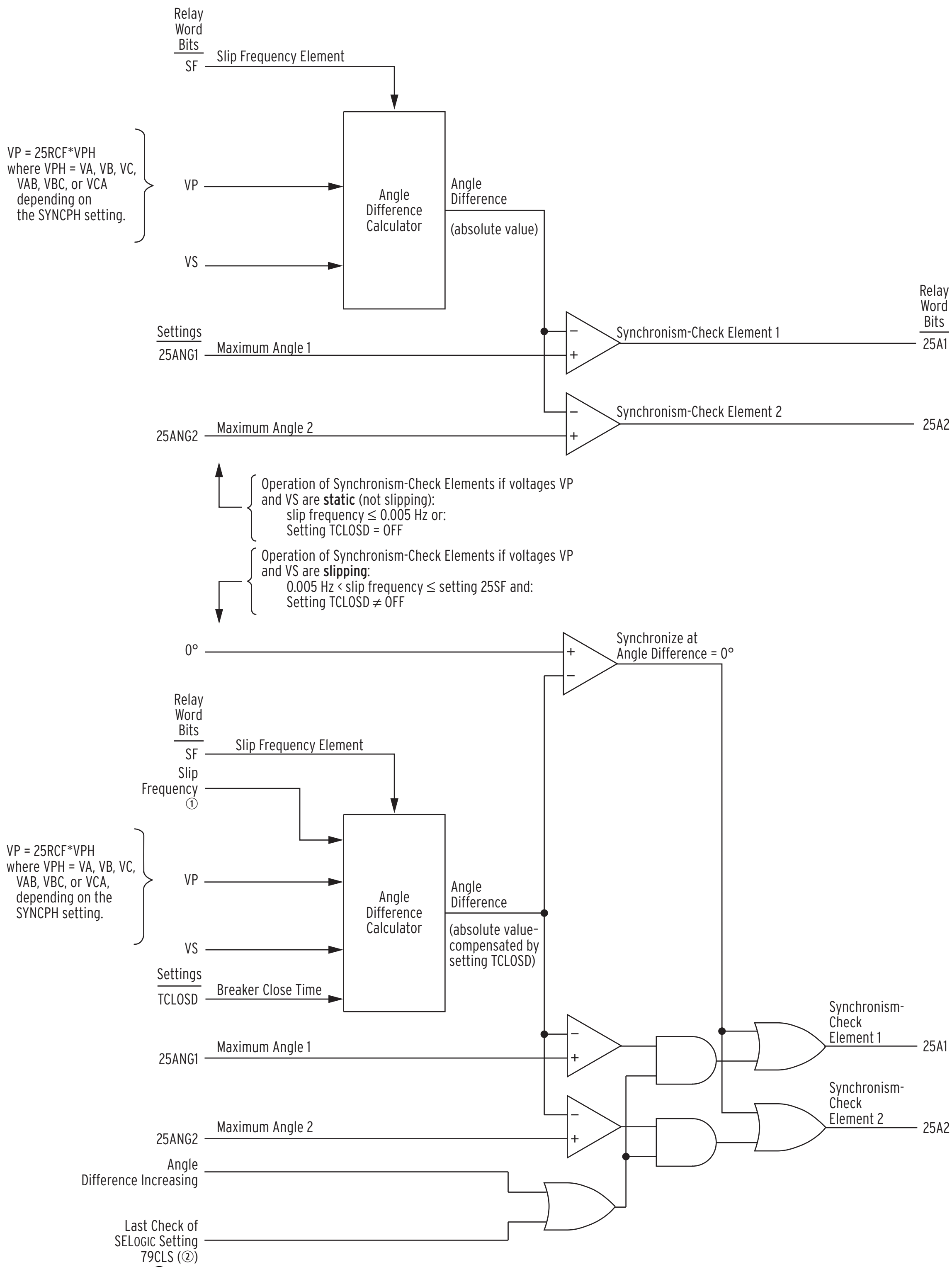


Figure 4.40 Synchronism-Check Voltage Window and Slip Frequency Elements



① From Figure 4.40 ② see Figure 4.53.

Figure 4.41 Synchronism-Check Elements

These synchronism-check elements are explained in detail in the following text.

Voltage Input VS Connected Phase-to-Phase or Beyond Delta-Wye Transformer

Sometimes synchronism-check voltage **VS** cannot be in phase with voltage VA, VB, or VC (wye connected PTs) or VAB, VBC, or VCA (delta-connected PTs). This happens in applications where voltage input **VS** is connected

- ➤ Phase-to-phase when using a wye-connected relay
- ➤ Phase-to-neutral when using a delta-connected relay
- ➤ Beyond a delta-wye transformer

For such applications requiring **VS** to be at a constant phase angle difference from any of the possible synchronizing voltages (VA, VB, or VC; VAB, VBC, or VCA), an angle setting is made with the SYNCPH setting (see *Table 4.33* and *Setting SYNCPH on page 4.60*).

Table 4.33 Synchronism-Check Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
SYNCH CHECK	Y, N	E25 := N
VS WINDOW LOW	0.00–300.00 V	25VLO := 105.00
VS WINDOW HIGH	0.00–300.00 V	25VHI := 130.00
V RATIO COR FAC	0.50–2.00	25RCF := 1.00
MAX SLIP FREQ	0.05–0.50 Hz	25SF := 0.20
MAX ANGLE 1	0–80 deg	25ANG1 := 25
MAX ANGLE 2	0–80 deg	25ANG2 := 40
SYNCH PHASE	VA, VB, VC, or 0, 30, 60, 90, 120, 150, 180, 210, 240, 270, 300, 330 deg lag VA[a]	SYNCPH := VA
SYNCH PHASE	VAB, VBC, VCA, or 0, 30, 60, 90, 120, 150, 180, 210, 240, 270, 300, 330 deg lag VAB[b]	SYNCPH := VAB
BRKR CLOSE TIME	OFF, 1-1000 ms	TCLOSD := 50
BLK SYNCH CHECK	SV	BSYNCH := 52A

[a] Range shown for DELTA_Y := WYE.
[b] Range shown for DELTA_Y := DELTA.

Setting SYNCPH

Enable the two single-phase synchronism-check elements by setting E25 := Y.

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 will display the setting entered (SYNCPH := VA or SYNCPH := 0).

Wye-Connected Voltages. 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 4.41*). For situations where VS cannot be in phase with VA, VB, or VC, the angle setting choices (0, 30, …, 300, or 330 degrees) are referenced to VA.

Delta-Connected Voltages. The angle setting choices (0, 30, …, 300, or 330 degrees) for setting SYNCPH are referenced to VAB, and they indicate how many degrees VS constantly lags VAB. In this application, voltage input **VA-VB** has to be connected and has to meet the “healthy voltage” criteria

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 will display the setting entered (SYNCPH := VAB or SYNCPH := 0).

(settings 25VHI and 25VLO—see *Figure 4.40*). 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 2.19 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 will be 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 will require 25RCF := 1.00, however some applications may need a different setting. For example, *Figure 2.19* requires 25RCF := PTR / (1.732*PTRS). This will be 0.58 if the PTR and PTRS are equal.

See the Application Guide entitled *Compensate for Constant Phase Angle Difference in Synchronism Check with the SEL-351 Relay Family* (also applies to SEL-751) for more information on setting SYNCPH with an angle setting.

Synchronism-Check Elements Voltage Inputs

The two synchronism-check elements are single-phase elements, for both of which you would use single-phase voltage inputs VP and VS:

1. VP Phase input voltage (VA, VB, or VC *25RCF for Delta_Y := Wye; VAB, VBC, or VCA*25RCF for Delta_Y := Delta), designated by setting SYNCPH (If SYNCPH is set to one of the angle settings, then VP = VA*25RCF or VAB*25RCF depending on the Delta_Y setting.)
2. VS Synchronism-check voltage, from SEL-751 rear-panel voltage input VS

For example, if the rear-panel voltage input VS-NS is connected to B-phase (or BC phase-to-phase for delta) then set SYNCPH := VB (or VBC for delta). The voltage across terminals VB-N (or VB-VC for delta) is synchronism checked with the voltage across terminals VS-NS (see *Figure 2.19*).

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 4.40* and *Figure 4.41*.

Voltage Window. Refer to *Figure 4.40*. 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 4.40*. The synchronism-check element slip frequency calculator runs if both voltages VP and VS are healthy (59VP and 59VS asserted to logical 1) and the SELOGIC control equation setting BSYNCH (Block Synchronism Check) is deasserted (= logical 0). Setting BSYNCH is most commonly set to block synchronism-check operation when the circuit breaker is closed (synchronism check is only necessary when the circuit breaker is open):

BSYNCH := **52A** (see *Figure 4.52*)

In addition, you can block synchronism-check operation when the relay is tripping:

BSYNCH := **... OR TRIP**

Slip Frequency Calculator. Refer to *Figure 4.40*. The synchronism-check element Slip Frequency Calculator in *Figure 4.40* runs if voltages VP and VS are healthy (59VP and 59VS asserted to logical 1) and the SELOGIC control equation setting BSYNCH (Block Synchronism Check) is deasserted (= logical 0). The Slip Frequency Calculator output is:

Slip Frequency = fP – fS (in units of Hz = slip cycles/second)

fP = frequency of voltage VP (in units of Hz = cycles/second)

fS = frequency of voltage VS (in units of Hz = cycles/second)

A complete slip cycle is one single 360-degree revolution of one voltage (e.g., VS) by another voltage (e.g., VP). Both voltages are thought of as revolving phasor-wise, so the “slipping” of VS past VP is the relative revolving of VS past VP.

For example, in *Figure 4.40*, 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 4.41* 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 4.41*. If the slip frequency is less than or equal to 0.005 Hz, the Angle Difference Calculator does *not* take into account breaker close time—it presumes voltages VP and VS are "static" (not "slipping" with respect to one another). This would usually be the case for an open breaker with voltages VP and VS that are paralleled via some other electric path in the power system. The Angle Difference Calculator calculates the angle difference between voltages VP and VS:

$$\text{Angle Difference} = |(\angle VP - \angle VS)|$$

For example, if SYNCPH := 90 (indicating VS constantly lags VP = VA by 90 degrees), but VS actually lags VA by 100 angular degrees on the power system at a given instant, the Angle Difference Calculator automatically accounts for the 90 degrees and:

$$\text{Angle Difference} = |(\angle VP - \angle VS)| = 10°$$

Also, if breaker close time setting TCLOSD = OFF, the Angle Difference Calculator does not take into account breaker close time, even if the voltages VP and VS are "slipping" with respect to one another. Thus, synchronism-check elements 25A1 or 25A2 assert to logical 1 if the Angle Difference is less than corresponding maximum angle setting 25ANG1 or 25ANG2.

Voltages VP and VS Are "Slipping". Refer to bottom of *Figure 4.41*. 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 4.42*). The Angle Difference Calculator calculates the Angle Difference between voltages VP and VS, compensated with the breaker close time:

$$\text{Angle Difference} = |(\angle VP - \angle VS) + [(fP - fS) \bullet TCLOSD \bullet (1 / 1000) \bullet (360°/\text{slip cycle})]|$$

Angle Difference Example (Voltages VP and VS are "Slipping"). Refer to bottom of *Figure 4.41*. For example, if the breaker close time is 100 ms, set TCLOSD := 100. Presume the slip frequency is the example slip frequency calculated previously. The Angle Difference Calculator calculates the angle difference between voltages VP and VS, compensated with the breaker close time:

$$\text{Angle Difference} = |(\angle VP - \angle VS) + [(fP - fS) \bullet TCLOSD \bullet (1 / 1000) \bullet (360°/\text{slip cycle})]|$$

NOTE: The angle compensation in Figure 4.42 appears much greater than 3.6 degrees. Figure 4.42 is for general illustrative purposes only.

Intermediate calculations:

$$(fP - fS) = (59.95\text{ Hz} - 60.05\text{ Hz}) = -0.10\text{ Hz} = -0.10\text{ slip cycles/second}$$
$$TCLOSD \bullet (1 / 1000) = 0.1\text{ second}$$

Resulting in:

Angle Difference

$$= |(\angle VP - \angle VS) + [(fP - fS) \bullet TCLOSD \bullet (1 / 1000) \bullet (360°/\text{slip cycle})]|$$
$$= |(\angle VP - \angle VS) + [-0.10 \bullet 0.1 \bullet 360°]|$$
$$= |(\angle VP - \angle VS) - 3.6°|$$

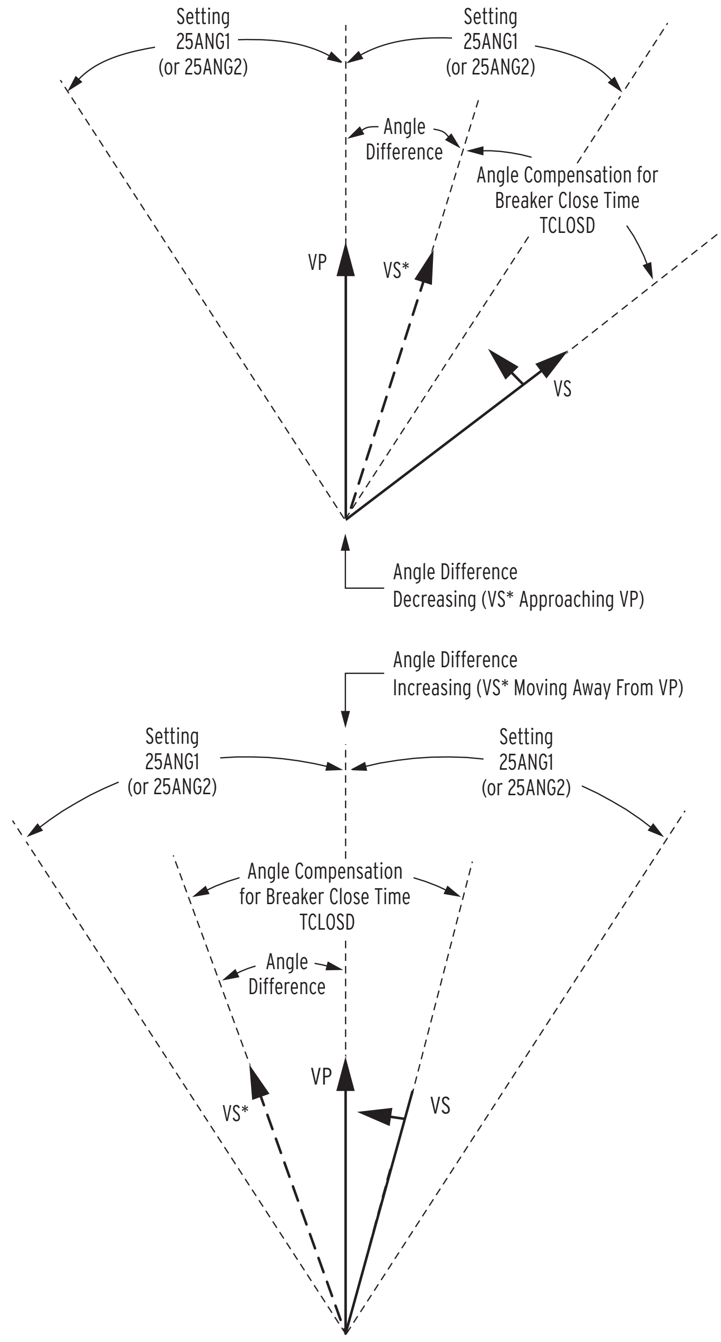


Figure 4.42 Angle Difference Between VP and VS Compensated by Breaker Close Time (fP < fS and VP Shown as Reference in This Example)

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 4.42*.

The top of *Figure 4.42* 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 4.42* 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 4.41*) 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 4.41*.

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 4.41*. 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 4.42* 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 4.42* 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 4.80*.

   Refer to the bottom of *Figure 4.53*. 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 Lockout State (see top of *Figure 4.54*).

Refer to the top of *Figure 4.53*. 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 4.42*. 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 4.41* 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 4.52*. Element 25A2 operates similarly.

Synchronism-Check Applications for Automatic Reclosing and Manual Closing

Refer to *Trip/Close Logic on page 4.78* and *Reclose Supervision Logic on page 4.80*.

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 4.53)
```

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 4.52)
```

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 4.52*) logic output).

Power Elements

You can enable as many as two independent three-phase power elements in the SEL-751. Each enabled element can be set to detect real power or reactive power. When voltage inputs to the relay are from delta-connected PTs or when you use a single voltage input, the relay cannot account for unbalance in the voltages in calculating the power. When you use one voltage (only the Va or Vab) and set SINGLEV := Y, the relay assumes that the system voltages are balanced in both magnitude and phase angle. Power and power factor are calculated assuming balanced voltages. Take this into consideration in applying the power elements.

Table 4.34 Voltages When Setting SINGLEV := Y

DELTA_Y Setting	PHROT Setting	Voltages
WYE	ABC	VA = |Va| ∠ϕ° VB = |Va| ∠ϕ–120° VC = |Va| ∠ϕ+120°
WYE	ACB	VA = |Va| ∠ϕ° VB = |Va| ∠ϕ+120° VC = |Va| ∠ϕ–120°
DELTA	ABC	VAB = |Vab| ∠ϕ° VBC = |Vab| ∠ϕ–120° VCA = |Vab| ∠ϕ+120°
DELTA	ACB	VAB = |Vab| ∠ϕ° VBC = |Vab| ∠ϕ+120° VCA = |Vab| ∠ϕ–120°

With SELOGIC control equations, the power elements provide a wide variety of protection and control applications. Typical applications are:

- Overpower and/or underpower protection/control
- Reverse power protection/control
- VAR control for capacitor banks

Table 4.35 Power Element Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PWR ELEM	N, 3P1, 3P2	EPWR := N
3PH PWR ELEM PU	OFF, 1.0–6500.0 VA[a] (secondary)	3PWR1P := OFF
PWR ELEM TYPE	+WATTS, –WATTS, +VARS, –VARS	PWR1T := +VARS
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

Table 4.35 Power Element Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
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 4.43* shows the power element logic diagram and *Figure 4.44* shows the operation in the Real/Reactive power plane.

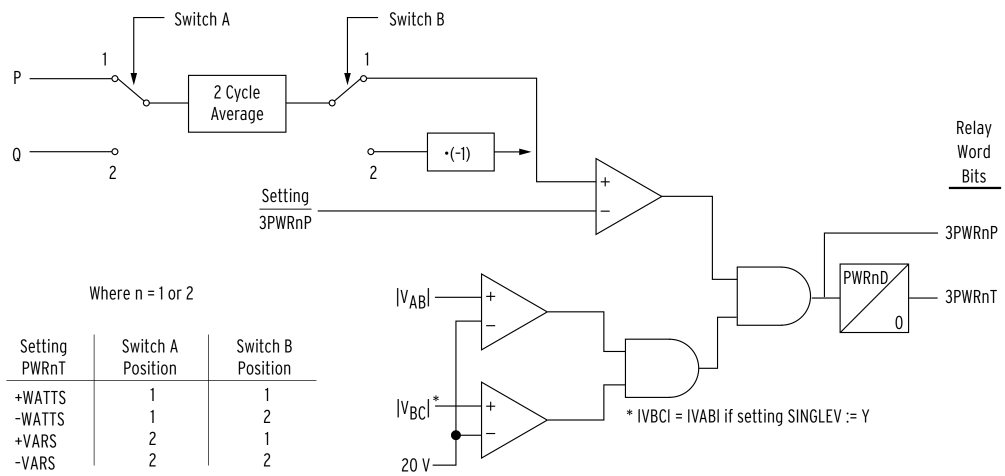


Figure 4.43 Three-Phase Power Elements Logic

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 4.43*. 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.

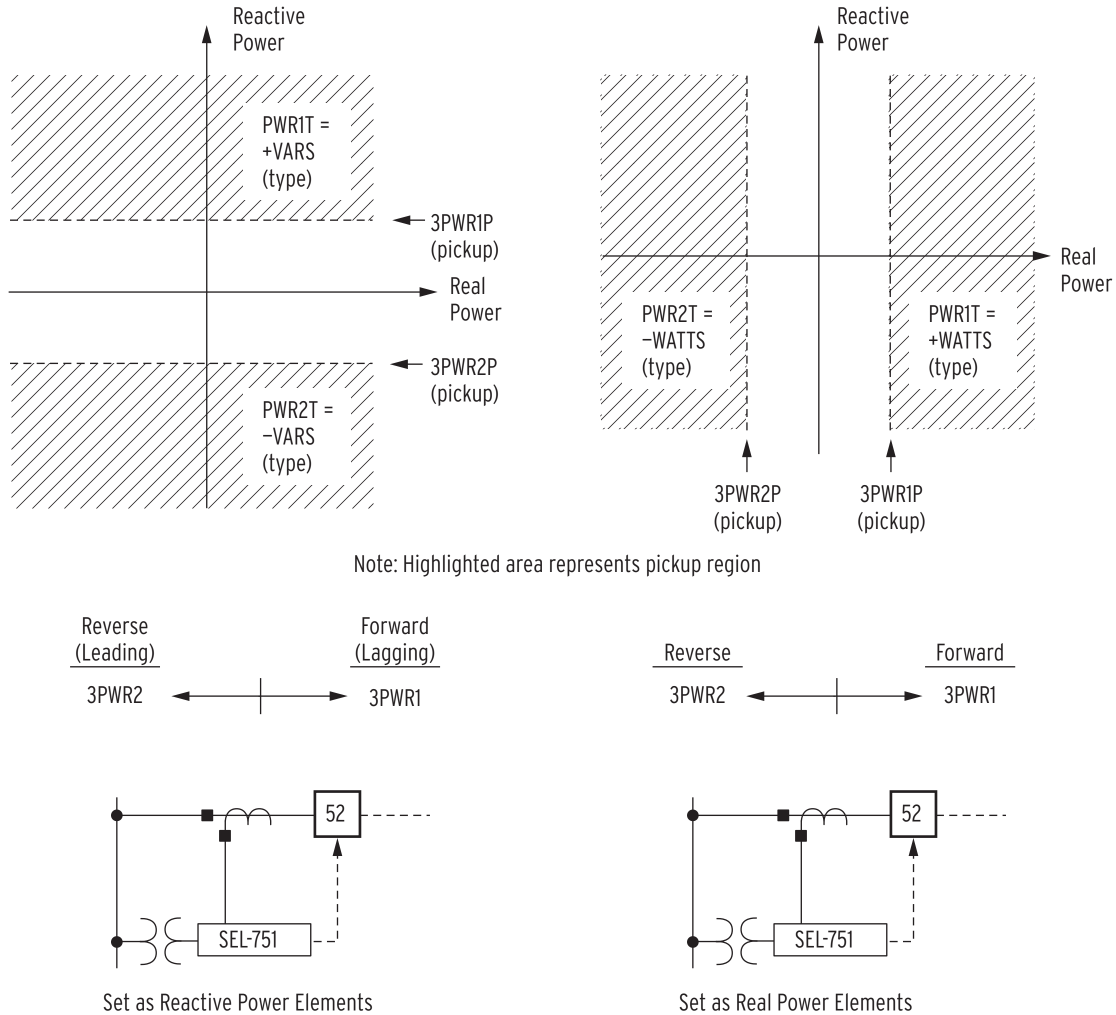


Figure 4.44 Power Elements Operation in the Real/Reactive Power Plane

Power Factor Elements

Table 4.36 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 4.45* 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.

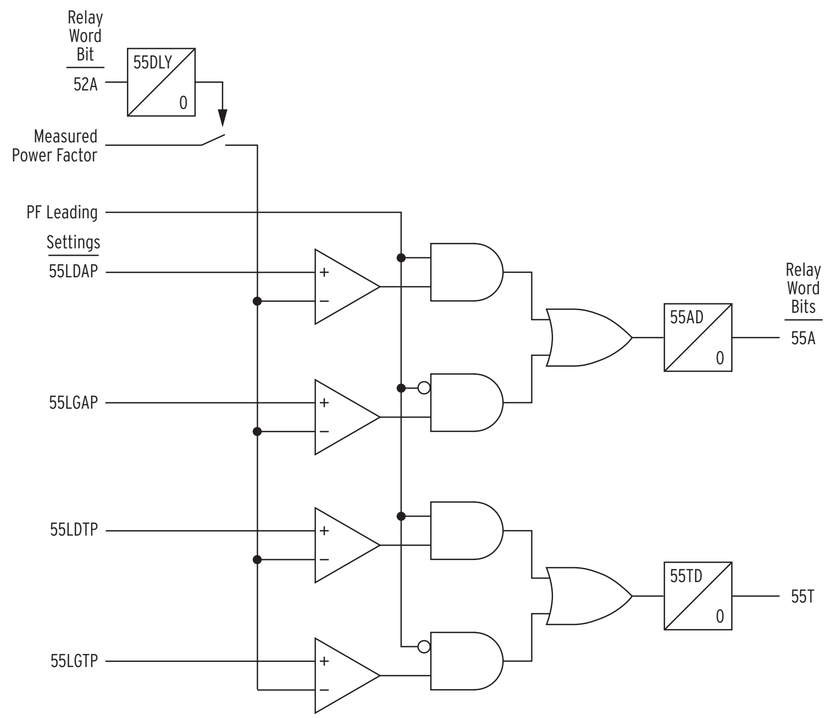


Figure 4.45 Power Factor Elements Logic

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.

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 60 cycles, then the relay latches the LOP Relay Word bit at logical 1. The relay resets LOP when the positive-sequence voltage (V1) returns to a level greater than 0.75 • Nominal Voltage while negative-sequence voltage (V2) and zero-sequence voltage (V0) are both less than 5 V secondary (VNOM is a relay setting).

Settings

The LOP function has no settings and is always active. You must incorporate the LOP function in a SELOGIC control equation to supervise relay protection elements (see *Example 4.7*).

LOP Impact on Other Protection Elements

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 4.7*). If you are using voltage-determined relay elements for tripping decisions, then blocking these elements is crucial when the voltage component is no longer valid.

EXAMPLE 4.7 Supervising 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.

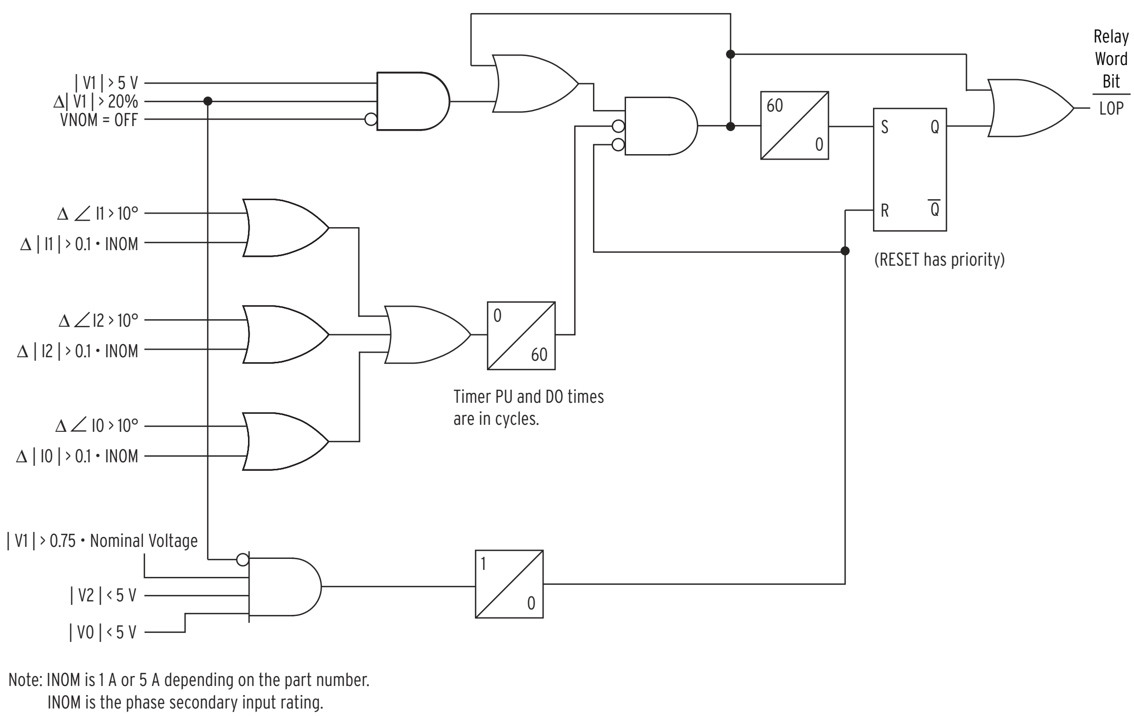


Figure 4.46 Loss-of-Potential (LOP) Logic

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.

Frequency Protection

Table 4.37 Frequency Settings

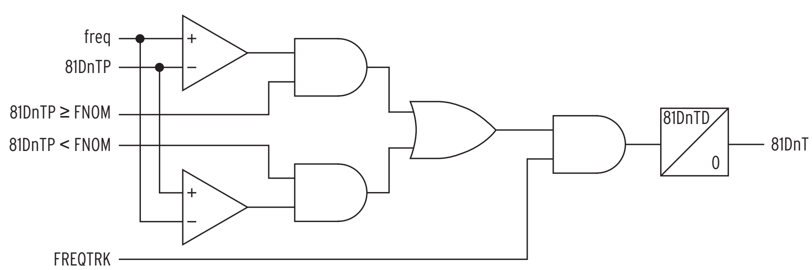
Setting Prompt	Setting Range	Setting Name := Factory Default
FREQ1 TRIP LEVEL	OFF, 15.00–70.00 Hz	81D1TP := OFF
FREQ1 TRIP DELAY[a]	0.00–240.00 sec	81D1TD := 1.00
FREQ2 TRIP LEVEL	OFF, 15.00–70.00 Hz	81D2TP := OFF
FREQ2 TRIP DELAY[a]	0.00–240.00 sec	81D2TD := 1.00
FREQ3 TRIP LEVEL	OFF, 15.00–70.00 Hz	81D3TP := OFF
FREQ3 TRIP DELAY[a]	0.00–240.00 sec	81D3TD := 1.00
FREQ4 TRIP LEVEL	OFF, 15.00–70.00 Hz	81D4TP := OFF
FREQ4 TRIP DELAY[a]	0.00–240.00 sec	81D4TD := 1.00
FREQ5 TRIP LEVEL	OFF, 15.00–70.00 Hz	81D5TP := OFF
FREQ5 TRIP DELAY[a]	0.00–240.00 sec	81D5TD := 1.00
FREQ6 TRIP LEVEL	OFF, 15.00–70.00 Hz	81D6TP := OFF
FREQ6 TRIP DELAY[a]	0.00–240.00 sec	81D6TD := 1.00

[a] Frequency element time delays are best set no less than five cycles. The relay requires at least three cycles to measure frequency.

NOTE: The relay measures system frequency for these elements with the positive-sequence voltage if the voltage input is present and the applied positive-sequence voltage is greater than 10 volts. Otherwise, the relay uses positive-sequence current as long as the minimum magnitude is 0.1 • (Nominal CT Rating). The measured frequency is set to nominal frequency setting (FNOM) if the signal is below the minimum level.

NOTE: Additionally, the Relay Word bit ORED81T := 81D1T OR 81D2T OR ... 81D6T.

The SEL-751 provides six trip over- or underfrequency elements with independent level and time-delay settings. 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 4.47* shows the logic diagram for the frequency elements.



n = Frequency Elements 1–6
freq = Measured Frequency
81DnTP = Frequency Pickup Setting
FNOM = Nominal Frequency Setting
81DnTD = Over- and Underfrequency Element Pickup Time Delay
81DnT = Definite-Time Delayed Over- and Underfrequency Element Relay Word Bit
FREQTRK = Relay Is Tracking Frequency

Figure 4.47 Over- and Underfrequency Element Logic

Rate-of-Change-of-Frequency (81R) Protection

Frequency changes occur in power systems when there is an unbalance between load and active power generated. Typically, generator control action adjusts the generated active power and restores the frequency to nominal value. Failure of such control action may lead to system instability unless remedial action, such as load shedding, is taken. You can use the rate of change of frequency element to detect and initiate a remedial action. The SEL-751 provides four rate-of-change-of-frequency elements. *Table 4.38* shows the settings available for the elements.

Table 4.38 Rate-of-Change-of-Frequency Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE 81R	N, 1–4	E81R := N
81R VOLTAGE SUP	OFF, 12.5–300.0 V	81RVSUP := 12.5
81R CURRENT SUP	OFF, 0.1–2.0*I_{NOM}[a]	81RISUP := OFF
81R1 TRIP LEVEL	OFF, 0.10–15.00 Hz/sec	81R1TP := OFF
81R1 TREND	INC, DEC, ABS	81R1TRND := ABS
81R1 TRIP DELAY	0.10–60.00 sec	81R1TD := 1.00
81R1 DO DELAY	0.00–60.00 sec	81R1DO := 0.00
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
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
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

[a] I_{NOM} is nominal rating of the phase CTs (1A or 5A).

Use E81R setting to enable the number of elements you want; *Figure 4.48* shows the element logic. The SEL-751 measures frequency (mf1) and second frequency (mf2) after a time window (dt) determined by Trip Level setting (81RnTP). Hysteresis is such that pickup is 100 percent of 81RnTP setting and dropout is 95 percent. *Table 4.39* shows the time windows for different trip level settings. Additionally, the Relay Word bit ORED81RT := 81R1T OR 81R2T OR 81R3T OR 81R4T.

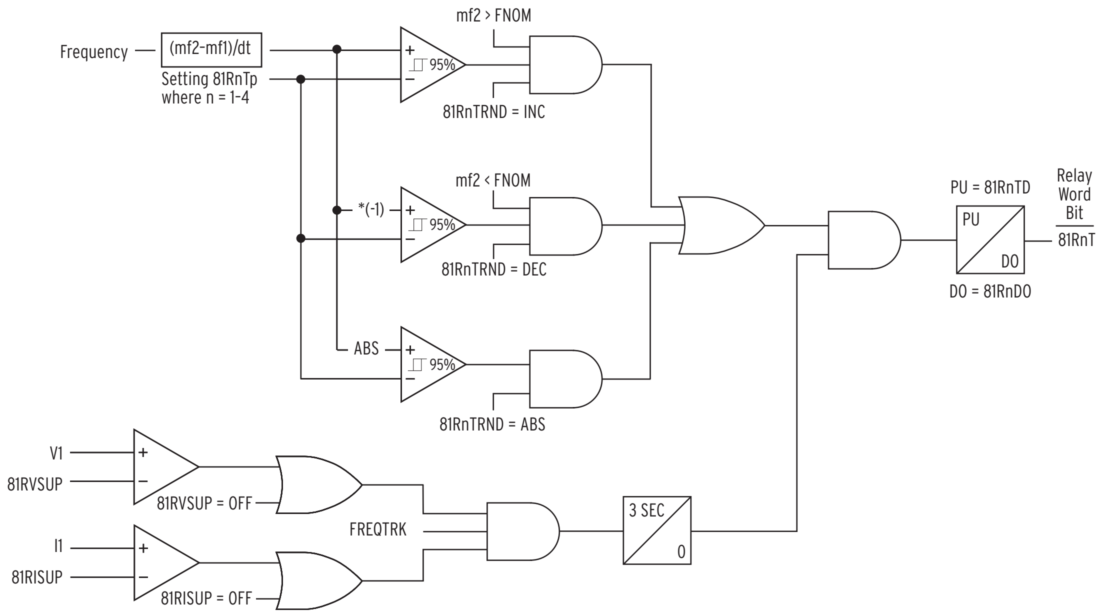


Figure 4.48 81R Frequency Rate-of-Change Scheme Logic

Table 4.39 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

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

Voltage and current supervision: A minimum positive-sequence Voltage and/ or Current is necessary for the operation of the 81R element when the levels are specified by the 81RISUP and 81RVSUP settings respectively. Set 81RISUP := OFF if no current supervision is necessary and similarly 81RVSUP := OFF if no voltage supervision is necessary. In any case, the element is also supervised by Relay Word FREQTRK, which ensures that the relay is tracking and measuring the system frequency.

Use the Relay Word bit 81R*n*T to operate output contacts to open appropriate breaker(s) as necessary for your load-shedding scheme.

Fast Rate-of-Change-of-Frequency (81RF) Protection

Fast Rate-of-Change-of-Frequency (81RF) Element (Aurora Vulnerability Mitigation)

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 4.49*) 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 4.40*).

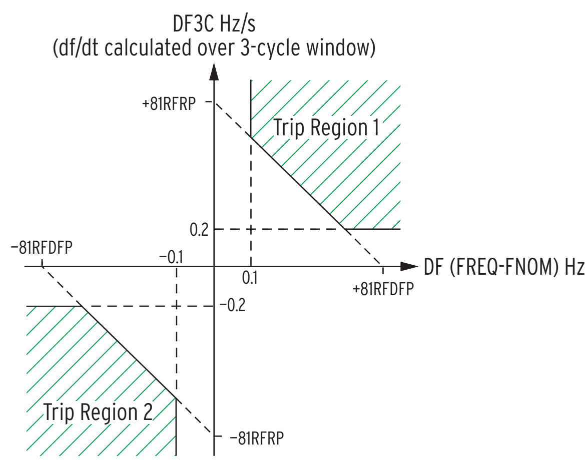


Figure 4.49 81RF Characteristics

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 4.40 Fast Rate-of-Change-of-Frequency Settings

Setting Prompt	Range	Setting Name := Factory Default
ENABLE 81RF	Y, N	E81RF := N
FREQDIF SETPOINT	0.1–10.0 Hz	81RFDFP := 1.0
DFDT SETPOINT	0.2–15.0 Hz/sec	81RFRP := 2.5
81RF PU DELAY	0.10–1.00 sec	81RFPU := 0.10
81RF DO DELAY	0.00–1.00 sec	81RFDO := 0.10
81RF VOLTAGE BLK	OFF, 2–300 V[a]	81RFVBLK := OFF
	OFF, 2–520 V[b]	81RFVBLK := OFF
81RF CURRENT BLK	OFF, 0.1–20 A • I_{NOM}	81RFIBLK := 10 • I_{NOM}
81RF BLOCK	SELOGIC	81RFBL := 0
81RF BLOCK DO	0.02–5.00 sec	81RFBLDO := 1.00

[a] Setting range shown is for DELTA_Y := DELTA.
[b] Setting range shown is for DELTA_Y := WYE.

Figure 4.50 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.

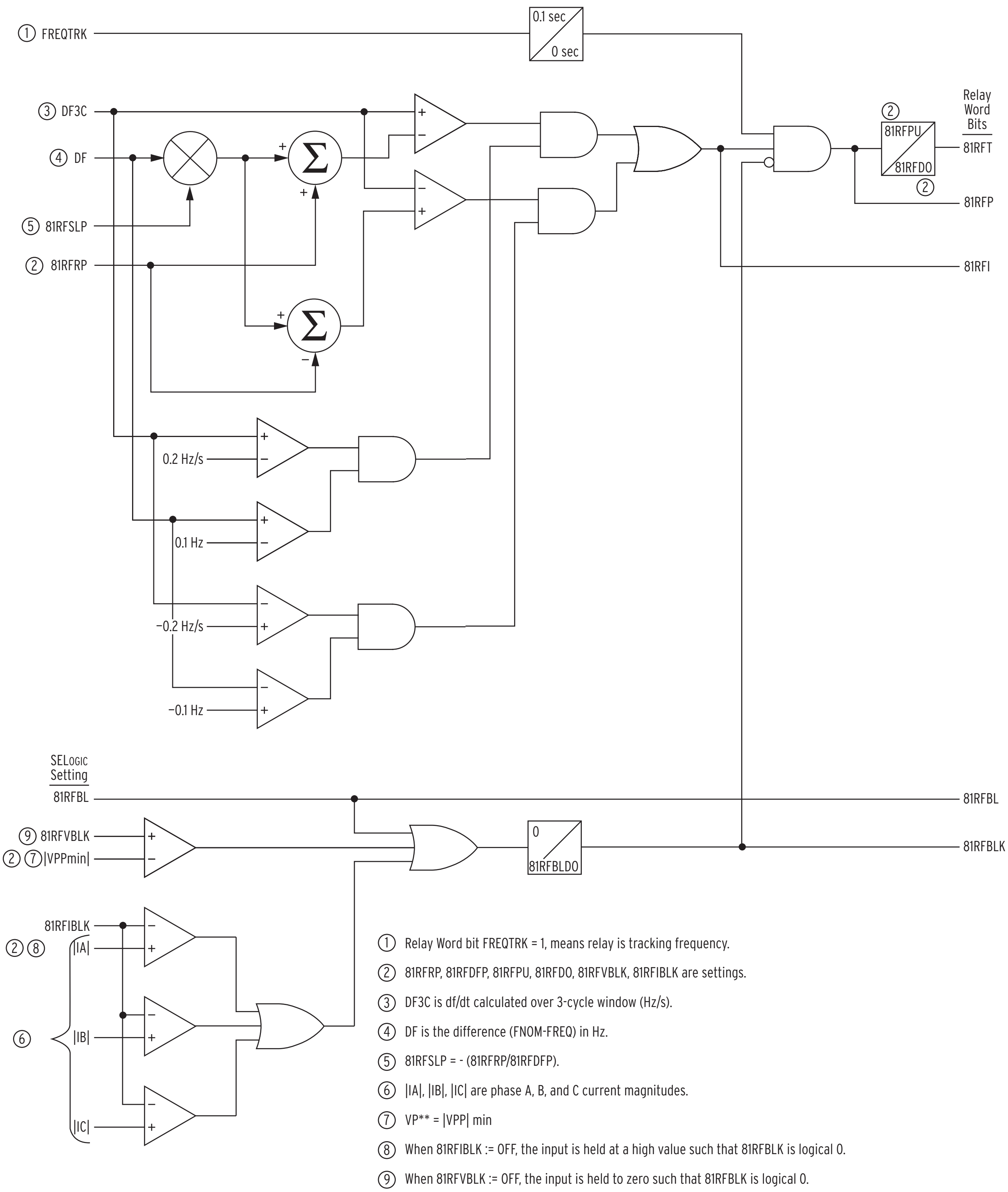


Figure 4.50 81RF Fast Rate-of-Change-of-Frequency Logic

Trip/Close Logic

Trip/Close Logic Settings

Table 4.41 Trip/Close Logic Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
MIN TRIP TIME	0.0–400.0 sec	TDURD := 0.5
CLOSE FAIL DLY	OFF, 0.0–400.0 sec	CFD := 1.0
TRIP EQUATION	SV	TR := ORED50T OR ORED51T OR ORED81T OR REMTRIP OR OC OR SV04T
REMOTE TRIP EQN	SV	REMTRIP := 0
UNLATCH TRIP	SV	ULTRIP := NOT (51P1P OR 51G1P OR 51N1P OR 52A)
BREAKER STATUS	SV	52A := 0
CLOSE EQUATION	SV	CL := SV03T AND LT02 OR CC
UNLATCH CLOSE	SV	ULCL := 0

NOTE: The factory default assignment of the Relay Word bit TRIP is the output **OUT103**. See Table 4.54 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 4.51* illustrates the tripping logic.

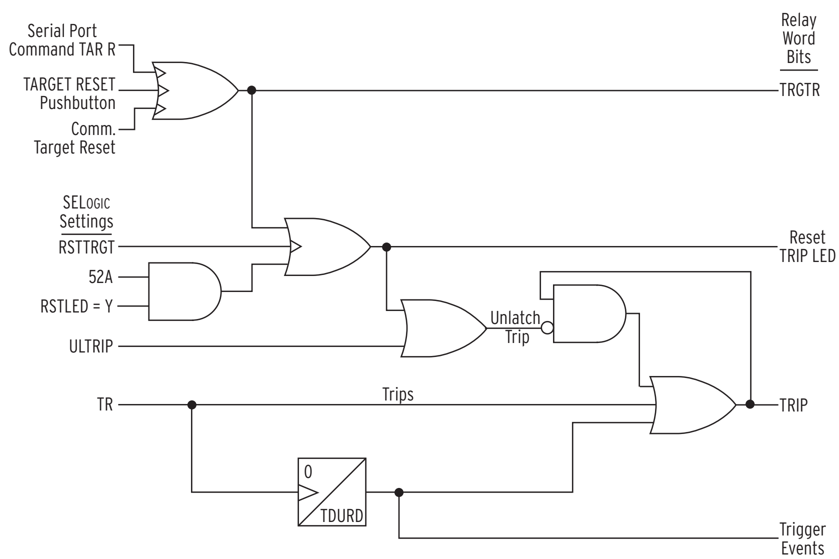


Figure 4.51 Trip Logic

The trip logic settings, including the SELOGIC control equations, are described in the following text.

TDURD Minimum Trip Time

This timer establishes the minimum time duration for which the TRIP Relay Word bit asserts. This is a rising-edge initiated timer.

Trips initiated by the TR Relay Word bit (includes **OPEN** command from front-panel and serial ports) are maintained for at least the duration of the minimum trip duration time (TDURD) setting.

TR Trip Conditions SELOGIC Control Equation

The SEL-751 TR SELOGIC control equation provides the trip logic to trip the breaker. The Relay Word bit TRIP is associated with the TR SELOGIC control equation.

The default TR setting is shown in *Table 4.41* 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 will 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 2.21*).

NOTE: You can use an indirect mapping (e.g., SV01) as in the factory default setting. See Table 4.51 for the SV01 settings.

Set the TR SELOGIC control equation to include an OR combination of all the Relay Word bits that you want to cause the relay to trip. The factory default setting already includes all commonly necessary Relay Word bits.

REMTRIP Remote Trip Conditions SELOGIC Control Equation

The REMTRIP SELOGIC control equation is intended to define a remote trip condition. For example, the following settings will trip the breaker by input IN303 via REMTRIP.

REMTRIP := IN303

TR := ... OR REMTRIP

The HMI will display `Remote Trip` to indicate the trip by Remote trip logic.

You can map any Relay Word bit or SELOGIC control equation to the REMTRIP to trip the breaker. For example, you can map a control input to REMTRIP. Add REMTRIP to the TR SELOGIC control equation (as in the default settings) to quickly see from the HMI target that it was a `Remote Trip` that tripped the breaker.

Unlatch Trip Logic

Following a fault, the trip signal is maintained until all of the following conditions are true:

NOTE: Factory default setting of the ULTRIP provides an automatic reset of the trip when breaker opens and selected 50/51 elements are not picked up.

- Minimum trip duration time (TDURD) passes.
- The TR SELOGIC control equation result deasserts to logical 0.
- One of the following occurs:
  - Unlatch Trip SELOGIC control equation setting ULTRIP asserts to logical 1.
  - Target Reset SELOGIC control equation setting RSTTRGT asserts to logical 1.
  - Target Reset Relay Word TRGTR asserts. The TRGTR is asserted when the front-panel **TARGET RESET** pushbutton is pressed or a target reset serial port command is executed (ASCII, Modbus, or DeviceNet).

52A Breaker Status Conditions SELOGIC Control Equation

You can connect an auxiliary contact of the breaker to the relay. The SELOGIC control equation 52A allows you to configure the relay for either 52b or 52a contact input (or other contact that indicates a closed breaker). The factory default setting assumes no auxiliary contact connection (52A := 0).

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

CL Close SELOGIC Control Equation

The SEL-751 Close Logic offers three ways to close the circuit breaker:

- Conditions mapped to CL
- Front-panel or serial port (including Modbus and DeviceNet) **CLOSE** command
- Automatic reclosing when open interval times out (qualified by SELOGIC control equation setting 79CLS—see *Figure 4.53*).

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 2.19* 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 will assert for 1/4 cycle. Use the CF bit as desired.

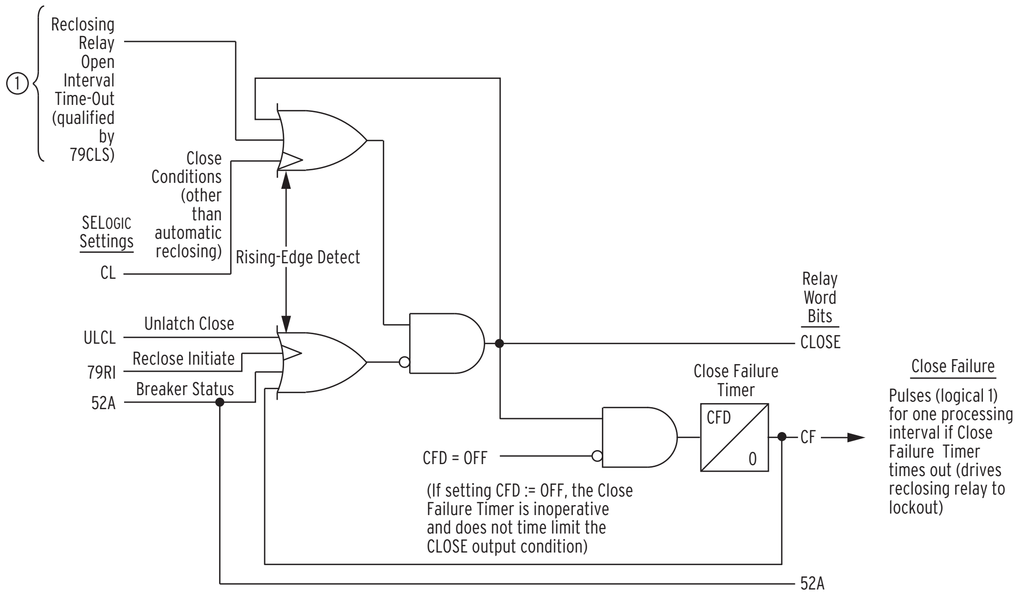
Reclose Supervision Logic

Note that one of the inputs into the close logic in *Figure 4.52* is:

Reclosing Relay Open Interval Time-Out (qualified by 79CLS)

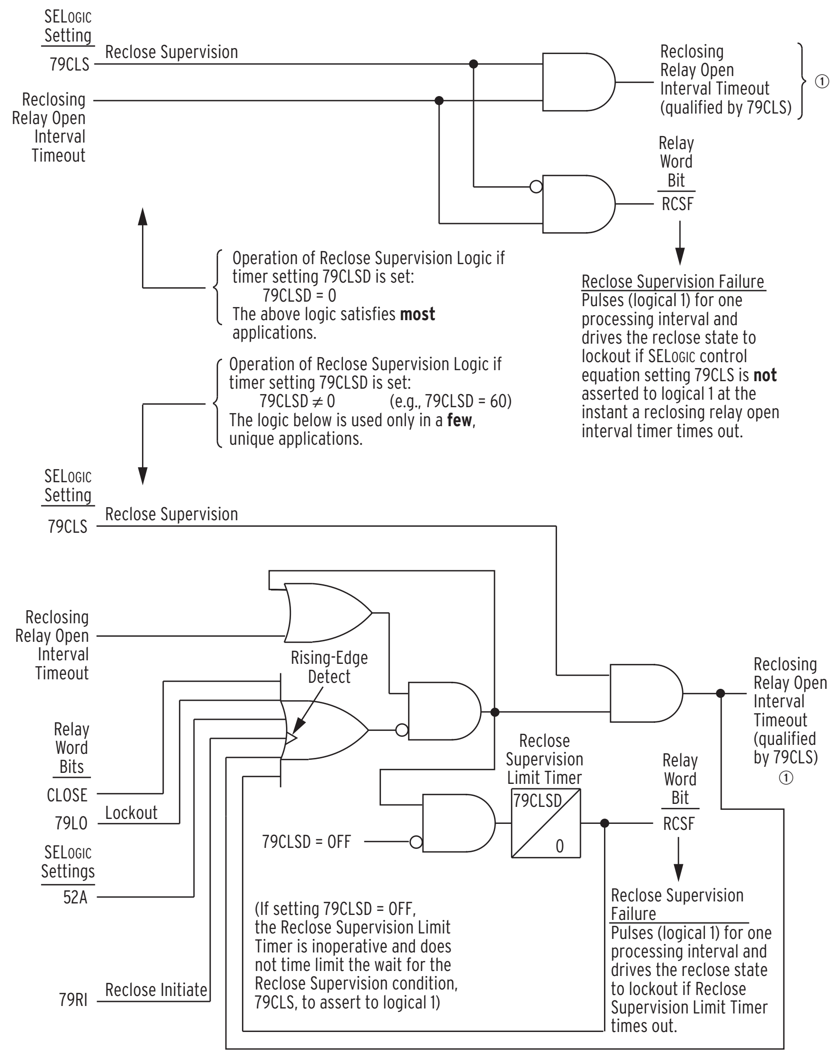
NOTE: The close logic is inoperative if 52A is set to 0 in SEL-751 models with reclosing option.

This input into the close logic in *Figure 4.52* is the indication that a reclosing relay open interval has timed out (see *Figure 4.54*), 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 4.52* is an output of the reclose supervision logic in the following *Figure 4.53*.



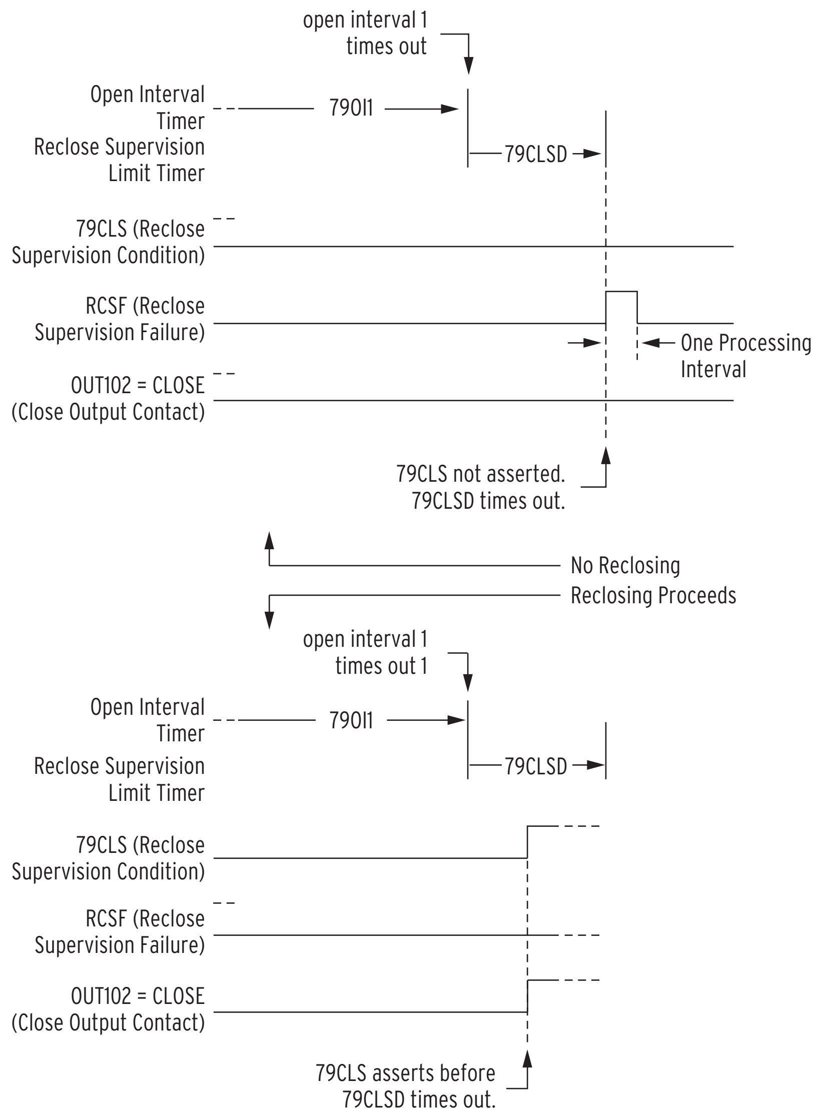
① From Figure 4.53

Figure 4.52 Close Logic



① To Figure 4.52

Figure 4.53 Reclose Supervision Logic (Following Open Interval Time-Out)



(Refer to Bottom of Figure 4.53)

Figure 4.54 Reclose Supervision Limit Timer Operation

Settings and General Operation

Figure 4.53 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 4.43* for Recloser Control settings.

For Most Applications

Refer to the top of Figure 4.53.

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 4.53* 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 will propagate onto the final close logic in *Figure 4.53* 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.
- The reclosing relay is driven to Lockout State.

See *Example 4.8*.

For A Few, Unique Applications

Refer to the bottom of *Figure 4.53* and *Figure 4.54*.

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 4.53* 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 will propagate onto the final close logic in *Figure 4.52* 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.
- The reclosing relay is driven to Lockout State.

The logic in the bottom of *Figure 4.53* is explained in more detail in the following text.

Set Reclose Supervision Logic.

Refer to the bottom of *Figure 4.53*. If *all* the following are true:

- The close logic output CLOSE (also see *Figure 4.52*) 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 in *Figure 4.53*. Then, when 79CLS asserts to logical 1, the sealed-in reclosing relay open interval time-out condition will propagate through *Figure 4.47* and on to the close logic in *Figure 4.52*.

Unlatch Reclose Supervision Logic.

Refer to the bottom of *Figure 4.53*.

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 4.53*) 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 4.52*.

See *Example 4.9*.

EXAMPLE 4.8 Settings Example 1

Refer to the top of Figure 4.53 and Figure 4.55.

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.

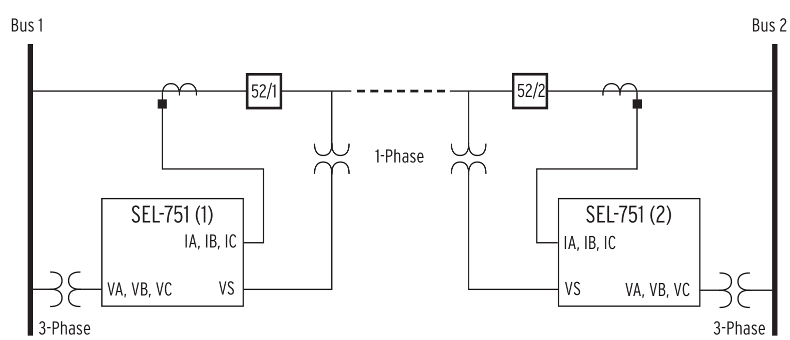


Figure 4.55 SEL-751 Relays Installed at Both Ends of a Transmission Line in a High-Speed Reclose Scheme

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 27S**

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 and Stall Open Interval Timing Settings (79SKP and 79STL, Respectively) on page 4.97*.

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 4.52*). Note the built-in 2-cycle qualification of the synchronism-check voltages shown in *Figure 4.40*.

EXAMPLE 4.9 Settings Example 2

Refer to subsection Synchronism-Check Elements on page 4.57. Also refer to Figure 4.54 and Figure 4.55.

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 4.65, 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.

Reclose Logic

Note that input:

Reclosing Relay Open Interval Time-Out

in *Figure 4.53* is the logic input that is qualified by SELOGIC control equation setting 79CLS, and then propagated on to the close logic in *Figure 4.52* 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 4.53*. 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, and 4. Setting E79 = N defeats the reclosing relay. Setting choices 1 through 4 are the number of automatic reclosures (see *Open Interval Timers on page 4.91*) you want. Setting choices 1 through 4 also have the reclosing relay go to the Lockout state upon reclose supervision failure (refer to *Reclose Supervision Logic on page 4.80*).

Reclosing Relay States and General Operation

Figure 4.56 explains in general the different states of the reclosing relay and its operation.

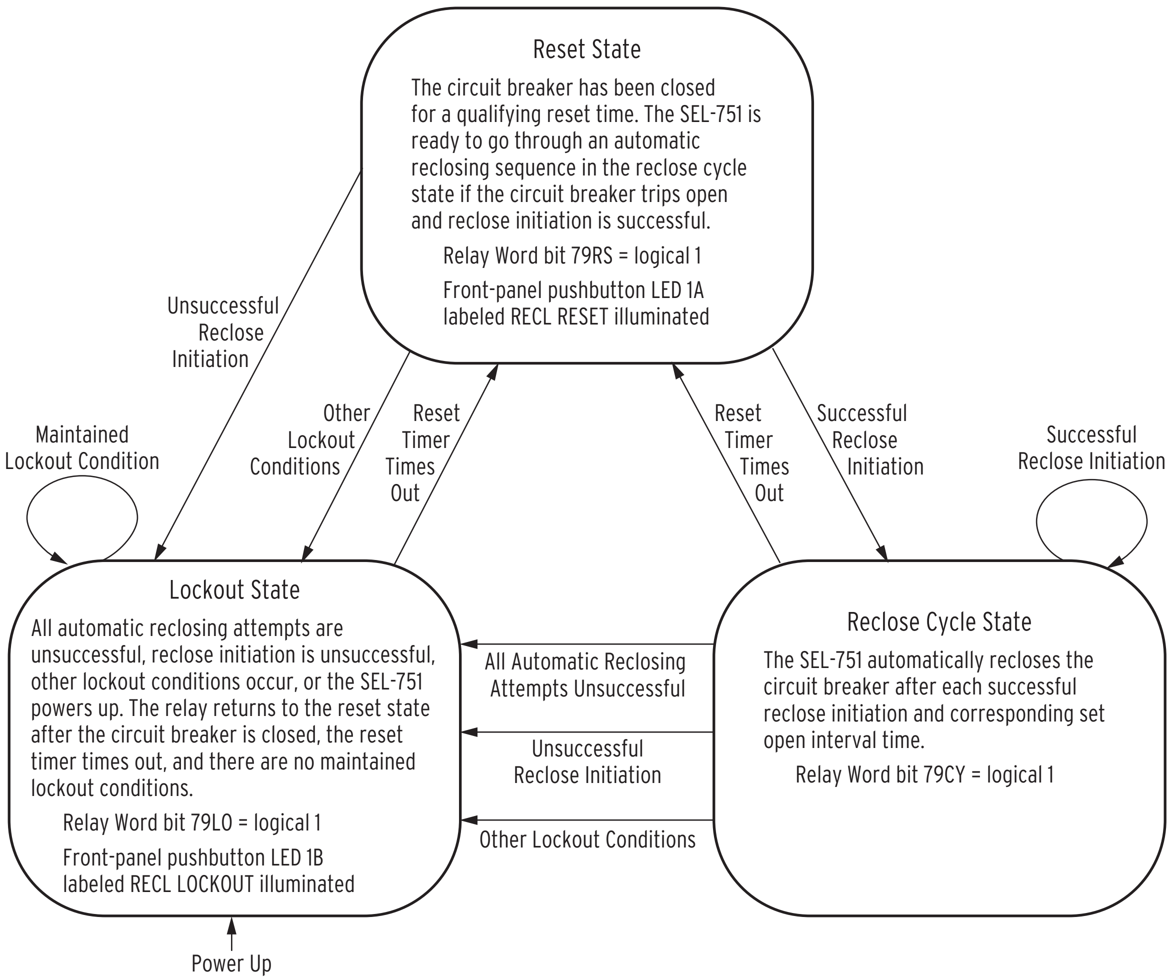


Figure 4.56 Reclosing Relay States and General Operation

Table 4.42 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 4.42*) 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 4.54*).
- 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 4.94*].
- 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 4.96*].
- The close failure timer (setting CFD) times out (see *Figure 4.52*).
- 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 4.53* and top of *Figure 4.54*) and the reclose enable setting, E79, has setting choices 1, 2, 3, or 4.
- 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 7.37* for more information on the **OPEN** command. Also, see *Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, Respectively) on page 4.96*.

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 will immediately go to the Lockout State, because shot = last shot.

Defeat the Reclosing Relay

If *any one* of the following reclosing relay settings are made:

- Reclose enable setting E79 = N.
- Open Interval 1 time setting 79OI1 = 0.00.

then the reclosing relay is defeated, and no automatic reclosing can occur.

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 4.42*).
- 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 4.52*) 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 4.43*:

Table 4.43 Reclosing Control Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE RECLOSER	N, 1–4 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

Table 4.43 Reclosing Control Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
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 4.43*, 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 4.43*, 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 4.57*.

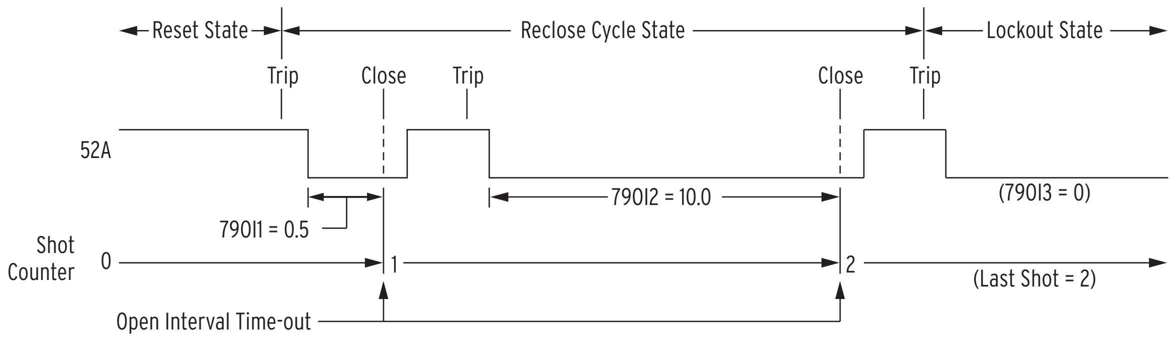


Figure 4.57 Reclosing Sequence From Reset to Lockout With Example Settings

SELOGIC control equation setting 79STL (stall open interval timing) can be set to control open interval timing [see *Skip Shot and Stall Open Interval Timing Settings (79SKP and 79STL, Respectively) on page 4.97*].

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 7.47* 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 4.78* 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 4.100*] 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 4.52*).

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 4.89*).

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 4.99*].

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 and Stall Open Interval Timing Settings (79SKP and 79STL, Respectively) on page 4.97*].

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 4.99.*

Reclosing Relay Shot Counter

Refer to *Figure 4.57*.

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 4.92*]. The shot counter resets back to shot = 0 when the reclosing relay returns to the Reset State.

Table 4.44 Shot Counter Correspondence to Relay Word Bits and Open Interval Times

Shot	Corresponding Relay Word Bit	Corresponding Open Interval
0	SH0	79OI1
1	SH1	79OI2
2	SH2	79OI3
3	SH3	79OI4
4	SH4	

When the shot counter is at a particular shot value (e.g., shot = 2), the corresponding Relay Word bit asserts to logical 1 (e.g., SH2 = logical 1).

The shot counter also increments for sequence coordination operation. The shot counter can increment beyond the last shot for sequence coordination [see *Sequence Coordination Setting (79SEQ) on page 4.100*].

Reclose Initiate and Reclose Initiate Supervision Settings (79RI and 79RIS, Respectively)

The reclose initiate setting 79RI is a rising-edge detect setting. The reclose initiate supervision setting 79RIS supervises setting 79RI. When setting 79RI senses a rising edge (logical 0 to logical 1 transition), setting 79RIS has to be at logical 1 (79RIS = logical 1) in order for open interval timing to be initiated.

If 79RIS = logical 0 when setting 79RI senses a rising edge (logical 0 to logical 1 transition), the relay goes to the Lockout State.

EXAMPLE 4.10 Factory Settings Example

With factory settings:

79RI := **TRIP**

79RIS := **52A OR 79CY**

the transition of the TRIP Relay Word bit from logical 0 to logical 1 initiates open interval timing only if the 52A or 79CY Relay Word bit is at logical 1 (52A = logical 1, or 79CY = logical 1). You must assign an input as the breaker status input (e.g., 52A := IN101).

The circuit breaker has to be closed (circuit breaker status 52A = logical 1) at the instant of the first trip of the auto-reclose cycle in order for the SEL-751 to successfully initiate reclosing and start timing on the first open interval. The SEL-751 is not yet in the reclose cycle state (79CY = logical 0) at the instant of the first trip.

Then for any subsequent trip operations in the auto-reclose cycle, the SEL-751 is in the reclose cycle state (79CY = logical 1) and the SEL-751 successfully initiates reclosing for each trip. Because of factory setting 79RIS = 52A OR 79CY, successful reclose initiation in the reclose cycle state (79CY = logical 1) is not dependent on the circuit breaker status (52A). This allows successful reclose initiation for the case of an instantaneous trip, but the circuit breaker status indication is slow—the instantaneous trip (reclose initiation) occurs before the SEL-751 sees the circuit breaker close.

If a flashover occurs in a circuit breaker tank during an open interval (circuit breaker open and the SEL-751 calls for a trip), the SEL-751 goes immediately to lockout.

EXAMPLE 4.11 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 will still be asserted to logical 1 when the circuit breaker opens (see Figure 4.33).

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 4.52 and accompanying explanation) may need to be made when 79RI := NOT 52A. ULCL := 0 avoids going to lockout prematurely for an instantaneous trip after an auto-reclose by not turning CLOSE off until the circuit breaker status indication tells the relay that the breaker is closed. The circuit breaker anti-pump circuitry should take care of the TRIP and CLOSE being on together for a short period of time.

Other Settings Considerations

In *Example 4.11* the preceding additional setting example, the reclose initiate setting (79RI) includes input **IN101**, that 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 will never take place (reclosing is never initiated). The reclosing relay is effectively inoperative.

If the following setting is made:

`79RIS := `**0**` (numeral 0)`

reclosing will never take 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 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 4.96*).
- ➤ Reclose initiation is by the breaker contact opening (e.g., 79RI := NOT 52A—refer to *Additional Settings Example on page 4.94*).

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 4.93*).

EXAMPLE 4.12 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 4.42.

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 4.13 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 and Stall Open Interval Timing Settings (79SKP and 79STL, Respectively)

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 4.44*). 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 4.89*).

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 4.44*). 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 4.89*).

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 4.93*).

EXAMPLE 4.14 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 4.15 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 4.45 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 4.45, 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 4.16 Additional Settings Example 2

If you use the SEL-751 Relay on a feeder with a line-side independent power producer (cogenerator), the utility should not reclose into a line still energized by an islanded generator. To monitor line voltage and block reclosing, connect a line-side single-phase potential transformer to channel VS on the SEL-751 as shown in Figure 4.58.

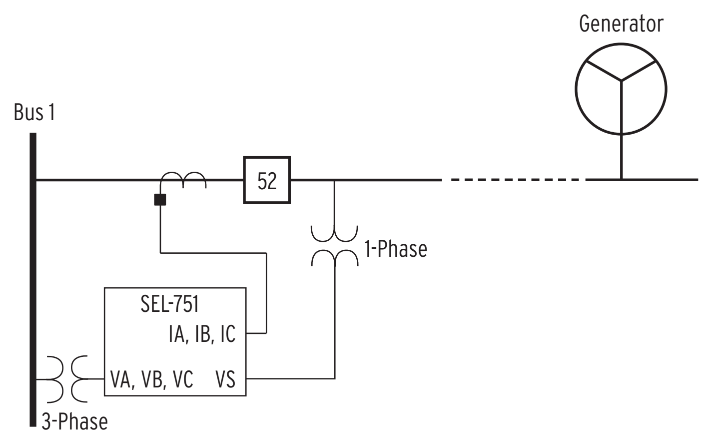


Figure 4.58 Reclose Blocking for Islanded Generator

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 4.17 Additional Settings Example 3

Refer to Figure 4.55 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 4.93*).

EXAMPLE 4.18 Factory Settings Example

The reset timing is blocked if Relay Word bit TRIP is asserted, regardless of the reclosing relay state:

79BRS := **TRIP**

EXAMPLE 4.19 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 4.56 and Table 4.42).

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 will time immediately on reset time 79RSLD and take 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 4.20 Additional Settings Example 2

If the block reset timing setting is:

79BRS := **51P1P OR 51G1P**

then reset timing is blocked if time-overcurrent pickup 51P1P or 51G1P is picked up, regardless of the reclosing relay state.

Sequence Coordination Setting (79SEQ)

The sequence coordination setting 79SEQ keeps the relay in step with a downstream line recloser in a sequence coordination scheme, which prevents overreaching SEL-751 overcurrent elements from tripping for faults beyond the line recloser. This is accomplished by incrementing the shot counter and supervising overcurrent elements with resultant shot counter elements.

In order for the sequence coordination setting 79SEQ to increment the shot counter, *both* the following conditions must be true:

- ➤ No trip present (Relay Word bit TRIP = logical 0)
- ➤ Circuit breaker closed (SELOGIC control equation setting 52A = logical 1, effectively)

The sequence coordination setting 79SEQ is usually set with some overcurrent element pickups. If the previous two conditions are both true, and a set overcurrent element pickup asserts for at least 1.25 cycles and then deasserts, the shot counter increments by one count. This assertion/deassertion indicates that a downstream device (e.g., line recloser—see *Figure 4.59*) 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 4.100* and *Additional Settings Example 2 on page 4.102*.

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 4.99*].

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 4.21 Factory Settings Example

Sequence coordination is not enabled in the factory settings:

79SEQ := **0**

EXAMPLE 4.22 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 4.59 and Figure 4.60.

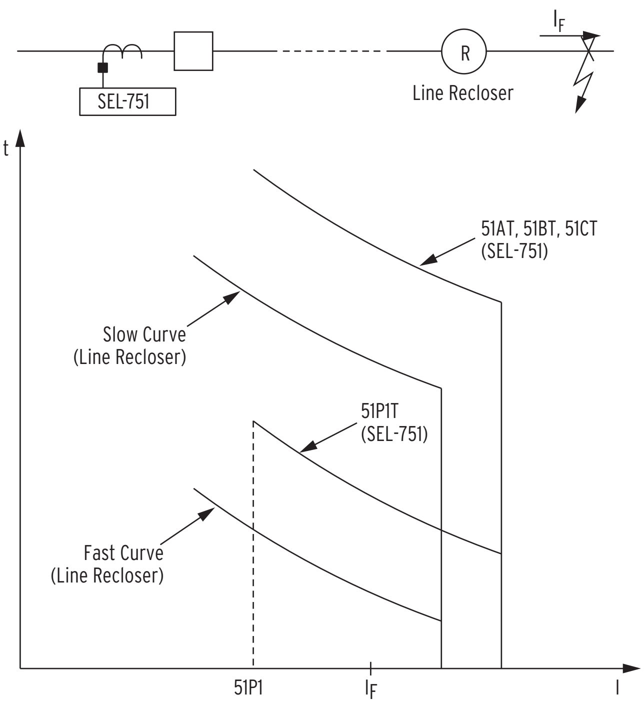
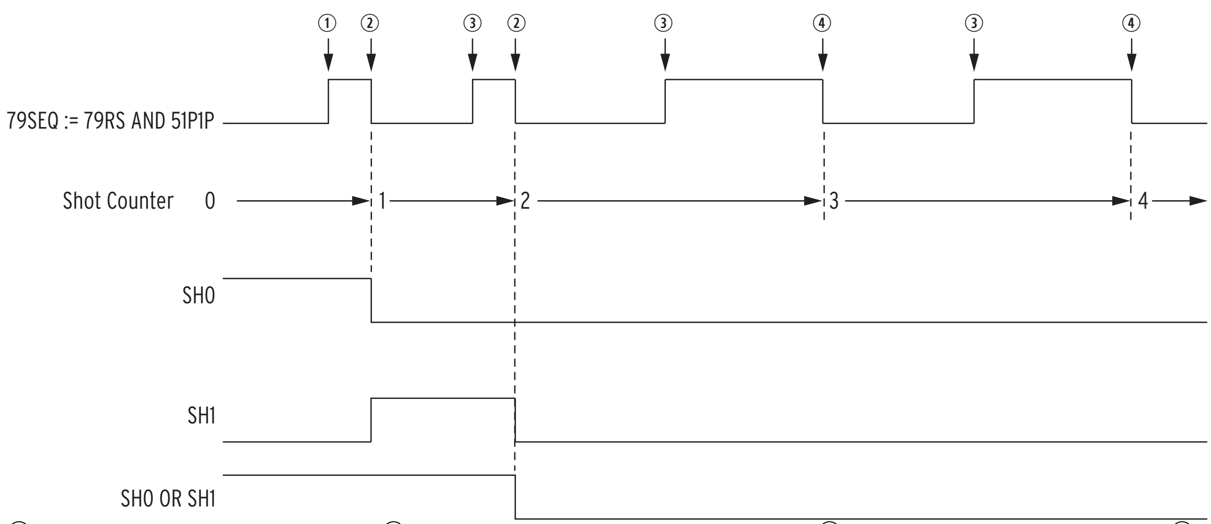


Figure 4.59 Sequence Coordination Between the SEL-751 and a Line Recloser

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 4.60 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 4.59), the line recloser fast curve operates to clear the fault.

> **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 SEL-751 also sees the fault. The phase time-overcurrent pickup 51P1P asserts and then deasserts without tripping, incrementing the relay shot counter from:

shot = 0 to shot = 1

When the line recloser recloses its circuit breaker, the line recloser fast curve operates again to clear the fault. The SEL-751 also sees the fault again. The phase time-overcurrent pickup 51P1P asserts and then deasserts without tripping, incrementing the relay shot counter from:

shot = 1 to shot = 2

The line recloser fast curve is now disabled after operating twice. When the line recloser recloses its circuit breaker, the line recloser slow curve operates to clear the fault. The relay does not operate on its faster-set phase time-overcurrent element 51P1 (51P1T is "below" the line recloser slow curve) because the shot counter is now at shot = 2. For this sequence coordination scheme, the SELOGIC control equation trip equation is:

TR := **51P1T AND (SH0 OR SH1) OR 51AT OR 51BT OR 51CT**

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 4.23 Additional Settings Example 2

Review preceding Example 1.

Assume that the line recloser in Figure 4.59 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 4.43 and Figure 4.57). 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 will increment all the way to shot = 4 (see Figure 4.60). If there is a coincident fault *between* the SEL-751 and the line recloser, the SEL-751 will trip and go 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**

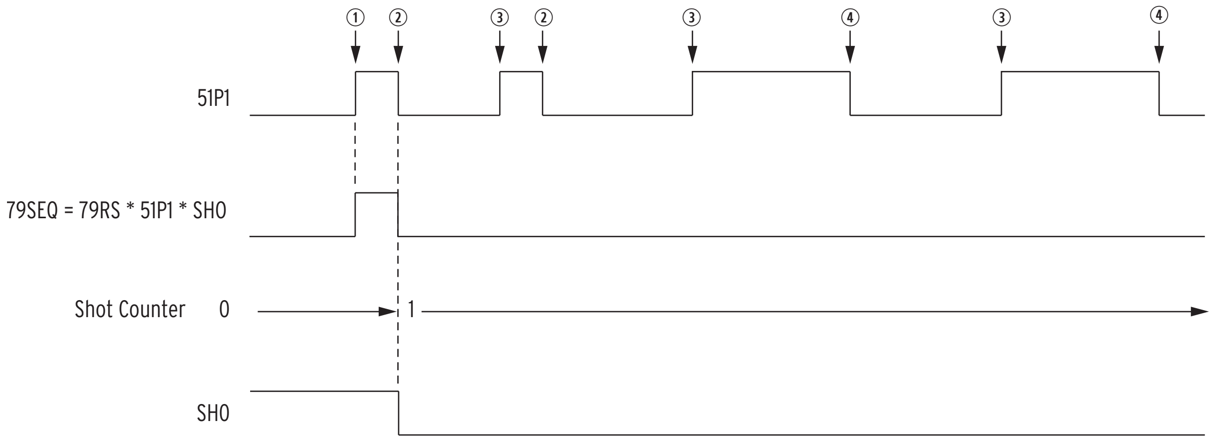
Refer to Figure 4.61.

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 4.59), the line recloser fast curve operates to clear the fault. The SEL-751 also sees the fault. The phase time-overcurrent pickup 51P1P asserts and then deasserts without tripping, incrementing the relay shot counter from:

shot = 0 to shot = 1

Now the SEL-751 cannot operate on its faster-set phase time-overcurrent element 51P1T because the shot counter is at shot = 1 (SH0 = logical 0):

TR := **51P1T AND SH0 OR 51AT OR 51BT OR 51CT = (logical 0) OR 51AT OR 51BT OR 51CT**



① Fault occurs beyond line recloser; ② fault cleared by line recloser fast curve; ③ line recloser recloses into fault; ④ fault cleared by line recloser slow curve.

Figure 4.61 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 will operate on 51AT, 51BT, or 51CT and then reclose 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 4.61.

Reclose Supervision Setting (79CLS)

See *Reclose Supervision Logic on page 4.80*.

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 4.46 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 4.46 Demand Meter Settings (Sheet 1 of 2)

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

Table 4.46 Demand Meter Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
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 4.62*.

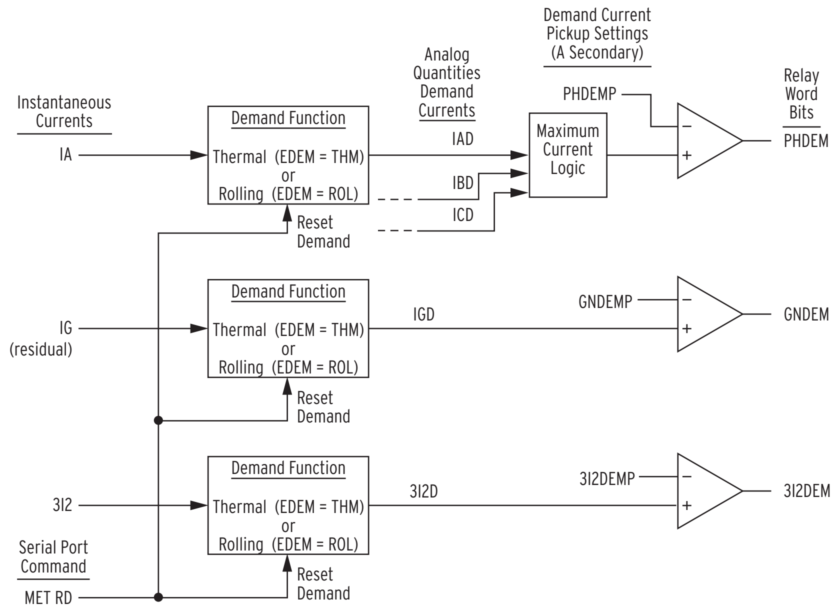


Figure 4.62 Demand Current Logic Outputs

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 will restore 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 4.63* 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”).

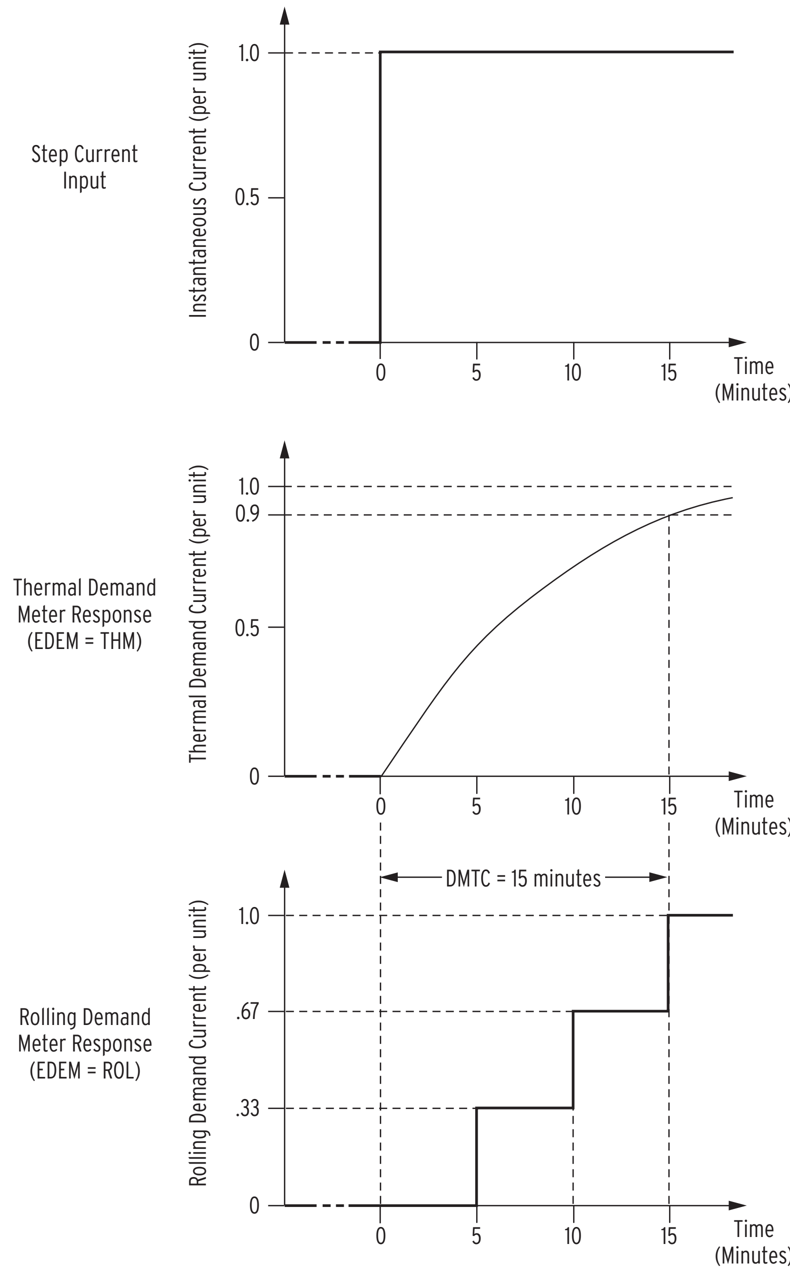


Figure 4.63 Response of Thermal and Rolling Demand Meters to a Step Input (Setting DMTC = 15 minutes)

Thermal Demand Meter Response

The response of the thermal demand meter in *Figure 4.63* (middle) to the step current input (top) is analogous to the series RC circuit in *Figure 4.64*.

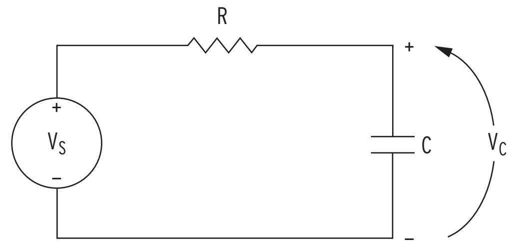


Figure 4.64 Voltage V_S Applied to Series RC Circuit

In the analogy:

Voltage V_S in *Figure 4.64* corresponds to the step current input in *Figure 4.63* (top).

Voltage V_C across the capacitor in *Figure 4.64* corresponds to the response of the thermal demand meter in *Figure 4.63* (middle).

If voltage V_S in *Figure 4.64* has been at zero (V_S = 0.0 per unit) for some time, voltage V_C across the capacitor in *Figure 4.64* is also at zero (V_C = 0.0 per unit). If voltage V_S is suddenly stepped up to some constant value (V_S = 1.0 per unit), voltage V_C across the capacitor starts to rise toward the 1.0 per unit value. This voltage rise across the capacitor is analogous to the response of the thermal demand meter in *Figure 4.62* (middle) to the step current input (top).

In general, as voltage V_C across the capacitor in *Figure 4.64* 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 4.46*). Note that in *Figure 4.63*, 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 4.63* (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 4.46*). Note in *Figure 4.63*, 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 4.63* 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 4.63* (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 4.47 shows the enable settings for latch bits (ELAT), SELOGIC control equations (including timers) (ESV), Counters (ESC), and math variable equations (EMV). This helps limit the number of settings that you need to make. For example, if you need six timers, only enable six timers.

Table 4.47 Enable Settings

Setting Prompt	Setting Range	Default Setting
SELOGIC Latches	N, 1–32	ELAT := 4
SV/Timers	N, 1–32	ESV := 5
SELOGIC Counters	N, 1–32	ESC := N
Math Variables	N, 1–32	EMV := N

Latch Bits

Latch control switches (latch bits are the outputs of these switches) replace traditional latching devices. Traditional latching devices maintain output contact state. The SEL-751 latch control switch also retains state even when power to the device is lost. If the latch control switch is set to a programmable output contact and power to the device is lost, the state of the latch control switch is stored in nonvolatile memory, but the device de-energizes the output contact. When power to the device is restored, the programmable output contact will go back to the state of the latch control switch after device initialization. Traditional latching device output contact states are changed by pulsing the latching device inputs (see *Figure 4.65*). 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).

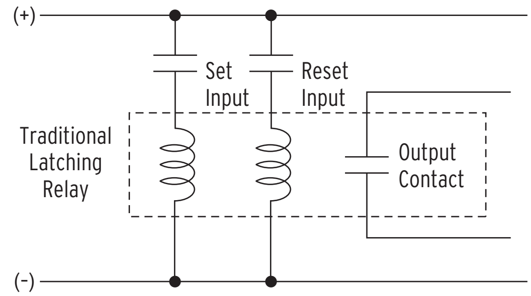


Figure 4.65 Schematic Diagram of a Traditional Latching Device

Thirty-two latch control switches in the SEL-751 provide latching device functionality. *Figure 4.66* shows the logic diagram of a latch switch. The output of the latch control switch is a Relay Word bit LT*n* (*n* = 01–32), called a latch bit.

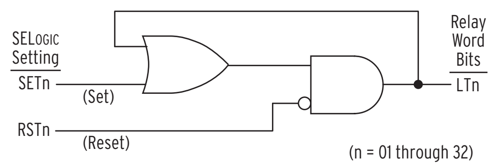


Figure 4.66 Logic Diagram of a Latch Switch

If setting SET*n* asserts to logical 1, latch bit LT*n* asserts to logical 1. If setting RST*n* asserts to logical 1, latch bit LT*n* deasserts to logical 0. If both settings SET*n* and RST*n* assert to logical 1, setting RST*n* has priority and latch bit LT*n* deasserts to logical 0. You can use these latch bits in SELOGIC control equations to create custom logic for your application.

The SEL-751 includes 32 latches. *Table 4.48* shows the **SET** and **RESET** default settings for Latch 1 through Latch 4. The remaining latches are all set to NA.

Table 4.48 Latch Bits Equation Settings

Settings Prompt	Setting Range	Setting Name := Factory Default
SET01	SELOGIC	SET01 := NA
RST01	SELOGIC	RST01 := NA
SET02	SELOGIC	SET02 := R_TRIG SV02T AND NOT LT02
RST02	SELOGIC	RST02 := R_TRIG SV02T AND LT02
SET03	SELOGIC	SET03 := PB03_PUL AND LT02 AND NOT 52A
RST03	SELOGIC	RST03 := (PB03_PUL OR PB04_PUL OR SV03T) AND LT03
SET04	SELOGIC	SET04 := PB04_PUL AND 52A
RST04	SELOGIC	RST04 := (PB03_PUL OR PB04_PUL OR SV04T) AND LT04
⋮	⋮	⋮
SET32	SELOGIC	SET32 := NA
RST32	SELOGIC	RST32 := NA

Latch Bits: Nonvolatile State

Power Loss

The states of the latch bits (LT01–LT32) are retained if power to the device is lost and then restored. If a latch bit is asserted (e.g., LT02 := logical 1) when power is lost, it is asserted (LT02 := logical 1) when power is restored. If a latch bit is deasserted (e.g., LT03 := logical 0) when power is lost, it is deasserted (LT03 := logical 0) when power is restored.

Settings Change

If individual settings are changed, the states of the latch bits (Relay Word bits LT01 through LT32) are retained, as in the preceding *Power Loss on page 4.110* explanation. If the individual settings change causes a change in SELOGIC control equation settings SET*n* or RST*n* (*n* = 1 through 32), the retained states of the latch bits can be changed, subject to the newly enabled settings SET*n* or RST*n*.

Make Latch Control Switch Settings With Care

The latch bit states are stored in nonvolatile memory so they can be retained during power loss or settings change. The nonvolatile memory is rated for a finite number of writes for all cumulative latch bit state changes. Exceeding the limit can result in a flash self-test failure. *An average of 70 cumulative latch bit state changes per day can be made for a 25-year device service life.*

Settings SET*n* and RST*n* cannot result in continuous cyclical operation of latch bit LT*n*. Use timers to qualify conditions set in settings SET*n* and RST*n*. If you use any optoisolated inputs in settings SET*n* and RST*n*, the inputs each have a separate debounce timer that can help in providing the necessary time qualification.

SELOGIC Control Equation Variables/ Timers

Enable the number of SELOGIC control equations necessary for your application. Only the enabled SELOGIC control equations appear for settings. Each SELOGIC control equation variable/timer has a SELOGIC control equation setting input and variable/timer outputs as shown in *Figure 4.67*. Timers SV01T through SV32T in *Figure 4.67* have a setting range of 0.00–3000.00 seconds. This timer setting range applies to both pickup and dropout times (SV*n*PU and SV*n*DO, *n* = 1 through 32).

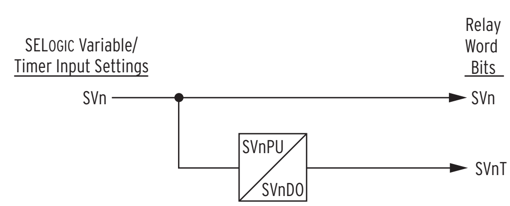


Figure 4.67 SELOGIC Control Equation Variable/Timers SV01/SV01T–SV32T

You can enter as many as 15 elements per SELOGIC control equation, including a total of 14 elements in parentheses (see *Table 4.49* 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 4.49*. Math SELOGIC control equation settings operate on numerical values, using one or more of the Mathematical operators listed in *Table 4.49*. These numerical values can be mathematical variables or actual real numbers.

The executed result of a math SELOGIC control equation is stored in a math variable. The smallest and largest values a math variable can represent are –16777215.99 and +16777215.99, respectively. If the executed result exceeds these limits, it 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.

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 4.50* 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 will be 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 4.49 SELOGIC Control Equation Operators (Listed in Operator Precedence) (Sheet 1 of 2)

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

Table 4.49 SELOGIC Control Equation Operators (Listed in Operator Precedence) (Sheet 2 of 2)

Operator	Function	Function Type (Boolean and/ or 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 4.68*.

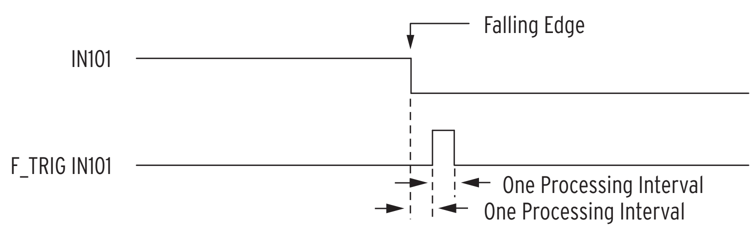


Figure 4.68 Result of Falling-Edge Operator on a Deasserting Input

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

Table 4.50 Other SELOGIC Control Equation Operators/Values

Operator/ Value	Function	Function Type (Boolean and/or Mathematical)
0	Set SELOGIC control equation directly to logical 0 (XXX := 0)	Boolean
1	Set SELOGIC control equation directly to logical 1 (XXX := 1)	Boolean
#	Characters entered after the # operator are not processed and deemed as comments	Boolean and Mathematical
\	Indicates that the preceding logic should be continued on the next line ("\" is entered only at the end of a line)	Boolean and Mathematical

Timers Reset When Power Lost or Settings Changed

If the device loses power or settings change, the SELOGIC control equation variables/timers reset. Relay Word bits SV*n* and SV*n*T (*n* = 01–32) reset to logical 0 after power restoration or a settings change. *Figure 4.69* 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)
```

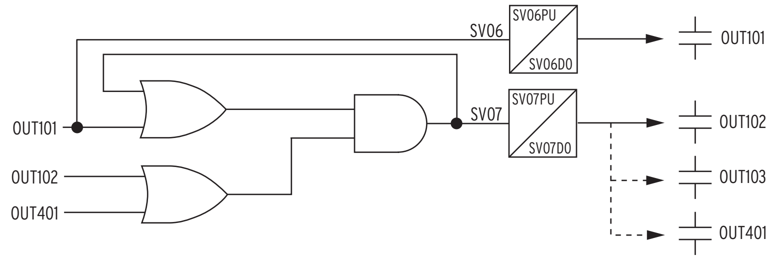


Figure 4.69 Example Use of SELOGIC Variables/Timers

SV/Timers Settings

The SEL-751 includes 32 SELOGIC variables. *Table 4.51* shows the pickup, dropout, and equation settings for SV/Timers.

Table 4.51 SELOGIC Variable Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
SV TIMER PICKUP	0.00–3000.00	SV01PU := 0.00
SV TIMER DROPOUT	0.00–3000.00	SV01DO := 0.00
SV INPUT	SELOGIC	SV01 := NA
SV TIMER PICKUP	0.00–3000.00	SV02PU := 3.00
SV TIMER DROPOUT	0.00–3000.00	SV02DO := 0.00
SV INPUT	SELOGIC	SV02 := PB02
SV TIMER PICKUP	0.00–3000.00	SV03PU := 0.00
SV TIMER DROPOUT	0.00–3000.00	SV03DO := 0.00
SV INPUT	SELOGIC	SV03 := LT03
SV TIMER PICKUP	0.00–3000.00	SV04PU := 0.00
SV TIMER DROPOUT	0.00–3000.00	SV04DO := 0.00
SV INPUT	SELOGIC	SV04 := LT04
SV TIMER PICKUP	0.00–3000.00	SV05PU := 0.25
SV TIMER DROPOUT	0.00–3000.00	SV05DO := 0.25
SV INPUT	SELOGIC	SV05 := (PB02 OR LT03 OR LT04) AND NOT SV05T
• • •	• • •	• • •

The pickup times of 0 for the SV03PU and SV04PU settings shown previously provide immediate Close and Trip actions from front-panel pushbuttons. For a delayed Close, set SV03PU to the desired delay. Similarly, set SV04PU for a delayed Trip action. See *Table 8.4* for more detail.

Counter Variables

NOTE: These counter elements conform to the standard counter function block #3 in IEC 1131-3 First Edition 1993-03 International Standard for Programmable controllers—Part 3: Programming languages.

NOTE: If setting SCnnCD is set to NA, the entire counter nn is disabled.

NOTE: If setting SCnnCU is set to NA, the counter counts downwards only.

SELOGIC counters are up- or down-counting elements, updated every processing interval.

Each counter element consists of one count setting, four control inputs, two digital outputs, and one analog output. *Figure 4.70* shows Counter 01, the first of 32 counters available in the device.

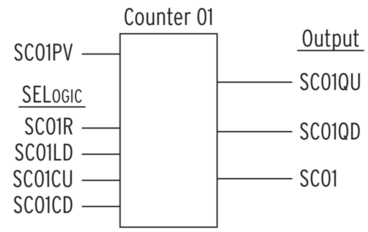


Figure 4.70 Counter 01

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 4.52* describes the counter inputs and outputs, and *Table 4.53* shows the order of precedence of the control inputs.

Table 4.52 Counter Input/Output Description

Name	Type	Description
SC*nn*LD	Active High Input	Load counter with the preset value to assert the output (SC*n*QU) (follows SELOGIC setting).
SC*nn*PV	Input Value	This Preset Value is loaded when SC*n*LD pulsed. This Preset Value is the number of counts before the output (SC*n*QU) asserts (follows SELOGIC setting).
SC*nn*CU	Rising-Edge Input	Count Up increments the counter (follows SELOGIC setting).
SC*nn*CD	Rising-Edge Input	Count Down decrements the counter (follows SELOGIC setting).
SC*nn*R	Active High Input	Reset counter to zero (follows SELOGIC setting)
SC*nn*QU	Active High Output	This Q Up output asserts when the Preset Value (maximum count) is reached (SC*n* = SC*n*PV, *n* = 01 to 32).
SC*nn*QD	Active High Output	This Q Down output asserts when the counter is equal to zero (SC*n* = 0, *n* = 01 to 32).
SC*nn*	Output Value	This counter output is an analog value that you can use with analog comparison operators in a SELOGIC control equation and view using the **COU** command.

Table 4.53 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 4.71 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.

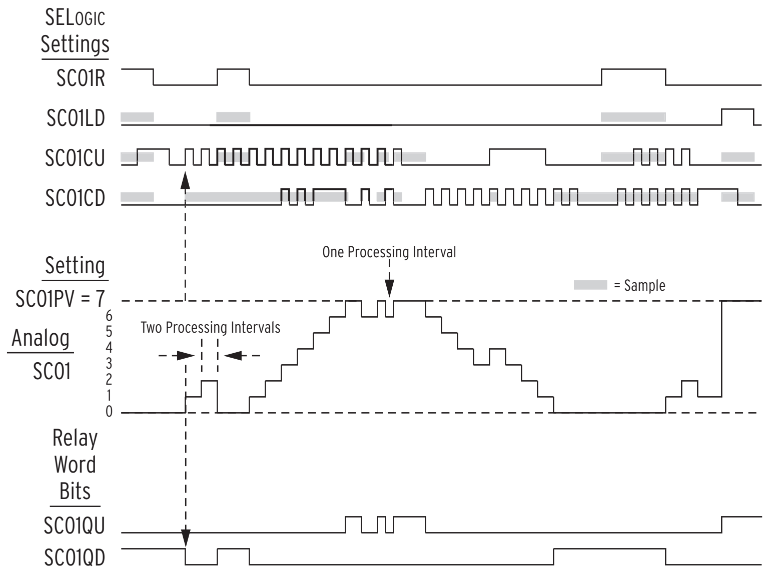


Figure 4.71 Example of the Effects of the Input Precedence

The shaded areas illustrate the precedence of the inputs:

- ➤ When SC01R is asserted, the SC01LD input is ignored.
- ➤ When SC01R or SC01LD is asserted, rising edges on the SC01CU or SC01CD inputs are ignored.
- ➤ When input SC01CU has a rising edge, a rising edge on SC01CD is ignored (unless SC01 is already at the maximum value SC01PV (= 7), in which case SC01CU is ignored, and the SC01CD is processed). An example of this exception appears in the previous diagram, just before the “one processing interval” notation.

A maintained logical 1 state on the SC01CU or SC01CD inputs is ignored (after the rising edge is processed). A rising edge received on the SC01CU or SC01CD inputs is ignored when the SC01R or SC01LD inputs are asserted.

A maintained logical 1 on the SC01CU or SC01CD inputs does not get treated as a rising edge when the SC01R or SC01LD input deasserts.

The same operating principles apply for all of the counters: SC01–SC*mm*, where *mm* = the number of enabled counters. When a counter is disabled by setting, the present count value is forced to 0 (SC*nn* := 0), causing Relay Word bit SC*nn*QD to assert (SC*nn*QD := logical 1), and Relay Word bit SC*nn*QU to deassert (SC*nn*QU := logical 0).

Output Contacts

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.

Table 4.54 Control Output Equations and Contact Behavior Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
OUT101 FAIL-SAFE	Y, N	OUT101FS := Y
OUT101	SELOGIC	OUT101 := HALARM OR SALARM

Table 4.54 Control Output Equations and Contact Behavior Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
OUT102 FAIL-SAFE	Y, N	OUT102FS := N
OUT102	SELOGIC	OUT102 := CLOSE
OUT103 FAIL-SAFE	Y, N	OUT103FS := N
OUT103	SELOGIC	OUT103 := TRIP
• • •	• • •	• • •
OUT401 FAIL-SAFE	Y, N	OUT401FS := N
OUT401	SELOGIC	OUT401 := 0
OUT402 FAIL-SAFE	Y, N	OUT402FS := N
OUT402	SELOGIC	OUT402 := 0
OUT403 FAIL-SAFE	Y, N	OUT403FS := N
OUT403	SELOGIC	OUT403 := 0
OUT404 FAIL-SAFE	Y, N	OUT404FS := N
OUT404	SELOGIC	OUT404 := 0
• • •	• • •	• • •

NOTE: When using fast hybrid contacts, do not use FAILSAFE mode for those outputs.

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

The SEL-751 provides the ability to use SELOGIC control equations to map protection (trip and warning) and general-purpose control elements to the outputs. In addition, you can enable fail-safe output contact operation for relay contacts on an individual basis.

If the contact fail-safe is enabled, the relay output is held in its energized position when relay control power is applied. The output falls to its de-energized position when control power is removed. Contact positions with de-energized output relays are indicated on the relay chassis and in *Figure 2.12* and *Figure 2.13*.

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

MIRRORED BITS Transmit SELOGIC Control Equations

See *Appendix I: MIRRORED BITS Communications* and *SEL-751 Settings Sheets* for details.

Global Settings (SET G Command)

General Settings

Table 4.55 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
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.

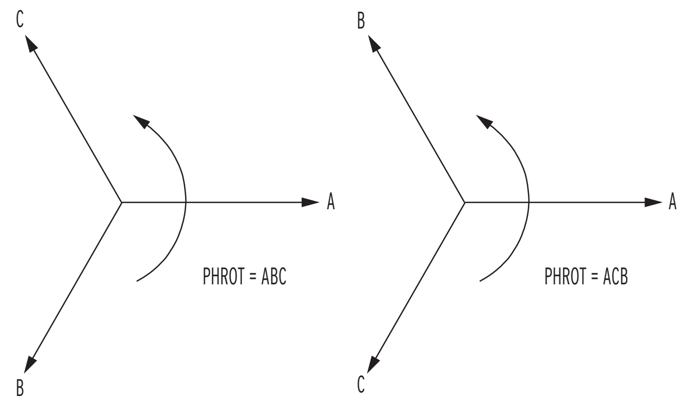


Figure 4.72 Phase Rotation Setting

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).

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 4.56 Event Messenger Settings (Sheet 1 of 2)

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

Table 4.56 Event Messenger Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
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, will be added at the end of the message, rounded to the nearest integer value (see *Example 4.24*).

EXAMPLE 4.24 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 4.25 Setting MPTXxx With a Specified Location of Analog Quantity

MPTX01 := THE LOAD CURRENT IS %.2f AMPERES

MPAQ01 value = 157.44

Formatted message out when triggered: THE LOAD CURRENT IS 157.44 AMPERES

MPTX01 := THE LOAD CURRENT IS %d AMPERES

MPAQ01 value = 157.44

Formatted message out when triggered: THE LOAD CURRENT IS 157 AMPERES

Group Selection

Table 4.57 Setting Group Selection

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

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

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

Synchrophasor Measurement

The SEL-751 provides Phasor Measurement Control Unit (PMCU) capabilities when connected to an IRIG-B time source. See *Appendix H: Synchrophasors* for the description and *Table H.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 H: Synchrophasors* for the description and *Table H.1* for the settings. For SNTP applications, refer to *Simple Network Time Protocol (SNTP) on page 7.12*. For time update from a DNP Master, see *Time Synchronization on page D.9*.

Table 4.58 shows the time and date management settings that are available in the Global settings.

Table 4.58 Time and Date Management Settings

Setting Description	Setting Range	Setting Name := Factory Default
IRIG-B Control Bits Definition	NONE, C37.118	IRIGC := NONE
Offset From UTC	–24.00 to 24.00 hours, rounds up to nearest 0.25 hour	UTC_OFF := 0.00
Month To begin DST	OFF, 1–12	DST_BEGM := OFF
Week Of The Month To Begin DST	1–3, L	DST_BEGW := 2
Day Of The Week To Begin DST	SUN, MON, TUE, WED, THU, FRI, SAT, SUN	DST_BEGD := SUN
Local Hour To Begin DST	0–23	DST_BEGH := 2
Month To End DST	1–12	DST_ENDM := 11
Week Of The Month To End DST	1–3, L	DST_ENDW := 1
Day Of The Week To End DST	SUN, MON, TUE, WED, THU, FRI, SAT, SUN	DST_ENDD := SUN
Local Hour To End DST	0–23	DST_ENDH := 2

IRIGC

IRIGC defines whether IEEE C37.118 control bit extensions are in use. Control bit extensions contain information such as Leap Second, UTC time, Daylight Savings Time, and Time Quality. When your satellite-synchronized clock provides these extensions, your relay will be able adjust the synchrophasor time-stamp accordingly.

- IRIGC := NONE will ignore bit extensions
- IRIGC := C37.118 will extract bit extensions and correct synchrophasor time accordingly

Coordinated Universal Time (UTC) Offset Setting

The SEL-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 will change to and from daylight-saving time every year at the specified time. Device Word bit DST asserts when daylight-saving time is active.

The SEL-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 will enter daylight-saving time on the last Sunday in March at 0200 h, and leave daylight-saving time on the third Wednesday in October at 0300 h. The relay asserts Relay Word bit DST when DST is active.

When 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 7.12* for a description and *Table 7.4* for the settings.

Breaker Failure Setting

Table 4.59 Breaker Failure Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
52A INTERLOCK	Y, N	52ABF := N
CURRENT DETECTOR	0.10–10.00 A[a]	50BFP:=0.1
BK FAILURE DELAY	0.00–2.00 sec	BFD :=0.50
AUX TIMER DELAY	Off, 0.01–2.00 sec	ATD :=OFF
BK FAIL INITIATE	SELOGIC	BFI =:R_TRIG TRIP

[a] Setting ranges and default Amp values shown are for 5 A nominal CT rating. Divide by 5 for 1 A CTs.

The SEL-751 provides flexible breaker failure logic (see *Figure 4.73*). In the default breaker failure logic, assertion of Relay Word bit TRIP starts the BFD timer if any of the phase current remains greater than the 50BFP setting. If any of the phase current remains greater than the threshold (50BFP) for BFD delay setting, Relay Word bit BFT will assert. Use the BFT to operate an output relay to trip appropriate backup breakers.

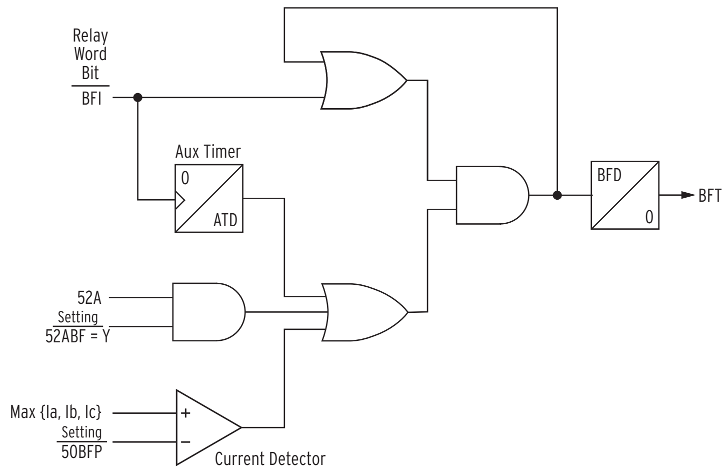


Figure 4.73 Breaker Failure Logic

Changing the BFI or the 52ABF, ATD, 50BFP settings can modify the default breaker failure logic.

- Set BFI = R_TRIG TRIP AND NOT IN102 if input IN102 is manual trip only and breaker failure initiation is not desired when the tripping is caused by this input.
- Set 52ABF = Y if you want the breaker failure logic to bypass the current detector.
- Aux timer (ATD) may be used to start the BFD timer in sequential trip applications where the current detector may not operate on initiation of the logic. If used, the ATD time must be set lower than the BFD time setting for secure operation.

Arc-Flash Protection

The SEL-751 offers advanced arc-flash protection capability aimed at minimizing the hazards associated with high energy arc (faults) in metal-enclosed and metal-clad switchgear. The system supports four 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 four 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 will typically be 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 four light inputs. Refer to *Application Guide AG2011-01: Using the SEL-751 and SEL-751A for Arc-Flash Detection* for more details.

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

Table 4.60 shows the settings for the arc-flash instantaneous overcurrent elements. Two elements are provided; the three-phase overcurrent element 50PAF and the neutral overcurrent element 50NAF.

Table 4.60 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, with the sampling rate of 16 samples per cycle. Individual samples are compared with the setting threshold as shown in *Figure 4.74*, 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 will normally be taken into account by the arc-flash “light based” supervision.

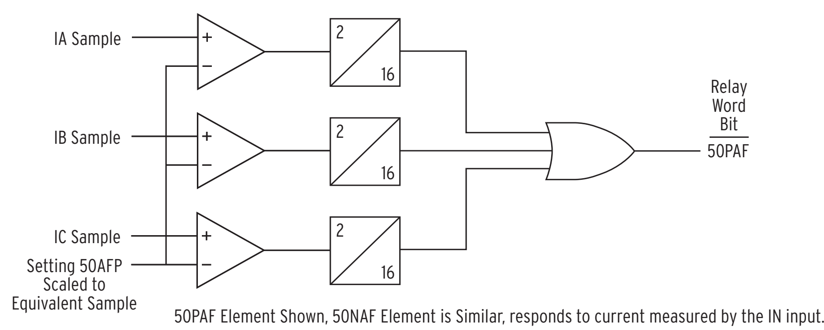


Figure 4.74 Arc-Flash Instantaneous Overcurrent Element Logic

Arc-Flash Time-Overlight Elements (TOL1 through TOL4)

The SEL-751 offers four 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 4.61* 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 4 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 4.62*. 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 4.61 Arc-Flash Time-Overlight Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
SENSOR 1 TYPE	NONE, POINT, FIBER	AFSENS1 := NONE
TOL 1 PICKUP	3.0–20.0 % [a] 0.6–4.0 % [b]	TOL1P := 3.0
SENSOR 2 TYPE	NONE, POINT, FIBER	AFSENS2 := NONE
TOL 2 PICKUP	3.0–20.0 % [a] 0.6–4.0 % [b]	TOL2P := 3.0
SENSOR 3 TYPE	NONE, POINT, FIBER	AFSENS3 := NONE
TOL 3 PICKUP	3.0–20.0 % [a] 0.6–4.0 % [b]	TOL3P := 3.0
SENSOR 4 TYPE	NONE, POINT, FIBER	AFSENS4 := NONE
TOL 4 PICKUP	3.0–20.0 % [a] 0.6–4.0 % [b]	TOL4P := 3.0
AFD OUTPUT SLOT	101_2, 301_2, 401_2	AOUTSLOT := 101_2

[a] Setting range with point sensor.
[b] Setting range with fiber sensor.

The default processing interval in the SEL-751 is ¼ of the power system cycle. However, to obtain a faster arc-flash protection you can select two outputs that will be processed every 1/16 of a power system cycle. Use the setting AOUTSLOT to select these outputs. For instance, if Slot **3** is selected (AOUTSLOT := 301_2) the SELOGIC control equations OUT301 and OUT302 will be processed at the 1/16 of a cycle rate. To get the fastest possible operate time use the contacts selected by the AOUTSLOT setting for tripping.

Figure 4.75 shows the TOL element logic diagram.

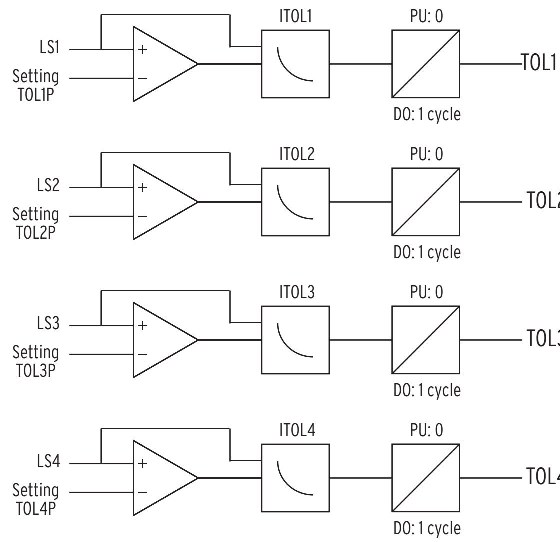


Figure 4.75 Inverse Time-Overlight Element Logic

Figure 4.76 shows the inverse time-overlight element curve shape. The element uses 32 samples per cycle data, processed 16 times per cycle. TOL element algorithm ensures that the light must be present for a minimum of two samples, regardless of the light level. It also ensures that for low light levels, element operation cannot be delayed for more than ¼ of a power system cycle.

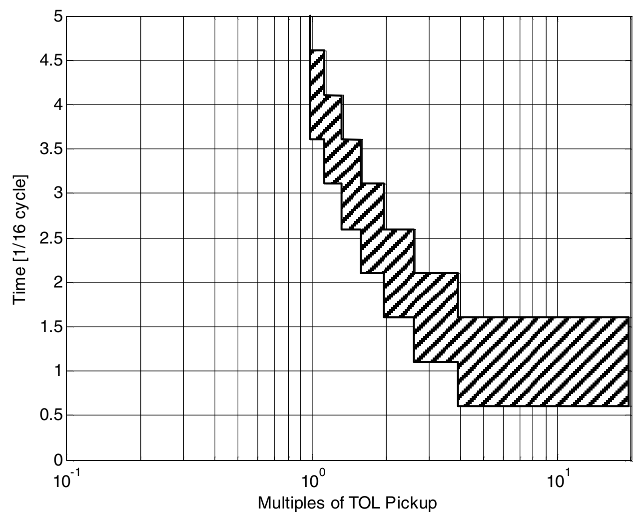


Figure 4.76 TOL Element Inverse Curve Characteristic

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 4.62*. 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 4.62 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 4.74* and *Figure 4.75*) are:

`50PAF, 50NAF, TOL1, TOL2, TOL3, and TOL4`

NOTE: When using fast hybrid output contacts, do not use the FAILSAFE mode for those outputs.

As described earlier, you select two output contacts for high-speed processing by setting AOUTSLOT appropriately. You should use the high-speed contact, instead of the default OUT103 shown in *Table 4.54*, 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 4.41* and *Figure 4.33* 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 will operate within 50 µs (as much as 8 ms faster than the standard electromechanical outputs).

EXAMPLE 4.26 Output Logic Programming Example 1:

SEL-751 applied at the source breaker.

Assume light sensors LS1, LS2, and LS3 are located downstream of the source breaker and output contacts in Slot **3** are selected for high-speed processing (AOUTSLOT := 301_2).

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 4.27 Output Logic Programming Example 2:

SEL-751 applied at the radial feeder breaker.

Assume light sensors LS1 and LS2 are located downstream, LS3 is located upstream of the feeder breaker, and output contacts in Slot **3** are selected for the high speed processing (AOUTSLOT := 301_2).

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 4.77*. Variable *x* displays the slot position (**3** through **5**), and variable *y* displays the transducer (analog) input number (1 through 4 or 8).

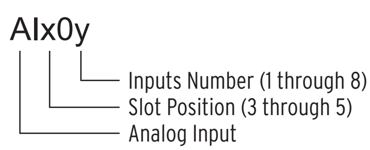


Figure 4.77 Analog Input Card Adaptive Name

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 uA or ±1 mV.

Signal offset compensation factor calculation procedure:

Step 1. Turn the SEL-751 on and allow it to warm up for a few minutes.

Step 2. Set the analog inputs for each analog channel to the desired range by using the AI*xxx*TYP, AI*xxx*L, AI*xxx*H, AI*xxx*EL, and AI*xxx*EH settings (for example, ±1 mA).

Step 3. Short each analog input in turn at the device terminals by using short, low resistance leads with solid connections.

Step 4. Issue the command **MET AI 10** to obtain 10 measurements for each channel.

Step 5. Record these 10 measurements, then calculate the average of the 10 measurements by adding the 10 values algebraically, and dividing the sum by 10. This is the average offset error in engineering units at zero input (for example, –0.014 mA).

Step 6. Negate this value (flip the sign) and add the result to each of the AI*xxx*EL and AI*xxx*EH quantities. For this example, the new AI*xxx*EL and AI*xxx*EH values are –0.986 mA and 1.014 mA.

Analog Input Setting Example

Assume we installed an analog card in Slot **3**. On Input 1 of this analog card, we connect a 4–20 mA transducer driven from a device that measures temperature on a transformer load tap changer mechanism. For this temperature transducer, 4 mA corresponds to –50°C, and 20 mA corresponds to 150°C. You have already installed the correct hardware jumper (see *Figure 2.3* for more information) for Input 1 to operate as a current input. At power up, allow approximately five seconds for the SEL-751 to boot up, perform self-diagnostics, and detect installed cards.

Table 4.63 summarizes the steps and describes the settings we will carry out in this example.

Table 4.63 Summary of Steps

	Step	Activity	Terse Description
General	1	SET G AI301NAM	Access settings for INPUT 1
	2	TX_TEMP	Enter a Tag name
	3	I	Select type of analog input; “I” for current
Transducer High/Low Output	4	4	Enter transducer low output (LOW IN VAL)
	5	20	Enter transducer high output (HI IN VAL)
Level	6	Degrees C	Enter Engineering unit
	7	–50	Enter Engineering unit value LOW
	8	150	Enter Engineering unit value HIGH
Low Warning/ Alarm	9	OFF	Enter LOW WARNING 1 value
	10	OFF	Enter LOW WARNING 2 value
	11	OFF	Enter LOW ALARM value
High Warning/ Alarm	12	65	Enter HIGH WARNING 1 value
	13	95	Enter HIGH WARNING 2 value
	14	105	Enter HIGH ALARM value

NOTE: The AIx0yNAM setting cannot accept the following and will issue the Invalid Element message:
- Analog Quantities
- Duplicate Names
- Other AI Names

Because the analog card is in Slot **3**, type **SET G AI301NAM <Enter>** to go directly to the setting for Slot **3**, Input 1. Although the device accepts alphanumeric characters, the name 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 4.78*. Set inputs connected to voltage driven transducers in a similar way.

```
=>>SET G AI301NAM TERSE <Enter>
Global
AI 301 Settings
AI301 TAG NAME (8 characters)
AI301NAM:= AI301
? TX_TEMP <Enter>
AI301 TYPE (I,V)                                  AI301TYP:= I       ? <Enter>
AI301 LOW IN VAL (-20.480 to 20.480 mA)           AI301L  := 4.000   ? <Enter>
AI301 HI IN VAL (-20.480 to 20.480 mA)            AI301H  := 20.000  ? <Enter>
AI301 ENG UNITS (16 characters)
AI301EU := mA
? degrees C <Enter>
AI301 EU LOW (-99999.000 to 99999.000)            AI301EL := 4.000   ? -50 <Enter>
AI301 EU HI (-99999.000 to 99999.000)             AI301EH := 20.000  ? 150 <Enter>
AI301 LO WARN L1 (OFF,-99999.000 to 99999.000) AI301LW1:= OFF     ? <Enter>
AI301 LO WARN L2 (OFF,-99999.000 to 99999.000) AI301LW2:= OFF     ? <Enter>
AI301 LO ALARM (OFF,-99999.000 to 99999.000)   AI301LAL:= OFF     ? <Enter>
AI301 HI WARN L1 (OFF,-99999.000 to 99999.000) AI301HW1:= OFF     ? 65 <Enter>
AI301 HI WARN L2 (OFF,-99999.000 to 99999.000) AI301HW2:= OFF     ? 95 <Enter>
AI301 HI ALARM (OFF,-99999.000 to 99999.000)   AI301HAL:= OFF     ? 115 <Enter>
AI 302 Settings
AI302 TAG NAME (8 characters)
AI302NAM:= AI302
? END  <Enter>
Save changes (Y,N)? Y <Enter>
Settings Saved
=>>
```

Figure 4.78 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 4.64 shows the setting prompt, setting range, and factory default settings for an analog input card in Slot 3. For the name setting (AI301NAM, for example), enter only alphanumeric and underscore characters. Characters are not case sensitive, but the device converts all lowercase characters to uppercase. Although the device accepts alphanumeric characters, the name AI301NAM setting must begin with an alpha character (A–Z) and not a number.

Table 4.64 Analog Input Card in Slot 3

Setting Prompt	Setting Range	Setting Name := Factory Default
AI301 TAG NAME	8 characters 0–9, A–Z, _	AI301NAM := AI301
AI301 TYPE	I, V	AI301TYP := I
AI301 LOW IN VAL	–20.480 to +20.480 mA	AI301L := 4.000
AI301 HI IN VAL	–20.480 to +20.480 mA	AI301H := 20.000
AI301 LOW IN VAL	–10.240 to +10.240 V	AI301L := 0.000[a]
AI301 HI IN VAL	–10.240 to +10.240 V	AI301H := 10.000[a]
AI301 ENG UNITS	16 characters	AI301EU := mA
AI301 EU LOW	–99999.000 to +99999.000	AI301EL := 4.000
AI301 EU HI	–99999.000 to +99999.000	AI301EH := 20.000
AI301 LO WARN 1	OFF, –99999.000 to +99999.000	AI301LW1 := OFF
AI301 LO WARN 2	OFF, –99999.000 to +99999.000	AI301LW1 := OFF
AI301 LO ALARM	OFF, –99999.000 to +99999.000	AI301LAL := OFF
AI301 HI WARN 1	OFF, –99999.000 to +99999.000	AI301HW1 := OFF
AI301 HI WARN 2	OFF, –99999.000 to +99999.000	AI301HW2 := OFF
AI301 HI ALARM	OFF, –99999.000 to +99999.000	AI301HAL := OFF

[a] Voltage setting range for a voltage transducer, 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 4.79* shows the *x* and *y* variable allocation for the analog output card.

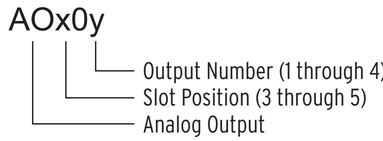


Figure 4.79 Analog Output Number Allocation

For an analog input/output card in Slot **3**, setting AO301AQ identifies the analog quantity we assign to Analog Output 1 (when set to OFF, the device hides all associated AO*x*0*y* settings and no value appears on the output). You can assign any of the analog quantities listed in *Appendix K: Analog Quantities*.

Table 4.65 shows the setting prompt, setting range, and factory default settings for an analog card in Slot **3**.

NOTE: The SEL-751 hides the following settings with default values when you use a 3 DI/4 DO/1 AO card:
AOxx1TYP := I
AOxx1L := 4.000
AOxx1H := 20.000

Table 4.65 Output Setting for a Card in Slot 3

Setting Prompt	Setting Range	Setting Name := Factory Default
AO301 ANALOG QTY	Off, 1 analog quantity	AO301AQ := OFF
AO301 TYPE	I, V	AO301TYP := I
AO301 AQTY LO	–2147483647.000 to +2147483647.000	AO301AQL := 4.000
AO301 AQTY HI	–2147483647.000 to +2147483647.000	AO301AQH := 20.000
AO301 LO OUT VAL	–20.480 to +20.480 mA	AO301L := 4.000
AO301 HI OUT VAL	–20.480 to +20.480 mA	AO301H := 20.000
AO301 LO OUT VAL	–10.240 to +10.240 V	AO301L := 0.000[a]
AO301 HI OUT VAL	–10.240 to +10.240 V	AO301H := 10.000[a]

[a] Voltage setting range for a voltage transducer, i.e., when AO301TYP := V.

Example

In this example, assume we want to display in the control room the analog quantity (refer to *Appendix K: Analog Quantities*) IA_MAG, Phase A current magnitude in primary Amps (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 4.80*. Note that the AO301 channel has to be configured as a "current analog output" channel (refer to *Figure 2.4* through *Figure 2.6*).

The display instrument expects -20 mA when the IA_MAG current is 0 A primary and +20 mA when it is 3000 A primary.

```
=>>SET G AO301AQ TERSE <Enter>
Global
AO 301 Settings
AO301 ANALOG QTY (OFF, 1 analog quantity)
AO301AQ := OFF
? IA_MAG <Enter>
AO301 TYPE (I,V)                              AO301TYP:= I        ? <Enter>
AO301 AQTY LO (-2147483647.000 to 2147483647.000)
                                              AO301AQL:= 4.000    ? 0 <Enter>
AO301 AQTY HI (-2147483647.000 to 2147483647.000)
                                              AO301AQH:= 20.000   ? 3000 <Enter>
AO301 LO OUT VAL (-20.480 to 20.480 mA)       AO301L  := 4.000    ? -20<Enter>
AO301 HI OUT VAL (-20.480 to 20.480 mA)       AO301H  := 20.000   ? 20<Enter>
AO 302 Settings
AO302 ANALOG QTY (OFF, 1 analog quantity)
AO302AQ := OFF
? END <Enter>
Save changes (Y,N)? Y <Enter>
Settings Saved
=>>
```

Figure 4.80 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 5.14* 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 4.81 shows the logic for the dc debounce mode of operation. To select the dc mode of debounce, set IN101D to any number between 0 and 65000 ms. In the figure, Input IN101 becomes IN101R (internal variable), after analog-to-digital conversion. On assertion, IN101R starts 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).

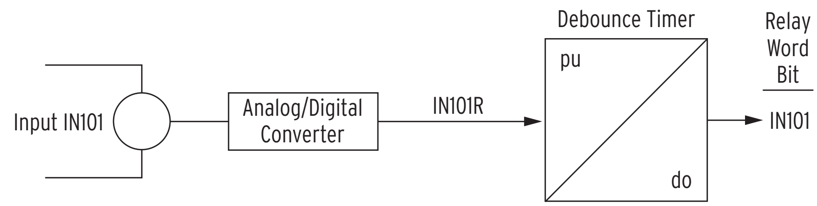


Figure 4.81 DC Mode Processing

AC Mode Processing (AC Control Voltage)

Figure 4.82 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.

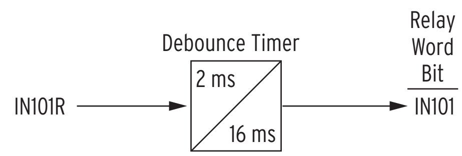


Figure 4.82 AC Mode Processing

Figure 4.83 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 6.10). If IN101R deasserts (points marked 2 in Figure 6.10) 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.

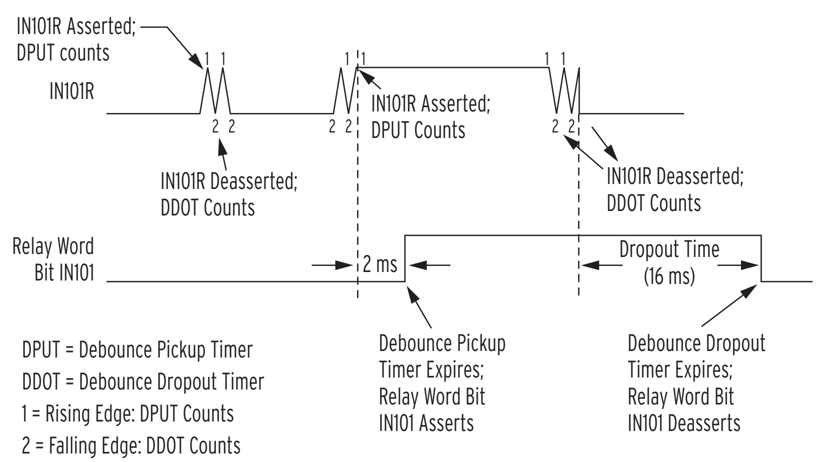


Figure 4.83 Timing Diagram for Debounce Timer Operation When Operating in AC Mode

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 4.66 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 4.66 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

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

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 4.33* 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 4.62* for the demand current logic diagram.

Access Control

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

The DSABLSET setting defines conditions for disabling all setting changes from the front-panel interface. To disable setting changes from the front-panel interface, assign a contact input (e.g., DSABLSET := IN402) to the DSABLSET setting. When Relay Word bit DSABLSET asserts, you can view the device settings from the front-panel interface, but you can only change settings through use of the serial port commands. *Table 4.67* shows the prompt, range, and factory default name for this setting.

Table 4.67 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 4.68* shows the setting to identify the input for the signal. Set TIME_SRC := IRIG1 when you use relay terminals B01/B02 or EIA-232 serial Port 3 for the time signal input. When you use fiber-optic Port 2 for the signal, set the TIME_SRC := IRIG2. Refer to *IRIG-B Time-Code Input on page 2.19* and *IRIG-B on page 7.5* for additional information.

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).

Table 4.68 Time-Synchronization Source Setting

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

Port Settings (SET P Command)

The SEL-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 a 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 4.69* through *Table 4.73* for the port settings, also see appropriate Appendix for additional information on the protocol (DNP, MODBUS, IEC-61850, DeviceNet, Synchrophasors, and MIRRORED BITS) of interest.

PORT F

Table 4.69 Front-Panel Serial Port Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PROTOCOL	SEL, MOD, EVMSG, PMU	PROTO := SEL
SPEED	300–38400 bps	SPEED := 9600
DATA BITS	7, 8 bits	BITS := 8
PARITY	O, E, N	PARITY := N
STOP BITS	1, 2 bits	STOP := 1
PORT TIME-OUT	0–30 min	T_OUT := 5
SEND AUTOMESSAGE	Y, N	AUTO := N
HDWR HANDSHAKING	Y, N	RTSCTS := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

PORT 1

IMPORTANT: Upon relay initial power up or Port 1 setting changes or Logic setting changes, you may have to wait as long as two minutes before an additional setting change can occur. Note that the relay is functional with protection enabled, as soon as the **ENABLED LED** comes ON (about 5–10 seconds from power up).

NOTE: The FAST OP MESSAGES setting only functions when using SEL Fast Operate protocol to operate/set/pulse breaker bits and remote bits. This setting has no effect on Modbus, DNP, or IEC 61850 protocols.

Table 4.70 Ethernet Port Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
IP ADDRESS	zzz.yyy.xxx.www	IPADDR := 192.168.1.2
SUBNET MASK	15 characters	SUBNETM := 255.255.255.0
DEFAULT ROUTER	15 characters	DEFRTR := 192.168.1.1
Enable TCP Keep-Alive	(Y, N)	ETCPKA := Y
TCP Keep-Alive Idle Range	1–20 sec	KAIDLE := 10
TCP Keep-Alive Interval Range	1–20 sec	KAINTV := 1
TCP Keep-Alive Count Range	1–20	KACNT := 6
FAST OP MESSAGES	Y, N	FASTOP := N
OPERATING MODE	FIXED, FAILOVER, SWITCHED	NETMODE := FAILOVER
FAILOVER TIMEOUT	0.10–65.00 sec	FTIME := 1.00
PRIMARY NETPORT	A, B, D	NETPORT := A

Table 4.70 Ethernet Port Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
NETWRK PORTA SPD	AUTO, 10, 100 Mbps	NETASPD := AUTO
NETWRK PORTB SPD	AUTO, 10, 100 Mbps	NETBSPD := AUTO
TELNET PORT	23, 1025–65534	TPORT := 23
TELNET TIME OUT	1–30 min	TIDLE := 15
FTP USER NAME	20 characters	FTPUSER := FTPUSER
Enable IEC 61850 Protocol	Y, N	E61850 := N
Enable IEC 61850 GSE	Y, N	EGSE := N
Enable Modbus Sessions	0–2	EMOD := 0
Modbus TCP Port 1	1–65534	MODNUM1 := 502
Modbus TCP Port 2	1–65534	MODNUM2 := 502
Modbus Timeout 1	15–900 sec	MTIMEO1 := 15
Modbus Timeout 2	15–900 sec	MTIMEO2 := 15
ENABLE PMU PROCESSING[a]	0–2	EPMIP := 0
Enable DNP Session[b]	0–3	EDNP := 0
Enable SNTP CLIENT[c]	OFF, UNICAST, MANYCAST, BROADCAST	ESNTP := OFF

[a] See Appendix H: Synchrophasors for a complete list of Synchrophasor settings and their descriptions.
[b] See Table D.1 for a complete list of the DNP3 session settings.
[c] See Table 7.4 for a complete list of SNTP settings and their descriptions.

PORT 2

NOTE: For additional settings when PROTO := MBxx, see Table I.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.

Table 4.71 Fiber-Optic Serial Port Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PROTOCOL	SEL, DNP, MOD, EVMSG, PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB	PROTO := SEL
SPEED	300–38400 bps	SPEED := 9600
DATA BITS	7, 8 bits	BITS := 8
PARITY	O, E, N	PARITY := N
STOP BITS	1, 2 bits	STOP := 1
PORT TIME-OUT	0–30 min	T_OUT := 5
SEND AUTOMESSAGE	Y, N	AUTO := N
FAST OP MESSAGES	Y, N	FASTOP := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

PORT 3

NOTE: For additional settings when PROTO := MBxx, see Table I.5 as well as MIRRORED BITS Transmit SELOGIC Control Equations.
For additional settings when PROTO := DNP, see Table D.7 for a complete list of the DNP3 session settings.

Table 4.72 Rear-Panel Serial Port (EIA-232) Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
PROTOCOL	SEL, DNP, MOD, EVMSG, PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB	PROTO := SEL
SPEED	300–38400 bps	SPEED := 9600

Table 4.72 Rear-Panel Serial Port (EIA-232) Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
DATA BITS	7, 8 bits	BITS := 8
PARITY	O, E, N	PARITY := N
STOP BITS	1, 2 bits	STOP := 1
PORT TIMEOUT	0–30 min	T_OUT := 5
SEND AUTOMESSAGE	Y, N	AUTO := N
HDWR HANDSHAKING	Y, N	RTSCTS := N
FAST OP MESSAGES	Y, N	FASTOP := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

PORT 4

NOTE: For additional settings when PROTO := MBxx, see Table I.5 as well as MIRRORED BITS Transmit SELOGIC Control Equations.
For additional settings when PROTO := DNP, see Table D.7 for a complete list of the DNP3 session settings.

Table 4.73 Rear-Panel Serial Port (EIA-232/EIA-485) Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PROTOCOL	SEL, MOD, DNET, DNP, EVMSG, PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB	PROTO := SEL
COMM INTERFACE	232, 485	COMMINF := 232
SPEED	300–38400 bps	SPEED := 9600
DATA BITS	7, 8 bits	BITS := 8
PARITY	O, E, N	PARITY := N
STOP BITS	1, 2 bits	STOP := 1
PORT TIMEOUT	0–30 min	T_OUT := 5
SEND AUTOMESSAGE	Y, N	AUTO := N
HDWR HANDSHAKING	Y, N	RTSCTS := N
FAST OP MESSAGES	Y, N	FASTOP := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

Set the speed, data bits, parity, and stop bits settings to match the serial port configuration of the equipment that is communicating with the serial port.

After Port Timeout minutes of inactivity on a serial port at Access Level 2, the port automatically returns to Access Level 0. This security feature helps prevent unauthorized access to the relay settings if the relay is accidentally left in Access Level 2. If you do not want the port to time out, set Port Timeout equal to 0 minutes.

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

Use the MBT option if you are using a Pulsar MBT9600 baud modem (see *Appendix I: MIRRORED BITS Communications* for more information). With this option set, the relay transmits a message every second processing interval and the device deasserts the RTS signal on the EIA-232 connector. Also, the device monitors the CTS signal on the EIA-232 connector, which the modem deasserts if the channel has too many errors. The modem uses the device RTS signal to determine whether the MB or MB8 MIRRORED BITS protocol is in use.

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

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

Set FASTOP := Y to enable binary Fast Operate messages at the serial port. Set FASTOP := N to block binary Fast Operate messages. Refer to *Appendix C: SEL Communications Processors* for the description of the SEL-751 Fast Operate commands.

Set PROTO := DNET to establish communications when you use the DeviceNet card. *Table 4.74* shows the additional settings, which can be set only at the rear on the DeviceNet card. Once the relay detects the DeviceNet card, all **Port 4** settings are hidden. Refer to *Appendix G: DeviceNet Communications* for details on DeviceNet.

Table 4.74 Rear-Panel DeviceNet Port Settings

Setting Name	Setting Range
MAC_ID	0–63
ASA	8 Hex characters assigned by factory
DN_Rate	125, 250, 500 kbps

Front-Panel Settings (SET F Command)

General Settings

Local bits provide control from the front panel (local bits), and display points display selected information on the LCD display. However, you need to first enable the appropriate number of local bits and display points necessary for your application. When your SEL-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.

Table 4.75 Display Point and Local Bit Default Settings

Setting	Setting Prompt	Range	Default
EDP	DISPLAY PTS ENABL	N, 1–32	4
ELB	LOCAL BITS ENABL	N, 1–32	N

To optimize the time you spend on setting the device, only the number of enabled display points and enabled local bits become available for use. Use the front-panel LCD timeout setting FP_TO as a security measure. If the display is within an Access Level 2 function when a timeout occurs, such as the device setting entry, the function is automatically terminated (without saving changes) after inactivity for this length of time. After terminating the function, the front-panel display returns to the default display.

If you prefer to disable the front-panel timeout function during device testing, set the LCD timeout equal to OFF. Use the front-panel LCD contrast setting FP_CONT to adjust the contrast of the liquid crystal display. Use the front-panel auto-message setting FP_AUTO to define displaying of Trip/Warning message. Set FP_AUTO either to OVERRIDE or add to the Rotating display when the relay triggers a Trip/Warning message. Set RSTLED := Y to reset the latched LEDs automatically when the breaker or contactor closes.

Table 4.76 LCD Display Settings

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

Display Points

NOTE: The rotating display is updated approximately every two (2) seconds.

Use display points to view either the state of internal relay elements (Boolean information) or analog information on the LCD display. Although the LCD screen displays a maximum of 16 characters at a time, you can enter as many as 60 valid characters. Valid characters are 0–9, A–Z, -, /, ", {, }, space. For text exceeding 16 characters, the LCD displays the first 16 characters, then scrolls through the remaining text not initially displayed on the screen.

Boolean Display Point Entry Composition

Boolean information is the status of Relay Word bits (see *Appendix J: Relay Word Bits*). In general, the legal syntax for Boolean display points consists of the following four fields or strings, separated by commas:

Relay Word Bit Name, “Alias”, “Set String”, “Clear String”.

where:

Name = Relay Word bit name (IN101, for example). All binary quantities occupy one line on the front-panel display (all analog quantities occupy two lines).

Alias = A more descriptive name for the Relay Word bit (such as TRANSFORMER 3), or the analog quantity (such as TEMPERATURE).

Set String = State what should be displayed on the LCD when the Relay Word bit is asserted (CLOSED, for example)

Clear String = State what should be displayed on the LCD when the Relay Word bit is deasserted (OPEN, for example)

Any or all of Alias, Set String, or Clear String can be empty. Although the relay accepts an empty setting Name as valid, a display point with an empty Name setting is always hidden (see 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 4.77* 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 4.77* shows examples of settings that always, never, or conditionally hide a display point.

Table 4.77 Settings That Always, Never, or Conditionally Hide a Display Point

Programmable Automation Controller Setting	Name	Alias	Set String	Clear String	Comment
DP01 := IN101, TRFR1, CLOSED, OPEN	IN101	TRFR1	CLOSED	OPEN	Never hidden
DP01 := IN101, TRFR1	IN101	TRFR1	—	—	Never hidden
DP01 := NA	—	—	—	—	Always hidden
DP01 := IN101,,,	IN101	—	—	—	Always hidden
DP01 := IN101, TRFR1,,	IN101	TRFR1	—	—	Always hidden
DP01 := IN101, TRFR1, CLOSED,	IN101	TRFR1	CLOSED	—	Hidden when IN101 is deasserted
DP01 := IN101, "TRFR 1",, OPEN	IN101	TRFR 1	—	OPEN	Hidden when IN101 is asserted

Following are examples of selected display point settings, showing the resulting front-panel displays. For example, at a certain station we want to display the status of both HV and LV circuit breakers of Transformer 1. When the HV circuit breaker is open, we want the LCD display to show: `TRFR 1 HV BRKR: OPEN`, 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 4.78 Entries for the Four Strings

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

Figure 4.84 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 4.84 Display Point Settings

Figure 4.85 shows the display when both HV and LV breakers are open (both IN101 and IN102 deasserted). *Figure 4.86* shows the display when the HV breaker is closed, and the LV breaker is open (IN101 asserted, but IN102 still deasserted).

Figure 4.85 Front-Panel Display—Both HV and LV Breakers Open

Figure 4.86 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 4.87*. 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 4.88*.

Figure 4.87 Front-Panel Display—Both HV and LV Breakers Closed

Figure 4.88 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 4.89*.

Figure 4.89 Front-Panel Display—HV Breaker Open, LV Breaker Closed

Name Only

Table 4.79 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 4.79 Binary Entry in the Name String Only

Name	Alias	Set String	Clear String
IN101	—	—	—

Figure 4.90 shows the front-panel display for the entry in *Table 4.79*. Input IN101 is deasserted in this display (`IN101=0`), but changes to `IN101=1` when Input IN101 asserts.

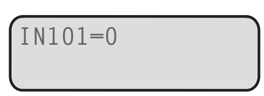


Figure 4.90 Front-Panel Display for a Binary Entry in the Name String Only

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

Table 4.80 Analog Entry in the Name String Only

Name	Alias	Set String	Clear String
AI301	—	—	—

Figure 4.91 shows the front-panel display for the entry in *Table 4.80*. Using the **SET F** command, select DP01. Set DP01 as follows:

```
DP01    := RID, “{16}”
 ? AI301 <Enter>
```

Figure 4.91 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 4.81* 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 4.81 Entry in the Name String and the Alias Strings

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

Figure 4.92 shows the front-panel display for the entry in *Table 4.81*. Input IN101 is deasserted in this display (0), and the display changes to `INPUT IN101=1` when Input IN101 asserts.

Figure 4.92 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 4.93*.

Figure 4.93 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 4.82*shows other options and front-panel displays for the User Text and Formatting settings.

Table 4.82 Example Settings and Displays

Example Display Point Setting Value	Example Display
AI301,"TEMP {4} deg C"	TEMP 1234 deg C
AI301,"TEMP = {4.1}"	TEMP = xx.x
AI301,"TEMP = {5}"	TEMP = 1230
AI301,"TEMP = {4.2,0.001} C"	TEMP = 1.23 C
AI301,"TEMP HV HS1 = {4,1000}"	TEMP HV HS1 =1234
1,{}	Empty line

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 4.94* 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 4.94 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 4.95*.

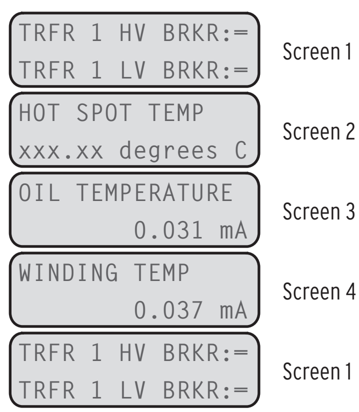


Figure 4.95 Rotating Display

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 will go back to their states after the device initialization. Each local bit requires three of the following four settings, using a maximum of 14 valid characters for the NLB*nn* setting, and a maximum 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 will appear on the LCD 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 4.96* 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 4.96 Adding Two Local Bits

Target LED Settings

The SEL-751 offers the following types of LEDs. See *Figure 8.1* and *Figure 8.26* for the programmable LED locations:

- One Enable and one TRIP tri-colored LEDs
- Six tri-colored Target LEDs
- Sixteen tri-colored Pushbutton LEDs

Your 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.

NOTE: If the LED latch setting (TnLEDL) is set to Y, and TRIP asserts, the LED latches to the state at TRIP assertion. The latched LED targets can be reset by using TARGET RESET if the target conditions are absent.

Settings T*n*_LEDL (*n* = 01 through 06) and T*n*_LED (*n* = 01 through 06) control the six front-panel LEDs. With T*n*_LEDL set to Y, the LEDs latch the LED state at TRIP assertion. To reset these latched LEDs, the corresponding LED equation must be deasserted (logical 0) and one of the following takes place:

- Pressing **TARGET RESET** on the front panel.
- Issuing the serial port command **TAR R**.
- The assertion of the SELOGIC control equation RSTTRGT.

With T*n*LEDL settings set to N, the LEDs do not latch and directly follow the state of the associated SELOGIC control equation setting.

Enter any of the Relay Word bits (or combinations of Relay Word bits) as conditions in the T*n*_LED SELOGIC control equation settings. When these Relay Word bits assert, the corresponding LED also asserts.

Table 4.83 Target LED Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
ENA_LED COLOR	R, G, A[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
TRIP LATCH T_LED	Y, N	T03LEDL := Y
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

Table 4.83 Target LED Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
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 := Y
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.

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 4.84* shows the setting prompts, settings ranges, and default settings for the LEDs.

Table 4.84 Pushbutton LED Settings (Sheet 1 of 2)

Setting Prompt	Setting Range[a]	Setting Name := Factory Default
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB1ALEDC := AO
PB1A_LED EQUATION	SELOGIC	PB1A_LED := 79RS
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB1BLEDC := AO
PB1B_LED EQUATION	SELOGIC	PB1B_LED := 79LO
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB2ALEDC := AO
PB2A_LED EQUATION	SELOGIC	PB2A_LED := NOT LT02 OR SV02 AND NOT SV02T AND SV05T
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB2BLEDC := AO
PB2B_LED EQUATION	SELOGIC	PB2B_LED := LT02 OR SV02 AND NOT SV02T AND SV05T
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB3ALEDC := AO
PB3A_LED EQUATION	SELOGIC	PB3A_LED := NOT LT02 AND NOT 52A
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB3BLEDC := AO
PB3B_LED EQUATION	SELOGIC	PB3B_LED := 52A OR SV03 AND NOT SV03T AND SV05T
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB4ALEDC := AO
PB4A_LED EQUATION	SELOGIC	PB4A_LED := 0
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB4BLEDC := AO
PB4B_LED EQUATION	SELOGIC	PB4B_LED := NOT 52A OR SV04 AND NOT SV04T AND SV05T
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB5ALEDC := AO
PB5A_LED EQUATION	SELOGIC	PB5A_LED := 0

Table 4.84 Pushbutton LED Settings (Sheet 2 of 2)

Setting Prompt	Setting Range[a]	Setting Name := Factory Default
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB5BLEDC := AO
PB5B_LED EQUATION	SELOGIC	PB5B_LED := 0
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB6ALEDC := AO
PB6A_LED EQUATION	SELOGIC	PB6A_LED := 0
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB6BLEDC := AO
PB6B_LED EQUATION	SELOGIC	PB6B_LED := 0
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB7ALEDC := AO
PB7A_LED EQUATION	SELOGIC	PB7A_LED := 0
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB7BLEDC := AO
PB7B_LED EQUATION	SELOGIC	PB7B_LED := 0
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB8ALEDC := AO
PB8A_LED EQUATION	SELOGIC	PB8A_LED := 0
PB_LED ASSERTED/DEASSRTED COLORS	R, G, A, O	PB8BLEDC := AO
PB8B_LED EQUATION	SELOGIC	PB8B_LED := 0

[a] 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 4.86* (see *Appendix J: Relay Word Bits* for more information).

SER Chatter Criteria

The SER includes an automatic deletion and reinsertion function to prevent overfilling of the SER buffer with chattering information. Each processing interval the relay checks the Relay Word bits in the four SER reports for any changes of state. When detecting a change of state, the relay adds a record to the SER report containing the Relay Word bit(s), new state, time stamp, and checksum (see *Section 9: Analyzing Events* for more information).

When detecting oscillating SER items, the relay automatically deletes these oscillating items from SER recording. *Table 4.85* shows the auto-removal settings.

Table 4.85 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) will be ignored for the next nine intervals. At the ninth interval, the chatter criteria will again be checked and, if the point does not exceed the criteria, it will be 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 will be 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 4.86* shows the settings prompt and default settings for the four SER trigger equations.

Table 4.86 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 4.87 Enable Alias Settings

Setting Prompt	Setting Range	Setting Name = Factory Default
Enable ALIAS Settings (N, 1–20)	N, 1–20	EALIAS = 4

To simplify your review of the information displayed in the SER record, the relay provides the Alias setting function. Using the Alias settings, you can change the way relay elements listed in the previous SER settings are displayed in the SER report. In addition, the Alias settings allow you to change the text displayed when a particular element is asserted and deasserted. The relay permits as many as 20 unique aliases, as defined by the Enable Alias Settings (EALIAS) setting. Factory default alias settings are shown in *Table 4.88*.

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 J.1* for the complete list of Relay Word bits. Use as many as 15 characters to define the alias, asserted text, and deasserted text strings. You can use capital letters (A–Z), numbers (0–9), and the underscore character (_)

within each string. Do not attempt to use a space within a string because the relay will interpret a space as the break between two strings. If you want to clear a string, simply type **NA**.

Table 4.88 SET R SER Alias Settings

Setting Prompt	Relay Word Bit	Alias	Asserted Text	Deasserted Text
ALIAS1 :=	PB01	FP_AUX1	PICKUP	DROPOUT
ALIAS2 :=	PB02	FP_LOCK	PICKUP	DROPOUT
ALIAS3 :=	PB03	FP_CLOSE	PICKUP	DROPOUT
ALIAS4 :=	PB04	FP_TRIP	PICKUP	DROPOUT
ALIAS5 –ALIAS20	NA			

Event Report Settings

NOTE: Event report data stored in the relay will be lost when you change the LER setting, You must save the data before changing the setting.

Table 4.89 Event Report Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
EVENT TRIGGER	SELOGIC	ER := R_TRIG 51P1P OR R_TRIG 51G1P OR R_TRIG 50P1P OR R_TRIG 50G1P OR R_TRIG 51N1P OR R_TRIG CF
EVENT LENGTH	15, 64, 180 cyc	LER := 15
PREFAULT LENGTH	1–175 cyc[a]	PRE := 5

[a] The range shown is for LER := 180. The generalized range is 1 - (LER-5) cyc.

Event reports can be either 15 cycles, 64 cycles, or 180 cycles in length as determined by the LER setting. For LER of 15, the prefault length, PRE, must be in the range of 1–10. The relay can hold as many as seventy-nine 15-cycle event reports, eighteen 64-cycle event reports, or six 180-cycle event reports.

HIF Event Report Settings

Table 4.90 HIF Event Report Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
HIF EVENT LENGTH	2, 5, 10, 20 min	HIFLER = 10

Load Profile Settings

Use the LDLIST setting to declare the analog quantities you want included in the Load Profile Report. Enter as many as 17 analog quantities, separated by spaces or commas, into LDLIST setting. See *Appendix K: 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 4.91 Load Profile Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
LDP LIST	NA, as many as 17 Analog Quantities	LDLIST := NA
LDP ACQ RATE	5, 10, 15, 30, 60 min	LDAR := 15

DNP Map Settings (Set DNP n Command, n = 1, 2, or 3)

Table 4.92 shows the available settings. See *Appendix D: DNP3 Communications* for additional details.

Table 4.92 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 4.93 shows the available settings. See *Appendix E: Modbus RTU Communications* for additional details.

Table 4.93 User Map Register Settings [a]

Setting Prompt	Setting Range	Setting Name := Factory Default
USER REG#1	NA, 1 Modbus Register Label	MOD_001 :=
•	•	•
•	•	•
•	•	•
USER REG#125	NA, 1 Modbus Register Label	MOD_125 :=

[a] See Appendix E: Modbus RTU Communications for Modbus Register Labels and factory default settings.

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Section 5
Metering and Monitoring

Overview

The SEL-751 Feeder Protection Relay includes metering functions to display the present values of current, voltage, analog inputs, and RTD measurements (with the external SEL-2600 RTD Module or an internal RTD card). The relay provides the following methods to read the present meter values:

- ➤ Front-panel rotating display
- ➤ Front-panel menu
- ➤ EIA-232 serial ports (by using SEL ASCII text commands or ACSELERATOR QuickSet® SEL-5030 Software)
- ➤ Telnet via Ethernet port
- ➤ Modbus® via EIA-485 port or EIA-232 port
- ➤ Modbus TCP via Ethernet port
- ➤ DNP3 Serial via EIA-232 port or EIA-485 port
- ➤ DNP3 LAN/WAN via Ethernet port
- ➤ DeviceNet port
- ➤ Analog outputs
- ➤ IEC 61850 via Ethernet 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 4000 time samples are stored.

Station DC Battery Monitor is available as an option in the SEL-751 with the 2 AVI/4 AFDI Voltage/arc-flash detection card. Refer to *Station DC Battery Monitor on page 5.14* 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*.

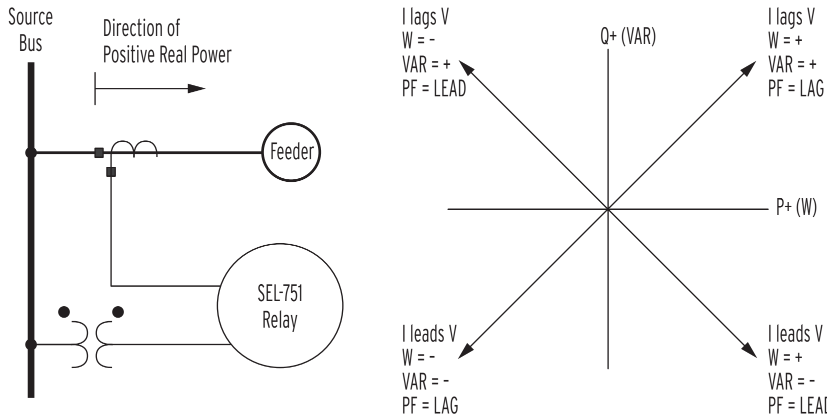

Figure 5.1 Complex Power Measurement Conventions

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
- HIF metering (high-impedance fault progress metering)—available in relays with the Arc-Sense Technology option for HIF detection

Fundamental Metering

Table 5.1 details each of the fundamental meter data types in the SEL-751. *Section 8: Front-Panel Operations* and *Section 7: Communications* describe how to access the various types of meter data by using the relay front panel and communications ports.

Table 5.1 Measured Fundamental Meter Values

Relay Option	Meter Values
All Models	Line Currents IA, IB, IC and IN (Core-Balance Ground Fault Current) magnitudes (A) and phase angles (deg) IG (Residual Ground Fault Current) magnitude (A) and phase angle (deg) IAV (Average Current Magnitude) Positive-Sequence Current (I1) Negative-Sequence Current (3I2) Current Imbalance %[a] System Frequency (Hz) (FREQ) VAB, VBC, VCA or VAN, VBN, VCN, VG magnitudes (V) and phase angles (deg) VAV, Average Voltage (L-L or L-N) Positive-Sequence Voltage (V1) Negative-Sequence Voltage (3V2) Voltage Imbalance %[1] Real Power (kW)[b] Reactive Power (kVAR)[2] Apparent Power (kVA)[2] Power Factor[2]
With Sync-Check and DC Station Battery Voltages and Arc-Flash Detection Inputs Option (2 AVI/4 AFDI Card MOT...x70x...)	VS (synchronism-check voltage) magnitude (V) and phase angle (deg) Synchronism-check voltage frequency FREQS (Hz) VDC (station battery voltage) (V dc)

[a] Current Imbalance % = 0 when IAV ≤ 0.25 * I_{NOM}; Voltage Imbalance = 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.

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. If the voltage VAB < 13 V (for delta-connected PT) or the voltage VAN < 13 V (for wye-connected PT), the angles are referenced to IA current. *Figure 5.2* shows an example of the **METER** command report.

The SEL-751 calculates percent imbalance current in one of two ways, depending on the magnitude of the average current. When the average current (Iav) is greater than the CT rated current (I_{NOM}) the relay calculates the percent imbalance as shown in *Equation 5.1*.

$$\text{UBI\%} = 100 \bullet \frac{\text{Im}}{\text{Iav}} \qquad \textbf{Equation 5.1}$$

When the average current is less than the I_{NOM} current, the relay calculates the percent imbalance as shown *Equation 5.2*.

$$\text{UBI\%} = 100 \bullet \frac{\text{Im}}{I_{NOM}} \qquad \textbf{Equation 5.2}$$

where:

UBI% = Current imbalance percentage

Im = Maximum deviation of Iav from highest and lowest magnitudes of the phase currents

Iav = Magnitude of the average phase current

I_{NOM} = CT rated current

In either case, the UBI% is not calculated if the average phase current magnitude is less than 25% of the I_{NOM} current. Voltage Imbalance % is calculated in a similar manner.

The SEL-751 calculates percent imbalance voltage in one of two ways, depending on the magnitude of the average voltage. When the average voltage (Vav) is greater than the rated voltage (Vnm, where Vnm = VNOM/1.732 when Wye, VNOM when Delta) the relay calculates the percent imbalance as shown in *Equation 5.3*.

$$UBV\% = 100 \bullet \frac{Vm}{Vav}$$ **Equation 5.3**

When the average voltage is less than Vnm, the relay calculates the percent imbalance as shown in *Equation 5.4*.

$$UBV\% = 100 \bullet \frac{Vm}{Vnm}$$ **Equation 5.4**

where:

UBV% = Voltage imbalance percentage

Vm = Maximum deviation of Vav from highest and lowest magnitudes of the phase voltages

Vav = 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% of the Vnm voltage.

```
=>>MET <Enter>

SEL-751                                  Date: 02/23/2012   Time: 00:47:50.504
FEEDER RELAY                             Time Source: Internal

                 IA         IB         IC         IN         IG         I1
Mag (A pri.)     1809.0     1804.0     1806.7      120.8       18.8     1806.5
Angle (deg)        -2.9     -122.5      117.9       -1.5     -116.6       -2.5

Ave Curr Mag     (A pri.)      1806.6
Neg-Seq Curr 3I2 (A pri.)        26.3
Current Imb (%)                   0.1

                 VAB        VBC        VCA        V1         VS
Mag (V pri.)    20851.0    20845.6    20965.8    12059.3    12238.0
Angle (deg)        30.2      -89.5      150.4        0.4       -2.8

                 VA         VB         VC         VG
Mag (V pri.)    12056.9    12060.9    12060.8      140.9
Angle (deg)         0.0     -119.7      120.8     -124.6
```

Figure 5.2 METER Command Report With Voltage/Arc-Flash Detection 2 AVI/4 AFDI Card in Slot E (Sheet 1 of 2)

```
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 (Sheet 2 of 2)

Thermal Metering

The thermal metering function reports the RTD meter values (see *Table 5.2* for details) and also reports the state of connected RTDs if any have failed (see *Table 5.3* for details).

Table 5.2 Thermal Meter Values

Relay Option	Thermal Values
With External SEL-2600 RTD Module or Internal RTD Option	All RTD Temperatures

Table 5.3 RTD Input Status Messages

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

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

```
=>MET T <Enter>

SEL-751                                    Date: 12/05/2010 Time: 17:24:11
FEEDER RELAY                                Time Source: External

Max Winding RTD  NA
Max Bearing RTD  NA
Ambient RTD        52 C
Max Other RTD      41 C

 RTD 1 OTH    -23 C
 RTD 2 OTH      9 C
 RTD 3 OTH     41 C
 RTD 4 AMB     52 C

=>>
```

Figure 5.3 METER T Command Report With RTDs

Energy Metering

The SEL-751 includes energy metering. Use this form of metering to quantify real, reactive, and apparent energy supplied to the feeder load. Following are the energy meter values.

- ➤ MWh3P-OUT—Real 3-phase energy (out of bus, into feeder)
- ➤ MWh3P-IN—Real 3-phase energy (from feeder into bus)

- MVARh3P-OUT—Reactive 3-phase energy (out of bus, into feeder)
- MVARh3P-IN—Reactive 3-phase energy (from feeder, into bus)
- MVAh3P—Apparent 3-phase energy
- Last date and time of energy meter quantities were reset

Figure 5.4 shows the device response to the **METER E** command.

NOTE: Energy values rollover after 99,999.999 MVAh and reset to 0.

```
=>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 (Sheet 1 of 2)

Relay Option	Max/Min Meter Values
Base Model	Maximum and minimum line currents I_A, I_B, I_C, and I_N (core-balance ground fault current) magnitudes (A) Maximum and minimum I_G (residual ground fault current) magnitude (A) Maximum and minimum V_{AB}, V_{BC}, V_{CA} or V_{AN}, V_{BN}, V_{CN} magnitudes (V) Maximum and minimum real, reactive and apparent 3-phase power (kW, kVAR, kVA) Maximum and minimum system frequency (Hz)
With Voltage Arc-Flash Detection 2 AVI/4 AFDI Card Option in Slot E	Maximum and minimum V_S magnitudes (V)

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

Relay Option	Max/Min Meter Values
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 will 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% 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.
- 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 element. The date and time of the reset are preserved and shown in the max/min meter report.

```
=>>MET RM <Enter>

Reset Metering Quantities (Y,N)? Y <Enter>
Reset Complete

=>>
```

Figure 5.7 METER RM Command Response

All maximum and minimum metering values are stored to nonvolatile memory four times per day and within one minute of the maximum and minimum metering values being reset.

Math Variable Metering

The SEL-751 includes 32 math variables. When you receive your SEL-751, no math variables are enabled. To use math variables, enable the number of math variables (between 1 and 32) you require, using the EMV setting in the Logic setting category. *Figure 5.8* shows the device response to the **METER MV M**(ath) **V**(ariable) command with 8 of the 32 math variables enabled.

```
=>>MET MV <Enter>

SEL-751                                 Date: 02/17/2011   Time: 12:32:10
FEEDER RELAY                             Time Source: Internal

MV01       1.00
MV02   -32767.00
MV03      -1.00
MV04       0.00
MV05    1000.59
MV06   -1000.61
MV07    2411.01
MV08    2410.99

=>>
```

Figure 5.8 METER MV Command Response

RMS Metering

The SEL-751 includes Root Mean Squared (rms) metering. Use rms metering to measure the entire signal (including harmonics). You can measure the rms quantities shown in *Table 5.5*.

Table 5.5 RMS Meter Values

Relay Option	RMS Meter Values
Base Model	RMS current IA, IB, IC, and IN magnitudes (A)
With Voltage/Arc-Flash Detection 2 AVI/4 AFDI Card Option	VAB, VBC, VCA or VAN, VBN, VCN, and VS (if ordered) magnitudes (V)

RMS quantities contain the total signal energy including harmonics. This differs from the fundamental meter (**METER** command) in that the fundamental meter quantities only contain the fundamental frequency (60 Hz for a 60-Hz system).

Figure 5.9 shows the **METER RMS** command.

```
=>>MET RMS <Enter>

SEL-751                                 Date: 12/02/2010   Time: 15:45:49
FEEDER RELAY                             Time Source: External

                IA       IB       IC       IN
RMS (A pri.)    998.3   1080.5    963.2      0.0

                VAB      VBC      VCA      VS
RMS (V pri.)     6648     6707     7502     6741

=>>
```

Figure 5.9 METER RMS Command Response

Analog Input Metering

The SEL-751 can monitor analog (transducer) quantities that it is measuring if equipped with optional analog inputs. Analog input metering shows transducer values from standard voltage and current transducers. You can then use these values for automation and control applications within an industrial plant or application.

Through the global settings, you can set each type of analog input to the type of transducer that drives that analog input. You also set the range of the transducer output. Analog inputs can accept both current and voltage transducer outputs. Ranges for the current transducers are ±20 mA and ranges for the voltage transducers are ±10 V. You also set the corresponding output of the analog inputs in engineering units. See *Section 4: Protection and Logic Functions* for an explanation of how to set up analog inputs for reading transducers. *Figure 5.10* shows an example of analog input metering

```
=>MET AI <Enter>

SEL-751                                 Date: 11/28/2010   Time: 16:22:22
FEEDER RELAY                             Time Source: Internal

Input Card 4
AI401 (psi)        99.97
AI402 (mA)          2.013
AI403 (Volts)      -0.0027
AI404 (ft-lbs)     993
AI405 (HP)       1423
AI406 (mA)          9.013
AI407 (mA)         -3.014
AI408 (mA)         -0.013

=>
```

Figure 5.10 METER AI Command Response

Arc-Flash Light Intensity Metering

When the SEL-751 is ordered with the arc-flash detection (AFD) option (order the 2 AVI /4 AFDI card for slot **E**), the relay provides light metering data with the METER LIGHT (**METER L** command) report. The light inputs LS1–LS4 are given in percent of full scale.

Figure 5.11 provides an example of **METER L** (Light) command report.

```
=>>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 4.103* 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)
	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 will be 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. As a method of periodically gathering synchrophasor data through a communications processor.

The **METER PM** command displays the same set of analog synchrophasor information, regardless of the global settings PHDATAV, PHDATAI, and PHCURR. The **METER PM** command can function even when no serial ports are sending synchrophasor data.

NOTE: To have the **MET PM xx:yy:zz** response transmitted from a serial port, the corresponding port must have the AUTO setting set to YES (Y).

The **METER PM** command will only operate when the SEL-751 is in the IRIG timekeeping mode, as indicated by Relay Word bit TSOK = logical 1. *Table 5.7* shows the measured values for the **METER PM** command. *Figure H.4* in *Appendix H: 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 will result in a response similar to *Figure H.4*, occurring just after 14:14:12, with the time stamp 14:14:12.000. Refer to *Appendix H: Synchrophasors*, for further details on synchrophasor measurements, settings, C37.118 Protocol, etc.

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 and 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%.

Table 5.7 Synchrophasor Measured Values

Relay Option	Meter Values
Currents	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	Voltage phasors: VA, VB, VC, VS (if VS option is available), and V1 (positive-sequence voltage), magnitudes (V or kV) and phase angles (deg)

[a] Only the data that occur at the "Top of the Second" will be used for METER PM responses.

Remote Analog Metering

Use remote analog metering to verify the values received from an external device. The SEL-751 includes 128 remote analog variables. In *Appendix C: SEL Communications Processors*, we show how to enter remote analog settings in an SEL Communications Processor and the SEL-751. *Figure 5.14* shows the device response to the **METER RA** command for the settings in *Appendix C: SEL Communications Processors*.

```
=>>MET RA <Enter>

SEL-751                                    Date: 02/11/2011   Time: 13:42:23
FEEDER RELAY                                Time Source: External

RA01       1.00
RA02 -32767.00
RA03      -1.00
RA04       0.00
RA05    1000.59
RA06   -1000.61
RA07    2411.01
RA08    2410.99
RA09   98303.00
RA10  -98303.00
RA11  -38400.00
RA12  -65536.00
RA13       0.00
RA14       0.00
RA15       0.00
 •          •
 •          •
 •          •
RA126      0.00
RA127      0.00
RA128      0.00

=>>
```

Figure 5.14 MET RA Command Response

High-Impedance Fault Metering (HIF)

When the SEL-751 is ordered with the Arc Sense™ technology (AST) option for high-impedance fault detection, the relay provides high-impedance fault metering data with the METER HIF (**MET H** command) report. The **MET HIF** command displays the progress of HIF detection alarm and fault in percent of their preset pickup values (see *Table 5.8* for details).

Table 5.8 High-Impedance Fault Metering Measured Values

Relay Option	High-Impedance Fault (HIF) Metering Values
All models with the AST option	Odd-harmonic alarm and fault values ALG.1 A, ALG.1 B, and ALG.1 C for Phases A, B and C in percent of preset alarm and fault thresholds. Non-harmonic alarm and fault values ALG.2 A, ALG.2 B, and ALG.2 C for Phases A, B and C in percent of preset alarm and fault thresholds.

If HIF enable setting EHIF is set to N, the command response is `HIF Not Enabled`. If setting EHIF is set to Y and any of the initial tuning Relay Word Bits ITUNE_A, ITUNE_B or ITUNE_C is asserted, the command response is `HIF Algorithm Tuning in Progress`. Initial tuning is a 24-hour window.

Figure 5.15 provides an example of **MET HIF** command report.

```
=>>MET HIF <Enter>

                                          Date: 03/31/2011   Time: 14:19:20.655
                                          Time Source: Internal


           ALG.1 A    ALG.1 B    ALG.1 C    ALG.2 A    ALG.2 B    ALG.2 C
Alarm (%)     0.00       0.00       0.00     100.00       0.00       0.00
Fault (%)     0.00       0.00       0.00       0.00       0.00       0.00


=>>
```

Figure 5.15 MET H (HIF) Command Response

Small Signal Cutoff for Metering

The relay applies a threshold to the voltage and current magnitude metering quantities to force a reading to zero when the measurement is near zero. The threshold for fundamental metering current values is 0.01 • I_{NOM} A (secondary) and for voltage values is 0.1 V (secondary). The threshold for rms metering current values is 0.03 • I_{NOM} A (secondary) and for voltage values is 0.3 V (secondary).

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 4.154*). Choose which analog quantities you want to monitor from the analog quantities listed in *Appendix K: Analog Quantities*. Set these quantities into the LDLIST load profile list report setting.

The relay memory can hold data for 4,000 time-stamped entries. For example, if you chose to monitor 10 values at a rate of every 15 minutes, you could store 41.67 days worth of data.

Use the serial port LDP command described in *LDP Command (Load Profile Report)* to download the load rate profile data. See *Figure 5.16* for an example of an **LDP** serial port command response.

```
=>LDP <Enter>

SEL-751                                       Date: 02/21/2011   Time: 13:07:02
FEEDER RELAY                                   Time Source: Internal

#      DATE         TIME          IAV       VAVE        P          PF
20  02/21/2011  11:31:24.468    277.636   13823.97   5908.951      0.889
19  02/21/2011  11:36:24.301    278.050   13824.34   5920.197      0.889
18  02/21/2011  11:41:24.035    278.012   13819.86   5920.606      0.890
17  02/21/2011  11:46:24.623    277.661   13824.90   5912.636      0.889
16  02/21/2011  11:51:24.885    278.072   13821.30   5922.041      0.890
15  02/21/2011  11:56:23.873    277.917   13821.33   5914.892      0.889
14  02/21/2011  12:01:23.923    277.630   13821.01   5907.527      0.889
13  02/21/2011  12:06:24.010    278.048   13821.97   5917.934      0.889
12  02/21/2011  12:11:24.140    277.988   13824.35   5917.830      0.889
11  02/21/2011  12:16:24.290    277.780   13820.97   5918.148      0.890
10  02/21/2011  12:21:24.203    277.740   13819.82   5920.595      0.891
9   02/21/2011  12:26:24.507    277.256   13823.17   5907.525      0.890
8   02/21/2011  12:31:24.332    277.973   13822.21   5921.495      0.890
7   02/21/2011  12:36:24.541    277.740   13819.83   5916.932      0.890
6   02/21/2011  12:41:24.791    288.393   13819.60   6593.658      0.955
5   02/21/2011  12:46:24.720    288.589   13820.86   6844.973      0.991
4   02/21/2011  12:51:23.816    288.547   13822.20   6843.819      0.991
3   02/21/2011  12:56:24.174    288.246   13821.41   6838.310      0.991
2   02/21/2011  13:01:24.750    288.232   13823.61   6835.954      0.991
1   02/21/2011  13:06:24.658    288.709   13820.80   6847.213      0.991

=>
```

Figure 5.16 LDP Command Response

Station DC Battery Monitor

The station dc battery monitor in the SEL-751 can alarm for under- or overvoltage dc battery conditions and give a view of how much the station dc battery voltage dips when tripping, closing, and other dc control functions take place. The monitor function is available with the voltage/arc-flash detection 2 AVI/4 AFDI card option in slot E of the relay. The monitor measures the station dc battery voltage applied to the rear-panel terminals labeled E3 (VBAT+) and E4 (VBAT-). The station dc battery monitor settings (DCLOP and DCHIP) are available via the **SET G** command (see *Table 5.9* and *Global Settings (SET G Command) on page .26*).

DC Under- and Overvoltage Elements

Table 5.9 Station DC Battery Monitor Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
DC UNDER VOLT PU	(OFF, 20.00-300.00) Vdc	DCLOP := OFF
DC OVER VOLT PU	(OFF, 20.00-300.00) Vdc	DCHIP := OFF

Refer to *Figure 5.17*. The station dc battery monitor compares the measured station battery voltage (Vdc) to the undervoltage (low) and overvoltage (high) pickups DCLOP and DCHIP. The setting range for pickup settings DCLOP and DCHIP is:

20 to 300 Vdc, 0.01Vdc increments

This range allows the SEL-751 to monitor nominal battery voltages of 24, 48, 110, 125, 220, and 250V. When testing the pickup settings DCLOP and DCHIP, do not operate the SEL-751 outside of its power supply limits. See *Specifications*: *General on page 1.10* for the various power supply specifications. The power supply rating is located on the serial number sticker on the relay side panel.

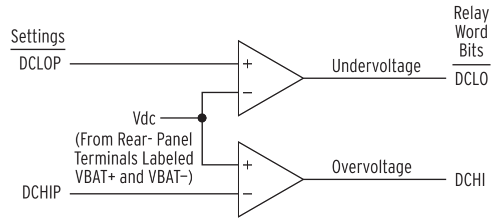

Figure 5.17 DC Under- and Overvoltage Elements

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.

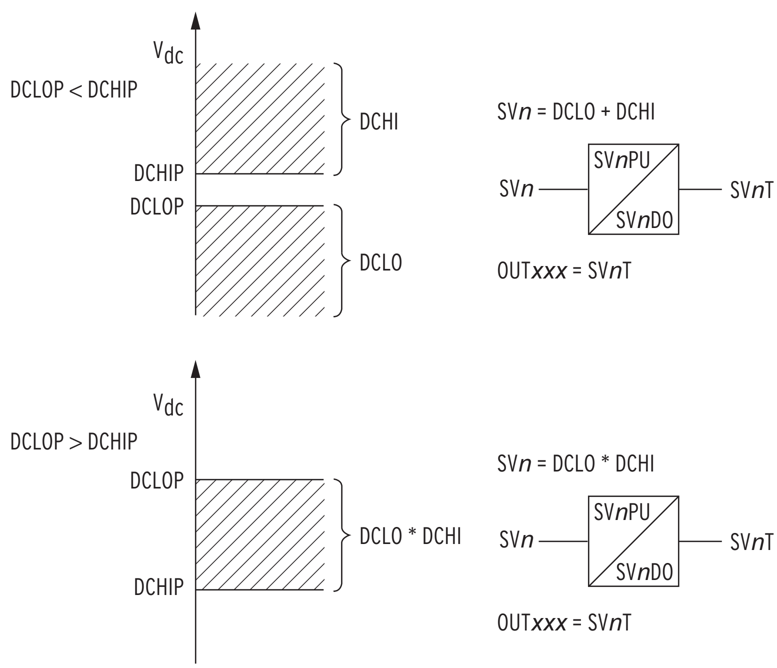

Figure 5.18 Create DC Voltage Elements With SELOGIC Control Equations

DCLO < DCHI (Top of Figure 5.18)

Output contact OUT*xxx* asserts when:

$V_{dc} \leq DCLOP$ or $V_{dc} \geq DCHIP$

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 (V_{dc} = 0 V)

$V_{dc} = < DCLOP$

then output contact OUT*xxx* should logically assert (according to top of *Figure 5.18*), but cannot because of the total loss of power (all output contacts deassert on total loss of power). Thus, the resultant dc voltage element at the bottom of *Figure 5.18* would probably be a better choice—see following discussion.

DCLO > DCHI (Bottom of Figure 5.18)

Output contact OUT*xxx* asserts when:

$DCHIP \leq V_{dc} \leq DCLOP$

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 (V_{dc} = 0 V)

$V_{dc} = < DCHIP$

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 8.6*.

Analyze Station DC Battery Voltage

The station dc battery voltage is displayed in column Vdc in the example event report in *Figure 9.3*. 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 9: 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 4.51*). 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 4.52*)

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 7.22* and *BRE n Command (Preload/Reset Breaker Wear) on page 7.22*.

The breaker monitor is set with breaker maintenance information provided by circuit breaker manufacturers. This breaker maintenance information lists the number of close/open operations that are permitted for a given current interruption level. The following is an example of breaker maintenance information for a 25 kV circuit breaker. The breaker maintenance information in *Table 5.10* is plotted in *Figure 5.19*.

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 COSP2 is set the same as COSP3, then KASP2 must be set the same as KASP3.
[d] KASP1 must be set less than KASP2 and KASP2 must be less than or equal to KASP3.
[e] KASP3 must be set at least five times (but no more than 100 times) the KASP1 setting value.

The following settings are made from the breaker maintenance information in *Table 5.10* and *Figure 5.19*. *Figure 5.20* shows the resultant breaker maintenance curve.

COSP1 = **10000**

COSP2 = **150**

COSP3 = **12**

KASP1 = **1.20**

KASP2 = **8.00**

KASP3 = **20.00**

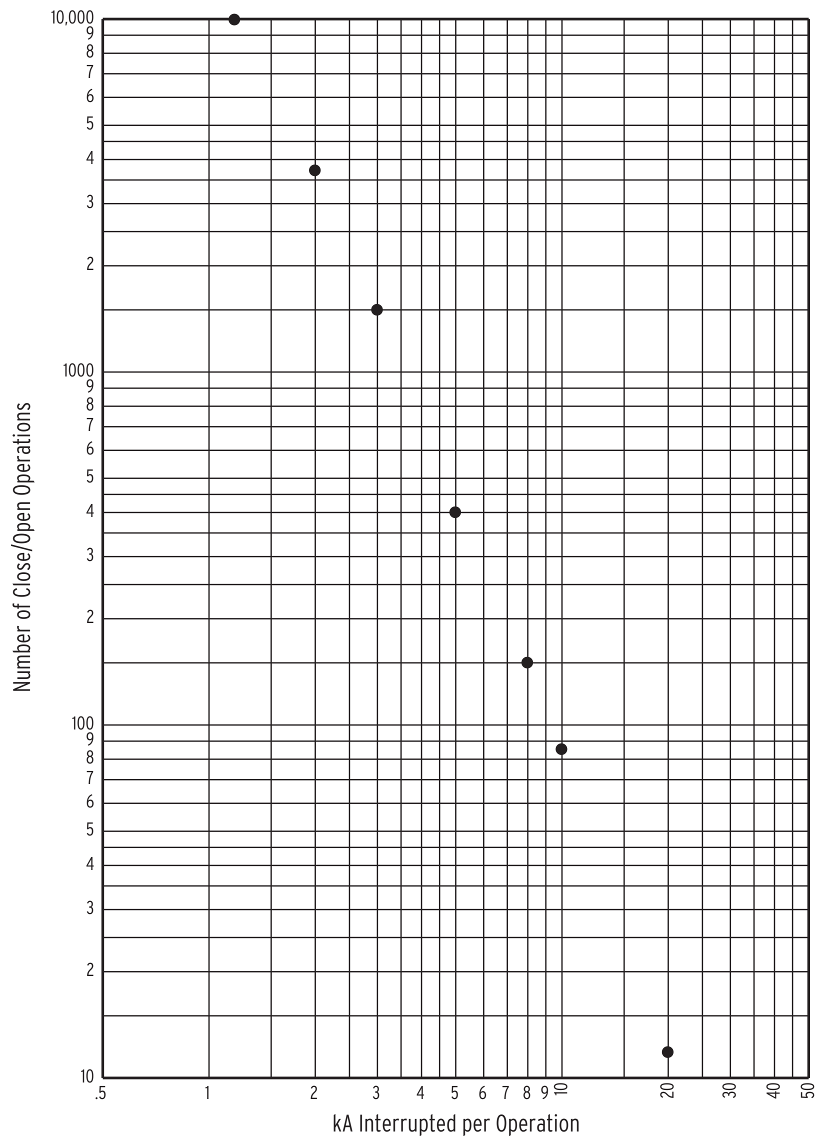

Figure 5.19 Plotted Breaker Maintenance Points for a 25 kV Circuit Breaker

Breaker Maintenance Curve Details

In *Figure 5.20*, note that set points KASP1, COSP1 and KASP3, COSP3 are set with breaker maintenance information from the two extremes in *Table 5.10* and *Figure 5.19*.

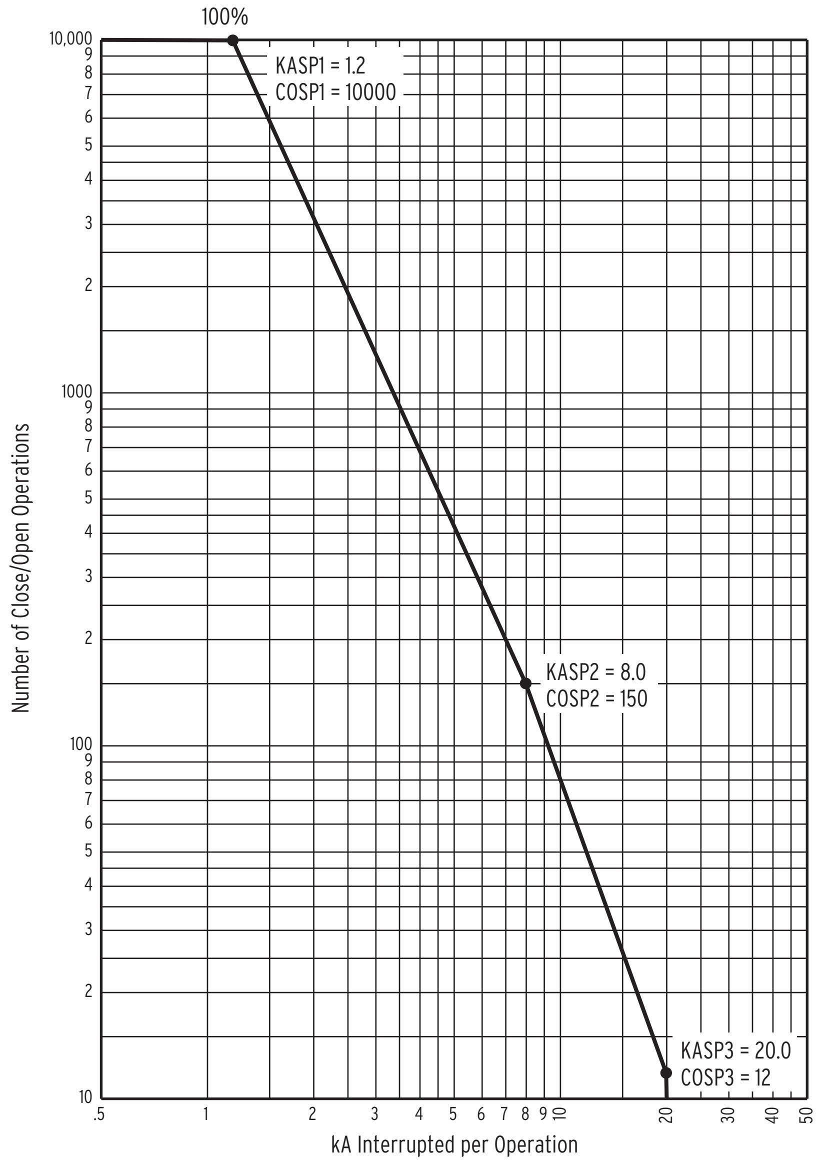

Figure 5.20 SEL-751 Breaker Maintenance Curve for a 25 kV Circuit Breaker

In this example, set point KASP2, COSP2 happens to be from an in-between breaker maintenance point in the breaker maintenance information in *Table 5.10* and *Figure 5.19*, but it does not have to be. Set point KASP2, COSP2 should be set to provide the best "curve-fit" with the plotted breaker maintenance points in *Figure 5.19*.

Each phase (A, B, and C) has its own breaker maintenance curve (like that in *Figure 5.20*), because the separate circuit breaker interrupting contacts for phases A, B, and C do not necessarily interrupt the same magnitude current (depending on fault type and loading).

In *Figure 5.20*, note that the breaker maintenance curve levels off horizontally above set point KASP1, COSP1. This is the close/open operation limit of the circuit breaker (COSP1 = 10000), regardless of interrupted current value.

Also, note that the breaker maintenance curve falls vertically below set point KASP3, COSP3. This is the maximum interrupted current limit of the circuit breaker (KASP3 = 20.0 kA). If the interrupted current is greater than setting KASP3, the interrupted current is accumulated as a current value equal to setting KASP3.

Operation of SELOGIC Control Equation Breaker Monitor Initiation Setting BKMON

The SELOGIC control equation breaker monitor initiation setting BKMON in *Table 5.11* determines when the breaker monitor reads in current values (Phases A, B, and C) for the breaker maintenance curve (see *Figure 5.20*) and the breaker monitor accumulated currents/trips [see *BRE Command (Breaker Monitor Data) on page 7.22*].

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 4.51*)

Refer to *Figure 5.21*. When BKMON asserts (Relay Word bit TRIP goes from logical 0 to logical 1), the breaker monitor reads in the current values and applies them to the breaker monitor maintenance curve and the breaker monitor accumulated currents/trips.

As detailed in *Figure 5.21*, the breaker monitor actually reads in the current values 1.5 cycles after the assertion of BKMON. This helps especially if an instantaneous trip occurs. The instantaneous element trips when the fault current reaches its pickup setting level. The fault current may still be "climbing" to its full value, at which it levels off. The 1.5-cycle delay on reading in the current values allows time for the fault current to level off.

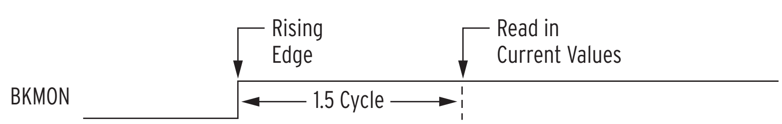

Figure 5.21 Operation of SELOGIC Control Equation Breaker Monitor Initiation Setting

See *Figure 5.26* and accompanying text for more information on setting BKMON. The operation of the breaker monitor maintenance curve, when new current values are read in, is explained in the following example.

Breaker Monitor Operation Example

As stated earlier, each phase (A, B, and C) has its own breaker maintenance curve. For this example, presume that the interrupted current values occur on a single phase in *Figure 5.22–Figure 5.25*. Also, presume that the circuit breaker interrupting contacts have no wear at first (brand new or recent maintenance performed).

Note in the following four figures (*Figure 5.22–Figure 5.25*) that the interrupted current in a given figure is the same magnitude for all the interruptions (e.g., in *Figure 5.23*, 2.5 kA is interrupted 290 times). This is not realistic, but helps in demonstrating the operation of the breaker maintenance curve and how it integrates for varying current levels.

0 Percent to 10 Percent Breaker Wear

Refer to *Figure 5.22*. 7.0 kA is interrupted 20 times (20 close/open operations = 20 – 0), pushing the breaker maintenance curve from the 0 percent wear level to the 10 percent wear level.

Compare the 100 percent and 10 percent curves and note that for a given current value, the 10 percent curve has only 1/10 of the close/open operations of the 100 percent curve.

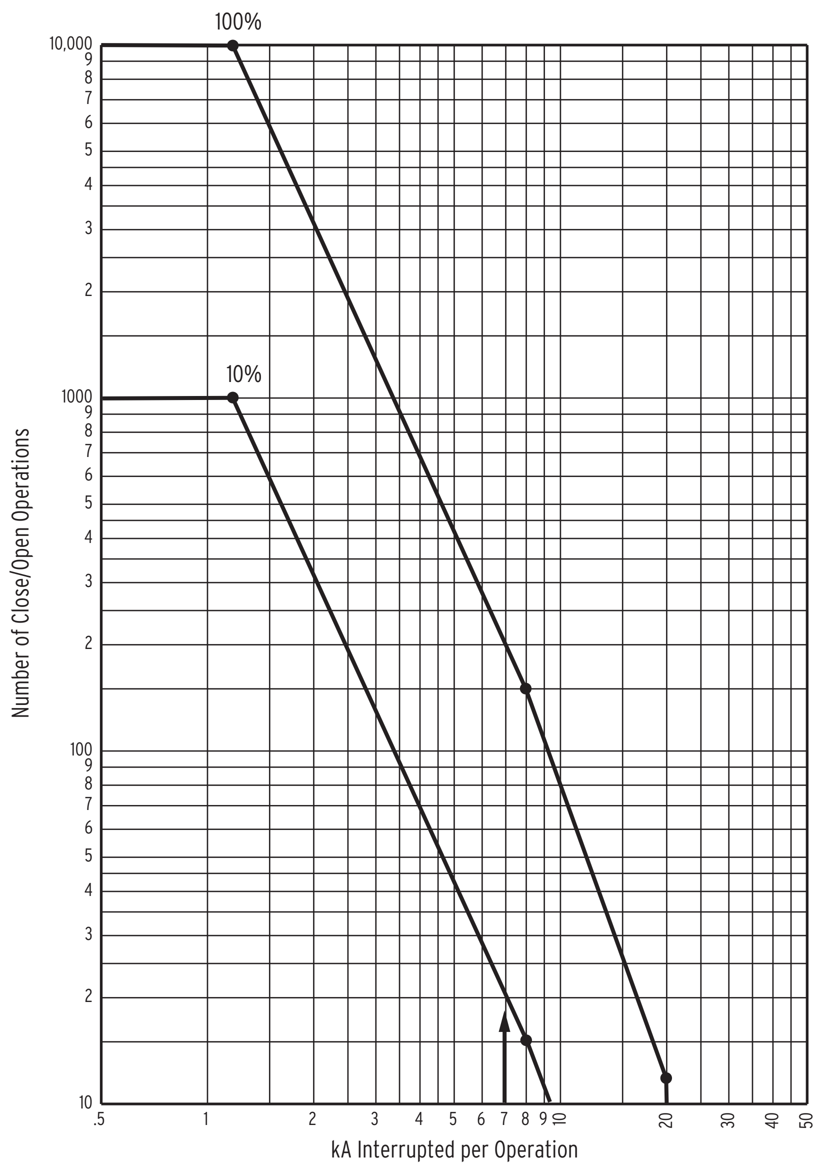

Figure 5.22 Breaker Monitor Accumulates 10 Percent Wear

10 Percent to 25 Percent Breaker Wear

Refer to *Figure 5.23*. The current value changes from 7.0 kA to 2.5 kA. 2.5 kA is interrupted 290 times (290 close/open operations = 480 – 190), pushing the breaker maintenance curve from the 10 percent wear level to the 25 percent wear level.

Compare the 100 percent and 25 percent curves and note that for a given current value, the 25 percent curve has only 1/4 of the close/open operations of the 100 percent curve.

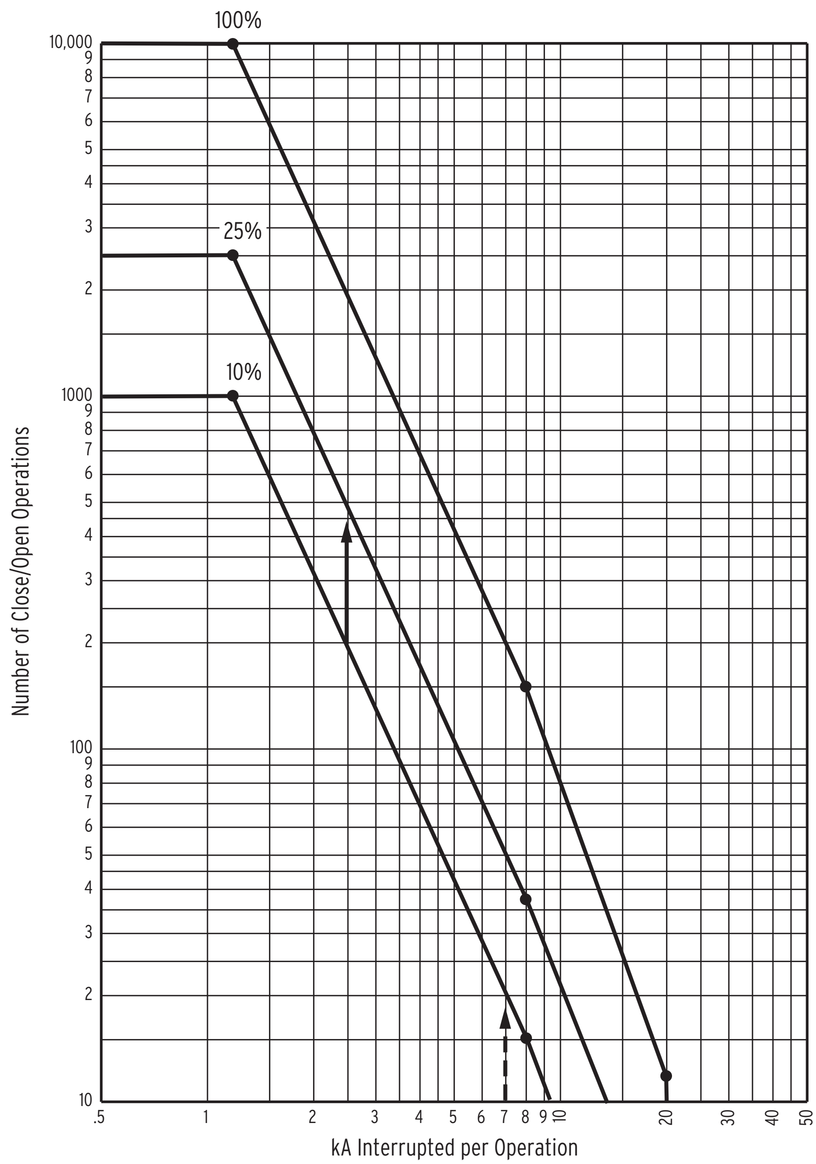

Figure 5.23 Breaker Monitor Accumulates 25 Percent Wear

25 Percent to 50 Percent Breaker Wear

Refer to *Figure 5.24*. The current value changes from 2.5 kA to 12.0 kA. 12.0 kA is interrupted 11 times (11 close/open operations = 24 – 13), pushing the breaker maintenance curve from the 25 percent wear level to the 50 percent wear level.

Compare the 100 percent and 50 percent curves and note that for a given current value, the 50 percent curve has only 1/2 of the close/open operations of the 100 percent curve.

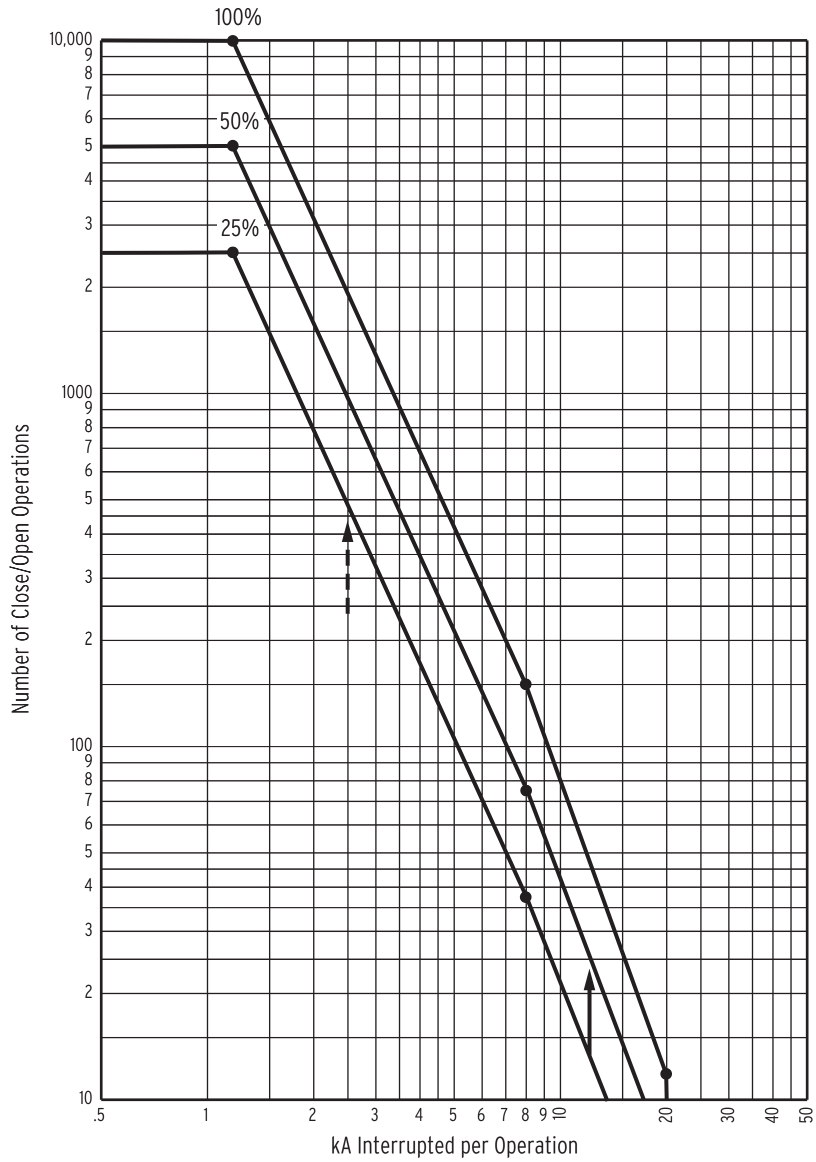

Figure 5.24 Breaker Monitor Accumulates 50 Percent Wear

50 Percent to 100 Percent Breaker Wear

Refer to *Figure 5.25*. The current value changes from 12.0 kA to 1.5 kA. 1.5 kA is interrupted 3000 times (3000 close/open operations = 6000 – 3000), pushing the breaker maintenance curve from the 50 percent wear level to the 100 percent wear level.

When the breaker maintenance curve reaches 100 percent for a particular phase, the percentage wear remains at 100 percent (even if additional current is interrupted), until reset by the **BRE R** command (see *View or Reset Breaker Monitor Information on page 5.27*). But the current and trip counts continue to be accumulated, until reset by the **BRE R** command.

Additionally, logic outputs assert for alarm or other control applications—see the following discussion.

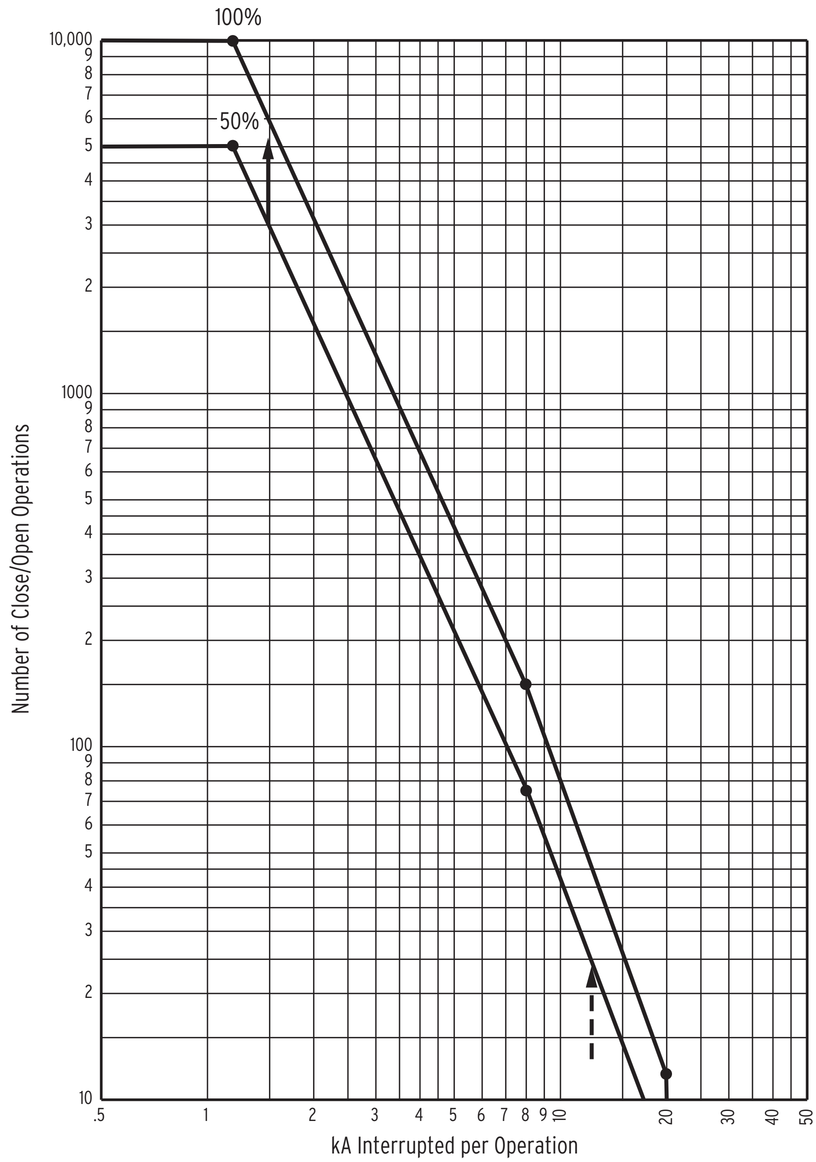

Figure 5.25 Breaker Monitor Accumulates 100 Percent Wear

Breaker Monitor Output

When the breaker maintenance curve for a particular phase (A, B, or C) reaches the 100 percent wear level (see *Figure 5.25*), a corresponding Relay Word bit (BCWA, BCWB, or BCWC) asserts.

Relay Word Bits	Definition
BCWA	Phase A breaker contact wear has reached the 100 percent wear level
BCWB	Phase B breaker contact wear has reached the 100 percent wear level
BCWC	Phase C breaker contact wear has reached the 100 percent wear level
BCW	BCWA or BCWB or BCWC

EXAMPLE 5.1 Example Applications

These logic outputs can be used to alarm:

OUT*xxx* = **BCW**

or drive the relay to lockout the next time the relay trips:

79DTL = **TRIP AND BCW**

View or Reset Breaker Monitor Information

Accumulated breaker wear/operations data are retained if the relay loses power or the breaker monitor is disabled (setting EBMON = N). The accumulated data can only be reset if the **BRE R** command is executed (see the following discussion on the **BRE R** command).

Via Serial Port

See *Section 7: Communications*. The **BRE** command displays the following information:

- Accumulated number of relay initiated trips
- Accumulated interrupted current from relay initiated trips
- Accumulated number of externally initiated trips
- Accumulated interrupted current from externally initiated trips
- Percent circuit breaker contact wear for each phase
- Date when the preceding items were last reset (via the **BRE R** command)

See *Section 7: Communications*. The **BRE W** command allows the trip counters, accumulated values, and percent breaker wear to be preloaded for each individual phase.

The **BRE R** command resets the accumulated values and the percent wear for all three phases. For example, if breaker contact wear has reached the 100 percent wear level for A-phase, the corresponding Relay Word bit BCWA asserts (BCWA = logical 1). Execution of the **BRE R** command resets the wear levels for all three phases back to 0 percent and consequently causes Relay Word bit BCWA to deassert (BCWA = logical 0).

Via Front Panel

The information and reset functions available via the previously discussed serial port commands **BRE** and **BRE R** are also available via the front panel. See *Section 8: Front-Panel Operations* for details.

Determination of Relay Initiated Trips and Externally Initiated Trips

See *Section 7: Communications*. Note in the **BRE** command response that the accumulated number of trips and accumulated interrupted current are separated into two groups of data: that generated by **relay initiated trips** (Rly Trips) and that generated by **externally initiated trips** (Ext Trips). The categorization of these data is determined by the status of the TRIP Relay Word bit when the SELOGIC control equation breaker monitor initiation setting BKMON operates.

Refer to *Figure 5.21* and accompanying explanation. If BKMON newly asserts (logical 0 to logical 1 transition), the relay reads in the current values (Phases A, B, and C). Now the decision has to be made: where is this current and trip count information accumulated? Under **relay initiated trips or externally initiated trips**?

To make this determination, the status of the TRIP Relay Word bit is checked at the instant BKMON newly asserts (TRIP is the logic output of *Figure 4.51*). If TRIP is asserted (TRIP = logical 1), the current and trip count information is accumulated under **relay initiated trips** (Rly Trips). If TRIP is deasserted (TRIP = logical 0), the current and trip count information is accumulated under **externally initiated trips** (Ext Trips).

Regardless of whether the current and trip count information is accumulated under relay initiated trips or externally initiated trips, this same information is routed to the breaker maintenance curve for continued breaker wear integration (see *Figure 5.21–Figure 5.25*).

Relay initiated trips (Rly Trips) are also referred to as **internally initiated trips** (Int Trips) in the course of this manual; the terms are interchangeable.

EXAMPLE 5.2 Factory Default Setting Example

As discussed previously, the SELOGIC control equation breaker monitor initiation factory default setting is:

BKMON = **TRIP**

Thus, any new assertion of BKMON will be deemed a relay trip, and the current and trip count information is accumulated under relay initiated trips (Rly Trips).

EXAMPLE 5.3 Additional Example

Refer to Figure 5.26. Output contact **OUT103** is set to provide tripping:

OUT103 = **TRIP**

Note that optoisolated input **INxxx** monitors the trip bus. If the trip bus is energized by output contact **OUT103**, an external control switch, or some other external trip, then **INxxx** is asserted.

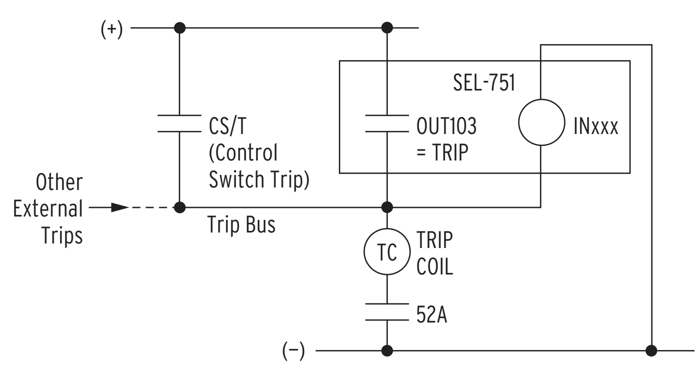

Figure 5.26 Input INxxx Connected to Trip Bus for Breaker Monitor Initiation

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

BKMON = **INxxx**

then the SEL-751 breaker monitor sees all trips.

If output contact **OUT103** asserts, energizing the trip bus, the breaker monitor will deem 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 will deem 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).

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Section 6
Settings

Overview

The SEL-751 Feeder Protection Relay stores the settings you enter in nonvolatile memory. Settings are divided into the following eight setting classes:

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

Some setting classes have multiple instances. In the previous list, there are five port setting instances, one for each port. Settings can be viewed or set in several ways, as shown in *Table 6.1*.

Table 6.1 Methods of Accessing Settings

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

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

Setting entry error messages, together with corrective actions, are also presented in this section to assist in correct settings entry.

The *SEL-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.

View/Change Settings With Front Panel

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

Enter the front-panel menu by pushing the **ESC** pushbutton. It will display the following message:

```
MAIN
Meter
```

Scroll down the menu by using the **Down Arrow** pushbutton until the display shows the following message:

```
Control
Set/Show
```

The cursor (underline) should be on the **Set/Show** command. Enter the **Set/Show** command by pushing the **ENT** pushbutton. The display shows the following message:

```
SET/SHOW
Global
```

Enter the underlined RELAY message with the **ENT** pushbutton, and the relay will present you with the RELAY settings as listed in the *SEL-751 Settings Sheets*. Use the **Up Arrow**, **Down Arrow**, **Left Arrow**, and **Right Arrow** pushbuttons to scroll through the relay settings. View and change the settings according to your needs by selecting and editing them. After viewing or changing the RELAY settings, press the **ESC** pushbutton until the following message appears:

```
Save Changes?
Yes   No
```

NOTE: Each SEL-751 is shipped with default factory settings. Calculate the settings for your application to ensure secure and dependable protection. Document the settings on the SEL-751 Settings Sheets at the end of this section before entering new settings in the relay.

Select and enter the appropriate command by pushing the **ENT** pushbutton. Select Yes to save the settings changes and No to discard the changes.

Figure 6.1 shows a front-panel menu navigation example for the relay to enter the PHASE PT RATIO, PTR setting.

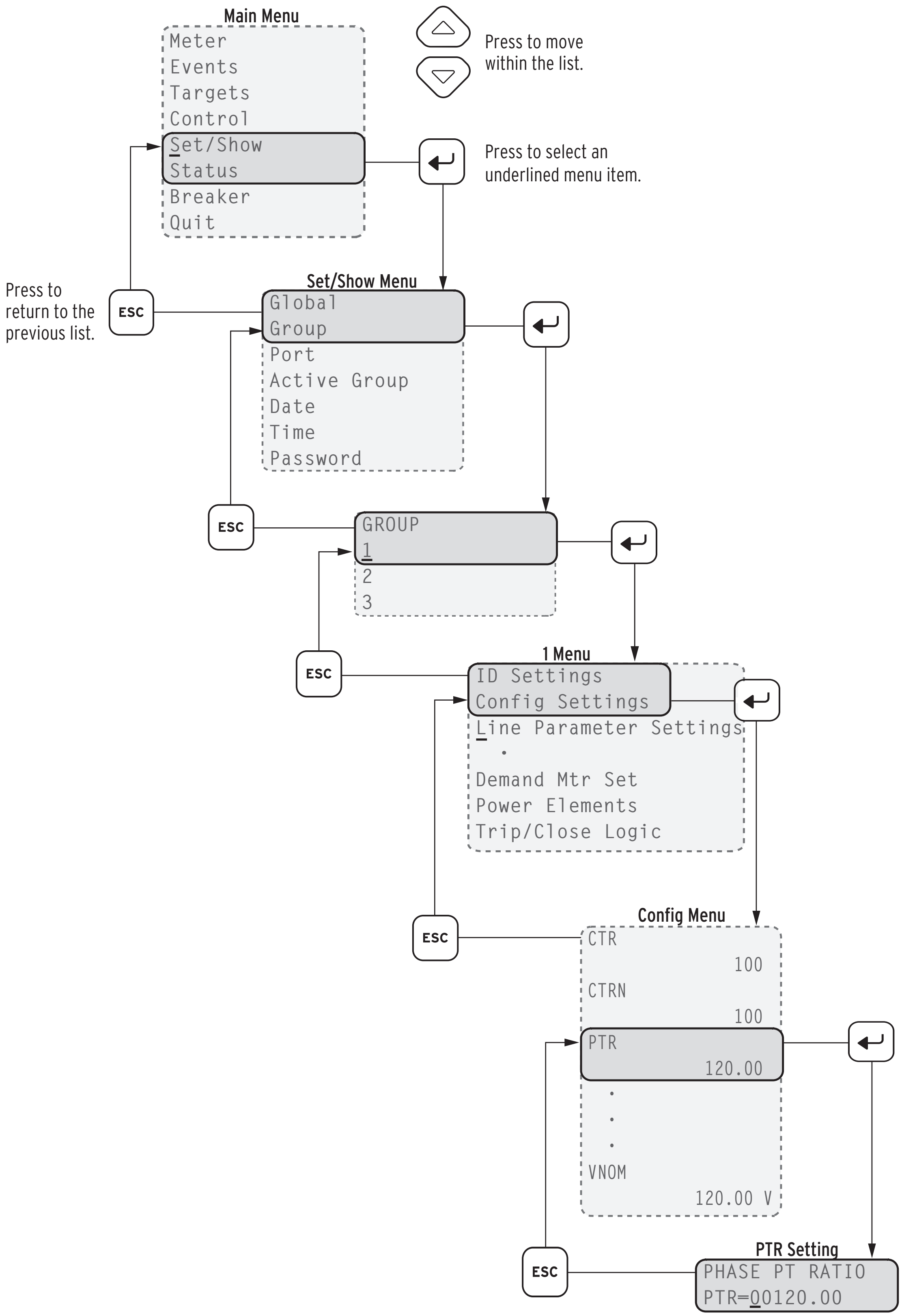


Figure 6.1 Front-Panel Setting Entry Example

View/Change Settings Over Communications Port

Refer to *Section 7: Communications* for information on how to set up and access the relay serial or Ethernet port with a personal computer and how to use ASCII commands to communicate with the relay.

View Settings

Use the **SHOW** command to view relay settings. The **SHOW** command is available from Access Level 1 and Access Level 2. *Table 6.2* lists the **SHOW** command options.

Table 6.2 SHOW Command Options

Command	Description
SHOW *n*	Show relay group settings: *n* specifies the settings group (1, 2, or 3); *n* defaults to active settings group if not listed.
SHO L *n*	Show logic settings: *n* specifies the settings group (1, 2, or 3); *n* defaults to active settings group if not listed.
SHO G	Show global configuration settings.
SHO P *n*	Show serial port settings for port *n* (*n* = F, 1, 2, 3, or 4).
SHO F	Show front-panel display and LED settings.
SHO R	Show Sequential Event Report (SER) and Event Report settings.
SHO M	Show Modbus settings.
SHO D	Show DNP3 map settings.

You can append a setting name to each of the commands to specify the first setting to display (e.g., **SHO 50P1P** displays the relay settings starting with setting 50P1P). The default is the first setting. The **SHOW** command displays only the enabled settings.

Enter Settings

The **SET** command (available from Access Level 2) allows you to view or change settings. *Table 6.3* lists the **SET** command options.

NOTE: The **SET** command is not available for as long as 90 seconds after the relay is powered up and as long as 40 seconds after a setting change. If you issue a **SET** command during this period, the relay responds with the following message:

```
Command Unavailable;
Relay Configuration in
Progress, Try Again.
```

Table 6.3 SET Command Options

Command	Settings Type	Description
SET *n*	Relay	Protection elements, timers, etc., for settings group *n* (1, 2, or 3)
SET L *n*	Logic	SELOGIC control equations for settings group *n* (1, 2, or 3)
SET G	Relay	Global configuration settings including Event Messenger, optoisolated input debounce timers, etc.
SET P *n*	Port	Serial port settings for serial port *n* (1, 2, 3, 4, or F)
SET F	Front Panel	Front-panel display and LED settings
SET R	Reports	SER and Event Report settings
SET M	Modbus	Modbus user map
SET D	DNP	DNP3 map settings

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

To change a specific setting, enter the command shown in *Table 6.5*.

Table 6.5 SET Command Format

SET n m s TERSE	
where:	
n	is left blank or is D, G, L, F, R, M, or P to identify the class of settings.
m	is blank (1) or is 1, 2, or 3 when *n* = G or L for group settings.
m	is left blank or is F, 1, 2, 3, or 4 when *n* = P.
s	is the name of the specific setting you want to jump to and begin setting. If *s* is not entered, the relay starts at the first setting (e.g., enter **50P1P** to start at Phase Overcurrent Trip level setting).
TERSE	instructs the relay to skip the settings display after the last setting. Use this parameter to speed up the **SET** command. If you want to review the settings before saving, do not use the **TERSE** option.

Setting Entry Error Messages

As you enter relay settings, the relay checks the setting entered against the range for the setting as published on the relay setting sheet. If any setting entered falls outside the corresponding range for that setting, the relay immediately responds `Out of Range` and prompts you to reenter the setting.

In addition to the immediate range check, several of the settings have interdependency checks with other settings. The relay checks setting interdependencies after you answer `Y` to the `Saves Settings?` prompt, but before the settings are stored. If any of these checks fail, the relay issues a self-explanatory error message, and returns you to the settings list for a correction.

SEL-751 Settings Sheets

These settings sheets include the definition and input range for each setting in the relay. You can access the settings from the relay front panel and the serial ports. See *Section 4: Protection and Logic Functions* for detailed descriptions of the settings.

- Some settings require an optional module. Refer to the SEL-751 Model Option Table, and the notes to the following settings for details on which settings are available in a specific model. ACSELERATOR QuickSet® SEL-5030 Software, which shows and hides settings depending on the MOT part number selected, is the best way to view settings available in a specific model.
- Some of the settings ranges may be more restrictive than shown, because of settings interdependency checks performed when new settings are saved (see *Setting Entry Error Messages on page 6.5*).
- The settings are not case sensitive.

Group Settings (SET Command)

Identifier

UNIT ID LINE 1 (16 Characters)	**RID**	:= ________
UNIT ID LINE 2 (16 Characters)	**TID**	:= ________

Configuration

PHASE CT RATIO (1–5000)	**CTR**	:= ________
NEUTRAL CT RATIO (1–5000)	**CTRN**	:= ________
PHASE PT RATIO (1.00–10000.00)	**PTR**	:= ________
SYNCV PT RATIO (1.00–10000.00) (*Hidden if sync voltage not included*)	**PTRS**	:= ________
XFMR CONNECTION (WYE, DELTA)	**DELTA_Y**	:= ________
SINGLE V INPUT (Y, N)	**SINGLEV**	:= ________
LINE VOLTAGE (OFF, 20.00–250.00 V {if DELTA_Y := DELTA}, OFF, 20.00–440.00 V {if DELTA_Y := WYE})	**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 VNOM := OFF)

FLT LOC ENABLE (Y, N) *(Hidden and set to N if VNOM := OFF)*	**EFLOC**	:=

Maximum Phase Overcurrent

MAXP OC TRIP LVL (OFF, 0.50–100.00 A {5 A nom.}, 0.10–20.00 A {1 A nom.})	**50P1P**	:=
MAXP OC TRIP DLY (0.00–400.00 sec) *(Hidden if 50P1P := OFF)*	**50P1D**	:=
MAXP OC TRQ CON (SELOGIC) *(Hidden if 50P1P := OFF)*	**50P1TC**	:=
MAXP OC TRIP LVL (OFF, 0.50–100.00 A {5 A nom.}, 0.10–20.00 A {1 A nom.})	**50P2P**	:=
MAXP OC TRIP DLY (0.00–400.00 sec) *(Hidden if 50P2P := OFF)*	**50P2D**	:=
MAXP OC TRQ CON (SELOGIC) *(Hidden if 50P2P := OFF)*	**50P2TC**	:=
MAXP OC TRIP LVL (OFF, 0.50–100.00 A {5 A nom.}, 0.10–20.00 A {1 A nom.})	**50P3P**	:=
MAXP OC TRIP DLY (0.00–400.00 sec) *(Hidden if 50P3P := OFF)*	**50P3D**	:=
MAXP OC TRQ CON (SELOGIC) *(Hidden if 50P3P := OFF)*	**50P3TC**	:=
MAXP OC TRIP LVL (OFF, 0.50–100.00 A {5 A nom.}, 0.10–20.00 A {1 A nom.})	**50P4P**	:=
MAXP OC TRIP DLY (0.00–400.00 sec) *(Hidden if 50P4P := OFF)*	**50P4D**	:=
MAXP OC TRQ CON (SELOGIC) *(Hidden if 50P4P := OFF)*	**50P4TC**	:=

Neutral Overcurrent

NEUT OC TRIP LVL (OFF, 0.50–100.00 A {5 A nom}, 0.10–20.00 A {1 A nom})	**50N1P**	:=
NEUT OC TRIP DLY (0.00–400.00 sec) *(Hidden if 50N1P := OFF)*	**50N1D**	:=
NEUT OC TRQ CON (SELOGIC) *(Hidden if 50N1P := OFF)*	**50N1TC**	:=
NEUT OC TRIP LVL (OFF, 0.50–100.00 A {5 A nom}, 0.10–20.00 A {1 A nom})	**50N2P**	:=
NEUT OC TRIP DLY (0.00–400.00 sec) *(Hidden if 50N2P := OFF)*	**50N2D**	:=
NEUT OC TRQ CON (SELOGIC) *(Hidden if 50N2P := OFF)*	**50N2TC**	:=
NEUT OC TRIP LVL (OFF, 0.50–100.00 A {5 A nom}, 0.10–20.00 A {1 A nom})	**50N3P**	:=
NEUT OC TRIP DLY (0.00–400.00 sec) *(Hidden if 50N3P := OFF)*	**50N3D**	:=
NEUT OC TRQ CON (SELOGIC) *(Hidden if 50N3P := OFF)*	**50N3TC**	:=
NEUT OC TRIP LVL (OFF, 0.50–100.00 A {5 A nom}, 0.10–20.00 A {1 A nom})	**50N4P**	:=
NEUT OC TRIP DLY (0.00–400.00 sec) *(Hidden if 50N4P := OFF)*	**50N4D**	:=
NEUT OC TRQ CON (SELOGIC) *(Hidden if 50N4P := OFF)*	**50N4TC**	:=

Residual Overcurrent

RES OC TRIP LVL (OFF, 0.50–100.00 A {5 A nom.}, 0.10–20.00 A {1 A nom.})	**50G1P**	:=
RES OC TRIP DLY (0.00–400.00 sec) *(Hidden if 50G1P := OFF)*	**50G1D**	:=
RES OC TRQ CON (SELOGIC) *(Hidden if 50G1P := OFF)*	**50G1TC**	:=
RES OC TRIP LVL (OFF, 0.50–100.00 A {5 A nom.}, 0.10–20.00 A {1 A nom.})	**50G2P**	:=
RES OC TRIP DLY (0.00–400.00 sec) *(Hidden if 50G2P := OFF)*	**50G2D**	:=
RES OC TRQ CON (SELOGIC) *(Hidden if 50G2P := OFF)*	**50G2TC**	:=
RES OC TRIP LVL (OFF, 0.50–100.00 A {5 A nom.}, 0.10–20.00 A {1 A nom.})	**50G3P**	:=
RES OC TRIP DLY (0.00–400.00 sec) *(Hidden if 50G3P := OFF)*	**50G3D**	:=
RES OC TRQ CON (SELOGIC) *(Hidden if 50G3P := OFF)*	**50G3TC**	:=
RES OC TRIP LVL (OFF, 0.50–100.00 A {5 A nom.}, 0.10–20.00 A {1 A nom.})	**50G4P**	:=
RES OC TRIP DLY (0.00–400.00 sec) *(Hidden if 50G4P := OFF)*	**50G4D**	:=
RES OC TRQ CON (SELOGIC) *(Hidden if 50G4P := OFF)*	**50G4TC**	:=

Negative-Sequence Overcurrent

NSEQ OC TRIP LVL (OFF, 0.50–100.00 A {5 A nom.}, 0.10–20.00 A {1 A nom.})	**50Q1P**	:=
NSEQ OC TRIP DLY (0.1–400.0 sec) *(Hidden if 50Q1P := OFF)*	**50Q1D**	:=
NSEQ OC TRQ CON (SELOGIC) *(Hidden if 50Q1P := OFF)*	**50Q1TC**	:=
NSEQ OC TRIP LVL (OFF, 0.50–100.00 A {5 A nom.}, 0.10–20.00 A {1 A nom.})	**50Q2P**	:=
NSEQ OC TRIP DLY (0.1–400.0 sec) *(Hidden if 50Q2P := OFF)*	**50Q2D**	:=
NSEQ OC TRQ CON (SELOGIC) *(Hidden if 50Q2P := OFF)*	**50Q2TC**	:=
NSEQ OC TRIP LVL (OFF, 0.50–100.00 A {5 A nom.}, 0.10–20.00 A {1 A nom.})	**50Q3P**	:=
NSEQ OC TRIP DLY (0.1–400.0 sec) *(Hidden if 50Q3P := OFF)*	**50Q3D**	:=
NSEQ OC TRQ CON (SELOGIC) *(Hidden if 50Q3P := OFF)*	**50Q3TC**	:=
NSEQ OC TRIP LVL (OFF, 0.50–100.00 A {5 A nom.}, 0.10–20.00 A {1 A nom.})	**50Q4P**	:=
NSEQ OC TRIP DLY (0.1–400.0 sec) *(Hidden if 50Q4P := OFF)*	**50Q4D**	:=
NSEQ OC TRQ CON (SELOGIC) *(Hidden if 50Q4P := OFF)*	**50Q4TC**	:=

Phase Time-Overcurrent

TOC TRIP LVL (OFF, 0.50–16.00 A {5 A nom.}, 0.10–3.20 A {1 A nom.})	**51AP**	:=
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51AP := OFF)*	**51AC**	:=
TOC TIME DIAL (0.50–15.00 {if 51_C := U_}, 0.05–1.50 {if 51_C := C_}) *(Hidden if 51AP := OFF)*	**51ATD**	:=

EM RESET DELAY (Y, N) *(Hidden if 51AP := OFF)*	**51ARS**	:=	
CONST TIME ADDER (0.00–1.00 sec) *(Hidden if 51AP := OFF)*	**51ACT**	:=	
MIN RESPONSE TIM (0.00–1.00 sec) *(Hidden if 51AP := OFF)*	**51AMR**	:=	
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51AP := OFF)*	**51ATC**	:=	
TOC TRIP LVL (OFF, 0.50–16.00 A {5 A nom.}, 0.10–3.20 A {1 A nom.})	**51BP**	:=	
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) (Hidden if 51BP := OFF)	**51BC**	:=	
TOC TIME DIAL (0.50–15.00 {if 51_C := U_}, 0.05–1.50 {if 51_C := C_}) *(Hidden if 51BP := OFF)*	**51BTD**	:=	
EM RESET DELAY (Y, N) *(Hidden if 51BP := OFF)*	**51BRS**	:=	
CONST TIME ADDER (0.00–1.00 sec) *(Hidden if 51BP := OFF)*	**51BCT**	:=	
MIN RESPONSE TIM (0.00–1.00 sec) *(Hidden if 51BP := OFF)*	**51BMR**	:=	
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51BP := OFF)*	**51BTC**	:=	
TOC TRIP LVL (OFF, 0.50–16.00 A {5 A nom.}, 0.10–3.20 A {1 A nom.})	**51CP**	:=	
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51CP := OFF)*	**51CC**	:=	
TOC TIME DIAL (0.50–15.00 {if 51_C := U_}, 0.05–1.50 {if 51_C := C_}) *(Hidden if 51CP := OFF)*	**51CTD**	:=	
EM RESET DELAY (Y, N) *(Hidden if 51CP := OFF)*	**51CRS**	:=	
CONST TIME ADDER (0.00–1.00 sec) *(Hidden if 51CP := OFF)*	**51CCT**	:=	
MIN RESPONSE TIM (0.00–1.00 sec) *(Hidden if 51CP := OFF)*	**51CMR**	:=	
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51CP := OFF)*	**51CTC**	:=	

Maximum Phase Time-Overcurrent

TOC TRIP LVL (OFF, 0.50–16.00 A {5 A nom.}, 0.10–3.20 A {1 A nom.})	**51P1P**	:=	
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51P1P := OFF)*	**51P1C**	:=	
TOC TIME DIAL (0.50–15.00 {if 51_C := U_}, 0.05–1.50 {if 51_C := C_}) *(Hidden if 51P1P := OFF)*	**51P1TD**	:=	
EM RESET DELAY (Y, N) *(Hidden if 51P1P := OFF)*	**51P1RS**	:=	
CONST TIME ADDER (0.00–1.00 sec) *(Hidden if 51P1P := OFF)*	**51P1CT**	:=	
MIN RESPONSE TIM (0.00–1.00 sec) *(Hidden if 51P1P := OFF)*	**51P1MR**	:=	
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51P1P := OFF)*	**51P1TC**	:=	
TOC TRIP LVL (OFF, 0.50–16.00 A {5 A nom.}, 0.10–3.20 A {1 A nom.})	**51P2P**	:=	
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51P2P := OFF)*	**51P2C**	:=	
TOC TIME DIAL (0.50–15.00 {if 51_C := U_}, 0.05–1.50 {if 51_C := C_}) *(Hidden if 51P2P := OFF)*	**51P2TD**	:=	
EM RESET DELAY (Y, N) *(Hidden if 51P2P := OFF)*	**51P2RS**	:=	

CONST TIME ADDER (0.00–1.00 sec) *(Hidden if 51P2P := OFF)*	**51P2CT**	:= ________
MIN RESPONSE TIM (0.00–1.00 sec) *(Hidden if 51P2P := OFF)*	**51P2MR**	:= ________
TOC TRQ CONTROL (SELOGIC) (Hidden if 51P2P := OFF)	**51P2TC**	:= ________

Negative-Sequence Time-Overcurrent

TOC TRIP LVL (OFF, 0.50–16.00 A {5 A nom.}, 0.10–3.20 A {1 A nom.})	**51QP**	:= ________
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51QP := OFF)*	**51QC**	:= ________
TOC TIME DIAL (0.50–15.00 {if 51_C := U_}, 0.05–1.50 {if 51_C := C_}) *(Hidden if 51QP := OFF)*	**51QTD**	:= ________
EM RESET DELAY (Y, N) *(Hidden if 51QP := OFF)*	**51QRS**	:= ________
CONST TIME ADDER (0.00–1.00 sec) *(Hidden if 51QP := OFF)*	**51QCT**	:= ________
MIN RESPONSE TIM (0.00–1.00 sec) *(Hidden if 51QP := OFF)*	**51QMR**	:= ________
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51QP := OFF)*	**51QTC**	:= ________

Neutral Time-Overcurrent

TOC TRIP LVL (OFF, 0.25–16.00 A {5 A nom.}, 0.05–3.20 A {1 A nom.})	**51N1P**	:= ________
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51N1P := OFF)*	**51N1C**	:= ________
TOC TIME DIAL (0.50–15.00 {if 51_C := U_}, 0.05–1.50 {if 51_C := C_}) *(Hidden if 51N1P := OFF)*	**51N1TD**	:= ________
EM RESET DELAY (Y, N) *(Hidden if 51N1P := OFF)*	**51N1RS**	:= ________
CONST TIME ADDER (0.00–1.00 sec) *(Hidden if 51N1P := OFF)*	**51N1CT**	:= ________
MIN RESPONSE TIM (0.00–1.00 sec) *(Hidden if 51N1P := OFF)*	**51N1MR**	:= ________
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51N1P := OFF)*	**51N1TC**	:= ________
TOC TRIP LVL (OFF, 0.25–16.00 A {5 A nom.}, 0.05–3.20 A {1 A nom.})	**51N2P**	:= ________
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51N2P := OFF)*	**51N2C**	:= ________
TOC TIME DIAL (0.50–15.00 {if 51_C := U_}, 0.05–1.50 {if 51_C := C_}) *(Hidden if 51N2P := OFF)*	**51N2TD**	:= ________
EM RESET DELAY (Y, N) *(Hidden if 51N2P := OFF)*	**51N2RS**	:= ________
CONST TIME ADDER (0.00–1.00 sec) *(Hidden if 51N2P := OFF)*	**51N2CT**	:= ________
MIN RESPONSE TIM (0.00–1.00 sec) *(Hidden if 51N2P := OFF)*	**51N2MR**	:= ________
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51N2P := OFF)*	**51N2TC**	:= ________

Residual Time-Overcurrent

TOC TRIP LVL (OFF, 0.50–16.00 A {5 A nom.}, 0.10–3.20 A {1 A nom.})	**51G1P**	:=
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51G1P := OFF)*	**51G1C**	:=
TOC TIME DIAL (0.50–15.00 {if 51_C := U_}, 0.05–1.50 {if 51_C := C_}) *(Hidden if 51G1P := OFF)*	**51G1TD**	:=
EM RESET DELAY (Y, N) *(Hidden if 51G1P := OFF)*	**51G1RS**	:=
CONST TIME ADDER (0.00–1.00 sec) *(Hidden if 51G1P := OFF)*	**51G1CT**	:=
MIN RESPONSE TIM (0.00–1.00 sec) *(Hidden if 51G1P := OFF)*	**51G1MR**	:=
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51G1P := OFF)*	**51G1TC**	:=
TOC TRIP LVL (OFF, 0.50–16.00 A {5 A nom.}, 0.10–3.20 A {1 A nom.})	**51G2P**	:=
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51G2P := OFF)*	**51G2C**	:=
TOC TIME DIAL (0.50–15.00 {if 51_C := U_}, 0.05–1.50 {if 51_C := C_}) *(Hidden if 51G2P := OFF)*	**51G2TD**	:=
EM RESET DELAY (Y, N) *(Hidden if 51G2P := OFF)*	**51G2RS**	:=
CONST TIME ADDER (0.00–1.00 sec) *(Hidden if 51G2P := OFF)*	**51G2CT**	:=
MIN RESPONSE TIM (0.00–1.00 sec) *(Hidden if 51G2P := OFF)*	**51G2MR**	:=
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51G2P := OFF)*	**51G2TC**	:=

Directional Control

(Hidden if Directional option is not selected in MOT)

DIR CONTROL ENBL (Y, AUTO, N) *(All of the following settings are hidden if EDIR := N)*	**EDIR**	:=
FWD DIR ON LOP (Y, N) *(Set to N and hidden 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 (I, V, Q, IV, VI, QV, VQ, IQ, QI, IVQ, IQV, VQI, VIQ, QIV, QVI, OFF) *('V' Hidden when DELTA_Y:= DELTA and 'Q,' and 'V' hidden when VNOM := OFF)*	**ORDER**	:=
PH DIR 3PH LVL (0.50–10.00 A {5 A nom.}, 0.10–2.00 A {1 A nom.}) *(Hidden if ELOAD := Y or hidden if VNOM := OFF)*	**50PDIRP**	:=
FWD DIR Z2 LVL (–128.00 to 128.00 ohm {5 A nom.}, –640.00 to 640.00 ohm {1 A nom.}) *(Auto-set to Z2R –1/INOM and hidden if EDIR := AUTO; Hidden if VNOM := OFF)*	**Z2F**	:=
REV DIR Z2 LVL (–128.00 to 128.00 ohm {5 A nom.}, –640.00 to 640.00 ohm {1 A nom.}) *(Auto-set to MIN [(Z1MAG/2) + (1/INOM), 640/INOM] and hidden if EDIR := AUTO. Hidden if VNOM := OFF)*	**Z2R**	:=

FWD DIR NSEQ LVL (0.25–5.00 A {5 A nom.}, 0.05–1.00 A {1 A nom.}) *(Auto-set to 0.10 • INOM and hidden if EDIR := AUTO. Hidden if VNOM := OFF)*	**50QFP**	:=
REV DIR NSEQ LVL (0.25–5.00 A {5 A nom.}, 0.05–1.00 A {1 A nom.}) *(Auto-set to 0.05 • INOM and hidden if EDIR := AUTO. Hidden if VNOM := OFF)*	**50QRP**	:=
I1 RST FAC I2/I1 (0.02–0.50) *(Auto-set to 0.10 and hidden if EDIR := AUTO; Hidden if VNOM := OFF)*	**a2**	:=
I0 RST FAC I2/I0 (0.10–1.20) *(Auto-set to 0.20 and hidden if EDIR := AUTO; Hidden if VNOM := OFF)*	**k2**	:=
FWD DIR RES LVL (0.05–5.00 A {5 A nom.}, 0.01–1.00 A {1 A nom.}) *(Auto-set to 0.10 • INOM and hidden if EDIR := AUTO; hidden if EDIR := Y and ORDER does not contain V or I)*	**50GFP**	:=
REV DIR RES LVL (0.05–5.00 A {5 A nom.}, 0.01–1.00 A {1 A nom.}) *(Auto-set to 0.05 • INOM and hidden if EDIR := AUTO; hidden if EDIR := Y and ORDER does not contain V or I)*	**50GRP**	:=
I1 RST FAC I0/I1 (0.02–0.50) *(Auto-set to 0.10 and hidden if EDIR := AUTO; hidden if EDIR := Y and ORDER does not contain V or I)*	**a0**	:=
FWD DIR Z0 LVL (–128.00 to 128.00 ohm {5 A nom.}, –640.00 to 640.00 ohm {1 A nom.}) *(Auto-set to Z0R – 1/INOM and hidden if EDIR := AUTO; hidden if EDIR := Y and ORDER does not contain V)*	**Z0F**	:=
REV DIR Z0 LVL (–128.00 to 128.00 ohm {5 A nom.}, –640.00 to 640.00 ohm {1 A nom.}) *(Auto-set to MIN [(Z0MAG/2) + (1/INOM), 640/INOM] and hidden if EDIR := AUTO; hidden if EDIR := Y and ORDER does not contain V)*	**Z0R**	:=
ZRO SQ MX TQ ANG (–90.00 to 90.00 Dead band –5 to +5, deg) *(Auto-set to Z0ANG and hidden if EDIR:=AUTO; hidden if EDIR := Y and ORDER does not contain V)*	**Z0MTA**	:=

Load Encroachment

LOAD ENCROACH EN (Y, N) *(Set to N and hidden if VNOM := OFF)*	**ELOAD**	:=
(All settings below 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**	:=

Date____________

High-Impedance Fault (HIF) Detection

(Hidden if high-impedance fault (HIF) detection (Arc Sense™ technology) is not selected in the MOT)

HIF EN (Y, N, T)	**EHIF**	:= ________
(All of the following settings are hidden if EHIF := N)		
HIF DETECTION SENSITIVITY (SELOGIC)	**HIFMODE**	:= ________
HIF EVENT REPORT EXT. TRIGGER (SELOGIC)	**HIFER**	:= ________

RTD

RTD ENABLE (INT, EXT, NONE)	**E49RTD**	:= ________
(All of the following 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 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 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**	:=

Undervoltage

UV TRIP1 LEVEL (OFF, 2.00–300.00 V) *(Hidden if DELTA_Y = DELTA)*	**27P1P**	:=
UV TRIP1 DELAY (0.00–120.00 sec) *(Hidden if 27P1P := OFF; hidden 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 sec) *(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 MOT Slot E := 70)*	**27S1P**	:=
UVS DELAY 1 (0.00–120.00 sec) *(Hidden if 27S1P := OFF)*	**27S1D**	:=
UVS LEVEL 2 (OFF, 2.00–300.00 V) *(Shown if MOT Slot E := 70)*	**27S2P**	:=
UVS DELAY 2 (0.00–120.00 sec) *(Hidden if 27S2P := OFF)*	**27S2D**	:=

Overvoltage

OV TRIP1 LEVEL (OFF, 2.00–300.00 V) *(Hidden if DELTA_Y = DELTA)*	**59P1P**	:=
OV TRIP1 DELAY (0.00–120.00 sec) *(Hidden if 59P1P := OFF; hidden 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 sec) *(Hidden if 59P2P := OFF; hidden 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 sec) *(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 sec) *(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 sec) *(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 sec) *(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 sec) *(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 sec) *(Hidden if 59Q2P := OFF; hidden if SINGLEV = Y)*	**59Q2D**	:=
OVS LEVEL 1 (OFF, 2.00–300.00 V) *(Shown if Slot E MOT = 70)*	**59S1P**	:=
OVS DELAY 1 (0.00–120.00 sec) *(Hidden if 59S1P := OFF)*	**59S1D**	:=
OVS LEVEL 2 (OFF, 2.00–300.00 V) *(Shown if Slot E MOT = 70)*	**59S2P**	:=
OVS DELAY 2 (0.00–120.00 sec) *(Hidden if 59S2P := OFF)*	**59S2D**	:=

Synchronism Check

(Hidden if the Slot E 2 AVI/4 AFDI card option with VS input is not included)

SYNCH CHECK (Y, N)	**E25**	:=
VS WINDOW LOW (0.00–300.00 V) *(Hidden if E25 := N)*	**25VLO**	:=
VS WINDOW HIGH (0.00–300.00 V) *(Hidden if E25 := N)*	**25VHI**	:=
V RATIO COR FAC (0.50–2.00)	**25RCF**	:=
MAX SLIP FREQUENCY (0.05–0.50 Hz) *(Hidden if E25 := N)*	**25SF**	:=
MAX ANGLE 1 (0–80 deg) *(Hidden if E25 := N)*	**25ANG1**	:=
MAX ANGLE 2 (0–80 deg) *(Hidden if E25 := N)*	**25ANG2**	:=
SYNCPH PHASE (VA, VB, VC, 0, 30, 60, 90, 120, 150, 180, 210, 240, 270, 300 330 deg lag VA *(Hidden if E25 := N; 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 E25 := N; hidden if DELTA_Y := WYE)*	**SYNCPH**	:=
BRKR CLOSE TIME (OFF, 1–1000 ms) *(Hidden if E25 := N)*	**TCLOSD**	:=
BLK SYNCH CHECK (SELOGIC) *(Hidden if E25 := N)*	**BSYNCH**	:=

Date____________

Power Factor

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 sec) *(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 sec) *(Hidden if both 55LDAP and 55LGAP := OFF)*	**55AD**	:= __________
PF ARMING DELAY (0–5000 sec) *(Hidden if all 55LGTP, 55LDTP, 55LGAP, and 55LDAP := OFF)*	**55DLY**	:= __________

Frequency

FREQ1 TRIP LEVEL (OFF, 15.00–70.00 Hz)	**81D1TP**	:= __________
FREQ1 TRIP DELAY (0.00–240.00 sec) *(Hidden if 81D1TP := OFF)*	**81D1TD**	:= __________
FREQ2 TRIP LEVEL (OFF, 15.00–70.00 Hz)	**81D2TP**	:= __________
FREQ2 TRIP DELAY (0.00–240.00 sec) *(Hidden if 81D2TP := OFF)*	**81D2TD**	:= __________
FREQ3 TRIP LEVEL (OFF, 15.00–70.00 Hz)	**81D3TP**	:= __________
FREQ3 TRIP DELAY (0.00–240.00 sec) *(Hidden if 81D3TP := OFF)*	**81D3TD**	:= __________
FREQ4 TRIP LEVEL (OFF, 15.00–70.00 Hz)	**81D4TP**	:= __________
FREQ4 TRIP DELAY (0.00–240.00 sec) (*Hidden if 81D4TP := OFF*)	**81D4TD**	:= __________
FREQ5 TRIP LEVEL (OFF, 15.00–70.00 Hz)	**81D5TP**	:= __________
FREQ5 TRIP DELAY (0.00–240.00 sec) (*Hidden if 81D5TP := OFF*)	**81D5TD**	:= __________
FREQ6 TRIP LEVEL (OFF, 15.00–70.00 Hz)	**81D6TP**	:= __________
FREQ6 TRIP DELAY (0.00–240.00 sec) (*Hidden if 81D6TP := OFF*)	**81D6TD**	:= __________

Rate-of-Change-of-Frequency

ENABLE 81R (N, 1–4)	**E81R**	:= __________
(All of 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})	**81RISUP**	:= __________
81R1 TRIP LEVEL (OFF, 0.10–15.00 Hz/sec)	**81R1TP**	:= __________
81R1 TREND (INC, DEC, ABS) (*Hidden if 81R1TP := OFF*)	**81R1TRND**	:= __________
81R1 TRIP DELAY (0.10–60.00 sec) (*Hidden if 81R1TP := OFF*)	**81R1TD**	:= __________
81R1 DO DELAY (0.00–60.00 sec) (*Hidden if 81R1TP := OFF*)	**81R1DO**	:= __________
81R2 TRIP LEVEL (OFF, 0.10–15.00 Hz/sec) *(Hidden if E81R < 2)*	**81R2TP**	:= __________

81R2 TREND (INC, DEC, ABS) (*Hidden if 81R2TP := OFF*)	**81R2TRND**	:= ____________
81R2 TRIP DELAY (0.10–60.00 sec) (*Hidden if 81R2TP := OFF*)	**81R2TD**	:= ____________
81R2 DO DELAY (0.00–60.00 sec) (*Hidden if 81R2TP := OFF*)	**81R2DO**	:= ____________
81R3 TRIP LEVEL (OFF, 0.10–15.00 Hz/sec) (*Hidden if E81R < 3)*	**81R3TP**	:= ____________
81R3 TREND (INC, DEC, ABS) (*Hidden if 81R3TP := OFF*)	**81R3TRND**	:= ____________
81R3 TRIP DELAY (0.10–60.00 sec) (*Hidden if 81R3TP := OFF*)	**81R3TD**	:= ____________
81R3 DO DELAY (0.00–60.00 sec) (*Hidden if 81R3TP := OFF*)	**81R3DO**	:= ____________
81R4 TRIP LEVEL (OFF, 0.10–15.00 Hz/sec) (*Hidden if E81R < 4)*	**81R4TP**	:= ____________
81R4 TREND (INC, DEC, ABS) (*Hidden if 81R4TP := OFF*)	**81R4TRND**	:= ____________
81R4 TRIP DELAY (0.10–60.00 sec) (*Hidden if 81R4TP := OFF*)	**81R4TD**	:= ____________
81R4 DO DELAY (0.00–60.00 sec) (*Hidden if 81R4TP := OFF*)	**81R4DO**	:= ____________

Fast Rate-of-Change-of-Frequency (81RF)

ENABLE 81RF (Y, N)	**E81RF**	:= ____________

(All of 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/sec)	**81RFRP**	:= ____________
81RF PU DELAY (0.10–1.00 sec)	**81RFPU**	:= ____________
81RF DO DELAY (0.0–1.00 sec)	**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 sec)	**81RFBLDO**	:= ____________

Demand Metering

ENABLE DEM MTR (THM, ROL)	**EDEM**	:= ____________
DEM TIME CONSTNT (5, 10, 15, 30, 60 min)	**DMTC**	:= ____________
PH CURR DEM LVL (OFF, 0.50–16.00 A {5 A nom}, 0.10–3.20 A {1 A nom})	**PHDEMP**	:= ____________
RES CURR DEM LVL (OFF, 0.50–16.00 A {5 A nom}, 0.10–3.20 A {1 A nom})	**GNDEMP**	:= ____________
3I2 CURR DEM LVL (OFF, 0.50–16.00 A {5 A nom}, 0.10–3.20 A {1 A nom})	**3I2DEMP**	:= ____________

Power

ENABLE PWR ELEM (N, 3P1, 3P2)	**EPWR**	:= ____________

(All Power element settings below 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 sec) **TDURD** := ________

CLOSE FAIL DLY (0.0–400.0 sec) **CFD** := ________

TRIP EQUATION (SELOGIC)
TR := ________

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

UNLATCH TRIP (SELOGIC) **ULTRIP** := ________

BREAKER STATUS (SELOGIC) **52A** := ________

CLOSE EQUATION (SELOGIC) **CL** := ________

UNLATCH CLOSE (SELOGIC) **ULCL** := ________

Reclosing Control

(Hidden if Reclosing Option is not included)

ENABLE RECLOSER (N, 1–4 shots) **E79** := ________

(All of the following settings are hidden if E79 := N is selected)

OPEN INTERVAL 1 (0.00–3000.00 sec) *(Forced to 0 if E79 := N)* **79OI1** := ________

OPEN INTERVAL 2 (0.00–3000.00 sec) *(Hidden and forced to 0 if E79 < 2 or E79 := N)* **79OI2** := ________

OPEN INTERVAL 3 (0.00–3000.00 sec) *(Hidden and forced to 0 if E79 < 3 or E79 := N)* **79OI3** := ________

OPEN INTERVAL 4 (0.00–3000.00 sec) *(Hidden and forced to 0 if E79 < 4 or E79 := N)* **79OI4** := ________

RST TM FROM RECL (0.00–3000.00 sec) **79RSD** := ________

RST TM FROM LO (0.00–3000.00 sec) **79RSLD** := ________

RECLS SUPV TIME (OFF, 0.00–3000.00 sec) *(Forced to OFF if E79 := N)* **79CLSD** := ________

RECLOSE INITIATE (SELOGIC) **79RI** := ________

RCLS INIT SUPVSN (SELOGIC) **79RIS** := ________

DRIVE-TO-LOCKOUT (SELOGIC) **79DTL** := ________

DRIVE-TO-LSTSHOT (SELOGIC) **79DLS** := ________

SKIP SHOT (SELOGIC) **79SKP** := ________

STALL OPN INTRVL (SELOGIC) **79STL** := ________

BLOCK RESET TMNG (SELOGIC)	**79BRS**	:=
SEQ COORDINATION (SELOGIC)	**79SEQ**	:=
RCLS SUPERVISION (SELOGIC)	**79CLS**	:=

Logic Settings (SET L Command)

SELOGIC Enables

SELOGIC LATCHES (N, 1–32)	**ELAT**	:=
SV/TIMERS (N, 1–32)	**ESV**	:=
SELOGIC COUNTERS (N, 1–32)	**ESC**	:=
MATH VARIABLES (N, 1–32)	**EMV**	:=

Latch Bits Equations

SET01	:=
RST01	:=
SET02	:=
RST02	:=
SET03	:=
RST03	:=
SET04	:=
RST04	:=
SET05	:=
RST05	:=
SET06	:=
RST06	:=
SET07	:=
RST07	:=
SET08	:=
RST08	:=
SET09	:=
RST09	:=
SET10	:=
RST10	:=
SET11	:=
RST11	:=
SET12	:=
RST12	:=
SET13	:=
RST13	:=
SET14	:=
RST14	:=

SET15 := ____________________
RST15 := ____________________
SET16 := ____________________
RST16 := ____________________
SET17 := ____________________
RST17 := ____________________
SET18 := ____________________
RST18 := ____________________
SET19 := ____________________
RST19 := ____________________
SET20 := ____________________
RST20 := ____________________
SET21 := ____________________
RST21 := ____________________
SET22 := ____________________
RST22 := ____________________
SET23 := ____________________
RST23 := ____________________
SET24 := ____________________
RST24 := ____________________
SET25 := ____________________
RST25 := ____________________
SET26 := ____________________
RST26 := ____________________
SET27 := ____________________
RST27 := ____________________
SET28 := ____________________
RST28 := ____________________
SET29 := ____________________
RST29 := ____________________
SET30 := ____________________
RST30 := ____________________
SET31 := ____________________
RST31 := ____________________
SET32 := ____________________
RST32 := ____________________

SV/Timers

SV TIMER PICKUP (0.00–3000.00 sec) **SV01PU** := ____________________
SV TIMER DROPOUT (0.00–3000.00 sec) **SV01DO** := ____________________
SV INPUT (SELOGIC) **SV01** := ____________________

SV TIMER PICKUP (0.00–3000.00 sec)	**SV02PU**	:=
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV02DO**	:=
SV INPUT (SELOGIC)	**SV02**	:=
SV TIMER PICKUP (0.00–3000.00 sec)	**SV03PU**	:=
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV03DO**	:=
SV INPUT (SELOGIC)	**SV03**	:=
SV TIMER PICKUP (0.00–3000.00 sec)	**SV04PU**	:=
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV04DO**	:=
SV INPUT (SELOGIC)	**SV04**	:=
SV TIMER PICKUP (0.00–3000.00 sec)	**SV05PU**	:=
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV05DO**	:=
SV INPUT (SELOGIC)	**SV05**	:=
SV TIMER PICKUP (0.00–3000.00 sec)	**SV06PU**	:=
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV06DO**	:=
SV INPUT (SELOGIC)	**SV06**	:=
SV TIMER PICKUP (0.00–3000.00 sec)	**SV07PU**	:=
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV07DO**	:=
SV INPUT (SELOGIC)	**SV07**	:=
SV TIMER PICKUP (0.00–3000.00 sec)	**SV08PU**	:=
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV08DO**	:=
SV INPUT (SELOGIC)	**SV08**	:=
SV TIMER PICKUP (0.00–3000.00 sec)	**SV09PU**	:=
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV09DO**	:=
SV INPUT (SELOGIC)	**SV09**	:=
SV TIMER PICKUP (0.00–3000.00 sec)	**SV10PU**	:=
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV10DO**	:=
SV INPUT (SELOGIC)	**SV10**	:=
SV TIMER PICKUP (0.00–3000.00 sec)	**SV11PU**	:=
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV11DO**	:=
SV INPUT (SELOGIC)	**SV11**	:=
SV TIMER PICKUP (0.00–3000.00 sec)	**SV12PU**	:=
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV12DO**	:=
SV INPUT (SELOGIC)	**SV12**	:=
SV TIMER PICKUP (0.00–3000.00 sec)	**SV13PU**	:=
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV13DO**	:=
SV INPUT (SELOGIC)	**SV13**	:=
SV TIMER PICKUP (0.00–3000.00 sec)	**SV14PU**	:=
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV14DO**	:=

SV INPUT (SELOGIC)	**SV14**	:= ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV15PU**	:= ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV15DO**	:= ____________
SV INPUT (SELOGIC)	**SV15**	:= ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV16PU**	:= ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV16DO**	:= ____________
SV INPUT (SELOGIC)	**SV16**	:= ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV17PU**	:= ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV17DO**	:= ____________
SV INPUT (SELOGIC)	**SV17**	:= ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV18PU**	:= ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV18DO**	:= ____________
SV INPUT (SELOGIC)	**SV18**	:= ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV19PU**	:= ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV19DO**	:= ____________
SV INPUT (SELOGIC)	**SV19**	:= ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV20PU**	:= ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV20DO**	:= ____________
SV INPUT (SELOGIC)	**SV20**	:= ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV21PU**	:= ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV21DO**	:= ____________
SV INPUT (SELOGIC)	**SV21**	:= ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV22PU**	:= ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV22DO**	:= ____________
SV INPUT (SELOGIC)	**SV22**	:= ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV23PU**	:= ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV23DO**	:= ____________
SV INPUT (SELOGIC)	**SV23**	:= ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV24PU**	:= ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV24DO**	:= ____________
SV INPUT (SELOGIC)	**SV24**	:= ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV25PU**	:= ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV25DO**	:= ____________
SV INPUT (SELOGIC)	**SV25**	:= ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV26PU**	:= ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV26DO**	:= ____________
SV INPUT (SELOGIC)	**SV26**	:= ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV27PU**	:= ____________

SV TIMER DROPOUT (0.00–3000.00 sec)	**SV27DO**	:=	________
SV INPUT (SELOGIC)	**SV27**	:=	________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV28PU**	:=	________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV28DO**	:=	________
SV INPUT (SELOGIC)	**SV28**	:=	________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV29PU**	:=	________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV29DO**	:=	________
SV INPUT (SELOGIC)	**SV29**	:=	________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV30PU**	:=	________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV30DO**	:=	________
SV INPUT (SELOGIC)	**SV30**	:=	________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV31PU**	:=	________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV31DO**	:=	________
SV INPU (SELOGIC)	**SV31**	:=	________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV32PU**	:=	________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV32DO**	:=	________
SV INPUT (SELOGIC)	**SV32**	:=	________

Counters Equations

SC PRESET VALUE (1–65000)	**SC01PV**	:=	________
SC RESET INPUT (SELOGIC)	**SC01R**	:=	________
SC LOAD PV INPUT (SELOGIC)	**SC01LD**	:=	________
SC CNT UP INPUT (SELOGIC)	**SC01CU**	:=	________
SC CNT DN INPUT (SELOGIC)	**SC01CD**	:=	________
SC PRESET VALUE (1–65000)	**SC02PV**	:=	________
SC RESET INPUT (SELOGIC)	**SC02R**	:=	________
SC LOAD PV INPUT (SELOGIC)	**SC02LD**	:=	________
SC CNT UP INPUT (SELOGIC)	**SC02CU**	:=	________
SC CNT DN INPUT (SELOGIC)	**SC02CD**	:=	________
SC PRESET VALUE (1–65000)	**SC03PV**	:=	________
SC RESET INPUT (SELOGIC)	**SC03R**	:=	________
SC LOAD PV INPUT (SELOGIC)	**SC03LD**	:=	________
SC CNT UP INPUT (SELOGIC)	**SC03CU**	:=	________
SC CNT DN INPUT (SELOGIC)	**SC03CD**	:=	________
SC PRESET VALUE (1–65000)	**SC04PV**	:=	________
SC RESET INPUT (SELOGIC)	**SC04R**	:=	________
SC LOAD PV INPUT (SELOGIC)	**SC04LD**	:=	________
SC CNT UP INPUT (SELOGIC)	**SC04CU**	:=	________

SC CNT DN INPUT (SELOGIC)	**SC04CD**	:= ________
SC PRESET VALUE (1–65000)	**SC05PV**	:= ________
SC RESET INPUT (SELOGIC)	**SC05R**	:= ________
SC LOAD PV INPUT (SELOGIC)	**SC05LD**	:= ________
SC CNT UP INPUT (SELOGIC)	**SC05CU**	:= ________
SC CNT DN INPUT (SELOGIC)	**SC05CD**	:= ________
SC PRESET VALUE (1–65000)	**SC06PV**	:= ________
SC RESET INPUT (SELOGIC)	**SC06R**	:= ________
SC LOAD PV INPUT (SELOGIC)	**SC06LD**	:= ________
SC CNT UP INPUT (SELOGIC)	**SC06CU**	:= ________
SC CNT DN INPUT (SELOGIC)	**SC06CD**	:= ________
SC PRESET VALUE (1–65000)	**SC07PV**	:= ________
SC RESET INPUT (SELOGIC)	**SC07R**	:= ________
SC LOAD PV INPUT (SELOGIC)	**SC07LD**	:= ________
SC CNT UP INPUT (SELOGIC)	**SC07CU**	:= ________
SC CNT DN INPUT (SELOGIC)	**SC07CD**	:= ________
SC PRESET VALUE (1–65000)	**SC08PV**	:= ________
SC RESET INPUT (SELOGIC)	**SC08R**	:= ________
SC LOAD PV INPUT (SELOGIC)	**SC08LD**	:= ________
SC CNT UP INPUT (SELOGIC)	**SC08CU**	:= ________
SC CNT DN INPUT (SELOGIC)	**SC08CD**	:= ________
SC PRESET VALUE (1–65000)	**SC09PV**	:= ________
SC RESET INPUT (SELOGIC)	**SC09R**	:= ________
SC LOAD PV INPUT (SELOGIC)	**SC09LD**	:= ________
SC CNT UP INPUT (SELOGIC)	**SC09CU**	:= ________
SC CNT DN INPUT (SELOGIC)	**SC09CD**	:= ________
SC PRESET VALUE (1–65000)	**SC10PV**	:= ________
SC RESET INPUT (SELOGIC)	**SC10R**	:= ________
SC LOAD PV INPUT (SELOGIC)	**SC10LD**	:= ________
SC CNT UP INPUT (SELOGIC)	**SC10CU**	:= ________
SC CNT DN INPUT (SELOGIC)	**SC10CD**	:= ________
SC PRESET VALUE (1–65000)	**SC11PV**	:= ________
SC RESET INPUT (SELOGIC)	**SC11R**	:= ________
SC LOAD PV INPUT (SELOGIC)	**SC11LD**	:= ________
SC CNT UP INPUT (SELOGIC)	**SC11CU**	:= ________
SC CNT DN INPUT (SELOGIC)	**SC11CD**	:= ________
SC PRESET VALUE (1–65000)	**SC12PV**	:= ________
SC RESET INPUT (SELOGIC)	**SC12R**	:= ________

SC LOAD PV INPUT (SELOGIC)	**SC12LD**	:=	________
SC CNT UP INPUT (SELOGIC)	**SC12CU**	:=	________
SC CNT DN INPUT (SELOGIC)	**SC12CD**	:=	________
SC PRESET VALUE (1–65000)	**SC13PV**	:=	________
SC RESET INPUT (SELOGIC)	**SC13R**	:=	________
SC LOAD PV INPUT (SELOGIC)	**SC13LD**	:=	________
SC CNT UP INPUT (SELOGIC)	**SC13CU**	:=	________
SC CNT DN INPUT (SELOGIC)	**SC13CD**	:=	________
SC PRESET VALUE (1–65000)	**SC14PV**	:=	________
SC RESET INPUT (SELOGIC)	**SC14R**	:=	________
SC LOAD PV INPUT (SELOGIC)	**SC14LD**	:=	________
SC CNT UP INPUT (SELOGIC)	**SC14CU**	:=	________
SC CNT DN INPUT (SELOGIC)	**SC14CD**	:=	________
SC PRESET VALUE (1–65000)	**SC15PV**	:=	________
SC RESET INPUT (SELOGIC)	**SC15R**	:=	________
SC LOAD PV INPUT (SELOGIC)	**SC15LD**	:=	________
SC CNT UP INPUT (SELOGIC)	**SC15CU**	:=	________
SC CNT DN INPUT (SELOGIC)	**SC15CD**	:=	________
SC PRESET VALUE (1–65000)	**SC16PV**	:=	________
SC RESET INPUT (SELOGIC)	**SC16R**	:=	________
SC LOAD PV INPUT (SELOGIC)	**SC16LD**	:=	________
SC CNT UP INPUT (SELOGIC)	**SC16CU**	:=	________
SC CNT DN INPUT (SELOGIC)	**SC16CD**	:=	________
SC PRESET VALUE (1–65000)	**SC17PV**	:=	________
SC RESET INPUT (SELOGIC)	**SC17R**	:=	________
SC LOAD PV INPUT (SELOGIC)	**SC17LD**	:=	________
SC CNT UP INPUT (SELOGIC)	**SC17CU**	:=	________
SC CNT DN INPUT (SELOGIC)	**SC17CD**	:=	________
SC PRESET VALUE (1–65000)	**SC18PV**	:=	________
SC RESET INPUT (SELOGIC)	**SC18R**	:=	________
SC LOAD PV INPUT (SELOGIC)	**SC18LD**	:=	________
SC CNT UP INPUT (SELOGIC)	**SC18CU**	:=	________
SC CNT DN INPUT (SELOGIC)	**SC18CD**	:=	________
SC PRESET VALUE (1–65000)	**SC19PV**	:=	________
SC RESET INPUT (SELOGIC)	**SC19R**	:=	________
SC LOAD PV INPUT (SELOGIC)	**SC19LD**	:=	________
SC CNT UP INPUT (SELOGIC)	**SC19CU**	:=	________
SC CNT DN INPUT (SELOGIC)	**SC19CD**	:=	________

SC PRESET VALUE (1–65000)	**SC20PV**	:=
SC RESET INPUT (SELOGIC)	**SC20R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC20LD**	:=
SC CNT UP INPUT (SELOGIC)	**SC20CU**	:=
SC CNT DN INPUT (SELOGIC)	**SC20CD**	:=
SC PRESET VALUE (1–65000)	**SC21PV**	:=
SC RESET INPUT (SELOGIC)	**SC21R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC21LD**	:=
SC CNT UP INPUT (SELOGIC)	**SC21CU**	:=
SC CNT DN INPUT (SELOGIC)	**SC21CD**	:=
SC PRESET VALUE (1–65000)	**SC22PV**	:=
SC RESET INPUT (SELOGIC)	**SC22R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC22LD**	:=
SC CNT UP INPUT (SELOGIC)	**SC22CU**	:=
SC CNT DN INPUT (SELOGIC)	**SC22CD**	:=
SC PRESET VALUE (1–65000)	**SC23PV**	:=
SC RESET INPUT (SELOGIC)	**SC23R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC23LD**	:=
SC CNT UP INPUT (SELOGIC)	**SC23CU**	:=
SC CNT DN INPUT (SELOGIC)	**SC23CD**	:=
SC PRESET VALUE (1–65000)	**SC24PV**	:=
SC RESET INPUT (SELOGIC)	**SC24R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC24LD**	:=
SC CNT UP INPUT (SELOGIC)	**SC24CU**	:=
SC CNT DN INPUT (SELOGIC)	**SC24CD**	:=
SC PRESET VALUE (1–65000)	**SC25PV**	:=
SC RESET INPUT (SELOGIC)	**SC25R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC25LD**	:=
SC CNT UP INPUT (SELOGIC)	**SC25CU**	:=
SC CNT DN INPUT (SELOGIC)	**SC25CD**	:=
SC PRESET VALUE (1–65000)	**SC26PV**	:=
SC RESET INPUT (SELOGIC)	**SC26R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC26LD**	:=
SC CNT UP INPUT (SELOGIC)	**SC26CU**	:=
SC CNT DN INPUT (SELOGIC)	**SC26CD**	:=
SC PRESET VALUE (1–65000)	**SC27PV**	:=
SC RESET INPUT (SELOGIC)	**SC27R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC27LD**	:=

SC CNT UP INPUT (SELOGIC)	**SC27CU**	:=	________
SC CNT DN INPUT (SELOGIC)	**SC27CD**	:=	________
SC PRESET VALUE (1–65000)	**SC28PV**	:=	________
SC RESET INPUT (SELOGIC)	**SC28R**	:=	________
SC LOAD PV INPUT (SELOGIC)	**SC28LD**	:=	________
SC CNT UP INPUT (SELOGIC)	**SC28CU**	:=	________
SC CNT DN INPUT (SELOGIC)	**SC28CD**	:=	________
SC PRESET VALUE (1–65000)	**SC29PV**	:=	________
SC RESET INPUT (SELOGIC)	**SC29R**	:=	________
SC LOAD PV INPUT (SELOGIC)	**SC29LD**	:=	________
SC CNT UP INPUT (SELOGIC)	**SC29CU**	:=	________
SC CNT DN INPUT (SELOGIC)	**SC29CD**	:=	________
SC PRESET VALUE (1–65000)	**SC30PV**	:=	________
SC RESET INPUT (SELOGIC)	**SC30R**	:=	________
SC LOAD PV INPUT (SELOGIC)	**SC30LD**	:=	________
SC CNT UP INPUT (SELOGIC)	**SC30CU**	:=	________
SC CNT DN INPUT (SELOGIC)	**SC30CD**	:=	________
SC PRESET VALUE (1–65000)	**SC31PV**	:=	________
SC RESET INPUT (SELOGIC)	**SC31R**	:=	________
SC LOAD PV INPUT (SELOGIC)	**SC31LD**	:=	________
SC CNT UP INPUT (SELOGIC)	**SC31CU**	:=	________
SC CNT DN INPUT (SELOGIC)	**SC31CD**	:=	________
SC PRESET VALUE (1–65000)	**SC32PV**	:=	________
SC RESET INPUT (SELOGIC)	**SC32R**	:=	________
SC LOAD PV INPUT (SELOGIC)	**SC32LD**	:=	________
SC CNT UP INPUT (SELOGIC)	**SC32CU**	:=	________
SC CNT DN INPUT (SELOGIC)	**SC32CD**	:=	________

Math Variables

MV01	:=	________
MV02	:=	________
MV03	:=	________
MV04	:=	________
MV05	:=	________
MV06	:=	________
MV07	:=	________
MV08	:=	________
MV09	:=	________
MV10	:=	________

MV11 := ______________________________
MV12 := ______________________________
MV13 := ______________________________
MV14 := ______________________________
MV15 := ______________________________
MV16 := ______________________________
MV17 := ______________________________
MV18 := ______________________________
MV19 := ______________________________
MV20 := ______________________________
MV21 := ______________________________
MV22 := ______________________________
MV23 := ______________________________
MV24 := ______________________________
MV25 := ______________________________
MV26 := ______________________________
MV27 := ______________________________
MV28 := ______________________________
MV29 := ______________________________
MV30 := ______________________________
MV31 := ______________________________
MV32 := ______________________________

Base Output

OUT101 FAIL-SAFE (Y, N) **OUT101FS** := ______________
OUT101 := ______________________________
OUT102 FAIL-SAFE (Y, N) **OUT102FS** := ______________
OUT102 := ______________________________
OUT103 FAIL-SAFE (Y, N) **OUT103FS** := ______________
OUT103 := ______________________________

Slot C Output

(Hidden if an output option is not included. The number of outputs depends on the I/O card option.)

OUT301 FAIL-SAFE (Y, N) **OUT301FS** := ______________
OUT301 := ______________________________
OUT302 FAIL-SAFE (Y, N) **OUT302FS** := ______________
OUT302 := ______________________________
OUT303 FAIL-SAFE (Y, N) **OUT303FS** := ______________
OUT303 := ______________________________
OUT303 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 **:=** ______________
OUT505 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** := ____________

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 sec)	**TGR**	:=
SELECT GROUP1 (SELOGIC)	**SS1**	:=
SELECT GROUP2 (SELOGIC)	**SS2**	:=
SELECT GROUP3 (SELOGIC)	**SS3**	:=

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)	**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 there is no VS voltage 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) rounded up to quarter	**UTC_OFF**	:=
MONTH TO BEGIN DST (OFF, 1–12)	**DST_BEGM**	:=
WEEK OF THE MONTH TO BEGIN DST (1–3, L) L = Last week of the month (*Hidden if DST_BEGM := OFF*)	**DST_BEGW**	:=
DAY OF THE WEEK TO BEGIN DST (SUN, MON, TUE, WED, THU, FRI, SAT) (*Hidden if DST_BEGM := OFF*)	**DST_BEGD**	:=
LOCAL HOUR TO BEGIN DST (0–23) (*Hidden if DST_BEGM := OFF*)	**DST_BEGH**	:=
MONTH TO END DST (1–12) (*Hidden if DST_BEGM := OFF*)	**DST_ENDM**	:=
WEEK OF THE MONTH TO END DST (1–3, L) L = Last week of the month (*Hidden if DST_BEGM := OFF*)	**DST_ENDW**	:=
DAY OF THE WEEK TO END DST (SUN, MON, TUE, WED, THU, FRI, SAT) (*Hidden if DST_BEGM := OFF*)	**DST_ENDD**	:=
LOCAL HOUR TO END DST (0–23) (*Hidden if DST_BEGM := OFF*)	**DST_ENDH**	:=

Breaker Failure

52A INTERLOCK (Y, N)	**52ABF**	:=
CURRENT DETECTOR (0.10–10.00 A {5 A nom.}, 0.02–2.00 A {1 A nom.})	**50BFP**	:=
BK FAILURE DELAY (0.00–2.00 sec)	**BFD**	:=
AUX TIMER DELAY (OFF, 0.01–2.00 sec)	**ATD**	:=
BK FAIL INITIATE (SELOGIC)	**BFI**	:=

Arc-Flash Protection

(Hidden if the voltage card with arc-flash detection is not included)

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**	:=

(All of the following settings are hidden if 50PAFP := OFF)

AF N OC TRP LVL (OFF, 0.50–100.00 A {5 A nom. neutral}, 0.10–20.00 A {1 A nom. neutral})	**50NAFP**	:=
SENSOR 1 TYPE (NONE, POINT, FIBER)	**AFSENS1**	:=
TOL 1 PICKUP (3.0–20.0% {POINT}, 0.6–4.0% {FIBER}) *(Hidden if AFSENS1 := NONE)*	**TOL1P**	:=

SENSOR 2 TYPE (NONE, POINT, FIBER)	**AFSENS2**	:= ____________
TOL 2 PICKUP (3.0–20.0% {POINT}, 0.6–4.0% {FIBER}) *(Hidden if AFSENS2 := NONE)*	**TOL2P**	:= ____________
SENSOR 3 TYPE (NONE, POINT, FIBER)	**AFSENS3**	:= ____________
TOL 3 PICKUP (3.0–20.0% {POINT}, 0.6–4.0% {FIBER}) *(Hidden if AFSENS3 := NONE)*	**TOL3P**	:= ____________
SENSOR 4 TYPE (NONE, POINT, FIBER)	**AFSENS4**	:= ____________
TOL 4 PICKUP (3.0–20.0% {POINT}, 0.6–4.0% {FIBER}) *(Hidden if AFSENS4 := NONE)*	**TOL4P**	:= ____________
AFD OUTPUT SLOT (101_2, 301_2, 401_2)	**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.)

AI*x*01

AI*x*01 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*01NAM**	:= ____________
AI*x*01 TYPE (I, V)	**AI*x*01TYP**	:= ____________
If AI*x*01TYP = I		
AI*x*01 LOW IN VAL (–20.480 to +20.480; mA)	**AI*x*01L**	:= ____________
AI*x*01 HI IN VAL (–20.480 to +20.480; mA)	**AI*x*01H**	:= ____________
If AI*x*01TYP = V		
AI*x*01 LOW IN VAL (–10.240 to +10.240 V)	**AI*x*01L**	:= ____________
AI*x*01 HI IN VAL (–10.240 to +10.240 V)	**AI*x*01H**	:= ____________

NOTE: Set Warn and Alarm to a value between Engr Low and Engr High settings.

AI*x*01 ENG UNITS (16 characters)	**AI*x*01EU**	:= ____________
AI*x*01 EU LOW (–99999.000 to +99999.000)	**AI*x*01EL**	:= ____________
AI*x*01 EU HI (–99999.000 to +99999.000)	**AI*x*01EH**	:= ____________
AI*x*01 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*01LW1**	:= ____________
AI*x*01 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*01LW2**	:= ____________
AI*x*01 LO ALARM (OFF, –99999.000 to +99999.000)	**AI*x*01LAL**	:= ____________
AI*x*01 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*01HW1**	:= ____________
AI*x*01 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*01HW2**	:= ____________
AI*x*01 HI ALARM (OFF, –99999.000 to +99999.000)	**AI*x*01HAL**	:= ____________

AI*x*02

AI*x*02 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*02NAM** := ________
AI*x*02 TYPE (I, V)	**AIx02TYP** := ________
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** := ________
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** := ________

AI*x*03

AI*x*03 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*03NAM** := ________
AI*x*03 TYPE (I, V)	**AIx03TYP** := ________
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** := ________
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** := ________

AI*x*04

AI*x*04 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*04NAM**	:= ________
AI*x*04 TYPE (I, V)	**AIx04TYP**	:= ________
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**	:= ________
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**	:= ________

AI*x*05

AI*x*05 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*05NAM**	:= ________
AI*x*05 TYPE (I, V)	**AIx05TYP**	:= ________
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**	:= ________
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**	:= ________

AI*x*06

AI*x*06 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*06NAM**	:= ________
AI*x*06 TYPE (I, V)	**AIx06TYP**	:= ________
If AI*x*06TYP = I		
AI*x*06 LOW IN VAL (–20.480 to +20.480; mA)	**AI*x*06L**	:= ________
AI*x*06 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**	:= ________
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**	:= ________

AI*x*07

AI*x*07 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*07NAM**	:= ________
AI*x*07 TYPE (I, V)	**AIx07TYP**	:= ________
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**	:= ________
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**	:= ________

AI*x*08

AI*x*08 TAG NAME (8 characters 0–9, A–Z, _) **AI*x*08NAM** := ____________

AI*x*08 TYPE (I, V) **AIx08TYP** := ____________

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** := ____________

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** := ____________

AO*x*01

AO*x*01 ANALOG QTY (Off, 1 analog quantity) **AO*x*01AQ** := ____________

AO*x*01 TYPE (I, V) **AO*x*01TYP** := ____________

AO*x*01 AQTY LOW (–2147483647 to +2147483647) **AO*x*01AQL** := ____________

AO*x*01 AQTY HI (–2147483647 to +2147483647) **AO*x*01AQH** := ____________

If AO*x*01TYP = I

AO*x*01 LO OUT VAL (–20.480 to +20.480 mA) **AO*x*01L** := ____________

AO*x*01 HI OUT VAL (–20.480 to +20.480 mA) **AO*x*01H** := ____________

If AO*x*01TYP = V

AO*x*01 LO OUT VAL (–10.240 to +10.240 V) **AO*x*01L** := ____________

AO*x*01 HI OUT VAL (–10.240 to +10.240 V) **AO*x*01H** := ____________

AO*x*02

AO*x*02 ANALOG QTY (Off, 1 analog quantity) **AO*x*02AQ** := ____________

AO*x*02 TYPE (I, V) **AO*x*02TYP** := ____________

AO*x*02 AQTY LOW (–2147483647 to +2147483647) **AO*x*02AQL** := ____________

AO*x*02 AQTY HI (–2147483647 to +2147483647) **AO*x*02AQH** := ____________

If AO*x*02TYP = I

AO*x*02 LO OUT VAL (–20.480 to +20.480 mA) **AO*x*02L** := ____________

AO*x*02 HI OUT VAL (–20.480 to +20.480 mA) **AO*x*02H** := ____________

If AO*x*02TYP = V		
AO*x*02 LO OUT VAL (–10.240 to +10.240 V)	**AO*x*02L**	:=
AO*x*02 HI OUT VAL (–10.240 to +10.240 V)	**AO*x*02H**	:=

AO*x*03

AO*x*03 ANALOG QTY (Off, 1 analog quantity)	**AO*x*03AQ**	:=
AO*x*03 TYPE (I, V)	**AO*x*03TYP**	:=
AO*x*03 AQTY LOW (–2147483647 to +2147483647)	**AO*x*03AQL**	:=
AO*x*03 AQTY HI (–2147483647 to +2147483647)	**AO*x*03AQH**	:=
If AO*x*03TYP = I		
AO*x*03 LO OUT VAL (–20.480 to +20.480 mA)	**AO*x*03L**	:=
AO*x*03 HI OUT VAL (–20.480 to +20.480 mA)	**AO*x*03H**	:=
If AO*x*03TYP = V		
AO*x*03 LO OUT VAL (–10.240 to +10.240 V)	**AO*x*03L**	:=
AO*x*03 HI OUT VAL (–10.240 to +10.240 V)	**AO*x*03H**	:=

AO*x*04

AO*x*04 ANALOG QTY (Off, 1 analog quantity)	**AO*x*04AQ**	:=
AO*x*04 TYPE (I, V)	**AO*x*04TYP**	:=
AO*x*04 AQTY LOW (–2147483647 to +2147483647)	**AO*x*04AQL**	:=
AO*x*04 AQTY HI (–2147483647 to +2147483647)	**AO*x*04AQH**	:=
If AO*x*04TYP = I		
AO*x*04 LO OUT VAL (–20.480 to +20.480 mA)	**AO*x*04L**	:=
AO*x*04 HI OUT VAL (–20.480 to +20.480 mA)	**AO*x*04H**	:=
If AO*x*04TYP = V		
AO*x*04 LO OUT VAL (–10.240 to +10.240 V)	**AO*x*04L**	:=
AO*x*04 HI OUT VAL (–10.240 to +10.240 V)	**AO*x*04H**	:=

Station DC Battery Monitor

(Hidden if the voltage option xx70xx is not included)

DC UNDER VOLT PU (OFF, 20.00–300.00 Vdc)	**DCLOP**	:=
DC OVER VOLT PU (OFF, 20.00–300.00 Vdc)	**DCHIP**	:=

Input Debounce Settings (Base Unit)

IN101 Debounce (AC, 0–65000 ms)	**IN101D**	:=
IN102 Debounce (AC, 0–65000 ms)	**IN102D**	:=

Input Debounce Settings (Slot C)

(Hidden if an input option is not included)

IN301 Debounce (AC, 0–65000 ms)	**IN301D**	:= ________
IN302 Debounce (AC, 0–65000 ms)	**IN302D**	:= ________
IN303 Debounce (AC, 0–65000 ms)	**IN303D**	:= ________
IN304 Debounce (AC, 0–65000 ms)	**IN304D**	:= ________
IN305 Debounce (AC, 0–65000 ms)	**IN305D**	:= ________
IN306 Debounce (AC, 0–65000 ms)	**IN306D**	:= ________
IN307 Debounce (AC, 0–65000 ms)	**IN307D**	:= ________
IN308 Debounce (AC, 0–65000 ms)	**IN308D**	:= ________

Input Debounce Settings (Slot D)

(Hidden if an input option is not included)

IN401 Debounce (AC, 0–65000 ms)	**IN401D**	:= ________
IN402 Debounce (AC, 0–65000 ms)	**IN402D**	:= ________
IN403 Debounce (AC, 0–65000 ms)	**IN403D**	:= ________
IN404 Debounce (AC, 0–65000 ms)	**IN404D**	:= ________
IN405 Debounce (AC, 0–65000 ms)	**IN405D**	:= ________
IN406 Debounce (AC, 0–65000 ms)	**IN406D**	:= ________
IN407 Debounce (AC, 0–65000 ms)	**IN407D**	:= ________
IN408 Debounce (AC, 0–65000 ms)	**IN408D**	:= ________

Input Debounce Settings (Slot E)

(Hidden if an input option is not included)

IN501 Debounce (AC, 0–65000 ms)	**IN501D**	:= ________
IN502 Debounce (AC, 0–65000 ms)	**IN502D**	:= ________
IN503 Debounce (AC, 0–65000 ms)	**IN503D**	:= ________
IN504 Debounce (AC, 0–65000 ms)	**IN504D**	:= ________
IN505 Debounce (AC, 0–65000 ms)	**IN505D**	:= ________
IN506 Debounce (AC, 0–65000 ms)	**IN506D**	:= ________
IN507 Debounce (AC, 0–65000 ms)	**IN507D**	:= ________
IN508 Debounce (AC, 0–65000 ms)	**IN508D**	:= ________

Breaker Monitor Settings

BREAKER MONITOR (Y, N)	**EBMON**	:= ________

(All subsequent settings are 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 (0.10–999.00)	**KASP1**	:= ________

kA PRI INTERRPTD 2 (0.10–999.00)	**KASP2**	:= ________
kA PRI INTERRPTD 3 (0.10–999.00)	**KASP3**	:= ________
Control Breaker Monitor (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

IRIG TIME SOURCE (IRIG1, IRIG2)	**TIME_SRC**	:= ________

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

PORT F

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

Communications

SPEED (300, 1200, 2400, 4800, 9600, 19200, 38400 bps)	**SPEED**	:= ________
DATA BITS (7, 8 bits) *(Hidden if PROTO := MOD, EVMSG, or PMU)*	**BITS**	:= ________
PARITY (O, E, N) *(Hidden if PROTO := EVMSG or PMU)*	**PARITY**	:= ________
STOP BITS (1, 2 bits) *(Hidden if PROTO := MOD or EVMSG)*	**STOP**	:= ________
PORT TIME-OUT (0–30 min) *(Hidden if PROTO := MOD, EVMSG, or PMU)*	**T_OUT**	:= ________
HDWR HANDSHAKING (Y, N) *(Hidden if PROTO := MOD or EVMSG)*	**RTSCTS**	:= ________
SEND AUTOMESSAGE (Y, N) *(Hidden if PROTO := MOD, EVMSG, or PMU)*	**AUTO**	:= ________

Modbus

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

PORT 1

(Ethernet Port in Slot B; hidden if 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)

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** :=	________
FAST OP MESSAGES (Y, N)	**FASTOP** :=	________
OPERATING MODE (FIXED, FAILOVER, SWITCHED) *(Hidden if not dual redundant Ethernet Port option)*	**NETMODE** :=	________
FAILOVER TIMEOUT (0.10–65.00 sec) *(Hidden if not dual redundant Ethernet Port option or if NETMODE is not set to FAILOVER)*	**FTIME** :=	________
PRIMARY NETPORT (A, B, D) *(Hidden if not dual redundant Ethernet Port option)*	**NETPORT** :=	________
NETWRK PORTA SPD (AUTO, 10, 100 Mbps) *(Hidden if not dual redundant Ethernet Port option)*	**NETASPD** :=	________
NETWRK PORTB SPD (AUTO, 10, 100 Mbps) *(Hidden if not dual redundant Ethernet Port option)*	**NETBSPD** :=	________
TELNET PORT (23, 1025–65534) *(Note: See Table SET.1 and the note at the end of Port 1 settings)*	**TPORT** :=	________
TELNET TIME-OUT (1–30 min)	**TIDLE** :=	________
FTP USER NAME (20 characters)	**FTPUSER** :=	________
Enable IEC 61850 Protocol (Y, N) (*Hidden if 61850 not supported*)	**E61850** :=	________
Enable IEC 61850 GSE (Y, N) (*Hidden if E61850 := N*)	**EGSE** :=	________
Enable Modbus Sessions (0–2)	**EMOD** :=	________
Modbus TCP Port1 (1–65534) *(Note: See Table SET.1 and the note at the end of Port 1 settings; hidden if EMOD := 0)*	**MODNUM1** :=	________
Modbus TCP Port2 (1–65534) *(Note: See Table SET.1 and the note at the end of Port 1 settings; hidden if EMOD := 0 or 1)*	**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** :=	________

SEL Synchrophasor Protocol Settings

Enable PMU Processing (0–2)	**EPMIP** :=	________
PMU Output 1 Transport Scheme (OFF, TCP, UDP_S, UDP_T, UDP_U) *(Hidden if EPMIP := 0)*	**PMOTS1** :=	________

PMU Output 1 Client IP Address [zzz.yyy.xxx.www] (15 characters) *(Hidden if PMOTS1 := OFF) (PMOIPA1 cannot be set to the same address as IPADDR. IP addresses from 224.0.0.1 through 239.255.255.255 are also valid when PMOTS1 =UDP_S. IP address 255.255.255.255 is also valid when PMOTS1 = UDP_S or TCP.)* **PMOIPA1 :=** ________________

PMU Output 1 TCP/IP Port Number (1–65534) *(Shown only when EPMIP is not equal to 0 and PMOTS1 is not equal to UDP_S; PMOTCP1 cannot be set to the same number as PMOTCP2; 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; 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

(All subsequent DNP3 settings are hidden if DNP3 is not an option)

Enable DNP Sessions (0–3) *(The following DNP3 settings are hidden if EDNP := 0)* **EDNP :=** ________________

DNP TCP and UDP Port (1–65534) *(Note: See Table SET.1 and the note at the end of Port 1 settings)* **DNPNUM :=** ________________

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

Session 1

(The DNP IP address of each session (DNPIP1, DNPIP2, etc.) must be unique)

IP Address {zzz.yyy.xxx.www} (15 characters) **DNPIP1 :=** ________________

Transport Protocol (UDP, TCP) **DNPTR1 :=** ________________

UDP Response Port (REQ, 1–65534) **DNPUDP1 :=** ________________

DNP Address to Report to (0–65519) **REPADR1 :=** ________________

DNP Map (1–3) **DNPMAP1 :=** ________________

Analog Input Default Variation (1–6) **DVARAI1 :=** ________________

Class for Binary Event Data (0–3) **ECLASSB1 :=** ________________

Class for Counter Event Data (0–3) **ECLASSC1 :=** ________________

Class for Analog Event Data (0–3) **ECLASSA1 :=** ________________

Currents Scaling Decimal Places (0–3)	**DECPLA1**	:= ________
Voltages Scaling Decimal Places (0–3)	**DECPLV1**	:= ________
Misc Data Scaling Decimal Places (0–3)	**DECPLM1**	:= ________
Amps Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBA1**	:= ________
Volts Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBV1**	:= ________
Misc Data Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA1 := 0 and ECLASSC1 := 0)*	**ANADBM1**	:= ________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ1**	:= ________
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO1**	:= ________
Seconds to send Data Link Heartbeat (0–7200) *(Hidden if DNPTR1 := UDP)*	**DNPINA1**	:= ________
Event Message Confirm Time-Out (1–50 sec))	**ETIMEO1**	:= ________
Enable Unsolicited Reporting (Y, N) *(Hidden if ECLASSA1 := 0, ECLASSB1 := 0, ECLASSC1 := 0, and ECLASSV1 := 0)*	**UNSOL1**	:= ________
Enable Unsolicited Reporting at Power-Up (Y, N) *(Hidden if UNSOL1 := N)*	**PUNSOL1**	:= ________
Number of Events to Transmit On (1–200) *(Hidden if UNSOL1 := N)*	**NUMEVE1**	:= ________
Oldest Event to Tx On (0.0–99999.0 sec) *(Hidden if UNSOL1 := N)*	**AGEEVE1**	:= ________
Unsolicited Message Max Retry Attempts (2–10) *(Hidden if UNSOL1 := N)*	**URETRY1**	:= ________
Unsolicited Message Offline Time-Out (1–5000 sec) *(Hidden if UNSOL1 := N)*	**UTIMEO1**	:= ________

Session 2

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

IP Address {zzz.yyy.xxx.www} (15 characters)	**DNPIP2**	:= ________
Transport Protocol (UDP, TCP)	**DNPTR2**	:= ________
UDP Response Port (REQ, 1–65534)	**DNPUDP2**	:= ________
DNP Address to Report to (0–65519)	**REPADR2**	:= ________
DNP Map (1–3)	**DNPMAP2**	:= ________
Analog Input Default Variation (1–6)	**DVARAI2**	:= ________
Class for Binary Event Data (0–3)	**ECLASSB2**	:= ________
Class for Counter Event Data (0–3)	**ECLASSC2**	:= ________
Class for Analog Event Data (0–3)	**ECLASSA2**	:= ________
Currents Scaling Decimal Places (0–3)	**DECPLA2**	:= ________
Voltages Scaling Decimal Places (0–3)	**DECPLV2**	:= ________
Misc Data Scaling Decimal Places (0–3)	**DECPLM2**	:= ________
Amps Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA2 := 0)*	**ANADBA2**	:= ________

Volts Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA2 := 0)*	**ANADBV2**	:=
Misc Data Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA2 := 0 and ECLASSC2 := 0)*	**ANADBM2**	:=
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ2**	:=
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO2**	:=
Seconds to send Data Link Heartbeat (0–7200) *(Hidden if DNPTR2 := UDP)*	**DNPINA2**	:=
Event Message Confirm Time-Out (1–50 sec))	**ETIMEO2**	:=
Enable Unsolicited Reporting (Y, N) *(Hidden if ECLASSA2 := 0, ECLASSB2 := 0, ECLASSC2 := 0, and ECLASSV2 := 0)*	**UNSOL2**	:=
Enable Unsolicited Reporting at Power-Up (Y, N) *(Hidden if UNSOL2 := N)*	**PUNSOL2**	:=
Number of Events to Transmit On (1–200) *(Hidden if UNSOL2 := N)*	**NUMEVE2**	:=
Oldest Event to Tx On (0.0–99999.0 sec) *(Hidden if UNSOL2 := N)*	**AGEEVE2**	:=
Unsolicited Message Max Retry Attempts (2–10) *(Hidden if UNSOL2 := N)*	**URETRY2**	:=
Unsolicited Message Offline Time-Out (1–5000 sec) *(Hidden if UNSOL2 := N)*	**UTIMEO2**	:=

Session 3

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

IP Address {zzz.yyy.xxx.www} (15 characters)	**DNPIP3**	:=
Transport Protocol (UDP, TCP)	**DNPTR3**	:=
UDP Response Port (REQ, 1–65534)	**DNPUDP3**	:=
DNP Address to Report to (0–65519)	**REPADR3**	:=
DNP Map (1–3)	**DNPMAP3**	:=
Analog Input Default Variation (1–6)	**DVARAI3**	:=
Class for Binary Event Data (0–3)	**ECLASSB3**	:=
Class for Counter Event Data (0–3)	**ECLASSC3**	:=
Class for Analog Event Data (0–3)	**ECLASSA3**	:=
Currents Scaling Decimal Places (0–3)	**DECPLA3**	:=
Voltages Scaling Decimal Places (0–3)	**DECPLV3**	:=
Misc Data Scaling Decimal Places (0–3)	**DECPLM3**	:=
Amps Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA3 := 0)*	**ANADBA3**	:=
Volts Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA3 := 0)*	**ANADBV3**	:=
Misc Data Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA3 := 0 and ECLASSC3 := 0)*	**ANADBM3**	:=
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ3**	:=
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO3**	:=

Seconds to send Data Link Heartbeat (0–7200) *(Hidden if DNPTR3 := UDP)*	**DNPINA3**	:= ______
Event Message Confirm Time-Out (1–50 sec))	**ETIMEO3**	:= ______
Enable Unsolicited Reporting (Y, N) *(Hidden if ECLASSA3 := 0, ECLASSB3 := 0, ECLASSC3 := 0, and ECLASSV3 := 0)*	**UNSOL3**	:= ______
Enable Unsolicited Reporting at Power-Up (Y, N) *(Hidden if UNSOL3 := N)*	**PUNSOL3**	:= ______
Number of Events to Transmit On (1–200) *(Hidden if UNSOL3 := N)*	**NUMEVE3**	:= ______
Oldest Event to Tx On (0.0–99999.0 sec) *(Hidden if UNSOL3 := N)*	**AGEEVE3**	:= ______
Unsolicited Message Max Retry Attempts (2–10) *(Hidden if UNSOL3 := N)*	**URETRY3**	:= ______
Unsolicited Message Offline Time-Out (1–5000 sec) *(Hidden if UNSOL3 := N)*	**UTIMEO3**	:= ______

SNTP Client Protocol Settings

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

Make the following setting when ESNTP ≠ OFF.

Primary Server IP Address (zzz.yyy.xxx.www) **SNTPPSIP** := ______
(Note: To accept updates from any server when ESNTP = BROADCAST, set SNTPPSIP to 0.0.0.0; only IP addresses in the range 224.0.0.1 through 239.255.255.255 are valid when ESNTP = MANYCAST)

Make the following settings when ESNTP = UNICAST.

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

SNTP IP (Local) Port Number (1–65534) **SNTPPORT** := ______
(Note: See Table SET.1 and the note at the end of Port 1 settings)

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

Make the following setting when ESNTP = UNICAST or MANYCAST.

SNTP Timeout (5–20 seconds) **SNTPTO** := ______
(Note: SNTPTO must be less than setting SNTPRATE)

Port Number Settings Must be Unique

When making the SEL-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 changes. If a port number is used more than once, or if it matches any of the fixed port numbers (20, 21, 102, 502), the relay will display an error message and return to the first setting that is in error or contains a duplicate value.

Table SET.1 Port Number Settings That Must be Unique

Setting	Name	Setting Required When
TPORT	Telnet Port	Always
MODNUM1	Modbus TCP Port 1	EMOD > 0
MODNUM2	Modbus TCP Port 2	EMOD > 1
PMOTCP1	PMU Output 1 TCP/IP (Local) Port Number	PMOTS1 = TCP, UDP_T, or UDP_U
PMOTCP2	PMU Output 2 TCP/IP (Local) Port Number	PMOTS2 = TCP, UDP_T, or UDP_U
DNPNUM	DNPTCP and UDP Port	EDNP > 0
SNTPPORT	SNTPIP (Local) Port Number	ESNTP • OFF

PORT 2

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

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

Communications

SPEED (300, 1200, 2400, 4800, 9600, 19200, 38400 bps)	**SPEED**	:= ______
DATA BITS (7, 8 bits) *(Hidden if PROTO := MOD, DNP, PMU, EVMSG, or MB_)*	**BITS**	:= ______
PARITY (O, E, N) *(Hidden if E49RTD := EXT or if PROTO := EVMSG, PMU, or MB_)*	**PARITY**	:= ______
STOP BITS (1, 2 bits) *(Hidden if PROTO := MOD, EVMSG, or MB_)*	**STOP**	:= ______
PORT TIME-OUT (0–30 min) *(Hidden if PROTO := MOD, PMU, EVMSG, or MB_)*	**T_OUT**	:= ______
SEND AUTOMESSAGE (Y, N) *(Hidden if PROTO := MOD, DNP, PMU, EVMSG, or MB_)*	**AUTO**	:= ______
FAST OP MESSAGES (Y, N) *(Hidden if PROTO := MOD, DNP, PMU, EVMSG, or MB_)*	**FASTOP**	:= ______
HDWR HANDSHAKING (Y, N) *(Hidden if PROTO := MOD, DNP, SEL, PMU, EVMSG, or MB_)*	**RTSCTS**	:= ______

Modbus

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

DNP3 Protocol

(Hidden if PROTO := SEL, EVMSG, MB, PMU, or MOD)

DNP Address (0–65519)	**DNPADR**	:= ______
DNP Address to Report to (0–65519)	**REPADR1**	:= ______
DNP Map (1–3)	**DNPMAP1**	:= ______
Analog Input Default Variation (1–6)	**DVARAI1**	:= ______
Class for Binary Event Data (0–3)	**ECLASSB1**	:= ______
Class for Counter Event Data (0–3)	**ECLASSC1**	:= ______
Class for Analog Event Data (0–3)	**ECLASSA1**	:= ______
Currents Scaling Decimal Places (0–3)	**DECPLA1**	:= ______
Voltages Scaling Decimal Places (0–3)	**DECPLV1**	:= ______
Misc Data Scaling Decimal Places (0–3)	**DECPLM1**	:= ______
Amps Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBA1**	:= ______
Volts Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBV1**	:= ______
Misc Data Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA1 := 0 and ECLASSC1 := 0)*	**ANADBM1**	:= ______
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ1**	:= ______

Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO1**	:= ________
Data Link Retries (0–15)	**DRETRY1**	:= ________
Seconds to Data Link Time-Out (0–5) *(Hidden if DRETRY1 := 0)*	**DTIMEO1**	:= ________
Event Message Confirm Time-Out (1–50 sec))	**ETIMEO1**	:= ________
Enable Unsolicited Reporting (Y, N) *(Hidden if ECLASSA1 := 0, ECLASSB1 := 0 and ECLASSC1 := 0)*	**UNSOL1**	:= ________
Enable Unsolicited Reporting at Power-Up (Y, N) *(Hidden if UNSOL1 := N)*	**PUNSOL1**	:= ________
Number of Events to Transmit On (1–200) *(Hidden if UNSOL1 := N)*	**NUMEVE1**	:= ________
Oldest Event to Tx On (0.0–99999.0 sec) *(Hidden if UNSOL1 := N)*	**AGEEVE1**	:= ________
Unsolicited Message Max Retry Attempts (2–10) *(Hidden if UNSOL1 := N)*	**URETRY1**	:= ________
Unsolicited Message Offline Time-Out (1–5000 sec) *(Hidden if UNSOL1 := N)*	**UTIMEO1**	:= ________

MIRRORED BITS Protocol

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

MB Transmit Identifier (1–4)	**TXID**	:= ________
MB Receive Identifier (1–4)	**RXID**	:= ________
MB RX Bad Pickup Time (0–10000 seconds)	**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**	:= ________

PORT 3

(EIA-232/485 Port in Slot B)

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

Communications

SPEED (300, 1200, 2400, 4800, 9600, 19200, 38400 bps)	**SPEED**	:= ________
DATA BITS (7, 8 bits) *(Hidden if PROTO := DNP, PMU, MOD, EVMSG, or MB_)*	**BITS**	:= ________
PARITY (O, E, N) *(Hidden if PROTO := EVMSG, PMU, or MB_)*	**PARITY**	:= ________
STOP BITS (1, 2 bits) *(Hidden if PROTO := MOD, EVMSG, or MB_)*	**STOP**	:= ________
PORT TIME-OUT (0–30 min) *(Hidden if PROTO := MOD, PMU, EVMSG, or MB_)*	**T_OUT**	:= ________
HDWR HANDSHAKING (Y, N) *(Hidden if COMMINF :=485 or PROTO := MOD, DNP, EVMSG, or MB_)*	**RTSCTS**	:= ________
SEND AUTOMESSAGE (Y, N) *(Hidden if PROTO := MOD, DNP, PMU, EVMSG, or MB_)*	**AUTO**	:= ________
FAST OP MESSAGES (Y, N) *(Hidden if PROTO := MOD, DNP, PMU, EVMSG, or MB_)*	**FASTOP**	:= ________

Modbus

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

DNP3 Protocol

(Hidden if PROTO := SEL, EVMSG, MB, PMU or MOD)

DNP Address (0–65519)	**DNPADR**	:= ________
DNP Address to Report to (0–65519)	**REPADR1**	:= ________
DNP Map (1–3)	**DNPMAP1**	:= ________
Analog Input Default Variation (1–6)	**DVARAI1**	:= ________
Class for Binary Event Data (0–3)	**ECLASSB1**	:= ________
Class for Counter Event Data (0–3)	**ECLASSC1**	:= ________
Class for Analog Event Data (0–3)	**ECLASSA1**	:= ________
Currents Scaling Decimal Places (0–3)	**DECPLA1**	:= ________
Voltages Scaling Decimal Places (0–3)	**DECPLV1**	:= ________
Misc Data Scaling Decimal Places (0–3)	**DECPLM1**	:= ________
Amps Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBA1**	:= ________
Volts Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBV1**	:= ________
Misc Data Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA1 := 0 and ECLASSC1 := 0)*	**ANADBM1**	:= ________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ1**	:= ________
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO1**	:= ________

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

Modem Protocol

(For DNP3 session and EIA-232 port only)

Modem Connected to Port (Y, N)	**MODEM**	:= ________
Modem Startup String (30 characters)	**MSTR**	:= ________
Phone Number for Dial-Out (30 characters)	**PH_NUM1**	:= ________
Phone Number for Dial-Out (30 characters)	**PH_NUM2**	:= ________
Retry Attempts for Phone 1 Dial-Out (1–20)	**RETRY1**	:= ________
Retry Attempts for Phone 2 Dial-Out (1–20)	**RETRY2**	:= ________
Time to Attempt Dial (5–300 sec)	**MDTIME**	:= ________
Time Between Dial-Out Attempts (5–3600 sec)	**MDRET**	:= ________

MIRRORED BITS Protocol

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

MB Transmit Identifier (1–4)	**TXID**	:= ________
MB Receive Identifier (1–4)	**RXID**	:= ________
MB RX Bad Pickup Time (0–10000 seconds)	**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**	:= ________

PORT 4

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

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

Interface Select

(Hidden if PROTO := DNET)

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

Communications

SPEED (300–38400 bps) *(Hidden if PROTO := DNET)*	**SPEED**	:= ________
DATA BITS (7, 8 bits) *(Hidden if PROTO := DNP, MOD, PMU, EVMSG, MB_, or DNET)*	**BITS**	:= ________
PARITY (O, E, N) *(Hidden if PROTO := DNET, EVMSG, PMU, or MB_)*	**PARITY**	:= ________
STOP BITS (1, 2 bits) *(Hidden if PROTO := MOD, EVMSG, MB_, or DNET)*	**STOP**	:= ________
PORT TIME-OUT (0–30 min) *(Hidden if PROTO := MOD, EVMSG, MB_, PMU, or DNET)*	**T_OUT**	:= ________
HDWR HANDSHAKING (Y, N) *(Hidden if COMMINF := 485 or PROTO := MOD, DNP, EVMSG, MB_, or DNET)*	**RTSCTS**	:= ________
SEND AUTOMESSAGE (Y, N) *(Hidden if PROTO := DNP, MOD, EVMSG, MB_, PMU, or DNET)*	**AUTO**	:= ________
FAST OP MESSAGES (Y, N) *(Hidden if PROTO := DNP, MOD, EVMSG, MB_, PMU, or DNET)*	**FASTOP**	:= ________

Modbus

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

DNP3 Protocol

(Hidden if PROTO := SEL, EVMSG, MB, PMU , DNET or MOD)

DNP Address (0–65519)	**DNPADR**	:= ________
DNP Address to Report to (0–65519)	**REPADR1**	:= ________
DNP Map (1–3)	**DNPMAP1**	:= ________
Analog Input Default Variation (1–6)	**DVARAI1**	:= ________
Class for Binary Event Data (0–3)	**ECLASSB1**	:= ________
Class for Counter Event Data (0–3)	**ECLASSC1**	:= ________
Class for Analog Event Data (0–3)	**ECLASSA1**	:= ________
Currents Scaling Decimal Places (0–3)	**DECPLA1**	:= ________
Voltages Scaling Decimal Places (0–3)	**DECPLV1**	:= ________
Misc Data Scaling Decimal Places (0–3)	**DECPLM1**	:= ________
Amps Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBA1**	:= ________
Volts Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBV1**	:= ________
Misc Data Reporting Dead-band Counts (0–32767) *(Hidden if ECLASSA1 := 0 and ECLASSC1 := 0)*	**ANADBM1**	:= ________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ1**	:= ________
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO1**	:= ________
Data Link Retries (0–15)	**DRETRY1**	:= ________
Seconds to Data Link Time-Out (0–5) *(Hidden if DRETRY1 := 0)*	**DTIMEO1**	:= ________
Event Message Confirm Time-Out (1–50 sec))	**ETIMEO1**	:= ________
Enable Unsolicited Reporting (Y, N) *(Hidden if ECLASSA1 := 0, ECLASSB1 := 0, ECLASSC1 := 0, and ECLASSV1 := 0)*	**UNSOL1**	:= ________
Enable Unsolicited Reporting at Power-Up (Y, N) *(Hidden if UNSOL1 := N)*	**PUNSOL1**	:= ________
Number of Events to Transmit On (1–200) *(Hidden if UNSOL1 := N)*	**NUMEVE1**	:= ________
Oldest Event to Tx On (0.0–99999.0 sec) *(Hidden if UNSOL1 := N)*	**AGEEVE1**	:= ________
Unsolicited Message Max Retry Attempts (2–10) *(Hidden if UNSOL1 := N)*	**URETRY1**	:= ________
Unsolicited Message Offline Time-Out (1–5000 sec) *(Hidden if UNSOL1 := N)*	**UTIMEO1**	:= ________
Minimum Seconds from DCD to TX (0.00–1.00)	**MINDLY**	:= ________
Maximum Seconds from DCD to TX (0.00–1.00)	**MAXDLY**	:= ________
Settle Time from RTS On to TX (OFF, 0.00–30.00 sec)	**PREDLY**	:= ________
Settle Time from TX to RTS OFF (0.00–30.00 sec)	**PSTDLY**	:= ________

Modem Protocol

(For DNP3 session and EIA232 port only)

Modem Connected to Port (Y, N)	**MODEM**	:= ________
Modem Startup String (30 characters)	**MSTR**	:= ________
Phone Number for Dial-Out (30 characters)	**PH_NUM1**	:= ________
Phone Number for Dial-Out (30 characters)	**PH_NUM2**	:= ________
Retry Attempts for Phone 1 Dial-Out (1–20)	**RETRY1**	:= ________
Retry Attempts for Phone 2 Dial-Out (1–20)	**RETRY2**	:= ________
Time to Attempt Dial (5–300 sec)	**MDTIME**	:= ________
Time Between Dial-Out Attempts (5–3600 sec)	**MDRET**	:= ________

MIRRORED BITS Protocol

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

MB Transmit Identifier (1–4)	**TXID**	:= ________
MB Receive Identifier (1–4)	**RXID**	:= ________
MB RX Bad Pickup Time (0–10000 seconds)	**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**	:= ________

Front-Panel Settings (SET F Command)

General

DISPLY PTS ENABL (N, 1–32)	**EDP**	:= ______
LOCAL BITS ENABL (N, 1–32)	**ELB**	:= ______
LCD TIMEOUT (OFF, 1–30 min)	**FP_TO**	:= ______
LCD CONTRAST (1–8)	**FP_CONT**	:= ______
FP AUTOMESSAGES (OVERRIDE, ROTATING)	**FP_AUTO**	:= ______
CLOSE RESET LEDS (Y, N)	**RSTLED**	:= ______
ENA_LED COLOR (R = Red, G = Green, A = Amber)	**LEDENAC**	:= ______
TRIP_LED COLOR (R = Red, G = Green, A = Amber)	**LEDTRPC**	:= ______

Target LED

(R = Red, G = Green, A = Amber)

TRIP LATCH T_LED (Y, N)	**T01LEDL**	:= ______
TARGET T_LED ASSERTED COLOR (R, G, A)	**T01LEDC**	:= ______
LED1 EQUATION (SELOGIC)	**T01_LED**	:= ______
TRIP LATCH T_LED (Y, N)	**T02LEDL**	:= ______
TARGET T_LED ASSERTED COLOR (R, G, A)	**T02LEDC**	:= ______
LED2 EQUATION (SELOGIC)	**T02_LED**	:= ______
TRIP LATCH T_LED (Y, N)	**T03LEDL**	:= ______
TARGET T_LED ASSERTED COLOR (R, G, A)	**T03LEDC**	:= ______
LED3 EQUATION (SELOGIC)	**T03_LED**	:= ______
TRIP LATCH T_LED (Y, N)	**T04LEDL**	:= ______
TARGET T_LED ASSERTED COLOR (R, G, A)	**T04LEDC**	:= ______
LED4 EQUATION (SELOGIC)	**T04_LED**	:= ______
TRIP LATCH T_LED (Y, N)	**T05LEDL**	:= ______
TARGET T_LED ASSERTED COLOR (R, G, A)	**T05LEDC**	:= ______
LED5 EQUATION (SELOGIC)	**T05_LED**	:= ______
TRIP LATCH T_LED (Y, N)	**T06LEDL**	:= ______
TARGET T_LED ASSERTED COLOR (R, G, A)	**T06LEDC**	:= ______
LED6 EQUATION (SELOGIC)	**T06_LED**	:= ______

Operator Control LED

(Asserted/deasserted color choices: R = Red, G = Green, A = Amber, O = Off. Asserted and deasserted colors must be different)

PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB1ALEDC**	:= ______
PB1A_LED EQUATION (SELOGIC)	**PB1A_LED**	:= ______
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB1BLEDC**	:= ______

PB1B_LED EQUATION (SELOGIC)	**PB1B_LED :=** ________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB2ALEDC:=** ________
PB2A_LED EQUATION (SELOGIC)	**PB2A_LED :=** ________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB2BLEDC:=** ________
PB2B_LED EQUATION (SELOGIC)	**PB2B_LED :=** ________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB3ALEDC:=** ________
PB3A_LED EQUATION (SELOGIC)	**PB3A_LED :=** ________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB3BLEDC:=** ________
PB3B_LED EQUATION (SELOGIC)	**PB3B_LED :=** ________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB4ALEDC:=** ________
PB4A_LED EQUATION (SELOGIC)	**PB4A_LED :=** ________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB4BLEDC:=** ________
PB4B_LED EQUATION (SELOGIC)	**PB4B_LED :=** ________
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

Display Point Settings (maximum 60 characters):
(Boolean): Relay Word Bit Name, "Alias", "Set String", "Clear String"
(Analog): Analog Quantity Name, "User Text and Formatting"

DISPLAY POINT DP01 (60 characters)	**DP01**	:= ________
DISPLAY POINT DP02 (60 characters)	**DP02**	:= ________
DISPLAY POINT DP03 (60 characters)	**DP03**	:= ________
DISPLAY POINT DP04 (60 characters)	**DP04**	:= ________
DISPLAY POINT DP05 (60 characters)	**DP05**	:= ________
DISPLAY POINT DP06 (60 characters)	**DP06**	:= ________
DISPLAY POINT DP07 (60 characters)	**DP07**	:= ________
DISPLAY POINT DP08 (60 characters)	**DP08**	:= ________
DISPLAY POINT DP09 (60 characters)	**DP09**	:= ________
DISPLAY POINT DP10 (60 characters)	**DP10**	:= ________
DISPLAY POINT DP11 (60 characters)	**DP11**	:= ________
DISPLAY POINT DP12 (60 characters)	**DP12**	:= ________
DISPLAY POINT DP13 (60 characters)	**DP13**	:= ________
DISPLAY POINT DP14 (60 characters)	**DP14**	:= ________
DISPLAY POINT DP15 (60 characters)	**DP15**	:= ________
DISPLAY POINT DP16 (60 characters)	**DP16**	:= ________
DISPLAY POINT DP17 (60 characters)	**DP17**	:= ________
DISPLAY POINT DP18 (60 characters)	**DP18**	:= ________
DISPLAY POINT DP19 (60 characters)	**DP19**	:= ________
DISPLAY POINT DP20 (60 characters)	**DP20**	:= ________
DISPLAY POINT DP21 (60 characters)	**DP21**	:= ________
DISPLAY POINT DP22 (60 characters)	**DP22**	:= ________
DISPLAY POINT DP23 (60 characters)	**DP23**	:= ________
DISPLAY POINT DP24 (60 characters)	**DP24**	:= ________
DISPLAY POINT DP25 (60 characters)	**DP25**	:= ________
DISPLAY POINT DP26 (60 characters)	**DP26**	:= ________
DISPLAY POINT DP27 (60 characters)	**DP27**	:= ________
DISPLAY POINT DP28 (60 characters)	**DP28**	:= ________
DISPLAY POINT DP29 (60 characters)	**DP29**	:= ________
DISPLAY POINT DP30 (60 characters)	**DP30**	:= ________
DISPLAY POINT DP31 (60 characters)	**DP31**	:= ________
DISPLAY POINT DP32 (60 characters)	**DP32**	:= ________

Date____________

Local Bits Labels

LB_NAME (14 characters)	**NLB01**	:= ________
CLEAR LB_ LABEL (7 characters)	**CLB01**	:= ________
SET LB_ LABEL (7 characters)	**SLB01**	:= ________
PULSE LB_ LABEL (7 characters)	**PLB01**	:= ________
LB_NAME (14 characters)	**NLB02**	:= ________
CLEAR LB_ LABEL (7 characters)	**CLB02**	:= ________
SET LB_ LABEL (7 characters)	**SLB02**	:= ________
PULSE LB_ LABEL (7 characters)	**PLB02**	:= ________
LB_NAME (14 characters)	**NLB03**	:= ________
CLEAR LB_ LABEL (7 characters)	**CLB03**	:= ________
SET LB_ LABEL (7 characters)	**SLB03**	:= ________
PULSE LB_ LABEL (7 characters)	**PLB03**	:= ________
LB_NAME (14 characters)	**NLB04**	:= ________
CLEAR LB_ LABEL (7 characters)	**CLB04**	:= ________
SET LB_ LABEL (7 characters)	**SLB04**	:= ________
PULSE LB_ LABEL (7 characters)	**PLB04**	:= ________
LB_NAME (14 characters)	**NLB05**	:= ________
CLEAR LB_ LABEL (7 characters)	**CLB05**	:= ________
SET LB_ LABEL (7 characters)	**SLB05**	:= ________
PULSE LB_ LABEL (7 characters)	**PLB05**	:= ________
LB_NAME (14 characters)	**NLB06**	:= ________
CLEAR LB_ LABEL (7 characters)	**CLB06**	:= ________
SET LB_ LABEL (7 characters)	**SLB06**	:= ________
PULSE LB_ LABEL (7 characters)	**PLB06**	:= ________
LB_NAME (14 characters)	**NLB07**	:= ________
CLEAR LB_ LABEL (7 characters)	**CLB07**	:= ________
SET LB_ LABEL (7 characters)	**SLB07**	:= ________
PULSE LB_ LABEL (7 characters)	**PLB07**	:= ________
LB_NAME (14 characters)	**NLB08**	:= ________
CLEAR LB_ LABEL (7 characters)	**CLB08**	:= ________
SET LB_ LABEL (7 characters)	**SLB08**	:= ________
PULSE LB_ LABEL (7 characters)	**PLB08**	:= ________
LB_NAME (14 characters)	**NLB09**	:= ________
CLEAR LB_ LABEL (7 characters)	**CLB09**	:= ________
SET LB_ LABEL (7 characters)	**SLB09**	:= ________
PULSE LB_ LABEL (7 characters)	**PLB09**	:= ________
LB_NAME (14 characters)	**NLB10**	:= ________

CLEAR LB_ LABEL (7 characters)	**CLB10**	:=	________
SET LB_ LABEL (7 characters)	**SLB10**	:=	________
PULSE LB_ LABEL (7 characters)	**PLB10**	:=	________
LB_NAME (14 characters)	**NLB11**	:=	________
CLEAR LB_ LABEL (7 characters)	**CLB11**	:=	________
SET LB_ LABEL (7 characters)	**SLB11**	:=	________
PULSE LB_ LABEL (7 characters)	**PLB11**	:=	________
LB_NAME (14 characters)	**NLB12**	:=	________
CLEAR LB_ LABEL (7 characters)	**CLB12**	:=	________
SET LB_ LABEL (7 characters)	**SLB12**	:=	________
PULSE LB_ LABEL (7 characters)	**PLB12**	:=	________
LB_NAME (14 characters)	**NLB13**	:=	________
CLEAR LB_ LABEL (7 characters)	**CLB13**	:=	________
SET LB_ LABEL (7 characters)	**SLB13**	:=	________
PULSE LB_ LABEL (7 characters)	**PLB13**	:=	________
LB_NAME (14 characters)	**NLB14**	:=	________
CLEAR LB_ LABEL (7 characters)	**CLB14**	:=	________
SET LB_ LABEL (7 characters)	**SLB14**	:=	________
PULSE LB_ LABEL (7 characters)	**PLB14**	:=	________
LB_NAME (14 characters)	**NLB15**	:=	________
CLEAR LB_ LABEL (7 characters)	**CLB15**	:=	________
SET LB_ LABEL (7 characters)	**SLB15**	:=	________
PULSE LB_ LABEL (7 characters)	**PLB15**	:=	________
LB_NAME (14 characters)	**NLB16**	:=	________
CLEAR LB_ LABEL (7 characters)	**CLB16**	:=	________
SET LB_ LABEL (7 characters)	**SLB16**	:=	________
PULSE LB_ LABEL (7 characters)	**PLB16**	:=	________
LB_NAME (14 characters)	**NLB17**	:=	________
CLEAR LB_ LABEL (7 characters)	**CLB17**	:=	________
SET LB_ LABEL (7 characters)	**SLB17**	:=	________
PULSE LB_ LABEL (7 characters)	**PLB17**	:=	________
LB_NAME (14 characters)	**NLB18**	:=	________
CLEAR LB_ LABEL (7 characters)	**CLB18**	:=	________
SET LB_ LABEL (7 characters)	**SLB18**	:=	________
PULSE LB_ LABEL (7 characters)	**PLB18**	:=	________
LB_NAME (14 characters)	**NLB19**	:=	________
CLEAR LB_ LABEL (7 characters)	**CLB19**	:=	________
SET LB_ LABEL (7 characters)	**SLB19**	:=	________

PULSE LB_ LABEL (7 characters)	**PLB19**	:=
LB_NAME (14 characters)	**NLB20**	:=
CLEAR LB_ LABEL (7 characters)	**CLB20**	:=
SET LB_ LABEL (7 characters)	**SLB20**	:=
PULSE LB_ LABEL (7 characters)	**PLB20**	:=
LB_NAME (14 characters)	**NLB21**	:=
CLEAR LB_ LABEL (7 characters)	**CLB21**	:=
SET LB_ LABEL (7 characters)	**SLB21**	:=
PULSE LB_ LABEL (7 characters)	**PLB21**	:=
LB_NAME (14 characters)	**NLB22**	:=
CLEAR LB_ LABEL (7 characters)	**CLB22**	:=
SET LB_ LABEL (7 characters)	**SLB22**	:=
PULSE LB_ LABEL (7 characters)	**PLB22**	:=
LB_NAME (14 characters)	**NLB23**	:=
CLEAR LB_ LABEL (7 characters)	**CLB23**	:=
SET LB_ LABEL (7 characters)	**SLB23**	:=
PULSE LB_ LABEL (7 characters)	**PLB23**	:=
LB_NAME (14 characters)	**NLB24**	:=
CLEAR LB_ LABEL (7 characters)	**CLB24**	:=
SET LB_ LABEL (7 characters)	**SLB24**	:=
PULSE LB_ LABEL (7 characters)	**PLB24**	:=
LB_NAME (14 characters)	**NLB25**	:=
CLEAR LB_ LABEL (7 characters)	**CLB25**	:=
SET LB_ LABEL (7 characters)	**SLB25**	:=
PULSE LB_ LABEL (7 characters)	**PLB25**	:=
LB_NAME (14 characters)	**NLB26**	:=
CLEAR LB_ LABEL (7 characters)	**CLB26**	:=
SET LB_ LABEL (7 characters)	**SLB26**	:=
PULSE LB_ LABEL (7 characters)	**PLB26**	:=
LB_NAME (14 characters)	**NLB27**	:=
CLEAR LB_ LABEL (7 characters)	**CLB27**	:=
SET LB_ LABEL (7 characters)	**SLB27**	:=
PULSE LB_ LABEL (7 characters)	**PLB27**	:=
LB_NAME (14 characters)	**NLB28**	:=
CLEAR LB_ LABEL (7 characters)	**CLB28**	:=
SET LB_ LABEL (7 characters)	**SLB28**	:=
PULSE LB_ LABEL (7 characters)	**PLB28**	:=
LB_NAME (14 characters)	**NLB29**	:=

CLEAR LB_ LABEL (7 characters)	**CLB29**	:=	
SET LB_ LABEL (7 characters)	**SLB29**	:=	
PULSE LB_ LABEL (7 characters)	**PLB29**	:=	
LB_NAME (14 characters)	**NLB30**	:=	
CLEAR LB_ LABEL (7 characters)	**CLB30**	:=	
SET LB_ LABEL (7 characters)	**SLB30**	:=	
PULSE LB_ LABEL (7 characters)	**PLB30**	:=	
LB_NAME (14 characters)	**NLB31**	:=	
CLEAR LB_ LABEL (7 characters)	**CLB31**	:=	
SET LB_ LABEL (7 characters)	**SLB31**	:=	
PULSE LB_ LABEL (7 characters)	**PLB31**	:=	
LB_NAME (14 characters)	**NLB32**	:=	
CLEAR LB_ LABEL (7 characters)	**CLB32**	:=	
SET LB_ LABEL (7 characters)	**SLB32**	:=	
PULSE LB_ LABEL (7 characters)	**PLB32**	:=	

Report Settings (SET R Command)

SER Chatter Criteria

Auto-Removal Enable (Y, N)	**ESERDEL**	:=	
Number of Counts (2–20 counts)	**SRDLCNT**	:=	
Removal Time (0.1–90.0 seconds)	**SRDLTIM**	:=	

SER Trigger Lists

SERn = As many as 24 Relay Word elements separated by spaces or commas. Use NA to disable setting.

SER1	:=	
SER2	:=	
SER3	:=	
SER4	:=	

Relay Word Bit Aliases

ALIASn= 'RW Bit'(space)'Alias'(space)'Asserted Text'(space)'Deasserted Text'. Alias, Asserted, and Deasserted text strings can be as many as 15 characters long. Use NA to disable setting.

Enable ALIAS (N, 1–20)	**EALIAS**	:=	
ALIAS1	**ALIAS1**	:=	
ALIAS2	**ALIAS2**	:=	
ALIAS3	**ALIAS3**	:=	
ALIAS4	**ALIAS4**	:=	
ALIAS5	**ALIAS5**	:=	
ALIAS6	**ALIAS6**	:=	

ALIAS7	**ALIAS7**	:= ______
ALIAS8	**ALIAS8**	:= ______
ALIAS 9	**ALIAS9**	:= ______
ALIAS10	**ALIAS10**	:= ______
ALIAS11	**ALIAS11**	:= ______
ALIAS12	**ALIAS12**	:= ______
ALIAS13	**ALIAS13**	:= ______
ALIAS14	**ALIAS14**	:= ______
ALIAS15	**ALIAS15**	:= ______
ALIAS16	**ALIAS16**	:= ______
ALIAS17	**ALIAS17**	:= ______
ALIAS18	**ALIAS18**	:= ______
ALIAS19	**ALIAS19**	:= ______
ALIAS20	**ALIAS20**	:= ______

Event Report

EVENT TRIGGER (SELOGIC)	**ER**	:= ______
EVENT LENGTH (15, 64, 180 cyc)	**LER**	:= ______
PREFAULT LENGTH (1–10 cyc {if LER := 15}, 1–59 cyc {if LER := 64}, 1–175 cyc {if LER := 180})	**PRE**	:= ______

HIF Event Reporting

(Hidden if the AST option is not included in the MOT.)

HIF EVENT LENGTH (2, 5, 10, 20 min)	**HIFLER**	:= ______

Fast Message Read Settings

FMRnNAM = Any valid string. (No spaces allowed; should be different from other FMRxNAM)

FMRn = As many as 24 analog quantities separated by spaces or commas. (Analog quantities listed here will be included in the Fast Message read request)

Use NA to disable setting.

FMR1 Name (9 characters)	**FMR1NAM**	:= ______
Fast Message Read FMR1 (24 analog quantities)	**FMR1**	:= ______
FMR2 Name (9 characters)	**FMR2NAM**	:= ______
Fast Message Read FMR2 (24 analog quantities)	**FMR2**	:= ______
FMR3 Name (9 characters)	**FMR3NAM**	:= ______
Fast Message Read FMR3 (24 analog quantities)	**FMR3**	:= ______
FMR4 Name (9 characters)	**FMR4NAM**	:= ______
Fast Message Read FMR4 (24 analog quantities)	**FMR4**	:= ______

Fast Message Remote Analog Settings

I = Integer, F = Float, L = Long

Remote Analog Value Type (I, F, L)	**RA01TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA02TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA03TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA04TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA05TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA06TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA07TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA08TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA09TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA10TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA11TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA12TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA13TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA14TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA15TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA16TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA17TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA18TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA19TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA20TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA21TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA22TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA23TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA24TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA25TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA26TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA27TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA28TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA29TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA30TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA31TYPE :=** ________
Remote Analog Value Type (I, F, L)	**RA32TYPE :=** ________

Load Profile

LDP LIST (NA, As many as 17 analog quantities)	**LDLIST** := ________
LDP ACQ RATE (5, 10, 15, 30, 60 min.)	**LDAR** := ________

Modbus Map Settings (SET M Command)

Modbus User Map

(See Appendix E: Modbus RTU Communications for additional details)

User Map Register Label Name (8 characters)	**MOD_001**	:= ______
User Map Register Label Name (8 characters)	**MOD_002**	:= ______
User Map Register Label Name (8 characters)	**MOD_003**	:= ______
User Map Register Label Name (8 characters)	**MOD_004**	:= ______
User Map Register Label Name (8 characters)	**MOD_005**	:= ______
User Map Register Label Name (8 characters)	**MOD_006**	:= ______
User Map Register Label Name (8 characters)	**MOD_007**	:= ______
User Map Register Label Name (8 characters)	**MOD_008**	:= ______
User Map Register Label Name (8 characters)	**MOD_009**	:= ______
User Map Register Label Name (8 characters)	**MOD_010**	:= ______
User Map Register Label Name (8 characters)	**MOD_011**	:= ______
User Map Register Label Name (8 characters)	**MOD_012**	:= ______
User Map Register Label Name (8 characters)	**MOD_013**	:= ______
User Map Register Label Name (8 characters)	**MOD_014**	:= ______
User Map Register Label Name (8 characters)	**MOD_015**	:= ______
User Map Register Label Name (8 characters)	**MOD_016**	:= ______
User Map Register Label Name (8 characters)	**MOD_017**	:= ______
User Map Register Label Name (8 characters)	**MOD_018**	:= ______
User Map Register Label Name (8 characters)	**MOD_019**	:= ______
User Map Register Label Name (8 characters)	**MOD_020**	:= ______
User Map Register Label Name (8 characters)	**MOD_021**	:= ______
User Map Register Label Name (8 characters)	**MOD_022**	:= ______
User Map Register Label Name (8 characters)	**MOD_023**	:= ______
User Map Register Label Name (8 characters)	**MOD_024**	:= ______
User Map Register Label Name (8 characters)	**MOD_025**	:= ______
User Map Register Label Name (8 characters)	**MOD_026**	:= ______
User Map Register Label Name (8 characters)	**MOD_027**	:= ______
User Map Register Label Name (8 characters)	**MOD_028**	:= ______
User Map Register Label Name (8 characters)	**MOD_029**	:= ______
User Map Register Label Name (8 characters)	**MOD_030**	:= ______
User Map Register Label Name (8 characters)	**MOD_031**	:= ______
User Map Register Label Name (8 characters)	**MOD_032**	:= ______
User Map Register Label Name (8 characters)	**MOD_033**	:= ______
User Map Register Label Name (8 characters)	**MOD_034**	:= ______

User Map Register Label Name (8 characters)	**MOD_035**	:= ________
User Map Register Label Name (8 characters)	**MOD_036**	:= ________
User Map Register Label Name (8 characters)	**MOD_037**	:= ________
User Map Register Label Name (8 characters)	**MOD_038**	:= ________
User Map Register Label Name (8 characters)	**MOD_039**	:= ________
User Map Register Label Name (8 characters)	**MOD_040**	:= ________
User Map Register Label Name (8 characters)	**MOD_041**	:= ________
User Map Register Label Name (8 characters)	**MOD_042**	:= ________
User Map Register Label Name (8 characters)	**MOD_043**	:= ________
User Map Register Label Name (8 characters)	**MOD_044**	:= ________
User Map Register Label Name (8 characters)	**MOD_045**	:= ________
User Map Register Label Name (8 characters)	**MOD_046**	:= ________
User Map Register Label Name (8 characters)	**MOD_047**	:= ________
User Map Register Label Name (8 characters)	**MOD_048**	:= ________
User Map Register Label Name (8 characters)	**MOD_049**	:= ________
User Map Register Label Name (8 characters)	**MOD_050**	:= ________
User Map Register Label Name (8 characters)	**MOD_051**	:= ________
User Map Register Label Name (8 characters)	**MOD_052**	:= ________
User Map Register Label Name (8 characters)	**MOD_053**	:= ________
User Map Register Label Name (8 characters)	**MOD_054**	:= ________
User Map Register Label Name (8 characters)	**MOD_055**	:= ________
User Map Register Label Name (8 characters)	**MOD_056**	:= ________
User Map Register Label Name (8 characters)	**MOD_057**	:= ________
User Map Register Label Name (8 characters)	**MOD_058**	:= ________
User Map Register Label Name (8 characters)	**MOD_059**	:= ________
User Map Register Label Name (8 characters)	**MOD_060**	:= ________
User Map Register Label Name (8 characters)	**MOD_061**	:= ________
User Map Register Label Name (8 characters)	**MOD_062**	:= ________
User Map Register Label Name (8 characters)	**MOD_063**	:= ________
User Map Register Label Name (8 characters)	**MOD_064**	:= ________
User Map Register Label Name (8 characters)	**MOD_065**	:= ________
User Map Register Label Name (8 characters)	**MOD_066**	:= ________
User Map Register Label Name (8 characters)	**MOD_067**	:= ________
User Map Register Label Name (8 characters)	**MOD_068**	:= ________
User Map Register Label Name (8 characters)	**MOD_069**	:= ________
User Map Register Label Name (8 characters)	**MOD_070**	:= ________
User Map Register Label Name (8 characters)	**MOD_071**	:= ________
User Map Register Label Name (8 characters)	**MOD_072**	:= ________

User Map Register Label Name (8 characters)	**MOD_073**	:=	______
User Map Register Label Name (8 characters)	**MOD_074**	:=	______
User Map Register Label Name (8 characters)	**MOD_075**	:=	______
User Map Register Label Name (8 characters)	**MOD_076**	:=	______
User Map Register Label Name (8 characters)	**MOD_077**	:=	______
User Map Register Label Name (8 characters)	**MOD_078**	:=	______
User Map Register Label Name (8 characters)	**MOD_079**	:=	______
User Map Register Label Name (8 characters)	**MOD_080**	:=	______
User Map Register Label Name (8 characters)	**MOD_081**	:=	______
User Map Register Label Name (8 characters)	**MOD_082**	:=	______
User Map Register Label Name (8 characters)	**MOD_083**	:=	______
User Map Register Label Name (8 characters)	**MOD_084**	:=	______
User Map Register Label Name (8 characters)	**MOD_085**	:=	______
User Map Register Label Name (8 characters)	**MOD_086**	:=	______
User Map Register Label Name (8 characters)	**MOD_087**	:=	______
User Map Register Label Name (8 characters)	**MOD_088**	:=	______
User Map Register Label Name (8 characters)	**MOD_089**	:=	______
User Map Register Label Name (8 characters)	**MOD_090**	:=	______
User Map Register Label Name (8 characters)	**MOD_091**	:=	______
User Map Register Label Name (8 characters)	**MOD_092**	:=	______
User Map Register Label Name (8 characters)	**MOD_093**	:=	______
User Map Register Label Name (8 characters)	**MOD_094**	:=	______
User Map Register Label Name (8 characters)	**MOD_095**	:=	______
User Map Register Label Name (8 characters)	**MOD_096**	:=	______
User Map Register Label Name (8 characters)	**MOD_097**	:=	______
User Map Register Label Name (8 characters)	**MOD_098**	:=	______
User Map Register Label Name (8 characters)	**MOD_099**	:=	______
User Map Register Label Name (8 characters)	**MOD_100**	:=	______
User Map Register Label Name (8 characters)	**MOD_101**	:=	______
User Map Register Label Name (8 characters)	**MOD_102**	:=	______
User Map Register Label Name (8 characters)	**MOD_103**	:=	______
User Map Register Label Name (8 characters)	**MOD_104**	:=	______
User Map Register Label Name (8 characters)	**MOD_105**	:=	______
User Map Register Label Name (8 characters)	**MOD_106**	:=	______
User Map Register Label Name (8 characters)	**MOD_107**	:=	______
User Map Register Label Name (8 characters)	**MOD_108**	:=	______
User Map Register Label Name (8 characters)	**MOD_109**	:=	______
User Map Register Label Name (8 characters)	**MOD_110**	:=	______

User Map Register Label Name (8 characters)	**MOD_111**	:=	______
User Map Register Label Name (8 characters)	**MOD_112**	:=	______
User Map Register Label Name (8 characters)	**MOD_113**	:=	______
User Map Register Label Name (8 characters)	**MOD_114**	:=	______
User Map Register Label Name (8 characters)	**MOD_115**	:=	______
User Map Register Label Name (8 characters)	**MOD_116**	:=	______
User Map Register Label Name (8 characters)	**MOD_117**	:=	______
User Map Register Label Name (8 characters)	**MOD_118**	:=	______
User Map Register Label Name (8 characters)	**MOD_119**	:=	______
User Map Register Label Name (8 characters)	**MOD_120**	:=	______
User Map Register Label Name (8 characters)	**MOD_121**	:=	______
User Map Register Label Name (8 characters)	**MOD_122**	:=	______
User Map Register Label Name (8 characters)	**MOD_123**	:=	______
User Map Register Label Name (8 characters)	**MOD_124**	:=	______
User Map Register Label Name (8 characters)	**MOD_125**	:=	______

DNP3 Map Settings (SET DNP n Command)

(Hidden if the DNP option is not included)

Use the ***SET DNP*** *n command with n = 1, 2, or 3 to create as many as three DNP User Maps. Refer to Appendix D: DNP3 Communications for details. This is DNP Map 1 (DNP Map 2 and DNP Map 3 tables are identical to DNP Map 1 table).*

Binary Input Map

DNP Binary Input Label Name (10 characters)	**BI_00**	:=	______
DNP Binary Input Label Name (10 characters)	**BI_01**	:=	______
DNP Binary Input Label Name (10 characters)	**BI_02**	:=	______
DNP Binary Input Label Name (10 characters)	**BI_03**	:=	______
DNP Binary Input Label Name (10 characters)	**BI_04**	:=	______
DNP Binary Input Label Name (10 characters)	**BI_05**	:=	______
DNP Binary Input Label Name (10 characters)	**BI_06**	:=	______
DNP Binary Input Label Name (10 characters)	**BI_07**	:=	______
DNP Binary Input Label Name (10 characters)	**BI_08**	:=	______
DNP Binary Input Label Name (10 characters)	**BI_09**	:=	______
DNP Binary Input Label Name (10 characters)	**BI_10**	:=	______
DNP Binary Input Label Name (10 characters)	**BI_11**	:=	______
DNP Binary Input Label Name (10 characters)	**BI_12**	:=	______
DNP Binary Input Label Name (10 characters)	**BI_13**	:=	______
DNP Binary Input Label Name (10 characters)	**BI_14**	:=	______
DNP Binary Input Label Name (10 characters)	**BI_15**	:=	______

DNP Binary Input Label Name (10 characters)	**BI_16**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_17**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_18**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_19**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_20**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_21**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_22**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_23**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_24**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_25**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_26**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_27**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_28**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_29**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_30**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_31**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_32**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_33**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_34**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_35**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_36**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_37**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_38**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_39**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_40**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_41**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_42**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_43**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_44**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_45**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_46**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_47**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_48**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_49**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_50**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_51**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_52**	:= ______
DNP Binary Input Label Name (10 characters)	**BI_53**	:= ______

DNP Binary Input Label Name (10 characters)	**BI_54**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_55**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_56**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_57**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_58**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_59**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_60**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_61**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_62**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_63**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_64**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_65**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_66**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_67**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_68**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_69**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_70**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_71**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_72**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_73**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_74**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_75**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_76**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_77**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_78**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_79**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_80**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_81**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_82**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_83**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_84**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_85**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_86**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_87**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_88**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_89**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_90**	:=	____________
DNP Binary Input Label Name (10 characters)	**BI_91**	:=	____________

DNP Binary Input Label Name (10 characters)	**BI_92**	:= ________
DNP Binary Input Label Name (10 characters)	**BI_93**	:= ________
DNP Binary Input Label Name (10 characters)	**BI_94**	:= ________
DNP Binary Input Label Name (10 characters)	**BI_95**	:= ________
DNP Binary Input Label Name (10 characters)	**BI_96**	:= ________
DNP Binary Input Label Name (10 characters)	**BI_97**	:= ________
DNP Binary Input Label Name (10 characters)	**BI_98**	:= ________
DNP Binary Input Label Name (10 characters)	**BI_99**	:= ________

Binary Output Map

DNP Binary Output Label Name (10 characters)	**BO_00**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_01**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_02**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_03**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_04**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_05**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_06**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_07**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_08**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_09**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_10**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_11**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_12**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_13**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_14**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_15**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_16**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_17**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_18**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_19**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_20**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_21**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_22**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_23**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_24**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_25**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_26**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_27**	:= ________

DNP Binary Output Label Name (10 characters)	**BO_28**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_29**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_30**	:= ________
DNP Binary Output Label Name (10 characters)	**BO_31**	:= ________

Analog Input Map

DNP Analog Input Label Name (24 characters)

AI_00	:= ________
AI_01	:= ________
AI_02	:= ________
AI_03	:= ________
AI_04	:= ________
AI_05	:= ________
AI_06	:= ________
AI_07	:= ________
AI_08	:= ________
AI_09	:= ________
AI_10	:= ________
AI_11	:= ________
AI_12	:= ________
AI_13	:= ________
AI_14	:= ________
AI_15	:= ________
AI_16	:= ________
AI_17	:= ________
AI_18	:= ________
AI_19	:= ________
AI_20	:= ________
AI_21	:= ________
AI_22	:= ________
AI_23	:= ________
AI_24	:= ________
AI_25	:= ________
AI_26	:= ________
AI_27	:= ________
AI_28	:= ________
AI_29	:= ________
AI_30	:= ________
AI_31	:= ________
AI_32	:= ________
AI_33	:= ________

AI_34 := ____________________
AI_35 := ____________________
AI_36 := ____________________
AI_37 := ____________________
AI_38 := ____________________
AI_39 := ____________________
AI_40 := ____________________
AI_41 := ____________________
AI_42 := ____________________
AI_43 := ____________________
AI_44 := ____________________
AI_45 := ____________________
AI_46 := ____________________
AI_47 := ____________________
AI_48 := ____________________
AI_49 := ____________________
AI_50 := ____________________
AI_51 := ____________________
AI_52 := ____________________
AI_53 := ____________________
AI_54 := ____________________
AI_55 := ____________________
AI_56 := ____________________
AI_57 := ____________________
AI_58 := ____________________
AI_59 := ____________________
AI_60 := ____________________
AI_61 := ____________________
AI_62 := ____________________
AI_63 := ____________________
AI_64 := ____________________
AI_65 := ____________________
AI_66 := ____________________
AI_67 := ____________________
AI_68 := ____________________
AI_69 := ____________________
AI_70 := ____________________
AI_71 := ____________________
AI_72 := ____________________
AI_73 := ____________________
AI_74 := ____________________

AI_75 := ______
AI_76 := ______
AI_77 := ______
AI_78 := ______
AI_79 := ______
AI_80 := ______
AI_81 := ______
AI_82 := ______
AI_83 := ______
AI_84 := ______
AI_85 := ______
AI_86 := ______
AI_87 := ______
AI_88 := ______
AI_89 := ______
AI_90 := ______
AI_91 := ______
AI_92 := ______
AI_93 := ______
AI_94 := ______
AI_95 := ______
AI_96 := ______
AI_97 := ______
AI_98 := ______
AI_99 := ______

Analog Output Map

DNP Analog Output Label Name (6 characters) **AO_00** := ______
DNP Analog Output Label Name (6 characters) **AO_01** := ______
DNP Analog Output Label Name (6 characters) **AO_02** := ______
DNP Analog Output Label Name (6 characters) **AO_03** := ______
DNP Analog Output Label Name (6 characters) **AO_04** := ______
DNP Analog Output Label Name (6 characters) **AO_05** := ______
DNP Analog Output Label Name (6 characters) **AO_06** := ______
DNP Analog Output Label Name (6 characters) **AO_07** := ______
DNP Analog Output Label Name (6 characters) **AO_08** := ______
DNP Analog Output Label Name (6 characters) **AO_09** := ______
DNP Analog Output Label Name (6 characters) **AO_10** := ______
DNP Analog Output Label Name (6 characters) **AO_11** := ______
DNP Analog Output Label Name (6 characters) **AO_12** := ______

DNP Analog Output Label Name (6 characters)	**AO_13**	:= ____________
DNP Analog Output Label Name (6 characters)	**AO_14**	:= ____________
DNP Analog Output Label Name (6 characters)	**AO_15**	:= ____________
DNP Analog Output Label Name (6 characters)	**AO_16**	:= ____________
DNP Analog Output Label Name (6 characters)	**AO_17**	:= ____________
DNP Analog Output Label Name (6 characters)	**AO_18**	:= ____________
DNP Analog Output Label Name (6 characters)	**AO_19**	:= ____________
DNP Analog Output Label Name (6 characters)	**AO_20**	:= ____________
DNP Analog Output Label Name (6 characters)	**AO_21**	:= ____________
DNP Analog Output Label Name (6 characters)	**AO_22**	:= ____________
DNP Analog Output Label Name (6 characters)	**AO_23**	:= ____________
DNP Analog Output Label Name (6 characters)	**AO_24**	:= ____________
DNP Analog Output Label Name (6 characters)	**AO_25**	:= ____________
DNP Analog Output Label Name (6 characters)	**AO_26**	:= ____________
DNP Analog Output Label Name (6 characters)	**AO_27**	:= ____________
DNP Analog Output Label Name (6 characters)	**AO_28**	:= ____________
DNP Analog Output Label Name (6 characters)	**AO_29**	:= ____________
DNP Analog Output Label Name (6 characters)	**AO_30**	:= ____________
DNP Analog Output Label Name (6 characters)	**AO_31**	:= ____________

Counter Map

DNP Counter Label Name (11 characters)	**CO_00**	:= ____________
DNP Counter Label Name (11 characters)	**CO_01**	:= ____________
DNP Counter Label Name (11 characters)	**CO_02**	:= ____________
DNP Counter Label Name (11 characters)	**CO_03**	:= ____________
DNP Counter Label Name (11 characters)	**CO_04**	:= ____________
DNP Counter Label Name (11 characters)	**CO_05**	:= ____________
DNP Counter Label Name (11 characters)	**CO_06**	:= ____________
DNP Counter Label Name (11 characters)	**CO_07**	:= ____________
DNP Counter Label Name (11 characters)	**CO_08**	:= ____________
DNP Counter Label Name (11 characters)	**CO_09**	:= ____________
DNP Counter Label Name (11 characters)	**CO_10**	:= ____________
DNP Counter Label Name (11 characters)	**CO_11**	:= ____________
DNP Counter Label Name (11 characters)	**CO_12**	:= ____________
DNP Counter Label Name (11 characters)	**CO_13**	:= ____________
DNP Counter Label Name (11 characters)	**CO_14**	:= ____________
DNP Counter Label Name (11 characters)	**CO_15**	:= ____________
DNP Counter Label Name (11 characters)	**CO_16**	:= ____________

DNP Counter Label Name (11 characters)	**CO_17**	:= ________
DNP Counter Label Name (11 characters)	**CO_18**	:= ________
DNP Counter Label Name (11 characters)	**CO_19**	:= ________
DNP Counter Label Name (11 characters)	**CO_20**	:= ________
DNP Counter Label Name (11 characters)	**CO_21**	:= ________
DNP Counter Label Name (11 characters)	**CO_22**	:= ________
DNP Counter Label Name (11 characters)	**CO_23**	:= ________
DNP Counter Label Name (11 characters)	**CO_24**	:= ________
DNP Counter Label Name (11 characters)	**CO_25**	:= ________
DNP Counter Label Name (11 characters)	**CO_26**	:= ________
DNP Counter Label Name (11 characters)	**CO_27**	:= ________
DNP Counter Label Name (11 characters)	**CO_28**	:= ________
DNP Counter Label Name (11 characters)	**CO_29**	:= ________
DNP Counter Label Name (11 characters)	**CO_30**	:= ________
DNP Counter Label Name (11 characters)	**CO_31**	:= ________

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 (RJ-45 connector) Option 2: Dual, redundant 10/100 BASE-T Ethernet (Port 1A, Port 1B) Option 3: 100BASE-FX Ethernet (LC connector) Option 4: Dual, redundant 100BASE-FX Ethernet (Port 1A, Port 1B)	Rear	Ordering Option
PORT 2[a]	Multimode Fiber-Optic Serial (ST® connector)	Rear	Standard
PORT 3	Option 1: EIA-232 Option 2: EIA-485	Rear	Ordering Option
PORT 4	Option 1: EIA-232 or EIA-485 Serial Communications Card Option 2: DeviceNet Communications Card[b]	Rear	Ordering Option

[a] This port can receive the RTD measurement information from the optional external SEL-2600 RTD Module. Refer to the applicable SEL-2600 RTD Module Instruction Manual for information on the fiber-optic interface.
[b] Refer to Appendix G: DeviceNet Communications for information on the DeviceNet communications card.

Be sure to evaluate the installation and communications necessary to integrate with existing devices before ordering your SEL-751. For example, consider the fiber-optic interface in noisy installations or for large communications distances. Following is general information on possible applications of the different interfaces.

Serial (EIA-232 and EIA-485) Port

Use the EIA-232 port for communications distances as far as 15 m (50 feet) in low noise environments. Use the optional EIA-485 port for communications distances as far as 1200 m (4000 feet) maximum distance (to achieve this performance, ensure proper line termination at the receiver).

To connect a PC serial port to the relay front-panel serial port and enter relay commands, you will need the following:

- A personal computer equipped with one available EIA-232 serial port
- A communications cable to connect the computer serial port to the relay serial ports
- Terminal emulation software to control the computer serial port
- An SEL-751 Relay

Some of the SEL devices available for integration or communications system robustness are included in the following list:

- SEL Communications Processors (SEL-2032, SEL-2030, SEL-2020), SEL-3530 RTAC Real-Time Automation Controller
- SEL-2800 series fiber-optic transceivers
- SEL-2890 Ethernet Transceiver
- SEL-3010 Event Messenger
- SEL-2505 Remote I/O Module (with ST® option only for fiber-optic link to Port 2)

A variety of terminal emulation programs on personal computers can communicate with the relay. For the best display, use VT-100 terminal emulation or the closest variation.

The default settings for all EIA-232 serial ports are as follows:

Baud Rate = 9600
Data Bits = 8
Parity = N
Stop Bits = 1

To change the port settings, use the **SET P** command (see *Section 6: Settings*) or the front-panel. *Section 8: Front-Panel Operations* provides details on making settings with the front panel.

Hardware Flow Control

All EIA-232 serial ports support RTS/CTS hardware handshaking (hardware flow control). To enable hardware handshaking, use the **SET P** command or front-panel PORT submenu to set RTSCTS = Y. Disable hardware handshaking by setting RTSCTS := N.

- If RTSCTS := N, the relay permanently asserts the RTS line.
- If RTSCTS := Y, the relay deasserts RTS when it is unable to receive characters.
- If RTSCTS := Y, the relay does not send characters until the CTS input is asserted.

Fiber-Optic Serial Port

Use the 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.

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 primary to backup network if the relay detects a failure in the primary network. In addition to failover mode, the unit can operate in a "fixed connection (to netport) mode" or in a "switched mode" (as an unmanaged switch).

Figure 7.1 shows an example of a Simple Ethernet Network Configuration, *Figure 7.2* shows an example of an Ethernet Network Configuration with Dual Redundant Connections, and *Figure 7.3* shows an example of an Ethernet Network Configuration with Ring Structure.

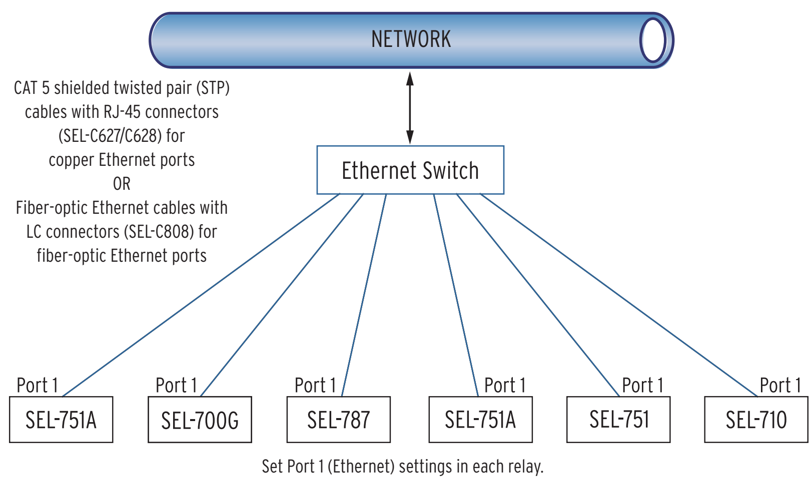


Figure 7.1 Simple Ethernet Network Configuration

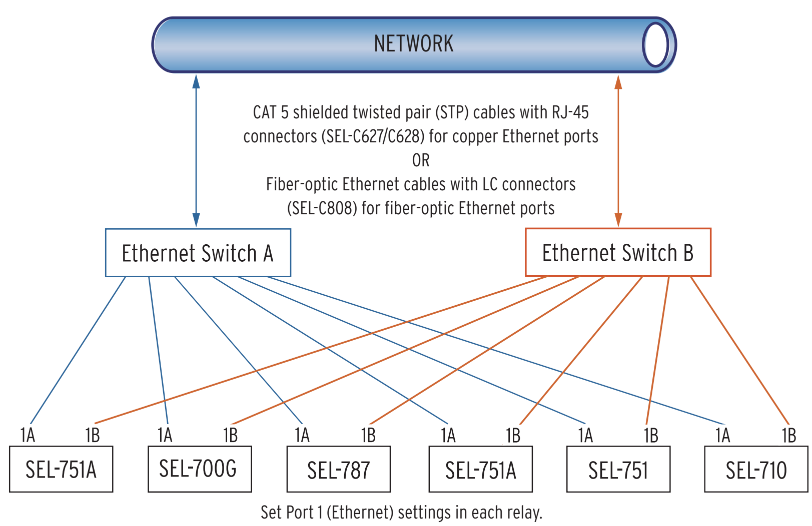


Figure 7.2 Ethernet Network Configuration With Dual Redundant Connections (Failover Mode)

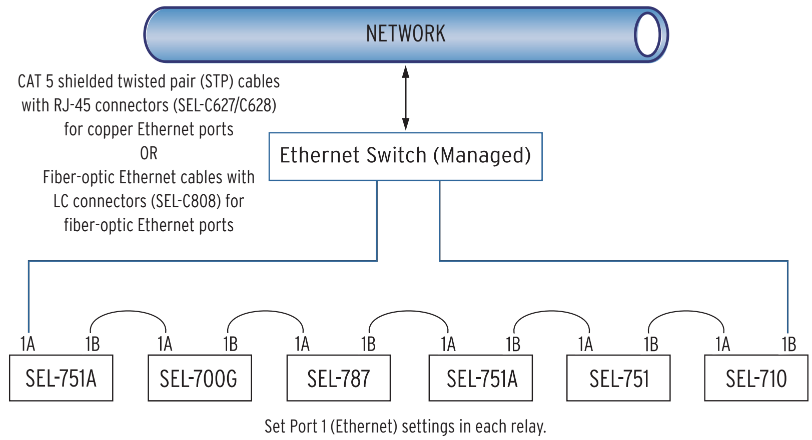


Figure 7.3 Ethernet Network Configuration With Ring Structure (Switched Mode)

Dual Network Port Operation

The SEL-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.

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.

After failover, while communicating via standby port, the SEL-751 checks the primary link periodically and continues checking until it detects a normal link status. The relay continues to communicate via the standby port even after the primary port returns to normal. The relay reevaluates the port of choice for communication upon a change of settings, at failure of the standby port, or upon reboot. The relay returns to operation on the primary link under those conditions if it detects a normal link status. When the active and backup links both fail, the relay alternates checking for the link status of the primary and standby ports.

Unmanaged Switch Mode

If you have a network configuration where you want to use the relay as an unmanaged switch, set NETMODE to SWITCHED. In this mode, both links are enabled. The relay will respond to the messages it receives on either port. All the messages received on one network port that are not addressed to the relay will be transmitted out of the other port without any modifications. In this mode, the relay ignores the NETPORT setting.

Fixed Connection Mode

If you have a single network and want to use only one network port, or if you have both ports connected but want to force usage of only one port for various reasons, set NETMODE to FIXED and set NETPORT to the port you want to use. Only the selected network port operates, and the other port is disabled.

Autonegotiation, Speed, and Duplex Mode

Single or dual copper Ethernet ports can autonegotiate to determine the link speed and duplex mode. Accomplish this by setting the NETASPD and NETBSPD (network speed) to AUTO. You can also set single or dual copper ports to specific speeds so that you can apply them in networks with older switch devices. However, the relay ignores the speed settings for fiber Ethernet ports. The relay hardware fixes the single and dual fiber Ethernet ports to work at 100 Mbps and full duplex mode.

NETPORT Selection

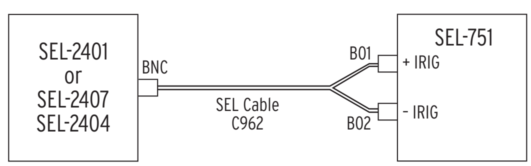
The NETPORT setting gives you the option of selecting the primary port of communication in failover or fixed communications modes. Selecting “D” for this setting disables both ports. This selection provides you the security of being able to turn off the ports even when these ports are physically connected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

IRIG-B

The SEL-751 has three different physical interfaces, depending on the model options, to provide demodulated IRIG-B time-code input for time synchronization. If the relay has multiple options for IRIG-B input, you can use only one input at a time. Connection diagrams for IRIG-B and settings selection are in *Figure 7.4* through *Figure 7.8* in this section.

Option 1: Terminals B01 and B02

This input is available on all models except models with dual Ethernet Port or Fiber-Optic Ethernet port. Refer to *Figure 7.4* for a connection diagram.



B01–B02 IRIG-B input is available on all models except those with fiber-optic Ethernet or dual-copper Ethernet.

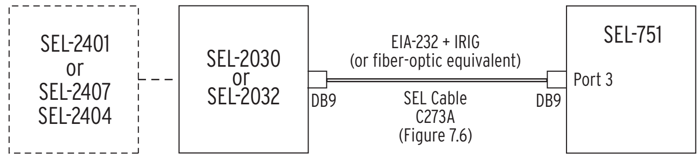
You cannot bring IRIG-B via Port 2 or 3 if you use the **B01–B02** input.

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

Figure 7.4 IRIG-B Input (Relay Terminals B01–B02)

Option 2: Port 3 (EIA-232 Option Only)

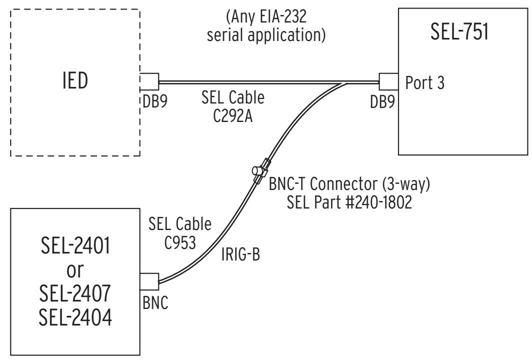
Connect to an SEL Communications Processor with SEL Cable C273A to bring IRIG-B input with the EIA-232 Port. Refer to *Figure 7.5* for a connection diagram. Refer to *Figure 7.6* on how to connect a SEL Time Source (SEL-2401, SEL-2404, SEL-2407) for IRIG-B Input to Port 3.



You cannot use B01–B02 input or Port 2 if you use Port 3.

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

Figure 7.5 IRIG-B Input Via EIA-232 Port 3 (SEL Communications Processor as Source)



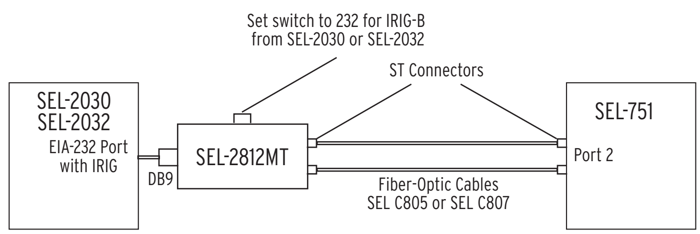
You cannot use B01–B02 input or Port 2 if you use Port 3.

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

Figure 7.6 IRIG-B Input VIA EIA-232 Port 3 (SEL-2401/2404/2407 Time Source)

Option 3: Port 2 (Fiber-Optic Serial Port)

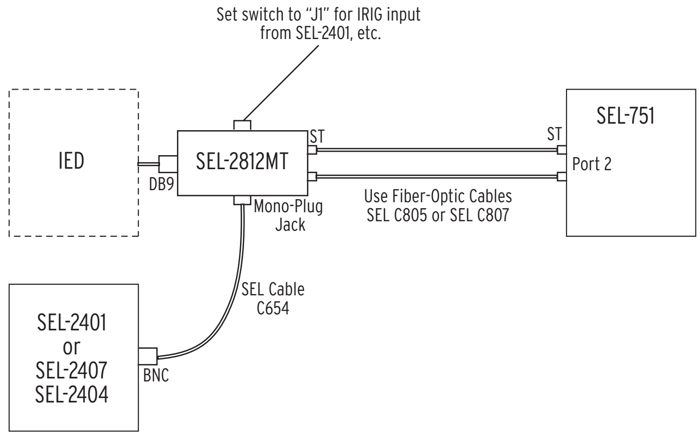
You can use Fiber-Optic Serial Port 2 to bring IRIG-B Input to the relay as shown in *Figure 7.7* and *Figure 7.8*.



You cannot use B01–B02 input or Port 3 input if you use Port 2 for IRIG-B input.

Set Global setting IRIG TIME SOURCE to TIME_SRC := IRIG2.

Figure 7.7 IRIG-B Input VIA Fiber-Optic EIA-232 Port 2 (SEL-2030/2032 Time Source)



You cannot use **B01–B02** input or Port 3 input if you use Port 2 for IRIG-B input.
Set Global setting IRIG TIME SOURCE to TIME_SRC := IRIG2.

Figure 7.8 IRIG-B Input VIA Fiber-Optic EIA-232 Port 2 (SEL-2401/2404/2407 Time Source)

+5 Vdc Power Supply

Serial port power can provide as much as 0.25 A total from all of the +5 Vdc pins. Some SEL communications devices require the +5 Vdc power supply. This +5 Vdc power is available on Pin 1 only.

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 7.2*. You can connect to a standard 9-pin computer port with SEL Cable C234A; wiring for this cable is shown in *Figure 7.10*. SEL Cable C234A and other cables are available from SEL. Use the SEL-5801 Cable Selector software to select an appropriate cable for another application. This software is available for free download from the SEL website at www.selinc.com.

For best performance, SEL Cable C234A should not be more than 15 meters (50 feet) long. For long-distance communications and for electrical isolation of communications ports, use the SEL family of fiber-optic transceivers. Contact SEL for more details on these devices.

Port Connector and Communications Cables

Figure 7.9 shows the front-panel EIA-232 serial port (**PORT F**) DB-9 connector pinout for the SEL-751.

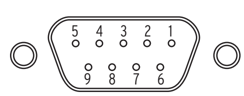


Figure 7.9 EIA-232 DB-9 Connector Pin Numbers

Table 7.2 shows the pin functions for the EIA-232 and EIA-485 serial ports.

Table 7.2 EIA-232/EIA-485 Serial Port Pin Functions (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 7.2 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.

The following cable diagrams show several types of EIA-232 serial communications cables that connect the SEL-751 to other devices. These and other cables are available from SEL. Contact the factory for more information.

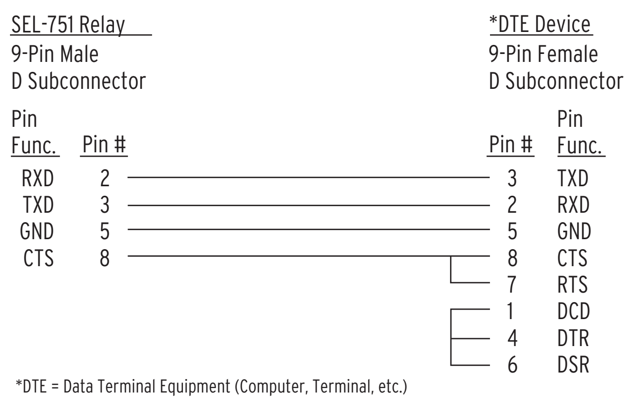


Figure 7.10 SEL Cable C234A—SEL-751 to DTE Device

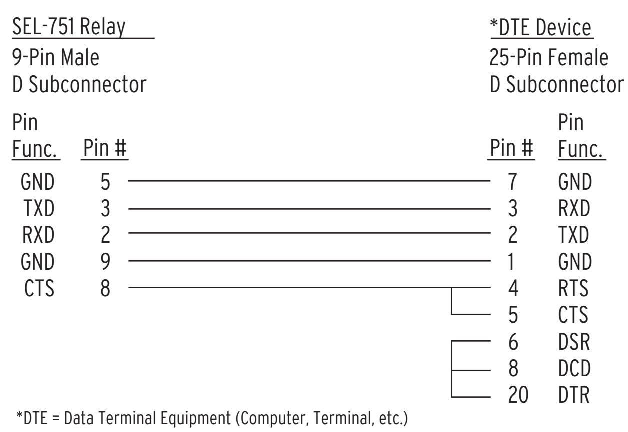


Figure 7.11 SEL Cable C227A—SEL-751 to DTE Device

SEL-751 Relay 9-Pin Male D Subconnector			**DCE Device 25-Pin Female D Subconnector	
Pin Func.	Pin #		Pin #	Pin Func.
GND	5		7	GND
TXD	3		2	TXD (IN)
RTS	7		20	DTR (IN)
RXD	2		3	RXD (OUT)
CTS	8		8	CD (OUT)
GND	9		1	GND

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

Figure 7.12 SEL Cable C222—SEL-751 to Modem

SEL Communications Processor 9-Pin Male D Subconnector			SEL-751 Relay 9-Pin Male D Subconnector	
Pin Func.	Pin #		Pin #	Pin Func.
RXD	2		3	TXD
TXD	3		2	RXD
GND	5		5	GND
RTS	7		8	CTS
CTS	8		7	RTS

Figure 7.13 SEL Cable C272A—SEL-751 to SEL Communications Processor Without IRIG-B Signal

SEL Communications Processor 9-Pin Male D Subconnector			SEL-751 Relay 9-Pin Male D Subconnector	
Pin Func.	Pin #		Pin #	Pin Func.
RXD	2		3	TXD
TXD	3		2	RXD
IRIG+	4		4	IRIG+
GND	5		5	GND
IRIG-	6		6	IRIG-
RTS	7		8	CTS
CTS	8		7	RTS

Figure 7.14 SEL Cable C273A—SEL-751 to SEL Communications Processor With IRIG-B Signal

SEL-751 Relay DTE* 9-Pin Male D Subconnector			SEL-3010 Event Messenger DCE** 9-Pin Male D Subconnector	
Pin Func.	Pin #		Pin #	Pin Func.
DCD***	1		1	+5 Vdc (IN)
RXD	2		2	RXD (OUT)
TXD	3		3	TXD (IN)
	4		4	Not Used
GND	5		5	GND
	6		6	Not Used
RTS	7		7	RTS (IN)
CTS	8		8	CTS (OUT)
GND	9		9	GND

*DTE = Data Terminal Equipment
**DCE = Data Communications Equipment (Modem, etc.)
***DC Voltage (+5 V) not available on front-panel EIA-232 port

Figure 7.15 SEL Cable C387—SEL-751 to SEL-3010

Communications Protocols

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 7.3* shows the ports and the protocols available on each port.

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

Table 7.3 Protocols Supported on the Various Ports

PORT	Supported Protocol
PORT F	SEL ASCII and Compressed ASCII Protocols, SELBOOT, File Transfer Protocol, Modbus RTU Slave, C37.118 Protocol (synchrophasor data), and Event Messenger
PORT 1	Modbus TCP/IP, FTP, TCP/IP, IEC 61850, DNP3 LAN/WAN, SNTP, and Telnet TCP/IP (SEL ASCII, Compressed ASCII, SEL Fast Meter, SEL Fast Operate, SEL Fast SER, SEL Fast Message)[a]
PORT 2	All the protocols supported by Port 3
PORT 3	SEL ASCII and Compressed ASCII Protocols, SEL Fast Meter, SEL Fast Operate, SEL Fast SER, SEL Fast Message, SEL Settings File Transfer, SEL MIRRORED BITS, DNP3, Modbus RTU Slave, C37.118 Protocol (synchrophasor data), and Event Messenger
PORT 4	All the protocols supported by Port 3 and DeviceNet

[a] PORT 1 concurrently supports two Modbus, three DNP3 LAN/WAN, two FTP, two Telnet, one SNTP, and six IEC 61850 sessions.

SEL Communications Protocols

SEL ASCII. This protocol is described in *SEL ASCII Protocol and Commands on page 7.14*.

SEL Compressed ASCII. This protocol provides compressed versions of some of the ASCII commands. The compressed commands are described in *SEL ASCII Protocol and Commands*, and the protocol is described in *Appendix C: SEL Communications Processors*.

SEL Fast Meter. This protocol supports binary messages to transfer metering and digital element messages. Compressed ASCII commands that support Fast Meter are described in *SEL ASCII Protocol and Commands*, and the protocol is described in *Appendix C: SEL Communications Processors*.

SEL Fast Operate. This protocol supports binary messages to transfer operation messages. The protocol is described in *Appendix C: SEL Communications Processors*.

SEL Fast 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.

Mirrored Bits Protocol

The SEL-751 supports two Mirrored Bits communications channels, designated A and B. Within each Mirrored Bits communications message for a given channel (A or B), there are eight logical data channels (1–8). You can, for example, set MBA on Port 3 of the base unit and MBB on Port 4A of the optional communications card. Attempting to set the PROTO setting to MBA, MB8A, or MBTA when channel A is already assigned to another port (or MBB, MB8B, or MBTB when channel B is already assigned on another port) results in the following error message: `This Mirrored Bits channel is assigned to another port.` After displaying the error message, the device returns to the PROTO setting for reentry.

C37.118 Protocol

The SEL-751 provides C37.118 protocol (synchrophasor data) support at one of the serial ports F, 2, 3, or 4. The protocol is described in *Appendix H: Synchrophasors*.

Modbus RTU Protocol

The SEL-751 provides Modbus RTU support. Modbus is an optional protocol described in *Appendix E: Modbus RTU Communications*.

DNP3 (Distributed Network Protocol)

The SEL-751 provides DNP3 protocol support if the option is selected. The DNP3 protocol is described in *Appendix D: DNP3 Communications*.

DeviceNet Protocol

The SEL-751 provides DeviceNet Support. DeviceNet is an optional protocol described in *Appendix G: DeviceNet Communications*.

Ethernet Protocols

As with other communications interfaces, you must choose a data exchange protocol that operates over the Ethernet network link to exchange data. The relay supports FTP, Telnet, Ping, Modbus/TCP, DNP3 LAN/WAN, and IEC 61850 protocols.

You should carefully design your Ethernet network to maximize reliability, minimize system administration effort, and provide adequate security. Work with a networking professional to design your substation Ethernet network.

FTP Server

Use the single FTP (File Transfer Protocol) session to access the following files:

CFG.XMLConfiguration read-only file in XML format

CFG.TXTConfiguration read-only file in TXT format

ERR.TXTError read-only file in text format

SET_61850.CIDIEC 61850 CID read-write file

SET_xx.TXTSetting files in TXT format

FTP is a standard TCP/IP protocol for exchanging files. A free FTP application is included with most web browser software. You can also obtain a free or inexpensive FTP application from the Internet. When you connect to the relay Ethernet port, you will find files stored in the root (top-level) directory.

Telnet Server

Use the Telnet session (TPORT default setting is port 23) to connect to the relay to use the protocols, which are described in more detail below:

- ➤ SEL ASCII
- ➤ Compressed ASCII
- ➤ Fast Meter
- ➤ Fast Operate

NOTE: Use the **QUIT** command prior to closing the Telnet-to-Host session to set the relay to Access Level 0. Otherwise, the relay will remain at an elevated access level until TIDLE expires.

Telnet is a terminal connection across a TCP/IP network that operates in a manner very similar to a direct serial port connection to one of the relay ports. As with FTP, Telnet is a part of TCP/IP. A free Telnet application is included with most computer operating systems, or you can obtain low-cost or free Telnet applications on the Internet.

Ping Server

Use a Ping client with the relay Ping server to verify that your network configuration is correct. Ping is an application based on ICMP over an IP network. A free Ping application is included with most computer operating systems.

IEC 61850

Use as many as six sessions of MMS over a TCP network to exchange data with the relay. Use GOOSE to do real-time data exchange with as many as 16 incoming messages and 8 outgoing messages. For more details on the IEC 61850 protocol, see *Appendix F: IEC 61850 Communications*.

Simple Network Time Protocol (SNTP)

When Port 1 (Ethernet port) setting ESNTP is not OFF, the internal clock of the relay conditionally synchronizes to the time of day served by a Network Time Protocol (NTP) server. The relay uses a simplified version of NTP called the Simple Network Time Protocol (SNTP). SNTP is not as accurate as IRIG-B. The relay can use SNTP as a less accurate primary time source, or as a backup to the higher accuracy IRIG-B time source.

SNTP as Primary or Backup Time Source

If an IRIG-B time source is connected and either Relay Word bit TSOK or Relay Word bit IRIGOK asserts, then the relay synchronizes the internal time-of-day clock to the incoming IRIB-G time code signal, even if SNTP is configured in the relay and an NTP server is available. If the IRIG-B source is disconnected (if both TSOK and IRIGOK deassert) then the relay synchronizes the internal time-of-day clock to the NTP server, if available. In this way, an NTP server acts either as the primary time source or as a backup time source to the more accurate IRIG-B time source.

Creating an NTP Server

Three SEL application notes, available from the SEL website, describe how to create an NTP server.

- *AN2009-10: Using an SEL-2401, SEL-2404, or SEL-2407 to Serve NTP Via the SEL-3530 RTAC*
- *AN2009-32: Using SEL Satellite-Synchronized Clocks With the SEL-3332 or SEL-3351 to Output NTP*
- *Using an SEL-2401, SEL-2404, or SEL-2407 to Create a Stratum 1 Linux NTP Server*

Configuring SNTP Client in the Relay

To enable SNTP in the relay, make Port 1 setting ESNTP = UNICAST, MANYCAST, or BROADCAST. *Table 7.4* shows each setting associated with SNTP.

Table 7.4 Settings Associated With SNTP

Setting	Range	Description
ESNTP	UNICAST, MANYCAST, BROADCAST	Selects the mode of operation of SNTP. See descriptions in *SNTP Operation Modes on page 7.13*.
SNTPPSIP	Valid IP Address	Selects primary NTP server when ENSTP = UNICAST, or broadcast address when ESNTP = MANYCAST or BROADCAST.
SNTPPSIB	Valid IP Address	Selects backup NTP server when ESNTP = UNICAST.
SNTPPORT	1–65534	Ethernet port used by SNTP. Leave at default value unless otherwise necessary.
SNTPRATE	15–3600 seconds	Determines the rate at which the relay asks for updated time from the NTP server when ESNTP = UNICAST or MANYCAST. Determines the time the relay will wait for an NTP broadcast when ENSTP = BROADCAST.
SNTPTO	5–20 seconds	Determines the time the relay will wait for the NTP master to respond when ENSTP = UNICAST or MANYCAST.

SNTP Operation Modes

The following sections explain the setting associated with each SNTP operation mode (UNICAST, MANYCAST, and BROADCAST).

ESNTP = UNICAST

In UNICAST mode of operation, the SNTP client in the relay requests time updates from the primary (IP address setting SNTPPSIP) or backup (IP address setting SNTPBSIP) NTP server at a rate defined by setting SNTPRATE. If the NTP server does not respond with the period defined by setting SNTPTO, then the relay tries the other SNTP server. When the relay successfully synchronizes to the primary NTP time server, Relay Word bit TSNTPP asserts. When the relay successfully synchronizes to the backup NTP time server, Relay Word bit TSNTPB asserts.

ESNTP = MANYCAST

In the MANYCAST mode of operation, the relay initially sends an NTP request to the broadcast address contained in setting SNTPPSIP. The relay continues to broadcast requests at a rate defined by setting SNTPRATE. When a server replies, the relay considers that server to be the primary NTP server, and switches to UNICAST mode, asserts Relay Word bit TSNTPP, and thereafter requests updates from the primary server. If the NTP server stops responding for time SNTPTO, the relay deasserts TSNTPP and begins to broadcast requests again until the original or another server responds.

ESNTP = BROADCAST

If setting SNTPPSIP = 0.0.0.0 while setting ESNTP = BROADCAST, the relay will listen for and synchronize to any broadcasting NTP server. If setting SNTPPSIP is set to a specific IP address while setting ESNTP = BROADCAST, then the relay will listen for and synchronize to only NTP server broadcasts from that address. When synchronized, the relay asserts Relay Word bit TSNTPP. Relay Word bit TNSTPP deasserts if the relay does not receive a valid broadcast within five seconds after the period defined by setting SNTPRATE.

SNTP Accuracy Considerations

The accuracy of the SNTP Server and the networking environment limit SNTP time synchronization accuracy. You can achieve the highest degree of SNTP time synchronization by minimizing the number of switches and routers between the SNTP Server and the SEL-751. You can also use network monitoring software to ensure that average and worst-case network bandwidth use is moderate.

When installed on a network configured with one Ethernet switch between the SEL-751 and the SNTP Server, and when using ESNTP = UNICAST or MANYCAST, the relay time synchronization error with the SNTP server is typically less than ±1 millisecond.

SEL ASCII Protocol and Commands

Message Format

SEL ASCII protocol is designed for manual and automatic communication. All commands the relay receives must be of the following form:

```
<command><CR>  or  <command><CRLF>
```

NOTE: The **<Enter>** key on most keyboards is configured to send the ASCII character 13 (**<Ctrl+M>**) for a carriage return. This manual instructs you to press the **<Enter>** key after commands to send the proper ASCII code to the SEL-751.

A command transmitted to the relay consists of the command followed by either a CR (carriage return) or a CRLF (carriage return and line feed). You can truncate commands to the first three characters. For example, **EVENT 1 <Enter>** becomes **EVE 1 <Enter>**. Use upper- and lowercase characters without distinction, except in passwords.

The relay transmits all messages in the following format:

```
<STX><MESSAGE LINE 1><CRLF>
<MESSAGE LINE 2><CRLF>
.
.
.
<LAST MESSAGE LINE><CRLF><ETX>
```

Each message begins with the start-of-transmission character (ASCII 02) and ends with the end-of-transmission character (ASCII 03). Each line of the message ends with a carriage return and line feed.

Software Flow Control

The relay implements XON/XOFF flow control. You can use the XON/XOFF protocol to control the relay during data transmission. When the relay receives XOFF during transmission, it pauses until it receives an XON character. If there is no message in progress when the relay receives XOFF, it blocks transmission of any message presented to the relay input buffer. Messages will be 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 7.5* lists these messages.

Table 7.5 Serial Port Automatic Messages

Condition	Description
Power Up	The relay sends a message containing the present date and time, Relay and Terminal Identifiers, and the Access Level 0 prompt when the relay is turned on.
Event Trigger	The relay sends an event summary each time an event report is triggered. See *Section 9: Analyzing Events*.
Self-Test Warning or Failure	The SEL-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 7.44*.

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)

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 7.18* for more detail.

Access Level 1

When the SEL-751 is in Access Level 1, the relay sends the following prompt:

```
=>
```

See the *SEL-751 Relay Command Summary* at the end of this manual for the commands available from Access Level 1. The relay can go to Access Level 2 from this level.

The **2AC** command places the relay in Access Level 2. See *Access Commands (ACCESS, 2ACCESS, and CAL)* for more detail. Enter the **2AC** command at the Access Level 1 prompt:

```
=>2AC <Enter>
```

Access Level 2

When the relay is in Access Level 2, the SEL-751 sends the prompt:

```
=>>
```

See the *SEL-751 Relay Command Summary* at the end of this manual for the commands available from Access Level 2.

Any of the Access Level 1 commands are also available in Access Level 2.

Access Level C

The CAL access level is for use exclusively by the SEL factory and SEL field service personnel to diagnose troublesome installations. A list of commands available at the **CAL** level is available from SEL upon request. Do not enter the **CAL** access level except as directed by SEL.

The **CAL** command allows the relay to go to Access Level C. 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 7.6 lists the header items and their definitions.

Table 7.6 Command Response Header Definitions

Item	Definition
`[RID Setting]`:	This is the RID (Relay Identifier) setting. The relay ships with the default setting `RID = 751`; see *ID Settings on page 4.3*.
`[TID Setting]`:	This is the TID (Terminal Identifier) setting. The relay ships with the default setting `TID = FEEDER RELAY`; see *ID Settings on page 4.3*.
`Date`:	This is the date when the command response was given, except for relay response to the **EVE** command (Event), when it is the date the event occurred. You can modify the date display format (Month/Day/Year, Year/Month/Day, or Day/Month/Year) by changing the DATE_F relay setting.
`Time`:	This is the time when the command response was given, except for relay response to the **EVE** command, 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 7.7*) 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 7.15* for a discussion of placing the relay in an access level.

Table 7.7 Access Commands

Command	Description	Access Level
ACC	Moves from Access Level 0 to Access Level 1.	0
2AC	Moves from Access Level 1 to Access Level 2.	1
CAL	Moves from Access Level 2 to Access Level 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 7.38*. At the prompt, enter the default password and press the **<Enter>** key. The relay responds with the following:

```
[RID Setting]                              Date: mm/dd/yyyy  Time: hh:mm:ss
[TID Setting]                              Time Source: external

Level 1
=>
```

The => prompt indicates that the relay is now in Access Level 1.

If the entered password is incorrect, the relay prompts you for the password again (`Password: ?`). The relay prompts for the password as many as three times. If the requested password is incorrectly entered three times, the relay pulses the SALARM Relay Word bit for one second and remains at Access Level 0 (= prompt).

Access Level Attempt (Password Not Required). Assume the following conditions:

- Access Level 1 password is disabled.
- Access Level is 0.

At the Access Level 0 prompt, enter the **ACC** command:

```
=ACC <Enter>
```

Because the password is disabled, the relay does not prompt you for a password and goes directly to Access Level 1. The relay responds with the following:

```
[RID Setting]                              Date: mm/dd/yyyy  Time: hh:mm:ss.sss
[TID Setting]                              Time Source: external
Level 1
=>
```

The => prompt indicates that the relay is now in Access Level 1.

The two previous examples demonstrate going from Access Level 0 to Access Level 1. The procedure to go from Access Level 1 to Access Level 2 with the **2AC** command entered at the access level screen prompt is similar. You can get to Access Level C from Access Level 2 with the **CAL** command. The relay pulses the SALARM Relay Word bit for one second after a successful Level 2 or Level C access, or if access is denied.

AFT Command (Arc-Flash Detection Channels Self-Test)

Use the **AFT** command (Access Level 2) to initiate a self-test of the arc-flash detection channels 1 to 4. This test requires that the relay has the SELECT 3AVI/4AFDI card in the slot E and the external fiber-optic connections are complete. The test checks the integrity of the arc-flash detection system. *Figure 7.16* shows an example of the **AFT** command response. Refer to *Section 10: Testing and Troubleshooting* for details on the arc-flash self tests.

```
=>>AFT <Enter>
Arc Flash Diagnostic in progress . . . . . . . . . . . . .

SEL-751                                Date: 12/09/2010    Time: 09:20:13
FEEDER RELAY                            Time Source: Internal

Channel #   Sensor  Test Light Limits  Measured      Sensor      Excess Ambient
            Type     Min(%)   Max(%)   Test Light(%) Diagnostic  Light

AF Input 1  Fiber    10.00    100.00   31.94         Pass        OK
AF Input 2  Fiber    10.00    100.00   27.08         Pass        OK
AF Input 3  None     ---.--   ---.--   ---.--        ---         ---
AF Input 4  Point    0.10     79.00    2.27          Pass        OK

=>>
```

Figure 7.16 AFT Command Response

ANALOG Command

Use the **ANA** command to test an analog output by temporarily assigning a value to an analog output channel (see *Table 7.8* for the command description and 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 7.8 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, we assume that the analog output signal type is 4–20 mA, and we want to test the analog output at 75 percent of rating for 5.5 minutes. To check the device output, calculate the expected mA output as follows:

$$\text{Output} = \left[(20.00\text{ mA} - 4.00\text{ mA}) \bullet \frac{75}{100}\right] + 4.00\text{ mA} = 16.00\text{ mA}$$

To start the test, enter **ANA A0301 75 5.5** at the Access Level 2 prompt:

```
=>> ANA A0301 75 5.5 <Enter>
Outputting 16.00 mA to Analog Output Port for 5.5 minutes.
Press any key to end test
```

Example 2

The following is an example of the ramp mode when the analog output signal type is 4–20 mA for a 9.0 minute test.

To check the device output, calculate the current/time (mA/min) output as follows:

$$\text{Output} = \left[\frac{20.00\text{ mA} - 4.00\text{ mA}}{9.0\text{ min}}\right] = 1.78\text{ mA/min}$$

To start the test, enter **ANA AO301 R 9.0** at the Access Level 2 prompt:

```
=>> ANA A0301 R 9.0 <Enter>
Ramping Analog Output at 1.78 mA/min; full scale in 9.0 minutes.
Press any key to end test
```

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 7.17 Breaker Monitor Report

BRE n Command (Preload/Reset Breaker Wear)

The **BRE W** command only saves new settings after the `Save Changes (Y/N)?` message. If you make a data entry error while using the **BRE W** command, the values echoed after the `Invalid format, changes not saved` message are the previous BRE values, unchanged by the aborted **BRE W** attempt.

```
=>> BRE W <Enter>

Breaker Wear Percent Preload

Relay (or Internal) Trip Counter (0-65000)    =     0     ? 14  <Enter>

Internal Current (0.0-999999 kA)      IA      = 0.0      ? 32.4  <Enter>
                                      IB      = 0.0      ? 18.6  <Enter>
                                      IC      = 0.0      ? 22.6  <Enter>

External Trip Counter (0-65000)               =     0     ? 2  <Enter>

External Current (0.0-999999 kA)      IA      = 0.0      ? 0.8  <Enter>
                                      IB      = 0.0      ? 0.6  <Enter>
                                      IC      = 0.0      ? 0.7  <Enter>

Percent Wear (0-100%)                 A-phase =   0       ? 22  <Enter>
                                      B-phase =   0       ? 28  <Enter>
                                      C-phase =   0       ? 25  <Enter>


Last Reset                            Date    = 12/04/2010 ? 12/04/2010 <Enter>

                                      Time    = 14:27:10  ? 17:50:12  <Enter>

Save changes (Y,N)? Y <Enter>

=>>
```

Figure 7.18 Breaker Wear Report

Use the **BRE R** command to reset the breaker monitor:

```
=>>BRE R <Enter>

Reset Breaker Wear (Y,N)? y
Clearing Complete

=>>LAST RESET 02/03/2011 05:41:07
```

Figure 7.19 Breaker Reset Response

See *Breaker Monitor on page 5.18* 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 Analytic Assistant software take advantage of the Compressed ASCII format. Use the **CHIS** command to display Compressed ASCII event history information. Use the **CSUM** command to display Compressed ASCII event summary information. Use the **CEVENT** (**CEV**) command to display Compressed ASCII event reports. See *Table C.2* for further information. Compressed ASCII Event Reports contain all of the Relay Word bits. The **CEV R** command gives the raw Compressed ASCII event report. Additionally, the compressed event report has the arc-flash detector light measurements.

CEV HIF (High-Impedance Fault) Command

The SEL-751 provides Compressed ASCII event reports to facilitate event report storage and display. SEL communications processors and the ACSELERATOR Analytic Assistant® SEL-5601 Software take advantage of the Compressed ASCII format. Use the **CEV HIF** command to display Compressed ASCII HIF event reports.

The relay generates compressed event reports to display analog data, and the state of related Relay Word bits from the odd and non harmonic HIF fault detection algorithm and Load Reduction. The relay provides user-programmable event report triggering conditions. An event report is triggered for all conditions listed in the **SUM HIF** command. When an event report is triggered for any of these conditions, the SEL-751 asserts Relay Word bit HIFREC, which stays asserted until the HIF event report has finished collecting. The relay does not generate additional event reports for triggering conditions that follow the initial triggering condition and are within the same report.

The number of event reports the relay shall be able to store depends on the HIFLER setting at the rate of 1sample/2 cycles. For example, if the HIFLER setting is 10 minutes, then the relay should be able to store at least four back-to-back event reports. *Figure 7.20* shows an example of the **CEV HIF** command response.

```
=>CEV HIF
“FID”,”0143”
“FID=SEL-751-X155-V0-Z001001-D20110411”,”08A5”
“MONTH”,”DAY”,”YEAR”,”HOUR”,”MIN”,”SEC”,”MSEC”,”0ACA”
4,11,2011,16,10,57,127,”045C”
“REC_NUM”,”NUM_CH_A”,”NUM_CH_D”,”SAM/CYC_A”,”SAM/CYC_D”,”NUM_OF_CYC”,”PRIM_VAL”,”14ED”
1,27,48,0.5000,0.5000,39600,”YES”,”06B7”
“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”,”TRIG”,”HIA1_A HIA1_B HIA1_C HIF1_A HIF1_B HIF1_C NTUNE_A NTUNE_B NTUNE_C
3PH_A 3PH_B 3PH_C DL2CLRA DL2CLRB DL2CLRC ITUNE_A ITUNE_B ITUNE_C DIA_DIS DIB_DIS DIC_DIS
DVA_DIS DVB_DIS DVC_DIS HIA2_A HIA2_B HIA2_C FRZCLRA FRZCLRB FRZCLRC DUPA DUPB DUPC HIF2_A
HIF2_B HIF2_C LRA LRB LRC DDNA DDNB DDNC 3PH_CLR LR3 HIFER HIFMODE 3PH_EVE HIFREC”,”9A50”
1,1,1,72,88,96,70,74,79,120,120,120,32,64,48,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FF1”
1,1,1,80,80,96,70,74,79,120,120,120,32,64,56,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FE7”
1,1,1,80,80,88,70,74,79,120,120,120,48,56,64,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FEF”
1,1,2,88,88,80,70,74,79,120,120,120,48,56,64,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FF8”
1,1,2,64,88,120,69,74,80,120,120,120,48,64,72,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”101B”
1,1,2,64,88,96,69,74,80,120,120,120,32,72,56,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FF1”
1,1,2,80,96,96,69,75,81,120,120,120,40,56,64,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FF0”
1,1,2,72,96,88,69,76,81,120,120,120,48,64,64,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FFA”
1,1,1,96,88,88,70,76,81,120,120,120,32,64,64,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FF1”
1,1,1,80,96,88,70,76,81,120,120,120,56,64,56,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FF0”
1,1,1,80,72,80,70,76,81,120,120,120,40,64,56,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FDB”
1,1,1,80,72,96,70,76,81,120,120,120,40,48,56,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FE4”
1,1,1,80,88,80,70,76,81,120,120,120,32,64,64,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FE2”
1,1,1,88,64,96,70,75,81,120,120,120,32,64,64,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FEA”
1,1,2,80,88,80,70,75,81,120,120,120,40,64,72,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FE0”
1,1,2,80,72,72,70,75,81,120,120,120,48,64,64,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FE3”
1,1,2,88,96,96,70,76,81,120,120,120,32,72,64,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FF0”
1,1,2,80,80,96,70,76,81,120,120,120,40,56,72,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FE1”
1,1,2,80,64,80,70,76,81,120,120,120,40,64,72,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FDB”
1,1,2,72,80,88,70,76,81,120,120,120,40,56,64,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FE4”
1,1,1,72,96,96,70,77,81,120,120,120,32,64,56,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FEB”
1,1,1,88,88,88,70,77,81,120,120,120,32,64,64,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FF3”
1,1,2,88,72,88,70,77,81,120,120,120,40,72,56,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FEC”
1,1,2,64,80,80,70,77,81,120,120,120,40,64,64,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FDD”
1,1,1,80,72,112,70,77,81,120,120,120,40,64,64,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”1007”
1,1,2,96,64,88,71,76,81,120,120,120,32,56,56,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FEF”
1,1,1,88,64,96,71,75,81,120,120,120,48,48,64,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FF4”
1,1,2,96,80,88,72,75,81,120,120,120,48,48,56,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FF5”
1,1,2,80,88,96,72,75,81,120,120,120,56,64,72,0,0,0,0,0,0,0,0,0,0,0,0, ,”000000000000”,”0FF0”
=>
```

Figure 7.20 CEV HIF Command Response

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 4.42* and *Figure 4.52* 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 will abort the command.

The main board breaker jumper (see *Table 2.14*) 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 BRKR Jumper
=>>
```

COMMUNICATIONS Command

The **COM *x*** command (see *Table 7.9*) displays communications statistics for the MIRRORED BITS communications channels. For more information on MIRRORED BITS communications, see *Appendix I: MIRRORED BITS Communications*. The summary report includes information on the failure of ROKA or ROKB. The `Last error` field displays the reason for the most recent channel error, even if the channel was already failed. We define failure reasons as one of the following error types:

- Device disabled
- Framing error
- Parity error
- Overrun
- Re-sync
- Data error
- Loopback
- Underrun

Table 7.9 COM Command

Command	Description	Access Level
COM S A or **COM S B**	Return a summary report of the last 255 records in the communications buffer for either MIRRORED BITS communications Channel A or Channel B when only one channel is enabled.	1
COM A	Return a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.	1
COM B	Return a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.	1
COM L A	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.	1
COM L B	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.	1
COM C	Clears all communications records. If both MIRRORED BITS channels are enabled, omitting the channel specifier (A or B) clears both channels.	1
COM C A	Clears all communications records for Channel A.	1
COM C B	Clears all communications records for Channel B.	1

CONTROL Command (Control Remote Bit)

Use the **CON** command (see *Table 7.10*) to control remote bits (Relay Word bits RB01–RB32). You can use the **CON** function from the front panel (`Control > Outputs`) to pulse the outputs. Remote bits are device variables that you set via serial port communication only; you cannot navigate Remote Bits via the front-panel HMI. You can select the control operation from three states: set, clear, or pulse, as described in *Table 7.11*.

Table 7.10 CONTROL Command

Command	Description	Access Level
CON RB *nn k*	Set a Remote Bit to set, clear, or pulse.	2
Parameters		
nn	a number from 01 to 32, representing RB01 through RB32.	
k	S, C, or P	

Table 7.11 Three Remote Bit States

Subcommand	Description	Access Level
S	Set Remote bit (ON position)	2
C	Clear Remote bit (OFF position)	2
P	Pulse Remote bit for 1/4 cycle (MOMENTARY position)	2

For example, use the following command to set Remote bit RB05:

```
=>>CON RB05 S <Enter>
```

COPY Command

Use the **COPY *j k*** command (see *Table 7.12*) to copy the settings of settings Group *j* to the settings of settings Group *k*. The settings of settings Group *j* effectively overwrite the settings of settings Group *k*. Parameters *j* and *k* can be any available settings group number 1 through 3.

Table 7.12 COPY Command

Command	Description	Access Level
COPY *j k*[a]	Copy settings in Group *j* to settings in Group *k*.	2

[a] Parameters *j* and *k* are 1–3.

For example, when you enter the **COPY 1 3** command, the relay responds, `Are you sure (Y/N)?` Answer **Y <Enter>** (for yes) to complete copying. The settings in Group 1 overwrite the settings in Group 3.

COUNTER Command (Counter Values)

The device generates the values of the 32 counters in response to the **COU** command (see *Table 7.13*).

Table 7.13 COUNTER Command

Command	Description	Access Level
COU *n*	Display current state of device counters *n* times, with a 1/2-second delay between each display	1

DATE Command (View/Change Date)

Use the **DATE** command (see *Table 7.14*) 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 7.14 Date Command

Command	Description	Access Level
DATE	Display the internal clock date.	1
DATE *date*	Set the internal clock date (DATE_F set to MDY, YMD, or DMY).	1

Separate the month, day, and year parameters with spaces, commas, slashes, colons, and semicolons. Set the year in 4-digit form (for dates 2000–2099). Global setting DATE_F sets the date format.

ETH Command

The **ETH** command (Access Level 1) can be used to display the Ethernet port (Port 1) status as shown in *Figure 7.21* for the redundant fiber-optic (FX) Ethernet **Port 1A** and **Port 1B** configuration. Copper Ethernet port is labeled as TX. The non-redundant port response is similar.

```
=>>ETH <Enter>

SEL-751                                 Date: 06/05/2010   Time: 10:41:37
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

 PRIMARY PORT:  PORT 1A
 ACTIVE PORT:   PORT 1B

             LINK   SPEED  DUPLEX   MEDIA
PORT 1A      Up    100M     Full    FX
PORT 1B      Down   --      --      FX

=>>
```

Figure 7.21 Ethernet Port (PORT 1) Status Report

The non-redundant port response is as shown in *Figure 7.22*.

```
=>>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 7.22 Non-Redundant Port Response

EVENT Command (Event Reports)

Use the **EVE** command (see *Table 7.15*) to view event reports. See *Section 9: Analyzing Events* for further details on retrieving and analyzing event reports. See the *HISTORY Command on page 7.30* for details on clearing event reports.

Table 7.15 EVENT Command (Event Reports)

Command	Description	Access Level
EVE *n*	Return the *n* event report with 4-samples/cycle data.	1
EVE *n* R	Return the *n* event report with raw (unfiltered) 16 samples/cycle analog data and 4 samples/cycle digital data.	1
Parameter		
n	Parameter *n* specifies the event report number to be returned. Use the **HIS** command to determine the event report number of the event you want to display. If *n* is not specified, the relay will display event report 1 by default.	

FILE Command

The **FIL** command (see *Table 7.16*) 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 7.16 FILE Command

Command	Description	Access Level
FIL DIR	Return a list of files.	1
FIL READ ***filename***	Transfer settings file *filename* from the relay to the PC.	1
FIL WRITE ***filename***	Transfer settings file *filename* from the PC to the relay.	2
FIL SHOW ***filename***	Filename 1 displays contents of the file *file-name*.	1

GOOSE Command

Use the **GOOSE** command to display transmit and receive GOOSE messaging information, which you can use for troubleshooting. The **GOOSE** command variants and options are shown in *Table 7.17*.

Table 7.17 GOOSE Command Variants

Command Variant	Description	Access Level
GOOSE	Display GOOSE information.	1
GOOSE count	Display GOOSE information count times.	1

The information displayed for each GOOSE IED is described in the following table.

IED	Description
`Transmit GOOSE Control Reference`	This field represents the GOOSE control reference information that includes the IED name, ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and GSEControl name (GSE Control Block Name) (e.g., SEL_751_1CFG/LLN0GOGPub01).
`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_751_2CFG/LLN0GOGPub01).
`MultiCastAddr` (Multicast Address)	This hexadecimal field represents the GOOSE multicast address.
`Ptag`	This three-bit decimal field represents the priority tag value, where spaces are used if the priority tag is unknown.
`Vlan`	This 12-bit decimal field represents the virtual LAN (Local Area Network) value, where spaces are used if the virtual LAN is unknown.
`StNum` (State Number)	This hexadecimal field represents the state number that increments with each state change.
`SqNum` (Sequence Number)	This hexadecimal field represents the sequence number that increments with each GOOSE message sent.

IED	Description
TTL (Time to Live)	This field contains the time (in ms) before the next message is expected.
Code	This text field contains warning or error condition text when appropriate that is abbreviated as follows: **Code Abbreviation** — **Explanation** OUT OF SEQUENC — Out of sequence error CONF REV MISMA — Configuration Revision mismatch NEED COMMISSIO — Needs Commissioning TEST MODE — Test Mode MSG CORRUPTED — Message Corrupted TTL EXPIRED — Time to live expired HOST DISABLED — Optional code for when the host is disabled or becomes unresponsive after the **GOOSE** command has been issued
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_751_1CFG/LLN0$GPDSet01).
Receive Data Set Reference	This field represents the datSetRef (Data Set Reference) that includes the iedName (IED name), ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and datSet (Data Set Name) (e.g., SEL_751_2CFG/LLN0$GPDSet01).

An example response to the **GOOSE** command is shown in *Figure 7.23*.

```
#>GOOSE <Enter>

GOOSE Transmit Status

   MultiCastAddr   Ptag:Vlan  StNum      SqNum      TTL    Code
---------------------------------------------------------------------------
SEL_751_1CFG/LLN0$GO$GPub01
   01-0C-CD-01-00-09  4:1     2          481        485
   Data Set: SEL_751_1CFG/LLN0$GPDSet01

GOOSE Receive Status

   MultiCastAddr   Ptag:Vlan  StNum      SqNum      TTL    Code
---------------------------------------------------------------------------
SEL_751_1CFG/LLN0$GO$NewGOOSEMessage5
   01-0C-CD-01-00-05  4:0     1          100425     160
   Data Set: SEL_751_1CFG/LLN0$DSet10

SEL_751_1CFG/LLN0$GO$NewGOOSEMessage3
   01-0C-CD-01-00-03  4:0     1          98531      120
   Data Set: SEL_751_1CFG/LLN0$DSet05

SEL_751_1CFG/LLN0$GO$NewGOOSEMessage2
   01-0C-CD-01-00-02  4:0     1          97486      200
   Data Set: SEL_751_1CFG/LLN0$DSet04

SEL_751_1CFG/LLN0$GO$NewGOOSEMessage1
   01-0C-CD-01-00-01  4:0     1          96412      190
   Data Set: SEL_751_1CFG/LLN0$DSet03

SEL_387E_1CFG/LLN0$GO$NewGOOSEMessage5
   01-0C-CD-01-00-06  4:0     1          116156     140
   Data Set: SEL_387E_1CFG/LLN0$DSet10
SEL_387E_1CFG/LLN0$GO$NewGOOSEMessage4
   01-0C-CD-01-00-05  4:0     1          116041     130
   Data Set: SEL_387E_1CFG/LLN0$DSet06
```

Figure 7.23 GOOSE Command Response (Sheet 1 of 2)

```
SEL_387E_1CFG/LLN0$GO$NewGOOSEMessage2
   01-0C-CD-01-00-02  4:0     1          115848     120
   Data Set: SEL_387E_1CFG/LLN0$DSet04

SEL_387E_1CFG/LLN0$GO$NewGOOSEMessage1
   01-0C-CD-01-00-01  4:0     1          115798     150
   Data Set: SEL_387E_1CFG/LLN0$DSet03

=>
```

Figure 7.23 GOOSE Command Response (Sheet 2 of 2)

GROUP Command

Use the **GROUP** command (see *Table 7.18*) to display the active settings group or try to force an active settings group change.

Table 7.18 GROUP Command

Command	Description	Access Level
GROUP	Display the active settings group.	1
GROUP *n*	Change the active group to Group *n*.	2
Parameter		
n	Parameter n indicates group numbers 1–3.	

When you change the active group, the relay responds with a confirmation prompt: `Are you sure (Y/N)?` Answer **Y <Enter>** to change the active group. The relay asserts the Relay Word bit SALARM for one second when you change the active group.

If any of the SELOGIC control equations SS1–SS3 are set when you issue the **GROUP *n*** command, the group change will fail. The relay responds: `Command Unavailable: Active setting group SELOGIC equations have priority over the GROUP command`.

HELP Command

The **HELP** command (see *Table 7.19*) 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 7.19 HELP Command

Command	Description	Access Level
HELP	Display a list of each command available at the present access level with a one-line description.	1
HELP *command*	Display information on the command ***command***.	1

HISTORY Command

Use the **HIS** command (see *Table 7.20*) to view a list of one-line descriptions of relay events or clear the list (and corresponding event reports) from nonvolatile memory. For more information on event reports, see *Section 9: Analyzing Events*.

Table 7.20 HISTORY Command

Command	Description	Access Level
HIS	Returns event histories with the oldest at the bottom of the list and the most recent at the top of the list.	1
HIS ***n***	Returns event histories with the oldest at the bottom of the list and the most recent at the top of the list, beginning at event *n*.	1
HIS C or R	Clears/resets the event history and all corresponding event reports from nonvolatile memory.	1

HIS HIF Command

The **HIS HIF** command displays a quick synopsis of the last 100 high-impedance fault (HIF) events that the relay has captured. The rows in the **HIS HIF** report contain the event reference number, date, time, event type, location, maximum current, active group, and targets. See *High-Impedance Fault Event History on page 9.21* 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 7.21 HIS HIF Command

Command	Description	Access Level
HIS HIF	Returns HIF event histories with the oldest at the bottom of the list and the most recent at the top of the list.	1
HIS HIF *n*	Returns the n most recent HIF event histories with the oldest at the bottom of the list and the most recent at the top of the list.	1
HIS HIF C or **R**	Clears/resets the HIF events reports but retains the event history.	1
HIS HIF CA or **RA**	Clears/resets the HIF event history and all the corresponding event reports from the nonvolatile memory.	1
Parameter		
n	Indicates a record number. The most recent event will have record number one (1).	

HIS C and HIS R Command

The **HIS C** and **HIS R** commands clear/reset the history data and corresponding high-resolution/event report data on the present port. The relay prompts, `Clear all event reports. Are you sure (Y/N)?` when you issue the **HIS C** and **HIS R** commands. If you answer `Y <Enter>`, the relay clears all **HIF** event reports.

HSG Command

When the SEL-751 is ordered with the Arc Sense™ technology (AST) option for the high-impedance fault (HIF) detection, the relay provides high-impedance fault histogram data with the **HSG** (histogram) command. The **HSG** command displays 100 long-term and 100 short-term histogram counter values of the Phases A, B, and C current odd-harmonic content (ISM) plus the learned limits for the histograms.

Table 7.22 HSG Command

Command	Description	Access Level
HSG	Use the **HSG** command to display high-impedance fault (HIF) histogram data.	1
NOTE:		
LT HIS A, **LT HIS B**, **LT HIS C**	Long-term histogram counter values of the Phases A, B and C current odd-harmonic content (ISM)	
ST HIS A, **ST HIS B**, **ST HIS C**	Short-term histogram counter values of the Phases A, B and C current odd-harmonic content (ISM)	
HISLIMA, **HISLIMB**, **HISLIMC**	Learned histogram thresholds for Phases A, B, and C	
Mean	Mean values of short- and long-term histograms for Phases A, B, C.	
Std	Standard deviations for the short- and long-term standard deviations for the short- and long-term histograms for Phases A, B, C.	
NFA, NFB, NFC	Pickup thresholds of decision timers for Phases A, B, C	

Figure 7.24 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 7.24 HSG Command Response

The purpose of the Statistics function is to learn the effects of feeder normal loads on the detection quantity ISM. The function keeps two histogram counters, each has 100 units.

HIF odd-harmonic decision function generates HIF alarms if the difference between two histograms is statistically substantial (determined by using their means and standard deviations). When the difference between the two histograms is not substantial, the long-term histogram is updated through an IIR filtering process from the short-term histogram. The long-term histogram therefore adapts to the feeder ambient load conditions and increases the overall HIF detection security.

IDENTIFICATION Command

Use the **ID** command (see *Table 7.23*) to extract device identification codes.

Table 7.23 IDENTIFICATION Command

Command	Description	Access Level
ID	Returns a list of device identification codes.	0

INI HIF Command

The **INI HIF** command (see *Table 7.24*) is used to restart the 24 -hour tuning process used in high-impedance fault detection. This command is only available when the relay supports **HIF** detection and **EHIF** is not set to N. If you issue the **INI HIF** commands, the relay prompts, `Initiate HIF 24-hour tuning (Y/N)?` If you answer `Y <Enter>`, the relay initiates the tuning process.

Table 7.24 INI HIF Command

Command	Description	Access Level
INI HIF	Initiates the 24 -hour tuning process used in high-impedance fault detection.	2

IRI Command

Use the **IRI** command to direct the relay to read the demodulated IRIG-B time code at the serial port or IRIG-B input (see *Table 7.25*).

Table 7.25 IRI Command

Command	Description	Access Level
IRI	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 **IRI** command to synchronize the relay clock with IRIG-B. Use the **IRI** command to determine if the relay is properly reading the IRIG-B signal.

LDP Command (Load Profile Report)

Use the **LDP** commands (see *Table 7.26*) 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 7.26 LDP Commands

Command	Description	Access Level
LDP ***row1 row2*** **LDP** ***date1 date2***	Uses the **LDP** command to display a numeric progression of all load profile report rows. Uses the **LDP** command with parameters to display a numeric or reverse numeric subset of the load profile rows.	1
LDP C	Use this command to clear the load profile report from nonvolatile memory.	1
Parameters		
row1 row2	Append *row1* to return a chronological progression of the first *row1* rows. Append *row1* and *row2* to return all rows between *row1* and *row2*, beginning with *row1* and ending with *row2*. Enter the smaller number first to display a numeric progression of rows through the report. Enter the larger number first to display a reverse numeric progression of rows.	
date1 date2	Append *date1* to return all rows with this date. Append *date1* and *date2* to return all rows between *date1* and date beginning with *date1* and ending with *date2*. Enter the oldest date first to display a chronological progression through the report. Enter the newest date first to display a reverse chronological progression. Date entries are dependent on the date format setting DATE_F.	

L_D Command (Load Firmware)

Use the **L_D** command (see *Table 7.27*) to load firmware. See *Appendix A: Firmware and Manual Versions* for information on changes to the firmware and instruction manual. See *Appendix B: Firmware Upgrade Instructions* for further details on downloading firmware. Only download firmware to the front port.

Table 7.27 L_D Command (Load Firmware)

Command	Description	Access Level
L_D	Download firmware to the control.	2

LOG HIF (High-Impedance Fault) Command

When the SEL-751 is ordered with the Arc Sense™ technology (AST) option for the high-impedance fault detection, the relay provides high-impedance fault detection progress data with the **LOG HIF** (**LOG H** command) report.

The **LOG HIF** command displays the progress of HIF detection in percentage of their final pickup, the update of each entry is adaptive based on HIF detection outputs. This command is available only when enable setting EHIF is set to Y and Relay Word bit ITUNE_*x* (where *x* is A,B, or C) is deasserted (tuning process has been completed).

Table 7.28 LOG HIF Command

Command	Description	Access Level
LOG H	Use the **LOG H** command to display the progress of high-impedance fault (HIF) detection.	1

NOTE:

- ➤ Odd-harmonic alarm and fault values ALG.1 A, ALG.1 B, and ALG.1 C for Phases A, B, and C in percent of preset alarm and fault thresholds.
- ➤ Non-harmonic alarm and fault values ALG.2 A, ALG.2 B, and ALG.2 C for Phases A, B, and C in percent of preset alarm and fault thresholds.
- ➤ HI1 and HI2 are the digital outputs of the odd-harmonic and non-harmonic alarm and fault detection logic. The HIF odd-harmonic alarm and fault output bits under HI1 are HIA1_A, HIA1_B, HIA1_C, and HIF1_A, HIF1_B, HIF1_C, respectively and the HIF non-harmonic alarm and fault output bits under HI2 are HIA2_A, HIA2_B, HIA2_C, and HIF2_A, HIF2_B, HIF2_C, respectively. These Relay Word bits assert when the corresponding percentage values reach 100%.

Figure 7.25 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 7.25 LOG H (HIF) Command Response

LOOPBACK Command

Use the **LOO** command (see *Table 7.29*) for testing the MIRRORED BITS communications channel for proper communication. For more information on MIRRORED BITS, see *Appendix I: MIRRORED BITS Communications*.

Table 7.29 LOO Command

Command	Description	Access Level
LOO	Enable loopback testing of MIRRORED BITS channels.	2
LOO A	Enable loopback on MIRRORED BITS Channel A for the next 5 minutes.	2
LOO B	Enable loopback on MIRRORED BITS Channel B for the next 5 minutes.	2

With the transmitter of the communications channel physically looped back to the receiver, the MIRRORED BITS addressing will be wrong and ROK will be deasserted. The **LOO** command tells the MIRRORED BITS software to temporarily expect to see its own data looped back as its input. In this mode, LBOK will assert 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 will cause both channels to be disabled.

```
=>>LOO R <Enter>
Loopback is disabled on both channels.
=>>
```

MAC Command

Use the **MAC** command to display the MAC addresses of **PORT 1**, as shown in the following.

```
=>MAC <Enter>
Port 1 MAC Address:  00-30-A7-00-00-00
=>
```

MET Command (Metering Data)

The **MET** command (see *Table 7.30* and *Table 7.31*) provides access to the relay metering data.

Table 7.30 Meter Command

Command	Description	Access Level
MET *c n*	Display metering data.	1
MET *c* R	Reset metering data.	2
Parameters		
c	Parameter for identifying meter class.	
n	Parameter used to specify number of times (1–32767) to repeat the meter response.	

Table 7.31 Meter Class

c	Meter Class
F	Fundamental Metering
E[a]	Energy Metering
M[a]	Maximum/Minimum Metering
R	RMS Metering
T	Thermal and RTD Metering
AI	Analog Input (transducer) Metering
DE[a]	Demand Metering
PE[a]	Peak Demand Metering
PM	Synchrophasor Metering
L	Light Metering for Arc-Flash Detection (AFD)
MV	SELOGIC Math Variable Metering
RA	Remote Analog Metering
HIF	High-Impedance Fault (HIF) Metering

[a] Reset Metering Available.

For more information on metering and example responses for each meter class, see *Section 5: Metering and Monitoring*.

On issuing the **MET *c* R** command for resetting metering quantities in class *c*, the relay responds: `Reset Metering Quantities (Y,N)?` Upon confirming (pressing **Y**), the metering quantities will be 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 4.41* and *Figure 4.33* 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 will abort the command.

The main board breaker jumper (see *Table 2.14*) 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 BRKR Jumper
=>>
```

PASSWORD Command (Change Passwords)

Use the **PAS** command (see *Table 7.32*) to change existing passwords.

Table 7.32 PASSWORD Command

Command	Description	Access Level
PAS ***level***	Change password for Access Level ***level***.	2, C
Parameter		
level	Represents the relay Access Levels 1, 2, or C.	

⚠WARNING

This device is shipped with default passwords. Default passwords should be changed to private passwords at installation. Failure to change each default password to a private password may allow unauthorized access. SEL shall not be responsible for any damage resulting from unauthorized access.

The factory default passwords are as shown in *Table 7.33*.

Table 7.33 Factory Default Passwords for Access Levels 1, 2, and C

Access Level	Factory Default Password
1	OTTER
2	TAIL
C	CLARKE

To change the password for Access Level 1 to #Ot3579!ijd7, enter the following command sequence:

```
=>>PAS 1 <Enter>
Old PW: ? ***** <Enter>
New PW: ? *********** <Enter>
Confirm PW: ? *********** <Enter>
Password Changed
=>>
```

Similarly, use **PAS 2** to change Level 2 passwords and **PAS C** to change Level C passwords.

Table 7.34 Valid Password Characters

Alpha	A B C D E F G H I J K L M N O P Q R S T U V W X Y Z a b c d e f g h i j k l m n o p q r s t u v w x y z
Numeric	0 1 2 3 4 5 6 7 8 9
Special	! " # $ % & ' ( ) * + , - . / : ; < = > ? @ [\ ] ^ _ ` { | } ~

Passwords can contain as many as 12 characters. Upper- and lowercase letters are treated as different characters. Strong passwords consist of 12 characters, with at least one special character or digit and mixed-case sensitivity, but do not form a name, date, acronym, or word. Passwords formed in this manner are less susceptible to password guessing and automated attacks.

Examples of valid, distinct, and strong passwords are as follows:

- #0t3579!ijd7
- (Ih2dcs)36dn
- $A24.68&,mvj
- *4u-Iwg+?lf-

PING Command

When you are setting up or testing substation networks, it is helpful to determine if the network is connected properly and if the other devices are powered up and configured properly. The **PING** command (Access Level 2) allows a user of the relay to determine if a host is reachable across an IP network and/or if the Ethernet port (Port 1) is functioning or configured correctly. A typical **PING** command response is shown in *Figure 7.26*.

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 7.26 PING Command Response

PULSE Command

NOTE: The **PULSE** command is available when the breaker control jumper on the mainboard is in the ENABLED position.

Use the **PULSE** command (see *Table 7.35*) to pulse any of the relay control outputs for a specified time. This function aids you in relay testing and commissioning. If the output is open, the **PUL** command momentarily closes the output; if the output is closed, the **PUL** command momentarily opens the output. The control outputs are **OUT*nnn***, where ***nnn*** represents 101–103 (standard), 301–304 (optional), 401–404 (optional), or 501–504 (optional).

Table 7.35 PUL OUT*nnn* Command

Command	Description	Access Level
PUL OUT*nnn*	Pulse output OUT*nnn* for 1 second.	2
PUL OUT*nnn s*	Pulse 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 7.36*) to revert to Access Level 0.

Table 7.36 QUIT Command

Command	Description	Access Level
QUIT	Go to Access Level 0.	0

Access Level 0 is the lowest access level; the SEL-751 performs no password check to descend to this level (or to remain at this level).

R_S Command (Restore Factory Defaults)

Use the **R_S** command (see *Table 7.37*) to restore factory default settings.

Table 7.37 R_S Command (Restore Factory Defaults)

Command	Description	Access Level
R_S	Restore the factory default settings and passwords and reboot the system.[a]	2

[a] Only available after a settings or critical RAM failure.

SER Command (Sequential Events Recorder Report)

Use the **SER** commands (see *Table 7.38*) to view and manage the Sequential Events Recorder report. See *Section 9: Analyzing Events* for further details on SER reports. If the requested SER report rows do not exist, the relay responds with `No SER data`.

Table 7.38 SER Command (Sequential Events Recorder Report)

Command	Description	Access Level
SER	Use the **SER** command to display a chronological progression of all available SER rows (as many as 1024 rows). Row 1 is the most recently triggered row and row 1024 is the oldest.	1
SER C or **R**	Use this command to clear/reset the SER records.	1
Parameter		
row1	Append *row1* to return a chronological progression of the first *row1* rows. For example, use **SER 5** to return the first five rows.	
row1 row2	Append *row1* and *row2* to return all rows between *row1* and *row2*, beginning with row1 and ending with *row2*. Enter the smaller number first to display a numeric progression of rows through the report. Enter the larger number first to display a reverse numeric progression of rows. For example, use **SER 1 10** to return the first 10 rows in numeric order or **SER 10 1** to return these same items in reverse numeric order.	
date1	Append *date1* to return all rows with this date. For example, use **SER 1/1/2003** to return all records for January 1, 2003.	
date1 date2	Append *date1* and *date2* to return all rows between date1 and date beginning with *date1* and ending with *date2*. Enter the oldest date first to display a chronological progression through the report. Enter the newest date first to display a reverse chronological progression. Date entries are dependent on the date format setting DATE_F. For example, use **SER 1/5/2003 1/7/2003** to return all records for January 5, 6, and 7, 2003	

SER D Command

The **SER D** command shows a list of SER items that the relay has automatically removed. These are “chattering” elements. You can automatically remove chattering SER elements in the SER Chatter Criteria category of the Report settings; the enable setting is ESERDEL. See *Section 4: Protection and Logic Functions*, *Report Settings (SET R Command)* for more information on SER automatic deletion and reinsertion.

Table 7.39 SER D Command

Command	Description	Access Level
SER D	List chattering SER elements that the relay is removing from the SER records.	1

If you issue the **SER D** command and you have not enabled automatic removal of chattering SER elements (Report setting ESERDEL), the relay responds, `Automatic removal of chattering SER elements not enabled`.

SET Command (Change Settings)

The **SET** command is for viewing or changing the relay settings (see *Table 7.40*).

Table 7.40 SET Command (Change Settings)

Command	Description	Access Level
SET *n s* TERSE	Set the Relay settings, beginning at the first setting for group *n* (*n = 1, 2, or 3*).	2
SET L *n s* TERSE	Set general logic settings for group *n* (*n = 1, 2, or 3*).	2
SET G *s* TERSE	Set global settings.	2
SET P *n s* TERSE	Set serial port settings. *n* specifies the PORT (**1**, **2**, **3**, **4**, or **F**); *n* defaults to the active port if not listed.	2
SET R *s* TERSE	Set report settings such as Sequential Events Recorder (SER) and Event Report (ER) settings.	2
SET F *s* TERSE	Set front-panel settings.	2
SET M *s* TERSE	Set Modbus User Map settings.	2
SET DNP *m s* TERSE	Set DNP Map *m* settings (*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 7.41*.

Table 7.41 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 7.42* for the **SHOW** command settings and for the command format.

Table 7.42 SHOW Command (Show/View Settings)

Command	Description	Access Level
SHO *n s*	Show Relay settings for group *n* (*n = 1, 2, or 3*).	1
SHO L *n s*	Show general logic settings for group *n* (*n = 1, 2, or 3*).	1
SHO G *s*	Show global settings.	1
SHO P *n s*	Show 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*	Show report settings such as Sequential Events Recorder (SER) and Event Report (ER) settings.	1
SHO F *s*	Show front-panel settings.	1
SHO M *s*	Show Modbus User Map settings.	1
SHO DNP *m s*	Show DNP Map *m* settings (*m* = 1, 2, or 3).	1
Parameter		
s	Appends, ***s***, the name of the specific setting you want to view, and jumps to this setting. If ***s*** is not entered, the relay starts at the first setting.	

```
=>>SHO <Enter>

Group 1
Relay Settings

ID Settings
RID      := SEL-751
TID      := FEEDER RELAY

Config Settings
CTR      := 120           CTRN     := 120           PTR      := 180.00
PTRS     := 180.00        DELTA_Y  := DELTA         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

Phase TOC
51AP     := 6.00          51AC     := U3            51ATD    := 3.00
51ARS    := N             51ACT    := 0.00          51AMR    := 0.00
51ATC    := 1
51BP     := 6.00          51BC     := U3            51BTD    := 3.00
51BRS    := N             51BCT    := 0.00          51BMR    := 0.00
51BTC    := 1
51CP     := 6.00          51CC     := U3            51CTD    := 3.00
51CRS    := N             51CCT    := 0.00          51CMR    := 0.00
51CTC    := 1

Maximum Ph TOC
51P1P    := 6.00          51P1C    := U3            51P1TD   := 3.00
51P1RS   := N             51P1CT   := 0.00          51P1MR   := 0.00
51P1TC   := 1
51P2P    := 6.00          51P2C    := U3            51P2TD   := 3.00
51P2RS   := N             51P2CT   := 0.00          51P2MR   := 0.00
51P2TC   := 1

Negative Seq TOC
51QP     := 6.00          51QC     := U3            51QTD    := 3.00
51QRS    := N             51QCT    := 0.00          51QMR    := 0.00
51QTC    := 1

Neutral TOC
51N1P    := OFF           51N2P    := OFF

Residual TOC
51G1P    := 0.50          51G1C    := U3            51G1TD   := 1.50
51G1RS   := N             51G1CT   := 0.00          51G1MR   := 0.00
51G1TC   := 1
51G2P    := 0.50          51G2C    := U3            51G2TD   := 1.50
51G2RS   := N             51G2CT   := 0.00          51G2MR   := 0.00
51G2TC   := 1

Directional Set
EDIR     := N
```

Figure 7.27 SHOW Command Example (Sheet 1 of 2)

```
Load Encroach Set
ELOAD    := N

High Impedance Fault Settings
EHIF     := N

RTD Settings
E49RTD   := NONE

Undervoltage Set
27PP1P   := OFF           27PP2P   := OFF           27S1P    := OFF
27S2P    := OFF

Overvoltage Set
59PP1P   := OFF           59PP2P   := OFF           59Q1P    := OFF
59Q2P    := OFF           59S1P    := OFF           59S2P    := OFF

SyncCheck Set
E25      := N

Power Factor Set
55LGTP   := OFF           55LDTP   := OFF           55LGAP   := OFF
55LDAP   := OFF

Frequency Set
81D1TP   := OFF           81D2TP   := OFF           81D3TP   := OFF
81D4TP   := OFF           81D5TP   := OFF           81D6TP   := OFF

Rate of Frequency Set
E81R     := N

Fast Rate of Frequency Set
E81RF    := N

Demand Mtr Set
EDEM     := THM           DMTC     := 5             PHDEMP   := 5.00
GNDEMP   := 1.00          3I2DEMP  := 1.00

Power Elements
EPWR     := N


Trip/Close Logic
TDURD    := 0.5           CFD      := 1.0
TR       := ORED50T OR ORED51T OR ORED81T OR REMTRIP OR OC OR SV04T
REMTRIP  := 0
ULTRIP   := NOT ( 51P1P OR 51G1P OR 51N1P OR 52A )
52A      := 0
CL       := SV03T AND LT02 OR CC
ULCL     := 0

Reclosing Control
E79      := N
=>>
```

Figure 7.27 SHOW Command Example (Sheet 2 of 2)

STATUS Command (Relay Self-Test Status)

The **STA** command (see *Table 7.43*) displays the status report.

Table 7.43 STATUS Command (Relay Self-Test Status)

Command	Description	Access Level
STA *n*	Display the relay self-test information ***n*** times (***n*** = 1–32767). Defaults to 1 if ***n*** is not specified.	1
STA S	Display the memory and execution utilization for the SELOGIC control equations.	1
STA C or **R**	Reboot the relay and clear self-test warning and failure status results.	2

Refer to *Section 10: Testing and Troubleshooting* for self-test thresholds and corrective actions, as well as hardware configuration conflict resolution. *Table 7.44* shows the status report definitions and message formats for each test.

Table 7.44 STATUS Command Report and Definitions

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 FGPA programming unsuccessful, or Front-Panel FPGA failed	OK/WARN
RAM	Volatile memory integrity	OK/FAIL
ROM	Firmware integrity	OK/FAIL
CR_RAM	Integrity of settings in RAM and code that runs in RAM	OK/FAIL
Non_Vol	Integrity of data stored in nonvolatile memory	OK/FAIL
Clock	Clock functionality	OK/WARN
RTD	Integrity of RTD module/communications	OK/FAIL
CID_FILE	Configured IED description file	OK/FAIL
x.x V	Power supply status (Refer to *Figure 1.4* and *Figure 1.5* for examples of **STATUS** command responses)	Voltage/FAIL
BATT	Clock battery voltage	Voltage/WARN
CARD_C	Integrity of Card C	OK/FAIL
CARD_D	Integrity of Card D	OK/FAIL
CARD_E	Integrity of Card E	OK/FAIL
CARD_Z	Integrity of CARD Z (current/voltage)	OK/FAIL
DN_MAC_ID	Specific DeviceNet card identification	Text Data
ASA	Manufacturers identifier for DeviceNet	Text Data
DN_Rate	DeviceNet card network communications data rate ___kbps	Text Data
DN_Status	DeviceNet connection and fault status 000b bbbb	Text Data
Current Offset (IA, IB, IC, IN)	DC offset in hardware circuits of current channels	OK/WARN
Voltage Offset (VA, VB, VC, VS)	DC offset in hardware circuits of voltage channels	OK/FAIL

Figure 7.28 shows the typical relay output for the **STATUS S** command, showing available SELOGIC control equation capability.

```
=>STA S <Enter>

SEL-751                                Date: 02/27/2010   Time: 15:04:16
FEEDER RELAY                            Time Source: Internal

Part Number  75101BBX5X7086030X
Global (%)    81
FP (%)        69
Report (%)    96

               GROUP 1  GROUP 2  GROUP 3
Execution (%)   90       90       90
Group (%)       81       81       81
Logic (%)       89       89       89

=>
```

Figure 7.28 Typical Relay Output for STATUS S Command

SUMMARY Command

The **SUM** command (see *Table 7.45*) displays an event summary in a readable format.

Table 7.45 SUMMARY Command

Command	Description	Access Level
SUM *n*	The command without arguments displays the latest event summary. Use *n* to display particular event summary.	1
SUM R or C	Use this command to clear the archive.	1

Each event summary report shows the date, time, current magnitudes (primary values), frequency, and, if the relay has the voltage option, voltage magnitudes (primary values). The relay reports the voltage and current when the largest current occurs during the event. The event summary report also shows the event type (e.g., Phase A 51 Trip).

SUMMARY HIF Command

Use the **SUM HIF** command (see *Table 7.46*) to view the HIF event summary reports in the relay memory. This command is only available when the relay supports HIF detection.

Table 7.46 SUM HIF Command

Command	Description	Access Level
SUM HIF	Return the most recent HIF event summary.	1
SUM HIF *n*	Return an event summary for HIF event n.	1
Parameter		
n	Indicates the record number; see the HIF event history report (**HIS HIF** command)	

TARGET Command (Display Relay Word Bit Status)

The **TAR** command (see *Table 7.47*) displays the status of front-panel target LEDs or Relay Word bit, whether these LEDs or Relay Word bits are asserted or deasserted.

NOTE: The **TARGET R** command cannot reset the latched targets if a TRIP condition is present.

Table 7.47 TARGET Command (Display Relay Word Bit Status)

Command	Description	Access Level
TAR *name* k **TAR *n*** **TAR *n k***	Use **TAR** without parameters to display Relay Word Row 0 or the last displayed target row.	1
TAR R	Clears front-panel tripping targets. Unlatches the trip logic for testing purposes (see *Figure 8.1*). Shows Relay Word Row 0.	1
Parameter		
name	Displays the Relay Word row with Relay Word bit name.	
n	Shows Relay Word row number ***n***.	
k	Repeats ***k*** times (1–32767)	

The elements are represented as Relay Word bits and are listed in rows of eight, called Relay Word rows. The first four rows, representing the front-panel operation and target LEDs, correspond to *Table 7.48*. All Relay Word rows are described in *Table J.1* and *Table J.2*.

Relay Word bits are used in SELOGIC control equations. See *Appendix J: Relay Word Bits*.

The **TAR** command does not remap the front-panel target LEDs, as is done in some previous SEL relays.

Table 7.48 Front-Panel LEDs and the TAR 0 Command

LEDs	7	6	5	4	3	2	1	0
TAR 0	ENABLED	TRIP_LED	TLED_01	TLED_02	TLED_03	TLED_04	TLED_05	TLED_06

TIME Command (View/Change Time)

The **TIME** command (see *Table 7.49*) 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 7.49 TIME Command (View/Change Time)

Command	Description	Access Level
TIME	Display the present internal clock time.	1
TIME *hh:mm*	Set the internal clock to ***hh:mm***.	1
TIME *hh:mm:ss*	Set the internal clock to ***hh:mm:ss***.	1

Use the **TIME *hh:mm*** and **TIME *hh:mm:ss*** commands to set the internal clock time. The value ***hh*** is for hours from 0–23; the value ***mm*** is for minutes from 0–59; the value ss is for seconds from 0–59. If you enter a valid time, the relay updates and saves the time in the nonvolatile clock, and displays the time you just entered. If you enter an invalid time, the SEL-751 responds with `Invalid Time`.

TRIGGER Command (Trigger Event Report)

Use the **TRI** command (see *Table 7.50*) to trigger the SEL-751 to record data for high-resolution oscillography and event reports.

Table 7.50 TRIGGER Command (Trigger Event Report)

Command	Description	Access Level
TRI	Trigger 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 9: Analyzing Events* for further details on event reports.

TRIGGER HIF Command

Use the **TRI HIF** command (see *Table 7.51*) to trigger the SEL-751 to record data for high-impedance fault event reports. This command is only available when the relay supports HIF detection and EHIF is not set to N. When you issue the **TRI HIF** command, the relay responds, `triggered`. If the event did not trigger within 1 second, the relay responds, `did not trigger`.

Table 7.51 TRIGGER HIF Command

Command	Description	Access Level
TRI HIF	Trigger HIF compressed event report data capture.	1

Section 8
Front-Panel Operations

Overview

The SEL-751 Feeder Protection Relay front panel makes feeder data collection and control quick and efficient. Use the front panel to analyze operating information, view and change relay settings, and perform control functions. The SEL-751 features a straightforward menu-driven control structure presented on the front-panel liquid crystal display (LCD). Front-panel targets and other LEDs give a clear indication of the SEL-751 operation status. The features that help you operate the relay from the front panel include the following:

- ➤ Reading metering
- ➤ Inspecting targets
- ➤ Accessing settings
- ➤ Controlling relay operations
- ➤ Viewing diagnostics

Front-Panel Layout

Figure 8.1 shows and identifies the following regions:

- ➤ Human-Machine Interface (HMI)
- ➤ TARGET RESET and navigation pushbuttons
- ➤ Operation and target LEDs
- ➤ Operator control pushbuttons and pushbutton LEDs
- ➤ EIA-232 Serial Port (PORT F). See *Section 7: Communications* for details on the serial port.

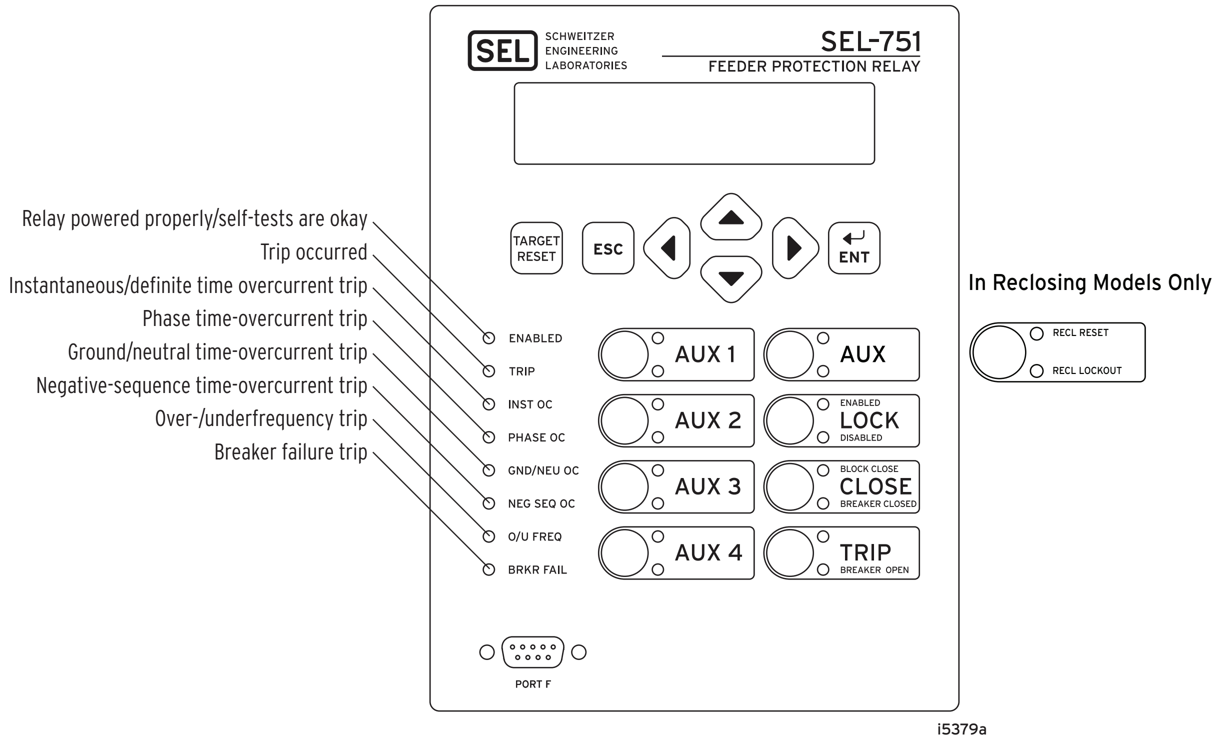


Figure 8.1 Front-Panel Overview

You can use the following features of the versatile 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.

Human-Machine Interface

Contrast

NOTE: See the Preface for an explanation of typographic conventions used to describe menus, the front-panel display, and the front-panel pushbuttons.

You can adjust the LCD screen contrast to suit your viewing angle and lighting conditions. To change screen contrast, press and hold the **ESC** pushbutton for two seconds. The SEL-751 displays a contrast adjustment box. Pressing the **Right Arrow** pushbutton increases the contrast. Pressing the **Left Arrow** pushbutton decreases the screen contrast. When you are finished adjusting the screen contrast, press the **ENT** pushbutton; this process is a shortcut for changing the LCD contrast setting FP_CONT in the front-panel settings.

Front-Panel Automatic Messages

The relay displays automatic messages that override the rotating display under the conditions described in *Table 8.1*. Relay failure has the highest priority, followed by trip and alarm when the front-panel setting FP_AUTO := OVERRIDE.

If the front-panel setting FP_AUTO := ROTATING, then the rotating display messages continue and any TRIP or ALARM message is added to the rotation. Relay failure will still override the rotating display.

Table 8.1 Front-Panel Automatic Messages (FP_AUTO := OVERRIDE)

Condition	Front-Panel Message
Relay detecting any failure	Displays the type of latest failure (see *Section 10: Testing and Troubleshooting*).
Relay trip has occurred	Displays the type or cause of the trip. Refer to *Table 9.1* for a list of trip display messages.
Relay alarm condition has occurred	Displays the type of alarm. The TRIP LED is also flashing during an alarm condition. See *Table 8.3* for a list of the alarm conditions.

Front-Panel Security

Front-Panel Access Levels

The SEL-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.

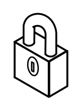


Figure 8.2 Access Level Security Padlock Symbol

Before you can perform a front-panel menu activity that is marked with the padlock symbol, you must enter the correct Access Level 2 password. After you have correctly entered the password, you can perform other Access Level 2 activities without reentering the password.

Access Level 2 Password Entry

When you try to perform an Access Level 2 activity, the relay determines whether you have entered the correct Access Level 2 password since the front-panel inactivity timer expired. If you have not, the relay displays the screen shown in *Figure 8.3* for you to enter the password.

Figure 8.3 Password Entry Screen

See *PASSWORD Command (Change Passwords) on page 7.38* for the list of default passwords and for more information on changing passwords.

Front-Panel Timeout

To help prevent unauthorized access to password-protected functions, the SEL-751 provides a front-panel timeout, setting FP_TO. A timer resets every time you press a front-panel pushbutton. Once the timeout period expires, the access level resets to Access Level 1. Manually reset the access level by selecting `Quit` from the `MAIN` menu.

Front-Panel Menus and Screens

Navigating the Menus

The SEL-751 front panel gives you access to most of the information that the relay measures and stores. You can also use front-panel controls to view or modify relay settings.

All of the front-panel functions are accessible through use of the six-button keypad and LCD display. Use the keypad (shown in *Figure 8.4*) to maneuver within the front-panel menu structure, described in detail throughout the remainder of this section. *Table 8.2* describes the function of each front-panel pushbutton.

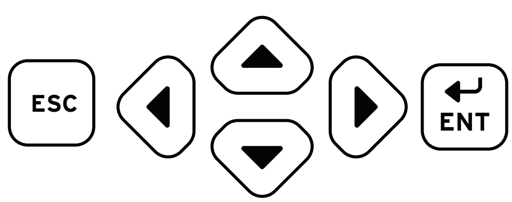


Figure 8.4 Front-Panel Pushbuttons

Table 8.2 Front-Panel Pushbutton Functions

Pushbutton	Function
Up Arrow	Move up within a menu or data list. While editing a setting value, increase the value of the underlined digit.
Down Arrow	Move down within a menu or data list. While editing a setting value, decrease the value of the underlined digit.
Left Arrow	Move the cursor to the left.
Right Arrow	Move the cursor to the right.
ESC	Escape from the 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 8.5 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.

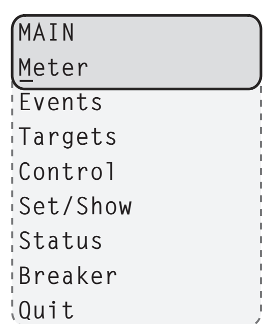


Figure 8.5 Main Menu

Meter Menu

Select the `Meter` menu item from the `MAIN` menu as shown in *Figure 8.6* to view metering data. The `Meter` menu has menu items for viewing different types of metering data like Fundamental, rms, Thermal, etc. Select the type of metering and view the data by using the **Up Arrow** or **Down Arrow** pushbuttons. See *Metering on page 5.2* for a description of the available data fields.

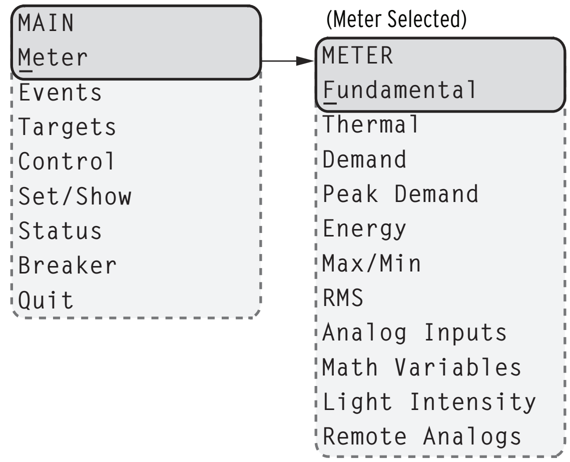


Figure 8.6 MAIN Menu and METER Submenu

For viewing Energy (or Max/Min) metering data, select the `Energy` (or `Max/Min`) menu item from the `METER` menu and select the `Display` menu item as shown in *Figure 8.7*.

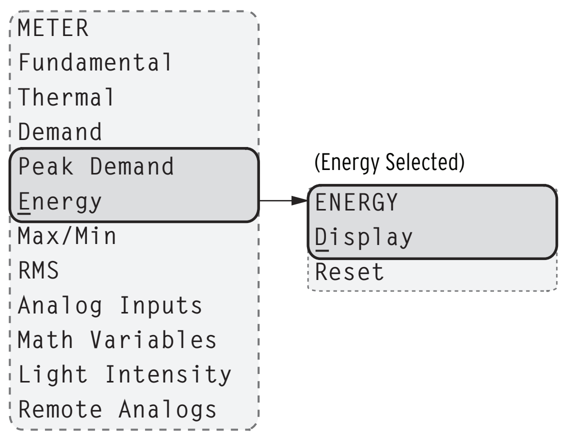


Figure 8.7 METER Menu and ENERGY Submenu

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 8.8*.

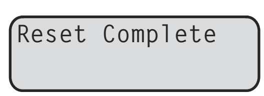


Figure 8.8 Relay Response When Energy (or Max/Min, Demand, Peak Demand) Metering Is Reset

Assume that the relay configuration contains no analog input cards. In response to a request for analog data (selecting `Analog Inputs`), the device displays the message as shown in *Figure 8.9*.

Figure 8.9 Relay Response When No Analog Cards Are Installed

Assume that the math variables are not enabled. In response to a request for math variable data (selecting `Math Variables`), the device displays the message as shown in *Figure 8.10*.

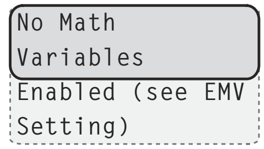


Figure 8.10 Relay Response When No Math Variables Enabled

Events Menu

Select the `Events` menu item from the `MAIN` menu as shown in *Figure 8.11*. `EVENTS` menu has `Display` and `Clear` as menu items. Select `Display` to view events and `Clear` to delete all the events data.

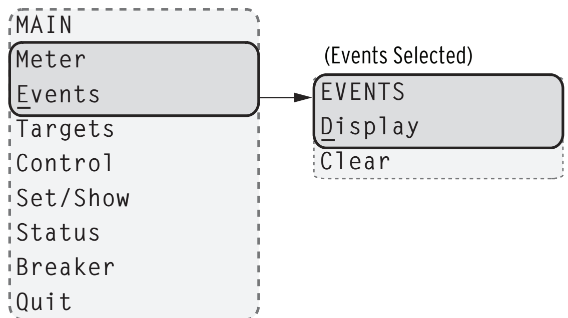


Figure 8.11 MAIN Menu and EVENTS Submenu

Figure 8.12 shows the `DISPLAY` menu when `Display` is selected from the `EVENTS` menu with events in the order of occurrence starting with the most recent. You can select an event from the `DISPLAY` menu and navigate through the event data.

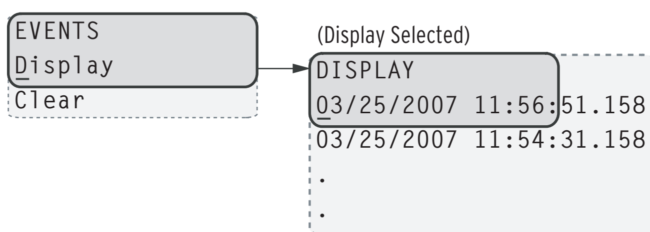


Figure 8.12 EVENTS Menu and DISPLAY Submenu

When `Display` is selected and no event data are available, the relay displays as shown in *Figure 8.13*.

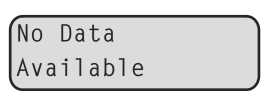


Figure 8.13 Relay Response When No Event Data Available

When you select `Clear` from the `EVENTS` menu and confirm the selection, the relay displays the response shown in *Figure 8.14* after it clears the events data.

Figure 8.14 Relay Response When Events Are Cleared

Targets Menu

Select the `Targets` menu item on the `MAIN` menu as shown in *Figure 8.15* to view the binary state of the target rows. Each target row has eight Relay Word bits as shown in *Table J.1*.

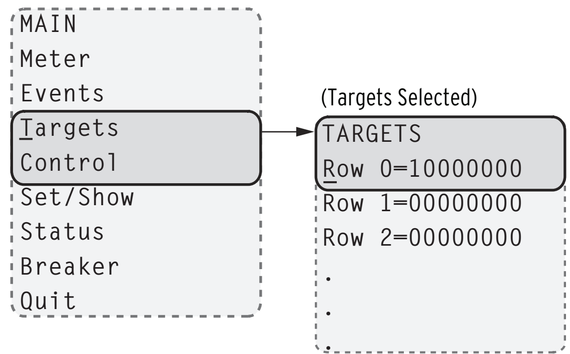


Figure 8.15 MAIN Menu and TARGETS Submenu

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

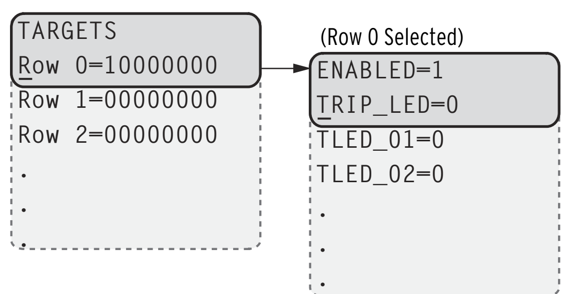


Figure 8.16 TARGETS Menu Navigation

Control Menu

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

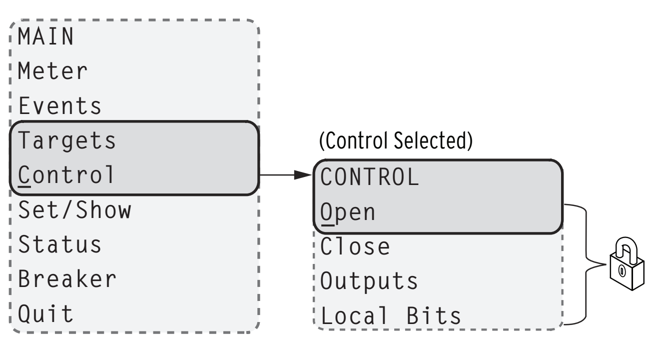


Figure 8.17 MAIN Menu and CONTROL Submenu

The `CONTROL` menu has `Open`, `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 4.37* for the TR equation and *Table J.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 4.52*). Note that this requires Level 2 access.

Select the Outputs menu item from the CONTROL menu as shown in *Figure 8.18* to test (pulse) SEL-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 Level 2 access and reconfirmation.

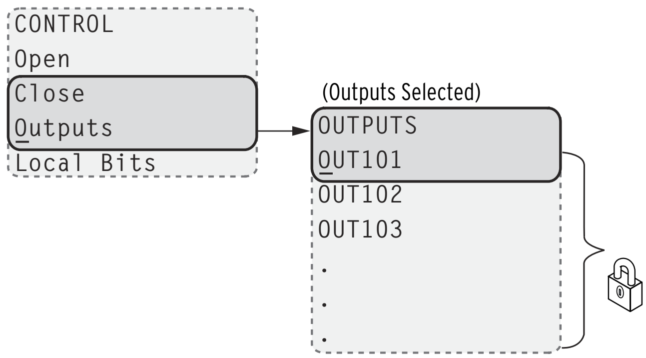


Figure 8.18 CONTROL Menu and OUTPUTS Submenu

Select the Local Bits menu item from the CONTROL menu for local control action. Local bits take the place of traditional panel switches and perform isolation, open, close, or pulse operations.

With the settings as per the example in *Section 4* (see *Local Bits on page 4.148* for more information), local bit 1 replaces a supervisory switch. *Figure 8.19* shows the screens in closing the supervisory switch. In this operation, local bit LB01 is deasserted (SUPER SW = OPEN). It then changes to asserted (SUPER SW = CLOSE) as shown in the final screen of *Figure 8.19*.

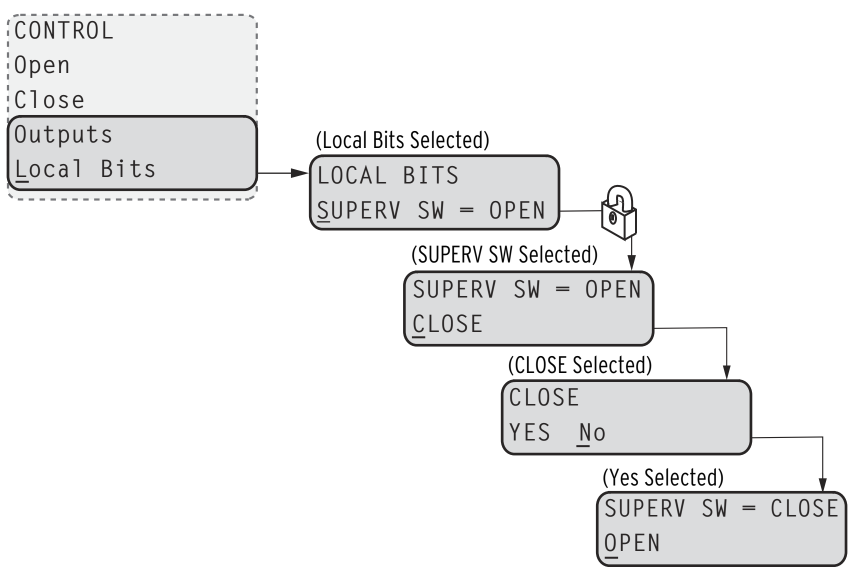


Figure 8.19 CONTROL Menu and LOCAL BITS Submenu

Set/Show Menu

Select the Set/Show menu item on the MAIN menu. 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.

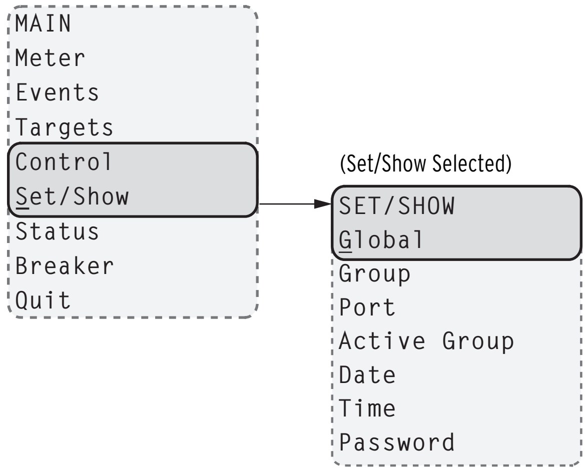


Figure 8.20 MAIN Menu and SET/SHOW Submenu

Each settings class (Global, Group, and Port) includes headings that create subgroups of associated settings as shown in the following illustration. Select the heading that contains the setting of interest, and then navigate to the particular setting. View or edit the setting by pressing the **ENT** pushbutton. For text settings, use the four navigation pushbuttons to scroll through the available alphanumeric and special character settings matrix. For numeric settings, use the **Left Arrow** and **Right Arrow** pushbuttons to select the digit to change and the **Up Arrow** and **Down Arrow** pushbuttons to change the value. Press the **ENT** pushbutton to enter the new setting.

You can also make settings changes by using ACSELERATOR QuickSet® SEL-5030 Software or ASCII **SET** commands via a communications port.

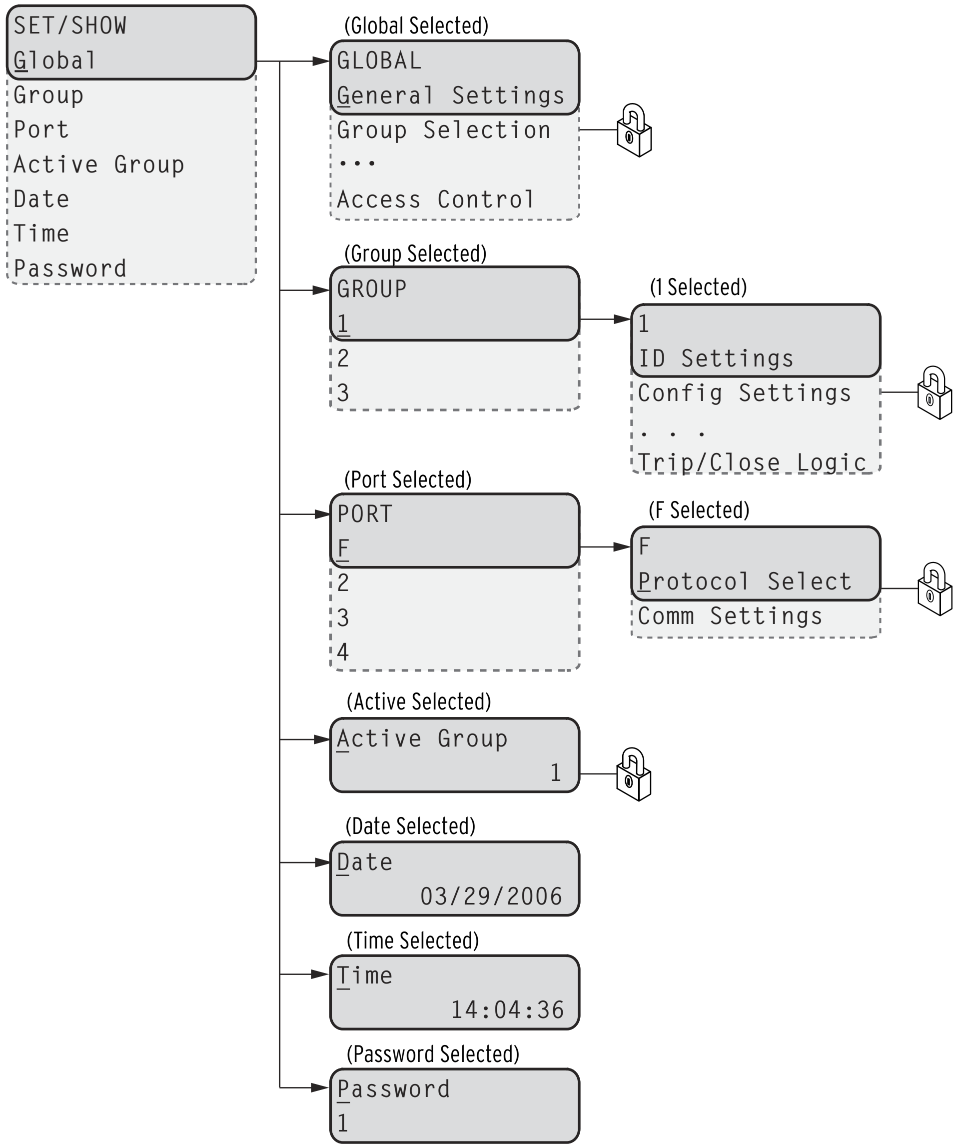


Figure 8.21 SET/SHOW Menu

Status Menu

Select the `Status` menu item on the `MAIN` menu as shown in *Figure 8.22* to access `Relay Status` data and `Reboot Relay`. See *STATUS Command (Relay Self-Test Status) on page 7.44* for the **STATUS** data field description.

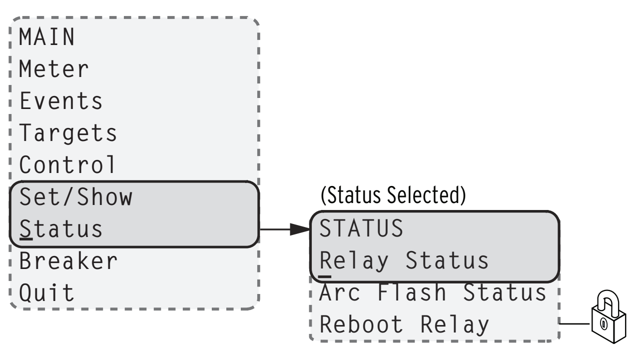


Figure 8.22 MAIN Menu and Status Submenu

Breaker Menu

Select the `Breaker` menu item on the `MAIN` menu as shown in *Figure 8.23* 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.

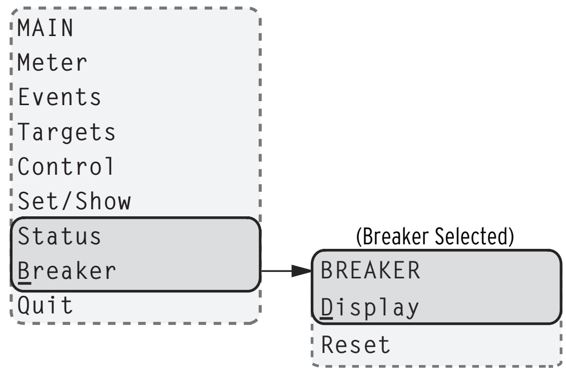


Figure 8.23 MAIN Menu and Breaker Submenu

Operation and Target LEDs

Programmable LEDs

The SEL-751 provides quick confirmation of relay conditions via operation and target LEDs. *Figure 8.24* shows this region with factory default text on the front-panel configurable labels. See *Target LED Settings on page 4.149* for the SELOGIC control equations and the tricolor LED color selection settings.

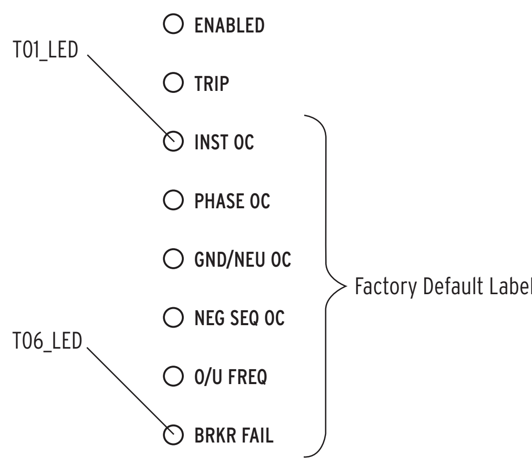


Figure 8.24 Factory Default Front-Panel LEDs

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 8.24*. Use settings T0nLEDC to select the LED color (R–red, G–green, A–amber). Parameter *n* is a number from 1 through 6 that indicates each LED. If the latch setting (T0*n*LEDL) for a certain LED is set to N, then the LED will follow the status of the corresponding control equation (T0*n*_LED). When the equation asserts, the LED will illuminate, and when the equation deasserts, the LED will extinguish. If the latch setting is set to Y, the LED will only assert if a trip condition occurs and the T0*n*_LED equation is asserted at the time of the trip. At this point, the LED will latch in. 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 4.7*.

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 J: 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 8.25 Target Reset Pushbutton

Lamp Test

The TARGET RESET pushbutton also provides a front-panel lamp test. Pressing and holding TARGET RESET illuminates all the front-panel LEDs, and these LEDs remain illuminated for as long as TARGET RESET is pressed. The target LEDs return to a normal operational state after release of the TARGET RESET pushbutton.

Other Target Reset Options

Use the ASCII command **TAR R** to reset the target LEDs; see *Table 7.11* 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 4.136* for further information.

Front-Panel Operator Control Pushbuttons

The SEL-751 features eight operator-controlled pushbuttons, each with two programmable tricolor pushbutton LEDs, for local control as shown in *Figure 8.26*.

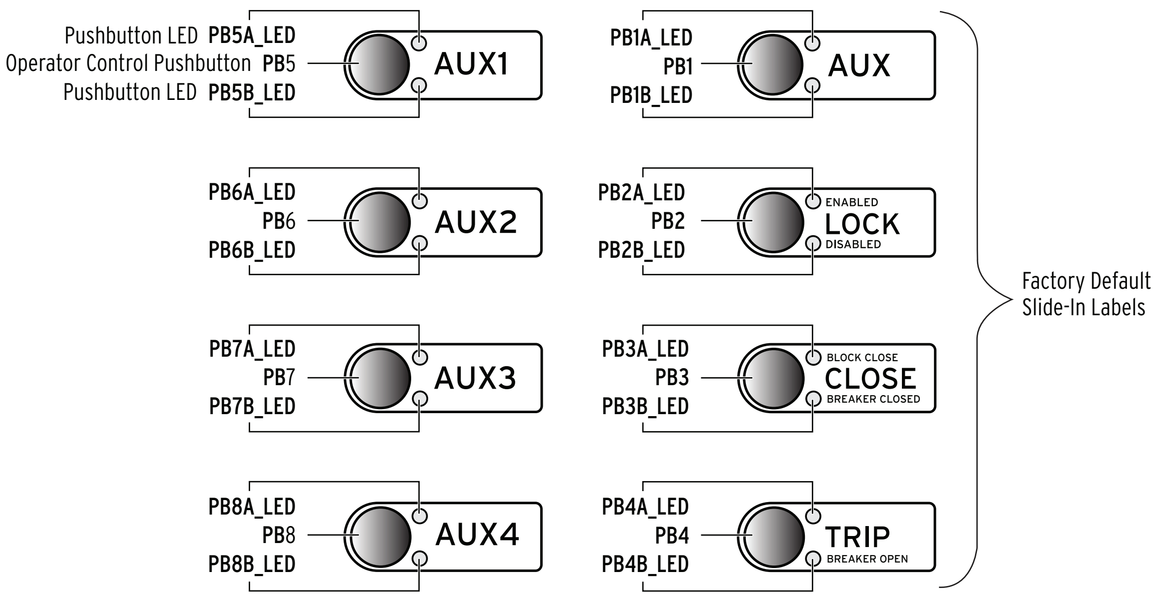


Figure 8.26 Operator Control Pushbuttons and LEDs

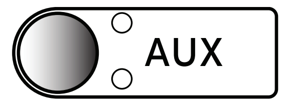
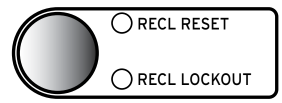
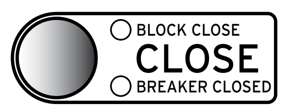
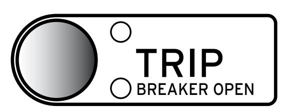
Pressing any one of these eight pushbuttons asserts the corresponding PB*n* (*n* = 01 through 08) Relay Word bit, and the corresponding PB*n*_PUL Relay Word bit. The PB*n* Relay Word bit remains asserted as long as the pushbutton is pressed, but the PB*n*_PUL Relay Word bit asserts only for the initial 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. Included on the SEL-751 Product Literature CD are word processor templates for printing slide-in labels. See the instructions included in the Configurable Label kit for more information on changing the slide-in labels.

Table 8.4 describes front-panel operator controls based on the factory default settings and operator control labels.

Table 8.4 SEL-751 Front-Panel Operator Control Functions

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.	
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 4.45* 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 4.45* for more information.	

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Section 9
Analyzing Events

Overview

The SEL-751 Feeder Protection Relay provides several tools (listed below) to analyze the cause of relay operations. Use these tools to help diagnose the cause of the relay operation and more quickly restore the protected equipment to service.

- Event Reporting
  - Event Summary Reports
  - Event History Reports
  - Event Reports
- Sequential Events Recorder Report
  - Resolution: 1 ms
  - Accuracy: ±1/4 cycle

All reports are stored in nonvolatile memory, ensuring that a loss of power to the SEL-751 will not result in lost data.

Event Reporting

NOTE: Arc-flash sensor light values and frequency are available only in Compressed ASCII event reports (**CEV** or **CEV R** commands)

Analyze events with the following event reporting functions:

- Event Summaries—Enable automatic messaging to allow the relay to send event summaries out a serial port when port setting AUTO := Y. A summary provides a quick overview of an event. You can also retrieve the summaries by using the **SUMMARY** command.
- Event History—The relay keeps an index of stored nonvolatile event reports. Use the **HISTORY** command to obtain this index. The index includes some of the event summary information so that you can identify and retrieve the appropriate event report.
- Event Reports—These detailed reports are stored in nonvolatile memory for later retrieval and detailed analysis.

Each time an event occurs, a new summary, history record, and report are created. Event report information includes:

- Date and time of the event
- Individual sample analog inputs (currents and voltages)
- Digital states of selected Relay Word bits (listed in *Table J.1*)
- Event summary, including the front-panel target states at the time of tripping, fault type, and fault location.
- Group, Logic, Global, and Report settings (that were in service when the event was recorded)

Compressed Event Reports

The SEL-751 provides Compressed ASCII event reports to facilitate event report storage and display. SEL communications processors and the ACSELERATOR Analytic Assistant® SEL-5601 Software take advantage of the Compressed ASCII format. Use the **CHIS** command to display Compressed ASCII event history information. Use the **CSUM** command to display Compressed ASCII event summary information. Use the **CEVENT** command to display Compressed ASCII event reports.

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 four 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 will clear all events in memory. Be sure to save critical event data prior to changing the LER setting.

The SEL-751 provides selectable event report length (LER) and prefault length (PRE). Event report length is either 15, 64, or 180 cycles. Prefault length is 1–10 cycles for LER = 15, 1–59 cycles for LER = 64, and 1–175 cycles for LER = 180. Prefault length is the first part of the total event report length and precedes the event report triggering point. Changing the PRE setting has no effect on the stored reports. The relay stores as many as six of the most recent 180-cycle, eighteen of the most recent 64-cycle, or as many as seventy-nine of the most recent 15-cycle event reports in nonvolatile memory. Refer to the **SET R** command in *SET Command (Change Settings) on page 7.41* and *Report Settings (SET R Command) on page .57*.

Triggering

The SEL-751 triggers (generates) an event report when any of the following occur:

- Relay Word bit TRIP asserts
- Programmable SELOGIC® control equation setting ER asserts (in Report settings)
- **TRI** (Trigger Event Reports) serial port command executes

Relay Word Bit TR

Refer to *Figure 4.51*. 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 7.41*). 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 4.153*.

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 7.48* for more information on the **TRI** (Trigger Event Report) command.

Event Summaries

IMPORTANT: Clearing the HISTORY report with the **HIS C** command also clears all event data within the SEL-751 event memory.

For every triggered event, the relay generates and stores an event summary. The relay stores as many as 79 of the most recent event summaries (if event report length setting LER := 15), as many as 18 (if LER := 64), or as many as 6 (if LER := 180). When the relay stores a new event summary, it discards the oldest event and event summary if the event memory is full. Event summaries contain the following information:

- ➤ The relay and terminal identification (RID and TID)
- ➤ The event number, date, time, event type, fault location, and frequency (see *Table 9.1*)
- ➤ The primary magnitudes of line, neutral and residual currents
- ➤ The primary magnitudes of the line-to-neutral voltages and residual voltage (if DELTA_Y := WYE) or phase-to-phase voltages (if DELTA_Y := DELTA)
- ➤ The hottest RTD temperatures

NOTE: Figure 9.3 is on multiple pages.

The relay includes the event summary in the event report. The identifiers, date, and time information are at the top of the event report, and the remaining information follows at the end (See *Figure 9.3*). The example event summary in *Figure 9.1* corresponds to the standard 15-cycle event report in *Figure 9.3*.

```
=>>SUM <Enter>

SEL-751                                  Date: 02/03/2011   Time: 10:51:34.267
FEEDER RELAY

Serial No = 000000000000000
FID = SEL-751-X120-V0-Z001001-D20110126                CID = 2038
EVENT LOGS =  5

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 9.1 Example Event Summary

The relay sends event summaries to all serial ports with setting AUTO := Y each time an event triggers.

Event Type

The `Event` field displays the event type. Event types and the logic used to determine event types are shown in *Table 9.1*. The event type designations AG through CAG are only entered in the `Event` field if the fault type is determined successfully.

Table 9.1 Event Types

Event Type	Event Type Logic
AG,BG,CG	Single phase-to-ground faults. Appends T if any overcurrent trip asserted.
ABC	Three-phase faults. Appends T if any overcurrent trip asserted.
AB, BC, CA	Phase-to-phase faults. Appends T if any overcurrent trip asserted.
ABG, BCG, CAG	Phase-to-phase-to-ground faults. Appends T if any overcurrent trip asserted.
Phase A1 50 Trip	50A1P * (50P1T + 67P1T) * TRIP[a]
Phase B1 50 Trip	50B1P * (50P1T + 67P1T) * TRIP[a]
Phase C1 50 Trip	50C1P * (50P1T + 67P1T) * TRIP[a]
Phase 50 Trip	(50P1T + 50P2T + 50P3T + 50P4T +67P1T +67P2T +67P3T +67P4T) * TRIP[a]
GND/NEUT 50 Trip	(50N1T + 50N2T + 50N3T + 50N4T + 50G1T + 50G2T + 50G3T + 50G4T + 67G1T + 67G2T + 67G3T + 67G4T) * 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)* TRIP
55 Trip	55T * TRIP
Underfreq 81 Trip	(81DnT * TRIP) when 81DnTP < FNOM setting, n = 1, 2, 3, 4, 5, or 6.
Overfreq 81 Trip	(81DnT * TRIP) when 81DnTP > FNOM setting, n = 1, 2, 3, 4, 5, or 6.
PowerElemnt Trip	(3PWR1T + 3PWR2T) * TRIP
Arc Flash Trip	(50PAF + 50NAF) * (TOL1 + TOL2 + TOL3 + TOL4) * TRIP
RTD Trip	(WDGTRIP + BRGTRIP + AMBTRIP + OTHTRIP) * TRIP
Remote Trip	REMTRIP * TRIP
27 Trip	(27P1T + 27P2T+ 27PP1T + 27PP2T) *!LOP * TRIP
RTD Fail Trip	RTDFLT * TRIP
Breaker Failure Trip	BFT * TRIP
CommIdleLossTrip	(COMMIDLE + COMMLOSS)*TRIP
Trigger	Trigger Command
ER Trigger	ER Equation assertion[a]
Trip	TRIP with no known cause

[a] The GFLT bit asserts if any one of the residual overcurrent or residual time-overcurrent Relay Word bits pick up during the event. 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 9.2 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 * GFLT * TRIP
BG T	PHASE_B * GFLT * TRIP
CG T	PHASE_C * GFLT * TRIP

The event type logic (PHASE_A, PHASE_B, PHASE_C) uses Relay Word bits FSA, FSB, and FSC to help determine the fault type and to select the appropriate fault location method. The SEL-751 asserts one of the Relay Word bits FSA, FSB, or FSC based on the magnitude and angle difference of negative- and zero-sequence current. The A-, B-, or C-phase naming of the FSA, FSB, and FSC Relay Word bits does not directly translate to assertion 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.

Fault Location

The relay reports the fault location if the EFLOC setting = Y and the fault locator operates successfully after an event report is generated. If the fault locator does not operate successfully, $$$$$$ is listed in the field. Fault location is based on the line impedance settings Z1MAG, Z1ANG, Z0MAG, and Z0ANG; source impedance settings Z0SMAG and Z0SANG; and corresponding line length setting LL. (See the *Line Parameter Settings on page 4.6*.) Because the fault locating function requires three-phase voltages, the Group setting EFLOC cannot be set to Y when Group setting VNOM = OFF. Similarly, the Group setting EFLOC is hidden and set to N internally when the Group setting SINGLEV := Y.

Fault Detector Elements

The fault locator algorithm uses the overcurrent elements: 50P1P–50P4P, 50N1P–50N4P, 50G1P–50G4P, 50Q1P–50Q4P, 51AP, 51BP, 51CP, 67P1P–67P4P, 67Q1P–67Q4P, 67G1P–67G4P, 51P1P, 51P2P, 51N1P, 51N2P, 51G1P, 51G2P, and 51Q as fault detectors. If you set any of these elements to low pickup values for use as load indicators, they can assert during nonfault conditions. In this situation, even though these elements are not being used for tripping the relay, they can still affect the operation of the fault locator, because the start of the disturbance may be unclear.

Fault Locator Operating Window

The SEL-751 uses a 15-cycle subset of the event report data to calculate the event type and fault location. For Global setting LER = 64, the relay processes the portion of stored data that includes the event report trigger. For LER = 15, the entire event report is available for calculation of the event type and fault location.

It is possible for the event type or fault location to be calculated from a different portion of the event report than expected. For example (with default settings), when the event report is first triggered by overcurrent element pickup (ER), but the trip occurs more than 12 cycles later, the conditions at the time of trip are not considered (unless covered by a new event report).

Currents, Voltages, and RTD Temperatures

The relay determines the maximum phase current during an event. The instant the maximum phase current occurs is marked by an asterisk (*) in the event report (see *Figure 9.3*). This row of data corresponds to the analogs shown in the summary report for the event.

The `Current Mag` fields display the primary current magnitudes at the instant when the maximum 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 9.2* 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 (if IRIG-B model)
- Event number, date, time, event type, and fault location (see *Table 9.1*)
- Maximum feeder current
- Frequency
- Target LED status

```
=>>HIS <Enter>

SEL-751                                  Date: 02/03/2011   Time: 11:22:50.424
FEEDER RELAY                             Time Source: Internal

FID = SEL-751-X120-V0-Z001001-D20110126
#      DATE         TIME        EVENT     LOCAT   CURRENT    FREQ     TARGETS
1   02/03/2011   10:51:34.267   BG T      64.23    9.3       60.0     11100001
2   02/02/2011   16:50:38.619   BCG T     60.43   18.0       60.0     11100001
3   02/02/2011   16:36:36.604   CAG T     86.77   17.6       60.0     11100001
4   02/01/2011   16:32:04.924   CAG T     75.44   18.0       59.7     11100001
5   02/01/2011   16:31:44.917   CG T      68.14   21.5       60.0     11100001
=>>
```

Event Number | Event Type | Location | Maximum Current | Frequency | User-Defined Target LEDs

Figure 9.2 Sample Event History

Viewing the Event History

Access the history report from the communications ports, using the **HIS** command or the analysis menu within ACSELERATOR QuickSet® SEL-5030 Software. View and download history reports from Access Level 1 and higher.

Use the **HIS** command from a terminal to obtain the event history. You can specify the number of the most recent events that the relay returns. See *HISTORY Command on page 7.30* 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 will clear all event summaries, history records, and reports.

Event Reports

The latest event reports are stored in nonvolatile memory. Each event report includes four sections:

- ➤ Analog values of current and voltage
- ➤ Digital states of the protection and control elements, including overcurrent, and voltage elements, plus status of digital output and input states
- ➤ Event Summary
- ➤ Settings in service at the time of event retrieval, consisting of Group, Logic, Global, and Report settings classes

Use the **EVE** command to retrieve the reports. There are several options to customize the report format.

Filtered and Unfiltered Event Reports

The SEL-751 samples the power system measurands (ac voltage and ac current) 32 times per power system cycle. A digital filter extracts the fundamental frequency component of the measurands. The relay operates on the filtered values and reports these values in the standard, filtered event report.

To view the raw inputs to the relay, use the **EVE R** command to select the unfiltered event report. Use the unfiltered event reports to observe power system conditions:

- ➤ Power system transients on current and voltage channels
- ➤ Decaying dc offset during fault conditions on current channels

Raw event reports display one extra cycle of data at the beginning of the report.

Event Report Column Definitions

NOTE: Figure 9.3 is on multiple pages.

Refer to the example event report in *Figure 9.3* to view event report columns. This example event report displays rows of information each 1/4 cycle. Retrieve this report with the **EVE** command.

The columns contain ac current, ac voltage, input, output, and protection and control element information. Use the serial port **SUM** command (see *SUMMARY Command on page 7.46*) to retrieve event summary reports.

Table 9.3 summarizes the event summary report current and voltage columns. *Table 9.4* summarizes the event summary report output, input, protection, and control element columns.

Table 9.3 Event Report Current and Voltage Columns (Sheet 1 of 2)

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)

Table 9.3 Event Report Current and Voltage Columns (Sheet 2 of 2)

Column Heading	Description
IN	Current measured by channel IN (primary A)
VAN or VAB	Voltage measured by channel VAN or VAB (primary V)
VBN or VBC	Voltage measured by channel VBN or VBC (primary V)
VCN or VCA	Voltage measured by channel VCN or VCA calculated from VAB and VBC (primary V)
VS	Voltage measured by channel VS (terminals VS, NS) (primary V)
VDC	Voltage measured by channel VDC (terminals VBAT+, VBAT-)

Table 9.4 Output, Input, Protection, and Control Element Event Report Columns (Sheet 1 of 2)

Column Heading	Column Symbols	Description
51ABC	.	51 Elements in reset state
	A	51AP Picked up
	B	51BP Picked up
	C	51CP Picked up
	a	Both 51AP & 51BP Picked up
	b	Both 51BP & 51CP Picked up
	c	Both 51CP & 51AP Picked up
	3	All three phases picked up
51P	1	51P1P Picked up
	2	51P2P Picked up
	3	Both 51P1P & 51P2P Picked up
51N	1	51N1P Picked up
	2	51N2P Picked up
	3	Both 51N1P & 51N2P Picked up
51G	1	51G1P Picked up
	2	51G2P Picked up
	3	Both 51G1P & 51G2P Picked up
51Q	1	51QP Picked up
50P	1	50P1P Picked up
	2	50P2P Picked up
	3	50P3P Picked up
	4	50P4P Picked up
	5	Both 50P1P & 50P2P Picked up
	6	Both 50P1P & 50P3P Picked up
	7	Both 50P1P & 50P4P Picked up
	8	Both 50P2P & 50P3P Picked up
	9	Both 50P2P & 50P4P Picked up
	A	Both 50P3P & 50P4P Picked up
	B	50P1P & 50P2P & 50P3P Picked up
	C	50P1P & 50P2P & 50P4P Picked up
	D	50P1P & 50P3P & 50P4P Picked up
	E	50P2P & 50P3P & 50P4P Picked up
	F	All four 50P1P & 50P2P & 50P3P & 50P4P Picked up

Table 9.4 Output, Input, Protection, and Control Element Event Report Columns (Sheet 2 of 2)

Column Heading	Column Symbols	Description
67P	1 2 3 4 5 6 7 8 9 A B C D E F	67P1P Picked up 67P2P Picked up 67P3P Picked up 67P4P Picked up Both 67P1P & 67P2P Picked up Both 67P1P & 67P3P Picked up Both 67P1P & 67P4P Picked up Both 67P2P & 67P3P Picked up Both 67P2P & 67P4P Picked up Both 67P3P & 67P4P Picked up 67P1P & 67P2P & 67P3P Picked up 67P1P & 67P2P & 67P4P Picked up 67P1P & 67P3P & 67P4P Picked up 67P2P & 67P3P & 67P4P Picked up All four 67P1P & 67P2P & 67P3P & 67P4P Picked up
50NQG	N Q G a b c 3	Any one of 50N1P / 50N2P / 50N3P / 50N4P Picked up Any one of 50Q1P / 50Q2P / 50Q3P / 50Q4P Picked up Any one of 50G1P / 50G2P / 50G3P / 50G4P Picked up Both 50NxP & 50QyP Picked up, x, y: any from 1-4 Both 50QxP & 50GyP Picked up, x, y: any from 1-4 Both 50GxP & 50NyP Picked up, x, y: any from 1-4 All 50NxP & 50QyP & 50GzP Picked up, x,y,z: any from 1-4
67QG	Q G a	Any one of 67Q1P / 67Q2P / 67Q3P / 67Q4P Picked up Any one of 67G1P / 67G2P / 67G3P / 67G4P Picked up Both 67QxP & 67GyP Picked up, x, y: any from 1-4
81	1	Any combination 81DxT Picked up, x = 1-6
RTD Wdg[a]	w W	WDGALRM * !WDGTRIP WDGTRIP
RTD Brg[a]	b B	BRGALRM * !BRGTRIP BRGTRIP
RTD Oth[a]	o O	OTHALRM * ! OTHTRIP OTHTRIP
RTD Amb[a]	a A	AMBALRM * ! AMBTRIP AMBTRIP
RTD In[a]	1	RTDIN
In 12	1 2 b	IN101 * ! IN102 IN102 * !IN101 IN101 * IN102
Out 12	1 2 b	OUT101 * !OUT102 OUT102 * !OUT101 OUT101 * OUT102
Out 3	3	OUT103

[a] These quantities are not displayed when the relay has the voltage card option with VS (sync voltage) and VDC (battery voltage) inputs.

Note that the ac values change from plus to minus (–) values in *Figure 9.3*, indicating the sinusoidal nature of the waveforms.

Other figures help in understanding the information available in the event report current columns:

➤ *Figure 9.4* shows how event report current column data relate to the actual sampled current waveform and rms current values.

➤ *Figure 9.5* 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 9.3* also corresponds to the example SER report in *Figure 9.10*.

In *Figure 9.3*, an arrow (>) in the column following the VDC column would identify the "trigger" row. This is the row that corresponds to the Date and Time values at the top of the event report.

The asterisk (*) in the column following the VDC column identifies the row with the maximum phase current. The SEL-751 calculates maximum phase current from the row identified with the asterisk and the row one quarter-cycle previous (see *Figure 9.4* and *Figure 9.5*). These currents are listed at the end of the event report in the event summary. If the trigger row (>) and the maximum phase current row (*) are the same row, the * symbol takes precedence.

Figure 9.4 and *Figure 9.5* look in detail at one cycle of A-phase current (channel IA) identified in *Figure 9.3*. *Figure 9.4* shows how the event report ac current column data relate to the actual sampled waveform and rms values. *Figure 9.5* shows how you can convert the event report current column data to phasor rms values. Voltages processing occurs similarly.

In *Figure 9.4*, note that you can use any two rows of current data from the event report in *Figure 9.3*, 1/4 cycle apart, to calculate rms current values.

```
=>>EVE <Enter>

SEL-751                            Date: 03/11/2011   Time: 14:16:39.043        Date and Time of Event

FEEDER RELAY

Serial Number=000000000000000

FID=SEL-751-X139-V0-Z001001-D201101309      CID=05A2                            Firmware and Checksum
                                                                                Identifier
                                                          a
                                                    55555 55 8   O
                                                    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      Optional Voltage Card
                                                                                Required

[1]
 -1739   467  1277  -0.0   4.2  -7429  -3317  10679  -7178  48 33... F. . . .3
   449 -1735  1256   0.0 -30.0   7994 -10399   2259   8071  48 33... F. . . .3
  1741  -468 -1279   0.0  -6.0   7421   3323 -10681   7173  48 33... F. . . .3
  -454  1736 -1258   0.0  24.0  -7999  10395  -2255  -8080  48 33... F. . . .3

[2]
 -1742   466  1278  -0.0   1.8  -7418  -3332  10679  -7171  48 33... F. . . .3
   454 -1737  1258  -0.0 -25.2   7999 -10397   2246   8084  48 33... F. . . .3   One Cycle of Data
  1738  -465 -1283   0.0 -10.2   7412   3334 -10685   7162  48 33... F. . . .3
  -456  1736 -1259   0.0  20.4  -8006  10391  -2243  -8087  48 33... F. . . .3
```

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

```
[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
```

Maximum Phase Current

```
  1363  -460 -1287   0.0  -384   7385   3368 -10692   7137  48 33.3.. F. . . .3

  -346  1738 -1256   0.0   136  -8030  10379  -2209  -8109  48>33.3.. F. . . .3
```

Trigger Row

```
[6]
  -788   458  1286  -0.0   956  -7384  -3377  10690  -7135  48 33.31 F. . . .3
   153 -1739  1254  -0.0  -332   8033 -10377   2200   8111  48 33.31 F. . . .3
   581  -458 -1286   0.0 -1163   7376   3379 -10694   7128  48 b3.31 F. . . .3
  -155  1738 -1255   0.0   328  -8039  10375  -2198  -8116  48 b3.31 F. . . .3
```

See Figure 9.4 and Figure 9.5

```
[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 ..... .. . . ..
```

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

```
Serial No = 000000000000000
FID = SEL-751-X141-V0-Z001001-D20110315                 CID = 6803
EVENT LOGS =  5

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

EPMU    := N
IRIGC   := NONE    UTC_OFF := 0.00    DST_BEGM:= OFF
52ABF   := N       50BFP   := 0.10    BFD     := 0.50    ATD     := OFF
BFI     := R_TRIG TRIP

50PAFP  := OFF     DCLOP   := OFF     DCHIP   := OFF

IN101D  := 10      IN102D  := 10

EBMON   := Y       COSP1   := 10000   COSP2   := 150     COSP3   := 12
KASP1   := 1.20    KASP2   := 8.00    KASP3   := 20.00   BKMON   := TRIP

RSTTRGT := 0
RSTENRGY:= 0
RSTMXMN := 0
RSTDEM  := 0
RSTPKDEM:= 0

DSABLSET:= 0
TIME_SRC:= IRIG1   TIME_SRC:= IRIG1
Group Settings

RID     := SEL-751
TID     := FEEDER RELAY
CTR     := 120     CTRN    := 120     PTR     := 180.00  PTRS    := 180.00
DELTA_Y := WYE     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
```

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

```
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



ELOAD   := N
E49RTD  := NONE
27PP1P  := OFF     27PP2P  := OFF
27S1P   := OFF     27S2P   := OFF

59PP1P  := OFF     59PP2P  := OFF     59Q1P   := OFF     59Q2P   := OFF

59S1P   := OFF     59S2P   := OFF


E25     := N
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 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
E79     := N
FMR1NAM := FMR1
FMR1    :=NA
FMR2NAM := FMR2
FMR2    :=NA
FMR3NAM := FMR3
FMR3    :=NA
FMR4NAM := FMR4
FMR4    :=NA
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_TRI G 51N1P OR
 R_TRIG CF
LER     := 15      PRE     := 5
```

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

```
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

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    := WDGTRIP OR BRGTRIP OR OTHTRIP OR AMBTRIP OR (27P1T OR 27P2T) AND NOT
LOP
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 9.3 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution (Sheet 5 of 5)

*Replaced with 67 (directional overcurrent) when setting EDIR := Y or AUTO.

Figure 9.4 and *Figure 9.5* look in detail at one cycle of A-phase current (channel IA) identified in *Figure 9.3*. *Figure 9.4* shows how the event report ac current column data relate to the actual sampled waveform and rms values. *Figure 9.5* shows how the event report current column data can be converted to phasor rms values. Voltages are processed similarly.

In *Figure 9.4*, note that you can use any two rows of current data from the event report in *Figure 9.3*, 1/4 cycle apart, to calculate rms current values.

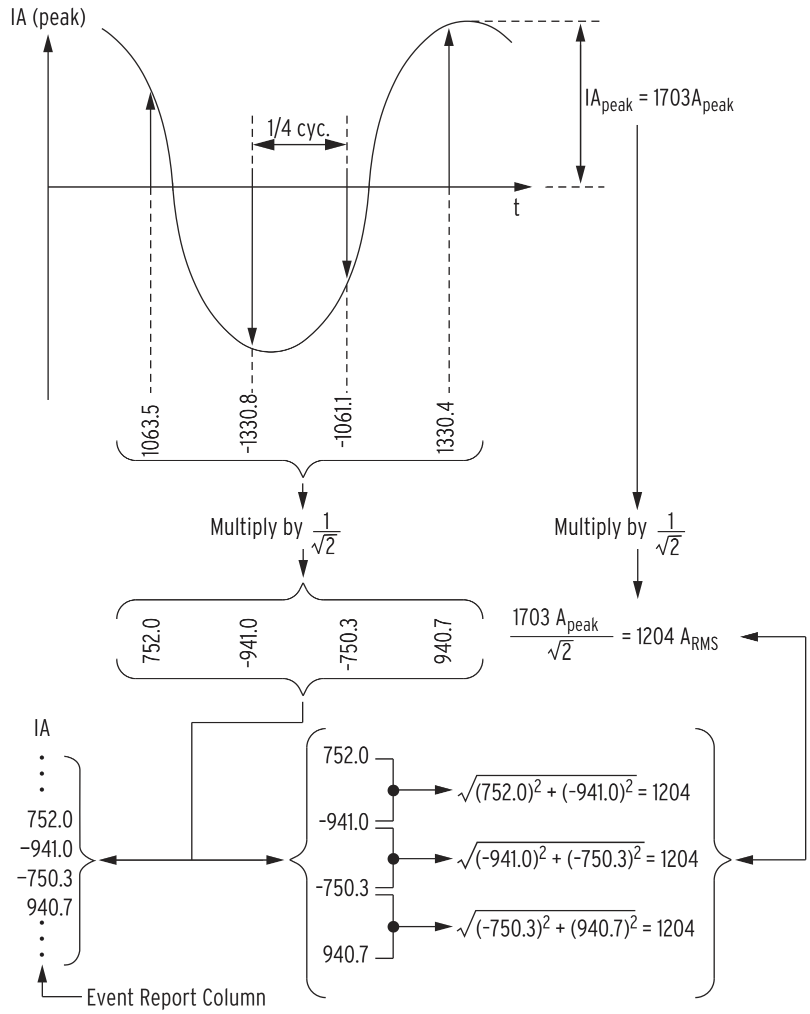


Figure 9.4 Derivation of Event Report Current Values and RMS Current Values From Sampled Current Waveform

In *Figure 9.5*, note that you can use two rows of current data from the event report in *Figure 9.3*, 1/4 cycle apart, to calculate phasor rms current values. In *Figure 9.5*, at the present sample, the phasor rms current value is:

$$IA = 1204\ A\ \angle -38.6° \qquad \textbf{Equation 9.1}$$

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

$$1204\ A \bullet \cos(-38.6°) = 940.7\ A \qquad \textbf{Equation 9.2}$$

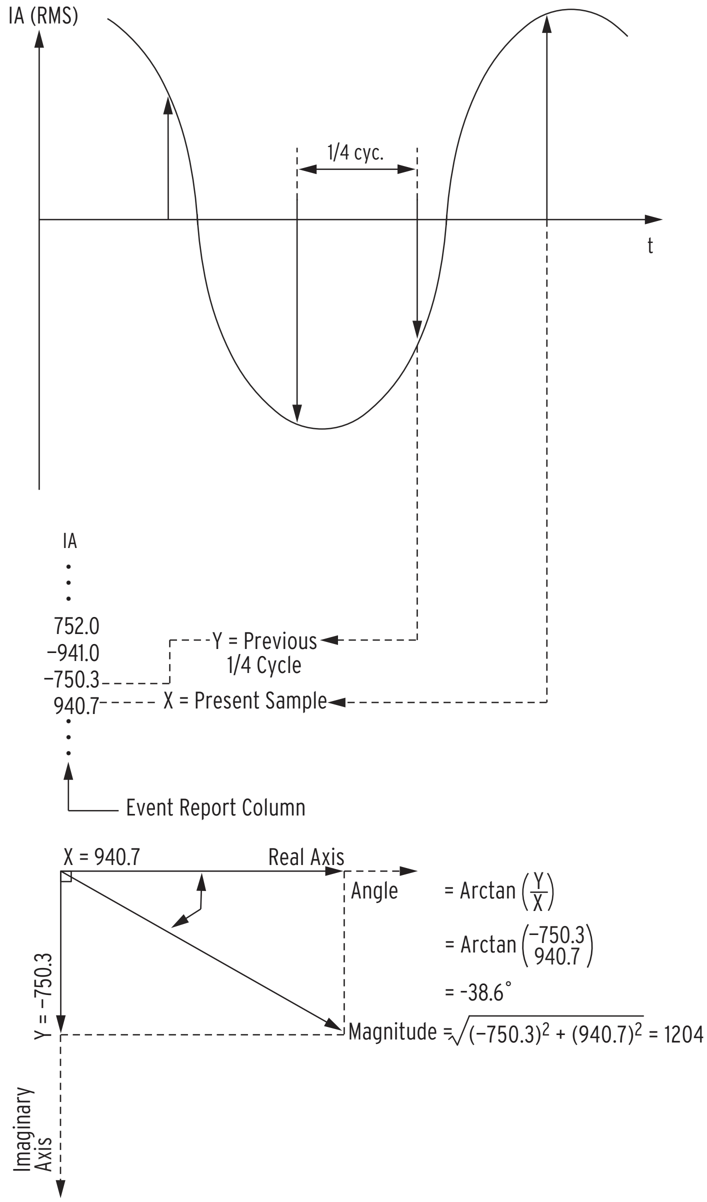


Figure 9.5 Derivation of Phasor RMS Current Values From Event Report Current Values

NOTE: The arctan function of many calculators and computing programs does not return the correct angle for the second and third quadrants (when X is negative). When in doubt, graph the X and Y quantities to confirm that the angle that your calculator reports is correct.

High-Impedance Fault Event Summary and History

High-impedance fault event information is available when the relay supports HIF detection. The relay stores event information in nonvolatile memory. Report setting HIFLER determines the length of the stored event report. The relay can store approximately 40 minutes of event report data, corresponding to two stored events at the maximum HIFLER setting of 20 minutes, or approximately 20 stored events at the minimum HIFLER setting of two minutes. The length of time reserved within the stored event report for the capture of pretrigger (prefault) data is fixed to 60 seconds (on a 60 Hz system) regardless of the HIFLER setting value. You can view information about a high-impedance fault event in one or more of the following forms:

- ➤ HIF event summary
- ➤ HIF event history

Event Numbering

Use the **CEV HIF *n*** command to access particular event reports; parameter ***n*** indicates the order of the event report. The most recent event report is record number one (1), the next most recent report is record number two (2), and so on. In addition, events can be accessed by their unique reference number. Reference numbers start at 10000 and increment with each event. When the event report list is cleared, the reference number resets to 10000. *Table 9.5* lists the **CEV HIF** commands.

Table 9.5 CEV HIF Commands

Command	Description
CEV HIF	Returns the most recent compressed HIF event report
CEV HIF *n*	Returns a particular ***n*** (***n*** = record or reference number) compressed HIF event report

High-Impedance Fault Event Summary

You can retrieve a shortened version of stored high-impedance fault event as HIF event summaries. These short-form reports present vital information about a triggered event. See *Figure 9.6* 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 9.6 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 9.6 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 will trigger an event (see *Triggering on page 9.2* 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 4.27*). You can also program this setting in a manner to aid in simultaneous event triggering in multiple relays.

Table 9.6 HIF Event Types

Event	Event Trigger
HIF ALARM	Assertion of any one of the following Relay Word bits and if no HIF fault has occurred: HIA1_A, HIA1_B, HIA1_C, HIA2_A, HIA2_B,HIA2_C
HIF FAULT	Assertion of any one of the following Relay Word bits: HIF1_A, HIF1_B, HIF1_C, HIF2_A, HIF2_B, HIF2_C
HIF Ext. TRI	Assertion of HIFER SELOGIC variable.
HIF TRI	Execution of the TRI HIF command.

Table 9.7 lists HIF phase involvement conditions. Multiple phases can be listed if the relay detects more than one phase involvement. If a HIF fault occurs (HIFx_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 will not generate additional event reports for triggering conditions that follow the initial triggering condition and are within the same report.

Table 9.7 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,

When a high-impedance fault is caused by a downed conductor, there can be a load current reduction. Depending on the position of the down conductor and the amount of load dropped, this load reduction event may or may not be detectable back in a substation. The Load Reduction Element is used to detect any load reduction at the time that the relay detects a high-impedance fault. The element is used to report a possible downed conductor event. *Table 9.8* lists HIF downed conductor conditions.

Table 9.8 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, using the **HIS HIF** command or the analysis menu within ACSELERATOR 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 9.21*.) *Table 9.9* lists the **SUM HIF** commands.

Table 9.9 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 will have 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 9.7*; 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 9.2* 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 9.7 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 9.8* 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 9.8 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 9.18*). As shown in *Figure 9.8*, 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, using the **HIS HIF** command or the analysis menu within ACSELERATOR 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 9.10 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 will have event identifier 10000.

CHISTORY HIF

The SEL-751 provides Compressed ASCII event reports to facilitate event report storage and display. SEL communications processors and the ACSELERATOR Analytic Assistant take advantage of the Compressed ASCII format. Use the **CHIS HIF** command to display Compressed ASCII event history information.

```
=>>CHIS HIF <Enter>
"FID","0143"
"FID=SEL-751-X141-V0-Z001001-D20110315","08A3"
"REC_NUM","REF_NUM","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","EVENT","D
 OWN
ED CONDUCTOR","GRP","184C"
1,10033,3,16,2011,15,57,17,900,"HIF Fault A,B","NO",2,"0B82"
2,10032,3,16,2011,15,53,21,727,"HIF Fault A,B","NO",2,"08EE"
3,10031,3,16,2011,14,29,24,269,"HIF Fault A,B","NO",1,"08F3"
4,10030,3,16,2011,13,57,55,952,"HIF Fault A,B","NO",1,"08F6"
5,10029,3,16,2011,12,41,59,983,"HIF Fault A,B","NO",1,"08FF"
```

Figure 9.9 Sample Compressed HIF History Report

High-Impedance Fault Compressed Event Report

The SEL-751 provides Compressed ASCII event reports to facilitate event report storage and display. SEL communications processors and the ACSELERATOR Analytic Assistant take advantage of the Compressed ASCII format. Use the **CEV HIF** command to display Compressed ASCII HIF event reports.

The relay generates compressed event reports to display analog data, and the state of related Relay Word bits from the odd and 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 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/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.

Sequential Events Recorder (SER) Report

The SER report captures relay element state changes during an extended period. SER report data are useful in commissioning tests and root-cause analysis studies. SER information is stored when state changes occur. The report records the most recent 1024 state changes if a relay element is listed in the SER trigger equations.

SER Triggering

Use settings SER1 through SER4 to select entries in the SER report. To capture relay element state changes in the SER report, the relay element name must be programmed into one of the four SER trigger equations. Each of the four programmable trigger equations allows entry of as many as 24 relay elements; the SER report can monitor a total of 96 relay elements.

The relay adds a message to the SER to indicate power up or settings change conditions:

```
Relay Powered Up
.
.
.
Relay Settings Changed
```

Each entry in the SER includes the SER row number, date, time, element name, and element state.

SER Aliases

You can rename as many as 20 of the SER trigger conditions by using the ALIAS settings. For instance, the factory default alias setting 2 renames Relay Word bit PB02 for reporting in the SER:

```
ALIAS2:= PB02 FP_LOCK PICKUP DROPOUT
```

When Relay Word bit PB02 is asserted, the SER report will show the date and time of FP_LOCK PICKUP. When Relay Word bit PB02 is deasserted, the SER report will show 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 4.153* for additional details.

See *SER Command (Sequential Events Recorder Report) on page 7.40* for details on retrieving and clearing SER reports with the **SER** command.

Example SER Report

The example SER report in *Figure 9.10* includes records of events that occurred before the beginning of the event summary report in *Figure 9.3*.

```
=>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 9.10 Example Sequential Events Recorder (SER) Event Report

Section 10
Testing and Troubleshooting

Overview

Relay testing is typically divided into two categories:

- Tests performed at the time the relay is installed or commissioned
- Tests performed periodically once the relay is in service

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

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 10.16* provides a guide to isolating and correcting the problem.

Testing Tools

Serial Port Commands

The following serial port commands assist you during relay testing.

The **METER** command shows the ac currents and voltages (magnitude and phase angle) presented to the relay in primary values. In addition, the command shows power system frequency. Compare these quantities against other devices of known accuracy. The **METER** command is available at the serial ports and front-panel display. See *Section 7: Communications* and *Section 8: Front-Panel Operations*.

The relay generates a 15- or 64-cycle event report in response to faults or disturbances. Each report contains current and voltage information, relay element states, and input/output contact information. If you question the relay response or your test method, use the event report for more information. The **EVENT** command is available at the serial ports. See *Section 9: Analyzing Events*.

The relay provides a Sequential Events Recorder (SER) event report that time-tags changes in relay element and input/output contact states. The SER provides a convenient means to verify the pickup/dropout of any element in the relay. The **SER** command is available at the serial ports. See *Section 9: Analyzing Events*.

Use the **TARGET** command to view the state of relay control inputs, relay outputs, and relay elements individually during a test. The **TARGET** command is available at the serial ports and the front panel. See *Section 7: Communications* and *Section 8: Front-Panel Operations*.

Low-Level Test Interface

NOTE: The SEL-RTS Relay Test System 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 (Slot Z) and 2 AVI/4 AFDI voltage card (Slot E). You can test the relay in either of two ways: conventionally, by applying ac signals to the relay inputs or by applying low magnitude ac voltage signals to the test interface on the printed circuit boards.

You can use the SEL-RTS Low-Level Relay Test System to provide signals to test the relay. *Figure 10.1* shows the Test Interface connectors.

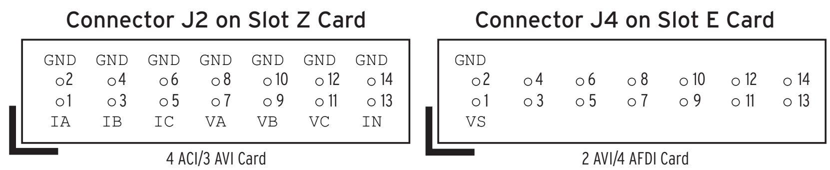


Figure 10.1 Low-Level Test Interface (J2 and J4)

Table 10.1 shows the signal scale factor information used by the AMS Relay Test System SEL-5401 Software for the calibrated inputs.

Table 10.1 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	250 V	218.4
VB	J2 on Slot Z card	5	250 V	218.4
VC	J2 on Slot Z card	6	250 V	218.4
IN	J2 on Slot Z card	7	5 A/1 A	106.14/21.23
VS	J4 on Slot E card	8	250 V	218.4

Access the low-level test interface connectors by using the following procedure. Make sure to power down the relay at the start of *Step 1*. Power the relay back up 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 jumpers JMP1–JMP6 and change them from Pin CT (normal position) to Pin AMS (low-level test position).

Step 5. Locate connector J2 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.

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.

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.

When simulating a delta PT connection, DELTA_Y := DELTA, with the low level test interface referenced in *Figure 10.1*, apply the following signals:

- Apply low-level test signal VAB to Pin VA.
- Apply low-level test signal –VBC (equivalent to VCB) to Pin VC.
- Do not apply any signal to pin VB.

Commissioning Tests

SEL performs a complete functional check and calibration of each SEL-751 Relay before it is shipped. This helps to ensure that you receive a relay that operates correctly and accurately. Commissioning tests confirm that the relay is properly connected including the control signal inputs and outputs.

The following connection tests help you enter settings into the SEL-751 and verify that the relay is properly connected. Brief functional tests ensure that the relay settings are correct. It is unnecessary to test every element, timer, and function in these tests. Modify the procedure as necessary to conform to your standard practices. Use the procedure at initial relay installation; you should not need to repeat it unless major changes are made to the relay electrical connections.

Required Equipment

- The SEL-751, installed and connected according to your protection design
- A PC with serial port, terminal emulation software, and serial communications cable
- *SEL-751 Settings Sheets* with settings appropriate to your application and protection design
- The ac and dc elementary schematics and wiring diagrams for this relay installation
- A continuity tester
- A protective relay ac test source
  - Minimum: single-phase voltage and current with phase angle control
  - Preferred: three-phase voltage and current with phase angle control

Connection Tests

Step 1. Remove control voltage and ac signals from the SEL-751 by opening the appropriate breaker(s) or removing fuses.

Step 2. Isolate the relay contact assigned to be the **TRIP** output.

Step 3. Verify correct ac and dc connections by performing point-to-point continuity checks on the associated circuits.

Step 4. Apply ac or dc control voltage to the relay.

After the relay is energized, the front-panel green **ENABLED** LED should illuminate.

Step 5. Use the appropriate serial cable (SEL Cable C234A or equivalent) to connect a PC to the relay.

Step 6. Start the PC terminal emulation software and establish communication with the relay.

Refer to *Section 7: Communications* for more information on serial port communications.

Step 7. Set the correct relay time and date by using either the front-panel or serial port commands.

Step 8. Using the **SET**, **SET P**, **SET G**, **SET L**, and **SET R** serial port commands, enter the relay settings from the settings sheets for your application.

Step 9. If you are connecting an external SEL-2600 RTD Module, perform the following substeps; otherwise, continue with the next step.

a. Connect the fiber-optic cable to the RTD Module fiber-optic output.

b. Plug the relay end of the fiber-optic cable into the relay fiber-optic input (Port 2).

Step 10. Verify the relay ac connections.

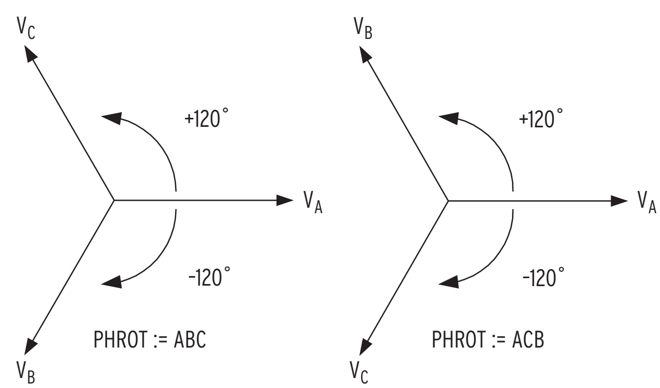
Step 11. Connect the ac test source current or voltage to the appropriate relay terminals.

NOTE: Make sure the current transformer secondary windings are shorted before they are disconnected from the relay.

a. Disconnect the current transformer and voltage transformer (if present) secondaries from the relay prior to applying test source quantities.

b. If you set the relay to accept phase-to-ground voltages (DELTA_Y := WYE), set the current and/or voltage phase angles as shown in *Figure 10.2*.

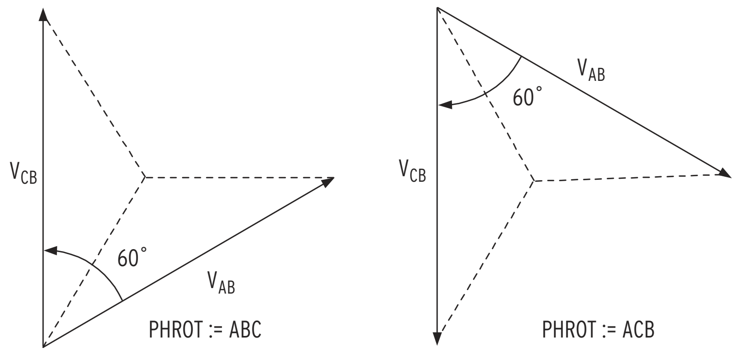
c. If you set the relay to accept delta voltages (DELTA_Y := DELTA), set the current and/or voltage phase angles as shown in *Figure 10.3*.



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 10.2 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 10.3 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 10.2* 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 10.2 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 10.4*.

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 10.2*.

Step 4. Set each phase current magnitude equal to the values listed in Column 1 of *Table 10.3*. Use the front panel to view the phase current values. The relay should display the applied current magnitude times the CTR setting.

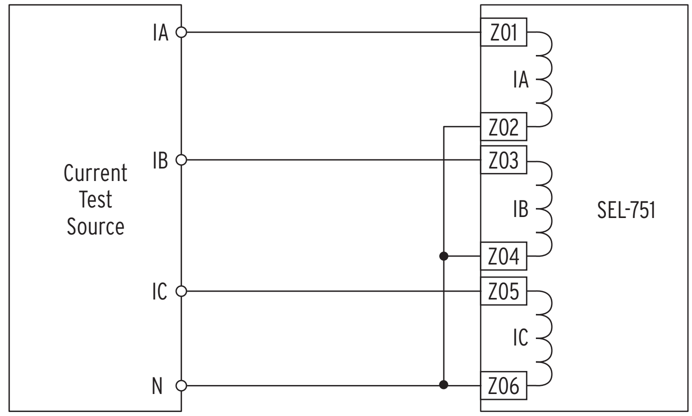


Figure 10.4 Current Source Connections

Table 10.3 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)
$0.2 \times I_{NOM}$				
$0.9 \times I_{NOM}$				
$1.6 \times I_{NOM}$				

[a] I_{NOM} = rated secondary amps (1 or 5).

Current Imbalance Metering Accuracy

Step 1. Connect the current source to the relay, as shown in *Figure 10.4*.

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 10.2*.

Step 4. Apply the appropriate magnitude for each phase current, as shown in Column 1 of *Table 10.4*.

Table 10.4 Current Unbalance Measuring Accuracy (Sheet 1 of 2)

|I| Apply (A secondary)	Expected Reading (%)	Actual Reading (%)
$\|IA\| = 0.9 \cdot I_{NOM}$ $\|IB\| = I_{NOM}$ $\|IC\| = I_{NOM}$	7%	
$\|IA\| = 0.75 \cdot I_{NOM}$ $\|IB\| = I_{NOM}$ $\|IC\| = I_{NOM}$	17%	
$\|IA\| = I_{NOM}$ $\|IB\| = 1.2 \cdot I_{NOM}$ $\|IC\| = 1.2 \cdot I_{NOM}$	12%	

Table 10.4 Current Unbalance Measuring Accuracy (Sheet 2 of 2)

|I| Apply (A secondary)	Expected Reading (%)	Actual Reading (%)
|IA| = 0.9 • I_{NOM} |IB| = 1.1 • I_{NOM} |IC| = 1.1 • 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 10.4*.

Step 2. Connect the voltage source to the relay, as shown in *Figure 10.5*. Make sure that DELTA_Y := WYE.

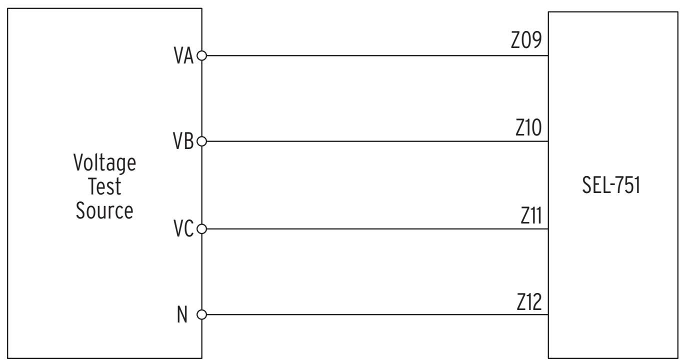


Figure 10.5 Wye Voltage Source Connections

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 10.5*.

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 10.5 Power Quantity Accuracy—Wye Voltages (Sheet 1 of 2)

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:**

Table 10.5 Power Quantity Accuracy—Wye Voltages (Sheet 2 of 2)

Apply Currents and Voltages	Real Power (kW)	Reactive Power (kVAR)	Power Factor (pf)
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 10.4*.

Step 2. Connect the voltage source to the relay, as shown in *Figure 10.6*. Make sure that DELTA_Y := DELTA.

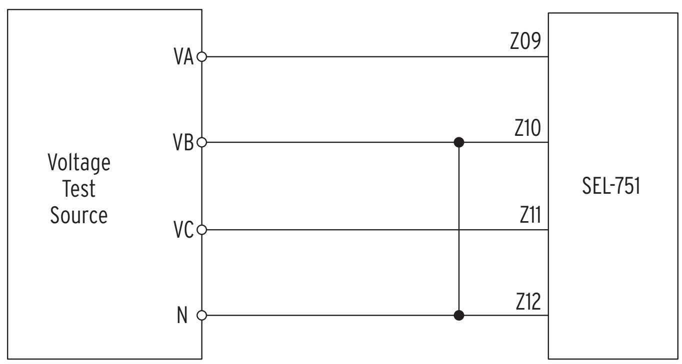


Figure 10.6 Delta Voltage Source Connections

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 10.6*.

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 10.6 Power Quantity Accuracy—Delta Voltages (Sheet 1 of 2)

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
Vab = 120 ∠+30 Vcb = 120 ∠+90	**Measured:**	**Measured:**	**Measured:**

Table 10.6 Power Quantity Accuracy—Delta Voltages (Sheet 2 of 2)

Apply Currents and Voltages	Real Power (kW)	Reactive Power (kVAR)	Power Factor (pf)
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
Vab = 120 ∠–30 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 will ensure 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-751A 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 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 for arc-flash protection (refer to *Section 4: Protection and Logic Functions* for details). If there is excessive background light (any of the Relay Word bits AFSnEL picks up) or if there is a diagnostic failure (any of the Relay Word bits AFSnDIAG picks up), the AFALARM Relay Word bit picks up and gives a WARNING on the relay front panel and asserts the ALARM output contact.

Command AFT (Arc-Flash test)

The relay performs the arc-flash self-test periodically as discussed previously. Additionally, by using the serial port ASCII command **AFT**, the relay performs the self-test on demand in all four channels and reports the status of each channel. This same test is also available from the Control Window in the ACSELERATOR QuickSet® SEL-5030 Software and the relay front panel STATUS sub-menu. Refer to *Figure 7.16* for the **AFT** command response example. The response shows the light measurements in percent of full scale and the PASS/FAIL status. The PASS indication means the channel is healthy and ready to detect an arc-flash event. The FAIL indication means the channel in question is not healthy and needs repair and testing when a convenient outage is available for maintenance.

Testing the Arc-Flash Time-Overlight Elements TOL1 to TOL4

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 to TOL4 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 using the ACSELERATOR Analytic Assistant® SEL-5601 Software. You can view the % light intensity analog quantity together with the TOL*n* Relay Word bit to verify the correct operation.

Testing the Arc-Flash Overcurrent Elements 50PAF and 50NAF

These current elements are similar to the 50P and 50N elements, except they use "raw" current input samples and act instantaneously to achieve fast response. You can test these elements similarly to the 50P and 50N elements. You can use the **CEV R** report as described previously to analyze the event.

Testing the Complete Arc-Flash Protection System

It is not necessary to verify the complete protection subsystem as the relay is tested at the factory before shipping. If a synchronized light and current pulse test source is available to simulate an arc, you can use it to exercise the arc-flash protection TOL*n* elements together with the 50PAF or the 50NAF elements. If the relay has been set for the arc-flash protection including the tripping logic, the test could exercise the breaker tripping (unenergized state). You can capture the total event with appropriate event report trigger settings and use the ACSELERATOR Analytic Assistant to view and analyze the **CEV R** (raw data) report. The **CEV R** report will show the analog currents and light channels together with the Relay Word bits so that you can analyze and qualify the response. *Figure 10.7* shows an example event report for a simulated arc-flash incident.

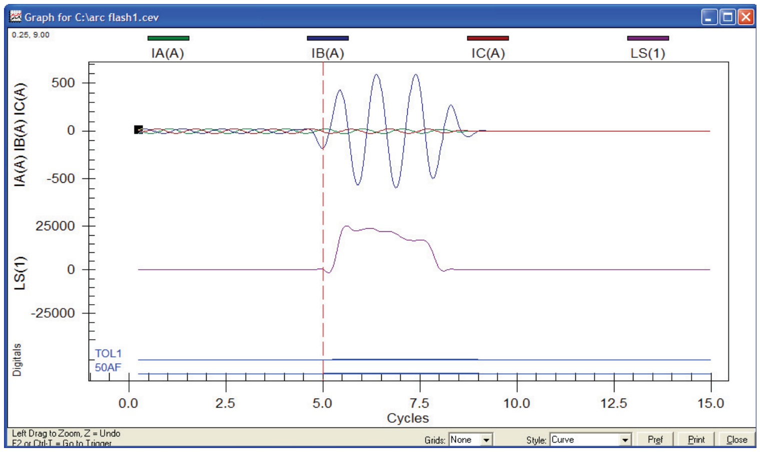


Figure 10.7 CEV R Light Event Capture Example

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 10.7 Periodic Relay Checks (Sheet 1 of 2)

Test	Description
Relay Status	Use the front-panel STATUS or serial port **STATUS** command to verify that the relay self-tests have not detected any WARN or FAIL conditions.
Arc-Flash Detection (AFD) Status	Use the serial port **AFT** command to verify that the AFD channel self-tests have not detected any FAIL condition in any of the channels.
Meter	Verify that the relay is correctly measuring current and voltage (if included) by comparing the relay meter readings to separate external meters.

Table 10.7 Periodic Relay Checks (Sheet 2 of 2)

Test	Description
Control Input	Using the front-panel `MAIN > Targets > Row 17` function, check the control input status in the relay. As you apply rated voltage to each input, the position in Row 17 corresponding to that input should change from zero (0) to one (1).
Contact Output	Program each of the output contacts you want to test to logical 1. This causes the output contact to close. For example, setting OUT101 := 1 causes the output **OUT101** contact to close. Make sure that each contact closure does what you want it to do in the annunciation, control, or trip circuit associated with that contact closure.

Self-Test

The SEL-751 runs a variety of self-tests. The relay takes the following corrective actions for out-of-tolerance conditions (see *Table 10.8*):

- Protection Disabled: The relay disables protection and control elements and trip/close logic. All output contacts are de-energized. The ENABLED front-panel LED is extinguished.
- ALARM Output: Two Relay Word bits, HALARM and SALARM, signal self-test problems. SALARM is pulsed for software programmed conditions, such as settings changes, access level changes, three consecutive unsuccessful password entry attempts, active group change, copy command, and password change. HALARM is pulsed for hardware self-test warnings. HALARM is continuously asserted (set to logical 1) for hardware self-test failures. A diagnostic alarm can be configured as explained in *Section 4: Protection and Logic Functions*. In the **Alarm Status** column of *Table 10.8*, 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 LCD display for failures.
- For certain failures, the relay will automatically restart as many as three times. In many instances, this will correct the failure. The failure message might not be fully displayed before automatic restart occurs. Indication that the relay restarted will be recorded in the Sequential Events Recorder (SER).

Use the serial port **STATUS** command or front-panel to view relay self-test status. Based on the self-test type, issue the **STA C** command as directed in the Corrective Actions column. Contact SEL if this does not correct the problem.

Table 10.8 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	
Mainboard FPGA (power up)	Fail if mainboard Field Programmable Gate Array does not accept program or the version number is incorrect		Yes	Latched	Yes	Status Fail FPGA Failure	Automatic restart. Contact SEL if failure returns.
Mainboard FPGA (run time)	Fail on lack of data acquisition interrupts or on detection of a CRC error in the FPGA code		Yes	Latched	Yes	Status Fail FPGA Failure	Automatic restart. Contact SEL if failure returns.
GPSB (back-plane) communications	Fail if GPSB is busy on entry to processing interval		Yes	Latched	Yes	Status Fail GPSB Failure	STA C, to clear the warning in the status report.
Front-Panel HMI (power up)	Fail if ID registers do not match expected or if FPGA programming is unsuccessful		No	Not Latched	Yes	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
External RAM (power up)	Performs a read/write test on system RAM		Yes	Latched	No	No	
External RAM (run time)	Performs a read/write test on system RAM		Yes	Latched	Yes	Status Fail RAM Failure	Automatic restart. Contact SEL if failure returns.
Internal RAM (power up)	Performs a read/write test on system CPU RAM		Yes	Latched	No	No	
Internal RAM (run time)	Performs a read/write test on system CPU RAM		Yes	Latched	Yes	Status Fail RAM Failure	Automatic restart. Contact SEL if failure returns.
Code Flash (power up)	SELBOOT qualifies code with a checksum		NA	NA	NA	NA	
Data Flash (power up)	Checksum is computed on critical data		Yes	Latched	Yes	Status Fail Non_Vol Failure	
Data Flash (run time)	Checksum is computed on critical data		Yes	Latched	Yes	Status Fail Non_Vol Failure	
Critical RAM (settings)	Performs a checksum test on the active copy of settings		Yes	Latched	Yes	Status Fail CR_RAM Failure	Automatic restart. Contact SEL if failure returns.
Critical RAM (run time)	Verify instruction matches FLASH image		Yes	Latched	Yes	Status Fail CR_RAM Failure	Automatic restart. Contact SEL if failure returns.
I/O Board Failure	Check if ID register matches part number		Yes	Latched	Yes	Status Fail Card [C|D|E] Failure	
DeviceNet Board Failure	DeviceNet card does not respond in three consecutive 300 ms time out periods		NA	NA	NA	COMMFLT Warning	

Table 10.8 Relay Self Tests (Sheet 2 of 3)

Self Test	Description	Normal Range	Protection Disabled on Failure	Alarm Status	Auto Message on Failure	Front Panel Message on Failure	Corrective Action
Card Z (power up)	Fail if ID register does not match part number or if A/D reference check fails		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.
Card E (power up)	Fail if ID register does not match part number or if A/D reference check fails		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.
+0.9 V Fail	Monitor +0.9 V power supply	0.855 to 0.945 V	Yes	Latched	Yes	Status Fail +0.9 V Failure	
+1.2 V Fail	Monitor +1.2 V power supply	1.152 to 1.248 V	Yes	Latched	Yes	Status Fail +1.2 V Failure	
+1.5 V Fail	Monitor +1.5 V power supply	1.35 to 1.65 V	Yes	Latched	Yes	Status Fail +1.5 V Failure	
+1.8 V Fail	Monitor +1.8 V power supply	1.71 to 1.89 V	Yes	Latched	Yes	Status Fail +1.8 V Failure	
+3.3 V Fail	Monitor +3.3 V power supply	3.07 to 3.53 V	Yes	Latched	Yes	Status Fail +3.3 V Failure	
+5 V Fail	Monitor +5 V power supply	4.65 to 5.35 V	Yes	Latched	Yes	Status Fail +5 V Failure	
+2.5 V Fail	Monitor +2.5 V power supply	2.32 to 2.68 V	Yes	Latched	Yes	Status Fail +2.5 V Failure	
+3.75 V Fail	Monitor +3.75 V power supply	3.48 to 4.02 V	Yes	Latched	Yes	Status Fail +3.75 V Failure	
–1.25 V Fail	Monitor -1.25 V power supply	–1.16 to –1.34 V	Yes	Latched	Yes	Status Fail –1.25 V Failure	
–5 V Fail	Monitor -5 V power supply	–4.65 to –5.35 V	Yes	Latched	Yes	Status Fail –5 V Failure	
Clock Battery	Monitor Clock Battery	2.3 to 3.5 V	No	Not Latched	Yes	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
Clock Chip	Unable to communicate with clock or fails time keeping test		No	Not Latched	Yes	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.

Table 10.8 Relay Self Tests (Sheet 3 of 3)

Self Test	Description	Normal Range	Protection Disabled on Failure	Alarm Status	Auto Message on Failure	Front Panel Message on Failure	Corrective Action
Clock Chip RAM	Clock chip static RAM fails		No	Not Latched	Yes	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
External RTD	Fail if no comm, or the external RTD module reports open RTDs, shorted RTDs, a power supply failure		NA	NA	No	RTD Failure	
CID (Configured IED Description) file (access)	Failure to Access/Read CID File		No	NA	No	Status Fail CID File Failure	
Exception Vector	CPU Error		Yes	Latched	NA	Vector nn Relay Disabled	Automatic restart. Contact SEL if failure returns.

Troubleshooting

Table 10.9 Troubleshooting (Sheet 1 of 2)

Symptom/Possible Cause	Diagnosis/Solution
The relay ENABLED front-panel LED is dark.	
Input power is not present or a fuse is blown.	Verify that input power is present. Check fuse continuity.
Self-test failure	View the self-test failure message on the front-panel display.
The relay front-panel display does not show characters.	
The relay front-panel has timed out.	Press the ESC pushbutton to activate the display.
The relay is de-energized.	Verify input power and fuse continuity.
The relay does not accurately measure voltages or currents.	
Wiring error	Verify input wiring.
Incorrect CTR, CTRN, or PTR setting	Verify instrument transformer ratios, connections, and associated settings.
Voltage neutral terminal (N) is not properly grounded.	Verify wiring and connections.
The relay does not respond to commands from a device connected to the serial port.	
Cable is not connected.	Verify the cable connections.
Cable is not the correct type.	Verify the cable pinout.
The relay or device is at an incorrect baud rate or has another parameter mismatch.	Verify Device software setup.
The relay serial port has received an XOFF, halting communications.	Type **<Ctrl+Q>** to send the relay XON and restart communications.

Table 10.9 Troubleshooting (Sheet 2 of 2)

Symptom/Possible Cause	Diagnosis/Solution
The relay does not respond to faults.	
The relay is improperly set.	Verify the relay settings.
Improper test source settings	Verify the test source settings.
Current or voltage input wiring error	Verify input wiring.
Failed relay self-test	Use the front-panel RELAY STATUS function to view self-test results.

Factory Assistance

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

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Appendix A
Firmware and Manual Versions

Firmware

Determining the Firmware Version in Your Relay

To find the firmware version number in your SEL-751 Feeder Protection Relay, use the **STA** command (see *STATUS Command (Relay Self-Test Status) on page 7.44* for more information on the **STA** command). The firmware revision number is after the R, and the release date is after the D. For example, the following is firmware revision number 100, release date June 1, 2011.

FID=SEL-751-R100-V0-Z001001-D20110601

Table A.1 lists the firmware versions, a description of modifications, and the instruction manual date code that corresponds to the firmware versions. The most recent firmware version is listed first.

Table A.1 Firmware Revision History (Sheet 1 of 3)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-751-R109-V0-Z004001-D20140402	➤ Manual update only (see *Table A.4*)	20150123
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 which 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).	20131101

Table A.1 Firmware Revision History (Sheet 2 of 3)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
	➤ Improved the security of RTD ALARM and TRIP by adding an approximately 6-second delay to qualify the event. ➤ Corrected an Ethernet issue with the initial Gratuitous ARP request not being sent for as long as five minutes after startup. ➤ Added support for Y-MODEM over Telnet. ➤ Corrected an issue with writing to User Map registers 1–125 with Modbus function code 06. ➤ Corrected an issue with DNP Binary Outputs reported as OFFLINE. ➤ Corrected an issue with angle calculations for analog quantities. ➤ 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, which used UTC time instead of local time. ➤ Corrected an issue with HIF HIS report, which 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 which gave the "No Data Available" message when the number of HIF events exceeded the maximum number of events for the given HIFLER setting. ➤ Corrected an issue with the rotating display which displayed a blank page 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.	20130206

Table A.1 Firmware Revision History (Sheet 3 of 3)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
	➤ 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	➤ Manual update only (see *Table A.4*).	20120903
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, which 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

DeviceNet and Firmware Versions

The firmware on the DeviceNet interface has two versions, as listed in *Table A.2*. The version number of this firmware is only accessible via the Device Net interface. The SEL-751 needs DeviceNet firmware version 1.005.

Table A.2 DeviceNet Card Versions

DeviceNet Card Software Version	Revisions	Release Date
Major Rev: 1, Minor Rev: 5 (Rev 1.005)	Reads product code, DeviceNet card parameter descriptions, etc., from the relay.	20080407
Major Rev: 1, Minor Rev: 1 (Rev 1.001)	Base version (card defines product code = 100, fixed descriptions for DeviceNet Card parameters, etc.)	20030612

The Electronic Data Sheet (EDS) file is not updated every time a firmware release is made. A new EDS file is released only when there is a change in the Modbus/DeviceNet parameters. The EDS file and an ICON file for the SEL-751 are zipped together on the SEL-751 Product Literature CD (SEL-xxxRxxx.zip). The file can also be downloaded from the SEL website at www.selinc.com. *Table A.3* lists the compatibility among the EDS files and the various firmware versions of the relay.

Table A.3 EDS File Compatibility

EDS File	Firmware Revisions Supported	Release Date
SEL-751R100.EDS	R101, R102, R103, R105, R106, R108, R109 (with DeviceNet version 1.005)	20110601

Instruction Manual

The date code at the bottom of each page of this manual reflects the creation or revision date. *Table A.4* lists the instruction manual release dates and a description of modifications. The most recent instruction manual revisions are listed at the top.

Table A.4 Instruction Manual Revision History (Sheet 1 of 4)

Revision Date	Summary of Revisions
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*. Section 2 ➤ Added a warning on CT circuits to *Current/Voltage Card Option (4 ACI/3 AVI)*. Section 10 ➤ Added a warning on CT circuits to *Overview.*
20140402	Preface ➤ Updated the *Product Compliance* label. Section 1 ➤ Updated the *Specifications* for element accuracy and oscillography length. Section 2 ➤ Updated *Card Configuration Procedure*. 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 up to 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.

Table A.4 Instruction Manual Revision History (Sheet 2 of 4)

Revision Date	Summary of Revisions
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. **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.

Table A.4 Instruction Manual Revision History (Sheet 3 of 4)

Revision Date	Summary of Revisions
	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*.
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*.

Table A.4 Instruction Manual Revision History (Sheet 4 of 4)

Revision Date	Summary of Revisions
	Section 6 Setting Sheets ➤ Revised CBADPU setting units to ppm (parts per million). Section 10 ➤ Updated *Table 10.8: Relay Self Tests* with Corrective Action column. ➤ Changed “Bare Fiber” to “Clear Fiber” as a result of the new fiber sensor design. ➤ Added SEL-4520 Arc Flash Test Module reference in *Arc-Flash Protection Tests*. Appendix A ➤ Updated for firmware version R103. Appendix E ➤ Removed *Modifying Relay Settings Using Modbus*
20110720	Appendix A ➤ Updated for firmware version R102.
20110601	➤ Initial version.

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Appendix B
Firmware Upgrade Instructions

Overview

These firmware upgrade instructions apply to all SEL-700 series industrial products except the SEL-701 Relay and SEL-734 Meter.

SEL occasionally offers firmware upgrades to improve the performance of your relay. Because SEL-751 relays store firmware in flash memory, changing physical components is not necessary. Upgrade the relay firmware by downloading a file from a personal computer to the relay via the front-panel serial port via ACSELERATOR QuickSet® SEL-5030 Software or a terminal emulator as outlined in the following sections. For relays with IEC 61850 option, verify IEC 61850 protocol after the upgrade (see *Verification of IEC 61850 Protocol for Relays With IEC 61850 Option*).

Required Equipment

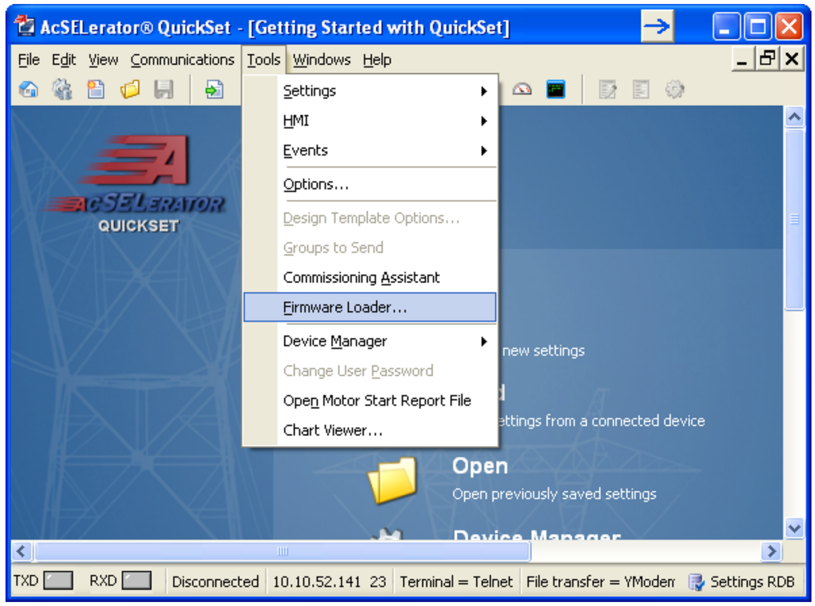
Gather the following equipment before starting this firmware upgrade:

- ➤ Personal computer (PC)
- ➤ Terminal emulation software that supports Xmodem/CRC or 1k Xmodem/CRC protocol
- ➤ Serial communications cable (SEL Cable C234A or equivalent, or a null-modem cable)
- ➤ Disk containing the firmware upgrade file (for example, r1017xxx.s19 or r1017xxx.z19)
- ➤ ACSELERATOR Software

NOTE: Firmware releases are also available as zip files (.z19). Use the zip file for faster download.

Upgrade Firmware Using ACSELERATOR

Select **Tools > Firmware Loader** from the ACSELERATOR menu bar to launch a wizard that walks you through the steps to load firmware into your SEL device. Refer to *Section 3: PC Software* for setup and connection procedures for ACSELERATOR.



Firmware Loader will not start if:

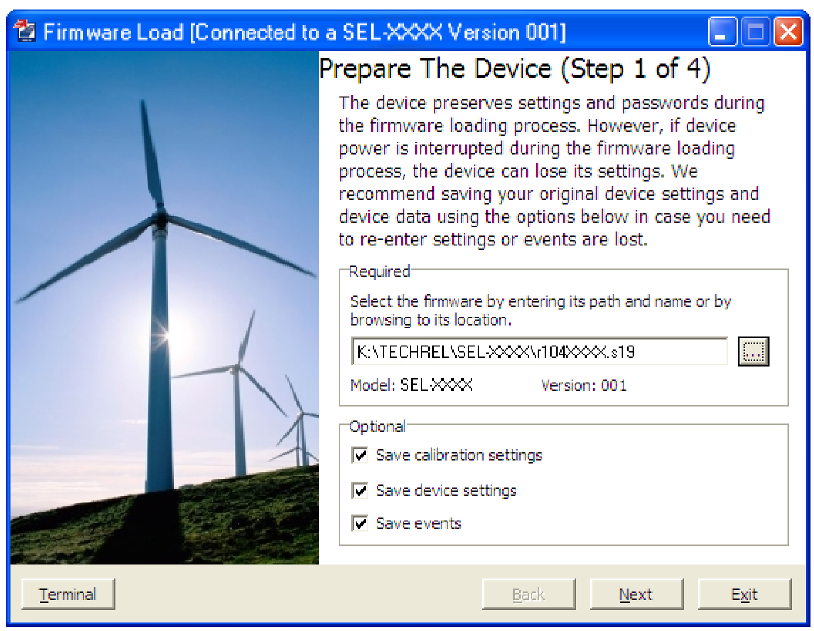
➤ The device is unsupported by ACSELERATOR.

➤ The device is not connected to the computer with a communications cable.

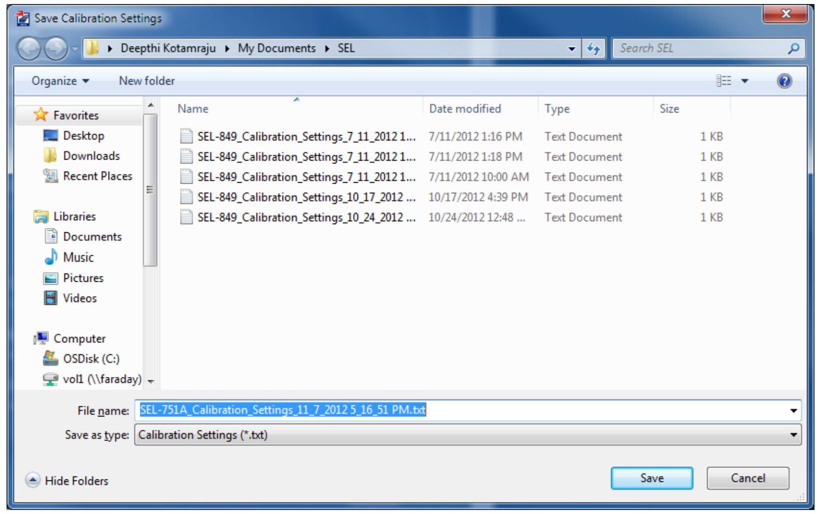
➤ The device is disabled.

Step 1. Prepare the device.

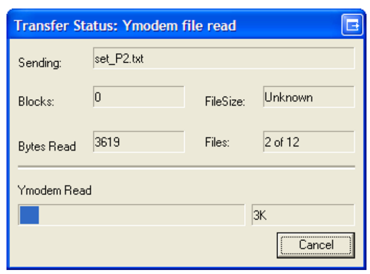
a. Select the firmware to be loaded using the browse control and select **Save calibration settings**, **Save device settings**, and **Save events**. Select **Next** to continue the wizard.

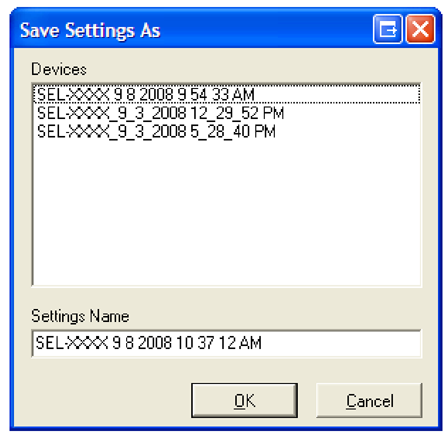


b. Select a file name to save the selected settings or accept the defaults as shown. Click **Save**.



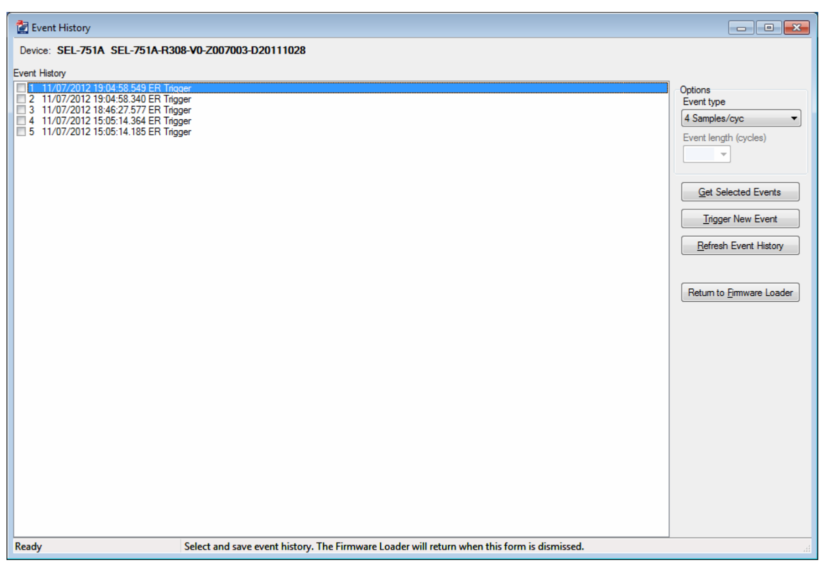
c. The **Transfer Status**: **Ymodem file read** window shows the transfer progress of the settings file. Clicking **Cancel** will stop the transfer.
After the device settings are downloaded, select a file name and path to save the settings or accept the default, as shown.





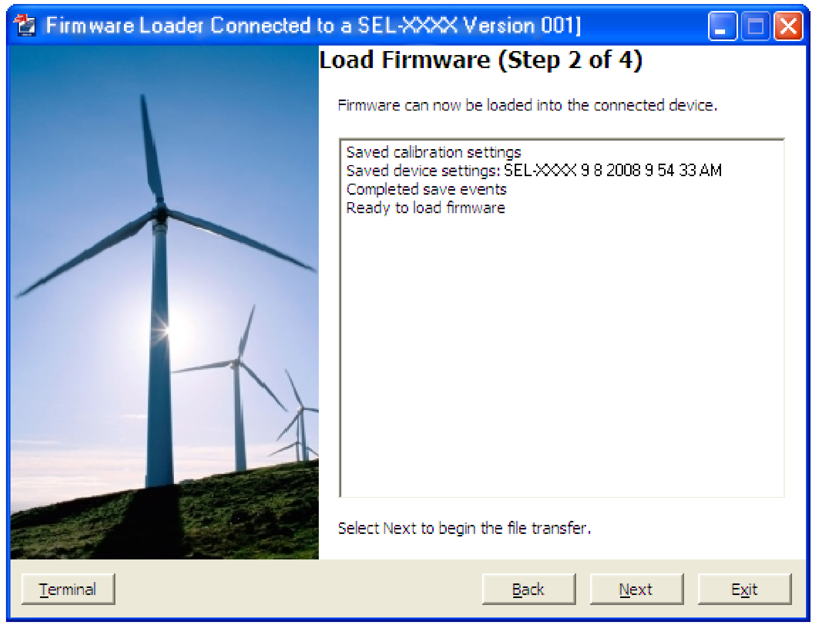
d. Click **Return to Firmware Loader** if this product does not have any event reports.

If there are any event reports to be saved, click the **Get Selected Event** button after selecting the events. After saving them, click the **Return to Firmware Loader** button.



Step 2. Transfer Firmware.

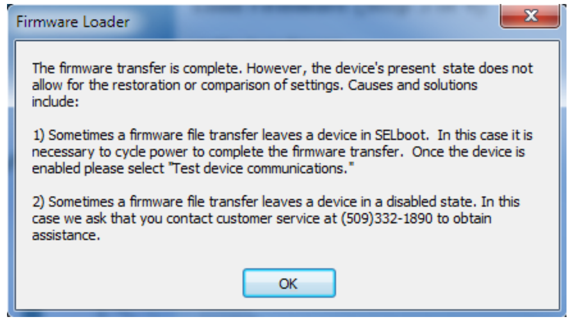
Click **Next** to begin the firmware transfer.



Step 3. Load Firmware.

During this step, the device is put in SELBOOT. The transfer speed is maximized and the firmware transfer begins.

NOTE: The following screen can appear if you have one of the two conditions mentioned.



If the relay is disabled as mentioned in condition number 2, check for the **ENABLED** LED on the front panel of the relay. If the **ENABLED** LED is not illuminated or the front panel displays `STATUS FAIL` or `Non_Vol Failure`, use the following procedure to restore the factory default settings:

a. Click on the Terminal button on the Firmware Load screen of ACSELERATOR.

b. Set the communications software settings to 9600 baud, 8 data bits, and 1 stop bit.

c. Enter Access Level 2 by issuing the **2AC** command.

d. Issue the **R_S** command to restore the factory default.

e. Enter Access Level 2.

f. Issue the **STATUS** command.

If the **STATUS** report shows option card `FAIL` and `Relay Disabled` and the message:

`Confirm Hardware Config`

`Accept & Reboot (Y/N)?`

Enter **Y**. This will save the relay calibration settings. The relay will respond:

`Config Accepted`

The relay will reboot and come up **ENABLED**.

Step 4. Verify Device.

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 re-initializes the device.

Compare Device Settings. This option verifies settings by reading them from the device and comparing them with settings saved to the database.

Restore Device Settings. This option restores settings by writing settings saved in the database to the device. Settings are converted automatically, if necessary.

Load Firmware into Another Device. Returns the wizard to *Step 1*: *Prepare Device* to repeat the firmware-loading process with another device.

Upgrade Firmware Using a Terminal Emulator

The following instructions assume you have a working knowledge of your personal computer terminal emulation software. In particular, you must be able to modify your serial communications parameters (baud rate, data bits, parity, etc.), select transfer protocol (Xmodem/CRC or 1k Xmodem/CRC), and transfer files (for example, send and receive binary files).

Step 1. If the relay is in service, open the relay control circuits.

Step 2. Connect the PC to the front-panel serial port and enter Access Level 2.

Step 3. Save the present relay settings.

You can use the PC software (described in the instruction manual PC software section) to save and restore settings easily. Otherwise, use the following steps.

a. Issue the following commands at the ASCII prompt:

SHO, **SHO L**, **SHO G**, **SHO P**, **SHO F**, **SHO R**, **SHO C**, etc.

NOTE: To save the calibration settings, perform **SHO C** from the terminal by logging into CAL level using the CAL level password. The factory-default password for CAL level is CLARKE.

b. Record all the settings for possible re-entry after the firmware upgrade.

c. We recommend that you save all stored data in the relay, including EVENTS, before the upgrade.

Step 4. Start upgrading of firmware.

a. Issue the **L_D** command to the relay.

b. Type **Y <Enter>** at the following prompt:

```
Disable relay to receive firmware (Y/N)?
```

c. Type **Y <Enter>** at the following prompt:

```
Are you sure (Y,N)?
```

The relay will send the `!>` prompt.

Step 5. Change the baud rate, if necessary.

NOTE: If you have difficulty at 115200 bps, choose a slower data transfer rate (for example, 38400 bps or 57600 bps). Be sure to match the relay and PC data rates.

a. Type **BAU 115200 <Enter>**.

This will change the baud rate of the communications port to 115200.

b. Change the baud rate of the PC to 115200 to match the relay.

Step 6. Begin the transfer of new firmware to the relay by issuing the **REC** command.

Step 7. Type **Y** to erase the existing firmware or press **<Enter>** to abort.

Step 8. Press any key (for example, **<Enter>**) when the relay sends a prompt.

Step 9. Start the file transfer.

Select the send file option in your communications software. Use the Xmodem protocol and send the file that contains the new firmware (for example, r101xxx.s19 or r101xxx.z19).

The file transfer takes less than 5–15 minutes at 115200 baud, depending on the product. After the transfer is complete, the relay will reboot and return to Access Level 0. *Figure B.1* shows the entire process.

```
=>>L_D <Enter>

Disable relay to receive firmware (Y,N)? Y <Enter>
Are you sure (Y,N)? Y <Enter>
Relay Disabled

BFID=BOOTLDR-R500-V0-Z000000-D20090925
!>BAU 115200 <Enter>
!>REC <Enter>
This command uploads new firmware.
When new firmware is uploaded successfully, IED will erase old firmware,
load new firmware and reboot.

Are you sure you want to erase the existing firmware(Y,N)? Y <Enter>
Press any key to begin transfer and then start transfer at the terminal.<Enter>
Erasing firmware.
Erase successful.
Writing new firmware.
Upload completed successfully. Attempting a restart.
```

Figure B.1 Firmware File Transfer Process

Step 10. The relay illuminates the **ENABLED** front-panel LED if the relay settings were retained through the download.

If the **ENABLED** LED is illuminated, proceed to *Step 11*.

If the **ENABLED** LED is not illuminated or the front panel displays `STATUS FAIL` or `Non_Vol Failure`, use the following procedure to restore the factory default settings:

a. Set the communications software settings to 9600 baud, 8 data bits, and 1 stop bit.

b. Enter Access Level 2 by issuing the **2AC** command.

c. Issue the **R_S** command to restore the factory default settings.

The relay will then reboot with the factory default settings.

d. Enter Access Level 2.

e. Issue the **STATUS** command.

If the relay is **ENABLED** go to *Step f*.

If the **STATUS** report shows option card `FAIL` and `Relay Disabled` and the message:

`Confirm Hardware Config`

`Accept & Reboot (Y/N)?`

Enter **Y**. This will save the relay calibration settings.

The relay will respond:

`Config Accepted`

The relay will reboot and come up **ENABLED**.

f. Restore relay settings back to the settings saved in *Step 3*.

Step 11. Change the baud rate of the PC to match that of the relay prior to *Step 5*, and enter Access Level 2.

Step 12. Issue the **STATUS** command; verify all relay self-test results are OK.

Step 13. Apply current and voltage signals to the relay.

Step 14. Issue the **METER** command; verify that the current and voltage signals are correct.

Step 15. Autoconfigure the SEL-2032, SEL-2030, or SEL-2020 port if you have a Communications Processor connected.

This step re-establishes automatic data collection between the SEL-2032, SEL-2030, or SEL-2020 Communications Processor and the SEL relay. Failure to perform this step can result in automatic data collection failure when cycling communications processor power.

Verification of IEC 61850 Protocol 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 will disable the IEC 61850 protocol, because it no longer has a valid configuration. To restart IEC 61850 protocol operation, you must transfer a valid CID file to the relay.

Perform the following steps to verify that the IEC 61850 protocol is still operational after a relay firmware upgrade and if not, re-enable it. This procedure assumes that IEC 61850 was operational with a valid CID file immediately before initiating the relay firmware upgrade.

Step 1. Establish an FTP connection to the relay Ethernet port.

Step 2. Open the ERR.TXT file.

If the ERR.TXT file is empty, the relay found no errors during CID file processing and IEC 61850 should be enabled. Go to *Step 3* if ERR.TXT is empty.

If the ERR.TXT file contains error messages relating to CID file parsing, the relay has disabled the IEC 61850 protocol. Use ACSELERATOR® Architect™ SEL-5032 Software to convert the existing CID file and make it compatible again.

a. Install the Architect software upgrade that supports your required CID file version.

b. Run Architect and open the project that contains the existing CID file for the relay.

c. Download the CID file to the relay.

Step 3. Upon connecting to the relay, Architect detects the upgraded relay firmware and prompts you to allow it to convert the existing CID file to a supported version. Once converted, downloaded, and processed, the valid CID file allows the relay to re-enable the IEC 61850 protocol.

Step 4. In the Telnet session, type GOO <Enter>.

Step 5. View the GOOSE status and verify that the transmitted and received messages are as expected.

The relay is now ready for your commissioning procedure.

Factory Assistance

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

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

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Appendix C

SEL Communications Processors

SEL Communications Protocols

The SEL-751 Feeder Protection Relay supports SEL protocols and command sets shown in *Table C.1*.

Table C.1 Supported Serial Command Sets

Command Set	Description
SEL ASCII	Use this protocol to send ASCII commands and receive ASCII responses that are human readable with an appropriate terminal emulation program.
SEL Compressed ASCII	Use this protocol to send ASCII commands and receive Compressed ASCII responses that are comma-delimited for use with spreadsheet and database programs or for use by intelligent electronic devices.
SEL Fast Meter	Use this protocol to send binary commands and receive binary meter and target responses.
SEL Fast Operate	Use this protocol to receive binary control commands.
SEL Fast SER	Use this protocol to receive binary Sequential Events Recorder unsolicited responses.
SEL Fast Message	Use this protocol to write Remote Analog data via unsolicited writes.

SEL ASCII Commands

We originally designed SEL ASCII commands for communication between the relay and a human operator via a keyboard and monitor or a printing terminal. A computer with a serial port can also use the SEL ASCII protocol to communicate with the relay, collect data, and issue commands.

SEL Compressed ASCII Commands

The relay supports a subset of SEL ASCII commands identified as Compressed ASCII commands. Each of these commands results in a comma-delimited message that includes a checksum field. Most spreadsheet and database programs can directly import comma-delimited files. Devices with embedded processors connected to the relay can execute software to parse and interpret comma-delimited messages without expending the customization and maintenance labor necessary to interpret nondelimited messages. The relay calculates a checksum for each line by numerically summing all of the bytes that precede the checksum field in the message. The program that uses the data can detect transmission errors in the message by summing the characters of the received message and comparing this sum to the received checksum.

Most commands are available only in SEL ASCII or Compressed ASCII format. Selected commands have versions in both standard SEL ASCII and Compressed ASCII formats. Compressed ASCII reports generally have fewer characters than conventional SEL ASCII reports because the compressed reports reduce blanks, tabs, and other white space between data fields to a single comma.

Table C.2 lists the Compressed ASCII commands and contents of the command responses.

Table C.2 Compressed ASCII Commands

Command	Response	Access Level
BNAME	ASCII names of Fast Meter status bits	0
CASCII	Configuration data of all Compressed ASCII commands available at access levels > 0	0
CEVENT	Event report	1
CHISTORY	List of events	1
CLDP	Load Profile Data	1
CMETER	Metering data, including fundamental, thermal demand, peak demand, energy, max/min, rms, analog inputs, and math variables	1
CSE	Sequence Of Events Data	1
CSTATUS	Relay status	1
CSUMMARY	Summary of an event report	1
DNAME	ASCII names of digital I/O reported in Fast Meter	0
ID	Relay identification	0
SNS	ASCII names for SER data reported in Fast Meter	0

Interleaved ASCII and Binary Messages

SEL relays have two separate data streams that share the same physical serial port. Human data communications with the relay consist of ASCII character commands and reports that you view through use of a terminal or terminal emulation package. The binary data streams can interrupt the ASCII data stream to obtain information; the ASCII data stream continues after the interruption. This mechanism uses a single communications channel for ASCII communication (transmission of an event report, for example) interleaved with short bursts of binary data to support fast acquisition of metering data. The device connected to the other end of the link requires software that uses the separate data streams to exploit this feature. However, you do not need a device to interleave data streams to use the binary or ASCII commands. Note that XON, XOFF, and CAN operations operate on only the ASCII data stream.

An example of using these interleaved data streams is when the SEL-751 communicates with an SEL communications processor. These SEL communications processors perform autoconfiguration by using a single data stream and SEL Compressed ASCII and binary messages. In subsequent operations, the SEL communications processor uses the binary data stream for Fast Meter and Fast Operate messages to populate a local database and to perform SCADA operations. At the same time, you can use the binary data stream to connect transparently to the SEL-751 and use the ASCII data stream for commands and responses.

SEL Fast Meter, Fast Operate, Fast SER, and Unsolicited Write

SEL Fast Meter is a binary message that you solicit with binary commands. Fast Operate is a binary message for control. The relay can also send unsolicited Fast SER messages automatically and receive unsolicited SEL Fast Messages (used in the SEL-751 for Remote Analogs). If the relay is connected to an SEL communications processor, these messages provide the mechanism that the communications processor uses for SCADA or DCS functions that occur simultaneously with ASCII interaction.

SEL Communications Processor

SEL offers SEL communications processors, powerful tools for system integration and automation. The SEL-2030 series and the SEL-2020 communications processors are similar, except that the SEL-2030 series has two slots for network protocol cards. The SEL-3530 Real Time Automation Controller (RTAC) has Ethernet ports as well as serial ports to connect to your SEL relay. These devices provide a single point of contact for integration networks with a star topology, as shown in *Figure C.1*.

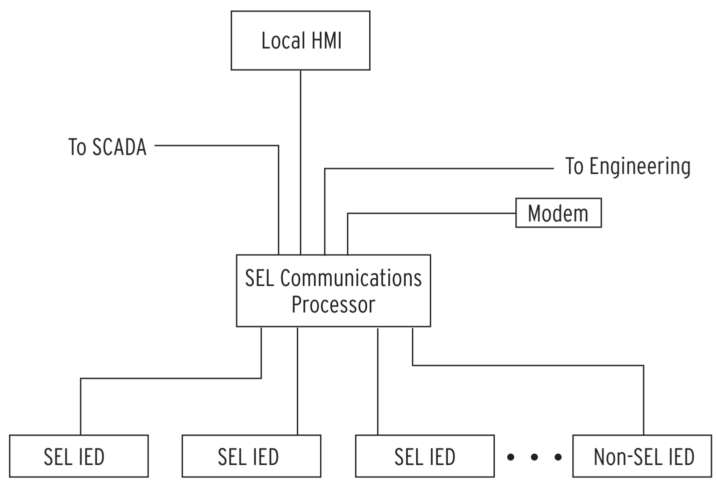


Figure C.1 SEL Communications Processor Star Integration Network

In the star topology network in *Figure C.1*, the SEL communications processor offers the following substation integration functions:

- ➤ Collection of real-time data from SEL and non-SEL IEDs
- ➤ Calculation, concentration, and aggregation of real-time IED data into databases for SCADA, HMI, and other data consumers
- ➤ Access to the IEDs for engineering functions including configuration, report data retrieval, and control through local serial, remote dial-in, and Ethernet network connections
- ➤ Distribution of IRIG-B time-synchronization signal to IEDs based on external IRIG-B input, internal clock, or protocol interface
- ➤ Simultaneous collection of SCADA data and engineering connection to SEL IEDs over a single cable
- ➤ Automated dial-out on alarms

The SEL communications processors have 16 serial ports plus a front port. This port configuration does not limit the size of a substation integration project, because you can create a multitiered solution as shown in *Figure C.2*. In this multitiered system, the lower-tier SEL communications processors forward data to the upper-tier SEL communications processor that serves as the central point of access to substation data and substation IEDs.

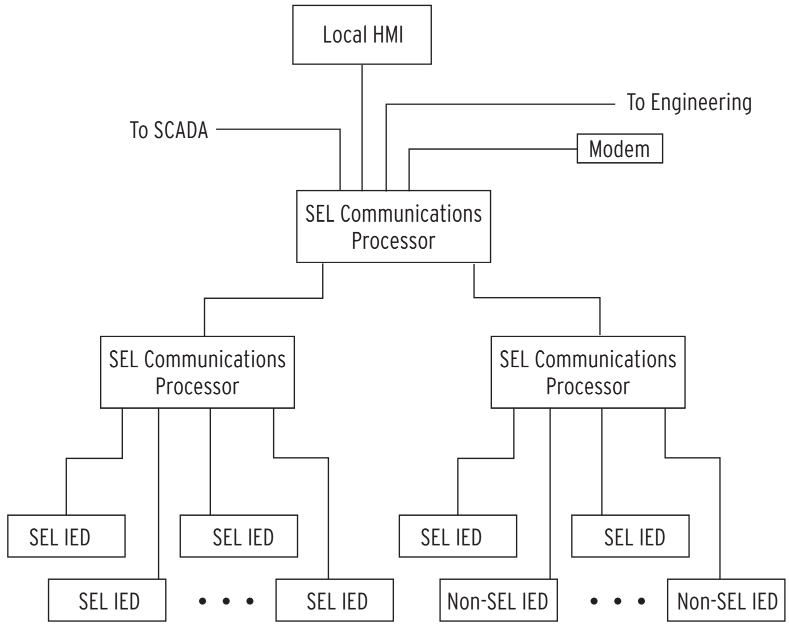


Figure C.2 Multitiered SEL Communications Processor Architecture

You can add additional communications processors to provide redundancy and eliminate possible single points of failure. SEL communications processors provide an integration solution with a reliability comparable to that of SEL relays. In terms of MTBF (mean time between failures), SEL communications processors are 100 to 1000 times more reliable than computer-based and industrial technology-based solutions.

Configuration of an SEL communications processor is different from other general-purpose integration platforms. You can configure SEL communications processors with a system of communication-specific keywords and data movement commands rather than programming in C or another general-purpose computer language. SEL communications processors offer the protocol interfaces listed in *Table C.3*.

Table C.3 SEL Communications Processors Protocol Interfaces

Protocol	Connect to
DNP3 Level 2 Slave	DNP3 masters
Modbus® RTU Protocol	Modbus masters
SEL ASCII/Fast Message Slave	SEL protocol masters
SEL ASCII/Fast Message Master	SEL protocol slaves including other communications processors and SEL relays
ASCII and Binary auto messaging	SEL and non-SEL IED master and slave devices
Modbus Plus[a]	Modbus Plus peers with global data and Modbus Plus masters
FTP (File Transfer Protocol)[b]	FTP clients
Telnet[b]	Telnet servers and clients
UCA2 GOMSFE[b]	UCA2 protocol masters
UCA2 GOOSE[b]	UCA2 protocol and peers

[a] Requires SEL-2711 Modbus Plus protocol card.
[b] Requires SEL-2701 Ethernet Processor.

SEL Communications Processor and Relay Architecture

You can apply SEL communications processors and SEL relays in a limitless variety of applications that integrate, automate, and improve station operation. Most system integration architectures utilizing SEL communications processors involve either developing a star network or enhancing a multidrop network.

Developing Star Networks

The simplest architecture using both the SEL-751 and an SEL communications processor is shown in *Figure C.1*. In this architecture, the SEL communications processor collects data from the SEL-751 and other station IEDs. The SEL communications processor acts as a single point of access for local and remote data consumers (local HMI, SCADA, engineers). The communications processor also provides a single point of access for engineering operations including configuration and the collection of report-based information.

By configuring a data set optimized to each data consumer, you can significantly increase the utilization efficiency on each link. A system that uses an SEL communications processor to provide a protocol interface to an RTU has a shorter lag time (data latency); communications overhead is much less for a single data exchange conversation to collect all substation data (from a communications processor) than for many conversations necessary to collect data directly from each individual IED. You can further reduce data latency by connecting any SEL communications processor directly to the SCADA master and eliminating redundant communications processing in the RTU.

The SEL communications processor is responsible for the protocol interface, so you can install, test, and even upgrade the system in the future without disturbing protective relays and other station IEDs. This insulation of the protective devices from the communications interface assists greatly in situations where different departments are responsible for SCADA operation, communication, and protection.

SEL communications processors equipped with an SEL-2701 Ethernet Processor can provide a UCA2 interface to SEL-751 Relays and other serial IEDs. The SEL-751 data appear in models in a virtual device domain. The combination of the SEL-2701 with an SEL communications processor offers a significant cost savings because you can use existing IEDs or purchase less expensive IEDs. For full details on applying the SEL-2701 with an SEL communications processor, see the SEL*-2701 Ethernet Processor Instruction Manual*.

The engineering connection can use either an Ethernet network connection through the SEL-2701 or a serial port connection. This versatility accommodates the channel that is available between the station and the engineering center. SEL software can use either a serial port connection or an Ethernet network connection from an engineering workstation to the relays in the field.

Enhancing Multidrop Networks

You can also use an SEL communications processor to enhance a multidrop architecture similar to the one shown in *Figure C.3*. In this example, the SEL communications processor enhances a system that uses the SEL-2701 with an Ethernet HMI multidrop network. In the example, there are two Ethernet networks, the SCADA LAN and the Engineering LAN. The SCADA LAN provides real-time data directly to the SCADA Control Center via a protocol gateway and to the HMI (Human Machine Interface).

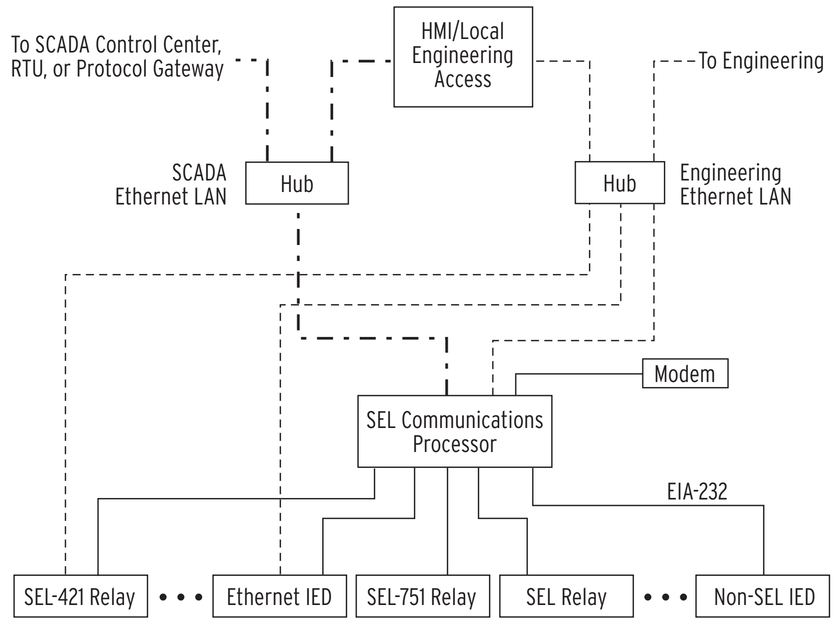


Figure C.3 Enhancing Multidrop Networks With SEL Communications Processors

In this example, the SEL communications processor provides the following enhancements when compared to a system that employs only the multidrop network:

- Ethernet access for IEDs with serial ports
- Backup engineering access through the dial-in modem
- IRIG-B time signal distribution to all station IEDs
- Integration of IEDs without Ethernet
- Single point of access for real-time data for SCADA, HMI, and other uses
- Significant cost savings by use of existing IEDs with serial ports

SEL Communications Processor Example

This example demonstrates the data and control points available in the SEL communications processor when you connect an SEL-751. The physical configuration used in this example is shown in *Figure C.4*.

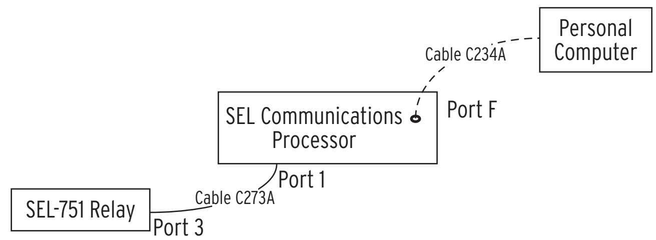


Figure C.4 Example of SEL Relay and SEL Communications Processor Configuration

Table C.4 shows the **Port 1** settings for the SEL communications processor.

Table C.4 SEL Communications Processor Port 1 Settings

Setting Name	Setting	Description
DEVICE	S	Connected device is an SEL device
CONFIG	Y	Allow autoconfiguration for this device
PORTID	*Relay 1*	Name of connected relay[a]
BAUD	19200	Channel speed of 19200 bits per second[a]
DATABIT	8	Eight data bits[a]
STOPBIT	1	One stop bit
PARITY	N	No parity
RTS_CTS	N	Hardware flow control enabled
XON_XOFF	Y	Enable XON/XOFF flow control
TIMEOUT	30	Idle timeout that terminates transparent connections of 30 seconds

[a] Automatically collected by the SEL communications processor during autoconfiguration.

Data Collection

The SEL communications processor is configured to collect data from the SEL-751, using the list in *Table C.5*.

Table C.5 SEL Communications Processor Data Collection Automessages

Message	Data Collected
20METER	Power system metering data
20DEMAND	Demand metering data
20TARGET	Selected Relay Word bit elements
20HISTORY	History Command (ASCII)
20STATUS	Status Command (ASCII)
20EVENTS	Standard 4 sample/cycle event report (data with settings)
20EVENT	Standard 4 sample/cycle event report (data only)

Table C.6 shows the automessage (**SET A**) settings for the SEL communications processor.

Table C.6 SEL Communications Processor Port 1 Automatic Messaging Settings

Setting Name	Setting	Description
AUTOBUF	Y	Save unsolicited messages
STARTUP	ACC\nOTTER\n	Automatically log-in at Access Level 1
SEND_OPER	Y	Send Fast Operate messages for remote bit and breaker bit control
REC_SER	N	Automatic sequential event recorder data collection disabled
NOCONN	NA	No SELOGIC® control equation entered to selectively block connections to this port
MSG_CNT	3	Three automessages
ISSUE1	P00:00:01.0	Issue Message 1 every second
MESG1	20METER	Collect metering data
ISSUE2	P00:00:01.0	Issue Message 2 every second
MESG2	20TARGET	Collect Relay Word bit data
ISSUE3	P00:01:00.0	Issue Message 3 every minute
MESG3	20DEMAND	Collect demand metering data
ARCH_EN	N	Archive memory disabled
USER	0	No USER region registers reserved

Table C.7 shows the map of regions in the SEL communications processor for data collected from the SEL-751. Use the **MAP *n*** command to view these data.

Table C.7 SEL Communications Processor Port 1 Region Map

Region	Data Collection Message Type	Region Name	Description
D1	Binary	METER	Relay metering data
D2	Binary	TARGET	Relay Word bit data
D3	Binary	DEMAND	Demand meter data
D4–D8	n/a	n/a	Unused
A1–A3	n/a	n/a	Unused
USER	n/a	n/a	Unused

Relay Metering Data

Table C.8 shows the list of meter data available in the SEL communications processor and the location and data type for the memory areas within D1 (Data Region 1). The type field indicates the data type and size. The *int* type is a 16-bit integer. The *float* type is a 32-bit IEEE floating point number. Use the **VIE *n*:D1** command to view these data.

Table C.8 Communications Processor METER Region Map With the 2 AVI/4 AFD Card Installed

Item	Starting Address	Type
_YEAR	2000h	int
DAY_OF_YEAR	2001h	int
TIME(ms)	2002h	int[2]
MONTH	2004h	char
DATE	2005h	char
YEAR	2006h	char
HOUR	2007h	char
MIN	2008h	char
SECONDS	2009h	char
MSEC	200Ah	int
IA	200Bh	float
IB	200Dh	float
IC	200Fh	float
IN	2011h	float
IG	2013h	float
UBI	2015h	float
VAB	2017h	float
VBC	2019h	float
VCA	201Bh	float
VS	201Dh	float
UBV	201Fh	float
P	2021h	float
Q	2023h	float
S	2025h	float
PF	2027h	float
FREQ	2029h	float
FREQS	202Bh	float
VDC	202Dh	float

Relay Word Bits Information

Table C.9 lists the Relay Word bit data available in the SEL communications processor TARGET region.

Table C.9 Communications Processor TARGET Region (Sheet 1 of 2)

Address	Relay Word Bits (in Bits 7–0)							
	7	6	5	4	3	2	1	0
2804h	*	*	*	*	*	PWRUP	STSET	*
2805h	See *Table J.1*, Row 0							
2806h	See *Table J.1*, Row 1							
2807h	See *Table J.1*, Row 2							
2808h	See *Table J.1*, Row 3							
2809h	See *Table J.1*, Row 4							

Table C.9 Communications Processor TARGET Region (Sheet 2 of 2)

Address	Relay Word Bits (in Bits 7–0)							
	7	6	5	4	3	2	1	0
280Ah	See *Table J.1*, Row 5							
280Bh	See *Table J.1*, Row 6							
280Ch	See *Table J.1*, Row 7							
280Dh	See *Table J.1*, Row 8							
280Eh	See *Table J.1*, Row 9							
280Fh	See *Table J.1*, Row 10							
2810h	See *Table J.1*, Row 11							
2811h	See *Table J.1*, Row 12							
•	•							
•	•							
•	•							
2895h	See *Table J.1*, Row 144							

Control Points

The SEL communications processor can automatically pass control messages, called Fast Operate messages, to the SEL-751. You must enable Fast Operate messages by using the FASTOP setting in the SEL-751 port settings for the port connected to the SEL communications processor. You must also enable Fast Operate messages in the SEL communications processor by setting the automessage setting SEND_OPER equal to Y.

NOTE: To use the Fast Operate function, the Breaker jumper must be installed (see Figure 2.7).

When you enable Fast Operate functions, the SEL communications processor automatically sends messages to the relay for changes in remote bits RB01–RB32 on the corresponding SEL communications processor port. For example, if you set RB01 on **Port 1** in the SEL communications processor, it automatically sets RB01 in the SEL-751.

Breaker bit BR1 operates differently than remote bits. There is one breaker bit in the SEL-751. For Circuit Breaker 1, when you set BR1, the SEL communications processor sends a message to the SEL-751 that asserts the OC bit for one processing interval. If you clear BR1, the SEL communications processor sends a message to the SEL-751 that asserts the CC bit for one processing interval. OC opens the breaker (via SELOGIC control equation TR) and CC closes the breaker (via SELOGIC control equation CL). See *Figure 4.51* and *Figure 4.52* for the breaker trip and breaker close logic diagrams, respectively.

Demand Data

Table C.10 lists the demand data available in the SEL Communications Processor and the location and data type for the memory areas within D3 (Data Region 3). The type field indicates the data type and size. The type “int” is a 16-bit integer. The type “float” is a 32-bit IEEE floating point number.

Table C.10 Communications Processor DEMAND Region Map

Item	Starting Address	Type
_YEAR	3000h	int
DAY_OF_YEAR	3001h	int
TIME(ms)	3002h	int[2]
MONTH	3004h	char
DATE	3005h	char
YEAR	3006h	char
HOUR	3007h	char
MIN	3008h	char
SECONDS	3009h	char
MSEC	300Ah	int
IAD(A)	300Bh	float
IBD(A)	300Dh	float
ICD(A)	300Fh	float
IGD(A)	3011h	float
3I2D(A)	3013h	float

SEL Communications Processor to SEL-751 Unsolicited Write Remote Analog Example

From the perspective of the SEL-751, Remote Analogs (RA01 through RA32) are specific, pre-allocated memory addresses. These memory addresses are available to accept and store values from remote devices such as an SEL-2032, SEL-2030, or SEL-2020 Communications Processor. Once these values from the remote devices are written into the memory addresses in the SEL-751, you can use these values similar to any other analog quantity in the SEL-751. When using the SEL communications processor to send the Remote Analogs to the SEL-751, we use the Unsolicited Write setting string and send the information by using the SEL Fast Message protocol. This example shows how to configure the Unsolicited Write message in the SEL communications processor to move data stored in the USER region of Port 6 of the SEL communications processor to an SEL-751 connected to Port 3 of the SEL communications processor. We also show how to select the correct Remote Analog data type in the SEL-751 to match the information in the Fast Message.

Although the SEL communications processor caters to static and dynamic data, this example uses static data in the SEL communications processor (entering the Unsolicited Write setting string is the same for static and dynamic data; see the SEL communications processor manual for dynamic data storing techniques). Assume the data are already stored in the USER region of Port 6 in the SEL communications processor. The Unsolicited Write message must be set in the Automatic messages on the SEL communications processor port to which the SEL-751 is connected. Because the SEL-751 is connected to Port 3 of the SEL communications processor, we use the Unsolicited Write Automatic (MESG1) message setting of Port 3 to build the Fast Message string, as shown in *Figure C.5* (see the SEL communications processor manual for in-depth discussions regarding the SEL communications processor Automatic message settings).

Setting the SEL Communications Processor

```
*>>SET A 3 <Enter>

Automatic message settings for Port 3


Save Unsolicited Messages (Y/N)             AUTOBUF = Y     ? <Enter>

Port Startup String
STARTUP ="?"
 ? <Enter>

Enable Automatic Sequential Events Recorder Collection (Y/N)REC_SER = N    ? <Enter>

Block external connections to this port
NOCONN  = NA
 ? <Enter>


Auto-message Settings

How many auto-message sequences (0-12)       MSG_CNT = 0     ? 1 <Enter>

Item 1 trigger D1
ISSUE1  = NA
 ? R1 <Enter>

Item 1 message
MESG1   = ""
 ? \W;06:USER:0000h;20,03:USER:0000h/ <Enter>

Archive Settings

Enable use of archive data items (Y/N)       ARCH_EN = N     ? END <Enter>

AUTOBUF = Y
STARTUP ="?"
REC_SER = N
NOCONN  = NA

MSG_CNT = 1

ISSUE1  = R1
MESG1   = "\W;06:USER:0000h;20,03:USER:0000h/"

ARCH_EN = N

USER    = 0

Save changes (Y/N) ? Y <Enter>

Port 3 Settings Changed

*>>
```

Figure C.5 Unsolicited Write Settings

The Unsolicited Write message string **\W;06:USER:0000h;20,03:USER:0000h/** contains all the information necessary to send the remote analog data to the SEL-751. Following is a discussion on the elements of the Unsolicited Write message string.

- **\W;** indicates this is an Unsolicited Write Message
- **06:User:0000H** indicates where the data are stored in the SEL communications processor (06 is the User regions port number where the data are stored, the beginning of the User region starts at F800H on each port, 0000H indicates what register in the User region to start at).
- **;20** indicates how many 16-bit registers from the SEL communications processor User region to send.
- **,03:USER:** is an SEL communications processor Unsolicited Write message compatibility requirement. 03 is the SEL communications processor port the SEL-751 is connected and the second parameter should always be USER, or F800h.

- **0000h/** indicates the first SEL-751 Remote Analog to begin writing to (0000H = RA01 – 003EH = RA32)
- The \ and / frames the message.

See the SEL communications processor manual for more information regarding the Unsolicited Write message string.

Following are 16-bit register data that are stored in the User region of Port 6 which we will send to the SEL-751 on Port 3. Remember that F800H is synonymous with the start of the USER region in the SEL communications processor. One register stores one Integer and two registers store one Float or Long data type.

```
*>>VIE 6:F800h NR 20 <Enter>

6:F800h

7FFFh 8001h FFFFh 0000h 447Ah 25C3h C47Ah 270Ah
4516h B029h 4516h AFD7h 0001h 7FFFh FFFEh 8001h
FFFFh 6A00h FFFFh 0000h

Starting at register 0000h, the first 4 registers contain 4 Integer data values
7FFFh 8001h FFFFh 0000h

Starting at register 0004h the next 8 registers contain 4 Float data values
447Ah 25C3h C47Ah 270Ah 4516h B029h 4516h AFD7h

Starting at register 000Ch the next 8 registers contain 4 Long data Values.
0001h 7FFFh FFFEh 8001h FFFFh 6A00h FFFFh 0000h
```

Setting the SEL-751

The SEL-751 interprets Remote Analogs as Integer, Float, or Long data types. For correct remote analog data transfer, the data type sent from the SEL communications processor must match the data type of each of the SEL-751 Remote Analogs. Use the RA*nn*TYPE settings (Report settings) to declare the Remote Analog type (I = Integer, F = Float, L = Long). Assume in our example we need only RA01 through RA12. In this example, we send 4 Integers, 4 Floats, and 4 Longs to the SEL-751. *Figure C.6* shows the correct settings for RA01 through RA13 accordingly, starting at RA01.

```
=>>SET R TERSE <Enter>

Report

SER Chatter Criteria

Auto-Removal EN (N,Y)                         ESERDEL := N         ? <Enter>

SER Trigger Lists
SERn = Up to 24 Device-Word elements separated by spaces or commas.
Use NA to disable setting.


SER Trigger List SER1 (24 Device Word bits)
SER1    := NA
? <Enter>
SER Trigger List SER2 (24 Device Word bits)
SER2    := NA
? <Enter>
SER Trigger List SER3 (24 Device Word bits)
SER3    := NA
? <Enter>
SER Trigger List SER4 (24 Device Word bits)
SER4    := NA
? <Enter>

Event Report Set

Event Trigger (SELogic)
ER      := NA
? <Enter>
Event Length (15,64 cyc)                      LER     := 15        ? <Enter>
Prefault Length (OFF,1-10 cyc)                PRE     := 4         ? <Enter>

Fast Message Remote Analog Settings

Remote Analog Value Type (I,F,L)              RA01TYPE:= I         ? I <Enter>
Remote Analog Value Type (I,F,L)              RA02TYPE:= I         ? I <Enter>
Remote Analog Value Type (I,F,L)              RA03TYPE:= I         ? I <Enter>
Remote Analog Value Type (I,F,L)              RA04TYPE:= I         ? I <Enter>
Remote Analog Value Type (I,F,L)              RA05TYPE:= I         ? F <Enter>
Remote Analog Value Type (I,F,L)              RA06TYPE:= I         ? F <Enter>
Remote Analog Value Type (I,F,L)              RA07TYPE:= I         ? F <Enter>
Remote Analog Value Type (I,F,L)              RA08TYPE:= I         ? F <Enter>
Remote Analog Value Type (I,F,L)              RA09TYPE:= I         ? L <Enter>
Remote Analog Value Type (I,F,L)              RA10TYPE:= I         ? L <Enter>
Remote Analog Value Type (I,F,L)              RA11TYPE:= I         ? L <Enter>
Remote Analog Value Type (I,F,L)              RA12TYPE:= I         ? L <Enter>
Remote Analog Value Type (I,F,L)              RA13TYPE:= I         ? END <Enter>
Save changes (Y,N)? Y <Enter>
Settings Saved

=>>
```

Figure C.6 Setting Remote Analogs RA01 Through RA13

Now every time the ISSUE1 condition in the Automatic Messages on Port 3 is true, the SEL communications processor sends an Unsolicited Write message to the SEL-751 and populate Remote Analogs 1–12 with the corresponding stored data in the SEL communications processor User region on Port 6.

Execute a **MET RA** or **CME RA** in the SEL-751 to retrieve the Remote Analog data.

Appendix D
DNP3 Communications

Overview

The SEL-751 Feeder Protection Relay provides a Distributed Network Protocol Version 3.0 (DNP3) Level 2 Outstation interface for direct serial and LAN/WAN network connections to the device.

This section covers the following topics:

- *Introduction to DNP3 on page D.1*
- *DNP3 in the SEL-751 on page D.6*
- *DNP3 Documentation on page D.13*

Introduction to DNP3

A Supervisory Control and Data Acquisition (SCADA) manufacturer developed the first versions of DNP from the lower layers of IEC 60870-5. Originally designed for use in telecontrol applications, Version 3.0 of the protocol has also become popular for local substation data collection. DNP3 is one of the protocols included in the IEEE® Recommended Practice for Data Communication between Remote Terminal Units (RTUs) and Intelligent Electronic Devices (IEDs) in a Substation.

The DNP Users Group maintains and publishes DNP3 standards. See the DNP Users Group website, www.dnp.org, for more information on standards, implementers, and tools for working with DNP3.

DNP3 Specifications

DNP3 is a feature-rich protocol with many ways to accomplish tasks, defined in an eight-volume series of specifications. Volume 8 of the specification, called the Interoperability Specification, simplifies DNP3 implementation by providing four standard interoperable implementation levels. The levels are listed in *Table D.1*.

Table D.1 DNP3 Implementation Levels

Level	Description	Equipment Types
1	Simple: limited communications requirements	Meters, simple IEDs
2	Moderately complex: monitoring and metering devices and multifunction devices that contain more data	Protective relays, RTUs
3	Sophisticated: devices with great amounts of data or complex communications requirements	Large RTUs, SCADA masters
4	Enhanced: additional data types and functionality for more complex requirements	Large RTUs, SCADA masters

Each level is a proper superset of the previous lower-numbered level. A higher-level device can act as a master to a lower-level device, but can only use the data types and functions implemented in the lower level device. For example, a typical SCADA master is a Level 3 device and can use Level 2 (or lower) functions to poll a Level 2 (or lower) device for Level 2 (or lower) data. Similarly, a lower-level device can poll a higher-level device, but the lower level device can only access the features and data available to its level.

In addition to the eight-volume DNP3 specification, the protocol is further refined by conformance requirements, optional features, and a series of technical bulletins. The technical bulletins supplement the specifications with discussions and examples of specific features of DNP3.

Data Handling

Objects

DNP3 uses a system of data references called objects, defined by the Basic 4 standard object library. Each subset level specification requires a minimum implementation of object types and recommends several optional object types. DNP3 object types, commonly referred to as objects, are specifications for the type of data the object carries. An object can include a single value or more complex data. Some objects serve as shorthand references for special operations, including collections of data, time synchronization, or even all data within the DNP3 device.

If there can be more than one instance of a type of object, then each instance of the object includes an index that makes it unique. For example, each binary status point (Object 1) has an index. If there are 16 binary status points, these points are Object 1, Index 0 through Object 1, Index 15.

Each object also includes multiple versions called variations. For example, Object 1 (binary inputs) has three variations: 0, 1, and 2. You can use variation 0 to request all variations, variation 1 to specify binary input values only, and variation 2 to specify binary input values with status information.

Each DNP3 device has both a list of objects and a map of object indices. The list of objects defines the available objects, variations, and qualifier codes. The map defines the indices for objects that have multiple instances and defines what data or control points correspond with each index.

A master initiates all DNP3 message exchanges except unsolicited data. DNP3 terminology describes all points from the perspective of the master. Binary points for control that move from the master to the outstation are called Binary Outputs, while binary status points within the outstation are called Binary Inputs.

Function Codes

Each DNP3 message includes a function code. Each object has a limited set of function codes that a master can use to manipulate the object. The object listing for the device shows the permitted function codes for each type of object. The most common DNP3 function codes are listed in *Table D.2*.

Table D.2 Selected DNP3 Function Codes

Function Code	Function	Description
1	Read	Request data from the outstation
2	Write	Send data to the outstation
3	Select	First part of a Select Before Operate operation
4	Operate	Second part of a Select Before Operate operation
5	Direct operate	One-step operation with reply
6	Direct operate, no reply	One-step operation with no reply

Qualifier Codes and Ranges

DNP3 masters use qualifier codes and ranges to make requests for specific objects by index. Qualifier codes specify the style of range, and the range specifies the indices of the objects of interest. DNP3 masters use qualifier codes to compose the shortest, most concise message possible when requesting points from a DNP3 outstation.

For example, the qualifier code 01 specifies that the request for points will include a start address and a stop address. Each of these two addresses uses two bytes. An example request using qualifier code 01 might have the four hexadecimal byte range field, 00h 04h 00h 10h, which specifies points in the range 4 to 16.

Access Methods

DNP3 has many features that help obtain maximum possible message efficiency. DNP3 masters use special objects, variations, and qualifiers that reduce the message size to send requests with the least number of bytes. Other features eliminate the continual exchange of static (unchanging) data values. These features optimize use of bandwidth and maximize performance over a connection of any speed.

DNP3 event data collection eliminates the need to use bandwidth to transmit values that have not changed. Event data are time-stamped records that show when observed measurements changed. For binary points, the remote device (DNP3 outstation) logs changes from logical 1 to logical 0 and from logical 0 to logical 1. For analog points, the outstation device logs changes that exceed a dead band. DNP3 outstation devices collect event data in a buffer that either the master can request or the device can send to the master without a request message. Data sent from the outstation to the master without a polling request are called unsolicited data.

DNP3 data fit into one of four event classes: 0, 1, 2, or 3. Class 0 is reserved for reading the present value data (static data). Classes 1, 2, and 3 are event data classes. The meaning of Classes 1 to 3 is arbitrary and defined by the application at hand. With outstations that contain great amounts of data or in large systems, the three event classes provide a framework for prioritizing different types of data. For example, you can poll once a minute for Class 1 data, once an hour for Class 2 data, and once a day for Class 3 data.

DNP3 also supports static polling: simple polling of the present value of data points within the outstation. By combining event data, unsolicited polling, and static polling, you can operate your system in one of the four access methods shown in *Table D.3*.

The access methods listed in *Table D.3* are listed in order of increasing communications efficiency. With various trade-offs, each method is less demanding of communications bandwidth than the previous one. For example, unsolicited report-by-exception consumes less communications bandwidth than polled report-by-exception because that method does not require polling messages from the master. To properly evaluate which access method provides optimum performance for your application, you must also consider overall system size and the volume of data communication expected.

Table D.3 DNP3 Access Methods

Access Method	Description
Polled static	Master polls for present value (Class 0) data only
Polled report-by-exception	Master polls frequently for event data and occasionally for Class 0 data
Unsolicited report-by-exception	Outstation devices send unsolicited event data to the master, and the master occasionally polls for Class 0 data
Quiescent	Master never polls and relies on unsolicited reports only

Binary Control Operations

DNP3 masters use Object 12, control device output block, to perform DNP3 binary control operations. The control device output block has both a trip/close selection and a code selection. The trip/close selection allows a single DNP3 index to operate two related control points such as trip and close or raise and lower. Trip/close pair operation is not recommended for new DNP3 devices, but is often included for interoperability with older DNP3 master implementations.

The control device output block code selection specifies either a latch or pulse operation on the point. In many cases, DNP3 outstations have only a limited subset of the possible combinations of the code field. Sometimes, DNP3 outstations assign special operation characteristics to the latch and pulse selections. *Table D.13* describes control point operation for the SEL-751.

Conformance Testing

In addition to the protocol specifications, the DNP Users Group has approved conformance-testing requirements for Level 1 and Level 2 devices. Some implementers perform their own conformance specification testing, while some contract with independent companies to perform conformance testing.

Conformance testing does not always guarantee that a master and outstation will be fully interoperable (that is, work together properly for all implemented features). Conformance testing does help to standardize the testing procedure and move the DNP3 implementers toward a higher level of interpretability.

DNP3 Serial Network Issues

Data Link Layer Operation

DNP3 employs a three-layer version of the seven-layer OSI (Open Systems Interconnect) model called the enhanced performance architecture. The layer definition helps to categorize functions and duties of various software components that make up the protocol. The middle layer, the Data Link Layer, includes several functions for error checking and media access control.

A feature called data link confirmation is a mechanism that provides positive confirmation of message receipt by the receiving DNP3 device. While this feature helps you recognize a failed device or failed communications link quickly, it also adds significant overhead to the DNP3 conversation. You should consider whether you require this link integrity function in your application at the expense of overall system speed and performance.

The DNP3 technical bulletin (*DNP Confirmation and Retry Guidelines 9804-002*) on confirmation processes recommends against using data link confirmations because these processes can add to traffic in situations where communications are marginal. The increased traffic will reduce connection throughput further, possibly preventing the system from operating properly.

Network Medium Contention

When more than one device requires access to a single (serial) network medium, you must provide a mechanism to resolve the resulting network medium contention. For example, unsolicited reporting results in network medium contention if you do not design your serial network as a star topology of point-to point connections or use carrier detection on a multidrop network.

To avoid collisions among devices trying to send messages, DNP3 includes a collision avoidance feature. Before sending a message, a DNP3 device listens for a carrier signal to verify that no other node is transmitting data. The device transmits if there is no carrier or waits for a random time before transmitting. However, if two nodes both detect a lack of carrier at the same instant, these two nodes could begin simultaneous transmission of data and cause a data collision. If your serial network allows for spontaneous data transmission including unsolicited event data transmissions, you also must use application confirmation to provide a retry mechanism for messages lost as a result of data collisions.

DNP3 LAN/WAN Overview

The main process for carrying DNP3 over an Ethernet Network (LAN/WAN) involves encapsulating the DNP3 data link layer data frames within the transport layer frames of the Internet Protocol (IP) suite. This allows the IP stack to deliver the DNP3 data link layer frames to the destination in place of the original DNP3 physical layer.

The DNP User Group Technical Committee has recommended the following guidelines for carrying DNP3 over a network:

NOTE: Link layer confirmations are explicitly disabled for DNP3 LAN/WAN. The IP suite provides a reliable delivery mechanism, which is backed up at the application layer by confirmations when necessary.

- DNP3 shall use the IP suite to transport messages over a LAN/WAN
- Ethernet is the recommended physical link, though others may be used
- TCP must be used for WANs
- TCP is strongly recommended for LANs
- User Datagram Protocol (UDP) may be used for highly reliable single segment LANs
- UDP is necessary if you need broadcast messages
- The DNP3 protocol stack shall be retained in full
- Link layer confirmations shall be disabled

The Technical Committee has registered a standard port number, 20000, for DNP3 with the Internet Assigned Numbers Authority (IANA). Use this port for either TCP or UDP.

TCP/UDP Selection

The Committee recommends the selection of TCP or UDP protocol as per the guidelines in *Table D.4*.

Table D.4 TCP/UDP Selection Guidelines

Use in the case of...	TCP	UDP
Most situations	X	
Non-broadcast or multicast	X	
Mesh Topology WAN	X	
Broadcast		X
Multicast		X
High-reliability single-segment LAN		X
Pay-per-byte, non-mesh WAN, for example, Cellular Digital Packet Data (CDPD)		X
Low priority data, for example, data monitor or configuration information		X

DNP3 in the SEL-751

The SEL-751 is a DNP3 Level 2 remote (outstation) device.

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 3. All settings with the same numerical suffix comprise the complete DNP3 session configuration.

Table D.5 DNP3 Access Methods

Access Method	Master Polling	SEL-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.

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 will resend 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.13*). You can prioritize data transmission with these event class features. For example, you might place high-priority points in event class 1 and set it with low thresholds (NUMEVE*n* and AGEEVE*n* settings) so that changes to these points will be 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 will wait for ETIMEO*n* seconds and then repeat 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.

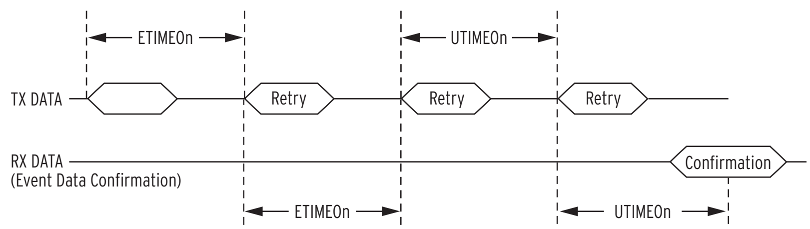


Figure D.1 Application Confirmation Timing With URETRY n = 2

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 will insert a random delay of 50 to 100 ms (milliseconds) between the end of carrier detection and the start of data transmission (see *Figure D.2*).

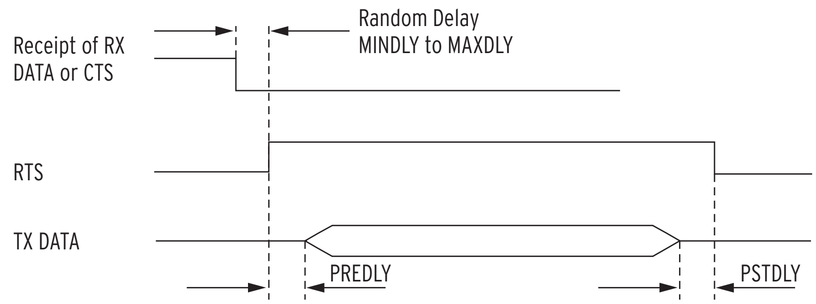


Figure D.2 Message Transmission Timing

Transmission Control

NOTE: PREDLY and POSTDLY settings are only available for EIA-232 and EIA-485 serial port sessions.

If you use a media transceiver (for example, EIA-232 to EIA-485) or a radio system for your DNP3 network, you may need to adjust data transmission properties. Use the PREDLY and POSTDLY settings to provide a delay between RTS signal control and data transmission (see *Figure D.2*). For example, an EIA-485 transceiver typically requires 10 to 20 ms to change from receive to transmit. If you set the pre-delay to 30 ms, you will avoid data loss resulting from data transmission beginning at the same time as RTS signal assertion.

Event Data

DNP3 event data objects contain change-of-state and time-stamp information that the SEL-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 will carry a time stamp based on the DNP map scan time. This may be significantly delayed from when the original source changed and should not be used for sequence-of-events determination. The DNP map is scanned approximately once per second to generate events. You can configure the SEL-751 to either report the data without a polling request from the master (unsolicited data) or hold the data until the master requests it with an event poll message.

With the event class settings ECLASSB*n*, ECLASSC*n*, and ECLASSA*n*, you can set the event class for binary, counter, and analog inputs for session *n*. You can use the classes as a simple priority system for collecting event data. The SEL-751 does not treat data of different classes differently with respect to message scanning, but it does allow the master to perform independent class polls.

NOTE: Most RTUs that act as substation DNP3 masters perform an event poll that collects event data of all classes simultaneously. You must confirm that the polling configuration of your master allows independent polling for each class before implementing separate classes in the SEL-751.

For event data collection you must also consider and enter appropriate settings for dead band and scaling operation on analog points shown in *Table D.7*. You can either:

- ➤ set and use default dead band and scaling according to data type, or
- ➤ use a custom data map to select dead bands on a point-by-point basis.

See *DNP3 Documentation* for a discussion of how to set scaling and dead-band operation on a point-by-point basis. You can modify dead bands for analog inputs at run-time by writing to Object 34.

The settings ANADBA*n*, ANADBV*n*, and ANADBM*n* control default dead-band operation for each type of analog data. Because DNP3 Objects 30 and 32 use integer data, you must use scaling to send digits after the decimal point and avoid rounding to a simple integer value.

With no scaling, the value of 12.632 would be sent as 12. With a scaling setting of 1, the value transmitted is 126. With a scaling setting of 3, the value transmitted is 12632. You must make certain that the maximum value does not exceed 32767 if you are polling the default 16-bit variations for Objects 30 and 32, but you can send some decimal values by using this technique. You must also configure the master to perform the appropriate division on the incoming value to display it properly.

You can set the default analog value scaling with the DECPLA*n*, DECPLV*n*, and DECPLM*n* settings. Application of event reporting dead bands occurs after scaling. For example, if you set DECPLA*n* to 2 and ANADBA*n* to 10, a measured current of 10.14 amps would be scaled to the value 1014 and would have to increase to more than 1024 or decrease to less than 1004 (a change in magnitude of ± 0.1 amps) for the device to report a new event value.

The SEL-751 uses the NUMEVE*n* and AGEEVE*n* settings to decide when to send unsolicited data to the master. The device sends an unsolicited report when the total number of events accumulated in the event buffer for master *n* reaches NUMEVE*n*. The device also sends an unsolicited report if the age of the oldest event in the master n buffer exceeds AGEEVE*n*. The SEL-751 has the buffer capacities listed in *Table D.6*.

Table D.6 SEL-751 Event Buffer Capacity

Type	Maximum Number of Events
Binary	1024
Analog	100
Counters	32

Binary Controls

The SEL-751 provides more than one way to control individual points. The SEL-751 maps incoming control points either to remote bits or to internal command bits that cause circuit breaker operations. *Table D.13* lists control points and control methods available in the SEL-751.

A DNP3 technical bulletin (*Control Relay Output Block Minimum Implementation 9701-002*) recommends that you use one point per Object 12, control block output device. You can use this method to perform Pulse On, Pulse Off, Latch On, and Latch Off operations on selected remote bits.

If your master does not support the single-point-per-index messages or single operation database points, you can use the trip/close operation or use the code field in the DNP3 message to specify operation of the points shown in *Control Point Operation on page D.22*.

Time Synchronization

The accuracy of DNP3 time synchronization is insufficient for most protection and oscillography needs. DNP3 time synchronization provides backup time synchronization in the event the device loses primary synchronization through the IRIG-B input. You can enable time synchronization with the TIMERQ*n* setting and then use Object 50, Variation 1, and Object 52, Variation 2, to set the time via the Session *n* DNP3 master (Object 50, variation 3 for DNP3 LAN/WAN).

By default, the SEL-751 accepts and ignores time set requests (TIMERQ*n* = I for “ignore”). (This mode allows the SEL-751 to use a high accuracy, IRIG time source, but still interoperate with DNP3 masters that send time-synchronization messages.) You can set the SEL-751 to request time synchronization periodically by setting the TIMERQ*n* setting to the desired period. You can also set it to not request, but accept, time synchronization (TIMERQ*n* = M for "master").

Modem Support

The SEL-751 DNP implementation includes modem support for serial ports. Your DNP3 master can dial-in to the SEL-751 and establish a DNP3 connection. The SEL-751 can automatically dial out and deliver unsolicited DNP3 event data.

When the device dials out, it waits for the "CONNECT" message from the local modem and for assertion of the device CTS line before continuing the DNP transaction. This requires a connection from the modem DCD to the device CTS line.

NOTE: Contact SEL for information on serial cable configurations and requirements for connecting your SEL-751 to other devices.

You can either connect the modem to a computer and configure it before connecting it to the SEL-751, or program the appropriate modem setup string in the modem startup string setting MSTR. You should use the PH_NUM1 and (optional) PH_NUM2 settings to set the phone numbers that you want the SEL-751 to call. The SEL-751 will automatically send 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 three concurrent DNP3 sessions. Each session defines the characteristics of the connected DNP3 Master, to which you assign one of the three available custom maps. Some settings only apply to DNP3 LAN/WAN, and are visible only when configuring the Ethernet Port. For example, you only have the ability to define multiple sessions on port 1, the Ethernet port. Likewise, settings applicable to serial DNP3 are visible only when configuring a serial port.

Table D.7 Port DNP3 Protocol Settings (Sheet 1 of 3)

Name	Description	Range	Default
EDNP[a]	Enable DNP3 Sessions	0–3	0
DNPNUM[a]	DNP3 TCP and UDP Port	1–65534	20000
DNPADR	Device DNP3 address	0–65534	0
Session 1 Settings			
DNPIP1[a]	IP address (zzz.yyy.xxx.www)	15 characters	""

Table D.7 Port DNP3 Protocol Settings (Sheet 2 of 3)

Name	Description	Range	Default
DNPTR1[a]	Transport protocol	UDP, TCP	TCP
DNPUDP1[a]	UDP response port	REQ, 1–65534	20000
REPADR1	DNP3 address of the Master to send messages to	0–65519	1
DNPMAP1	DNP3 Session Custom Map	1–3	1
DVARAI1	Analog Input Default Variation	1–6	4
ECLASSB1	Class for binary event data, 0 disables	0–3	1
ECLASSC1	Class for counter event data, 0 disables	0–3	0
ECLASSA1	Class for analog event data, 0 disables	0–3	2
DECPLA1	Decimal places scaling for Current data	0–3	1
DECPLV1	Decimal places scaling for Voltage data	0–3	1
DECPLM1	Decimal places scaling for Miscellaneous data	0–3	1
ANADBA1	Analog reporting dead band for current; hidden if ECLASSA1 set to 0	0–32767	100
ANADBV1	Analog reporting dead band for voltages; hidden if ECLASSA1 set to 0	0–32767	100
ANADBM1	Analog reporting dead band for miscellaneous analogs; hidden if ECLASSA and ECLASSC set to 0	0–32767	100
TIMERQ1	Time-set request interval, minutes (M = Disables time sync requests, but still accepts and applies time syncs from Master; I = Ignores (does not apply) time syncs from Master)	I, M, 1–32767	I
STIMEO1	Select/operate time-out, seconds	0.0–30.0	1.0
DNPINA1[a]	Send Data Link Heartbeat, seconds; hidden if DNPTR1 set to UDP	0.0–7200	120
DRETRY1[b]	Data link retries	0–15	3
DTIMEO1[b]	Data link time-out, seconds; hidden if DRETRY1 set to 0	0.0–5.0	1
ETIMEO1	Event message confirm time-out, seconds	1–50	5
UNSOL1	Enable unsolicited reporting; hidden and set to N if ECLASSB1, ECLASSC1, and ECLASSA1 set to 0	Y, N	N
PUNSOL1	Enable unsolicited reporting at power up; hidden and set to N if UNSOL1 set to N	Y, N	N
NUMEVE1[c]	Number of events to transmit on	1–200	10
AGEEVE1[c]	Oldest event to transmit on, seconds	0.0–99999.0	2.0
URETRY1[c]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO1[c]	Unsolicited messages offline timeout, seconds	1–5000	60
Session 2 Settings			
DNPIP2[a]	IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR2[a]	Transport protocol	UDP, TCP	TCP
. . .			
URETRY2[a,c]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO2[a,c]	Unsolicited messages offline timeout, seconds	1–5000	60
Session 3 Settings			
DNPIP3[a]	IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR3[a]	Transport protocol	UDP, TCP	TCP
. . .			

Table D.7 Port DNP3 Protocol Settings (Sheet 3 of 3)

Name	Description	Range	Default
URETRY3[a,c]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO3[a,c]	Unsolicited messages offline timeout, seconds	1–5000	60
Serial Port Settings			
MINDLY[b]	Minimum delay from DCD to TX, seconds	0.00–1.00	0.05
MAXDLY[b]	Maximum delay from DCD to TX, seconds	0.00–1.00	0.10
PREDLY[b]	Settle time from RTS on to TX; Off disables PSTDLY	OFF, 0.00–30.00	0.00
PSTDLY[b]	Settle time from TX to RTS off; hidden if PREDLY set to Off	0.00–30.00	0.00

[a] Available only on Ethernet ports. Set DNPIPn = 0.0.0.0 to accept connections from any DNP master.
[b] Available only on serial ports.
[c] Hidden if UNSOLn set to N.

The modem settings in *Table D.8* are only available for DNP3 serial port sessions.

Table D.8 Serial Port DNP3 Modem Settings

Name	Description	Range	Default
MODEM	Modem connected to port; all following settings are hidden if MODEM set to N	Y, N	N
MSTR	Modem startup string	As many as 30 characters	"E0X0&D0S0 = 4"
PH_NUM1	Primary phone number for dial-out	As mant 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 resulting from no connection, seconds	5–300	60
MDRET	Time between dial-out attempts	5–3600	120

DNP3 Documentation

Object List

Table D.9 lists the objects and variations with supported function codes and qualifier codes available in the SEL-751. The list of supported objects conforms to the format laid out in the DNP specifications and includes both supported and unsupported objects for DNP3 implementation Level 2 and higher and unsupported objects for DNP3 implementation Level 2 only. Those that are supported include the function and qualifier codes. The objects that are not supported are shown without any corresponding function and qualifier codes.

Table D.9 SEL-751 DNP Object List (Sheet 1 of 6)

Obj.	Var.	Description	Request[a] 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]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
0	243	Device Attributes—Device manufacturer's hardware version	1	0	129	0,17
0	245	Device Attributes—User-assigned location name	1	0	129	0,17
0	246	Device Attributes—User assigned ID code/number	1	0	129	0,17
0	247	Device Attributes—User assigned ID code/number	1	0	129	0,17
0	248	Device Attributes—Device serial number	1	0	129	0,17
0	249	Device Attributes—DNP subset and conformance	1	0	129	0,17
0	250	Device Attributes—Device manufacturer's product name and model	1	0	129	0,17
0	252	Device Attributes—Device manufacturer's name	1	0	129	0,17
0	254	Device Attributes—Non-specific all attributes request	1	0	129	0,17
0	255	Device Attributes—List of attribute variations	1	0	129	0,17
1	0	Binary Input—All Variations	1	0, 1, 6, 7, 8, 17, 28		
1	1	Binary Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
1	2[e]	Binary Input With Status	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
2	0	Binary Input Change—All Variations	1	6, 7, 8		
2	1	Binary Input Change Without Time	1	6, 7, 8	129	17, 28
2	2[e]	Binary Input Change With Time	1	6, 7, 8	129, 130	17, 28
2	3	Binary Input Change With Relative Time	1	6, 7, 8	129	17, 28
10	0	Binary Output—All Variations	1	0, 1, 6, 7, 8		
10	1	Binary Output				
10	2[e]	Binary Output Status	1	0, 1, 6, 7, 8	129	0, 1
12	0	Control Block—All Variations				
12	1	Control Relay Output Block	3, 4, 5, 6	17, 28	129	echo of request
12	2	Pattern Control Block	3, 4, 5, 6	7	129	echo of request
12	3	Pattern Mask	3, 4, 5, 6	0, 1	129	echo of request
20	0	Binary Counter—All Variations	1, 7, 8, 9, 10	0, 1, 6, 7, 8, 17, 28		
20	1	32-Bit Binary Counter	1, 7, 8, 9, 10	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
20	2	16-Bit Binary Counter	1, 7, 8, 9, 10	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
20	3	32-Bit Delta Counter				
20	4	16-Bit Delta Counter				
20	5	32-Bit Binary Counter Without Flag	1, 7, 8, 9, 10	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
20	6[e]	16-Bit Binary Counter Without Flag	1, 7, 8, 9, 10	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
20	7	32-Bit Delta Counter Without Flag				
20	8	16-Bit Delta Counter Without Flag				
21	0	Frozen Counter—All Variations				
21	1	32-Bit Frozen Counter				
21	2	16-Bit Frozen Counter				
21	3	32-Bit Frozen Delta Counter				
21	4	16-Bit Frozen Delta Counter				

Table D.9 SEL-751 DNP Object List (Sheet 3 of 6)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
21	5	32-Bit Frozen Counter With Time of Freeze				
21	6	16-Bit Frozen Counter With Time of Freeze				
21	7	32-Bit Frozen Delta Counter With Time of Freeze				
21	8	16-Bit Frozen Delta Counter With Time of Freeze				
21	9	32-Bit Frozen Counter Without Flag				
21	10	16-Bit Frozen Counter Without Flag				
21	11	32-Bit Frozen Delta Counter Without Flag				
21	12	16-Bit Frozen Delta Counter Without Flag				
22	0	Counter Change Event—All Variations	1	6, 7, 8		
22	1	32-Bit Counter Change Event Without Time	1	6, 7, 8	129	17, 28
22	2[e]	16-Bit Counter Change Event Without Time	1	6, 7, 8	129, 130	17, 28
22	3	32-Bit Delta Counter Change Event Without Time				
22	4	16-Bit Delta Counter Change Event Without Time				
22	5	32-Bit Counter Change Event With Time	1	6, 7, 8	129	17, 28
22	6	16-Bit Counter Change Event With Time	1	6, 7, 8	129	17, 28
22	7	32-Bit Delta Counter Change Event With Time				
22	8	16-Bit Delta Counter Change Event With Time				
23	0	Frozen Counter Event—All Variations				
23	1	32-Bit Frozen Counter Event Without Time				
23	2	16-Bit Frozen Counter Event Without Time				
23	3	32-Bit Frozen Delta Counter Event Without Time				
23	4	16-Bit Frozen Delta Counter Event Without Time				
23	5	32-Bit Frozen Counter Event With Time				
23	6	16-Bit Frozen Counter Event With Time				
23	7	32-Bit Delta Counter Change Event With Time				
23	8	16-Bit Delta Counter Change Event With Time				
30[f]	0	Analog Input—All Variations	1	0, 1, 6, 7, 8, 17, 28		
30[f]	1	32-Bit Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[f]	2	16-Bit Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[f]	3	32-Bit Analog Input Without Flag	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[f]	4	16-Bit Analog Input Without Flag	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[f]	5	Short Floating Point Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[f]	6	Long Floating Point Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
31	0	Frozen Analog Input—All Variations				
31	1	32-Bit Frozen Analog Input				
31	2	16-Bit Frozen Analog Input				
31	3	32-Bit Frozen Analog Input With Time of Freeze				
31	4	16-Bit Frozen Analog Input With Time of Freeze				
31	5	32-Bit Frozen Analog Input Without Flag				

Table D.9 SEL-751 DNP Object List (Sheet 4 of 6)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
31	6	16-Bit Frozen Analog Input Without Flag				
31	7	Short Floating Point Frozen Analog Input				
31	8	Long Floating Point Frozen Analog Input				
32[f]	0	Analog Change Event—All Variations	1	6, 7, 8		
32[f]	1	32-Bit Analog Change Event Without Time	1	6, 7, 8	129	17, 28
32[f]	2	16-Bit Analog Change Event Without Time	1	6, 7, 8	129, 130	17, 28
32[f]	3	32-Bit Analog Change Event With Time	1	6, 7, 8	129	17, 28
32[f]	4	16-Bit Analog Change Event With Time	1	6, 7, 8	129	17, 28
32[f]	5	Short Floating Point Analog Change Event	1	6, 7, 8	129	17, 28
32[f]	6	Long Floating Point Analog Change Event	1	6, 7, 8	129	17, 28
32[f]	7	Short Floating Point Analog Change Event With Time	1	6, 7, 8	129	17, 28
32[f]	8	Long Floating Point Analog Change Event With Time	1	6, 7, 8	129	17, 28
33	0	Frozen Analog Event—All Variations				
33	1	32-Bit Frozen Analog Event Without Time				
33	2	16-Bit Frozen Analog Event Without Time				
33	3	32-Bit Frozen Analog Event With Time				
33	4	16-Bit Frozen Analog Event With Time				
33	5	Short Floating Point Frozen Analog Event				
33	6	Long Floating Point Frozen Analog Event				
33	7	Short Floating Point Frozen Analog Event With Time				
33	8	Long Floating Point Frozen Analog Event With Time				
34	0	Analog Deadband—All Variations				
34	1[e]	16-Bit Analog Input Reporting Deadband Object	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
34	2	32-Bit Analog Input Reporting Deadband Object	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
34	3	Floating Point Analog Input Reporting Deadband Object	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
40	0	Analog Output Status—All Variations	1	0, 1, 6, 7, 8	129	
40	1	32-Bit Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
40	2[e]	16-Bit Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
40	3	Short Floating Point Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
40	4	Long Floating Point Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
41	0	Analog Output Block—All Variations				
41	1	32-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
41	2[e]	16-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
41	3	Short Floating Point Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
50	0	Time and Date—All Variations				
50	1	Time and Date	1, 2	7, 8 index = 0	129	07, quantity = 1

Table D.9 SEL-751 DNP Object List (Sheet 5 of 6)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
50	2	Time and Date With Interval				
50	3	Time and Date Last Recorded	2	7 quantity = 1	129	
51	0	Time and Date CTO—All Variations				
51	1	Time and Date CTO				
51	2	Unsynchronized Time and Date CTO			129	07, quantity = 1
52	0	Time Delay—All Variations				
52	1	Time Delay, Coarse				
52	2	Time Delay, Fine			129	7, quantity = 1
60	0	All Classes of Data	1, 20, 21	6, 7, 8		
60	1	Class 0 Data	1, 20, 21	6, 7, 8		
60	2	Class 1 Data	1	6, 7, 8		
60	3	Class 2 Data	1, 20, 21	6, 7, 8		
60	4	Class 3 Data	1, 20, 21	6, 7, 8		
70	1	File Identifier				
70	2	Authentication Object				
70	3	File Command Object				
70	4	File Command Status Object				
70	5	File Transport Object				
70	6	File Transport Status Object				
70	7	File Descriptor Object				
80	1	Internal Indications	2	0, 1 index = 7		
81	1	Storage Object				
82	1	Device Profile				
83	1	Private Registration Object				
83	2	Private Registration Object Descriptor				
90	1	Application Identifier				
100	1	Short Floating Point				
100	2	Long Floating Point				
100	3	Extended Floating Point				
101	1	Small Packed Binary-Coded Decimal				
101	2	Medium Packed Binary-Coded Decimal				
101	3	Large Packed Binary-Coded Decimal				
110	All	Octet String				
111	All	Octet String Event				
112	All	Virtual Terminal Output Block				

Table D.9 SEL-751 DNP Object List (Sheet 6 of 6)

Obj.	Var.	Description	Request[a] Funct. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Funct. Codes[c]	Response[b] Qual. Codes[d]
113	All	Virtual Terminal Event Data				
N/A		No object required for the following function codes: 13 cold start 14 warm start 23 delay measurement	13, 14, 23			

[a] Supported in requests from master.
[b] May generate in response to master.
[c] Decimal.
[d] Hexadecimal.
[e] Default variation.
[f] Default variation specified by serial port setting DVARAI (or DVARAIn for Ethernet session n [n = 1, 2, or 3]).

Device Profile

The DNP3 Device Profile document, available on the supplied CD or as a download from the SEL website, contains the standard device profile information for the SEL-751.This information is also available in XML format. Please refer to this document for complete information on DNP3 Protocol support in the SEL-751.

Reference Data Map

Table D.10 shows the SEL-751 reference data map. The reference map shows the data available to a DNP3 master. You can use the default map or the custom DNP3 mapping functions of the SEL-751 to retrieve only the points necessary for your application.

NOTE: Dead-band changes via Object 34 are not stored in nonvolatile memory. Make sure to reissue the Object 34 dead bands after a warm (**STA C**) or cold start (power cycle).

The SEL-751 scales analog values by the indicated settings or fixed scaling indicated in the description. Analog dead bands for event reporting use the indicated settings, or ANADBM if you have not specified a setting.

NOTE: Although the reference maps do not include Relay Word bit labels, you can use these labels for creating custom maps.

Table D.10 DNP3 Reference Data Map (Sheet 1 of 2)

Object	Labels	Description
Binary Inputs		
01, 02	STFAIL	Relay diagnostic failure
	STWARN	Relay diagnostic warning
	STSET.	Relay settings change or restart
	Enabled–TLED_06[a]	Relay Word Elements Target Row 0 (see *Table J.1*)
	50A1P–FIDEN[a]	Relay Word Elements Row1 to Row 140 (see *Table J.1*)
	PFL	Power Factor Leading for Three-Phase Currents
	0	Logical 0
	1	Logical 1
Binary Outputs		
10,12	RB01–RB32	Remote bits RB01–RB32
10,12	RB01:RB02 RB03:RB04 RB05:RB06 … RB29:RB30 RB31:RB32	Remote bit pairs RB01–RB32
10,12	OC	Pulse Open Circuit Breaker command

Table D.10 DNP3 Reference Data Map (Sheet 2 of 2)

Object	Labels	Description
10,12	CC	Pulse Close Circuit Breaker command
10,12	OC:CC	Open/Close pair for Circuit Breaker
Counters		
20, 22	SC*xx*	SELOGIC Counter Values (*xx* = 01–32)
	GROUP	Active Settings Group
Analog Inputs		
30, 32, 34	IA_MAG–RA128[b,c]	Analog Quantities from *Table K.1* with an “x” in the DNP column
	SER_NUM	Serial Number
	0	Numeric 0
	1	Numeric 1
Analog Outputs		
40, 41	RAxxx	Remote Analogs (RA001 to RA128)
	GROUP	Active Settings Group
	NOOP	No operation, no error

[a] Valid Relay Word bits depend on the relay model.
[b] Valid analog inputs depend on the relay model.
[c] Refer to Default Analog Inputs for default analog input scaling and dead bands.

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.20*. Outside that scope, they contain the value NA.
10, 12	0–31	RB01–RB32 Remote Bits
20, 22	0–31	NA

Table D.11 DNP3 Default Data Map (Sheet 2 of 2)

Object	Default Index	Point Label
30, 32, 34	0	IA_MAG
	1	IB_MAG
	2	IC_MAG
	3	IG_MAG
	4	IN_MAG
	5	IAV
	6	3I2
	7	FREQ
	8	VAB_MAG
	9	VBC_MAG
	10	VCA_MAG
	11	VAVE
	12	3V2
	13	P
	14	Q
	15	S
	16	PF
	17–99	A portion of these analog inputs can have default values as described in *Default Analog Inputs on page D.20*. Outside that scope, they contain the value NA.
40, 41	0–31	NA

Default Binary Inputs

The SEL-751 dynamically creates the default Binary Input map after you issue an **R_S** command. The SEL-751 uses the Part Number to determine the presence of Digital Input cards in slots 3, 4, and 5. If present, each digital input point label, IN*x*0*y* (where *x* is the slot number and *y* is the point), is added to the default map in numerical order.

Default Analog Inputs

NOTE: Dead-band changes via Object 34 are stored in nonvolatile memory. Make sure to reissue the Object 34 dead bands after a warm (HIS C) or cold start (power cycle).

The SEL-751 dynamically creates the default Analog Input map after you issue an **R_S** command. The SEL-751 then uses the Part Number to determine the presence of Analog Input cards in slots 3, 4, and 5. If these cards are present, the SEL-751 adds each analog input point label, AI*x*0*y* (where *x* is the slot and *y* is the point number), to the default map in numerical order to the DNP map.

Device Attributes (Object 0)

Table D.10 includes the supported Object 0 Device Attributes and variations. In response to Object 0 requests, the SEL-751 will send attributes that apply to that particular DNP3 session. Because the SEL-751 supports custom DNP3 maps, these values will likely be different for each session. The SEL-751 uses its internal settings for the following variations:

- Variation 242-FID string
- Variation 243-Part Number

- Variation 245-TID setting
- Variation 246-RID setting
- Variation 247-RID setting
- Variation 248-Serial Number

Variation 249 shall contain the DNP subset and conformance, “2:2009”. Variation 250 shall contain the product model, “SEL-751” and variation 252 shall contain “SEL”.

Binary Inputs

Binary Inputs (objects 1 & 2) are supported as defined by *Table D.11*. The default variation for both static and event inputs is 2. Only the Read function code (1) is allowed with these objects. All variations are supported. Object 2, variation 3 will be responded to, but will contain no data.

Binary Inputs are scanned approximately once per second to generate events. When time is reported with these event objects, it is the time at which the scanner observed the bit change. This can be significantly delayed from the time when the original source change occurred and should not be used for sequence-of-events determination. Binary inputs registered with SER are derived from the SER and carry the time stamp of actual occurrence. Some additional binary inputs are available only to DNP. For example, STWARN and STFAIL are derived from the diagnostic task data. Another binary input, STSET, is derived from the SER and carries the time stamp of actual occurrence. Static reads of this input will always show 0.

Binary Outputs

Binary Output status (Object 10 variation 2) is supported. Static reads of points RB1–RB32, OC/CC respond with the on-line bit set and the state of the requested bit. Reads from control-only binary output points respond with the on-line bit set and a state of 0.The SEL-751 supports Control Relay Output Block objects (Object 12,Variation 1). The control relays correspond to the remote bits and other functions as shown previously. Each DNP Control message contains a Trip/Close code (TRIP, CLOSE, or NUL) and an Operation type (PULSE ON, LATCH ON, LATCH OFF, or NUL). The Trip/Close code works with the Operation Type to produce set, clear, and pulse operations.

Control operations differ slightly for single-point controls compared to paired outputs. Paired outputs correspond to the complementary two-output model, and single-point controls follow the complementary latch or activation model. In the complementary two-output model, paired points only support Trip or Close operations, which, when issued, will 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 will only honor the first ten points in an Object 12, Variation 1 request. Any additional points in the request will 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 will result in a TRIP of indexes 0, 1, 3 to 5, and 7. Multiple binary output point control operations are not guaranteed to occur during the same processing interval.

Control Point Operation

Use the Trip and Close, Latch On/Off and Pulse On operations with Object 12 control relay output block command messages to operate the points shown in *Table D.13*. Pulse operations provide a pulse with duration of one protection processing interval.

Table D.12 SEL-751 Object 12 Control Operations

Label	Close/Pulse On	Trip/Pulse On	Nul/Latch On	Nul/Latch Off	Nul/Pulse On
RB01–RB32	Pulse Remote Bit RB01–RB32	Pulse Remote Bit RB01–RB32	Set Remote Bit RB01–RB32	Clear Remote Bit RB01–RB32	Pulse Remote Bit RB01–RB32
RBxx:RByy	Pulse RByy RB01–RB32	Pulse RBxx RB01–RB32	Pulse RByy RB01–RB32	Pulse RBxx RB01–RB32	Not Supported
OC	Open Circuit Breaker (Pulse OC)	Open Circuit Breaker (Pulse OC)	Open Circuit Breaker (Pulse OC)	No action	Open Circuit Breaker (Pulse OC)
CC	Close Circuit Breaker (Pulse CC)	Close Circuit Breaker (Pulse CC)	Close Circuit Breaker (Pulse CC)	No action	Close Circuit Breaker (Pulse CC)
OC:CC	Close Circuit Breaker (Pulse CC)	Open Circuit Breaker (Pulse OC)	Close Circuit Breaker (Pulse CC)	Open Circuit Breaker (Pulse OC)	Not Supported

Analog Inputs

NOTE: Dead-band changes via Object 34 are not stored in nonvolatile memory. Make sure to reissue the Object 34 dead-band changes you want to retain after a change to DNP port settings, issuing a **STA C** command, or a relay cold-start (power-cycle).

Analog Inputs (30) and Analog Change Events (32) are supported as defined in *Table D.11*. The DVARAI1 (DVARAI*n* for DNP3 LAN/WAN session *n*) setting defines the default variation for both static and event inputs. Only the Read function code (1) is allowed with these objects. Unless otherwise indicated, analog values are reported in primary units. See *Appendix K: Analog Quantities* for a list of all available analog inputs.

For all currents, the default scaling is the DECPLA setting on magnitudes and scale factor of 100 on angles. The default dead band for currents is ANADBV on magnitudes and ANADBM on angles. For all voltages, the default scaling is the DECPLV setting on magnitudes and scale factor of 100 on angles. The default dead band for voltages is ANADBV on magnitudes and ANADBM on angles. For all Powers and Energies, the default scaling is the DECPLM setting and default dead band is ANADBM. For all other quantities, the default scaling is 1 and default dead band is ANADBM.

Default scaling and dead bands can be overridden by per-point scaling and dead band. See *Configurable Data Mapping* for more information. Dead bands for analog inputs can also be modified by writing to object 34.

A dead band check is done after any scaling has been applied. Event class messages are generated whenever an input changes beyond the value given by the appropriate dead band setting. The voltage and current phase angles will only generate an event if, in addition to their dead band check, the corresponding magnitude changes beyond its own dead band. Analog inputs are scanned at approximately a 1 second rate. All events generated during a scan will use the time the scan was initiated.

Configurable Data Mapping

One of the most powerful features of the SEL-751 implementation is the ability to remap DNP3 data and, for analog values, specify per-point scaling and dead bands. Remapping is the process of selecting data from the reference map and organizing it into a data subset optimized for your application. The SEL-751 uses object and point labels, rather than point indices, to streamline the remapping process. This enables you to quickly create a custom map without having to search for each point index in a large reference map.

You can use any of the three available DNP3 maps simultaneously with as many as three unique DNP3 masters. Each map is initially populated with default data points, as described in *Default Data Map on page D.19*. You can remap the points in a default map to create a custom map with as many as the following:

- 100 Binary Inputs (Select from supported Relay Word bits in *Appendix J: Relay Word Bits*)
- 32 Binary Outputs
- 100 Analog Inputs
- 32 Analog Outputs
- 32 Counters

You can use the **SHOW DNP *x* <Enter>** command to view the DNP3 data map settings, where ***x*** is the DNP3 map number from 1 to 3. See *Figure D.3* for an example display of map 1.

```
=>>SHO DNP 1 <Enter>

DNP Map 1 Settings

Binary Input Map
BI_00    := ENABLED
BI_01    := TRIP_LED
BI_02    := TLED_01
BI_03    := TLED_02
…
BI_97    := IN101
BI_98    := IN102
BI_99    := 50P1P

Binary Output Map
BO_00    := RB01
BO_01    := RB02
BO_02    := RB03
…
BO_29    := RB30
BO_30    := RB31
BO_31    := RB32

Analog Input Map
AI_00    := IA_MAG
AI_01    := IB_MAG
AI_02    := IC_MAG
…
AI_95    := FREQ
AI_96    := P
AI_97    := Q
AI_98    := S
AI_99    := PF

Analog Output Map
AO_00    := GROUP
AO_01    := RA001
AO_02    := NA
…
AO_29    := NA
AO_30    := RA120
AO_31    := RA128

Counter Map
CO_00    := SC01
CO_01    := SC02
CO_02    := SC03

…
CO_29    := SC30
CO_30    := SC31
CO_31    := SC32

=>>
```

Figure D.3 Sample Response to SHO DNP Command

You can also use the **MAP DNP *y s* <Enter>** command to display DNP3 maps, but the parameter ***y*** is the port number from 1 to 4. Because port 1, the Ethernet port, can support multiple DNP3 sessions, it may have a different map assigned to each session selected by parameter *s* for sessions 1 to 3. See *Figure D.4* for an example of a **MAP** command that shows the same map as in *Figure D.3*.

```
=>MAP DNP 11 <Enter>

SEL-751                                     Date: 12/14/2010   Time: 09:33:39
FEEDER RELAY                                 Time Source: Internal

Map                          1
Transport                    TCP
Device IP Address            10.201.5.3
Master IP Address            10.200.0.139
Device DNP TCP and UDP Port  20000
Device DNP Address           15
Master DNP Address           0

Binary Inputs

--------------------------------------------------------------------------------
  INDEX  POINT LABEL  EVENT CLASS  SER TIMESTAMP
  0      ENABLED      1            No
  1      TRIP_LED     1            No
  2      TLED_01      1            No
  3      TLED_02      1            No
…
  97     IN101        1            No
  98     IN102        1            No
  99     5P1P         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

Analog Inputs
--------------------------------------------------------------------------------
  INDEX  POINT LABEL  EVENT CLASS  SCALE FACTOR  DEADBAND
  0      IA_MAG       2                 10.0000  1000
  1      IB_MAG       2                 10.0000  1000
  2      IC_MAG       2                 10.0000  1000
  3      IG_MAG       2                 10.0000  1000
  4      IN_MAG       2                 10.0000  1000
  5      IAV          2                 10.0000  1000
  6      3I2          2                 10.0000  1000

  7      FREQ         2                 1.0000    100
  8      VAB_MAG      2                 10.0000  2000
  9      VBC_MAG      2                 10.0000  2000
  10     VCA_MAG      2                 10.0000  2000
  11     VAVE         2                 10.0000  2000
  12     3V2          2                 10.0000  2000
…
…
  96     P            2                 10.0000  100
  97     Q            2                 10.0000  100
  98     S            2                 10.0000  100
  99     PF           2                 10.0000  100

Analog Outputs
--------------------------------------------------------------------------------
INDEX  POINT LABEL
  0      GROUP
  1      RA001
```

Figure D.4 Port MAP Command

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 amps to 11 amps. You can use scaling to include decimal point values by multiplying by a number larger than one. If you use 10 as a scaling factor, 11.4 amps will be 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 will lose some precision as the last digit is rounded off in the scaling process, but you can transmit the scaled value by using standard DNP3 Objects 30 and 32.

You can customize the DNP3 analog input map with per-point scaling, and dead-band settings. Per-point customization is not necessary, but class scaling (DECPLA, DECPLV, and DECPLM) and dead-band (ANADBA, ANADBV, and ANADBM) settings are applied to indices that do not have per-point entries. Unlike per-point scaling described previously, class-level scaling is specified by an integer in the range 0–3 (inclusive), which indicates the number of decimal place shifts. In other words, you should select 0 to multiply by 1, 1 for 10, 2 for 100, or 3 for 1000.

If it is important to maintain tight data coherency (that is, all data read of a certain type was sampled or calculated at the same time), then you should group that data together within your custom map. For example, if you want all the currents to be coherent, you should group points IA_MAG, IB_MAG, IC_MAG, IN_MAG, and IG_MAG together in the custom map. If points are not grouped together, they might not come from the same data sample.

The following example describes how to create a custom DNP3 map by point type. The example demonstrates the SEL ASCII command **SET DNP** for each point type, but you can complete the entire configuration without saving changes between point types. To do this, you simply continue entering data and save the entire map at the end. Alternatively, you can use ACSELERATOR QuickSet to simplify custom data map creation.

Consider a case where you want to set the AI points in a map as shown in *Table D.13*.

Table D.13 Sample Custom DNP3 AI Map

Desired Point Index	Description	Label	Scaling	Deadband
0	IA magnitude	IA_MAG	default	default
1	IB magnitude	IB_MAG	default	default
2	IC magnitude	IC_MAG	default	default
3	IN magnitude	IN_MAG	default	default
4	3-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 ACSELERATOR QuickSet to enter the previous AI map settings as shown in the screen capture in *Figure D.6*. You can enter scaling and dead-band settings in the same pop-up dialog used to select the AI point, as shown in *Figure D.7*.

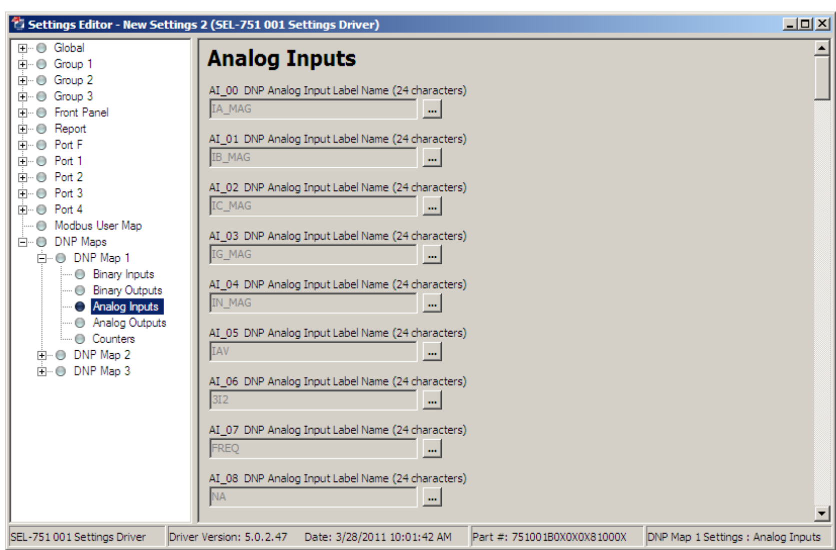


Figure D.6 Analog Input Map Entry in ACSELERATOR QuickSet Software

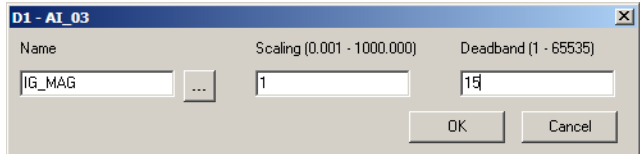


Figure D.7 AI Point Label, Scaling and Deadband in ACSELERATOR QuickSet Software

The **SET DNP x AO_00<Enter>** command allows you to populate the DNP analog output map with any of the 128 Remote Analogs (RA001–RA128) or the GROUP variable (present settings group) as shown in *Figure D.8*.

```
=>>SET DNP 1 AO_00 TERSE <Enter>

DNP Map 1 Settings

Analog Output Map

DNP Analog Output Label Name (6 characters)    AO_00   := NA        ? group
DNP Analog Output Label Name (6 characters)    AO_01   := NA        ? ra001
DNP Analog Output Label Name (6 characters)    AO_02   := NA        ? ra002
DNP Analog Output Label Name (6 characters)    AO_03   := NA        ? ra120
DNP Analog Output Label Name (6 characters)    AO_04   := NA        ? ra128
DNP Analog Output Label Name (6 characters)    AO_05   := NA        ?
DNP Analog Output Label Name (6 characters)    AO_06   := NA        ? end
Save changes (Y,N)? y
Settings Saved

=>>
```

Figure D.8 Sample Custom DNP3 AO Map Settings

You can also use ACSELERATOR Quickset to enter the AO map settings as shown in the screen capture in *Figure D.9*.

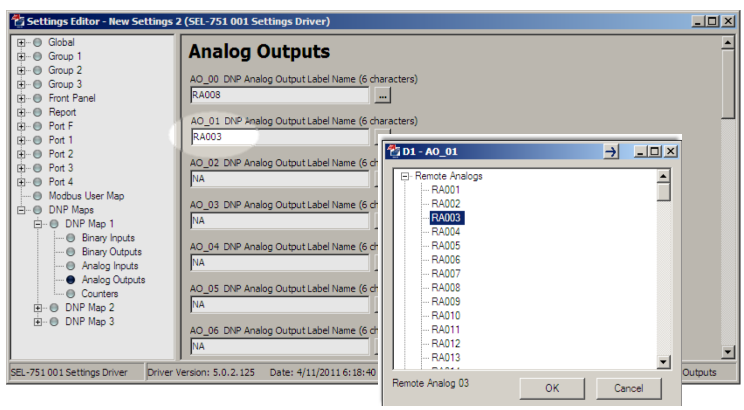


Figure D.9 Analog Output Map Entry in ACSELERATOR QuickSet Software

The **SET DNP *x* CO_00 <Enter>** command allows you to populate the DNP counter map with per-point dead bands. Entering these settings is similar to defining the analog input map settings.

You can use the command **SET DNP *x* BO_00 TERSE <Enter>** to change the binary output map ***x*** as shown in *Figure D.10*. You can populate the custom BO map with any of the 32 remote bits (RB01–RB32). You can define bit pairs in BO maps by including a colon (:) between the bit labels.

```
=>>SET DNP 1 BO_00 TERSE <Enter>
Binary Output Map

DNP Binary Output Label Name (23 characters)
BO_00   := NA
? > RB01 <Enter>

DNP Binary Output Label Name (23 characters)
BO_01   := NA
? > RB02 <Enter>

DNP Binary Output Label Name (23 characters)
BO_02   := NA
? > RB03:RB04 <Enter>

DNP Binary Output Label Name (23 characters)
BO_03   := NA
? > RB05:RB06 <Enter>

DNP Binary Output Label Name (23 characters)
BO_04   := NA
? > end <Enter>

=>>
```

Figure D.10 Sample Custom DNP3 BO Map Settings

You can also use ACSELERATOR QuickSet to enter the BO map settings as shown in the screen capture in *Figure D.11*.

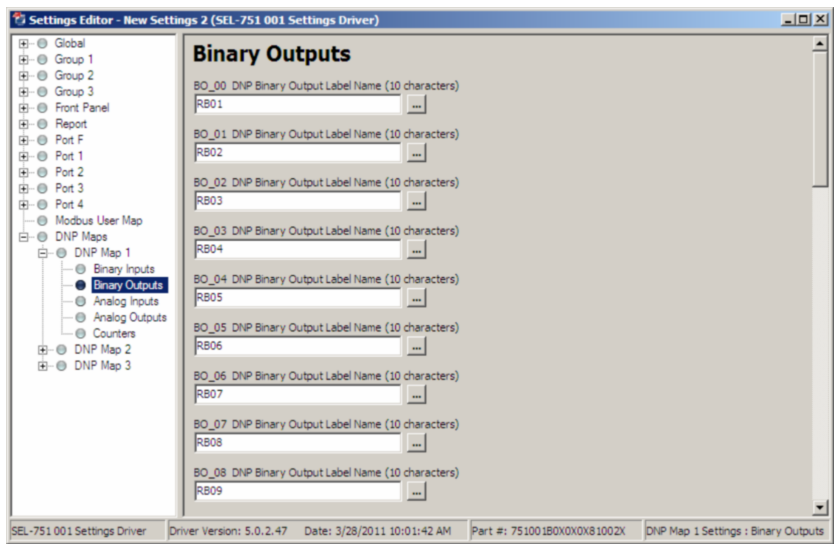


Figure D.11 Binary Output Map Entry in ACSELERATOR QuickSet Software

The binary input (BI) maps are modified in a similar manner, but pairs are not allowed.

Appendix E
Modbus RTU Communications

Overview

This appendix describes Modbus® RTU communications features supported by the SEL-751 Feeder Protection Relay. Complete specifications for the Modbus protocol are available from the Modbus user's group website at www.modbus.org.

Enable Modbus TCP protocol with the optional Ethernet port settings. The SEL-751 supports as many as two Modbus TCP sessions. The TCP port number for each session is selected with the Ethernet port settings. The default TCP port number is the Modbus TCP registered port 502. Modbus TCP uses the device IP address as the Modbus identifier and accesses the data in the relay using the same function codes and data maps as Modbus RTU.

Enable Modbus RTU protocol with the serial port settings. When Modbus RTU protocol is enabled, the relay switches the port to Modbus RTU protocol and deactivates the ASCII protocol.

Modbus RTU is a binary protocol that permits communication between a single master device and multiple slave devices. The communication is half duplex—only one device transmits at a time. The master transmits a binary command that includes the address of the slave device you want. All of the slave devices receive the message, but only the slave device with the matching address responds.

The SEL-751 Modbus communication allows a Modbus master device to do the following:

- Acquire metering, monitoring, and event data from the relay.
- Control SEL-751 output contacts.
- Read the SEL-751 self-test status and learn the present condition of all the relay protection elements.
- Read most of the relay settings and modify the relay settings.

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 zeroes to make an even byte. *Table E.14* includes the coil number and lists all possible coils (identified as Outputs and Remote bits) available in the device. Note that the command depends on the device hardware configuration; the device responds only to installed cards.

The relay responses to errors in the query are shown in *Table E.5*.

Table E.5 Responses to 01h Read Discrete Output Coil Query Errors

Error	Error Code Returned	Communications Counter Increments
Invalid bit to read	Illegal Data Address (02h)	Invalid Address
Invalid number of bits to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

02 Read Input Status Command

Use function code 02h to read the On/Off status of the selected bits (inputs), as shown in *Table E.6*. You can read the status of as many as 2000 bits per query. Note that input addresses start at 0 (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
2 bytes	Number of bits to read

Table E.6 02h Read Input Status Command (Sheet 2 of 2)

Bytes	Field
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (02h)
1 byte	Bytes of data (*n*)
n bytes	Data
2 bytes	CRC-16

To build the response, the device calculates the number of bytes necessary to contain the number of bits requested. If the number of bits requested is not evenly divisible by eight, the device adds one more byte to maintain the balance of bits, padded by zeroes to make an even byte.

In each row, the input numbers are assigned from the right-most input to the left-most input (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
•	•	•
•	•	•
•	•	•
1144–1151	2	Relay Element Status Row 143
1152–1159	2	Relay Element Status Row 144

[a] The input numbers are assigned from the right-most input to the left-most input in the Relay row as show in the following example.
Address 7 = ENABLED
Address 6 = TRIP
Address 5 = T01_LED
Address 4 = T02_LED
Address 3 = T03_LED
Address 2 = T04_LED
Address 1 = T05_LED
Address 0 = T06_LED

The relay responses to errors in the query are shown in *Table E.8*.

Table E.8 Responses to 02h Read Input Query Errors

Error	Error Code Returned	Communications Counter Increments
Invalid bit to read	Illegal Data Address (02h)	Invalid Address
Invalid number of bits to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

03h Read Holding Register Command

Use function code 03h to read directly from the Modbus Register Map shown in *Table E.34*. You can read a maximum of 125 registers at once with this function code. Most masters use 4X references with this function code. If you are accustomed to 4X references with this function code, for five-digit addressing, add 40001 to the standard database address.

Table E.9 03h Read Holding Register Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (03h)
2 bytes	Starting Register Address
2 bytes	Number of Registers to Read
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (03h)
1 byte	Bytes of data (*n*)
n bytes	Data (2–250)
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table E.10*.

Table E.10 Responses to 03h Read Holding Register Query Errors

Error	Error Code Returned	Communications Counter Increments
Illegal register to read	Illegal Data Address (02h)	Invalid Address
Illegal number of registers to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

04h Read Input Register Command

Use function code 04h to read directly from the Modbus Register Map shown in *Table E.34*. You can read a maximum of 125 registers at once with this function code. Most masters use 3X references with this function code. If you are accustomed to 3X references with this function code, for five-digit addressing, add 30001 to the standard database address.

Table E.11 04h Read Input Register Command (Sheet 1 of 2)

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (04h)
2 bytes	Starting Register Address
2 bytes	Number of Registers to Read
2 bytes	CRC-16

Table E.11 04h Read Input Register 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 (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 4)

Coil Address (Decimal)	Function Code Supported	Coil Description
0	01, 05	Pulse OUT101 1 second
1	01, 05	Pulse OUT102 1 second
2	01, 05	Pulse OUT103 1 second
3	01, 05	Pulse OUT301 1 second
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

Table E.14 01h, 05h SEL-751 Output (Sheet 2 of 4)

Coil Address (Decimal)	Function Code Supported	Coil Description
8	01, 05	Pulse OUT306 1 second
9	01, 05	Pulse OUT307 1 second
10	01, 05	Pulse OUT308 1 second
11	01, 05	Pulse OUT401 1 second
12	01, 05	Pulse OUT402 1 second
13	01, 05	Pulse OUT403 1 second
14	01, 05	Pulse OUT404 1 second
15	01, 05	Pulse OUT405 1 second
16	01, 05	Pulse OUT406 1 second
17	01, 05	Pulse OUT407 1 second
18	01, 05	Pulse OUT408 1 second
19	01, 05	Pulse OUT501 1 second
20	01, 05	Pulse OUT502 1 second
21	01, 05	Pulse OUT503 1 second
22	01, 05	Pulse OUT504 1 second
23	01, 05	Pulse OUT505 1 second
24	01, 05	Pulse OUT506 1 second
25	01, 05	Pulse OUT507 1 second
26	01, 05	Pulse OUT508 1 second
27	01, 05	RB01
28	01, 05	RB02
29	01, 05	RB03
30	01, 05	RB04
31	01, 05	RB05
32	01, 05	RB06
33	01, 05	RB07
34	01, 05	RB08
35	01, 05	RB09
36	01, 05	RB10
37	01, 05	RB11
38	01, 05	RB12
39	01, 05	RB13
40	01, 05	RB14
41	01, 05	RB15
42	01, 05	RB16
43	01, 05	RB17
44	01, 05	RB18
45	01, 05	RB19

Table E.14 01h, 05h SEL-751 Output (Sheet 3 of 4)

Coil Address (Decimal)	Function Code Supported	Coil Description
46	01, 05	RB20
47	01, 05	RB21
48	01, 05	RB22
49	01, 05	RB23
50	01, 05	RB24
51	01, 05	RB25
52	01, 05	RB26
53	01, 05	RB27
54	01, 05	RB28
55	01, 05	RB29
56	01, 05	RB30
57	01, 05	RB31
58	01, 05	RB32
59	01, 05	Pulse RB01[a]
60	01, 05	Pulse RB02[a]
61	01, 05	Pulse RB03[a]
62	01, 05	Pulse RB04[a]
63	01, 05	Pulse RB05[a]
64	01, 05	Pulse RB06[a]
65	01, 05	Pulse RB07[a]
66	01, 05	Pulse RB08[a]
67	01, 05	Pulse RB09[a]
68	01, 05	Pulse RB10[a]
69	01, 05	Pulse RB11[a]
70	01, 05	Pulse RB12[a]
71	01, 05	Pulse RB13[a]
72	01, 05	Pulse RB14[a]
73	01, 05	Pulse RB15[a]
74	01, 05	Pulse RB16[a]
75	01, 05	Pulse RB17[a]
76	01, 05	Pulse RB18[a]
77	01, 05	Pulse RB19[a]
78	01, 05	Pulse RB20[a]
79	01, 05	Pulse RB21[a]
80	01, 05	Pulse RB22[a]
81	01, 05	Pulse RB23[a]
82	01, 05	Pulse RB24[a]
83	01, 05	Pulse RB25[a]

Table E.14 01h, 05h SEL-751 Output (Sheet 4 of 4)

Coil Address (Decimal)	Function Code Supported	Coil Description
84	01, 05	Pulse RB26[a]
85	01, 05	Pulse RB27[a]
86	01, 05	Pulse RB28[a]
87	01, 05	Pulse RB29[a]
88	01, 05	Pulse RB30[a]
89	01, 05	Pulse RB31[a]
90	01, 05	Pulse RB32[a]

[a] Pulsing a Set remote bit will cause the remote bit to be cleared at the end of the pulse (1 SELOGIC Processing Interval).

Coil addresses start at 0000 (i.e., Coil 1 is located at Coil address 0000). If the device is disabled or the breaker jumper is not installed, it will respond with error code 4 (Device Error). In addition to Error Code 4, the device responses to errors in the query are shown in *Table E.15*.

Table E.15 Responses to 05h Force Single Coil Query Errors

Error	Error Code Returned	Communications Counter Increments
Invalid bit (coil)	Illegal Data Address (02h)	Invalid Address
Invalid bit state requested	Illegal Data Value (03h)	Illegal Register
Format Error	Illegal Data Value (03h)	Bad Packet Format

06h Preset Single Register Command

The SEL-751 uses this function to allow a Modbus master to write directly to a database register. Refer to the Modbus Register Map in *Table E.34* for a list of registers that you can write by using this function code. If you are accustomed to 4X references with this function code, for six-digit addressing, add 400001 to the standard database addresses.

In *Table E.16*, the command response is identical to the command the master required.

Table E.16 06h Preset Single Register Command

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

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (10h)
2 bytes	Starting Address
2 bytes	Number of Registers to Write
1 byte	Number of Bytes of Data (*n*)
n bytes	Data
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (10h)
2 bytes	Starting Address
2 bytes	Number of Registers
2 bytes	CRC-16

The relay responses to errors in the query are as follows.

Table E.21 10h Preset Multiple Registers Query Error Messages

Error	Error Code Returned	Communications Counter Increments
Illegal register to set	Illegal Data Address (02h)	Invalid Address Illegal Write
Illegal number of registers to set	Illegal Data Value (03h)	Illegal Register Illegal Write
Incorrect number of bytes in query data region	Illegal Data Value (03h)	Bad Packet Format Illegal Write
Invalid register data value	Illegal Data Value (03h)	Illegal Write

60h Read Parameter Information Command

The SEL-751 uses this function to allow a Modbus master to read parameter information from the relay. One parameter (setting) is read in each query.

Table E.22 60h Read Parameter Information Command (Sheet 1 of 2)

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (60h)
2 bytes	Parameter Number
2 bytes	CRC-16

Table E.22 60h Read Parameter Information Command (Sheet 2 of 2)

Bytes	Field
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (60h)
2 bytes	Parameter Number
1 byte	Parameter Descriptor
1 byte	Parameter Conversion
2 bytes	Parameter Minimum Settable Value
2 bytes	Parameter Maximum Settable Value
2 bytes	Parameter Default Value
2 bytes	CRC-16

The Parameter Descriptor field is defined in *Table E.23*.

Table E.23 60h Read Parameter Descriptor Field Definition

Bit	Name	Description
0	RO: Read-only	1 when the setting is read-only
1	H: Hidden	1 when the setting is hidden
2	DBL: 32-bit	1 when the following setting is a fractional value of this setting
3	RA: RAM-only	1 when the setting is not saved in nonvolatile memory
4	RR: Read-only if running	1 when the setting is read-only if in running/operational state
5	P: Power Cycle or Reset	1 when the setting change requires a power cycle or reset
6	0	Reserved
7	Extend	Reserved to extend the descriptor table

The Parameter Conversion field is defined in *Table E.24*.

Table E.24 60h Read Parameter Conversion Field Definition (Sheet 1 of 2)

Conversion Value	Type	Multiplier	Divisor	Offset	Base
0	Boolean	1	1	0	1
1	Unsigned Integer	1	1	0	1
2	Unsigned Integer	1	10	0	1
3	Unsigned Integer	1	100	0	1
4	Unsigned Integer	1	1000	0	1
5	Hexidecimal	1	1	0	1
6	Integer	1	1	0	1
7	Integer	1	10	0	1
8	Integer	1	100	0	1
9	Integer	1	1000	0	1

Table E.24 60h Read Parameter Conversion Field Definition (Sheet 2 of 2)

Conversion Value	Type	Multiplier	Divisor	Offset	Base
10	Enumeration	1	1	0	1
11	Bit Enumeration	1	1	0	1

Use *Equation E.1* to calculate the actual (not scaled) value of the parameter (setting):

$$\text{value} = \frac{(\text{ParameterValue} + \text{Offset}) \bullet \text{Multiplier} \bullet \text{Base}}{\text{Divisor}}$$

Equation E.1

Use *Equation E.2* to calculate the scaled setting value:

$$\text{value} = \frac{\text{value} \bullet \text{Divisor}}{\text{Multiplier} \bullet \text{Base}} - \text{Offset}$$

Equation E.2

The relay response to errors in the query are shown *Table E.25*.

Table E.25 Responses to 60h Read Parameter Information Query Errors

Error	Error Code Returned	Communications Counter Increments
Illegal parameter to read	Illegal Address (02h)	Invalid Address

61h Read Parameter Text Command

The SEL-751 uses this function to allow a Modbus master to read parameter text from the relay. One parameter text (setting name) is read in each query.

Table E.26 61h Read Parameter Text Command

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (61h)
2 bytes	Parameter Number
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (61h)
2 bytes	Parameter Number
16 bytes	Parameter Text (setting name)
4 bytes	Parameter Units (e.g., Amps)
2 bytes	CRC-16

The relay responses to errors in the query are as follows.

Table E.27 61h Read Parameter Text Query Error Messages

Error	Error Code Returned	Communications Counter Increments
Illegal parameter to read	Illegal Address (02h)	Invalid Address

62h Read Enumeration Text Command

The SEL-751 uses this function to allow a Modbus master to read parameter enumeration or bit enumeration values (setting lists) from the relay. One parameter enumeration is read in each query.

Table E.28 62h Read Enumeration Text Command

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (62h)
2 bytes	Parameter Number
1 byte	Enumeration Index
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (62h)
2 bytes	Parameter Number
1 byte	Enumeration Index
16 bytes	Enumeration Text
2 bytes	CRC-16

The relay responses to errors in the query are as follows.

Table E.29 61h Read Parameter Enumeration Text Query Error Messages

Error	Error Code Returned	Communications Counter Increments
Illegal parameter to read	Illegal Address (02h)	Invalid Address
Illegal enumeration in index	Illegal Data Value (03h)	Illegal Register

7Dh Encapsulated Packet With Control Command

The SEL-751 uses this function to allow a Modbus master to perform control operations and another Modbus function with one query. The Device Net card will transmit this command periodically to achieve high-speed I/O processing and establish a heartbeat between the DeviceNet card and the main board.

Table E.30 7Dh Encapsulated Packet With Control Command (Sheet 1 of 2)

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Control Command (same as write to 2000h)

Table E.30 7Dh Encapsulated Packet With Control Command (Sheet 2 of 2)

Bytes	Field
1 byte	Embedded Modbus Function
n bytes	Optional Data to Support Modbus Function (0–250)
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Status Information (Register 2100h or 2101h based on Bit 3 in Control Command Word)
1 byte	Embedded Modbus Function
n bytes	Optional data to support the Modbus function (0–250)
2 bytes	CRC-16

Table E.31 shows the format of the relay responses to errors in the query.

Table E.31 7Dh Encapsulated Packet Query Errors

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Status Information (Register 2100h or 2101h based on Bit 3 in Control Command Word)
1 byte	Modbus Function with Error Flag
1 bytes	Function Error Code[a]
2 bytes	CRC-16

[a] If the embedded function code is invalid, then an illegal function code is returned here and the illegal function counter is incremented. This error code is returned by the embedded function for all valid embedded functions.

7Eh NOP Command

This function code has no operation. This allows a Modbus master to perform a control operation without any other Modbus command. This is only used inside of the 7Dh when no regular Modbus query is necessary.

Table E.32 7Eh NOP Command

Bytes	Field
An example of a 7D message response using 7E will have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Status Information
1 byte	Function Code (7Eh)
2 bytes	CRC-16

Reading Parameter Information and Value Using Modbus

Through use of Modbus commands, you can read the present value of a parameter as well as parameter name, units, low limit, high limit, scale, and even the enumeration string (if the parameter is an enumeration type). This means that you can use a general user interface to retrieve and display specific parameter details from the relay. Use the **60h**, **61h**, and **62h** commands to retrieve parameter information, and use the **03** command to retrieve values.

Controlling Output Contacts Using Modbus

The SEL-751 includes registers for controlling some of the outputs. See LOGIC COMMAND (2000h), RESET COMMAND (2001h), and registers in the Reset Settings region for the control features supported by the relay. Use Modbus function codes 06h or 10h to write appropriate flags. Remember that when writing to the Logic command register with output contacts, it is not a bit operation. You must write all the bits in that register together to reflect the state you want for each of the outputs.

User-Defined Modbus Data Region and SET M Command

The SEL-751 Modbus Register Map defines an area of 125 contiguous addresses whose contents are defined by 125 user-settable addresses. This feature allows you to take 125 discrete values from anywhere in the Modbus Register Map and place them in contiguous registers that you can then read in a single command. SEL ASCII command **SET M** provides a convenient method to define the user map addresses. You can also define the user map by writing to user map registers MOD_001 to MOD_125.

To use the user-defined data region, perform the following steps.

Step 1. Define the list of desired quantities (as many as 125). Arrange the quantities in any order that is convenient for you to use.

Step 2. Refer to *Table E.33* for a list of the Modbus label for each quantity.

Step 3. Execute **SET M** command from the command line to map user registers 001 to 125 (MOD_001 to MOD_125) by using the labels in *Table E.33*.

Note that you can also use Modbus protocol to perform this step. Use Modbus Function Code 06h to write to registers MOD_001 through MOD_125.

Step 4. Use Modbus function code 03h or 04h to read the quantities you want from addresses 126 through 250 (user map values).

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 1 of 6)

Register Address	Label
280	FPGA
281	GPSB
282	HMI
283	RAM
284	ROM
285	CR_RAM
286	NON_VOL
287	CLKSTS
288	CID_FILE
289	RTD
290	P0P9PS
291	P1P2PS
292	P1P5PS
293	P1P8PS
294	P2P5PS
295	P3P3PS
296	P3P75PS
297	P5PS
298	N1P25PS
299	N5PS
300	CLKBAT
301	CARDC
302	CARDD
303	CARDE
304	CARDZ
305	IASTS
306	IBSTS
307	ICSTS
308	INSTS
309	VASTS
310	VBSTS
311	VCSTS
312	VSSTS
313	RLYSTS
314	SER_NUMH
315	SER_NUML
316–319[a]	
320	IA_MAG
321	IA_ANG
322	IB_MAG
323	IB_ANG
324	IC_MAG
325	IC_ANG
326	IN_MAG
327	IN_ANG
328	IG_MAG
329	IG_ANG
330	I1_MAG
331	I1_ANG
332	IAV
333	3I2
334	UBI

Register Address	Label
335	VAB_MAG
336	VAB_ANG
337	VBC_MAG
338	VBC_ANG
339	VCA_MAG
340	VCA_ANG
341	VAVE
342	V1_MAG
343	V1_ANG
344	VA_MAG
345	VA_ANG
346	VB_MAG
347	VB_ANG
348	VC_MAG
349	VC_ANG
350	VG_MAG
351	VG_ANG
352	VAVE
353	3V2
354	UBV
355	VS_MAG
356	VS_ANG
357	VDC
358–359[a]	
360	PA
361	QA
362	SA
363	PFA
364	PB
365	QB
366	SB
367	PFB
368	PC
369	QC
370	SC
371	PFC
372	P
373	Q
374	S
375	PF
376	FREQ
377	FREQS
378–379[a]	
380	MWH3PIH
381	MWH3PIL
382	MWH3POH
383	MWH3POL
384	MVRH3PIH
385	MVRH3PIL
386	MVRH3POH
387	MVRH3POL
388	MVAH3PH

Register Address	Label
389	MVAH3PL
390	ENRGY_S
391	ENRGYMN
392	ENRGY_H
393	ENRGY_D
394	ENRGYMO
395	ENRGY_Y
396–399[a]	
400	RTDWDGMX
401	RTDBRGMX
402	RTDAMB
403	RTDOTHMX
404	RTD1
405	RTD2
406	RTD3
407	RTD4
408	RTD5
409	RTD6
410	RTD7
411	RTD8
412	RTD9
413	RTD10
414	RTD11
415	RTD12
416–419[a]	
420	LSENS1
421	LSENS2
422	LSENS3
423	LSENS4
424–429[a]	
430	IARMS
431	IBRMS
432	ICRMS
433	INRMS
434	VARMS
435	VBRMS
436	VCRMS
437	VABRMS
438	VBCRMS
439	VCARMS
440	VSRMS
441–449[a]	
450	IAD
451	IBD
452	ICD
453	IGD
454	3I2D
455	IAPD
456	IBPD
457	ICPD
458	IGPD
459	3I2PD

Register Address	Label
460	PDEM_R_S
461	PDEM_RMN
462	PDEM_R_H
463	PDEM_R_D
464	PDEM_RMO
465	PDEM_R_Y
466–469[a]	
470	INTT
471	EXTT
472	INTIA
473	EXTIA
474	INTIB
475	EXTIB
476	INTIC
477	EXTIC
478	WEARA
479	WEARB
480	WEARC
481	BRKR_R_S
482	BRKR_RMN
483	BRKR_R_H
484	BRKR_R_D
485	BRKR_RMO
486	BRKR_R_Y
487–489[a]	
490	AI301H
491	AI301L
492	AI302H
493	AI302L
494	AI303H
495	AI303L
496	AI304H
497	AI304L
498	AI305H
499	AI305L
500	AI306H
501	AI306L
502	AI307H
503	AI307L
504	AI308H
505	AI308L
506	AI401H
507	AI401L
508	AI402H
509	AI402L
510	AI403H
511	AI403L
512	AI404H
513	AI404L
514	AI405H
515	AI405L
516	AI406H

Register Address	Label
517	AI406L
518	AI407H
519	AI407L
520	AI408H
521	AI408L
522	AI501H
523	AI501L
524	AI502H
525	AI502L
526	AI503H
527	AI503L
528	AI504H
529	AI504L
530	AI505H
531	AI505L
532	AI506H
533	AI506L
534	AI507H
535	AI507L
536	AI508H
537	AI508L
538–539[a]	
540	MV01H
541	MV01L
542	MV02H
543	MV02L
544	MV03H
545	MV03L
546	MV04H
547	MV04L
548	MV05H
549	MV05L
550	MV06H
551	MV06L
552	MV07H
553	MV07L
554	MV08H
555	MV08L
556	MV09H
557	MV09L
558	MV10H
559	MV10L
560	MV11H
561	MV11L
562	MV12H
563	MV12L
564	MV13H
565	MV13L
566	MV14H
567	MV14L
568	MV15H
569	MV15L

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 2 of 6)

Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label
570	MV16H	622	SC19	677	RA019_L	729	RA045_L	781	RA071_L
571	MV16L	623	SC20	678	RA020_H	730	RA046_H	782	RA072_H
572	MV17H	624	SC21	679	RA020_L	731	RA046_L	783	RA072_L
573	MV17L	625	SC22	680	RA021_H	732	RA047_H	784	RA073_H
574	MV18H	626	SC23	681	RA021_L	733	RA047_L	785	RA073_L
575	MV18L	627	SC24	682	RA022_H	734	RA048_H	786	RA074_H
576	MV19H	628	SC25	683	RA022_L	735	RA048_L	787	RA074_L
577	MV19L	629	SC26	684	RA023_H	736	RA049_H	788	RA075_H
578	MV20H	630	SC27	685	RA023_L	737	RA049_L	789	RA075_L
579	MV20L	631	SC28	686	RA024_H	738	RA050_H	790	RA076_H
580	MV21H	632	SC29	687	RA024_L	739	RA050_L	791	RA076_L
581	MV21L	633	SC30	688	RA025_H	740	RA051_H	792	RA077_H
582	MV22H	634	SC31	689	RA025_L	741	RA051_L	793	RA077_L
583	MV22L	635	SC32	690	RA026_H	742	RA052_H	794	RA078_H
584	MV23H	636-639[a]		691	RA026_L	743	RA052_L	795	RA078_L
585	MV23L	640	RA001_H	692	RA027_H	744	RA053_H	796	RA079_H
586	MV24H	641	RA001_L	693	RA027_L	745	RA053_L	797	RA079_L
587	MV24L	642	RA002_H	694	RA028_H	746	RA054_H	798	RA080_H
588	MV25H	643	RA002_L	695	RA028_L	747	RA054_L	799	RA080_L
589	MV25L	644	RA003_H	696	RA029_H	748	RA055_H	800	RA081_H
590	MV26H	645	RA003_L	697	RA029_L	749	RA055_L	801	RA081_L
591	MV26L	646	RA004_H	698	RA030_H	750	RA056_H	802	RA082_H
592	MV27H	647	RA004_L	699	RA030_L	751	RA056_L	803	RA082_L
593	MV27L	648	RA005_H	700	RA031_H	752	RA057_H	804	RA083_H
594	MV28H	649	RA005_L	701	RA031_L	753	RA057_L	805	RA083_L
595	MV28L	650	RA006_H	702	RA032_H	754	RA058_H	806	RA084_H
596	MV29H	651	RA006_L	703	RA032_L	755	RA058_L	807	RA084_L
597	MV29L	652	RA007_H	704	RA033_H	756	RA059_H	808	RA085_H
598	MV30H	653	RA007_L	705	RA033_L	757	RA059_L	809	RA085_L
599	MV30L	654	RA008_H	706	RA034_H	758	RA060_H	810	RA086_H
600	MV31H	655	RA008_L	707	RA034_L	759	RA060_L	811	RA086_L
601	MV31L	656	RA009_H	708	RA035_H	760	RA061_H	812	RA087_H
602	MV32H	657	RA009_L	709	RA035_L	761	RA061_L	813	RA087_L
603	MV32L	658	RA010_H	710	RA036_H	762	RA062_H	814	RA088_H
604	SC01	659	RA010_L	711	RA036_L	763	RA062_L	815	RA088_L
605	SC02	660	RA011_H	712	RA037_H	764	RA063_H	816	RA089_H
606	SC03	661	RA011_L	713	RA037_L	765	RA063_L	817	RA089_L
607	SC04	662	RA012_H	714	RA038_H	766	RA064_H	818	RA090_H
608	SC05	663	RA012_L	715	RA038_L	767	RA064_L	819	RA090_L
609	SC06	664	RA013_H	716	RA039_H	768	RA065_H	820	RA091_H
610	SC07	665	RA013_L	717	RA039_L	769	RA065_L	821	RA091_L
611	SC08	666	RA014_H	718	RA040_H	770	RA066_H	822	RA092_H
612	SC09	667	RA014_L	719	RA040_L	771	RA066_L	823	RA092_L
613	SC10	668	RA015_H	720	RA041_H	772	RA067_H	824	RA093_H
614	SC11	669	RA015_L	721	RA041_L	773	RA067_L	825	RA093_L
615	SC12	670	RA016_H	722	RA042_H	774	RA068_H	826	RA094_H
616	SC13	671	RA016_L	723	RA042_L	775	RA068_L	827	RA094_L
617	SC14	672	RA017_H	724	RA043_H	776	RA069_H	828	RA095_H
618	SC15	673	RA017_L	725	RA043_L	777	RA069_L	829	RA095_L
619	SC16	674	RA018_H	726	RA044_H	778	RA070_H	830	RA096_H
620	SC17	675	RA018_L	727	RA044_L	779	RA070_L	831	RA096_L
621	SC18	676	RA019_H	728	RA045_H	780	RA071_H	832	RA097_H

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 3 of 6)

Register Address	Label
833	RA097_L
834	RA098_H
835	RA098_L
836	RA099_H
837	RA099_L
838	RA100_H
839	RA100_L
840	RA101_H
841	RA101_L
842	RA102_H
843	RA102_L
844	RA103_H
845	RA103_L
846	RA104_H
847	RA104_L
848	RA105_H
849	RA105_L
850	RA106_H
851	RA106_L
852	RA107_H
853	RA107_L
854	RA108_H
855	RA108_L
856	RA109_H
857	RA109_L
858	RA110_H
859	RA110_L
860	RA111_H
861	RA111_L
862	RA112_H
863	RA112_L
864	RA113_H
865	RA113_L
866	RA114_H
867	RA114_L
868	RA115_H
869	RA115_L
870	RA116_H
871	RA116_L
872	RA117_H
873	RA117_L
874	RA118_H
875	RA118_L
876	RA119_H
877	RA119_L
878	RA120_H
879	RA120_L
880	RA121_H
881	RA121_L
882	RA122_H
883	RA122_L
884	RA123_H
885	RA123_L
886	RA124_H
887	RA124_L
888	RA125_H
889	RA125_L
890	RA126_H
891	RA126_L
892	RA127_H
893	RA127_L
894	RA128_H
895	RA128_L
896-899[a]	
900	IAMX
901	IAX_S
902	IAXMN
903	IAX_H
904	IAX_D
905	IAXMO
906	IAX_Y
907	IAMN
908	IAN_S
909	IANMN
910	IAN_H
911	IAN_D
912	IANMO
913	IAN_Y
914	IBMX
915	IBX_S
916	IBXMN
917	IBX_H
918	IBX_D
919	IBXMO
920	IBX_Y
921	IBMN
922	IBN_S
923	IBNMN
924	IBN_H
925	IBN_D
926	IBNMO
927	IBN_Y
928	ICMX
929	ICX_S
930	ICXMN
931	ICX_H
932	ICX_D
933	ICXMO
934	ICX_Y
935	ICMN
936	ICN_S
937	ICNMN
938	ICN_H
939	ICN_D
940	ICNMO
941	ICN_Y
942	INMX
943	INX_S
944	INXMN
945	INX_H
946	INX_D
947	INXMO
948	INX_Y
949	INMN
950	INN_S
951	INNMN
952	INN_H
953	INN_D
954	INNMO
955	INN_Y
956	IGMX
957	IGX_S
958	IGXMN
959	IGX_H
960	IGX_D
961	IGXMO
962	IGX_Y
963	IGMN
964	IGN_S
965	IGNMN
966	IGN_H
967	IGN_D
968	IGNMO
969	IGN_Y
970	VABMX
971	VABX_S
972	VABXMN
973	VABX_H
974	VABX_D
975	VABXMO
976	VABX_Y
977	VABMN
978	VABN_S
979	VABNMN
980	VABN_H
981	VABN_D
982	VABNMO
983	VABN_Y
984	VBCMX
985	VBCX_S
986	VBCXMN
987	VBCX_H
988	VBCX_D
989	VBCXMO
990	VBCX_Y
991	VBCMN
992	VBCN_S
993	VBCNMN
994	VBCN_H
995	VBCN_D
996	VBCNMO
997	VBCN_Y
998	VCAMX
999	VCAX_S
1000	VCAXMN
1001	VCAX_H
1002	VCAX_D
1003	VCAXMO
1004	VCAX_Y
1005	VCAMN
1006	VCAN_S
1007	VCANMN
1008	VCAN_H
1009	VCAN_D
1010	VCANMO
1011	VCAN_Y
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[a]	
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

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 4 of 6)

Register Address	Label
1103	RTD1N_Y
1104	RTD2MX
1105	RTD2X_S
1106	RTD2XMN
1107	RTD2X_H
1108	RTD2X_D
1109	RTD2XMO
1110	RTD2X_Y
1111	RTD2MN
1112	RTD2N_S
1113	RTD2NMN
1114	RTD2N_H
1115	RTD2N_D
1116	RTD2NMO
1117	RTD2N_Y
1118	RTD3MX
1119	RTD3X_S
1120	RTD3XMN
1121	RTD3X_H
1122	RTD3X_D
1123	RTD3XMO
1124	RTD3X_Y
1125	RTD3MN
1126	RTD3N_S
1127	RTD3NMN
1128	RTD3N_H
1129	RTD3N_D
1130	RTD3NMO
1131	RTD3N_Y
1132	RTD4MX
1133	RTD4X_S
1134	RTD4XMN
1135	RTD4X_H
1136	RTD4X_D
1137	RTD4XMO
1138	RTD4X_Y
1139	RTD4MN
1140	RTD4N_S
1141	RTD4NMN
1142	RTD4N_H
1143	RTD4N_D
1144	RTD4NMO
1145	RTD4N_Y
1146	RTD5MX
1147	RTD5X_S
1148	RTD5XMN
1149	RTD5X_H
1150	RTD5X_D
1151	RTD5XMO
1152	RTD5X_Y
1153	RTD5MN
1154	RTD5N_S
1155	RTD5NMN
1156	RTD5N_H
1157	RTD5N_D
1158	RTD5NMO
1159	RTD5N_Y
1160	RTD6MX
1161	RTD6X_S
1162	RTD6XMN
1163	RTD6X_H
1164	RTD6X_D
1165	RTD6XMO
1166	RTD6X_Y
1167	RTD6MN
1168	RTD6N_S
1169	RTD6NMN
1170	RTD6N_H
1171	RTD6N_D
1172	RTD6NMO
1173	RTD6N_Y
1174	RTD7MX
1175	RTD7X_S
1176	RTD7XMN
1177	RTD7X_H
1178	RTD7X_D
1179	RTD7XMO
1180	RTD7X_Y
1181	RTD7MN
1182	RTD7N_S
1183	RTD7NMN
1184	RTD7N_H
1185	RTD7N_D
1186	RTD7NMO
1187	RTD7N_Y
1188	RTD8MX
1189	RTD8X_S
1190	RTD8XMN
1191	RTD8X_H
1192	RTD8X_D
1193	RTD8XMO
1194	RTD8X_Y
1195	RTD8MN
1196	RTD8N_S
1197	RTD8NMN
1198	RTD8N_H
1199	RTD8N_D
1200	RTD8NMO
1201	RTD8N_Y
1202	RTD9MX
1203	RTD9X_S
1204	RTD9XMN
1205	RTD9X_H
1206	RTD9X_D
1207	RTD9XMO
1208	RTD9X_Y
1209	RTD9MN
1210	RTD9N_S
1211	RTD9NMN
1212	RTD9N_H
1213	RTD9N_D
1214	RTD9NMO
1215	RTD9N_Y
1216	RTD10MX
1217	RTD10X_S
1218	RTD10XMN
1219	RTD10X_H
1220	RTD10X_D
1221	RTD10XMO
1222	RTD10X_Y
1223	RTD10MN
1224	RTD10N_S
1225	RTD10NMN
1226	RTD10N_H
1227	RTD10N_D
1228	RTD10NMO
1229	RTD10N_Y
1230	RTD11MX
1231	RTD11X_S
1232	RTD11XMN
1233	RTD11X_H
1234	RTD11X_D
1235	RTD11XMO
1236	RTD11X_Y
1237	RTD11MN
1238	RTD11N_S
1239	RTD11NMN
1240	RTD11N_H
1241	RTD11N_D
1242	RTD11NMO
1243	RTD11N_Y
1244	RTD12MX
1245	RTD12X_S
1246	RTD12XMN
1247	RTD12X_H
1248	RTD12X_D
1249	RTD12XMO
1250	RTD12X_Y
1251	RTD12MN
1252	RTD12N_S
1253	RTD12NMN
1254	RTD12N_H
1255	RTD12N_D
1256	RTD12NMO
1257	RTD12N_Y
1258–1269[a]	
1270	AI301MXH
1271	AI301MXL
1272	AI301X_S
1273	AI301XMN
1274	AI301X_H
1275	AI301X_D
1276	AI301XMO
1277	AI301X_Y
1278	AI301MNH
1279	AI301MNL
1280	AI301N_S
1281	AI301NMN
1282	AI301N_H
1283	AI301N_D
1284	AI301NMO
1285	AI301N_Y
1286	AI302MXH
1287	AI302MXL
1288	AI302X_S
1289	AI302XMN
1290	AI302X_H
1291	AI302X_D
1292	AI302XMO
1293	AI302X_Y
1294	AI302MNH
1295	AI302MNL
1296	AI302N_S
1297	AI302NMN
1298	AI302N_H
1299	AI302N_D
1300	AI302NMO
1301	AI302N_Y
1302	AI303MXH
1303	AI303MXL
1304	AI303X_S
1305	AI303XMN
1306	AI303X_H
1307	AI303X_D
1308	AI303XMO
1309	AI303X_Y
1310	AI303MNH
1311	AI303MNL
1312	AI303N_S
1313	AI303NMN
1314	AI303N_H
1315	AI303N_D
1316	AI303NMO
1317	AI303N_Y
1318	AI304MXH
1319	AI304MXL
1320	AI304X_S
1321	AI304XMN
1322	AI304X_H
1323	AI304X_D
1324	AI304XMO
1325	AI304X_Y
1326	AI304MNH
1327	AI304MNL
1328	AI304N_S
1329	AI304NMN
1330	AI304N_H
1331	AI304N_D
1332	AI304NMO
1333	AI304N_Y
1334	AI305MXH
1335	AI305MXL
1336	AI305X_S
1337	AI305XMN
1338	AI305X_H
1339	AI305X_D
1340	AI305XMO
1341	AI305X_Y
1342	AI305MNH
1343	AI305MNL
1344	AI305N_S
1345	AI305NMN
1346	AI305N_H
1347	AI305N_D
1348	AI305NMO
1349	AI305N_Y
1350	AI306MXH
1351	AI306MXL
1352	AI306X_S
1353	AI306XMN
1354	AI306X_H
1355	AI306X_D
1356	AI306XMO
1357	AI306X_Y
1358	AI306MNH
1359	AI306MNL
1360	AI306N_S
1361	AI306NMN
1362	AI306N_H
1363	AI306N_D
1364	AI306NMO
1365	AI306N_Y
1366	AI307MXH
1367	AI307MXL
1368	AI307X_S
1369	AI307XMN
1370	AI307X_H
1371	AI307X_D
1372	AI307XMO
1373	AI307X_Y

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 5 of 6)

Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label
1374	AI307MNH	1426	AI402N_H	1478	AI406MXH	1530	AI501X_H	1582	AI504MNH
1375	AI307MNL	1427	AI402N_D	1479	AI406MXL	1531	AI501X_D	1583	AI504MNL
1376	AI307N_S	1428	AI402NMO	1480	AI406X_S	1532	AI501XMO	1584	AI504N_S
1377	AI307NMN	1429	AI402N_Y	1481	AI406XMN	1533	AI501X_Y	1585	AI504NMN
1378	AI307N_H	1430	AI403MXH	1482	AI406X_H	1534	AI501MNH	1586	AI504N_H
1379	AI307N_D	1431	AI403MXL	1483	AI406X_D	1535	AI501MNL	1587	AI504N_D
1380	AI307NMO	1432	AI403X_S	1484	AI406XMO	1536	AI501N_S	1588	AI504NMO
1381	AI307N_Y	1433	AI403XMN	1485	AI406X_Y	1537	AI501NMN	1589	AI504N_Y
1382	AI308MXH	1434	AI403X_H	1486	AI406MNH	1538	AI501N_H	1590	AI505MXH
1383	AI308MXL	1435	AI403X_D	1487	AI406MNL	1539	AI501N_D	1591	AI505MXL
1384	AI308X_S	1436	AI403XMO	1488	AI406N_S	1540	AI501NMO	1592	AI505X_S
1385	AI308XMN	1437	AI403X_Y	1489	AI406NMN	1541	AI501N_Y	1593	AI505XMN
1386	AI308X_H	1438	AI403MNH	1490	AI406N_H	1542	AI502MXH	1594	AI505X_H
1387	AI308X_D	1439	AI403MNL	1491	AI406N_D	1543	AI502MXL	1595	AI505X_D
1388	AI308XMO	1440	AI403N_S	1492	AI406NMO	1544	AI502X_S	1596	AI505XMO
1389	AI308X_Y	1441	AI403NMN	1493	AI406N_Y	1545	AI502XMN	1597	AI505X_Y
1390	AI308MNH	1442	AI403N_H	1494	AI407MXH	1546	AI502X_H	1598	AI505MNH
1391	AI308MNL	1443	AI403N_D	1495	AI407MXL	1547	AI502X_D	1599	AI505MNL
1392	AI308N_S	1444	AI403NMO	1496	AI407X_S	1548	AI502XMO	1600	AI505N_S
1393	AI308NMN	1445	AI403N_Y	1497	AI407XMN	1549	AI502X_Y	1601	AI505NMN
1394	AI308N_H	1446	AI403MXH	1498	AI407X_H	1550	AI502MNH	1602	AI505N_H
1395	AI308N_D	1447	AI403MXL	1499	AI407X_D	1551	AI502MNL	1603	AI505N_D
1396	AI308NMO	1448	AI403X_S	1500	AI407XMO	1552	AI502N_S	1604	AI505NMO
1397	AI308N_Y	1449	AI403XMN	1501	AI407X_Y	1553	AI502NMN	1605	AI505N_Y
1398	AI401MXH	1450	AI403X_H	1502	AI407MNH	1554	AI502N_H	1606	AI506MXH
1399	AI401MXL	1451	AI403X_D	1503	AI407MNL	1555	AI502N_D	1607	AI506MXL
1400	AI401X_S	1452	AI403XMO	1504	AI407N_S	1556	AI502NMO	1608	AI506X_S
1401	AI401XMN	1453	AI403X_Y	1505	AI407NMN	1557	AI502N_Y	1609	AI506XMN
1402	AI401X_H	1454	AI404MNH	1506	AI407N_H	1558	AI503MXH	1610	AI506X_H
1403	AI401X_D	1455	AI404MNL	1507	AI407N_D	1559	AI503MXL	1611	AI506X_D
1404	AI401XMO	1456	AI404N_S	1508	AI407NMO	1560	AI503X_S	1612	AI506XMO
1405	AI401X_Y	1457	AI404NMN	1509	AI407N_Y	1561	AI503XMN	1613	AI506X_Y
1406	AI401MNH	1458	AI404N_H	1510	AI408MXH	1562	AI503X_H	1614	AI506MNH
1407	AI401MNL	1459	AI404N_D	1511	AI408MXL	1563	AI503X_D	1615	AI506MNL
1408	AI401N_S	1460	AI404NMO	1512	AI408X_S	1564	AI503XMO	1616	AI506N_S
1409	AI401NMN	1461	AI404N_Y	1513	AI408XMN	1565	AI503X_Y	1617	AI506NMN
1410	AI401N_H	1462	AI405MXH	1514	AI408X_H	1566	AI503MNH	1618	AI506N_H
1411	AI401N_D	1463	AI405MXL	1515	AI408X_D	1567	AI503MNL	1619	AI506N_D
1412	AI401NMO	1464	AI405X_S	1516	AI408XMO	1568	AI503N_S	1620	AI506NMO
1413	AI401N_Y	1465	AI405XMN	1517	AI408X_Y	1569	AI503NMN	1621	AI506N_Y
1414	AI402MXH	1466	AI405X_H	1518	AI408MNH	1570	AI503N_H	1622	AI507MXH
1415	AI402MXL	1467	AI405X_D	1519	AI408MNL	1571	AI503N_D	1623	AI507MXL
1416	AI402X_S	1468	AI405XMO	1520	AI408N_S	1572	AI503NMO	1624	AI507X_S
1417	AI402XMN	1469	AI405X_Y	1521	AI408NMN	1573	AI503N_Y	1625	AI507XMN
1418	AI402X_H	1470	AI405MNH	1522	AI408N_H	1574	AI504MXH	1626	AI507X_H
1419	AI402X_D	1471	AI405MNL	1523	AI408N_D	1575	AI504MXL	1627	AI507X_D
1420	AI402XMO	1472	AI405N_S	1524	AI408NMO	1576	AI504X_S	1628	AI507XMO
1421	AI402X_Y	1473	AI405NMN	1525	AI408N_Y	1577	AI504XMN	1629	AI507X_Y
1422	AI402MNH	1474	AI405N_H	1526	AI501MXH	1578	AI504X_H	1630	AI507MNH
1423	AI402MNL	1475	AI405N_D	1527	AI501MXL	1579	AI504X_D	1631	AI507MNL
1424	AI402N_S	1476	AI405NMO	1528	AI501X_S	1580	AI504XMO	1632	AI507N_S
1425	AI402NMN	1477	AI405N_Y	1529	AI501XMN	1581	AI504X_Y	1633	AI507NMN

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 6 of 6)

Register Address	Label
1634	AI507N_H
1635	AI507N_D
1636	AI507NMO
1637	AI507N_Y
1638	AI508MXH
1639	AI508MXL
1640	AI508X_S
1641	AI508XMN
1642	AI508X_H
1643	AI508X_D
1644	AI508XMO
1645	AI508X_Y
1646	AI508MNH
1647	AI508MNL
1648	AI508N_S
1649	AI508NMN
1650	AI508N_H
1651	AI508N_D
1652	AI508NMO
1653	AI508N_Y
1654	MXMN_R_S
1655	MXMN_RMN
1656	MXMN_R_H
1657	MXMN_R_D
1658	MXMN_RMO
1659	MXMN_R_Y
1660–1689[a]	
1690	FLOC
1691	NUMEVE
1692	EVESEL
1693	EVE_S
1694	EVEMN
1695	EVE_H
1696	EVE_D
1697	EVEMO
1698	EVE_Y
1699	EVE_TYPE
1700	EV_LOCAT
1701	EVE_TRGT
1702	EVE_IA
1703	EVE_IB
1704	EVE_IC
1705	EVE_IN
1706	EVE_IG
1707	EVE_VAB
1708	EVE_VBC
1709	EVE_VCA
1710	EVE_VG
1711	EVE_DY
1712	EVE_FREQ
1713	EVE_MAXW
1714	EVE_MAXB
1715	EVE_MAXA
1716	EVE_MAXO
1717–1729[a]	
1730	TRIP_LO
1731	TRIP_HI
1732	WARN_LO
1733	WARN_HI
1734–1739[a]	
1740	NUMRCV
1741	NUMOTH
1742	INVADR
1743	BADCRC
1744	UARTERR
1745	ILLFUNC
1746	ILLREG
1747	ILLWR
1748	BADPKTF
1749	BADPKTL
1750–1759[a]	
1760	ROW_0
1761	ROW_1
1762	ROW_2
1763	ROW_3
1764	ROW_4
1765	ROW_5
1766	ROW_6
1767	ROW_7
1768	ROW_8
1769	ROW_9
1770	ROW_10
1771	ROW_11
1772	ROW_12
1773	ROW_13
1774	ROW_14
1775	ROW_15
1776	ROW_16
1777	ROW_17
1778	ROW_18
1779	ROW_19
1780	ROW_20
1781	ROW_21
1782	ROW_22
1783	ROW_23
1784	ROW_24
1785	ROW_25
1786	ROW_26
1787	ROW_27
1788	ROW_28
1789	ROW_29
1790	ROW_30
1791	ROW_31
1792	ROW_32
1793	ROW_33
1794	ROW_34
1795	ROW_35
1796	ROW_36
1797	ROW_37
1798	ROW_38
1799	ROW_39
1800	ROW_40
1801	ROW_41
1802	ROW_42
1803	ROW_43
1804	ROW_44
1805	ROW_45
1806	ROW_46
1807	ROW_47
1808	ROW_48
1809	ROW_49
1810	ROW_50
1811	ROW_51
1812	ROW_52
1813	ROW_53
1814	ROW_54
1815	ROW_55
1816	ROW_56
1817	ROW_57
1818	ROW_58
1819	ROW_59
1820	ROW_60
1821	ROW_61
1822	ROW_62
1823	ROW_63
1824	ROW_64
1825	ROW_65
1826	ROW_66
1827	ROW_67
1828	ROW_68
1829	ROW_69
1830	ROW_70
1831	ROW_71
1832	ROW_72
1833	ROW_73
1834	ROW_74
1835	ROW_75
1836	ROW_76
1837	ROW_77
1838	ROW_78
1839	ROW_79
1840	ROW_80
1841	ROW_81
1842	ROW_82
1843	ROW_83
1844	ROW_84
1845	ROW_85
1846	ROW_86
1847	ROW_87
1848	ROW_88
1849	ROW_89
1850	ROW_90
1851	ROW_91
1852	ROW_92
1853	ROW_93
1854	ROW_94
1855	ROW_95
1856	ROW_96
1857	ROW_97
1858	ROW_98
1859	ROW_99
1860	ROW_100
1861	ROW_101
1862	ROW_102
1863	ROW_103
1864	ROW_104
1865	ROW_105
1866	ROW_106
1867	ROW_107
1868	ROW_108
1869	ROW_109
1870	ROW_110
1871	ROW_111
1872	ROW_112
1873	ROW_113
1874	ROW_114
1875	ROW_115
1876	ROW_116
1877	ROW_117
1878	ROW_118
1879	ROW_119
1880	ROW_120
1881	ROW_121
1882	ROW_122
1883	ROW_123
1884	ROW_124
1885	ROW_125
1886	ROW_126
1887	ROW_127
1888	ROW_128
1889	ROW_129
1890	ROW_130
1891	ROW_131
1892	ROW_132
1893	ROW_133
1894	ROW_134
1895	ROW_135
1896	ROW_136
1897	ROW_137
1898	ROW_138
1899	ROW_139
1900	ROW_140
1901	ROW_141
1902	ROW_142
1903	ROW_143
1904	ROW_144
1905–1920[a]	

[a] All the reserved registers between the data areas in the map may also be assigned to the user registers with a label RES_xxxx where xxxx is the register number.

Reading History Data Using Modbus

Through use of the Modbus Register Map (*Table E.34*), you can download a complete history of the last 50 events via Modbus. The history contains the date and time stamp, type of event that triggered the report, currents, and voltages at the time of the event. Please refer to the Historical Data section in the map.

To use Modbus to download history data, write the event number (1–50) to the EVENT LOG SEL register at address 1692 (when event number zero is written by accident for the first time, the relay will treat selected event number as one). Then read the history of the specific event number you requested from the registers shown in the Historical Data section of the Modbus Register Map (*Table E.34*). After a power cycle, the history data registers will show the history data corresponding to the latest event. This information updates dynamically; as whenever there is a new event, the history data registers update automatically with new event data. If specific event number data have been retrieved using a write to the EVENT LOG SEL register, the event data registers will stay frozen with that specific event history. These registers will return to the free running latest event history data mode when a zero is written to the event selection register from a prior nonzero selection.

Modbus Register Map

Table E.34 lists the data available in the Modbus interface and their description, range, and scaling information. The table also shows the parameter number for access through use of the DeviceNet interface. The DeviceNet parameter number is obtained by adding 100 to the Modbus register address.

Table E.34 Modbus Register Map[a] (Sheet 1 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
0 (R)	Reserved[c]		0	100	1		
User Map Register							
1 (R/W)	USER REG #1		610	1947	650	1	101
	•						
	•						
	•						
125 (R/W)	USER REG #125		610	1947	1947	1	225
User Map Register Values							
126 (R)	USER REG#1 VAL		0	65535	0	1	226
	•						
	•						
	•						
250 (R)	USER REG#125 VAL		0	65535	0	1	350
Reserved Area 1							
251–260 (R)	Reserved[c]		0	0	0		351–360

Table E.34 Modbus Register Map[a] (Sheet 2 of 39)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
Reset Settings								
261	(R/W)	RESET DATA Bit 0 = TRIP 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	0	361
262–269	(R)	Reserved[c]		0	0	0	1	362–369
Date/Time Set								
270	(R/W)	SET SEC		0	5999	0	0	370
271	(R/W)	SET MIN		0	59	0	0	371
272	(R/W)	SET HOUR		0	23	0	0	372
273	(R/W)	SET DAY		1	31	1	0	373
274	(R/W)	SET MONTH		1	12	1	0	374
275	(R/W)	SET YEAR		2000	9999	2000	0	375
276–279	(R)	Reserved[c]		0	0	0	1	376–379
Device Status 0 = OK 1 = WARN 2 = FAIL								
280	(R)	FPGA STATUS		0	2	0	1	380
281	(R)	GPSB STATUS		0	2	0	1	381
282	(R)	HMI STATUS		0	2	0	1	382
283	(R)	RAM STATUS		0	2	0	1	383
284	(R)	ROM STATUS		0	2	0	1	384
285	(R)	CR_RAM STATUS		0	2	0	1	385
286	(R)	NON_VOL STATUS		0	2	0	1	386
287	(R)	CLOCK STATUS		0	2	0	1	387
288	(R)	CID FILE STATUS		0	2	0	1	388
289	(R)	RTD STATUS		0	2	0	1	389
290	(R)	+0.9V STATUS		0	2	0	1	390
291	(R)	+1.2V STATUS		0	2	0	1	391
292	(R)	+1.5V STATUS		0	2	0	1	392
293	(R)	+1.8V STATUS		0	2	0	1	393
294	(R)	+2.5V STATUS		0	2	0	1	394
295	(R)	+3.3V STATUS		0	2	0	1	395
296	(R)	+3.75V STATUS		0	2	0	1	396
297	(R)	+5.0V STATUS		0	2	0	1	397
298	(R)	-1.25V STATUS		0	2	0	1	398
299	(R)	-5.0V STATUS		0	2	0	1	399
300	(R)	CLK_BAT STATUS		0	2	0	1	400

Table E.34 Modbus Register Map[a] (Sheet 3 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
316–319 (R)	Reserved[c]		0	0	0	1	416–419
Current Data							
320 (R)	IA CURRENT	A	0	65535	0	1	420
321 (R)	IA ANGLE	deg	-1800	1800	0	0.1	421
322 (R)	IB CURRENT	A	0	65535	0	1	422
323 (R)	IB ANGLE	deg	-1800	1800	0	0.1	423
324 (R)	IC CURRENT	A	0	65535	0	1	424
325 (R)	IC ANGLE	deg	-1800	1800	0	0.1	425
326 (R)	IN CURRENT	A	0	65535	0	1	426
327 (R)	IN ANGLE	deg	-1800	1800	0	0.1	427
328 (R)	IG CURRENT	A	0	65535	0	1	428
329 (R)	IG ANGLE	deg	-1800	1800	0	0.1	429
330 (R)	I1 CURRENT	A	0	65535	0	1	430
331 (R)	I1 ANGLE	deg	-1800	1800	0	0.1	431
332 (R)	AVERAGE CURRENT	A	0	65535	0	1	432
333 (R)	NEG-SEQ CURR 3I2	A	0	65535	0	1	433
334 (R)	CURRENT IMBAL	%	0	1000	0	0.01	434
Voltage Data							
335 (R)	VAB	kV	0	65535	0	0.01	435
336 (R)	VAB ANGLE	deg	-1800	1800	0	0.1	436
337 (R)	VBC	kV	0	65535	0	0.01	437
338 (R)	VBC ANGLE	deg	-1800	1800	0	0.1	438
339 (R)	VCA	kV	0	65535	0	0.01	439
340 (R)	VCA ANGLE	deg	-1800	1800	0	0.1	440
341 (R)	AVERAGE LINE[d]	kV	0	65535	0	0.01	441
342 (R)	V1	kV	0	65535	0	0.01	442

Table E.34 Modbus Register Map[a] (Sheet 4 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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[e]	kV	0	65535	0	0.01	452
353 (R)	NEG-SEQ VOLT 3V2	kV	0	65535	0	0.01	453
354 (R)	VOLTAGE IMBAL	%	0	1000	0	0.1	454
355 (R)	VSN	kV	0	65535	0	0.01	455
356 (R)	VSN ANGLE	deg	-1800	1800	0	0.1	456
357 (R)	VDC	V	0	65535	0	0.1	457
358–359 (R)	Reserved[c]		0	0	0	1	458–459
Power Data							
360 (R)	A REAL POWER	kW	-32768	32767	0	1	460
361 (R)	A REACTIVE POWER	kVAR	-32768	32767	0	1	461
362 (R)	A APPARENT POWER	kVA	-32768	32767	0	1	462
363 (R)	A POWER FACTOR		-100	100	0	0.01	463
364 (R)	B REAL POWER	kW	-32768	32767	0	1	464
365 (R)	B REACTIVE POWER	kVAR	-32768	32767	0	1	465
366 (R)	B APPARENT POWER	kVA	-32768	32767	0	1	466
367 (R)	B POWER FACTOR		-100	100	0	0.01	467
368 (R)	C REAL POWER	kW	-32768	32767	0	1	468
369 (R)	C REACTIVE POWER	kVAR	-32768	32767	0	1	469
370 (R)	C APPARENT POWER	kVA	-32768	32767	0	1	470
371 (R)	C POWER FACTOR		-100	100	0	0.01	471
372 (R)	REAL POWER	kW	-32768	32767	0	1	472
373 (R)	REACTIVE POWER	kVAR	-32768	32767	0	1	473
374 (R)	APPARENT POWER	kVA	-32768	32767	0	1	474
375 (R)	POWER FACTOR		-100	100	0	0.01	475
376 (R)	FREQUENCY	Hz	2000	7000	6000	0.01	476
377 (R)	SYNC FREQUENCY	Hz	2000	7000	6000	0.01	477
378–379 (R)	Reserved[c]		0	0	0	1	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

Table E.34 Modbus Register Map[a] (Sheet 5 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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[c]		0	0	0	1	496–499
RTD Data							
400 (R)	MAX WINDING RTD 7FFFh = Open 8000h = Short 7FFCh = Comm Fail 7FF8h = Stat Fail 7FFEh = Fail 7FF0h = NA	°C	-32768	32767	0	1	500
401 (R)	MAX BEARING RTD	°C	-32768	32767	0	1	501
402 (R)	MAX AMBIENT RTD	°C	-32768	32767	0	1	502
403 (R)	MAX OTHER RTD	°C	-32768	32767	0	1	503
404 (R)	RTD1	°C	-32768	32767	0	1	504
405 (R)	RTD2	°C	-32768	32767	0	1	505
406 (R)	RTD3	°C	-32768	32767	0	1	506
407 (R)	RTD4	°C	-32768	32767	0	1	507
408 (R)	RTD5	°C	-32768	32767	0	1	508
409 (R)	RTD6	°C	-32768	32767	0	1	509
410 (R)	RTD7	°C	-32768	32767	0	1	510
411 (R)	RTD8	°C	-32768	32767	0	1	511
412 (R)	RTD9	°C	-32768	32767	0	1	512
413 (R)	RTD10	°C	-32768	32767	0	1	513
414 (R)	RTD11	°C	-32768	32767	0	1	514
415 (R)	RTD12	°C	-32768	32767	0	1	515
416–419 (R)	Reserved[c]		0	0	0	1	516–519
Light Meter Data							
420 (R)	LS 1	%	0	1000	0	0.1	520
421 (R)	LS 2	%	0	1000	0	0.1	521
422 (R)	LS 3	%	0	1000	0	0.1	522
423 (R)	LS 4	%	0	1000	0	0.1	523
424–429 (R)	Reserved[c]		0	0	0	1	524–529
RMS Data							
430 (R)	IA RMS	A	0	65535	0	1	530

Table E.34 Modbus Register Map[a] (Sheet 6 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
431 (R)	IB RMS	A	0	65535	0	1	531
432 (R)	IC RMS	A	0	65535	0	1	532
433 (R)	IN RMS	A	0	65535	0	1	533
434 (R)	VA RMS	kV	0	65535	0	0.01	534
435 (R)	VB RMS	kV	0	65535	0	0.01	535
436 (R)	VC RMS	kV	0	65535	0	0.01	536
437 (R)	VAB RMS	kV	0	65535	0	0.01	537
438 (R)	VBC RMS	kV	0	65535	0	0.01	538
439 (R)	VCA RMS	kV	0	65535	0	0.01	539
440 (R)	VS RMS	kV	0	65535	0	0.01	540
441–449 (R)	Reserved[c]		0	0	0	1	541–549
Demand Data							
450 (R)	IA DEMAND	A	0	65535	0	1	550
451 (R)	IB DEMAND	A	0	65535	0	1	551
452 (R)	IC DEMAND	A	0	65535	0	1	552
453 (R)	IG DEMAND	A	0	65535	0	1	553
454 (R)	3I2 DEMAND	A	0	65535	0	1	554
455 (R)	IA PEAK DEMAND	A	0	65535	0	1	555
456 (R)	IB PEAK DEMAND	A	0	65535	0	1	556
457 (R)	IC PEAK DEMAND	A	0	65535	0	1	557
458 (R)	IG PEAK DEMAND	A	0	65535	0	1	558
459 (R)	3I2 PEAK DEMAND	A	0	65535	0	1	559
460 (R)	PEAKD RST TIM-ss		0	5999	0	0.01	560
461 (R)	PEAKD RST TIM-mm		0	59	0	1	561
462 (R)	PEAKD RST TIM-hh		0	23	0	1	562
463 (R)	PEAKD RST DAT-dd		1	31	1	1	563
464 (R)	PEAKD RST DAT-mm		1	12	1	1	564
465 (R)	PEAKD RST DAT-yy		2000	9999	2000	1	565
466–469 (R)	Reserved[c]		0	0	0	1	566–569
Breaker Monitor							
470 (R)	RLY TRIPS		0	65535	0	1	570
471 (R)	EXT TRIPS		0	65535	0	1	571
472 (R)	IA RLY	kA	0	65535	0	1	572
473 (R)	IA EXT	kA	0	65535	0	1	573
474 (R)	IB RLY	kA	0	65535	0	1	574
475 (R)	IB EXT	kA	0	65535	0	1	575
476 (R)	IC RLY	kA	0	65535	0	1	576
477 (R)	IC EXT	kA	0	65535	0	1	577
478 (R)	A WEAR	%	0	100	0	1	578
479 (R)	B WEAR	%	0	100	0	1	579
480 (R)	C WEAR	%	0	100	0	1	580
481 (R)	BRKR RST TIM-ss		0	5999	0.01	1	581

Table E.34 Modbus Register Map[a] (Sheet 7 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
482 (R)	BRKR RST TIM-mm		0	59	0	1	582
483 (R)	BRKR RST TIM-hh		0	23	0	1	583
484 (R)	BRKR RST DAT-dd		1	31	1	1	584
485 (R)	BRKR RST DAT-mm		1	12	1	1	585
486 (R)	BRKR RST DAT-yy		2000	9999	2000	1	586
487–489 (R)	Reserved[c]		0	0	0	1	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
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

Table E.34 Modbus Register Map[a] (Sheet 8 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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[c]		0	0	0	1	638–639
Math Variables							
540 (R)	MV01 - HI		-32768	32767	0	0.01	640
541 (R)	MV01 - LO		-32768	32767	0	0.01	641
542 (R)	MV02 - HI		-32768	32767	0	0.01	642
543 (R)	MV02 - LO		-32768	32767	0	0.01	643
544 (R)	MV03 - HI		-32768	32767	0	0.01	644
545 (R)	MV03 - LO		-32768	32767	0	0.01	645
546 (R)	MV04 - HI		-32768	32767	0	0.01	646
547 (R)	MV04 - LO		-32768	32767	0	0.01	647
548 (R)	MV05 - HI		-32768	32767	0	0.01	648
549 (R)	MV05 - LO		-32768	32767	0	0.01	649
550 (R)	MV06 - HI		-32768	32767	0	0.01	650
551 (R)	MV06 - LO		-32768	32767	0	0.01	651
552 (R)	MV07 - HI		-32768	32767	0	0.01	652
553 (R)	MV07 - LO		-32768	32767	0	0.01	653
554 (R)	MV08 - HI		-32768	32767	0	0.01	654
555 (R)	MV08 - LO		-32768	32767	0	0.01	655
556 (R)	MV09 - HI		-32768	32767	0	0.01	656
557 (R)	MV09 - LO		-32768	32767	0	0.01	657
558 (R)	MV10 - HI		-32768	32767	0	0.01	658
559 (R)	MV10 - LO		-32768	32767	0	0.01	659
560 (R)	MV11 - HI		-32768	32767	0	0.01	660
561 (R)	MV11 - LO		-32768	32767	0	0.01	661
562 (R)	MV12 - HI		-32768	32767	0	0.01	662
563 (R)	MV12 - LO		-32768	32767	0	0.01	663
564 (R)	MV13 - HI		-32768	32767	0	0.01	664
565 (R)	MV13 - LO		-32768	32767	0	0.01	665
566 (R)	MV14 - HI		-32768	32767	0	0.01	666

Table E.34 Modbus Register Map[a] (Sheet 9 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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	0.01	704–735
636–639 (R)	Reserved[c]		0	0	0	1	736–739

Table E.34 Modbus Register Map[a] (Sheet 10 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
Remote Analog Data							
640 (R/W)	RA001 (0:UW)		-32768	32767	0	0.01	740
641 (R/W)	RA001 (1:LW)		-32768	32767	0	0.01	741
642 (R/W)	RA002 (0:UW)		-32768	32767	0	0.01	742
643 (R/W)	RA002 (1:LW)		-32768	32767	0	0.01	743
644 (R/W)	RA003 (0:UW)		-32768	32767	0	0.01	744
645 (R/W)	RA003 (1:LW)		-32768	32767	0	0.01	745
646 (R/W)	RA004 (0:UW)		-32768	32767	0	0.01	746
647 (R/W)	RA004 (1:LW)		-32768	32767	0	0.01	747
648 (R/W)	RA005 (0:UW)		-32768	32767	0	0.01	748
649 (R/W)	RA005 (1:LW)		-32768	32767	0	0.01	749
650 (R/W)	RA006 (0:UW)		-32768	32767	0	0.01	750
651 (R/W)	RA006 (1:LW)		-32768	32767	0	0.01	751
652 (R/W)	RA007 (0:UW)		-32768	32767	0	0.01	752
653 (R/W)	RA007 (1:LW)		-32768	32767	0	0.01	753
654 (R/W)	RA008 (0:UW)		-32768	32767	0	0.01	754
655 (R/W)	RA008 (1:LW)		-32768	32767	0	0.01	755
656 (R/W)	RA009 (0:UW)		-32768	32767	0	0.01	756
657 (R/W)	RA009 (1:LW)		-32768	32767	0	0.01	757
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

Table E.34 Modbus Register Map[a] (Sheet 11 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
681 (R/W)	RA021 (1:LW)		-32768	32767	0	0.01	781
682 (R/W)	RA022 (0:UW)		-32768	32767	0	0.01	782
683 (R/W)	RA022 (1:LW)		-32768	32767	0	0.01	783
684 (R/W)	RA023 (0:UW)		-32768	32767	0	0.01	784
685 (R/W)	RA023 (1:LW)		-32768	32767	0	0.01	785
686 (R/W)	RA024 (0:UW)		-32768	32767	0	0.01	786
687 (R/W)	RA024 (1:LW)		-32768	32767	0	0.01	787
688 (R/W)	RA025 (0:UW)		-32768	32767	0	0.01	788
689 (R/W)	RA025 (1:LW)		-32768	32767	0	0.01	789
690 (R/W)	RA026 (0:UW)		-32768	32767	0	0.01	790
691 (R/W)	RA026 (1:LW)		-32768	32767	0	0.01	791
692 (R/W)	RA027 (0:UW)		-32768	32767	0	0.01	792
693 (R/W)	RA027 (1:LW)		-32768	32767	0	0.01	793
694 (R/W)	RA028 (0:UW)		-32768	32767	0	0.01	794
695 (R/W)	RA028 (1:LW)		-32768	32767	0	0.01	795
696 (R/W)	RA029 (0:UW)		-32768	32767	0	0.01	796
697 (R/W)	RA029 (1:LW)		-32768	32767	0	0.01	797
698 (R/W)	RA030 (0:UW)		-32768	32767	0	0.01	798
699 (R/W)	RA030 (1:LW)		-32768	32767	0	0.01	799
700 (R/W)	RA031 (0:UW)		-32768	32767	0	0.01	800
701 (R/W)	RA031 (1:LW)		-32768	32767	0	0.01	801
702 (R/W)	RA032 (0:UW)		-32768	32767	0	0.01	802
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

Table E.34 Modbus Register Map[a] (Sheet 12 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
723 (R/W)	RA042 (1:LW)		-32768	32767	0	0.01	823
724 (R/W)	RA043 (0:UW)		-32768	32767	0	0.01	824
725 (R/W)	RA043 (1:LW)		-32768	32767	0	0.01	825
726 (R/W)	RA044 (0:UW)		-32768	32767	0	0.01	826
727 (R/W)	RA044 (1:LW)		-32768	32767	0	0.01	827
728 (R/W)	RA045 (0:UW)		-32768	32767	0	0.01	828
729 (R/W)	RA045 (1:LW)		-32768	32767	0	0.01	829
730 (R/W)	RA046 (0:UW)		-32768	32767	0	0.01	830
731 (R/W)	RA046 (1:LW)		-32768	32767	0	0.01	831
732 (R/W)	RA047 (0:UW)		-32768	32767	0	0.01	832
733 (R/W)	RA047 (1:LW)		-32768	32767	0	0.01	833
734 (R/W)	RA048 (0:UW)		-32768	32767	0	0.01	834
735 (R/W)	RA048 (1:LW)		-32768	32767	0	0.01	835
736 (R/W)	RA049 (0:UW)		-32768	32767	0	0.01	836
737 (R/W)	RA049 (1:LW)		-32768	32767	0	0.01	837
738 (R/W)	RA050 (0:UW)		-32768	32767	0	0.01	838
739 (R/W)	RA050 (1:LW)		-32768	32767	0	0.01	839
740 (R/W)	RA051 (0:UW)		-32768	32767	0	0.01	840
741 (R/W)	RA051 (1:LW)		-32768	32767	0	0.01	841
742 (R/W)	RA052 (0:UW)		-32768	32767	0	0.01	842
743 (R/W)	RA052 (1:LW)		-32768	32767	0	0.01	843
744 (R/W)	RA053 (0:UW)		-32768	32767	0	0.01	844
745 (R/W)	RA053 (1:LW)		-32768	32767	0	0.01	845
746 (R/W)	RA054 (0:UW)		-32768	32767	0	0.01	846
747 (R/W)	RA054 (1:LW)		-32768	32767	0	0.01	847
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

Table E.34 Modbus Register Map[a] (Sheet 13 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
765 (R/W)	RA063 (1:LW)		-32768	32767	0	0.01	865
766 (R/W)	RA064 (0:UW)		-32768	32767	0	0.01	866
767 (R/W)	RA064 (1:LW)		-32768	32767	0	0.01	867
768 (R/W)	RA065 (0:UW)		-32768	32767	0	0.01	868
769 (R/W)	RA065 (1:LW)		-32768	32767	0	0.01	869
770 (R/W)	RA066 (0:UW)		-32768	32767	0	0.01	870
771 (R/W)	RA066 (1:LW)		-32768	32767	0	0.01	871
772 (R/W)	RA067 (0:UW)		-32768	32767	0	0.01	872
773 (R/W)	RA067 (1:LW)		-32768	32767	0	0.01	873
774 (R/W)	RA068 (0:UW)		-32768	32767	0	0.01	874
775 (R/W)	RA068 (1:LW)		-32768	32767	0	0.01	875
776 (R/W)	RA069 (0:UW)		-32768	32767	0	0.01	876
777 (R/W)	RA069 (1:LW)		-32768	32767	0	0.01	877
778 (R/W)	RA070 (0:UW)		-32768	32767	0	0.01	878
779 (R/W)	RA070 (1:LW)		-32768	32767	0	0.01	879
780 (R/W)	RA071 (0:UW)		-32768	32767	0	0.01	880
781 (R/W)	RA071 (1:LW)		-32768	32767	0	0.01	881
782 (R/W)	RA072 (0:UW)		-32768	32767	0	0.01	882
783 (R/W)	RA072 (1:LW)		-32768	32767	0	0.01	883
784 (R/W)	RA073 (0:UW)		-32768	32767	0	0.01	884
785 (R/W)	RA073 (1:LW)		-32768	32767	0	0.01	885
786 (R/W)	RA074 (0:UW)		-32768	32767	0	0.01	886
787 (R/W)	RA074 (1:LW)		-32768	32767	0	0.01	887
788 (R/W)	RA075 (0:UW)		-32768	32767	0	0.01	888
789 (R/W)	RA075 (1:LW)		-32768	32767	0	0.01	889
790 (R/W)	RA076 (0:UW)		-32768	32767	0	0.01	890
791 (R/W)	RA076 (1:LW)		-32768	32767	0	0.01	891
792 (R/W)	RA077 (0:UW)		-32768	32767	0	0.01	892
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

Table E.34 Modbus Register Map[a] (Sheet 14 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
807 (R/W)	RA084 (1:LW)		-32768	32767	0	0.01	907
808 (R/W)	RA085 (0:UW)		-32768	32767	0	0.01	908
809 (R/W)	RA085 (1:LW)		-32768	32767	0	0.01	909
810 (R/W)	RA086 (0:UW)		-32768	32767	0	0.01	910
811 (R/W)	RA086 (1:LW)		-32768	32767	0	0.01	911
812 (R/W)	RA087 (0:UW)		-32768	32767	0	0.01	912
813 (R/W)	RA087 (1:LW)		-32768	32767	0	0.01	913
814 (R/W)	RA088 (0:UW)		-32768	32767	0	0.01	914
815 (R/W)	RA088 (1:LW)		-32768	32767	0	0.01	915
816 (R/W)	RA089 (0:UW)		-32768	32767	0	0.01	916
817 (R/W)	RA089 (1:LW)		-32768	32767	0	0.01	917
818 (R/W)	RA090 (0:UW)		-32768	32767	0	0.01	918
819 (R/W)	RA090 (1:LW)		-32768	32767	0	0.01	919
820 (R/W)	RA091 (0:UW)		-32768	32767	0	0.01	920
821 (R/W)	RA091 (1:LW)		-32768	32767	0	0.01	921
822 (R/W)	RA092 (0:UW)		-32768	32767	0	0.01	922
823 (R/W)	RA092 (1:LW)		-32768	32767	0	0.01	923
824 (R/W)	RA093 (0:UW)		-32768	32767	0	0.01	924
825 (R/W)	RA093 (1:LW)		-32768	32767	0	0.01	925
826 (R/W)	RA094 (0:UW)		-32768	32767	0	0.01	926
827 (R/W)	RA094 (1:LW)		-32768	32767	0	0.01	927
828 (R/W)	RA095 (0:UW)		-32768	32767	0	0.01	928
829 (R/W)	RA095 (1:LW)		-32768	32767	0	0.01	929
830 (R/W)	RA096 (0:UW)		-32768	32767	0	0.01	930
831 (R/W)	RA096 (1:LW)		-32768	32767	0	0.01	931
832 (R/W)	RA097 (0:UW)		-32768	32767	0	0.01	932
833 (R/W)	RA097 (1:LW)		-32768	32767	0	0.01	933
834 (R/W)	RA098 (0:UW)		-32768	32767	0	0.01	934
835 (R/W)	RA098 (1:LW)		-32768	32767	0	0.01	935
836 (R/W)	RA099 (0:UW)		-32768	32767	0	0.01	936
837 (R/W)	RA099 (1:LW)		-32768	32767	0	0.01	937
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

Table E.34 Modbus Register Map[a] (Sheet 15 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
849 (R/W)	RA105 (1:LW)		-32768	32767	0	0.01	949
850 (R/W)	RA106 (0:UW)		-32768	32767	0	0.01	950
851 (R/W)	RA106 (1:LW)		-32768	32767	0	0.01	951
852 (R/W)	RA107 (0:UW)		-32768	32767	0	0.01	952
853 (R/W)	RA107 (1:LW)		-32768	32767	0	0.01	953
854 (R/W)	RA108 (0:UW)		-32768	32767	0	0.01	954
855 (R/W)	RA108 (1:LW)		-32768	32767	0	0.01	955
856 (R/W)	RA109 (0:UW)		-32768	32767	0	0.01	956
857 (R/W)	RA109 (1:LW)		-32768	32767	0	0.01	957
858 (R/W)	RA110 (0:UW)		-32768	32767	0	0.01	958
859 (R/W)	RA110 (1:LW)		-32768	32767	0	0.01	959
860 (R/W)	RA111 (0:UW)		-32768	32767	0	0.01	960
861 (R/W)	RA111 (1:LW)		-32768	32767	0	0.01	961
862 (R/W)	RA112 (0:UW)		-32768	32767	0	0.01	962
863 (R/W)	RA112 (1:LW)		-32768	32767	0	0.01	963
864 (R/W)	RA113 (0:UW)		-32768	32767	0	0.01	964
865 (R/W)	RA113 (1:LW)		-32768	32767	0	0.01	965
866 (R/W)	RA114 (0:UW)		-32768	32767	0	0.01	966
867 (R/W)	RA114 (1:LW)		-32768	32767	0	0.01	967
868 (R/W)	RA115 (0:UW)		-32768	32767	0	0.01	968
869 (R/W)	RA115 (1:LW)		-32768	32767	0	0.01	969
870 (R/W)	RA116 (0:UW)		-32768	32767	0	0.01	970
871 (R/W)	RA116 (1:LW)		-32768	32767	0	0.01	971
872 (R/W)	RA117 (0:UW)		-32768	32767	0	0.01	972
873 (R/W)	RA117 (1:LW)		-32768	32767	0	0.01	973
874 (R/W)	RA118 (0:UW)		-32768	32767	0	0.01	974
875 (R/W)	RA118 (1:LW)		-32768	32767	0	0.01	975
876 (R/W)	RA119 (0:UW)		-32768	32767	0	0.01	976
877 (R/W)	RA119 (1:LW)		-32768	32767	0	0.01	977
878 (R/W)	RA120 (0:UW)		-32768	32767	0	0.01	978
879 (R/W)	RA120 (1:LW)		-32768	32767	0	0.01	979
880 (R/W)	RA121 (0:UW)		-32768	32767	0	0.01	980
881 (R/W)	RA121 (1:LW)		-32768	32767	0	0.01	981
882 (R/W)	RA122 (0:UW)		-32768	32767	0	0.01	982
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

Table E.34 Modbus Register Map[a] (Sheet 16 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
891 (R/W)	RA126 (1:LW)		-32768	32767	0	0.01	991
892 (R/W)	RA127 (0:UW)		-32768	32767	0	0.01	992
893 (R/W)	RA127 (1:LW)		-32768	32767	0	0.01	993
894 (R/W)	RA128 (0:UW)		-32768	32767	0	0.01	994
895 (R/W)	RA128 (1:LW)		-32768	32767	0	0.01	995
896–899 (R)	Reserved[c]		0	0	0	1	996–999
MAX/MIN Motor Data							
900 (R)	IA MAX	A	0	65535	0	1	1000
901 (R)	IA MAX TIME ss		0	5999	0	0.01	1001
902 (R)	IA MAX TIME mm		0	59	0	1	1002
903 (R)	IA MAX TIME hh		0	23	0	1	1003
904 (R)	IA MAX DAY dd		1	31	1	1	1004
905 (R)	IA MAX DAY mm		1	12	1	1	1005
906 (R)	IA MAX DAY yy		2000	9999	2000	1	1006
907 (R)	IA MIN	A	0	65535	0	1	1007
908 (R)	IA MIN TIME ss		0	5999	0	0.01	1008
909 (R)	IA MIN TIME mm		0	59	0	1	1009
910 (R)	IA MIN TIME hh		0	23	0	1	1010
911 (R)	IA MIN DAY dd		1	31	1	1	1011
912 (R)	IA MIN DAY mm		1	12	1	1	1012
913 (R)	IA MIN DAY yy		2000	9999	2000	1	1013
914 (R)	IB MAX	A	0	65535	0	1	1014
915 (R)	IB MAX TIME ss		0	5999	0	0.01	1015
916 (R)	IB MAX TIME mm		0	59	0	1	1016
917 (R)	IB MAX TIME hh		0	23	0	1	1017
918 (R)	IB MAX DAY dd		1	31	1	1	1018
919 (R)	IB MAX DAY mm		1	12	1	1	1019
920 (R)	IB MAX DAY yy		2000	9999	2000	1	1020
921 (R)	IB MIN	A	0	65535	0	1	1021
922 (R)	IB MIN TIME ss		0	5999	0	0.01	1022
923 (R)	IB MIN TIME mm		0	59	0	1	1023
924 (R)	IB MIN TIME hh		0	23	0	1	1024
925 (R)	IB MIN DAY dd		1	31	1	1	1025
926 (R)	IB MIN DAY mm		1	12	1	1	1026
927 (R)	IB MIN DAY yy		2000	9999	2000	1	1027
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

Table E.34 Modbus Register Map[a] (Sheet 17 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
935 (R)	IC MIN	A	0	65535	0	1	1035
936 (R)	IC MIN TIME ss		0	5999	0	0.01	1036
937 (R)	IC MIN TIME mm		0	59	0	1	1037
938 (R)	IC MIN TIME hh		0	23	0	1	1038
939 (R)	IC MIN DAY dd		1	31	1	1	1039
940 (R)	IC MIN DAY mm		1	12	1	1	1040
941 (R)	IC MIN DAY yy		2000	9999	2000	1	1041
942 (R)	IN MAX	A	0	65535	0	1	1042
943 (R)	IN MAX TIME ss		0	5999	0	0.01	1043
944 (R)	IN MAX TIME mm		0	59	0	1	1044
945 (R)	IN MAX TIME hh		0	23	0	1	1045
946 (R)	IN MAX DAY dd		1	31	1	1	1046
947 (R)	IN MAX DAY mm		1	12	1	1	1047
948 (R)	IN MAX DAY yy		2000	9999	2000	1	1048
949 (R)	IN MIN	A	0	65535	0	1	1049
950 (R)	IN MIN TIME ss		0	5999	0	0.01	1050
951 (R)	IN MIN TIME mm		0	59	0	1	1051
952 (R)	IN MIN TIME hh		0	23	0	1	1052
953 (R)	IN MIN DAY dd		1	31	1	1	1053
954 (R)	IN MIN DAY mm		1	12	1	1	1054
955 (R)	IN MIN DAY yy		2000	9999	2000	1	1055
956 (R)	IG MAX	A	0	65535	0	1	1056
957 (R)	IG MAX TIME ss		0	5999	0	0.01	1057
958 (R)	IG MAX TIME mm		0	59	0	1	1058
959 (R)	IG MAX TIME hh		0	23	0	1	1059
960 (R)	IG MAX DAY dd		1	31	1	1	1060
961 (R)	IG MAX DAY mm		1	12	1	1	1061
962 (R)	IG MAX DAY yy		2000	9999	2000	1	1062
963 (R)	IG MIN	A	0	65535	0	1	1063
964 (R)	IG MIN TIME ss		0	5999	0	0.01	1064
965 (R)	IG MIN TIME mm		0	59	0	1	1065
966 (R)	IG MIN TIME hh		0	23	0	1	1066
967 (R)	IG MIN DAY dd		1	31	1	1	1067
968 (R)	IG MIN DAY mm		1	12	1	1	1068
969 (R)	IG MIN DAY yy		2000	9999	2000	1	1069
970 (R)	VAB MAX	kV	0	65535	0	0.01	1070
971 (R)	VAB MX TIM ss		0	5999	0	0.01	1071
972 (R)	VAB MX TIM mm		0	59	0	1	1072
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

Table E.34 Modbus Register Map[a] (Sheet 18 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
977 (R)	VAB MIN	kV	0	65535	0	0.01	1077
978 (R)	VAB MN TIM ss		0	5999	0	0.01	1078
979 (R)	VAB MN TIM mm		0	59	0	1	1079
980 (R)	VAB MN TIM hh		0	23	0	1	1080
981 (R)	VAB MN DAY dd		1	31	1	1	1081
982 (R)	VAB MN DAY mm		1	12	1	1	1082
983 (R)	VAB MN DAY yy		2000	9999	2000	1	1083
984 (R)	VBC MAX	kV	0	65535	0	0.01	1084
985 (R)	VBC MX TIM ss		0	5999	0	0.01	1085
986 (R)	VBC MX TIM mm		0	59	0	1	1086
987 (R)	VBC MX TIM hh		0	23	0	1	1087
988 (R)	VBC MX DAY dd		1	31	1	1	1088
989 (R)	VBC MX DAY mm		1	12	1	1	1089
990 (R)	VBC MX DAY yy		2000	9999	2000	1	1090
991 (R)	VBC MIN	kV	0	65535	0	0.01	1091
992 (R)	VBC MN TIM ss		0	5999	0	0.01	1092
993 (R)	VBC MN TIM mm		0	59	0	1	1093
994 (R)	VBC MN TIM hh		0	23	0	1	1094
995 (R)	VBC MN DAY dd		1	31	1	1	1095
996 (R)	VBC MN DAY mm		1	12	1	1	1096
997 (R)	VBC MN DAY yy		2000	9999	2000	1	1097
998 (R)	VCA MAX	kV	0	65535	0	0.01	1098
999 (R)	VCA MX TIM ss		0	5999	0	0.01	1099
1000 (R)	VCA MX TIM mm		0	59	0	1	1100
1001 (R)	VCA MX TIM hh		0	23	0	1	1101
1002 (R)	VCA MX DAY dd		1	31	1	1	1102
1003 (R)	VCA MX DAY mm		1	12	1	1	1103
1004 (R)	VCA MX DAY yy		2000	9999	2000	1	1104
1005 (R)	VCA MIN	kV	0	65535	0	0.01	1105
1006 (R)	VCA MN TIM ss		0	5999	0	0.01	1106
1007 (R)	VCA MN TIM mm		0	59	0	1	1107
1008 (R)	VCA MN TIM hh		0	23	0	1	1108
1009 (R)	VCA MN DAY dd		1	31	1	1	1109
1010 (R)	VCA MN DAY mm		1	12	1	1	1110
1011 (R)	VCA MN DAY yy		2000	9999	2000	1	1111
1012 (R)	VS MAX	kV	0	65535	0	0.01	1112
1013 (R)	VS MAX TIME ss		0	5999	0	0.01	1113
1014 (R)	VS MAX TIME mm		0	59	0	1	1114
1015 (R)	VS MAX TIME hh		0	23	0	1	1115
1016 (R)	VS MAX DAY dd		1	31	1	1	1116
1017 (R)	VS MAX DAY mm		1	12	1	1	1117
1018 (R)	VS MAX DAY yy		2000	9999	2000	1	1118

Table E.34 Modbus Register Map[a] (Sheet 19 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1019 (R)	VS MIN	kV	0	65535	0	1	1119
1020 (R)	VS MIN TIME ss		0	5999	0	0.01	1120
1021 (R)	VS MIN TIME mm		0	59	0	1	1121
1022 (R)	VS MIN TIME hh		0	23	0	1	1122
1023 (R)	VS MIN DAY dd		1	31	1	1	1123
1024 (R)	VS MIN DAY mm		1	12	1	1	1124
1025 (R)	VS MIN DAY yy		2000	9999	2000	1	1125
1026 (R)	KW3P MAX	kW	-32768	32767	0	1	1126
1027 (R)	KW3P MX TIM ss		0	5999	0	0.01	1127
1028 (R)	KW3P MX TIM mm		0	59	0	1	1128
1029 (R)	KW3P MX TIM hh		0	23	0	1	1129
1030 (R)	KW3P MX DAY dd		1	31	1	1	1130
1031 (R)	KW3P MX DAY mm		1	12	1	1	1131
1032 (R)	KW3P MX DAY yy		2000	9999	2000	1	1132
1033 (R)	KW3P MIN	kW	-32768	32767	0	1	1133
1034 (R)	KW3P MN TIM ss		0	5999	0	0.01	1134
1035 (R)	KW3P MN TIM mm		0	59	0	1	1135
1036 (R)	KW3P MN TIM hh		0	23	0	1	1136
1037 (R)	KW3P MN DAY dd		1	31	1	1	1137
1038 (R)	KW3P MN DAY mm		1	12	1	1	1138
1039 (R)	KW3P MN DAY yy		2000	9999	2000	1	1139
1040 (R)	KVAR3P MAX	kVAR	-32768	32767	0	1	1140
1041 (R)	KVAR3P MX TIM ss		0	5999	0	0.01	1141
1042 (R)	KVAR3P MX TIM mm		0	59	0	1	1142
1043 (R)	KVAR3P MX TIM hh		0	23	0	1	1143
1044 (R)	KVAR3P MX DAY dd		1	31	1	1	1144
1045 (R)	KVAR3P MX DAY mm		1	12	1	1	1145
1046 (R)	KVAR3P MX DAY yy		2000	9999	2000	1	1146
1047 (R)	KVAR3P MIN	kVAR	-32768	32767	0	1	1147
1048 (R)	KVAR3P MN TIM ss		0	5999	0	0.01	1148
1049 (R)	KVAR3P MN TIM mm		0	59	0	1	1149
1050 (R)	KVAR3P MN TIM hh		0	23	0	1	1150
1051 (R)	KVAR3P MN DAY dd		1	31	1	1	1151
1052 (R)	KVAR3P MN DAY mm		1	12	1	1	1152
1053 (R)	KVAR3P MN DAY yy		2000	9999	2000	1	1153
1054 (R)	KVA3P MAX	kVA	-32768	32767	0	1	1154
1055 (R)	KVA3P MX TIM ss		0	5999	0	0.01	1155
1056 (R)	KVA3P MX TIM mm		0	59	0	1	1156
1057 (R)	KVA3P MX TIM hh		0	23	0	1	1157
1058 (R)	KVA3P MX DAY dd		1	31	1	1	1158
1059 (R)	KVA3P MX DAY mm		1	12	1	1	1159
1060 (R)	KVA3P MX DAY yy		2000	9999	2000	1	1160

Table E.34 Modbus Register Map[a] (Sheet 20 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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[c]		0	0	0	1	1182–1189
MAX/MIN RTD Data							
1090 (R)	RTD1 MAX	°C	-32768	32767	0	1	1190
1091 (R)	RTD1 MX TIM ss		0	5999	0	0.01	1191
1092 (R)	RTD1 MX TIM mm		0	59	0	1	1192
1093 (R)	RTD1 MX TIM hh		0	23	0	1	1193
1094 (R)	RTD1 MX DAY dd		1	31	1	1	1194
1095 (R)	RTD1 MX DAY mm		1	12	1	1	1195
1096 (R)	RTD1 MX DAY yy		2000	9999	2000	1	1196
1097 (R)	RTD1 MIN	°C	-32768	32767	0	1	1197
1098 (R)	RTD1 MN TIM ss		0	5999	0	0.01	1198
1099 (R)	RTD1 MN TIM mm		0	59	0	1	1199
1100 (R)	RTD1 MN TIM hh		0	23	0	1	1200
1101 (R)	RTD1 MN DAY dd		1	31	1	1	1201
1102 (R)	RTD1 MN DAY mm		1	12	1	1	1202
1103 (R)	RTD1 MN DAY yy		2000	9999	2000	1	1203
1104 (R)	RTD2 MAX	°C	-32768	32767	0	1	1204
1105 (R)	RTD2 MX TIM ss		0	5999	0	0.01	1205
1106 (R)	RTD2 MX TIM mm		0	59	0	1	1206
1107 (R)	RTD2 MX TIM hh		0	23	0	1	1207
1108 (R)	RTD2 MX DAY dd		1	31	1	1	1208

Table E.34 Modbus Register Map[a] (Sheet 21 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
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

Table E.34 Modbus Register Map[a] (Sheet 22 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
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

Table E.34 Modbus Register Map[a] (Sheet 23 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
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

Table E.34 Modbus Register Map[a] (Sheet 24 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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		0	0	0	1	1358–1369
MAX/MIN AI3 Data							
1270 (R)	AI301 MX - HI	EU	-32768	32767	0	0.001	1370
1271 (R)	AI301 MX - LO	EU	-32768	32767	0	0.001	1371
1272 (R)	AI301 MX TIM ss		0	5999	0	0.01	1372
1273 (R)	AI301 MX TIM mm		0	59	0	1	1373
1274 (R)	AI301 MX TIM hh		0	23	0	1	1374
1275 (R)	AI301 MX DAY dd		1	31	1	1	1375
1276 (R)	AI301 MX DAY mm		1	12	1	1	1376
1277 (R)	AI301 MX DAY yy		2000	9999	2000	1	1377
1278 (R)	AI301 MN - HI	EU	-32768	32767	0	0.001	1378
1279 (R)	AI301 MN - LO	EU	-32768	32767	0	0.001	1379
1280 (R)	AI301 MN TIM ss		0	5999	0	0.01	1380
1281 (R)	AI301 MN TIM mm		0	59	0	1	1381
1282 (R)	AI301 MN TIM hh		0	23	0	1	1382
1283 (R)	AI301 MN DAY dd		1	31	1	1	1383
1284 (R)	AI301 MN DAY mm		1	12	1	1	1384
1285 (R)	AI301 MN DAY yy		2000	9999	2000	1	1385
1286 (R)	AI302 MX - HI	EU	-32768	32767	0	0.001	1386

Table E.34 Modbus Register Map[a] (Sheet 25 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
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

Table E.34 Modbus Register Map[a] (Sheet 26 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
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

Table E.34 Modbus Register Map[a] (Sheet 27 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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.34 Modbus Register Map[a] (Sheet 28 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	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

Table E.34 Modbus Register Map[a] (Sheet 29 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1454 (R)	AI404 MN - HI	EU	-32768	32767	0	0.001	1554
1455 (R)	AI404 MN - LO	EU	-32768	32767	0	0.001	1555
1456 (R)	AI404 MN TIM ss		0	5999	0	0.01	1556
1457 (R)	AI404 MN TIM mm		0	59	0	1	1557
1458 (R)	AI404 MN TIM hh		0	23	0	1	1558
1459 (R)	AI404 MN DAY dd		1	31	1	1	1559
1460 (R)	AI404 MN DAY mm		1	12	1	1	1560
1461 (R)	AI404 MN DAY yy		2000	9999	2000	1	1561
1462 (R)	AI405 MX - HI	EU	-32768	32767	0	0.001	1562
1463 (R)	AI405 MX - LO	EU	-32768	32767	0	0.001	1563
1464 (R)	AI405 MX TIM ss		0	5999	0	0.01	1564
1465 (R)	AI405 MX TIM mm		0	59	0	1	1565
1466 (R)	AI405 MX TIM hh		0	23	0	1	1566
1467 (R)	AI405 MX DAY dd		1	31	1	1	1567
1468 (R)	AI405 MX DAY mm		1	12	1	1	1568
1469 (R)	AI405 MX DAY yy		2000	9999	2000	1	1569
1470 (R)	AI405 MN - HI	EU	-32768	32767	0	0.001	1570
1471 (R)	AI405 MN - LO	EU	-32768	32767	0	0.001	1571
1472 (R)	AI405 MN TIM ss		0	5999	0	0.01	1572
1473 (R)	AI405 MN TIM mm		0	59	0	1	1573
1474 (R)	AI405 MN TIM hh		0	23	0	1	1574
1475 (R)	AI405 MN DAY dd		1	31	1	1	1575
1476 (R)	AI405 MN DAY mm		1	12	1	1	1576
1477 (R)	AI405 MN DAY yy		2000	9999	2000	1	1577
1478 (R)	AI406 MX - HI	EU	-32768	32767	0	0.001	1578
1479 (R)	AI406 MX - LO	EU	-32768	32767	0	0.001	1579
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

Table E.34 Modbus Register Map[a] (Sheet 30 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1496 (R)	AI407 MX TIM ss		0	5999	0	0.01	1596
1497 (R)	AI407 MX TIM mm		0	59	0	1	1597
1498 (R)	AI407 MX TIM hh		0	23	0	1	1598
1499 (R)	AI407 MX DAY dd		1	31	1	1	1599
1500 (R)	AI407 MX DAY mm		1	12	1	1	1600
1501 (R)	AI407 MX DAY yy		2000	9999	2000	1	1601
1502 (R)	AI407 MN - HI	EU	-32768	32767	0	0.001	1602
1503 (R)	AI407 MN - LO	EU	-32768	32767	0	0.001	1603
1504 (R)	AI407 MN TIM ss		0	5999	0	0.01	1604
1505 (R)	AI407 MN TIM mm		0	59	0	1	1605
1506 (R)	AI407 MN TIM hh		0	23	0	1	1606
1507 (R)	AI407 MN DAY dd		1	31	1	1	1607
1508 (R)	AI407 MN DAY mm		1	12	1	1	1608
1509 (R)	AI407 MN DAY yy		2000	9999	2000	1	1609
1510 (R)	AI408 MX - HI	EU	-32768	32767	0	0.001	1610
1511 (R)	AI408 MX - LO	EU	-32768	32767	0	0.001	1611
1512 (R)	AI408 MX TIM ss		0	5999	0	0.01	1612
1513 (R)	AI408 MX TIM mm		0	59	0	1	1613
1514 (R)	AI408 MX TIM hh		0	23	0	1	1614
1515 (R)	AI408 MX DAY dd		1	31	1	1	1615
1516 (R)	AI408 MX DAY mm		1	12	1	1	1616
1517 (R)	AI408 MX DAY yy		2000	9999	2000	1	1617
1518 (R)	AI408 MN - HI	EU	-32768	32767	0	0.001	1618
1519 (R)	AI408 MN - LO	EU	-32768	32767	0	0.001	1619
1520 (R)	AI408 MN TIM ss		0	5999	0	0.01	1620
1521 (R)	AI408 MN TIM mm		0	59	0	1	1621
1522 (R)	AI408 MN TIM hh		0	23	0	1	1622
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

Table E.34 Modbus Register Map[a] (Sheet 31 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1537 (R)	AI501 MN TIM mm		0	59	0	1	1637
1538 (R)	AI501 MN TIM hh		0	23	0	1	1638
1539 (R)	AI501 MN DAY dd		1	31	1	1	1639
1540 (R)	AI501 MN DAY mm		1	12	1	1	1640
1541 (R)	AI501 MN DAY yy		2000	9999	2000	1	1641
1542 (R)	AI502 MX - HI	EU	-32768	32767	0	0.001	1642
1543 (R)	AI502 MX - LO	EU	-32768	32767	0	0.001	1643
1544 (R)	AI502 MX TIM ss		0	5999	0	0.01	1644
1545 (R)	AI502 MX TIM mm		0	59	0	1	1645
1546 (R)	AI502 MX TIM hh		0	23	0	1	1646
1547 (R)	AI502 MX DAY dd		1	31	1	1	1647
1548 (R)	AI502 MX DAY mm		1	12	1	1	1648
1549 (R)	AI502 MX DAY yy		2000	9999	2000	1	1649
1550 (R)	AI502 MN - HI	EU	-32768	32767	0	0.001	1650
1551 (R)	AI502 MN - LO	EU	-32768	32767	0	0.001	1651
1552 (R)	AI502 MN TIM ss		0	5999	0	0.01	1652
1553 (R)	AI502 MN TIM mm		0	59	0	1	1653
1554 (R)	AI502 MN TIM hh		0	23	0	1	1654
1555 (R)	AI502 MN DAY dd		1	31	1	1	1655
1556 (R)	AI502 MN DAY mm		1	12	1	1	1656
1557 (R)	AI502 MN DAY yy		2000	9999	2000	1	1657
1558 (R)	AI503 MX - HI	EU	-32768	32767	0	0.001	1658
1559 (R)	AI503 MX - LO	EU	-32768	32767	0	0.001	1659
1560 (R)	AI503 MX TIM ss		0	5999	0	0.01	1660
1561 (R)	AI503 MX TIM mm		0	59	0	1	1661
1562 (R)	AI503 MX TIM hh		0	23	0	1	1662
1563 (R)	AI503 MX DAY dd		1	31	1	1	1663
1564 (R)	AI503 MX DAY mm		1	12	1	1	1664
1565 (R)	AI503 MX DAY yy		2000	9999	2000	1	1665
1566 (R)	AI503 MN - HI	EU	-32768	32767	0	0.001	1666
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

Table E.34 Modbus Register Map[a] (Sheet 32 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1579 (R)	AI504 MX DAY dd		1	31	1	1	1679
1580 (R)	AI504 MX DAY mm		1	12	1	1	1680
1581 (R)	AI504 MX DAY yy		2000	9999	2000	1	1681
1582 (R)	AI504 MN - HI	EU	-32768	32767	0	0.001	1682
1583 (R)	AI504 MN - LO	EU	-32768	32767	0	0.001	1683
1584 (R)	AI504 MN TIM ss		0	5999	0	0.01	1684
1585 (R)	AI504 MN TIM mm		0	59	0	1	1685
1586 (R)	AI504 MN TIM hh		0	23	0	1	1686
1587 (R)	AI504 MN DAY dd		1	31	1	1	1687
1588 (R)	AI504 MN DAY mm		1	12	1	1	1688
1589 (R)	AI504 MN DAY yy		2000	9999	2000	1	1689
1590 (R)	AI505 MX - HI	EU	-32768	32767	0	0.001	1690
1591 (R)	AI505 MX - LO	EU	-32768	32767	0	0.001	1691
1592 (R)	AI505 MX TIM ss		0	5999	0	0.01	1692
1593 (R)	AI505 MX TIM mm		0	59	0	1	1693
1594 (R)	AI505 MX TIM hh		0	23	0	1	1694
1595 (R)	AI505 MX DAY dd		1	31	1	1	1695
1596 (R)	AI505 MX DAY mm		1	12	1	1	1696
1597 (R)	AI505 MX DAY yy		2000	9999	2000	1	1697
1598 (R)	AI505 MN - HI	EU	-32768	32767	0	0.001	1698
1599 (R)	AI505 MN - LO	EU	-32768	32767	0	0.001	1699
1600 (R)	AI505 MN TIM ss		0	5999	0	0.01	1700
1601 (R)	AI505 MN TIM mm		0	59	0	1	1701
1602 (R)	AI505 MN TIM hh		0	23	0	1	1702
1603 (R)	AI505 MN DAY dd		1	31	1	1	1703
1604 (R)	AI505 MN DAY mm		1	12	1	1	1704
1605 (R)	AI505 MN DAY yy		2000	9999	2000	1	1705
1606 (R)	AI506 MX - HI	EU	-32768	32767	0	0.001	1706
1607 (R)	AI506 MX - LO	EU	-32768	32767	0	0.001	1707
1608 (R)	AI506 MX TIM ss		0	5999	0	0.01	1708
1609 (R)	AI506 MX TIM mm		0	59	0	1	1709
1610 (R)	AI506 MX TIM hh		0	23	0	1	1710
1611 (R)	AI506 MX DAY dd		1	31	1	1	1711
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

Table E.34 Modbus Register Map[a] (Sheet 33 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1621 (R)	AI506 MN DAY yy		2000	9999	2000	1	1721
1622 (R)	AI507 MX - HI	EU	-32768	32767	0	0.001	1722
1623 (R)	AI507 MX - LO	EU	-32768	32767	0	0.001	1723
1624 (R)	AI507 MX TIM ss		0	5999	0	0.01	1724
1625 (R)	AI507 MX TIM mm		0	59	0	1	1725
1626 (R)	AI507 MX TIM hh		0	23	0	1	1726
1627 (R)	AI507 MX DAY dd		1	31	1	1	1727
1628 (R)	AI507 MX DAY mm		1	12	1	1	1728
1629 (R)	AI507 MX DAY yy		2000	9999	2000	1	1729
1630 (R)	AI507 MN - HI	EU	-32768	32767	0	0.001	1730
1631 (R)	AI507 MN - LO	EU	-32768	32767	0	0.001	1731
1632 (R)	AI507 MN TIM ss		0	5999	0	0.01	1732
1633 (R)	AI507 MN TIM mm		0	59	0	1	1733
1634 (R)	AI507 MN TIM hh		0	23	0	1	1734
1635 (R)	AI507 MN DAY dd		1	31	1	1	1735
1636 (R)	AI507 MN DAY mm		1	12	1	1	1736
1637 (R)	AI507 MN DAY yy		2000	9999	2000	1	1737
1638 (R)	AI508 MX - HI	EU	-32768	32767	0	0.001	1738
1639 (R)	AI508 MX - LO	EU	-32768	32767	0	0.001	1739
1640 (R)	AI508 MX TIM ss		0	5999	0	0.01	1740
1641 (R)	AI508 MX TIM mm		0	59	0	1	1741
1642 (R)	AI508 MX TIM hh		0	23	0	1	1742
1643 (R)	AI508 MX DAY dd		1	31	1	1	1743
1644 (R)	AI508 MX DAY mm		1	12	1	1	1744
1645 (R)	AI508 MX DAY yy		2000	9999	2000	1	1745
1646 (R)	AI508 MN - HI	EU	-32768	32767	0	0.001	1746
1647 (R)	AI508 MN - LO	EU	-32768	32767	0	0.001	1747
1648 (R)	AI508 MN TIM ss		0	5999	0	0.01	1748
1649 (R)	AI508 MN TIM mm		0	59	0	1	1749
1650 (R)	AI508 MN TIM hh		0	23	0	1	1750
1651 (R)	AI508 MN DAY dd		1	31	1	1	1751
1652 (R)	AI508 MN DAY mm		1	12	1	1	1752
1653 (R)	AI508 MN DAY yy		2000	9999	2000	1	1753
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
Reserved Area 5							
1660–1689 (R)	Reserved[c]		0	0	0	1	1760–1789

Table E.34 Modbus Register Map[a] (Sheet 34 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
Fault Location							
1690 (R)	FAULT LOCATION		-32768	32767	0	0.1	1790
Historical Data							
1691 (R)	NO. EVENT LOGS		0	50	0	1	1791
1692 (R/W)	EVENT LOG SEL.		0	50	0	0	1792
1693 (R)	EVENT TIME ss		0	5999	0	0.01	1793
1694 (R)	EVENT TIME mm		0	59	0	1	1794
1695 (R)	EVENT TIME hh		0	23	0	1	1795
1696 (R)	EVENT DAY dd		0	31	1	1	1796
1697 (R)	EVENT DAY mm		0	12	1	1	1797
1698 (R)	EVENT DAY yy		0	9999	2000	1	1798
1699 (R)	EVENT TYPE		0	55	0	1	1799
	0 = TRIP* 1 = PHASE A1 50 TRIP 2 = PHASE B1 50 TRIP 3 = PHASE C1 50 TRIP 4 = PHASE 50 TRIP 5 = GND/NEUT 50 TRIP 6 = NEG SEQ 50 TRIP 7 = PHASE A 51 TRIP 8 = PHASE B 51 TRIP 9 = PHASE C 51 TRIP 10 = PHASE 51 TRIP 11 = GND/NEUT 51 TRIP 12 = NEG SEQ 51 TRIP 13 = 59 TRIP 14 = 55 TRIP 15 = 81 UF TRIP 16 = 81 OF TRIP 17 = POWERELEMNT TRIP 18 = ARC FLASH TRIP 19 = RTD TRIP 20 = REMOTE TRIP 21 = 27 TRIP 22 = RTD FAIL TRIP 23 = BKR FAILURE TRIP 24 = COMMIDLELOSSTRIP 25 = TRIGGER 26 = ER TRIGGER 27 = TRIP 28 = AG 29 = BG 30 = ABG 31 = CG 32 = CAG 33 = BCG 34 = ABC 35 = AG T 36 = BG T 37 = ABG T 38 = CG T 39 = CAG T 40 = BCG T 41 = ABC T 42 = AG 43 = BG 44 = AB 45 = CG 46 = CA 47 = BC 48 = ABC 49 = AG T 50 = BG T 51 = AB T 52 = CG T 53 = CA T 54 = BC T 55 = ABC T						
1700 (R)	FAULT LOCATION		-32768	32767	0	0.1	1800
1701 (R)	EVENT TARGETS Bit 0 = TLED_06 Bit 1 = TLED_05 Bit 2 = TLED_04 Bit 3 = TLED_03 Bit 4 = TLED_02 Bit 5 = TLED_01 Bit 6 = TRIP_LED Bit 7 = ENABLED		0	255	0	1	1801
1702 (R)	EVENT IA	A	0	65535	0	1	1802
1703 (R)	EVENT IB	A	0	65535	0	1	1803
1704 (R)	EVENT IC	A	0	65535	0	1	1804
1705 (R)	EVENT IN	A	0	65535	0	1	1805
1706 (R)	EVENT IG	A	0	65535	0	1	1806
1707 (R)	EVENT VAB/VAN	kV	0	65535	0	0.01	1807
1708 (R)	EVENT VBC/VBN	kV	0	65535	0	0.01	1808
1709 (R)	EVENT VCA/VCN	kV	0	65535	0	0.01	1809
1710 (R)	EVENT VG	kV	0	65535	0	0.01	1810

Table E.34 Modbus Register Map[a] (Sheet 35 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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
1717–1729 (R)	Reserved[c]		0	0	0	1	1817–1829
Trip/Warn Data							
The Trip and Warn Status registers bits are "sticky" (once set they are not cleared until target reset is issued from any interface) when a trip event occurs.							
1730 (R)	TRIP STATUS LO 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
1732 (R)	WARN STATUS LO Bit 0 = PHASE 50P2 Bit 1 = PHASE 50P3 Bit 2 = PHASE 50P4 Bit 3 = GROUND 50G2 Bit 4 = GROUND 50G3 Bit 5 = GROUND 50G4 Bit 6 = NEUTRAL 50N2 Bit 7 = NEUTRAL 50N3 Bit 8 = NEUTRAL 50N4 Bit 9 = NEG SEQ 50Q2 Bit 10 = NEG SEQ 50Q3 Bit 11 = NEG SEQ 50Q4 Bit 12 = PHASE 51P2 Bit 13 = GROUND 51G2 Bit 14 = NEUTRAL 51N2 Bit 15 = RESERVED		0	65535	0	1	1832
1733 (R)	WARN STATUS HI Bit 0 = POWER FACTOR 55 Bit 1 = SALARM Bit 2 = WARNING Bit 3 = RTD-WIND BEAR Bit 4 = RTD-OTHER Bit 5 = RTD-AMBIENT Bit 6 = UNDERVOLT 27P2 Bit 7 = OVERVOLT 59P2 Bit 8 = FREQUENCY 81D3 Bit 9 = FREQUENCY 81D4 Bit 10 = RESERVED Bit 11 = RESERVED Bit 12 = RESERVED Bit 13 = RESERVED Bit 14 = RESERVED Bit 15 = RESERVED		0	65535	0	1	1833
1734–1739 (R)	Reserved[c]		0	0	0		1834–1839

Table E.34 Modbus Register Map[a] (Sheet 36 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
Relay Elements							
1740 (R)	NUM MSG RCVD		0	65535	0	1	1840
1741 (R)	NUM OTHER MSG		0	65535	0	1	1841
1742 (R)	INVALID ADDR		0	65535	0	1	1842
1743 (R)	BAD CRC		0	65535	0	1	1843
1744 (R)	UART ERROR		0	65535	0	1	1844
1745 (R)	ILLEGAL FUNCTION		0	65535	0	1	1845
1746 (R)	ILLEGAL REGISTER		0	65535	0	1	1846
1747 (R)	ILLEGAL WRITE		0	65535	0	1	1847
1748 (R)	BAD PKT FORMAT		0	65535	0	1	1848
1749 (R)	BAD PKT LENGTH		0	65535	0	1	1849
1750–1759 (R)	Reserved[c]		0	0	0		1850–1859
Relay Elements							
1760–1904 (R)	ROW 0–ROW 144		0	255	0	1	1860–2004
1905–1920 (R)	Reserved[c]		0	255	0	1	2004–2020
Control I/O Commands							
2000H (W)	LOGIC COMMAND		0	65535	0	na	
	Bit 0 = Breaker Close Bit 1 = Breaker Open Bit 2 = Reserved Bit 3 = Return Status 0/1 Bit 4 = DN Aux 1 Cmd Bit 5 = DN Aux 2 Cmd Bit 6 = DN Aux 3 Cmd Bit 7 = DN Aux 4 Cmd	Bit 8 = DN Aux 5 Cmd Bit 9 = DN Aux 6 Cmd Bit 10 = DN Aux 7 Cmd Bit 11 = DN Aux 8 Cmd Bit 12 = DN Aux 9 Cmd Bit 13 = DN Aux 10 Cmd Bit 14 = DN Aux 11 Cmd Bit 15 = Reserved					
2001H (W)	RESET DATA		0	1023	0	na	
	Bit 0 = TRIP RESET Bit 1 = Reserved Bit 2 = RESET STAT DATA Bit 3 = RESET HIST DATA Bit 4 = RESET COMM CNTR Bit 5 = Reserved Bit 6 = RST ENRGY DATA Bit 7 = RST MX/MN DATA	Bit 8 = RST DEMAND Bit 9 = RST PEAK DEMAND Bit 10 = RST BKMON DATA Bits 11–15 = Reserved					
Relay Elements							
2100H (R)	FAST STATUS 0		0	65535	0	na	
	Bit 0 = Faulted Bit 1 = Warning Bit 2 = IN1/IN101 Status Bit 3 = IN2/IN102 Status Bit 4 = IN3/IN401 Status Bit 5 = IN4/IN402 Status Bit 6 = IN5/IN403 Status Bit 7 = Reserved	Bit 8 = AUX1/OUT101 Status Bit 9 = AUX2/OUT102 Status Bit 10 = AUX3/OUT401 Status Bit 11 = AUX4/OUT402 Status Bit 12 = AUX5/OUT403 Status Bit 13 = AUX6/OUT404 Status Bit 14 = Reserved Bit 15 = Reserved					

Table E.34 Modbus Register Map[a] (Sheet 37 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
2101H (R)	FAST STATUS 1 Bit 0 = Enabled Bit 1 = Reserved Bit 2 = IN6/IN404 Status Bit 3 = IN7/IN501 Status Bit 4 = IN8/IN502 Status Bit 5 = IN9/IN503 Status Bit 6 = IN10/IN504 Status Bit 7 = Reserved Bit 8 = AUX7/OUT501 Status Bit 9 = AUX8/OUT502 Status Bit 10 = AUX9/OUT503 Status Bit 11 = AUX10/OUT504 Status Bit 12 = 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[c]					na	
210BH (R)	CURRENT IMBAL					na	
210CH (R)	MAX WINDING RTD					na	
210DH (R)	IG CURRENT					na	
210EH (R)	IN CURRENT					na	
210FH (R)	Reserved[c]					na	
2110H (R)	FAST STATUS 2 Bit 0 = IN11/IN301 Status Bit 1 = IN12/IN302 Status Bit 2 = IN13/IN303 Status Bit 3 = IN14/IN304 Status Bit 4 = IN15/IN305 Status Bit 5 = IN16/IN306 Status Bit 6 = IN17/IN307 Status Bit 7 = IN18/IN308 Status Bit 8 = OUT11/OUT301 Status Bit 9 = OUT12/OUT302 Status Bit 10 = OUT13/OUT303 Status Bit 11 = OUT14/OUT304 Status Bit 12 = OUT305 Status Bit 13 = OUT306 Status Bit 14 = OUT307 Status Bit 15 = OUT308 Status		0	65535	0	na	
2111H (R)	FAST STATUS 3 Bit 0 = IN19/IN405 Status Bit 1 = IN20/IN406 Status Bit 2 = IN21/IN407 Status Bit 3 = IN22/IN408 Status Bit 4 = IN23/IN505 Status Bit 5 = IN24/IN506 Status Bit 6 = IN25/IN507 Status Bit 7 = IN26/IN508 Status Bit 8 = OUT505 Status Bit 9 = OUT506 Status Bit 10 = OUT507 Status Bit 11 = OUT508 Status Bit 12–15 = Reserved		0	65535	0	na	
PAR Group Indices							
3000H (R)	Reserved		0	0	0		
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		

Table E.34 Modbus Register Map[a] (Sheet 38 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
3006H (R)	DEVICE STATUS		280	319	280		
3007H (R)	CURRENT DATA		320	334	320		
3008H (R)	VOLTAGE DATA		335	359	335		
3009H (R)	POWER DATA		360	379	360		
300AH (R)	ENERGY DATA		380	399	380		
300BH (R)	RTD DATA		400	419	400		
300CH (R)	LIGHT MTR DATA		420	429	420		
300DH (R)	RMS DATA		430	449	430		
300EH (R)	DEMAND DATA		450	469	450		
300FH (R)	BREAKER MONITOR		470	489	470		
3010H (R)	ANA INP DATA		490	539	490		
3011H (R)	MATH VARIABLES		540	603	540		
3012H (R)	DEVICE COUNTERS		604	639	604		
3013H (R)	REMOTE ANALOGS1		640	767	640		
3014H (R)	REMOTE ANALOGS2		768	895	768		
3015H (R)	RESERVED AREA6		896	899	896		
3016H (R)	MAX/MIN MTR DATA		900	1089	900		
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)	RESERVED AREA5		1660	1689	1660		
301DH (R)	FAULT LOCATION		1690	1690	1690		
301EH (R)	HISTORICAL DATA		1691	1729	1691		
301FH (R)	TRIP/WARN DATA		1730	1739	1730		
3020H (R)	COMMN COUNTERS		1740	1759	1740		
3021H (R)	RELAY ELEMENTS		1760	1920	1760		
Product Information							
4000H (R)	VENDOR CODE 865 = SEL		0	65535	865	na	
4001H (R)	PRODDUCT CODE		0	65535	103	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	1960	na	
4006H (R)	NUM OF PAR GROUP		1	100	30	na	
4007H (R/W)	MAC ID 64–99 = Swr Configurable		1	99	0	na	

Table E.34 Modbus Register Map[a] (Sheet 39 of 39)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
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[c]						
4014H (R)	CONFIGURED BIT Bit 0 = Unit Configured Bits 1–15 = Reserved				0	na	
4015H (R)	Reserved[c]		0	0	0	na	
4016H (R)	ERROR REGISTER Bit 0–Bit 15 = Reserved		0	65535	0	na	
4017H (R)	ERROR ADDRESS		0	65535	0		
4018H–401FH (R)	Reserved[c]		0	0	0		

[a] All addresses in this table refer to the register addresses in the Modbus packet.
[b] Registers labeled (R/(W) are read-write registers. Registers labeled (W) are write-only registers. Registers Labeled (R) are read-only registers.
[c] Reserved addresses return 0.
[d] Read this register only when the PT connection is DELTA.
[e] Read this register only when the PT connection is WYE.

Appendix F
IEC 61850 Communications

Features

The SEL-751 Relay uses Ethernet® and IEC 61850 to support the following features:

- SCADA—Connect as many as six simultaneous IEC 61850 MMS client sessions. The SEL-751 also supports as many as six buffered and six unbuffered report control blocks. See the CON Logical Device Table for Logical Node mapping that enables SCADA control via a Manufacturing Messaging Specification (MMS) browser. Controls support the direct control, Select Before Operate (SBO) control, and SBO with enhanced security control models.
- Peer-to-Peer Real-Time Status and Control—Use GOOSE with as many as 16 incoming (receive) and 8 outgoing (transmit) messages. You can map virtual bits (VB001–VB128), Breaker Open (OC), and Breaker Close (CC) bits from incoming GOOSE messages.
- Configuration—Use FTP client software or ACSELERATOR Architect® SEL-5032 Software to transfer the Substation Configuration Language (SCL) Configured IED Description (CID) file to the relay.
- Commissioning and Troubleshooting—Use software such as MMS Object Explorer and AX-S4 MMS from Sisco, Inc., to browse the relay logical nodes and verify functionality.

NOTE: The SEL-751 supports one CID file, which should be transferred only if a change in the relay configuration is necessary. If an invalid CID file is transferred, the relay will no longer have a valid IEC 61850 configuration, and the protocol will stop operating. To restart protocol operation, a valid CID must be transferred to the relay.

This appendix presents the information you need to use the IEC 61850 features of the SEL-751:

- Introduction to IEC 61850
- IEC 61850 Operation
- IEC 61850 Configuration
- Logical Nodes
- Logical Node Extensions
- Protocol Implementation Conformance Statement
- ACSI Conformance Statement

Introduction to IEC 61850

In the early 1990s, the Electric Power Research Institute (EPRI) and the Institute of Electrical and Electronics Engineers, Inc. (IEEE) began to define a Utility Communications Architecture (UCA). They initially focused on inter-control center and substation-to-control center communications and produced the Inter-Control Center Communications Protocol (ICCP) specification. This specification, later adopted by the IEC as 60870-6 TASE.2, became the standard protocol for real-time exchange of data between databases.

In 1994, EPRI and IEEE began work on UCA 2.0 for Field Devices (simply referred to as UCA2). In 1997, they combined efforts with Technical Committee 57 of the IEC to create a common international standard. Their joint efforts created the current IEC 61850 standard.

The IEC 61850 standard, a superset of UCA2, contains most of the UCA2 specification, plus additional functionality. The standard describes client/server and peer-to-peer communications, substation design and configuration, testing, and project standards. The IEC 61850 standard consists of the parts listed in *Table F.1*.

Table F.1 IEC 61850 Document Set

IEC 61850 Sections	Definitions
IEC 61850-1	Introduction and overview
IEC 61850-2	Glossary
IEC 61850-3	General requirements
IEC 61850-4	System and project management
IEC 61850-5	Communications requirements
IEC 61850-6	Configuration description language for substation IEDs
IEC 61850-7-1	Basic communications structure for substations and feeder equipment—Principles and models
IEC 61850-7-2	Basic communications structure for substations and feeder equipment—Abstract Communication Service Interface (ACSI)
IEC 61850-7-3	Basic communications structure for substations and feeder equipment—Common data classes
IEC 61850-7-4	Basic communications structure for substations and feeder equipment—Compatible logical node (LN) classes and data classes
IEC 61850-8-1	SCSM-Mapping to Manufacturing Messaging Specification (MMS) (ISO/IEC 9506-1 and ISO/IEC 9506-2 over ISO/IEC 8802-3)
IEC 61850-9-1	SCSM-Sampled values over serial multidrop point-to-point link
IEC 61850-9-2	SCSM-Sampled values over ISO/IEC 8802-3
IEC 61850-10	Conformance testing

The IEC 61850 document set, available directly from the IEC at http://www.iec.ch, contains information necessary for successful implementation of this protocol. SEL strongly recommends that anyone involved with the design, installation, configuration, or maintenance of IEC 61850 systems be familiar with the appropriate sections of these documents.

IEC 61850 Operation

Ethernet Networking

IEC 61850 and Ethernet networking are available as options in the SEL-751. In addition to IEC 61850, the Ethernet port provides support protocols and data exchange, including FTP and Telnet. Access the SEL-751 Port 1 settings to configure all of the Ethernet settings, including IEC 61850 enable settings.

The SEL Ethernet port supports IEC 61850 services, including transport of logical node objects, over TCP/IP. The Ethernet port can coordinate a maximum of six concurrent IEC 61850 sessions.

Object Models

The IEC 61850 standard relies heavily on the Abstract Communication Service Interface (ACSI) model to define a set of service and the responses to those services. In terms of network behavior, abstract modeling enables all IEDs to act identically. You can use these abstract models to create objects (data items) and services that exist independently of any underlying protocols. These objects are in conformance with the common data class (CDC) specification IEC 61850 7 3, which describes the type and structure of each element within a logical node. CDCs for status, measurements, controllable analogs and statuses, and settings all have unique CDC attributes. Each CDC attribute belongs to a set of functional constraints that groups the attributes into specific categories such as status (ST), description (DC), and substituted value (SV). Functional constraints, CDCs and CDC attributes are used as building blocks for defining Local Nodes.

UCA2 uses GOMSFE (Generic Object Models for Substation and Feeder Equipment) to present data from station IEDs as a series of objects called models or bricks. The IEC working group has incorporated GOMSFE concepts into the standard, with some modifications to terminology; one change was the renaming of bricks to logical nodes. Each logical node represents a group of data (controls, status, measurements, etc.) associated with a particular function. For example, the MMXU logical node (polyphase measurement unit) contains measurement data and other points associated with three-phase metering including voltages and currents. Each IED can contain many functions such as protection, metering, and control. Multiple logical nodes represent the functions in multifunction devices.

You can organize logical nodes into logical devices that are similar to directories on a computer disk. As represented in the IEC 61850 network, each physical device can contain many logical devices, and each logical device can contain many logical nodes. Many relays, meters, and other IEC 61850 devices contain one primary logical device where all models are organized.

IEC 61850 devices are capable of self-description. You do not need to refer to the specifications for the logical nodes, measurements, and other components to request data from another IEC 61850 device. IEC 61850 clients can request and display a list and description of the data available in an IEC 61850 server device. This process is similar to the autoconfiguration process used within SEL communications processors (SEL-2032 and SEL-2030). Simply run an MMS browser to query devices on an IEC 61850 network and discover what data are available. Self-description also permits extensions to both standard and custom data models. Instead of having to look up data in a profile stored in its database, an IEC 61850 client can simply query an IEC 61850 device and receive a description of all logical devices, logical nodes, and available data.

Unlike other Supervisory Control and Data Acquisition (SCADA) protocols that present data as a list of addresses or indices, IEC 61850 presents data with descriptors in a composite notation made up of components. *Table F.2* shows how the A-phase current expressed as MMXUAphsA$cVal is broken down into its component parts.

Table F.2 Example IEC 61850 Descriptor Components

Components		Description
MMXU	Logical Node	Polyphase measurement unit
A	Data Object	Phase-to-ground amperes
PhsA	Sub-Data Object	Phase A
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 61850-5:2003(E) and IEC 61850-7-4:2003(E) for the mandatory content and usage of these LNs. The SEL-751 logical nodes are grouped under Logical Devices for organization based on function. See *Table F.3* for descriptions of the Logical Devices in an SEL-751. See Logical Nodes for a description of the LNs that make up these Logical Devices.

Table F.3 SEL-751 Logical Devices

Logical Device	Description
ANN	Annunciator elements—alarms, status values
CFG	Configuration elements—datasets and report control blocks
CON	Control elements—Remote bits
MET	Metering or Measurement elements—currents, voltages, power, etc.
PRO	Protection elements—protection functions and breaker control

MMS

Manufacturing Messaging Specification (MMS) provides services for the application-layer transfer of real-time data within a substation LAN. MMS was developed as a network independent data exchange protocol for industrial networks in the 1980s and standardized as ISO 9506.

In theory, you can map IEC 61850 to any protocol. However, it can be unwieldy and quite complicated to map objects and services to a protocol that only provides access to simple data points via registers or index numbers. MMS supports complex named objects and flexible services that enable mapping to IEC 61850 in a straightforward manner. This was why the UCA users group used MMS for UCA from that start, and why the IEC chose to keep it for IEC 61850.

GOOSE

The Generic Object Oriented Substation Event (GOOSE) object within IEC 61850 is for high-speed control messaging. IEC 61850 GOOSE automatically broadcasts messages containing status, controls, and measured values onto the network for use by other devices. IEC 61850 GOOSE sends the messages several times, increasing the likelihood that other devices receive the messages.

IEC 61850 GOOSE objects can quickly and conveniently transfer status, controls, and measured values between peers on an IEC 61850 network. Configure SEL devices to respond to GOOSE messages from other network with ACSELERATOR Architect software. Also, configure outgoing GOOSE messages for SEL devices in ACSELERATOR Architect. See the ACSELERATOR Architect online help for more information.

Each IEC 61850 GOOSE sender includes a text identification string (GOOSE Control Block Reference) in each outgoing message and an Ethernet multicast group address. Devices that receive GOOSE messages use the text identification and multicast group to identify and filter incoming GOOSE messages.

NOTE: Any device bits mapped to GOOSE subscriptions retain state until overwritten or the device restarts. When loading a new CID file, be sure to issue an **STA C** command or cycle power to the device to clear the device bits if the configuration has changed.

Virtual bits (VB001–VB128) are control inputs that you can map to GOOSE receive messages by using the ACSELERATOR Architect software. See the VB*nnn* bits in *Table F.15* for details on which logical nodes and names are used for these bits. This information can be useful when searching through device data with MMS browsers. If you intend to use any SEL-751 virtual bits for controls, you must create SELOGIC control equations to define these operations. The Virtual Bit Logical Nodes only contain Virtual Bit status, and only those Virtual Bits that are assigned to an SER report will be able to track bit transitions (via reporting) between LN data update scans.

In addition to the Virtual Bits, the breaker control bits CC and OC can also be mapped to GOOSE receive messages.

File Services

The Ethernet File System allows reading or writing data as files. The File System supports FTP. The File System provides:

- A means for the devices to transfer data as files
- A hierarchical file structure for the device data (root level only for SEL-700 series devices)

SCL Files

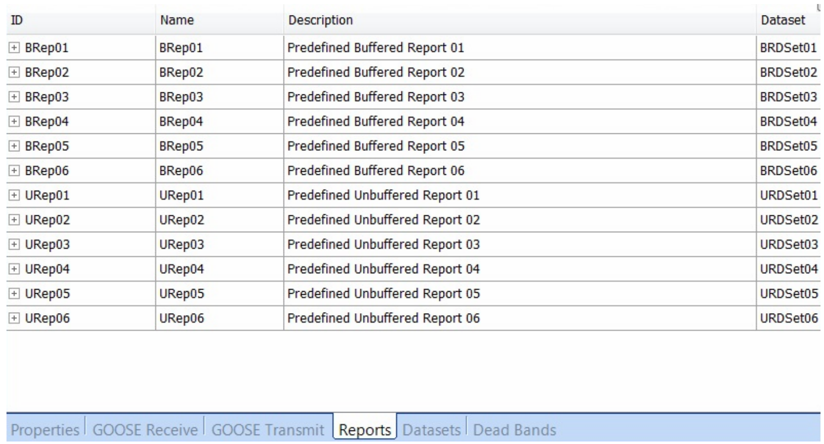
Substation Configuration Language (SCL) is an XML-based configuration language used to support the exchange of database configuration data between different tools, which may come from different manufacturers. There are four types of SCL files:

- IED Capability Description file (.ICD)
- System Specification Description (.SSD) file
- Substation Configuration Description file (.SCD)
- Configured IED Description file (.CID)

The ICD file described the capabilities of an IED, including information on LN and GOOSE support. The SSD file describes the single-line diagram of the substation and the necessary LNs. The SCD file contains information on all IEDs, communications configuration data, and a substation description. The CID file, of which there may be several, describes a single instantiated IED within the project, and includes address information.

Reports

The SEL-751 supports buffered and unbuffered report control blocks in the report model as defined in IEC 61850-8-1:2004(E). The predefined reports shown in *Figure F.1* are available by default via IEC 61850.



ID	Name	Description	Dataset
BRep01	BRep01	Predefined Buffered Report 01	BRDSet01
BRep02	BRep02	Predefined Buffered Report 02	BRDSet02
BRep03	BRep03	Predefined Buffered Report 03	BRDSet03
BRep04	BRep04	Predefined Buffered Report 04	BRDSet04
BRep05	BRep05	Predefined Buffered Report 05	BRDSet05
BRep06	BRep06	Predefined Buffered Report 06	BRDSet06
URep01	URep01	Predefined Unbuffered Report 01	URDSet01
URep02	URep02	Predefined Unbuffered Report 02	URDSet02
URep03	URep03	Predefined Unbuffered Report 03	URDSet03
URep04	URep04	Predefined Unbuffered Report 04	URDSet04
URep05	URep05	Predefined Unbuffered Report 05	URDSet05
URep06	URep06	Predefined Unbuffered Report 06	URDSet06

Figure F.1 SEL-751 Predefined Reports

There are 12 report control blocks, six buffered reports and six unbuffered. For each report control block, there can be just one client association, i.e., only one client can be associated to a report control block (BRCB or URCB) at any given time. The number of reports (12) and the type of reports (buffered or unbuffered) cannot be changed. However, by using ACSELERATOR Architect, you can reallocate data within each report dataset to present different data attributes for each report beyond the predefined datasets. For buffered reports, connected clients can edit the report parameters shown in *Table F.4*.

Table F.4 Buffered Report Control Block Client Access

RCB Attribute	User changeable (Report Disabled)	User changeable (Report Enabled)	Default Values
RptId	YES		BRep01–BRep06
RptEna	YES	YES	FALSE
OptFlds	YES		seqNum timeStamp dataSet configRef reasonCode dataRef
BufTm	YES		500
TrgOp	YES		dchg qchg
IntgPd	YES		0
GI	YES[a b]	YES[a]	FALSE
PurgeBuf	YES[a]		FALSE
EntryId	YES		0

a Exhibits a pulse behavior. Write a one to issue the command. Once command is accepted will return to zero. Always read as zero.
b When disabled, a GI will be processed and the report buffered if a buffer has been previously established. A buffer is established when the report is enabled for the first time.

Similarly, for unbuffered reports, connected clients can edit the report parameters shown in *Table F.5*.

Table F.5 Unbuffered Report Control Block Client Access

RCB Attribute	User changeable (Report Disabled)	User changeable (Report Enabled)	Default Values
RptId	YES		URep01–URep06
RptEna	YES	YES	FALSE
Resv	YES		FALSE
OptFlds	YES		seqNum timeStamp dataSet configRef reasonCode dataRef
BufTm	YES		250
TrgOps	YES		dchg qchg
IntgPd	YES		0
GI		YES[a]	

[a] Exhibits a pulse behavior. Write a one to issue the command. Once command is accepted will return to zero. Always read as zero.

For Buffered Reports, only one client can enable the RptEna attribute of the BRCB at a time resulting in a client association for that BRCB. Once enabled, the associated client has exclusive access to the BRCB until the connection is closed or the client disables the RptEna attribute. Once enabled, all unassociated clients have read only access to the BRCB.

For Unbuffered Reports, as many as six (6) clients can enable the RptEna attribute of the URCB at a time, resulting in multiple client associations for that URCB. Once enabled, each client has independent access to a copy of that URCB. The Resv attribute is writable, however, the SEL-751 does not support reservations. Writing any field of the URCB causes the client to obtain its own copy of the URCB-in essence, acquiring a reservation.

Reports are serviced at a 2 Hz rate. The client can set the IntgPd to any value with a resolution of 1 ms. However, the integrity report is only sent when the period has been detected as having expired. The report service rate of 2 Hz results in a report being sent within 500 ms of expiration of the IntgPd. The new IntgPd will begin at the time that the current report is serviced.

Datasets

Datasets are configured using ACSELERATOR Architect and contain data attributes that represent real data values within the SEL-751 device. See Logical Nodes for the logical node tables that list the available data attributes for each logical node and the Relay Word bit mapping for these data attributes. The datasets listed in *Figure F.2* are the defaults for an SEL-751 device. Datasets BRDSet01–BRDSet06 and URDSet01–URDSet06 are preconfigured with common FCDAs to be used for reporting. These datasets can be configured to represent the data you want to monitor. Dataset GPDSet01, which contains breaker status and control data attributes, is used in the default Goose Control Publication.

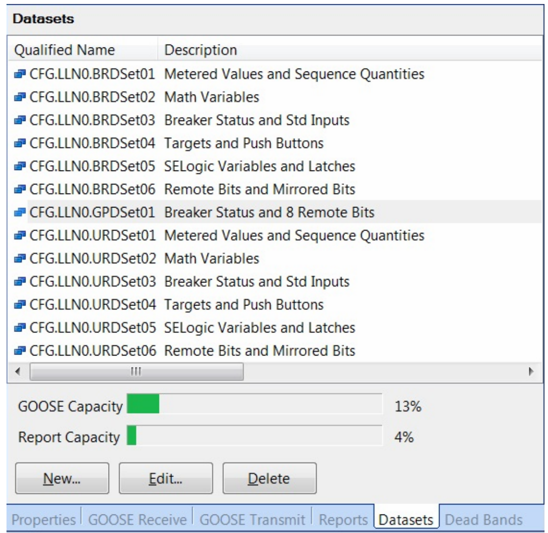


Figure F.2 SEL-751 Datasets

Within ACSELERATOR Architect, IEC 61850 datasets have two main purposes:

- GOOSE: You can use predefined or edited datasets, or create new datasets for outgoing GOOSE transmission.
- Reports: Twelve predefined datasets (BRDSet01 to BRDSet06 and URDSet01–URDSet06) correspond to the default six buffered and six unbuffered reports, respectively. Note that you cannot change the number (12) or type of reports (buffered or unbuffered) within ACSELERATOR Architect. However, you can alter the data attributes that a dataset contains and so define what data an IEC 61850 client receives with a report.

NOTE: Do not edit the dataset names used in reports. Changing or deleting any of those dataset names will cause a failure in generating the corresponding report.

Supplemental Software

Examine the data structure and value of the supported IEC 61850 LNs with an MMS browser such as MMS Object Explorer and AX-S4 MMS from Sisco, Inc. The settings necessary to browse an SEL-751 with an MMS browser are as follows:

OSI-PSEL (Presentation Selector)	00000001
OSI-SSEL (Session Selector)	0001
OSI-TSEL (Transport Selector)	0001

Time Stamps and Quality

In addition to the various data values, the two attributes quality and t (time stamp) are available at any time. The relay determines the time stamp when it detects a change in quality or data.

The relay applies a timestamp 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 timestamp) within the relay.

For all other Booleans or Bstrings, the relay detects the change via the scanner, which compares the last state against the previous state to detect the change. For analogs, the scanner looks at the amount of change relative to the dead band configured for the point to indicate a change and apply the timestamp. In all cases, the relay uses these timestamps for the reporting model.

Functionally Constrained Data Attributes mapped to points assigned to the SER report have 4 ms SER-accurate timestamps for data change events. To ensure that you will get SER-quality timestamps for changes to certain points, you must include those points in the SER report. All other FCDAs are scanned for data changes on a 1/2-second interval and have 1/2-second timestamp accuracy. See the **SET R** command for information on programming the SER report.

The SEL-751 uses GOOSE quality attributes to indicate the quality of the data in its transmitted GOOSE messages. Under normal conditions, all attributes are zero, indicating good quality data. *Figure F.3* shows the GOOSE quality attributes available to devices that subscribe to GOOSE messages from SEL-751 datasets that contain them. Internal status indicators provide the information necessary for the device to set these attributes.

For example, if the device becomes disabled, as shown via status indications (e.g., an internal self-test failure), the SEL-751 will set 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 will always indicate FALSE (0). See the ACSELERATOR Architect online help for additional information on GOOSE Quality attributes.

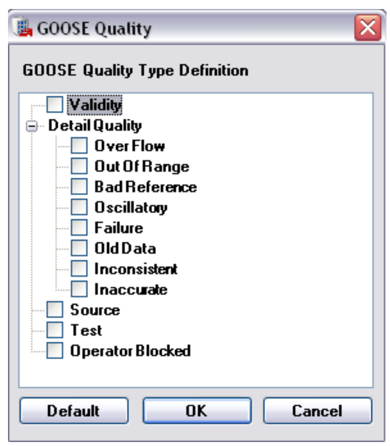


Figure F.3 GOOSE Quality

GOOSE Processing

SEL devices support GOOSE processing as defined by IEC 61850-7-1:2003(E), IEC 61850-7-2:2003(E), and IEC 61850-8-1:2004(E) via the installed Ethernet port. Outgoing GOOSE messages are processed in accordance with the following constraints:

- ➤ You can define as many as eight outgoing GOOSE messages consisting of any Data Attribute (DA) from any logical node. You can map a single DA to one or more outgoing GOOSE, or one or more times within the same outgoing GOOSE. You can also map a single GOOSE dataset to multiple GOOSE control blocks.
- ➤ The SEL-751 transmits all configured GOOSE immediately upon successful initialization. If a GOOSE is not retriggered, then, following initial transmission, the SEL-751 will retransmit that GOOSE on a curve. The curve begins at 10 ms and doubles for each retransmission until leveling at the

maximum specified in the CID file for that GOOSE. For example, a message with a maximum retransmit interval of 100 ms is retransmitted at intervals of 10 ms, 20 ms, 40 ms, 80 ms, and 100 ms, then repeated every 100 ms until a trigger causes the transmission sequence to be repeated. The time-to-live reported in each transmitted message, is three times the current interval, or two times the interval, if the maximum time-to-live has been reached (30 ms, 60 ms, 120 ms, 240 ms, and 200 ms for the previous example; see IEC 61850-8-1, sec. 18.1).

- GOOSE transmission is squelched (silenced) after a permanent (latching) self-test failure.
- Each outgoing GOOSE includes communications parameters (VLAN, Priority, and Multicast Address) and is transmitted entirely in a single network frame.
- The SEL-751 maintains the configuration of outgoing GOOSE through a power cycle and device reset.

Incoming GOOSE messages are processed in accordance with the following constraints:

- You can configure the SEL-751 to subscribe to as many as 16 incoming GOOSE messages.

  The SEL-751 recognizes incoming GOOSE messages as valid based on the following content. Any GOOSE message that fails these checks is rejected.
  - Source broadcast MAC address
  - Dataset Reference
  - Application ID
  - GOOSE Control Reference
- Rejection of all DA contained in an incoming GOOSE, based on the accumulation of the following error indications created by inspection of the received GOOSE:
  - **Configuration Mismatch**: the configuration number of the incoming GOOSE changes.
  - **Needs Commissioning**: this Boolean parameter of the incoming GOOSE is true.
  - **Test Mode**: this Boolean parameter of the incoming GOOSE is true.
  - **Decode Error**: the format of the incoming GOOSE is not as configured.
- The SEL-751 discards incoming GOOSE under the following conditions:
  - after a permanent (latching) self-test failure
  - when the relay is disabled
  - when EGSE is set to No

Link-layered priority tagging and virtual LAN is supported as described in Annex C of IEC 61850-8-1:2004(E).

IEC 61850 Configuration

Settings

Table F.6 lists IEC 61850 settings. IEC 61850 settings are only available if your device includes the optional IEC 61850 protocol.

Table F.6 IEC 61850 Settings

Label	Description	Range	Default
E61850	IEC 61850 interface enable	Y, N	N
EGSE	Outgoing IEC 61850 GSE message enable	Y[a], N	N

[a] Requires E61850 set to Y to send IEC 61850 GSE messages.

Configure all other IEC 61850 settings, including subscriptions to incoming GOOSE messages, with ACSELERATOR Architect.

ACSELERATOR Architect

The ACSELERATOR Architect software enables protection and integration engineers to design and commission IEC 61850 substations containing SEL IEDs.

Engineers can use ACSELERATOR Architect to:

- ➤ Organize and configure all SEL IEDs in a substation project
- ➤ Configure incoming and outgoing GOOSE messages
- ➤ Read non-SEL IED Capability Description (ICD) and Configured IED Description (CID) files and determine the available IEC 61850 messaging options
- ➤ Load device settings and IEC 61850 CID files into SEL IEDs
- ➤ Generate ICD files that will provide SEL IED descriptions to other manufacturer's tools so they can use SEL GOOSE messages and reporting features
- ➤ Configure protection, logic, control, and communications settings of all SEL IEDs in the substation

NOTE: Any device bits mapped to GOOSE subscriptions retain state until overwritten or the device restarts. When loading a new CID file, be sure to issue an **STA C** command or cycle power to the device to clear the device bits if the configuration has changed.

ACSELERATOR Architect provides a Graphical User Interface (GUI) for engineers to select, edit, and create IEC 61850 GOOSE messages important for substation protection, coordination, and control schemes. Typically, the engineer first places icons representing IEDs in a substation container, then edits the outgoing GOOSE messages or creates new ones for each IED. The engineer can also select incoming GOOSE messages for each IED to receive from any other IEDs in the domain. ACSELERATOR Architect has the capability to read other manufacturer's ICD and CID files, enabling the engineer to map the data seamlessly into SEL IED logic. See the ACSELERATOR Architect Instruction Manual or online help for more information.

SEL ICD File Versions

ACSELERATOR Architect version R.1.1.69.0 and later supports multiple ICD file versions for each type of IED in a project. Relays with different firmware versions can require different CID file versions, so you can manage the CID files of all IEDs within a single project.

Please ensure that you work with the appropriate version of ACSELERATOR Architect relative to your current configuration, existing project files, and ultimate goals. If you want the best available IEC 61850 functionality for your SEL relay, obtain the latest version of ACSELERATOR Architect and select the appropriate ICD version(s) for your needs. As of this writing, ACSELERATOR Architect comes with two versions of the SEL-751 ICD file for use with new or existing projects. Ensure that you use the “SEL_751 004 R106 and above” version for configuration of the SEL-751. Use of this file requires SEL-751 firmware version R106 or higher. Note that the ICD file version “SEL_751 004 R105 and earlier” can be used with firmware versions R105 and earlier, as well as with newer firmware versions.

Logical Node Extensions

The following Logical Nodes and Data Classes were created in this device as extensions to the IEC 61850 standard, in accordance with IEC 61850 guidelines.

Table F.7 New Logical Node Extensions

Logical Node	IEC 61850	Description or Comments
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 for Thermal Monitoring.
Demand Metering Statistics	MDST	This LN shall be used for calculation of demand currents in a three-phase system. This shall not be used for billing purposes.
Circuit Breaker Supervision	SCBR	Circuit breaker supervision abrasion and operation values.

Table F.8 defines the data class Arc-Flash Detection. This class represents Arc-Flash Detection status.

Table F.8 Arc-Flash Detection

PAFD Class				
Attribute Name	**Attr. Type**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		Shall be inherited from Logical-Node Class (see IEC 61850-7-2).		
Data				
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Status Information				
Str	ACD	Start		E
Op	ACT	Operate	T	E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table F.9 defines the data class, Thermal Metering Data. This class is a collection of simultaneous measurements (or evaluations) that represent the RTD thermal metering values. Valid data depend on the presence and configuration of the RTD module(s).

Table F.9 Thermal Metering Data Logical Node Class Definition

MTHR Class				
Attribute Name	**Attr. Type**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and the LN-Instance-ID according to IEC 61850-7-2.		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
EEHealth	INS	External equipment health (RTD Communications Status)		E
Data Objects				
Measured values				
MaxAmbTmp	MV	Maximum Ambient Temperature		E
MaxBrgTmp	MV	Maximum Bearing Temperature		E
MaxOthTmp	MV	Maximum Other Temperature		E
MaxWdgTmp	MV	Maximum Winding Temperature		E
Tmp	MV	Temperature		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table F.10 defines the data class Demand Metering Statistics. This class is a collection of demand currents and energy.

Table F.10 Demand Metering Statistics Logical Node Class Definition

MDST Class				
Attribute Name	**Attr. Type**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and the LN-Instance-ID according to IEC 61850-7-2.		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Measured values				
DmdA	WYE	Demand Currents		E
PkDmdA	WYE	Peak Demand Currents		E
SupWh	MV	Real energy supply (default supply direction: energy flow towards busbar)		E
SupVArh	MV	Reactive energy supply (default supply direction: energy flow towards busbar)		E
DmdWh	MV	Real energy demand (default demand direction: energy flow from busbar away)		E
DmdVArh	MV	Reactive energy demand (default demand direction: energy flow from busbar away)		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table F.11 Circuit Breaker Supervision (Per-Phase) Logical Node Class Definition

SCBR Class				
Attribute Name	**Attr. Type**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and the LN-Instance-ID according to IEC 61850-7-2.		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Status Information				
ColOpn	SPS	Open command of trip coil		M
Measured Values				
AbrPrt	MV	Calculated or measured wear (e.g. of main contact), expressed in % where 0 % corresponds to new condition		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table F.12 Compatible Logical Nodes With Extensions

Logical Node	IEC 61850	Description or comments
Metering Statistics	MSTA	This LN is used for power system metering statistics.
Circuit Breaker	XCBR	This LN is used for circuit breaker status and measurement data.
Generic Process I/O	GGIO	This LN is used for Remote Analog data.

Table F.13 Metering Statistics Logical Node Class Definition (Sheet 1 of 2)

MSTA Class				
Attribute Name	**Attr. Type**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and the LN-Instance-ID according to IEC 61850-7-2.		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Measured and Metered values				
AvAmps	MV	Average Current		O
AvVolts	MV	Average Voltage		O
MaxVA	MV	Maximum apparent power		O
MinVA	MV	Minimum apparent power		O
MaxW	MV	Maximum real power		O
MinW	MV	Minimum real power		O
MaxVAr	MV	Maximum reactive power		O
MinVAr	MV	Minimum reactive power		O
MaxA	WYE	Maximum Phase Currents		E
MinA	WYE	Minimum Phase Currents		E
MaxPhV	WYE	Maximum Phase to Ground Voltages		E

Table F.13 Metering Statistics Logical Node Class Definition (Sheet 2 of 2)

MSTA Class				
Attribute Name	**Attr. Type**	**Explanation**	**T[a]**	**M/O/ C/E[b]**
MinPhV	WYE	Minimum Phase to Ground Voltages		E
MaxP2PV	DEL	Maximum Phase to Phase Voltages		E
MinP2PV	DEL	Minimum Phase to Phase Voltages		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension

Table F.14 Circuit Breaker Logical Node Class Definition

XCBR Class				
Attribute Name	**Attr. Type**	**Explanation**	**T[a]**	**M/O/ C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and the LN-Instance-ID according to IEC 61850-7-2.		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Status Information				
Loc	SPS	Local control behavior		M
OpCnt	INS	Operation counter		M
OpCntEx	INS	Operation counter – external		E
Measured and Metered values				
Pos	DPC	Switch position		M
BlkOpn	SPC	Block opening		M
BlkCls	SPC	Block closing		M

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table F.15 Generic Process I/O Logical Node Class Definition (Sheet 1 of 2)

GGIO Class				
Attribute Name	**Attr. Type**	**Explanation**	**T[a]**	**M/O/ C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and the LN-Instance-ID according to IEC 61850-7-2.		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Measured values				
AnIn	MV	Analog input		O
Ra	MV	Remote analog		E
Controls				
SPCSO	SPC	Single point controllable status output		O

Table F.15 Generic Process I/O Logical Node Class Definition (Sheet 2 of 2)

GGIO Class				
Attribute Name	**Attr. Type**	**Explanation**	**T**[a]	**M/O/ C/E**[b]
Status Information				
Ind	SPS	General indication (binary input)		O

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Logical Nodes

The following tables, *Table F.16* through *Table F.20*, show the Logical Nodes (LN) supported in the SEL-751 and the associated Relay Word bits or measured quantities. *Table F.16* shows the LN associated with protection elements defined as Logical Device PRO.

Table F.16 Logical Device: PRO (Protection) (Sheet 1 of 8)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = CO			
BKR1CSWI1	Pos.Oper.ctlVal	CC[a]	Breaker close/open command
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PARTNO	Part number
Functional Constraint = 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	Phase A time-overcurrent element trip
ATPTOC20	Str.general	51AP	Phase A time-overcurrent element pickup
ATPTOC20	Str.dirGeneral	unknown	Direction unknown due to settings
BFR1RBRF1	OpEx.general	BFT	Breaker failure trip
BFR1RBRF1	Str.general	BFI	Breaker failure initiation
BK1XCBR1	BlkCls.stVal	0	Breaker close blocking not configured by default
BK1XCBR1	BlkOpn.stVal	0	Breaker open blocking not configured by default
BK1XCBR1	CBOpCap.stVal	None	Breaker/Contactor physical operation capabilities not known to relay
BK1XCBR1	Loc.stVal	0	Breaker/Contactor local control status not configured by default
BK1XCBR1	OpCnt.stVal	INTT	Internal trip counter
BK1XCBR1	OpCntEx.stVal	EXTT	External trip counter
BK1XCBR1	Pos.stVal	52A?1:2[b]	Breaker position (52A = false, breaker opened; 52A = true, breaker closed)
BKR1CSWI1	OpCls.general	CC	Breaker close control
BKR1CSWI1	OpOpn.general	OC	Breaker open control
BKR1CSWI1	Pos.stVal	52A?1:2[b]	Breaker position (52A = false, breaker opened; 52A = true, breaker closed)
BTPTOC21	Op.general	51BT	Phase B time-overcurrent element trip

Table F.16 Logical Device: PRO (Protection) (Sheet 2 of 8)

Logical Node	Attribute	Data Source	Comment
BTPTOC21	Str.general	51BP	Phase B time-overcurrent element pickup
BTPTOC21	Str.dirGeneral	unknown	Direction unknown due to settings
CTPTOC22	Op.general	51CT	Phase C time-overcurrent element trip
CTPTOC22	Str.general	51CP	Phase C time-overcurrent element pickup
CTPTOC22	Str.dirGeneral	unknown	Direction unknown due to settings
D1TPTOF1	Op.general	81D1T	Level 1 trip definite time over/underfrequency elements
D1TPTOF1	Str.general	81D1T	Level 1 trip definite time over/underfrequency elements
D1TPTOF1	Str.dirGeneral	unknown	Direction undefined
D2TPTOF2	Op.general	81D2T	Level 2 trip definite time over/underfrequency elements
D2TPTOF2	Str.general	81D2T	Level 2 trip definite time over/underfrequency elements
D2TPTOF2	Str.dirGeneral	unknown	Direction undefined
D3TPTOF3	Op.general	81D3T	Level 3 trip definite time over/underfrequency elements
D3TPTOF3	Str.general	81D3T	Level 3 trip definite time over/underfrequency elements
D3TPTOF3	Str.dirGeneral	unknown	Direction undefined
D4TPTOF4	Op.general	81D4T	Level 4 trip definite time over/underfrequency elements
D4TPTOF4	Str.general	81D4T	Level 4 trip definite time over/underfrequency elements
D4TPTOF4	Str.dirGeneral	unknown	Direction undefined
D5TPTOF5	Op.general	81D5T	Level 5 trip definite time over/underfrequency elements
D5TPTOF5	Str.general	81D5T	Level 5 trip definite time over/underfrequency elements
D5TPTOF5	Str.dirGeneral	unknown	Direction undefined
D6TPTOF6	Op.general	81D6T	Level 6 trip definite time over/underfrequency elements
D6TPTOF6	Str.general	81D6T	Level 6 trip definite time over/underfrequency elements
D6TPTOF6	Str.dirGeneral	unknown	Direction undefined
G1TPIOC9	Op.general	50G1T	Level 1 residual ground instantaneous overcurrent element trip
G1TPIOC9	Str.general	50G1P	Level 1 residual ground instantaneous overcurrent element pickup
G1TPIOC9	Str.dirGeneral	unknown	Direction undefined
G1TPTOC17	Op.general	51G1T	Level 1 residual ground time-overcurrent element trip
G1TPTOC17	Str.general	51G1P	Level 1 residual ground time-overcurrent element pickup
G1TPTOC17	Str.dirGeneral	unknown	Direction unknown due to settings
G1TPTOV8	Op.general	59G1T	Level 1 zero-sequence instantaneous overvoltage element trip
G1TPTOV8	Str.general	59G1	Level 1 zero-sequence instantaneous overvoltage element pickup
G1TPTOV8	Str.dirGeneral	unknown	Direction undefined
G2TPIOC10	Op.general	50G2T	Level 2 residual ground instantaneous overcurrent element trip
G2TPIOC10	Str.general	50G2P	Level 2 residual ground instantaneous overcurrent element pickup
G2TPIOC10	Str.dirGeneral	unknown	Direction undefined
G2TPTOC18	Op.general	51G2T	Level 2 residual ground time-overcurrent element trip
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

Table F.16 Logical Device: PRO (Protection) (Sheet 3 of 8)

Logical Node	Attribute	Data Source	Comment
G3TPIOC11	Op.general	50G3T	Level 3 residual ground instantaneous overcurrent element trip
G3TPIOC11	Str.general	50G3P	Level 3 residual ground instantaneous overcurrent element pickup
G3TPIOC11	Str.dirGeneral	unknown	Direction undefined
G4TPIOC12	Op.general	50G4T	Level 4 residual ground instantaneous overcurrent element trip
G4TPIOC12	Str.general	50G4P	Level 4 residual ground instantaneous overcurrent element pickup
G4TPIOC12	Str.dirGeneral	unknown	Direction undefined
GFPIOC21	Op.general	50GF	Residual forward direction decision supervision
GFPIOC21	Str.general	50GF	Residual forward direction decision supervision
GFPIOC21	Str.dirGeneral	unknown	Direction undefined
GFRDIR1	Dir.general	DIRGF	Forward directional control routed to residual ground overcurrent elements
GFRDIR1	Dir.dirGeneral	DIRGF?0:1	Forward directional control routed to residual ground overcurrent elements, direction (DIRGF = false, direction unknown; DIRGF = true, direction forward)
GRPIOC22	Op.general	50GR	Residual reverse direction decision supervision
GRPIOC22	Str.general	50GR	Residual reverse direction decision supervision
GRPIOC22	Str.dirGeneral	unknown	Direction undefined
GRRDIR1	Dir.general	DIRGR	Reverse directional control routed to residual ground overcurrent elements
GRRDIR1	Dir.dirGeneral	DIRGR?0:2	Reverse directional control routed to residual ground overcurrent elements, direction (DIRGR = false, direction unknown; DIRGR = true, direction reverse)
HIZPHIZ1	Op.phsA	HIF1_A	A-phase HIF detection
HIZPHIZ1	Op.phsB	HIF1_B	B-phase HIF detection
HIZPHIZ1	Op.phsC	HIF1_C	C-phase HIF detection
HIZPHIZ1	Op.general	OREDHIF1	HIF1_A OR HIF1_B OR HIF1_C
HIZPHIZ1	Str.general	OREDHIF1	HIF1_A OR HIF1_B OR HIF1_C
HIZPHIZ1	Str.dirGeneral	unknown	Direction undefined
HIZPHIZ2	Op.phsA	HIF2_A	A-phase HIF detection
HIZPHIZ2	Op.phsB	HIF2_B	B-phase HIF detection
HIZPHIZ2	Op.phsC	HIF2_C	C-phase HIF detection
HIZPHIZ2	Op.general	OREDHIF2	HIF2_A OR HIF2_B OR HIF2_C
HIZPHIZ2	Str.general	OREDHIF2	HIF2_A OR HIF2_B OR HIF2_C
HIZPHIZ2	Str.dirGeneral	unknown	Direction undefined
LOPPTUV5	Op.general	LOP	Loss of potential
LOPPTUV5	Str.general	LOP	Loss of potential
LOPPTUV5	Str.dirGeneral	unknown	Direction undefined
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

Table F.16 Logical Device: PRO (Protection) (Sheet 4 of 8)

Logical Node	Attribute	Data Source	Comment
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
P2TPTOV2	Op.general	59P2T	Level 2 phase overvoltage element trip
P2TPTOV2	Str.general	59P2	Level 2 phase overvoltage element pickup
P2TPTOV2	Str.dirGeneral	unknown	Direction undefined
P2TPTUV2	Op.general	27P2T	Level 2 phase undervoltage element trip
P2TPTUV2	Str.general	27P2	Level 2phase undervoltage element pickup
P2TPTUV2	Str.dirGeneral	unknown	Direction undefined
P3PTOV5	Op.general	3P59	3-phase overvoltage pickup when all 3 phases are above 59P1P
P3PTOV5	Str.general	3P59	3-phase overvoltage pickup when all 3 phases are above 59P1P

Table F.16 Logical Device: PRO (Protection) (Sheet 5 of 8)

Logical Node	Attribute	Data Source	Comment
P3PTOV5	Str.dirGeneral	unknown	Direction undefined
P3PTUV6	Op.general	3P27	3-phase undervoltage pickup when all 3 phases are below 27P1P
P3PTUV6	Str.general	3P27	3-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
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

Table F.16 Logical Device: PRO (Protection) (Sheet 6 of 8)

Logical Node	Attribute	Data Source	Comment
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)
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)
PWR1PDOP1	Op.general	3PWR1T	3-Phase Power Element 1 trip
PWR1PDOP1	Str.general	3PWR1P	3-Phase Power Element 1 pickup
PWR1PDOP1	Str.dirGeneral	unknown	Direction undefined
PWR1PDUP1	Op.general	3PWR1T	3-Phase Power Element 1 trip
PWR1PDUP1	Str.general	3PWR1P	3-Phase Power Element 1 pickup
PWR1PDUP1	Str.dirGeneral	unknown	Direction undefined
PWR2PDOP1	Op.general	3PWR2T	3-Phase Power Element 2 trip
PWR2PDOP1	Str.general	3PWR2P	3-Phase Power Element 2 pickup
PWR2PDOP1	Str.dirGeneral	unknown	Direction undefined
PWR2PDUP1	Op.general	3PWR2T	3-Phase Power Element 2 trip
PWR2PDUP1	Str.general	3PWR2P	3-Phase Power Element 2 pickup
PWR2PDUP1	Str.dirGeneral	unknown	Direction undefined
Q1TPIOC13	Op.general	50Q1T	Level 1 negative-sequence instantaneous overcurrent element trip
Q1TPIOC13	Str.general	50Q1P	Level 1 negative-sequence instantaneous overcurrent element pickup

Table F.16 Logical Device: PRO (Protection) (Sheet 7 of 8)

Logical Node	Attribute	Data Source	Comment
Q1TPIOC13	Str.dirGeneral	unknown	Direction undefined
Q1TPTOV10	Op.general	59Q1T	Negative-sequence instantaneous overvoltage element trip
Q1TPTOV10	Str.general	59Q1	Negative-sequence instantaneous overvoltage element pickup
Q1TPTOV10	Str.dirGeneral	unknown	Direction undefined
Q2TPIOC14	Op.general	50Q2T	Level 2 negative-sequence instantaneous overcurrent element trip
Q2TPIOC14	Str.general	50Q2P	Level 2 negative-sequence instantaneous overcurrent element pickup
Q2TPIOC14	Str.dirGeneral	unknown	Direction undefined
Q2TPTOV11	Op.general	59Q2T	Negative-sequence instantaneous overvoltage element trip
Q2TPTOV11	Str.general	59Q2	Negative-sequence instantaneous overvoltage element pickup
Q2TPTOV11	Str.dirGeneral	unknown	Direction undefined
Q3TPIOC15	Op.general	50Q3T	Level 3 negative-sequence instantaneous overcurrent element trip
Q3TPIOC15	Str.general	50Q3P	Level 3 negative-sequence instantaneous overcurrent element pickup
Q3TPIOC15	Str.dirGeneral	unknown	Direction undefined
Q4TPIOC16	Op.general	50Q4T	Level 4 negative-sequence instantaneous overcurrent element trip
Q4TPIOC16	Str.general	50Q4P	Level 4 negative-sequence instantaneous overcurrent element pickup
Q4TPIOC16	Str.dirGeneral	unknown	Direction undefined
QFPIOC19	Op.general	50QF	Negative-sequence forward direction decision supervision
QFPIOC19	Str.general	50QF	Negative-sequence forward direction decision supervision
QFPIOC19	Str.dirGeneral	unknown	Direction undefined
QFRDIR1	Dir.general	DIRQF	Forward directional control routed to negative sequence overcurrent elements
QFRDIR1	Dir.dirGeneral	DIRQF?0:1	Forward directional control routed to negative sequence overcurrent elements, direction (DIRQF = false, direction unknown; DIRQF = true, direction forward)
QRPIOC20	Op.general	50QR	Negative-sequence reverse direction decision supervision
QRPIOC20	Str.general	50QR	Negative-sequence reverse direction decision supervision
QRPIOC20	Str.dirGeneral	unknown	Direction undefined
QRRDIR1	Dir.general	DIRQR	Reverse directional control routed to negative sequence overcurrent elements
QRRDIR1	Dir.dirGeneral	DIRQR?0:2	Reverse directional control routed to negative sequence overcurrent elements, direction (DIRQR = false, direction unknown; DIRQR = true, direction reverse
QTPTOC19	Op.general	51QT	Negative-sequence time-overcurrent element trip
QTPTOC19	Str.general	51QP	Negative-sequence time-overcurrent element pickup
QTPTOC19	Str.dirGeneral	unknown	Direction unknown due to settings
R1TPFRC1	Op.general	81R1T	Level 1 rate-of-change-of-frequency element trip
R1TPFRC1	Str.general	81R1T	Level 1 rate-of-change-of-frequency element trip
R1TPFRC1	Str.dirGeneral	unknown	Direction undefined
R2TPFRC2	Op.general	81R2T	Level 2 rate-of-change-of-frequency element trip
R2TPFRC2	Str.general	81R2T	Level 2 rate-of-change-of-frequency element trip
R2TPFRC2	Str.dirGeneral	unknown	Direction undefined
R3TPFRC3	Op.general	81R3T	Level 3 rate-of-change-of-frequency element trip
R3TPFRC3	Str.general	81R3T	Level 3 rate-of-change-of-frequency element trip

Table F.16 Logical Device: PRO (Protection) (Sheet 8 of 8)

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	81R4T	Level 4 rate-of-change-of-frequency element trip
R4TPFRC4	Str.dirGeneral	unknown	Direction undefined
S1TPTOV6	Op.general	59S1T	Level 1 VS channel overvoltage element with time delay
S1TPTOV6	Str.general	59S1	Level 1 VS channel overvoltage element pickup
S1TPTOV6	Str.dirGeneral	unknown	Direction undefined
S1TPTUV7	Op.general	27S1T	Level 1 VS channel undervoltage element with time delay
S1TPTUV7	Str.general	27S1	Level 1 VS channel undervoltage element pickup
S1TPTUV7	Str.dirGeneral	unknown	Direction undefined
S2TPTOV7	Op.general	59S2T	Level 2 VS channel overvoltage element with time delay
S2TPTOV7	Str.general	59S2	Level 2 VS channel overvoltage element pickup
S2TPTOV7	Str.dirGeneral	unknown	Direction undefined
S2TPTUV8	Op.general	27S2T	Level 2 VS channel undervoltage element with time delay
S2TPTUV8	Str.general	27S2	Level 2 VS channel undervoltage element pickup
S2TPTUV8	Str.dirGeneral	unknown	Direction undefined
T55POPF2	Op.general	55T	Power factor trip
T55POPF2	Str.general	55T	Power factor trip
T55POPF2	Str.dirGeneral	unknown	Direction undefined
TOL1PAFD1	Op.general	TOL1	Arc-Flash Light Input 1 element pickup
TOL1PAFD1	Str.general	TOL1	Arc-Flash Light Input 1 element pickup
TOL1PAFD1	Str.dirGeneral	unknown	Direction undefined
TOL2PAFD2	Op.general	TOL2	Arc-Flash Light Input 2 element pickup
TOL2PAFD2	Str.general	TOL2	Arc-Flash Light Input 2 element pickup
TOL2PAFD2	Str.dirGeneral	unknown	Direction undefined
TOL3PAFD3	Op.general	TOL3	Arc-Flash Light Input 3 element pickup
TOL3PAFD3	Str.general	TOL3	Arc-Flash Light Input 3 element pickup
TOL3PAFD3	Str.dirGeneral	unknown	Direction undefined
TOL4PAFD4	Op.general	TOL4	Arc-Flash Light Input 4 element pickup
TOL4PAFD4	Str.general	TOL4	Arc-Flash Light Input 4 element pickup
TOL4PAFD4	Str.dirGeneral	unknown	Direction undefined
TRIPPTRC1	Tr.general	TRIP	Trip logic output

Table F.17 shows the LN associated with measuring elements defined as Logical Device MET.

Table F.17 Logical Device: MET (Metering) (Sheet 1 of 4)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PARTNO	Part number
Functional Constraint = MX[a b]			
DCZBAT1	Vol.instMag.f	VDC	Station dc battery voltage

Table F.17 Logical Device: MET (Metering) (Sheet 2 of 4)

Logical Node	Attribute	Data Source	Comment
METMDST1	DmdA.nseq.instCVal.mag.f	3I2D	Negative-sequence current demand
METMDST1	DmdA.phsA.instCVal.mag.f	IAD	Phase A current demand
METMDST1	DmdA.phsB.instCVal.mag.f	IBD	Phase B current demand
METMDST1	DmdA.phsC.instCVal.mag.f	ICD	Phase C current demand
METMDST1	DmdA.res.instCVal.mag.f	IGD	Residual current demand
METMDST1	DmdVArh.instMag.f	MVARH3PO	3-phase reactive energy OUT
METMDST1	DmdWh.instMag.f	MWH3P	3-phase real energy OUT
METMDST1	PkDmdA.nseq.instCVal.mag.f	3I2PD	Negative-sequence current peak demand
METMDST1	PkDmdA.phsA.instCVal.mag.f	IAPD	Phase A current peak demand
METMDST1	PkDmdA.phsB.instCVal.mag.f	IBPD	Phase B current peak demand
METMDST1	PkDmdA.phsC.instCVal.mag.f	ICPD	Phase C current peak demand
METMDST1	PkDmdA.res.instCVal.mag.f	IGPD	Residual current peak demand
METMDST1	SupVArh.instMag.f	MVARH3PI	Reactive energy, 3-phase IN
METMDST1	SupWh.instMag.f	MWH3PI	3-phase real energy IN
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

Table F.17 Logical Device: MET (Metering) (Sheet 3 of 4)

Logical Node	Attribute	Data Source	Comment
METMMXU1	PPV.phsCA.instCVal.mag.f	VCA_MAG	Voltage, C-to-A-phase, magnitude
METMMXU1	TotPF.instMag.f	PF	Power factor, 3-phase, magnitude
METMMXU1	TotVA.instMag.f	S	Apparent power, 3-phase, magnitude
METMMXU1	TotVAr.instMag.f	Q	Reactive power, 3-phase, magnitude
METMMXU1	TotW.instMag.f	P	Real power, 3-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
METMMXU1	W.phsC.instCVal.mag.f	PC	Real power, C-phase, magnitude
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	I2_MAG	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	V2_MAG	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

Table F.17 Logical Device: MET (Metering) (Sheet 4 of 4)

Logical Node	Attribute	Data Source	Comment
METMSTA1	MaxVA.instMag.f	KVA3PMX	Apparent power, 3-phase, maximum magnitude
METMSTA1	MaxVAr.instMag.f	KVAR3PMX	Reactive power, 3-phase, maximum magnitude
METMSTA1	MaxW.instMag.f	KW3PMX	Real power, 3-phase, maximum magnitude
METMSTA1	MinA.phsA.instCVal.mag.f	IAMN	Current, A-phase, minimum magnitude
METMSTA1	MinA.phsB.instCVal.mag.f	IBMN	Current, B-phase, minimum magnitude
METMSTA1	MinA.phsC.instCVal.mag.f	ICMN	Current, C-phase, minimum magnitude
METMSTA1	MinA.res.instCVal.mag.f	IGMN	Current, residual, minimum magnitude
METMSTA1	MinA.neut.instCVal.mag.f	INMN	Current, neutral, minimum magnitude
METMSTA1	MinP2PV.phsAB.instCVal.mag.f	VABMN	Voltage, A-to-B-phase, minimum magnitude
METMSTA1	MinP2PV.phsBC.instCVal.mag.f	VBCMN	Voltage, B-to-C-phase, minimum magnitude
METMSTA1	MinP2PV.phsCA.instCVal.mag.f	VCAMN	Voltage, C-to-A-phase, minimum magnitude
METMSTA1	MinPhV.phsA.instCVal.mag.f	VAMN	Voltage, A-phase-to-neutral, minimum magnitude
METMSTA1	MinPhV.phsB.instCVal.mag.f	VBMN	Voltage, B-phase-to-neutral, minimum magnitude
METMSTA1	MinPhV.phsC.instCVal.mag.f	VCMN	Voltage, C-phase-to-neutral, minimum magnitude
METMSTA1	MinVA.instMag.f	KVA3PMN	Apparent power, 3-phase, minimum magnitude
METMSTA1	MinVAr.instMag.f	KVAR3PMN	Reactive power, 3-phase, minimum magnitude
METMSTA1	MinW.instMag.f	KW3PMN	Real power, 3-phase, minimum magnitude
RMSMMXU2	A.phsA.instCVal.mag.f	IARMS	RMS current, A-phase, magnitude
RMSMMXU2	A.phsB.instCVal.mag.f	IBRMS	RMS current, B-phase, magnitude
RMSMMXU2	A.phsC.instCVal.mag.f	ICRMS	RMS current, C-phase, magnitude
RMSMMXU2	A.neut.instCVal.mag.f	INRMS	RMS current, neutral, magnitude
RMSMMXU2	PhV.phsA.instCVal.mag.f	VARMS	RMS voltage, A-phase, magnitude
RMSMMXU2	PhV.phsB.instCVal.mag.f	VBRMS	RMS voltage, B-phase, magnitude
RMSMMXU2	PhV.phsC.instCVal.mag.f	VCRMS	RMS voltage, C-phase, magnitude
RMSMMXU2	PPV.phsAB.instCVal.mag.f	VABRMS	RMS voltage, AB-phase-to-phase, magnitude
RMSMMXU2	PPV.phsBC.instCVal.mag.f	VBCRMS	RMS voltage, BC-phase-to-phase, magnitude
RMSMMXU2	PPV.phsCA.instCVal.mag.f	VCARMS	RMS voltage, CA-phase-to-phase, magnitude
THERMMTHR1	MaxAmbTmp.instMag.f	RTDAMB[c]	Ambient RTD temperature
THERMMTHR1	MaxBrgTmp.instMag.f	RTDBRGMX[3]	Maximum bearing RTD temperature
THERMMTHR1	MaxOthTmp.instMag.f	RTDOTHMX[3]	Other maximum RTD temperature
THERMMTHR1	MaxWdgTmp.instMag.f	RTDWDGMX[3]	Maximum winding RTD temperature
THERMMTHR1	Tmp01.instMag.f–Tmp12.instMag.f	RTD1 - RTD12[3]	RTD1–RTD12 temperature
Functional Constraint = ST			
DCZBAT1	BatHi.stVal	DCHI	Station dc battery instantaneous overvoltage element
DCZBAT1	BatLo.stVal	DCLO	Station dc battery instantaneous undervoltage element
THERMMTHR1	EEHealth.stVal	RTDFLT?1:3[3]	RTD input or communication status

[a] MX values contain instantaneous attributes (instMag and instCVal), which are updated whenever the source updates and other attributes which are only updated when the source goes outside the data sources dead band (mag and cVal). Only the instantaneous values are shown in the table.
[b] Data validity depends on the relay model and installed card options. Refer to Section 1: Introduction and Specifications for different relay models and available card options. Refer to Section 5: Metering and Monitoring for the model dependent metering quantities.
[c] Valid data depend on E49RTD and RTD1LOC–RTD12LOC settings.

Table F.18 shows the LN associated with control elements defined as Logical Device CON.

Table F.18 Logical Device: CON (Remote Control)

Logical Node	Status	Control	Relay Word Bit	Comment
RBGGIO1	SPCSO01.stVal–SPCSO08.stVal	SPCSO01.Oper.ctlVal–SPCSO08.Oper.ctlVal	RB01–RB08	Remote Bits RB01–RB08
RBGGIO2	SPCSO09.stVal–SPCSO16.stVal	SPCSO09.Oper.ctlVal–SPCSO16.Oper.ctlVal	RB09–RB16	Remote Bits RB09–RB16
RBGGIO3	SPCSO17.stVal–SPCSO24.stVal	SPCSO17.Oper.ctlVal–SPCSO24.Oper.ctlVal	RB17–RB24	Remote Bits RB17–RB24
RBGGIO4	SPCSO25.stVal–SPCSO32.stVal	SPCSO25.Oper.ctlVal–SPCSO32.Oper.ctlVal	RB25–RB32	Remote Bits RB25–RB32

Table F.19 shows the LN associated with annunciation elements defined as Logical Device ANN.

Table F.19 Logical Device: ANN (Annunciation) (Sheet 1 of 5)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PARTNO	Part number
Functional Constraint = MX[a]			
AINCGGIO21	AnIn01.instMag.f–AnIn08.instMag.f	AI301–AI308[b]	Analog inputs (AI301 to AI308)—Slot C
AINDGGIO22	AnIn01.instMag.f–AnIn08.instMag.f	AI401–AI408[2]	Analog inputs (AI401 to AI408)—Slot D
AINEGGIO23	AnIn01.instMag.f–AnIn08.instMag.f	AI501–AI508[2]	Analog inputs (AI501 to AI508)—Slot E
BWASCBR1	AbrPrt.instMag.f	WEARA	Breaker–Contact A wear
BWBSCBR2	AbrPrt.instMag.f	WEARB	Breaker–Contact B wear
BWCSCBR3	AbrPrt.instMag.f	WEARC	Breaker–Contact C wear
LSGGIO35	AnIn01.instMag.f–AnIn04.instMag.f	LSENS1–LSENS4[c]	Arc-flash sensor light (LSENS1–LSENS4)
MVGGIO12	AnIn01.instMag.f–AnIn32.instMag.f	MV01–MV32[d]	Math variables (MV01 to MV32)
PWRGGIO34	AnIn01.instMag.f	KWADI[e]	Real power, A-phase demand IN
PWRGGIO34	AnIn02.instMag.f	KWBDI[5]	Real power, B-phase demand IN
PWRGGIO34	AnIn03.instMag.f	KWCDI[5]	Real power, C-phase demand IN
PWRGGIO34	AnIn04.instMag.f	KW3DI[5]	Real power, 3-phase demand IN
PWRGGIO34	AnIn05.instMag.f	KVARADI[5]	Reactive power, A-phase demand IN
PWRGGIO34	AnIn06.instMag.f	KVARBDI[5]	Reactive power, B-phase demand IN
PWRGGIO34	AnIn07.instMag.f	KVARCDI[5]	Reactive power, C-phase demand IN
PWRGGIO34	AnIn08.instMag.f	KVAR3DI[5]	Reactive power, 3-phase demand IN
PWRGGIO34	AnIn09.instMag.f	KWADO[5]	Real power, A-phase demand OUT
PWRGGIO34	AnIn10.instMag.f	KWBDO[5]	Real power, B-phase demand OUT
PWRGGIO34	AnIn11.instMag.f	KWCDO[5]	Real power, C-phase demand OUT
PWRGGIO34	AnIn12.instMag.f	KW3DO[5]	Real power, 3-phase demand OUT
PWRGGIO34	AnIn13.instMag.f	KVARADO[5]	Reactive power, A-phase demand OUT

Table F.19 Logical Device: ANN (Annunciation) (Sheet 2 of 5)

Logical Node	Attribute	Data Source	Comment
PWRGGIO34	AnIn14.instMag.f	KVARBDO[5]	Reactive power, B-phase demand OUT
PWRGGIO34	AnIn15.instMag.f	KVARCDO[5]	Reactive power, C-phase demand OUT
PWRGGIO34	AnIn16.instMag.f	KVAR3DO[5]	Reactive power, 3-phase demand OUT
PWRGGIO34	AnIn17.instMag.f	KWAPDI[5]	Real power, A-phase peak demand IN
PWRGGIO34	AnIn18.instMag.f	KWBPDI[5]	Real power, B-phase peak demand IN
PWRGGIO34	AnIn19.instMag.f	KWCPDI[5]	Real power, C-phase peak demand IN
PWRGGIO34	AnIn20.instMag.f	KW3PDI[5]	Real power, 3-phase peak demand IN
PWRGGIO34	AnIn21.instMag.f	KVARAPDI[5]	Reactive power, A-phase peak demand IN
PWRGGIO34	AnIn22.instMag.f	KVARBPDI[5]	Reactive power, B-phase peak demand IN
PWRGGIO34	AnIn23.instMag.f	KVARCPDI[5]	Reactive power, C-phase peak demand IN
PWRGGIO34	AnIn24.instMag.f	KVAR3PDI[5]	Reactive power, 3-phase peak demand IN
PWRGGIO34	AnIn25.instMag.f	KWAPDO[5]	Real power, A-phase peak demand OUT
PWRGGIO34	AnIn26.instMag.f	KWBPDO[5]	Real power, B-phase peak demand OUT
PWRGGIO34	AnIn27.instMag.f	KWCPDO[5]	Real power, C-phase peak demand OUT
PWRGGIO34	AnIn28.instMag.f	KW3PDO[5]	Real power, 3-phase peak demand OUT
PWRGGIO34	AnIn29.instMag.f	KVARAPDO[5]	Reactive power, A-phase peak demand OUT
PWRGGIO34	AnIn30.instMag.f	KVARBPDO[5]	Reactive power, B-phase peak demand OUT
PWRGGIO34	AnIn31.instMag.f	KVARCPDO[5]	Reactive power, C-phase peak demand OUT
PWRGGIO34	AnIn32.instMag.f	KVAR3PDO[5]	Reactive power, 3-phase peak demand OUT
RAGGIO24	Ra001.instMag.f–Ra032.instMag.f	RA001–RA032	Remote analogs (RA001 to RA032)
RAGGIO25	Ra033.instMag.f–Ra064.instMag.f	RA033–RA064	Remote analogs (RA033 to RA064)
RAGGIO26	Ra065.instMag.f–Ra096.instMag.f	RA065–RA096	Remote analogs (RA065 to RA096)
RAGGIO27	Ra097.instMag.f–Ra128.instMag.f	RA097–RA128	Remote analogs (RA097 to RA128)
SCGGIO20	AnIn01.instMag.f–AnIn32.inst-Mag.f	SC01–SC32[f]	SELOGIC counters (SC01 to SC32)
Functional Constraint = ST			
BWASCBR1	ColOpn.stVal	OC	Open breaker
BWBSCBR2	ColOpn.stVal	OC	Open breaker
BWCSCBR3	ColOpn.stVal	OC	Open breaker
INAGGIO1	Ind01.stVal–Ind02.stVal	IN101–IN102	Digital inputs (IN101 to IN102)—Slot A
INCGGIO13	Ind01.stVal–Ind08.stVal	IN301–IN308[2]	Digital inputs (IN301 to IN308)—Slot C
INDGGIO15	Ind01.stVal–Ind08.stVal	IN401–IN408[2]	Digital inputs (IN401 to IN408)—Slot D
INEGGIO17	Ind01.stVal–Ind08.stVal	IN501–IN508[2]	Digital inputs (IN501 to IN508)—Slot E
LBGGIO31	Ind01.stVal–Ind32.stVal	LB01–LB32[g]	Local bits (LB01 to LB32)
LTGGIO5	Ind01.stVal–Ind32.stVal	LT01–LT32[h]	Latch bits (LT01 to LT32)
MBOKGGIO32	Ind01.stVal	ROKA	Channel A, received data ok
MBOKGGIO32	Ind02.stVal	RBADA	Channel A, outage duration over threshold
MBOKGGIO32	Ind03.stVal	CBADA	Channel A, channel unavailability over threshold
MBOKGGIO32	Ind04.stVal	LBOKA	Channel A, looped back ok
MBOKGGIO32	Ind05.stVal	ROKB	Channel B, received data ok
MBOKGGIO32	Ind06.stVal	RBADB	Channel B, outage duration over threshold

Table F.19 Logical Device: ANN (Annunciation) (Sheet 3 of 5)

Logical Node	Attribute	Data Source	Comment
MBOKGGIO32	Ind07.stVal	CBADB	Channel B, channel unavailability over threshold
MBOKGGIO32	Ind08.stVal	LBOKB	Channel B, looped back ok
MISCGGIO33	Ind01.stVal–Ind03.stVal	SG1–SG3	Setting Group 1 to 3 selection
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 Savings 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–Ind04.stVal	OUT301–OUT304[2]	Digital outputs (OUT301 to OUT304)—Slot C
OUTDGGIO16	Ind01.stVal–Ind04.stVal	OUT401–OUT404[2]	Digital outputs (OUT401 to OUT404)—Slot D
OUTEGGIO18	Ind01.stVal–Ind04.stVal	OUT501–OUT504[2]	Digital outputs (OUT501 to OUT504)—Slot E
PBLEDGGIO7	Ind01.stVal	PB1A_LED	Pushbutton PB1A LED
PBLEDGGIO7	Ind02.stVal	PB1B_LED	Pushbutton PB1B LED
PBLEDGGIO7	Ind03.stVal	PB2A_LED	Pushbutton PB2A LED
PBLEDGGIO7	Ind04.stVal	PB2B_LED	Pushbutton PB2B LED
PBLEDGGIO7	Ind05.stVal	PB3A_LED	Pushbutton PB3A LED
PBLEDGGIO7	Ind06.stVal	PB3B_LED	Pushbutton PB3B LED
PBLEDGGIO7	Ind07.stVal	PB4A_LED	Pushbutton PB4A LED
PBLEDGGIO7	Ind08.stVal	PB4B_LED	Pushbutton PB4B LED
PROGGIO29	Ind01.stVal	AFALARM	Arc-flash system integrity alarm
PROGGIO29	Ind02.stVal	FREQTRK	Frequency tracking enable bit
PROGGIO29	Ind03.stVal–Ind06.stVal	AFS1EL–AFS4EL[3]	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 ¼ cycle)
PROGGIO29	Ind09.stVal	RCSF	Reclose supervision failure (asserts for ¼ 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

Table F.19 Logical Device: ANN (Annunciation) (Sheet 4 of 5)

Logical Node	Attribute	Data Source	Comment
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–Ind32.stVal	0	Reserved for future use
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)
SVGGIO3	Ind01.stVal–Ind32.stVal	SV01–SV32[i]	SELOGIC variables (SV01 to SV32)
SVTGGIO4	Ind01.stVal–Ind32.stVal	SV01T–SV32T[9]	SELOGIC variable timers (SV01T to SV32T)
TLEDGGIO6	Ind01.stVal	ENABLED	ENABLED LED
TLEDGGIO6	Ind02.stVal	TRIP_LED	TRIP LED
TLEDGGIO6	Ind03.stVal–Ind08.stVal	TLED_01–TLED_06	Target LEDs TLED_01–TLED_06
TMBAGGIO9	Ind01.stVal–Ind08.stVal	TMB1A–TMB8A	Transmit MIRRORED BITS (TMB1A to TMB8A)
TMBBGGIO11	Ind01.stVal–Ind08.stVal	TMB1B–TMB8B	Transmit MIRRORED BITS (TMB1B to TMB8B)
TRIPGGIO28	Ind01.stVal	AMBTRIP	Ambient temperature trip
TRIPGGIO28	Ind02.stVal	BRGTRIP	Bearing temperature trip
TRIPGGIO28	Ind03.stVal	FAULT	Indicates fault condition
TRIPGGIO28	Ind04.stVal	OTHTRIP	Other temperature trip
TRIPGGIO28	Ind05.stVal	REMTRIP	Remote trip
TRIPGGIO28	Ind06.stVal	RTDFLT	Asserts when an open or short circuit condition is detected on any enabled RTD input, or communication with the external RTD module has been interrupted
TRIPGGIO28	Ind07.stVal	ULTRIP	Unlatch (auto reset) trip from SELOGIC equation

Table F.19 Logical Device: ANN (Annunciation) (Sheet 5 of 5)

Logical Node	Attribute	Data Source	Comment
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)

[a] MX values contain instantaneous attributes (instMag and instCVal), which are updated whenever the source updates and other attributes which are only updated when the source goes outside the data sources dead band (mag and cVal). Only the instantaneous values are shown in the table.
[b] Active data only if optional I/O card is installed in the slot.
[c] Active data only if optional arc-flash card is 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 F.20 Logical Device: CFG (Configuration)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PARTNO	Part number
DevIDLPHD1	PhyNam.serNum	SER_NUM	Serial number
LLN0	NamPlt.swRev	FID	Firmware revision

Protocol Implementation Conformance Statement

The following tables are as shown in the IEC 61850 standard, Part 8-1, Section 24. Note that because the standard explicitly dictates which services and functions must be implemented to achieve conformance, only the optional services and functions are listed.

Table F.21 PICS for A-Profile Support

Profile		Client	Server	Value/Comment
A1	Client/Server	N	Y	
A2	GOOSE/GSE management	Y	Y	Only GOOSE, not GSSE Management
A3	GSSE	N	N	
A4	Time Sync	N	N	

Table F.22 PICS for T-Profile Support

Profile		Client	Server	Value/Comment
T1	TCP/IP	N	Y	
T2	OSI	N	N	
T3	GOOSE/GSE	Y	Y	Only GOOSE, Not GSSE
T4	GSSE	N	N	
T5	Time Sync	Y	N	

Refer to the ACSI Conformance statements in the Reference Manual for information on the supported services.

MMS Conformance

The Manufacturing Messaging Specification (MMS) stack provides the basis for many IEC 61850 Protocol services. *Table F.23* defines the service support requirement and restrictions of the MMS services in the SEL-700 series products supporting IEC 61850. Generally, only those services whose implementation is not mandatory are shown. Refer to the IEC 61850 standard Part 8-1 for more information.

Table F.23 MMS Service Supported Conformance (Sheet 1 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
status		YES
getNameList		YES
identify		YES
rename		
read		YES
write		YES
getVariableAccessAttributes		YES
defineNamedVariable		
defineScatteredAccess		
getScatteredAccessAttributes		
deleteVariableAccess		
defineNamedVariableList		
getNamedVariableListAttributes		YES
deleteNamedVariableList		
defineNamedType		
getNamedTypeAttributes		
deleteNamedType		
input		
output		
takeControl		
relinquishControl		
defineSemaphore		
deleteSemaphore		
reportPoolSemaphoreStatus		
reportSemaphoreStatus		
initiateDownloadSequence		
downloadSegment		
terminateDownloadSequence		
initiateUploadSequence		
uploadSegment		
terminateUploadSequence		
requestDomainDownload		
requestDomainUpload		

Table F.23 MMS Service Supported Conformance (Sheet 2 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
loadDomainContent		
storeDomainContent		
deleteDomain		
getDomainAttributes		YES
createProgramInvocation		
deleteProgramInvocation		
start		
stop		
resume		
reset		
kill		
getProgramInvocationAttributes		
obtainFile		
defineEventCondition		
deleteEventCondition		
getEventConditionAttributes		
reportEventConditionStatus		
alterEventConditionMonitoring		
triggerEvent		
defineEventAction		
deleteEventAction		
alterEventEnrollment		
reportEventEnrollmentStatus		
getEventEnrollmentAttributes		
acknowledgeEventNotification		
getAlarmSummary		
getAlarmEnrollmentSummary		
readJournal		
writeJournal		
initializeJournal		
reportJournalStatus		
createJournal		
deleteJournal		
fileOpen		
fileRead		
fileClose		
fileRename		
fileDelete		
fileDirectory		
unsolicitedStatus		
informationReport		YES

Table F.23 MMS Service Supported Conformance (Sheet 3 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
eventNotification		
attachToEventCondition		
attachToSemaphore		
conclude		YES
cancel		YES
getDataExchangeAttributes		
exchangeData		
defineAccessControlList		
getAccessControlListAttributes		
reportAccessControlledObjects		
deleteAccessControlList		
alterAccessControl		
ReconfigureProgramInvocation		

Table F.24 lists specific settings for the MMS parameter Conformance Building Block (CBB).

Table F.24 MMS Parameter CBB

MMS Parameter CBB	Client-CR Supported	Server-CR Supported
STR1		YES
STR2		YES
VNAM		YES
VADR		YES
VALT		YES
TPY		YES
VLIS		YES
CEI		

The following Variable Access conformance statements are listed in the order specified in the IEC 61850 standard, Part 8-1. Generally, only those services whose implementation is not mandatory are shown. Refer to the IEC 61850 standard Part 8-1 for more information.

Table F.25 AlternateAccessSelection Conformance Statement (Sheet 1 of 2)

AlternateAccessSelection	Client-CR Supported	Server-CR Supported
accessSelection		YES
component		YES
index		
indexRange		
allElements		
alternateAccess		YES
selectAccess		YES
component		YES

Table F.25 AlternateAccessSelection Conformance Statement (Sheet 2 of 2)

AlternateAccessSelection	Client-CR Supported	Server-CR Supported
index		
indexRange		
allElements		

Table F.26 VariableAccessSpecification Conformance Statement

VariableAccessSpecification	Client-CR Supported	Server-CR Supported
listOfVariable		YES
variableSpecification		YES
alternateAccess		YES
variableListName		YES

Table F.27 VariableSpecification Conformance Statement

VariableSpecification	Client-CR Supported	Server-CR Supported
name		YES
address		
variableDescription		
scatteredAccessDescription		
invalidated		

Table F.28 Read Conformance Statement

Read	Client-CR Supported	Server-CR Supported
Request		
specificationWithResult		
variableAccessSpecification		
Response		
variableAccessSpecification		YES
listOfAccessResult		YES

Table F.29 GetVariableAccessAttributes Conformance Statement

GetVariableAccessAttributes	Client-CR Supported	Server-CR Supported
Request		
name		
address		
Response		
mmsDeletable		YES
address		
typeSpecification		YES

Table F.30 DefineNamedVariableList Conformance Statement

DefineVariableAccessAttributes	Client-CR Supported	Server-CR Supported
Request		
variableListName		
listOfVariable		
variableSpecification		
alternateAccess		
Response		

Table F.31 GetNamedVariableListAttributes Conformance Statement

GetNamedVariableListAttributes	Client-CR Supported	Server-CR Supported
Request		
ObjectName		
Response		
mmsDeletable		YES
listOfVariable		YES
variableSpecification		YES
alternateAccess		YES

Table F.32 DeleteNamedVariableList

DeleteNamedVariableList	Client-CR Supported	Server-CR Supported
Request		
Scope		
listOfVariableListName		
domainName		
Response		
numberMatched		
numberDeleted		
DeleteNamedVariableList-Error		

GOOSE Services Conformance Statement

Table F.33 GOOSE Conformance

	Subscriber	Publisher	Value/Comment
GOOSE Services	YES	YES	
SendGOOSEMessage		YES	
GetGoReference			
GetGOOSEElementNumber			
GetGoCBValues		YES	
SetGoCBValues			
GSENotSupported			
GOOSE Control Block (GoCB)		YES	

ACSI Conformance Statements

Table F.34 ACSI Basic Conformance Statement

		Client/Subscriber	Server/Publisher	SEL-751 Support
Client-Server Roles				
B11	Server side (of Two-Party Application Association)	-	cl[a]	YES
B12	Client side (of Two-Party Application Association)	cl[a]	-	
SCMS Supported				
B21	SCSM: IEC 61850-8-1 used			YES
B22	SCSM: IEC 61850-9-1 used			
B23	SCSM: IEC 61850-9-2 used			
B24	SCSM: other			
Generic Substation Event Model (GSE)				
B31	Publisher side	-	O[b]	YES
B32	Subscriber side	O[b]	-	YES
Transmission of Sampled Value Model (SVC)				
B41	Published side	-	O[b]	
B42	Subscriber side	O[b]	-	

[a] c1 shall be mandatory if support for LOGICAL-DEVICE model has been declared.
[b] O = Optional.

Table F.35 ACSI Models Conformance Statement (Sheet 1 of 2)

		Client/Subscriber	Server/Publisher	SEL-751 Support
If Server Side (B11) Supported				
M1	Logical device	c2[a]	c2[a]	YES
M2	Logical node	c3[b]	c3[b]	YES
M3	Data	c4[c]	c4[c]	YES
M4	Data set	c5[d]	c5[d]	YES
M5	Substation	O[e]	O[e]	
M6	Setting group control	O[e]	O[e]	
Reporting				
M7	Buffered report control	O[e]	O[e]	YES
M7-1	sequence-number			YES
M7-2	report-time-stamp			YES
M7-3	reason-for-inclusion			YES
M7-4	data-set-name			YES
M7-5	data-reference			YES
M7-6	buffer-overflow			YES
M7-7	entryID			YES
M7-8	BufTm			YES
M7-9	IntgPd			YES
M7-10	G1			YES

Table F.35 ACSI Models Conformance Statement (Sheet 2 of 2)

		Client/Subscriber	Server/Publisher	SEL-751 Support
M8	Unbuffered report control	O[e]	O[e]	YES
M8-1	sequence-number			YES
M8-2	report-time-stamp			YES
M8-3	reason-for-inclusion			YES
M8-4	data-set-name			YES
M8-5	data-reference			YES
M8-6	BufTm			YES
M8-7	IntgPd			YES
M-8-8	GI			YES
Logging				
M9	Log control	O[e]	O[e]	
M9-1	IntgPd	O[e]	O[e]	
M10	Log	O[e]	O[e]	
M11	Control	M[f]	M[f]	YES
If GSE (B31/32) Is Supported				
M12	GOOSE	O[e]	O[e]	YES
M12-1	entryID			YES
M12-2	DataReflnc			YES
M13	GSSE	O[e]	O[e]	
If GSE (B41/42) Is Supported				
M14	Multicast SVC	O[e]	O[e]	
M15	Unicast SVC	O[e]	O[e]	
M16	Time	M[f]	M[f]	
M17	File Transfer	O[e]	O[e]	

[a] c2 shall be "M" if support for LOGICAL-NODE model has been declared.
[b] c3 shall be "M" if support for DATA model has been declared.
[c] c4 shall be "M" if support for DATA-SET, Substitution, Report, Log Control, or Time model has been declared.
[d] c5 shall be "M" if support for Report, GSE, or SV models has been declared.
[e] O = Optional.
[f] M = Mandatory.

Table F.36 ACSI Services Conformance Statement (Sheet 1 of 4)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-751 Support
Server (Clause 6)					
S1	ServerDirectory	TP		M[a]	YES
Application Association (Clause 7)					
S2	Associate		M[a]	M[a]	YES
S3	Abort		M[a]	M[a]	YES
S4	Release		M[a]	M[a]	YES
Logical Device (Clause 8)					
S5	LogicalDeviceDirectory	TP	M[a]	M[a]	YES

Table F.36 ACSI Services Conformance Statement (Sheet 2 of 4)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-751 Support
Logical Node (Clause 9)					
S6	LogicalNodeDirectory	TP	M[a]	M[a]	YES
S7	GetAllDataValues	TP	O[b]	M[a]	YES
Data (Clause 10)					
S8	GetDataValues	TP	M[a]	M[a]	YES
S9	SetDataValues	TP	O[b]	O[b]	
S10	GetDataDirectory	TP	O[b]	M[a]	YES
S11	GetDataDefinition	TP	O[b]	M[a]	YES
Data Set (Clause 11)					
S12	GetDataSetValues	TP	O[b]	M[a]	YES
S13	SetDataSetValues	TP	O[b]	O[b]	
S14	CreateDataSet	TP	O[b]	O[b]	
S15	DeleteDataSet	TP	O[b]	O[b]	
S16	GetDataSetDirectory	TP	O[b]	O[b]	YES
Substitution (Clause 12)					
S17	SetDataValues	TP	M[a]	M[a]	
Setting Group Control (Clause 13)					
S18	SelectActiveSG	TP	O[b]	O[b]	
S19	SelectEditSG	TP	O[b]	O[b]	
S20	SetSGvalues	TP	O[b]	O[b]	
S21	ConfirmEditSGVal	TP	O[b]	O[b]	
S22	GetSGValues	TP	O[b]	O[b]	
S23	GetSGCBValues	TP	O[b]	O[b]	
S24	Report	TP	c6[c]	c6[c]	YES
S24-1	data-change (dchg)				YES
S24-2	qchg-change (qchg)				YES
S24-3	data-update (dupd)				
S25	GetBRCBValues	TP	c6[c]	c6[c]	YES
S26	SetBRCBValues	TP	c6[c]	c6[c]	YES
Unbuffered Report Control Block (URCB)					
S27	Report	TP	c6[c]	c6[c]	YES
S27-1	data-change (dchg)				YES
S27-2	qchg-change (qchg)				YES
S27-3	data-update (dupd)				
S28	GetURCBValues	TP	c6[c]	c6[c]	YES
S29	SetURCBValues	TP	c6[c]	c6[c]	YES

Table F.36 ACSI Services Conformance Statement (Sheet 3 of 4)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-751 Support
Logging (Clause 14)					
Log Control Block					
S30	GetLCBValues	TP	M[a]	M[a]	
S31	SetLCBValues	TP	O[b]	M[a]	
LOG					
S32	QueryLogByTime	TP	c7[d]	M[a]	
S33	QueryLogByEntry	TP	c7[d]	M[a]	
S34	GetLogStatusValues	TP	M[a]	M[a]	
Generic Substation Event Model (GSE) (Clause 14.3.5.3.4)					
GOOSE-Control-Block					
S35	SendGOOSEMessage	MC	c8[e]	c8[e]	YES
S36	GetReference	TP	O[b]	c9[f]	
S37	GetGOOSEElement				
Number	TP	O[b]	c9[f]		
S38	GetGoCBValues	TP	O[b]	O[b]	YES
S39	SetGoCBValues	TP	O[b]	O[b]	
ONLY					
GSSE-Control-Block					
S40	SendGSSEMessage	MC	c8[e]	c8[e]	
S41	GetReference	TP	O[b]	c9[f]	
S42	GetGSSEElement				
Number	TP	Ob	c9[f]		
S43	GetGsCBValues	TP	O[b]	O[b]	
S44	GetGsCBValues	TP	O[b]	O[b]	
Transmission of Sample Value Model (SVC) (Clause 16)					
Multicast SVC					
S45	SendMSVMessage	MC	c10[g]	c10[g]	
S46	GetMSVCBValues	TP	O[b]	O[b]	
S47	SetMSVCBValues	TP	O[b]	O[b]	
Unicast SVC					
S48	SendUSVMessage	MC	c10[g]	c10[g]	
S49	GetUSVCBValues	TP	O[b]	O[b]	
S50	SetUSVCBValues	TP	O[b]	O[b]	
Control (Clause 16.4.8)					
S51	Select		M[a]	O[b]	
S52	SelectWithValue	TP	Ma	O[b]	YES
S53	Cancel	TP	O[b]	M[a]	YES
S54	Operate	TP	M[a]	M[a]	YES
S55	Command-Termination	TP	M[a]	M[a]	YES
S56	TimeActivated-Operate	TP	O[b]	O[b]	

Table F.36 ACSI Services Conformance Statement (Sheet 4 of 4)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-751 Support
File Transfer (Clause 20)					
S57	GetFile	TP	O[b]	M[a]	
S58	SetFile	TP	O[b]	O[b]	
S59	DeleteFile	TP	O[b]	O[b]	
S60	GetFileAttributeValues	TP	O[b]	M[a]	
Time (Clause 5.5)					
T1	Time resolution of internal clock (nearest negative power of 2 in seconds)				20 (1 µs)
T2	Time accuracy of internal clock				7 (10 ms) for SNTP 18 (4 µs) for IRIG-B
	T1				YES (for IRIG-B)
	T2				YES (for IRIG-B)
	T3				YES (for IRIG-B)
	T4				YES (for IRIG-B)
T3	Supported TimeStamp resolution (nearest negative power of 2 in seconds)				7 (10 ms) for SNTP 18 (4 µs) for IRIG-B

[a] M = Mandatory.
[b] O = Optional.
[c] c6 shall declare support for at least one (BRCB or URCB).
[d] c7 shall declare support for at least one (QueryLogByTime or QueryLogAfter).
[e] c8 shall declare support for at least one (SendGOOSEMessage or SendGSSEMessage).
[f] c9 shall declare support if TP association is available.
[g] c10 shall declare support for at least one (SendMSVMessage or SendUSVMessage).

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Appendix G
DeviceNet Communications

Overview

This appendix describes DeviceNet communications features supported by the SEL-751 Feeder Protection Relay.

DeviceNet is a low-level communications network that provides direct connectivity among industrial devices, resulting in improved communication and device-level diagnostics that are otherwise either unavailable or inaccessible through expensive hardwired I/O interfaces. Industrial devices for which DeviceNet provides this direct connectivity include limit switches, photoelectric sensors, valve manifolds, motor starters, process sensors, bar code readers, variable frequency drives, panel displays, and operator interfaces.

The *SEL DeviceNet Communications Card User's Guide* contains more information on the installation and use of the DeviceNet card.

DeviceNet Card

The DeviceNet Card is an optional accessory that enables connection of the SEL-751 to the DeviceNet automation network. The card (see *Figure G.1*) occupies the communications expansion Slot **C** in the relay.

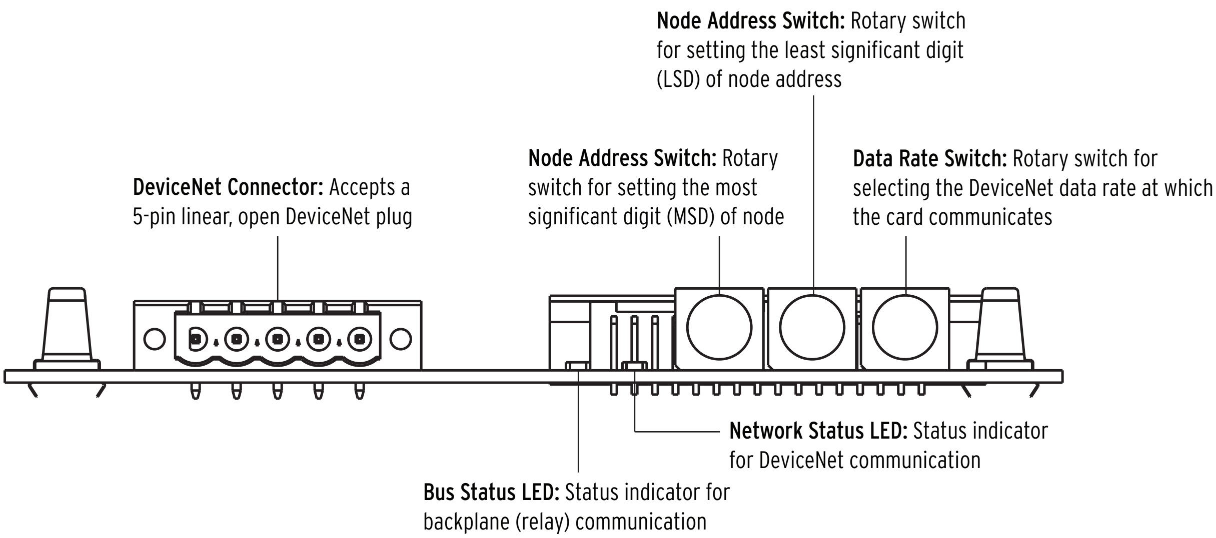

Figure G.1 DeviceNet Card Component Overview

Features

The DeviceNet Card features the following:

- The card receives the necessary power from the DeviceNet network.
- Rotary switches let you set the node address and network data rate prior to mounting in the SEL-751 and applying power. Alternatively, you can set the switches to positions that allow for configuration of these settings over the DeviceNet network, using a network configuration tool such as RSNetWorx for DeviceNet.
- Status indicators report the status of the device bus and network communications. They are visible from the back panel of the SEL-751 as installed.

You can do the following with the DeviceNet interface:

- Retrieve metering data such as the following:
  - Currents
  - Voltages
  - Power
  - Energy
  - Max/Min
  - Analog Inputs
  - Counters
- Retrieve and modify relay settings
- Read and set time
- Monitor device status, trip/warning status, and I/O status
- Perform high-speed control
- Reset trip, target, and accumulated data
- Retrieve events history

You can configure the DeviceNet interface through the use of address and data transmission rate switches. Indicators on the card at the back of the relay show network status and network activity.

Electronic Data Sheet

The Electronic Data Sheet (EDS) is a specially formatted file that includes configurable parameters for the device and public interfaces to those parameters. The EDS file contains information such as number of parameters; groupings; parameter name; minimum, maximum, and default values; units; data format; and scaling. This information makes possible user-friendly configuration tools (e.g., RSNetWorx for DeviceNet or DeviceNet Configurator from OMRON®) for device parameter monitoring, modification, or both. The interface to the device can also be easily updated without revision of the configuration software tool itself.

All the registers defined in the Modbus® Register Map (*Table E.34*) are available as parameters in a DeviceNet configuration. Parameter names, data ranges, and scaling; enumeration values and strings; parameter groups; and product information are the same as specified in the Modbus Register Map defined in *Table E.34*. The parameter numbers are offset by a count of 100 from the register numbers.

The EDS file for the SEL-751, SEL-xxxRxxx.EDS, is located on the SEL-751 Product Literature CD, or can also be downloaded from the SEL website at www.selinc.com.

Complete specifications for the DeviceNet protocol are available on the Open DeviceNet Vendor's Association (ODVA) website www.odva.org. ODVA is an independent supplier organization that manages the DeviceNet specification and supports the worldwide growth of DeviceNet.

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Appendix H
Synchrophasors

Overview

The SEL-751 Relay provides Phasor Measurement Unit (PMU) capabilities when connected to an IRIG-B time source with an accuracy of ±10 µs or better. Synchrophasor data are available via the **MET PM** ASCII command and the C37.118 Protocol.

Synchrophasor measurement refers to the concept of providing measurements taken on a synchronized schedule in multiple locations. A high-accuracy clock, commonly called a Global Positioning System (GPS) receiver, such as the SEL-2407® Satellite-Synchronized Clock, makes synchrophasor measurement possible.

The availability of an accurate time reference over a large geographic area allows multiple devices, such as SEL-751 Relays, to synchronize the gathering of power system data. The accurate clock allows precise event report triggering and other off-line analysis functions. Synchrophasors are still measured if the high-accuracy time source is not connected; however, the data are not time-synchronized to any external reference, as indicated by Relay Word bits TSOK := logical 0 and PMDOK := logical 0.

The SEL-751 Global settings class contains the synchrophasor settings, including the choice of transmitted synchrophasor data set. The Port settings class selects which serial port(s) or Ethernet port you can use for synchrophasor protocol. See *Settings for Synchrophasors on page H.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 H.10*.

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 H.10*.

The value of synchrophasor data increases greatly when you can share the data over a communications network in real time. A synchrophasor protocol is available in the SEL-751 that allows for a centralized device to collect data efficiently from several phasor measurement units (PMUs). Some possible uses of a system-wide synchrophasor system include the following:

- Power-system state measurement
- Generator Model Validation
- Wide-area network protection and control schemes
- Small-signal analysis
- Power-system disturbance analysis

The SEL-3306 Synchrophasor Processor is a PC-based communications processor specifically designed to interface with PMUs. The SEL-3306 has two primary functions. The first is to collect and correlate synchrophasor data from multiple PMUs. The second is to then compact and transmit synchrophasor data either to a data historian for post-analysis or to visualization software for real-time viewing of a power system.

The SEL-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 H.12*.

Synchrophasor Measurement

The phasor measurement unit in the SEL-751 measures voltages and currents on a constant-time basis. These samples are time-stamped with the IRIG time source. The relay then filters the measured samples according to Global setting PMAPP := Fast or Narrow (see *PMAPP on page H.5*).

The phase angle is measured relative to an absolute time reference, which is represented by a cosine function in *Figure H.1*. The time-of-day is shown for the two time marks. The reference is consistent with the phase reference defined in the C37.118 standard. During steady-state conditions, you can compare the SEL-751 synchrophasor values directly to values from other phasor measurement units that conform to C37.118.

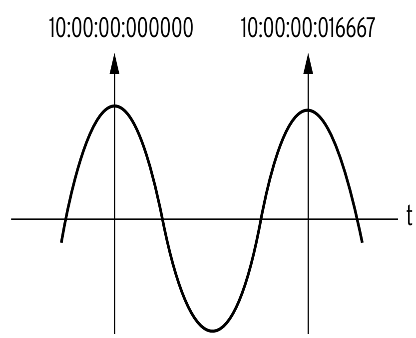

Figure H.1 Phase Reference

The TSOK Relay Word bit asserts when the SEL-751 has determined that the IRIG-B time source has sufficient accuracy and the synchrophasor data meets the specified accuracy. Synchrophasors are still measured if the time source threshold is not met, as indicated by Relay Word bit TSOK = logical 0. The **MET PM** command is not available in this case.

The instrumentation transformers (PTs or CTs) and the interconnecting cables can introduce a time shift in the measured signal. Global settings VCOMP, VSCOMP, and ICOMP, entered in degrees, are added to the measured phasor angles to create the corrected phasor angles, as shown in *Figure H.2*,

Figure H.3, and *Equation H.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.

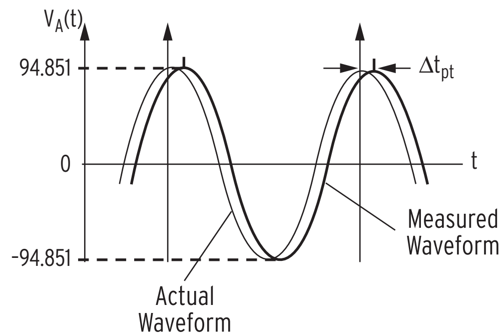

Figure H.2 Waveform at Relay Terminals May Have a Phase Shift

$$\text{Compensation Angle} = \frac{\Delta t_{pt}}{\left(\frac{1}{freq_{nominal}}\right)} \cdot 360^\circ = \Delta t_{pt} \cdot freq_{nominal} \cdot 360^\circ$$

Equation H.1

If the time shift on the PT measurement path Δt_{pt} = 0.784 ms and the nominal frequency, $freq_{nominal}$ = 60Hz, use *Equation H.2* to obtain the correction angle:

$$0.784 \cdot 10^{-3}s \cdot 60s^{-1} \cdot 360^\circ = 16.934^\circ$$

Equation H.2

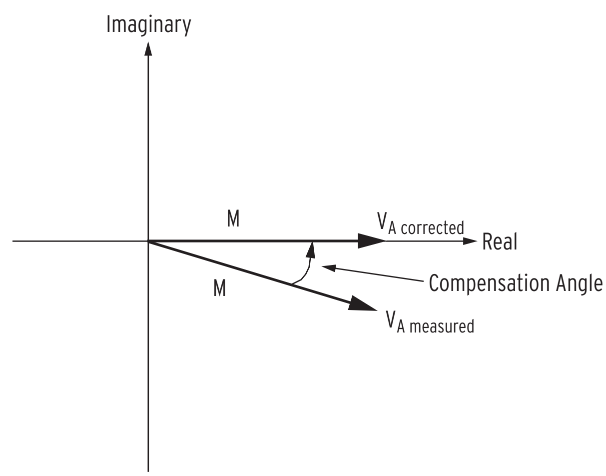

Figure H.3 Correction of Measured Phase Angle

The phasors are rms values scaled in primary units, as determined by Group settings PTR, PTRS (for synchronism-check input), CTR, and CTRN.

Because the sampling reference is based on the GPS clock (IRIG-B signal) and not synchronized to the power system, an examination of successive synchrophasor data sets almost always shows some angular change between samples of the same signal. This is not a malfunction of the relay or the power system, but is merely a result of viewing data from one system with an instrument with an independent time base. In other words, a power system has a nominal frequency of either 50 or 60 Hz, but on closer examination, it is usually running a little faster or slower than nominal.

Settings for Synchrophasors

The phasor measurement unit (PMU) settings are listed in *Table H.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 H.5* or Ethernet port settings in *Table H.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 H.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 deg)	0.00
VSCOMP	VS Voltage Angle Comp Factor (–179.99 to 180 deg)	0.00
PHDATAI	Phasor Data Set, Currents (I1, ALL, NA)	I1
ICOMP	Current Angle Comp Factor (–179.99 to 180 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
TREA4	Trigger Reason Bit 4 (SELOGIC)	27P1T OR 27P2T

Table H.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.

Certain settings in *Table H.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 H.1* are as follows:

MRATE

Selects the message rate in messages per second for synchrophasor data streaming on serial ports.

Choose the MRATE setting that suits the needs of your PMU application. This setting is one of seven settings that determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size. See *Communications Bandwidth on page H.12* 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 H.12* 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 H.2 describes the order of synchrophasors inside the data packet.

Table H.2 Synchrophasor Order in Data Stream (Voltages and Currents)

Synchrophasors[a b c]		Included When Global Settings Are as Follows:
Polar		
Magnitude	Angle	
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 H.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 H.12* 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 H.2* for details on these settings.

Table H.2 describes the order of synchrophasors inside the data packet. Synchrophasors are transmitted in the order indicated from the top to the bottom of the table. Real values are transmitted first and imaginary values are transmitted second.

Synchrophasors are only transmitted if specified to be included by the PHDATAV and PHDATAI settings. For example, if PHDATAV := ALL and PHDATAI := I1, selected phase voltages are transmitted first (See PHVOLT setting), followed by VS input voltage, positive-sequence voltage, and positive-sequence current.

NUMANA

Selects the number of user-definable analog values to be included in the synchrophasor data stream.

This setting is one of seven settings that determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size. See *Communications Bandwidth on page H.12* for detailed information.

The choices for this setting depend on the synchrophasor system design.

- Setting NUMANA := 0 sends no user-definable analog values.
- Setting NUMANA := 1–4 sends the user-definable analog values, as listed in *Table H.3*.

The format of the user-defined analog data is always floating point, and each value occupies four bytes.

Table H.3 User-Defined Analog Values Selected by the NUMANA Setting

NUMANA Setting	Analog Quantities Sent	Total Number of Bytes Used for Analog Values
0	None	0
1	MV29	4
2	Previous, plus MV30	8
3	Previous, plus MV31	12
4	Previous, plus MV32	16

NUMDSW

Selects the number of user-definable digital status words to be included in the synchrophasor data stream.

This setting is one of seven settings that determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size. See *Communications Bandwidth on page H.12* for detailed information.

The choices for this setting depend on the synchrophasor system design. The inclusion of binary data can help indicate breaker status or other operational data to the synchrophasor processor.

- Setting NUMDSW := 0 sends no user-definable binary status words.
- Setting NUMDSW := 1 sends the user-definable binary status words, as listed in *Table H.4*.

Table H.4 User-Defined Digital Status Words Selected by the NUMDSW Setting

NUMDSW Setting	Digital Status Words Sent	Total Number of Bytes Used for Digital Values
0	None	0
1	[SV32, SV31…SV17]	2

TREA1, TREA2, TREA3, TREA4, and PMTRIG

Defines the programmable trigger bits as allowed by IEEE C37.118.

Each of the four Trigger Reason settings, TREA1–TREA4, and the PMU Trigger setting, PMTRIG, are SELOGIC control equations in the Global settings class. The SEL-751 evaluates these equations and places the results in Relay Word bits with the same names: TREA1–TREA4, and PMTRIG.

NOTE: The PM Trigger function is not associated with the SEL-751 Event Report Trigger ER, a SELOGIC control equation in the Report settings class.

The trigger reason equations represent the Trigger Reason bits in the STAT field of the data packet. After the trigger reason bits are set to convey a message, the PMTRIG equation should be asserted for a reasonable amount of time, to allow the synchrophasor processor to read the TREA1–TREA4 fields.

The SEL-751 automatically sets the TREA1–TREA4 or PMTRIG Relay Word bits based on their default SELOGIC control equation. You must program these bits to change their operation.

You can use these bits to send various messages at a low bandwidth via the synchrophasor message stream. You can also use Digital Status Words to send binary information directly, without the need to manage the coding of the trigger reason messages in SELOGIC control equations.

Use these Trigger Reason bits if your synchrophasor system design requires these bits. The SEL-751 synchrophasor processing and protocol transmission are not affected by the status of these bits.

IRIGC

Defines if IEEE C37.118 control bit extensions are in use. Control bit extensions contain information such as Leap Second, UTC time, Daylight Savings Time, and Time Quality. When your satellite-synchronized clock provides these extensions, your relay can adjust the synchrophasor time stamp accordingly.

- IRIGC := NONE ignores bit extensions
- IRIGC := C37.118 extracts bit extensions and corrects synchrophasor time accordingly

Serial Port Settings for IEEE C37.118 Synchrophasors

IEEE C37.118 compliant synchrophasors are available via serial or Ethernet port. The associated serial port settings are shown in *Table H.5*.

Table H.5 SEL-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 H.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 H.5*, do not include the settings BITS and PARITY; these two settings are internally fixed as BITS := 8, PARITY := N.

Serial port setting PROTO cannot be set to PMU (see *Table H.5*) when Global setting EPMU := N. Synchrophasors must be enabled (EPMU := Y) before PROTO can be set to PMU.

If you use a computer terminal session or ACSELERATOR QuickSet® SEL-5030 Software connected to a serial port, and then set that same serial port PROTO setting to PMU, you lose the ability to communicate with the relay through ASCII commands. If this happens, either connect via another serial port (that has PROTO := SEL) or use the front-panel HMI SET/SHOW screen to change the port PROTO setting back to SEL.

Ethernet Port Settings for IEEE C37.118 Synchrophasors

IEEE C37.118 compliant synchrophasors are available via serial or Ethernet port. The associated Ethernet port settings are shown in *Table H.6*.

Table H.6 SEL-751 Ethernet Port Settings for Synchrophasors

Setting	Description	Default
EPMIP[a]	Enable PMU Processing (0–2)	0[b]
PMOTS1	PMU Output 1 Transport Scheme (OFF, TCP, UDP_S, UDP_T, UDP_U)	OFF
PMOIPA1	PMU Output 1 Client IP (Remote) Address (www.xxx.yyy.zzz)	192.168.1.3
PMOTCP1	PMU Output 1TCP/IP (Local) Port Number (1–65534)	4712
PMOUDP1	PMU Output 1 UDP/IP Data (Remote) Port Number (1–65534)	4713
PMOTS2	PMU Output 2 Transport Scheme (OFF, TCP, UDP_S, UDP_T, UDP_U)	OFF
PMOIPA2	PMU Output 2 Client IP (Remote) Address (www.xxx.yyy.zzz)	192.168.1.4
PMOTCP2	PMU Output 2 TCP/IP (Local) Port Number (1–65534)	4722
PMOUDP2	PMU Output 2 UDP/IP Data (Remote) Port Number (1–65534)	4713

[a] Setting is hidden when EPMU := N.
[b] Set EPMIP := 1 or 2 to access other settings and to enable IEEE C37.118 protocol synchrophasors on this port. Setting EPMIP is not available when Global setting EPMU is set to N.

Ethernet port setting EPMIP cannot be set (see *Table H.6*) when Global setting EPMU := N. Synchrophasors must be enabled (EPMU := Y) before EPMIP can be set.

Synchrophasor Relay Word Bits

Table H.7 and *Table H.8* list the SEL-751 Relay Word bits that are related to synchrophasor measurement. The Synchrophasor Trigger Relay Word bits in *Table H.7* follow the state of the SELOGIC control equations of the same name, listed at the bottom of *Table H.1*. These Relay Word bits are included in the IEEE C37.118 synchrophasor data frame STAT field. See *Table H.4* for standard definitions for these settings.

Table H.7 Synchrophasor Trigger Relay Word Bits

Name	Description
PMTRIG	Trigger (SELOGIC)
TREA4	Trigger Reason Bit 4 (SELOGIC)
TREA3	Trigger Reason Bit 3 (SELOGIC)
TREA2	Trigger Reason Bit 2 (SELOGIC)
TREA1	Trigger Reason Bit 1 (SELOGIC)

The Time Synchronization Relay Word bits in *Table H.8* indicate the present status of the timekeeping function of the SEL-751.

Table H.8 Time Synchronization Relay Word Bits

Name	Description
IRIGOK	Asserts while relay time is based on IRIG-B time source.
TSOK	Time Synchronization OK. Asserts while time is based on an IRIG-B time source of sufficient accuracy for synchrophasor measurement.
PMDOK	Phasor Measurement Data OK. Asserts when the SEL-751 is enabled and synchrophasors are enabled (Global setting EPMU := Y).

View Synchrophasors Using the MET PM Command

You can use the **MET PM** serial port ASCII command to view the SEL-751 synchrophasor measurements. See *MET Command (Metering Data) on page 7.36* for general information on the **MET** command.

There are multiple ways to use the **MET PM** command:

- ➤ As a test tool, to verify connections, phase rotation, and scaling
- ➤ As an analytical tool, to capture synchrophasor data at an exact time and to compare it with similar data captured in other phasor measurement unit(s) at the same time
- ➤ As a method of periodically gathering synchrophasor data through a communications processor

The **MET PM** command displays the same set of analog synchrophasor information, regardless of the Global settings PHDATAV and PHDATAI. The **MET PM** command can function even when no serial ports are sending synchrophasor data—it is unaffected by serial port setting PROTO.

NOTE: To have the MET PM xx:yy:zz response transmitted from a serial port, the corresponding port must have the AUTO setting set to Y (YES).

The **MET PM** command only operates when the SEL-751 is in the IRIG timekeeping mode, as indicated by Relay Word bit TSOK = logical 1.

Figure H.4 shows a sample **MET PM** command response. The synchrophasor data are also available via the **HMI > Meter PM** menu in ACSELERATOR QuickSet, and has a similar format to *Figure H.4*.

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 H.4* occurring just after 14:14:12, with the time stamp 14:14:12.000. See *Section 7: Communications* for complete command options, and error messages.

```
=>MET PM <Enter>

SEL-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 H.4 Sample MET PM Command Response

C37.118 Synchrophasor Protocol

The SEL-751 complies with IEEE C37.118, Standard for Synchrophasors for Power Systems. The protocol is available on serial ports 2, 3, 4, and F by setting the corresponding port setting PROTO := PMU. In addition, synchrophasor data can be accessed through the Ethernet port when the EPMIP setting is enabled.

This section does not cover the details of the protocol, but highlights some of the important features and options that are available.

Settings Affect Message Contents

The SEL-751 allows several options for transmitting synchrophasor data. These are controlled by Global settings described in *Settings for Synchrophasors on page H.4*. You can select how often to transmit the synchrophasor messages (MRATE) and which synchrophasors to transmit (PHDATAV and PHDATAI). The SEL-751 automatically includes the frequency and rate-of-change-of-frequency in the synchrophasor messages.

The relay can include as many as four user-programmable analog values in the synchrophasor message, as controlled by Global setting NUMANA, and 0 or 16 digital status values, as controlled by Global setting NUMDSW.

The SEL-751 always includes the results of four synchrophasor trigger reason SELOGIC control equations TREA1, TREA2, TREA3, and TREA4, and the trigger SELOGIC control equation result PMTRIG, in the synchrophasor message.

Communications Bandwidth

A phasor measurement unit (PMU) that is configured to transmit a single synchrophasor (positive-sequence voltage, for example) at a message rate of once per second places little burden on the communications channel. As more synchrophasors, analog values, or digital status words are added, or if the message rate is increased, some communications channel restrictions come into play.

The C37.118 synchrophasor message format always includes 18 bytes for the message header and terminal ID, time information, status bits, and CRC value. The selection of synchrophasor data, numeric format, programmable analog, and programmable digital data adds to the byte requirements. You can use *Table H.9* to calculate the number of bytes in a synchrophasor message.

Table H.9 Size of a C37.118 Synchrophasor Message

Item	Possible Number of Quantities	Bytes per Quantity	Number of Bytes	
			Minimum	Maximum
Fixed			18	18
Synchrophasors	0–18	4	0	72
Frequency/DFDT	2 (fixed)	2	4	4
Analog Values	0–4	4	0	16
Digital Status Words	0–1	2	0	2
Total (Minimum and Maximum)			22	112

Table H.10 lists the baud settings available on any SEL-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 H.10 Serial Port Bandwidth for Synchrophasors (in Bytes) (Sheet 1 of 2)

Global Setting MRATE	Port Setting SPEED								
	300	600	1200	2400	4800	9600	19200	38400	57600
1	21	42	85	170	340	680	1360	2720	4080
2		21	42	85	170	340	680	1360	2040
4 (60 Hz only)			21	42	85	170	340	680	1020

Table H.10 Serial Port Bandwidth for Synchrophasors (in Bytes) (Sheet 2 of 2)

Global Setting MRATE	Port Setting SPEED								
	300	600	1200	2400	4800	9600	19200	38400	57600
5				34	68	136	272	544	816
10					34	68	136	272	408
12 (60 Hz only)					28	56	113	226	340
15 (60 Hz only)					21	45	90	181	272
20 (60 Hz only)						34	68	136	204
25 (50 Hz only)						27	54	108	163
30 (60 Hz only)						22	45	90	136
50 (50 Hz only)							27	54	81
60 (60 Hz only)							22	45	68

Referring to *Table H.9* and *Table H.10*, it is clear that the lower SPEED settings are very restrictive.

The smallest practical synchrophasor message would be comprised of one digital status word, and this message would consume 24 bytes (includes frequency and DFDT). This type of message could be sent at any message rate (MRATE = 60) when SPEED := 38400, 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-3306. The synchrophasor processor controls the PMU functions of the SEL-751, with IEEE C37.118 commands, including commands to start and stop synchrophasor data transmission, and commands to request a configuration block from the relay, so the synchrophasor processor can automatically build a database structure.

The SEL-751 does not begin transmitting synchrophasors until an enable message is received from the synchrophasor processor. The relay stops synchrophasor transmission when the appropriate command is received from the synchrophasor processor. The SEL-751 can also indicate when a configuration change occurs, so the synchrophasor processor can request a new configuration block and keep its database up-to-date.

The SEL-751 only responds to configuration block request messages when it is in the non-transmitting mode.

IEEE C37.118 PMU Setting Example

A utility is upgrading its distribution system to use the SEL-751 for feeder protection and power-system state measurement. The utility also wants to install phasor measurement units (PMUs) in each substation to collect data to monitor voltages and currents throughout the system.

The PMU data collection requirements call for the following data, collected at 10 messages per second:

- ➤ Frequency
- ➤ Positive-sequence voltage from the bus in each substation
- ➤ Three-phase, positive-sequence, and neutral current for each line
- ➤ Indication when the breaker is open
- ➤ Indication when the voltage or frequency information is unusable

The utility is able to meet the requirements with the SEL-751 for each line, an SEL-2407 Satellite-Synchronized Clock, and an SEL-3306 Synchrophasor Processor 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 H.9*, and determines the necessary message size. The system requirements, in order of appearance in *Table H.9*, are as follows:

- ➤ 6 Synchrophasors, in integer representation
- ➤ Integer representation for the frequency data
- ➤ 3 digital status bits, which require one status word

The message size is 18 + 6 • 4 + 2 • 2 + 1 • 2 = 48 bytes. Using *Table H.10*, the engineer verifies that the port baud of 9600 is adequate for the message, at 10 messages per second.

The Protection SELOGIC Variables SV14, SV15, and SV16 are used to transmit the breaker status, loss-of-potential alarm, and frequency measurement status, respectively. Make the Global settings as shown in *Table H.11*.

Table H.11 Example Synchrophasor Global Settings

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 H.12 Example Synchrophasor Logic Settings

Logic Setting	Description	Value
TREA1	Trigger Reason Bit 1 (SELOGIC Equation)	NA
TREA2	Trigger Reason Bit 2 (SELOGIC Equation)	NA
TREA3	Trigger Reason Bit 3 (SELOGIC Equation)	NA
TREA4	Trigger Reason Bit 4 (SELOGIC Equation)	NA
PMTRIG	Trigger (SELOGIC Equation)	NA

The three Relay Word bits this example uses must be placed in certain SELOGIC variables. Make the settings in *Table H.13* in all seven setting groups.

Table H.13 Example Synchrophasor SELOGIC Settings

Setting	Value
SV14	52A
SV15	LOP
SV16	FREQTRK

Make the *Table H.14* settings for serial port 3, using the **SET P 3** command.

Table H.14 Example Synchrophasor Port Settings

Setting	Description	Value
PROTO	Protocol (SEL, MOD, DNP, EVMSG, PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB)	PMU
SPEED	Data Speed (300 to 38400)	19200
STOPBIT	Stop Bits (1, 2 bits)	1
RTSCTS	Enable Hardware Handshaking (Y, N)	N

The SEL-751 does not begin transmitting synchrophasors until an enable message is received from the synchrophasor processor. The relay stops synchrophasor transmission when the appropriate command is received from the synchrophasor processor. The SEL-751 can also indicate when a configuration change occurs, so the synchrophasor processor can request a new configuration block and keep its database up-to-date.

The SEL-751 only responds to configuration block request messages when it is in the non-transmitting mode.

Appendix I
Mirrored Bits Communications

Overview

Mirrored Bits® is a direct relay-to-relay communications protocol that allows IEDs to exchange information quickly, securely, and with minimal expense. Use Mirrored Bits for functions such as remote control and remote sensing. The SEL-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.

IMPORTANT: Be sure to configure the port before connecting to a Mirrored Bits device. If you connect an unconfigured port to a Mirrored Bits device, the device will appear to be locked up.

NOTE: Complete all of the port settings for a port that you use for Mirrored Bits communications before you connect an external Mirrored Bits communications device. If you connect a Mirrored Bits communications device to a port that is not set for Mirrored Bits communications operation, the port will be continuously busy.

Because of different applications, the SEL product range supports several variations of the Mirrored Bits communications protocol. Through port settings, you can set the SEL-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 baud rate and the power system cycle. At baud rates slower than 9600, the SEL-751 transmits Mirrored Bits as fast as possible for the given rate. At rates of 9600 baud 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 baud rates of 9600, 19200, and 38400. *Table I.1* shows the transmission rates of the Mirrored Bits messages at different baud.

Table I.1 Number of MIRRORED BITS Messages for Different Baud

Baud Rate	Transmission Rate of MIRRORED BITS Packets
2400	15 ms
4800	7.5 ms
9600	4 times a power system cycle (automatic pacing mode)
19200	4 times a power system cycle (automatic pacing mode)
38400	4 times a power system cycle (automatic pacing mode)

Transmitting at longer intervals for baud rates faster than 9600 avoids overflowing relays that receive MIRRORED BITS at a slower rate.

Message Reception Overview

During synchronized MIRRORED BITS communications with the communications channel in normal state, the relay decodes and checks each received message. If the message is valid, the relay sends each received logic bit (RMB*n*, where *n* = 1 through 8) to the corresponding pickup and dropout security counters, that in turn set or clear the RMB*n*A and RMB*n*B relay element bits.

Message Decoding and Integrity Checks

Set the RX_ID of the local SEL-751 to match the TX_ID of the remote SEL-751. The SEL-751 provides indication of the status of each MIRRORED BITS communications channel with Relay Word bits ROKA (receive OK) and ROKB. During normal operation, the relay sets the ROK*c* (*c* = A or B). Upon detecting any of the following conditions, the relay clears the ROK*c* bit when:

- The relay is disabled.
- MIRRORED BITS communications is not enabled.
- Parity, framing, or overrun errors.
- Receive message identification error.
- No message received in the time three messages have been sent when PROTO = MB*c*, or seven messages have been sent when PROTO = MB8*c*.
- Loopback is enabled.

The relay asserts ROK*c* only after successful synchronization as in the following description and after two consecutive messages pass all of the data checks previously described. After ROK*c* is reasserted, received data may be delayed while passing through the security counters described in the following text.

While ROK*c* is deasserted, the relay does not transfer new RMB data to the pickup-dropout security counters described in the following text. Instead, the relay sends one of the user-definable default values to the security counter inputs. For each RMB*n*, use the RXDFLT setting to determine the default state the MIRRORED BITS should use in place of received data if the relay detects an error condition. The setting is a mask of 1s, 0s, and/or Xs (for RMB1A–RMB8A), where X represents the most recently received valid value. The positions of the 1s and 0s correspond to the respective positions of the MIRRORED BITS in the Relay Word bits (see *Appendix J: Relay Word Bits*). *Table I.2* is an extract of *Appendix J: Relay Word Bits*, showing the positions of the MIRRORED BITS.

Table I.2 Positions of the MIRRORED BITS

Bit/ Row	7	6	5	4	3	2	1	0
88	RMB8A	RMB7A	RMB6A	RMB5A	RMB4A	RMB3A	RMB2A	RMB1A
90	RMB8B	RMB7B	RMB6B	RMB5B	RMB4B	RMB3B	RMB2B	RMB1B

Table I.3 shows an example of the values of the MIRRORED BITS for a RXDFLT setting of 10100111.

Table I.3 MIRRORED BITS Values for a RXDFLT Setting of 10100111

Bit/ Row	7	6	5	4	3	2	1	0
88	1	0	1	0	0	1	1	1

Individual pickup and dropout security counters supervise the movement of each received data bit into the corresponding RMB*n* element. You can set each pickup/dropout security counter from 1 to 8. A setting of 1 causes a security counter to pass every occurrence, while a setting of 8 causes a counter to wait for eight consecutive occurrences in the received data before updating the data bits. The pickup and dropout security count settings are separate. Control the security count settings with the settings RMB*n*PU and RMB*n*DO.

A pickup/dropout security counter operates identically to a pickup/dropout timer, except that the counter uses units of counted received messages instead of time. Select a setting for the security counter in accordance with the transmission rate (see *Table I.1*). For example, when transmitting at 2400 baud, a security counter set to 2 counts delays a bit by about 30 ms. However, when operating at 9600 baud, a setting of 2 counts delays a bit by about 8.5 ms.

You must consider the impact of the security counter settings in the receiving relay to determine the channel timing performance, particularly when two relays of different processing rates are communicating via MIRRORED BITS, such as an SEL-321 and an SEL-751. The SEL-321 processes power system information each 1/8 power system cycle, but, when transmitting at 19200 baud, 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 baud and faster, see *Table I.1*), a counter set to two in the SEL-321 delays a received bit by another approximately 1/2 cycle. However, a security counter in the SEL-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 will go all the way around the loop until the originating relay receives it. The message then dies and data transmission resumes. This method of synchronization allows the relays to reliably determine which byte is the first byte of the message. It also forces unsynchronized UARTs to become resynchronized. On the down side, this method takes down the entire loop for a receive error at any relay in the loop. This decreases availability. It also makes one-way communications impossible.

Loopback Testing

Use the **LOOP** command to enable loopback testing. In the loopback mode, you loop the transmit port to the receive port of the same relay to verify transmission messages. While in loopback mode, ROK*c* is deasserted, and another user accessible Relay Word bit, LBOK*c* (Loop Back OK) asserts and deasserts based on the received data checks (see the *Section 7: Communications* for the ACSII commands).

Channel Monitoring

Based on the results of data checks (described previously), the relay collects information regarding the 255 most recent communications errors. Each record contains at least the following fields:

- DATE—Date when the dropout occurred
- TIME—Time when the dropout occurred
- RECOVERY_DATE—Date when the channel returned to service (if the channel is currently failed, it is displayed and included in the calculations, as if its recovery were to occur at the time the report was requested)
- RECOVERY_TIME—Time when the channel returned to service (if the channel is currently failed, it is displayed and included in the calculations, as if its recovery were to occur at the time the report was requested)
- DURATION—Time elapsed during dropout
- CAUSE—Reason for dropout (see *Message Decoding and Integrity Checks on page I.2*)

There is a single record for each outage, but an outage can evolve. For example, the initial cause could be a data disagreement, but framing errors can extend the outage. If the channel is currently failed, it is displayed and included in the calculations, as if its recovery were to occur at the time the report was requested.

NOTE: Combine error conditions including RBADA, RBADB, CBADA, and CBADB with other alarm conditions by using SELOGIC control equations. You can use these alarm conditions to program the relay to take appropriate action when it detects a communications channel failure.

When the duration of an outage on Channel A or B exceeds a user-definable threshold, the relay asserts a user-accessible Relay Word bit, RBADA or RBADB. When channel unavailability exceeds a user-definable threshold for Channel A or B, the relay asserts a user-accessible Relay Word bit, CBADA or CBADB. Use the **COMM** command to generate a long or summary report of the communications errors.

Use the RBADPU setting to determine how long a channel error must last before the meter element RBADA is asserted. RBADA is deasserted when the channel error is corrected. RBADPU is accurate to ±1 second.

Use the CBADPU setting to determine the ratio of channel down time to the total channel time before the meter element CBADA is asserted. The times used in the calculation are those that are available in the COM records. See the *COMMUNICATIONS Command* in *Section 7: Communications* for more information.

MIRRORED BITS Protocol for the Pulsar 9600 Baud Modem

To use a Pulsar MBT modem, set setting PROTO := MBTA or MBTB (Port settings). Setting PROTO := MBTA or MBTB hides setting SPEED (forces the baud to 9600), hides setting PARITY (forces parity to a value of 0), hides setting RTSCTS (forces RTSCTS to a value of N), and forces the transmit time to be faster than double the power system cycle. *Table I.4* shows the difference in message transmission periods 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 I.4 MIRRORED BITS Communications Message Transmission Period

Baud	PROTO ≠ MBTA or MBTB	PROTO = MBTA or MBTB
38400	4 times a power system cycle	n/a
19200	4 times a power system cycle	n/a
9600	4 times a power system cycle	2 times a power system cycle
4800	7.5 ms	n/a

The relay sets RTS to a negative voltage at the EIA-232 connector to signify that MIRRORED BITS communications matches this specification.

Settings

Set PROTO = MBA or MB8A to enable the MIRRORED BITS protocol channel A on this port. Set PROTO = MBB or MB8B to enable the MIRRORED BITS protocol channel B on this port. The standard MIRRORED BITS protocols MBA and MBB use a 6-data bit format for data encoding. The MB8 protocols MB8A and MB8B use an 8-data bit format, which allows MIRRORED BITS to operate on communications channels requiring an 8-data bit format. For the remainder of this section, PROTO = MBA is assumed. *Table I.5* shows the MIRRORED BITS protocol port settings, ranges, and default settings for Port F, Port 3, and Port 4.

Table I.5 MIRRORED BITS Protocol Settings (Sheet 1 of 2)

Setting Prompt	Setting Description	Factory Default Setting
TXID	MIRRORED BITS ID of This Device (1–4)	2
RXID	MIRRORED BITS ID of Device Receiving From (1–4)	1
RBADPU	Outage Duration to Set RBAD (0–10000 seconds)	60
CBADPU	Channel Unavailability to Set CBAD (1–10000 ppm)	1000
RXDFLT	8 char string of 1s, 0s, or Xs	XXXXXXXX
RMB1PU	RMB1 Pickup Debounce Messages (1–8 messages)	1
RMB1DO	RMB1 Dropout Debounce Messages (1–8 messages)	1

Table I.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 J
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 J.1 and *Table J.2* show a list of Relay Word bits and corresponding descriptions. The Relay Word bit row numbers correspond to the row numbers used in the **TAR** command (see *TARGET Command (Display Relay Word Bit Status) on page 7.47*).

You can use any Relay Word bit (except Row 0) in SELOGIC® control equations (see *Section 4: Protection and Logic Functions*) and the Sequential Events Recorder (SER) trigger list settings (see *Section 9: Analyzing Events*).

Table J.1 SELOGIC Relay Word Bits (Sheet 1 of 5)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
TAR 0	ENABLED	TRIP_LED	TLED_01	TLED_02	TLED_03	TLED_04	TLED_05	TLED_06
1	50A1P	50B1P	50C1P	50PAF	ORED50T	ORED51T	50NAF	52A
2	50P1P	50P2P	50P3P	50P4P	50Q1P	50Q2P	50Q3P	50Q4P
3	50P1T	50P2T	50P3T	50P4T	50Q1T	50Q2T	50Q3T	50Q4T
4	50N1P	50N2P	50N3P	50N4P	50G1P	50G2P	50G3P	50G4P
5	50N1T	50N2T	50N3T	50N4T	50G1T	50G2T	50G3T	50G4T
6	51AP	51BP	51CP	51P1P	51P2P	51N1P	51N2P	51QP
7	51AT	51BT	51CT	51P1T	51P2T	51N1T	51N2T	51QT
8	51AR	51BR	51CR	51P1R	51P2R	51N1R	51N2R	51QR
9	51G1P	51G1T	51G1R	51G2P	51G2T	51G2R	27P1	27P1T
10	27P2	27P2T	59P1	59P1T	59P2	59P2T	3P59	3P27
11	81D1T	81D2T	81D3T	81D4T	81D5T	81D6T	55A	55T
12	AMBALRM	AMBTRIP	OTHALRM	OTHTRIP	BKMON	*	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 J.1 SELogic Relay Word Bits (Sheet 2 of 5)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
16	PB01_PUL	PB02_PUL	PB03_PUL	PB04_PUL	PB05_PUL	PB06_PUL	PB07_PUL	PB08_PUL
17	IN101	IN102	*	*	*	*	*	*
18	IN301	IN302	IN303	IN304	IN305	IN306	IN307	IN308
19	IN401	IN402	IN403	IN404	IN405	IN406	IN407	IN408
20	IN501	IN502	IN503	IN504	IN505	IN506	IN507	IN508
21	OUT101	OUT102	OUT103	*	*	ORED81T	ORED81RT	TRIP
22	OUT301	OUT302	OUT303	OUT304	OUT305	OUT306	OUT307	OUT308
23	OUT401	OUT402	OUT403	OUT404	OUT405	OUT406	OUT407	OUT408
24	OUT501	OUT502	OUT503	OUT504	OUT505	OUT506	OUT507	OUT508
25	WDGALRM	WDGTRIP	BRGALRM	BRGTRIP	RSTENRGY	RSTMXMN	RSTDEM	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	*	*	DI_C	DI_B	DI_A
33	CC	OC	*	ER	ULTRIP	TR	FREQTRK	PMTRIG
34	DNAUX1	DNAUX2	DNAUX3	DNAUX4	DNAUX5	DNAUX6	DNAUX7	DNAUX8
35	DNAUX9	DNAUX10	DNAUX11	RELAY_EN	TREA1	TREA2	TREA3	TREA4
36	PB1A_LED	PB1B_LED	PB2A_LED	PB2B_LED	PB3A_LED	PB3B_LED	PB4A_LED	PB4B_LED
37	PB5A_LED	PB5B_LED	PB6A_LED	PB6B_LED	PB7A_LED	PB7B_LED	PB8A_LED	PB8B_LED
38	CL	ULCL	T01_LED	T02_LED	T03_LED	T04_LED	T05_LED	T06_LED
39	LB01	LB02	LB03	LB04	LB05	LB06	LB07	LB08
40	LB09	LB10	LB11	LB12	LB13	LB14	LB15	LB16
41	LB17	LB18	LB19	LB20	LB21	LB22	LB23	LB24
42	LB25	LB26	LB27	LB28	LB29	LB30	LB31	LB32
43	RB01	RB02	RB03	RB04	RB05	RB06	RB07	RB08
44	RB09	RB10	RB11	RB12	RB13	RB14	RB15	RB16
45	RB17	RB18	RB19	RB20	RB21	RB22	RB23	RB24
46	RB25	RB26	RB27	RB28	RB29	RB30	RB31	RB32
47	SV01	SV02	SV03	SV04	SV05	SV06	SV07	SV08
48	SV01T	SV02T	SV03T	SV04T	SV05T	SV06T	SV07T	SV08T
49	SV09	SV10	SV11	SV12	SV13	SV14	SV15	SV16
50	SV09T	SV10T	SV11T	SV12T	SV13T	SV14T	SV15T	SV16T
51	SV17	SV18	SV19	SV20	SV21	SV22	SV23	SV24
52	SV17T	SV18T	SV19T	SV20T	SV21T	SV22T	SV23T	SV24T
53	SV25	SV26	SV27	SV28	SV29	SV30	SV31	SV32
54	SV25T	SV26T	SV27T	SV28T	SV29T	SV30T	SV31T	SV32T
55	LT01	LT02	LT03	LT04	LT05	LT06	LT07	LT08

Table J.1 SELOGIC Relay Word Bits (Sheet 3 of 5)

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	*	AIHW1	AIHW2	AIHAL	*
68	AI301LW1	AI301LW2	AI301LAL	*	AI301HW1	AI301HW2	AI301HAL	*
69	AI302LW1	AI302LW2	AI302LAL	*	AI302HW1	AI302HW2	AI302HAL	*
70	AI303LW1	AI303LW2	AI303LAL	*	AI303HW1	AI303HW2	AI303HAL	*
71	AI304LW1	AI304LW2	AI304LAL	*	AI304HW1	AI304HW2	AI304HAL	*
72	AI305LW1	AI305LW2	AI305LAL	*	AI305HW1	AI305HW2	AI305HAL	*
73	AI306LW1	AI306LW2	AI306LAL	*	AI306HW1	AI306HW2	AI306HAL	*
74	AI307LW1	AI307LW2	AI307LAL	*	AI307HW1	AI307HW2	AI307HAL	*
75	AI308LW1	AI308LW2	AI308LAL	*	AI308HW1	AI308HW2	AI308HAL	*
76	AI401LW1	AI401LW2	AI401LAL	*	AI401HW1	AI401HW2	AI401HAL	*
77	AI402LW1	AI402LW2	AI402LAL	*	AI402HW1	AI402HW2	AI402HAL	*
78	AI403LW1	AI403LW2	AI403LAL	*	AI403HW1	AI403HW2	AI403HAL	*
79	AI404LW1	AI404LW2	AI404LAL	*	AI404HW1	AI404HW2	AI404HAL	*
80	AI405LW1	AI405LW2	AI405LAL	*	AI405HW1	AI405HW2	AI405HAL	*
81	AI406LW1	AI406LW2	AI406LAL	*	AI406HW1	AI406HW2	AI406HAL	*
82	AI407LW1	AI407LW2	AI407LAL	*	AI407HW1	AI407HW2	AI407HAL	*
83	AI408LW1	AI408LW2	AI408LAL	*	AI408HW1	AI408HW2	AI408HAL	*
84	AI501LW1	AI501LW2	AI501LAL	*	AI501HW1	AI501HW2	AI501HAL	*
85	AI502LW1	AI502LW2	AI502LAL	*	AI502HW1	AI502HW2	AI502HAL	*
86	AI503LW1	AI503LW2	AI503LAL	*	AI503HW1	AI503HW2	AI503HAL	*
87	AI504LW1	AI504LW2	AI504LAL	*	AI504HW1	AI504HW2	AI504HAL	*
88	AI505LW1	AI505LW2	AI505LAL	*	AI505HW1	AI505HW2	AI505HAL	*
89	AI506LW1	AI506LW2	AI506LAL	*	AI506HW1	AI506HW2	AI506HAL	*
90	AI507LW1	AI507LW2	AI507LAL	*	AI507HW1	AI507HW2	AI507HAL	*
91	AI508LW1	AI508LW2	AI508LAL	*	AI508HW1	AI508HW2	AI508HAL	*
92	RMB8A	RMB7A	RMB6A	RMB5A	RMB4A	RMB3A	RMB2A	RMB1A
93	TMB8A	TMB7A	TMB6A	TMB5A	TMB4A	TMB3A	TMB2A	TMB1A
94	RMB8B	RMB7B	RMB6B	RMB5B	RMB4B	RMB3B	RMB2B	RMB1B
95	TMB8B	TMB7B	TMB6B	TMB5B	TMB4B	TMB3B	TMB2B	TMB1B

Table J.1 SELOGIC Relay Word Bits (Sheet 4 of 5)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
96	LBOKB	CBADB	RBADB	ROKB	LBOKA	CBADA	RBADA	ROKA
97	VB001	VB002	VB003	VB004	VB005	VB006	VB007	VB008
98	VB009	VB010	VB011	VB012	VB013	VB014	VB015	VB016
99	VB017	VB018	VB019	VB020	VB021	VB022	VB023	VB024
100	VB025	VB026	VB027	VB028	VB029	VB030	VB031	VB032
101	VB033	VB034	VB035	VB036	VB037	VB038	VB039	VB040
102	VB041	VB042	VB043	VB044	VB045	VB046	VB047	VB048
103	VB049	VB050	VB051	VB052	VB053	VB054	VB055	VB056
104	VB057	VB058	VB059	VB060	VB061	VB062	VB063	VB064
105	VB065	VB066	VB067	VB068	VB069	VB070	VB071	VB072
106	VB073	VB074	VB075	VB076	VB077	VB078	VB079	VB080
107	VB081	VB082	VB083	VB084	VB085	VB086	VB087	VB088
108	VB089	VB090	VB091	VB092	VB093	VB094	VB095	VB096
109	VB097	VB098	VB099	VB100	VB101	VB102	VB103	VB104
110	VB105	VB106	VB107	VB108	VB109	VB110	VB111	VB112
111	VB113	VB114	VB115	VB116	VB117	VB118	VB119	VB120
112	VB121	VB122	VB123	VB124	VB125	VB126	VB127	VB128
113	PHDEM	3I2DEM	GNDEM	*	BCWA	BCWB	BCWC	BCW
114	59VP	59VS	AFALARM	SF	25A1	25A2	DCHI	DCLO
115	59S1	59S1T	59S2	59S2T	27S1	27S1T	27S2	27S2T
116	TQUAL8	TQUAL4	TQUAL2	TQUAL1	DST	DSTP	LPSEC	LPSECP
117	FREQFZ	*	TUTCS	TUTC1	TUTC2	TUTC4	TUTC8	TUTCH
118	59G1	59G1T	59G2	59G2T	59Q1	59Q1T	59Q2	59Q2T
119	81R1T	81R2T	81R3T	81R4T	AFS1DIAG	AFS2DIAG	AFS3DIAG	AFS4DIAG
120	TOL1	TOL2	TOL3	TOL4	AFS1EL	AFS2EL	AFS3EL	AFS4EL
121	27PP1	27PP1T	27PP2	27PP2T	59PP1	59PP1T	59PP2	59PP2T
122	67P1P	67P2P	67P3P	67P4P	67P1T	67P2T	67P3T	67P4T
123	67Q1P	67Q2P	67Q3P	67Q4P	67Q1T	67Q2T	67Q3T	67Q4T
124	67G1P	67G2P	67G3P	67G4P	67G1T	67G2T	67G3T	67G4T
125	50QF	50QR	50GF	50GR	DIRVE	DIRQGE	DIRIE	DIRQE
126	FDIRP	RDIRP	FDIRQ	RDIRQ	FDIRQG	RDIRQG	FDIRV	RDIRV
127	FDIRI	RDIRI	DIRPF	DIRPR	DIRQF	DIRQR	DIRGF	DIRGR
128	G1DIR	G2DIR	G3DIR	G4DIR	Q1DIR	Q2DIR	Q3DIR	Q4DIR
129	P1DIR	P2DIR	P3DIR	P4DIR	50PDIR	*	TSNTPB	TSNTPP
130	*	*	*	81RFBLK	81RFT	81RFBL	81RFP	81RFI
131	ZLOAD	ZLOUT	ZLIN	VPOLV	PHASE_A	PHASE_B	PHASE_C	GFLT
132	INI_HIF	*	*	*	HIFER	HIFMODE	HIFREC	3PH_EVE
133	*	HIA1_C	HIA1_B	HIA1_A	*	HIA2_C	HIA2_B	HIA2_A
134	*	HIF1_C	HIF1_B	HIF1_A	*	HIF2_C	HIF2_B	HIF2_A
135	*	NTUNE_C	NTUNE_B	NTUNE_A	*	ITUNE_C	ITUNE_B	ITUNE_A

Table J.1 SELogic Relay Word Bits (Sheet 5 of 5)

Bit/Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
136	*	DIC_DIS	DIB_DIS	DIA_DIS	*	DVC_DIS	DVB_DIS	DVA_DIS
137	*	DL2CLRC	DL2CLRB	DL2CLRA	*	FRZCLRC	FRZCLRB	FRZCLRA
138	*	DUPC	DUPB	DUPA	*	DDNC	DDNB	DDNA
139	3PH_CLR	3PH_C	3PH_B	3PH_A	LR3	LRC	LRB	LRA
140	OREDHIF1	OREDHIF2	*	*	FSA	FSB	FSC	FIDEN
141	*	*	*	*	*	*	*	*
142	*	*	*	*	*	*	*	*
143	*	*	*	*	*	*	*	*
144	*	*	*	*	*	*	*	*

Definitions

Table J.2 Relay Word Bit Definitions for the SEL-751 (Sheet 1 of 12)

Bit	Definition	Row
3I2DEM	Negative-sequence current demand pickup	113
3P27	3-Phase undervoltage pickup	10
3P59	3-Phase overvoltage pickup	10
3PH_A	A-phase above 3-phase event level	139
3PH_B	B-phase above 3-phase event level	139
3PH_C	C-phase above 3-phase event level	139
3PH_CLR	3-phase events cleared	139
3PH_EVE	3-phase event detection	132
3PWR1P	3-phase power element 1 pickup	26
3PWR1T	3-phase power element 1 trip	14
3PWR2P	3-phase power element 2 pickup	26
3PWR2T	3-phase power element 2 trip	14
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
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

Table J.2 Relay Word Bit Definitions for the SEL-751 (Sheet 2 of 12)

Bit	Definition	Row
50A1P	Level 1 A-phase instantaneous overcurrent element pickup	1
50B1P	Level 1 B-phase instantaneous overcurrent element pickup	1
50C1P	Level 1 C-phase instantaneous overcurrent element pickup	1
50G1P	Level 1 residual ground instantaneous overcurrent element pickup	4
50G1T	Level 1 residual ground instantaneous overcurrent element trip	5
50G2P	Level 2 residual ground instantaneous overcurrent element pickup	4
50G2T	Level 2 residual ground instantaneous overcurrent element trip	5
50G3P	Level 3 residual ground instantaneous overcurrent element pickup	4
50G3T	Level 3 residual ground instantaneous overcurrent element trip	5
50G4P	Level 4 residual ground instantaneous overcurrent element pickup	4
50G4T	Level 4 residual ground instantaneous overcurrent element trip	5
50GF	Forward direction residual ground overcurrent threshold exceeded	125
50GR	Reverse direction residual ground overcurrent threshold exceeded	125
50N1P	Level 1 neutral ground instantaneous overcurrent element pickup	4
50N1T	Level 1 neutral ground instantaneous overcurrent element trip	5
50N2P	Level 2 neutral ground instantaneous overcurrent element pickup	4
50N2T	Level 2 neutral ground instantaneous overcurrent element trip	5
50N3P	Level 3 neutral ground instantaneous overcurrent element pickup	4
50N3T	Level 3 neutral ground instantaneous overcurrent element trip	5
50N4P	Level 4 neutral ground instantaneous overcurrent element pickup	4
50N4T	Level 4 neutral ground instantaneous overcurrent element trip	5
50NAF	Sample based neutral overcurrent element pickup	1
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	3-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

Table J.2 Relay Word Bit Definitions for the SEL-751 (Sheet 3 of 12)

Bit	Definition	Row
50QR	Reverse direction negative-sequence overcurrent threshold exceeded	8
51AP	Phase A time-overcurrent element pickup	6
51AR	Phase A time-overcurrent element reset	8
51AT	Phase A time-overcurrent element trip	7
51BP	Phase B time-overcurrent element pickup	6
51BR	Phase B time-overcurrent element reset	8
51BT	Phase B time-overcurrent element trip	7
51CP	Phase C time-overcurrent element pickup	6
51CR	Phase C time-overcurrent element reset	8
51CT	Phase C 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 contact—A state	1
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
59P1	Level 1 phase overvoltage element pickup	10
59P1T	Level 1 phase overvoltage element trip	10
59P2	Level 2 phase overvoltage element pickup	10

Table J.2 Relay Word Bit Definitions for the SEL-751 (Sheet 4 of 12)

Bit	Definition	Row
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
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
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
79CY	Reclosing relay in reclose cycle state	30

Table J.2 Relay Word Bit Definitions for the SEL-751 (Sheet 5 of 12)

Bit	Definition	Row
79LO	Reclosing relay in lockout state	30
79RS	Reclosing relay in reset state	30
81D1T	Level 1 definite-time over/underfrequency trip	11
81D2T	Level 2 definite-time over/underfrequency trip	11
81D3T	Level 3 definite-time over/underfrequency trip	11
81D4T	Level 4 definite-time over/underfrequency trip	11
81D5T	Level 5 definite-time over/underfrequency trip	11
81D6T	Level 6 definite-time over/underfrequency trip	11
81R1T–81R4T	Level 1–Level 4 rate-of-change-of-frequency element trips	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
AFALARM	Arc-Flash system integrity alarm, logical OR of all AF diagnostics and excessive light bits (AFSnDIAG & AFSnSEL)	114
AFS1DIAG–AFS4DIAG	AF light input 1–4 diagnostic failure	119
AFS1EL–AFS4EL	AF light input 1–4 excessive ambient light pickup for long time	120
AIHAL	Analog inputs high alarm limit	67
AIHW1	Analog inputs high warning, level 1	67
AIHW2	Analog inputs high warning, level 2	67
AILAL	Analog inputs low alarm limit	67
AILW1	Analog inputs low warning, level 1	67
AILW2	Analog inputs low warning, level 2	67
AMBALRM	Ambient temperature alarm. AMBALRM asserts if the healthy ambient RTD temperature exceeds its alarm set point.	12
AMBTRIP	Ambient temperature trip. AMBTRIP asserts when the healthy ambient RTD temperature exceeds its trip set point.	12
BCW	BCWA + BCWB + BCWC	113
BCWA	Phase A breaker contact wear has reached the 100 percent wear level	113
BCWB	Phase B breaker contact wear has reached the 100 percent wear level	113
BCWC	Phase C breaker contact wear has reached the 100 percent wear level	113
BFI	Breaker failure initiation. Asserts when the SELOGIC control equation BFI result in a logical 1. Use to indicate that the breaker failure logic has started.	12
BFT	Breaker failure trip. Asserts when the relay issues a breaker failure trip.	12
BKMON	Breaker monitor initiation	12
BRGALRM	Bearing temperature alarm BRGALRM asserts when any healthy bearing RTD temperature exceeds its alarm set point.	25
BRGTRIP	Bearing temperature trip BRGTRIP asserts when one or two (when EBRGV = Y) healthy bearing RTD temperatures exceed their trip set points.	25
CBADA	Channel A, outage duration over threshold	96
CBADB	Channel B, outage duration over threshold	96

Table J.2 Relay Word Bit Definitions for the SEL-751 (Sheet 6 of 12)

Bit	Definition	Row
CC	Close command—asserts when serial port command CC (CLOSE/) or front panel or Modbus/ DeviceNet close command is issued (replaces START)	33
CF	Close condition failure (asserts for ¼ cycle)	31
CFGFLT	Asserts on failed settings interdependency check during Modbus setting change.	14
CL	Close SELOGIC control equation	38
CLOSE	Close logic output	31
COMMFLT	Time-out of internal communication between CPU board and DeviceNet board	14
COMMIDLE	DeviceNet card in programming mode	14
COMMLOSS	DeviceNet communications 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 phase A	32
DI_B	B-phase distortion index phase B	32
DI_C	C-phase distortion index phase C	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
DIRPF	Forward directional control routed to phase overcurrent elements	127
DIRPR	Reverse directional control routed to phase overcurrent elements	127
DIRQE	Internal enable for negative-sequence voltage-polarized directional element	125
DIRQF	Forward directional control routed to negative-sequence overcurrent elements	127
DIRQGE	Internal enable for negative-sequence voltage-polarized directional element	125
DIRQR	Reverse directional control routed to negative-sequence overcurrent elements	127
DIRVE	Internal enable for zero-sequence voltage-polarized directional element	125
DL2CLRA	A-phase decision logic clear	137
DL2CLRB	B-phase decision logic clear	137
DL2CLRC	C-phase decision logic clear	137
DNAUX1–DNAUX8	DeviceNet/ModBus AUX1–AUX8 assert bits	34
DNAUX9–DNAUX11	DeviceNet/ModBus AUX9–AUX11 assert bit	35
DSABLSET	SELOGIC control equation: do not allow settings changes from front-panel interface when asserted.	26
DST	Daylight savings time pending	116
DSTP	Direction of the upcoming leap second. During the time that LPSECP is asserted, if LPSEC is asserted, the upcoming leap second is deleted; otherwise, the leap second is added.	116
DUPA	A-phase tuning threshold increase	138
DUPB	B-phase tuning threshold increase	138

Table J.2 Relay Word Bit Definitions for the SEL-751 (Sheet 7 of 12)

Bit	Definition	Row
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
ER	Event report trigger SELOGIC control equation	33
FAULT	Indicates fault condition. Asserts when SELOGIC control equation FAULT result in a logical 1.	13
FDIRI	Forward channel IN current-polarized directional element	127
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
FIDEN	Fault identification logic ENabled	140
FREQFZ	Synchrophasor Bit that asserts if the measured frequency > +/- 20 Hz from nominal. Reserved	117
FREQTRK	Frequency tracking enable bit-tracking enabled when bit is asserted	33
FRZCLRA	A-phase average freeze and trending clear condition	137
FRZCLRB	B-phase average freeze and trending clear condition	137
FRZCLRC	C-phase average freeze and trending clear condition	137
FSA	A-phase fault selection	140
FSB	B-phase fault selection	140
FSC	C-phase fault selection	140
G1DIR	Directional control for element 67G1P and 51G1P	128
G2DIR	Directional control for element 67G2P and 51G2P	128
G3DIR	Directional control for element 67G3P	128
G4DIR	Directional control for element 67G4P	128
GFLT	Ground fault; asserts for x cycles, where x = LER–PRE–0.75 (LER and PRE are event report settings)	131
GNDEM	Zero-sequence current demand pickup	113
HALARM	Diagnostics failure	26
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

Table J.2 Relay Word Bit Definitions for the SEL-751 (Sheet 8 of 12)

Bit	Definition	Row
HIFER	HIF event report external trigger SELOGIC setting	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
IN401–IN408	Contact inputs IN401–IN408 (available only with optional I/O module	19
IN501–IN508	Contact inputs IN501–IN508 (available only with optional I/O module	20
INI_HIF	INI HIF command Relay Word bit, set by INI command & cleared by adaptive tuning enable	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
LBOKA	Channel A, channel unavailability over threshold	96
LBOKB	Channel B, channel unavailability over threshold	96
LINKA	Assert if Ethernet Port A detects link	13
LINKB	Assert if Ethernet Port B detects link	13
LINKFAIL	Failure of active Ethernet Port link	31
LOP	Loss of potential	14
LPSEC	Leap second pending	116
LPSECP	Time quality bit, add 8 when asserted	116
LR3	3-phase load reduction event	139
LRA	A-phase load reduction	139
LRB	B-phase load reduction	139
LRC	C-phase load reduction	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
NTUNE_A	A-phase normal tuning	135
NTUNE_B	B-phase normal tuning	135
NTUNE_C	C-phase normal tuning	135
OC	Open command–asserts when serial port command Open or Front Panel or Modbus/ DeviceNet Open command is issued (replaces STOP)	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

Table J.2 Relay Word Bit Definitions for the SEL-751 (Sheet 9 of 12)

Bit	Definition	Row
ORED81T	ORed over/under frequency element	21
OREDHIF1	HIF1_A OR HIF1_B OR HIF1_C	140
OREDHIF2	HIF2_A OR HIF2_B OR HIF2_C	140
OTHALRM	Other temperature alarm. OTHALRM asserts when any healthy other RTD temperature exceeds its alarm set point.	12
OTHTRIP	Other temperature trip. OTHTRIP asserts when one or more healthy Other RTD temperatures exceed their trip set points.	12
OUT101–OUT103	Control equation for contact outputs OUT101–OUT103	21
OUT301–OUT308	Control equation for contact outputs OUT301–OUT308 (Available only with optional I/O module)	22
OUT401–OUT408	Control equation for contact outputs OUT401–OUT408 (Available only with optional I/O module)	23
OUT501–OUT508	Control equation for contact outputs OUT501–OUT508(Available only with optional I/O module)	24
P1DIR	Directional control for element 67P1P and 51P1P	129
P2DIR	Directional control for element 67P2P and 51P2P	129
P3DIR	Directional control for element 67P3P	129
P4DIR	Directional control for element 67P4P	129
PASEL	Ethernet Port A is active	31
PB01_PUL–PB08_PUL	Front-panel pushbutton 1–8 pulse bit (asserted for one processing interval when PB01–PB08 is pressed)	16
PB01–PB08	Front-panel pushbutton 1–8 bit (asserted when PB0–PB081 is pressed)	15
PB1A_LED–PB4A_LED	SELOGIC control equation: drives LED PB1A–LED PB4A	36
PB1B_LED–PB4B_LED	SELOGIC control equation: drives LED PB1B–LED PB4B	36
PB5A_LED–PB8A_LED	SELOGIC control equation: drives LED PB5A–LED PB8A	37
PB5B_LED–PB8B_LED	SELOGIC control equation: drives LED PB5B–LED PB8B	37
PBSEL	Ethernet Port B is active	31
PHASE_A	A-phase involved in the fault; asserts for x cycles, where x = LER–PRE–0.75 (LER and PRE are event report settings)	131
PHASE_B	B-phase involved in the fault; asserts for x cycles, where x = LER–PRE–0.75 (LER and PRE are event report settings)	131
PHASE_C	C-phase involved in the fault; asserts for x cycles, where x = LER–PRE–0.75 (LER and PRE are event report settings)	131
PHDEM	Phase current demand pickup	113
PMDOK	Assert if data acquisition system is operating correctly	13
PMTRIG	Trigger for synchrophasors	33
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

Table J.2 Relay Word Bit Definitions for the SEL-751 (Sheet 10 of 12)

Bit	Definition	Row
RBADA	Channel A, received data ok	96
RBADB	Channel B, received data ok	96
RCSF	Reclose Supervision failure (asserts for ¼ cycle)	31
RDIRI	Reverse channel IN current-polarized directional element	127
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
RELAY_EN	Relay data quality flag	35
REMTRIP	Remote trip	14
RMB1A–RMB8A	Channel A receive mirror bits RMB1A through RMB8A	92
RMB1B–RMB8B	Channel B receive mirror bits RMB1B through RMB8B	94
ROKA	Channel B, looped back ok	96
ROKB	Channel A, looped back ok	96
RSTDEM	Reset demand meter.	25
RSTENRGY	Reset energy metering. Assert when the SELOGIC control equation RSTENRG result is logical 1.	25
RSTMN	Reset timer is timing	31
RSTMXMN	Reset Max Min metering. Assert when the SELOGIC control equation RSTMXMN result is logical 1.	25
RSTPKDEM	Reset peak demand meter.	25
RSTTRGT	SELOGIC control equation: reset trip logic and targets when asserted.	
RTD1A–RTD4A RTD1T–RTD4T	RTD1 through RTD4: alarms and trips	27
RTD5A–RTD8A RTD5T–RTD8T	RTD5 through RTD8: alarms and trips	28
RTD9A–RTD12A RTD9T–RTD12T	RTD9 through RTD12: alarms and trips	29
RTDFLT	Asserts when the relay detects an open or short-circuit condition on any enabled RTD input, or when communication with the external RTD module has been interrupted.	26
RTDIN	Indicates status of contact connected to SEL-2600A RTD module.	26
SALARM	Software alarms: invalid password, changing access levels, settings changes, 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
SF	Slip frequency of voltages VP and VS and less than setting 25SF	114
SG1	Asserts when setting group 1 is active.	32

Table J.2 Relay Word Bit Definitions for the SEL-751 (Sheet 11 of 12)

Bit	Definition	Row
SG2	Asserts when setting group 2 is active.	32
SG3	Asserts when setting group 3 is active.	32
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
SHO	Reclosing relay shot counter = 0	30
SV01–SV08	SELOGIC control equation variables SV01 through SV08	47
SV01T–SV08T	SELOGIC control equation variable SV01T through SV08T with settable pickup and dropout time delay	48
SV09–SV16	SELOGIC control equation variables SV09 through SV16	49
SV09T–SV16T	SELOGIC control equation variable SV09T through SV16T with settable pickup and dropout time delay	50
SV17–SV24	SELOGIC control equation variables SV17 through SV24	51
SV17T–SV24T	SELOGIC control equation variable SV17T through SV24T with settable pickup and dropout time delay	52
SV25–SV32	SELOGIC control equation variables SV25 through SV32	53
SV25T–SV32T	SELOGIC control equation variable SV25T through SV32T with settable pickup and dropout time delay	54
T01_LED–T06_LED	SELOGIC control equation: drives T01_LED–T06_LED	38
TLED_01–TLED_06	Target LED 1–Target LED 6	0
TMB1A–TMB8A	Channel A transmit mirror bits TMB1A through TMB8A	93
TMB1B–TMB8B	Channel B transmit mirror bits TMB1B through TMB8B	95
TOL1–TOL4	Arc-flash light input 1–4 element pickups	120
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
TUTC1	Offset hours from UTC time, binary, add 1 if asserted	117
TUTC2	Offset hours from UTC time, binary, add 2 if asserted	117
TUTC4	Offset hours from UTC time, binary, add 4 if asserted	117
TUTC8	Offset hours from UTC time, binary, add 8 if asserted	117
TUTCH	Offset half-hour from UTC time, binary, add 0.5 if asserted	117

Table J.2 Relay Word Bit Definitions for the SEL-751 (Sheet 12 of 12)

Bit	Definition	Row
TUTCS	Offset hours sign from UTC time, subtract the UTC offset if TUTCS is asserted; otherwise, add.	117
ULCL	Unlatch close conditions SELOGIC control equation state	38
ULTRIP	Unlatch (autvb bo reset) trip from SELOGIC control equation	33
VBxxx	Virtual bits used for incoming GOOSE messages (xxx = 1–128)	97–112
VPOLV	X side positive-sequence polarization voltage valid	131
WARNING	Relay Word WARNING	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	Y side load encroachment “load in” element	131
ZLOAD	Load encroachment element pickup	131
ZLOUT	Y side load encroachment “load out” element	131

Appendix K
Analog Quantities

The SEL-751 Feeder Protection Relay contains several analog quantities that you can use for more than one function. The actual analog quantities available depend on the part number of the relay you use. Analog quantities are typically generated and used by a primary function, such as metering, and selected quantities are made available for one or more supplemental functions, for example, the load profile.

Note that all analog quantities available for use in SELOGIC control equations are processed every 25 ms and may not be suitable for fast-response control and protection applications.

Table K.1 lists analog quantities that you can use in the following specific functions:

- SELOGIC control equations (see *Section 4: Protection and Logic Functions*.)
- Display points (see *Section 8: Front-Panel Operations*.)
- Load profile recorder (see *Section 5: Metering and Monitoring*.)
- DNP (see *Appendix D: DNP3 Communications*.)
- Fast Meter (see *Appendix C: SEL Communications Processors*.)

For a list of analog quantities available for Modbus communications, see *Appendix E: Modbus RTU Communications*.

Table K.1 Analog Quantities (Sheet 1 of 7)

Name	Description	Units	Display Points	SELOGIC	Load Profile	DNP	Fast Meter
Fundamental Instantaneous Metering							
IA_MAG	A-phase line current	A pri	x	x	x	x	x
IA_ANG	Angle of the A-phase line current	degrees	x	x	x	x	
IB_MAG	B-phase line current	A pri	x	x	x	x	x
IB_ANG	Angle of the B-phase line current	degrees	x	x	x	x	
IC_MAG	C-phase line current	A pri	x	x	x	x	x
IC_ANG	Angle of the C-phase line current	degrees	x	x	x	x	
IN_MAG	Neutral current	A pri	x	x	x	x	x
IN_ANG	Angle of the neutral current	degrees	x	x	x	x	
IG_MAG	Calculated-residual current	A pri	x	x	x	x	x
IG_ANG	Angle of the calculated-residual current	degrees	x	x	x	x	
IAV	Average line current	A pri	x	x	x	x	
3I2	Negative-sequence current	A pri	x	x	x	x	

Table K.1 Analog Quantities (Sheet 2 of 7)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP	Fast Meter
UBI	Current unbalance	%	x	x	x	x	x
VA_MAG	A-phase-to-neutral voltage	V pri	x	x	x	x	
VA_ANG	Angle of the A-phase-to-neutral voltage	degrees	x	x	x	x	
VB_MAG	B-phase-to-neutral voltage	V pri	x	x	x	x	
VB_ANG	Angle of the B-phase-to-neutral voltage	degrees	x	x	x	x	
VC_MAG	C-phase-to-neutral voltage	V pri	x	x	x	x	
VC_ANG	Angle of the C-phase-to-neutral voltage	degrees	x	x	x	x	
VAB_MAG	A-to-B-phase voltage	V pri	x	x	x	x	x
VAB_ANG	Angle of the A-to-B-phase voltage	degrees	x	x	x	x	
VBC_MAG	B-to-C-phase voltage	V pri	x	x	x	x	x
VBC_ANG	Angle of the B-to-C-phase voltage	degrees	x	x	x	x	
VCA_MAG	C-to-A-phase voltage	V pri	x	x	x	x	x
VCA_ANG	Angle of the C-to-A-phase voltage	degrees	x	x	x	x	
VG_MAG	Zero Sequence Voltage	V pri	x	x	x	x	
VG_ANG	Angle of the zero sequence voltage	degrees	x	x	x	x	
VS_MAG	Sync. voltage	V pri	x	x	x	x	x
VS_ANG	Angle of the sync. voltage	degrees	x	x	x	x	
VAVE	Average voltage	V pri	x	x	x	x	
3V2	Negative-sequence voltage	V pri	x	x	x	x	
UBV	Voltage unbalance	%	x	x	x	x	x
SA	A-phase apparent power	kVA pri	x	x	x	x	
SB	B-phase apparent power	kVA pri	x	x	x	x	
SC	C-phase apparent power	kVA pri	x	x	x	x	
S	3-phase apparent power	kVA pri	x	x	x	x	x
PA	A-phase real power	kW pri	x	x	x	x	
PB	B-phase real power	kW pri	x	x	x	x	
PC	C-phase real power	kW pri	x	x	x	x	
P	3-phase real power	kW pri	x	x	x	x	x
QA	A-phase reactive power	kVAR pri	x	x	x	x	
QB	B-phase reactive power	kVAR pri	x	x	x	x	
QC	C-phase reactive power	kVAR pri	x	x	x	x	
Q	3-phase reactive power	kVAR pri	x	x	x	x	x
PFA	A-phase power factor		x	x	x	x	
PFB	B-phase power factor		x	x	x	x	
PFC	C-phase power factor		x	x	x	x	
PF	3-phase power factor		x	x	x	x	x
FREQ	Frequency	Hz	x	x	x	x	x
FREQS	Synch Frequency	Hz	x	x	x	x	x
DFDT	Frequency Rate-of-Change	Hz/sec.	x	x			

Table K.1 Analog Quantities (Sheet 3 of 7)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP	Fast Meter
VDC	Station dc battery voltage	Vdc	x	x	x	x	x
I1_MAG	Positive-sequence current	A pri	x	x	x	x	
I1_ANG	Angle of Positive-sequence current	degrees	x	x		x	
V1_MAG	Positive-sequence voltage	V pri	x	x	x	x	
V1_ANG	Angle of Positive-sequence voltage	degrees	x	x		x	
Fault Information							
FLOC	Fault location		x	x		x	
FIA	Phase A Fault Current from maximum current event report row	A pri	x	x		x	
FIB	Phase B Fault Current from maximum current event report row	A pri	x	x		x	
FIC	Phase C Fault Current from maximum current event report row	A pri	x	x		x	
FIG	Ground Fault Current from maximum current event report row	A pri	x	x		x	
FIN	Neutral Fault Current from maximum current event report row	A pri	x	x		x	
FFREQ	Event Frequency	Hz	x	x		x	
Light Metering							
LSENS1	Arc-Flash sensor 1 light	%	x	x	x	x	
LSENS2	Arc-Flash sensor 2 light	%	x	x	x	x	
LSENS3	Arc-Flash sensor 3 light	%	x	x	x	x	
LSENS4	Arc-Flash sensor 4 light	%	x	x	x	x	
Thermal Metering							
RTDWDGMX	Maximum winding RTD temperature	°C	x	x		x	
RTDBRGMX	Maximum bearing RTD temperature	°C	x	x		x	
RTDAMB	Ambient RTD Temperature	°C	x	x		x	
RTDOTHMX	Other Maximum RTD Temperature	°C	x	x		x	
RTD1 to RTD12	RTD1 temperature to RTD12 temperature[a]	°C	x	x	x	x	
Analog Input Metering							
AI301 to AI308	Analog inputs for an analog card in Slot C[b]		x	x	x	x	
AI401 to AI408	Analog inputs for an analog card in Slot D[b]		x	x	x	x	
AI501 to AI508	Analog inputs for an analog card in Slot E[b]		x	x	x	x	
Energy Metering							
EM_LRDH	Energy Last Reset Date/Time High Word					x	
EM_LRDM	Energy Last Reset Date/Time Middle Word					x	
EM_LRDL	Energy Last Reset Date/Time Low Word					x	
MWH3PI	3-phase real energy IN	MWh pri	x	x	x	x	
MWH3P	3-phase real energy OUT	MWh pri	x	x	x	x	

Table K.1 Analog Quantities (Sheet 4 of 7)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP	Fast Meter
MVARH3PI	3-phase reactive energy IN	MVARh pri	x	x	x	x	
MVARH3PO	3-phase reactive energy OUT	MVARh pri	x	x	x	x	
MVAH3P	3-phase apparent energy	MVAh pri	x	x	x	x	
Maximum/minimum Metering							
MM_LRDH	Max/Min Last Reset Date/Time High Word					x	
MM_LRDM	Max/Min Last Reset Date/Time Middle Word					x	
MM_LRDL	Max/Min Last Reset Date/Time Low Word					x	
IAMX	A-phase maximum current	A pri	x	x	x	x	
IBMX	B-phase maximum current	A pri	x	x	x	x	
ICMX	C-phase maximum current	A pri	x	x	x	x	
INMX	Neutral maximum current	A pri	x	x	x	x	
IGMX	Calculated residual maximum current	A pri	x	x	x	x	
IAMN	A-phase minimum current	A pri	x	x	x	x	
IBMN	B-phase minimum current	A pri	x	x	x	x	
ICMN	C-phase minimum current	A pri	x	x	x	x	
INMN	Neutral minimum current	A pri	x	x	x	x	
IGMN	Calculated residual minimum current	A pri	x	x	x	x	
VABMX	A-to-B-phase maximum voltage	V pri	x	x	x	x	
VBCMX	B-to-C-phase maximum voltage	V pri	x	x	x	x	
VCAMX	C-to-A-phase maximum voltage	V pri	x	x	x	x	
VAMX	A-phase maximum voltage	V pri	x	x	x	x	
VBMX	B-phase, maximum voltage	V pri	x	x	x	x	
VCMX	C-phase maximum voltage	V pri	x	x	x	x	
VSMX	Vsync maximum voltage	V pri	x	x		x	
VABMN	A-to-B-phase minimum voltage	V pri	x	x	x	x	
VBCMN	B-to-C-phase minimum voltage	V pri	x	x	x	x	
VCAMN	C-to-A-phase minimum voltage	V pri	x	x	x	x	
VAMN	A-phase minimum voltage	V pri	x	x	x	x	
VBMN	B-phase minimum voltage	V pri	x	x	x	x	
VCMN	C-phase minimum voltage	V pri	x	x	x	x	
VSMN	Vsync minimum voltage	V pri	x	x		x	
KVA3PMX	3-phase maximum apparent power	kVA pri	x	x	x	x	
KW3PMX	3-phase, maximum real power	kW pri	x	x	x	x	
KVAR3PMX	3-phase, maximum reactive power	kVAR pri	x	x	x	x	
KVA3PMN	3-phase minimum apparent power	kVA pri	x	x	x	x	
KW3PMN	3-phase minimum real power	kW pri	x	x	x	x	
KVAR3PMN	3-phase, minimum reactive power	kVAR pri	x	x	x	x	
FREQMX	Maximum frequency	Hz	x	x	x	x	
FREQMN	Minimum frequency	Hz	x	x	x	x	
RTD1MX to RTD12MX	RTD1 maximum to RTD12 maximum	°C	x	x	x	x	

Table K.1 Analog Quantities (Sheet 5 of 7)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP	Fast Meter
RTD1MN to RTD12MN	RTD1 minimum to RTD12 minimum	°C	x	x	x	x	
AI301MX to AI308MX	Analog transducer input 301–308 maximum[b]		x	x	x	x	
AI301MN to AI308MN	Analog transducer input 301–308 minimum[b]		x	x	x	x	
AI401MX to AI408MX	Analog transducer input 401–408 maximum[b]		x	x	x	x	
AI401MN to AI408MN	Analog transducer input 401–408 minimum[b]		x	x	x	x	
AI501MX to AI508MX	Analog transducer input 501–508 maximum[b]		x	x	x	x	
AI501MN to AI508MN	Analog transducer input 501–508 minimum[b]		x	x	x	x	
RMS Metering							
IARMS	A-phase rms current	A pri	x	x	x	x	
IBRMS	B-phase rms current	A pri	x	x	x	x	
ICRMS	C-phase rms current	A pri	x	x	x	x	
INRMS	Neutral RMS current	A pri	x	x	x	x	
VARMS	A-phase rms voltage	V pri	x	x	x	x	
VBRMS	B-phase rms voltage	V pri	x	x	x	x	
VCRMS	C-phase rms voltage	V pri	x	x	x	x	
VSRMS	Vsync rms voltage	V pri	x	x	x	x	
VABRMS	A-to-B-phase rms voltage	V pri	x	x	x	x	
VBCRMS	B-to-C-phase rms voltage	V pri	x	x	x	x	
VCARMS	C-to-A-phase rms voltage	V pri	x	x	x	x	
Demand Metering							
IAD	A-phase current demand	A pri	x	x		x	x
IBD	B-phase current demand	A pri	x	x		x	x
ICD	C-phase current demand	A pri	x	x		x	x
IGD	Residual current demand	A pri	x	x		x	x
3I2D	Negative-sequence current Demand	A pri	x	x		x	x
KWADI	Real power, A-phase demand IN	kW pri	x	x		x	
KWBDI	Real power, B-phase demand IN	kW pri	x	x		x	
KWCDI	Real power, C-phase demand IN	kW pri	x	x		x	
KW3DI	Real power, 3-phase demand IN	kW pri	x	x		x	
KVARADI	Reactive power, A-phase demand IN	kVAR pri	x	x		x	
KVARBDI	Reactive power, B-phase demand IN	kVAR pri	x	x		x	
KVARCDI	Reactive power, C-phase demand IN	kVAR pri	x	x		x	
KVAR3DI	Reactive power, 3-phase demand IN	kVAR pri	x	x		x	
KWADO	Real-power, A-phase demand OUT	kW pri	x	x		x	
KWBDO	Real power, B-phase demand OUT	kW pri	x	x		x	
KWCDO	Real power, C-phase demand OUT	kW pri	x	x		x	
KW3DO	Real power, 3-phase demand OUT	kW pri	x	x		x	
KVARADO	Reactive power, A-phase demand OUT	kVAR pri	x	x		x	
KVARBDO	Reactive power, B-phase demand OUT	kVAR pri	x	x		x	

Table K.1 Analog Quantities (Sheet 6 of 7)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP	Fast Meter
KVARCDO	Reactive power, C-phase demand OUT	kVAR pri	x	x		x	
KVAR3DO	Reactive power, 3-phase demand OUT	kVAR pri	x	x		x	
Peak Demand Metering							
PM_LRDH	Peak demand last reset date/time high word					x	
PM_LRDM	Peak demand last reset date/time middle word					x	
PM_LRDL	Peak demand last reset date/time low word					x	
IAPD	A-phase current peak demand	A pri	x	x		x	x
IBPD	B-phase current peak demand	A pri	x	x		x	x
ICPD	C-phase current peak demand	A pri	x	x		x	x
IGPD	Residual current peak demand	A pri	x	x		x	x
3I2PD	Negative-sequence current peak demand	A pri	x	x		x	x
KWAPDI	Real power, A-phase peak demand IN	kW pri	x	x		x	
KWBPDI	Real power, B-phase peak demand IN	kW pri	x	x		x	
KWCPDI	Real power, C-phase peak demand IN	kW pri	x	x		x	
KW3PDI	Real power, 3-phase peak demand IN	kW pri	x	x		x	
KVARAPDI	Reactive power, A-phase peak demand IN	kVAR pri	x	x		x	
KVARBPDI	Reactive power, B-phase peak demand IN	kVAR pri	x	x		x	
KVARCPDI	Reactive power, C-phase peak demand IN	kVAR pri	x	x		x	
KVAR3PDI	Reactive power, 3-phase peak demand IN	kVAR pri	x	x		x	
KWAPDO	Real power, A-phase peak demand OUT	kW pri	x	x		x	
KWBPDO	Real power, B-phase peak demand OUT	kW pri	x	x		x	
KWCPDO	Real power, C-phase peak demand OUT	kW pri	x	x		x	
KW3PDO	Real power, 3-phase peak demand OUT	kW pri	x	x		x	
KVARAPDO	Reactive power, A-phase peak demand OUT	kVAR pri	x	x		x	
KVARBPDO	Reactive power, B-phase peak demand OUT	kVAR pri	x	x		x	
KVARCPDO	Reactive power, C-phase peak demand OUT	kVAR pri	x	x		x	
KVAR3PDO	Reactive power, 3-phase peak demand OUT	kVAR pri	x	x		x	
Breaker Monitoring							
INTT	Internal trips—counter		x	x	x	x	
INTIA	Accumulated current—internal trips, A-phase	kA pri	x	x	x	x	
INTIB	Accumulated current—internal trips, B phase	kA pri	x	x	x	x	
INTIC	Accumulated current—internal trips, C phase	kA pri	x	x	x	x	
EXTT	External trips—counter		x	x	x	x	
EXTIA	Accumulated current—external trips, A phase	kA pri	x	x	x	x	
EXTIB	Accumulated current—external trips, B phase	kA pri	x	x	x	x	
EXTIC	Accumulated current—external trips, C phase	kA pri	x	x	x	x	
WEARA	Breaker wear, A-phase	%	x	x	x	x	
WEARB	Breaker wear, B-phase	%	x	x	x	x	
WEARC	Breaker wear, C-phase	%	x	x	x	x	

Table K.1 Analog Quantities (Sheet 7 of 7)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP	Fast Meter
AST/HIF (High-Impedance Fault)							
SDIA	A-phase total inter-harmonic content	A pri		x			
SDIB	B-phase total inter-harmonic content	A pri		x			
SDIC	C-phase total inter-harmonic content	A pri		x			
SDIAREF	A-phase reference total inter-harmonic content	A pri		x			
SDIBREF	B-phase reference total inter-harmonic content	A pri		x			
SDICREF	C-phase reference total inter-harmonic content	A pri		x			
ISMA	A-phase total odd-harmonic content	A pri		x			
ISMB	B-phase total odd-harmonic content	A pri		x			
ISMC	C-phase total odd-harmonic content	A pri		x			
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							
DATE[c]	Present date		x			x	x
TIME[c]	Present time		x			x	x
YEAR	Year number (0000–9999)			x			
DAYY	Day of year number (1–366)			x			
WEEK	Week number (1–52)			x			
DAYW	Day of week number (1–7)			x			
MINSM	Minutes since midnight			x			
RID/TID							
RID[d]	Relay identifier		x				
TID[d]	Terminal identifier		x				
Serial Number							
SER_NUM	Serial number of the relay					x	
Setting Group							
GROUP	Active setting group #		x	x	x	x	
Math Variables							
MV01 to MV32	Math variable 01 to math variable 32		x	x	x	x	
SELogic Counters[e]							
SC01 to SC32	SELogic counter 01 to SELogic counter 32		x	x	x	x	
Remote Analogs							
RA001 to RA128	Remote analog 01 to remote analog 128		x	x	x	x	x

[a] RTD open is equivalent to +32767 and RTD short is equivalent to –32768 when RTDs are monitored via LDP.
[b] See the Engineering Unit settings (e.g., AI301EU) of the respective analog input quantity for the unit.
[c] Also available via DNP object 50.
[d] RID, and TID are only available for display point settings (DP01 to DP32).
[e] Also available as DNP counter object.

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Glossary

A — Abbreviation for amps or amperes; units of electrical current magnitude.

ACSELERATOR QuickSet® SEL-5030 Software — A Windows®-based program that simplifies settings and provides analysis support.

ACSELERATOR Architect® SEL-5032 Software — Design and commissioning tool for IEC 61850 communications.

Ambient Temperature — Temperature of the 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
32	Directional Power Element
49	Thermal Element
50	Instantaneous Overcurrent Element
51	Inverse Time-Overcurrent Element
52	AC Circuit Breaker
55	Power Factor Element
59	Overvoltage Element
60	Loss of Potential Element
67	Directional Overcurrent Element
79	Reclosing Control Logic
81	Frequency Element
81R	Rate-of-Change-of-Frequency Element

These numbers are frequently used within a suffix letter to further designate application. The suffix letters used in this instruction manual include:

P	Phase Element
G	Residual/Ground Element
N	Neutral/Ground Element
Q	Negative-Sequence (3I2) Element

Apparent Power, S — Complex power expressed in units of volt-amps (VA), kilovolt-amps (kVA), or megavolt-amps (MVA). Accounts for both real (P) and reactive (Q) power dissipated in a circuit: S = P + jQ.

Arc-Flash Detection — The sensing of an arc-flash condition by detection of light and overcurrent by the relay.

- **Clear-Jacketed Fiber Sensor**—The fiber optic loop sensor used for arc-flash detection.
- **Point Sensor**—The fiber-optic cable sensor with a light diffuser on the end and used for arc-flash detection.

Arc-Flash Protection (Relay) — An action performed by the relay to minimize the arc-flash hazard.

Arc-Flash Hazard A dangerous condition associated with the release of energy caused by an electric arc.

ASCII Abbreviation for American Standard Code for Information Interchange. Defines a standard way to communicate text characters between two electronic devices. The SEL-751 Feeder Protection Relay uses ASCII text characters to communicate through the relay front- and rear-panel EIA-232 serial ports.

Assert To activate; to fulfill the logic or electrical requirements necessary to operate a device. To apply a short-circuit or closed contact to an SEL-751 input. To set a logic condition to the true state (logical 1). To close a normally-open output contact. To open a normally-closed output contact.

AST Arc Sense technology used for the high-impedance fault (HIF) detection elements.

Best Choice Ground Directional Supervision™ Logic An SEL logic that determines the directional element that the relay uses for ground faults.

Breaker Auxiliary Contact A spare electrical contact associated with a circuit breaker that opens or closes to indicate the breaker position. A form-a breaker auxiliary contact (ANSI Standard Device Number 52A) closes when the breaker is closed, opens when the breaker is open. A form-b breaker auxiliary contact (ANSI Standard Device Number 52B) opens when the breaker is closed and closes when the breaker is open.

C37.118 C37.118 IEEE Standard for Synchrophasors for Power Systems.

Checksum A numeric identifier of the firmware in the relay. Calculated by the result of a mathematic sum of the relay code.

CID Abbreviation for Checksum Identifier. The checksum of the specific firmware installed in the relay.

Contiguous Items in sequence; the second immediately following the first.

CR_RAM Abbreviation for Critical RAM. Refers to the area of relay Random Access Memory (RAM) where the relay stores mission-critical data.

CRC-16 Abbreviation for Cyclical Redundancy Check-16. A mathematical algorithm applied to a block of digital information to produce a unique, identifying number. Used to ensure that the information was received without data corruption.

CT Abbreviation for current transformer.

Current Unbalance The SEL-751 calculates the magnitudes of the measured phase currents, calculates the average of those magnitudes, determines the magnitude with the largest deviation from average. It then calculates the difference between the magnitude average and magnitude of the phase with the largest deviation from the average. Finally, the relay calculates the percent unbalance current by dividing the difference value by the CT nominal current or by the average magnitude, whichever is larger.

Deassert To deactivate; to remove the logic or electrical requirements necessary to operate a device. To remove a short-circuit or closed contact from an SEL-751 input. To clear a logic condition to the false state (logical 0). To open a normally-open output contact. To close a normally-closed output contact.

Delta A phase-to-phase connection of voltage transformers for electrical measuring purposes. Typically, two voltage transformers are used with one primary lead of the first transformer connected to A-phase and the other lead connected to B-phase. The second voltage transformer is connected to measure the voltage from B-phase to C-phase. When two transformers are used, this connection is frequently called “Open-Delta.”

Dropout Time The time measured from the removal of an input signal until the output signal deasserts. The time can be settable, as in the case of a logic variable timer, or can be a result of the characteristics of an element algorithm, as in the case of an overcurrent element dropout time.

Directional Supervision The relay uses directional elements to determine whether protective elements operate based on the direction of a fault relative to the relay.

DNP (Distributed Network Protocol) Manufacturer-developed, hardware-independent communications protocol.

EEPROM Abbreviation for Electrically Erasable Programmable Read-Only Memory. Nonvolatile memory where relay settings, event reports, SER records, and other nonvolatile data are stored.

Ethernet A network physical and data link layer defined by IEEE 802.2 and IEEE 802.3.

Event History A quick look at recent relay activity that includes a standard report header; event number, date, time, and type; maximum fault phase current; and targets.

Event Report A text-based collection of data stored by the relay in response to a triggering condition, such as a fault or command. The data show relay measurements before and after the trigger, in addition to the states of protection elements, relay inputs, and relay outputs each processing interval. After an electrical system fault, use event reports to analyze relay and system performance.

Event Summary A shortened version of stored event reports. An event summary includes items such as event date and time, event type, fault voltages, currents, etc. The relay sends an event report summary (if auto messaging is enabled) to the relay serial port a few seconds after an event.

Fail-Safe Refers to an output contact that is energized during normal relay operation and de-energized when relay power is removed or if the relay fails.

Fast Meter, Fast Operate Binary serial port commands that the relay recognizes at the relay front-and rear-panel EIA-232 serial ports. These commands and the responses from the relay make relay data collection by a communications processor faster and more efficient than transfer of the same data through use of formatted ASCII text commands and responses.

FID Relay firmware identification string. Lists the relay model, firmware version and date code, and other information that uniquely identifies the firmware installed in a particular relay.

Firmware The nonvolatile program stored in the relay that defines relay operation.

Flash — A type of nonvolatile relay memory used for storing large blocks of nonvolatile data, such as load profile records.

FTP — File transfer protocol.

Fundamental Frequency — The component of the measured electrical signal for which frequency is equal to the normal electrical system frequency, usually 50 or 60 Hz. Generally used to differentiate between the normal system frequency and any harmonic frequencies present.

Fundamental Meter — Type of meter data presented by the SEL-751 that includes the present values measured at the relay ac inputs. The word “Fundamental” is used to indicate that the values are Fundamental Frequency values and do not include harmonics.

Ground Directional Element Priority — The order the relay uses to select directional elements to provide ground directional decisions; relay setting ORDER.

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 61850 — Standard protocol for real-time exchange of data between databases in multi-vendor devices.

IG — Residual current, calculated from the sum of the phase currents. In normal, balanced operation, this current is very small or zero. When a ground fault occurs, this current can be large.

IN — Neutral current measured by the relay IN input. The IN input is typically connected to the secondary winding of a window-CT for ground fault detection on resistance-grounded systems.

IP Address — An identifier for a computer or device on a TCP/IP network. Networks using the TCP/IP protocol route messages based on the IP address of the destination. The format of an IP address is a 32-bit numeric address written as four numbers separated by periods. Each number can be zero to 255. For example, 1.160.10.240 could be an IP address.

IRIG-B — A time code input that the relay can use to set the internal relay clock.

LCD — Abbreviation for Liquid Crystal Display. Used as the relay front-panel alphanumeric display.

LED — Abbreviation for Light-Emitting Diode. Used as indicator lamps on the relay front panel.

HIF — High-impedance ground fault such as a downed conductor.

Load Encroachment — The load-encroachment feature allows setting of phase overcurrent elements independent of load levels.

Loss-of-Potential — Loss of one or more phase voltage inputs to the relay.

MAC Address — The Media Access Control (hardware) address of a device connected to a shared network medium, most often used with Ethernet networks.

MMS Manufacturing Messaging Specification, a data exchange protocol used by IEC 61850.

MIRRORED BITS Protocol for direct relay-to-relay communications.

NEMA Abbreviation for National Electrical Manufacturers Association.

Neutral Overcurrent Element A protection element that causes the relay to trip when the neutral current magnitude (measured by the IN input) exceeds a user-settable value. Used to detect and trip in response to ground faults.

Nominal Frequency Normal electrical system frequency, usually 50 or 60 Hz.

Nonfail-Safe Refers to an output contact that is not energized during normal relay operation. When referred to a trip output contact, the protected equipment remains in operation unprotected when relay power is removed or if the relay fails.

Nonvolatile Memory Relay memory that is able to correctly maintain data it is storing even when the relay is de-energized.

Overfrequency Element A protection element that causes the relay to trip when the measured electrical system frequency exceeds a settable frequency.

Phase Rotation The sequence of voltage or current phasors in a multi-phase electrical system. In an ABC phase rotation system, the B-phase voltage lags the A-phase voltage by 120 degrees, and the C-phase voltage lags B-phase voltage by 120 degrees. In an ACB phase rotation system, the C-phase voltage lags the A-phase voltage by 120°, and the B-phase voltage lags the C-phase voltage by 120 degrees.

Pickup Time The time measured from the application of an input signal until the output signal asserts. The time can be settable, as in the case of a logic variable timer, or can be a result of the characteristics of an element algorithm, as in the case of an overcurrent element pickup time.

Pinout The definition or assignment of each electrical connection at an interface. Typically refers to a cable, connector, or jumper.

Power, P Real part of the complex power (S) expressed in units of Watts (W), kilowatts (kW), or megawatts (MW).

Power Factor The cosine of the angle by which phase current lags phase voltage in an ac electrical circuit. Power factor equals 1.0 for power flowing to a resistive load.

Power, Q Reactive part of the complex power (S) expressed in units of Vars (W), kilovars (kVar), or megavars (MVar).

Protection and Control Processing Processing interval is four times per power system cycle (except for math variables and analog quantities, which are processed every 25 ms).

PT Abbreviation for potential transformer. Also referred to as a voltage transformer or VT.

RAM Abbreviation for Random Access Memory. Volatile memory where the relay stores intermediate calculation results, Relay Word bits, and other data that are updated every processing interval.

Rate-of-Change-of-Frequency Element A protection element that causes the relay to trip when the measured electrical system rate of change of frequency exceeds a settable rate.

Relay Word The collection of relay element and logic results. Each element or result is represented by a unique identifier, known as a Relay Word bit.

Relay Word Bit A single relay element or logic result that the relay updates once each processing interval. A Relay Word bit can be equal to either logical 1 or logical 0. Logical 1 represents a true logic condition, picked up element, or asserted contact input or contact output. Logical 0 represents a false logic condition, dropped out element, or deasserted contact input or contact output. You can use Relay Word bits in SELOGIC control equations to control relay tripping, event triggering, and output contacts, as well as other functions.

Remote Bit A Relay Word bit for which state is controlled by serial port commands, including the **CONTROL** command, binary Fast Operate command, or Modbus® command.

Residual Current The sum of the measured phase currents. In normal, balanced operation, this current is very small or zero. When a ground fault occurs, this current can be large.

RMS Abbreviation for Root-Mean-Square. Refers to the effective value of the sinusoidal current and voltage measured by the relay, accounting for the fundamental frequency and higher order harmonics in the signal.

ROM Abbreviation for Read-Only Memory. Nonvolatile memory where the relay firmware is stored.

RTD Abbreviation for Resistance Temperature Device. An RTD is made of a metal having a precisely known resistance and temperature coefficient of resistance. The SEL-751 (and the SEL-2600 RTD Module) can measure the resistance of the RTD, and thus determine the temperature at the RTD location. Typically embedded in the motor windings or attached to the races of bearings.

Self-Test A function that verifies the correct operation of a critical device subsystem and indicates if the relay has detected an out-of-tolerance condition. The SEL-751 is equipped with self-tests that validate the relay power supply, microprocessor, memory, and other critical systems.

SELOGIC® Control Equation A relay setting that allows you to control a relay function (such as an output contact) by using a logical combination of relay element outputs and fixed logic outputs. Logical AND, OR, INVERT, rising edge [/], and falling edge [\] operators, plus a single level of parentheses are available to use in each control equation setting.

Sequential Events Recorder A relay function that stores a record of the date and time of each assertion and deassertion of every Relay Word bit in a settable list. Provides a useful way to determine the order and timing of events following a relay operation.

SER Abbreviation for Sequential Events Recorder or the relay serial port command to request a report of the latest 1024 sequential events.

Synchrophasors The word synchrophasor is derived from two words: synchronized phasor. Synchrophasor measurement refers to the concept of providing measurements taken on a synchronized schedule in multiple locations. A high-accuracy clock, commonly a Global Positioning System (GPS) receiver such as the

SEL-2407 Satellite-Synchronized Clock, makes synchrophasor measurement possible.

Terminal Emulation Software Personal computer (PC) software that you can use to send and receive ASCII text messages via the PC serial port.

Transducer Device that converts the input to the device to an analog output quantity of either current (±1, 2.5, 5, 10 and 20 mA, or 4–20 ma), or voltage (±1, 2.5, 5, or 10 V).

Underfrequency Element A protection element that causes the relay to trip when the measured electrical system frequency is less than a settable frequency.

VA, VB, VC Measured A-, B-, and C-phase-to-neutral voltages.

VAB, VBC, VCA Measured or calculated phase-to-phase voltages.

VG Residual voltage calculated from the sum of the three phase-to-neutral voltages, if connected.

VS Measured phase-neutral or phase-phase synchronism-check voltage.

VT Abbreviation for voltage transformer. Also referred to as a potential transformer or PT.

Wye As used in this instruction manual, a phase-to-neutral connection of voltage transformers for electrical measuring purposes. Three voltage transformers are used with one primary lead of the first transformer connected to A-phase and the other lead connected to ground. The second and third voltage transformers are connected to measure the voltage from B-phase and C-phase-to-ground, respectively. This connection is frequently called “four-wire wye,” alluding to the three phase leads plus the neutral lead.

Z-Number That portion of the relay RID string that identifies the proper ACSELERATOR QuickSet SEL-5030 software relay driver version when creating or editing relay settings files.

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SEL-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.

Serial Port Command	Command Description
Access Level 0 Commands	
ACC	Goes to Access Level 1.
ID	Relay identification code.
QUI	Goes to Access Level 0.
Access Level 1 Commands	
2AC	Goes to Access Level 2.
BRE	Displays breaker monitor data (trips, interrupted current, wear).
CEV *n*	Shows compressed event report number ***n***, at 1/4-cycle resolution. Attach R for compressed raw report, at 1/32- cycle resolution.
CEV HIF *n*	Shows compressed HIF (high-impedance fault) event record or reference number ***n***, at 2-cycle resolution
COM A	Returns a summary report of the last 255 records in the communications buffer for MIRRORED BITS® communications Channel A.
COM B	Returns a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.
COM C	Clears all communications records. If both MIRRORED BITS channels are enabled, omitting the channel specifier (A or B) clears both channels.
COM C A	Clears all communications records for Channel A.
COM C B	Clears all communications records for Channel B.
COM L	Appends a long report to the summary report of the last 255 records in the MIRRORED BITS communications buffer.
COM L A	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.
COM L B	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.
COM S	Returns a summary report of the last 255 records in the MIRRORED BITS communications buffer.
COU *n*	Shows current state of device counters. *n* = repeat the report *n* times, with a 1/2 second delay between each report.
DAT	Views the date.
DAT *dd/mm/yyyy*	Enters date in DMY format.
DAT *mm/dd/yyyy*	Enters date in MDY format if DATE_F setting is MDY.
DAT *yyyy/mm/dd*	Enters date in YMD format if DATE_F setting is YMD.
ETH	Shows the Ethernet port status.
EVE *n*	Shows event report *n* with 4 samples per cycle. If *n* is omitted, most recent report is displayed.
EVE R *n*	Shows event report *n* with raw (unfiltered) 32 samples per cycle analog data and 4 samples per cycle digital data.
FIL DIR	Returns a list of files.
FIL READ *filename*	Transfers settings file *filename* from the relay to the PC.

Serial Port Command	Command Description
FIL SHOW *filename*	Filename 1 displays contents of the file filename.
GOO *k*	Displays transmit and receive GOOSE messaging information. Enter number *k* to scroll the GOOSE data *k* times on the screen.
GRO	Displays active group setting.
HEL	Displays a short description of selected commands.
HIS *n*	Shows summary of *n* latest event reports, where *n* = 1 is the most recent entry. If *n* is not specified, all event report summaries are displayed.
HIS C or **R**	Clears or resets history buffer.
HIS HIF *n*	Shows summary of as many as the last *n* HIF events the relay has captured. If *n* is not specified, all 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 high-impedance fault (HIF) detection).
IRIG	Forces synchronization of internal control clock to IRIG-B time-code input.
LDP	Displays signal profile data.
LDP C	Clears signal profile data.
LOG HIF *nnn*	Displays the progress log (*nnn* entries, as many as 500) of HIF (high-impedance fault) detection in 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	Displasy instantaneous metering data.
MET *k*	Displays instantaneous metering data *k* times, where *k* is between 1 and 32767.
MET AI	Displays analog input (transducer) data.
MET DEM k	Displays demand metering data, in primary amperes. Enter k to scroll metering k times on screen.
MET E	Displays energy metering data.
MET HIF	Displays the progress of HIF (high-impedance fault) detection in percentage of their final pickup values.
MET L	Displays arc-flash detector (AFD) light input (relay requires the 3 AVI/4 AFDI card in slot E).
MET M	Display minimum and maximum metering data.
MET MV	Displays SELOGIC math variable data.
MET PEA k	Displays peak demand metering data, in primary amperes. Enter k to scroll metering k times on screen.
MET PM	Displays synchrophasor metering data.
MET RA	Displays remote analog metering data.
MET RD	Resets demand metering values.
MET RE	Resets energy metering data.
MET RM	Reset minimum and maximum metering data.
MET RMS	Displays rms metering data.
MET RP	Resets peak demand metering values.
MET T	Displays RTD metering data.
PING x.x.x.x t	Determines if Ethernet port is functioning or configured properly. x.x.x.x is the IP address and "t" is the PING interval settable from 2 to 255 seconds. Default "t" is 1 second. Press Q to stop.
SER	Displays all Sequential Events Recorder (SER) data.

Serial Port Command	Command Description
SER *d1*	Displays all SER records made on date *d1*.
SER *d1 d2*	Displays all SER records made from dates *d2* to *d1*, inclusive, starting with *d2*.
SER *n*	Displays the *n* most recent SER records starting with record *n*.
SER *n1 n2*	Displays SER records *n2* to *n1*, starting with *n2*.
SER C or **R**	Clears SER data.
SER D	Displays SER Delete Report, which shows deleted items (use when SER Auto Deletion is selected to remove chatter).
SHO *n*	Displays relay settings for group *n* (*n = 1, 2, or 3*). If *n* is not specified, default is the active settings group.
SHO F	Displays front-panel settings.
SHO G	Displays global settings.
SHO L *n*	Displays general logic settings for group *n* (*n = 1, 2, or 3*). If *n* is not specified, default is the active settings group.
SHO M	Displays Modbus User Map settings.
SHO P *n*	Displays port settings, where *n* specifies the port (1, 2, 3, 4, or F); *n* defaults to the active port if not listed.
SHO R	Displays report settings.
STA	Displays relay self-test status.
STA S	Displays SELOGIC usage status report.
SUM	Displays an event summary.
SUM HIF	Displays the most recent HIF (High-Impedance Fault) event summary.
SUM R or **C**	Resets event summary buffer.
TAR	Displays default target row or the most recently viewed target row.
TAR *n*	Displays target row *n*.
TAR *n k*	Displays target row *n*. Repeat display of row *n* for repeat count *k*.
TAR *name*	Displays the target row with target name in the row.
TAR *name k*	Displays the target row with target name in the row. Repeat display of this row for repeat count *k*.
TAR R	Resets any latched targets and the most recently viewed target row.
TIM	Views time.
TIM *hh:mm:ss*	Sets time by entering **TIM** followed by hours, minutes, and seconds, as shown (24-hour clock).
TRI	Triggers an event report data capture.
TRI HIF	Triggers an HIF event report data capture
Access Level 2 Commands	
AFT	Tests arc-flash detector channels 1–4
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 breaker data.
BRE W	Preloads 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 circuit breaker.
CON RB*nn k*	Selects a remote bit to set, clear, or pulse where *nn* is a number from 01 to 32, representing RB01 through RB32. *k* is S, C, or P for Set, Clear, or Pulse.

Serial Port Command	Command Description
COP 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.
GRO *n*	Modifies the active group setting.
INI HIF	Restarts the 24-hour tuning process used in high-impedance fault detection.
L_D	Loads new firmware.
LOO	Enables loopback testing of MIRRORED BITS channels.
LOO A	Enables loopback on MIRRORED BITS Channel A for the next 5 minutes.
LOO B	Enables loopback on MIRRORED BITS Channel B for the next 5 minutes.
OPE	Opens circuit breaker.
PAS 1	Changes the Access Level 1 password.
PAS 2	Changes the Access Level 2 password.
PUL *n t*	Pulsse Output Contact *n* (*n* = OUT101…) for *t* (1 to 30, default is 1) seconds.
SET *n*	Modifies relay settings for group *n* (*n = 1, 2, or 3*). If *n* is not specified, default is the active settings group.
SET *name*	For all **SET** commands, jump ahead to a specific setting by entering the setting name, e.g., 50P1P.
SET F	Modifies the front-panel settings.
SET G	Modifies the global settings.
SET L *n*	Modifies the SELOGIC variable and timer settings for group *n* (*n = 1, 2, or 3*). If *n* is not specified, default is the active settings group.
SET M	Modifies the Modbus User Map settings.
SET P *n*	Modifies the port *n* settings (*n* = 1, 2, 3, 4, or F; if not specified, the default is the active port).
SET R	Modifies sthe report settings.
SET … TERSE	For all **SET** commands, **TERSE** disables the automatic **SHO** command after the settings entry.
STA R or **C**	Clears the self-test status and restarts the relay.
Access Level CAL Commands	
PAS C	Changes the Access Level C password.

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.

Serial Port Command	Command Description
Access Level 0 Commands	
ACC	Goes to Access Level 1.
ID	Relay identification code.
QUI	Goes to Access Level 0.
Access Level 1 Commands	
2AC	Goes to Access Level 2.
BRE	Displays breaker monitor data (trips, interrupted current, wear).
CEV *n*	Shows compressed event report number ***n***, at 1/4-cycle resolution. Attach R for compressed raw report, at 1/32- cycle resolution.
CEV HIF *n*	Shows compressed HIF (high-impedance fault) event record or reference number ***n***, at 2-cycle resolution
COM A	Returns a summary report of the last 255 records in the communications buffer for MIRRORED BITS® communications Channel A.
COM B	Returns a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.
COM C	Clears all communications records. If both MIRRORED BITS channels are enabled, omitting the channel specifier (A or B) clears both channels.
COM C A	Clears all communications records for Channel A.
COM C B	Clears all communications records for Channel B.
COM L	Appends a long report to the summary report of the last 255 records in the MIRRORED BITS communications buffer.
COM L A	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.
COM L B	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.
COM S	Returns a summary report of the last 255 records in the MIRRORED BITS communications buffer.
COU *n*	Shows current state of device counters. *n* = repeat the report *n* times, with a 1/2 second delay between each report.
DAT	Views the date.
DAT *dd/mm/yyyy*	Enters date in DMY format.
DAT *mm/dd/yyyy*	Enters date in MDY format if DATE_F setting is MDY.
DAT *yyyy/mm/dd*	Enters date in YMD format if DATE_F setting is YMD.
ETH	Shows the Ethernet port status.
EVE *n*	Shows event report *n* with 4 samples per cycle. If *n* is omitted, most recent report is displayed.
EVE R *n*	Shows event report *n* with raw (unfiltered) 32 samples per cycle analog data and 4 samples per cycle digital data.
FIL DIR	Returns a list of files.
FIL READ *filename*	Transfers settings file *filename* from the relay to the PC.

Serial Port Command	Command Description
FIL SHOW *filename*	Filename 1 displays contents of the file filename.
GOO *k*	Displays transmit and receive GOOSE messaging information. Enter number *k* to scroll the GOOSE data *k* times on the screen.
GRO	Displays active group setting.
HEL	Displays a short description of selected commands.
HIS *n*	Shows summary of *n* latest event reports, where *n* = 1 is the most recent entry. If *n* is not specified, all event report summaries are displayed.
HIS C or **R**	Clears or resets history buffer.
HIS HIF *n*	Shows summary of as many as the last *n* HIF events the relay has captured. If *n* is not specified, all 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 high-impedance fault (HIF) detection).
IRIG	Forces synchronization of internal control clock to IRIG-B time-code input.
LDP	Displays signal profile data.
LDP C	Clears signal profile data.
LOG HIF *nnn*	Displays the progress log (*nnn* entries, as many as 500) of HIF (high-impedance fault) detection in 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	Displasy instantaneous metering data.
MET *k*	Displays instantaneous metering data *k* times, where *k* is between 1 and 32767.
MET AI	Displays analog input (transducer) data.
MET DEM k	Displays demand metering data, in primary amperes. Enter k to scroll metering k times on screen.
MET E	Displays energy metering data.
MET HIF	Displays the progress of HIF (high-impedance fault) detection in percentage of their final pickup values.
MET L	Displays arc-flash detector (AFD) light input (relay requires the 3 AVI/4 AFDI card in slot E).
MET M	Display minimum and maximum metering data.
MET MV	Displays SELOGIC math variable data.
MET PEA k	Displays peak demand metering data, in primary amperes. Enter k to scroll metering k times on screen.
MET PM	Displays synchrophasor metering data.
MET RA	Displays remote analog metering data.
MET RD	Resets demand metering values.
MET RE	Resets energy metering data.
MET RM	Reset minimum and maximum metering data.
MET RMS	Displays rms metering data.
MET RP	Resets peak demand metering values.
MET T	Displays RTD metering data.
PING x.x.x.x t	Determines if Ethernet port is functioning or configured properly. x.x.x.x is the IP address and "t" is the PING interval settable from 2 to 255 seconds. Default "t" is 1 second. Press Q to stop.
SER	Displays all Sequential Events Recorder (SER) data.

Serial Port Command	Command Description
SER ***d1***	Displays all SER records made on date *d1*.
SER ***d1 d2***	Displays all SER records made from dates *d2* to *d1*, inclusive, starting with *d2*.
SER ***n***	Displays the *n* most recent SER records starting with record *n*.
SER ***n1 n2***	Displays SER records *n2* to *n1*, starting with *n2*.
SER C or **R**	Clears SER data.
SER D	Displays SER Delete Report, which shows deleted items (use when SER Auto Deletion is selected to remove chatter).
SHO ***n***	Displays relay settings for group *n* (*n = 1, 2, or 3*). If *n* is not specified, default is the active settings group.
SHO F	Displays front-panel settings.
SHO G	Displays global settings.
SHO L ***n***	Displays general logic settings for group *n* (*n = 1, 2, or 3*). If *n* is not specified, default is the active settings group.
SHO M	Displays Modbus User Map settings.
SHO P ***n***	Displays port settings, where *n* specifies the port (1, 2, 3, 4, or F); *n* defaults to the active port if not listed.
SHO R	Displays report settings.
STA	Displays relay self-test status.
STA S	Displays SELOGIC usage status report.
SUM	Displays an event summary.
SUM HIF	Displays the most recent HIF (High-Impedance Fault) event summary.
SUM R or **C**	Resets event summary buffer.
TAR	Displays default target row or the most recently viewed target row.
TAR ***n***	Displays target row *n*.
TAR ***n k***	Displays target row *n*. Repeat display of row *n* for repeat count *k*.
TAR ***name***	Displays the target row with target name in the row.
TAR ***name k***	Displays the target row with target name in the row. Repeat display of this row for repeat count *k*.
TAR R	Resets any latched targets and the most recently viewed target row.
TIM	Views time.
TIM ***hh:mm:ss***	Sets time by entering **TIM** followed by hours, minutes, and seconds, as shown (24-hour clock).
TRI	Triggers an event report data capture.
TRI HIF	Triggers an HIF event report data capture
Access Level 2 Commands	
AFT	Tests arc-flash detector channels 1–4
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 breaker data.
BRE W	Preloads 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 circuit breaker.
CON RB*nn k*	Selects a remote bit to set, clear, or pulse where *nn* is a number from 01 to 32, representing RB01 through RB32. *k* is S, C, or P for Set, Clear, or Pulse.

Serial Port Command	Command Description
COP 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.
GRO ***n***	Modifies the active group setting.
INI HIF	Restarts the 24-hour tuning process used in high-impedance fault detection.
L_D	Loads new firmware.
LOO	Enables loopback testing of MIRRORED BITS channels.
LOO A	Enables loopback on MIRRORED BITS Channel A for the next 5 minutes.
LOO B	Enables loopback on MIRRORED BITS Channel B for the next 5 minutes.
OPE	Opens circuit breaker.
PAS 1	Changes the Access Level 1 password.
PAS 2	Changes the Access Level 2 password.
PUL ***n t***	Pulsse Output Contact *n* (*n* = OUT101…) for *t* (1 to 30, default is 1) seconds.
SET ***n***	Modifies relay settings for group *n* (*n = 1, 2, or 3*). If *n* is not specified, default is the active settings group.
SET ***name***	For all **SET** commands, jump ahead to a specific setting by entering the setting name, e.g., 50P1P.
SET F	Modifies the front-panel settings.
SET G	Modifies the global settings.
SET L ***n***	Modifies the SELOGIC variable and timer settings for group *n* (*n = 1, 2, or 3*). If *n* is not specified, default is the active settings group.
SET M	Modifies the Modbus User Map settings.
SET P ***n***	Modifies the port *n* settings (*n* = 1, 2, 3, 4, or F; if not specified, the default is the active port).
SET R	Modifies sthe report settings.
SET … TERSE	For all **SET** commands, **TERSE** disables the automatic **SHO** command after the settings entry.
STA R or **C**	Clears the self-test status and restarts the relay.
Access Level CAL Commands	
PAS C	Changes the Access Level C password.