SEL-751A
Feeder Protection Relay

Instruction Manual

20150206

SCHWEITZER ENGINEERING LABORATORIES, INC.

PM751A-01

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Preface

Manual Overview

The SEL-751A 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-751A; lists the relay specifications.

Section 2: Installation. Describes how to mount and wire the SEL-751A; 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 enter and record settings for basic protection, voltage-based protection, and RTD-based protection.

Section 7: Communications. Describes how to connect the SEL-751A 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-751A with the SEL-2032, SEL-2030, and SEL-2020 Communications Processors for total substation automation solutions.

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

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

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

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

Appendix H: Synchrophasors. Describes the Phasor Measurement Control Unit (PMCU), and accessing synchrophasor data via ASCII Command (MET PM) and IEEE C37.118 Protocol.

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

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

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

SEL-751A 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 Terminal Blocks: 0.9–1.4 Nm (8–12 in-lb) Compression Plug: 0.5–1.0 Nm (4.4–8.8 in-lb) Compression Plug Mounting Ear Screw: 0.18–0.25 Nm (1.6–2.2 in-lb)	Valeurs nominales des bornes Matériau de fil Utiliser seulement conducteurs en cuivre 75°C (167°F) . Couple de serrage 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: 0,18–0,25 Nm (1,6–2,2 livres-pouce)

Hazardous Locations Safety Marks

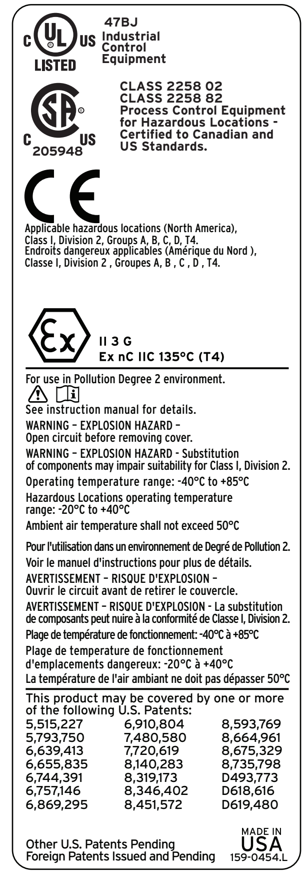
WARNING – EXPLOSION HAZARD Open circuit before removing cover.	**AVERTISSEMENT – DANGER D'EXPLOSION** Ouvrir le circuit avant de déposer le couvercle.
WARNING – EXPLOSION HAZARD Substitution of components may impair suitability for Class I, Division 2.	**AVERTISSEMENT – DANGER D'EXPLOSION** La substitution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

Hazardous Locations Approvals

The SEL-751A 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-751A 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.



Product Compliance Label for the SEL-751A

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 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.

General Information

Typographic Conventions

There are many ways to communicate with the SEL-751A. 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.

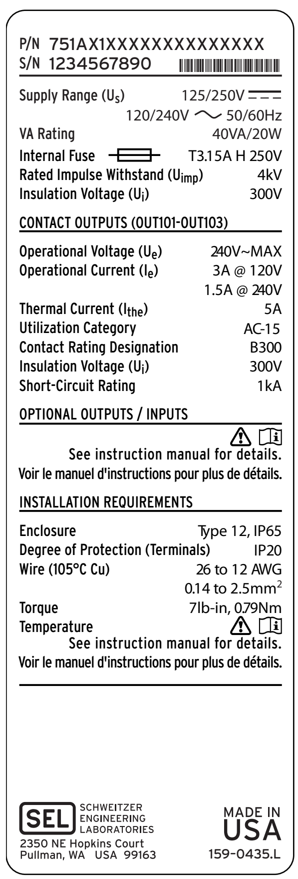
Example	Description
STATUS	Commands typed at a command line interface on a PC.
<Enter>	Single keystroke on a PC keyboard.
<Ctrl+D>	Multiple/combination keystroke on a PC keyboard.
Start > Settings	PC dialog boxes and menu selections. The > character indicates submenus.
CLOSE	Relay front-panel pushbuttons.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

Examples

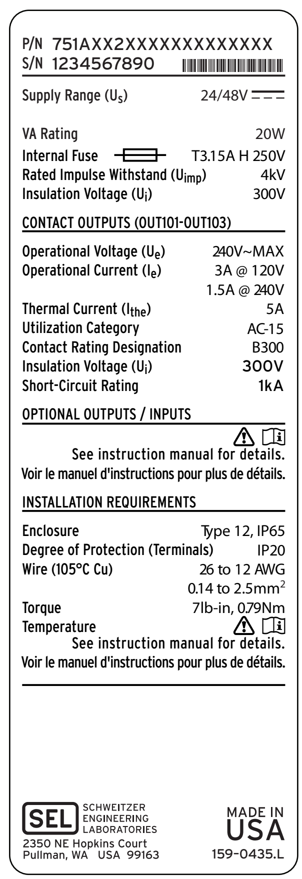
This instruction manual uses several example illustrations and instructions to explain how to effectively operate the SEL-751A. These examples are for demonstration purposes only; the firmware identification information or settings values included in these examples may not necessarily match those in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

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

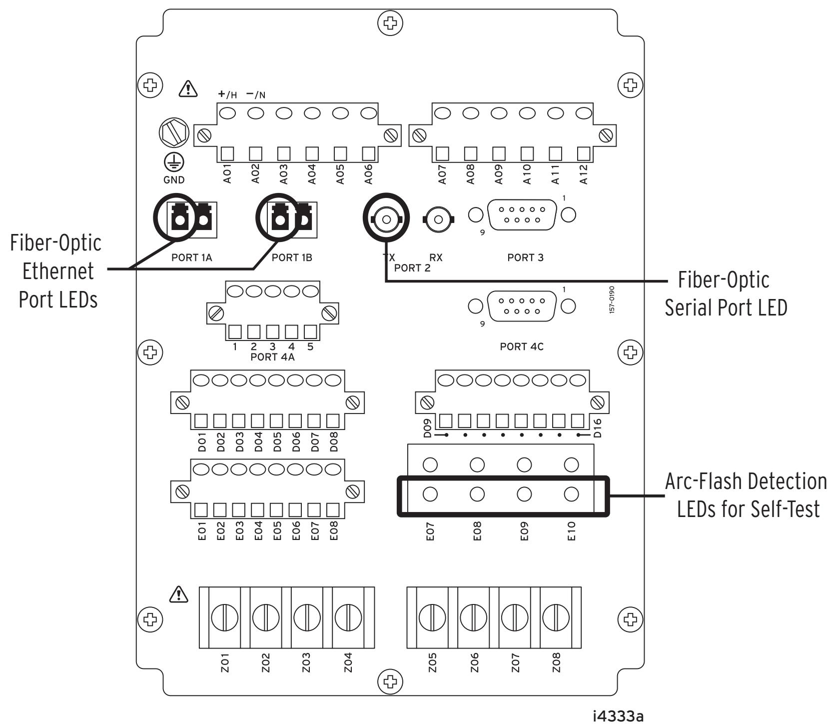
⚠CAUTION
Use of controls, adjustments, or performance of procedures other than those specified herein may result in hazardous radiation exposure.

⚠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-751A (see *Figure 2.10* for the location of the ports using these LEDs on the relay).

Item	Fiber-Optic Ethernet PORT 1 (1A, 1B)	PORT 2	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-751A (see *Figure 2.10* for the complete rear-panel drawing).



SEL-751A LED Locations

LED Safety Warnings and Precautions

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

Environmental Conditions and Voltage Information

The following table lists important environmental and voltage information.

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

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

Wire Sizes and Insulation

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-751A 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

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Section 1
Introduction and Specifications

Overview

The SEL-751A Feeder Protection Relay is designed to provide overcurrent protection to feeders, transformers, etc. The basic relay provides instantaneous and inverse time-overcurrent protection. Voltage-based, Arc-Flash Detector (AFD)-based, and RTD-based protection are available as options. All relay models provide monitoring functions.

This manual contains the information necessary to install, set, test, operate, and maintain any SEL-751A. 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)
- Frequency (81)
- Breaker Failure Protection
- Breaker Wear Monitor

Optional Protection Features

- Autoreclosing Control (79)
- Voltage-Based Protection
  - Undervoltage (27)
  - Overvoltage (59)
  - Negative-Sequence Overvoltage (59Q)
  - Residual (Zero-Sequence) Overvoltage (59G)
  - Power Elements (32)
  - Power Factor (55)
  - Loss of Potential (60LOP)

- Rate-of-Change of Frequency (81R)
- Fast Rate-of-Change of Frequency (81RF) for Aurora Mitigation
- Optional Residual Current CT-based Overcurrent and Time Overcurrent (50G/51G)
- Arc-Flash Protection
- Demand and Peak Demand Metering
- 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

Communications and Control

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

Models, Options, and Accessories

Models

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

SEL-751A Base Unit

- Front panel with large LCD display
  - Four programmable pushbuttons with eight LEDs
  - Eight target LEDs (six programmable)
  - Operator control interface
  - EIA-232 port
- Power supply card with two digital inputs and three digital outputs (Slot A)
- Processor and communications card (Slot B)
  - EIA-232 serial port with IRIG-B time code input
- Three expansion slots for optional cards (Slots C, D, E)
- Four ac current inputs 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 option
  - Autoreclosing Control
- Voltage/Current Options (see *Table 1.1*)
- 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)
  - Multimode (ST®) fiber-optic serial port
  - Modbus TCP/IP protocol
  - DeviceNet
  - IEC 61850 Communications
  - DNP3 serial and LAN/WAN

Table 1.1 Voltage Input Options

Voltage Input Options	Option (71)	Option (72)	Option (73)	Option (74)	Option (75/76)
	SELECT 3AVI[a]	SELECT 5AVI[b]	SELECT 5AVI[c]	SELECT 3 AVI/4 AFDI[d]	SELECT 5 AVI/1 ACI[e]
Under- and overvoltage elements (27, 59)	x	x	x	x	x
Voltage based frequency measurement and tracking	x	x	x	x	x
Over-, underfrequency elements (81)	x	x	x	x	x
Power factor elements (55)	x	x	x	x	x
Loss of potential element (60LOP)	x	x	x	x	x
Real, reactive, apparent power, and power factor metering	x	x	x	x	x
Energy metering	x	x	x	x	x
Synchronism-check elements including under- and overvoltage elements (25, 27S, 59S)		x	x		x
Station dc battery voltage monitor		x	x		x
Demand and peak demand metering			x	x	x
Residual overvoltage element (59G)			x	x	x
Negative-sequence overvoltage element (59Q)			x	x	x
Rate-of-change-of-frequency element (81R)			x	x	x
Fast rate-of-change-of-frequency element (81RF), Aurora mitigation			x	x	x
Power elements (32)			x	x	x
4-channel optical arc-flash sensor inputs with continuous self-testing (AFD)				x	
Arc-flash protection elements (50PAF, 50NAF)				x	
Residual current (IG) CT-based residual overcurrent elements (50G, 51G)					x

[a] Voltage Options.
[b] With Monitoring Package.
[c] With Monitoring and Advanced Metering and Protection Packages.
[d] With 4-channel Arc-Flash Detector Inputs and Protection.
[e] SELECT 5AVI/1 ACI with Residual Ground CT Input.

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-751A
- 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-751A 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

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

Applications

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

- Distribution feeder protection (feeder protection with core-balance CT)
- Delta-wye transformer overcurrent protection
- Wye-delta-wye transformer overcurrent protection
- With or without external RTD module
- With Arc-Flash Protection

Figure 1.1 shows typical current connections. Refer to *Section 2: Installation* for additional applications and the related connection diagrams.

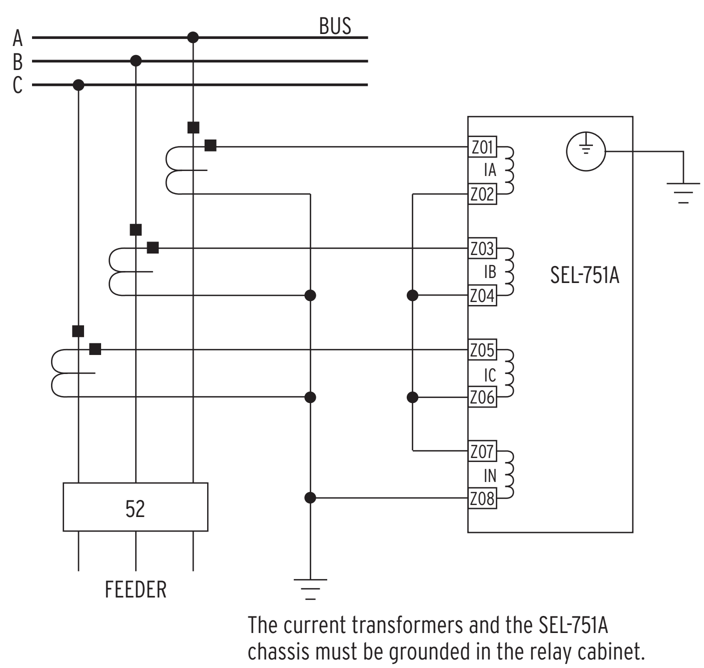

Figure 1.1 Typical Current Connections

Getting Started

Understanding basic relay operation principles and methods will help you use the SEL-751A effectively. This section presents the fundamental knowledge you need to operate the SEL-751A, 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-751A with 125/250 Vac/dc or 24/48 Vdc, depending on the part number.

- ➤ Observe proper polarity, as indicated by the **+/H** (terminal **A01**) and the **–/N** (terminal **A02**) on the power connections.
- ➤ Connect the ground lead; see *Grounding (Earthing) Connections on page 2.19*.
- ➤ Once connected to power, the relay does an internal self-check and the **ENABLED** LED illuminates.

Establishing Communication

The SEL-751A has two EIA-232 serial communications ports. The following steps require PC terminal emulation software and an SEL Cable C234A (or equivalent) to connect the SEL-751A to the PC. See *Section 6: Settings* for further information on serial communications connections and the required cable pinout.

Step 1. Connect the PC and the SEL-751A 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 1.2*. 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 1.2*.

Table 1.2 SEL-751A 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 1.2*. If you see jumbled characters, change the terminal emulation type in the PC terminal emulation program.

```
=>QUIT <Enter>
Feeder xyz          Date: 03/10/2007  Time: 10:31:43
Station 1           Time Source: Internal
```

Figure 1.2 Response Header

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

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

Checking Relay Status

Use the **STA** serial port command to view the SEL-751A operational status. Analog channel dc offset and monitored component status are listed in the status report depicted in *Figure 1.3*.

```
=>STA <Enter>

SEL-751A                                  Date: 08/13/2009   Time: 20:24:29
FEEDER RELAY                              Time Source: External

Serial Num = 000000000000000
FID = SEL-751A-X402-V0-Z005003-D20090803               CID = CD05
PART NUM = 751A01B1X0X7386163X

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   1.19

  +1.5V  +1.8V  +2.5V  +3.3V  +3.75V  +5.0V  -1.25V  -5.0V   BATT
  1.49   1.81   2.49   3.33   3.76    4.97   -1.25   -4.91   3.07

Option Cards
  CARD_C  CARD_D  CARD_E  CURRENT
  OK      OK      OK      OK

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

  Relay Enabled

=>
```

Figure 1.3 STA Command Response—No Communications Card or EIA-232/EIA-485 Communications Card

If a communications card with the DeviceNet protocol is present, the status report depicted in *Figure 1.4* applies. If a communications card with Modbus RTU protocol is present, the status report depicted in *Figure 1.3* applies.

```
=>STA <Enter>

SEL-751A                                    Date: 08/13/2009   Time: 20:29:29
FEEDER RELAY                                Time Source: External

Serial Num = 000000000000000
FID = SEL-751A-X402-V0-Z005003-D20090803                CID = CD05
PART NUM = 751A01BA30X7386163X

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   1.19

  +1.5V  +1.8V  +2.5V  +3.3V  +3.75V  +5.0V  -1.25V  -5.0V   BATT
  1.49   1.81   2.49   3.33   3.76    4.97   -1.25   -4.91   3.07

Option Cards
  CARD_C  CARD_D  CARD_E  CURRENT
  OK      OK      OK      OK

DeviceNet
  DN_MAC_ID     ASA        DN_RATE         DN_STATUS
  3         1a0d c1e9h     500kbps         0000 0000

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

  Relay Enabled

=>
```

Figure 1.4 STA Command Response—Communications Card/DeviceNet Protocol

Table 7.48 provides the definition of each status report designator and *Table 10.7* shows all the self-tests performed by the relay. The beginning of the status report printout (see *Figure 1.3*) 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-751A. If the date stored in the relay is July 29, 2003, and the DATE_F setting is MDY, the relay will reply:

```
7/29/2003
```

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

```
2003/7/29
```

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

```
29/7/2003
```

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, 2003 (DATE_F = MDY), enter the following at the action prompt:

```
DAT 5/2/03
```

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-751A. The relay will reply with the stored time.

```
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.

CSA:	C22.2 No. 61010-1
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, Neutral, and Residual Currents

I_{NOM} = 1 A, 5 A, 50 mA, or 2.5 mA (high sensitivity) secondary depending on model.

INOM = 5 A

Continuous Rating:	15 A, linear to 100 A symmetrical
1 Second Thermal	500 A
Burden (Per Phase):	< 0.1 VA @ 5 A

INOM = 1 A

Continuous:	3 A, linear to 20 A symmetrical
1 Second Thermal	100 A
Burden (Per Phase):	< 0.01 VA @ 1 A

INOM = 50 mA

Continuous Rating:	3 A, linear to 1000.0 mA symmetrical
1 Second Thermal	100 A
Burden (Per Phase):	< 2 mVA @ 50 mA

INOM = 2.5 mA

Continuous Rating:	3 A, linear to 12.50 mA symmetrical
1 Second Thermal	100 A
Burden (Per Phase):	< 0.1 mVA @ 2.5 mA
Measurement Category:	II

AC Voltage Inputs

VNOM (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:	10 MΩ differential (phase-phase) 5 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 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.

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

DC Output Ratings

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

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

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

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

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

AC Output Ratings

Maximum Operational Voltage (U_e) Rating:	240 Vac
Insulation Voltage (U_i) Rating (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: $V_{ih} \geq 2.2$ V

Off (0) State: $V_{il} \leq 0.8$ V

Input Impedance: 2 kΩ

Synchronization Accuracy

Internal Clock:	±1 µs
Synchrophasor Reports (e.g., **MET PM**):	±10 µs
All Other Reports:	±5 ms

Simple Network Time Protocol (SNTP) Accuracy

Internal Clock:	±5 ms
Unsynchronized Clock Drift Relay Powered:	2 minutes per year, typically

Communications Ports

Standard EIA-232 (2 Ports)

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

EIA-485 Port (Optional)

Location:	Rear Panel
Data Speed:	300–19200 bps

Ethernet Port (Optional)

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

Multimode Fiber-Optic Port (Optional)

Location:	Rear panel
Data Speed:	300–38400 bps

Fiber-Optic Ports Characteristics

Port 1 (or 1A, 1B) Ethernet

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

Wavelength:	640 nm
Optical Connector Type:	V-Pin
Fiber Type:	Multimode
Link Budget:	27 dB
Typical TX Power:	–12 dBm
RX Min. Sensitivity:	–39 dBm
Fiber Size:	1000 µm
Approximate Range:	To 35 m (Point Sensor) To 70 m (Clear-Jacketed Fiber Sensor)
Data Rate:	NA
Typical Fiber Attenuation:	–0.15 dB/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 impaired for temperatures below –20°C and above +70°C.

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

Operating Environment

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

Dimensions

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

Weight

2.7 kg (6.0 lbs)

Relay Mounting Screws (#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” maximum

Terminal Block Tightening Torque

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

Compression Plug Tightening Torque

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

Compression Plug Mounting Ear Screw Tightening Torque

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

Type Tests

Environmental Tests

Enclosure Protection:	IEC 60529:2001 + 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 IEEE 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 61000-4-4:2004 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:	16 samples per power system cycle
Frequency Tracking Range:	15–70 Hz
Digital Filtering:	One-cycle cosine after low-pass analog filtering. Net filtering (analog plus digital) rejects dc and all harmonics greater than the fundamental.
Protection and Control Processing:	Processing interval is 4 times per power system cycle (except for math variables and analog quantities, which are processed every 100 ms)
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 or 64 cycles
Sampling Rate:	16 samples per cycle, unfiltered 4 samples per cycle, filtered
Trigger:	Programmable, using Boolean expressions
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
50 mA Models:	5.0–1000.0 mA, 0.1 mA steps
2.5 mA Models:	0.13–12.50 mA, 0.01 mA steps

(The 50N elements in the 2.5 mA and 50 mA models have a built-in 30 ms security qualifier time delay.)

Accuracy:	±5% of setting plus ±0.02 • I_{NOM} A secondary (steady-state pickup)
Time Delay:	0.00–5.00 seconds, 0.01 seconds steps
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
1 A Models:	0.10–3.20 A, 0.01 A steps
50 mA Models:	5.0–160.0 mA, 0.1 mA steps
2.5 mA Models:	0.13–2.00 mA, 0.01 mA steps
Accuracy:	±5% of setting plus ±0.02 • I_{NOM} A secondary (steady-state pickup)

Time Dial:

U.S.:	0.50–15.00, 0.01 steps
IEC:	0.05–1.00, 0.01 steps
Accuracy:	±1.5 cycles, plus ±4% between 2 and 30 multiples of pickup (within rated range of current)

Undervoltage (27)

Vnm := VNOM if DELTA_Y := DELTA;
Vnm := VNOM/1.732 if DELTA_Y := WYE

Setting Range:	Off, 0.02–1.00 • Vnm
Accuracy:	±1% of setting plus ±0.5 V (±5% of setting ±2 V with the *xx*71*xx* card)
Pickup/Dropout Time:	< 1.5 cycles

Overvoltage (59, 59G, 59Q)

Vnm := VNOM if DELTA_Y := DELTA;
Vnm := VNOM/1.732 if DELTA_Y := WYE

Setting Range:	Off, 0.02–1.20 • Vnm
Accuracy:	±1% of setting plus ±0.5 V (± 5% of setting ± 2 V with the *xx*71*xx* card)
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) and ±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) and ±5% of setting at unity power factor for power elements and zero power factor for reactive power elements (1 A nominal)
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}

Frequency (81)

Setting Range:	Off, 20.00–70.00 Hz
Accuracy:	±0.01 Hz (V1 > 60 V) with voltage tracking ±0.05 Hz (I1 > 0.8 • I_{NOM}) with current tracking
Pickup/Dropout Time:	< 4 cycles

Rate-of-Change of Frequency (81R)

Setting Range:	Off, 0.10–15.00 Hz/s
Accuracy:	±100 mHz/s, plus ±3.33% of pickup

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 12.5–300 V)
Slip Frequency Pickup Range:	0.05 Hz–0.50 Hz
Slip Frequency Pickup Accuracy:	±0.05 Hz
Phase Angle Range:	0–80°
Phase Angle Accuracy:	±4°

Synchronism-Check Undervoltage (27S)

Setting Range:	Off, 2.00–300.00 V
Accuracy:	±1% of setting plus ±0.5 V (over the range of 12.5–300 V)
Pickup/Dropout Time:	< 1.5 cycles

Synchronism-Check Overvoltage (59S)

Setting Range:	Off, 2.00–300.00 V
Accuracy:	±1% of setting plus ±0.5 V (over the range of 12.5–300 V)
Pickup/Dropout Time:	< 1.5 cycles

Station Battery Voltage Monitor

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

Timers

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

RTD Protection

Setting Range:	Off, 1–250°C
Accuracy:	±2°C
RTD Open-Circuit Detection:	> 250°C
RTD Short-Circuit Detection:	< –50°C
RTD Types:	PT100, NT100, NI120, CU10
RTD Lead Resistance:	25 ohm max. per lead
Update Rate:	< 3 s
Noise Immunity on RTD Inputs:	To 1.4 Vac (peak) at 50 Hz or greater frequency
RTD Trip/Alarm Time Delay:	Approx. 6 s

Metering

Accuracies are specified at 20°C, nominal frequency, ac currents within (0.4–20.0) • I_{NOM} A secondary, and ac voltages within 50–250 V secondary unless otherwise noted.

Phase Currents:	±2% of reading, ±2°
3-Phase Average Current:	±2% of reading
Current Imbalance (%):	±2% of reading
IG (Residual Current):	±3% of reading, ±2°
IN (Neutral Current):	±2% of reading, ±2°
3I2 Negative-Sequence Current:	±3% of reading
System Frequency:	±0.01 Hz of reading for frequencies within 20.00–70.00 Hz (V1 > 60 V) with voltage tracking ±0.05 Hz of reading for frequencies within 20.00–70.00 Hz (I1 > 0.8 • I_{NOM}) with current tracking
Line-to-Line Voltages:	±1% of reading (±2% with the *xx*71*xx* card), ±1° for voltages within 24–264 V
3-Phase Average Line-to-Line Voltage:	±1% of reading (±2% with the *xx*71*xx* card) for voltages within 24–264 V
Line-to-Ground Voltages:	±1% of reading (±2% with the *xx*71*xx* card), ±1° for voltages within 24–264 V
3-Phase Average Line-to-Ground Voltages:	±1% of reading (±2% with the *xx*71*xx* card) for voltages within 24–264 V
Voltage Imbalance (%):	±1% of reading (±2% with the *xx*71*xx* card) for voltages within 24–264 V
3V2 Negative-Sequence Voltage:	±3% of reading for voltages within 24–264 V
Real 3-Phase Power (kW):	±5% of reading for 0.10 < pf < 1.00
Reactive 3-Phase Power (kVAR):	±5% of reading for 0.00 < pf < 0.90
Apparent 3-Phase Power (kVA):	±2% of reading
Power Factor:	±2% of reading
RTD Temperatures:	±2°C

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Section 2
Installation

Overview

The first steps in applying the SEL-751A 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-751A. 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-751A product page on the SEL website. This allows you to use SELOGIC® control equations and slide-in configurable front-panel labels to change the function and identification of target LEDs.

Relay Placement

Proper placement of the SEL-751A helps to ensure years of trouble-free protection. Use the following guidelines for proper physical installation of the SEL-751A.

Physical Location

You can mount the SEL-751A 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-751A 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-751A 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-751A 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.

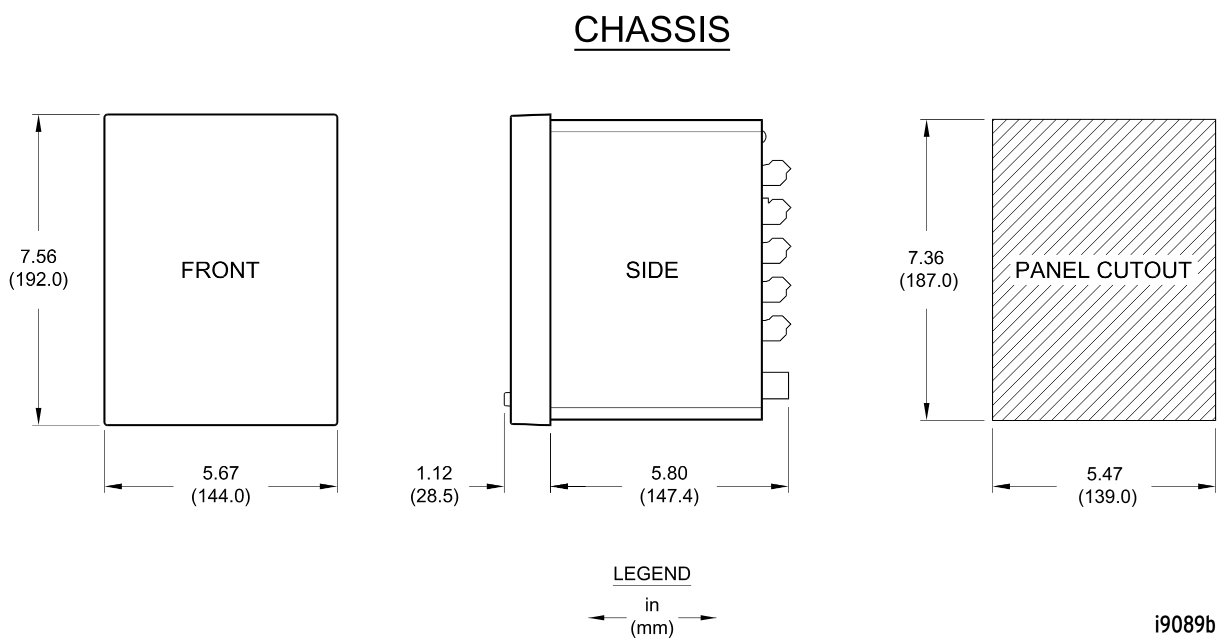


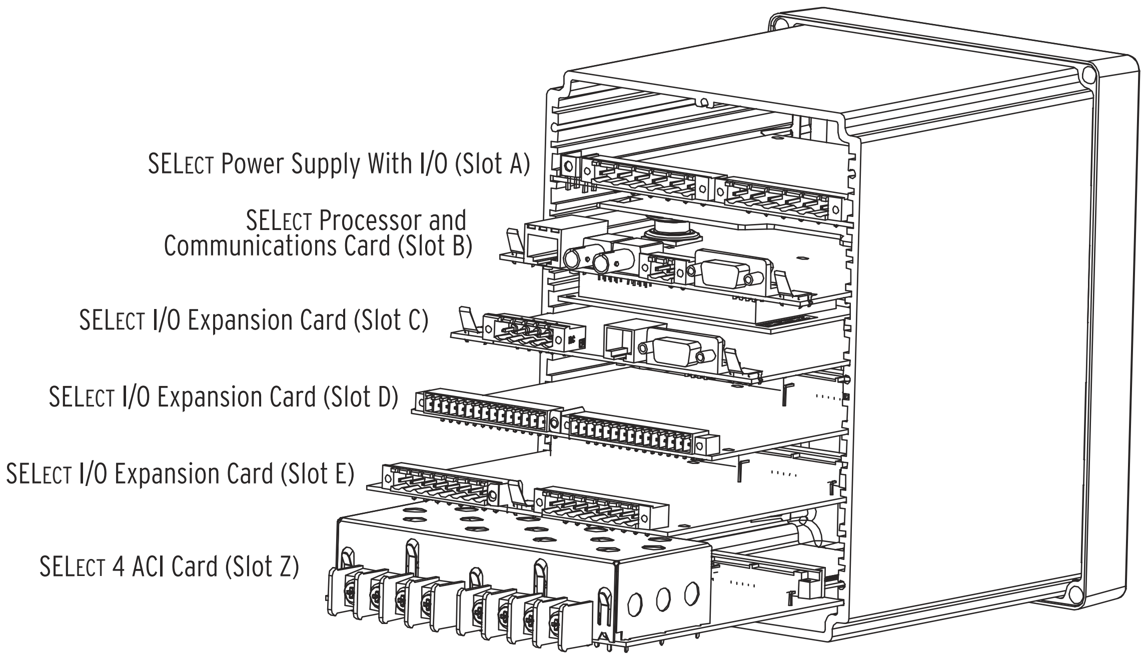
Figure 2.1 Relay Panel-Mount Dimensions

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

I/O Configuration

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

Because installations differ substantially, the SEL-751A 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/current card	4 ACI CT 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 8AI			•	•	•	n/a
SELECT 4 AI/4 AO (one card per relay)			•	•	•	n/a
SELECT 10 RTD			n/a	•	n/a	n/a
SELECT 3 AVI (MOT… x71x…)			n/a	n/a	•	n/a
SELECT 5 AVI (MOT … x72x…)			n/a	n/a	•	n/a
SELECT 5 AVI (MOT … x73x…)			n/a	n/a	•	n/a
SELECT 3 AVI/4 AFDI (MOT … x74x…)			n/a	n/a	•	n/a
SELECT 5 AVI/1 ACI (MOT … x75/76x…)			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 (optional EIA-232 fiber-optic serial port).
[c] Digital or analog.

Figure 2.2 Slot Allocations for Different Cards

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

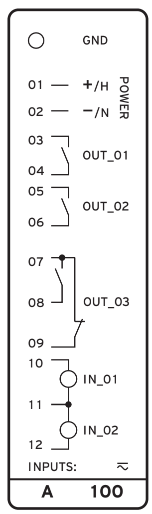
Select appropriate power supply option for the application:

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

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

Table 2.1 Power Supply Card Inputs Terminal Designation

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

Base-Unit Communications Ports (Slot B)

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

Table 2.2 Communications Ports

Port	Location	Feature	Description
F	Front Panel	Standard	Nonisolated EIA-232 serial port
1	Rear Panel	Optional	(Single/Dual) Isolated 10/100BASE-T Ethernet copper port or 100BASE-FX Ethernet fiber-optic port
2	Rear Panel	Optional	Isolated multimode fiber-optic serial port with ST® connectors
3	Rear Panel	Standard	Either nonisolated EIA-232 or isolated EIA-485 serial port

PORT F supports the following protocols:

- ➤ SELBOOT
- ➤ Modbus® RTU Slave
- ➤ SEL ASCII and Compressed ASCII
- ➤ SEL Settings File Transfer

- Event Messenger
- C37.118 (Synchrophasor Data)

PORT 1 (Ethernet) supports the following protocols:

- Modbus TCP/IP
- DNP3 LAN/WAN
- IEC 61850
- 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

Use the PORT 4 setting, COMM Interface, to select either EIA-232 or EIA-485 functionality. *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)

Voltage Card Option (3 AVI)

MOT...x71x... Supported in Slot **E** only, order this card when you have either single or three-phase (wye or delta) PTs. With a voltage card installed, the SEL-751A samples the voltages 16 times a cycle—*see Processing Specifications and Oscillography on page 1.13* for more information. *Table 2.4* shows the terminal allocation.

Table 2.4 3 AVI Voltage Card Terminal Designation

Terminal Number	Description
01	VA, Phase A voltage input
02	VB, Phase B voltage input
03	VC, Phase C voltage input
04	N, Common connection for VA, VB, VC
05	N, Common connection for VA, VB,VC
06	N, Common connection for VA, VB,VC

Enhanced Voltage Card Option With Monitoring Package (5 AVI)

MOT...x72x... Supported in Slot **E** only, order this card when you have voltage inputs including synchronism-check voltage input and station dc battery monitor input. With a voltage card installed, the SEL-751A samples the voltages 16 times a cycle. *Table 2.5* shows the terminal allocation.

Table 2.5 5 AVI Voltage Card Terminal Designation

Terminal Number	Description
01	VA, Phase A voltage input
02	VB, Phase B voltage input
03	VC, Phase C voltage input
04	N, Common connection for VA, VB, VC
05	VS, synchronism-check voltage input
06	NS, common connection for synchronism-check voltage input
07	VBAT+ station battery (positive) voltage input
08	VBAT– station battery (negative) voltage input

Enhanced Voltage Card Option With Advanced Metering and Protection Package (5 AVI)

MOT...x73x... Supported in Slot E only, order this card when you have voltage inputs including synchronism-check voltage input and station dc battery monitor input. With a voltage card installed, the SEL-751A samples the voltages 16 times a cycle. This option also provides demand and peak demand metering, and protection elements 32, 59G, 59Q, 81R, and 81RF (for Aurora mitigation). The connections are shown in *Table 2.5*.

Voltage Card Option With Arc-Flash Detection (AFD) Inputs (3 AVI/4 AFDI)

MOT...x74x... Supported in Slot E only, order this card when you have either single or three phase (wye or delta) PTs. With a voltage card installed, the SEL-751A samples the voltages 16 times a cycle. *Table 2.6* shows the terminal allocation. This option also provides 4-channel arc-flash detection (AFD) inputs with continuous self-testing.

Table 2.6 3 AVI/4 AFDI Voltage Card With Arc-Flash Detection Inputs Terminal Designation

Terminal Number	Description
01	VA, Phase A voltage input
02	VB, Phase B voltage input
03	VC, Phase C voltage input
04	N, Common connection for VA, VB, VC
05	N, Common connection for VA, VB, VC
06	N, Common connection for VA, VB, VC
07	AF1 Channel TX and RX Inputs
08	AF2 Channel TX and RX Inputs
09	AF3 Channel TX and RX Inputs
10	AF4 Channel TX and RX Inputs

Enhanced Voltage Card Option With Advanced Metering and Protection Package and Residual Current Input (5 AVI/1 ACI)

MOT...x75/76x... Supported in Slot E only, order this card when you have voltage inputs including synchronism-check voltage input and station dc battery monitor input and residual current (IG) input. Order ...x75x... for 5 A CT or ...x76x... for 1 A CT input. With this card installed, the SEL-751A samples the voltages and current 16 times a cycle. This option also provides demand and peak demand metering, and protection elements 32, 59G, 59Q, 81R and 81RF. The connections are shown in *Table 2.7*.

Table 2.7 5 AVI/1 ACI Voltage/Current Card Terminal Designation

Terminal Number	Description
01	VA, Phase A voltage input
02	VB, Phase B voltage input
03	VC, Phase C voltage input
04	N, common connection for VA, VB, VC
05	VS, synchronism-check voltage input
06	NS, common connection for synchronism-check voltage input
07	VBAT+ station battery (positive) voltage input
08	VBAT– station battery (negative) voltage input
09, 10	IG, residual current input

Current Card

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

Supported in Slot **Z** only, this card provides current inputs for three-phase CTs and one neutral CT. Secondary phase current ratings are either all 1 A or all 5 A; you cannot order a combination of 1 A and 5 A phase CTs on one card. However, the phase CTs and the neutral CT can be of different current rating. You can order one of four neutral CT ratings, 1 A, 5 A, 50 mA, or 2.5 mA (high sensitivity). With a current card installed, the SEL-751A samples the currents 16 times a cycle—see *Processing Specifications and Oscillography on page 1.13* for more information. *Table 2.8* shows the terminal allocation.

Table 2.8 Current Card Terminal Designation

Terminal Number	Description
01, 02	IA, Phase A current input
03, 04	IB, Phase B current input
05, 06	IC, Phase C current input
07, 08	IN, neutral current input

Analog Input Card (8 AI)

Supported in any nonbase unit slot (Slot **C** through Slot **E**), this card has eight analog inputs. *Table 2.9* shows the terminal allocation.

Table 2.9 Eight Analog Input (8 AI) Card Terminal Allocation

Terminal Number	Software Reference, 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)

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 2.10* shows the terminal allocation.

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

Table 2.10 Four Analog Input/Four Analog Output (4 AI/4 AO) Card Terminal Allocation

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

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

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

NOTE: All digital input and digital output (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 2.11* shows the terminal allocation.

Table 2.11 I/O (3 DI/4 DO/1 AO) Card Terminal Allocation

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

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

RTD Card (10 RTD)

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

Supported in Slot D only, this card has 10 three-wire RTD inputs. *Table 2.12* shows the terminal allocation.

Table 2.12 RTD (10 RTD) Card Terminal Allocation

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

I/O Card (4 DI/3 DO)

Supported in any nonbase unit slot (Slot **C** through Slot **E**), this card has four digital inputs, one Form-B digital output (normally closed contact output) and two Form-C digital output contacts. *Table 2.13* shows the terminal allocation.

Table 2.13 Four Digital Inputs, One Form-B Digital Output, Two Form-C Digital Outputs (4 DI/3 DO) Card Terminal Allocation

Terminal Number	Description[a]
01, 02	OUT*x*01, driven by OUT*x*01 SELOGIC control equation
03, 04, 05	OUT*x*02, driven by OUT*x*02 SELOGIC control equation
06, 07, 08	OUT*x*03, driven by OUT*x*03 SELOGIC control equation
09, 10	IN*x*01, drives IN*x*01 element
11, 12	IN*x*02, drives IN*x*02 element
13, 14	IN*x*03, drives IN*x*03 element
15, 16	IN*x*04, drives IN*x*04 element

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

I/O Card (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 2.14* shows the terminal allocation.

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

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

Terminal Number	Software Reference, Description[a]
01, 02	OUT*x*01, driven by OUT*x*01 SELOGIC control equation
03, 04	OUT*x*02, driven by OUT*x*02 SELOGIC control equation
05, 06	OUT*x*03, driven by OUT*x*03 SELOGIC control equation
07, 08	OUT*x*04, driven by OUT*x*04 SELOGIC control equation
09, 10	IN*x*01, drives IN*x*01 element
11, 12	IN*x*02, drives IN*x*02 element
13, 14	IN*x*03, drives IN*x*03 element
15, 16	IN*x*04, drives IN*x*04 element

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

I/O Card (8 DI)

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

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

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

[a] x = 3, 4, or 5 (e.g. IN401, IN402, etc. if the card was installed in Slot D).

Card Configuration Procedure

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

The SEL-751A offers flexibility in tailoring I/O for your specific application. The SEL-751A has six rear-panel slots, labeled as Slots **A**, **B**, **C**, **D**, **E**, and **Z**. Slots **A**, **B**, and **Z** are base unit slots, each associated with a specific function. Optional digital/analog I/O cards are available for the SEL-751A in Slots **C, D,** and **E**. Optional communications cards are available only for Slot **C**, an RTD card is available only for Slot **D**, 1 A/5 A CT combinations for voltage/current cards are available only for Slot **E**, and current cards are available for Slot **Z**. *Figure 2.2* shows the slot allocations for the cards. Because installations differ substantially, the SEL-751A offers a variety of card configurations that provide options for many diverse applications. Choose the combination of cards most suited for your application.

Swapping Optional I/O Boards

When an I/O board is moved from one slot to a different slot, the associated settings for the slot the card is moved from are lost. For example, if a 4 DI/4 DO card is installed in Slot 4 (Slot **D**), the SELOGIC 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.

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

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

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

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

Step 3. fDisconnect all the connection plugs.

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

Step 4. Loosen the eight (8) screws on the rear and remove the rear cover.

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

Step 6. Insert the card in the correct slot.

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

Step 7. Before reattaching the rear cover, check for and remove any foreign material that may remain inside the SEL-710 case.

Step 8. Carefully reattach the rear cover.

Step 9. Tighten the eight (8) screws that secure the rear cover to the case.

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

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

```
STATUS FAIL
X Card Failure
```

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

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

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

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

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

The front panel displays the following:

```
STATUS
Relay Status
```

Step 15. Press the **ENT** button.

The front panel displays the following:

```
Serial Num
000000000000000000000000
```

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

The front panel displays the following:

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

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

The front panel displays the following:

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

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

The relay restarts and the **ENABLED** light turns on to indicate thecard was installed correctly.

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

Use the **STATUS** command to view the part number.

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

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

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

Slot B CPU Card Replacement

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

Step 1. Ensure that the card has the latest firmware from the factory.

Step 2. Review the firmware revision history for the changes that were made; note that new settings added, if any, might affect existing settings in the relay or its application.

Step 3. Save all the settings and event reports before replacing the card.

Step 4. If the IEC 61850 protocol option was used previously, verify that the IEC 61850 protocol is still operational after the replacement. If not, reenable it. Refer to Protocol Verification for Relays With IEC 61850 Option in Appendix B: Firmware Upgrade Instructions.

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

Step 1. Turn off the power to the relay.

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

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

Step 4. Remove the rear panel.

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

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

Step 7. Apply new side stickers to the relay.

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

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

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

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

The CAL level default password is CLARKE.

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

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

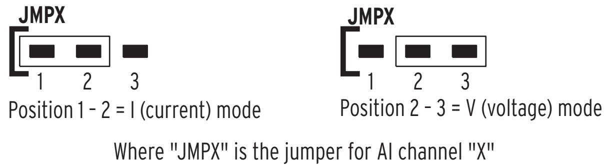


Figure 2.3 Circuit Board of Analog I/O Board, Showing Jumper Selection

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.

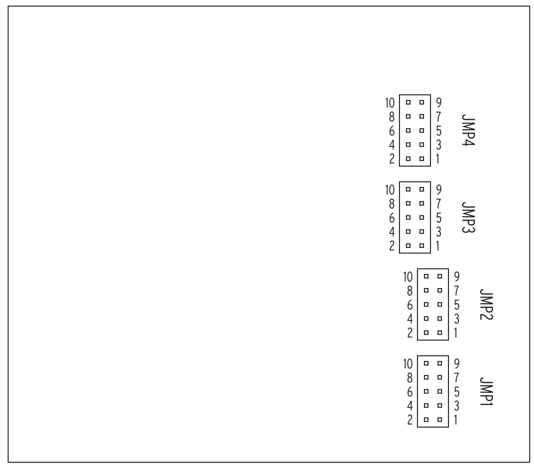


Figure 2.4 JMP1 Through JMP4 Locations on 4 AI/4 AO Board

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.

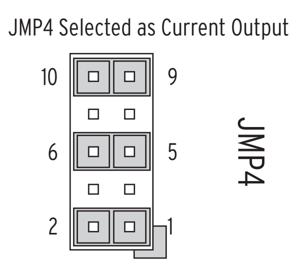


Figure 2.5 Current Output Jumpers

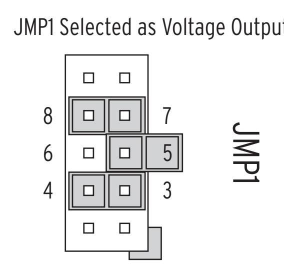


Figure 2.6 Voltage Output Jumpers

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.

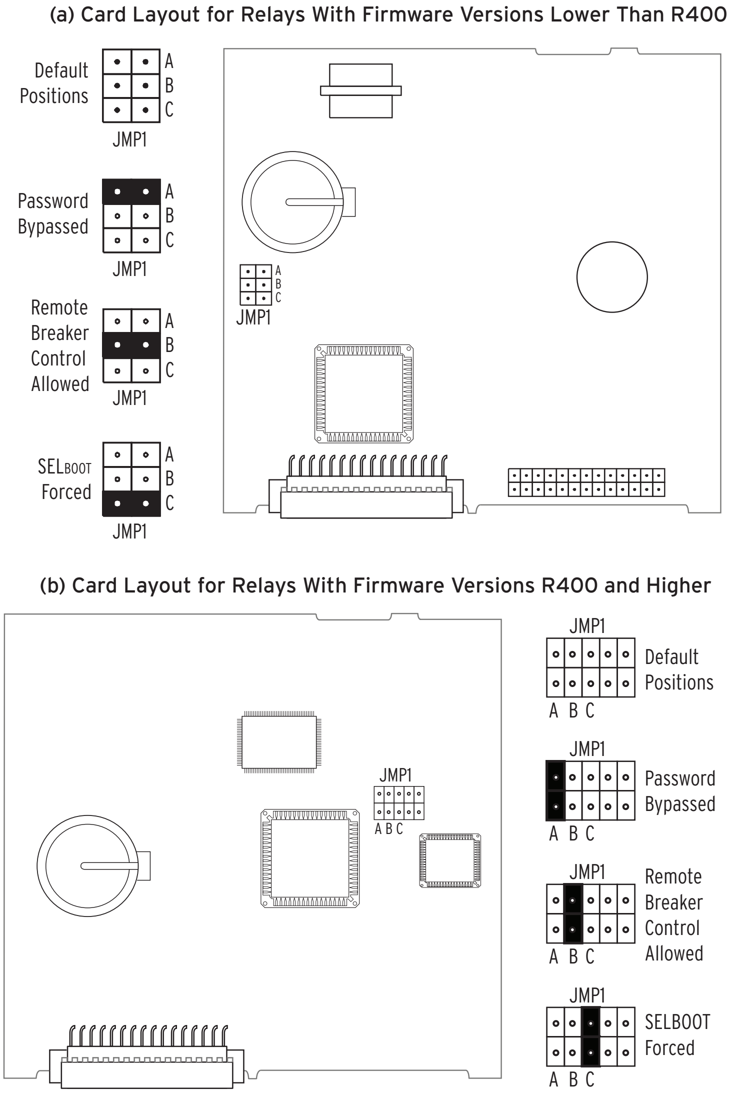


Figure 2.7 Pins for Password, Breaker Control, and SELBOOT Jumper

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-751A suffers an internal failure, communications with the relay can be compromised. Forcing the relay to SELBOOT provides a means of downloading new firmware. To force the relay to SELBOOT, position the jumper in Position C, as shown in *Figure 2.7* (SELBOOT forced). Once the relay is forced to SELBOOT, you can communicate with the relay only through the front-panel port.

To gain access to Level 1 and Level 2 command levels without passwords, position the jumper in position A, as shown in *Figure 2.7* (Password bypassed). Although you gain access to Level 2 without a password, the alarm contact still closes momentarily when you access Level 2. *Table 2.16* tabulates the functions of the three sets of pins and jumper default positions.

Table 2.16 Jumper Functions and Default Positions

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

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

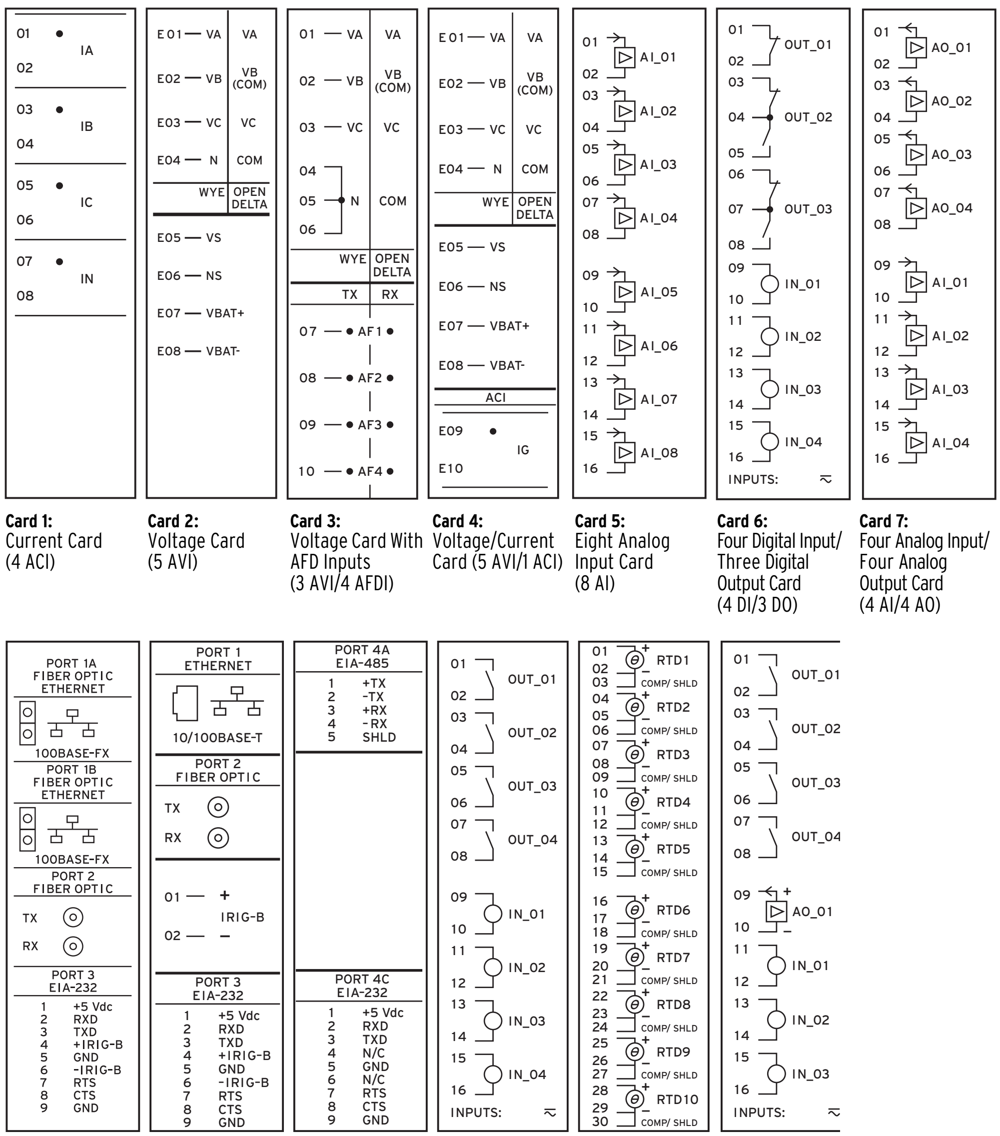
Rear-Panel Connections

Figure 2.8 shows the rear-panel connections for selected cards. Connections for additional cards are shown in *Figure 2.9* through *Figure 2.11*.

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

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

NOTE: Analog outputs are isolated from each other and from the chassis ground.



Card 1: Current Card (4 ACI)

Card 2: Voltage Card (5 AVI)

Card 3: Voltage Card With AFD Inputs (3 AVI/4 AFDI)

Card 4: Voltage/Current Card (5 AVI/1 ACI)

Card 5: Eight Analog Input Card (8 AI)

Card 6: Four Digital Input/Three Digital Output Card (4 DI/3 DO)

Card 7: Four Analog Input/Four Analog Output Card (4 AI/4 AO)

Card 8: Main Board With Dual, Fiber-Optic Ethernet, Fiber-Optic Serial, and EIA-232 Rear Ports

Card 9: Main Board With Single, Copper Ethernet, Fiber-Optic Serial, and EIA-232 Rear Ports

Card 10: Communications Card (EIA-232/EIA-485)

Card 11: Four Digital Input/Four Digital Output Card (4 DI/4 DO)

Card 12: RTD Card (10 RTD)

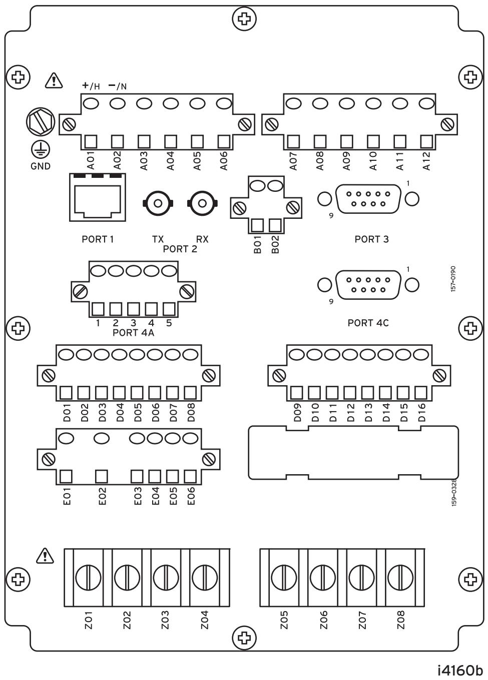
Card 13: Three Digital Input/Four Digital Output/One Analog Output Card (3 DI/4 DO/1 AO)

Figure 2.8 Rear-Panel Connections of Selected Cards

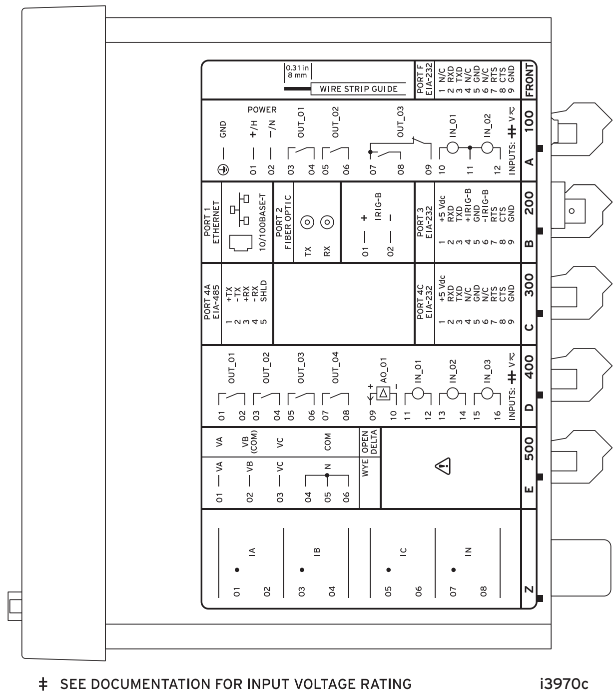
Rear-Panel Connections

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-751A are shown in *Figure 2.9*, *Figure 2.10*, and *Figure 2.11*.

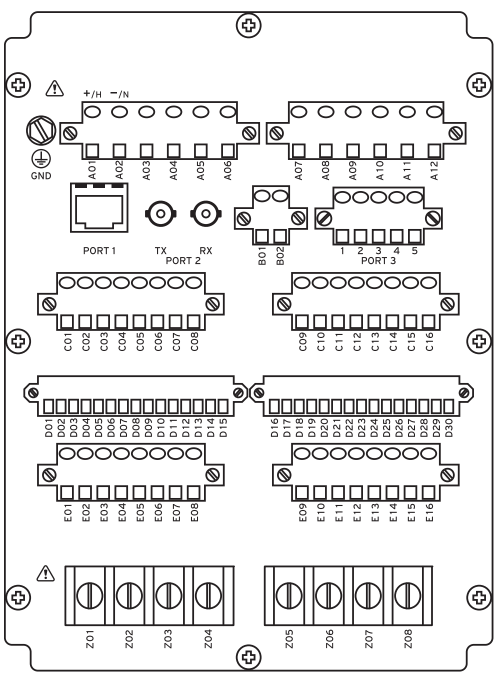


(A) Rear-Panel Layout

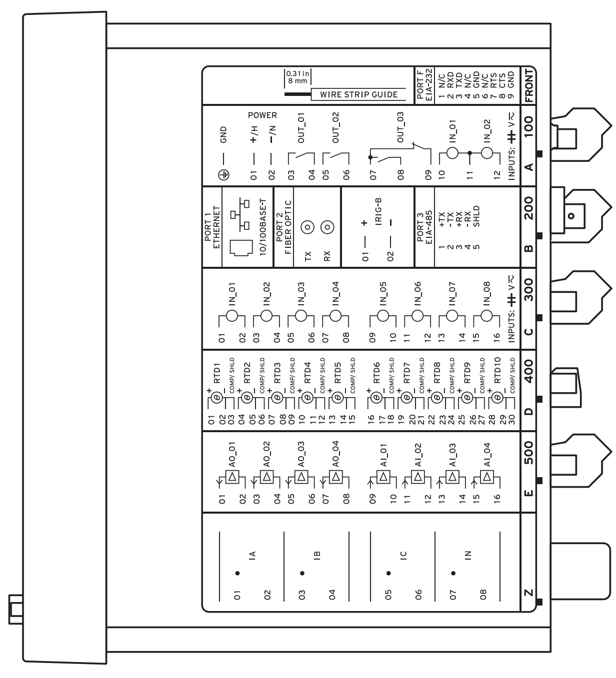


(B) Side-Panel Input and Output Designations

Figure 2.9 Fiber-Optic Serial, Ethernet, EIA-232 Communication, 3 DI/4 DO/1 AO, and 3 AVI Voltage Option

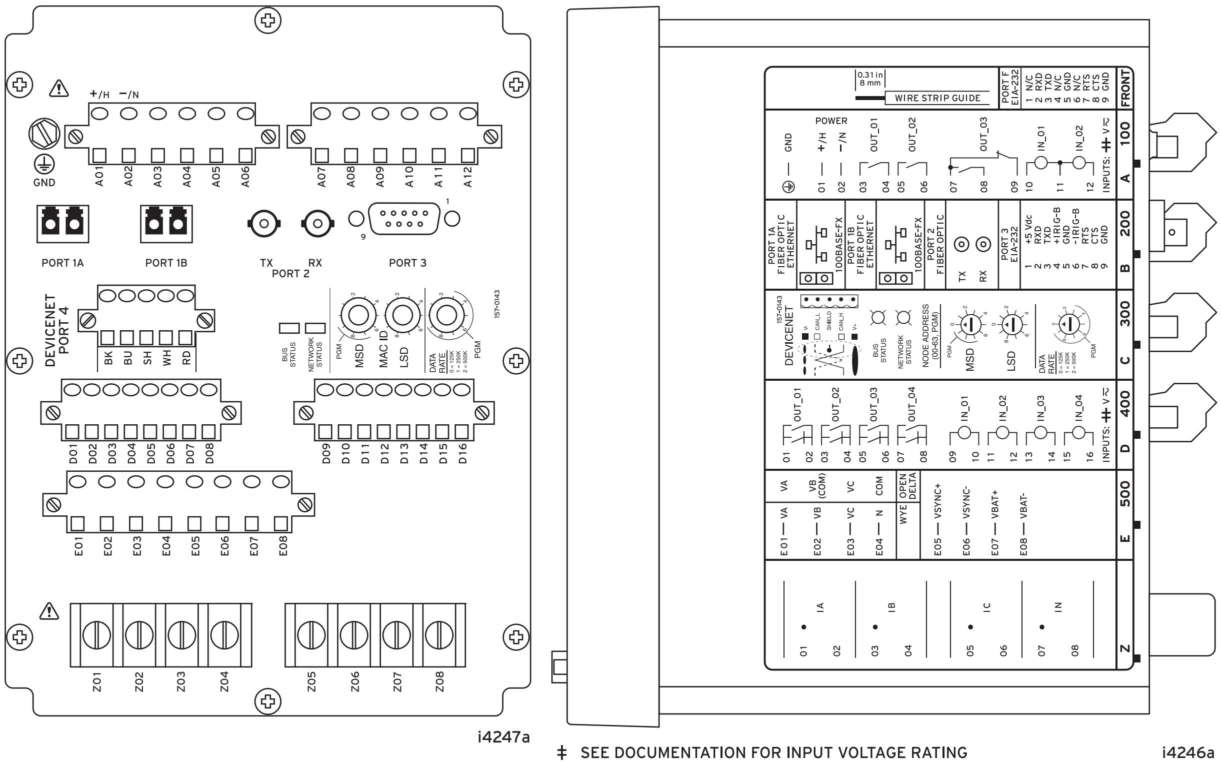


(A) Rear-Panel Layout



(B) Side-Panel Input and Output Designations

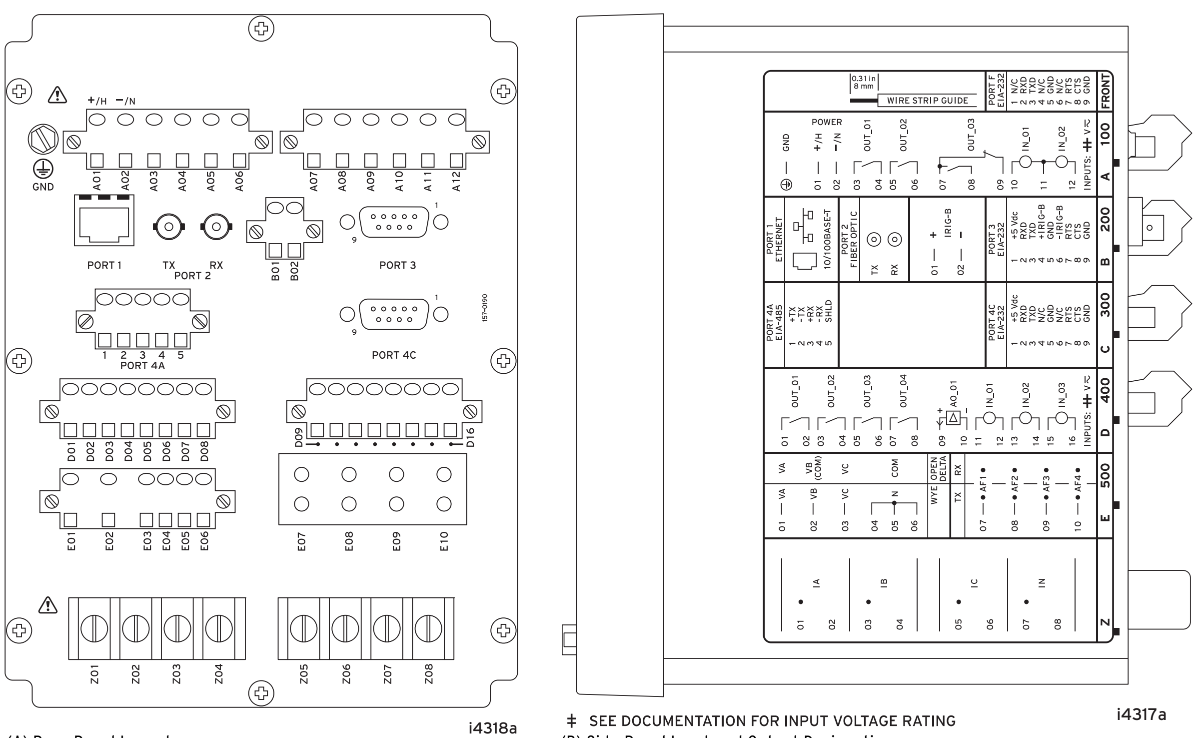
Figure 2.10 Fiber-Optic Serial, Ethernet, 8 DI, RTD, and 4 AI/4 AO Option



(A) Rear-Panel Layout

(B) Side-Panel Input and Output Designations

Figure 2.11 Dual Fiber-Optic Ethernet, Fiber-Optic Serial, DeviceNet, Fast Hybrid 4 DI/4 DO, and Voltage Option With Monitoring Package



(A) Rear-Panel Layout

(B) Side-Panel Input and Output Designations

Figure 2.12 Fiber-Optic Serial, Ethernet, EIA-232 Communication, 4 DO/3 DI/1AO, and 3 AVI/4 AFDI Voltage Option With Arc-Flash Detector Inputs

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

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

Grounding (Earthing) Connections

You must connect the ground terminal labeled GND on the rear panel to a rack frame or switchgear ground for proper safety and performance. Use 14 AWG (2.1 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-751A accepts a demodulated IRIG-B time signal to synchronize the internal clock with an external source. Three options for IRIG-B signal input are given, but only one should be used at a time. You can use IRIG-B (B01 and B02) inputs or an SEL communications processor connected to EIA-232 serial PORT 3. The available communications processors are the SEL-2032, SEL-2030, SEL-2020, and the SEL-2100 Logic Processor.

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

Ethernet Port

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

Fiber-Optic Serial Port

The optional fiber-optic serial port is compatible with the SEL-2812 (with IRIG-B) or the SEL-2814 Fiber-Optic Transceivers 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 2.13* and *Figure 2.14*.

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

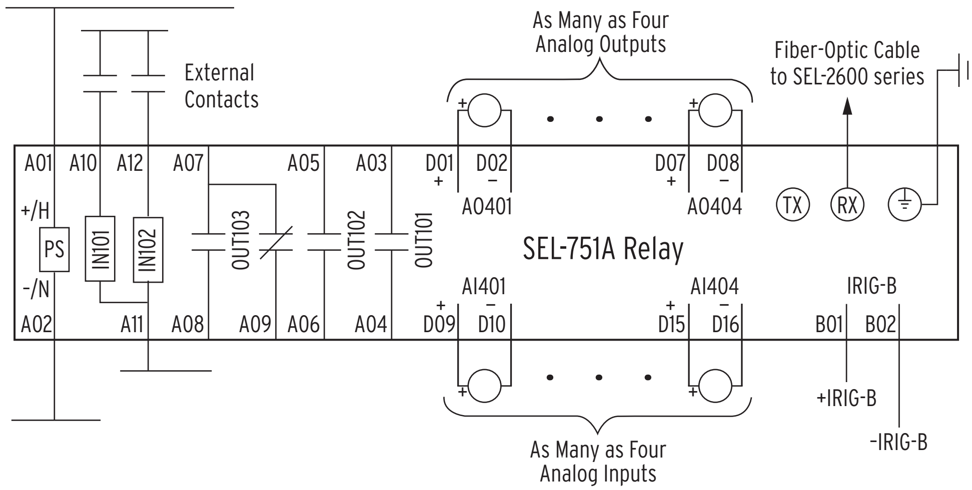


Figure 2.13 Control I/O Connections—4 AI/4 AO Option in Slot D and Fiber-Optic Port in Slot B

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

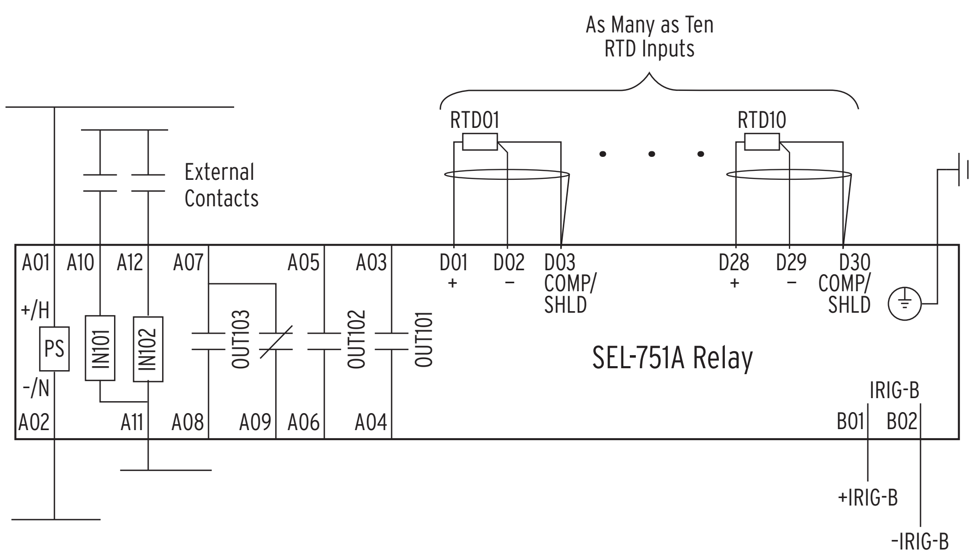


Figure 2.14 Control I/O Connections—Internal RTD Option

Notes:

- ➤ The chassis ground connector located on the rear-panel card Slot **A** must always be connected to the local ground mat.
- ➤ Power supply rating (125–250 Vac/dc or 24–48 Vdc) depends on 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 optional and is located on the card in Slot **B**. A Simplex 62.5/125 µm fiber-optic cable is necessary to connect the SELOGIC with an SEL-2600 series RTD Module. This fiber-optic cable should be 1000 meters or shorter.

Table 2.17 shows the maximum cable lengths for the RTD connections.

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

Table 2.17 Typical Maximum RTD Lead Length

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

Analog Output Wiring

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

Connect the two terminals of the analog output as shown in *Figure 2.15*. Also, connect the analog output cable shield to ground at the relay chassis ground, programmable logic controller (PLC), or meter location. Do not connect the shield to ground at both locations.

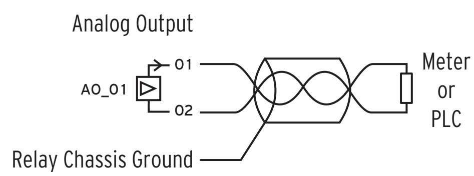


Figure 2.15 Analog Output Wiring Example

AC/DC Control Connection Diagrams

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

Fail-Safe/Nonfail-Safe Tripping

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

Figure 2.16 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.

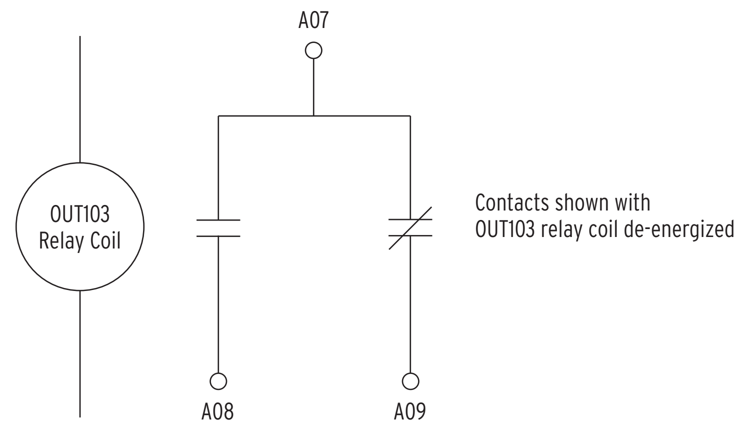


Figure 2.16 Output OUT103 Relay Output Contact Configuration

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

Figure 2.17 shows fail-safe and nonfail-safe wiring methods to control breakers.

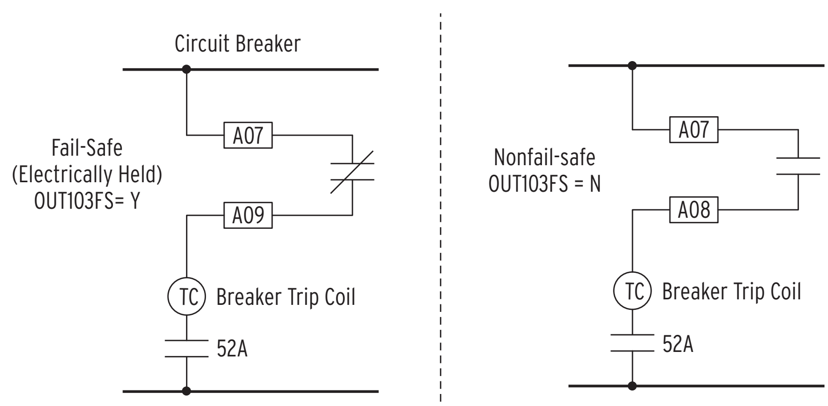


Figure 2.17 OUT103 Contact Fail-Safe and Nonfail-Safe Options

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 using a connected, wye-wye VT connection. Use an open-delta VT connection, or use a single-phase VT. *Figure 2.18* and *Figure 2.19* show the methods of connecting single-phase and three-phase voltages.

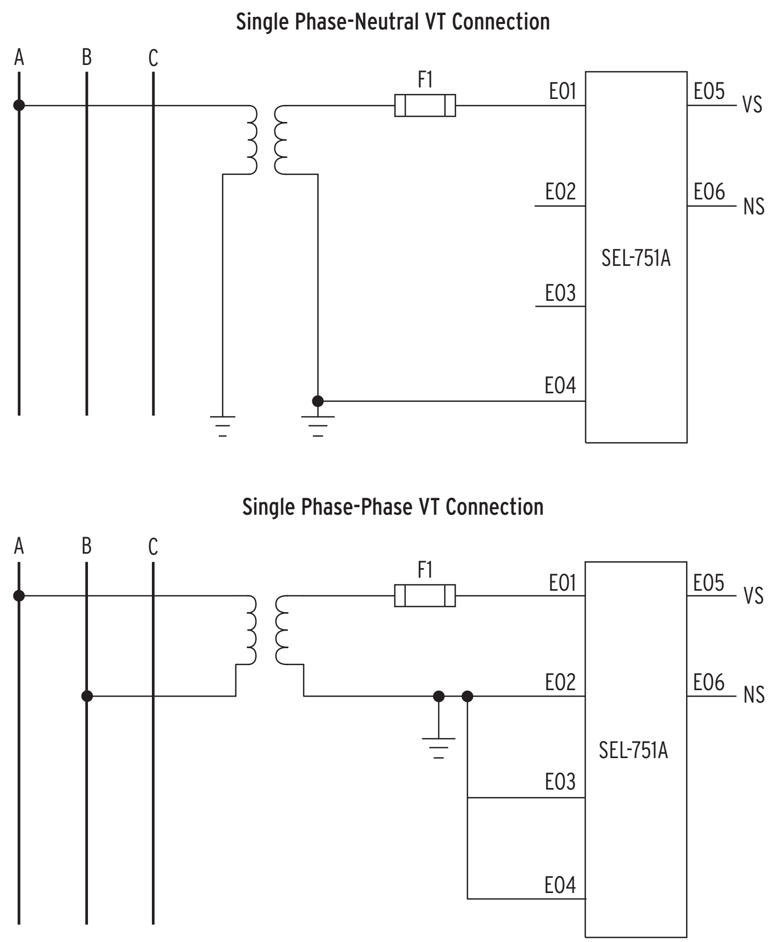
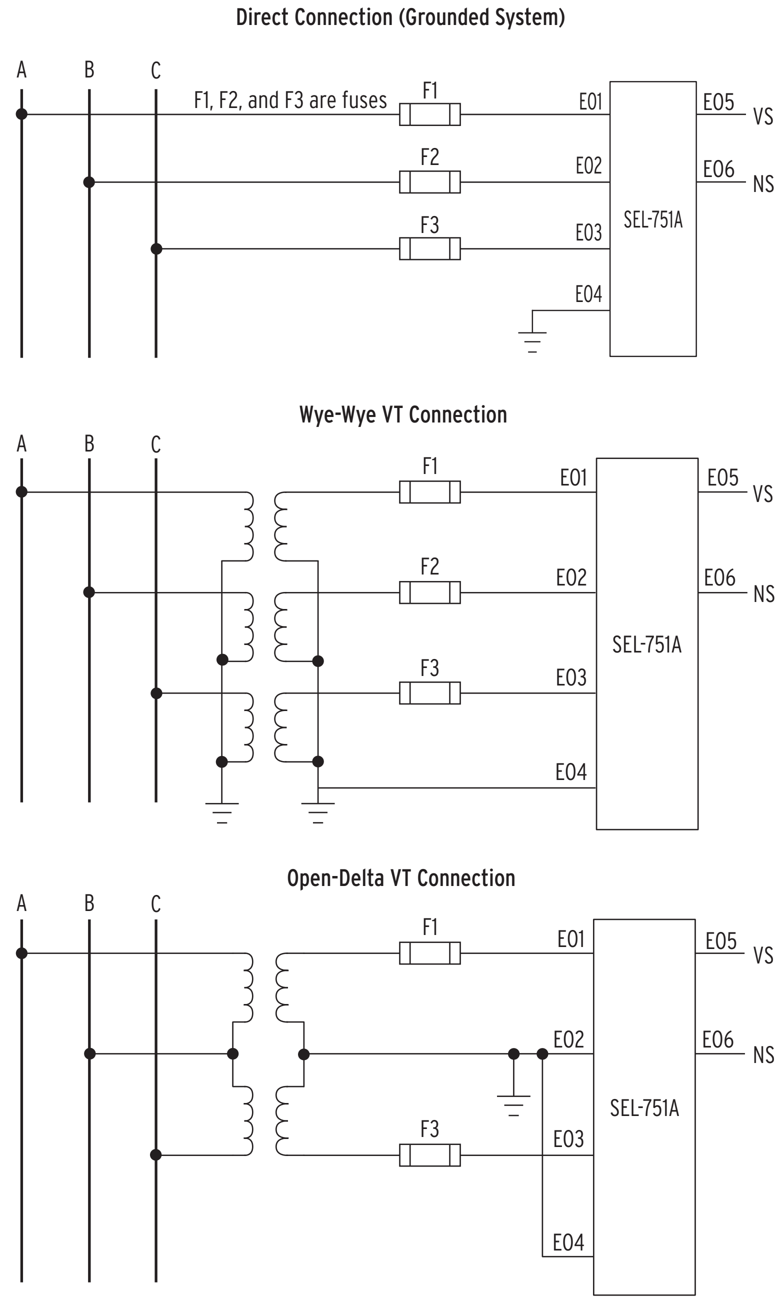


Figure 2.18 Single-Phase Voltage Connections



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

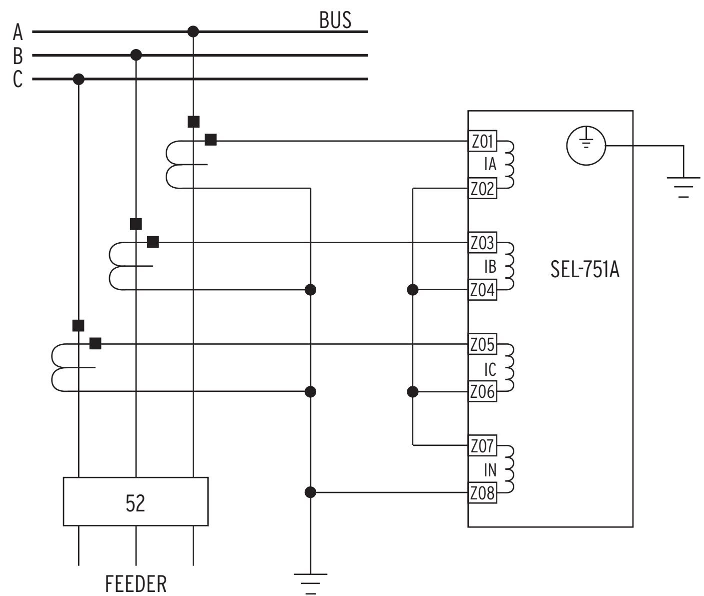
Figure 2.19 Voltage Connections

Station DC Battery Monitor

Use the station dc battery monitor (one of the options available with the Voltage Card options) in the SEL-751A 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 E07 (VBAT+) and E08 (VBAT-) of the SELECT 5AVI voltage card in slot E. Refer to *Section 5: Metering and Monitoring* for details on the station dc battery monitor function and settings.

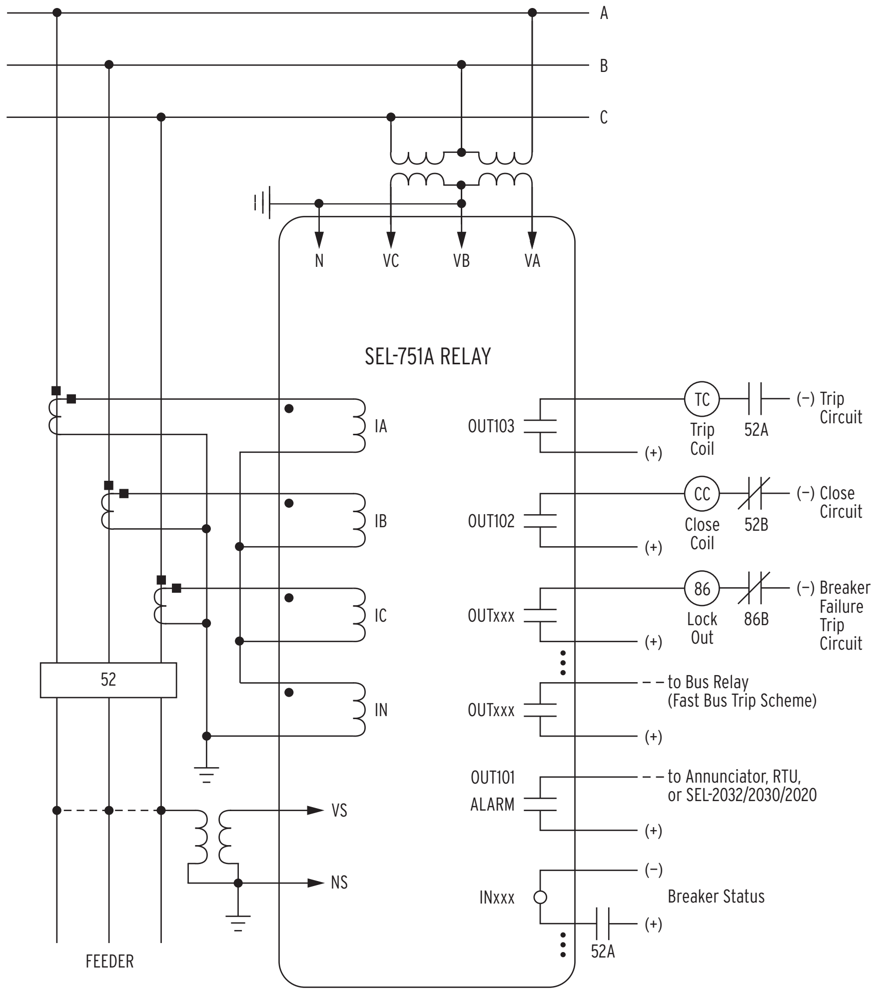
AC/DC Connections and Applications

Figure 2.20 shows typical phase and neutral current connections for a feeder application. *Figure 2.21* through *Figure 2.25* show ac/dc connection diagrams for various applications, however, wye-connected PTs are shown. See *Figure 2.18* and *Figure 2.19* for other voltage connections.



The current transformers and the SEL-751A chassis should be grounded in the relay cabinet.

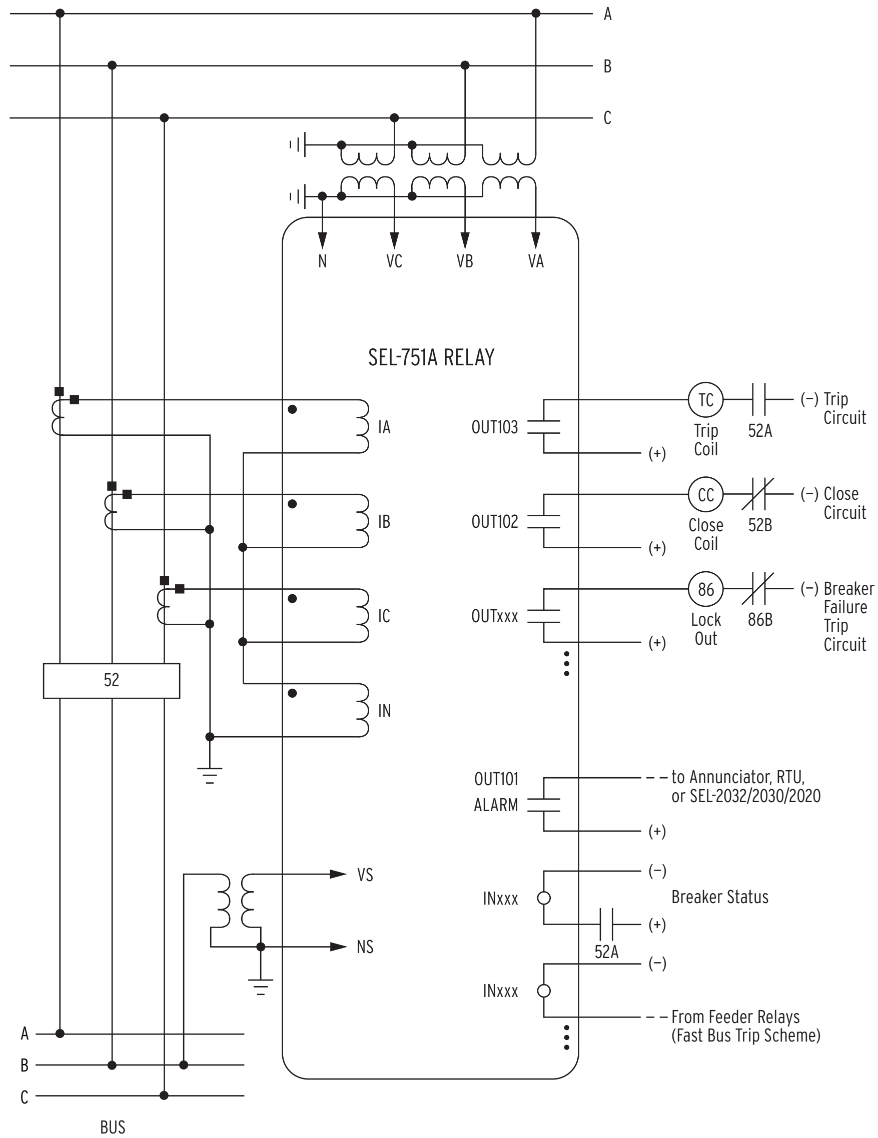
Figure 2.20 Typical Current Connections



Voltage option is necessary for voltage elements, synchronism-check elements, 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 input such as 3VO from a broken delta PT connection as long as you take care to disable the synchronism-check elements.

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

Figure 2.21 SEL-751A Provides Overcurrent Protection and Reclosing for a Distribution Feeder (Includes Fast Bus Trip Scheme) (Delta-Connected PTs)



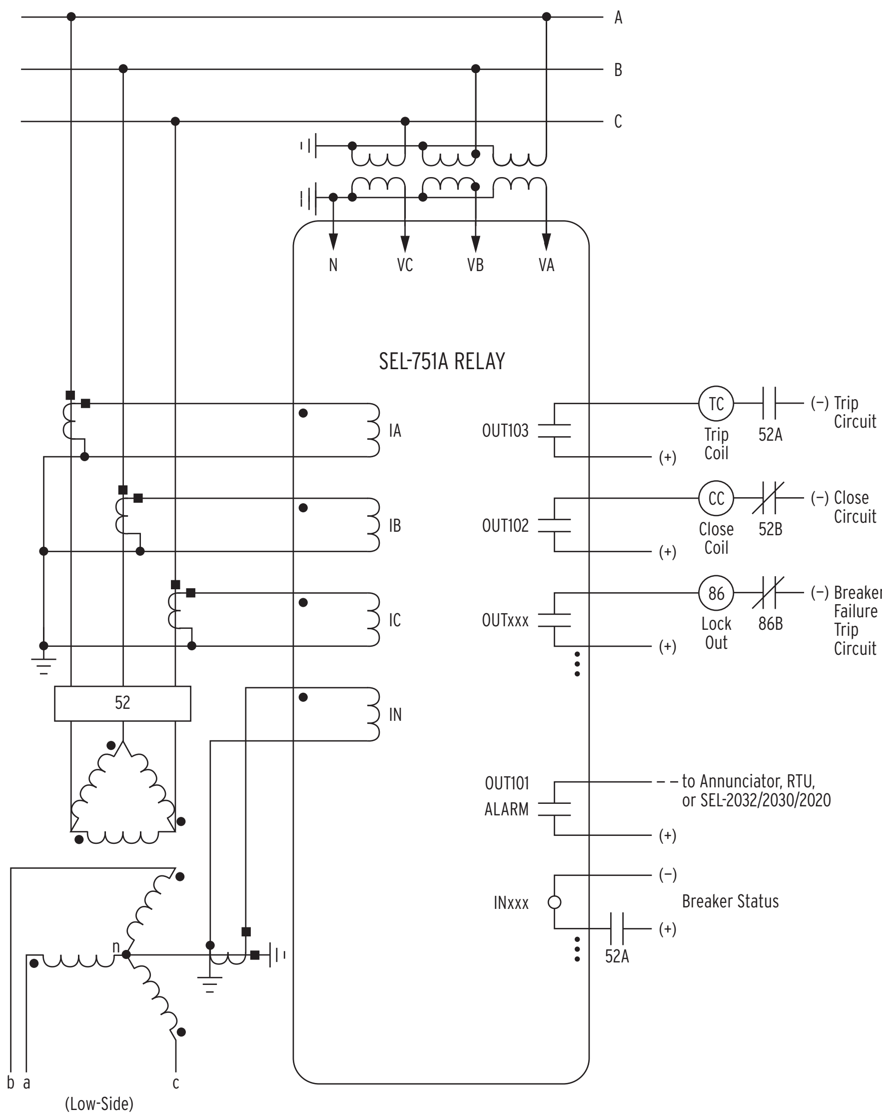
The fast bus trip scheme is often referred to as a reverse-interlocking or zone-interlocking scheme.

Voltage option is necessary for voltage elements, synchronism-check elements, 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 input such as 3VO from a broken delta PT connection as long as you take care to disable the synchronism-check elements.

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

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

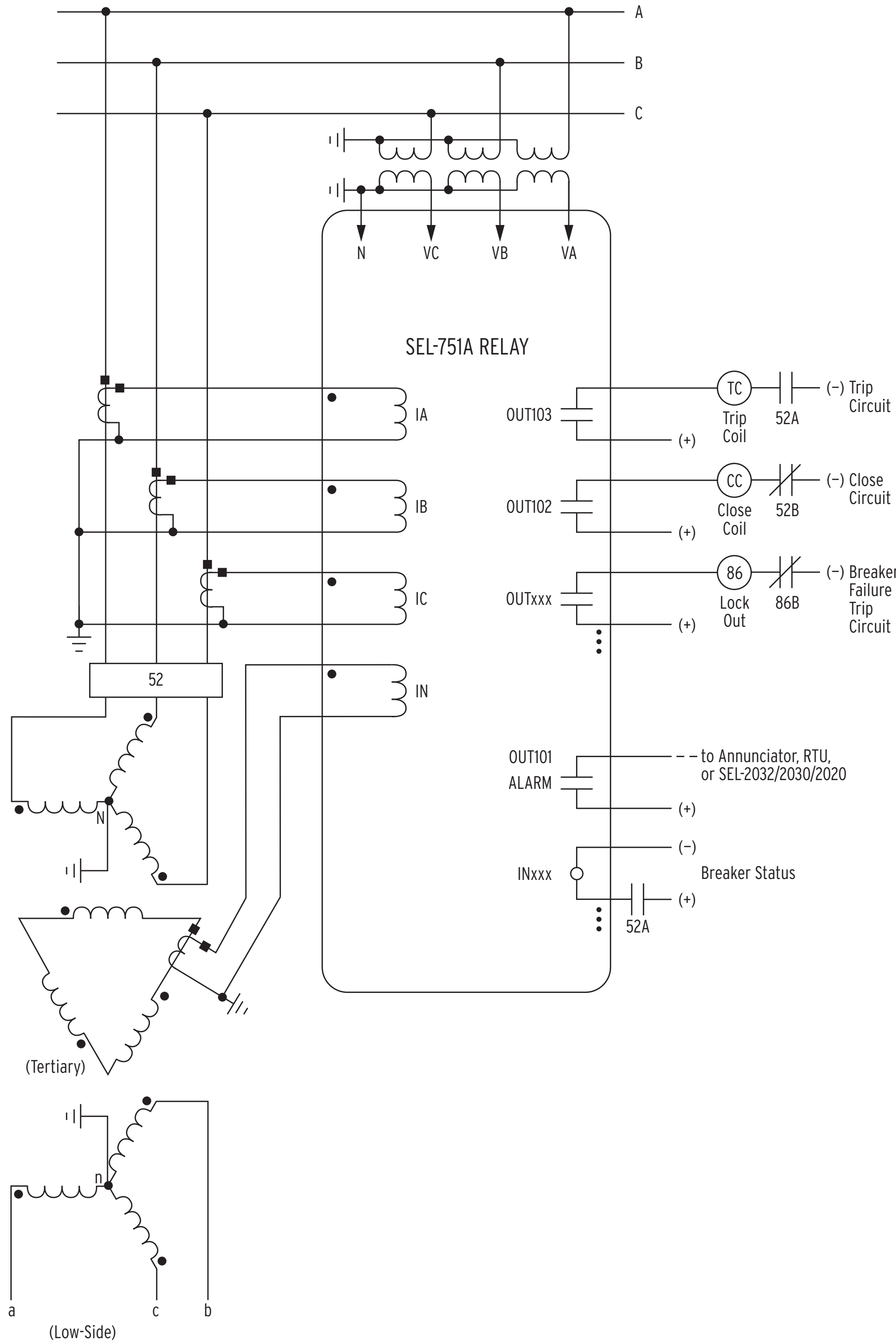
Figure 2.22 SEL-751A Provides Overcurrent Protection for a Distribution Bus (Includes Fast Bus Trip Scheme) (Wye-Connected PTs)



Voltage option is necessary for voltage elements and metering (e.g., voltage, KW, KVAR). INxxx and OUTxxx indicate user-configurable optional digital inputs and outputs.

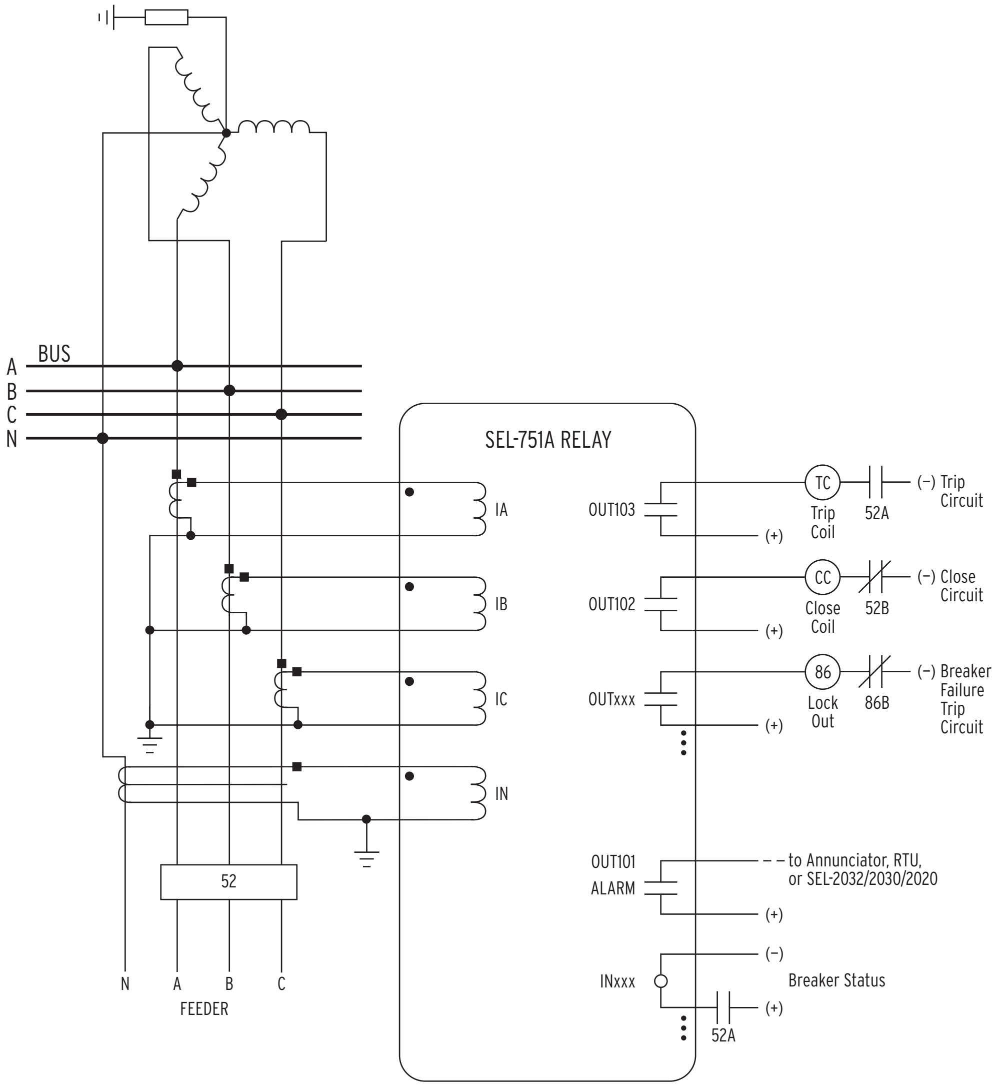
For sensitive earth fault (SEF) applications, the SEL-751A should be ordered with Channel **IN** rated at 2.5 mA nominal. See current input specifications in the subsection Specifications, General on page 1.10. See neutral-ground overcurrent element pickup specifications in Section 4: Protection and Logic Functions.

Figure 2.23 SEL-751A Provides Overcurrent Protection for a Delta-Wye Transformer Bank (Wye-Connected PTs)



Voltage option is necessary for voltage elements and metering (e.g., voltage, KW, KVAR). INxxx and OUTxxx indicate user-configurable optional digital inputs and outputs.

Figure 2.24 SEL-751A 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.

For sensitive earth fault (SEF) applications, the SEL-751A should be ordered with Channel **IN** rated at 2.5 mA nominal. See current input specifications in the subsection Specifications, General on page 1.10. See neutral-ground overcurrent element pickup specifications in Section 4: Protection and Logic Functions.

Figure 2.25 SEL-751A 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-751A for Arc-Flash Detection* for more details.

Figure 2.26 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 2.12* shows the rear-panel layout and the side-panel I/O designations for a relay model with the 3 AVI/4 AFDI card for arc-flash protection.

Figure 2.26 SEL-751A 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 2.27* shows an example of a typical black-jacketed fiber installation.

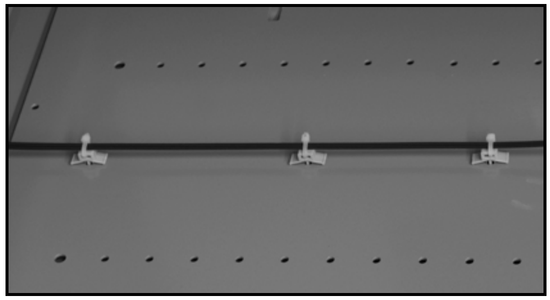


Figure 2.27 Black-Jacketed Fiber Installation Example

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-751A relay as shown in *Figure 2.28*.

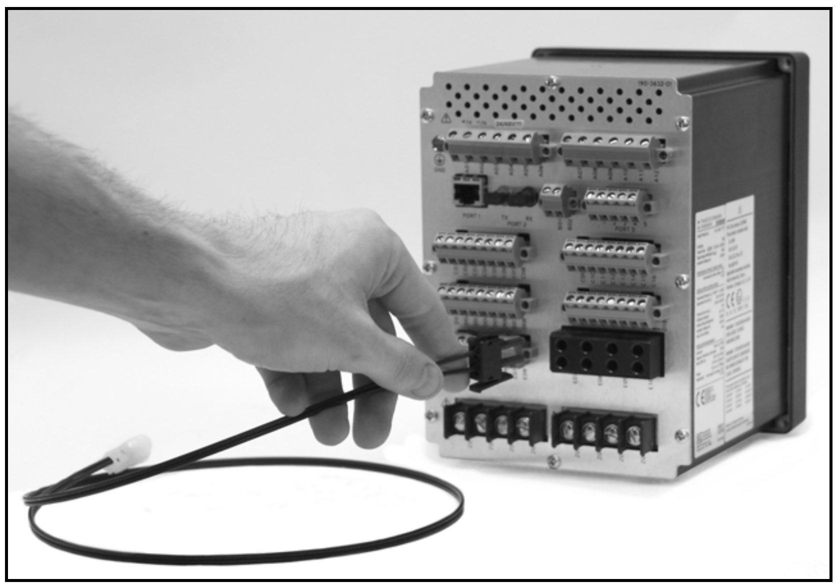


Figure 2.28 Connecting Sensor Fibers to the Relay

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

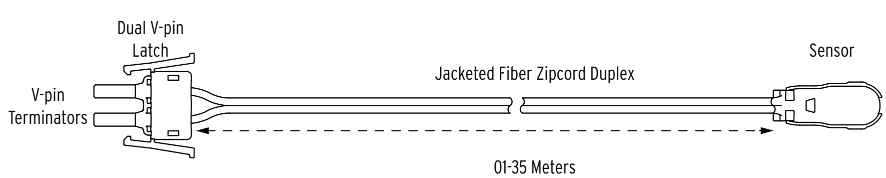
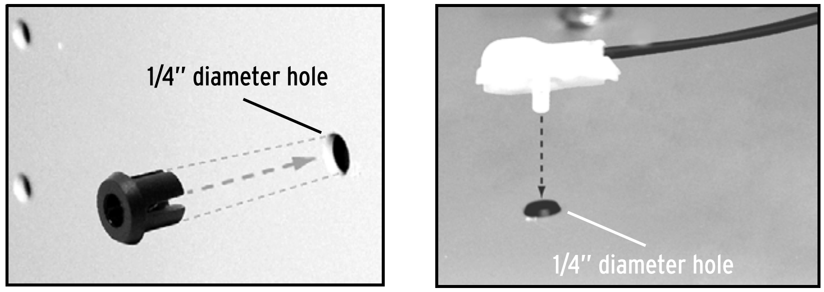


Figure 2.29 Point-Sensor Assembly

The sensor is mounted flush on the switchgear cabinet wall, using a standard 1/4-inch hole. Mounting steps are shown in *Figure 2.30*.



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

Figure 2.30 Point-Sensor Installation

The point sensor is omnidirectional with a slight loss of sensitivity at the fiber entry point. *Figure 2.31*, *Figure 2.32*, and *Figure 2.33* 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.

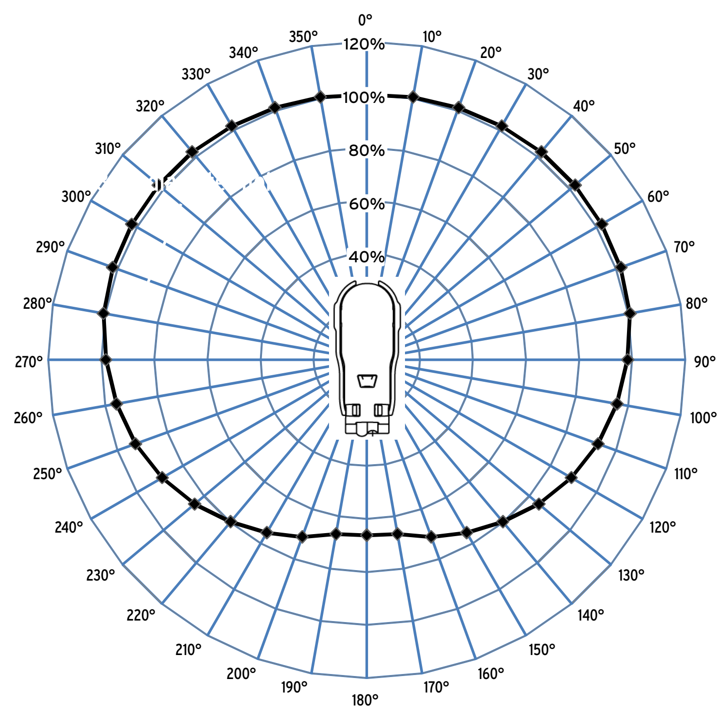


Figure 2.31 Point-Sensor Directivity (0–360° Around the Mounting Plane)

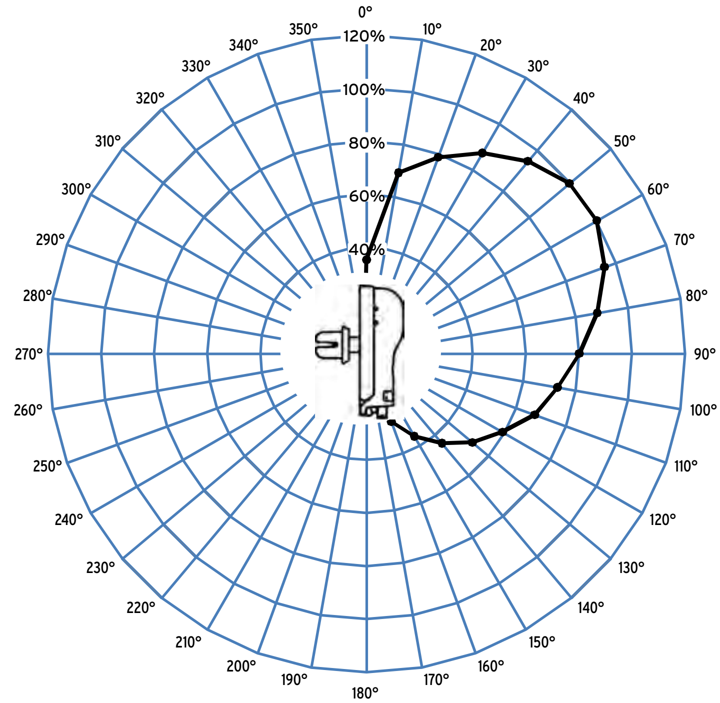


Figure 2.32 Point-Sensor Directivity (Front to Back, Above the Mounting Plane)

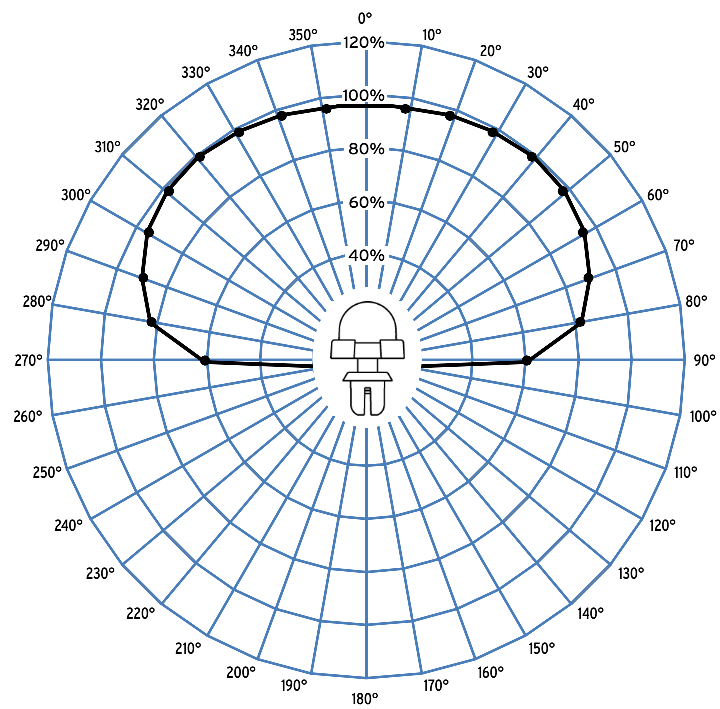
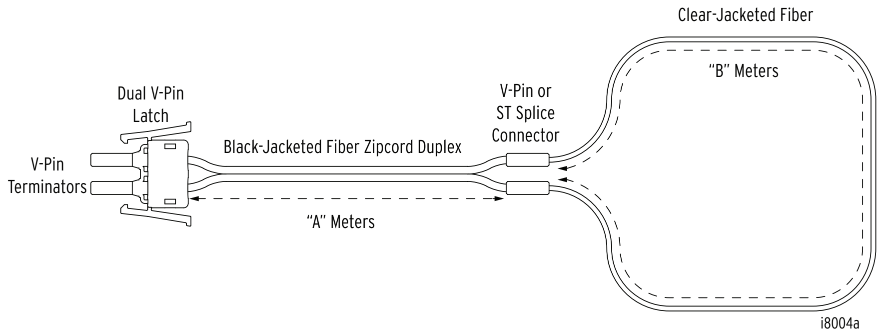


Figure 2.33 Point-Sensor Directivity (Left to Right, Above the Mounting Plane)

Clear-Jacketed 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 2.34* shows a schematic diagram of the clear-jacketed fiber sensor. *Figure 2.35* 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 2.34 Clear-Jacketed Fiber Sensor Assembly

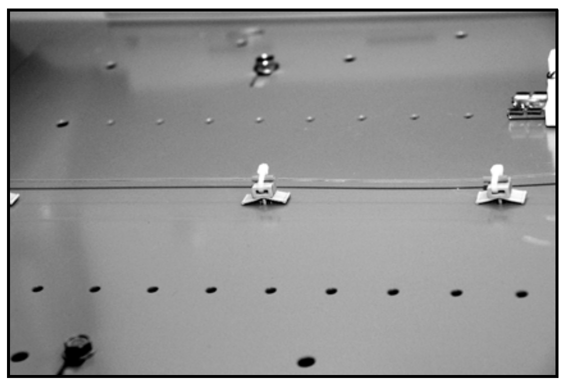


Figure 2.35 Clear-Jacketed Fiber Sensor Mounting Example

A clear-jacketed fiber sensor consists of the major components shown in *Figure 2.36*. Two connector options (V-pin and ST) are available for transitioning from the black-jacketed to the clear-jacketed fiber section as shown in *Figure 2.37*. The ST® connector option is generally superior because of positive locking and lower coupling loss.

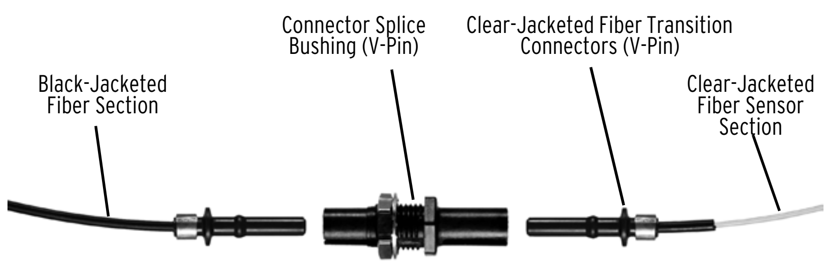
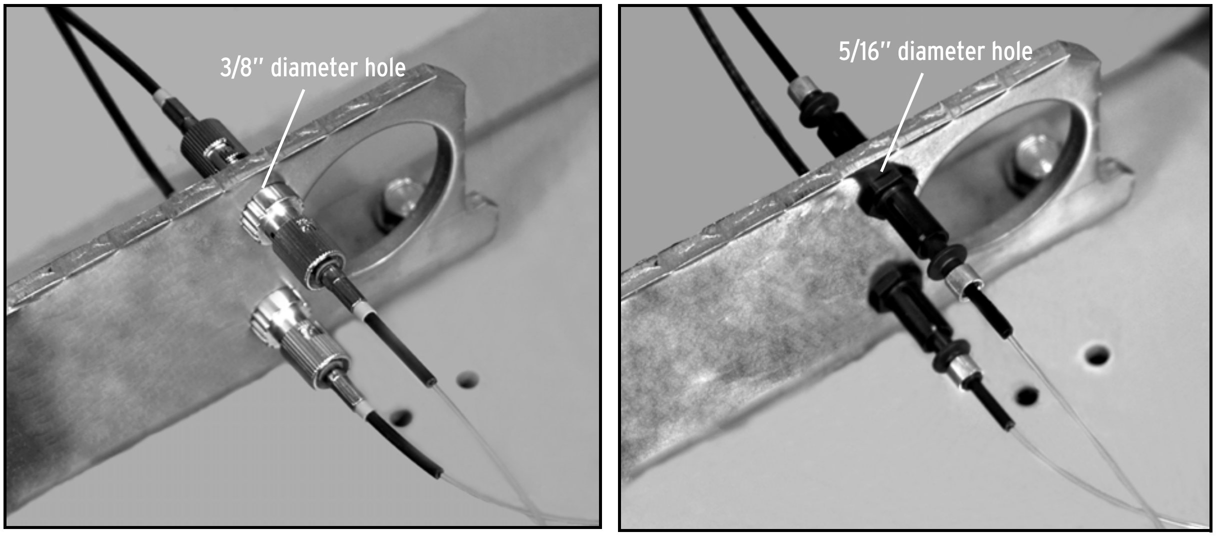


Figure 2.36 Clear-Jacketed Fiber Sensor Components (V-Pin Style)

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 exposed to the light. The maximum length of the clear-jacketed fiber sensor is limited to 70 m and includes both clear-jacketed 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 2.37*.



ST Connection (3/8″ diameter hole) V-Pin Connection (5/16″ diameter hole)

Figure 2.37 Transition From Clear-Jacketed to Black-Jacketed Fiber Section

You should return the clear-jacketed fiber loop 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 less than 35 m, irrespective of the SEL-751A dual V-pin connector orientation.

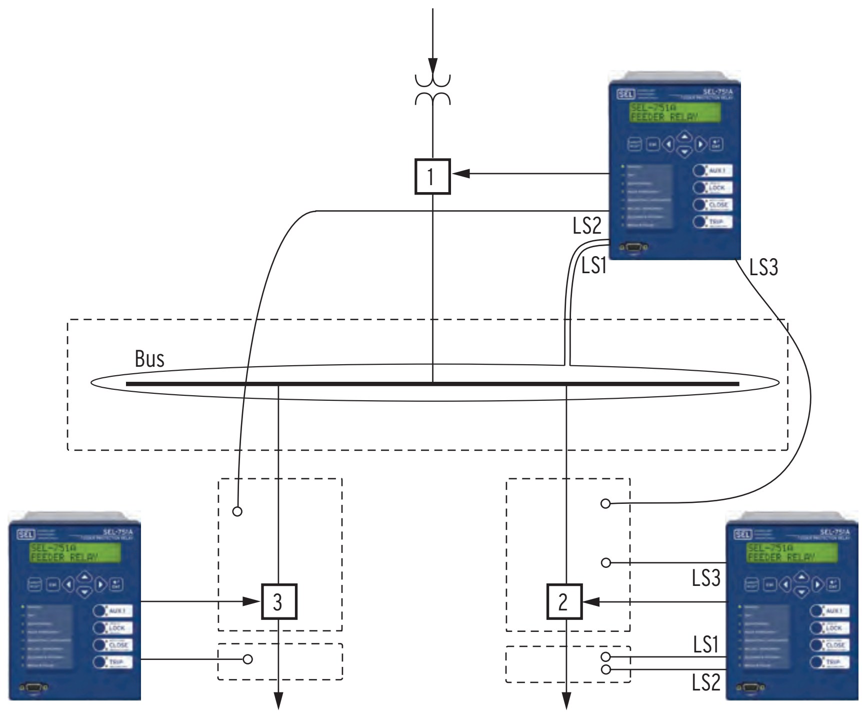
Care should be exercised not to scratch or otherwise damage the clear-jacketed sensing fiber during installation. Surface scratches can result in increased light leakage that will be detected by the SEL-751A sensor diagnostics. Once damaged, the fiber must be replaced.

Application Example

Figure 2.38 shows a typical switchgear application example with one incoming and two radial (outgoing) feeders. All three feeders are protected with an SEL-751A relay 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 2.38*). Sensor LS1 is implemented as a clear-jacketed fiber loop enclosing entire length of the bus.

When necessary, 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 necessary 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 2.38 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-751A firmware can be upgraded in the field; refer to *Appendix B: Firmware Upgrade Instructions* for firmware upgrade instructions. You can 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 know if the analog front-end (not monitored by relay self-test) is functional. Refer to *Section 10: Testing and Troubleshooting* for detailed testing and troubleshooting information.

The only two components that can be replaced in the field are the power supply fuse and the real-time clock battery. A lithium battery powers the clock (date and time) if the external power source is lost or removed. The battery is a 3 V lithium coin cell, Ray-O-Vac® BR2335 or equivalent. At room temperature (25°C), the battery 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-751A and other SEL devices. *Table 3.1* lists SEL-751A 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-751A 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-751A. *Table 3.2* shows the suite of ACSELERATOR QuickSet applications provided for the SEL-751A.

Table 3.2 ACSELERATOR QuickSet SEL-5030 Software

Application	Description
Rules Based Settings Editor	Provides on-line or off-line device settings that include interdependency checks. Use this feature to create and manage settings for multiple devices in a database.
HMI	Provides a summary view of device operation. Use this feature to simplify commissioning testing
Design Templates[a]	Allows you to customize relay settings to particular applications and store those settings in Design Templates. You can lock settings to match your standards or lock and hide settings that are not used.
Event Analysis	Provides oscillography and other event analysis tools.
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 communications and directly interface with the device
Help	Provides general ACSELERATOR QuickSet and device-specific ACSELERATOR QuickSet context help.

[a] Available in licensed versions of ACSELERATOR QuickSet.

Setup

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

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

Step 2. Apply power to the SEL-751A.

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-751A. Perform the following steps to configure ACSELERATOR QuickSet to communicate effectively with the relay.

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

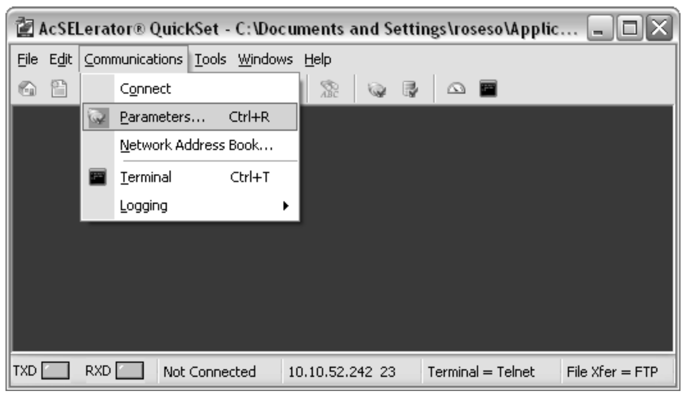


Figure 3.1 Serial Port Communication Dialog Box

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

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

Step 4. Configure ACSELERATOR QuickSet to match the SEL-751A 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-751A, always select FTP as the File Transfer Option.

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

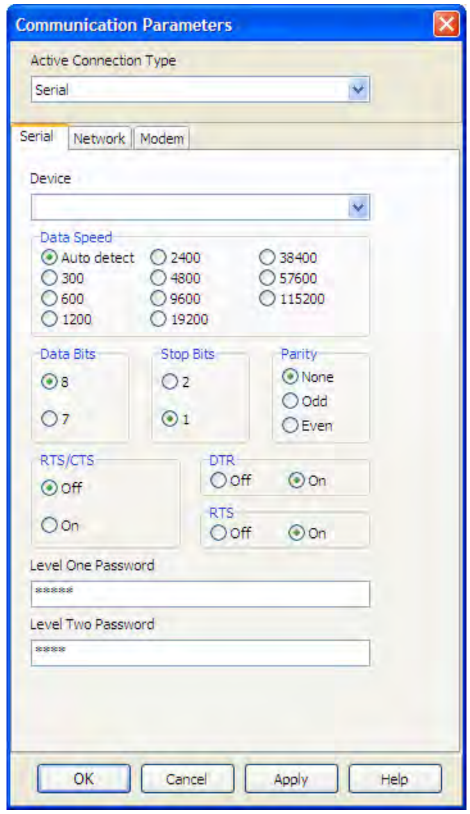


Figure 3.2 Serial Port Communication Parameters Dialog Box

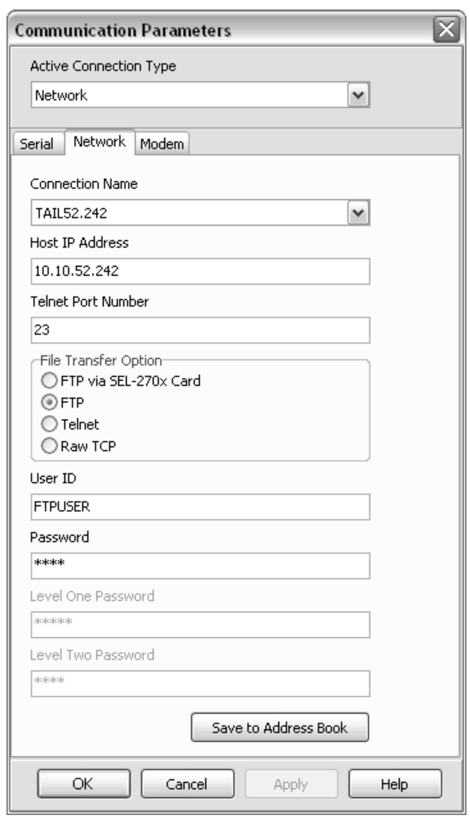


Figure 3.3 Network Communication Parameters Dialog Box

Terminal

Terminal Window

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

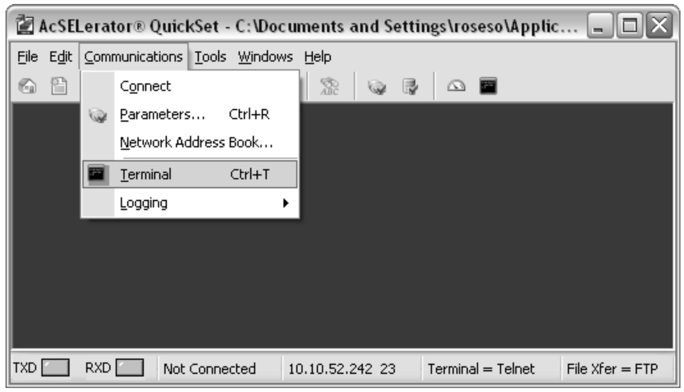


Figure 3.4 Tools Menu

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-751A-R100-V0-Z001001-D20070410","08EE"
"BFID=BOOTLDR-R303-V0-Z000000-D20060612","0949"
"CID=9B42","025E"
"DEVID=SEL-751A","0408"
"DEVCODE=69","0316"
"PARTNO=751A01B6X3X7183021X","06D9"
"CONFIG=11251201","03F0"
"iedName =TEMPLATE","05DC"
"type =SEL_751A","04B0"
"configVersion =ICD-751A-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 3.9*. Compare the part number (PARTNO=751A0XXXXXXXXXXXXXX) with the Model Option Table (MOT) to ensure the correct relay configuration.

Settings Database Management and Drivers

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

Database Manager

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

Settings Database

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

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

Step 2. Enter descriptions for the database and 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 exiting 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-751A relays. Store existing relay settings downloaded from SEL-751A relays with ACSELERATOR QuickSet, creating a library of relay settings, then modify and upload these settings from the settings library to an SEL-751A. ACSELERATOR QuickSet makes setting the relay easy and efficient. However, you do not have to use ACSELERATOR QuickSet to configure the SEL-751A; 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-751A 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-751A and then create and open a new record. Use the **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-751A settings with the **Settings Editor** in the **Editor Mode**, select **File > New** from the main menu bar and SEL-751A and **004** from the **Settings Editor Selection** window, as shown in *Figure 3.6*.

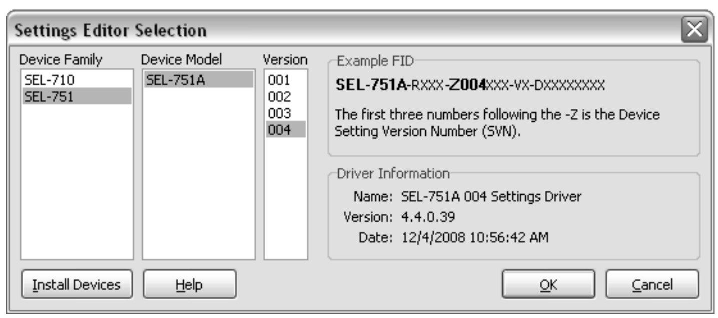


Figure 3.6 Selection of Drivers

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.

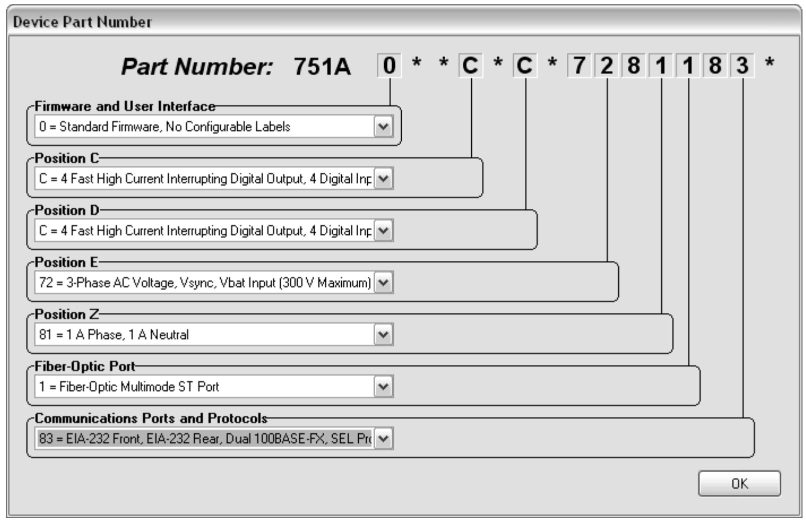


Figure 3.7 Update Part Number

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.

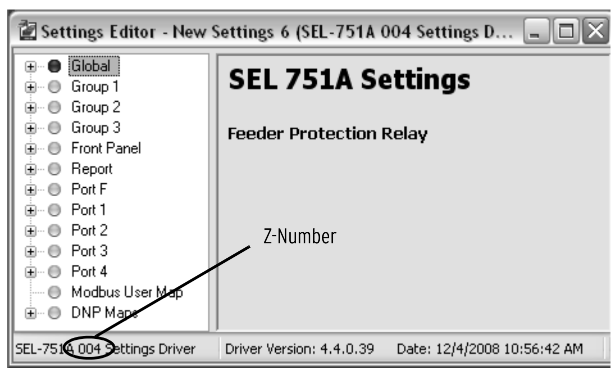


Figure 3.8 New Setting Screen

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 is upgrade an existing settings file to a newer version because devices are using a newer version number. ACSELERATOR QuickSet provides a **Convert Settings** report that shows missed, changed, and invalid settings created as a result of the conversion. Review this report to determine whether changes are necessary.

Settings Editor (Editor Mode)

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

Entering Settings

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

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

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

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

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

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

Expression Builder

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

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

Access the Expression Builder

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

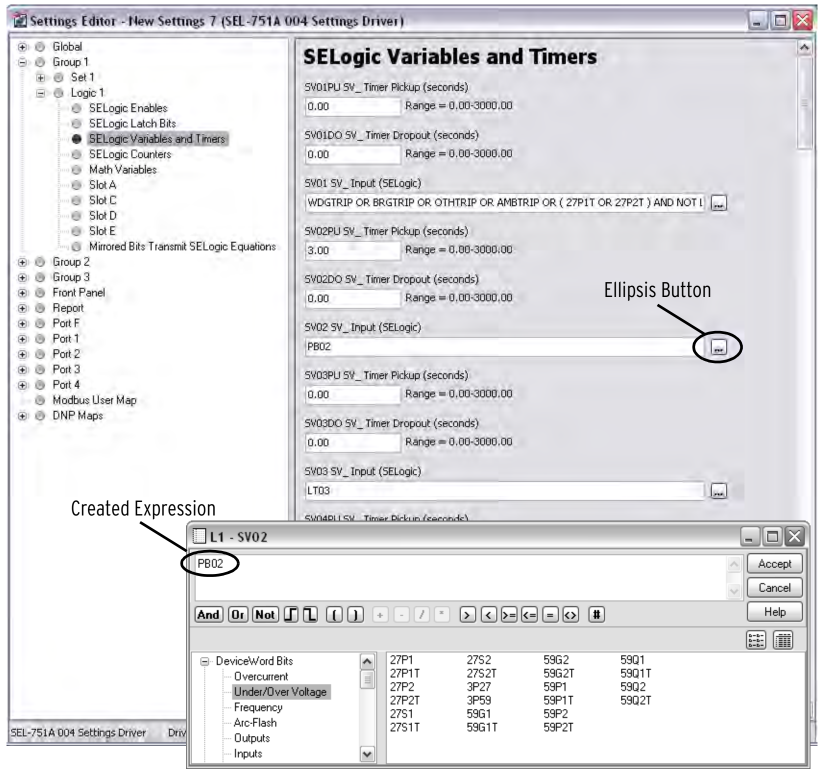


Figure 3.9 Expressions Created With Expression Builder

Expression Builder Organization

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

Using the Expression Builder

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

File > Save

Select the **Save** menu item from the **File** menu item of the **Settings Editor** once settings are entered into ACSELERATOR QuickSet. This will help 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-751A stores to evaluate the performance of a system (select **Tools > Events > Get Event Files**). *Figure 3.10* shows composite screens for retrieving events.

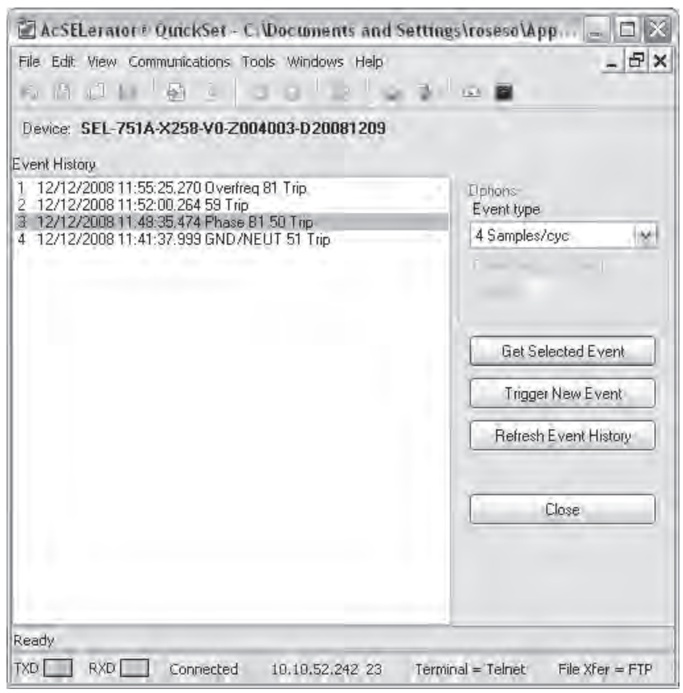


Figure 3.10 Composite Screens for Retrieving Events

Event Waveforms

The relay provides two types of event data captures: event reports that use 4 samples/cycle filtered data and 16 samples/cycle unfiltered (raw) data. See *Section 9: Analyzing Events* for information on recording events. Use the **Options** function in *Figure 3.10* to select the 16 samples/cycle unfiltered (raw) data event (default is 4 samples/cycle filtered data).

View Event History

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

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 16 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*.

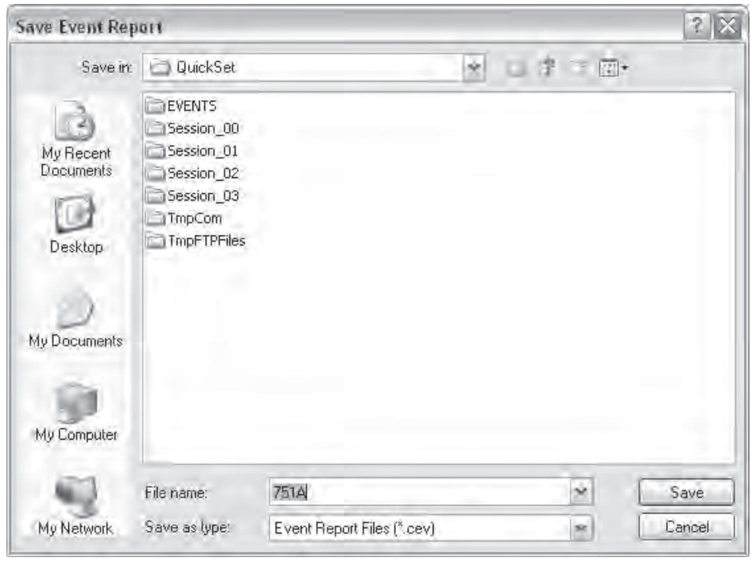


Figure 3.11 Saving the Retrieved Event

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.

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

Relay Word bit, and click the **Update** button to assign the Relay Word bit to the LED. To change the color of the LED, click in the square and make your selection from the color palette.

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

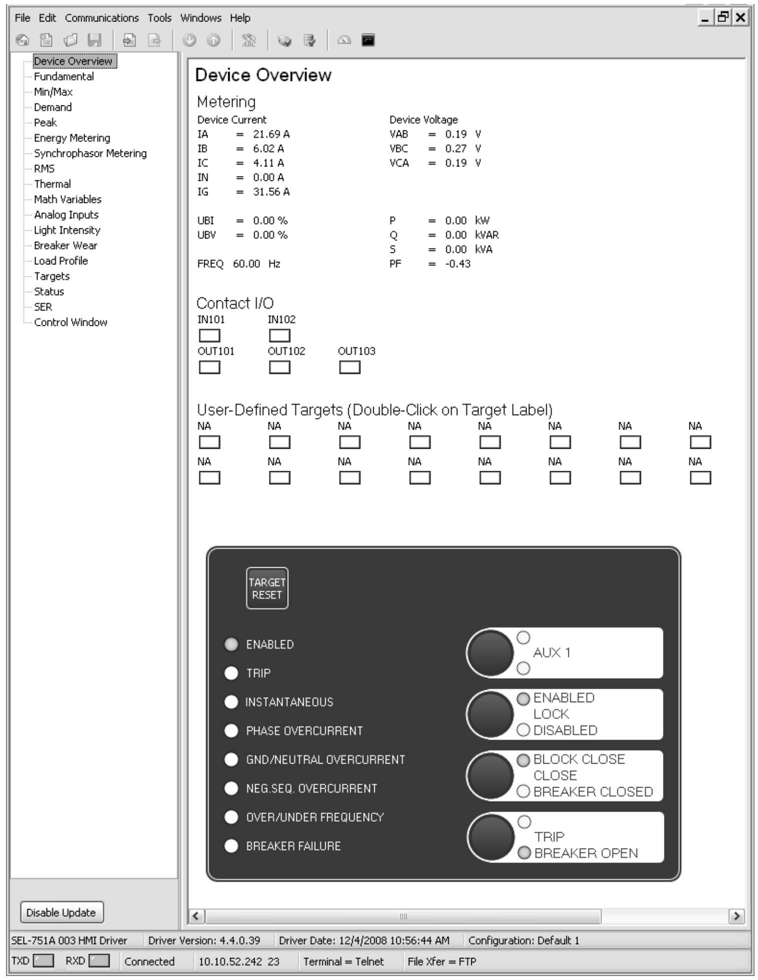


Figure 3.12 Device Overview Screen

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 your SEL-751A supports such tests, you can run arc-flash sensor diagnostics.

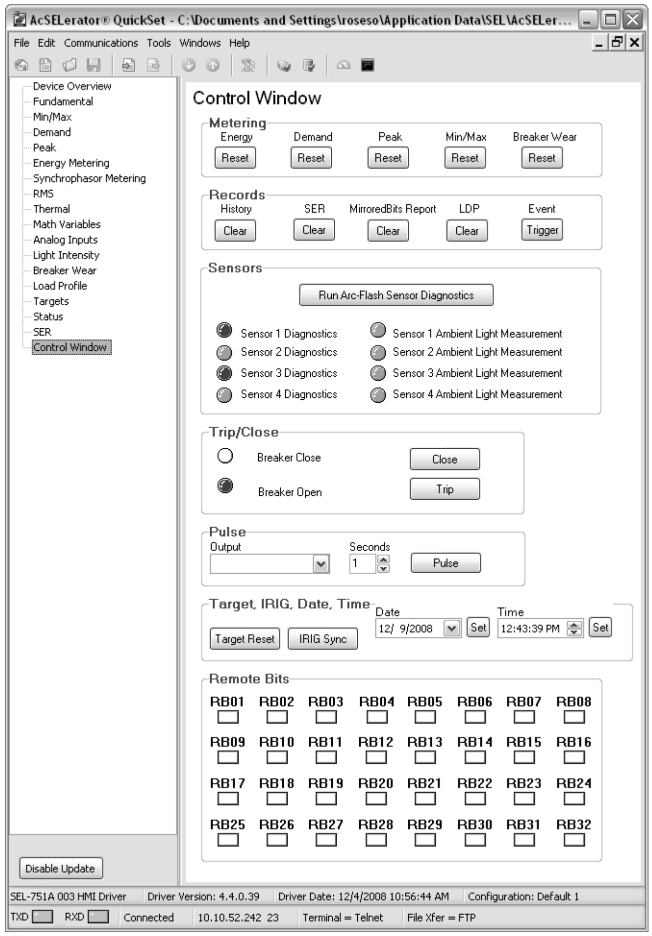


Figure 3.13 Control Screen

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

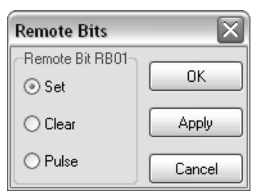


Figure 3.14 Remote Operation Selection

ACSELERATOR 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 Help

Help	Description
General ACSELERATOR QuickSet	Select **Help** from the main menu bar
SEL-751A 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-751A 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-751A 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 you calculate the relay settings.

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

Basic Protection. Lists settings for protection elements included in all models of the SEL-751A, 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, and synchronism-check elements. These elements are available when an optional voltage input card is present. You can skip this subsection if your relay is not equipped with optional voltage inputs.

Frequency Protection. Lists settings included in all models of the SEL-751A with enhanced and/or expanded performance when optional voltage inputs are used.

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 settings for resetting targets, energy metering, max/min metering, demand metering, and peak demand metering.

Access Control. Describes SELOGIC setting used for disabling settings changes from the relay front panel.

Time-Synchronization Source. Describes setting used 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.

When you calculate the protection element settings, proceed through the subsections listed earlier. Skip the RTD- and voltage-based protection subsections if they do not apply to your specific relay model or installation.

See *Section 6: Settings* for the list of all settings (*SEL-751A Settings Sheets*) and various methods of accessing them. All current and voltage settings in the SEL-751A 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*), the DeviceNet port (see *Appendix G: DeviceNet Communications*), or the Ethernet port (see *Section 7: Communications*).

Application Data

It is faster and easier for you to calculate settings for the SEL-751A 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-751A 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-751A
UNIT ID LINE 2	16 Characters	TID := FEEDER RELAY

The SEL-751A 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
IG SOURCE	MEAS, CALC	IG_SRC := MEAS
RESIDU CT RATIO	1–5000	CTRG := 120

The CT ratio settings configure the relay to accurately scale measured values and report the primary quantities. Calculate the phase, neutral, and residual current (optional) 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 voltage settings for relay models with optional voltage inputs.

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	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 optional 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 14400:120 V rated voltage transformers (connected in open delta) are used.

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 2.18*, 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.

Relays that are not equipped with phase voltage inputs hide these settings and disable voltage-based protection and metering functions.

VNOM Range Check

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

Basic Protection

Overcurrent Elements

Four levels of instantaneous/definite-time elements are available for phase, neutral, residual, and negative-sequence overcurrent as shown in *Table 4.4* through *Table 4.7* and in *Figure 4.1*.

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

Table 4.4 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	0.00–5.00 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	0.00–5.00 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	0.00–5.00 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	0.00–5.00 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, this can severely delay and even jeopardize the operation of any high-set instantaneous overcurrent element. For any phase instantaneous overcurrent element in the SEL-751A relay set in excess of 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 4.5 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], 0.13–12.50 mA[c] 5.0–1000.0 mA[d]	50N1P := OFF
NEUT OC TRIP DLY	0.00–5.00 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], 0.13–12.50 mA[c] 5.0–1000.0 mA[d]	50N2P := OFF
NEUT OC TRIP DLY	0.00–5.00 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], 0.13–12.50 mA[c] 5.0–1000.0 mA[d]	50N3P := OFF
NEUT OC TRIP DLY	0.00–5.00 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], 0.13–12.50 mA[c] 5.0–1000.0 mA[d]	50N4P := OFF
NEUT OC TRIP DLY	0.00–5.00 sec	50N4D := 0.50
NEUT OC TRQ CON	SELOGIC	50N4TC := 1

[a] For I_{NOM} = 5 A.
[b] For I_{NOM} = 1 A.
[c] For I_{NOM} = 2.5 mA.
[d] For I_{NOM} = 50 mA.

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 or with measured residual current IG through the use of the optional **CT** input on the SELECT 5 AVI/1 ACI card in Slot **E** (see *Figure 4.1*).

NOTE: In Figure 4.1, Residual Current Magnitude IIGI is either calculated residual current or measured residual current depending on the setting IG_SRC and the availability of 5 AVI/ 1 ACI card in Slot **E**.

Not shown in the figure, Relay Word bit ORED50T is asserted if any of the 50PnT, 50NnT, 50GnT, or 50QnT Relay Word bits are asserted (n = 1 to 4).

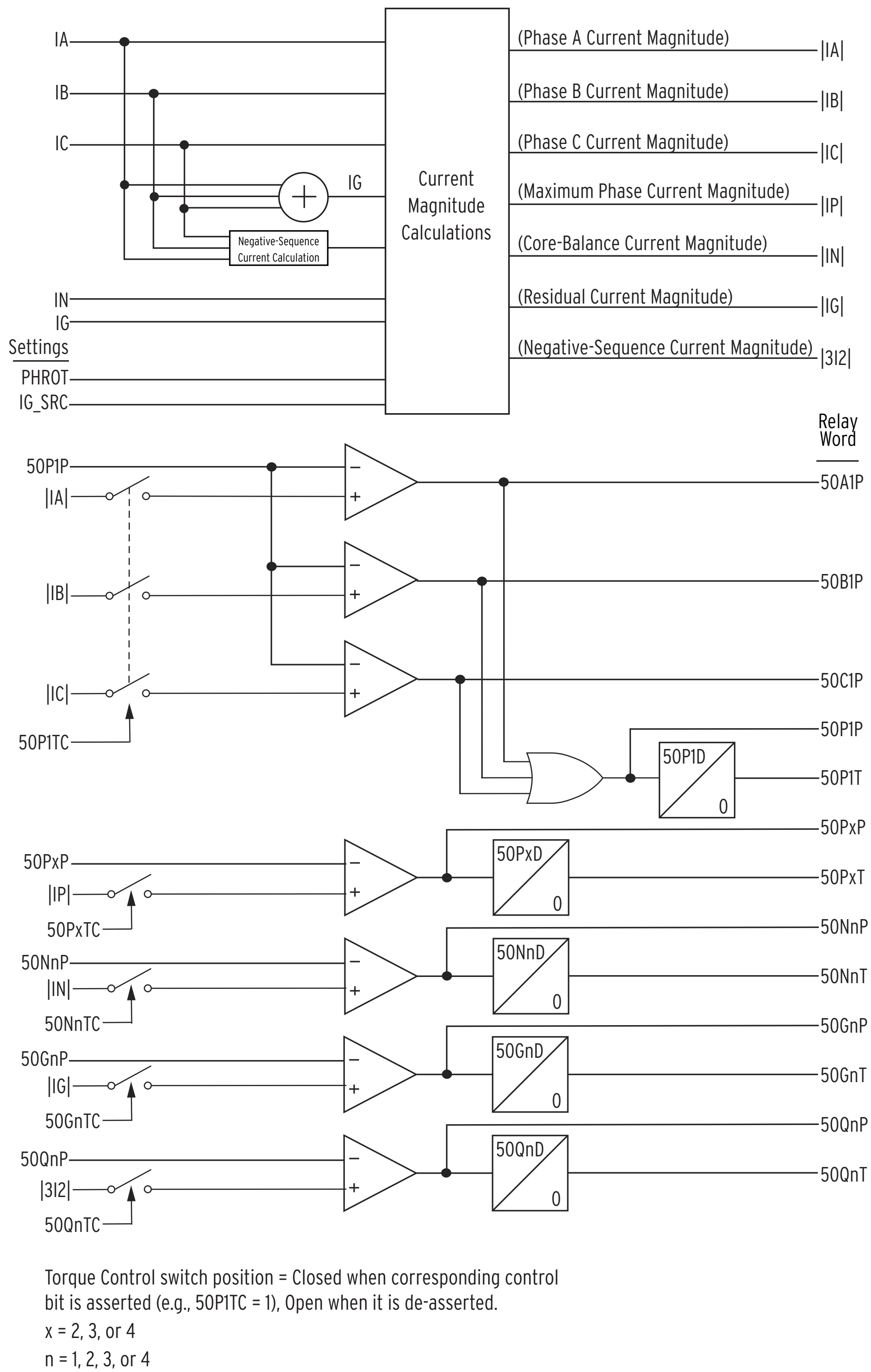


Figure 4.1 Instantaneous Overcurrent Element Logic

When a core-balance CT is connected to the relay **IN** input, as in *Figure 2.25*, use the neutral overcurrent element to detect the ground faults. Calculate the trip level settings according to the available ground fault current and the core-balance CT ratio.

EXAMPLE 4.3 Ground Fault Core-Balance CT Application

A resistance-grounded power system limits the ground fault currents. The resistor is sized to limit the current to 10 A primary. The three feeder leads are passed through the window of a 10:1 core-balance CT. The CT secondary is connected to the SEL-751A **IN** current input (terminals Z07, Z08), as shown in Figure 4.2. Setting the Neutral OC CT Ratio (CTRN, see Figure 4.2) equal to 10 and Neutral Trip Lvl (50N1P) equal to 0.5 A or lower with 0.10-second time delay ensures that the element will quickly detect and trip for feeder ground faults.

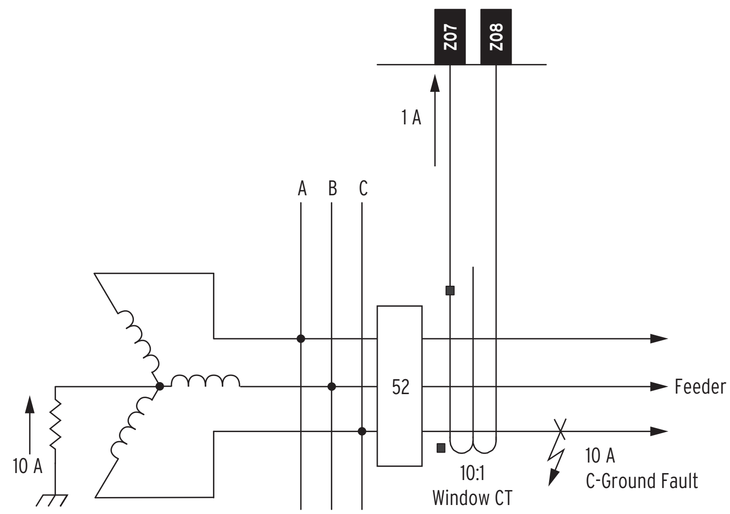


Figure 4.2 Ground Fault Protection Using Core-Balance CT

Table 4.6 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	0.00–5.00 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	0.00–5.00 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	0.00–5.00 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	0.00–5.00 sec	50G4D := 0.50
RES OC TRQ CON	SELOGIC	50G4TC := 1

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

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

A core-balance **CT** input can also be connected to the **IG** input (terminals **E09** and **E10**) in relays with the SELECT 5 AVI/1 ACI card in Slot **E** of the relay. Set the CT ratio setting CTRG and set the residual current IG source setting IG_SRC := MEAS. When a core-balance CT is not available, use the 50G residual overcurrent elements based on the calculated residual current IG (set IG_SRC := CALC).

Table 4.7 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	0.1–120.0 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	0.1–120.0 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	0.1–120.0 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	0.1–120.0 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 4.3 and *Figure 4.4* show pickup and reset time curves applicable to all nondirectional instantaneous overcurrent elements with sinusoidal waveforms applied (60 Hz or 50 Hz relays). These times do not include output contact operating time and, thus, are accurate for determining element operation time for use in internal SELOGIC control equations. Output contact pickup/dropout time is approximately 4 ms (0.25 cycle for a 60 Hz relay; 0.20 cycle for a 50 Hz relay).

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

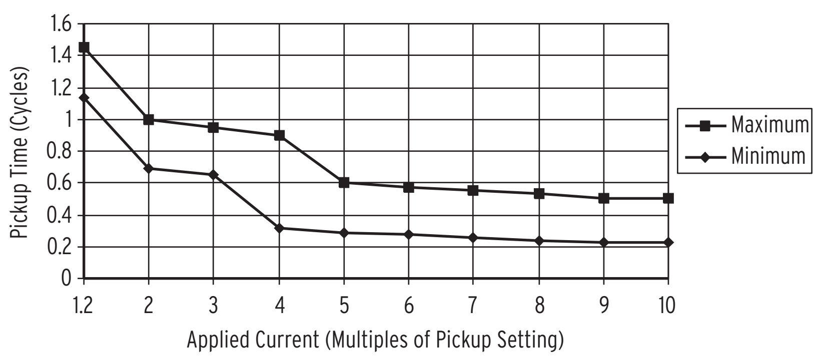


Figure 4.3 Instantaneous Overcurrent Element Pickup Time Curve

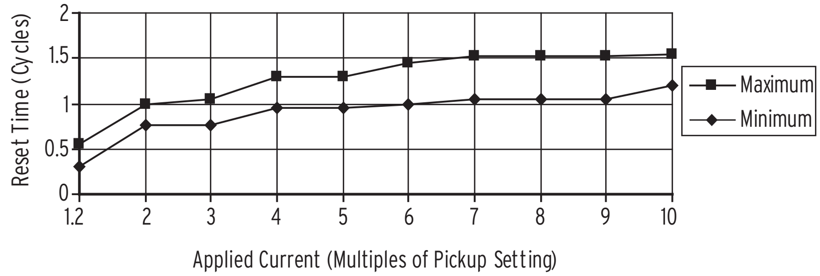


Figure 4.4 Instantaneous Overcurrent Element Reset Time Curve

Time-Overcurrent Elements

One level of inverse time element is available for 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 4.8* through *Table 4.12* for available settings.

You can select from five U.S. and five IEC inverse characteristics. *Table 4.13* and *Table 4.14* show equations for the curves and *Figure 4.10* through *Figure 4.19* show the curves. The curves and equations shown do not account for constant time adder and minimum response time (settings 51_CT and 51_MR respectively, each assumed equal to zero). Use the 51_CT if you want to raise the curves by a constant time. Also, you can use the 51_MR if you want to ensure the curve times no faster than a minimum response time.

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

Table 4.8 Phase A, B, and C Time-Overcurrent Settings (Sheet 1 of 2)

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], 0.05–1.00[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], 0.05–1.00[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

Table 4.8 Phase A, B, and C Time-Overcurrent Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
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], 0.05–1.00[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 *Figure 4.5*.

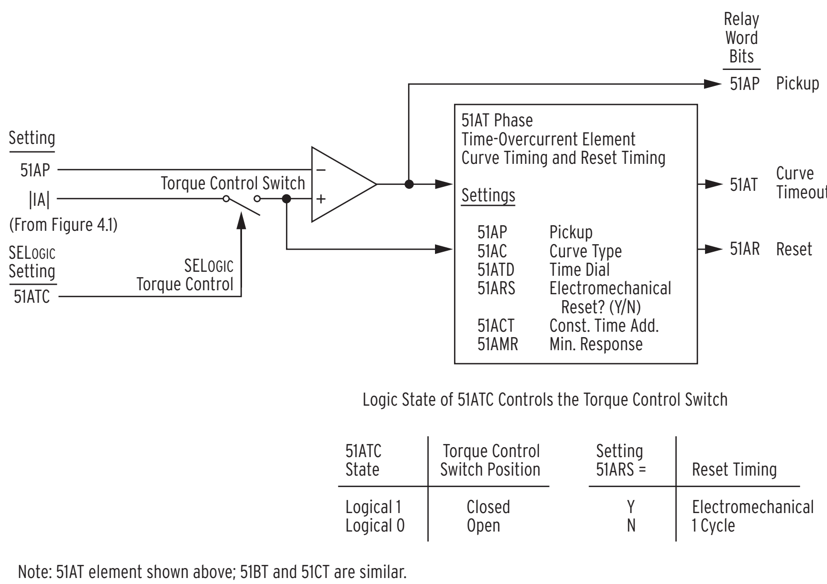


Figure 4.5 Phase Time-Overcurrent Elements 51AT, 51BT, and 51CT

Table 4.9 Maximum Phase Time-Overcurrent (Sheet 1 of 2)

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], 0.05–1.00[d]	51P1TD := 3.00
EM RESET DELAY	Y, N	51P1RS := N
CONST TIME ADDER	0.00–1.00 sec	51P1CT := 0.00

Table 4.9 Maximum Phase Time-Overcurrent (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
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], 0.05–1.00[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 *Figure 4.6*.

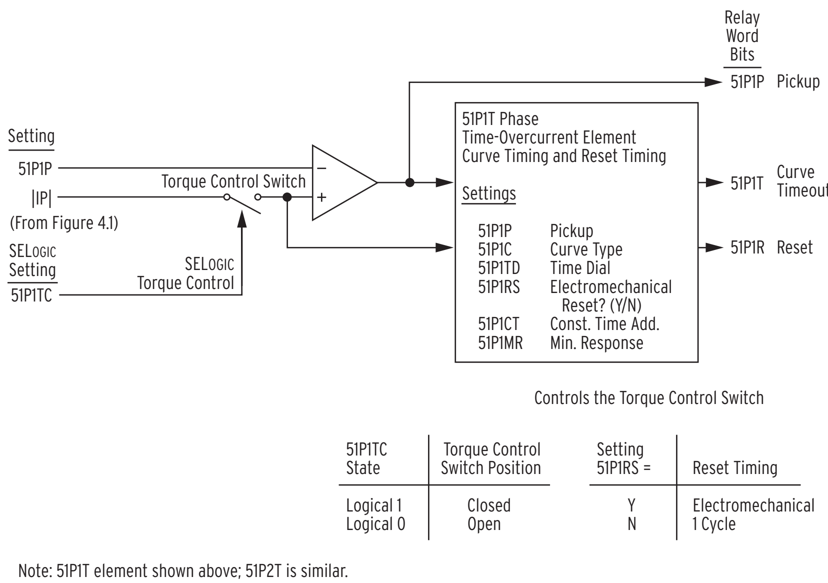


Figure 4.6 Maximum Phase Time-Overcurrent Elements 51P1T and 51P2T

Table 4.10 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], 0.05–1.00[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 in *Figure 4.7*.

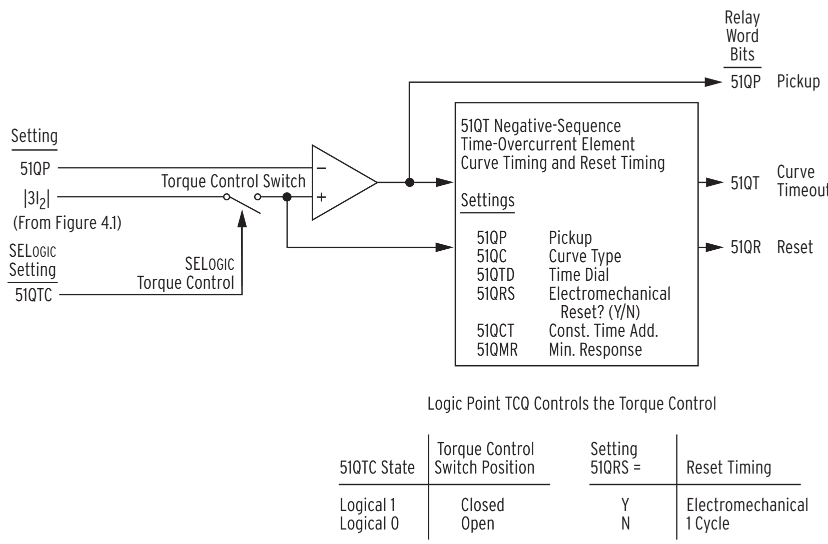


Figure 4.7 Negative-Sequence Time-Overcurrent Element 51QT

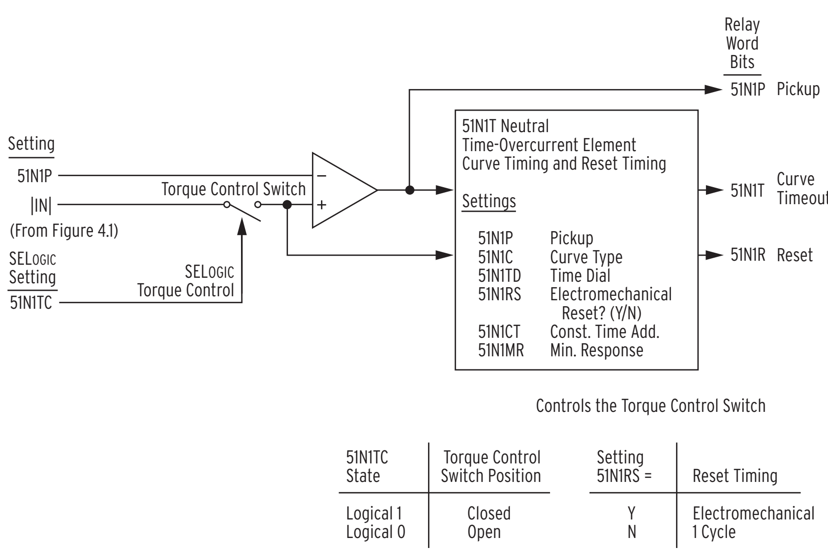
False negative-sequence current can transiently appear when a circuit breaker is closed and balanced load current suddenly appears. To avoid tripping for this transient condition, do not use a time-dial setting that results in curve times below three cycles.

Table 4.11 Neutral 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] 0.13–2.00 mA[c] 5.0–160.0 mA[d]	51N1P := OFF
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51N1C := U3
TOC TIME DIAL	0.50–15.00[e] 0.05–1.00[f]	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, 0.50–16.00 A[a] 0.10–3.20 A[b] 0.13–2.00 mA[c] 5.0–160.0 mA[d]	51N2P := OFF
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51N2C := U3
TOC TIME DIAL	0.50–15.00[e] 0.05–1.00[f]	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 I_{NOM} = 2.5 mA.
[d] For I_{NOM} = 50 mA.
[e] For 51_C := U_.
[f] For 51_C := C_.

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



Note: 51N1T element shown above; 51N2T is similar.

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

Table 4.12 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], 0.05–1.00[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], 0.05–1.00[d]	51G2TD := 1.50
EM RESET DELAY	Y, N	51G2RS := N
CONST TIME ADDER	0.00–1.00 sec	51G2CT := 0.00
MIN RESPONSE TIM	0.00–1.00	51G2MR := 0.00
TOC TRQ CONTROL	SELOGIC	51G2TC := 1

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

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

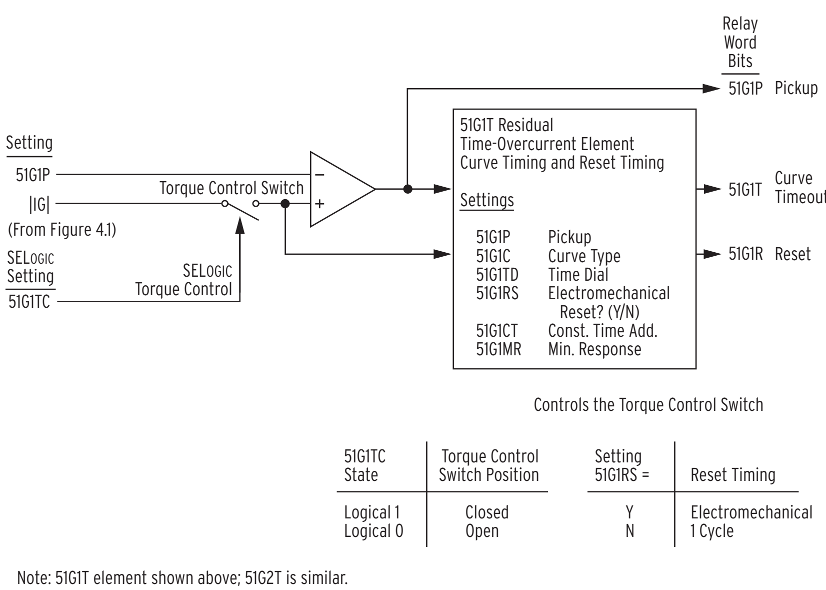


Figure 4.9 Residual Time-Overcurrent Elements 51G1T and 51G2T

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 4.5* through *Figure 4.9*). The U.S. and IEC time-overcurrent relay curves are shown in *Figure 4.10* through *Figure 4.19*. Curves U1, U2, and U3 (*Figure 4.10* through *Figure 4.12*) conform to IEEE C37.112-1996 IEEE Standard Inverse-Time Characteristic Equations for Overcurrent Relays.

Relay Word Bit ORED51T

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

Table 4.13 Equations Associated With U.S. Curves

Curve Type	Operating Time	Reset Time	Figure
U1 (Moderately Inverse)	$t_p = TD \cdot \left(0.0226 + \frac{0.0104}{M^{0.02} - 1}\right)$	$t_r = TD \cdot \left(\frac{1.08}{1 - M^2}\right)$	*Figure 4.10*
U2 (Inverse)	$t_p = TD \cdot \left(0.180 + \frac{5.95}{M^2 - 1}\right)$	$t_r = TD \cdot \left(\frac{5.95}{1 - M^2}\right)$	*Figure 4.11*
U3 (Very Inverse)	$t_p = TD \cdot \left(0.0963 + \frac{3.88}{M^2 - 1}\right)$	$t_r = TD \cdot \left(\frac{3.88}{1 - M^2}\right)$	*Figure 4.12*
U4 (Extremely Inverse)	$t_p = TD \cdot \left(0.0352 + \frac{5.67}{M^2 - 1}\right)$	$t_r = TD \cdot \left(\frac{5.67}{1 - M^2}\right)$	*Figure 4.13*
U5 (Short-Time Inverse)	$t_p = TD \cdot \left(0.00262 + \frac{0.00342}{M^{0.02} - 1}\right)$	$t_r = TD \cdot \left(\frac{0.323}{1 - M^2}\right)$	*Figure 4.14*

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 4.14 Equations Associated With IEC Curves

Curve Type	Operating Time	Reset Time	Figure
C1 (Standard Inverse)	$t_p = TD \cdot \left(\frac{0.14}{M^{0.02} - 1}\right)$	$t_r = TD \cdot \left(\frac{13.5}{1 - M^2}\right)$	*Figure 4.15*
C2 (Very Inverse)	$t_p = TD \cdot \left(\frac{13.5}{M - 1}\right)$	$t_r = TD \cdot \left(\frac{47.3}{1 - M^2}\right)$	*Figure 4.16*
C3 (Extremely Inverse)	$t_p = TD \cdot \left(\frac{80}{M^2 - 1}\right)$	$t_r = TD \cdot \left(\frac{80}{1 - M^2}\right)$	*Figure 4.17*
C4 (Long-Time Inverse)	$t_p = TD \cdot \left(\frac{120}{M - 1}\right)$	$t_r = TD \cdot \left(\frac{120}{1 - M}\right)$	*Figure 4.18*
C5 (Short-Time Inverse)	$t_p = TD \cdot \left(\frac{0.05}{M^{0.04} - 1}\right)$	$t_r = TD \cdot \left(\frac{4.85}{1 - M^2}\right)$	*Figure 4.19*

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]

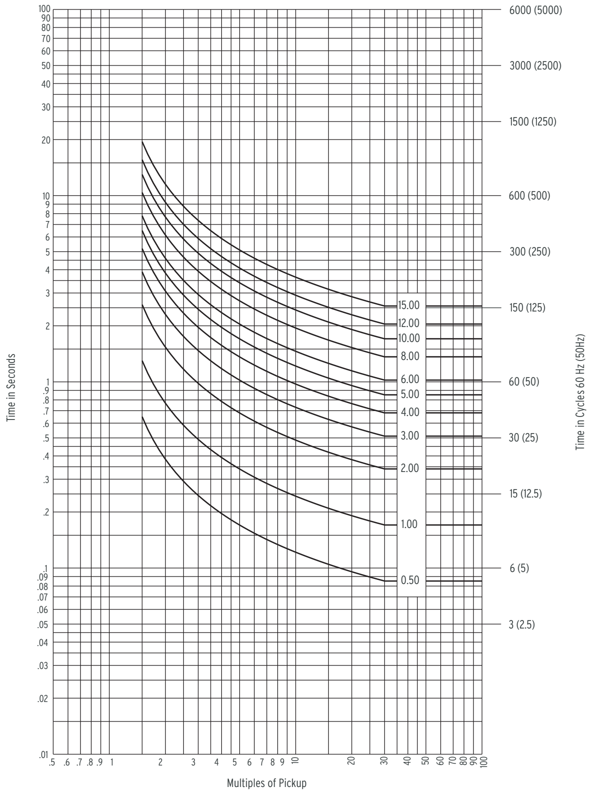


Figure 4.10 U.S. Moderately Inverse Curve: U1

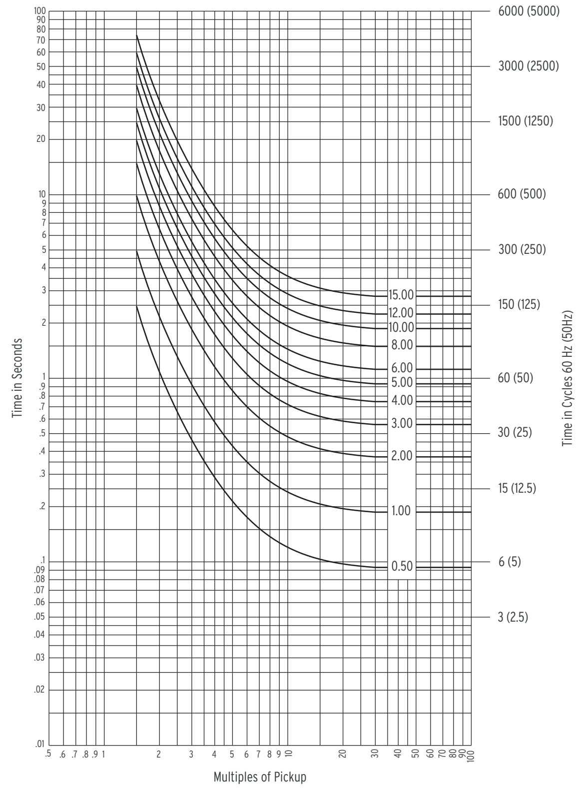


Figure 4.11 U.S. Inverse Curve: U2

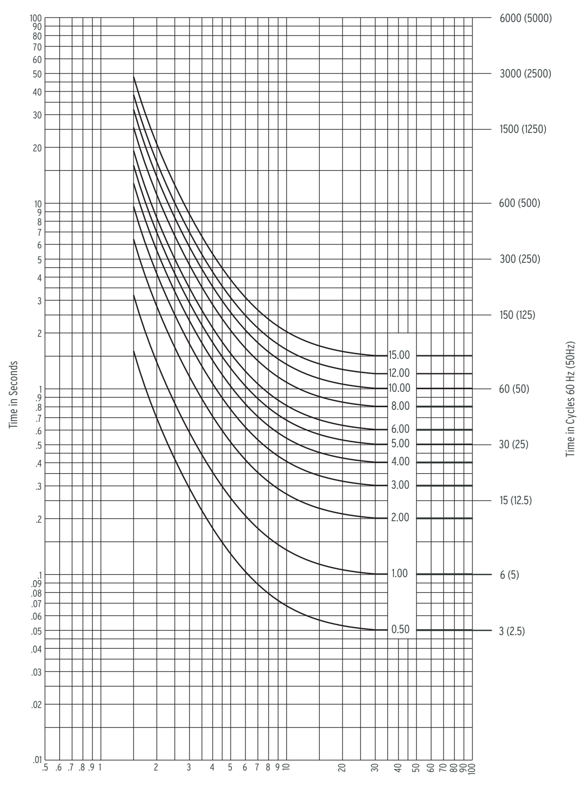


Figure 4.12 U.S. Very Inverse Curve: U3

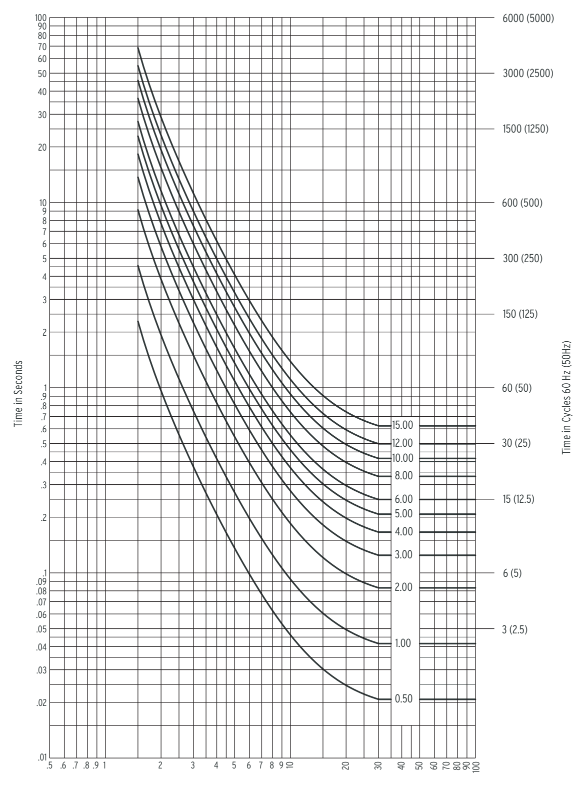


Figure 4.13 U.S. Extremely Inverse Curve: U4

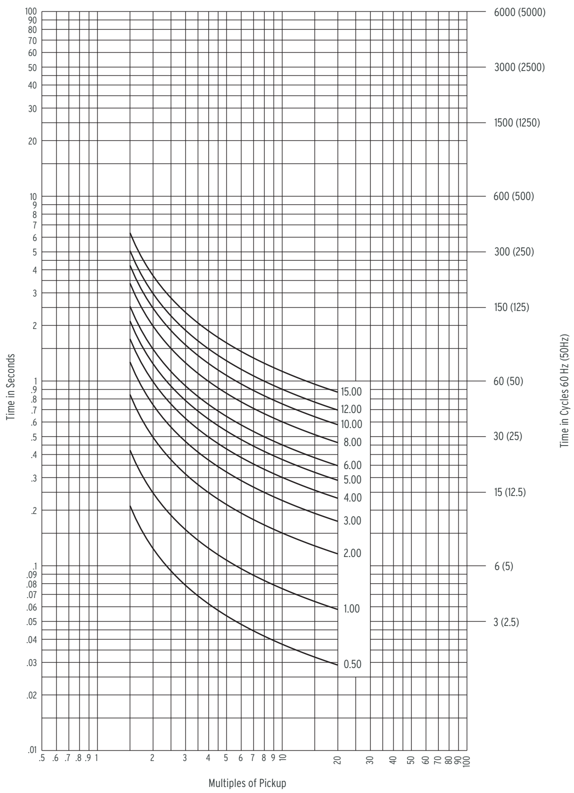


Figure 4.14 U.S. Short-Time Inverse Curve: U5

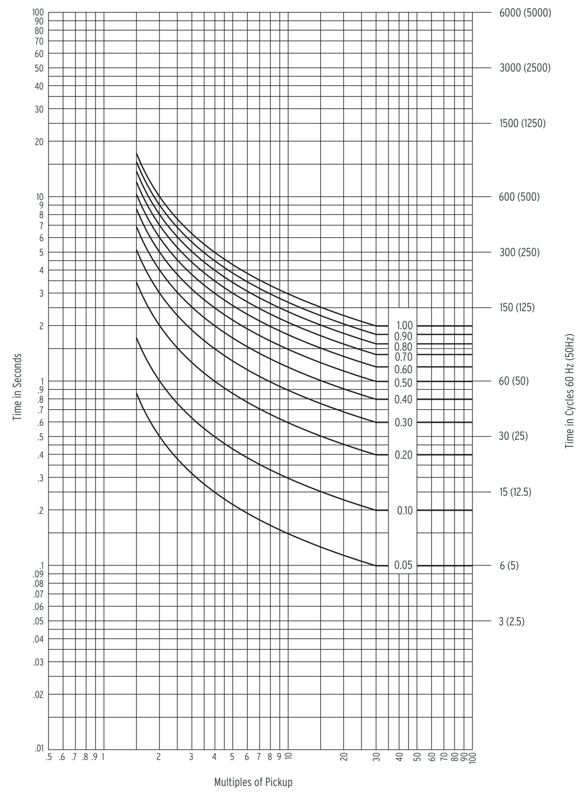


Figure 4.15 IEC Class A Curve (Standard Inverse): C1

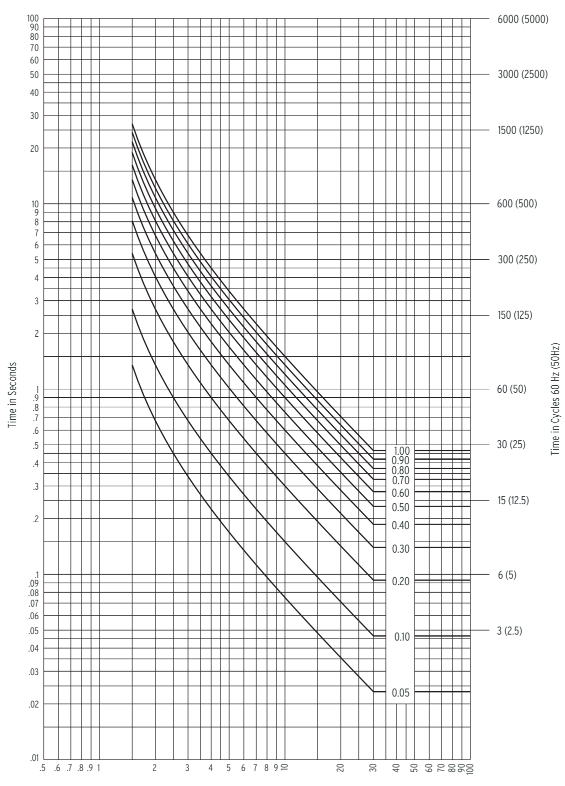


Figure 4.16 IEC Class B Curve (Very Inverse): C2

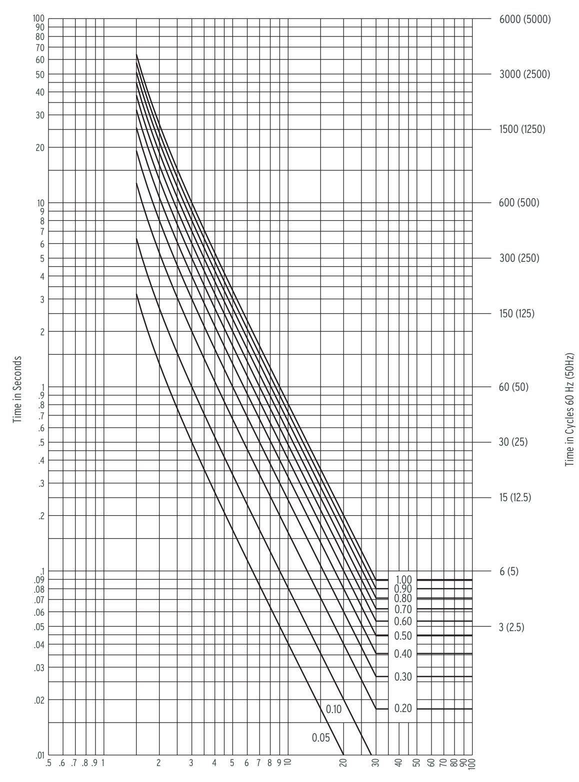


Figure 4.17 IEC Class C Curve (Extremely Inverse): C3

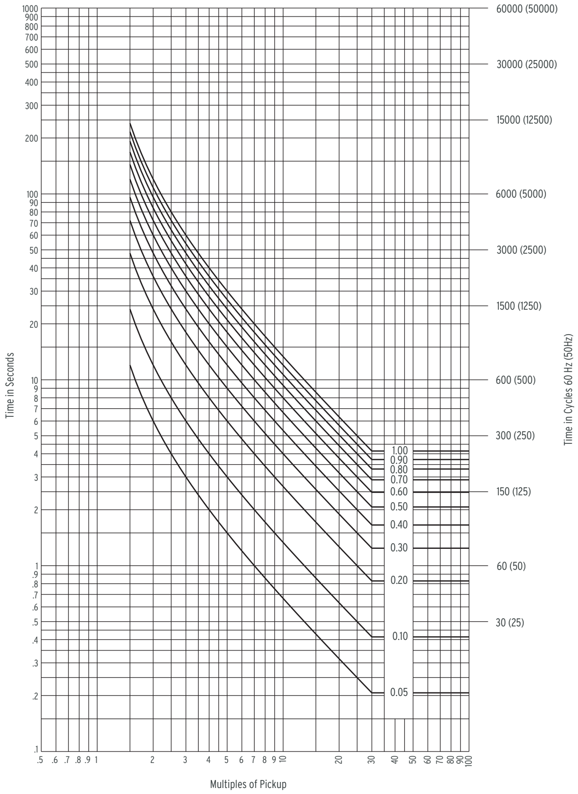


Figure 4.18 IEC Long-Time Inverse Curve: C4

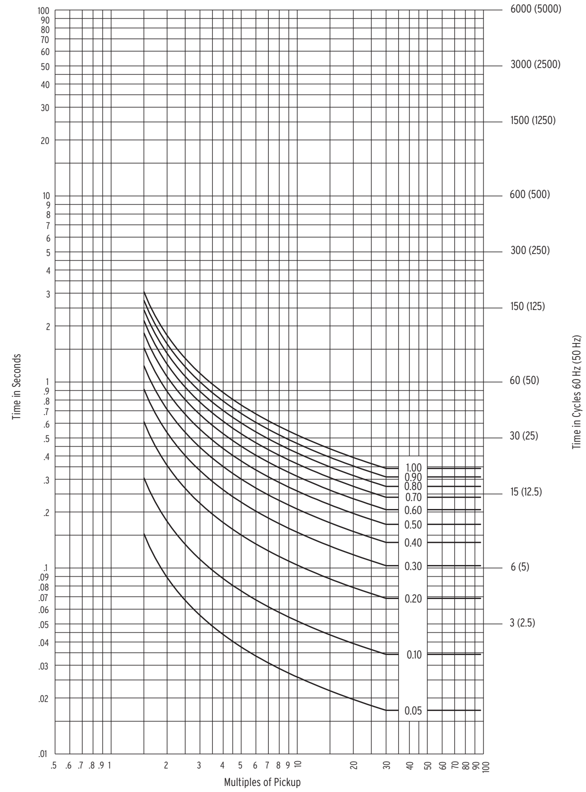


Figure 4.19 IEC Short-Time Inverse Curve: C5

RTD-Based Protection

RTD Input Function

When you connect an SEL-2600 RTD Module (set E49RTD := EXT) or order the internal RTD card (set E49RTD := INT) option, the SEL-751A offers several protection and monitoring functions, settings for which are described in *Table 4.15*. See *Figure 2.13* 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-751A 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 4.15 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 4.15 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 settings.

Define the RTD location settings through use of the following suggestions:

- ➤ If an RTD is not connected to an input or has failed in place and will not be replaced, set the RTD location for that input equal to OFF.
- ➤ For RTDs embedded in 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 are:

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

RTD Trip/Warning Levels

The SEL-751A provides temperature warnings and trips through use of the RTD temperature measurements and the warning and trip temperature settings 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 equals Y. Only one excessive temperature indication is necessary if winding trip voting is not enabled. Bearing trip voting works similarly.

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

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

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

Table 4.16 lists the RTD resistance versus temperature for the four supported RTD types.

Table 4.16 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

The following information applies to relay models with voltage inputs.

Undervoltage Function

Table 4.17 Undervoltage Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
UV TRIP1 LEVEL	OFF, 0.02–1.00 xVnm	27P1P := OFF
UV TRIP1 DELAY	0.0–120.0 sec	27P1D := 0.5
UV TRIP2 LEVEL	OFF, 0.02–1.00 xVnm	27P2P := OFF
UV TRIP2 DELAY	0.0–120.0 sec	27P2D := 5.0
UVS LEVEL 1	OFF, 2.00–300.00 V	27S1P := OFF
UVS DELAY 1	0.0–120.0 sec	27S1D := 0.5
UVS LEVEL 2	OFF, 2.00–300.00 V	27S2P := OFF
UVS DELAY 2	0.0–120.0 sec	27S2D := 0.5

Overvoltage Function

Table 4.18 Overvoltage Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
OV TRIP1 LEVEL	OFF, 0.02–1.20 xVnm	59P1P := 1.10
OV TRIP1 DELAY	0.0–120.0 sec	59P1D := 0.5
OV TRIP2 LEVEL	OFF, 0.02–1.20 xVnm	59P2P := OFF
OV TRIP2 DELAY	0.0–120.0 sec	59P2D := 5.0
ZS OV TRIP1 LVL	OFF, 0.02-1.20 xVnm	59G1P := OFF
ZS OV TRIP1 DLY	0.0-120.0 sec	59G1D := 0.5
ZS OV TRIP2 LVL	OFF, 0.02-1.20 xVnm	59G2P := OFF
ZS OV TRIP2 DLY	0.0-120.0 sec	59G2D := 5.0
NSQ OV TRIP1 LVL	OFF, 0.02-1.20 xVnm	59Q1P := OFF
NSQ OV TRIP1 DLY	0.0-120.0 sec	59Q1D := 0.5
NSQ OV TRIP2 LVL	OFF, 0.02-1.20 xVnm	59Q2P := OFF
NSQ OV TRIP2 DLY	0.0-120.0 sec	59Q2D := 5.0
OVS LEVEL 1	OFF, 2.00–300.00 V	59S1P := OFF
OVS DELAY 1	0.0–120.0 sec	59S1D := 0.5
OVS LEVEL 2	OFF, 2.00–300.00 V	59S2P := OFF
OVS DELAY 2	0.0–120.0 sec	59S2D := 0.5

NOTE: The under- and overvoltage level settings 27P and 59P are in per-unit nominal voltage, Vnm. The relay automatically calculates Vnm, using the settings VNOM and DELTA_Y as follows:
Vnm = VNOM if DELTA_Y := DELTA;
Vnm = VNOM/1.732 if DELTA_Y := WYE.
The level settings 27S and 59S are in secondary voltage.

When you connect the SEL-751A voltage inputs to phase-to-phase connected VTs (single-phase or three-phase), as in *Figure 2.18* or *Figure 2.19*, the relay provides two levels of phase-to-phase overvoltage and undervoltage elements.

When you connect the SEL-751A voltage inputs to phase-to-neutral connected VTs (single-phase or three-phase), as in *Figure 2.18* or *Figure 2.19*, the relay provides two levels of phase-to-neutral overvoltage and undervoltage elements. When a synchronism voltage input is present (e.g., VS input shown in *Figure 2.19*) the SEL-751A 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 4.20* and *Figure 4.21* show the logic diagram for the undervoltage and overvoltage elements, respectively. To disable any of these elements, set the level settings equal to OFF.

NOTE: The under- and overvoltage level settings 27P and 59P are in per-unit nominal voltage, Vnm. The relay automatically calculates Vnm, using the settings VNOM and DELTA_Y as follows:
Vnm = VNOM if DELTA_Y := DELTA;
Vnm = VNOM/1.732 if DELTA_Y := WYE.
The level settings 27S and 59S are in secondary voltage.

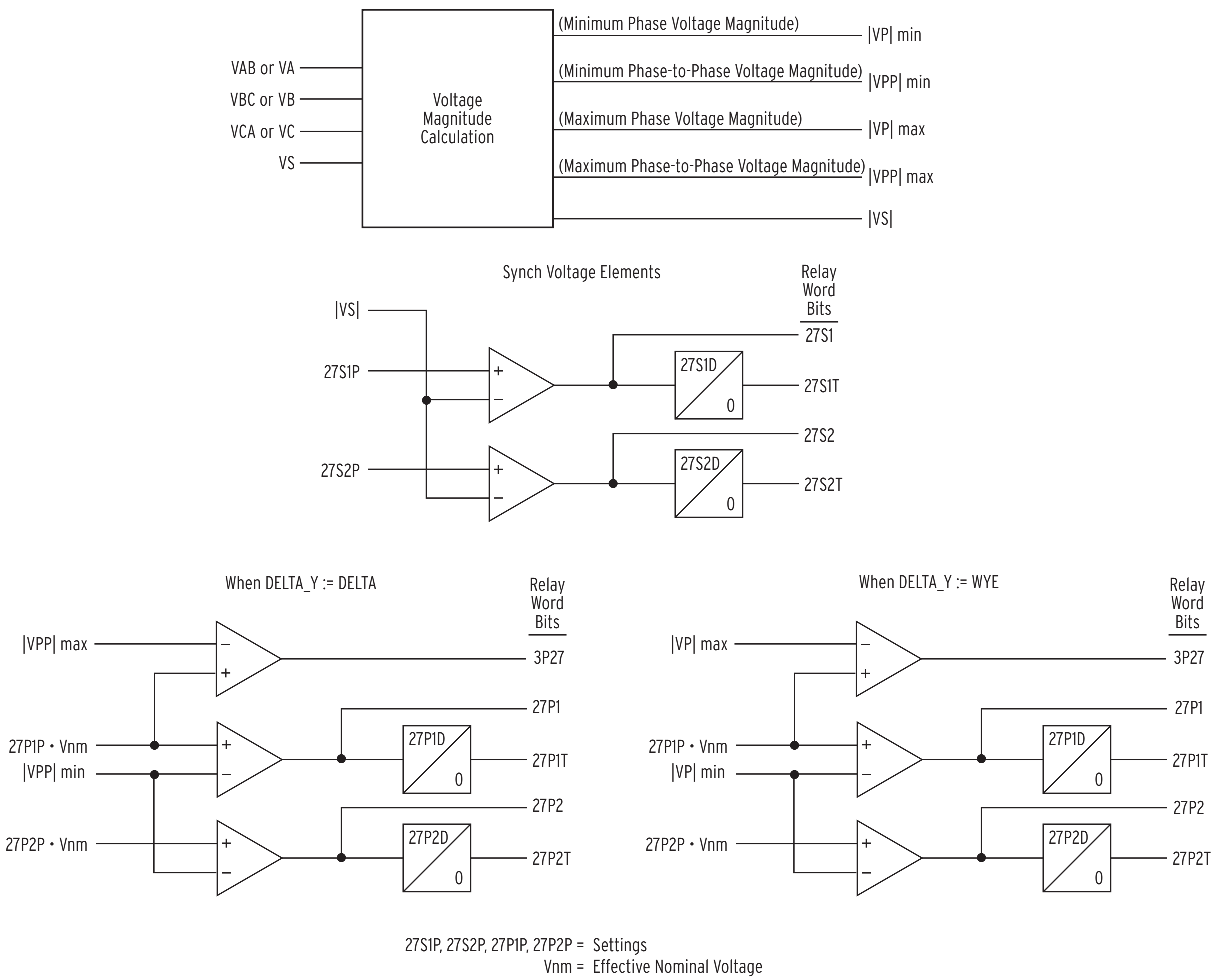


Figure 4.20 Undervoltage Element Logic

NOTE: The under- and overvoltage level settings 27P and 59P are in per-unit nominal voltage, Vnm. The relay automatically calculates Vnm, using the settings VNOM and DELTA_Y as follows:

Vnm = VNOM if DELTA_Y := DELTA;

Vnm = VNOM/1.732 if DELTA_Y := WYE.

The level settings 27S and 59S are in secondary voltage.

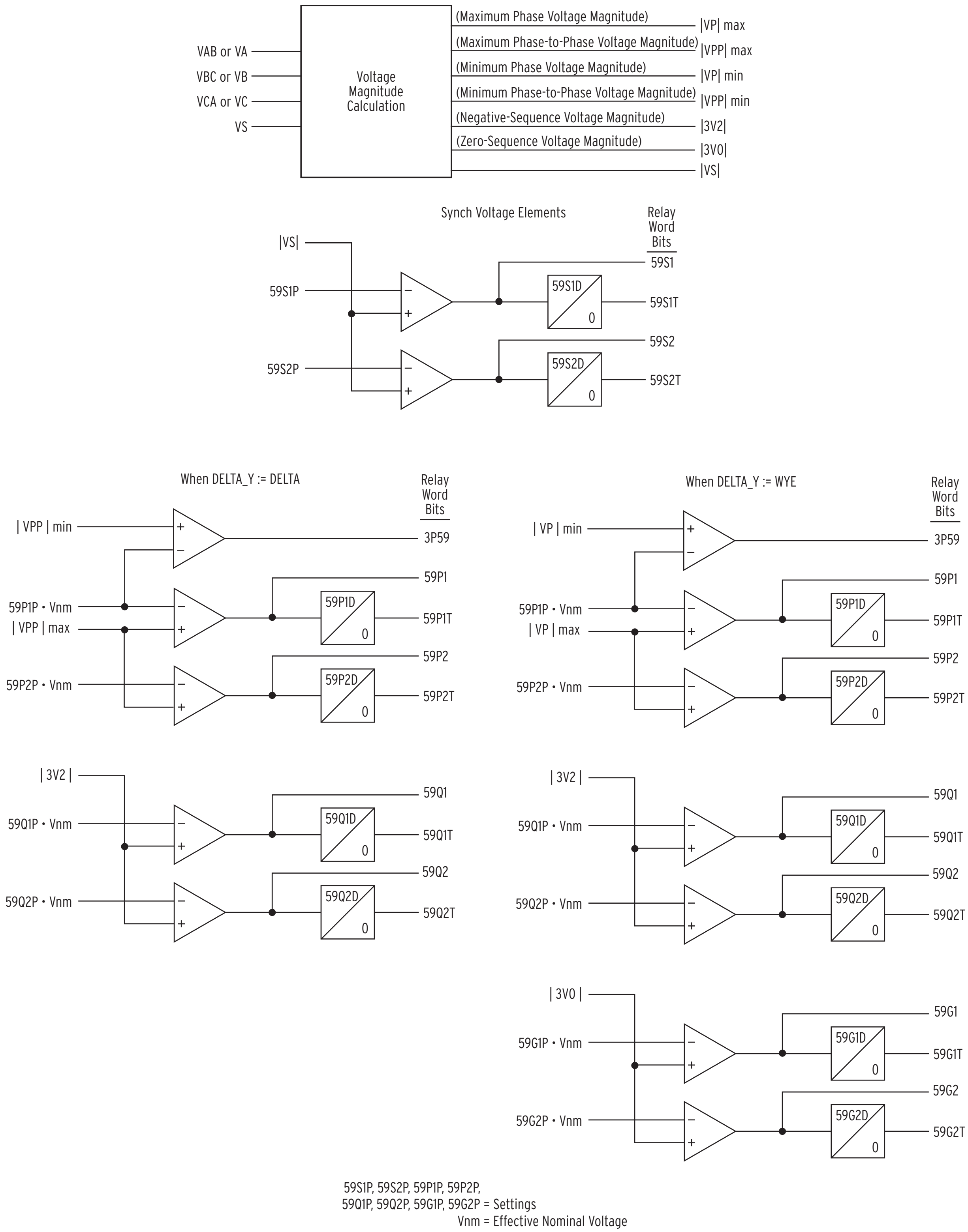


Figure 4.21 Overvoltage Element Logic

Synchronism-Check Elements

Figure 2.21, and *Figure 2.22* 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 ensure healthy voltage), frequency window (FNOM ±5 Hz), and slip frequency settings (see *Figure 4.22* and *Figure 4.23*). 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 4.23*. The relay checks these angle settings for synchronism-check closing.

If the voltages are not static (voltages slipping with respect to one another), the two synchronism-check elements operate as shown in the bottom of *Figure 4.23*. 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.

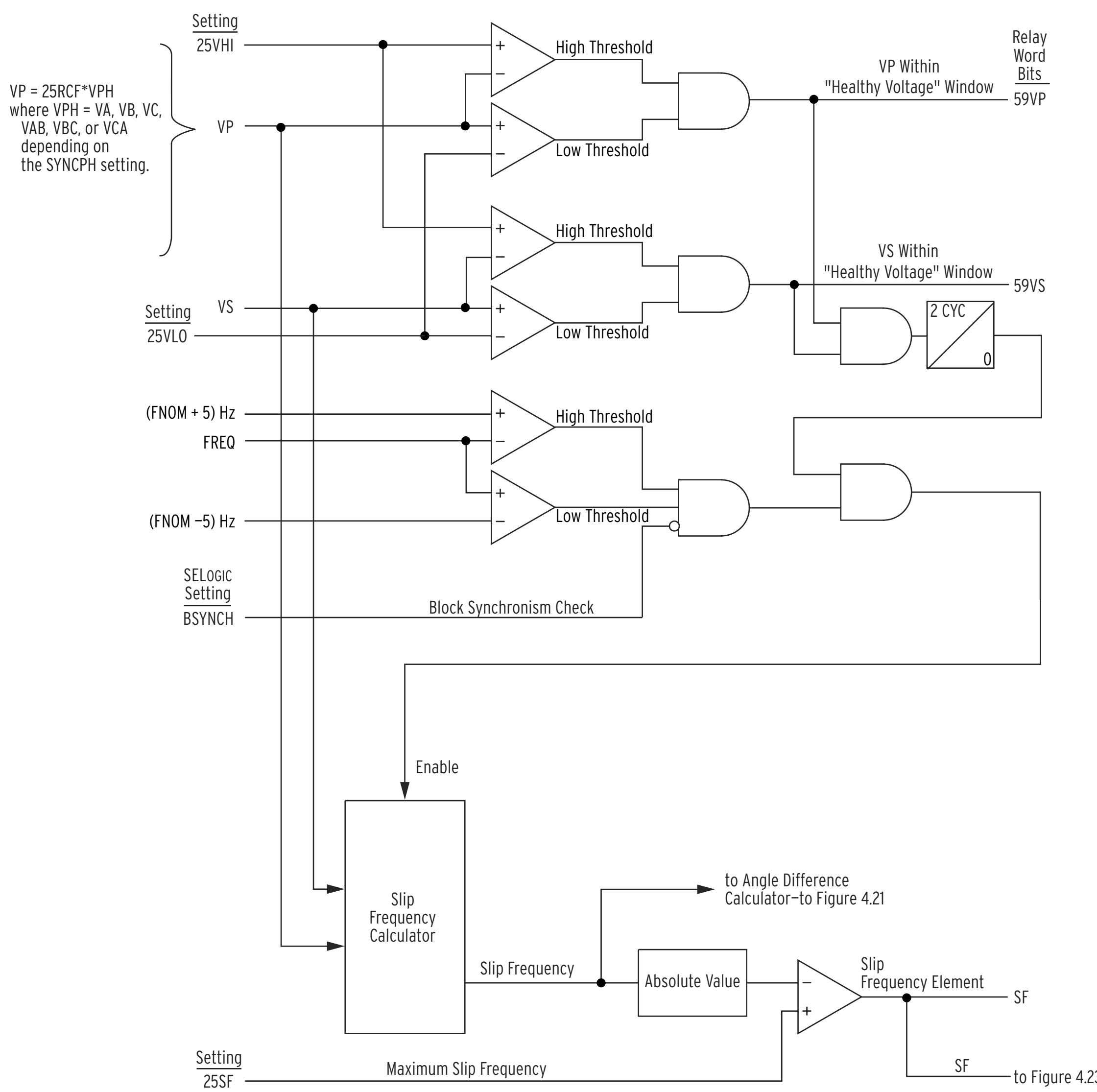
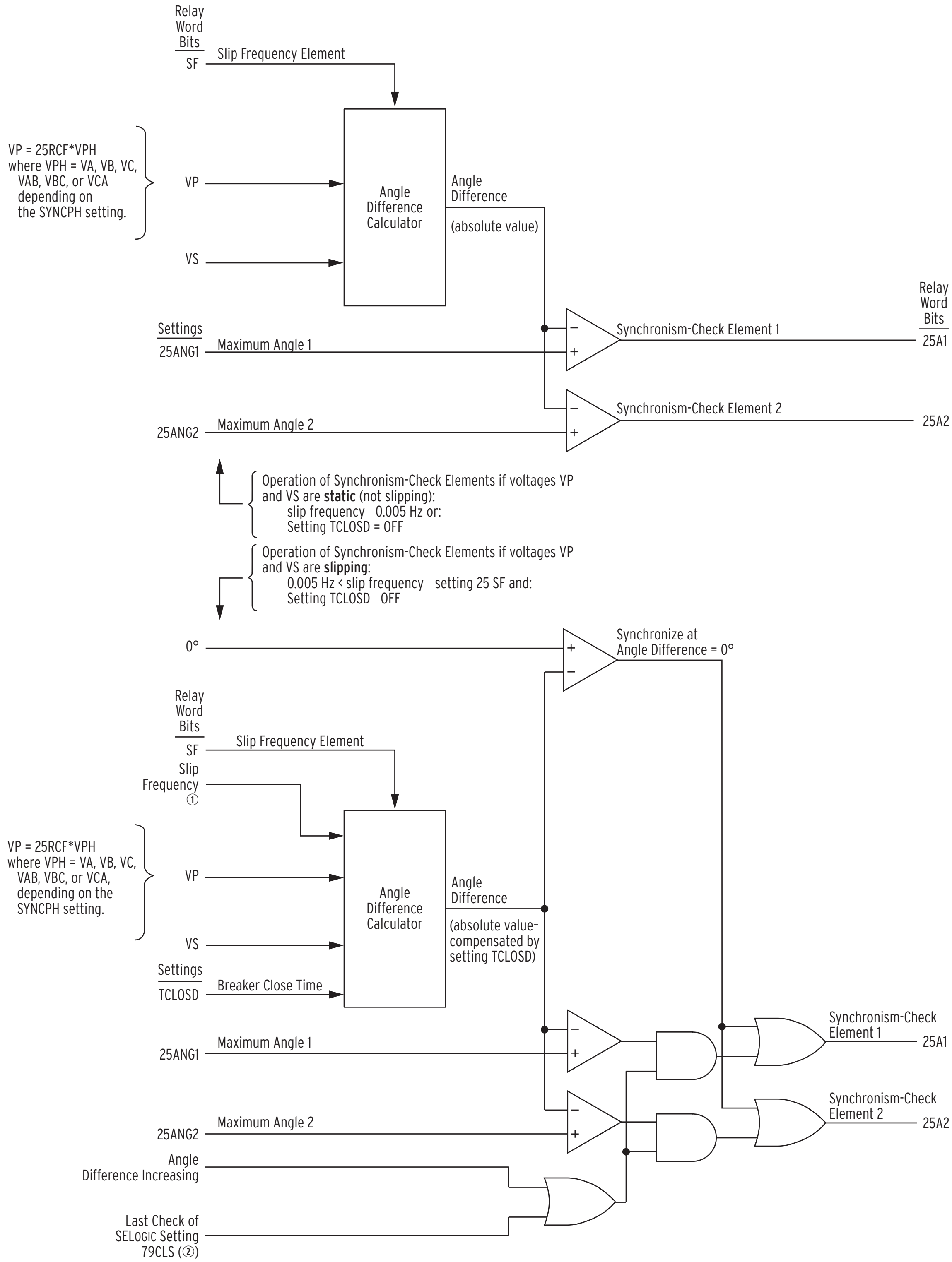


Figure 4.22 Synchronism-Check Voltage Window and Slip Frequency Elements



① From Figure 4.22; ② see Figure 4.35.

Figure 4.23 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 4.19* and *Setting SYNCPH on page 4.27*).

Table 4.19 Synchronism-Check Settings

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

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

Setting SYNCPH

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

Wye-Connected Voltages.

NOTE: Settings SYNCPH := 0 and SYNCPH := VA are effectively the same (voltage VS is directly synchronism checked with voltage VA; VS does not lag VA). The relay will display the setting entered (SYNCPH := VA or SYNCPH := 0)

The angle setting choices (0, 30, …, 300, or 330 degrees) for setting SYNCPH are referenced to VA, and they indicate how many degrees VS constantly lags VA. In this case, voltage input **VA-N** has to be connected and has to meet the "healthy voltage" criteria (settings 25VHI and 25VLO—see *Figure 4.23*). 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

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)

The angle setting choices (0, 30, …, 300, or 330 degrees) for setting SYNCPH are referenced to VAB, and they indicate how many degrees VS constantly lags VAB. In this application, voltage input VA-VB has to be connected and has to meet the "healthy voltage" criteria (settings 25VHI and 25VLO—see *Figure 4.22*). 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 2.21 shows a relay wired with delta-connected phase PTs, and a C-phase-to-ground connected VS-NS input. With ABC rotation, the correct SYNCPH setting for this example is 270 degrees, the amount that VC lags VAB. However, the setting angle is 90 degrees for the ACB phase rotation.

Use the voltage ratio correction factor (setting 25RCF) to compensate magnitude of the phase voltage to match the synchronism voltage VS. Many applications will require 25RCF := 1.00, however some applications may need a different setting. For example, *Figure 2.21* 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-751A) for more information on setting SYNCPH with an angle setting.

Synchronism-Check Elements Voltage Inputs

The two synchronism-check elements are single-phase elements, with single-phase voltage inputs VP and VS used for both elements:

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.)

VS Synchronism-check voltage, from SEL-751A 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 2.21*).

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 4.22* and *Figure 4.23*.

Voltage Window

Refer to *Figure 4.22*. 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 you use them in the synchronism-check logic.

If synchronism check is not being used, Relay Word bits 59VP and 59VS can still be used in other logic, with voltage limit settings 25VLO and 25VHI set as necessary. 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, the synchronism-check logic outputs (Relay Word bits SF, 25A1, and 25A2) do not need to be used.

Block Synchronism-Check Conditions

Refer to *Figure 4.22*. 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 4.34*)

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

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

Slip Frequency Calculator

Refer to *Figure 4.22*. The synchronism-check element Slip Frequency Calculator in *Figure 4.22* 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 a 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 4.22*, 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 relay runs the absolute value of the Slip Frequency output 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 4.23* 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 4.23*. If the slip frequency is less than or equal to 0.005 Hz, the Angle Difference Calculator does *not* take into account breaker close time—it presumes voltages VP and VS are "static" (not "slipping" with respect to one another). This would usually be the case for an open breaker with voltages VP and VS that are paralleled via some other electric path in the power system. The Angle Difference Calculator calculates the angle difference between voltages VP and VS:

Angle Difference = |(∠VP – ∠VS)|

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

Angle Difference = |(∠ VP – ∠ 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 4.23*. 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 4.24*). The Angle Difference Calculator calculates the Angle Difference between voltages VP and VS, compensated with the breaker close time:

Angle Difference = |(∠VP – ∠VS) + [(fP – fS) • TCLOSD • (1 / 1000) • (360°/slip cycle)]|

Angle Difference Example (Voltages VP and VS are "Slipping"). Refer to bottom of *Figure 4.23*. For example, if the breaker close time is 100 ms, set TCLOSD := 100. Presume the slip frequency is the example slip frequency calculated previously. The Angle Difference Calculator calculates the angle difference between voltages VP and VS, compensated with the breaker close time:

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

Intermediate calculations:

$(fP - fS) = (59.95\ \text{Hz} - 60.05\ \text{Hz}) = -0.10\ \text{Hz} = -0.10$ slip cycles/second
$TCLOSD \cdot (1 / 1000) = 0.1$ second

Resulting in:

NOTE: The angle compensation in Figure 4.24 appears much greater than 3.6 degrees. Figure 4.24 is for general illustrative purposes only.

Angle Difference

$= |(\angle VP - \angle VS) + [(fP - fS) \cdot TCLOSD \cdot (1 / 1000) \cdot (360°/\text{slip cycle})]|$
$= |(\angle VP - \angle VS) + [-0.10 \cdot 0.1 \cdot 360°]|$
$= |(\angle VP - \angle VS) - 3.6°|$

During the breaker close time (TCLOSD), the voltage angle difference between voltages VP and VS changes by 3.6 degrees. The relay applies this angle compensation to voltage VS, resulting in derived voltage VS*, as shown in *Figure 4.24*.

The top of *Figure 4.24* 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 4.24* 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.

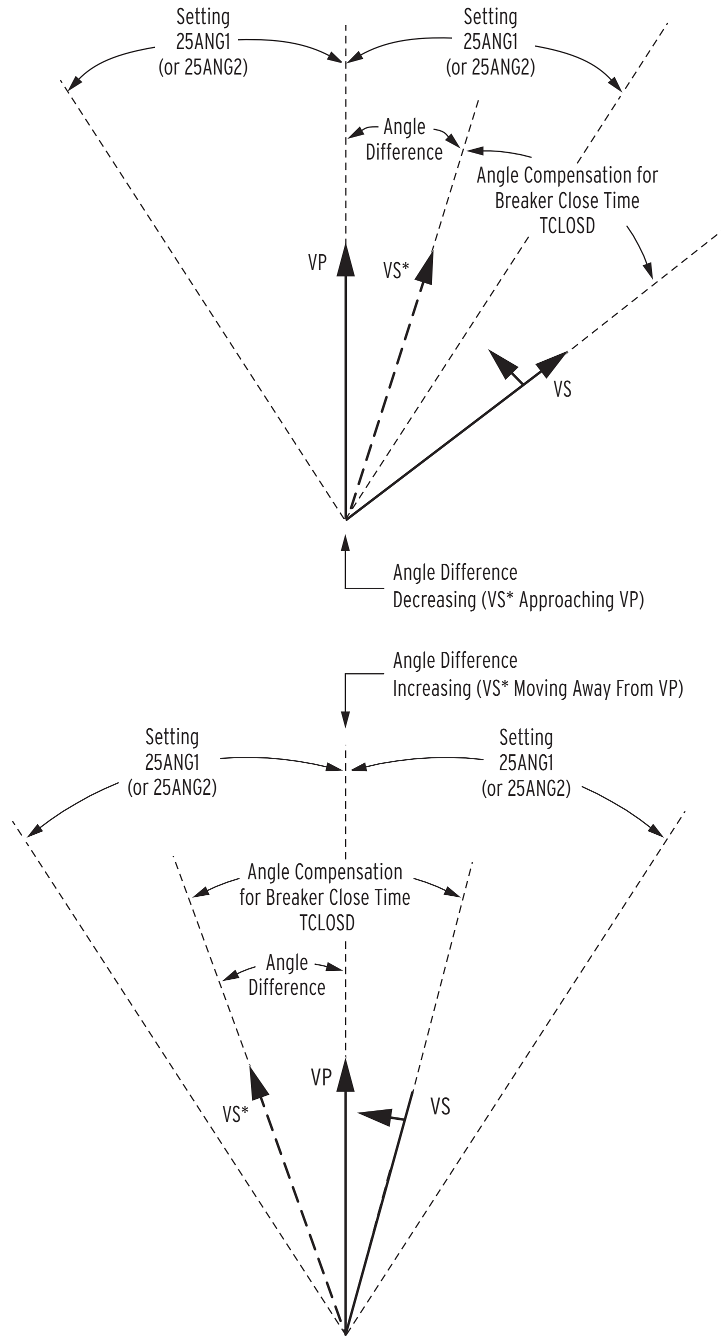


Figure 4.24 Angle Difference Between VP and VS Compensated by Breaker Close Time (fP < fS and VP Shown as Reference in This Example)

Synchronism-Check Element Outputs

Synchronism-check element outputs (Relay Word bits 25A1 and 25A2 in *Figure 4.23*) 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 SEL-751A performs the synchronism check as the top of *Figure 4.23* describes.

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 4.23*. 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 4.24* 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 4.24* 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 4.48*.

   Refer to the bottom of *Figure 4.35*. 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 4.36*).

   Refer to the top of *Figure 4.35*. If timer 79CLSD is set to zero (79CLSD := 0.00), the relay checks SELOGIC control equation setting 79CLS (Reclose Supervision) 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 4.24*. 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. 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 4.23* 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 4.34*. Element 25A2 operates similarly.

Synchronism-Check Applications for Automatic Reclosing and Manual Closing

Refer to *Trip/Close Logic on page 4.45* and *Reclose Supervision Logic on page 4.48*.

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 4.35)

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 4.34)

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 4.34*) logic output).

Power Elements

You can enable as many as two independent three-phase power elements in the SEL-751A relay. Each enabled element can be set to detect real power or reactive power. When voltage inputs to the relay are from delta connected PTs or when you use a single voltage input, the relay cannot account for unbalance in the voltages in calculating the power. Take this into consideration in applying the power elements.

With SELOGIC control equations, the power elements provide a wide variety of protection and control applications. Typical applications are:

- Overpower and/or underpower protection/control
- Reverse power protection/control
- VAR control for capacitor banks

Table 4.20 Power Element Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PWR ELEM	N, 3P1, 3P2	EPWR := N
3PH PWR ELEM PU	OFF, 1.0–6500.0 VA[a] (secondary)	3PWR1P := OFF
PWR ELEM TYPE	+WATTS, –WATTS, +VARS, –VARS	PWR1T := +VARS
PWR ELEM DELAY	0.0–240.0 s	PWR1D := 0.0
3PH PWR ELEM PU	OFF, 1.0–6500.0 VA[a] (secondary)	3PWR2P := OFF
PWR ELEM TYPE	+WATTS, –WATTS, +VARS, –VARS	PWR2T := +VARS
PWR ELEM DELAY	0.0–240.0 s	PWR2D := 0.0

[a] The range shown is for 5 A input; range for 1 A input is OFF, 0.2–1300.0 VA.

EPWR := 3P1 enables one three-phase power element. Set EPWR := 3P2 if you want to use both elements.

Set the element pickup, 3PH PWR ELEM PU, to the values you want. *Figure 4.25* shows the power element logic diagram and *Figure 4.26* shows the operation in the Real/Reactive power plane.

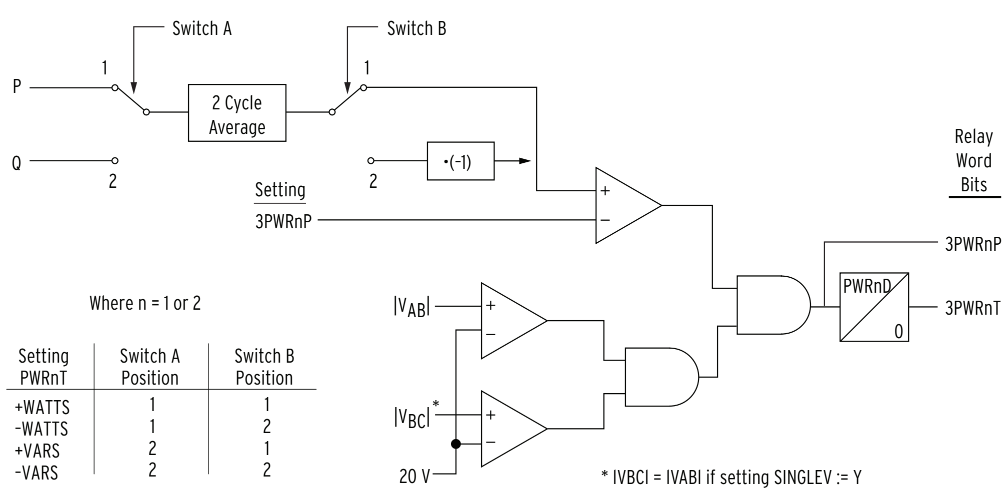


Figure 4.25 Three-Phase Power Elements Logic

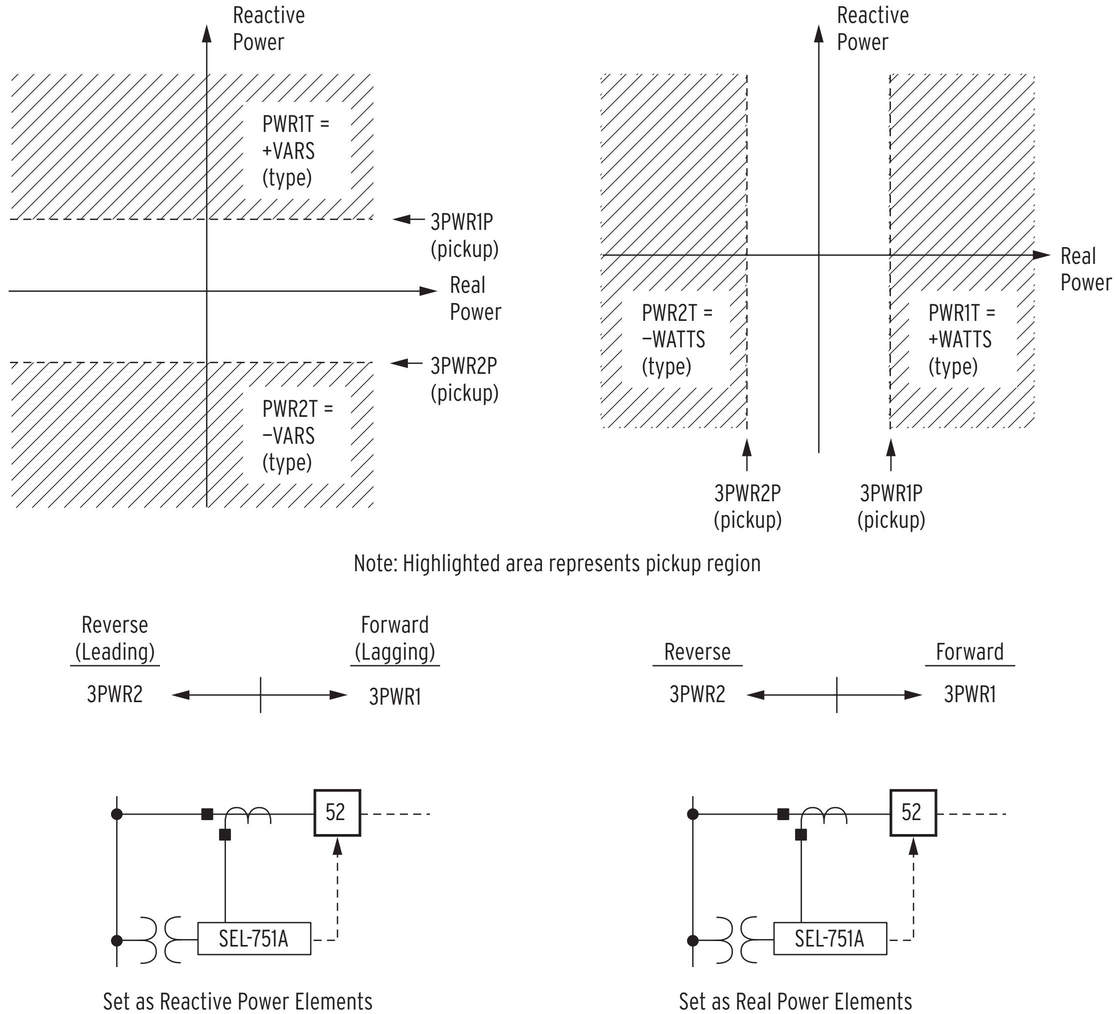


Figure 4.26 Power Elements Operation in the Real/Reactive Power Plane

The power element type settings are made in reference to the load convention:

- +WATTS: positive or forward real power
- –WATTS: negative or reverse real power
- +VARS: positive or forward reactive power
- –VARS: negative or reverse reactive power

You can set the two power element time delay settings (PWR1D and PWR2D) 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 can 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 4.25*. If the protection application requires overcurrent protection in addition to the power elements, there can 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.

Power Factor Elements

Table 4.21 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 4.27* 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.

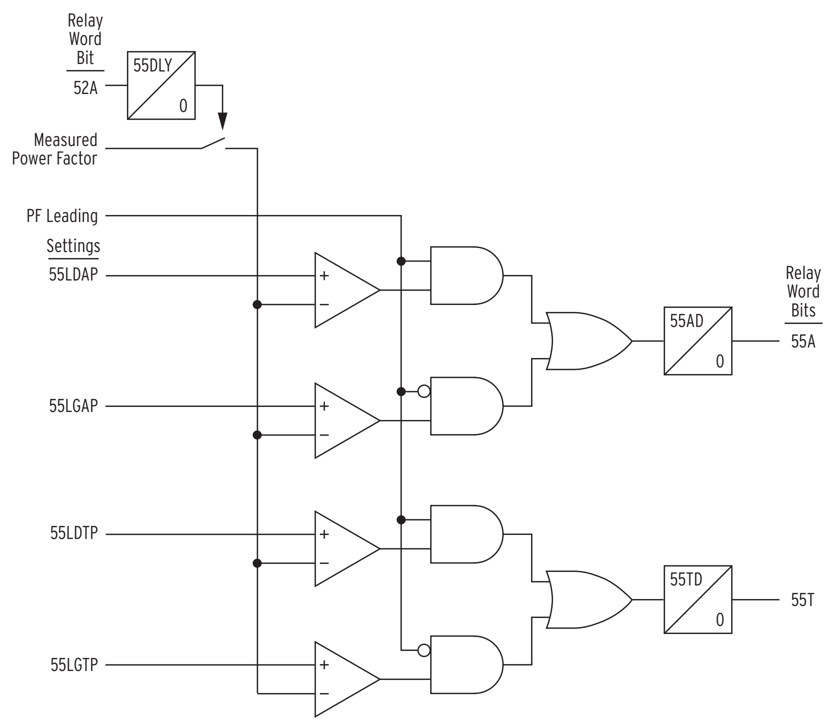


Figure 4.27 Power Factor Elements Logic

Loss-of-Potential (LOP) Protection

The SEL-751A 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 25 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 • VNOM/1.73 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 4.4*).

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 4.4*). 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 4.4 Supervising Voltage-Element Tripping With LOP

The factory-default setting supervises undervoltage trip by the LOP as follows:

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.

LOP Monitoring and Alarms

You should take steps to immediately correct an LOP problem so that normal protection is rapidly reestablished. 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.

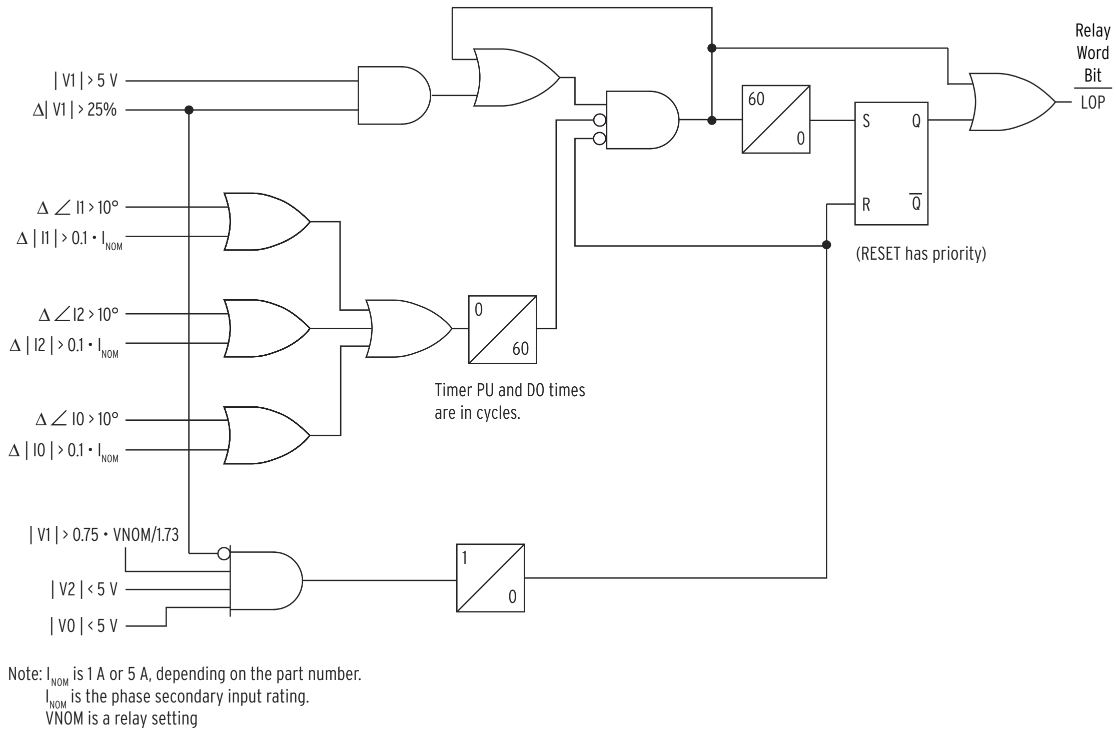


Figure 4.28 Loss-of-Potential (LOP) Logic

Frequency Protection

Frequency Elements

Table 4.22 Frequency Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
FREQ1 TRIP LEVEL	OFF, 20.00–70.00 Hz	81D1TP := OFF
FREQ1 TRIP DELAY[a]	0.00–240.00 sec	81D1TD := 1.00
FREQ2 TRIP LEVEL	OFF, 20.00–70.00 Hz	81D2TP := OFF
FREQ2 TRIP DELAY[a]	0.00–240.00 sec	81D2TD := 1.00
FREQ3 TRIP LEVEL	OFF, 20.00–70.00 Hz	81D3TP := OFF
FREQ3 TRIP DELAY[a]	0.00–240.00 sec	81D3TD := 1.00
FREQ4 TRIP LEVEL	OFF, 20.00–70.00 Hz	81D4TP := OFF
FREQ4 TRIP DELAY[a]	0.00–240.00 sec	81D4TD := 1.00
FREQ5 TRIP LEVEL	OFF, 20.00–70.00 Hz	81D5TP := OFF
FREQ5 TRIP DELAY[a]	0.00–240.00 sec	81D5TD := 1.00
FREQ6 TRIP LEVEL	OFF, 20.00–70.00 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 option is present and the applied positive-sequence voltage is greater than 10 volts for at least three cycles. 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 less than the minimum level.

The SEL-751A 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 4.29* shows the logic diagram for the frequency elements.

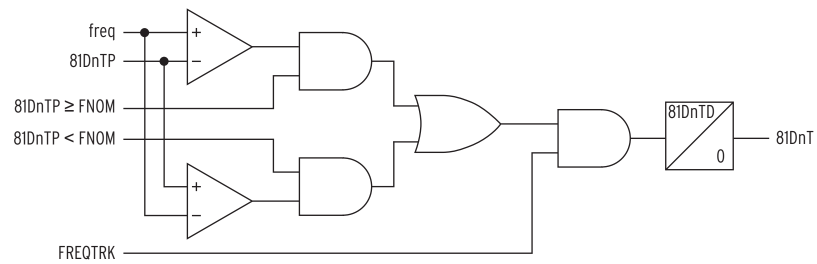


Figure 4.29 Over- and Underfrequency Element Logic

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 can 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-751A provides four rate-of-change-of-frequency elements. *Table 4.23* shows the settings available for the elements.

Table 4.23 Rate-of-Change-of-Frequency Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE 81R	OFF, 1–4	E81R := OFF
81R VOLTAGE SUP	OFF, 0.1–1.3*Vnm[a]	81RVSUP := 0.1*Vnm
81R CURRENT SUP	OFF, 0.1–2.0*I_{NOM}[b]	81RISUP := OFF
81R1 TRIP LEVEL	OFF, 0.10–15.00	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	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	81R3TP := OFF

Table 4.23 Rate-of-Change-of-Frequency Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
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	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] See Note on page 4.22 for explanation of Vnm.
[b] I_{NOM} is nominal rating of the phase CTs (1A or 5A).

Use the E81R setting to enable the number of elements you need, *Figure 4.30* shows the element logic. The SEL-751A 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 4.24* shows the time windows for different trip level settings.

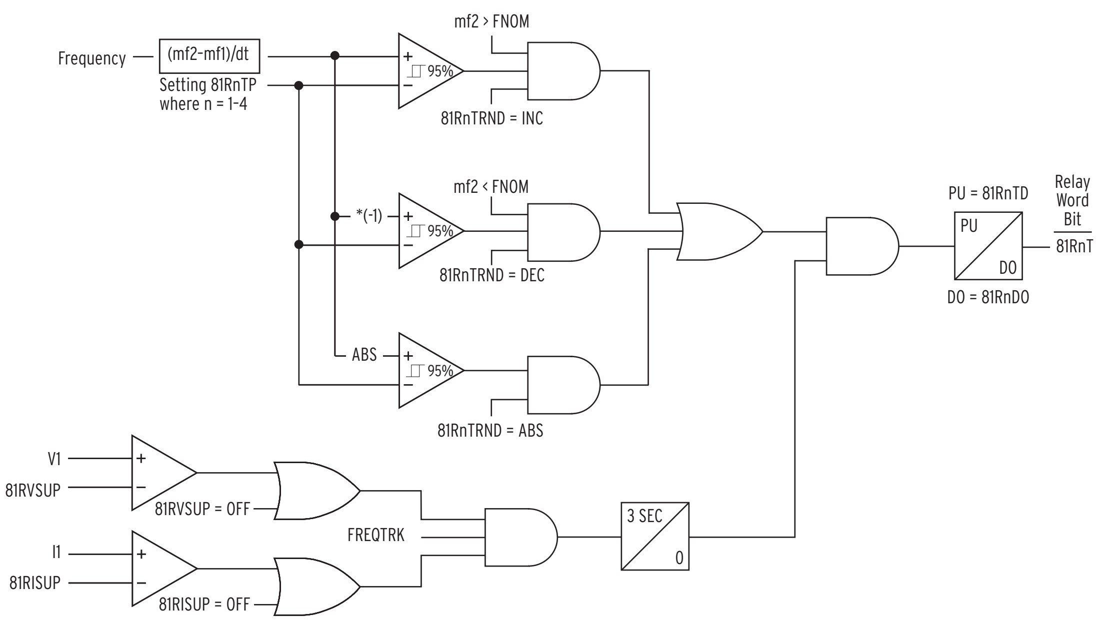


Figure 4.30 81R Frequency Rate-of-Change Scheme Logic

Table 4.24 Time Window Versus 81RnTP Setting (Sheet 1 of 2)

81RnTP Setting (Hz/sec)	Time Window (Cycles)
15.00–2.33	3
2.32–1.17	6
1.16–0.78	9
0.77–0.58	12
0.57–0.47	15
0.46–0.38	18
0.37–0.33	21

Table 4.24 Time Window Versus 81RnTP Setting (Sheet 2 of 2)

81RnTP Setting (Hz/sec)	Time Window (Cycles)
0.32–0.29	24
0.28–0.26	27
< 0.25	30

Set 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 receives supervision from 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 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 set 81RVSUP := OFF if no voltage supervision is necessary. In any case, the element receives supervision from Relay Word FREQTRK, which ensures that the relay is tracking and measuring the system frequency.

Use the Relay Word bit 81RnT to operate output contacts to open appropriate breaker(s) according to your load-shedding scheme requirements.

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 4.31*) based on frequency deviation from nominal frequency (DF = FREQ – FNOM) and rate-of-change of frequency (DF3C) to detect islanding conditions. The SEL-751A 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 acceleration or deceleration of the islanded system, the operating point enters Trip Region 1 or Trip Region 2 of the characteristic. 81RFDFP in Hz and 81RFRP in Hz/s are the settings used to configure the characteristic (see *Table 4.25*).

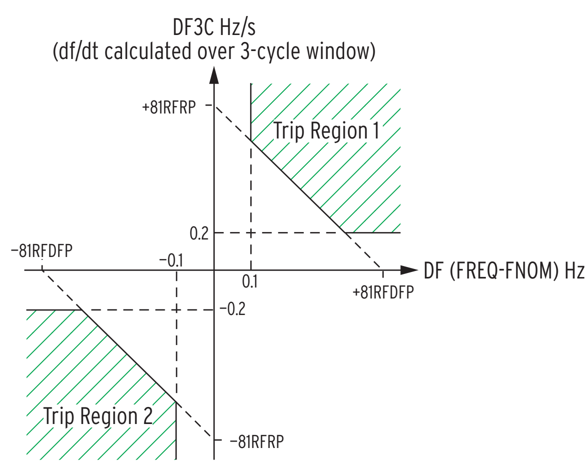


Figure 4.31 81RF Characteristics

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-751A Relay*, also available on the SEL website.

Table 4.25 Fast Rate-of-Change-of-Frequency Settings

Setting Prompt	Range	Setting Name := Factory Default
ENABLE 81RF	Y, N	E81RF := N
FREQDIF SETPOINT	0.1–10.0 Hz	81RFDFP := 1.0
DFDT SETPOINT	0.2–15.0 Hz/sec	81RFRP := 2.5
81RF PU DELAY	0.10–1.00 sec	81RFPU := 0.10
81RF DO DELAY	0.00–1.00 sec	81RFDO := 0.10
81RF VOLTAGE BLK	OFF, 2–300 V[a] OFF, 2–520 V[b]	81RFVBLK := OFF 81RFVBLK := OFF
81RF CURRENT BLK	OFF, 0.1–20 A • INOM	81RFIBLK := 10 • INOM
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 4.32 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. When 81RFVBLK := OFF, the undervoltage blocking scheme is disabled. Similarly, when 81RFIBLK := OFF, the overcurrent blocking scheme is disabled. You can use the 81RFBL SELOGIC control equation to include additional blocking elements. Relay Word bit 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.

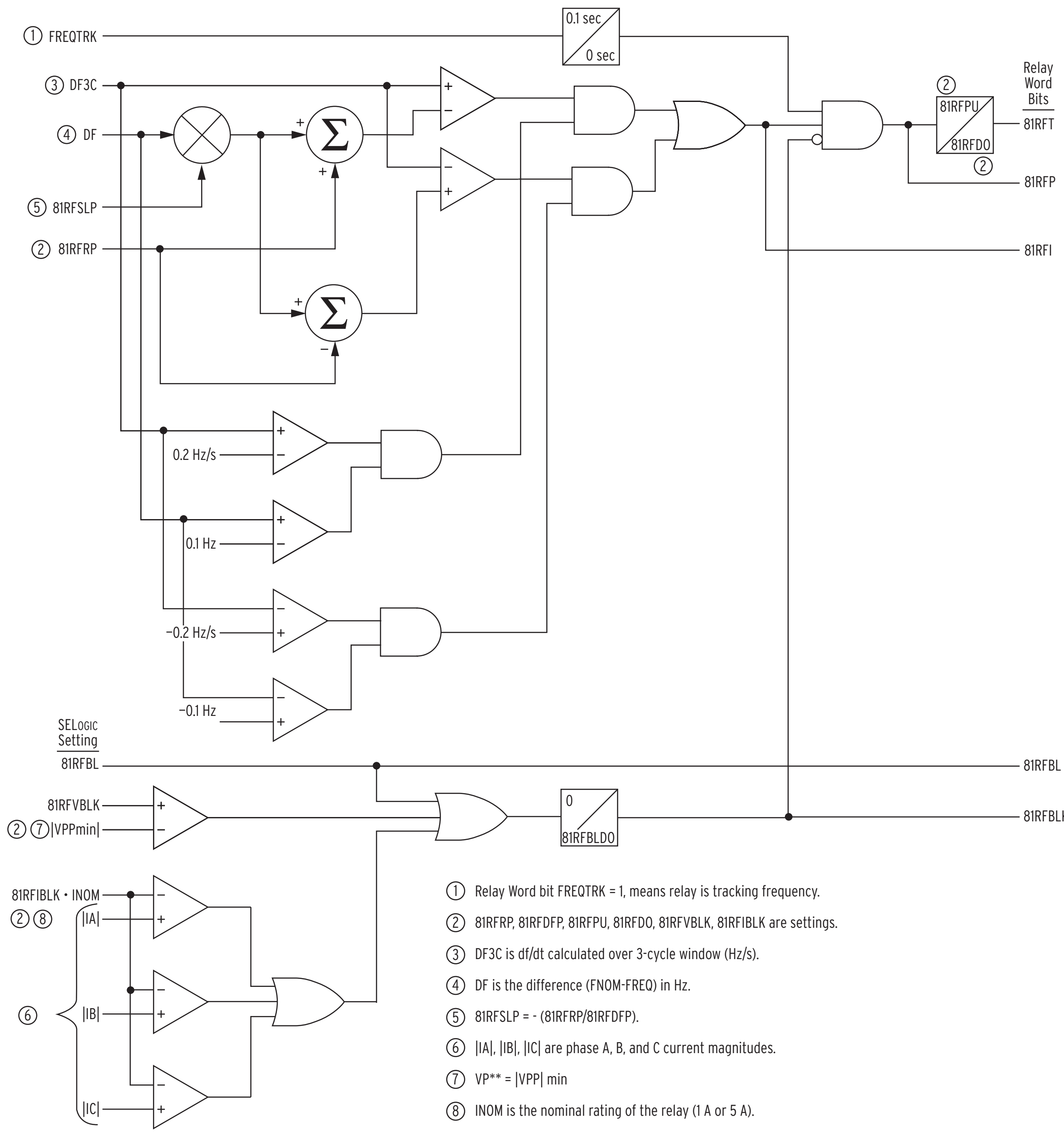


Figure 4.32 81RF Fast Rate-of-Change-of-Frequency Logic

Trip/Close Logic

Trip/Close Logic Settings

Table 4.26 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 81D1T OR 81D2T OR 81D3T OR 81D4T OR 59P1T OR 59P2T OR 55T OR REMTRIP OR SV01 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 4.39 for the output contacts settings.

The SEL-751A 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 4.33* illustrates the tripping logic.

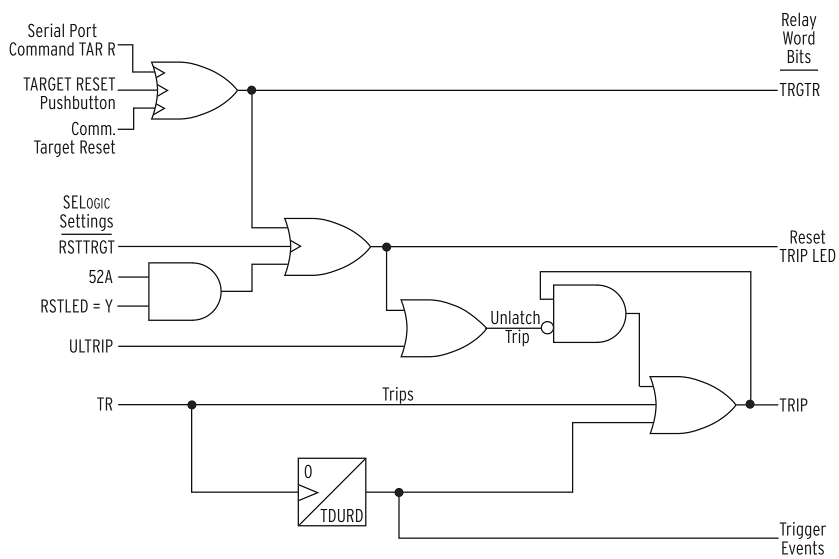


Figure 4.33 Trip Logic

The trip logic settings, including the SELOGIC control equations, are described in the following paragraphs.

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-751A 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 4.26* 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 2.22*).

NOTE: You can use an indirect mapping (e.g., SV01) as in the factory-default setting. See Table 4.36 for the SV01 settings.

Set the TR SELOGIC control equation to include an OR combination of all the Relay Word bits for which you want 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).

NOTE: The close logic is inoperative if 52A is set to 0 in SEL-751A models with reclosing option.

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.

Figure 4.34 shows the breaker close logic.

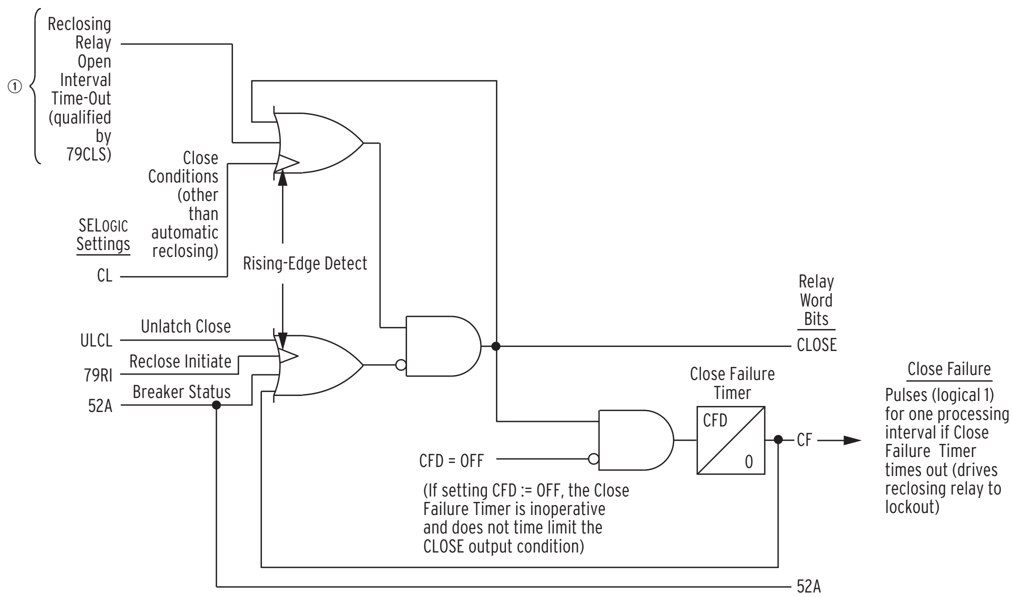


Figure 4.34 Close Logic

CL Close SELOGIC Control Equation

The SEL-751A 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 4.35*).

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 2.21* for typical close circuit connection.

Set the CL SELOGIC control equation to include an OR-combination of all Relay Word bits for which you want the relay to close the 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

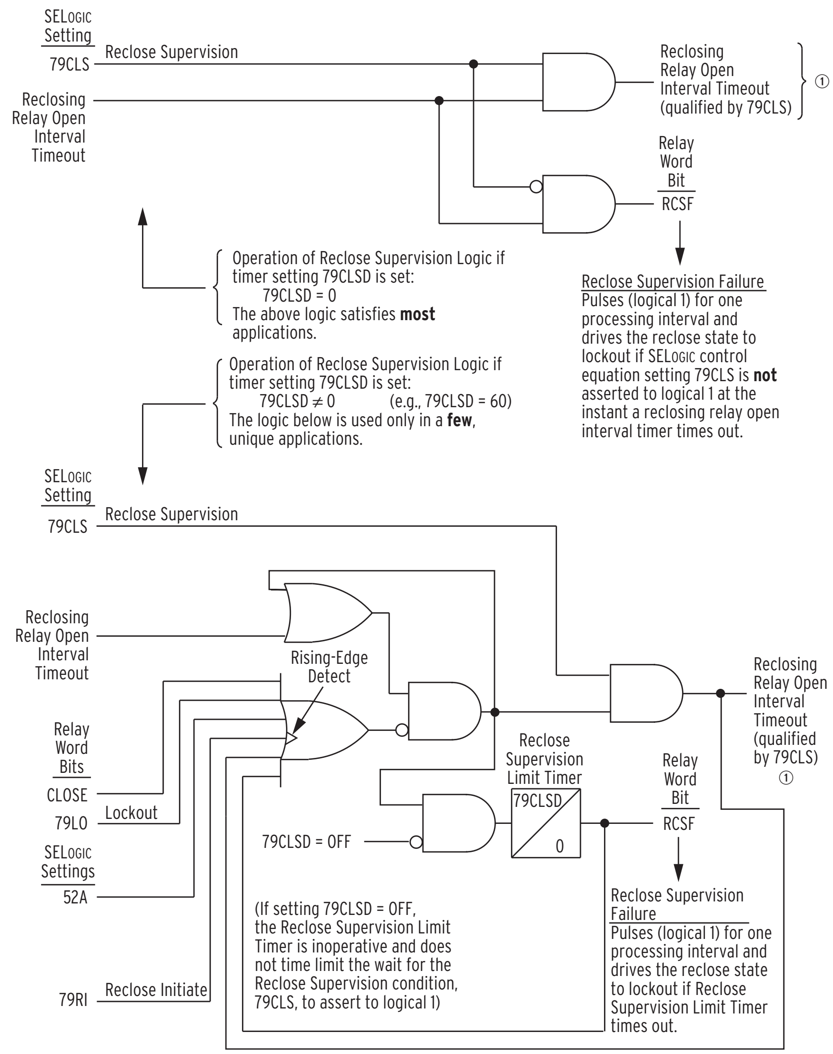
Set the close failure delay (setting CFD) equal to highest breaker close time plus a safety margin. If the breaker fails to close, the Relay Word CF will assert for 1/4 cycle. Use the CF bit as necessary.

Reclose Supervision Logic

Note that one of the inputs into the close logic in *Figure 4.34* is:

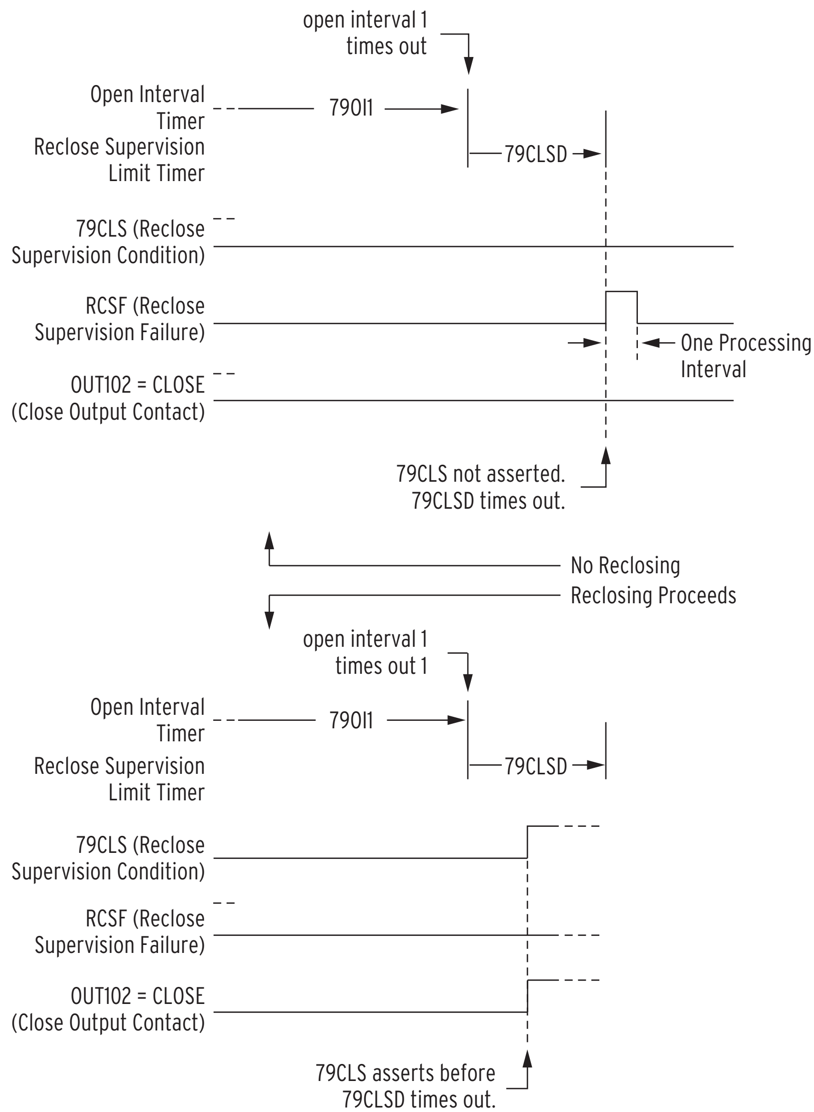
Reclosing Relay Open Interval Time-Out (qualified by 79CLS)

This input is the indication that a reclosing relay open interval has timed out (see *Figure 4.36*), 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 4.34* is an output of the reclose supervision logic in the following *Figure 4.35*.



① To Figure 4.34

Figure 4.35 Reclose Supervision Logic (Following Open Interval Time-Out)



(Refer to Bottom of Figure 4.35)

Figure 4.36 Reclose Supervision Limit Timer Operation

Settings and General Operation

Figure 4.35 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 4.28* for Recloser Control settings.

For Most Applications (Top of Figure 4.35)

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 4.35* is operative. When an open interval times out, the relay checks the SELOGIC control equation reclose supervision setting 79CLS *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 4.35* 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 *Settings Example 1 on page 4.52*.

For a Few, Unique Applications (Bottom of Figure 4.35 and Figure 4.36)

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 4.35* 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 4.34* 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 4.35* is explained in more detail in the following text.

Set Reclose Supervision Logic (Bottom of Figure 4.35)

Refer to the bottom of *Figure 4.35*. If *all* the following are true:

- ➤ The close logic output CLOSE (also see *Figure 4.34*) 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 4.35*. Then, when 79CLS asserts to logical 1, the sealed-in reclosing relay open interval time-out condition will propagate through *Figure 4.29* and on to the close logic in *Figure 4.34*.

Unlatch Reclose Supervision Logic (Bottom of Figure 4.35)

Refer to the bottom of *Figure 4.29*. 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 4.35*) 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, the relay checks reclose supervision condition 79CLS indefinitely until one of the other previously listed unlatch conditions 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 4.34*.

See *Settings Example 2 on page 4.53*.

EXAMPLE 4.5 Settings Example 1

Refer to the top of Figure 4.35 and Figure 4.37.

SEL-751A 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-751A(1) recloses circuit breaker 52/1 first, followed by the SEL-751A(2) reclosing circuit breaker 52/2, after a synchronism check across circuit breaker 52/2.

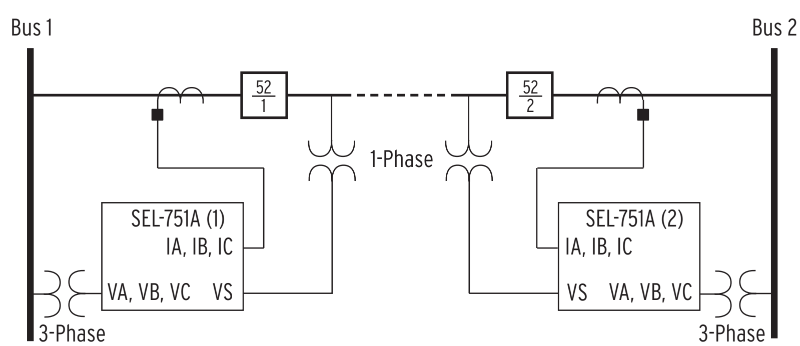


Figure 4.37 SEL-751A Relays Installed at Both Ends of a Transmission Line in a High-Speed Reclose Scheme

SEL-751A(1) Relay

Before allowing circuit breaker 52/1 to be reclosed after an open interval time-out, the SEL-751A(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-751A(2) Relay

The SEL-751A(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-751A(1) and SEL-751A(2) Relays

Refer to *Skip Shot and Stall Open Interval Timing Settings (79SKP and 79STL, Respectively) on page 4.63*.

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-751A(1) has no intentional open interval timing stall condition (circuit breaker 52/1 closes first after a transmission line fault):

79STL := **0**

The SEL-751A(2) starts open interval timing after circuit breaker 52/1 at the remote end has reenergized the line. The SEL-751A(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-751A(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-751A(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-751A(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-751A(2) (see *Figure 4.34*). Note the built-in 2-cycle qualification of the synchronism-check voltages shown in *Figure 4.22*.

EXAMPLE 4.6 Settings Example 2

Refer to subsection Synchronism-Check Elements on page R.4.25. Also refer to Figure 4.36 and Figure 4.37.

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 relay checks the status of synchronism-check element 25A1 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 previously referenced subsection, note item 3 under Synchronism-Check Element Outputs on page R.4.32, 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 4.35* is the logic input that is qualified by SELOGIC control equation setting 79CLS, and then propagated on to the close logic in *Figure 4.34* 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 4.35*. 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 OFF, 1, 2, 3, and 4. Setting E79 = OFF defeats the reclosing relay. Setting choices 1 through 4 are the number of automatic reclosures you want (see *Open Interval Timers on page 4.58*). 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 4.48*).

Reclosing Relay States and General Operation

Figure 4.38 explains in general the different states of the reclosing relay and its operation.

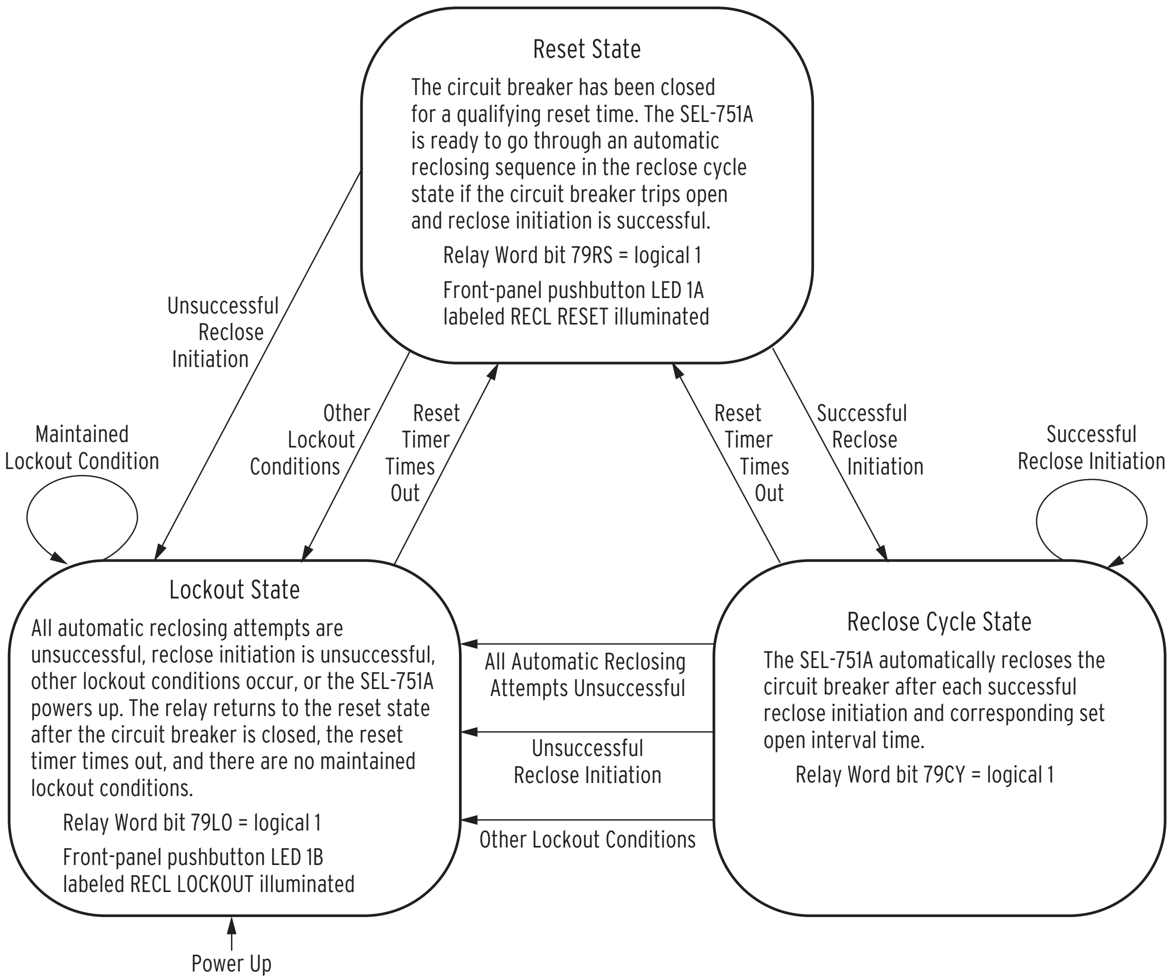


Figure 4.38 Reclosing Relay States and General Operation

Table 4.27 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 4.27*) 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 4.36*).
- ➤ 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 4.61*].
- ➤ 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 4.62*].
- ➤ The close failure timer (setting CFD) times out (see *Figure 4.34*).
- ➤ 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 4.35* and top of *Figure 4.36*) 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 7.34* for more information on the **OPEN** command. Also, see *Drive-to-Lockout and Drive-to-Last Shot Settings (79DTL and 79DLS, Respectively) on page 4.62*.

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 = OFF.
- 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 4.27*).
- 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 4.34*) 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 4.28*.

Table 4.28 Reclosing Control Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE RECLOSER	OFF, 1–4 Shots	E79 := OFF
OPEN INTERVAL 1	0.00–3000.00 secs	79OI1 := 5.00
OPEN INTERVAL 2	0.00–3000.00 secs	79OI2 := 0.00
OPEN INTERVAL 3	0.00–3000.00 secs	79OI3 := 0.00
OPEN INTERVAL 4	0.00–3000.00 secs	79OI4 := 0.00

Table 4.28 Reclosing Control Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
RST TM FROM RECL	0.00–3000.00 secs	79RSD := 15.00
RST TM FROM LO	0.00–3000.00 secs	79RSLD := 5.00
RECLS SUPV TIME	OFF, 0.00–3000.00 secs	79CLSD := 0.00
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 you can set. For example, if setting E79 := 3, the first three open interval time settings in *Table 4.28*, 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 4.28*, 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 4.39*.

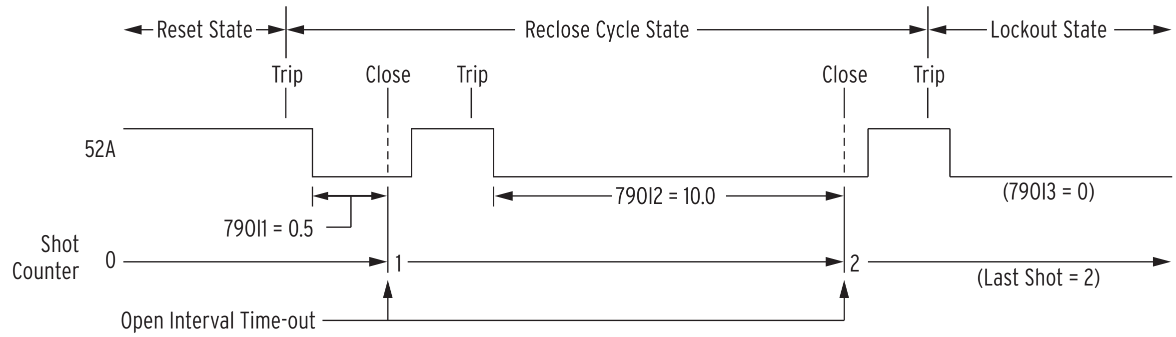


Figure 4.39 Reclosing Sequence From Reset to Lockout With Example Settings

You can set the SELOGIC control equation setting 79STL (stall open interval timing) to control open interval timing [see *Skip Shot and Stall Open Interval Timing Settings (79SKP and 79STL, Respectively) on page 4.63*].

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 7.42* 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 4.45* 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 used in sequence coordination schemes [see *Sequence Coordination Setting (79SEQ) on page 4.66*].

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 4.34*).

Setting 79RSLD is also the reset timer used when the relay 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 4.56*).

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 necessary). You can set SELOGIC control equation setting 79BRS (block reset timing) to control reset timing (see *Block Reset Timing Setting (79BRS) on page 4.65*).

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 4.63*].

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 4.65*.

Reclosing Relay Shot Counter

Refer to *Figure 4.39*.

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 4.59*]. The shot counter resets back to shot = 0 when the reclosing relay returns to the Reset State.

Table 4.29 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 4.66*].

Reclose Initiate and Reclose Initiate Supervision Settings (79RI and 79RIS, Respectively)

The reclose initiate setting 79RI is a rising-edge detect setting. The reclose initiate supervision setting 79RIS supervises setting 79RI. When setting 79RI senses a rising edge (logical 0 to logical 1 transition), setting 79RIS has to be at logical 1 (79RIS = logical 1) for open interval timing to be initiated.

If 79RIS = logical 0 when setting 79RI senses a rising edge (logical 0 to logical 1 transition), the relay goes to the Lockout State.

EXAMPLE 4.7 Factory Settings Example

With factory settings:

79RI := **TRIP**

79RIS := **52A OR 79CY**

the transition of the TRIP Relay Word bit from logical 0 to logical 1 initiates open interval timing only if the 52A or 79CY Relay Word bit is at logical 1 (52A = logical 1, or 79CY = logical 1). You must assign an input as the breaker status input (e.g., 52A := IN101).

The circuit breaker has to be closed (circuit breaker status 52A = logical 1) at the instant of the first trip of the autoreclose cycle for the SEL-751A to successfully initiate reclosing and start timing on the first open interval. The SEL-751A is not yet in the reclose cycle state (79CY = logical 0) at the instant of the first trip.

Then for any subsequent trip operations in the autoreclose cycle, the SEL-751A is in the reclose cycle state (79CY = logical 1) and the SEL-751A 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-751A sees the circuit breaker close.

If a flashover occurs in a circuit breaker tank during an open interval (circuit breaker open and the SEL-751A calls for a trip), the SEL-751A goes immediately to lockout.

EXAMPLE 4.8 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 4.34 and accompanying explanation) may need to be made when 79RI := NOT 52A. ULCL := 0 avoids going to lockout prematurely for an instantaneous trip after an autoreclose by not turning CLOSE off until the circuit breaker status indication tells the relay that the breaker is closed. The circuit breaker anti-pump circuitry should take care of the TRIP and CLOSE being on together for a short period of time.

Other Settings Considerations

In *Example 4.8* 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 necessary, make the following setting:

```
79RIS := 1 (numeral 1)
```

Setting 79RIS := logical 1 at all times. Any time setting 79RI 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 4.63*).
- ➤ Reclose initiation is by the breaker contact opening (e.g., 79RI := NOT 52A—refer to *Additional Settings Example on page 4.61*).

Then the drive-to-lockout condition overlaps reclose initiation and the SEL-751A 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 4.60*).

EXAMPLE 4.9 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 4.27.

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 4.10 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 necessary, 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 skipping of a reclose shot. Thus, the SEL-751A 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 4.29*). 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 4.56*).

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 4.29*). 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 4.56*).

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 4.60*).

EXAMPLE 4.11 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 4.12 Additional Settings Example 1

With skip shot setting:

79SKP := **50P2P AND SH0**

if shot = 0 (Relay Word bit SH0 = logical 1) and phase current exceeds the phase instantaneous overcurrent element 50P2 threshold (Relay Word bit 50P2P = logical 1), at the instant of successful reclose initiation, the shot counter increments 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 4.30 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 4.30, 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 increments to shot = 1, Relay Word bit SH0 = logical 0 and then setting 79SKP = logical 0, regardless of Relay Word bit 50P2P.

EXAMPLE 4.13 Additional Settings Example 2

If the SEL-751A Relay is in use 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-751A as shown in Figure 4.40.

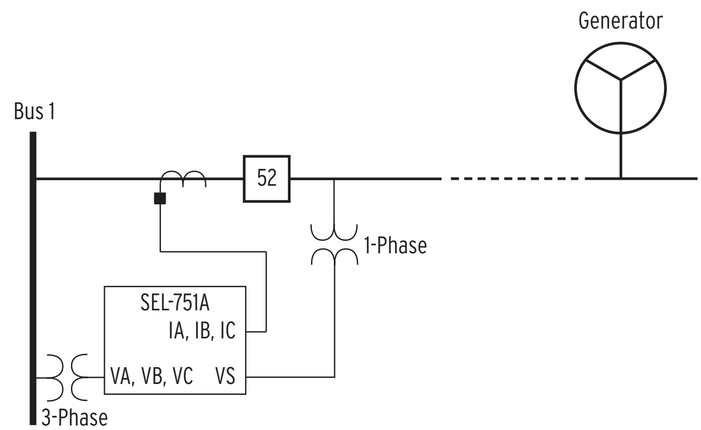


Figure 4.40 Reclose Blocking for Islanded Generator

If the line is energized, you can set channel VS overvoltage element 59S1 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 4.14 Additional Settings Example 3

Refer to Figure 4.37 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 necessary, 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 4.60*).

EXAMPLE 4.15 Factory Settings Example

The reset timing is blocked if Relay Word bit TRIP is asserted, regardless of the reclosing relay state:

79BRS := **TRIP**

EXAMPLE 4.16 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 4.38 and Table 4.27).

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 4.17 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-751A overcurrent elements from tripping for faults beyond the line recloser. This is accomplished by incrementing the shot counter and supervising overcurrent elements with resultant shot counter elements.

For the sequence coordination setting 79SEQ to increment the shot counter, *both* the following conditions must be true:

- No trip present (Relay Word bit TRIP = logical 0)
- Circuit breaker closed (SELOGIC control equation setting 52A = logical 1, effectively)

The sequence coordination setting 79SEQ is usually set with some overcurrent element pickups. If the previous two conditions are both true, and a set overcurrent element pickup asserts for at least 1.25 cycles and then deasserts, the shot counter increments by one count. This assertion/deassertion indicates that a downstream device (e.g., line recloser—see *Figure 4.41*) has operated to clear a fault. Incrementing the shot counter keeps the SEL-751A "in step" with the downstream device, as is shown in *Additional Settings Example 1 on page 4.67* and *Additional Settings Example 2 on page 4.68*.

Every time a sequence coordination operation occurs, the shot counter increments, 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 4.65*].

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 4.18 Factory Settings Example

Sequence coordination is not enabled in the factory settings:

79SEQ := **0**

EXAMPLE 4.19 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 4.41 and Figure 4.42.

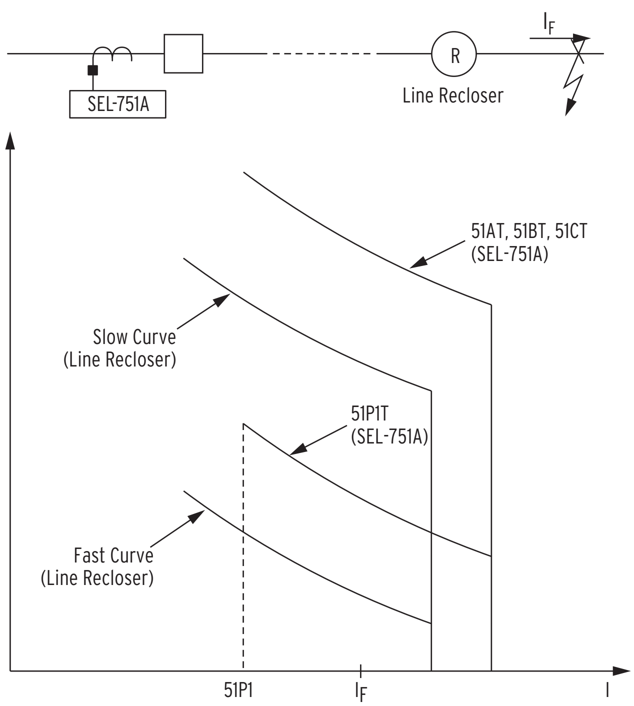
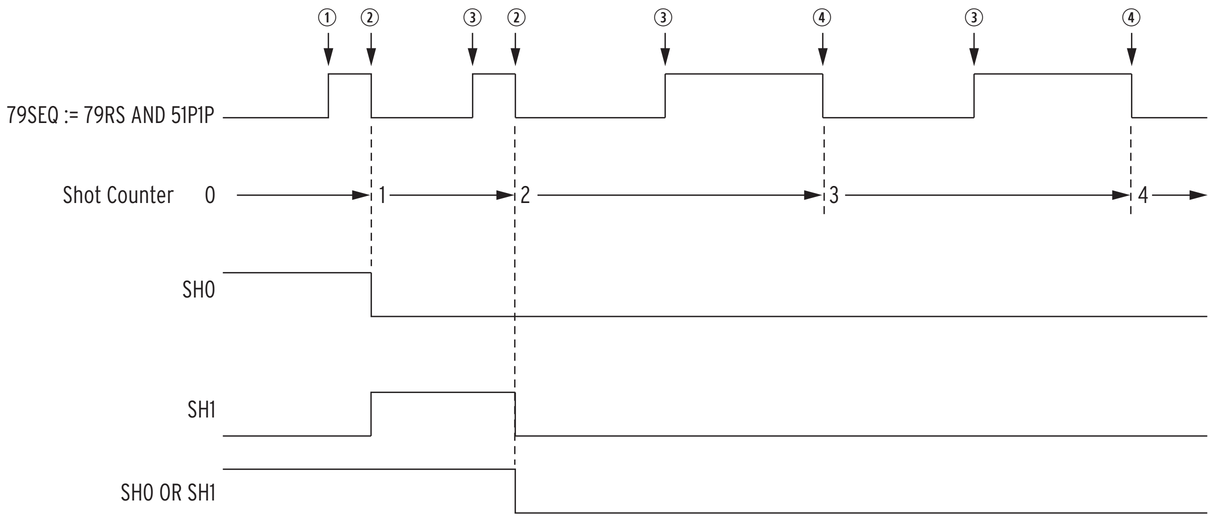


Figure 4.41 Sequence Coordination Between the SEL-751A and a Line Recloser

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-751A phase time-overcurrent element 51P1T is coordinated with the line recloser fast curve. The SEL-751A 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 4.42 Operation of SEL-751A Shot Counter for Sequence Coordination With Line Recloser (Additional Settings Example 1)

If the SEL-751A is in the Reset State (79RS = logical 1) and then a permanent fault beyond the line recloser occurs (fault current I_F in Figure 4.41), the line recloser fast curve operates to clear the fault. The SEL-751A 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-751A also sees the fault again. The phase time-overcurrent pickup 51P1P asserts and then deasserts without tripping, incrementing the relay shot counter from:

shot = 1 to shot = 2

NOTE: Sequence coordination can increment the shot counter beyond last shot in this example (last shot = 2 in this factory setting example) but no further than shot = 4.

The following Example 2 limits sequence coordination shot counter incrementing.

The line recloser fast curve is now disabled after operating twice. When the line recloser recloses its circuit breaker, the line recloser slow curve operates to clear the fault. The relay does not operate on its faster-set phase time-overcurrent element 51P1 (51P1T is "below" the line recloser slow curve) because the shot counter is now at shot = 2. For this sequence coordination scheme, the SELOGIC control equation trip equation is:

TR := **51P1T AND (SH0 OR SH1) OR 51AT OR 51BT OR 51CT**

With the shot counter at shot = 2, Relay Word bits SH0 (shot = 0) and SH1 (shot = 1) are both deasserted to logical 0. This keeps the 51PT phase time-overcurrent element from tripping. The 51P1T phase time-overcurrent element is still operative, and its pickup (51P1P) can still assert and then deassert, thus continuing the sequencing of the shot counter to shot = 3, etc. The 51P1T phase time-overcurrent element cannot cause a trip because shot ≥ 2, and SH0 and SH1 both are deasserted to logical 0.

The shot counter returns to shot = 0 after the reset timer (loaded with reset time 79RSD) times out.

EXAMPLE 4.20 Additional Settings Example 2

Review preceding Example 1.

Assume that the line recloser in Figure 4.41 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-751A is set to operate once on 51P1T and then twice on 51AT, 51BT, or 51CT for faults between the SEL-751A 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 4.28 and Figure 4.39). 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-751A will increment all the way to shot = 4 (see Figure 4.42). If there is a coincident fault between the SEL-751A and the line recloser, the SEL-751A 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**

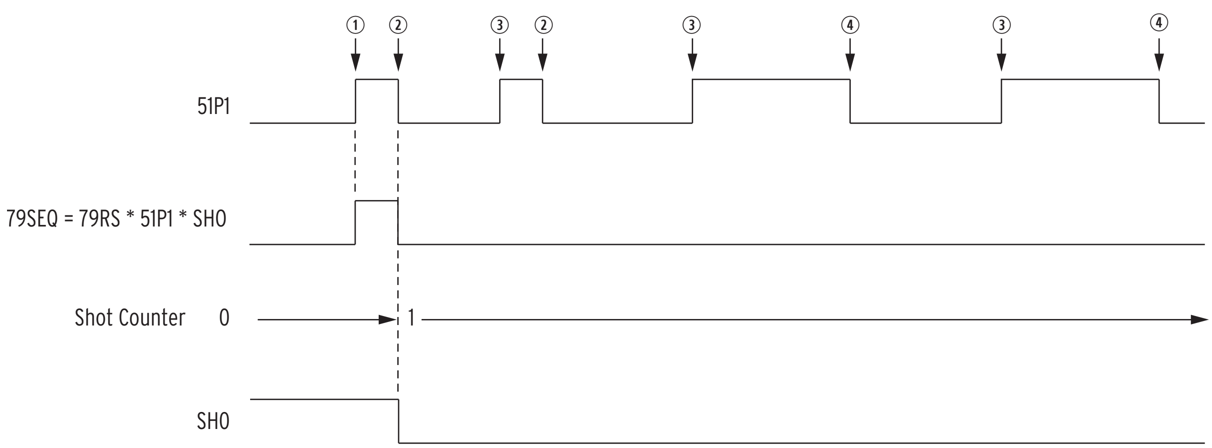
Refer to Figure 4.43.

If the SEL-751A 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 4.41), the line recloser fast curve operates to clear the fault. The SEL-751A 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-751A 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 4.43 Operation of SEL-751A 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-751A 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-751A and the line recloser, the SEL-751A 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 4.43.

Reclose Supervision Setting (79CLS)

See *Reclose Supervision Logic on page 4.48*.

Demand Metering

The SEL-751A 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 4.31 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 4.31 Demand Meter Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE DEM MTR	THM, ROL	EDEM := THM
DEM TIME CONSTNT	5, 10, 15, 30, 60 min	DMTC := 5
PH CURR DEM LVL	OFF, 0.50-16.00 A [a] OFF. 0.10-3.20 A [b]	PHDEMP := 5.00[a] PHDEMP := 1.00 b
RES CURR DEM LVL	OFF, 0.50-16.00 A [a] OFF, 0.10-3.2 A [b]	GNDEMP := 1.00[a] GNDEMP := 0.20[b]
3I2 CURR DEM LVL	OFF, 0.50-16.00 A [a] OFF, 0.10-3.2 A [b]	3I2DEMP := 1.00[a] 3I2DEMP := 0.20[b]

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

The demand current level settings are applied to demand current meter outputs, as shown in *Figure 4.44*.

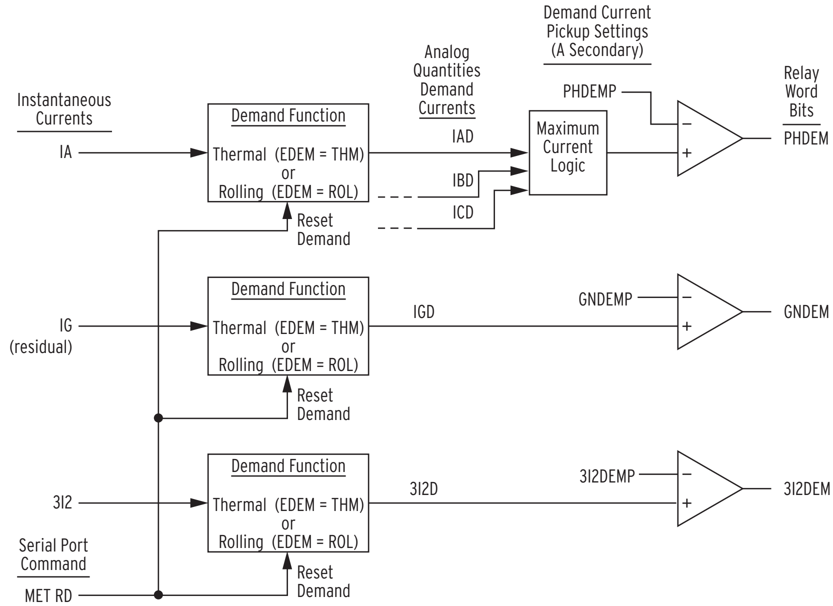


Figure 4.44 Demand Current Logic Outputs

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 4.45* 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”).

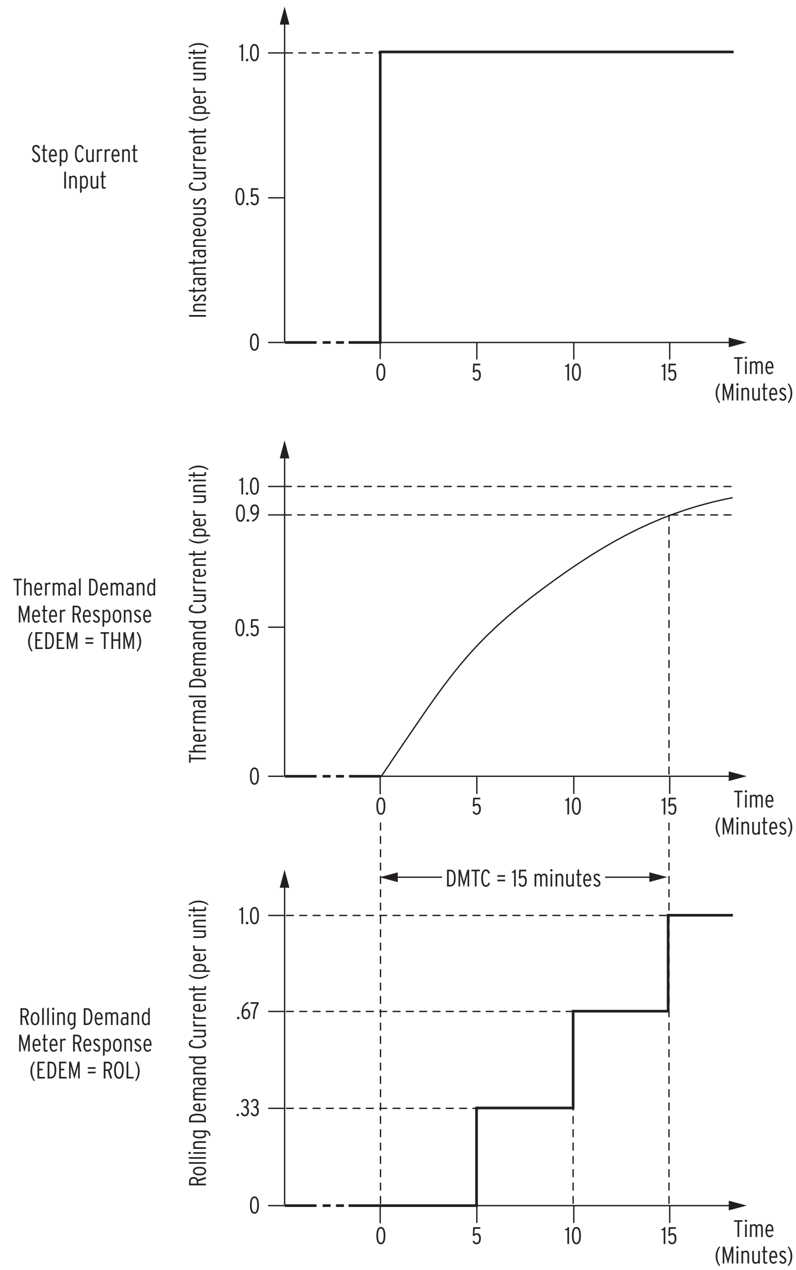


Figure 4.45 Response of Thermal and Rolling Demand Meters to a Step Input (Setting DMTC = 15 minutes)

Thermal Demand Meter Response

The response of the thermal demand meter in *Figure 4.45* (middle) to the step current input (top) is analogous to the series RC circuit in *Figure 4.46*.

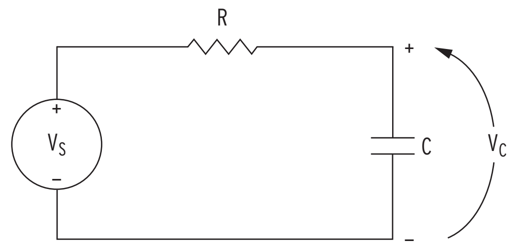


Figure 4.46 Voltage V_S Applied to Series RC Circuit

In the analogy:

Voltage V_S in *Figure 4.46* corresponds to the step current input in *Figure 4.45* (top).

Voltage V_C across the capacitor in *Figure 4.46* corresponds to the response of the thermal demand meter in *Figure 4.45* (middle).

If voltage V_S in *Figure 4.46* has been at zero (V_S = 0.0 per unit) for some time, voltage V_C across the capacitor in *Figure 4.46* 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 4.44* (middle) to the step current input (top).

In general, as voltage V_C across the capacitor in *Figure 4.46* 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 4.31*). Note in *Figure 4.45*, the thermal demand meter response (middle) is at 90 percent (0.9 per unit) of full applied value (1.0 per unit) after a time period equal to setting DMTC = 15 minutes, referenced to when the step current input is first applied.

The SEL-751A updates thermal demand values approximately every second.

Rolling Demand Meter Response

The SEL-751A calculates the response of the rolling demand meter in *Figure 4.45* (bottom) to the step current input (top) 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 4.31*). Note in *Figure 4.45*, 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 SEL-751A performs this integration 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 4.45* example, the rolling demand meter averages the three latest five-minute totals because setting DMTC = 15 (15/5 = 3). The relay updates the rolling demand meter response every five minutes, after it calculates a new five-minute total.

The following is a step-by-step calculation of the rolling demand response example in *Figure 4.45* (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)

Settings associated with latches, timers, counters, math variables, and output contacts are listed in the following table.

SELOGIC Enables

The following table 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 4.32 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-751A 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 4.47*). 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).

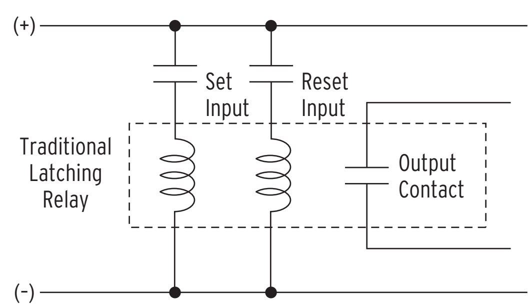


Figure 4.47 Schematic Diagram of a Traditional Latching Device

Thirty-two latch control switches in the SEL-751A provide latching device functionality. *Figure 4.48* 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.

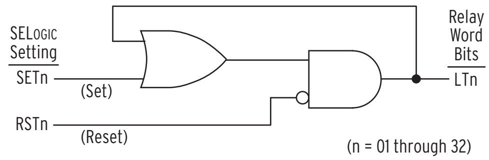


Figure 4.48 Logic Diagram of a Latch Switch

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-751A includes 32 latches. *Table 4.33* shows the **SET** and **RESET** default settings for Latch 1 through Latch 4. The remaining latches are all set to NA.

Table 4.33 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 4.76* 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 4.49*. Timers SV01T through SV32T in *Figure 4.49* 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).

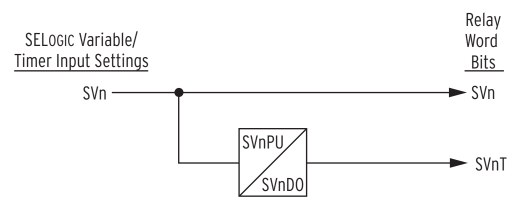


Figure 4.49 SELOGIC Control Equation Variable/Timers SV01/SV01T–SV32T

You can enter as many as 15 elements per SELOGIC control equation, including a total of 14 elements in parentheses (see *Table 4.34* for more information).

SELOGIC Control Equation Operators

Use the Boolean operators to combine values with a resulting Boolean value. Edge trigger operators provide a pulse output. Combine the operators and operands to form statements that evaluate complex logic. SELOGIC control equations are either Boolean type or math type. Because the equals sign (=) is already used as an equality comparison, both Boolean type and math type 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 4.34*. Math SELOGIC control equation settings operate on numerical values, using one or more of the mathematical operators listed in *Table 4.34*. These numerical values can be mathematical variables or real numbers.

The executed result of a math SELOGIC control equation is stored in a math variable. The smallest and largest values a math variable can represent are –16777215.99 and +16777215.99, respectively. If the executed result exceeds these limits, it 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.

You can add comments 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 4.35* 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-751A 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 4.34 SELOGIC Control Equation Operators (Listed in Operator Precedence)

Operator	Function	Function Type (Boolean and/ or Mathematical)
( )	parentheses	Boolean and Mathematical (highest precedence)
–	negation	Mathematical
NOT	NOT	Boolean
R_TRIG	rising-edge trigger/detect	Boolean
F_TRIG	falling-edge trigger/detect	Boolean
* /	multiply divide	Mathematical
+ -	add subtract	Mathematical
<, >, <=, >=	comparison	Boolean
= <>	equality inequality	Boolean
AND	AND	Boolean
OR	OR	Boolean (lowest precedence)

Parentheses Operator ( )

You can use more than one set of parentheses in a SELOGIC control equation setting. For example, the following Boolean SELOGIC control equation setting has two sets of parentheses:

```
SV04 := (SV04 OR IN102) AND (PB01_LED OR RB01)
```

In the previous example, the logic within the parentheses is processed first and then the two parentheses resultants are ANDed together. Use as many as 14 sets of parentheses in a single SELOGIC control equation setting. The parentheses can be "nested" (parentheses within parentheses).

Math Negation Operator (–)

The negation operator – changes the sign of a numerical value. For example:

```
MV01 := RB01
```

When Remote bit RB01 asserts, Math variable MV01 has a value of 1, i.e., MV01 = 1. We can change the sign on MV01 with the following expression:

```
MV01 := -1 * RB01
```

Now, when Remote bit RB01 asserts, Math variable MV01 has a value of –1, i.e., MV01 = –1.

Boolean NOT Operator (NOT)

Apply the NOT operator to a single Relay Word bit and to multiple elements (within parentheses).

An example of a single Relay Word bit is as follows:

```
SV01 := NOT RB01
```

When Remote bit RB01 asserts from logical 0 to logical 1, the Boolean NOT operator, in turn, changes the logical 1 to a logical 0. In this example, SV01 deasserts when RB01 asserts.

Following is an example of the NOT operator applied to multiple elements within parentheses.

The Boolean SELOGIC control equation OUT101 setting could be set as follows:

```
OUT101 := NOT(RB01 OR SV02)
```

If both RB01 and SV02 are deasserted (= logical 0), output contact OUT101 asserts, i.e., OUT101 := NOT(logical 0 OR logical 0) = NOT(logical 0) = logical 1.

In a Math SELOGIC control equation, use the NOT operator with any Relay Word bits. This allows a simple if/else type equation, as shown in the following example.

```
MV01 := 12 * IN101 + (MV01 + 1) * NOT IN101
```

The previous equation sets MV01 to 12 whenever IN101 asserts, otherwise it increments MV01 by 1 each time the equation is executed.

Boolean Rising-Edge Operator (R_TRIG)

Apply the rising-edge operator, R_TRIG, to individual Relay Word bits only; you cannot apply R_TRIG to groups of elements within parentheses. When any Relay Word bit asserts (going from logical 0 to logical 1), R_TRIG interprets this logical 0 to logical 1 transition as a “rising edge” and asserts to logical 1 for one processing interval.

For example, the Boolean SELOGIC control equation event report generation setting uses rising-edge operators:

```
ER := R_TRIG IN101 OR R_TRIG IN102
```

The rising-edge operators detect a logical 0 to logical 1 transition each time one of IN101 or IN102 asserts. Using these settings, the device triggers a new event report each time IN101 or IN102 asserts anew, if the device is not already recording an event report. You can use the rising-edge operator with the NOT operator as long as the NOT operator precedes the R_TRIG operator. The NOT R_TRIG combination produces a logical 0 for one processing interval when it detects a rising edge on the specified element.

Boolean Falling-Edge Operator (F_TRIG)

Apply the falling-edge operator, F_TRIG, to individual Relay Word bits only; you cannot apply F_TRIG to groups of elements within parentheses. The falling-edge operator, F_TRIG, operates similarly to the rising-edge operator, but operates on Relay Word bit deassertion (elements going from logical 1 to logical 0) instead of Relay Word bit assertion. When the Relay Word bit deasserts, F_TRIG interprets this logical 1 to logical 0 transition as a “falling edge” and asserts to logical 1 for one processing interval, as shown in *Figure 4.50*.

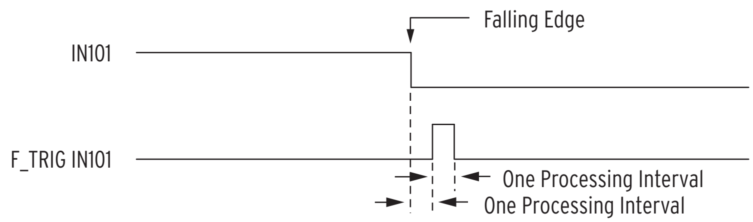


Figure 4.50 Result of Falling-Edge Operator on a Deasserting Input

You can use the falling-edge operator with the NOT operator as long as the NOT operator precedes the F_TRIG operator. The NOT F_TRIG combination produces a logical 0 for one processing interval when it detects a falling edge on the specified element.

Math Arithmetic Operators (*, /, +, and –)

If Relay Word bits (which are effectively Boolean resultants, equal to logical 1 or logical 0) are used in mathematical operations, they are treated as numerical values 0 and 1, depending on if the Relay Word bit is equal to logical 0 or logical 1, respectively.

Boolean Comparison Operators (<, >, <=, and >=)

Comparisons are mathematical operations that compare two numerical values, with the result being a logical 0 (if the comparison is not true) or logical 1 (if the comparison is true). Thus, what starts out as a mathematical comparison ends up as a Boolean resultant. For example, if the output of a math variable exceeds a certain value, an output contact is asserted:

```
OUT103 := MV01 > 8
```

If the math variable (MV01) is greater than 8, output contact OUT103 asserts (OUT103 = logical 1). If the math variable (MV01) is less that or equal to 8, output contact OUT103 deasserts (OUT103 = logical 0).

Boolean Equality (=) and Inequality (<>) Operators

Equality and inequality operators operate similarly to the comparison operators. These are mathematical operations that compare two numerical values, with the result being a logical 0 (if the comparison is not true), or logical 1 (if the comparison is true). Thus, what starts out as a mathematical comparison, ends up as a Boolean resultant. For example, if the output of a math variable is not equal to a certain value, an output contact is asserted:

```
OUT102 := MV01 <> 45
```

If the math variable (MV01) is not equal to 45, output contact OUT102 asserts (effectively OUT102 := logical 1). If the math variable (MV01) is equal to 45, output contact OUT102 deasserts (effectively OUT102 := logical 0). The following table shows other operators and values that you can use in writing SELOGIC control equations.

Table 4.35 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 4.51* 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)**

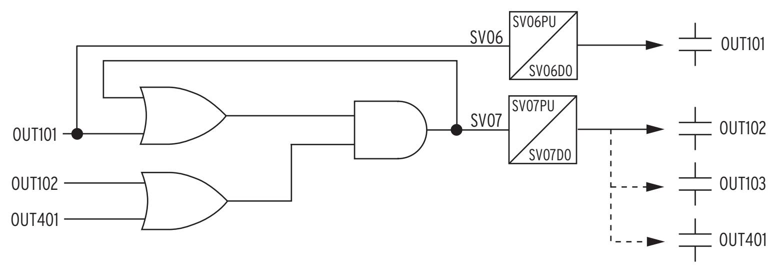


Figure 4.51 Example Use of SELOGIC Variables/Timers

SV/Timers Settings

The SEL-751A includes 32 SELOGIC variables. *Table 4.36* shows the pickup, dropout, and equation settings for SV01 and SV02. The remaining SELOGIC variables have the same default settings as SV02.

Table 4.36 SELOGIC Variable Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Default Settings
SV TIMER PICKUP	0.00–3000.00	SV01PU := 0.00
SV TIMER DROPOUT	0.00–3000.00	SV01DO := 0.00
SV INPUT	SELOGIC	SV01 := WDGTRIP OR BRGTRIP OR OTHTRIP OR AMBTRIP OR (27P1T OR 27P2T) AND NOT LOP
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

Table 4.36 SELOGIC Variable Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Default Settings
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 an immediate close and trip actions from front-panel pushbuttons. For a delayed close, set SV03PU to the necessary 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 4.52* shows Counter 01, the first of 32 counters available in the device.

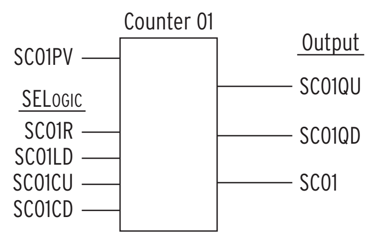


Figure 4.52 Counter 01

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 4.37* describes the counter inputs and outputs, and *Table 4.38* shows the order of precedence of the control inputs.

Table 4.37 Counter Input/Output Description (Sheet 1 of 2)

Name	Type	Description
SC*nn*LD	Active High Input	Load counter with the preset value to assert the output (SC*n*QU) (follows SELOGIC setting).
SC*nn*PV	Input Value	This Preset Value is loaded when SC*n*LD pulsed. This Preset Value is the number of counts before the output (SC*n*QU) asserts (follows SELOGIC setting).
SC*nn*CU	Rising-Edge Input	Count Up increments the counter (follows SELOGIC setting).
SC*nn*CD	Rising-Edge Input	Count Down decrements the counter (follows SELOGIC setting).

Table 4.37 Counter Input/Output Description (Sheet 2 of 2)

Name	Type	Description
SC*nn*R	Active High Input	Reset counter to zero (follows SELOGIC setting)
SC*nn*QU	Active High Output	This Q Up output asserts when the Preset Value (maximum count) is reached (SC*n* = SC*n*PV, *n* = 01 to 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 can be used with analog comparison operators in a SELOGIC control equation and viewed through use of the **COU** command.

Table 4.38 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 4.53 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.

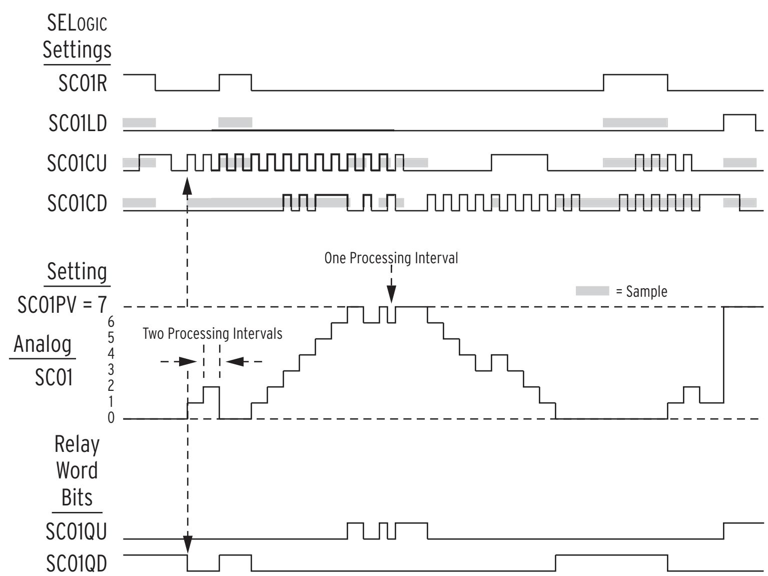


Figure 4.53 Example of the Effects of the Input Precedence

The shaded areas illustrate the precedence of the inputs:

- When SC01R is asserted, the SC01LD input is ignored.
- When SC01R or SC01LD is asserted, rising edges on the SC01CU or SC01CD inputs are ignored.

- ➤ When input SC01CU has a rising edge, a rising edge on SC01CD is ignored (unless SC01 is already at the maximum value SC01PV (= 7), in which case SC01CU is ignored, and the SC01CD is processed). An example of this exception appears in the previous diagram, just before the "one processing interval" notation.

A maintained logical 1 state on the SC01CU or SC01CD inputs is ignored (after the rising edge is processed). A rising edge received on the SC01CU or SC01CD inputs is ignored when the SC01R or SC01LD inputs are asserted.

A maintained logical 1 on the SC01CU or SC01CD inputs does not get treated as a rising edge when the SC01R or SC01LD input deasserts.

The same operating principles apply for all of the counters: SC01–SC*mm*, where *mm* = the number of enabled counters. When a counter is disabled by setting, the present count value is forced to 0 (SC*nn* := 0), causing Relay Word bit SC*nn*QD to assert (SC*nn*QD := logical 1), and Relay Word bit SC*nn*QU to deassert (SC*nn*QU := logical 0).

Output Contacts

Table 4.39 Control Output Equations and Contact Behavior Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
OUT101 FAIL-SAFE	Y, N	OUT101FS := Y
OUT101	SELOGIC	OUT101 := HALARM OR SALARM
OUT102 FAIL-SAFE	Y, N	OUT102FS := N
OUT102	SELOGIC	OUT102 := CLOSE
OUT103 FAIL-SAFE	Y, N	OUT103FS := N
OUT103	SELOGIC	OUT103 := TRIP
⋮	⋮	⋮
OUT401 FAIL-SAFE	Y, N	OUT401FS := N
OUT401	SELOGIC	OUT401 := 0
OUT402 FAIL-SAFE	Y, N	OUT402FS := N
OUT402	SELOGIC	OUT402 := 0
OUT403 FAIL-SAFE	Y, N	OUT403FS := N
OUT403	SELOGIC	OUT403 := 0
OUT404 FAIL-SAFE	Y, N	OUT404FS := N
OUT404	SELOGIC	OUT404 := 0
⋮	⋮	⋮

NOTE: When an output contact is not used for a specific function you must set the associated SELOGIC control equation to either 0 or 1.

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

The SEL-751A 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 2.13* and *Figure 2.14*.

When TRIP output fail-safe is enabled and the **TRIP** contact is appropriately connected (see *Figure 2.17*), the breaker is automatically tripped when relay control power fails.

MIRRORED BITS Transmit SELOGIC Control Equations

See *Appendix I: MIRRORED BITS Communications* and *SEL-751A Settings Sheets* for details.

Global Settings (SET G Command)

General Settings

Table 4.40 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,	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.

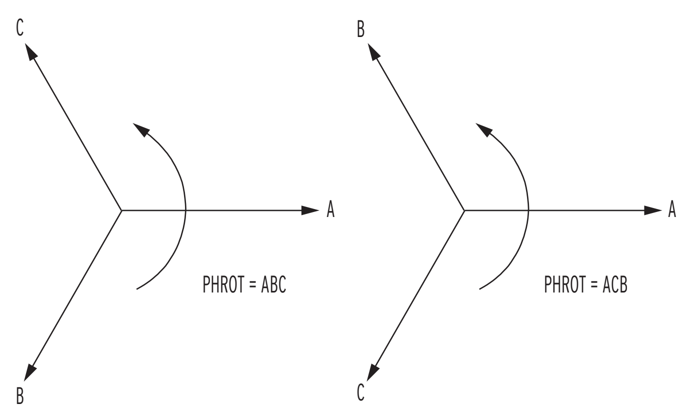


Figure 4.54 Phase Rotation Setting

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-751A to automatically send ASCII message on a communications port when the trigger condition is satisfied. Use the **SET P** command to set PROTO := EVMSG on the necessary port to select the port. This feature is designed to send messages to the SEL-3010 Event Messenger, but you can use any device capable of receiving ASCII messages.

Table 4.41 Event Messenger Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
EVE MSG PTS ENABL	N, 1–32	EMP := N
MESSENGER POINT MP01 TRIGGER	Off, 1 Relay Word bit	MPTR01 := OFF
MESSENGER POINT MP01 AQ	None, 1 analog quantity	MPAQ01 := NONE
MESSENGER POINT MP01 TEXT	148 characters	MPTX01 :=
• • •	• • •	• • •
MESSENGER POINT MP32 TRIGGER	Off, 1 Relay Word bit	MPTR32 := OFF
MESSENGER POINT MP32 AQ	None, 1 analog quantity	MPAQ32 := NONE
MESSENGER POINT MP32 TEXT	148 characters	MPTX32 :=

Set EMP to enable the necessary number of message points.

Set each of MPTR*xx* (*xx* = 01–32) to the necessary Relay Word bits, the rising edge of which defines the trigger condition.

MPAQ*xx* is an optional setting and you can use it to specify an Analog Quantity to be formatted into a single message, as described next.

Use MPTX*xx* to construct the message you want. Note that by default the relay adds the analog quantity value, if specified, at the end of the message, rounded to the nearest integer value (see *Example 4.21*).

EXAMPLE 4.21 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 necessary)

EXAMPLE 4.22 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 4.42 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 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-751A relay 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-751A 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 4.43 shows the time and date management settings that are available in the Global settings.

Table 4.43 Time and Date Management Settings (Sheet 1 of 2)

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

Table 4.43 Time and Date Management Settings (Sheet 2 of 2)

Setting Description	Setting Range	Setting Name := Factory Default
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 to 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-751A 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-751A 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-751A will change to and from daylight-saving time every year at the specified time. Relay Word bit DST asserts when daylight-saving time is active.

The SEL-751A 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 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_ENDM = 10
DST_BEGW = L	DST_ENDW = 3
DST_BEGD = SUN	DST_ENDD = WED
DST_BEGH = 2	DST_ENDH = 3

With these example settings, the relay will enter daylight-saving time on the last Sunday in March at 0200 h, and leave daylight-saving time on the third Wednesday in October at 0300 h. The relay asserts Relay Word bit DST when DST is active.

When an IRIG-B time source is being used, the relay time follows the IRIG-B time, including daylight-saving time start and end, as commanded by the time source. If there is a discrepancy between the daylight-saving time settings and the received IRIG-B signal, the relay follows the IRIG-B signal.

When using IEEE C37.118 compliant IRIG-B signals (e.g., Global setting IRIGC = C37.118), the relay automatically populates the DST Relay Word bit, regardless of the daylight-saving time settings.

When using regular IRIG-B signals (e.g., Global setting IRIGC = NONE), the relay only populates the DST Relay Word bit of the daylight-saving time settings are properly configured.

Simple Network Time Protocol (SNTP)

The SEL-751A **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 4.44 Breaker Failure Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
52A INTERLOCK	Y, N	52ABF := N
BK FAILURE DELAY	0.00–2.00 sec	BFD := 0.50
BK FAIL INITIATE	SELOGIC	BFI := R_TRIG TRIP

The SEL-751A provides flexible breaker failure logic (see *Figure 4.55*). In the default breaker failure logic, assertion of Relay Word bit TRIP starts the BFD timer if the sum of positive-sequence and negative-sequence currents exceed $0.02 \cdot I_{NOM}$. If the current remains greater than the threshold for BFD delay setting, Relay Word bit BFT will assert. Use the BFT to operate an output relay to trip appropriate backup breakers.

Changing the BFI and/or 52ABF 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 unnecessary when the tripping is caused by this input.
- Set 52ABF = Y if you want the breaker failure logic to detect failure of breaker/contactor auxiliary contact to operate during the trip operation as defined by the BFI setting.

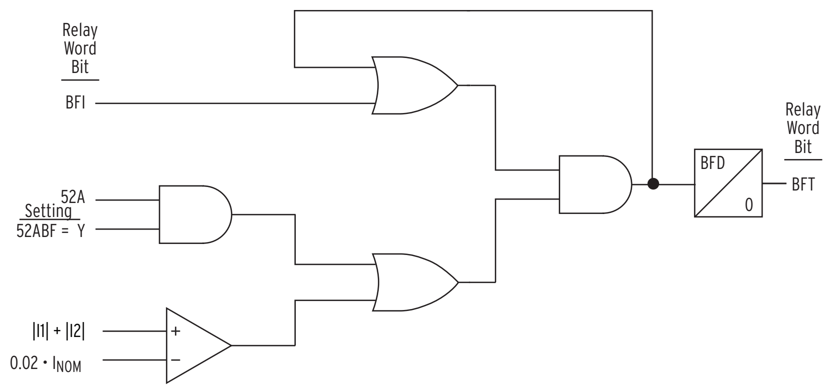


Figure 4.55 Breaker Failure Logic

Arc-Flash Protection

The SEL-751A 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-751A 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 omnidirectional ***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. A loopback-based attenuation measurement method supervises both types of sensors and you can use them 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 4.45 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 4.45 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 4.56*, followed by a security counter requiring that two samples in a row exceed 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.

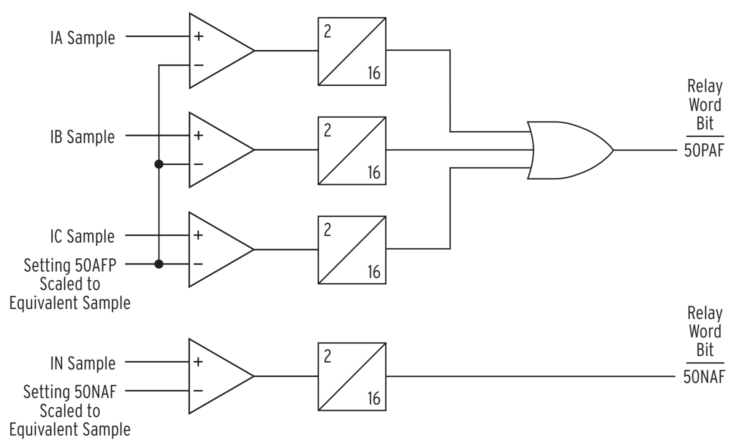


Figure 4.56 Arc-Flash Instantaneous Overcurrent Element Logic

Arc-Flash Time-Overlight Elements (TOL1 through TOL4)

The SEL-751A relay offers four fiber-optic light sensor inputs. Each input is associated with one inverse time-over light 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 4.46* 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 4.47*. However, 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 4.46 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-751A is 1/4 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 4.57 shows the TOL element logic diagram.

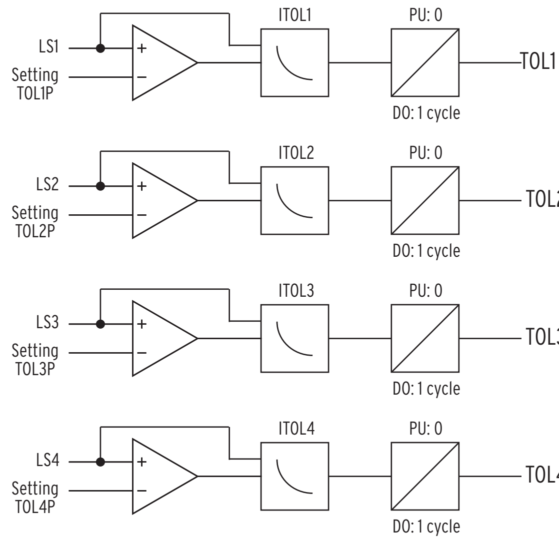


Figure 4.57 Inverse Time-Overlight Element Logic

Figure 4.58 shows the inverse time-overlight element curve shape. The element uses 32 samples per cycle data, processed 16 times per cycle. TOL element algorithm ensures that the light must be present for a minimum of two samples, regardless of the light level. It also ensures that for low light levels, element operation cannot be delayed for more than 1/4 of a power system cycle.

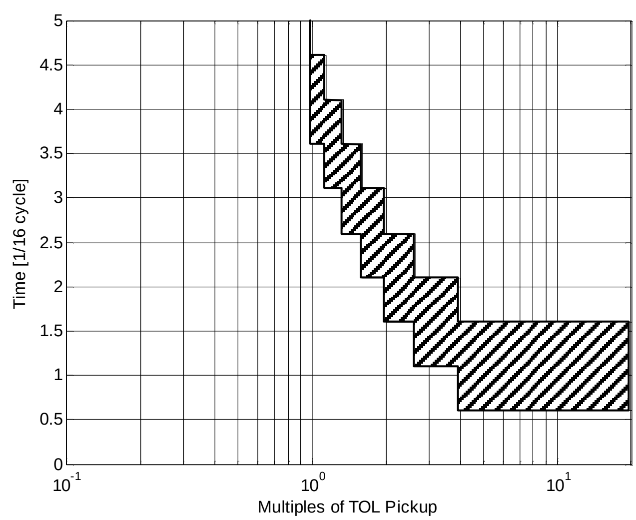


Figure 4.58 TOL Element Inverse Curve Characteristic

Setting the Arc-Flash Time-Overlight Element

Given the critical nature of the arc-flash protection function, it is recommended that you set the element 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 4.47*. 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 least possible light intensity level but greater than the highest-expected ambient light intensity level at each light-sensor installation.

Table 4.47 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 (non critical loads), it may be necessary to operate without overcurrent element supervision (OUT*xxx* := TOL*n*), relying only on the light detection element instead of having the overcurrent element (50PAF) supervise the light element (TOL*n*) in the output logic (OUT*xxx* := 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 4.56* and *Figure 4.57*) are:

`50PAF, 50NAF, TOL1, TOL2, TOL3, and TOL4`

As described earlier, you select two output contacts for high-speed processing by setting AOUTSLOT appropriately. The high-speed contact should be used for arc-flash tripping instead of the default OUT103 shown in *Table 4.39*. 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 4.26* and *Figure 4.33* for detail).

NOTE: The high-speed outputs selected by AOUTSLOT setting being Form A, cannot be used in fail safe mode and should be disabled (set OUTxxxFS := N).

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 4.23 Output Logic Programming Example 1

SEL-751A 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 4.24 Output Logic Programming Example 2

SEL-751A 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 necessary, 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 necessary.

Analog Inputs

The SEL-751A 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 4.59*. Variable *x* displays the slot position (**3** through **5**), and variable *y* displays the transducer (analog) input number (1 through 4 or 8).

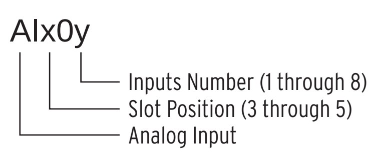


Figure 4.59 Analog Input Card Adaptive Name

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-751A on and allow it to warm up for a few minutes.

Step 2. Set the analog inputs for each analog channel to the necessary range by using the AI*xxx*TYP, AI*xxx*L, AI*xxx*H, AI*xxx*EL, and AI*xxx*EH settings (for example, ±1 mA).

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-751A to boot up, perform self-diagnostics, and detect installed cards.

Table 4.48 summarizes the steps and describes the settings we will carry out in this example.

Table 4.48 Summary of Steps (Sheet 1 of 2)

	Step	Activity	Terse Description
General	1	SET G AI301NAM	Access settings for INPUT 1
	2	TX_TEMP	Enter a Tag name
	3	I	Select type of analog input; “I” for current
Transducer High/Low Output	4	4	Enter transducer low output (LOW IN VAL)
	5	20	Enter transducer high output (HI IN VAL)
Level	6	Degrees C	Enter Engineering unit
	7	–50	Enter Engineering unit value LOW
	8	150	Enter Engineering unit value HIGH

Table 4.48 Summary of Steps (Sheet 2 of 2)

	Step	Activity	Terse Description
Low Warning/ Alarm	9	OFF	Enter LOW WARNING 1 value
	10	OFF	Enter LOW WARNING 2 value
	11	OFF	Enter LOW ALARM value
High Warning/ Alarm	12	65	Enter HIGH WARNING 1 value
	13	95	Enter HIGH WARNING 2 value
	14	105	Enter HIGH ALARM value

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

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

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

Use the Instrument Tag Name to give the analog quantity a more descriptive name. This tag name 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 name characters are: 0–9, A–Z, and the underscore (_). For this example, we assign TX_TEMP as the tag name.

Because this is a 4–20 mA transducer, enter **I <Enter>** (for 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-751A 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 4.60*. 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 4.60 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 4.49 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 4.49 Analog Input Card in Slot 3 (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
AI301 TAG NAME	8 characters 0–9, A–Z, _	AI301NAM := AI301
AI301 TYPE	I, V	AI301TYP := I
AI301 LOW IN VAL	–20.480 to +20.480 mA	AI301L := 4.000
AI301 HI IN VAL	–20.480 to +20.480 mA	AI301H := 20.000
AI301 LOW IN VAL	–10.240 to +10.240 V	AI301L := 0.000[a]
AI301 HI IN VAL	–10.240 to +10.240 V	AI301H := 10.000[a]
AI301 ENG UNITS	16 characters	AI301EU := mA
AI301 EU LOW	–99999.000 to +99999.000	AI301EL := 4.000
AI301 EU HI	–99999.000 to +99999.000	AI301EH := 20.000
AI301 LO WARN 1	OFF, –99999.000 to +99999.000	AI301LW1 := OFF
AI301 LO WARN 2	OFF, –99999.000 to +99999.000	AI301LW1 := OFF
AI301 LO ALARM	OFF, –99999.000 to +99999.000	AI301LAL := OFF

Table 4.49 Analog Input Card in Slot 3 (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
AI301 HI WARN 1	OFF, –99999.000 to +99999.000	AI301HW1 := OFF
AI301 HI WARN 2	OFF, –99999.000 to +99999.000	AI301HW2 := OFF
AI301 HI ALARM	OFF, –99999.000 to +99999.000	AI301HAL := OFF

[a] Voltage setting range for a voltage transducer, i.e., when AI301TYP := V

Analog Outputs

If an SEL-751A 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 4.61* shows the *x* and *y* variable allocation for the analog output card.

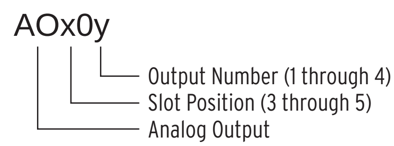


Figure 4.61 Analog Output Number Allocation

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

NOTE: The SEL-751A 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 4.50 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 that 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) during use of 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 4.62*. 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 amperes primary and +20 mA when it is 3000 amperes primary.

```
=>>SET G AO301AQ TERSE <Enter>
Global
AO 301 Settings
AO301 ANALOG QTY (OFF, 1 analog quantity)
AO301AQ := OFF
? 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 4.62 Analog Output Settings

Station DC Battery Monitor

The station dc battery monitor in the SEL-751A 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 enhanced voltage option with monitoring package that includes the 5AVI card in Slot **E** of the relay. Refer to *Station DC Battery Monitor on page 5.13* for a detailed description and *Table 5.8* for settings.

Breaker Monitor

The breaker monitor in the SEL-751A helps in scheduling circuit breaker maintenance. Refer to *Breaker Monitor on page 5.17* for a detailed description and *Table 5.10* for settings.

Digital Input Debounce

To comply with different control voltages, the SEL-751A offers dc debounce 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 used in device logic, as well as to the time stamping in the SER. Following is a description of the two modes.

DC Mode Processing (DC Control Voltage)

Figure 4.63 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).

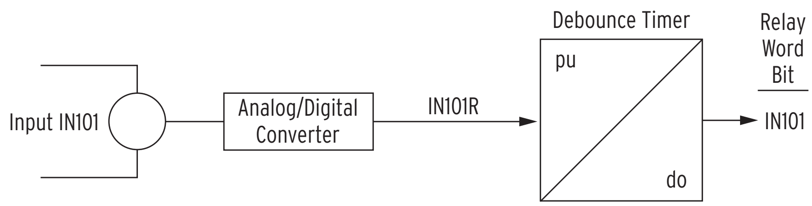


Figure 4.63 DC Mode Processing

AC Mode Processing (AC Control Voltage)

Figure 4.64 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.

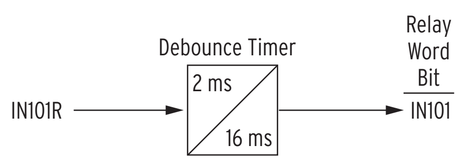


Figure 4.64 AC Mode Processing

Figure 4.65 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.

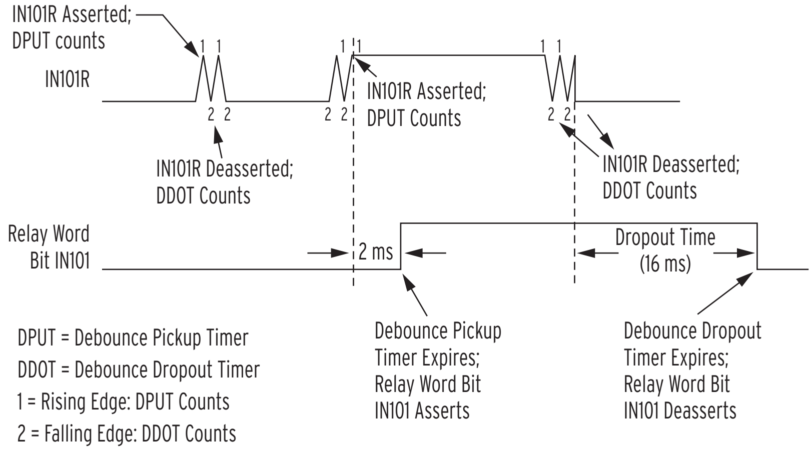


Figure 4.65 Timing Diagram for Debounce Timer Operation When Operating in AC Mode

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 4.51 shows the settings prompt, setting range, and factory-default settings for a card in Slot C. See the *SEL-751A Settings Sheets* for a complete list of input debounce settings.

Table 4.51 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

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 4.44* 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, for example, 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 the use of serial port commands. *Table 4.52* shows the settings prompt, setting range, and factory-default settings.

Use the BLOCK MODBUS SET setting to block relay settings changes via Modbus or DeviceNet protocols. The factory-default setting, BLKMBSET := NONE, allows all setting changes via Modbus or DeviceNet communications. The BLKMBSET := R_S setting prevents Modbus or DeviceNet communications from resetting to the factory-default settings. The BLKMBSET := ALL setting blocks all changes to the settings via the Modbus or the DeviceNet protocol.

Table 4.52 Setting Change Disable Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
DISABLE SETTINGS	SELOGIC	DSABLSET := 0
BLOCK MODBUS SET	NONE, R_S, ALL	BLKMBSET := NONE

Time-Synchronization Source

The SEL-751A accepts a demodulated IRIG-B time signal. *Table 4.53* shows the setting to identify the input for the signal. Set TIME_SRC := IRIG1 when you use relay terminals B01/B02 or EIA-232 serial **PORT 3** for the time signal input. When you use fiber-optic **PORT 2** for the signal, set the TIME_SRC := IRIG2. Refer to *IRIG-B Time-Code Input on page 2.19* and *IRIG-B on page 7.5* for additional information.

Table 4.53 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-751A provides settings that allow you to configure the parameters for the communications ports. See *Section 2: Installation* for a detailed description of port connections. On the base unit: **Port F** (front panel) is an EIA-232 port; **Port 1** is an optional Ethernet port(s); **Port 2** is an optional fiber-optic serial port; and **Port 3** (rear) is optionally an EIA-232 or EIA-485 port. On the optional communications card, you can select **Port 4** as either EIA-485 or EIA-232 (not both) with the COMMINF setting. See *Table 4.54* through *Table 4.58* 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 4.54 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: FAST OP messages setting only takes effect when using SEL Fast Operate protocol to operate/set/pulse Breaker bits and Remote bits. It has no effect on Modbus, DNP or IEC 61850 protocols.

Table 4.55 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
NETWRK PORTA SPD	AUTO, 10, 100 Mbps	NETASPD := AUTO
NETWRK PORTB SPD	AUTO, 10, 100 Mbps	NETBSPD := AUTO

Table 4.55 Ethernet Port Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
TELNET PORT	23, 1025–65534	TPORT := 23
TELNET TIME OUT	1–30 min	TIDLE := 15
FTP USER NAME	20 characters	FTPUSER := FTPUSER
Enable IEC 61850 Protocol	Y, N	E61850 := N
Enable IEC 61850 GSE	Y, N	EGSE := N
Enable Modbus Sessions	0–2	EMOD := 0
Modbus TCP Port 1	1–65534	MODNUM1 := 502
Modbus TCP Port 2	1–65534	MODNUM2 := 502
Enable DNP Session[a]	0—3	EDNP := 0
Modbus Timeout 1	15–900 sec	MTIMEO1 := 15
Modbus Timeout 2	15–900 sec	MTIMEO2 := 15

[a] See Table D.7 for a complete list of the DNP3 session settings.

PORT 2

NOTE: For additional settings when PROTO := MBxx, see Table I.5 as well as MIRRORED BITS Transmit SELOGIC Control Equations on page SET.25. For additional settings when PROTO := DNP, see Table D.7 for a complete list of the DNP3 session settings.

Table 4.56 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 on page SET.25. For additional settings when PROTO := DNP, see Table D.7 for a complete list of the DNP3 session settings.

Table 4.57 Rear-Panel Serial Port (EIA-232) Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PROTOCOL	SEL, DNP, MOD, EVMSG, PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB	PROTO := SEL
SPEED	300–38400 bps	SPEED := 9600
DATA BITS	7, 8 bits	BITS := 8
PARITY	O, E, N	PARITY := N
STOP BITS	1, 2 bits	STOP := 1
PORT TIMEOUT	0–30 min	T_OUT := 5
SEND AUTOMESSAGE	Y, N	AUTO := N
HDWR HANDSHAKING	Y, N	RTSCTS := N

Table 4.57 Rear-Panel Serial Port (EIA-232) Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
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 on page SET.25. For additional settings when PROTO := DNP, see Table D.7 for a complete list of the DNP3 session settings.

Table 4.58 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-751A Fast Operate commands.

Set PROTO := DNET to establish communications when you use the DeviceNet card. *Table 4.59* shows the additional settings, which you can 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 4.59 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-751A 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 4.60 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 time-out setting FP_TO as a security measure. If the display is within an Access Level 2 function when a time-out 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 time-out function during device testing, set the LCD time-out 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 4.61 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 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 4.62* 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 4.62* shows examples of settings that always, never, or conditionally hide a display point.

Table 4.62 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-751A, 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 4.63 Entries for the Four Strings

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

Figure 4.66 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>
.
.
.
Target LED Set
TRIP LATCH T_LED (Y,N)                        T01LEDL := Y         ? > <Enter>
Display Point Settings (maximum 60 characters):
(Boolean): Relay Word Bit Name, "Alias", "Set String", "Clear String"
(Analog) : Analog Quantity Name, "User Text and Formatting"
DISPLAY POINT DP01 (60 characters)
DP01    := RID,"{16}"
? IN101,"TRFR 1 HV BRKR:",CLOSED,OPEN <Enter>
DISPLAY POINT DP02 (60 characters)
DP02    := TID,"{16}"
? IN102,"TRFR 1 LV BRKR:",CLOSED,OPEN <Enter>
DISPLAY POINT DP03 (60 characters)
DP03    := IAV, "IAV CURR {5} A"
? END <Enter>
Save changes (Y,N)? Y <Enter>
Settings Saved
=>>
```

Figure 4.66 Display Point Settings

Figure 4.67 shows the display when both HV and LV breakers are open (both IN101 and IN102 deasserted). *Figure 4.68* shows the display when the HV breaker is closed, and the LV breaker is open (IN101 asserted, but IN102 still deasserted).

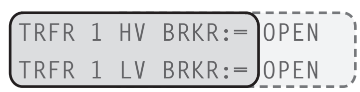


Figure 4.67 Front-Panel Display—Both HV and LV Breakers Open

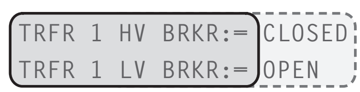


Figure 4.68 Front-Panel Display—HV Breaker Closed, LV Breaker Open

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 4.69*. 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 4.70*.

Figure 4.69 Front-Panel Display—Both HV and LV Breakers Closed

Figure 4.70 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 4.71*.

Figure 4.71 Front-Panel Display—HV Breaker Open, LV Breaker Closed

Name Only

Table 4.64 shows an entry in the Name String only (leaving the Alias string, Set String, and Clear String void), using the **SET F** command as follows:

```
DP01    := RID, “{16}”
 ? IN101 <Enter>
```

Table 4.64 Binary Entry in the Name String Only

Name	Alias	Set String	Clear String
IN101	—	—	—

Figure 4.72 shows the front-panel display for the entry in *Table 4.64*. Input IN101 is deasserted in this display (`IN101=0`), but changes to `IN101=1` when Input IN101 asserts.

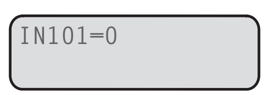


Figure 4.72 Front-Panel Display for a Binary Entry in the Name String Only

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

Table 4.65 Analog Entry in the Name String Only

Name	Alias	Set String	Clear String
AI301	—	—	—

Figure 4.73 shows the front-panel display for the entry in *Table 4.65*, using the **SET F** command as follows:

```
DP01    := RID, “{16}”
 ? AI301 <Enter>
```

Figure 4.73 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 4.66* 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 as follows:

```
DP01    := RID, “{16}”
 ? IN101,"INPUT IN101:" <Enter>
DP02    := TID, “{16}”
 ? AI301,TEMPERATURE: <Enter>
```

Table 4.66 Entry in the Name String and the Alias Strings

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

Figure 4.74 shows the front-panel display for the entry in *Table 4.66*. Input IN101 is deasserted in this display (0), and the display changes to INPUT IN101=1 when Input IN101 asserts.

Figure 4.74 Front-Panel Display for an Entry in (a) Boolean Name and Alias Strings and (b) Analog Name and User Text and Formatting Strings

If the engineering units are set, then the front-panel display shows the engineering units. For example, in the Group setting example, we set AI301EU to degrees C. With this setting, the front-panel display looks similar to *Figure 4.75*.

Figure 4.75 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.” The following table shows other options and front-panel displays for the User Text and Formatting settings.

Table 4.67 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 4.76* shows the settings to add the three transducer measurements. (Use the > character to move to the next settings category).

```
=>>SET F TERSE <Enter>
Front Panel
General Settings
DISPLY PTS ENABL (N,1-32)                     EDP     := 4        ? 5 <Enter>
LOCAL BITS ENABL (N,1-32)                     ELB     := 1        ? ><Enter>
.
.
.
Target LED Set
TRIP LATCH T_LED (Y,N)                        T01LEDL := Y        ?><Enter>
Display Point Settings (maximum 60 characters):
(Boolean): Relay Word Bit Name, "Alias", "Set String", "Clear String"
(Analog) : Analog Quantity Name, "User Text and Formatting"
DISPLAY POINT DP01 (60 characters)
DP01    := IN101,"TRFR 1 HV BRKR:",CLOSED,OPEN
? <Enter>
DISPLAY POINT DP02 (60 characters)
DP02    := IN102,"TRFR 1 LV BRKR:",CLOSED,OPEN
? <Enter>

DISPLAY POINT DP03 (60 characters)
DP03    := IAV, "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 4.76 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 4.77*.

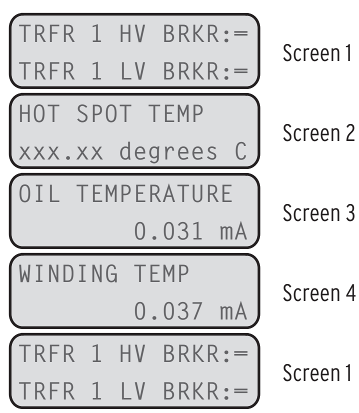


Figure 4.77 Rotating Display

To change the temperature units to more descriptive engineering units, enter the necessary 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 4.78* shows the settings to program the two local bits.

```
=>>SET F TERSE <Enter>
Front Panel
General Settings
DISPLY PTS ENABL (N,1-32)                     EDP     := 5        ? <Enter>
LOCAL BITS ENABL (N,1-32)                     ELB     := N        ? 2 <Enter>
LCD TIMEOUT (OFF,1-30 min)                    FP_TO   := 15       ? ><Enter>
.
.
.
Target LED Set
TRIP LATCH T_LED (Y,N)                        T01LEDL := Y        ? > <Enter>

Display Point Settings (maximum 60 characters):
(Boolean): Relay Word Bit Name, "Alias", "Set String", "Clear String"
(Analog) : Analog Quantity Name, "User Text and Formatting"

DISPLAY POINT DP01 (60 characters)
DP01    := IN101,"TRFR 1 HV BRKR:",CLOSED,OPEN
?> <Enter>

Local Bits Labels:
LB_ NAME (14 characters; Enter NA to null)
NLB01   :=
? SPERV SW <Enter>

CLEAR LB_ LABEL (7 characters; Enter NA to null)
CLB01   :=
? OPEN <Enter>

SET LB_ LABEL (7 characters; Enter NA to null)
SLB01   :=
? CLOSE <Enter>

PULSE LB_ LABEL (7 characters; Enter NA to null)
PLB01   :=
? NA <Enter>
```

Figure 4.78 Adding Two Local Bits (Sheet 1 of 2)

```
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 4.78 Adding Two Local Bits (Sheet 2 of 2)

Target LED Settings

The SEL-751A offers the following two types of LEDs. See *Figure 8.1* and *Figure 8.26* for the programmable LED locations:

- ➤ Six Target LEDs
- ➤ Eight Pushbutton LEDs

Your can program all 14 LEDs through the use of SELOGIC control equations, the only difference being that the Target LEDs also include a latch function.

Target LEDs

NOTE: If the LED latch setting (TnLEDL) is set to Y, and TRIP asserts, the LED latches to the state at TRIP assertion. The latched LED targets can be reset 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 4.68 Target LED Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
TRIP LATCH T_LED	Y, N	T01LEDL := Y
LED1 EQUATION	SELOGIC	T01_LED := ORED50T
TRIP LATCH T_LED	Y, N	T02LEDL := Y
LED2 EQUATION	SELOGIC	T02_LED := 51AT OR 51BT OR 51CT OR 51P1T OR 51P2T

Table 4.68 Target LED Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
TRIP LATCH T_LED	Y, N	T03LEDL := Y
LED3 EQUATION	SELOGIC	T03_LED := 51N1T OR 51G1T OR 51N2T OR 51G2T
TRIP LATCH T_LED	Y, N	T04LEDL := Y
LED4 EQUATION	SELOGIC	T04_LED := 51QT
TRIP LATCH T_LED	Y, N	T05LEDL := Y
LED5 EQUATION	SELOGIC	T05_LED := 81D1T OR 81D2T OR 81D3T OR 81D4T
TRIP LATCH T_LED	Y, N	T06LEDL := N
LED6 EQUATION	SELOGIC	T06_LED := (BFT OR T06_LED) AND NOT TRGTR

Pushbutton LEDs

Enter any of the Relay Word bits (or combinations of Relay Word bits) as conditions in the PB*p*_LED (*p* = 1A, 1B, . . . 4A, 4B) SELOGIC control equation settings. When these Relay Word bits assert, the corresponding LED also asserts. The following table shows the setting prompts, settings ranges, and default settings for the LEDs.

Table 4.69 Pushbutton LED Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PB1A_LED EQUATION	SELOGIC	PB1A_LED := 79RS
PB1B_LED EQUATION	SELOGIC	PB1B_LED := 79LO
PB2A_LED EQUATION	SELOGIC	PB2A_LED := NOT LT02 OR SV02 AND NOT SV02T AND SV05T
PB2B_LED EQUATION	SELOGIC	PB2B_LED := LT02 OR SV02 AND NOT SV02T AND SV05T
PB3A_LED EQUATION	SELOGIC	PB3A_LED := NOT LT02 AND NOT 52A
PB3B_LED EQUATION	SELOGIC	PB3B_LED := 52A OR SV03 AND NOT SV03T AND SV05T
PB4A_LED EQUATION	SELOGIC	PB4A_LED := 0
PB4B_LED EQUATION	SELOGIC	PB4B_LED := NOT 52A OR SV04 AND NOT SV04T AND SV05T

Report Settings (SET R Command)

The report settings use Relay Word bits for the SER trigger as shown in *Table 4.71* (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 4.70* shows the auto-removal settings.

Table 4.70 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 auto-deletion function via the SER settings. Any auto-deletion 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 4.71* shows the settings prompt and default settings for the four SER trigger equations.

Table 4.71 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 4.72 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 previously in the SER settings are displayed in the SER report. In addition, the Alias settings allow you to change the text displayed when a particular element is asserted and deasserted. The relay permits as many as 20 unique aliases, as defined by the Enable Alias Settings (EALIAS) setting. Factory-default alias settings are shown in *Table 4.73*.

Define the enabled alias settings by entering the Relay Word bit name, a space, the alias you want to use, 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 4.73 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

Table 4.74 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 cyc	LER := 15
PREFAULT LENGTH	1–59 cyc	PRE := 5

NOTE: Event report data stored in the relay will be lost when you change the LER setting, You must save the data before changing the setting.

Event reports can be either 15 cycles or 64 cycles in length as determined by the LER setting. For LER of 15, the prefault length, PRE, must be in the range 1–10. The relay can hold as many as seventy-seven 15-cycle event reports or nineteen 64-cycle event reports.

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 necessary acquisition rate for the report.

IMPORTANT: All stored load data are lost when you change the LDLIST setting.

Table 4.75 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 4.76 shows the available settings. See *Appendix D: DNP3 Communications* for additional details.

Table 4.76 DNP Map Settings[a] (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
DNP Binary Input Label Name	10 characters	BI_00 := ENABLED
DNP Binary Input Label Name	10 characters	BI_01 := TRIP_LED
DNP Binary Input Label Name	10 characters	BI_02 := TLED_01
DNP Binary Input Label Name	10 characters	BI_03 := TLED_02
• • •		
DNP Binary Input Label Name	10 characters	BI_99 := NA

Table 4.76 DNP Map Settings[a] (Sheet 2 of 2)

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

Table 4.77 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-751A Feeder Protection Relay includes metering functions to display the present values of current, voltage (if included), analog inputs (if included), and RTD measurements (with the external SEL-2600 RTD Module or an internal RTD card). The relay provides the following methods to read the present meter values:

- ➤ Front-panel rotating display
- ➤ Front-panel menu
- ➤ EIA-232 serial ports (using SEL ASCII text commands or ACSELERATOR QuickSet® SEL-5030 Software)
- ➤ Telnet via Ethernet port
- ➤ Modbus® via EIA-485 port or EIA-232 port
- ➤ Modbus TCP via Ethernet port
- ➤ DNP3 Serial via EIA-232 port or EIA-485 port
- ➤ DNP3 LAN/WAN via Ethernet port
- ➤ DeviceNet port
- ➤ Analog outputs
- ➤ IEC 61850 via Ethernet port
- ➤ C37.118 Synchrophasor Protocol via serial port

Feeder load monitoring and trending are possible through use of the Load Profile function. The relay automatically configures itself to save as many as 17 quantities (selected from the Analog Quantities) every 5, 10, 15, 30, or 60 minutes. The data are stored in nonvolatile memory. As many as 6500 time samples are stored.

Station DC Battery Monitor is available as an option in the SEL-751A relay. Refer to *Station DC Battery Monitor on page 5.13* for description and application details.

The Breaker Monitor feature is available in all SEL-751A relays. Refer to *Breaker Monitor on page 5.17* for description and application details.

Power Measurement Conventions

The SEL-751A uses the IEEE convention for power measurement. The implications of this convention are depicted in *Figure 5.1*.

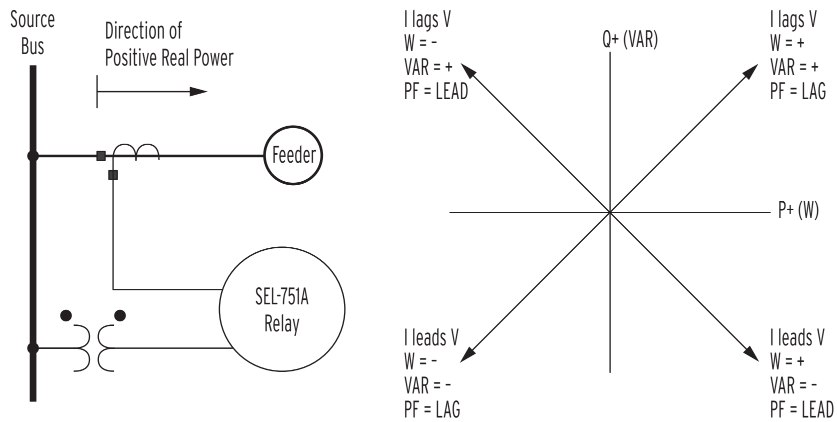

Figure 5.1 Complex Power Measurement Conventions

Metering

The SEL-751A 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)

Fundamental Metering

Table 5.1 details each of the fundamental meter data types in the SEL-751A. *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) Negative-Sequence Current (3I2) Current Imbalance %[a] System Frequency (Hz)
With Voltage Option (3AVI Card) (MOT …x71x…) OR With Voltage and Arc-Flash Detection Inputs Option (3 AVI/4 AFDI Card) MOT…x74x…)	VAB, VBC, VCA or VAN, VBN, VCN, VG magnitudes (V) and phase angles (deg) Average Voltage (L-L or L-N) Negative-Sequence (3V2) Voltage Imbalance % Real Power (kW)[b] Reactive Power (kVAR)[b] Apparent Power (kVA)[b] Power Factor[b]
With Enhanced Voltage Option With Monitoring Package (5 AVI Card) (MOT …x72x…) OR With Enhanced Voltage Option With Monitoring, Advanced Metering and Protection Packages (5AVI-A Card) (MOT …x73x…)	VAB, VBC, VCA or VAN, VBN, VCN, VG magnitudes (V) and phase angles (deg) Average Voltage (L-L or L-N) Negative-Sequence (3V2) Voltage Imbalance % Real Power (kW)[b] Reactive Power (kVAR)[b] Apparent Power (kVA)[b] Power Factor[b] VS (sync check voltage) magnitude (V) and phase angle (deg) VDC (station battery voltage) (V dc)

[a] Current Imbalance % = 0 when IAV ≤ 0.25 * INOM. 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 channels are not supported, or if VAB < 13 V (for delta-connected PT) or 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-751A 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*.

$$UBI\% = 100 \bullet \frac{Im}{Iav}$$

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*.

$$UBI\% = 100 \bullet \frac{Im}{I_{NOM}}$$

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 percent of the I_{NOM} current. Voltage Imbalance % is calculated in a similar manner.

The SEL-751A 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 currents

Vav = Magnitude of the average phase 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-751A                                    Date: 06/04/2008   Time: 09:29:35
FEEDER RELAY                                Time Source: Internal

                                IA       IB       IC       IN       IG
Current Magnitude (A pri.)   2395.3   2390.9   2395.8      0.0     25.7
Current Angle (deg)           -32.5   -152.2     88.3    129.7   -164.3

Ave Curr Mag    (A pri.)     2394.0

Neg-Seq Curr 3I2 (A pri.)       34.5
Current Imb (%)                  0.1

                      VA       VB       VC       VG       VS
Volt Mag (V pri.)  22222.6  22229.8  22237.5    322.9  22002.8
Volt Angle (deg)       0.0   -119.4    121.0   -112.9      1.3

Avg Phase (V pri.)           22230
Neg-Seq Volt 3V2 (V pri.)      326.1
Voltage Imb (%)                  0.0

                             A              B              C             3P
Real Pwr (kW)             44886          44660          44858         134404
Reactive Pwr (kVAR)       28611          28815          28741          86168
Apparent Pwr (kVA)        53229          53149          53276         159654
Pwr Factor                    0.84           0.84           0.84           0.84
                             LAG            LAG            LAG            LAG

Frequency (Hz)   60.0

VDC (V)    125.0

=>>
```

Figure 5.2 METER Command Report With Enhanced Voltage Option With Monitoring Package

NOTE: Calculated phase-to-phase voltages for wye-connected PTs are available in the analog quantities and can be selected as display points. See Appendix K: Analog Quantities.

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-751A                                  Date: 12/05/2008   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-751A with the voltage option 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-751A                                  Date: 12/01/2008   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 = 11/09/2008 03:54:34

=>
```

Figure 5.4 Device Response to the METER E Command

To reset energy meter values, issue the **METER RE** command as shown in *Figure 5.5*.

```
=>>MET RE <Enter>
Reset Metering Quantities (Y,N)? Y <Enter>
Reset Complete
=>>
```

Figure 5.5 Device Response to the METER RE Command

Energy metering values are stored to nonvolatile memory four times per day and within one minute of the energy metering values being reset.

Maximum and Minimum Metering

Maximum and minimum metering allows you to determine maximum and minimum operating quantities such as currents, voltages, power, analog input quantities, RTD quantities and frequency. *Table 5.4* lists the max/min metering quantities.

Table 5.4 Maximum/Minimum Meter Values

Relay Option	Max/Min Meter Values
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 system frequency (Hz)
With Voltage Option	V_{AB}, V_{BC}, V_{CA} or V_{AN}, V_{BN}, V_{CN}, and V_S (if ordered) magnitudes (V) Maximum and minimum real, reactive and apparent 3-phase power (kW, kVAR, kVA)
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 these values occurred. The analog quantities from *Table 5.4* are checked approximately every 0.5 seconds and, if a new maximum or minimum value occurs, this value is saved along with the date and time that the maximum or minimum value occurred. Maximum and minimum values are only checked if relay element FAULT is deasserted (no fault condition exists) for at least one second.

Additionally, the following minimum thresholds must also be met:

- 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 all must exceed their thresholds.
- Voltage 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 exceed their thresholds.

Figure 5.6 shows an example device response to the **METER M** command.

```
=>>MET M <Enter>

SEL-751A                                  Date: 12/02/2008   Time: 15:46:02
FEEDER RELAY                              Time Source: External

                  MAX       DATE       TIME       MIN        DATE       TIME
IA (A)           1005.8  12/02/2008  15:41:43       19.8  11/09/2008  03:55:41
IB (A)           1097.1  12/02/2008  15:41:26      197.3  11/16/2008  11:41:10
IC (A)            972.7  12/02/2008  15:45:11      206.0  11/16/2008  11:40:47
IN (A)              0.5  11/11/2008  18:20:00        0.4  11/16/2008  11:39:43
IG (A)            155.9  12/02/2008  15:42:32        0.4  11/12/2008  00:31:39
VAB (V)          6650.4  12/02/2008  15:45:45     6647.4  12/02/2008  15:41:14
VBC (V)          6671.9  12/02/2008  15:42:56     6666.8  12/02/2008  15:39:54
VCA (V)          7505.1  12/02/2008  15:41:05     7502.9  12/02/2008  15:45:42
VS (V)           6741.4  12/02/2008  15:45:11     6647.4  12/02/2008  15:41:14
KW3P (kW)        7797.2  11/11/2008  13:45:15   -11108    12/02/2008  15:41:42
KVAR3P (kVAR)    5031.8  12/02/2008  15:42:49    -1396.3  12/02/2008  15:45:24
KVA3P (kVA)     12187    12/02/2008  15:41:42      608.1  11/16/2008  11:42:27
FREQ (Hz)          60.1  11/16/2008  11:36:54       60.0  12/02/2008  15:45:23

LAST RESET = 11/09/2008 03:54:34

=>>
```

Figure 5.6 Device Response to the METER M Command

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 Device Response to the METER RM Command

All maximum and minimum metering values are stored to nonvolatile memory four times per day and within one minute of the maximum and minimum metering values being reset.

Math Variable Metering

The SEL-751A includes 32 math variables. When you receive your SEL-751A, 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-751A                                    Date: 04/17/2007   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 Device Response to the METER MV Command

RMS Metering

The SEL-751A 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 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-751A                                    Date: 12/02/2008   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 Device Response to the METER RMS Command

Analog Input Metering

The SEL-751A 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. These values can then be used 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-751A                                  Date: 11/28/2007   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 Device Response to the METER AI Command

Arc-Flash Light Intensity Metering

When the SEL-751A is ordered with the arc-flash detection (AFD) option (order the 3 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-751A                                  Date: 12/01/2008   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 Device Response to the METER L (Light) Command

Demand Metering

The SEL-751A 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 4.70* for detailed descriptions and settings selection.

Table 5.6 Demand Values (Sheet 1 of 2)

Relay Option	Demand/Peak Demand Values
All models with voltage card options 73, 74, 75, 76	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)

Table 5.6 Demand Values (Sheet 2 of 2)

Relay Option	Demand/Peak Demand Values
	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 of single-phase kilovars kVARA, B, C (wye-connected voltage inputs only) Demand/peak demand value of three-phase kilovars, kVAR3P

```
=>>MET DE <Enter>

SEL-751A                                  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 Device Response to the MET DE Command

```
=>>MET PE <Enter>

SEL-751A                                  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 Device Response to the MET PE Command

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

The **METER PM** serial port ASCII command can be used to view the SEL-751A 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, 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-751A is in the IRIG timekeeping mode, as indicated by Relay Word bit TSOK = logical 1. *Table 5.7* below, shows the measured values for the **METER PM** Command. *Table 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-751A 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.

Table 5.7 Synchrophasor Measured Values

Relay Option	Meter Values
All Models	Currents: IA, IB, IC, IN, I1 (positive-sequence current) magnitudes (A primary) and phase angles (deg)
Digitals	TSOK and SV17–SV32 Relay Word Bit status
Analogs	MV29–MV32 Math Variables[a]
	System Frequency (Hz)
	Rate-of-change of Frequency (Hz/Second)
Additional Data With Voltage Option	Voltage phasors: VA, VB, VC, VS (if available), and V1 (positive-sequence voltage), magnitudes (V or kV) and phase angles (deg)

[a] These data are calculated every 100 ms. Only the data that occur at the "Top of the Second" will be used for METER PM responses.

Small Signal Cutoff for Metering

The relay applies a threshold to the voltage and current magnitude metering quantities to force a reading to zero when the measurement is near zero. The threshold for fundamental metering current values is 0.01 • INOM A (secondary) and for voltage values is 0.1 V (secondary). The threshold for rms metering current values is 0.03 • INOM A (secondary) and for voltage values is 0.3 V (secondary).

Load Profiling

The SEL-751A 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 4.120*). 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 6,500 time-stamped entries. For example, if you choose to monitor 10 values at a rate of every 15 minutes, you could store 41.67 days worth of data.

Download the load rate profile data using the serial port **LDP** command described in *LDP Command (Load Profile Report) on page 7.31*. *Figure 5.14* shows an example **LDP** serial port command response.

```
=>LDP <Enter>

SEL-751A                                   Date: 02/21/2007   Time: 13:07:02
FEEDER RELAY                               Time Source: Internal

#     DATE         TIME          IAV       VAVE        P          PF
20  02/21/2007  11:31:24.468    277.636   13823.97   5908.951     0.889
19  02/21/2007  11:36:24.301    278.050   13824.34   5920.197     0.889
18  02/21/2007  11:41:24.035    278.012   13819.86   5920.606     0.890
17  02/21/2007  11:46:24.623    277.661   13824.90   5912.636     0.889
16  02/21/2007  11:51:24.885    278.072   13821.30   5922.041     0.890
15  02/21/2007  11:56:23.873    277.917   13821.33   5914.892     0.889
14  02/21/2007  12:01:23.923    277.630   13821.01   5907.527     0.889
13  02/21/2007  12:06:24.010    278.048   13821.97   5917.934     0.889
12  02/21/2007  12:11:24.140    277.988   13824.35   5917.830     0.889
11  02/21/2007  12:16:24.290    277.780   13820.97   5918.148     0.890
10  02/21/2007  12:21:24.203    277.740   13819.82   5920.595     0.891
9   02/21/2007  12:26:24.507    277.256   13823.17   5907.525     0.890
8   02/21/2007  12:31:24.332    277.973   13822.21   5921.495     0.890
7   02/21/2007  12:36:24.541    277.740   13819.83   5916.932     0.890
6   02/21/2007  12:41:24.791    288.393   13819.60   6593.658     0.955
5   02/21/2007  12:46:24.720    288.589   13820.86   6844.973     0.991
4   02/21/2007  12:51:23.816    288.547   13822.20   6843.819     0.991
3   02/21/2007  12:56:24.174    288.246   13821.41   6838.310     0.991
2   02/21/2007  13:01:24.750    288.232   13823.61   6835.954     0.991
1   02/21/2007  13:06:24.658    288.709   13820.80   6847.213     0.991

=>
```

Figure 5.14 Device Response to the LDP Command

Station DC Battery Monitor

The station dc battery monitor in the SEL-751A 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 enhanced voltage option with monitoring package that includes the 5AVI card in slot E of the relay. The monitor measures the station dc battery voltage applied to the rear-panel terminals labeled E7 (VBAT+) and E8 (VBAT-). The station dc battery monitor settings (DCLOP and DCHIP) are available via the **SET G** command (see *Table 5.8* and *Global Settings (SET G Command) on page SET.26*).

DC Under- and Overvoltage Elements

Table 5.8 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 5.15*. 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-751A 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-751A 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.

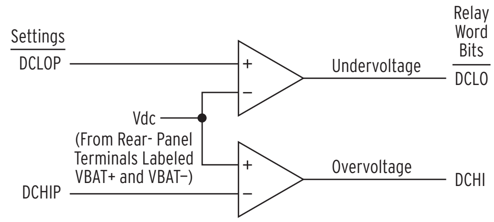

Figure 5.15 DC Under- and Overvoltage Elements

Logic outputs DCLO and DCHI in *Figure 5.15* 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 Necessary Logic for DC Under- and Overvoltage Alarming

Pickup settings DCLOP and DCHIP are set independently. Thus, you can set these as follows:

DCLOP < DCHIP or DCLOP > DCHIP

Figure 5.16 shows the resultant dc voltage elements that you can create 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.

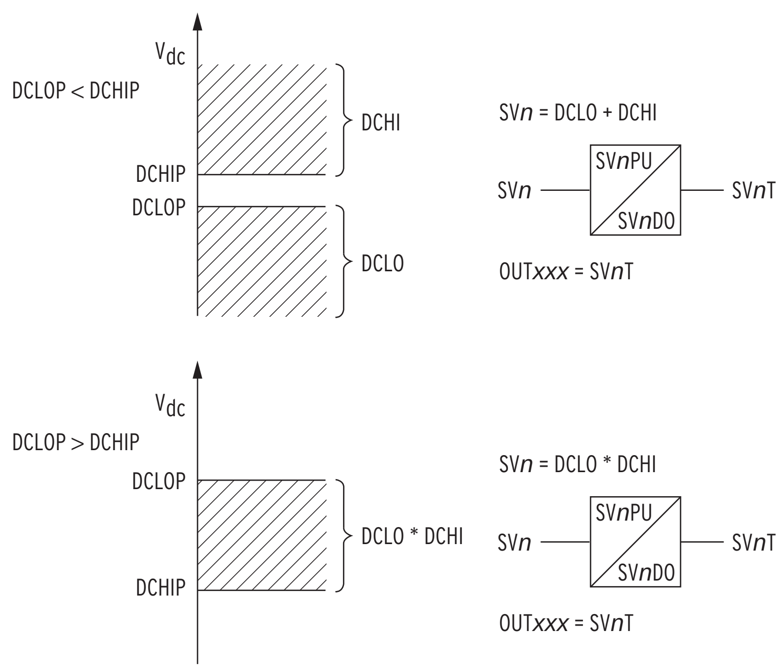

Figure 5.16 Create DC Voltage Elements With SELOGIC Control Equations

DCLO < DCHI (Top of Figure 5.16)

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 is 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 5.16*), 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 5.16* would probably be a better choice—see following discussion.

DCLO > DCHI (Bottom of Figure 5.16)

Output contact OUT*xxx* asserts when:

DCHIP ≤ V_{dc} ≤ 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 5.16*), 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 not just for alarming, but also 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 5.16*. 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*. You can observe changes in station dc battery voltage for an event (e.g., circuit breaker tripping). 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 4.33*). For example, output contact OUT103 is set to trip:

OUT103 = **TRIP**

Anytime output contact OUT103 closes and energizes the circuit breaker trip coil, you can observe any dip in station dc battery voltage 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, you can observe any dip in station dc battery voltage in column Vdc in the event report.

Station DC Battery Voltage Dips During Circuit Breaker Closing

To generate an event report when the SEL-751A 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 4.34*)

Anytime output contact **OUT102** closes and energizes the circuit breaker close coil, you can observe any dip in station dc battery voltage 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 5.16*. 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-751A helps in scheduling circuit breaker maintenance. The breaker monitor is enabled with the enable setting:

EBMON = **Y**

The breaker monitor settings in *Table 5.10* 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 5.9* is plotted in *Figure 5.17*.

Table 5.9 Breaker Maintenance Information for a 25 kV Circuit Breaker

Current Interruption Level (kA)	Permissible Number of Close/Open Operations[a]
0.00–1.20	10,000
2.00	3,700
3.00	1,500
5.00	400
8.00	150
10.00	85
20.00	12

[a] The action of a circuit breaker closing and then later opening is counted as **one** close/open operation.

Connect the plotted points in *Figure 5.17* for a breaker maintenance curve. To estimate this breaker maintenance curve in the SEL-751A 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 5.10*.

Table 5.10 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 5.9* and *Figure 5.17*. *Figure 5.18* shows the resultant breaker maintenance curve.

COSP1 = **10000**

COSP2 = **150**

COSP3 = **12**

KASP1 = **1.20**

KASP2 = **8.00**

KASP3 = **20.00**

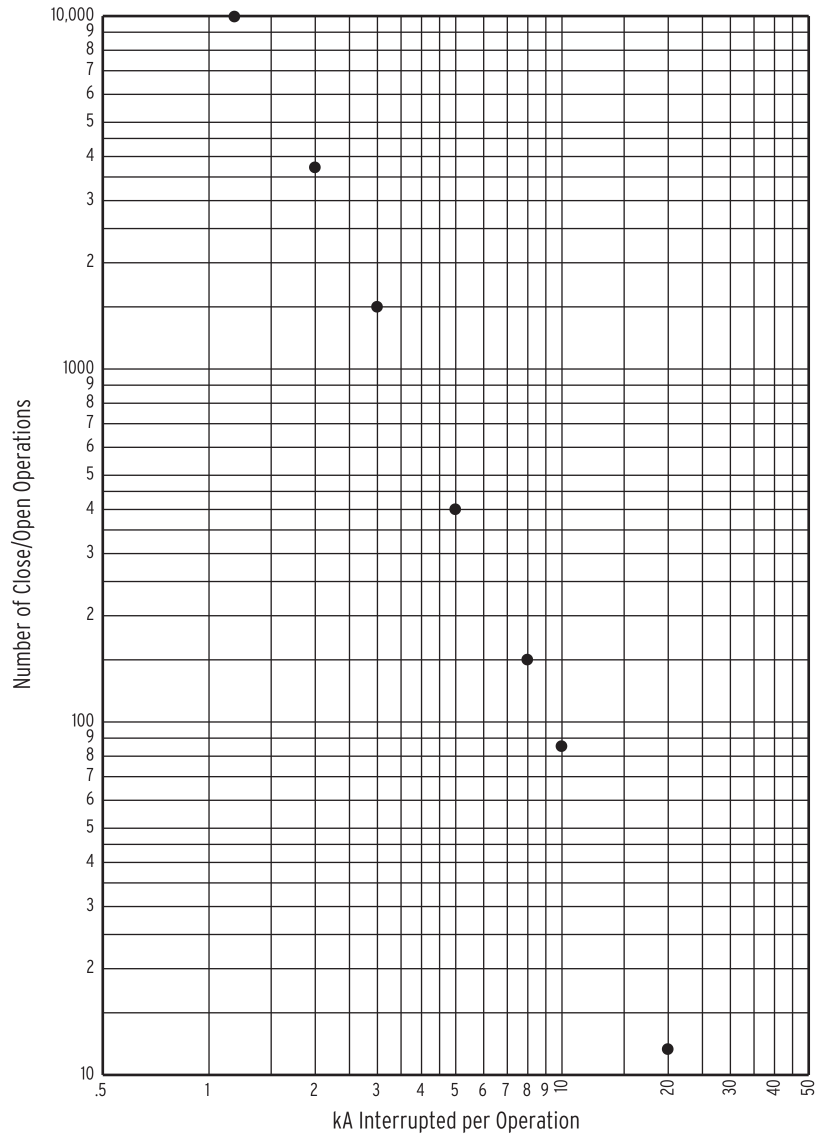

Figure 5.17 Plotted Breaker Maintenance Points for a 25 kV Circuit Breaker

Breaker Maintenance Curve Details

In *Figure 5.18*, note that set points KASP1, COSP1 and KASP3, COSP3 are set with breaker maintenance information from the two extremes in *Table 5.9* and *Figure 5.17*.

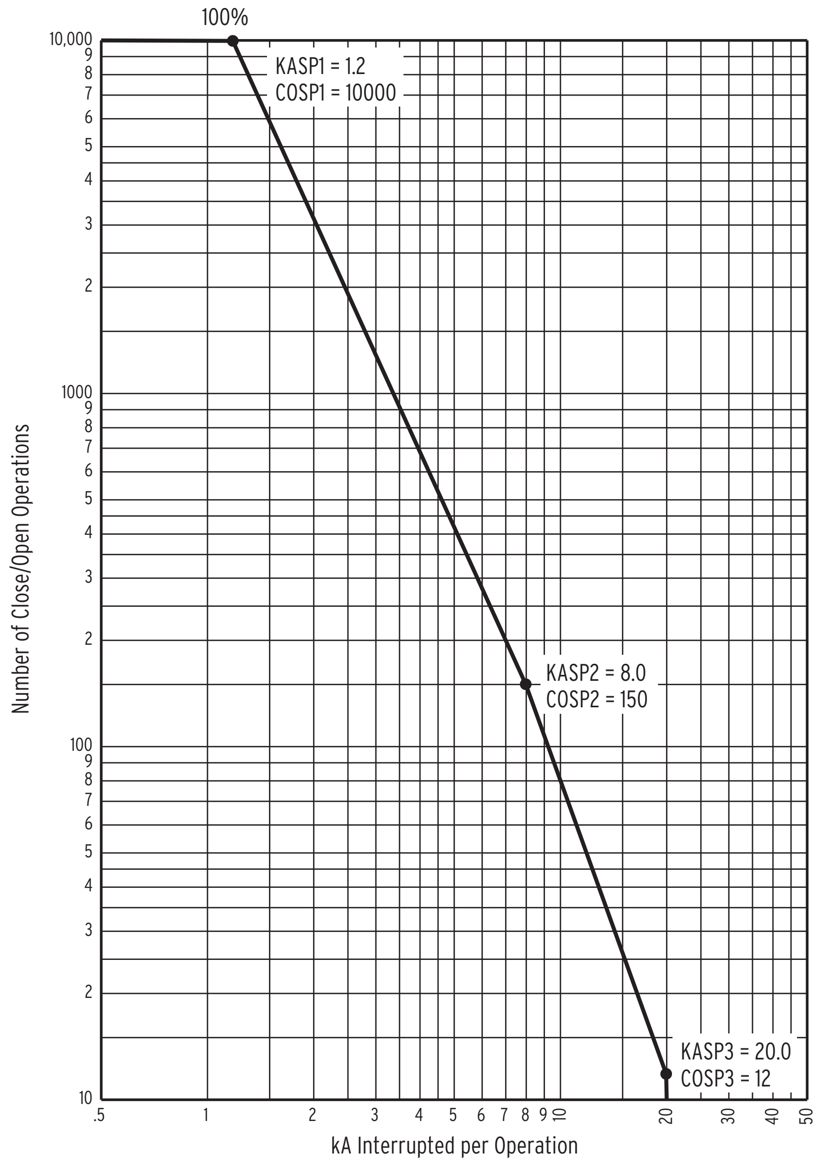

Figure 5.18 SEL-751A Breaker Maintenance Curve for a 25 kV Circuit Breaker

In this example, set point KASP2, COSP2 happens to be from an in-between breaker maintenance point in the breaker maintenance information in *Table 5.9* and *Figure 5.17*, 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 5.17*.

Each phase (A, B, and C) has its own breaker maintenance curve (like that in *Figure 5.18*), 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 5.18*, 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 5.10* determines when the breaker monitor reads in current values (Phases A, B, and C) for the breaker maintenance curve (see *Figure 5.18*) 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 4.33*)

Refer to *Figure 5.19*. When BKMON asserts (Relay Word bit TRIP goes from logical 0 to logical 1), the breaker monitor reads in the current values and applies these values to the breaker monitor maintenance curve and the breaker monitor accumulated currents/trips.

As detailed in *Figure 5.19*, the breaker monitor actually reads in the current values 1.5 cycles after the assertion of BKMON. This helps especially if an instantaneous trip occurs. The instantaneous element trips when the fault current reaches its pickup setting level. The fault current can still be “climbing” to its full value, at which it levels off. The 1.5-cycle delay on reading in the current values allows time for the fault current to level off.

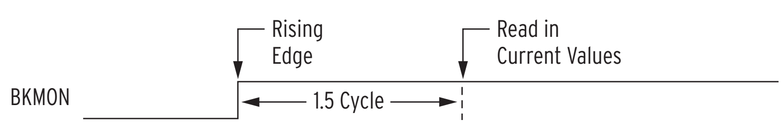

Figure 5.19 Operation of SELOGIC Control Equation Breaker Monitor Initiation Setting

See *Figure 5.24* and accompanying text for more information on setting BKMON. 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 5.20–Figure 5.23*. 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 5.20–Figure 5.23*) that the interrupted current in a given figure is the same magnitude for all the interruptions (e.g., in *Figure 5.21*, 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 5.20*. 7.0 kA is interrupted 20 times (20 close/open operations = 20 – 0), pushing the breaker maintenance curve from the 0 percent wear level to the 10 percent wear level.

Compare the 100 percent and 10 percent curves 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.

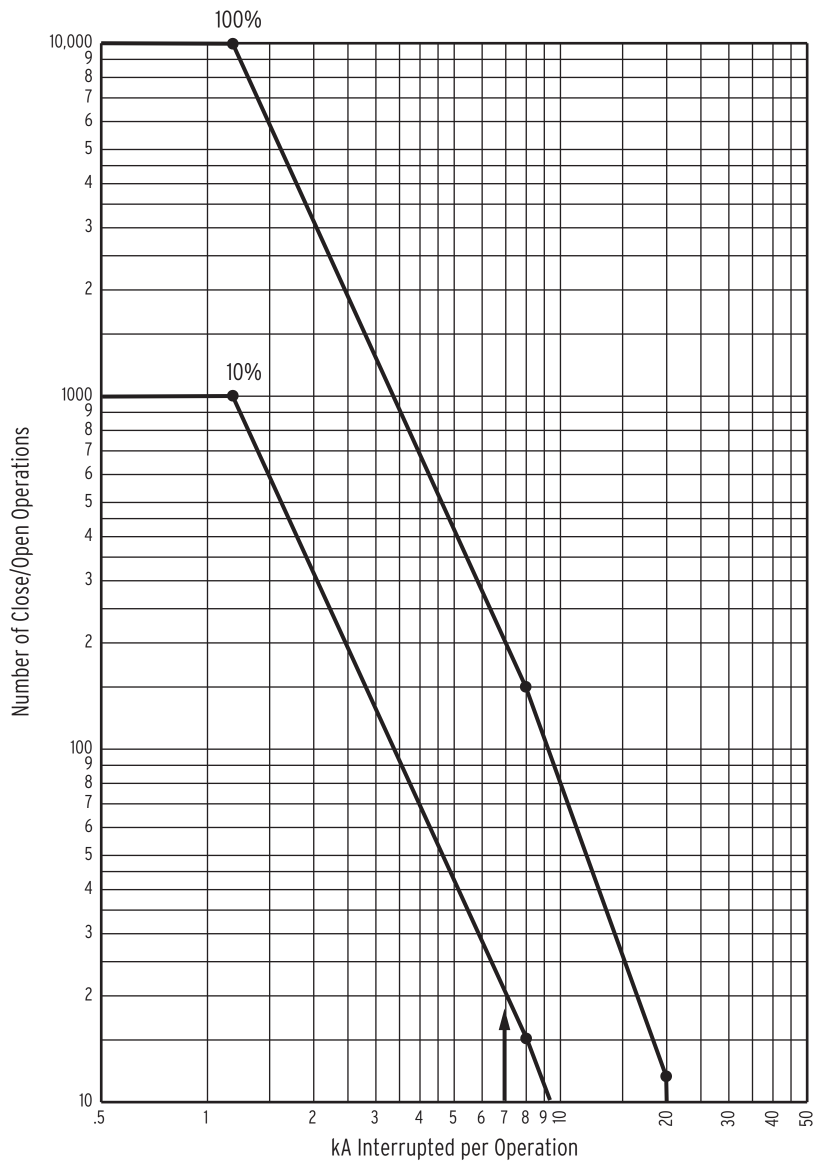

Figure 5.20 Breaker Monitor Accumulates 10 Percent Wear

10 Percent to 25 Percent Breaker Wear

Refer to *Figure 5.21*. The current value changes from 7.0 kA to 2.5 kA. 2.5 kA is interrupted 290 times (290 close/open operations = 480 – 190), pushing the breaker maintenance curve from the 10 percent wear level to the 25 percent wear level.

Compare the 100 percent and 25 percent curves 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.

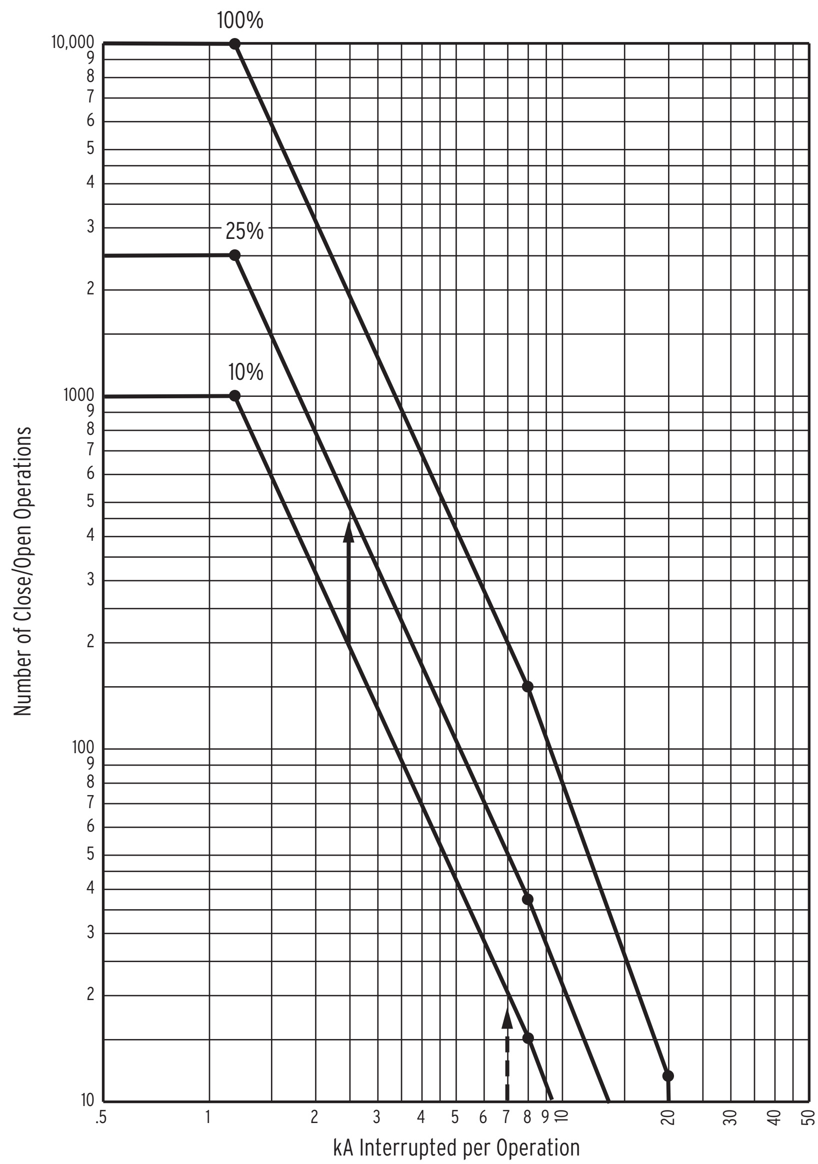

Figure 5.21 Breaker Monitor Accumulates 25 Percent Wear

25 Percent to 50 Percent Breaker Wear

Refer to *Figure 5.22*. The current value changes from 2.5 kA to 12.0 kA. 12.0 kA is interrupted 11 times (11 close/open operations = 24 – 13), pushing the breaker maintenance curve from the 25 percent wear level to the 50 percent wear level.

Compare the 100 percent and 50 percent curves 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.

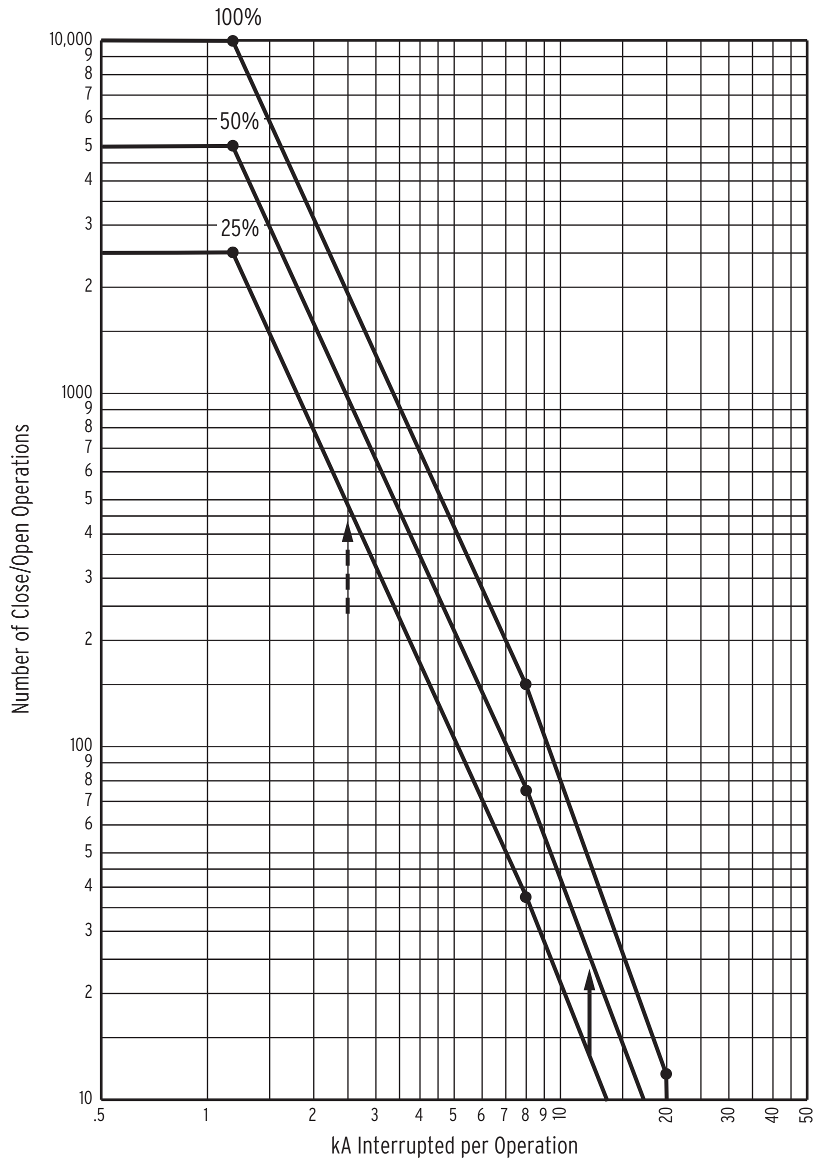

Figure 5.22 Breaker Monitor Accumulates 50 Percent Wear

50 Percent to 100 Percent Breaker Wear

Refer to *Figure 5.23*. The current value changes from 12.0 kA to 1.5 kA. 1.5 kA is interrupted 3000 times (3000 close/open operations = 6000 – 3000), pushing the breaker maintenance curve from the 50 percent wear level to the 100 percent wear level.

When the breaker maintenance curve reaches 100 percent for a particular phase, the percentage wear remains at 100 percent (even if additional current is interrupted), until reset by the **BRE R** command (see *View or Reset Breaker Monitor Information on page 5.26*). But the current and trip counts continue to be accumulated until the **BRE R** command resets these counts.

Additionally, logic outputs assert for alarm or other control applications—see the following discussion.

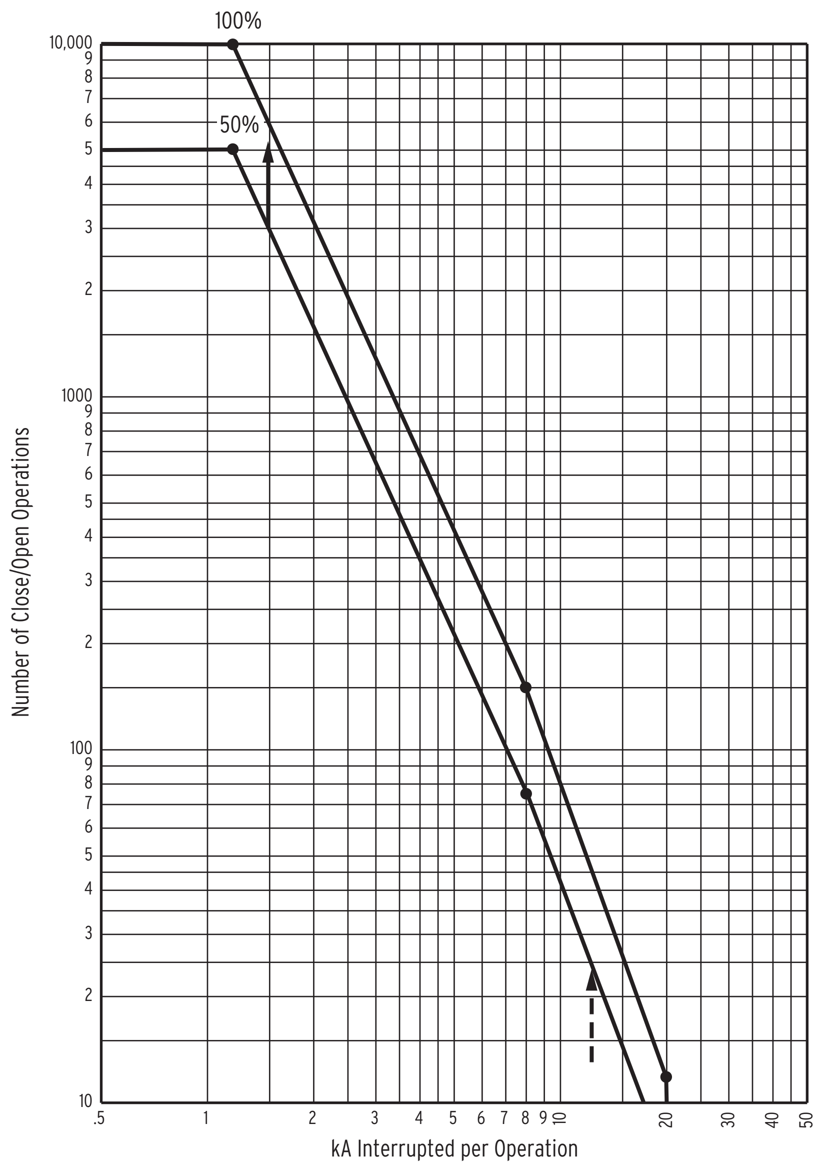

Figure 5.23 Breaker Monitor Accumulates 100 Percent Wear

Breaker Monitor Output

When the breaker maintenance curve for a particular phase (A, B, or C) reaches the 100 percent wear level (see *Figure 5.23*), 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

You can use these logic outputs to alarm:

OUTxxx = **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 are determined by the status of the TRIP Relay Word bit when the SELOGIC control equation breaker monitor initiation setting BKMON operates.

Refer to *Figure 5.19* 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 relay checks the status of the TRIP Relay Word bit at the instant BKMON newly asserts (TRIP is the logic output of *Figure 4.33*). 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 5.19–Figure 5.23*).

Relay-initiated trips (Rly Trips) are also referred to as **internally initiated trips** (Int Trips) in the course of this manual; the terms are interchangeable.

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 5.24. 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.

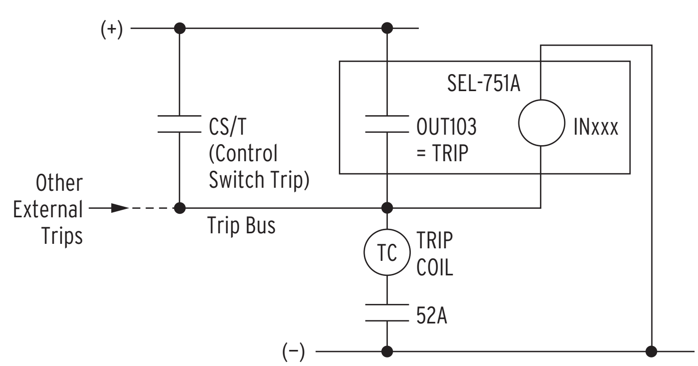

Figure 5.24 Input INxxx Connected to Trip Bus for Breaker Monitor Initiation

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

BKMON = **INxxx**

then the SEL-751A 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).

Section 6
Settings

Overview

The SEL-751A 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-751A Settings Sheets* at the end of this section list all SEL-751A 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-751A 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:

NOTE: Each SEL-751A is shipped with default factory settings. Calculate the settings for your application to ensure secure and dependable protection. Document the settings on the SEL-751A Settings Sheets at the end of this section before entering new settings in the relay.

```
Save Changes?
Yes   No
```

Select and enter the appropriate command by pushing the **ENT** pushbutton. Select `Yes` to save the settings changes and `No` to discard the changes.

Figure 6.1 shows a front-panel menu navigation example for the relay to enter the `PHASE PT RATIO, PTR` setting.

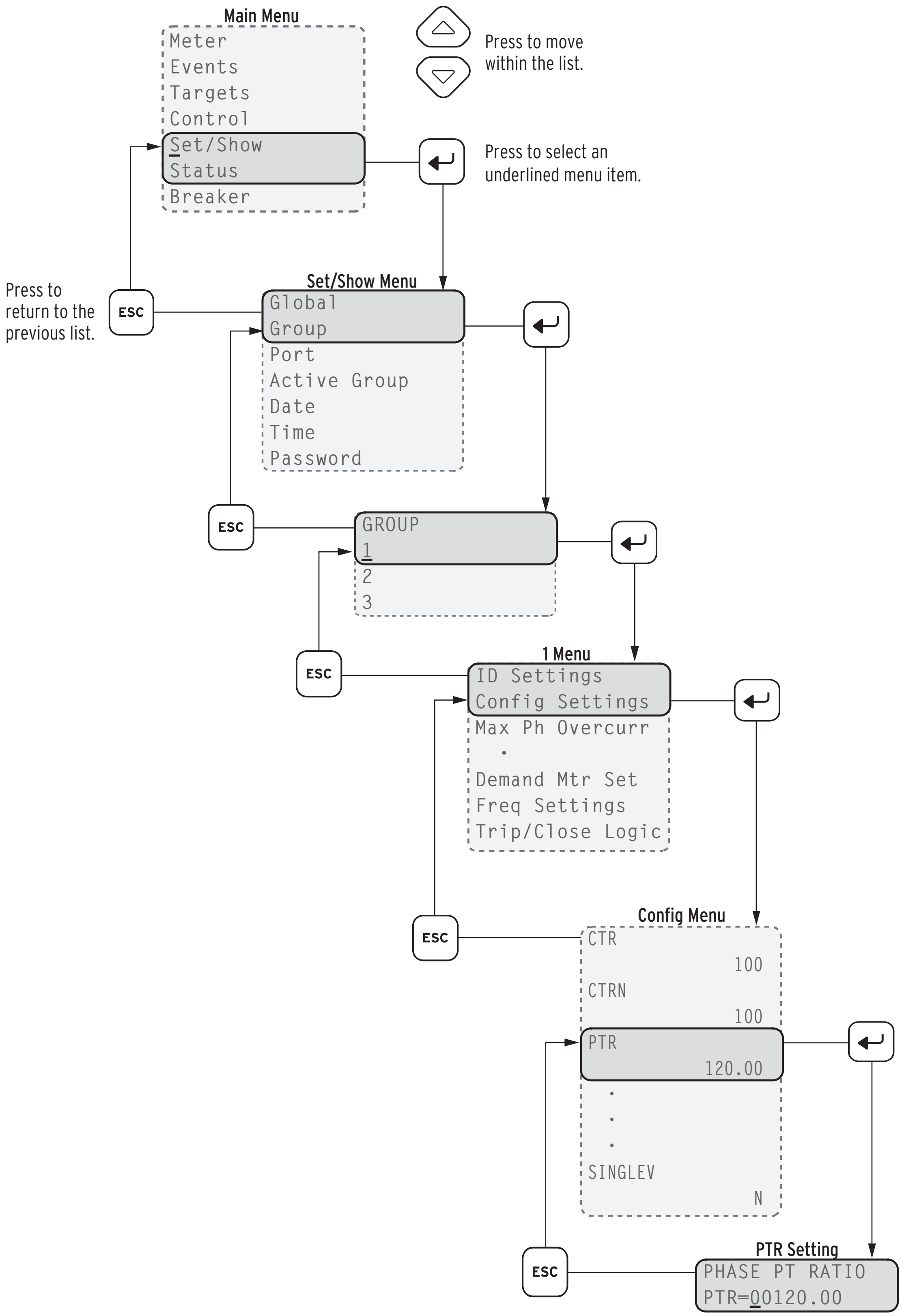

Figure 6.1 Front-Panel Setting Entry Example

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 to which you want to jump 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 settings entered against the ranges for the settings 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.

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SEL-751A 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 SEL-751A Model Option Table, *Table 1.1*, and notes with the settings below for details.)
- Some of the settings ranges can 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**	:= ________
IG (residual) SOURCE (MEAS, CALC) *(Hidden if Voltage Card Option is Not xx75xx or xx76xx, see Table 1.1)*	**IG_SRC**	:= ________
RESIDU CT RATIO (*Hidden if Voltage Card Option is Not xx75xx or xx76xx (see Table 1.1); OR IG_SRC := CALC)*	**CTRG**	: = ________
PHASE PT RATIO (1.00–10000.00) *(Hidden if voltages not included)*	**PTR**	:= ________
SYNCV PT RATIO (1.00–10000.00) (*Hidden if sync voltage not included*)	**PTRS**	:= ________
XFMR CONNECTION (WYE, DELTA) *(Hidden if voltages not included)*	**DELTA_Y**	:= ________
LINE VOLTAGE (20–250 {if DELTA_Y := DELTA}, 20–440 {if DELTA_Y := WYE}) *(Hidden if voltages not included)*	**VNOM**	:= ________
SINGLE V INPUT *(Y, N) (Hidden if voltages not included)*	**SINGLEV**	:= ________

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 (0.00–5.00 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 (0.00–5.00 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 (0.00–5.00 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 (0.00–5.00 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}, 0.13–12.50 mA {2.5 mA nom}, 5.0–1000.0 mA {50 mA nom})	**50N1P**	:=
NEUT OC TRIP DLY (0.00–5.00 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}, 0.13–12.50 mA {2.5 mA nom}, 5.0–1000.0 mA {50 mA nom})	**50N2P**	:=
NEUT OC TRIP DLY (0.00–5.00 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}, 0.13–12.50 mA {2.5 mA nom}, 5.0–1000.0 mA {50 mA nom})	**50N3P**	:=
NEUT OC TRIP DLY (0.00–5.00 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}, 0.13–12.50 mA {2.5 mA nom}, 5.0–1000.0 mA {50 mA nom})	**50N4P**	:=
NEUT OC TRIP DLY (0.00–5.00 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 (0.00–5.00 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 (0.00–5.00 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 (0.00–5.00 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 (0.00–5.00 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 (0.1–120.0 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 (0.1–120.0 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 (0.1–120.0 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 (0.1–120.0 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_}, 0.05–1.00 {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_}, 0.05–1.00 {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_}, 0.05–1.00 {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_}, 0.05–1.00 {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_}, 0.05–1.00 {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_}, 0.05–1.00 {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, 0.50–16.00 A {5 A nom.}, 0.10–3.20 A {1 A nom.}, 0.13–2.00 mA {2.5 mA nom.}, 5.0–160.0 mA {50 mA 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_}, 0.05–1.00 {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, 0.50–16.00 A {5 A nom.}, 0.10–3.20 A {1 A nom.}, 0.13–2.00 mA {2.5 mA nom.}, 5.0–160.0 mA {50 mA 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_}, 0.05–1.00 {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_}, 0.05–1.00 {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_}, 0.05–1.00 {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**	:=

RTD (Hidden if RTD card and PORT 2 not included)

RTD ENABLE (INT, EXT, NONE) *(All RTD settings below Hidden if E49RTD := NONE)*	**E49RTD**	:=
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

(All or some of the settings below are hidden if the appropriate voltage card option is not included, see **Table 1.1**)

UV TRIP1 LEVEL (OFF, 0.02–1.00 xVnm)	**27P1P**	:=
UV TRIP1 DELAY (0.0–120.0 sec) *(Hidden if 27P1P := OFF)*	**27P1D**	:=
UV TRIP2 LEVEL (OFF, 0.02–1.00 xVnm)	**27P2P**	:=

UV TRIP2 DELAY (0.0–120.0 sec) *(Hidden if 27P2P := OFF)*	**27P2D**	:=
UVS LEVEL 1 (OFF, 2.00–300.00 V)	**27S1P**	:=
UVS DELAY 1 (0.0–120.0 sec) *(Hidden if 27S1P := OFF)*	**27S1D**	:=
UVS LEVEL 2 (OFF, 2.00–300.00 V)	**27S2P**	:=
UVS DELAY 2 (0.0–120.0 sec) *(Hidden if 27S2P := OFF)*	**27S2D**	:=

Overvoltage

(All or some of the settings below are hidden if the appropriate voltage card option is not included, see Table 1.1)

OV TRIP1 LEVEL (OFF, 0.02–1.20 xVnm)	**59P1P**	:=
OV TRIP1 DELAY (0.0–120.0 sec) *(Hidden if 59P1P := OFF)*	**59P1D**	:=
OV TRIP2 LEVEL (OFF, 0.02–1.20 xVnm)	**59P2P**	:=
OV TRIP2 DELAY (0.0–120.0 sec) *(Hidden if 59P2P := OFF)*	**59P2D**	:=
ZS OV TRIP1 LVL (OFF, 0.02–1.20 xVnm) *(Hidden if DELTA Y := DELTA)*	**59G1P**	:=
ZS OV TRIP1 DLY (0.0–120.0 sec) (*Hidden if 59G1P := OFF*)	**59G1D**	:=
ZS OV TRIP2 LVL (OFF, 0.02–1.20 xVnm) *(Hidden if DELTA Y := DELTA)*	**59G2P**	:=
ZS OV TRIP2 DLY (0.0–120.0 sec) (*Hidden if 59G2P := OFF*)	**59G2D**	:=
NSQ OV TRIP1 LVL (OFF, 0.02–1.20 xVnm)	**59Q1P**	:=
NSQ OV TRIP1 DLY (0.0–120.0 sec) (*Hidden if 59Q1P := OFF*)	**59Q1D**	:=
NSQ OV TRIP2 LVL (OFF, 0.02–1.20 xVnm)	**59Q2P**	:=
NSQ OV TRIP2 DLY (0.0–120.0 sec) (*Hidden if 59Q2P := OFF*)	**59Q2D**	:=
OVS LEVEL 1 (OFF, 2.00–300.00 V)	**59S1P**	:=
OVS DELAY 1 (0.0–120.0 sec) *(Hidden if 59S1P := OFF)*	**59S1D**	:=
OVS LEVEL 2 (OFF, 2.00–300.00 V)	**59S2P**	:=
OVS DELAY 2 (0.0–120.0 sec) *(Hidden if 59S2P := OFF)*	**59S2D**	:=

Synchronism Check

(Hidden if voltage card option with VS input 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**	:=	________

Power Factor

(Hidden if voltage card option not included)

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, 20.00–70.00 Hz)	**81D1TP**	:=	________
FREQ1 TRIP DELAY (0.00–240.00 sec) *(Hidden if 81D1TP := OFF)*	**81D1TD**	:=	________
FREQ2 TRIP LEVEL (OFF, 20.00–70.00 Hz)	**81D2TP**	:=	________
FREQ2 TRIP DELAY (0.00–240.00 sec) *(Hidden if 81D2TP := OFF)*	**81D2TD**	:=	________
FREQ3 TRIP LEVEL (OFF, 20.00–70.00 Hz)	**81D3TP**	:=	________
FREQ3 TRIP DELAY (0.00–240.00 sec) *(Hidden if 81D3TP := OFF)*	**81D3TD**	:=	________
FREQ4 TRIP LEVEL (OFF, 20.00–70.00 Hz)	**81D4TP**	:=	________
FREQ4 TRIP DELAY (0.00–240.00 sec) *(Hidden if 81D4TP := OFF)*	**81D4TD**	:=	________
FREQ5 TRIP LEVEL (OFF, 20.00–70.00 Hz)	**81D5TP**	:=	________
FREQ5 TRIP DELAY (0.00–240.00 sec) *(Hidden if 81D5TP := OFF)*	**81D5TD**	:=	________
FREQ6 TRIP LEVEL (OFF, 20.00–70.00 Hz)	**81D6TP**	:=	________
FREQ6 TRIP DELAY (0.00–240.00 sec) *(Hidden if 81D6TP := OFF)*	**81D6TD**	:=	________

Rate-of-Change-of-Frequency

(Hidden if the appropriate voltage card option is not included, see Table 1.1)

ENABLE 81R (OFF,1–4) *(All Rate-of-Change-of-Frequency settings below Hidden if E81R := NONE)*	**E81R**	:= ________
81R VOLTAGE SUP (OFF,0.1–1.3 xVnm)	**81RVSUP**	:= ________
81R CURRENT SUP (OFF,0.1–2.0 xI_{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)	**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)	**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)	**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)

(Hidden if the appropriate voltage card option is not included, see Table 1.1)

ENABLE 81RF (Y, N) *(All Fast Rate-of-Change-of-Frequency settings below Hidden if E81RF := N)*	**E81RF**	:= ________
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, 0.2–1.0 x Vnm)	**81RFVBLK**	:= ________
81RF CURRENT BLK (OFF, 0.1–20 x INOM)	**81RFIBLK**	:= ________
81RF BLOCK (SELOGIC)	**81RFBL**	:= ________
81RF BLOCK DO (0.02–5.00 sec)	**81RFBLDO**	:= ________

Demand Metering

(Hidden if the appropriate voltage card option is not included, see Table 1.1)

ENABLE DEM MTR (THM,ROL)	**EDEM**	:= ____________
DEM TIME CONSTNT (5, 10, 15, 30, 60 min)	**DMTC**	:= ____________
PH CURR DEM LVL (OFF, 0.50–16.00 A {5 A nom}, 0.10–3.20 A {1 A nom})	**PHDEMP**	:= ____________
RES CURR DEM LVL (OFF,0.50–16.00 A {5 A nom}, 0.10–3.20 A {1 A nom})	**GNDEMP**	:= ____________
3I2 CURR DEM LVL (OFF,0.50–16.00 A {5 A nom}, 0.10–3.20 A {1 A nom})	**3I2DEMP**	:= ____________

Power

(Hidden if the appropriate voltage card option is not included, see Table 1.1)

ENABLE PWR ELEM (N, 3P1, 3P2) *(All Power element settings below hidden if EPWR := N)*	**EPWR**	:= ____________
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 (OFF,1–4 shots) *(All settings below are hidden if OFF is selected)*	**E79**	:=
OPEN INTERVAL 1 (0.00–3000.00 sec)	**79OI1**	:=
OPEN INTERVAL 2 (0.00–3000.00 sec)	**79OI2**	:=
OPEN INTERVAL 3 (0.00–3000.00 sec)	**79OI3**	:=
OPEN INTERVAL 4 (0.00–3000.00 sec)	**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)	**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 Output Option Not Included)

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 := ______________________________

Slot D Output

(Hidden If Output Option Not Included)

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 := ______________________________

Slot E Output

(Hidden If Output Option Not Included)

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	:= ________		

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) (*All subsequent PMU settings Hidden if EPMU :=N*) **EPMU** := ______________

MESSAGES PER SEC (1, 2, 5, 10) **MRATE** := ______________

STATION NAME (16 characters) **PMSTN** := ______________

PMU HARDWARE ID (1–65534) **PMID** := ______________

VOLTAGE DATA SET (V1, ALL, NA) (*Hidden if no voltages*) **PHDATAV** := ______________

VOLT COMP ANGLE (–179.99 to 180.00 deg) (*Hidden if PHDATAV := NA*) **VCOMP** := ______________

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** :=	____________
BK FAILURE DELAY (0.00–2.00 sec)	**BFD** :=	____________
BK FAIL INITIATE (SELOGIC)	**BFI** :=	____________

Arc-Flash Protection

(Hidden If Voltage Card With Arc-Flash Detection Not Included, see Table 1.1)

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** :=	____________

Note: All settings below 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.)

AIx01

AI*x*01 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*01NAM**	:= ________
AI*x*01 TYPE (I, V)	**AI*x*01TYP**	:= ________
If AI*x*01TYP = I		
AI*x*01 LOW IN VAL (–20.480 to +20.480; mA)	**AI*x*01L**	:= ________
AI*x*01 HI IN VAL (–20.480 to +20.480; mA)	**AI*x*01H**	:= ________
If AI*x*01TYP = V		
AI*x*01 LOW IN VAL (–10.240 to +10.240 V)	**AI*x*01L**	:= ________
AI*x*01 HI IN VAL (–10.240 to +10.240 V)	**AI*x*01H**	:= ________

NOTE: Set Warn and Alarm to a value between Engr Low and Engr High settings.

AI*x*01 ENG UNITS (16 characters)	**AI*x*01EU**	:= ________
AI*x*01 EU LOW (–99999.000 to +99999.000)	**AI*x*01EL**	:= ________
AI*x*01 EU HI (–99999.000 to +99999.000)	**AI*x*01EH**	:= ________
AI*x*01 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*01LW1**	:= ________
AI*x*01 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*01LW2**	:= ________
AI*x*01 LO ALARM (OFF, –99999.000 to +99999.000)	**AI*x*01LAL**	:= ________
AI*x*01 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*01HW1**	:= ________
AI*x*01 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*01HW2**	:= ________
AI*x*01 HI ALARM (OFF, –99999.000 to +99999.000)	**AI*x*01HAL**	:= ________

AIx02

AI*x*02 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*02NAM**	:= ________
AI*x*02 TYPE (I, V)	**AI*x*02TYP**	:= ________
If AI*x*02TYP = I		
AI*x*02 LOW IN VAL (–20.480 to +20.480; mA)	**AI*x*02L**	:= ________
AI*x*02 HI IN VAL (–20.480 to +20.480; mA)	**AI*x*02H**	:= ________
If AI*x*02TYP = V		
AI*x*02 LOW IN VAL (–10.240 to +10.240 V)	**AI*x*02L**	:= ________
AI*x*02 HI IN VAL (–10.240 to +10.240 V)	**AI*x*02H**	:= ________
AI*x*02 ENG UNITS (16 characters)	**AI*x*02EU**	:= ________
AI*x*02 EU LOW (–99999.000 to +99999.000)	**AI*x*02EL**	:= ________
AI*x*02 EU HI (–99999.000 to +99999.000)	**AI*x*02EH**	:= ________

AI*x*02 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*02LW1** :=
AI*x*02 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*02LW2** :=
AI*x*02 LO ALARM (OFF, –99999.000 to +99999.000)	**AI*x*02LAL** :=
AI*x*02 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*02HW1** :=
AI*x*02 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*02HW2** :=
AI*x*02 HI ALARM (OFF, –99999.000 to +99999.000)	**AI*x*02HAL** :=

AIx03

AI*x*03 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*03NAM** :=
AI*x*03 TYPE (I, V)	**AI*x*03TYP** :=
If AI*x*03TYP = I	
AI*x*03 LOW IN VAL (–20.480 to +20.480; mA)	**AI*x*03L** :=
AI*x*03 HI IN VAL (–20.480 to +20.480; mA)	**AI*x*03H** :=
If AI*x*03TYP = V	
AI*x*03 LOW IN VAL (–10.240 to +10.240 V)	**AI*x*03L** :=
AI*x*03 HI IN VAL (–10.240 to +10.240 V)	**AI*x*03H** :=
AI*x*03 ENG UNITS (16 characters)	**AI*x*03EU** :=
AI*x*03 EU LOW (–99999.000 to +99999.000)	**AI*x*03EL** :=
AI*x*03 EU HI (–99999.000 to +99999.000)	**AI*x*03EH** :=
AI*x*03 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*03LW1** :=
AI*x*03 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*03LW2** :=
AI*x*03 LO ALARM (OFF, –99999.000 to +99999.000)	**AI*x*03LAL** :=
AI*x*03 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*03HW1** :=
AI*x*03 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*03HW2** :=
AI*x*03 HI ALARM (OFF, –99999.000 to +99999.000)	**AI*x*03HAL** :=

AIx04

AI*x*04 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*04NAM** :=
AI*x*04 TYPE (I, V)	**AI*x*04TYP** :=
If AI*x*04TYP = I	
AI*x*04 LOW IN VAL (–20.480 to +20.480; mA)	**AI*x*04L** :=
AI*x*04 HI IN VAL (–20.480 to +20.480; mA)	**AI*x*04H** :=
If AI*x*04TYP = V	
AI*x*04 LOW IN VAL (–10.240 to +10.240 V)	**AI*x*04L** :=
AI*x*04 HI IN VAL (–10.240 to +10.240 V)	**AI*x*04H** :=
AI*x*04 ENG UNITS (16 characters)	**AI*x*04EU** :=

AI*x*04 EU LOW (–99999.000 to +99999.000)	**AI*x*04EL**	:= ________
AI*x*04 EU HI (–99999.000 to +99999.000)	**AI*x*04EH**	:= ________
AI*x*04 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*04LW1**	:= ________
AI*x*04 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*04LW2**	:= ________
AI*x*04 LO ALARM (OFF, –99999.000 to +99999.000)	**AI*x*04LAL**	:= ________
AI*x*04 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*04HW1**	:= ________
AI*x*04 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*04HW2**	:= ________
AI*x*04 HI ALARM (OFF, –99999.000 to +99999.000)	**AI*x*04HAL**	:= ________

AIx05

AI*x*05 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*05NAM**	:= ________
AI*x*05 TYPE (I, V)	**AI*x*05TYP**	:= ________
If AI*x*05TYP = I		
AI*x*05 LOW IN VAL (–20.480 to +20.480; mA)	**AI*x*05L**	:= ________
AI*x*05 HI IN VAL (–20.480 to +20.480; mA)	**AI*x*05H**	:= ________
If AI*x*05TYP = V		
AI*x*05 LOW IN VAL (–10.240 to +10.240 V)	**AI*x*05L**	:= ________
AI*x*05 HI IN VAL (–10.240 to +10.240 V)	**AI*x*05H**	:= ________
AI*x*05 ENG UNITS (16 characters)	**AI*x*05EU**	:= ________
AI*x*05 EU LOW (–99999.000 to +99999.000)	**AI*x*05EL**	:= ________
AI*x*05 EU HI (–99999.000 to +99999.000)	**AI*x*05EH**	:= ________
AI*x*05 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*05LW1**	:= ________
AI*x*05 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*05LW2**	:= ________
AI*x*05 LO ALARM (OFF, –99999.000 to +99999.000)	**AI*x*05LAL**	:= ________
AI*x*05 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*05HW1**	:= ________
AI*x*05 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*05HW2**	:= ________
AI*x*05 HI ALARM (OFF, –99999.000 to +99999.000)	**AI*x*05HAL**	:= ________

AIx06

AI*x*06 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*06NAM**	:= ________
AI*x*06 TYPE (I, V)	**AI*x*06TYP**	:= ________
If AI*x*06TYP = I		
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**	:= ________

AIx07

AI*x*07 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*07NAM**	:= ________
AI*x*07 TYPE (I, V)	**AI*x*07TYP**	:= ________
If AI*x*07TYP = I		
AI*x*07 LOW IN VAL (–20.480 to +20.480; mA)	**AI*x*07L**	:= ________
AI*x*07 HI IN VAL (–20.480 to +20.480; mA)	**AI*x*07H**	:= ________
If AI*x*07TYP = V		
AI*x*07 LOW IN VAL (–10.240 to +10.240 V)	**AI*x*07L**	:= ________
AI*x*07 HI IN VAL (–10.240 to +10.240 V)	**AI*x*07H**	:= ________
AI*x*07 ENG UNITS (16 characters)	**AI*x*07EU**	:= ________
AI*x*07 EU LOW (–99999.000 to +99999.000)	**AI*x*07EL**	:= ________
AI*x*07 EU HI (–99999.000 to +99999.000)	**AI*x*07EH**	:= ________
AI*x*07 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*07LW1**	:= ________
AI*x*07 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*07LW2**	:= ________
AI*x*07 LO ALARM (OFF, –99999.000 to +99999.000)	**AI*x*07LAL**	:= ________
AI*x*07 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*07HW1**	:= ________
AI*x*07 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*07HW2**	:= ________
AI*x*07 HI ALARM (OFF, –99999.000 to +99999.000)	**AI*x*07HAL**	:= ________

AIx08

AI*x*08 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*08NAM**	:= ________
AI*x*08 TYPE (I, V)	**AI*x*08TYP**	:= ________
If AI*x*08TYP = I		
AI*x*08 LOW IN VAL (–20.480 to +20.480; mA)	**AI*x*08L**	:= ________
AI*x*08 HI IN VAL (–20.480 to +20.480; mA)	**AI*x*08H**	:= ________

If AI*x*08TYP = V		
AI*x*08 LOW IN VAL (–10.240 to +10.240 V)	**AI*x*08L**	:=
AI*x*08 HI IN VAL (–10.240 to +10.240 V)	**AI*x*08H**	:=
AI*x*08 ENG UNITS (16 characters)	**AI*x*08EU**	:=
AI*x*08 EU LOW (–99999.000 to +99999.000)	**AI*x*08EL**	:=
AI*x*08 EU HI (–99999.000 to +99999.000)	**AI*x*08EH**	:=
AI*x*08 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*08LW1**	:=
AI*x*08 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*08LW2**	:=
AI*x*08 LO ALARM (OFF, –99999.000 to +99999.000)	**AI*x*08LAL**	:=
AI*x*08 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*08HW1**	:=
AI*x*08 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*08HW2**	:=
AI*x*08 HI ALARM (OFF, –99999.000 to +99999.000)	**AI*x*08HAL**	:=

AOx01

AO*x*01 ANALOG QTY (Off, 1 analog quantity)	**AO*x*01AQ**	:=
AO*x*01 TYPE (I, V)	**AO*x*01TYP**	:=
AO*x*01 AQTY LOW (–2147483647 to +2147483647)	**AO*x*01AQL**	:=
AO*x*01 AQTY HI (–2147483647 to +2147483647)	**AO*x*01AQH**	:=
If AO*x*01TYP = I		
AO*x*01 LO OUT VAL (–20.480 to +20.480 mA)	**AO*x*01L**	:=
AO*x*01 HI OUT VAL (–20.480 to +20.480 mA)	**AO*x*01H**	:=
If AO*x*01TYP = V		
AO*x*01 LO OUT VAL (–10.240 to +10.240 V)	**AO*x*01L**	:=
AO*x*01 HI OUT VAL (–10.240 to +10.240 V)	**AO*x*01H**	:=

AOx02

AO*x*02 ANALOG QTY (Off, 1 analog quantity)	**AO*x*02AQ**	:=
AO*x*02 TYPE (I, V)	**AO*x*02TYP**	:=
AO*x*02 AQTY LOW (–2147483647 to +2147483647)	**AO*x*02AQL**	:=
AO*x*02 AQTY HI (–2147483647 to +2147483647)	**AO*x*02AQH**	:=
If AO*x*02TYP = I		
AO*x*02 LO OUT VAL (–20.480 to +20.480 mA)	**AO*x*02L**	:=
AO*x*02 HI OUT VAL (–20.480 to +20.480 mA)	**AO*x*02H**	:=
If AO*x*02TYP = V		
AO*x*02 LO OUT VAL (–10.240 to +10.240 V)	**AO*x*02L**	:=
AO*x*02 HI OUT VAL (–10.240 to +10.240 V)	**AO*x*02H**	:=

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 Voltage Option xx74xx is included, see Table 1.1)

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 Input Option Not Included)

IN301 Debounce (AC, 0–65000 ms)	**IN301D**	:= ________
IN302 Debounce (AC, 0–65000 ms)	**IN302D**	:= ________
IN303 Debounce (AC, 0–65000 ms)	**IN303D**	:= ________

IN304 Debounce (AC, 0–65000 ms)	**IN304D**	:=	____________
IN305 Debounce (AC, 0–65000 ms)	**IN305D**	:=	____________
IN306 Debounce (AC, 0–65000 ms)	**IN306D**	:=	____________
IN307 Debounce (AC, 0–65000 ms)	**IN307D**	:=	____________
IN308 Debounce (AC, 0–65000 ms)	**IN308D**	:=	____________

Input Debounce Settings (Slot D)

(Hidden If Input Option Not Included)

IN401 Debounce (AC, 0–65000 ms)	**IN401D**	:=	____________
IN402 Debounce (AC, 0–65000 ms)	**IN402D**	:=	____________
IN403 Debounce (AC, 0–65000 ms)	**IN403D**	:=	____________
IN404 Debounce (AC, 0–65000 ms)	**IN404D**	:=	____________
IN405 Debounce (AC, 0–65000 ms)	**IN405D**	:=	____________
IN406 Debounce (AC, 0–65000 ms)	**IN406D**	:=	____________
IN407 Debounce (AC, 0–65000 ms)	**IN407D**	:=	____________
IN408 Debounce (AC, 0–65000 ms)	**IN408D**	:=	____________

Input Debounce Settings (Slot E)

(Hidden If Input Option Not Included)

IN501 Debounce (AC, 0–65000 ms)	**IN501D**	:=	____________
IN502 Debounce (AC, 0–65000 ms)	**IN502D**	:=	____________
IN503 Debounce (AC, 0–65000 ms)	**IN503D**	:=	____________
IN504 Debounce (AC, 0–65000 ms)	**IN504D**	:=	____________
IN505 Debounce (AC, 0–65000 ms)	**IN505D**	:=	____________
IN506 Debounce (AC, 0–65000 ms)	**IN506D**	:=	____________
IN507 Debounce (AC, 0–65000 ms)	**IN507D**	:=	____________
IN508 Debounce (AC, 0–65000 ms)	**IN508D**	:=	____________

Breaker Monitor Settings

BREAKER MONITOR (Y,N) *(All subsequent settings Hidden if EBMON :=N)*	**EBMON**	:=	____________
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) *(Hidden if Voltage Card Option is xx71xx or xx72xx)*	**RSTDEM**	:=
RESET PK DEMAND (SELOGIC) *(Hidden if Voltage Card Option is xx71xx or xx72xx)*	**RSTPKDEM**	:=

Access Control

DISABLE SETTINGS (SELOGIC)	**DSABLSET**	:=
BLOCK MODBUS SET (NONE, R_S, ALL)	**BLKMBSET**	:=

Time-Synchronization Source

(Hidden if Fiber-Optic PORT 2 Not Available)

IRIG TIME SOURCE (IRIG1, IRIG2)	**TIME_SRC**	:=

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

PORT F

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

Communications

SPEED (300, 1200, 2400, 4800, 9600, 19200, 38400 bps)	**SPEED**	:=
DATA BITS (7, 8 bits) *(Hidden if PROTO := MOD, EVMSG, or PMU)*	**BITS**	:=
PARITY (O, E, N) *(Hidden if PROTO := EVMSG or PMU)*	**PARITY**	:=
STOP BITS (1, 2 bits) *(Hidden if PROTO := MOD or EVMSG)*	**STOP**	:=
PORT TIME-OUT (0–30 min) *(Hidden if PROTO := MOD, EVMSG, or PMU)*	**T_OUT**	:=
HDWR HANDSHAKING (Y, N) *(Hidden if PROTO := MOD or EVMSG)*	**RTSCTS**	:=
SEND AUTOMESSAGE (Y, N) *(Hidden if PROTO := MOD, EVMSG, or PMU)*	**AUTO**	:=

Modbus

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

PORT 1 (Ethernet Port in Slot B) (Hidden If Ethernet Option Not Included)

IP ADDRESS (zzz.yyy.xxx.www)	**IPADDR**	:= ____________
SUBNET MASK (zzz.yyy.xxx.www)	**SUBNETM**	:= ____________
DEFAULT ROUTER (zzz.yyy.xxx.www)	**DEFRTR**	:= ____________
Enable TCP Keep-Alive (Y, N)	**ETCPKA**	:= ____________
TCP Keep-Alive Idle Range (1–20 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)	**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) **(Hidden if EMOD := 0)*	**MODNUM1**	:= ____________
Modbus TCP Port2 (1–65534) **(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**	:= ____________

* Exclude the following port numbers: 20 (FTP Data), 21 (FTP Control), TPORT setting, SNTP, and DNPNUM setting if present.

DNP3 Protocol

All DNP3 settings below are hidden if DNP3 is not an option.

Enable DNP Sessions (0–3) (DNP3 settings below *Hidden if EDNP := 0)*	**EDNP**	:= ________
DNP TCP and UDP Port (1–65534)	**DNPNUM**	:= ________
DNP Address (0–65519)	**DNPADR**	:= ________

Session 1

IP Address {zzz.yyy.xxx.www} (15 characters)	**DNPIP1**	:= ________
Transport Protocol (UDP, TCP)	**DNPTR1**	:= ________
UDP Response Port (REQ, 1–65534)	**DNPUDP1**	:= ________
DNP Address to Report to (0–65519)	**REPADR1**	:= ________
DNP Map (1–3)	**DNPMAP1**	:= ________
Analog Input Default Variation (1–6)	**DVARAI1**	:= ________
Class for Binary Event Data (0–3)	**ECLASSB1**	:= ________
Class for Counter Event Data (0–3)	**ECLASSC1**	:= ________
Class for Analog Event Data (0–3)	**ECLASSA1**	:= ________
Currents Scaling Decimal Places (0–3)	**DECPLA1**	:= ________
Voltages Scaling Decimal Places (0–3)	**DECPLV1**	:= ________
Misc Data Scaling Decimal Places (0–3)	**DECPLM1**	:= ________
Amps Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBA1**	:= ________
Volts Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBV1**	:= ________
Misc Data Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0 and ECLASSC1 := 0)*	**ANADBM1**	:= ________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ1**	:= ________
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO1**	:= ________
Seconds to send Data Link Heartbeat (0–7200) *(Hidden if DNPTR1 := UDP)*	**DNPINA1**	:= ________
Event Message Confirm Time-Out (1–50 sec))	**ETIMEO1**	:= ________
Enable Unsolicited Reporting (Y, N) *(Hidden 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 Deadband Counts (0–32767) *(Hidden if ECLASSA2 := 0)*	**ANADBA2**	**:=** ________
Volts Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA2 := 0)*	**ANADBV2**	**:=** ________
Misc Data Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA2 := 0 and ECLASSC2 := 0)*	**ANADBM2**	**:=** ________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ2**	**:=** ________
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO2**	**:=** ________
Seconds to send Data Link Heartbeat (0–7200) *(Hidden if DNPTR2 := UDP)*	**DNPINA2**	**:=** ________
Event Message Confirm Time-Out (1–50 sec))	**ETIMEO2**	**:=** ________
Enable Unsolicited Reporting (Y, N) *(Hidden 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 Deadband Counts (0–32767) *(Hidden if ECLASSA3 := 0)*	**ANADBA3**	:= ________
Volts Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA3 := 0)*	**ANADBV3**	:= ________
Misc Data Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA3 := 0 and ECLASSC3 := 0)*	**ANADBM3**	:= ________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ3**	:= ________
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO3**	:= ________
Seconds to send Data Link Heartbeat (0–7200) *(Hidden if DNPTR3 := UDP)*	**DNPINA3**	:= ________
Event Message Confirm Time-Out (1–50 sec))	**ETIMEO3**	:= ________
Enable Unsolicited Reporting (Y, N) *(Hidden 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 settings when ESNTP ≠ OFF.

Primary Server IP Address (zzz.yyy.xxx.www)

NOTE: To accept updates from any server when ESNTP = BROADCAST, set SNTPPSIP to 0.0.0.0.

	SNTPPSIP	:= ______

Make the following setting when ESNTP = UNICAST.

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

SNTP IP (Local) Port Number (1-65534)

NOTE: SNTPPORT cannot be set to 20, 21, 102, 502, 23, TPORT, or DNPNUM	**SNTPPORT**	:= ______
SNTP Update Rate (15–3600 seconds)	**SNTPRATE**	: = ______

Make the following setting when ESNTP = UNICAST or MANYCAST.

SNTP Timeout (5–20 seconds)

NOTE: SNTPTO must be less than setting SNTPRATE.	**SNTPTO**	: = ______

PORT 2 (Fiber-Optic Serial Port in Slot B) (Hidden if E49RTD := EXT or PORT 2 Not Included)

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 Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBA1**	:= ________
Volts Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBV1**	:= ________
Misc Data Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0 and ECLASSC1 := 0)*	**ANADBM1**	:= ________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ1**	:= ________
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO1**	:= ________
Data Link Retries (0–15)	**DRETRY1**	:= ________
Seconds to Data Link Time-Out (0–5) *(Hidden if DRETRY1 := 0)*	**DTIMEO1**	:= ________
Event Message Confirm Time-Out (1–50 sec))	**ETIMEO1**	:= ________
Enable Unsolicited Reporting (Y, N) *(Hidden 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 Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBA1**	:= ________
Volts Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBV1**	:= ________
Misc Data Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0 and ECLASSC1 := 0)*	**ANADBM1**	:= ________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ1**	:= ________
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO1**	:= ________
Data Link Retries (0–15)	**DRETRY1**	:= ________
Seconds to Data Link Time-Out (0–5) *(Hidden if DRETRY1 := 0)*	**DTIMEO1**	:= ________
Event Message Confirm Time-Out (1–50 sec))	**ETIMEO1**	:= ________
Enable Unsolicited Reporting (Y, N) *(Hidden 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 Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBA1**	:= ________
Volts Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0)*	**ANADBV1**	:= ________
Misc Data Reporting Deadband Counts (0–32767) *(Hidden if ECLASSA1 := 0 and ECLASSC1 := 0)*	**ANADBM1**	:= ________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ1**	:= ________
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO1**	:= ________
Data Link Retries (0–15)	**DRETRY1**	:= ________
Seconds to Data Link Time-Out (0–5) *(Hidden if DRETRY1 := 0)*	**DTIMEO1**	:= ________
Event Message Confirm Time-Out (1–50 sec))	**ETIMEO1**	:= ________
Enable Unsolicited Reporting (Y, N) *(Hidden 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**	:= ________

Target LED

TRIP LATCH T_LED (Y, N)	**T01LEDL**	:= ________
LED1 EQUATION (SELOGIC)	**T01_LED**	:= ________
TRIP LATCH T_LED (Y, N)	**T02LEDL**	:= ________
LED2 EQUATION (SELOGIC)	**T02_LED**	:= ________
TRIP LATCH T_LED (Y, N)	**T03LEDL**	:= ________
LED3 EQUATION (SELOGIC)	**T03_LED**	:= ________
TRIP LATCH T_LED (Y, N)	**T04LEDL**	:= ________
LED4 EQUATION (SELOGIC)	**T04_LED**	:= ________
TRIP LATCH T_LED (Y, N)	**T05LEDL**	:= ________
LED5 EQUATION (SELOGIC)	**T05_LED**	:= ________
TRIP LATCH T_LED (Y, N)	**T06LEDL**	:= ________
LED6 EQUATION (SELOGIC)	**T06_LED**	:= ________
PB1A_LED EQUATION (SELOGIC)	**PB1A_LED**	:= ________
PB1B_LED EQUATION (SELOGIC)	**PB1B_LED**	:= ________
PB2A_LED EQUATION (SELOGIC)	**PB2A_LED**	:= ________
PB2B_LED EQUATION (SELOGIC)	**PB2B_LED**	:= ________
PB3A_LED EQUATION (SELOGIC)	**PB3A_LED**	:= ________
PB3B_LED EQUATION (SELOGIC)	**PB3B_LED**	:= ________
PB4A_LED EQUATION (SELOGIC)	**PB4A_LED**	:= ________
PB4B_LED EQUATION (SELOGIC)	**PB4B_LED**	:= ________

Date____________

Display Points

Display Point Settings (maximum 60 characters):

- ➤ (Boolean): Relay Word Bit Name, "Alias", "Set String", "Clear String"
- ➤ (Analog): Analog Quantity Name, "User Text and Formatting"

DISPLAY POINT DP01 (60 characters)	**DP01**	:= ____________
DISPLAY POINT DP02 (60 characters)	**DP02**	:= ____________
DISPLAY POINT DP03 (60 characters)	**DP03**	:= ____________
DISPLAY POINT DP04 (60 characters)	**DP04**	:= ____________
DISPLAY POINT DP05 (60 characters)	**DP05**	:= ____________
DISPLAY POINT DP06 (60 characters)	**DP06**	:= ____________
DISPLAY POINT DP07 (60 characters)	**DP07**	:= ____________
DISPLAY POINT DP08 (60 characters)	**DP08**	:= ____________
DISPLAY POINT DP09 (60 characters)	**DP09**	:= ____________
DISPLAY POINT DP10 (60 characters)	**DP10**	:= ____________
DISPLAY POINT DP11 (60 characters)	**DP11**	:= ____________
DISPLAY POINT DP12 (60 characters)	**DP12**	:= ____________
DISPLAY POINT DP13 (60 characters)	**DP13**	:= ____________
DISPLAY POINT DP14 (60 characters)	**DP14**	:= ____________
DISPLAY POINT DP15 (60 characters)	**DP15**	:= ____________
DISPLAY POINT DP16 (60 characters)	**DP16**	:= ____________
DISPLAY POINT DP17 (60 characters)	**DP17**	:= ____________
DISPLAY POINT DP18 (60 characters)	**DP18**	:= ____________
DISPLAY POINT DP19 (60 characters)	**DP19**	:= ____________
DISPLAY POINT DP20 (60 characters)	**DP20**	:= ____________
DISPLAY POINT DP21 (60 characters)	**DP21**	:= ____________
DISPLAY POINT DP22 (60 characters)	**DP22**	:= ____________
DISPLAY POINT DP23 (60 characters)	**DP23**	:= ____________
DISPLAY POINT DP24 (60 characters)	**DP24**	:= ____________
DISPLAY POINT DP25 (60 characters)	**DP25**	:= ____________
DISPLAY POINT DP26 (60 characters)	**DP26**	:= ____________
DISPLAY POINT DP27 (60 characters)	**DP27**	:= ____________
DISPLAY POINT DP28 (60 characters)	**DP28**	:= ____________
DISPLAY POINT DP29 (60 characters)	**DP29**	:= ____________
DISPLAY POINT DP30 (60 characters)	**DP30**	:= ____________

DISPLAY POINT DP31 (60 characters)	**DP31**	:=
DISPLAY POINT DP32 (60 characters)	**DP32**	:=

Local Bits Labels

LB_NAME (14 characters)	**NLB01**	:=
CLEAR LB_ LABEL (7 characters)	**CLB01**	:=
SET LB_ LABEL (7 characters)	**SLB01**	:=
PULSE LB_ LABEL (7 characters)	**PLB01**	:=
LB_NAME (14 characters)	**NLB02**	:=
CLEAR LB_ LABEL (7 characters)	**CLB02**	:=
SET LB_ LABEL (7 characters)	**SLB02**	:=
PULSE LB_ LABEL (7 characters)	**PLB02**	:=
LB_NAME (14 characters)	**NLB03**	:=
CLEAR LB_ LABEL (7 characters)	**CLB03**	:=
SET LB_ LABEL (7 characters)	**SLB03**	:=
PULSE LB_ LABEL (7 characters)	**PLB03**	:=
LB_NAME (14 characters)	**NLB04**	:=
CLEAR LB_ LABEL (7 characters)	**CLB04**	:=
SET LB_ LABEL (7 characters)	**SLB04**	:=
PULSE LB_ LABEL (7 characters)	**PLB04**	:=
LB_NAME (14 characters)	**NLB05**	:=
CLEAR LB_ LABEL (7 characters)	**CLB05**	:=
SET LB_ LABEL (7 characters)	**SLB05**	:=
PULSE LB_ LABEL (7 characters)	**PLB05**	:=
LB_NAME (14 characters)	**NLB06**	:=
CLEAR LB_ LABEL (7 characters)	**CLB06**	:=
SET LB_ LABEL (7 characters)	**SLB06**	:=
PULSE LB_ LABEL (7 characters)	**PLB06**	:=
LB_NAME (14 characters)	**NLB07**	:=
CLEAR LB_ LABEL (7 characters)	**CLB07**	:=
SET LB_ LABEL (7 characters)	**SLB07**	:=
PULSE LB_ LABEL (7 characters)	**PLB07**	:=
LB_NAME (14 characters)	**NLB08**	:=
CLEAR LB_ LABEL (7 characters)	**CLB08**	:=

SET LB_ LABEL (7 characters)	**SLB08**	:=	________
PULSE LB_ LABEL (7 characters)	**PLB08**	:=	________
LB_NAME (14 characters)	**NLB09**	:=	________
CLEAR LB_ LABEL (7 characters)	**CLB09**	:=	________
SET LB_ LABEL (7 characters)	**SLB09**	:=	________
PULSE LB_ LABEL (7 characters)	**PLB09**	:=	________
LB_NAME (14 characters)	**NLB10**	:=	________
CLEAR LB_ LABEL (7 characters)	**CLB10**	:=	________
SET LB_ LABEL (7 characters)	**SLB10**	:=	________
PULSE LB_ LABEL (7 characters)	**PLB10**	:=	________
LB_NAME (14 characters)	**NLB11**	:=	________
CLEAR LB_ LABEL (7 characters)	**CLB11**	:=	________
SET LB_ LABEL (7 characters)	**SLB11**	:=	________
PULSE LB_ LABEL (7 characters)	**PLB11**	:=	________
LB_NAME (14 characters)	**NLB12**	:=	________
CLEAR LB_ LABEL (7 characters)	**CLB12**	:=	________
SET LB_ LABEL (7 characters)	**SLB12**	:=	________
PULSE LB_ LABEL (7 characters)	**PLB12**	:=	________
LB_NAME (14 characters)	**NLB13**	:=	________
CLEAR LB_ LABEL (7 characters)	**CLB13**	:=	________
SET LB_ LABEL (7 characters)	**SLB13**	:=	________
PULSE LB_ LABEL (7 characters)	**PLB13**	:=	________
LB_NAME (14 characters)	**NLB14**	:=	________
CLEAR LB_ LABEL (7 characters)	**CLB14**	:=	________
SET LB_ LABEL (7 characters)	**SLB14**	:=	________
PULSE LB_ LABEL (7 characters)	**PLB14**	:=	________
LB_NAME (14 characters)	**NLB15**	:=	________
CLEAR LB_ LABEL (7 characters)	**CLB15**	:=	________
SET LB_ LABEL (7 characters)	**SLB15**	:=	________
PULSE LB_ LABEL (7 characters)	**PLB15**	:=	________
LB_NAME (14 characters)	**NLB16**	:=	________
CLEAR LB_ LABEL (7 characters)	**CLB16**	:=	________
SET LB_ LABEL (7 characters)	**SLB16**	:=	________
PULSE LB_ LABEL (7 characters)	**PLB16**	:=	________

LB_NAME (14 characters)	**NLB17**	:= ______
CLEAR LB_ LABEL (7 characters)	**CLB17**	:= ______
SET LB_ LABEL (7 characters)	**SLB17**	:= ______
PULSE LB_ LABEL (7 characters)	**PLB17**	:= ______
LB_NAME (14 characters)	**NLB18**	:= ______
CLEAR LB_ LABEL (7 characters)	**CLB18**	:= ______
SET LB_ LABEL (7 characters)	**SLB18**	:= ______
PULSE LB_ LABEL (7 characters)	**PLB18**	:= ______
LB_NAME (14 characters)	**NLB19**	:= ______
CLEAR LB_ LABEL (7 characters)	**CLB19**	:= ______
SET LB_ LABEL (7 characters)	**SLB19**	:= ______
PULSE LB_ LABEL (7 characters)	**PLB19**	:= ______
LB_NAME (14 characters)	**NLB20**	:= ______
CLEAR LB_ LABEL (7 characters)	**CLB20**	:= ______
SET LB_ LABEL (7 characters)	**SLB20**	:= ______
PULSE LB_ LABEL (7 characters)	**PLB20**	:= ______
LB_NAME (14 characters)	**NLB21**	:= ______
CLEAR LB_ LABEL (7 characters)	**CLB21**	:= ______
SET LB_ LABEL (7 characters)	**SLB21**	:= ______
PULSE LB_ LABEL (7 characters)	**PLB21**	:= ______
LB_NAME (14 characters)	**NLB22**	:= ______
CLEAR LB_ LABEL (7 characters)	**CLB22**	:= ______
SET LB_ LABEL (7 characters)	**SLB22**	:= ______
PULSE LB_ LABEL (7 characters)	**PLB22**	:= ______
LB_NAME (14 characters)	**NLB23**	:= ______
CLEAR LB_ LABEL (7 characters)	**CLB23**	:= ______
SET LB_ LABEL (7 characters)	**SLB23**	:= ______
PULSE LB_ LABEL (7 characters)	**PLB23**	:= ______
LB_NAME (14 characters)	**NLB24**	:= ______
CLEAR LB_ LABEL (7 characters)	**CLB24**	:= ______
SET LB_ LABEL (7 characters)	**SLB24**	:= ______
PULSE LB_ LABEL (7 characters)	**PLB24**	:= ______
LB_NAME (14 characters)	**NLB25**	:= ______
CLEAR LB_ LABEL (7 characters)	**CLB25**	:= ______

SET LB_ LABEL (7 characters)	**SLB25**	:=
PULSE LB_ LABEL (7 characters)	**PLB25**	:=
LB_NAME (14 characters)	**NLB26**	:=
CLEAR LB_ LABEL (7 characters)	**CLB26**	:=
SET LB_ LABEL (7 characters)	**SLB26**	:=
PULSE LB_ LABEL (7 characters)	**PLB26**	:=
LB_NAME (14 characters)	**NLB27**	:=
CLEAR LB_ LABEL (7 characters)	**CLB27**	:=
SET LB_ LABEL (7 characters)	**SLB27**	:=
PULSE LB_ LABEL (7 characters)	**PLB27**	:=
LB_NAME (14 characters)	**NLB28**	:=
CLEAR LB_ LABEL (7 characters)	**CLB28**	:=
SET LB_ LABEL (7 characters)	**SLB28**	:=
PULSE LB_ LABEL (7 characters)	**PLB28**	:=
LB_NAME (14 characters)	**NLB29**	:=
CLEAR LB_ LABEL (7 characters)	**CLB29**	:=
SET LB_ LABEL (7 characters)	**SLB29**	:=
PULSE LB_ LABEL (7 characters)	**PLB29**	:=
LB_NAME (14 characters)	**NLB30**	:=
CLEAR LB_ LABEL (7 characters)	**CLB30**	:=
SET LB_ LABEL (7 characters)	**SLB30**	:=
PULSE LB_ LABEL (7 characters)	**PLB30**	:=
LB_NAME (14 characters)	**NLB31**	:=
CLEAR LB_ LABEL (7 characters)	**CLB31**	:=
SET LB_ LABEL (7 characters)	**SLB31**	:=
PULSE LB_ LABEL (7 characters)	**PLB31**	:=
LB_NAME (14 characters)	**NLB32**	:=
CLEAR LB_ LABEL (7 characters)	**CLB32**	:=
SET LB_ LABEL (7 characters)	**SLB32**	:=
PULSE LB_ LABEL (7 characters)	**PLB32**	:=

Report Settings (SET R Command)

SER Chatter Criteria

Auto-Removal Enable (Y, N)	**ESERDEL**	:= ________
Number of Counts (2–20 counts)	**SRDLCNT**	:= ________
Removal Time (0.1–90.0 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 as long as 15 characters. 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 cyc)	**LER**	:= ______
PREFAULT LENGTH (1–59 cyc {if LER := 15}, 1–10 cyc {if LER := 64})	**PRE**	:= ______

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 DNP Option Not Included)

Use **SET DNP n** command with n = 1, 2, or 3 to create as many as three DNP User Maps. Refer to *Appendix D: DNP3 Communications* for details.

This is DNP Map 1 (DNP Map 2 and DNP Map 3 tables are identical to DNP Map 1 table).

Binary Input Map

DNP Binary Input Label Name (10 characters)	**BI_00**	:= ______________
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-751A 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-751A 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-751A Communications Port Interfaces

	Communications Port Interfaces	Location	Feature
PORT F	EIA-232	Front	Standard
PORT 1	Option 1: 10/100BASE-T Ethernet (RJ45 connector) Option 2: Dual, redundant 10/100 BASE-T Ethernet (Port 1A, Port 1B) Option 3: 100BASE-FX Ethernet (LC connector) Option 4: Dual, redundant 100BASE-FX Ethernet (Port 1A, Port 1B)	Rear	Ordering Option
PORT 2[a]	Multimode Fiber-Optic Serial (ST® connector)	Rear	Ordering Option
PORT 3	Option 1: EIA-232 Option 2: EIA-485	Rear	Ordering Option
PORT 4	Option 1: EIA-232 or EIA-485 Serial Communications Card Option 2: DeviceNet Communications Card[b]	Rear	Ordering Option

[a] This port can receive the RTD measurement information from the optional external SEL-2600 RTD Module. Refer to the 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-751A. For example, consider the fiber-optic interface in noisy installations or for large communications distances. Following is general information on possible applications of the different interfaces.

Serial (EIA-232 and EIA-485) Port

Use the EIA-232 port for communications distances of as long as 15 m (50 feet) in low noise environments. Use the optional EIA-485 port for communications distances as long 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-751A Relay

Some of the SEL devices available for integration or communication system robustness are included in the following list:

- SEL Communications Processors (SEL-2032, SEL-2030, SEL-2020)
- SEL-2800 series fiber-optic transceivers
- SEL-2890 Ethernet Transceiver
- SEL-3010 Event Messenger
- SEL-2505 Remote I/O Module (with ST® option only for fiber-optic link to Port 2)

A variety of terminal emulation programs on personal computers can communicate with the relay. For the best display, use VT-100 terminal emulation or the closest variation.

The default settings for all EIA-232 serial ports are listed below:

Baud Rate = 9600
Data Bits = 8
Parity = N
Stop Bits = 1

To change the port settings, use the **SET P** command (see *Section 6: Settings*) or the front-panel. *Section 8: Front-Panel Operations* provides details on making settings with the front panel.

Hardware Flow Control

All EIA-232 serial ports support RTS/CTS hardware handshaking (hardware flow control). To enable hardware handshaking, use the **SET P** command or front-panel PORT submenu to set RTSCTS = Y. Disable hardware handshaking by setting RTSCTS := N.

- ➤ If RTSCTS := N, the relay permanently asserts the RTS line.
- ➤ If RTSCTS := Y, the relay deasserts RTS when it is unable to receive characters.
- ➤ If RTSCTS := Y, the relay does not send characters until the CTS input is asserted.

Fiber-Optic Serial Port

Use the optional fiber-optic port (**PORT 2**) for safety and communications distances as far as 1 km. Communications distances as far as 4 km can be achieved by using an SEL-2812 transceiver on **PORT 3**. While **PORT 2** and the SEL-2812 are compatible, **PORT 2** is less sensitive than the SEL-2812, which limits the distance to 1 km.

Ethernet Port

Use the Ethernet port for interfacing with an Ethernet network environment. SEL-751A 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.

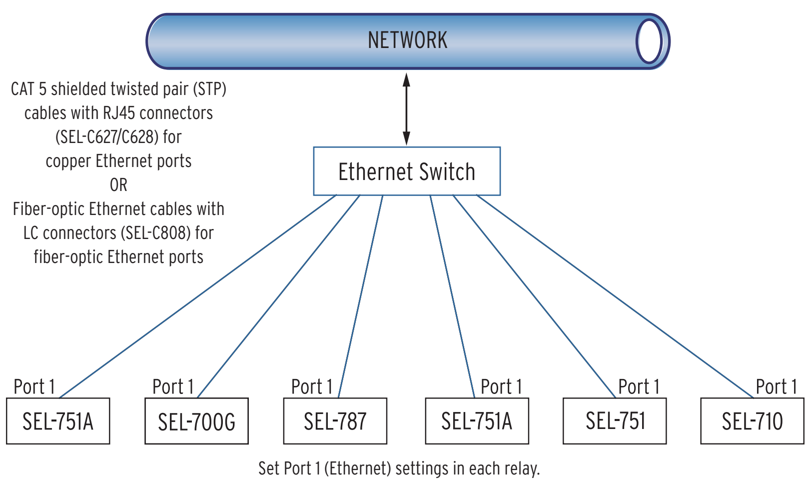


Figure 7.1 Simple Ethernet Network Configuration

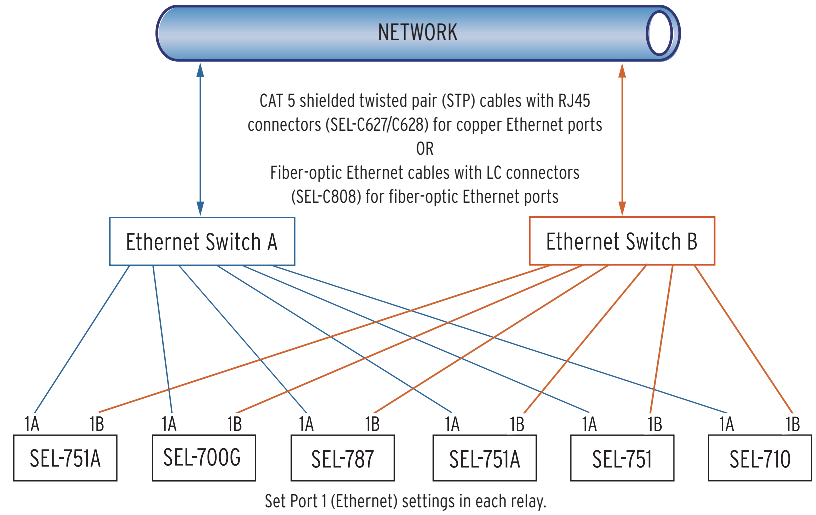


Figure 7.2 Ethernet Network Configuration With Dual Redundant Connections (Failover Mode)

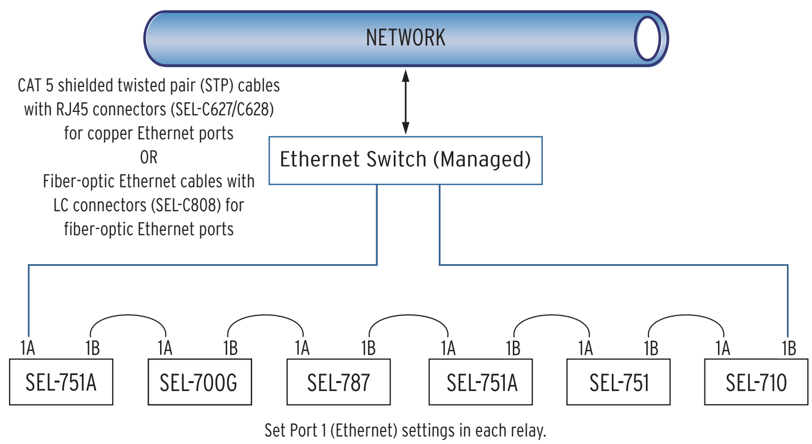


Figure 7.3 Ethernet Network Configuration With Ring Structure (Switched Mode)

Dual Network Port Operation

The SEL-751A 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 necessary 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-751A 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-751A checks the primary link periodically and continues checking until it detects a normal link status. The relay continues to communicate via the standby port even after the primary port returns to normal. The relay reevaluates your port of choice for communications on a change of settings, at failure of the standby port, or on reboot. The relay returns to operation on the primary link under those conditions if it detects a normal link status. When the active and backup links both fail, the relay alternates checking for the link status of the primary and standby ports.

Unmanaged Switch Mode

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

Fixed Connection Mode

If you have a single network and want to use only one network port, or if you have both ports connected but want to force usage of only one port for various reasons, set NETMODE to FIXED and set NETPORT to the port you want to use. Only the selected network port operates and the other port is disabled.

Autonegotiation, Speed, and Duplex Mode

Single or dual copper Ethernet ports 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 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

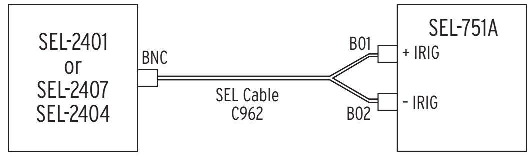
The NETPORT setting gives you the option to select the primary port of communication in failover or fixed communications modes. Selecting "D" for this setting disables both ports. This selection provides you the security of being able to turn off the ports even when these ports are physically connected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

IRIG-B

The SEL-751A 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.

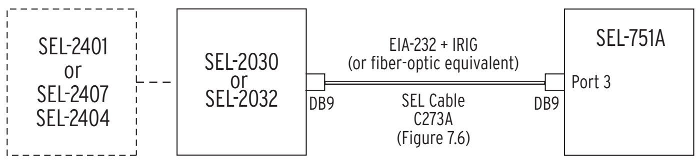
Set Global setting IRIG TIME SOURCE to TIME_SRC := IRIG1.

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.

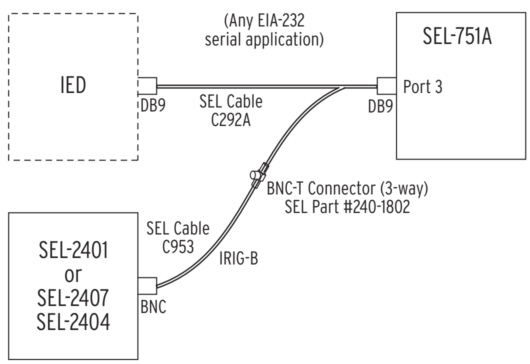
Refer to *Figure 7.6* on how to connect a SEL Time Source (SEL-2401, SEL-2404, SEL-2407) for IRIG-B Input to Port 3.



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)



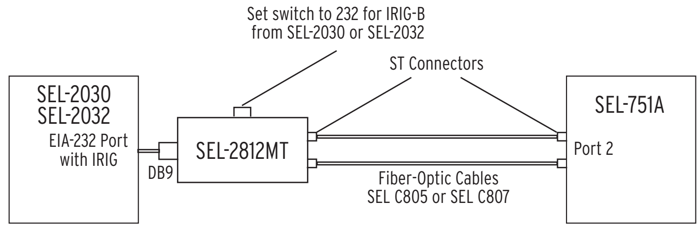
You cannot use **B01–B02** input or **PORT 2** if you use **PORT 3**.

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)

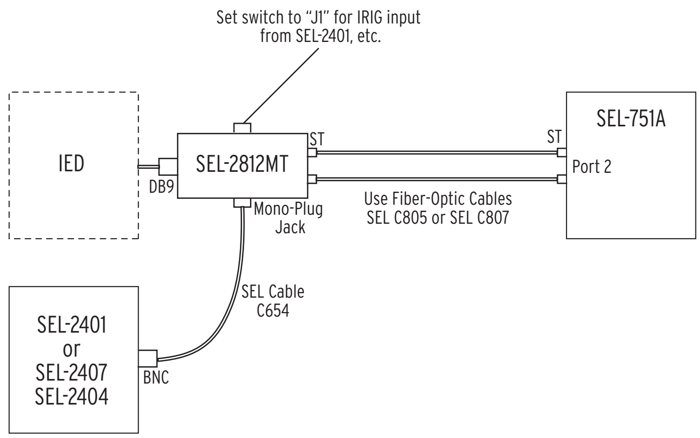
You can use Fiber-Optic Serial **PORT 2** to bring IRIG-B Input to the relay as shown in *Figure 7.7* and *Figure 7.8*.



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 is available on Pin 1 only.

Connect Your PC to the Relay

The front port of the SEL-751A 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-751A.

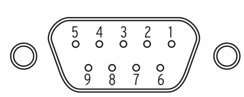


Figure 7.9 EIA-232 DB-9 Connector Pin Numbers

Table 7.2 shows the pin functions for the EIA-232 and EIA-485 serial ports.

Table 7.2 EIA-232/EIA-485 Serial Port Pin Functions

Pin[a]	PORT 3 EIA-232	PORT 3 EIA-485[a]	PORT 4C EIA-232	PORT 4A EIA-485[a]	PORT F EIA-232
1	+5 Vdc	+TX	+5 Vdc	+TX	N/C
2	RXD	–TX	RXD	–TX	RXD
3	TXD	+RX	TXD	+RX	TXD
4	IRIG+	–RX	N/C	–RX	N/C
5	GND	Shield	GND	Shield	GND
6	IRIG–		N/C		N/C
7	RTS		RTS		RTS
8	CTS		CTS		CTS
9	GND		GND		GND

[a] For EIA-485, the pin numbers represent relay terminals _01 through _05.

The following cable diagrams show several types of EIA-232 serial communications cables that connect the SEL-751A to other devices. These and other cables are available from SEL. Contact the factory for more information.

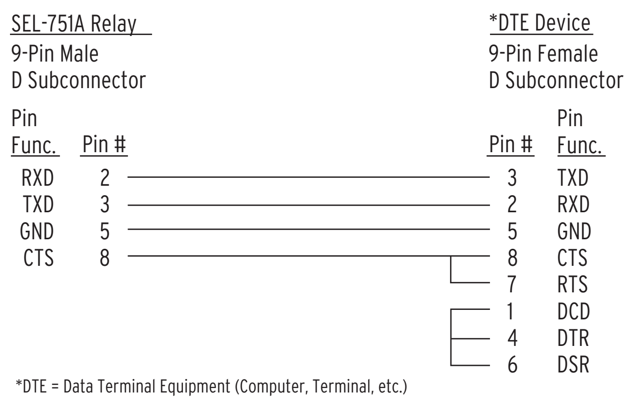


Figure 7.10 SEL Cable C234A—SEL-751A to DTE Device

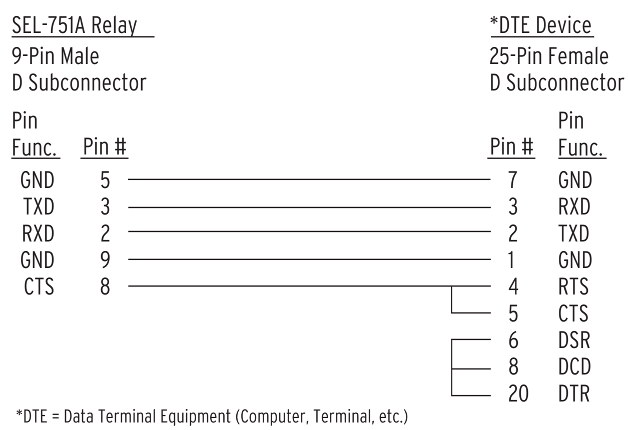


Figure 7.11 SEL Cable C227A—SEL-751A to DTE Device

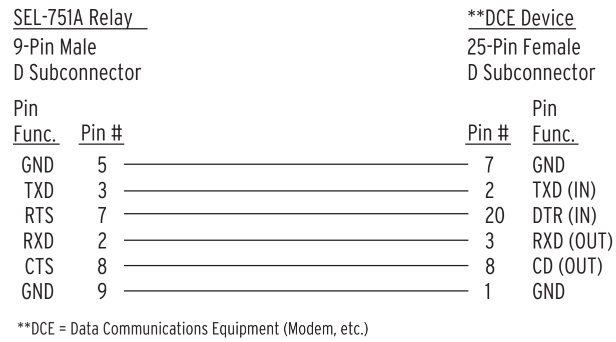


Figure 7.12 SEL Cable C222—SEL-751A to Modem

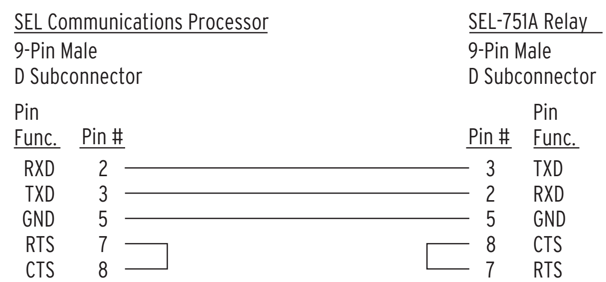


Figure 7.13 SEL Cable C272A—SEL-751A to SEL Communications Processor Without IRIG-B Signal

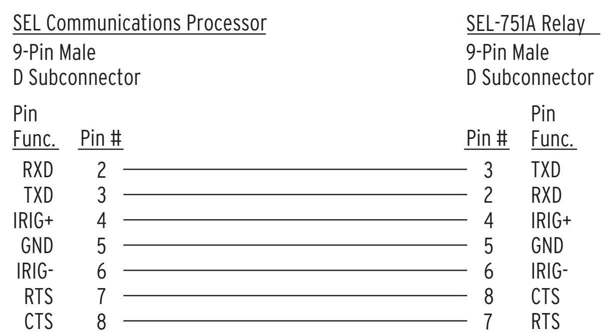


Figure 7.14 SEL Cable C273A—SEL-751A to SEL Communications Processor With IRIG-B Signal

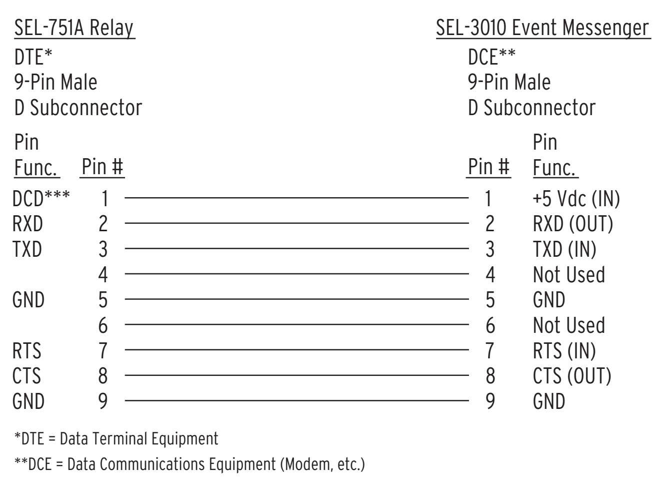


Figure 7.15 SEL Cable C387—SEL-751A to SEL-3010

Communications Protocols

Protocols

Although the SEL-751A 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)[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 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 SER. Use this protocol to receive binary Sequential Events Record unsolicited responses. The protocol is described in *Appendix C: SEL Communications Processors*.

SEL Event Messenger. This is an SEL ASCII protocol with 8 Data bits, No Parity, and 1 Stop bit for transmitting data to SEL-3010 Event Messenger. You can change only the Communications Speed to match the settings in the SEL-3010.

MIRRORED BITS Protocol

The SEL-751A 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-751A 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-751A provides Modbus RTU support. Modbus is an optional protocol described in *Appendix E: Modbus RTU Communications*.

DNP3 (Distributed Network Protocol)

The SEL-751A provides DNP3 protocol support if the option is selected. The DNP3 protocol is described in *Appendix D: DNP3 Communications*.

DeviceNet Protocol

The SEL-751A 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-751A. 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-751A 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-751A.

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, and transmission 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-751A sends a status report each time it detects a self-test warning or failure condition. See *STATUS Command (Relay Self-Test Status) on page 7.40*.

Access Levels

You can issue commands to the SEL-751A 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-751A 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-751A 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-751A, 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-751A 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-751A to Access Level 1. See *Access Commands (ACCESS, 2ACCESS, and CAL) on page 7.18* for more detail.

Access Level 1

When the SEL-751A is in Access Level 1, the relay sends the following prompt:

```
=>
```

See the *SEL-751A 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-751A sends the prompt:

```
=>>
```

See the *SEL-751A 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-751A Relay Command Summary* at the end of this manual lists the serial port commands alphabetically. Much of the information available from the serial port commands is also available via the front-panel pushbuttons.

Access Level Functions

The serial port commands at the different access levels offer varying levels of control:

- ➤ The Access Level 0 commands provide the first layer of security. In addition, Access Level 0 supports several commands necessary for SEL communications processors.
- ➤ The Access Level 1 commands are primarily for reviewing information only (settings, metering, etc.), not changing it.
- ➤ The Access Level 2 commands are primarily for changing relay settings.
- ➤ Access Level C (restricted access level, should be used under direction of SEL only)

The SEL-751A 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 = 751A`; 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 it is external if an input is attached.

Command Explanations

This section lists ASCII commands alphabetically. Commands, command options, and command variables to enter are shown in bold. Lowercase italic letters and words in a command represent command variables that are determined based on the application. For example, time ***t*** = 1 to 30 seconds, remote bit number ***n*** = 01 to 32, and ***level***.

Command options appear with brief explanations about the command function. Refer to the references listed with the commands for more information on the control function corresponding to the command or examples of the control response to the command.

You can simplify the task of entering commands by shortening any ASCII command to the first three characters; for example, **ACCESS** becomes **ACC**. Always send a carriage return **<CR>** character or a carriage return character followed by a line feed character **<CR><LF>** to command the control to process the ASCII command. Usually, most terminals and terminal programs interpret the Enter key as a **<CR>**. For example, to send the **ACCESS** command, type **ACC <Enter>**.

Tables in this section show the access level(s) where the command or command option is active. Access levels in this device are Access Level 0, Access Level 1, and Access Level 2.

Access Commands (ACCESS, 2ACCESS, and CAL)

The **ACC**, **2AC**, and **CAL** commands (see *Table 7.7*) provide entry to the multiple access levels. Different commands are available at the different access levels, as shown in the *SEL-751A 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

Passwords are necessary unless they are disabled. See *PASSWORD Command (Change Passwords) on page 7.34* for the list of default passwords and for more information on changing and disabling passwords.

Access Level Attempt (Password Required). Assume the following conditions:

- ➤ Access Level 1 password is not disabled.
- ➤ Access Level is 0.

At the Access Level 0 prompt, enter the **ACC** command:

```
=ACC <Enter>
```

Because the password is not disabled, the relay prompts you for the Access Level 1 password:

```
Password: ?
```

The relay is shipped with the default Access Level 1 password shown in *PASSWORD Command (Change Passwords) on page 7.34*. 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
Arc Flash Diagnostic in progress . . . . . . . . . . . . .

SEL-751A                                  Date: 12/09/2008   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 *Table 7.9* for the format). After entering the **ANA** command, the device suspends normal operation of the analog output channel and scales the output to a percentage of full scale. After assigning the specified value for the specified time, the device returns to normal operation. Entering any character (including pressing the space key) ends the command before it reaches the specified interval completion. You can test the analog output in one of the following two modes:

- Fixed percentage: Outputs a fixed percentage of the signal for a specified duration
- Ramp: Ramps the output from minimum to maximum of full scale 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

Table 7.9 ANALOG Command Format

Parameter	Description
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 a scaled output from 4-20 mA, 0 percent is 4 mA and 100 percent is 20 mA.

When parameter *p* is a percentage, the relay displays the following message during the test:

```
Outputting xx.xx [units] to Analog Output Port for y.y
minutes. Press any key to end test
```

where:

`xx.xx` is the calculation of percent of full scale
`[units]` is either mA or V, depending on the channel type setting
`y.y` is the time in minutes

When parameter *p* is a ramp function, the device displays the following message during the test:

```
Ramping Analog Output at xx.xx [units]/min; full scale in
y.y minutes. Press any key to end test
```

where:

`xx.xx` is the calculation based upon range/time t
`[units]` is either mA or V, depending on the channel type setting
`y.y` is the time in minutes

For either mode of operation (percentage or ramp), when the time expires, or upon pressing a key, the analog output port returns to normal operation and the device displays the following message:

```
Analog Output Port Test Complete
```

Example 1

The following is an example of the device response to the **ANA** command in the percentage mode. For this example, we assume that the analog output signal type is 4–20 mA, and we want to test the analog output at 75 percent of rating for 5.5 minutes. To check the device output, calculate the expected mA output as follows:

$$\text{Output} = \left[(20.00\text{ mA} - 4.00\text{ mA}) \bullet \frac{75}{100}\right] + 4.00\text{ mA} = 16.00\text{ mA}$$

To start the test, enter **ANA A0301 75 5.5** at the Access Level 2 prompt:

```
=>>ANA A0301 75 5.5 <Enter>
Outputting 16.00 mA to Analog Output Port for 5.5 minutes.
Press any key to end test
```

Example 2

The following is an example of the ramp mode when the analog output signal type is 4–20 mA for a 9.0 minute test.

To check the device output, calculate the current/time (mA/min) output as follows:

$$\text{Output} = \left[\frac{20.00\text{ mA} - 4.00\text{ mA}}{9.0\text{ min}}\right] = 1.78\text{ mA/min}$$

To start the test, enter **ANA AO301 R 9.0** at the Access Level 2 prompt:

```
=>>ANA A0301 R 9.0 <Enter>
Ramping Analog Output at 1.78 mA/min; full scale in 9.0 minutes.
Press any key to end test
```

BRE Command (Breaker Monitor Data)

Use the **BRE** command to view the breaker monitor report.

```
=>>BRE <Enter>

SEL-751A                                  Date: 12/04/2008   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  11/25/2008 11:16:21

=>>
```

See *Breaker Monitor on page 5.17* for further details on the breaker monitor.

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    = 12/04/2008 ? 12/04/2008  <Enter>

                                      Time    = 14:27:10  ? 17:50:12  <Enter>

Save changes (Y,N)? y

=>>
```

Use the **BRE R** command to reset the breaker monitor:

```
=>>BRE R <Enter>

Reset Breaker Wear (Y,N)? y
Clearing Complete

=>>LAST RESET 02/03/01 05:41:07
```

See *Breaker Monitor on page 5.17* for further details on the breaker monitor.

CEV Command

The SEL-751A 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 and frequency measurements.

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 4.24* and *Figure 4.34* 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 2.16*) 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 7.10*) displays communications statistics for the MIRRORED BITS communications channels. For more information on MIRRORED BITS communications, see *Appendix I: MIRRORED BITS Communications*. The summary report includes information on the failure of ROKA or ROKB. The `Last error` field displays the reason for the most recent channel error, even if the channel was already failed. We define failure reasons as one of the following error types:

- Device disabled
- Framing error
- Parity error
- Overrun
- Re-sync
- Data error
- Loopback
- Underrun

Table 7.10 COM Command

Command	Description	Access Level
COM S A or **COM S B**	Return a summary report of the last 255 records in the communications buffer for either MIRRORED BITS communications Channel A or Channel B when only one channel is enabled.	1
COM A	Return a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.	1
COM B	Return a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.	1
COM L A	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.	1
COM L B	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.	1
COM C	Clears all communications records. If both MIRRORED BITS channels are enabled, omitting the channel specifier (A or B) clears both channels.	1
COM C A	Clears all communications records for Channel A.	1
COM C B	Clears all communications records for Channel B.	1

CONTROL Command (Control Remote Bit)

Use the **CON** command (see *Table 7.11*) to control remote bits (Relay Word bits RB01–RB32). You can use the **CON** function from the front panel (`Control > Outputs`) to pulse the outputs. Remote bits are device variables that you set via serial port communication only; you cannot navigate Remote Bits via the front-panel HMI. You can select the control operation from three states: set, clear, or pulse, as described in *Table 7.12*.

Table 7.11 CONTROL Command

Command	Description	Access Level
CON RB*nn*[a] *k*[b]	Set a Remote Bit to set, clear, or pulse.	2

[a] Parameter nn is a number from 01 to 32, representing RB01 through RB32.
[b] Parameter k is S, C, or P.

Table 7.12 Three Remote Bit States

Subcommand	Description	Access Level
S	Set Remote bit (ON position)	2
C	Clear Remote bit (OFF position)	2
P	Pulse Remote bit for 1/4 cycle (MOMENTARY position)	2

For example, use the following command to set Remote bit RB05:

```
=>>CON RB05 S <Enter>
```

COPY Command

Use the **COPY *j k*** command (see *Table 7.13*) to copy the settings of settings Group *j* to the settings of settings Group *k*. The settings of settings Group *j* effectively overwrite the settings of settings Group *k*. Parameters *j* and *k* can be any available settings group number 1 through 3.

Table 7.13 COPY Command

Command	Description	Access Level
COPY *j k*[a]	Copy settings in Group *j* to settings in Group *k*.	2

[a] Parameters j and k are 1–3.

For example, when you enter the **COPY 1 3** command, the relay responds, `Are you sure (Y/N)?` Answer **Y <Enter>** (for yes) to complete copying. The settings in Group 1 overwrite the settings in Group 3.

COUNTER Command (Counter Values)

The device generates the values of the 32 counters in response to the **COU** command (see *Table 7.14*).

Table 7.14 COUNTER Command

Command	Description	Access Level
COU *n*	Display present state of device counters *n* times, with a 1/2-second delay between each display	1

DATE Command (View/Change Date)

Use the **DATE** command (see *Table 7.15*) to view and set the relay date.

Table 7.15 Date Command

Command	Description	Access Level
DATE	Display the internal clock date.	1
DATE ***date***	Set the internal clock date (DATE_F set to MDY, YMD, or DMY).	1

The relay can overwrite the date you enter by using other time sources such as IRIG. Enter the **DATE** command with a date to set the internal clock date.

Separate the month, day, and year parameters with spaces, commas, slashes, colons, and semicolons. Set the year in 4-digit form (for dates 2000–2099). Global setting DATE_F sets the date format.

ETH Command

The **ETH** command (Access Level 1) can be used to display the Ethernet port (Port 1) status as shown in *Figure 7.17* for the redundant fiber-optic (FX) Ethernet **Port 1A** and **Port 1B** configuration. Copper Ethernet port is labelled as TX. The non-redundant port response is similar.

```
=>>ETH <Enter>

SEL-751A                                 Date: 06/05/2008   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 7.17 Ethernet Port (PORT 1) Status Report

The non-redundant port response is as shown in *Figure 7.18*.

```
=>>ETH <Enter>

SEL-751A                                 Date: 06/05/2008   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 7.18 Non-Redundant Port Response

EVENT Command (Event Reports)

Use the **EVE** command (see *Table 7.16* and *Table 7.17*) to view event reports. See *Section 9: Analyzing Events* for further details on retrieving and analyzing event reports. See the *HISTORY Command on page 7.30* for details on clearing event reports.

Table 7.16 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

Table 7.17 EVENT Command Format

Parameter	Description
n	Parameter *n* specifies the event report number to be returned. Use the **HIS** command to determine the event report number of the event you want to display. If *n* is not specified, the relay will display event report 1 by default.

FILE Command

The **FIL** command (see *Table 7.18*) 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 **FILE** command is supported if you connect over serial or Ethernet ports.

Table 7.18 FILE Command

Command	Description	Access Level
FIL DIR	Return a list of files.	1
FIL READ *filename*	Transfer settings file *filename* from the relay to the PC.	1
FIL WRITE *filename*	Transfer settings file *filename* from the PC to the relay.	2
FIL SHOW *filename*	Filename 1 displays contents of the file *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 7.19*.

Table 7.19 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_751A_1CFG/LLN0GOGooseDSet13).
Receive GOOSE Control Reference	This field represents the goCbRef (GOOSE Control Block Reference) information that includes the iedName (IED name), ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and cbName (GSE Control Block Name) (e.g., SEL_751A_1CFG/LLN0GOGooseDSet13).
MultiCastAddr (Multicast Address)	This hexadecimal field represents the GOOSE multicast address.
Ptag	This three-bit decimal field represents the priority tag value, where spaces are used if the priority tag is unknown.
Vlan	This 12-bit decimal field represents the virtual LAN (Local Area Network) value, where spaces are used if the virtual LAN is unknown.
StNum (State Number)	This hexadecimal field represents the state number that increments with each state change.
SqNum (Sequence Number)	This hexadecimal field represents the sequence number that increments with each GOOSE message sent.
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_751A_1/LLN0$DSet13).
Receive Data Set Reference	This field represents the datSetRef (Data Set Reference) that includes the iedName (IED name), ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and datSet (Data Set Name) (e.g., SEL_751A_1CFG/LLN0$DSet13).

An example response to the **GOOSE** commands is shown in *Figure 7.19*.

```
#>GOOSE <Enter>

GOOSE Transmit Status

   MultiCastAddr   Ptag:Vlan  StNum      SqNum      TTL    Code
-----------------------------------------------------------------------------
SEL_751A_2CFG/LLN0$GO$GooseDSet13
   01-0C-CD-01-00-04  4:1     2          20376      50
   Data Set: SEL_751A_2CFG/LLN0$DSet13
GOOSE Receive Status

   MultiCastAddr   Ptag:Vlan  StNum      SqNum      TTL    Code
-----------------------------------------------------------------------------
SEL_751A_1CFG/LLN0$GO$NewGOOSEMessage5
   01-0C-CD-01-00-05  4:0     1          100425     160
   Data Set: SEL_751A_1CFG/LLN0$DSet10

SEL_751A_1CFG/LLN0$GO$NewGOOSEMessage3
   01-0C-CD-01-00-03  4:0     1          98531      120
   Data Set: SEL_751A_1CFG/LLN0$DSet05

SEL_751A_1CFG/LLN0$GO$NewGOOSEMessage2
   01-0C-CD-01-00-02  4:0     1          97486      200
   Data Set: SEL_751A_1CFG/LLN0$DSet04

SEL_751A_1CFG/LLN0$GO$NewGOOSEMessage1
   01-0C-CD-01-00-01  4:0     1          96412      190
   Data Set: SEL_751A_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



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 7.19 GOOSE Command Response

GROUP Command

Use the **GROUP** command (see *Table 7.20*) to display the active settings group or try to force an active settings group change.

Table 7.20 GROUP Command

Command	Description	Access Level
GROUP	Display the active settings group.	1
GROUP n[a]	Change the active group to Group *n*.	2

[a] Parameter n indicates group numbers 1–3.

When you change the active group, the relay responds with a confirmation prompt: `Are you sure (Y/N)?` Answer **Y <Enter>** to change the active group. The relay asserts the Relay Word bit SALARM for one second when you change the active group.

If any of the SELOGIC control equations SS1–SS3 are set when you issue the **GROUP *n*** command, the group change will fail. The relay responds: `Command Unavailable: Active setting group SELOGIC equations have priority over the GROUP command`.

HELP Command

The **HELP** command (see *Table 7.21*) 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 7.21 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 7.22*) to view a list of one-line descriptions of relay events or clear the list (and corresponding event reports) from nonvolatile memory.

Table 7.22 HISTORY Command

Command	Description	Access Level
HIS	Return event histories with the oldest at the bottom of the list and the most recent at the top of the list.	1
HIS *n*	Return event histories with the oldest at the bottom of the list and the most recent at the top of the list, beginning at event *n*.	1
HIS C or R	Clear/reset the event history and all corresponding event reports from nonvolatile memory.	1

For more information on event reports, see *Section 9: Analyzing Events*.

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	Return a list of device identification codes.	0

IRI Command

Use the **IRI** command to direct the relay to read the demodulated IRIG-B time code at the serial port or IRIG-B input (see *Table 7.24*).

Table 7.24 IRI Command

Command	Description	Access Level
IRI	Force synchronization of internal control clock to IRIG-B time-code input.	1

To force the relay to synchronize to IRIG-B, enter the following command:

```
=>IRI <Enter>
```

If the relay successfully synchronizes to IRIG-B, it sends the following header and access level prompt:

```
SEL-751A                   Date: 12/10/2003 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 7.25* and *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 7.25 LDP Commands

Command	Description	Access Level
LDP *row1 row2* **LDP *date1 date2***	Use the **LDP** command to display a numeric progression of all load profile report rows. Use the **LDP** command with parameters to display a numeric or reverse numeric subset of the load profile rows.	1
LDP C	Use this command to clear the load profile report from nonvolatile memory.	1

Table 7.26 LDP Command Parameters

Parameter	Description
row1 row2	Append *row1* to return a chronological progression of the first *row1* rows. Append *row1* and *row2* to return all rows between *row1* and *row2*, beginning with *row1* and ending with *row2*. Enter the smaller number first to display a numeric progression of rows through the report. Enter the larger number first to display a reverse numeric progression of rows.
date1 date2	Append *date1* to return all rows with this date. Append *date1* and *date2* to return all rows between *date1* and date beginning with *date1* and ending with *date2*. Enter the oldest date first to display a chronological progression through the report. Enter the newest date first to display a reverse chronological progression. Date entries are dependent on the date format setting DATE_F.

L_D Command (Load Firmware)

Use the **L_D** command (see *Table 7.27*) 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

LOOPBACK Command

Use the **LOO** command (see *Table 7.28*) for testing the MIRRORED BITS communications channel for proper communication. For more information on MIRRORED BITS, see *Appendix I: MIRRORED BITS Communications*. With the transmitter of the communications channel physically looped back to the receiver, the MIRRORED BITS addressing will be wrong and ROK will be deasserted. The **LOO** command tells the MIRRORED BITS software to temporarily expect to see its own data looped back as its input. In this mode, LBOK will assert if error-free data are received. The **LOO** command, with just the channel specifier, enables loop back mode on that channel for five minutes, while the inputs are forced to the default values.

Table 7.28 LOO Command

Command	Description	Access Level
LOO	Enable loopback testing of MIRRORED BITS channels.	2
LOO A	Enable loopback on MIRRORED BITS Channel A for the next 5 minutes.	2
LOO B	Enable loopback on MIRRORED BITS Channel B for the next 5 minutes.	2

```
=>>LOO A <Enter>
Loopback will be enabled on Mirrored Bits channel A for the next 5 minutes.
The RMB values will be forced to default values while loopback is enabled.
Are you sure (Y/N)?
=>>
```

If only one MIRRORED BITS port is enabled, the channel specifier (A or B) can be omitted. To enable loopback mode for other than the 5-minute default, enter the necessary number of minutes (1–5000) 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 follows.

```
=>MAC <Enter>
Port 1 MAC Address:  00-30-A7-00-00-00
=>
```

MET Command (Metering Data)

The **MET** command (see *Table 7.29*, *Table 7.30*, and *Table 7.31*) provides access to the relay metering data.

Table 7.29 Meter Command

Command	Description	Access Level
MET *c n*	Display metering data.	1
MET *c* R	Reset metering data.	2

Table 7.30 Meter Command Parameters

Parameter	Description
c	Parameter for identifying meter class.
n	Parameter used to specify number of times (1–32767) to repeat the meter response.

Table 7.31 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

[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 4.26* 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 prompt will abort the command.

The main board breaker jumper (see *Table 2.16*) 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* and *Table 7.33*) to change existing passwords.

Table 7.32 PASSWORD Command

Command	Description	Access Level
PAS *level*	Change password for Access Level ***level***.	2, 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.

Table 7.33 PAS Command Format

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

The factory-default passwords are as shown in *Table 7.34*.

Table 7.34 Factory-Default Passwords for Access Levels 1, 2, and C

Access Level	Factory-Default Password
1	OTTER
2	TAIL
C	CLARKE

To change the password for Access Level 1 to #Ot3579!ijd7, enter the following command sequence:

```
=>>PAS 1 <Enter>
Old PW: ? ***** <Enter>
New PW: ? *********** <Enter>
Confirm PW: ? *********** <Enter>
Password Changed
=>>
```

Similarly, use **PAS 2** to change Level 2 passwords and **PAS C** to change Level C passwords.

Table 7.35 Valid Password Characters

Alpha	A B C D E F G H I J K L M N O P Q R S T U V W X Y Z a b c d e f g h i j k l m n o p q r s t u v w x y z
Numeric	0 1 2 3 4 5 6 7 8 9
Special	! " # $ % & ' ( ) * + , - . / : ; < = > ? @ [\ ] ^ _ ` { | } ~

Passwords can contain as many as 12 characters. Upper- and lowercase letters are treated as different characters. Strong passwords consist of 12 characters, with at least one special character or digit and mixed-case sensitivity, but do not form a name, date, acronym, or word. Passwords formed in this manner are less susceptible to password guessing and automated attacks.

Examples of valid, distinct, and strong passwords are as follows:

- #0t3579!ijd7
- (Ih2dcs)36dn
- $A24.68&,mvj
- *4u-Iwg+?lf-

PING Command

When you are setting up or testing substation networks, it is helpful to determine if the network is connected properly and if the other devices are powered up and configured properly. The **PING** command (Access Level 2) allows a user of the relay to determine if a host is reachable across an IP network and/or if the Ethernet port (Port 1) is functioning or configured correctly. A typical **PING** command response is shown in *Figure 7.20*.

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 7.20 PING Command Response

PULSE Command

NOTE: The **PULSE** command is available when the breaker control jumper on the main board is in the ENABLED position.

Use the **PULSE** command (see *Table 7.36*) to pulse any of the relay control outputs for a specified time. This function aids you in relay testing and commissioning. When a **PUL** command is issued, the selected contact will close or open depending on the output contact type (a or b). The **PUL** command energizes the coil and does not have any effect if the coil is already energized. The control outputs are **OUT*nnn***, where ***nnn*** represents 101–103 (standard), 301–304 (optional), 401–404 (optional), or 501–504 (optional).

Table 7.36 PUL OUTnnn Command

Command	Description	Access Level
PUL OUT*nnn*[a]	Pulse output OUT*nnn* for 1 second.	2
PUL OUT*nnn s*[b]	Pulse output OUT*nnn* for *s* seconds.	2

[a] Parameter nnn is a control output number.
[b] Parameter s is time in seconds, with a range of 1–30.

QUIT Command

Use the **QUIT** command (see *Table 7.37*) to revert to Access Level 0.

Table 7.37 QUIT Command

Command	Description	Access Level
QUIT	Go to Access Level 0.	0

Access Level 0 is the lowest access level; the SEL-751A performs no password check to descend to this level (or to remain at this level).

R_S Command (Restore Factory Defaults)

Use the **R_S** command (see *Table 7.38*) to restore factory-default settings.

Table 7.38 R_S Command (Restore Factory Defaults)

Command	Description	Access Level
R_S	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 7.39* and *Table 7.40*) to view and manage the Sequential Events Recorder report. See *Section 9: Analyzing Events* for further details on SER reports.

Table 7.39 SER Command (Sequential Events Recorder Report)

Command	Description	Access Level
SER	Use the **SER** command to display a chronological progression of all available SER rows (as many as 1024 rows). Row 1 is the most recently triggered row and row 1024 is the oldest.	1
SER C or **R**	Use this command to clear/reset the SER records.	1

Table 7.40 SER Command Format

Parameter	Description
row1	Append *row1* to return a chronological progression of the first *row1* rows. For example, use **SER 5** to return the first five rows.
row1 row2	Append *row1* and *row2* to return all rows between *row1* and *row2*, beginning with row1 and ending with *row2*. Enter the smaller number first to display a numeric progression of rows through the report. Enter the larger number first to display a reverse numeric progression of rows. For example, use **SER 1 10** to return the first 10 rows in numeric order or **SER 10 1** to return these same items in reverse numeric order.
date1	Append *date1* to return all rows with this date. For example, use **SER 1/1/2003** to return all records for January 1, 2003.
date1 date2	Append *date1* and *date2* to return all rows between date1 and date beginning with *date1* and ending with *date2*. Enter the oldest date first to display a chronological progression through the report. Enter the newest date first to display a reverse chronological progression. Date entries are dependent on the date format setting DATE_F. For example, use **SER 1/5/2003 1/7/2003** to return all records for January 5, 6, and 7, 2003.

If the requested SER report rows do not exist, the relay responds with `No SER data`.

SER D Command

The **SER D** command shows a list of SER items that the relay has automatically removed. These are "chattering" elements. You can automatically remove chattering SER elements in the SER Chatter Criteria category of the Report settings; the enable setting is ESERDEL. See *Section 4: Protection and Logic Functions, Report Settings (SET R Command)* for more information on SER automatic deletion and reinsertion.

Table 7.41 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 7.42* and *Table 7.43*).

Table 7.42 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

Table 7.43 SET Command Format

Parameter	Description
s	Append ***s***, the name of the specific setting you want to view and jumps to this setting. If ***s*** is not entered, the relay starts at the first setting.
TERSE	Append **TERSE** to skip the settings display after the last setting. Use this parameter to speed up the **SET** command. If you want to review the settings before saving, do not use the TERSE option.

When you issue the **SET** command, the relay presents a list of settings one at a time. Enter a new setting or press **<Enter>** to accept the existing setting. Editing keystrokes are shown in *Table 7.44*.

Table 7.44 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 7.45* for the **SHOW** command settings and *Table 7.46* for the command format.

Table 7.45 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

Table 7.46 SHOW Command Format

Parameter	Description
s	Appends, ***s***, the name of the specific setting you want to view, and jumps to this setting. If ***s*** is not entered, the relay starts at the first setting.

```
=>>SHO <Enter>

Group 1
Relay Settings

ID Settings
RID      := SEL-751A
TID      := FEEDER RELAY

Config Settings
CTR      := 120          CTRN     := 120          PTR      := 180.00
DELTA_Y  := DELTA        VNOM     := 120.00       SINGLEV  := 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
```

Figure 7.21 SHOW Command Example (Sheet 1 of 2)

```
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

RTD Settings
E49RTD   := NONE

Undervoltage Set
27P1P    := OFF           27P2P    := OFF

Overvoltage Set
59P1P    := 1.10          59P1D    := 0.5           59P2P    := OFF
59Q1P    := OFF           59Q2P    := OFF


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     := OFF

Demand Mtr Set
EDEM     := THM           DMTC     := 5             PHDEMP   := 5.00
GNDEMP   := 1.00          3I2DEMP  := 1.00

Trip/Close Logic
TDURD    := 0.5           CFD      := 1.0
TR       := ORED50T OR ORED51T OR 81D1T OR 81D2T OR 81D3T OR 81D4T OR 59P1T OR
            59P2T OR 55T OR REMTRIP OR SV01 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      := OFF

=>>
```

Figure 7.21 SHOW Command Example (Sheet 2 of 2)

STATUS Command (Relay Self-Test Status)

The **STA** command (see *Table 7.47*) displays the status report.

Table 7.47 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 7.48* shows the status report definitions and message formats for each test.

Table 7.48 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 1.3* and *Figure 1.4* 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
CURRENT	Integrity of current board	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 7.22 shows the typical relay output for the **STATUS S** command, showing available SELOGIC control equation capability.

```
=>STA S <Enter>

SEL-751A                                  Date: 02/27/2007   Time: 15:04:16
FEEDER RELAY                              Time Source: Internal

Part Number  751A01BBX5X7186030X
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 7.22 Typical Relay Output for STATUS S Command

SUMMARY Command

The **SUM** command (see *Table 7.49*) displays an event summary in human-readable format.

Table 7.49 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).

TARGET Command (Display Relay Word Bit Status)

The **TAR** command (see *Table 7.50* and *Table 7.51*) displays the status of front-panel target LEDs or Relay Word bit, whether these LEDs or Relay Word bits are asserted or deasserted.

Table 7.50 TARGET Command (Display Relay Word Bit Status)

Command	Description	Access Level
TAR *name* k **TAR *n*** **TAR *n k***	Use **TAR** without parameters to display Relay Word Row 0 or last displayed target row.	1
TAR R	Clears front-panel tripping targets. Unlatches the trip logic for testing purposes (see *Figure 8.1*). Shows Relay Word Row 0.	1

NOTE: The **TARGET R** command cannot reset the latched targets if a TRIP condition is present.

Table 7.51 TARGET Command Format

Parameter	Description
name	Display the Relay Word row with Relay Word bit name.
n	Show Relay Word row number ***n***.
k	Repeat ***k*** times (1–32767)

The elements are represented as Relay Word bits and are listed in rows of eight, called Relay Word rows. The first four rows, representing the front-panel operation and target LEDs, correspond to *Table 7.52*. 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 7.52 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 7.53*) returns information about the SEL-751A 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 7.53 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-751A responds with `Invalid Time`.

TRIGGER Command (Trigger Event Report)

Use the **TRI** command (see *Table 7.55*) to trigger the SEL-751A to record data for high-resolution oscillography and event reports.

Table 7.54 TRIGGER Command (Trigger Event Report)

Command	Description	Access Level
TRI	Trigger event report data capture.	1

When you issue the **TRI** command, the SEL-751A responds with `Triggered`. If the event did not trigger within one second, the relay responds with `Did not trigger`. See *Section 9: Analyzing Events* for further details on event reports.

VEC Command (Show Diagnostic Information)

Issue the **VEC** command (see *Table 7.55*) under the direction of SEL. The information contained in a vector report is formatted for SEL in-house use only. Your SEL application engineer or the factory may request a **VEC** command capture to help diagnose a relay or system problem.

Table 7.55 VEC Command

Command	Description	Access Level
VEC D	Displays the standard vector report.	2
VEC E	Displays the extended vector report	2

Section 8
Front-Panel Operations

Overview

The SEL-751A 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-751A 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-751A operation status. The features that help you operate the relay from the front panel include the following:

- Reading metering
- Inspecting targets
- Accessing settings
- Controlling relay operations
- Viewing diagnostics

Front-Panel Layout

Figure 8.1 shows and identifies the following regions:

- Human-Machine Interface (HMI)
- TARGET RESET and navigation pushbuttons
- Operation and target LEDs
- Operator control pushbuttons and pushbutton LEDs
- EIA-232 Serial Port (PORT F). See *Section 7: Communications* for details on the serial port.

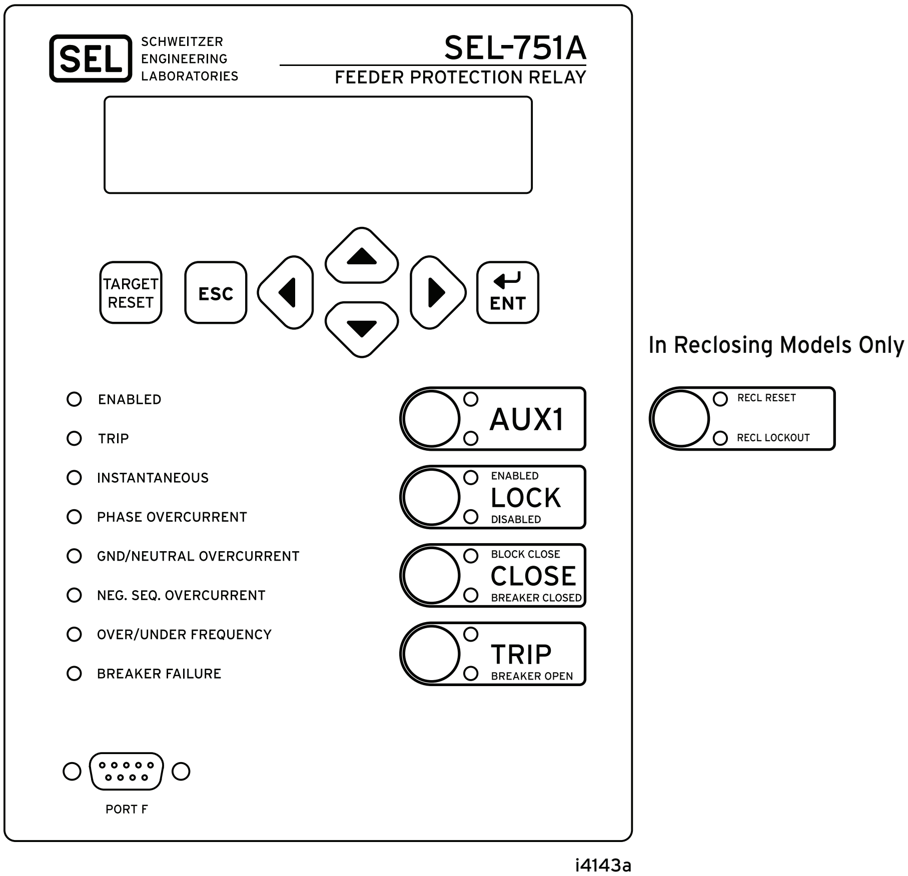


Figure 8.1 Front-Panel Overview

You can use the following features of the versatile front panel to customize it to your needs:

- Rotating display on the HMI
- Programmable target LEDs
- Programmable pushbutton LEDs
- Optional 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-751A 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-751A 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.

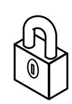


Figure 8.2 Access Level Security Padlock Symbol

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.

```
Password=
Del Clr Accept
A B C D E F G H
I J K L M N O P
Q R S T U V W X
Y Z . . . . . .
a b c d e f g h
i j k l m n o p
q r s t u v w x
y z . . . . . .
0 1 2 3 4 5 6 7
8 9 . . . . . .
! " # $ % & ' (
) * + , - . / :
; < = > ? @ [ \
] ^ _ ` { | } ~
```

Figure 8.3 Password Entry Screen

See *PASSWORD Command (Change Passwords) on page 7.34* 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-751A provides a front-panel time-out, setting FP_TO. A timer resets every time you press a front-panel pushbutton. Once the time-out 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-751A 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.

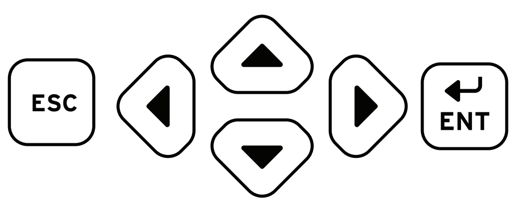


Figure 8.4 Front-Panel Pushbuttons

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-751A 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.

```
MAIN
Meter
Events
Targets
Control
Set/Show
Status
Breaker
```

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 through use of the **Up Arrow** or **Down Arrow** pushbuttons. See *Metering on page 5.2* for a description of the available data fields.

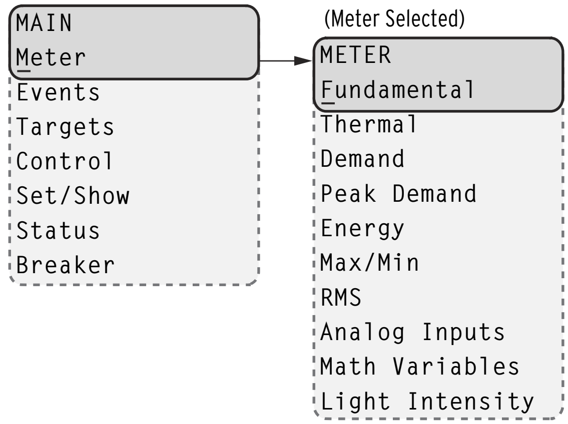


Figure 8.6 MAIN Menu and METER Submenu

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*.

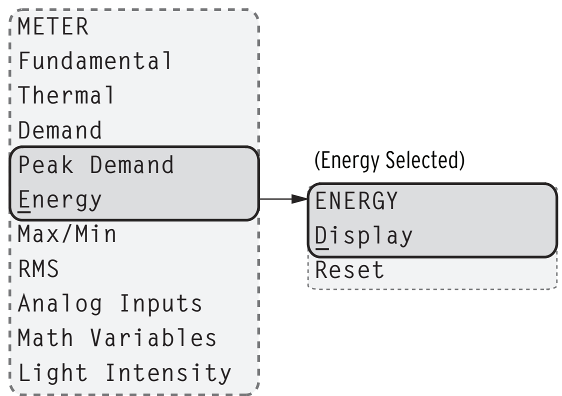


Figure 8.7 METER Menu and ENERGY Submenu

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*.

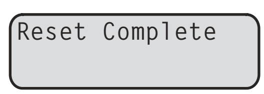


Figure 8.8 Relay Response When Energy (or Max/Min, Demand, Peak Demand) Metering Is Reset

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*.

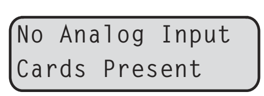


Figure 8.9 Relay Response When No Analog Cards Are Installed

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*.

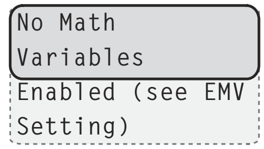


Figure 8.10 Relay Response When No Math Variables Enabled

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.

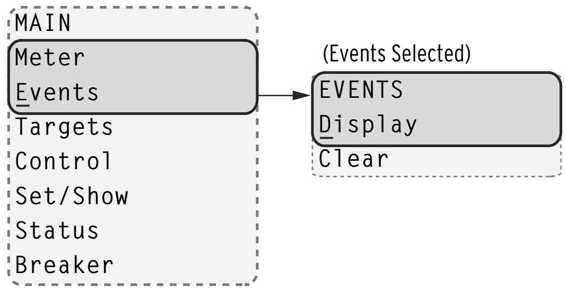


Figure 8.11 MAIN Menu and EVENTS Submenu

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.

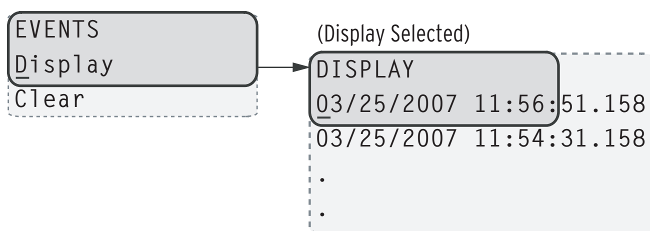


Figure 8.12 EVENTS Menu and DISPLAY Submenu

When `Display` is selected and no event data are available, the relay displays as shown in *Figure 8.13*.

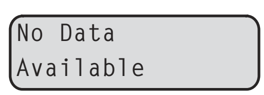


Figure 8.13 Relay Response When No Event Data Available

When you select `Clear` from the `EVENTS` menu and confirm the selection, the relay displays as shown in *Figure 8.14* after it clears the events data.

Figure 8.14 Relay Response When Events Are Cleared

Targets Menu

Select the `Targets` menu item on the `MAIN` menu as shown in *Figure 8.15* to view the binary state of the target rows. Each target row has eight Relay Word bits as shown in *Table J.1*.

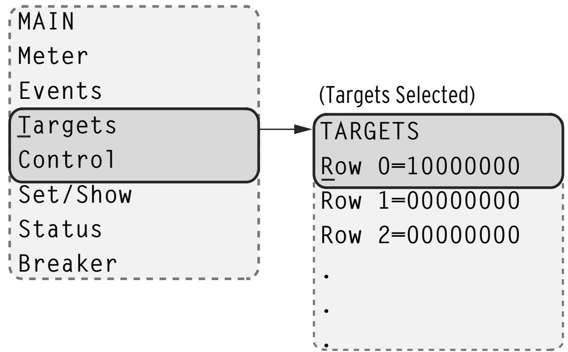


Figure 8.15 MAIN Menu and TARGETS Submenu

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

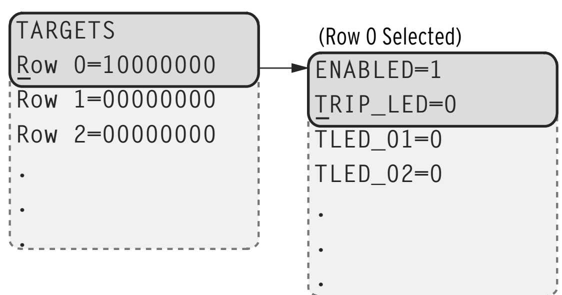


Figure 8.16 TARGETS Menu Navigation

Control Menu

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

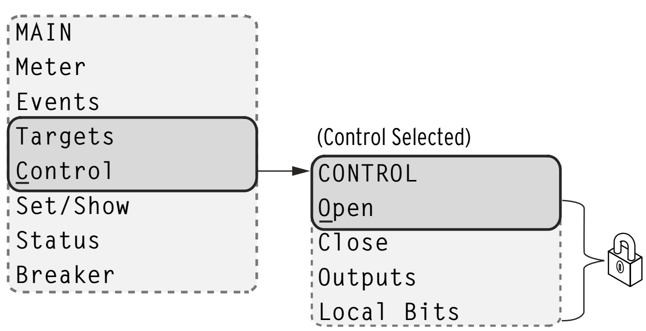


Figure 8.17 MAIN Menu and CONTROL Submenu

The `CONTROL` menu has `Open`, `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 4.22* 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 4.34*). 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-751A 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.

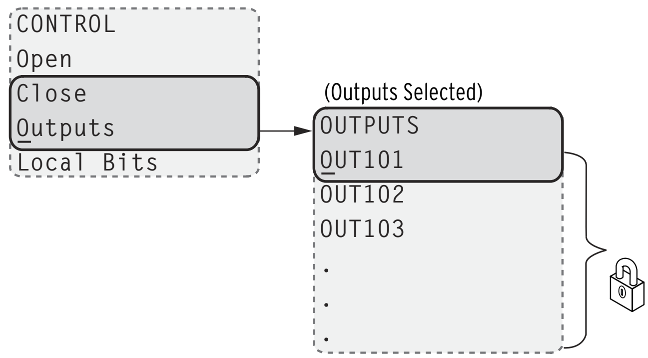


Figure 8.18 CONTROL Menu and OUTPUTS Submenu

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 4.114* 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*.

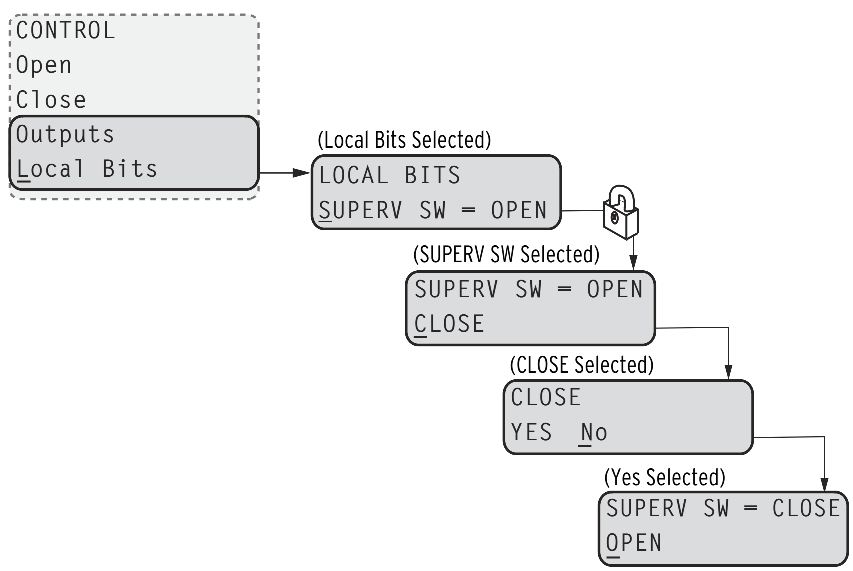


Figure 8.19 CONTROL Menu and LOCAL BITS Submenu

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.

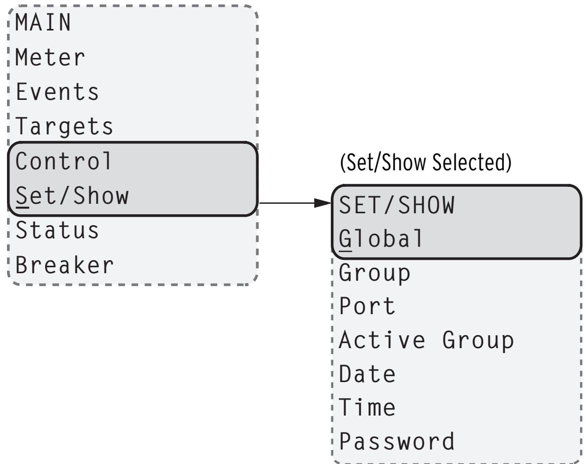


Figure 8.20 MAIN Menu and SET/SHOW Submenu

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.

Setting changes can also be made by using ACSELERATOR QuickSet® SEL-5030 Software or ASCII **SET** commands via a communications port.

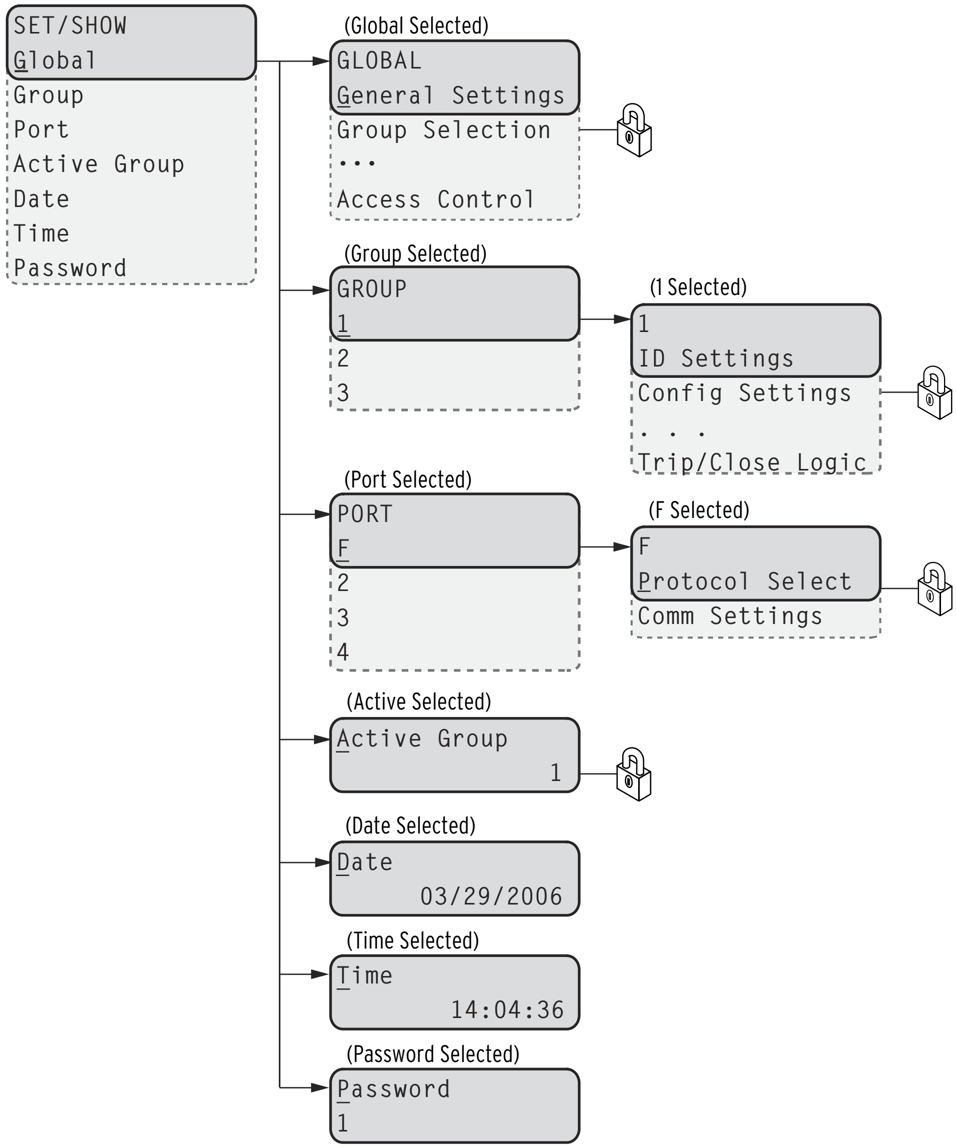


Figure 8.21 SET/SHOW Menu

Status Menu

Select the `Status` menu item on the `MAIN` menu as shown in *Figure 8.22* to access `Relay Status` data and `Reboot Relay`. See *STATUS Command (Relay Self-Test Status) on page 7.40* for the **STATUS** data field description.

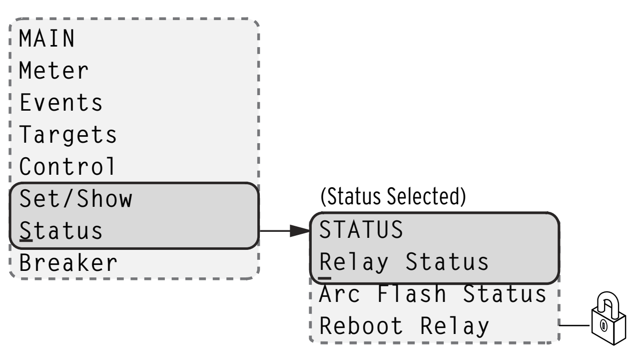


Figure 8.22 MAIN Menu and Status Submenu

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 5.17*, in *Section 5: Metering and Monitoring* for a detailed description.

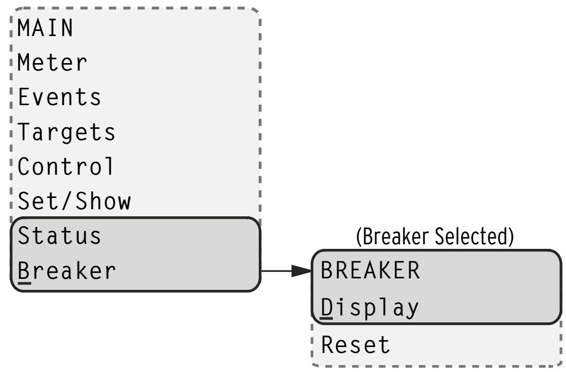


Figure 8.23 MAIN Menu and Breaker Submenu

Operation and Target LEDs

Programmable LEDs

The SEL-751A 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 4.116* for the SELOGIC control equations.

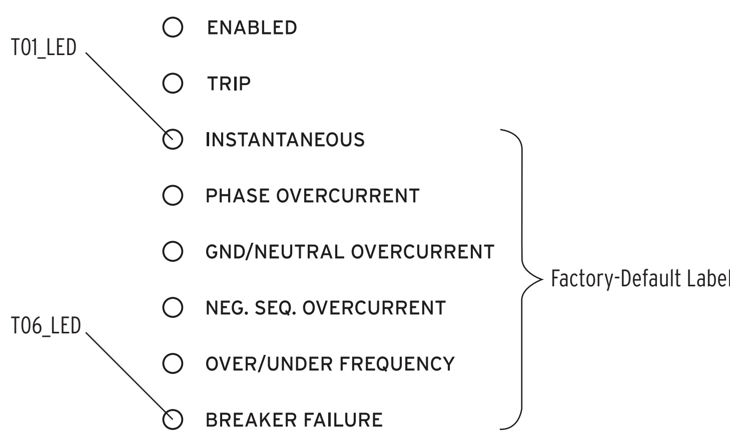


Figure 8.24 Factory-Default Front-Panel LEDs

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*. 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 4.68*.

You can order the SEL-751A with optional 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-751A is ordered with the Configurable Labels option.

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-751A latches the trip-involved target LEDs except for the ENABLED LED. Press the TARGET RESET pushbutton to reset the latched target LEDs. When a new trip event occurs and the previously latched trip targets have not been reset, the relay clears the latched targets and displays the new trip targets. Pressing and holding the TARGET RESET pushbutton illuminates all the LEDs. Upon release of the TARGET RESET pushbutton, two possible trip situations can exist: the conditions that caused the relay to trip have cleared, or the trip conditions remain present at the relay inputs. If the trip conditions have cleared, the latched target LEDs turn off. If the trip event conditions remain, the relay re-illuminates the corresponding target LEDs. The TARGET RESET pushbutton also removes the trip automatic message displayed on the LCD menu screens if the trip conditions have cleared.

Figure 8.25 Target Reset Pushbutton

Lamp Test

The TARGET RESET pushbutton also provides a front-panel lamp test. Pressing and holding TARGET RESET illuminates all the front-panel LEDs, and these LEDs remain illuminated for as long as TARGET RESET is pressed. The target LEDs return to a normal operational state after release of the TARGET RESET pushbutton.

Other Target Reset Options

Use the ASCII command **TAR R** to reset the target LEDs; see *Table 7.12* for more information. Programming specific conditions in the SELOGIC control equation RSTTRGT is another method for resetting target LEDs. Access RSTTRGT in *Global Settings (SET G Command), Data Reset on page 4.102* for further information.

Front-Panel Operator Control Pushbuttons

The SEL-751A features four operator-controlled pushbuttons, each with two programmable pushbutton LEDs, for local control as shown in *Figure 8.26*.

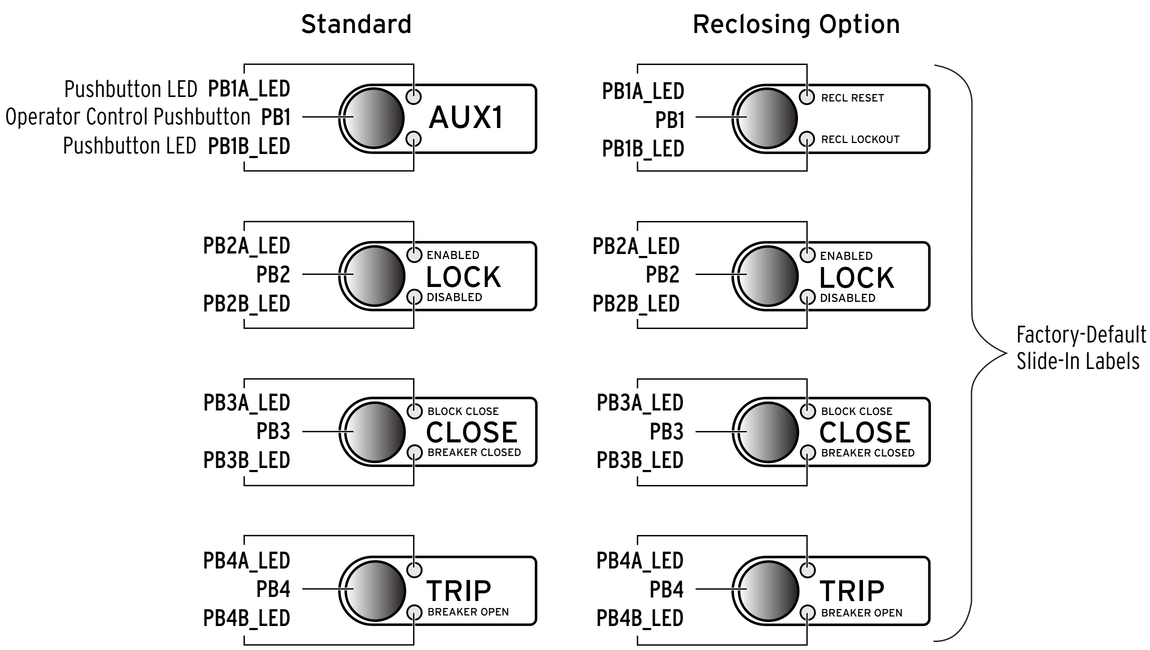


Figure 8.26 Operator Control Pushbuttons and LEDs

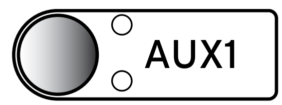
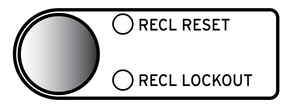
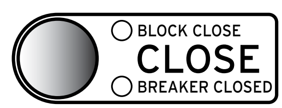
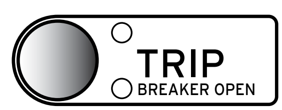
Pressing any one of these four pushbuttons asserts the corresponding PB*n* (*n* = 01 through 04) Relay Word bit, and the corresponding PB*n*_PUL Relay Word bit. The PB*n* Relay Word bit remains asserted as long as the pushbutton is pressed, but the PB*n*_PUL Relay Word bit asserts only for the initial processing interval, even if the button is still being pressed. Releasing the pushbutton, and then pressing the pushbutton again asserts the corresponding PB*n*_PUL Relay Word bit for another processing interval. The pushbutton LEDs are independent of the pushbutton.

Pushbutton LEDs are programmable through the use of front-panel settings PB*nm*_LED (where *n* = 1 through 4 and *m* = A or B). PB*nm* _LED settings are SELOGIC control equations that, when asserted, illuminate the corresponding LED for as long as the input is asserted. When the input deasserts, the LED also deasserts without latching.

Using SELOGIC control equations, you can readily change the default LED and pushbutton functions. Use the optional slide-in label to mark the pushbuttons and pushbutton LEDs with custom names to reflect any programming changes that you make. Included on the SEL-751A 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-751A Front-Panel Operator Control Functions

Press the AUX 1 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 1 operator control does not perform any function with the factory settings.	
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-751A 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 4.36* 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-751A 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 4.36* for more information.	

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Section 9
Analyzing Events

Overview

The SEL-751A 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-751A will not result in lost data.

Event Reporting

Analyze events with the following event reporting functions:

- Event Summaries—Enable automatic messaging to allow the relay to send event summaries out a serial port when port setting AUTO := Y. A summary provides a quick overview of an event. You can also retrieve the summaries by using the **SUMMARY** command.
- Event History—The relay keeps an index of stored nonvolatile event reports. Use the **HISTORY** command to obtain this index. The index includes some of the event summary information so that you can identify and retrieve the appropriate event report.
- Event Reports—These detailed reports are stored in nonvolatile memory for later retrieval and detailed analysis.

NOTE: Arc-flash sensor light values and frequency are available only in Compressed ASCII event reports (**CEV** or **CEV R** commands).

Each time an event occurs, a new summary, history record, and report are created. Event report information includes:

- Date and time of the event
- Individual sample analog inputs (currents and voltages)
- Digital states of selected Relay Word bits (listed in *Table J.1*)

- Event summary, including the front-panel target states at the time of tripping and fault type
- Group, Logic, Global, and Report settings (that were in service when the event was retrieved)

Compressed Event Reports

The SEL-751A 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-751A 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-751A provides selectable event report length (LER) and prefault length (PRE). Event report length is either 15 or 64 cycles. Prefault length is 1–10 cycles for LER = 15 and 1–59 cycles for LER = 64. 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 19 of the most recent 64-cycle or as many as 77 of the most recent 15-cycle event reports in nonvolatile memory. Refer to the **SET R** command in *SET Command (Change Settings) on page 7.38* and *Report Settings (SET R Command) on page SET.57*.

Triggering

The SEL-751A 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 4.33*. 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 7.38*). When setting ER detects a logical 0 to logical 1 transition, it generates an event report (if the SEL-751A is not already generating a report that encompasses the new transition). The factory setting is shown in *Event Report Settings on page 4.120*.

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 7.43* 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-751A event memory.

For every triggered event, the relay generates and stores an event summary. The relay stores as many as 77 of the most recent event summaries (if event report length setting LER := 15); or, as many as 19 (if LER := 64). When the relay stores a new event summary, it discards the oldest event and event summary if the event memory is full. Event summaries contain the following information:

- Relay and Terminal Identification (RID and TID)
- Event number, date, time, event type, 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), optional Voltage Inputs card necessary
- Hottest RTD temperatures, SEL-2600 RTD Module or internal RTD card option necessary

NOTE: Figure 9.3 is on multiple pages.

The relay includes the event summary in the event report. The identifiers, date, and time information are at the top of the event report, and the remaining information follows at the end (See *Figure 9.3*). The example event summary in *Figure 9.1* corresponds to the standard 15-cycle event report in *Figure 9.3*.

```
=>>SUM <Enter>

SEL-751A                                  Date: 02/28/2007   Time: 13:58:23.629
FEEDER RELAY

Serial No = 2007XXXXXXXXXXX
FID = SEL-751A-R100-V0-Z001001-D20070410               CID = 5052
EVENT LOGS =  7

Event:     Trigger
Targets    10000000
Freq (Hz)  60.0

Current Mag
        IA            IB            IC            IN       IG
(A)     110.7         107.5         103.3          0.24     7.24

Voltage Mag
       VAN    VBN    VCN    VG
(V)   11476  11482  11503    150

=>>
```

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.

The relay processes the TRIP type in the same order shown in Table 9.1, starting from the top with Arc-Flash Trip. As soon as it reaches an active TRIP type it stops the process of looking for TRIP type. If it reaches the bottom of the table without finding a TRIP type then it simply calls it TRIP as shown in the table.

Table 9.1 Event Types (Sheet 1 of 2)

Event Type	Event Type Logic
Arc Flash Trip	(50PAF OR 50NAF) AND (TOL1 OR TOL2 OR TOL3 OR TOL4) AND TRIP
AG, BG, CG	Single phase-to-ground faults. Appends T if any overcurrent trip asserted.
ABC	Three-phase faults. Appends T if any overcurrent trip asserted.
AB, BC, CA	Phase-to-phase faults. Appends T if any overcurrent trip asserted.
ABG, BCG, CAG[a]	Phase-to-phase-to-ground faults. Appends T if any overcurrent trip asserted.
`Phase A1 50 Trip`	50A1P AND 50P1T AND TRIP
`Phase B1 50 Trip`	50B1P AND 50P1T AND TRIP
`Phase C1 50 Trip`	50C1P AND 50P1T AND TRIP
`Phase 50 Trip`	(50P2T OR 50P3T OR 50P4T) AND TRIP
`GND/NEUT 50 Trip`	(50N1T OR 50N2T OR 50N3T OR 50N4T OR 50G1T OR 50G2T OR 50G3T OR 50G4T) AND TRIP
`NEG SEQ 50 Trip`	(50Q1T OR 50Q2T OR 50Q3T OR 50Q4T) AND TRIP
`Phase A 51 Trip`	51AT AND TRIP
`Phase B 51 Trip`	51BT AND TRIP
`Phase C 51 Trip`	51CT AND TRIP
`Phase 51 Trip`	(51P1T OR 51P2T) AND TRIP

Table 9.1 Event Types (Sheet 2 of 2)

Event Type	Event Type Logic
GND/NEUT 51 Trip	(51N1T OR 51N2T OR 51G1T OR 51G2T) AND TRIP
NEG SEQ 51 Trip	(51QT) AND TRIP
59 Trip	(59P1T OR 59P2T OR 59G1T OR 59G2T OR 59Q1T OR 59Q2T) AND TRIP
55 Trip	55T AND TRIP
Underfreq 81 Trip	(81D*n*T AND TRIP) when 81D*n*TP < FNOM setting, *n* = 1, 2, 3, 4, 5, or 6
Overfreq 81 Trip	(81D*n*T AND TRIP) when 81D*n*TP > FNOM setting, *n* = 1, 2, 3, 4, 5, or 6
PowerElemnt Trip	(3PWR1T OR 3PWR2T) AND TRIP
RTD Trip	(WDGTRIP OR BRGTRIP OR AMBTRIP OR OTHTRIP) AND TRIP
Remote Trip	REMTRIP AND TRIP
27 Trip	(27P1T OR 27P2T) AND NOT LOP AND TRIP
RTD Fail Trip	RTDFLT AND TRIP
Breaker Failure Trip	BFT AND TRIP
CommIdleLossTrip	(COMMIDLE OR COMMLOSS) AND TRIP
Trigger	Serial port **TRI** command
ER Trigger	ER Equation assertion. Phase involvement is indeterminate.
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 are 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.

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 listed below:

- Line Currents (IA, IB, IC)
- Neutral Current (IN)
- Residual Current (IG), calculated from IA, IB, IC

The `Voltage Mag` fields display primary voltage magnitudes at the instant maximum current was measured. The voltages displayed are listed below:

- 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 listed below:

- 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-751A.

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 (see *Table 9.1*)
- Maximum feeder current
- Frequency
- Target LED status

```
=>>HIS <Enter>

SEL-751A                                   Date: 02/28/2007   Time: 15:06:13
FEEDER RELAY                               Time Source: Internal

FID = SEL-751A-R100-V0-Z001001-D20070410

#    DATE        TIME           EVENT            CURRENT   FREQ    TARGETS
1    02/28/2007  13:58:23.629   Trigger           110.7    60.0    10000000
2    02/28/2007  13:54:10.003   Phase 51 Trip    1170.1    60.0    11010001
3    02/28/2007  13:54:09.607   ER Trigger       1190.1    60.0    11010001
4    02/28/2007  13:47:36.121   Phase 51 Trip    1172.4    59.9    11010000
5    02/28/2007  13:47:35.725   ER Trigger       1171.7    59.9    10000000
6    02/28/2007  13:43:30.393   Phase 51 Trip     483.9    60.1    11010001
7    02/28/2007  13:43:29.347   ER Trigger        484.9    60.0    11010001
=>>
```

Event Number | Event Type | Maximum Current | Frequency | User-Defined Target LEDs

Figure 9.2 Sample Event History

Viewing the Event History

Access the history report from the communications ports, using the **HIS** command or the analysis menu within ACSELERATOR QuickSet® SEL-5030 software. View and download history reports from Access Level 1 and higher.

Use the **HIS** command from a terminal to obtain the event history. You can specify the number of the most recent events that the relay returns. See *HISTORY Command on page 7.30* for information on the **HIS** command.

Use the front-panel MAIN > Events > Display menu to display event history data on the SEL-751A 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-751A samples the power system measurands (ac voltage and ac current) 16 times per power system cycle. A digital filter extracts the fundamental frequency component of the measurands. The relay operates on the filtered values and reports these values in the standard, filtered event report.

To view the raw inputs to the relay, use the **EVE R** command to select the unfiltered event report. Use the unfiltered event reports to observe power system conditions:

- ➤ Power system transients on current and voltage channels
- ➤ Decaying dc offset during fault conditions on current channels

Raw event reports display one extra cycle of data at the beginning of the report.

Event Report Column Definitions

Refer to the example event report in *Figure 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.

NOTE: Figure 9.3 is on multiple pages.

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 7.42*) to retrieve event summary reports.

Table 9.2 summarizes the event summary report current and voltage columns. *Table 9.3* summarizes the event summary report output, input, protection, and control element columns.

Table 9.2 Event Report Current and Voltage Columns

Column Heading	Description
IA	Current measured by channel IA (primary A)
IB	Current measured by channel IB (primary A)
IC	Current measured by channel IC (primary A)
IG	Residual current (IA + IB + IC, primary A)
IN	Current measured by channel IN (primary A)
VAN or VAB	Voltage measured by channel VAN or VAB (primary V)
VBN or VBC	Voltage measured by channel VBN or VBC (primary V)
VCN or VCA	Voltage measured by channel VCN or VCA calculated from VAB and VBC (primary V)
VS	Voltage measured by channel VS (terminals VS, NS) (primary V)
VDC	Voltage measured by channel VDC (terminals VBAT+, VBAT-)

Table 9.3 Output, Input, Protection, and Control Element Event Report Columns (Sheet 1 of 2)

Column Heading	Column Symbols	Description
51ABC	.	51A, B, and C Elements in reset state
	A	51AP AND NOT (51BP OR 51CP)
	B	51BP AND NOT (51AP OR 51CP)
	C	51CP AND NOT (51AP OR 51BP)
	a	51AP AND 51BP AND NOT 51CP
	b	51BP AND 51CP AND NOT 51AP
	c	51CP AND 51AP AND NOT 51BP
	3	51AP AND 51BP AND 51AC
51P	1	51P1P AND NOT 51P2P
	2	51P2P AND NOT 51P1P
	3	51P1P AND 51P2P
51N	1	51N1P AND NOT 51N2P
	2	51N2P AND NOT 51N1P
	3	51N1P AND 51N2P
51G	1	51G1P AND NOT 51G2P
	2	51G2P AND NOT 51G1P
	3	51G1P AND 51G2P
51Q	1	51QP

Table 9.3 Output, Input, Protection, and Control Element Event Report Columns (Sheet 2 of 2)

Column Heading	Column Symbols	Description
50P	1	50P1P AND NOT (50P2P OR 50P3P OR 50P4P)
	2	50P2P AND NOT (50P1P OR 50P3P OR 50P4P)
	3	50P3P AND NOT (50P1P OR 50P2P OR 50P4P)
	4	50P4P AND NOT (50P1P OR 50P2P OR 50P3P)
	5	50P1P AND 50P2P
	6	50P1P AND 50P3P
	7	50P1P AND 50P4P
	8	50P2P AND 50P3P
	9	50P2P AND 50P4P
	A	50P3P AND 50P4P
	B	50P1P AND 50P2P AND 50P3P
	C	50P1P AND 50P2P AND 50P4P
	D	50P1P AND 50P3P AND 50P4P
	E	50P2P AND 50P3P AND 50P4P
	F	50P1P AND 50P2P AND 50P3P AND 50P4P
50NQG	N	50N1P OR 50N2P OR 50N3P OR 50N4P
	Q	50Q1P OR 50Q2P OR 50Q3P OR 50Q4P
	G	50G1P OR 50G2P OR 50G3P OR 50G4P
	a	50NxP AND 50QyP, x, y = any from 1-4
	b	50QxP AND 50GyP, x, y = any from 1-4
	c	50GxP AND 50NyP, x, y = any from 1-4
	3	50NxP AND 50QyP AND 50GzP, x, y, z = any from 1-4
81	1	81D1T OR 81D2T OR 81D3T OR 81D4T OR 81D5T OR 81D6T
RTD Wdg[a,b]	w	WDGALRM AND NOT WDGTRIP
	W	WDGTRIP
RTD Brg[a,b]	b	BRGALRM AND NOT BRGTRIP
	B	BRGTRIP
RTD Oth[a,b]	o	OTHALRM AND NOT OTHTRIP
	O	OTHTRIP
RTD Amb[a,b]	a	AMBALRM AND NOT AMBTRIP
	A	AMBTRIP
RTD In[b]	1	RTDIN
In 12	1	IN101 AND NOT IN102
	2	NOT IN101 AND IN102
	b	IN101 AND IN102
Out 12	1	OUT101 AND NOT OUT102
	2	NOT OUT101 AND OUT102
	b	OUT101 AND OUT102
Out 3	3	OUT103

[a] SEL-2600 RTD Module or RTD card necessary.
[b] 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 9.6*.

In *Figure 9.3*, an arrow (`>`) in the column following the `VCA` 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 `DC` column identifies the row with the maximum phase current. The SEL-751A calculates the 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.

```
=>>EVE <Enter>

SEL-751A                              Date: 06/05/2008   Time: 13:40:26.270      Date and Time of Event

FEEDER RELAY

Serial Number=000000000000000
FID=SEL-751A-X215-V0-Z003002-D20080530   CID=0E1E
                                                                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     VA      VB      VC      VS VDC CPNGQ PG   2 2
[1]
  -1739   467  1277  -0.0   4.2  -7429  -3317  10679  -7178  48 33... F. . . .3     Optional Voltage Card Required

    449 -1735  1256   0.0 -30.0   7994 -10399   2259   8071  48 33... F. . . .3
   1741  -468 -1279   0.0  -6.0   7421   3323 -10681   7173  48 33... F. . . .3
   -454  1736 -1258   0.0  24.0  -7999  10395  -2255  -8080  48 33... F. . . .3

[2]
  -1742   466  1278  -0.0   1.8  -7418  -3332  10679  -7171  48 33... F. . . .3
    454 -1737  1258  -0.0 -25.2   7999 -10397   2246   8084  48 33... F. . . .3     One Cycle of Data
   1738  -465 -1283   0.0 -10.2   7412   3334 -10685   7162  48 33... F. . . .3
   -456  1736 -1259   0.0  20.4  -8006  10391  -2243  -8087  48 33... F. . . .3

[3]
  -1737   461  1283   0.0   7.2  -7409  -3341  10685  -7160  48 33... F. . . .3
    455 -1737  1258  -0.0 -24.0   8010 -10393   2236   8089  48 33... F. . . .3
   1735  -460 -1284  -0.0  -9.6   7402   3346 -10688   7153  48 33... F. . . .3
   -456  1736 -1259   0.0  20.4  -8015  10388  -2232  -8095  48 33... F. . . .3
[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     See Figure 9.4 and Figure 9.5
    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
```

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

```
[7]
  -583   454  1283  -0.0  1154  -7373  -3386  10692  -7126  48 b3.31 F. . . .3
   154 -1737  1253   0.0  -331   8039 -10377   2191   8120  48 b3.31 F. . . .3
   581  -454 -1288   0.0 -1160   7367   3391 -10696   7119  48 b3.31 F. . . .3
  -155  1735 -1252   0.0   327  -8044  10373  -2187  -8127  48 b3.31 F. . . .3

[8]
  -582   453  1289   0.0  1160  -7367  -3400  10696  -7115  48 b3.31 F. . . .3
   154 -1739  1249  -0.0  -337   8048 -10372   2178   8127  48 b3.31 F. . . .3
   580  -452 -1291   0.0 -1163   7358   3404 -10699   7108  48 b3.31 F. . . .3
  -155  1738 -1249   0.0   333  -8055  10368  -2173  -8134  48 b3.31 F. . . .3
[9]
  -584   450  1291  -0.0  1157  -7357  -3411  10699  -7106  48 b3.31 F. . . .3
   156 -1738  1247  -0.0  -335   8059 -10370   2165   8136  48 b3.31 F. . . .3
   581  -451 -1293   0.0 -1163   7351   3413 -10701   7101  48 b3.31 F. . . .3
  -159  1737 -1248   0.0   330  -8064  10366  -2162  -8141  48 b3.31 F. . . .3
[10]
  -582   449  1292  -0.0  1159  -7348  -3422  10699  -7097  48 b3.31 F. . . .3
   156 -1737  1247  -0.0  -334   8064 -10366   2155   8143  48 b3.31 F. . . .3
   580  -450 -1297  -0.0 -1167   7340   3427 -10705   7090  48 b3.31 F. . . .3
  -157  1738 -1248   0.0   333  -8071  10361  -2151  -8150  48 b3.31 F. . . .3
[11]
  -583   449  1296   0.0  1162  -7339  -3434  10705  -7088  48 b3.31 F. . . .3
   156 -1741  1245  -0.0  -340   8073 -10359   2140   8152  48 b3.31 F. . . .3
   581  -448 -1295   0.0 -1162   7333   3438 -10706   7083  48 b3.31 F. . . .3
  -159  1738 -1246   0.0   333  -8078  10355  -2137  -8158  48 b3.31 F. . . .3
[12]
  -583   446  1294  -0.0  1157  -7331  -3445  10706  -7081  48 b3.31 F. . . .3
   156 -1519  1243  -0.0  -121   8080 -10355   2128   8159  48 b3.31 F. . . .3
   581  -276 -1296   0.0  -991   7322   3449 -10708   7074  48 b3.31 F. . . .3
  -158   941 -1243   0.0  -460  -8086  10352  -2124  -8165  48 b3.31 F. . . .3
[13]
  -582   124  1296  -0.0   838  -7319  -3456  10706  -7072  48 b3.31 F. . . .3
   158  -586   981  -0.0   553   8089 -10354   2117   8168  48 C3.31 F. . . .3
   581  -149 -1085   0.0  -652   7313   3461 -10710   7065  48 C3.31 F. . . .3
  -160   585  -569   0.0  -145  -8096  10350  -2111  -8174  48 C3.3. F. . . .3
[14]
  -583   145   651  -0.0   212  -7310  -3469  10710  -7061  48 C3.3. .. . . .3
   158  -585   413  -0.0 -13.8   8096 -10350   2106   8174  48 C3.3. .. . . .3
   581  -146  -436   0.0  -0.6   7304   3472 -10714   7056  48 ..... .. . . .3
  -159   583  -414   0.0   9.6  -8104  10346  -2102  -8181  48 ..... .. . . .3
[15]
  -581   146   435  -0.0   0.0  -7303  -3479  10714  -7052  48 ..... .. . . .3
   157  -584   413  -0.0 -14.4   8107 -10346   2093   8183  48 ..... .. . . .3
   579  -148  -436   0.0  -4.2   7297   3483 -10715   7047  48 ..... .. . . .3
  -158   584  -414   0.0  12.0  -8111  10341  -2088  -8188  48 ..... .. . . ..

Serial No = 2008xxxxxxxxxxx

FID = SEL-751A-X215-V0-Z003002-D20080530               CID = 0E1E

EVENT LOGS =  2

Event:     ER Trigger
Targets    11100001
Freq (Hz)  60.0

Current Mag
        IA            IB            IC            IN       IG
(A)    1806.6        1796.0        1796.0          0.00    16.94

Voltage Mag
       VAN    VBN    VCN    VG
(V)   10910  10916  10916    162

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

52ABF   := N       BFD     := 0.50    BFI     := R_TRIG TRIP

AO301AQ :=OFF
DCLOP   := OFF     DCHIP   := OFF

IN101D  := 10      IN102D  := 10
IN301D  := 10      IN302D  := 10      IN303D  := 10      IN401D  := 10
IN402D  := 10      IN403D  := 10      IN404D  := 10
```

Firmware Identifier and Firmware Checksum Identifier

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

```
RSTTRGT := 0
RSTENRGY:= 0
RSTMXMN := 0

DSABLSET:= 0


Group Settings

RID     := SEL-751A
TID     := FEEDER RELAY
CTR     := 120     CTRN    := 120     PTR     := 180.00  PTRS    := 180.00
DELTA_Y := WYE     VNOM    := 120.00  SINGLEV := N

50P1P   := 10.00   50P1D   := 0.00    50P1TC  := 1
50P2P   := 10.00   50P2D   := 0.00    50P2TC  := 1
50P3P   := 10.00   50P3D   := 0.00    50P3TC  := 1
50P4P   := 10.00   50P4D   := 0.00    50P4TC  := 1
50N1P   := OFF     50N2P   := OFF     50N3P   := OFF     50N4P   := OFF
50G1P   := OFF     50G2P   := OFF     50G3P   := OFF     50G4P   := OFF
50Q1P   := OFF     50Q2P   := OFF     50Q3P   := OFF     50Q4P   := OFF

51AP    := 6.00
51AC    := U3      51ATD   := 3.00    51ARS   := N
51ACT   := 0.00    51AMR   := 0.00    51ATC   := 1

51BP    := 6.00    51BC    := U3      51BTD   := 3.00    51BRS   := N
51BCT   := 0.00    51BMR   := 0.00    51BTC   := 1
51CP    := 6.00    51CC    := U3      51CTD   := 3.00    51CRS   := N

51CCT   := 0.00    51CMR   := 0.00    51CTC   := 1

51P1P   := 6.00    51P1C   := U3      51P1TD  := 3.00    51P1RS  := N
51P1CT  := 0.00    51P1MR  := 0.00    51P1TC  := 1

51P2P   := 6.00    51P2C   := U3      51P2TD  := 3.00    51P2RS  := N
51P2CT  := 0.00    51P2MR  := 0.00    51P2TC  := 1

51QP    := 6.00    51QC    := U3      51QTD   := 3.00    51QRS   := N
51QCT   := 0.00    51QMR   := 0.00    51QTC   := 1

51N1P   := OFF     51N2P   := OFF     51G1P   := 0.50    51G1C   := U3
51G1TD  := 1.50    51G1RS  := N
51G1CT  := 0.00    51G1MR  := 0.00    51G1TC  := 1

51G2P   := 0.50    51G2C   := U3      51G2TD  := 1.50    51G2RS  := N
51G2CT  := 0.00    51G2MR  := 0.00    51G2TC  := 1
E49RTD  := NONE
27P1P   := OFF     27P2P   := OFF     27S1P   := OFF     27S2P   := OFF

59P1P   := 1.10    59P1D   := 0.5     59P2P   := OFF     59S1P   := OFF
59S2P   := OFF

E25     := N
55LGTP  := OFF     55LDTP  := OFF     55LGAP  := OFF     55LDAP  := OFF
81D1TP  := OFF     81D2TP  := OFF
81D3TP  := OFF
81D4TP  := OFF

TDURD   := 0.5     CFD     := 1.0
TR      := ORED50T OR ORED51T OR 81D1T OR 81D2T OR 81D3T OR 81D4T OR 59P1T OR 59P2T OR 55T OR
    REMTRIP OR SV01 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     := OFF
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
```

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

```
ER     := R_TRIG 51P1P OR R_TRIG 51G1P OR R_TRIG 50P1P OR R_TRIG 50G1P OR R_TRIG 51N1P OR R_TRIG CF
LER     := 15      PRE     := 5

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
OUT102FS:= N       OUT102  := CLOSE
OUT103FS:= N       OUT103  := TRIP
OUT301FS:= N       OUT301  := 0
OUT302FS:= N       OUT302  := 0
OUT303FS:= N       OUT303  := 0
OUT304FS:= N       OUT304  := 0
OUT401FS:= N       OUT401  := 0
OUT402FS:= N       OUT402  := 0
OUT403FS:= N       OUT403  := 0
OUT404FS:= N       OUT404  := 0

=>>
```

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

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.

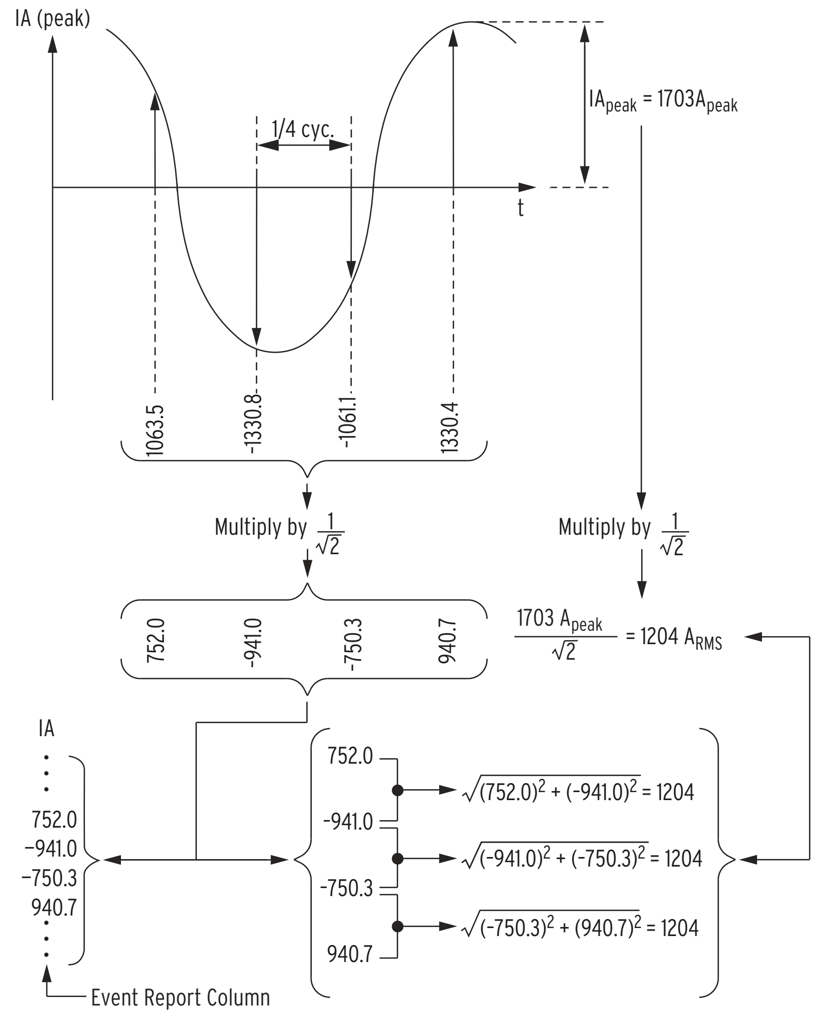


Figure 9.4 Derivation of Event Report Current Values and RMS Current Values From Sampled Current Waveform

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:

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

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

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

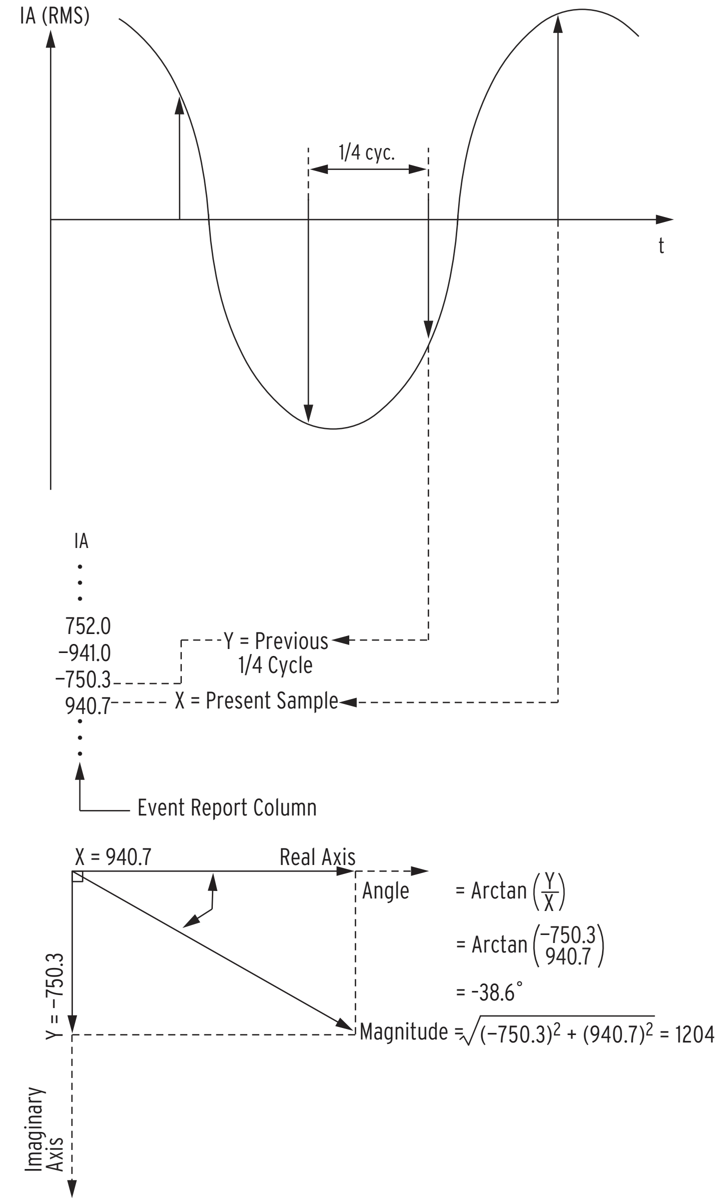


Figure 9.5 Derivation of Phasor RMS Current Values From Event Report Current Values

NOTE: The arctan function of many calculators and computing programs does not return the correct angle for the second and third quadrants (when X is negative). When in doubt, graph the X and Y quantities to confirm that the angle that your calculator reports is correct.

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 use the ALIAS settings to rename as many as 20 of the SER trigger conditions. 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 4.119* for additional details.

See *SER Command (Sequential Events Recorder Report) on page 7.37* for details on retrieving and clearing SER reports with the **SER** command.

Example SER Report

The example SER report in *Figure 9.6* includes records of events that occurred before the beginning of the event summary report in *Figure 9.3*.

```
=>SER 8 <Enter>

SEL-751A                                 Date: 02/28/2007   Time: 16:34:28
FEEDER RELAY                             Time Source: Internal

Serial No = 2007XXXXXXXXXXX
FID = SEL-751A-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 9.6 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

⚠WARNING
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-751A Feeder Protection Relay. Because the SEL-751A 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 10.15* 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*.

Commissioning Tests

SEL performs a complete functional check and calibration of each SEL-751A 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-751A 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-751A, installed and connected according to your protection design
- A PC with serial port, terminal emulation software, and serial communications cable
- *SEL-751A 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-751A 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, follow the substeps below; 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.

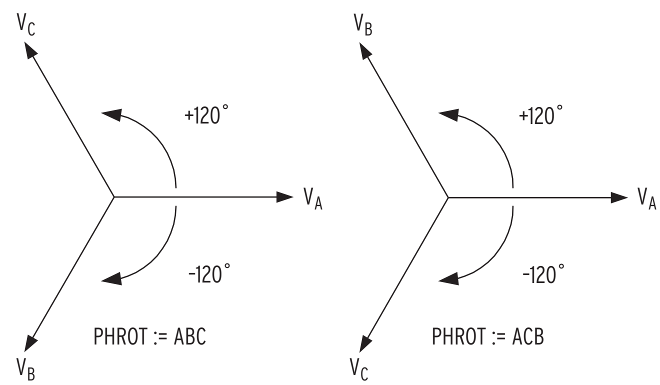
Step 11. Connect the ac test source current or voltage to the appropriate relay terminals.

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 10.1*.

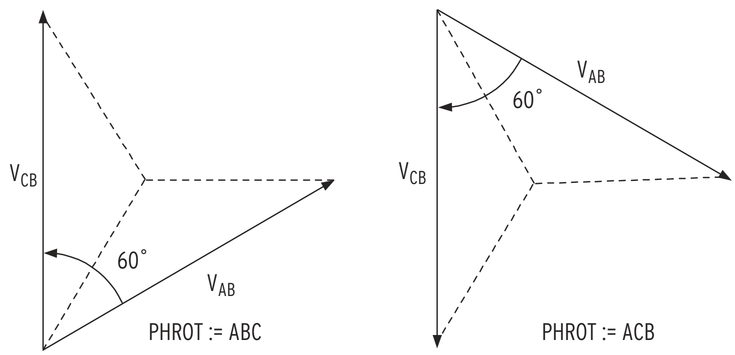
c. If you set the relay to accept delta voltages (DELTA_Y := DELTA), set the current and/or voltage phase angles as shown in *Figure 10.2*.



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 10.1 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 10.2 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). The expected phase angle is zero (0).

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:

a. For each output contact, set the input to logical 1. This causes the output contact to close. For example, setting OUT101 = 1 causes the output **OUT101** contact to close.

b. Repeat the process for all contact outputs.

Make sure that each contact closure does what you want it to do in the annunciation, control, or trip circuit associated with that contact closure.

Step 19. Perform any necessary 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 10.1* 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 10.1 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-751A 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 10.3*.

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 10.1*.

Step 4. Set each phase current magnitude equal to the values listed in Column 1 of *Table 10.2*. Use the front panel to view the phase current values. The relay should display the applied current magnitude times the CTR setting.

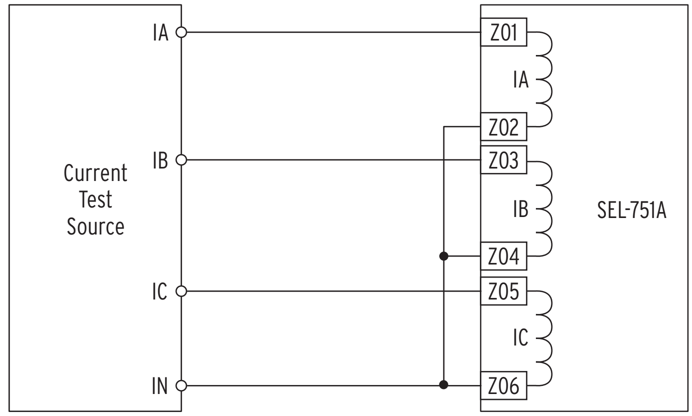


Figure 10.3 Current Source Connections

Table 10.2 Phase Current Measuring Accuracy

|I| Applied (A secondary)[a]	Expected Reading CTR x |I|	A-Phase Reading (A primary)	B-Phase Reading (A primary)	C-Phase Reading (A primary)
0.4 x I_{NOM}				
0.9 x I_{NOM}				
1.6 x I_{NOM}				

[a] I_{NOM} = rated secondary amperes (1 or 5).

Current Imbalance Metering Accuracy

Step 1. Connect the current source to the relay, as shown in *Figure 10.3*.

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 10.1*.

Step 4. Apply the appropriate magnitude for each phase current, as shown in Column 1 of *Table 10.3*.

Table 10.3 Current Unbalance Measuring Accuracy (Sheet 1 of 2)

|I| Applied (A secondary)	Expected Reading (%)	Actual Reading (%)
|IA| = 0.9 • I_{NOM} |IB| = I_{NOM} |IC| = I_{NOM}	7%	
|IA| = 0.75 • I_{NOM} |IB| = I_{NOM} |IC| = I_{NOM}	17%	
|IA| = I_{NOM} |IB| = 1.2 • I_{NOM} |IC| = 1.2 • I_{NOM}	12%	

Table 10.3 Current Unbalance Measuring Accuracy (Sheet 2 of 2)

|I| Applied (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 10.3*.

Step 2. Connect the voltage source to the relay, as shown in *Figure 10.4*. Make sure that DELTA_Y := WYE.

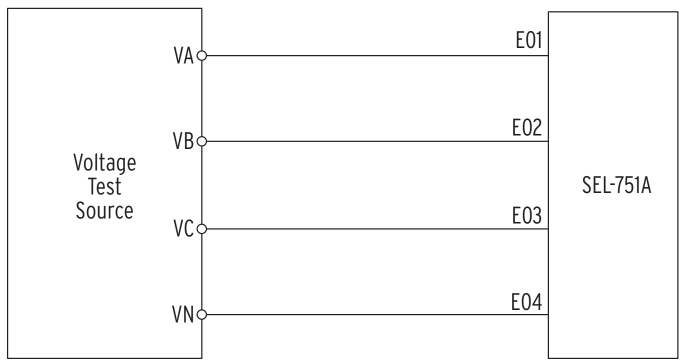


Figure 10.4 Wye Voltage Source Connections

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 10.4*.

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 10.4 Power Quantity Accuracy—Wye Voltages (Sheet 1 of 2)

Applied 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 10.4 Power Quantity Accuracy—Wye Voltages (Sheet 2 of 2)

Applied 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 10.3*.

Step 2. Connect the voltage source to the relay, as shown in *Figure 10.5*. Make sure that DELTA_Y := DELTA.

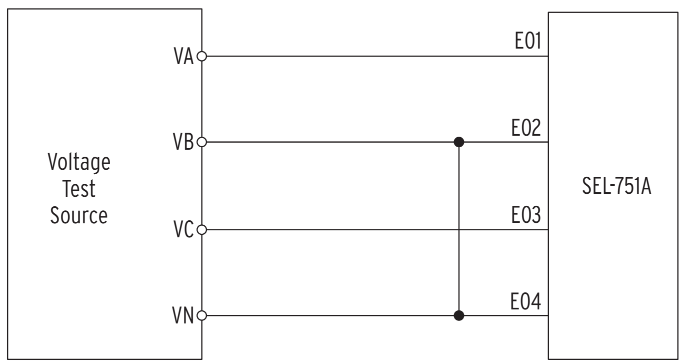


Figure 10.5 Delta Voltage Source Connections

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 10.5*.

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 10.5 Power Quantity Accuracy—Delta Voltages (Sheet 1 of 2)

Applied 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 Vbc = 120 ∠–90	**Measured:**	**Measured:**	**Measured:**

Table 10.5 Power Quantity Accuracy—Delta Voltages (Sheet 2 of 2)

Applied 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 Vbc = 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 in the ENABLED state. Refer to Application Guide *AG2011-01: Using the SEL-751 and SEL-751A for Arc-Flash Detection* for more details.

Arc-Flash Detection (AFD) System Continuous Self-Testing

The SEL-751A relay 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 relay uses the light measurement by the detector 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 in determining the “Time-Over Light” 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 AFS*n*EL picks up) or if there is a diagnostic failure (any of the Relay Word bits AFS*n*DIAG 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 CLEAR-JACKETED 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 through use of 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 as mentioned in the commissioning tests described previously. 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 10.6* shows an example event report for a simulated arc-flash incident.

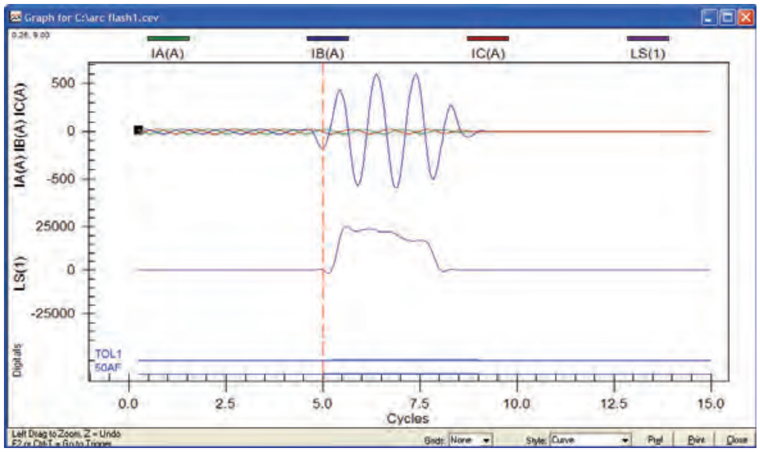


Figure 10.6 CEV R Light Event Capture Example

Periodic Tests (Routine Maintenance)

Because the SEL-751A 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-751A 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 10.6 Periodic Relay Checks

Test	Description
Relay Status	Use the front-panel `STATUS` or serial port **STATUS** command to verify that the relay self-tests have not detected any WARN or FAIL conditions.
Arc-Flash Detection (AFD) Status	Use the serial port **AFT** command to verify that the AFD channel self-tests have not detected any FAIL condition in any of the channels.
Meter	Verify that the relay is correctly measuring current and voltage (if included) by comparing the relay meter readings to separate external meters.
Control Input	Using the front-panel `MAIN > Targets > Row 13` function, check the control input status in the relay. As you apply rated voltage to each input, the position in Row 13 corresponding to that input should change from zero (0) to one (1).
Contact Output	For each output contact, set the input to Logic 1. This causes the output contact to close. For example, setting OUT101 := 1 causes the output **OUT101** contact to close. Repeat the process for all contact outputs. Make sure that each contact closure does what you want it to do in the annunciation, control, or trip circuit associated with that contact closure.

Self-Test

The SEL-751A runs a variety of self-tests. The relay takes the following corrective actions for out-of-tolerance conditions (see *Table 10.7*):

- Protection Disabled: The relay disables protection and control elements and trip/close logic. All output contacts are de-energized. The ENABLED front-panel LED is extinguished.
- ALARM Output: Two Relay Word bits, HALARM and SALARM, signal self-test problems. SALARM is pulsed for software programmed conditions, such as settings changes, access level changes, and three consecutive unsuccessful password entry attempts, active group changes, copy commands, or password changes. HALARM is pulsed for hardware self-test warnings. HALARM is continuously asserted (set to logical 1) for hardware self-test failures. A diagnostic alarm may be configured as explained in *Section 4: Protection and Logic Functions*. In the Alarm Status column of *Table 10.7*, 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 10.7 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

Table 10.7 Relay Self Tests (Sheet 2 of 3)

Self Test / Description	Normal Range	Protection Disabled on Failure	Alarm Status	Auto Message on Failure	Front Panel Message on Failure	Corrective Action
Front-Panel HMI (power up) Fail if ID registers do not match expected or if FPGA programming is unsuccessful		No	Not Latched	Yes	NA	STA C 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	
CT Board (power up) Fail if ID register does not match part number		Yes	Latched	Yes	Status Fail CT Card Fail	
CT Board A/D Offset Warn Measure dc offset at each input channel	–50 mV to +50 mV	No	Not Latched	No	NA	STA C Contact SEL if failure returns.
VT Board (power up) Fail if ID register does not match part number		Yes	Latched	Yes	Status Fail Card E Fail	
VT Board A/D Offset Warn Measure dc offset at each input channel	–50 to +50 mV	No	Not Latched	No	NA	STA C 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	

Table 10.7 Relay Self Tests (Sheet 3 of 3)

Self Test	Description	Normal Range	Protection Disabled on Failure	Alarm Status	Auto Message on Failure	Front Panel Message on Failure	Corrective Action
+1.2 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 Contact SEL if failure returns.
Clock Chip	Unable to communicate with clock or fails time keeping test		No	Not Latched	Yes	NA	STA C Contact SEL if failure returns.
Clock Chip RAM	Clock chip static RAM fails		No	Not Latched	Yes	NA	STA C 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 10.8 Troubleshooting

Symptom/Possible Cause	Diagnosis/Solution
The relay ENABLED front-panel LED is dark.	
Input power is not present or a fuse is blown.	Verify that input power is present. Check fuse continuity.
Self-test failure	View the self-test failure message on the front-panel display.
The relay front-panel display does not show characters.	
The relay front-panel has timed out.	Press the **ESC** pushbutton to activate the display.
The relay is de-energized.	Verify input power and fuse continuity.
The relay does not accurately measure voltages or currents.	
Wiring error	Verify input wiring.
Incorrect 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.
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-751A Feeder Protection Relay, use the **STA** command (see *STATUS Command (Relay Self-Test Status) on page 7.40* for more information on the **STA** command). The firmware revision number is after the R, and the release date is after the D. For example, the following is firmware revision number 100, release date April 10, 2007.

FID=SEL-751A-R100-V0-Z001001-D20070410

Table A.1 through *Table A.4* list 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.1 400 Series Firmware Revision History (Sheet 1 of 4)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-751A-R419-V0-Z011003-D20131025	➤ Manual update only (see *Table A.8*).	20150206
SEL-751A-R419-V0-Z011003-D20131025	➤ Corrected an issue with R418 where the IEC 61850 CID file was not preserved while upgrading to R418. R419 preserves the IEC 61850 CID file. Firmware version R419 is for upgrading relays with R400–R418 firmware.	20131025
SEL-751A-R418-V0-Z011003-D20130726	➤ Improved the security of RTD ALARM and TRIP by adding an approximately six-second delay to qualify the event. ➤ Added Breaker Wear Data to the ICD files. ➤ Corrected an issue where the device was sending continuous Gratuitous ARP requests while in switched mode. ➤ Added a feature to allow YMODEM file transfers over TELNET. ➤ Added Flash File System Support. ➤ Changed the latch and local bits storage to flash memory from RTC RAM. ➤ Corrected an issue with 81RFIBLK = OFF setting. When 81RFIBLK = OFF, the overcurrent blocking scheme is disabled. ➤ Added power demand analog quantities to IEC 61850. ➤ Revised firmware for HMI FPGA part replacement. Firmware version R418 is for upgrading relays with R400–R417 firmware.	20130802

Table A.1 400 Series Firmware Revision History (Sheet 2 of 4)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-751A-R417-V0-Z011003-D20130329	➤ Forced RTS to high and ignored CTS when PREDLY setting is OFF to power certain fiber-optic transceivers. ➤ Corrected an Ethernet Failover Switching issue for dual Ethernet models. ➤ Corrected an issue where old packets were returned on new connections when polling Modbus at a high speed. ➤ Revised the order of SELOGIC control equation processing. To correct a latency issue, the 79 element control equations now run after the 52A control equation. ➤ Corrected an issue with the initial Gratuitous ARP request not being sent for as long as five minutes after startup. Firmware version R417 is for upgrading relays with R400–R415 firmware.	20130329
SEL-751A-R415-V0-Z011003-D20130117	➤ Added event fault current data to analog quantities for DNP. ➤ Improved the PHASE LED logic. ➤ Added frequency measurement (FREQ) to CEV report. ➤ Updated units to parts per million (ppm) for CBADPU in Mirrored Bits Protocol. ➤ Updated error messages for setting interdependency checks to match the global setting AOx0yH. ➤ Modified Real Time Clock (RTC) diagnostics logic to show failure only if the RTC diagnostics fail for three consecutive times. ➤ Added a feature in Modbus to always show the latest event data unless another event is selected. ➤ Corrected an issue with the data type “Units_0” in the IEC 61850 ICD file. ➤ Improved the product ordering options to allow for IEC 61850 option or DNP option, or both. ➤ Corrected an issue where synch-check voltage frequency “FREQS” was not recognized as a valid analog quantity. ➤ Added new demand power metering and analog quantities. ➤ Corrected an issue with EVE, CEV, and CEV R reports that showed station battery voltage VBAT to be 0V for all values of VBAT. ➤ Corrected an issue with DC offset on analog channels upon relay power up.	20130117
SEL-751A-R414-V0-Z010003-D20120622	➤ Manual update only (see *Table A.8*).	20120903
SEL-751A-R414-V0-Z010003-D20120622	➤ Corrected an issue in firmware R413 that occurred when changing settings. The relay intermittently disabled and locked up all communications ports and the front panel when settings were revised and saved.	20120622
SEL-751A-R413-V0-Z010003-D20120518	➤ Fixed an issue that caused port settings to not be accepted when relay settings were downloaded using ACSELERATOR QuickSet® SEL-5030 Software. ACSELERATOR QuickSet reported with a message that settings files were not received. ➤ Corrected an issue where IN304 was shown in targets for the 3 DI/4 DO/1 AO card, which has only three inputs. ➤ Fixed an issue where there was an ER (event report) trigger with no trip and the relay reported ABCT as the trip type. ➤ Fixed an issue where the relay was not allowing FREQS analog quantity in the LDLIST setting for the Load Profile report.	20120518

Table A.1 400 Series Firmware Revision History (Sheet 3 of 4)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-751A-R412-V0-Z010003-D20111028	➤ Enhanced firmware to make serial number visible to IEC 61850 protocol and also revised the ICD file to add serial and part number information to PhyNam DO similar to the SEL-400 series relays. ➤ Corrected an issue with the rms meter values, where in some cases the values would spike for a short time. ➤ Fixed an issue with **LDP** (Load Profile) command response, where in some instances the column data and header were not matched correctly. ➤ Fixed an issue with ENABLED LED which did not turn off when the relay was disabled.	20111028
SEL-751A-R411-V0-Z010003-D20110621	➤ Added a squelch threshold for very low-level secondary voltages (below 0.3 V) and currents (below 3.0% of INOM) in the rms metering quantities command response. ➤ Lowered the low end of the VNOM setting range from 100 V to 20 V. ➤ Corrected DNP polling issue with IN101. ➤ Corrected issue with AOUTSLOT setting to work correctly with 4 DI/3 DO card option.	20110621
SEL-751A-R410-V0-Z009003-D20110509	➤ Corrected issue of SALARM not asserting for a settings group change. ➤ Corrected IEC 61850 KEMA compliance issue (Sisco library). ➤ Added df (frequency deviation) and df/dt (rate-of-change-of-frequency) qualifiers to 81RF function. ➤ Corrected issue in Demand Meter report where it was not capturing 3I2PD (negative-sequence peak demand) when setting EDEM := ROLL. ➤ Corrected RECLOSER setting issue where any recloser time settings above 2147 seconds were not handled correctly.	20110509
SEL-751A-R408-V0-Z009003-D20110201	➤ Corrected issue with Inverse Time Overcurrent elements (did not accumulate time correctly for FNOM = 50 Hz nominal frequency). ➤ Corrected issue with **PULSE** command use with OUT101 and OUT102 in relays with Arc-Flash Detection option. ➤ Updated firmware revision history for version R406 to show the implementation of improved diagnostics and actions in the relay self-tests.	20110201
SEL-751A-R407-V0-Z009003-D20101230	➤ Added support for Simple Network Time Protocol (SNTP) to Ethernet port (Port 1) including new settings. ➤ Added new settings for time and date management (including daylight saving time) under Global Settings. ➤ Improved frequency measurement algorithm performance during transient voltage and current changes. ➤ Corrected an issue of missing SER records upon warm start. ➤ Fixed SEL-751A SV/SVT variables status problem at IEC 61850 client end.	20101230
SEL-751A-R406-V0-Z008003-D20101018	➤ Manual update only (see *Table A.8*).	20101217

Table A.1 400 Series Firmware Revision History (Sheet 4 of 4)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-751A-R406-V0-Z008003-D20101018	➤ Added residual current IG input CT capability on a new option card SELECT 5 AVI/1 ACI. ➤ Added Fast Rate-of-Change of Frequency element (81RF) for Aurora mitigation. ➤ Corrected **LDP** command issue (relay lockup if data exceeds a threshold) in R400–403 firmware. ➤ Added a squelch threshold for very low-level secondary voltages (below 0.1 V) and currents (below 1% of INOM) in the metering quantities command response. ➤ Added calculated phase-to-phase voltages for wye-connected PTs to the analog quantities to allow selection for display points. ➤ Corrected issue with Inverse Time Overcurrent elements (did not accumulate time correctly at off-nominal frequency). ➤ Implemented improved diagnostics and actions in the relay self-tests. For certain failures, the relay will automatically restart as many as three times.	20101018
SEL-751A-R403-V0-Z007003-D20100709	➤ Manual update only (see *Table A.8*).	20100907
SEL-751A-R403-V0-Z007003-D20100709	➤ Added two time-out settings for Modbus TCP sessions on the Ethernet port. ➤ Added the Select Before Operate (SBO) control to the IEC 61850 protocol. ➤ Added Access Control setting BLOCK MODBUS SET (BLKMBSET) to be able to block settings changes from a remote Modbus or DeviceNet master. ➤ Added new, 4 DI/3 DO, optional I/O card, which has one Form-B and two Form-C outputs. ➤ Corrected relay status reporting via Modbus when relay is disabled. ➤ Updated Ethernet port settings IPADDR, SUBNETM, and DEFRTR validation to allow addresses in the private address space. ➤ Added calculated phase-to-phase voltages for wye-connected PTs to the analog quantities. ➤ Revised arc-flash settings rules to disable arc-flash subsystem when 50PAFP setting is SET to OFF. ➤ Added I1_MAG positive-sequence current magnitude to the analog quantities. Firmware version R403 is only for upgrading relays with R400–R402 firmware.	20100709
SEL-751A-R402-V0-Z006003-D20100129	➤ Added faulted phase Identification logic and included the faulted phase information in the Event Summary Report Event Type field. Also made it available in the Modbus Map. Firmware version R402 is only for upgrading relays with R400 or higher firmware.	20100129
SEL-751A-R401-V0-Z005003-D20100118	➤ Corrected an occasional IEC 61850 communications defect where the firmware incorrectly reads an opcode from Flash memory and results in a vector. Firmware version R401 is only for upgrading relays with R400 or higher firmware.	20100118
SEL-751A-R400-V0-Z005003-D20090910	➤ Revised firmware for processor update. Previous versions cannot be upgraded to R400. ➤ Extended event report storage capability to at least seventy-seven 15-cycle or nineteen 64-cycle event reports.	20090910

Table A.2 300 Series Firmware Revision History (Sheet 1 of 3)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-751A-R310-V0-Z007003-D20150206	➤ Resolved an issue with the "involved" phase identification logic where the output was not long enough in duration to latch the phase LEDs when a trip occurred. ➤ Resolved an issue with dc offset on analog channels when the relay was turned on. ➤ Resolved an issue of missing SER records upon settings change for the IEC 61850 and DNP protocols. ➤ Resolved an issue with all previous firmware versions in which SALARM did not assert for a settings group change. ➤ Resolved an issue with DNP polling in previous firmware versions. When a group switch was performed, the DNP protocol reported an incorrect status for the first Relay Word bit in the SER1 trigger list. ➤ Resolved an issue that caused some non-trip events to be reported as trip events. ➤ Improved frequency measurement algorithm performance during transient voltage and current changes. ➤ Modified the firmware to process RSTTRGT SELOGIC equation output on the rising edge. ➤ Improved the measuring accuracy of the frequency measurement by using VA instead of V1 for single-phase voltage input applications.	20150206
SEL-751A-R309-V0-Z007003-D20130329	➤ Manual update only (see *Table A.8*).	20131025
SEL-751A-R309-V0-Z007003-D20130329	➤ Manual update only (see *Table A.8*).	20130802
SEL-751A-R309-V0-Z007003-D20130329	➤ Forced RTS to high and ignored CTS when PREDLY setting is OFF to power certain fiber-optic transceivers. ➤ Corrected an Ethernet Failover Switching issue for dual Ethernet models. ➤ Corrected an issue where old packets were returned on new connections when polling Modbus at a high speed. ➤ Revised the order of SELOGIC control equation processing. To correct a latency issue, the 79 element control equations now run after the 52A control equation. ➤ Corrected an issue with the initial Gratuitous ARP request not being sent for as long as 5 minutes after startup. Firmware version R309 is for upgrading relays with R101-R308 firmware.	20130329
SEL-751A-R308-V0-Z007003-D20111028	➤ Manual update only (see *Table A.8*)	20130117
SEL-751A-R308-V0-Z007003-D20111028	➤ Manual update only (see *Table A.8*).	20120903
SEL-751A-R308-V0-Z007003-D20111028	➤ Manual update only (see *Table A.8*).	20120622
SEL-751A-R308-V0-Z007003-D20111028	➤ Manual update only (see *Table A.8*).	20120518
SEL-751A-R308-V0-Z007003-D20111028	➤ Corrected an issue with the rms meter values, where in some cases the values would spike for a short time. ➤ Fixed an issue with ENABLED LED which did not turn off when the relay was disabled.	20111028
SEL-751A-R307-V0-Z007003-D20110509	➤ Manual update only (see *Table A.8*).	20110621
SEL-751A-R307-V0-Z007003-D20110509	➤ Corrected issue in Demand Meter report where it was not capturing 3I2PD (negative-sequence peak demand) when setting EDEM := ROLL. ➤ Corrected RECLOSER setting issue where any recloser time settings above 2147 seconds were not handled correctly.	20110509
SEL-751A-R306-V0-Z007003-D20110201	➤ Corrected issue with Inverse Time Overcurrent elements (did not accumulate time correctly for FNOM = 50 Hz nominal frequency).	20110201

Table A.2 300 Series Firmware Revision History (Sheet 2 of 3)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-751A-R305-V0-Z007003-D20101018	➤ Manual update only (see *Table A.8*).	20101217
SEL-751A-R305-V0-Z007003-D20101018	➤ Added a squelch threshold for very low-level secondary voltages (below 0.1 V) and currents (below 1% of INOM) in the metering quantities command response. ➤ Added calculated phase-to-phase voltages for wye-connected PTs to the analog quantities to allow selection for display points. ➤ Corrected issue with Inverse Time Overcurrent elements (did not accumulate time correctly at off-nominal frequency).	20101018
SEL-751A-R303-V0-Z007003-D20100709	➤ Manual update only (see *Table A.8*).	20100907
SEL-751A-R303-V0-Z007003-D20100709	➤ Added two time-out settings for the Modbus TCP sessions on the Ethernet port. ➤ Added the Select Before Operate (SBO) control to the IEC 61850 protocol. ➤ Added Access Control setting BLOCK MODBUS SET (BLKMBSET) to be able to block settings changes from a remote Modbus or DeviceNet master. ➤ Added new I/O card option of 4 DI/3 DO, which has one Form-B and two Form-C outputs. ➤ Corrected relay status reporting via Modbus when relay is disabled. ➤ Updated Ethernet port settings IPADDR, SUBNETM, and DEFRTR validation to allow addresses in the private address space. ➤ Added calculated phase-to-phase voltages for wye-connected PTs to the analog quantities. ➤ Revised arc-flash settings rules to disable arc-flash subsystem when 50PAFP setting is SET to OFF. ➤ Added I1_MAG positive-sequence current magnitude to the analog quantities. Firmware version R303 is only for upgrading relays with R101-R302 firmware.	20100709
SEL-751A-R302-V0-Z006003-D20100129	➤ Added faulted phase Identification logic and included the faulted phase information in the Event Summary Report Event Type field. Also made it available in the Modbus Map. Firmware version R302 is for upgrading relays with R101–R301 firmware.	20100129
SEL-751A-R301-V0-Z005003-D20090501	➤ Added new power elements option with selected voltage card options. ➤ Added new neutral CT current range option 5.0–1000.0 mA, (50 mA nom). ➤ Added FASTOP setting to PORT 1 (Ethernet) settings to allow breaker control using Fast Operate. ➤ SEL-751A firmware versions R301 and higher require DeviceNet card firmware version 1.005.	20090501

Table A.2 300 Series Firmware Revision History (Sheet 3 of 3)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-751A-R300-V0-Z004003-D20090109	➤ Added new arc-flash detection (AFD), arc-flash time-overlight (TOL) and overcurrent (50PAF and 50NAF) protection options. Added arc-flash light measurements to the CEV report and created a meter light report. ➤ Added DNP3 serial and LAN/WAN protocol options. ➤ Added synchrophasor measurements, metering, and C37.118 Protocol to the SEL-751A base model. ➤ Added breaker monitor function to the SEL-751A base model. ➤ Added demand and peak demand metering option to selected models. ➤ Added IRIG-B input capability to fiber-optic serial PORT 2 option. ➤ Improved frequency measurement and frequency element accuracy to 0.01 Hz resolution. ➤ Increased frequency elements (81) from 4 to 6. ➤ Added rate-of-change-of-frequency (81R) elements to selected models. ➤ Added residual overvoltage (59G) and negative-sequence overvoltage (59Q) elements option to selected models. ➤ Added voltage ratio correction factor (setting 25RCF) to synchronism-check element (25). ➤ Added Relay Word bits 3P27 (all voltage phases below 27P1P setting) and 3P59 (all voltage phases above 59P1P setting). ➤ Updated rms and max/min metering quantities to include VS (synchronism voltage). ➤ Improved energy metering resolution to one kWh and updated energy metering convention. ➤ Increased 59P elements settings range to 0.02–1.20 xVnm from 1.00–1.20 xVnm. ➤ Added relay serial number field in DNP and Modbus.	20090109

Table A.3 200 Series Firmware Revision History (Sheet 1 of 2)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-751A-R204-V0-Z003002-D20081124	➤ Manual update only (see *Table A.8*).	20150206
SEL-751A-R204-V0-Z003002-D20081124	➤ Manual update only (see *Table A.8*).	20131025
SEL-751A-R204-V0-Z003002-D20081124	➤ Manual update only (see *Table A.8*).	20130802
SEL-751A-R204-V0-Z003002-D20081124	➤ Manual update only (see *Table A.8*)	20130329
SEL-751A-R204-V0-Z003002-D20081124	➤ Manual update only (see *Table A.8*)	20130117
SEL-751A-R204-V0-Z003002-D20081124	➤ Manual update only (see *Table A.8*).	20120903
SEL-751A-R204-V0-Z003002-D20081124	➤ Manual update only (see *Table A.8*).	20120622
SEL-751A-R204-V0-Z003002-D20081124	➤ Manual update only (see *Table A.8*).	20120518
SEL-751A-R204-V0-Z003002-D20081124	➤ Manual update only (see *Table A.8*).	20111028
SEL-751A-R204-V0-Z003002-D20081124	➤ Manual update only (see *Table A.8*).	20110621
SEL-751A-R204-V0-Z003002-D20081124	➤ Manual update only (see *Table A.8*).	20110509
SEL-751A-R204-V0-Z003002-D20081124	➤ Manual update only (see *Table A.8*).	20110201

Table A.3 200 Series Firmware Revision History (Sheet 2 of 2)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-751A-R204-V0-Z003002-D20081124	➤ Manual update only (see *Table A.8*).	20101217
SEL-751A-R204-V0-Z003002-D20081124	➤ Manual update only (see *Table A.8*).	20100907
SEL-751A-R204-V0-Z003002-D20081124	➤ Corrected firmware upgrade issue in firmware version R203 when upgrading relays with previous firmware versions R200–R202.	20081124
SEL-751A-R203-V0-Z003002-D20081104	➤ Corrected 55 element operation (an issue in firmware R201 only). ➤ Corrected VDC (VBAT) metering (an issue in firmware R202 only).	20081104
SEL-751A-R202-V0-Z003002-D20081022 SEL-751A-R105-V0-Z002001-D20081022	➤ Updated IEC 61850 firmware to enhance security, streamline MMS processing, and improve TCP/IP connections. ➤ Improved security (see www.selinc.com/privacy.htm for details).	20081022
SEL-751A-R201-V0-Z003002-D20080808	➤ Improved active Ethernet port selection logic during relay startup (applies to dual redundant Ethernet port option relays).	20080808
SEL-751A-R200-V0-Z003002-D20080627	➤ Added a four-shot automatic reclosing (79) option. ➤ Added synchronism-check voltage input (VS) and element (25) option. ➤ Added synchronism voltage input (VS) based over- and undervoltage elements (27S, 59S). ➤ Added new Ethernet port options. ➢ single fiber-optic Ethernet. ➢ dual fiber-optic or copper Ethernet ports with FAILOVER or SWITCH modes. ➤ Added capability to support two Modbus TCP sessions. ➤ Added station dc battery monitor function. ➤ Added single-phase power, reactive power, apparent power, and power factor metering when wye-connected PTs are used. ➤ Improved VNOM setting resolution from (xxx) to two decimal places (xxx.xx). ➤ Changed setting range for 27P1P and 27P2P settings from (OFF, 0.60–1.00 x Vnm) to (OFF, 0.02–1.00 x Vnm). ➤ Extended 50 elements range as follows: ➢ 1 A nom (OFF, 0.10–20.00 A) from (OFF, 0.10–19.20 A). ➢ 5 A nom (OFF, 0.50–100.00 A) from (OFF, 0.50–96.00 A). ➤ Corrected MIRRORED BITS communication using MBT-9600 modem.	20080627

Table A.4 100 Series Firmware Revision History (Sheet 1 of 2)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-751A-R104-V0-Z002001-D20080508	➤ Manual update only (see *Table A.8*).	20150206
SEL-751A-R104-V0-Z002001-D20080508	➤ Manual update only (see *Table A.8*).	20131025
SEL-751A-R104-V0-Z002001-D20080508	➤ Manual update only (see *Table A.8*).	20130802
SEL-751A-R104-V0-Z002001-D20080508	➤ Manual update only (see *Table A.8*)	20130329
SEL-751A-R104-V0-Z002001-D20080508	➤ Manual update only (see *Table A.8*)	20130117
SEL-751A-R104-V0-Z002001-D20080508	➤ Manual update only (see *Table A.8*).	20120903
SEL-751A-R104-V0-Z002001-D20080508	➤ Manual update only (see *Table A.8*).	20120622
SEL-751A-R104-V0-Z002001-D20080508	➤ Manual update only (see *Table A.8*).	20120518
SEL-751A-R104-V0-Z002001-D20080508	➤ Manual update only (see *Table A.8*).	20111028
SEL-751A-R104-V0-Z002001-D20080508	➤ Manual update only (see *Table A.8*).	20110621
SEL-751A-R104-V0-Z002001-D20080508	➤ Manual update only (see *Table A.8*).	20110509

Table A.4 100 Series Firmware Revision History (Sheet 2 of 2)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-751A-R104-V0-Z002001-D20080508	➤ Manual update only (see *Table A.8*).	20110201
SEL-751A-R104-V0-Z002001-D20080508	➤ Manual update only (see *Table A.8*).	20101217
SEL-751A-R104-V0-Z002001-D20080508	➤ Manual update only (see *Table A.8*).	20100907
SEL-751A-R104-V0-Z002001-D20080508	➤ Revised I_N scaling for the I_{NOM} = 2.5 mA, high sense neutral CT input, for proper operation of the 50N elements.	20080508
SEL-751A-R103-V0-Z002001-D20080325	➤ Corrected reporting of digital inputs (INxxx) during relay power up to MMS for IEC 61850 protocol. ➤ Corrected setting change function using Modbus Function Code 06 when voltage board is not installed. ➤ Corrected SER captures of digital input transitions.	20080325
SEL-751A-R102-V0-Z002001-D20080121	➤ Corrected 51N pickup setting for relays with different nominal ratings for their phase and neutral inputs. ➤ Removed solid-state outputs option and added fast hybrid (high-speed, high-current interrupting) outputs option. ➤ Enhanced IEC 61850 functionality with KEMA certification updates.	20080121
SEL-751A-R101-V0-Z002001-D20070806	➤ Internal changes to support new hardware (current and voltage cards). ➤ Revised for PORT 2 as an optional fiber-optic serial port. ➤ Added de-bounce settings for digital inputs.	20070806
SEL-751A-R100-V0-Z001001-D20070410	This original firmware version was not production released.	20070410

DeviceNet and Firmware Versions

The firmware on the DeviceNet interface has two versions as listed in *Table A.5*. The version number of this firmware is only accessible via the DeviceNet interface.

Table A.5 DeviceNet Card Versions

DeviceNet Card Software Version	Revisions	Release Date
Major Rev: 1, Minor Rev: 5 (Rev 1.005)	Reads product code, DeviceNet card parameter descriptions, etc., from the relay.	20080407
Major Rev: 1, Minor Rev: 3 (Rev 1.003)	Resolves some conformance issues (Card defines product code = 100, fixed descriptions for DeviceNet card parameters, etc.)	20050922

The Electronic Data Sheet (EDS) file is not updated every time a firmware release is made. New EDS files are released only when there is a change in the Modbus or DeviceNet parameters. The EDS file and an ICON file for the SEL-751A are zipped together on the SEL-751A Product Literature CD (SEL-xxxRxxx.exe). The file can also be downloaded from the SEL website at www.selinc.com. *Table A.6* lists the compatibility among the EDS files and the various firmware versions of the relay.

Table A.6 EDS File Compatibility

EDS File	Firmware Revisions Supported	Release Date
SEL-751AR502.EDS	R407, R408, R410, R411, and later (with DeviceNet version 1.005)	20101230
SEL-751AR501.EDS	R406 (with DeviceNet version 1.005)	20101018
SEL-751AR403.EDS	R403, R303, R305, R306, R307, R308, and R309 (with DeviceNet version 1.005)	20100618
SEL-751AR301.EDS	R402, R401, R302, R301 (with DeviceNet version 1.005)	20090415
SEL-751AR300.EDS	R400, R300 (with DeviceNet version 1.005)	20090109
SEL-751AR300X.EDS	R400, R300 (with DeviceNet version 1.001)	20090109
SEL-751AR200.EDS	R200, R201, R202, R203, R204 (with DeviceNet version 1.005)	20080623
SEL-751AR200X.EDS	R200, R201, R202, R203, R204 (with DeviceNet version 1.001)	20080623
SEL-751AR101.EDS	R101, R102, R103, R104, R105 (with DeviceNet version 1.005)	20070727
SEL-751AR101X.EDS	R101, R102, R103, R104, R105 (with DeviceNet version 1.001)	20070727

ICD File

Determining the ICD File Version in Your Relay

To find the ICD revision number in your relay, view the configVersion using the **ID** command. The configVersion is the last item displayed in the information returned from the **ID** command.

configVersion=ICD-751A-R304-V0-Z000000-D20130726

The ICD revision number is after the R (e.g., 100) and the release date is after the D. This revision number is not related to the relay firmware revision number. The configVersion revision displays the ICD file version used to create the CID file that is loaded in the relay.

Table A.7 lists the ICD file versions, a description of modifications, and the instruction manual date code that corresponds to the versions. The most recent version is listed first.

Table A.7 SEL-751A ICD File Revision History (Sheet 1 of 3)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect		Manual Date Code
				File Description	Software Version	
ICD-751A-R304-V0-Z000000-D20130726	➤ Made corrections per KEMA recommendations. ➤ Updated Report Control attributes. ➤ Updated orCat control instances to proprietary node. ➤ Corrected datatype for DmdA, and PkDmdA DOs. ➤ Corrected dead bands for several Logical Node attributes in MET and ANN LDevices. ➤ Added new OpCntEx attribute to BK1XCBR1 LN.	R418 and higher	004[a]	751A R418 and above	1.1.141.0 and higher	20130802

Table A.7 SEL-751A ICD File Revision History (Sheet 2 of 3)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect		Manual Date Code
				File Description	Software Version	
	➤ Added new TOL1PAFD1, TOL2PAFD2, TOL3PAFD3, and TOL4PAFD4 Logical Nodes and attributes to PRO LDevice. ➤ Added new TRIPGGIO24, PROGGIO25, RCGGIO26, LBGGIO27, MBOKGGIO28, MISCGGIO29, PWRGGIO30, and LSGGIO31 Logical Nodes and attributes to ANN LDevice. ➤ Added new RMSMMXU2 and DCZBAT1 Logical Nodes and attributes to MET LDevice. ➤ Added new BWASCBR1, BWBSCBR2, and BWCSCBR3 Logical Nodes and attributes for Breaker Wear.					
ICD-751A-R303-V0-Z000000-D20121128	➤ Improved IEC 61850 conformance ➤ Added Serial and Model Number attributes to PhyNam DO.	R410 and higher	004[a]	751A R410 and above	1.1.141.0 and higher	20111028
ICD-751A-R201-V0-Z000000-D20101207	➤ Remove UTC offset attribute.	R407–R408	004[a]	751A R407/R408	1.1.99.0 and higher	20101230
ICD-751A-R200-V0-Z000000-D20100702	➤ Added select before operate (SBO) and enhanced security SBO modes to 61850 MMS.	R303 and higher R403 and higher	003[b]	Enhanced Controls R303/R403 and above	1.1.92.0 and higher	20100709
ICD-751A-R106-V0-Z002001-D20090109	➤ Added additional attribute INTT to BK1XCBR1 LN. ➤ Added new Protection LNs PAFPIOC17, NAFPIOC18, D5TPTOF5, D6TPTOF6, R1TPFRC1, R2TPFRC2, R3TPFRC3, R4TPFRC4, P3PTUV4, S1TPTUV5, S2TPTUV6, P3PTOV3, S1TPTOV4, S2TPTOV5, G1TPTOV6, G2TPTOV7, Q1TPTOV8, Q2TPTOV9, and BFR1RBRF1. ➤ Added new LN METMDST1 for Demand Data.	R300–R302 R400–R402	002	R300 or greater	1.1.82.0 and higher	20090109
ICD-751A-R105-V0-Z002001-D20080618	➤ Added additional attributes for Power Quantities to METMMXU1 LN. ➤ Added new SCGGIO20 LN for SELOGIC Counters. ➤ Added new AINCGGIO21, AINDGGIO22, and AINEGGIO23 LNs for Analog Inputs.	R200–R204	002	R200 or greater	1.1.75.0 and higher	20080627
ICD-751A-R104-V0-Z002001-D20080508	➤ Made corrections per KEMA recommendations.	R102–R105	002	Short LN Prefixes	1.1.73.0 and higher	20080508

Table A.7 SEL-751A ICD File Revision History (Sheet 3 of 3)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect		Manual Date Code
				File Description	Software Version	
ICD-751A-R103-V0-Z002001-D20080324	➤ Modified default GOOSE data set GooseDSet13 and MSTA LN.	R102–R105	002[c]	N/A	N/A	20080325
ICD-751A-R102-V0-Z002001-D20080110	➤ Modifications for Conformance testing.	R102 –R105	002[c]	N/A	N/A	20080121
ICD-751A-R101-V0-Z001001-D20070712	➤ Initial ICD file release.	R101	001[c]	N/A	N/A	20070806

[a] ICD files with ClassFileVersion 004 require R4xx series firmware and do not work with R3xx firmware.
[b] ICD files with ClassFileVersion 003 can be used with R4xx series firmware with 61850 device library 004. Architect will convert the ICD file to ClassFileVersion 004 and send to the relay.
[c] These ICD files are no longer supported and are not included with Architect.

Instruction Manual

The date code at the bottom of each page of this manual reflects the creation or revision date. *Table A.8* lists the instruction manual release dates and a description of modifications. The most recent instruction manual revisions are listed at the top.

Table A.8 Instruction Manual Revision History (Sheet 1 of 10)

Revision Date	Summary of Revisions
20150206	Preface ➤ Added *Safety Information* and *General Information*. ➤ Updated the product labels and compliance label. Section 1 ➤ Changed the *Certifications* section title to *Compliance* and relocated the section to the beginning of *Specifications*. ➤ Added the applied current at which the burden is measured for INOM = 2.5 mA, 50 mA, 1 A , 5 A in *Specifications*. ➤ Updated *Arc Flash Specifications* for pickup setting range. ➤ Updated the accuracy specifications. Section 2 ➤ Added a note on CT circuits to applicable current card descriptions. ➤ Updated the note for *Table 2.16: Jumper Functions and Default Positions*. ➤ Updated *Card Configuration Procedure*. ➤ Added *Analog Output Wiring*. ➤ Added a note stating that the fail-safe option should not be used for fast hybrid output contacts in fail-safe/nonfail-safe tripping. Section 5 ➤ Updated the number of time-stamped entries that the relay memory can hold for load profiling. Section 7 ➤ Updated the ***PULSE*** *Command* description and added the breaker control jumper note. ➤ Added ***VEC*** *Command (Show Diagnostic Information)*. Section 10 ➤ Added a note on CT circuits. ➤ Updated *Table 10.7: Relay Self-Tests*. Appendix A ➤ Updated for firmware version R310. ➤ Added ICD File, including *Table A.7: SEL-751A ICD File Revision History*.

Table A.8 Instruction Manual Revision History (Sheet 2 of 10)

Revision Date	Summary of Revisions
	Appendix F ➤ Added a note for GOOSE and ACSELERATOR Architect regarding GOOSE subscriptions when loading a new CID file. Appendix K ➤ Added a note to *Table K.1: Analog Quantities* for RTDWDG, RTDBRG, RTDAMB, and RTDOTHMX analog quantities.
20131025	Section 1 ➤ Update the ac current inputs and the input voltage range for the power supply in *Specifications*. Appendix A ➤ Updated for firmware version R419.
20130802	Section 1 ➤ Corrected the continuous rating specification for I_{NOM} = 5 A, 1 A, 50 mA, and 2.5 mA. ➤ Updated the ac voltage rating specification for VNOM. ➤ Added RTD Trip/Alarm Time Delay to the RTD Protection category of the *Specifications*. Section 10 ➤ Added a note for clear-jacketed fiber sensor. Appendix A ➤ Updated for firmware version R418. 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*, *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*, and *Table F.14: Circuit Breaker Logical Node Class Definition*. ➤ Revised *Table F.15: Logical Device: PRO (Protection)*, *Table F.16: Logical Device: MET (Metering)*, *Table F.17: Logical Device: CON (Remote Control)*, *Table F.18: Logical Device: ANN (Annunciation)*, and *Table F.19: Logical Device: CFG (Configuration)*.
20130329	Section 1 ➤ Added open state leakage current for Fast Hybrid contacts to the *Specifications*. Section 2 ➤ Revised the *Table 2.16: Jumper Functions and Default Positions* footnote to clarify the impact of the jumper position on breaker control. ➤ Added a note to *Figure 2.18: Voltage Connections*. Section 7 ➤ Updated the *Fiber-Optic Serial Port* paragraph. ➤ Updated +5 Vdc availability statement in *+5 Vdc Power Supply*. Appendix A ➤ Updated for firmware versions R417 and R309.
20130117	Preface ➤ Updated the product labels for the SEL-751A. Section 1 ➤ Added current/voltage input terminal block information under Terminal Connections category of the *Specifications*. Section 4 ➤ Added a note for display points stating that they are updated approximately every two seconds. ➤ Corrected *Table 4.63: Entries for the Four Strings* for set and clear strings. Section 5 ➤ Updated *Table 5.6: Demand Values* with new power demand quantities. ➤ Updated the metering screen captures for demand and peak demand functions.

Table A.8 Instruction Manual Revision History (Sheet 3 of 10)

Revision Date	Summary of Revisions
	Section 9 ➤ Updated the note for event reporting to state that frequency is now available in CEV or CEVR reports. ➤ Updated the footnote for *Table 9.1: Event Types* with the logic of the GFLT Relay Word bit. Appendix A ➤ Updated *Table A.1: 400 Series Firmware Revision History* for R407 and R412 firmware and *Table A.2: 300 Series Firmware Revision History* for R308 firmware. ➤ Added a summary of revisions for R415. Appendix B ➤ Added instructions for upgrading firmware using ACSELERATOR Quickset. Appendix E ➤ Added a statement that Event History will display the latest event data when no number is written to the event log SEL register in *Reading History Data Using Modbus*. Appendix J ➤ Updated the Relay Word bit definition for GFLT, PHASE_A, PHASE_B, and PHASE_C. ➤ Added a footnote for Relay Word bits RTD1 through RTD12. Appendix K ➤ Added new demand and peak demand metering quantities for DNP and Fault Information in *Table K.1:Analog Quantities*.
20120903	Preface ➤ Updated product label examples in *Product Labels*. Section 1 ➤ Updated *Specifications*.
20120622	Appendix A ➤ Updated for firmware version R414.
20120518	Preface ➤ Updated Compliance Label. Section 1 ➤ Added *Relay Mounting Screws (#8-32) Tightening Torque* specification. Section 2 ➤ Revised Note in *Table 2.16: Jumper Functions and Default Positions* to clarify the impact of the ENABLE/DISABLE breaker control jumper. Section 4 ➤ Revised *Figure 4.28: Loss-of-Potential (LOP) Logic* to include VNOM. ➤ Added IN sample to *Figure 4.56: Arc-Flash Instantaneous Overcurrent Element Logic*. ➤ Added note to FAST OP MESSAGES setting. Section 5 ➤ Updated threshold values in *Small Signal Cutoff for Metering* section. Section 9 ➤ Revised Event Type paragraph on page 9.4 to clarify TRIP type processing order. Appendix A ➤ Updated for firmware versions R413. Appendix E ➤ Added BLOCK MODBUS SET setting paragraph. ➤ Revised breaker jumper impact statement on page E.13. The breaker jumper has no impact on breaker control using Modbus. Appendix G ➤ Added BLOCK MODBUS SET setting paragraph.

Table A.8 Instruction Manual Revision History (Sheet 4 of 10)

Revision Date	Summary of Revisions
20111028	Section 1 ➤ Added *Compression Plug Mounting Ear Screw Tightening Torque* specification. Section 4 ➤ Revised *Figure 4.33: Trip Logic* to show target reset when 52A asserts with setting RSTLED = Y. Appendix A ➤ Updated for firmware versions R308 and R412.
20110621	Section 1 ➤ Updated Optoisolated Control Inputs voltage specifications. Section 2 ➤ Added *Table 2.17: Typical Maximum RTD Lead Length*. Section 4 ➤ Revised the low end of the VNOM setting range to 20 V from 100 V. Settings Sheets ➤ Updated to include the new VNOM setting range. Section 7 ➤ Revised *Table 7.2: EIA-232/EIA-485 Serial Port Pin Functions* to add PORT 3 as EIA-485. Appendix A ➤ Updated for firmware version R411. Appendix E ➤ Added *08h Loopback Diagnostic Command*.
20110509	Section 4 ➤ Updated *Fast Rate-of-Change-of-Frequency (81RF)* function text and figures for the addition of df and df/dt qualifiers. Appendix A ➤ Updated for firmware versions R307 and R410. Appendix F ➤ Updated *Protocol Implementation Conformance Statement*.
20110201	Section 10 ➤ Updated *Self-Test* descriptions to reflect the improvements (including automatic restarts in some cases) implemented in firmware version R406. Appendix A ➤ Updated for firmware versions R306 and R408. ➤ Addendum to R406 for the self-test firmware improvements.
20101230	Section 1 ➤ Added *Simple Network Time Protocol (SNTP) Accuracy Internal Clock* accuracy specification. Section 2 ➤ Added *Power Supply Card PSIO/2DI/3DO (Slot A)* description and terminal designations. Section 4 ➤ Added *Time and Date Management* and *Simple Network Time Protocol (SNTP)* subsections. Section 6 ➤ Updated *Settings Sheets* with *Time and Date Management* and *SNTP Client Protocol* settings. Section 7 ➤ Added *Simple Network Time Protocol (SNTP)* subsection. Appendix A ➤ Updated for firmware version R407. Appendix E ➤ Updated Modbus map for new settings. Appendix J ➤ Updated with new Relay Word bits TSNTPP and TSNTPB.

Table A.8 Instruction Manual Revision History (Sheet 5 of 10)

Revision Date	Summary of Revisions
20101217	Section 1 ➤ Revised Analog Output (1AO) accuracy specification to < ±1%, full scale, at 25°C in *Specifications*. ➤ Updated Dielectric (HiPot) type tests in *Specifications*.
20101018	Section 1 ➤ Added new element 81RF for Aurora mitigation. ➤ Added optional residual current CT based Overcurrent and Time Overcurrent (50G/51G). ➤ Added 5 AVI/1 ACI card to *Table 1.1: Voltage Input Options*. Section 2 ➤ Added new card SELECT 5AVI /1 ACI and description. Section 4 ➤ Added new settings and descriptions for the residual current CT input option. ➤ Added new element 81RF settings and description (fast rate-of-change of frequency) for Aurora mitigation. Section 6 ➤ Added settings for new residual current CT input ➤ Added settings for new 81RF element (fast rate-of-change of frequency) for Aurora mitigation. Appendix A ➤ Updated for firmware versions R305 and R406. Appendix E ➤ Updated Modbus Map for the new settings. Appendix J ➤ Added new Relay Word bits for the 81RF element.
20100907	Section 1 ➤ Updated *Specifications* for UL508 certification. Section 4 ➤ Updated single voltage input (SINGLEV setting) application considerations. Section 8 ➤ Updated *Table 8.3: Possible Warning Conditions (Flashing TRIP LED)* to include the warning messages.
20100709	Section 1 ➤ Updated Analog Inputs accuracy specifications and Type Tests descriptive data. Added Arc-Flash processing specifications. Section 2 ➤ Added SELECT 4DI/3 DO (2 Form C, 1 Form B) card information. Added note that digital inputs and outputs are polarity neutral. Section 4 ➤ Added a description of the new Access Control setting BLOCK MODBUS SET (BLKMBSET), which blocks settings changes from remote Modbus or DeviceNet masters. ➤ Added figures for overcurrent (50) elements pickup and dropout times. ➤ Revised *Figure 4.26: Loss-of- Potential (LOP) Logic*. ➤ Added Modbus time-out settings for the Ethernet port. Section 5 ➤ Added note for the energy meter rollover value. Section 6 ➤ Updated for new settings. Section 7 ➤ Added CAL level access and password information. Section 8 ➤ Updated *Figure 8.26: Operator Control Pushbuttons and LEDs* and added note for the target LEDs latching with trip.

Table A.8 Instruction Manual Revision History (Sheet 6 of 10)

Revision Date	Summary of Revisions
	Appendix A ➤ Updated for firmware versions R403 and R303. Appendix F ➤ Updated for Select Before Operate (SBO) control changes. Appendix J ➤ Added calculated phase-to-phase voltages for wye-connected PTs and I1_MAG positive-sequence current to the analog quantities. Command Summary ➤ Added CAL level commands.
20100129	Section 9 ➤ Updated *Table 9.1: Event Types* with faulted phase identification in event types. Appendix A ➤ Updated for firmware versions R302 and R402. Appendix E ➤ Added faulted phase identification event types in Modbus map Historical data register 1754. Appendix J ➤ Added Relay Word bits Phase_A, Phase_B, Phase_C, and GFLT to Row 117.
20100118	Appendix A ➤ Updated for firmware version R401.
20090910	Section 1 ➤ Updated CT ratings, and voltage element and metering accuracy specifications. Updated *Figures 1.3: STA Command Response—No Communications Card or EIA-232•EIA-485 Communications Card* and *1.4: STA Command Response—Communications Card/DeviceNet Protocol*. Section 2 ➤ Updated *Figure 2.7: Pins for Password, Breaker Control, and* SELBOOT *Jumper* to show jumper locations on updated processor card. Section 4 ➤ Updated number of event reports that can be stored. Revised *Figure 4.24: Loss-of-Potential (LOP) Logic*. Section 10 ➤ Updated *Table 10.7: Relay Self-Tests* to show additional voltage checks on updated processor card. Appendix A ➤ Updated for firmware version R400.
20090501	Preface ➤ Updated labels. Section 1 ➤ Added Power elements specifications and new CT current range option. Section 4 ➤ Added Power elements description, added new neutral CT current range option, added Port1 setting FASTOP. Section 6 ➤ Added new settings for Power elements, neutral CT range addition, and FASTOP setting addition to Port 1. Section 9 ➤ Added power element to the TRIP message list. Appendix A ➤ Updated for firmware version R301. Appendix E ➤ Updated Modbus map. Appendix H ➤ Added Relay Word bits for power elements.

Table A.8 Instruction Manual Revision History (Sheet 7 of 10)

Revision Date	Summary of Revisions
20090109	Preface ➤ Updated for new functions, including arc-flash protection, breaker monitor, synchrophasors, and DNP. Section 1 ➤ Added and revised specifications for arc-flash protection, 80, 81R, 59G, and 59Q elements. Section 2 ➤ Added arc-flash protection installation instructions. Section 3 ➤ Revised screen captures for the ACSELERATOR QuickSet driver update. Section 4 ➤ Added description and settings for arc-flash protection. ➤ Added description and settings for rate-of-change-of-frequency elements (81R). ➤ Added description and settings for residual overvoltage element (59G). ➤ Added description and settings for negative-sequence overvoltage element (59Q). ➤ Added RCF setting to synchronism-check element (25). ➤ Added 3P27 and 3P59 elements. Section 5 ➤ Updated **MET RMS**, **MET M** (min/max), and **MET E** (energy) sections. ➤ Added demand (**MET DEM**) and peak demand (**MET PEA**) metering. ➤ Added synchrophasor metering (**MET PM**). ➤ Added arc-flash light metering (**MET L**). ➤ Added description and settings for breaker monitor function. Section 6 ➤ Updated settings sheets for the additions listed under *Section 4* above. Section 7 ➤ Added ASCII commands **BREn**, **AFT**, **MET DEM**, **MET PEA**, **MET PM**, and **MET L**. ➤ Added Ethernet network configuration figures. ➤ Added IRIG-B connection figures and updated for IRIG-B using Port 2. ➤ Added DNP3 and synchrophasor (C37.118) protocols. Section 8 ➤ Added description of new front-panel setting that allows the new choice of continuing rotating display for trip and warning messages. ➤ Updated HMI menus for the new additions (demand, etc.). Section 9 ➤ Added arc-flash trip to *Table 9.1: Event Types*. ➤ Added note to show that CEV includes arc-flash light measurements. Section 10 ➤ Added arc-flash protection commissioning and functional tests. Appendix A ➤ Updated for firmware version R300. Appendix C ➤ Updated *Table C.9: Communications Processor TARGET Region*. Appendix D ➤ New release. Appendix E ➤ Updated Modbus map for the new functions added. Appendix F ➤ Updated for ICD Ver 002 R300. ➤ Updated the logical device tables.

Table A.8 Instruction Manual Revision History (Sheet 8 of 10)

Revision Date	Summary of Revisions
	Appendix H ➤ New release. Appendix J ➤ Added new rows 116–119. ➤ Added new Relay Word bits for the new functions. Appendix K ➤ Added LSENS1–LSENS4 (arc-flash light measurements). ➤ Added breaker monitor quantities. ➤ Added demand and peak demand quantities.
20081104	Appendix A ➤ Updated for firmware version R203.
20081022	Appendix A ➤ Updated for firmware versions R105 and R202.
20080808	Appendix A ➤ Updated for firmware version R201.
20080627	Preface ➤ Updated for new functions, including reclosing and synchronism check. Section 1 ➤ Added synchronism check, station dc battery monitor specifications, and new Ethernet options. Section 2 ➤ Added new options, including new Ethernet choices, synchronism-check voltage, and station dc battery monitor. Revised applications figures to show new functions. Section 3 ➤ Updated figures for the new additions. Section 4 ➤ Added reclosing control description and settings. ➤ Added synchronism-check description and settings. ➤ Revised VNOM, 27P1P, 27P2P, and 50 elements settings ranges. ➤ Added new Ethernet port options description and settings. Section 5 ➤ Updated **MET** command response (*Figure 5.1: METER Command Report With Enhanced Voltage Option With Monitoring Package*) to show synchronism-check voltage (VS), station dc battery voltage (VDC), and single-phase P, Q, S, and PF quantities. Section 6 Updated for new settings for reclosing, synchronism check, Ethernet ports, and station dc battery monitor. Section 7 ➤ Added **ETH** (Ethernet) and **PING** command descriptions. Section 8 ➤ Updated configurable label descriptions. Section 9 ➤ Updated **EVE** command response (*Figure 9.3: Example Standard 15-Cycle Event Report 1/4-Cycle Resolution*) to show new VS and VDC quantities. Section 10 ➤ Removed power supply warning self-tests from *Table 10.7: Relay Self-Tests*. Appendix A ➤ Updated for firmware version R200.

Table A.8 Instruction Manual Revision History (Sheet 9 of 10)

Revision Date	Summary of Revisions
	Appendix C ➤ Added VS and VDC to metering data. Appendix D ➤ Updated Modbus map for new functionality additions. Appendix E ➤ Updated for ICD version Ver 002 R200. ➤ Updated logical device tables (*Table E.10–E.13*). Appendix H ➤ Added new Relay Word bit rows 110-115 to the table. ➤ Added new Relay Word bits for reclosing, synchronism check, battery monitor, and Ethernet functions. Appendix I ➤ Added VS, VDC, and per phase P, Q, S, and PF quantities.
20080508	Appendix A ➤ Updated for firmware version R104.
20080325	Appendix A ➤ Updated for firmware version R103.
20080121	Section 1 ➤ Added fast hybrid output specifications. ➤ Removed solid-state output specifications. Section 2 ➤ Updated *Figure 2.10: Fiber-Optic Serial, DeviceNet, Fast Hybrid 4 DI/4 DO, and Voltage Option*. Appendix A ➤ Updated for firmware version R102. ➤ Added *Table A.2: ACSELERATOR Architect CID File Compatibility*. Appendix B ➤ Added IEC 61850 verification testing. Appendix E ➤ Added table to document new ICD file versions supported by ACSELERATOR Architect version R.1.1.69.0. ➤ Added *Table E.7: ICD Logical Nodes Summary*. ➤ Updated *Table E.10: Logical Device: PRO (Protection)*, *Table E.11: Logical Device: MET (Metering)*, *Table E.12: Logical Device: CON (Control)*, and *Table E.13: Logical Device: ANN (Annunciation)*.
20070806	Section 1 ➤ Added Fiber-Optic port to *Communications Options* list. ➤ Updated AC Current Input specifications. ➤ Added Solid-State Output specifications. Section 2 ➤ Updated *Table 2.1: Slot Allocations for Different Cards* and *Table 2.2: Communication Ports*. ➤ Updated *Figure 2.7: Rear-Panel Connections of Selected Cards*. ➤ Updated titles in *Figure 2.8: Fiber-Optic Serial, Ethernet, EIA-232 Communication, 3 DI/4 DO/1 AO, and Voltage Option* through *Figure 2.11: Control I/O Connections—4 AI/4 AO Option in Slot D and Fiber-Optic Port in Slot B*. ➤ Revised Fiber-Optic Serial Port information. ➤ Updated *Figure 2.12: Control I/O Connections—Internal RTD Option*. ➤ Updated *Figure 2.18: SEL-751A Provides Overcurrent Protection for a Distribution Feeder* through *Figure 2.21: SEL-751A Provides Overcurrent Protection for a Transformer Bank With a Tertiary Winding*. Section 3 ➤ Updated *Figure 3.7: Update Part Number*. Section 4 Added information regarding commenting in SELOGIC Control Equation Operators.

Table A.8 Instruction Manual Revision History (Sheet 10 of 10)

Revision Date	Summary of Revisions
	Section 6 ➤ Added *Input Debounce Settings* to SEL-751A Settings Sheets. Section 7 ➤ Updated *Table 7.1: SEL-751A Communication Port Interfaces*, *Table 7.31: PASSWORD Command*, and *Table 7.32: PAS Command Format*. Section 8 ➤ Updated Configurable Label information in *Programmable LEDs*. Section 9 ➤ Updated *Figure 9.3: Example Standard 15-Cycle Event Report 1/4-Cycle Resolution*. Section 10 ➤ Removed *Low-Level Test Interface*. ➤ Updated *Table 10.7: Relay Self-Tests*. Appendix A ➤ Updated for firmware version R101.
20070410	Note: The initial version was not released from the factory.

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Appendix B
Firmware Upgrade Instructions

Overview

These firmware upgrade instructions apply to all SEL-700 series industrial products except the SEL-701 Relay and SEL-734 Meter.

SEL occasionally offers firmware upgrades to improve the performance of your relay. Because the SEL-751A Relays store firmware in flash memory, changing physical components is not necessary. Upgrade the relay firmware by downloading a file from a personal computer to the relay via the front-panel serial port via ACSELERATOR QuickSet or terminal emulator as outlined in the following sections. For relays with IEC 61850 option, verify IEC 61850 protocol after the upgrade (see *Relays With IEC 61850 Option*).

Required Equipment

Gather the following equipment before starting this firmware upgrade:

- Personal computer (PC)
- Terminal emulation software that supports Xmodem/CRC or 1k Xmodem/CRC protocol
- Serial communications cable (SEL Cable C234A or equivalent, or a null-modem cable)
- Disk containing the firmware upgrade file (for example, r1017xxx.s19 or r1017xxx.z19)
- ACSELERATOR QuickSet Software

NOTE: Firmware releases are also available as zip files (.z19). Use the zip file for faster download.

Upgrade Firmware Using ACSELERATOR QuickSet

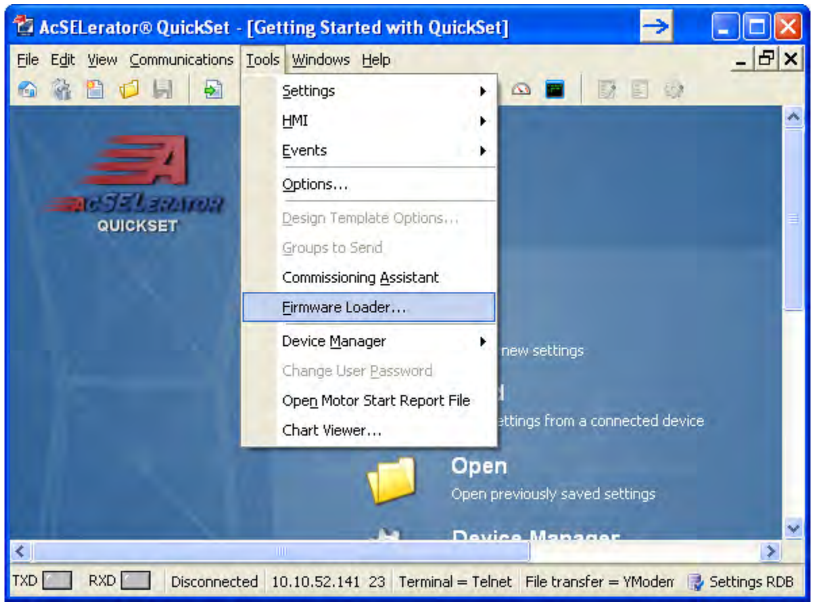
Select **Tools** > **Firmware Loader** from the ACSELERATOR QuickSet menu bar to launch a wizard that walks you through the steps to load firmware into your SEL device. Refer to *Section 3: PC Software* for setup and connection procedures for ACSELERATOR QuickSet.

Firmware Loader will not start if:

➤ The device is unsupported by ACSELERATOR QuickSet.

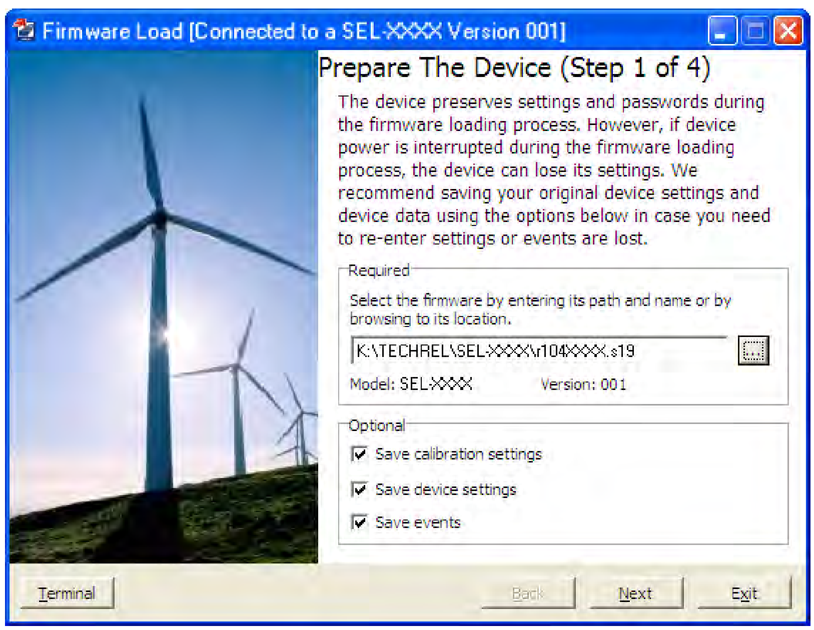
➤ The device is not connected to the computer with a communications cable.

➤ The device is disabled.

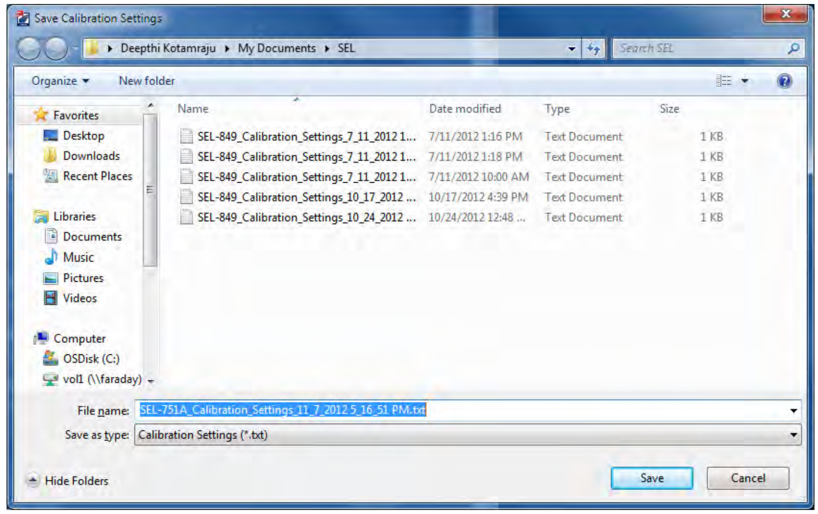


Step 1. Prepare the device.

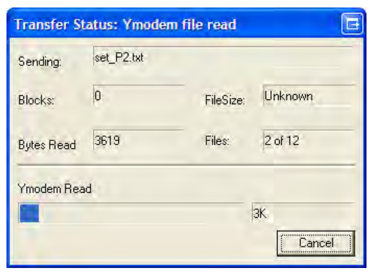
a. Select the firmware to be loaded using the browse control and select save calibration settings, device settings, and event report files. Click **Next** to continue the wizard.

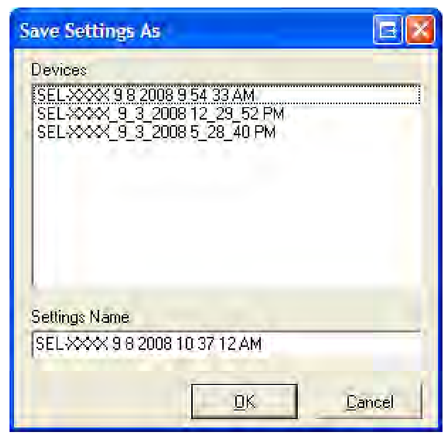


b. Select a file name to save the selected settings or accept the defaults as shown. Click **Save**.



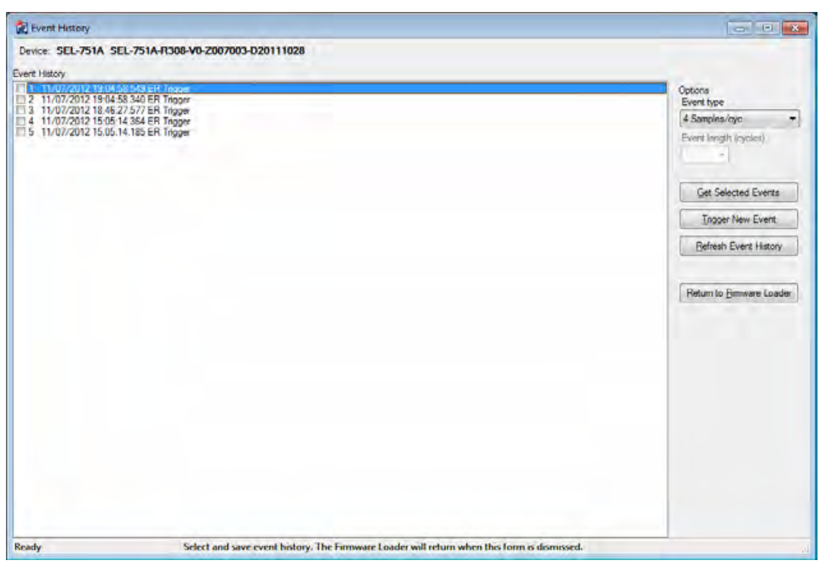
c. The **Transfer Status**: **Ymodem file read** window shows the transfer progress of the settings file. Clicking **Cancel** will stop the transfer.
After the device settings are downloaded, select a file name and path to save the settings or accept the default, as shown.





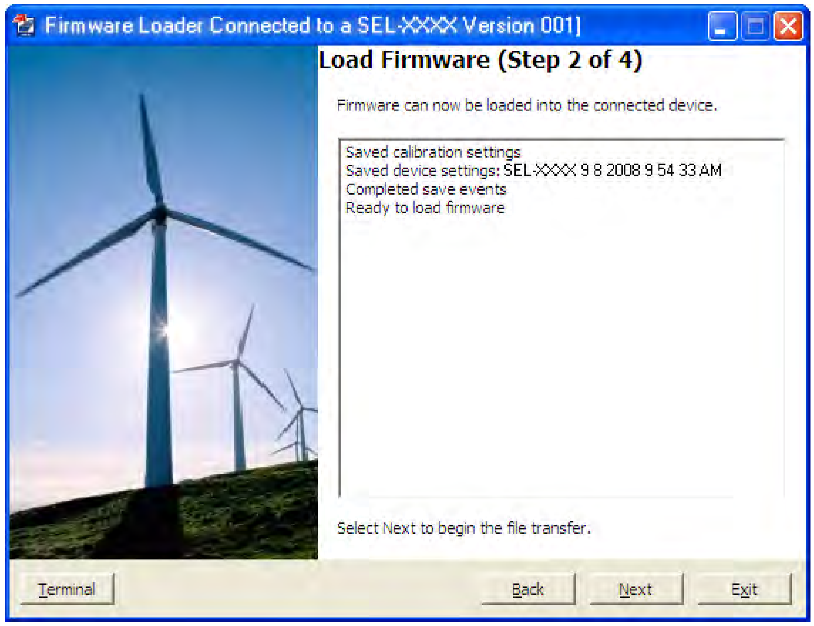
d. Click **Return to Firmware Loader** if this product does not have any event reports.

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.

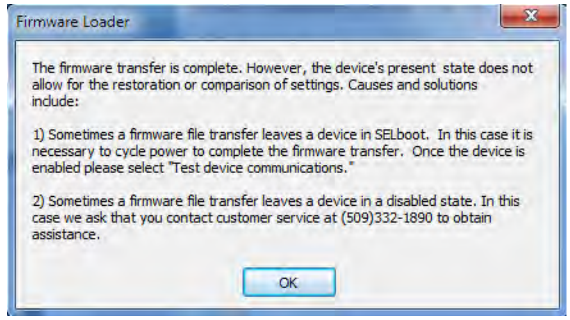


Step 3. Load Firmware.

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`, `EEPROM FAILURE`, or `Non_Vol Failure`, use the following procedure to restore the factory-default settings:



a. Click on the Terminal button on the Firmware Load screen of ACSELERATOR QuickSet.

b. Set the communications software settings to 9600 baud, 8 data bits, and 1 stop bit.

c. Enter Access Level 2 by issuing the **2AC** command.

d. Issue the **R_S** command to restore the factory default.

e. Enter Access Level 2.

f. Issue the **STATUS** command.

If the **STATUS** report shows option card `FAIL` and `Relay Disabled` and the message:

```
Confirm Hardware Config
Accept & Reboot (Y/N)?
```

Enter **Y**. This will save the relay calibration settings. The relay will respond:

```
Config Accepted
```

The relay will reboot and come up **ENABLED**.

Step 4. Verify Device.

Four verification options are provided and when enabled these options perform as follows.

Test Device Communications. If the device cannot be restarted, then turn power off and back on to restart it. Once the device is enabled, this option reconnects and re-initializes the device.

Compare Device Settings. This option verifies settings by reading them from the device and comparing them with settings saved to the database.

Restore Device Settings. This option restores settings by writing settings saved in the database to the device. Settings are converted automatically, if necessary.

Load Firmware into Another Device. Returns the wizard to *Step 1: Prepare Device* to repeat the firmware-loading process with another device.

Upgrade Firmware Using a Terminal Emulator

The following instructions assume you have a working knowledge of your personal computer terminal emulation software. In particular, you must be able to modify your serial communications parameters (baud rate, data bits, parity, etc.), select transfer protocol (Xmodem/CRC or 1k Xmodem/CRC), and transfer files (for example, send and receive binary files).

Step 1. If the relay is in service, open the relay control circuits.

Step 2. Connect the PC to the front-panel serial port and enter Access Level 2.

Step 3. Save the present relay settings.

You can use the PC software (described in the instruction manual PC software section) to save and restore settings easily. Otherwise, use the following steps.

a. Issue the following commands at the ASCII prompt:
`SHO, SHO L, SHO G, SHO P, SHO F, SHO R, SHO C,`

NOTE: To save the calibration settings, perform **SHO C** from the terminal by logging in to CAL level using the CAL level password. 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)?`

NOTE: Change the data rate of the relay serial port to 9600 before issuing the **L_D** command to start the upgrade process.

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, EEPROM FAILURE, or Non_Vol Failure, use the following procedure to restore the factory-default settings:

a. Set the communications software settings to 9600 baud, 8 data bits, and 1 stop bit.

b. Enter Access Level 2 by issuing the **2AC** command.

c. Issue the **R_S** command to restore the factory-default settings.

The relay 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.

Relays With IEC 61850 Option

NOTE: A relay with optional IEC 61850 protocol requires the presence of one valid CID file to enable the protocol. You should only transfer a CID file to the relay if you want to implement a change in the IEC 61850 configuration or if new relay firmware does not support the current CID file version. If you transfer an invalid CID file, the relay will disable the IEC 61850 protocol, because it no longer has a valid configuration. To restart IEC 61850 protocol operation, you must transfer a valid CID file to the relay.

Perform the following steps to verify that the IEC 61850 protocol is still operational after a relay firmware upgrade and if not, re-enable it. This procedure assumes that IEC 61850 was operational with a valid CID file immediately before initiating the relay firmware upgrade.

Step 1. Establish an FTP connection to the relay Ethernet port.

Step 2. Open the ERR.TXT file.

If the ERR.TXT file is empty, the relay found no errors during CID file processing and IEC 61850 should be enabled. Go to *Step 3* if ERR.TXT is empty.

If the ERR.TXT file contains error messages relating to CID file parsing, the relay has disabled the IEC 61850 protocol. Use ACSELERATOR Architect® SEL-5032 Software to convert the existing CID file and make it compatible again.

a. Install the ACSELERATOR Architect software upgrade that supports your required CID file version.

b. Run ACSELERATOR Architect and open the project that contains the existing CID file for the relay.

c. Download the CID file to the relay.

Step 3. Upon connecting to the relay, ACSELERATOR Architect will detect the upgraded relay firmware and prompt you to allow it to convert the existing CID file to a supported version. Once converted, downloaded, and processed, the valid CID file allows the relay to re-enable the IEC 61850 protocol.

Step 4. In the Telnet session, type GOO <Enter>.

Step 5. View the GOOSE status and verify that the transmitted and received messages are as expected.

The relay is now ready for your commissioning procedure.

Factory Assistance

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

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA 99163-5603 U.S.A.
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-751A 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 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-751A 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-751A and use the ASCII data stream for commands and responses.

SEL Fast Meter, Fast Operate, and Fast SER

SEL Fast Meter is a binary message that you solicit with binary commands. Fast Operate is a binary message for control. The relay can also send unsolicited Fast SER messages automatically. If the relay is connected to an SEL communications processor, these messages provide the mechanism that the communications processor uses for SCADA or DCS functions that occur simultaneously with ASCII interaction.

SEL Communications Processor

SEL offers SEL communications processors, powerful tools for system integration and automation. The SEL-2030 series and the SEL-2020 communications processors are similar, except that the SEL-2030 series has two slots for network protocol cards. These devices provide a single point of contact for integration networks with a star topology, as shown in *Figure C.1*.

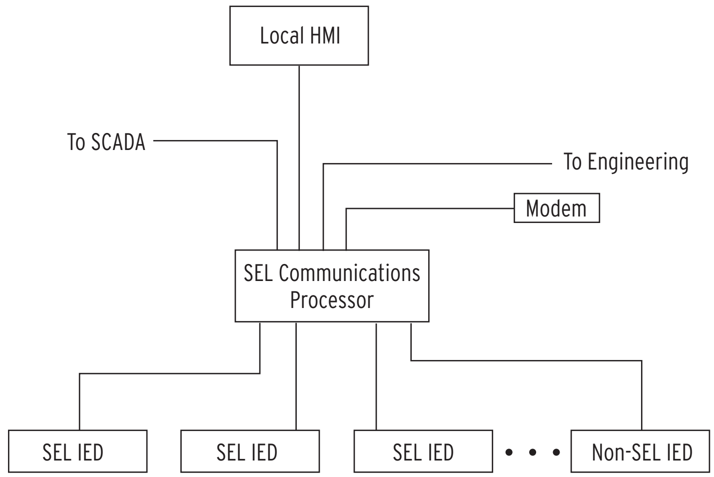

Figure C.1 SEL Communications Processor Star Integration Network

In the star topology network in *Figure C.1*, the SEL communications processor offers the following substation integration functions:

- Collection of real-time data from SEL and non-SEL IEDs
- Calculation, concentration, and aggregation of real-time IED data into databases for SCADA, HMI, and other data consumers
- Access to the IEDs for engineering functions including configuration, report data retrieval, and control through local serial, remote dial-in, and Ethernet network connections
- Distribution of IRIG-B time-synchronization signal to IEDs based on external IRIG-B input, internal clock, or protocol interface
- Simultaneous collection of SCADA data and engineering connection to SEL IEDs over a single cable
- Automated dial-out on alarms

The SEL communications processors have 16 serial ports plus a front port. This port configuration does not limit the size of a substation integration project, because you can create a multitiered solution as shown in *Figure C.2*. In this multitiered system, the lower-tier SEL communications processors forward data to the upper-tier SEL communications processor that serves as the central point of access to substation data and substation IEDs.

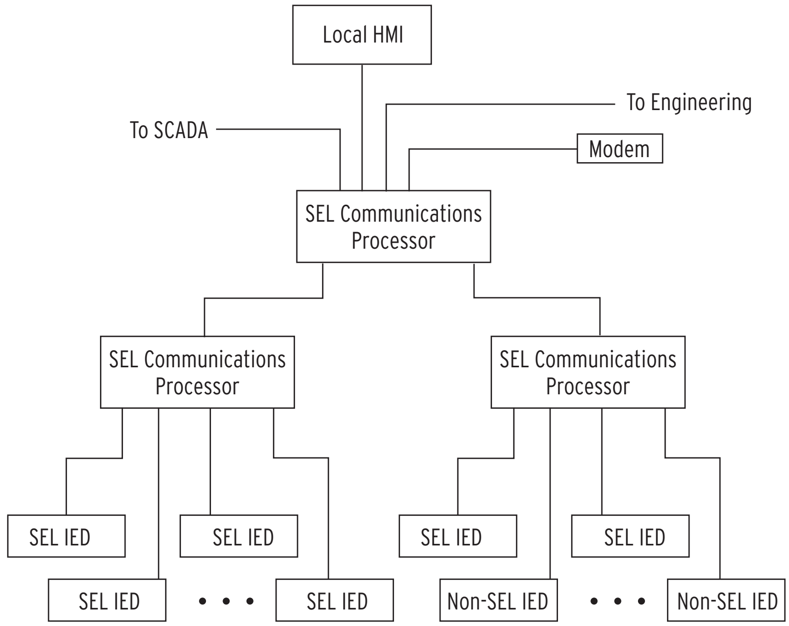

Figure C.2 Multitiered SEL Communications Processor Architecture

You can add additional communications processors to provide redundancy and eliminate possible single points of failure. SEL communications processors provide an integration solution with a reliability comparable to that of SEL relays. In terms of MTBF (mean time between failures), SEL communications processors are 100 to 1000 times more reliable than computer-based and industrial technology-based solutions.

Configuration of an SEL communications processor is different from other general-purpose integration platforms. You can configure SEL communications processors with a system of communication-specific keywords and data movement commands rather than programming in C or another general-purpose computer language. SEL communications processors offer the protocol interfaces listed in *Table C.3*.

Table C.3 SEL Communications Processors Protocol Interfaces

Protocol	Connect to
DNP3 Level 2 Slave	DNP3 masters
Modbus® RTU Protocol	Modbus masters
SEL ASCII/Fast Message Slave	SEL protocol masters
SEL ASCII/Fast Message Master	SEL protocol slaves including other communications processors and SEL relays
ASCII and Binary auto messaging	SEL and non-SEL IED master and slave devices
Modbus Plus[a]	Modbus Plus peers with global data and Modbus Plus masters
FTP (File Transfer Protocol)[b]	FTP clients
Telnet[b]	Telnet servers and clients
UCA2 GOMSFE[b]	UCA2 protocol masters
UCA2 GOOSE[b]	UCA2 protocol and peers

[a] Requires SEL-2711 Modbus Plus protocol card.
[b] Requires SEL-2701 Ethernet Processor.

SEL Communications Processor and Relay Architecture

You can apply SEL communications processors and SEL relays in a limitless variety of applications that integrate, automate, and improve station operation. Most system integration architectures utilizing SEL communications processors involve either developing a star network or enhancing a multidrop network.

Developing Star Networks

The simplest architecture using both the SEL-751A and an SEL communications processor is shown in *Figure C.1*. In this architecture, the SEL communications processor collects data from the SEL-751A 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 will have a shorter lag time (data latency); communication overhead is much less for a single data exchange conversation to collect all substation data (from a communications processor) than for many conversations necessary to collect data directly from each individual IED. You can further reduce data latency by connecting any SEL communications processor directly to the SCADA master and eliminating redundant communication processing in the RTU.

The SEL communications processor is responsible for the protocol interface, so you can install, test, and even upgrade the system in the future without disturbing protective relays and other station IEDs. This insulation of the protective devices from the communications interface assists greatly in situations where different departments are responsible for SCADA operation, communication, and protection.

SEL communications processors equipped with an SEL-2701 Ethernet Processor can provide a UCA2 interface to SEL-751A relays and other serial IEDs. The SEL-751A 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 will accommodate 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).

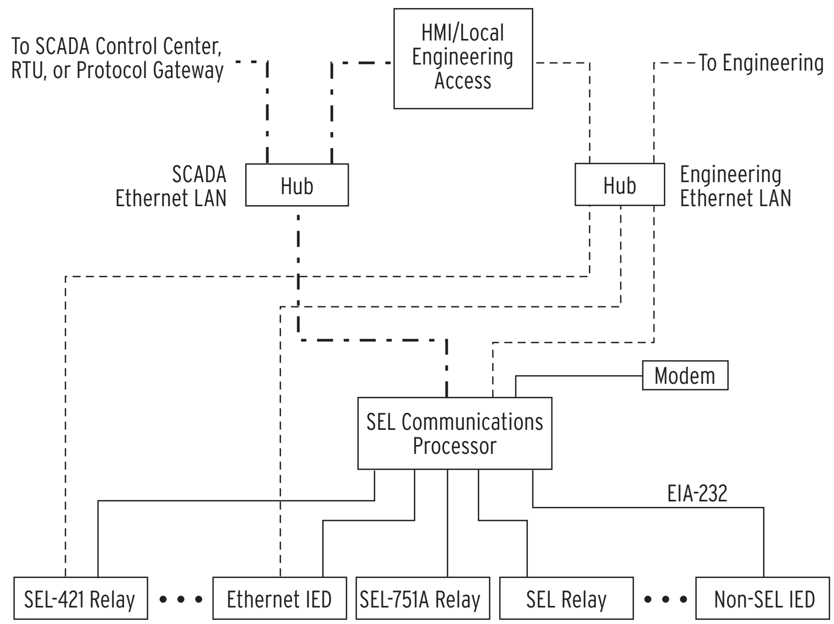

Figure C.3 Enhancing Multidrop Networks With SEL Communications Processors

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-751A. The physical configuration used in this example is shown in *Figure C.4*.

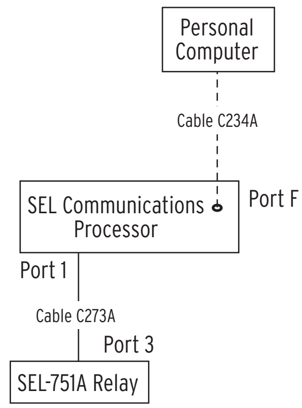

Figure C.4 Example of SEL Relay and SEL Communications Processor Configuration

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 time-out 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-751A, 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-751A. 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

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
*	201Dh	float
VS	201Fh	float
UBV	2021h	float
P	2023h	float
Q	2025h	float
S	2027h	float
PF	2029h	float
FREQ	202Bh	float
FREQS	202Dh	float
VDC	202Fh	float
WDG	2031h	float
BRG	2033h	float
AMB	2035h	float
OTH	2037h	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

Address	Relay Word Bits (in Bits 7–0)							
	7	6	5	4	3	2	1	0
2804h	*	*	*	*	*	PWRUP	STSET	*
2805h	See *Table J.1*, Row 0							
2806h	See *Table J.1*, Row 1							
2807h	See *Table J.1*, Row 2							
2808h	See *Table J.1*, Row 3							
2809h	See *Table J.1*, Row 4							
280Ah	See *Table J.1*, Row 5							
280Bh	See *Table J.1*, Row 6							
280Ch	See *Table J.1*, Row 7							
280Dh	See *Table J.1*, Row 8							
280Eh	See *Table J.1*, Row 9							
280Fh	See *Table J.1*, Row 10							
2810h	See *Table J.1*, Row 11							
2811h	See *Table J.1*, Row 12							
• • •	• • •							
287Ch	See *Table J.1*, Row 119							

Control Points

The SEL communications processor can automatically pass control messages, called Fast Operate messages, to the SEL-751A. You must enable Fast Operate messages by using the FASTOP setting in the SEL-751A port settings for the port connected to the SEL communications processor. You must also enable Fast Operate messages in the SEL communications processor by setting the automessage setting SEND_OPER equal to Y.

When you enable Fast Operate functions, the SEL communications processor automatically sends messages to the relay for changes in remote bits RB01–RB32 on the corresponding SEL communications processor port. In this example, if you set RB01 on **PORT 1** in the SEL communications processor, it automatically sets RB01 in the SEL-751A.

Breaker bit BR1 operates differently than remote bits. There is one breaker bit in the SEL-751A. For Circuit Breaker 1, when you set BR1, the SEL communications processor sends a message to the SEL-751A that asserts the OC bit for one processing interval. If you clear BR1, the SEL communications processor sends a message to the SEL-751A that asserts the CC bit for one processing interval. OC will open the breaker (via SELOGIC control equation TR) and CC will close the breaker (via SELOGIC control equation CL). See *Figure 4.33* and *Figure 4.34* 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

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Appendix D
DNP3 Communications

Overview

The SEL-751A 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

A Supervisory Control and Data Acquisition (SCADA) manufacturer developed the first versions of DNP from the lower layers of IEC 60870-5. Originally designed for use in telecontrol applications, Version 3.0 of the protocol has also become popular for local substation data collection. DNP3 is one of the protocols included in the IEEE® Recommended Practice for Data Communication between Remote Terminal Units (RTUs) and Intelligent Electronic Devices (IEDs) in a Substation.

The DNP Users Group maintains and publishes DNP3 standards. See the DNP Users Group website, www.dnp.org, for more information on standards, implementers, and tools for working with DNP3.

DNP3 Specifications

DNP3 is a feature-rich protocol with many ways to accomplish tasks, defined in an eight-volume series of specifications. Volume 8 of the specification, called the Interoperability Specification, simplifies DNP3 implementation by providing four standard interoperable implementation levels. The levels are listed in *Table D.1*.

Table D.1 DNP3 Implementation Levels

Level	Description	Equipment Types
1	Simple: limited communication requirements	Meters, simple IEDs
2	Moderately complex: monitoring and metering devices and multifunction devices that contain more data	Protective relays, RTUs
3	Sophisticated: devices with great amounts of data or complex communication requirements	Large RTUs, SCADA masters
4	Enhanced: additional data types and functionality for more complex requirements	Large RTUs, SCADA masters

Each level is a proper superset of the previous lower-numbered level. A higher-level device can act as a master to a lower-level device, but can only use the data types and functions implemented in the lower level device. For example, a typical SCADA master is a Level 3 device and can use Level 2 (or lower) functions to poll a Level 2 (or lower) device for Level 2 (or lower) data. Similarly, a lower-level device can poll a higher-level device, but the lower level device can only access the features and data available to its level.

In addition to the eight-volume DNP3 specification, the protocol is further refined by conformance requirements, optional features, and a series of technical bulletins. The technical bulletins supplement the specifications with discussions and examples of specific features of DNP3.

Data Handling

Objects

DNP3 uses a system of data references called objects, defined by the Basic 4 standard object library. Each subset level specification requires a minimum implementation of object types and recommends several optional object types. DNP3 object types, commonly referred to as objects, are specifications for the type of data the object carries. An object can include a single value or more complex data. Some objects serve as shorthand references for special operations, including collections of data, time synchronization, or even all data within the DNP3 device.

If there can be more than one instance of a type of object, then each instance of the object includes an index that makes it unique. For example, each binary status point (Object 1) has an index. If there are 16 binary status points, these points are Object 1, Index 0 through Object 1, Index 15.

Each object also includes multiple versions called variations. For example, Object 1 (binary inputs) has three variations: 0, 1, and 2. You can use variation 0 to request all variations, variation 1 to specify binary input values only, and variation 2 to specify binary input values with status information.

Each DNP3 device has both a list of objects and a map of object indices. The list of objects defines the available objects, variations, and qualifier codes. The map defines the indices for objects that have multiple instances and defines what data or control points correspond with each index.

A master initiates all DNP3 message exchanges except unsolicited data. DNP3 terminology describes all points from the perspective of the master. Binary points for control that move from the master to the outstation are called Binary Outputs, while binary status points within the outstation are called Binary Inputs.

Function Codes

Each DNP3 message includes a function code. Each object has a limited set of function codes that a master may use to manipulate the object. The object listing for the device shows the permitted function codes for each type of object. The most common DNP3 function codes are listed in *Table D.2*.

Table D.2 Selected DNP3 Function Codes

Function Code	Function	Description
1	Read	Request data from the outstation
2	Write	Send data to the outstation
3	Select	First part of a Select Before Operate operation
4	Operate	Second part of a Select Before Operate operation
5	Direct operate	One-step operation with reply
6	Direct operate, no reply	One-step operation with no reply

Qualifier Codes and Ranges

DNP3 masters use qualifier codes and ranges to make requests for specific objects by index. Qualifier codes specify the style of range, and the range specifies the indices of the objects of interest. DNP3 masters use qualifier codes to compose the shortest, most concise message possible when requesting points from a DNP3 outstation.

For example, the qualifier code 01 specifies that the request for points 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 communication efficiency. With various trade-offs, each method is less demanding of communication bandwidth than the previous one. For example, unsolicited report-by-exception consumes less communication bandwidth than polled report-by-exception because that method does not require polling messages from the master. To properly evaluate which access method provides optimum performance for your application, you must also consider overall system size and the volume of data communication expected.

Table D.3 DNP3 Access Methods

Access Method	Description
Polled static	Master polls for present value (Class 0) data only
Polled report-by-exception	Master polls frequently for event data and occasionally for Class 0 data
Unsolicited report-by-exception	Outstation devices send unsolicited event data to the master, and the master occasionally polls for Class 0 data
Quiescent	Master never polls and relies on unsolicited reports only

Binary Control Operations

DNP3 masters use Object 12, control device output block, to perform DNP3 binary control operations. The control device output block has both a trip/close selection and a code selection. The trip/close selection allows a single DNP3 index to operate two related control points such as trip and close or raise and lower. Trip/close pair operation is not recommended for new DNP3 devices, but is often included for interoperability with older DNP3 master implementations.

The control device output block code selection specifies either a latch or pulse operation on the point. In many cases, DNP3 outstations have only a limited subset of the possible combinations of the code field. Sometimes, DNP3 outstations assign special operation characteristics to the latch and pulse selections. *Table D.12* describes control point operation for the SEL-751A.

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-751A

The SEL-751A is a DNP3 Level 2 remote (outstation) device.

Data Access

Table D.5 lists DNP3 data access methods along with corresponding SEL-751A 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-751A Settings
Polled static	Class 0	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to 0; UNSOL*n* to No
Polled report-by-exception	Class 0 occasionally, Class 1, 2, 3 frequently	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to the necessary event class; UNSOL*n* to No
Unsolicited report-by-exception	Class 0 occasionally, optional Class 1, 2, 3 less frequently; mainly relies on unsolicited messages	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to the necessary event class; set UNSOL*n* to Yes and PUNSOL*n* to Yes or No
Quiescent	Class 0, 1, 2, 3 never; relies completely on unsolicited messages	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to the necessary event class; set UNSOL*n* and PUNSOL*n* to Yes.

In both the unsolicited report-by-exception and quiescent polling methods shown in *Table D.5*, you must make a selection for the PUNSOL*n* setting. This setting enables or disables unsolicited data reporting at power up. If your DNP3 master can send a message to enable unsolicited reporting on the SEL-751A, 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 information 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-751A 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-751A 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-751A 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-751A pauses UTIMEO*n* seconds and then transmits the unsolicited data again. *Figure D.1* provides an example with URETRY*n* = 2.

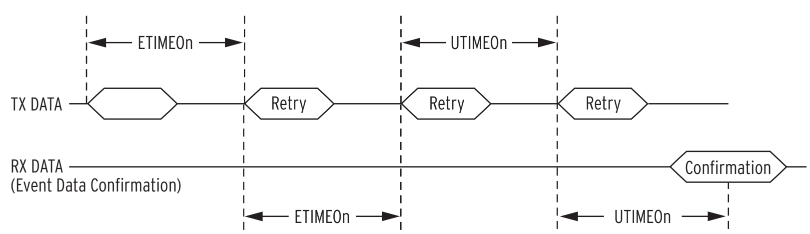


Figure D.1 Application Confirmation Timing With URETRY n = 2

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-751A 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-751A 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-751A 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*).

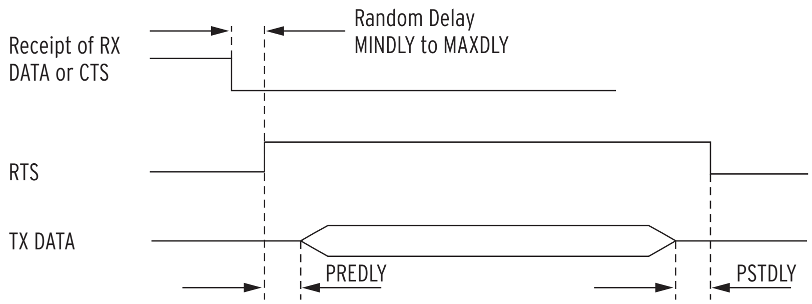


Figure D.2 Message Transmission Timing

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-751A 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-751A to either report the data without a polling request from the master (unsolicited data) or hold the data until the master requests the data 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-751A 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-751A.

For event data collection you must also consider and enter appropriate settings for dead band and scaling operation on analog points shown in *Table D.7*. You can either:

- set and use default dead band and scaling according to data type, or
- use a custom data map to select dead bands on a point-by-point basis.

See *DNP3 Documentation on page D.13* for a discussion of how to set scaling and dead-band operation on a point-by-point basis. You can modify dead bands for analog inputs at run-time by writing to Object 34.

The settings ANADBA*n*, ANADBV*n*, and ANADBM*n* control default dead-band operation for each type of analog data. Because DNP3 Objects 30 and 32 use integer data, you must use scaling to send digits after the decimal point and avoid rounding to a simple integer value.

With no scaling, the value of 12.632 would be sent as 12. With a scaling setting of 1, the value transmitted is 126. With a scaling setting of 3, the value transmitted is 12632. You must make certain that the maximum value does not exceed 32767 if you are polling the default 16-bit variations for Objects 30 and 32, but you can send some decimal values by using this technique. You must also configure the master to perform the appropriate division on the incoming value to display it properly.

You can set the default analog value scaling with the DECPLA*n*, DECPLV*n*, and DECPLM*n* settings. Application of event reporting dead bands occurs after scaling. For example, if you set DECPLA*n* to 2 and ANADBA*n* to 10, a measured current of 10.14 A would be scaled to the value 1014 and would have to increase to more than 1024 or decrease to less than 1004 (a change in magnitude of ± 0.1 A) for the device to report a new event value.

The SEL-751A 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-751A has the buffer capacities listed in *Table D.6*.

Table D.6 SEL-751A Event Buffer Capacity

Type	Maximum Number of Events
Binary	1024
Analog	100
Counters	32

Binary Controls

The SEL-751A provides more than one way to control individual points. The SEL-751A maps incoming control points either to remote bits or to internal command bits that cause circuit breaker operations. *Table D.12* lists control points and control methods available in the SEL-751A.

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-751A accepts and ignores time set requests (TIMERQ*n* = I for “ignore”). (This mode allows the SEL-751A to use a high accuracy, IRIG time source, but still interoperate with DNP3 masters that send time-synchronization messages.) You can set the SEL-751A to request time synchronization periodically by setting the TIMERQ*n* setting to the necessary period. You can also set it to not request, but accept time synchronization (TIMERQ*n* = M for “master”).

Modem Support

The SEL-751A DNP implementation includes modem support for serial ports. Your DNP3 master can dial-in to the SEL-751A and establish a DNP3 connection. The SEL-751A 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-751A to other devices.

You can either connect the modem to a computer and configure it before connecting it to the SEL-751A, 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-751A to call. The SEL-751A 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-751A tries to dial PH_NUM1 before dialing PH_NUM2. Similarly, the RETRY2 setting is the number of attempts the SEL-751A 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-751A 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 serial DNP3 and are visible only when configuring a serial port. Likewise, 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. The IP address for each session must be unique. Setting the IP address to 0.0.0.0 will allow any master IP address to connect to the session, as long as that IP address is not configured for another DNP3 session. Only one connection is supported on that session at a time.

Extreme care should be observed to ensure network security, especially when setting the IP address to 0.0.0.0, as there is no limitation on what DNP3 master may connect to the session.

Table D.7 Port DNP3 Protocol Settings (Sheet 1 of 2)

Name	Description	Range	Default
EDNP[a]	Enable DNP3 Sessions	0–3	0
DNPNUM[a]	DNP3 TCP and UDP Port	1–65534	20000
DNPADR	Device DNP3 address	0–65534	0
Session 1 Settings			
DNPIP1[a]	IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR1[a,b]	Transport protocol	UDP, TCP	TCP
DNPUDP1[a]	UDP response port	REQ, 1–65534	20000
REPADR1	DNP3 address of the Master to send messages to	0–65519	1
DNPMAP1	DNP3 Session Custom Map	1–3	1
DVARAI1	Analog Input Default Variation	1–6	4
ECLASSB1	Class for binary event data, 0 disables	0–3	1
ECLASSC1	Class for counter event data, 0 disables	0–3	0
ECLASSA1	Class for analog event data, 0 disables	0–3	2
DECPLA1	Decimal places scaling for Current data	0–3	1
DECPLV1	Decimal places scaling for Voltage data	0–3	1
DECPLM1	Decimal places scaling for Miscellaneous data	0–3	1
ANADBA1	Analog reporting dead band for current; hidden if ECLASSA1 set to 0	0–32767	100
ANADBV1	Analog reporting dead band for voltages; hidden if ECLASSA1 set to 0	0–32767	100
ANADBM1	Analog reporting dead band for miscellaneous analogs; hidden if ECLASSA and ECLASSC set to 0	0–32767	100
TIMERQ1	Time-set request interval, minutes (M = Disables time sync requests, but still accepts and applies time syncs from Master; I = Ignores (does not apply) time syncs from Master)	I, M, 1–32767	I
STIMEO1	Select/operate time-out, seconds	0.0–30.0	1.0
DNPINA1[a]	Send Data Link Heartbeat, seconds; hidden if DNPTR1 set to UDP	0.0–7200	120
DRETRY1[c]	Data link retries	0–15	3
DTIMEO1[c]	Data link time-out, seconds; hidden if 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[d]	Number of events to transmit on	1–200	10
AGEEVE1[d]	Oldest event to transmit on, seconds	0.0–99999.0	2.0
URETRY1[d]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO1[d]	Unsolicited messages offline time-out, seconds	1–5000	60
Session 2 Settings			
DNPIP2[a]	IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR2[a]	Transport protocol	UDP, TCP	TCP
. . .			
URETRY2[a,d]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO2[a,d]	Unsolicited messages offline time-out, seconds	1–5000	60

Table D.7 Port DNP3 Protocol Settings (Sheet 2 of 2)

Name	Description	Range	Default
Session 3 Settings			
DNPIP3[a]	IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR3[a]	Transport protocol	UDP, TCP	TCP
. . .			
URETRY3[a,d]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO3[a,d]	Unsolicited messages offline time-out, seconds	1–5000	60
Serial Port Settings			
MINDLY[c]	Minimum delay from DCD to TX, seconds	0.00–1.00	0.05
MAXDLY[c]	Maximum delay from DCD to TX, seconds	0.00–1.00	0.10
PREDLY[c]	Settle time from RTS on to TX; Off disables PSTDLY	OFF, 0.00–30.00	0.00
PSTDLY[c]	Settle time from TX to RTS off; hidden if PREDLY set to Off	0.00–30.00	0.00

[a] Available only on Ethernet ports. The DNP IP Address of each session (DNPIP1, DNPIP2, etc.) must be unique. Set DNPIPn := 0.0.0.0 to accept connections from any DNP master.
[b] If DNPIPx is 0.0.0.0, DNPTRx must be set to TCP.
[c] Available only on serial ports.
[d] Hidden if UNSOLn set to N.

The modem settings in *Table D.8* are only available for DNP3 serial port sessions.

Table D.8 Serial Port DNP3 Modem Settings

Name	Description	Range	Default
MODEM	Modem connected to port; all following settings are hidden if MODEM set to N	Y, N	N
MSTR	Modem startup string	As many as 30 characters	“E0X0&D0S0 = 4”
PH_NUM1	Primary phone number for dial-out	As many as 30 characters	“”
PH_NUM2	Secondary phone number for dial-out	As many as 30 characters	“”
RETRY1	Retry attempts for primary dial-out; hidden and unused if PH_NUM2 set to “”	1–20	5
RETRY2	Retry attempts for secondary dial-out; hidden and unused if PH_NUM2 set to “”	1–20	5
MDTIME	Time from initiating call to failure 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-751A. 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 above and non-supported 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-751A 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-751A 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-751A 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-751A DNP Object List (Sheet 4 of 6)

Obj.	Var.	Description	Request[a] Funct. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Funct. Codes[c]	Response[b] Qual. Codes[d]
31	6	16-Bit Frozen Analog Input Without Flag				
31	7	Short Floating Point Frozen Analog Input				
31	8	Long Floating Point Frozen Analog Input				
32[f]	0	Analog Change Event—All Variations	1	6, 7, 8		
32[f]	1	32-Bit Analog Change Event Without Time	1	6, 7, 8	129	17, 28
32[f]	2	16-Bit Analog Change Event Without Time	1	6, 7, 8	129, 130	17, 28
32[f]	3	32-Bit Analog Change Event With Time	1	6, 7, 8	129	17, 28
32[f]	4	16-Bit Analog Change Event With Time	1	6, 7, 8	129	17, 28
32[f]	5	Short Floating Point Analog Change Event	1	6, 7, 8	129	17, 28
32[f]	6	Long Floating Point Analog Change Event	1	6, 7, 8	129	17, 28
32[f]	7	Short Floating Point Analog Change Event With Time	1	6, 7, 8	129	17, 28
32[f]	8	Long Floating Point Analog Change Event With Time	1	6, 7, 8	129	17, 28
33	0	Frozen Analog Event—All Variations				
33	1	32-Bit Frozen Analog Event Without Time				
33	2	16-Bit Frozen Analog Event Without Time				
33	3	32-Bit Frozen Analog Event With Time				
33	4	16-Bit Frozen Analog Event With Time				
33	5	Short Floating Point Frozen Analog Event				
33	6	Long Floating Point Frozen Analog Event				
33	7	Short Floating Point Frozen Analog Event With Time				
33	8	Long Floating Point Frozen Analog Event With Time				
34	0	Analog Deadband—All Variations				
34	1[e]	16-Bit Analog Input Reporting Deadband Object	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
34	2	32-Bit Analog Input Reporting Deadband Object	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
34	3	Floating Point Analog Input Reporting Deadband Object	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
40	0	Analog Output Status—All Variations	1	0, 1, 6, 7, 8	129	
40	1	32-Bit Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
40	2[e]	16-Bit Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
40	3	Short Floating Point Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
40	4	Long Floating Point Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
41	0	Analog Output Block—All Variations				
41	1	32-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
41	2[e]	16-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
41	3	Short Floating Point Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
50	0	Time and Date—All Variations				
50	1	Time and Date	1, 2	7, 8 index = 0	129	07, quantity = 1

Table D.9 SEL-751A 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	07, quantity = 1
60	0	All Classes of Data	1, 20, 21	6, 7, 8		
60	1	Class 0 Data	1, 20, 21	6, 7, 8		
60	2	Class 1 Data	1	6, 7, 8		
60	3	Class 2 Data	1, 20, 21	6, 7, 8		
60	4	Class 3 Data	1, 20, 21	6, 7, 8		
70	1	File Identifier				
70	2	Authentication Object				
70	3	File Command Object				
70	4	File Command Status Object				
70	5	File Transport Object				
70	6	File Transport Status Object				
70	7	File Descriptor Object				
80	1	Internal Indications	2	0, 1 index = 7		
81	1	Storage Object				
82	1	Device Profile				
83	1	Private Registration Object				
83	2	Private Registration Object Descriptor				
90	1	Application Identifier				
100	1	Short Floating Point				
100	2	Long Floating Point				
100	3	Extended Floating Point				
101	1	Small Packed Binary-Coded Decimal				
101	2	Medium Packed Binary-Coded Decimal				
101	3	Large Packed Binary-Coded Decimal				
110	all	Octet String				
111	all	Octet String Event				
112	All	Virtual Terminal Output Block				

Table D.9 SEL-751A 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 necessary for the following function codes: 13 cold start 14 warm start 23 delay measurement	13, 14, 23			

[a] Supported in requests from master.
[b] May generate in response to master.
[c] Decimal.
[d] Hexadecimal.
[e] Default variation.
[f] Default variation specified by serial port setting DVARAI (or DVARAIn for Ethernet session n [n = 1, 2, or3]).

Device Profile

The DNP3 Device Profile document, available on the supplied CD or as a download from the SEL website, contains the standard device profile information for the SEL-751A.This information is also available in XML format. Please refer to this document for complete information on DNP3 Protocol support in the SEL-751A.

Reference Data Map

Table D.10 shows the SEL-751A 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-751A 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-751A 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 show Relay Word bit labels, you can use any Relay Word bit label for creating custom maps.

Table D.10 DNP3 Reference Data Map (Sheet 1 of 2)

Object	Labels	Description
Binary Inputs		
01, 02	STFAIL	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–AFS4EL[a]	Relay Word Elements (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–SC32[b,c]	Analog Quantities from *Table K.1* with an "x" in the DNP column
	SER_NUM	Serial Number
	0	Numeric 0
	1	Numeric 1
Analog Outputs		
40, 41	GROUP	Active Settings Group
	NOOP	No operation, no error

[a] Valid Relay Word bits depend on the relay model.
[b] Valid analog inputs depend on the relay model.
[c] Refer to 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-751A part number. *Table D.11* shows the SEL-751A 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
30, 32, 34	0	IA_MAG

Table D.11 DNP3 Default Data Map (Sheet 2 of 2)

Object	Default Index	Point Label
	1	IB_MAG
	2	IC_MAG
	3	IG_MAG
	4	IN_MAG
	5	IAV
	6	3I2
	7	FREQ
	8–99	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-751A dynamically creates the default Binary Input map after you issue an **R_S** command. The SEL-751A 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-751A dynamically creates the default Analog Input map after you issue an **R_S** command. The SEL-751A first checks for a voltage option in the part number, and if voltages are present, adds VAB_MAG, VBC_MAG, VCA_MAG, VAVE, 3V2, P, Q, S, and PF to the default DNP map. The SEL-751A then uses the Part Number to determine the presence of Analog Input cards in slots 3, 4, and 5. If present, the SEL-751A 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-751A will send attributes that apply to that particular DNP3 session. Because the SEL-751A supports custom DNP3 maps, these values will likely be different for each session. The SEL-751A 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-751A” 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 may be significantly delayed from when the original source changed and should not be used for sequence-of-events determination. Binary inputs registered with SER are derived from the SER and carry the time stamp of actual occurrence. Some additional binary inputs are available only to DNP. For example, STWARN and STFAIL are derived from the diagnostic task data. Another binary input, STSET, is derived from the SER and carries the time stamp of actual occurrence. Static reads of this input 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-751A 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, LATCHON, 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. An operation in progress may be cancelled by issuing a NUL Trip/Close Code with a NUL Operation Type. Single output points support both Pulse and Latch operations. See *Control Point Operation* for details on control operations.

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-751A 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-751A 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.12*. Pulse operations provide a pulse with duration of one protection processing interval.

Table D.12 SEL-751A 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	Not Supported	Not Supported	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)	Not Supported	Not Supported	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 (DVARAIn 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 may 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-751A 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-751A 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 of the following as:

- 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    := NOOP
AO_02    := NA
…
AO_29    := NA
AO_30    := NOOP
AO_31    := NOOP
```

Figure D.3 Sample Response to SHO DNP Command (Sheet 1 of 2)

```
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 (Sheet 2 of 2)

You can also use the **MAP DNP *y s* <Enter>** command to display DNP3 maps, but the parameter ***y*** is the port number from 1 to 4. Because port 1, the Ethernet port, can support multiple DNP3 sessions, it may have a different map assigned to each session selected by parameter ***s*** for sessions 1 to 3. See *Figure D.4* for an example of a **MAP** command that shows the same map as in *Figure D.3*.

```
=>MAP DNP 1 1 <Enter>

SEL-751A                                       Date: 12/14/2008   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
```

Figure D.4 Port MAP Command (Sheet 1 of 2)

```
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      NOOP
```

Figure D.4 Port MAP Command (Sheet 2 of 2)

You can use the command **SET DNP *x***, where *x* is the map number, to edit or create custom DNP3 data maps. You can also use the ACSELERATOR QuickSet® SEL-5030 Software, which is recommended for this purpose.

Scaling factors allow you to overcome the limitations imposed by the integer nature of the default variations of Objects 30 and 32. For example, the device rounds a value of 11.4 A to 11 A. You can use scaling to include decimal point values by multiplying by a number larger than one. If you use 10 as a scaling factor, 11.4 A 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 the entire configuration may be completed without saving changes between point types. To do this, you simply continue entering data and save the entire map at the end. 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 may 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*.

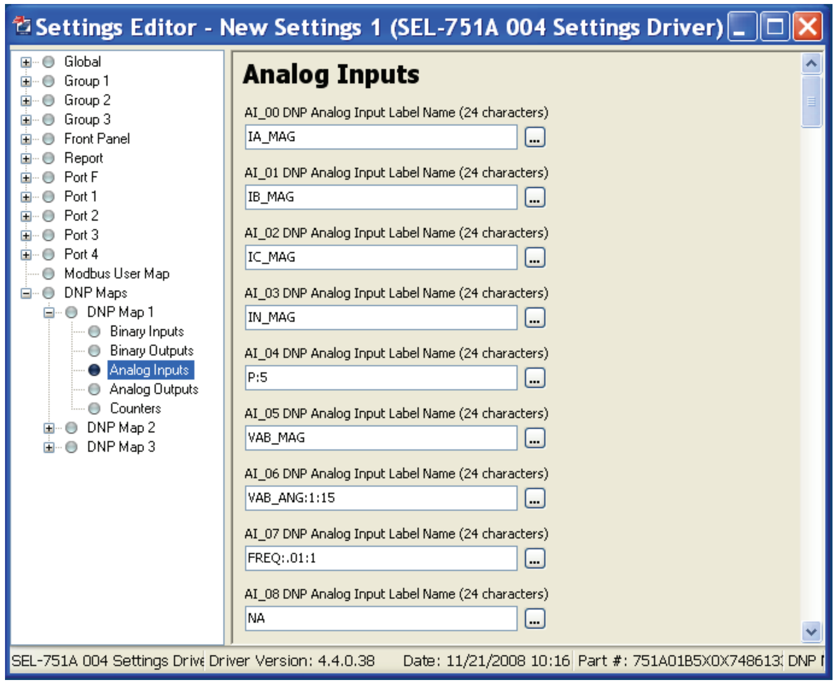


Figure D.6 Analog Input Map Entry in ACSELERATOR QuickSet Software

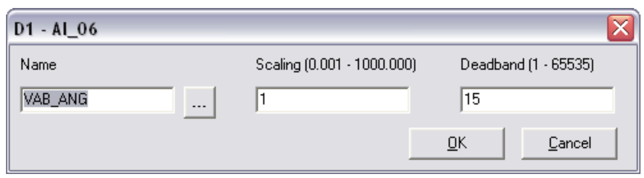


Figure D.7 AI Point Label, Scaling and Deadband in ACSELERATOR QuickSet Software

The **SET DNP *x* CO_00 <Enter>** command allows you to populate the DNP counter map with per-point dead bands. Entering these settings is similar to defining the analog input map settings.

You can use the command **SET DNP *x* BO_00 TERSE <Enter>** to change the binary output map ***x*** as shown in *Figure D.8*. You can populate the custom BO map with any of the 32 remote bits (RB01–RB32). You can define bit pairs in BO maps by including a colon (:) between the bit labels.

```
=>>SET DNP 1 BO_00 TERSE <Enter>
Binary Output Map

DNP Binary Output Label Name (23 characters)
BO_00    := NA
? > RB01 <Enter>
DNP Binary Output Label Name (23 characters)
BO_01    := NA
? > RB02 <Enter>
DNP Binary Output Label Name (23 characters)
BO_02    := NA
? > RB03:RB04 <Enter>
DNP Binary Output Label Name (23 characters)
BO_03    := NA
? > RB05:RB06 <Enter>
DNP Binary Output Label Name (23 characters)
BO_04    := NA
? > end <Enter>

=>>
```

Figure D.8 Sample Custom DNP3 BO Map Settings

You may also use ACSELERATOR QuickSet to enter the BO map settings as shown in the screen capture in *Figure D.9*.

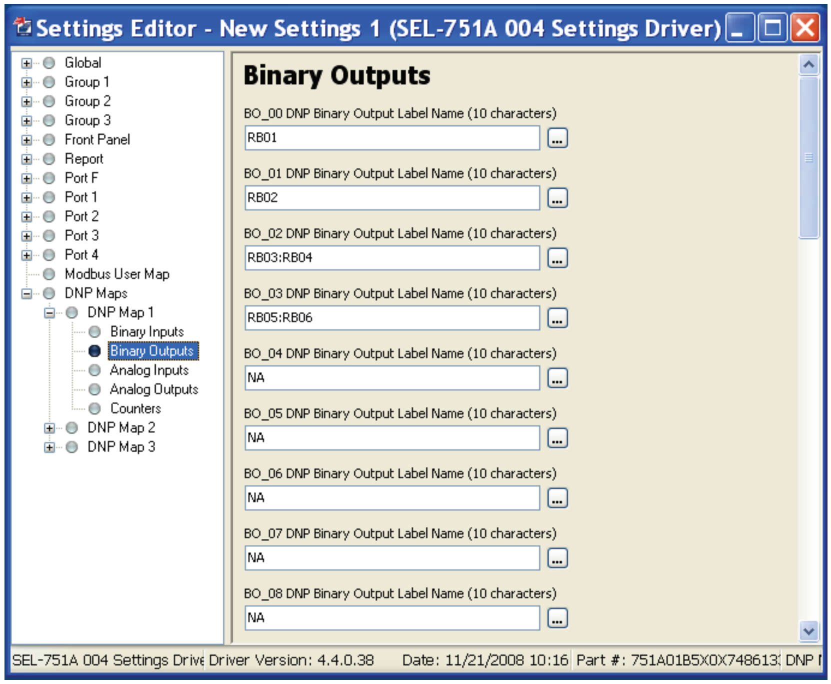


Figure D.9 Binary Output Map Entry in ACSELERATOR QuickSet Software

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-751A 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-751A 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-751A Modbus communication allows a Modbus master device to do the following:

- Acquire metering, monitoring, and event data from the relay.
- Control SEL-751A output contacts.
- Read the SEL-751A 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.

NOTE: User should be aware of the following setting in the relay: Under Global settings =====›› Access Control, there is a setting called BLOCK MODBUS SET.

The BLOCK MODBUS SET setting is used to block relay settings changes via Modbus or DeviceNet protocols. The factory-default setting, BLKMBSET := NONE, **allows** all setting changes via Modbus or DeviceNet communications. The BLKMBSET := R_S setting **prevents** Modbus or DeviceNet communications from resetting to the factory-default settings. The BLKMBSET := ALL setting **blocks** all changes to the settings via the Modbus or the DeviceNet protocol.

The customer is strongly advised to change the BLKMBSET (BLOCK MODBUS SET) := ALL if they (customer) do not want the PLC (Programmable Logic Controller) or DCS (Distributed Control System) to send the settings to the SEL-751A relay. There is a strong possibility that under special conditions like a reboot, the PLC/DCS will send default settings to the relay, overwriting the existing settings. To protect the existing settings under these conditions it is highly recommended to set the setting to "ALL."

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-751A SLAVEID setting defines the device address. Set this value to a unique number for each device on the Modbus network. For Modbus communication to operate properly, no two slave devices may have the same address.

The cyclical redundancy check detects errors in the received data. If the relay detects an error, it discards the packet.

Modbus Responses

The slave device sends a response message after it performs the action the query specifies. If the slave cannot execute the query command for any reason, it sends an error response. Otherwise, the slave device response is formatted similarly to the query and includes the slave address, function code, data (if applicable), and a cyclical redundancy check value.

Supported Modbus Function Codes

The SEL-751A supports the Modbus function codes shown in *Table E.2*.

Table E.2 SEL-751A 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-751A sends an exception code under the conditions described in *Table E.3*.

Table E.3 SEL-751A 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-751A 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-751A 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-751A, 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-751A 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 (Sheet 1 of 2)

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (01h)
2 bytes	Address of the first bit
2 bytes	Number of bits to read

Table E.4 01h Read Discrete Output Coil 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 (01h)
1 byte	Bytes of data (*n*)
n bytes	Data
2 bytes	CRC-16

To build the response, the SEL-751A 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	Communication Counter Increments
Invalid bit to read	Illegal Data Address (02h)	Invalid Address
Invalid number of bits to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

02 Read Input Status Command

Use function code 02h to read the On/Off status of the selected bits (inputs), as shown in *Table E.6*. You can read the status of as many as 2000 bits per query. Note that input addresses start at 0 (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
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*)

Table E.6 02h Read Input Status Command (Sheet 2 of 2)

Bytes	Field
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-751A Inputs (Sheet 1 of 4)

Coil Address (Decimal)	Function Code Supported	Coil Description[a]
0–7	2	Relay Element Status Row 0
8–15	2	Relay Element Status Row 1
16–23	2	Relay Element Status Row 2
24–31	2	Relay Element Status Row 3
32–39	2	Relay Element Status Row 4
40–47	2	Relay Element Status Row 5
48–55	2	Relay Element Status Row 6
56–63	2	Relay Element Status Row 7
64–71	2	Relay Element Status Row 8
72–79	2	Relay Element Status Row 9
80–87	2	Relay Element Status Row 10
88–95	2	Relay Element Status Row 11
96–103	2	Relay Element Status Row 12
104–111	2	Relay Element Status Row 13
112–119	2	Relay Element Status Row 14
120–127	2	Relay Element Status Row 15
128–135	2	Relay Element Status Row 16
136–143	2	Relay Element Status Row 17
144–151	2	Relay Element Status Row 18
152–159	2	Relay Element Status Row 19
160–167	2	Relay Element Status Row 20
168–175	2	Relay Element Status Row 21
176–183	2	Relay Element Status Row 22
184–191	2	Relay Element Status Row 23
192–199	2	Relay Element Status Row 24

Table E.7 02h SEL-751A Inputs (Sheet 2 of 4)

Coil Address (Decimal)	Function Code Supported	Coil Description[a]
200–207	2	Relay Element Status Row 25
208–215	2	Relay Element Status Row 26
216–223	2	Relay Element Status Row 27
224–231	2	Relay Element Status Row 28
232–239	2	Relay Element Status Row 29
240–247	2	Relay Element Status Row 30
248–255	2	Relay Element Status Row 31
256–263	2	Relay Element Status Row 32
264–271	2	Relay Element Status Row 33
272–279	2	Relay Element Status Row 34
280–287	2	Relay Element Status Row 35
288–295	2	Relay Element Status Row 36
296–303	2	Relay Element Status Row 37
304–311	2	Relay Element Status Row 38
312–319	2	Relay Element Status Row 39
320–327	2	Relay Element Status Row 40
328–335	2	Relay Element Status Row 41
336–343	2	Relay Element Status Row 42
344–351	2	Relay Element Status Row 43
352–359	2	Relay Element Status Row 44
360–367	2	Relay Element Status Row 45
368–375	2	Relay Element Status Row 46
376–383	2	Relay Element Status Row 47
384–391	2	Relay Element Status Row 48
392–399	2	Relay Element Status Row 49
400–407	2	Relay Element Status Row 50
408–415	2	Relay Element Status Row 51
416–423	2	Relay Element Status Row 52
424–431	2	Relay Element Status Row 53
432–439	2	Relay Element Status Row 54
440–447	2	Relay Element Status Row 55
448–455	2	Relay Element Status Row 56
456–463	2	Relay Element Status Row 57
464–471	2	Relay Element Status Row 58
472–479	2	Relay Element Status Row 59
480–487	2	Relay Element Status Row 60
488–495	2	Relay Element Status Row 61
496–503	2	Relay Element Status Row 62

Table E.7 02h SEL-751A Inputs (Sheet 3 of 4)

Coil Address (Decimal)	Function Code Supported	Coil Description[a]
504–511	2	Relay Element Status Row 63
512–519	2	Relay Element Status Row 64
520–527	2	Relay Element Status Row 65
528–535	2	Relay Element Status Row 66
536–543	2	Relay Element Status Row 67
544–551	2	Relay Element Status Row 68
552–559	2	Relay Element Status Row 69
560–567	2	Relay Element Status Row 70
568–575	2	Relay Element Status Row 71
576–583	2	Relay Element Status Row 72
584–591	2	Relay Element Status Row 73
592–599	2	Relay Element Status Row 74
600–607	2	Relay Element Status Row 75
608–615	2	Relay Element Status Row 76
616–623	2	Relay Element Status Row 77
624–631	2	Relay Element Status Row 78
632–639	2	Relay Element Status Row 79
640–647	2	Relay Element Status Row 80
648–655	2	Relay Element Status Row 81
656–663	2	Relay Element Status Row 82
664–671	2	Relay Element Status Row 83
672–679	2	Relay Element Status Row 84
680–687	2	Relay Element Status Row 85
688–695	2	Relay Element Status Row 86
696–703	2	Relay Element Status Row 87
704–711	2	Relay Element Status Row 88
712–719	2	Relay Element Status Row 89
720-727	2	Relay Element Status Row 90
728–735	2	Relay Element Status Row 91
736–743	2	Relay Element Status Row 92
744–751	2	Relay Element Status Row 93
752–759	2	Relay Element Status Row 94
760–767	2	Relay Element Status Row 95
768–775	2	Relay Element Status Row 96
776–783	2	Relay Element Status Row 97
784–791	2	Relay Element Status Row 98
792–799	2	Relay Element Status Row 99
800–807	2	Relay Element Status Row 100

Table E.7 02h SEL-751A Inputs (Sheet 4 of 4)

Coil Address (Decimal)	Function Code Supported	Coil Description[a]
808–815	2	Relay Element Status Row 101
816–823	2	Relay Element Status Row 102
824–831	2	Relay Element Status Row 103
832–839	2	Relay Element Status Row 104
840–847	2	Relay Element Status Row 105
848–855	2	Relay Element Status Row 106
856–863	2	Relay Element Status Row 107
864–871	2	Relay Element Status Row 108
872–879	2	Relay Element Status Row 109
880–887	2	Relay Element Status Row 110
888–895	2	Relay Element Status Row 111
896–903	2	Relay Element Status Row 112
904–911	2	Relay Element Status Row 113
912–919	2	Relay Element Status Row 114
920–927	2	Relay Element Status Row 115
928–935	2	Relay Element Status Row 116
936–943	2	Relay Element Status Row 117
944–951	2	Relay Element Status Row 118
952–959	2	Relay Element Status Row 119

[a] The input numbers are assigned from the right-most input to the left-most input in the Relay row as shown 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	Communication Counter Increments
Invalid bit to read	Illegal Data Address (02h)	Invalid Address
Invalid number of bits to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

03h Read Holding Register Command

Use function code 03h to read directly from the Modbus Register Map shown in *Table E.34*. You can read a maximum of 125 registers at once with this function code. Most masters use 4X references with this function code. If you are accustomed to 4X references with this function code, for five-digit addressing, add 40001 to the standard database address.

Table E.9 03h Read Holding Register Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (03h)
2 bytes	Starting Register Address
2 bytes	Number of Registers to Read
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (03h)
1 byte	Bytes of data (*n*)
n bytes	Data (2–250)
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table E.10*.

Table E.10 Responses to 03h Read Holding Register Query Errors

Error	Error Code Returned	Communication Counter Increments
Illegal register to read	Illegal Data Address (02h)	Invalid Address
Illegal number of registers to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

04h Read Input Register Command

Use function code 04h to read directly from the Modbus Register Map shown in *Table E.34*. You can read a maximum of 125 registers at once with this function code. Most masters use 3X references with this function code. If you are accustomed to 3X references with this function code, for five-digit addressing, add 30001 to the standard database address.

Table E.11 04h Read Input Register Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (04h)
2 bytes	Starting Register Address
2 bytes	Number of Registers to Read
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (04h)
1 byte	Bytes of data (*n*)
n bytes	Data (2–250)
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table E.12*.

Table E.12 Responses to 04h Read Input Register Query Errors

Error	Error Code Returned	Communication Counter Increments
Illegal register to read	Illegal Data Address (02h)	Invalid Address
Illegal number of registers to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

05h Force Single Coil Command

Use function code 05h to set or clear a coil. In *Table E.13*, the command response is identical to the command request.

Table E.13 05h Force Single Coil Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (05h)
2 bytes	Coil Reference
1 byte	Operation Code (FF for bit set, 00 for bit clear)
1 byte	Placeholder (00)
2 bytes	CRC-16

Table E.14 lists the coil numbers supported by the SEL-751A. 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-751A Output (Sheet 1 of 3)

Coil Address (Decimal)	Function Code Supported	Coil Description
0	01, 05	Pulse OUT101 1 second
1	01, 05	Pulse OUT102 1 second
2	01, 05	Pulse OUT103 1 second
3	01, 05	Pulse OUT301 1 second
4	01, 05	Pulse OUT302 1 second
5	01, 05	Pulse OUT303 1 second
6	01, 05	Pulse OUT304 1 second
7	01, 05	Reserved
8	01, 05	Reserved
9	01, 05	Reserved
10	01, 05	Reserved
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	Reserved
16	01, 05	Reserved

Table E.14 01h, 05h SEL-751A Output (Sheet 2 of 3)

Coil Address (Decimal)	Function Code Supported	Coil Description
17	01, 05	Reserved
18	01, 05	Reserved
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	Reserved
24	01, 05	Reserved
25	01, 05	Reserved
26	01, 05	Reserved
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
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

Table E.14 01h, 05h SEL-751A Output (Sheet 3 of 3)

Coil Address (Decimal)	Function Code Supported	Coil Description
55	01, 05	RB29
56	01, 05	RB30
57	01, 05	RB31
58	01, 05	RB32
59	01, 05	Pulse RB01[a]
60	01, 05	Pulse RB02[a]
61	01, 05	Pulse RB03[a]
62	01, 05	Pulse RB04[a]
63	01, 05	Pulse RB05[a]
64	01, 05	Pulse RB06[a]
65	01, 05	Pulse RB07[a]
66	01, 05	Pulse RB08[a]
67	01, 05	Pulse RB09[a]
68	01, 05	Pulse RB10[a]
69	01, 05	Pulse RB11[a]
70	01, 05	Pulse RB12[a]
71	01, 05	Pulse RB13[a]
72	01, 05	Pulse RB14[a]
73	01, 05	Pulse RB15[a]
74	01, 05	Pulse RB16[a]
75	01, 05	Pulse RB17[a]
76	01, 05	Pulse RB18[a]
77	01, 05	Pulse RB19[a]
78	01, 05	Pulse RB20[a]
79	01, 05	Pulse RB21[a]
80	01, 05	Pulse RB22[a]
81	01, 05	Pulse RB23[a]
82	01, 05	Pulse RB24[a]
83	01, 05	Pulse RB25[a]
84	01, 05	Pulse RB26[a]
85	01, 05	Pulse RB27[a]
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 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	Communication Counter Increments
Invalid bit (coil)	Illegal Data Address (02h)	Invalid Address
Invalid bit state requested	Illegal Data Value (03h)	Illegal Register
Format Error	Illegal Data Value (03h)	Bad Packet Format

06h Preset Single Register Command

The SEL-751A 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 necessary for the master.

Table E.16 06h Preset Single Register Command

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (06h)
2 bytes	Register Address
2 bytes	Data
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table E.17*.

Table E.17 Responses to 06h Preset Single Register Query Errors

Error	Error Code Returned	Communication Counter Increments
Illegal register address	Illegal Data Address (02h)	Invalid Address Illegal Write
Illegal register value	Illegal Data Value (03h)	Illegal Write
Format error	Illegal Data Value (03h)	Bad Packet Format

08h Loopback Diagnostic Command

The SEL-751A 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 (Sheet 1 of 2)

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (08h)

Table E.18 08h Loopback Diagnostic Command (Sheet 2 of 2)

Bytes	Field
2 bytes	Subfunction (0000h)
2 bytes	Data Field
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (08h)
2 bytes	Subfunction (0000h)
2 bytes	Data Field (identical to data in Master request)
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table E.19*.

Table E.19 Responses to 08h Loopback Diagnostic Query Errors

Error	Error Code Returned	Communication Counter Increments
Illegal subfunction code	Illegal Data Value (03h)	Invalid Function Code/Op Code
Format error	Illegal Data Value (03h)	Bad Packet Format

10h Preset Multiple Registers Command

This function code works much like code 06h, except that it allows you to write multiple registers at once, 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	Communication Counter Increments
Illegal register to set	Illegal Data Address (02h)	Invalid Address Illegal Write
Illegal number of registers to set	Illegal Data Value (03h)	Illegal Register Illegal Write
Incorrect number of bytes in query data region	Illegal Data Value (03h)	Bad Packet Format Illegal Write
Invalid register data value	Illegal Data Value (03h)	Illegal Write

60h Read Parameter Information Command

The SEL-751A uses this function to allow a Modbus master to read parameter information from the relay. One parameter (setting) is read in each query.

Table E.22 60h Read Parameter Information Command

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (60h)
2 bytes	Parameter Number
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (60h)
2 bytes	Parameter Number
1 byte	Parameter Descriptor
1 byte	Parameter Conversion
2 bytes	Parameter Minimum Settable Value
2 bytes	Parameter Maximum Settable Value
2 bytes	Parameter Default Value
2 bytes	CRC-16

The Parameter Descriptor field is defined in *Table E.23*.

Table E.23 60h Read Parameter Descriptor Field Definition (Sheet 1 of 2)

Bit	Name	Description
0	RO: Read-only	1 when the setting is read-only
1	H: Hidden	1 when the setting is hidden
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

Table E.23 60h Read Parameter Descriptor Field Definition (Sheet 2 of 2)

Bit	Name	Description
6	0	Reserved
7	Extend	Reserved to extend the descriptor table

The Parameter Conversion field is defined in *Table E.24*.

Table E.24 60h Read Parameter Conversion Field Definition

Conversion Value	Type	Multiplier	Divisor	Offset	Base
0	Boolean	1	1	0	1
1	Unsigned Integer	1	1	0	1
2	Unsigned Integer	1	10	0	1
3	Unsigned Integer	1	100	0	1
4	Unsigned Integer	1	1000	0	1
5	Hexidecimal	1	1	0	1
6	Integer	1	1	0	1
7	Integer	1	10	0	1
8	Integer	1	100	0	1
9	Integer	1	1000	0	1
10	Enumeration	1	1	0	1
11	Bit Enumeration	1	1	0	1

Use *Equation E.1* to calculate the actual (not scaled) value of the parameter (setting):

$$\text{value} = \frac{(\text{ParameterValue} + \text{Offset}) \bullet \text{Multiplier} \bullet \text{Base}}{\text{Divisor}}$$

Equation E.1

Use *Equation E.2* to calculate the scaled setting value:

$$\text{value} = \frac{\text{value} \bullet \text{Divisor}}{\text{Multiplier} \bullet \text{Base}} - \text{Offset}$$

Equation E.2

The relay response to errors in the query are shown *Table E.25*.

Table E.25 Responses to 60h Read Parameter Information Query Errors

Error	Error Code Returned	Communication Counter Increments
Illegal parameter to read	Illegal Address (02h)	Invalid Address

61h Read Parameter Text Command

The SEL-751A 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-751A 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	Communication Counter Increments
Illegal parameter to read	Illegal Address (02h)	Invalid Address
Illegal enumeration in index	Illegal Data Value (03h)	Illegal Register

7Dh Encapsulated Packet With Control Command

The SEL-751A 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

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Control Command (same as write to 2000h)
1 byte	Embedded Modbus Function
n bytes	Optional Data to Support Modbus Function (0–250)
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Status Information (Register 2100h or 2101h based on Bit 3 in Control Command Word)
1 byte	Embedded Modbus Function
n bytes	Optional data to support the Modbus function (0–250)
2 bytes	CRC-16

Table E.31 shows the format of the relay responses to errors in the query.

Table E.31 7Dh Encapsulated Packet Query Errors

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Status Information (Register 2100h or 2101h based on Bit 3 in Control Command Word)
1 byte	Modbus Function with Error Flag
1 bytes	Function Error Code[a]
2 bytes	CRC-16

[a] If the embedded function code is invalid, then an illegal function code returns here and the illegal function counter is increments. 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.

Modifying Relay Settings Using Modbus

The SEL-751A does not provide password protection. It is assumed that because the interface is a binary protocol with CRC-16 protection, the interface is being handled by an intelligent master system. Therefore, the master would provide password protection.

You can change any of the settings listed in the Modbus Register Map (*Table E.34*). The high and low limits provided in the table might cover a wider range than what is acceptable by the particular model or configuration. The settings are not saved as and when they are received. The relay acknowledges the write operation, but it does not change the relay settings. The relay holds these settings until there are no further edits for a time specified by SETTINGS TIMEOUT register (4010h). After this time-out, the relay attempts to save the settings. If there are no errors, the settings are saved. If, however, a setting interdependency rule is violated, the settings are not saved. The relay will set the Config Fault bit in the TRIP STATUS HI register to indicate that the save settings operation has failed. The relay will also set ERROR REGISTER (4016h) flags to indicate the type of error.

You can change parameters such as date and time with the appropriate registers by using Modbus Function Code 06h or 10h.

You can block the ability to change the settings via Modbus protocol by using the Global Setting BLKMBSET or BLOCK MODBUS SET register.

Controlling Output Contacts Using Modbus

The SEL-751A 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-751A Modbus Register Map defines an area of 125 contiguous addresses whose contents are defined by 125 user-settable addresses. This feature allows you to take 125 discrete values from anywhere in the Modbus Register Map and place them in contiguous registers that you can then read in a single command. SEL ASCII command **SET M** provides a convenient method to define the user map addresses. The user map can also be defined by writing to user map registers MOD_001 to MOD_125.

To use the user-defined data region, perform the following steps.

Step 1. Define the list of necessary quantities (as many as 125). Arrange the quantities in any order that is convenient for you to use.

Step 2. Refer to *Table E.33* for a list of the Modbus label for each quantity.

Step 3. Execute **SET M** command from the command line to map user registers 001 to 125 (MOD_001 to MOD_125) through use of the labels in *Table E.33*.

Note that this step can also be performed through the use of the Modbus protocol. Use Modbus Function Code 06h to write to registers MOD_001 through MOD_125.

Step 4. Use Modbus function code 03h or 04h to read the 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 5)

Register Address	Label
610	FPGA
611	GPSB
612	HMI
613	RAM
614	ROM
615	CR_RAM
616	NON_VOL
617	CLKSTS
618	CID_FILE
619	RTD
620	P3P3PS
621	P5PS
622	P2P5PS
623	P3P75PS
624	N1P25PS
625	N5PS
626	CLKBAT
627	CTBRD
628	CARDC
629	CARDD
630	CARDE
631	IASTS
632	IBSTS
633	ICSTS
634	INSTS
635	VASTS
636	VBSTS
637	VCSTS
638	RLYSTS
639	VSSTS
640	SER_NUMH
641	SER_NUML
642	IGSTS
643-649[a]	
650	IA_MAG
651	IA_ANG
652	IB_MAG
653	IB_ANG
654	IC_MAG
655	IC_ANG
656	IN_MAG
657	IN_ANG
658	IG_MAG
659	IG_ANG
660	IAV
661	RES_661
662	3I2
663	UBI
664	VS_MAG
665	VS_ANG
666	VDC
667	VAB_MAG
668	VAB_ANG
669	VBC_MAG
670	VBC_ANG
671	VCA_MAG
672	VCA_ANG
673	VAVE
674	VA_MAG
675	VA_ANG
676	VB_MAG
677	VB_ANG
678	VC_MAG
679	VC_ANG
680	VG_MAG
681	VG_ANG
682	VAVE
683	3V2
684	UBV
685	P
686	Q
687	S
688	PF
689	FREQ
690	MWH3PH
691	MWH3PL
692	MVRH3PIH
693	MVRH3PIL
694	MVRH3POH
695	MVRH3POL
696	MVAH3PH
697	MVAH3PL
698	ENRGY_S
699	ENRGYMN
700	ENRGY_H
701	ENRGY_D
702	ENRGYMO
703	ENRGY_Y
704	MWH3PIH
705	MWH3PIL
706	FREQS
707-711[a]	
712	RTDWDGMX
713	RTDBRGMX
714	RTDAMB
715	RTDOTHMX
716	RTD1
717	RTD2
718	RTD3
719	RTD4
720	RTD5
721	RTD6
722	RTD7
723	RTD8
724	RTD9
725	RTD10
726	RTD11
727	RTD12
728	RES_728
729	LSENS1
730	LSENS2
731	LSENS3
732	LSENS4
733-738[a]	
739	VSRMS
740	IARMS
741	IBRMS
742	ICRMS
743	INRMS
744	VARMS
745	VBRMS
746	VCRMS
747	VABRMS
748	VBCRMS
749	VCARMS
750	IAMX
751	IAX_S
752	IAXMN
753	IAX_H
754	IAX_D
755	IAXMO
756	IAX_Y
757	IAMN
758	IAN_S
759	IANMN
760	IAN_H
761	IAN_D
762	IANMO
763	IAN_Y
764	IBMX
765	IBX_S
766	IBXMN
767	IBX_H
768	IBX_D
769	IBXMO
770	IBX_Y
771	IBMN
772	IBN_S
773	IBNMN
774	IBN_H
775	IBN_D
776	IBNMO
777	IBN_Y
778	ICMX
779	ICX_S
780	ICXMN
781	ICX_H
782	ICX_D
783	ICXMO
784	ICX_Y
785	ICMN
786	ICN_S
787	ICNMN
788	ICN_H
789	ICN_D
790	ICNMO
791	ICN_Y
792	INMX
793	INX_S
794	INXMN
795	INX_H
796	INX_D
797	INXMO
798	INX_Y
799	INMN
800	INN_S
801	INNMN
802	INN_H
803	INN_D
804	INNMO
805	INN_Y
806	IGMX
807	IGX_S
808	IGXMN
809	IGX_H
810	IGX_D
811	IGXMO
812	IGX_Y
813	IGMN
814	IGN_S
815	IGNMN
816	IGN_H
817	IGN_D
818	IGNMO
819	IGN_Y
820	VABMX
821	VABX_S
822	VABXMN
823	VABX_H
824	VABX_D
825	VABXMO
826	VABX_Y
827	VABMN
828	VABN_S
829	VABNMN
830	VABN_H
831	VABN_D
832	VABNMO
833	VABN_Y
834	VBCMX
835	VBCX_S
836	VBCXMN
837	VBCX_H
838	VBCX_D
839	VBCXMO
840	VBCX_Y
841	VBCMN
842	VBCN_S
843	VBCNMN
844	VBCN_H
845	VBCN_D
846	VBCNMO
847	VBCN_Y
848	VCAMX
849	VCAX_S
850	VCAXMN
851	VCAX_H
852	VCAX_D
853	VCAXMO
854	VCAX_Y
855	VCAMN
856	VCAN_S
857	VCANMN
858	VCAN_H
859	VCAN_D
860	VCANMO
861	VCAN_Y
862	KW3PMX
863	KW3X_S
864	KW3XMN
865	KW3X_H
866	KW3X_D
867	KW3XMO
868	KW3X_Y
869	KW3PMN
870	KW3N_S
871	KW3NMN
872	KW3N_H
873	KW3N_D
874	KW3NMO

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 2 of 5)

Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label
875	KW3N_Y	925	RTD1MN	975	RTD5X_S	1025	RTD8NMN	1075	RTD12X_H
876	KVAR3PMX	926	RTD1N_S	976	RTD5XMN	1026	RTD8N_H	1076	RTD12X_D
877	KVR3X_S	927	RTD1NMN	977	RTD5X_H	1027	RTD8N_D	1077	RTD12XMO
878	KVR3XMN	928	RTD1N_H	978	RTD5X_D	1028	RTD8NMO	1078	RTD12X_Y
879	KVR3X_H	929	RTD1N_D	979	RTD5XMO	1029	RTD8N_Y	1079	RTD12MN
880	KVR3X_D	930	RTD1NMO	980	RTD5X_Y	1030	RTD9MX	1080	RTD12N_S
881	KVR3XMO	931	RTD1N_Y	981	RTD5MN	1031	RTD9X_S	1081	RTD12NMN
882	KVR3X_Y	932	RTD2MX	982	RTD5N_S	1032	RTD9XMN	1082	RTD12N_H
883	KVAR3PMN	933	RTD2X_S	983	RTD5NMN	1033	RTD9X_H	1083	RTD12N_D
884	KVR3N_S	934	RTD2XMN	984	RTD5N_H	1034	RTD9X_D	1084	RTD12NMO
885	KVR3NMN	935	RTD2X_H	985	RTD5N_D	1035	RTD9XMO	1085	RTD12N_Y
886	KVR3N_H	936	RTD2X_D	986	RTD5NMO	1036	RTD9X_Y	1086	AI301MXH
887	KVR3N_D	937	RTD2XMO	987	RTD5N_Y	1037	RTD9MN	1087	AI301MXL
888	KVR3NMO	938	RTD2X_Y	988	RTD6MX	1038	RTD9N_S	1088	AI301X_S
889	KVR3N_Y	939	RTD2MN	989	RTD6X_S	1039	RTD9NMN	1089	AI301XMN
890	KVA3PMX	940	RTD2N_S	990	RTD6XMN	1040	RTD9N_H	1090	AI301X_H
891	KVA3X_S	941	RTD2NMN	991	RTD6X_H	1041	RTD9N_D	1091	AI301X_D
892	KVA3XMN	942	RTD2N_H	992	RTD6X_D	1042	RTD9NMO	1092	AI301XMO
893	KVA3X_H	943	RTD2N_D	993	RTD6XMO	1043	RTD9N_Y	1093	AI301X_Y
894	KVA3X_D	944	RTD2NMO	994	RTD6X_Y	1044	RTD10MX	1094	AI301MNH
895	KVA3XMO	945	RTD2N_Y	995	RTD6MN	1045	RTD10X_S	1095	AI301MNL
896	KVA3X_Y	946	RTD3MX	996	RTD6N_S	1046	RTD10XMN	1096	AI301N_S
897	KVA3PMN	947	RTD3X_S	997	RTD6NMN	1047	RTD10X_H	1097	AI301NMN
898	KVA3N_S	948	RTD3XMN	998	RTD6N_H	1048	RTD10X_D	1098	AI301N_H
899	KVA3NMN	949	RTD3X_H	999	RTD6N_D	1049	RTD10XMO	1099	AI301N_D
900	KVA3N_H	950	RTD3X_D	1000	RTD6NMO	1050	RTD10X_Y	1100	AI301NMO
901	KVA3N_D	951	RTD3XMO	1001	RTD6N_Y	1051	RTD10MN	1101	AI301N_Y
902	KVA3NMO	952	RTD3X_Y	1002	RTD7MX	1052	RTD10N_S	1102	AI302MXH
903	KVA3N_Y	953	RTD3MN	1003	RTD7X_S	1053	RTD10NMN	1103	AI302MXL
904	FREQMX	954	RTD3N_S	1004	RTD7XMN	1054	RTD10N_H	1104	AI302X_S
905	FREQX_S	955	RTD3NMN	1005	RTD7X_H	1055	RTD10N_D	1105	AI302XMN
906	FREQXMN	956	RTD3N_H	1006	RTD7X_D	1056	RTD10NMO	1106	AI302X_H
907	FREQX_H	957	RTD3N_D	1007	RTD7XMO	1057	RTD10N_Y	1107	AI302X_D
908	FREQX_D	958	RTD3NMO	1008	RTD7X_Y	1058	RTD11MX	1108	AI302XMO
909	FREQXMO	959	RTD3N_Y	1009	RTD7MN	1059	RTD11X_S	1109	AI302X_Y
910	FREQX_Y	960	RTD4MX	1010	RTD7N_S	1060	RTD11XMN	1110	AI302MNH
911	FREQMN	961	RTD4X_S	1011	RTD7NMN	1061	RTD11X_H	1111	AI302MNL
912	FREQN_S	962	RTD4XMN	1012	RTD7N_H	1062	RTD11X_D	1112	AI302N_S
913	FREQNMN	963	RTD4X_H	1013	RTD7N_D	1063	RTD11XMO	1113	AI302NMN
914	FREQN_H	964	RTD4X_D	1014	RTD7NMO	1064	RTD11X_Y	1114	AI302N_H
915	FREQN_D	965	RTD4XMO	1015	RTD7N_Y	1065	RTD11MN	1115	AI302N_D
916	FREQNMO	966	RTD4X_Y	1016	RTD8MX	1066	RTD11N_S	1116	AI302NMO
917	FREQN_Y	967	RTD4MN	1017	RTD8X_S	1067	RTD11NMN	1117	AI302N_Y
918	RTD1MX	968	RTD4N_S	1018	RTD8XMN	1068	RTD11N_H	1118	AI303MXH
919	RTD1X_S	969	RTD4NMN	1019	RTD8X_H	1069	RTD11N_D	1119	AI303MXL
920	RTD1XMN	970	RTD4N_H	1020	RTD8X_D	1070	RTD11NMO	1120	AI303X_S
921	RTD1X_H	971	RTD4N_D	1021	RTD8XMO	1071	RTD11N_Y	1121	AI303XMN
922	RTD1X_D	972	RTD4NMO	1022	RTD8X_Y	1072	RTD12MX	1122	AI303X_H
923	RTD1XMO	973	RTD4N_Y	1023	RTD8MN	1073	RTD12X_S	1123	AI303X_D
924	RTD1X_Y	974	RTD5MX	1024	RTD8N_S	1074	RTD12XMN	1124	AI303XMO

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 3 of 5)

Register Address	Label
1125	AI303X_Y
1126	AI303MNH
1127	AI303MNL
1128	AI303N_S
1129	AI303NMN
1130	AI303N_H
1131	AI303N_D
1132	AI303NMO
1133	AI303N_Y
1134	AI304MXH
1135	AI304MXL
1136	AI304X_S
1137	AI304XMN
1138	AI304X_H
1139	AI304X_D
1140	AI304XMO
1141	AI304X_Y
1142	AI304MNH
1143	AI304MNL
1144	AI304N_S
1145	AI304NMN
1146	AI304N_H
1147	AI304N_D
1148	AI304NMO
1149	AI304N_Y
1150	AI305MXH
1151	AI305MXL
1152	AI305X_S
1153	AI305XMN
1154	AI305X_H
1155	AI305X_D
1156	AI305XMO
1157	AI305X_Y
1158	AI305MNH
1159	AI305MNL
1160	AI305N_S
1161	AI305NMN
1162	AI305N_H
1163	AI305N_D
1164	AI305NMO
1165	AI305N_Y
1166	AI306MXH
1167	AI306MXL
1168	AI306X_S
1169	AI306XMN
1170	AI306X_H
1171	AI306X_D
1172	AI306XMO
1173	AI306X_Y
1174	AI306MNH
1175	AI306MNL
1176	AI306N_S
1177	AI306NMN
1178	AI306N_H
1179	AI306N_D
1180	AI306NMO
1181	AI306N_Y
1182	AI307MXH
1183	AI307MXL
1184	AI307X_S
1185	AI307XMN
1186	AI307X_H
1187	AI307X_D
1188	AI307XMO
1189	AI307X_Y
1190	AI307MNH
1191	AI307MNL
1192	AI307N_S
1193	AI307NMN
1194	AI307N_H
1195	AI307N_D
1196	AI307NMO
1197	AI307N_Y
1198	AI308MXH
1199	AI308MXL
1200	AI308X_S
1201	AI308XMN
1202	AI308X_H
1203	AI308X_D
1204	AI308XMO
1205	AI308X_Y
1206	AI308MNH
1207	AI308MNL
1208	AI308N_S
1209	AI308NMN
1210	AI308N_H
1211	AI308N_D
1212	AI308NMO
1213	AI308N_Y
1214	AI401MXH
1215	AI401MXL
1216	AI401X_S
1217	AI401XMN
1218	AI401X_H
1219	AI401X_D
1220	AI401XMO
1221	AI401X_Y
1222	AI401MNH
1223	AI401MNL
1224	AI401N_S
1225	AI401NMN
1226	AI401N_H
1227	AI401N_D
1228	AI401NMO
1229	AI401N_Y
1230	AI402MXH
1231	AI402MXL
1232	AI402X_S
1233	AI402XMN
1234	AI402X_H
1235	AI402X_D
1236	AI402XMO
1237	AI402X_Y
1238	AI402MNH
1239	AI402MNL
1240	AI402N_S
1241	AI402NMN
1242	AI402N_H
1243	AI402N_D
1244	AI402NMO
1245	AI402N_Y
1246	AI403MXH
1247	AI403MXL
1248	AI403X_S
1249	AI403XMN
1250	AI403X_H
1251	AI403X_D
1252	AI403XMO
1253	AI403X_Y
1254	AI403MNH
1255	AI403MNL
1256	AI403N_S
1257	AI403NMN
1258	AI403N_H
1259	AI403N_D
1260	AI403NMO
1261	AI403N_Y
1262	AI403MXH
1263	AI403MXL
1264	AI403X_S
1265	AI403XMN
1266	AI403X_H
1267	AI403X_D
1268	AI403XMO
1269	AI403X_Y
1270	AI404MNH
1271	AI404MNL
1272	AI404N_S
1273	AI404NMN
1274	AI404N_H
1275	AI404N_D
1276	AI404NMO
1277	AI404N_Y
1278	AI405MXH
1279	AI405MXL
1280	AI405X_S
1281	AI405XMN
1282	AI405X_H
1283	AI405X_D
1284	AI405XMO
1285	AI405X_Y
1286	AI405MNH
1287	AI405MNL
1288	AI405N_S
1289	AI405NMN
1290	AI405N_H
1291	AI405N_D
1292	AI405NMO
1293	AI405N_Y
1294	AI406MXH
1295	AI406MXL
1296	AI406X_S
1297	AI406XMN
1298	AI406X_H
1299	AI406X_D
1300	AI406XMO
1301	AI406X_Y
1302	AI406MNH
1303	AI406MNL
1304	AI406N_S
1305	AI406NMN
1306	AI406N_H
1307	AI406N_D
1308	AI406NMO
1309	AI406N_Y
1310	AI407MXH
1311	AI407MXL
1312	AI407X_S
1313	AI407XMN
1314	AI407X_H
1315	AI407X_D
1316	AI407XMO
1317	AI407X_Y
1318	AI407MNH
1319	AI407MNL
1320	AI407N_S
1321	AI407NMN
1322	AI407N_H
1323	AI407N_D
1324	AI407NMO
1325	AI407N_Y
1326	AI408MXH
1327	AI408MXL
1328	AI408X_S
1329	AI408XMN
1330	AI408X_H
1331	AI408X_D
1332	AI408XMO
1333	AI408X_Y
1334	AI408MNH
1335	AI408MNL
1336	AI408N_S
1337	AI408NMN
1338	AI408N_H
1339	AI408N_D
1340	AI408NMO
1341	AI408N_Y
1342	AI501MXH
1343	AI501MXL
1344	AI501X_S
1345	AI501XMN
1346	AI501X_H
1347	AI501X_D
1348	AI501XMO
1349	AI501X_Y
1350	AI501MNH
1351	AI501MNL
1352	AI501N_S
1353	AI501NMN
1354	AI501N_H
1355	AI501N_D
1356	AI501NMO
1357	AI501N_Y
1358	AI502MXH
1359	AI502MXL
1360	AI502X_S
1361	AI502XMN
1362	AI502X_H
1363	AI502X_D
1364	AI502XMO
1365	AI502X_Y
1366	AI502MNH
1367	AI502MNL
1368	AI502N_S
1369	AI502NMN
1370	AI502N_H
1371	AI502N_D
1372	AI502NMO
1373	AI502N_Y
1374	AI503MXH

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 4 of 5)

Register Address	Label
1375	AI503MXL
1376	AI503X_S
1377	AI503XMN
1378	AI503X_H
1379	AI503X_D
1380	AI503XMO
1381	AI503X_Y
1382	AI503MNH
1383	AI503MNL
1384	AI503N_S
1385	AI503NMN
1386	AI503N_H
1387	AI503N_D
1388	AI503NMO
1389	AI503N_Y
1390	AI504MXH
1391	AI504MXL
1392	AI504X_S
1393	AI504XMN
1394	AI504X_H
1395	AI504X_D
1396	AI504XMO
1397	AI504X_Y
1398	AI504MNH
1399	AI504MNL
1400	AI504N_S
1401	AI504NMN
1402	AI504N_H
1403	AI504N_D
1404	AI504NMO
1405	AI504N_Y
1406	AI505MXH
1407	AI505MXL
1408	AI505X_S
1409	AI505XMN
1410	AI505X_H
1411	AI505X_D
1412	AI505XMO
1413	AI505X_Y
1414	AI505MNH
1415	AI505MNL
1416	AI505N_S
1417	AI505NMN
1418	AI505N_H
1419	AI505N_D
1420	AI505NMO
1421	AI505N_Y
1422	AI506MXH
1423	AI506MXL
1424	AI506X_S
1425	AI506XMN
1426	AI506X_H
1427	AI506X_D
1428	AI506XMO
1429	AI506X_Y
1430	AI506MNH
1431	AI506MNL
1432	AI506N_S
1433	AI506NMN
1434	AI506N_H
1435	AI506N_D
1436	AI506NMO
1437	AI506N_Y
1438	AI507MXH
1439	AI507MXL
1440	AI507X_S
1441	AI507XMN
1442	AI507X_H
1443	AI507X_D
1444	AI507XMO
1445	AI507X_Y
1446	AI507MNH
1447	AI507MNL
1448	AI507N_S
1449	AI507NMN
1450	AI507N_H
1451	AI507N_D
1452	AI507NMO
1453	AI507N_Y
1454	AI508MXH
1455	AI508MXL
1456	AI508X_S
1457	AI508XMN
1458	AI508X_H
1459	AI508X_D
1460	AI508XMO
1461	AI508X_Y
1462	AI508MNH
1463	AI508MNL
1464	AI508N_S
1465	AI508NMN
1466	AI508N_H
1467	AI508N_D
1468	AI508NMO
1469	AI508N_Y
1470	MXMN_R_S
1471	MXMN_RMN
1472	MXMN_R_H
1473	MXMN_R_D
1474	MXMN_RMO
1475	MXMN_R_Y
1476–1480[a]	
1481	PA
1482	QA
1483	SA
1484	PFA
1485	PB
1486	QB
1487	SB
1488	PFB
1489	PC
1490	QC
1491	SC
1492	PFC
1493	AI301H
1494	AI301L
1495	AI302H
1496	AI302L
1497	AI303H
1498	AI303L
1499	AI304H
1500	AI304L
1501	AI305H
1502	AI305L
1503	AI306H
1504	AI306L
1505	AI307H
1506	AI307L
1507	AI308H
1508	AI308L
1509	AI401H
1510	AI401L
1511	AI402H
1512	AI402L
1513	AI403H
1514	AI403L
1515	AI404H
1516	AI404L
1517	AI405H
1518	AI405L
1519	AI406H
1520	AI406L
1521	AI407H
1522	AI407L
1523	AI408H
1524	AI408L
1525	AI501H
1526	AI501L
1527	AI502H
1528	AI502L
1529	AI503H
1530	AI503L
1531	AI504H
1532	AI504L
1533	AI505H
1534	AI505L
1535	AI506H
1536	AI506L
1537	AI507H
1538	AI507L
1539	AI508H
1540	AI508L
1541–1546[a]	
1547	MV01H
1548	MV01L
1549	MV02H
1550	MV02L
1551	MV03H
1552	MV03L
1553	MV04H
1554	MV04L
1555	MV05H
1556	MV05L
1557	MV06H
1558	MV06L
1559	MV07H
1560	MV07L
1561	MV08H
1562	MV08L
1563	MV09H
1564	MV09L
1565	MV10H
1566	MV10L
1567	MV11H
1568	MV11L
1569	MV12H
1570	MV12L
1571	MV13H
1572	MV13L
1573	MV14H
1574	MV14L
1575	MV15H
1576	MV15L
1577	MV16H
1578	MV16L
1579	MV17H
1580	MV17L
1581	MV18H
1582	MV18L
1583	MV19H
1584	MV19L
1585	MV20H
1586	MV20L
1587	MV21H
1588	MV21L
1589	MV22H
1590	MV22L
1591	MV23H
1592	MV23L
1593	MV24H
1594	MV24L
1595	MV25H
1596	MV25L
1597	MV26H
1598	MV26L
1599	MV27H
1600	MV27L
1601	MV28H
1602	MV28L
1603	MV29H
1604	MV29L
1605	MV30H
1606	MV30L
1607	MV31H
1608	MV31L
1609	MV32H
1610	MV32L
1611	SC01
1612	SC02
1613	SC03
1614	SC04
1615	SC05
1616	SC06
1617	SC07
1618	SC08
1619	SC09
1620	SC10
1621	SC11
1622	SC12
1623	SC13
1624	SC14
1625	SC15
1626	SC16
1627	SC17
1628	SC18
1629	SC19
1630	SC20
1631	SC21
1632	SC22
1633	SC23

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 5 of 5)

Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label
1634	SC24	1696	ICPD	1797	BADPKTF	1852	ROW_47	1902	ROW_97
1635	SC25	1697	IGPD	1798	BADPKTL	1853	ROW_48	1903	ROW_98
1636	SC26	1698	3I2PD	1799–1804[a]		1854	ROW_49	1904	ROW_99
1637	SC27	1699	PDEM_R_S	1805	ROW_0	1855	ROW_50	1905	ROW_100
1638	SC28	1700	PDEM_RMN	1806	ROW_1	1856	ROW_51	1906	ROW_101
1639	SC29	1701	PDEM_R_H	1807	ROW_2	1857	ROW_52	1907	ROW_102
1640	SC30	1702	PDEM_R_D	1808	ROW_3	1858	ROW_53	1908	ROW_103
1641	SC31	1703	PDEM_RMO	1809	ROW_4	1859	ROW_54	1909	ROW_104
1642	SC32	1704	PDEM_R_Y	1810	ROW_5	1860	ROW_55	1910	ROW_105
1643–1647[a]		1705–1745[a]		1811	ROW_6	1861	ROW_56	1911	ROW_106
1648	INTT	1746	NUMEVE	1812	ROW_7	1862	ROW_57	1912	ROW_107
1649	EXTT	1747	EVESEL	1813	ROW_8	1863	ROW_58	1913	ROW_108
1650	INTIA	1748	EVE_S	1814	ROW_9	1864	ROW_59	1914	ROW_109
1651	EXTIA	1749	EVEMN	1815	ROW_10	1865	ROW_60	1915	ROW_110
1652	INTIB	1750	EVE_H	1816	ROW_11	1866	ROW_61	1916	ROW_111
1653	EXTIB	1751	EVE_D	1817	ROW_12	1867	ROW_62	1917	ROW_112
1654	INTIC	1752	EVEMO	1818	ROW_13	1868	ROW_63	1918	ROW_113
1655	EXTIC	1753	EVE_Y	1819	ROW_14	1869	ROW_64	1919	ROW_114
1656	WEARA	1754	EVE_TYPE	1820	ROW_15	1870	ROW_65	1920	ROW_115
1657	WEARB	1755	EVE_TRGT	1821	ROW_16	1871	ROW_66	1921	ROW_116
1658	WEARC	1756	EVE_IA	1822	ROW_17	1872	ROW_67	1922	ROW_117
1659	BRKR_R_S	1757	EVE_IB	1823	ROW_18	1873	ROW_68	1923	ROW_118
1660	BRKR_RMN	1758	EVE_IC	1824	ROW_19	1874	ROW_69	1924	ROW_119
1661	BRKR_R_H	1759	EVE_IN	1825	ROW_20	1875	ROW_70	1925–1946[a]	
1662	BRKR_R_D	1760	EVE_IG	1826	ROW_21	1876	ROW_71	1947	NA
1663	BRKR_RMO	1761	EVE_VAB	1827	ROW_22	1877	ROW_72		
1664	BRKR_R_Y	1762	EVE_VBC	1828	ROW_23	1878	ROW_73		
1665–1666[a]		1763	EVE_VCA	1829	ROW_24	1879	ROW_74		
1667	VSMX	1764	EVE_VG	1830	ROW_25	1880	ROW_75		
1668	VSX_S	1765	EVE_DY	1831	ROW_26	1881	ROW_76		
1669	VSXMN	1766	EVE_FREQ	1832	ROW_27	1882	ROW_77		
1670	VSX_H	1767–1769[a]		1833	ROW_28	1883	ROW_78		
1671	VSX_D	1770	EVE_MAXW	1834	ROW_29	1884	ROW_79		
1672	VSXMO	1771	EVE_MAXB	1835	ROW_30	1885	ROW_80		
1673	VSX_Y	1772	EVE_MAXA	1836	ROW_31	1886	ROW_81		
1674	VSMN	1773	EVE_MAXO	1837	ROW_32	1887	ROW_82		
1675	VSN_S	1774–1779[a]		1838	ROW_33	1888	ROW_83		
1676	VSNMN	1780	TRIP_LO	1839	ROW_34	1889	ROW_84		
1677	VSN_H	1781	TRIP_HI	1840	ROW_35	1890	ROW_85		
1678	VSN_D	1782	WARN_LO	1841	ROW_36	1891	ROW_86		
1679	VSNMO	1783	WARN_HI	1842	ROW_37	1892	ROW_87		
1680	VSN_Y	1784–1788[a]		1843	ROW_38	1893	ROW_88		
1681–1688[a]		1789	NUMRCV	1844	ROW_39	1894	ROW_89		
1689	IAD	1790	NUMOTH	1845	ROW_40	1895	ROW_90		
1690	IBD	1791	INVADR	1846	ROW_41	1896	ROW_91		
1691	ICD	1792	BADCRC	1847	ROW_42	1897	ROW_92		
1692	IGD	1793	UARTERR	1848	ROW_43	1898	ROW_93		
1693	3I2D	1794	ILLFUNC	1849	ROW_44	1899	ROW_94		
1694	IAPD	1795	ILLREG	1850	ROW_45	1900	ROW_95		
1695	IBPD	1796	ILLWR	1851	ROW_46	1901	ROW_96		

[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, including TRIP TYPE information, write the event number of interest (1–50) to the EVENT LOG SEL register at address 1747. 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 is dynamically updated, as whenever there is a new event, the history data registers will be automatically updated 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. This will return to the free running 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 its 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 55)

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							
251–259 (R)	Reserved[c]		0	0	0		351–359
Access Control							
260 (R/W)	BLOCK MODBUS SET 0 = NONE 1 = R_S 2 = ALL		0	2	0		360
General Settings							
261 (R/W)	PHASE ROTATION 0 = ABC 1 = ACB		0	1	0		361

Table E.34 Modbus Register Map[a] (Sheet 2 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
262 (R/W)	RATED FREQ. 0 = 50 Hz 1 = 60 Hz	Hz	0	1	1	1	362
263 (R/W)	DATE FORMAT 0 = MDY 1 = YMD 2 = DMY		0	2	0	1	363
264 (R/W)	EVE MSG PTS EN 0 = N, 1–32		0	32	0	1	364
Group Selection							
265 (R/W)	GRP CHG DELAY	sec	0	400	3	1	365
Breaker Failure Settings							
266 (R/W)	52A INTERLOCK 0 = N 1 = Y		0	1	0		366
267 (R/W)	BK FAILURE DELAY	sec	0	200	50	00.01	367
268 (R)	Reserved[c]		0	0	0		368
DC Battery Monitor							
269 (R/W)	DC UNDER VOLT EN 0 = N 1 = Y		0	1	0		369
270 (R/W)	DC UNDER VOLT PU	V	2000	30000	2000	0.01	370
271 (R/W)	DC OVER VOLT EN 0 = N 1 = Y		0	1	0		371
272 (R/W)	DC OVER VOLT PU	V	2000	30000	30000	0.01	372
Configuration Settings							
273 (R/W)	PHASE CT RATIO		1	5000	120	1	373
274 (R/W)	NEUTRAL CT RATIO		1	5000	120	1	374
275 (R/W)	PHASE PT RATIO-I		1	10000	180	1	375
276 (R/W)	PHASE PT RATIO-F		0	99	0	0.01	376
277 (R/W)	SYNCV PT RATIO-I		1	10000	180	1	377
278 (R/W)	SYNCV PT RATIO-F		0	99	0	0.01	378
279 (R/W)	XFMR CONNECTION 0 = DELTA 1 = WYE		0	1	0		379
280 (R/W)	LINE VOLTAGE	V	2000	44000	12000	0.01	380
281 (R/W)	SINGLE V INPUT 0 = N 1 = Y		0	1	0		381
282 (R/W)	IG (residual current) SOURCE 0 = MEAS 1 = CALC		0	1	0		382
283 (R/W)	RESIDU CT RATIO		1	5000	120	1	383
Maximum Phase Overcurrent							
284 (R/W)	MAXP OC L1 EN 0 = N 1 = Y		0	1	1		384

Table E.34 Modbus Register Map[a] (Sheet 3 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
285 (R/W)	MAXP OC TRIP L1	A	10	10000	1000	0.01	385
286 (R/W)	MAXP OC L1 DLY	sec	0	500	0	0.01	386
287 (R/W)	MAXP OC L2 EN 0 = N 1 = Y		0	1	1		387
288 (R/W)	MAXP OC TRIP L2	A	10	10000	1000	0.01	388
289 (R/W)	MAXP OC L2 DLY	sec	0	500	0	0.01	389
290 (R/W)	MAXP OC L3 EN 0 = N 1 = Y		0	1	1		390
291 (R/W)	MAXP OC TRIP L3	A	10	10000	1000	0.01	391
292 (R/W)	MAXP OC L3 DLY	sec	0	500	0	0.01	392
293 (R/W)	MAXP OC L4 EN 0 = N 1 = Y		0	1	1		393
294 (R/W)	MAXP OC TRIP L4	A	10	10000	1000	0.01	394
295 (R/W)	MAXP OC L4 DLY	sec	0	500	0	0.01	395
Neutral Overcurrent							
296 (R/W)	NEUT OC L1 EN 0 = N 1 = Y		0	1	0		396
297 (R/W)	NEUT OC TRIP L1	A	10	10000	200	0.01	397
298 (R/W)	NEUT OC TRIP L1	mA	1	10000	100	0.1	398
299 (R/W)	NEUT OC L1 DLY	sec	0	500	50	0.01	399
300 (R/W)	NEUT OC L2 EN 0 = N 1 = Y		0	1	0		400
301 (R/W)	NEUT OC TRIP L2	A	10	10000	200	0.01	401
302 (R/W)	NEUT OC TRIP L2	mA	1	10000	100	0.1	402
303 (R/W)	NEUT OC L2 DLY	sec	0	500	50	0.01	403
304 (R/W)	NEUT OC L3 EN 0 = N 1 = Y		0	1	0		404
305 (R/W)	NEUT OC TRIP L3	A	10	10000	200	0.01	405
306 (R/W)	NEUT OC TRIP L3	mA	1	10000	100	0.1	406
307 (R/W)	NEUT OC L3 DLY	sec	0	500	50	0.01	407
308 (R/W)	NEUT OC L4 EN 0 = N 1 = Y		0	1	0		408
309 (R/W)	NEUT OC TRIP L4	A	10	10000	200	0.01	409
310 (R/W)	NEUT OC TRIP L4	mA	1	10000	100	0.1	410
311 (R/W)	NEUT OC L4 DLY	sec	0	500	50	0.01	411
Residual Overcurrent							
312 (R/W)	RES OC L1 EN 0 = N 1 = Y		0	1	0		412
313 (R/W)	RES OC TRIP L1	A	10	10000	200	0.01	413
314 (R/W)	RES OC L1 DLY	sec	0	500	50	0.01	414

Table E.34 Modbus Register Map[a] (Sheet 4 of 55)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
315	(R/W)	RES OC L2 EN 0 = N 1 = Y		0	1	0		415
316	(R/W)	RES OC TRIP L2	A	10	10000	200	0.01	416
317	(R/W)	RES OC L2 DLY	sec	0	500	50	0.01	417
318	(R/W)	RES OC L3 EN 0 = N 1 = Y		0	1	0		418
319	(R/W)	RES OC TRIP L3	A	10	10000	200	0.01	419
320	(R/W)	RES OC L3 DLY	sec	0	500	50	0.01	420
321	(R/W)	RES OC L4 EN 0 = N 1 = Y		0	1	0		421
322	(R/W)	RES OC TRIP L4	A	10	10000	200	0.01	422
323	(R/W)	RES OC L4 DLY	sec	0	500	50	0.01	423
Negative-Sequence Overcurrent								
324	(R/W)	NSEQ OC L1 EN 0 = N 1 = Y		0	1	0		424
325	(R/W)	NSEQ OC TRIP L1	A	10	10000	200	0.01	425
326	(R/W)	NSEQ OC L1 DLY	sec	1	1200	2	0.01	426
327	(R/W)	NSEQ OC L2 EN 0 = N 1 = Y		0	1	0		427
328	(R/W)	NSEQ OC TRIP L2	A	10	10000	200	0.01	428
329	(R/W)	NSEQ OC L2 DLY	sec	1	1200	2	0.01	429
330	(R/W)	NSEQ OC L3 EN 0 = N 1 = Y		0	1	0		430
331	(R/W)	NSEQ OC TRIP L3	A	10	10000	200	0.01	431
332	(R/W)	NSEQ OC L3 DLY	sec	1	1200	2	0.01	432
333	(R/W)	NSEQ OC L4 EN 0 = N 1 = Y		0	1	0		433
334	(R/W)	NSEQ OC TRIP L4	A	10	10000	200	0.01	434
335	(R/W)	NSEQ OC L4 DLY	sec	1	1200	2	0.01	435
Phase Time Overcurrent								
336	(R/W)	PHA TOC TRIP EN 0 = N 1 = Y		0	1	1		436
337	(R/W)	PHA TOC TRIP LVL	A	10	1600	120	0.01	437
338	(R/W)	PHA TOC CURVE 0 = U1 5 = C1 1 = U2 6 = C2 2 = U3 7 = C3 3 = U4 8 = C4 4 = U5 9 = C5		0	9	2		438
339	(R/W)	PHA TOC TIM DIAL		5	1500	300	0.01	439

Table E.34 Modbus Register Map[a] (Sheet 5 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
340 (R/W)	PHA EM RST DLAY 0 = N 1 = Y		0	1	0		440
341 (R/W)	PHA CONST TIME	sec	0	100	0	0.01	441
342 (R/W)	PHA MIN RESP TIM	sec	0	100	0	0.01	442
343 (R/W)	PHB TOC TRIP EN 0 = N 1 = Y		0	1	1		443
344 (R/W)	PHB TOC TRIP LVL	A	10	1600	120	0.01	444
345 (R/W)	PHB TOC CURVE 0 = U1 5 = C1 1 = U2 6 = C2 2 = U3 7 = C3 3 = U4 8 = C4 4 = U5 9 = C5		0	9	2		445
346 (R/W)	PHB TOC TIM DIAL		5	1500	300	0.01	446
347 (R/W)	PHB EM RST DLAY 0 = N 1 = Y		0	1	0		447
348 (R/W)	PHB CONST TIME	sec	0	100	0	0.01	448
349 (R/W)	PHB MIN RESP TIM	sec	0	100	0	0.01	449
350 (R/W)	PHC TOC TRIP EN 0 = N 1 = Y		0	1	1		450
351 (R/W)	PHC TOC TRIP LVL	A	10	1600	120	0.01	451
352 (R/W)	PHC TOC CURVE 0 = U1 5 = C1 1 = U2 6 = C2 2 = U3 7 = C3 3 = U4 8 = C4 4 = U5 9 = C5		0	9	2	1	452
353 (R/W)	PHC TOC TIM DIAL		5	1500	300	0.01	453
354 (R/W)	PHC EM RST DLAY 0 = N 1 = Y		0	1	0		454
355 (R/W)	PHC CONST TIME	sec	0	100	0	0.01	455
356 (R/W)	PHC MIN RESP TIM	sec	0	100	0	0.01	456
Maximum Phase Time Overcurrent							
357 (R/W)	TOC TRIP L1 EN 0 = N 1 = Y		0	1	1		457
358 (R/W)	TOC TRIP LVL1	A	10	1600	120	0.01	458
359 (R/W)	TOC CURVE SEL1 0 = U1 5 = C1 1 = U2 6 = C2 2 = U3 7 = C3 3 = U4 8 = C4 4 = U5 9 = C5		0	9	2	1	459
360 (R/W)	TOC TIME DIAL1		5	1500	300	0.01	460
361 (R/W)	EM RESET DELAY1 0 = N 1 = Y		0	1	0		461

Table E.34 Modbus Register Map[a] (Sheet 6 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
362 (R/W)	CONST TIME1	sec	0	100	0	0.01	462
363 (R/W)	MIN RESP TIME1	sec	0	100	0	0.01	463
364 (R/W)	TOC TRIP L2 EN 0 = N 1 = Y		0	1	1		464
365 (R/W)	TOC TRIP LVL2	A	10	1600	120	0.01	465
366 (R/W)	TOC CURVE SEL2 0 = U1 5 = C1 1 = U2 6 = C2 2 = U3 7 = C3 3 = U4 8 = C4 4 = U5 9 = C5		0	9	2	1	466
367 (R/W)	TOC TIME DIAL2		5	1500	300	0.01	467
368 (R/W)	EM RESET DELAY2 0 = N 1 = Y		0	1	0		468
369 (R/W)	CONST TIME2	sec	0	100	0	0.01	469
370 (R/W)	MIN RESP TIME2	sec	0	100	0	0.01	470
Negative-Sequence Time Overcurrent							
371 (R/W)	NSTOC TRIP EN 0 = N 1 = Y		0	1	1		471
372 (R/W)	NSTOC TRIP LVL	A	10	1600	120	0.01	472
373 (R/W)	NSTOC CURVE SEL 0 = U1 5 = C1 1 = U2 6 = C2 2 = U3 7 = C3 3 = U4 8 = C4 4 = U5 9 = C5		0	9	2	1	473
374 (R/W)	NSTOC TIME DIAL		5	1500	300	0.01	474
375 (R/W)	NSTOC EM RST DLY 0 = N 1 = Y		0	1	0		475
376 (R/W)	NSTOC CONST TIME	sec	0	100	0	0.01	476
377 (R/W)	NSTOC MIN RESP	sec	0	100	0	0.01	477
Neutral Time Overcurrent							
378 (R/W)	NEUT TOC L1 EN 0 = N 1 = Y		0	1	0		478
379 (R/W)	NEU TOC TRIP L1	A	10	1600	120	0.01	479
380 (R/W)	NEU TOC TRIP L1	mA	13	16000	100	0.01	480
381 (R/W)	NEUT TOC CURVE1 0 = U1 5 = C1 1 = U2 6 = C2 2 = U3 7 = C3 3 = U4 8 = C4 4 = U5 9 = C5		0	9	2	1	481
382 (R/W)	NEU TOC TIM DL1		5	1500	150	0.01	482
383 (R/W)	NEU EM RST DLAY1 0 = N 1 = Y		0	1	0		483
384 (R/W)	NEUT CONST TIME1	sec	0	100	0	0.01	484

Table E.34 Modbus Register Map[a] (Sheet 7 of 55)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
385	(R/W)	NEU MIN RESP T1	sec	0	100	0	0.01	485
386	(R/W)	NEUT TOC L2 EN 0 = N 1 = Y		0	1	0		486
387	(R/W)	NEU TOC TRIP L2	A	10	1600	120	0.01	487
388	(R/W)	NEU TOC TRIP L2	mA	13	16000	100	0.01	488
389	(R/W)	NEUT TOC CURVE2 0 = U1 5 = C1 1 = U2 6 = C2 2 = U3 7 = C3 3 = U4 8 = C4 4 = U5 9 = C5		0	9	2	1	489
390	(R/W)	NEU TOC TIM DL2		5	1500	150	0.01	490
391	(R/W)	NEU EM RST DLAY2 0 = N 1 = Y		0	1	0		491
392	(R/W)	NEUT CONST TIME2	sec	0	100	0	0.01	492
393	(R/W)	NEU MIN RESP T2	sec	0	100	0	0.01	493
Residual Time Overcurrent								
394	(R/W)	RES TOC L1 EN 0 = N 1 = Y		0	1	1		494
395	(R/W)	RES TOC TRIP L1	A	10	1600	10	0.01	495
396	(R/W)	RES TOC CURVE1 0 = U1 5 = C1 1 = U2 6 = C2 2 = U3 7 = C3 3 = U4 8 = C4 4 = U5 9 = C5		0	9	2	1	496
397	(R/W)	RES TOC TIM DL1		5	1500	150	0.01	497
398	(R/W)	RES EM RST DLAY1 0 = N 1 = Y		0	1	0		498
399	(R/W)	RES CONST TIME1	sec	0	100	0	0.01	499
400	(R/W)	RES MIN RESP T1	sec	0	100	0	0.01	500
401	(R/W)	RES TOC L2 EN 0 = N 1 = Y		0	1	1		501
402	(R/W)	RES TOC TRIP L2	A	10	1600	10	0.01	502
403	(R/W)	RES TOC CURVE2 0 = U1 5 = C1 1 = U2 6 = C2 2 = U3 7 = C3 3 = U4 8 = C4 4 = U5 9 = C5		0	9	2	1	503
404	(R/W)	RES TOC TIM DL2		5	1500	150	0.01	504
405	(R/W)	RES EM RST DLAY2 0 = N 1 = Y		0	1	0		505
406	(R/W)	RES CONST TIME2	sec	0	100	0	0.01	506
407	(R/W)	RES MIN RESP T2	sec	0	100	0	0.01	507
408–410	(R)	Reserved[c]		0	0	0		508–510

Table E.34 Modbus Register Map[a] (Sheet 8 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
RTD Settings							
411 (R/W)	RTD ENABLE 0 = NONE 1 = INT 2 = EXT		0	2	0		511
412 (R/W)	RTD1 LOCATION 0 = OFF 1 = WDG 2 = BRG 3 = AMB 4 = OTH		0	4	0		512
413 (R/W)	RTD1 TYPE 0 = PT100 1 = NI100 2 = NI120 3 = CU10		0	3	0		513
414 (R/W)	RTD1 TRIP LEVEL 0 = Off	°C	0	250	0	1	514
415 (R/W)	RTD1 WARN LEVEL 0 = Off	°C	0	250	0	1	515
416 (R/W)	RTD2 LOCATION 0 = OFF 1 = WDG 2 = BRG 3 = AMB 4 = OTH		0	4	0	1	516
417 (R/W)	RTD2 TYPE 0 = PT100 1 = NI100 2 = NI120 3 = CU10		0	3	0	1	517
418 (R/W)	RTD2 TRIP LEVEL 0 = Off	°C	0	250	0	1	518
419 (R/W)	RTD2 WARN LEVEL 0 = Off	°C	0	250	0	1	519
420 (R/W)	RTD3 LOCATION 0 = OFF 1 = WDG 2 = BRG 3 = AMB 4 = OTH		0	4	0	1	520
421 (R/W)	RTD3 TYPE 0 = PT100 1 = NI100 2 = NI120 3 = CU10		0	3	0	1	521
422 (R/W)	RTD3 TRIP LEVEL 0 = Off	°C	0	250	0	1	522
423 (R/W)	RTD3 WARN LEVEL 0 = Off	°C	0	250	0	1	523
424 (R/W)	RTD4 LOCATION 0 = OFF 1 = WDG 2 = BRG 3 = AMB 4 = OTH		0	4	0	1	524

Table E.34 Modbus Register Map[a] (Sheet 9 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
425 (R/W)	RTD4 TYPE 0 = PT100 1 = NI100 2 = NI120 3 = CU10		0	3	0	1	525
426 (R/W)	RTD4 TRIP LEVEL 0 = Off	°C	0	250	0	1	526
427 (R/W)	RTD4 WARN LEVEL 0 = Off	°C	0	250	0	1	527
428 (R/W)	RTD5 LOCATION 0 = OFF 1 = WDG 2 = BRG 3 = AMB 4 = OTH		0	4	0	1	528
429 (R/W)	RTD5 TYPE 0 = PT100 1 = NI100 2 = NI120 3 = CU10		0	3	0	1	529
430 (R/W)	RTD5 TRIP LEVEL 0 = Off	°C	0	250	0	1	530
431 (R/W)	RTD5 WARN LEVEL 0 = Off	°C	0	250	0	1	531
432 (R/W)	RTD6 LOCATION 0 = OFF 1 = WDG 2 = BRG 3 = AMB 4 = OTH		0	4	0	1	532
433 (R/W)	RTD6 TYPE 0 = PT100 1 = NI100 2 = NI120 3 = CU10		0	3	0	1	533
434 (R/W)	RTD6 TRIP LEVEL 0 = Off	°C	0	250	0	1	534
435 (R/W)	RTD6 WARN LEVEL 0 = Off	°C	0	250	0	1	535
436 (R/W)	RTD7 LOCATION 0 = OFF 1 = WDG 2 = BRG 3 = AMB 4 = OTH		0	4	0	1	536
437 (R/W)	RTD7 TYPE 0 = PT100 1 = NI100 2 = NI120 3 = CU10		0	3	0	1	537
438 (R/W)	RTD7 TRIP LEVEL 0 = Off	°C	0	250	0	1	538
439 (R/W)	RTD7 WARN LEVEL 0 = Off	°C	0	250	0	1	539

Table E.34 Modbus Register Map[a] (Sheet 10 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
440 (R/W)	RTD8 LOCATION 0 = OFF 1 = WDG 2 = BRG 3 = AMB 4 = OTH		0	4	0	1	540
441 (R/W)	RTD8 TYPE 0 = PT100 1 = NI100 2 = NI120 3 = CU10		0	3	0	1	541
442 (R/W)	RTD8 TRIP LEVEL 0 = Off	°C	0	250	0	1	542
443 (R/W)	RTD8 WARN LEVEL 0 = Off	°C	0	250	0	1	543
444 (R/W)	RTD9 LOCATION 0 = OFF 1 = WDG 2 = BRG 3 = AMB 4 = OTH		0	4	0	1	544
445 (R/W)	RTD9 TYPE 0 = PT100 1 = NI100 2 = NI120 3 = CU10		0	3	0	1	545
446 (R/W)	RTD9 TRIP LEVEL 0 = Off	°C	0	250	0	1	546
447 (R/W)	RTD9 WARN LEVEL 0 = Off	°C	0	250	0	1	547
448 (R/W)	RTD10 LOCATION 0 = OFF 1 = WDG 2 = BRG 3 = AMB 4 = OTH		0	4	0	1	548
449 (R/W)	RTD10 TYPE 0 = PT100 1 = NI100 2 = NI120 3 = CU10		0	3	0	1	549
450 (R/W)	RTD10 TRIP LEVEL 0 = Off	°C	0	250	0	1	550
451 (R/W)	RTD10 WARN LEVEL 0 = Off	°C	0	250	0	1	551
452 (R/W)	RTD11 LOCATION 0 = OFF 1 = WDG 2 = BRG 3 = AMB 4 = OTH		0	4	0	1	552
453 (R/W)	RTD11 TYPE 0 = PT100 1 = NI100 2 = NI120 3 = CU10		0	3	0	1	553

Table E.34 Modbus Register Map[a] (Sheet 11 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
454 (R/W)	RTD11 TRIP LEVEL 0 = Off	°C	0	250	0	1	554
455 (R/W)	RTD11 WARN LEVEL 0 = Off	°C	0	250	0	1	555
456 (R/W)	RTD12 LOCATION 0 = OFF 1 = WDG 2 = BRG 3 = AMB 4 = OTH		0	4	0	1	556
457 (R/W)	RTD12 TYPE 0 = PT100 1 = NI100 2 = NI120 3 = CU10		0	3	0	1	557
458 (R/W)	RTD12 TRIP LEVEL 0 = Off	°C	0	250	0	1	558
459 (R/W)	RTD12 WARN LEVEL 0 = Off	°C	0	250	0	1	559
460 (R/W)	WIND TRIP VOTING 0 = N 1 = Y		0	1	0	1	560
461 (R/W)	BEAR TRIP VOTING 0 = N 1 = Y		0	1	0	1	561
Undervoltage Settings							
462 (R/W)	UV TRIP1 ENABLE 0 = N 1 = Y		0	1	0		562
463 (R/W)	UV TRIP1 LEVEL	xVnm	2	100	80	0.01	563
464 (R/W)	UV TRIP1 DELAY	sec	0	1200	5	0.1	564
465 (R/W)	UV TRIP2 ENABLE 0 = N 1 = Y		0	1	0		565
466 (R/W)	UV TRIP2 LEVEL	xVnm	2	100	80	0.01	566
467 (R/W)	UV TRIP2 DELAY	sec	0	1200	50	0.1	567
468 (R/W)	UVS LVL1 ENABLE 0 = N 1 = Y		0	1	0		568
469 (R/W)	UVS LEVEL1	V	200	30000	200	0.01	569
470 (R/W)	UVS DELAY1	sec	0	1200	5	0.1	570
471 (R/W)	UVS LVL2 ENABLE 0 = N 1 = Y		0	1	0		571
472 (R/W)	UVS LEVEL2	V	200	30000	200	0.01	572
473 (R/W)	UVS DELAY2	sec	0	1200	5	0.1	573
Overvoltage Settings							
474 (R/W)	OV TRIP1 ENABLE 0 = N 1 = Y		0	1	1		574
475 (R/W)	OV TRIP1 LEVEL	xVnm	2	120	110	0.01	575
476 (R/W)	OV TRIP1 DELAY	sec	0	1200	5	0.1	576

Table E.34 Modbus Register Map[a] (Sheet 12 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
477 (R/W)	OV TRIP2 ENABLE 0 = N 1 = Y		0	1	0		577
478 (R/W)	OV TRIP2 LEVEL	xVnm	2	120	110	0.01	578
479 (R/W)	OV TRIP2 DELAY	sec	0	1200	50	0.1	579
480 (R/W)	OVS LVL1 ENABLE 0 = N 1 = Y		0	1	0		580
481 (R/W)	OVS LEVEL1	V	200	30000	30000	0.01	581
482 (R/W)	OVS DELAY1	sec	0	1200	5	0.1	582
483 (R/W)	OVS LVL2 ENABLE 0 = N 1 = Y		0	1	0		583
484 (R/W)	OVS LEVEL2	V	200	30000	30000	0.01	584
485 (R/W)	OVS DELAY2	sec	0	1200	5	0.1	585
Reclosing Control							
486 (R/W)	ENABLE RECLOSER		0	4	0	1	586
487 (R/W)	OPEN INTERVAL1-I	sec	0	3000	5	1	587
488 (R/W)	OPEN INTERVAL1-F	sec	0	99	0	0.01	588
489 (R/W)	OPEN INTERVAL2-I	sec	0	3000	0	1	589
490 (R/W)	OPEN INTERVAL2-F	sec	0	99	0	0.01	590
491 (R/W)	OPEN INTERVAL3-I	sec	0	3000	0	1	591
492 (R/W)	OPEN INTERVAL3-F	sec	0	99	0	0.01	592
493 (R/W)	OPEN INTERVAL4-I	sec	0	3000	0	1	593
494 (R/W)	OPEN INTERVAL4-F	sec	0	99	0	0.01	594
495 (R/W)	RST FROM RECL-I	sec	0	3000	15	1	595
496 (R/W)	RST FROM RECL-F	sec	0	99	0	0.01	596
497 (R/W)	RST FROM LO-I	sec	0	3000	5	1	597
498 (R/W)	RST FROM LO-F	sec	0	99	0	0.01	598
499 (R/W)	RECLS SUPV EN 0=N 1=Y		0	1	1		599
500 (R/W)	RECL SUPV TIME-I	sec	0	3000	0	1	600
501 (R/W)	RECL SUPV TIME-F	sec	0	99	0	0.01	601
Power Factor Settings							
502 (R/W)	PF LAG TRIP ENABL 0 = N 1 = Y		0	1	0		602
503 (R/W)	PF LAG TRIP LEVL		5	99	50	0.01	603
504 (R/W)	PF LD TRIP ENABL 0 = N 1 = Y		0	1	0		604
505 (R/W)	PF LD TRIP LEVEL		5	99	50	0.01	605
506 (R/W)	PF TRIP DELAY	sec	1	240	1	1	606
507 (R/W)	PF LAG WARN ENABL 0 = N 1 = Y		0	1	0		607

Table E.34 Modbus Register Map[a] (Sheet 13 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
508 (R/W)	PF LAG WARN LEVL		5	99	50	0.01	608
509 (R/W)	PF LD WARN ENABL 0 = N 1 = Y		0	1	0		609
510 (R/W)	PF LD WARN LEVEL		5	99	50	0.01	610
511 (R/W)	PF WARN DELAY	sec	1	240	1	1	611
512 (R/W)	PF ARMING DELAY	sec	0	5000	0	1	612
Frequency Settings							
513 (R/W)	FREQ1 TRIP ENABL 0 = N 1 = Y		0	1	0		613
514 (R/W)	FREQ1 TRIP LEVEL	Hz	2000	7000	6000	0.01	614
515 (R/W)	FREQ1 TRIP DELAY	sec	0	2400	10	0.1	615
516 (R/W)	FREQ2 TRIP ENABL 0 = N 1 = Y		0	1	0		616
517 (R/W)	FREQ2 TRIP LEVEL	Hz	2000	7000	6000	0.01	617
518 (R/W)	FREQ2 TRIP DELAY	sec	0	2400	10	0.1	618
519 (R/W)	FREQ3 TRIP ENABL 0 = N 1 = Y		0	1	0		619
520 (R/W)	FREQ3 TRIP LEVEL	Hz	2000	7000	6000	0.01	620
521 (R/W)	FREQ3 TRIP DELAY	sec	0	2400	10	0.1	621
522 (R/W)	FREQ4 TRIP ENABL 0 = N 1 = Y		0	1	0		622
523 (R/W)	FREQ4 TRIP LEVEL	Hz	2000	7000	6000	0.01	623
524 (R/W)	FREQ4 TRIP DELAY	sec	0	2400	10	0.1	624
Synch Check Set							
525 (R/W)	SYNCH CHECK 0 = N 1 = Y		0	1	0		625
526 (R/W)	VS WINDOW LOW	V	0	30000	10500	0.01	626
527 (R/W)	VS WINDOW HIGH	V	0	30000	13000	0.01	627
528 (R/W)	MAX SLIP FREQ	Hz	50	500	200	0.001	628
529 (R/W)	MAX ANGLE 1	deg	0	80	25		629
530 (R/W)	MAX ANGLE 2	deg	0	80	40		630

Table E.34 Modbus Register Map[a] (Sheet 14 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
531 (R/W)	SYNCH PHASE 0 = VA (or VAB) 1 = VB (or VBC) 2 = VC (or VCA) 3 = 0 4 = 30 5 = 60 6 = 90 7 = 120 8 = 150 9 = 180 10 = 210 11 = 240 12 = 270 13 = 300 14 = 330	deg	0	14	0		631
532 (R/W)	BRKR CLOSE TIME	ms	0	1000	50		632
Trip/Close Logic							
533 (R/W)	MIN TRIP TIME	sec	0	4000	5	0.1	633
534 (R/W)	CLS FAIL DLY EN 0 = N 1 = Y		0	1	1		634
535 (R/W)	CLOSE FAIL DELAY	sec	0	4000	10	0.1	635
536–541 (R)	Reserved[c]		0	0	0		636–641
SELogic Enables							
542 (R/W)	SELOGIC LATCHES		0	32	4	1	642
543 (R/W)	SV/TIMERS		0	32	5	1	643
544 (R/W)	SELOGIC COUNTERS		0	32	0	1	644
545 (R/W)	MATH VARIABLES		0	32	0	1	645
546–550 (R)	Reserved[c]		0	0	0		646–650
Output Contacts 0 = N 1 = Y							
551 (R/W)	OUT101 FAIL-SAFE		0	1	1		651
552 (R/W)	OUT102 FAIL-SAFE		0	1	0		652
553 (R/W)	OUT103 FAIL-SAFE		0	1	0		653
554 (R/W)	OUT301 FAIL-SAFE		0	1	0		654
555 (R/W)	OUT302 FAIL-SAFE		0	1	0		655
556 (R/W)	OUT303 FAIL-SAFE		0	1	0		656
557 (R/W)	OUT304 FAIL-SAFE		0	1	0		657
558 (R/W)	OUT401 FAIL-SAFE		0	1	0		658
559 (R/W)	OUT402 FAIL-SAFE		0	1	0		659
560 (R/W)	OUT403 FAIL-SAFE		0	1	0		660
561 (R/W)	OUT404 FAIL-SAFE		0	1	0		661
562 (R/W)	OUT501 FAIL-SAFE		0	1	0		662
563 (R/W)	OUT502 FAIL-SAFE		0	1	0		663
564 (R/W)	OUT503 FAIL-SAFE		0	1	0		664
565 (R/W)	OUT504 FAIL-SAFE		0	1	0		665
566–570 (R)	Reserved[c]		0	0	0		666–670

Table E.34 Modbus Register Map[a] (Sheet 15 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
Event Report Settings							
571 (R/W)	EVENT LENGTH 0 = 15 1 = 64	cyc	0	1	0		671
572 (R/W)	PREFAULT LENGTH	cyc	1	59	5	1	672
573 (R)	Reserved[c]		0	0	0		673
574 (R/W)	ENABLE ALIASES		0	20	4		674
575 (R/W)	LDP ACQ RATE 0 = 5 1 = 10 2 = 15 3 = 30 4 = 60	min	0	4	2	1	675
576 (R/W)	AUTO-REMOVAL EN 0 = N 1 = Y		0	1	0		676
577 (R/W)	NUM OF COUNTS		2	20	5	1	677
578 (R/W)	REMOVAL TIME	sec	1	900	10	0.1	678
579–580 (R)	Reserved[c]		0	0	0		679–680
Front-Panel Settings							
581 (R/W)	DISPLAY PTS ENABL		0	32	4	1	681
582 (R/W)	LOCAL BITS ENABL		0	32	0	1	682
583 (R/W)	LCD TIMEOUT 0 = Off	min	0	30	15	1	683
584 (R/W)	LCD CONTRAST		1	8	5	1	684
585 (R/W)	CLOSE RESET LEDS 0 = N 1 = Y		0	1	1		685
586 (R/W)	FP AUTOMESSAGES 0 = OVERRIDE 1 = ROTATING		0	1	0		686
587–590 (R)	Reserved[c]		0	0	0		687–690
Reset Settings							
591 (R/W)	RESET DATA Bit 0 = Trip Reset Bit 1 = Set to Defaults 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 10–15 = Reserved		0	1023	0	1	691
592–601 (R)	Reserved[c]		0	0	0		692–701

Table E.34 Modbus Register Map[a] (Sheet 16 of 55)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
Date/Time Settings								
602	(R/W)	SET SEC		0	5999	0	0.01	702
603	(R/W)	SET MIN		0	59	0	1	703
604	(R/W)	SET HOUR		0	23	0	1	704
605	(R/W)	SET DAY		1	31	1	1	705
606	(R/W)	SET MONTH		1	12	1	1	706
607	(R/W)	SET YEAR		2000	9999	2000	1	707
608	(R)	Reserved[c]		0	0	0		708
609	(R)	Reserved[c]		0	0	0		709
Device Status		0 = OK 1 = WARN 2 = FAIL						
610	(R)	FPGA STATUS		0	2	0		710
611	(R)	GPSB STATUS		0	2	0		711
612	(R)	HMI STATUS		0	2	0		712
613	(R)	RAM STATUS		0	2	0		713
614	(R)	ROM STATUS		0	2	0		714
615	(R)	CR_RAM STATUS		0	2	0		715
616	(R)	NON_VOL STATUS		0	2	0		716
617	(R)	CLOCK STATUS		0	2	0		717
618	(R)	CID FILE STATUS		0	2	0		718
619	(R)	RTD STATUS		0	2	0		719
620	(R)	+3.3V STATUS		0	2	0		720
621	(R)	+5.0V STATUS		0	2	0		721
622	(R)	+2.5V STATUS		0	2	0		722
623	(R)	+3.75V STATUS		0	2	0		723
624	(R)	–1.25V STATUS		0	2	0		724
625	(R)	–5.0V STATUS		0	2	0		725
626	(R)	CLK_BAT STATUS		0	2	0		726
627	(R)	CT BOARD STATUS		0	2	0		727
628	(R)	CARD C STATUS		0	2	0		728
629	(R)	CARD D STATUS		0	2	0		729
630	(R)	CARD E STATUS		0	2	0		730
631	(R)	IA STATUS		0	2	0		731
632	(R)	IB STATUS		0	2	0		732
633	(R)	IC STATUS		0	2	0		733
634	(R)	IN STATUS		0	2	0		734
635	(R)	VA STATUS		0	2	0		735
636	(R)	VB STATUS		0	2	0		736
637	(R)	VC STATUS		0	2	0		737
638	(R)	RELAY STATUS 0 = ENABLED 1 = DISABLED		0	1	0		738
639	(R)	VS STATUS		0	2	0		739
640	(R)	SERIAL NUMBER H		0	65535	0		740

Table E.34 Modbus Register Map[a] (Sheet 17 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
641 (R)	SERIAL NUMBER L		0	65535	0		741
642 (R)	IG STATUS 0 = OK 1 = WARN 2 = FAIL		0	2	0		742
643–649 (R)	Reserved[c]		0	0	0		743–749
Current Data							
650 (R)	IA CURRENT	A	0	65535	0	1	750
651 (R)	IA ANGLE	deg	–1800	1800	0	0.1	751
652 (R)	IB CURRENT	A	0	65535	0	1	752
653 (R)	IB ANGLE	deg	–1800	1800	0	0.1	753
654 (R)	IC CURRENT	A	0	65535	0	1	754
655 (R)	IC ANGLE	deg	–1800	1800	0	0.1	755
656 (R)	IN CURRENT	A	0	65535	0	1	756
657 (R)	IN ANGLE	deg	–1800	1800	0	0.1	757
658 (R)	IG CURRENT	A	0	65535	0	1	758
659 (R)	IG ANGLE	deg	–1800	1800	0	0.1	759
660 (R)	AVERAGE CURRENT	A	0	65535	0	1	760
661 (R)	Reserved[c]		0	0	0		761
662 (R)	NEG-SEQ CURR 3I2	A	0	65535	0	1	762
663 (R)	CURRENT IMBAL	%	0	1000	0	0.1	763
Extra Voltage Date							
664 (R)	VSN	V	0	65535	0	1	764
665 (R)	VSN ANGLE	deg	–1800	1800	0	0.1	765
666 (R)	VDC	V	0	65535	0	0.1	766
Voltage Data							
667 (R)	VAB	V	0	65535	0	1	767
668 (R)	VAB ANGLE	deg	–1800	1800	0	0.1	768
669 (R)	VBC	V	0	65535	0	1	769
670 (R)	VBC ANGLE	deg	–1800	1800	0	0.1	770
671 (R)	VCA	V	0	65535	0	1	771
672 (R)	VCA ANGLE	deg	–1800	1800	0	0.1	772
673 (R)	AVERAGE LINE[d]	V	0	65535	0	1	773
674 (R)	VAN	V	0	65535	0	1	774
675 (R)	VAN ANGLE	deg	–1800	1800	0	0.1	775
676 (R)	VBN	V	0	65535	0	1	776
677 (R)	VBN ANGLE	deg	–1800	1800	0	0.1	777
678 (R)	VCN	V	0	65535	0	1	778
679 (R)	VCN ANGLE	deg	–1800	1800	0	0.1	779
680 (R)	VG	V	0	65535	0	1	780
681 (R)	VG ANGLE	deg	–1800	1800	0	0.1	781
682 (R)	AVERAGE PHASE[e]	V	0	65535	0	1	782
683 (R)	NEG-SEQ VOLT 3V2	V	0	65535	0	1	783
684 (R)	VOLTAGE IMBAL	%	0	1000	0	0.1	784

Table E.34 Modbus Register Map[a] (Sheet 18 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
Power Data							
685 (R)	REAL POWER	kW	–32768	32767	0	1	785
686 (R)	REACTIVE POWER	kVAR	–32768	32767	0	1	786
687 (R)	APPARENT POWER	kVA	–32768	32767	0	1	787
688 (R)	POWER FACTOR		–100	100	0	0.01	788
689 (R)	FREQUENCY	Hz	2000	7000	6000	0.01	789
Energy Data							
690 (R)	MWH3PO HI	MWhr	0	65535	0	0.001	790
691 (R)	MWH3PO LO	MWhr	0	65535	0	0.001	791
692 (R)	MVARH3PI HI	MVARh	0	65535	0	0.001	792
693 (R)	MVARH3PI LO	MVARh	0	65535	0	0.001	793
694 (R)	MVARH3PO HI	MVARh	0	65535	0	0.001	794
695 (R)	MVARH3PO LO	MVARh	0	65535	0	0.001	795
696 (R)	MVAH3P HI	MVAh	0	65535	0	0.001	796
697 (R)	MVAH3P LO	MVAh	0	65535	0	0.001	797
698 (R)	LAST RST TIME ss		0	5999	0	0.01	798
699 (R)	LAST RST TIME mm		0	59	0	1	799
700 (R)	LAST RST TIME hh		0	23	0	1	800
701 (R)	LAST RST DATE dd		1	31	1	1	801
702 (R)	LAST RST DATE mm		1	12	1	1	802
703 (R)	LAST RST DATE yy		2000	9999	2000	1	803
704 (R)	MWH3PI HI	MWhr	0	65535	0	0.001	804
705 (R)	MWH3PI LO	MWhr	0	65535	0	0.001	805
706 (R)	SYNC FREQUENCY	Hz	2000	7000	6000	0.01	806
707–711 (R)	Reserved[c]		0	0	0		807–811
RTD Data							
712 (R)	MAX WINDING RTD 7FFFh = Open 8000h = Short 7FFCh = Comm Fail 7FF8h = Stat Fail 7FFEh = Fail 7FF0h = NA	°C	–32768	32767	0	1	812
713 (R)	MAX BEARING RTD	°C	–32768	32767	0	1	813
714 (R)	MAX AMBIENT RTD	°C	–32768	32767	0	1	814
715 (R)	MAX OTHER RTD	°C	–32768	32767	0	1	815
716–727 (R)	RTD 1 through RTD 12	°C	–32768	32767	0	1	816–827
728 (R)	Reserved[c]		0	0	0		828
Light Meter Data							
729 (R)	LS 1	%	0	1000	0	0.1	829
730 (R)	LS 2	%	0	1000	0	0.1	830
731 (R)	LS 3	%	0	1000	0	0.1	831
732 (R)	LS 4	%	0	1000	0	0.1	832
733–738 (R)	Reserved[c]		0	0	0		833–838

Table E.34 Modbus Register Map[a] (Sheet 19 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
RMS Data							
739 (R)	VS RMS	V	0	65535	0	1	839
740 (R)	IA RMS	A	0	65535	0	1	840
741 (R)	IB RMS	A	0	65535	0	1	841
742 (R)	IC RMS	A	0	65535	0	1	842
743 (R)	IN RMS	A	0	65535	0	1	843
744 (R)	VA RMS	V	0	65535	0	1	844
745 (R)	VB RMS	V	0	65535	0	1	845
746 (R)	VC RMS	V	0	65535	0	1	846
747 (R)	VAB RMS	V	0	65535	0	1	847
748 (R)	VBC RMS	V	0	65535	0	1	848
749 (R)	VCA RMS	V	0	65535	0	1	849
MAX/MIN Meter Data							
750 (R)	IA MAX	A	0	65535	0	1	850
751 (R)	IA MAX TIME ss		0	5999	0	0.01	851
752 (R)	IA MAX TIME mm		0	59	0	1	852
753 (R)	IA MAX TIME hh		0	23	0	1	853
754 (R)	IA MAX DAY dd		1	31	1	1	854
755 (R)	IA MAX DAY mm		1	12	1	1	855
756 (R)	IA MAX DAY yy		2000	9999	2000	1	856
757 (R)	IA MIN	A	0	65535	0	1	857
758 (R)	IA MIN TIME ss		0	5999	0	0.01	858
759 (R)	IA MIN TIME mm		0	59	0	1	859
760 (R)	IA MIN TIME hh		0	23	0	1	860
761 (R)	IA MIN DAY dd		1	31	1	1	861
762 (R)	IA MIN DAY mm		1	12	1	1	862
763 (R)	IA MIN DAY yy		2000	9999	2000	1	863
764 (R)	IB MAX	A	0	65535	0	1	864
765 (R)	IB MAX TIME ss		0	5999	0	0.01	865
766 (R)	IB MAX TIME mm		0	59	0	1	866
767 (R)	IB MAX TIME hh		0	23	0	1	867
768 (R)	IB MAX DAY dd		1	31	1	1	868
769 (R)	IB MAX DAY mm		1	12	1	1	869
770 (R)	IB MAX DAY yy		2000	9999	2000	1	870
771 (R)	IB MIN	A	0	65535	0	1	871
772 (R)	IB MIN TIME ss		0	5999	0	0.01	872
773 (R)	IB MIN TIME mm		0	59	0	1	873
774 (R)	IB MIN TIME hh		0	23	0	1	874
775 (R)	IB MIN DAY dd		1	31	1	1	875
776 (R)	IB MIN DAY mm		1	12	1	1	876
777 (R)	IB MIN DAY yy		2000	9999	2000	1	877
778 (R)	IC MAX	A	0	65535	0	1	878

Table E.34 Modbus Register Map[a] (Sheet 20 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
779 (R)	IC MAX TIME ss		0	5999	0	0.01	879
780 (R)	IC MAX TIME mm		0	59	0	1	880
781 (R)	IC MAX TIME hh		0	23	0	1	881
782 (R)	IC MAX DAY dd		1	31	1	1	882
783 (R)	IC MAX DAY mm		1	12	1	1	883
784 (R)	IC MAX DAY yy		2000	9999	2000	1	884
785 (R)	IC MIN	A	0	65535	0	1	885
786 (R)	IC MIN TIME ss		0	5999	0	0.01	886
787 (R)	IC MIN TIME mm		0	59	0	1	887
788 (R)	IC MIN TIME hh		0	23	0	1	888
789 (R)	IC MIN DAY dd		1	31	1	1	889
790 (R)	IC MIN DAY mm		1	12	1	1	890
791 (R)	IC MIN DAY yy		2000	9999	2000	1	891
792 (R)	IN MAX	A	0	65535	0	1	892
793 (R)	IN MAX TIME ss		0	5999	0	0.01	893
794 (R)	IN MAX TIME mm		0	59	0	1	894
795 (R)	IN MAX TIME hh		0	23	0	1	895
796 (R)	IN MAX DAY dd		1	31	1	1	896
797 (R)	IN MAX DAY mm		1	12	1	1	897
798 (R)	IN MAX DAY yy		2000	9999	2000	1	898
799 (R)	IN MIN	A	0	65535	0	1	899
800 (R)	IN MIN TIME ss		0	5999	0	0.01	900
801 (R)	IN MIN TIME mm		0	59	0	1	901
802 (R)	IN MIN TIME hh		0	23	0	1	902
803 (R)	IN MIN DAY dd		1	31	1	1	903
804 (R)	IN MIN DAY mm		1	12	1	1	904
805 (R)	IN MIN DAY yy		2000	9999	2000	1	905
806 (R)	IG MAX	A	0	65535	0	1	906
807 (R)	IG MAX TIME ss		0	5999	0	0.01	907
808 (R)	IG MAX TIME mm		0	59	0	1	908
809 (R)	IG MAX TIME hh		0	23	0	1	909
810 (R)	IG MAX DAY dd		1	31	1	1	910
811 (R)	IG MAX DAY mm		1	12	1	1	911
812 (R)	IG MAX DAY yy		2000	9999	2000	1	912
813 (R)	IG MIN	A	0	65535	0	1	913
814 (R)	IG MIN TIME ss		0	5999	0	0.01	914
815 (R)	IG MIN TIME mm		0	59	0	1	915
816 (R)	IG MIN TIME hh		0	23	0	1	916
817 (R)	IG MIN DAY dd		1	31	1	1	917
818 (R)	IG MIN DAY mm		1	12	1	1	918
819 (R)	IG MIN DAY yy		2000	9999	2000	1	919
820 (R)	VAB/VA MAX	V	0	65535	0	1	920

Table E.34 Modbus Register Map[a] (Sheet 21 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
821 (R)	VAB/VA MX TIM ss		0	5999	0	0.01	921
822 (R)	VAB/VA MX TIM mm		0	59	0	1	922
823 (R)	VAB/VA MX TIM hh		0	23	0	1	923
824 (R)	VAB/VA MX DAY dd		1	31	1	1	924
825 (R)	VAB/VA MX DAY mm		1	12	1	1	925
826 (R)	VAB/VA MX DAY yy		2000	9999	2000	1	926
827 (R)	VAB/VA MIN	V	0	65535	0	1	927
828 (R)	VAB/VA MN TIM ss		0	5999	0	0.01	928
829 (R)	VAB/VA MN TIM mm		0	59	0	1	929
830 (R)	VAB/VA MN TIM hh		0	23	0	1	930
831 (R)	VAB/VA MN DAY dd		1	31	1	1	931
832 (R)	VAB/VA MN DAY mm		1	12	1	1	932
833 (R)	VAB/VA MN DAY yy		2000	9999	2000	1	933
834 (R)	VBC/VB MAX	V	0	65535	0	1	934
835 (R)	VBC/VB MX TIM ss		0	5999	0	0.01	935
836 (R)	VBC/VB MX TIM mm		0	59	0	1	936
837 (R)	VBC/VB MX TIM hh		0	23	0	1	937
838 (R)	VBC/VB MX DAY dd		1	31	1	1	938
839 (R)	VBC/VB MX DAY mm		1	12	1	1	939
840 (R)	VBC/VB MX DAY yy		2000	9999	2000	1	940
841 (R)	VBC/VB MIN	V	0	65535	0	1	941
842 (R)	VBC/VB MN TIM ss		0	5999	0	0.01	942
843 (R)	VBC/VB MN TIM mm		0	59	0	1	943
844 (R)	VBC/VB MN TIM hh		0	23	0	1	944
845 (R)	VBC/VB MN DAY dd		1	31	1	1	945
846 (R)	VBC/VB MN DAY mm		1	12	1	1	946
847 (R)	VBC/VB MN DAY yy		2000	9999	2000	1	947
848 (R)	VCA/VC MAX	V	0	65535	0	1	948
849 (R)	VCA/VC MX TIM ss		0	5999	0	0.01	949
850 (R)	VCA/VC MX TIM mm		0	59	0	1	950
851 (R)	VCA/VC MX TIM hh		0	23	0	1	951
852 (R)	VCA/VC MX DAY dd		1	31	1	1	952
853 (R)	VCA/VC MX DAY mm		1	12	1	1	953
854 (R)	VCA/VC MX DAY yy		2000	9999	2000	1	954
855 (R)	VCA/VC MIN	V	0	65535	0	1	955
856 (R)	VCA/VC MN TIM ss		0	5999	0	0.01	956
857 (R)	VCA/VC MN TIM mm		0	59	0	1	957
858 (R)	VCA/VC MN TIM hh		0	23	0	1	958
859 (R)	VCA/VC MN DAY dd		1	31	1	1	959
860 (R)	VCA/VC MN DAY mm		1	12	1	1	960
861 (R)	VCA/VC MN DAY yy		2000	9999	2000	1	961
862 (R)	KW3P MAX	kW	–32768	32767	0	1	962

Table E.34 Modbus Register Map[a] (Sheet 22 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
863 (R)	KW3P MX TIM ss		0	5999	0	0.01	963
864 (R)	KW3P MX TIM mm		0	59	0	1	964
865 (R)	KW3P MX TIM hh		0	23	0	1	965
866 (R)	KW3P MX DAY dd		1	31	1	1	966
867 (R)	KW3P MX DAY mm		1	12	1	1	967
868 (R)	KW3P MX DAY yy		2000	9999	2000	1	968
869 (R)	KW3P MIN	kW	–32768	32767	0	1	969
870 (R)	KW3P MN TIM ss		0	5999	0	0.01	970
871 (R)	KW3P MN TIM mm		0	59	0	1	971
872 (R)	KW3P MN TIM hh		0	23	0	1	972
873 (R)	KW3P MN DAY dd		1	31	1	1	973
874 (R)	KW3P MN DAY mm		1	12	1	1	974
875 (R)	KW3P MN DAY yy		2000	9999	2000	1	975
876 (R)	KVAR3P MAX	kVAR	–32768	32767	0	1	976
877 (R)	KVAR3P MX TIM ss		0	5999	0	0.01	977
878 (R)	KVAR3P MX TIM mm		0	59	0	1	978
879 (R)	KVAR3P MX TIM hh		0	23	0	1	979
880 (R)	KVAR3P MX DAY dd		1	31	1	1	980
881 (R)	KVAR3P MX DAY mm		1	12	1	1	981
882 (R)	KVAR3P MX DAY yy		2000	9999	2000	1	982
883 (R)	KVAR3P MIN	kVAR	–32768	32767	0	1	983
884 (R)	KVAR3P MN TIM ss		0	5999	0	0.01	984
885 (R)	KVAR3P MN TIM mm		0	59	0	1	985
886 (R)	KVAR3P MN TIM hh		0	23	0	1	986
887 (R)	KVAR3P MN DAY dd		1	31	1	1	987
888 (R)	KVAR3P MN DAY mm		1	12	1	1	988
889 (R)	KVAR3P MN DAY yy		2000	9999	2000	1	989
890 (R)	KVA3P MAX	kVA	–32768	32767	0	1	990
891 (R)	KVA3P MX TIM ss		0	5999	0	0.01	991
892 (R)	KVA3P MX TIM mm		0	59	0	1	992
893 (R)	KVA3P MX TIM hh		0	23	0	1	993
894 (R)	KVA3P MX DAY dd		1	31	1	1	994
895 (R)	KVA3P MX DAY mm		1	12	1	1	995
896 (R)	KVA3P MX DAY yy		2000	9999	2000	1	996
897 (R)	KVA3P MIN	kVA	–32768	32767	0	1	997
898 (R)	KVA3P MN TIM ss		0	5999	0	0.01	998
899 (R)	KVA3P MN TIM mm		0	59	0	1	999
900 (R)	KVA3P MN TIM hh		0	23	0	1	1000
901 (R)	KVA3P MN DAY dd		1	31	1	1	1001
902 (R)	KVA3P MN DAY mm		1	12	1	1	1002
903 (R)	KVA3P MN DAY yy		2000	9999	2000	1	1003
904 (R)	FREQ MAX	Hz	0	65535	0	0.01	1004

Table E.34 Modbus Register Map[a] (Sheet 23 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
905 (R)	FREQ MX TIM ss		0	5999	0	0.01	1005
906 (R)	FREQ MX TIM mm		0	59	0	1	1006
907 (R)	FREQ MX TIM hh		0	23	0	1	1007
908 (R)	FREQ MX DAY dd		1	31	1	1	1008
909 (R)	FREQ MX DAY mm		1	12	1	1	1009
910 (R)	FREQ MX DAY yy		2000	9999	2000	1	1010
911 (R)	FREQ MIN	Hz	0	65535	0	0.01	1011
912 (R)	FREQ MN TIM ss		0	5999	0	0.01	1012
913 (R)	FREQ MN TIM mm		0	59	0	1	1013
914 (R)	FREQ MN TIM hh		0	23	0	1	1014
915 (R)	FREQ MN DAY dd		1	31	1	1	1015
916 (R)	FREQ MN DAY mm		1	12	1	1	1016
917 (R)	FREQ MN DAY yy		2000	9999	2000	1	1017
MAX/MIN RTD Data							
918 (R)	RTD1 MAX	°C	–32768	32767	0	1	1018
919 (R)	RTD1 MX TIM ss		0	5999	0	1	1019
920 (R)	RTD1 MX TIM mm		0	59	0	1	1020
921 (R)	RTD1 MX TIM hh		0	23	0	1	1021
922 (R)	RTD1 MX DAY dd		1	31	1	1	1022
923 (R)	RTD1 MX DAY mm		1	12	1	1	1023
924 (R)	RTD1 MX DAY yy		2000	9999	2000	1	1024
925 (R)	RTD1 MIN	°C	–32768	32767	0	1	1025
926 (R)	RTD1 MN TIM ss		0	5999	0	0.01	1026
927 (R)	RTD1 MN TIM mm		0	59	0	1	1027
928 (R)	RTD1 MN TIM hh		0	23	0	1	1028
929 (R)	RTD1 MN DAY dd		1	31	1	1	1029
930 (R)	RTD1 MN DAY mm		1	12	1	1	1030
931 (R)	RTD1 MN DAY yy		2000	9999	2000	1	1031
932 (R)	RTD2 MAX	°C	–32768	32767	0	1	1032
933 (R)	RTD2 MX TIM ss		0	5999	0	0.01	1033
934 (R)	RTD2 MX TIM mm		0	59	0	1	1034
935 (R)	RTD2 MX TIM hh		0	23	0	1	1035
936 (R)	RTD2 MX DAY dd		1	31	1	1	1036
937 (R)	RTD2 MX DAY mm		1	12	1	1	1037
938 (R)	RTD2 MX DAY yy		2000	9999	2000	1	1038
939 (R)	RTD2 MIN	°C	–32768	32767	0	1	1039
940 (R)	RTD2 MN TIM ss		0	5999	0	0.01	1040
941 (R)	RTD2 MN TIM mm		0	59	0	1	1041
942 (R)	RTD2 MN TIM hh		0	23	0	1	1042
943 (R)	RTD2 MN DAY dd		1	31	1	1	1043
944 (R)	RTD2 MN DAY mm		1	12	1	1	1044
945 (R)	RTD2 MN DAY yy		2000	9999	2000	1	1045

Table E.34 Modbus Register Map[a] (Sheet 24 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
946 (R)	RTD3 MAX	°C	–32768	32767	0	1	1046
947 (R)	RTD3 MX TIM ss		0	5999	0	0.01	1047
948 (R)	RTD3 MX TIM mm		0	59	0	1	1048
949 (R)	RTD3 MX TIM hh		0	23	0	1	1049
950 (R)	RTD3 MX DAY dd		1	31	1	1	1050
951 (R)	RTD3 MX DAY mm		1	12	1	1	1051
952 (R)	RTD3 MX DAY yy		2000	9999	2000	1	1052
953 (R)	RTD3 MIN	°C	–32768	32767	0	1	1053
954 (R)	RTD3 MN TIM ss		0	5999	0	0.01	1054
955 (R)	RTD3 MN TIM mm		0	59	0	1	1055
956 (R)	RTD3 MN TIM hh		0	23	0	1	1056
957 (R)	RTD3 MN DAY dd		1	31	1	1	1057
958 (R)	RTD3 MN DAY mm		1	12	1	1	1058
959 (R)	RTD3 MN DAY yy		2000	9999	2000	1	1059
960 (R)	RTD4 MAX	°C	–32768	32767	0	1	1060
961 (R)	RTD4 MX TIM ss		0	5999	0	0.01	1061
962 (R)	RTD4 MX TIM mm		0	59	0	1	1062
963 (R)	RTD4 MX TIM hh		0	23	0	1	1063
964 (R)	RTD4 MX DAY dd		1	31	1	1	1064
965 (R)	RTD4 MX DAY mm		1	12	1	1	1065
966 (R)	RTD4 MX DAY yy		2000	9999	2000	1	1066
967 (R)	RTD4 MIN	°C	–32768	32767	0	1	1067
968 (R)	RTD4 MN TIM ss		0	5999	0	0.01	1068
969 (R)	RTD4 MN TIM mm		0	59	0	1	1069
970 (R)	RTD4 MN TIM hh		0	23	0	1	1070
971 (R)	RTD4 MN DAY dd		1	31	1	1	1071
972 (R)	RTD4 MN DAY mm		1	12	1	1	1072
973 (R)	RTD4 MN DAY yy		2000	9999	2000	1	1073
974 (R)	RTD5 MAX	°C	–32768	32767	0	1	1074
975 (R)	RTD5 MX TIM ss		0	5999	0	0.01	1075
976 (R)	RTD5 MX TIM mm		0	59	0	1	1076
977 (R)	RTD5 MX TIM hh		0	23	0	1	1077
978 (R)	RTD5 MX DAY dd		1	31	1	1	1078
979 (R)	RTD5 MX DAY mm		1	12	1	1	1079
980 (R)	RTD5 MX DAY yy		2000	9999	2000	1	1080
981 (R)	RTD5 MIN	°C	–32768	32767	0	1	1081
982 (R)	RTD5 MN TIM ss		0	5999	0	0.01	1082
983 (R)	RTD5 MN TIM mm		0	59	0	1	1083
984 (R)	RTD5 MN TIM hh		0	23	0	1	1084
985 (R)	RTD5 MN DAY dd		1	31	1	1	1085
986 (R)	RTD5 MN DAY mm		1	12	1	1	1086
987 (R)	RTD5 MN DAY yy		2000	9999	2000	1	1087

Table E.34 Modbus Register Map[a] (Sheet 25 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
988 (R)	RTD6 MAX	°C	–32768	32767	0	1	1088
989 (R)	RTD6 MX TIM ss		0	5999	0	0.01	1089
990 (R)	RTD6 MX TIM mm		0	59	0	1	1090
991 (R)	RTD6 MX TIM hh		0	23	0	1	1091
992 (R)	RTD6 MX DAY dd		1	31	1	1	1092
993 (R)	RTD6 MX DAY mm		1	12	1	1	1093
994 (R)	RTD6 MX DAY yy		2000	9999	2000	1	1094
995 (R)	RTD6 MIN	°C	–32768	32767	0	1	1095
996 (R)	RTD6 MN TIM ss		0	5999	0	0.01	1096
997 (R)	RTD6 MN TIM mm		0	59	0	1	1097
998 (R)	RTD6 MN TIM hh		0	23	0	1	1098
999 (R)	RTD6 MN DAY dd		1	31	1	1	1099
1000 (R)	RTD6 MN DAY mm		1	12	1	1	1100
1001 (R)	RTD6 MN DAY yy		2000	9999	2000	1	1101
1002 (R)	RTD7 MAX	°C	–32768	32767	0	1	1102
1003 (R)	RTD7 MX TIM ss		0	5999	0	0.01	1103
1004 (R)	RTD7 MX TIM mm		0	59	0	1	1104
1005 (R)	RTD7 MX TIM hh		0	23	0	1	1105
1006 (R)	RTD7 MX DAY dd		1	31	1	1	1106
1007 (R)	RTD7 MX DAY mm		1	12	1	1	1107
1008 (R)	RTD7 MX DAY yy		2000	9999	2000	1	1108
1009 (R)	RTD7 MIN	°C	–32768	32767	0	1	1109
1010 (R)	RTD7 MN TIM ss		0	5999	0	0.01	1110
1011 (R)	RTD7 MN TIM mm		0	59	0	1	1111
1012 (R)	RTD7 MN TIM hh		0	23	0	1	1112
1013 (R)	RTD7 MN DAY dd		1	31	1	1	1113
1014 (R)	RTD7 MN DAY mm		1	12	1	1	1114
1015 (R)	RTD7 MN DAY yy		2000	9999	2000	1	1115
1016 (R)	RTD8 MAX	°C	–32768	32767	0	1	1116
1017 (R)	RTD8 MX TIM ss		0	5999	0	0.01	1117
1018 (R)	RTD8 MX TIM mm		0	59	0	1	1118
1019 (R)	RTD8 MX TIM hh		0	23	0	1	1119
1020 (R)	RTD8 MX DAY dd		1	31	1	1	1120
1021 (R)	RTD8 MX DAY mm		1	12	1	1	1121
1022 (R)	RTD8 MX DAY yy		2000	9999	2000	1	1122
1023 (R)	RTD8 MIN	°C	–32768	32767	0	1	1123
1024 (R)	RTD8 MN TIM ss		0	5999	0	0.01	1124
1025 (R)	RTD8 MN TIM mm		0	59	0	1	1125
1026 (R)	RTD8 MN TIM hh		0	23	0	1	1126
1027 (R)	RTD8 MN DAY dd		1	31	1	1	1127
1028 (R)	RTD8 MN DAY mm		1	12	1	1	1128
1029 (R)	RTD8 MN DAY yy		2000	9999	2000	1	1129

Table E.34 Modbus Register Map[a] (Sheet 26 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1030 (R)	RTD9 MAX	°C	–32768	32767	0	1	1130
1031 (R)	RTD9 MX TIM ss		0	5999	0	0.01	1131
1032 (R)	RTD9 MX TIM mm		0	59	0	1	1132
1033 (R)	RTD9 MX TIM hh		0	23	0	1	1133
1034 (R)	RTD9 MX DAY dd		1	31	1	1	1134
1035 (R)	RTD9 MX DAY mm		1	12	1	1	1135
1036 (R)	RTD9 MX DAY yy		2000	9999	2000	1	1136
1037 (R)	RTD9 MIN	°C	–32768	32767	0	1	1137
1038 (R)	RTD9 MN TIM ss		0	5999	0	0.01	1138
1039 (R)	RTD9 MN TIM mm		0	59	0	1	1139
1040 (R)	RTD9 MN TIM hh		0	23	0	1	1140
1041 (R)	RTD9 MN DAY dd		1	31	1	1	1141
1042 (R)	RTD9 MN DAY mm		1	12	1	1	1142
1043 (R)	RTD9 MN DAY yy		2000	9999	2000	1	1143
1044 (R)	RTD10 MAX	°C	–32768	32767	0	1	1144
1045 (R)	RTD10 MX TIM ss		0	5999	0	0.01	1145
1046 (R)	RTD10 MX TIM mm		0	59	0	1	1146
1047 (R)	RTD10 MX TIM hh		0	23	0	1	1147
1048 (R)	RTD10 MX DAY dd		1	31	1	1	1148
1049 (R)	RTD10 MX DAY mm		1	12	1	1	1149
1050 (R)	RTD10 MX DAY yy		2000	9999	2000	1	1150
1051 (R)	RTD10 MIN	°C	–32768	32767	0	1	1151
1052 (R)	RTD10 MN TIM ss		0	5999	0	0.01	1152
1053 (R)	RTD10 MN TIM mm		0	59	0	1	1153
1054 (R)	RTD10 MN TIM hh		0	23	0	1	1154
1055 (R)	RTD10 MN DAY dd		1	31	1	1	1155
1056 (R)	RTD10 MN DAY mm		1	12	1	1	1156
1057 (R)	RTD10 MN DAY yy		2000	9999	2000	1	1157
1058 (R)	RTD11 MAX	°C	–32768	32767	0	1	1158
1059 (R)	RTD11 MX TIM ss		0	5999	0	0.01	1159
1060 (R)	RTD11 MX TIM mm		0	59	0	1	1160
1061 (R)	RTD11 MX TIM hh		0	23	0	1	1161
1062 (R)	RTD11 MX DAY dd		1	31	1	1	1162
1063 (R)	RTD11 MX DAY mm		1	12	1	1	1163
1064 (R)	RTD11 MX DAY yy		2000	9999	2000	1	1164
1065 (R)	RTD11 MIN	°C	–32768	32767	0	1	1165
1066 (R)	RTD11 MN TIM ss		0	5999	0	0.01	1166
1067 (R)	RTD11 MN TIM mm		0	59	0	1	1167
1068 (R)	RTD11 MN TIM hh		0	23	0	1	1168
1069 (R)	RTD11 MN DAY dd		1	31	1	1	1169
1070 (R)	RTD11 MN DAY mm		1	12	1	1	1170
1071 (R)	RTD11 MN DAY yy		2000	9999	2000	1	1171

Table E.34 Modbus Register Map[a] (Sheet 27 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1072 (R)	RTD12 MAX	°C	–32768	32767	0	1	1172
1073 (R)	RTD12 MX TIM ss		0	5999	0	0.01	1173
1074 (R)	RTD12 MX TIM mm		0	59	0	1	1174
1075 (R)	RTD12 MX TIM hh		0	23	0	1	1175
1076 (R)	RTD12 MX DAY dd		1	31	1	1	1176
1077 (R)	RTD12 MX DAY mm		1	12	1	1	1177
1078 (R)	RTD12 MX DAY yy		2000	9999	2000	1	1178
1079 (R)	RTD12 MIN	°C	–32768	32767	0	1	1179
1080 (R)	RTD12 MN TIM ss		0	5999	0	0.01	1180
1081 (R)	RTD12 MN TIM mm		0	59	0	1	1181
1082 (R)	RTD12 MN TIM hh		0	23	0	1	1182
1083 (R)	RTD12 MN DAY dd		1	31	1	1	1183
1084 (R)	RTD12 MN DAY mm		1	12	1	1	1184
1085 (R)	RTD12 MN DAY yy		2000	9999	2000	1	1185
MAX/MIN AI3 Data							
1086 (R)	AI301 MX–HI	EU	–32768	32767	0	0.001	1186
1087 (R)	AI301 MX–LO	EU	–32768	32767	0	0.001	1187
1088 (R)	AI301 MX TIM ss		0	5999	0	0.01	1188
1089 (R)	AI301 MX TIM mm		0	59	0	1	1189
1090 (R)	AI301 MX TIM hh		0	23	0	1	1190
1091 (R)	AI301 MX DAY dd		1	31	1	1	1191
1092 (R)	AI301 MX DAY mm		1	12	1	1	1192
1093 (R)	AI301 MX DAY yy		2000	9999	2000	1	1193
1094 (R)	AI301 MN–HI	EU	–32768	32767	0	0.001	1194
1095 (R)	AI301 MN–LO	EU	–32768	32767	0	0.001	1195
1096 (R)	AI301 MN TIM ss		0	5999	0	0.01	1196
1097 (R)	AI301 MN TIM mm		0	59	0	1	1197
1098 (R)	AI301 MN TIM hh		0	23	0	1	1198
1099 (R)	AI301 MN DAY dd		1	31	1	1	1199
1100 (R)	AI301 MN DAY mm		1	12	1	1	1200
1101 (R)	AI301 MN DAY yy		2000	9999	2000	1	1201
1102 (R)	AI302 MX–HI	EU	–32768	32767	0	0.001	1202
1103 (R)	AI302 MX–LO	EU	–32768	32767	0	0.001	1203
1104 (R)	AI302 MX TIM ss		0	5999	0	0.01	1204
1105 (R)	AI302 MX TIM mm		0	59	0	1	1205
1106 (R)	AI302 MX TIM hh		0	23	0	1	1206
1107 (R)	AI302 MX DAY dd		1	31	1	1	1207
1108 (R)	AI302 MX DAY mm		1	12	1	1	1208
1109 (R)	AI302 MX DAY yy		2000	9999	2000	1	1209
1110 (R)	AI302 MN–HI	EU	–32768	32767	0	0.001	1210
1111 (R)	AI302 MN–LO	EU	–32768	32767	0	0.001	1211
1112 (R)	AI302 MN TIM ss		0	5999	0	0.01	1212

Table E.34 Modbus Register Map[a] (Sheet 28 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1113 (R)	AI302 MN TIM mm		0	59	0	1	1213
1114 (R)	AI302 MN TIM hh		0	23	0	1	1214
1115 (R)	AI302 MN DAY dd		1	31	1	1	1215
1116 (R)	AI302 MN DAY mm		1	12	1	1	1216
1117 (R)	AI302 MN DAY yy		2000	9999	2000	1	1217
1118 (R)	AI303 MX–HI	EU	–32768	32767	0	0.001	1218
1119 (R)	AI303 MX–LO	EU	–32768	32767	0	0.001	1219
1120 (R)	AI303 MX TIM ss		0	5999	0	0.01	1220
1121 (R)	AI303 MX TIM mm		0	59	0	1	1221
1122 (R)	AI303 MX TIM hh		0	23	0	1	1222
1123 (R)	AI303 MX DAY dd		1	31	1	1	1223
1124 (R)	AI303 MX DAY mm		1	12	1	1	1224
1125 (R)	AI303 MX DAY yy		2000	9999	2000	1	1225
1126 (R)	AI303 MN–HI	EU	–32768	32767	0	0.001	1226
1127 (R)	AI303 MN–LO	EU	–32768	32767	0	0.001	1227
1128 (R)	AI303 MN TIM ss		0	5999	0	0.01	1228
1129 (R)	AI303 MN TIM mm		0	59	0	1	1229
1130 (R)	AI303 MN TIM hh		0	23	0	1	1230
1131 (R)	AI303 MN DAY dd		1	31	1	1	1231
1132 (R)	AI303 MN DAY mm		1	12	1	1	1232
1133 (R)	AI303 MN DAY yy		2000	9999	2000	1	1233
1134 (R)	AI304 MX–HI	EU	–32768	32767	0	0.001	1234
1135 (R)	AI304 MX–LO	EU	–32768	32767	0	0.001	1235
1136 (R)	AI304 MX TIM ss		0	5999	0	0.01	1236
1137 (R)	AI304 MX TIM mm		0	59	0	1	1237
1138 (R)	AI304 MX TIM hh		0	23	0	1	1238
1139 (R)	AI304 MX DAY dd		1	31	1	1	1239
1140 (R)	AI304 MX DAY mm		1	12	1	1	1240
1141 (R)	AI304 MX DAY yy		2000	9999	2000	1	1241
1142 (R)	AI304 MN–HI	EU	–32768	32767	0	0.001	1242
1143 (R)	AI304 MN–LO	EU	–32768	32767	0	0.001	1243
1144 (R)	AI304 MN TIM ss		0	5999	0	0.01	1244
1145 (R)	AI304 MN TIM mm		0	59	0	1	1245
1146 (R)	AI304 MN TIM hh		0	23	0	1	1246
1147 (R)	AI304 MN DAY dd		1	31	1	1	1247
1148 (R)	AI304 MN DAY mm		1	12	1	1	1248
1149 (R)	AI304 MN DAY yy		2000	9999	2000	1	1249
1150 (R)	AI305 MX–HI	EU	–32768	32767	0	0.001	1250
1151 (R)	AI305 MX–LO	EU	–32768	32767	0	0.001	1251
1152 (R)	AI305 MX TIM ss		0	5999	0	0.01	1252
1153 (R)	AI305 MX TIM mm		0	59	0	1	1253
1154 (R)	AI305 MX TIM hh		0	23	0	1	1254

Table E.34 Modbus Register Map[a] (Sheet 29 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1155 (R)	AI305 MX DAY dd		1	31	1	1	1255
1156 (R)	AI305 MX DAY mm		1	12	1	1	1256
1157 (R)	AI305 MX DAY yy		2000	9999	2000	1	1257
1158 (R)	AI305 MN–HI	EU	–32768	32767	0	0.001	1258
1159 (R)	AI305 MN–LO	EU	–32768	32767	0	0.001	1259
1160 (R)	AI305 MN TIM ss		0	5999	0	0.01	1260
1161 (R)	AI305 MN TIM mm		0	59	0	1	1261
1162 (R)	AI305 MN TIM hh		0	23	0	1	1262
1163 (R)	AI305 MN DAY dd		1	31	1	1	1263
1164 (R)	AI305 MN DAY mm		1	12	1	1	1264
1165 (R)	AI305 MN DAY yy		2000	9999	2000	1	1265
1166 (R)	AI306 MX–HI	EU	–32768	32767	0	0.001	1266
1167 (R)	AI306 MX–LO	EU	–32768	32767	0	0.001	1267
1168 (R)	AI306 MX TIM ss		0	5999	0	0.01	1268
1169 (R)	AI306 MX TIM mm		0	59	0	1	1269
1170 (R)	AI306 MX TIM hh		0	23	0	1	1270
1171 (R)	AI306 MX DAY dd		1	31	1	1	1271
1172 (R)	AI306 MX DAY mm		1	12	1	1	1272
1173 (R)	AI306 MX DAY yy		2000	9999	2000	1	1273
1174 (R)	AI306 MN–HI	EU	–32768	32767	0	0.001	1274
1175 (R)	AI306 MN–LO	EU	–32768	32767	0	0.001	1275
1176 (R)	AI306 MN TIM ss		0	5999	0	0.01	1276
1177 (R)	AI306 MN TIM mm		0	59	0	1	1277
1178 (R)	AI306 MN TIM hh		0	23	0	1	1278
1179 (R)	AI306 MN DAY dd		1	31	1	1	1279
1180 (R)	AI306 MN DAY mm		1	12	1	1	1280
1181 (R)	AI306 MN DAY yy		2000	9999	2000	1	1281
1182 (R)	AI307 MX–HI	EU	–32768	32767	0	0.001	1282
1183 (R)	AI307 MX–LO	EU	–32768	32767	0	0.001	1283
1184 (R)	AI307 MX TIM ss		0	5999	0	0.01	1284
1185 (R)	AI307 MX TIM mm		0	59	0	1	1285
1186 (R)	AI307 MX TIM hh		0	23	0	1	1286
1187 (R)	AI307 MX DAY dd		1	31	1	1	1287
1188 (R)	AI307 MX DAY mm		1	12	1	1	1288
1189 (R)	AI307 MX DAY yy		2000	9999	2000	1	1289
1190 (R)	AI307 MN–HI	EU	–32768	32767	0	0.001	1290
1191 (R)	AI307 MN–LO	EU	–32768	32767	0	0.001	1291
1192 (R)	AI307 MN TIM ss		0	5999	0	0.01	1292
1193 (R)	AI307 MN TIM mm		0	59	0	1	1293
1194 (R)	AI307 MN TIM hh		0	23	0	1	1294
1195 (R)	AI307 MN DAY dd		1	31	1	1	1295
1196 (R)	AI307 MN DAY mm		1	12	1	1	1296

Table E.34 Modbus Register Map[a] (Sheet 30 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1197 (R)	AI307 MN DAY yy		2000	9999	2000	1	1297
1198 (R)	AI308 MX–HI	EU	–32768	32767	0	0.001	1298
1199 (R)	AI308 MX–LO	EU	–32768	32767	0	0.001	1299
1200 (R)	AI308 MX TIM ss		0	5999	0	0.01	1300
1201 (R)	AI308 MX TIM mm		0	59	0	1	1301
1202 (R)	AI308 MX TIM hh		0	23	0	1	1302
1203 (R)	AI308 MX DAY dd		1	31	1	1	1303
1204 (R)	AI308 MX DAY mm		1	12	1	1	1304
1205 (R)	AI308 MX DAY yy		2000	9999	2000	1	1305
1206 (R)	AI308 MN–HI	EU	–32768	32767	0.001	0.001	1306
1207 (R)	AI308 MN–LO	EU	–32768	32767	0.001	0.001	1307
1208 (R)	AI308 MN TIM ss		0	5999	0.01	0.01	1308
1209 (R)	AI308 MN TIM mm		0	59	1	1	1309
1210 (R)	AI308 MN TIM hh		0	23	1	1	1310
1211 (R)	AI308 MN DAY dd		1	31	1	1	1311
1212 (R)	AI308 MN DAY mm		1	12	1	1	1312
1213 (R)	AI308 MN DAY yy		2000	9999	1	1	1313
MAX/MIN AI4 Data							
1214 (R)	AI401 MX–HI	EU	–32768	32767	1	0.001	1314
1215 (R)	AI401 MX–LO	EU	–32768	32767	0	0.001	1315
1216 (R)	AI401 MX TIM ss		0	5999	0	0.01	1316
1217 (R)	AI401 MX TIM mm		0	59	0	1	1317
1218 (R)	AI401 MX TIM hh		0	23	0	1	1318
1219 (R)	AI401 MX DAY dd		1	31	1	1	1319
1220 (R)	AI401 MX DAY mm		1	12	1	1	1320
1221 (R)	AI401 MX DAY yy		2000	9999	2000	1	1321
1222 (R)	AI401 MN–HI	EU	–32768	32767	0	0.001	1322
1223 (R)	AI401 MN–LO	EU	–32768	32767	0	0.001	1323
1224 (R)	AI401 MN TIM ss		0	5999	0	0.01	1324
1225 (R)	AI401 MN TIM mm		0	59	0	1	1325
1226 (R)	AI401 MN TIM hh		0	23	0	1	1326
1227 (R)	AI401 MN DAY dd		1	31	1	1	1327
1228 (R)	AI401 MN DAY mm		1	12	1	1	1328
1229 (R)	AI401 MN DAY yy		2000	9999	2000	1	1329
1230 (R)	AI402 MX–HI	EU	–32768	32767	0	0.001	1330
1231 (R)	AI402 MX–LO	EU	–32768	32767	0	0.001	1331
1232 (R)	AI402 MX TIM ss		0	5999	0	0.01	1332
1233 (R)	AI402 MX TIM mm		0	59	0	1	1333
1234 (R)	AI402 MX TIM hh		0	23	0	1	1334
1235 (R)	AI402 MX DAY dd		1	31	1	1	1335
1236 (R)	AI402 MX DAY mm		1	12	1	1	1336
1237 (R)	AI402 MX DAY yy		2000	9999	2000	1	1337

Table E.34 Modbus Register Map[a] (Sheet 31 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1238 (R)	AI402 MN–HI	EU	–32768	32767	0	0.001	1338
1239 (R)	AI402 MN–LO	EU	–32768	32767	0	0.001	1339
1240 (R)	AI402 MN TIM ss		0	5999	0	0.01	1340
1241 (R)	AI402 MN TIM mm		0	59	0	1	1341
1242 (R)	AI402 MN TIM hh		0	23	0	1	1342
1243 (R)	AI402 MN DAY dd		1	31	1	1	1343
1244 (R)	AI402 MN DAY mm		1	12	1	1	1344
1245 (R)	AI402 MN DAY yy		2000	9999	2000	1	1345
1246 (R)	AI403 MX–HI	EU	–32768	32767	0	0.001	1346
1247 (R)	AI403 MX–LO	EU	–32768	32767	0	0.001	1347
1248 (R)	AI403 MX TIM ss		0	5999	0	0.01	1348
1249 (R)	AI403 MX TIM mm		0	59	0	1	1349
1250 (R)	AI403 MX TIM hh		0	23	0	1	1350
1251 (R)	AI403 MX DAY dd		1	31	1	1	1351
1252 (R)	AI403 MX DAY mm		1	12	1	1	1352
1253 (R)	AI403 MX DAY yy		2000	9999	2000	1	1353
1254 (R)	AI403 MN–HI	EU	–32768	32767	0	0.001	1354
1255 (R)	AI403 MN–LO	EU	–32768	32767	0	0.001	1355
1256 (R)	AI403 MN TIM ss		0	5999	0	0.01	1356
1257 (R)	AI403 MN TIM mm		0	59	0	1	1357
1258 (R)	AI403 MN TIM hh		0	23	0	1	1358
1259 (R)	AI403 MN DAY dd		1	31	1	1	1359
1260 (R)	AI403 MN DAY mm		1	12	1	1	1360
1261 (R)	AI403 MN DAY yy		2000	9999	2000	1	1361
1262 (R)	AI404 MX–HI	EU	–32768	32767	0	0.001	1362
1263 (R)	AI404 MX–LO	EU	–32768	32767	0	0.001	1363
1264 (R)	AI404 MX TIM ss		0	5999	0	0.01	1364
1265 (R)	AI404 MX TIM mm		0	59	0	1	1365
1266 (R)	AI404 MX TIM hh		0	23	0	1	1366
1267 (R)	AI404 MX DAY dd		1	31	1	1	1367
1268 (R)	AI404 MX DAY mm		1	12	1	1	1368
1269 (R)	AI404 MX DAY yy		2000	9999	2000	1	1369
1270 (R)	AI404 MN–HI	EU	–32768	32767	0	0.001	1370
1271 (R)	AI404 MN–LO	EU	–32768	32767	0	0.001	1371
1272 (R)	AI404 MN TIM ss		0	5999	0	0.01	1372
1273 (R)	AI404 MN TIM mm		0	59	0	1	1373
1274 (R)	AI404 MN TIM hh		0	23	0	1	1374
1275 (R)	AI404 MN DAY dd		1	31	1	1	1375
1276 (R)	AI404 MN DAY mm		1	12	1	1	1376
1277 (R)	AI404 MN DAY yy		2000	9999	2000	1	1377
1278 (R)	AI405 MX–HI	EU	–32768	32767	0	0.001	1378
1279 (R)	AI405 MX–LO	EU	–32768	32767	0	0.001	1379

Table E.34 Modbus Register Map[a] (Sheet 32 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1280 (R)	AI405 MX TIM ss		0	5999	0	0.01	1380
1281 (R)	AI405 MX TIM mm		0	59	0	1	1381
1282 (R)	AI405 MX TIM hh		0	23	0	1	1382
1283 (R)	AI405 MX DAY dd		1	31	1	1	1383
1284 (R)	AI405 MX DAY mm		1	12	1	1	1384
1285 (R)	AI405 MX DAY yy		2000	9999	2000	1	1385
1286 (R)	AI405 MN–HI	EU	–32768	32767	0	0.001	1386
1287 (R)	AI405 MN–LO	EU	–32768	32767	0	0.001	1387
1288 (R)	AI405 MN TIM ss		0	5999	0	0.01	1388
1289 (R)	AI405 MN TIM mm		0	59	0	1	1389
1290 (R)	AI405 MN TIM hh		0	23	0	1	1390
1291 (R)	AI405 MN DAY dd		1	31	1	1	1391
1292 (R)	AI405 MN DAY mm		1	12	1	1	1392
1293 (R)	AI405 MN DAY yy		2000	9999	2000	1	1393
1294 (R)	AI406 MX–HI	EU	–32768	32767	0	0.001	1394
1295 (R)	AI406 MX–LO	EU	–32768	32767	0	0.001	1395
1296 (R)	AI406 MX TIM ss		0	5999	0	0.01	1396
1297 (R)	AI406 MX TIM mm		0	59	0	1	1397
1298 (R)	AI406 MX TIM hh		0	23	0	1	1398
1299 (R)	AI406 MX DAY dd		1	31	1	1	1399
1300 (R)	AI406 MX DAY mm		1	12	1	1	1400
1301 (R)	AI406 MX DAY yy		2000	9999	2000	1	1401
1302 (R)	AI406 MN–HI	EU	–32768	32767	0	0.001	1402
1303 (R)	AI406 MN–LO	EU	–32768	32767	0	0.001	1403
1304 (R)	AI406 MN TIM ss		0	5999	0	0.01	1404
1305 (R)	AI406 MN TIM mm		0	59	0	1	1405
1306 (R)	AI406 MN TIM hh		0	23	0	1	1406
1307 (R)	AI406 MN DAY dd		1	31	1	1	1407
1308 (R)	AI406 MN DAY mm		1	12	1	1	1408
1309 (R)	AI406 MN DAY yy		2000	9999	2000	1	1409
1310 (R)	AI407 MX–HI	EU	–32768	32767	0	0.001	1410
1311 (R)	AI407 MX–LO	EU	–32768	32767	0	0.001	1411
1312 (R)	AI407 MX TIM ss		0	5999	0	0.01	1412
1313 (R)	AI407 MX TIM mm		0	59	0	1	1413
1314 (R)	AI407 MX TIM hh		0	23	0	1	1414
1315 (R)	AI407 MX DAY dd		1	31	1	1	1415
1316 (R)	AI407 MX DAY mm		1	12	1	1	1416
1317 (R)	AI407 MX DAY yy		2000	9999	2000	1	1417
1318 (R)	AI407 MN–HI	EU	–32768	32767	0	0.001	1418
1319 (R)	AI407 MN–LO	EU	–32768	32767	0	0.001	1419
1320 (R)	AI407 MN TIM ss		0	5999	0	0.01	1420
1321 (R)	AI407 MN TIM mm		0	59	0	1	1421

Table E.34 Modbus Register Map[a] (Sheet 33 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1322 (R)	AI407 MN TIM hh		0	23	0	1	1422
1323 (R)	AI407 MN DAY dd		1	31	1	1	1423
1324 (R)	AI407 MN DAY mm		1	12	1	1	1424
1325 (R)	AI407 MN DAY yy		2000	9999	2000	1	1425
1326 (R)	AI408 MX–HI	EU	–32768	32767	0	0.001	1426
1327 (R)	AI408 MX–LO	EU	–32768	32767	0	0.001	1427
1328 (R)	AI408 MX TIM ss		0	5999	0	0.01	1428
1329 (R)	AI408 MX TIM mm		0	59	0	1	1429
1330 (R)	AI408 MX TIM hh		0	23	0	1	1430
1331 (R)	AI408 MX DAY dd		1	31	1	1	1431
1332 (R)	AI408 MX DAY mm		1	12	1	1	1432
1333 (R)	AI408 MX DAY yy		2000	9999	2000	1	1433
1334 (R)	AI408 MN–HI	EU	–32768	32767	0	0.001	1434
1335 (R)	AI408 MN–LO	EU	–32768	32767	0	0.001	1435
1336 (R)	AI408 MN TIM ss		0	5999	0	0.01	1436
1337 (R)	AI408 MN TIM mm		0	59	0	1	1437
1338 (R)	AI408 MN TIM hh		0	23	0	1	1438
1339 (R)	AI408 MN DAY dd		1	31	1	1	1439
1340 (R)	AI408 MN DAY mm		1	12	1	1	1440
1341 (R)	AI408 MN DAY yy		2000	9999	2000	1	1441
MAX/MIN AI5 Data							
1342 (R)	AI501 MX–HI	EU	–32768	32767	0	0.001	1442
1343 (R)	AI501 MX–LO	EU	–32768	32767	0	0.001	1443
1344 (R)	AI501 MX TIM ss		0	5999	0	0.01	1444
1345 (R)	AI501 MX TIM mm		0	59	0	1	1445
1346 (R)	AI501 MX TIM hh		0	23	0	1	1446
1347 (R)	AI501 MX DAY dd		1	31	1	1	1447
1348 (R)	AI501 MX DAY mm		1	12	1	1	1448
1349 (R)	AI501 MX DAY yy		2000	9999	2000	1	1449
1350 (R)	AI501 MN–HI	EU	–32768	32767	0	0.001	1450
1351 (R)	AI501 MN–LO	EU	–32768	32767	0	0.001	1451
1352 (R)	AI501 MN TIM ss		0	5999	0	0.01	1452
1353 (R)	AI501 MN TIM mm		0	59	0	1	1453
1354 (R)	AI501 MN TIM hh		0	23	0	1	1454
1355 (R)	AI501 MN DAY dd		1	31	1	1	1455
1356 (R)	AI501 MN DAY mm		1	12	1	1	1456
1357 (R)	AI501 MN DAY yy		2000	9999	2000	1	1457
1358 (R)	AI502 MX–HI	EU	–32768	32767	0	0.001	1458
1359 (R)	AI502 MX–LO	EU	–32768	32767	0	0.001	1459
1360 (R)	AI502 MX TIM ss		0	5999	0	0.01	1460
1361 (R)	AI502 MX TIM mm		0	59	0	1	1461
1362 (R)	AI502 MX TIM hh		0	23	0	1	1462

Table E.34 Modbus Register Map[a] (Sheet 34 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1363 (R)	AI502 MX DAY dd		1	31	1	1	1463
1364 (R)	AI502 MX DAY mm		1	12	1	1	1464
1365 (R)	AI502 MX DAY yy		2000	9999	2000	1	1465
1366 (R)	AI502 MN–HI	EU	–32768	32767	0	0.001	1466
1367 (R)	AI502 MN–LO	EU	–32768	32767	0	0.001	1467
1368 (R)	AI502 MN TIM ss		0	5999	0	0.01	1468
1369 (R)	AI502 MN TIM mm		0	59	0	1	1469
1370 (R)	AI502 MN TIM hh		0	23	0	1	1470
1371 (R)	AI502 MN DAY dd		1	31	1	1	1471
1372 (R)	AI502 MN DAY mm		1	12	1	1	1472
1373 (R)	AI502 MN DAY yy		2000	9999	2000	1	1473
1374 (R)	AI503 MX–HI	EU	–32768	32767	0	0.001	1474
1375 (R)	AI503 MX–LO	EU	–32768	32767	0	0.001	1475
1376 (R)	AI503 MX TIM ss		0	5999	0	0.01	1476
1377 (R)	AI503 MX TIM mm		0	59	0	1	1477
1378 (R)	AI503 MX TIM hh		0	23	0	1	1478
1379 (R)	AI503 MX DAY dd		1	31	1	1	1479
1380 (R)	AI503 MX DAY mm		1	12	1	1	1480
1381 (R)	AI503 MX DAY yy		2000	9999	2000	1	1481
1382 (R)	AI503 MN–HI	EU	–32768	32767	0	0.001	1482
1383 (R)	AI503 MN–LO	EU	–32768	32767	0	0.001	1483
1384 (R)	AI503 MN TIM ss		0	5999	0	0.01	1484
1385 (R)	AI503 MN TIM mm		0	59	0	1	1485
1386 (R)	AI503 MN TIM hh		0	23	0	1	1486
1387 (R)	AI503 MN DAY dd		1	31	1	1	1487
1388 (R)	AI503 MN DAY mm		1	12	1	1	1488
1389 (R)	AI503 MN DAY yy		2000	9999	2000	1	1489
1390 (R)	AI504 MX–HI	EU	–32768	32767	0	0.001	1490
1391 (R)	AI504 MX–LO	EU	–32768	32767	0	0.001	1491
1392 (R)	AI504 MX TIM ss		0	5999	0	0.01	1492
1393 (R)	AI504 MX TIM mm		0	59	0	1	1493
1394 (R)	AI504 MX TIM hh		0	23	0	1	1494
1395 (R)	AI504 MX DAY dd		1	31	1	1	1495
1396 (R)	AI504 MX DAY mm		1	12	1	1	1496
1397 (R)	AI504 MX DAY yy		2000	9999	2000	1	1497
1398 (R)	AI504 MN–HI	EU	–32768	32767	0	0.001	1498
1399 (R)	AI504 MN–LO	EU	–32768	32767	0	0.001	1499
1400 (R)	AI504 MN TIM ss		0	5999	0	0.01	1500
1401 (R)	AI504 MN TIM mm		0	59	0	1	1501
1402 (R)	AI504 MN TIM hh		0	23	0	1	1502
1403 (R)	AI504 MN DAY dd		1	31	1	1	1503
1404 (R)	AI504 MN DAY mm		1	12	1	1	1504

Table E.34 Modbus Register Map[a] (Sheet 35 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1405 (R)	AI504 MN DAY yy		2000	9999	2000	1	1505
1406 (R)	AI505 MX–HI	EU	–32768	32767	0	0.001	1506
1407 (R)	AI505 MX–LO	EU	–32768	32767	0	0.001	1507
1408 (R)	AI505 MX TIM ss		0	5999	0	0.01	1508
1409 (R)	AI505 MX TIM mm		0	59	0	1	1509
1410 (R)	AI505 MX TIM hh		0	23	0	1	1510
1411 (R)	AI505 MX DAY dd		1	31	1	1	1511
1412 (R)	AI505 MX DAY mm		1	12	1	1	1512
1413 (R)	AI505 MX DAY yy		2000	9999	2000	1	1513
1414 (R)	AI505 MN–HI	EU	–32768	32767	0	0.001	1514
1415 (R)	AI505 MN–LO	EU	–32768	32767	0	0.001	1515
1416 (R)	AI505 MN TIM ss		0	5999	0	0.01	1516
1417 (R)	AI505 MN TIM mm		0	59	0	1	1517
1418 (R)	AI505 MN TIM hh		0	23	0	1	1518
1419 (R)	AI505 MN DAY dd		1	31	1	1	1519
1420 (R)	AI505 MN DAY mm		1	12	1	1	1520
1421 (R)	AI505 MN DAY yy		2000	9999	2000	1	1521
1422 (R)	AI506 MX–HI	EU	–32768	32767	0	0.001	1522
1423 (R)	AI506 MX–LO	EU	–32768	32767	0	0.001	1523
1424 (R)	AI506 MX TIM ss		0	5999	0	0.01	1524
1425 (R)	AI506 MX TIM mm		0	59	0	1	1525
1426 (R)	AI506 MX TIM hh		0	23	0	1	1526
1427 (R)	AI506 MX DAY dd		1	31	1	1	1527
1428 (R)	AI506 MX DAY mm		1	12	1	1	1528
1429 (R)	AI506 MX DAY yy		2000	9999	2000	1	1529
1430 (R)	AI506 MN–HI	EU	–32768	32767	0	0.001	1530
1431 (R)	AI506 MN–LO	EU	–32768	32767	0	0.001	1531
1432 (R)	AI506 MN TIM ss		0	5999	0	0.01	1532
1433 (R)	AI506 MN TIM mm		0	59	0	1	1533
1434 (R)	AI506 MN TIM hh		0	23	0	1	1534
1435 (R)	AI506 MN DAY dd		1	31	1	1	1535
1436 (R)	AI506 MN DAY mm		1	12	1	1	1536
1437 (R)	AI506 MN DAY yy		2000	9999	2000	1	1537
1438 (R)	AI507 MX–HI	EU	–32768	32767	0	0.001	1538
1439 (R)	AI507 MX–LO	EU	–32768	32767	0	0.001	1539
1440 (R)	AI507 MX TIM ss		0	5999	0	0.01	1540
1441 (R)	AI507 MX TIM mm		0	59	0	1	1541
1442 (R)	AI507 MX TIM hh		0	23	0	1	1542
1443 (R)	AI507 MX DAY dd		1	31	1	1	1543
1444 (R)	AI507 MX DAY mm		1	12	1	1	1544
1445 (R)	AI507 MX DAY yy		2000	9999	2000	1	1545

Table E.34 Modbus Register Map[a] (Sheet 36 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1446 (R)	AI507 MN–HI	EU	–32768	32767	0	0.001	1546
1447 (R)	AI507 MN–LO	EU	–32768	32767	0	0.001	1547
1448 (R)	AI507 MN TIM ss		0	5999	0	0.01	1548
1449 (R)	AI507 MN TIM mm		0	59	0	1	1549
1450 (R)	AI507 MN TIM hh		0	23	0	1	1550
1451 (R)	AI507 MN DAY dd		1	31	1	1	1551
1452 (R)	AI507 MN DAY mm		1	12	1	1	1552
1453 (R)	AI507 MN DAY yy		2000	9999	2000	1	1553
1454 (R)	AI508 MX–HI	EU	–32768	32767	0	0.001	1554
1455 (R)	AI508 MX–LO	EU	–32768	32767	0	0.001	1555
1456 (R)	AI508 MX TIM ss		0	5999	0	0.01	1556
1457 (R)	AI508 MX TIM mm		0	59	0	1	1557
1458 (R)	AI508 MX TIM hh		0	23	0	1	1558
1459 (R)	AI508 MX DAY dd		1	31	1	1	1559
1460 (R)	AI508 MX DAY mm		1	12	1	1	1560
1461 (R)	AI508 MX DAY yy		2000	9999	2000	1	1561
1462 (R)	AI508 MN–HI	EU	–32768	32767	0	0.001	1562
1463 (R)	AI508 MN–LO	EU	–32768	32767	0	0.001	1563
1464 (R)	AI508 MN TIM ss		0	5999	0	0.01	1564
1465 (R)	AI508 MN TIM mm		0	59	0	1	1565
1466 (R)	AI508 MN TIM hh		0	23	0	1	1566
1467 (R)	AI508 MN DAY dd		1	31	1	1	1567
1468 (R)	AI508 MN DAY mm		1	12	1	1	1568
1469 (R)	AI508 MN DAY yy		2000	9999	2000	1	1569
MAX/MIN RST Data							
1470 (R)	MX/MN RST TIM ss		0	5999	0	0.01	1570
1471 (R)	MX/MN RST TIM mm		0	59	0	1	1571
1472 (R)	MX/MN RST TIM hh		0	23	0	1	1572
1473 (R)	MX/MN RST DAT dd		1	31	1	1	1573
1474 (R)	MX/MN RST DAT mm		1	12	1	1	1574
1475 (R)	MX/MN RST DAT yy		2000	9999	2000	1	1575
1476–1480 (R)	Reserved[c]		0	0	0		1576–1580
Per Phase Power Data							
1481 (R)	A REAL POWER	kW	–32768	32767	0	1	1581
1482 (R)	A REACTIVE POWER	kVAR	–32768	32767	0	1	1582
1483 (R)	A APPARENT POWER	kVA	–32768	32767	0	1	1583
1484 (R)	A POWER FACTOR		–100	100	0	0.01	1584
1485 (R)	B REAL POWER	kW	–32768	32767	0	1	1585
1486 (R)	B REACTIVE POWER	kVAR	–32768	32767	0	1	1586
1487 (R)	B APPARENT POWER	kVA	–32768	32767	0	1	1587
1488 (R)	B POWER FACTOR		–100	100	0	0.01	1588
1489 (R)	C REAL POWER	kW	–32768	32767	0	1	1589

Table E.34 Modbus Register Map[a] (Sheet 37 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1490 (R)	C REACTIVE POWER	kVAR	–32768	32767	0	1	1590
1491 (R)	C APPARENT POWER	kVA	–32768	32767	0	1	1591
1492 (R)	C POWER FACTOR		-100	100	0	0.01	1592
Analog Input Data							
1493 (R)	AI301–HI	EU	–32768	32767	0	0.001	1593
1494 (R)	AI301–LO	EU	–32768	32767	0	0.001	1594
1495 (R)	AI302–HI	EU	–32768	32767	0	0.001	1595
1496 (R)	AI302–LO	EU	–32768	32767	0	0.001	1596
1497 (R)	AI303–HI	EU	–32768	32767	0	0.001	1597
1498 (R)	AI303–LO	EU	–32768	32767	0	0.001	1598
1499 (R)	AI304–HI	EU	–32768	32767	0	0.001	1599
1500 (R)	AI304–LO	EU	–32768	32767	0	0.001	1600
1501 (R)	AI305–HI	EU	–32768	32767	0	0.001	1601
1502 (R)	AI305–LO	EU	–32768	32767	0	0.001	1602
1503 (R)	AI306–HI	EU	–32768	32767	0	0.001	1603
1504 (R)	AI306–LO	EU	–32768	32767	0	0.001	1604
1505 (R)	AI307–HI	EU	–32768	32767	0	0.001	1605
1506 (R)	AI307–LO	EU	–32768	32767	0	0.001	1606
1507 (R)	AI308–HI	EU	–32768	32767	0	0.001	1607
1508 (R)	AI308–LO	EU	–32768	32767	0	0.001	1608
1509 (R)	AI401–HI	EU	–32768	32767	0	0.001	1609
1510 (R)	AI401–LO	EU	–32768	32767	0	0.001	1610
1511 (R)	AI402–HI	EU	–32768	32767	0	0.001	1611
1512 (R)	AI402–LO	EU	–32768	32767	0	0.001	1612
1513 (R)	AI402–HI	EU	–32768	32767	0	0.001	1613
1514 (R)	AI403–LO	EU	–32768	32767	0	0.001	1614
1515 (R)	AI404–HI	EU	–32768	32767	0	0.001	1615
1516 (R)	AI404–LO	EU	–32768	32767	0	0.001	1616
1517 (R)	AI405–HI	EU	–32768	32767	0	0.001	1617
1518 (R)	AI405–LO	EU	–32768	32767	0	0.001	1618
1519 (R)	AI406–HI	EU	–32768	32767	0	0.001	1619
1520 (R)	AI406–LO	EU	–32768	32767	0	0.001	1620
1521 (R)	AI407–HI	EU	–32768	32767	0	0.001	1621
1522 (R)	AI407–LO	EU	–32768	32767	0	0.001	1622
1523 (R)	AI408–HI	EU	–32768	32767	0	0.001	1623
1524 (R)	AI408–LO	EU	–32768	32767	0	0.001	1624
1525 (R)	AI501–HI	EU	–32768	32767	0	0.001	1625
1526 (R)	AI501–LO	EU	–32768	32767	0	0.001	1626
1527 (R)	AI502–HI	EU	–32768	32767	0	0.001	1627
1528 (R)	AI502–LO	EU	–32768	32767	0	0.001	1628
1529 (R)	AI503–HI	EU	–32768	32767	0	0.001	1629
1530 (R)	AI503–LO	EU	–32768	32767	0	0.001	1630

Table E.34 Modbus Register Map[a] (Sheet 38 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1531 (R)	AI504–HI	EU	–32768	32767	0	0.001	1631
1532 (R)	AI504–LO	EU	–32768	32767	0	0.001	1632
1533 (R)	AI505–HI	EU	–32768	32767	0	0.001	1633
1534 (R)	AI505–LO	EU	–32768	32767	0	0.001	1634
1535 (R)	AI506–HI	EU	–32768	32767	0	0.001	1635
1536 (R)	AI506–LO	EU	–32768	32767	0	0.001	1636
1537 (R)	AI507–HI	EU	–32768	32767	0	0.001	1637
1538 (R)	AI507–LO	EU	–32768	32767	0	0.001	1638
1539 (R)	AI508–HI	EU	–32768	32767	0	0.001	1639
1540 (R)	AI508–LO	EU	–32768	32767	0	0.001	1640
1541–1546 (R)	Reserved[c]		0	0	0		1641–1646
Math Variables							
1547 (R)	MV01–HI		–32768	32767	0	0.01	1647
1548 (R)	MV01–LO		–32768	32767	0	0.01	1648
1549 (R)	MV02–HI		–32768	32767	0	0.01	1649
1550 (R)	MV02–LO		–32768	32767	0	0.01	1650
1551 (R)	MV03–HI		–32768	32767	0	0.01	1651
1552 (R)	MV03–LO		–32768	32767	0	0.01	1652
1553 (R)	MV04–HI		–32768	32767	0	0.01	1653
1554 (R)	MV04–LO		–32768	32767	0	0.01	1654
1555 (R)	MV05–HI		–32768	32767	0	0.01	1655
1556 (R)	MV05–LO		–32768	32767	0	0.01	1656
1557 (R)	MV06–HI		–32768	32767	0	0.01	1657
1558 (R)	MV06–LO		–32768	32767	0	0.01	1658
1559 (R)	MV07–HI		–32768	32767	0	0.01	1659
1560 (R)	MV07–LO		–32768	32767	0	0.01	1660
1561 (R)	MV08–HI		–32768	32767	0	0.01	1661
1562 (R)	MV08–LO		–32768	32767	0	0.01	1662
1563 (R)	MV09–HI		–32768	32767	0	0.01	1663
1564 (R)	MV09–LO		–32768	32767	0	0.01	1664
1565 (R)	MV10–HI		–32768	32767	0	0.01	1665
1566 (R)	MV10–LO		–32768	32767	0	0.01	1666
1567 (R)	MV11–HI		–32768	32767	0	0.01	1667
1568 (R)	MV11–LO		–32768	32767	0	0.01	1668
1569 (R)	MV12–HI		–32768	32767	0	0.01	1669
1570 (R)	MV12–LO		–32768	32767	0	0.01	1670
1571 (R)	MV13–HI		–32768	32767	0	0.01	1671
1572 (R)	MV13–LO		–32768	32767	0	0.01	1672
1573 (R)	MV14–HI		–32768	32767	0	0.01	1673
1574 (R)	MV14–LO		–32768	32767	0	0.01	1674
1575 (R)	MV15–HI		–32768	32767	0	0.01	1675
1576 (R)	MV15–LO		–32768	32767	0	0.01	1676

Table E.34 Modbus Register Map[a] (Sheet 39 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1577 (R)	MV16–HI		–32768	32767	0	0.01	1677
1578 (R)	MV16–LO		–32768	32767	0	0.01	1678
1579 (R)	MV17–HI		–32768	32767	0	0.01	1679
1580 (R)	MV17–LO		–32768	32767	0	0.01	1680
1581 (R)	MV18–HI		–32768	32767	0	0.01	1681
1582 (R)	MV18–LO		–32768	32767	0	0.01	1682
1583 (R)	MV19–HI		–32768	32767	0	0.01	1683
1584 (R)	MV19–LO		–32768	32767	0	0.01	1684
1585 (R)	MV20–HI		–32768	32767	0	0.01	1685
1586 (R)	MV20–LO		–32768	32767	0	0.01	1686
1587 (R)	MV21–HI		–32768	32767	0	0.01	1687
1588 (R)	MV21–LO		–32768	32767	0	0.01	1688
1589 (R)	MV22–HI		–32768	32767	0	0.01	1689
1590 (R)	MV22–LO		–32768	32767	0	0.01	1690
1591 (R)	MV23–HI		–32768	32767	0	0.01	1691
1592 (R)	MV23–LO		–32768	32767	0	0.01	1692
1593 (R)	MV24–HI		–32768	32767	0	0.01	1693
1594 (R)	MV24–LO		–32768	32767	0	0.01	1694
1595 (R)	MV25–HI		–32768	32767	0	0.01	1695
1596 (R)	MV25–LO		–32768	32767	0	0.01	1696
1597 (R)	MV26–HI		–32768	32767	0	0.01	1697
1598 (R)	MV26–LO		–32768	32767	0	0.01	1698
1599 (R)	MV27–HI		–32768	32767	0	0.01	1699
1600 (R)	MV27–LO		–32768	32767	0	0.01	1700
1601 (R)	MV28–HI		–32768	32767	0	0.01	1701
1602 (R)	MV28–LO		–32768	32767	0	0.01	1702
1603 (R)	MV29–HI		–32768	32767	0	0.01	1703
1604 (R)	MV29–LO		–32768	32767	0	0.01	1704
1605 (R)	MV30–HI		–32768	32767	0	0.01	1705
1606 (R)	MV30–LO		–32768	32767	0	0.01	1706
1607 (R)	MV31–HI		–32768	32767	0	0.01	1707
1608 (R)	MV31–LO		–32768	32767	0	0.01	1708
1609 (R)	MV32–HI		–32768	32767	0	0.01	1709
1610 (R)	MV32–LO		–32768	32767	0	0.01	1710
Device Counters							
1611 (R)	COUNTER SC01		0	65000	0	1	1711
	• • •						
1642 (R)	COUNTER SC32		0	65000	0	1	1742
1643–1647 (R)	Reserved[c]		0	0	0		1743–1747

Table E.34 Modbus Register Map[a] (Sheet 40 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
Breaker Monitor Data							
1648 (R)	RLY TRIPS		0	65535	0	1	1748
1649 (R)	EXT TRIPS		0	65535	0	1	1749
1650 (R)	IA RLY	kA	0	65535	0	1	1750
1651 (R)	IA EXT	kA	0	65535	0	1	1751
1652 (R)	IB RLY	kA	0	65535	0	1	1752
1653 (R)	IB EXT	kA	0	65535	0	1	1753
1654 (R)	IC RLY	kA	0	65535	0	1	1754
1655 (R)	IC EXT	kA	0	65535	0	1	1755
1656 (R)	A WEAR	%	0	100	0	1	1756
1657 (R)	B WEAR	%	0	100	0	1	1757
1658 (R)	C WEAR	%	0	100	0	1	1758
1659 (R)	BRKR RST TIM ss		0	5999	0	0.01	1759
1660 (R)	BRKR RST TIM mm		0	59	0	1	1760
1661 (R)	BRKR RST TIM hh		0	23	0	1	1761
1662 (R)	BRKR RST DAT dd		1	31	1	1	1762
1663 (R)	BRKR RST DAT mm		1	12	1	1	1763
1664 (R)	BRKR RST DAT yy		2000	9999	2000	1	1764
1665-1666 (R)	Reserved[c]		0	0	0		1765-1766
VS Maximum/Minimum Data							
1667 (R)	VS MAX		0	65535	0	1	1767
1668 (R)	VS MAX TIME ss		0	5999	0	0.01	1768
1669 (R)	VS MAX TIME mm		0	59	0	1	1769
1670 (R)	VS MAX TIME hh		0	23	0	1	1770
1671 (R)	VS MAX DAY dd		1	31	1	1	1771
1672 (R)	VS MAX DAY mm		1	12	1	1	1772
1673 (R)	VS MAX DAY yy		2000	9999	2000	1	1773
1674 (R)	VS MIN		0	65535	0	1	1774
1675 (R)	VS MIN TIME ss		0	5999	0	0.01	1775
1676 (R)	VS MIN TIME mm		0	59	0	1	1776
1677 (R)	VS MIN TIME hh		0	23	0	1	1777
1678 (R)	VS MIN DAY dd		1	31	1	1	1778
1679 (R)	VS MIN DAY mm		1	12	1	1	1779
1680 (R)	VS MIN DAY yy		2000	9999	2000	1	1780
1681-1688 (R) (R)	Reserved[c]		0	0	0		1781-1788
Demand Data							
1689 (R)	IA DEMAND		0	65535	0	1	1789
1690 (R)	IB DEMAND		0	65535	0	1	1790
1691 (R)	IC DEMAND		0	65535	0	1	1791
1692 (R)	IG DEMAND		0	65535	0	1	1792
1693 (R)	3I2 DEMAND		0	65535	0	1	1793
1694 (R)	IA PEAK DEMAND		0	65535	0	1	1794

Table E.34 Modbus Register Map[a] (Sheet 41 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1695 (R)	IB PEAK DEMAND		0	65535	0	1	1795
1696 (R)	IC PEAK DEMAND		0	65535	0	1	1796
1697 (R)	IG PEAK DEMAND		0	65535	0	1	1797
1698 (R)	3I2 PEAK DEMAND		0	65535	0	1	1798
1699 (R)	PEAKD RST TIM ss		0	5999	0	0.01	1799
1700 (R)	PEAKD RST TIM mm		0	59	0	1	1800
1701 (R)	PEAKD RST TIM hh		0	23	0	1	1801
1702 (R)	PEAKD RST DAT dd		1	31	1	1	1802
1703 (R)	PEAKD RST DAT mm		1	12	1	1	1803
1704 (R)	PEAKD RST DAT yy		2000	9999	2000	1	1804
1705-1718 (R)	Reserved[c]		0	0	0		1805-1818
Reserved Area 5							
1719–1745 (R)	Reserved[c]		0	0	0		1819–1845
Historical Data							
1746 (R)	NO. EVENT LOGS		0	50	0	1	1846
1747 (R/W)	EVENT LOG SEL.		0	50	0	1	1847
1748 (R)	EVENT TIME ss		0	5999	0	0.01	1848
1749 (R)	EVENT TIME mm		0	59	0	1	1849
1750 (R)	EVENT TIME hh		0	23	0	1	1850
1751 (R)	EVENT DAY dd		1	31	1	1	1851
1752 (R)	EVENT DAY mm		1	12	1	1	1852
1753 (R)	EVENT DAY yy		0	9999	2000	1	1853
1754 (R)	EVENT TYPE 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 28 = AG fault, no OC trip, GFLT=1 29 = BG fault, no OC trip, GFLT=1 30 = ABG fault, no OC trip, GFLT=1 31 = CG fault, no OC trip, GFLT=1 32 = CAG fault, no OC trip, GFLT=1 33 = BCG fault, no OC trip, GFLT=1 34 = ABC fault, no OC trip, GFLT=1 35 = AG fault, OC trip, GFLT=1 36 = BG fault, OC trip, GFLT=1 37 = ABG fault, OC trip, GFLT=1 38 = CG fault, OC trip, GFLT=1 39 = CAG fault, OC trip, GFLT=1 40 = BCG fault, OC trip, GFLT=1 41 = ABC fault, OC trip, GFLT=1 42 = AG fault, no OC trip, GFLT=0 43 = BG fault, no OC trip, GFLT=0 44 = AB fault, no OC trip, GFLT=0 45 = CG fault, no OC trip, GFLT=0 46 = CA fault, no OC trip, GFLT=0 47 = BC fault, no OC trip, GFLT=0 48 = ABC fault, no OC trip, GFLT=0 49 = AG fault, OC trip, GFLT=0 50 = BG fault, OC trip, GFLT=0		0	55	0	1	1854

Table E.34 Modbus Register Map[a] (Sheet 42 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
	23 = BREAKER FAILURE TRIP	51 = AB fault, OC trip, GFLT=0					
	24 = COMMIDLELOSSTRIP	52 = CG fault, OC trip, GFLT=0					
	25 = TRIGGER	53 = CA fault, OC trip, GFLT=0					
	26 = ER TRIGGER	54 = BC fault, OC trip, GFLT=0					
	27 = TRIP	55 = ABC fault, OC trip, GFLT=0					
1755 (R)	EVENT TARGETS Bit 0 = T06_Led Bit 1 = T05_Led Bit 2 = T04_Led Bit 3 = T03_Led Bit 4 = T02_Led Bit 5 = T01_Led Bit 6 = Trip Bit 7 = Enabled		0	255	0	1	1855
1756 (R)	EVENT IA	A	0	65535	0	1	1856
1757 (R)	EVENT IB	A	0	65535	0	1	1857
1758 (R)	EVENT IC	A	0	65535	0	1	1858
1759 (R)	EVENT IN	A	0	65535	0	1	1859
1760 (R)	EVENT IG	A	0	65535	0	1	1860
1761 (R)	EVENT VAB/VAN	V	0	65535	0	1	1861
1762 (R)	EVENT VBC/VBN	V	0	65535	0	1	1862
1763 (R)	EVENT VCA/VCN	V	0	65535	0	1	1863
1764 (R)	EVENT VG	V	0	65535	0	1	1864
1765 (R)	EVENT DELTA/WYE 0 = DELTA 1 = WYE		0	1	0		1865
1766 (R)	EVENT FREQ	Hz	2000	7000	6000	0.01	1866
1767–1769 (R)	Reserved[c]		0	0	0		1867–1769
1770 (R)	EVNT MAX WDG RTD	°C	–32768	32767	0	1	1870
1771 (R)	EVNT MAX BRG RTD	°C	–32768	32767	0	1	1871
1772 (R)	EVNT MAX AMB RTD	°C	–32768	32767	0	1	1872
1773 (R)	EVNT MAX OTH RTD	°C	–32768	32767	0	1	1873
1774–1779 (R)	Reserved[c]		0	0	0		1874–1879
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.							
1780 (R)	TRIP STATUS LO		0	65535	0	1	1880
	Bit 0 = PHASE A1 50	Bit 8 = PHASE B 51					
	Bit 1 = PHASE B1 50	Bit 9 = PHASE C 51					
	Bit 2 = PHASE C1 50	Bit 10 = PHASE 51P1					
	Bit 3 = PHASE 50P1	Bit 11 = GROUND 51G1					
	Bit 4 = GROUND 50G1	Bit 12 = NEUTRAL 51N1					
	Bit 5 = NEUTRAL 50N1	Bit 13 = NEG SEQ 51Q					
	Bit 6 = NEG SEQ 50Q1	Bit 14 = UNDERVOLT 27P1					
	Bit 7 = PHASE A 51	Bit 15 = OVERVOLT 59P1					

Table E.34 Modbus Register Map[a] (Sheet 43 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1781 (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	1881
1782 (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	1882
1783 (R)	WARN STATUS HI Bit 0 = RESERVED 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	1883
1784–1788 (R)	Reserved[c]		0	0	0		1884–1888
Communications Counters							
1789 (R)	NUM MSG RCVD		0	65535	0	1	1889
1790 (R)	NUM OTHER MSG		0	65535	0	1	1890
1791 (R)	INVALID ADDR		0	65535	0	1	1891
1792 (R)	BAD CRC		0	65535	0	1	1892
1793 (R)	UART ERROR		0	65535	0	1	1893
1794 (R)	ILLEGAL FUNCTION		0	65535	0	1	1894
1795 (R)	ILLEGAL REGISTER		0	65535	0	1	1895
1796 (R)	ILLEGAL WRITE		0	65535	0	1	1896
1797 (R)	BAD PKT FORMAT		0	65535	0	1	1897
1798 (R)	BAD PKT LENGTH		0	65535	0	1	1898
1799–1804 (R)	Reserved[c]		0	0	0		1899–1904
Relay Elements							
1805 (R)	ROW 0 Bit 0 = T06_LED Bit 1 = T05_LED Bit 2 = T04_LED Bit 3 = T03_LED Bit 4 = T02_LED Bit 5 = T01_LED Bit 6 = TRIP Bit 7 = ENABLED		0	255	0	1	1905

Table E.34 Modbus Register Map[a] (Sheet 44 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1806 (R)	ROW 1 Bit 0 = 52A Bit 1 = * Bit 2 = ORED51T Bit 3 = ORDE50T Bit 4 = * Bit 5 = 50C1P Bit 6 = 50B1P Bit 7 = 50A1P		0	255	0	1	1906
1807 (R)	ROW 2 Bit 0 = 50Q4P Bit 1 = 50Q3P Bit 2 = 50Q2P Bit 3 = 50Q1P Bit 4 = 50P4P Bit 5 = 50P3P Bit 6 = 50P2P Bit 7 = 50P1P		0	255	0	1	1907
1808 (R)	ROW 3 Bit 0 = 50Q4T Bit 1 = 50Q3T Bit 2 = 50Q2T Bit 3 = 50Q1T Bit 4 = 50P4T Bit 5 = 50P3T Bit 6 = 50P2T Bit 7 = 50P1T		0	255	0	1	1908
1809 (R)	ROW 4 Bit 0 = 50G4P Bit 1 = 50G3P Bit 2 = 50G2P Bit 3 = 50G1P Bit 4 = 50N4P Bit 5 = 50N3P Bit 6 = 50N2P Bit 7 = 50N1P		0	255	0	1	1909
1810 (R)	ROW 5 Bit 0 = 50G4T Bit 1 = 50G3T Bit 2 = 50G2T Bit 3 = 50G1T Bit 4 = 50N4T Bit 5 = 50N3T Bit 6 = 50N2T Bit 7 = 50N1T		0	255	0	1	1910
1811 (R)	ROW 6 Bit 0 = 51QP Bit 1 = 51N2P Bit 2 = 51N1P Bit 3 = 51P2P Bit 4 = 51P1P Bit 5 = 51CP Bit 6 = 51BP Bit 7 = 51AP		0	255	0	1	1911

Table E.34 Modbus Register Map[a] (Sheet 45 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1812 (R)	ROW 7 Bit 0 = 51QT Bit 1 = 51N2T Bit 2 = 51N1T Bit 3 = 51P2T Bit 4 = 51P1T Bit 5 = 51CT Bit 6 = 51BT Bit 7 = 51AT		0	255	0	1	1912
1813 (R)	ROW 8 Bit 0 = 51QR Bit 1 = 51N2R Bit 2 = 51N1R Bit 3 = 51P2R Bit 4 = 51P1R Bit 5 = 51CR Bit 6 = 51BR Bit 7 = 51AR		0	255	0	1	1913
1814 (R)	ROW 9 Bit 0 = 27P1T Bit 1 = 27P1 Bit 2 = 51G2R Bit 3 = 51G2T Bit 4 = 51G2P Bit 5 = 51G1R Bit 6 = 51G1T Bit 7 = 51G1P		0	255	0	1	1914
1815 (R)	ROW 10 Bit 0 = 3P27 Bit 1 = 3P59 Bit 2 = 59P2T Bit 3 = 59P2 Bit 4 = 59P1T Bit 5 = 59P1 Bit 6 = 27P2T Bit 7 = 27P2		0	255	0	1	1915
1816 (R)	ROW 11 Bit 0 = 55T Bit 1 = 55A Bit 2 = 81D6T Bit 3 = 81D5T Bit 4 = 81D4T Bit 5 = 81D3T Bit 6 = 81D2T Bit 7 = 81D1T		0	255	0	1	1916
1817 (R)	ROW 12 Bit 0 = BFT Bit 1 = BFI Bit 2 = * Bit 3 = BKMON Bit 4 = OTHTRIP Bit 5 = OTHALRM Bit 6 = AMBTRIP Bit 7 = AMBALRM		0	255	0	1	1917

Table E.34 Modbus Register Map[a] (Sheet 46 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1818 (R)	ROW 13 Bit 0 = FAULT Bit 1 = IRIGOK Bit 2 = TSOK Bit 3 = WARNING Bit 4 = SALARM Bit 5 = PMDOK Bit 6 = LINKB Bit 7 = LINKA		0	255	0	1	1918
1819 (R)	ROW 14 Bit 0 = LOP Bit 1 = 3PWR2T Bit 2 = 3PWR1T Bit 3 = CFGFLT Bit 4 = COMMFLT Bit 5 = REMTRIP Bit 6 = COMMLOSS Bit 7 = COMMIDLE		0	255	0	1	1919
1820–1825 (R)	ROW 15 through ROW 20		0	255	0	1	1920–1925
1826 (R)	ROW 21 Bit 0 = RSTPKDEM Bit 1 = RSTDEM Bit 2 = RSTMXMN Bit 3 = RSTENRGY Bit 4 = BRGTRIP Bit 5 = BRGALRM Bit 6 = WDGTRIP Bit 7 = WDGALRM		0	255	0	1	1926
1827 (R)	ROW 22 Bit 0 = HALARM Bit 1 = RSTTRGT Bit 2 = DSABLSET Bit 3 = 3PWR2P Bit 4 = 3PWR1P Bit 5 = TRGTR Bit 6 = RTDIN Bit 7 = RTDFLT		0	255	0	1	1927
1828–1924 (R)	ROW 23 through ROW 119		0	255	0	1	1928–2024
1925–1947 (R)	Reserved[c]		0	0	0		2025–2047
Extra Settings							
1948 (R/W)	BREAKER MONITOR 0 = N 1 = Y		0	1	1		2048
1949 (R/W)	CL/OPN OPS SETP1		0	65000	10000	1	2049
1950 (R/W)	CL/OPN OPS SETP2		0	65000	150	1	2050
1951 (R/W)	CL/OPN OPS SETP3		0	65000	12	1	2051
1952 (R/W)	KA PRI INTRPD1-I		0	999	1	1	2052
1953 (R/W)	KA PRI INTRPD1-F		0	99	20	0.01	2053
1954 (R/W)	KA PRI INTRPD2-I		0	999	8	1	2054
1955 (R/W)	KA PRI INTRPD2-F		0	99	0	0.01	2055
1956 (R/W)	KA PRI INTRPD3-I		0	999	20	1	2056

Table E.34 Modbus Register Map[a] (Sheet 47 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1957 (R/W)	KA PRI INTRPD3-F		0	99	0	0.01	2057
1958 (R/W)	ENBL AF PH OC 0 = N 1 = Y		0	1	0		2058
1959 (R/W)	AF PH OC TRP LVL	A	10	10000	100	0.01	2059
1960 (R/W)	ENBL AF N OC 0 = N 1 = Y		0	1	0		2060
1961 (R/W)	AF N OC TRP LVL	A	10	10000	100	0.01	2061
1962 (R/W)	SENSOR 1 TYPE 0 = NONE 1 = POINT 2 = FIBER		0	2	0		2062
1963 (R/W)	TOL 1 PICKUP	%	30	200	50	0.1	2063
1964 (R/W)	SENSOR 2 TYPE 0 = NONE 1 = POINT 2 = FIBER		0	2	0		2064
1965 (R/W)	TOL 2 PICKUP	%	30	200	50	0.1	2065
1966 (R/W)	SENSOR 3 TYPE 0 = NONE 1 = POINT 2 = FIBER		0	2	0		2066
1967 (R/W)	TOL 3 PICKUP	%	30	200	50	0.1	2067
1968 (R/W)	SENSOR 4 TYPE 0 = NONE 1 = POINT 2 = FIBER		0	2	0		2068
1969 (R/W)	TOL 4 PICKUP	%	30	200	50	0.1	2069
1970 (R/W)	ARC OUTPUT SLOT 0 = 101_2 1 = 301_2 2 = 401_2		0	2	0		2070
1971 (R/W)	EN SYNCHRO PHSOR 0 = N 1 = Y		0	1	0		2071
1972 (R/W)	MESSAGES PER SEC 0 = 1 1 = 2 2 = 5 3 = 10		0	3	3		2072
1973 (R/W)	PMU HARDWARE ID		1	65534	1	1	2073
1974 (R/W)	VOLTAGE DATA SET 0 = V1 1 = ALL 2 = NA		0	2	0		2074
1975 (R/W)	VOLT COMP ANGLE	deg	-17999	18000	0	0.01	2075
1976 (R/W)	CURRENT DATA SET 0 = I1 1 = ALL 2 = NA		0	2	0		2076
1977 (R/W)	CURR COMP ANGLE	deg	-17999	18000	0	0.01	2077
1978 (R/W)	NUM ANALOGS		0	4	0	1	2078

Table E.34 Modbus Register Map[a] (Sheet 48 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1979 (R/W)	NUMDSW 0 = N 1 = Y		0	1	0		2079
1980 (R/W)	CTRL BITS DEFN 0 = NONE 1 = C37.118		0	1	0		2080
1981 (R/W)	IRIG TIME SOURCE 0 = IRIG1 1 = IRIG2		0	1	0		2081
1982 (R/W)	OFFSET FROM UTC	hour	-2400	2400	0	0.01	2082
1983 (R/W)	ENABLE DST 0 = N 1 = Y		0	1	0		2083
1984 (R/W)	MONTH DST BEGINS		1	12	1	1	2084
1985 (R/W)	WEEK DST BEGINS 0 = L 1 = 1 2 = 2 3 = 3		0	3	2		2085
1986 (R/W)	DAY DST BEGINS 0 = SUN 1 = MON 2 = TUE 3 = WED 4 = THU 5 = FRI 6 = SAT		0	6	0		2086
1987 (R/W)	HOUR DST BEGINS		0	23	2	1	2087
1988 (R/W)	MONTH DST ENDS		1	12	11	1	2088
1989 (R/W)	WEEK DST ENDS 0 = L 1 = 1 2 = 2 3 = 3		0	3	1		2089
1990 (R/W)	DAY DST ENDS 0 = SUN 1 = MON 2 = TUE 3 = WED 4 = THU 5 = FRI 6 = SAT		0	6	0		2090
1991 (R/W)	HOUR DST ENDS		0	23	2	1	2091
1992 (R/W)	FREQ5 TRIP ENABL 0 = N 1 = Y		0	1	0		2092
1993 (R/W)	FREQ5 TRIP LEVEL	Hz	2000	7000	6000	0.01	2093
1994 (R/W)	FREQ5 TRIP DELAY	sec	0	2400	10	0.1	2094
1995 (R/W)	FREQ6 TRIP ENABL 0 = N 1 = Y		0	1	0		2095
1996 (R/W)	FREQ6 TRIP LEVEL	Hz	2000	7000	6000	0.01	2096
1997 (R/W)	FREQ6 TRIP DELAY	sec	0	2400	10	0.1	2097
1998 (R/W)	V RATIO COR FAC		50	200	100	0.01	2098

Table E.34 Modbus Register Map[a] (Sheet 49 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
1999 (R/W)	ZS OV TRIP1 ENBL 0 = N 1 = Y		0	1	0		2099
2000 (R/W)	ZS OV TRIP1 LVL	xVnm	2	120	110	0.01	2100
2001 (R/W)	ZS OV TRIP1 DLY	sec	0	1200	5	0.1	2101
2002 (R/W)	ZS OV TRIP2 ENBL 0 = N 1 = Y		0	1	0		2102
2003 (R/W)	ZS OV TRIP2 LVL	xVnm	2	120	110	0.01	2103
2004 (R/W)	ZS OV TRIP2 DLY	sec	0	1200	50	0.1	2104
2005 (R/W)	NSQ OV TRIP1 EBL 0 = N 1 = Y		0	1	0		2105
2006 (R/W)	NSQ OV TRIP1 LVL	xVnm	2	120	110	0.01	2106
2007 (R/W)	NSQ OV TRIP1 DLY	sec	0	1200	5	0.1	2107
2008 (R/W)	NSQ OV TRIP2 EBL 0 = N 1 = Y		0	1	0		2108
2009 (R/W)	NSQ OV TRIP2 LVL	xVnm	2	120	110	0.01	2109
2010 (R/W)	NSQ OV TRIP2 DLY	sec	0	1200	50	0.1	2110
2011 (R/W)	ENABLE 81R		0	4	0	1	2111
2012 (R/W)	81R VOLTAGE SUP	xVnm	0	13	0	0.1	2112
2013 (R/W)	81R CURRENT SUP	xInm	0	20	0	0.1	2113
2014 (R/W)	ENABLE 81R1 0 = N 1 = Y		0	1	0		2114
2015 (R/W)	81R1 TRIP LEVEL	Hz/s	10	1500	1500	0.01	2115
2016 (R/W)	81R1 TREND 0 = INC 1 = DEC 2 = ABS		0	2	2		2116
2017 (R/W)	81R1 TRIP DELAY	sec	10	6000	100	0.01	2117
2018 (R/W)	81R1 DO DELAY	sec	0	6000	0	0.01	2118
2019 (R/W)	ENABLE 81R2 0 = N 1 = Y			0	1	0	2119
2020 (R/W)	81R2 TRIP LEVEL	Hz/s	10	1500	1500	0.01	2120
2021 (R/W)	81R2 TREND 0 = INC 1 = DEC 2 = ABS			0	2	2	2121
2022 (R/W)	81R2 TRIP DELAY	sec	10	6000	100	0.01	2122
2023 (R/W)	81R2 DO DELAY	sec	0	6000	0	0.01	2123
2024 (R/W)	ENABLE 81R3 0 = N 1 = Y			0	1	0	2124
2025 (R/W)	81R3 TRIP LEVEL	Hz/s	10	1500	1500	0.01	2125

Table E.34 Modbus Register Map[a] (Sheet 50 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
2026 (R/W)	81R3 TREND 0 = INC 1 = DEC 2 = ABS			0	2	2	2126
2027 (R/W)	81R3 TRIP DELAY	sec	10	6000	100	0.01	2127
2028 (R/W)	81R3 DO DELAY	sec	0	6000	0	0.01	2128
2029 (R/W)	ENABLE 81R4 0 = N 1 = Y		0	1	0		2129
2030 (R/W)	81R4 TRIP LEVEL	Hz/s	10	1500	1500	0.01	2130
2031 (R/W)	81R4 TREND 0 = INC 1 = DEC 2 = ABS		0	2	2		2131
2032 (R/W)	81R4 TRIP DELAY	sec	10	6000	100	0.01	2132
2033 (R/W)	81R4 DO DELAY	sec	0	6000	0	0.01	2133
2034 (R/W)	DEMAND MTR 0 = THM 1 = ROL		0	1	0		2134
2035 (R/W)	DEM TIME CONSTNT 0 = 5 1 = 10 2 = 15 3 = 30 4 = 60	min	0	4	0		2135
2036 (R/W)	PH CURR DEM LVL	A	1	160	50	0.1	2136
2037 (R/W)	RES CURR DEM LVL	A	1	160	10	0.1	2137
2038 (R/W)	3I2 CURR DEM LVL	A	1	160	10	0.1	2138
2039 (R/W)	ENABLE PWR ELEM 0 = N 1 = 3P1 2 = 3P2		0	2	0		2139
2040 (R/W)	ENABLE 3PWR1P 0 = N 1 = Y		0	1	0		2140
2041 (R/W)	3PH PWR ELEM PU	VA	2	65000	20000	0.1	2141
2042 (R/W)	PWR ELEM TYPE 0 = + WATTS 1 = – WATTS 2 = + VARS 3 = –VARS		0	3	2		2142
2043 (R/W)	PWR ELEM DELAY	sec	0	2400	0	0.1	2143
2044 (R/W)	ENABLE 3PWR2P 0 = N 1 = Y		0	1	0		2144
2045 (R/W)	3PH PWR ELEM PU	VA	2	65000	20000	0.1	2145
2046 (R/W)	PWR ELEM TYPE 0 = + WATTS 1 = – WATTS 2 = + VARS 3 = – VARS		0	3	2		2146
2047 (R/W)	PWR ELEM DELAY	sec	0	2400	0	0.1	2147

Table E.34 Modbus Register Map[a] (Sheet 51 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
2048 (R/W)	ENABLE 81RF 0 = N 1 = Y		0	1	0		2148
2049 (R/W)	FREQDIF SETPOINT	Hz	1	100	10	0.1	2149
2050 (R/W)	DFDT SETPOINT	Hz/sec	2	150	25	0.1	2150
2051 (R/W)	81RF PU DELAY	sec	10	100	10	0.01	2151
2052 (R/W)	81RF DO DELAY	sec	0	100	10	0.01	2152
2053 (R/W)	ENABLE 81RFVBLK 0 = N 1 = Y		0	1	0		2153
2054 (R/W)	81RFVOLTAGE BLK	xVnm	2	10	8	0.1	2154
2055 (R/W)	ENABLE 81RFIBLK 0 = N 1 = Y		0	1	0		2155
2056 (R/W)	81RF CURRENT BLK	xINOM	1	200	100	0.1	2156
2057 (R/W)	81RF BLOCK DO	sec	2	500	100	0.01	2157
2058-2070 (R)	Reserved[c]		0	0	0		2158-2170
Control I/O Commands							
2000H (W)	LOGIC COMMAND 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		0	65535	0	na	
2001H (W)	RESET COMMAND Bit 0 = Trip Reset Bit 1 = Set to Defaults 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 10–15 = Reserved		0	1023	0	na	
Relay Elements							
2100H (R)	FAST STATUS 0 Bit 0 = Faulted Bit 1 = Warning Bit 2 = IN1/IN101 Status Bit 3 = IN2/IN102 Status Bit 4 = IN3/IN401 Status Bit 5 = IN4/IN402 Status Bit 6 = IN5/IN403 Status Bit 7 = Reserved Bit 8 = AUX1/OUT101 Status Bit 9 = AUX2/OUT102 Status Bit 10 = AUX3/OUT401 Status Bit 11 = AUX4/OUT402 Status Bit 12 = AUX5/OUT403 Status Bit 13 = AUX6/OUT404 Status Bit 14 = Reserved Bit 15 = Reserved		0	65535	0	na	

Table E.34 Modbus Register Map[a] (Sheet 52 of 55)

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 = Reserved Bit 13 = Reserved Bit 14 = Reserved Bit 15 = Reserved		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 = OUT11/OUT301 Status Bit 5 = OUT12/OUT302 Status Bit 6 = OUT13/OUT303 Status Bit 7 = OUT14/OUT304 Status Bit 8 = IN15/IN305 Status Bit 9 = IN16/IN306 Status Bit 10 = IN17/IN307 Status Bit 11 = IN18/IN308 Status Bit 12 = Reserved Bit 13 = Reserved Bit 14 = Reserved Bit 15 = Reserved		0	65535	0	na	
2111H (R)	FAST STATUS 3 Bit 0 = IN19/IN405 Status Bit 1 = IN20/IN406 Status Bit 2 = IN21/IN407 Status Bit 3 = IN22/IN408 Status Bit 4 = IN23/IN505 Status Bit 5 = IN24/IN506 Status Bit 6 = IN25/IN507 Status Bit 7 = IN26/IN508 Status Bit 8–15 = Reserved		0	65535	0	na	
PAR Group Indices							
3000H (R)	Reserved[c]		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	259	251		
3004H (R)	ACCESS CONTROL		260	260	260		
3005H (R)	GENERAL SETTINGS		261	264	261		

Table E.34 Modbus Register Map[a] (Sheet 53 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
3006H (R)	GROUP SELECTION		265	265	265		
3007H (R)	BK FAILURE SET		266	268	266		
3008H (R)	DC BATTERY MONITOR		269	272	269		
3009H (R)	CONFIG SETTINGS		273	283	273		
300AH (R)	MAX PH OVERCURR		284	295	284		
300BH (R)	NEUTRAL OVERCURR		296	311	296		
300CH (R)	RESIDUAL OVERCUR		312	323	312		
300DH (R)	NEG SEQ OVERCURR		324	335	324		
300EH (R)	PHASE TOC		336	356	336		
300FH (R)	MAXIMUM PH TOC		357	370	357		
3010H (R)	NEGATIVE SEQ TOC		371	377	371		
3011H (R)	NEUTRAL TOC		378	393	378		
3012H (R)	RESIDUAL TOC		394	410	394		
3013H (R)	RTD SETTINGS		411	461	411		
3014H (R)	UNDERVOLTAGE SET		462	473	462		
3015H (R)	OVERVOLTAGE SET		474	485	474		
3016H (R)	RECLOSING CONTROL		486	501	486		
3017H (R)	POWER FACTOR SET		502	512	502		
3018H (R)	FREQ SETTINGS		513	524	513		
3019H (R)	SYNC CHECK SET		525	532	525		
301AH (R)	TRIP/CLOSE LOGIC		533	541	533		
301BH (R)	SELOGIC ENABLES		542	550	542		
301CH (R)	OUTPUT CONTACTS		551	570	551		
301DH (R)	EVENT REPORT SET		571	580	571		
301EH (R)	FRONT PANEL SET		581	590	581		
301FH (R)	RESET SETTINGS		591	601	591		
3020H (R)	DATE/TIME SET		602	609	602		
3021H (R)	DEVICE STATUS		610	649	610		
3022H (R)	CURRENT DATA		650	663	650		
3023H (R)	EXTRA VOLTAGE DATA		664	666	664		
3024H (R)	VOLTAGE DATA		667	684	667		
3025H (R)	POWER DATA		685	689	685		
3026H (R)	ENERGY DATA		690	711	690		
3027H (R)	RTD DATA		712	728	712		
3028H (R)	LIGHT MTR DATA		729	738	729		
3029H (R)	RMS DATA		739	749	739		
302AH (R)	MAX/MIN MTR DATA		750	917	750		
302BH (R)	MAX/MIN RTD DATA		918	1085	918		
302CH (R)	MAX/MIN AI3 DATA		1086	1213	1086		
302DH (R)	MAX/MIN AI4 DATA		1214	1341	1214		
302EH (R)	MAX/MIN AI5 DATA		1342	1469	1342		
302FH (R)	MAX/MIN RST DATA		1470	1480	1470		

Table E.34 Modbus Register Map[a] (Sheet 54 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
3030H (R)	PER PHASE POWER DATA		1481	1492	1481		
3031H (R)	ANA INP DATA		1493	1546	1493		
3032H (R)	MATH VARIABLES		1547	1610	1547		
3033H (R)	DEVICE COUNTERS		1611	1647	1611		
3034H (R)	BREAKER MONITOR		1648	1666	1648		
3035H (R)	VS MAXMIN DATA		1667	1688	1667		
3036H (R)	DEMAND DATA		1689	1718	1689		
3037H (R)	RESERVED AREA5		1719	1745	1719		
3038H (R)	HISTORICAL DATA		1746	1779	1746		
3039H (R)	TRIP/WARN DATA		1780	1788	1780		
303AH (R)	COMMN COUNTERS		1789	1804	1789		
303BH (R)	RELAY ELEMENTS		1805	1947	1805		
303CH (R)	EXTRA SETTINGS		1948	2070	1948		
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	2070	na	
4006H (R)	NUM OF PAR GROUP		1	100	60	na	
4007H (R/W)	MAC ID 64–99 = Swr Configurable		1	99	0	na	
4008H (R/W)	DN BAUD RATE 0 = 125 kbps 1 = 250 kbps 2 = 500 kbps 3 = AUTO 4–9 = Swr Configurable		0	9	0	na	
4009H (R/W)	DN STATUS Bit 0 = Explicit Cnxn Bit 1 = I/O Cnxn Bit 2 = Explicit Fault Bit 3 = I/O Fault Bit 4 = I/O Idle Bit 5–Bit 15 = Reserved		0	31	0	na	
400AH	not used						
400BH (R)	CONFIG PAR CKSUM				0	na	
400CH (R)	LANGUAGE CODE 0 = English 1 = French 2 = Spanish (Mexican) 3 = Italian 4 = German 5 = Japanese 6 = Portuguese				0	na	

Table E.34 Modbus Register Map[a] (Sheet 55 of 55)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Scale Factor	DeviceNet Parameter Numbers
	7 = Mandarin Chinese 8 = Russian 9 = Dutch						
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 = Settings Read Error Bit 1 = Setting Write Error Bit 2 = Settings Update Error Bit 3 = Settings Resource Error Bit 4 = Settings Locked Bit 5 = Group Settings Error Bit 6 = Global Settings Error Bit 7 = Logic Settings Error Bit 8 = Report Settings Error Bit 9 = Front Panel Settings Error Bit 10 = Memory Not Available Bit 11 = Settings Prep Error Bit 12 = Setting Changes Disabled Bit 13 = Memory Diag Error Bit 14 = Reserved 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 PT connection is DELTA.
[e] Read this register only when PT connection is WYE.

Appendix F
IEC 61850 Communications

Features

The SEL-751A relay supports the following features through use of Ethernet and IEC 61850:

- SCADA—Connect as many as six simultaneous IEC 61850 MMS client sessions. The SEL-751A 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-751A 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-751A:

- Introduction to IEC 61850
- IEC 61850 Operation
- IEC 61850 Configuration
- Logical Nodes
- Logical Node Extensions
- Protocol Implementation Conformance Statement
- ACSI Conformance Statement

Introduction to IEC 61850

In the early 1990s, the Electric Power Research Institute (EPRI) and the Institute of Electrical and Electronics Engineers, Inc. (IEEE) began to define a Utility Communications Architecture (UCA). They initially focused on inter-control center and substation-to-control center communications and produced the Inter-Control Center Communications Protocol (ICCP) specification. This specification, later adopted by the IEC as 60870-6 TASE.2, became the standard protocol for real-time exchange of data between databases.

In 1994, EPRI and IEEE began work on UCA 2.0 for Field Devices (simply referred to as UCA2). In 1997, they combined efforts with Technical Committee 57 of the IEC to create a common international standard. Their joint efforts created the current IEC 61850 standard.

The IEC 61850 standard, a superset of UCA2, contains most of the UCA2 specification, plus additional functionality. The standard describes client/server and peer-to-peer communications, substation design and configuration, testing, and project standards. The IEC 61850 standard consists of the parts listed in *Table F.1*.

Table F.1 IEC 61850 Document Set

IEC 61850 Sections	Definitions
IEC 61850-1	Introduction and overview
IEC 61850-2	Glossary
IEC 61850-3	General requirements
IEC 61850-4	System and project management
IEC 61850-5	Communication requirements
IEC 61850-6	Configuration description language for substation IEDs
IEC 61850-7-1	Basic communication structure for substations and feeder equipment-Principles and models
IEC 61850-7-2	Basic communication structure for substations and feeder equipment—Abstract Communication Service Interface (ACSI)
IEC 61850-7-3	Basic communication structure for substations and feeder equipment-Common data classes
IEC 61850-7-4	Basic communication structure for substations and feeder equipment—Compatible logical node (LN) classes and data classes
IEC 61850-8-1	SCSM-Mapping to Manufacturing Messaging Specification (MMS) (ISO/IEC 9506-1 and ISO/IEC 9506-2 over ISO/IEC 8802-3)
IEC 61850-9-1	SCSM-Sampled values over serial multidrop point-to-point link
IEC 61850-9-2	SCSM-Sampled values over ISO/IEC 8802-3
IEC 61850-10	Conformance testing

The IEC 61850 document set, available directly from the IEC at http://www.iec.ch, contains information necessary for successful implementation of this protocol. SEL strongly recommends that anyone involved with the design, installation, configuration, or maintenance of IEC 61850 systems be familiar with the appropriate sections of these documents.

IEC 61850 Operation

Ethernet Networking

IEC 61850 and Ethernet networking are available as options in the SEL-751A. In addition to IEC 61850, the Ethernet port provides support protocols and data exchange, including FTP and Telnet. Access the SEL-751A 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 defined by SEL. Refer to IEC 61850-5:2003(E) and IEC 61850-7-4:2003(E) for the mandatory content and usage of these LNs. The SEL-751A 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-751A. See Logical Nodes for a description of the LNs that make up these Logical Devices.

Table F.3 SEL-751A 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.18* 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-751A 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

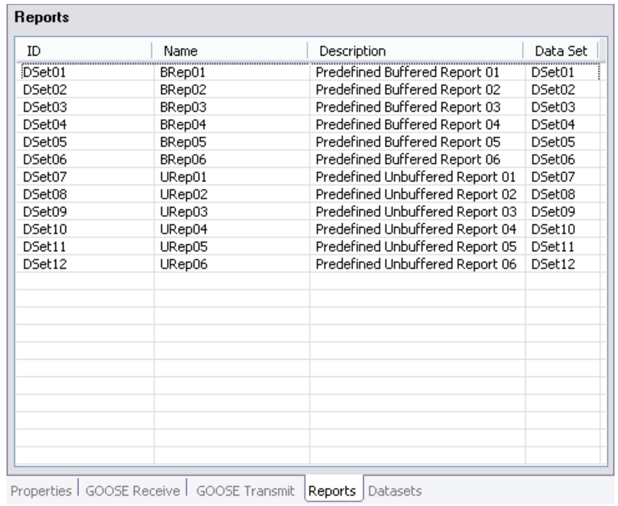
Substation Configuration Language (SCL) is an XML-based configuration language used to support the exchange of database configuration data between different tools, which may come from different manufacturers. There are four types of SCL files:

- 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-751A 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.


Reports

ID	Name	Description	Data Set
DSet01	BRep01	Predefined Buffered Report 01	DSet01
DSet02	BRep02	Predefined Buffered Report 02	DSet02
DSet03	BRep03	Predefined Buffered Report 03	DSet03
DSet04	BRep04	Predefined Buffered Report 04	DSet04
DSet05	BRep05	Predefined Buffered Report 05	DSet05
DSet06	BRep06	Predefined Buffered Report 06	DSet06
DSet07	URep01	Predefined Unbuffered Report 01	DSet07
DSet08	URep02	Predefined Unbuffered Report 02	DSet08
DSet09	URep03	Predefined Unbuffered Report 03	DSet09
DSet10	URep04	Predefined Unbuffered Report 04	DSet10
DSet11	URep05	Predefined Unbuffered Report 05	DSet11
DSet12	URep06	Predefined Unbuffered Report 06	DSet12

Properties | GOOSE Receive | GOOSE Transmit | Reports | Datasets

Figure F.1 SEL-751A 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 may edit the report parameters shown in *Table F.4*.

Table F.4 Buffered Report Control Block Client Access

RCB Attribute	User Changeable (Report Disabled)	User Changeable (Report Enabled)	Default Values
RptId	YES		Dset01 - Dset06
RptEna	YES	YES	FALSE
OptFlds	YES		seqNum timeStamp dataSet reasonCode configRef
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 may edit the report parameters shown in *Table F.5*.

Table F.5 Unbuffered Report Control Block Client Access

RCB Attribute	User changeable (Report Disabled)	User changeable (Report Enabled)	Default Values
RptId	YES		Dset07 - Dset12
RptEna	YES	YES	FALSE
Resv	YES		FALSE
OptFlds	YES		seqNum
			timeStamp
			dataSet
			reasonCode
			configRef
BufTm	YES		250
TrgOps	YES		dchg
			qchg
IntgPd	YES		0
GI		YES[a]	0

[a] Exhibits a pulse behavior. Write a one to issue the command. Once command is accepted 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-751A 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

Within ACSELERATOR Architect, IEC 61850 datasets have two main purposes:

- GOOSE: You can use predefined or edited datasets, or create new datasets for outgoing GOOSE transmission.
- Reports: Twelve predefined datasets (DSet01 to DSet12) correspond to the default six buffered and six unbuffered reports. Note that you cannot change the number (12) or type of reports (buffered or unbuffered) within ACSELERATOR Architect. However, you can alter the data attributes that a dataset contains and so define what data an IEC 61850 client

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.

receives with a report. The last dataset, DSet13, is a list of the Breaker Status and Control Data Attributes that are in the SEL-751A.

The list of datasets in *Figure F.2* is the default for an SEL-751A device.

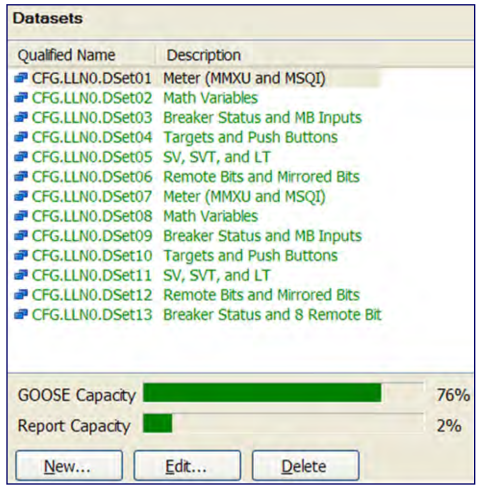


Figure F.2 SEL-751A Datasets

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-751A 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 data or quality.

The relay applies the time stamp to all data and quality attributes (Boolean, Bstrings, Analogs, etc.) in the same fashion as when it detects a data or quality change. However, there is a difference in how the relay detects the change between the different attribute types. For points that are assigned as SER points, i.e., programmed in the SER report, the relay detects the change as the receipt of an SER record (which contains the SER time stamp) within the relay.

For all other Booleans or Bstrings, the relay detects the change via the scanner, which compares the last state against the previous state to detect the change. For analogs, the scanner looks at the amount of change relative to the deadband configured for the point to indicate a change and apply the timestamp. In all cases, the relay uses these time stamps for the reporting model.

Functionally Constrained Data Attributes mapped to points assigned to the SER report have 4 ms SER-accurate 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-751A 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-751A 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-751A will set the Validity attribute to invalid and the Failure attribute to TRUE. Note that the SEL-751A 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.

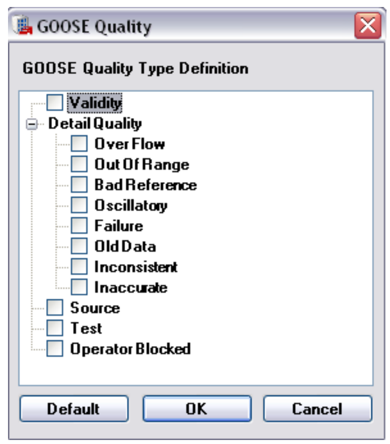


Figure F.3 GOOSE Quality

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-751A will transmit all configured GOOSE immediately upon successful initialization. If a GOOSE is not retriggered, then, following initial transmission, the SEL-751A 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 communication parameters (VLAN, Priority, and Multicast Address) and is transmitted entirely in a single network frame.
- The SEL-751A will maintain 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-751A to subscribe to as many as 16 incoming GOOSE messages.

  The SEL-751A will recognize incoming GOOSE messages as valid based on the following content. Any GOOSE message that fails these checks shall be rejected.
  - Source broadcast MAC address
  - Dataset Reference
  - Application ID
  - GOOSE Control Reference
- Rejection of all DA contained in an incoming GOOSE, based on the accumulation of the following error indications created by inspection of the received GOOSE:
  - **Configuration Mismatch**: the configuration number of the incoming GOOSE changes.
  - **Needs Commissioning**: this Boolean parameter of the incoming GOOSE is true.
  - **Test Mode**: this Boolean parameter of the incoming GOOSE is true.
  - **Decode Error**: the format of the incoming GOOSE is not as configured.
- The SEL-751A will discard 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® SEL-5032 Software.

ACSELERATOR Architect

Architect enables users to design and commission IEC 61850 substations containing SEL IEDs.Users can use Architect to do the following:

- Organize and configure all SEL IEDs in a substation project.
- Configure incoming and outgoing GOOSE messages.
- Edit and create GOOSE datasets.
- Read non-SEL IED Capability Description (ICD) and Configured IED Description (CID) files and determine the available IEC 61850 messaging options.
- Use or edit preconfigured datasets for reports.
- Load IEC 61850 CID files into SEL IEDs.
- Generate ICD and CID files that will provide SEL IED descriptions to other manufacturers' tools so they can use SEL GOOSE messages and reporting features.
- Edit dead-band settings for measured values.

Architect provides a Graphical User Interface (GUI) for users to select, edit, and create IEC 61850 GOOSE messages important for substation protection, coordination, and control schemes. Typically, the user first places icons representing IEDs in a substation container, then edits the outgoing GOOSE messages or creates new ones for each IED. The user can also select incoming GOOSE messages for each IED to receive from any other IEDs in the domain.

Some measured values are reported to IEC 61850 only when the value changes beyond a defined dead-band value. Architect allows a dead band to be changed during the CID file configuration. Check and set the dead-band values for your particular application when configuring the CID file for a device.

Architect has the capability to read other manufacturers' ICD and CID files, enabling the user to map the data seamlessly into SEL IED logic. See the Architect online help for more information.

SEL ICD File Versions

Architect generates CID files from ICD files so the ICD file version Architect uses also determines the CID file version generated. Details about the different SEL-751A ICD files can be found in Table A.7.

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 used 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 (Sheet 1 of 2)

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 LN-Instance-ID according to IEC 61850-7-2.		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
EEHealth	INS	External equipment health (RTD Communications Status)		E

Table F.9 Thermal Metering Data Logical Node Class Definition (Sheet 2 of 2)

MTHR Class				
Attribute Name	**Attr. Type**	**Explanation**	**T[a]**	**M/O/ C/E[b]**
Data Objects				
Measured Values				
MaxAmbTmp	MV	Maximum Ambient Temperature		E
MaxBrgTmp	MV	Maximum Bearing Temperature		E
MaxOthTmp	MV	Maximum Other Temperature		E
MaxWdgTmp	MV	Maximum Winding Temperature		E
Tmp	MV	Temperature		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension

Table F.10 defines the data class 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 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 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.

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 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
MinPhV	WYE	Minimum 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]**
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 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

Logical Nodes

The following tables, *Table F.15* through *Table F.19*, show the Logical Nodes (LN) supported in the SEL-751A and the associated Relay Word bits or measured quantities. *Table F.15* shows the LN associated with protection elements defined as Logical Device PRO.

Table F.15 Logical Device: PRO (Protection) (Sheet 1 of 5)

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

Table F.15 Logical Device: PRO (Protection) (Sheet 2 of 5)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = ST			
A55POPF1	Op.general	55A	Power factor alarm
A55POPF1	Str.general	55A	Power factor alarm
ATPTOC8	Op.general	51AT	Phase A time-overcurrent element trip
ATPTOC8	Str.general	51AP	Phase A time-overcurrent element pickup
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 physical operation capabilities not known to relay
BK1XCBR1	Loc.stVal	0	Breaker 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)
BTPTOC9	Op.general	51BT	Phase B time-overcurrent element trip
BTPTOC9	Str.general	51BP	Phase B time-overcurrent element pickup
CTPTOC10	Op.general	51CT	Phase C time-overcurrent element trip
CTPTOC10	Str.general	51CP	Phase C time-overcurrent element pickup
D1TPTOF1	Op.general	81D1T	Level 1 trip definite time over/underfrequency elements
D1TPTOF1	Str.general	81D1T	Level 1 trip definite time over/underfrequency elements
D2TPTOF2	Op.general	81D2T	Level 2 trip definite time over/underfrequency elements
D2TPTOF2	Str.general	81D2T	Level 2 trip definite time over/underfrequency elements
D3TPTOF3	Op.general	81D3T	Level 3 trip definite time over/underfrequency elements
D3TPTOF3	Str.general	81D3T	Level 3 trip definite time over/underfrequency elements
D4TPTOF4	Op.general	81D4T	Level 4 trip definite time over/underfrequency elements
D4TPTOF4	Str.general	81D4T	Level 4 trip definite time over/underfrequency elements
D5TPTOF5	Op.general	81D5T	Level 5 trip definite time over/underfrequency elements
D5TPTOF5	Str.general	81D5T	Level 5 trip definite time over/underfrequency elements
D6TPTOF6	Op.general	81D6T	Level 6 trip definite time over/underfrequency elements
D6TPTOF6	Str.general	81D6T	Level 6 trip definite time over/underfrequency elements
G1TPIOC9	Op.general	50G1T	Level 1 residual-ground instantaneous overcurrent element trip
G1TPIOC9	Str.general	50G1P	Level 1 residual-ground instantaneous overcurrent element pickup
G1TPTOC5	Op.general	51G1T	Level 1 residual-ground time-overcurrent element trip
G1TPTOC5	Str.general	51G1P	Level 1 residual-ground time-overcurrent element pickup
G1TPTOV6	Op.general	59G1T	Level 1 zero-sequence instantaneous overvoltage element trip
G1TPTOV6	Str.general	59G1	Level 1 zero-sequence instantaneous overvoltage element pickup

Table F.15 Logical Device: PRO (Protection) (Sheet 3 of 5)

Logical Node	Attribute	Data Source	Comment
G2TPIOC10	Op.general	50G2T	Level 2 residual-ground instantaneous overcurrent element trip
G2TPIOC10	Str.general	50G2P	Level 2 residual-ground instantaneous overcurrent element pickup
G2TPTOC6	Op.general	51G2T	Level 2 residual-ground time-overcurrent element trip
G2TPTOC6	Str.general	51G2P	Level 2 residual-ground time-overcurrent element pickup
G2TPTOV7	Op.general	59G2T	Zero-sequence instantaneous overvoltage element trip
G2TPTOV7	Str.general	59G2	Zero-sequence instantaneous overvoltage element pickup
G3TPIOC11	Op.general	50G3T	Level 3 residual-ground instantaneous overcurrent element trip
G3TPIOC11	Str.general	50G3P	Level 3 residual-ground instantaneous overcurrent element pickup
G4TPIOC12	Op.general	50G4T	Level 4 residual-ground instantaneous overcurrent element trip
G4TPIOC12	Str.general	50G4P	Level 4 residual-ground instantaneous overcurrent element pickup
LOPPTUV3	Op.general	LOP	Loss of Potential
LOPPTUV3	Str.general	LOP	Loss of Potential
N1TPIOC5	Op.general	50N1T	Level 1 neutral-ground instantaneous overcurrent element trip
N1TPIOC5	Str.general	50N1P	Level 1 neutral-ground instantaneous overcurrent element pickup
N1TPTOC3	Op.general	51N1T	Level 1 neutral-ground time-overcurrent element trip
N1TPTOC3	Str.general	51N1P	Level 1 neutral-ground time-overcurrent element pickup
N2TPIOC6	Op.general	50N2T	Level 2 neutral-ground instantaneous overcurrent element trip
N2TPIOC6	Str.general	50N2P	Level 2 neutral-ground instantaneous overcurrent element pickup
N2TPTOC4	Op.general	51N2T	Level 2 neutral-ground time-overcurrent element trip
N2TPTOC4	Str.general	51N2P	Level 2 neutral-ground time-overcurrent element pickup
N3TPIOC7	Op.general	50N3T	Level 3 neutral-ground instantaneous overcurrent element trip
N3TPIOC7	Str.general	50N3P	Level 3 neutral-ground instantaneous overcurrent element pickup
N4TPIOC8	Op.general	50N4T	Level 4 neutral-ground instantaneous overcurrent element trip
N4TPIOC8	Str.general	50N4P	Level 4 neutral-ground instantaneous overcurrent element pickup
NAFPIOC18	Op.general	50NAF	Sample based neutral overcurrent element
NAFPIOC18	Str.general	50NAF	Sample based neutral overcurrent element
P1TPIOC1	Op.general	50P1T	Level 1 phase instantaneous overcurrent element trip
P1TPIOC1	Str.general	50P1P	Level 1 phase instantaneous overcurrent element pickup
P1TPTOC1	Op.general	51P1T	Level 1 maximum phase time-overcurrent element trip
P1TPTOC1	Str.general	51P1P	Level 1 maximum phase time-overcurrent element pickup
P1TPTOV1	Op.general	59P1T	Level 1phase overvoltage element trip
P1TPTOV1	Str.general	59P1	Level 1phase overvoltage element pickup
P1TPTUV1	Op.general	27P1T	Level 1 phase undervoltage element trip
P1TPTUV1	Str.general	27P1	Level 1phase undervoltage element pickup
P2TPIOC2	Op.general	50P2T	Level 2 phase instantaneous overcurrent element trip
P2TPIOC2	Str.general	50P2P	Level 2 phase instantaneous overcurrent element pickup
P2TPTOC2	Op.general	51P2T	Level 2 maximum phase time-overcurrent element trip
P2TPTOC2	Str.general	51P2P	Level 2 maximum phase time-overcurrent element pickup
P2TPTOV2	Op.general	59P2T	Level 2 phase overvoltage element trip
P2TPTOV2	Str.general	59P2	Level 2 phase overvoltage element pickup
P2TPTUV2	Op.general	27P2T	Level 2 phase undervoltage element trip

Table F.15 Logical Device: PRO (Protection) (Sheet 4 of 5)

Logical Node	Attribute	Data Source	Comment
P2TPTUV2	Str.general	27P2	Level 2 phase undervoltage element pickup
P3PTOV3	Op.general	3P59	3-phase overvoltage pickup when all 3 phases are above 59P1P
P3PTOV3	Str.general	3P59	3-phase overvoltage pickup when all 3 phases are above 59P1P
P3PTUV4	Op.general	3P27	3-phase undervoltage pickup when all 3 phases are below 27P1P
P3PTUV4	Str.general	3P27	3-phase undervoltage pickup when all 3 phases are below 27P1P
P3TPIOC3	Op.general	50P3T	Level 3 phase instantaneous overcurrent element trip
P3TPIOC3	Str.general	50P3P	Level 3 phase instantaneous overcurrent element pickup
P4TPIOC4	Op.general	50P4T	Level 4 phase instantaneous overcurrent element trip
P4TPIOC4	Str.general	50P4P	Level 4 phase instantaneous overcurrent element pickup
PAFPIOC17	Op.general	50PAF	Sample based phase overcurrent element
PAFPIOC17	Str.general	50PAF	Sample based phase overcurrent element
PWR1PDOP1	Op.general	3PWR1T	3-phase power element 1 trip
PWR1PDOP1	Str.general	3PWR1P	3-phase power element 1 pickup
PWR1PDUP1	Op.general	3PWR1T	3-phase power element 1 trip
PWR1PDUP1	Str.general	3PWR1P	3-phase power element 1 pickup
PWR2PDOP1	Op.general	3PWR2T	3-phase power element 2 trip
PWR2PDOP1	Str.general	3PWR2P	3-phase power element 2 pickup
PWR2PDUP1	Op.general	3PWR2T	3-phase power element 2 trip
PWR2PDUP1	Str.general	3PWR2P	3-phase power element 2 pickup
Q1TPIOC13	Op.general	50Q1T	Level 1 negative-sequence instantaneous overcurrent element trip
Q1TPIOC13	Str.general	50Q1P	Level 1 negative-sequence instantaneous overcurrent element pickup
Q1TPTOV8	Op.general	59Q1T	Negative-sequence instantaneous overvoltage element trip
Q1TPTOV8	Str.general	59Q1	Negative-sequence instantaneous overvoltage element pickup
Q2TPIOC14	Op.general	50Q2T	Level 2 negative-sequence instantaneous overcurrent element trip
Q2TPIOC14	Str.general	50Q2P	Level 2 negative-sequence instantaneous overcurrent element pickup
Q2TPTOV9	Op.general	59Q2T	Negative-sequence instantaneous overvoltage element trip
Q2TPTOV9	Str.general	59Q2	Negative-sequence instantaneous overvoltage element pickup
Q3TPIOC15	Op.general	50Q3T	Level 3 negative-sequence instantaneous overcurrent element trip
Q3TPIOC15	Str.general	50Q3P	Level 3 negative-sequence instantaneous overcurrent element pickup
Q4TPIOC16	Op.general	50Q4T	Level 4 negative-sequence instantaneous overcurrent element trip
Q4TPIOC16	Str.general	50Q4P	Level 4 negative-sequence instantaneous overcurrent element pickup
QTPTOC7	Op.general	51QT	Negative-sequence time-overcurrent element trip
QTPTOC7	Str.general	51QP	Negative-sequence time-overcurrent element pickup
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
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
R3TPFRC3	Op.general	81R3T	Level 3 rate-of-change-of-frequency element trip

Table F.15 Logical Device: PRO (Protection) (Sheet 5 of 5)

Logical Node	Attribute	Data Source	Comment
R3TPFRC3	Str.general	81R3T	Level 3 rate-of-change-of-frequency element trip
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
S1TPTOV4	Op.general	59S1T	Level 1 VS channel overvoltage element with time delay
S1TPTOV4	Str.general	59S1	Level 1 VS channel overvoltage element pickup
S1TPTUV5	Op.general	27S1T	Level 1 VS channel undervoltage element with time delay
S1TPTUV5	Str.general	27S1	Level 1 VS channel undervoltage element pickup
S2TPTOV5	Op.general	59S2T	Level2 VS channel overvoltage element with time delay
S2TPTOV5	Str.general	59S2	Level 2 VS channel overvoltage element pickup
S2TPTUV6	Op.general	27S2T	Level 1 VS channel undervoltage element with time delay
S2TPTUV6	Str.general	27S2	Level 2 VS channel undervoltage element pickup
T55POPF2	Op.general	55T	Power factor trip
T55POPF2	Str.general	55T	Power factor trip
TOL1PAFD1	Op.general	TOL1	Arc-Flash Light Input 1 element pickup
TOL1PAFD1	Str.general	TOL1	Arc-Flash Light Input 1 element pickup
TOL2PAFD2	Op.general	TOL2	Arc-Flash Light Input 2 element pickup
TOL2PAFD2	Str.general	TOL2	Arc-Flash Light Input 2 element pickup
TOL3PAFD3	Op.general	TOL3	Arc-Flash Light Input 3 element pickup
TOL3PAFD3	Str.general	TOL3	Arc-Flash Light Input 3 element pickup
TOL4PAFD4	Op.general	TOL4	Arc-Flash Light Input 4 element pickup
TOL4PAFD4	Str.general	TOL4	Arc-Flash Light Input 4 element pickup
TRIPPTRC	Tr.general	TRIP	Trip logic output

[a] Writing a 0 to BKR1CSWI1.CO.Pos.Oper.ctlVal will cause OC to assert and writing any other value will cause CC to assert.
[b] If breaker is closed, value = 10(2). If breaker is opened, value = 01(1).

Table F.16 shows the LN associated with measuring elements defined as Logical Device MET.

Table F.16 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[ab]			
DCZBAT1	Vol.instMag.f	VDC	Station dc battery voltage
METMDST1	DmdA.nseq.instCVal.mag.f	3I2D	Negative-sequence current demand
METMDST1	DmdA.phsA.instCVal.mag.f	IAD	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

Table F.16 Logical Device: MET (Metering) (Sheet 2 of 4)

Logical Node	Attribute	Data Source	Comment
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	PhV.phsA.instCVal.ang.f	VA_ANG	Voltage, A-phase-to-neutral, angle
METMMXU1	PhV.phsA.instCVal.mag.f	VA_MAG	Voltage, A-phase-to-neutral, magnitude
METMMXU1	PhV.phsB.instCVal.ang.f	VB_ANG	Voltage, B-phase-to-neutral, angle
METMMXU1	PhV.phsB.instCVal.mag.f	VB_MAG	Voltage, B-phase-to-neutral, magnitude
METMMXU1	PhV.phsC.instCVal.ang.f	VC_ANG	Voltage, C-phase-to-neutral, angle
METMMXU1	PhV.phsC.instCVal.mag.f	VC_MAG	Voltage, C-phase-to-neutral, magnitude
METMMXU1	PhV.res.instCVal.ang.f	VG_ANG	Zero-sequence voltage, angle
METMMXU1	PhV.res.instCVal.mag.f	VG_MAG	Zero-sequence voltage, magnitude
METMMXU1	PPV.phsAB.instCVal.ang.f	VAB_ANG	Voltage, A-to-B-phase, angle
METMMXU1	PPV.phsAB.instCVal.mag.f	VAB_MAG	Voltage, A-to-B-phase, magnitude
METMMXU1	PPV.phsBC.instCVal.ang.f	VBC_ANG	Voltage, B-to-C-phase, angle
METMMXU1	PPV.phsBC.instCVal.mag.f	VBC_MAG	Voltage, B-to-C-phase, magnitude
METMMXU1	PPV.phsCA.instCVal.ang.f	VCA_ANG	Voltage, C-to-A-phase, angle
METMMXU1	PPV.phsCA.instCVal.mag.f	VCA_MAG	Voltage, C-to-A-phase, magnitude
METMMXU1	TotPF.instMag.f	PF	Power factor, 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
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

Table F.16 Logical Device: MET (Metering) (Sheet 3 of 4)

Logical Node	Attribute	Data Source	Comment
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
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

Table F.16 Logical Device: MET (Metering) (Sheet 4 of 4)

Logical Node	Attribute	Data Source	Comment
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[c]	Maximum bearing RTD temperature
THERMMTHR1	MaxOthTmp.instMag.f	RTDOTHMX[c]	Other maximum RTD temperature
THERMMTHR1	MaxWdgTmp.instMag.f	RTDWDGMX[c]	Maximum winding RTD temperature
THERMMTHR1	Tmp01.instMag.f –Tmp12.instMag.f	RTD1 - RTD12[c]	RTD1 - RTD12 temperature
Functional Constraint = ST			
DCZBAT1	BatHi.stVal	DCHI	Station dc battery instantaneous overvoltage element
DCZBAT1	BatLo.stVal	DCLO	Station dc battery instantaneous undervoltage element
THERMMTHR1	EEHealth.stVal	RTDFLT?1:3[c]	RTD input or communication status

[a] MX values contain instantaneous attributes (instMag and instCVal), which are updated whenever the source updates and other attributes which are only updates when the source goes outside the data source's deadband (mag and cVal). Only the instantaneous values are shown in the table.
[b] Data validity depends on the relay model and installed card options. Refer to Section 1: Introduction and Specifications for different relay models and available 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.17*shows the LN associated with control elements defined as Logical Device CON.

Table F.17 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.18 shows the LN associated with annunciation elements defined as Logical Device ANN.

Table F.18 Logical Device: ANN (Annunciation) (Sheet 1 of 5)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PARTNO	Part number

Table F.18 Logical Device: ANN (Annunciation) (Sheet 2 of 5)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = MX[a]			
AINCGGIO21	AnIn01.instMag.f–AnIn08.instMag.f	AI301–AI308[b]	Analog Inputs (AI301 to AI308)—Slot C
AINDGGIO22	AnIn01.instMag.f–AnIn08.instMag.f	AI401–AI408[b]	Analog Inputs (AI401 to AI408)—Slot D
AINEGGIO23	AnIn01.instMag.f–AnIn08.instMag.f	AI501–AI508[b]	Analog Inputs (AI501 to AI508)—Slot E
BWASCBR1	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
LSGGIO31	AnIn01.instMag.f–AnIn04.instMag.f	LSENS1–LSENS4[c]	Arc-flash sensor light (LSENS1-LSENS8)
MVGGIO12	AnIn01.instMag.f–AnIn32.instMag.f	MV01–MV32[d]	Math Variables (MV01 to MV32)
PWRGGIO30	AnIn01.instMag.f	KWADI[e]	Real power, A-phase demand IN
PWRGGIO30	AnIn02.instMag.f	KWBDI[e]	Real power, B-phase demand IN
PWRGGIO30	AnIn03.instMag.f	KWCDI[e]	Real power, C-phase demand IN
PWRGGIO30	AnIn04.instMag.f	KW3DI[e]	Real power, 3-phase demand IN
PWRGGIO30	AnIn05.instMag.f	KVARADI[e]	Reactive power, A-phase demand IN
PWRGGIO30	AnIn06.instMag.f	KVARBDI[e]	Reactive power, B-phase demand IN
PWRGGIO30	AnIn07.instMag.f	KVARCDI[e]	Reactive power, C-phase demand IN
PWRGGIO30	AnIn08.instMag.f	KVAR3DI[e]	Reactive power, 3-phase demand IN
PWRGGIO30	AnIn09.instMag.f	KWADO[e]	Real power, A-phase demand OUT
PWRGGIO30	AnIn10.instMag.f	KWBDO[e]	Real power, B-phase demand OUT
PWRGGIO30	AnIn11.instMag.f	KWCDO[e]	Real power, C-phase demand OUT
PWRGGIO30	AnIn12.instMag.f	KW3DO[e]	Real power, 3-phase demand OUT
PWRGGIO30	AnIn13.instMag.f	KVARADO[e]	Reactive power, A-phase demand OUT
PWRGGIO30	AnIn14.instMag.f	KVARBDO[e]	Reactive power, B-phase demand OUT
PWRGGIO30	AnIn15.instMag.f	KVARCDO[e]	Reactive power, C-phase demand OUT
PWRGGIO30	AnIn16.instMag.f	KVAR3DO[e]	Reactive power, 3-phase demand OUT
PWRGGIO30	AnIn17.instMag.f	KWAPDI[e]	Real power, A-phase peak demand IN
PWRGGIO30	AnIn18.instMag.f	KWBPDI[e]	Real power, B-phase peak demand IN
PWRGGIO30	AnIn19.instMag.f	KWCPDI[e]	Real power, C-phase peak demand IN
PWRGGIO30	AnIn20.instMag.f	KW3PDI[e]	Real power, 3-phase peak demand IN
PWRGGIO30	AnIn21.instMag.f	KVARAPDI[e]	Reactive power, A-phase peak demand IN
PWRGGIO30	AnIn22.instMag.f	KVARBPDI[e]	Reactive power, B-phase peak demand IN
PWRGGIO30	AnIn23.instMag.f	KVARCPDI[e]	Reactive power, C-phase peak demand IN
PWRGGIO30	AnIn24.instMag.f	KVAR3PDI[e]	Reactive power, 3-phase peak demand IN
PWRGGIO30	AnIn25.instMag.f	KWAPDO[e]	Real power, A-phase peak demand OUT
PWRGGIO30	AnIn26.instMag.f	KWBPDO[e]	Real power, B-phase peak demand OUT
PWRGGIO30	AnIn27.instMag.f	KWCPDO[e]	Real power, C-phase peak demand OUT
PWRGGIO30	AnIn28.instMag.f	KW3PDO[e]	Real power, 3-phase peak demand OUT
PWRGGIO30	AnIn29.instMag.f	KVARAPDO[e]	Reactive power, A-phase peak demand OUT

Table F.18 Logical Device: ANN (Annunciation) (Sheet 3 of 5)

Logical Node	Attribute	Data Source	Comment
PWRGGIO30	AnIn30.instMag.f	KVARBPDO[e]	Reactive power, B-phase peak demand OUT
PWRGGIO30	AnIn31.instMag.f	KVARCPDO[e]	Reactive power, C-phase peak demand OUT
PWRGGIO30	AnIn32.instMag.f	KVAR3PDO[e]	Reactive power, 3-phase peak demand OUT
SCGGIO20	AnIn01.instMag.f–AnIn32.instMag.f	SC01–SC32[f]	SELOGIC Counters (SC01 to SC32)
Functional Constraint = ST			
BWASCBR1	ColOpn.stVal	OC	Open breaker
BWBSCBR2	ColOpn.stVal	OC	Open breaker
BWCSCBR3	ColOpn.stVal	OC	Open breaker
INAGGIO1	Ind01.stVal–Ind02.stVal	IN101–IN102	Digital Inputs (IN101 to IN102)—Slot A
INCGGIO13	Ind01.stVal–Ind08.stVal	IN301–IN308[b]	Digital Inputs (IN301 to IN308)—Slot C
INDGGIO15	Ind01.stVal–Ind08.stVal	IN401–IN408[b]	Digital Inputs (IN401 to IN408)—Slot D
INEGGIO17	Ind01.stVal–Ind08.stVal	IN501–IN508[b]	Digital Inputs (IN501 to IN508)—Slot E
LBGGIO27	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)
MBOKGGIO28	Ind01.stVal	ROKA	Channel A, received data ok
MBOKGGIO28	Ind02.stVal	RBADA	Channel A, outage duration over threshold
MBOKGGIO28	Ind03.stVal	CBADA	Channel A, channel unavailability over threshold
MBOKGGIO28	Ind04.stVal	LBOKA	Channel A, looped back ok
MBOKGGIO28	Ind05.stVal	ROKB	Channel B, received data ok
MBOKGGIO28	Ind06.stVal	RBADB	Channel B, outage duration over threshold
MBOKGGIO28	Ind07.stVal	CBADB	Channel B, channel unavailability over threshold
MBOKGGIO28	Ind08.stVal	LBOKB	Channel B, looped back ok
MISCGGIO29	Ind01.stVal–Ind03.stVal	SG1–SG3	Setting Group 1 to 3 selection
MISCGGIO29	Ind04.stVal	HALARM	Indication of a diagnostic failure or warning that warrants an ALARM
MISCGGIO29	Ind05.stVal	SALARM	Indication of software or user activity that warrants an ALARM
MISCGGIO29	Ind06.stVal	WARNING	Relay Word WARNING
MISCGGIO29	Ind07.stVal	IRIGOK	IRIG-B time synch input data is valid
MISCGGIO29	Ind08.stVal	TSOK	Time synchronization OK
MISCGGIO29	Ind09.stVal	DST	Daylight savings time active
MISCGGIO29	Ind10.stVal	LINKA	Asserted when a valid link is detected on Port 1A
MISCGGIO29	Ind11.stVal	LINKB	Asserted when a valid link is detected on Port 1B
MISCGGIO29	Ind12.stVal	LINKFAIL	Asserted when a valid link is not detected on the active port(s)
MISCGGIO29	Ind13.stVal	PASEL	Asserted when port 1A is active
MISCGGIO29	Ind14.stVal	PBSEL	Asserted when port 1B is active
MISCGGIO29	Ind15.stVal	COMMLOSS	DeviceNet communication failure
MISCGGIO29	Ind16.stVal	COMMFLT	DeviceNet internal communication failure
OUTAGGIO2	Ind01.stVal–Ind03.stVal	OUT101–OUT103	Digital Outputs (OUT101 to OUT103)—Slot A
OUTCGGIO14	Ind01.stVal–Ind04.stVal	OUT301–OUT304[b]	Digital Outputs (OUT301 to OUT304)—Slot C

Table F.18 Logical Device: ANN (Annunciation) (Sheet 4 of 5)

Logical Node	Attribute	Data Source	Comment
OUTDGGIO16	Ind01.stVal–Ind04.stVal	OUT401–OUT404[b]	Digital Outputs (OUT401 to OUT404)—Slot D
OUTEGGIO18	Ind01.stVal–Ind04.stVal	OUT501–OUT504[b]	Digital Outputs (OUT501 to OUT504)—Slot E
PBLEDGGIO7	Ind01.stVal	PB1A_LED	Pushbutton PB1A LED
PBLEDGGIO7	Ind02.stVal	PB1B_LED	Pushbutton PB1B LED
PBLEDGGIO7	Ind03.stVal	PB2A_LED	Pushbutton PB2A LED
PBLEDGGIO7	Ind04.stVal	PB2B_LED	Pushbutton PB2B LED
PBLEDGGIO7	Ind05.stVal	PB3A_LED	Pushbutton PB3A LED
PBLEDGGIO7	Ind06.stVal	PB3B_LED	Pushbutton PB3B LED
PBLEDGGIO7	Ind07.stVal	PB4A_LED	Pushbutton PB4A LED
PBLEDGGIO7	Ind08.stVal	PB4B_LED	Pushbutton PB4B LED
PROGGIO25	Ind01.stVal	AFALARM	Arc-flash system integrity alarm
PROGGIO25	Ind02.stVal	FREQTRK	Frequency tracking enable bit
PROGGIO25	Ind03.stVal–Ind06.stVal	AFS1EL–AFS4EL[c]	AF Light Input 1-4 excessive ambient light pickup
PROGGIO25	Ind07.stVal	CLOSE	Close logic output
PROGGIO25	Ind08.stVal	CF	Close condition failure (asserts for ¼ cycle)
PROGGIO25	Ind09.stVal	RCSF	Reclose supervision failure (asserts for ¼ cycle)
PROGGIO25	Ind10.stVal	OPTMN	Open interval timer is timing
PROGGIO25	Ind11.stVal	RSTMN	Reset timer is timing
PROGGIO25	Ind12.stVal	PHDEM	Phase current demand pickup
PROGGIO25	Ind13.stVal	3I2DEM	Negative-sequence current demand pickup
PROGGIO25	Ind14.stVal	GNDEM	Zero-sequence current demand pickup
PROGGIO25	Ind15.stVal	59VP	Phase voltage window element (selected phase voltage [VP] between settings 25VLO and 25VHI)
PROGGIO25	Ind16.stVal	59VS	VS channel voltage window element (selected phase voltage [VS] between settings 25VLO and 25VHI)
PROGGIO25	Ind17.stVal	SF	Slip frequency of voltages VP and VS and less than setting 25SF
PROGGIO25	Ind18.stVal	81RFBLK	Fast rate-of-change overall block logic output
PROGGIO25	Ind19.stVal	81RFT	Fast rate-of-change trip output
PROGGIO25	Ind20.stVal	81RFBL	Fast rate-of-change block output SELOGIC
PROGGIO25	Ind21.stVal	81RFP	Fast rate-of-change pickup
PROGGIO25	Ind22.stVal	81RFI	Fast rate-of-change initiate
PROGGIO25	Ind23.stVal	25A1	Level 1 synchronism-check element
PROGGIO25	Ind24.stVal	25A2	Level 2 synchronism-check element
RCGGIO26	Ind01.stVal	79RS	Reclosing relay in reset state
RCGGIO26	Ind02.stVal	79CY	Reclosing relay in reclose cycle state
RCGGIO26	Ind03.stVal	79LO	Reclosing relay in lockout state
RCGGIO26	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[i]	SELOGIC Variable Timers (SV01T to SV32T)

Table F.18 Logical Device: ANN (Annunciation) (Sheet 5 of 5)

Logical Node	Attribute	Data Source	Comment
TLEDGGIO6	Ind01.stVal	ENABLED	ENABLED LED
TLEDGGIO6	Ind02.stVal	TRIP_LED	TRIP LED
TLEDGGIO6	Ind03.stVal–Ind08.stVal	TLED_01–TLED_06	Target LEDs TLED_01 to TLED_06
TMBAGGIO9	Ind01.stVal–Ind08.stVal	TMB1A–TMB8A	Transmit MIRRORED BITS (TMB1A to TMB8A)
TMBBGGIO11	Ind01.stVal–Ind08.stVal	TMB1B–TMB8B	Transmit MIRRORED BITS (TMB1B to TMB8B)
TRIPGGIO24	Ind01.stVal	AMBTRIP	Ambient temperature trip
TRIPGGIO24	Ind02.stVal	BRGTRIP	Bearing temperature trip
TRIPGGIO24	Ind03.stVal	FAULT	Indicates fault condition
TRIPGGIO24	Ind04.stVal	OTHTRIP	Other temperature trip
TRIPGGIO24	Ind05.stVal	REMTRIP	Remote trip
TRIPGGIO24	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
TRIPGGIO24	Ind07.stVal	ULTRIP	Unlatch (auto reset) trip from SELOGIC equation
TRIPGGIO24	Ind08.stVal	WDGTRIP	Winding temperature trip
VBGGIO19	Ind001.stVal–Ind128.stVal	VB001–VB128	Virtual Bits (VB001 to VB128)

[a] MX values contain instantaneous attributes (instMag and instCVal), which are updated whenever the source updates and other attributes which are only updated when the source goes outside the data source's deadband (mag and cVal). Only the instantaneous values are shown in the table.
[b] Active data only if optional I/O card is installed in the slot.
[c] Active data only if optional Arc-Flash card is installed.
[d] Active data depend on the EMV setting.
[e] Data validity depends on the relay models and installed card options. Refer to Section 1: Introduction and Specifications for different relay models and available card options. Refer to Section 5: Metering and Monitoring for the model dependent metering quantities.
[f] Active data depends on the ESC setting.
[g] Active data depends on the ELB setting.
[h] Active data depends on the ELAT setting.
[i] Active data depends on the ESV setting.

Table F.19 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 the standard explicitly dictates which services and functions must be implemented to achieve conformance, so only the optional services and functions are listed.

Table F.20 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.21 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.22* 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.22 MMS Service Supported Conformance (Sheet 1 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
status		Y
getNameList		Y
identify		Y
rename		
read		Y
write		Y
getVariableAccessAttributes		Y
defineNamedVariable		
defineScatteredAccess		
getScatteredAccessAttributes		
deleteVariableAccess		
defineNamedVariableList		

Table F.22 MMS Service Supported Conformance (Sheet 2 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
getNamedVariableListAttributes		Y
deleteNamedVariableList		
defineNamedType		
getNamedTypeAttributes		
deleteNamedType		
input		
output		
takeControl		
relinquishControl		
defineSemaphore		
deleteSemaphore		
reportPoolSemaphoreStatus		
reportSemaphoreStatus		
initiateDownloadSequence		
downloadSegment		
terminateDownloadSequence		
initiateUploadSequence		
uploadSegment		
terminateUploadSequence		
requestDomainDownload		
requestDomainUpload		
loadDomainContent		
storeDomainContent		
deleteDomain		
getDomainAttributes		Y
createProgramInvocation		
deleteProgramInvocation		
start		
stop		
resume		
reset		
kill		
getProgramInvocationAttributes		
obtainFile		
defineEventCondition		
deleteEventCondition		
getEventConditionAttributes		
reportEventConditionStatus		
alterEventConditionMonitoring		
triggerEvent		
defineEventAction		

Table F.22 MMS Service Supported Conformance (Sheet 3 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
deleteEventAction		
alterEventEnrollment		
reportEventEnrollmentStatus		
getEventEnrollmentAttributes		
acknowledgeEventNotification		
getAlarmSummary		
getAlarmEnrollmentSummary		
readJournal		
writeJournal		
initializeJournal		
reportJournalStatus		
createJournal		
deleteJournal		
fileOpen		
fileRead		
fileClose		
fileRename		
fileDelete		
fileDirectory		
unsolicitedStatus		
informationReport		Y
eventNotification		
attachToEventCondition		
attachToSemaphore		
conclude		Y
cancel		Y
getDataExchangeAttributes		
exchangeData		
defineAccessControlList		
getAccessControlListAttributes		
reportAccessControlledObjects		
deleteAccessControlList		
alterAccessControl		
ReconfigureProgramInvocation		

Table F.23 lists specific settings for the MMS parameter Conformance Building Block (CBB).

Table F.23 MMS Parameter CBB

MMS Parameter CBB	Client-CR Supported	Server-CR Supported
STR1		Y
STR2		Y
VNAM		Y
VADR		Y
VALT		Y
TPY		Y
VLIS		Y
CEI		

The following Variable Access conformance statements are listed in the order specified in the IEC 61850 standard, Part 8-1. Generally, only those services whose implementation is not mandatory are shown. Refer to the IEC 61850 standard Part 8-1 for more information.

Table F.24 Alternate Access Selection Conformance Statement

Alternate Access Selection	Client-CR Supported	Server-CR Supported
accessSelection		Y
component		Y
index		
indexRange		
allElements		
alternateAccess		Y
selectAccess		Y
component		Y
index		
indexRange		
allElements		

Table F.25 VariableAccessSpecification Conformance Statement

VariableAccessSpecification	Client-CR Supported	Server-CR Supported
listOfVariable		Y
variableSpecification		Y
alternateAccess		Y
variableListName		Y

Table F.26 VariableSpecification Conformance Statement

VariableSpecification	Client-CR Supported	Server-CR Supported
name		Y
address		
variableDescription		
scatteredAccessDescription		
invalidated		

Table F.27 Read Conformance Statement

Read	Client-CR Supported	Server-CR Supported
Request		
specificationWithResult		
variableAccessSpecification		
Response		
variableAccessSpecification		Y
listOfAccessResult		Y

Table F.28 GetVariableAccessAttributes Conformance Statement

GetVariableAccessAttributes	Client-CR Supported	Server-CR Supported
Request		
name		
address		
Response		
mmsDeletable		Y
address		
typeSpecification		Y

Table F.29 DefineNamedVariableList Conformance Statement

DefineVariableAccessAttributes	Client-CR Supported	Server-CR Supported
Request		
variableListName		
listOfVariable		
variableSpecification		
alternateAccess		
Response		

Table F.30 GetNamedVariableListAttributes Conformance Statement

GetNamedVariableListAttributes	Client-CR Supported	Server-CR Supported
Request		
ObjectName		
Response		
mmsDeletable		Y
listOfVariable		Y
variableSpecification		Y
alternateAccess		Y

Table F.31 DeleteNamedVariableList

DeleteNamedVariableList	Client-CR Supported	Server-CR Supported
Request		
Scope		
listOfVariableListName		
domainName		
Response		
numberMatched		
numberDeleted		
DeleteNamedVariableList-Error		

GOOSE Services Conformance Statement

Table F.32 GOOSE Conformance

	Subscriber	Publisher	Value/Comment
GOOSE Services	Y	Y	
SendGOOSEMessage		Y	
GetGoReference			
GetGOOSEElementNumber			
GetGoCBValues		Y	
SetGoCBValues			
GSENotSupported			
GOOSE Control Block (GoCB)		Y	

ACSI Conformance Statements

Table F.33 ACSI Basic Conformance Statement

		Client/Subscriber	Server/Publisher	SEL-751A 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.34 ACSI Models Conformance Statement (Sheet 1 of 2)

		Client/Subscriber	Server/Publisher	SEL-751A 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.34 ACSI Models Conformance Statement (Sheet 2 of 2)

		Client/Subscriber	Server/Publisher	SEL-751A 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.35 ACSI Services Conformance Statement (Sheet 1 of 4)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-751A 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.35 ACSI Services Conformance Statement (Sheet 2 of 4)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-751A 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.35 ACSI Services Conformance Statement (Sheet 3 of 4)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-751A 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.35 ACSI Services Conformance Statement (Sheet 4 of 4)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-751A 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)			2-10 (1 ms)	T1
T2	Time accuracy of internal clock				10/9
	T1				YES
	T2				YES
	T3				YES
	T4				YES
T3	Supported TimeStamp resolution (nearest negative power of 2 in seconds)			2-10 (1 ms)	10

[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 the DeviceNet communications features supported by the SEL-751A 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.

The BLOCK MODBUS SET setting is used to block relay settings changes via Modbus or DeviceNet protocols. The factory-default setting, BLKMBSET := NONE, allows all setting changes via Modbus or DeviceNet communications. The BLKMBSET := R_S setting prevents Modbus or DeviceNet communications from resetting to the factory-default settings. The BLKMBSET := ALL setting blocks all changes to the settings via the Modbus or the DeviceNet protocol.

NOTE: Be aware of the following setting in the relay: Under Global settings =====>> Access Control, there is a setting called BLOCK MODBUS SET.

The customer is strongly advised to change the BLKMBSET (BLOCK MODBUS SET) := ALL if they (customer) do not want the PLC (Programmable Logic Controller) or DCS (Distributed Control System) to send the settings to the SEL-751A relay. There is a strong possibility that under special conditions like a reboot, the PLC/DCS will send default settings to the relay, overwriting the existing settings. To protect the existing settings under these conditions it is highly recommended to set the setting to "ALL."

DeviceNet Card

The DeviceNet Card is an optional accessory that enables connection of the SEL-751A to the DeviceNet automation network. The card (see *Figure G.1*) occupies the communications expansion Slot **C** in the relay.

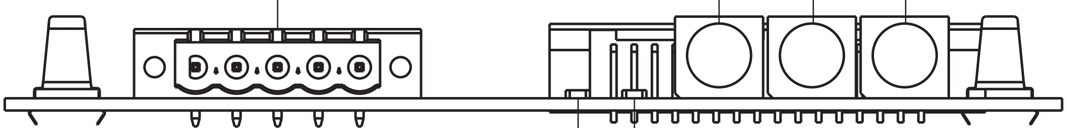

Figure G.1 DeviceNet Card Component Overview

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-751A 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-751A 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-751A, SEL-xxxRxxx.EDS, is located on the SEL-751A 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-751A Feeder Protection Relay provides Phasor Measurement Control Unit (PMCU) 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 at precise instants in time. 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-751A relays, to synchronize the gathering of power system data. The accurate clock allows precise event report triggering and other off-line analysis functions.

The SEL-751A Global settings class contains the synchrophasor settings, including the choice of transmitted synchrophasor data set. The Port settings class selects which serial port(s) you can use for synchrophasor protocol. See *Settings for Synchrophasors on page H.4*.

The SEL-751A 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.8*.

When synchrophasor measurement is enabled, the SEL-751A 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.9*.

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-751A 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
- 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-751A supports the protocol portion of the IEEE C37.118, Standard for Synchrophasors for Power Systems. In the SEL-751A, this protocol is referred to simply as C37.118. See *Settings Affect Message Contents on page H.10*.

Synchrophasor Measurement

The phasor measurement unit in the SEL-751A measures four voltages (V_A, V_B, V_C, and V_{sync}) and four currents (I_A, I_B, I_C, and I_N) on a constant-time basis. These samples are time-stamped with the IRIG time source. 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-751A synchrophasor values directly to values from other phasor measurement units that conform to C37.118. Synchrophasor values are available for the full frequency range of the SEL-751A.

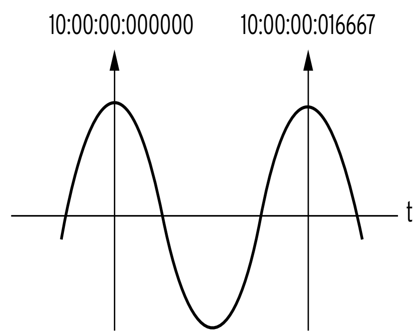

Figure H.1 Phase Reference

The TSOK Relay Word bit asserts when the SEL-751A 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 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 and ICOMP settings can be positive or negative values.

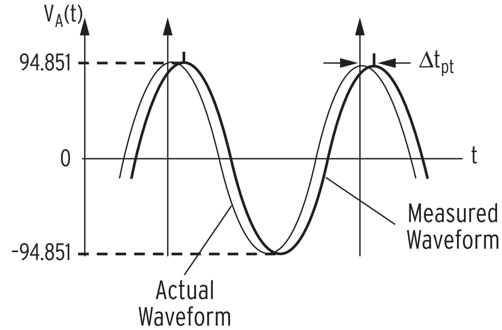

Figure H.2 Waveform at Relay Terminals May Have a Phase Shift

$$\text{Compensation Angle} = \frac{\Delta t_{pt}}{\left(\frac{1}{freq_{nominal}}\right)} \cdot 360° = \Delta t_{pt} \cdot freq_{nominal} \cdot 360°$$ **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:

$$0.784 \cdot 10^{-3}s \cdot 60s^{-1} \cdot 360° = 16.934°$$ **Equation H.2**

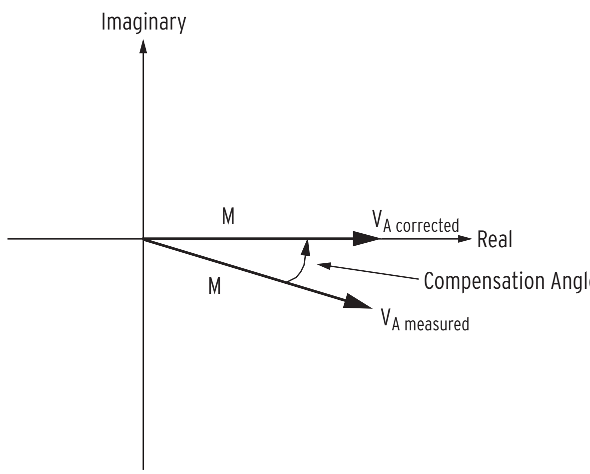

Figure H.3 Correction of Measured Phase Angle

The phasors are rms values scaled in primary units, as determined by Group setting PTR, PTRS (for sync 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 will almost always show 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-751A synchrophasor settings are available. No synchrophasor data collection can take place when EPMU := N.

You must make the serial port settings in *Table H.2* to transmit data with a synchrophasor protocol. It is possible to set EPMU := Y without using any serial ports for synchrophasor protocols. For example, the serial port **MET PM** ASCII command can still be used.

Table H.1 PMU Settings in the SEL-751A for C37.118 Protocol in Global Settings

Setting	Description	Default
EPMU	Enable Synchronized Phasor Measurement (Y, N)	N[a]
MRATE	Messages per Second {1, 2, 5, 10}	10
PMSTN	Station Name (16 characters)	SEL-751A 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
PHDATAI	Phasor Data Set, Currents (I1, ALL, NA)	NA
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
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.

The Port settings for PROTO := PMU, shown in *Table H.2*, do not include the settings DATABIT and PARITY; these two settings are internally fixed as DATABIT := 8, PARITY := N (None). See *Section 7: Communications* for descriptions of these functions.

Table H.2 SEL-751A Serial Port Settings for Synchrophasors

Setting	Description	Default
PROTO	Protocol (SEL, MOD, EVMSG, PMU, MBA, MBB, MB8A, MB8B, MBTA, MBTB)[a, b]	SEL[c]
SPEED	Data Speed (300, 1200, 2400, 4800, 9600, 19200, 38400 bps)	9600
STOPBIT	Stop Bits (1, 2)	1
RTSCTS	HDWR HANDSHAKING (Y, N)	N

[a] Some of the other PROTO setting choices may not be available.
[b] Setting choice PMU is not available on PORT 1.
[c] Set PROTO := PMU to enable (on this port) the synchrophasor protocol.

PROTO := PMU Does Not Allow Commands on That Serial Port

You can make the PROTO := PMU settings choice in *Table H.2* even when Global setting EPMU := N. However, in this situation, the serial port will not respond to any commands or requests. Either enable synchrophasors by making the *Table H.1* settings, or change the port PROTO setting to SEL.

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 will lose the ability to communicate with the relay through ASCII commands or virtual file interface 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 disabled port PROTO setting back to SEL.

Descriptions of Synchrophasor Settings

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 six settings that determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size. See *Communications Bandwidth on page H.10* for detailed information.

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 and VCOMP

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 six settings that determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size—see *Communications Bandwidth on page H.10* for detailed information.

- PHDATAV := V1 will transmit only positive-sequence voltage, V_1
- PHDATAV := ALL will transmit V_1, V_A, V_B, V_C, and V_S (if available)
- PHDATAV := NA will not transmit any voltages

Table H.3 describes the order of synchrophasors inside the data packet.

The VCOMP setting allows 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 five settings that determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size—see *Communications Bandwidth on page H.10* for detailed information.

- PHDATAI := I1 will transmit only positive-sequence current, I_1
- PHDATAI := ALL will transmit I_1, I_A, I_B, I_C, and I_N
- PHDATAI := NA will not transmit any currents

Table H.3 describes the order of synchrophasors inside the data packet.

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.3 Synchrophasor Order in Data Stream (Voltages and Currents)

Synchrophasors[a]		Included When Global Settings Are as Follows:
Polar		
Magnitude	Angle	
V_1	V_1	PHDATAV := V1 or ALL
V_A	V_A	PHDATAV := ALL
V_B	V_B	
V_C	V_C	
V_S	V_S	
I_1	I_1	PHDATAI := I1 or ALL
I_A	I_A	PHDATAI := ALL
I_B	I_B	
I_C	I_C	
I_N	I_N	

[a] Synchrophasors are included in the order shown (i.e., voltages, if selected, will always precede currents).

NUMANA

Selects the number of user-definable analog values to be included in the synchrophasor data stream.

This setting is one of six settings that determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size—see *Communications Bandwidth on page H.10* 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.4*.

The format of the user-defined analog data are always floating point, and each value occupies four bytes.

Table H.4 User-Defined Analog Values Selected by the NUMANA Setting

NUMANA Setting	Analog Quantities Sent	Total Number of Bytes Used for Analog Values
0	None	0
1	MV29	4
2	Above, plus MV30	8
3	Above, plus MV31	12
4	Above, plus MV32	16

NUMDSW

Selects the number of user-definable digital status words to be included in the synchrophasor data stream.

This setting is one of six settings that determine the minimum port SPEED necessary to support the synchrophasor data packet rate and size—see *Communications Bandwidth on page H.10* 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.5*.

Table H.5 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-751A 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-751A 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 time to allow the synchrophasor processor to read the TREA1–TREA4 fields.

The SEL-751A automatically sets the TREA1–TREA4 or PMTRIG Relay Word bits based on their default SELOGIC control equations. To change the operation of these bits they must be programmed.

These bits may be used to send various messages at a low bandwidth via the synchrophasor message stream. Digital Status Words may also be used to send binary information directly, without the need to manage the coding of the trigger reason messages in SELOGIC.

Use these Trigger Reason bits when your synchrophasor system design requires these bits. The SEL-751A synchrophasor processing and protocol transmission are not affected by the status of these bits.

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

Synchrophasor Relay Word Bits

Table H.6 and *Table H.7* list the SEL-751A Relay Word bits that are related to synchrophasor measurement. The Synchrophasor Trigger Relay Word bits in *Table H.6* 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.5* for standard definitions for these settings.

Table H.6 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.7* indicate the present status of the timekeeping function of the SEL-751A.

Table H.7 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-751A 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-751A synchrophasor measurements. See *MET Command (Metering Data) on page 7.33* for general information on the **MET** command.

There are multiple ways to use the **MET PM** command:

- As a test tool, to verify connections, phase rotation, and scaling
- As an analytical tool, to capture synchrophasor data at an exact time, to compare it with similar data captured in other phasor measurement unit(s) at the same time
- As a method of periodically gathering synchrophasor data through a communications processor

The **MET PM** command displays the same set of analog synchrophasor information, regardless of the Global settings PHDATAV, PHDATAI, and PHCURR. The **MET PM** command can function even when no serial ports are sending synchrophasor data—it is unaffected by serial port setting PROTO.

The **MET PM** command will only operate when the SEL-751A 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*.

NOTE: In order to have the **MET PM xx:yy:zz** response transmitted from a serial port, the corresponding port must have the AUTO setting set to YES (Y).

You can use the **MET PM *time*** command to direct the SEL-751A to display the synchrophasor for an exact specified time, in 24-hour format. For example, entering the command **MET 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.

See *Section 7: Communications* for complete command options, and error messages.

```
=>MET PM <Enter>

SEL-751A                                   Date: 10/24/2008   Time: 02:43:44
FEEDER RELAY                               Time Source: External

Time Quality   Maximum time synchronization error:    0.000 (ms)  TSOK = 0

Synchrophasors

                   Phase Voltages     Sync Voltage  Pos. Seq. Voltage
               VA        VB        VC        VS          V1
MAG (V)      134.14     131.64   128.60   120.79      131.45
ANG (DEG)    129.22      10.57  -111.89   129.50      129.50

                   Phase Currents     Neut. Current Pos. Seq. Current
               IA        IB        IC        IN          I1
MAG (A)     365.40    359.22    379.54     12.00     367.91
ANG (DEG)   114.78     -2.35   -120.40    -26.35     118.65

FREQ (Hz) 60.000
Rate-of-change of FREQ (Hz/s)    0.00

Digitals

SV24    SV23    SV22    SV21    SV20    SV19    SV18    SV17
 0       0       1       0       0       0       1       0
SV32    SV31    SV30    SV29    SV28    SV27    SV26    SV25
 1       0       0       0       1       0       0       0

Analogs

MV29      2.123  MV30      10.450  MV31      -120.300  MV32      40.120

=>
```

Figure H.4 Sample MET PM Command Response

C37.118 Synchrophasor Protocol

The SEL-751A complies with IEEE C37.118, Standard for Synchrophasors for Power Systems. The protocol is available on serial ports 2, 3, 4, and F by setting the corresponding Port setting PROTO := PMU.

This subsection 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-751A 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-751A 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-751A always includes the results of four synchrophasor trigger reason SELOGIC control equations TREA1, TREA2, TREA3, and TREA4, and the trigger SELOGIC control equation result PMTRIG, in the synchrophasor message.

Communications Bandwidth

A phasor measurement unit (PMU) that is configured to transmit a single synchrophasor (positive-sequence voltage, for example) at a message rate of once per second places little burden on the communications channel. As more synchrophasors, analog values, or digital status words are added, or if the message rate is increased, some communications channel restrictions come into play.

The C37.118 synchrophasor message format always includes 18 bytes for the message header and terminal ID, time information, status bits, and CRC value. The selection of synchrophasor data, numeric format, programmable analog, and programmable digital data will add to the byte requirements. You can use *Table H.8* to calculate the number of bytes in a synchrophasor message.

Table H.8 Size of a C37.118 Synchrophasor Message

Item	Possible Number of Quantities	Bytes per Quantity	Minimum Number of Bytes	Maximum Number of Bytes
Fixed			18	18
Synchrophasors	0, 1, 2, 4, 5, 6, 9, or 10	4	0	40
Frequency	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	80

Table H.9 lists the baud settings available on any SEL-751A 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.9 Serial Port Bandwidth for Synchrophasors (in Bytes)

Global Setting MRATE	Port Setting SPEED							
	300	600	1200	2400	4800	9600	19200	38400
1	21	42	85	170	340	680	1360	2720
2		21	42	85	170	340	680	1360
5				34	68	136	272	544
10					34	68	136	272

Referring to *Table H.8* and *Table H.9*, 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. This type of message could be sent at any message rate (MRATE) when SPEED := 4800 to 38400, as much as MRATE := 5 when SPEED := 2400, and as much as MRATE := 1 when SPEED := 600.

Another example application has messages comprised of nine synchrophasors, one digital status word, and two analog values. This type of message would consume 68 bytes. The 68-byte message could be sent at any message rate (MRATE) when SPEED := 9600.

Protocol Operation

The SEL-751A will only transmit synchrophasor messages over serial ports that have setting PROTO := PMU. The connected device will typically be a synchrophasor processor, such as the SEL-3306. The synchrophasor processor controls the PMU functions of the SEL-751A, with IEEE C37.118 commands, NOTE: Only one serial port can be set to PROTO:=PMU at one time.

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.

Transmit Mode Control

The SEL-751A will not begin transmitting synchrophasors until an enable message is received from the synchrophasor processor. The relay will stop synchrophasor transmission when the appropriate command is received from the synchrophasor processor. The SEL-751A 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-751A will only respond to configuration block request messages when it is in the non-transmitting mode.

Appendix I
MIRRORED BITS Communications

Overview

IMPORTANT: Be sure to configure the port before connecting to a MIRRORED BITS device. If you connect an unconfigured port to a MIRRORED BITS device, the device will appear to be locked up.

NOTE: Complete all of the port settings for a port that you use for MIRRORED BITS communications before you connect an external MIRRORED BITS communications device. If you connect a MIRRORED BITS communications device to a port that is not set for MIRRORED BITS communications operation, the port will be continuously busy.

MIRRORED BITS® is a direct relay-to-relay communications protocol that allows IEDs to exchange information quickly, securely, and with minimal expense. Use MIRRORED BITS for functions such as remote control and remote sensing. The SEL-751A Feeder Protection Relay supports two MIRRORED BITS communications channels, designated A and B. Use the port setting PROTO to assign one of the MIRRORED BITS communications channels to a serial port; PROTO:=MBA for MIRRORED BITS communications Channel A or PROTO:=MBB for MIRRORED BITS communications Channel B. MIRRORED BITS are either Transmit MIRRORED BITS (TMB) or Received MIRRORED BITS (RMB). Transmit MIRRORED BITS include TMB1A–TMB8A (channel A) and TMB1B–TMB8B (channel B). The last letter (A or B) designates with which channel the bits are associated. Received bits include RMB1A–RMB8A and RMB1B–RMB8B. Control the transmit MIRRORED BITS in SELOGIC® control equations. Use the received MIRRORED BITS as arguments in SELOGIC control equations. The channel status bits are ROKA, RBADA, CBADA, LBOKA, ROKB, RBADB, CBADB, and LBOKB. You can also use these channel status bits as arguments in SELOGIC control equations. Use the **COM** command (see *Section 7: Communications*) for additional channel status information.

Because of different applications, the SEL product range supports several variations of the MIRRORED BITS communications protocol. Through port settings, you can set the SEL-751A 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-751A, 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-751A transmits MIRRORED BITS as fast as possible for the given rate. At rates at and faster than 9600 baud the SEL-751A 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-751A 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-751A to match the TX_ID of the remote SEL-751A. The SEL-751A 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 described in the following text and two consecutive messages pass all of the data checks described previously. After ROK*c* is reasserted, received data may be delayed while passing through the security counters described 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-751A. The SEL-321 processes power system information each 1/8 power system cycle, but, when transmitting at 19200 baud, the SEL-751A 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-751A 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-751A with a setting of two delays a received bit from the SEL-321 by 1/4 cycle, because the SEL-751A is receiving new MIRRORED BITS messages each 1/8 cycle from the SEL-321.

Channel Synchronization

When an SEL-751A detects a communications error, it deasserts ROKA or ROKB. If an SEL-751A 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 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 communication channels requiring an 8-data bit format. For the remainder of this section, PROTO = MBA is assumed. *Table I.5* shows the MIRRORED BITS protocol port settings, ranges, and default settings for Port F, Port 3, and Port 4.

Table I.5 MIRRORED BITS Protocol Settings (Sheet 1 of 2)

Setting Prompt	Setting Description	Factory-Default Setting
TXID	MIRRORED BITS ID of This Device (1–4)	2
RXID	MIRRORED BITS ID of Device Receiving From (1–4)	1
RBADPU	Outage Duration to Set RBAD (1–10000 seconds)	60
CBADPU	Channel Unavailability to Set CBAD (1–10000 ppm)	1000
RXDFLT	8 char string of 1s, 0s, or Xs	XXXXXXXX
RMB1PU	RMB1 Pickup Debounce Messages (1–8 messages)	1
RMB1DO	RMB1 Dropout Debounce Messages (1–8 messages)	1
RMB2PU	RMB2 Pickup Debounce Messages (1–8 messages)	1

Table I.5 MIRRORED BITS Protocol Settings (Sheet 2 of 2)

Setting Prompt	Setting Description	Factory-Default Setting
RMB2DO	RMB2 Dropout Debounce Messages (1–8 messages)	1
RMB3PU	RMB3 Pickup Debounce Messages (1–8 messages)	1
RMB3DO	RMB3 Dropout Debounce Messages (1–8 messages)	1
RMB4PU	RMB4 Pickup Debounce Messages (1–8 messages)	1
RMB4DO	RMB4 Dropout Debounce Messages (1–8 messages)	1
RMB5PU	RMB5 Pickup Debounce Messages (1–8 messages)	1
RMB5DO	RMB5 Dropout Debounce Messages (1–8 messages)	1
RMB6PU	RMB6 Pickup Debounce Messages (1–8 messages)	1
RMB6DO	RMB6 Dropout Debounce Messages (1–8 messages)	1
RMB7PU	RMB7 Pickup Debounce Messages (1–8 messages)	1
RMB7DO	RMB7 Dropout Debounce Messages (1–8 messages)	1
RMB8PU	RMB8 Pickup Debounce Messages (1–8 messages)	1
RMB8DO	RMB8 Dropout Debounce Messages (1–8 messages)	1

Appendix J
Relay Word Bits

Overview

The protection and control element results are represented by Relay Word bits in the SEL-751A 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 7.42*).

You can use any Relay Word bit (except Row 0) in SELOGIC® control equations (see *Section 4: Protection and Logic Functions*) and the Sequential Events Recorder (SER) trigger list settings (see *Section 9: Analyzing Events*).

Table J.1 SEL-751A Relay Word Bits (Sheet 1 of 4)

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	TRIP	OUT101	OUT102	OUT103	OUT301	OUT302	OUT303	OUT304

Table J.1 SEL-751A Relay Word Bits (Sheet 2 of 4)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
16	OUT401	OUT402	OUT403	OUT404	OUT501	OUT502	OUT503	OUT504
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	WDGALRM	WDGTRIP	BRGALRM	BRGTRIP	RSTENRGY	RSTMXMN	RSTDEM	RSTPK-DEM
22	RTDFLT	RTDIN	TRGTR	3PWR1P	3PWR2P	DSABLSET	RSTTRGT	HALARM
23	RTD1A	RTD1T	RTD2A	RTD2T	RTD3A	RTD3T	RTD4A	RTD4T
24	RTD5A	RTD5T	RTD6A	RTD6T	RTD7A	RTD7T	RTD8A	RTD8T
25	RTD9A	RTD9T	RTD10A	RTD10T	RTD11A	RTD11T	RTD12A	RTD12T
26	79RS	79CY	79LO	SH0	SH1	SH2	SH3	SH4
27	CLOSE	CF	RCSF	OPTMN	RSTMN	LINKFAIL	PASEL	PBSEL
28	SG1	SG2	SG3	*	*	DI_C	DI_B	DI_A
29	CC	OC	*	ER	ULTRIP	TR	FREQTRK	PMTRIG
30	DNAUX1	DNAUX2	DNAUX3	DNAUX4	DNAUX5	DNAUX6	DNAUX7	DNAUX8
31	DNAUX9	DNAUX10	DNAUX11	RELAY_EN	TREA1	TREA2	TREA3	TREA4
32	PB01	PB02	PB03	PB04	PB01_PUL	PB02_PUL	PB03_PUL	PB04_PUL
33	PB1A_LED	PB1B_LED	PB2A_LED	PB2B_LED	PB3A_LED	PB3B_LED	PB4A_LED	PB4B_LED
34	CL	ULCL	T01_LED	T02_LED	T03_LED	T04_LED	T05_LED	T06_LED
35	LB01	LB02	LB03	LB04	LB05	LB06	LB07	LB08
36	LB09	LB10	LB11	LB12	LB13	LB14	LB15	LB16
37	LB17	LB18	LB19	LB20	LB21	LB22	LB23	LB24
38	LB25	LB26	LB27	LB28	LB29	LB30	LB31	LB32
39	RB01	RB02	RB03	RB04	RB05	RB06	RB07	RB08
40	RB09	RB10	RB11	RB12	RB13	RB14	RB15	RB16
41	RB17	RB18	RB19	RB20	RB21	RB22	RB23	RB24
42	RB25	RB26	RB27	RB28	RB29	RB30	RB31	RB32
43	SV01	SV02	SV03	SV04	SV05	SV06	SV07	SV08
44	SV01T	SV02T	SV03T	SV04T	SV05T	SV06T	SV07T	SV08T
45	SV09	SV10	SV11	SV12	SV13	SV14	SV15	SV16
46	SV09T	SV10T	SV11T	SV12T	SV13T	SV14T	SV15T	SV16T
47	SV17	SV18	SV19	SV20	SV21	SV22	SV23	SV24
48	SV17T	SV18T	SV19T	SV20T	SV21T	SV22T	SV23T	SV24T
49	SV25	SV26	SV27	SV28	SV29	SV30	SV31	SV32
50	SV25T	SV26T	SV27T	SV28T	SV29T	SV30T	SV31T	SV32T
51	LT01	LT02	LT03	LT04	LT05	LT06	LT07	LT08
52	LT09	LT10	LT11	LT12	LT13	LT14	LT15	LT16
53	LT17	LT18	LT19	LT20	LT21	LT22	LT23	LT24
54	LT25	LT26	LT27	LT28	LT29	LT30	LT31	LT32

Table J.1 SEL-751A Relay Word Bits (Sheet 3 of 4)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
55	SC01QU	SC02QU	SC03QU	SC04QU	SC05QU	SC06QU	SC07QU	SC08QU
56	SC01QD	SC02QD	SC03QD	SC04QD	SC05QD	SC06QD	SC07QD	SC08QD
57	SC09QU	SC10QU	SC11QU	SC12QU	SC13QU	SC14QU	SC15QU	SC16QU
58	SC09QD	SC10QD	SC11QD	SC12QD	SC13QD	SC14QD	SC15QD	SC16QD
59	SC17QU	SC18QU	SC19QU	SC20QU	SC21QU	SC22QU	SC23QU	SC24QU
60	SC17QD	SC18QD	SC19QD	SC20QD	SC21QD	SC22QD	SC23QD	SC24QD
61	SC25QU	SC26QU	SC27QU	SC28QU	SC29QU	SC30QU	SC31QU	SC32QU
62	SC25QD	SC26QD	SC27QD	SC28QD	SC29QD	SC30QD	SC31QD	SC32QD
63	AILW1	AILW2	AILAL	*	AIHW1	AIHW2	AIHAL	*
64	AI301LW1	AI301LW2	AI301LAL	*	AI301HW1	AI301HW2	AI301HAL	*
65	AI302LW1	AI302LW2	AI302LAL	*	AI302HW1	AI302HW2	AI302HAL	*
66	AI303LW1	AI303LW2	AI303LAL	*	AI303HW1	AI303HW2	AI303HAL	*
67	AI304LW1	AI304LW2	AI304LAL	*	AI304HW1	AI304HW2	AI304HAL	*
68	AI305LW1	AI305LW2	AI305LAL	*	AI305HW1	AI305HW2	AI305HAL	*
69	AI306LW1	AI306LW2	AI306LAL	*	AI306HW1	AI306HW2	AI306HAL	*
70	AI307LW1	AI307LW2	AI307LAL	*	AI307HW1	AI307HW2	AI307HAL	*
71	AI308LW1	AI308LW2	AI308LAL	*	AI308HW1	AI308HW2	AI308HAL	*
72	AI401LW1	AI401LW2	AI401LAL	*	AI401HW1	AI401HW2	AI401HAL	*
73	AI402LW1	AI402LW2	AI402LAL	*	AI402HW1	AI402HW2	AI402HAL	*
74	AI403LW1	AI403LW2	AI403LAL	*	AI403HW1	AI403HW2	AI403HAL	*
75	AI404LW1	AI404LW2	AI404LAL	*	AI404HW1	AI404HW2	AI404HAL	*
76	AI405LW1	AI405LW2	AI405LAL	*	AI405HW1	AI405HW2	AI405HAL	*
77	AI406LW1	AI406LW2	AI406LAL	*	AI406HW1	AI406HW2	AI406HAL	*
78	AI407LW1	AI407LW2	AI407LAL	*	AI407HW1	AI407HW2	AI407HAL	*
79	AI408LW1	AI408LW2	AI408LAL	*	AI408HW1	AI408HW2	AI408HAL	*
80	AI501LW1	AI501LW2	AI501LAL	*	AI501HW1	AI501HW2	AI501HAL	*
81	AI502LW1	AI502LW2	AI502LAL	*	AI502HW1	AI502HW2	AI502HAL	*
82	AI503LW1	AI503LW2	AI503LAL	*	AI503HW1	AI503HW2	AI503HAL	*
83	AI504LW1	AI504LW2	AI504LAL	*	AI504HW1	AI504HW2	AI504HAL	*
84	AI505LW1	AI505LW2	AI505LAL	*	AI505HW1	AI505HW2	AI505HAL	*
85	AI506LW1	AI506LW2	AI506LAL	*	AI506HW1	AI506HW2	AI506HAL	*
86	AI507LW1	AI507LW2	AI507LAL	*	AI507HW1	AI507HW2	AI507HAL	*
87	AI508LW1	AI508LW2	AI508LAL	*	AI508HW1	AI508HW2	AI508HAL	*
88	RMB8A	RMB7A	RMB6A	RMB5A	RMB4A	RMB3A	RMB2A	RMB1A
89	TMB8A	TMB7A	TMB6A	TMB5A	TMB4A	TMB3A	TMB2A	TMB1A
90	RMB8B	RMB7B	RMB6B	RMB5B	RMB4B	RMB3B	RMB2B	RMB1B
91	TMB8B	TMB7B	TMB6B	TMB5B	TMB4B	TMB3B	TMB2B	TMB1B
92	LBOKB	CBADB	RBADB	ROKB	LBOKA	CBADA	RBADA	ROKA
93	VB001	VB002	VB003	VB004	VB005	VB006	VB007	VB008
94	VB009	VB010	VB011	VB012	VB013	VB014	VB015	VB016

Table J.1 SEL-751A Relay Word Bits (Sheet 4 of 4)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
95	VB017	VB018	VB019	VB020	VB021	VB022	VB023	VB024
96	VB025	VB026	VB027	VB028	VB029	VB030	VB031	VB032
97	VB033	VB034	VB035	VB036	VB037	VB038	VB039	VB040
98	VB041	VB042	VB043	VB044	VB045	VB046	VB047	VB048
99	VB049	VB050	VB051	VB052	VB053	VB054	VB055	VB056
100	VB057	VB058	VB059	VB060	VB061	VB062	VB063	VB064
101	VB065	VB066	VB067	VB068	VB069	VB070	VB071	VB072
102	VB073	VB074	VB075	VB076	VB077	VB078	VB079	VB080
103	VB081	VB082	VB083	VB084	VB085	VB086	VB087	VB088
104	VB089	VB090	VB091	VB092	VB093	VB094	VB095	VB096
105	VB097	VB098	VB099	VB100	VB101	VB102	VB103	VB104
106	VB105	VB106	VB107	VB108	VB109	VB110	VB111	VB112
107	VB113	VB114	VB115	VB116	VB117	VB118	VB119	VB120
108	VB121	VB122	VB123	VB124	VB125	VB126	VB127	VB128
109	PHDEM	3I2DEM	GNDEM	*	BCWA	BCWB	BCWC	BCW
110	59VP	59VS	AFALARM	SF	25A1	25A2	DCHI	DCLO
111	59S1	59S1T	59S2	59S2T	27S1	27S1T	27S2	27S2T
112	TQUAL1	TQUAL2	TQUAL4	TQUAL8	DST	DSTP	LPSEC	LPSECP
113	TSNTPB	TSNTPP	TUTCS	TUTC1	TUTC2	TUTC4	TUTC8	TUTCH
114	59G1	59G1T	59G2	59G2T	59Q1	59Q1T	59Q2	59Q2T
115	81R1T	81R2T	81R3T	81R4T	AFS1DIAG	AFS2DIAG	AFS3DIAG	AFS4DIAG
116	TOL1	TOL2	TOL3	TOL4	AFS1EL	AFS2EL	AFS3EL	AFS4EL
117	*	*	*	*	PHASE_A	PHASE_B	PHASE_C	GFLT
118	*	*	*	81RFBLK	81RFT	81RFBL	81RFP	81RFI
119	*	*	*	*	*	*	*	*

Definitions

Table J.2 Relay Word Bit Definitions for the SEL-751A (Sheet 1 of 11)

Bit	Definition	Row
*	Reserved for future use.	—
3I2DEM	Negative-Sequence Demand Pickup.	109
3P27	3-Phase Undervoltage Trip Pickup (all phases less than the 27P1P setting).	10
3P59	3-Phase Overvoltage Trip Pickup (all phases exceeding 59P1P setting).	10
3PWR1P	3-Phase Power Element 1 Pickup.	22
3PWR1T	3-Phase Power Element 1 Trip.	14
3PWR2P	3-Phase Power Element 2 Pickup.	22
3PWR2T	3-Phase Power Element 2 Trip.	14

Table J.2 Relay Word Bit Definitions for the SEL-751A (Sheet 2 of 11)

Bit	Definition	Row
25A1	Synchronism-Check Element Level 1 Pickup.	110
25A2	Synchronism-Check Element Level 2 Pickup.	110
27P1	Phase Undervoltage Trip 1 Pickup (see *Figure 4.20*).	9
27P1T	Phase Undervoltage Trip 1 Output (see *Figure 4.20*).	9
27P2	Phase Undervoltage Trip 2 Pickup (see *Figure 4.20*).	10
27P2T	Phase Undervoltage Trip 2 Output (see *Figure 4.20*).	10
27S1	Level 1 VS Channel Undervoltage Element Pickup	111
27S1T	Level 1 VS Channel Undervoltage Element With Time Delay	111
27S2	Level 2 VS Channel Undervoltage Element Pickup	111
27S2T	Level 2 VS Channel Undervoltage Element With Time Delay	111
50G1P	Definite-Time Residual Overcurrent Trip 1 Pickup (see *Figure 4.1*).	4
50G1T	Definite-Time Residual Overcurrent Trip 1 Output (see *Figure 4.1*).	5
50G2P	Definite-Time Residual Overcurrent Trip 2 Pickup (see *Figure 4.1*).	4
50G2T	Definite-Time Residual Overcurrent Trip 2 Output (see *Figure 4.1*).	5
50G3P	Definite-Time Residual Overcurrent Trip 3 Pickup (see *Figure 4.1*).	4
50G3T	Definite-Time Residual Overcurrent Trip 3 Output (see *Figure 4.1*).	5
50G4P	Definite-Time Residual Overcurrent Trip 4 Pickup (see *Figure 4.1*).	4
50G4T	Definite-Time Residual Overcurrent Trip 4 Output (see *Figure 4.1*).	5
50N1P	Definite-Time Neutral Overcurrent Trip 1 Pickup (see *Figure 4.1*).	4
50N1T	Definite-Time Neutral Overcurrent Trip 1 Output (see *Figure 4.1*).	5
50N2P	Definite-Time Neutral Overcurrent Trip 2 Pickup (see *Figure 4.1*).	4
50N2T	Definite-Time Neutral Overcurrent Trip 2 Output (see *Figure 4.1*).	5
50N3P	Definite-Time Neutral Overcurrent Trip 3 Pickup (see *Figure 4.1*).	4
50N3T	Definite-Time Neutral Overcurrent Trip 3 Output (see *Figure 4.1*).	5
50N4P	Definite-Time Neutral Overcurrent Trip 4 Pickup (see *Figure 4.1*).	4
50N4T	Definite-Time Neutral Overcurrent Trip 4 Output (see *Figure 4.1*).	5
50NAF	Sample-Based Neutral Overcurrent Element (Arc-Flash Protection)	1
50P1P	Definite-Time Phase Overcurrent Trip 1 Pickup (see *Figure 4.1*).	2
50P1T	Definite-Time Phase Overcurrent Trip 1 Output (see *Figure 4.1*).	3
50P2P	Definite-Time Phase Overcurrent Trip 2 Pickup (see *Figure 4.1*).	2
50P2T	Definite-Time Phase Overcurrent Trip 2 Output (see *Figure 4.1*).	3
50P3P	Definite-Time Phase Overcurrent Trip 3 Pickup (see *Figure 4.1*).	2
50P3T	Definite-Time Phase Overcurrent Trip 3 Output (see *Figure 4.1*).	3
50P4P	Definite-Time Phase Overcurrent Trip 4 Pickup (see *Figure 4.1*).	2
50P4T	Definite-Time Phase Overcurrent Trip 4 Output (see *Figure 4.1*).	3
50PAF	Sample-Based Phase Overcurrent Element (Arc-Flash Protection)	1
50Q1P	Definite-Time Negative-Sequence Overcurrent Trip 1 Pickup (see *Figure 4.1*).	2
50Q1T	Definite-Time Negative-Sequence Overcurrent Trip 1 Output (see *Figure 4.1*).	3
50Q2P	Definite-Time Negative-Sequence Overcurrent Trip 2 Pickup (see *Figure 4.1*).	2
50Q2T	Definite-Time Negative-Sequence Overcurrent Trip 2 Output (see *Figure 4.1*).	3
50Q3P	Definite-Time Negative-Sequence Overcurrent Trip 3 Pickup (see *Figure 4.1*).	2

Table J.2 Relay Word Bit Definitions for the SEL-751A (Sheet 3 of 11)

Bit	Definition	Row
50Q3T	Definite-Time Negative-Sequence Overcurrent Trip 3 Output (see *Figure 4.1*).	3
50Q4P	Definite-Time Negative-Sequence Overcurrent Trip 4 Pickup (see *Figure 4.1*).	2
50Q4T	Definite-Time Negative-Sequence Overcurrent Trip 4 Output (see *Figure 4.1*).	3
51AP	Phase A Time-Overcurrent Element Pickup (see *Figure 4.5*).	6
51AR	Phase A Time-Overcurrent Element Reset (see *Figure 4.5*).	8
51AT	Phase A Time-Overcurrent Element Trip (see *Figure 4.5*).	7
51BP	Phase B Time-Overcurrent Element Pickup (see *Figure 4.5*).	6
51BR	Phase B Time-Overcurrent Element Reset (see *Figure 4.5*).	8
51BT	Phase B Time-Overcurrent Element Trip (see *Figure 4.5*).	7
51CP	Phase C Time-Overcurrent Element Pickup (see *Figure 4.5*).	6
51CR	Phase C Time-Overcurrent Element Reset (see *Figure 4.5*).	8
51CT	Phase C Time-Overcurrent Element Trip (see *Figure 4.5*).	7
51G1P	Residual Time-Overcurrent Trip 1 Pickup (see *Figure 4.9*).	9
51G1R	Residual Time-Overcurrent Trip 1 Reset (see *Figure 4.9*).	9
51G1T	Residual Time-Overcurrent Trip 1 Output (see *Figure 4.9*).	9
51G2P	Residual Time-Overcurrent Trip 2 Pickup (see *Figure 4.9*).	9
51G2R	Residual Time-Overcurrent Trip 2 Reset (see *Figure 4.9*).	9
51G2T	Residual Time-Overcurrent Trip 2 Output (see *Figure 4.9*).	9
51N1P	Neutral Time-Overcurrent Trip 1 Pickup (see *Figure 4.8*).	6
51N1R	Neutral Time-Overcurrent Trip 1 Reset (see *Figure 4.8*).	8
51N1T	Neutral Time-Overcurrent Trip 1 Output (see *Figure 4.8*).	7
51N2P	Neutral Time-Overcurrent Trip 2 Pickup (see *Figure 4.8*).	6
51N2R	Neutral Time-Overcurrent Trip 2 Reset (see *Figure 4.8*).	8
51N2T	Neutral Time-Overcurrent Trip 2 Output (see *Figure 4.8*).	7
51P1P	Maximum Phase Time-Overcurrent Trip 1 Pickup (see *Figure 4.6*).	6
51P1R	Maximum Phase Time-Overcurrent Trip 1 Reset (see *Figure 4.6*).	8
51P1T	Maximum Phase Time-Overcurrent Trip 1 Output (see *Figure 4.6*).	7
51P2P	Maximum Phase Time-Overcurrent Trip 2 Pickup (see *Figure 4.6*).	6
51P2R	Maximum Phase Time-Overcurrent Trip 2 Reset (see *Figure 4.6*).	8
51P2T	Maximum Phase Time-Overcurrent Trip 2 Output (see *Figure 4.6*).	7
51QP	Negative-Sequence Time-Overcurrent Element Pickup (see *Figure 4.7*).	6
51QR	Negative-Sequence Time-Overcurrent Element Reset (see *Figure 4.7*).	8
51QT	Negative-Sequence Time-Overcurrent Element Trip Output (see *Figure 4.7*).	7
52A	Asserts when the SELOGIC control equation 52A result is logical 1. Use to indicate that the circuit breaker is closed.	1
55A	Power Factor Alarm. Asserts when the relay issues a power factor element alarm/warning (see *Figure 4.27*).	11
55T	Power Factor Trip. Asserts when the relay issues a power factor element alarm or trip (see *Figure 4.27*).	11
59G1	Level 1 Zero-Sequence Overvoltage Element Pickup.	114
59G1T	Level 1 Zero-Sequence Overvoltage Element Trip.	114
59G2	Level 2 Zero-Sequence Overvoltage Element Pickup.	114

Table J.2 Relay Word Bit Definitions for the SEL-751A (Sheet 4 of 11)

Bit	Definition	Row
59G2T	Level 2 Zero-Sequence Overvoltage Element Trip.	114
59P1	Phase Overvoltage Trip 1 Pickup (see *Figure 4.21*).	10
59P1T	Phase Overvoltage Trip 1 Output (see *Figure 4.21*).	10
59P2	Phase Overvoltage Trip 2 Pickup (see *Figure 4.21*).	10
59P2T	Phase Overvoltage Trip 2 Output (see *Figure 4.21*).	10
59Q1	Level 1 Negative-Sequence Overvoltage Element Pickup.	114
59Q1T	Level 1 Negative-Sequence Overvoltage Element Trip.	114
59Q2	Level 2 Negative-Sequence Overvoltage Element Pickup.	114
59Q2T	Level 2 Negative-Sequence Overvoltage Element Trip.	114
59S1	Level 1 VS Channel Overvoltage Element Pickup.	111
59S1T	Level 1 VS Channel Overvoltage Element With Time Delay.	111
59S2	Level 2 VS Channel Overvoltage Element Pickup.	111
59S2T	Level 2 VS Channel Overvoltage Element With Time Delay.	111
59VP	Phase Voltage window element (selected phase voltage [VP] between settings 25VLO and 25VHI).	110
59VS	VS Channel Voltage window element (selected phase voltage [VS] between settings 25VLO and 25VHI).	110
79RS	Reclosing Relay in Reset State.	26
79CY	Reclosing Relay in Reclose Cycle State.	26
79LO	Reclosing Relay in Lockout State.	26
81D1T	Definite-Time Over- and Underfrequency Element (Trip Level 1). Asserts when the frequency has been either greater or less than the element set point for a definite time (see *Figure 4.29*).	11
81D2T	Definite-Time Over- and Underfrequency Element (Trip Level 2). Asserts when the frequency has been either greater or less than the element set point for a definite time (see *Figure 4.29*).	11
81D3T	Definite-Time Over- and Underfrequency Element (Trip Level 3). Asserts when the frequency has been either greater or less than the element set point for a definite time (see *Figure 4.29*).	11
81D4T	Definite-Time Over- and Underfrequency Element (Trip Level 4). Asserts when the frequency has been either greater or less than the element set point for a definite time (see *Figure 4.29*).	11
81D5T	Definite-Time Over- and Underfrequency Element (Trip Level 5). Asserts when the frequency has been either greater or less than the element set point for a definite time. (see *Figure 4.29*).	11
81D6T	Definite-Time Over- and Underfrequency Element (Trip Level 6). Asserts when the frequency has been either greater or less than the element set point for a definite time. (see *Figure 4.29*).	11
81R1T	Level 1 Rate-of-change-of-frequency element trip.	115
81R2T	Level *2* Rate-of-change-of-frequency element trip.	115
81R3T	Level 3 Rate-of-change-of-frequency element trip.	115
81R4T	Level 4 Rate-of-change-of-frequency element trip.	115
81RFBLK	Fast Rate-of-change-of-frequency overall block logic output	118
81RFT	Fast Rate-of-change-of-frequency trip output	118
81RFBL	Fast Rate-of-change-of-frequency block output SELOGIC	118
81RFP	Fast Rate-of-change-of-frequency pickup	118
81RFI	Fast Rate-of-change-of-frequency initiate	118
AFS1DIAG	Arc-Flash Sensor input 1 diagnostic failure.	115
AFS2DIAG	Arc-Flash Sensor input 2 diagnostic failure.	115
AFS3DIAG	Arc-Flash Sensor input 3 diagnostic failure.	115

Table J.2 Relay Word Bit Definitions for the SEL-751A (Sheet 5 of 11)

Bit	Definition	Row
AFS4DIAG	Arc-Flash Sensor input 4 diagnostic failure.	115
AFALARM	Arc-Flash system integrity alarm (AFS1EL OR AFS2EL OR AFS3EL OR AFS4EL OR AFS1DIAG OR AFS2DIAG OR AFS3DIAG OR AFS4DIAG)	110
AFS1EL	Arc-Flash Sensor input 1 excessive ambient light pickup for 10 seconds.	116
AFS2EL	Arc-Flash Sensor input 2 excessive ambient light pickup for 10 seconds.	116
AFS3EL	Arc-Flash Sensor input 3 excessive ambient light pickup for 10 seconds.	116
AFS4EL	Arc-Flash Sensor input 4 excessive ambient light pickup for 10 seconds.	116
AIHAL	Analog inputs High Alarm Limit. If any AI*xxx*HAL = 1, then AIHAL = 1.	63
AIHW1	Analog inputs High Warning, Level 1. If any AI*xxx*HW1 = 1, then AIHW1 = 1.	63
AIHW2	Analog inputs High Warning, Level 2. If any AI*xxx*HW2 = 1, then AIHW2 = 1.	63
AILAL	Analog inputs Low Alarm Limit. If any AI*xxx*LAL = 1, then AILAL = 1.	63
AILW1	Analog inputs Low Warning, Level 1. If any AI*xxx*LW1 = 1, then AILW1 = 1.	63
AILW2	Analog inputs Low Warning, Level 2. If any AI*xxx*LW2 = 1, then AILW2 = 1.	63
AI*xxx*HAL	Analog inputs 301–508 Warnings/Alarms (where *xxx* = 301–508) High Alarm Limit.	64–87
AI*xxx*HW1	Analog inputs 301–508 Warnings/Alarms (where *xxx* = 301–508) High Warning, Level 1.	64–87
AI*xxx*HW2	Analog inputs 301–508 Warnings/Alarms (where *xxx* = 301–508) High Warning, Level 2.	64–87
AI*xxx*LAL	Analog inputs 301–508 Warnings/Alarms (where *xxx* = 301–508) Low Alarm Limit.	64–87
AI*xxx*LW1	Analog inputs 301–508 Warnings/Alarms (where *xxx* = 301–508) Low Warning, Level 1.	64–87
AI*xxx*LW2	Analog inputs 301–508 Warnings/Alarms (where *xxx* = 301–508) Low Warning, Level 2.	64–87
AMBALRM	Ambient Temperature Alarm. Asserts if the healthy ambient RTD temperature exceeds the alarm/warning set point for that temperature.	12
AMBTRIP	Ambient Temperature Trip. Asserts when the healthy ambient RTD temperature exceeds its trip set point.	12
BCWA	Phase A breaker contact wear has reached the 100 percent wear level.	109
BCWB	Phase B breaker contact wear has reached the 100 percent wear level.	109
BCWC	Phase C breaker contact wear has reached the 100 percent wear level.	109
BCW	BCWA OR BCWB OR BCWC has asserted.	109
BFI	Breaker Failure Initiation. Asserts when the SELOGIC control equation BFI result in a logical 1.	12
BFT	Breaker Failure Trip. Asserts when the relay issues a breaker failure trip (see *Figure 4.55*).	12
BKMON	SELOGIC control equation BKMON asserts (initiates breaker monitoring (see *Figure 5.19*)	12
BRGALRM BRGTRIP	Bearing Temperature Alarm and Trip. BRGALRM asserts when any healthy bearing RTD temperature exceeds the corresponding alarm set point. BRGTRIP asserts when one or two (when EBRGV = Y) healthy bearing RTD temperatures exceed corresponding trip set points.	21
CBADA	Channel A, channel unavailability over threshold.	92
CBADB	Channel B, channel unavailability over threshold.	92
CC	Close command—asserts when serial port command **CLOSE** or front-panel or Modbus®/DeviceNet **CLOSE** command is issued (see *Table 4.26* and *Figure 4.34*).	29
CF	Close condition failure–asserts for 1/4 cycle.	27
CFGFLT	Asserts on failed settings interdependency check during Modbus setting change.	14
CL	Close SELOGIC control equation.	34
CLOSE	Close logic output.	27
COMMFLT	Time-out of internal communication between CPU board and DeviceNet board.	14
COMMIDLE	DeviceNet Card in programming mode.	14

Table J.2 Relay Word Bit Definitions for the SEL-751A (Sheet 6 of 11)

Bit	Definition	Row
COMMLOSS	DeviceNet Card communication failure.	14
DCHI	Station dc battery instantaneous overvoltage element pickup.	110
DCLO	Station dc battery instantaneous undervoltage element pickup.	110
DI_A	Distortion index phase A (see *Overcurrent Elements on page 4.5*).	28
DI_B	Distortion index phase B (see *Overcurrent Elements on page 4.5*).	28
DI_C	Distortion index phase C (see *Overcurrent Elements on page 4.5*).	28
DNAUX*n*	DeviceNet/Modbus AUX*n* assert bit, where *n* = 1 to 8.	30
DNAUX*n*	DeviceNet/Modbus AUX*n* assert bit, where *n* = 9 to 11.	31
DSABLSET	Settings changes not allowed from the front-panel interface—when asserted.	22
DST	Daylight Savings Time (Synchrophasors).	112
DSTP	Daylight Savings Time Pending (Synchrophasors).	112
ENABLED	Relay Enabled.	0
ER	Event report trigger SELOGIC control equation (see *Table 4.66*).	29
FAULT	Fault indication. Asserts when the SELOGIC control equation FAULT result in a logical 1.	13
FREQTRK	Asserts when relay is tracking frequency.	29
GFLT	Ground fault. The GFLT bit asserts if any one of the residual overcurrent or residual time-overcurrent Relay Word bits pick up. The GFLT bit asserts for a fixed duration of (LER-PRE-0.75) cycles.	117
GNDEM	Zero-Sequence Current Demand Pickup	109
HALARM	Hardware alarm (see *Self-Test on page 10.12*).	22
IN101	Contact input.	17
IN102	Contact input.	17
IN*nnn*	Contact input *nnn*, where *nnn* = 301 to 304 (available only with optional I/O module).	18
IN*nnn*	Contact input *nnn*, where *nnn* = 401 to 404 (available only with optional I/O module).	19
IN*nnn*	Contact input *nnn*, where *nnn* = 501 to 504 (available only with optional I/O module).	20
IRIGOK	IRIG-B input OK.	13
LB01 to LB08	Local Bit *n* asserted, where *n* = 1 to 8.	35
LB09 to LB16	Local Bit *n* asserted, where *n* = 9 to 16.	36
LB17 to LB24	Local Bit *n* asserted, where *n* = 17 to 24.	37
LB25 to LB32	Local Bit *n* asserted, where *n* = 25 to 32.	38
LBOKA	Channel A, looped back ok.	92
LBOKB	Channel B, looped back ok.	92
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	27
LOP	Loss-of-Potential logic asserted (see *Figure 4.28*).	14
LPSEC	Direction of the upcoming leap second. During the time that LPSECP is asserted, if LPSEC is asserted, the upcoming leap second is deleted; otherwise, the leap second is added (synchrophasors)	112
LPSECP	Leap second pending (synchrophasors)	112
LT*nn*	Latch Bit *nn* asserted, where *nn* = 01 to 08 (see *Figure 4.48*).	51
LT*nn*	Latch Bit *nn* asserted, where *nn* = 09 to 16 (see *Figure 4.48*).	52

Table J.2 Relay Word Bit Definitions for the SEL-751A (Sheet 7 of 11)

Bit	Definition	Row
LT*nn*	Latch Bit *nn* asserted, where *nn* = 17 to 24 (see *Figure 4.48*).	53
LT*nn*	Latch Bit *nn* asserted, where *nn* = 25 to 32 (see *Figure 4.48*).	54
OC	Open command—asserts when serial port command **OPEN** or front-panel or Modbus/DeviceNet **OPEN** command is issued (see *Table 4.26* and *Figure 4.33*).	29
OPTMN	Open interval timer is timing.	27
ORED50T	Logical OR of all the instantaneous overcurrent elements tripped outputs (see *Figure 4.1*).	1
ORED51T	Logical OR of all the time-overcurrent elements tripped outputs (see *Figure 4.5* through *Figure 4.9*).	1
OTHALRM	Other Temperature Alarm. Asserts when any healthy Other RTD temperature exceeds the alarm/warning set point for that temperature.	12
OTHTRIP	Other Temperature Trip. Asserts when one (or more) healthy Other RTD temperature exceeds the trip set points.	12
OUT101	Control equation for contact output.	15
OUT102	Control equation for contact output.	15
OUT103	Control equation for contact output.	15
OUT301	Control equation for contact output (available only with optional I/O module).	15
OUT302	Control equation for contact output (available only with optional I/O module).	15
OUT303	Control equation for contact output (available only with optional I/O module).	15
OUT304	Control equation for contact output (available only with optional I/O module).	16
OUT401	Control equation for contact output (available only with optional I/O module).	16
OUT402	Control equation for contact output (available only with optional I/O module).	16
OUT403	Control equation for contact output (available only with optional I/O module).	16
OUT404	Control equation for contact output (available only with optional I/O module).	16
OUT501	Control equation for contact output (available only with optional I/O module).	16
OUT502	Control equation for contact output (available only with optional I/O module).	16
OUT503	Control equation for contact output (available only with optional I/O module).	16
OUT504	Control equation for contact output (available only with optional I/O module).	16
PASEL	Ethernet Port A is active.	27
PBSEL	Ethernet Port B is active.	27
PB01	Front-panel pushbutton 1 bit.	32
PB01_PUL	Front-panel pushbutton 1 pulse bit (asserted for one processing interval when PB01 is pressed).	32
PB02	Front-panel pushbutton 2 bit.	32
PB02_PUL	Front-panel pushbutton 2 pulse bit (asserted for one processing interval when PB02 is pressed).	32
PB03	Front-panel pushbutton 3 bit.	32
PB03_PUL	Front-panel pushbutton 3 pulse bit (asserted for one processing interval when PB03 is pressed).	32
PB04	Front-panel pushbutton 4 bit.	32
PB04_PUL	Front-panel pushbutton 4 pulse bit (asserted for one processing interval when PB04 is pressed).	32
PB1A_LED	Asserts when the SELOGIC control equation PB1A_LED results in logical 1.	33
PB1B_LED	Asserts when the SELOGIC control equation PB1B_LED results in logical 1.	33
PB2A_LED	Asserts when the SELOGIC control equation PB2A_LED results in logical 1.	33
PB2B_LED	Asserts when the SELOGIC control equation PB2B_LED results in logical 1.	33
PB3A_LED	Asserts when the SELOGIC control equation PB3A_LED results in logical 1.	33

Table J.2 Relay Word Bit Definitions for the SEL-751A (Sheet 8 of 11)

Bit	Definition	Row
PB3B_LED	Asserts when the SELOGIC control equation PB3B_LED results in logical 1.	33
PB4A_LED	Asserts when the SELOGIC control equation PB4A_LED results in logical 1.	33
PB4B_LED	Asserts when the SELOGIC control equation PB4B_LED results in logical 1.	33
PHASE_A	"A" phase involved in the fault. Asserts for a fixed duration of (LER–PRE–0.75) cycles.	117
PHASE_B	"B" phase involved in the fault. Asserts for a fixed duration of (LER–PRE–0.75) cycles.	117
PHASE_C	"C" phase involved in the fault. Asserts for a fixed duration of (LER–PRE–0.75) cycles.	117
PHDEM	Phase Current Demand Pickup	109
PMDOK	Phasor Measurement Data OK. Asserts when the SEL-751A is enabled and synchrophasors are enabled (Global setting EPMU:= Y) (see *Table H.7*).	13
PMTRIG	Trigger for Synchrophasors (see *Table H.7*).	29
RBADA	Channel A, outage duration over threshold.	92
RBADB	Channel B, outage duration over threshold.	92
RB*nn*	Remote Bit *nn* asserted, where *nn* = 01 to 08.	39
RB*nn*	Remote Bit *nn* asserted, where *nn* = 09 to 16.	40
RB*nn*	Remote Bit *nn* asserted, where *nn* = 17 to 24.	41
RB*nn*	Remote Bit *nn* asserted, where *nn* = 25 to 32.	42
RCSF	Reclose supervision failure—asserts for 1/4 cycle.	27
RELAY_EN	Relay OK flag used by IEC 61850.	31
REMTRIP	Remote trip control input asserted (see *Table 4.26*).	14
RMB1A to RMB8A	Channel A receives MIRRORED BITS RMB1A through RMB8A.	88
RMB1B to RMB8B	Channel B receives MIRRORED BITS RMB1B through RMB8B.	90
ROKA	Channel A, received data ok.	92
ROKB	Channel B, received data ok.	92
RSTDEM	Reset Demand metering.	21
RSTENRGY	Reset Energy metering.	21
RSTMN	Reset timer is timing	27
RSTMXMN	Reset Max/Min metering.	21
RSTPKDEM	Reset Peak Demand metering.	21
RSTTRGT	Asserts when the SELOGIC control equation RSTTRGT result is logical 1. Used to reset trip logic and target LEDs (see *Table 4.50*).	22
RTD10A	RTD10 Alarm.	25
RTD10T	RTD10 Trip.	25
RTD11A	RTD11 Alarm.	25
RTD11T	RTD11 Trip.	25
RTD12A	RTD12 Alarm.	25
RTD12T	RTD12 Trip.	25
RTD1A	RTD1 Alarm.	23
RTD1T	RTD1 Trip.	23
RTD2A	RTD2 Alarm.	23
RTD2T	RTD2 Trip.	23
RTD3A	RTD3 Alarm.	23
RTD3T	RTD3 Trip.	23

Table J.2 Relay Word Bit Definitions for the SEL-751A (Sheet 9 of 11)

Bit	Definition	Row
RTD4A	RTD4 Alarm.	23
RTD4T	RTD4 Trip.	23
RTD5A	RTD5 Alarm.	24
RTD5T	RTD5 Trip.	24
RTD6A	RTD6 Alarm.	24
RTD6T	RTD6 Trip.	24
RTD7A	RTD7 Alarm.	24
RTD7T	RTD7 Trip.	24
RTD8A	RTD8 Alarm.	24
RTD8T	RTD8 Trip.	24
RTD9A	RTD9 Alarm.	25
RTD9T	RTD9 Trip.	25
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.	22
RTDIN	Indicates status of contact connected to an SEL-2600 RTD Module.	22
SALARM	Pulses for the following conditions: setting changes, access level changes, and three unsuccessful password entry attempts, active group changes, copy commands, and password changes.	13
SC01QD to SC08QD	SELOGIC Counters 01 through 08 asserted when counter = 0.	56
SC01QU to SC08QU	SELOGIC Counters 01 through 08 asserted when counter = preset value.	55
SC09QD to SC16QD	SELOGIC Counters 09 through 16 asserted when counter = 0.	58
SC09QU to SC16QU	SELOGIC Counters 09 through 16 asserted when counter = preset value.	57
SC17QD to SC24QD	SELOGIC Counters 17 through 24 asserted when counter = 0.	60
SC17QU to SC24QU	SELOGIC Counters 17 through 24 asserted when counter = preset value.	59
SC25QD to SC32QD	SELOGIC Counters 25 through 32 asserted when counter = 0.	62
SC25QU to SC32QU	SELOGIC Counters 25 through 32 asserted when counter = preset value.	61
SF	Slip frequency of voltages VP and VS is less than setting 25SF.	110
SG*n*	Setting Group *n* active, where *n* = 1 to 3.	28
SH0	Reclosing relay shot counter = 0	26
SH1	Reclosing relay shot counter = 1	26
SH2	Reclosing relay shot counter = 2	26
SH3	Reclosing relay shot counter = 3	26
SH4	Reclosing relay shot counter = 4	26
SV*nn*	SELOGIC control equation variable timer input SV*nn* asserted, where *nn* = 01 to 08 (see *Figure 4.49*).	43
SV*nn*	SELOGIC control equation variable timer input SV*nn* asserted, where *nn* = 09 to 16 (see *Figure 4.49*).	45
SV*nn*	SELOGIC control equation variable timer input SV*nn* asserted, where *nn* = 17 to 24 (see *Figure 4.49*).	47
SV*nn*	SELOGIC control equation variable timer input SV*nn* asserted, where *nn* = 25 to 32 (see *Figure 4.49*).	49
SV*nn*T	SELOGIC control equation variable timer output SV*nn*T asserted, where *nn* = 01 to 08 (see *Figure 4.49*).	44
SV*nn*T	SELOGIC control equation variable timer output SV*nn*T asserted, where *nn* = 09 to 16 (see *Figure 4.49*).	46

Table J.2 Relay Word Bit Definitions for the SEL-751A (Sheet 10 of 11)

Bit	Definition	Row
SV*nn*T	SELOGIC control equation variable timer output SV*nn*T asserted, where *nn* = 17 to 24 (see *Figure 4.49*).	48
SV*nn*T	SELOGIC control equation variable timer output SV*nn*T asserted, where *nn* = 25 to 32 (see *Figure 4.49*).	50
T01_LED	Asserts when the SELOGIC control equation T01_LED result is logical 1 (see *Table 4.68*).	34
T02_LED	Asserts when the SELOGIC control equation T02_LED result is logical 1 (see *Table 4.68*).	34
T03_LED	Asserts when the SELOGIC control equation T03_LED result is logical 1 (see *Table 4.68*).	34
T04_LED	Asserts when the SELOGIC control equation T04_LED result is logical 1 (see *Table 4.68*).	34
T05_LED	Asserts when the SELOGIC control equation T05_LED result is logical 1 (see *Table 4.68*).	34
T06_LED	Asserts when the SELOGIC control equation T06_LED result is logical 1 (see *Table 4.68*).	34
TLED_01	Front-Panel T01_LED.	0
TLED_02	Front-Panel T02_LED.	0
TLED_03	Front-Panel T03_LED.	0
TLED_04	Front-Panel T04_LED.	0
TLED_05	Front-Panel T05_LED.	0
TLED_06	Front-Panel T06_LED.	0
TMB1A to TMB8A	Channel A transmit MIRRORED BITS TMB1A through TMB8A.	89
TMB1B to TMB8B	Channel B transmit MIRRORED BITS TMB1B through TMB8B.	91
TOL1	Arc-Flash light input 1 element pickup.	116
TOL2	Arc-Flash light input 2 element pickup.	116
TOL3	Arc-Flash light input 3 element pickup.	116
TOL4	Arc-Flash light input 4 element pickup.	116
TQUAL1	Time Quality Bit, add 1 when asserted (synchrophasors).	112
TQUAL2	Time Quality Bit, add 2 when asserted (synchrophasors).	112
TQUAL4	Time Quality Bit, add 4 when asserted (synchrophasors).	112
TQUAL8	Time Quality Bit, add 8 when asserted (synchrophasors).	112
TR	Trip SELOGIC control equation (see *Figure 4.1*).	29
TREA1	Trigger Reason for Bit 1 for Synchrophasors (see *Table H.7*).	31
TREA2	Trigger Reason for Bit 2 for Synchrophasors (see *Table H.7*).	31
TREA3	Trigger Reason for Bit 3 for Synchrophasors (see *Table H.7*).	31
TREA4	Trigger Reason for Bit 4 for Synchrophasors (see *Table H.7*).	31
TRGTR	Target Reset. Asserts for one quarter-cycle when you execute a front-panel, serial port target reset command, or Modbus target reset.	22
TRIP	Output of Trip Logic (see *Figure 4.33*).	15
TRIP_LED	Front-Panel TRIP LED.	0
TSNTPB	SNTP Secondary Server is active.	113
TSNTPP	SNTP Primary Server is active.	113
TSOK	Assert if current time source accuracy is sufficient for synchronized phasor measurements. (Refer to *Table H.8*.)	13
TUTCS	Offset hours sign from UTC time, subtract the UTC offset if TUTCS is asserted; otherwise, add. (Synchrophasors)	113
TUTC1	Offset hours from UTC time, binary, add 1 if asserted	113
TUTC2	Offset hours from UTC time, binary, add 2 if asserted	113

Table J.2 Relay Word Bit Definitions for the SEL-751A (Sheet 11 of 11)

Bit	Definition	Row
TUTC4	Offset hours from UTC time, binary, add 4 if asserted	113
TUTC8	Offset hours from UTC time, binary, add 8 if asserted	113
TUTCH	Offset half-hour from UTC time, binary, add 0.5 if asserted	113
ULCL	Unlatch close conditions SELOGIC control equation state (see *Table 4.26*).	34
ULTRIP	Unlatch (auto reset) trip from SELOGIC control equation (see *Table 4.26*).	29
VB*xxx*	Virtual bits used for incoming GOOSE messages (*xxx* = 001 to 128) (see Virtual Bits description on *page F.5*).	93–108
WARNING	Asserts when any of the protection elements (warning level) operates or when the relay detects self-test failure (see *Table 10.7*), RTD faults, or DeviceNet communications alarms.	13
WDGALRM WDGTRIP	Winding Temperature Alarm and Trip. WDGALRM asserts when any healthy winding RTD temperature exceeds the corresponding alarm set point. WDGTRIP asserts when one or two (when EWDGV = Y) healthy winding RTD temperatures exceed corresponding trip set points.	21

Appendix K
Analog Quantities

The SEL-751A 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 used. 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 are processed every 100 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)

Label	Description	Units	Display Points	SELOGIC	Load Profile	DNP	Fast Meter
Fundamental Instantaneous Metering							
IA_MAG	A-phase line current	A primary	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 primary	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 primary	x	x	x	x	x
IC_ANG	Angle of the C-phase line current	degrees	x	x	x	x	
IN_MAG	Neutral current	A primary	x	x	x	x	x
IN_ANG	Angle of the neutral current	degrees	x	x	x	x	
IG_MAG	Calculated or measured residual current	A primary	x	x	x	x	x
IG_ANG	Angle of the calculated or measured residual current	degrees	x	x	x	x	
IAV	Average line current	A primary	x	x	x	x	
3I2	Negative-sequence current	A primary	x	x	x	x	

Table K.1 Analog Quantities (Sheet 2 of 7)

Label	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 primary	x	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 primary	x	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 primary	x	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 primary	x	x	x	x	x
VAB_ANG	Angle of the A-to-B phase voltage	degrees	x	x	x	x	

NOTE: Calculated phase-to-phase voltages are available in the analog quantities for wye-connected PTs.

Label	Description	Units	Display Points	SELogic	Load Profile	DNP	Fast Meter
VBC_MAG	B-to-C phase voltage	V primary	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 primary	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 primary	x	x	x	x	x
VG_ANG	Angle of the zero-sequence voltage	degrees	x	x	x	x	
VS_MAG	Sync. voltage	V primary	x	x	x	x	x
VS_ANG	Angle of sync. voltage	degrees	x	x	x	x	
VAVE	Average voltage	V primary	x	x	x	x	
3V2	Negative-sequence voltage	V primary	x	x	x	x	
UBV	Voltage unbalance	%	x	x	x	x	x
SA	A-phase apparent power	kVA primary	x	x	x	x	
SB	B-phase apparent power	kVA primary	x	x	x	x	
SC	C-phase apparent power	kVA primary	x	x	x	x	
S	3-phase apparent power	kVA primary	x	x	x	x	
		VA primary					x
PA	A-phase real power	kW primary	x	x	x	x	
PB	B-phase real power	kW primary	x	x	x	x	
PC	C-phase real power	kW primary	x	x	x	x	
P	3-phase real power	kW primary	x	x	x	x	
		W primary					x
QA	A-phase reactive power	kVAR primary	x	x	x	x	
QB	B-phase reactive power	kVAR primary	x	x	x	x	
QC	C-phase reactive power	kVAR primary	x	x	x	x	
Q	3-phase reactive power	kVAR primary	x	x	x	x	
		VAR primary					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	

Table K.1 Analog Quantities (Sheet 3 of 7)

Label	Description	Units	Display Points	SELogic	Load Profile	DNP	Fast Meter
PF	3-phase power factor		x	x	x	x	x
FREQ	Frequency	Hz	x	x	x	x	x
FREQS	Sync. Frequency	Hz	x	x	x	x	x
VDC	Station dc battery voltage	V		x	x		
Miscellaneous Quantities							
DFDT	Frequency rate-of-change	Hz/sec.	x	x			
I1_MAG	Positive-sequence current	A primary		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[a]	Maximum winding RTD temperature	°C	x	x		x	x
RTDBRGMX[a]	Maximum bearing RTD temperature	°C	x	x		x	x
RTDAMB[a]	Ambient RTD temperature	°C	x	x		x	x
RTDOTHMX[a]	Other maximum RTD temperature	°C	x	x		x	x
RTD1 to RTD12[b]	RTD1 temperature to RTD12 temperature	°C	x	x	x	x	
Analog Input Metering[c]							
AI301 to AI308	Analog inputs for an analog card in Slot C		x	x	x	x	
AI401 to AI408	Analog inputs for an analog card in Slot D		x	x	x	x	
AI501 to AI508	Analog inputs for an analog card in Slot E		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 primary	x	x	x	x	
MWH3P	3-phase real energy OUT	MWh primary	x	x	x	x	
MVARH3PI	3-phase reactive energy IN	MVARh primary	x	x	x	x	
MVARH3PO	3-phase reactive energy OUT	MVARh primary	x	x	x	x	
MVAH3P	3-phase apparent energy	MVAh primary	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 primary	x	x	x	x	
IBMX	B-phase maximum current	A primary	x	x	x	x	
ICMX	C-phase maximum current	A primary	x	x	x	x	
INMX	Neutral maximum current	A primary	x	x	x	x	
IGMX	Calculated residual maximum current	A primary	x	x	x	x	

Table K.1 Analog Quantities (Sheet 4 of 7)

Label	Description	Units	Display Points	SELOGIC	Load Profile	DNP	Fast Meter
IAMN	A-phase minimum current	A primary	x	x	x	x	
IBMN	B-phase minimum current	A primary	x	x	x	x	
ICMN	C-phase minimum current	A primary	x	x	x	x	
INMN	Neutral minimum current	A primary	x	x	x	x	
IGMN	Calculated residual minimum current	A primary	x	x	x	x	
VABMX	A-to-B phase maximum voltage	V primary	x	x	x	x	
VBCMX	B-to-C phase maximum voltage	V primary	x	x	x	x	
VCAMX	C-to-A phase maximum voltage	V primary	x	x	x	x	
VAMX	A-phase maximum voltage	V primary	x	x	x	x	
VBMX	B-phase maximum voltage	V primary	x	x	x	x	
VCMX	C-phase maximum voltage	V primary	x	x	x	x	
VSMX	Vsync maximum voltage	V primary	x	x	x	x	
VABMN	A-to-B phase minimum voltage	V primary	x	x	x	x	
VBCMN	B-to-C phase minimum voltage	V primary	x	x	x	x	
VCAMN	C-to-A phase minimum voltage	V primary	x	x	x	x	
VAMN	A-phase minimum voltage	V primary	x	x	x	x	
VBMN	B-phase minimum voltage	V primary	x	x	x	x	
VCMN	C-phase minimum voltage	V primary	x	x	x	x	
VSMN	Vsync minimum voltage	V primary	x	x	x	x	
KVA3PMX	3-phase maximum apparent power	kVA primary	x	x	x	x	
KW3PMX	3-phase maximum real power	kW primary	x	x	x	x	
KVAR3PMX	3-phase maximum reactive power	kVAR primary	x	x	x	x	
KVA3PMN	3-phase minimum apparent power	kVA primary	x	x	x	x	
KW3PMN	3-phase minimum real power	kW primary	x	x	x	x	
KVAR3PMN	3-phase minimum reactive power	kVAR primary	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	
RTD1MN to RTD12MN	RTD1 minimum to RTD12 minimum	°C	x	x	x	x	
AI301MX to AI308MX[c]	Analog transducer input 301–308 maximum		x	x	x	x	
AI301MN to AI308MN[c]	Analog transducer input 301–308 minimum		x	x	x	x	
AI401MX to AI408MX[c]	Analog transducer input 401–408 maximum		x	x	x	x	
AI401MN to AI408MN[c]	Analog transducer input 401–408 minimum		x	x	x	x	

Table K.1 Analog Quantities (Sheet 5 of 7)

Label	Description	Units	Display Points	SELogic	Load Profile	DNP	Fast Meter
AI501MX to AI508MX[c]	Analog transducer input 501–508 maximum		x	x	x	x	
AI501MN to AI508MN[c]	Analog Transducer Input 501–508 minimum		x	x	x	x	
RMS Metering							
IARMS	A-phase rms current	A primary	x	x	x	x	
IBRMS	B-phase rms current	A primary	x	x	x	x	
ICRMS	C-phase rms current	A primary	x	x	x	x	
INRMS	Neutral rms current	A primary	x	x	x	x	
VARMS	A-phase rms voltage	V primary	x	x	x	x	
VBRMS	B-phase rms voltage	V primary	x	x	x	x	
VCRMS	C-phase rms voltage	V primary	x	x	x	x	
VSRMS	Vsync rms voltage	V primary	x	x	x	x	
VABRMS	A-to-B phase rms voltage	V primary	x	x	x	x	
VBCRMS	B-to-C phase rms voltage	V primary	x	x	x	x	
VCARMS	C-to-A phase rms voltage	V primary	x	x	x	x	
Demand Metering							
IAD	Phase A Current Demand	A pri	x	x		x	x
IBD	Phase B Current Demand	A pri	x	x		x	x
ICD	Phase C 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	
KVARCDO	Reactive Power, C-phase Demand OUT	kVAR pri	x	x		x	
KVAR3DO	Reactive Power, 3-phase Demand OUT	kVAR pri	x	x		x	

Table K.1 Analog Quantities (Sheet 6 of 7)

Label	Description	Units	Display Points	SELogic	Load Profile	DNP	Fast Meter
Peak Demand Metering							
PM_LRDH	Peak Demand Last Reset Date/Time High Word		x	x		x	
PM_LRDM	Peak Demand Last Reset Date/Time Middle Word		x	x		x	
PM_LRDL	Peak Demand Last Reset Date/Time Low Word		x	x		x	
IAPD	Phase A Current Peak Demand	A pri	x	x		x	x
IBPD	Phase B Current Peak Demand	A pri	x	x		x	x
ICPD	Phase C 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 primary	x	x	x	x	
INTIB	Accumulated current—internal trips, B-phase	kA primary	x	x	x	x	
INTIC	Accumulated current—internal trips, C-phase	kA primary	x	x	x	x	
EXTT	External trips—counter		x	x	x	x	
EXTIA	Accumulated current—external trips, A-phase	kA primary	x	x	x	x	
EXTIB	Accumulated current—external trips, B-phase	kA primary	x	x	x	x	
EXTIC	Accumulated current—external trips, C-phase	kA primary	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	
Date/Time							
DATE[d,e]	Present date		x				
TIME[d,e]	Present time		x				

Table K.1 Analog Quantities (Sheet 7 of 7)

Label	Description	Units	Display Points	SELOGIC	Load Profile	DNP	Fast Meter
YEAR	Year number (0000–9999)			x	x		
DAYY	Day of year number (1–366)			x	x		
WEEK	Week number (1–52)			x	x		
DAYW	Day of week number (1–7)			x	x		
MINSM	Minutes since midnight			x	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[f]							
SC01 to SC32	SELOGIC counter 01 to SELOGIC counter 32		x	x	x	x	
Fault Information							
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	

[a] SEL Fast Message Label names for RTDWDGMX, RTDBRGMX, RTDAMB, and RTDOTHMX are WDG, BRG, AMB, and OTH, respectively.
[b] RTD open is equivalent to +32767 and RTD short is equivalent to –32768 when RTDs are monitored via LDP.
[c] See the Engineering Unit settings (e.g., AI301EU) of the respective analog input quantity for the unit.
[d] DATE, TIME, RID, and TID are only available for display point settings (DP01 to DP32).
[e] Also available via DNP object 50.
[f] 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
49	Thermal Element
50	Instantaneous Overcurrent Element
51	Inverse Time-Overcurrent Element
52	AC Circuit Breaker
55	Power Factor Element
59	Overvoltage 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 cause 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-751A Feeder Protection Relay uses ASCII text characters to communicate through use of 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-751A input. To set a logic condition to the true state (logical 1). To close a normally open output contact. To open a normally closed output contact.

Breaker Auxiliary Contact A spare electrical contact associated with a circuit breaker that opens or closes to indicate the breaker position. A form-a breaker auxiliary contact (ANSI Standard Device Number 52A) closes when the breaker is closed, opens when the breaker is open. A form-b breaker auxiliary contact (ANSI Standard Device Number 52B) opens when the breaker is closed and closes when the breaker is open.

Checksum A numeric identifier of the firmware in the relay. Calculated by the result of a mathematic sum of the relay code.

CID Abbreviation for Checksum Identifier. The checksum of the specific firmware installed in the relay.

Contiguous Items in sequence; the second immediately following the first.

CR_RAM Abbreviation for Critical RAM. Refers to the area of relay Random Access Memory (RAM) where the relay stores mission-critical data.

CRC-16 Abbreviation for Cyclical Redundancy Check-16. A mathematical algorithm applied to a block of digital information to produce a unique, identifying number. Used to ensure that the information was received without data corruption.

CT Abbreviation for current transformer.

Current Unbalance The SEL-751A 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-751A input. To clear a logic condition to the false state (logical 0). To open a normally open output contact. To close a normally closed output contact.

Delta A phase-to-phase connection of voltage transformers for electrical measuring purposes. Typically, two voltage transformers are used with one primary lead of the first transformer connected to A-phase and the other lead connected to B-phase. The second voltage transformer is connected to measure the voltage from B-phase to C-phase. When two transformers are used, this connection is frequently called “Open-Delta.”

Dropout Time The time measured from the removal of an input signal until the output signal deasserts. The time can be settable, as in the case of a logic variable timer, or can be a result of the characteristics of an element algorithm, as in the case of an overcurrent element dropout time.

EEPROM Abbreviation for Electrically Erasable Programmable Read-Only Memory. Nonvolatile memory where relay settings, event reports, SER records, and other nonvolatile data are stored.

Event History A quick look at recent relay activity that includes a standard report header; event number, date, time, and type; maximum fault phase current; and targets.

Event Report A text-based collection of data stored by the relay in response to a triggering condition, such as a fault or command. The data show relay measurements before and after the trigger, in addition to the states of protection elements, relay inputs, and relay outputs each processing interval. After an electrical system fault, use event reports to analyze relay and system performance.

Event Summary A shortened version of stored event reports. An event summary includes items such as event date and time, event type, fault voltages, currents, etc. The relay sends an event report summary (if auto messaging is enabled) to the relay serial port a few seconds after an event.

Fail-Safe Refers to an output contact that is energized during normal relay operation and de-energized when relay power is removed or if the relay fails.

Fast Meter, Fast Operate Binary serial port commands that the relay recognizes at the relay front-and rear-panel EIA-232 serial ports. These commands and the responses from the relay make relay data collection by a communications processor faster and more efficient than transfer of the same data through use of formatted ASCII text commands and responses.

FID Relay firmware identification string. Lists the relay model, firmware version and date code, and other information that uniquely identifies the firmware installed in a particular relay.

Firmware The nonvolatile program stored in the relay that defines relay operation.

Flash A type of nonvolatile relay memory used for storing large blocks of nonvolatile data, such as load profile records.

Fundamental Frequency The component of the measured electrical signal for which frequency is equal to the normal electrical system frequency, usually 50 or 60 Hz. Generally used to differentiate between the normal system frequency and any harmonic frequencies present.

Fundamental Meter Type of meter data presented by the SEL-751A that includes the present values measured at the relay ac inputs. The word “Fundamental” indicates that the values are Fundamental Frequency values and do not include harmonics.

IA, IB, IC Measured A-, B-, and C-phase currents.

IEC 61850 Standard protocol for real-time exchange of data between databases in multi-vendor devices.

IG Residual current, calculated from the sum of the phase currents. In normal, balanced operation, this current is very small or zero. When a ground fault occurs, this current can be large.

IN Neutral current measured by the relay IN input. The IN input is typically connected to the secondary winding of a window-CT for ground fault detection on resistance-grounded systems.

LCD Abbreviation for Liquid Crystal Display. Used as the relay front-panel alphanumeric display.

LED Abbreviation for Light-Emitting Diode. Used as indicator lamps on the relay front panel.

MIRRORED BITS Protocol for direct relay-to-relay communications.

NEMA Abbreviation for National Electrical Manufacturers Association.

Neutral Overcurrent Element A protection element that causes the relay to trip when the neutral current magnitude (measured by the IN input) exceeds a user-settable value. Used to detect and trip in response to ground faults.

Nominal Frequency Normal electrical system frequency, usually 50 or 60 Hz.

Nonfail-Safe Refers to an output contact that is not energized during normal relay operation. When referred to a trip output contact, the protected equipment remains in operation unprotected when relay power is removed or if the relay fails.

Nonvolatile Memory Relay memory that is able to correctly maintain data it is storing even when the relay is de-energized.

Overfrequency Element A protection element that causes the relay to trip when the measured electrical system frequency exceeds a settable frequency.

Phase 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).

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-751A (and the SEL-2600 RTD Module) can measure the resistance of the RTD, and thus determine the temperature at the RTD location. Typically embedded in the motor windings or attached to the races of bearings.

Transducer Device that converts the input to the device to an analog output quantity of either current (±1, 2.5, 5, 10 and 20 mA, or 4–20 ma), or voltage (±1, 2.5, 5, or 10 V).

Self-Test A function that verifies the correct operation of a critical device subsystem and indicates if the relay has detected an out-of-tolerance condition. The SEL-751A 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.

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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Page numbers appearing in bold mark the location of the topic's primary discussion.

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SEL-751A 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 they can also be entered by using lowercase letters.

Serial Port Command	Command Description
Access Level 0 Commands	
ACC	Go to Access Level 1.
ID	Relay identification code.
QUI	Go to Access Level 0.
Access Level 1 Commands	
2AC	Go to Access Level 2.
BRE	Display breaker monitor data (trips, interrupted current, wear).
CEV *n*	Show compressed event report number n, at 1/4-cycle resolution. Attach R for compressed raw report, at 1/16- cycle resolution.
COM A	Return a summary report of the last 255 records in the communications buffer for MIRRORED BITS® communications Channel A.
COM B	Return 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	Return a summary report of the last 255 records in the MIRRORED BITS communications buffer.
COU *n*	Show current state of device counters. *n* = repeat the report *n* times, with a 1/2 second delay between each report.
DAT	View the date.
DAT *dd/mm/yyyy*	Enter date in DMY format.
DAT *mm/dd/yyyy*	Enter date in MDY format if DATE_F setting is MDY.
DAT *yyyy/mm/dd*	Enter date in YMD format if DATE_F setting is YMD.
ETH	Show the Ethernet port status.
EVE *n*	Show event report *n* with 4 samples per cycle. If *n* is omitted, most recent report is displayed.
EVE R *n*	Show event report *n* with raw (unfiltered) 16 samples per cycle analog data and 4 samples per cycle digital data.
FIL DIR	Return a list of files.
FIL READ *filename*	Transfer settings file *filename* from the relay to the PC.
FIL SHOW *filename*	Filename 1 displays contents of the file filename.
GOO *k*	Display transmit and receive GOOSE messaging information. Enter number *k* to scroll the GOOSE data *k* times on the screen.
GRO	Display active group setting.
HEL	Display a short description of selected commands.

Serial Port Command	Command Description
HIS *n*	Show 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	Clear or reset history buffer.
IRIG	Force synchronization of internal control clock to IRIG-B time-code input.
LDP	Display signal profile data.
LDP C	Clear signal profile data.
MAC	Display the MAC address of the Ethernet port (PORT 1).
MET	Display instantaneous metering data.
MET *k*	Display instantaneous metering data *k* times, where *k* is between 1 and 32767.
MET AI	Display analog input (transducer) data.
MET DEM k	Display demand metering data, in primary amperes. Enter k to scroll metering k times on screen.
MET E	Display energy metering data.
MET L	Display 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	Display SELOGIC math variable data.
MET PEA k	Display peak demand metering data, in primary amperes. Enter k to scroll metering k times on screen.
MET PM	Display synchrophasor metering data.
MET RD	Reset demand metering values.
MET RE	Reset energy metering data.
MET RM	Reset minimum and maximum metering data.
MET RMS	Display **RMS** metering data.
MET RP	Reset peak demand metering values.
MET T	Display **RTD** metering data.
PING x.x.x.x t	Determine 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	Display all Sequential Events Recorder (SER) data.
SER *d1*	Display all **SER** records made on date *d1*.
SER *d1 d2*	Display all **SER** records made from dates *d2* to *d1*, inclusive, starting with *d2*.
SER *n*	Display the *n* most recent **SER** records starting with record *n*.
SER *n1 n2*	Display **SER** records *n2* to *n1*, starting with *n2*.
SER C or R	Clear **SER** data.
SER D	Display **SER** Delete Report, which shows deleted items (use when **SER** Auto Deletion is selected to remove chatter).
SHO *n*	Display relay settings for group *n* (*n = 1, 2, or 3*). If *n* is not specified, default is the active settings group.
SHO F	Display front-panel settings.
SHO G	Display global settings.
SHO L *n*	Display general logic settings for group *n* (*n = 1, 2, or 3*). If *n* is not specified, default is the active settings group.
SHO M	Display Modbus User Map settings.
SHO P *n*	Display port settings, where *n* specifies the port (1, 2, 3, 4, or F); *n* defaults to the active port if not listed.
SHO R	Display report settings.
STA	Display relay self-test status.
STA S	Display SELOGIC usage status report.
SUM	Display an event summary.
SUM R or C	Reset event summary buffer.
TAR	Display default target row or the most recently viewed target row.

Serial Port Command	Command Description
TAR *n*	Display target row *n*.
TAR *n k*	Display target row *n*. Repeat display of row *n* for repeat count *k*.
TAR *name*	Display the target row with target name in the row.
TAR *name k*	Display the target row with target name in the row. Repeat display of this row for repeat count *k*.
TAR R	Reset any latched targets and the most recently viewed target row.
TIM	View time.
TIM *hh:mm:ss*	Set time by entering **TIM** followed by hours, minutes, and seconds, as shown (24-hour clock).
TRI	Trigger an event report data capture.
Access Level 2 Commands	
AFT	Test arc-flash detector channels 1–4
ANA *c p t*	Test 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	Reset breaker data.
BRE W	Preload breaker data.
CAL	Enter 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	Close circuit breaker.
CON RB*nn k*	Select a remote bit to set, clear, or pulse where *nn* is a number from 01 to 32, representing RB01 through RB32. *k* is S, C, or P for Set, Clear, or Pulse.
COP m n	Copy relay and logic settings from Group *m* to Group *n*.
FIL WRITE *filename*	Transfer settings file *filename* from the PC to the relay.
GRO *n*	Modify active group setting.
L_D	Load new firmware.
LOO	Enables loopback testing of MIRRORED BITS channels.
LOO A	Enable loopback on MIRRORED BITS Channel A for the next 5 minutes.
LOO B	Enable loopback on MIRRORED BITS Channel B for the next 5 minutes.
OPE	Open circuit breaker.
PAS 1	Change Access Level 1 password.
PAS 2	Change Access Level 2 password.
PUL *n t*	Pulse Output Contact *n* (*n* = OUT101…) for *t* (1 to 30, default is 1) seconds.
SET *n*	Modify 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	Modify front-panel settings.
SET G	Modify global settings.
SET L *n*	Modify 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	Modify Modbus User Map settings.
SET P *n*	Modify port *n* settings (*n* = 1, 2, 3, 4, or F; if not specified, the default is the active port).
SET R	Modify report settings.
SET … TERSE	For all **SET** commands, **TERSE** disables the automatic **SHO** command after the settings entry.
STA R or C	Clear self-test status and restart relay.
Access Level CAL Commands	
PAS C	Changes Access Level C password.

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SEL-751A 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 they can also be entered by using lowercase letters.

Serial Port Command	Command Description
Access Level 0 Commands	
ACC	Go to Access Level 1.
ID	Relay identification code.
QUI	Go to Access Level 0.
Access Level 1 Commands	
2AC	Go to Access Level 2.
BRE	Display breaker monitor data (trips, interrupted current, wear).
CEV *n*	Show compressed event report number n, at 1/4-cycle resolution. Attach R for compressed raw report, at 1/16- cycle resolution.
COM A	Return a summary report of the last 255 records in the communications buffer for MIRRORED BITS® communications Channel A.
COM B	Return 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	Return a summary report of the last 255 records in the MIRRORED BITS communications buffer.
COU *n*	Show current state of device counters. *n* = repeat the report *n* times, with a 1/2 second delay between each report.
DAT	View the date.
DAT *dd/mm/yyyy*	Enter date in DMY format.
DAT *mm/dd/yyyy*	Enter date in MDY format if DATE_F setting is MDY.
DAT *yyyy/mm/dd*	Enter date in YMD format if DATE_F setting is YMD.
ETH	Show the Ethernet port status.
EVE *n*	Show event report *n* with 4 samples per cycle. If *n* is omitted, most recent report is displayed.
EVE R *n*	Show event report *n* with raw (unfiltered) 16 samples per cycle analog data and 4 samples per cycle digital data.
FIL DIR	Return a list of files.
FIL READ *filename*	Transfer settings file *filename* from the relay to the PC.
FIL SHOW *filename*	Filename 1 displays contents of the file filename.
GOO *k*	Display transmit and receive GOOSE messaging information. Enter number *k* to scroll the GOOSE data *k* times on the screen.
GRO	Display active group setting.
HEL	Display a short description of selected commands.

Serial Port Command	Command Description
HIS *n*	Show 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	Clear or reset history buffer.
IRIG	Force synchronization of internal control clock to IRIG-B time-code input.
LDP	Display signal profile data.
LDP C	Clear signal profile data.
MAC	Display the MAC address of the Ethernet port (PORT 1).
MET	Display instantaneous metering data.
MET *k*	Display instantaneous metering data *k* times, where *k* is between 1 and 32767.
MET AI	Display analog input (transducer) data.
MET DEM k	Display demand metering data, in primary amperes. Enter k to scroll metering k times on screen.
MET E	Display energy metering data.
MET L	Display 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	Display SELOGIC math variable data.
MET PEA k	Display peak demand metering data, in primary amperes. Enter k to scroll metering k times on screen.
MET PM	Display synchrophasor metering data.
MET RD	Reset demand metering values.
MET RE	Reset energy metering data.
MET RM	Reset minimum and maximum metering data.
MET RMS	Display **RMS** metering data.
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MET T	Display **RTD** metering data.
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