SEL-849

Motor Management Relay

Instruction Manual

20250117

SCHWEITZER ENGINEERING LABORATORIES

 PM849-01

Table of Contents

Section 5: Metering and Monitoring

Section 6: Settings

Section 7: Communications

Section 8: Human-Machine Interface (HMI)

Section 9: Analyzing Events

Section 10: Testing and Troubleshooting

Appendix A: Firmware, ICD, and Manual Versions

Appendix B: Firmware Upgrade Instructions

Appendix C: SEL Communications Processors

Appendix D: DNP3 Communications

Appendix E: Modbus Communications

Appendix F: EtherNet/IP Communications

Appendix G: IEC 61850 Communications

Appendix H: Relay Word Bits

Appendix I: Analog Quantities

Appendix J: Cybersecurity Features

Glossary

SEL-849 Command Summary

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List of Tables

List of Figures

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Preface

Manual Overview

The SEL-849 Motor Management Relay Instruction Manual describes common aspects of motor 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-849; lists the relay specifications.

Section 2: Installation. Describes how to mount and wire the SEL-849; illustrates wiring connections for various applications.

Section 3: PC Interface. Describes the built-in web server and its features, including setting the relay, meter and monitoring, control, and events retrieving. Also describes the features, installation methods, and types of help available with the ACSELERATOR QuickSet SEL-5030 Software.

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

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

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

Section 7: Communications. Describes how to connect the SEL-849 to a personal computer (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 ports.

Section 8: Human-Machine Interface (HMI). Explains the features and use of the SEL-3421 and SEL-3422 Motor Relay HMI modules, including control pushbuttons, configurable pushbuttons, LED targets, navigation pushbuttons, command menu, default displays, automatic messages, and how to update the relay IP and router addresses.

Section 9: Analyzing Events. Describes the relay trip-type messages, event summary data, standard event reports, COMTRADE event reports, and Sequential Events Recorder (SER) reports.

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

Appendix A: Firmware, ICD, and Manual Versions. Lists the current relay firmware version and details differences between the current 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-849 with SEL Communications Processors for total system automation solutions.

Appendix D: DNP3 Communications. Describes the DNP3 protocol support provided by the SEL-849.

Appendix E: Modbus Communications. Describes the Modbus protocol support provided by the SEL-849.

Appendix F: EtherNet/IP Communications. Describes the EtherNet/IP support provided by the SEL-849.

Appendix G: IEC 61850 Communications. Describes IEC 61850 implementation in the SEL-849.

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

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

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

SEL-849 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.

> ⚠**WARNING**
> To avoid the risk of electrostatic discharge when using the SEL-3421 or SEL-3422 HMI, take one of the following precautions: 1) touch the front panel with an insulated object, 2) use ESD shoe covers to insulate shoes from the ground before touching the front panel, or 3) step on an insulated mat before touching the front panel.

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

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 3 environment.	Pour l'utilisation dans un environnement de Degré de Pollution 3.
Per UL compliance, ambient air temperature shall not exceed 40°C (104°F).	Conforme à la norme UL, la température ambiante desera de l'air ne doit pas dépasser les 40°C (104°F).
Terminal Ratings Wire Material Use 75°C (167°F) copper conductors only Tightening Torque Compression Plug: 0.5–1.0 Nm (4.4–8.8 in-lb) Compression Plug Mounting Ear Screw: 0.18–0.25 Nm (1.6–2.2 in-lb)	Spécifications des bornes Type de filage Utiliser seulement conducteurs en cuivre spécifiés à 75°C (167°F). Couple de serrage 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)
Stripping Length: 8 mm	Longueur de dénudement : 8 mm
Holes in the enclosure for mounting and wiring the HMI shall not be greater than 775 mm^2.	Les trous dans boîtier pour le montage et le câblage de l’IHM ne doivent pas dépasser 775 mm^2.

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.
For ATEX compliance, the ambient temperature range shall be –20°C to +40°C (–4°F to +104°F).	Pour conformer à la norme ATEX, la plage de températures ambiantes sera de –20°C à +40°C (–4°F à +104°F).
For UL Class I, Division 2 compliance, the ambient temperature range shall be –25°C to +40°C (–13°F to +104°F).	Pour conformer à la norme UL Classe I, Division 2, la plage de températures ambiantes sera de –25°C à +40°C (–13°F à +104°F).

Other Safety Marks

⚠WARNING Use of this equipmen t 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.
⚠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.

Compliance Approvals

To satisfy safety requirements, the unit shall be installed in a suitable fire/electrical/mechanical enclosure. To protect against electrical shock hazards, the enclosure shall prevent access to hazardous voltages.

Specific Conditions of Use for ATEX Installations:

SEL-849 Relay

- The SEL-849 shall be installed within a tool-accessible enclosure that meets the requirements of IEC 60079-0, which provides a minimum ingress protection of IP54 in accordance with IEC 60079-7.
- The equipment shall be installed with a manual override system.

⚠WARNING
To avoid the risk of electrostatic discharge when using the SEL-3421 or SEL-3422 HMI, take one of the following precautions: 1) touch the front panel with an insulated object, 2) use ESD shoe covers to insulate shoes from the ground before touching the front panel, or 3) step on an insulated mat before touching the front panel.

SEL-3421 and SEL-3422 HMI Modules

- ➤ The SEL-3421 or SEL-3422 shall be connected to the SEL-849 for hazardous locations suitability.
- ➤ The SEL-3421 or SEL-3422 shall be mounted on the same surface of a tool-accessible enclosure as the SEL-849 that meets the requirements of IEC 60079-0, which provides a minimum ingress protection of IP54 in accordance with IEC 60079-7.
- ➤ The SEL-3421 or SEL-3422 shall be installed in a low-risk mechanical impact area.

General Information

Typographic Conventions

You can communicate with the SEL-849 in four ways.

- ➤ Use the built-in web server with a PC connected to the Ethernet port.
- ➤ Use a command line interface on a PC terminal emulation window.
- ➤ Use the SEL-3421 or the SEL-3422 Motor Relay HMI module.
- ➤ Use ACSELERATOR QuickSet on a PC connected to the relay with a serial port or the Ethernet port (Telnet session).

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

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

Trademarks

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

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

ACSELERATOR Analytic Assistant®	Compass®
ACSELERATOR Architect®	Modbus®
ACSELERATOR QuickSet®	SELOGIC®
ACSELERATOR Report Server®	SYNCHROWAVE®

Examples

This instruction manual uses several example illustrations and instructions to explain how to effectively operate the SEL-849. These examples are for demonstration purposes only; the firmware identification information or settings values included in these examples may not necessarily match those in the current version of your SEL-849.

Environmental Conditions and Voltage Information

The following table lists important environmental and voltage information.

Condition	Range/Description
Indoor/outdoor use	Indoor
Altitude[a]	To 2000 m
Temperature	
IEC Performance Rating (per IEC/EN 60068-2-1 and IEC/EN 60068-2-2)	–40° to +85°C
Relative humidity	5% to 95%, noncondensing
Main supply voltage fluctuations	±10% of nominal voltage
Overvoltage	Category II
Insulation	Class 1
Pollution	Degree 3
Atmospheric pressure	80 to 110 kPa

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

Wire Sizes and Insulation

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

Connection Type	Wire Size		Insulation Voltage
	Minimum	Maximum	
Grounding (Earthing)	18 AWG (0.8 mm^2)	14 AWG (2.10 mm^2)	300 V min
Current[a]	16 AWG (1.3 mm^2)	12 AWG (3.30 mm^2)	300 V min
Potential (Voltage)	18 AWG (0.8 mm^2)	14 AWG (2.10 mm^2)	690 V min
Contact I/O	18 AWG (0.8 mm^2)	14 AWG (2.10 mm^2)	300 V min
Other	20 AWG (0.5 mm^2)	14 AWG (2.10 mm^2)	300 V min

[a] For external 1 A or 5 A CT secondary.

The power terminals are isolated from the chassis ground. Use 14 AWG (2.10 mm^2) to 16 AWG (1.30 mm^2) size wire to connect to the power terminals.

Instructions for Cleaning and Decontamination

Use a mild soap or detergent solution and a damp cloth to carefully clean the SEL-849 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 Support

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: +1.509.338.3838
Fax: +1.509.332.7990
Internet: selinc.com/support
Email: info@selinc.com

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Section 1
Introduction and Specifications

Overview

The SEL-849 Motor Management Relay is designed to protect three-phase motors. The basic relay provides locked rotor, overload, overtemperature, unbalance, and short circuit protection. Voltage-based protection elements are available as options. Additionally, the relay includes inverse time-overcurrent elements suitable for feeder protection. All relay models provide monitoring functions.

This manual contains the information needed to install, set, test, operate, and maintain any SEL-849. You need not review the entire manual to perform specific tasks.

Features

Standard Protection Features

- Thermal Overload (Thermal Model) (49)
- Undercurrent (Load Loss) (37)
- Current Balance and Phase Loss (46)
- Overcurrent (Load Jam)
- Short Circuit (50P)
- Ground Fault—Residual Overcurrent (50G)
- Ground Fault—Core-Balance Overcurrent (50N)
- Arc-Flash Protection
- Motor Restart Logic
- Negative-Sequence Overcurrent (50Q)
- Phase Time-Overcurrent (51P)
- Ground (Residual) Time-Overcurrent (51G)
- Negative-Sequence Time-Overcurrent (51Q)
- Neutral Time-Overcurrent (51N)
- Second- and Fifth Harmonic Blocking (HBL)
- Phase Reversal (47), current based
- Motor Starting/Running
  - Start Motor Timer
  - Notching or Jogging Device (66)
  - Thermal Capacity Utilization (TCU) Start Inhibit

- Antibackspin Timer
- Emergency Start
- Two-Speed Protection
- Reduced Voltage Starting (19)
- Stall-Speed Switch (14)

- Breaker/Contactor Failure Protection
- Positive Temperature Coefficient (PTC) Overtemperature Switching Thermistor (49)

Optional Protection Features

- Frequency (81)
- Voltage-Based Protection
  - Undervoltage (27)
  - Overvoltage (59)
  - Power Elements (32)
  - Phase Reversal (47)
  - Power Factor (55)

Monitoring Features

- Event Summaries that contain relay ID, date and time, trip cause, and current/voltage magnitudes
- Event Reports including filtered and raw analog data
- Sequential Events Recorder (SER)
- Motor operating statistics since the last reset
  - Running and stopped times
  - Number of starts and emergency starts
  - Average and peak metering values during start and run periods
  - Load profiling
  - Number of various alarms and trips
- Motor Start Reports, for as long as 240 seconds, for each of the last five starts
- Motor Start Trend data for the past eighteen 30-day intervals
- A complete suite of accurate metering functions

Communications and Control

- Single copper Ethernet port
- User-selectable EIA-232 or EIA-485 port
- Built-in web server
- Modbus RTU slave, Modbus TCP/IP, Ethernet FTP, Telnet, EtherNet/IP, SNTP, DNP3 serial, DNP3 LAN/WAN, PRP, and File Transfer Protocols
- 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-849 Model Option Table at selinc.com.

Options

- **Power Supply Options:** high-voltage supply 110/240 Vac/ 125/250 Vdc; low-voltage supply 24/48 Vdc
- **Voltage Option:** four-wire direct connection (as high as 690 Vac, line-to-line); four-wire wye, open-delta or single-phase connected VTs
- **Digital Outputs:** three Form A output contacts, one Form C output contact
- **Analog Output**
- **Digital Inputs:**
  - Internally wetted to 24 Vdc: high- or low-voltage power supply models with six or twelve internally wetted digital inputs
  - Externally wetted to 110/125 Vdc/Vac: high- or low-voltage power supply models with six externally wetted digital inputs
  - Externally wetted to 24/48 Vdc/Vac: high-voltage power supply models with six externally wetted digital inputs
  - Externally wetted to 24/48 Vdc/Vac: low-voltage power supply models with six externally wetted digital inputs
- **Communications Options (Protocol/Ports):** additional user-selectable EIA-232/EIA-485 port, dual Ethernet port, DNP3 serial, DNP3 LAN/WAN, EtherNet/IP, and IEC 61850 communications
- **Conformal Coating:** additional barrier against contaminants in harsh environments.

Accessories

NOTE: All SEL-3421 and SEL-3422 HMI electronic boards are conformally coated.

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

- SEL-3421 Motor Relay HMI (P/N 3421XXX1)
- SEL-3422 Motor Relay HMI (P/N 3422XXX1)
- SEL-849 Configurable Labels (P/N 915900268) (customize the LED labels on the SEL-3421/3422 modules, see selinc.com/products/849/docs)
- SEL-849 Accessory Lug Kit (P/N 915900325) (supports applications up to FLA 128.0 A; refer to *Section 2: Installation*, *SEL-849 Accessory Lug Kit Installation*.)
- Core-Balance CTs (see selinc.com/products/ct)
- Panel-Mounted Quick Connect RJ45 Connector Kit (P/N 915900615) (allows the connection of Port A or Port B to the RJ45 jack kit mounted through a panel wall or door)

For all SEL-849 accessories, refer to the SEL-849 Model Option Table at selinc.com, under SEL Literature, Ordering Information (Model Option Tables).

Order P/N 915900269 for replacement screws, DIN rail clips, and DIN rail supports for as many as five SEL-3421/SEL-3422 HMIs.

Applications

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

- With or without external current and/or voltage transformer
- Variable frequency drive (VFD) applications
- Full voltage nonreversing (FVNR) starter (across the line)
- Star-delta starter
- Two-speed/forward/reverse starter

Figure 1.1 shows across-the-line starting ac connections. Refer to *Section 2: Installation* for additional applications and the related connection diagrams.

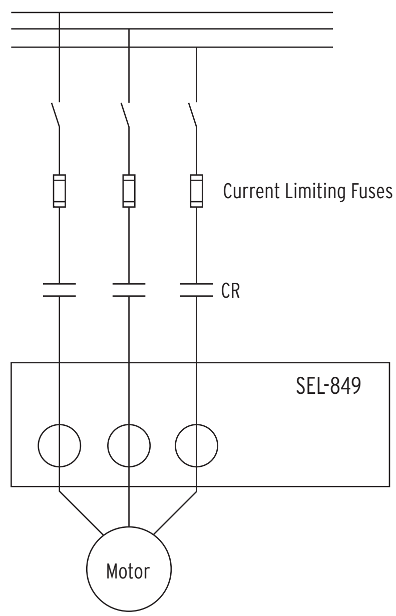

Figure 1.1 AC Connections—Across-the-Line Starting

Getting Started

Understanding basic relay operation principles and methods will help you use the SEL-849 effectively. This section presents the fundamental knowledge you need to operate the SEL-849, 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-849 with 110/240 Vac or 125/250 Vdc (high-voltage power supply option), or 24/48 Vdc (low-voltage power supply option).

- Observe proper polarity, as indicated by the **+/H** (terminal **A3**) and the **–/N** (terminal **A2**) on the power connections.
- Connect the ground lead, see *Power Supply Connections (Terminal Block A) on page 2.8*.
- Once connected to power, the relay does an internal self-check and the **ENABLED** LED illuminates.

Establishing Communication

The standard SEL-849 has an EIA-232 serial communications port as well as an Ethernet port. The following steps require PC terminal emulation software and an EIA-232 cable (SEL-C234T) to connect the SEL-849 to the PC. See *Section 7: Communications* for further information on serial communications connections and the required cable pinout.

Step 1. Connect the PC and the SEL-849, using the serial communications cable.

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

Step 3. Start the PC terminal emulation program.

Step 4. Set the PC terminal emulation program to the communications port settings listed in the Default Value column of *Table 1.1*. Also, set the terminal program to emulate either VT100 or VT52 terminals.

Step 5. Press **<Enter>** to check the communications link.

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

If you do not see the = prompt, check the cable connections, and confirm that the settings in the terminal emulation program are the default values in *Table 1.1*.

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

You will see a computer screen display similar to *Figure 1.2*. If you see jumbled characters, change the terminal emulation type in the PC terminal emulation program.

Step 7. Type **ACC <Enter>** and the appropriate password (see *Table 7.14* for factory-default passwords) to go to Access Level 1.

Table 1.1 SEL-849 Serial Port Settings

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

```
=>QUIT <Enter>
SEL-849 Date:04/24/2012  Time: 10:31:43
MOTOR RELAY            Time Source: Internal
```

Figure 1.2 Response Header

Checking Relay Status

Use the **STA** serial port command to view the SEL-849 operational status. Analog module and monitored component status are listed in the status report depicted in *Figure 1.3*.

```
=>>STA <Enter>

SEL-849                                   Date: 05/09/2023   Time: 01:34:59.655
MOTOR RELAY                               Time Source: Internal


Serial Num = 1130210564
FID = SEL-849-R109-V0-Z006004-D20230811          CID = 8159
BFID = BOOTLDR-R105-V0-Z000000-D20160509
PART NUM = 084900100000000
CAL Version =  100
HMI Version =  101

SELF TESTS (W=Warn)
  RAM     ROM     CR_RAM  NON_VOL HMI     CLOCK   CLK_BAT   PTC     AF
  OK      OK      OK      OK      OK      OK      OK        OK      OK

Analog Module
  COMM    DIAG
  OK      OK

  Relay Enabled

=>>
```

Figure 1.3 STA Command Response

Table 7.45 provides the definition of each status report designator. The beginning of the status report printout (see *Figure 1.3*) contains the relay serial number, firmware identification (FID) string, SELBOOT firmware identification (BFID) string, part number, and checksum (CID) string. 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-849. If the date stored in the relay is July 29, 2012, and the DATE_F setting is MDY, the relay will reply:

```
7/29/2012
```

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

```
2012/7/29
```

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

```
29/7/2012
```

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, 2012 (DATE_F = MDY), enter the following at the action prompt:

```
DAT 5/2/12
```

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-849. The relay will reply with the stored time. For example:

```
13:52:44
```

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

Changing the Time

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

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

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

Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

47 CFR 15B, Class A

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

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

UL Listed to U.S. and Canadian safety standards (File E212775, NRGU/7, KDAX, NKCR/7)

CE Mark

RCM Mark

UKCA Mark

Hazardous Locations

UL Listed for Hazardous Locations to U.S. and Canadian standards (File E470448; NRAK/NRAK7)

EU

II 3 G
Ex ec ic nC IIC T4 Gc
SEL 24 ATEX 0001X

IEC 60947-4-1 Type 2 Coordination Compatible. For short circuits, the relay withstands as much as 100 kA.

General

Rogowski Coil-Based AC Current Inputs—Phase

Rated Range: 0.5–256.0 A
Rated Frequency: 50/60 Hz
Burden (Per Phase): Not applicable

Core-Balance CT Current (IN)

Rated Current Range: 0.010–40.000 mA
Rated Continuous Thermal Current: 1.0 A
1-Second Thermal Current: 10 A
Saturation Current Range: 7–48 mA (actual range will depend on the 50N1P setting)
Burden: <0.012 VA at 40 mA

AC Voltage Inputs (Line-to-Line)

Rated Operating Voltage (Ue): 100–690 Vac
Rated Continuous Voltage: 800 Vac
10-Second Thermal: 1000 Vac
Rated Frequency: 50/60 Hz
Burden: <0.2 VA
Input Impedance: 12 M Ω (phase-to-neutral)
12 M Ω (phase-to-phase)

Power Supply

Relay Start-Up Time: Approximately 5 seconds (after power is applied until ENABLED LED turns on); approximately 2 seconds (after power is applied until ENABLED LED turns on) if Motor Restart feature is enabled and the Relay Word bit RSACTIVE is asserted before the relay powers down.

High-Voltage Supply

Rated Supply Voltage: 110–240 Vac, 50–60 Hz, 125–250 Vdc
Absolute Operating Range (Design Range): 85–264 Vac, 85 –275 Vdc
Power Consumption: <30 VA (ac)
<12 W (dc)
Interruptions: 20 ms minimum

Low-Voltage Supply

Rated Supply Voltage: 24–48 Vdc
Absolute Operating Range (Design Range): 19.2–57.6 Vdc
Power Consumption: <12 W (dc)
Interruptions: 20 ms minimum

Fuse Ratings

LV Power Supply Fuse

Rating: 2.5 A
Maximum Rated Voltage: 125 Vdc, 125 Vac
Breaking Capacity: 50 A at 125 Vac
Type: Time-lag T

HV Power Supply Fuse

Rating: 0.5 A
Maximum Rated Voltage: 600 Vac
Breaking Capacity: 75 A at 600 Vac
Type: Time-lag T

Fuses are not serviceable.

Output Contacts

The relay supports Form A and C outputs.

Dielectric Test Voltages: 2500 Vac
Impulse Withstand Voltage (U_{IMP}): 4700 V
Mechanical Durability: 100,000 no-load operations

Standard Contacts (Electromechanical)

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

DC Output Ratings

OUT01 (Form C)

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: 385 Vdc, 9.6 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

OUT02, 03, 04 (Form A)

Rated Operational Voltage: 30 Vdc

Rated Voltage Range: 19.2–275 Vdc

Rated Insulation Voltage: 300 Vdc

Make: 5 A @ 30 Vdc

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

Thermal: 25 A for 1 s

Contact Protection: 385 Vdc, 9.6 J MOV protection across open contacts

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

24 Vdc	0.2 A	L/R = 40 ms
48 Vdc	0.15 A	L/R = 40 ms
125 Vdc	0.1 A	L/R = 40 ms
250 Vdc	0.05 A	L/R = 40 ms

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

24 Vdc	0.2 A	L/R = 40 ms
48 Vdc	0.15 A	L/R = 40 ms
125 Vdc	0.1 A	L/R = 40 ms
250 Vdc	0.05 A	L/R = 40 ms

AC Output Ratings

Maximum Operational Voltage (U_e) Rating: 277 Vac

Insulation Voltage (U_i) Rating (excluding EN 61010-1): 300 Vac

1-Second Thermal: 50 A

Contact Rating Designation: B300

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

Utilization Category: AC-15

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

Voltage Protection Across Open Contacts: 300 Vac, 9.6 J

Optoisolated Control Inputs (Internally Wetted to 24 Vdc)

Current Draw at Nominal dc Voltage: 2 mA (at 24 V)

Rated Impulse Withstand Voltage (U_{imp}): 4000 V

Pickup Time: <60 ms

Dropout Time: <40 ms

Optoisolated Control Inputs (Externally Wetted to 24/48 Vdc/Vac or 110/125 Vdc/Vac)

Minimum Current Draw: 1.5 mA

Rated Impulse Withstand Voltage (U_{imp}): 4000 V

Pickup Time: <60 ms

Dropout Time: <40 ms

When Used With DC Control Signals:

110/125 Vdc: ON between 95 and 156.2 Vdc
OFF below 70 Vdc

24/48 Vdc: ON between 19.2 and 60 Vdc
OFF below 14.4 Vdc

When Used With AC Control Signals:

110/125 Vac: ON between 95 and 137.5 Vac
OFF below 66 Vac

24/48 Vac: ON between 19.2 and 60 Vac
OFF below 14.4 Vac

Analog Output (Optional)

Current: 0–20 mA

Load at 20 mA: 0–300 ohms

Refresh Rate: 25 ms

% Error, Full Scale, at 25°C: ±1%

Select From: Analog quantities available in the relay

Frequency and Phase Rotation

System Frequency: 50, 60 Hz

Phase Rotation: ABC, ACB

Frequency Tracking: 12.5–72.5 Hz

Time-Code Input

Simple Network Time Protocol (SNTP) Accuracy

Internal Clock: ±5 ms

Unsynchronized Clock Drift Relay Powered: 10 minutes per year, typically

Communications Ports

EIA-232 (as many as 2 Ports)

Data Speed: 300–57600 bps

EIA-485 Port (as many as 2 Ports)

Data Speed: 300–57600 bps

Ethernet Port

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

Communications Protocols

SEL, Modbus RTU and TCP/IP, FTP, Telnet, EtherNet/IP, SNTP, DNP3 serial, DNP3 LAN/WAN, PRP, HTTP, HTTPS, IEC 61850 Edition 1 (optional)

Operating Temperature

SEL-849 Motor Relay/ 3422 Motor Relay HMI: –40° to +85°C (–40° to +185°F)

SEL-3421 Motor Relay HMI: –20° to +70°C (–4° to +158°F)

Note: The front-panel display is impaired for temperatures below –20° and above 70°C.

Not applicable to UL or ATEX hazardous locations applications

Operating Environment

Insulation Class: 1

Pollution Degree:	3
Overvoltage Category:	II
Atmospheric Pressure:	80–110 kPa
Relative Humidity:	5%–95%, noncondensing
Maximum Altitude Without Derating (Consult Factory for Higher Altitude Derating):	2000 m

Dimensions

71.1 mm (2.8 in) x 127.0 mm (5 in) x 152.4 mm (6 in)

Weight

1.0 kg (2.2 lb)

Terminal Connections

Compression Plug Tightening Torque

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

Compression Plug Mounting Ear Screw Tightening Torque

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

Product Standards

Electromagnetic Compatibility:	IEC 60255-26:2013
General Safety:	IEC 60255-27:2013
Hazardous Locations Standards:	UL 121201, Ninth Edition CSA C22.2 No. 213-17 EN 60079-0:2018/A11:2024 EN 60079-7:2015/A1:2018/A11:2024 EN 60079-11:2012 EN 60079-15:2019

Type Tests

Environmental Tests

Enclosure Protection:	IEC 60529:2001 + CRDG:2003 IP20 for SEL-849 IP65 for SEL-3421/3422
Vibration Resistance:	IEC 60255-21-1:1998 IEC 60255-27:2013; Section 10.6.2.1
Endurance:	Class 2 (panel mounted only) Class 1 (DIN-rail mounted only)
Response:	Class 2
Shock Resistance:	IEC 60255-21-2:1998 IEC 60255-27:2013; Section 10.6.2.2 IEC 60255-27:2013; Section 10.6.2.3
Withstand:	Class 1
Response:	Class 2
Bump:	Class 1
Seismic (Quake):	IEC 60255-21-3:1993 IEC 60255-27:2013; Section 10.6.2.4
Response:	Class 2
Cold:	IEC 60068-2-1:2007 IEC 60255-27:2013; Section 10.6.1.2 IEC 60255-27:2013; Section 10.6.1.4 –40°C, 16 hours
Dry Heat:	IEC 60068-2-2:2007 IEC 60255-27:2013; Section 10.6.1.1 IEC 60255-27:2013; Section 10.6.1.3 85°C, 16 hours
Damp Heat, Steady State:	IEC 60068-2-78:2001 IEC 60255-27:2013; Section 10.6.1.5 40°C, 93% relative humidity, 10 days
Damp Heat, Cyclic:	IEC 60068-2-30:2001 IEC 60255-27:2013: Section 10.6.1.6 25–55°C, 6 cycles, 95% relative humidity

Dielectric Strength and Impulse Tests

Dielectric (HiPot):	IEC 60255-27:2013; Section 10.6.4.3 IEEE C37.90-2005 2.5 kVac on current inputs, ac voltage inputs, and contact outputs 1.5 kVdc on PTC input and analog output 2.83 kVdc on power supply, contact inputs
Impulse:	IEC 60255-27:2013; Section 10.6.4.2 0.5 J, 5.0 kV on power supply, contact I/O, ac current, and voltage inputs 0.5 J, 2 kV on PTC input, analog output, serial port, and Ethernet port

RFI and Interference Tests

EMC Immunity

Electrostatic Discharge Immunity:	IEC 61000-4-2:2008 IEC 60255-26:2013; Section 7.2.3 Severity Level 3 6 kV contact discharge 8 kV air discharge
Radiated RF Immunity:	IEC 61000-4-3:2010 IEC 60255-26:2013; Section 7.2.4 10 V/m IEEE C37.90.2:2004 20 V/m
Fast Transient, Burst Immunity:	IEC 61000-4-4:2012 IEC 60255-26:2013; Section 7.2.5 4 kV @ 5.0 kHz 2 kV @ 5.0 kHz for comm. ports
Surge Immunity:	IEC 61000-4-5:2005 IEC 60255-26:2013; Section 7.2.7 1 kV line-to-line 2 kV line-to-earth
Surge Withstand Capability Immunity:	IEC 61000-4-18:2010 IEC 60255-26:2013; Section 7.2.6 2.5 kV common mode 1 kV differential mode 1 kV common mode on comm. ports IEEE C37.90.1:2012 2.5 kV oscillatory 4 kV fast transient
Conducted RF Immunity:	IEC 61000-4-6:2008 IEC 60255-26:2013; Section 7.2.8 10 Vrms
Magnetic Field Immunity:	IEC 61000-4-8:2009 IEC 60255-26:2013; Section 7.2.10 Severity Level 5 Class B 1000 A/m for 3 seconds 300 A/m for 1 minute IEC 61000-4-8:2009 IEC 60255-26:2013; Section 7.2.10 Severity Level 4 Class A 300 A/m for 3 seconds 30 A/m for 1 minute No binary input filtering IEC 61000-4-9:2001 300 A/m IEC 61000-4-10:2001 100 A/m (100 kHz and 1 Mhz)
Power Supply Immunity:	IEC 61000-4-11:2004 IEC 61000-4-17:1999 IEC 61000-4-29:2000 IEC 60255-26:2013; Section 7.2.11 IEC 60255-26:2013; Section 7.2.12 IEC 60255-26:2013; Section 7.2.13

EMC Emissions

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

Processing Specifications and Oscillography

AC Voltage and Current Inputs:	32 samples per power system cycle
Frequency Tracking Range:	12.5–72.5 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:	Four times per power system cycle (except for math variables and analog quantities which are processed every 25 ms)

Oscillography

Length:	15, 60, or 120 cycles
Sampling Rate:	1, 2, or 4 kHz sampling rate for raw (unfiltered) data and 4 samples per cycle for filtered data
Trigger:	Programmable with Boolean expression
Format:	ASCII and Compressed ASCII for filtered and unfiltered data and files in binary COMTRADE format (ANSI C37.111-1999) for raw data
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

Thermal Overload (49)

Full-Load Current (FLA) Limits:	0.5–256.0 A
Locked Rotor Current:	2.5–10.0 • FLA (if FLA ≤ 128 A) 2.5–6.0 • FLA (if FLA > 128 A)
Locked Rotor Time:	1–600 seconds
Overload Pickup:	1.01–1.50 • FLA
Accuracy:	5% ±25 ms at multiples of FLA > 2 (cold inverse curves)

PTC Overtemperature (49)

Type of Control Unit:	IEC34-11-2 Mark A
Max. Number of Thermistors:	6 in a series connection
Max. Cold Resistance:	1500 ohms
Trip Resistance:	3400 ±150 ohms
Reset Resistance:	1500–1650 ohms
Short-Circuit Trip Resistance:	25 ohms ±10 ohms

Undercurrent (Load Loss) (37)

Setting Range:	Off, 0.20–1.00 • FLA
Accuracy:	±5% of setting ±0.1 A
Maximum Pickup/Dropout Time:	1.5 cycles

Current Unbalance and Phase Loss (46)

Setting Range:	Off, 5%–80%
Accuracy:	±10% of setting
Maximum Pickup/Dropout Time:	1.5 cycles

Overcurrent (Load Jam) (48)

Setting Range:	Off, 1.00–6.00 • FLA
Accuracy:	±5% of setting
Maximum Pickup/Dropout Time:	1.5 cycles

Short Circuit (50P)[a]

Setting Range:	Off, 0.5–1280.0 A
Accuracy:	±5% of setting ±0.01 A
Maximum Pickup/Dropout Time:	1.5 cycles

Ground (Residual, 50G) [a]

Setting Range:	Off, 0.5–1280.0 A
Accuracy:	±5% of setting ±0.01 A
Maximum Pickup/Dropout Time:	1.5 cycles

Ground (Core-Balance, 50N) [a]

Setting Range:	Off, 0.010–40.000 mA
Accuracy:	±5% of setting ±0.005 mA
Maximum Pickup/Dropout Time:	1.5 cycles

Arc-Flash Instantaneous Overcurrent (50PAF)

Setting Range:	Off, 0.5–1280.0 A
Accuracy:	±5% of setting ±0.01 A
Typical Pickup/Dropout Time:	4 ms/1 cycle

(Does not include contact pickup time of 8 ms [maximum].)

Arc-Flash Instantaneous Overcurrent (50GAF)

Setting Range:	Off, 0.15–320.0 A
Accuracy:	±5% of setting ±0.01 A
Typical Pickup/Dropout Time:	4 ms/1 cycle

(Does not include contact pickup time of 8 ms (maximum).)

Negative-Sequence Overcurrent (50Q) [a]

Setting Range:	Off, 0.5–1280.0 A
Accuracy:	±5% of setting ±0.01 A
Maximum Pickup/Dropout Time:	1.5 cycles

Inverse-Time Overcurrent (51P, 51Q) [a]

Setting Range:	Off, 0.5–512.0 A
Accuracy:	±5% of setting ±0.1 A

Time Dial:
- U.S.: 0.50–15.00, 0.01 steps
- IEC: 0.05–1.00, 0.01 steps

Accuracy: ±1.5 cycles, ±4% between 2 and 30 multiples of pickup (within the range of current measurement, see the current measurement table in *Metering on page 1.12*)

Inverse-Time Overcurrent (51G) [a]

Setting Range: Off, 0.5–512.0 A
Accuracy: ±5% of setting ±0.01 A
Time Dial
- U.S.: 0.50–15.00, 0.01 steps
- IEC: 0.05–1.00, 0.01 steps

Accuracy: ±1.5 cycles, ±4% between 2 and 30 multiples of pickup (within the range of current measurement, see the current measurement table in *Metering on page 1.12*)

Inverse-Time Overcurrent (51N) [a]

Setting Range: Off, 0.010–4.800 mA
Accuracy: ±5% of setting ±0.005 mA
Time Dial
- U.S.: 0.50–15.00, 0.01 steps
- IEC: 0.05–1.00, 0.01 steps

Accuracy: ±1.5 cycles, ±4% between 2 and 30 multiples of pickup (within rated range of current)

Phase-to-Phase Undervoltage (27)

Setting Range: Off, 5.0–800.0 V
Accuracy: ±2% (±5% for transient) of setting ±2 V
Maximum Pickup/Dropout Time: 1.5 cycles

Phase-to-Phase Overvoltage (59)

Setting Range: Off, 5.0–800.0 V
Accuracy: ±2% (±5% for transient) of setting ±2 V
Maximum Pickup/Dropout Time: 1.5 cycles

Harmonic Blocking

Pickup Range (% of Fundamental): 5.0%–100%, 1% steps
Pickup Accuracy: ±2.5 percentage points
Time Delay Range: 0.00–120.00 seconds, 0.01 second steps
Time Delay Accuracy: ±0.5% of setting plus ±0.25 cycle

Directional Power (32, 37)

Setting Range: Off, 20.0%–200.0% VA (VA = 1.732 • VNOM • FLA1)
Accuracy: ±3% of setting ±5 VA
Pickup Types: +WATTS, –WATTS, +VARS, –VARS
Maximum Pickup/Dropout Time: 10 cycles

Power Factor (55)

Setting Range: Off, 0.05–0.99
Accuracy: ±5% of full scale for current > 0.2 • FLA at 120 V
Maximum Pickup/Dropout Time: 10 cycles

Phase Reversal (47)

No Settings, Except ENABLE
Pickup Time: Approximately 0.5 s

Frequency (81)

Setting Range: Off, 15.00–70.00 Hz
Accuracy: ±0.01 Hz
Maximum Pickup/Dropout Time: 4 cycles

Timers

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

Metering

Accuracies are specified at 20°C, 50 or 60 Hz nominal frequency (for VFD applications RMS accuracies apply), ac currents within the range shown in the following table, and ac voltages within 40–800 V unless otherwise noted.

Current Measurement Ranges Versus FLA[a]

FLA	Current Measurement Range
0.5–3.9 A	0.2 –74 A
4.0–15.9 A	0.8–295 A
16.0–47.9 A	3.2–1,178 A
48.0–256.0 A	6.4–2,357 A

[a] For the purpose of measurement accuracies

Phase Currents: Magnitude ±1% of reading ±0.01 A; phase ±3°
IN (Core-Balance Ground Current): Magnitude ±2%, ±0.005 mA
Average Current: ±2% of reading ±0.01 A
Average Motor Load: (xFLA): ±2% of reading ±0.01 A
Current Unbalance (%): ±2% of reading or ±1% of full scale
IG (Residual Ground Current): Magnitude ±2% of reading ±0.01 A; phase ±3°
3I2 Negative-Sequence Current: ±3% of reading ±0.01 A;
System Frequency: ±0.01 Hz of reading for frequencies within 12.5–72.5 Hz (V1 > 60 V)
Thermal Capacity: ±3% of TCU
Time to Trip: ±5% or ±1 second
Line-to-Line Voltages: Magnitude ±1% of reading, phase ±3°
3-Phase Average Line-to-Line Voltage: ±2% of reading
Line-to-Ground Voltages: Magnitude ±1% of reading, phase ±3°
3-Phase Average Line-to-Ground Voltages: ±2% of reading
Voltage Unbalance (%): ±2% of reading
3V2 Negative-Sequence Voltage: Magnitude ±3% of reading
Real Power (kW): ±5% of reading for 0.10 < pf < 1.00
Reactive Power (kVAR): ±5% of reading for 0.00 < pf < 0.95
Apparent 3-Phase Power (kVA): ±2% of reading
Power Factor: ±2% of reading for 0.97 ≤ pf ≤ 1
PTC Temperatures: ±2°C

RMS Metering Accuracies

Phase and Residual (IG) Currents:	±2% of reading ±0.01 A; for current range 0.2 • FLA to 15 • FLA A (includes fundamental through 15th harmonic)
IN (Core-Balance Ground Current):	±2% of reading ±0.005 mA [a]
Voltages:	±2% of reading (includes fundamental through 15th harmonic)
Harmonic and THD Metering:	Range 0%–100%
Accuracy:	±5% of full scale

[a] Actual setting ranges will be restrictive depending on the FLA setting.

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Section 2
Installation

Overview

The first steps in applying the SEL-849 Motor Management 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-849. Use these drawings as a starting point for planning your particular relay application.

The installation and connection details for the optional operator control modules are presented in this section. There are two options:

- SEL-3421 Motor Relay HMI with graphical display
- SEL-3422 Motor Relay HMI without graphical display

Relay Placement

Proper placement of the SEL-849 helps to ensure years of trouble-free motor management. Use the following guidelines for proper physical installation of the SEL-849.

Physical Location

The SEL-849 is EN 61010 certified at Installation/Overvoltage Category II and Pollution Degree 3. This allows mounting of the SEL-849 in a sheltered indoor environment (a motor control center drawer or bucket, or an enclosed cabinet) that does not exceed the temperature and humidity ratings for the relay.

The SEL-849 is required to be mounted in an indoor or outdoor (extended) locked enclosure that provides a degree of protection to personnel against access to hazardous parts. In either environment, the relay shall be protected from direct sunlight, precipitation, and full wind pressure.

You can place the relay in extreme temperature and humidity locations (see *Operating Temperature* and *Operating Environment on page 1.9*). For EN 61010 certification, the SEL-849 rating is 2000 m (6562 ft) above mean sea level. Consult the factory for product derating specifications for higher altitude applications.

To comply with the requirements of the European ATEX standard for hazardous locations, the SEL-849 shall be installed in an ATEX-certified enclosure with a tool-removable door or cover that provides a degree of protection not less than IP54, in accordance with EN 60079-0. The enclosure should be certified to these requirements or be tested for compliance as part of the complete assembly. The enclosure must be marked "WARNING – Do not open when an explosive atmosphere is present." In North America, the relay is approved for Class I, Division 2, Groups A, B, C, and D, and temperature class T4 with a maximum surrounding air temperature of 40°C.

Relay Features and Connections

Figure 2.1 shows the relay features and connections to cover all the ordering options. The wiring terminal blocks are labeled A through H as shown on the relay.

Terminal	EIA-232	EIA-485
G1/D1	TXD	+TX
G2/D2	RTS	-TX
G3/D3	RXD	+RX
G4/D4	CTS	-RX
G5/D5	GND	SHLD

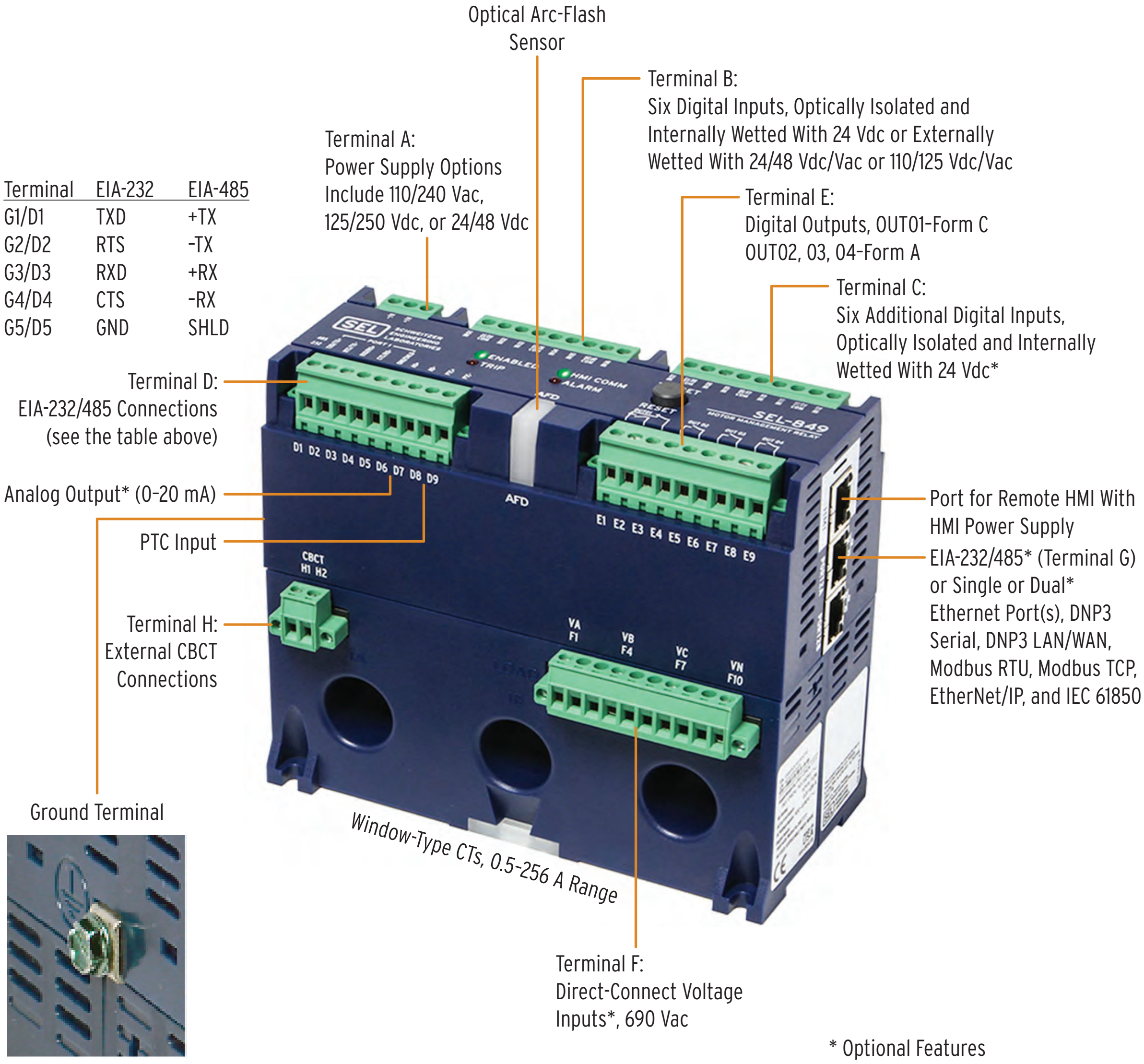


Figure 2.1 Relay Features and Connections

Figure 2.2 shows the relay drawings with dimensions to cover all the ordering options. Please note that the actual relay may differ based on the options included. The wiring terminal blocks are labeled A through H as shown in the drawing and on the relay.

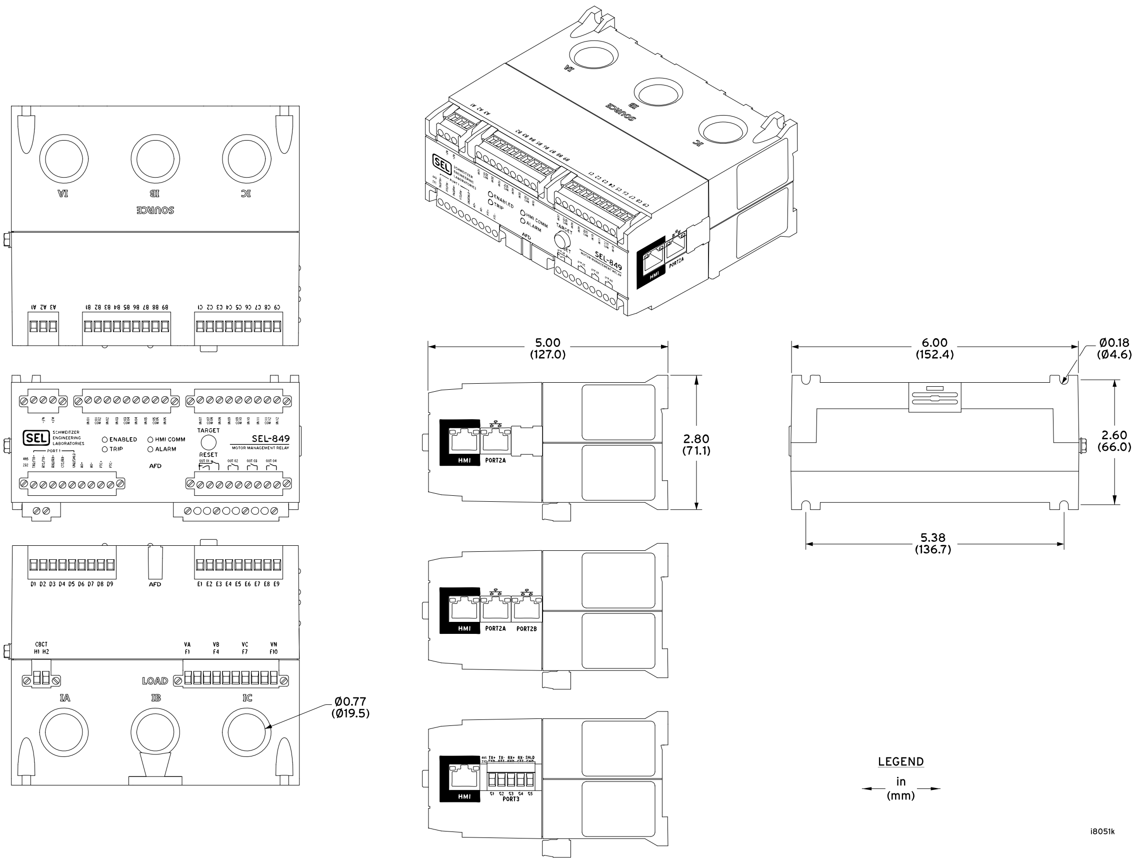


Figure 2.2 Relay Panel-Mount Dimensions

Relay Mounted on DIN Rail

The SEL-849 can be mounted on a 35 mm (1.38 in) DIN rail. Install the relay on the DIN rail as shown in *Figure 2.3* and push the relay towards the rail until the bottom clip latches and the relay clicks into place.

To remove the relay, use a small flat-bladed screw driver or other similar tool. Insert the tool into the latching clip and pry it towards the relay. The clip slides away from the DIN rail, releasing it.

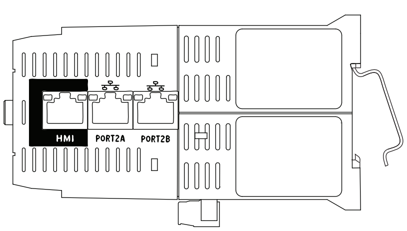


Figure 2.3 Relay Mounting on DIN Rail

Relay Mounted on Solid Surface or Panel

The drawing in *Figure 2.4* shows how the relay is mounted on a panel or a flat surface. The screws are #8 or 4 mm and the tightening torque specification is 9.0 in-lb (1.0 Nm). Use the panel drilling template for the location of the screw holes.

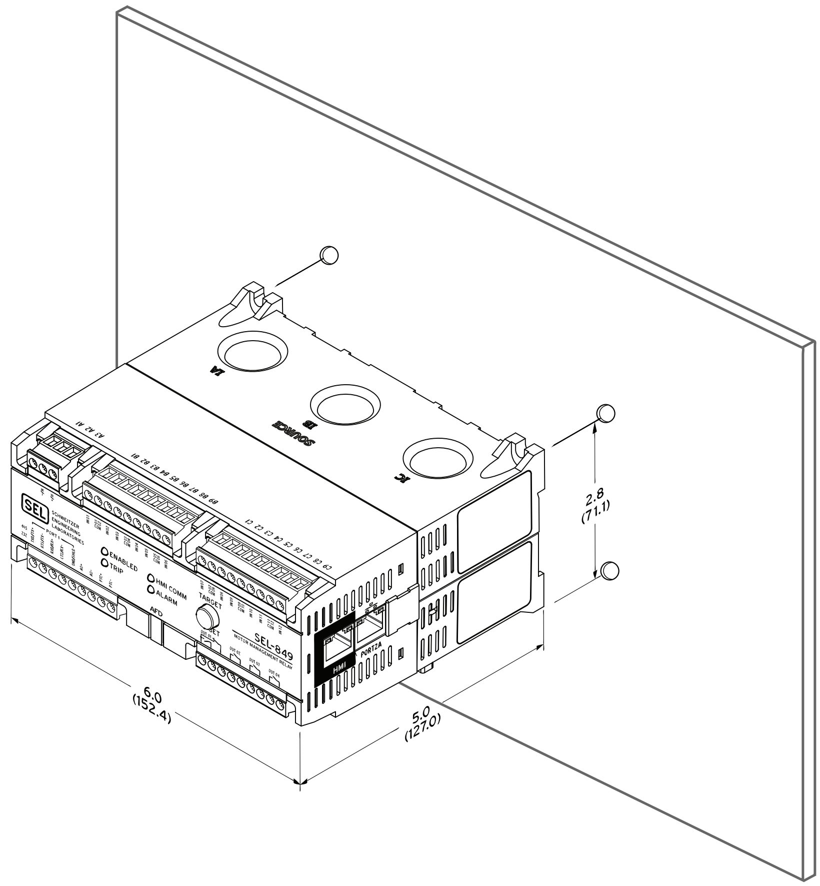


Figure 2.4 Relay Mounting on Solid Surface or Panel

Relay Connections

This section will provide a guide to complete connections to the relay for various functions.

Connecting to a PC

The PC Ethernet port is connected to the SEL-849 Ethernet port (Port 2) using an SEL-C627M cable.

Connecting to HMI Module

Both the SEL-3421 and the SEL-3422 Motor Relay HMI modules connect to the SEL-849 HMI port using an SEL-C627M cable. The HMI module is powered from the relay through the HMI port.

Current Connections

The SEL-849 has markings on the sides to indicate the direction of the current flow. The SOURCE side is the side from which the current from the contactor or the breaker flows through the relay. The LOAD side is the side from which the cable connects to the load (e.g., motor). This connection convention requires the relay setting CURR_IN := Normal. If the installation of the relay requires the current to enter from the LOAD side of the relay and exit from the SOURCE side, set CURR_IN := Reverse.

Direct Current Input

The SEL-849 supports direct current input up to full-load Amps (FLA) of 256 FLA if the current cable outer diameter is less than the relay opening diameter. Refer to *Figure 2.12* for an application example. The CT ratio setting CTR is set equal to 1 for the direct current inputs. Additionally, the relay supports external CT connections. *Figure 2.18* shows an application example with external CTs. This application requires CT ratio setting greater than 1.

External Line Current Transformer Application (UL Approved)

The SEL-849 overload relays are designed for use with separately mounted, customer supplied, line current transformers (CTs) that are required in many applications. See *Table 2.1* for the CT part numbers supported by the relay for applications of FLA primary current ratings as high as 1000 A. You must set the CT ratio of the relay according to the table.

Table 2.1 UL Approved 5 A CTs for SEL-849 Overload Relay Applications

Rated Motor FLA A pri	Ratio	SEL-849 CTR Setting	Rockwell CT P/N		ITI/GE CT Model		AMRAN CT Model	
			Foot-Mounted	Donut	Foot-Mounted	Donut	Foot-Mounted	Donut
128–150	150:5	30	1411-2SFT-151	1411-2DRL-151	2SFT151	2DRL151	CT225-151-03	CT211-151
150–200	200:5	40	1411-2SFT-201	1411-2DRL-201	2SFT201	2DRL201	CT225-201-07	CT211-201
200–300	300:5	60	1411-2SFT-301	1411-2DRL-301	2SFT301	2DRL301	CT225-301-07	CT211-301
300–500	500:5	100			7SFT501	7ARL501		
500–600	600:5	120	1411-8SHT-601	1411-180RL-601	7SFT601	7ARL601		
600–1000	1000:5	200		1411-8RL-102	8SHT-102	8RL-102		

5 A/1 A CTs

For the above applications, the intended use is for SEL-849 overload relays with CTs having a rated secondary current of 5 A maximum. The installer provides one CT for each motor phase and connects the CT secondary terminals with an appropriately sized and insulated cable (refer to *Table 2.2* for wire size guidelines). The cable passes through the appropriate current phase window in the relay, as shown in *Figure 2.5*, following the Load Side/Motor Side convention previously described in *Current Connections*.

Table 2.1 details the appropriate ratio for the CTs. You must set the relay setting to the proper CTR setting. The CT is rated for protective relaying that accommodates the high inrush currents associated with motor startup and has an accuracy of ±2 percent over its normal operating range.

An improper selection of a current transformer can result in the SEL-849 reporting inaccurate motor operational data and can cause possible motor damage.

You must loop the secondary current through the relay current windows such that there are five turns on the secondary for SEL-849 overload relays with CTs that have a rated secondary current of 1 A maximum. This makes the rated secondary current input 5 A, achieving the same accuracy as the 5 A CTs.

SEL-849 relays used with customer supplied CTs must be mounted as far away from the high-current conductors as is practical. Magnetic fields created by the conductors can produce undesired relay readings, particularly in dense, low-voltage control cubicles. Increasing the relay secondary current (multiple turns through the relay current windows) helps alleviate this problem.

NOTE: External CT connections shall be wye-grounded.

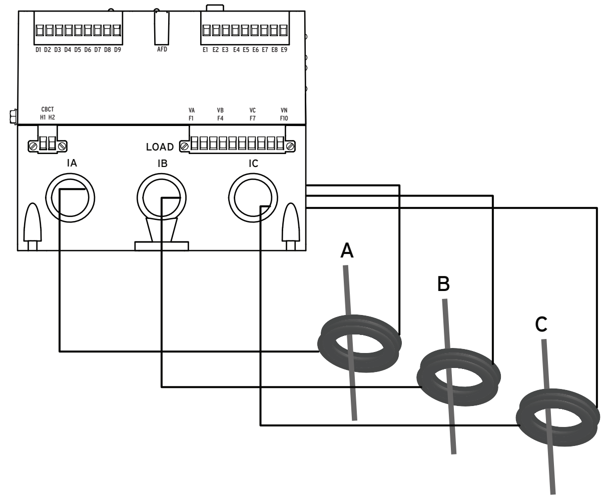


Figure 2.5 CT Installation

Terminal Block Connections

The connection terminal blocks are labeled on the relay from A to G. The terminal blocks can be removed by gently prying them with a small, flat screwdriver. After installing them on the relay, it is recommended to tighten the two end screws so that the terminal block is securely fastened to the relay. The torque requirements for the terminal blocks are:

- Compression Plug Tightening Torque
  - Minimum: 0.5 Nm (4.4 in-lb)
  - Maximum: 1.0 Nm (8.8 in-lb)
- Compression Plug Mounting Ear Screw Tightening Torque
  - Minimum: 0.225 Nm (1.6 in-lb)
  - Maximum: 0.25 Nm (2.2 in-lb)
- Ground Terminal Screw Tightening Torque
  - 1 Nm (9 in-lb)

Wire Sizes

NOTE: Strip the wire insulation to 8 mm (0.31 in) before installation.

Wire sizes for grounding (earthing), current, voltage, and contact connections are dictated by the terminal blocks and expected load current. Use *Table 2.2* as a guide in selecting wire sizes.

Table 2.2 Wire Connection Selection Guide

Connection Type	Wire Size Minimum	Wire Size Maximum	Insulation Voltage
Grounding (Earthing)	18 AWG (0.8 mm^2)	14 AWG (2.1 mm^2)	300 V min
Current[a]	16 AWG (1.3 mm^2)	12 AWG (3.3 mm^2)	300 V min
Potential Voltage	18 AWG (0.8 mm^2)	14 AWG (2.1 mm^2)	690 V min
Contact I/O	18 AWG (0.8 mm^2)	14 AWG (2.1 mm^2)	300 V min
Other	20 AWG (0.5 mm^2)	14 AWG (2.1 mm^2)	300 V min

[a] For external 1 A or 5 A CT secondary.

Power Supply Connections (Terminal Block A)

Table 2.3 Terminal Block A—Power Supply Connections

Terminal Number	Label	Description
A1		Not used
A2	-/N	Negative or neutral terminal
A3	+/H	Positive or hot (line) terminal

The POWER terminals on the relay (A3(+/H) and A2(−/N)) must connect to 110/240 Vac, 125/250 Vdc, or 24/48 Vdc power source (see *Power Supply on page 1.8* 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-849; this device should interrupt both the hot (+/H) and neutral (-/N) power leads. The maximum current rating for the power disconnect circuit breaker or optional overcurrent device (fuse) should be 20 A. Be sure to place this device within 3.0 m (9.8 feet) of the relay.

Operational power is internally fused by a power supply fuse. Please note that the complete relay is nonserviceable.

Digital Inputs (6) Connections (Terminal Block B)

⚠CAUTION
For internally wetted contact inputs, do not connect external voltages. Because the contact inputs are internally wetted, permanent damage to the relay or external equipment may result from connecting external voltage to a relay contact input.

Table 2.4 Terminal Block B—Base Relay Six (6) Optoisolated Digital Inputs[a]

Terminal Number	Label	Description
B1	IN01	Digital input IN01, drives IN01 element
B2	COM 01, 02	Common for IN01 and IN02
B3	IN02	Digital input IN02, drives IN02 element
B4	IN03	Digital input IN03, drives IN03 element
B5	COM 03, 04	Common for IN03 and IN04
B6	IN04	Digital input IN04, drives IN04 element
B7	IN05	Digital input IN05, drives IN05 element
B8	COM 05, 06	Common for IN05 and IN06
B9	IN06	Digital input IN06, drives IN06 element

[a] All COM terminals are internally connected to each other in case of internally wetted digital inputs only.

Terminal Block B, shown in *Table 2.4*, supports either internally or externally wetted contact inputs based on the model option selected. Terminal Block C, shown in *Table 2.5*, only supports internally wetted contact inputs. Digital inputs are internally wetted to +24 Vdc, so you only need to connect a dry contact, switch, or jumper to the input.

Additional Digital Inputs (6) (Optional) Connections (Terminal Block C)

Table 2.5 Terminal Block C—Optional Six (6) Additional Optoisolated Digital Inputs[a]

Terminal Number	Label	Description
C1	IN07	Digital input IN07, drives IN07 element
C2	COM 07, 08	Common for IN07 and IN08
C3	IN08	Digital input IN08, drives IN08 element
C4	IN09	Digital input IN09, drives IN09 element
C5	COM 09, 10	Common for IN09 and IN10
C6	IN10	Digital input IN10, drives IN10 element
C7	IN11	Digital input IN11, drives IN11 element
C8	COM 11, 12	Common for IN11 and IN12
C9	IN12	Digital input IN12, drives IN12 element

[a] All COM terminals are internally connected to each other in case of internally wetted digital inputs only.

Port 1, Analog Output (Optional), and PTC Connections (Terminal Block D)

Table 2.6 Terminal Block D—Port 1 (EIA-485/EIA-232), Analog Output (Optional), PTC Input

Terminal Number	Label	Description
Port 1 EIA-485		
D1	+TX	
D2	-TX	
D3	+RX	EIA-485 serial port configuration terminals
D4	-RX	
D5	SHLD	
Port 1 EIA-232		
D1	TXD	
D2	RTS	
D3	RXD	EIA-232 serial port configuration terminals
D4	CTS	
D5	GND	
D6	AO+	Analog output terminals (0–20 mA max)
D7	AO-	
D8	PTC+	PTC input terminals
D9	PTC-	

EIA-232/EIA-485 Port Connections

Connect Terminals D1–D5 for Port 1 as either an EIA-485 or an EIA-232 serial port, as shown in *Table 2.6*. Make sure the Port 1 communications interface setting COMMINF is set accordingly. Refer to *Section 7: Communications* for more details on serial communications and protocols available. *Figure 2.6* shows the connection diagram for an SEL-849 EIA-485 port to a 2-wire half duplex Modbus Master device in a Modbus protocol application. SEL-849 also supports connecting to a 4-wire half duplex Modbus Master device.

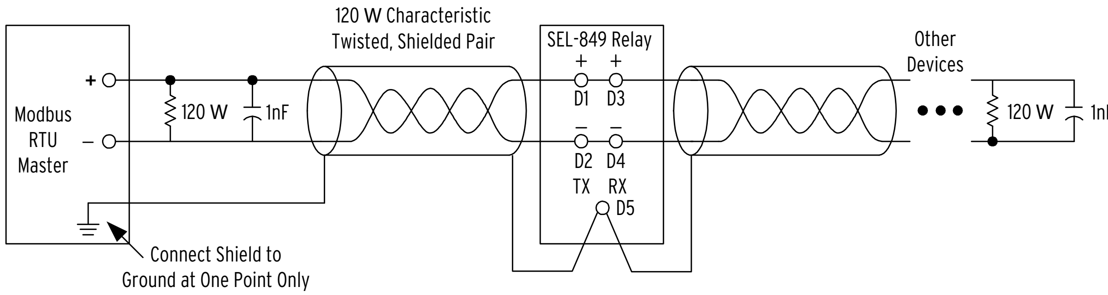


Figure 2.6 2-Wire Half Duplex EIA-485 Serial Port Connections

Analog Output Connections (Optional)

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

Terminals D6 (AO+) and D7 (AO-) provide a programmable analog output in the range of 0–20 mA (maximum load resistance is 300 ohms). The relay outputs a dc signal proportional to your choice of a selected analog quantity available in the relay. These can include average current, percent of full-load current, percent of stator or rotor thermal capacity used, etc. Refer to *Section 4: Protection and Logic Functions* for analog output settings. Connect the relay output to the input of your DCS or panel meter. Use a shielded cable to connect the relay to the DCS system, making sure to ground the shield at one end only.

PTC Connections

Connect the positive temperature coefficient (PTC) thermistor to Terminals D8 (PTC+) and D9 (PTC-). You can connect as many as six thermistors in a series. *Table 2.7* shows the maximum cable lengths for the PTC connections.

Table 2.7 PTC Cable Requirements

Wire Size, Twisted Pair AWG No.	Maximum Length (Meters)	
	Shielded Cable	Unshielded Cable
20	200	100
18	300	100
17	400	100
16	600	100
14	1000	100

Digital Outputs (1 Form C and 3 Form A) Connections (Terminal Block E)

Table 2.8 Terminal Block E—Four (4) Digital Outputs (Contact Outputs)

Terminal Number	Label		Description
E1 E2 E3		OUT01	OUT01, driven by the OUT01 SELOGIC control equation Form C output, E1–E2 NO, E1–E3 NC
E4 E5		OUT02	OUT02, driven by the OUT02 SELOGIC control equation Form A output, E4–E5 NO
E6 E7		OUT03	OUT03, driven by the OUT03 SELOGIC control equation Form A output, E6–E7 NO
E8 E9		OUT04	OUT04, driven by the OUT04 SELOGIC control equation Form A output, E8–E9 NO

The SEL-849 comes with one Form C (OUT01) and three Form A output contacts (OUT02, OUT03, OUT04). OUT01 is rated for higher continuous carry current of 6 A at 70 degrees C. OUT02–OUT04 are rated for 4 A at 70 degrees C.

Refer to *Section 1: Introduction and Specifications* for more details. The contact positions indicated in the table above are for the case when the relay is de-energized.

Fail-Safe/Nonfail-Safe Tripping

NOTE: OUT01 is the default trip output. It is hidden when the factory logic setting (FACTLOG) is set equal to Y. Refer to the settings sheets, available at selinc.com, for the output settings hide rules.

Figure 2.7 shows the OUT01 relay coil and Form C contact. When the relay coil is de-energized, the contact between E1 and E2 is open while the contact between E1 and E3 is closed.

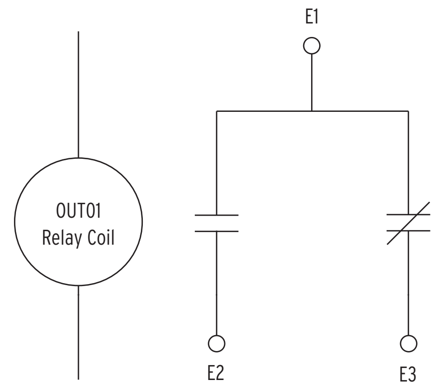


Figure 2.7 OUT01 Relay Output Contact Configuration

The SEL-849 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-849 is powered and operational.
- When the SEL-849 generates a trip signal, the relay coil is de-energized.
- The relay coil is also de-energized if the SEL-849 power supply voltage is removed or if the SEL-849 fails (self-test status is FAIL).

Figure 2.8 shows examples of traditional fail-safe and nonfail-safe wiring methods to control breakers and contactors. When you use the factory-default logic (setting FACTLOG := Y), the SEL-849 achieves fail-safe functionality using SELOGIC control equations. See *Table 4.5* for additional details.

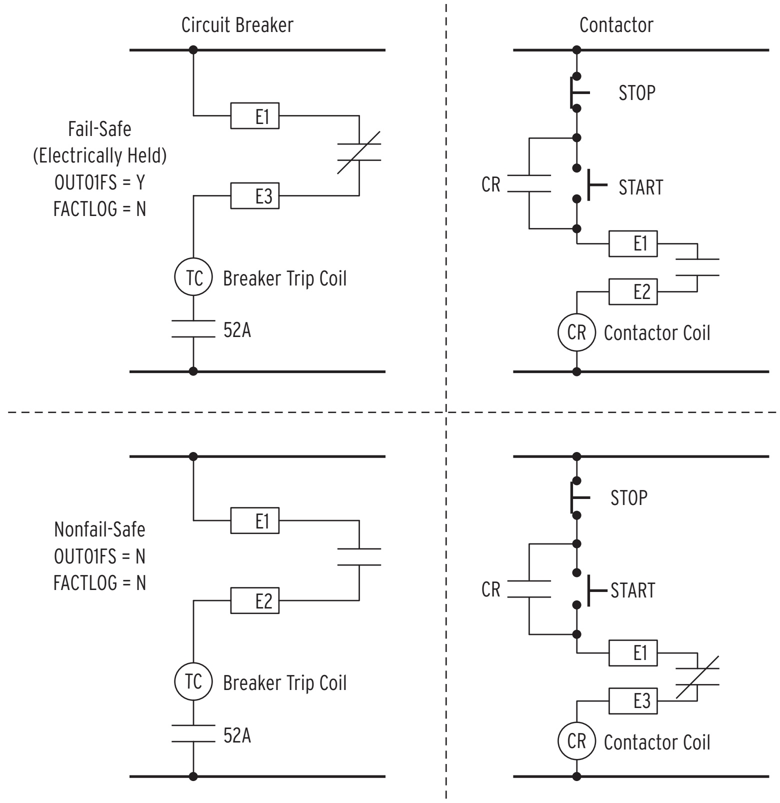


Figure 2.8 OUT01 Contact Fail-Safe and Nonfail-Safe Options

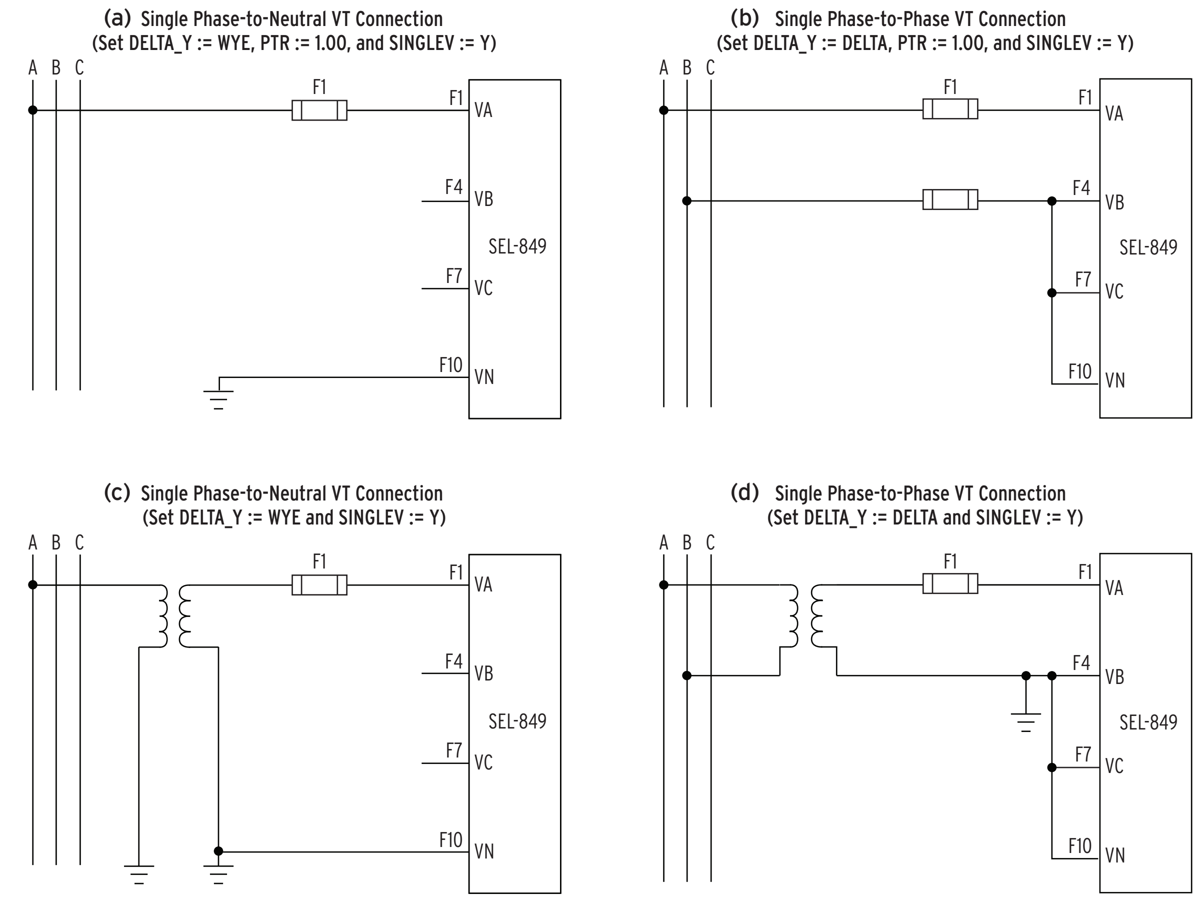
Voltage Connections (Terminal Block F)

Table 2.9 Terminal Block F—Optional AC Voltage Inputs (as High as 690 Vac Line-to-Line)

Terminal Number	Label	Description
F1	VA	Phase A voltage input
F4	VB	Phase B voltage input
F7	VC	Phase C voltage input
F10	VN	Common connection for VA, VB, VC

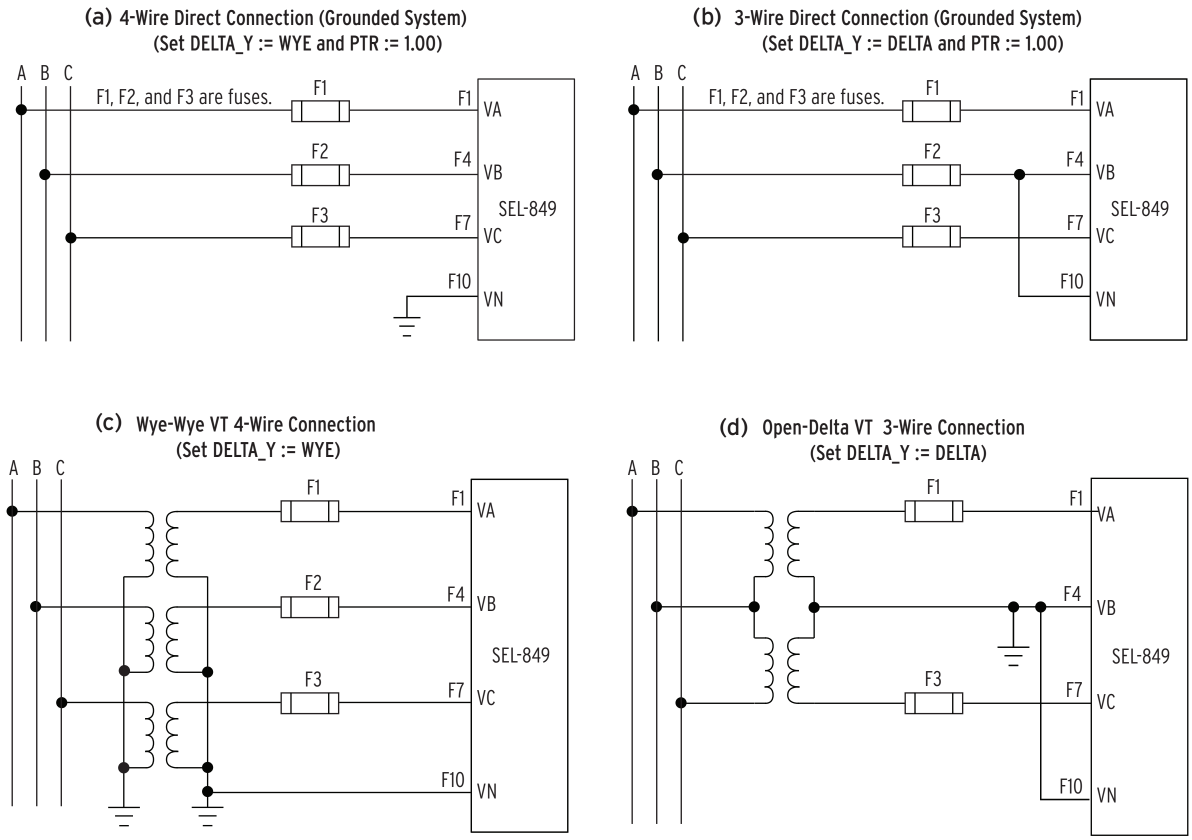
NOTE: Current-limiting fuses in direct-connected voltage applications are recommended to limit short circuit arc-flash incident energy.

With the voltage inputs option, the ac voltages may be directly connected, wye-wye VT connected, or open-delta VT connected. A single-phase VT can also be used. *Figure 2.9* and *Figure 2.10* show the methods of connecting single-phase and three-phase voltages.



As shown in (b) and (d), VN and VB must be connected (VN is electrically isolated) for DELTA_Y := DELTA for the relay to work correctly.

Figure 2.9 Single-Phase Voltage Connections



For open-delta connections, the figure (d) shows grounding Phase B (F4). You can choose to ground Phase A or Phase C instead of Phase B only in (d); however, keep the jumper between terminals F4 and F10 as is.

As shown in (b) and (d), VN and VB must be connected (VN is electrically isolated) for DELTA_Y := DELTA for the relay to work correctly.

Note: *Figure 2.9* and *Figure 2.10* assume a 4-wire neutral grounded system with neutral not available.

Figure 2.10 Three-Phase Voltage Connections

Optional Port 3 Connections (Terminal Block G)

Table 2.10 Terminal Block G—Optional Port 3 (EIA-485/EIA-232)

Terminal Number	Label	Description
Port 3 EIA-485		
G1	+TX	EIA-485 serial port configuration terminals
G2	-TX	
G3	+RX	
G4	-RX	
G5	SHLD	
Port 3 EIA-232		
G1	TXD	EIA-232 serial port configuration terminals
G2	RTS	
G3	RXD	
G4	CTS	
G5	GND	

Connect Terminals **G1**–**G5** for Port 3 as either an EIA-485 or an EIA-232 serial port, as shown in *Table 2.10*. Make sure the Port 3 communications interface setting COMMINF is set accordingly. Refer to *Section 7: Communications* for more details on the serial communications and protocols available.

Core-Balance CT Connections (Terminal Block H)

Table 2.11 Terminal Block H—Core-Balance CT Inputs

Terminal Number	Label	Description
H1, H2	CBCT	Core-Balance CT input terminals

The CBCT input terminals **H1**–**H2** allow you to connect an optional core-balance current transformer, which measures the ground fault and/or leakage current directly from the three-phase motor conductors and neutral (when used). This method can be used with solidly or impedance grounded power systems requiring sensitive ground current measurement.

Limit the maximum length of the twisted pair of wires from the CBCT to the SEL-849 Relay terminals **H1** and **H2** to 5 meters or less, and make sure not to ground the CBCT secondary leads.

Refer to *Figure 2.12* and *Figure 2.13* for examples of CBCT application connections. Refer to *Basic Settings* in *Section 4: Protection and Logic Functions*, for details on CBCT application and settings considerations.

Ground Terminal Connection

Connect the ground terminal of the relay to the chassis or cabinet ground by using 14 AWG (2.10 mm^2) to 18 AWG (0.08 mm^2) wire shorter than 2 m (6.6 ft).

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 2.11*. 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.

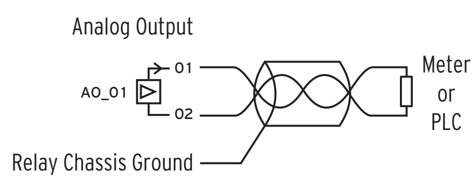


Figure 2.11 Analog Output Wiring Example

AC/DC Control Connection Diagrams

The following section describes various types of applications for the SEL-849 and displays the ac/dc connection diagrams for each one, together with settings required for it. In all the following applications, ac voltage inputs can be added if necessary for the application. Refer to *Voltage Connections (Terminal Block F) on page 2.12*.

Pre-Configured Starter Applications

Full-Voltage Nonreversing Starter (Setting STARTRTY := FVNR)

NOTE: The preferred location of the control power transformer (CPT), if present, is on the bus side of both the SEL-849 relay and the contactor.

The full-voltage nonreversing starter type is a full-voltage or across-the-line nonreversing starter. *Figure 2.12* shows the connection diagram for factory-default I/O assignments for this starter application. Please note that the settings necessary to configure this application are as shown in the figure.

The CURR_IN setting and configuration impact is explained in *Current Connections on page 2.4*. If the optional HMI is not connected, the Select Control Mode contact input when CLOSED represents REMOTE control. The input is ignored if the HMI is connected. See *Section 8: Human-Machine Interface (HMI)* for more details. START contact closure is used to start the motor, and STOP contact closure is used to stop the motor.

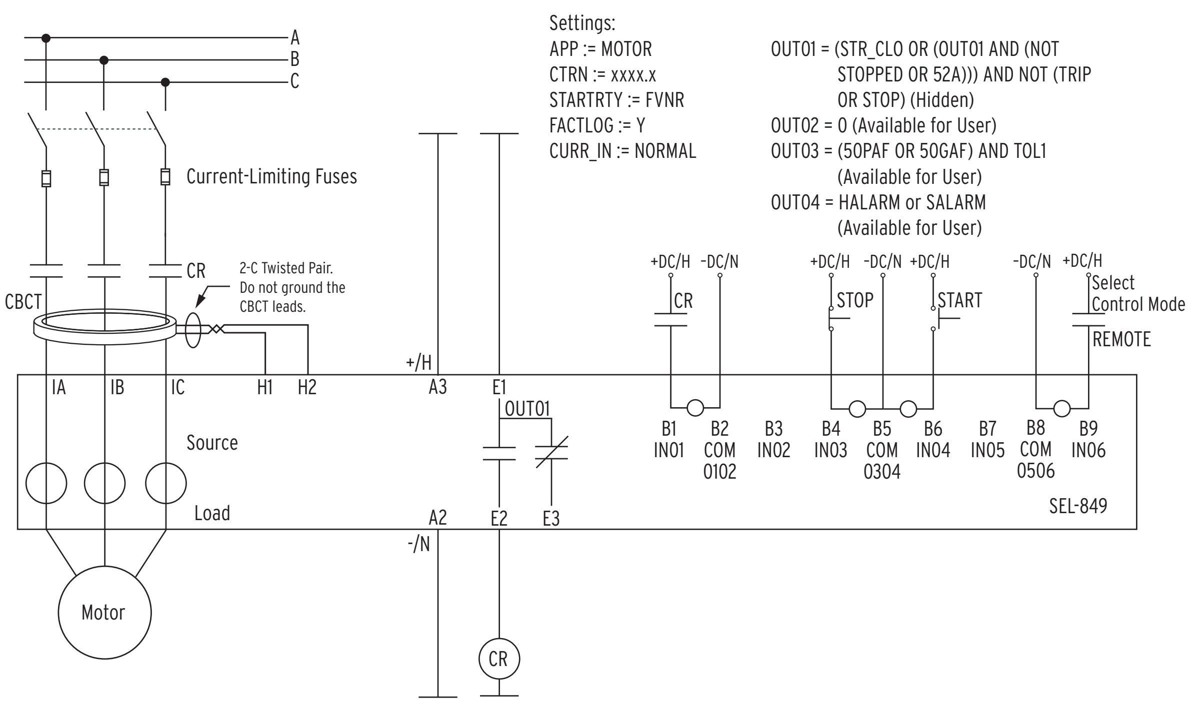


Figure 2.12 Connection Diagram for Factory-Default I/O Assignments Full-Voltage Nonreversing Starter (STARTRTY := FVNR) With Ungrounded Motor Neutral

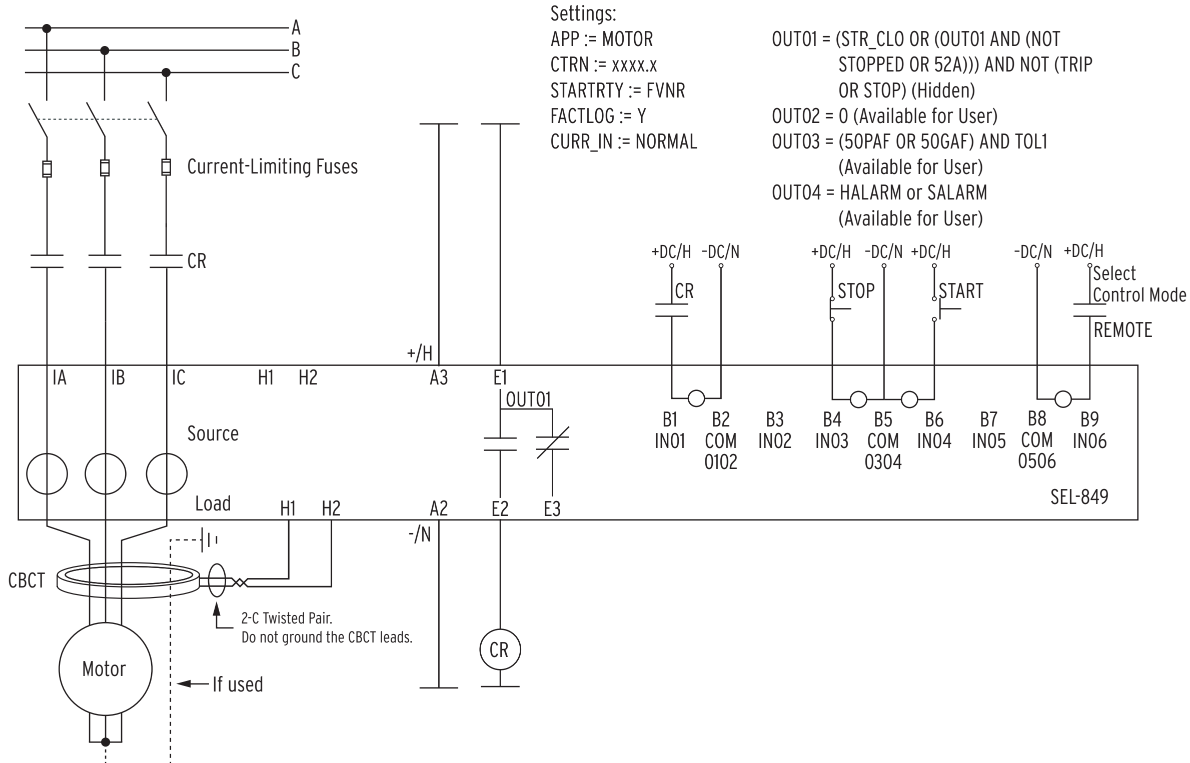


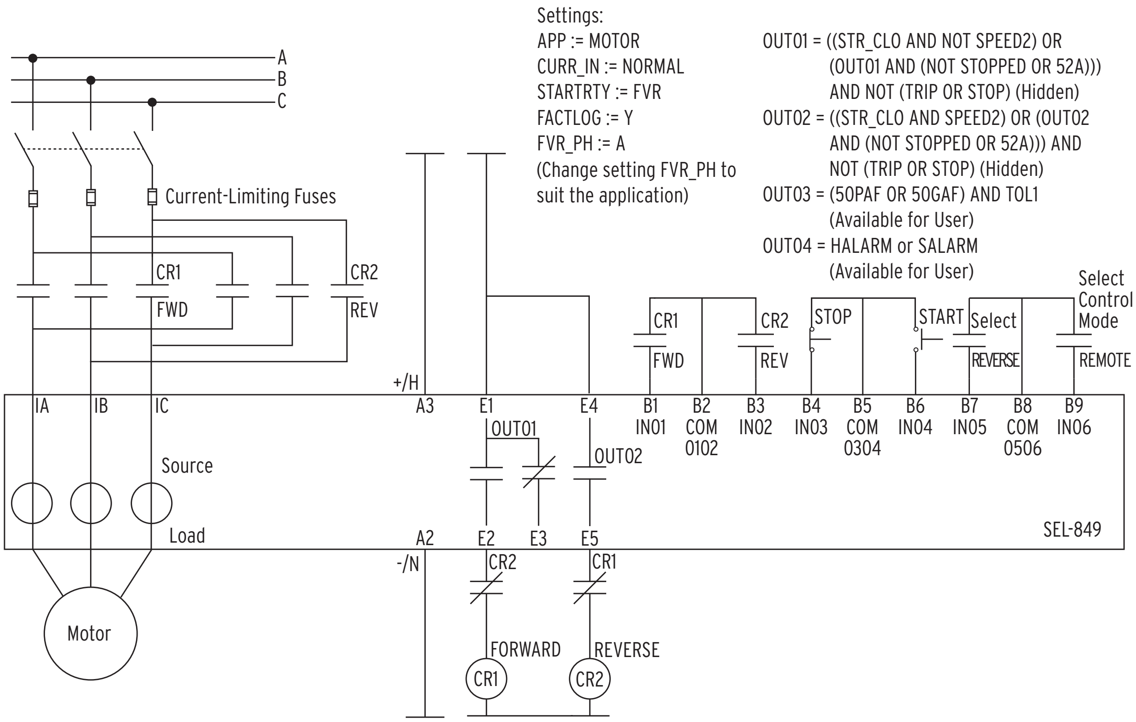
Figure 2.12 and Figure 2.13 relays shown with externally wetted digital inputs.

The CBCT input (terminals H1—H2) allows you to connect a core-balance current transformer, which measures the ground fault and/or leakage current directly from the three-phase motor conductors and neutral (when used), see Figure 2.12 and Figure 2.13.

Figure 2.13 Connection Diagram for Factory-Default I/O Assignments Full-Voltage Nonreversing Starter (STARTRTY := FVNR) With Grounded Motor Neutral

Full-Voltage Reversing Starter (Setting STARTRTY := FVR)

The full-voltage reversing starter type is a full-voltage or across-the-line reversing starter. *Figure 2.14* shows the connection diagram for factory-default I/O assignments for this starter application.



Relay shown with internally wetted digital inputs.

Figure 2.14 Connection Diagram for Factory-Default I/O Assignments Full-Voltage Reversing Starter (STARTRTY := FVR)

You select the forward/reverse direction, either from the optional HMI SEL-3421 or the control input **IN05**, before starting the motor. Note that for this application, SPEED1 is for the FORWARD direction and SPEED2 is for the REVERSE direction. See *Table 4.40* for more detail.

Use setting FVR_PH to select which phase remains unchanged when the FWD/REV direction is selected. *Table 2.12* shows the changed phase identification of the current channels based on the FVR_PH setting when SPEED2 = 1 (Reverse).

Table 2.12 Changed Phase Identification for the FVR_PH Setting

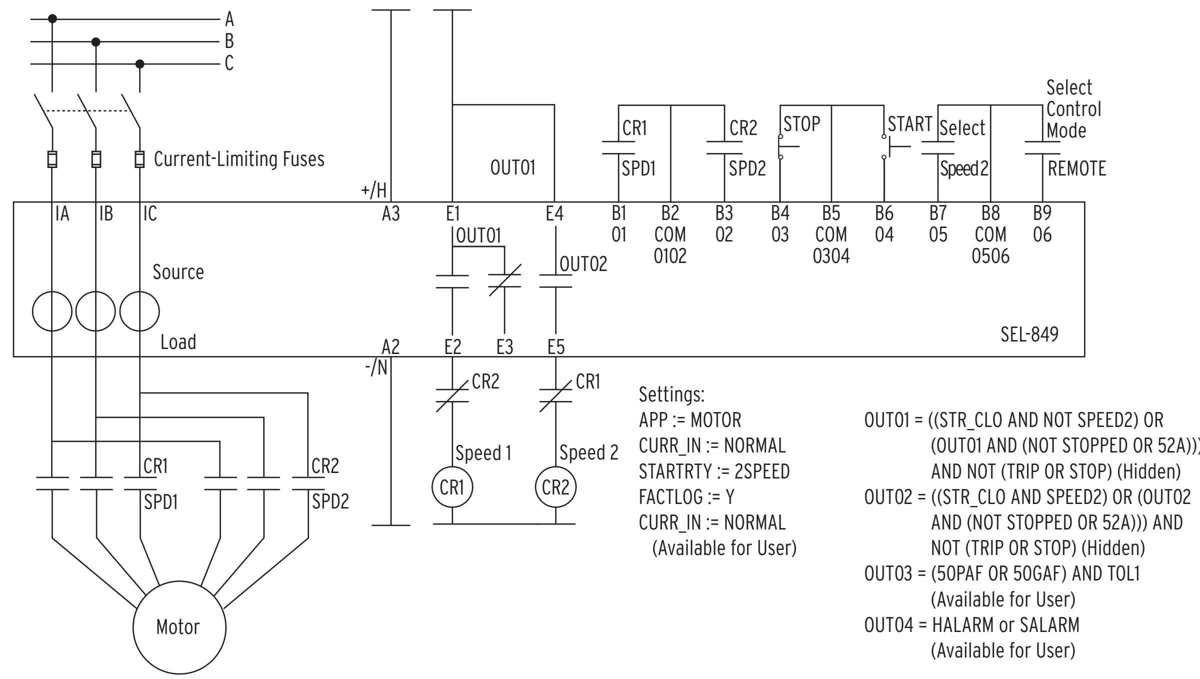
Original Channel Identification	Modified Identification of the Current Channels		
FVR_PH = None	**FVR_PH = A**	**FVR_PH = B**	**FVR_PH = C**
IA	IA	IC	IB
IB	IC	IB	IA
IC	IB	IA	IC

When the phase current measurement is located on the bus side of the contactor, set FVR_PH := NONE.

Two Speed Starter (Setting STARTRTY := 2SPEED)

This starter type is a full-voltage or across-the-line two speed starter. *Figure 2.15* shows the connection diagram for factory-default I/O assignments for this starter application. Please note that the settings required to configure this application are as shown in the figure.

You select the motor speed, either from the optional HMI SEL-3421 or the control input IN05, before starting the motor, see *Table 4.40* for more details.

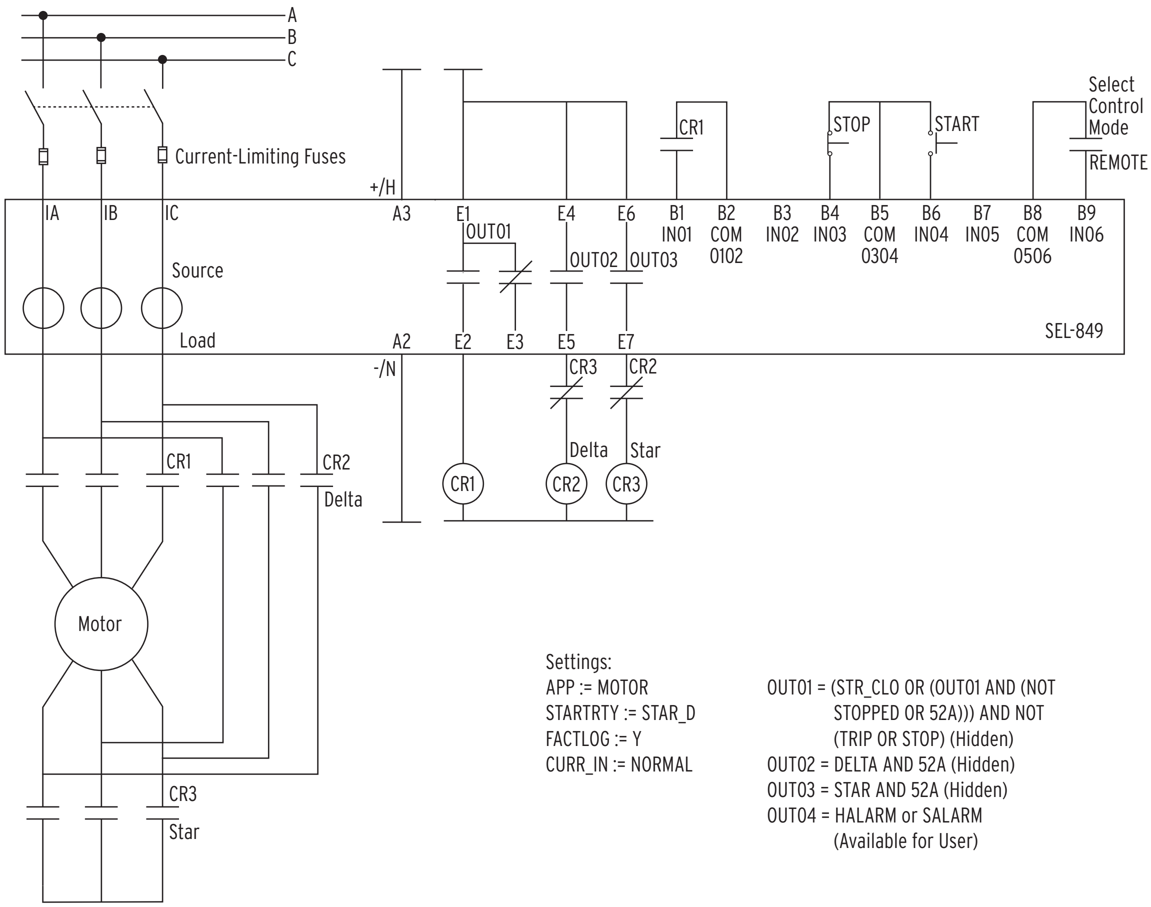


Relay shown with internally wetted digital inputs.

Figure 2.15 Connection Diagram for Factory-Default I/O Assignments Two-Speed Starter (STARTRTY := 2SPEED)

Star-Delta Starter (Setting STARTRTY := STAR_D)

Figure 2.16 shows the connection diagram for factory-default I/O assignments for this starter application. Please note the settings that are required to configure this application are as shown in the figure. A single winding motor rated for Star-Delta starting is required. The current measurement must be located as shown, outside the delta.



Relay shown with internally wetted digital inputs.

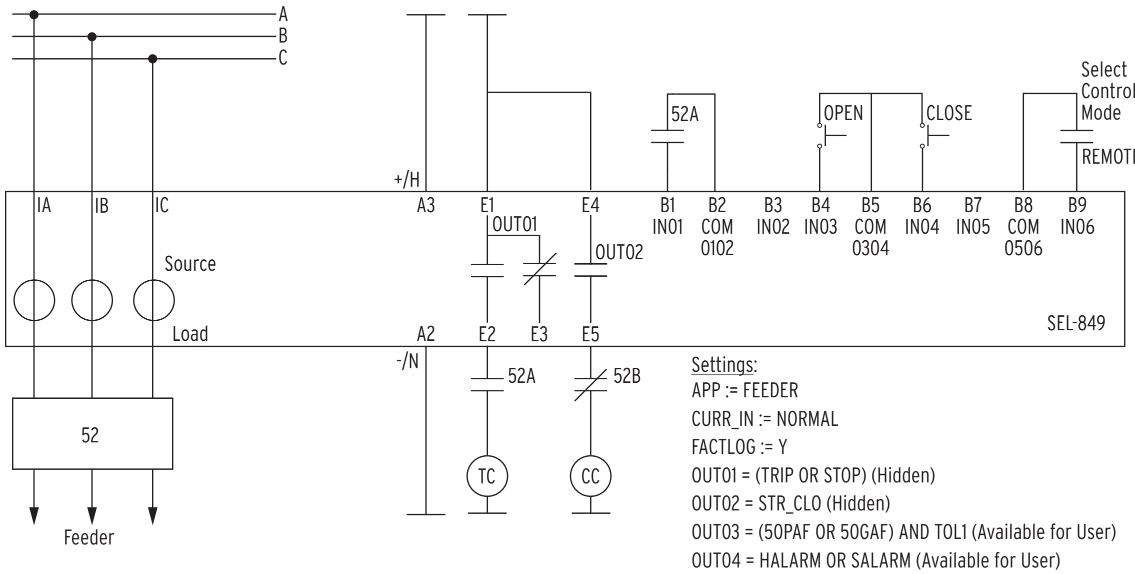
Figure 2.16 Connection Diagram for Factory-Default I/O Assignments Star-Delta Starter (STARTRTY := Star_D)

Other Applications

Feeder Protection

NOTE: Applications that require voltage input to the relay also require an external PT if the nominal voltage of the feeder exceeds 690 Vac. The nominal line-to-line secondary voltage input is selectable between 100–240 Vac.

Figure 2.17 shows the connection diagram for factory-default I/O assignments for this feeder protection (setting APP := FEEDER) application. Please note the settings that are required to configure this application are as shown in the figure.

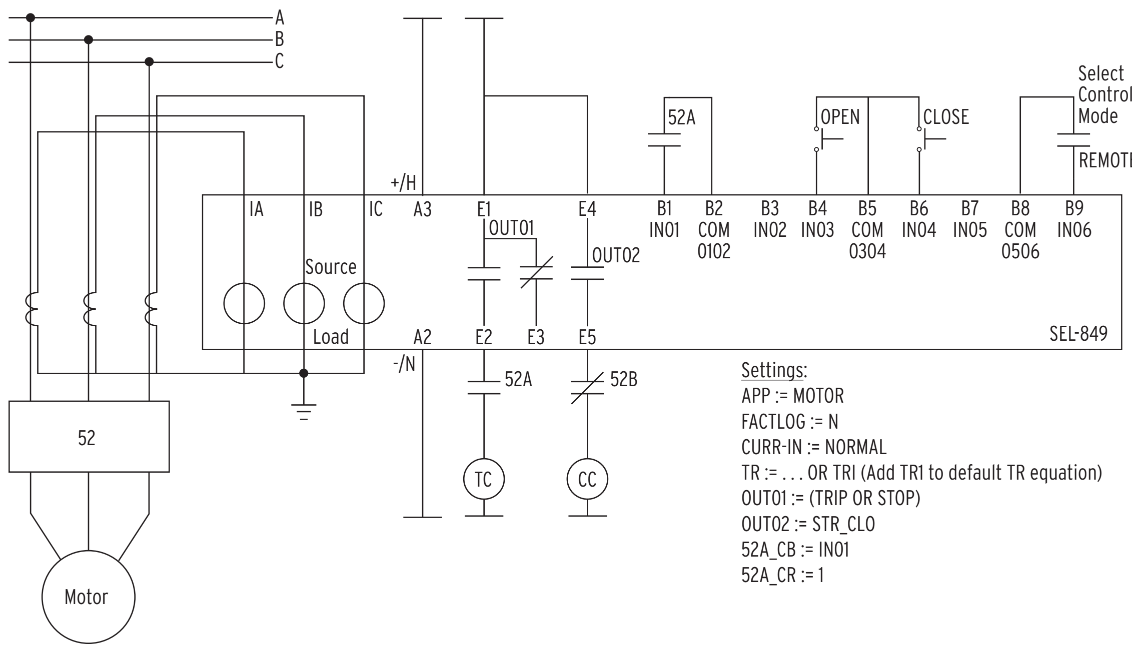


Relay shown with internally wetted digital inputs.

Figure 2.17 Connection Diagram for Factory-Default I/O Assignments Feeder Application (APP := Feeder)

Motor Application Using Breaker

Figure 2.18 shows the connection diagram for motor application using breaker and full-voltage nonreversing starter. Please note the settings that are required to configure this application are as shown in the figure. This application illustrates the use of external CTs with the secondary windings routed through the Rogowski coil sensors.



Relay shown with internally wetted digital inputs.

Figure 2.18 Connection Diagram for Motor Application Using Breaker Full-Voltage Nonreversing Starter

Single-Phase Feeder Protection

Figure 2.19 shows the connection diagram to protect a single-phase feeder load using the 51G function. Note that the settings required to configure this application are as shown in the figure. This application has the line input connected to the Phase A current inputs of the relay and the neutral input connected to the Phase B or Phase C input depending on the application. The line voltage input is connected to the VA terminal and the neutral voltage input is connected to the VN terminal. VB and VC terminals are shorted to the VN terminal. The line current IL + neutral current IN = IG (residual current) is the operating quantity for the 51G element.

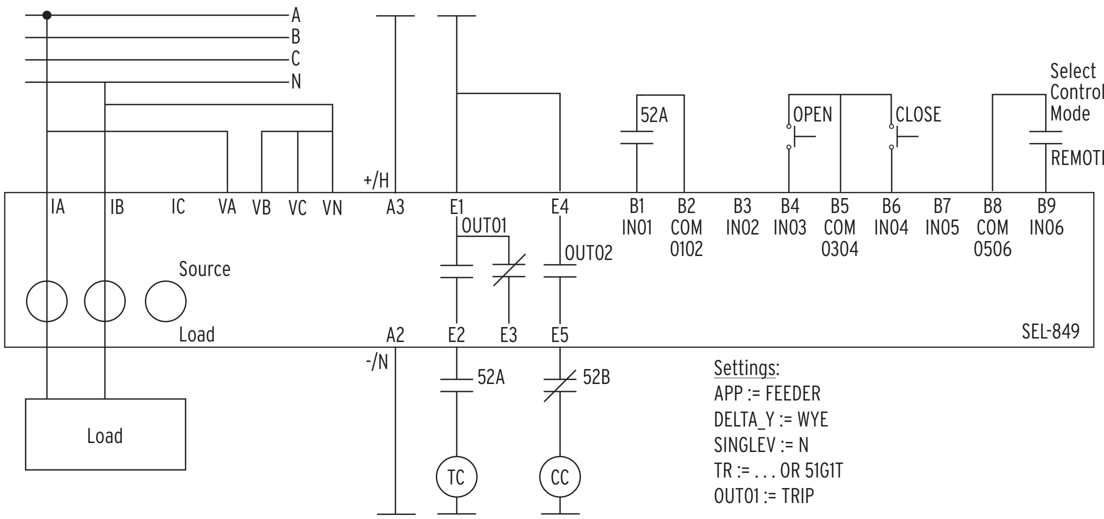
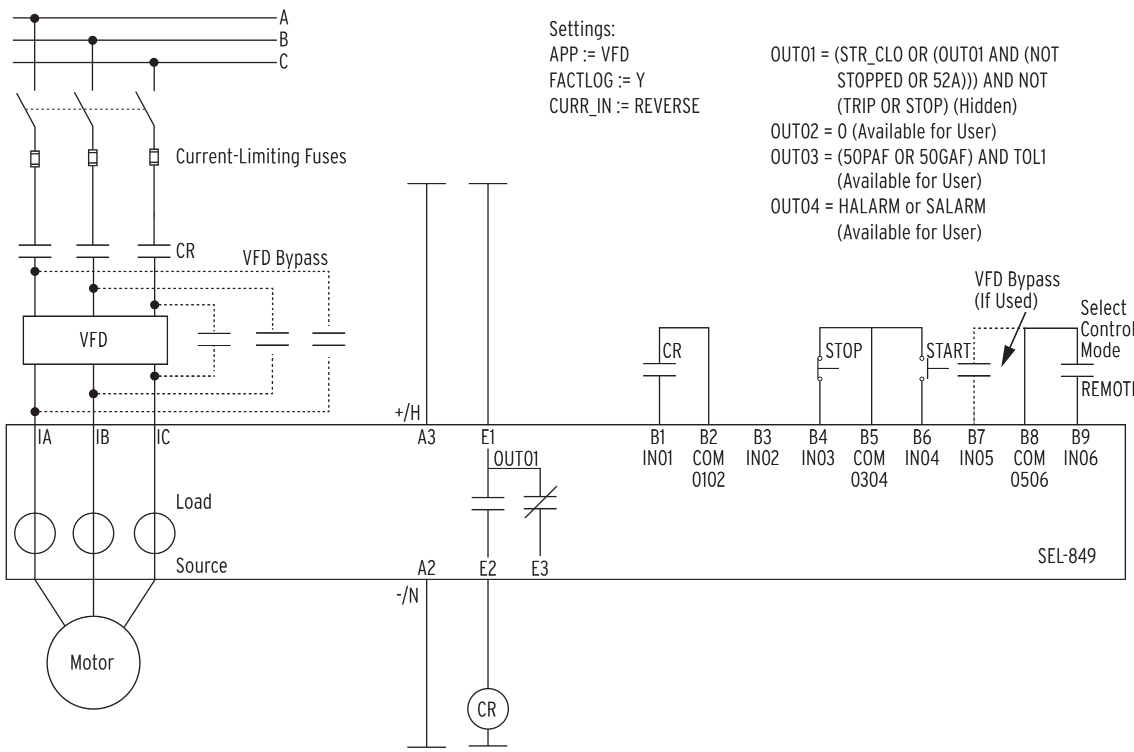


Figure 2.19 Connection Diagram for Single-Phase Feeder Load Protection

VFD or VSD Motor Protection

Figure 2.20 shows the connection diagram for factory-default I/O assignments with this variable frequency drive (VFD) motor application. Please note the settings that are required to configure this application are as shown in the figure. The VFD Bypass feature is as shown if used in the application. In a VFD application, the SEL-849 uses rms current magnitude instead of fundamental for the phase/ground overcurrent and the motor thermal model elements (50P, 50G, 50N, 51P, 51G, 51N, and 49T). The SEL-849 with VFD tracks frequency of the phase current inputs only. It is recommended that you do not use voltage-based protection, including over- and undervoltage, power factor, underpower, and reactive power (27/59, 55, 37, and VAR) elements unless the voltage measurements are substantially sinusoidal without multiple zero crossings. When voltage inputs are used, they should be from the same side of the VFD as the current inputs (e.g., the load side for connections shown in *Figure 2.20*).



Relay shown with internally wetted digital inputs.

Figure 2.20 Connection Diagram for Factory-Default I/O Assignments Full-Voltage Nonreversing Starter (With Variable Frequency Drive)

Motor Relay HMI Installations

Connection

- ➤ The RJ45 port on the rear of the SEL-3421/3422 connects to the HMI port on the SEL-849 Relay and receives power from the HMI port.
- ➤ Connection to the relay requires an RJ45 Ethernet cable, such as the SEL-C627M, double-shielded, 600 V, MCC-rated, category 5e Ethernet cable, with a maximum length of 7.62 meters (25 feet).

Gasket Installation for Panel Mounting

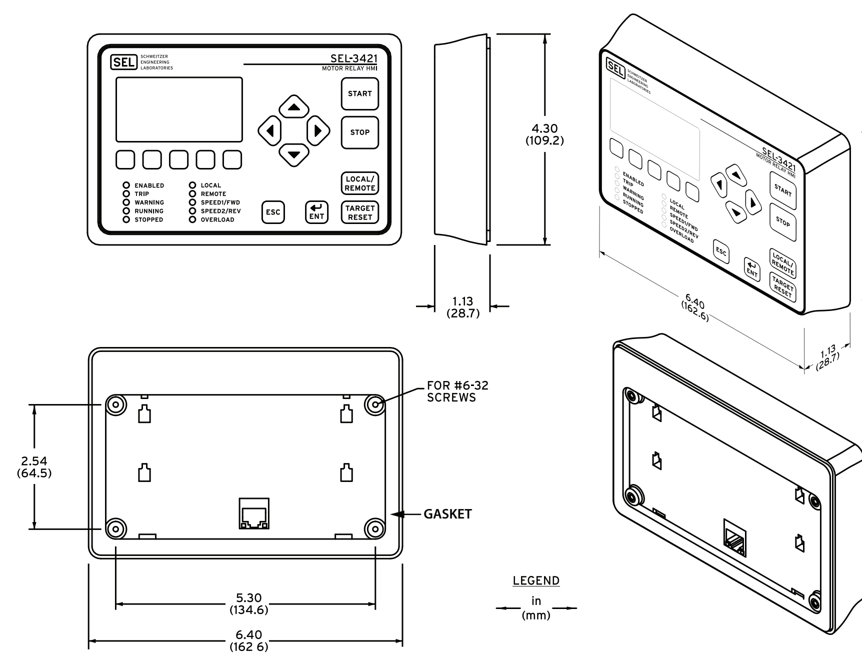
Step 1. Remove the inner rectangular section from the gasket.

Step 2. Peel off the paper to expose the adhesive.

Step 3. Position the gasket, with the adhesive side to the rear of the SEL-3421/3422, so that the gasket is inside the outer edge of the plastic casing and the four screw holes are inside the inner rectangle of the gasket.

Step 4. Press the gasket to the rear of the SEL-3421/3422 to create a seal around the edge of the SEL-3421/3422.

SEL-3421 Dimensions and Mounting Options



Note: To ensure that the electrical connections are completely enclosed, make sure the HMI is mounted with a gasket and that the enclosure has punch holes for the RJ45 connector and the screws.

Note: The SEL-3421 mounting drill template shows the location of the four screw holes (4.49 mm diameter) and the HMI communications port hole (25.4 mm diameter).

Figure 2.21 SEL-3421 Panel Mount

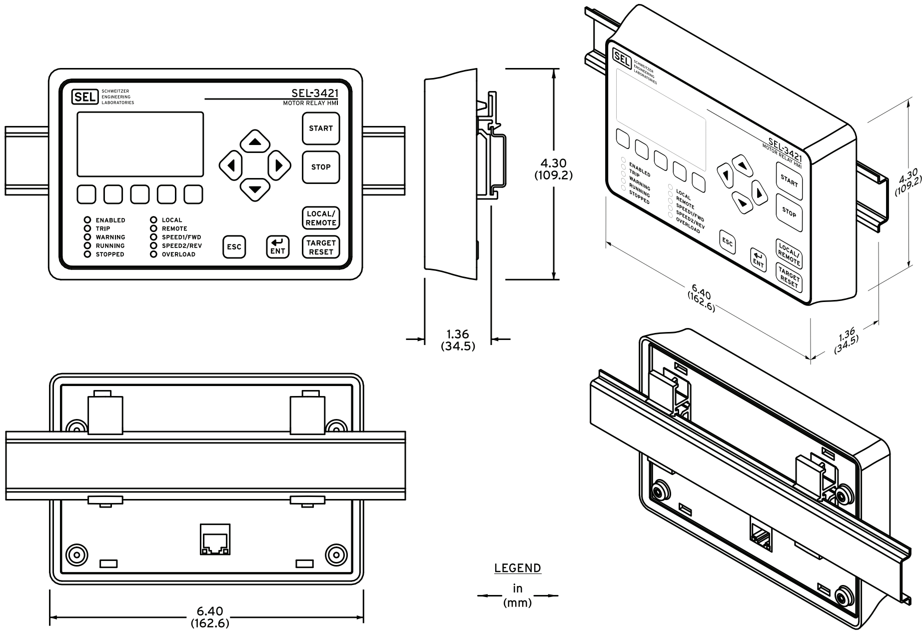
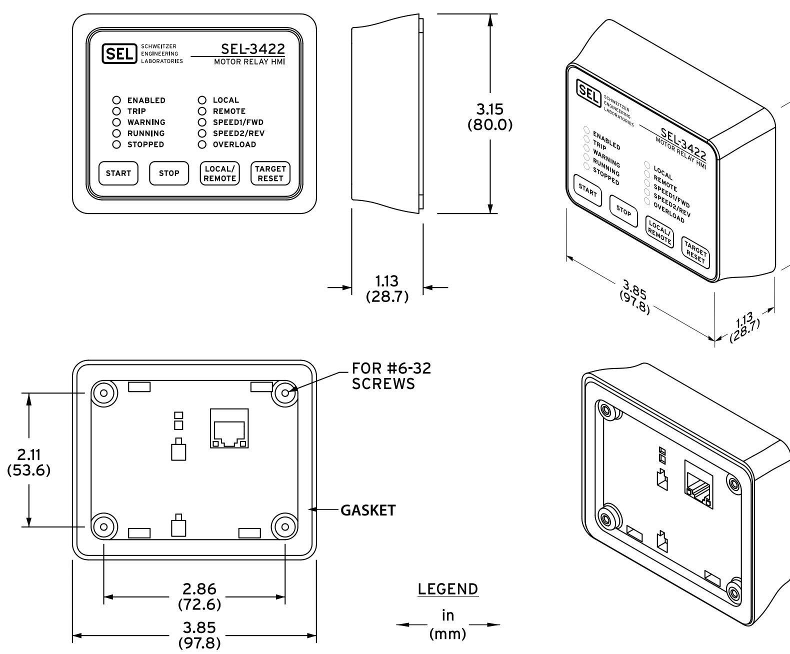


Figure 2.22 SEL-3421 DIN-Rail Mount

SEL-3422 Dimensions and Mounting Options



Note: To ensure that the electrical connections are completely enclosed, make sure the HMI is mounted with a gasket and that the enclosure has punch holes for the RJ45 connector and the screws.

Note: The SEL-3422 mounting drill template shows the location of the four screw holes (4.49 mm diameter) and the HMI communications port hole (25.4 mm diameter).

Figure 2.23 SEL-3422 Panel Mount

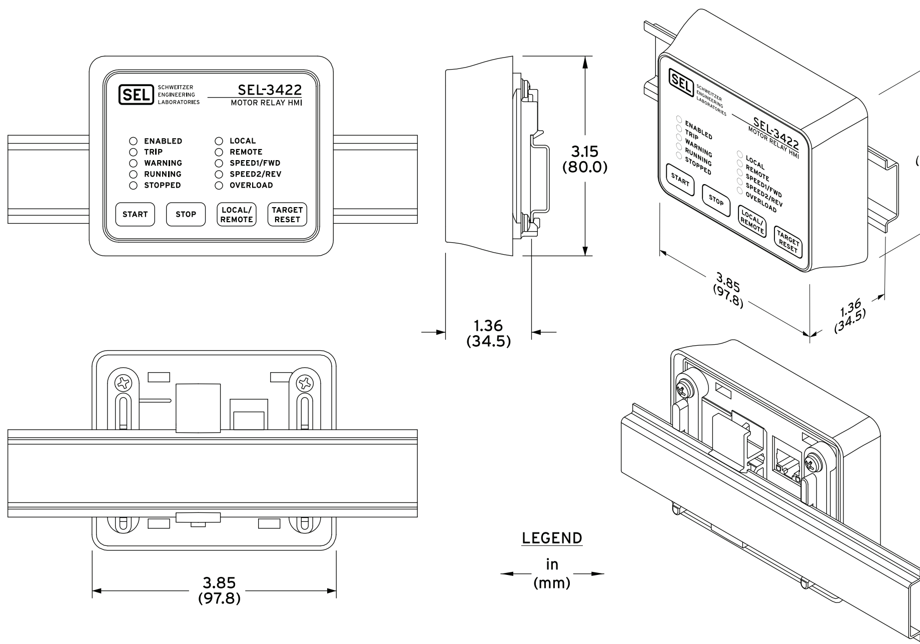


Figure 2.24 SEL-3422 DIN-Rail Mount

SEL-849 Accessory Lug Kit Installation

See *Figure 2.25* for the connection diagram for the current inputs using the optional lug kit (Part Number 915900325). This kit only supports applications up to an FLA 128.0 A.

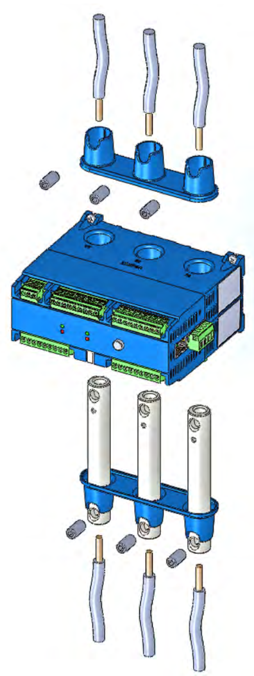


Figure 2.25 Optional Lug Kit Current Inputs Connection Diagram

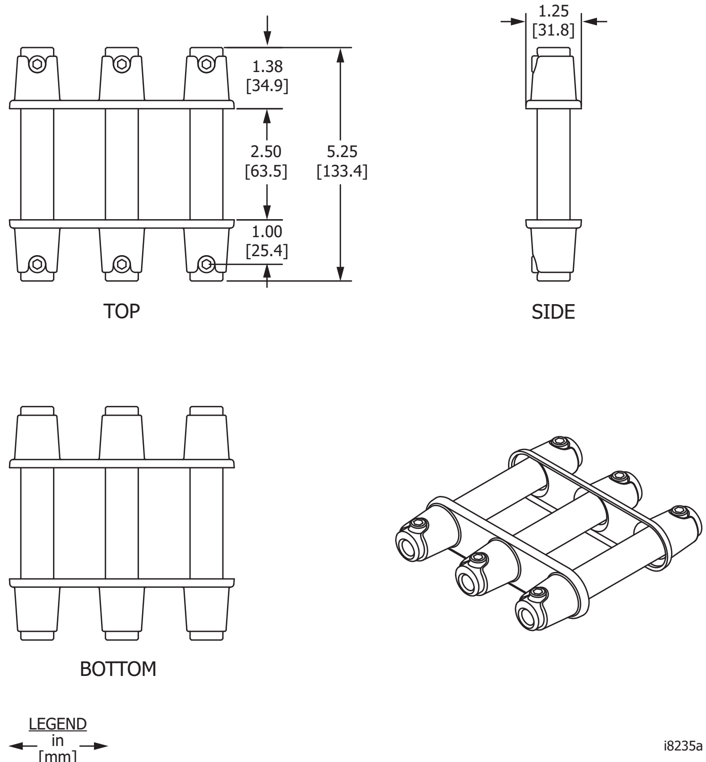


Figure 2.26 Lug Kit Dimensions

SEL-849 Lug Kit does not meet IP1X. Refer to the SEL-849 *Accessory Lug Kit Installation Guide* for technical specifications of the kit. The installation guide is available online on the SEL-849 product page at selinc.com/products/849/.

Field Serviceability

The SEL-849 firmware can be upgraded in the field; refer to *Appendix B: Firmware Upgrade Instructions* for firmware upgrade instructions. You may know when a self-test failure has occurred by configuring an output contact to create a diagnostic alarm as explained in *Section 4: Protection and Logic Functions*. By using the metering functions, you may know if the analog front-end (not monitored by relay self-test) is functional.

The SEL-849 does not have any field serviceable parts. Return a faulty or failed unit to the factory for repair or replacement.

Section 3
PC Interface

Overview

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

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

The SEL-849 Motor Management Relay is able to communicate with your computer in three different ways. All three methods present the same data (metering, settings, and reports) and provide the same control (open/close contactor).

- The web server requires a web browser (Microsoft Internet Explorer, Mozilla FireFox, Google Chrome, etc.) and an Ethernet cable.
- The SEL software solution requires downloading ACSELERATOR QuickSet SEL-5030 Software (via Compass) to your computer. Communication to the relay is accomplished through a serial or Ethernet port.
- The ASCII command line requires PC-based terminal emulation software (HyperTerminal, Tera Term, etc.), a serial or Ethernet port, and a serial or Ethernet cable to connect to the relay (see *Section 7: Communications*).

Web Server

Connection and Login to Web Server

The web server provides a graphical user interface to the relay without loading any software on your PC. The user interface is contained in the relay firmware. To connect to the web server of the SEL-849, the relay and your PC must be connected to the same Ethernet network. The network can be of any size, from a company-wide network to a direct-connect from your PC to the relay. The connection from the relay is through the Ethernet port of the relay (Port 2). To start communicating with the relay, you must enter a valid IP address (SET P 2 IPADDR) and valid default router (SET P 2 DEFRTR) via the serial port (Port 1) of the relay. Be sure to obtain the IP address and default router from your IT resource to avoid network conflicts with duplicate IP addresses.

The SEL-849 comes pre-loaded with settings that enable you to communicate with the relay over a simple network. The network consists of connecting the SEL-849 (via Port 2) directly to the Ethernet port (via an RJ45 cable) of your computer. This connection requires that the computer not be connected to any other network (see *Figure 3.1*).

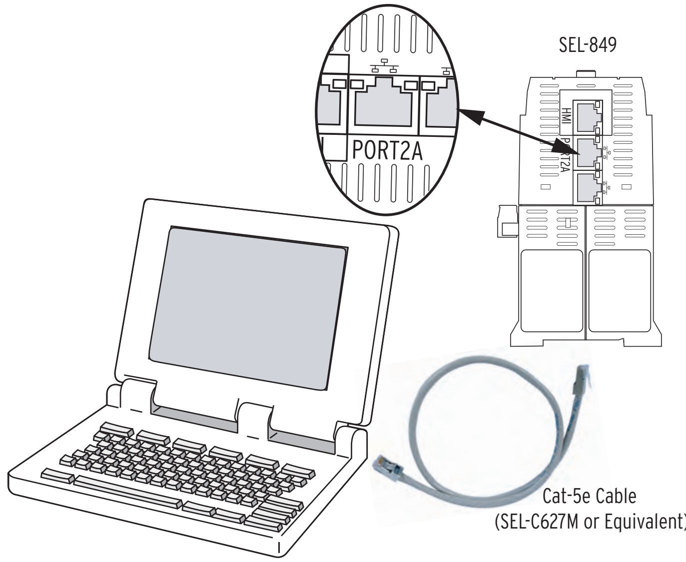


Figure 3.1 Direct Connection of SEL-849 to a Computer

The default IP address is 169.254.0.1 and the default router is 0.0.0.0. Once the network is configured, as shown in *Figure 3.1*, you can connect to the web server in the relay by entering 169.254.0.1 in the address bar of your web browser (as shown in *Figure 3.2*).

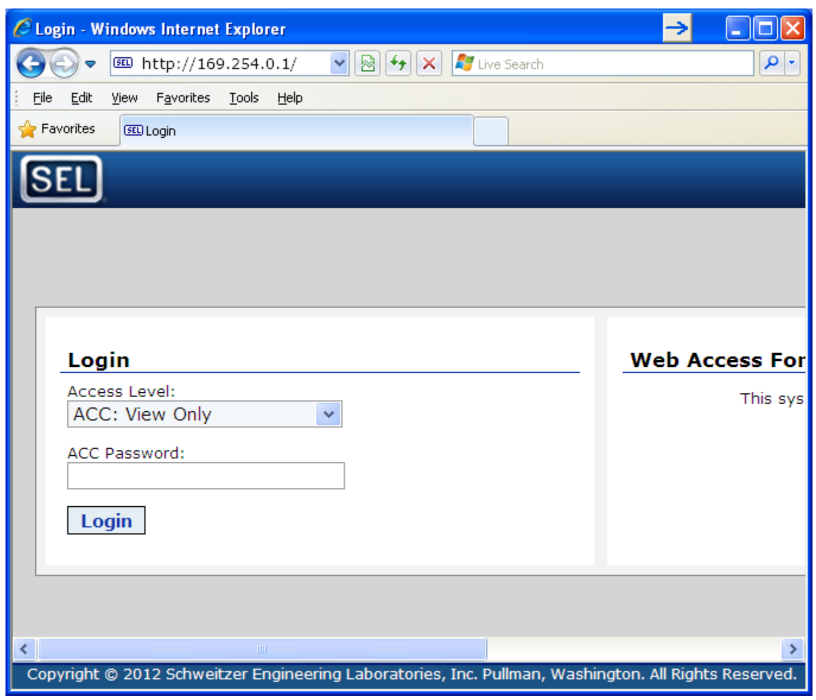


Figure 3.2 Login Page of Web Server for SEL-849

The Login page of the web server allows you to access either ACC, 2AC, or CAL level. The menu item you select under Access Level determines the access level at which you enter the web server (see *Figure 3.3*). For factory-default passwords, refer to *Table 7.34: Factory-Default Passwords for Access Levels 1, 2, and C.*

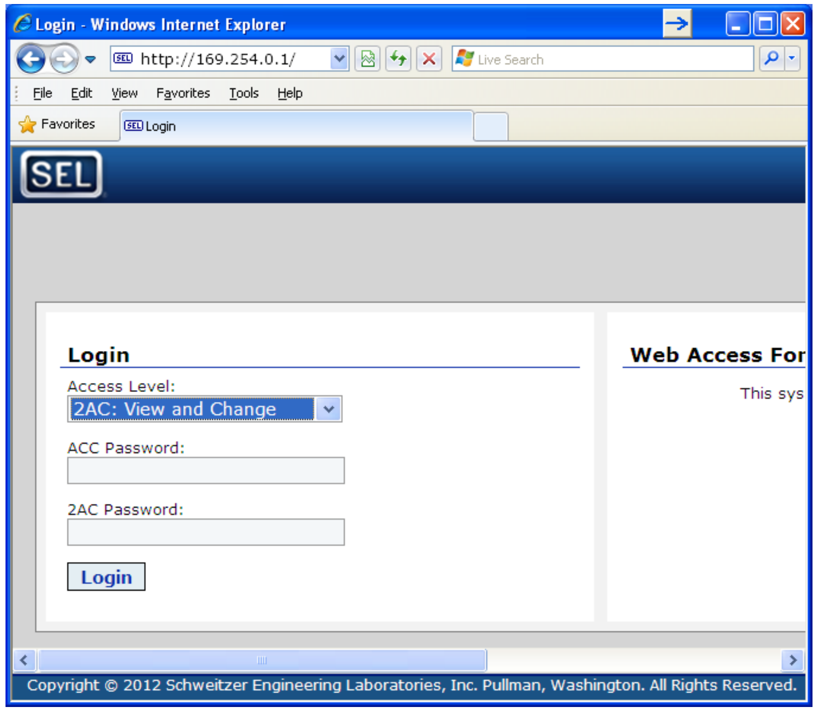


Figure 3.3 Selecting Access Level 2 From Web Server Login

Setting Changes

Logging in to the web server with 2AC access allows you to modify relay settings (with ACC access, you can only view settings). When you select **Settings** from the navigation pane, the screen displays all available classes of settings in the SEL-849 (see *Figure 3.4*).

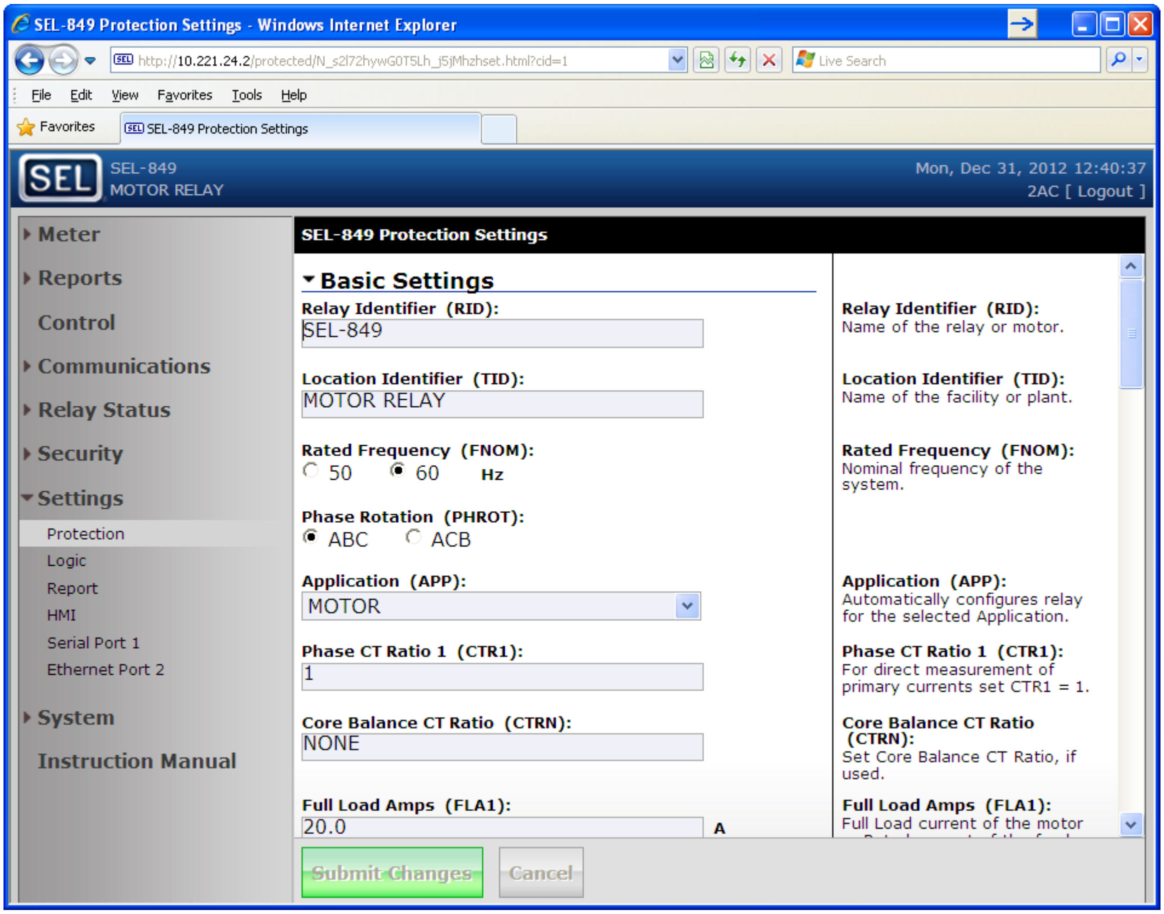


Figure 3.4 Protection Settings Webpage

When you select a class of settings, you can view and set each of the settings in that class (Protection, Logic, Report, HMI, Serial Port 1, Ethernet Port 2, etc.). *Figure 3.4* shows the Basic Settings category of the **Protection** class under **Settings**. Use the right-side scroll bar to reveal addition settings (Configuration Settings, Thermal Overload Settings, etc.). Each class of settings can be modified on the web server and downloaded to the SEL-849. See *Section 4: Protection and Logic Functions* for descriptions of each of the settings and the class to which they belong.

Once you modify a setting, the changed setting will be shown in italics. After you modify the settings, click **Submit Changes** (located on the bottom of the screen) to download settings to the relay (see *Figure 3.5*).

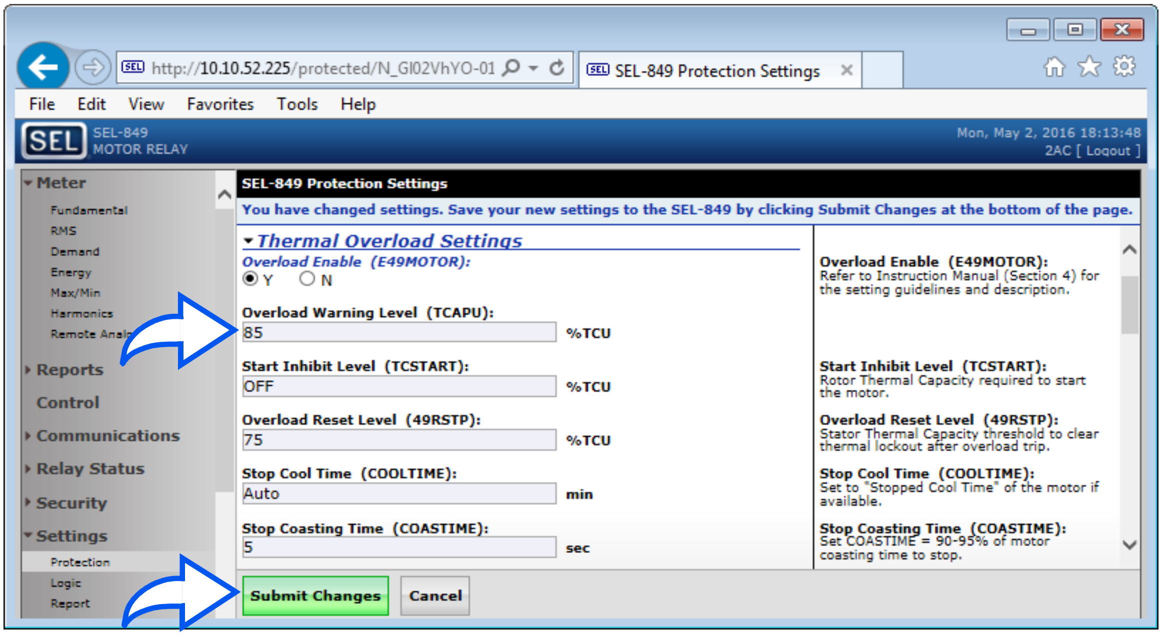


Figure 3.5 Change Settings Webpage

When you click **Submit Changes**, a prompt appears asking you to verify that you want to save the settings to the relay (see *Figure 3.6*).

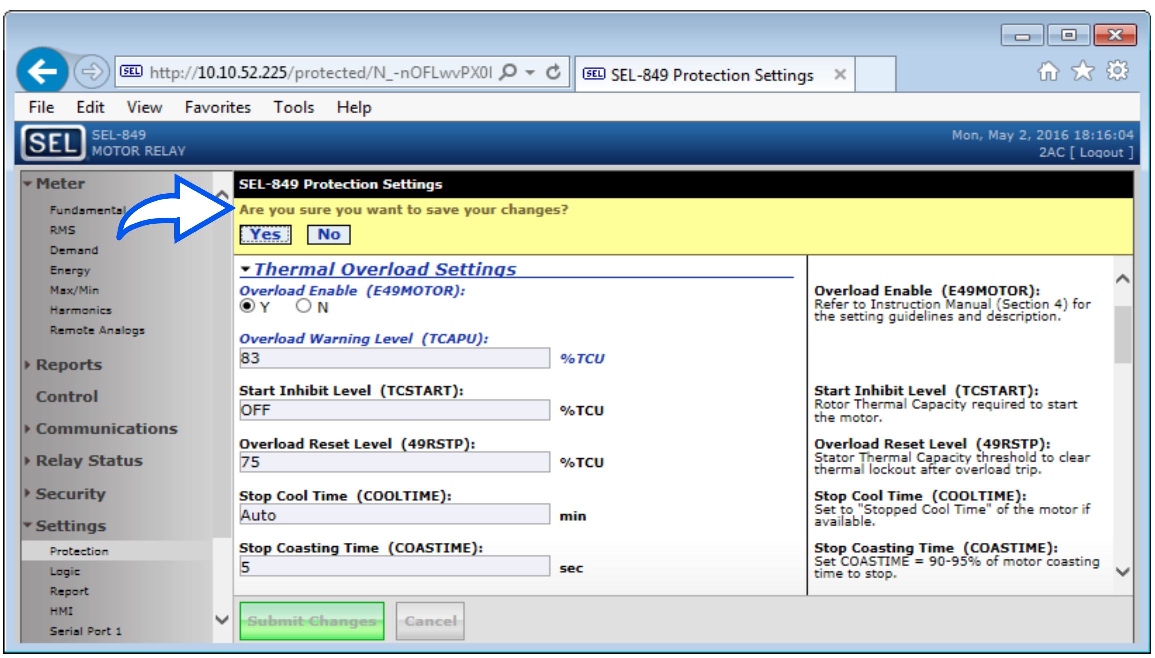


Figure 3.6 Save Setting Changes Webpage

Export/Import Settings

The web server is a convenient way to both export settings from a relay and import settings to a relay. Each settings class is saved in a separate file. Located on the navigation pane, **System** consists of four categories (File Management, Passwords, Date/Time, and Device Reset). Use **File Management** to export and import settings from the relay.

Select the class of settings you want to export from **Settings**. You can save these settings as a text file. Then, you can click **Import Settings** to set other relays with the exported file (see *Figure 3.7*).

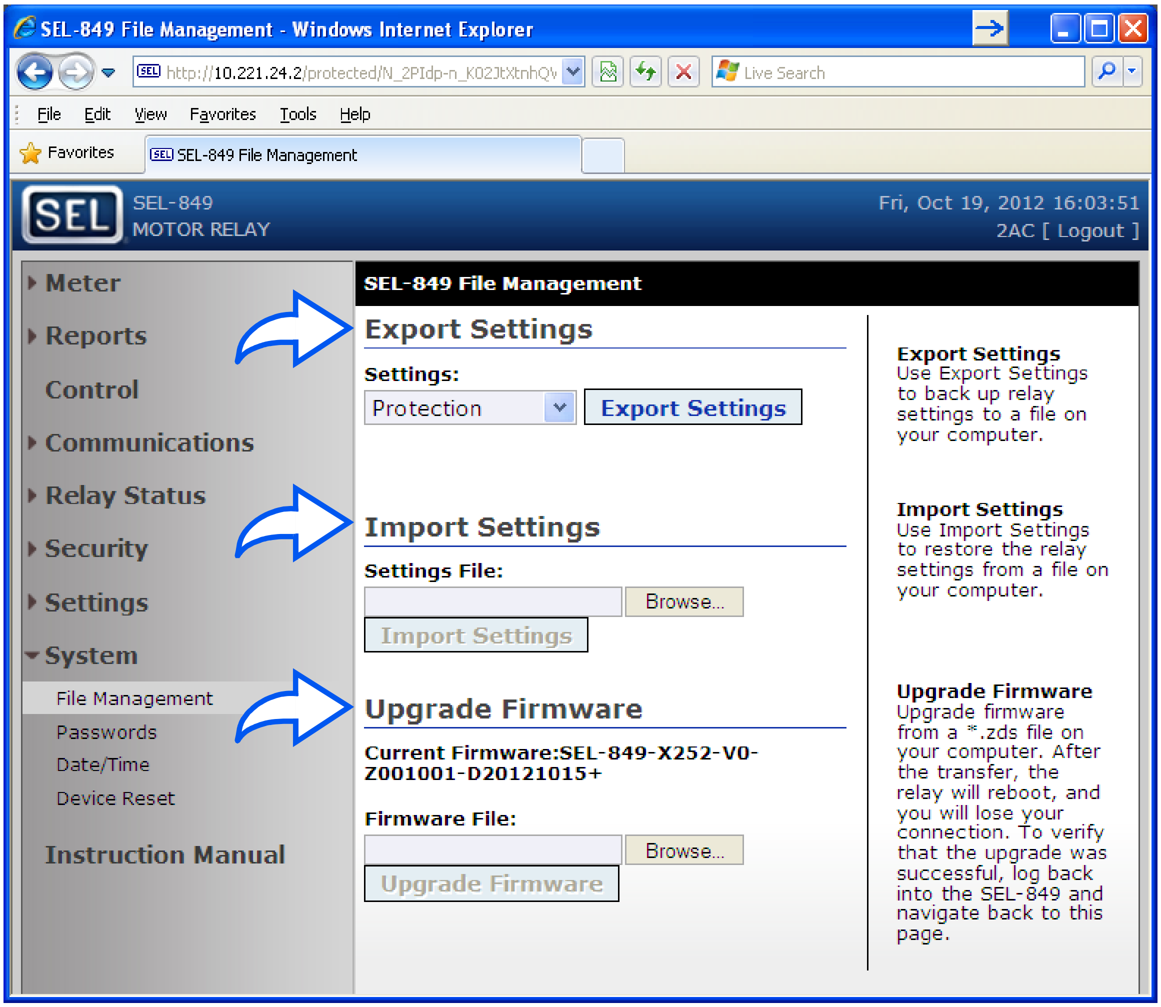


Figure 3.7 Import Settings, Export Settings, and Upgrade Relay Firmware From the File Management Webpage

Upgrade Firmware

The web server offers a convenient method for upgrading relay firmware. Located on the navigation pane, the **System** menu contains four categories (File Management, Passwords, Date/Time, and Device Reset). **File Management** allows you to upgrade the relay firmware (see *Figure 3.7*).

When preparing to upgrade relay firmware you must first have the new relay firmware. The firmware is designated with a .zds extension. Use the **Browse** button to select the firmware you want sent to the relay, then click **Upgrade Firmware** to start the upgrade process (see *Figure 3.7*). See *Appendix B: Firmware Upgrade Instructions* for more information.

Change Passwords

The web server offers a convenient method for changing relay passwords. Located on the navigation pane, the **System** menu consists of four categories (File Management, Passwords, Date/Time, and Device Reset). Click **Passwords** to change the relay passwords (see *Figure 3.8*). SEL recommends changing the default passwords immediately upon receiving the relay.

You are able to change the password of any level, including the level into which you are presently logged. For example, to change the 2AC password, you must log in at the 2AC level (see *Connection and Login to Web Server*). To change the password, select the level from the Access Level drop down menu.

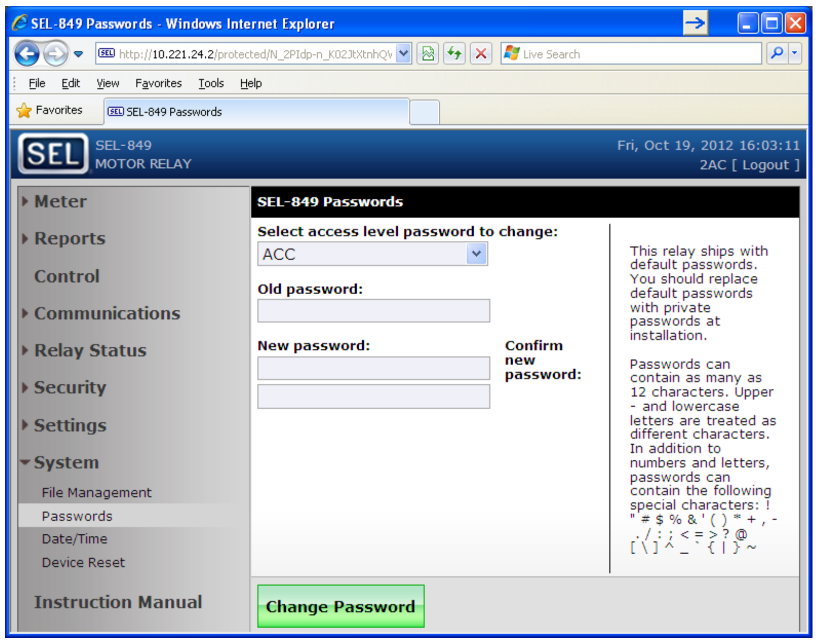


Figure 3.8 Change Passwords Webpage

Device Reset

NOTE: This will change the communication settings including the IP address.

To restore all relay settings to their default values, select **System** > **Device Reset** (see *Figure 3.9*). This menu item displays the **Device Reset** webpage. When you select the **Reset to Factory Settings and Reboot** button, all relay settings revert to their factory-default values (except calibration settings). This feature can be helpful in ensuring that no additional settings are modified when making setting changes.

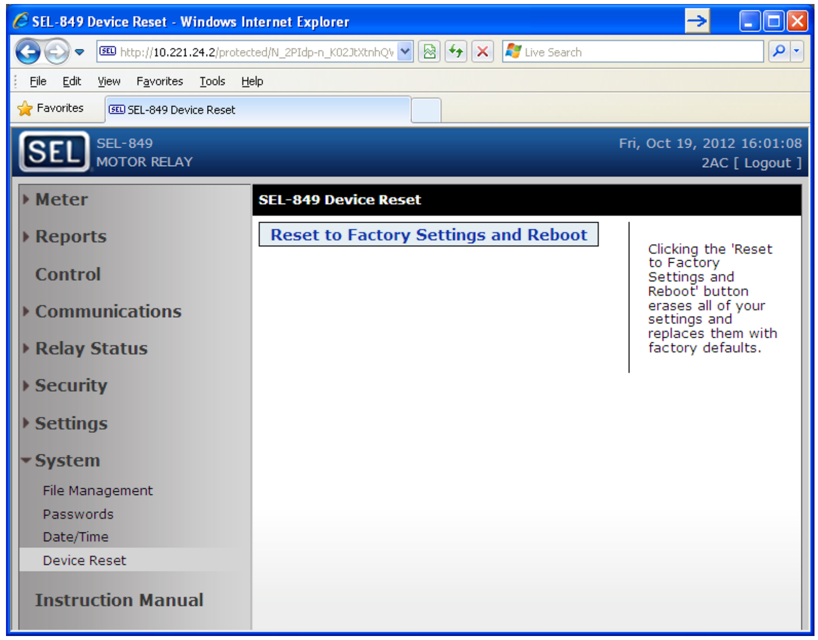


Figure 3.9 Reset Relay Settings to Default Values Using the Web Server

Meter

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

The web server offers a convenient method for displaying all metering reports stored in the relay (Fundamental, RMS, Demand, Energy, Max/Min, Harmonics, and Remote Analogs). Located on the navigation pane, the **Meter** menu contains categories for each of the meter reports. When you select a category from the **Meter** menu, its corresponding meter report is displayed (see *Figure 3.10*).

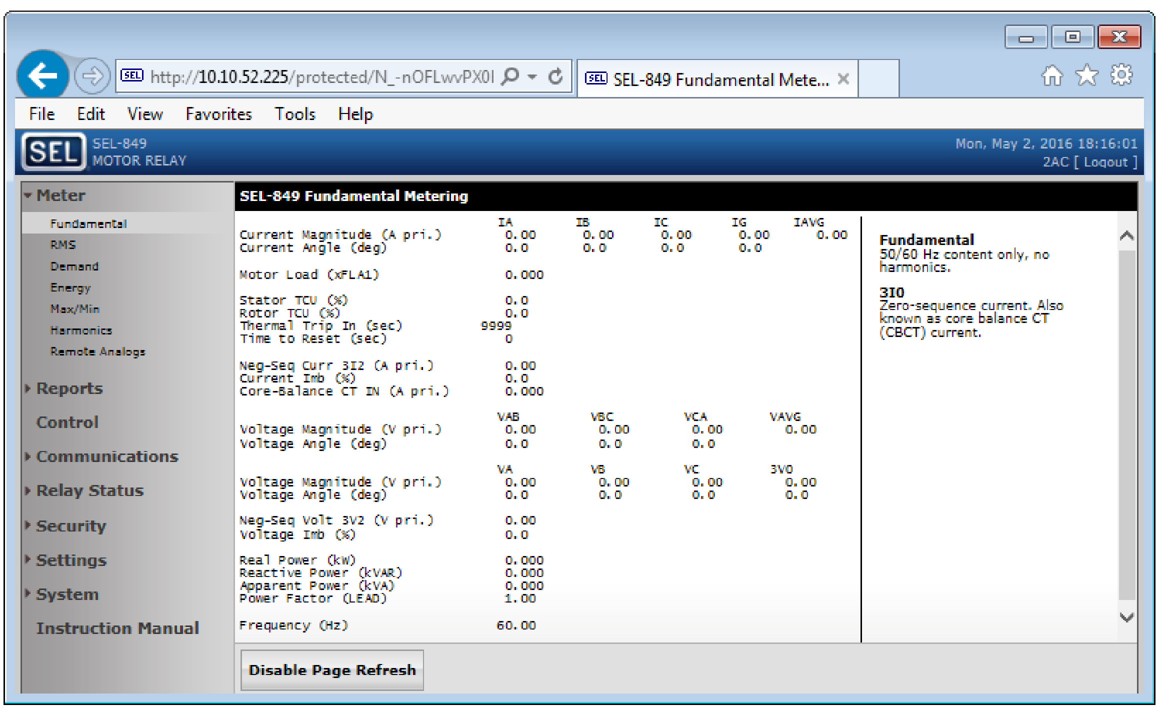


Figure 3.10 Fundamental Meter Report

Reports

Event Reports

In addition to meter data, the SEL-849 collects and stores a variety of data and statistics from the power system. These data are stored and reported through a series of reports. Located on the navigation pane, the **Report** menu contains categories for each of the reports stored in the relay (Event Reports, Sequential Events Recorder, Load Profile, Motor Statistics, Motor Start, and Motor Start Trend). When you select a category from the **Reports** menu, its corresponding report is displayed.

Event reports stored in the SEL-849 can be exported in two different formats (COMTRADE or Filtered CEV format). When the **Event Reports** menu item is selected the display shows all the event reports presently stored in the relay (see *Figure 3.11*).

After selecting the event format to be used (COMTRADE or SEL CEV), select the event report to export by clicking on the event needed. The pop-up window will enable you to save the corresponding event file.

In addition to retrieving events, the **Event Reports** page allows you to clear all events stored in the relay or to trigger events. Clear Event Report History erases the event from the nonvolatile memory of the relay. Trigger Event Report commands the relay to do an event capture of the present voltages and currents seen by the relay (see *Figure 3.11*).

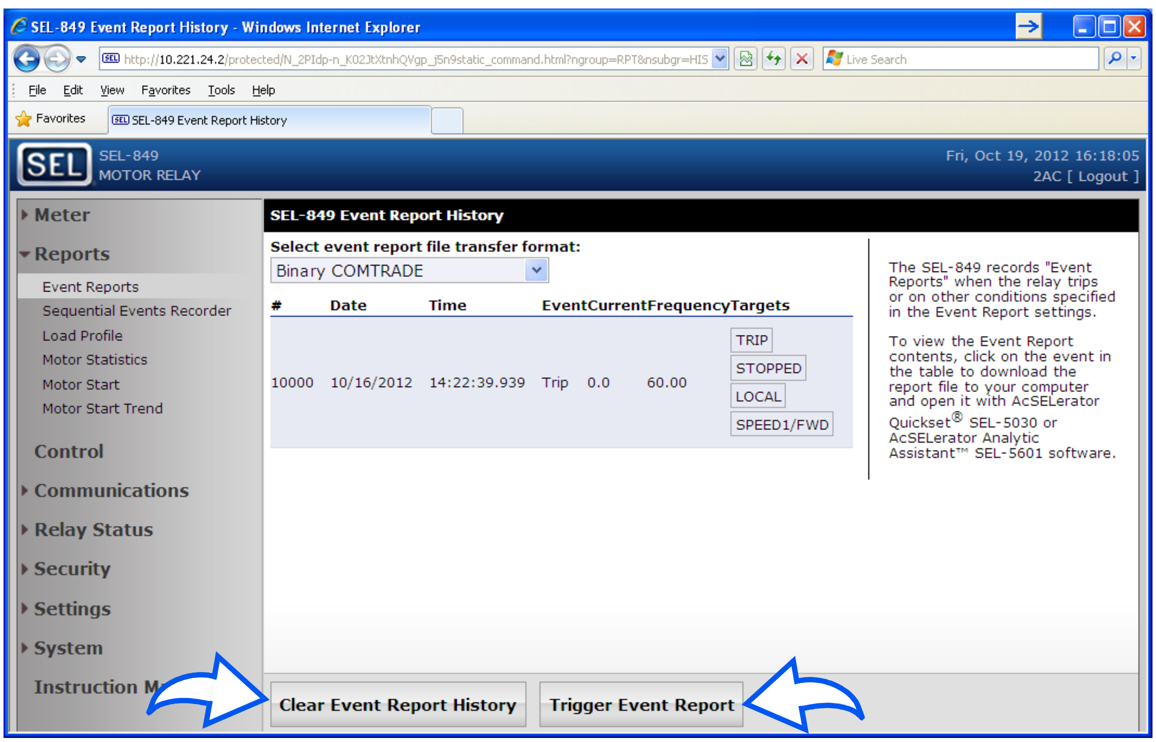


Figure 3.11 Event Report Webpage

Sequential Events Recorder

In addition to **Event Reports**, the SEL-849 collects and stores time-stamped data for assertion and deassertion of Relay Word bits. These data are captured in the Sequential Events Recorder (SER) and can be exported through the web server. Located on the left panel of the screen, the **Reports** menu contains categories for each of the reports stored in the relay (Event Reports, Sequential Events Recorder, Load Profile, Motor Statistics, Motor Start, and Motor Start Trend). When you select **Sequential Events Recorder** from the **Reports** menu, the SER report will display.

When you select **Sequential Events Recorder**, all SER presently stored in the relay will display (see *Figure 3.12*). SER reports stored in the SEL-849 can be downloaded or cleared by clicking the appropriate button at the bottom of the webpage.

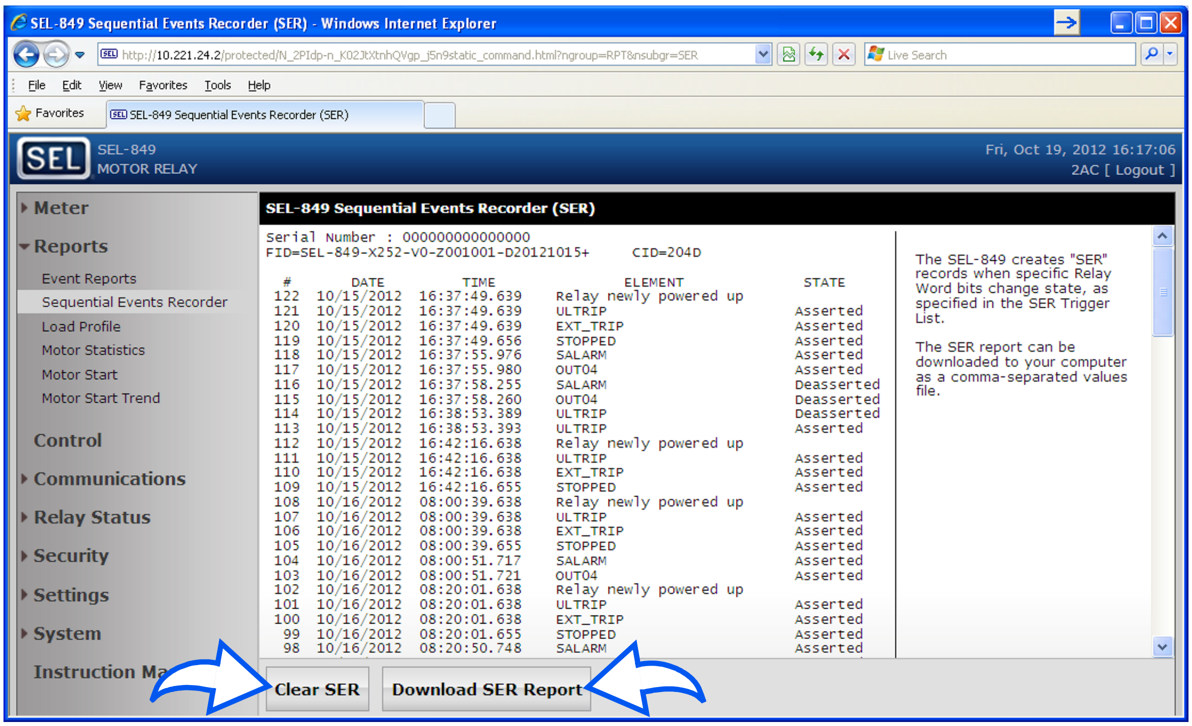


Figure 3.12 Sequential Events Recorder Report

Load Profile

The SEL-849 collects and stores time-stamped data of analog quantities. These data are reported in the load-profile report. The **Reports** menu, which is located on the navigation pane, contains categories for each of the reports stored in the relay (Event Reports, Sequential Events Recorder, Load Profile, Motor Statistics, Motor Start, and Motor Start Trend). When you select the Load Profile category from the **Reports** menu, the load-profile report displays.

When you select the **Load Profile** menu item, all the load-profile reports presently stored in the relay display (see *Figure 3.13*). You can export or clear the load-profile reports stored in the SEL-849 using the two buttons at the bottom of the display window.

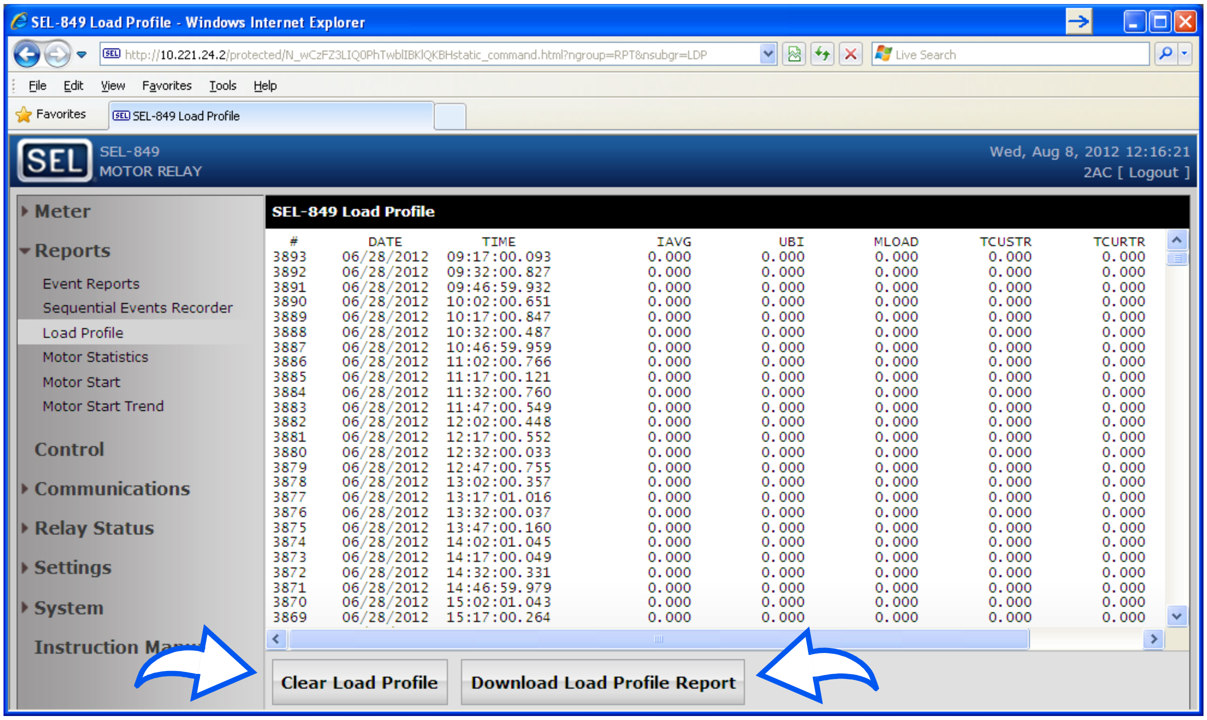


Figure 3.13 Load-Profile Webpage

Motor Statistics

The SEL-849 collects and stores statistics of the motor service. These data are reported in the Motor Statistics Report. The **Reports** menu, located on the left panel of the screen, contains categories for each of the reports stored in the relay (Event Reports, Sequential Events Recorder, Load Profile, Motor Statistics, Motor Start, and Motor Start Trend). When you select **Motor Statistics** from the **Reports** menu, the Motor Statistics report appears in the display window.

When you select **Motor Statistics**, all the motor operating statistics reports presently stored in the relay will display (see *Figure 3.14*). Motor operating statistics reports stored in the SEL-849 can be cleared using the **Clear Motor Operating Statistics** button at the bottom of the screen. This webpage is updated automatically. The automatic update can be disabled by clicking **Disable Page Refresh** at the bottom of the screen.

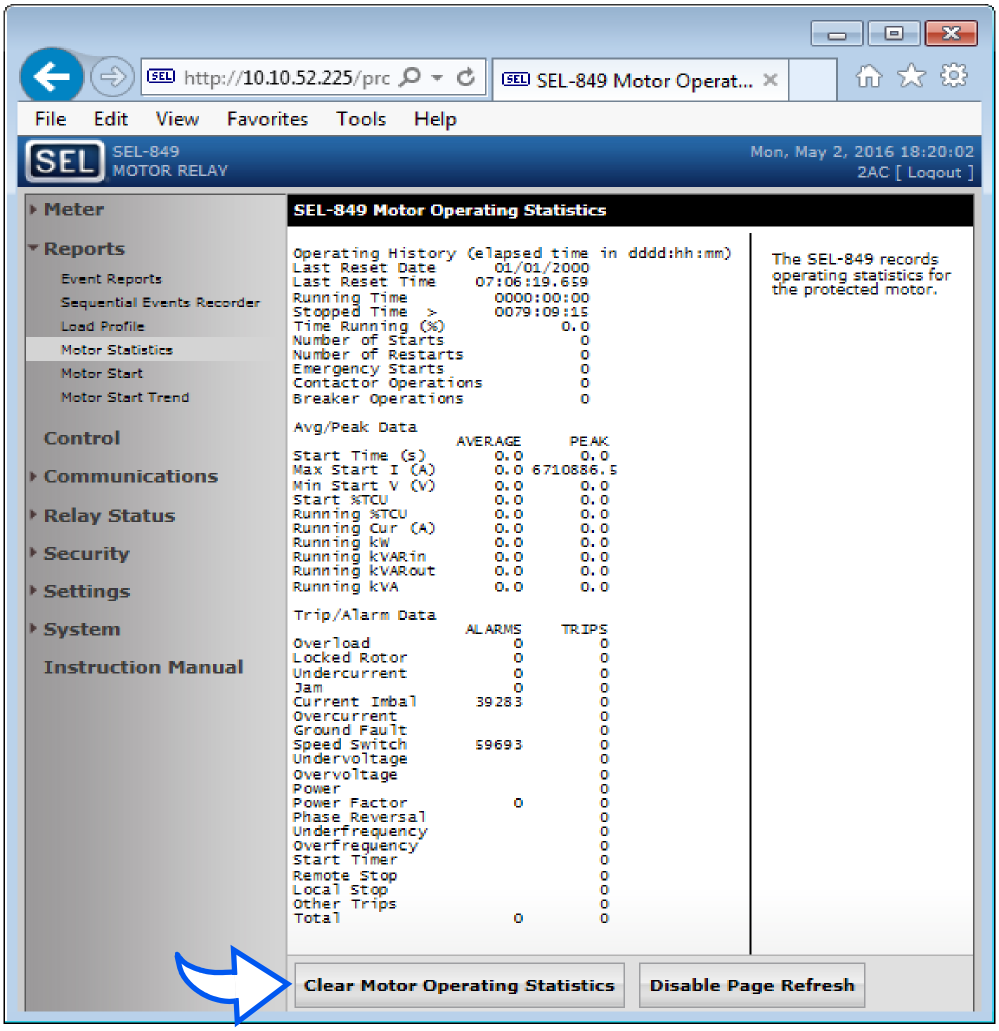


Figure 3.14 Motor Operating Statistics Webpage

Motor Start

The SEL-849 collects and stores statistics of each start of the motor. These data are reported in separate Motor Start reports. Located on the navigation pane, **Reports** contains categories for each of the reports stored in the relay (Event Reports, Sequential Events Recorder, Load Profile, Motor Statistics, Motor Start, and Motor Start Trend).

When you select **Motor Start**, the Motor Start reports presently stored in the relay are displayed (see *Figure 3.15*). Click on the report to download it to your computer and open the report with the Motor Start report viewer in QuickSet.

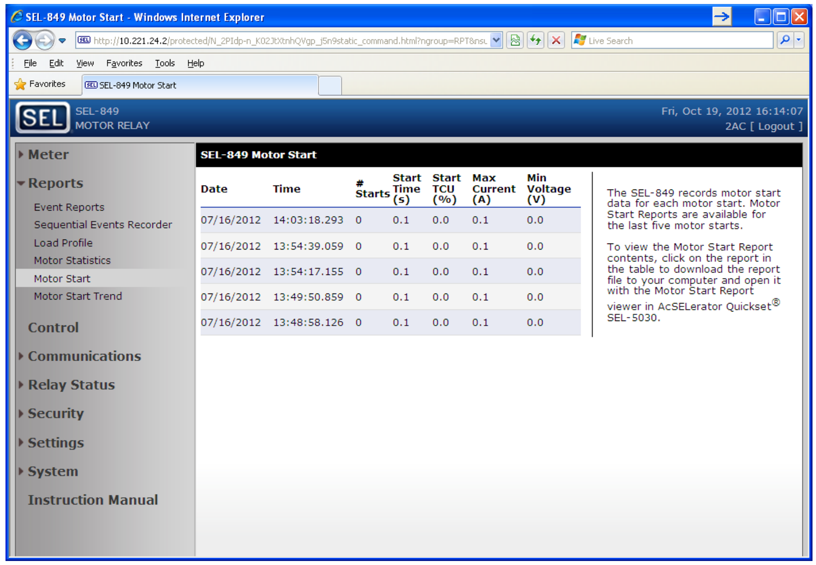


Figure 3.15 Motor Start Report Webpage

Motor Start Trend

The SEL-849 collects and stores statistics of each start over an 18-month period. These data are reported in the Motor Start Trend report. Located on the navigation pane, **Reports** contains categories for each of the reports stored in the relay (Event Reports, Sequential Events Recorder, Load Profile, Motor Statistics, Motor Start, and Motor Start Trend).

When you select **Motor Start Trend**, the Motor Start Trend report presently stored in the relay displays (see *Figure 3.16*). The Motor Start Trend report stored in the SEL-849 can be either cleared or downloaded with the buttons at the bottom of the screen.

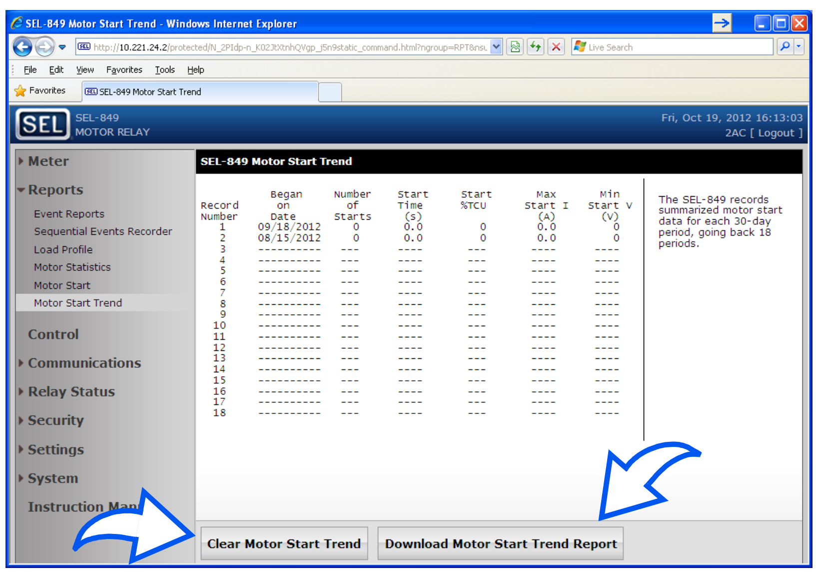


Figure 3.16 Motor Start Trend

Control

In addition to viewing and downloading data from the SEL-849, you can control output contacts and remote bits from the **Control** webpage. Also, the present target information can be seen on the **Control** webpage. When you select **Control** from the navigation pane, an HMI simulation, as well as access to control of the remote bits and output contacts, is displayed (available at 2AC level only). In addition, you can START and STOP the motor by clicking the corresponding button on the HMI (when in REMOTE mode, see REMOTE Relay Word bit). Targets can also be cleared by clicking TARGET RESET.

The simulated HMI shown on the **Control** webpage gives real-time updates of the Target LEDs (see *Figure 3.17*). The **Control** display window also shows the label of each LED as saved using the T0X_LBL setting in the HMI settings (see *HMI Settings (SET H Command)*).

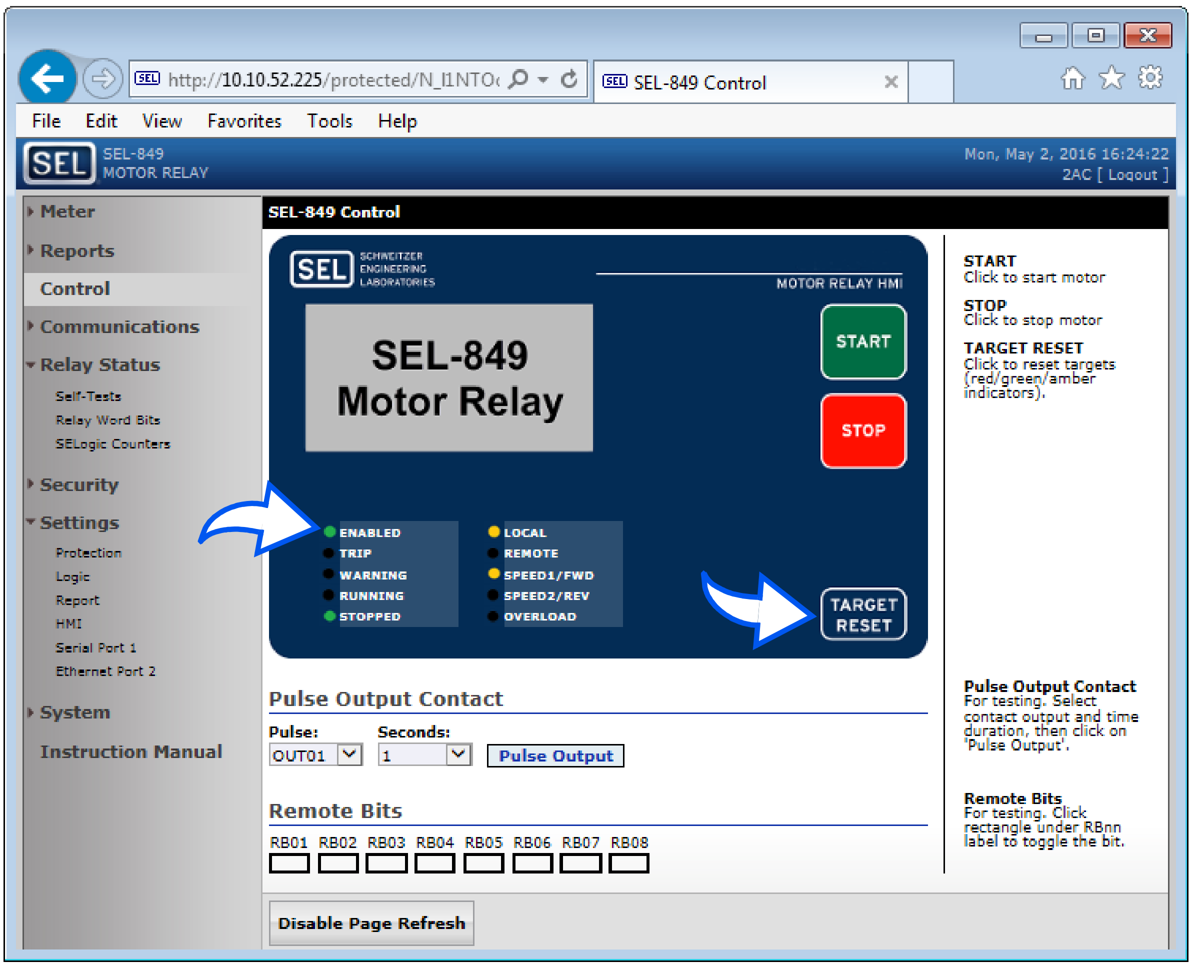


Figure 3.17 Control Webpage

To operate the Remote Bits, double-click on the remote bit you need and select the operation to perform (see *Figure 3.18*).

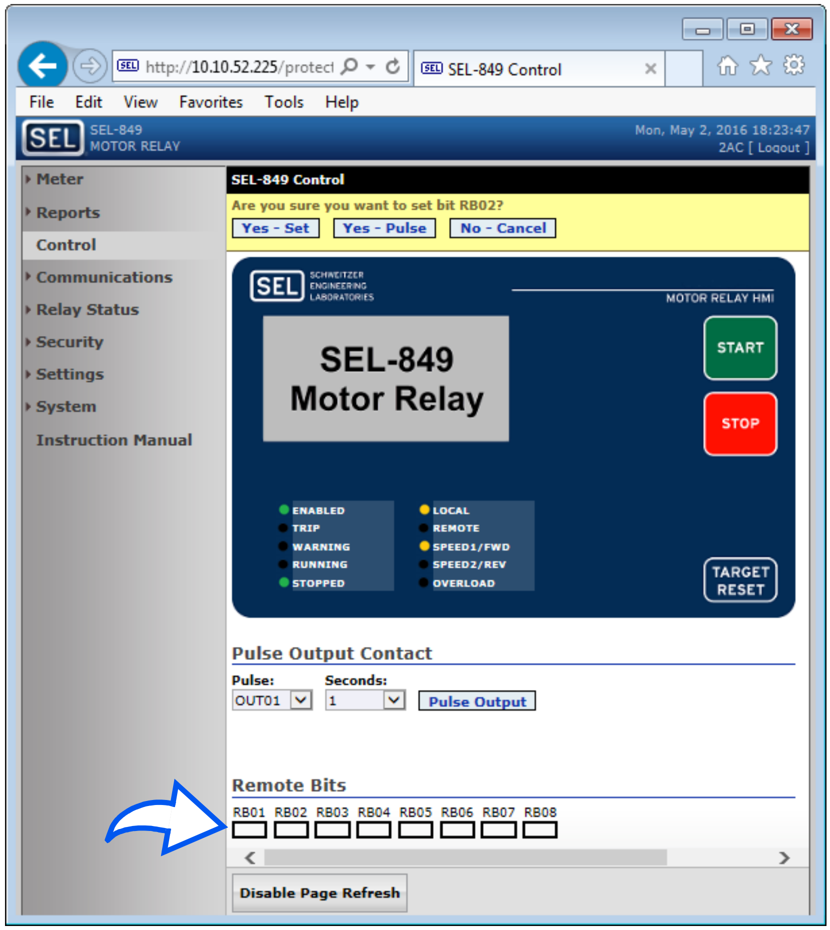


Figure 3.18 Confirmation Message for Operating Remote Bits

Relay Status

Self-Tests

The SEL-849 has continual diagnostics that verify the status of the relay hardware. The results of these diagnostics can be viewed by selecting **Relay Status** > **Self-Tests** from the navigation pane. **Relay Status** contains categories for each of the status pages in the web server (Self-Tests, Relay Word Bits, and SELOGIC Counters). When you select the category from the **Relay Status** menu, the corresponding report displays.

When you select **Relay Status** > **Self-Tests**, the status of the relay, including the serial number, part number, and self-tests results, are displayed (see *Figure 3.19*).

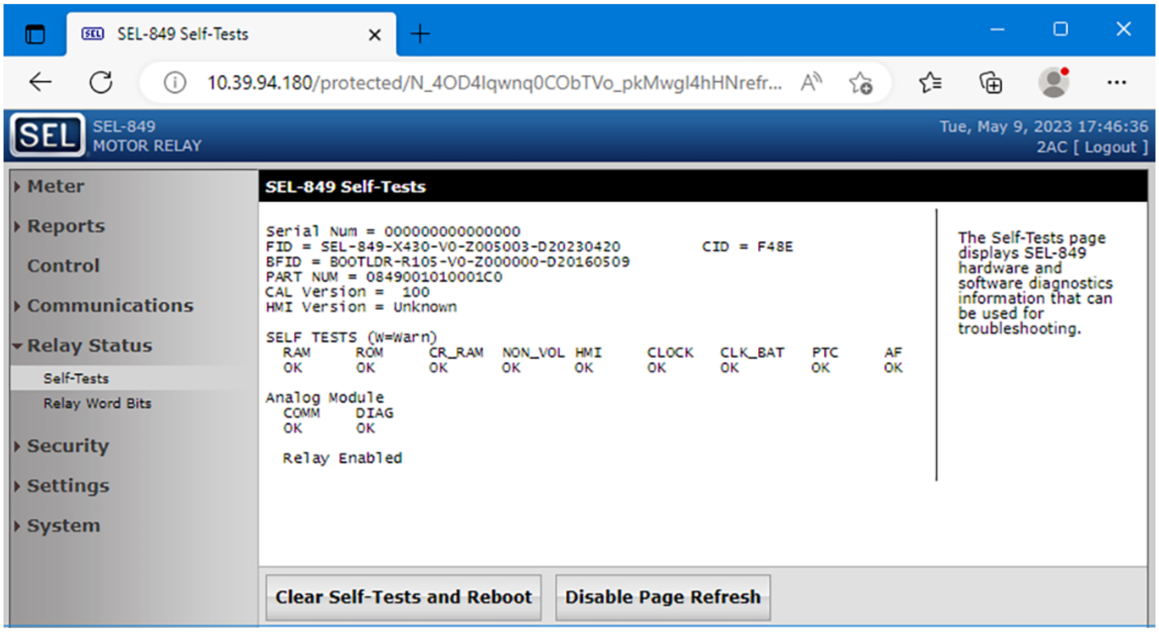
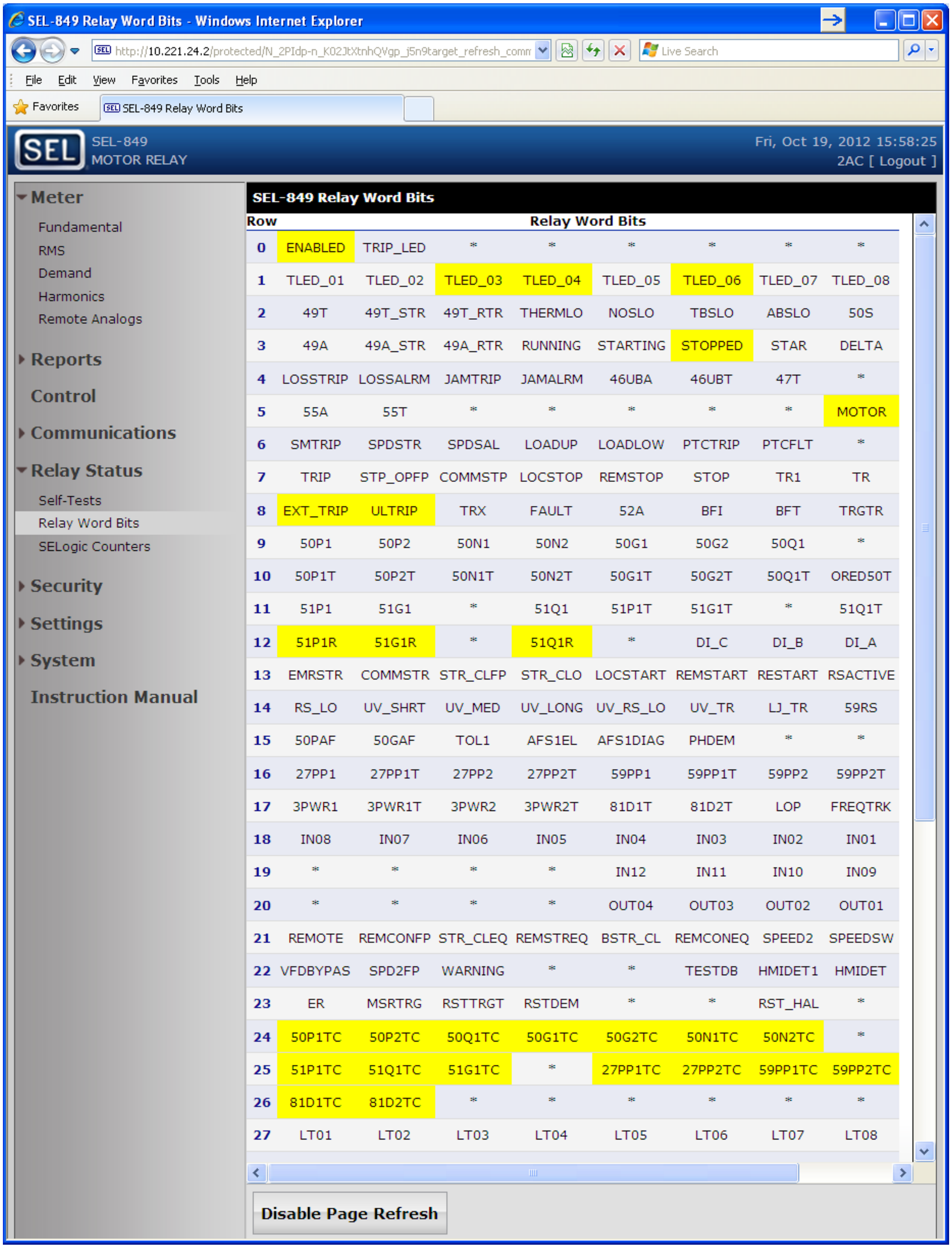


Figure 3.19 Self-Tests Webpage

Relay Word Bits

The web server has the capability to display the present state of the Relay Word bits of the relay. Located on the navigation pane, **Relay Status** contains categories for each of the status pages in the web server (Self-Tests, Relay Word Bits, and SELOGIC Counters). When you select a category from **Relay Status**, the corresponding report displays.

Selecting **Relay Word Bits** displays the state of all the Relay Word bits in the relay (see *Figure 3.20*). Note that Relay Word bits shown in yellow are asserted. This webpage is updated automatically. Scroll up or down to view the remaining Relay Word bits not visible on the screen.



Row	Relay Word Bits							
0	ENABLED	TRIP_LED	*	*	*	*	*	*
1	TLED_01	TLED_02	TLED_03	TLED_04	TLED_05	TLED_06	TLED_07	TLED_08
2	49T	49T_STR	49T_RTR	THERMLO	NOSLO	TBSLO	ABSLO	50S
3	49A	49A_STR	49A_RTR	RUNNING	STARTING	STOPPED	STAR	DELTA
4	LOSSTRIP	LOSSALRM	JAMTRIP	JAMALRM	46UBA	46UBT	47T	*
5	55A	55T	*	*	*	*	*	MOTOR
6	SMTRIP	SPDSTR	SPDSAL	LOADUP	LOADLOW	PTCTRIP	PTCFLT	*
7	TRIP	STP_OPFP	COMMSTP	LOCSTOP	REMSTOP	STOP	TR1	TR
8	EXT_TRIP	ULTRIP	TRX	FAULT	52A	BFI	BFT	TRGTR
9	50P1	50P2	50N1	50N2	50G1	50G2	50Q1	*
10	50P1T	50P2T	50N1T	50N2T	50G1T	50G2T	50Q1T	ORED50T
11	51P1	51G1	*	51Q1	51P1T	51G1T	*	51Q1T
12	51P1R	51G1R	*	51Q1R	*	DI_C	DI_B	DI_A
13	EMRSTR	COMMSTR	STR_CLFP	STR_CLO	LOCSTART	REMSTART	RESTART	RSACTIVE
14	RS_LO	UV_SHRT	UV_MED	UV_LONG	UV_RS_LO	UV_TR	LJ_TR	59RS
15	50PAF	50GAF	TOL1	AFS1EL	AFS1DIAG	PHDEM	*	*
16	27PP1	27PP1T	27PP2	27PP2T	59PP1	59PP1T	59PP2	59PP2T
17	3PWR1	3PWR1T	3PWR2	3PWR2T	81D1T	81D2T	LOP	FREQTRK
18	IN08	IN07	IN06	IN05	IN04	IN03	IN02	IN01
19	*	*	*	*	IN12	IN11	IN10	IN09
20	*	*	*	*	OUT04	OUT03	OUT02	OUT01
21	REMOTE	REMCONFP	STR_CLEQ	REMSTREQ	BSTR_CL	REMCONEQ	SPEED2	SPEEDSW
22	VFDBYPAS	SPD2FP	WARNING	*	*	TESTDB	HMIDET1	HMIDET
23	ER	MSRTRG	RSTTRGT	RSTDEM	*	*	RST_HAL	*
24	50P1TC	50P2TC	50Q1TC	50G1TC	50G2TC	50N1TC	50N2TC	*
25	51P1TC	51Q1TC	51G1TC	*	27PP1TC	27PP2TC	59PP1TC	59PP2TC
26	81D1TC	81D2TC	*	*	*	*	*	*
27	LT01	LT02	LT03	LT04	LT05	LT06	LT07	LT08

Figure 3.20 Relay Word Bits Webpage

SELogic Counters

The SEL-849 has eight SELogic counters (see *Table 4.49*). The web server has the capability to display the present count of each of the enabled counters. Located on the navigation pane, **Relay Status** contains categories for each of the status pages in the web server (Self-Tests, Relay Word Bits, and SELogic Counters). When you select a category, the corresponding report displays.

When you select **Relay Status > SELogic Counters**, the count of each of the enabled SELogic counters displays (see *Figure 3.21*). Note that the counter only displays when it is enabled.

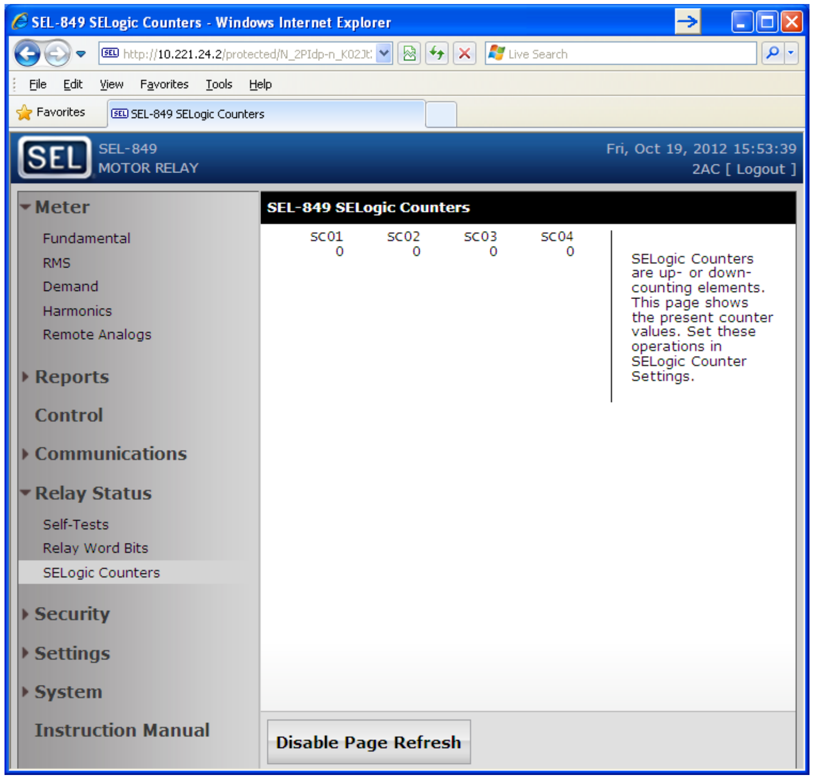


Figure 3.21 SELogic Counters Webpage

Communications

The **Communications** page of the web server allows you to view the MAC address of the relay. When you select **Communications** from the navigation pane, the MAC address of the relay displays (see *Figure 3.22*).

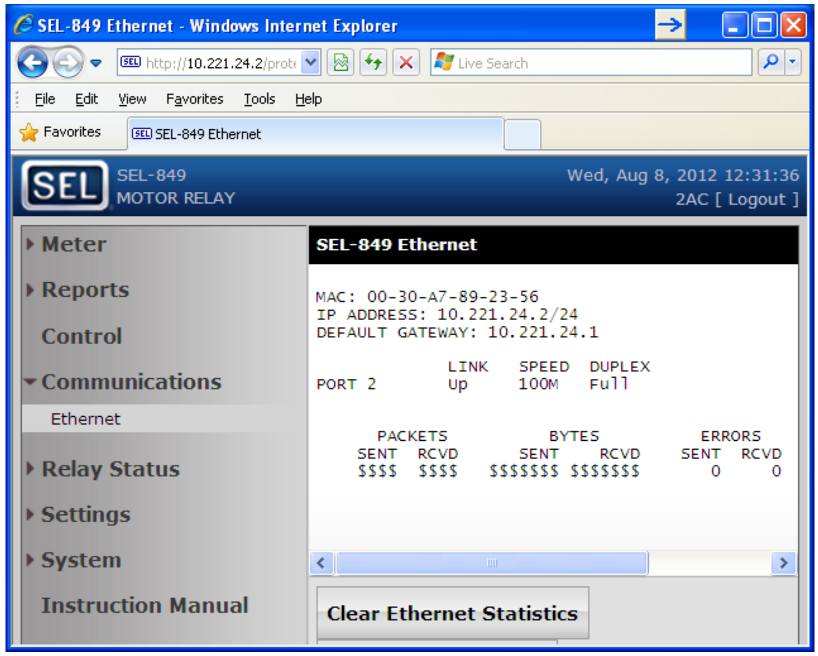


Figure 3.22 MAC Address

QuickSet Software

SEL provides many PC software solutions (applications) to support the SEL-849 Motor Management Relay and other SEL devices. *Table 3.1* lists SEL-849 software solutions.

Table 3.1 SEL Software Solutions

Part Number	Product Name	Description
SEL-5030	ACSELERATOR QuickSet SEL-5030 Software	See *Table 3.2*
SEL-5032	ACSELERATOR Architect SEL-5032 Software	Configures IEC 61850 communications
SEL-5040	ACSELERATOR Report Server SEL-5040 Software	Automatically retrieves, files, and summarizes reports
SEL-5601-2	SEL-5601-2 SYNCHROWAVE Event Software	Plots COMTRADE and SEL Compressed ASCII format event report oscillography; performs custom calculations on analog, digital, and complex quantities
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-849 and QuickSet software. QuickSet is a powerful setting, event analysis, and measurement tool that aids in setting, applying, and using the SEL-849. *Table 3.2* shows the suite of QuickSet applications provided for the SEL-849.

Table 3.2 QuickSet Applications

Application	Description
Terminal	Provides a direct connection to the SEL device. Use this communications method to interface directly with the device.
Rules-Based Settings Editor	Provides online or offline relay settings that include interdependency checks. Use this feature to create and manage settings for multiple relays in a database.
Event Analysis	Provides oscillography and other event analysis tools.
Meter and Control	Provides human-machine interface (HMI) for metering and control features.
Setting Database Management	QuickSet uses a database to manage the settings of multiple devices.
Help	Provides general QuickSet and relay-specific QuickSet context help.

Setup

Follow the steps outlined in *Section 2: Installation* to prepare the SEL-849 for use. Perform the following steps to initiate communications:

Step 1. Connect the appropriate communications cable between the SEL-849 and the PC with an SEL-C627M or equivalent for an Ethernet connection, an SEL-C234T or equivalent for a serial port connection, or an SEL-C285T or equivalent for connection to an SEL communications processor.

Step 2. Apply power to the SEL-849.

Step 3. Start QuickSet.

Communications

QuickSet uses relay communications **Port 1** through **Port 3** to communicate with the SEL-849. Perform the following steps to configure QuickSet to communicate with the relay.

Step 1. Select **Communications** from the QuickSet main menu bar, as shown in *Figure 3.23*.

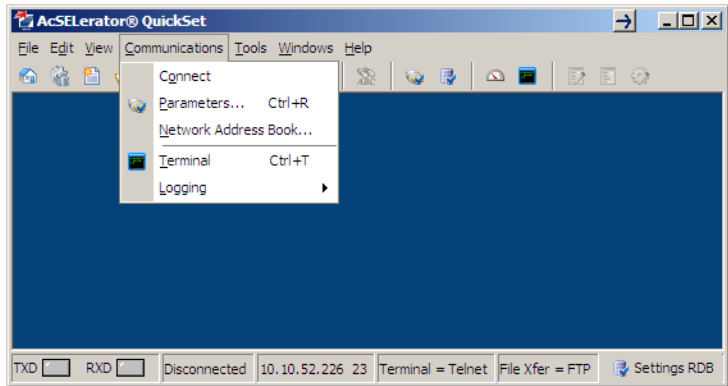


Figure 3.23 Communications Parameter Menu Selection

Step 2. Select the **Parameters** submenu to display the screen shown in *Figure 3.24*.

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

Step 4. Configure QuickSet to match the SEL-849 default settings by entering Access Level 1 and Access Level 2 passwords in the respective text boxes.

Step 5. If a telephone modem is chosen from the relay text box, enter the dial-up telephone number in the **Phone Number** text box.

Step 6. For network communications, check the **Use Network** check box and enter the network parameters as shown in *Figure 3.25*.

Step 7. Exit the menus by clicking **OK** when finished.

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

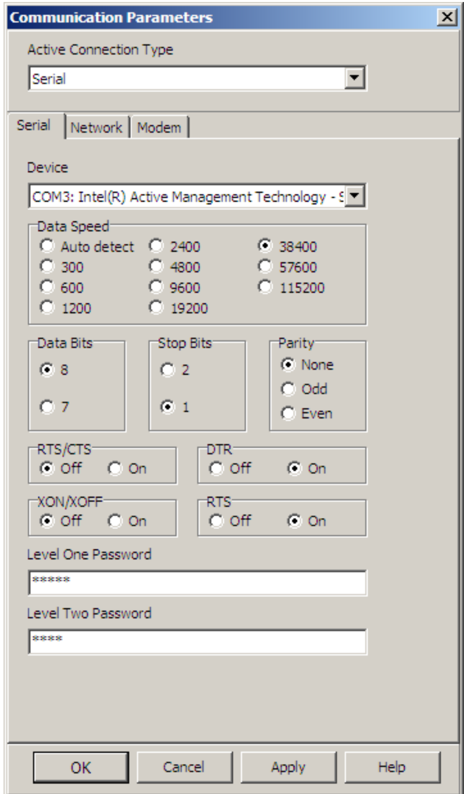
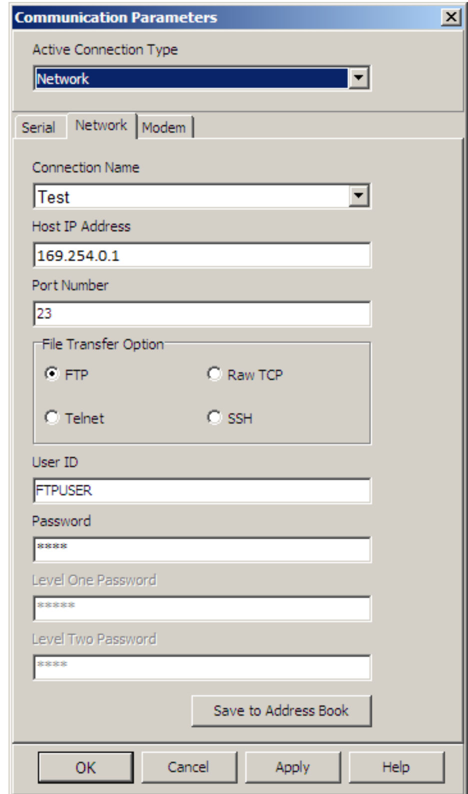


Figure 3.24 Serial Port Communication Parameters Dialog Box



NOTE: Set EFTPSERV := Y to communicate with the SEL-849 via FTP, otherwise, select Telnet for your File Transfer Option.

Figure 3.25 Network Communication Parameters Dialog Box

Terminal Window

Select **Communications > Terminal** on the QuickSet main menu bar to open the terminal window (see *Figure 3.26*).

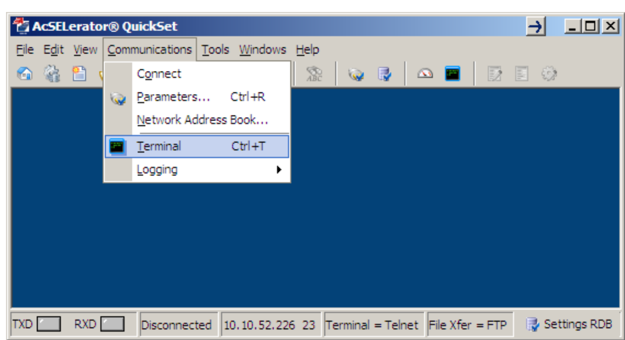


Figure 3.26 Communications Terminal Menu Selection

The terminal window is an ASCII interface with the relay. This is a basic terminal emulation. Many third-party terminal emulation programs are available with file transfer encoding schemes. Open the terminal window by either clicking **Communications > Terminal** or by pressing **<Ctrl+T>**. Verify proper communication 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 3.27*.

```
=>ID <Enter>

"FID=SEL-849-X201-V0-Z000000-D20120511+","08D0"
"BFID=BOOTLDR-R100-V0-Z000000-D20120229","0945"
"CID=0000","023D"
"DEVID=SEL-849","03CF"
"DEVCODE=78","0316"
"PARTNO=084900101100000","0569"
"SERIALNO=20129002900","0533"
"CONFIG=11002201","03EA"

=>
```

Figure 3.27 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 3.27*). Compare the part number (PARTNO=084900101100000) with the Model Option Table (MOT) to ensure the correct relay configuration.

Settings Database Management and Drivers

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

Database Manager

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

Settings Database

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

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

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

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

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

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

Copy/Move Settings Between Databases

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

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

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

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

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

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

Create a New Database, Copy an Existing Database

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

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

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

Step 3. Click **OK**.

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

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

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

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

Step 3. Type a new database name, click the **Open** button, and click **Yes**; the program creates a new empty database. Load devices into the new database as in *Copy/Move Settings Between Databases on page 3.24*.

Settings

QuickSet offers the capability of creating settings for one or more SEL-849 relays. Store existing relay settings downloaded from SEL-849 relays with QuickSet, creating a library of relay settings, then modify and upload these settings from the settings library to an SEL-849. QuickSet makes setting the relay easy and efficient. However, you do not have to use QuickSet to configure the SEL-849; you can use an ASCII terminal or a computer running terminal emulation software. QuickSet provides the advantages of rules-based settings checks, SELOGIC control equation Expression Builder, operator control and metering HMI, event analysis, and help.

Settings Editor

The **Settings Editor** shows the relay settings in easy-to-understand categories. The SEL-849 settings structure makes setting the relay easy and efficient. Settings are grouped logically, and relay elements that are not used in the selected protection scheme are not accessible. For example, if there is only one analog card installed in the relay, you can access settings for this one card only. Settings for the other slots are dimmed (grayed) in the QuickSet menus. QuickSet shows all of the settings categories in the settings tree view. The settings tree view remains constant whether settings categories are enabled or disabled. However, any disabled settings are dimmed when accessed by clicking an item in the tree view.

Settings Menu

QuickSet uses a database to store and manage SEL relay settings. Each unique relay has its own record of settings. Use the **File** menu to open an existing record, create and open a new record, or read relay settings from a connected SEL-849 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. QuickSet makes the new settings files from the driver that you specify in the **Settings Editor Selection** dialog box. QuickSet uses the Z-number in the FID string to create a particular version of settings. To get started making SEL-849 settings with the **Settings Editor** in the **Editor Mode**, select **File > New** from the main menu bar, and SEL-849 and **001** from the **Settings Editor Selection** window as shown in *Figure 3.28*.

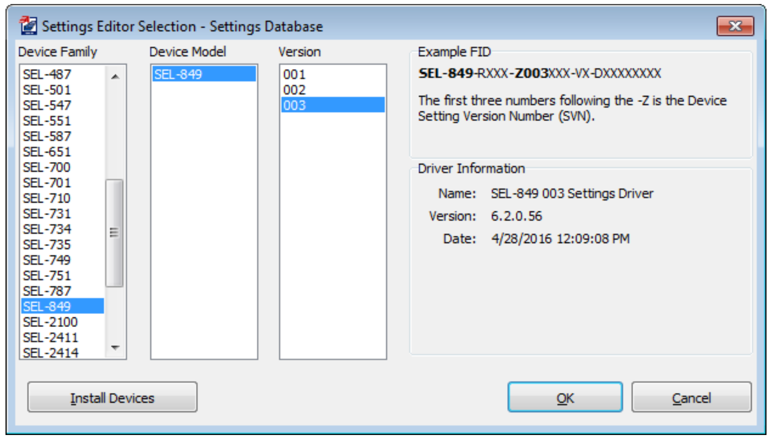


Figure 3.28 Selection of Drivers

After the relay model and settings driver selection, QuickSet presents the **Relay 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 3.29*. Click **OK** when finished.

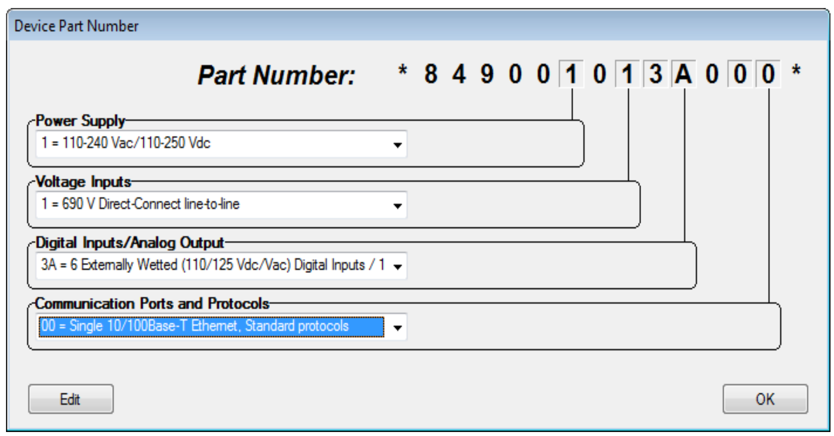


Figure 3.29 Update Part Number

Figure 3.30 shows the **Settings Editor** screen. View the bottom of the Settings Editor window to check the **Settings Driver** number. Compare the QuickSet Settings Driver number and the first portion of the Z-number in the FID string (select **Tools > Meter and Control > Status**). These numbers must match. QuickSet uses this first portion of the Z-number to determine the correct **Settings Editor** to display.

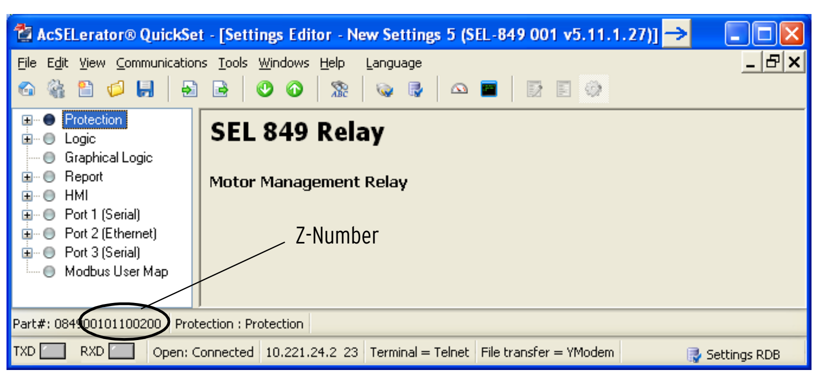


Figure 3.30 New Setting Screen

File > Open

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

File > Read

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

Tools > Convert

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

Settings Editor (Editor Mode)

Use the **Settings Editor (Editor Mode)** to enter settings. These features include the 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 the **Send** menu item.

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

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

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

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

Step 5. If you enter a setting that is out of range or has an error, QuickSet shows the error at the bottom of the **Settings Editor**. Double click the error listing to go to the setting and enter 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. 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 3.31*.

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.

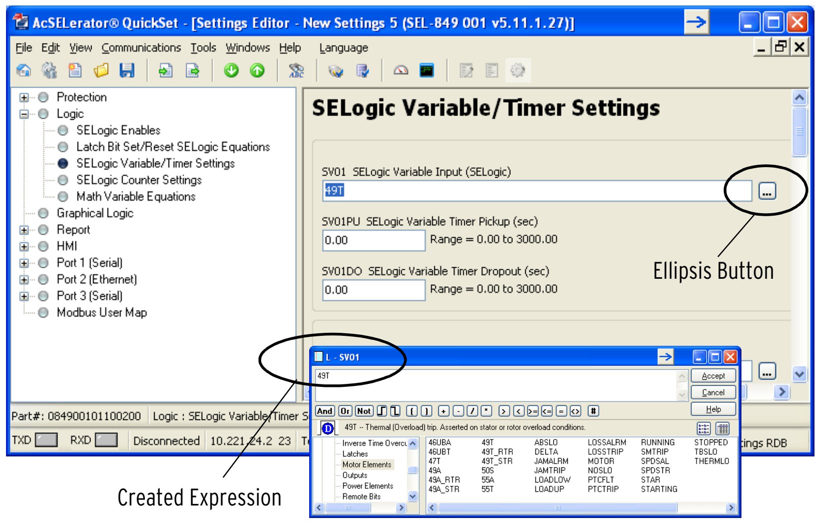


Figure 3.31 Expressions Created With Expression Builder

File > Save

Once settings are entered into QuickSet, select **File > Save** in the Settings Editor to help ensure that the settings are not lost.

File > Send

To transfer the edits made in the QuickSet edit session, you must send the settings to the relay. Select **File > Send**. 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 > Import** or **Tools > Export** on the QuickSet menu bar to import or export settings from or to a text file. Use this feature to create a file that can be more easily stored or sent electronically.

Event Analysis

QuickSet has integrated analysis tools that help you retrieve information about relay operations quickly and easily. Use the event information that the SEL-849 stores to evaluate the performance of a system (select **Tools > Events > Get Event Files**). *Figure 3.32* shows composite screens for retrieving events.

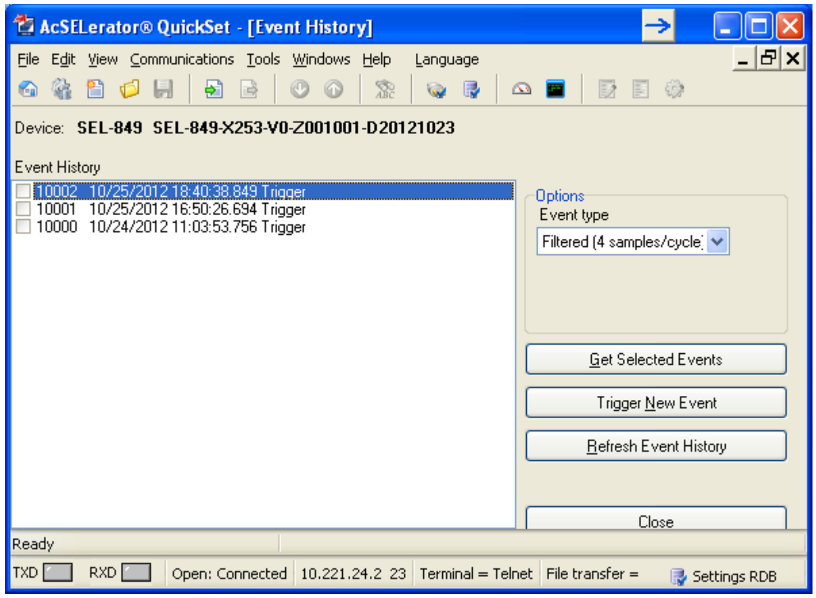


Figure 3.32 Composite Screens for Retrieving Events

Event Waveforms

NOTE: Neither filtered nor unfiltered event reports display exact sampling rates of the data. If exact timing of the samples is needed, use the COMTRADE format event reports.

The relay provides three types of event data captures: 4 samples per cycle of filtered data, 32 samples per cycle of unfiltered (raw) data, or COMTRADE format. See *Section 9: Analyzing Events* for information on recording events. Use the **Options** function in *Figure 3.32* to select the 32 samples per cycle unfiltered (raw) data event or COMTRADE format event data (default is 4 samples per 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 *Processing Specifications and Oscillography on page 1.11*. To download event files from the device, click **Tools > Events > Get Event Files**. The **Event History** dialog box appears, as shown in *Figure 3.32*.

Get Event

Highlight the event you want to view (e.g., **Event 1** in *Figure 3.32*), 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, QuickSet queries whether to save the file on your computer, as shown in *Figure 3.33*.

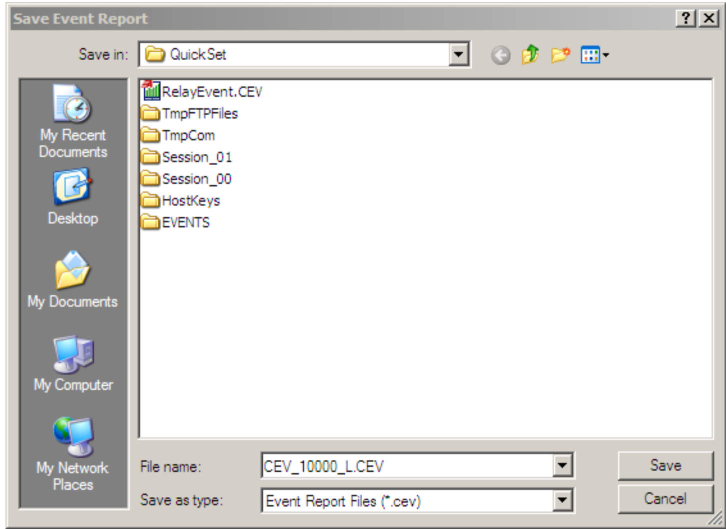


Figure 3.33 Saving the Retrieved Event

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

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

Meter and Control

Click **Tools > HMI > HMI** to bring up the screen shown in *Figure 3.34*. 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.

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 six inputs (or optionally, 12 inputs) and four 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 (see *Figure 3.34*). 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 LEDs display the status of the Relay Word bits as seen on the optional HMI (SEL-3421 or SEL-3422). The corresponding text adjacent to the LED can be changed using the relay setting T0x_LBL in the HMI category of settings (see *Section 8: Human-Machine Interface (HMI)*). Use the HMI settings to change the HMI LED assignments.

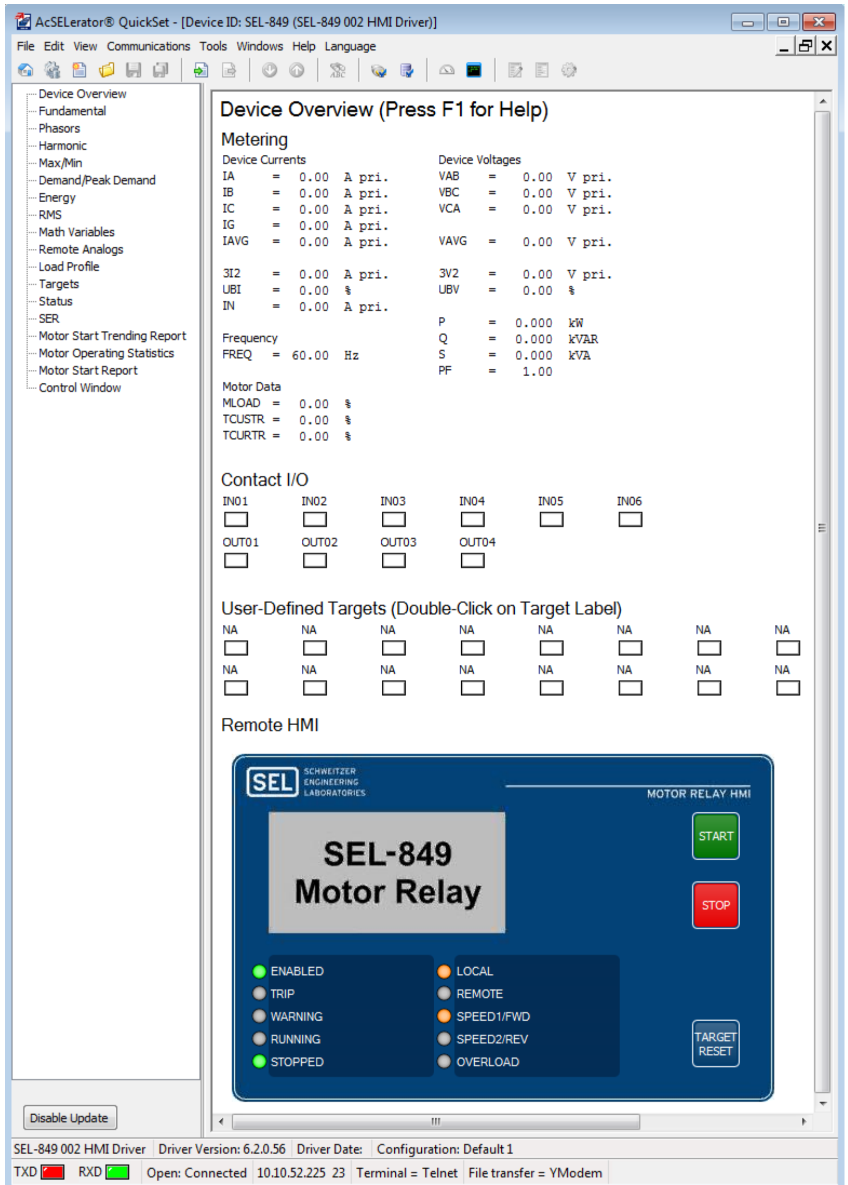


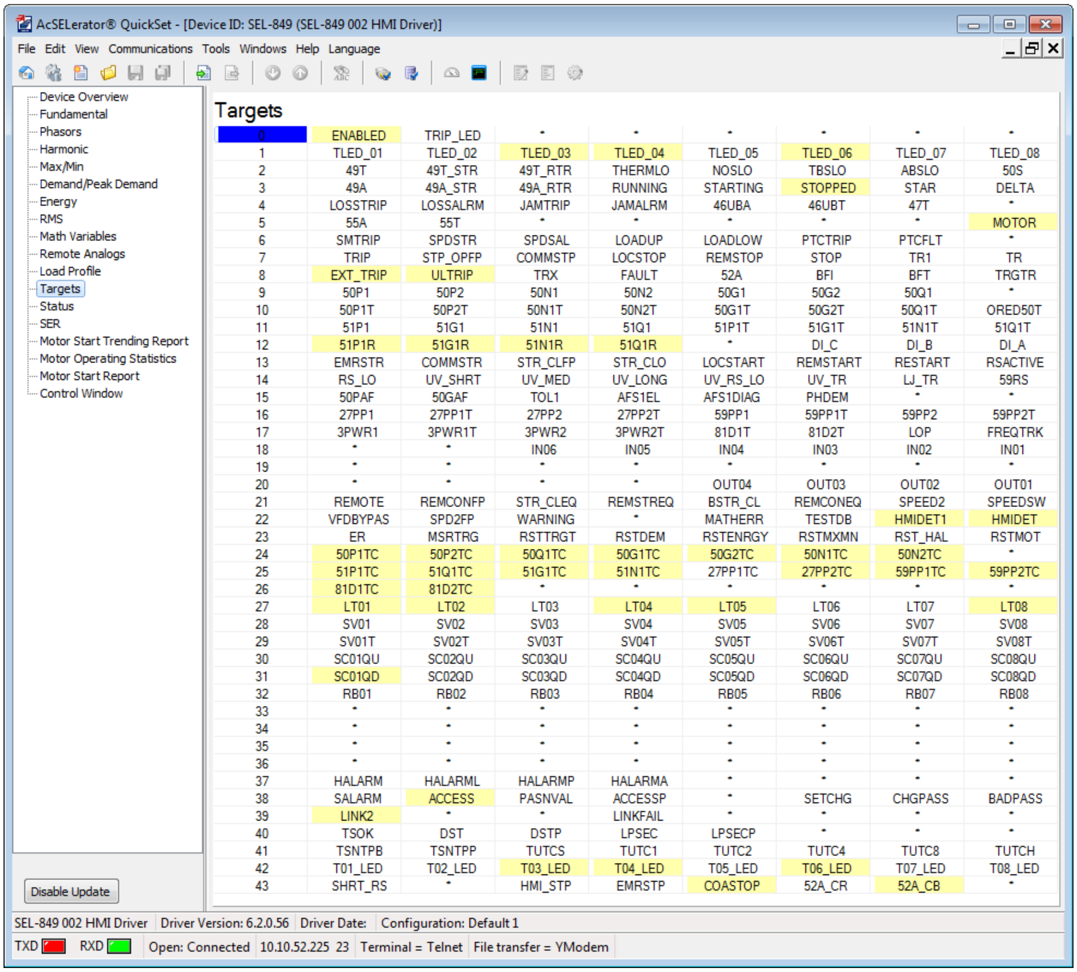
Figure 3.34 Device Overview Screen

The **Fundamental**, **Phasors**, **Harmonics**, **Max/Min**, **Demand/Peak Demand**, **Energy**, etc., screens display the corresponding values. Select these metering screens by clicking on the corresponding name on the left column.

Targets

Click on the **Targets** button to view the status of all the Relay Word bits (see *Figure 3.35*). 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 (e.g., 49T = 0), the Relay Word bit is deasserted. When the bit shown in *Figure 3.35* is highlighted in yellow, that corresponds to being asserted in the relay.

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



0	ENABLED	TRIP_LED	•	•	•	•	•	•
1	TLED_01	TLED_02	TLED_03	TLED_04	TLED_05	TLED_06	TLED_07	TLED_08
2	49T	49T_STR	49T_RTR	THERMLO	NOSLO	TBSLO	ABSLO	50S
3	49A	49A_STR	49A_RTR	RUNNING	STARTING	STOPPED	STAR	DELTA
4	LOSSTRIP	LOSSALRM	JAMTRIP	JAMALRM	46UBA	46UBT	47T	•
5	55A	55T	•	•	•	•	•	MOTOR
6	SMTRIP	SPDSTR	SPDSAL	LOADUP	LOADLOW	PTCTRIP	PTCFLT	•
7	TRIP	STP_OPFP	COMMSTP	LOCSTOP	REMSTOP	STOP	TR1	TR
8	EXT_TRIP	ULTRIP	TRX	FAULT	52A	BFI	BFT	TRGTR
9	50P1	50P2	50N1	50N2	50G1	50G2	50Q1	•
10	50P1T	50P2T	50N1T	50N2T	50G1T	50G2T	50Q1T	ORED50T
11	51P1	51G1	51N1	51Q1	51P1T	51G1T	51N1T	51Q1T
12	51P1R	51G1R	51N1R	51Q1R	•	DI_C	DI_B	DI_A
13	EMRSTR	COMMSTR	STR_CLFP	STR_CLO	LOCSTART	REMSTART	RESTART	RSACTIVE
14	RS_LO	UV_SHRT	UV_MED	UV_LONG	UV_RS_LO	UV_TR	LJ_TR	59RS
15	50PAF	50GAF	TOL1	AFS1EL	AFS1DIAG	PHDEM	•	•
16	27PP1	27PP1T	27PP2	27PP2T	59PP1	59PP1T	59PP2	59PP2T
17	3PWR1	3PWR1T	3PWR2	3PWR2T	81D1T	81D2T	LOP	FREQTRK
18	•	•	IN06	IN05	IN04	IN03	IN02	IN01
19	•	•	•	•	•	•	•	•
20	•	•	•	•	OUT04	OUT03	OUT02	OUT01
21	REMOTE	REMCONFP	STR_CLEQ	REMSTREQ	BSTR_CL	REMCONEQ	SPEED2	SPEEDSW
22	VFDBYPAS	SPD2FP	WARNING	•	MATHERR	TESTDB	HMIDET1	HMIDET
23	ER	MSRTRG	RSTTRGT	RSTDEM	RSTENRGY	RSTMXMN	RST_HAL	RSTMOT
24	50P1TC	50P2TC	50Q1TC	50G1TC	50G2TC	50N1TC	50N2TC	•
25	51P1TC	51Q1TC	51G1TC	51N1TC	27PP1TC	27PP2TC	59PP1TC	59PP2TC
26	81D1TC	81D2TC	•	•	•	•	•	•
27	LT01	LT02	LT03	LT04	LT05	LT06	LT07	LT08
28	SV01	SV02	SV03	SV04	SV05	SV06	SV07	SV08
29	SV01T	SV02T	SV03T	SV04T	SV05T	SV06T	SV07T	SV08T
30	SC01QU	SC02QU	SC03QU	SC04QU	SC05QU	SC06QU	SC07QU	SC08QU
31	SC01QD	SC02QD	SC03QD	SC04QD	SC05QD	SC06QD	SC07QD	SC08QD
32	RB01	RB02	RB03	RB04	RB05	RB06	RB07	RB08
33	•	•	•	•	•	•	•	•
34	•	•	•	•	•	•	•	•
35	•	•	•	•	•	•	•	•
36	•	•	•	•	•	•	•	•
37	HALARM	HALARML	HALARMP	HALARMA	•	•	•	•
38	SALARM	ACCESS	PASNVAL	ACCESSP	•	SETCHG	CHGPASS	BADPASS
39	LINK2	•	•	LINKFAIL	•	•	•	•
40	TSOK	DST	DSTP	LPSEC	LPSECP	•	•	•
41	TSNTPB	TSNTPP	TUTCS	TUTC1	TUTC2	TUTC4	TUTC8	TUTCH
42	T01_LED	T02_LED	T03_LED	T04_LED	T05_LED	T06_LED	T07_LED	T08_LED
43	SHRT_RS	•	HMI_STP	EMRSTP	COASTOP	52A_CR	52A_CB	•

Figure 3.35 SEL-849 Relay Word Bits (Targets)

Motor Start

Click on the **Motor Start Report > Data** button to display the compressed (*.cmsr) motor start report data or on the **Graph** button to display the report graphically as shown in *Figure 3.36*.

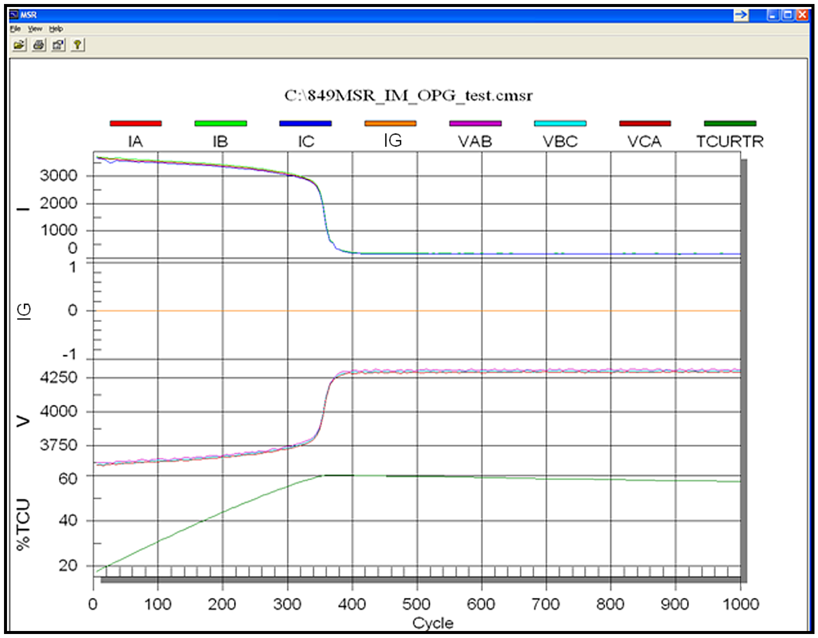


Figure 3.36 Graphical Display of Motor Start Report

Control

Figure 3.37 shows the **Control Window**. From here you can clear the event history, motor start trend reports, SER, LDP reports, MOT reports, trigger events, and reset metering data. You can also reset the targets and set the time and date.

To start or stop the motor, click the **Start/Stop** button (see *Figure 3.37*). The **Start** and **Stop** buttons work only when the relay is in REMOTE mode (Relay Word Bit REMOTE is asserted). Motor STOPPED/RUNNING indicators are also provided.

To determine the status of the arc-flash sensor, check the Arc-Flash Sensor Diagnostics (Sensor Diagnostics corresponds to Relay Word Bit AFS1DIAG) and Sensor Ambient Light Measurement (Sensor Ambient Light Measurement corresponds to Relay Word Bit AFS1EL).

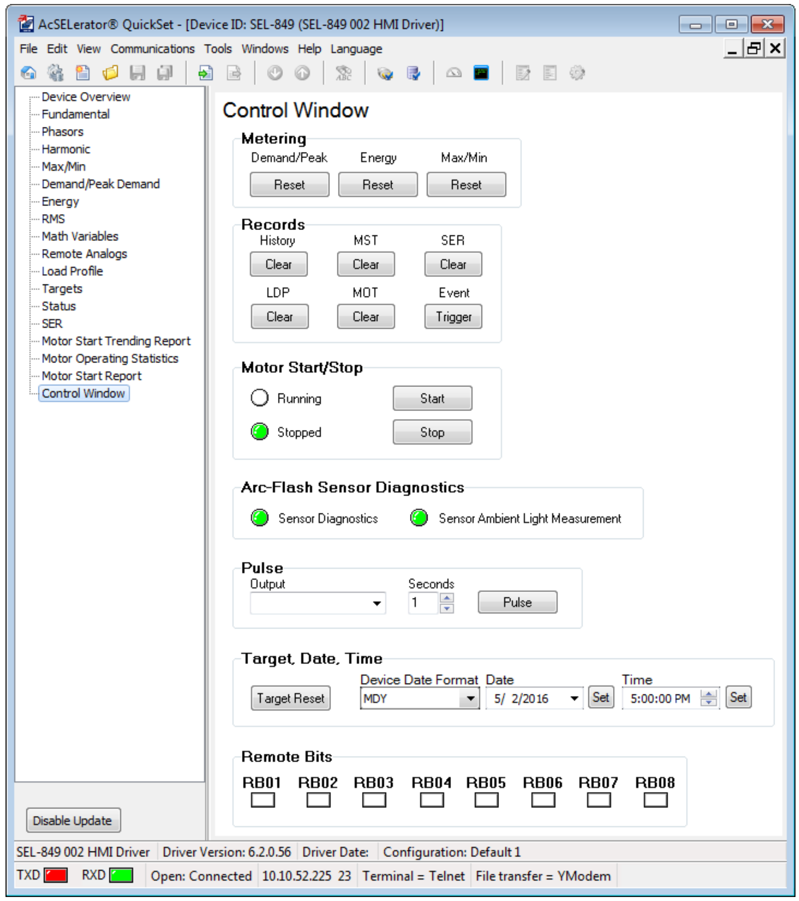


Figure 3.37 Control Screen

To control the remote bits, click on the appropriate square, then select the operation from the box shown in *Figure 3.38*.

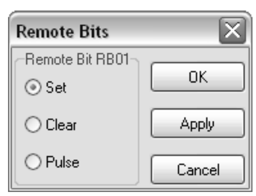


Figure 3.38 Remote Operation Selection

Help

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

Table 3.4 QuickSet Help

Help	Description
General QuickSet	Select **Help** from the main menu bar.
SEL-849 Settings	Select **Settings Help** from the **Help** menu bar while the **Settings Editor** is open.

Section 4

Protection and Logic Functions

Overview

NOTE: Each SEL-849 is shipped with factory-default settings. Calculate the settings for your application to ensure secure and dependable protection. To document and enter the settings, see Section 6: Settings.

This section describes the SEL-849 Motor Management Relay settings, including the motor management elements and basic functions, control I/O logic, as well as the settings that control the communications ports and HMI display.

Settings are determined by the part number of the relay and certain interdependencies; consequently, some of the settings in this section may not be available on your relay. Refer to the Settings Sheets (available on selinc.com) for a complete list with the hide rules.

This section includes the following subsections:

Application Data. Lists information that you will need to know (e.g., about the protected motor) before calculating the relay settings.

Protection Settings (SET Command). Lists protection, control, and configuration settings for various elements including accurate display of the ac current and optional voltage input signals.

Basic Protection. Lists settings for protection elements included in all models of the SEL-849, including the thermal element, overcurrent elements, load-loss functions, and load-jam functions.

Voltage-Based Protection. Lists settings associated with the optional ac voltage-based protection elements. You can skip this subsection if your relay is not equipped with optional voltage inputs.

Trip/Close Logic and Motor Control. Lists Trip Inhibit, Trip/Close logic, and Motor Control logic.

Logic Settings (SET L Command). Lists settings associated with latches, timers, counters, and math variables.

Port Settings (SET P Command). Lists settings that configure the relay top- and side-panel communications ports.

HMI Settings (SET H Command). Lists settings for the HMI display, pushbuttons, and LED control.

Report Settings (SET R Command). Lists settings for the Sequential Events Recorder reports, event, motor start, and load-profile reports.

DNP3 Map Settings (SET D Command). Shows the DNP3 user map register settings.

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

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

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

You can enter the settings by using the EIA-232 port, the EIA-485 port, or the Ethernet port (see *Section 7: Communications*).

Application Data

It is faster and easier for you to calculate settings for the SEL-849 if you collect the following information before you begin (collect the information for each speed for a two-speed motor application). For the feeder application, ignore the motor-specific items listed below.

- Specifications of the protected motor, including the following details:
  - Rated full-load current
  - Service factor
  - Locked rotor current at 100% voltage
  - Maximum locked rotor time with the motor at ambient and/or operating temperature (or trip class for low voltage NEMA/IEC motors)
  - Maximum motor starts per hour, if known
  - Minimum time between motor starts, if known
- Additional data regarding the motor application, including the following information:
  - Minimum no load current or power, if known
  - Motor accelerating time. This is the normal time required for the motor to reach full speed.
  - Maximum time to reach motor full load. This time can be significantly longer than the motor accelerating time, particularly in pump motor applications where the motor may run at full speed for some time before the pump reaches full head and full load.
  - Motor coast-to-stop time. This is the time required for the rotor to reach near zero speed on a normal motor stop.
- Current transformer primary and secondary ratings, if used
- System phase rotation and nominal frequency
- Voltage transformer ratios and connections, if used
- Expected fault current magnitudes for motor or feeder ground and three-phase faults

Protection Settings (SET Command)

All current and voltage settings are in secondary when external CTs or PTs are used. The primary and secondary values are the same when CTs/PTs are not used.

Basic Settings

All SEL-849 models have the identifier settings described in *Table 4.1*. The SEL-849 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, process, circuit, size, or equipment number of the protected motor.

Table 4.1 Basic Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Relay Identifier	16 Characters	RID := SEL-849
Location Identifier	16 Characters	TID := MOTOR RELAY
Rated Frequency	50, 60 Hz	FNOM := 60
Phase Rotation	ABC, ACB	PHROT := ABC
Application	MOTOR, FEEDER, VFD	APP := MOTOR
Phase CT Ratio 1	1–6000	CTR1 := 1
Core-Balance CT Ratio	None, 50.0–2000.0	CTRN := None
Full Load Amps	0.5–256.0 A if CTR = 1 or 0.5–8.0 A if CTR > 1	FLA1 := 20.0
Service Factor	1.00–1.50	SERFACTR := 1.15
Trip Class	10_NEMA, 20_NEMA, 30_NEMA, 5_IEC, 10_IEC, 20_IEC, 30_IEC, None	TRIPCLAS := 10_NEMA

Set the Rated Frequency (FNOM) and Phase Rotation (PHROT) to match your system parameters.

Use the APP settings to select appropriate application. Set APP := MOTOR for most motor applications. For the motors connected to a variable frequency drive (VFD), use APP := VFD. The relay uses rms current magnitudes instead of fundamental for the phase/ground overcurrent and the motor thermal model elements (50P, 50G, 50N, 51P, 51G, 51N, and 49T) when the VFD application is selected and the VFD is not bypassed.

NOTE: When you set APP := MOTOR or VFD, the SEL-849 asserts Relay Word bit MOTOR, which is used in Trip Logic (see Figure 4.49).

NOTE: When you set APP := FEEDER, the MOT, MSR, and MST reports are not available.

NOTE: When CTR1 = 1, the secondary and primary current values are equal.

NOTE: Traditional external CTs can also be used if the full-load current is less than 256 A.

Set APP := FEEDER if the relay is used for feeder protection.

The SEL-849 uses Rogowski coils with maximum rated full-load current of 256 A. Set CTR1 = 1 for applications with no external CTs. Traditional external CTs should be used if the full-load current is higher than 256 A. The CT ratio setting configures the relay to accurately scale measured values for reports using the primary quantities. Calculate the ratio CTR1 by dividing the CT primary rating by the secondary rating. If you use a Core-Balance CT (CBCT) for ground fault current input (IN) set the CTRN equal to the CBCT ratio to activate 50N protection elements (see *Figure 4.8* and *Table 4.11* for details).

EXAMPLE 4.1 Phase CT Ratio Setting Calculation

Consider an application where the phase CT rating is 100:5 A.
Set CTR1 or CTR2 := 100/5 := 20.

The Full-Load Amps (FLA) settings are in secondary amperes, see *Example 4.3* for sample calculations of Motor FLA. The relay uses FLA1 to determine the setting range factor (see *Table 4.2*) to optimize various setting ranges to suit the full load current. For feeder application, set the FLA equal to current rating of the feeder.

Table 4.2 Setting Range Factor (SRF)

FLA1	SRF
0.5–3.9 A	32
4.0–15.9 A	8
16.0–47.9 A	2
48.0–256.0 A	1

The FLA range 0.5–3.9 A is intended for the applications using 1 A secondary rated external CTs. If an application requires an FLA setting close to or below 0.5 A you can use five turns for the phase current inputs. For example, 250:1 A CTs with five turns will look like 250:5 A or CTR = 50/1 and this value must be used in the relay setting calculations. See *Figure 4.1* for an example installation.

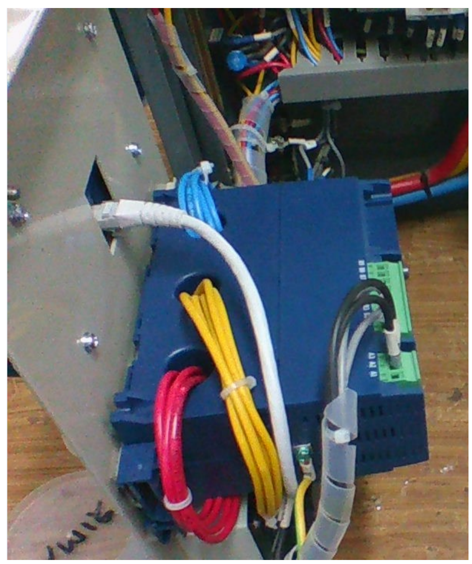


Figure 4.1 SEL-849 Installation With Five Turns Phase Current Inputs

NOTE: The FLA > 128 A should be used with caution if measurement accuracy at "multiple of FLA" is important. For example, the published accuracies apply at 18.4 xFLA (for FLA = 128 A) and linearly decreases to 9.2 xFLA for FLA = 256 A.

The SEL-849 Relay determines the current range to optimize the measurement accuracies for the FLA setting as shown in *Table 4.3*.

Table 4.3 Current Measurement Ranges Versus FLA[a]

FLA	Current Measurement Range
0.5–3.9 A	0.2–74 A
4.0–15.9 A	0.8–295 A
16.0–47.9 A	3.2–1,178 A
48.0–256.0 A	6.4–2,357 A

[a] For the purpose of measurement accuracies.

For NEMA motors, use the Service Factor specified by the motor manufacturer. You can set Service Factor to 1.00 for the IEC motor if it is not available.

When you set the Trip Class, which is typically used for low-voltage motors, the relay automatically sets many of the settings to simplify the overload protection (see *Thermal Overload Element on page 4.8*).

Table 4.4 Basic Voltage Configuration Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Phase PT Ratio	1.00–300.00	PTR := 1.00
Nominal Line-Line Voltage[a]	200–690 V if PTR = 1 or 100–250 V if PTR > 1	VNOM := 240
Phase Voltage Connection	Delta, Wye	DELTA_Y := Wye
Single Voltage Input	Y, N	SINGLEV := N

[a] The line voltage setting is in secondary volts (when PTR = 1.00 the secondary and primary voltage values are equal).

Table 4.4 shows the basic voltage settings for relay models with optional voltage inputs. These settings configure the voltage inputs to correctly measure and scale the voltage signals. If external PTs are used, set the PT ratio (PTR) setting equal to the PT ratio.

Set the Nominal Line-to-Line Voltage (VNOM) in secondary volts if external PTs are used. Note that the VNOM is always in line-to-line voltage, irrespective of the DELTA or WYE input configuration.

EXAMPLE 4.2 Voltage Input Setting Calculations

Consider a 4000 V motor application where 4200:120 V rated voltage transformers (connected in open delta) are used.

PT Ratio = 4200/120 = 35

Nominal Line-Line Voltage = 4000/35 = 114.3 V

Set PTR := 35, VNOM := 114, and DELTA_Y := DELTA

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

In applications where only a single voltage is available, set SINGLEV := Y. As shown in *Figure 2.9*, the single voltage must be connected to the A-phase input, but it may be an A-N or an A-B voltage. Be sure to set DELTA_Y := WYE for an A-N input or DELTA_Y := DELTA for an A-B input voltage. When you set SINGLEV := 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 that magnitude and phase angle. The relay displays zero for the magnitudes of the unmeasured voltages. Balanced voltages are assumed for power, power factor, 3V0, and 3V2 metering.

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

Configuration Settings

Table 4.5 Configuration Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Factory Logic	Y, N	FACTLOG := Y
Current Input Polarity	Normal, Reverse	CURR_IN := Normal
Starter Type	FVNR, FVR, 2SPEED, STAR_D	STARTRTY := FVNR
Phase CT Ratio 2nd	1–6000	CTR2 := 1
Full-Load Amps 2nd	6.4–256.0 A, if SRF = 1; MAX (6.4/SRF, 0.5)–128/SRF A, if SRF > 1[a]	FLA2 := 20
FVR Phasing	None, A, B, C	FVR_PH := None
Rated Load at Zero Speed	MAX(6.4/SRF, 0.5)–128.0 A	LOAD_ZS := 20
Minimum Frequency at Full Load	10.0–70.0 Hz	FREQ_FL := 60
Date Format	MDY, YMD, DMY	DATE_F := MDY
Fault Condition	SELOGIC	FAULT := TRIP OR 50G1 OR 50Q1 OR 51P1 OR 51Q1 OR STARTING AND MOTOR

[a] The SRF is determined from the FLA1 setting. See Table 4.2.

NOTE: For motors with a service factor of less than 1.05 that are being operated at FLA, SEL recommends that you set OLPU to a value greater than 1.05.

When you set Factory Logic (FACTLOG) to Y, the SEL-849 does the following:

- Automatically sets the Overload Pickup (OLPU) equal to the Service Factor setting or 1.05, whichever is higher.
- Automatically assigns default contact inputs and outputs for all combinations of the Application (APP) and Starter Type (STARTRTY) settings. See *Figure 2.12* through *Figure 2.20* for typical default connection diagrams.

You can change the default I/O assignments and Overload Pickup by setting FACTLOG := N.

Normal current circuit routing should follow the Source and Load side for proper polarity. However, you can reverse the polarity by using the Current Input Polarity (CURR_IN) setting, see *Section 2: Installation* and *Figure 2.20* for additional description. This feature provides wiring flexibility to minimize bends in the current circuit cables, particularly useful in confined installations.

SEL-849 supports four types of motor starters:

- Full-Voltage Nonreversing (FVNR)
- Full-Voltage Reversing (FVR)
- Two Speed (2SPEED)
- Star-Delta (STAR_D)

Figure 2.12 through *Figure 2.20* show typical connection diagrams.

When the STARTRTY := 2SPEED (or FVR) the relay uses CT Ratio (CTR) and Full-Load Amps (FLA) based on the status of Relay Word bit SPEED2 (see *Table 4.40*):

- ➤ CTR = CTR1 and FLA = FLA1 if SPEED2 = 0 (Speed 1 or Forward Speed)
- ➤ CTR = CTR2 and FLA = FLA2 if SPEED2 = 1 (Speed 2 or Reverse Speed)

When STARTRTY := FVR, set the FVR Phasing (FVR_PH) to identify the phase that is not affected by the Reverse contactor. See *Figure 2.14* for an example that requires FVR_PH := A. However, if phase CTs are located on the bus side of the contactor, set FVR_PH := None.

A sustained low-speed operation in the Variable Frequency Drive applications can cause motor damage unless overload protection accounts for the poor cooling due to the low speed. Set the rated load at zero speed (LOAD_ZS) to continuous current allowed at zero speed and minimum frequency at full load (FREQ_FL) to the frequency below which the full load should be derated. The relay automatically adapts the trip threshold of the stator and rotor thermal protection elements by a factor KVF using their respective thermal time constant. *Figure 4.2* shows the typical steady state characteristics of the KVF for specific example settings.

Set the LOAD_ZS to 40%–100% of FLA if the rated load at zero speed is not available. At higher LOAD_ZS settings, the influence of the KVF factor becomes less effective on the trip threshold and it has no effect if LOAD_ZS = 100% of FLA.

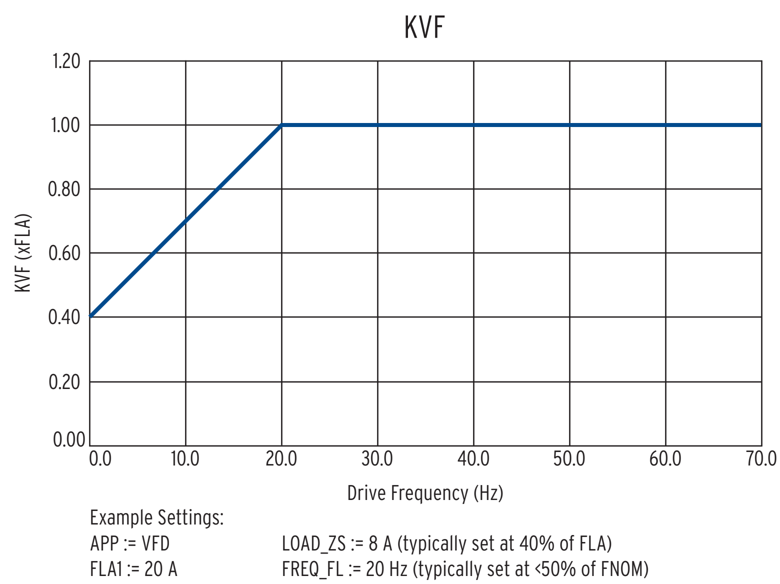


Figure 4.2 KVF Factor Versus VFD Output Frequency

The DATE_F settings 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 demand metering.

Basic Protection

Thermal Overload Element

The SEL-849 motor thermal element provides integrated protection for all of the following motor operating conditions:

- Locked rotor starts
- Running overload
- Unbalanced current/negative-sequence current heating
- Repeated or frequent starting

The Thermal Method setting (SETMETH) selects the thermal element algorithm that will be used in the SEL-849. The Thermal Method setting essentially offers the following two options.

NOTE: When you set Run State Time Constant (RTC1 or RTC2) to Auto, the relay automatically configures the overload curves so that the hot stator and cold rotor limits are the same at locked rotor current, which is typical for a rotor limited motor. For a stator limited motor, see the discussions later in this section.

Rating Thermal Method (SETMETH := Rating_1). When this method is selected, the relay configures a thermal curve based on the motor full-load amps, overload pickup level, run state time constant, locked rotor amps, hot locked rotor time, and acceleration factor (locked rotor trip time dial).

Curve Thermal Method (SETMETH := Curve). When selected, you choose from 45 motor thermal limit curves. The relay automatically derives and hides the following settings.

- Run state time constant
- Locked rotor amps
- Locked rotor time
- Acceleration factor

Both thermal element setting methods can provide outstanding motor protection. In each case the relay operates a thermal model with a trip value defined by the relay settings and a present heat estimate that varies with time and changing motor current. The relay expresses the present motor thermal estimate as a Thermal Capacity Used in percentage of trip level for stator and for rotor. When either Thermal Capacity reaches 100 percent, the relay trips. You can see the present Thermal Capacity values by using the Human Machine Interface (HMI) `Meter > Thermal` function or the serial port **METER** command.

If the thermal model is turned off (E49MOTOR := N), the thermal model is disabled, the output of the thermal model is blocked, and the relay reports the Thermal Capacity as 0, as noted in *Section 5: Metering and Monitoring*.

NOTE: The Overload Alarm function (Relay Word bit 49A) has a built-in hysteresis of 10% of the pickup level (setting TCAPU). The hysteresis prevents the alarm from chattering. The alarm drops out when the TCU drops below 90% of the pickup level.

Table 4.6 Thermal Overload Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
Overload Enable	Y, N	E49MOTOR := Y
Overload Pickup Level	1.01–1.50 xFLA	OLPU := 1.15
Thermal Method	Rating_1, Curve	SETMETH := Rating_1
Thermal Overload Curve	1–45	CURVE1 := 5
Thermal Overload Curve 2nd	1–45	CURVE2 := 5
Locked Rotor Amps	2.5–10.0 xFLA[a]	LRA1 := 6.0
Locked Rotor Time	1.0–600.0 sec	LRTHOT1 := 8.3
Acceleration Factor	0.10–1.50	TD1 := 1.00
Stator Time Constant	Auto, 1–2000 min	RTC1 := Auto
Locked Rotor Amps 2nd	2.5–10.0 xFLA[a]	LRA2 := 6.0

Table 4.6 Thermal Overload Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
Locked Rotor Time 2nd	1.0–600.0 sec	LRTHOT2 := 8.3
Acceleration Factor 2nd	0.10–1.50	TD2 := 1.00
Stator Time Constant 2nd	Auto, 1–2000 min	RTC2 := Auto
Overload Warning Level	OFF, 50–99 %TCU	TCAPU := 85
Start Inhibit Level	OFF, 1–99 %TCU	TCSTART := OFF
Overload Reset Level	10–99 %TCU	49RSTP := 75
Stop Cool Time	AUTO, 1–6000 min	COOLTIME := Auto
Stop Coasting Time	1–3600 sec	COASTIME := 5

[a] The LRAn range is 2.5–6.0 xFLA for FLAn > 128 A (n = 1, 2).

When you enable overload protection, the relay requires information about the protected motor capabilities. Obtain the required information (except the acceleration factor) from the motor specifications. The relay automatically determines the Overload Pickup setting based on the Service Factor setting if the Factory Logic is used as described earlier (see *Table 4.5*).

When you set the Trip Class, which is typically used for low-voltage motors, the relay automatically sets many of the settings to simplify the overload protection.

Rating Thermal Method

The SEL-849 runs rotor and stator models simultaneously. The rotor thermal model trips in hot locked rotor time at locked rotor current when the rotor is at the normal operating temperature. The stator model provides overload protection by limiting the stator heat energy estimate to a value represented by the overload settings.

Note that the locked rotor time setting is for a hot-rotor condition. If only one locked rotor time is specified for a particular motor, unless the specification states otherwise, assume the time is the cold locked rotor time. Multiply the cold locked rotor time by 0.833 to determine a hot locked rotor time that is acceptable for most motors.

NOTE: The SEL-849 normally uses settings CTR1, FLA1, LRA1, LRTHOT1, TD1, and RTC1. When setting STARTRTY is either 2SPEED or FVR and SPEED2 control input is asserted, the relay will instead use CTR2, FLA2, LRA2, LRTHOT2, TD2, and RTC2 (see Table 4.29).

EXAMPLE 4.3 Thermal Element Setting

A 400 V, 60 HP motor is protected by the SEL-849 thermal overload element. The motor data sheet includes the following information.

Rated Horsepower = 60 HP
Rated Voltage = 400 V
Rated Full-Load Current = 80 A
Rated Locked Rotor Amps = 480 A (at 100% volts)
Safe Stall Time at 100% Volts:
Cold = 18 seconds
Hot = 15 seconds
Service Factor = 1.2

NOTE: The relay will automatically set the overload pickup to the same value as the Service Factor, OLPU := 1.2.

NOTE: For motors with a service factor of less than 1.05 that are being operated at FLA, SEL recommends that you set OLPU to a value greater than 1.05.

No CTs or PTs are used in this example. The SEL-849 settings for the application are calculated as shown below:

CTR1 := 1 (see Protection Settings (SET Command))
Full-Load Amps (FLA): FLA1 := 80/1 = 80 A (see Protection Settings (SET Command))
Service Factor: SERFACTR := 1.2

Trip Class: TRIPCLAS := None
Factory Logic: FACTLOG := Y
Locked Rotor Amps: LRA1 := 480.0/80.0 := 6.0 xFLA
Hot Locked Rotor Time: LRTHOT1 := 15.0 seconds
Run State Time Constant: RTC1 := Auto

We recommend that the RTC1, RTC2, and COOLTIME be set to the specific values supplied by the motor manufacturer for optimum overload protection. For this example, assume that the actual RTC and COOLTIME data are not available and the motor is rotor limited. When set to AUTO, the relay uses the following rotor limited motor equation to calculate the RTC.

$$\mathrm{RTC} = \frac{(\mathrm{TD} + 0.2) \bullet \mathrm{LRTHOT}}{60 \bullet \ln\left[\dfrac{\mathrm{LRA}^2 - (0.9 \bullet \mathrm{OLPU})^2}{\mathrm{LRA}^2 - \mathrm{OLPU}^2}\right]} \text{minutes}$$

$$\mathrm{RTC1} = 39 \text{ minutes}$$

$$\mathrm{COOLTIME} > 3 \bullet \mathrm{RTC1} = 3 \bullet 39 + 1 = 118 \text{ minutes}$$

Equation 4.1

If the RTC data are not available for a stator limited motor, use the following equation to calculate the RTC.

$$\mathrm{RTC} = \frac{\mathrm{LRTHOT}}{60 \bullet \ln\left[\dfrac{\mathrm{LRA}^2 - 0.4^2}{\mathrm{LRA}^2 - \mathrm{OLPU}^2}\right]} \text{ minutes}$$

The acceleration factor (TD1) setting reduces or extends the allowed accelerating time under locked rotor conditions. You can always safely set this value equal to 1.00. minutes

If you know that the driven load will accelerate in less than the rated locked rotor time, you may wish to use a TD1 setting less than 1.00 to provide a faster trip in locked rotor conditions. Do not, however, set the TD1 setting greater than 1.00, except to allow a start with a longer than normal accelerating time (e.g., high-inertia motor application, emergency condition). When TD1 is set greater than 1.00, use the speed switch (see *Table 4.29*) to provide locked rotor protection. See *Figure 4.3* for the thermal overload limits for selected settings.

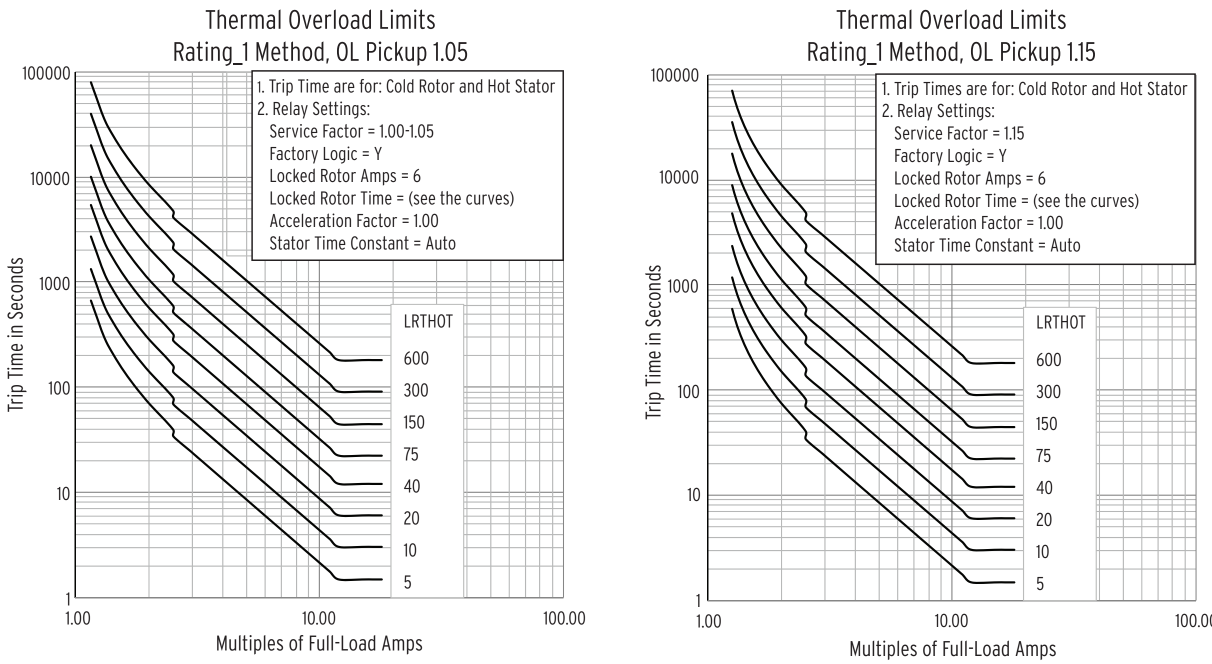


Figure 4.3 Thermal Overload Limits (Rating Method)

EXAMPLE 4.4 Acceleration Factor (TD1) Setting Calculation

In a particular application, a motor with a 10-second hot locked rotor time starts in 5 seconds.

Setting the TD1 equal to 0.75 causes the relay to trip in 7.5 seconds under locked rotor conditions. This setting allows ample time for the motor to start, but does not subject the motor to the full 10 seconds of locked rotor current if a locked rotor start attempt takes place.

Trip Class

Overload Protection for Motors With Trip Class

When the SEL-849 Trip Class (see *Table 4.1*) is set to either NEMA or IEC, it forces the following settings to the values shown below and hides them.

- SETMETH := Rating_1
- TD*n* := 1.00
- RTC*n* := Auto
- LRA*n* and LRTHOT*n* (see *Table 4.7*)
- Where *n* = 1 or 2

Table 4.7 Forced Setting Values Versus Trip Class (n = 1, 2)

	NEMA		IEC	
Trip Class	**LRAn**	**LRTHOTn**	**LRAn**	**LRTHOTn**
5	–	–	7.2	4.2
10	6.0	8.3	7.2	8.3
20	6.0	16.7	7.2	16.7
30	6.0	25.0	7.2	25.0

The forced settings ensure thermal trip in Trip Class seconds at LRA (Locked Rotor Amps) shown at an ambient condition. For example, if Trip Class is set to 10_NEMA, the thermal element should operate in ten seconds at balanced currents of six times the FLA (Full Load Amps). The relay uses overload limit curves shown in *Figure 4.4* and *Figure 4.5* when NEMA or IEC Trip Class is set.

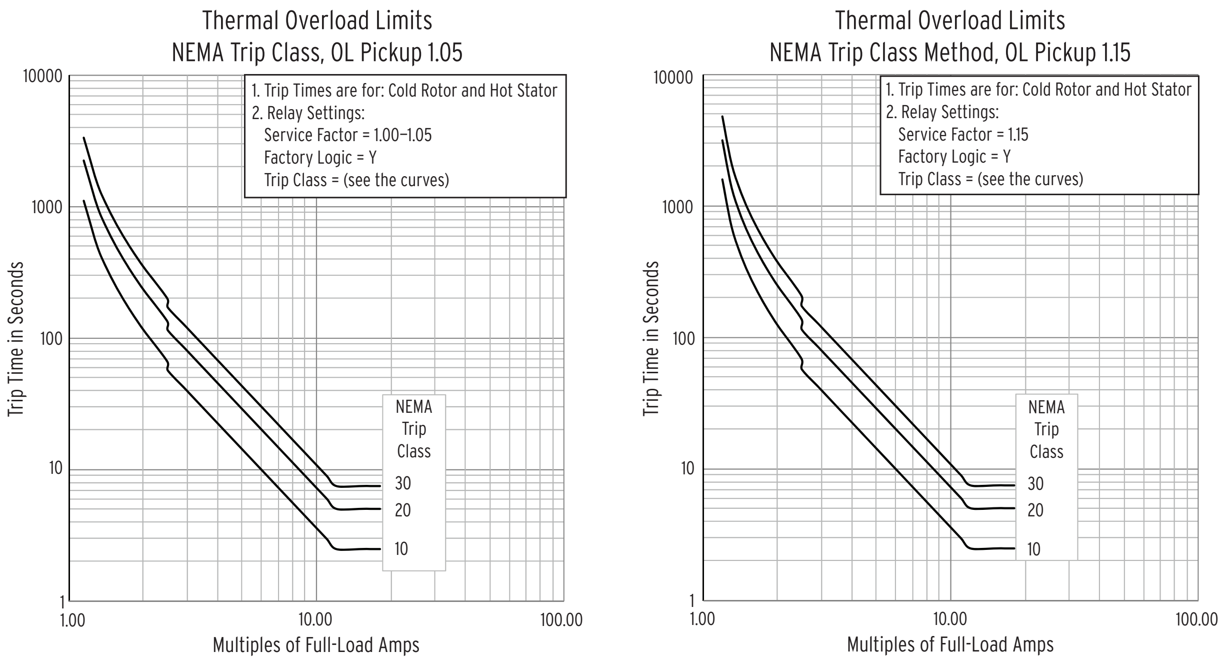


Figure 4.4 Thermal Overload Limits (NEMA Trip Class Method)

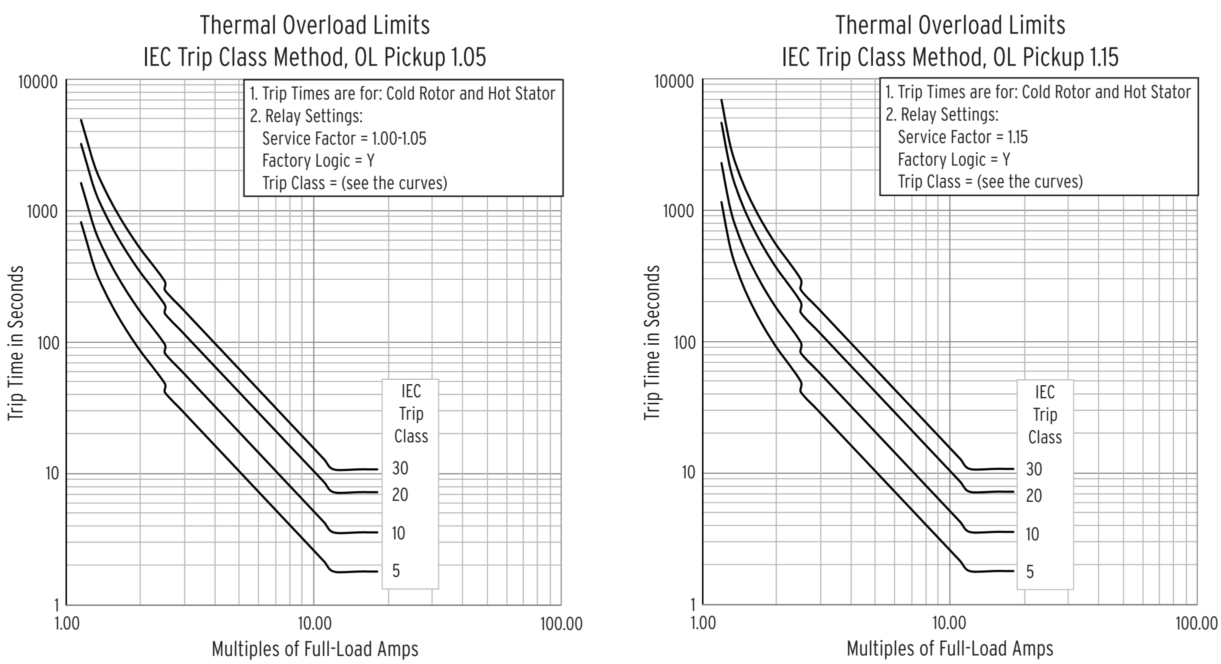


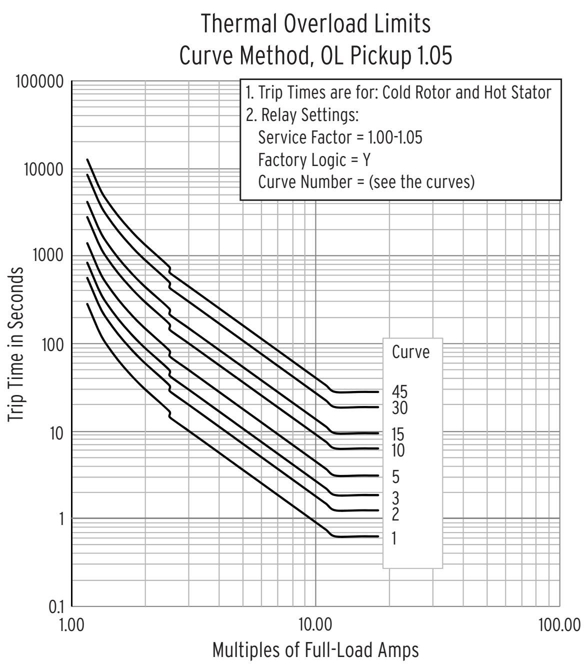
Figure 4.5 Thermal Overload Limits (IEC Trip Class Method)

Curve Thermal Method

The Curve method is similar to the Rating_1 method, except that you select one of the 45 available thermal overload curves. The relay automatically calculates the following settings and hides them.

- LRA = 6.0
- LRTHOT = 2.08 • CURVE
- TD = 1.00
- RTC = Auto (see *Equation 4.1* in *Example 4.3*)

Figure 4.6 shows several of the available curves. Be sure that the curve you select trips in a time less than or equal to the motor-rated locked rotor time at locked rotor current. Each increase in the curve number yields a 2.5-second increase in the cold thermal limit time at six times the full-load current. For example, for a rotor at ambient temperature, the curve 10 trip time at six times the full-load current is 25 seconds. If the rotor is at normal operating temperature (Hot), each increase in the curve number will yield a (2.5/1.2) = 2.08 second increase in the thermal limit time at six times the full-load current.



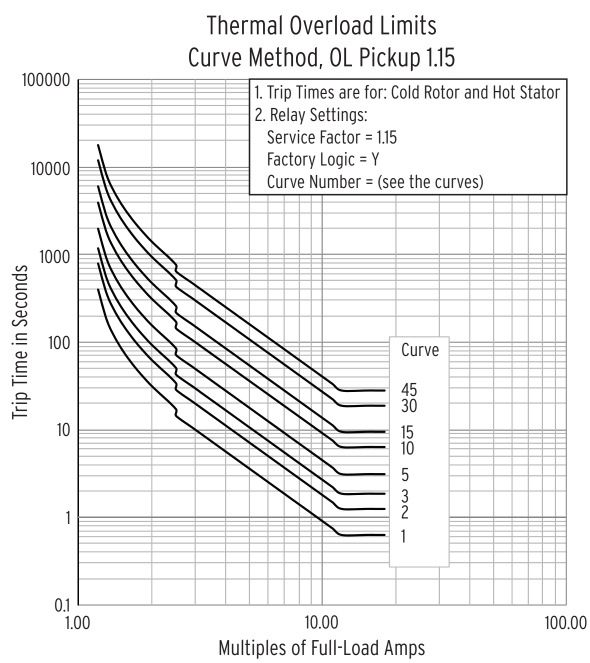


Figure 4.6 Thermal Overload Limits (Curve Method)

EXAMPLE 4.5 Thermal Element Curve Method Setting

A 4160 V, 800 HP motor is to be protected through use of the SEL-849 Thermal Element Curve Method. The motor data sheet includes the following information.

Rated Horsepower (HP) = 800 HP
Rated Voltage (V) = 4160 V
Rated Full-Load Current (A) = 101.0 A
Rated Locked Rotor Amps (A) = 620.4 A
Safe Stall Time, Hot = 30 seconds
Service Factor = 1.15

We select the curve number by using the following equation:

$$\text{Curve Number} < \frac{(\text{Locked Rotor Amps/FLA})^2 \bullet (\text{Safe Stall Time, Hot in Seconds})}{36 \bullet 2.08}$$

$$\text{Curve} < 15.12;\ \text{select curve 15}$$

Phase current transformers having 150:5 ratios are selected for the application. The SEL-849 settings for the application are shown below.

Current Transformer Ratio (CTR) = 150/5 = 30
Full-Load Amps (FLA) = 101/30 = 3.4 A secondary
Service Factor = 1.15
Trip Class = None
Factory Logic = Y
Curve Number (CURVE) = 15
COOLTIME (see Additional Thermal Overload Settings)

Continue calculating the balance of thermal element settings with the overload settings in *Table 4.8*.

Refer to Application Guide AG2018-23: "Testing Curve 46 in SEL Motor Protection Relays." This application guide describes how to test user-defined thermal curve 46 in SEL motor protection relays.

Additional Thermal Overload Settings

When the motor thermal capacity used exceeds the overload warning level setting (TCAPU), the relay issues a warning and asserts Relay Word bit 49A. The early warning may allow you to correct the load problem before a thermal trip occurs. Note that the warning and Relay Word bit 49A deassert when the thermal capacity used goes below 90% of the pickup level.

Set TCAPU using the following criterion to avoid nuisance overload warnings when running the motor at full load.

$$\text{TCAPU} > \frac{100}{\text{OLPU}^2}$$

Equation 4.2

The motor tripping and starting functions include supervision to help prevent a thermal trip on a normal start. The relay prevents motor starting until the thermal element has enough available rotor thermal capacity to allow a motor start without tripping. Set the start inhibit level TCSTART greater than the rotor thermal capacity required to start (Start TCU) the motor. Refer to *Figure 4.50*, which shows the TCSTART usage for the thermal lockout logic. This feature can be disabled by setting TCSTART equal to OFF.

$$\text{TCSTART} > (\text{Start TCU})$$

Equation 4.3

NOTE: A 5–10 percent margin is suggested for Equation 4.3 and Equation 4.4.

The function of setting 49RSTP is similar to that of TCSTART, except that 49RSTP determines the stator thermal capacity above which the relay does not allow reset.

$$\text{49RSTP} < \frac{100}{\text{OLPU}^2}$$

Equation 4.4

A stopped motor can take longer to cool than a running motor because of reduced airflow or loss of forced coolant. Motor manufacturers sometimes provide cooling parameters for a stopped motor in the form of either a cooling Time Constant or a Cooling Time. If a Time Constant is provided, multiply this value by three to calculate the motor stopped Cooling Time setting (COOLTIME). If a time is provided, use this time directly for COOLTIME. The factory-default COOLTIME setting is AUTO and uses *Equation 4.5*, which assumes that the stopped motor cools at the same rate as when it is running.

$$\text{COOLTIME} = 3 \bullet \text{RTC minutes}$$

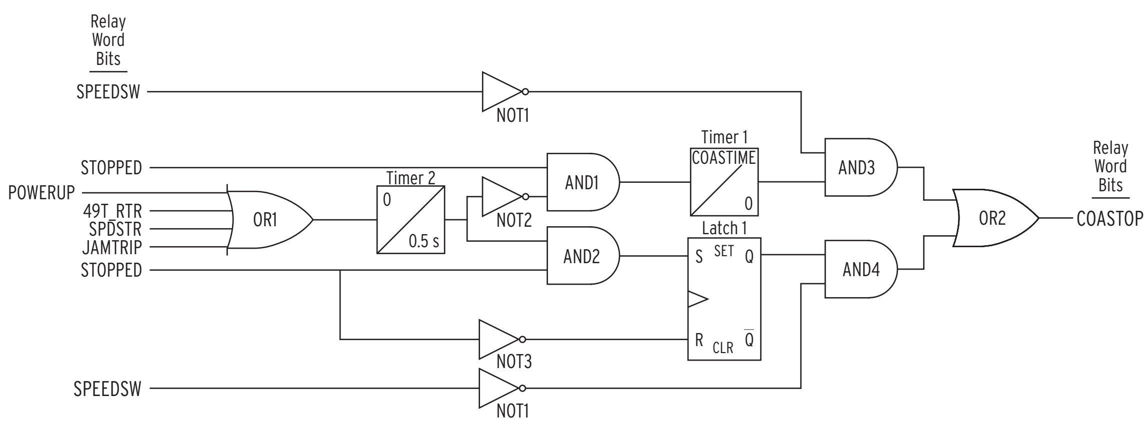
Equation 4.5

where:

RTC = RTC1 or RTC2 (whichever is higher)

Use the actual motor data to determine the COOLTIME setting, particularly in applications requiring frequent starts and stops.

Set COASTIME to 90–95 percent of the time the motor coasts before the rotor stops on a normal stop. The relay automatically delays the use of the slower cooling rate (based on COOLTIME) by this setting, which can significantly reduce the wait time before the next start may be allowed by thermal lock out. *Figure 4.7* shows the coast-stop logic diagram. If the normal motor coast time is not available or if it is not necessary to minimize the wait time before the next motor start, you can safely leave the COASTIME setting at the default value of 5 seconds.



Note: POWERUP is an internal bit; it asserts for 1/4 cycle every time the relay powers up.

Figure 4.7 Coast Stop Logic Diagram

Thermal Overload Trip Equations

Figure 4.3 to *Figure 4.6* shows trip time curves for selected settings of the thermal element. The motor model consists of distinct rotor and stator thermal elements. *Table 4.8* shows the equations for each element. For simplicity, all motor currents are assumed to be balanced three phase and in per unit of full-load current (e.g., motor current I = motor current/full-load current).

Definitions

- I = Motor current in per unit of full-load current
- Tp = Thermal element trip time in seconds
- SETMETH = Thermal element method setting
- OLPU = Overload pickup settings
- RTC = Run-time constant (setting in minutes, see *Table 4.6*)

$$\text{If RTC} = \text{Auto}$$

$$= \left[\frac{T_O \bullet (TD + 0.2)}{\ln\left[\frac{I_L^2 - (0.9 \bullet OLPU)^2}{I_L^2 - OLPU^2}\right]}\right]\text{seconds}$$

- ➤ T_O = Locked rotor time hot (setting LRTHOT in seconds)
- ➤ I_L = Locked rotor current (setting LRA)
- ➤ R = Thermal resistance = $0.2 \bullet I_L^2 \bullet T_O$
- ➤ TD = Acceleration factor setting
- ➤ CURVE = Curve number setting (when SETMETH = Curve)

Table 4.8 Overload Trip Time Equations

	Trip Time in Seconds
SETMETH := Rating_1:	
Cold Rotor Time $12 \geq I \geq 2.5$	$Tp = \frac{[(TD + 0.2) \bullet T_O \bullet I_L^2]}{I^2}$
Hot Stator Time $2.5 > I > OLPU$	$Tp = 60 \bullet RTC \bullet \ln\left[\frac{I^2 - (0.9 \bullet OLPU)^2}{I^2 - OLPU^2}\right]$
Cold Stator Time[a] $2.5 > I > OLPU$	$Tp = 60 \bullet RTC \bullet \ln\left[\frac{I^2}{I^2 - OLPU^2}\right]$
SETMETH := Curve:	
Cold Rotor Time $12 \geq I \geq 2.5$	$Tp = \frac{[90 \bullet CURVE]}{I^2}$
Hot Stator Time $2.5 > I > OLPU$	$Tp = \left[\frac{(2.5 \bullet CURVE)}{\ln\left[\frac{36 - (0.9 \bullet OLPU)^2}{36 - OLPU^2}\right]}\right] \bullet \ln\left[\frac{I^2 - (0.9 \bullet OLPU)^2}{I^2 - OLPU^2}\right]$
Cold Stator Time[a] $2.5 > I > OLPU$	$Tp = \left[\frac{(2.5 \bullet CURVE)}{\ln\left[\frac{36 - (0.9 \bullet OLPU)^2}{36 - OLPU^2}\right]}\right] \bullet \ln\left[\frac{I^2}{I^2 - OLPU^2}\right]$

[a] The Cold Stator Time equations are provided for bench tests only and do not have practical significance.

Overcurrent Elements

Table 4.9 Phase Instantaneous Overcurrent Settings[a]

Setting Prompt	Setting Range	Setting Name := Factory Default
Maximum Phase IOC 1 Pickup	OFF, MAX(6.4/SRF, 0.5)–(1280/SRF) A	50P1P := OFF
Maximum Phase IOC 1 Delay	OFF, 0.10–240.00 sec	50P1D := 0.20
Maximum Phase IOC 1 Torque Control	SELOGIC	50P1TC := 1
Maximum Phase IOC 2 Pickup	OFF, MAX(6.4/SRF, 0.5)–(1280/SRF) A	50P2P := OFF
Maximum Phase IOC 2 Delay	OFF, 0.10–240.00 sec	50P2D := 0.20
Maximum Phase IOC 2 Torque Control	SELOGIC	50P2TC := 1

[a] See Table 4.2 for the definition of SRF.

If the SEL-849 is connected to a motor protected by a fused contactor, disable the phase overcurrent element by setting its trip level to OFF. If the relay is connected to a device capable of interrupting fault current, use the element to detect and trip for phase overcurrent faults. Set the phase overcurrent trip level (50P1P) equal to 2.0 times the motor locked rotor current with a 0.1 second time delay. Set the phase overcurrent warn level (50P2P) to the desired value with an appropriate time delay.

The phase overcurrent elements (50P1 and 50P2; see *Figure 4.8*) normally operate using the output of the cosine filter, but during CT saturation (in applications where external CTs are used) the phase current is the output of a bipolar peak detector if the overcurrent element pickup is equal to or greater than eight times the CT rating and the harmonic distortion index is high.

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

NOTE: The residual elements (50G) may not be effective if the available ground fault current is lower than 10 A.

The relay offers two types of ground fault detecting overcurrent elements. The core-balance CT (CBCT) overcurrent elements (50N1T and 50N2T) operate with current measured by the **IN** input. The residual (RES) overcurrent elements (50G1T and 50G2T) operate with the current derived from the phase currents (see *Figure 4.8*).

When a core-balance CT is connected to the relay **IN** input, as in *Figure 2.12* and *Figure 2.13*, use the CBCT overcurrent element for sensitive detection of motor ground faults and/or ground leakage current. Calculate the pickup settings based on the available ground fault current and the core-balance CT ratio.

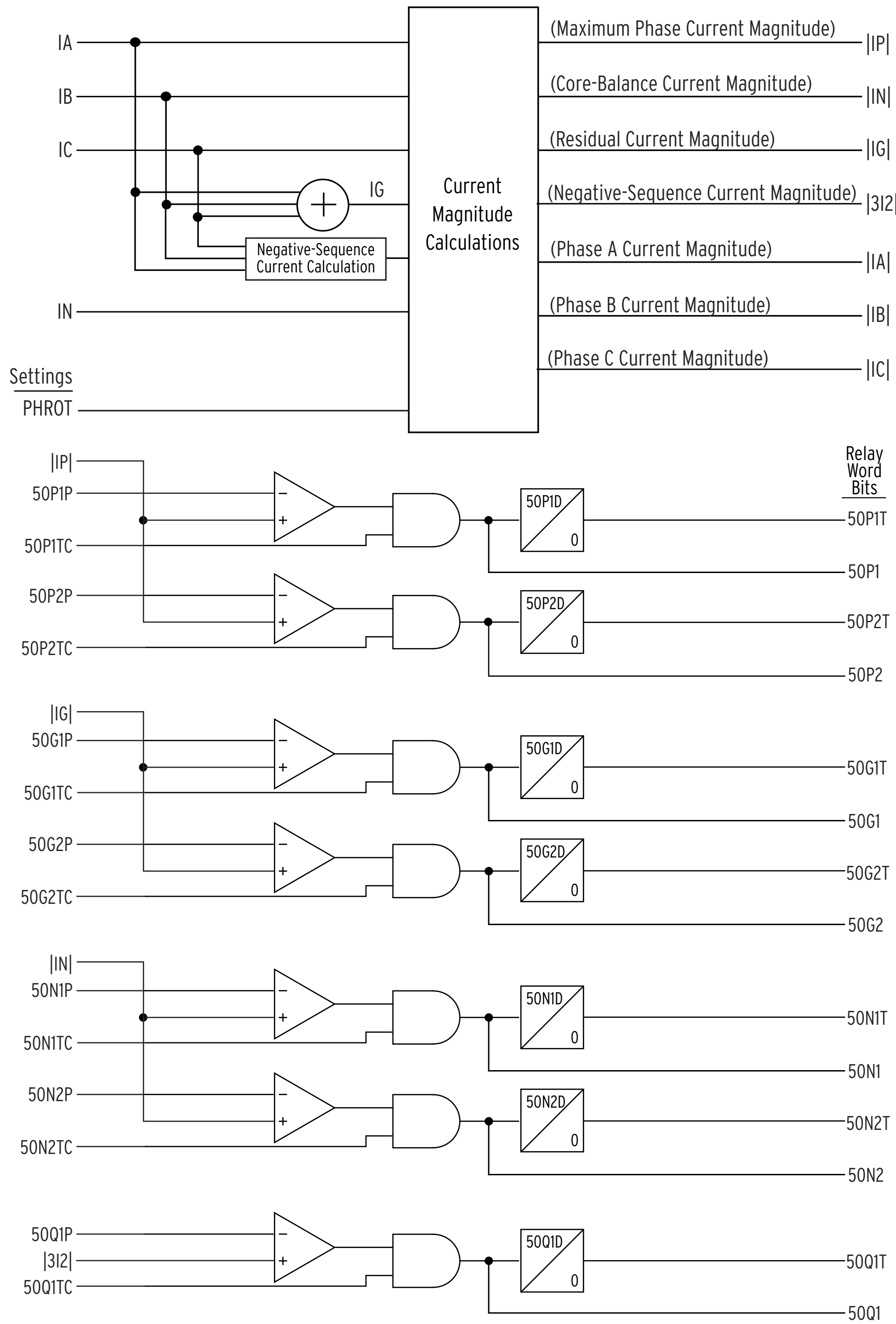


Figure 4.8 Overcurrent Element Logic

Table 4.10 Residual Instantaneous Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Residual IOC 1 Pickup	OFF, MAX(6.4/SRF, 0.5)–(1280/SRF) A	50G1P := OFF
Residual IOC 1 Delay	OFF, 0.10–240.00 sec	50G1D := 0.50
Residual IOC 1 Torque Control	SELOGIC	50G1TC := 1
Residual IOC 2 Pickup	OFF, MAX(6.4/SRF, 0.5)–(1280/SRF) A	50G2P := OFF
Residual IOC 2 Delay	OFF, 0.10–240.00 sec	50G2D := 0.50
Residual IOC 2 Torque Control	SELOGIC	50G2TC := 1

Set the residual overcurrent trip level (50G1P) between one-half and one-fifth of the full-load phase current, and set the residual overcurrent trip delay (50G1D) equal to 0.2 seconds. Set level 2 more sensitively, but with a longer time delay. The long time delay allows the sensitive element to ride through the false residual current that can be caused by phase CT (if used) saturation during motor starting.

Table 4.11 CBCT Instantaneous Overcurrent

Setting Prompt	Setting Range	Setting Name := Factory Default
GF-CB IOC 1 Pickup	OFF, 0.010–40.000 mA[a]	50N1P := OFF
GF-CB IOC 1 Delay	OFF, 0.10–240.00 sec	50N1D := 0.50
GF-CB IOC 1 Torque Control	SELOGIC	50N1TC := 1
GF-CB IOC 2 Pickup	OFF, 0.010–7.000 mA[a]	50N2P := OFF
GF-CB IOC 2 Delay	OFF, 0.10–240.00 sec	50N2D := 0.50
GF-CB IOC 2 Torque Control	SELOGIC	50N2TC := 1

[a] The 50N2P setting range shown is for 50N1P < 6 mA,
50N2P setting range is OFF, 0.040–28.000 mA for 6 ≤ 50N1P < 25 mA, and
50N2P setting range is OFF, 0.080–40.000 mA for 50N1P ≥ 25 mA.

EXAMPLE 4.6 Ground Fault Core-Balance CT Application

A resistance-grounded transformer limits the current for motor or cable ground faults. The resistor is sized to limit the current to 10 A primary. The three motor leads are passed through the window of a 1000:1 core-balance CT. The CT secondary is connected to the SEL-849 IN current input (terminals H1, H2), as shown in Figure 4.9.

Set the Core-Balance CT Ratio (CTRN) = 1000.

For a ground fault/leakage current detection of 40 mA primary, set GF-CB IOC 1 Pickup (50N1P) = 40/1000 = 0.04 mA with a 0.10 second time delay to ensure that the element will quickly detect and trip for motor ground faults, but prevent misoperation resulting from unequal breaker or contactor pole closing times.

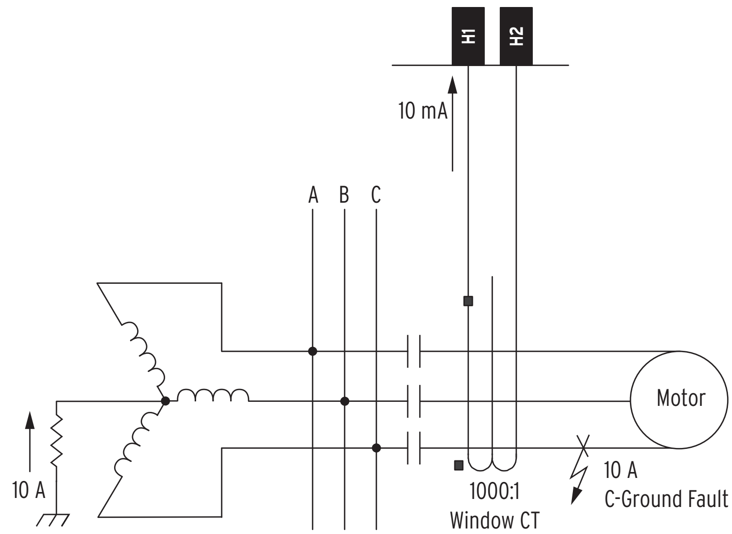


Figure 4.9 Ground Fault Protection Using Core-Balance CT

Table 4.12 Negative-Sequence Instantaneous Overcurrent

Setting Prompt	Setting Range	Setting Name := Factory Default
Negative-Sequence IOC Pickup	OFF, MAX(6.4/SRF, 0.5)–(1280/SRF) A	50Q1P := OFF
Negative-Sequence IOC Delay	OFF, 0.10–240.00 sec	50Q1D := 0.20
Negative-Sequence IOC Torque Control	SELOGIC	50Q1TC := 1

The relay offers a negative-sequence overcurrent element to be used in addition to or instead of the 46 Current Unbalance element to detect phase-to-phase faults, phase reversal, single phasing, and heavy motor unbalance.

Time-Overcurrent Elements

NOTE: Time-overcurrent elements trip level settings are in secondary amperes.

One level of inverse time element is available for each of the maximum phase, negative-sequence, and residual overcurrents. See *Table 4.13* through *Table 4.15* for available settings. You can select from five U.S. and five IEC inverse characteristics as shown in *Figure 4.14* through *Figure 4.23*.

Each element can be torque controlled using an appropriate SELOGIC control equation (for example, the 51P1 element will be operational only if 51P1TC is logical 1).

Table 4.13 Phase Time-Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
MAX Phase TOC Pickup	OFF, MAX(6.4/SRF, 0.5)–(512/SRF) A	51P1P := OFF
MAX Phase TOC Curve	U1–U5, C1–C5	51P1C := U3
MAX Phase TOC Time Dial	0.50–15.00 for U1–U5, 0.05–1.00 for C1–C5	51P1TD := 3.00
MAX Phase TOC EM Reset Delay	Y, N	51P1RS := N
MAX Phase TOC Torque Control	SELOGIC	51P1TC := 1

The maximum phase time-overcurrent element, 51P1T, responds to the highest of A-, B-, and C-phase currents as shown in *Figure 4.10*.

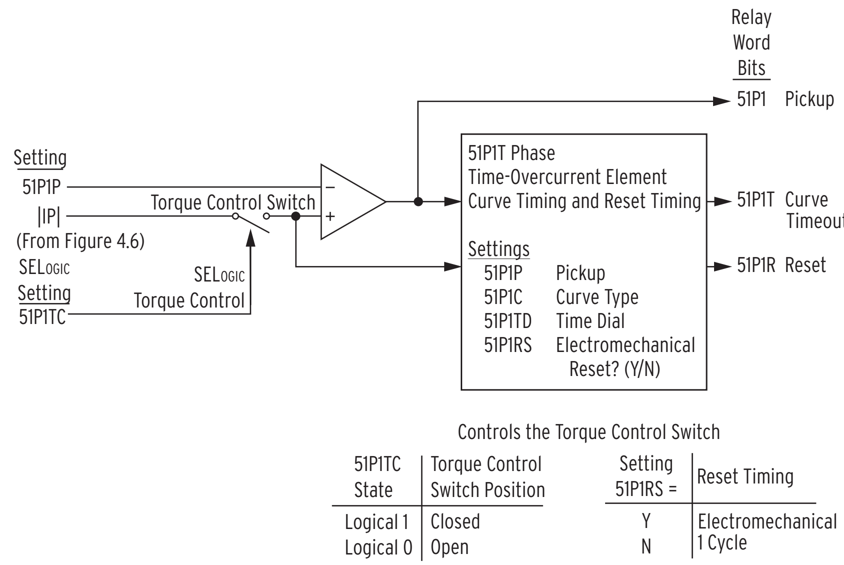


Figure 4.10 Maximum Phase Time-Overcurrent Element 51P1T

Table 4.14 Negative-Sequence Time-Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
NEG SEQ TOC Pickup	OFF, MAX(6.4/SRF, 0.5)–(512/SRF) A	51Q1P := OFF
NEG SEQ TOC Curve	U1–U5, C1–C5	51Q1C := U3
NEG SEQ TOC Time Dial	0.50–15.00 for U1–U5, 0.05–1.00 for C1–C5	51Q1TD := 3.00
NEG SEQ TOC EM Reset Delay	Y, N	51Q1RS := N
NEG SEQ TOC Torque Control	SELOGIC	51Q1TC := 1

The negative-sequence time-overcurrent element 51Q1T responds to the 3I2 current, as shown in *Figure 4.11*.

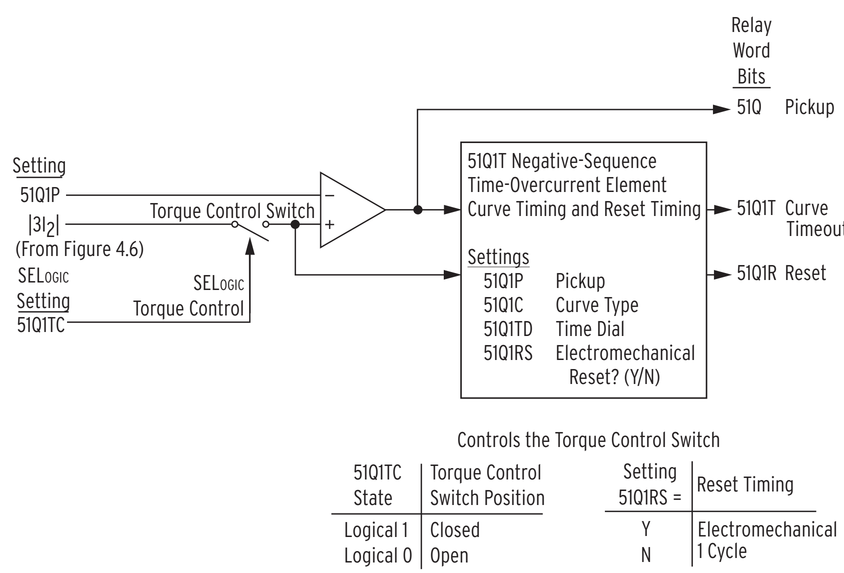


Figure 4.11 Negative-Sequence Time-Overcurrent Element 51Q1T

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 4.15 Residual Time-Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Residual Ground TOC Pickup	OFF, MAX(6.4/SRF, 0.5)–(512/SRF) A	51G1P := OFF
Residual Ground TOC Curve	U1–U5, C1–C5	51G1C := U3
Residual Ground TOC Time Dial	0.50–15.00 for U1–U5, 0.05–1.00 for C1–C5	51G1TD := 1.50
Residual Ground TOC EM Reset Delay	Y, N	51G1RS := N
Residual Ground TOC Torque Control	SELOGIC	51G1TC := 1

The residual time-overcurrent element 51G1T responds to residual current IG as shown in *Figure 4.12*.

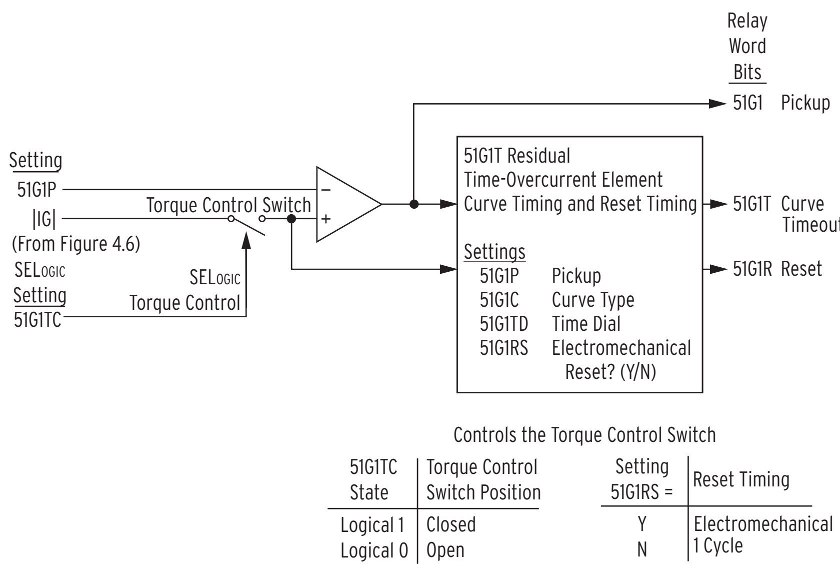


Figure 4.12 Residual Time-Overcurrent Element 51G1T

Table 4.16 CBCT Time-Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
GF-CB TOC Pickup	OFF, 0.080–4.800 mA[a]	51N1P := OFF
GF-CB TOC Curve	U1–U5, C1–C5	51N1C := U3
GF-CB TOC Time Dial	0.50–15.00 for U1–U5, 0.05–1.00 for C1–C5	51N1TD := 3.00
GF-CB TOC EM Reset Delay	Y, N	51N1RS := N
GF-CB TOC Torque Control	SELOGIC	51N1TC := 1

[a] The 51N1P setting range shown is for 25 ≤ 50N1P < 40 mA or 50N1P = OFF. The 51N1P setting range shown is OFF, 0.040–2.400 mA for 6 ≤ 50N1P < 25 mA. The 50N1P setting range shown is OFF, 0.010–1.000 mA for 50N1P < 6 mA.

The CBCT (neutral) time-overcurrent element 51N1T responds to CBCT current IN as shown in *Figure 4.13*.

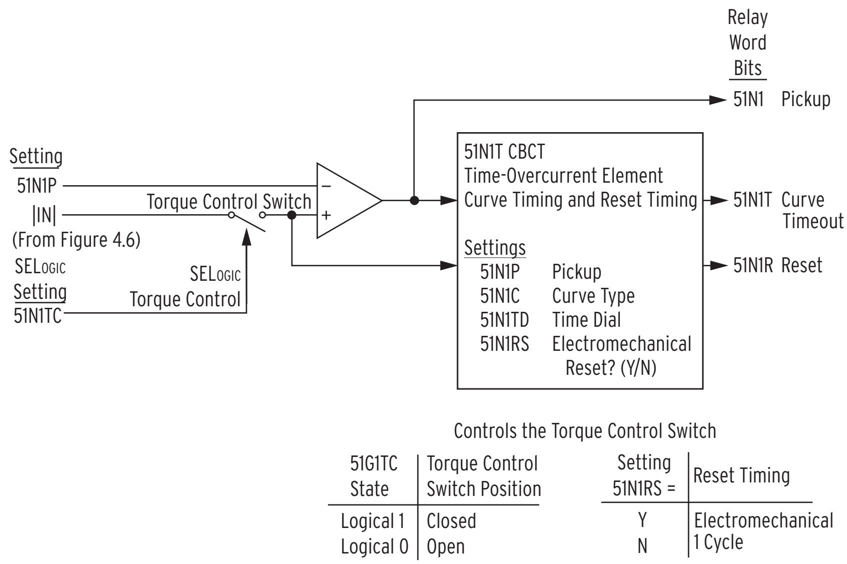


Figure 4.13 CBCT/Neutral Time-Overcurrent Element 51N1T

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 4.11* and *Figure 4.12*). The U.S. and IEC time-overcurrent relay curves are shown in *Figure 4.14* through *Figure 4.23*. Curves U1, U2, and U3 (see *Figure 4.14* through *Figure 4.16*) conform to IEEE C37.112-1996, *IEEE Standard Inverse-Time Characteristic Equations for Overcurrent Relays*.

Table 4.17 Equations Associated With U.S. Curves

Curve Type	Operating Time	Reset Time	Figure
U1 (Moderately Inverse)	$t_p = TD \bullet \left(0.0226 + \frac{0.0104}{M^{0.02} - 1}\right)$	$t_r = TD \bullet \left(\frac{1.08}{1 - M^2}\right)$	*Figure 4.14*
U2 (Inverse)	$t_p = TD \bullet \left(0.180 + \frac{5.95}{M^2 - 1}\right)$	$t_r = TD \bullet \left(\frac{5.95}{1 - M^2}\right)$	*Figure 4.15*
U3 (Very Inverse)	$t_p = TD \bullet \left(0.0963 + \frac{3.88}{M^2 - 1}\right)$	$t_r = TD \bullet \left(\frac{3.88}{1 - M^2}\right)$	*Figure 4.16*
U4 (Extremely Inverse)	$t_p = TD \bullet \left(0.0352 + \frac{5.67}{M^2 - 1}\right)$	$t_r = TD \bullet \left(\frac{5.67}{1 - M^2}\right)$	*Figure 4.17*
U5 (Short-Time Inverse)	$t_p = TD \bullet \left(0.00262 + \frac{0.00342}{M^{0.02} - 1}\right)$	$t_r = TD \bullet \left(\frac{0.323}{1 - M^2}\right)$	*Figure 4.18*

where:

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

Table 4.18 Equations Associated With IEC Curves

Curve Type	Operating Time	Reset Time	Figure
C1 (Standard Inverse)	$t_p = TD \bullet \left(\frac{0.14}{M^{0.02} - 1}\right)$	$t_r = TD \bullet \left(\frac{13.5}{1 - M^2}\right)$	*Figure 4.19*
C2 (Very Inverse)	$t_p = TD \bullet \left(\frac{13.5}{M - 1}\right)$	$t_r = TD \bullet \left(\frac{47.3}{1 - M^2}\right)$	*Figure 4.20*
C3 (Extremely Inverse)	$t_p = TD \bullet \left(\frac{80}{M^2 - 1}\right)$	$t_r = TD \bullet \left(\frac{80}{1 - M^2}\right)$	*Figure 4.21*
C4 (Long-Time Inverse)	$t_p = TD \bullet \left(\frac{120}{M - 1}\right)$	$t_r = TD \bullet \left(\frac{120}{1 - M}\right)$	*Figure 4.22*
C5 (Short-Time Inverse)	$t_p = TD \bullet \left(\frac{0.05}{M^{0.04} - 1}\right)$	$t_r = TD \bullet \left(\frac{4.85}{1 - M^2}\right)$	*Figure 4.23*

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)

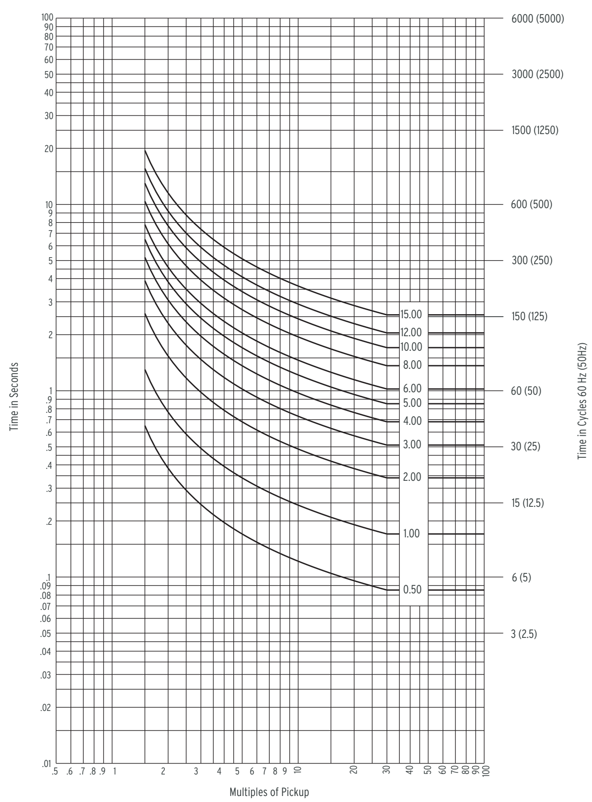


Figure 4.14 U.S. Moderately Inverse Curve: U1

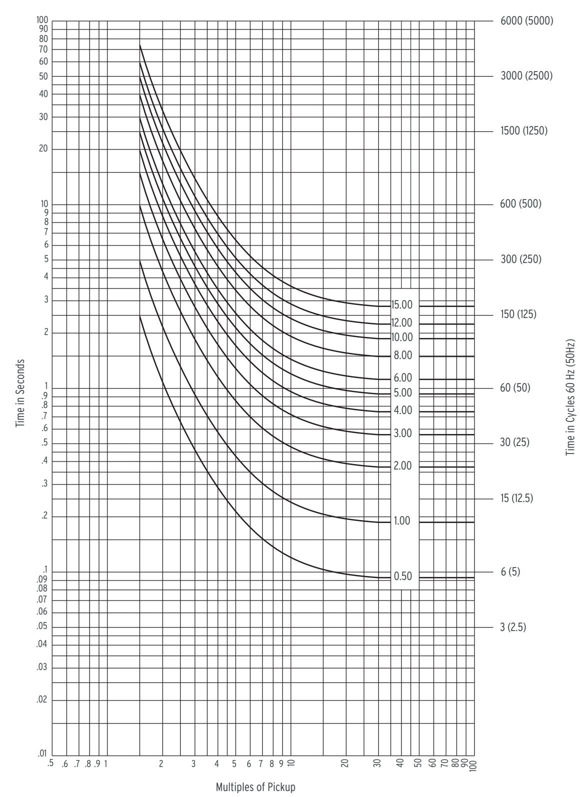


Figure 4.15 U.S. Inverse Curve: U2

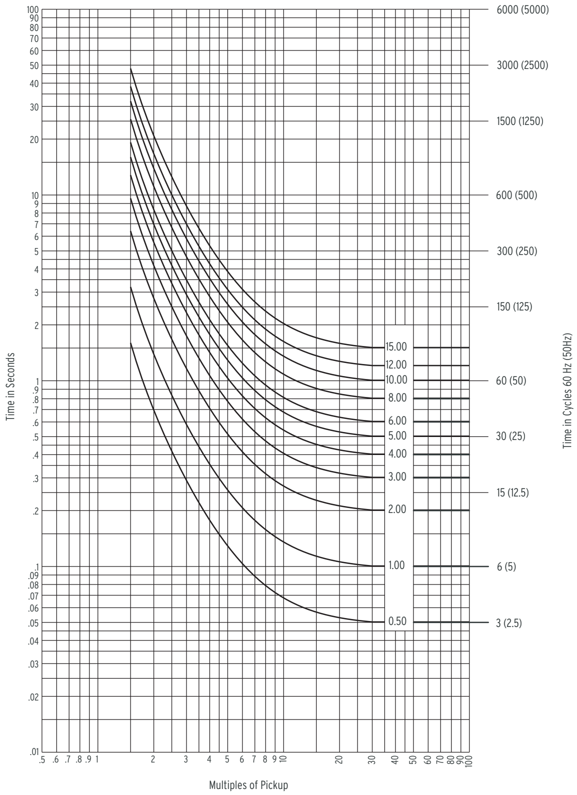


Figure 4.16 U.S. Very Inverse Curve: U3

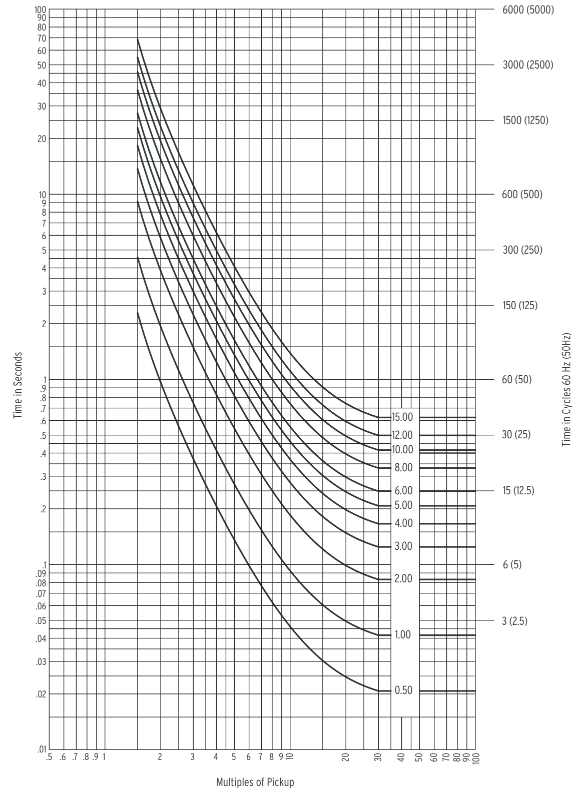


Figure 4.17 U.S. Extremely Inverse Curve: U4

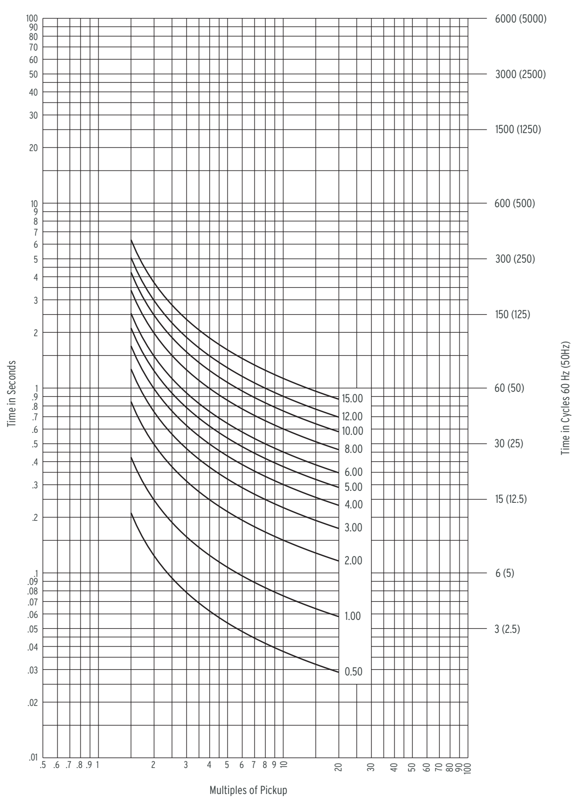


Figure 4.18 U.S. Short-Time Inverse Curve: U5

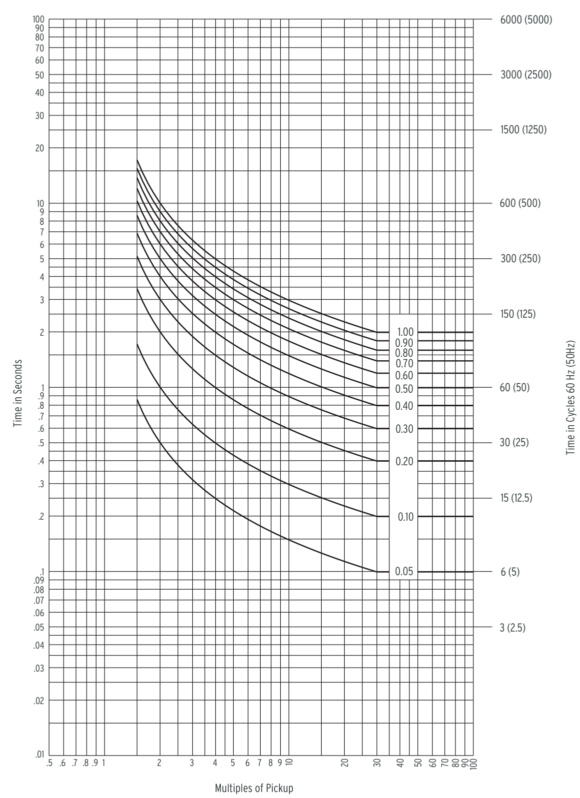


Figure 4.19 IEC Class A Curve (Standard Inverse): C1

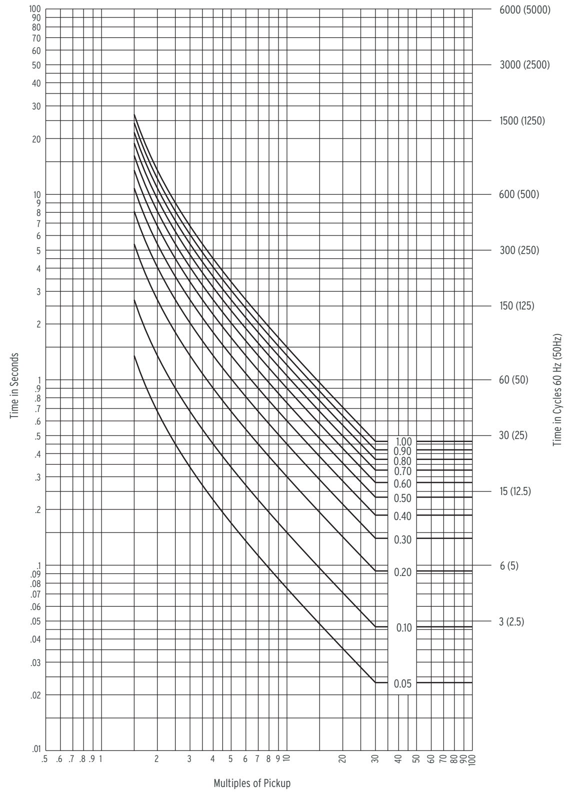


Figure 4.20 IEC Class B Curve (Very Inverse): C2

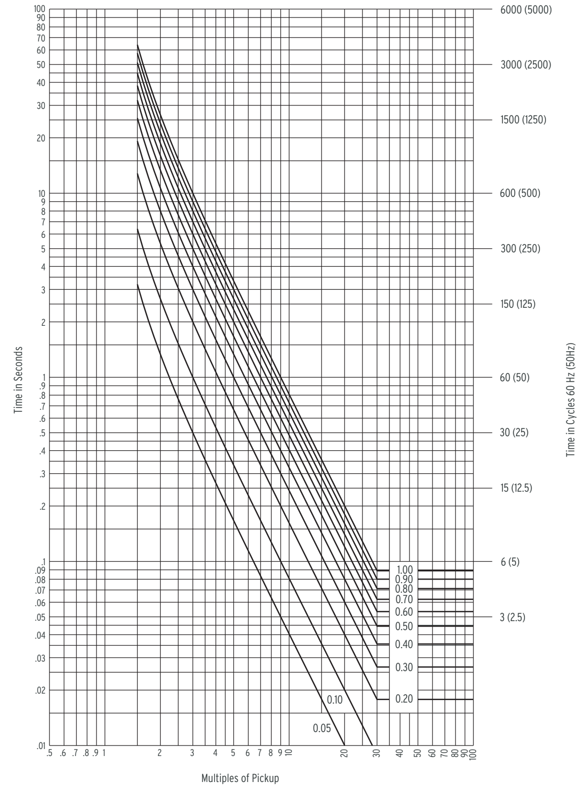


Figure 4.21 IEC Class C Curve (Extremely Inverse): C3

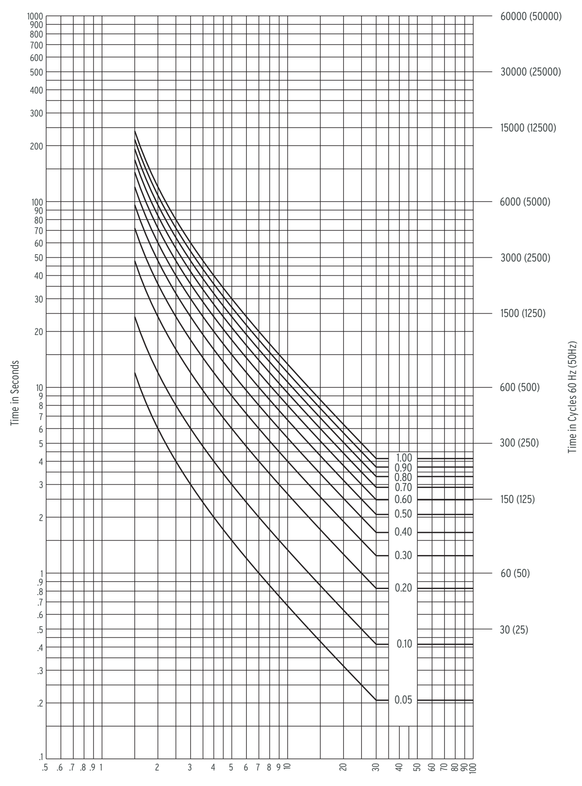


Figure 4.22 IEC Long-Time Inverse Curve: C4

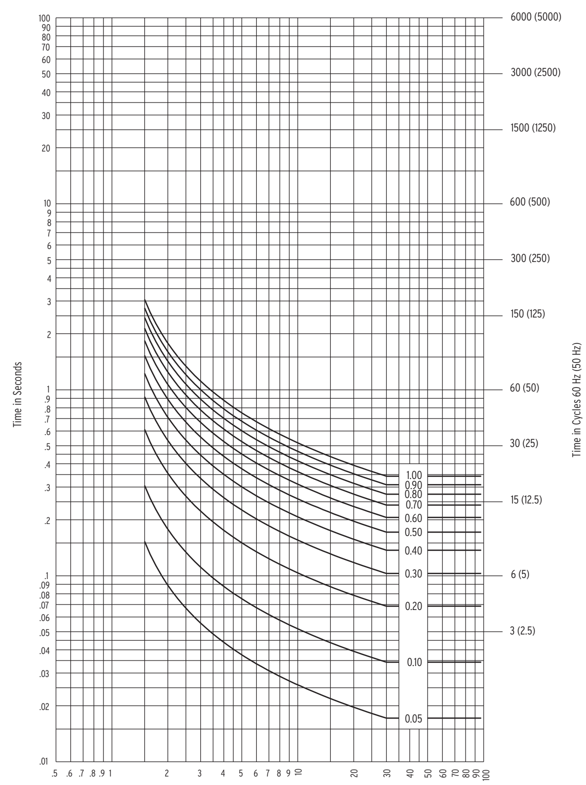


Figure 4.23 IEC Short-Time Inverse Curve: C5

Load-Jam Elements

Load-jam protection is available only when the relay detects that the motor is in the RUNNING state. During a load-jam condition, the motor stalls and the phase current rises to near the locked rotor value. When load-jam tripping is enabled and the phase current exceeds the jam trip level setting (LJTPU) for longer than the time-delay setting (LJTDLY), the relay trips (see *Figure 4.24*). Set the jam trip level greater than the expected normal load current but less than the rated locked rotor current. This setting is entered in per unit of the FLA setting.

Table 4.19 Load-Jam Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Load Jam Trip Pickup	OFF, 1.00–6.00 xFLA	LJTPU := OFF
Load Jam Trip Delay	0.0–120.0 sec	LJTDLY := 0.5
Load Jam Warning Pickup	OFF, 1.00–6.00 xFLA	LJAPU := OFF
Load Jam Warning Delay	0.0–120.0 sec	LJADLY := 5.0

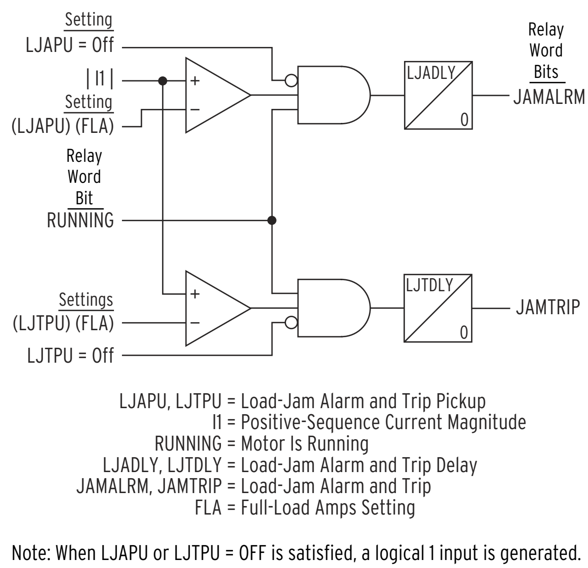


Figure 4.24 Load-Jam Element Logic

Undercurrent (Load-Loss) Elements

The relay arms the load-loss detection logic a settable time after the motor starts, as defined by the undercurrent start delay time setting (LLSDLY) (see *Table 4.20*). Set this delay to allow pumps or compressors to reach normal load. Once armed, this function issues a warning or trip if phase current drops below warn or trip level for the specified time delay. You can block these elements using SELOGIC (see *Table 4.52*).

Table 4.20 Undercurrent/Load-Loss Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Load Loss Trip Pickup	OFF, 0.20–1.00 xFLA	LLTPU := OFF
Load Loss Trip Delay	0.4–120.0 sec	LLTDLY := 5.0
Load Loss Warning Pickup	OFF, 0.10–1.00 xFLA	LLAPU := OFF
Load Loss Warning Delay	0.4–120.0 sec	LLADLY := 10.0
Load Loss Start Delay	0–5000 sec	LLSDLY := 0

Set the undercurrent trip and warn levels greater than the expected motor no-load current, but less than the minimum current expected when the motor is operating normally. These settings are entered in per unit of the FLA setting.

If you expect the motor to normally operate at no load, disable the trip and warn elements by setting LLTPU and LLAPU equal to OFF. The relay automatically hides the associated time-delay settings.

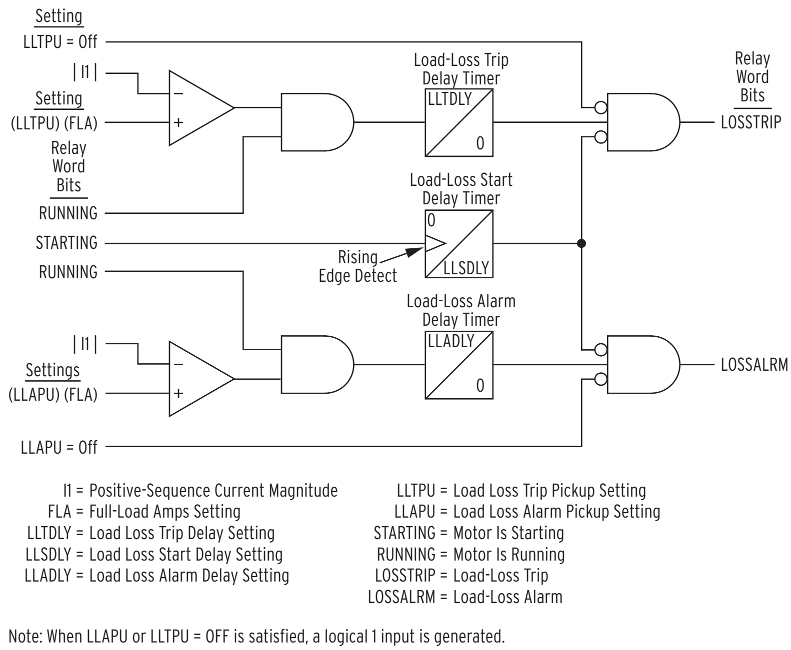


Figure 4.25 Undercurrent (Load-Loss) Logic

Current Unbalance Elements

Unbalanced motor terminal voltages cause unbalanced stator currents to flow in the motor. The negative-sequence current component of the unbalanced current causes significant rotor heating. While the SEL-849 motor thermal element models the heating effect of the negative-sequence current, you may want the additional unbalanced and single-phasing protection offered by the current unbalance element.

Table 4.21 Current Imbalance Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Current Imbalance Trip Pickup	OFF, 5–80%	46UBT := 20
Current Imbalance Trip Delay	1–240 sec	46UBTD := 5
Current Imbalance Warning Pickup	OFF, 5–80%	46UBA := 10
Current Imbalance Warning Delay	1–240 sec	46UBAD := 10

The SEL-849 calculates percent unbalance current in one of two ways, depending on the magnitude of the average current. When the average current, Iav, is greater than the motor-rated full-load current, the relay calculates the percent unbalance:

$$\mathrm{UB\%} = 100 \bullet \frac{\mathrm{Im}}{\mathrm{Iav}}$$

Equation 4.6

When the average current is less than the motor-rated full-load current, the relay calculates the percent unbalance:

$$\text{UB\%} = 100 \bullet \frac{\text{Im}}{\text{FLA}}$$

where

$$\begin{aligned}
\text{UB\%} &= \text{Current unbalance percentage} \\
\text{Im} &= \max\{|\text{Imax} - \text{Iav}|, |\text{Imin} - \text{Iav}|\} \\
&\quad \text{where} \\
&\qquad \text{Imax} = \max\{|\text{Ia}|, |\text{Ib}|, |\text{Ic}|\} \\
&\qquad \text{Imin} = \min\{|\text{Ia}|, |\text{Ib}|, |\text{Ic}|\} \\
\text{Iav} &= (|\text{Ia}| + |\text{Ib}| + |\text{Ic}|)/3 \\
\text{FLA} &= \text{Motor-rated full-load current}
\end{aligned}$$

Equation 4.7

In either case, the function is disabled if the average phase current magnitude is less than 25 percent of the FLA setting (see *Figure 4.26*).

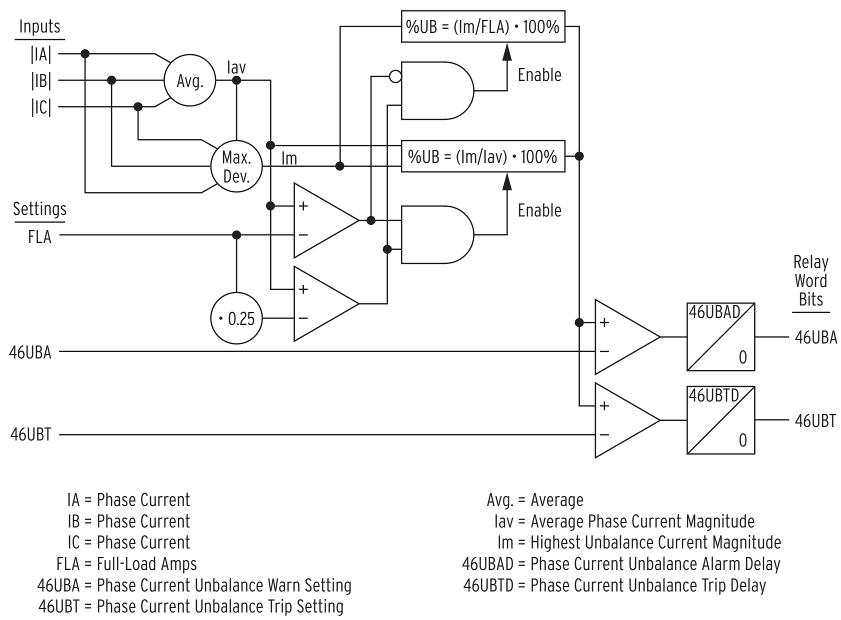


Figure 4.26 Current Unbalance Element Logic

A 1 percent voltage unbalance typically causes approximately 6 percent current unbalance in induction motors. If a 2 percent voltage unbalance can occur in your location, set the current unbalance warn level greater than 12 percent to prevent nuisance alarms. A 15 percent current unbalance warn level setting corresponds to an approximately 2.5 percent voltage unbalance, and a 20 percent current unbalance trip setting corresponds to an approximately 3.3 percent voltage unbalance. A 10-second alarm delay and 5-second trip delay should provide adequate performance in most applications.

Second- and Fifth-Harmonic Blocking Logic

When a distribution feeder supplies many transformers, magnetizing inrush currents may cause sensitive overcurrent elements to operate when the line is energized. The second-harmonic blocking logic can prevent this by blocking such elements until inrush currents have subsided. As shown in *Figure 4.27* and *Figure 4.28*, this logic uses the ratio of the second-harmonic content of each phase to the fundamental current of the same phase to calculate the percent harmonic content. The fifth-harmonic blocking logic can be used to detect transformer over-excitation conditions. The fifth-harmonic blocking logic is analogous to the second-harmonic logic. *Table 4.23* lists the settings associated with the harmonic blocking elements.

When the SELOGIC torque-control equation HBL2TC evaluates to logical 1, and if the second-harmonic content of a particular phase (e.g., IAHC2 for A-phase in *Figure 4.27*) exceeds the adjustable pickup threshold HBL2P for the pickup time delay HBL2PU, the blocking Relay Word bit for that phase asserts. The relay determines minimum current threshold (IMINHB) based on the setting range factor (see *Table 4.22*). Once the output is asserted, if the second-harmonic content falls below the threshold for the dropout time delay HBL2DO, the output deasserts. If any of the phase outputs asserts, Relay Word bit HBL2T also asserts. The same logic applies to fifth-harmonic blocking.

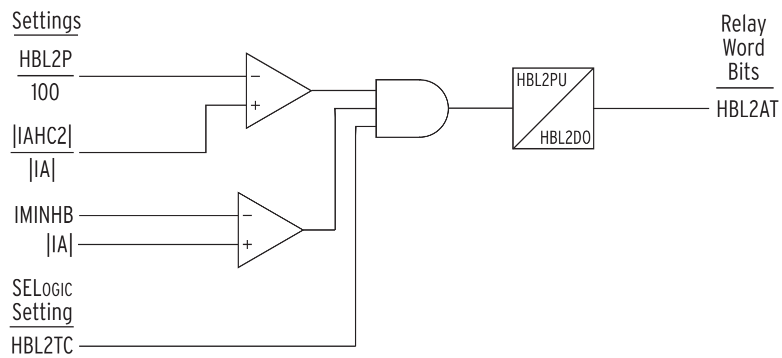


Figure 4.27 A-Phase Second-Harmonic Blocking

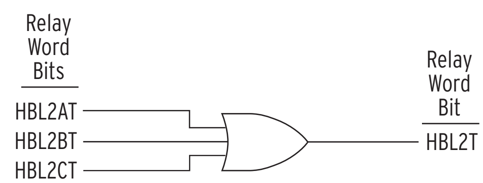


Figure 4.28 Three-Phase Second- and Fifth Harmonic Blocking Logic

Table 4.22 Minimum Current Threshold (IMINHB)

SRF[a]	IMINHB Threshold
32	0.2 A
8	0.8 A
2	3.2 A
1	6.4 A

[a] Refer to Table 4.2 for how the relay determines the setting range factor.

Table 4.23 Harmonic Blocking Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
2ND HARMONIC BLOCK ENABLE	Y, N	EHBL2 := N
2ND HARMONIC BLOCK PICKUP	5–100%	HBL2P := 10
2ND HARMONIC BLOCK PICKUP DELAY	0.00–120.00 sec	HBL2PU := 0.00

Table 4.23 Harmonic Blocking Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
2ND HARMONIC BLOCK DROPOUT DELAY	0.00–120.00 sec	HBL2DO := 0.00
2ND HARMONIC BLOCK TORQUE CONTROL	SELOGIC	HBL2TC := 1
5TH HARMONIC BLOCK ENABLE	Y, N	EHBL5 := N
5TH HARMONIC BLOCK PICKUP	5–100%	HBL5P := 10
5TH HARMONIC BLOCK PICKUP DELAY	0.00–120.00 sec	HBL5PU := 0.00
5TH HARMONIC BLOCK DROPOUT DELAY	0.00–120.00 sec	HBL5DO := 0.00
5TH HARMONIC BLOCK TORQUE CONTROL	SELOGIC	HBL5TC := 1

Second- and/or fifth-harmonic blocking elements are typically used to supervise sensitive overcurrent elements. CT saturation during faults can cause the relay to measure harmonic currents. The harmonic blocking elements may also assert briefly when the fundamental frequency current changes. Either condition might delay the supervised element. Set an unsupervised element above the expected inrush current to provide fast protection during large faults. Set the harmonic blocking timer pickup for more than one cycle in applications that cannot tolerate the element operating because of current changes.

EXAMPLE 4.7 Instantaneous Overcurrent Element Blocking

In this example, including second-harmonic blocking element HBL2T in the torque-control equation for Level 1 phase overcurrent element 50P1 helps prevent operation because of transformer inrush.

50P1P := **10.00 A**
50P2P := **20.00 A**
50P1D := **0.03 sec**
50P1TC := **NOT HBL2T**
50P2TC := **1**
TR := **...OR 50P1T OR 50P2T OR...**

The Level 1 time delay 50P1D allows time for the blocking element to assert. Level 2 phase overcurrent element setting 50P2P is high enough that the element does not operate when the line is energized but low enough to operate for high current faults when current transformer saturation or fundamental frequency current change might briefly block the Level 1 element.

Start Monitoring

NOTE: With Star-Delta (Wye-Delta) starting, the total starting time (Star and Delta) is monitored. If immediate tripping is required in the event of stalling, monitoring must be provided by a speed switch function.

If motor starting has not finished by the START_T time, the relay produces a trip if Relay Word SMTRIP (start motor time-out) asserts and is included in the TR equation. The start monitoring is independent of the overload protection provided by the thermal model. *Figure 4.29* shows the typical current during motor start and the START_T time setting.

Table 4.24 Start Monitoring Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Start Motor Time	OFF, 1–240 sec	START_T := OFF

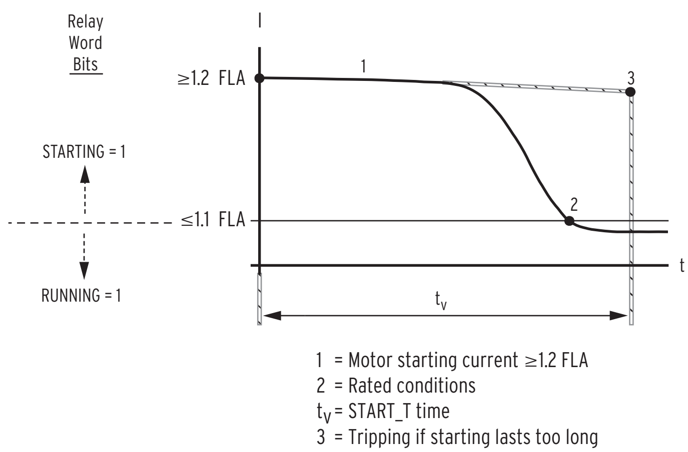


Figure 4.29 Monitoring Starting Time

Star-Delta (Wye-Delta) Starting

NOTE: In addition to enabling the Star-Delta, you must assign Star and Delta to auxiliary output relays (one each); see Figure 2.16 for a connection diagram using default assignments.

The SEL-849 issues the command to switch from Star to Delta (Wye to Delta) as soon as the starting current drops to near rated value in Star (Wye). The relay will make the change to Delta within the STAR_MAX setting (if used), regardless of the magnitude of the starting current.

Table 4.25 Star-Delta Starting Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Maximum Star Time	OFF, 1–600 sec	STAR_MAX := OFF

You can switch on or off, as desired, the maximum permissible time for Star (Wye) operation. If it is off, the change to Delta is made solely based on the motor current. If the motor has to be switched off when the total start time (Star and Delta) exceeds a set time, start monitoring must also be used.

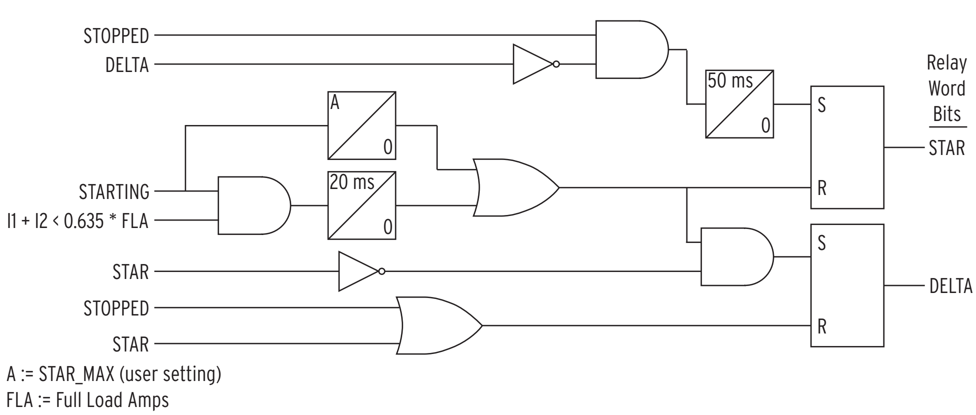


Figure 4.30 Star-Delta Starting

Motor Restart

The SEL-849 offers an automatic restart when the motor is tripped by an undervoltage or load-jam element. You can customize the restart delays to avoid too many simultaneous motor restarts in the plant that can cause brownout. See *Table 4.26* for the settings available for the application flexibility.

Table 4.26 Motor Restart Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Restart Enable	Y, N	ERESTART := N
Restart Elements	UV, UV_LJ, LJ	RE_ELE := LJ
Restart Voltage Level	100.0–800.0 V (if PTR = 1.00) 50.0–400.0 V (if PTR > 1.00)	59RSLVL := 120.0
Undervoltage Time, Short	OFF, 0.100–0.500 sec	UVTMSHRT := OFF
Undervoltage Time, Medium	OFF, 1.0–10.0 sec	UVTMMED := OFF
Undervoltage Time, Long	OFF, 1–3600 sec	UVTMLONG := OFF
Restart Delay, Medium	0.2–99.9 sec	RSDMED := 0.2
Restart Delay, Long	1–3600 sec	RSDLONG := 1
Restart Lockout Time	OFF, 0.1–60.0 min	RS_LO_TM := OFF

Set Restart Element (RE_ELE) to select the tripping elements, undervoltage (UV) and/or load jam (LJ), to initiate the restart sequence. See *Figure 4.31* through *Figure 4.34* for the logic diagrams. The voltage option is required for the UV choice and also for the restart voltage level (59RSLVL). Set the 59RSLVL to the minimum voltage required to allow the restart.

You can define the voltage dip that caused the motor trip as short, medium, or long duration by using the undervoltage time settings, UVTMSHRT, UVTMMED, and UVTMLONG, respectively. For example, the dip is considered short if it is shorter than the UVTMSHRT time, and so on.

NOTE: In addition to the Restart Delay setting for the medium voltage dip, the setting RSDMED is also used for the delay after a load-jam trip.

Use the restart delay settings, RSDMED and RSDLONG, to stagger the restart of various motors tripped by the same medium or long voltage dip. This feature helps to limit the total motor starting currents and avoid brownouts. There is no intentional delay for the restart after the first short voltage dip in a restart sequence. The UVTMSHRT setting should be low enough to avoid an out-of-sync restart of the motor. This typically depends on the induced voltage characteristic of the motors tripped by the short voltage dip and may require a motor-starting study (refer to IEEE standard *P3002.7 - Recommended Practice for Conducting Motor-Starting Studies in Industrial and Commercial Power Systems*). Any subsequent “short” voltage dips within one second after a restart are considered either medium or long dips.

The restart logic is designed to lock out after each attempt to restart the motor, except for the attempts after a first short voltage dip in a one second moving window. Set the Restart Lockout Time (RS_LO_TM) setting to automatically reset the logic after the set time delay or set it to OFF for a manual reset by target reset (Relay Word bit TRGTR). The TRGTR asserts for one processing interval when the relay top-panel or HMI **TARGET RESET** pushbutton is pressed or a target reset command is executed (ASCII, Ethernet, Modbus), or Target Reset SELOGIC control equation setting RSTTRGT asserts to logical 1.

If relay power is lost during a restart sequence, the relay restores and continues the sequence when the relay powers up.

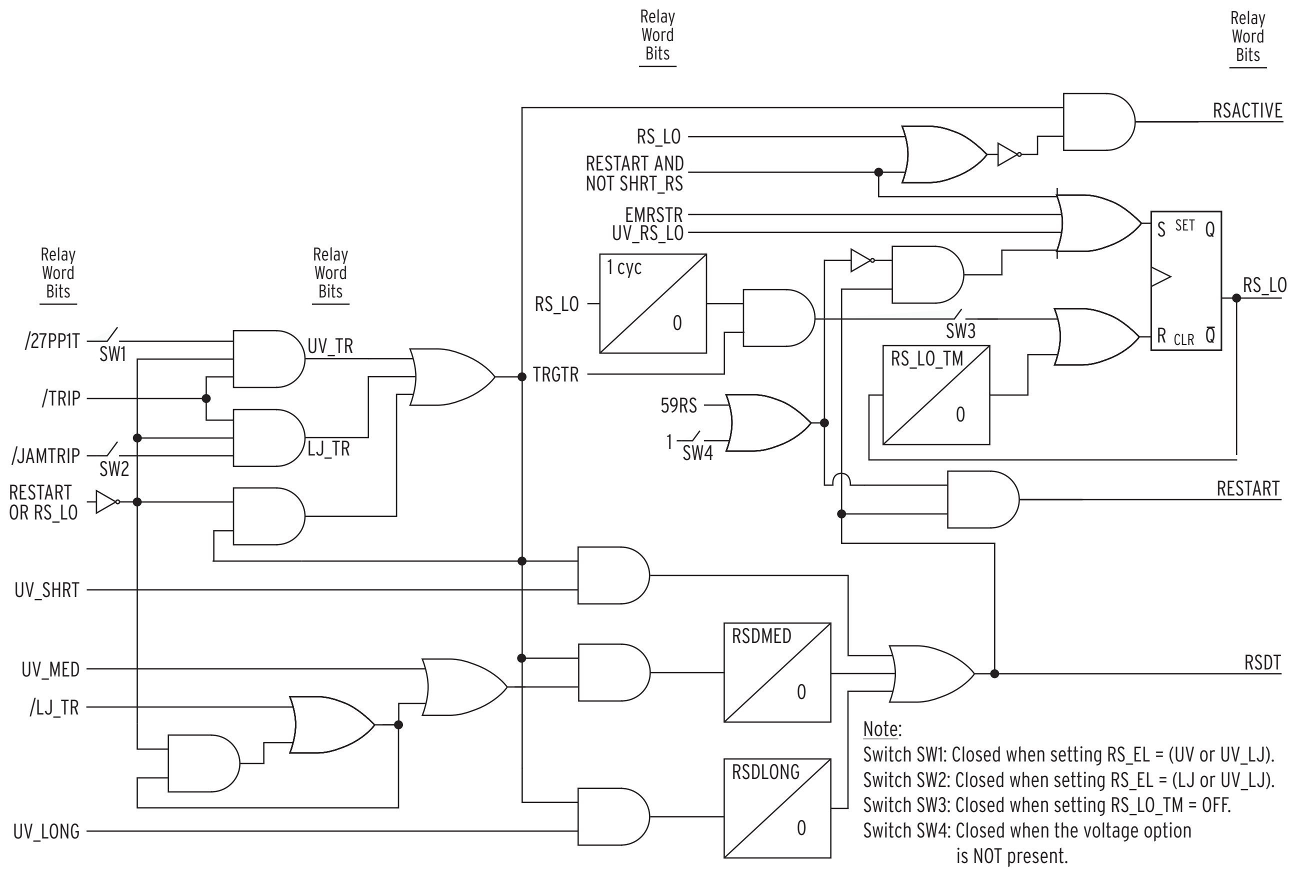


Figure 4.31 Motor Restart Logic

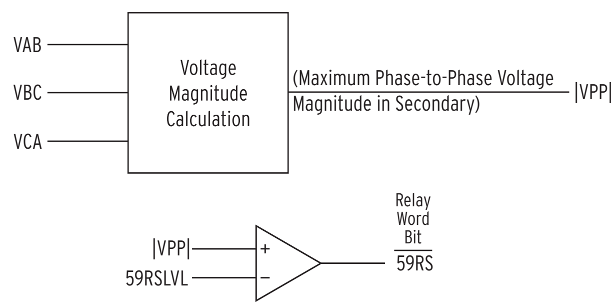


Figure 4.32 Overvoltage Reset Logic

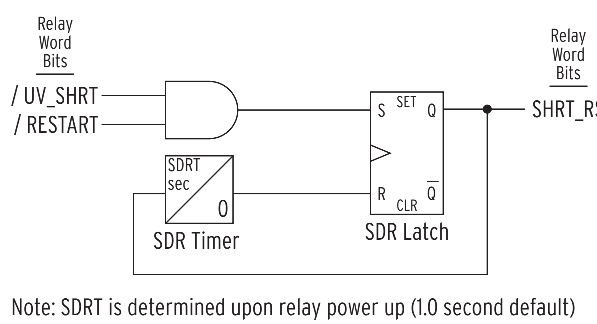
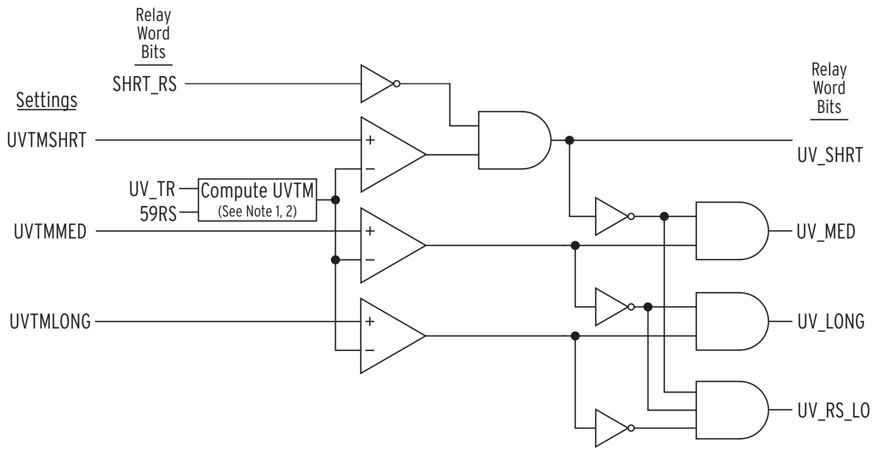


Figure 4.33 Short Voltage Dip Restart (SDR) Detection Logic



Notes:
1. Clear output bits (UV_SHRT, UV_MED, UV_LONG, UV_RS_LO), time tags, and UVTM time if:
   - Setting ERESTART = N
   - Switch SW1 is Open, or
   - (RESTART OR RS_LO) = 1
2. Enable computation of UVTM by /UV_TR. Compute UVTM as follows and then compute the output bits.
   - UVTM = (/59RS time tag - /UV_TR time tag) seconds or
   - UVTM = MAX (UVTMSHRT, UVTMMED, UVTMLONG) seconds if 59RS does not assert in MAX (UVTMSHRT, UVTMMED, UVTMLONG) seconds.

Figure 4.34 Undervoltage Duration Logic

Start Inhibit Function

NOTE: See Figure 4.49 and Figure 4.52 for the stop/trip and start/close logic diagrams, respectively.

NOTE: The relay uses the assertion of the STARTING Relay Word bit to determine the number of starts.

When the protected motor is rated for a specific maximum number of starts per hour or minimum time between starts, set the MAXSTART and TBSDLY settings accordingly. If the relay detects MAXSTART starts within 60 minutes and the motor stops or is tripped, the relay asserts the TRIP output contact to prevent an additional start until 60 minutes after the oldest start. If the motor stops or is tripped within TBSDLY minutes of the last start, the relay asserts the TRIP output contact to prevent a new start until TBSDLY minutes after the most recent start.

Table 4.27 Motor Start Inhibit Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Maximum Starts/Hour	OFF, 1–10	MAXSTART := OFF
Minimum Time Between Starts	OFF, 1–150 min	TBSDLY := OFF
Minimum Motor-Stopped Time	OFF, 1–3600 sec	ABSDLY := OFF

In certain pump applications, fluid flowing backward through the pump may spin the pump motor for a short time after the motor is stopped. Any attempt to start the motor during this time can be damaging. To prevent motor starts during the backspin period, enter a time in minutes in the Minimum Motor-Stopped Time setting. If the relay trips or the motor is stopped, the relay will generate a trip signal and maintain it for at least this amount of time. The relay will not issue a start during this period.

NOTE: You can set TRIPONLO to N if the trip is not desired on lockout condition. The start inhibit will be achieved by the BSTR_CL control equation (see Table 4.39).

The relay will maintain the trip signal until enough time passes for the motor to be safely restarted. During the lockout period, the relay will display a countdown time in minutes to the next allowed start.

The emergency restart function overrides all three limits, allowing the motor to be placed back in service in an emergency.

Phase Reversal Protection

The SEL-849 uses phase currents or phase voltages (if available) to determine that the phase rotation of signals applied to the relay matches the phase rotation setting, PHROT. When you set E47T equal to Y, the relay trips 0.5 seconds after incorrect phase rotation signals are applied to the relay. For relays equipped with current inputs only, the trip will occur approximately 0.5 seconds after the motor start is initiated. When the relay is equipped with voltage inputs, the trip will occur approximately 0.5 seconds after ac voltages are applied to the relay (see *Figure 4.35*).

Table 4.28 Phase Reversal Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Phase Reversal Protection Enable	Y, N	E47T := Y

To ensure that phase reversal protection is enabled in case PHROT is set wrong, make sure the setting E47T is equal to Y and Relay Word bit 47T is in the TRIP equation.

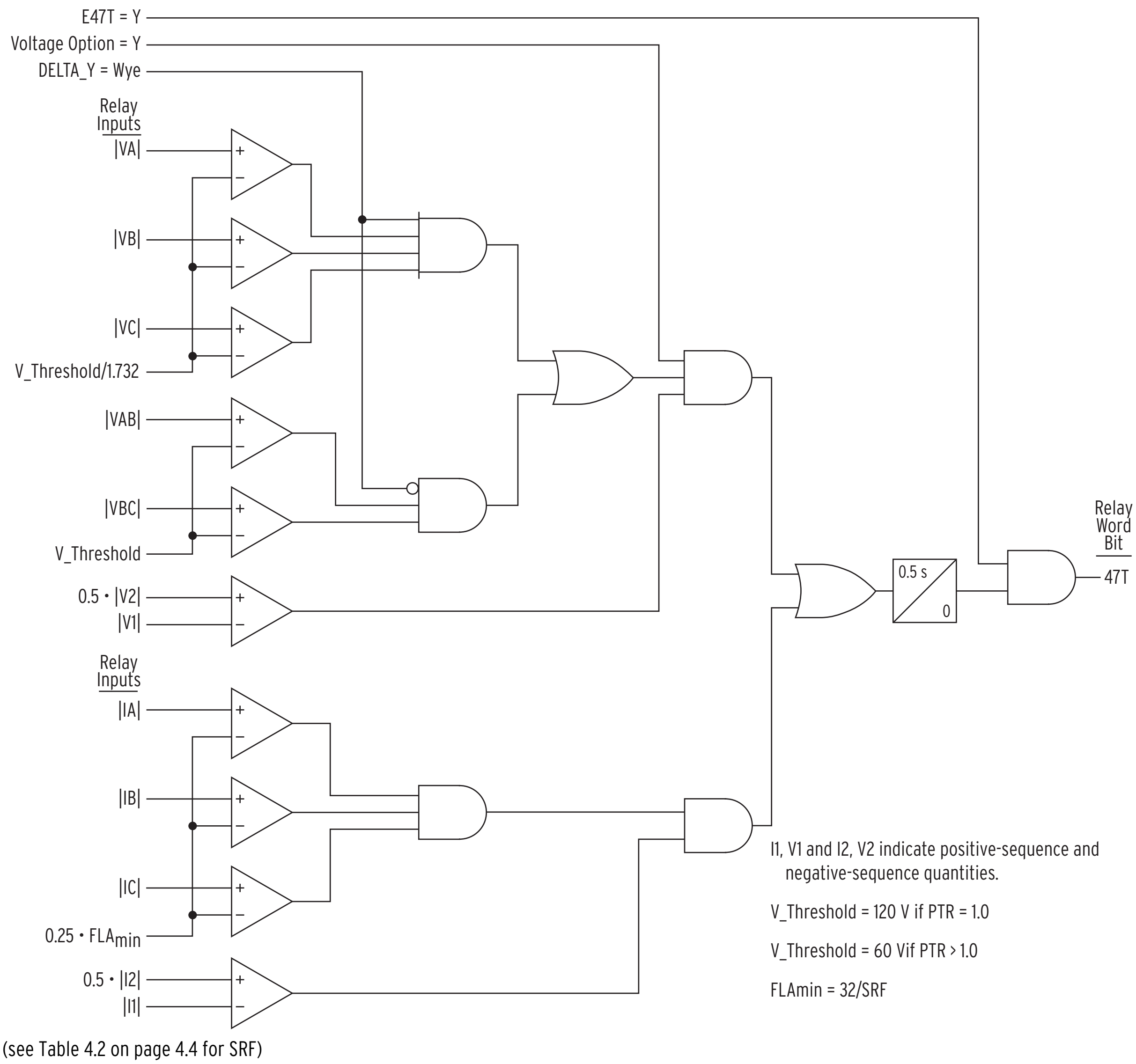


Figure 4.35 Phase Reversal Element Logic

Speed Switch (Stalling During Start) Function

NOTE: In addition to setting the Speed Switch Delay, you must connect the speed switch contact to an input assigned to the Speed Switch (see Figure 2.15).

When the motor is equipped with a speed switch, you may want to provide additional locked rotor protection by using the relay speed switch input. When the Speed Switch Trip Delay is set, the relay will trip if the speed switch is not closed SPDSDLYT seconds after the motor start begins. A separate delay, SPDSDLYA, can also be set to provide a warning before the speed switch trip. *Figure 4.36* shows typical currents during motor start (normal and stall during start) and the Speed Switch Trip Delay time setting. *Figure 4.37* shows the speed switch logic.

Table 4.29 Motor Speed Switch Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Speed Switch Trip Delay	OFF, 1–240 sec	SPDSDLYT := OFF
Speed Switch Warning Delay	OFF, 1–240 sec	SPDSDLYA := OFF

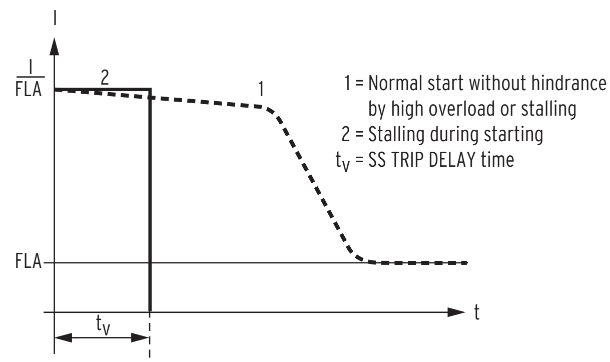


Figure 4.36 Stalling During Starting

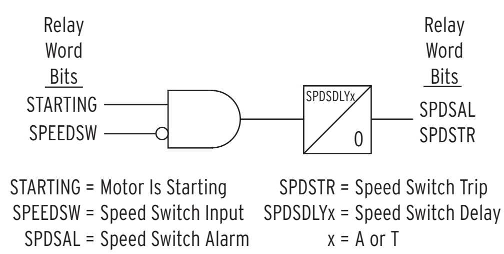


Figure 4.37 Speed Switch Logic

PTC-Based Protection

Thermistor (PTC) Input Function

NOTE: In addition to enabling the PTC function, you must also connect at least one thermistor to the relay (see PTC Connections on page 2.10 for connection details).

You can connect as many as six thermistor detectors (PTC) to the SEL-849 with PTC option. The detectors are typically embedded in the stator winding of the motor, and they monitor the actual temperature of the winding. This function is independent of the thermal model and accounts for conditions such as ambient temperature, obstructed cooling, etc. The sensors have a low resistance below the rated response temperature, and they increase their resistance (exponentially) in the range of the rated response temperature. The rated response temperature is defined by the PTC sensor. Motors with different thermal insulation classes (Class F or H) are equipped with different PTC sensors, each of which has its own response temperature, such as 120°, 130°, and 140°C. The detectors and their leads are monitored for short circuits. *Figure 4.38* shows the characteristics of the PTC.

Table 4.30 PTC Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PTC Enable	Y, N	EPTC := N

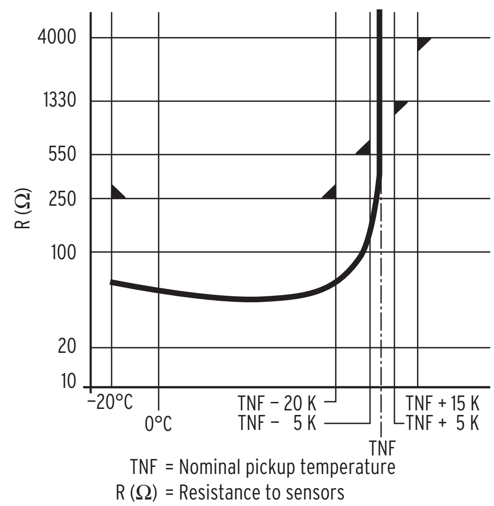


Figure 4.38 Characteristic of PTC Sensors From IEC 34-11-2

Voltage-Based Protection

The following information applies to relay models with voltage inputs.

Undervoltage Function

Table 4.31 Undervoltage Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Undervoltage Pickup 1	OFF, 5.0–800.0 V (if PTR = 1.00) OFF, 5.0–400.0 V (if PTR > 1.00)	27PP1P := OFF
Undervoltage Delay 1	0.00–240.00 sec	27PP1D := 0.01
Undervoltage Torque Control 1	SELOGIC	27PP1TC := RUNNING
Undervoltage Pickup 2	OFF, 5.0–800.0 V (if PTR = 1.00) OFF, 5.0–400.0 V (if PTR > 1.00)	27PP2P := OFF
Undervoltage Delay 2	0.00–240.00 sec	27PP2D := 5.00
Undervoltage Torque Control 2	SELOGIC	27PP2TC := 1

Overvoltage Function

Table 4.32 Overvoltage Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
Overvoltage Pickup 1	OFF, 5.0–800.0 V (if PTR = 1.00) OFF, 5.0–400.0 V (if PTR > 1.00)	59PP1P := OFF
Overvoltage Delay 1	0.0–240.0 sec	59PP1D := 1.0
Overvoltage Torque Control 1	SELOGIC	59PP1TC := 1

Table 4.32 Overvoltage Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
Overvoltage Pickup 2	OFF, 5.0–500.0 V (if PTR = 1.00) OFF, 5.0–400.0 V (if PTR > 1.00)	59PP2P := OFF
Overvoltage Delay 2	0.0–240.0 sec	59PP2D := 5.0
Overvoltage Torque Control 2	SELOGIC	59PP2TC := 1

The SEL-849 provides two levels of phase-to-phase overvoltage and undervoltage elements regardless of the phase voltage input connections. See *Figure 2.9* and *Figure 2.10* for connection diagrams.

Each of the elements has an associated time-delay and torque-control settings. You can use these elements as you choose for tripping and/or control. *Figure 4.39* and *Figure 4.40* show the logic diagram for the undervoltage and overvoltage elements, respectively. To disable any of these elements, set the level settings equal to OFF.

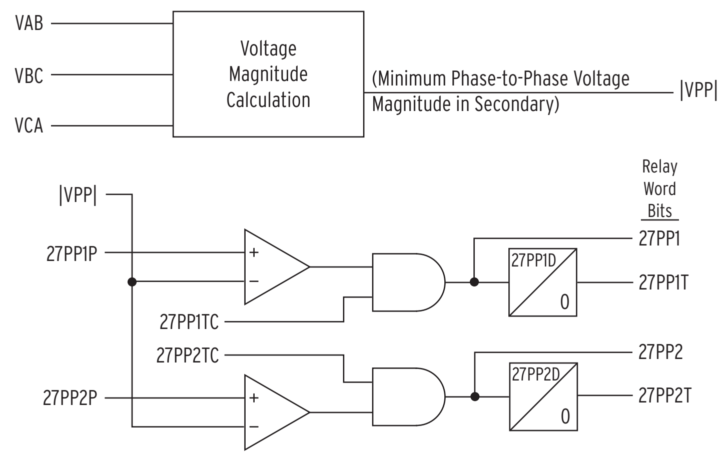


Figure 4.39 Undervoltage Element Logic

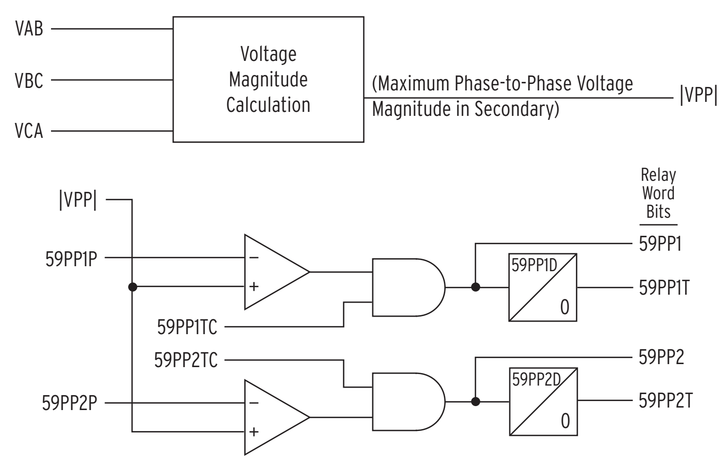


Figure 4.40 Overvoltage Element Logic

Power Elements

You can enable as many as two independent, three-phase power elements in the SEL-849. 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 single voltage input is used, 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 include the following:

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

Table 4.33 Three-Phase Power Element Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Enable Power Elements	N, 1–2	EPWR := 2
Power Element-1 Pickup	OFF, 20.0–200.0 %VA[a]	3PWR1P := OFF
Power Element-1 Type	+WATTS, –WATTS, +VARS, –VARS	PWR1T := –WATTS
Power Element-1 Delay	0.00–240.00 sec	PWR1D := 20.00
Power Element-2 Pickup	OFF, 20.0–200.0 %VA[a]	3PWR2P := OFF
Power Element-2 Type	+WATTS, –WATTS, +VARS, –VARS	PWR2T := +WATTS
Power Element-2 Delay	0.00–240.00 sec	PWR2D := 1.00

[a] The range is in % of Nominal VA (1.732 • VNOM • FLA1). For example, default Nominal VA = 1.732 • 240 • 20 = 8,314 VA.

EPWR := 1 enables one three-phase power element. Set EPWR := 2 if you want to use both elements.

Set the Power Element-1 Pickup, 3PWR1P, to the value you want. *Figure 4.41* shows the power element logic diagram, and *Figure 4.42* shows the operation in the real/reactive power plane.

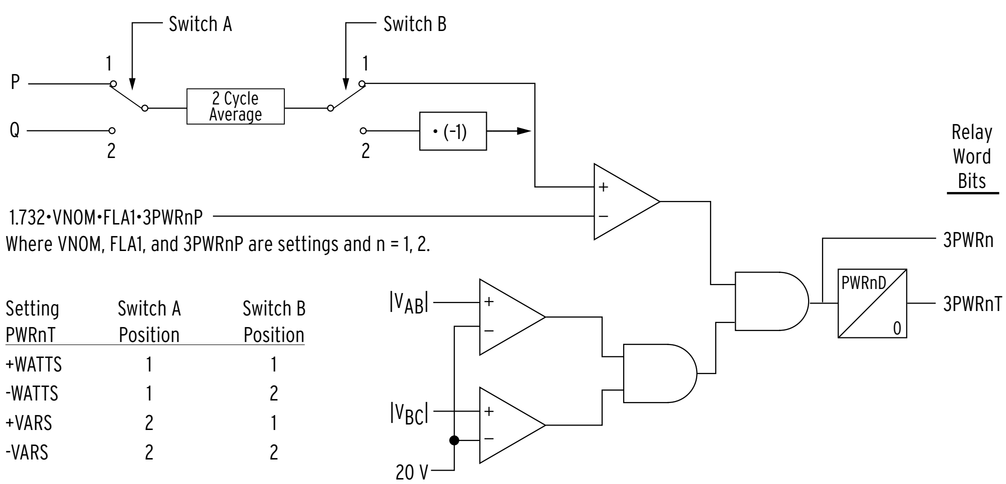


Figure 4.41 Three-Phase Power Elements Logic

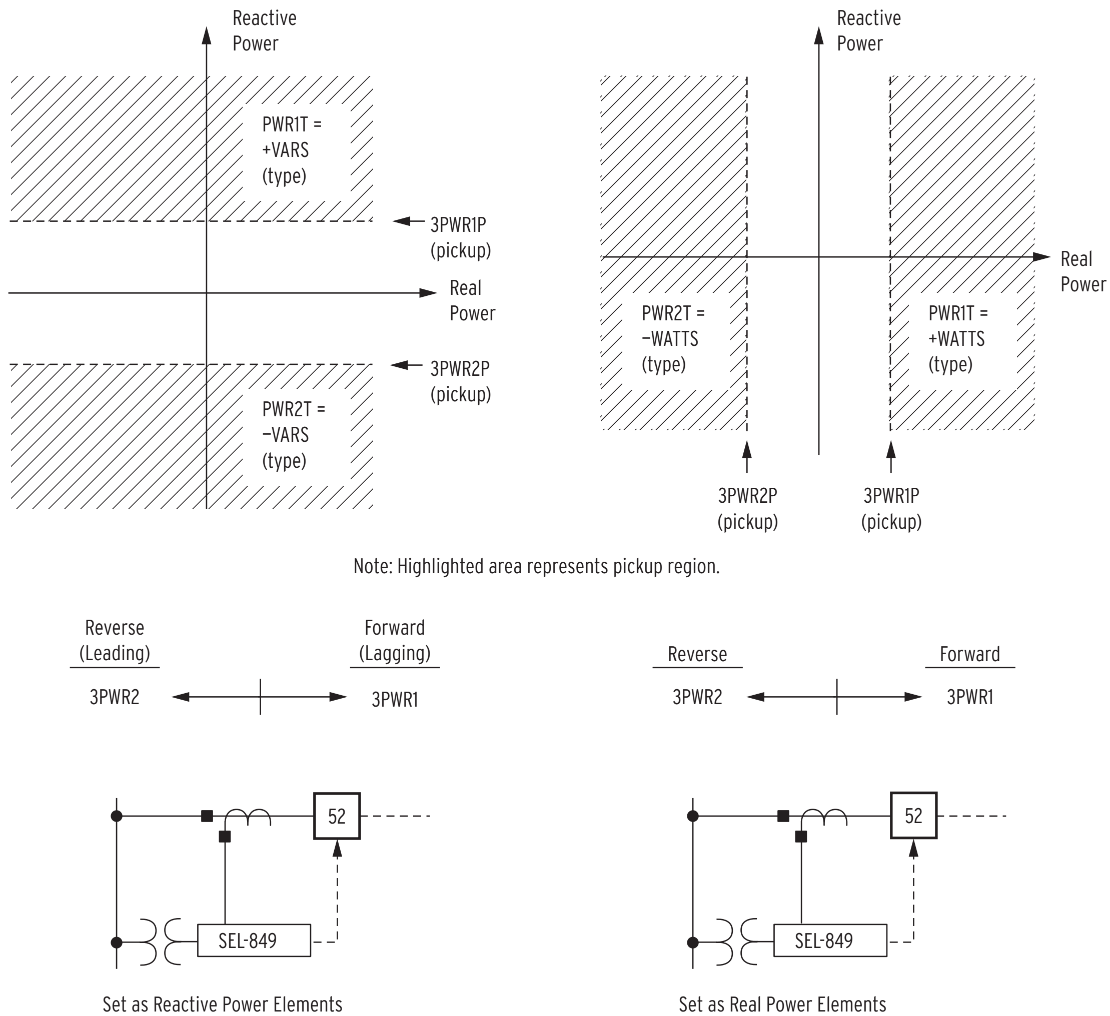


Figure 4.42 Power Elements Operation in the Real/Reactive Power Plane

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

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

The two power element time-delay settings (PWR1D and PWR2D) can be set to have no intentional delay for testing purposes. For protection applications involving the power element Relay Word bits, SEL recommends a minimum time-delay setting of 0.1 second for general applications. The classical power calculation is a product of voltage and current, to determine the real and reactive power quantities. During a system disturbance, because of the high sensitivity of the power elements, the changing system phase angles and/or frequency shifts may cause transient errors in the power calculation.

The power elements are not supervised by any relay elements other than the minimum voltage check shown in *Figure 4.41*. If the protection application requires overcurrent protection in addition to the power elements, there may be a race condition, during a fault, between the overcurrent element(s) and the power element(s) if the power element(s) are still receiving sufficient operating quantities. Use the power element time-delay setting to avoid such race conditions.

Power Factor Elements

Table 4.34 Power Factor Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PF Lag Trip Level	OFF, 0.05–0.99	55LGTP := OFF
PF Lead Trip Level	OFF, 0.05–0.99	55LDTP := OFF
PF Trip Delay	1–240 sec	55TD := 1
PF Lag Alarm Level	OFF, 0.05–0.99	55LGAP := OFF
PF Lead Alarm Level	OFF, 0.05–0.99	55LDAP := OFF
PF Alarm Delay	1–240 sec	55AD := 1
PF Arming Delay	0–5000 sec	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. Use the setting 55DLY to set any arming delay required by your application or set it to zero for no delay. The power factor elements are disabled when the motor is stopped or starting. *Figure 4.43* shows the logic diagram for the power factor elements. These elements can be used to detect synchronous motor out-of-step or loss-of-field conditions. Refer to *Figure 5.1* for the relay power measurement convention.

For application on an induction motor, disable the elements by setting all four power factor level settings to OFF.

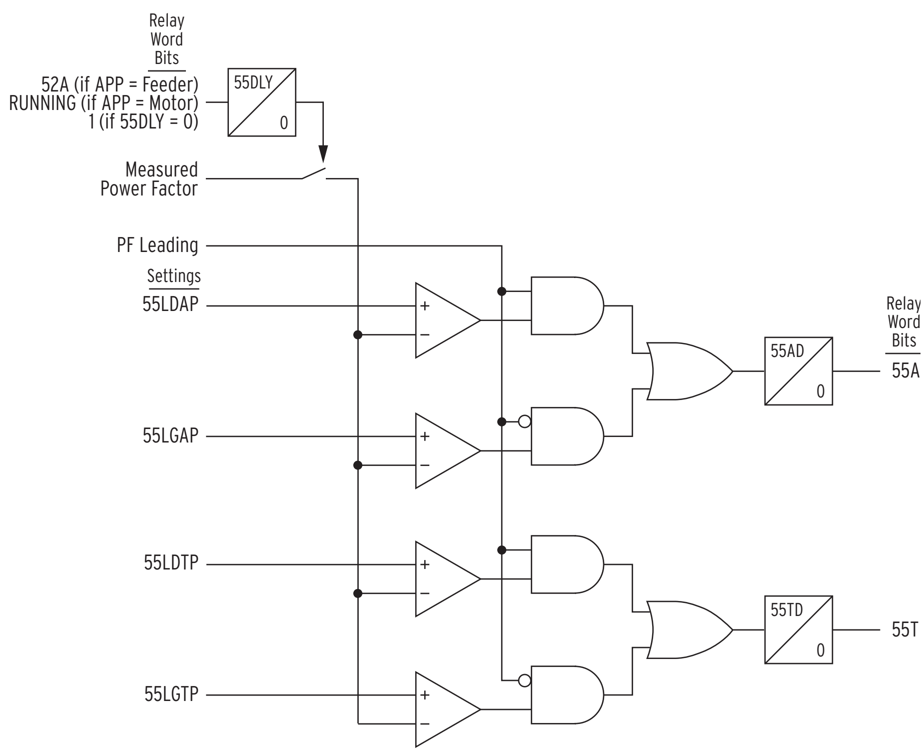


Figure 4.43 Power Factor Elements Logic

Loss-of-Potential (LOP) Protection

The SEL-849 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 required by certain protection elements (undervoltage 27 elements, for example), you can use the LOP function to supervise these protection elements.

The relay declares an LOP when there is more than a 25 percent drop in the measured positive-sequence voltage (V1) with no corresponding magnitude or angle change (above a pre-determined threshold) in positive-sequence (I1), negative-sequence (I2), or zero-sequence currents (I0). If this condition persists for 1 second, then the relay latches the LOP Relay Word bit at logical 1. The relay resets the LOP Relay Word bit when the conditions to the RESET input of the latch are met as shown in *Figure 4.44*.

Settings

The LOP function has no settings and is always active except when APP = VFD. You must incorporate the LOP function in a SELOGIC control equation to supervise relay protection elements (see *Example 4.8*).

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, if a wrench drops 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 4.8*). 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 4.8 Supervising Voltage-Element Tripping With LOP

Use the LOP function to supervise undervoltage tripping. If you use the undervoltage trip element 27PP1, then change a portion of the TRX equation to the following:

TRX := **…(27PP1T AND NOT LOP) OR…**

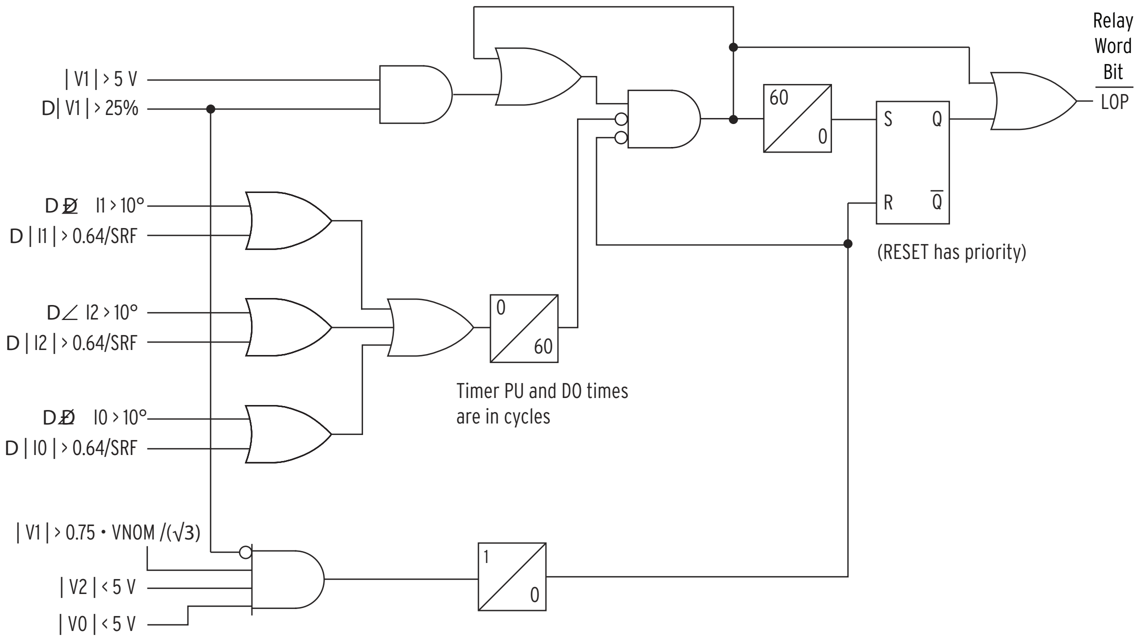
Similarly, if you want the remaining voltage-affected elements to act only when there are correct relaying potentials voltage, use the following in the equation:

…OR (NOT LOP AND (LOADLOW OR NOT 3PWR1T OR 55T)) OR…

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 re-established. Include the LOP Relay Word bit in an output contact alarm to notify operation personnel of abnormal voltage input conditions and failures that can be detrimental to the protection system performance if not quickly corrected.



Where Δ is the change from the present sample and the 1-cycle old sample, the SRF depends on the FLA1 (Full-Load Current). See Table 4.2 for details.

VNOM (in secondary volts) is the nominal line-line voltage setting.

Figure 4.44 Loss-of-Potential (LOP) Logic

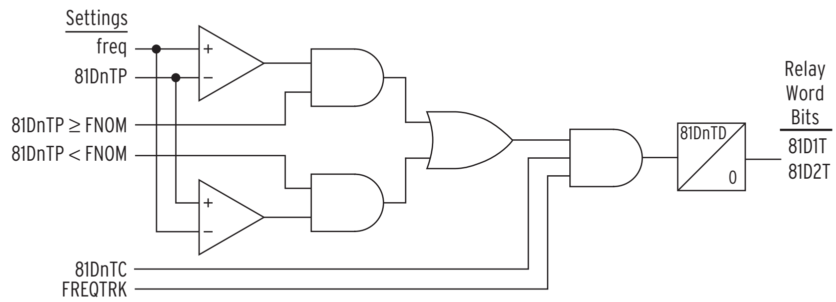
Frequency Elements

NOTE: The relay measures system frequency for these elements with the phase voltages, if the voltage input option is present and the voltage is greater than 5 volts for at least three cycles. Otherwise, the relay uses phase currents if the magnitude is above 4.4/SRF (see Table 4.2 for SRF details). The measured frequency is set to nominal frequency setting (FNOM) if all the signals are below the minimum level.

The SEL-849 provides two trip over- or underfrequency elements with independent level, time-delay, and torque-control 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 4.45* shows the logic diagram for the frequency elements.

Table 4.35 Frequency Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Frequency Trip Level 1	OFF, 15.00–70.00 Hz	81D1TP := OFF
Frequency Trip Delay 1	0.1–240.0 sec	81D1TD := 1.0
Frequency Torque Control 1	SELOGIC	81DTC := 1
Frequency Trip Level 2	OFF, 15.00–70.00 Hz	81D2TP := OFF
Frequency Trip Delay 2	0.1–240.0 sec	81D2TD := 1.0
Frequency Torque Control 2	SELOGIC	81D2TC := 1



n = Frequency Elements 1–2
freq = Measured Frequency
81DnTP = Frequency Pickup Setting
FNOM = Nominal Frequency Setting
81DnTD = Over- and Underfrequency Element Pickup Time Delay
81DnT = Definite-Time Delayed Over- and Underfrequency Element Relay Word Bit
81nTC = Frequency Torque Control Setting
FREQTRK = Relay Is Tracking Frequency

Figure 4.45 Over- and Underfrequency Element Logic

Breaker Failure Protection

The SEL-849 provides flexible contactor/breaker failure logic (see *Figure 4.46*). In the default breaker failure logic, assertion of Relay Word bit TRIP starts the breaker failure delay (BFD) timer if the average phase current is above 6.4/SRF (see *Table 4.2* for definition of SRF). If the current remains above 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 EXT_TRIP where Relay Word bit EXT_TRIP is manual trip only and breaker failure initiation is not wanted when the tripping is caused by manual trip.
- ➤ Set 52ABF = Y if you want the logic interlocked with the auxiliary contact of the contactor/breaker. This feature allows you to bypass the IAV current supervision, if desired.

Table 4.36 Breaker Failure Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
52A INTERLOCK	Y, N	52ABF := N
Breaker Failure Delay	0.00–2.00 sec	BFD := 0.25
Breaker Failure Initiate	SELOGIC	BFI := R_TRIG TRIP OR R_TRIG STOP

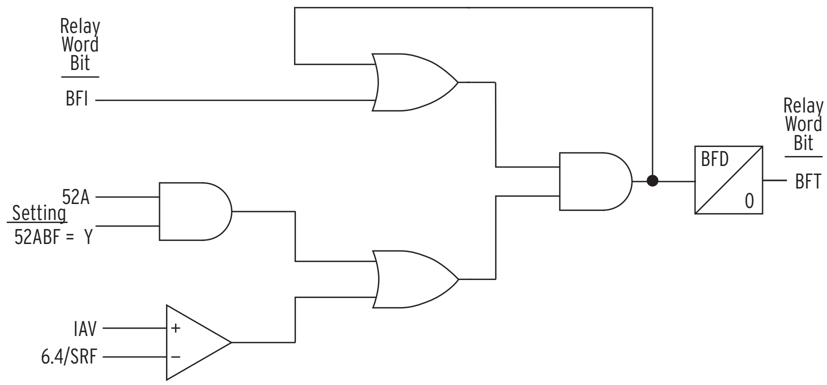


Figure 4.46 Breaker Failure Logic

Arc-Flash Protection

The SEL-849 offers arc-flash protection capability aimed at minimizing the hazards associated with high-energy arc (faults) in metal enclosed and metal-clad switchgear. The system consists of a built-in fiber-optic light sensor that is capable of detecting the high energy arc-flash event and tripping the breaker within milliseconds of the fault. High speed instantaneous overcurrent elements (50PAF and 50GAF) are included to supervise the light sensor for enhanced security against false trips. Use a SELOGIC control equation to route the arc-flash trip to an output to trip the source breaker.

SEL-849 arc-flash protection is exceptionally fast. Typical relay operating times are in the order of 7–13 ms. Fault clearing time will typically be longer, determined by the breaker operating time, which often adds three to five cycles.

Arc-Flash Overcurrent Elements (50PAF, 50GAF)

Table 4.37 shows the settings for the arc-flash instantaneous overcurrent elements. Two elements are provided: the three-phase overcurrent element 50PAF and the residual overcurrent element 50GAF.

Table 4.37 Arc-Flash Protection Settings[a]

Setting Prompt	Setting Range	Setting Name := Factory Default
Arc-Flash Phase OC Trip Level	OFF, 0.5–1280/SRF A[b]	50PAFP := OFF
Arc-Flash Residual OC Trip Level	OFF, 0.5–320/SRF A[c]	50GAFP := OFF

[a] See Table 4.2 for the definition of SRF.
[b] Note that the lower end of setting 50PAFP ≥ MAX(0.5, FLA1).
[c] Note that the lower end of setting 50GAFP ≥ MAX(0.5, 0.25 • FLA1).

NOTE: In addition to the arc-flash settings, you must set an output contact (e.g., see Table 4.43 for default setting of OUT03) and connect it to trip an appropriate upstream breaker.

The arc-flash overcurrent elements use raw A/D converter samples, with the sampling rate of 32 samples per cycle. Individual samples are compared with the setting threshold every millisecond as shown in *Figure 4.47*, followed by a security counter requiring that two samples in a row be above the setting threshold. Although both elements operate on instantaneous current values, additional scaling is applied to present settings in 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 twice 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.

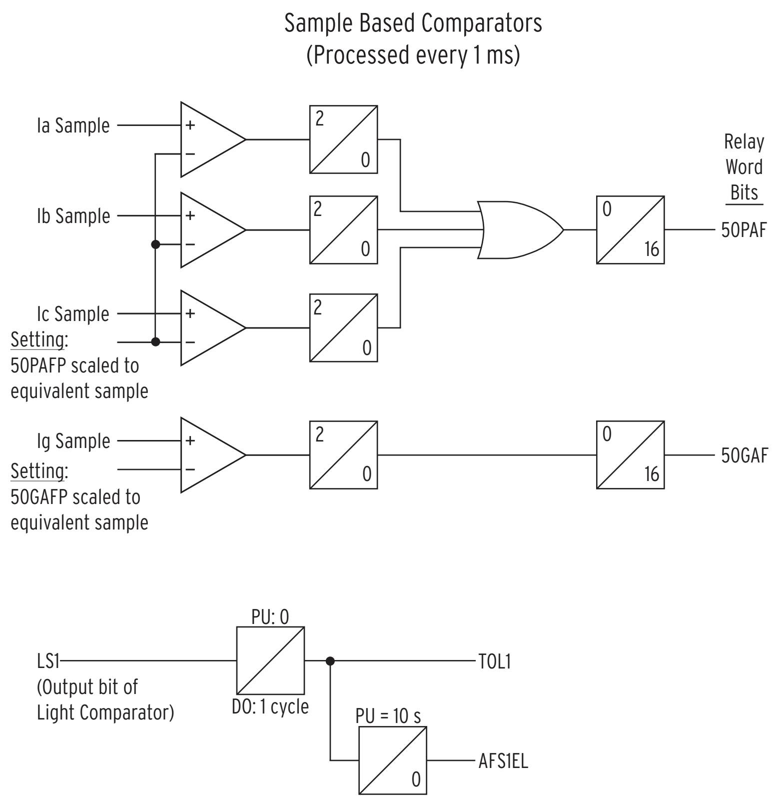


Figure 4.47 Arc-Flash Instantaneous Current/Light Element Logic

The built-in fiber-optic sensor incorporates a wide-angle characteristic to maximize light input, including reflected light when the arc-flash and the sensor locations are not most ideal. The sensor system also includes periodic self-diagnostic (see Relay Word bit AFS1DIAG in *Appendix H: Relay Word Bits*) providing a reliable detection of arc-flash light without any user settings.

Analog Output Settings

This feature is available if the SEL-849 part number includes the analog outputs option. Setting AOAQ identifies the analog quantity assigned to the analog output (when set to OFF, the device hides all associated AO settings and no value appears on the output). You can assign any of the analog quantities listed in *Appendix I: Analog Quantities*. See *Table 4.38* below for the setting prompt, setting range, and factory-default settings for the analog output.

Table 4.38 Analog Output Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
AO Analog Quantity	OFF, Analog Quantity	AOAQ := OFF
AO Analog Qty Low Limit	(–2147483647.000–2147483647.000)	AOAQL := 4
AO Analog Qty High Limit	(–2147483647.000–2147483647.000)	AOAQH := 20
Analog Output Low Limit	0.0–20.0 mA	AOLOVAL := 4
Analog Output High Limit	0.0–20.0 mA	AOHIVAL := 20

For example, let us assume we want to display in the control room the analog quantity IA_MAG (refer to *Appendix I: Analog Quantities*), Phase A current magnitude in primary amperes (0 to 300 A range) using 4 to 20 mA. The display instrument expects 4 mA when the IA_MAG current is 0 A primary and +20 mA when it is 300 A primary. *Figure 4.48* shows the required settings.

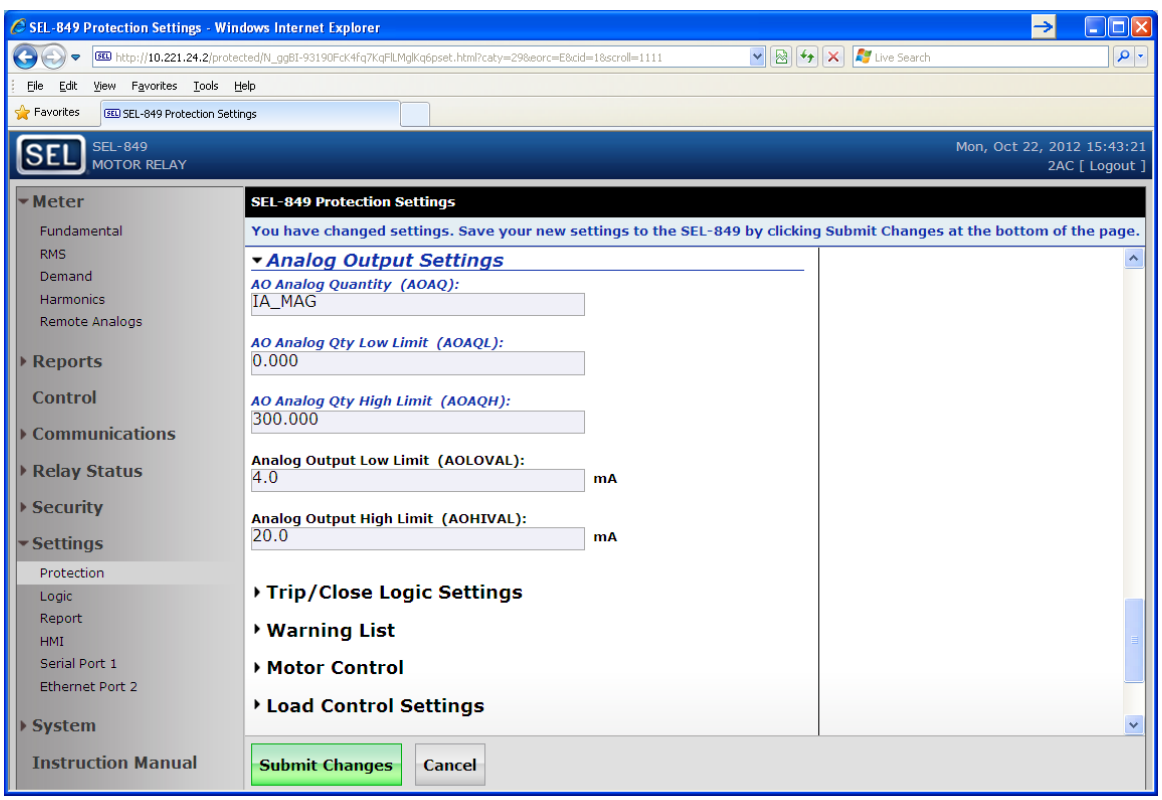


Figure 4.48 Analog Output Settings (Viewed Using Web Browser)

Trip/Close Logic and Motor Control

Trip/Close Logic

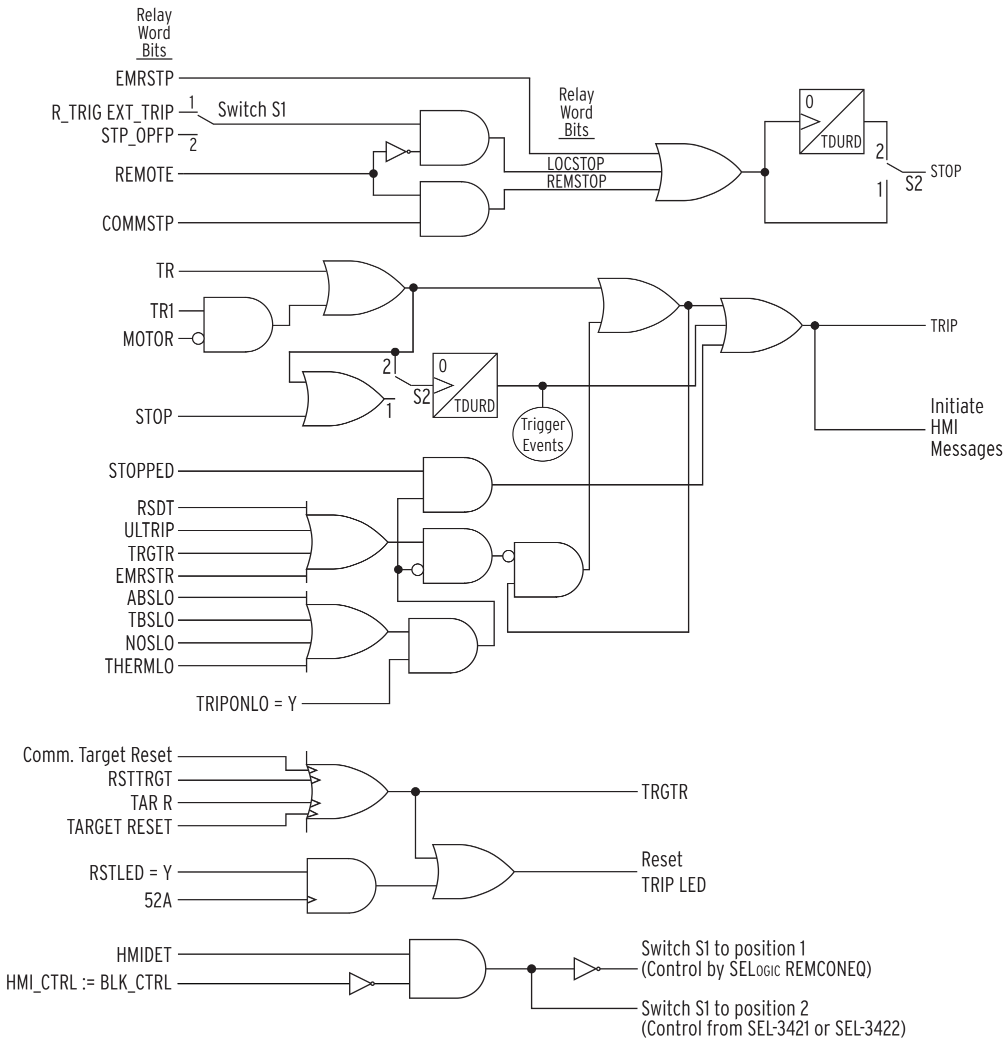
The SEL-849 tripping logic is designed to trip or stop motors energized through circuit breakers or contactors. The relay logic lets you define the conditions that cause a trip, the conditions that unlatch the trip, and the performance of the relay output contact.

Table 4.39 Trip and Close Logic Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Minimum Trip Duration	0.0–400.0 sec	TDURD := 0.1
Protection Trip Equation[a]	SELOGIC	TR := MOTOR AND (49T OR SPDSTR OR SMTRIP OR 46UBT OR LOSSTRIP OR JAMTRIP OR PTCTRIP OR 50N1T OR 50N2T) OR 47T OR TRX
Extended Trip Equation	SELOGIC	TRX := MOTOR AND (27PP1T AND NOT LOP OR 59PP1T OR 55T) OR 81D1T OR 81D2T (Voltage input model shown; TRX := 0 for models without voltage option)
Protection Trip Equation 1	SELOGIC	TR1 := ORED50T OR 51P1T OR 51G1T OR 51QIT OR (50PAF OR 50GAF) AND TOL1
External Trip Equation	SELOGIC	EXT_TRIP := NOT IN03[b]
Unlatch Trip Equation	SELOGIC	ULTRIP := NOT 52A
Emergency Stop	SELOGIC	EMRSTP := HMI_STP
Trip On Lockout	Y, N	TRIPONLO := Y
Trip On Stop	Y, N	TRIPONST := N
Contactor/Breaker Status	SELOGIC	52A := IN01[c]
Contactor Status	SELOGIC	52A_CR := IN01[d]
Breaker Status	SELOGIC	52A_CB := 1[e]
Local Start/Close Equation	SELOGIC	STR_CLEQ := IN04
Remote Start Equation	SELOGIC	REMSTREQ := 0
Block Start/Close Equation	SELOGIC	BSTR_CL := (TRIP OR STOP OR RSACTIVE) AND NOT RSDT
Emergency Start	SELOGIC	EMRSTR := 0

[a] TR equation needs to include Relay Word bit TRX for the SELOGIC equation TRX to extend the SELOGIC equation TR.
[b] The default setting of EXT_TRIP := IN03 when APP := FEEDER.
[c] 52A is automatically set to IN01 or IN01 OR IN02 if FACTLOG := Y and to 52A_CR AND 52A_CB if FACTLOG := N.
[d] The default setting of 52A_CR := 1 when APP := FEEDER.
[e] The default setting of 52A_CB := IN01 when APP := FEEDER.

Figure 4.49 illustrates the tripping logic. The trip logic settings, including the SELOGIC control equations, are described on the following pages.



STP_OPFP = Stop/Open command from HMI
COMMSTP = Stop/Open Command from communications ports (Serial/Ethernet)
TRGTR = Target Reset Command from all sources
TRIPONLO = Trip On Lockout Setting
STOP = Motor Stop Command, HMI, or Serial Ports
TR, TR1 = Trip SELOGIC Control Equation
ULTRIP = Unlatch Trip SELOGIC Control Equation
REMOTE = Control in Remote Mode
RSTTRGT = Reset Targets SELOGIC Control Equation
TAR R = Serial Port Target Reset Command
TARGET RESET = Relay Top-panel/HMI TARGET RESET pushbutton
Comm. Target Reset = Target Reset Via Serial/Ethernet Communications Protocol

EMRSTR = Emergency Start SELOGIC control equation
EMRSTP = Emergency Stop SELOGIC control equation
STOPPED = Motor Stopped Relay Word Bit
ABSLO = Antibackspin Lockout
TBSLO = Minimum Time Between Starts Lockout
NOSLO = Starts-Per-Hour Lockout
THERMLO = Thermal Element Lockout
TDURD = Minimum Trip Time Setting
HMIDET = Either SEL-3421 or SEL-3422 is detected
RSDT = Restart Delay Timed Out

Note: Switch S2 is in position 1 if TRIPONST := Y, else Switch S2 is in position 2.

Figure 4.49 Stop/Trip Logic

TDURD Minimum Trip Time

This timer establishes the minimum time duration for which the TRIP Relay Word bit asserts. In addition, it also establishes the minimum time duration for which the STOP Relay Word bit asserts based on the Switch S2 position in *Figure 4.49*. This is a rising-edge initiated timer.

The STOP Relay Word bit is an OR combination of the local stop, LOCSTOP, initiated via the HMI, or the remote stop, REMSTOP, initiated via the serial or Ethernet port. The switch, S2, in *Figure 4.49*, is controlled by the Trip On Stop setting, TRIPONST. If TRIPONST := Y, then S2 is in position 1. In this position the dropout timer in the path of the STOP bit is bypassed and the STOP bit is ORed into the TRIP path. If TRIPONST := N, then S2 is in position 2. In this position the dropout timer is included in the path of the STOP bit and the STOP bit is isolated from the TRIP path.

Set TRIPONST := Y if you intend to generate a TRIP when a Local or Remote STOP is issued. This will trigger an event type, Local or Remote STOP, and also increment the Local or Remote Trip counts, respectively, in the Motor Operating Characteristics report (see *Motor Operating Statistics on page 5.9*). Set TRIPONST := N if you do not intend to generate a TRIP when a Local or Remote STOP is issued.

TR and TR1 Trip Conditions SELOGIC Control Equation

NOTE: The outputs in the SEL-849 are not designed to interrupt the trip coil current. An auxiliary contact with adequate current interrupting capacity must clear the trip coil current before the output of the SEL-849 opens. Failure to observe this safeguard could result in damage to the SEL-849 output contacts. Avoid programming Relay Word bit TR or TR1 in the output equation to directly trip the breaker. Instead, use Relay Word bit TRIP, which stays asserted for at least the duration of the TDURD setting or until TRIP is unlatched, whichever is longer.

The SEL-849 Trip Logic offers two ways to stop the motor by protection elements.

- SELOGIC control equation TR is intended for tripping the contactor that is typically not capable of interrupting short circuit currents. See *Figure 2.12* through *Figure 2.20* for default configuration for various motor connections.
- Use SELOGIC control equation TR1 for the elements requiring interruption of the short circuit currents that are typically used for feeder application (APP := FEEDER, see *Figure 2.17*). Refer to *Figure 2.18* for an example of motor application using a breaker and suggested changes to the settings TR and TR1.

A trip by either of the two 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 **OUT01** set to trip. The fail-safe trip operation is functionally achieved by SELOGIC control equation **OUT01** for the motor applications (APP := MOTOR or VFD). See *Fail-Safe/Nonfail-Safe Tripping on page 2.11* for more information.

EXT_TRIP External Trip SELOGIC Control Equation

The relay allows manual trip/stop of the motor in only one of the following two ways:

- **STOP** pushbutton on HMI
- Contact Input

The relay automatically selects the **STOP** button if the HMI is connected. Use the External Trip setting to assign Contact Input for the trip when the HMI is not used. In any case, the relay must be in Local control mode for manual operation (see *Local/Remote Control on page 4.54*).

ULTRIP Unlatch Trip Conditions SELOGIC Control Equation

Following a fault, the trip signal is maintained until all of the following conditions are true:

NOTE: Factory-default setting of the ULTRIP provides a manual reset of the protection trips. Set the ULTRIP := 1 if you want an automatic reset. You can make the automatic reset by a selected element; for example, set ULTRIP := F_TRIG 49T in a two-wire motor control circuit.

- Minimum trip duration time (TDURD) passes.
- The TR SELOGIC control equation result deasserts to logical 0.
- All the motor lockout functions, described below, deassert to logical 0. This is applicable only if TRONLO, which is described later, is set to Y.
- One of the following occurs:
  - Unlatch Trip SELOGIC control equation setting ULTRIP asserts to logical 1.
  - Target Reset Relay Word TRGTR asserts. The TRGTR is asserted when the top-panel/HMI **TARGET RESET** pushbutton is pressed or a target reset serial port command is executed (ASCII, Ethernet, Modbus, or Target Reset SELOGIC control equation setting RSTTRGT asserts to logical 1).
  - An emergency restart command is executed or the EMRSTR SELOGIC control equation setting asserts to logical 1.

Lockout After Stop

When the motor is stopped, the relay automatically locks out the motor by asserting the trip signal under any of the following conditions if the Trip On Lockout setting (TRIPONLO) is set to Y. The trip signal is maintained until all the enabled motor lockout conditions are satisfied. TRIP deasserts once all the lockout conditions are cleared.

- **Antibackspin Lockout.** The ABSDLY timer has not expired since the motor trip occurred. The trip signal is maintained until the ABSDLY timer expires.
- **Minimum Time Between Starts Lockout.** A new start is not permitted until after the minimum time between starts has passed. The trip signal is maintained until a start is permitted.
- **Starts-Per-Hour Limit Lockout.** If the starts-per-hour limit has been met, a new start is not permitted until 60 minutes after the oldest start. The trip signal is maintained until a start is permitted.
- **Thermal Element Lockout.** The motor thermal element % Thermal Capacity Used value is too high to permit a normal motor start without tripping. The trip signal is maintained until the % Thermal Capacity decreases to a level where a start can safely take place (see *Figure 4.50* for details).

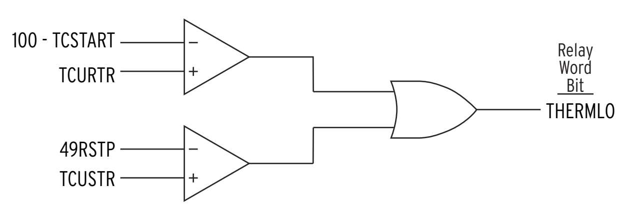


Figure 4.50 Thermal Element Lockout Logic

Set TRIPONLO = N if you want to disable the automatic assertion of Trip described previously. The motor start is blocked if any of the enabled lockout conditions are present (see *Figure 4.52*).

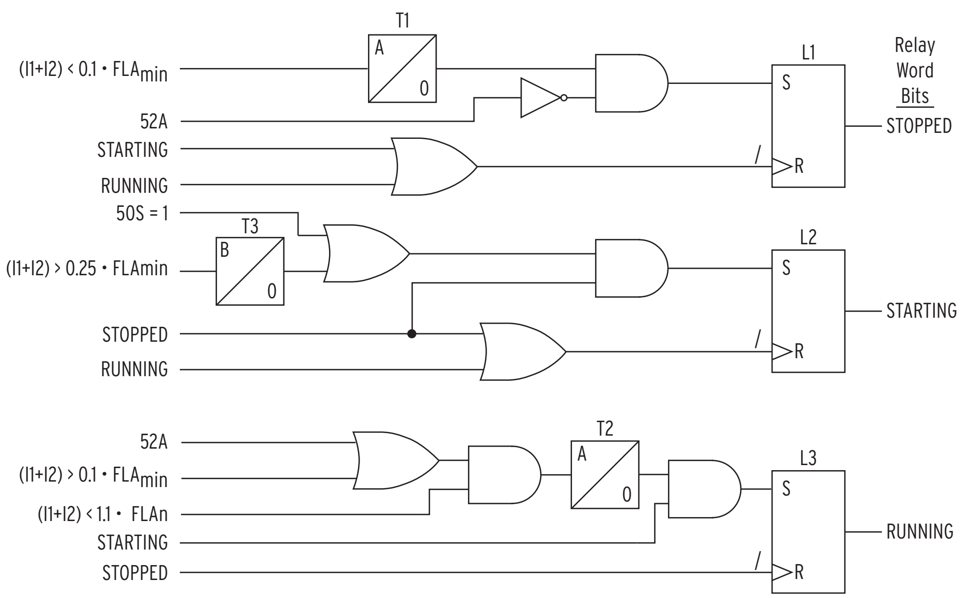
52A, 52A_CR, and 52A_CB Contactor/Breaker Status Conditions SELOGIC Control Equations

The 52A setting is always set automatically by the relay and hidden. The 52A_CR and 52A_CB settings are only set automatically when FACTLOG := Y.

Connect an auxiliary contact of the contactor or the breaker to the relay. Digital input IN01 or IN01/IN02 is assigned to the equation 52A by default depending on the Starter Type selected. See *Figure 2.12* through *Figure 2.20* for connection diagrams. When FACTLOG := N, the relay automatically sets 52A = 52A_CR AND 52A_CB.

You can change the 52A_CR and 52A_CB factory-default logic equations to suit your application when FACTLOG := N. Set 52A_CR to assert when the motor contactor closes. Likewise, set 52A_CB to assert when the circuit breaker closes. If the configuration does not include either a contactor or a breaker, set the appropriate equation to 1 (e.g., 52A_CB = 1 if the configuration does not include a breaker).

Appropriate control inputs for the 52A_CR and/or 52A_CB are required for proper operation when Starter Type selected is FVR, 2SPEED, or STAR_D. For Starter Type FVNR it enhances the motor state logic (see *Figure 4.51*). This is particularly important if the motor has low operational idling current (less than 10 percent FLA). Additionally, 52A, in conjunction with setting RSTLED := Y, resets the targets on the rising edge of 52A automatically (see *Figure 4.49*).



FLAn = Effective full-load current (n is 1 or 2 for Speed 1 or Speed 2)
FLA_{min} = Higher of 6.4/SRF and 0.5
I1, I2 = Positive-/negative-sequence motor current
Exception: (I1 + I2) = average magnitude of filtered phase currents for VFD applications

T1, T2, and T3 are timers with pickup times as follows:
If setting ERESTART = N, A = 300 ms and B = 50 ms
If setting ERESTART = Y, A = 30 ms and B = 20 ms
L1, L2, and L3 are Latches
/ indicates reset on rising edge of the Reset input
50S, 52A are Relay Word bits

See Table 4.2 for the definition of SRF.

Figure 4.51 Motor State Logic

Control

You can customize control features of the SEL-849 through the use of the settings described below (see *Table 4.40* through *Table 4.43*). Many of the settings are automatically set to the most appropriate default shown and hidden. To change the hidden setting, you must first set Factory Logic = N.

Table 4.40 Motor Control Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Remote Control Equation	SELOGIC	REMCONEQ := IN06
Speed 2	SELOGIC	SPEED2 := ((SPD2FP OR IN05) AND NOT RUNNING) OR (SPEED2 AND RUNNING)
Speed Switch	SELOGIC	SPEEDSW := 0
VFD Bypass	SELOGIC	VFDBYPAS := IN05

Table 4.41 Load Control Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Load Control Select	OFF, Current, TCU	LOAD := OFF
Load Control Upper Limit	OFF, 0.20–2.00 xFLA	LOADUPP := OFF
Load Control Lower Limit	OFF, 0.20–2.00 xFLA	LOADLOWP := OFF
Load Control Upper Limit	OFF, 1–99 %TCU	LOADUPP := OFF
Load Control Lower Limit	OFF, 1–99 %TCU	LOADLOWP := OFF

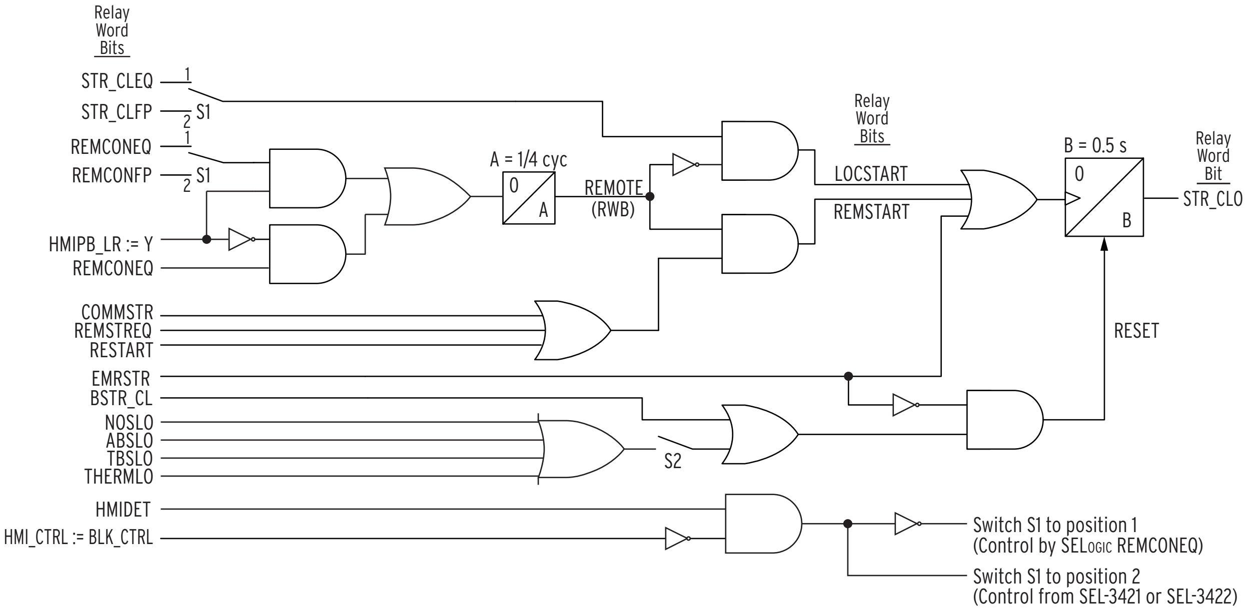
Local/Remote Control

Figure 4.52 shows the logic the relay uses to initiate motor starts. At any one time, the SEL-849 can be in either Local or Remote mode for manual Start/Close and Stop/Trip controls. The HMI (SEL-3421 or SEL-3422) is the Local control location. Local mode is required for the HMI **START/STOP** pushbuttons to be effective. The control mode can be selected using one of the following:

NOTE: When FACTLOG := Y, the REMCONEQ is set to the default value and is hidden.

- Local/Remote pushbutton on the HMI when the pushbutton is enabled and control is not blocked by settings (HMIPB_LR = Y and HMI_CTRL = ACK_EN or ACK_DIS).
- SELOGIC control equation REMCONEQ when the pushbutton is disabled or when the control is blocked (setting HMIPB_LR := N or HMI_CTRL := BLK_CTRL). The control mode is solely selected by SELOGIC control equation REMCONEQ when no HMI is detected (HMIDET := 0).

By default, the Local/Remote button is enabled, the HMI control is not blocked, and REMCONEQ is set to a contact input. Change the default settings to suit your specific control strategy. See *Section 8: Human-Machine Interface (HMI)* for a description of the HMI (SEL-3421 and SEL-3422). In any case, the relay must be in Local control mode (Relay Word bit REMOTE := 0) for manual operation (e.g., START or STOP via HMI pushbuttons) and in Remote control mode (Relay Word bit REMOTE := 1) for remote control operation (e.g., serial/Ethernet, autorestart, etc.). Use Local control mode for personnel safety, (e.g., during equipment maintenance operations). The emergency stop/restart and protection operations are not affected by the control mode.



Notes:
- HMIDET = 1 if either the SEL-3421 or SEL-3422 is connected to the SEL-849, else HMIDET = 0.
- STR_CLEQ = Local Start/Close SELOGIC control equation setting.
- STR_CLFP = Start/Close command from HMI (SEL-3421 or SEL-3422).
- REMCONEQ = Remote Control SELOGIC control equation setting.
- REMCONFP = Remote Control selected from HMI (SEL-3421 or SEL-3422).
- HMIPB_LR = HMI LOCAL/REMOTE pushbutton enable setting.
- COMMSTR = Start/Close command from communications ports (Serial or Ethernet).
- REMSTREQ = Remote Start SELOGIC control equation setting.
- EMRSTR = Emergency Restart SELOGIC control equation setting.
- RESTART and EMRSTR := 0 if APP := FEEDER.
- BSTR_CL is Block Start/Close SELOGIC control equation setting.
- Switch S2 is closed if APP := MOTOR or VFD and open if APP := FEEDER.
- THERMLO = Motor lockout condition due to stator or rotor TCU being too high.
- TBSLO = Motor lockout condition driven by minimum time-between-starts function.
- ABSLO = Motor lockout condition driven by minimum motor-stopped time (anti-backspin) function.
- NOSLO = Motor lockout condition driven by starts-per-hour function.

Figure 4.52 Start/Close Logic

Start/Stop Control

The relay allows manual Start/Stop of the motor in either of the following two ways.

- **START**/**STOP** pushbuttons on HMI
- Contact inputs (via SELOGIC settings STR_CLEQ, REMSTREQ, EXT_TRIP)

NOTE: EXT_TRIP and STR_CLEQ are set to default values and are hidden when FACTLOG := Y.

The relay automatically uses the **START**/**STOP** pushbuttons if the HMI is connected and the HMI control is enabled (HMI_CTRL is not set to BLK_CTRL). Use External Trip (EXT_TRIP) and Local Start/Close control equation (STR_CLEQ) settings to assign a contact input for the trip/start when either the HMI is not connected or the HMI is connected and the HMI control is disabled (HMI_CTRL is set to BLK_CTRL).

Set the Emergency Stop SELOGIC control equation (EMRSTP) to stop the motor irrespective of the control mode (Local/Remote, etc.). For example, to convert an SEL-3421 (or SEL-3422) **STOP** pushbutton from Normal to Emergency Stop operation, set the HMI STOP pushbutton setting (see *Table 4.58* and *Figure 4.62* for additional detail) to EMERGENCY and the setting EMRSTP to HMI_STP.

Use the Remote Start control equation (REMSTREQ) to start from a remote location, e.g., contact input.

NOTE: Emergency Start and Stop (EMRSTR and EMRSTP) bypass all Block Control constraints including the Local/Remote control mode.

The Block Start/Close control equation (BSTR_CL) should include conditions under which a start/close is not desirable. When the setting APP := MOTOR or VFD, the Switch S2 in *Figure 4.52* is closed so as to OR all four lockout conditions (THERMLO, TBSLO, ABSLO, and NOSLO) with the BSTR_CL SELOGIC equation. When APP := FEEDER, the Switch S2 is open and none of the lockouts are processed. Use the SELOGIC control equation EMRSTR for Emergency Start.

Speed Controls

You can assign any control input to the SELOGIC control equations SPEED2 and SPEEDSW. For Two Speed and Full Voltage Reversing motor applications (STARTRTY = 2SPEED or FVR) when Relay Word bit SPEED2 is asserted, the SEL-849 selects second values for the settings shown in *Table 4.42*. See *Table 4.1* and *Table 4.5* for full description of various settings. You can also use the 2SPEED feature in applications where ambient temperature varies appreciably (e.g., exposed water pumps with different capacities during daytime and at night).

The SPEEDSW control input provides an indication of the rotor speed to the speed switch logic shown in *Figure 4.37*.

In VFD applications, connect auxiliary contact of the bypass switch (if used) to the input assigned to setting VFD Bypass (VFDBYPAS). The relay automatically switches from rms to fundamental magnitudes of the currents for various protection elements when the VFD is bypassed.

Table 4.42 Settings Selected by SPEED2 Input

Setting Description	Normal Setting Prompt (Normal Setting Name)	Second Setting Prompt (Second Setting Name)
Phase CT Ratio	PHASE CT RATIO 1 (CTR1)	PHASE CT RATIO–2nd (CTR2)
Full-Load Current	FULL LOAD AMPS (FLA1)	FULL LOAD AMPS–2nd (FLA2)
Locked Rotor Current	LOCKED ROTOR AMPS (LRA1)	LOCKED ROTOR AMPS–2nd (LRA2)
Hot-Locked Rotor Time	LOCKED ROTOR TIME (LRTHOT1)	LOCKED ROTOR TIME–2nd (LRTHOT2)
Acceleration Factor	ACCELERATION FACTOR (TD1)	ACCELERATION FACTOR–2nd (TD2)
Run State Time Constant	STATOR TIME CONSTANT (RTC1)	STATOR TIME CONSTANT–2nd (RTC2)
Overload Curve Number	THERMAL OVERLOAD CURVE (CURVE1)	THERMAL OVERLOAD CURVE–2nd (CURVE2)

Load Control Function

The SEL-849 provides an ability to control external devices based on the parameter load control selection. You can select current or stator thermal capacity utilized to operate auxiliary outputs. Load control is active only when the motor is in the running state.

NOTE: In addition to setting the load control levels, you must assign LOADUP and LOADLOW to auxiliary output relays (one each); see Table 4.43 and Digital Outputs (1 Form C and 3 Form A) Connections (Terminal Block E) on page 2.10 for details.

When the selected parameter exceeds the load control upper setting level for one second, the auxiliary relay assigned to LOADUP will operate. The auxiliary relay will reset when the parameter drops below the upper level setting for one second.

When the selected parameter drops below the load control lower setting level for one second, the auxiliary relay assigned to LOADLOW will operate. The auxiliary relay will reset when the parameter is above the lower-level setting for one second. You can use this feature to control the motor load within set limits.

Output Settings

The SEL-849 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 as in *Figure 2.16*.

When fail-safe setting is set to Y on the TRIP output and the TRIP contact is appropriately connected to the motor breaker or contactor, the motor is automatically tripped when relay control power fails. This setting/connection philosophy is appropriate if the protected motor is more valuable than the process that the motor supports.

In critical applications where the protected motor is not more valuable than the process, you may want the motor to run even if the relay is out of service. In this case, set fail-safe setting to N on TRIP output. In addition, you can select any of the auxiliary outputs to be fail-safe or nonfail-safe, according to what you need for your application.

NOTE: OUT01 is the default trip output. It is hidden when the factory logic setting (FACTLOG) is set equal to Y. Refer to the settings sheets, available at selinc.com, for the output settings hide rules.

Table 4.43 Control Output Equations and Contact Behavior Settings

Setting Prompt	Setting Range	Setting Name := Factory Default[a]
OUT01 Fail-Safe	Y, N	OUT01FS := N
OUT01	SELOGIC	OUT01 := (STR_CLO OR (OUT01 AND (NOT STOPPED OR 52A))) AND NOT (TRIP OR STOP)
OUT02 Fail-Safe	Y, N	OUT02FS := N
OUT02	SELOGIC	OUT02 := 0
OUT03 Fail-Safe	Y, N	OUT03FS := N
OUT03	SELOGIC	OUT03 := (50PAF OR 50GAF) AND TOL1
OUT04 Fail-Safe	Y, N	OUT04FS := Y
OUT04	SELOGIC	OUT04 := HALARM OR SALARM

[a] Default settings shown are for FACTLOG = Y, APP = MOTOR, and STARTRTY = FVNR. The relay automatically changes the default settings as follows when the APP and or STARTRTY setting is changed.
When STARTRTY := FVR or 2SPEED,
OUT01 := ((STR_CLO AND NOT SPEED2) OR (OUT01 AND (NOT STOPPED OR 52A))) AND NOT (TRIP OR STOP)
OUT02 := ((STR_CLO AND SPEED2) OR (OUT02 AND (NOT STOPPED OR 52A))) AND NOT (TRIP OR STOP)
When APP := FEEDER,
OUT01 := TRIP OR STOP
OUT02 := STR_CLO
When STARTRTY := STAR_D,
OUT02 := DELTA AND 52A
OUT03 := STAR AND 52A

Warning List

Enter as many as 24 Relay Word bits. The Warning List entries (**SET WARN** command) are Text-Edit mode settings with line number prompts. The available Text-Edit Mode actions are shown in the following table.

Table 4.44 Text-Edit Mode Actions (Sheet 1 of 2)

Action	Control Response
<Enter>	Accept the setting and move to the next line; if at the last line or at a blank line, exit settings.
>*n* <Enter>	Move to line *n*. If this is beyond the end of the list, move to a blank line following the last line.

Table 4.44 Text-Edit Mode Actions (Sheet 2 of 2)

Action	Control Response
^ <Enter>	Move to the previous line; if at the first line, stay at the present line.
< <Enter>	Move to the first line.
> <Enter>	Move to a blank line following the last line.
LIST <Enter>	List all settings and return to the present action prompt.
DELETE [*n*] <Enter>	Delete the present line and subsequent lines for a total of *n* lines; *n* = 1 if not provided. Lines after deletion shift upward by the number of lines deleted.
INSERT <Enter>	Insert a blank line at the present location; the present line and subsequent lines shift downward.
END <Enter>	Go to the end of the present settings session. Prepare to exit settings via the `Save settings (Y,N)?` prompt.
<Ctrl+X>	Abort editing session without saving changes.

Table 4.45 Warning List Factory-Default Settings

Line Number	Default Factory Settings
1:	49A
2:	LOSSALRM
3:	JAMALRM
4:	46UBA
5:	SPDSAL
6:	PTCFLT
7:	AFSIEL

The SEL-3421 Motor Relay HMI will use the Relay Word bit alias to display the warning message when the Relay Word bits in the Warning List settings have a corresponding Alias setting under the Report settings.

For example, if ALIAS01 := 49A THERMAL_ALARM PICKUP DROPOUT, then the SEL-3421 Motor Relay HMI will display THERMAL_ALARM when 49A asserts.

Time and Date Management Settings

The SEL-849 supports several methods of updating the relay time and date. For SNTP applications, refer to *Simple Network Time Protocol (SNTP) on page 7.15*. *Table 4.46* shows the time and date management settings.

Table 4.46 Time and Date Management Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Offset From UTC	–24.00 to 24.00 hours	UTC_OFF := 0.00
Month To Begin DST	NA, 1–12	DST_BEGM := NA
Week of the Month To Begin DST	1–3, L (L = last)	DST_BEGW := 2
Day of the Week To Begin DST	SUN–SAT	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 (L = last)	DST_ENDW := 1
Day of the Week To End DST	SUN–SAT	DST_ENDD := SUN
Local Hour To End DST	0–23	DST_ENDH := 2

Coordinated Universal Time (UTC) Offset Setting

The SEL-849 has a Time and Date Management setting, UTC_OFF, settable from –24.00 to 24.00 hours, in 0.25 hour increments. The relay HTTP/HTTPS (Web) Server uses the UTC_OFF setting to calculate UTC timestamps in request headers.

The relay also uses the UTC_OFF setting to calculate local (relay) time from the UTC source when configured for Simple Network Time Protocol (SNTP) updating via Ethernet. When a time source other than SNTP is updating the relay time, the UTC_OFF setting is not considered because the other time sources are defined as local time.

Automatic Daylight-Saving Time Settings

The SEL-849 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-849 will change to and from daylight-saving time every year at the specified time. Device Word bit DST asserts when daylight-saving time is active.

The SEL-849 interprets the week number settings DST_BEGW and DST_ENDW (1–3, L = Last) as follows:

- ➤ The first seven days of the month are considered to be in week 1.
- ➤ The second seven days of the month are considered to be in week 2.
- ➤ The third seven days of the month are considered to be in week 3.
- ➤ The last seven days of the month are considered to be in week “L”.

This method of counting of the weeks allows easy programming of statements like “the first Sunday”, “the second Saturday”, or “the last Tuesday” of a month.

As an example, consider the following settings:

DST_BEGM = 3	DST_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.

Simple Network Time Protocol (SNTP)

The SEL-849 Port 2 (Ethernet Port) supports the SNTP Client protocol. See *Section 7: Communications*, *Simple Network Time Protocol (SNTP) on page 7.15* for a description and *Table 7.10* for the settings.

Demand Meter Settings

The SEL-849 provides demand and peak demand metering, selectable between thermal and rolling demand types, for the IA, IB, and IC phase currents (A primary).

Table 4.47 shows the demand metering settings. Also refer to *Section 5: Metering and Monitoring* and *Section 7: Communications* for other related information regarding the demand meter.

Table 4.47 Demand Metering Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Enable Demand Meter	THM, ROL	EDEM := THM
Demand Time Constant	5, 10, 15, 30, 60 min	DMTC := 5
Phase Current Demand Level	OFF, 0.1–200.0 A	PHDEMP := OFF

The demand current level settings are applied to demand current meter outputs as shown in *Figure 4.53*.

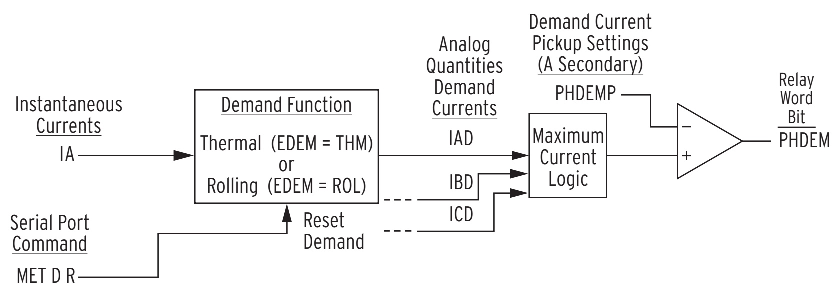


Figure 4.53 Demand Current Logic Outputs

For example, when phase A current goes above corresponding demand pickup PHDEMP, Relay Word bit PHDEM asserts to logical 1. Use the demand current logic output, PHDEM, 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 4.54* 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").

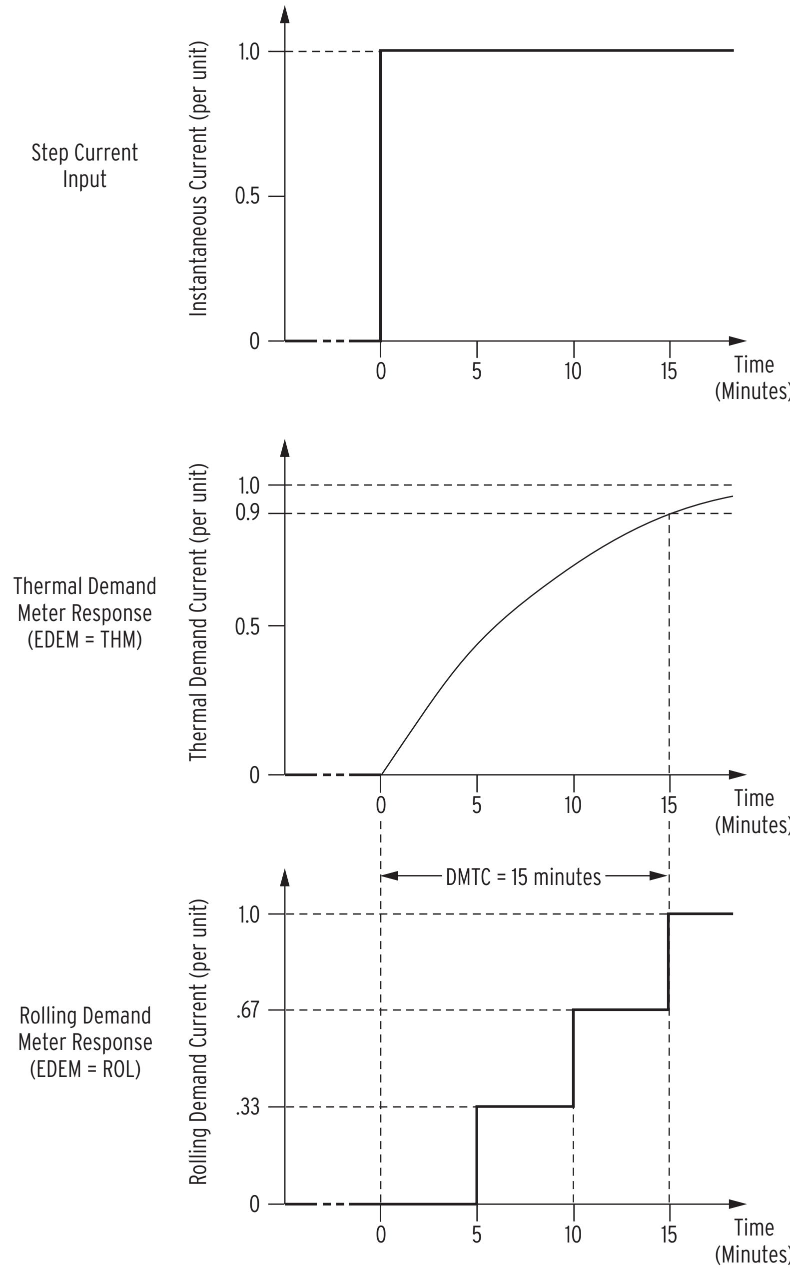


Figure 4.54 Response of Thermal and Rolling Demand Meters to a Step Input (Setting DMTC = 15 minutes)

Thermal Demand Meter Response

The response of the thermal demand meter in *Figure 4.54* (middle) to the step current input (top) is analogous to the series RC circuit in *Figure 4.55*.

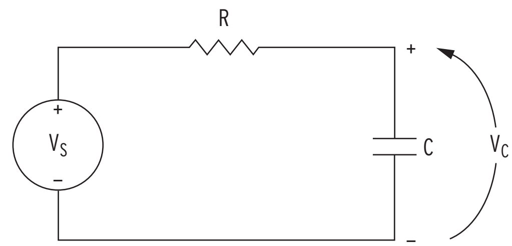


Figure 4.55 Voltage V_S Applied to Series RC Circuit

In the analogy:

- Voltage V_S in *Figure 4.55* corresponds to the step current input in *Figure 4.54* (top).
- Voltage V_C across the capacitor in *Figure 4.55* corresponds to the response of the thermal demand meter in *Figure 4.54* (middle).

If voltage V_S in *Figure 4.55* has been at zero (V_S = 0.0 per unit) for some time, voltage V_C across the capacitor in *Figure 4.55* 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 4.53* (middle) to the step current input (top).

In general, as voltage V_C across the capacitor in *Figure 4.55* 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 4.47*). Note in *Figure 4.54*, 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-849 updates thermal demand values approximately every second.

Rolling Demand Meter Response

The response of the rolling demand meter in *Figure 4.54* (bottom) to the step current input (top) is calculated with a sliding time-window arithmetic average calculation. The width of the sliding time-window is equal to the demand meter time constant setting DMTC (see *Table 4.47*). Note in *Figure 4.54*, the rolling demand meter response (bottom) is at 100 percent (1.0 per unit) of full applied value (1.0 per unit) after a time period equal to setting DMTC = 15 minutes, referenced to when the step current input is first applied.

The rolling demand meter integrates the applied signal (e.g., step current) input in five-minute intervals. The integration is performed approximately every second. The average value for an integrated five-minute interval is derived and stored as a five-minute total. The rolling demand meter then averages a number of the five-minute totals to produce the rolling demand meter response. In the *Figure 4.54* example, the rolling demand meter averages the three latest five-minute totals because setting DMTC = 15 (15/5 = 3). The rolling demand meter response is updated every five minutes, after a new five-minute total is calculated.

The following is a step-by-step calculation of the rolling demand response example in *Figure 4.54* (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.

Data Reset and Alarm Settings

Table 4.48 shows the data reset and alarm settings. The RSTTRGT SELOGIC setting, on the rising edge of assertion, resets the trip output and relay top-panel **HMI TRIP** LED, provided there is no trip condition present.

The RSTENRGY and RSTMXMN settings reset the Energy and Max/Min metering values, respectively. Use the RSTMOT setting to reset the motor statistics and the motor start reports. The RSTDEM setting resets demand and peak demand. See *Figure 4.53* for the demand current logic diagram. You should assign a contact input (for example, RSTTRGT := IN04) to each of these settings if you want remote reset.

Program software alarm conditions into SALARM SELOGIC setting. Refer to *Table 4.48* for the factory-default SALARM setting. Program reset hardware alarm condition into RST_HAL SELOGIC setting.

Table 4.48 Data Reset and Alarm Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Reset Targets	SELOGIC	RSTTRGT := R_TRIG STR_CLO
Reset Energy	SELOGIC	RSTENRGY := 0
Reset Max/Min	SELOGIC	RSTMXMN := 0
Reset Motor Statistics	SELOGIC	RSTMOT := 0
Reset Demand	SELOGIC	RSTDEM := 0
Software Alarm Conditions[a]	SELOGIC	SALARM := BADPASS OR CHGPASS OR SETCHG OR ACCESSP OR PASNVAL
Reset Hardware Alarm	SELOGIC	RST_HAL := 0

[a] The SALARM bit pulses for 1 second when the SEL-3421/3422 Motor Relay HMI is connected to the relay because the HMI enters Access Level 2. The SALARM bit also pulses when the relay powers up.

Logic Settings (SET L Command)

Settings associated with latches, timers, counters, math variables, and output contacts are listed below.

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 4.49 Enable Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
SELOGIC Latches	N, 1–8	ELAT := N
SV Timers	N, 1–8	ESV := N
SELOGIC Counters	N, 1–8	ESC := N
Math Variables	N, 1–8	EMV := N

SV/Timers Settings

The SEL-849 includes eight SELOGIC variables. *Table 4.50* shows the pickup, dropout, and equation settings for SV01 and SV02. The remaining SELOGIC variables have the same default settings as SV02.

Table 4.50 SELOGIC Variable Settings

Setting Prompt	Setting Range	Default Settings
SV INPUT	SELOGIC	SV01 := NA
SV TIMER PICKUP	0.00–3000.00	SV01PU := 0.00
SV TIMER DROPOUT	0.00–3000.00	SV01DO := 0.00
SV INPUT	SELOGIC	SV02 := NA
SV TIMER PICKUP	0.00–3000.00	SV02PU := 0.000
SV TIMER DROPOUT	0.00–3000.00	SV02DO := 0.000
• • •		

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-849 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 4.50*). 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).

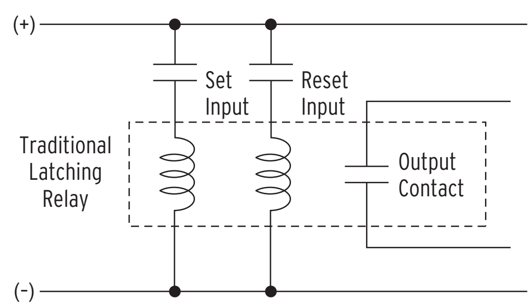


Figure 4.56 Schematic Diagram of a Traditional Latching Device

Eight latch control switches in the SEL-849 provide latching device functionality. *Figure 4.57* shows the logic diagram of a latch switch. The output of the latch control switch is a Relay Word bit LT*n* (*n* = 01–08), called a latch bit.

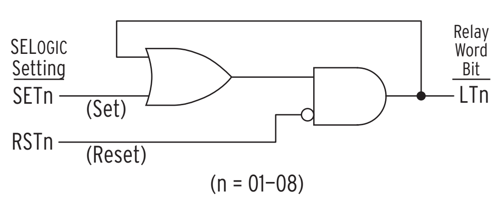


Figure 4.57 Logic Diagram of a Latch Switch

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-849 includes eight latches. *Table 4.51* shows the **SET** and **RESET** default settings for Latch 1. The remaining latches have the same settings.

Table 4.51 Latch Bits Equation Settings

Settings Prompt	Setting Range[a]	Setting Name := Factory Default
SET01	SELOGIC	SET01 := NA
RST01	SELOGIC	RST01 := NA
•	•	•
•	•	•
•	•	•
SET08	SELOGIC	SET08 := NA
RST08	SELOGIC	RST08 := NA

[a] As many as 15 elements are allowed in each SELOGIC equation.

Latch Bits: Nonvolatile State

Power Loss

The states of the latch bits (LT01–LT08) 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 stays asserted (LT02 := logical 1) when power is restored. If a latch bit is deasserted (e.g., LT03 := logical 0) when power is lost, it stays 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–LT08) are retained, as in the preceding *Power Loss* explanation. If the individual settings change causes a change in SELOGIC control equation settings SET*n* or RST*n* (*n* = 1–08), 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 fixed pickup and dropout debounce delay of 8 ms 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 4.58*. Timers SV01T–SV08T in *Figure 4.58* 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* = 1–08).

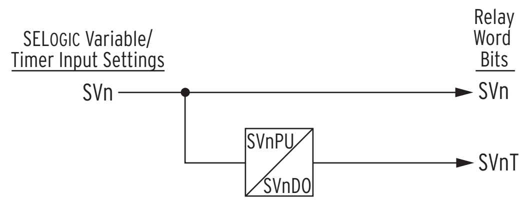


Figure 4.58 SELOGIC Control Equation Variable/Timers SV01/SV01T–SV08T

You can enter as many as 15 elements per SELOGIC control equation, including a total of 14 elements in parentheses (see *Table 4.52* 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 4.52*. Math SELOGIC control equation settings operate on numerical values, using one or more of the Mathematical operators listed in *Table 4.52*. These numerical values can be mathematical variables or actual real numbers.

The executed result of a math SELOGIC control equation is stored in a math variable. The smallest and largest values a math variable can represent are –16777215.99 and +16777215.99, respectively. If the executed result exceeds these limits, it will be clipped at the limit value. For example, when the MV01 := executed result is –16777219.00, MV01 will be –16777215.99. Similarly, when the MV02 := executed result is +16777238.00, MV02 will be +16777215.99.

Operator Precedence

When you combine several operators and operands within a single expression, the SEL-849 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 4.52 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 IN02) AND (PB01_LED OR RB01)**

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 OUT01 setting could be set as follows:

OUT01 := **NOT(RB01 OR SV02)**

If both RB01 and SV02 are deasserted (= logical 0), output contact OUT01 asserts, i.e., OUT01 := 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 * IN01 + (MV01 + 1) * NOT IN01**

This equation sets MV01 to 12 whenever IN01 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 IN01 OR R_TRIG IN02**

The rising-edge operators detect a logical 0 to logical 1 transition each time one of IN01 or IN02 asserts. Using these settings, the device triggers a new event report each time IN01 or IN02 asserts, 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 4.59*.

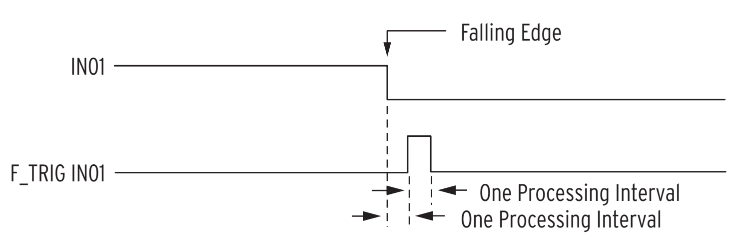


Figure 4.59 Result of Falling-Edge Operator on a Deasserting Input

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

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

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

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

Comparisons are mathematical operations that compare two numerical values, with the result being a logical 0 (if the comparison is not true) or logical 1 (if the comparison is true). Thus, what starts out as a mathematical comparison ends up as a Boolean resultant.

For example, if the output of a math variable is above a certain value, an output contact is asserted:

OUT03 := **MV01 > 8**

If the math variable (MV01) is greater than 8 in value, output contact OUT03 asserts (OUT03 = logical 1). If the math variable (MV01) is less than that or equal to 8 in value, output contact OUT03 deasserts (OUT03 = logical 0).

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

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

OUT02 := **MV01 <> 45**

If the math variable (MV01) is not equal to 45 in value, output contact OUT02 asserts (effectively OUT02 := logical 1). If the math variable (MV01) is equal to 45 in value, output contact OUT02 deasserts (effectively OUT02 := logical 0). *Table 4.53* shows other operators and values that you can use in writing SELOGIC control equations.

Table 4.53 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* = 01–08) reset to logical 0 after power restoration or a settings change.

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: For device configurations that include either current or voltage cards, the SEL-849 tracks the frequency. When tracking the frequency, the processing interval varies with the frequency.

NOTE: If setting SCnnCD is set to NA, the entire counter nn is disabled.

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 4.60* shows Counter 01, the first of eight counters available in the device.

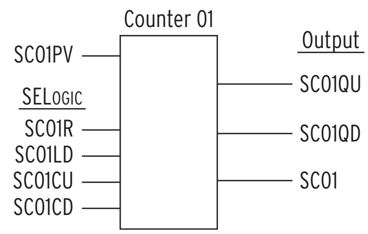


Figure 4.60 Counter01

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 4.54* describes the counter inputs and outputs, and *Table 4.55* shows the order of precedence of the control inputs.

Table 4.54 Counter Input/Output Description

Name	Type	Description
SC*nn*LD	Active High Input	Load counter with the preset value to assert the output (SC*n*QU) (follows SELOGIC setting).
SC*nn*PV	Input Value	This Preset Value is loaded when SC*n*LD pulsed. This Preset Value is the number of counts before the output (SC*n*QU) asserts (follows SELOGIC setting).
SC*nn*CU	Rising-Edge Input	Count Up increments the counter (follows SELOGIC setting).
SC*nn*CD	Rising-Edge Input	Count Down decrements the counter (follows SELOGIC setting).
SC*nn*R	Active High Input	Reset counter to zero (follows SELOGIC setting).
SC*nn*QU	Active High Output	This Q Up output asserts when the Preset Value (maximum count) is reached (SC*n* = SC*n*PV, *n* = 01 to 08).
SC*nn*QD	Active High Output	This Q Down output asserts when the counter is equal to zero (SC*n* = 0, *n* = 01 to 08).
SC*nn*	Output Value	This counter output is an analog value that may be used with analog comparison operators in a SELOGIC control equation and viewed using the **COU** command.

Table 4.55 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 4.61 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 an 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.

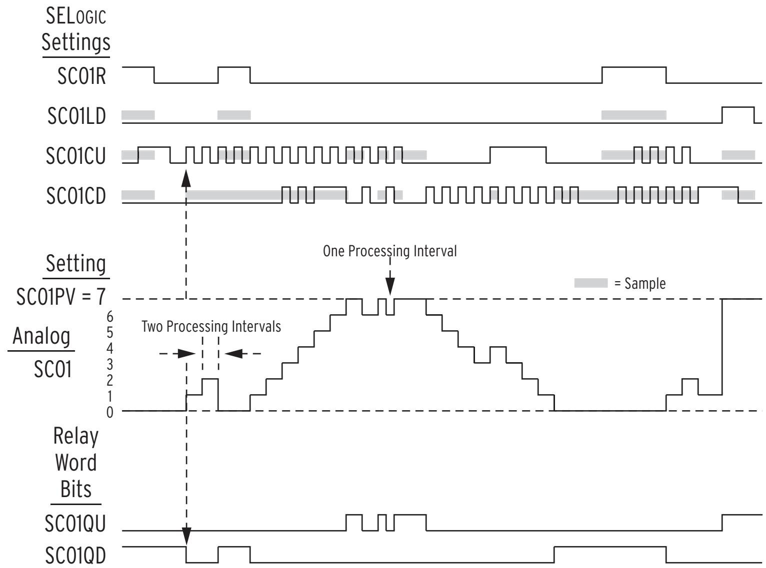


Figure 4.61 Example of the Effects of the Input Precedence

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 *Figure 4.61*, 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).

SELOGIC Math Variables

SELOGIC Math Variables (MV) allows you to enter as many as eight math SELOGIC control equations (see setting EMV, *Table 4.49*). Use any of the available analog quantities, Relay Word bits, and mathematical operators shown in *Table 4.52* to form the equations MV01–MV08. The math variables are processed once every 25 ms and are suitable for control and metering applications.

Port Settings (SET P Command)

The SEL-849 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 1** (top panel) is an EIA-232/EIA-485 port and **Port 2** (side panel) is an Ethernet port. Optionally, you can select **Port 2** as Dual Ethernet or **Port 3** EIA-232/EIA-485 (not both). See *Table 4.56* and *Table 4.57* for the serial port settings. See the appropriate appendix for additional information on communications protocols (DNP3, Modbus, EtherNet/IP, and IEC 61850) of interest.

The EPORT and MAXACC settings provide you with access control for the corresponding port. Setting EPORT to N disables the port and hides the remaining port settings. The MAXACC setting selects the highest level for the port.

PORT 1 or PORT 3

Table 4.56 EIA-232/EIA-485 Port Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Enable Port[a]	Y, N	EPORT := Y
Protocol	SEL, MOD, DNP3	PROTO := SEL
Maximum Access Level[a]	1, 2	MAXACC := 2
Communications Interface	232, 485	COMMINF := 232
Baud Rate	300–57600 bps	SPEED := 9600
Data Bits	7, 8 bits	BITS := 8
Parity	O, E, N	PARITY := N
Stop Bits	1, 2	STOP := 1
Enable Hardware Handshaking	Y, N	RTSCTS := N
Minutes to Port Time-out	0–30 min	T_OUT := 15
Send Auto Messages to Port	Y, N	AUTO := N
Fast Operate Enable	Y, N	FASTOP := N
Modbus Slave Id	1–247	SLAVEID := 1

[a] This setting only applies to Port 3.

Set the communication interface, 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 Time-Out (T_OUT), minutes of inactivity on a serial port above Access Level 0, 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 above Access Level 0. If you do not want the port to time-out, set Port Time-Out equal to 0 minutes.

Set the MAXACC setting accordingly so as to limit the port to a desired access level.

Set PROTO := SEL (standard SEL ASCII protocol), or MOD (Modbus protocol), as needed for your application. For detailed information on SEL ASCII protocol, refer to *Appendix C: SEL Communications Processors*. For detailed information on Modbus protocol, refer to *Appendix E: Modbus Communications*.

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 descriptions of the SEL-849 Fast Operate commands.

PORT 2

Table 4.57 Ethernet Port Settings (Sheet 1 of 3)

Setting Prompt	Setting Range	Setting Name := Factory Default
Enable Ethernet Port Communication	Y, N	EPORT := Y
Device IP Address / CIDR prefix (w.x.y.z/t)	w: 0–126, 128–223 x: 0–255 y: 0–255 z: 0–255 t: 1–30	IPADDR := 169.254.0.1/16
Default Router (w.x.y.z)	w: 0–126, 128–223 x: 0–255 y: 0–255 z: 0–255	DEFRTR := 0.0.0.0
Enable TCP Keep-Alive	Y, N	ETCPKA := N
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 sec	KACNT := 6
Operating Mode	FIXED, FAILOVER, SWITCHED, PRP	NETMODE := FAILOVER
Failover Time-out	OFF, 0.10–65.00 sec	FTIME := 1
Network Link Failure	SELOGIC	NETFAIL := 0
Primary Network Port	A, B	NETPORT := A
PRP Entry Timeout	400–10000 msec	PRPTOUT := 500
PRP Destination Addr LSB	0–255	PRPADDR := 0
PRP Supervision TX Interval	1–10 sec	PRPINTV := 2
Port A Speed	AUTO, 10, 100 Mbps	NETASPD := AUTO
Port B Speed	AUTO, 10, 100 Mbps	NETBSPD := AUTO
Telnet Settings		
Enable Telnet	Y, N	ETELNET := Y
Maximum Access Level	1, 2, C	MAXACC := 2
Telnet Port	23, 1025–65534	TPORT := 23

Table 4.57 Ethernet Port Settings (Sheet 2 of 3)

Setting Prompt	Setting Range	Setting Name := Factory Default
Telnet Connect Banner	254 ASCII printable characters	TCBAN := Terminal Server
Telnet Port Timeout	1–30 min	TIDLE := 15
Send Auto Messages to Port	Y, N	AUTO := N
Fast Operate Enable	Y, N	FASTOP := N
FTP Settings		
Enable FTP	Y, N	EFTPSERV := Y
FTP Maximum Access Level	1, 2, C	FTPACC := 2
FTP User Name	20 ASCII printable characters	FTPUSER := FTPUSER
FTP Connect Banner	254 ASCII printable characters	FTPCBAN := FTP Server
FTP Idle Timeout	5–255 min	FTPIDLE := 5
HTTP Settings		
Enable HTTP Server	Y, N	EHTTP := Y
Enable HTTPS Server	Y, N	EHTTPS := N
HTTP Maximum Access Level	1, 2, C	HTTPACC := 2
TCP/IP Port	1–65535	HTTPPORT := 80
HTTPS Server TCP/IP Port Number	1–65534	HTTPSPRT := 443
HTTP Connect Banner	254 ASCII printable characters	HTTPBAN := This system is for the use of authorized personnel only.
HTTP Web Server Timeout	1–60 min	HTTPIDLE := 10
IEC 61850 Settings		
Enable IEC 61850 Protocol	Y, N	E61850 := N
Enable IEC 61850 GSE	Y, N	EGSE := N
Modbus Protocol Settings		
Enable Modbus (0 [none], 1 [1 session], 2 [2 sessions])	0–2	EMOD := 0
IP Address (w.x.y.z)	w: 0–126, 128–223 x: 0–255 y: 0–255 z: 0–255	MODIP[*n*] := 192.168.1.[k][a]
Modbus TCP/IP Port	1–65535	MODPORT[*n*] := 502
Modbus Session Time-out	15–900 sec	MTIMEO[*n*] := 15
DNP3 Settings		
Enable DNP Sessions[b]	0–5	EDNP := 0
SNTP Client Settings		
Enable SNTP Client	OFF, UNICAST, MANYCAST, BROADCAST	ESNTP := OFF
SNTP Primary Server IP Address (w.x.y.z)	w: 0–126, 128–239 x: 0–255 y: 0–255 z: 0–255	SNTPPSIP := 192.168.1.110

Table 4.57 Ethernet Port Settings (Sheet 3 of 3)

Setting Prompt	Setting Range	Setting Name := Factory Default
SNTP Backup Server IP Address (w.x.y.z)	w: 0–126, 128–223 x: 0–255 y: 0–255 z: 0–255	SNTPBSIP := 192.168.1.111
SNTP IP (Local) Port Number	1–65534	SNTPPORT := 123
SNTP Update Rate	15–3600 sec	SNTPRATE := 60
SNTP Timeout	5–20 sec	SNTPTO := 5
EtherNet/IP Settings		
Enable EtherNet/IP[c]	Y, N	EEIP := N

[a] n equals 1 (TCP Port 1) or 2 (TCP Port 2) and k = 100 • n.
[b] See Table D.7 for a complete list of the DNP3 session settings.
[c] See Table F.22 for a complete list of EtherNet/IP settings and their descriptions.

For a complete description of the Ethernet settings, refer to *Section 7: Communications*. For detailed information on communications protocols, refer to *Appendix C: SEL Communications Processors*, *Appendix D: DNP3 Communications*, *Appendix E: Modbus Communications*, *Appendix F: EtherNet/IP Communications*, and *Appendix G: IEC 61850 Communications*.

HMI Settings (SET H Command)

The SEL-849 relay has a top-panel HMI and an optional HMI interface, making motor monitoring, data collection, and control quick and efficient. The SEL-3421 and the SEL-3422 constitute the optional HMI interfaces. Refer to *Section 8: Human-Machine Interface (HMI)* for more information about each of these HMIs. The LCD is only available on the SEL-3421.

General Settings

Display points display selected information on the LCD. However, you need to first enable the appropriate number of display points necessary for your application. When your SEL-849 arrives, two display points are already enabled. If more display points are necessary for your application, use the EDP setting to enable as many as eight display points. Factory-default HMI general settings are shown in *Table 4.58*.

Table 4.58 HMI General Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
Enable Display Points	N, 1–8	EDP := 2
HMI Control Mode	ACK_EN, ACK_DIS, BLK_CTRL	HMI_CTRL := ACK_DIS
HMI Display Timeout	OFF, 1–30 min	HMI_TO := 15
HMI Automessages	OVERRIDE, ROTATING	HMI_AUTO := OVERRIDE
HMI STOP Pushbutton	NORMAL, EMERGENCY	HMIPBSTP := NORMAL
HMI LR Pushbutton Enable	Y, N	HMIPB_LR := Y
HMI Start Delay	0–30 sec	HMI_STRD := 0

Table 4.58 HMI General Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
Reset Trip-latched LEDs On Close	Y, N	RSTLED := Y
Enable Pushbuttons	Y, N	EPB := N

NOTE: If HMI_CTRL := ACK_DIS, the motor will start or stop with a single press of the START/STOP pushbutton.

NOTE: If you make a change to the HMI_CTRL and/or HMIPBSTP setting(s), the HMI will restart upon saving the settings.

NOTE: To adjust the contrast on the HMI, simultaneously press the right and left navigation pushbuttons (< >) for 10 seconds. This will display the contrast adjust control.

Use the HMI control mode setting, HMI_CTRL, to either enable (ACK_EN) or disable (ACK_DIS) the acknowledgment of a control action performed via the HMI. It can also be set to block (BLK_CTRL) some of the control actions via the HMI. The HMI_CTRL setting affects START, STOP, and LOCAL/REMOTE control on both the SEL-3421 and the SEL-3422. Additionally, it also affects the Emergency Restart control on the SEL-3421. The HMIPB_LR setting enables or disables mode control via the **LOCAL/REMOTE** HMI pushbutton. When HMIPB_LR is set equal to Y, local or remote mode can be selected via the **LOCAL/REMOTE** HMI pushbutton if not blocked by the setting HMI_CTRL.

Use the HMI LCD time-out setting (HMI_TO) to set the LCD time-out. The LCD will go into the rotating display mode with the backlight dimmed if the LCD is in one of the menus not already in the rotating display mode. Disable the LCD time-out by setting HMI_TO := OFF.

Use the HMI automessage setting HMI_AUTO to define displaying of the trip or warning message. Set HMI_AUTO either to OVERRIDE or ROTATING to add to the rotating display when the relay triggers a trip or warning message. Refer to *Section 8: Human-Machine Interface (HMI)* for more information on automessages.

The default configuration of the HMI **STOP** pushbutton is for Normal operation (HMIPBSTP = NORMAL). *Figure 4.62* shows the logic used when HMIPBSTP is set to EMERGENCY. You must include Relay Word bit HMI_STP in the setting EMRSTP (described previously) if Emergency Stop is desired when the HMI **STOP** pushbutton is pressed.

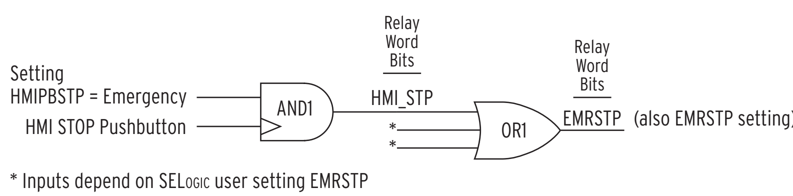


Figure 4.62 Configuration of HMI STOP Pushbutton for Emergency Stop

You can delay a motor start long enough to walk away to a safe distance after initiating the start from the SEL-3421 or SEL-3422 HMI by setting the HMI start delay setting (HMI_STRD). Pressing the HMI **STOP** pushbutton at any time during the delay cancels the start.

Set RSTLED := Y to reset the latched LEDs automatically when the breaker or contactor closes.

Set EPB := Y to enable HMI function keys to operate as pushbuttons. See *HMI Operation When Pushbuttons Are Enabled on page 8.14* for more information on configuration.

Display Points

Use display points to view either the state of internal relay elements (Boolean information) or analog information on the LCD. The HMI allocates two rows to display each of the programmed display points, binary or analog quantity. A maximum of 21 characters can be displayed in each row.

If the resulting length of the display point to be displayed is within 21 characters, then the HMI displays it on the 1st row and leaves the 2nd row empty. If the resulting length of the display point to be displayed is greater than 21 characters but less than or equal to 42 characters, then the HMI displays it on both the rows. If the resulting length of the display point to be displayed is greater than 42 characters, then the HMI displays part or all of the Alias or user text if it fits. The HMI does not show the value associated with the Name if the resulting length is greater than 42 characters (see below for more information on the terms Name, Alias and user text).

NOTE: Display points are updated every 5 seconds.

Although the LCD screen displays a maximum of 21 characters per row and a total of 42 characters in two rows for each display point, you can program as many as 60 valid characters in each of the display point setting. Valid characters are 0–9, A–Z, -, /, ", {, }, space. For text exceeding 21 characters, the LCD shows the first 21 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 H: 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 is the Relay Word bit name (IN01, for example). If only the Name is provided as part of the setting without the Alias string, then the HMI will add “=” at the end of Name when it is displayed on the LCD.

“Alias” is a more descriptive name for the Relay Word bit (such as, MOTOR 3), or the analog quantity (such as, TEMPERATURE). If an Alias string is provided in the setting, then the HMI will add “ = ” at the end of Alias string when it is displayed on the LCD.

“Set String” is the state that should be displayed on the LCD when the Relay Word bit is asserted (CLOSED, for example).

“Clear String” is the state that should be displayed on the LCD when the Relay Word bit is deasserted (OPEN, for example).

Any or all of Alias, Set String, or Clear String can be empty. Although the relay accepts an empty setting Name as valid, a display point with an empty Name setting is always hidden (see below). Commas are significant in identifying and separating the four strings. Use quotation marks only if the text you enter for Alias, Set String, or Clear String contains commas or spaces. For example, DP01 = Name,Text is valid, but Name, Alias 3 is not valid (contains a space). Correct the Alias name by using the quotation marks: Name, “Text 3”. You can customize the data display format by entering data in selected strings only. *Table 4.59* 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* = 01–08 and XX = any valid setting), but nothing shows on the HMI display. *Table 4.59* shows examples of settings that always, never, or conditionally hide a display point.

Table 4.59 Settings That Always, Never, or Conditionally Hide a Display Point

Programmable Automation Controller Setting	Name	Alias	Set String	Clear String	Comment
DP01 := IN01,TRFR1,CLOSED,OPEN	IN01	TRFR1	CLOSED	OPEN	Never hidden
DP01 := IN01,TRFR1	IN01	TRFR1	—	—	Never hidden
DP01 :=	—	—	—	—	Always hidden
DP01 := IN01,,,	IN01	—	—	—	Always hidden
DP01 := IN01,TRFR1,	IN01	TRFR1	—	—	Always hidden
DP01 := IN01,TRFR1,CLOSED,	IN01	TRFR1	CLOSED	—	Hidden when IN01 is deasserted
DP01 := IN01,"TRFR 1",, OPEN	IN01	TRFR 1	—	OPEN	Hidden when IN01 is asserted

Following are examples of selected display point settings, showing the resulting HMI displays. For example, at a certain station we want to display the status of both HV and LV circuit breakers of Transformer 1. When the HV circuit breaker is open, we want the LCD to show: `XFR1 HV BKR = OPEN`, and when the HV circuit breaker is closed, we want the display to show: `XFR1 HV BKR = 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 **IN01** and a similar contact from the LV circuit breaker to Input **IN02** of the SEL-849, we are ready to program the display points, using the following information for the HV breaker (LV breaker similar):

- Relay Word bit—IN01
- Alias—TRFR 1 HV BRKR
- Set String—CLOSED (the Form A [normally open] contact asserts or sets Relay Word bit IN01 when the circuit breaker is closed)
- Clear String—OPEN (the Form A [normally open] contact deasserts or clears Relay Word bit IN01 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 4.60 Entries for the Four Strings

Name	Alias	Set String	Clear String
IN01	XFR1 HV BKR	CLOSED	OPEN

Figure 4.63 displays the settings for the example when you click **Settings** > **HMI** on the navigation panel of the webpage.

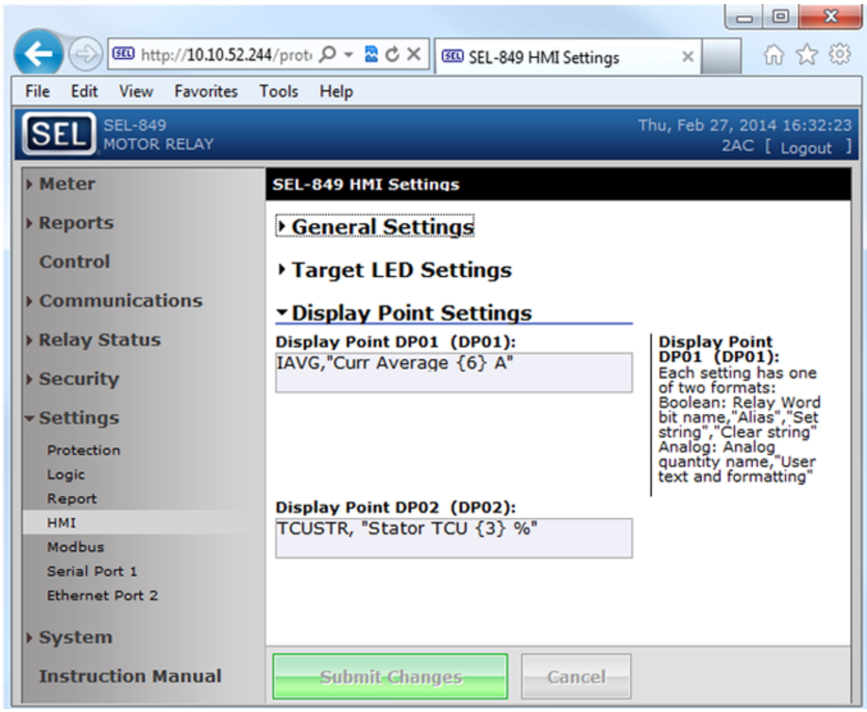


Figure 4.63 Display Point Settings, Viewed Using Web Browser

Figure 4.64 shows the display when both HV and LV breakers are open (both IN01 and IN02 deasserted). *Figure 4.65* shows the display when the HV breaker is closed, and the LV breaker is open (IN01 asserted, but IN02 still deasserted).

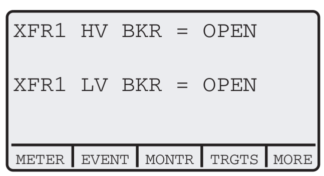


Figure 4.64 HMI Display—Both HV and LV Breakers Open

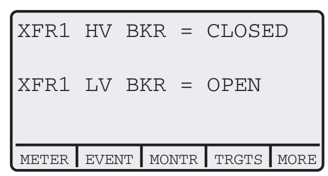


Figure 4.65 HMI Display—HV Breaker Closed, LV Breaker Open

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 H** command as follows:

```
DP01    := RID, “{16}”
 ? IN01,"XFR1 HV BKR","CLOSED" <Enter>
```

When the Relay Word bit IN01 deasserts, the relay removes the complete line with the omitted Clear String (XFR1 HV BKR). 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 4.66*. 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 4.67*.

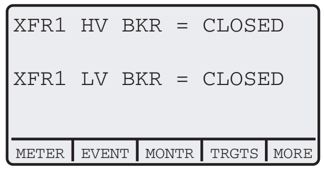


Figure 4.66 HMI Display—Both HV and LV Breakers Closed

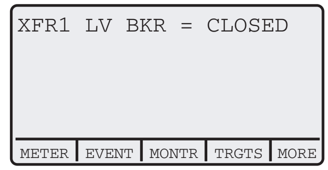


Figure 4.67 HMI Display—HV Breaker Open, LV Breaker Closed

If you want the relay to display a blank state when IN01 deasserts, instead of removing the line altogether, use the curly brackets {} for the Clear String, as follows:

```
DP01    := RID, "{16}"
 ? IN01,"XFR1 HV BKR","CLOSED",{} <Enter>
```

When Input IN01 now deasserts, the relay still displays the line with the HV breaker information, but the state is left blank, as shown in *Figure 4.68*.

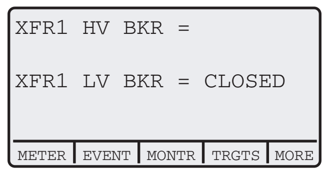


Figure 4.68 HMI Display—HV Breaker Open With Blank State, LV Breaker Closed

Name Only

Table 4.61 shows an entry in the Name String only (leaving the Alias string, Set String, and Clear String void), using the **SET H** command as follows:

```
DP01    := RID, "{16}"
 ? IN01 <Enter>
```

Table 4.61 Binary Entry in the Name String Only

Name	Alias	Set String	Clear String
IN01	—	—	—

Figure 4.69 shows the HMI display for the entry in *Table 4.61*. Input IN01 is deasserted in this display (`IN01 = 0`), but changes to `IN01 = 1` when Input IN01 asserts.

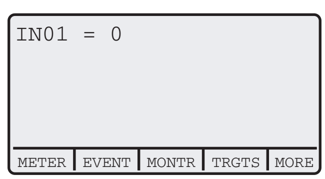


Figure 4.69 HMI Display for a Binary Entry in the Name String Only

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 is the analog quantity name (IAVG for example). If only the Name is provided as part of the setting without User text and numerical formatting, then the HMI will add “ = ” at the end of Name when it is displayed on the LCD.

“User Text and Numerical Formatting” displays the user text followed by the value associated with Name in the set numerical format {width.dec,scale}. The value associated with Name is scaled by “scale”, formatted with total width “width” and “dec” decimal places.

If only the user text is specified without any numerical formatting ({width.dec,scale}), then the HMI will add “ = ” at the end of Name when it is displayed on the LCD.

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.

The maximum value that can be displayed is 10^{21}. If the resulting value after taking the product of the value associated with Name and the “scale” is greater than 10^{21} then the LCD shows it as $$$$$$$$$$.

Table 4.62 shows an entry in the Name string only (leaving the User Text and Formatting string void) with the following syntax:

Table 4.62 Analog Entry in the Name String Only

Name	Alias	Set String	Clear String
IAVG	—	—	—

Consider that the analog quantity, IAVG, contains a value of 100.51 A. *Figure 4.70* shows the HMI display for the entry in *Table 4.62*, using the **SET H** command as follows:

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

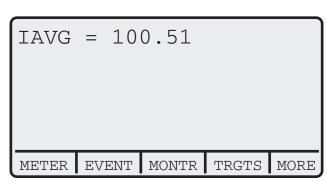


Figure 4.70 HMI Display for an Analog Entry in the Name String Only

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 4.63* 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 H** command as follows:

```
DP01    := RID, “{16}”
 ? IN01,"INPUT IN01:" <Enter>
DP02    := TID, “{16}”
 ? TCUSTR,“STATOR TCU:” <Enter>
```

Table 4.63 Entry in the Name String and the Alias Strings

Name	Alias	Set String	Clear String
IN01	INPUT IN01	—	—
TCUSTR	STATOR TCU	—	—

Figure 4.71 shows the HMI display for the entry in *Table 4.63*. Input IN01 is deasserted in this display (0), and the display changes to `INPUT IN01 = 1` when Input IN01 asserts. Stator TCU is 58.2% in this display.

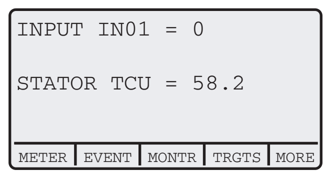


Figure 4.71 HMI Display for an Entry in (a) Boolean Name and Alias Strings and (b) Analog Name and User Text and Formatting Strings

For fixed text, enter a 1 in the Name String, then enter the fixed text as the alias text. For example, to display the word DEFAULT and SETTINGS on two different lines, use a display point for each word, i.e., DP01 = 1, “DEFAULT” and DP02 = 1,“SETTINGS”. *Table 4.64* shows other options and HMI displays for the User Text and Formatting settings. MV01 with a value of 1234.00 stored in the variable is used as an example in the table.

Table 4.64 Example Settings and Displays

Example Display Point Setting Value	Example Display
MV01.“MV01 = {4}%”	MV01 = 1234%
MV01,“MV01 = {4.1}”	MV01 = 1234.0
MV01,“MV01 = {5}”	MV01 = 1234
MV01,“MV01 = {4.2,0.001}%”	MV01 = 1.23%
MV01,“MV01 ANALOG = {4,1000}”	MV01 ANALOG = 1234000
1,{}	Empty line

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 4.72*.

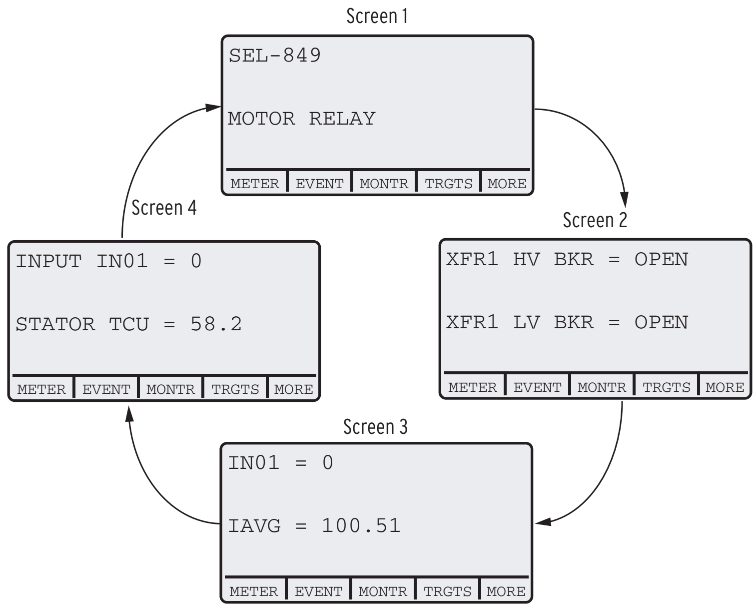


Figure 4.72 Rotating Display

Pushbutton Settings

The function keys can be converted into eight pushbuttons. Use the corresponding pushbutton Relay Word bit in a SELOGIC control equation to customize your interaction with the HMI and SEL-849 relay. For more details on using the function keys as pushbuttons, refer to *HMI Operation When Pushbuttons Are Enabled on page 8.14*

Use the **SET H** command to set EPB := Y to enable the pushbuttons. You can use the **SET H** or **SET H P** command to change the pushbuttons labels (settings PB01_LBL–PB08_LBL, see *Table 4.65*).

Table 4.65 Pushbutton Label Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Pushbutton 1 Label	6 characters	PB01_LBL := PB01
Pushbutton 2 Label	6 characters	PB02_LBL := PB02
• • •	• • •	• • •
Pushbutton 7 Label	6 characters	PB07_LBL := PB07
Pushbutton 8 Label	6 characters	PB08_LBL := PB08

Target LED Settings

The SEL-849 offers the following two types of LEDs. See *Figure 8.1*, *Figure 8.2*, and *Figure 8.21* for the programmable LED locations:

➤ Four fixed LEDs on relay top panel
➤ Two fixed and eight programmable Target LEDs on HMI

Target LEDs

NOTE: If the LED latch setting (TnLEDL) is set to Y, and TRIP asserts, the LED latches to the state at TRIP assertion. The latched LED targets can be reset using TARGET RESET if the target conditions are absent.

Settings T*n*LEDL (*n* = 01–08) and T*n*_LED (*n* = 01–08) control the eight HMI LEDs. With T*n*LEDL set to Y, the LEDs latch the LED state at TRIP assertion. The latched LEDs can be reset by one of the following approaches:

- Pressing **TARGET RESET** on the HMI or top 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. Default target LED settings are shown in *Table 4.66*.

Table 4.66 Target LED Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
Trip Latch T_LED	Y, N	T01LEDL := N
Target T_LED Asserted Color	R, G, A	T01LEDC := R
LED1 Equation	SELOGIC	T01_LED := WARNING
Target LED1 Label	16 Characters	T01_LBL := WARNING
Trip Latch T_LED	Y, N	T02LEDL := N
Target T_LED Asserted Color	R, G, A	T02LEDC := R
LED2 Equation	SELOGIC	T02_LED := RUNNING OR STARTING
Target LED2 Label	16 Characters	T02_LBL := RUNNING
Trip Latch T_LED	Y, N	T03LEDL := N
Target T_LED Asserted Color	R, G, A	T03LEDC := G
LED3 Equation	SELOGIC	T03_LED := STOPPED
Target LED3 Label	16 Characters	T03_LBL := STOPPED
Trip Latch T_LED	Y, N	T04LEDL := N
Target T_LED Asserted Color	R, G, A	T04LEDC := A
LED4 Equation	SELOGIC	T04_LED := NOT REMOTE
Target LED4 Label	16 Characters	T04_LBL := LOCAL
Trip Latch T_LED	Y, N	T05LEDL := N
Target T_LED Asserted Color	R, G, A	T05LEDC := A
LED5 Equation	SELOGIC	T05_LED := REMOTE
Target LED5 Label	16 Characters	T05_LBL := REMOTE
Trip Latch T_LED	Y, N	T06LEDL := N
Target T_LED Asserted Color	R, G, A	T06LEDC := A
LED6 Equation	SELOGIC	T06_LED := NOT SPEED2
Target LED6 Label	16 Characters	T06_LBL := SPEED1/FWD
Trip Latch T_LED	Y, N	T07LEDL := N
Target T_LED Asserted Color	R, G, A	T07LEDC := A
LED7 Equation	SELOGIC	T07_LED := SPEED2

Table 4.66 Target LED Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
Target LED7 Label	16 Characters	T07_LBL := SPEED2/REV
Trip Latch T_LED	Y, N	T08LEDL := Y
Target T_LED Asserted Color	R, G, A	T08LEDC := R
LED8 Equation	SELOGIC	T08_LED := 49T OR PTCTRIP
Target LED8 Label	16 Characters	T08_LBL := OVERLOAD

Report Settings (SET R Command)

The report settings use Relay Word bits for the SER and event report trigger as shown in *Table 4.67* and *Table 4.68*. See *Appendix H: Relay Word Bits* for detail. Refer to *Section 9: Analyzing Events* for additional information about SER and event reports.

SER Trigger List

Enter up to 96 Relay Word bits. The SER List entries (**SET R SER** command) are text-edit mode settings with line number prompts. See *Table 4.44* for the text-edit mode actions.

Table 4.67 SER List Factory-Default Values (Sheet 1 of 2)

Line Number	Factory-Default Setting	Line Number	Factory-Default Setting	Line Number	Factory-Default Setting
1:	IN01	26:	STR_CLFP	51:	49T_RTR
2:	IN02	27:	REMCONEQ	52:	50S
3:	IN03	28:	REMCONFP	53:	LOSSTRIP
4:	IN04	29:	COMMSTR	54:	JAMTRIP
5:	IN05	30:	REMSTREQ	55:	46UBT
6:	IN06	31:	RESTART	56:	ORED50T
7:	OUT01	32:	EMRSTR	57:	PTCTRIP
8:	OUT02	33:	BSTR_CL	58:	47T
9:	OUT03	34:	REMOTE	59:	51P1T
10:	OUT04	35:	LOCSTART	60:	51G1T
11:	52A	36:	REMSTART	61:	50PAF
12:	ABSLO	37:	STR_CLO	62:	50GAF
13:	TBSLO	38:	EXT_TRIP	63:	TOL1
14:	NOSLO	39:	STP_OPFP	64:	55T
15:	THERMLO	40:	COMMSTP	65:	3PWR1T
16:	STOPPED	41:	LOCSTOP	66:	27PP1T
17:	STARTING	42:	REMSTOP	67:	UV_TR
18:	RUNNING	43:	STOP	68:	LJ_TR
19:	SALARM	44:	ULTRIP	69:	UV_SHRT
20:	HALARM	45:	TRGTR	70:	UV_MED
21:	WARNING	46:	TR	71:	UV_LONG

Table 4.67 SER List Factory-Default Values (Sheet 2 of 2)

Line Number	Factory-Default Setting	Line Number	Factory-Default Setting	Line Number	Factory-Default Setting
22:	HMIDET	47:	TR1	72:	RSACTIVE
23:	VFDBYPAS	48:	TRIP	73:	RS_LO
24:	SPEED2	49:	49A	74:	59RS
25:	STR_CLEQ	50:	49T_STR	75:	UV_RS_LO

Relay Word Bit Aliases

Table 4.68 Enable Alias Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Enable ALIAS Settings	N, 1–10	EALIAS := 3

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 the relay elements listed in the previous SER settings are displayed in the SER report. In addition, the Alias settings allow you to change the text displayed when a particular element is asserted and deasserted. The relay permits as many as 10 unique aliases, as defined by the Enable Alias Settings (EALIAS) setting. Factory-default alias settings are shown in *Table 4.69*.

Define the enabled alias settings by entering the Relay Word bit name, a space, the desired alias, a space, the text to display when the condition asserts, a space, and the text to display when the condition deasserts.

```
ALIAS1 = STARTING MOTOR_STARTING BEGINS ENDS
```

See *Table H.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 wish to clear a string, simply type **NA**.

Table 4.69 SET R SER Alias Factory-Default Settings

Setting Prompt	Relay Word Bit	Alias	Asserted Text	Deasserted Text
ALIAS01 :=	49A	THERMAL_ALARM	PICKUP	DROPOUT
ALIAS02 :=	49T	THERMAL_TRIP	PICKUP	DROPOUT
ALIAS03 :=	47T	REVERSE_SEQ_TRP	PICKUP	DROPOUT
ALIAS04 :=	NA			
ALIAS05 :=	NA			
ALIAS06 :=	NA			
ALIAS07 :=	NA			
ALIAS08 :=	NA			
ALIAS09 :=	NA			
ALIAS10 :=	NA			

Event Report Settings

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

COMTRADE event reports are reported at 1, 2, or 4 kHz sampling rate determined by the SRATE setting. Set LER to the length of the Event reports desired. For LER of 15, the prefault length, PRE, must be in the range 1–10. The relay can typically hold at least forty 15-cycle event reports or two 120-cycle event reports. LER and PRE settings are in nominal frequency (FNOM) cycles, irrespective of the tracked frequency. For more information on event reports, go to *Section 9: Analyzing Events*.

Table 4.70 Event Report Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Event Trigger	SELOGIC	ER := R_TRIG LOSSALRM OR R_TRIG 46UBA OR R_TRIG 49A OR R_TRIG 55A
Sample Rate of Event Report	1, 2, 4 kHz	SRATE := 4
Length of Event Report	15, 60, 120 cyc	LER := 15
Length of Prefault	OFF, 1-(LER-5) cyc	PRE := 10

Start Report Setting

Table 4.71 Motor Start Report Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
Motor Start Report Resolution	0.25, 0.5, 1, 2, 5, 20 cyc	MSRR := 5
Motor Start Report Trigger	SELOGIC	MSRTRG := 0

The setting MSRR defines the resolution of the motor start report. The report is always triggered by each motor start; to trigger for additional conditions, use the SELOGIC control equation MSRTRG. For more information on the motor start report, go to *Section 5: Metering and Monitoring*.

Load-Profile List

Enter up to 16 analog quantities. The load-profile list entries (**SET R LDLIST** command) are text-edit mode settings with line number prompts. The available text-edit mode actions are shown in *Table 4.44*. See *Table 4.72* for the line number prompts and factory-default values.

Table 4.72 Load-Profile List Factory-Default Values

Line Number	Factory-Default Values
1:	IAVG
2:	UBI

Table 4.73 Load-Profile Settings

IMPORTANT: All stored load data are lost when changing the LDLIST.

Setting Prompt	Setting Range	Setting Name := Factory Default
LDP LIST	As many as 16 analog quantities	See *Table 4.72*
LDP ACQ RATE	5, 10, 15, 30, 60 min	LDAR := 15

Energy Meter Report Unit Setting

Table 4.74 Energy Meter Report Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
ENERGY METER UNIT	Kilo, Mega	EMU := Mega

The EMU setting provides the flexibility to report quantities in kilo or mega in the energy meter report. If the setting is selected as kilo, all the quantities in the energy meter report are displayed in kilo. Refer to *Energy Metering* for the energy meter command response.

DNP3 Map Settings (SET D Command)

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

Table 4.75 DNP3 Map Settings[a] (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
DNP Binary Input Label Name	10 characters	0:
DNP Binary Input Label Name	10 characters	1:
• • •	• • •	• • •
DNP Binary Input Label Name	10 characters	98:
DNP Binary Input Label Name	10 characters	99:
DNP Binary Output Label Name	10 characters	0:
DNP Binary Output Label Name	10 characters	1:
• • •	• • •	• • •
DNP Binary Output Label Name	10 characters	30:
DNP Binary Output Label Name	10 characters	31:
DNP Analog Input Label Name	24 characters	0:
DNP Analog Input Label Name	24 characters	1:
• • •	• • •	• • •
DNP Analog Input Label Name	24 characters	98:
DNP Analog Input Label Name	24 characters	99:
DNP Analog Output Label Name	6 characters	0:
DNP Analog Output Label Name	6 characters	1:
• • •	• • •	• • •
DNP Analog Output Label Name	6 characters	30:
DNP Analog Output Label Name	6 characters	31:
DNP Counter Label Name	11 characters	0:
DNP Counter Label Name	11 characters	1:
• • •	• • •	• • •

Table 4.75 DNP3 Map Settings[a] (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
DNP Counter Label Name	11 characters	30:
DNP Counter Label Name	11 characters	31:

[a] See Appendix D: DNP3 Communications for Modbus register labels and factory-default settings.

Modbus Map Settings (SET M Command)

Modbus User Map

Table 4.76 shows the available settings. See *Appendix E: Modbus Communications* for additional details.

Table 4.76 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#250	NA, 1 Modbus Register Label	MOD_250 :=

[a] See Appendix E: Modbus Communications for Modbus register labels and factory-default settings.

EtherNet/IP Assembly Map Settings (SET E Command)

Table 4.73 shows the available assembly map settings. See *Appendix F: EtherNet/IP Communications* for additional details.

Table 4.77 EtherNet/IP Assembly Map

Setting Prompt	Setting Range	Setting Name := Factory Default
Input Assembly (IA) Binary		
EIP Input Assembly Binary Label Name Point 0	10 characters	
• • •	• • •	
EIP Input Assembly Binary Label Name Point 99	10 characters	
Input Assembly (IA) Analog		
EIP Input Assembly Analog Label Name Point 0	10 characters	0: NOOP
EIP Input Assembly Analog Label Name Point 1	10 characters	
• • •	• • •	
EIP Input Assembly Analog Label Name Point 99	10 characters	
Output Assembly (OA) Binary		
EIP Output Assembly Binary Label Name Point 0	10 characters	
• • •	• • •	
EIP Input Assembly Binary Label Name Point 31	10 characters	
Output Assembly (OA) Analog		
EIP Output Assembly Analog Label Name Point 0	10 characters	0: NOOP
EIP Output Assembly Analog Label Name Point 1	10 characters	
• • •	• • •	
EIP Output Assembly Analog Label Name Point 31	10 characters	

Section 5
Metering and Monitoring

Overview

The SEL-849 Motor Management Relay includes metering functions to display the present values of current and voltage (if included). The relay provides the following methods to read the present meter values:

- ➤ HMI rotating display
- ➤ HMI menu
- ➤ Web server via Ethernet port
- ➤ EIA-232 serial ports (using SEL ASCII text commands or ACSELERATOR QuickSet SEL-5030 Software)
- ➤ Telnet via Ethernet port
- ➤ EtherNet/IP via Ethernet port
- ➤ DNP3 serial via EIA-232 port or EIA-485 port
- ➤ DNP3 LAN/WAN via Ethernet port
- ➤ Modbus via EIA-485 port or EIA-232 port
- ➤ Modbus TCP via Ethernet port
- ➤ Analog outputs
- ➤ IEC 61850 via Ethernet port

Motor load monitoring and trending are possible using the load-profile function. The relay automatically configures itself to save as many as 16 quantities (selected from the analog quantities) every 5, 10, 15, 30, or 60 minutes. The data are stored in nonvolatile memory. As many as 4000 time samples are stored.

For monitoring and preventive maintenance purposes, the SEL-849 provides a motor operating statistics report, available using either the HMI, the web server, or the serial port.

Also helpful in preventive maintenance tasks, the SEL-849 calculates and stores motor starting information. The relay retains motor start reports for the five latest motor starts. The motor start trending function stores motor start averages for the last eighteen 30-day periods.

Power Measurement Conventions

The SEL-849 uses the IEEE convention for power measurement assuming motor action. The implications of this convention are depicted in *Figure 5.1*.

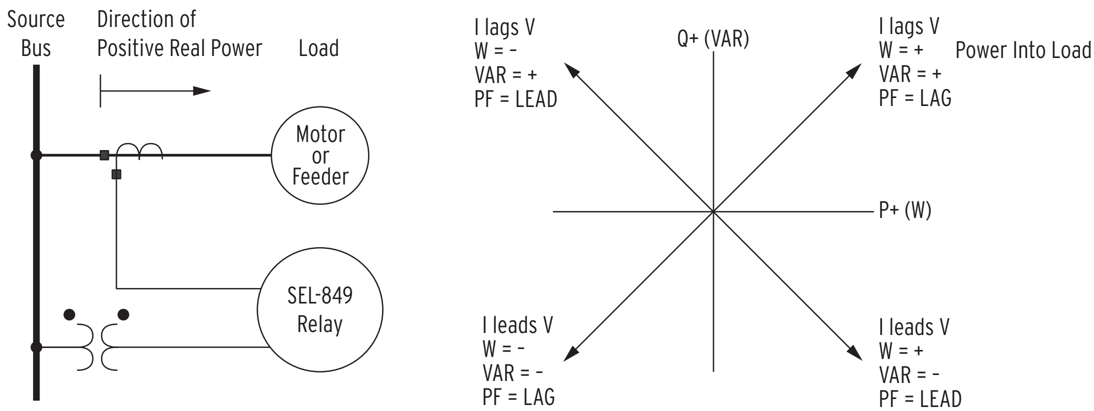


Figure 5.1 Complex Power Measurement Conventions

Metering

The SEL-849 meter data fall into the following categories:

- Fundamental metering
- Demand metering
- Math variable metering
- RMS metering
- Harmonic metering
- Remote analog metering
- Energy metering
- Maximum and Minimum metering

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 current values is 0.2 • 6.4/SRF secondary and for voltage values is 1.0 V secondary.

Fundamental Metering

NOTE: The "Thermal Trip In" time is valid only during the running overload condition. The time displayed is 9999 second during normal running (I1 < Overload Pickup), stopped, and also during the starting and load-jam conditions, and should be disregarded.

Table 5.1 details each of the fundamental meter data types in the SEL-849. *Section 7: Communications* describe how to access the various types of meter data using the relay HMI 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 Current) magnitudes (A) and phase angles (deg)
	Calculated Residual Current IG (IG = 3I0 = IA + IB + IC)
	IAVG (Average Current Magnitude)
	Motor Load (xFLA), Stator TCU (%), Rotor TCU (%), Thermal Trip In (sec), and Time to Reset (sec)
	Negative-Sequence Current (3I2)
	Current Unbalance %
	System Frequency (Hz)
Models With Voltage	VAB, VBC, VCA (delta-connected PTs) or VAN, VBN, VCN, VG, VAB, VBC, VCA, 3V0 (wye-connected PTs) magnitudes (V) and phase angles (deg)
	Average Voltage (L-L) Negative-Sequence (3V2) Voltage Unbalance %
	Real Power (kW) Reactive Power (kVAR) Apparent Power (kVA) Power Factor

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 I: Analog Quantities).

All angles are displayed between –180 and +180 degrees. The angles are referenced to VAB, 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.

NOTE: The time to thermal trip calculation is only performed when the motor is running and the current in per unit satisfies OLPU < I < 2.5. When time to thermal trip is not calculated, it is displayed as 9999.

NOTE: If the overload protection is disabled by setting E49MOTOR := N, the relay always reports %Thermal Capacity = 0 and Calculated Time to Thermal Trip (s) = 9999.

```
=>>MET <Enter>

SEL-849                                    Date: 10/05/2012   Time: 01:46:14.422
MOTOR RELAY                                Time Source: Internal

                                  IA        IB        IC        IG       IAVG
Current Magnitude (A pri.)         1.03      1.01      1.00      0.03      1.01
Current Angle (deg)               -1.3    -120.9     118.9     -26.0

Motor Load (xFLA1)                 0.406

Stator TCU (%)                     0.2
Rotor TCU (%)                      0.3
Thermal Trip In (sec)           9999
Time to Reset (sec)                0

Neg-Seq Curr 3I2 (A pri.)          0.02
Current Imb (%)                    0.7
Core-Balance CT IN (A pri.)        0.000

                                  VAB         VBC         VCA        VAVG
Voltage Magnitude (V pri.)       115.87      115.94      116.00      115.93
Voltage Angle (deg)               30.0       -90.0       150.0

                                  VA          VB          VC         3V0
Voltage Magnitude (V pri.)       66.93       66.85       67.03        0.17
Voltage Angle (deg)                0.0      -120.0       120.0        98.8
```

Figure 5.2 METER Command Report With the Voltage Option

```
Neg-Seq Volt 3V2 (V pri.)         0.13
Voltage Imb (%)                   0.1

Real Power (kW)                   0.204
Reactive Power (kVAR)             0.004
Apparent Power (kVA)              0.204
Power Factor ( LAG)               1.00

Frequency (Hz)                   59.99

=>>
```

Figure 5.2 METER Command Report With the Voltage Option (Continued)

Energy Metering

The SEL-849 with the voltage option includes energy metering. Use this form of metering to quantify how much real, reactive, and apparent energy your motor is using. You can also determine if your motor is giving reactive power back to the power system. Based on the EMU setting selection (*Table 4.74*), energy quantities are reported in units of kilo or mega. Below are the energy meter values.

- MWh3P—Real 3-phase energy (out of bus)
- NEGATIVE MVARh3P_IN—Reactive 3-phase energy (into bus)
- POSITIVE MVARh3P_OUT—Reactive 3-phase energy (out of bus)
- MVAh3P—Apparent 3-phase energy
- KWh3P—Real 3-phase energy (out of bus)
- NEGATIVE KVARh3P_IN—Reactive 3-phase energy (into bus)
- POSITIVE KVARh3P_OUT—Reactive 3-phase energy (out of bus)
- KVAh3P—Apparent 3-phase energy
- Last date and time of energy meter quantities being reset

NOTE: Energy values roll over and reset to 0 after reaching a value of 999,999.999.

Figure 5.3 shows the device response to the **METER E** command when EMU is set equal to Mega.

```
=>>MET E <Enter>

SEL-849                                  Date: 03/09/2016   Time: 14:24:19.802
MOTOR RELAY                              Time Source: Internal

MWh3P (MWh)                  2.208
NEG MVARh3P-IN (MVArh)       0.000
POS MVARh3P-OUT (MVArh)      0.050
MVAh3P-OUT (MVAh)            2.209

LAST RESET = 03/09/2016 14:22:51.727

=>>
```

Figure 5.3 Device Response to the METER E Command

Figure 5.4 shows the device response to the **METER E** command with the EMU setting set to kilo.

```
=>>MET E <Enter>

SEL-849                                 Date: 07/06/2023   Time: 16:04:46.936
MOTOR RELAY                             Time Source: Internal

KWh3P (KWh)                   2228
NEG KVARh3P-IN (KVArh)        0
POS KVARh3P-OUT (KVArh)       1356
KVAh3P-OUT (KVAh)             2609

LAST RESET = 07/05/2023 23:32:50.113

=>>
```

Figure 5.4 Device Response to the METER E Command

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

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

=>>
```

Figure 5.5 Device Response to the METER E R Command

Maximum and Minimum Metering

Maximum and minimum metering allows you to determine maximum and minimum operating quantities of the motor such as currents, voltages, power, and frequency. *Table 5.2* lists the max/min metering quantities.

Table 5.2 Maximum/Minimum Meter Values

Relay Option	Max/Min Meter Values
Base Model	Maximum and minimum line current IA, IB, IC, and IN (core-balance ground fault current) magnitudes (A) Maximum and minimum IG (residual ground fault current) magnitude (A) Maximum and minimum system frequency (Hz)
With Voltage Option	Maximum and minimum VAB, VBC, VCA or VAN, VBN, VCN magnitudes (V) Maximum and minimum real, reactive, and apparent 3-phase power (kW, kVAR, kVA)

All maximum and minimum metering values will have the date and time that they occurred. The analog quantities from *Table 5.2* 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 Word bit FAULT is deasserted (no fault condition exists) and either the motor is in the running state or the breaker is closed, depending on motor or feeder application, respectively (MOTOR AND RUNNING = 1 or NOT MOTOR AND 52A = 1).

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

```
=>>MET MM <Enter>

SEL-849                                     Date: 03/09/2016   Time: 14:27:12.585
MOTOR RELAY                                 Time Source: Internal


                   MAX        DATE       TIME       MIN        DATE       TIME
IA (A)              51.7  03/09/2016  14:26:11       50.7  03/09/2016  14:27:12
IB (A)              50.9  03/09/2016  14:27:01       49.1  03/09/2016  14:26:11
IC (A)              51.3  03/09/2016  14:27:12       50.3  03/09/2016  14:26:17
IN (A)               1.0  03/09/2016  14:26:50        1.0  03/09/2016  14:27:09
IG (A)               3.6  03/09/2016  14:26:10        1.8  03/09/2016  14:26:52
VA (V)           30070.4  03/09/2016  14:26:10     6712.9  03/09/2016  14:26:39
VB (V)           29949.4  03/09/2016  14:26:14     6688.2  03/09/2016  14:26:20
VC (V)           30064.0  03/09/2016  14:26:11     6716.1  03/09/2016  14:26:11
KW3P (kW)         4507.5  03/09/2016  14:26:12     1011.2  03/09/2016  14:26:17
KVAR3P (kVAR)      137.1  03/09/2016  14:26:12       32.9  03/09/2016  14:26:17
KVA3P (kVA)       4509.5  03/09/2016  14:26:12     1011.9  03/09/2016  14:26:17
FREQ (Hz)           60.0  03/09/2016  14:26:35       60.0  03/09/2016  14:26:14

LAST RESET = 03/09/2016 14:23:12.543


=>>
```

Figure 5.6 Device Response to the METER MM Command

To reset maximum/minimum meter values, issue the **MET MM R** command as shown in *Figure 5.7*. The max/min meter values can be reset from the serial port, Modbus, the front panel, or assertion of the RSTMXMN Relay Word bit. The date and time of the reset are preserved and shown in the max/min meter report.

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

=>>
```

Figure 5.7 Device Response to the METER MM R 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.

Demand Metering

The SEL-849 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 and peak demand (**METER D** command) metering. *Table 5.3* shows the values reported. *Figure 5.8* provides an example of the **METER D** (Demand) command report. Refer to *Demand Meter Settings on page 4.60* for detailed descriptions and settings selection.

Table 5.3 Measured Demand Metering Values

Relay Option	Demand Values
All Models	Demand and peak demand values of line currents IA, IB, and IC magnitudes (A primary)

```
=>>MET D <Enter>

SEL-849                                   Date: 6/31/2012   Time: 10:17:13.888
MOTOR RELAY                               Time Source: Internal


                        IAD        IBD       ICD
DEMAND (A pri.)           2.00       2.00      2.00


                        IAPD       IBPD      ICPD
PEAK DEMAND (A pri.)      2.00       2.00      2.00


LAST DEMAND RESET = 6/31/2012  10:10:41.566
```

Figure 5.8 METER D Command Response

Math Variable Metering

The SEL-849 includes eight math variables. When you receive your SEL-849, no math variables are enabled. To use math variables, enable the number of math variables (between 1 and 8) you require, using the EMV setting in the Logic setting category. *Figure 5.9* shows the device response to the **METER MV M**(ath) **V**(ariable) command with eight math variables enabled.

```
=>>MET MV <Enter>

SEL-849                                   Date: 6/31/2012   Time:9:33:28.312
MOTOR RELAY                               Time Source: Internal

MV01                       1.000
MV02                  -32767.000
MV03                      -1.000
MV04                       0.000
MV05                    1000.000
MV06                   -1000.000
MV07                    2411.000
MV08                    2410.999
```

Figure 5.9 MET MV Command Response

RMS Metering

The SEL-849 includes root-mean-square (rms) metering. Use rms metering to measure the entire signal (including harmonics) at which the motor is running. You can measure the rms quantities shown in *Table 5.4*.

Table 5.4 RMS Meter Values

Relay Option	RMS Meter Values
Base Model	RMS current IA, IB, IC, IG, and IN magnitudes (A)
With Voltage Option	VAB, VBC, VCA or VAN, VBN, and VCN 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 5.10* shows the **METER RMS** command.

```
=>>MET RMS <Enter>

SEL-849                                   Date: 11/05/2012   Time: 04:52:28.729
MOTOR RELAY                               Time Source: Internal

                    IA         IB        IC        IG        IN
RMS (A pri.)         0.94       0.04      0.98      0.94      0.000

                      VA         VB        VC
RMS (V pri.)        66.93      66.87     67.01

=>>
```

Figure 5.10 METER RMS Command Response

Harmonic Metering

The harmonic metering function in the SEL-849 reports the current and voltage harmonics through the fifth harmonic and the total harmonic distortion percentage (THD %). *Table 5.5* shows the harmonic values reported. *Figure 5.11* provides an example of the **METER H** (Harmonic) command report.

Table 5.5 Measured Harmonic Meter Values

Relay Option	Harmonic Values
Current Only	Fundamental magnitude (secondary A) and 2nd, 3rd, 4th, harmonic % values and THD % of line currents IA, IB, IC, IA, IB, and IC
With Voltage Option	Fundamental magnitude (secondary V), 2nd, 3rd, 4th, and 5th harmonic % values and THD % of voltages VAB, VBC, VCA or VAN, VBN, VCN

```
=>>MET H <Enter>

SEL-849                                   Date: 6/29/2012   Time: 12:05:34.531
MOTOR RELAY                               Time Source: Internal

                 IA       IB       IC       VA      VB      VC
Fund (Pri)        0.00     0.00     0.00     0.00    0.00    0.00
2nd  (%)          0.00     0.00     0.00    0.00    0.00    0.00
3rd  (%)          0.00     0.00     0.00    0.00    0.00    0.00
4th  (%)          0.00     0.00     0.00    0.00    0.00    0.00
5th  (%)          0.00     0.00     0.00    0.00    0.00    0.00
THD  (%)          0.00     0.00     0.00    0.00    0.00    0.00
```

Figure 5.11 METER H Command Response

Remote Analog Metering

Use remote analog metering to verify the values received from an external device. The SEL-849 includes 32 remote analog variables. In *Appendix C: SEL Communications Processors*, we show how to enter remote analog settings in an SEL Communications Processor and the SEL-849. *Figure 5.12* shows the device response to the **METER RA** command for the settings in *Appendix C: SEL Communications Processors*.

```
=>>MET RA <Enter>

SEL-849                                  Date: 02/11/2012 Time: 1:18:29.889
MOTOR RELAY                               Time Source: Internal

RA01 1.00
RA02 -32767.00
RA03 -1.00
RA04 0.00
RA05 1000.59
RA06 -1000.61
RA07 2411.01
RA08 2410.99
RA09 98303.00
RA10 -98303.00
RA11 -38400.00
RA12 -65536.00
RA13 0.00
RA14 0.00
RA15 0.00
. .
. .
. .
RA32 0.00
=>>
```

Figure 5.12 MET RA Command Response

Load Profiling

The SEL-849 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 List on page 4.88*). Choose which analog quantities you want to monitor from the analog quantities listed in *Appendix I: Analog Quantities*. Set these quantities into the LDLIST load-profile list report setting.

The relay memory can hold data for 4,000 time-stamped entries. For example, if you chose to monitor 10 values at a rate of every 15 minutes, you could store 41.67 days worth of data.

Download the load rate profile data using the serial port **LDP** command described in *LDP Command (Load-Profile Report) on page 7.32*. *Figure 5.13* shows an example **LDP** serial port command response.

```
=>LDP <Enter>

SEL-849                                  Date: 06/01/2012   Time: 06:53:57.397
MOTOR RELAY                              Time Source: Internal

  #       DATE         TIME               IA_MAG       IB_MAG       IC_MAG
   3    06/01/2012  05:50:20.429          12.063       12.008       12.023
   2    06/01/2012  06:20:20.131          12.109       12.047       12.086
   1    06/01/2012  06:50:20.535          12.117       12.086       12.055
=>
```

Figure 5.13 LDP Command Response

Motor Operating Statistics

NOTE: While the relay power is off, the elapsed timers do not advance. If relay power is off for a significant amount of time, the elapsed calendar time will not match the elapsed time recorded by the relay.

NOTE: The relay records motor operating statistics to nonvolatile memory every six hours. If power is removed from the relay, the relay loses the information collected between the last save and the time of the power removal.

The SEL-849 retains useful machine operating statistics information for the protected motor. Use the serial port **MOTOR** command, the HMI MONITOR menu, or the web browser to view motor operating statistics. The data also appear in the Modbus memory map. You can reset the data using either a communications port (e.g., serial port **MOTOR R** command), the web browser **Clear Motor Operating Statistics** button, SELOGIC control equation setting RSTMOT, or the HMI MONITOR menu.

The motor start reports are also reset when the motor statistics data are reset.

Items included in the report are shown in *Figure 5.14*. The trip counts associated with Local Stop and Remote Stop are accumulated only when TRIPONST := Y.

```
=>>MOT <Enter>

SEL-849                                    Date: 6/30/2012   Time: 10:14:37.358
MOTOR RELAY                                Time Source: Internal


Operating History (elapsed time in dddd:hh:mm)
Last Reset Date       6/28/2012
Last Reset Time     10:22:51.562
Running Time          0000:00:00
Stopped Time  >       0002:22:44
Time Running (%)             0.0
Number of Starts               0
Number of Restarts             0
Emergency Starts               0
Contactor Operations           0
Breaker Operations             0

Avg/Peak Data
                 AVERAGE     PEAK
Start Time (s)       0.0      0.0
Max Start I (A)      0.0      0.0
Min Start V (V)      0.0   9999.9
Start %TCU           0.0      0.0
Running %TCU         0.0      0.0
Running Cur (A)      0.0      0.0
Running kW           0.0      0.0
Running kVARin       0.0      0.0
Running kVARout      0.0      0.0
Running kVA          0.0      0.0

Trip/Alarm Data
                  ALARMS    TRIPS
Overload               0        0
Locked Rotor           0        0
Undercurrent           0        0
Jam                    0        0
Current Imbal          0        0
Overcurrent                     0
Ground Fault                    0
Speed Switch           0        0
Undervoltage                    0
Overvoltage                     0
Power                           0
Power Factor           0        0
Phase Reversal                  0
Underfrequency                  0
Overfrequency                   0
PTC                             0
Start Timer                     0
Local Stop                      0
Remote Stop                     0
Other Trips                     0
Total                  0        0
```

Figure 5.14 MOTOR Command Example

Motor Start Report

The SEL-849 records motor start data for each motor start. The relay stores the five latest motor start reports in nonvolatile memory. View any of the five latest motor start reports using the serial port **MSR *n*** command, where *n* = 1–5, and *n* = 1 is the most recent report. The motor start reports can also be accessed via the web server or ACSELERATOR QuickSet.

The motor start reports are automatically reset when the motor statistics data are reset (see *Motor Operating Statistics on page 5.9*).

Each report consists of two parts.

- ➤ A summary
- ➤ The start data

Summary Data

The summary shows the following information:

- Date and time of the motor start
- Number of starts since last reset
- Motor start time
- Start % rotor thermal capacity used (%TCU)
- Maximum start current
- Minimum start voltage, if the voltage inputs card option is installed

NOTE: The relay reports %TCU values during starting based upon the starting model trip value, thus providing the appropriate %TCU magnitude scaling.

The relay calculates the motor start time from the time the starting current is detected until the running state is declared (see *Figure 5.14*). The %TCU value is the rotor thermal element capacity used at the end of the start, expressed in percent of the trip value.

Start Data

The motor start data are taken periodically after the starting current is detected. The relay stores 720 sets of the data with the period determined by the motor start report resolution (MSRR) setting.

The following data are stored.

- Magnitude of A-, B-, and C-phase currents
- Magnitude of residual ground current, IG
- % rotor thermal capacity used (%TCU)
- Magnitude of AB, BC, and CA phase-to-phase voltages, if included

Figure 5.15 shows data from an example Motor Start Report.

```
=>>MSR <Enter>

SEL-849                                    Date: 10/05/2012   Time: 01:46:48.197
MOTOR RELAY

FID=SEL-849-X251-V0-Z001001-D20120927      CID=DA18

Start Date = 10/05/2012
Start Time = 01:46:12.881

# Starts                  22
Start Time (s)           0.3
Start TCU  (%)           0.2
MaxCurrent (A)           1.0
MinVoltage (V)         115.8

 CYCLE       IA       IB       IC       IG      VAB      VBC      VCA    TCURTR
             (A)      (A)      (A)      (A)     (V)      (V)      (V)      (%)
    0.00     1.0      1.0      1.0      0.0    115.9    115.9    116.0    0.2
    0.25     1.0      1.0      1.0      0.0    115.9    115.9    116.0    0.2
    0.50     1.0      1.0      1.0      0.0    115.8    115.9    116.0    0.2
    0.75     1.0      1.0      1.0      0.0    115.9    115.9    116.0    0.2
    1.00     1.0      1.0      1.0      0.0    115.8    115.9    116.0    0.2
    1.25     1.0      1.0      1.0      0.0    115.9    115.9    115.9    0.2
    1.50     1.0      1.0      1.0      0.0    115.8    115.9    116.0    0.2
    1.75     1.0      1.0      1.0      0.0    115.9    115.9    116.0    0.2
    2.00     1.0      1.0      1.0      0.0    115.8    115.9    116.0    0.2
    2.25     1.0      1.0      1.0      0.0    115.9    115.9    116.0    0.2
    2.50     1.0      1.0      1.0      0.0    115.9    115.9    116.0    0.2
    2.75     1.0      1.0      1.0      0.0    115.9    115.9    116.0    0.2
    3.00     1.0      1.0      1.0      0.0    115.9    115.9    116.0    0.2
    3.25     1.0      1.0      1.0      0.0
=>>
```

Figure 5.15 Motor Start Report Example

Motor Start Trending

NOTE: All the trend data collected each day are added to nonvolatile memory at midnight. If the relay power is removed, the information collected between midnight and power removal is lost.

NOTE: While the relay power is off, the elapsed timers do not advance. If relay power is off for a significant amount of time, the elapsed calendar time will not match the elapsed time recorded by the relay.

For each motor start, the relay stores a motor start report and adds these data (described in *Summary Data on page 5.11*) to the motor start trending buffer. Motor start trending tracks motor start data for the past eighteen 30-day periods. For each 30-day interval, the relay records the following information:

- The date the interval began
- The total number of starts in the interval
- The averages of the following quantities:
  - Motor start time
  - Start % rotor thermal capacity used
  - Maximum start current
  - Minimum start voltage, if voltage inputs card option is installed

View the motor start trending data using the serial port **MST** command. *Figure 5.16* shows data from an example Motor Start Trending Report.

```
=>>MST <Enter>

SEL-849                                 Date: 01/06/2014   Time: 19:38:09.790
MOTOR RELAY                             Time Source: Internal


           Began     Number    Start     Start      Max      Min
Record      on         of      Time      %TCU     Start I  Start V
Number     Date      Starts     (s)                 (A)      (V)
   1     06/29/2012      4     14.4       18        913      2578
   2        ---        ---      ---       ---       ---       ---
   3        ---        ---      ---       ---       ---       ---
   4        ---        ---      ---       ---       ---       ---
   5        ---        ---      ---       ---       ---       ---
   6        ---        ---      ---       ---       ---       ---
   7        ---        ---      ---       ---       ---       ---
   8        ---        ---      ---       ---       ---       ---
   9        ---        ---      ---       ---       ---       ---
  10        ---        ---      ---       ---       ---       ---
  11        ---        ---      ---       ---       ---       ---
  12        ---        ---      ---       ---       ---       ---
  13        ---        ---      ---       ---       ---       ---
  14        ---        ---      ---       ---       ---       ---
  15        ---        ---      ---       ---       ---       ---
  16        ---        ---      ---       ---       ---       ---
  17        ---        ---      ---       ---       ---       ---
  18        ---        ---      ---       ---       ---       ---
=>>
```

Figure 5.16 Motor Start Trending Report Example

Section 6
Settings

Overview

This section is an overview of the ways in which the settings for the SEL-849 Motor Management Relay can be viewed and set. Setting entry error messages, together with corrective actions, are also covered in this section to assist you with settings entry. Settings, which are stored in nonvolatile memory, are divided into the following setting classes:

- Protection
- Logic
- Report
- HMI
- DNP3
- Modbus
- EtherNet/IP
- Port *p* (where *p* = 1 and 2 [Ethernet ports: 2A, 2B] or 1 and 3)

Some setting classes have multiple instances. In the previous list, there are three port setting instances, one for each port. Settings may be viewed or set in several ways, as shown in *Table 6.1*.

Table 6.1 Methods of Accessing Settings

	Web Server[a]	Serial Port Commands[b]	ACSELERATOR QuickSet SEL-5030 Software[a]
Display Settings	All settings	All settings (**SHO** command)	All settings
Change Settings	All settings	All settings (**SET** command)	All settings

[a] Refer to Section 3: PC Interface for detailed information.
[b] Refer to Section 7: Communications for detailed information on set-up and use of the serial communications port and Ethernet port.

The *SEL-849 Settings Sheets*, available on the SEL website under the SEL-849 product category, list all settings, setting definitions, and input ranges. Refer to *Section 4: Protection and Logic Functions* for detailed information on individual elements and settings.

View or Change Settings Using the Web Server

Refer to *Section 3: PC Interface* for information on how to set up communication and how to access the relay on an Ethernet port with a personal computer.

View Settings

Once communication with the relay is established through the web server, the home page screen appears in your browser window. Click on **Settings** from the navigation pane to view all the available setting classes, as shown in *Figure 6.1*. Access Level 1 is view only. At this level, settings are dimmed and you cannot modify them. Click on a settings class to view its settings.

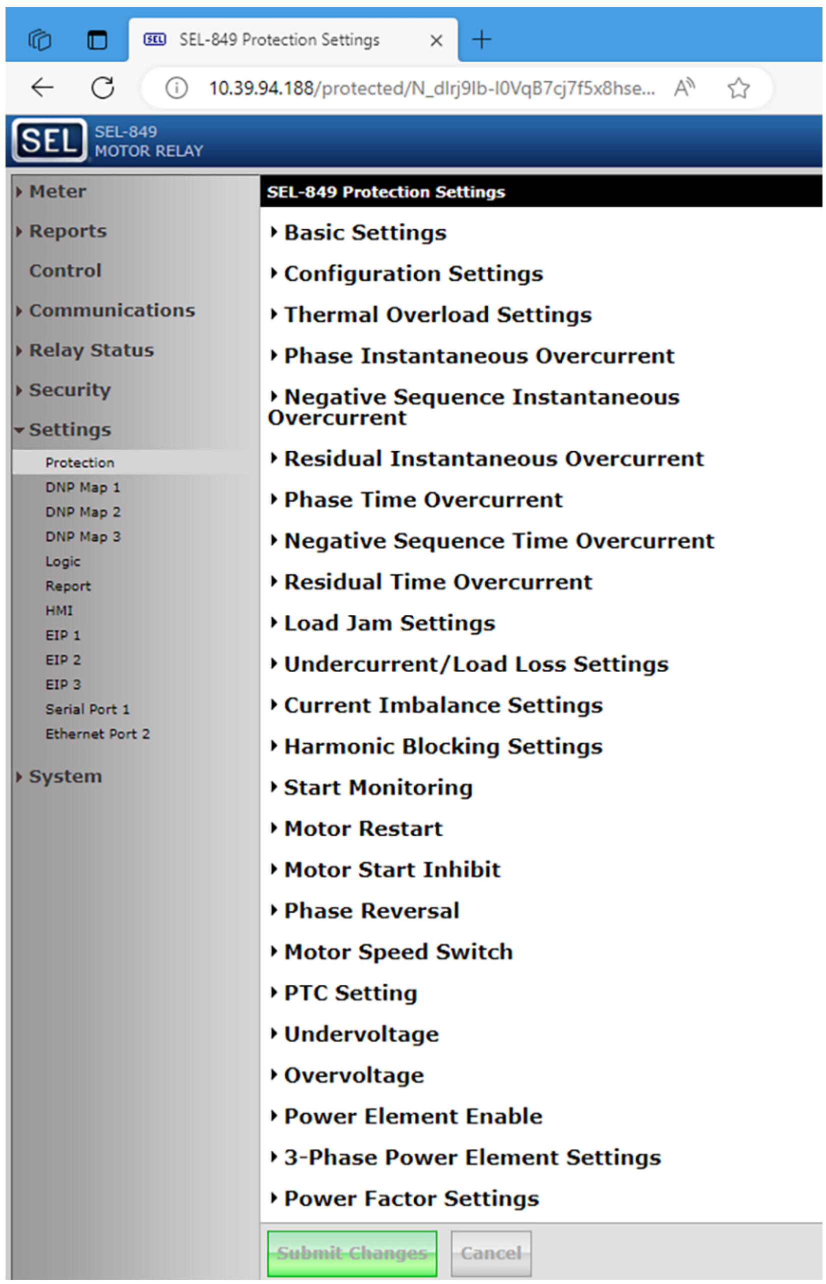


Figure 6.1 Web Server Settings Screen

Enter Settings

To set or modify the relay settings, log in to the relay at Access Level 2. On the navigation pane, click **Settings** to access the settings you want to edit. If an edited setting is out of range or invalid, the following message appears: **The settings colored red are in error. Changes cannot be submitted until the errors are corrected.** As shown in *Figure 6.2*, the green **Submit Changes** button is also unavailable.

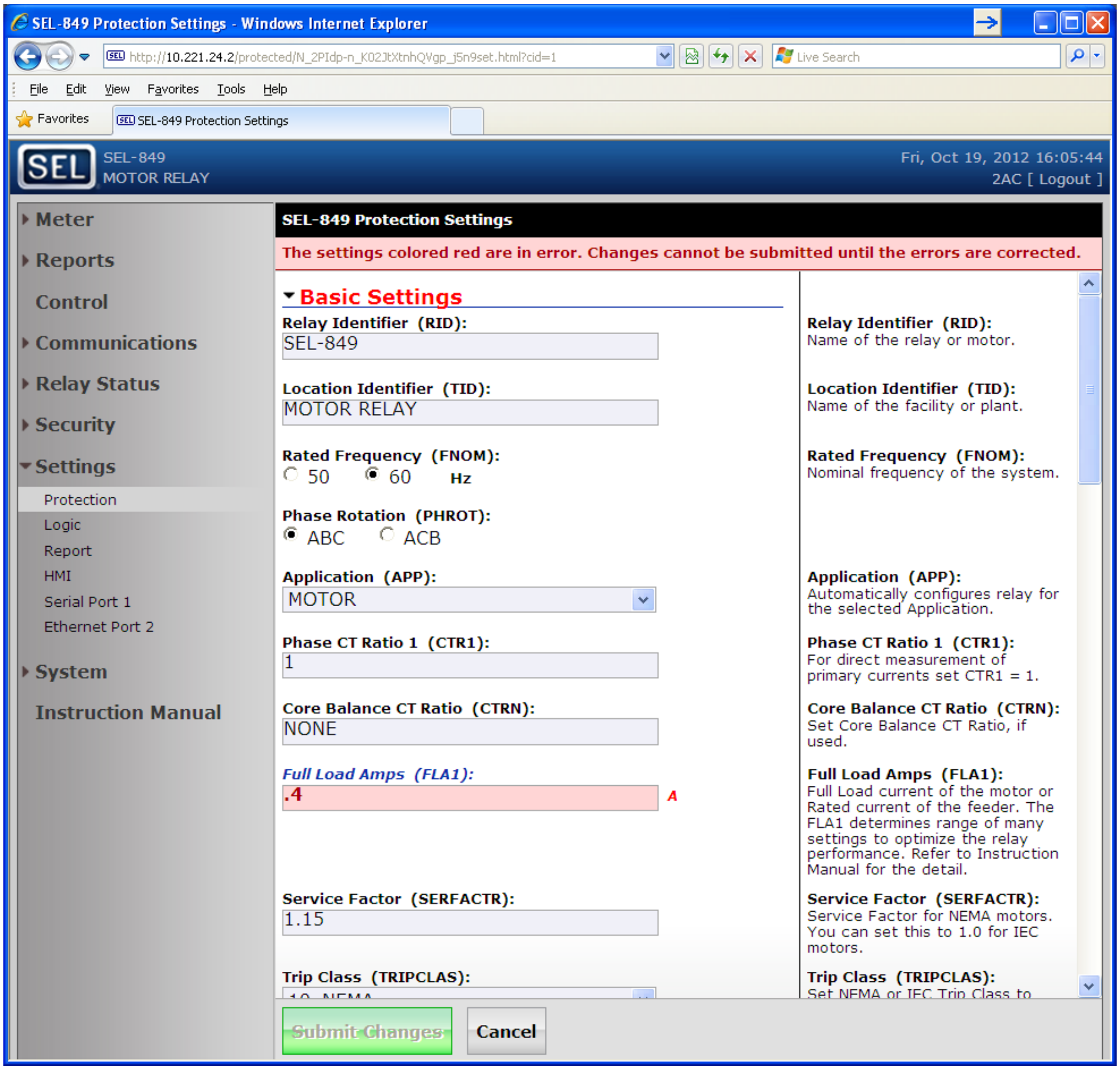


Figure 6.2 Web Server—Submit Changes Button Disabled When Entered Settings Are Incorrect

If the settings are edited without any errors, the **Submit Changes** button is enabled. Click on the button to submit the changes. As shown in *Figure 6.3*, the following message appears: **Are you sure you want to save your changes?**

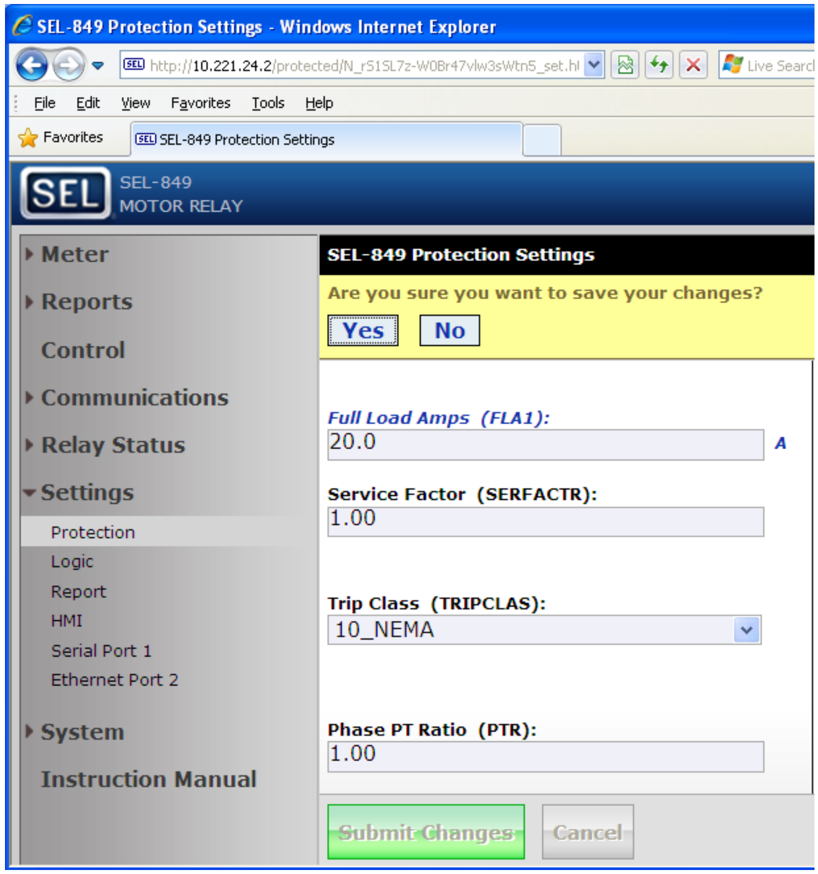


Figure 6.3 Web Server—Acknowledges to Confirm Submit Setting Changes to the Relay

Click **Yes** to save the edited settings to the relay; otherwise, click **No**. When **Yes** is selected the web server saves the settings to the relay, refreshes the webpage and acknowledges with the message, **Changes Saved**, as shown in *Figure 6.4*.

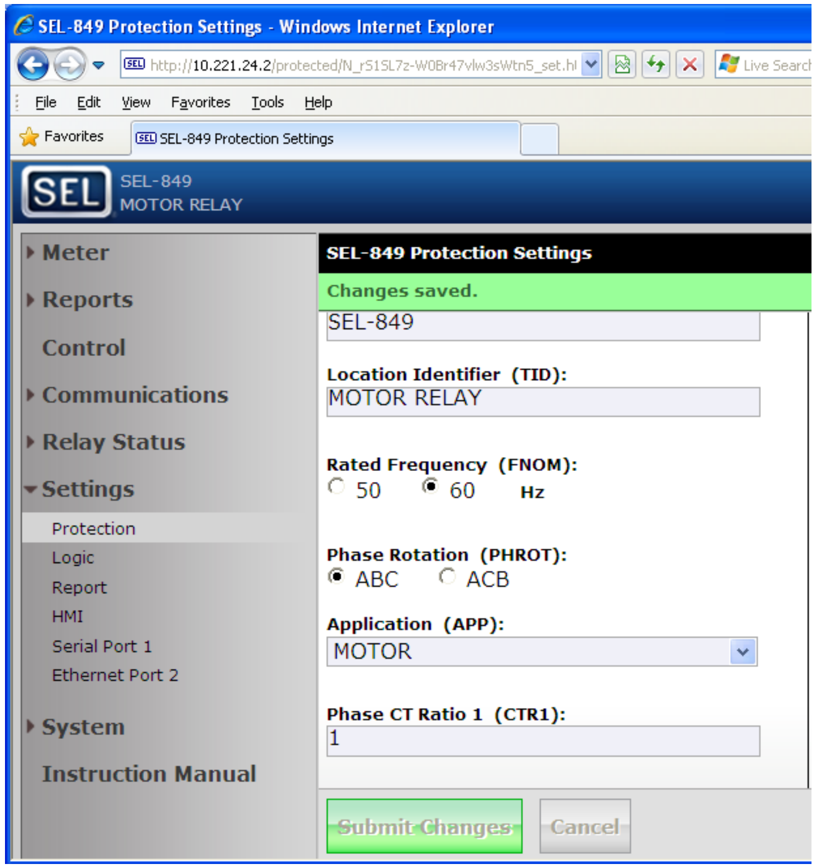


Figure 6.4 Web Server—Acknowledges Submitted Settings Were Saved to Relay

View or Change Settings Using ACSELERATOR QuickSet

Refer to *Section 3: PC Interface* for detailed information on how to set up communication and how to access the relay on an Ethernet or serial port with a personal computer.

View/Edit Settings

With ACSELERATOR QuickSet, you can edit relay settings online or offline. Once the settings database has been created and communication to the relay has been established at Access Level 1, select **Read > File** to read the current settings in the relay. The software may take a few minutes to read all the relay settings. Once read, all the settings are populated for viewing or editing, as shown in *Figure 6.5*. From the navigation pane, select the **Settings** class for the settings you want to view or edit. If the edited settings are out-of-range or invalid, then a message appears in the **Errors** window, as shown in *Figure 6.5*.

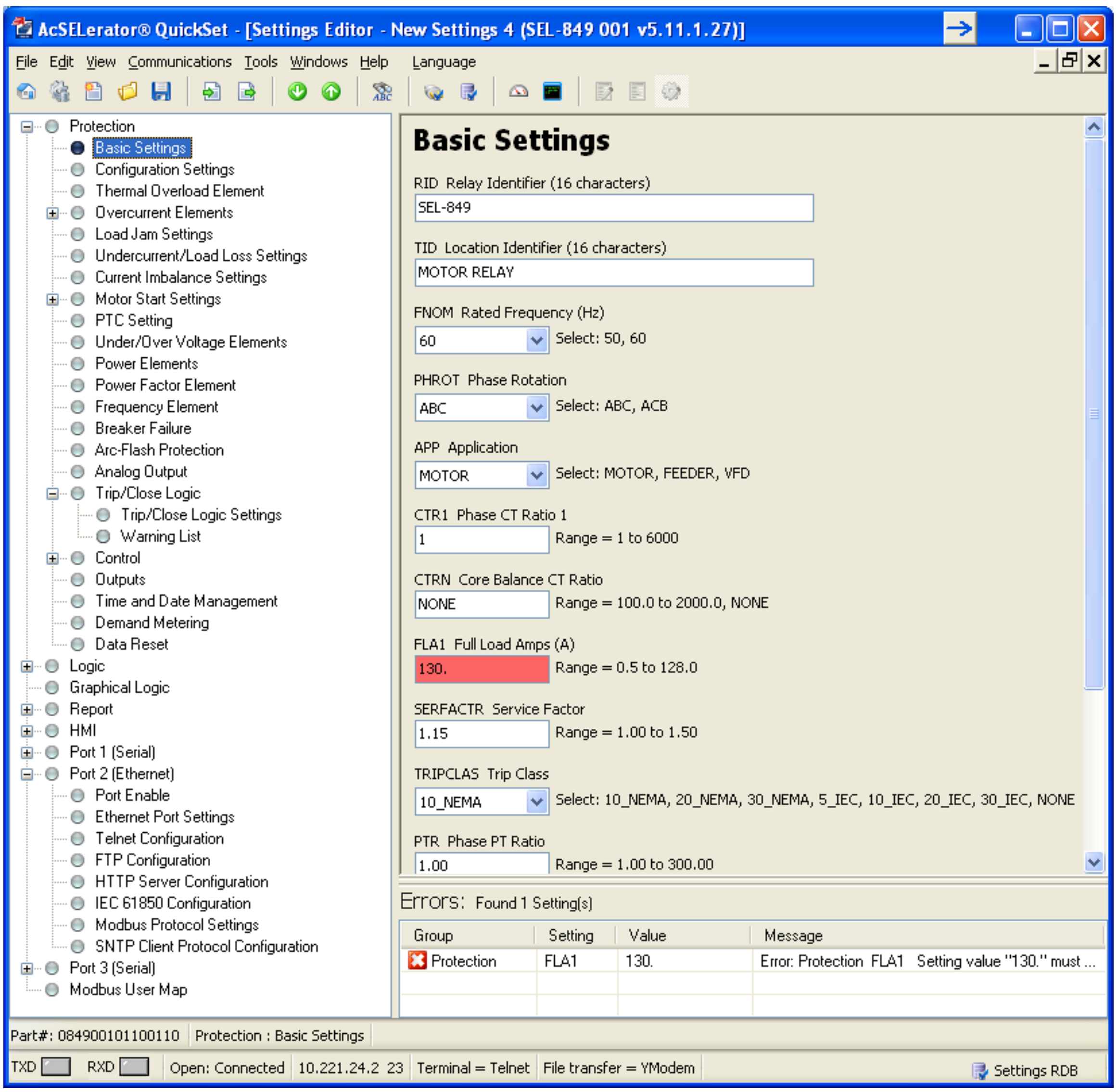


Figure 6.5 ACSELERATOR QuickSet Settings Editor—Displays Error if Invalid Settings Entered

You do not have to be at Access Level 2 to edit the settings; however, you must be at Access Level 2 to send the edited settings to the relay. Select **File > Send** to send the settings to the relay. The settings have to be free of errors before you can send them to the relay. One of the many advantages of ACSELERATOR QuickSet is its ability to save settings on your computer for record keeping and offline, anytime viewing or editing.

View or Change Settings Using the 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. *Table 6.2* lists the **SHOW** command options.

Table 6.2 SHOW Command Options

Command	Description
SHOW	Show relay protection settings.
SHO L	Show logic setting.
SHO HMI	Show HMI settings.
SHO P *n*	Show port settings for Port *n* (*n* = 1 and 2 or 1 and 3).
SHO R	Show Sequential Events Recorder (SER) and event report settings.
SHO D	Show DNP3 settings.
SHO M	Show Modbus settings.
SHO E	Show EtherNet/IP assembly map settings.

You may 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 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	Protection	Protection elements, timers, etc., settings
SET L	Logic	SELOGIC control equations for settings protection
SET HMI	HMI	HMI display settings
SET P *n*	Port	Serial port settings for serial port *n* (1 and 2 or 1 and 3)
SET R	Reports	SER and event report settings
SET D	DNP3	DNP3 map settings
SET M	Modbus	Modbus user map
SET E	EtherNet/IP	EtherNet/IP assembly map settings

You may 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 L, HMI, R, M, or P to identify the class of settings.
m	is left blank or is 1 and 2 or 1 and 3 when *n* = P.
s	is the name of the specific setting you wish to jump to and begin setting. If *s* is not entered, the relay starts at the first setting (e.g., enter **50P1P** to start at Phase Overcurrent Trip level setting).
TERSE	instructs the relay to skip the settings display after the last setting. Use this parameter to speed up the **SET** command. If you wish to review the settings before saving, do not use the **TERSE** option.

Setting Entry Error Messages

As you enter relay settings, the relay checks the setting entered against the range for the setting as published on the relay setting sheet. If any setting entered falls outside the corresponding range for that setting, the relay immediately responds `Out of Range` and prompts you to reenter the setting.

In addition to the immediate range check, several of the settings have interdependency checks with other settings. The relay checks setting interdependencies after you answer **Y** to the `Saves Settings?` prompt, but before the settings are stored. If any of these checks fail, the relay issues an error message, shown in *Table 6.6*, and returns you to the settings list for a correction.

Table 6.6 Setting Interdependency Error Messages

Error Message	Setting /Function	Correct the Condition
`LOAD_ZS must be between x.x and yyy.y`	Basic and Configuration Settings	Modify LOAD_ZS setting to satisfy: x.x < LOAD_ZS < yyy.y
`At least one UVTM__ must be set for UV Restart`	Motor Restart	Modify such that RS_ELE = LJ or one of the UVTM_ settings (UVTMSHRT, UVTMMED, UVTM-LONG) to a value other than OFF.

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Section 7

Communications

Overview

A communications interface and protocol are required for communicating with the SEL-849 Motor Management 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.

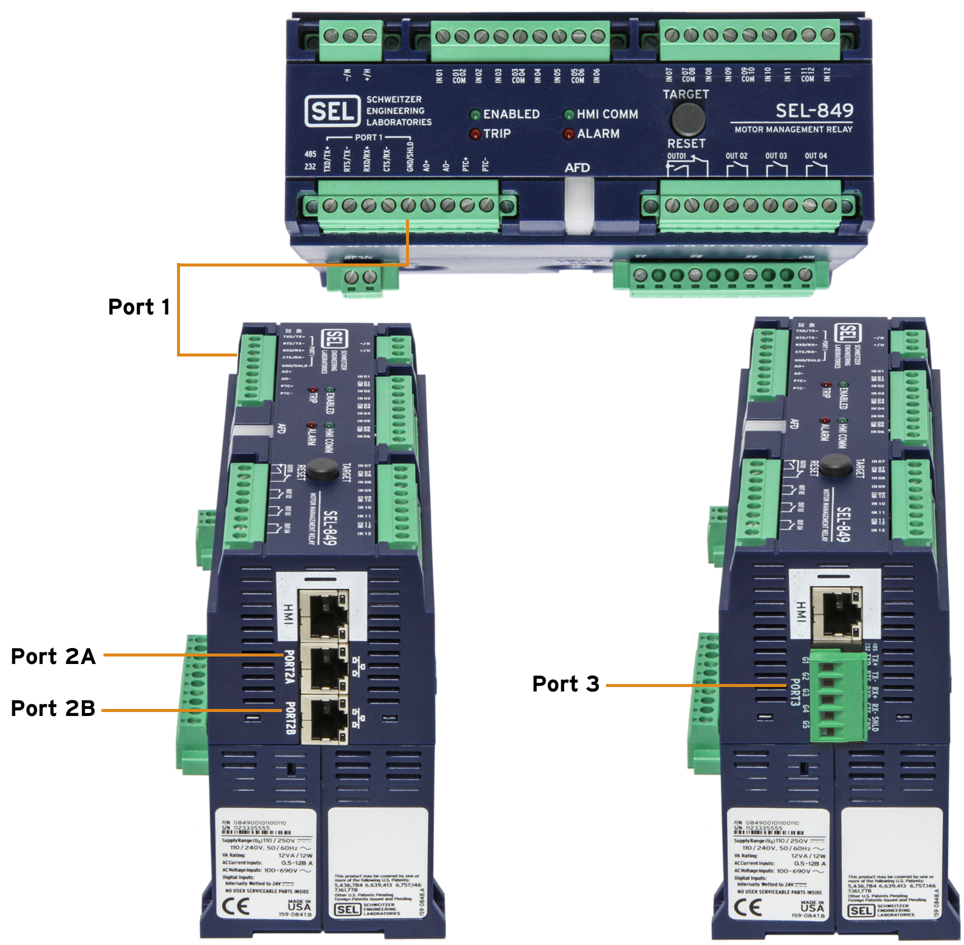

Figure 7.1 Location of Communications Ports

Communications Interfaces

The SEL-849 physical interfaces are shown in *Table 7.1*. The SEL-849 provides for a variety of physical interfaces including EIA-485, EIA-232, and copper Ethernet (single- or dual-redundant). Be sure to evaluate the installation and communication necessary to integrate with existing devices before ordering your SEL-849. See *Figure 7.1* for the communications ports listed in *Table 7.1*.

Table 7.1 SEL-849 Communications Port Interfaces

Port	Communications Port Interface	Location	Feature
PORT 1	EIA-232 or EIA-485 (settings selectable)	D1–D5 Terminals	Standard
PORT 2A	10/100BASE-T Ethernet (RJ45 connector)	Side Panel	Standard
PORT 2B	Dual redundant 10/100BASE-T Ethernet	Side Panel	Ordering Option
PORT 3	EIA-232 or EIA-485 (settings selectable)	G1–G5 Terminals	Ordering Option

Establishing Communication Using an EIA-232 or EIA-485 Port

Use the EIA-232 port for communications distances 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 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-849 Relay

Some of the SEL devices available for integration or communications system robustness are included in the following list:

- ➤ SEL Communications Processors (SEL-3530, SEL-2032, SEL-2030, SEL-2020)
- ➤ SEL-2800 series fiber-optic transceivers

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*).

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 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.

Establishing Communication Using an Ethernet Port and Telnet or the Web Server

NOTE: Telnet and the web server work with other NETMODE settings also, but NETMODE = SWITCHED is easiest to begin communication. The relay hides setting NETMODE when equipped with a single Ethernet port.

Factory-default settings for the Ethernet ports disable all Ethernet protocols except Telnet, HTTP, and PING. Command **SET P 2** accesses settings for both Ethernet ports on the SEL-849: Port 2A and Port 2B.

See Ethernet port settings in *Table 4.57 on page 4.74* for a sample of the **SET P 2** command with factory-default settings.

Make the following settings using the **SET P 2** command:

- IPADDR := IP Address assigned by network administrator
- DEFRTR := Default router IP Address assigned by network administrator
- NETMODE := SWITCHED (available with dual Ethernet ports)
- ETELNET := Y
- EHTTP := Y

Leave all other settings at their default values.

Connect an Ethernet cable between your PC or a network switch and any Ethernet port on the relay. Verify that the amber **Link** LED illuminates on the connected relay port. Many computers and most Ethernet switches support autocrossover, so nearly any Cat 5 Ethernet cable with RJ45 connectors, such as an SEL-C627 cable will work. When the computer does not support autocrossover, use a crossover cable, such as an SEL-C628 cable. If your relay is equipped with dual Ethernet ports, connect to either port. Use a Telnet application or ACSELERATOR QuickSet on the host PC to communicate with the relay. To terminate a Telnet session, use the command **EXI** from any access level.

In addition, you can communicate with the relay through your web browser. Launch a web browser and browse address http://IPADDR or https://IPADDR for nonsecure or secure HTTP communication, respectively, where IPADDR is the **Port 2** IPADDR setting. To terminate the session, close the web browser (see *Section 3: PC Interface* for more details).

Ethernet Port

Use the Ethernet port for interfacing with an Ethernet network environment. To enable the Ethernet port, set EPORT := Y on **PORT 2**.

Ethernet Network Operation Settings

Several settings control how the SEL-849 with the Ethernet port operates on an Ethernet network. These settings include IP addressing information, network port failover options, and network speed.

Network Configuration

Use the network configuration settings shown in *Table 7.2* to configure the SEL-849 for operation on an IP network and to set other parameters affecting the physical Ethernet network interface operation.

Table 7.2 Ethernet Port Configuration Settings

Label	Description	Range	Default
EPORT	Enable Ethernet port communication	Y, N	Y
IPADDR	IP network address/CIDR network prefix	IP address w.x.y.z/t where: w = 0–126, 128–223 x = 0–255 y = 0–255 z = 0–255 t = 1–30	169.254.0.1/16
DEFRTR	Default router	w = 0–126, 128–223 x = 0–255 y = 0–255 z = 0–255	0.0.0.0
ETCPKA	TCP keep-alive functionality enable	Y, N	N
KAIDLE	Length of time to wait with no detected activity before sending a keep-alive packet	1–20 s (must be greater than or equal to KAINTV)	10
KAINTV	Length of time to wait between sending keep-alive packets after receiving no response for the prior keep-alive packet	1–20 s (must be less than or equal to KAIDLE)	1
KACNT	Maximum number of keep-alive packets to send	1–20	6
NETMODE	Network operating mode	FIXED, FAILOVER, SWITCHED, PRP	FAILOVER
FTIME	Failover time-out	OFF, 0.10–65 sec	1
NETFAIL	Network link failure	SELOGIC	0
NETPORT	Primary network port	A, B	A
NETASPD	Network speed or autodetect on Port **A**	AUTO, 10 Mbps, 100 Mbps	Auto
NETBSPD	Network speed or autodetect on Port **B**	AUTO, 10 Mbps, 100 Mbps	Auto

The SEL-849 IPADDR setting uses Classless Inter-Domain Routing (CIDR) notation and a variable-length subnet mask (VLSM) to define its local network and host address.

An IP address consists of two parts: a prefix that identifies the network followed by a host address within that network. Early network devices used a subnet mask to define the network prefix of an associated host address. Within the mask, subnet boundaries were defined by the 8-bit segments of the 32-bit IP address. These boundaries constrained network prefixes to 8, 16, or 24 bits, defining Class A, B, and C networks, respectively.

This classful networking often created subnetworks that were not sized efficiently for actual requirements. CIDR allows more effective usage of a given range of IP addresses. In CIDR notation, you enter the IPADDR setting in the form a.b.c.d/p, where a.b.c.d is the host address in standard dotted decimal form and p is the network prefix expressed as the number of “1” bits in the mask. For example, if IPADDR := 192.168.1.2/24, the host address is 192.168.1.2 and the network prefix is the first 24 bits of the address, or 192.168.1. The network address is derived by applying the network prefix to IPADDR and filling the remaining bits with zeros (in our example, it is

192.168.1.0). The broadcast address is derived similarly, but the remaining bits are filled with ones (192.168.1.255 for the example above). Neither the network (base) address nor the broadcast address can be used for any host or router addresses on the network.

The SEL-849 uses the DEFRTR address setting to determine how to communicate with nodes on other local networks. The SEL-849 communicates with the default router to send data to nodes on other local networks. The default router must be on the same local network as the SEL-849 or the SEL-849 will reject the DEFRTR setting. You must also coordinate the default router with your general network implementation and administration plan. See *Table 7.3* for examples of how IPADDR and SUBNETM define the network and node and how these settings affect the DEFRTR setting.

Table 7.3 DEFRTR Address Setting Examples

IPADDR (CIDR)	SUBNET Mask (Non-CIDR)	Network Address	Broadcast Address	DEFRTR Range[a]
192.168.1.2/28	255.255.255.240	192.168.1.0	192.168.1.15	192.168.1.0–192.168.1.15
192.168.1.2/24	255.255.255.0	192.168.1.0	192.168.1.255	192.168.1.*z*[b]
192.168.1.2/20	255.255.240.0	192.168.0.0	192.168.15.255	192.168.0.*z*[b]–192.168.15.*z*[b]
192.168.1.2/16	255.255.0.0	192.168.0.0	192.168.255.255	192.168.*y*[b].*z*[b]
192.168.1.2/12	255.240.0.0	192.160.0.0	192.175.255.255	192.160.*y*[b].*z*[b]–192.175.*y*[b].*z*[b]
192.168.1.2/8	255.0.0.0	192.0.0.0	192.255.255.255	192.*x*[b].*y*[b].*z*[b]
192.168.1.2/4	240.0.0.0	192.0.0.0	207.255.255.255	192.*x*[b].*y*[b].*z*[b]–207.*x*[b].*y*[b].*z*[b]

[a] DEFRTR cannot be the same as IPADDR, Network Address, or Broadcast Address.
[b] Value in the range 0–255.

The ETCPKA setting, along with the KAIDLE, KAINTV, and KACNT settings, can be used to verify that the computer at the remote end of a TCP connection is still available. If ETCPKA is enabled and the SEL-849 does not transmit any TCP data within the interval specified by the KAIDLE setting, the SEL-849 sends a keep-alive packet to the remote computer. If the SEL-849 does not receive a response from the remote computer within the time specified by KAINTV, the keep-alive packet is retransmitted as many as KACNT times. After this count is reached, the SEL-849 considers the remote device no longer available, so the SEL-849 can terminate the connection without waiting for the idle timer (TIDLE or FTPIDLE) to expire.

The SEL-849 Ethernet port operates over twisted-pair media. For twisted-pair connections, the Ethernet port can autodetect the network speed or you can set a fixed speed (10 or 100 mps).

SEL-849 Ethernet port choices include single or dual copper configurations. With dual Ethernet ports the unit includes an unmanaged Ethernet switch. Redundant configurations support automatic failover switching from primary to backup network if a failure in the primary network is detected. In addition to failover mode, the unit can operate in a “fixed connection (to netport) mode” or in a “switched mode” (as an unmanaged switch).

Figure 7.2 shows an example of a Simple Ethernet Network Configuration, *Figure 7.3* shows an example of an Ethernet Network Configuration with Dual Redundant Connections, and *Figure 7.4* shows an example of an Ethernet Network Configuration with Ring Structure. *Figure 7.5* shows an example using Network Link Failure (NETFAIL SELOGIC equation) to force switchover in a dual Ethernet configuration with NETMODE := FAILOVER.

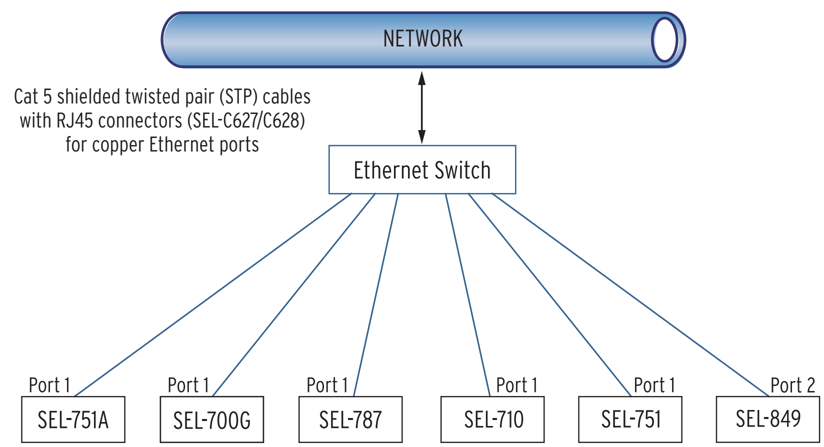

Figure 7.2 Simple Ethernet Network Configuration

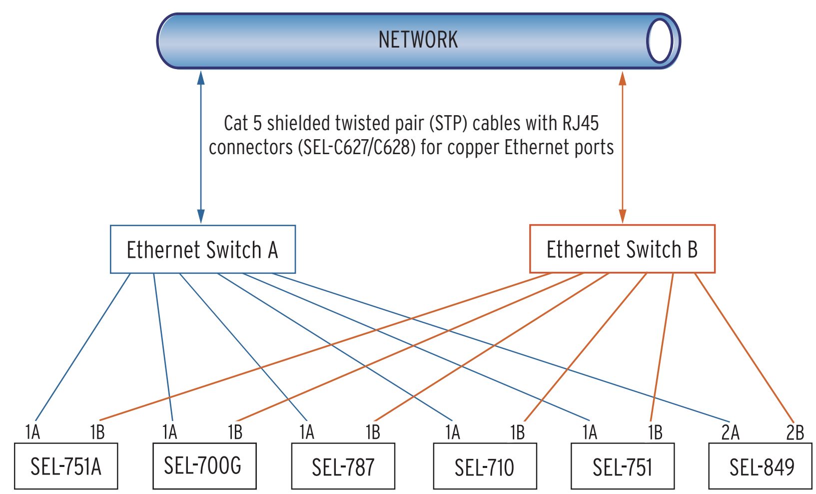

Figure 7.3 Ethernet Network Configuration With Dual Redundant Connections

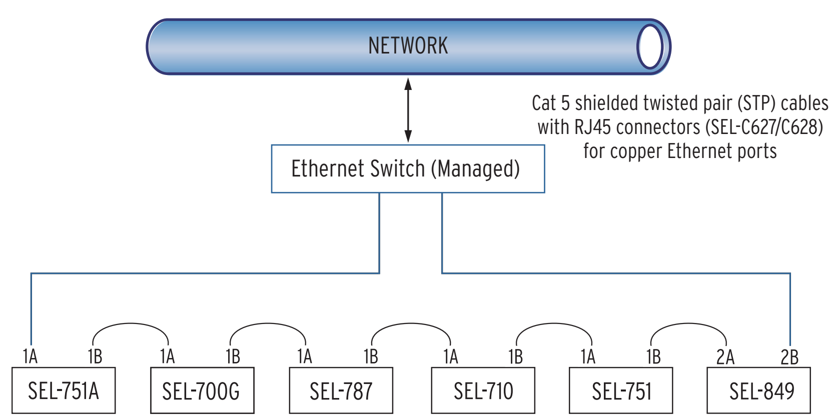

Figure 7.4 Ethernet Network Configuration With Ring Structure

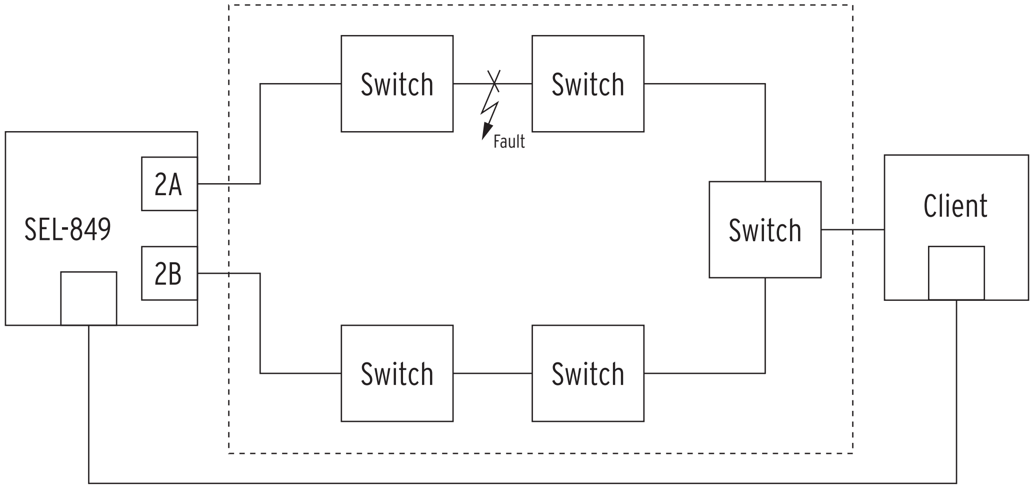

Figure 7.5 Dual Ethernet Configuration With NETMODE := FAILOVER and Using Network Link Failure (SELOGIC Equation) Setting to Force Switchover

Dual Network Port Operation

The SEL-849 dual Ethernet port option has two network ports. Network port failover mode enables the dual Ethernet port to operate as a single network adapter with a primary and standby physical interface. You can connect the two network ports to the same network or to different networks depending on your specific Ethernet network architecture.

Failover Mode

In the failover mode operation, the relay determines the active port. To use failover mode, proceed with the following steps.

Step 1. Set NETMODE to FAILOVER.

Step 2. Set the NETFAIL SELOGIC equation to cover link failures that are not detectable by the relay to initiate failover switching.

Step 3. Set FTIME to the desired network port failover time (OFF, 0.01–65.00 seconds).

Step 4. Set NETPORT to the preferred network interface.

NOTE: If you change settings for the host port in the relay and the standby network port is active, the relay resets and returns to operation on the primary port.

On startup, the relay communicates via the NETPORT (primary port) selected. If the SEL-849 detects a link failure on the primary port, it activates the standby port after the failover time, FTIME, elapses. If the link returns to normal before the failover time expires, the failover timer resets and uninterrupted operation continues on the primary network port.

Setting FTIME = OFF allows fast port switching (with no intentional delay). Fast port switching can occur within one processing interval (typically 4 to 5 ms) and can help with IEC 61850 GOOSE performance. Use the NETFAIL (SELOGIC equation) setting to cover link failures that are not detectable by the relay to initiate failover switching. The relay processes the rising edge of the NETFAIL SELOGIC control equation to initiate the switchover. The switchover time depends on the FTIME setting. The next rising edge of NETFAIL after the switchover causes switchback to the original network.

After failover, while communicating via the standby port, the SEL-849 checks the primary link periodically and continues checking until it detects a normal link status. The relay continues to communicate via the standby port even after the primary port returns to normal. The relay reevaluates the port of choice for communication upon a change of settings, at failure of the standby port, or upon reboot. The relay returns to operation on the primary link under those conditions if it detects a normal link status. When the active and backup links both fail, the relay alternates checking for the link status of the primary and standby ports.

Unmanaged Switch Mode

If you have a network configuration where you want to use the relay as an unmanaged switch, set NETMODE to SWITCHED. In this mode, both links are enabled. The relay will respond to the messages received on either port. All the messages received on one network port that are not addressed to the relay will be transmitted out of the other port without any modifications. In this mode the relay ignores the NETPORT setting.

Fixed Connection Mode

If you have a single network and want to use only one network port, or if you have both ports connected but want to force usage of only one port for various reasons, set NETMODE to FIXED and set NETPORT to the port you want to use. Only the selected network port operates and the other port is disabled.

PRP Connection Mode

Parallel Redundancy Protocol (PRP) is part of an IEC standard for high availability automation networks (IEC 62439-3). The purpose of the protocol is to provide seamless recovery from any single Ethernet network failure.

The basic concept is that the Ethernet network and all traffic are fully duplicated with the two copies operating in parallel.

Make the following settings for Port 2 to configure the relay for PRP mode.

- ➤ NETMODE = PRP
- ➤ PRPTOUT = desired timeout for PRP frame entry
- ➤ PRPADDR = PRP destination MAC address LSB (least significant byte of “01-15-4E-00-01-*XX*,” converted to decimal and entered as 0–255)
- ➤ PRPINTV = desired supervision frame transmit interval

When NETMODE is not set to PRP, the following settings are hidden.

Table 7.4 PRP Settings

Setting Prompt	Setting Description	Setting Range	Setting Name := Factory Default
PRP ENTRY TIMEOUT	PRP Entry Timeout	400–10000 ms	PRPTOUT := 500
PRP DESTINATION ADDR LSB	The multicast MAC address of PRP supervision frames is 01-15-4E-00-01-*XX* where *XX* is specified by this setting in decimal notation as 0–255.	0–255	PRPADDR := 0
PRP SUPERVISION TX INTERVAL	PRP Supervision TX Interval	1–10 s	PRPINTV := 2

Autonegotiation, Speed, and Duplex Mode

Single or dual copper Ethernet ports are capable of autonegotiating to determine the link speed and duplex mode. This is accomplished by setting the NETASPD and NETBSPD (network speed) to AUTO. Single or dual copper ports can also be set to a specific speed to be able to apply them in networks with older switch devices.

NETPORT Selection

The NETPORT setting gives you the option to select the primary port of communication in failover or fixed communication modes. Setting EPORT to N disables both the ports thereby providing you with the security of turning off the ports even if the ports are physically connected to the network.

Connect Your PC to the Relay

The serial ports of the SEL-849 use a terminal block connection with pin numbering shown in *Figure 7.6*. The pinout assignments for these ports are shown in *Table 7.5*. You can connect to a standard 9-pin computer port with an SEL-C234T cable, wiring for this cable is shown in *Figure 7.7*. The SEL-C285T cable and other cables are available from SEL. Use the SEL-5801 Cable Selector program to select an appropriate cable for another application. This software is available for free download from the SEL website at selinc.com.

For best performance, the SEL-C234T cable 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 7.6 shows the EIA-232/EIA-485 serial port (PORT 1) connector pinout for the SEL-849.

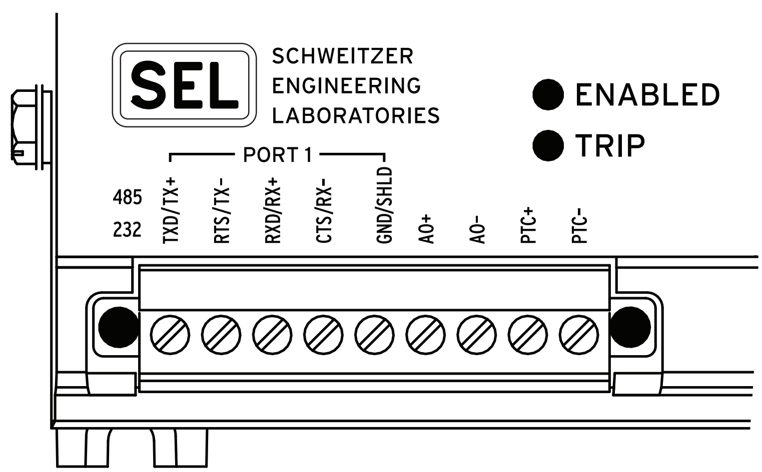

Figure 7.6 EIA-232/EIA-485 Connector Pin Numbers

Table 7.5 shows the pin functions for the EIA-232 and EIA-485 serial ports.

Table 7.5 EIA-232/EIA-485 Serial Port Pin Functions

Pin	Terminal D PORT 1		Terminal G PORT 3	
	EIA-232	EIA-485	EIA-232	EIA-485
1	TXD	+TX	TXD	+TX
2	RTS	–TX	RTS	–TX
3	RXD	+RX	RXD	+RX
4	CTS	–RX	CTS	–RX
5	GND	Shield	GND	Shield

Figure 7.7 and *Figure 7.8* are diagrams showing EIA-232 serial communications cables that connect the SEL-849 to other devices. These and other cables are available from SEL. Contact the factory for more information.

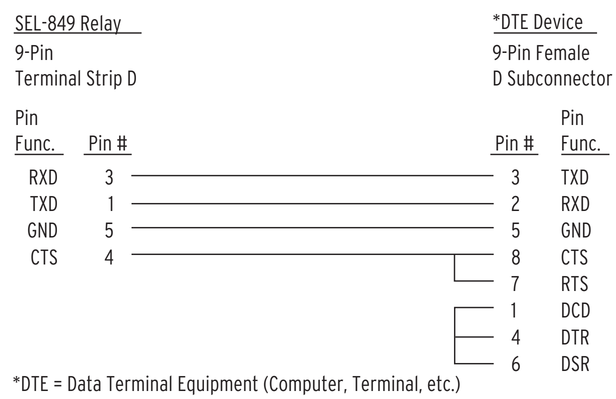

Figure 7.7 SEL-C234T Cable—SEL-849 to DTE Device

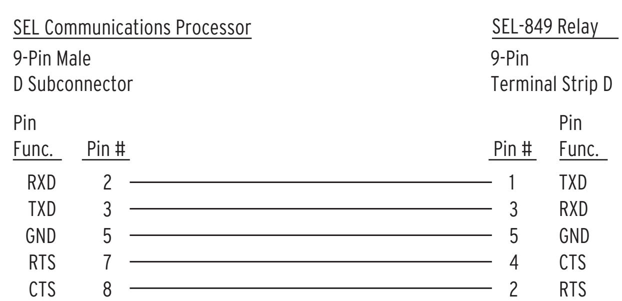

Figure 7.8 SEL-C285T Cable—SEL-849 to SEL Communications Processor

Communications Protocols

The SEL-849 supports many communications protocols, as shown in *Table 7.6*.

Table 7.6 Supported SEL-849 Communications Protocols

Protocol	Port 1	Port 3	2, 2A, 2B Ethernet	Section
SEL ASCII and Compressed ASCII	x	x	Telnet	*Section 7: Communications*
SEL Fast Operate, SEL Fast Meter, Fast SER	x	x	Telnet	*Section 7: Communications*
SEL Settings File Transfer	x	x	Telnet	*Section 7: Communications*
DNP3	x	x	x	*Appendix D: DNP3 Communications*
Modbus/RTU	x	x		*Appendix E: Modbus Communications*
Modbus/TCP			x	*Appendix E: Modbus Communications*
SNTP			x	*Section 7: Communications*
EtherNet/IP			x	*Appendix F: EtherNet/IP Communications*
Web Server (HTTP/HTTPS)			x	*Section 7: Communications*
FTP			x	*Section 7: Communications*
Telnet			x	*Section 7: Communications*
IEC 61850			x[a]	*Appendix G: IEC 61850 Communications*
PRP			x	*Section 7: Communications*

[a] Available as an ordering option.

SEL ASCII, Compressed ASCII, and Fast protocols are available when the serial port setting PROTO is set to SEL and when using Telnet.

Session Limits

The SEL-849 supports multiple simultaneous sessions of many of the protocols listed in *Table 7.6*. The number of allowed protocol sessions depends on what other protocols are enabled, as shown in *Table 7.7*.

Table 7.7 Protocol Session Limits (Sheet 1 of 2)

Protocol	Sessions Supported[a]
IEC 61850	The relay supports six simultaneous sessions of IEC 61850.
DNP3	The relay supports five total DNP3 sessions (combined serial and Ethernet).
Modbus	The relay supports three total Modbus sessions (combined serial and Ethernet).
EtherNet/IP	The relay supports 8 connections. Of these, as many as 2 Class 1 (I/O) connections and as many as 6 Class 3 messages and Unconnected Message Manager (UCMM) messages.
FTP	The relay supports one session of File Transfer Protocol on Port 2.

Table 7.7 Protocol Session Limits (Sheet 2 of 2)

Protocol	Sessions Supported[a]
Telnet	The number of available simultaneous Telnet sessions depends on Port 2 relay settings E61850, EHTTP/EHTTPS (Web Server), and EMOD (Modbus TCP) as follows: When Port 2 setting E61850 = N[b], the relay supports three simultaneous Telnet sessions. When Port 2 settings E61850 = Y, EHTTP = N, EHTTPS = N, and EMOD = 0, the relay supports three simultaneous Telnet sessions. When Port 2 settings E61850 = Y, EHTTP = Y, or EHTTPS = Y, and EMOD = 0, the relay supports two simultaneous Telnet sessions. When Port 2 settings E61850 = Y, EHTTP = N, EHTTPS = N, and EMOD > 0, the relay supports two simultaneous Telnet sessions. When Port 2 settings E61850 = Y, EHTTP = Y, or EHTTPS = Y, and EMOD > 0, the relay supports one Telnet session.
Web Server (HTTP/HTTPS)	The relay always supports three simultaneous web server sessions.
SNTP	The relay supports one session of SNTP on Port 2. Some operation modes of SNTP allow the relay to synchronize to one of multiple NTP servers.

[a] When properly configured (enable settings, IP addresses, etc.).
[b] Relays ordered without IEC 61850 are treated as if E61850 = N.

SEL Communications Protocols

SEL ASCII

SEL ASCII protocol is described in *SEL ASCII Protocol and Commands*.

SEL Compressed ASCII

SEL Compressed ASCII protocol provides compressed versions of some of the relay 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

SEL Fast Meter protocol supports binary messages to transfer metering and digital element messages. 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

SEL Fast Operate protocol supports binary messages to transfer operation messages. This protocol is described in *SEL ASCII Protocol and Commands*.

SEL Fast Sequential Events Recorder (SER)

SEL Fast Sequential Events Recorder (SER) protocol, also known as SEL Unsolicited Sequential Events Recorder, provides SER events to an automated data collection system. SEL Fast SER protocol is available on any serial or Ethernet port. The protocol is described in *Appendix C: SEL Communications Processors*.

Other Supported Protocols

Distributed Network Protocol (DNP3)

The SEL-849 provides DNP3 protocol support if the option is selected. The DNP3 protocol is described in *Appendix D: DNP3 Communications*.

Modbus Protocol

The relay supports Modbus protocol as described in *Appendix E: Modbus Communications*.

Ethernet Protocols

As with other communications interfaces, you must choose a data exchange protocol that operates over the Ethernet network link in order to exchange data. The relay supports IEC 61850, DNP3, Modbus, EtherNet/IP, Telnet, PING, Simple Network Time Protocol (SNTP), HTTP/HTTPS, and File Transfer Protocol (FTP) protocols.

You should carefully design your Ethernet network to maximize reliability, minimize system administration effort, and provide adequate security. Work with a networking professional to design your substation Ethernet network.

File Transfer Protocol (FTP)

File Transfer Protocol (FTP) is a standard protocol for exchanging files between computers over a TCP/IP network. The SEL-849 operates as an FTP server, presenting files to FTP clients. The relays supports one FTP session at a time. Requests to establish additional FTP sessions are denied.

File Structure

The file structure is organized as a directory and subdirectory tree similar to that used by Windows and other common operating systems. The SEL-849 root directory contains the CFG.TXT file and an ERR.TXT file (see *FILE Command on page 7.29*), the SET_61850.CID file (see *Appendix G: IEC 61850 Communications*), a SETTINGS directory, and an EVENTS directory. The SETTINGS directory contains the same files available using the **FIL** command. The EVENTS directory contains event files as discussed in *Retrieving Raw Data Oscillograms on page 9.10*.

File dates within the last 12 months are displayed with month, day, hour, and minutes. Dates older than 12 months have the year, month, and day. The times are UTC.

Access Control

To log in to the FTP server, enter the value of the Port 2 setting FTPUSER as the username in your FTP application. Enter the Level 2 password as the password in your FTP application. Note that FTP does not encrypt passwords before sending them to the server.

Using FTP

A free FTP application is included with most web browser software and PC operating systems. You can also obtain free or inexpensive FTP applications from the Internet. Once you have retrieved the necessary files, be sure to close the FTP connection using the disconnect function of your FTP application or completely closing the application. Failure to do so can cause the FTP connection to remain open, which blocks subsequent connection attempts until FTPIDLE time expires.

Table 7.8 lists the settings that are available to configure the FTP server in the SEL-849.

Table 7.8 FTP Settings

Settings	Description	Range	Default
EFTPSERV	Enable FTP	Y, N	Y
FTPACC	FTP Maximum Access Level	1, 2, C	2
FTPUSER	FTP User Name	20 characters	FTPUSER
FTPCBAN	FTP Connect Banner	254 characters	FTP server
FTPIDLE	FTP Idle Timeout	5–255 minutes	5

Telnet Server

The relay supports a Telnet server on Port 2. Use the Telnet session to connect to the relay to use the SEL ASCII, Compressed SEL ASCII, Fast Meter, Fast Operate, etc.

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. A free Telnet application is included with most computer operating systems, or you can obtain a low-cost or free Telnet application on the Internet.

Table 7.9 lists the settings that are available to configure the FTP server in the SEL-849.

Table 7.9 Telnet Settings

Setting	Description	Range	Default
ETELNET	Enable Telnet	Y, N	Y
MAXACC	Maximum Access Level	1, 2, C	2
TPORT	Telnet Port	23, 1025-65534	23
TCBAN	Telnet Connect Banner	254 characters	TERMINAL SERVER
TIDLE	Telnet Port Time-Out	1–30 min	15
AUTO	Send Auto Messages to Port	Y, N	N
FASTOP	Fast Operate Enable	Y, N	N

Ping Server

The relay supports a 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 Protocol

The relay supports IEC 61850 protocol, including GOOSE, as described in *Appendix G: IEC 61850 Communications*.

Simple Network Time Protocol (SNTP)

When Port 2 (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 (see *Simple Network Time Protocol (SNTP) Accuracy on page 1.9* for SNTP accuracy information).

Creating an NTP Server

Three SEL application notes, available from the SEL website, describe how to create an NTP server.

- *AN2009-10: Using an SEL-2401, SEL-2404, or SEL-2407 to Serve NTP Via the SEL-3530 RTAC*
- *AN2009-38: Using SEL Satellite-Synchronized Clocks With the SEL-3332 or SEL-3354 to Output NTP*
- *AN2010-03: Using an SEL-2401, SEL-2404, or SEL-2407 to Create a Stratum 1 Linux NTP Server*

Configuring SNTP Client in the Relay

To enable SNTP in the relay, make Port 2 setting ESNTP = UNICAST, MANYCAST, or BROADCAST. *Table 7.10* shows each setting associated with SNTP.

Table 7.10 Settings Associated With SNTP

Setting	Range	Description
ESNTP	OFF, UNICAST, MANYCAST, BROADCAST	Selects the mode of operation of SNTP. See descriptions in *SNTP Operation Modes*.
SNTPPSIP	Valid IP Address	Selects primary NTP server when ENSTP = UNICAST, or broadcast address when ESNTP = MANYCAST or BROADCAST.
SNTPPSIB	Valid IP Address	Selects backup NTP server when ESNTP = UNICAST.
SNTPPORT	1–65534	Ethernet port used by SNTP. Leave at default value unless otherwise required.
SNTPRATE	15–3600 seconds	Determines the rate at which the relay asks for updated time from the NTP server when ESNTP = UNICAST or MANYCAST. Determines the time the relay will wait for an NTP broadcast when ENSTP = BROADCAST.
SNTPTO	5–20 seconds	Determines the time the relay will wait for the NTP master to respond when ENSTP = UNICAST or MANYCAST.

SNTP Operation Modes

The following sections explain the setting associated with each SNTP operation mode (UNICAST, MANYCAST, and BROADCAST).

ESNTP = UNICAST. In unicast mode of operation, the SNTP client in the relay requests time updates from the primary (IP address setting SNTPPSIP) or backup (IP address setting SNTPPSIB) NTP server at a rate defined by setting SNTPRATE. If the NTP server does not respond with the period defined by setting SNTPTO, then the relay tries the other SNTP server. When the relay successfully synchronizes to the primary NTP time server, Relay

Word bit TSNTPP asserts. When the relay successfully synchronizes to the backup NTP time server, Relay Word bit TSNTPB asserts.

ESNTP = MANYCAST. In the manycast mode of operation, the relay initially sends an NTP request to the broadcast address contained in setting SNTPPSIP. The relay continues to broadcast requests at a rate defined by setting SNTPRATE. When a server replies, the relay considers that server to be the primary NTP server, and switches to UNICAST mode, asserts Relay Word bit TSNTPP, and thereafter requests updates from the primary server. If the NTP server stops responding for time SNTPTO, the relay deasserts TSNTPP and begins to broadcast requests again until the original or another server responds.

ESNTP = BROADCAST. If setting SNTPPSIP = 0.0.0.0 while setting ESNTP = BROADCAST, the relay will listen for and synchronize to any broadcasting NTP server. If setting SNTPPSIP is set to a specific IP address while setting ESNTP = BROADCAST, then the relay will listen for and synchronize to only NTP server broadcasts from that address. When synchronized, the relay asserts Relay Word bit TSNTPP. Relay Word bit TNSTPP deasserts if the relay does not receive a valid broadcast within five seconds after the period defined by setting SNTPRATE.

SNTP Accuracy Considerations

SNTP time synchronization accuracy is limited by the accuracy of the SNTP server and by the networking environment. The highest degree of SNTP time synchronization can be achieved by minimizing the number of switches and routers between the SNTP server and the SEL-849. Network monitoring software can also be used to ensure that average and worst-case network bandwidth use is moderate.

When installed on a network configured with one Ethernet switch between the SEL-849 and the SNTP server, and when using ESNTP = UNICAST or MANYCAST, the relay time-synchronization error with the SNTP server is typically less than ±5 milliseconds.

Embedded Web Server (HTTP/HTTPS)

When Port 2 setting EHTTP = Y, the relay serves webpages displaying settings, metering, status reports, event files, etc. The relay embedded web server has been optimized and tested to work with the most popular web browsers, but should work with any standard web browser. As many as three users can access the embedded web server simultaneously. To begin using the embedded read-only web server, launch your web browser, and browse to http://IPADDR, where IPADDR is the Port 2 setting IPADDR (e.g., http://192.168.1.2). The relay responds with a login screen as shown in *Figure 7.9*.

⚠WARNING
Relay does not disable nonsecure webserver unless EHTTP := N when EHTTPS := Y.

To enable secure HTTP communications, set EHTTPS = Y and use https://IPADDR. Setting EHTTPS to Y alone does not enable secure HTTP communications; “https” should be used in association with the IPADDR. If both EHTTP and EHTTPS are set to N, then the HTTP communications are disabled. Either one of them should be set to Y for corresponding HTTP communications. If both EHTTP and EHTTPS are set to Y, then both nonsecure and secure HTTP communications are enabled. If you want to use only secure HTTP communications, set EHTTP to N and EHTTPS to Y.

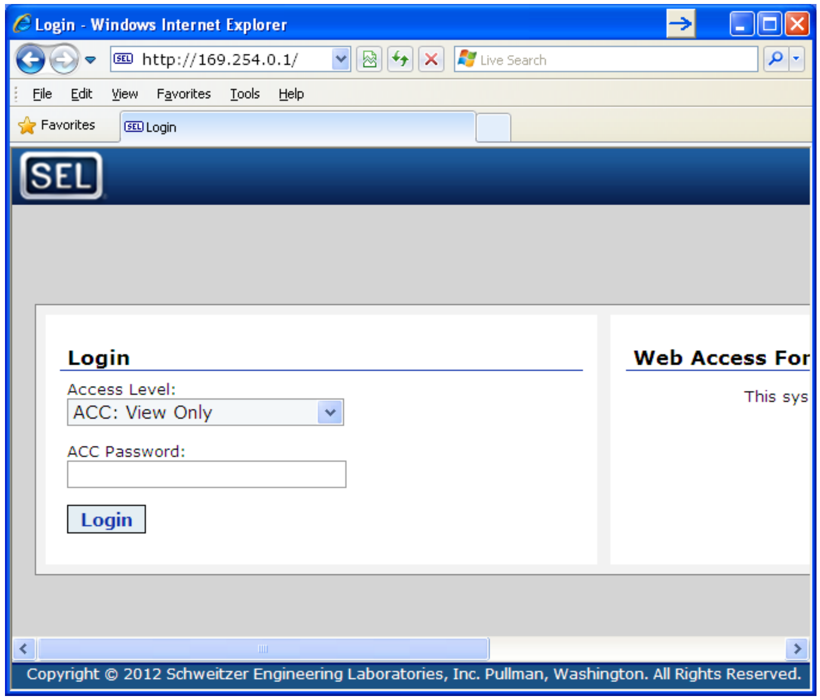

Figure 7.9 Web Server Login Screen

Enter Access Level **ACC** or **2AC**, provide the password for the level, and then click **Login**. The relay responds with the home page shown in *Figure 7.10*.

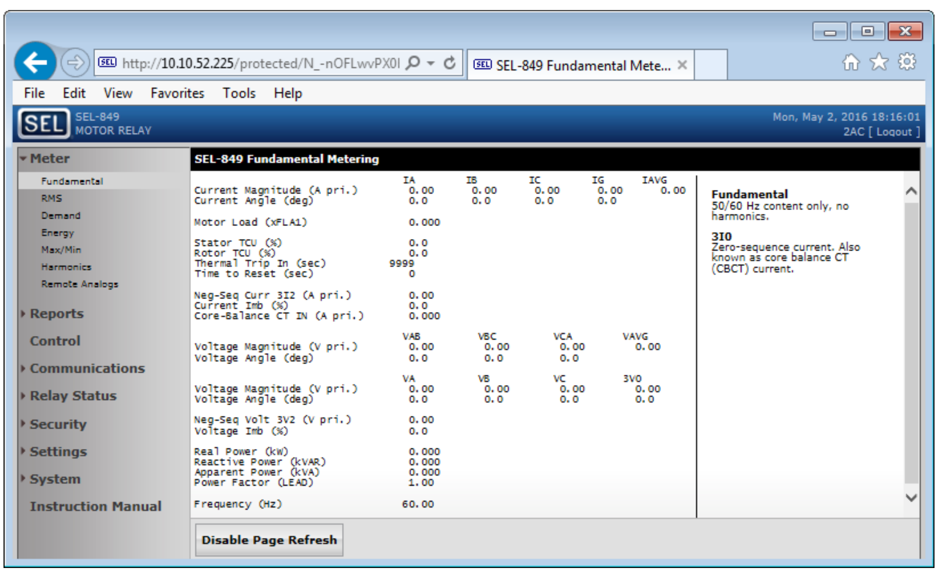

Figure 7.10 Web Server Home Page and Response to the Fundamental Meter Menu Selection

Click on any menu selection from the left pane to retrieve various reports. Some menus expand to reveal more menus, such as the **Settings** menu shown in *Figure 7.11*.

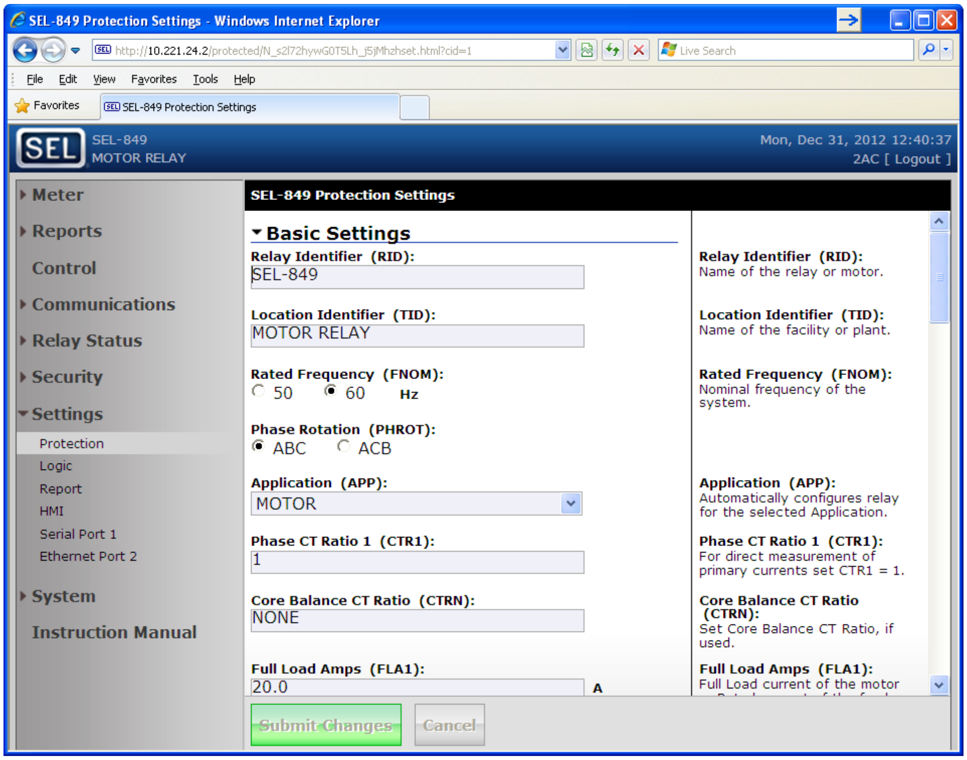

Figure 7.11 Web Server Show Settings Screen

The **Meter** reports screens update automatically about every five seconds. To log out, either close the web browser window or click on **Logout** in the banner bar near the top of the webpage. For more information on the web server, see *Section 3: PC Interface*.

Table 7.11 lists the HTTP settings that are available for configuring the web server.

Table 7.11 HTTP Server Configuration

Setting Prompt	Setting Range	Setting Name := Factory Default
Enable HTTP Server	Y, N	EHTTP := Y
Enable HTTPS Server	Y, N	EHTTPS := N
HTTP Maximum Access Level	1, 2, C	HTTPACC := 2
TCP/IP Port	1–65535	HTTPPORT := 80
HTTPS TCP/IP Port Number	1–65534	HTTPSPRT := 443
HTTP Connect Banner	254 ASCII printable characters	HTTPBAN := This system is for the use of authorized personnel only.
HTTP Web Server Timeout	1–60 min	HTTPIDLE := 10

Security (X.509 Certificates)

HTTPS connections require authentication to confirm that the server with which you are communicating is the correct server. This authentication is through X.509 certificates. By default, the device has a self-signed X.509 certificate that can cause your web browser to issue security alert. This security alert will require a security exception for authentication to continue.

To prevent this security alert from appearing, install a CA-signed X.509 certificate on the device. If your web browser has been configured to trust the CA issuing and signing the certificate, the X.509 certificate will be trusted and the security alert will no longer appear. The device supports one X.509 certificate that is used for HTTPS communications between the client web browser and the web server running on the device. The certificate must have an RSA signature using SHA-256 and be imported as a PEM file with a private key. The private key must be an RSA key no longer than 2048 bits. Note that the Device Reset, either done via Web Server or terminal or by holding the **TARGET RESET** button on the relay for 10 seconds or longer during power up, will delete the installed X.509 certificate and the relay will revert back to its default certificate.

EtherNet/Industrial Protocol (IP)

EtherNet/IP is an industrial protocol that uses standard Ethernet and TCP/IP technology to transport Common Industrial Protocol (CIP) packets. You can enable EtherNet/IP on Port 2 for a maximum of eight simultaneous CIP connections. Of these eight simultaneous connections, you can have as many as two Class 1 (I/O) connections and as many as six combined Class 3 messages and Unconnected Message Manager Messages (UCMM) messages. When configuring EIP on Port 2, you can create as many as six Class 1 (I/O) connection configurations. Of these six, only two can be used simultaneously. Of the remaining six available connection configurations, as many as three can be Exclusive Owner connection configurations. The remaining connection configurations must be Input Only connection configurations. EtherNet/IP is described in detail in *Appendix F: EtherNet/IP Communications*.

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-849.

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 XOFF is received and 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 7.12* lists these messages.

Table 7.12 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-849 sends a status report each time a self-test warning or failure condition is detected (see *STATUS Command (Relay Self-Test Status) on page 7.42*).

Access Levels

Commands can be issued to the SEL-849 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-849 Command Summary* at the end of this manual. These commands can be accessed only from the corresponding access level, as shown in the *SEL-849 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-849, 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-849 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-849 to Access Level 1. See *Access Commands (ACCESS, 2ACCESS, and CAL) on page 7.23* for more detail.

Access Level 1

When the SEL-849 is in Access Level 1, the relay sends the following prompt:

```
=>
```

See the *SEL-849 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) on page 7.23* 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-849 sends the prompt:

```
=>>
```

See the *SEL-849 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 used exclusively by the SEL factory and SEL field service personnel to diagnose troublesome installations. 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-849 Command Summary* at the end of this manual lists the serial port commands alphabetically.

Access Level Functions

The serial port commands at the different access levels offer varying levels of control:

- ➤ The Access Level 0 commands provide the first layer of security. In addition, Access Level 0 supports several commands required by SEL communications processors.
- ➤ The Access Level 1 commands are primarily for reviewing information only (settings, metering, etc.), not changing it.
- ➤ The Access Level 2 commands are primarily for changing relay settings.
- ➤ Access Level C (restricted access level; should be used under direction of SEL only)

The SEL-849 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 7.13 lists the header items and their definitions.

Table 7.13 Command Response Header Definitions

Item	Definition
`[RID Setting]`	This is the RID (Relay Identifier) setting. The relay ships with the default setting `RID = 849`; see *Basic Settings on page 4.3*.
`[TID Setting]`	This is the TID (Terminal Identifier) setting. The relay ships with the default setting `TID = MOTOR RELAY`; see *Basic Settings on page 4.3*.
`Date`	This is the date when the command response was given, except for relay response to the **EVE** command (Event), when it is the date the event occurred. You can modify the date display format (Month/Day/Year, Year/Month/Day, or Day/Month/Year) by changing the DATE_F relay setting.
`Time`	This is the time when the command response was given, except for relay response to the **EVE** command, when it is the time the event occurred.
`Time Source`	This is internal if no time-code input is attached and external if an SNTP time synchronism is used.

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.

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, Access Level 2, and Access Level C.

Access Commands (ACCESS, 2ACCESS, and CAL)

The **ACC**, **2AC**, and **CAL** commands (see *Table 7.14*) provide entry to the multiple access levels. Different commands are available at the different access levels, as shown in the *SEL-849 Command Summary* at the end of this manual. Commands **ACC** and **2AC** are explained together because they operate similarly. See *Access Levels on page 7.20* for a discussion of placing the relay in an access level.

Table 7.14 Access Commands

Command	Description	Access Level
ACC	Moves from Access Level 0 to Access Level 1.	0
2AC	Moves from Access Level 1 to Access Level 2.	1
CAL	Moves from Access Level 2 to Access Level C.	2

Password Requirements

⚠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.

NOTE: If the passwords are lost or forgotten, you can use the TARGET RESET pushbutton on the relay top panel to restore the default passwords for the relay. Refer to Restoring Passwords and Port 1 Settings to Default Using the TARGET RESET Pushbutton on the Relay Top Panel Only on page 8.3.

Passwords are required unless they are disabled. See *PASSWORD Command (Change Passwords) on page 7.35* 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 7.35*. At the prompt, enter the default password and press the **<Enter>** key. The relay responds with the following:

```
[RID Setting]                              Date: mm/dd/yyyy  Time: hh:mm:ss
[TID Setting]                              Time Source: external

Level 1
=>
```

The => prompt indicates the relay is now in Access Level 1.

If the entered password is incorrect, the relay prompts you for the password again (`Password: ?`). The relay prompts for the password as many as three times. If the requested password is incorrectly entered three times, the relay pulses the BADPASS Relay Word bit for one second, displays an invalid access message, prevents further access attempts for 30 seconds, and remains at Access Level 0 (= prompt). The relay pulses PASNVAL Relay Word bit for one second each time an incorrect password is entered.

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 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. Access Level C can be accessed 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.

ANALOG Command

Use the **ANA** command to test an analog output by temporarily assigning a value to an analog output channel (see *Table 7.15* for the command description and format). After entering the **ANA** command, the device suspends normal operation of the analog output channel and scales the output to a percentage of full scale. After assigning the specified value for the specified time, the device returns to normal operation. Entering any character (including pressing the space key) ends the command before reaching the specified interval completion.

You can test the analog output in one of the following two modes:

- **Fixed percentage:** Outputs a fixed percentage of the signal for a specified duration
- **Ramp:** Ramps the output from minimum to maximum of full scale over the time specified

Table 7.15 ANALOG Command

Command	Description	Access Level
ANA *p t*	Temporarily assigns a value to the analog output channel.	2
Parameter	**Description**	
p	Parameter *p* is a percentage of full scale, or either the letter “R” or “r” to indicate ramp mode.	
t	Parameter *t* is the duration (in decimal minutes) of the test.	

NOTE: 0% = low span, 100% = high span. For scaled output from 4–20 mA, 0% is 4 mA and 100% 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 mA
`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 mA
`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 want to test the analog output at 50 percent of rating for 5.5 minutes. To check the device output, calculate the expected mA output as follows:

$$\text{Output} = \left[(20.00\text{ mA} - 4.00\text{ mA}) \bullet \frac{50}{100}\right] + 4.00\text{ mA} = 12.00\text{ mA}$$

To start the test, enter **ANA 50 5.5** at the Access Level 2 prompt:

```
=>>ANA 50 5.5 <Enter>
Outputting 12.00 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 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 R 9.0** at the Access Level 2 prompt:

```
=>>ANA R 9.0 <Enter>
Ramping Analog Output at 1.78 mA/min; full scale in 9.0 minutes.
Press any key to end test
```

CEV Command

The SEL-849 provides Compressed ASCII event reports to facilitate event report storage and display. SEL communications processors and the SEL-5601-2 SYNCHROWAVE Event Software take advantage of the Compressed ASCII format. Use the **CHIS** command to display Compressed ASCII event history information. Use the **CSUM** command to display Compressed ASCII event summary information. Use the **CEVENT** (**CEV**) command to display Compressed ASCII event reports. See *Section 9: Analyzing Events* 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.

CONTROL Command

Use the **CON** command (see *Table 7.16*) to control outputs and remote bits (Relay Word bits RB01–RB08). Remote bits are device variables that you set via serial port communication only; you cannot navigate Remote Bits via the HMI. You can select the control operation of Remote Bits from three states: set, clear, or pulse, as described in *Table 7.17*.

Table 7.16 CONTROL Command

Command	Description	Access Level
CON RB*nn*[a] ***k***[b]	Set, clear, or pulse a Remote Bit.	2
CON O OUT*xx n*[c]	Pulse an Output.	2

[a] Parameter nn is a number from 01–08, representing RB01–RB08.
[b] Parameter k is S, C, or P.
[c] Parameter n is the pulse duration from 1–30 seconds.

Table 7.17 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>
```

You can pulse an output using the **CON** command. For example, use the following command to pulse OUT01 for 5 seconds.

```
=>>CON O OUT01 5 <Enter>
Pulse OUT01
Are you sure (Y/N)? Y
```

COUNTER Command (Counter Values)

The device displays the values of the enabled counters in response to the **COU** command (see *Table 7.18*).

Table 7.18 COUNTER Command

Command	Description	Access Level
COU *n*	Display current value of enabled 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 7.19*) to view and set the relay date.

Table 7.19 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 entered by using other time sources such as SNTP. 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) may be used to display the Ethernet port (Port 2) status as shown in *Figure 7.12* for the redundant Ethernet PORT 2A and PORT 2B configuration. The nonredundant port response is similar.

```
=>>ETH <Enter>

SEL-849                                     Date: 07/02/2012   Time: 10:30:51.614
MOTOR RELAY                                 Time Source: Internal

MAC: 00-30-A7-78-12-23
IP ADDRESS: 169.254.0.1/16
DEFAULT GATEWAY: 0.0.0.0

NETMODE: FAILOVER
PRIMARY PORT:  2A
ACTIVE PORT:   2A

             LINK   SPEED  DUPLEX
PORT 2A      Up     100M   Full
PORT 2B      Down   --     --

      PACKETS          BYTES          ERRORS
    SENT  RCVD      SENT    RCVD    SENT  RCVD
       2     0       128       0       0     0

=>>
```

Figure 7.12 Ethernet Port (PORT 2) Status Report

The nonredundant port response is as shown in *Figure 7.13*.

```
=>>ETH <Enter>

SEL-849                                     Date: 07/02/2012   Time: 10:29:56.846
MOTOR RELAY                                 Time Source: Internal


MAC: 00-30-A7-78-12-23
IP ADDRESS: 169.254.0.1/16
DEFAULT GATEWAY: 0.0.0.0

             LINK   SPEED  DUPLEX
PORT 2       Up     100M   Full

      PACKETS          BYTES          ERRORS
    SENT  RCVD      SENT    RCVD    SENT  RCVD
       2  3378       128  258848       0     0

=>>
```

Figure 7.13 Nonredundant Port Response

EVENT Command (Event Reports)

Use the **EVE** command (see *Table 7.20*) to view event reports. See *Section 9: Analyzing Events* for further details on retrieving and analyzing event reports. See the *HISTORY Command on page 7.31* for details on clearing event reports.

Table 7.20 EVENT Command (Event Reports)

Command	Description	Access Level
EVE *n*	Return the *n* event report with 4 samples per cycle data.	1
EVE *n* R	Return the *n* event report with raw (unfiltered) 32 samples per cycle analog data and 4 samples per cycle digital data.	1
Parameter	**Description**	
n	Parameter *n* specifies the event report number to be returned. The report number can either be the Reference Number (> 10000) or the Record Number (starts at 1). All events have a Reference Number and Record Number. 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 7.21*) is intended to be a safe and efficient means of transferring files between intelligent electronic devices (IEDs) and external support software (ESS). The **FIL** command ignores the hide rules and transfers visible as well as hidden settings, except the settings hidden by a part number. The **FIL** command is supported using Telnet if you connect over Ethernet. However, transferring files via FTP over Ethernet is more efficient.

Table 7.21 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*	Displays contents of the file *filename*.	1

```
=>>FIL DIR <Enter>

CFG.TXT                          R   2012/01/16 10:56:12
ERR.TXT                          R   2012/01/16 10:56:12
SET_ALL.TXT                      R   2012/01/16 10:56:12
SET_1.TXT                        RW  2012/01/16 06:54:07
SET_H.TXT                        RW  2012/01/14 12:31:17
SET_L.TXT                        RW  2012/01/15 08:11:19
SET_M.TXT                        RW  2012/01/14 12:31:17
SET_P1.TXT                       RW  2012/01/14 13:01:14
SET_P2.TXT                       RW  2012/01/14 12:31:51
SET_R.TXT                        RW  2012/01/16 06:53:12
CR_10003.CFG                     R   2012/01/16 06:54:19
CR_10003.DAT                     R   2012/01/16 06:54:19
CR_10003.HDR                     R   2012/01/16 06:54:19
CR_10002.CFG                     R   2012/01/16 06:53:16
CR_10002.DAT                     R   2012/01/16 06:53:16
CR_10002.HDR                     R   2012/01/16 06:53:16
CR_10001.CFG                     R   2012/01/16 06:52:27
CR_10001.DAT                     R   2012/01/16 06:52:27
CR_10001.HDR                     R   2012/01/16 06:52:27
CR_10000.CFG                     R   2012/01/15 07:10:13
CR_10000.DAT                     R   2012/01/15 07:10:13
CR_10000.HDR                     R   2012/01/15 07:10:13

=>>
```

Figure 7.14 FILE Directory Response

GOOSE Command

Use the **GOOSE** command to display transmit and receive GOOSE messaging information, which can be used for troubleshooting. The **GOOSE** command variants and options are shown in *Table 7.22*.

Table 7.22 GOOSE Command Variants

Command Variant	Description	Access Level
GOOSE	Display GOOSE information.	1
GOOSE *count*	Display GOOSE information *count* times.	1

The following table describes the information displayed for each GOOSE IED.

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_849_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_849_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 mis-match 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_849_1/LLN0$DSet13).
Receive Data Set Reference	This field represents the datSetRef (Data Set Reference) that includes the iedName (IED name), ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and datSet (Data Set Name) (e.g., SEL_849_1CFG/ LLN0$DSet13).

An example response to the **GOOSE** commands is shown in *Figure 7.15*.

```
#>GOOSE <Enter>

GOOSE Transmit Status

   MultiCastAddr   Ptag:Vlan  StNum      SqNum      TTL    Code
----------------------------------------------------------------------------
SEL_710_2CFG/LLN0$GO$GooseDSet13
   01-0C-CD-01-00-04  4:1     2          20376      50
   Data Set: SEL_710_2CFG/LLN0$DSet13

GOOSE Receive Status

   MultiCastAddr   Ptag:Vlan  StNum      SqNum      TTL    Code
----------------------------------------------------------------------------
SEL_710_1CFG/LLN0$GO$NewGOOSEMessage5
   01-0C-CD-01-00-05  4:0     1          100425     160
   Data Set: SEL_710_1CFG/LLN0$DSet10

SEL_710_1CFG/LLN0$GO$NewGOOSEMessage3
   01-0C-CD-01-00-03  4:0     1          98531      120
   Data Set: SEL_710_1CFG/LLN0$DSet05

SEL_710_1CFG/LLN0$GO$NewGOOSEMessage2
   01-0C-CD-01-00-02  4:0     1          97486      200
   Data Set: SEL_710_1CFG/LLN0$DSet04

SEL_710_1CFG/LLN0$GO$NewGOOSEMessage1
   01-0C-CD-01-00-01  4:0     1          96412      190
   Data Set: SEL_710_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 7.15 GOOSE Command Response

HELP Command

The **HELP** command (see *Table 7.23*) 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 7.23 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 7.24*) to view a list of one-line descriptions of relay events or clear the list (and corresponding event reports) from nonvolatile memory.

Table 7.24 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*** **HIS** ***row1 row2*** **HIS** ***date1 date2***	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 7.25*) to extract device identification codes.

Table 7.25 IDENTIFICATION Command

Command	Description	Access Level
ID	Return a list of device identification codes.	0

LDP Command (Load-Profile Report)

Use the **LDP** commands (see *Table 7.26*) to view and manage the load-profile report (see *Figure 5.13*). If there is no stored data and an **LDP** command is issued, the relay responds with `No data available`.

Table 7.26 LDP Commands

Command	Description	Access Level
LDP ***row1 row2*** **LDP** ***date1 date2***	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
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.	

If there is no stored data and an **LDP** command is issued, the relay responds with `No data available.`

L_D Command (Load Firmware)

Use the **L_D** command (see *Table 7.27*) to load firmware. See *Appendix A: Firmware, ICD, and Manual Versions* for information on changes to the firmware and instruction manual. See *Appendix B: Firmware Upgrade Instructions* for further details on downloading firmware.

Table 7.27 L_D Command (Load Firmware)

Command	Description	Access Level
L_D	Download firmware to the relay.	2

MAC Command

Use the **MAC** command to display the MAC addresses of PORT 2, as shown below.

```
=>>MAC <Enter>
Port 2 (IP) MAC Address:  00-30-A7-00-00-00
=>>
```

MET Command (Metering Data)

The **MET** command (see *Table 7.28* and *Table 7.29*) provides access to the relay metering data.

Table 7.28 Meter Command

Command	Description	Access Level
MET *c n*	Display metering data.	1
MET *c* R	Reset metering data.	1
Parameter	**Description**	
c	Parameter for identifying meter class.	
n	Parameter used to specify number of times (1–32767) to repeat the meter response.	

Table 7.29 Meter Class

c	Meter Class
F	Fundamental Metering
E[a]	Energy Metering
RA	Remote Analog Metering
RMS	RMS Metering
H	Harmonics Metering
D[a]	Demand Metering
MM[a]	Max/Min Metering
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 reset and the relay responds with `Reset Complete`.

MOTOR Command

The **MOT** command (see *Table 7.30*) displays motor operating statistics including the following:

- Motor running time, stopped time, and percent time running
- Total number of motor starts
- Number of emergency starts

Table 7.30 MOTOR Command

Command	Description	Access Level
MOT	Display machine operating statistical monitoring of the protected device.	1
MOT C or **R**	Use this command to clear/reset the motor statistic and motor start report records.	1

Section 5: Metering and Monitoring includes additional details on the motor operating statistics report. Issuing the **MOT R** or **MOT C** command from Access Level 1 or higher clears the report.

MSR or CMSR Command

Use the **MSR** (Motor Start Report) command (see *Table 7.31*) to view motor start reports. The relay records a 720-data point report each time the motor starts. Use the **CMSR *n*** command for compressed motor start reports. ACSELERATOR QuickSet supports viewing of the compressed motor start reports (*.cmsr).

Table 7.31 MSR (Motor Start Report) Command

Command	Description	Access Level
MSR *n*	Return the *n* motor start report where *n* is event number. The *n* defaults to 1, where 1 is the most recent event.	1

See *Section 5: Metering and Monitoring* for information on the contents of motor start reports. Motor Start Report data are cleared when the **MOT R** or **MOT C** command is executed.

MST Command

Use the **MST** (Motor Start Trend) command (see *Table 7.32*) to review the motor start trend data. The relay records the number of starts and average information for each of the past eighteen 30-day periods. See *Section 5: Metering and Monitoring* for information on the contents of the motor start trend data.

Table 7.32 MST (Motor Start Trend) Command

Command	Description	Access Level
MST	Return the motor start trend data.	1
MST R or **C**	Reset or clear the data stored in the motor start trend buffers.	1

PASSWORD Command (Change Passwords)

⚠WARNING
This device is shipped with default passwords. Default passwords should be changed to private passwords at installation. Failure to change each default password to a private password may allow unauthorized access. SEL shall not be responsible for any damage resulting from unauthorized access.

Use the **PAS** command (see *Table 7.33*) to change existing passwords.

Table 7.33 PASSWORD Command

Command	Description	Access Level
PAS ***level new-password***	Set a password *new-password* for Access Level *level*.	2, C
Parameter	**Description**	
level	**Parameter *level* represents the relay Access Levels 1, 2, or C.**	
new-password	**New password.**	

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>
New PW: ?#Ot3579!ijd7 <Enter>
Confirm PW: ?#Ot3579!ijd7 <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

<table>
<tr><td>Alpha</td><td>A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
a b c d e f g h i j k l m n o p q r s t u v w x y z</td></tr>
<tr><td>Numeric</td><td>0 1 2 3 4 5 6 7 8 9</td></tr>
<tr><td>Special</td><td>! " # $ % & ' ( ) * + , - . / : ; < = > ? @ [\ ] ^ _ ` { | } ~</td></tr>
</table>

Passwords can contain as many as 12 characters. Upper- and lowercase letters are treated as different characters. Strong passwords consist of 12 characters, with at least one special character or digit and mixed-case sensitivity, but do not form a name, date, acronym, or word. Passwords formed in this manner are less susceptible to password guessing and automated attacks.

Examples of valid, distinct, and strong passwords are shown below:

- #0t3579!ijd7
- $A24.68&,mvj
- (Ih2dcs)36dn
- *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 2) is functioning or configured correctly. A typical **PING** command response is shown in *Figure 7.16*.

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 2–255 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 7.16 PING Command Response

PULSE Command

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 momentarily close or open depending on the output contact type (a or b). The **PUL** command momentarily energizes the coil and does not have any effect if the coil is already energized. The control outputs are **OUT*nn***, where ***nn*** = 01–04 for OUT01–OUT04.

Table 7.36 PUL OUTnn Command

Command	Description	Access Level
PUL OUT*nn*[a]	Pulse output OUT*nn* for 1 second.	2
PUL OUT*nn s*[b]	Pulse output OUT*nn* for *s* seconds.	2

[a] Parameter nn is a control output number. (nn = 01–04 for OUT01–OUT04)
[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. Access Level 0 is the lowest access level; the SEL-849 performs no password check to descend to this level (or to remain at this level).

Table 7.37 QUIT Command

Command	Description	Access Level
QUIT	Go to Access Level 0.	0

R_S Command (Restore Factory Defaults)

NOTE: The relay firmware retains the IP address, subnet mask, and default router settings after an **R_S** command is issued.

Use the **R_S** command (see *Table 7.38*) 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 **SER *row1 row2*** **SER *date1 date2***	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 (Sheet 1 of 2)

Parameter	Description
row1	Append *row1* to return a chronological progression of the first *row1* rows. For example, use **SER 5** to return the first five rows.
row1 row2	Append *row1* and *row2* to return all rows between *row1* and *row2*, beginning with row1 and ending with *row2*. Enter the smaller number first to display a numeric progression of rows through the report. Enter the larger number first to display a reverse numeric progression of rows. For example, use **SER 1 10** to return the first 10 rows in numeric order or **SER 10 1** to return these same items in reverse numeric order.

Table 7.40 SER Command Format (Sheet 2 of 2)

Parameter	Description
date1	Append *date1* to return all rows with this date. For example, use **SER 1/1/2003** to return all records for January 1, 2003.
date1 date2	Append *date1* and *date2* to return all rows between date1 and date beginning with *date1* and ending with *date2*. Enter the oldest date first to display a chronological progression through the report. Enter the newest date first to display a reverse chronological progression. Date entries are dependent on the date format setting DATE_F. For example, use **SER 1/5/2003 1/7/2003** to return all records for January 5, 6, and 7, 2003.

If the requested SER report rows do not exist, the relay responds with `No SER data`.

SET Command (Change Settings)

The **SET** command is for viewing or changing the relay settings (see *Table 7.41*).

Table 7.41 SET Command (Change Settings)

Command	Description	Access Level
SET *s* TERSE	Set the protection class settings.	2
SET L *s* TERSE	Set logic class settings for protection.	2
SET P *n s* TERSE	Set communication port class settings. *n* specifies the **PORT** (**1**, **2**, or **3**); *n* defaults to the active port if not listed.	2
SET R *s* TERSE	Set report class settings such as Sequential Events Recorder (SER) and Event Report (ER) settings.	2
SET H *s* TERSE	Set HMI settings.	2
SET M *s* TERSE	Set Modbus User Map settings.	2
SET E *m s* TERSE	Sets the EtherNet/IP Assembly Map *m* settings (*m* = 1, 2, or 3).	2
SET DNP *m s* TERSE	Sets DNP Map *m* settings (*m* = 1, 2, or 3).	2
Parameter	**Description**	
s	Append *s* to name the specific setting you want to view and to jump 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. **TE** can be substituted for **TERSE**.	

When you issue the **SET** command, the relay presents a list of settings one at a time. Enter a new setting or press **<Enter>** to accept the existing setting. Editing keystrokes are shown in *Table 7.42*.

Table 7.42 SET Command Editing Keystrokes

Press Key(s)	Results
<Enter>	Retains the setting and moves to the next setting.
^ <Enter>	Returns to the previous setting.
< <Enter>	Returns to the previous setting category.
> <Enter>	Moves to the next setting category.
END <Enter>	Exits the editing session, then prompts you to save the settings.
<Ctrl+X>	Aborts the editing session without saving changes.

The relay checks each setting to ensure that it is within the allowed range. If the setting is not within the allowed range, the relay generates an `Out of Range` message and prompts you for the setting again.

When all the settings are entered, the relay displays the new settings and prompts you for approval to enable them. Answer **Y <Enter>** to enable the new settings. The relay is disabled for as long as one second while it saves the new settings. The SETCHG Relay Word bit is set momentarily and the **ENABLED** LED extinguishes while the relay is disabled.

SHOW Command (Show/View Settings)

When showing settings, the relay displays the settings label and the present value from nonvolatile memory for each setting class. See *Table 7.43* for the **SHOW** command settings and format.

Table 7.43 SHOW Command (Show/View Settings)

Command	Description	Access Level
SHO *s*	Show protection class settings.	1
SHO L *s*	Show logic class settings for protection.	1
SHO P *n s*	Show communication port settings. *n* specifies the **PORT** (**1**, **2**, or **3**); ***n*** defaults to the active port if not listed.	1
SHO R *s*	Show report class settings such as Sequential Events Recorder (SER) and Event Report (ER) settings.	1
SHO H *s*	Show HMI settings.	1
SHO M *s*	Show Modbus User Map settings.	1
SHO E *m s*	Shows the EtherNet/IP Assembly IP Map *m* settings (*m* = 1, 2, or 3).	1
SHO DNP *m s*	Shows DNP Map *m* settings (*m* = 1, 2, or 3).	1

Parameter	Description
s	Append *s* to name the specific setting you want to view and to jumps to this setting. If *s* is not entered, the relay starts at the first setting.

```
=>>SHO <Enter>

Protection Settings

Basic Settings
RID      := SEL-849
TID      := MOTOR RELAY
FNOM     := 60           PHROT    := ABC          APP      := MOTOR
CTR1     := 1            CTRN     := NONE         FLA1     := 2.5
SERFACTR := 1.15         TRIPCLAS := 10_NEMA      PTR      := 1.00
VNOM     := 240          DELTA_Y  := WYE          SINGLEV  := N

Configuration Settings
FACTLOG  := Y            CURR_IN  := NORMAL       STARTRTY := FVNR
DATE_F   := MDY
FAULT    := TRIP OR 50G1 OR 50Q1 OR 51P1 OR 51Q1 OR STARTING AND MOTOR

Thermal Overload Settings
E49MOTOR := Y            TCAPU    := 85           TCSTART  := OFF
49RSTP   := 75           COOLTIME := Auto

Phase Instantaneous Overcurrent
50P1P    := OFF          50P2P    := OFF

Negative Sequence Instantaneous Overcurrent
50Q1P    := OFF

Residual Instantaneous Overcurrent
50G1P    := OFF          50G2P    := OFF

CBCT Instantaneous Overcurrent
50N1P    := OFF          50N2P    := OFF

Phase Time Overcurrent
51P1P    := OFF

Negative Sequence Time Overcurrent
51Q1P    := OFF

Residual Time Overcurrent
51G1P    := OFF

Load Jam Settings
LJTPU    := OFF          LJAPU    := OFF

Undercurrent/Load Loss Settings
LLTPU    := OFF          LLAPU    := OFF

Current Imbalance Settings
46UBT    := 20           46UBTD   := 5            46UBA    := 10
46UBAD   := 10

Start Monitoring
START_T  := OFF

Motor Restart
ERESTART := N

Motor Start Inhibit
MAXSTART := OFF          TBSDLY   := OFF          ABSDLY   := OFF

Phase Reversal
E47T     := Y

Motor Speed Switch
SPDSDLYT := OFF          SPDSDLYA := OFF

PTC Setting
EPTC     := N
```

Figure 7.17 SHOW Command Response

```
Undervoltage
27PP1P   := OFF           27PP2P   := OFF

Overvoltage
59PP1P   := OFF           59PP2P   := OFF

Power Element Enable
EPWR     := 2

3-Phase Power Element Settings
3PWR1P   := OFF           3PWR2P   := OFF

Power Factor Settings
55LGTP   := OFF           55LDTP   := OFF           55LGAP   := OFF
55LDAP   := OFF

Frequency Settings
81D1TP   := OFF           81D2TP   := OFF

Breaker Failure Settings
52ABF    := N             BFD      := 0.25
BFI      := R_TRIG TRIP

Arc-Flash Protection Settings
50PAFP   := OFF

Trip/Close Logic Settings
TDURD    := 0.1
TR       := MOTOR AND (49T OR SPDSTR OR SMTRIP OR 46UBT OR LOSSTRIP OR JAMTRIP
            OR PTCTRIP OR 50N1T OR 50N2T) OR 47T OR TRX
TRX      := MOTOR AND (27PP1T AND NOT LOP OR 59PP1T OR 55T) OR 81D1T OR 81D2T
TR1      := ORED50T OR 51P1T OR 51G1T OR 51Q1T OR (50PAF OR 50GAF) AND TOL1
ULTRIP   := NOT 52A
TRIPONLO := Y
REMSTREQ := 0
BSTR_CL  := TRIP OR MOTOR AND (THERMLO OR NOSLO OR TBSLO OR ABSLO OR RSACTIVE)
EMRSTR   := 0

Warning List
(Enter up to 24 Relay Word bits, one per line.)
1: 49A
2: LOSSALRM
3: JAMALRM
4: 46UBA
5: SPDSAL
6: PTCFLT
7: AFS1EL

Motor Control
SPEEDSW  := 0

Load Control Settings
LOAD     := OFF

Output Settings
OUT02FS  := N
OUT02    := 0
OUT03FS  := N
OUT03    := (50PAF OR 50GAF) AND TOL1
OUT04FS  := Y
OUT04    := HALARM OR SALARM

Time and Date Management
UTC_OFF  := 0.00          DST_BEGM := NA

Demand Meter Settings
EDEM     := THM           DMTC     := 5             PHDEMP   := OFF

Data Reset Settings
RSTTRGT  := 0
RSTDEM   := 0

Alarm Settings
SALARM   := BADPASS OR CHGPASS OR SETCHG OR ACCESSP OR PASNVAL
RST_HAL  := 0

=>>
```

Figure 7.17 SHOW Command Response (Continued)

STATUS Command (Relay Self-Test Status)

The **STA** command (see *Table 7.44*) displays the status report. See *Figure 7.18* for an example of a status report.

Table 7.44 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 7.45* shows the status report definitions and message formats for each test. Refer to *Figure 1.3* and for an example of the **STATUS** command response.

Table 7.45 STATUS Command Report and Definitions

STATUSReport Designator	Definition	Message Format
Serial Num	Serial number	Text Data
FID	Firmware identifier string	Text Data
BFID	SELBOOT firmware identifier string	Text Data
CID	Firmware checksum identifier	Hex
PART NUM	Part number	Text Data
CAL Version	Calibration board software version	
HMI Version	Firmware version on the HMI	
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
HMI	Status of HMI display	OK/WARN/FAIL
CLOCK	Clock functionality	OK/WARN
CLK_BAT	Clock battery voltage	OK/WARN
PTC	Integrity of PTC	OK/FAIL
AF	Integrity of arc-flash sensor	OK/WARN
PS	Integrity of power supply	OK/FAIL
Analog Module		
COMMS	Status of the communications with analog module	OK/FAIL
DIAG	Indicates the self-test status of the analog module	OK/FAIL

NOTE: The STA S report shows the available SELOGIC capacity of the relay. For example, Execution 90% means 90% of the execution capacity is still available.

Figure 7.18 shows the typical relay output for the **STATUS S** command, showing available SELOGIC control equation capability.

```
=>STA S <Enter>

SEL-849                                 Date: 06/16/2012   Time: 12:28:40.126
MOTOR RELAY                             Time Source: Internal

Serial Num = 000000000000000
FID = SEL-849-R109-V0-Z006004-D20230811       CID = 0000
BFID = BOOTLDR-R105-V0-Z000000-D20160509
PART NUM = 084900101100000

Protection (%)   90
Logic (%)        94
Report (%)       95
Hmi (%)          97

Execution (%)    98

=>
```

Figure 7.18 STATUS S Command Response

STOP Command

The **STOP** command (see *Table 7.46*) causes the relay to trip, opening the motor contactor or circuit breaker and stopping the motor. For the **STOP** command to work, the relay must be in remote mode. For further details, refer to *Figure 4.49* and *Local/Remote Control on page 4.54*.

Table 7.46 STOP Command

Command	Description	Access Level
STOP	Initiates user operation of an output to stop the motor.	2

STR Command

The **STR** command (see *Table 7.47*) uses internal relay logic to initiate a motor start. For the **STR** command to work, the relay must be in remote mode. For further details, refer to *Figure 4.52* and *Local/Remote Control on page 4.54*.

Table 7.47 STR Command

Command	Description	Access Level
STR	Initiates user operation of an output to start and run the motor.	2

SUMMARY Command

The **SUM** command (see *Table 7.48*) displays an event summary in human readable format.

Table 7.48 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., OVERLOAD TRIP).

TARGET Command (Display Relay Word Bit Status)

The **TAR** command (see *Table 7.49*) displays the status of target LEDs or Relay Word bits, whether these LEDs or Relay Word bits are asserted or deasserted.

Table 7.49 TARGET Command (Display Relay Word Bit Status)

Command	Description	Access Level
TAR *name* k **TAR *n k***	Use **TAR** without parameters to display Relay Word Row 0 or last displayed target row.	1
TAR R	Clears the tripping targets. Unlatches the trip logic for testing purposes. Shows Relay Word Row 0.	1
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).	

NOTE: The **TARGET R** command cannot reset the latched targets if a TRIP condition is present.

The elements are represented as Relay Word bits and are listed in rows of eight, called Relay Word rows. The first row, representing the ENABLED and TRIP_LED LEDs, correspond to *Table 7.50*. All Relay Word rows are described in *Table H.1*. Relay Word bits are used in SELOGIC control equations (see *Appendix H: Relay Word Bits*).

The **TAR** command does not remap the target LEDs, as is done in some previous SEL relays.

Table 7.50 Target LEDs and the TAR 0 Command

LEDs	7	6	5	4	3	2	1	0
TAR 0	ENABLED	TRIP_LED	*	*	*	*	*	*

TCUR Command (Thermal Reset)

The **TCUR** command (see *Table 7.51*) resets the stator and rotor thermal capacity used to zero. It also resets THERMLO, TBSLO, and NOSLO.

Table 7.51 TCUR Command

Command	Description	Access Level
TCUR	Resets the stator and rotor thermal capacity used to zero. Also resets THERMLO, TBSLO, and NOSLO.	2

The SER log is updated with a “Thermal capacity reset” entry upon manual reset of the thermal capacity. Successful reset of the thermal capacities via the **TCUR** command requires the motor to be in the STOPPED state.

TEST DB Command

Use the **TEST DB** command to temporarily force the relay to send fixed analog and/or digital values over communications interfaces for protocol testing.

Table 7.52 TEST DB Commands

Command	Description	Access Level
TEST DB	Displays the present status of digital and analog overrides.	2
TEST DB A *name value*	Forces the protocol analog element *name* to override *value*.	2
TEST DB D *name value*	Forces the protocol digital element *name* to override *value*.	2
TEST DB *name* OFF	Clears (analog or digital) override for element *name*.	2
TEST DB A OFF	Clears all analog overrides.	2
TEST DB D OFF	Clears all digital overrides	2
TEST DB OFF	Clears all analog and digital overrides.	2

⚠WARNING
To reduce the chance of a false operating decision when using the **TEST DB** command, ensure that protocol master device(s) flag the data as "forced or test data". One possible method is to monitor the TESTDB Relay Word bit.

The **TEST DB** command provides a method to override Relay Word bits or analog values to aid testing of communications interfaces. The command overrides values in the communications interfaces (ASCII, SEL Fast Message, DNP3, Modbus, EtherNet/IP, and IEC 61850) only. The actual values used by the relay for protection and control are not changed. However, remote devices may use these analog and digital signals to make control decisions. Ensure that remote devices are properly configured to receive the overridden data before using the **TEST DB** command.

NOTE: When using the **TEST DB** command to generate values for Fast Meter testing, you may need to override all current and voltage angles (IA_ANG, VA_ANG, etc.) to ensure the expected phase relationship.

NOTE: When using the **TEST DB** command, specifying a negative value may yield an unexpected display in some instances.

To override analog data in a communications interface, enter the following from Access Level 2:

```
=>>TEST DB A name value <Enter>
```

where *value* is a numerical value and *name* is an analog label from *Table I.1*, Analog Quantities, with an "x" in the DNP3, Modbus, Fast Meter, EtherNet/IP, or IEC 61850 column. For example, the **TEST DB** command can be used to force the value of the A-phase current magnitude transmitted to a remote device to 100 amperes:

```
=>>TEST DB A IA_MAG 100 <Enter>
```

To override digital data in an SEL ASCII, SEL Fast Message, Modbus, DNP3, EtherNet/IP, or IEC 61850 communications interface, enter the following from Access Level 2:

```
=>>TEST DB D name value <Enter>
```

where *name* is a Relay Word bit (see *Table H.1*) and *value* is 1 or 0. For example, if Relay Word bit 51P1T := logical 0, the **TEST DB** command can be used effectively to test the communications interface by forcing the communicated status of this Relay Word bit to logical 1:

```
=>>TEST DB D 51P1T 1 <Enter>
```

Values listed in the SER triggers SER1, SER2, SER3, and SER4 cannot be overridden.

When the relay is not in Test Mode, the relay responds to either the digital or analog override request with the following message:

```
WARNING:  TEST MODE is not a regular operation.
Communication outputs of the device will be overridden by simulated values.

Are you sure (Y/N)? Y <Enter>
```

The relay responds:

```
Test Mode Active.  Use Test DB OFF command to exit Test Mode.
Override Added
```

Relay Word bit TESTDB will also assert to indicate that Test Mode is active. If the relay is already in the test mode (overrides are already active), the relay responds:

```
Override Added
```

The **TEST DB** command alone displays the present status of digital and analog overrides. An example **TEST DB** response after two analogs follows:

```
=>>TEST DB <Enter>

SEL-849                          Date: 02/02/09    Time: 16:24:38.764
FEEDER RELAY                     Time Source: Internal

NAME          OVERRIDE VALUE
IA_MAG             100.0000
FREQ                60.0000

=>>
```

Individual overrides are cleared using the **TEST DB** command with the OFF parameter:

```
=>>TEST DB D or A name OFF <Enter>
```

Entering **TEST DB A OFF** clears all analog overrides and **TEST DB D OFF** clears all digital overrides. Entering **TEST DB OFF** without any parameters clears all overrides. When there are no overrides, the relay automatically exits the Test Mode and clears all overrides if no **TEST DB** commands are entered for 30 minutes.

TIME Command (View/Change Time)

The **TIME** command (see *Table 7.53*) returns information about the SEL-849 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-849 responds with `Invalid Time`.

TRIGGER Command (Trigger Event Report)

Use the **TRI** command (see *Table 7.54*) to trigger the SEL-849 to record data for high-resolution oscillographs 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-849 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 at the direction of SEL.

Command	Description	Access Level
VEC D	Display the standard vector report	2
VEC E	Display the extended vector report	2

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.

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Section 8
Human-Machine Interface (HMI)

Overview

The SEL-849 Motor Management Relay has a relay top-panel HMI and an optional HMI interface making motor monitoring, data collection, and control quick and efficient. Use the relay top panel to analyze the basic operating information, including whether the relay is enabled, is tripped, has an HMI connected, or has an alarm. A multifunction TARGET RESET pushbutton is also provided. The SEL-849 supports two HMI modules: the SEL-3421 Motor Relay HMI (with LCD) and the SEL-3422 Motor Relay HMI (no display).

The SEL-3421 features a straightforward menu-driven liquid crystal display (LCD). The LEDs on the HMI give a clear indication of the SEL-849 operational status. SEL-3421 features include the following:

- Reading metering, monitoring, and events data
- Inspecting targets
- Controlling relay operations
- Viewing diagnostics
- Display, trigger, or clear events
- Edit relay IP and router address settings
- Configurable pushbuttons

The relay has pushbuttons for LOCAL/REMOTE control selection, motor START/STOP control, and TARGET RESET. The SEL-3422 has the same features as the SEL-3421, except for the LCD and associated functions.

Relay Top Panel

The top panel of the relay has four LEDs that indicate relay **ENABLED** status, **TRIP** status, **HMI COMM** communications status, and relay **ALARM** status. A **TARGET RESET** pushbutton is also provided to reset the targets.

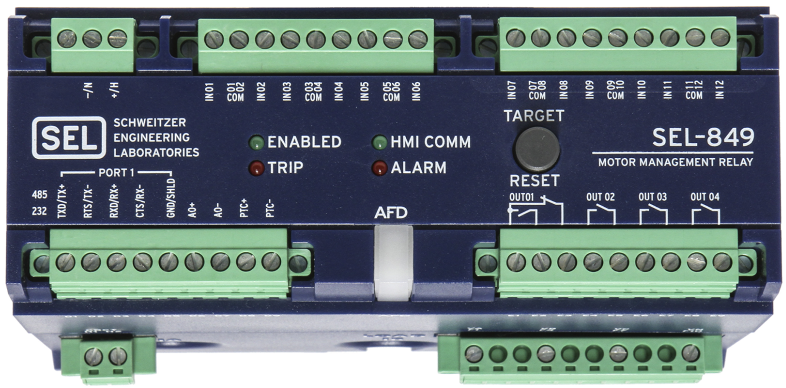


Figure 8.1 SEL-849 Top Panel

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. A **TRIP** LED can be ON for any of the conditions listed in *Table 9.7: Event Types*. The **ALARM** LED notifies you of warning conditions, SALARM, and HALARM Relay Word bit assertions.

Under the default settings when the **ALARM** LED is on, any of the warning conditions listed in *Table 8.1* are active when the corresponding Relay Word bit asserts. For Relay Word bit definitions see *Appendix H: Relay Word Bits*.

Table 8.1 Warning List With Default Settings

Warning Message	Relay Word Bit Logic Condition
Undercurrent Warning	LOSSALRM
Jam Warning	JAMALRM
Current Imbalance Warning	46UBA
Speed Switch Warning	SPDSAL
Arc-Flash Sensor input excessive ambient light pickup.	AFS1EL
PTC Failure	PTCFLT

You can enter as many as 24 Relay Word bits in the Warning List setting, 1 per line, WARN01–WARN24. Refer to *Section 4: Protection and Logic Functions* for the Warning List setting support.

The **HMI COMM** LED is ON when the HMI port is connected and communicating to the SEL-3421 or SEL-3422 Motor Relay HMI.

TARGET RESET Pushbutton

For a trip event, the SEL-849 latches the **TRIP** LED. Press the **TARGET RESET** pushbutton to reset the latched **TRIP** LED. Pressing and holding the **TARGET RESET** pushbutton illuminates all the LEDs. Upon release of the **TARGET RESET** pushbutton, two possible 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 **TRIP** LED turns off. If the trip event conditions remain, the **TRIP** LED stays lit.

Restoring Passwords and Port 1 Settings to Default Using the TARGET RESET Pushbutton on the Relay Top Panel Only

Press and hold the **TARGET RESET** pushbutton while the relay is turning on for 10 seconds or longer to restore the default passwords and Port 1 settings. If the pushbutton is released before 10 seconds, the relay continues with normal startup. All LEDs may be ON when the **TARGET RESET** pushbutton is pressed and held on startup. Wait for the **ENABLED** LED to turn OFF as a visual indication that the relay recognized the button being held and then release the button to proceed with restoring the Port 1 setting, password, and security certificate defaults. Once the **TARGET RESET** pushbutton is released, the relay restores Port 1 settings and passwords to the defaults, deletes the installed X.509 certificate, and reverts to its default certificate.

LED Test

The **TARGET RESET** pushbutton also provides a top-panel LED test. Pressing and holding **TARGET RESET** illuminates all the top-panel LEDs, and these LEDs remain illuminated for as long as **TARGET RESET** is pressed. The LEDs return to the normal operational state after release of the **TARGET RESET** pushbutton.

SEL-3421 Motor Relay HMI Module (With LCD)

The SEL-3421 features a straightforward menu-driven liquid crystal display (LCD), which makes motor data collection and control quick and efficient. The LEDs on the module give a clear indication of the SEL-849 operational status.

SEL-3421 features include:

- Read metering and monitoring data
- Inspect targets
- Control relay operations
- View diagnostics
- Display, trigger, or clear events
- Edit relay IP and router addresses
- Eight configurable pushbuttons

The SEL-3421 has ten LEDs, of which eight are tricolored and programmable with configurable labels. The **ENABLED** LED and **TRIP** LED are the two fixed LEDs. This module has a graphical LCD with six pushbuttons for navigation, five function keys for operations, and four pushbuttons for control.

Figure 8.2 shows the SEL-3421 module, including the LCD, the control pushbuttons, the function keys, the navigation pushbuttons, and the operations and target LEDs.

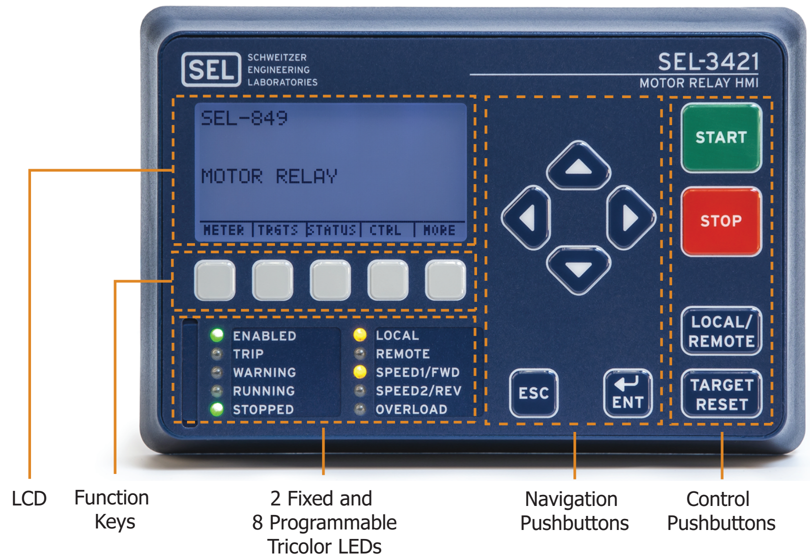


Figure 8.2 SEL-3421 Motor Relay HMI Layout

LCD Backlight Adjustment

The HMI display consists of four lines with twenty-one characters per line. In addition to the four lines, there are five text strings that correspond to the action to be taken by the five function keys. You can adjust the LCD screen backlight to suit your viewing angle and lighting conditions. To change the backlight, press and hold the **Left** and **Right Arrow** pushbuttons for about five seconds. The SEL-3421 displays a backlight adjustment box. Pressing the **Up Arrow** pushbutton increases the brightness. Pressing the **Down Arrow** pushbutton decreases the brightness. When you are finished adjusting the screen backlight, press the **ESC** pushbutton.

HMI Automatic Display Messages

NOTE: You can program as many as eight rotating display points. Refer to Section 4: Protection and Logic Functions, HMI Settings (SET H Command) for details on display point settings.

The SEL-3421 displays automatic messages, overriding the rotating display, under the conditions described in *Table 8.2: HMI Automatic Messages*. Relay failure has the highest priority, followed by trip/trip on lockout, time to thermal trip, and warning, respectively, when the HMI setting HMI_AUTO := OVERRIDE. The trip message will continue to be displayed until one of the following occurs:

- **TARGET RESET** pushbutton is pressed (and the **TRIP** has cleared)
- New Auto Message is received

If the HMI setting FP_AUTO := ROTATING, then the rotating display messages continues and any trip message is added to the rotation.

Table 8.2 HMI Automatic Messages (Sheet 1 of 2)

Condition	HMI Display Message
Relay detects any self-test failure	Displays the type of latest failure (see *Section 10: Testing and Troubleshooting*).
Relay trip occurs without any lockouts	Displays the latest trip reason until the targets are unlatched.
Relay trip occurs along with a lockout	Displays the type or cause of the trip and Time to Reset along with the lockout type. Refer to *Table 9.7* for a list of trip display messages.

Table 8.2 HMI Automatic Messages (Sheet 2 of 2)

Condition	HMI Display Message
When the relay has lockout due to number of starts or time between starts or antibackspin or thermal lockout	Displays the type of lockout condition, the lockout time remaining, and TRIP ON LOCKOUT if TRIPONLO := Y. Use **TARGET RESET** to clear TRIP ON LOCKOUT. If TRIPONLO := N, there will be no lockout related display message until a start is attempted. If a start is attempted on a lockout, a block start message with lockout time remaining displays.
Motor running overload	Displays the predicted time to thermal element trip in seconds.
Relay Warning condition occurs	Displays the type of warning.

HMI Menus and Screens

Navigating the Menus

The SEL-3421 front panel gives you access to most of the information that the relay measures and stores. All of the front-panel functions are accessible through use of the six-button keypad and LCD. Use the keypad (shown in *Figure 8.3*) to maneuver within the front-panel menu structure, described in detail throughout the remainder of this section. *Table 8.3* describes the function of each navigation pushbutton.

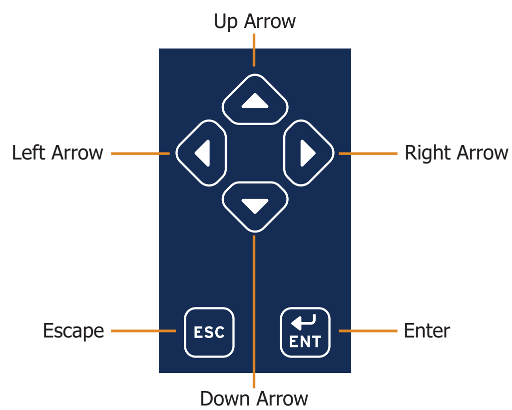


Figure 8.3 HMI Navigation Pushbuttons

Table 8.3 Navigation Pushbutton Functions

Pushbutton	Function
Up Arrow	Move up within a menu or data list.
Down Arrow	Move down within a menu or data list.
Left Arrow	Used for backlight adjustment and to move left when changing the IP or router address.
Right Arrow	Used for backlight adjustment and to move right when changing the IP or router address.
ESC	Escape from the current menu or display.
ENT	Move from the rotating display to the main menu. Select the menu item at the cursor.

Table 8.4 SEL-3421 Motor Relay HMI Navigation (Sheet 1 of 2)

Main Menu	Submenu	Fields in Submenu	Subfields in Submenu
Meter			
	Fundamental	IA, IB, IC, IG, IN, IAVG, Motor load, Stator TCU, Rotor TCU, Thermal Trip, Time to reset (lockout), 3I2, Current Imb %,VAB, VBC, VCA, VA, VB, VC, 3V0 VAVG, 3V2, Voltage Imb %, Real Power kW, Reactive Power kVAR, Apparent Power kVA, Power Factor, Frequency Hz	
	RMS	IArms. IBrms, ICrms, IGrms, INrms, VArms, VBrms, VCrms	
	Demand	Demand Display	IAD, IBD, ICD, IAPD, IBPD, ICPD, Last Demand Reset
		Demand Reset	Reset Demand? Yes or No
	Energy	Energy Display	MWH3P, MVARH3PI, MVARH3PO, MVAH3P, Last Reset
		Energy Reset	Reset Energy? Yes or No
	Max/Min	Max/Min Display	IAMX, IAMN, IBMX, IBMN, ICMX, ICMN, INMX, INMN, IGMX, IGMN, VAMX, VAMN, VBMX, VBMN, VCMX, VCMN, KW3PMX, KW3PMN, KVAR3PMX, KVAR3PMN, KVA3PMX, KVA3PMN, FREQMX, FREQMN, Last reset
		Max/Min Reset	Reset Max/Min? Yes or No
	Harmonics	Fundamental Quantities for voltages and currents and 2nd, 3rd, 4th, 5th Harmonics as % of fundamental quantities, THDs for voltages and currents	
	Math Variables	Displays Math Variables if Enabled (see EMV Setting)	
	Remote Analogs	Displays 32 Remote Analogs	
Events			
	Display Events	Displays Events stored in the relay with time stamp of its occurrence	
	Clear Events	Asks Yes or No for clearing events	
	Trigger Events	Asks Yes or No for triggering events	
Monitor			
	Display Motor Data	Motor Use data	Last Reset Date, Last Reset Time, Running Time, Stopped Time, Time Running %, Number of Starts, Number of Restarts, Emergency Starts, Contactor Operations, Breaker Operations
		Avg/Peak data	Start Time, Max Start I, Min Start V, Start %TCU, Running %TCU, Running Current, Running KW, Running KVAR IN, Running KVAR OUT, Running KVA

Table 8.4 SEL-3421 Motor Relay HMI Navigation (Sheet 2 of 2)

Main Menu	Submenu	Fields in Submenu	Subfields in Submenu
		Trip/Alarm Data	Overload, Locked Rotor, Undercurrent, Jam, Current Imbalance, Overcurrent, Ground Fault, Speed Switch, Undervoltage, Overvoltage, Power, Power Factor, Phase Reversal, Underfrequency, Overfrequency, PTC, Start Timer, Remote Stop, Local Stop, Other Trips, Total
	Clear Motor Data	Asks Yes or No for clearing motor data	
Targets			
	Current Row	Displays 43 target rows with 8 Relay Word bits in each row. Use the Up and Down navigation pushbuttons to navigate between rows. Jump to target rows 10, 20, 30, or 40 using the corresponding function keys.	
Control			
	Stop Motor	Refer to *Control Pushbutton Operation on page 8.16*.	
	Emergency Restart	Refer to *Control Pushbutton Operation on page 8.16*.	
	Start Motor	Refer to *Control Pushbutton Operation on page 8.16*.	
	Select Speed1/ Speed2	When starter type setting STARTRTY := 2SPEED and if on Speed1, asks Yes or No to switch to Speed2 and vice versa. When starter type setting STARTRTY := FVR and if on Forward/Spd1, asks Yes or No to switch to Reverse/Spd2 and vice versa.	
	Reset TCU	Asks Yes or No for resetting TCU	
Status			
	Display Status	Serial number, FID, CID, part number, RAM, ROM, critical RAM, nonvolatile Flash, HMI, clock, PTC, arc-flash sensor, power supply, clock battery, SPI DMA,CT/PT, offsets for currents and voltages, relay status	
	Reboot Relay	Asks Yes or No for rebooting the relay	If Yes, relay reboots
Info			
	IP Address Default Router MAC Address P1 Protocol P1 Baud Rate	Displays these settings from the relay; also allows for the modification of the IP and router addresses (see *Info Menu on page 8.13* for additional details)	

Main Menu

NOTE: When EPB := Y, the pushbutton names are visible at the bottom of the screen. Press **ENT** to exit the rotating screen to view the main menu.

Figure 8.4 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. Alternately, the menu items can be selected by pressing the function keys right below the corresponding function key grid text shown in *Figure 8.4*. Press the function key below `MORE` to toggle between all available menu items. Each menu item is explained in detail in the following paragraphs.

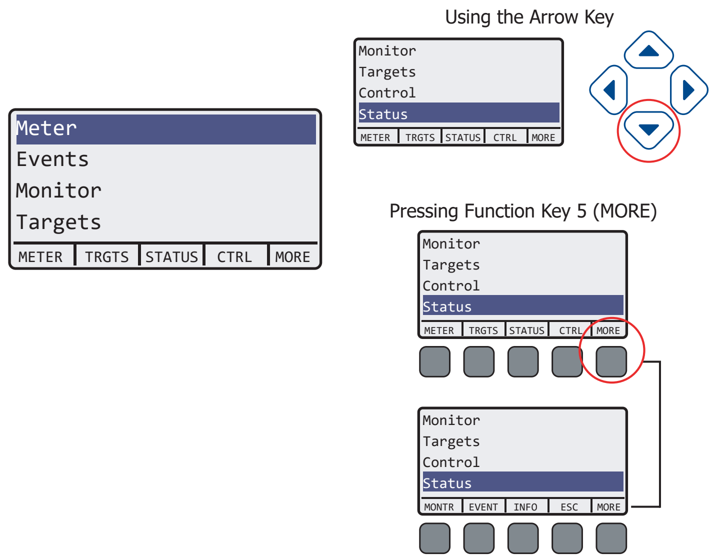


Figure 8.4 Main Menu

Meter Menu

Select `Meter` from the main menu, as shown in *Figure 8.5*, to view metering data. The `Meter` menu has menu items for viewing different types of metering data, such as `Fundamental`, `RMS`, `Demand`, etc. Select the type of metering and view the data using the **Up Arrow** or **Down Arrow** and **ENT** pushbuttons. See *Metering on page 5.2* for a description of the available data fields.

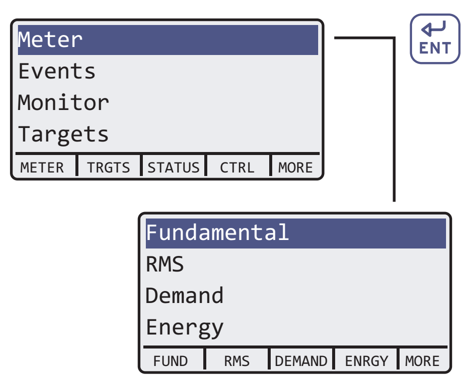


Figure 8.5 Main Menus and Meter Submenu

To view the Demand metering data, select `Demand` from the `Meter` menu and then select `Demand Display`, as shown in *Figure 8.6*.

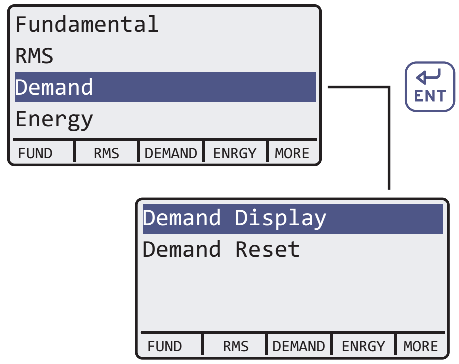


Figure 8.6 Meter Menu and Demand Submenu

Demand metering data can be reset from the HMI by selecting `Demand Reset` from the `Demand` menu. After selecting `Demand Reset` and confirming the reset, the relay displays as shown in *Figure 8.7*.

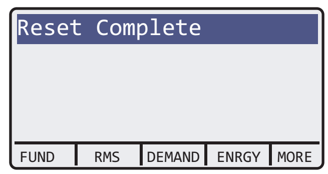


Figure 8.7 Relay Response When Demand Metering Is Reset

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 shown in *Figure 8.8*.

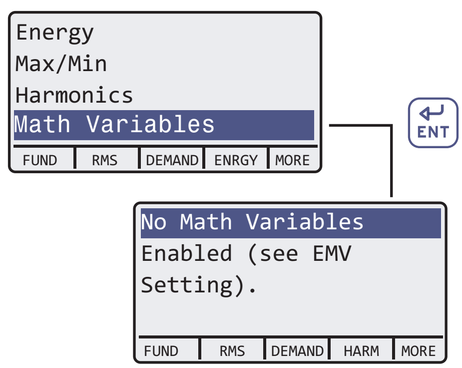


Figure 8.8 Relay Responses When No Math Variables Enabled

Events Menu

Select `Events` from the main menu, as shown in *Figure 8.9*. The Events menu has `Display`, `Clear`, and `Trigger` as its menu items. Select `Display` to view events, `Clear` to delete all the events data, and `Trigger` to trigger an event report.

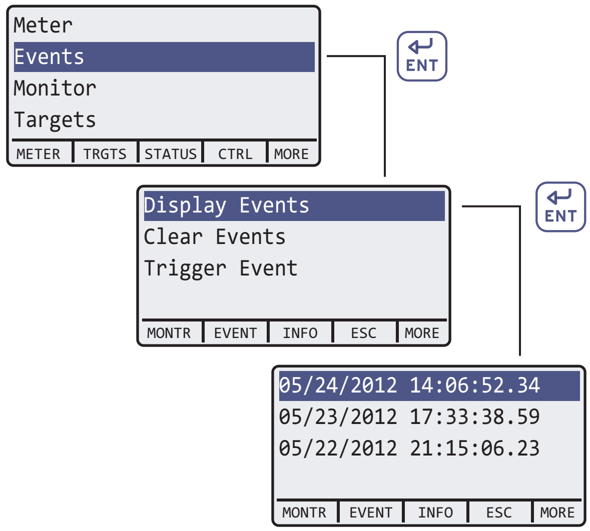


Figure 8.9 Events Menu and Display Submenu

When you select `Display` and no event data are available, the relay displays as shown in *Figure 8.10*.

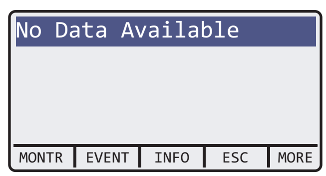


Figure 8.10 Relay Response When No Event Data Available

When you select `Clear` from the `Events` menu and confirm the selection, the relay displays as shown in *Figure 8.11*, after clearing the events data.

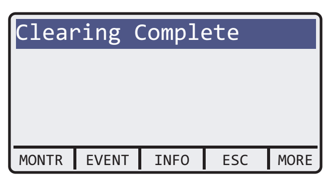


Figure 8.11 Relay Responses When Events Are Cleared

When you select `Trigger` from the `Events` menu and confirm the selection, the relay displays as shown in *Figure 8.12*, after triggering the event.

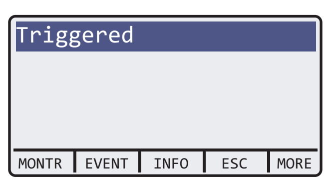


Figure 8.12 Relay Response When Event Is Triggered

Monitor Menu

Select `Monitor` on the main menu, as shown in *Figure 8.13*. `Monitor` has `Display Motor Data` and `Clear Motor Data` as its menu items.

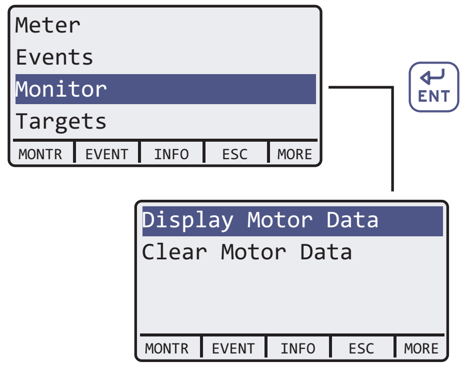


Figure 8.13 Main Menu and Monitor Submenu

Select `Display Motor Data` from the `Monitor` menu, as shown in *Figure 8.14*, to view motor operating statistics. See *Motor Operating Statistics on page 5.9* for a description of the data available.

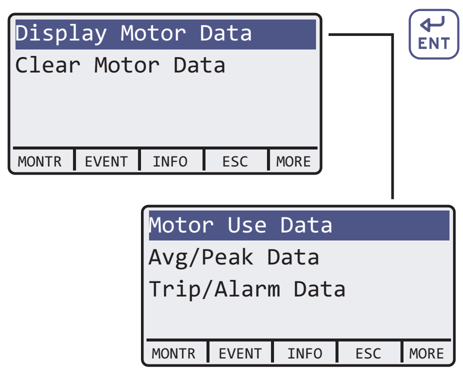


Figure 8.14 Monitor Menu and Display Motor Data Submenu

The motor operating statistics can be cleared from the SEL-3421 module by selecting `Clear Motor Data` from the `Monitor` menu.

Targets Menu

Select Targets from 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 *Appendix H: Relay Word Bits*.

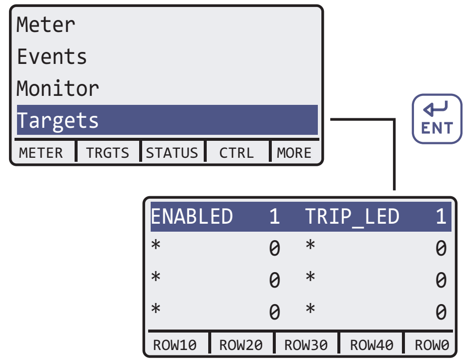


Figure 8.15 Targets Menu Navigation

Control Menu

Select Control from the main menu, as shown in *Figure 8.16*, to go to the Control menu.

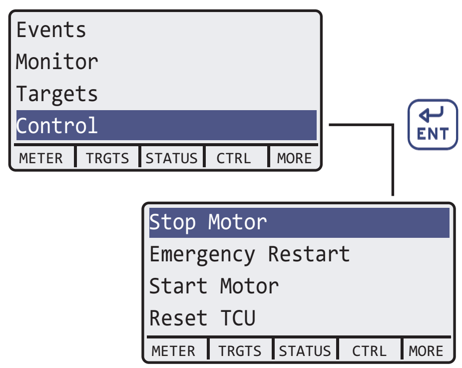


Figure 8.16 Main Menu and Control Submenu

NOTE: A stop motor action executed from the Control menu is always a normal stop. A stop action executed by the **STOP** pushbutton on the HMI can be a normal stop or an emergency stop, depending on the HMIPBSTP setting.

NOTE: HMI_STRD does not affect the emergency restart function in the Control menu. The emergency restart function works independently of the LOCAL/REMOTE mode.

When APP := MOTOR or VFD, the Control menu has Stop Motor, Emergency Restart, Start Motor, Select Speed1/Speed2 (or Select Forward/Spd1 or Reverse/Spd2), and Reset TCU as its menu items. When APP := FEEDER, only Stop Motor and Start Motor are available under the Control menu. Select Stop Motor to assert the Relay Word bit, STOP, which stops the motor (see *Figure 4.49*). Select Emergency Restart to assert Relay Word bit, EMRSTR, which initiates an emergency start (see *Figure 4.52*). Select Start Motor to assert Relay Word bit, STR_CLO, which initiates a motor start (see *Figure 4.52*). When STARTRTY := 2SPEED, use the Select Speed1/Speed2 menu to switch from Speed1 to Speed2 or vice versa, and when STARTRTY := FVR, use the Select Forward/Spd1 or Reverse/Spd2 menu to switch from Speed1 to Speed2 or vice versa. This option is only available when STARTRTY is set to FVR or 2SPEED. Select Reset TCU to reset the thermal capacity used (see *Thermal Overload Element on page 4.8* for a description).

Status Menu

Select Status from the main menu, as shown in *Figure 8.17*, to access Relay Status data and Reboot Relay. See *STATUS Command (Relay Self-Test Status) on page 7.42* for the STATUS data field description.

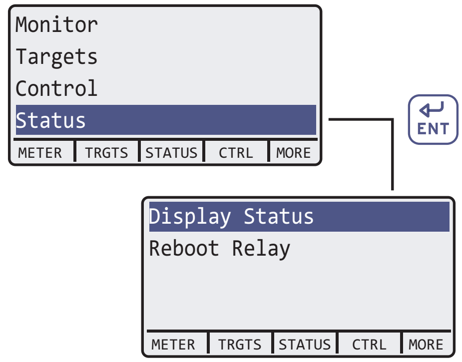


Figure 8.17 Main Menu and Status Submenu

Info Menu

Select Info from the main menu, as shown in *Figure 8.18*, to access the relay communications settings. The Port 1 baud rate and protocol and Port 2 IP address, default router address, and MAC address are presented under this menu. You can edit the relay IP or default router address through this menu. Note that you can only have one editing session (web browser, HMI, or terminal) open at a time when making edits.

To change the IP or default router address you must be in Access Level 2. Select 2AC to enter the Access Level 2 password and press the **ENT** pushbutton. Update the settings as necessary, as shown in *Figure 8.18*. Press the SAVE function key to save your settings. If you press the ESC function key before saving your settings, the relay prompts Lose Settings? No Yes. If you press ACC, the relay prompts Exit 2AC No Yes.

Exit Access Level 2 by pressing the ACC function key, or press **ESC** to exit the Info submenu without signing out of Access Level 2. The Info submenu displays ACC if you remain signed into Access Level 2.

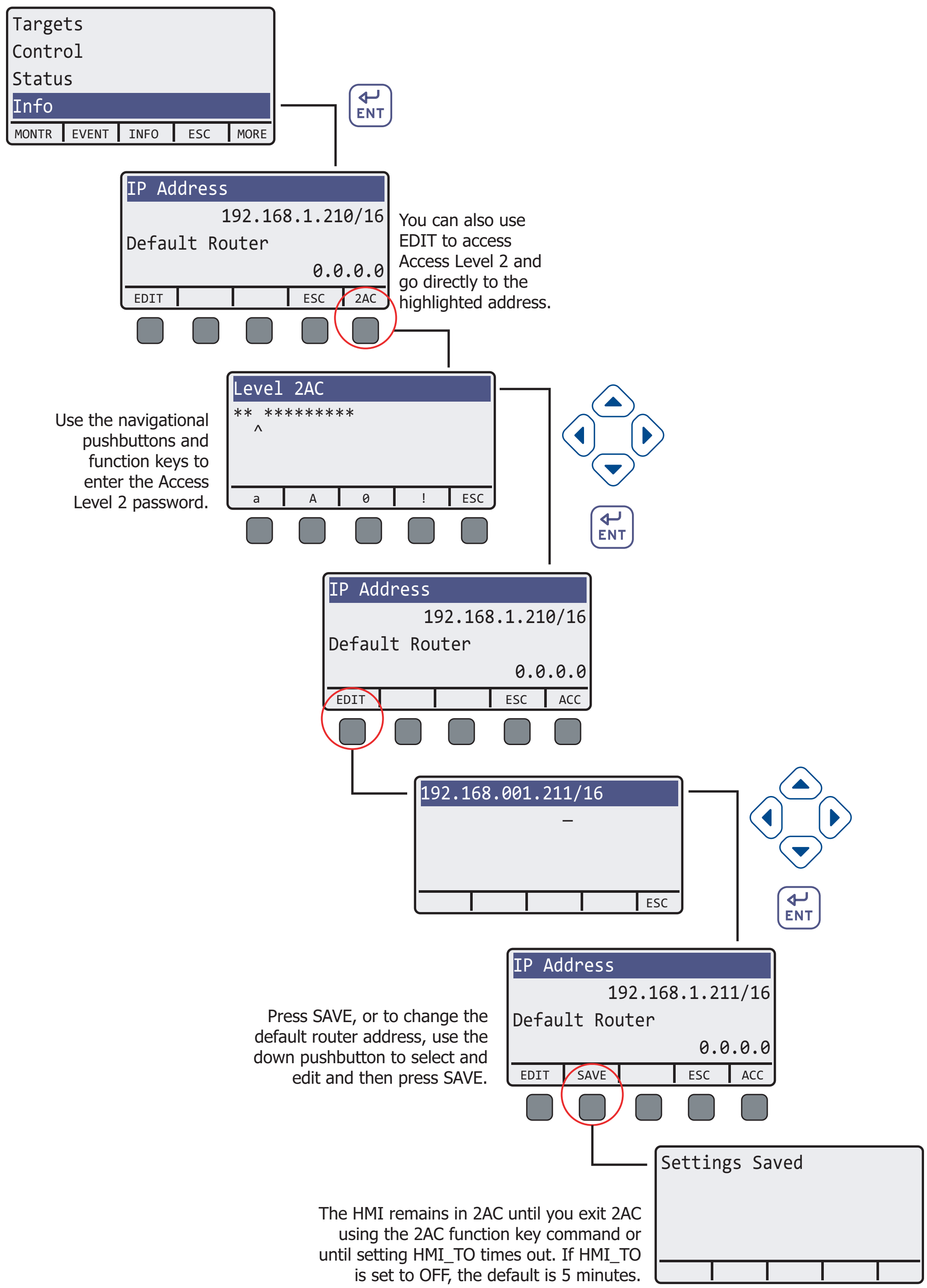


Figure 8.18 Info Menu and IP Address and Default Router Submenu

HMI Operation When Pushbuttons Are Enabled

When EPB := Y, four of the five function keys can be used as eight pushbuttons. The fifth button (MORE) toggles the function keys between PB01–PB04 and PB05–PB08. Pressing any one of these eight pushbuttons asserts the corresponding PB*n* (*n* = 01 through 08) Relay Word bit. The PB*n* Relay Word bit remains asserted as long as the pushbutton is pressed.The pushbuttons labels can be customized using as many as 6 characters.

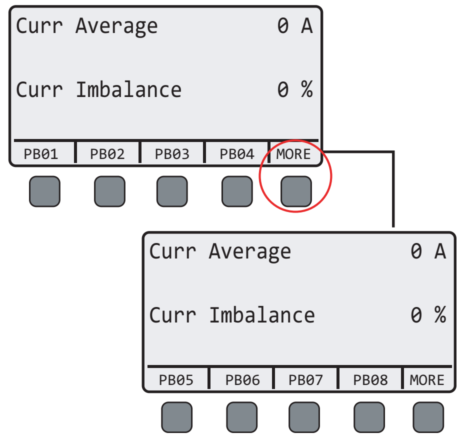


Figure 8.19 Pushbutton (PB01–PB08) Function Keys

To access the main screen when in this mode, press **ESC** until the rotating screen with the pushbuttons is visible.

Operation and Target LEDs

Programmable LEDs

The SEL-3421 module provides quick confirmation of relay conditions via operation and target LEDs. *Figure 8.20* shows this region with factory-default text on the front-panel configurable labels. See *Target LED Settings on page 4.84* for the SELOGIC control equations.

Figure 8.20 Factory-Default HMI 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.

T0*n*_LED settings are SELOGIC control equations that work with the corresponding T0*n*LEDL latch settings to illuminate the LEDs shown in *Figure 8.20*. Parameter *n* is a number from 1–8 that indicates each LED. If the latch setting (T0*n*LEDL) for a certain LED is set to N, then the LED will follow the status of the corresponding control equation (T0*n*_LED). When the equation asserts, the LED will illuminate, and when the equation deasserts, the LED will extinguish. If the latch setting is set to Y, the LED will only assert if a trip condition occurs and the T0*n*_LED equation is asserted at the time of the trip. At this point, the LED will latch in and can be reset using the **TARGET RESET** pushbutton or the **TAR R** command as long as the target conditions are absent. For a concise listing of the default programming on the HMI LEDs, see *Table 4.66*.

The SEL-3421 module features slide-in labels for custom LED designations that match custom LED logic. Use the slide-in labels to mark the LEDs with these custom names. The Configurable Label kit (P/N 915900268), which includes blank labels, word processor templates, and instructions, can be ordered at selinc.com.

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. A **TRIP** LED can be ON for any of the conditions listed in *Table 9.7: Event Types*.

TARGET RESET Pushbutton

For a TRIP event, the SEL-849 latches the **TRIP** LED. Press the **TARGET RESET** pushbutton to reset the latched **TRIP** LED. Pressing and holding the **TARGET RESET** pushbutton illuminates all the LEDs. Upon release of the **TARGET RESET** pushbutton, two possible 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 **TRIP** LED turns off. If the trip event conditions remain, the **TRIP** LED remains lit. The **TARGET RESET** pushbutton also removes the trip automatic message displayed on the LCD menu screens if the trip conditions have cleared.

LED Test

The **TARGET RESET** pushbutton also provides a front-panel LED 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 LEDs cycle between red, green, and amber as long as the pushbutton is pressed. Each state lasts about five seconds. The LEDs return to the normal operational state after release of the **TARGET RESET** pushbutton.

Control Pushbutton Operation

NOTE: If HMI_CTRL := ACK_DIS, the motor will start or stop with a single press of the **START** or **STOP** pushbutton, respectively.

NOTE: If you make a change to the HMI_CTRL and/or HMIPBSTP settings, the HMI will restart upon saving the settings.

The functionality of the **START** and **LOCAL/REMOTE** pushbuttons on the SEL-3421 HMI are determined by the HMI_CTRL and HMIPB_LR settings, and the functionality of the **STOP** pushbutton is determined by both the HMI_CTRL and HMIPBSTP settings.

LOCAL/REMOTE Pushbutton: The HMI is the local control location. When the pushbutton is enabled and control is not blocked by settings (i.e., HMIPB_LR = Y and HMI_CTRL = ACK_EN or ACK_DIS) the HMI operator can select LOCAL to take over control or select REMOTE to relinquish control to a remote location. Press the **LOCAL/REMOTE** pushbutton momentarily to toggle between the LOCAL and REMOTE modes. When HMIPB_LR = N or HMI_CTRL := BLK_CTRL, control is automatically relinquished to the remote location, and the HMI operator cannot select the LOCAL/REMOTE mode.

START Pushbutton: As soon as the **START** pushbutton is pressed, the HMI processes the following conditions in the order shown.

- HMI_CTRL := ACK_EN, ACK_DIS, or BLK_CTRL
- The control is in LOCAL mode
- The relay is in the ENABLED state
- The motor is in the STOPPED state
- No Block Start (BSRT_CL evaluates to zero) or Lockout conditions exist
- HMI_STRD := 0 or a value other than 0 (see *Table 4.58* for information on the HMI_STRD setting)

Based on the HMI_CTRL and HMI_STRD settings, the behavior of the HMI on a START request is captured in the following table.

HMI Control Mode Setting Value (HMI_CTRL)	HMI START Delay Setting Value (HMI_STRD)	Initiating a START
ACK_EN	0	When a START is performed from the HMI via either the START pushbutton or the control menu, it acknowledges with YES or NO options requiring the user to confirm the operation. The control must be in LOCAL mode to initiate a START by using the START pushbutton or the control menu.
	Any non-zero value	When a START operation is performed from the HMI via either the START pushbutton or the control menu, it will display the message “Start delay active ESC or STOP to cancel START in *xx* seconds,” where *xx* is the start delay timer that is counting down. Note that when the start delay timer is set to a value, the HMI does not respond with YES or NO options for a START operation. The control must be in LOCAL mode to initiate a START by using the START pushbutton or the control menu.
ACK_DIS	0	When a START is performed from the HMI, the HMI initiates the command with just one press of the START pushbutton. The control must be in LOCAL mode to initiate a START by using the START pushbutton or the control menu.
	Any non-zero value	When a START operation is performed from the HMI, it will display the message “Start delay active ESC or STOP to cancel START in *xx* seconds,” where *xx* is the start delay timer that is counting down. The control must be in LOCAL mode to initiate a START by using the START pushbutton or the control menu.
BLK_CTRL	NA	START is blocked from the HMI.

If the above conditions are satisfied, a START request gets initiated. Otherwise, the request is aborted.

Pressing the STOP or ESC pushbutton during the delay wait time will cancel the START request.

NOTE: When HMI_CTRL := ACK_EN, pressing the START or STOP pushbutton twice on the SEL-3421 will also initiate START or STOP, respectively.

STOP Pushbutton: As soon as the STOP pushbutton is pressed, the HMI verifies the following conditions in the order shown.

- HMIPBSTP := NORMAL or EMERGENCY
- HMI_CTRL := ACK_EN or ACK_DIS
- The control is in LOCAL or REMOTE mode
- The relay is enabled

Based on the HMI_CTRL and HMIPBSTP settings, the behavior of the HMI on a STOP request is captured in the following table.

HMI Control Mode Setting Value (HMI_CTRL)	HMI STOP Pushbutton Setting Value (HMIPBSTP)	Initiating a STOP Using the STOP Pushbutton
ACK_EN	NORMAL	When a STOP is performed from the HMI it acknowledges with YES or NO options requiring the user to confirm the operation. The control must be in LOCAL mode to initiate a STOP by using the STOP pushbutton.
	EMERGENCY	Momentarily pressing the STOP pushbutton will initiate a STOP operation. An EMERGENCY STOP operation occurs regardless of whether the control is in LOCAL or REMOTE mode.
ACK_DIS	NORMAL	Momentarily pressing the STOP pushbutton will initiate a STOP operation. The control must be in LOCAL mode to initiate a STOP by using the STOP pushbutton.
	EMERGENCY	Momentarily pressing the STOP pushbutton will initiate a STOP operation. An EMERGENCY STOP operation occurs regardless of whether the control is in LOCAL or REMOTE mode.

HMI Control Mode Setting Value (HMI_CTRL)	HMI STOP Pushbutton Setting Value (HMIPBSTP)	Initiating a STOP Using the STOP Pushbutton
BLK_CTRL	NORMAL	STOP is blocked from the HMI.
	EMERGENCY	Momentarily pressing the **STOP** pushbutton will initiate a STOP operation. An EMERGENCY STOP operation occurs regardless of whether the control is in LOCAL or REMOTE mode.

If the above conditions are satisfied, a STOP request gets initiated. Otherwise, the request is aborted.

SEL-3422 Motor Relay HMI Module (No Display)

The SEL-3422 Motor Relay HMI Module has the same features as the SEL-3421 without the LCD. The SEL-3422 is a mini-module and gives a clear indication of the SEL-849 operation status through the ten LEDs on the front panel, eight of which are programmable as in the SEL-3421.

The SEL-3422 controls the relay with the **LOCAL**/**REMOTE**, **START,** and **STOP** pushbuttons. The **TARGET RESET** pushbutton is provided to allow resetting of targets.

Figure 8.21 SEL-3422 Motor Relay HMI Module

Control Pushbutton Operation

NOTE: If HMI_CTRL := ACK_DIS, the motor will start or stop with one press of the **START/STOP** pushbutton.

The functionality of the **START** and **LOCAL/REMOTE** pushbuttons on the SEL-3422 HMI are determined by the HMI_CTRL and HMIPB_LR settings, and the functionality of the **STOP** pushbutton is determined by both the HMI_CTRL and HMIPBSTP settings.

LOCAL/REMOTE Pushbutton: The HMI is the local control location. When the pushbutton is enabled and control is not blocked by settings (i.e., HMIPB_LR = Y and HMI_CTRL = ACK_EN or ACK_DIS) the HMI operator can select LOCAL to take over control or select REMOTE to relinquish control to a remote location. Press the **LOCAL/REMOTE** pushbutton momentarily to toggle between the LOCAL and REMOTE modes. When HMIPB_LR = N or HMI_CTRL := BLK_CTRL, control is automatically relinquished to the remote location, and the HMI operator cannot select the LOCAL/REMOTE mode.

NOTE: If you make a change to the HMI_CTRL or HMIPBSTP setting, the HMI will restart upon saving the setting.

START Pushbutton: As soon as the **START** pushbutton is pressed, the HMI verifies the following conditions in the order shown.

- ➤ HMI_CTRL := ACK_EN, ACK_DIS, or BLK_CTRL
- ➤ The control is in LOCAL mode
- ➤ The relay is enabled
- ➤ The motor is in STOPPED state
- ➤ No Block Start (BSRT_CL evaluates to zero) or Lockout conditions exist
- ➤ HMI_STRD := 0 or a value other than 0 (see *Table 4.58* for information on setting HMI_STRD)

Based on the HMI_CTRL and HMI_STRD settings, the behavior of the HMI on a START request is captured in the table below.

HMI Control Mode Setting Value (HMI_CTRL)	HMI START Delay Setting Value (HMI_STRD)	Initiating a START Using the START Pushbutton
ACK_EN	0	Pressing and holding the **START** pushbutton for at least five (5) seconds initiates a START. During this time, the **ENABLED** LED blinks at a faster rate. The blinking stops once the START is initiated at the end of five (5) seconds. If the **START** pushbutton is released before the initiation, the corresponding operation gets aborted. The control must be in LOCAL mode to initiate a START by using the **START** pushbutton.
	Any non-zero value	Pressing and holding the **START** pushbutton for at least five (5) seconds initiates a START. When HMI_STRD is set to a value other than zero, a START request is initiated after the delay timer expires. The **ENABLED** LED will blink at a faster rate for the first five (5) seconds and will blink once per second during the HMI_STRD wait time. The blinking stops once the START is initiated. The control must be in LOCAL mode to initiate a START by using the **START** pushbutton.
ACK_DIS	0	Momentarily pressing the **START** pushbutton will initiate a START operation. The control must be in LOCAL mode to initiate a START by using the **START** pushbutton.
	Any non-zero value	Momentarily pressing the **START** pushbutton will initiate a START operation. After the first press of the **START** pushbutton, the **ENABLED** LED will blink once per second during the HMI_STRD wait time. The control must be in LOCAL mode to initiate a START by using the **START** pushbutton.
BLK_CTRL	NA	START is blocked from the HMI.

If the above conditions are satisfied, a start request gets initiated. Otherwise, the request is aborted.

Pressing the **STOP** pushbutton during the delay wait time will cancel the start request.

STOP Pushbutton: As soon as the **STOP** pushbutton is pressed, the HMI verifies the following conditions in the order shown.

- ➤ HMIPBSTP := NORMAL or EMERGENCY
- ➤ HMI_CTRL := ACK_EN or ACK_DIS
- ➤ The control is in LOCAL or REMOTE mode
- ➤ The relay is enabled

Based on the HMI_CTRL and HMIPBSTP settings, the behavior of the HMI on a STOP request is captured in the following table.

HMI Control Mode Setting Value (HMI_CTRL)	HMI STOP Pushbutton Setting Value (HMIPBSTP)	Initiating a STOP Using the STOP Pushbutton
ACK_EN	NORMAL	Pressing and holding the STOP pushbutton for at least five (5) seconds initiates a stop. During this time, the ENABLED LED blinks at a faster rate. The blinking stops once the STOP is initiated at the end of five (5) seconds. If the STOP pushbutton is released before the initiation, the corresponding operation gets aborted. The control must be in LOCAL mode to initiate a STOP by using the STOP pushbutton. **NOTE:** With ACK_EN, pressing the STOP pushbutton can abort a START process only when HMI_STRD > 5 s because the STOP pushbutton needs to be held for at least five (5) seconds before a STOP action is initiated.
	EMERGENCY	When a STOP is performed, the HMI will execute the operation with only one press of the STOP pushbutton. An EMERGENCY STOP operation occurs regardless of whether the control is in LOCAL or REMOTE mode.
ACK_DIS	NORMAL	Momentarily pressing the STOP pushbutton will initiate a STOP operation. The control must be in LOCAL mode to initiate a STOP by using the STOP pushbutton.
	EMERGENCY	Momentarily pressing the STOP pushbutton will initiate a STOP operation. An EMERGENCY STOP operation occurs regardless of whether the control is in LOCAL or REMOTE mode.
BLK_CTRL	NORMAL	STOP is blocked from the HMI.
	EMERGENCY	Momentarily pressing the STOP pushbutton will initiate a STOP operation. An EMERGENCY STOP operation occurs regardless of whether the control is in LOCAL or REMOTE mode.

If the above conditions are satisfied, a STOP request gets initiated. Otherwise, the request is aborted.

Section 9
Analyzing Events

Overview

The SEL-849 Motor Management Relay features comprehensive power system data analysis capabilities. The relay provides these useful analysis tools:

- ➤ *Data Processing*
- ➤ *Raw and Filtered Data on page 9.3*
- ➤ *Duration of Data Captures and Event Reports on page 9.4*
- ➤ *Duration of Data Captures and Event Reports on page 9.5*
- ➤ *Event Report Oscillography on page 9.10*
- ➤ *Viewing the Event History on page 9.27*

An event is a representation of the operating conditions of the power system at a specific time. Events include instances such as a relay trip, an abnormal situation in the power system that triggers a relay element, or an event capture command.

Information from oscillograms, relay event reports, and sequential event recorder (SER) data are very valuable if you are responsible for outage analysis, outage management, or relay settings coordination.

When the SEL-849 has an Ethernet port, it can accept an SNTP input for high-accuracy timing. When SNTP is used, the SEL-849 synchronizes the data acquisition system to the received signal. Knowledge of the precise time of sampling (as shown in COMTRADE files) allows comparisons of data across the power system. Use a coordinated network of SEL-849 relays to create moment-in-time "snapshots" of the power system. These data are useful for determining power system dynamic voltage and current phasors, impedances, load flow, and system states.

Data Processing

The SEL-849 is a numeric, or microprocessor-based, relay that samples power system conditions via the current and voltage inputs. The relay converts these analog inputs to digital information for processing to determine relaying quantities for protection and automation. *Figure 9.1* shows a general overview of the input processing diagram for the SEL-849.

Raw and Filtered Data

The SEL-849 outputs two types of analytical data: high-resolution COMTRADE and SEL ASCII (filtered/unfiltered) data. *Figure 9.1* shows the path a power system signal takes through relay input processing. An analog input begins at hardware acquisition and sampling, continues through software filtering, and progresses to protection and automation processing. The initial hardware low-pass filter half-power or –3 dB point is 1.1 kHz with the relay sampling the power system voltage or current with a 4000-samples/second A/D (analog to digital) converter. This is the tap point for high-resolution raw data captures. You can select 4000-samples/second, 2000-samples/second, and 1000-samples/second effective sampling rates for presentation and storage of the high-resolution raw data COMTRADE format (see *Duration of Data Captures and Event Reports on page 9.5*).

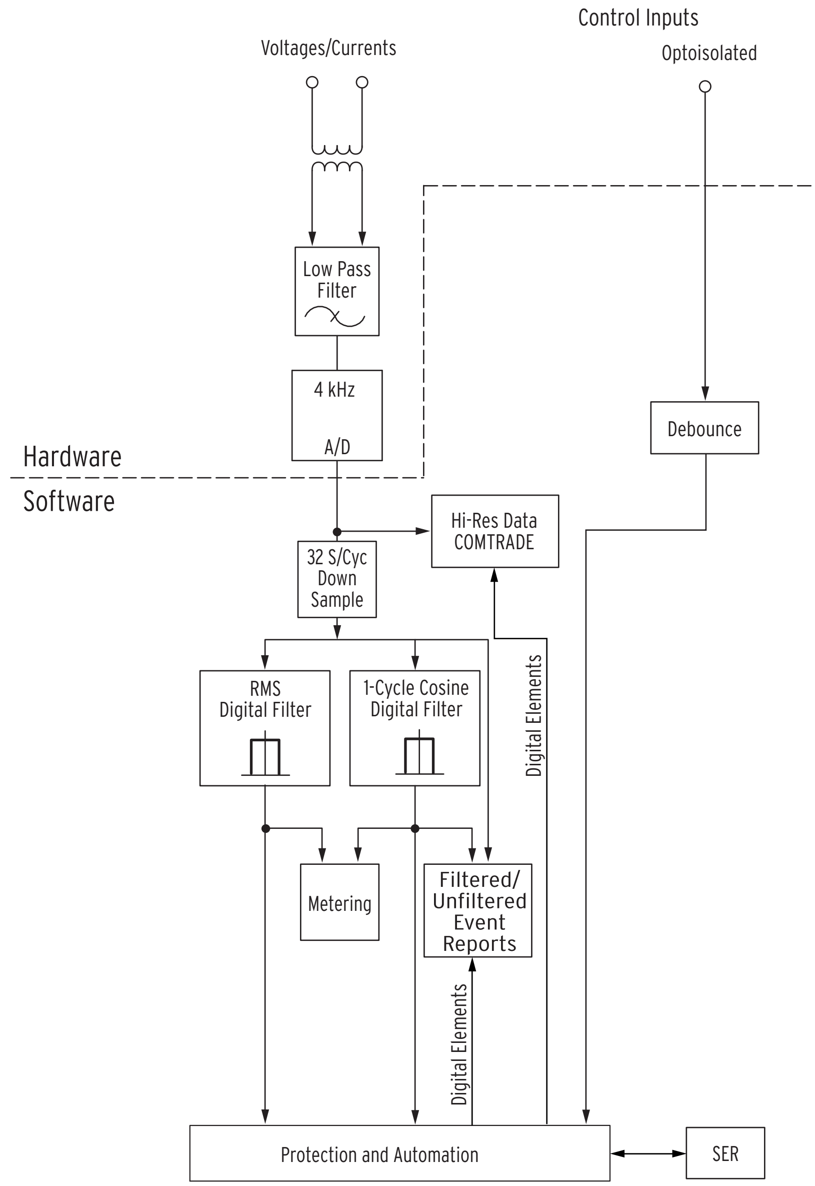


Figure 9.1 SEL-849 Input Processing

Subsequent processing decimates the sampled data to 4 samples per power system cycle using additional digital filtering with a 1-cycle cosine window. This 4-samples/cycle information is used as filtered data for event reports and other relay functions. The relay can also report 32-samples/cycle data for unfiltered reports.

The SEL-849 samples the control inputs at a rate of once per millisecond. The control inputs are reported at quarter-cycle intervals regardless of COMTRADE or filtered event reports.

The SEL-849 filters control inputs with debounce logic, and updates the resulting Relay Word bits four times per cycle. Event reports will include the filtered control input Relay Word bits.

Control input state changes will occur at the same rate in COMTRADE oscillography files, event reports (**EVE/CEV** command), and Sequential Events Recorder reports (**SER** command).

Triggering Data Captures and Event Reports

The SEL-849 displays power system data from oscillograms, event reports, event summaries, event histories, and SER data. For information on the SER, see *Sequential Events Recorder (SER)*. All of these features, except the SER, require sampled or filtered data from the power system, and are triggered both internally and externally depending on the event trigger that you program in the relay.

Use an event trigger to initiate capturing power system data. Both high-resolution raw data oscillography and event reports use the same triggering methods. The trigger for data captures comes from three possible sources:

- Relay Word bit TR assertions
- SELOGIC control equation ER (Event Report Trigger)
- **TRI** command
- Front panel or serial port (including Modbus) **STOP** command

Relay Word Bit TR

Refer to *Figure 4.49*. 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.

SELOGIC Control Equation ER

The programmable SELOGIC control equation event report trigger setting ER is set to trigger event reports for conditions other than trip conditions (see *Target LEDs on page 4.86*). When setting ER detects a logical 0 to logical 1 transition, it generates an event report (if the SEL-849 is not already generating a report that encompasses the new transition). The factory setting is shown in *Event Report Settings on page 4.88*.

You can also use the falling-edge operator, F_TRIG, to initiate data captures. See SELOGIC *Control Equation Operators on page 4.67* for more information on falling edge operators.

TRI (Trigger Event Report) Command

Use the **TRI** command from any communications port to trigger the SEL-849 to begin recording high-resolution raw data and event report data. When testing with the **TRI** command, you can gain a glimpse of power system operating conditions that occur immediately after you issue the **TRI** command. See *TRIGGER Command (Trigger Event Report) on page 7.47* for more information on the **TRI** command.

Duration of Data Captures and Event Reports

The SEL-849 stores high-resolution raw data and filtered data. The number of stored high-resolution raw data captures and event reports is a function of the amount of data contained in each capture. You can configure the relay to record long data captures, although this reduces the total number of stored events you can retrieve from the relay.

To use the data capture functions, select the data capture times. Relay setting LER, listed in *Table 9.1*, determines the number of cycles the relay records per event. You can set LER to 15 cycles, 60 cycles, or 120 cycles.

The length of the data capture/event report (setting LER) and the pretrigger or prefault time (setting PRE) are related, as shown in *Figure 9.2*. The LER setting is the overall length of the event report data capture; the PRE setting determines the time reserved in the LER period when the relay records pretrigger (prefault) data. Typically, you set the PRE time to 20 percent of the total LER period. *Table 9.1* shows the relay settings for the prefault data capture recording times at each event length.

Table 9.1 Report Settings

Label	Description	Range	Default
LER	Length of event report	15, 60, 120 cycles	15 cycles
PRE[a]	Length of prefault	OFF, 1–10 cycles	10 cycles
PRE[b]	Length of prefault	OFF, 1–55 cycles	10 cycles
PRE[c]	Length of prefault	OFF, 1–115 cycles	10 cycles

[a] LER = 15.
[b] LER = 60.
[c] LER = 120.

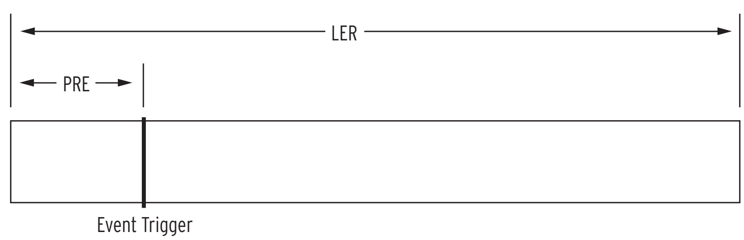


Figure 9.2 Data Capture/Event Report Times

The relay stores all data captures to volatile RAM and then moves these data to nonvolatile memory storage. There is enough volatile RAM to store one maximum length capture (maximum LER time). No data captures can be triggered while the volatile RAM is full; the relay must move at least one data capture to nonvolatile storage to reenable data capture triggering. Thus, to record sequential events, you must set LER to half or less than half of the maximum LER setting. The relay stores more event data captures as you set LER smaller.

Table 9.2 lists the maximum number of data captures/event reports the relay stores in nonvolatile memory for various report lengths and sample rates. The relay automatically overwrites the oldest events with the newest events when the nonvolatile storage capacity is exceeded.

The relay stores approximately 360 cycles of high-resolution raw or filtered data in nonvolatile memory. If you have selected LER at 60 cycles, you can store nine one-second reports. These nine reports are at 4000 samples/second resolution. *Table 9.2* lists the storage capability of the SEL-849 for common event report lengths.

Table 9.2 Event Report Nonvolatile Storage Capability

Event Report Length	Maximum Number of Stored Reports
120 cycles	3
60 cycles	9
15 cycles	42

Oscillography

The SEL-849 features three types of oscillography:

- ➤ Raw data oscillography—effective sampling rate as fast as 4000-samples/second (referred to as COMTRADE)
- ➤ Event report oscillography from filtered data—4 samples per cycle (referred to as Compressed Event Report—CEV)
- ➤ Event report oscillography from unfiltered data—32 samples per cycle (referred to as Compressed Event Report—CEV R)

NOTE: Neither the filtered nor the unfiltered event reports display exact sampling rates of the data. If exact timing of the samples is needed, use the COMTRADE format event reports.

Use high-resolution raw data oscillography to view transient conditions in the power system. You can set the relay to report these high-resolution oscillograms at 4000-samples/second, 2000-samples/second, and 1000-samples/second effective sampling rates (see *Duration of Data Captures and Event Reports*). The high-resolution raw data oscillograms are available as files through the use of a serial connection and Ymodem file transfer, the web server, or FTP (file transfer protocol) in the binary COMTRADE file format output (*IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems, IEEE C37.111-1999)*.

The filtered data oscillograms at 4 samples per cycle give you accurate information on the relay protection and automation processing quantities. The relay outputs 4-samples per cycle filtered and 32-samples per cycle unfiltered event reports through a terminal or as files in ASCII format and Compressed ASCII format. *Figure 9.3* shows a sample CEV oscillogram. *Figure 9.4* shows a sample COMTRADE oscillography.

Both the CEV and the COMTRADE files can be viewed in the following ways:

- ➤ ACSELERATOR QuickSet SEL-5030 Software via SYNCHROWAVE Event Software (SEL-5601-2)
- ➤ SYNCHROWAVE Event Software (SEL-5601-2)

QuickSet provides an option to choose between Analytic Assistant or SYNCHROWAVE Event (SEL-5601-2) to view the event reports. Navigate to the **Options** menu under **Tools** and select either **Analytic Assistant** or SYNCHROWAVE **Event** as the event viewer.

To view the saved events using Analytic Assistant or QuickSet via Analytic Assistant, click on the **View Event Files** function from the **Tools** > **Events** menu to select the event you want to view (QuickSet remembers the location where you stored the previous event record).

Use **View Combined Event Files** to simultaneously view as many as three separate events. To view the saved events using SYNCHROWAVE Event, click on the **Load Event** functions on the right side of the screen.

As shown in *Figure 9.3*, all the ac analog data points shown in a CEV report, when viewed with Analytic Assistant or QuickSet via Analytic Assistant, are scaled down by $\sqrt{2}$. SEL introduced SYNCHROWAVE Event, also known as SEL-5601-2 Software, for displaying and analyzing relay event reports. The ac analog signals in a CEV report, when viewed using SYNCHROWAVE Event Software, are scaled up by a factor of $\sqrt{2}$ to display the instantaneous magnitudes.

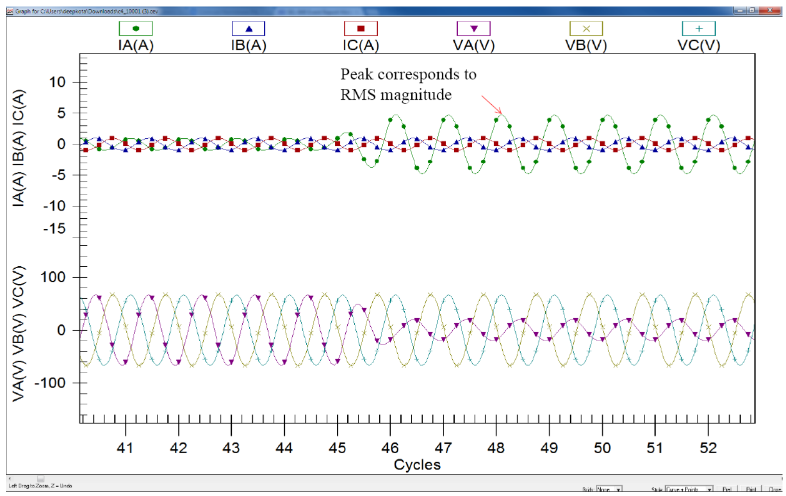


Figure 9.3 Sample CEV Report Viewed With Analytic Assistant or ACSELERATOR QuickSet Via Analytic Assistant

As shown in *Figure 9.4*, the peak in a COMTRADE report viewed with ACSELERATOR Analytic Assistant or ACSELERATOR QuickSet corresponds to peak magnitude.

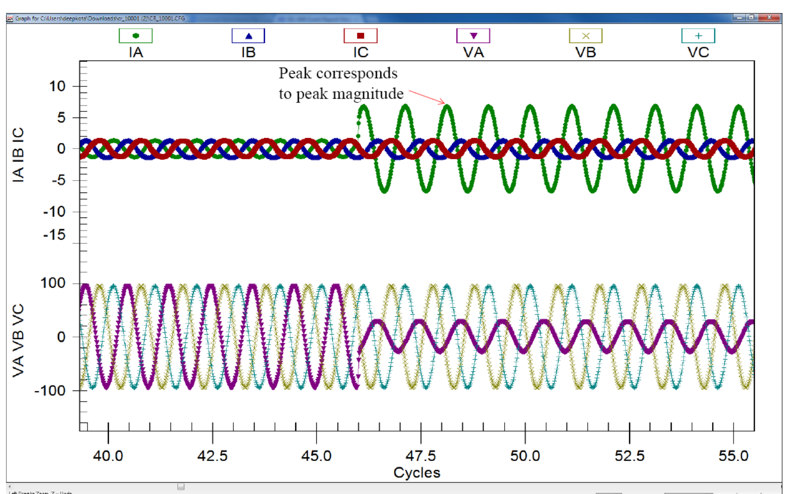


Figure 9.4 Sample COMTRADE Report Viewed With Analytic Assistant or ACSELERATOR QuickSet Via Analytic Assistant

With ACSELERATOR Analytic Assistant you have two options for converting CEV reports to COMTRADE, as shown in *Figure 9.5*.

- Keep COMTRADE Files
- Use Peak Measurement

Keep COMTRADE Files allows you to convert the CEV report to COMTRADE. **Use Peak Measurement** allows you to scale all the quantities by 1.414 to represent peak quantities as peak in the converted COMTRADE.

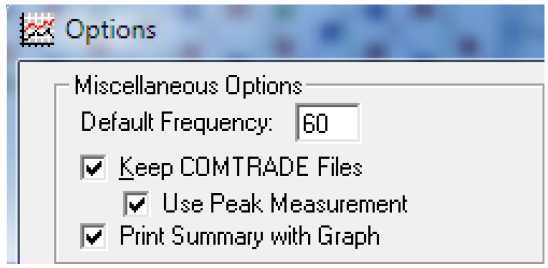


Figure 9.5 Options for Converting CEV Reports to COMTRADE in Analytic Assistant

Raw Data Oscillography

Raw data oscillography produces oscillograms that track power system anomalies that occur outside relay digital filtering.

COMTRADE files include all Relay Word bits from each row of the Relay Word table (see *Table H.1*).

The SEL-849 stores high-resolution raw data oscillography in binary format and uses COMTRADE file types to output these data:

- .HDR—header file
- .CFG—configuration file
- .DAT—high-resolution raw data file

The .HDR file contains summary information about the event in ASCII format. The .CFG file is an ASCII configuration file that describes the layout of the .DAT file. The .DAT file is in binary format and contains the values for each input channel for each sample in the record. These data conform to the IEEE C37.111-1999 COMTRADE standard.

.HDR File

The .HDR file contains the summary and relay settings information that appears in the event report for the data capture. The settings portion is in a comma-delimited format as illustrated in *Figure 9.6*.

```
FID=SEL-849-X251-V0-Z001001-D20120927
CEV_VER = 2.0.1
MONTH = 1
DAY = 24
YEAR = 2012
HOUR = 21
MIN = 33
SEC = 2
MSEC = 598
REC_NUM = 1
NUM_CH_A = 8
NUM_CH_D = 352
FREQ = 60.00
NFREQ = 60
SAM/CYC_A = 32
SAM/CYC_D = 32
NUM_OF_CYC = 16
PRIM_VAL = YES
CTR_IA = 1.00
CTR_IB = 1.00
CTR_IC = 1.00
CTR_IG = 1.00
CTR_IN = 0.00
PTR_VA = 1.00
PTR_VB = 1.00
PTR_VC = 1.00
EVENT = Lockd Rotor Trip
GROUP = 1
IA(A) = 14.43
IB(A) = 14.35
IC(A) = 14.35
IG(A) = 0.10
IN(A) = 0.000
VA(V) = 66.97
VB(V) = 66.86
VC(V) = 67.05
VG(V) = 0.16
PRE_FAULT_CYCLES = 11.000
START_TIME = 24/01/2012,21:33:02.415188
TRIG_TIME = 24/01/2012,21:33:02.598000
```

Summary Event Information

```
RID      := SEL-849
TID      := MOTOR RELAY
FNOM     := 60             PHROT    := ABC          APP      := MOTOR
CTR1     := 1              CTRN     := NONE         FLA1     := 2.5
SERFACTR := 1.15           TRIPCLAS := 10_NEMA      PTR      := 1.00
VNOM     := 240            DELTA_Y  := WYE          SINGLEV  := N
FACTLOG  := Y              CURR_IN  := NORMAL       STARTRTY := FVNR
DATE_F   := MDY
FAULT    := TRIP OR 50G1 OR 50Q1 OR 51P1 OR 51Q1 OR STARTING AND MOTOR
E49MOTOR := Y              TCAPU    := 85           TCSTART  := OFF
49RSTP   := 75             COOLTIME := Auto
50P1P    := OFF            50P2P    := OFF
50Q1P    := OFF
50G1P    := OFF            50G2P    := OFF
50N1P    := OFF            50N2P    := OFF
51P1P    := OFF
51Q1P    := OFF
51G1P    := OFF
LJTPU    := OFF            LJAPU    := OFF
LLTPU    := OFF            LLAPU    := OFF
46UBT    := 20             46UBTD   := 5            46UBA    := 10
.
.
.
1: IAVG
2: UBI
3: MLOAD
4: TCUSTR
5: TCURTR
LDAR     := 15
MSRR     := 0.25
MSRTRG   := 0
```

Relay Settings

Figure 9.6 Sample COMTRADE .HDR Header File

.CFG File

The .CFG file contains data such as sample rates, number of channels, line frequency, channel information, and transformer ratios (see *Figure 9.7*). A <CR><LF> follows each line.

`FID=SEL-849-X251-V0-Z001001-D20120927,0,1999`	COMTRADE Standard
`360,8A,352D`	Total Channels, Analog, Digital

`1,IA(A),,,A,0.00004094,-20.56973634,0,0,999900,1.00,1,P`
`2,IB(A),,,A,0.00004072,-20.32931993,0,0,999900,1.00,1,P`
`3,IC(A),,,A,0.00004065,-20.23456707,0,0,999900,1.00,1,P`
`4,IN(A),,,A,0.00000000,0.00000000,0,0,999900,0.00,1,P`
`5,VA(V),,,V,0.00018952,-94.46947012,0,0,999900,1.00,1,P`
`6,VB(V),,,V,0.00018924,-94.46947012,0,0,999900,1.00,1,P`
`7,VC(V),,,V,0.00019023,-95.45941530,0,0,999900,1.00,1,P`
`8,FREQ,,,Hz,0.00008486,0.00000000,0,0,999900,1.00,1,P`
	Analog Channel Data

`1,ENABLED,,,0`
`2,TRIP_LED,,,0`
`3,*,,,0`
`4,*,,,0`
`5,*,,,0`
`6,*,,,0`
`7,*,,,0`
`8,*,,,0`
`9,TLED_01,,,0`
`10,TLED_02,,,0`
`11,TLED_03,,,0`
`12,TLED_04,,,0`
`13,TLED_05,,,0`
.
.
.
	Digital (Status) Channel Data

`60`	Line Frequency
`1`	
`1920,512`	Sample Rate & Number of Samples
`24/01/2012,21:33:02.415188`	First Data Point
`24/01/2012,21:33:02.598000`	Trigger Point
`ASCII` `1`	

Figure 9.7 COMTRADE .CFG Configuration File Data

The configuration file has the following format:

- Relay name, device identification, COMTRADE standard year
- Number and type of channels
- Channel name units and conversion factors
- Line frequency
- Sample rate and number of samples
- Date and time of first data point
- Date and time of trigger point
- Data file type
- Time-stamp multiplication factor

.DAT File

The .DAT file follows the COMTRADE binary standard. The format of the binary data files is sample number, time stamp, data value for each analog channel, and grouped status channel data for each sample in the file. There are no data separators in the binary file, and the file contains no carriage return/line feed characters. The sequential position of the data in the binary file determines the data translation. Refer to the *IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems, IEEE C37.111-1999* for more information. Many programs read the binary COMTRADE files. These programs include ACSELERATOR Analytic Assistant and ACSELERATOR QuickSet.

Generating Raw Data Oscillograms

To use high-resolution raw data oscillography, select the type of triggering event and use a trigger event method described in *Raw and Filtered Data on page 9.3*. Use the settings SRATE, LER, and PRE to set the SEL-849 for the appropriate data sampling rate and data capture time (see *Duration of Data Captures and Event Reports on page 9.4*).

Retrieving Raw Data Oscillograms

You can also use ACSELERATOR QuickSet or the web server to identify and download data captures (see *Section 3: PC Interface*). Ethernet File Transfer Protocol can also be used to retrieve the COMTRADE files from the relay (see *Communications Protocols* in *Section 7: Communications*). In addition, you can use a computer terminal emulation program and the **FILE** commands at any communications port to retrieve the stored high-resolution raw data capture from the relay file structure. See *FILE Command on page 7.29* for the method of identifying and downloading COMTRADE files.

Event Report Oscillography

Use a terminal or SEL-supplied PC software to retrieve filtered event report files stored in the relay and transfer these files to your computer. Both ACSELERATOR QuickSet and the Analytic Assistant read the compressed event files that the relay generates for an event. See *Section 3: PC Interface* for instructions on viewing event report oscillography with ACSELERATOR QuickSet.

Event Reports, Event Summaries, and Event Histories

Event reports simplify postfault analysis and help you improve your understanding of protection scheme operations. Event reports also aid in testing and troubleshooting relay settings and protection schemes because these reports contain detailed data on voltage, current, and relay element status. For further analysis assistance, the relay appends the active relay settings to each event report. The relay stores event reports in nonvolatile memory (see *EVENT Command (Event Reports) on page 7.28*).

The SEL-849 records the filtered power system data that the relay uses in protection and automation processing. You can view filtered information about an event in one or more of the following forms.

- Event report
- Event summary
- Event history

Event Report

The relay generates event reports to display analog data, digital data (control inputs, control outputs, and the state of Relay Word bits), and relay settings. The event report is a complete description of the data that the relay recorded in response to an event trigger. Each event report includes these components:

- Report header and analog section: Currents and voltages
- Digital section: Relay Word bit elements, control outputs, and control inputs
- Event summary
- Settings
  - Protection settings
  - Report settings
  - Logic settings

Viewing the Event Report

Access event reports from the communications ports at Access Level 1 and higher. You can view event summary information on the HMI display, but you cannot view entire event reports; see *Section 8: Human-Machine Interface (HMI)*.

You can use the **EVE** command and a terminal to retrieve event reports by event order or by event serial number. (The relay labels each new event with a unique serial number as reported in the **HIS** command history report; see *Event History*.)

Event Numbering

Use the **EVE *n*** command to access a particular event report, where *n* is the event number. The most recent event report is 1, the next most recent report is 2, and so on. In addition, events can be accessed by their unique event identification number. Serial numbers start at 10000 and increment with each event until the event reports are cleared. When the event reports are cleared, the serial number resets to 10000. *Table 9.3* lists a summary of **EVE** commands. *Table 9.4* shows a few examples of command options that you can use with the **EVE** command.

Table 9.3 EVE Command

Command	Description
EVE	Return the most recent event report (including settings and summary) at full length with 4-samples-per-cycle data.
EVE *n*	Return a particular *n* event report (including settings and summary) at full length with 4-samples/cycle data.
EVE R	Return a raw event report with 32-samples/cycle data.
EVE R *n*	Return a particular *n* event report (including settings and summary) with 32-samples/cycle data.

Table 9.4 EVE Command Examples

Example	Description
EVE 5	For the fifth most recent event, return the event report with 4-samples/cycle data.
EVE 2 R	For the second most recent event, return the event report with 32-samples/cycle data.

You can retrieve event reports with the ACSELERATOR QuickSet **Analysis > View Event History** menu. The **Analysis > View Event Files** menu gives you oscillogram/element displays, phasor displays, harmonic analysis, and an event summary for each event you select in the **Event History** dialog box. See *Event Analysis on page 3.28* and *Reports on page 3.9* for more information on viewing event reports with ACSELERATOR QuickSet and the web server. Retrieving event reports can be performed with both ACSELERATOR QuickSet or the web server.

The following discussion shows sample portions of an event report that you download from the relay using a terminal and the **EVE** command. An event report contains analog, digital, summary, and settings sections without breaks.

Report Header, Analog Section, and Digital Section of the Event Report

The first portion of an event report is the report header followed by the analog and digital section. See *Figure 9.8* for the location of items included in a sample analog and digital section of an event report.

The report header is the standard SEL-849 header listing the relay identifiers, date, and time. Report headers help you organize report data. Each event report begins with information about the relay and the event. The report lists the RID setting (Relay ID) and the TID setting (Location ID). The FID string identifies the relay model, Flash firmware version, and the date code of the firmware. The relay reports a date and time stamp to indicate the internal clock time when the relay triggered the event. The relay reports the firmware checksum as CID.

The event report column labels follow the header. The data underneath the analog and digital column labels contain samples of power system voltages and currents in primary volts and primary amperes, respectively. These quantities are instantaneous values scaled by $\sqrt{2}/2$ (0.707) and are described in *Table 9.5*. To obtain phasor rms values, use the methods illustrated in *Report Header, Analog Section, and Digital Section of the Event Report on page 9.14*, *Figure 9.9*, and *Figure 9.10*.

```
=>>EVE <Enter>

SEL-849                                 Date: 01/24/2012   Time: 21:33:02.598
MOTOR RELAY

Serial Number : 000000000000000
FID=SEL-849-X251-V0-Z001001-D20120927       CID=DA18
Event Number=10005
```

Header and Firmware ID

```
                                              M L    O/C     O
                                              o o            u
                                              t a444 555 In  t
       Currents (A Pri)       Voltages (V Pri) o d679 000 135 13
    IA     IB     IC      IN   VA    VB    VC  r      PGQ 246 24
```

Analog and Digital Header

```
[1]
-267.31   2.11 -13.34  0.000    11   -63    52 S ...A ... ... ..
 -76.95  14.20  -5.28  0.000    66   -23   -43 S ...A ... ... ..
 265.32  -2.11  13.34  0.000   -11    63   -52 S ...A ... ... ..
  76.95 -14.20   5.28  0.000   -66    23    43 S ...A ... ... ..
```

One Cycle of Data

```
[2]
-267.31   2.10 -13.34  0.000    11   -63    52 S ...A ... ... ..
 -76.95  14.20  -5.28  0.000    66   -23   -43 S ...A ... ... ..
 265.32  -2.11  13.34  0.000   -11    63   -52 S ...A ... ... ..
  76.95 -14.20   5.28  0.000   -66    23    43 S ...A ... ... ..
```

Figure 9.8 Event Report (EVE)

```
.
.
.
[6]
-267.31   2.10 -13.34  0.000   11   -63   52 S ...A ... ... ..
 -76.95  14.20  -5.29  0.000   66   -23  -43 S ...A ... ... ..
 265.32  -2.10  13.34  0.000  -11    63  -52 S ...A ... ... ..

  76.95 -14.20   5.29  0.000  -66    23   43*S ...A ... ... ..      Current Row for Summary Data

.
.
.
[10]
-267.31   2.11 -13.34  0.000   11   -63   52 S ...A ... ... ..
 -76.95  14.20  -5.29  0.000   66   -23  -43 S ...A ... ... ..
 265.32  -2.10  13.34  0.000  -11    63  -52 S ...A ... ... ..

  76.95  -14.20   5.28  0.000  -66    23   43>S ...T ... ... ..     Trigger Row

.
.
.
[15]
-267.31   2.10 -13.34  0.000   11   -63   52 S ...T ... ... ..
 -76.95  14.20  -5.30  0.000   66   -23  -43 S ...T ... ... ..
 265.32  -2.10  13.33  0.000  -11    63  -52 S ...T ... ... ..
  76.95 -14.21   5.29  0.000  -66    23   43 S ...T ... ... ..
.
.
.
```

Figure 9.8 Event Report (EVE) (Continued)

Table 9.5 Event Report Metered Analog Quantities

Quantity	Description
IA	Instantaneous filtered line current, A-phase
IB	Instantaneous filtered line current, B-phase
IC	Instantaneous filtered line current, C-phase
IG	Instantaneous filtered line current, residual (or ground)
IN	Core-balance ground current
VA	Instantaneous filtered A-phase voltage
VB	Instantaneous filtered B-phase voltage
VC	Instantaneous filtered C-phase voltage

Figure 9.8 contains selected data from the analog section of a 4 samples per cycle event report for an overcurrent fault. The bracketed numbers at the left of the report (for example, [15]) indicate the cycle number; *Figure 9.8* presents four cycles of 4-samples/cycle data.

The trigger row includes the > character following immediately after the VC/VCA column to indicate the trigger point. This is the dividing point between the prefault or PRE time and the fault or remainder of the data capture.

The row that the relay uses for the currents in the event summary is the row with the largest current magnitudes; the relay marks this row on the event report with an asterisk (*) character immediately after the VC/VCA column. The * takes precedence over the > if both occur on the same row in the analog section of the event report.

Obtaining RMS Phasors From 4 Samples per Cycle Event Reports

Use the column data in an event report to calculate rms values. You can use a calculator to convert rectangular data to phasor data, or use hand-calculations to separately determine the magnitude and angle of the rms phasor.

Hand Calculation Method. The procedure in the following steps explains a method for obtaining a current phasor from the IA channel data in the event report of *Figure 9.8*. You can process voltage data columns similarly. The drawings in *Figure 9.9* and *Figure 9.10* show one cycle of A-phase current in detail. *Figure 9.9* shows how to relate the event report ac current column data to the sampled waveform and rms values. *Figure 9.10* shows how to find the phasor angle. If you use the larger 8 samples per cycle event report, take every other sample and apply those values in this procedure.

This example demonstrates using a terminal or terminal emulation program. A more convenient method is to use ACSELERATOR QuickSet or ACSELERATOR Analytic Assistant. These programs automate the analysis process presented in this example and provide you with voltage and current phasors as software outputs.

This example assumes that you have successfully established communication with the relay; see *Establishing Communication Using an EIA-232 or EIA-485 Port on page 7.2* for step-by-step instructions.

Step 1. Prepare to monitor the relay at Access Level 1.

a. Using a communications terminal, type **ACC <Enter>**.

b. Type the Access Level 1 password and press **<Enter>**.

You will see the Access Level 1 => prompt.

Step 2. Identify an event.

a. Type **HIS <Enter>**.

The **HIS** command gives a quick, one-row listing of relay-stored events (see *Event History* for more information).

This example uses the latest captured event.

b. If no events are available, use the **TRI** command to generate an event (see *Triggering Data Captures and Event Reports*).

Step 3. Gather data from the event report.

a. Enable terminal data capture (usually a **Transfer > Capture Text** menu) in your terminal or terminal emulation program.

b. Type **EVE <Enter>** at the Access Level 1 => prompt to obtain an event report similar to *Figure 9.8* (see *Table 9.3* for a summary of **EVENT** commands).

The relay responds with the entire event report.

Step 4. Calculate the phasor magnitude.

a. Select a cycle of data from the IA column of the event report.

The *Figure 9.8*, Cycle [1] data for this example are shown in *Figure 9.9*. There are three pairs of scaled instantaneous current samples from Cycle [1].

b. Compute phasor magnitude using the following expression,

$$\sqrt{X^2 + Y^2} = |\text{Phasor}| \qquad \textbf{Equation 9.1}$$

In *Equation 9.1*, Y is the first row of IA column current of a data pair, and the next row is X, the present value of the pair. For this example, the computation shown in *Figure 9.9* yields 277.0 A.

c. Compute phasor magnitudes from the remaining data pairs for Cycle [1].

d. Confirm that all values are similar.

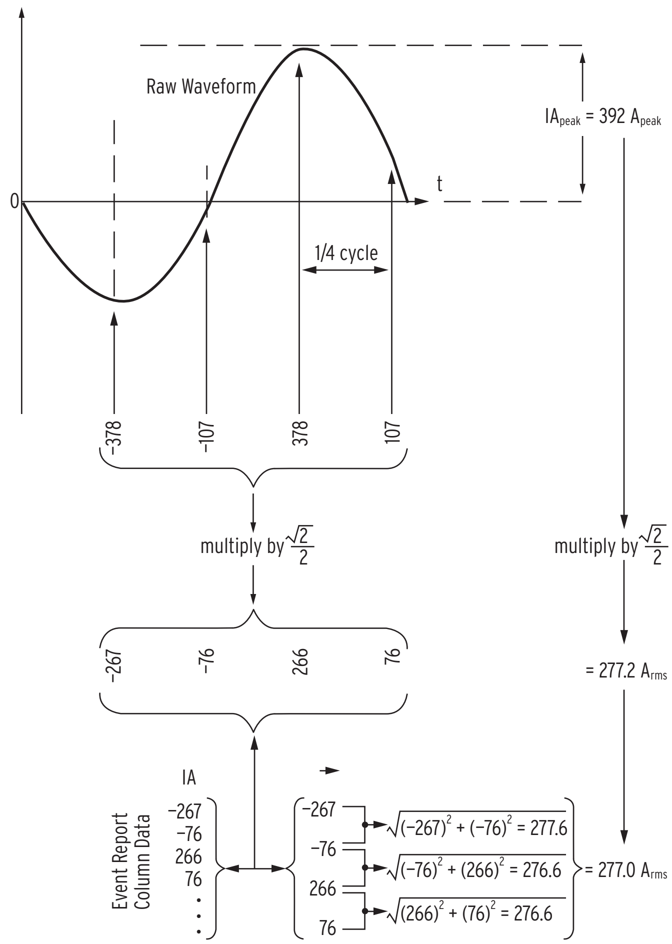


Figure 9.9 Event Report Current Column Data and RMS Current Magnitude

Step 5. Calculate the immediate phase angle.

a. Select the same cycle of data from the IA column of the event report as you did when finding the magnitude (Cycle [1] data for this example).

b. Compute phasor angle using the following expression.

$$\theta = \arctan\left(\frac{Y}{X}\right) = \angle\text{Phasor} \qquad \textbf{Equation 9.2}$$

In *Equation 9.2*, Y is the first (or previous value) IA column current of a data pair, and X is the present value of the pair. For this example, the computation shown in *Figure 9.10* yields –105.9 degrees.

c. Compute phasor angles from the remaining data pairs for Cycle [1].

NOTE: The arctan function of many calculators and computing programs does not return the correct angle for the second and third quadrants (when X is negative). When in doubt, graph the X and Y quantities to confirm that the angle that your calculator reports is correct.

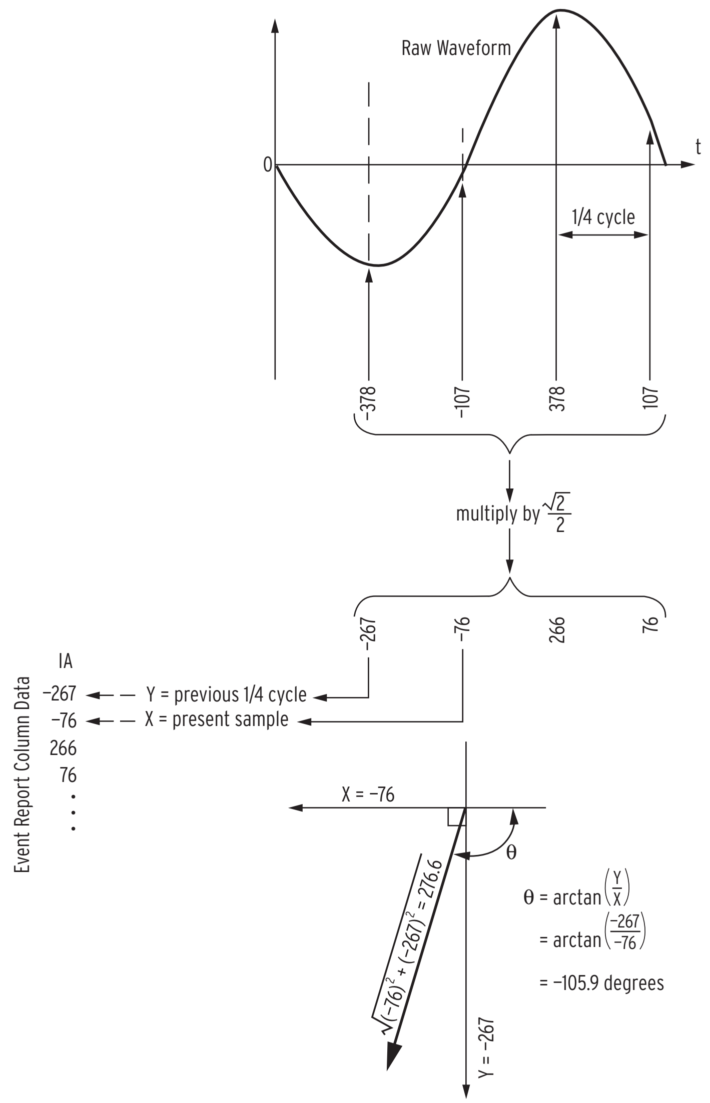


Figure 9.10 Event Report Current Column Data and RMS Current Angle

Step 6. Calculate the reference phase angle. Usually, you compare power system angles to a reference phasor (positive-sequence A-phase voltage, for example).

Repeat *Step 5* for the row data in the VA column that correspond to the IA column data values you used in *Step 5*. The angle calculation for the VA data is the following.

$$\begin{aligned}\theta &= \angle \mathrm{VA} \\ &= \arctan\left(\frac{\mathrm{Y}}{\mathrm{X}}\right) \\ &= \arctan\left(\frac{-288.0}{-223.7}\right) \\ &= -127.8^\circ\end{aligned}$$ **Equation 9.3**

(This is an example of an arctan calculation that yields the incorrect answer from some calculators and math programs.)

Step 7. Calculate the absolute phase angle.

Subtract the IA angle from the VA angle to obtain the A-phase-referenced phasor angle for IA.

$$\angle \mathrm{VA} - \angle \mathrm{IA} = -127.8^\circ - (-105.9^\circ) = -21.9^\circ$$ **Equation 9.4**

I_A leads V_A; thus, the rms phasor for current IA at the present sample is 277.0 A $\angle 21.9°$, referenced to V_A.

In the previous procedure, you use two rows of current data from the event report to calculate an rms phasor current. At the first sample pair of Cycle [1], the rms phasor is I_A = 277.0 A $\angle -105.9°$.

The present sample of the sample pair (X = –76) is a scaled instantaneous current value (not an rms quantity) that relates to the rms phasor current value by the expression

$$\mathrm{X} = -76 = 277.0 \bullet \cos(-105.9^\circ)$$ **Equation 9.5**

Polar Calculator Method. A method for finding the phasor magnitude and angle from event report quarter-cycle data pairs is to use a polar-capable calculator or computer program. Many calculators and computer programs convert Cartesian (X and Y) coordinate data to polar data. Key or enter the X value (present value or lower value of a column pair) and the Y value (later value or upper value in a column pair) as Cartesian (rectangular) coordinates. Perform the keystrokes necessary for your calculator or computing program to convert to polar coordinates. This is the phasor value for the data pair.

Digital Section of the Event Report

The second portion of an event report is the digital section. Inspect the digital data to evaluate relay element response during an event. See *Figure 9.8* for the locations of items in a sample event report digital section. In the digital portion of the event report, the relay indicates deasserted elements with a period (.) and asserted elements with the characters in *Table 9.6*.

The element and digital information labels are single character columns. Read these columns from top to bottom. The trigger row includes a > character following immediately after the last digital element column to indicate the trigger point. The relay marks the row used to report the maximum fault current with an asterisk (*) character at the right of the last digital element column.

Table 9.6 Output, Input, Protection, and Control Element Event Report Columns

Column Designation	Column Symbols	Column Symbol Relay Word Bits
Motor	S R .	STARTING RUNNING STOPPED
Load	J 1 L	JAMTRIP LOSSALRM * !LOSSTRIP LOSSTRIP
46	A T	46UBA * !46UBT 46UBT
47	T	47T
49	A T	49A * !49T 49T
O/C 50P	1 2 b	50P1T * !50P2T !50P1T * 50P2T 50P1T * 50P2T
O/C 50G	1 2 b	50G1T * !50G2T !50G1T * 50G2T 50G1T * 50G2T
O/C 50Q	1	50Q1T
In 12	1 2 b	IN01 * !IN02 IN02 * !IN01 IN01 * IN02
In 34	3 4 b	IN03 * !IN04 IN04 * !IN03 IN03 * IN04
In 56	5 6 b	IN05 * !IN06 IN06 * !IN05 IN05 * IN06
In 78	7 8 b	IN07 * !IN08 IN08 * !IN07 IN07 * IN08
In 90	9 0 b	IN09 * !IN10 IN10 * !IN09 IN09 * IN10
In 12 (appearing at the end)	1 2 b	IN11 * !IN12 IN12 * !IN11 IN11 * IN12
Out 12	1 2 b	OUT01 * !OUT02 OUT02 * !OUT01 OUT01 * OUT02
Out 34	3 4 b	OUT03 * !OUT04 OUT04 * !OUT03 OUT03 * OUT04

Settings Section of the Event Report

The final portion of an event report is the settings section. See *Figure 9.11* for the locations of items included in a sample settings section of an event report. The settings portion of the event report lists important relay settings at the time the relay event triggered. The event report shows protection, report, and logic settings. The settings order in the event report is the same order as when you issue a **SHOW** command from a terminal. See *SHOW Command (Show/View Settings) on page 7.39* for information on the **SHOW** command.

Protection Settings

```
RID      := SEL-849
TID      := MOTOR RELAY
FNOM     := 60            PHROT    := ABC           APP      := MOTOR
CTR1     := 1             CTRN     := NONE          FLA1     := 2.5
SERFACTR := 1.15          TRIPCLAS := 10_NEMA       PTR      := 1.00
VNOM     := 240           DELTA_Y  := WYE           SINGLEV  := N

FACTLOG  := Y             CURR_IN  := NORMAL        STARTRTY := FVNR
DATE_F   := MDY
FAULT    := TRIP OR 50G1 OR 50Q1 OR 51P1 OR 51Q1 OR STARTING AND MOTOR

E49MOTOR := Y             TCAPU    := 85            TCSTART  := OFF
49RSTP   := 75            COOLTIME := Auto

50P1P    := OFF           50P2P    := OFF

50Q1P    := OFF

50G1P    := OFF           50G2P    := OFF

50N1P    := OFF           50N2P    := OFF

51P1P    := OFF

51Q1P    := OFF

51G1P    := OFF

LJTPU    := OFF           LJAPU    := OFF

LLTPU    := OFF           LLAPU    := OFF
.
.
.
```

Logic Settings

```
ELAT     := N             ESV      := N             ESC      := N
EMV      := N
```

Report Settings

```
1: IN01
2: IN02
3: IN03
4: IN04
5: IN05
6: IN06
7: OUT01
8: OUT02
9: OUT03
10: OUT04
11: 52A
12: ABSLO
13: TBSLO
14: NOSLO
15: THERMLO
.
.
.
73: RS_LO
74: 59RS
75: UV_RS_LO
EALIAS   := 3
ALIAS01  := 49A THERMAL_ALARM PICKUP DROPOUT
ALIAS02  := 49T THERMAL_TRIP PICKUP DROPOUT
ALIAS03  := 47T REVERSE_SEQ_TRP PICKUP DROPOUT

ER       := R_TRIG LOSSALRM OR R_TRIG 46UBA OR R_TRIG 49A OR R_TRIG 55A
SRATE    := 4             LER      := 15            PRE      := 10

1: IAVG
2: UBI
3: MLOAD
4: TCUSTR
5: TCURTR

LDAR     := 15

MSRR     := 0.25
MSRTRG   := 0

=>>
```

Figure 9.11 Settings Section of the Event Report

CEVENT

The relay provides a Compressed ASCII event report for SCADA and other automation applications. ACSELERATOR QuickSet uses Compressed ASCII commands to gather event report data. If you want to view the Compressed ASCII event report data, use a terminal to issue ASCII command **CEV**. A sample of the report appears in *Figure 9.12*; this is a comma-delimited ASCII file. The relay appends a four-digit hex checksum at the end of the lines in the Compressed ASCII report.

Items included in the Compressed ASCII event report are similar to the event report, although the relay reports the items in a special order. CEV files (and COMTRADE files) include all eight Relay Word bits (see *Appendix H: Relay Word Bits*). See *SEL Compressed ASCII Commands on page C.1* for more information on the Compressed ASCII command set.

Report Header

```
CEV <Enter>
"FID","CEV_VER","03DD"
"FID=SEL-849-X251-V0-Z001001-D20120927","2.0.1","0A16"
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","0ACA"
1,24,2012,21,33,2,598,"042E"
```

Summary Labels

```
"REC_NUM","NUM_CH_A","NUM_CH_D","FREQ","NFREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","PRIM_VAL","CTR_IA","
    CTR_IB","CTR_IC","CTR_IG","C
TR_IN","PTR_VA","PTR_VB","PTR_VC","EVENT","GROUP","IA(A)","IB(A)","IC(A)","IG(A)","IN(A)","VA(V)","VB(V)"
    ,"VC(V)","VG(V)","3D70"
```

Summary Data

```
1,8,352,60.00,60,4,4,15,"YES",1.00,1.00,1.00,1.00,0.00,1.00,1.00,1.00,"Lockd Rotor
Trip",1,14.43,14.35,14.35,0.10,0.000,66.97,66.86,67.05,0.16,"1DF2"
```

Column Labels

```
"IA(A)","IB(A)","IC(A)","IN(A)","VA(V)","VB(V)","VC(V)","FREQ","TRIG","ENABLED TRIP_LED * * * * * *
    TLED_01 TLED_02 TLED_03 TLED_04
TLED_05 TLED_06 TLED_07 TLED_08 49T 49T_STR 49T_RTR THERMLO NOSLO TBSLO ABSLO 50S 49A 49A_STR 49A_RTR
    RUNNING STARTING STOPPED STAR
DELTA LOSSTRIP LOSSALRM JAMTRIP JAMALRM 46UBA 46UBT 47T * 55A 55T * * * * * MOTOR SMTRIP SPDSTR SPDSAL
    LOADUP LOADLOW PTCTRIP PTCFLT
* TRIP STP_OPFP COMMSTP LOCSTOP REMSTOP STOP TR1 TR EXT_TRIP ULTRIP TRX FAULT 52A BFI BFT TRGTR 50P1 50P2
    50N1 50N2 50G1 50G2 50Q1 *
50P1T 50P2T 50N1T 50N2T 50G1T 50G2T 50Q1T ORED50T 51P1 51G1 * 51Q1 51P1T 51G1T * 51Q1T 51P1R 51G1R * 51Q1R
    * DI_C DI_B DI_A EMRSTR
COMMSTR STR_CLFP STR_CLO LOCSTART REMSTART RESTART RSACTIVE RS_LO UV_SHRT UV_MED UV_LONG UV_RS_LO UV_TR
    LJ_TR 59RS 50PAF 50GAF TOL1
AFS1EL AFS1DIAG PHDEM * * 27PP1 27PP1T 27PP2 27PP2T 59PP1 59PP1T 59PP2 59PP2T 3PWR1 3PWR1T 3PWR2 3PWR2T
    81D1T 81D2T LOP FREQTRK IN08
IN07 IN06 IN05 IN04 IN03 IN02 IN01 * * * * IN12 IN11 IN10 IN09 * * * * OUT04 OUT03 OUT02 OUT01 REMOTE
    REMCONFP STR_CLEQ REMSTREQ
BSTR_CL REMCONEQ SPEED2 SPEEDSW VFDBYPAS SPD2FP WARNING * * TESTDB HMIDET1 HMIDET ER MSRTRG RSTTRGT RSTDEM
    * * RST_HAL * 50P1TC
50P2TC 50Q1TC 50G1TC 50G2TC 50N1TC 50N2TC * 51P1TC 51Q1TC 51G1TC * 27PP1TC 27PP2TC 59PP1TC 59PP2TC 81D1TC
    81D2TC * * * * * * LT01
LT02 LT03 LT04 LT05 LT06 LT07 LT08 SV01 SV02 SV03 SV04 SV05 SV06 SV07 SV08 SV01T SV02T SV03T SV04T SV05T
    SV06T SV07T SV08T SC01QU
SC02QU SC03QU SC04QU SC05QU SC06QU SC07QU SC08QU SC01QD SC02QD SC03QD SC04QD SC05QD SC06QD SC07QD SC08QD
    RB01 RB02 RB03 RB04 RB05
RB06 RB07 RB08 VB001 VB002 VB003 VB004 VB005 VB006 VB007 VB008 VB009 VB010 VB011 VB012 VB013 VB014 VB015
    VB016 VB017 VB018 VB019
VB020 VB021 VB022 VB023 VB024 VB025 VB026 VB027 VB028 VB029 VB030 VB031 VB032 HALARM HALARML HALARMP
    HALARMA * * * * SALARM ACCESS
PASNVAL ACCESSP * SETCHG CHGPASS BADPASS LINK2 LINK2A LINK2B LINKFAIL P2ASEL P2BSEL * * TSOK DST DSTP LPSEC
    LPSECP * * * TSNTPB
TSNTPP TUTCS TUTC1 TUTC2 TUTC4 TUTC8 TUTCH T01_LED T02_LED T03_LED T04_LED T05_LED T06_LED T07_LED T08_LED
    * * * * * * * *","FA28"
```

Event Data (Cycle 1)

```
11.313,2.109,-13.342,0.000,11.1,-62.6,51.7,60.00,
,"C0D501A800010000D0000000D00000000001000000000 2300FEEFC000000000000000000000000040800000D400","1B7E"
-8.947,14.191,-5.281,0.000,66.0,-23.4,-42.6,60.00,
,"C0D501A800010000D0000000D00000000001000000000 2300FEEFC000000000000000000000000040800000D400","1BC5"
-11.319,-2.108,13.339,0.000,-11.1,62.6,-51.7,60.00,
,"C0D501A800010000D0000000D00000000001000000000 2300FEEFC000000000000000000000000040800000D400","1BE3"
8.947,-14.195,5.281,0.000,-66.0,23.4,42.6,59.99,
,"C0D501A800010000D0000000D00000000001000000000 2300FEEFC000000000000000000000000040800000D400","1B89"
```

Figure 9.12 Sample Compressed ASCII Event Report

```
11.319,2.102,-13.339,0.000,11.0,-62.6,51.7,60.00,
,"C0D501A800010000D0000000D0000000000100000002300FEEFC000000000000000000000000040800000D400","1B82"
-8.950,14.202,-5.283,0.000,66.0,-23.5,-42.7,60.00,
,"C0D501A800010000D0000000D0000000000100000002300FEEFC000000000000000000000000040800000D400","1BBC"
-11.319,-2.108,13.336,0.000,-11.1,62.6,-51.7,60.00,
,"C0D501A800010000D0000000D0000000000100000002300FEEFC000000000000000000000000040800000D400","1BE0"
8.947,-14.200,5.283,0.000,-66.0,23.4,42.6,60.00,
,"C0D501A800010000D0000000D0000000000100000002300FEEFC000000000000000000000000040800000D400","1B64"
.
.
.
```

Event Data (Cycle 4-7)

```
8.956,-14.192,5.286,0.000,-
    66.1,23.5,42.6,60.00,"*","C0D501A800010000D0000000D0000000000100000002300FEEFC0000000000000000000000
    04080 0000D400","1BC1"
```

Largest Current (to Event Summary)

```
11.316,2.103,-13.344,0.000,11.0,-62.6,51.7,60.00,
,"C0D501A800010000D0000000D0000000000100000002300FEEFC000000000000000000000000040800000D400","1B7C"
-8.948,14.189,-5.283,0.000,66.0,-23.5,-42.6,60.00,
,"C0D501A800010000D0000000D0000000000100000002300FEEFC000000000000000000000000040800000D400","1BD0"
-11.320,-2.106,13.344,0.000,-11.0,62.6,-51.8,60.00,
,"C0D501A800010000D0000000D0000000000100000002300FEEFC000000000000000000000000040800000D400","1BD5"
8.944,-14.197,5.281,0.000,-66.0,23.5,42.6,60.00,
,"C0D501A800010000D0000000D0000000000100000002300FEEFC000000000000000000000000040800000D400","1B6F"
.
.
.
```

```
8.950,-14.195,5.284,0.000,-
    66.0,23.5,42.6,60.00,">","C0D5A1A800010081D0000000D0000000000100000002300FEEFC0000000000000000000000
    040800000D500","1BEA"
```

Trigger

```
11.322,2.094,-13.334,0.000,11.0,-62.6,51.7,60.00,
,"C0D5A1A800010081D4000000D0000000000100000082300FEEFC000000000000000000000000040800000D500","1BA8"
-8.952,14.202,-5.292,0.000,66.1,-23.5,-42.6,60.00,
,"C0D5A1A800010081D0000000D0000000000100000082300FEEFC000000000000000000000000040800000D500","1BE1"
-11.322,-2.100,13.333,0.000,-11.0,62.6,-51.7,60.00,
,"C0D5A1A800010081D0000000D0000000000100000082300FEEFC000000000000000000000000040800000D500","1BF1"
8.945,-14.203,5.288,0.000,-66.1,23.5,42.6,60.00,
,"C0D5A1A800010081D0000000D0000000000100000082300FEEFC000000000000000000000000040800000D500","1B8F"
.
.
.
```

```
RID      := SEL-849
TID      := MOTOR RELAY
FNOM     := 60           PHROT    := ABC          APP      := MOTOR
CTR1     := 1            CTRN     := NONE         FLA1     := 2.5
SERFACTR := 1.15         TRIPCLAS := 10_NEMA      PTR      := 1.00
VNOM     := 240          DELTA_Y  := WYE          SINGLEV  := N

FACTLOG  := Y            CURR_IN  := NORMAL       STARTRTY := FVNR
DATE_F   := MDY
FAULT    := TRIP OR 50G1 OR 50Q1 OR 51P1 OR 51Q1 OR STARTING AND MOTOR

E49MOTOR := Y            TCAPU    := 85           TCSTART  := OFF
49RSTP   := 75           COOLTIME := Auto

50P1P    := OFF          50P2P    := OFF

50Q1P    := OFF

50G1P    := OFF          50G2P    := OFF

50N1P    := OFF          50N2P    := OFF

51P1P    := OFF

51Q1P    := OFF

51G1P    := OFF

LJTPU    := OFF          LJAPU    := OFF

LLTPU    := OFF          LLAPU    := OFF

.
.
.
```

Protection Settings

```
ELAT     := N            ESV      := N            ESC      := N
EMV      := N
```

Logic Settings

Figure 9.12 Sample Compressed ASCII Event Report (Continued)

```
Report Settings

1: IN01
2: IN02
3: IN03
4: IN04
5: IN05
6: IN06
7: OUT01
8: OUT02
9: OUT03
10: OUT04
.
.
.
EALIAS   := 3
ALIAS01  := 49A THERMAL_ALARM PICKUP DROPOUT
ALIAS02  := 49T THERMAL_TRIP PICKUP DROPOUT
ALIAS03  := 47T REVERSE_SEQ_TRP PICKUP DROPOUT

ER       := R_TRIG LOSSALRM OR R_TRIG 46UBA OR R_TRIG 49A OR R_TRIG 55A
SRATE    := 4             LER      := 15            PRE      := 10

1: IAVG
2: UBI
3: MLOAD
4: TCUSTR
5: TCURTR

LDAR     := 15

MSRR     := 0.25
MSRTRG   := 0
","2E69"

=>>
```

Report Settings

Figure 9.12 Sample Compressed ASCII Event Report (Continued)

The order of the labels in the digital portion of the Column Labels field matches the order of the HEX-ASCII Relay Word. Each numeral in the HEX-ASCII Relay Word reflects the status of four Relay Word bits from the Digital Column Labels field of the Compressed ASCII event report. The HEX-ASCII Relay Word from the trigger cycle, follows.

```
"805400080001008190808100D00000000003000002000000F8EFC000000000000000000000000400000
    005400"
```

In this HEX-ASCII Relay Word, the third numeral in the HEX-ASCII Relay Word is a 5. In binary, this is 0101. Mapping the labels to the digital Column Labels yields the following:

```
49T   49T_STR    49T_RTR    THERMLO
0     1          0          1
```

49T_STR and THERMLO are elements that picked up at the first sample of the trigger cycle (see *Figure 9.12*).

Event Files Download

You can download the event file from the relay and save these files to a PC to keep as a record or examine later. Use a terminal emulation program with file transfer capability. For example, type **FILE READ CR 10007.TXT <Enter>** at an Access Level 1 prompt or higher to download a 4 samples per cycle event report with serial number 10007. Start the terminal download routine to store the file on your computer. Use the Y-modem protocol.

If you want the Compressed ASCII file, type **CEV 10007 <Enter>**. In addition, you can use the web server or ACSELERATOR QuickSet to download event files.

Event Summary

You can retrieve a shortened version of stored event reports as event summaries. These short-form reports present vital information about a triggered event. The relay generates an event in response to power system faults and other trigger events (see *Triggering Data Captures and Event Reports*). See *Figure 9.13* for a sample event summary.

```
=>>SUM <Enter>

SEL-849                                   Date: 01/24/2012   Time: 21:33:02.598
MOTOR RELAY

Serial Number = 000000000000000
FID = SEL-849-X251-V0-Z001001-D20120927             CID = DA18
EVENT LOGS =   4

Event:       Lockd Rotor Trip
Targets      1111010101
Freq (Hz)    60.00

Current Mag
            IA       IB       IC        IG        IN
(A)        14.43     14.35     14.35      0.10      0.000

Voltage Mag
            VA       VB       VC
(V)        66.97     66.86     67.05

=>>
```

Figure 9.13 Sample Event Summary Report

The event summary contains the following information:

- Standard report header
  - Relay and terminal identification
  - Event date and time
- Serial number
- Firmware identification
- Event number
- Event type
- Targets
- System frequency
- Current and voltage magnitudes

The relay derives the summary target information from the event row with the largest current (see *Figure 9.12*).

The SEL-849 reports the event type according to the output of the trip logic algorithm. *Table 9.7* lists event types in fault reporting priority. Fault event types (overload trip, for example) have reporting priority over indeterminate fault events. For example, you can trigger an event when there is no fault condition on the power system by using the **TRI** command. In this case, when there is no fault, the relay reports the event type as TRIG.

Table 9.7 Event Types

Type	Condition
Thermal Overload Trip	(49T * RUNNING) * TRIP
Locked Rotor Trip	(49T * STARTING) * TRIP
Undercurrent Trip	LOSSTRIP * TRIP
Load Jam Trip	JAMTRIP * TRIP
Curr Imbalance Trip	(46UBT + 50Q1T) * TRIP
Phase Inst OC Trip	(50P1T + 50P2T) * TRIP
Ground Inst OC Trip	(50G1T + 50G2T + 50N1T + 50N2T) * TRIP
Phase Time OC Trip	51P1T * TRIP
Ground Time OC Trip	51G1T * TRIP
Neg Sequence TOC Trip	51Q1T * TRIP
Speed Switch Trip	SPDSTR*TRIP
Undervoltage Trip	(27PP1T + 27PP2T) * !LOP * TRIP
Overvoltage Trip	(59PP1T + 59PP2T) * TRIP
Power Factor Trip	55T * TRIP
Phase Reversal Trip	47T * TRIP
Underfrequency Trip	(81DnT * TRIP) when 81DnTP < FNOM setting, n = 1 or 2
Overfrequency Trip	(81DnT * TRIP) when 81DnTP > FNOM setting, n = 1 or 2
Power Element Trip	(3PWR1T + 3PWR2T) * TRIP
PTC Trip	PTCTRIP * TRIP
Start Time Trip	SMTRIP * TRIP
PTC Fail Trip	PTCFLT * TRIP
Breaker Failure Trip	BFT * TRIP
Arc Flash Trip	TOL1 * TRIP
Trigger	Trigger command
Remote Stop	Stop issued from a communications port
Local Stop	Stop issued from the HMI or by means of a contact output
Event Report Trigger	
Undefined Trip	TRIP not defined above (e.g., trip due to an external source)

Viewing the Event Summary

Access the event summary from the communications ports. View and download summary reports from Access Level 1 and higher.

You can use the **SUM** command to retrieve event summaries by event number. (The relay labels each new event with a unique number as reported in the **HIS** command history report; see *Event History*.) *Table 9.8* lists the **SUM** commands. Additionally, you can access summaries by the order in which they occur, with the most recent summary being SUM 1.

Table 9.8 SUM Command

Command	Description
SUM	Return the most recent event summary.
SUM *n*	Return a particular *n* event summary.

CSUMMARY

The relay outputs a Compressed ASCII summary report for SCADA and other automation applications. Issue ASCII command **CSU** to view the Compressed ASCII summary report. A sample of the summary report appears in *Figure 9.14*; this is a comma-delimited ASCII file. The relay appends a four-digit hex checksum at the end of the lines in the Compressed ASCII report.

Items included in the Compressed ASCII summary report are similar to those included in the summary report, although the relay reports the items in a special order.

See *SEL Compressed ASCII Commands on page C.1* and for more information on the Compressed ASCII command set.

```
=>CSUM 2 <Enter>
"MONTH","DAY","YEAR","04E5"
1,24,2012,"01DD"
"HOUR","MIN","SEC","MSEC","05E5"
21,32,51,923,"027C"
"SERIALNUMBER","03F9"
"000000000000000","0340"
"FID","CID","0283"
"SEL-849-X251-V0-Z001001-D20120927","DA18","0905"
"EVENTLOGS","0327"
4,"0060"
"EVENTS","0245"
"Lockd Rotor Trip","0652"
"TARGETS","028A"
"1111010101","0257"
"FREQ","019E"
60.00,"0120"
"IA","IB","IC","IG","IN","04F8"
14.44,14.35,14.35,0.10,0.000,"057A"
"VA","VB","VC","0318"
66.96,66.87,67.04,"0395"

=>
```

Figure 9.14 Sample Compressed ASCII Summary

Event History

The event history gives you a quick look at recent relay activity. The relay labels each new event with a unique number from 10000 to 42767. (At 42767, the top of the numbering range, the relay returns to 10000 for the next event number and then continues to increment.) See *Figure 9.15* for a sample event history.

The event history contains the following:

- Standard report header
  - Relay and terminal identification
  - Date and time of report
- Event number
- Event date and time
- Event type
- Maximum phase current from summary fault data
- Targets

Figure 9.15 is a sample event history from a terminal. The event types in the event history are the same as the event types in the event summary (see *Table 9.7* for event types).

```
=>HIS <Enter>

SEL-849                                     Date: 04/30/2012   Time: 15:39:26.982
MOTOR RELAY                                 Time Source: Internal


FID=SEL-849-R100-V0-Z000000-D20120427

#          DATE         TIME            EVENT              CURRENT   FREQ S   TARGET
10001   04/30/2012   15:35:50.631   Jam Trip                   3.1   60.00    1100110100
10000   04/30/2012   15:04:09.662   Overcurrent Trip           4.3   60.01    1101010100

=>
```

Event Number

Event Type

Figure 9.15 Sample Event History

Viewing the Event History

Access the history report from the communications ports and communications cards. View and download history reports from Access Level 1 and higher. You can also clear or reset history data from Access Levels 1 and higher (with the **HIS C** and **HIS R** commands).

Use the **HIS** command from a terminal to obtain the event history. You can view event histories by date or by date range, or you can specify the number of the most recent events that the relay returns. See *HISTORY Command on page 7.31* for information on the **HIS** command. *Table 9.9* lists the **HIS** commands.

Table 9.9 HIS Command

Command	Description
HIS	Return event histories with the oldest at the bottom of the list and the most recent at the top of the list.
HIS *k*	Return the *k* most recent event summaries with the oldest at the bottom of the list and the most recent at the top of the list.
HIS *date1*	Return the event summaries on date *date1*[a].
HIS *date1 date2*	Return the event summaries from *date1* to *date2*, with *date1* at the bottom of the list and *date2* at the top of the list.
HIS C	Clear all event data.
HIS R	Clear all event data.

[a] Use the same date format as Global setting DATE_F.

You can use the web server to view **Event History** (see *Reports on page 3.9*). You can also use ACSELERATOR QuickSet to retrieve the relay event history. Use the **Tools > Events > Get Event Files** menu to view the **Event History** dialog box.

CHISTORY

The relay outputs a Compressed ASCII history report for SCADA and other automation applications. Issue the **CHI** command to view the Compressed ASCII history report. A sample of the report appears in *Figure 9.16*; this is a comma-delimited ASCII file. The relay appends a four-digit hex checksum at the end of each history in the Compressed ASCII history report.

Items included in the Compressed ASCII history report are similar to those included in the history report, although the relay reports the items in a special order. See *SEL Compressed ASCII Commands on page C.1* for more information on the Compressed ASCII command set.

```
=>CHIS <Enter>
"FID","0143"
"FID=SEL-849-R100-V0-Z000000-D20120427","08AA"
"REC_NUM","REF_NUM","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","EVENT","CURRENT","FREQ","TARGETS","18AC"
1,10001,4,30,2012,15,35,50,631,"Jam Trip",0.1,60.00,"1100110100","0D4C"
2,10000,4,30,2012,15,4,9,662,"Overcurrent Trip",4.8,60.01,"1101010100","1086"

=>
```

Figure 9.16 Sample Compressed ASCII History Report

Sequential Events Recorder (SER)

The SEL-849 SER (Sequential Events Recorder) gives you detailed information on relay states and relay element operation. The SER captures and time-tags state changes of Relay Word bit elements and relay conditions. These conditions include power-up, settings changes, and clearing of the SER. The SEL-849 stores the latest 1024 SER entries to nonvolatile memory. *Figure 9.17* is a sample SEL-849 SER report. The SER report contains the following:

- Standard report header
  - Relay and terminal identification
  - Date and time of report
- SER number
- SER date and time
- Relay element or condition
- Element state

```
=>SER <Enter>

SEL-849                                   Date: 04/26/2023   Time: 19:26:08.314
MOTOR RELAY                               Time Source: Internal

Serial Number : 000000000000000
FID=SEL-849-X430-V0-Z005003-D20230420      CID=F48E

   #     DATE          TIME              ELEMENT                   STATE
  22   04/26/2023   18:44:51.318   SER archive cleared
  21   04/26/2023   19:22:42.705   STOPPED                      Deasserted
  20   04/26/2023   19:22:42.705   STARTING                     Asserted
  19   04/26/2023   19:22:42.863   ORED50T                      Asserted
  18   04/26/2023   19:22:42.943   STARTING                     Deasserted
  17   04/26/2023   19:22:42.943   RUNNING                      Asserted
  16   04/26/2023   19:23:08.577   Relay settings changed
  15   04/26/2023   19:23:08.581   ORED50T                      Deasserted
  14   04/26/2023   19:23:08.781   ORED50T                      Asserted
  13   04/26/2023   19:23:28.647   ORED50T                      Deasserted
  12   04/26/2023   19:23:28.964   STOPPED                      Asserted
  11   04/26/2023   19:23:28.964   RUNNING                      Deasserted
  10   04/26/2023   19:23:43.068   Relay newly powered up
   9   04/26/2023   19:23:43.068   ULTRIP                       Asserted
   8   04/26/2023   19:23:43.068   EXT_TRIP                     Asserted
   7   04/26/2023   19:23:43.085   STOPPED                      Asserted
   6   04/26/2023   19:24:14.200   Thermal capacity reset
   5   04/26/2023   19:26:05.110   STOPPED                      Deasserted
   4   04/26/2023   19:26:05.110   STARTING                     Asserted
   3   04/26/2023   19:26:05.273   ORED50T                      Asserted
   2   04/26/2023   19:26:05.356   STARTING                     Deasserted
   1   04/26/2023   19:26:05.356 p RUNNING                      Asserted

=>
```

SER Number   Relay Element or Condition

Figure 9.17 Sample SER Report

In the SER report, the oldest information has the highest number. The newest information is always #1.

Viewing the SER Report

The relay displays the SER records in ASCII and binary formats. For more information on binary SER messaging, see *Interleaved ASCII and Binary Messages on page C.2*.

Access the SER report from the communications ports in Access Level 1 and higher. To clear all SER data on a serial port, use the **SER C** or **SER R** command.

Use an ASCII terminal, the web server, or ACSELERATOR QuickSet to examine SER records. You can use the **SER** command to view the SER report by date, date range, SER number, or SER number range. The relay labels each new SER record with a unique number. See *Table 9.10* for more information on the **SER** command.

Table 9.10 SER Commands

Command[a]	Description
SER	Return the 20 most recent records from the SER, with the oldest (highest number) at the top of the list and the most recent (lowest number) at the bottom of the list.
SER *k*	Return the *k* most recent records from the SER, with the oldest (highest number) at the top of the list and the most recent (lowest number) at the bottom of the list.
SER *m n*	Return the SER records from *m* to *n*. If *m* is greater than *n*, records appear with the oldest (highest number) at the top of the list and the most recent (lowest number) at the bottom of the list. If *m* is less than *n*, records appear with the most recent (lowest number) at the top of the list and the oldest (highest number) at the bottom of the list.
SER *date1*[b]	Return the SER records on date *date1*.
SER *date1 date2*	Return the SER records from *date1* at the top of the list to *date2* at the bottom of the list.
SER C or **R**	Clear SER records on the present port.

[a] The parameters m and n indicate SER numbers that the relay assigns at each SER trigger.
[b] Use the same date format as Global setting DATE_F.

You can retrieve SER records with ACSELERATOR QuickSet. The **Tools > HMI** menu item gives you the SER report Device Overview screen. Select SER to display the SER report. In addition, SER records are accessible from the web server (see *Section 3: PC Interface*).

SER Aliases

You may rename as many as 10 of the SER trigger conditions using the ALIAS settings. For instance, the factory-default alias setting 1 renames Relay Word bit 49A for reporting in the SER:

```
ALIAS1:= 49A THERMAL_ALARM PICKUP DROPOUT
```

When Relay Word bit 49A is asserted, the SER report will show the date and time of THERMAL_ALARM. When Relay Word bit 49A is deasserted, the SER report will show the date and time of THERMAL_ALARM. With this and other alias assignments, the SER record is easier for the operator to review. See *Relay Word Bit Aliases on page 4.87* for additional details.

Setting SER Point

You program the relay elements that trigger an SER record. You can select as many as 96 elements. These triggers, or points, include all available Relay Word bits. Use the **SET R** command from a terminal, or use ACSELERATOR QuickSet **Report** branch of the **Settings** tree view to enter **SER Points**. Use the text-edit line mode settings method to enter or delete SER elements.

Text-Edit Mode Line Editing

Some SEL-849 settings present multiple input lines to your terminal; you use basic line text editing commands to construct the setting. For display, the relay references each line of the setting by line number, not by the setting name.

While in the text-edit mode, you see a prompt consisting of the line number and the present setting for that line. You can keep the setting, enter a new setting, or delete the setting. *Table 9.11* lists the commands for text-edit mode.

Table 9.11 Actions at Text-Edit Mode Prompts Action Relay Response

Action	Response
?<Enter>	Accept the setting and move to the next line; if at the last line or at a blank line, exit settings.
>*n* <Enter>	Move to line *n*. If this is beyond the end of the list, move to a blank line following the last line.
^ <Enter>	Move to the previous line; if at the first line, stay at the present line.
< <Enter>	Move to the first line.
> <Enter>	Move to a blank line following the last line.
LIST <Enter>	List all settings and return to the present action prompt.
DELETE [*n*] <Enter>	Delete the present line and subsequent lines for a total of *n* lines; *n* = 1 if not provided. Lines after deletion shift upward by the number of lines deleted.
INSERT <Enter>	Insert a blank line at the present location; the present line and subsequent lines shift downward.
END <Enter>	Go to the end of the present settings session. Prepare to exit settings via the "Save settings (Y, N) ?" prompt.
<Ctrl+X>	Abort editing session without saving changes.

Use commas to separate the items in a text-edit mode setting when you are entering multiple items per line. After you enter each line, the relay checks the validity of the setting. If the entered setting is invalid, the relay responds with an error message and prompts you again for the setting.

Section 10

Testing and Troubleshooting

Overview

Relay testing is typically divided into two categories:

- Tests performed at the time the relay is installed or commissioned
- Tests performed periodically once the relay is in service

This section provides information on both types of testing for the SEL-849 Motor Management Relay. Although the procedure in this section refers to motor applications, the same can be extended to feeder applications. Because the SEL-849 is equipped with extensive self-tests, traditional periodic test procedures may be eliminated or greatly reduced.

Should a problem arise during either commissioning or periodic tests, the section on *Troubleshooting on page 10.11* provides a guide to isolating and correcting the problem.

Testing Tools

Web Server

The following web server screens assist you during relay testing.

The Meter Fundamental (METER) shows the ac currents and voltages (magnitude and phase angle) presented to the relay in primary values. In addition, it shows power system frequency. Compare these quantities against other devices of known accuracy. The METER fundamental is also available via the serial port, PC software, and the HMI display (see *Section 7: Communications* and *Section 8: Human-Machine Interface (HMI)*).

The relay generates a 15-, 60-, or 120-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 report event is also available via PC software and the serial port (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 also available via PC software and the serial port (see *Section 9: Analyzing Events*).

Use the Relay Word bits (TARGET) to view the state of relay control inputs, relay outputs, and relay elements individually during a test. The TARGET is also available via PC software, the serial port and the HMI display (see *Section 7: Communications* and *Section 8: Human-Machine Interface (HMI)*).

Commissioning Tests

SEL performs a complete functional check and calibration of each SEL-849 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 to the motor and all auxiliary equipment, and they verify control signal inputs and outputs.

The following connection tests help you enter settings into the SEL-849 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-849, installed and connected according to your protection design
- ➤ A PC with Ethernet port (standard Ethernet cable) or serial port (use terminal emulation software and serial communication cable)
- ➤ *SEL-849 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; three-phase voltage and current with phase angle control

Connection Tests

Step 1. Remove control voltage and ac signals from the SEL-849 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 green **ENABLED** LED should illuminate.

Step 5. Use the appropriate Ethernet or serial cable to connect a PC to the relay.

Step 6. Establish communication with the relay.

Refer to *Section 7: Communications* for more information on serial port communication.

Step 7. Set the correct relay time and date by using the web server, PC software, or serial port commands.

Step 8. Enter the relay settings from the settings sheets for your application.

Step 9. Verify the relay ac connections.

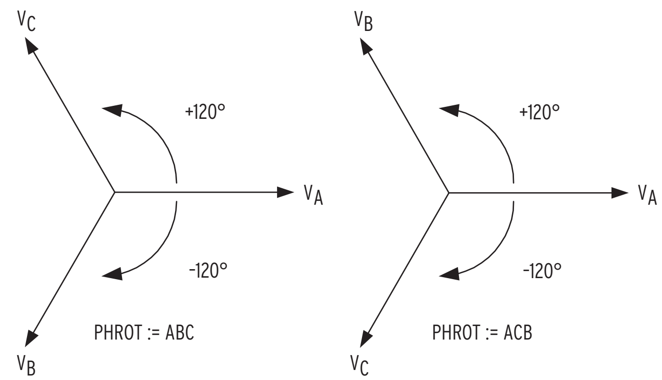
Step 10. Connect the ac test source current or voltage to the appropriate relay terminals.

a. Disconnect the current transformer and voltage transformer (if present) secondaries from the relay prior to applying test source quantities.

NOTE: Make sure the current transformer secondary windings are shorted before they are disconnected from the relay.

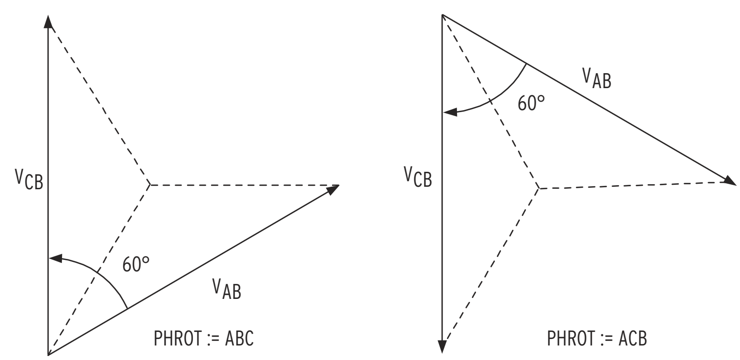
b. If you set the relay to accept phase-to-ground voltages (DELTA_Y := WYE), set the current and/or voltage phase angles as shown in *Figure 10.1*.

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 11. Apply rated full-load current (secondary).

Step 12. If the relay is equipped with voltage inputs, apply rated voltage for your application.

Step 13. Use the METER fundamental to verify that the relay is measuring the magnitude and phase angle of both voltage and current correctly, it takes into account the relay PTR and CTR1 settings when external PT and CT are used and the fact that the quantities are displayed in primary units.

Step 14. Verify control input connections. Using Relay Word bits, check the control input status in the relay.

As you assert each input, the position Relay Word bits corresponding to that input should change from zero (0) to one (1).

Step 15. Verify output contact operation.

a. For each output contact, set the input to logical 1. This causes the output contact to close. For example, setting OUT01 = 1 causes the output OUT01 contact to close.

b. Repeat the process for all contact outputs.

Make sure that each contact closure does what you want it to do in the annunciation, control, or trip circuit associated with that contact closure.

Step 16. Perform any desired protection element tests. Perform only enough tests to prove that the relay operates as intended; exhaustive element performance testing is not necessary for commissioning.

Step 17. Connect the relay for tripping duty.

Step 18. Verify that any settings changed during the tests performed in *Step 15* and *Step 16* are changed back to the correct values for your application.

Step 19. Clear the relay data buffers (Clear Load Profile, Clear Motor Statistics, Clear Motor Start Trend, Clear SERs, Clear Event Report History). For corresponding serial port commands, see *Table 10.1* 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
MOT R	Clears Motor Statistics buffers
MST R	Resets Start Trend Data
SER R	Resets Sequential Events Recorder buffer
SUM R	Resets Event Report and Summary Command buffers

Step 20. When it is safe to do so, start the motor.

Step 21. Verify the following ac quantities by using the METER fundamental.

➢ Phase current magnitudes should be nearly equal.

➢ Phase current angles should be balanced, have proper phase rotation, and have the appropriate phase relationship to the phase voltages.

Step 22. If your relay is equipped with voltage inputs, check the following:

➢ Phase voltage magnitudes should be nearly equal.

➢ Phase voltage phase angles should be balanced and have proper phase rotation.

The SEL-849 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*.

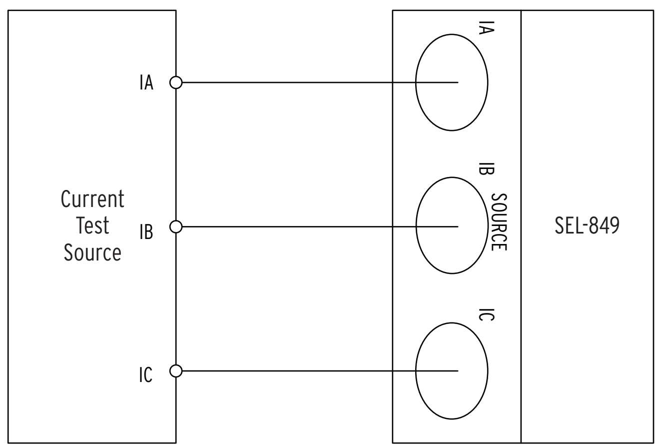


Figure 10.3 Current Source Connections

Step 2. Record the CTR1 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 the first column of *Table 10.2*. Meter fundamental should display the applied current magnitude times the CTR1 setting when external CT is used.

Table 10.2 Phase Current Measuring Accuracy

|I| Applied (A)	Expected Reading |I|[a]	A-Phase Reading (A primary)	B-Phase Reading (A primary)	C-Phase Reading (A primary)
0.2 • FLA1				
0.9 • FLA1				
1.6 • FLA1				

[a] The expected reading is CTR1 • |I| when external CT is used.

Current Unbalance Element Accuracy

Step 1. Connect the current source to the relay, as shown in *Figure 10.3*.

Step 2. Record the CTR1, PHROT, and FLA1 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

|I| Applied (A)	Expected Reading (%)	Actual Reading (%)
|IA| = 0.9 • FLA1 |IB| = FLA1 |IC| = FLA1	7%	
|IA| = 0.75 • FLA1 |IB| = FLA1 |IC| = FLA1	17%	
|IA| = FLA1 |IB| = 1.2 • FLA1 |IC| = 1.2 • FLA1	12%	
|IA| = 0.9 • FLA1 |IB| = 1.1 • FLA1 |IC| = 1.1 • FLA1	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.

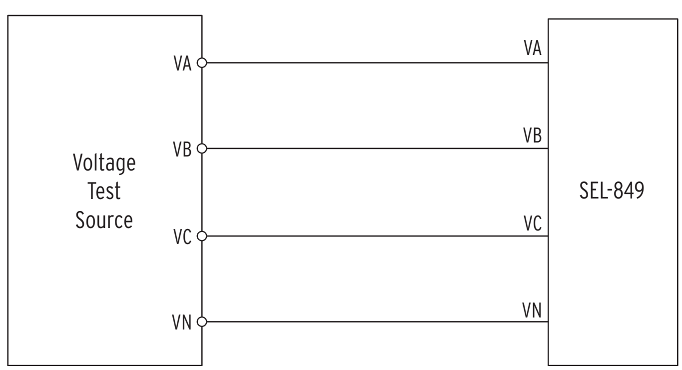


Figure 10.4 Wye Voltage Source Connections

Step 3. Record the CTR1, 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 METER fundamental to verify the results.

Table 10.4 Power Quantity Accuracy—Wye Voltages

Applied Currents and Voltages	Real Power (kW)[a]	Reactive Power (kVAR)[a]	Power Factor (pf)
PHROT := ABC Ia = 2.5 ∠-26 Ib = 2.5 ∠–146 Ic = 2.5 ∠+94	**Expected:** P = 0.4523	**Expected:** Q = 0.2211	**Expected:** pf = 0.90 lag
Va = 67 ∠0 Vb = 67 ∠–120 Vc = 67 ∠+120	**Measured:**	**Measured:**	**Measured:**
PHROT := ACB Ia = 2.5 ∠–26 Ib = 2.5 ∠+94 Ic = 2.5 ∠–146	**Expected:** P = 0.4523	**Expected:** Q = 0.2211	**Expected:** pf = 0.90 lag
Va = 67 ∠0 Vb = 67 ∠+120 Vc = 67 ∠–120	**Measured:**	**Measured:**	**Measured:**

[a] The expected real and reactive power readings are multiplied by CTR1 • PTR when external CT and PT are used.

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.

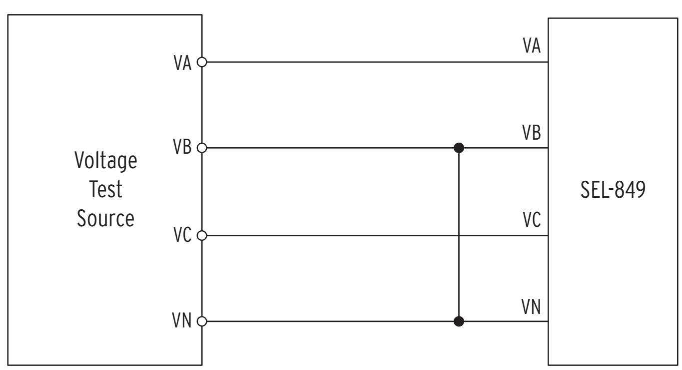


Figure 10.5 Delta Voltage Source Connections

Step 3. Record the CTR1, PTR, and PHROT setting values.

Step 4. Apply the current and voltage quantities shown in the first column of *Table 10.5*.

Values are given for PHROT := ABC and PHROT := ACB.

Step 5. Use the METER fundamental to verify the results.

Table 10.5 Power Quantity Accuracy—Delta Voltages

Applied Currents and Voltages	Real Power (kW)[a]	Reactive Power (kVAR)[a]	Power Factor (pf)
PHROT := ABC Ia = 2.5 ∠–26 Ib = 2.5 ∠–146 Ic = 2.5 ∠+94	**Expected:** P = 0.4677	**Expected:** Q = 0.2286	**Expected** pf = 0.90 lag
Vab = 120 ∠+30 Vbc = 120 ∠–90	**Measured:**	**Measured:**	**Measured:**
PHROT := ACB Ia = 2.5 ∠–26 Ib = 2.5 ∠+94 Ic = 2.5 ∠–146	**Expected:** P = 0.4677	**Expected:** Q = 0.2286	**Expected:** pf = 0.90 lag
Vab = 120 ∠–30 Vbc = 120 ∠+90	**Measured:**	**Measured:**	**Measured:**

[a] The expected real and reactive power readings are multiplied by CTR1 • PTR when external CT and PT are used.

Periodic Tests (Routine Maintenance)

Because the SEL-849 is equipped with extensive self-tests, the most effective maintenance task is to monitor the self-tests 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-849 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 (Sheet 1 of 2)

Test	Description
Relay Status	Use self-tests to verify that the relay self-tests have not detected any WARN or FAIL conditions.
Meter	Verify that the relay is correctly measuring current and voltage (if included) by comparing the relay meter readings to separate external meters.

Table 10.6 Periodic Relay Checks (Sheet 2 of 2)

Test	Description
Control Input	Using the Relay Word bits, check the control input status in the relay. As you assert each input, the Relay Word bit 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 OUT01 := 1 causes the output **OUT01** 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-849 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** LED is extinguished.
- ALARM Output: Two Relay Word bits, HALARM and SALARM, signal self-test problems. Refer to *Table 4.48* for the factory-default SELOGIC setting, SALARM. The SALARM Relay Word bit asserts based on the programmed software conditions in the SALARM SELOGIC control equation. 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. Program RST_HAL (refer to *Table 4.48*) to reset hardware alarm conditions.
- 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 HMI 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 SER.
- When the SEL-3421/3422 Motor Relay HMI is unable to communicate with the SEL-849, the HMI displays `HMI COMM FAILED`. The SEL-849 will automatically reboot the HMI as many as 10 times to restore communications. In many instances, this will correct the HMI communications failure. However, in cases where rebooting does not clear the failure, the relay STA report will show FAIL for the HMI status bit. The HMI is out of service at this point. Unplug the HMI for

30 seconds and connect it back to the relay. If the relay cannot restore communications with the HMI, contact the SEL factory for further assistance.

Use the serial port **STATUS** command or HMI 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 2)

Self-Test	Description	Normal Range	Protection Disabled on Failure	Alarm Status	Auto-Message on Failure	HMI Message on Failure	Corrective Action
Watchdog Timer Periodic Resetting (1/32 cycle)			Yes	De-energized	No	No	
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 (C)	Checksum is computed on critical data		Yes	Latched	Yes	Status Fail Non_Vol Fail	
Data Flash (Run Time)	Checksum is computed on critical data		Yes	Latched	Yes	Status Fail Non_Vol Fail	
Critical RAM (Settings)	Performs a checksum test on the active copy of settings		Yes	Latched	Yes	Status Fail CR_RAM Fail	Automatic restart. Contact SEL if failure returns.
Critical RAM (Run Time)	Verify instruction matches Flash image		Yes	Latched	Yes	Status Fail CR_RAM Fail	Automatic restart. Contact SEL if failure returns.
HMI	Monitors HMI heartbeat and issues a warning if not detected within a certain time		No	Not Latched	Yes	HMI COMM Failed	
Arc Flash Diagnostics	Monitors arc-flash sensor health once every 10 minutes		No	Not Latched	No	No	
PTC	Fails if short is detected		No	Not Latched	No		
Analog Module COMMS (Power Up)	Fail if communications with the Analog Module are interrupted		Yes	Latched	Yes		Automatic restart. Contact SEL if failure returns.
Analog Module DIAG (Power Up)	Fail if the Analog Module self-tests indicate failure		Yes	Latched	Yes		Automatic restart. Contact SEL if failure returns.

Table 10.7 Relay Self-Tests (Sheet 2 of 2)

Self-Test	Description	Normal Range	Protection Disabled on Failure	Alarm Status	Auto-Message on Failure	HMI Message on Failure	Corrective Action
Clock Battery	Monitor clock battery	2.3 to 3.5 V	No	Not Latched	Yes	NA	STA C Contact SEL if failure returns.
Clock	Unable to communicate with clock or fails time keeping test		No	Not Latched	Yes	NA	STA C Contact SEL if failure returns.
Exception Vector	CPU error		Yes	Latched	NA	Vector nn Relay Disabled	Automatic restart. Contact SEL if failure returns.

Troubleshooting

Table 10.8 Troubleshooting (Sheet 1 of 2)

Symptom/Possible Cause	Diagnosis/Solution
The relay ENABLED LED is dark.	
Input power unavailable or fuse blown	Verify that input power is present. Check fuse continuity.
Self-test failure	View the self-test failure message on the HMI display.
The relay does not accurately measure voltages or currents.	
Wiring error	Verify input wiring.
Incorrect CTR1 or PTR setting	Verify instrument transformer ratios, connections, and associated settings.
Voltage neutral terminal (N) improperly grounded	Verify wiring and connections.
The relay does not respond to commands from a device connected to the serial port.	
Cable disconnected	Verify the cable connections.
Incorrect cable type	Verify the cable pinout.
Incorrect baud rate or mismatched parameter	Verify device software setup.
The relay serial port receives an XOFF, halting communications	Type **<Ctrl+Q>** to send the relay XON and restart communications.
The relay does not respond to faults.	
Improperly set relay	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 HMI `RELAY STATUS` function to view self-test results.

Table 10.8 Troubleshooting (Sheet 2 of 2)

Symptom/Possible Cause	Diagnosis/Solution
The user is unable to communicate with the relay via serial port.	
Incorrect password or incorrect Port 1 settings	Press and hold the TARGET RESET pushbutton for 10 seconds or longer while the relay is powering up to restore the default passwords and Port 1 settings.

Technical Support

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

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Tel: +1.509.338.3838
Fax: +1.509.332.7990
Internet: selinc.com/support
Email: info@selinc.com

Appendix A

Firmware, ICD, and Manual Versions

Firmware

Determining the Firmware Version

To determine the firmware version, view the status report by using the serial port **STATUS** command or the front panel **STATUS** pushbutton. The status report displays the firmware identification (FID) string.

The firmware version will be either a standard release or a point release. A standard release adds new functionality to the firmware beyond the specifications of the existing version. A point release is reserved for modifying firmware functionality to conform to the specifications of the existing version.

A standard release is identified by a change in the R-number of the device FID string.

Existing firmware:

FID=SEL-849-**R100**-V0-Z001001-D20130104

Standard release firmware:

FID=SEL-849-**R101**-V0-Z001001-D20130104

A point release is identified by a change in the V-number of the device FID number.

Existing firmware:

FID=SEL-849-R106-**V0**-Z001001-D20130104

Point release firmware:

FID=SEL-849-R106-**V1**-Z001001-D20130104

Table A.1 lists the firmware versions, revision descriptions, and corresponding instruction manual date codes. The most recent firmware version is listed first.

Starting with revisions published after March 1, 2022, changes that address security vulnerabilities are marked with “[Cybersecurity]”. Other improvements to cybersecurity functionality that should be evaluated for potential cybersecurity importance are marked with “[Cybersecurity Enhancement]”.

Table A.1 SEL-849 Firmware Revision History (Sheet 1 of 8)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-849-R110-V0-Z007004-D20250117	➤ Added the ability to change the IP and router addresses by using the SEL-3421 Motor Relay HMI. ➤ Added the ability to configure four function keys as eight pushbuttons.	20250117

Table A.1 SEL-849 Firmware Revision History (Sheet 2 of 8)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
	➤ Added an MOT option for a low-voltage power supply with 110–125 ac/dc inputs. ➤ Resolved an issue where a CPU error was generated while attempting to read an event report via FTP. ➤ Resolved an issue with the reporting of the 50PAF Relay Word bit in the COMTRADE event report. **NOTE:** The R110-V0 relay firmware requires that the HMI be upgraded to the corresponding R107-V0 HMI firmware.	
SEL-849-R109-V1-Z006004-D20250117	Includes all the functions of SEL-849-R109-V0-Z006004-D20231031 with the following additions: ➤ Resolved an issue where a CPU error was generated while attempting to read an event report via FTP. ➤ Resolved an issue with the reporting of the 50PAF Relay Word bit in the COMTRADE event report.	20250117
SEL-849-R109-V0-Z006004-D20231031	➤ [Cybersecurity] Updated a software component to remove support for deprecated Transport Layer Security (TLS) versions used by the web server. ➤ [Cybersecurity Enhancement] Added the SELBOOT revision number to the **STATUS** (**STA**) command response. ➤ Added the HMIPB_LR setting that can disable the **LOCAL/REMOTE** pushbutton on the HMI and relinquish mode selection to a remote location. ➤ Added second- and fifth-harmonic blocking elements. ➤ Added the EMU setting to allow for the energy quantities to be reported in either Kilo or Mega units. ➤ Added support for the baud rate of 57600 bps for Port 1 and Port 3. ➤ Added an entry to the Sequential Events Recorder (SER) for when the thermal capacity is reset manually. ➤ Decreased the lower limit of the core-balance CT ratio setting CTRN from 100.0 to 50.0. ➤ Resolved an issue where the relay could incorrectly assert the thermal overload trip when there was a rapid drop in variable frequency drive (VFD) frequency and the LOAD_ZS setting was being applied (not equal to motor full-load current). ➤ Resolve an issue with the DAT file size in the COMTRADE event record. ➤ Resolved an issue where the relay incorrectly evaluated the motor run time (MRT) and the number of starts (NUMSTRT) analog quantities when APP := FEEDER. **NOTE:** The R109-V0 relay firmware requires that the HMI be upgraded to the corresponding R106-V0 HMI firmware.	20231031
SEL-849-R108-V3-Z005003-D20250117	Includes all the functions of SEL-849-R108-V2-Z005003-D20231031 with the following additions: ➤ Resolved an issue where a CPU error was generated while attempting to read an event report via FTP. ➤ Resolved an issue with the reporting of the 50PAF Relay Word bit in the COMTRADE event report.	20250117

Table A.1 SEL-849 Firmware Revision History (Sheet 3 of 8)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-849-R108-V2-Z005003-D20231031	Includes all the functions of SEL-849-R108-V1-Z005003-D20210917 with the following additions: ➤ Resolved an issue with the DAT file size in the COMTRADE event record. ➤ Resolved an issue where the relay incorrectly evaluated the motor run time (MRT) and the number of starts (NUMSTRT) analog quantities when APP := FEEDER.	20231031
SEL-849-R108-V1-Z005003-D20210917	Includes all the functions of SEL-849-R108-V0-Z005003-D20200921 with the following additions: ➤ Resolved an issue where EtherNet/IP communications stopped after approximately 25 days. ➤ Resolved an issue where the relay loses all communications with the HMI. ➤ Resolved an issue where the relay did not accept 0.0.0.0 as a valid DNPIP*n* setting. ➤ Resolved an issue in which Modbus communications could occasionally cease on Port 1 or Port 3 when the respective port was configured as an RS-485 communications interface.	20210917
SEL-849-R108-V0-Z005003-D20200921	➤ Added the EtherNet/IP communication protocol option for relays equipped with Ethernet. ➤ Added DNP3 serial and DNP3 LAN/WAN communication protocol options. ➤ Added IEC 62439-3 Parallel Redundancy Protocol (PRP) for models with the dual Ethernet port option. ➤ Enhanced the relay firmware to retain configuration settings for the IP address, subnet mask, and default router for Port 2 during a firmware upgrade. ➤ Improved the diagnostics for HMI communications. ➤ Resolved an issue where analog quantities and Relay Word bits were not always updated every 500 ms for the communication protocols. ➤ Resolved an issue with successive motor start report (MSR) triggers. ➤ Resolved an issue with the IPADDR setting of Port 2.	20200921
SEL-849-R107-V5-Z004002-D20250117	Includes all the functions of SEL-849-R107-V4-Z004002-D20231031 with the following additions: ➤ Resolved an issue where a CPU error was generated while attempting to read an event report via FTP. ➤ Resolved an issue with the reporting of the 50PAF Relay Word bit in the COMTRADE event report.	20250117
SEL-849-R107-V4-Z004002-D20231031	Includes all the functions of SEL-849-R107-V3-Z004002-D20210917 with the following additions: ➤ Resolved an issue with the DAT file size in the COMTRADE event record. ➤ Resolved an issue where the relay incorrectly evaluated the motor run time (MRT) and the number of starts (NUMSTRT) analog quantities when APP := FEEDER.	20231031
SEL-849-R107-V3-Z004002-D20210917	Includes all the functions of SEL-849-R107-V2-Z004002-D20200921 with the following additions: ➤ Resolved an issue in which Modbus communications could occasionally cease on Port 1 or Port 3 when the respective port was configured as an RS-485 communications interface.	20210917

Table A.1 SEL-849 Firmware Revision History (Sheet 4 of 8)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-849-R107-V2-Z004002-D20200921	Includes all the functions of SEL-849-R107-V1-Z004002-D20190222 with the following additions: ➤ Improved the diagnostics for HMI communications. ➤ Resolved an issue where analog quantities and Relay Word bits were not always updated every 500 ms for the communication protocols. ➤ Resolved an issue with successive motor start report (MSR) triggers. ➤ Resolved an issue with the IPADDR setting of Port 2.	20200921
SEL-849-R107-V1-Z004002-D20190222	Includes all the functions of SEL-849-R107-V0-Z004002-D20180907 with the following additions: ➤ Resolved an issue where certain Ethernet traffic could cause the relay to safely restart. **NOTE:** R107-V1 relay firmware requires that the SELBOOT and HMI firmwares be upgraded to the corresponding R105 SELBOOT and R105 HMI firmwares. In order to upgrade SELBOOT to the R105 firmware, the relay must first be upgraded to the R107-V1 relay firmware.	20190222
SEL-849-R107-V0-Z004002-D20180907	➤ Increased the FLA setting range from 128 A to 256 A and also updated the upper limit of LRA*n*, 51P1P, 51Q1P, and 51G1P. ➤ Added REF_NUM (Unique Event ID) to the CEV, EVE, and CSUM, SUM Reports. ➤ Resolved an issue where issuing Emergency Restart did not clear Start TCU and Stator Energy while the motor is in Speed 2. ➤ Added six externally wetted contact inputs as an ordering option for SEL-849 Relays with the low-voltage power supply option. ➤ Added new FLTRDRE1 Logical Node to report fault event data and also added new data attributes to MOTORMMOT1 Logical Node. ➤ Added ability to write 0 to EVESEL register in MODBUS to get latest event data if any events are available. Also added ability to write either Unique Event ID (between 10000 and 42767) or relative ID (0 to 50) to EVESEL register in order to request event data. ➤ Modified firmware to prevent delays in periodic MMS reports. ➤ Resolved an issue with incorrect reporting of firmware version number in the Modbus Map quantity FWREV. Added a new quantity, FWVNUM, to report point release firmware version number. ➤ Resolved an issue with the loss of motor-related data including the lockout(s) state, time to reset, number of starts counter, stator/rotor TCU, etc. on power cycle, when the time management settings UTC_OFF or DST_BEGM are set to non-default values. ➤ Resolved an issue with the number of STOP bits being set incorrectly when Protocol is set to MODBUS. **NOTE:** R107 relay firmware requires that the SELBOOT and HMI firmwares be upgraded to the corresponding R105 SELBOOT and R105 HMI firmwares. In order to upgrade SELBOOT to the R105 firmware, the relay must first be upgraded to the R107 relay firmware.	20180907
SEL-849-R106-V8-Z003002-D20250117	Includes all the functions of SEL-849-R106-V7-Z003002-D20231031 with the following additions: ➤ Resolved an issue where a CPU error was generated while attempting to read an event report via FTP. ➤ Resolved an issue with the reporting of the 50PAF Relay Word bit in the COMTRADE event report.	20250117

Table A.1 SEL-849 Firmware Revision History (Sheet 5 of 8)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-849-R106-V7-Z003002-D20231031	Includes all the functions of SEL-849-R106-V6-Z003002-D20210917 with the following additions: ➤ Resolved an issue with the DAT file size in the COMTRADE event record. ➤ Resolved an issue where the relay incorrectly evaluated the motor run time (MRT) and the number of starts (NUMSTRT) analog quantities when APP := FEEDER.	20231031
SEL-849-R106-V6-Z003002-D20210917	Includes all the functions of SEL-849-R106-V5-Z003002-D20200921 with the following additions: ➤ Resolved an issue in which Modbus communications could occasionally cease on Port 1 or Port 3 when the respective port was configured as an RS-485 communications interface.	20210917
SEL-849-R106-V5-Z003002-D20200921	Includes all the functions of SEL-849-R106-V4-Z003002-D20190222 with the following additions: ➤ Improved the diagnostics for HMI communications. ➤ Resolved an issue where analog quantities and Relay Word bits were not always updated every 500 ms for the communication protocols. ➤ Resolved an issue with successive motor start report (MSR) triggers. ➤ Resolved an issue with the IPADDR setting of Port 2.	20200921
SEL-849-R106-V4-Z003002-D20190222	Includes all the functions of SEL-849-R106-V3-Z003002-D20180212 with the following additions: ➤ Resolved an issue where certain Ethernet traffic could cause the relay to safely restart. **NOTE:** R106-V4 relay firmware requires that the SELBOOT and HMI firmwares be upgraded to the corresponding R105 SELBOOT and R105 HMI firmwares. In order to upgrade SELBOOT to the R105 firmware, the relay must first be upgraded to the R106-V4 relay firmware.	20190222
SEL-849-R106-V3-Z003002-D20180212	Includes all the functions of SEL-849-R106-V2-Z003002-D20170814 with the following additions: ➤ Resolved an issue with the HTTPS server where certain Ethernet traffic could cause diagnostic restarts. ➤ Resolved an Ethernet processing issue where certain Ethernet traffic could cause diagnostic restarts. **NOTE:** R106-V3 relay firmware requires that the SELBOOT and HMI firmwares be upgraded to the corresponding R105 SELBOOT and R105 HMI firmwares. In order to upgrade SELBOOT to the R105 firmware, the relay must first be upgraded to the R106-V3 relay firmware.	20180907
SEL-849-R106-V2-Z003002-D20170814	Includes all the functions of SEL-849-R106-V1-Z003002-D20161223 with the following additions: ➤ Resolved an issue where certain Ethernet traffic could cause diagnostic restarts in devices when IEC 61850 is enabled. ➤ Resolved an issue with relays that stopped communicating when the optional Port 3 was configured as an EIA-485 port. This issue affects R106-V1 and R106-V0 firmware versions only. ➤ Resolved an issue where the relay disabled and stopped communicating if there was a loop on the Ethernet network. ➤ Resolved an issue where certain Ethernet traffic could cause memory allocated to Ethernet communications to be exhausted. **NOTE:** R106-V2 relay firmware requires that the SELBOOT and HMI firmwares be upgraded to the corresponding R105 SELBOOT and R105 HMI firmwares. In order to upgrade SELBOOT to the R105 firmware, the relay must first be upgraded to the R106-V2 relay firmware.	20170814

Table A.1 SEL-849 Firmware Revision History (Sheet 6 of 8)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-849-R106-V1-Z003002-D20161223	Includes all the functions of SEL-849-R106-V0-Z003002-D20160509 with the following additions: ➤ Resolved an issue (present in R106-V0 firmware only) with restoring default passwords on power up with the Target Reset button sequence as described in the manual. ➤ Resolved an issue with the GOOSE Message reception stopping in the presence of a GOOSE data storm on the network. ➤ Resolved an issue with the SEL HTTPS Web Server connection being rejected by the Internet Explorer and Firefox browsers. **NOTE:** R106-V1 relay firmware requires that the SELBOOT and HMI firmwares be upgraded to the corresponding R105 SELBOOT and R105 HMI firmwares. In order to upgrade SELBOOT to the R105 firmware, the relay must first be upgraded to the R106-V1 relay firmware.	20161223
SEL-849-R106-V0-Z003002-D20160509	➤ Added contactor and breaker operation counters to the motor monitor report (MOT). ➤ Enhanced motor undervoltage restart function to include a second automatic restart if a voltage dip occurs within one second of a short dip. ➤ Enhanced the Motor State Logic to use average rms instead of sequence currents for VFD application. ➤ Added maximum and minimum metering that allows to determine maximum and minimum operating quantities of the motor such as currents, voltages, power, and frequency. ➤ Enhanced motor thermal model by allowing for faster cooling rate during coasting to stop. Based on the new COASTIME setting, the relay automatically delays the use of the slower cooling rate (based on COOLTIME) which can significantly reduce the wait time before the next start may be allowed by thermal lock out. ➤ Updated Modbus Map to add a new quantity MLOADHR to report MLOAD at higher resolution. ➤ Added SELOGIC control equation setting NETFAIL to force the failover for Ethernet ports in dual Ethernet configuration with setting NETMODE := FAILOVER. This setting can be used to cover link failures that are not detectable by the relay to initiate failover switching. ➤ Added 51N time-overcurrent element. ➤ Resolved an issue with the ANA command that did not work in relays with the externally wetted input option. ➤ Added energy metering with real, reactive, and apparent energy quantities. ➤ Added RSTMOT SELOGIC control equation setting to reset MOT data. ➤ Added the emergency STOP functionality, regardless of LOCAL/REMOTE status, via the STOP pushbutton on the HMI and an optional delay for a START issued from HMI. ➤ Modified GOOSE subscription to update data after the messages transition from lower to better quality. ➤ Resolved an issue with Motor Run Time (analog quantity MRT) being calculated incorrectly. **NOTE:** R106 relay firmware requires that the SELBOOT and HMI firmwares be upgraded to the corresponding R105 SELBOOT and R105 HMI firmwares. In order to upgrade SELBOOT to the R105 SELBOOT firmware, the relay must first be upgraded to the R106 relay firmware.	20160509

Table A.1 SEL-849 Firmware Revision History (Sheet 7 of 8)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-849-R105	➤ R105 was not production released. R106 follows R104.	NA
SEL-849-R104-V0-Z002002-D20141107	➤ Resolved an issue with the SELOGIC compiler where the SELOGIC edge detect operator used with parenthesis might not have worked correctly in some applications. ➤ Resolved an issue with the SEL-849 dual Ethernet models. When NETMODE = FAILOVER and both Ethernet ports of the relay were connected to the same external switch, the SEL-849 Ethernet and HMI communications might have stopped responding. ➤ Revised the firmware to increase the resolution for the IN channel in the MODBUS map. ➤ Improved web server security by disabling support for SSL 3.0. ➤ Improved HMI/relay communications and diagnostics. **NOTE:** R104 relay firmware requires that the HMI be upgraded to the corresponding R104 HMI firmware.	20141107
SEL-849-R103-V0-Z002002-D20140502	➤ Added six externally wetted contact inputs as an ordering option for the SEL-849 relays with the high voltage power supply option. ➤ Revised TRIP logic. Added a new setting, TRIPONST (Trip on Stop), to enable or disable the assertion of the TRIP Relay Word bit and latching of the TRIP target LED when a **STOP** command is issued. The default setting for TRIPONST is N. In R101, a **STOP** command always asserted the TRIP Relay Word bit and latched the TRIP target LED, which was equivalent to TRIPONST := Y. ➤ Enhanced the firmware to preserve the R101 behavior of the SEL-849 on START/STOP by forcing the new setting TRIPONST := Y and HMI_CTRL := ACK_EN when upgrading from R101 to R103 firmware. ➤ Revised the firmware to change the default setting for RSTRGT (Reset Targets) from 0 to R_TRIG STR_CLO. This enhancement was made to clear the targets automatically when the motor starts. ➤ Modified the default Enable Display Point setting, EDP, from four to two. Modified the default display point settings DP01 and DP02 from RID and TID to IAVG (Average Current) and UBI (Current Imbalance), respectively. ➤ Modified the default settings for display points in the HMI settings and the load profile list, LDLIST, in the report settings to remove motor specific quantities. The default setting will now apply even if the application type setting APP is changed from MOTOR to FEEDER or VFD. ➤ Added a new event type for the arc-flash trip in event reports. ➤ Enhanced the firmware to hide inapplicable MOT, MSR, and MST reports when APP setting is set to the FEEDER application. ➤ Enhanced the firmware for the event type text to make the descriptions more detailed. ➤ Revised the firmware to change the default setting of EFTPSERV (Enable FTP) from N to Y. This enhancement facilitates communication with the SEL-849 via FTP without having to change the default port settings. ➤ Warning messages on the HMI are revised to use ALIAS strings that are set for any of the Relay Word bits that are in the warning list. If the Relay Word bit does not have an ALIAS setting, then the HMI will continue to display the Relay Word bit name in the warning message. ➤ Resolved an issue that can cause small jumps in the angle calculations for analog quantities.	20140502

Table A.1 SEL-849 Firmware Revision History (Sheet 8 of 8)

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
	➤ Resolved an issue with labels requiring two-register allocation in the Modbus map. In R101, these two-register labels were being counted incorrectly and the use of such labels was reducing the available user map size. ➤ Resolved an issue with output contact OUT01 and 52A. In R101, output contact OUT01 was deasserting and 52A was asserting following a settings change. ➤ Resolved a COMTRADE event reporting issue where the channels were not being reported correctly for relays without the voltage option. ➤ Changed storage of the latches from volatile to nonvolatile memory. ➤ Resolved an issue with load profile reporting values that were out of range for the analog quantities being used. ➤ Resolved an issue where the SEL-849 did not allow communication via the serial port after the TARGET RESET pushbutton on the relay top panel was pressed for 10 seconds or longer. ➤ For certain self-test failures, the relay will automatically restart as many as three times. In many instances, this will correct the failure. The failure message may not be fully displayed before the automatic restart occurs. Indication that the relay restarted will be recorded in the SER. ➤ Updated the web server in the relay by using a standards-compliant method for verifying that the input file name is a valid settings file name. NOTE: R103 relay firmware requires that the HMI be upgraded to the corresponding R103 HMI firmware.	
SEL-849-R102	➤ R102 was not production released. R103 follows R101.	NA
SEL-849-R101-V0-Z001001-D20130318	➤ Implemented manufacturing test enhancements. NOTE: R101 relay firmware requires that the HMI be upgraded to the corresponding R101 HMI firmware.	20130318
SEL-849-R100-V0-Z001001-D20130104	➤ Initial version. NOTE: R100 HMI firmware is compatible with R100 relay firmware only.	20130104

Table A.2 SEL-3421 and SEL-3422 Firmware Revision History (Sheet 1 of 2)

HMI Firmware Identification Number[a]	Summary of Revisions	Manual Date Code
SEL-3421-R107-V0-Z000000-D20250117	➤ Added the ability to change the IP and router addresses by using the SEL-3421 Motor Relay HMI. ➤ Added the ability to configure four function keys as eight pushbuttons. NOTE: The R107-V0 HMI firmware requires that the relay be upgraded to the corresponding R110-V0 relay firmware.	20250117
SEL-3421-R106-V0-Z000000-D20231031	➤ Added analog quantities KWh3P, KVARh3P_IN, KVARh3P_OUT, and KVAh3P under energy metering menu when the EMU setting is set to Kilo. NOTE: The R106-V0 HMI firmware requires that the relay be upgraded to the corresponding R109-V0 relay firmware.	20231031

Table A.2 SEL-3421 and SEL-3422 Firmware Revision History (Sheet 2 of 2)

HMI Firmware Identification Number[a]	Summary of Revisions	Manual Date Code
SEL-3421-R105-V0-Z000000-D20160509	➤ Added energy metering menu to display real, reactive, and apparent energy a motor is using. ➤ Added max/min metering menu to display maximum and minimum operating quantities of the motor such as currents, voltages, power, and frequency. **NOTE:** R105 HMI firmware requires that the relay and SELBOOT firmwares be upgraded to the corresponding R106 or R107 relay firmware and R105 SELBOOT firmware. In order to upgrade SELBOOT to the R105 SELBOOT firmware, the relay must first be upgraded to either the R106 or R107 relay firmware.	20160509
SEL-3421-R104-V0-Z000000-D20141107	➤ Improved HMI/relay communications and diagnostics **NOTE:** R104 HMI firmware requires that the relay be upgraded to the corresponding R104 relay firmware.	20141107
SEL-3421-R103-V0-Z000000-D20140502	➤ Enhanced the firmware to show the control (CTRL) menu in the first row of the function keys. ➤ Added the information (INFO) menu to display relay IP address, default router, Port 1 protocol, and baud rate settings. ➤ Resolved an issue with the display of invalid targets upon power up. ➤ Revised the START/STOP control operations to provide responses to indicate if either motor Start or Stop was successful in starting or stopping the motor or if it failed. ➤ Enhanced HMI diagnostics. **NOTE:** R103 HMI firmware requires that the relay be upgraded to the corresponding R103 relay firmware.	20140502
SEL-3421-R102	➤ R102 was not production released. R103 follows R101.	NA
SEL-3421-R101-V0-Z000000-D20130318	➤ Implemented usability enhancements. **NOTE:** R101 HMI firmware requires that the relay be upgraded to the corresponding R101 relay firmware.	20130318
SEL-3421-R100-V0-Z000000-D20130104	➤ Initial version. **NOTE:** R100 HMI firmware is compatible with R100 relay firmware only.	20130104

[a] The same firmware applies for both the SEL-3421 and SEL-3422 modules.

Table A.3 SELBOOT Firmware Revision History

Boot Firmware Identification Number	Summary of Revisions	Manual Date Code
BOOTLDR-R105-V0-Z000000-D20160509	➤ Enhanced the firmware to allow for faster startup during undervoltage restart sequence. **NOTE:** R105 SELBOOT firmware requires that the relay and HMI firmwares be upgraded to either the R106 or R107 relay firmware and the corresponding R105 HMI firmware. In order to upgrade SELBOOT to the R105 SELBOOT firmware, the relay must first be upgraded to either the R106 or R107 relay firmware.	20160509
BOOTLDR-R101-V0-Z000000-D20140317	➤ Minor enhancements.	20140502
BOOTLDR-R100-V0-Z000000-D20130104	➤ Initial version.	20130104

ICD File

Determining the ICD File Version in Your Relay

To find the ICD revision number in your relay, view the configVersion using the serial port **ID** command. The configVersion is the last item displayed in the information returned from the **ID** command.

configVersion=ICD-849-R101-V0-Z102005-D20140317

The ICD revision number is after the R (e.g., 101) and the date code 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.

NOTE: The Z-number representation is implemented with ICD File Revision R101. Previous ICD File Revisions do not provide an informative Z-number.

The configVersion contains other useful information. The Z-number consists of six digits. The first three digits following the Z represent the minimum IED firmware required to be used with the ICD (e.g., 102). The second three digits represent the ICD ClassFileVersion (e.g., 005). The ClassFileVersion increments when there is a major addition or change to the IEC 61850 implementation of the relay.

Table A.4 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.4 SEL-849 ICD File Revision History (Sheet 1 of 2)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect File Description	Manual Date Code
ICD-849-R103-V0-Z107005-D20180907	➤ Added new FLTRDRE1 Logical Node and attributes to PRO LDevice. ➤ Added new data attributes Mstp, NumTrips, and NumAlrms to MOTORMMOT1 Logical Node.	R107 or higher	005	SEL-849 R107 or higher	20180907
ICD-849-R102-V0-Z105005-D20160509	➤ Added new N1TPTOC6 Logical Node. ➤ Added Ind17 to Ind22 attributes to MOTGGIO7 Logical Node. ➤ Added Ind07 data attributes to ETHGGIO11 Logical Node. ➤ Added new data attributes for Max/Min metering to METMSTA1 Logical Node. ➤ Added new data attributes for Energy metering to METMDST1 Logical Node. ➤ Added new data attributes for Motor Monitor to MOTORMMOT1 Logical Node. ➤ Removed maxEntries and maxMappedItems.	R105 or higher	005	SEL-849 R105 and higher	20160509

Table A.4 SEL-849 ICD File Revision History (Sheet 2 of 2)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect File Description	Manual Date Code
ICD-849-R101-V0-Z102005-D20140317	➤ Increased number of MMS Reports to 14. ➤ Modified default MMS Report and Dataset names. ➤ Updated all Report Control attributes. ➤ Corrected ReportControl rptID attributes to display report name instead of dataset name. ➤ Updated orCat control instances to proprietary node. ➤ Made corrections per KEMA recommendations. ➤ Added new P1TPTOC3, G1TPTOC4, Q1TPTOC5, PAFPIOC10, and GAFPIOC11 Logical Nodes. ➤ Added Ind12 to Ind16 attributes to MOTGGIO7 Logical Node. ➤ Added Ind15 to Ind32 data attributes to MISCGGIO8 Logical Node. ➤ Corrected Indxx attributes of VBGGIO9 Logical node to Indxxx. ➤ Corrected dataNs attribute of RAGGIO15 Logical Node.	R102–R104	005	SEL-849 R102 and higher	20141107
ICD-849-R100-V0-Z000000-D20130101	➤ Initial ICD File Release.	R101	005	SEL-849 R101 F/W	20130104

Instruction Manual

The date code at the bottom of each page of this manual reflects the creation or revision date. *Table A.5* lists the instruction manual release dates and a description of modifications. The most recent instruction manual revisions are listed at the top.

Table A.5 Instruction Manual Revision History (Sheet 1 of 11)

Date Code	Summary of Revisions
20250117	**Preface** ➤ Updated the *Section 8: Human-Machine Interface (HMI)* summary in *Manual Overview*. **Section 1** ➤ Updated *Options* and *Specifications*. **Section 4** ➤ Added *Pushbutton Settings*, including *Table 4.65: Pushbutton Label Settings*.

Table A.5 Instruction Manual Revision History (Sheet 2 of 11)

Date Code	Summary of Revisions
	Section 8 ➤ Updated *SEL-3421 Motor Relay HMI Module (With LCD)*. ➤ Updated *Figure 8.3: HMI Navigation Pushbuttons*, *Table 8.3: Navigation Pushbutton Functions*, and *Table 8.4: SEL-3421 Motor Relay HMI Navigation*. ➤ Added a note pertaining to the EPB setting to *Main Menu*. ➤ Updated *Info Menu*, including *Figure 8.18: Info Menu and IP Address and Default Router Submenu*. ➤ Added *HMI Operation When Pushbuttons Are Enabled*, including *Figure 8.19: Pushbuttons (PB01–PB08) Function Keys*. Appendix A ➤ Updated the **STA** command response revision from [Cybersecurity] to [Cybersecurity Enhancement] for firmware version R109-V0. ➤ Updated Summary of Revisions for firmware versions R107-V7, R107-V4, and R108-V2. ➤ Updated the Z-number for firmware versions R106-V6, R106-V7, R107-V3, and R107-V4. ➤ Updated for firmware versions R106-V8, R107-V5, R108-V3, R109-V1, and R110-V0. ➤ Updated for firmware version R107-V0 for the SEL-3421 and SEL-3422.
20240614	Preface ➤ Updated *Compliance Approvals*. Section 1 ➤ Updated *Compliance* and *Product Standards* of *Specifications*.
20231031	Section 1 ➤ Updated *Features*. ➤ Update *Figure 1.3: STA Command Response*. ➤ Updated *Compliance*, *General*, *Relay Elements*, and *Metering* of *Specifications*. Section 2 ➤ ➤ Updated *Table 2.1: UL Approved 5 A CTs for SEL-849 Overload Relay Applications* and *Figure 2.9: Single-Phase Voltage Connections*. ➤ Added *Figure 2.26: Lug Kit Dimensions*. Section 3 ➤ Updated *Figure 3.19: Self-Tests Webpage*. Section 4 ➤ Updated *Table 4.1: Basic Settings*. ➤ Updated *Configuration Settings*. ➤ Updated *Table 4.9: Phase Instantaneous Overcurrent Settings*, *Table 4.10: Residual Instantaneous Overcurrent Settings*, *Table 4.11: CBCT Instantaneous Overcurrent*, and *Table 4.12: Negative-Sequence Instantaneous Overcurrent*. ➤ Added *Second- and Fifth Harmonic Blocking Logic*. ➤ Updated *Start Inhibit Function* and *Local/Remote Control*. ➤ Updated *Figure 4.52: Start/Close Logic* and *Output Settings*. ➤ Updated *Table 4.54: EIA-232/EIA-485 Port Settings*. ➤ Updated *General Settings*, including *Table 4.56: HMI General Settings*. ➤ Updated *Event Report Settings*. ➤ Added *Energy Meter Report Unit Setting*. Section 5 ➤ Updated *Energy Metering*. including adding *Figure 5.4: Device Response to the METER E R Command*. Section 7 ➤ Updated *Simple Network Time Protocol (SNTP)*. ➤ Updated *R_S Command (Restore Factory Defaults)*. ➤ Updated *Table 7.45: STATUS Command Report and Definitions*. ➤ Updated *Figure 7.18: STATUS S Command Response*. ➤ Updated *TCUR Command (Thermal Reset)*. Section 8 ➤ Updated *Control Pushbutton Operation*.

Table A.5 Instruction Manual Revision History (Sheet 3 of 11)

Date Code	Summary of Revisions
	Section 9 ➤ Updated *Oscillography*. ➤ Updated *Figure 9.17: Sample SER Report*. Appendix A ➤ Updated for R106-V7, R107-V4, R108-V2, and R109-V0 firmware versions and R106-V0 SELBOOT version. ➤ Revised R103-V0, R108-V1, R106-V6, R107-V3, and R108-V1 firmware revision summaries. Appendix B ➤ Updated *Upgrade Via a Terminal Emulator Using a Serial Port*. Appendix C ➤ Updated *Enhancing Multidrop Networks* and *Time Synchronization*. Appendix E ➤ Updated *Table E.8: 02h SEL-849 Inputs* and *Table E.23: Modbus Quantities*. Appendix G ➤ Updated *Table G.17: Logical Device: ANN (Annunciation)*. Appendix H ➤ Updated *Table H.1: Relay Word Bits*. Appendix I ➤ Updated *Table I.1: Analog Quantities*. Appendix J ➤ Updated *Table J.1: IP Port Numbers*. ➤ Added *Vulnerability Notification Process*.
20220318	Preface ➤ Updated *Compliance Approvals*. Section 1 ➤ Updated *Specifications*.
20210917	Section 1 ➤ Updated *RFI and Interference Tests* conducted and radiated emissions. Appendix A ➤ Updated *Table A.1: SEL-849 Firmware Revision History* for firmware versions R106-V6, R107-V3, and R108-V1.
20200921	Preface ➤ Updated *Compliance Approvals*. Section 1 ➤ Updated *Communications and Control* for DNP3, EtherNet/IP, and PRP. ➤ Updated *Options* and *Powering the Relay*. ➤ Updated *Specifications*. Section 2 ➤ Updated *Figure 2.1: Relay Features and Connections* for DNP3 and EtherNet/IP. ➤ Updated *Direct Current Input* and *5 A/1 A CTs*. ➤ Added a note on external CTs to *Figure 2.5: CT Installation*. ➤ Updated *Pre-Configured Starter Applications*, including adding a note on the location of the control power transformer and adding *Single-Phase Feeder Protection* with *Figure 2.19: Connection Diagram for Single-Phase Feeder Load Protection*. Section 3 ➤ Updated *Control*. ➤ Updated *Table 3.1: SEL Software Solutions* for SEL-5601-2 SYNCHROWAVE Event Software. ➤ Updated *View Event Files*.

Table A.5 Instruction Manual Revision History (Sheet 4 of 11)

Date Code	Summary of Revisions
	Section 4 ➤ Updated *Overview* for *DNP3 Map Settings (SET D Command)* and *EtherNet/IP Assembly Map Settings (SET E Command)*. ➤ Added a note on traditional external CTs to *Basic Settings*. ➤ Updated *Thermal Overload Element*. ➤ Added an application guide reference to *Curve Thermal Method*. ➤ Added *Figure 4.28: Star-Delta Starting* to *Star-Delta (Wye-Delta) Starting*. ➤ Added a note on relay output contact to *TR and TR1 Trip Conditions SELOGIC Control Equation*. ➤ Updated *Lockout After Stop*. ➤ Updated *Port Settings (SET P Command)*, including *Table 4.54: EIA-232/EIA-485 Port Settings*, for DNP3 and EtherNet/IP settings and *Table 4.55: Ethernet Port Settings* for DNP3, EtherNet/IP, and PRP settings. ➤ Added *DNP Map Settings (SET D Command)* and *EtherNet/IP Assembly Map Settings (SET E Command)*. Section 5 ➤ Updated *Overview* for DNP3 and EtherNet/IP. Section 6 ➤ Updated *Overview* for DNP3 and EtherNet/IP communications. ➤ Updated *Table 6.2: SHOW Command Options* for SHO E and SHO D commands. ➤ Updated *Table 6.3: SET Command Options* for SET E and SET D commands. Section 7 ➤ Updated *Table 7.2: Ethernet Port Configuration Settings* for PRP. ➤ Added *PRP Connection Mode*. ➤ Updated *Communications Protocols*, including *Table 7.5: Supported SEL-849 Communications Protocols* for DNP3, EtherNet/IP and PRP and *Table 7.6: Protocol Session Limits* for DNP3 and EtherNet/IP. ➤ Updated *CEV Command* for SEL-5602-1 SYNCHROWAVE Event Software. ➤ Updated *Table 7.40: SET Command (Change Settings)* for SET E *m s* TERSE and SET DNP *m s* TERSE. ➤ Updated *Table 7.42: SHOW Command (Show/View Settings)* for SHO E *m s* and SHO DNP *m s*. ➤ Updated *TEST DB Command* for DNP3 and EtherNet/IP. Appendix A ➤ Updated *Table A.1: SEL-849 Firmware Revision History* for firmware versions R106-V5, R107-V2, and R108-V0. Appendix B ➤ Updated Step 1 of *Upgrade the Relay Firmware Using ACSELERATOR QuickSet*. Appendix D ➤ Added *Appendix D: DNP3 Communications*. Appendix E ➤ Updated *Table E.23: Modbus Quantities Table*. ➤ Added *Additional Modbus Registers (RID, TID, PART_NUM)*. Appendix F ➤ Added *Appendix F: EtherNet/IP Communications*. Appendix G ➤ Updated a note on VLAN IDs in *ACSELERATOR Architect*. Appendix I ➤ Updated *Table I.1: Analog Quantities*. Appendix J ➤ Updated *Table J.1: IP Port Numbers* and *Monitoring and Logging* for DNP3 and EtherNet/IP. Glossary ➤ Added Distributed Network Protocol (DNP), EtherNet/IP, and PRP. Command Summary ➤ Added show and set commands for DNP3 and EtherNet/IP.
20190222	Appendix A ➤ Updated *Table A.1: SEL-849 Firmware Revision History* for firmware versions R107-V1 and R106-V4.

Table A.5 Instruction Manual Revision History (Sheet 5 of 11)

Date Code	Summary of Revisions
20180907	Preface ➤ Updated *Compliance Approvals.* ➤ Updated *Product Labels*. ➤ Updated *Environmental Conditions and Voltage Information*. ➤ Updated the insulation voltage for potential connections in *Wire Sizes and Insulation*. Section 1 ➤ Updated *Specifications*. Section 2 ➤ Updated *Physical Location* under *Relay Placement*. ➤ Updated *Figure 2: 2-Wire Half Duplex EIA-485 Serial Port Connections.* ➤ Updated *Figure 2.9: Single-Phase Voltage Connections.* ➤ Added a note to *Figure 2.10: Three-Phase Voltage Connections.* ➤ Added *Analog Output Wiring.* ➤ Updated *Figure 2.11: Connection Diagram for Factory-Default I/O Assignments Full-Voltage Nonreversing Starter (STARTRTY := FVNR) With Ungrounded Motor Neutral.* ➤ Updated *Figure 2.12: Connection Diagram for Factory-Default I/O Assignments Full-Voltage Nonreversing Starter (STARTRTY := FVNR) With Grounded Motor Neutral* Section 4 ➤ Updated *Basic Settings* under *Protection Settings (SET Command)*. ➤ Updated footnote to *Table 4.5: Configuration Settings*. ➤ Added footnote to *Table 4.6: Thermal Overload Settings*. ➤ Updated the setting range of the MAX phase TOC pickup in *Table 4.12: Phase Time-Overcurrent Settings.* ➤ Updated the setting range of the NEG SEQ TOC pickup in *Table 4.13: Negative-Sequence Time-Overcurrent Settings.* ➤ Updated the setting range of the residual ground TOC pickup in *Table 4.14: Residual Time-Overcurrent Settings.* ➤ Updated *Thermistor (PTC) Input Function* under *PTC-Based Protection*. Section 7 ➤ Added a warning to *Using the Embedded Web Server (HTTP/HTTPS)*. ➤ Updated *Security (X.509 Certificates)*. ➤ Added *Test DB Command*. Section 9 ➤ Updated *Figure 9.1: SEL-849 Input Processing.* Appendix A ➤ Updated *Table A.1: SEL-849 Firmware Revision History* for firmware version R107-V0. ➤ Updated *Table A.4: SEL-849 ICD File Revision History* for ICD version R103-V0. Appendix B ➤ Updated *Overview*. ➤ Updated Upgrade the *Relay SELBOOT Firmware Loader Using a Terminal Emulator.* Appendix D ➤ Updated *Table D.23: Modbus Quantities Table.* ➤ Added *Reading Event Data Using Modbus*. Appendix E ➤ Updated *Table E.9: Arc Flash Detection Logical Node Class Definition.* ➤ Updated *Table E.10: Demand Metering Statistics Logical Node Class Definition.* ➤ Updated *Table E.11: Motor Measurement Data Logical Node Class Definition.* ➤ Updated *Table E.13: Generic Process I/O Logical Node Class Definition.* ➤ Updated *Table E.14: Logical Device: PRO (Protection).* ➤ Updated *Table E.15: Logical Device: MET (Metering).* Appendix F ➤ Updated Bit 49T in *Table F.1: Relay Word Bits.*
20180212	Appendix A ➤ Updated *Table A.1: SEL-849 Firmware Revision History* for firmware version R106-V3.

Table A.5 Instruction Manual Revision History (Sheet 6 of 11)

Date Code	Summary of Revisions
20171110	Preface ➤ Updated *Safety Information* for the ESD warning. ➤ Updated *Compliance Approvals*, *SEL-849 Relay* for hazardous locations, including the compliance label for the SEL-849. ➤ Updated *Compliance Approvals*, *SEL-3421 and SEL-3422 HMI Modules* for hazardous locations, including the product and compliance labels for the SEL-3421 and SEL-3422. ➤ Added *Wire Sizes and Insulation*. Section 1 ➤ Updated *Specifications*, *Compliance* for EN 60079-11:2012. Section 2 ➤ Updated *Motor Relay HMI Installations*. ➤ Updated *Figure 2.19: SEL-3421 Panel Mount*, *Figure 2.20: SEL-3421 DIN-Rail Mount*, *Figure 2.21: SEL-3422 Panel Mount*, and *Figure 2.22: SEL-3422 DIN-Rail Mount*. Section 3 ➤ Updated *Figure 3.24: Communications Parameter Menu Selection* and *Figure 3.27: Communications Terminal Menu Selection*. ➤ Updated *Table 3.4: QuickSet Help*.
20170814	Appendix A ➤ Updated *Table A.1: SEL-849 Firmware Revision History* for firmware version R106-V2.
20170726	Preface ➤ Updated the *General Safety Marks* and *Hazardous Locations Safety Marks* tables. ➤ Updated *Compliance Approvals*, including the compliance label for the SEL-849 and the product and compliance labels for the SEL-3421 and SEL-3422. ➤ Updated *Product Labels*, *Environmental Conditions and Voltage Information*, and *Technical Assistance*. Section 1 ➤ Updated *Specifications*, including *Compliance* and *Operating Environment* (pollution degree). Section 2 ➤ Updated *Physical Location* for the pollution degree and ATEX compliance. ➤ Updated *SEL-3421 Motor Relay HMI Installation*, including adding a note to *Figure 2.19: SEL-3421 Panel Mount* for completely enclosed electrical connections and updated *Connection*. ➤ Updated *SEL-3422 Motor Relay HMI Installation*, including adding a note to *Figure 2.21: SEL-3422 Panel Mount* for completely enclosed electrical connections and updated *Connection*. Section 4 ➤ Updated *Table 4.7: Overload Trip Time Equations* for SETMETH := Curve. Section 10 ➤ Updated *Factory Assistance*. Appendix H ➤ Updated *Security Vulnerabilities*.
20161223	Appendix A ➤ Updated *Table A.1: SEL-849 Firmware Revision History* for firmware version R106-V1.
20160509	Preface ➤ Updated *Safety Marks* and *Compliance Approvals*. ➤ Added *Trademarks*. Section 1 ➤ Updated *Standard Protection Features* and *Checking Relay Status*. ➤ Updated *Compliance*, the burden for *Core-Balance CT Current (IN)*, and *Optoisolated Control Inputs (Externally Wetted to 24/48 Vdc/Vac or 110/125 Vdc/Vac)*. ➤ Added *Inverse-Time Overcurrent (51N)*. Section 2 ➤ Updated *Core-Balance CT Connections (Terminal Block H)*. ➤ Updated *Figure 2.10: Connection Diagram for Factory-Default I/O Assignments Full-Voltage Nonreversing Starter (STARTRTY := FVNR) With Ungrounded Motor Neutral* and added *Figure 2.11: Connection Diagram for Factory-Default I/O Assignments Full-Voltage Nonreversing Starter (STARTRTY := FVNR) With Grounded Motor Neutral*.

Table A.5 Instruction Manual Revision History (Sheet 7 of 11)

Date Code	Summary of Revisions
	➤ Updated *Figure 2.12: Connection Diagram for Factory-Default I/O Assignments Full-Voltage Reversing Starter (STARTRTY := FVR)*, *Figure 2.13: Connection Diagram for Factory-Default I/O Assignments Two-Speed Starter (STARTRTY := 2SPEED)*, *Figure 2.14: Connection Diagram for Factory-Default I/O Assignments Star-Delta Starter (STARTRTY := Star_D)*, *Figure 2.15: Connection Diagram for Factory-Default I/O Assignments Feeder Application (APP := Feeder)*, and *Figure 2.16: Connection Diagram for Motor Application Using Breaker Full-Voltage Nonreversing Starter*. ➤ Updated *VFD or VSD Motor Protection* and *Figure 2.17: Connection Diagram for Factory-Default I/O Assignments Full-Voltage Nonreversing Starter (With Variable Frequency Drive)*. Section 3 ➤ Updated *Figure 3.5: Change Settings Webpage* and *Figure 3.6: Save Setting Changes Webpage*. ➤ Updated *Meter* and *Figure 3.10: Fundamental Meter Report*. ➤ Updated *Motor Statistics* and *Figure 3.14: Motor Operating Statistics Webpage*. ➤ Updated *Figure 3.17: Control Webpage*, *Figure 3.18: Confirmation Message for Operating Remote Bits*, *Figure 3.29: Selection of Drivers*, and *Figure 3.30: Update Part Number*. ➤ Updated *Device Overview* and *Figure 3.35: Device Overview Screen*. ➤ Updated *Figure 3.36: SEL-849 Relay Word Bits (Targets)* and *Figure 3.38: Control Screen*. Section 4 ➤ Updated *Application Data*. ➤ Updated *Basic Settings*. ➤ Updated *Configuration Settings*, including *Figure 4.1: KVF Factor Versus VFD Output Frequency*. ➤ Updated *Table 4.5: Thermal Overload Settings*. ➤ Updated *Example 4.3: Thermal Element Setting* in *Rating Thermal Method*. ➤ Updated *Additional Thermal Overload Settings* including *Figure 4.6: Coast Stop Logic Diagram*. ➤ Updated *Table 4.10: CBCT Instantaneous Overcurrent*. ➤ Updated *Time-Overcurrent Elements*. ➤ Updated *Figure 4.9: Maximum Phase Time-Overcurrent Element 51P1T*, *Figure 4.10: Negative-Sequence Time-Overcurrent Element 51Q1T*, *Figure 4.11: Residual Time-Overcurrent Element 51G1T*, and added *Figure 4.12: CBCT/Neutral Time-Overcurrent Element 51N1T*. ➤ Updated *Motor Restart* and added *Figure 4.29: Short Voltage Dip Restart (SDR) Detection Logic*. ➤ Updated *Figure 4.27: Motor Restart Logic*, *Figure 4.28: Overvoltage Reset Logic*, and *Figure 4.30: Undervoltage Duration Logic*. ➤ Updated *Table 4.28: Undervoltage Settings*, *Table 4.29: Overvoltage Settings*, and *Table 4.32: Frequency Settings*. ➤ Updated *Breaker Failure Protection*. ➤ Updated *Table 4.34: Arc-Flash Protection Settings* and *Table 4.36: Trip and Close Logic Settings*. ➤ Updated *Figure 4.45: Stop/Trip Logic*. ➤ Updated *52A, 52A_CR, and 52A_CB Contactor/Breaker Status Conditions SELOGIC Control Equations* including *Figure 4.47: Motor State Logic*. ➤ Updated *Start/Stop Control*. ➤ Updated *Data Reset and Alarm Settings*, including *Table 4.45: Data Reset and Alarm Settings*. ➤ Updated *Table 4.54: Ethernet Port Settings*. ➤ Updated *General Settings* and *Table 4.55: HMI General Settings* and added *Figure 4.58: Configuration of HMI STOP Pushbutton for Emergency Stop*. Section 5 ➤ Updated *Metering*. ➤ Added *Energy Metering* and *Maximum and Minimum Metering*, including *Table 5.2: Maximum/Minimum Meter Values*. ➤ Updated *Motor Operating Statistics*, including *Figure 5.13: MOTOR Command Example*. ➤ Updated *Motor Start Report*. Section 7 ➤ Updated *Network Configuration* and *Table 7.2: Ethernet Port Configuration Settings* and added *Figure 7.5: Dual Ethernet Configuration With NETMODE := FAILOVER and Using Network Link Failure (SELOGIC Equation) Setting to Force Switchover*. ➤ Updated *Failover Mode* and *Unmanaged Switch Mode*. ➤ Updated *Figure 7.17: SHOW Command Response*. ➤ Updated *Table 7.28: Meter Class* and *Table 7.29: MOTOR Command*. ➤ Added a note on the STA S report to *STATUS Command (Relay Self-Test Status)*.

Table A.5 Instruction Manual Revision History (Sheet 8 of 11)

Date Code	Summary of Revisions
	Section 8 ➤ Updated *Figure 8.2: SEL-3421 Motor Relay HMI Layout* and *Table 8.4: SEL-3421 Motor Relay HMI Navigation*. ➤ Updated *Figure 8.5: Main Menus and Meter Submenu*, *Figure 8.6: Meter Menu and Demand Submenu*, *Figure 8.7: Relay Response When Demand Metering is Reset*, *Figure 8.8: Relay Responses When No Math Variables Enabled*, *Figure 8.9: Events Menu and Display Submenu*, *Figure 8.10: Relay Response When No Event Data Available*, *Figure 8.11: Relay Responses When Events Are Cleared*, *Figure 8.12: Relay Response When Events Is Triggered*, *Figure 8.13: Main Menu and Monitor Submenu*, and *Figure 8.14: Monitor Menu and Display Motor Data Submenu*. ➤ Updated *Control Menu* and added a stop motor action note as well as one for the HMI_STRD setting. ➤ Updated *Figure 8.18: Main Menu and Info Submenu*. ➤ Updated *Control Pushbuttons Operation*. ➤ Updated *START/STOP Pushbutton Operation* and added a note on for HMI_CTRL := ACK_DIS as well as one for changes to the HMI_CTRL and HMIPBSTP settings. Section 10 ➤ Updated *Table 10.8: Troubleshooting*. Appendix A ➤ Updated *Table A.1: SEL-849 Firmware Revision History*, *Table A.2: SEL-3421 and SEL-3422 Firmware Revision History*, *Table A.3: SELBOOT Firmware Revision History*, and *Table A.4: SEL-849 ICD File Revision History*. Appendix B ➤ Updated *Upgrade the Relay SELBOOT Firmware Loader Using a Terminal Emulator* and added a note for the R105 firmware. ➤ Updated *Upgrade the Relay Firmware Using the Web Server*, *Upgrade the Relay Firmware Using ACSELERATOR QuickSet*, and *Upgrading the HMI Firmware*. Appendix D ➤ Updated *Table D.23: Modbus Quantities Table*. Appendix E ➤ Updated *GOOSE* and *SEL ICD File Versions*. ➤ *Table E.8: New Logical Node Extensions*, *Table E.10: Demand Metering Statistics*, *Table E.11: Motor Measurement Data*, *Table E.13: Generic Process I/O Logical Node Class Definition*, *Table E.14: Logical Device: PRO (Protection)*, *Table E.15: Logical Device: MET (Metering)*, *Table E.16: Logical Device: CON (Remote Control)*, *Table E.17: Logical Device: ANN (Annunciation)*, and *Table E.18: Logical Device: CFG (Configuration)*. Appendix F ➤ Updated *Table F.1: Relay Word Bits*. Appendix G ➤ Updated *Table G.1: Analog Quantities*. Command Summary ➤ Added MET E, MET E R, MET MM, and MET MM R commands. ➤ Updated VEC D and VEC E command descriptions.
20150220	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 the *Specifications*.
20141107	Section 2 ➤ Updated *Figure 2.1: Relay Features and Connections* for G5/D5 and G3/D3 terminal on EIA-232 port. ➤ Revised *Table 2.8: Terminal Block F—Optional AC Voltage Inputs (as High as 690 Vac Line-to-Line)* for terminal numbers. ➤ Revised *Figure 2.8: Single-Phase Voltage Connections* for terminal numbers. ➤ Added a 3-Wire Direct Connection (Grounded System) (Set DELTA_Y := DELTA and PTR := 1.00) to *Figure 2.9: Voltage Connections.* ➤ Added a note to *Figure 2.9: Voltage Connections* about VN connecting VN and VB when DELTA_Y := DELTA to ensure correct operation of the relay.

Table A.5 Instruction Manual Revision History (Sheet 9 of 11)

Date Code	Summary of Revisions
	Section 4 ➤ Updated equation in *Table 4.7: Overload Trip Time Equations* for Hot Stator Time when 2.5 >I>OLPU when SETMETH := Curve. Section 9 ➤ Updated *Oscillography* for SYNCHROWAVE Event 2015. Appendix A ➤ Updated *Table A.1: SEL-849 Firmware Revision History, Table A.2: SEL-3421 and SEL-3422 Firmware Revision History,* and *Table A.4: SEL-849 ICD File Revision History* for firmware version R104.
20140703	Section 1 ➤ Added the SEL-849 Accessory Lug Kit information to *Accessories*. Section 2 ➤ Added the part number, installation drawing, and installation guide information for the SEL-849 Accessory Lug Kit.
20140502	Preface ➤ Added the product label for externally wetted inputs with high voltage power supply. Section 1 ➤ Added the externally wetted digital inputs option to *Models, Options, and Accessories*. ➤ Added *Optoisolated Control Inputs (Externally Wetted to 24/48 Vdc/Vac or 110/125 Vdc/Vac)* to the *Specifications*. ➤ Updated the pickup and dropout times for *Optoisolated Control Inputs (Internally Wetted to 24 Vdc)* in the *Specifications*. Section 2 ➤ Added text for *Table 2.3: Terminal Block B–Base Relay Six (6) Optoisolated Digital Inputs*. ➤ Updated *Figure 2.10: Connection Diagram for Factory-Default I/O Assignments Full-Voltage Nonreversing Starter (STARTRTY := FVR)*. ➤ Added a note for *Figure 2.12: Connection Diagram for Factory-Default I/O Assignments Two-Speed Starter (STARTRTY := 2SPEED)*. ➤ Added a note for *Figure 2.13: Connection Diagram for Factory-Default I/O Assignments Star-Delta Starter (STARTRTY := STAR_D)*. ➤ Added a note for *Figure 2.14: Connection Diagram for Factory-Default I/O Assignments Feeder Application (APP := FEEDER)*. ➤ Added a note for *Figure 2.15: Connection Diagram for Motor Application Using Breaker Full-Voltage Nonreversing Starter*. ➤ Added a note for *Figure 2.16: Connection Diagram for Factory-Default I/O Assignments Full-Voltage Nonreversing Starter (With Variable Frequency Drive)*. Section 3 ➤ Updated the note for *Figure 3.26: Network Communications Parameters Dialog Box*. Section 4 ➤ Updated *Figure 4.42: Stop/Trip Logic* and *Figure 4.45: Start/Close Logic*. ➤ Revised the default setting for OUT01 to include STOP. OUT01 := (STR_CLO OR (OUT01 AND (NOT STOPPED OR 52A))) AND NOT (TRIP OR STOP) in *Table 4.39: Control Output Equations and Contact Behavior Settings*. ➤ Added the setting TRIP ON STOP, TRIPONST := N, which disables latching of the TRIP LED when the motor is stopped in *Table 4.35: Trip and Close Logic Settings*. ➤ Updated the text for *TDURD Minimum Trip Time*. ➤ Updated the text for *Local/Remote Control*. ➤ Added HMI Control Mode HMI_CTRL setting which enables you to enable/disable or block the control operations via the SEL-3421 or SEL-3422 HMI in *Table 4.54: HMI General Settings*. ➤ Added a caution note for *Table 4.54: HMI General Settings*. ➤ Revised the default setting for the number of display points, EDP = 2, in *Table 4.54: HMI General Settings*. ➤ Updated the text for *Start/Stop Control*. ➤ Updated *Figure 4.55: Display Point Settings, Viewed Using Web Browser*. ➤ Updated the default setting for EFTPSERV to Y in *Table 4.53: Ethernet Port Settings*.

Table A.5 Instruction Manual Revision History (Sheet 10 of 11)

Date Code	Summary of Revisions
	Section 7 ➤ Added a note for *Password Requirements*. ➤ Updated *Communications Protocols* text, *Table 7.5: Supported* SEL-849 *Communications Protocols*, *Table 7.6: Protocol Session Limits*, and *Table 7.7: Telnet Settings*. ➤ Updated text for *File Transfer Protocol (FTP)* and added *Table 7.8: FTP Settings*. Section 8 ➤ Updated text for *Control Menu*. ➤ Added text for *Restoring Passwords and Port 1 Settings to Default Using the TARGET RESET Pushbutton*. ➤ Updated *Table 8.4: SEL-3421 Motor Relay HMI Navigation*. ➤ Added a note for *Control Pushbuttons Operation*. ➤ Revised conditions for START pushbutton operation in *Control Pushbuttons Operation*. ➤ Revised conditions for STOP pushbutton operation in *Control Pushbuttons Operation*. ➤ Revised *START/STOP Pushbutton Operation*. Section 9 ➤ Updated text for Ethernet File Transfer Protocol COMTRADE file retrieval in *Retrieving Raw Data Oscillograms*. Section 10 ➤ Added text for HMI diagnostics in *Self-Test*. ➤ Updated *Table 10.7: Relay Self-Tests*. Appendix A ➤ Updated *Table A.1: SEL-849 Firmware Revision History*. Appendix E ➤ Updated *Features* simultaneous IEC 61850 MMS client sessions from six to seven. ➤ Updated the number of buffered and unbuffered report control blocks from six to seven in *Features* and *IEC 61850 Operation* and the total number of report control blocks from twelve to fourteen in *IEC 61850 Operation*. ➤ Updated *Figure E.1:* SEL-849 *Predefined Reports*. ➤ Updated the default values in *Table E.4: Buffered Report Control Block Client Access*. ➤ Updated the default values in *Table E.5: Unbuffered Report Control Block Client Access*. ➤ Updated the text and *Figure E.2:* SEL-849 *Datasets* for *Datasets*. ➤ Updated *Table E.8: New Logical Node Extensions*. ➤ Added *Table E.12: Thermal Metering Data Logical Node Class Definition*, *Table E.13: Compatible Logical Nodes With Extensions*, and *Table E.14: Generic Process I/O Logical Node Class Definition*. ➤ Updated *Table E.15: Logical Device: PRO (Protection)*, *Table E.16: Logical Device: MET (Metering)*, *Table E.17: Logical Device: CON (Remote Control)*, *Table E.18: Logical Device: ANN (Annunciation)*, and *Table E.19: Logical Device: CFG (Configuration)*. ➤ Updated the default values in *Table E.5: Unbuffered Report Control Block Client Access*. ➤ Updated the text and *Figure E.2:* SEL-849 *Datasets* for *Datasets*. ➤ Updated *Table E.8: New Logical Node Extensions*. ➤ Added *Table E.12: Thermal Metering Data Logical Node Class Definition*, *Table E.13: Compatible Logical Nodes With Extensions*, and *Table E.14: Generic Process I/O Logical Node Class Definition*. ➤ Updated *Table E.15: Logical Device: PRO (Protection)*, *Table E.16: Logical Device: MET (Metering)*, *Table E.17: Logical Device: CON (Remote Control)*, *Table E.18: Logical Device: ANN (Annunciation)*, and *Table E.19: Logical Device: CFG (Configuration)*.
20130920	Preface ➤ Updated product compliance labels. Section 1 ➤ Updated the *Specifications* for cULus approvals, contact outputs, and power supply. Section 2 ➤ Updated the paragraph for VFD or VSD motor protection. Section 3 ➤ Added a note showing the default passwords for Access Levels 1 and 2 for *Figure 3.25: Serial Port Communication Parameters Dialog Box* and *Figure 3.26: Network Communication Parameters Dialog Box*. ➤ Added a note for *Figure 3.26: Network Communication Parameters Dialog Box* to set EFTPSERV := Y to communicate with SEL-849 via FTP.

Table A.5 Instruction Manual Revision History (Sheet 11 of 11)

Date Code	Summary of Revisions
	Section 4 ➤ Added an SALARM footnote to *Table 4.44: Data Reset and Alarm Setting*. Section 7 ➤ Corrected the default setting of EPORT to Y in *Table 7.2: Ethernet Port Configuration Settings*. ➤ Corrected the default setting of ETELNET to Y in *Table 7.6: Telnet Settings*. Appendix A ➤ Updated *Table A.1: SEL-849 Firmware Revision History*. Appendix B ➤ Updated the description for *Upgrading the HMI Firmware*.
20130318	Appendix A ➤ Updated for firmware revision R101.
20130104	➤ Initial version.

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Appendix B
Firmware Upgrade Instructions

Overview

These instructions guide you through the process of upgrading firmware in the device. The firmware upgrade will be either a standard release or a point release. A standard release adds new functionality to the firmware beyond the specifications of the existing version. A point release is reserved for modifying firmware functionality to conform to the specifications of the existing version.

A standard release is identified by a change in the R-number of the device FID string.

Existing firmware:

FID=SEL-849-**R100**-V0-Z001001-D20130104

Standard release firmware:

FID=SEL-849-**R101**-V0-Z001001-D20130104

A point release is identified by a change in the V-number of the device FID number.

Existing firmware:

FID=SEL-849-R106-**V0**-Z001001-D20130104

Point release firmware:

FID=SEL-849-R106-**V1**-Z001001-D20130104

SEL occasionally offers firmware upgrades to improve the performance of your relay. Because the SEL-849 relays store firmware in flash memory, changing physical components is unnecessary. Upgrade the relay firmware by downloading a file from your computer to the relay via the front-panel serial port using ACSELERATOR QuickSet SEL-5030 Software or a terminal emulator as outlined in the following sections. For relays with the IEC 61850 option, verify the IEC 61850 protocol after the upgrade (see *Protocol Verification for Relays With IEC 61850 Option*).

Digitally Signed Firmware Files

The SEL-849 supports digitally signed firmware files for firmware upgrades. These firmware upgrade files are in compressed form to reduce file transfer times and are digitally signed by SEL using a secure hash algorithm. The signature ensures that the file has been provided by SEL and that its contents have not been altered. Once uploaded to the relay, the signature of the firmware is verified with a public key number that is stored on the relay from the factory. If the relay cannot verify the signature, it rejects the file.

The name of the digitally signed firmware file is of the form r*xxx*849.zds, where r*xxx* is the firmware revision number, 849 indicates the relay type, and .zds is the file extension reserved for digitally signed files.

Upgrade the Relay SELBOOT Firmware Loader Using a Terminal Emulator

NOTE: Make sure the relay, HMI, and SELBOOT firmware revisions are compatible. Refer to Appendix A: Firmware, ICD, and Manual Versions in this manual.

The process for upgrading SELBOOT is similar to *Upgrade the Relay Firmware Using a Terminal Emulator*. To determine if SELBOOT must be updated, do the following:

Step 1. Establish communication between the relay and a personal computer, as described in *Step 2* of *Upgrade the Relay Firmware Using a Terminal Emulator*.

Step 2. From the computer, type **ID <Enter>**.

The relay responds with the following:

```
=>>ID <Enter>
"FID=SEL-849-R104-V0-Z002002-D20141107","08A9"
"BFID=BOOTLDR-R101-V0-Z000000-D20140317","0946"
"CID=20B9","025A"
"DEVID=SEL-849","03CF"
"DEVCODE=78","0316"
"PARTNO=0849001002B0200","057D"
"SERIALNO=1141110441","04FC"
"CONFIG=11000201","03E8"
"iedName=","0360"
"type=","026F"
"configVersion=","0609"
=>>
```

Step 3. Locate the Boot Firmware Identification String (BFID).

Step 4. Find the SELBOOT revision number in the BFID (R*xxx*). Compare the revision number with the revision numbers listed in *Table A.3* to determine if it is necessary to upgrade SELBOOT. If an upgrade is necessary, follow the process mentioned below. Otherwise, upgrade the relay firmware using one of the three methods mentioned later in the section.

Step 5. To upgrade SELBOOT, obtain the new SELBOOT file (r*xxx*8*xx*.zds) by contacting SEL technical support. Follow the instructions under *Upgrade the Relay Firmware Using a Terminal Emulator*. In *Step 6* replace the **REC** command with **REC BOOT** and follow the prompts.

Step 6. When the relay prompts: `Press any key to begin transfer and then start transfer at the terminal`. press **<Enter>** and select the SELBOOT file.

Step 7. When the SELBOOT upgrade is successful, the relay prompts:

`Erasing` SELBOOT`. Writing` SELBOOT`.`

SELBOOT `upload completed successfully. Restarting` SELBOOT`.`

Change the data rate of the communications software to 9600 bps and press **<Enter>**.

Step 8. Type **EXI <Enter>** at the SELBOOT `!>` prompt to exit SELBOOT. The relay should display the = prompt.

If the relay does not return the SELBOOT `!>` prompt within two minutes after displaying `Restarting SELboot`, cycle the relay power. The relay should restart and display the = prompt.

Once the SELBOOT upgrade is complete, select a firmware upgrade method as discussed later in the section. It is not necessary to save the relay settings and other data again if you did this before upgrading SELBOOT.

Upgrade the Relay Firmware Using the Web Server

The web server offers a convenient method for upgrading relay firmware. Located on the left navigation pane of the screen, the **System** menu contains four categories: **File Management**, **Passwords**, **Date/Time**, and **Device Reset**. **File Management** allows you to upgrade firmware in the relay.

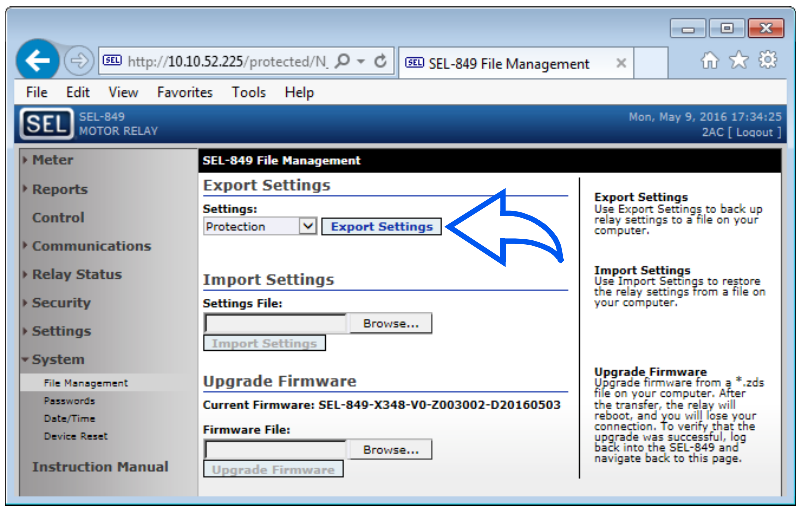
When preparing to upgrade relay firmware, you must first have the new relay firmware. The firmware is designated with a .zds extension.

Refer to *Section 3: PC Interface* for connecting and logging on to the SEL-849 web server using the Ethernet port.

Step 1. Save the current relay settings and other data.

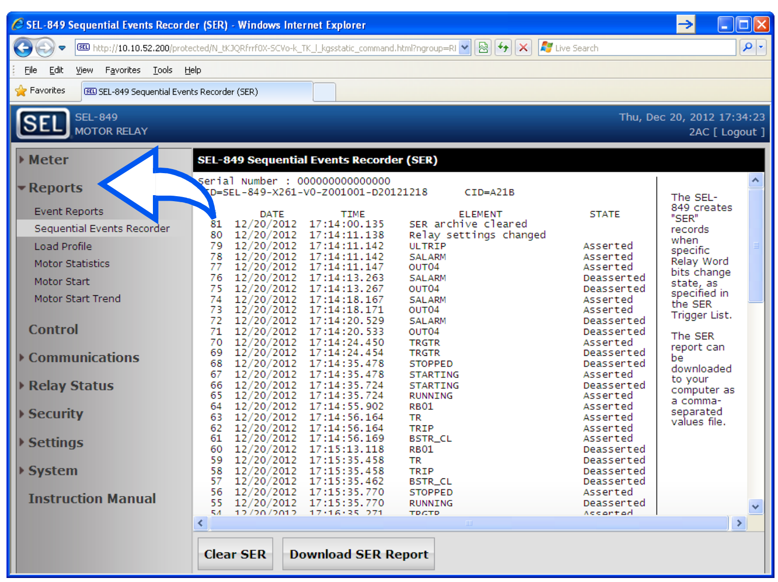
a. Click **System > File Management** from the left navigation pane of the webpage.

b. Select the category from the **Settings** list to export and save settings from the relay before starting the upgrade process.



c. Save the various reports by clicking **Reports** on the left navigation pane of the webpage.

Refer to *Reports on page 3.9* for more details on saving different reports.

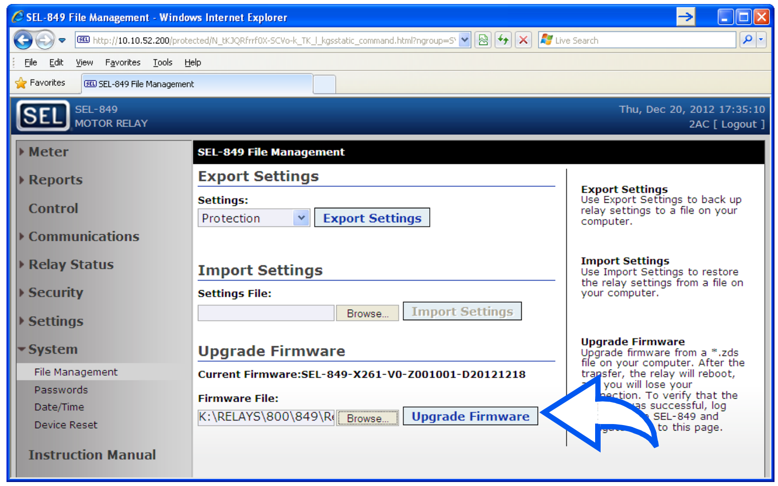


Step 2. After saving the relay settings and other data, proceed with the firmware upgrade process.

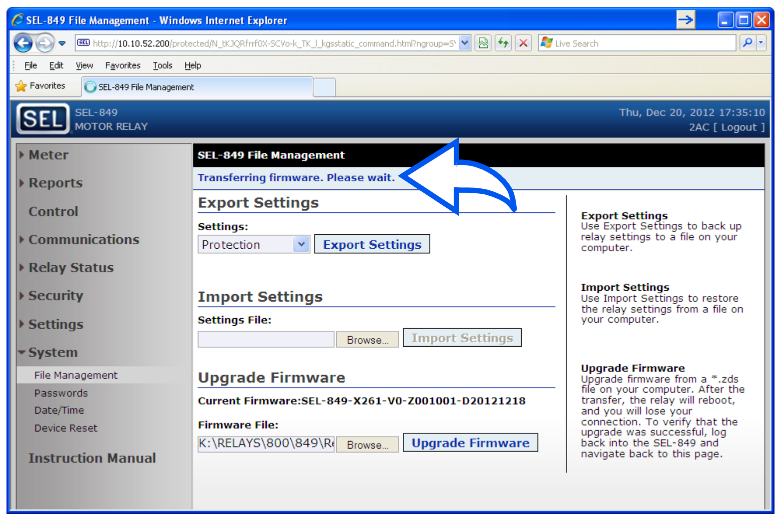
a. Click **System > File Management** from the left navigation pane of the webpage.

b. Click the **Browse** button to select the firmware you want to send to the relay.

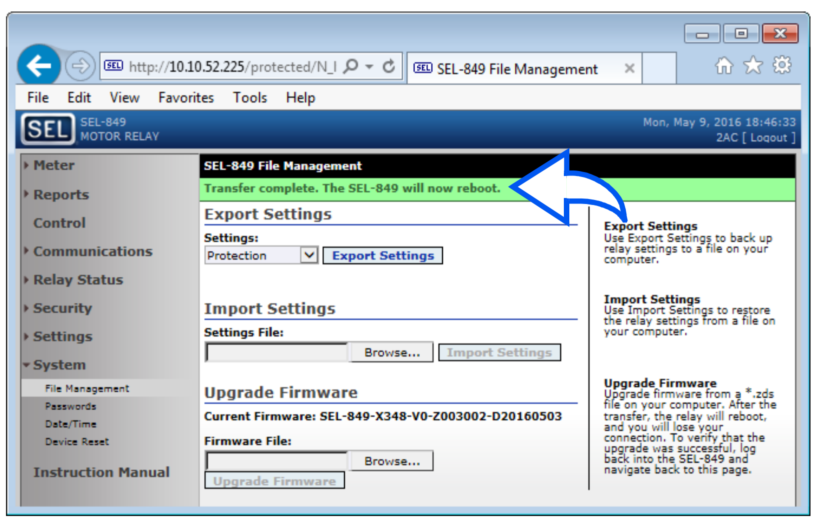
c. Click **Upgrade Firmware** to start the upgrade process.



Once the upgrade process is in progress, the relay acknowledges with the message, **Transferring firmware. Please wait**.



After the relay finishes the firmware transfer, an acknowledgment message appears and the relay reboots.



NOTE: After the relay reboots, if the **ENABLED** LED on the top panel of the relay is not illuminated or if the HMI shows a STATUS FAIL or Non_Vol Failure, then open a terminal emulator using the serial port and use the following procedure to restore the factory-default settings. Refer to Upgrade the Relay Firmware Using a Terminal Emulator for terminal emulator setup and connections.

a. Set the communications software settings to 9600 bps, 8 data bits, and 1 stop bit.

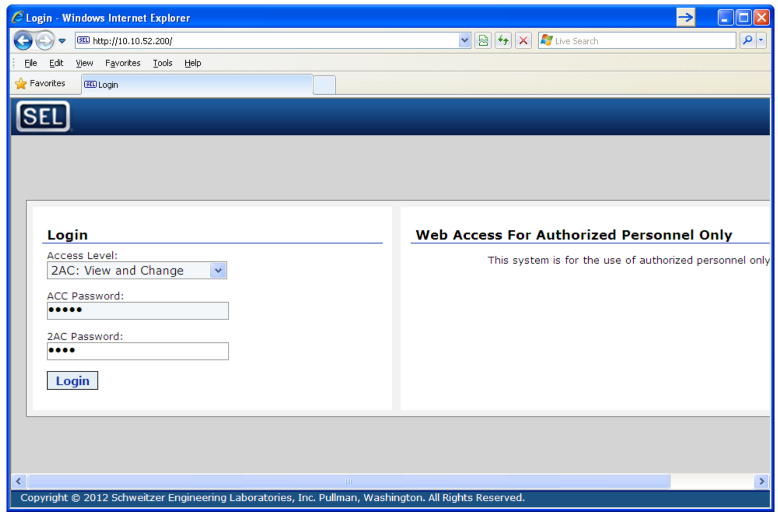
b. Enter Access Level 2 by issuing the **2AC** command.

c. Issue the **R_S** command to restore the factory default.

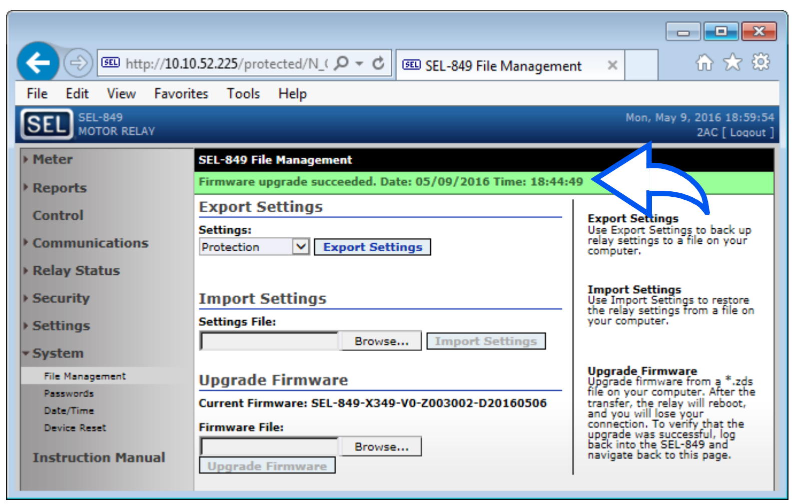
The relay will reboot and come up ENABLED.

Note that the relay firmware retains the IP address, subnet mask, and default router settings after an **R_S** command is issued.

Step 3. After the relay reboots, the Login screen appears on the web server. Log in to the relay to verify completion of the firmware upgrade process.

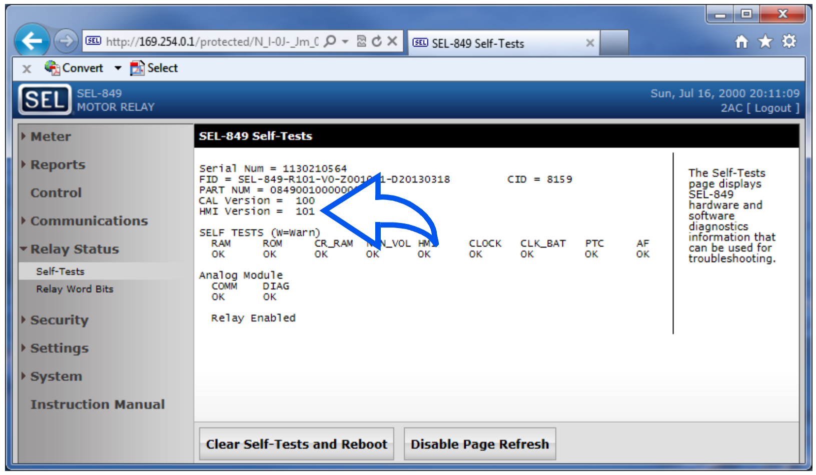


An acknowledgment message appears that verifies a successful firmware upgrade.



Step 4. Check that the relay firmware version matches the version that was used for the upgrade and that the relay is enabled.

Click on **Relay Status** > **Self-Tests** to view the status report.



Upgrade the Relay Firmware Using ACSELERATOR QuickSet

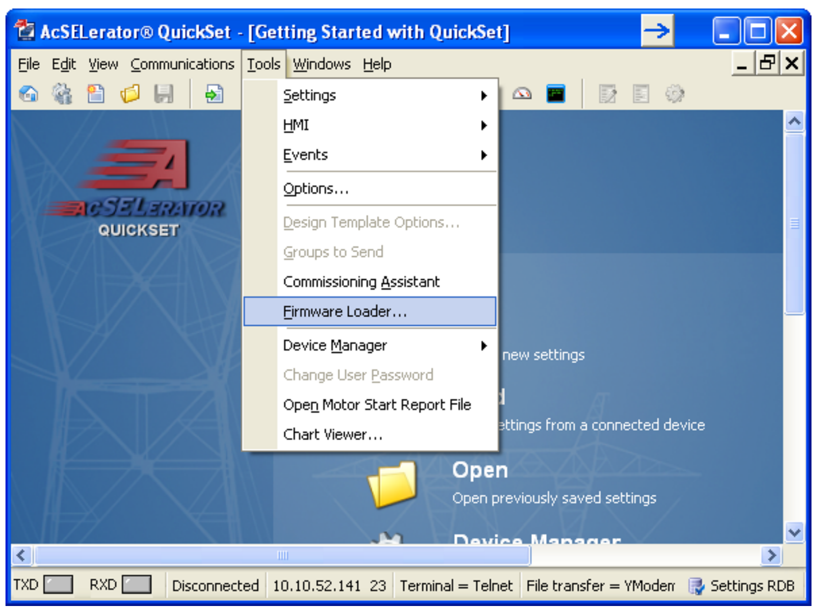
Refer to *Section 3: PC Interface, QuickSet Software on page 3.20* for setup and connection procedure.

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.

NOTE: Change the baud rate of the relay serial port to 9600 before starting the Firmware Loader.

Firmware Loader does not start if:

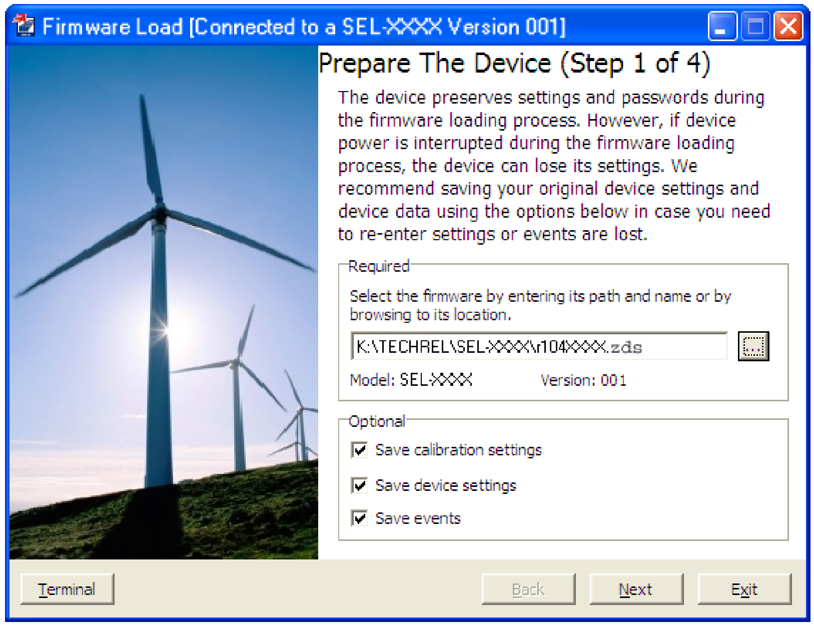
- ➤ The device is unsupported by ACSELERATOR QuickSet.
- ➤ The device is not connected to the computer with a communications cable.
- ➤ The device is disabled.



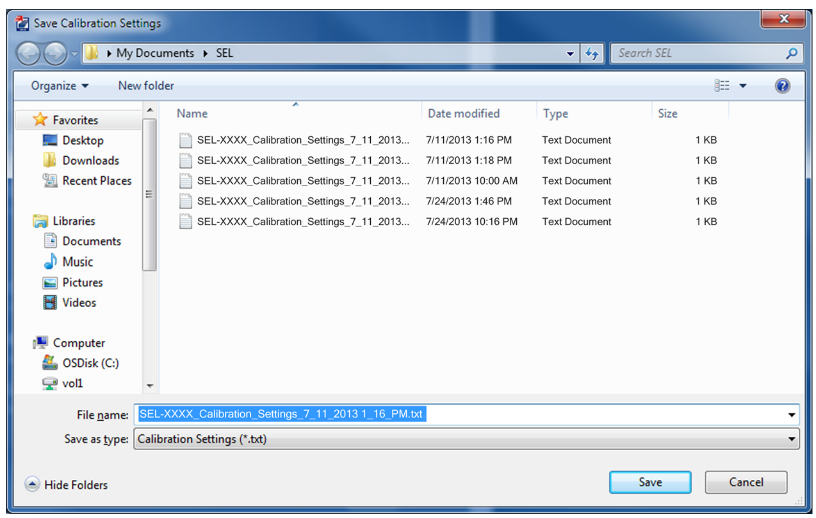
Step 1. If the relay is in service, open the relay control circuits.

Step 2. Prepare the device.

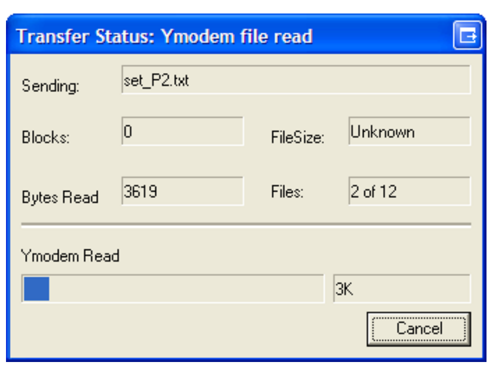
a. Select the firmware to be loaded using the browse control and select **Save calibration settings**, **Save device settings**, and **Save events** from **Optional**. Select **Next** to continue the wizard.



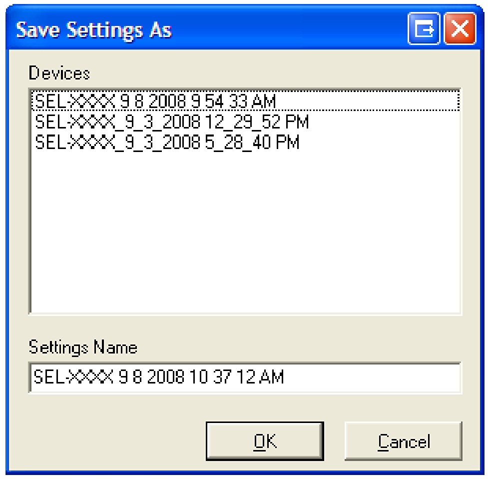
b. Select a file name in which to save the selected settings or accept the defaults as shown. Click **Save**.



c. The **Transfer Status**: **Ymodem file read** window shows the transfer progress of the settings file. Clicking **Cancel** stops the transfer.

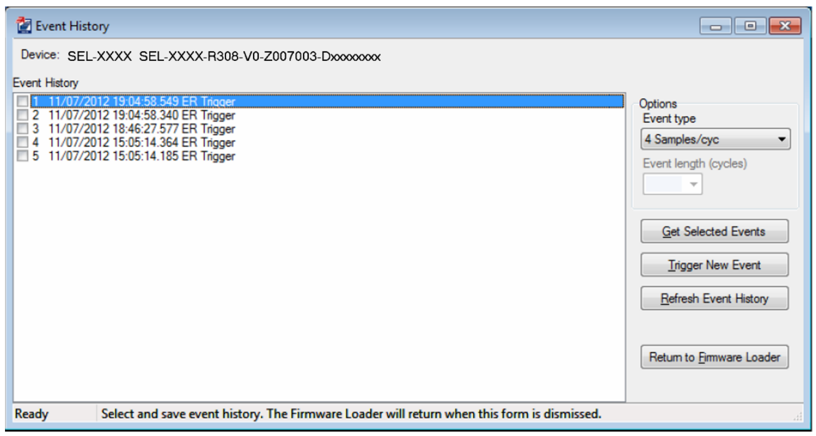


After the device settings are downloaded, select a file name and path to save the settings or accept the default, as shown.



d. Click **Return to Firmware Loader** if this product does not have any event reports.

If there are any event reports to be saved, click the **Get Selected Event** button after selecting the events. After saving them, click the **Return to Firmware Loader** button.

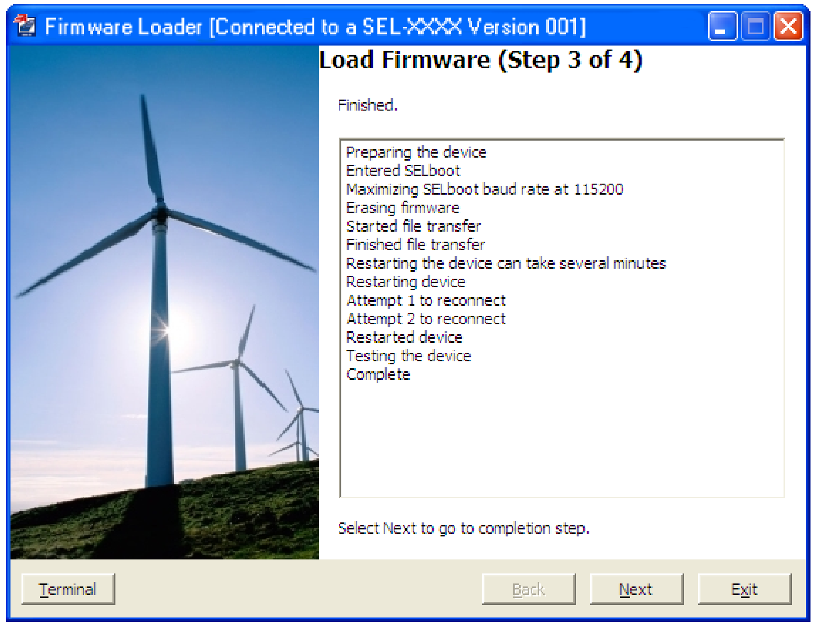


Step 3. Transfer Firmware.

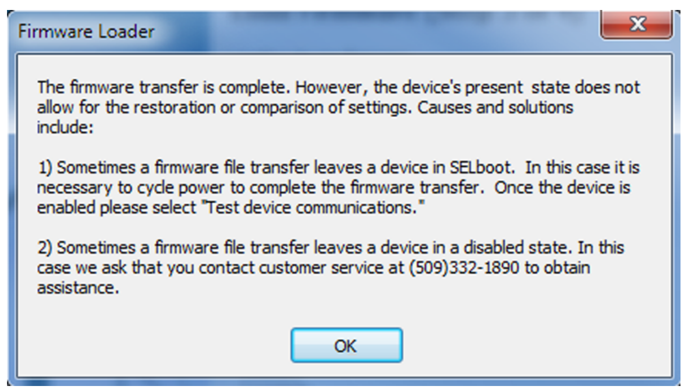
Click **Next** to begin the firmware transfer.

Step 4. 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 appears when one of the two conditions mentioned occurs.



If the relay is disabled as mentioned in condition number two, check the **ENABLED** LED on the top panel of the relay. If the **ENABLED** LED is not illuminated or the HMI displays `STATUS FAIL` or `Non_Vol Failure`, use the following procedure to restore the factory-default settings.

a. Click on the **Terminal** button on the Firmware Loader screen of ACSELERATOR QuickSet.

b. Set the communications software settings to 9600 bps, 8 data bits, and 1 stop bit.

c. Enter Access Level 2 by issuing the **2AC** command.

d. Issue the **R_S** command to restore the factory-default settings.

The relay reboots and is ENABLED.

Note that the port settings are restored to the default settings due to the **R_S** command.

Step 5. Verify Device.

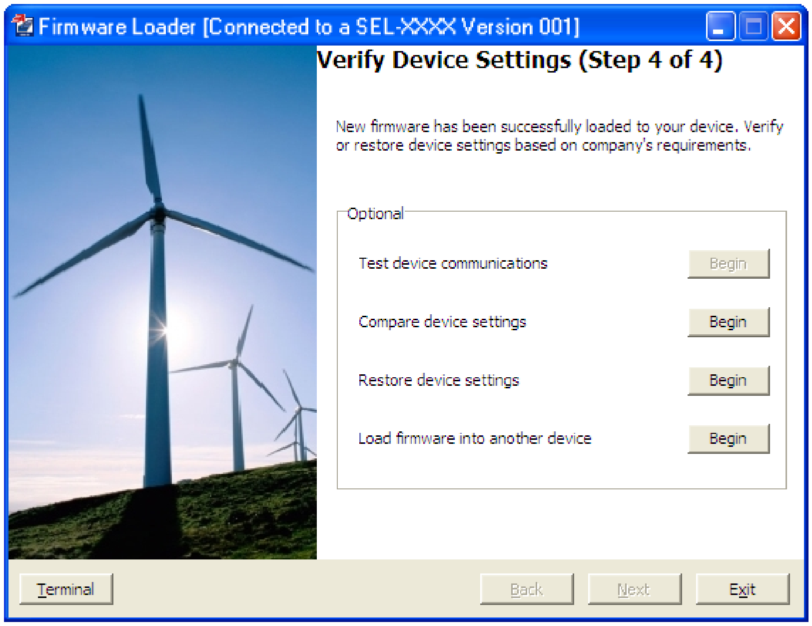
Four verification options are provided and when enabled these options perform as follows.

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 2*: *Prepare Device* to repeat the firmware-loading process with another device.



Upgrade the Relay Firmware Using a Terminal Emulator

The following instructions assume that 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 (e.g., send and receive binary files).

Step 1. If the relay is in service, open the relay control circuits.

Step 2. Connect the PC to serial Port 1 using an SEL-C234T (or equivalent) serial communications cable to the personal computer serial port and enter Access Level 2.

Step 3. Save the current relay settings and other data.

PC software (described in *Section 3: PC Interface*) can be used to save and restore settings easily. Otherwise, use the following steps.

NOTE: In order to save the calibration settings, perform the **SHO C** command from the terminal by logging into the CAL level using the CAL level password. The factory-default password for CAL level is CLARKE.

a. Issue the following commands at the ASCII prompt: **SHO**, **SHO L**, **SHO P**, **SHO H**, **SHO R**, **SHO C**, etc.

b. Record all the settings for possible re-entry after the firmware upgrade.

c. We recommend that you save all stored data in the relay, including events, before the upgrade.

Step 4. Start the firmware upgrade.

NOTE: Change the data rate of the relay serial port to 9600 before issuing the **L_D** command to start the upgrade process.

a. Issue the **L_D** command to the relay.

b. Type **Y** <**Enter**> at the following prompt:

`Disable relay to receive firmware (Y/N)?`

c. Type **Y** <**Enter**> at the following prompt:

`Are you sure (Y,N)?`

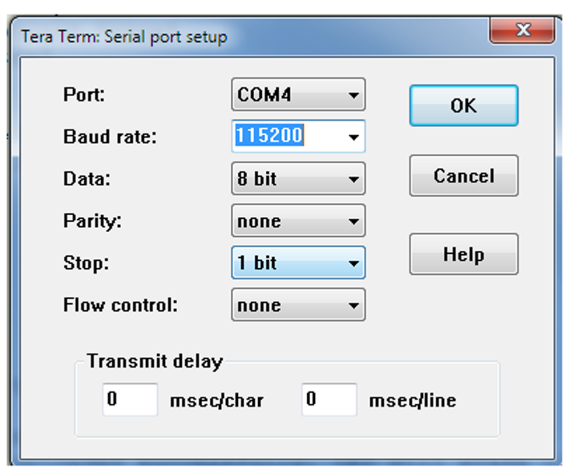
The relay will send the `!>` prompt.

Step 5. Change the baud rate, if necessary.

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.



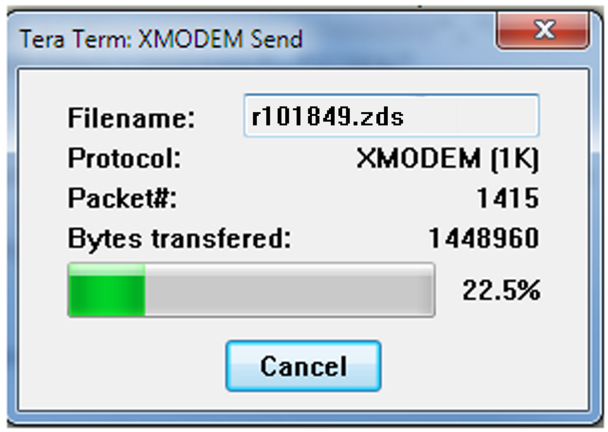
Step 6. Begin the transfer of new firmware to the relay by issuing the **REC** command.

Step 7. Type **Y** to erase the existing firmware or press <**Enter**> to abort.

Step 8. Press any key (e.g., <**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-1K protocol and send the file that contains the new firmware (e.g., r101*xxx*.zds).



The file transfer takes less than 5–15 minutes at 115200 bps, 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, including checking the **ID** command and **STA** command responses.

```
=>>L_D <Enter>
Disable relay to receive firmware (Y,N)? Y <Enter>
Are you sure (Y,N)?  Y <Enter>
Relay Disabled


!>BAU 115200 <Enter>

!>

!>REC <Enter>
Receive New Firmware Y/N? Y <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.CC
Erasing firmware.
Erase successful.
Writing new firmware.
Upload completed successfully. Attempting a restart.


=

=

=ACC <Enter>
Password: ? *****
```

Figure B.1 Firmware File Transfer Process

```
=>>2ACC <Enter>
Password: ? *****

=>>ID <Enter>
"FID=SEL-849-R101-V0-Z001001-D20130318","08A6"
"BFID=BOOTLDR-R100-V0-Z000000-D20130104","093E"
"CID=8159","0254"
"DEVID=SEL-849","03CF"
"DEVCODE=78","0316"
"PARTNO=084900100000000","0567"
"SERIALNO=1130210564","0501"
"CONFIG=11000201","03E8"

=>>STA <Enter>

SEL-849                                  Date: 07/16/2000   Time: 01:37:32.437
MOTOR RELAY                              Time Source: Internal


Serial Num = 1130210564
FID = SEL-849-R101-V0-Z001001-D20130318         CID = 8159
PART NUM = 084900100000000
CAL Version =  100
HMI Version =  101

SELF TESTS (W=Warn)
  RAM     ROM     CR_RAM  NON_VOL HMI     CLOCK   CLK_BAT   PTC     AF
  OK      OK      OK      OK      OK      OK      OK        OK      OK

Analog Module
  COMM    DIAG
  OK      OK

  Relay Enabled

=>>
```

Figure B.1 Firmware File Transfer Process (Continued)

Step 10. The relay illuminates the **ENABLED** top-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 HMI displays `STATUS FAIL` or `Non_Vol Failure`, use the following procedure to restore the factory-default settings:

a. Set the communications software settings to 9600 bps, 8 data bits, and 1 stop bit.

b. Enter Access Level 2 by issuing the **2AC** command.

c. Issue the **R_S** command to restore the factory-default settings.

The relay will reboot and come up ENABLED.

Note that the relay firmware retains the IP address, subnet mask, and default router settings after an **R_S** command is issued.

d. 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 communications processor port if you have a communications processor connected.

This step re-establishes automatic data collection between the SEL communications processor and the SEL relay. Failure to perform this step can result in automatic data collection failure when cycling communications processor power.

Protocol Verification for Relays With IEC 61850 Option

NOTE: A relay with optional IEC 61850 protocol requires the presence of one valid CID file to enable the protocol. You should only transfer a CID file to the relay if you want to implement a change in the IEC 61850 configuration or if new relay firmware does not support the current CID file version. If you transfer an invalid CID file, the relay will disable the IEC 61850 protocol, as it no longer has a valid configuration. To restart IEC 61850 protocol operation, you must transfer a valid CID file to the relay.

Perform the following steps to verify that the IEC 61850 protocol is still operational after a relay firmware upgrade 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.

a. Establish an FTP connection to the relay Ethernet port.

b. Open the ERR.TXT file.

   If the ERR.TXT file is empty, the relay found no errors during CID file processing and IEC 61850 should be enabled. Go to *Step c* if ERR.TXT is empty.

   If the ERR.TXT file contains error messages relating to CID file parsing, the relay has disabled the IEC 61850 protocol. Use ACSELERATOR Architect SEL-5032 Software to convert the existing CID file and make it compatible again.

   i. Install the ACSELERATOR Architect Software upgrade that supports your required CID file version.

   ii. Run ACSELERATOR Architect and open the project that contains the existing CID file for the relay.

   iii. Download the CID file to the relay.

   Upon connecting to the relay, ACSELERATOR Architect detects the upgraded relay firmware and prompts you to allow it to convert the existing CID file to a supported version. Once converted, downloaded, and processed, the valid CID file allows the relay to re-enable the IEC 61850 protocol.

c. In the Telnet session, type **GOO** <**Enter**>.

d. View the GOOSE status and verify that the transmitted and received messages are as expected.

The relay is now ready for your commissioning procedure.

Upgrading the HMI Firmware

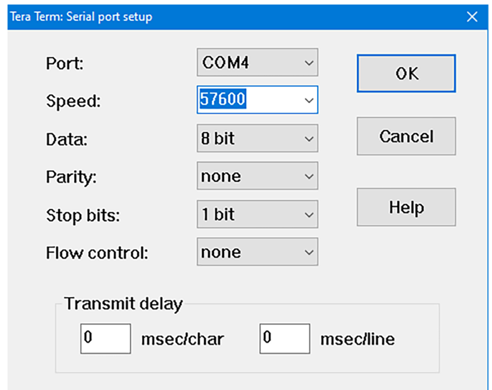
NOTE: This firmware file applies to both the SEL-3421 and the SEL-3422.

The HMI firmware upgrade version is distributed as r*xxx*3421.S19. Rename or copy the file as an HMI.S19 file and save it to your preferred location.

Upgrade Via a Terminal Emulator Using a Serial Port

You can upgrade the HMI firmware using the following steps:

Step 1. Apply power to the SEL-849 and connect the HMI. Change the baud rate on the SEL-849 to 57600 bps to reduce the transmission time. Set the baud rate of the serial communications port to 57600 bps.



Step 2. Log in to the 2AC level of the relay via the terminal emulator.

Step 3. Before the upgrade, note the HMI version using the **STA** command. The SEL-3421 or SEL-3422 Motor Relay HMI must be communicating with the SEL-849.

Step 4. The HMI firmware upgrade version is distributed as r*xxx*3421.S19. Rename or copy the file as an HMI.S19 file and save it to your preferred location. Use the command **FILE WRITE HMI.S19** to start the process.

```
=>>FILE WRITE HMI.S19
C#001 Transfer Complete
```

Browse and select the firmware file from the stored location using the send file option in your communications software. Use the Ymodem and send the file that contains the new firmware. The file write command will transfer the file from the PC to the relay.

The progress of the transfer process is shown on the PC screen.

NOTE: Command should use Ymodem protocol.

Step 5. After the file is sent to the relay, the relay starts the transfer of the code to the HMI. The progress of this transfer is shown on the LCD screen of the SEL-3421 and also as a blinking progression of the LED indicators on the SEL-3421 and SEL-3422 HMIs.

Step 6. The HMI will reboot after the upgrade. Using the **STA** command, verify that the HMI firmware version is upgraded to the new version.

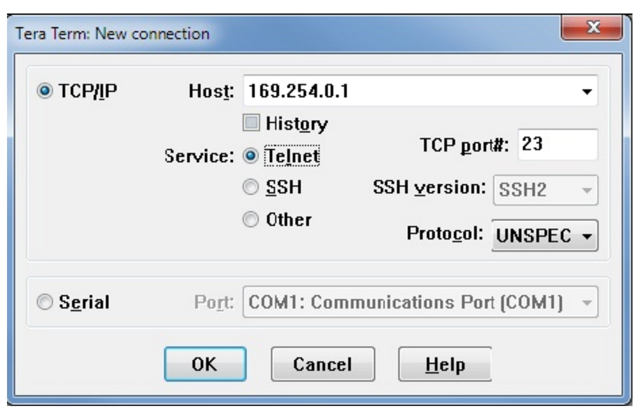
```
=>>STA <Enter>

SEL-849                                      Date: 07/16/2013   Time: 01:34:59.655
MOTOR RELAY                                  Time Source: Internal


Serial Num = 1130210564
FID = SEL-849-R101-V0-Z001001-D20130318          CID = 8159
PART NUM = 0849001000000000
CAL Version =  100
HMI Version =  101

SELF TESTS (W=Warn)
  RAM     ROM     CR_RAM  NON_VOL HMI     CLOCK   CLK_BAT   PTC     AF
  OK      OK      OK      OK      OK      OK      OK        OK      OK

Analog Module
  COMM    DIAG
  OK      OK

  Relay Enabled

=>>
```

Upgrade Via a Telnet Session Using an Ethernet Port

Step 1. Open a Telnet session for the relay using Hyper-Terminal or any terminal emulator.

Step 2. Log in to the 2AC level of the relay via the terminal emulator.

Step 3. Before the upgrade, note the HMI version using a **STA** command. The SEL-3421 or SEL-3422 Motor Relay HMI must be communicating with the SEL-849.



Step 4. The HMI firmware upgrade version is distributed as r*xxx*3421.S19. Rename or copy the file as an HMI.S19 file and save it to your preferred location. Use the command **FILE WRITE HMI.S19** to start the process. Browse and select the firmware file from the stored location using the send file option in your communications software. Use the Ymodem and send the file that contains the new firmware. The file write command will transfer the file from the PC to the relay. The progress of the transfer process is shown on the PC screen.

```
=>>FILE WRITE HMI.S19
C#001 Transfer Complete
```

NOTE: Command should use Ymodem protocol.

Step 5. After the file is sent to the relay, the relay starts the transfer of the code to the HMI. The progress of this transfer is shown on the LCD screen of the SEL-3421 and also as a blinking progression of the LED indicators on the SEL-3421 and SEL-3422 HMIs.

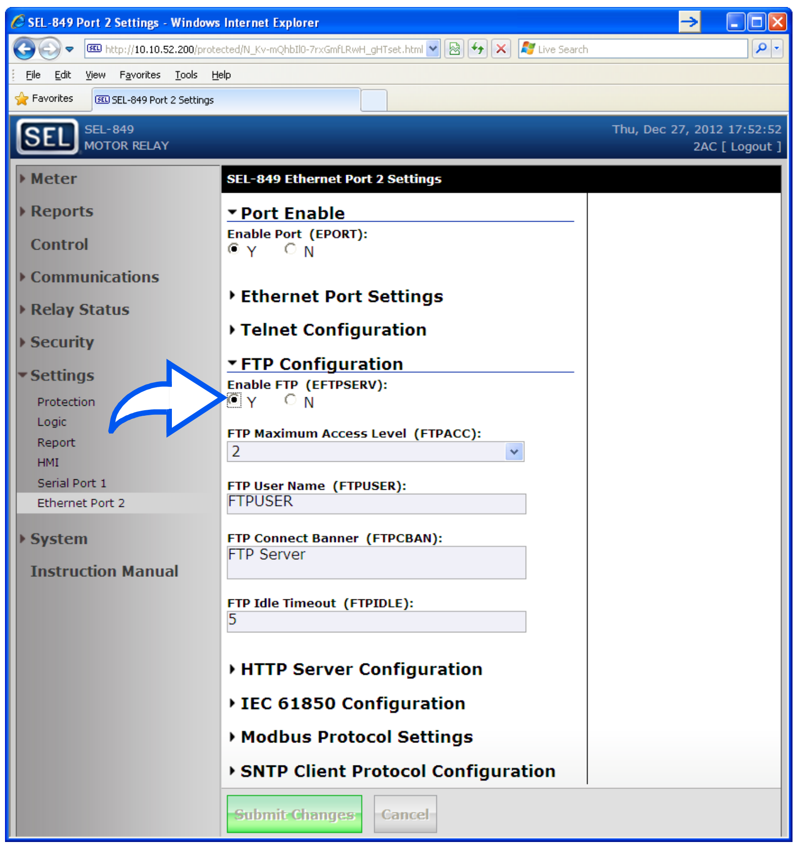
Step 6. The HMI will reboot after the upgrade. Using the **STA** command, verify that the HMI firmware version is upgraded to the new version.

NOTE: HMI firmware upgrade via a Telnet session using Ethernet port is normally faster than the upgrade via terminal emulator using serial port.

```
=>>STA <Enter>

SEL-849                                   Date: 07/16/2013   Time: 01:34:59.655
MOTOR RELAY                               Time Source: Internal


Serial Num = 1130210564
FID = SEL-849-R101-V0-Z001001-D20130318        CID = 8159
PART NUM = 084900100000000
CAL Version =  100
HMI Version =  101

SELF TESTS (W=Warn)
  RAM     ROM     CR_RAM  NON_VOL HMI     CLOCK   CLK_BAT   PTC     AF
  OK      OK      OK      OK      OK      OK      OK        OK      OK

Analog Module
  COMM    DIAG
  OK      OK

  Relay Enabled

=>>
```

Upgrade Via an FTP Session Using an Ethernet Port

Step 1. Log in to the 2AC level of the relay and set EFTPSERV := Y in Port 2 settings using the **Settings** menu shown on the left navigation pan of the web server screen.



Step 2. Open an FTP session in the PC command line for the relay.

Step 3. Log in using the default username FTPUSER and the Access Level 2 password.

```
Z:\>FTP 169.254.0.1
Connected to 169.254.0.1
220 FTP Server
User <169.254.0.1 :<none> >: FTPUSER
331 User name okay, need password.
Password:
230 User logged in, proceed.
```

Step 4. The HMI firmware upgrade version is distributed as r*xxx*3421.S19. Rename or copy the file as an HMI.S19 file and save it to your preferred location. Use the command **PUT C:\HMI.S19,** as shown in the example, to write the firmware file to the HMI.

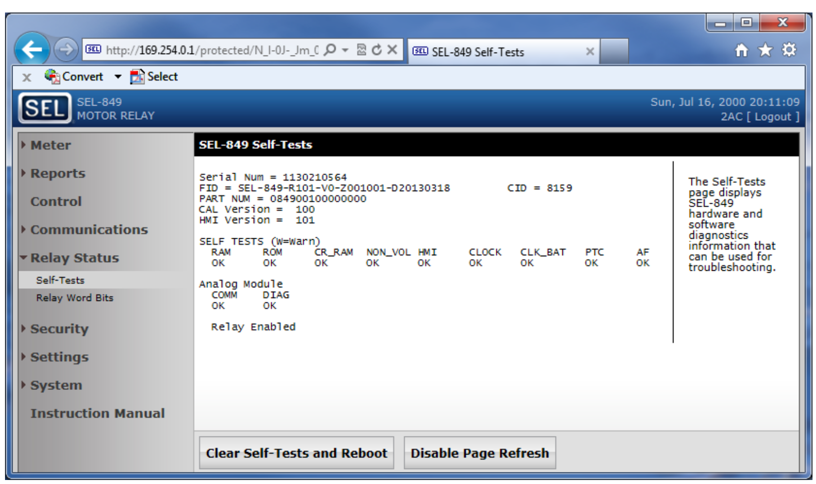
```
ftp> PUT C:\HMI.S19
200 PORT Command okay.
150 File status okay; about to open data connection.
226 Closing data connection.
ftp: 1773429 bytes sent in 1.17Seconds 1513.16Kbytes/sec.
ftp> _
```

Step 5. The progress of this transfer is shown on the LCD screen on the SEL-3421 and also as a blinking progression of the LED indicators on the SEL-3421 and SEL-3422 HMIs.

Step 6. The HMI will reboot after the upgrade.

Check **Relay Status > Self-Tests** on the web server to verify that the HMI firmware is upgraded to the new version.

NOTE: An FTP session is the fastest way to upgrade HMI firmware.



Appendix C
SEL Communications Processors

SEL Communications Protocols

The SEL-849 Motor Management Relay supports the SEL protocols and command sets shown in *Table C.1*.

Table C.1 Supported Serial Command Sets

Command Set	Description
SEL ASCII	Use this protocol to send ASCII commands and receive ASCII responses that are human readable with an appropriate terminal emulation program.
SEL Compressed ASCII	Use this protocol to send ASCII commands and receive Compressed ASCII responses that are comma-delimited for use with spreadsheet and database programs or for use by intelligent electronic devices.
SEL Fast Meter	Use this protocol to send binary commands and receive binary meter and target responses.
SEL Fast Operate	Use this protocol to receive binary control commands.
SEL Fast SER	Use this protocol to receive binary Sequential Events Recorder unsolicited responses.
SEL Fast Message	Use this protocol to write Remote Analog data via unsolicited writes.

SEL ASCII Commands

We originally designed SEL ASCII commands for communication between the relay and a human operator via a keyboard and monitor or a printing terminal. A computer with a serial port can also use the SEL ASCII protocol to communicate with the relay, collect data, and issue commands.

SEL Compressed ASCII Commands

The relay supports a subset of SEL ASCII commands identified as Compressed ASCII commands. Each of these commands results in a comma-delimited message that includes a checksum field. Most spreadsheet and database programs can directly import comma-delimited files. Devices with embedded processors connected to the relay can execute software to parse and interpret comma-delimited messages without expending the customizing and maintenance labor needed to interpret nondelimited messages. The relay calculates a checksum for each line by numerically summing all of the bytes that precede the checksum field in the message. The program that uses the data can detect transmission errors in the message by summing the characters of the received message and comparing this sum to the received checksum.

Most commands are available only in SEL ASCII or Compressed ASCII format. Selected commands have versions in both standard SEL ASCII and Compressed ASCII formats. Compressed ASCII reports generally have fewer characters than conventional SEL ASCII reports because the compressed reports reduce blanks, tabs, and other white space between data fields to a single comma. *Table C.2* lists the Compressed ASCII commands and contents of the command responses.

Table C.2 Compressed ASCII Commands

Command	Response	Access Level
BNA	ASCII names of Fast Meter status bits	0
CAS	Configuration data of all Compressed ASCII commands available at access levels > 0	0
CEV	Event report	1
CHI	List of events	1
CLDP	Load-profile data	1
CMET	Metering data, including fundamental, thermal demand, peak demand, energy, max/min, rms, analog inputs, and math variables	1
CMOT	Motor statistics data	1
CMSR	Motor start data	1
CSER	Sequence of events data	1
CST	Relay status	1
CSU	Summary of an event report	1
DNA	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 communication 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-849 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-849 and use the ASCII data stream for commands and responses.

SEL Fast Meter, Fast Operate, Fast SER, and Unsolicited Write

SEL Fast Meter is a binary message that you solicit with binary commands. Fast Operate is a binary message for control. The relay can also send unsolicited Fast SER messages automatically and receive unsolicited SEL Fast Messages (used in the SEL-849 for Remote Analogs). If the relay is connected to an SEL communications processor, these messages provide the mechanism that the communications processor uses for SCADA or DCS functions that occur simultaneously with ASCII interaction.

SEL Communications Processor

SEL offers SEL communications processors, powerful tools for system integration and automation. The SEL-2030 series and the SEL-2020 communications processors are similar, except that the SEL-2030 series has two slots for network protocol cards. The SEL-3530 Real-Time Automation Controller (RTAC) has Ethernet ports as well as serial ports to connect to your SEL relay. These devices provide a single point of contact for integration networks with a star topology, as shown in *Figure C.1*.

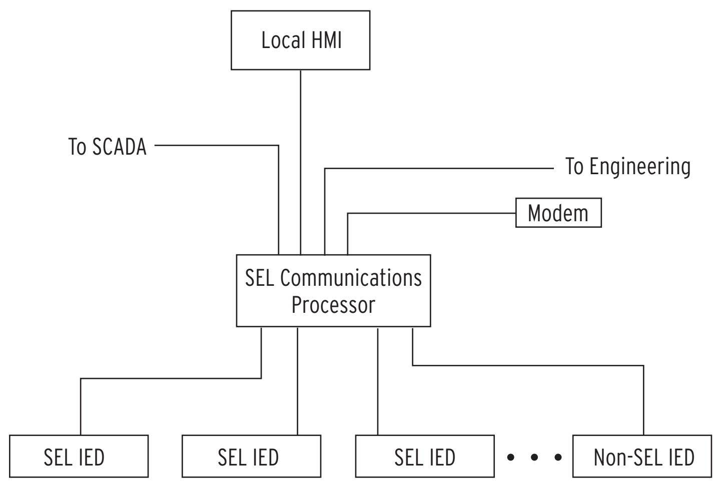


Figure C.1 SEL Communications Processor Star Integration Network

In the star topology network in *Figure C.1* the SEL communications processor offers the following substation integration functions:

- Collection of real-time data from SEL and non-SEL IEDs
- Calculation, concentration, and aggregation of real-time IED data into databases for SCADA, HMI, and other data consumers
- Access to the IEDs for engineering functions including configuration, report data retrieval, and control through local serial, remote dial-in, and Ethernet network connections
- Simultaneous collection of SCADA data and engineering connection to SEL IEDs over a single cable
- Automated dial-out on alarms

The SEL communications processors have 16 serial ports plus a front port. This port configuration does not limit the size of a substation integration project, because you can create a multitiered solution as shown in *Figure C.2*.

In this multitiered system, the lower-tier SEL communications processors forward data to the upper-tier SEL communications processor that serves as the central point of access to substation data and substation IEDs.

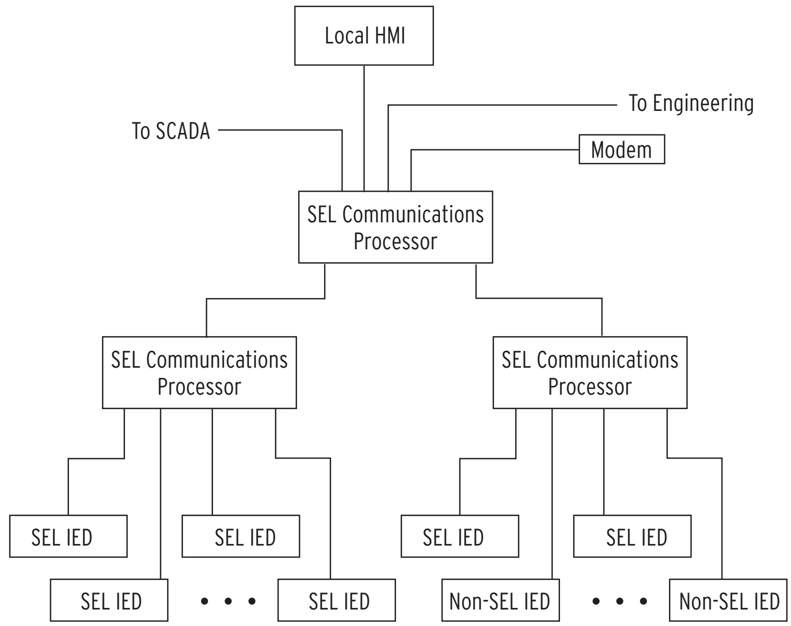


Figure C.2 Multitiered SEL Communications Processor Architecture

You can add additional communications processors to provide redundancy and eliminate possible single points of failure. SEL communications processors provide an integration solution with a reliability comparable to that of SEL relays. In terms of MTBF (mean time between failures), SEL communications processors are 100 to 1000 times more reliable than computer-based and industrial technology-based solutions.

Configuration of an SEL communications processor is different from other general-purpose integration platforms. You can configure SEL communications processors with a system of communication-specific keywords and data movement commands rather than programming in C or another general-purpose computer language. SEL communications processors offer the protocol interfaces listed in *Table C.3*.

Table C.3 SEL Communications Processors Protocol Interfaces (Sheet 1 of 2)

Protocol	Connect to
DNP3 Level 2 Outstation	DNP3 masters
Modbus RTU Protocol	Modbus masters
SEL ASCII/Fast Message Slave	SEL protocol masters
SEL ASCII/Fast Message Master	SEL protocol slaves including other communications processors and SEL relays
ASCII and Binary automessaging	SEL and non-SEL IED master and slave devices
Modbus Plus[a]	Modbus Plus peers with global data and Modbus Plus masters

Table C.3 SEL Communications Processors Protocol Interfaces (Sheet 2 of 2)

Protocol	Connect to
FTP (File Transfer Protocol)[b]	FTP clients
Telnet[b]	Telnet servers and clients
UCA2 GOMSFE[b]	UCA2 protocol masters
UCA2 GOOSE[b]	UCA2 protocol and peers

[a] Requires an SEL-2711 Modbus Plus protocol card.
[b] Requires an 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-849 and an SEL communications processor is shown in *Figure C.3*. In this architecture, the SEL communications processor collects data from the SEL-849 and other station IEDs. The SEL communications processor acts as a single point of access for local and remote data consumers (local HMI, SCADA, engineers). The communications processor also provides a single point of access for engineering operations including configuration and the collection of report-based information.

By configuring a data set optimized to each data consumer, you can significantly increase the utilization efficiency on each link. A system that uses an SEL communications processor to provide a protocol interface to an RTU has a shorter lag time (data latency); communication overhead is much less for a single data exchange conversation to collect all substation data (from a communications processor) than for many conversations required to collect data directly from each individual IED. You can further reduce data latency by connecting any SEL communications processor directly to the SCADA master and eliminating redundant communication processing in the RTU.

The SEL communications processor is responsible for the protocol interface, so you can install, test, and even upgrade the system in the future without disturbing protective relays and other station IEDs. This insulation of the protective devices from the communications interface assists greatly in situations where different departments are responsible for SCADA operation, communication, and protection.

SEL communications processors equipped with an SEL-2701 Ethernet Processor can provide a UCA2 interface to SEL-849 relays and other serial IEDs. The SEL-849 data appear in models in a virtual device domain. The combination of the SEL-2701 with an SEL communications processor offers a significant cost savings because you can use existing IEDs or purchase less expensive IEDs. For full details on applying the SEL-2701 with an SEL communications processor, see the SEL*-2701 Ethernet Processor Instruction Manual*.

The engineering connection can use either an Ethernet network connection through the SEL-2701 or a serial port connection. This versatility accommodates the channel that is available between the station and the engineering center. SEL software can use either a serial port connection or an Ethernet network connection from an engineering workstation to the relays in the field.

Enhancing Multidrop Networks

You can also use an SEL communications processor to enhance a multidrop architecture similar to the one shown in *Figure C.3*. In this example, the SEL communications processor enhances a system that uses the SEL-2701 with an Ethernet HMI multidrop network. In the example, there are two Ethernet networks, the SCADA LAN and the Engineering LAN. The SCADA LAN provides real-time data directly to the SCADA Control Center via a protocol gateway and to the HMI.

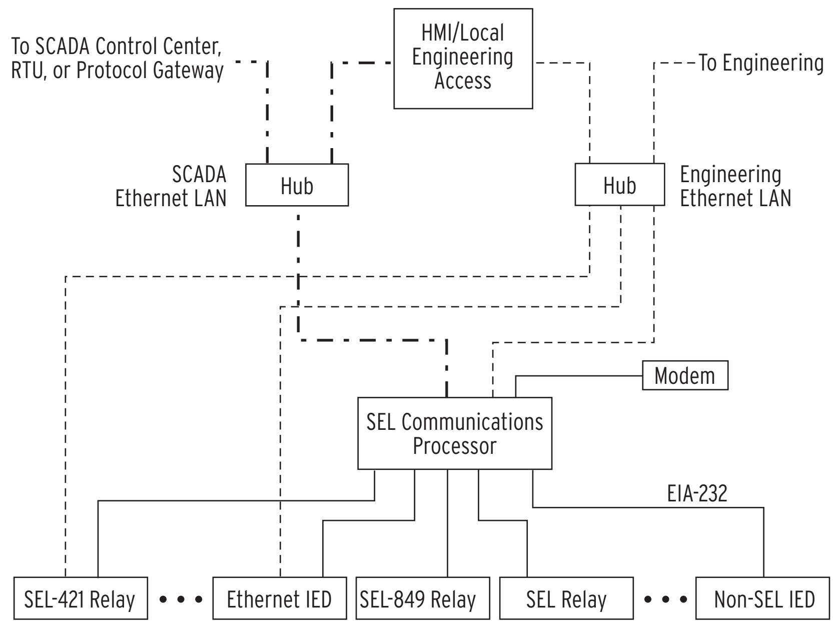


Figure C.3 Enhancing Multidrop Networks With SEL Communications Processors

In this example, the SEL communications processor provides the following enhancements when compared to a system that employs only the multidrop network:

- ➤ Ethernet access for IEDs with serial ports
- ➤ Backup engineering access through the dial-in modem
- ➤ 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-849. The physical configuration used in this example is shown in *Figure C.4*.

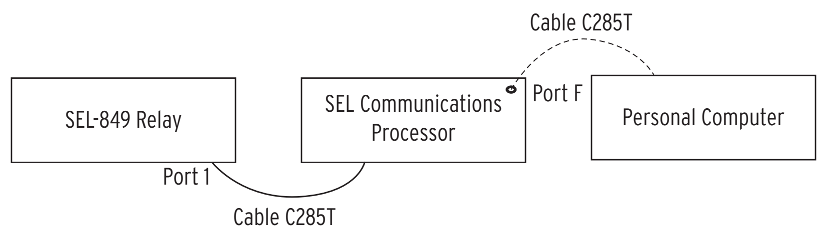


Figure C.4 Example of SEL Relay and SEL Communications Processor Configuration

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-849, 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	Saves unsolicited messages.
STARTUP	ACC\nOTTER\n[a]	Automatically logs in at Access Level 1.
SEND_OPER	Y	Sends Fast Operate messages for remote bit and breaker bit control.
REC_SER	N	Automatic sequential events recorder data collection is disabled.
NOCONN	NA	No SELOGIC control equation is entered to selectively block connections to this port.
MSG_CNT	3	Three automessages
ISSUE1	P00:00:01.0	Issues Message 1 every second.
MESG1	20METER	Collects metering data.
ISSUE2	P00:00:01.0	Issues Message 2 every second.
MESG2	20TARGET	Collects Relay Word bit data.
ISSUE3	P00:01:00.0	Issues Message 3 every minute.
MESG3	20DEMAND	Collects demand metering data.
ARCH_EN	N	Archive memory is disabled.
USER	0	No USER region registers are reserved.

[a] Use the actual Access Level 1 password if it is something other than OTTER.

Table C.7 shows the map of regions in the SEL communications processor for data collected from the SEL-849. Use the **MAP *n*** command to view these data.

Table C.7 SEL Communications Processor Port 1 Region Map

Region	Data Collection Message Type	Region Name	Description
D1	Binary	METER	Relay metering data
D2	Binary	TARGET	Relay Word bit data
D3	Binary	DEMAND	Demand meter data
D4–D8	N/A	N/A	Unused
A1–A3	N/A	N/A	Unused
USER	N/A	N/A	Unused

Relay Metering Data

Table C.8 shows the list of meter data available in the SEL communications processor and the location and data type for the memory areas within D1 (Data Region 1). The type field indicates the data type and size. The *int* type is a 16-bit integer. The *float* type is a 32-bit IEEE floating point number. Use the **VIE *n*:D1** command to view these data.

Table C.8 Communications Processor METER Region Map With the Voltage Option Installed

Item	Starting Address	Type
_YEAR	2000h	int
DAY_OF_YEAR	2001h	int
TIME (ms)	2002h	int[2]
MONTH	2004h	char
DATE	2005h	char
YEAR	2006h	char
HOUR	2007h	char
MIN	2008h	char
SECONDS	2009h	char
MSEC	200Ah	int
IA	200Bh	float
IB	200Dh	float
IC	200Fh	float
IG	2011h	float
IN	2013h	float
IAVG	2015h	float
MLOAD	2017h	float
3I2	2019h	float
UBI	201Bh	float
VAB	201Dh	float
VBC	201Fh	float
VCA	2021h	float
VAVG	2023h	float
3V2	2025h	float
UBV	2027h	float
P	2029h	float
Q	202Bh	float
S	202Dh	float
PF	202Fh	float
FREQ	2031h	float
TCUSTR	2033h	float
TCURTR	2035h	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 H.1*, Row 0							
2806h	See *Table H.1*, Row 1							
2807h	See *Table H.1*, Row 2							
2808h	See *Table H.1*, Row 3							
2809h	See *Table H.1*, Row 4							
280Ah	See *Table H.1*, Row 5							
280Bh	See *Table H.1*, Row 6							
280Ch	See *Table H.1*, Row 7							
280Dh	See *Table H.1*, Row 8							
280Eh	See *Table H.1*, Row 9							
280Fh	See *Table H.1*, Row 10							
2810h	See *Table H.1*, Row 11							
2811h	See *Table H.1*, Row 12							
• • •	• • •							
2830h	See *Table H.1*, Row 43							

Control Points

The SEL communications processor can automatically pass control messages, called Fast Operate messages, to the SEL-849. You must enable Fast Operate messages by using the FASTOP setting in the SEL-849 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 = Y.

NOTE: To use the Fast Operate function, the FASTOP setting must be set to Y (see Section 6: Settings).

When you enable Fast Operate functions, the SEL communications processor automatically sends messages to the relay for changes in remote bits RB01–RB08 on the corresponding SEL communications processor port. For example, if you set RB01 on Port 1 in the SEL communications processor, it automatically sets RB01 in the SEL-849.

Breaker bit BR1 operates differently than remote bits. There are no breaker bits in the SEL-849. For the contactor, when you set BR1, the SEL communications processor sends a message to the SEL-849 that asserts the COMMSTP bit for one processing interval. If you clear BR1, the SEL communications processor sends a message to the SEL-849 that asserts the COMMSTR bit for one processing interval. COMMSTP opens the contactor and COMMSTR closes the contactor. See *Figure 4.49* and *Figure 4.52* for the motor stop and motor start 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

SEL Communications Processor to SEL-849 Unsolicited Write Remote Analog Example

From the perspective of the SEL-849, remote analogs RA001–RA032 are specific, pre-allocated memory addresses. These memory addresses are available to accept and store values from remote devices such as an SEL-2032, SEL-2030, or SEL-2020 Communications Processor. Once these values from the remote devices are written into the memory addresses in the SEL-849, you can use these values similar to any other analog quantity in the SEL-849. When using the SEL communications processor to send the remote analogs to the SEL-849, we use the Unsolicited Write setting string and send the information using the SEL Fast Message protocol. This example shows how to configure the Unsolicited Write message in the SEL communications processor to move data stored in the USER region of Port 6 of the SEL communications processor to an SEL-849 connected to Port 3 of the SEL communications processor.

Although the SEL communications processor caters to static and dynamic data, this example uses static data in the SEL communications processor (entering the Unsolicited Write setting string is the same for static and dynamic data; see the SEL communications processor manual for dynamic data storing techniques). Assume the data are already stored in the USER region of Port 6 in the SEL communications processor. The Unsolicited Write message must be set in the Automatic messages on the SEL communications processor port to which the SEL-849 is connected. Because the SEL-849 is connected to Port 3 of the SEL communications processor, we use the Unsolicited Write Automatic (MESG1) message setting of Port 3 to build the Fast Message string, as shown in *Figure C.5* (see the SEL communications processor manual for in-depth discussions regarding the SEL communications processor Automatic message settings).

Setting the SEL Communications Processor

```
*>>SET A 3 <Enter>

Automatic message settings for Port 3


Save Unsolicited Messages (Y/N)             AUTOBUF = Y     ? <Enter>

Port Startup String
STARTUP ="?"
 ? <Enter>

Enable Automatic Sequential Events Recorder Collection (Y/N)REC_SER = N    ? <Enter>

Block external connections to this port
NOCONN  = NA
 ? <Enter>


Auto-message Settings

How many auto-message sequences (0-12)       MSG_CNT = 0     ? 1 <Enter>

Item 1 trigger D1
ISSUE1  = NA
 ? R1 <Enter>

Item 1 message
MESG1   = ""
 ? \W;06:USER:0000h;20,03:USER:0000h/ <Enter>

Archive Settings

Enable use of archive data items (Y/N)       ARCH_EN = N     ? END <Enter>

AUTOBUF = Y
STARTUP ="?"
REC_SER = N
NOCONN  = NA

MSG_CNT = 1

ISSUE1  = R1
MESG1   = "\W;06:USER:0000h;20,03:USER:0000h/"

ARCH_EN = N

USER    = 0

Save changes (Y/N) ? Y <Enter>

Port 3 Settings Changed

*>>
```

Figure C.5 Unsolicited Write Settings

The Unsolicited Write message string **\W;06:USER:0000h;20,03:USER:0000h/** contains all the information necessary to send the remote analog data to the SEL-849. Following is a discussion on the elements of the Unsolicited Write message string.

- **\W;** indicates this is an Unsolicited Write Message.
- **06:USER:0000h** indicates where the data are stored in the SEL communications processor (06 is the User regions port number where the data are stored, the beginning of the User region starts at F800H on each port, 0000H indicates what register in the User region to start at).
- **;20** indicates how many 16-bit registers from the SEL communications processor User region to send.

- **,03:USER:** is an SEL communications processor Unsolicited Write message compatibility requirement. 03 is the SEL communications processor port to which the SEL-849 is connected and the second parameter should always be USER, or F800h.
- **0000h/** indicates the first SEL-849 remote analog to begin writing to (0000H = RA01 – 003EH = RA32).
- The \ and / frame the message.

See the SEL communications processor manual for more information regarding the Unsolicited Write message string.

Below are 16-bit register data that are stored in the User region of Port 6, which we will send to the SEL-849 on Port 3. Remember that F800H is synonymous with the start of the USER region in the SEL communications processor. One register stores one Integer and 2 registers store one Float or Long data type.

```
*>>VIE 6:F800h NR 20 <Enter>

6:F800h

447Ah 25C3h C47Ah 270Ah 4516h B029h 4516h AFD7h 4500H 6789h  56ABh 3245h
435Bh 67DAh 47ADh 76DAh 5434 ACDEh
45ECh A567h

Starting at register 0000h, the first 20 registers contain 10 Float data values.
```

Setting the SEL-849

The SEL-849 interprets remote analogs as float data types. Assume in our example we need only RA01 through RA10. In this example, we send 10 Floats to the SEL-849.

Now every time the ISSUE1 condition in the Automatic Messages on Port 3 is true, the SEL communications processor sends an Unsolicited Write message to the SEL-849 and populate Remote Analogs 1–10 with the corresponding stored data in the SEL communications processor User region on Port 6.

Execute a **MET RA** or **CMET RA** in the SEL-849 to retrieve the remote analog data.

Appendix D
DNP3 Communications

Overview

The SEL-849 Motor Management 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 Communications Between Remote Terminal Units and Intelligent Electronic Devices in a Substation.

The DNP Users Group maintains and publishes DNP3 standards. See the DNP Users Group website, www.dnp.org, for more information on standards, implementers, and tools for working with DNP3.

DNP3 Specifications

DNP3 is a feature-rich protocol with many ways to accomplish tasks, defined in an eight-volume series of specifications. Volume 8 of the specification, called the Interoperability Specification, simplifies DNP3 implementation by providing four standard interoperable implementation levels. The levels are listed in *Table D.1*.

Table D.1 DNP3 Implementation Levels

Level	Description	Equipment Types
1	Simple: limited communication requirements	Meters, simple IEDs
2	Moderately complex: monitoring and metering devices and multifunction devices that contain more data	Protective relays, RTUs
3	Sophisticated: devices with great amounts of data or complex communication requirements	Large RTUs, SCADA masters
4	Enhanced: additional data types and functionality for more complex requirements	Large RTUs, SCADA masters

Each level is a proper superset of the previous lower-numbered level. A higher-level device can act as a master to a lower-level device, but can only use the data types and functions implemented in the lower level device. For example, a typical SCADA master is a Level 3 device and can use Level 2 (or lower) functions to poll a Level 2 (or lower) device for Level 2 (or lower) data. Similarly, a lower-level device can poll a higher-level device, but the lower level device can only access the features and data available to its level.

In addition to the eight-volume DNP3 specification, the protocol is further refined by conformance requirements, optional features, and a series of technical bulletins. The technical bulletins supplement the specifications with discussions and examples of specific features of DNP3.

Data Handling

Objects

DNP3 uses a system of data references called objects, defined by the Basic 4 standard object library. Each subset level specification requires a minimum implementation of object types and recommends several optional object types. DNP3 object types, commonly referred to as objects, are specifications for the type of data the object carries. An object can include a single value or more complex data. Some objects serve as shorthand references for special operations, including collections of data, time synchronization, or even all data within the DNP3 device.

If there can be more than one instance of a type of object, then each instance of the object includes an index that makes it unique. For example, each binary status point (Object 1) has an index. If there are 16 binary status points, these points are Object 1, Index 0 through Object 1, Index 15.

Each object also includes multiple versions called variations. For example, Object 1 (binary inputs) has three variations: 0, 1, and 2. You can use Variation 0 to request all variations, Variation 1 to specify binary input values only, and Variation 2 to specify binary input values with status information.

Each DNP3 device has both a list of objects and a map of object indices. The list of objects defines the available objects, variations, and qualifier codes. The map defines the indices for objects that have multiple instances and defines what data or control points correspond with each index.

A master initiates all DNP3 message exchanges except unsolicited data. DNP3 terminology describes all points from the perspective of the master. Binary points for control that move from the master to the outstation are called binary outputs, while binary status points within the outstation are called binary inputs.

Function Codes

Each DNP3 message includes a function code. Each object has a limited set of function codes that a master can use to manipulate the object. The object listing for the device shows the permitted function codes for each type of object. The most common DNP3 function codes are listed in *Table D.2*.

Table D.2 Selected DNP3 Function Codes

Function Code	Function	Description
1	Read	Request data from the outstation
2	Write	Send data to the outstation
3	Select	First part of a Select-Before-Operate operation
4	Operate	Second part of a Select-Before-Operate operation
5	Direct operate	One-step operation with reply
6	Direct operate, no reply	One-step operation with no reply

Qualifier Codes and Ranges

DNP3 masters use qualifier codes and ranges to make requests for specific objects by index. Qualifier codes specify the style of range, and the range specifies the indices of the objects of interest. DNP3 masters use qualifier codes to compose the shortest, most concise message possible when requesting points from a DNP3 outstation.

For example, the qualifier code 01 specifies that the request for points includes a start address and a stop address. Each of these two addresses uses two bytes. An example request using qualifier code 01 might have the four hexadecimal byte range field, 00h 04h 00h 10h, which specifies points in the range 4 to 16.

Access Methods

DNP3 has many features that help obtain maximum possible message efficiency. DNP3 masters send requests with the least number of bytes using special objects, variations, and qualifiers that reduce the message size. Other features eliminate the continual exchange of static (unchanging) data values. These features optimize use of bandwidth and maximize performance over a connection of any speed.

DNP3 event data collection eliminates the need to use bandwidth to transmit values that have not changed. Event data are time-stamped records that show when observed measurements changed. For binary points, the remote device (DNP3 outstation) logs changes from logical 1 to logical 0 and from logical 0 to logical 1. For analog points, the outstation device logs changes that exceed a deadband. DNP3 outstation devices collect event data in a buffer that either the master can request or the device can send to the master without a request message. Data sent from the outstation to the master without a polling request are called unsolicited data.

DNP3 data fit into one of four event classes: 0, 1, 2, or 3. Class 0 is reserved for reading the present value data (static data). Classes 1, 2, and 3 are event data classes. The meaning of Classes 1 to 3 is arbitrary and defined by the application at hand. With outstations that contain great amounts of data or in large systems, the three event classes provide a framework for prioritizing different types of data. For example, you can poll once a minute for Class 1 data, once an hour for Class 2 data, and once a day for Class 3 data.

DNP3 also supports static polling: simple polling of the present value of data points within the outstation. By combining event data, unsolicited polling, and static polling, you can operate your system in one of the four access methods shown in *Table D.3*.

The access methods listed in *Table D.3* are listed in order of increasing 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.11* describes control point operation for the SEL-849.

Conformance Testing

In addition to the protocol specifications, the DNP Users Group has approved conformance-testing requirements for Level 1 and Level 2 devices. Some implementers perform their own conformance specification testing, while some contract with independent companies to perform conformance testing.

Conformance testing does not always guarantee that a master and outstation are fully interoperable (that is, work together properly for all implemented features). Conformance testing does help to standardize the testing procedure and move the DNP3 implementers toward a higher level of interoperability.

DNP3 Serial Network Issues

Data Link Layer Operation

DNP3 employs a three-layer version of the seven-layer OSI (Open System Interconnection) 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. Consider whether you require this link integrity function in your application at the expense of overall system speed and performance.

The DNP3 technical bulletin (*DNP Confirmation and Retry Guidelines 9804-002*) on confirmation processes recommends against using data link confirmations because these processes can add to traffic in situations where communications are marginal. The increased traffic reduces connection throughput further, possibly preventing the system from operating properly.

Network Medium Contention

When more than one device requires access to a single (serial) network medium, you must provide a mechanism to resolve the resulting network medium contention. For example, unsolicited reporting results in network medium contention if you do not design your serial network as a star topology of point-to-point connections or use carrier detection on a multidrop network.

To avoid collisions among devices trying to send messages, DNP3 includes a collision avoidance feature. Before sending a message, a DNP3 device listens for a carrier signal to verify that no other node is transmitting data. The device transmits if there is no carrier or waits for a random time before transmitting. However, if two nodes both detect a lack of carrier at the same instant, these two nodes could begin simultaneous transmission of data and cause a data collision. If your serial network allows for spontaneous data transmission including unsolicited event data transmissions, you also must use application confirmation to provide a retry mechanism for messages lost in data collisions.

DNP3 LAN/WAN Overview

The main process for carrying DNP3 over an Ethernet network (LAN/WAN) involves encapsulating the DNP3 data link layer data frames within the transport layer frames of the IP suite. This allows the IP stack to deliver the DNP3 data link layer frames to the destination in place of the original DNP3 physical layer.

The DNP User Group Technical Committee has recommended the following guidelines for carrying DNP3 over a network:

NOTE: Link layer confirmations are explicitly disabled for DNP3 LAN/WAN. The IP suite provides a reliable delivery mechanism, which is backed up at the application layer by confirmations when required.

- DNP3 shall use the IP suite to transport messages over a LAN/WAN
- Ethernet is the recommended physical link, though you can use others
- TCP must be used for WANs
- TCP is strongly recommended for LANs
- UDP can be used for highly reliable single-segment LANs
- UDP is necessary if broadcast messages are required
- The DNP3 protocol stack shall be retained in full
- Link layer confirmations shall be disabled

The technical committee has registered a standard port number, 20000, for DNP3 with the Internet Assigned Numbers Authority (IANA). This port is used for either TCP or UDP.

TCP/UDP Selection

The committee recommends the selection of TCP or UDP protocol as per the guidelines in *Table D.4*.

Table D.4 TCP/UDP Selection Guidelines

Use in the case of...	TCP	UDP
Most situations	X	
Non-broadcast or multicast	X	
Mesh Topology WAN	X	
Broadcast		X
Multicast		X
High-reliability single-segment LAN		X
Pay-per-byte, non-mesh WAN, for example, Cellular Digital Packet Data (CDPD)		X
Low priority data, for example, data monitor or configuration information		X

DNP3 in the SEL-849

The SEL-849 is a DNP3 Level 2 remote (outstation) device, without dual end point.

Data Access

Table D.5 lists DNP3 data access methods along with their corresponding SEL-849 settings. You must select a data access method and configure each DNP3 master for polling as specified.

NOTE: Because unsolicited messaging is problematic in most circumstances, SEL recommends using the polled report-by-exception access method to maximize performance and minimize risk of configuration problems.

NOTE: In the settings in Table D.5, the suffix n represents the DNP3 session number from 1 to 5. All settings with the same numerical suffix comprise the complete DNP3 session configuration.

Table D.5 Configuring DNP3 Access Methods

Access Method	Master Polling	SEL-849 Settings
Polled static	Class 0	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to 0; UNSOL*n* to No
Polled report-by-exception	Class 0 occasionally, Class 1, 2, 3 frequently	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to the desired event class; UNSOL*n* to No
Unsolicited report-by-exception	Class 0 occasionally, optional Class 1, 2, 3 less frequently; mainly relies on unsolicited messages	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to the desired event class; set UNSOL*n* to Yes and PUNSOL*n* to Yes or No
Quiescent	Class 0, 1, 2, 3 never; relies completely on unsolicited messages	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to the desired event class; set UNSOL*n* and PUNSOL*n* to Yes.

The SEL-849 is an outstation device without dual end point. For a TCP connection, the relay sends out unsolicited messages only if a DNP3 master has already established a session and enabled unsolicited messaging for that session. However, for a Serial/Modem/UDP connection, the relay automatically dials out and sends unsolicited messages as defined by the settings.

In both the unsolicited report-by-exception and quiescent polling methods shown in *Table D.5*, you must make a selection for the PUNSOL*n* setting. This setting enables or disables unsolicited data reporting when the device is turned on. If your DNP3 master can send a message to enable unsolicited reporting on the SEL-849, set PUNSOL*n* to No.

While automatic unsolicited data transmission on power up is convenient, this can cause problems if your DNP3 master is not prepared to start receiving data immediately on power up. If the master does not acknowledge the unsolicited data with an Application Confirm, the device resends the data until it is acknowledged. On a large system, or in systems where the processing power of the master is limited, you can have problems when several devices simultaneously begin sending data and waiting for acknowledgment messages.

The SEL-849 allows you to set the conditions for transmitting unsolicited event data on a class-by-class basis. It also allows you to assign points to event classes on a point-by-point basis (see *DNP3 Documentation on page D.14*). You can prioritize data transmission with these event class features. For example, you might place high-priority points in event Class 1 and set it with low thresholds (NUMEVE*n* and AGEEVE*n* settings) so that changes to these points are sent to the master quickly. You can then place low priority data in event Class 2 with higher thresholds.

If the SEL-849 does not receive an Application Confirm in response to unsolicited data, it waits for ETIMEO*n* seconds and then repeats the unsolicited message. To prevent clogging of the network with unsolicited data retries, the SEL-849 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-849 pauses UTIMEO*n* seconds and then transmits the unsolicited data again. *Figure D.1* provides an example with URETRY*n* = 2.

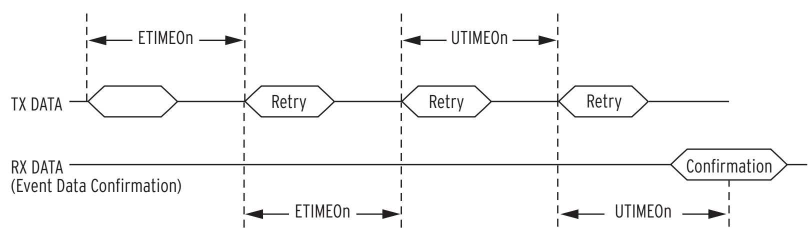


Figure D.1 Application Confirmation Timing With URETRY*n* = 2

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-849 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-849 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-849 inserts a random delay of 50 to 100 ms between the end of carrier detection and the start of data transmission (see *Figure D.2*).

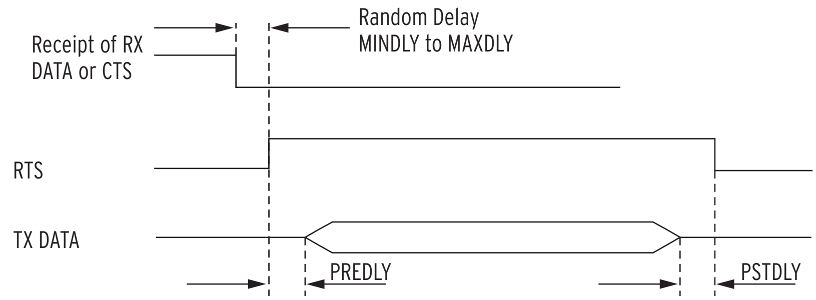


Figure D.2 Message Transmission Timing

Transmission Control

NOTE: PREDLY and POSTDLY settings are only available for EIA-232 and EIA-485 serial port sessions.

If you use a media transceiver (for example, EIA-232 to EIA-485) or a radio system for your DNP network, you may need to adjust data transmission properties. Use the PREDLY and POSTDLY settings to provide a delay between RTS signal control and data transmission (see *Figure D.2*). For example, an EIA-485 transceiver typically requires 10 to 20 ms to change from receive to transmit. If you set the pre-delay to 30 ms, you avoid data loss resulting from the data transmission beginning at the same time as the RTS signal assertion.

Event Data

DNP3 event data objects contain change-of-state and time-stamp information that the SEL-849 collects and stores in a buffer. Points assigned in the Binary Input Map that are also assigned in the Sequential Events Recorder (SER) settings carry the time stamp of actual occurrence. Binary input points not assigned in the SER settings carry a time stamp based on the DNP map scan time. This may be significantly delayed from when the original source changed and should not be used for sequence-of-events determination. The DNP map is scanned approximately once per second to generate events. You can configure the SEL-849 to either report the data without a polling request from the master (unsolicited data) or hold the data until the master requests it with an event poll message.

With the event class settings ECLASSB*n*, ECLASSC*n*, and ECLASSA*n*, you can set the event class for binary, counter, and analog inputs for Session *n*. You can use the classes as a simple priority system for collecting event data. The SEL-849 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-849.

For event data collection you must also consider and enter appropriate settings for deadband and scaling operation on analog points shown in *Table D.7*. You can either:

➤ set and use default deadband and scaling according to data type, or

➤ use a custom data map to select deadbands on a point-by-point basis.

See *DNP3 Documentation on page D.14* for a discussion of how to set scaling and deadband operation on a point-by-point basis. You can modify deadbands for analog inputs at run-time by writing to Object 34.

The settings ANADBA*n*, ANADBV*n*, and ANADBM*n* control default dead-band operation for each type of analog data. Because DNP3 Objects 30 and 32 use integer data, you must use scaling to send digits after the decimal point and avoid rounding to a simple integer value.

With no scaling, the value of 12.632 would be sent as 12. With a scaling setting of 1, the value transmitted is 126. With a scaling setting of 3, the value transmitted is 12632. You must make certain that the maximum value does not exceed 32767 if you are polling the default 16-bit variations for Objects 30 and 32, but you can send some decimal values using this technique. You must also configure the master to perform the appropriate division on the incoming value to display it properly.

You can set the default analog value scaling with the DECPLA*n*, DECPLV*n*, and DECPLM*n* settings. Application of event reporting deadbands occurs after scaling. For example, if you set DECPLA*n* to 2 and ANADBA*n* to 10, a measured current of 10.14 Amps would be scaled to the value 1014 and would have to increase to more than 1024 or decrease to less than 1004 (a change in magnitude of ± 0.1 Amps) for the device to report a new event value.

The SEL-849 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-849 has the buffer capacities listed in *Table D.6*.

Table D.6 SEL-849 Event Buffer Capacity

Type	Maximum Number of Events
Binary	1024
Analog	100
Counters	32

Binary Controls

The SEL-849 provides more than one way to control individual points. The SEL-849 maps incoming control points either to remote bits or to internal command bits that cause circuit breaker operations. *Table D.11* lists control points and control methods available in the SEL-849.

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.21*.

Time Synchronization

The accuracy of DNP3 time synchronization is insufficient for most protection and oscillography needs. 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-849 accepts and ignores time set requests (TIMERQ*n* = I for “ignore”). (This mode allows the SEL-849 to still interoperate with DNP3 masters that send time-synchronization messages.) You can set the SEL-849 to request time synchronization periodically by setting the TIMERQ*n* setting to the desired period. You can also set it to not request, but accept, time synchronization (TIMERQ*n* = M for “master”).

The SEL-849 prioritizes its time-synchronization sources. These time sources fall under one of two categories: primary time sources and secondary time sources. SNTP is the primary time source. All other time sources such as DNP3, Modbus, and serial port time and date commands are secondary time sources.

As the primary time source, the SEL-849 synchronizes its time with that SNTP time source even if other secondary time sources are available. If SNTP is not available, the SEL-849 synchronizes with the remaining time sources that could be available. These include DNP3, Modbus, or serial port time and date commands. These four time sources take on the same priority. At any given time, the relay synchronizes with the one that most recently established synchronization with the relay. In summary, time-synchronization prioritization starts with SNTP, followed by DNP3, Modbus, or serial port time and date commands.

Modem Support

The SEL-849 DNP implementation includes modem support for serial ports. Your DNP3 master can dial-in to the SEL-849 and establish a DNP3 connection. The SEL-849 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-849 to other devices.

NOTE: To enable hardware handshaking, set the modem settings to Y if you are using a Null modem cable for DOP protocol implementation.

You can either connect the modem to a computer and configure it before connecting it to the SEL-849, or program the appropriate modem setup string in the modem startup string setting MSTR. Use the PH_NUM1 and (optional) PH_NUM2 settings to set the phone numbers that you want the SEL-849 to call. The SEL-849 automatically sends the ATDT modem dial command and then the contents of the PH_NUM1 setting when dialing the modem. If PH_NUM2 is set, use the RETRY1 setting to configure the number of times the SEL-849 tries to dial PH_NUM1 before dialing PH_NUM2. Similarly, the RETRY2 setting is the number of attempts the SEL-849 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-849 are shown in *Table D.7*. You can enable DNP3 on Ethernet Port 2 or on serial Port 1 or 3, to a maximum of five concurrent DNP3 sessions. Each session defines the characteristics of the connected DNP3 Master, to which you assign one of the three available custom maps. Some settings only apply to DNP3 LAN/WAN, and are visible only when configuring the Ethernet port. For example, you only have the ability to define multiple sessions on Port 2, the Ethernet port. Likewise, settings applicable to serial DNP3 are visible only when configuring a serial port.

Table D.7 Port DNP3 Protocol Settings (Sheet 1 of 2)

Name	Description	Range	Default
EDNP[a]	Enable DNP3 Sessions	0–5	0
DNPNUM[a]	DNP3 TCP and UDP Port	1–65534	20000
DNPADR	Device DNP3 address	0–65519	0
Session 1 Settings			
DNPIP1[a,b]	DNP3 Master IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR1[a]	Transport protocol	UDP, TCP	TCP
DNPUDP1[a]	UDP response port	REQ, 1–65534	20000
REPADR1	DNP3 address of the Master to send messages to	0–65519	1
DNPMAP1	DNP3 Session Custom Map	1–3	1
DVARAI1	Analog Input Default Variation	1–6	4
ECLASSB1	Class for binary event data, 0 disables	0–3	1
ECLASSC1	Class for counter event data, 0 disables	0–3	0
ECLASSA1	Class for analog event data, 0 disables	0–3	2
DECPLA1	Decimal places scaling for Current data	0–3	1
DECPLV1	Decimal places scaling for Voltage data	0–3	1
DECPLM1	Decimal places scaling for Miscellaneous data	0–3	1
ANADBA1	Analog reporting deadband for current; hidden if ECLASSA1 set to 0	0–32767	100
ANADBV1	Analog reporting deadband for voltages; hidden if ECLASSA1 set to 0	0–32767	100
ANADBM1	Analog reporting deadband for miscellaneous analogs; hidden if ECLASSA and ECLASSC set to 0	0–32767	100
TIMERQ1	Time-set request interval, minutes (M = Disables time 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,c]	Send Data Link Heartbeat, seconds; hidden if DNPTR1 set to UDP	0.0–7200	120
DRETRY1[d]	Data link retries	0–15	3
DTIMEO1[d]	Data link time-out, seconds; hidden if DRETRY1 set to 0	0.0–5.0	1
ETIMEO1	Event message confirm time-out, seconds	1–50	5
UNSOL1	Enable unsolicited reporting; hidden and set to N if ECLASSB1, ECLASSC1, and ECLASSA1 set to 0	Y, N	N
PUNSOL1	Enable unsolicited reporting at turn on; hidden and set to N if UNSOL1 set to N	Y, N	N
NUMEVE1[e]	Number of events to transmit on	1–200	10
AGEEVE1[e]	Oldest event to transmit on, seconds	0.0–99999.0	2.0
URETRY1[e]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO1[e]	Unsolicited messages offline time-out, seconds	1–5000	60
Session 2 Settings			
DNPIP2[a,b]	DNP3 Master IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR2[a]	Transport protocol	UDP, TCP	TCP
• • •			

Table D.7 Port DNP3 Protocol Settings (Sheet 2 of 2)

Name	Description	Range	Default
URETRY2[a,e]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO2[a,e]	Unsolicited messages offline time-out, seconds	1–5000	60
Session 3 Settings			
DNPIP3[a,b]	DNP3 Master IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR3[a]	Transport protocol	UDP, TCP	TCP
• • •			
URETRY3[a,e]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO3[a,e]	Unsolicited messages offline time-out, seconds	1–5000	60
Session 4 Settings			
DNPIP4[a,b]	DNP3 Master IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR4[a]	Transport protocol	UDP, TCP	TCP
• • •			
URETRY4[a,e]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO4[a,e]	Unsolicited messages offline time-out, seconds	1–5000	60
Session 5 Settings			
DNPIP5[a,b]	DNP3 Master IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR5[a]	Transport protocol	UDP, TCP	TCP
• • •			
URETRY5[a,e]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO5[a,e]	Unsolicited messages offline time-out, seconds	1–5000	60
Serial Port Settings			
MINDLY[d]	Minimum delay from DCD to TX, seconds	0.00–1.00	0.05
MAXDLY[d]	Maximum delay from DCD to TX, seconds	0.00–1.00	0.10
PREDLY[d]	Settle time from RTS on to TX; Off disables PSTDLY	OFF, 0.00–30.00	0.00
PSTDLY[d]	Settle time from TX to RTS off; hidden if PREDLY set to Off	0.00–30.00	0.00

[a] Available only on Ethernet ports.
[b] Set DNPIP*n* = 0.0.0.0 to accept connections from any DNP master.
[c] DNPINA*n* allows the user to set the wait time to detect a bad TCP connection. The relay closes the unused TCP connection after the DNPINA*n* response timeout. It is recommended you set this value to less than 20 seconds. Disabling DNPINA*n* violates the DNP3 standard and should only be done for testing.
[d] Available only on serial ports.
[e] Hidden if UNSOLn set to N.

The modem settings in *Table D.8* are available only 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 because of no connection, seconds	5–300	60
MDRET	Time between dial-out attempts	5–3600	120

DNP3 Documentation

Object List

Table D.9 lists the objects and variations with supported function codes and qualifier codes available in the SEL-849. The list of supported objects conforms to the format laid out in the DNP specifications and includes both supported and unsupported objects for DNP3 implementation Level 2 and higher and 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-849 DNP3 Object List (Sheet 1 of 6)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
0	211	Device Attributes—User-specific sets of attributes	1	0	129	0,17
0	212	Device Attributes—Master data set prototypes	1	0	129	0,17
0	213	Device Attributes—Outstation data set prototypes	1	0	129	0,17
0	214	Device Attributes—Master data sets	1	0	129	0,17
0	215	Device Attributes—Outstation data sets	1	0	129	0,17
0	216	Device Attributes—Max binary outputs per request	1	0	129	0,17
0	219	Device Attributes—Support for analog output events	1	0	129	0,17
0	220	Device Attributes—Max analog output index	1	0	129	0,17
0	221	Device Attributes—Number of analog outputs	1	0	129	0,17
0	222	Device Attributes—Support for binary output events	1	0	129	0,17
0	223	Device Attributes—Max binary output index	1	0	129	0,17
0	224	Device Attributes—Number of binary outputs	1	0	129	0,17
0	225	Device Attributes—Support for frozen counter events	1	0	129	0,17
0	226	Device Attributes—Support for frozen counters	1	0	129	0,17
0	227	Device Attributes—Support for counter events	1	0	129	0,17
0	228	Device Attributes—Max counter index	1	0	129	0,17
0	229	Device Attributes—Number of counters	1	0	129	0,17
0	230	Device Attributes—Support for frozen analog inputs	1	0	129	0,17
0	231	Device Attributes—Support for analog input events	1	0	129	0,17
0	232	Device Attributes—Max analog input index	1	0	129	0,17
0	233	Device Attributes—Number of analog inputs	1	0	129	0,17
0	234	Device Attributes—Support for double-bit events	1	0	129	0,17
0	235	Device Attributes—Max double-bit binary index	1	0	129	0,17
0	236	Device Attributes—Number of double-bit binaries	1	0	129	0,17
0	237	Device Attributes—Support for binary input events	1	0	129	0,17
0	238	Device Attributes—Max binary input index	1	0	129	0,17
0	239	Device Attributes—Number of binary inputs	1	0	129	0,17
0	240	Device Attributes—Max transmit fragment size	1	0	129	0,17

Table D.9 SEL-849 DNP3 Object List (Sheet 2 of 6)

Obj.	Var.	Description	Request[a] Funct. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Funct. Codes[c]	Response[b] Qual. Codes[d]
0	241	Device Attributes—Max receive fragment size	1	0	129	0,17
0	242	Device Attributes—Device manufacturer's software version	1	0	129	0,17
0	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				

Table D.9 SEL-849 DNP3 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	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				
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	6	Long Floating Point Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28

Table D.9 SEL-849 DNP3 Object List (Sheet 4 of 6)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
31	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				
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	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

Table D.9 SEL-849 DNP3 Object List (Sheet 5 of 6)

Obj.	Var.	Description	Request[a] Funct. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Funct. Codes[c]	Response[b] Qual. Codes[d]
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
50	2	Time and Date With Interval				
50	3	Time and Date Last Recorded	2	7 quantity = 1	129	
51	0	Time and Date CTO—All Variations				
51	1	Time and Date CTO				
51	2	Unsynchronized Time and Date CTO			129	07, quantity=1
52	0	Time Delay—All Variations				
52	1	Time Delay, Coarse				
52	2	Time Delay, Fine			129	7, quantity=1
60	0	All Classes of Data	1, 20, 21	6, 7, 8		
60	1	Class 0 Data	1, 20, 21	6, 7, 8		
60	2	Class 1 Data	1	6, 7, 8		
60	3	Class 2 Data	1, 20, 21	6, 7, 8		
60	4	Class 3 Data	1, 20, 21	6, 7, 8		
70	1	File Identifier				
70	2	Authentication Object				
70	3	File Command Object				
70	4	File Command Status Object				
70	5	File Transport Object				
70	6	File Transport Status Object				
70	7	File Descriptor Object				
80	1	Internal Indications	2	0, 1 index=7		
81	1	Storage Object				
82	1	Device Profile				
83	1	Private Registration Object				
83	2	Private Registration Object Descriptor				
90	1	Application Identifier				
100	1	Short Floating Point				
100	2	Long Floating Point				
100	3	Extended Floating Point				
101	1	Small Packed Binary-Coded Decimal				
101	2	Medium Packed Binary-Coded Decimal				

Table D.9 SEL-849 DNP3 Object List (Sheet 6 of 6)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
101	3	Large Packed Binary-Coded Decimal				
110	all	Octet String				
111	all	Octet String Event				
112	All	Virtual Terminal Output Block				
113	All	Virtual Terminal Event Data				
N/A		No object required for the following function codes: 13 cold start 14 warm start 23 delay measurement	13, 14, 23			

[a] Supported in requests from master.
[b] May generate in response to master.
[c] Decimal.
[d] Hexadecimal.
[e] Default variation.
[f] Default variation specified by serial port setting DVARAI (or DVARAIn for Ethernet session n [n = 1, 2, 3, 4, or 5]).

Device Profile

The DNP3 Device Profile document (SEL-849_dnpDP.zip), available as a download from selinc.com, contains the standard device profile information for the SEL-849. This information is also available in XML format. Please refer to this document for complete information on DNP3 Protocol support in the SEL-849.

Reference Data Map

Table D.10 shows the SEL-849 reference data map. The reference map shows the data available to a DNP3 master. Since the default map is empty, you will need to use the custom DNP3 mapping functions of the SEL-849 to retrieve only the points required by your application.

NOTE: Deadband changes via Object 34 are not stored in nonvolatile memory. Make sure to reissue the Object 34 deadbands after a warm (**STA C**) or cold start (power cycle).

The SEL-849 scales analog values by the indicated settings or fixed scaling indicated in the description. Analog deadbands for event reporting use the indicated settings, or ANADBM if you have not specified a setting.

NOTE: Although the reference maps do not include Relay Word bit labels, you can use these labels in 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 (HALARM is latched)
	STWARN	Relay Diagnostic Warning (HALARM is pulsed)
	STSET	Relay Settings Change Or Restart
	ENABLED–TLED_08[a]	Relay Word Elements Target Row 0 and Row 1 (see *Table H.1*)
	49T–52A_CB[a]	Relay Word Elements (see *Table H.1*)
	PFL	Power Factor Leading for Three-Phase Currents
	0	Logical 0
	1	Logical 1

Table D.10 DNP3 Reference Data Map (Sheet 2 of 2)

Object	Labels	Description
Binary Outputs		
10, 12	RB01–RB08	Remote bits RB01–RB08
	RB01:RB02 RB03:RB04 RB05:RB06 RB07:RB08	Remote bit pairs RB01–RB08
	COMMSTP	Stop motor command, pulse to stop the motor
	COMMSTR	Start motor command, pulse to start the motor
	COMMSTP:COMMSTR	Stop/start motor pair
Counters		
20, 22	SC*xx*	SELOGIC Counter Values (*xx* = 01–08)
Analog Inputs		
30, 32, 34	IA_MAG–RA032[b]	Analog Quantities from *Appendix I* with an "x" in the DNP3 column
	SER_NUM	Serial Number
	0	Numeric 0
	1	Numeric 1
Analog Outputs		
40, 41	RA*xxx*	Remote Analogs (RA001 to RA032)
	NOOP	No operation, no error

[a] Valid Relay Word bits depend on the relay model.
[b] Valid analog inputs depend on the relay model.

NOTE: All fault information analog inputs contain data from the latest captured event (see Appendix I: Analog Quantities).

Device Attributes (Object 0)

Table D.9 includes the supported Object 0 device attributes and variations. In response to Object 0 requests, the SEL-849 sends attributes that apply to that particular DNP3 session. Because the SEL-849 supports custom DNP3 maps, these values are likely to be different for each session. The SEL-849 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-849" and Variation 252 shall contain "SEL."

Binary Inputs

Binary inputs (Objects 1 and 2) are supported. The default variation for both static and event inputs is 2. Only the Read function code (1) is allowed with these objects. All variations are supported. Object 2, variation 3 will be responded to, but will contain no data.

Binary inputs are scanned approximately once per second to generate events. When time is reported with these event objects, it is the time at which the scanner observed the bit change. This can be significantly delayed from 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 communication protocols such as DNP and EtherNet/IP. For example, STWARN and STFAIL are derived from the diagnostic task data. Another binary input, STSET, is derived from the SER and carries the time stamp of actual occurrence. Static reads of this input will always show 0.

Binary Outputs

Binary output status (Object 10, Variation 2) is supported. Static reads of points RB01–RB08 and COMMSTP/COMMSTR respond with the on-line bit set and the state of the requested bit. Reads from control-only binary output points respond with the online bit set and a state of 0.

The SEL-849 supports Control Relay Output Block objects (Object 12,Variation 1). The control relays correspond to the remote bits and other functions as shown previously. Each DNP Control message contains a Trip/Close code (TRIP, CLOSE, or NUL) and an Operation type (PULSE ON, LATCH ON, LATCH OFF, or NUL). The Trip/Close code works with the Operation Type to produce set, clear, and pulse operations.

Control operations differ slightly for single-point controls compared to paired outputs. Paired outputs correspond to the complementary two-output model, and single-point controls follow the complementary latch or activation model. In the complementary two-output model, paired points only support Trip or Close operations, which, when issued, Pulse On the first or second point in the pair, respectively. An operation in progress can be canceled 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 on page D.21* for details on control operations.

The Status field is used exactly as defined. All other fields are ignored. A pulse operation is asserted for a single processing interval. 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-849 only honors the first 10 points in an Object 12, Variation 1 request. Any additional points in the request returns the DNP3 status code TOO_MANY_OBJS.

The SEL-849 also supports Pattern Control Blocks (Object 12, Variations 2 and 3) to control multiple binary output points. Variation 2 defines the control type (Trip/Close, Set/Clear, or Pulse) and the range of points to operate. Variation 3 provides a pattern mask that indicates which points in that range should be operated. Object 12, Variations 2 and 3 define the entire control command: the DNP3 master must send both for a successful control. For example, the DNP3 master sends an Object 12, Variation 2 message to request a Trip of the range of indices 0–7. The DNP3 master then sends an Object 12, Variation 3 message with a hexadecimal value of “BB” as the pattern mask (converted to binary notation: 10111011). Read right to left in increasing bit order, the Pattern Block Control command results in a TRIP of indexes 0, 1, 3 to 5, and 7. Multiple binary output point control operations are not guaranteed to occur during the same processing interval.

Control Point Operation

Use the Trip and Close, Latch On/Off and Pulse On operations with Object 12 control relay output block command messages to operate the points shown in *Table D.11*. Pulse operations provide a pulse with duration of one protection processing interval.

Table D.11 SEL-849 Object 12 Control Operations

Label	Close/Pulse On	Trip/Pulse On	Nul/Latch On	Nul/Latch Off	Nul/Pulse On
RB01–RB08	Pulse Remote Bit RB01–RB08	Pulse Remote Bit RB01–RB08	Set Remote Bit RB01–RB08	Clear Remote Bit RB01–RB08	Pulse Remote Bit RB01–RB08
RB*xx*:RB*yy*	Pulse RB*yy* RB01–RB08	Pulse RB*xx* RB01–RB08	Pulse RB*yy* RB01–RB08	Pulse RB*xx* RB01–RB08	Pulse RB*yy* RB01–RB08
COMMSTP	Stop Motor (Pulse COMMSTP)	Stop Motor (Pulse COMMSTP)	Stop Motor (Pulse COMMSTP)	No action	Stop Motor (Pulse COMMSTP)
COMMSTR	Start Motor (Pulse COMMSTR)	Start Motor (Pulse COMMSTR)	Start Motor (Pulse COMMSTR)	No action	Start Motor (Pulse COMMSTR)
COMMSTP: COMMSTR	Start Motor (Pulse COMMSTR)	Stop Motor (Pulse COMMSTP)	Start Motor (Pulse COMMSTR)	Stop Motor (Pulse COMMSTP)	Start Motor (Pulse COMMSTR)

Analog Inputs

Analog Inputs (30) and Analog Change Events (32) are supported as defined in *Table D.9* and *Table D.10*. The DVARAI1 (DVARAI*n* for DNP3 LAN/WAN Session *n*) setting defines the default variation for both static and event inputs. Only the Read function code (1) is allowed with these objects.

NOTE: Deadband changes via Object 34 are not stored in nonvolatile memory. Be sure to reissue the Object 34 deadband changes you want to retain after changing DNP port settings, issuing a **STA C** command, or cold-starting the relay (power-cycle).

Unless otherwise indicated, analog values are reported in primary units. See *Appendix I: 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 deadband for currents is ANADBV on magnitudes and ANADBM on angles. For all voltages, the default scaling is the DECPLV setting on magnitudes and scale factor of 100 on angles. The default deadband for voltages is ANADBV on magnitudes and ANADBM on angles. For all powers and energies, the default scaling is the DECPLM setting and default deadband is ANADBM. For all other quantities, the default scaling is 1 and default deadband is ANADBM.

Default scaling and deadbands can be overridden by per-point scaling and deadband. See *Configurable Data Mapping on page D.22* for more information. Deadbands for analog inputs can also be modified by writing to Object 34.

A deadband check is done after any scaling has been applied. Event class messages are generated whenever an input changes beyond the value given by the appropriate deadband setting. The voltage and current phase angles only generate an event if, in addition to their deadband check, the corresponding magnitude changes beyond its own deadband. Analog inputs are scanned at approximately a one-second rate. All events generated during a scan use the time the scan was initiated.

Configurable Data Mapping

One of the most powerful features of the SEL-849 implementation is the ability to remap DNP3 data and, for analog values, specify per-point scaling and deadbands. Remapping is the process of selecting data from the reference map and organizing it into a data subset optimized for your application. The SEL-849 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 five unique DNP3 masters. You can map the points to create a custom map with as many as:

- 100 Binary Inputs
- 32 Binary Outputs

- 100 Analog Inputs
- 32 Analog Outputs
- 32 Counters

You can use the **SHOW DNP *x* <Enter>** command to view the DNP 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
0: ENABLED
1: TLED_01
2: TLED_02
…
98: IN07
99: IN08

Binary Output Map
0: RB01
1: RB02
2: RB03
…
30: COMMSTP
31: COMMSTR

Analog Input Map
0: IA_MAG
1: IB_MAG
2: IC_MAG
…
98: VB_MAG
99: VC_MAG

Analog Output Map
0: RA001
1: RA002
2: RA003
…
30: RA031
31: RA032

Counter Map
0: SC01
1: SC02
2: SC03
…
30: SC07
31: SC08

=>>
```

Figure D.3 Sample Response to SHO DNP Command

You can use the command **SET DNP *x***, where ***x*** is the map number, to edit or create custom DNP3 data maps. You can also use ACSELERATOR QuickSet SEL-5030 Software, which is recommended for this purpose.

Scaling factors allow you to overcome the limitations imposed by the integer nature of the default variations of Objects 30 and 32. For example, the device rounds a value of 11.4 A to 11 A. You can use scaling to include decimal point values by multiplying by a number larger than one. If you use 10 as a scaling factor, 11.4 A is transmitted as 114. You must divide the value by 10 in the master to see the original value including one decimal place.

You can also use scaling to avoid overflowing the 16-bit maximum integer value of 32767. For example, if you have a value that can reach 157834, you cannot send it using DNP3 16-bit analog object variations. You could use a scaling factor of 0.1 so that the maximum value reported is 15783. You can then multiply the value by 10 in the master to see a value of 157830. You lose some precision as the last digit is rounded off in the scaling process, but you can transmit the scaled value using standard DNP3 Objects 30 and 32.

You can customize the DNP3 analog input map with per-point scaling, and deadband settings. Per-point customization is not required, but class scaling (DECPLA, DECPLV, and DECPLM) and deadband (ANADBA, ANADBV, and ANADBM) settings are applied to indices that do not have per-point entries. Unlike per-point scaling described above, class-level scaling is specified by an integer in the range 0–3 (inclusive), which indicates the number of decimal place shifts. In other words, 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 group those data together within your custom map. For example, if you want all the currents to be coherent, group points IA_MAG, IB_MAG, IC_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 can be completed without saving changes between point types. To do this, you simply continue entering data and save the entire map at the end. Alternately, you can use QuickSet to simplify custom data map creation.

Consider a case where you want to set the AI points in a map, as shown in *Table D.12*.

Table D.12 Sample Custom DNP3 AI Map

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	IG magnitude	IG_MAG	default	default
4	Three-Phase Real Power	P	5	default
5	AB Phase-to-Phase Voltage Magnitude	VAB_MAG	default	default
6	AB Phase-to-Phase Voltage Angle	VAB_ANG	1	15
7	Frequency	FREQ	.01	1

To set these points as part of custom Map 1, you can use the command **SET DNP 1 AI_00 TERSE <Enter>** command as shown in *Figure D.4*.

```
=>>SET DNP 1 AI_00 TERSE <Enter>

DNP Map 1 Settings

Analog Input Map

0:
 ? IA_MAG
```

Figure D.4 Sample Custom DNP3 AI Map Settings

```
1:
 ? IB_MAG
2:
 ? END
Save Changes (Y,N)? Y
Settings Saved

=>>
```

Figure D.4 Sample Custom DNP3 AI Map Settings (Continued)

You can also use QuickSet to enter the above AI map settings as shown in the screen capture in *Figure D.5*. Enter scaling and deadband settings in the same pop-up dialog used to select the AI point, as shown in *Figure D.6*.

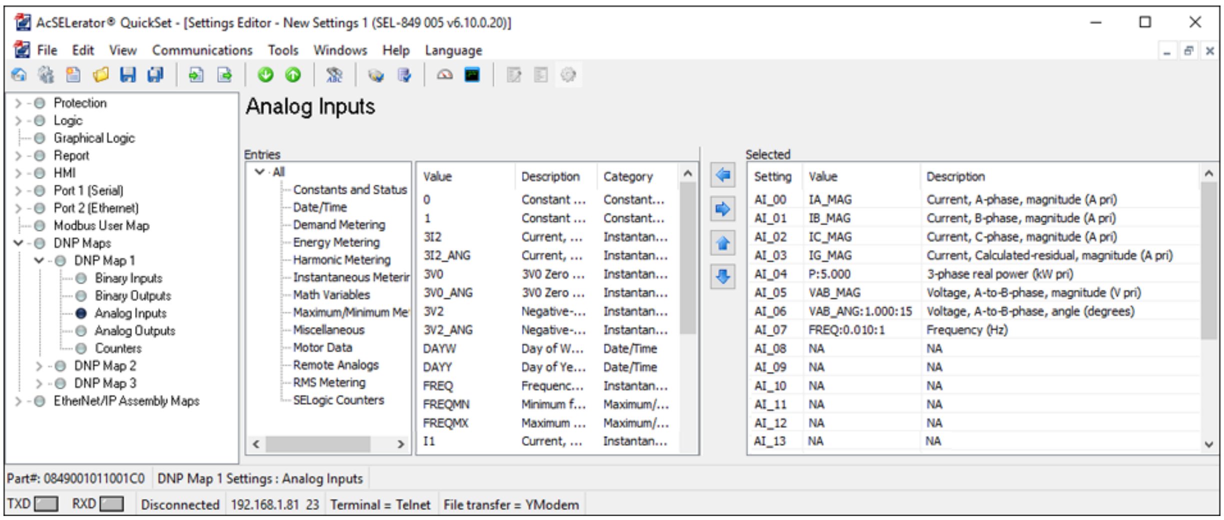


Figure D.5 Analog Input Map Entry in QuickSet Software

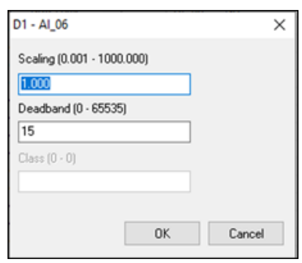


Figure D.6 AI Point, Scaling and Deadband in QuickSet Software

The **SET DNP *x* AO_00<Enter>** command allows you to populate the DNP analog output map with any of the 32 remote analogs (RA001–RA032) or the NOOP variable as shown in *Figure D.7*.

```
=>>SET DNP 1 AO_00 TERSE <Enter>

DNP Map 1 Settings

Analog Output Map

0:
 ? NOOP
1:
 ? RA001
2:
 ? END
Save Changes (Y,N)? Y
Settings Saved

=>>
```

Figure D.7 Sample Custom DNP3 AO Map Settings

You can also use QuickSet to enter the AO map settings as shown in the screen capture in *Figure D.8*.

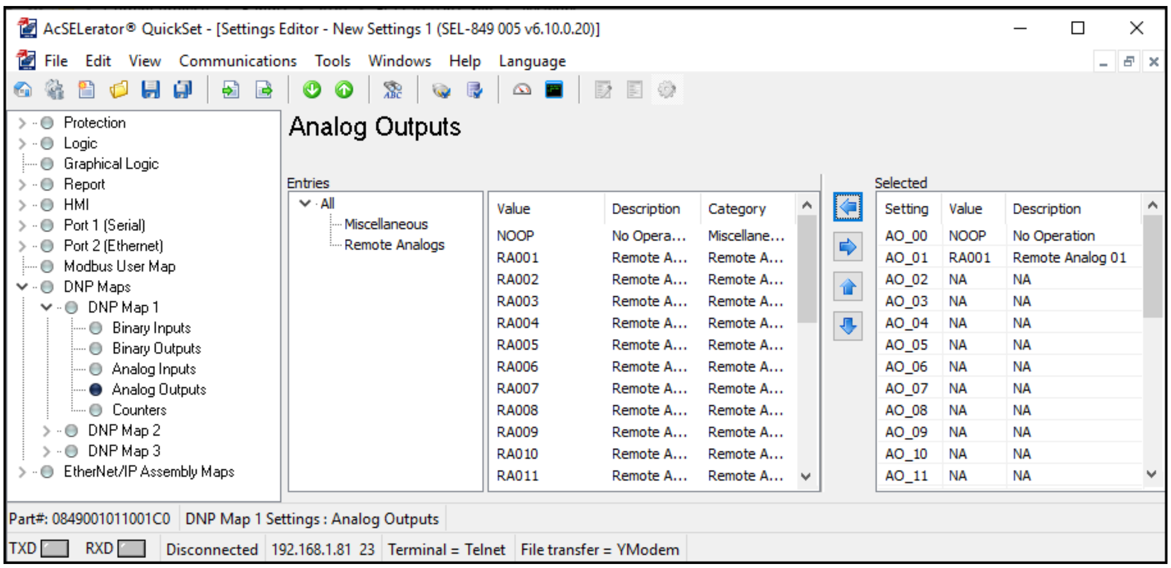


Figure D.8 Analog Output Map Entry in QuickSet Software

The **SET DNP *x* CO_00 <Enter>** command allows you to populate the DNP counter map with per-point deadbands. Entering these settings is similar to defining the analog input map settings.

Use the command **SET DNP *x* BO_00 TERSE <Enter>** to change the binary output Map *x* as shown in *Figure D.9*. You can populate the custom BO map with any of the 8 remote bits (RB01–RB08). Define bit pairs in BO maps by including a colon (:) between the bit labels.

```
=>>SET DNP 1 BO_00 TERSE <Enter>

DNP Map 1 Settings

Binary Output Map

0:
 ? RB01
1:
 ? RB02
2:
 ? END
Save Changes (Y,N)? Y
Settings Saved

=>>
```

Figure D.9 Sample Custom DNP3 BO Map Settings

You can also use QuickSet to enter the BO map settings as shown in the screen capture in *Figure D.10*.

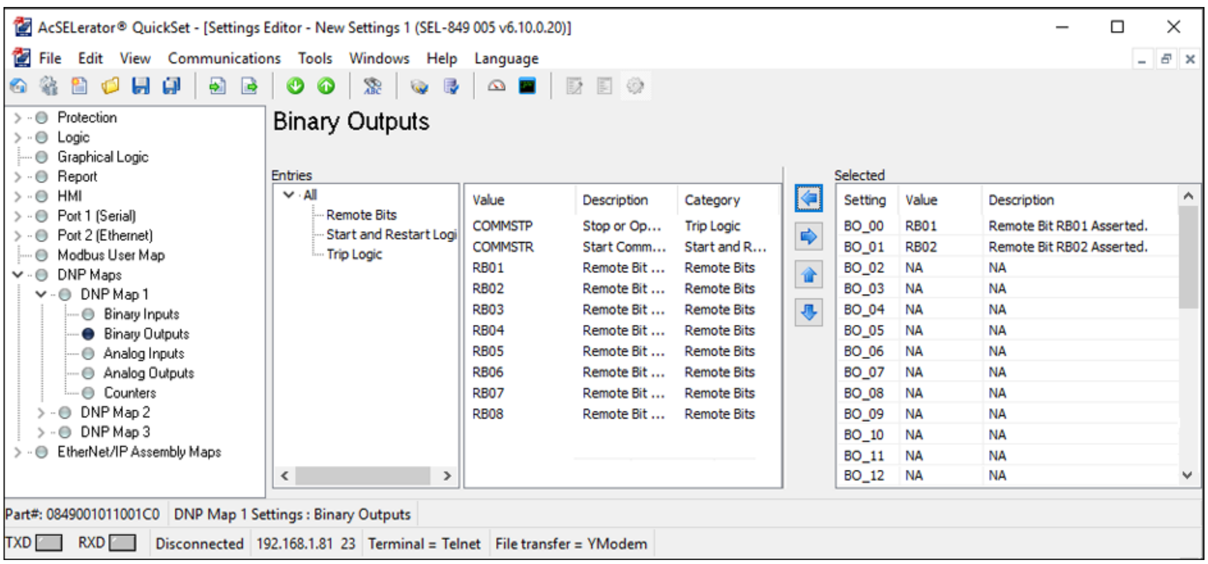


Figure D.10 Binary Output Map Entry in QuickSet Software

The binary input (BI) maps are modified in a similar manner, but pairs are not allowed.

Appendix E
Modbus Communications

Overview

This appendix describes the Modbus RTU and TCP communications features supported by the SEL-849 Motor Management Relay. Complete specifications for the Modbus protocol are available from the Modbus user's group website at modbus.org.

The SEL-849 allows as many as two simultaneous Modbus sessions on the Ethernet port and one on each of the serial ports. The SEL-849 Modbus communication allows a Modbus master device to do the following:

- ➤ Acquire metering, monitoring, and event data from the relay.
- ➤ Control SEL-849 output contacts and remote bits.
- ➤ Read and set the time and date.
- ➤ Reset targets, demand and peak data, and event history data.

Enable Modbus TCP protocol with the Ethernet port setting EMOD. The master IP address for each session is selected with the Ethernet port settings MODIP1 and MODIP2. The Master IP address 0.0.0.0 is a valid entry and is used to accept a connection from any master. Use caution when using this address as any Modbus master may connect to the Ethernet port through this connection. When a Modbus TCP master attempts to connect, the relay will first search the valid master IP addresses. If no matching Modbus master IP address is found, and one of the MODIP*x* addresses is 0.0.0.0, the master will be allowed to connect through that connection. The 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. The time-out settings, MTIME01 and MTIME02, will cause the relay to close a Modbus session if no communication is received from the master within the setting time.

Modbus RTU is a binary protocol that permits communication between a single master device and multiple slave devices. The communication is half duplex—only one device transmits at a time. The master transmits a binary command that includes the address of the desired slave device (port setting SLAVEID). All of the slave devices receive the message, but only the slave device with the matching address responds.

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.

Communications Protocol

Modbus RTU Queries

Modbus master devices initiate all exchanges by sending a query. The query format for Modbus RTU 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
Cyclic Redundancy Check (CRC)	2 bytes

The SEL-849 serial port SLAVEID setting defines the device address. Set this value to a unique number for each device on the Modbus network. For Modbus RTU communication to operate properly, no two slave devices may have the same address.

The cyclic redundancy check detects errors in the received data. If an error is detected, the relay discards the packet.

Modbus TCP Queries

The Modbus request or response is encapsulated when carried on a Modbus TCP/IP network. A dedicated header used on TCP/IP identifies the Modbus Application Data Unit (ADU). The header, called the MBAP (Modbus Application Protocol header), contains the fields shown in *Table E.2*.

Table E.2 Modbus TCP Header Fields

Field	Number of Bytes
Transaction Identifier	2 Bytes
Protocol Identifier	2 Bytes (0 = MODBUS protocol)
Length	2 Bytes
Unit Identifier	1 Byte

The Modbus TCP Message consists of the MBAP Header, followed by the Modbus function code and the data supporting the function code. The Modbus TCP message does not contain the 2 byte CRC that is included in the RTU message, as the error checking is accomplished through TCP. Otherwise the data following the MBAP header is identical to the Modbus RTU message.

The remainder of this section will cover the Modbus Function codes in terms of the Modbus RTU protocol.

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 cyclic redundancy check value.

Supported Modbus Function Codes

The SEL-849 supports the Modbus function codes shown in *Table E.3*.

Table E.3 SEL-849 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

Modbus Exception Responses

The SEL-849 sends an exception code under the conditions described in *Table E.4*.

Table E.4 SEL-849 Modbus Exception Codes

Exception Code	Error Type	Description
1	Illegal Function Code	The received function code is either undefined or unsupported.
2	Illegal Data Address	The received command contains an unsupported address in the data field.
3	Illegal Data Value	The received command contains a value that is out of range.
4	Device Error	The SEL-849 is in the wrong state for the function a query specifies. The relay is unable to perform the action specified by a query (i.e., cannot write to a read-only register, device is disabled, 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 occur, the relay assembles a response message that includes the exception code in the data field. The relay sets the most significant bit in the function code field to indicate to the master that the data field contains an error code, instead of the required data.

Cyclic Redundancy Check

The SEL-849 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 RTU response. When the master device receives the response, it recalculates the CRC. If the calculated CRC matches the CRC sent by the SEL-849, 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 Output Coils shown in *Table E.15*). The SEL-849 coil addresses start at 0. 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.5 01h Read Discrete Output Coil Status Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (01h)
2 bytes	Address of the first bit
2 bytes	Number of bits to read
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (01h)
1 byte	Bytes of data (*n*)
n bytes	Data
2 bytes	CRC-16

To build the response, the SEL-849 calculates the number of bytes required to contain the number of bits requested. If the number of bits requested is not evenly divisible by eight, the device adds one more byte to maintain the balance of bits, padded by zeros to make an even byte. *Table E.15* includes the coil number and lists all possible coils (identified as Outputs and Remote bits) available in the device. The relay responses to errors in the query are shown in *Table E.6*.

Table E.6 Responses to 01h Read Discrete Output Coil Query Errors

Error	Error Code Returned	Communications Counter Increments
Invalid bit to read	Illegal Data Address (02h)	Invalid Address
Invalid number of bits to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

02h Read Input Status Command

Use function code 02h to read the On/Off status of the selected bits (inputs), as shown in *Table E.7*. Input addresses start at 0. 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.7 02h Read Input Status Command (Sheet 1 of 2)

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (02h)
2 bytes	Address of the first bit

Table E.7 02h Read Input Status Command (Sheet 2 of 2)

Bytes	Field
2 bytes	Number of bits to read
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (02h)
1 byte	Bytes of data (*n*)
n bytes	Data
2 bytes	CRC-16

To build the response, the device calculates the number of bytes required to contain the number of bits requested. If the number of bits requested is not evenly divisible by eight, the device adds one more byte to maintain the balance of bits, padded by zeros 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 address 15 is TLED_01 and input address 7 is ENABLED). Input addresses start at 0000. *Table E.8* includes the input address in decimal and hexadecimal and lists all possible inputs (Relay Word bits) available in the device.

Table E.8 02h SEL-849 Inputs[a] (Sheet 1 of 3)

Discrete Input Address in Decimal	Discrete Input Address in Hex	Function Code Supported	Discrete Address Description	Notes
0–7	0–7	2	Relay Element Status Row 0	The Address numbers are assigned from the right-most Address to the left-most Address in the Relay row as shown in the SEL-849 example below. Address 7 = ENABLED Address 6 = TRIP_LED Address 5 = * Address 4 = * Address 3 = * Address 2 = * Address 1 = * Address 0 = *
8–15	8–F	2	Relay Element Status Row 1	Address 15 = TLED_01 Address 14 = TLED_02 Address 13 = TLED_03 Address 12 = TLED_04 Address 11 = TLED_05 Address 10 = TLED_06 Address 9 = TLED_07 Address 8 = TLED_08
16–23	10–17	2	Relay Element Status Row 2	
24–31	18–1F	2	Relay Element Status Row 3	
32–39	20–27	2	Relay Element Status Row 4	
40–47	28–2F	2	Relay Element Status Row 5	
48–55	30–37	2	Relay Element Status Row 6	
56–63	38–3F	2	Relay Element Status Row 7	

Table E.8 02h SEL-849 Inputs[a] (Sheet 2 of 3)

Discrete Input Address in Decimal	Discrete Input Address in Hex	Function Code Supported	Discrete Address Description	Notes
64–71	40–47	2	Relay Element Status Row 8	
72–79	48–4F	2	Relay Element Status Row 9	
80–87	50–57	2	Relay Element Status Row 10	
88–95	58–5F	2	Relay Element Status Row 11	
96–103	60–67	2	Relay Element Status Row 12	
104–111	68–6F	2	Relay Element Status Row 13	
112–119	70–77	2	Relay Element Status Row 14	
120–127	78–7F	2	Relay Element Status Row 15	
128–135	80–87	2	Relay Element Status Row 16	
136–143	88–8F	2	Relay Element Status Row 17	
144–151	90–97	2	Relay Element Status Row 18	
152–159	98–9F	2	Relay Element Status Row 19	
160–167	A0–A7	2	Relay Element Status Row 20	
168–175	A8–AF	2	Relay Element Status Row 21	
176–183	B0–B7	2	Relay Element Status Row 22	
184–191	B8–BF	2	Relay Element Status Row 23	
192–199	C0–C7	2	Relay Element Status Row 24	
200–207	C8–CF	2	Relay Element Status Row 25	
208–215	D0–D7	2	Relay Element Status Row 26	
216–223	D8–DF	2	Relay Element Status Row 27	
224–231	E0–E7	2	Relay Element Status Row 28	
232–239	E8–EF	2	Relay Element Status Row 29	
240–247	F0–F7	2	Relay Element Status Row 30	
248–255	F8–FF	2	Relay Element Status Row 31	
256–263	100–107	2	Relay Element Status Row 32	
264–271	108–10F	2	Relay Element Status Row 33	
272–279	110–117	2	Relay Element Status Row 34	
280–287	118–11F	2	Relay Element Status Row 35	
288–295	120–127	2	Relay Element Status Row 36	
296–303	128–12F	2	Relay Element Status Row 37	
304–311	130–137	2	Relay Element Status Row 38	
312–319	138–13F	2	Relay Element Status Row 39	
320–327	140–147	2	Relay Element Status Row 40	
328–335	148–14F	2	Relay Element Status Row 41	
336–343	150–157	2	Relay Element Status Row 42	
344–351	158–15F	2	Relay Element Status Row 43	
352–359	160–167	2	Relay Element Status Row 44	
360–367	168–16F	2	Relay Element Status Row 45	
368–375	170–177	2	Relay Element Status Row 46	
376–383	178–17F	2	Relay Element Status Row 47	
384–391	180–187	2	Relay Element Status Row 48	
392–399	188–18F	2	Relay Element Status Row 49	

Table E.8 02h SEL-849 Inputs[a] (Sheet 3 of 3)

Discrete Input Address in Decimal	Discrete Input Address in Hex	Function Code Supported	Discrete Address Description	Notes
400–407	190–197	2	Relay Element Status Row 50	
408–415	198–19F	2	Relay Element Status Row 51	

[a] See Appendix H: Relay Word Bits for relay element row numbers and definitions.

The relay responses to errors in the query are shown in *Table E.9*.

Table E.9 Responses to 02h Read Input Query Errors

Error	Error Code Returned	Communications Counter Increments
Invalid bit to read	Illegal Data Address (02h)	Invalid Address
Invalid number of bits to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

03h Read Holding Register Command

Use function code 03h to read directly from the Modbus Register Map shown in *Table E.23*. Use the **SET M** command (see *User-Defined Modbus Data Region and SET M Command*) to configure the map using the register label names shown in *Table E.23*. You can read a maximum of 125 registers at once with this function code. Most masters use 4X references with this function code.

Table E.10 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.11*.

Table E.11 Responses to 03h Read Holding Register Query Errors

Error	Error Code Returned	Communications Counter Increments
Illegal register to read	Illegal Data Address (02h)	Invalid Address
Illegal number of registers to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

04h Read Input Register Command

Use function code 04h to read directly from the Modbus Register Map shown in *Table E.23*. Use the **SET M** command (see *User-Defined Modbus Data Region and SET M Command*) to configure the map using the register label names shown in *Table E.23*. You can read a maximum of 125 registers at once with this function code. Most masters use 3X references with this function code.

Table E.12 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.13*.

Table E.13 Responses to 04h Read Input Register Query Errors

Error	Error Code Returned	Communications Counter Increments
Illegal register to read	Illegal Data Address (02h)	Invalid Address
Illegal number of registers to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

05h Force Single Coil Command

Use function code 05h to set or clear a coil. The command response is identical to the command request shown in *Table E.14*.

Table E.14 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.15 lists the coil numbers supported by the SEL-849. The physical coils (coils 00–03) are self-resetting. Pulsing a Set remote bit (decimal addresses 12 through 19) causes the remote bit to be cleared at the end of the pulse.

Table E.15 01h, 05h SEL-849 Output Coils

Coil Address in Decimal	Coil Address in Hex	Function Code Supported	Coil Description	Coil Function	Duration
0	0	1,5	OUT01[a]	Pulse	1 second
1	1	1,5	OUT02 [a]	Pulse	1 second
2	2	1,5	OUT03 [a]	Pulse	1 second
3	3	1,5	OUT04 [a]	Pulse	1 second
4	4	1,5	RB01	Set/Clear	
5	5	1,5	RB02	Set/Clear	
6	6	1,5	RB03	Set/Clear	
7	7	1,5	RB04	Set/Clear	
8	8	1,5	RB05	Set/Clear	
9	9	1,5	RB06	Set/Clear	
10	A	1,5	RB07	Set/Clear	
11	B	1,5	RB08	Set/Clear	
12	C	1,5	RB01	Pulse[b]	1 SELOGIC Processing Interval
13	D	1,5	RB02	Pulse[b]	1 SELOGIC Processing Interval
14	E	1,5	RB03	Pulse[b]	1 SELOGIC Processing Interval
15	F	1,5	RB04	Pulse[b]	1 SELOGIC Processing Interval
16	10	1,5	RB05	Pulse[b]	1 SELOGIC Processing Interval
17	11	1,5	RB06	Pulse[b]	1 SELOGIC Processing Interval
18	12	1,5	RB07	Pulse[b]	1 SELOGIC Processing Interval
19	13	1,5	RB08	Pulse[b]	1 SELOGIC Processing Interval
20	14	1,5	Motor Stop	Pulse[c]	1 SELOGIC Processing Interval
21	15	1,5	Motor Start	Pulse[d]	1 SELOGIC Processing Interval
22	16	1,5	Reserved		
23	17	1,5	Reserved		
24	18	1,5	Target Reset	Pulse	
25	19	1,5	Reset History	Pulse	
26	1A	1,5	Reset Motor Data	Pulse	
27	1B	1,5	Reset Demands	Pulse	
28	1C	1,5	Reset Hardware Alarm	Pulse	
29	1D	1,5	Reset Energy		
30	1E	1,5	Reset Mxmn		
31	1F	1,5	Reserved		
32	20	1,5	Reserved		
33	21	1,5	Reserved		
34	22	1,5	Reserved		
35	23	1,5	Reserved		
36	24	1,5	Reserved		

[a] Coils are also controlled by the SELOGIC control equation of the same name.
[b] Pulsing a remote bit which is already set will cause the remote bit to be cleared at the end of the pulse.
[c] COMMSTP Relay Word bit is pulsed for one processing interval. See Figure 4.49 in Trip/Close Logic for the Motor Stop Logic.
[d] COMMSTR Relay Word bit is pulsed for one processing interval. See Figure 4.52 in Trip/Close Logic for the Motor Start Logic.

The device responses to errors in the query are shown in *Table E.16*.

Table E.16 Responses to 05h Force Single Coil Query Errors

Error	Error Code Returned	Communications Counter Increments
Invalid bit (coil)	Illegal Data Address (02h)	Invalid Address
Invalid bit state requested	Illegal Data Value (03h)	Illegal Register
Format Error	Illegal Data Value (03h)	Bad Packet Format

06h Preset Single Register Command

The SEL-849 uses this function to allow a Modbus master to write directly to a database register. Refer to the Modbus Quantities Table in *Table E.23* for a list of registers that can be written by using this function code. The command response is identical to the command request shown in *Table E.17*.

Table E.17 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.18*.

Table E.18 Responses to 06h Preset Single Register Query Errors

Error	Error Code Returned	Communications Counter Increments
Illegal register address	Illegal Data Address (02h)	Invalid Address Illegal Write
Illegal register value	Illegal Data Value (03h)	Illegal Write
Format error	Illegal Data Value (03h)	Bad Packet Format

08h Loopback Diagnostic Command

The SEL-849 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.19 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)
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)

Table E.19 08h Loopback Diagnostic Command (Sheet 2 of 2)

Bytes	Field
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.20*.

Table E.20 Responses to 08h Loopback Diagnostic Query Errors

Error	Error Code Returned	Communications Counter Increments
Illegal subfunction code	Illegal Data Value (03h)	Illegal 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, to as many as 100 per operation.

Table E.21 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 shown *Table E.22*.

Table E.22 10h Preset Multiple Registers Query Error Messages

Error	Error Code Returned	Communications Counter Increments
Illegal register to set	Illegal Data Address (02h)	Invalid Address Illegal Write
Illegal number of registers to set	Illegal Data Value (03h)	Illegal Register Illegal Write
Incorrect number of bytes in query data region	Illegal Data Value (03h)	Bad Packet Format Illegal Write
Invalid register data value	Illegal Data Value (03h)	Illegal Write

Bit Operations Using Function Codes 06h and 10h

The SEL-849 includes registers for controlling some of the outputs or resetting data within the relay. See LOG_CMD and RSTDAT in *Table E.23*. Use Modbus function codes 06h or 10h to write appropriate flags. Remember that when writing to the Logic command register with output contacts, it is not a bit operation. All the bits in that register need to be written together to reflect the state you want for each of the outputs.

User-Defined Modbus Data Region and SET M Command

The SEL-849 Modbus Register Map defines an area of 250 contiguous addresses whose contents are defined by user-settable labels. This feature allows you to take 250 discrete values from anywhere in the Modbus Quantities Table (*Table E.23*) and place them in contiguous registers that you can then read in a single command. Use the ASCII command **SET M** (or the Modbus User Map settings in ACSELERATOR QuickSet SEL-5030 Software or the web server) to define the user map addresses. A default map is provided with the relay. If the default Modbus map is not appropriate or more data are desired, edit the map as required for your application.

To use the user-defined data region, perform the following the steps.

Step 1. Define the list of desired quantities (as many as 250). Arrange the quantities in any order that is convenient for you to use.

Step 2. Refer to *Table E.23* for a list of the Modbus labels for each quantity.

Step 3. Use the **SET M** command from the command line or ACSELERATOR QuickSet Modbus User Map to map user registers 001 to 250 (MOD_001 to MOD_250) using the labels in *Table E.23*.

Step 4. Use Modbus function code 03h or 04h to read the desired quantities from addresses 0 through 249 (decimal).

Note that the Modbus addresses begin with zero, which corresponds to **SET M** setting MOD_001.

As each label is entered in a register via the **SET M** command, the relay will increment to the next valid register.

NOTE: If your master uses 5- or 6-digit address references, add the appropriate number to the Modbus Address provided in Table E.23 when configuring your master. For example, if your master uses 5-digit addressing, add 40001 for holding register operations. For Input register functions, add 30001. If your master uses 6-digit addressing, add 400001 for holding register operations or 300001 for input register functions. The actual address that appears in the address field of the message will be the Modbus Address shown in Table E.23. For example, MOD_001 is address 0000 (see Table E.23 for Modbus register addresses). A master using 6-digit addresses to read a holding register may be configured for address 400001. However, the data address field of the message from the master will contain address 0000.

If a label is entered for a 32-bit quantity register (e.g., P, Q, S, MV01), the relay will automatically skip a register in the sequence. In the following example, MOD_015 was previously set to 3I2, which is a 16-bit value and consumes one register. By changing the register label to P, a 32-bit value, the next register shown available for setting is MOD_017.

```
=>>SET M MOD_015 <Enter>
Modbus Map, Section 1:
USER REG#015
MOD_015 = 3I2
      ? P
USER REG#017
MOD_017 = MV01
      ?
USER REG#019
MOD_019 = IA_MAG
      ?
=>>
```

Similarly, in this example, MOD_017 was previously set to MV01, which is a 32-bit value and consumes two registers. By changing the register label to IA_MAG, a 16-bit value, the next register shown available for setting is

MOD_018. Because MOD_018 was previously not available, as it was the second register used for MOD_017 (MV01), there is no label assigned to it and shows NA.

```
=>>SET M MOD_017 <Enter>

Modbus Map, Section 1:
USER REG#017
MOD_017 = MV01
     ? IA_MAG

USER REG#018
MOD_018 = NA
     ? IB_MAG

USER REG#019
MOD_019 = VA
     ? IC_MAG

=>>
```

Table E.23 Modbus Quantities (Sheet 1 of 12)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Default	Number of 16-Bit Registers	Value		Scaling (X1 unless specified)
					Min	Max	
Special Quantities							
Constants							
Constant Value	03	0	0	0	0	0	1
Constant Value	03	1	1	0	1	1	1
Relay Information							
Relay Firmware Revision	03	FWREV	0	1	0	9999	1
Relay Firmware Point Release Version	03	FWVNUM	0	1	0	9999	1
Relay Serial Number, Lowest 4 digits	03	SER_NUML	0	1	0	9999	1
Relay Serial Number, Middle 4 digits	03	SER_NUMM	0	1	0	9999	1
Relay Serial Number, Highest 4 digits	03	SER_NUMH	0	1	0	9999	1
Modbus Device Code	03	DEVCODE	78	1	0	65535	1
Miscellaneous							
No Operation	03/06	NOOP		na	0	65535	1
Reset Bits							
Reset Data Bit 0 = Reset Targets Bit 1 = Reserved[c] Bit 2 = Reserved[c] Bit 3 = Reset History Data Bit 4 = Reset Comm Counters Bit 5 = Reset MOT Data Bit 6 = Reset Max/Min Data Bit 7 = Reset Energy Data Bit 8 = Reset Demands Bit 9 = Reserved[c] Bit 10 = Reset Hardware Alarm Bits 11–15 = Reserved[c]	06	RSTDAT[b]	0	1	0	65535	

Table E.23 Modbus Quantities (Sheet 2 of 12)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Default	Number of 16-Bit Registers	Value		Scaling (X1 unless specified)
					Min	Max	
Date/Time Set							
Set Seconds	03/06	TIME_S[b]	0	1	0	59	1
Set Minutes	03/06	TIME_M[b]	0	1	0	59	1
Set Hour	03/06	TIME_H[b]	0	1	0	23	1
Set Day	03/06	DATE_D[b]	1	1	1	31	1
Set Month	03/06	DATE_M[b]	1	1	1	12	1
Set Year	03/06	DATE_Y[b]	2000	1	2000	2550	1
Historical Data							
No. of Event Logs	03	NUMEVE	0	1	0	50	1
Event Log SEL	03/06	EVESEL[b]	0	1	0	50	1
Event Time ss	03	ETIME_S[b]	0	1	0	59999	1000
Event Time mm	03	ETIME_M[b]	0	1	0	59	1
Event Time hh	03	ETIME_H[b]	0	1	0	23	1
Event Day dd	03	EDATE_D[b]	1	1	0	31	1
Event Day mm	03	EDATE_M[b]	1	1	0	12	1
Event Day yy	03	EDATE_Y[b]	2000	1	0	9999	1
Event Type	03	EVE_TYPE[b]	0	1	0	28	
0 = Trip on Lockout 1 = Overload Trip 2 = Locked Rotor Trip 3 = Undercurrent Trip 4 = Loadjam Trip 5 = Current Imbalance Trip 6 = Phase IOC Trip 7 = Residual IOC Trip 8 = Phase TOC Trip 9 = Residual TOC Trip 10 = Neg. Seq. TOC Trip 11 = Speed Switch Trip 12 = Under Voltage Trip 13 = Over Voltage Trip 14 = Power Factor Trip		15 = Phase Rev Trip 16 = Under Frequency Trip 17 = Over Frequency Trip 18 = Power Element Trip 19 = PTC Trip 20 = Start Time Trip 21 = PTC Fail Trip 22 = Breaker Failure Trip 23 = Arc Flash Trip 24 = Trigger 25 = Remote Stop 26 = Local Stop 27 = ER Trigger 28 = Trip					
Event Targets Bit 0–5 = Reserved[c] Bit 6 = TRIP_LED Bit 7 = Enabled Bit 8 = TLED_08 Bit 9 = TLED_07 Bit 10 = TLED_06 Bit 11 = TLED_05 Bit 12 = TLED_04 Bit 13 = TLED_03 Bit 14 = TLED_02 Bit 15 = TLED_01	03	EVE_TRGT[b]	0	1	0	65535	
Event IA	03	EVE_IA[b]	0	1	0	65535	1
Event IB	03	EVE_IB[b]	0	1	0	65535	1
Event IC	03	EVE_IC[b]	0	1	0	65535	1

Table E.23 Modbus Quantities (Sheet 3 of 12)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Default	Number of 16-Bit Registers	Value Min	Value Max	Scaling (X1 unless specified)
Event IG	03	EVE_IG[b]	0	1	0	65535	1
Event IN	03	EVE_IN[b]	0	1	0	65535	1
Event VAB/VAN	03	EVE_VAB[b]	0	1	0	65535	1
Event VBC/VBN	03	EVE_VBC[b]	0	1	0	65535	1
Event VCA/VCN	03	EVE_VCA[b]	0	1	0	65535	1
Event Delta/Wye 0 = Delta 1 = Wye	03	EVE_DY[b]	0	1	0	1	
Event Freq.	03	EVE_FREQ[b]	6000	1	1250	7250	100
Trips and Alarm Elements Note 1: The Trip and Alarm Status register bits are momentarily set as long as the "assert" conditions exist. However, they are latched only to the rising edge of the TRIP Relay Word bit and are not cleared until target reset is issued from any interface.							
Trip Alarm Status 1 Bit 0 = Overload or Locked Rotor Trip Bit 1 = Undercurrent Trip Bit 2 = Load-Jam Trips Bit 3 = Current Imbalance Trip Bit 4 = Phase IOC 1 Bit 5 = Residual IOC1 Bit 6 = Phase TOC Bit 7 = Residual TOC Bit 8 = Neg. Seq. TOC Bit 9 = Speed Switch Trip Bit 10 = Under Voltage1 Bit 11 = Over Voltage1 Bit 12 = Power Factor Trip Bit 13 = Phase Reversal Bit 14 = Frequency1 Bit 15 = Frequency2	03	TRALRM_1	0	1	0	65535	
Trip Alarm Status 2 Bit 0 = Power Element1 Bit 1 = PTC Bit 2 = Start Time Bit 3 = PTC Fault Bit 4 = Breaker Fail Bit 5 = LOP Bit 6 = Phase IOC2 Bit 7 = Residual IOC2 Bit 8 = Under Voltage2 Bit 9 = Over Voltage2 Bit 10 = Power Element2 Bits 11–15 = Reserved[c]	03	TRALRM_2	0	1	0	65535	

Table E.23 Modbus Quantities (Sheet 4 of 12)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Default	Number of 16-Bit Registers	Value		Scaling (X1 unless specified)
					Min	Max	
Trip Alarm Status 3	03	TRALRM_3	0	1	0	65535	
Bit 0 = Overload or Locked Rotor Alarm Bit 1 = Undercurrent Alarm Bit 2 = Load-Jam Alarm Bit 3 = Current Imbalance Alarm Bit 4 = Speed Switch Alarm Bit 5 = Power Factor Alarm Bits 6–12 = Reserved[c]							
SALARM		Bit 13					
WARNING		Bit 14					
HALARM		Bit 15					
I/O Status							
I/O Status	03	IO_STS	0	1	0	65535	
Bit 0 = IN01 Status Bit 1 = IN02 Status Bit 2 = IN03 Status Bit 3 = IN04 Status Bit 4 = IN05 Status Bit 5 = IN06 Status Bit 6 = IN07 Status Bit 7 = IN08 Status Bit 8 = IN09 Status Bit 9 = IN10 Status Bit 10 = IN11 Status Bit 11 = IN12 Status Bit 12 = OUT01 Status Bit 13 = OUT02 Status Bit 14 = OUT03 Status Bit 15 = OUT04 Status							
Control I/O Commands							
Logic Command	06	LOG_CMD	0	na	0	65535	
Bit 0 = Motor Start[d] Bit 1 = Motor Stop[d] Bit 2 = Emergency Restart[d] Bits 3–15 = Reserved[c]							
Current Data[e]							
IA Current	03	IA_MAG	0	1	0	65535	1
IA Angle	03	IA_ANG	0	1	–1800	1800	10
IB Current	03	IB_MAG	0	1	0	65535	1
IB Angle	03	IB_ANG	0	1	–1800	1800	10
IC Current	03	IC_MAG	0	1	0	65535	1
IC Angle	03	IC_ANG	0	1	–1800	1800	10
IG Current	03	IG	0	1	0	65535	1
IG Angle	03	IG_ANG	0	1	–1800	1800	10
IN Current	03	IN_MAG	0	1	0	65535	100
Pos. Seq. Current I1	03	I1	0	1	0	65535	1

Table E.23 Modbus Quantities (Sheet 5 of 12)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Default	Number of 16-Bit Registers	Value		Scaling (X1 unless specified)
					Min	Max	
I1 Angle	03	I1_ANG	0	1	–1800	1800	10
Neg. Seq. Current 3I2	03	3I2	0	1	0	65535	1
I2 Angle	03	3I2_ANG	0	1	–1800	1800	10
Average Current	03	IAVG	0	1	0	65535	1
Current Imbalance	03	UBI	0	1	0	1000	10
Voltage Data							
VAB	03	VAB_MAG	0	1	0	65535	1
VAB Angle	03	VAB_ANG	0	1	–1800	1800	10
VBC	03	VBC_MAG	0	1	0	65535	1
VBC Angle	03	VBC_ANG	0	1	–1800	1800	10
VCA	03	VCA_MAG	0	1	0	65535	1
VCA Angle	03	VCA_ANG	0	1	–1800	1800	10
VAN	03	VA_MAG	0	1	0	65535	1
VAN Angle	03	VA_ANG	0	1	–1800	1800	10
VBN	03	VB_MAG	0	1	0	65535	1
VBN Angle	03	VB_ANG	0	1	–1800	1800	10
VCN	03	VC_MAG	0	1	0	65535	1
VCN Angle	03	VC_ANG	0	1	–1800	1800	10
3V0 Voltage	03	3V0	0	1	0	65535	1
3V0 Angle	03	3V0_ANG	0	1	–1800	1800	10
Pos. Seq. V1	03	V1	0	1	0	65535	1
V1 Angle	03	V1_ANG	0	1	–1800	1800	10
Neg. Seq. Voltage V2	03	3V2	0	1	0	65535	1
3V2 Angle	03	3V2_ANG	0	1	–1800	1800	10
Average Voltage	03	VAVG[f]	0	1	0	65535	1
Voltage Imbalance	03	UBV	0	1	0	1000	10
Motor and Thermal Data							
Motor Load	03	MLOAD	0	1	0	120	10
Motor Load, High Resolution	03	MLOADHR	0	1	0	65535	1000
Stator %TCU	03	TCUSTR	0	1	0	65535	10
Rotor %TCU	03	TCURTR	0	1	0	65535	10
Thermal Time to Trip	03	THRMTP	0	1	0	9999	1
Time to Reset	03	TRST	0	1	0	9999	1
Starts Available	03	STRTAV	0	1	0	255	1
Power Data							
Real Power	03	P	0	2	–2147483648	2147483647	1
Reactive Power	03	Q	0	2	–2147483648	2147483647	1
Apparent Power	03	S	0	2	–2147483648	2147483647	1
Power Factor	03	PF	0	1	–100	100	100
PF Lead Lag	03	PFL	1	1	0	1	1
Frequency	03	FREQ	6000	1	1500	7000	100

Table E.23 Modbus Quantities (Sheet 6 of 12)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Default	Number of 16-Bit Registers	Value		Scaling (X1 unless specified)
					Min	Max	
RMS Data							
IA RMS	03	IARMS	0	1	0	65535	1
IB RMS	03	IBRMS	0	1	0	65535	1
IC RMS	03	ICRMS	0	1	0	65535	1
IG RMS	03	IGRMS	0	1	0	65535	1
IN RMS	03	INRMS	0	1	0	65535	1
VA RMS	03	VARMS	0	1	0	65535	1
VB RMS	03	VBRMS	0	1	0	65535	1
VC RMS	03	VCRMS	0	1	0	65535	1
VAB RMS	03	VABRMS	0	1	0	65535	1
VBC RMS	03	VBCRMS	0	1	0	65535	1
VCA RMS	03	VCARMS	0	1	0	65535	1
Energy Data							
REAL ENERGY, 3-PHASE OUT OF BUS	3	MWH3P	0	2	0	4294967295	1
REACTIVE ENERGY, 3-PHASE IN TO BUS	3	MVARH3PI	0	2	0	4294967295	1
REACTIVE ENERGY, 3-PHASE OUT OF BUS	3	MVARH3PO	0	2	0	4294967295	1
APPARENT ENERGY, 3-PHASE	3	MVAH3P	0	2	0	4294967295	1
ENERGY RST TIME ss	3	EMLRT_S	0	1	0	59999	4
ENERGY RST TIME mm	3	EMLRT_M	0	1	0	59	1
ENERGY RST TIME hh	3	EMLRT_H	0	1	0	23	1
ENERGY RST TIME dd	3	EMLRD_D	1	1	0	31	1
ENERGY RST TIME mm	3	EMLRD_M	1	1	0	12	1
ENERGY RST TIME yy	3	EMLRD_Y	2000	1	0	9999	1
Demand Data							
IA Demand	03	IAD	0	1	0	65535	1
IB Demand	03	IBD	0	1	0	65535	1
IC Demand	03	ICD	0	1	0	65535	1
IA Peak Demand	03	IAPD	0	1	0	65535	1
IB Peak Demand	03	IBPD	0	1	0	65535	1
IC Peak Demand	03	ICPD	0	1	0	65535	1
Demand RST Time ss	03	DMLRT_S	0	1	0	59999	1000
Demand RST Time mm	03	DMLRT_M	0	1	0	59	1
Demand RST Time hh	03	DMLRT_H	0	1	0	23	1
Demand RST Time dd	03	DMLRD_D	1	1	0	31	1
Demand RST Time mm	03	DMLRD_M	1	1	0	12	1
Demand RST Time yy	03	DMLRD_Y	2000	1	0	9999	1
MAX/MIN Data							
IA MAX	3	IAMX	0	1	0	65535	1
IB MAX	3	IBMX	0	1	0	65535	1
IC MAX	3	ICMX	0	1	0	65535	1

Table E.23 Modbus Quantities (Sheet 7 of 12)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Default	Number of 16-Bit Registers	Value		Scaling (X1 unless specified)
					Min	Max	
IN MAX	3	INMX	0	1	0	65535	1
IG MAX	3	IGMX	0	1	0	65535	1
IA MIN	3	IAMN	0	1	0	65535	1
IB MIN	3	IBMN	0	1	0	65535	1
IC MIN	3	ICMN	0	1	0	65535	1
IN MIN	3	INMN	0	1	0	65535	1
IG MIN	3	IGMN	0	1	0	65535	1
VAB MAX	3	VABMX	0	1	0	65535	1
VBC MAX	3	VBCMX	0	1	0	65535	1
VCA MAX	3	VCAMX	0	1	0	65535	1
VA MAX	3	VAMX	0	1	0	65535	1
VB MAX	3	VBMX	0	1	0	65535	1
VC MAX	3	VCMX	0	1	0	65535	1
VAB MIN	3	VABMN	0	1	0	65535	1
VBC MIN	3	VBCMN	0	1	0	65535	1
VCA MIN	3	VCAMN	0	1	0	65535	1
VA MIN	3	VAMN	0	1	0	65535	1
VB MIN	3	VBMN	0	1	0	65535	1
VC MIN	3	VCMN	0	1	0	65535	1
KVA3P MAX	3	KVA3PMX	0	2	–2147483648	2147483647	1
KW3P MAX	3	KW3PMX	0	2	–2147483648	2147483647	1
KVAR3P MAX	3	KVAR3PMX	0	2	–2147483648	2147483647	1
KVA3P MIN	3	KVA3PMN	0	2	–2147483648	2147483647	1
KW3P MIN	3	KW3PMN	0	2	–2147483648	2147483647	1
KVAR3P MIN	3	KVAR3PMN	0	2	–2147483648	2147483647	1
FREQ MAX	3	FREQMX	0	1	1500	7000	100
FREQ MIN	3	FREQMN	0	1	1500	7000	100
MAX/MIN RST TIME ss	3	MMLRT_S	0	1	0	59999	1000
MAX/MIN RST TIME mm	3	MMLRT_M	0	1	0	59	1
MAX/MIN RST TIME hh	3	MMLRT_H	0	1	0	23	1
MAX/MIN RST TIME dd	3	MMLRD_D	1	1	0	31	1
MAX/MIN RST TIME mm	3	MMLRD_M	1	1	0	12	1
MAX/MIN RST TIME yy	3	MMLRD_Y	2000	1	0	9999	1
Harmonic Metering Data							
IA THD	03	IA_THD		1	0	995	1
IB THD	03	IB_THD		1	0	995	1
IC THD	03	IC_THD		1	0	995	1
VA THD	03	VA_THD		1	0	995	1
VB THD	03	VB_THD		1	0	995	1
VC THD	03	VC_THD		1	0	995	1
VAB THD	03	VAB_THD		1	0	995	1

Table E.23 Modbus Quantities (Sheet 8 of 12)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Default	Number of 16-Bit Registers	Value Min	Value Max	Scaling (X1 unless specified)
VBC THD	03	VBC_THD		1	0	995	1
VCA THD	03	VCA_THD		1	0	995	1
Device Status 0 = OK 1 = WARN 2 = FAIL							
RAM Status	03	RAM	0	1	0	2	
ROM Status	03	ROM	0	1	0	2	
CR_RAM Status	03	CR_RAM	0	1	0	2	
NON_VOL Status	03	NON_VOL	0	1	0	2	
HMI Status	03	HMI	0	1	0	2	
CLOCK Status	03	CLKSTS	0	1	0	2	
CLK_BAT Status	03	CLK_BAT	0	1	0	2	
PTC Status	03	PTC	0	1	0	2	
AF Status	03	AFSTS	0	1	0	2	
DAQ Comm	03	DAQCOMM	0	1	0	2	
DAQ DIAG	03	DAQDIAG	0	1	0	2	
IA Status	03	IASTS	0	1	0	2	
IB Status	03	IBSTS	0	1	0	2	
IC Status	03	ICSTS	0	1	0	2	
IN Status	03	INSTS	0	1	0	2	
VA Status	03	VASTS	0	1	0	2	
VB Status	03	VBSTS	0	1	0	2	
VC Status	03	VCSTS	0	1	0	2	
Relay Status 0 = Enabled 1 = Disabled	03	RLYSTS	0	1	0	1	
Math Variables							
Math Variable MV01	03	MV01	0	2	–1677721599	1677721599	100
Math Variable MV02	03	MV02	0	2	–1677721599	1677721599	100
Math Variable MV03	03	MV03	0	2	–1677721599	1677721599	100
Math Variable MV04	03	MV04	0	2	–1677721599	1677721599	100
Math Variable MV05	03	MV05	0	2	–1677721599	1677721599	100
Math Variable MV06	03	MV06	0	2	–1677721599	1677721599	100
Math Variable MV07	03	MV07	0	2	–1677721599	1677721599	100
Math Variable MV08	03	MV08	0	2	–1677721599	1677721599	100
Device Counters							
Counter SC01	03	SC01	0	1	0	65000	1
Counter SC02	03	SC02	0	1	0	65000	1
Counter SC03	03	SC03	0	1	0	65000	1
Counter SC04	03	SC04	0	1	0	65000	1
Counter SC05	03	SC05	0	1	0	65000	1
Counter SC06	03	SC06	0	1	0	65000	1
Counter SC07	03	SC07	0	1	0	65000	1
Counter SC08	03	SC08	0	1	0	65000	1

Table E.23 Modbus Quantities (Sheet 9 of 12)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Default	Number of 16-Bit Registers	Value		Scaling (X1 unless specified)
					Min	Max	
Remote Analogs							
Remote Analog RA001	03/06	RA001	0	2	–9999999	9999999	100
Remote Analog RA002	03/06	RA002	0	2	–9999999	9999999	100
Remote Analog RA003	03/06	RA003	0	2	–9999999	9999999	100
Remote Analog RA004	03/06	RA004	0	2	–9999999	9999999	100
Remote Analog RA005	03/06	RA005	0	2	–9999999	9999999	100
Remote Analog RA006	03/06	RA006	0	2	–9999999	9999999	100
Remote Analog RA007	03/06	RA007	0	2	–9999999	9999999	100
Remote Analog RA008	03/06	RA008	0	2	–9999999	9999999	100
Remote Analog RA009	03/06	RA009	0	2	–9999999	9999999	100
Remote Analog RA010	03/06	RA010	0	2	–9999999	9999999	100
Remote Analog RA011	03/06	RA011	0	2	–9999999	9999999	100
Remote Analog RA012	03/06	RA012	0	2	–9999999	9999999	100
Remote Analog RA013	03/06	RA013	0	2	–9999999	9999999	100
Remote Analog RA014	03/06	RA014	0	2	–9999999	9999999	100
Remote Analog RA015	03/06	RA015	0	2	–9999999	9999999	100
Remote Analog RA016	03/06	RA016	0	2	–9999999	9999999	100
Remote Analog RA017	03/06	RA017	0	2	–9999999	9999999	100
Remote Analog RA018	03/06	RA018	0	2	–9999999	9999999	100
Remote Analog RA019	03/06	RA019	0	2	–9999999	9999999	100
Remote Analog RA020	03/06	RA020	0	2	–9999999	9999999	100
Remote Analog RA021	03/06	RA021	0	2	–9999999	9999999	100
Remote Analog RA022	03/06	RA022	0	2	–9999999	9999999	100
Remote Analog RA023	03/06	RA023	0	2	–9999999	9999999	100
Remote Analog RA024	03/06	RA024	0	2	–9999999	9999999	100
Remote Analog RA025	03/06	RA025	0	2	–9999999	9999999	100
Remote Analog RA026	03/06	RA026	0	2	–9999999	9999999	100
Remote Analog RA027	03/06	RA027	0	2	–9999999	9999999	100
Remote Analog RA028	03/06	RA028	0	2	–9999999	9999999	100
Remote Analog RA029	03/06	RA029	0	2	–9999999	9999999	100
Remote Analog RA030	03/06	RA030	0	2	–9999999	9999999	100
Remote Analog RA031	03/06	RA031	0	2	–9999999	9999999	100
Remote Analog RA032	03/06	RA032	0	2	–9999999	9999999	100
Motor Statistics							
Elapsed Time-mm	03	MOT_E_M	0	1	0	59	1
Elapsed Time-hh	03	MOT_E_H	0	1	0	23	1
Elapsed Time-dd	03	MOT_E_D	0	1	0	65535	1
Running Time-mm	03	MOT_R_M	0	1	0	59	1
Running Time-hh	03	MOT_R_H	0	1	0	23	1
Running Time-dd	03	MOT_R_D	0	1	0	65535	1
Stopped Time-mm	03	MOT_S_M	0	1	0	59	1
Stopped Time-hh	03	MOT_S_H	0	1	0	23	1

Table E.23 Modbus Quantities (Sheet 10 of 12)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Default	Number of 16-Bit Registers	Value		Scaling (X1 unless specified)
					Min	Max	
Stopped Time-dd	03	MOT_S_D	0	1	0	65535	1
% Time Running	03	TIMERUN	0	1	0	1000	10
Motor Running Time	03	MRT	0	1	0	65535	1
Starts Count	03	NUMSTRT	0	1	0	65535	1
Restarts Count	03	NUMRSTRT	0	1	0	65535	1
EMER Start Count	03	NUMEMRST	0	1	0	65535	1
Contactor Operations Count	03	NUMCONOP	0	1	0	65535	1
Breaker Operations Count	03	NUMBKROP	0	1	0	65535	1
MOT RST Time-ss	03	MOTRST_S	0	1	0	59999	1000
MOT RST Time-mm	03	MOTRST_M	0	1	0	59	1
MOT RST Time-hh	03	MOTRST_H	0	1	0	23	1
MOT RST Date-dd	03	MOTRSD_D	1	1	1	31	1
MOT RST Date-mm	03	MOTRSD_M	1	1	1	12	1
MOT RST Date-yy	03	MOTRSD_Y	2000	1	2000	9999	1
Average Statistics							
Start Time	03	STRT_T_A	0	1	0	9999	10
Max Start I	03	MAXSTI_A	0	1	0	65535	1
Min Start V	03	MINSTV_A	0	1	0	65535	1
Start %TCU	03	STRTTC_A	0	1	0	65535	10
Running %TCU	03	RUNTC_A	0	1	0	65535	10
Running CUR	03	RUNI_A	0	1	0	65535	10
Running KW	03	RUNKW_A	0	1	0	65535	10
Running KVARIN	03	RUKVRI_A	0	1	0	65535	10
Running KVAROUT	03	RUKVRO_A	0	1	0	65535	10
Running KVA	03	RUNKVA_A	0	1	0	65535	10
Peak Statistics							
Start Time	03	STRT_T_P	0	1	0	9999	10
Max Start I	03	MAXSTI_P	0	1	0	65535	1
Min Start V	03	MINSTV_P	0	1	0	65535	1
Start %TCU	03	STRTTC_P	0	1	0	65535	10
Running %TCU	03	RUNTC_P	0	1	0	65535	10
Running CUR	03	RUNI_P	0	1	0	65535	10
Running KW	03	RUNKW_P	0	1	0	65535	10
Running KVARIN	03	RUKVRI_P	0	1	0	65535	10
Running KVAROUT	03	RUKVRO_P	0	1	0	65535	10
Running KVA	03	RUNKVA_P	0	1	0	65535	10
Alarm Counters							
Overload	03	THERM_A	0	1	0	65535	1
Locked Rotor	03	LOCKR_A	0	1	0	65535	1
Undercurrent	03	LDLOSS_A	0	1	0	65535	1
Jam	03	LDJAM_A	0	1	0	65535	1
Current Imbalance	03	UBI_A	0	1	0	65535	1

Table E.23 Modbus Quantities (Sheet 11 of 12)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Default	Number of 16-Bit Registers	Value		Scaling (X1 unless specified)
					Min	Max	
Speed Switch	03	SPDSW_A	0	1	0	65535	1
Power Factor	03	PF_A	0	1	0	65535	1
Total Alarms	03	TOTAL_A	0	1	0	65535	1
Trip Counters							
Overload	03	THERM_T	0	1	0	65535	1
Locked Rotor	03	LOCKR_T	0	1	0	65535	1
Undercurrent	03	LDLOSS_T	0	1	0	65535	1
Jam	03	LDJAM_T	0	1	0	65535	1
Current Imbalance	03	UBI_T	0	1	0	65535	1
Overcurrent	03	PHFLT_T	0	1	0	65535	1
Ground Fault	03	GRFLT_T	0	1	0	65535	1
Speed Switch	03	SPDSW_T	0	1	0	65535	1
Undervoltage	03	UNDV_T	0	1	0	65535	1
Overvoltage	03	OVRV_T	0	1	0	65535	1
Power	03	POWER_T	0	1	0	65535	1
Power Factor	03	PF_T	0	1	0	65535	1
Phase Reversal	03	PHREV_T	0	1	0	65535	1
Underfrequency	03	UNDFRQ_T	0	1	0	65535	1
Overfrequency	03	OVRFRQ_T	0	1	0	65535	1
PTC	03	PTC_T	0	1	0	65535	1
Start Timer	03	STTIM_T	0	1	0	65535	1
Remote Stop	03	COMM_T	0	1	0	65535	1
Local Stop	03	LOC_T	0	1	0	65535	1
Other Trips	03	OTHTR_T	0	1	0	65535	1
Total Trips	03	TOTAL_T	0	1	0	65535	1
Modbus Communication Counters							
Num Messages Received	03	MSGRCD[b]	0	1	0	65535	1
Num Msgs to Other devices (Other ID)	03	MSGOID[b]	0	1	0	65535	1
Illegal Address	03	ILLADDR[b]	0	1	0	65535	1
Bad CRC	03	BADCRC[b]	0	1	0	65535	1
Uart Error	03	UARTER[b]	0	1	0	65535	1
Illegal Function	03	ILLFUNC[b]	0	1	0	65535	1
Illegal Register	03	ILLREG[b]	0	1	0	65535	1
Illegal Data	03	ILLDATA[b]	0	1	0	65535	1

Table E.23 Modbus Quantities (Sheet 12 of 12)

Description	Valid Function Codes	SET_M Point Label/Enums[a]	Default	Number of 16-Bit Registers	Value		Scaling (X1 unless specified)
					Min	Max	
Bad Packet Format	03	BADPF[b]	0	1	0	65535	1
Bad Packet Length	03	BADPL[b]	0	1	0	65535	1
Relay Elements[g]							
ROW 0—ROW 51	03	ROW_0–ROW_44	0	1	0	255	

[a] Point names appearing in bold can be written with function code 06h or 10h.
[b] These analogs may only be assigned to a single register. Relay will respond with the error message, "Value may only appear in the map once," if an attempt is made to assign one of the analogs to multiple registers.
[c] Reserved bits shall accept 0 or 1.
[d] Motor Start, Motor Stop, and Emergency Restart are mutually exclusive and the relay shall assert any of these bits and return the Exception Response if an attempt is made to write to more than one bit.
[e] The following data are a list of Modbus Analogs and their attributes. These analogs can be set via the SET M command to an address in the user region.
[f] This register gives the average phase voltage for wye-connected PTs and the average phase-to-phase voltage for delta-connected PTS.
[g] See Appendix H: Relay Word Bits for element information in the Relay Word rows.

Table E.24 Default Modbus Map

Modbus Address	User Map Register	Mapped Register Label
000	MOD_001	IA_MAG
001	MOD_002	IB_MAG
002	MOD_003	IC_MAG
003	MOD_004	IG_MAG
004	MOD_005	IN_MAG
005	MOD_006	IAVG
006	MOD_007	MLOAD
007	MOD_008	3I2
008	MOD_009	UBI
009	MOD_010	FREQ
010	MOD_011	TCUSTR
011	MOD_012	TCURTR
012	MOD_013	THRMTP
013	MOD_014	TRST
014	MOD_015	STRTAV
015	MOD_016	IARMS
016	MOD_017	IBRMS
017	MOD_018	ICRMS
018	MOD_019	IGRMS
019	MOD_020	INRMS
020	MOD_021	NUMSTRT
021	MOD_022	NUMRSTRT
022	MOD_023	NUMEMRST
023	MOD_024	TIMERUN
024	MOD_025	TRALRM_1
025	MOD_026	TRALRM_2
026	MOD_027	TRALRM_3

Additional Modbus Registers (RID, TID, PART_NUM)

The SEL-849 Modbus Register Map has separate register addresses assigned for labels RID, TID, and PART_NUM. These labels cannot be mapped in the Modbus Map. You can poll for these labels using the register addresses specified in *Table E.25*.

Table E.25 RID, TID, and PART_NUM Registers

Description	Register Address	Valid Function Codes	Default	Number of 16-Bit Registers	Value	
					Min	Max
RID	1001–1016[a]	03	0	1	0	65535
TID	1017–1032[a]	03	0	1	0	65535
PART_NUM	1033–1040	03	0	1	0	65535

[a] Modbus Addresses 1001 through 1032 contain string data. Strings are packed 2 characters per register with the MSB containing the character closest to the beginning of the string.

Reading Event Data Using Modbus

The SEL-849 provides a feature that allows relay event history data to be retrieved via Modbus. The Event History registers are listed in *Table E.23* under the Historical Data description heading. To read the history data, set the Modbus Map to contain the EVESEL label, along with the other Fault History related labels. The following example shows some of the available history data labels in the Modbus Map:

```
=>>sho m

Modbus Settings

User Map Register Settings

1: EVESEL
2: ETIME_S
3: ETIME_M
4: ETIME_H
5: EDATE_D
6: EDATE_M
7: EDATE_Y
8: EVE_TYPE
9: NUMEVE

=>>
```

Use Modbus function code 03 or 04 to read the Modbus registers. The NUMEVE label will contain the number of events listed in the event history, **HIS** command, and response. To read relay event history data using Modbus, use function code 06 to write the event number, which is the relative ID (1–50) or the unique event number (between 10000 and 42767), to the Modbus register containing the EVESEL label. The relay will return the history data using the unique event number as long as that event is currently in the history data. The SEL-849 will populate the other event related registers with the data related to the event number specified in the EVESEL label address. Issue a Modbus function code 03 or 04 command to read the registers containing the history data.

For example, use the following relay response to the **HIS** command:

```
=>>his

SEL-849                                     Date: 09/14/2018   Time: 21:44:28.904
MOTOR RELAY                                 Time Source: Internal


FID = SEL-849-R106-V3-Z003002-D20180212

#        DATE        TIME     EVENT                           CURR  FREQ TARGETS
10004 09/14/2018 21:44:16.283 Thermal Overload Trip      68.9 59.99 1111010101
10003 09/14/2018 21:44:11.728 ER Trigger                 68.9 59.99 1011010100
10002 09/14/2018 21:42:16.485 Trigger                     0.1 60.00 1100110100
10001 09/14/2018 21:42:01.042 Phase Reversal Trip         5.0 59.99 1101010100
10000 09/14/2018 21:41:33.030 Phase Reversal Trip        22.2 59.99 1101010100
```

Retrieve the history data in this example for event number 4, using the map shown above, by setting register address 0001 to the value of 4 using a function code 06 command. (Note: The Modbus Map is indexed beginning with 1, which corresponds to register address 0 in Modbus). If a value is written to the EVESEL register for an event that does not currently exist in the history data, the SEL-849 will respond with an exception code 03.

Following the function code 06 command, issue a function code 03 or 04 command to read registers 0–9 as shown in the previous **SHO M** capture. The data returned in registers 2–9 would contain the event time, event date, and event type associated with event number 4.

When the history data are cleared in the relay, either from the **HIS C** command or from a remote control point, the NUMEVE register will contain the value of 0, indicating there are no events that can be read using Modbus. After a power cycle, the history data registers show the history data corresponding to the latest event. This information updates dynamically; whenever there is a new event, the history data registers update automatically with new event data. If specific event number data have been retrieved using a write to the EVESEL register, the event data registers stay frozen with that specific event history. These registers return the latest event history data when a zero is written to the event selection register from a prior nonzero selection.

Appendix F
EtherNet/IP Communications

Overview

EtherNet/IP, or Ethernet/Industrial Protocol, is an industrial protocol that uses standard Ethernet and TCP/IP technology to transport Common Industrial Protocol (CIP) packets.

The SEL-849 Motor Management Relay supports EtherNet/IP. This section discusses general specifications for EtherNet/IP implementation, as well as the CIP data model, the allocation of the CIP connections, the EtherNet/IP Port 2 settings, and the Electronic Data Sheet (EDS) file in the SEL-849.

The SEL-849 supports two ways of exchanging data via EtherNet/IP:

➤ **Implicit Message Adapter**. The I/O data is mapped into Assembly object instances. The SEL-849 exchanges this I/O data via EtherNet/IP Implicit Class 1 connections with a remote EtherNet/IP Scanner device using UDP packets.

➤ **Explicit Message Server.** The I/O data is mapped into Assembly object instances. The SEL-849 responds to generic TCP EtherNet/IP Explicit message requests initiated by a remote EtherNet/IP Client device.

For more information on EtherNet/IP, visit www.odva.org.

Specifications

Table F.1 EtherNet/IP Specifications (Sheet 1 of 2)

EtherNet/IP Services
Implicit Message Adapter (Class 1) Explicit Message Server (Class 3 and unconnected)
CIP Model-Implemented Objects
Identity Object Message Router Object Assembly Object Connection Manager Object File Object TCP/IP Interface Object Ethernet Link Object Vendor Specific Object

Table F.1 EtherNet/IP Specifications (Sheet 2 of 2)

Implicit Message Adapter	
Number of Connections	As many as eight (two Class 1 connections and six Class 3/unconnected connections)
Class 1 Connection Types	Unicast Multicast
Class 1 Connection Transport Types	Exclusive Owner Input Only Listen Only
Class 1 Connection Trigger Types	Cyclic Change of State
Input Only Heartbeat Connection Point	238
Listen Only Heartbeat Connection Point	237

CIP Data Model

Profile

Table F.2 CIP Data Model Profile

Class Name	Class ID	Number of Instances
Identity Object	0x01	1
Message Router Object	0x02	1
Assembly Object	0x04	Determined by the user/based on the application
Connection Manager Object	0x06	1
File Object	0x37	2
TCP/IP Interface Object	0xF5	1
Ethernet Link Object	0xF6	See *Ethernet Link Object (0xF6)*
Vendor Specific Object	0x64	1

Identity Object (0x01)

Instances Implemented

The SEL-849 supports one instance (Instance ID = 1) or the Identity Object.

Table F.3 Identity Object List of Attributes (Sheet 1 of 2)

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	1	The revision of this CIP Object
2	Max Instance	GET	UINT	1	The maximum Identity Object Instance ID
3	Number of Instances	GET	UINT	1	Total number of Identity Objects
4	Optional Attribute List	GET	[UINT, Array of UINT]	[1, [21]]	[Number of Optional Instance Attributes, List of Optional Instance Attributes]

Table F.3 Identity Object List of Attributes (Sheet 2 of 2)

Attribute ID	Name	Access	Data Type	Default	Description
6	Maximum ID Number Class Attributes	GET	UINT	7	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	21	Maximum Instance Attribute ID
Instance Attributes					
1	Vendor ID	GET	UINT	865	
2	Device Type	GET	UINT	0x2B	
3	Product Code	GET	UINT		The most significant byte is the Device Code (DEVCODE as found in the **ID** command of the SEL-849) and its least significant byte is the user-configurable Configuration ID as provided in the Ethernet port settings
4	[Major Revision, Minor Revision]	GET	[USINT, USINT]	[1,1]	
5	Status	GET	WORD		Refer to *Table F.4*
6	Serial Number	GET	UDINT		The low-order 32 bits of the MAC address of the Ethernet port
7	Product Name	GET	STRING		The existing default product name (the default RID string) of the SEL-849 plus the value of the user-configurable Configuration ID as provided in the Ethernet port settings. The general format is, "<Default RID>-<Configuration ID>"
21	Catalog Number	GET	STRING		The existing default product name (the default RID string) of the SEL-849 plus the value of the user-configurable Configuration ID as provided in the Ethernet port settings. The general format is, "<Default RID>-<Configuration ID>"

Table F.4 Status WORD Bits Descriptions

Bit Number[a]	Name	Description
0	Owned	TRUE, if at least one scanner has established an Exclusive Owner Class 1 connection to the SEL-849. FALSE, if the SEL-849 has no active Exclusive Owner connections to a scanner.
2	Configured	Always TRUE.
4 to 7	Extended Device Status	Hexadecimal value: 2: A Class 1 connection has timed out. 3: No Class 1 connection has been established. 6: At least one Class 1 connection is active. 7: In any other case.
11	Major Unrecoverable Fault	TRUE if the product is disabled due to an unrecoverable fault; otherwise, it is FALSE.

[a] The Status WORD bits not listed in this table are always set to FALSE.

Table F.5 Identity Object Supported Services

Service Code	Service Name	Class	Instance	Description
0x01	Get Attributes All	Yes	Yes	Returns a list of all of the values of the attributes.
0x05	Reset	No	Yes	Restarts the EtherNet/IP service in the SEL-849. Only reset type 0 is allowed.
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.

Message Router Object (0x02)

Table F.6 Message Router Object List of Attributes

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	1	The revision of this CIP Object
2	Max Instance	GET	UINT	1	The maximum Message Router Object Instance ID
3	Number of Instances	GET	UINT	1	Total number of Message Router Object Instances
4	Optional Attribute List	GET	[UINT, Array of UINT]	[3,[1,2,3]]	[Number of Optional Instance Attributes, List of Optional Instance Attributes]
5	Optional Service List	GET	[UINT, Array of UINT]	[1.[10]]	Number of Optional Service Codes followed by the List of Optional Service Codes
6	Maximum ID Number Class Attributes	GET	UINT	7	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	3	Maximum Instance Attribute ID
Instance Attributes					
1	Class List	GET	[UINT, Array of UINT]		Implemented object list
2	Maximum Connections	GET	UINT		Maximum number of connections supported
3	Number of Connections	GET	UINT		Number of connections currently used

Table F.7 Message Router Supported Services

Service Code	Service Name	Class	Instance	Description
0x01	Get Attribute All	Yes	Yes	Returns a list of all of the attributes.
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.
0x0A	Multiple Service Packet	No	Yes	

Assembly Object (0x04)

Instances Implemented

The SEL-849 relay settings define the number of Assembly Object Instances based on the number and type of connections configured and the data content of each instance. Each assembly is as large as 500 bytes in size. The SEL-849 supports a total of six assemblies (three Input Assemblies and three Output Assemblies).

Table F.8 Assembly Object List of Attributes

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	2	The revision of this CIP Object
2	Max Instance	GET		Determined by the settings	The maximum Assembly Object Instance ID defined by the user
3	Number of Instances	GET		Determined by the settings	Total number of Assembly Object instances defined by the user.
4	Optional Attribute List	GET	[UINT, Array of UINT]	[1,[4]]	[Number of Optional Instance Attributes, List of Optional Instance Attributes]
6	Maximum ID Number Class Attributes	GET	UINT	7	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	4	Maximum Instance Attribute ID
Instance Attributes					
1	Number of Members	GET	UINT		Number of Assembly Members defined by the user
2	Member List	GET	Array of [UINT, UINT, EPATH]		Only 500 bytes are allowed
3	Data	GET, SET	Array of Bytes		Data map defined with **SET E**, **1**, **2**, or **3**
4	Size	GET	UINT		Number of bytes in Instance Attribute 3

Table F.9 Assembly Object Supported Services

Service Code	Service Name	Class	Instance	Description
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.
0x10	Set Attribute Single	No	Yes	Sets the value of a specific attribute.
0x18	Get Member	No	Yes	Returns the value of a member of the data attribute.
0x19	Set Member	No	Yes	Modifies the value of a member of the data attribute.

Connection Manager Object (0x06)

Table F.10 Connection Manager Object List of Attributes

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	1	The revision of this CIP Object
2	Max Instance	GET	UINT		The maximum Connection Manager Object Instance ID
3	Number of Instances	GET	UINT		Total number of Connection Manager Object Instances
4	Optional Attribute List	GET	[UINT, Array of UINT]	[8,[1,2,3,4,5,6,7,8]]	[Number of Optional Instance Attributes, List of Optional Instance Attributes]
6	Maximum ID Number Class Attributes	GET	UINT	7	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	8	Maximum Instance Attribute ID
Instance Attributes					
1	Open Requests	GET/SET	UINT		Number of FWD Open service requests received
2	Open Format Rejects	GET/SET	UINT		Number of FWD Open service requests rejected because of bad format
3	Open Resource Rejects	GET/SET	UINT		Number of FWD Open service requests rejected because of lack of resources
4	Open Other Rejects	GET/SET	UINT		Number of FWD Open service requests rejected for reasons other than bad format or lack or resources
5	Close Requests	GET/SET	UINT		Number of FWD Close service requests received
6	Close Format Rejects	GET/SET	UINT		Number of FWD Close service requests rejected because of bad format
7	Close Other Rejects	GET/SET	UINT		Number of FWD Open service requests rejected for reasons other than bad format
8	Connection Timeouts	GET/SET	UINT		Number of connection timeouts

Table F.11 Connection Manager Object Supported Services (Sheet 1 of 2)

Service Code	Service Name	Class	Instance	Description
0x01	Get Attribute All	Yes	Yes	Returns a list of all of the attributes.
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.
0x10	Set Attribute Single	No	Yes	Sets the value of a specific attribute.
0x02	Set Attribute All	No	Yes	Sets the value of all attributes.
0x54	Forward Open	No	Yes	Establishes a CIP connection.
0x4E	Forward Close	No	Yes	Closes a CIP connection.

Table F.11 Connection Manager Object Supported Services (Sheet 2 of 2)

Service Code	Service Name	Class	Instance	Description
0x5B	Large Forward Open	No	Yes	Establishes a CIP connection that allows a large connection size.
0x5A	Get Connection Owner	No	Yes	Returns data about the connection that owns the object.

File Object (0x37)

The File Object stores the EDS and icon files. The EDS file is generated by the SEL-849 based on the EtherNet/IP Port 2 settings and the SET E 1, 2, or 3 settings. The relay can retrieve the file using the File Object services. You cannot write an EDS file to the relay using the File Object services.

The SEL-849 implements two instances of the File Object:

- ➤ Instance 0xC8 returns an uncompressed version of the EDS file with an embedded icon.
- ➤ Instance 0xC9 returns a compressed version of the icon file.

Table F.12 File Object List of Attributes (Sheet 1 of 2)

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	1	The revision of this CIP Object
2	Max Instance	GET	UINT	201	
3	Number of Instances	GET	UINT	2	
6	Maximum ID Number Class Attributes	GET	UINT	32	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	11	Maximum Instance Attribute ID
32	Directory	GET	[UINT, STRINGI, STRINGI] [UINT, STRINGI, STRINGI]	[0xC8,(ENG)‘EDS and Icon Files’, (ENG)‘EDS.txt’] [0xC9, (ENG)‘Related EDS and Icon Files’, (ENG)‘EDSCollection.gz’]	List of all File Object instance and file names present in the SEL-849 and the associated instance numbers
0xC8 Instance Attributes					
1	State	GET	USINT	2	
2	Instance Name	GET	STRINGI	(ENG)‘EDS and Icon Files’	
3	File Format Version	GET	UINT	1	
4	File Name	GET	STRINGI	(ENG)‘EDS.txt’	
5	File Revision	GET	[USINT, USINT]		[Major EDS revision Ethernet port setting, Minor EDS revision Ethernet port setting]
6	File Size	GET	UDINT		Size of the EDS file in bytes
7	File Checksum	GET	UINT		Checksum of the EDS file (2s complement of the 16-bit sum of all octets in the file)
8	Invocation Method	GET	USINT	255	
9	File Save Parameters	GET	USINT	0	
10	File Access Rule	GET	USINT	1	
11	File Encoding Format	GET	USINT	0	

Table F.12 File Object List of Attributes (Sheet 2 of 2)

Attribute ID	Name	Access	Data Type	Default	Description
0xC9 Instance Attributes					
1	State	GET	USINT	2	
2	Instance Name	GET	STRINGI	(ENG)'Related EDS and Icon Files'	
3	File Format Version	GET	UINT	1	
4	File Name	GET	STRINGI	(ENG)'EDSCollection.gz'	
5	File Revision	GET	[USINT, USINT]	[1,1]	[Major Revision, Minor Revision]
6	File Size	GET	UDINT		Size of the loaded file in bytes
7	File Checksum	GET	UINT		Checksum of the EDSCollection file (2s complement of the 16-bit sum of all octets in the file)
8	Invocation Method	GET	USINT	255	
9	File Save Parameters	GET	USINT	0	
10	File Access Rule	GET	USINT	1	
11	File Encoding Format	GET	USINT	1	

Table F.13 File Object Supported Services

Service Code	Service Name	Class	Instance	Description
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.
0x4B	Initiate Upload	No	Yes	
0x4F	Upload Transfer	No	Yes	

TCP/IP Interface Object (0xF5)

Instances Implemented

The number of instances of the TCP/IP Interface Object is always 1, regardless of whether the CPU card contains a single Ethernet port or a dual Ethernet port.

Table F.14 TCP/IP Interface Object List of Attributes (Sheet 1 of 3)

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	4	The revision of this CIP Object
2	Max Instance	GET	UINT	1	The maximum TCP/IP Object Instance ID
3	Number of Instances	GET	UINT	1	Total number of TCP/IP Object Instances
4	Optional Attribute List	GET	[UINT, Array of UINT]	[4,[8,9,16,17]]	[Number of Optional Instance Attributes, List of Optional Instance Attributes]

Table F.14 TCP/IP Interface Object List of Attributes (Sheet 2 of 3)

Attribute ID	Name	Access	Data Type	Default	Description
6	Maximum ID Number Class Attributes	GET	UINT	7	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	17	Maximum Instance Attribute ID
Instance Attributes					
1	Status	GET	DWORD	2	
2	Configuration Capability	GET	DWORD	32	Any change in the configuration will be updated when the server is restarted.
3	Configuration Control	GET	DWORD	0	IP addresses must be configured statically. DHCP and DNS are not supported.
4	Physical Link Object	GET	[UINT, EPATH]		[Path size, Path to the corresponding Ethernet link object instance] For a dual Ethernet port CPU card, the value is 00 00 (path size of 0). For a single Ethernet port CPU card, the value is 02 00 20 F6 24 01, where 02 00 is the path size (number of 16-bit words), 20 is the 8-bit class segment type, F6 is the Ethernet Link Object class, 24 is the 8-bit instance segment type, and 01 is Instance 1.
5	Interface Configuration	GET	[UDINT, UDINT, UDINT, UDINT, UDINT, STRING]		[IP address, Network mask, Gateway address, 0, 0, null]
6	Host Name	GET	STRING		When converted to ASCII, this displays, “[Product Name]-[Serial Number]”. This attribute cannot be set by the scanner.
8	TTL Value	GET/SET	USINT	1	The scanner can set this attribute.
9	Mcast Config	GET/SET	[USINT, USINT, UINT, UDINT]	[Alloc control, Reserved, Num Mcast, Mcast Start Address]	The scanner can set this attribute only if the control is 01 00. 1st and 2nd Byte: This represents the control. When the value is 00 00, the scanner cannot change the number of multicast connections nor the Mcast Start Address. To change these, all eight bytes must be written at once, e.g., 01 00 *xx xx yy yy yy yy*. 3rd and 4th Byte: Number of multicast connections supported by the product in little endian order. 02 00 is the default value. The maximum number of multicast connections supported is two. 5th–8th Byte: Mcast Start Address according to the default algorithm specified in Section 3-5.3 of Volume 2 of the standard.
13	Encapsulation Inactivity Timeout	GET/SET	UINT	120	The scanner can set this value.

Table F.14 TCP/IP Interface Object List of Attributes (Sheet 3 of 3)

Attribute ID	Name	Access	Data Type	Default	Description
16	Active TCP Connections	GET	UINT	1	
17	Non-CIP Encapsulation Messages per Second	GET	UDINT	0	

Table F.15 TCP/IP Interface Object Supported Services

Service Code	Service Name	Class	Instance	Description
0x01	Get Attribute All	Yes	Yes	Returns a list of all of the attributes.
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.
0x10	Set Attribute Single	No	Yes	Sets the value of a specific attribute.

Ethernet Link Object (0xF6)

Instances Implemented

The number of instances of the Ethernet Link Object depends on whether the CPU card contains a single Ethernet port or a dual Ethernet port. The value will be 1 for a single Ethernet port and 2 for a dual Ethernet port.

Table F.16 Ethernet Link Object List of Attributes

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	4	The revision of this CIP Object
2	Max Instance	GET	UINT		The maximum Ethernet Link Object Instance ID
3	Number of Instances	GET	UINT		Total number of Ethernet Link Object Instances
4	Optional Attribute List	GET	[UINT, Array of UINT]	[1,[10]]	[Number of Optional Instance Attributes, List of Optional Instance Attributes]
6	Maximum ID Number Class Attributes	GET	UINT	7	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	11	Maximum Instance Attribute ID
Instance Attributes					
1	Interface Speed	GET	UINT		Speed (MBPS) in use on the corresponding interface
2	Interface Flags	GET	DWORD		See *Table F.17*
3	Physical Address	GET	USINT[6]		MAC address of the corresponding interface
10	Interface Label	GET	STRING		SEL-849 interface name, e.g., “PORT 2A”
11	Interface Capability	GET	[DWORD, USINT]		[Capability bits, Array Element Count]

Table F.17 Interface Flags Bits Descriptions

Bit Number	Name	Description
0	Link Status	0: The Ethernet interface link is inactive. 1: The link is active.
1	Half/Full Duplex	0: The interface is running half duplex. 1: The interface is running full duplex.
2–4	Negotiation Status	Octal unsigned value: 0: Auto negotiation in progress. 1: Auto negotiation and speed detection failed. Using default values. 2: Auto negotiation failed, but detected speed. 3: Successfully negotiated speed and duplex. 4: Auto negotiation not attempted.
5	Manual Setting Requires Reset	Set to 1.

Table F.18 Ethernet Link Object Supported Services

Service Code	Service Name	Class	Instance	Description
0x01	Get Attribute All	Yes	Yes	Returns a list of all of the attributes.
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.

Vendor Specific Object (0x64)

Instances Implemented

The SEL-849 supports one instance (Instance ID = 1) of the Vendor Specific Object.

Table F.19 Vendor Specific Object List of Attributes

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	1	The revision of this CIP Object
2	Max Instance	GET	UINT	1	The maximum Vendor Specific Object Instance ID
3	Number of Instances	GET	UINT	1	Total number of Vendor Specific Object Instances
Instance Attributes					
100	Enabled[a]	GET	BOOL		Relay Enabled Status
101	Trip	GET	BOOL		Protection Trip

[a] This attribute reflects the value of the Relay Word bit indicating Enabled status of the SEL-849.

Table F.20 Vendor Specific Object Supported Services

Service Code	Service Name	Class	Instance	Description
0x01	Get Attribute All	Yes	Yes	Returns a list of all of the attributes.
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.

CIP Connections and Corresponding Assembly Maps

The SEL-849 supports as many as eight simultaneous CIP connections. Of the eight simultaneous connections, as many as two of them can be Class 1 (I/O) connections and as many as six of them can be a combination of Class 3 messages and Unconnected Message Manager (UCMM) messages. Class 3 connections are created internally by the SEL-849 when the appropriate connection is made by the EtherNet/IP scanner.

When configuring EtherNet/IP (EIP) on Port 2, you can create as many as six Class 1 (I/O) connection configurations. Of these six, only two can be used simultaneously. Of the six available connection configurations, as many as three can be Exclusive Owner connection configurations. The remaining number of connection configurations must be Input Only connection configurations.

An Exclusive Owner connection configuration contains both a Target to Originator (T->O, data flows from the SEL-849 to the scanner) connection and an Originator to Target (O->T, data flows from the scanner to the SEL-849) connection. An Input Only connection configuration contains a (T->O) connection only. For every distinct (T->O) connection, the SEL-849 automatically creates a Listen Only connection configuration. Listen Only connection configurations do not count against the six Class 1 (I/O) connection configurations. For the SEL-849, the types of supported connections are shown in *Table F.21*.

The flow of data is represented via assemblies. Input Assemblies 100, 102, and 104 are always associated with (T->O) connections and Output Assemblies 101, 103, and 105 are always associated with (O->T) connections. Note that these Output Assemblies can also be associated with (T->O) connections. The Input Assemblies can contain both binary input (from *Table H.1*) and analog input (from *Table I.1*) data. The Output Assemblies can contain both binary output and analog output data. Input Assembly 100 and Output Assembly 101 consist of data that can be chosen by setting the EtherNet/IP Assembly Map 1 settings using the **SET E 1** command. Similarly, Input Assembly 102 and Output Assembly 103 consist of data that can be chosen by setting the EtherNet/IP Assembly Map 2 settings using the **SET E 2** command. Input Assembly 104 and Output Assembly 105 consist of data that can be chosen by setting the EtherNet/IP Assembly Map 3 settings using the **SET E 3** command. Each of these assembly maps contains 100 binary input points, 100 analog input points, 32 binary output points, and 32 analog output points. It is important to note that the binary output points can take on the value of any remote bit (SET/CLEAR) within the SEL-849. The COMMSTP and COMMSTR bits are also allowed (SET by the scanner and pulsed by the SEL-849 outside of the EIP library). The analog output points can take on the value of NOOP (writing to this point reports no errors and modifies no internal values). All the remote analogs are controllable.

Both the EIP settings on Port 2 and the configured assembly maps are used by the SEL-849 to create the Electronic Data Sheet (EDS) file. Only the SEL-849 can create and modify the EDS file. Refer to *Electronic Data Sheet File* for more information.

Table F.21 Class 1 Connection Support

Class 1 Connections	Supported Connections
Input Only	Point-to-point Point to-multicast
Listen Only	Point-to-point Point to-multicast
Exclusive Owner	Point-to-point Point to-multicast

EtherNet/IP Settings

Table F.22 shows the EtherNet/IP Port 2 settings in the SEL-849.

Table F.22 Port 2 EtherNet/IP Protocol Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE ETHERNET/IP	Y, N	EEIP := N
CONFIGURATION ID	0–255	CONFIGID := 0
MAJOR EDS REVISION	1–255	MAJOREDS := 1
MINOR EDS REVISION	1–255	MINOREDS := 1
NUMBER OF IP ADDRESSES FOR EIP SCANNER	OFF, 1–8	NUMIP := 1
IP ADDRESS *zzz.yyy.xxx.www*	*zzz*: 1–126, 128–223 *yyy*: 0–255 *xxx*: 0–255 *www*: 0–255	EIPIP1 := 169.254.0.151 EIPIP2 := 169.254.0.152 EIPIP3 := 169.254.0.153 EIPIP4 := 169.254.0.154 EIPIP5 := 169.254.0.155 EIPIP6 := 169.254.0.156 EIPIP7 := 169.254.0.157 EIPIP8 := 169.254.0.158
NUMBER OF I/O CONNECTIONS	1–6	NUMCONN := 1
APPLICATION TYPE	EXCLUSIVE_OWNER, INPUT_ONLY	APPTYP*n* := INPUT_ONLY
INPUT ASSEMBLY	IA1, IA2, IA3, OA1, OA2, OA3	INASSM*n* := IA1
OUTPUT ASSEMBLY	OA1, OA2, OA3	OUTASSM*n* := OA1

Electronic Data Sheet File

EtherNet/IP uses an EDS file to define the interface between the EIP library and the scanner. The scanner uses this information to determine what objects, attributes, and services are supported by the SEL-849.

In the SEL-849, the EDS file consists of the following sections:

- *File Description Section, [File]*
- *Device Description Section, [Device]*

- *Device Classification Section, [Device Classification]*
- *Parameters Section, [Params]*
- *Assembly Section, [Assembly]*
- *Connections Section, [Connection Manager]*
- *Vendor Specific Object Section*
- *Capacity Section, [Capacity]*
- *Ethernet Link Class, [Ethernet Link Class]*

File Description Section, [File]

The File Description Section of the EDS file contains the entries listed in *Table F.23*.

Table F.23 File Description Section Entries

Name	Keyword	Value
File Description Text	DescText	Contains the product specific name <Prod Name> as specified by the product. It is of the format "<Prod Name> EtherNet/IP Adapter EDS File".
File Creation Date	CreateDate	UTC date value that is hardcoded to match the R-release date of the firmware.
File Creation Time	CreateTime	UTC time value that is hardcoded to match the R-release time of the firmware.
Last Modification Date	ModDate	UTC data value that is determined when the EDS file is generated.
Last Modification Time	ModTime	UTC time value that is determined when the EDS file is generated.
EDS Revision	Revision	The format is MAJOREDS.MINOREDS, where MAJOREDS and MINOREDS are populated by the correspondingly named parameters in the Port 2 settings.

Device Description Section, [Device]

The Device Description Section of the EDS file contains the entries listed in *Table F.24*

Table F.24 Device Description Section Entries (Sheet 1 of 2)

Name	Keyword	Value
Vendor ID	VendCode	SEL Vendor ID number, 865
Vendor Name	VendName	"Schweitzer Engineering Laboratories"
Device Type	ProdType	43
Device Type String	ProdTypeStr	"Generic Device Type"
Product Code	ProdCode	The number derived from the Device Code (DEVCODE as found in the **ID** command of the SEL-849) and Configuration ID as provided in the Ethernet port settings
Major Revision	MajRev	The Major Revision is assigned internally by the SEL-849
Minor Revision	MinRev	The Minor Revision is assigned internally by the SEL-849

Table F.24 Device Description Section Entries (Sheet 2 of 2)

Name	Keyword	Value
Product Name	ProdName	Takes on the existing default product name (the default RID string in a two-line display model or the default STRING RID in a touchscreen display model) of the SEL-849 plus the value of the user-configurable Configuration ID as provided in the Port 2 settings. The general format is "<Default RID>-<Configuration ID>".
Catalog Number	Catalog	Takes on the existing default product name (the default RID string in a two-line display model or the default STRING RID in a touchscreen display model) of the SEL-849 plus the value of the user-configurable Configuration ID as provided in the Port 2 settings. The general format is "<Default RID>-<Configuration ID>".
Icon File Name	Icon	SEL849.ICO
Icon Contents	IconContents	Uncompressed content of characters

Device Classification Section, [Device Classification]

The Device Classification Section of the EDS file contains the entry listed in *Table F.25*.

Table F.25 Device Classification Section Entry

Name	Keyword	Value
Device Classification	Class1	"EtherNetIP"

Parameters Section, [Params]

Each parameter entry is named as *ParamN,* where *N* is a sequential number starting from 1 and ending at the maximum number of parameter object instances as defined in the corresponding assembly map.

All parameters of the EDS file are defined for *ParamN* in *Table F.26*.

Table F.26 Parameters of the EDS File (Sheet 1 of 2)

Label	Value
Reserved	0
Path Size, Path	Left empty
Descriptor	0x0000
Data Type	Digitals: BOOL (0xC1) 1 Byte (0 or 1) Analogs: SINT (0xC2) Signed 1 Byte Integer, USINT (0xC6) Unsigned 1 Byte Integer, INT (0xC3) Signed 2 Byte Integer, UINT (0xC7) Unsigned 2 Byte Integer, DINT (0xC4) Signed 4 Byte Integer, UDINT (0xC8) Unsigned 4 Byte Integer, REAL (0xCA) 4 Byte Float, LREAL (0xCB) 8 Byte Float, LINT (0xC5) Signed 8 Byte Integer, or ULINT (0xC9) Unsigned 8 Byte Integer
Data Size (Bytes)	See previous

Table F.26 Parameters of the EDS File (Sheet 2 of 2)

Label	Value
Name	Takes on the label name as defined in the corresponding assembly map. Names are unique.
Units	The value is “” for digitals. The value is determined internally by the SEL-849 for analogs.
Help String	“”
Min, max, default data values	It is 0,1,0 for digitals and ,,0, for analogs
Mult, div, base, offset scaling	It is ,,,, for all instances
Mult, div, base, offset links	It is ,,,, for all instances
Decimal places	0

RPI Parameter

The Requested Packet Interval (RPI) parameter entry falls immediately after the last parameter object instance as defined previously. This RPI parameter entry, Param(N+1), follows the structure detailed in *Table F.27*.

Table F.27 RPI Parameter Structure

Label	Value
Reserved	0
Path Size, Path	,,
Descriptor	0x0004
Data Type	0xC8
Data Size (Bytes)	4
Name	“RPI Range”
Units	“ms”
Help String	“This parameter limits the range of the RPI value”
Min, max, default data values	100000,,1000000
Mult, div, base, offset scaling	1,1000,1,0
Mult, div, base, offset links	,,,,
Decimal Places	1

Assembly Section, [Assembly]

The Assembly Section of the EDS file contains the entries listed in *Table F.28* for all of the available assemblies in the product.

Table F.28 Assembly Section Entries (Sheet 1 of 2)

Label	Value
Name	*Name* reflects the name of the Assembly type and instance, e.g., Input Assembly 1, Output Assembly 1, Input Assembly 2, etc.
Path	Set to “20 04 24 *InstID* 30 03” where InstID is the hexadecimal representation of the Assembly instance ID number.
Size	*Size_Bytes* reflects the total size in bytes of the mapped parameters in the Assembly instance.
Descriptor	0x0000

Table F.28 Assembly Section Entries (Sheet 2 of 2)

Label	Value
Reserved	Left empty
Member Size	Each mapped parameter in the corresponding Assembly instance is included in the EDS file using the following format: Member Size, Member Reference, Member Size, Member Reference, ... Member Size, Member Reference *MemberSize* reflects the data size for each parameter mapped in the corresponding Assembly instance in bits.
Member Reference	*MemberReference* reflects the name of each parameter entry "ParamN" (where N is the parameter instance) mapped in the corresponding Assembly instance.

Connections Section, [Connection Manager]

The Connections Section of the EDS file contains the entries listed in *Table F.29*, *Table F.30*, and *Table F.31*.

Table F.29 Input Only Connection Entries

Field	Value
Trigger and transport	0x02030002
Connection parameters	0x44640305
O->T RPI	Left empty
O->T size	0
O->T format	Left empty
T->O RPI	Set to "*ParamN*" where *N* is the parameter entry that defines the RPI for the device.
T->O size	Left empty
T->O format	*Input_Assem* is set to "*AssemN*" where *N* is the configured input assembly for the connection point.
Connection name string	*Connection_Name* contains "INPUT ONLY" as part of the string. All names are enumerated, e.g., "INPUT ONLY 1", etc.
Help string	""
Path	Set to "20 04 2C EE 2C *In*" where *In* is the hexadecimal representation of the configured input assembly instance ID number.

Table F.30 Listen Only Connection Entries (Sheet 1 of 2)

Field	Value
Trigger and transport	0x01030002
Connection parameters	0x44640305
O->T RPI	Left empty
O->T size	0

Table F.30 Listen Only Connection Entries (Sheet 2 of 2)

Field	Value
O->T format	Left empty
T->O RPI	Set to “*ParamN*” where *N* is the parameter entry that defines the RPI for the device.
T->O size	Left empty
T->O format	*Input_Assem* is set to “AssemN” where *N* is the configured input assembly for the connection point.
Connection name string	*Connection_Name* contains “LISTEN ONLY” as part of the string. All names shall be enumerated, e.g., “LISTEN ONLY 1”, etc.
Help string	“”
Path	Set to “20 04 2C ED 2C *In*” where *In* is the hexadecimal representation of the configured input assembly instance ID number.

Table F.31 Exclusive Owner Connection Entries

Field	Value
Trigger and transport	0x04030002
Connection parameters	0x44640405
O->T RPI	Set to *“ParamN*” where *N* is the parameter entry that defines the RPI for the device.
O->T size	Left empty
O->T format	*Output_Assem* is set to *“AssemN*” where *N* is the configured output assembly for the connection point.
T->O RPI	Set to *“ParamN*” where N is the parameter entry that defines the RPI for the device.
T->O size	Left empty
T->O format	*Input_Assem* is set to *“AssemN*” where *N* is the configured input assembly for the connection point.
Connection name string	*Connection_Name* contains “EXCLUSIVE OWNER” as part of the string. All names are enumerated, e.g., “EXCLUSIVE OWNER 1”, etc.
Help string	“”
Path	“20 04 2C *Out* 2C *In*” where *Out* is the hexadecimal representation of the configured output assembly instance ID number and *In* is the hexadecimal representation of the configured input assembly instance ID number.

Vendor Specific Object Section

The Vendor Specific Object Section of the EDS file contains the entries listed in *Table F.32*.

Table F.32 Vendor Specific Object Section Entries

Label	Value
Revision	1
Maximum Instance Number	1
Number of Static Instances	1
Maximum Number of Dynamic Instances	0
Object Name	“Relay Status”
Object Class Code	0x64

Capacity Section, [Capacity]

The Capacity Section of the EDS file contains the entries listed in *Table F.33*.

Table F.33 Capacity Section Entries

Keyword	Value
MaxIOConnections	2
MaxMsgConnections	6

Ethernet Link Class, [Ethernet Link Class]

The Ethernet Link Class Section of the EDS file contains the entries listed in *Table F.34*.

Table F.34 Ethernet Link Class Entries

Keyword	Value
Revision	4
Object_Name	"Ethernet Link Object"
Object_Class_Code	0xF6
MaxInst	It is 2 if a dual Ethernet port CPU card is used. It is 1 if a single Ethernet port CPU card is used.
Number_Of_Static_Instances	It is 2 if a dual Ethernet port CPU card is used. It is 1 if a single Ethernet port CPU card is used.
Max_Number_Of_Dynamic_Instances	0
InterfaceLabel1	It is “PORT 2A” if a single Ethernet port CPU card is used. It is “PORT 2A” if a dual Ethernet port CPU card is used.
InterfaceLabel2	Does not exist if a single Ethernet port CPU card is used. It is “PORT 2B” if a dual Ethernet port CPU card is used.

Appendix G

IEC 61850 Communications

Features

NOTE: The SEL-849 supports one CID file, which should be transferred only if a change in the relay configuration is required. If an invalid CID file is transferred, the relay will no longer have a valid IEC 61850 configuration, and the protocol will stop operating. To restart protocol operation, a valid CID must be transferred to the relay. The maximum CID file size supported is up to 108 KB.

The SEL-849 Motor Management Relay supports the following features through the use of the Ethernet and IEC 61850, Edition 1 protocols.

- SCADA—Connect as many as seven simultaneous IEC 61850 MMS client sessions. The SEL-849 also supports as many as seven buffered and seven unbuffered report control blocks. See *Table G.16*, the CON Logical Device table for logical node mapping that enables SCADA control via a Manufacturing Messaging Specification (MMS) browser. Controls support the Direct control, Select Before Operate control (SBO), and SBO With Enhanced Security control models.
- Peer-to-Peer Real-Time Status and Control—Use GOOSE with as many as 16 incoming (receive) and 8 outgoing (transmit) messages. Virtual bits (VB001–VB032), motor stop (COMMSTP) and motor start (COMMSTR) bits, and remote analogs (RA001–RA032) can be mapped from GOOSE receive messages.
- Configuration—Use an FTP client software or ACSELERATOR Architect SEL-5032 Software to transfer the Substation Configuration Language (SCL) Configured IED Description (CID) file to the relay.
- Commissioning and Troubleshooting—Use software such as AX-S4 61850 Explorer and AX-S4 61850 Client from Sisco, Inc., to browse the relay logical nodes and verify functionality.

This appendix presents the information you need to use the IEC 61850 features of the SEL-849.

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 G.1*.

Table G.1 IEC 61850 Document Set

IEC 61850 Core Standards	Sections
IEC 61850-1	Part 1: Introduction and Overview
IEC 61850-2	Part 2: Glossary
IEC 61850-3	Part 3: General Requirements
IEC 61850-4	Part 4: System and Project Management
IEC 61850-5	Part 5: Communication Requirements for Functions and Device Models
IEC 61850-6	Part 6: Configuration Description Language for Communication in Electrical Substations Related to IEDs
IEC 61850-7-1	Part 7-1: Principles and Models
IEC 61850-7-2	Part 7-2: Abstract Communication Service Interface (ACSI)
IEC 61850-7-3	Part 7-3: Common Data Classes
IEC 61850-7-4	Part 7-4: Compatible Logical Node Classes And Data Classes
IEC 61850-8-1	Part 8-1: Mappings to Manufacturing Messaging Specification (MMS) (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3)
IEC 61850-9-1	Part 9-1: Sampled Values Over Serial Unidirectional Multidrop Point-to-point Link
IEC 61850-9-2	Part 9-2: Sampled Values Over ISO/IEC 8802-3
IEC 61850-10	Part 10: Conformance Testing

The IEC 61850 document set, which is available directly from the IEC at iec.ch, contains the information necessary for successful implementation of this protocol. SEL strongly recommends that anyone involved with the design, installation, configuration, or maintenance of IEC 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-849. In addition to IEC 61850, the relay provides support protocols and data exchange, including FTP and Telnet. Access the SEL-849 Port 2 settings to configure all of the Ethernet settings, including IEC 61850 enable settings.

The SEL-849 supports IEC 61850 services, including transport of Logical Node objects, over TCP/IP. The relay can coordinate a maximum of six concurrent IEC 61850 sessions.

Object Models

The IEC 61850 standard relies heavily on the Abstract Communication Service Interface (ACSI) model to define a set of service and the responses to those services. In terms of network behavior, abstract modeling enables all IEDs to act identically. These abstract models are used to create objects (data items) and services that exist independently of any underlying protocols. These objects are in conformance with the common data class (CDC) specification IEC 61850-7-3, which describes the type and structure of each element within a logical node. CDCs for status, measurements, controllable analogs and statuses, and settings all have unique CDC attributes. Each CDC attribute belongs to a set of functional constraints that groups the attributes into specific categories such as status (ST), description (DC), and substituted value (SV). Functional constraints, CDCs and CDC attributes are used as building blocks for defining Logical Nodes.

UCA2 uses GOMSFE (Generic Object Models for Substation and Feeder Equipment) to present data from station IEDs as a series of objects called models or bricks. The IEC working group has incorporated GOMSFE concepts into the standard, with some modifications to terminology; one change was the renaming of bricks to logical nodes. Each logical node represents a group of data (controls, status, measurements, etc.) associated with a particular function. For example, the MMXU logical node (polyphase measurement unit) contains measurement data and other points associated with three-phase metering including voltages and currents. Each IED may contain many functions such as protection, metering, and control. Multiple logical nodes represent the functions in multifunction devices.

Logical nodes can be organized into logical devices that are similar to directories on a computer disk. As represented in the IEC 61850 network, each physical device can contain many logical devices, and each logical device can contain many logical nodes. Many relays, meters, and other IEC 61850 devices contain one primary logical device where all models are organized.

IEC 61850 devices are capable of self-description. You do not need to refer to the specifications for the logical nodes, measurements, and other components to request data from another IEC 61850 device. IEC 61850 clients can request and display a list and description of the data available in an IEC 61850 server device. This process is similar to the autoconfiguration process used within SEL communications processors (SEL-2032 and SEL-2030). Simply run an MMS browser to query devices on an IEC 61850 network and discover what data are available. Self-description also permits extensions to both standard and custom data models. Instead of having to look up data in a profile stored in its database, an IEC 61850 client can simply query an IEC 61850 device and receive a description of all logical devices, logical nodes, and available data.

Unlike other Supervisory Control and Data Acquisition (SCADA) protocols that present data as a list of addresses or indices, IEC 61850 presents data with descriptors in a composite notation made up of components. *Table G.2* shows the A-phase current expressed as MMXUAphsA$cVal broken down into its component parts.

Table G.2 Example IEC 61850 Descriptor Components

Components		Description
MMXU	Logical Node	Polyphase measurement unit
A	Data Object	Phase-to-ground amperes
PhsA	Sub-Data Object	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-849 Logical Nodes are grouped under Logical Devices for organization based on function. See *Table G.3* for descriptions of the Logical Devices in an SEL-849. See *Logical Nodes* for a description of the LNs that make up these Logical Devices.

Table G.3 SEL-849 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 the 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. 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: Virtual bits and remote analogs mapped to GOOSE subscriptions retain their state until they are overwritten, a new CID file is loaded, or the device is restarted. To reset the virtual bits and remote analogs by restarting the device, issue a **STA C** command or remove and then restore power to the device.

Virtual bits (VB001–VB032) are control inputs that you can map to GOOSE receive messages using ACSELERATOR Architect. See the VB*nnn* bits in *Table G.16* 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-849 Virtual bits for controls, you must create SELOGIC equations to define these operations. In addition to the Virtual bits, the motor stop (COMMSTP) and motor start (COMMSTR) can also be mapped to GOOSE receive messages. The SEL-849 is capable of receiving analog values via peer-to-peer GOOSE messages. Remote analogs (RA001–RA032) are analog inputs that you can map to values from incoming GOOSE messages.

File Services

The Ethernet File System allows reading or writing data as files. The File System supports FTP. The File System provides:

- A means for the devices to transfer data as files
- A hierarchical file structure for the device data

SCL Files

Substation Configuration Language (SCL) is an XML-based configuration language used to support the exchange of database configuration data among different tools, which may come from different manufacturers. There are four types of SCL files:

- IED Capability Description file (.ICD)
- System Specification Description file (.SSD)
- Substation Configuration Description file (.SCD)
- Configured IED Description file (.CID)

The ICD file described the capabilities of an IED, including information on LN and GOOSE support. The SSD file describes the single-line diagram of the substation and the required LNs. The SCD file contains information on all IEDs, communications configuration data, and a substation description. The CID file, of which there may be several, describes a single instantiated IED within the project, and includes address information.

Reports

The SEL-849 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 G.1* are available by default via IEC 61850.

ID	Name	Description	Dataset
BRep01	BRep01	Predefined Buffered Report 01	BRDSet01
BRep02	BRep02	Predefined Buffered Report 02	BRDSet02
BRep03	BRep03	Predefined Buffered Report 03	BRDSet03
BRep04	BRep04	Predefined Buffered Report 04	BRDSet04
BRep05	BRep05	Predefined Buffered Report 05	BRDSet05
BRep06	BRep06	Predefined Buffered Report 06	BRDSet06
BRep07	BRep07	Predefined Buffered Report 07	BRDSet07
URep01	URep01	Predefined Unbuffered Report 01	URDSet01
URep02	URep02	Predefined Unbuffered Report 02	URDSet02
URep03	URep03	Predefined Unbuffered Report 03	URDSet03
URep04	URep04	Predefined Unbuffered Report 04	URDSet04
URep05	URep05	Predefined Unbuffered Report 05	URDSet05
URep06	URep06	Predefined Unbuffered Report 06	URDSet06
URep07	URep07	Predefined Unbuffered Report 07	URDSet07

Figure G.1 SEL-849 Predefined Reports

There are fourteen report control blocks, seven buffered reports and seven unbuffered. For each buffered report control block, there can be just one client association, i.e., only one client can be associated to a report control block (BRCB or URCB) at any given time. The number of reports (14) and the type of reports (buffered or unbuffered) cannot be changed. However, by using ACSELERATOR Architect, you can reallocate data within each report dataset to present different data attributes for each report beyond the predefined datasets. For buffered reports, connected clients can edit the report parameters shown in *Table G.4*.

Table G.4 Buffered Report Control Block Client Access

RCB Attribute	User Changeable (Report Disabled)	User Changeable (Report Enabled)	Default Values
RptId	YES		BRep01–BRep07
RptEna	YES	YES	FALSE
OptFlds	YES		seqNum timeStamp dataSet reasonCode dataRef 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 can edit the report parameters shown in *Table G.5*.

Table G.5 Unbuffered Report Control Block Client Access

RCB Attribute	User Changeable (Report Disabled)	User Changeable (Report Enabled)	Default Values
RptId	YES		URep01–URep07
RptEna	YES	YES	FALSE
Resv	YES		FALSE
OptFlds	YES		seqNum timeStamp dataSet reasonCode dataRef 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 seven (7) 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-849 does not support reservations. Writing any field of the URCB causes the client to obtain their own copy of the URCB-in essence, acquiring a reservation.

Reports are serviced at a 2-Hz rate. The client can set the IntgPd attribute 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 attribute takes effect at the time that the current report is serviced.

Datasets

Datasets are configured using ACSELERATOR Architect and contain data attributes that represent real data values within the SEL-849 device. See *Logical Nodes* for the logical node tables that list the available data attributes for each logical node and the Relay Word bit mapping for these data attributes. The datasets listed in *Figure G.2* are the defaults for an SEL-849 device. Datasets BRDSet01–BRDSet07 and URDSet01–URDSet07 are preconfigured with common FCDAs to be used for reporting. These datasets can be configured to represent the data you want to monitor. Dataset GPDSet01, which contains breaker status and control data attributes, is used in the default Goose Control Publication.

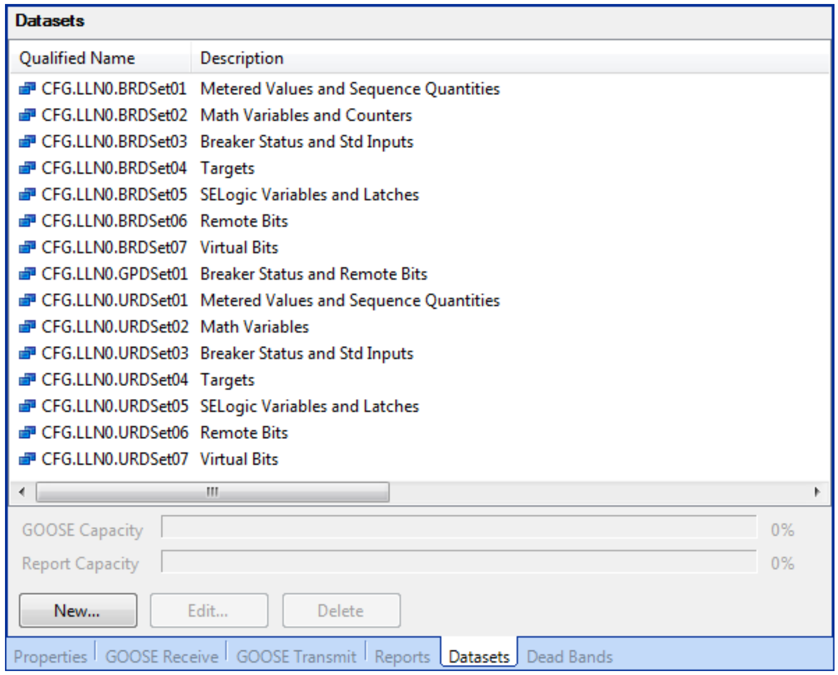


Figure G.2 SEL-849 Datasets

Within Architect, IEC 61850 datasets have two main purposes:

- GOOSE: You can use predefined or edited datasets, or create new datasets for outgoing GOOSE transmission.
- Reports: Fourteen predefined datasets (BRDSet01 to BRDSet07 and URDSet01 to URDSet07) correspond to the default seven buffered and seven unbuffered reports. Note that you cannot change the number (14) or type of reports (buffered or unbuffered) within ACSELERATOR Architect. However, you can alter the data attributes that a dataset contains and so define what data an IEC 61850 client receives with a report.

NOTE: Do not edit the dataset names used in reports. Changing or deleting any of those dataset names will cause a failure in generating the corresponding report.

Supplemental Software

Examine the data structure and value of the supported IEC 61850 LNs with an MMS browser, such as AX-S4 61850 Explorer and AX-S4 61850 Client from Sisco, Inc. The settings needed to browse an SEL-849 with an MMS browser are shown in *Table G.6*:

Table G.6 SEL-849 Browser Settings

OSI-PSEL (Presentation Selector)	00000001
OSI-SSEL (Session Selector)	0001
OSI-TSEL (Transport Selector)	0001

Time Stamps and Quality

In addition to the various data values, the two attributes quality and t (time stamp) are available at any time. The time stamp is determined when data or quality change is detected and is UTC reported as the Second of Century since January 1, 1970, plus fractional seconds.

The time stamp is applied to all data and quality attributes (Boolean, Bstrings, Analogs, etc.) in the same fashion when a data or quality change is detected. However, there is a difference in how the change is detected between the different attribute types. For points that are assigned as SER points, i.e., programmed in the SER report, the change is detected on the generation of an SER record (which contains the SER time stamp) within the relay.

For all other Booleans or Bstrings, the change is detected via the scanner, which compares the last state against the previous state to detect the change. For analogs, the scanner looks at the amount of change relative to the deadband configured for the point to indicate a change and apply the time stamp. In all cases, these time stamps are used for the reporting model.

Functionally Constrained Data Attributes mapped to points in the SER report have SER-accuracy time stamps for data change events. In order to ensure that you will get SER-quality time stamps for changes to certain points, you must include those points in the SER report. All other FCDAs are scanned for data changes on a 1/2-second interval and have 1/2-second time-stamp accuracy. See the **SET R** command for information on programming the SER report.

The SEL-849 uses GOOSE quality attributes to indicate the quality of the data in its transmitted GOOSE messages. Under normal conditions, all attributes are zero, indicating good quality data. *Figure G.3* shows the GOOSE quality attributes available to devices that subscribe to GOOSE messages from SEL-849 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-849 will set the Validity attribute to invalid and the Failure attribute to TRUE. Note that the SEL-849 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.

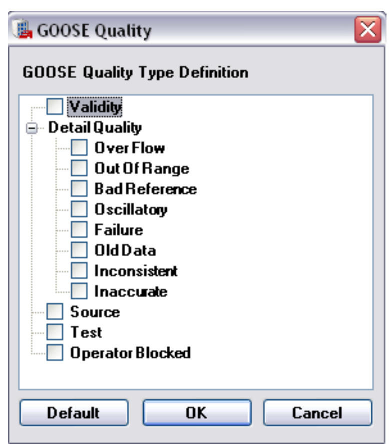


Figure G.3 GOOSE Quality

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). Outgoing GOOSE messages are processed in accordance with the following constraints:

- The user can define as many as eight outgoing GOOSE messages consisting of any Data Attribute (DA) from any Logical Node. A single DA can be mapped to one or more outgoing GOOSE, or one or more times within the same outgoing GOOSE. A user can also map a single GOOSE dataset to multiple GOOSE control blocks.

- High-speed GOOSE messaging is available for GOOSE messages that contain all digital data.
- The SEL-849 transmits all configured GOOSE immediately upon successful initialization. If a GOOSE is not retriggered i.e, if the state number does not increase, then the relay retransmits the message after a time interval. The first transmission occurs immediately upon the trigger occurring. The second occurs approximately MinTime later. The third occurs approximately MinTime after the second. The fourth occurs twice MinTime after the third. All subsequent transmissions occur at the MaxTime interval. For example, MinTime is 4 ms and MaxTime is 100 ms, the intervals between transmissions will be 4 ms, 4 ms, 8 ms, and then 100 ms. If MaxTime is not greater than twice MinTime, the third and all subsequent transmissions will occur at the MaxTime interval. The MinTime and MaxTime intervals can be configured for each GOOSE transmit message using ACSELERATOR Architect. The time-to-live reported in the first two messages is three times MinTime. The time-to-live in all subsequent messages is two times MaxTime.
- GOOSE transmission is squelched (silenced) after a permanent (latching) self-test failure.
- Each outgoing GOOSE includes communications parameters (VLAN, Priority, and Multicast Address) and is transmitted entirely in a single network frame.
- The SEL-849 maintains the configuration of outgoing GOOSE through a power cycle and device reset.

Incoming GOOSE messages are processed in accordance with the following constraints:

- The user can configure the SEL-849 to subscribe to as many as 16 incoming GOOSE messages.

  The SEL-849 recognizes incoming GOOSE messages as valid based on the following content. Any GOOSE message that fails these checks shall be rejected.

  - Source broadcast MAC address
  - Dataset Reference
  - Application ID
  - GOOSE Control Reference
- Rejection of all DA contained in an incoming GOOSE, based on the accumulation of the following error indications created by inspection of the received GOOSE:
  - **Configuration Mismatch**: the configuration number of the incoming GOOSE changes.
  - **Needs Commissioning**: this Boolean parameter of the incoming GOOSE is true.

  - **Test Mode**: this Boolean parameter of the incoming GOOSE is true.
  - **Decode Error**: the format of the incoming GOOSE is not as configured.
- The SEL-849 discards incoming GOOSE under the following conditions:
  - After a permanent (latching) self-test failure
  - When EGSE is set to No
  - When the relay is disabled

Link-layered priority tagging and virtual LAN is supported as described in Annex C of IEC 61850-8-1:2004(E).

IEC 61850 Configuration

Goose Processing and Performance

Settings

Table G.7 lists IEC 61850 settings. IEC 61850 settings are only available if your device includes the optional IEC 61850 protocol.

Table G.7 IEC 61850 Settings

Label	Description	Range	Default
E61850	IEC 61850 interface enable	Y, N	N
EGSE	Outgoing IEC 61850 GSE message enable	Y[a], N	N

[a] Requires E61850 set to Y to send IEC 61850 GSE messages.

Configure all other IEC 61850 settings, including subscriptions to incoming GOOSE messages, with ACSELERATOR Architect.

ACSELERATOR Architect

ACSELERATOR Architect enables protection and integration engineers to design and commission IEC 61850 substations containing SEL IEDs.

Engineers can use ACSELERATOR Architect to:

- Organize and configure all SEL IEDs in a substation project
- Configure incoming and outgoing GOOSE messages
- Read non-SEL IED Capability Description (ICD) and Configured IED Description (CID) files and determine the available IEC 61850 messaging options
- Load device settings and IEC 61850 CID files into SEL IEDs
- Generate ICD files that will provide SEL IED descriptions to other manufacturer’s tools so they can use SEL GOOSE messages and reporting features
- Configure protection, logic, control, and communications settings of all SEL IEDs in the substation

NOTE: Starting with firmware version R108, VLAN IDs 4093–4095 are reserved for internal use and should not be used in either incoming or outgoing GOOSE messages.

ACSELERATOR Architect provides a Graphical User Interface (GUI) for engineers to select, edit, and create IEC 61850 GOOSE messages important for substation protection, coordination, and control schemes. Typically, the engineer first places icons representing IEDs in a substation container, then edits the outgoing GOOSE messages or creates new ones for each IED. The engineer may also select incoming GOOSE messages for each IED to receive from any other IEDs in the domain. ACSELERATOR Architect has the capability to read other manufacturer's ICD and CID files, enabling the engineer to map the data seamlessly into SEL IED logic. See ACSELERATOR Architect or online help for more information.

SEL ICD File Versions

ACSELERATOR Architect version R.1.1.69.0 and later support multiple ICD file versions for each type of IED in a project. Because relays with different firmware versions can require different CID file versions, you can manage the CID files of all IEDs within a single project. Please ensure that you work with the appropriate version of ACSELERATOR Architect relative to your present configuration, existing project files, and ultimate goals. If you want the best available IEC 61850 functionality for your SEL relay, obtain the latest version of ACSELERATOR Architect and select the appropriate ICD version(s) for your needs. As of this writing, ACSELERATOR Architect comes with three versions of the SEL-849 ICD file for use with new or existing projects. Ensure that you use the "SEL-849 005 SEL-849 R105 and above" version for configuration of the SEL-849. Use of this file requires SEL-849 firmware version R105 or higher. The default Datasets, Reports, and Logical Nodes documented in this manual version correspond to this ICD file version. For the default Datasets, Reports, and Logical Nodes corresponding to the earlier ICD file versions, refer to older manual versions. Refer to *Table A.4*: *ICD File Revision History* in *Appendix A: Firmware, ICD, and Manual Versions* for the details of each revision.

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 G.8 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.
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.
Motor Measurement Data	MMOT	This LN shall be used for the motor measurement data.

Table G.9 defines the data class Arc Flash Detection. This class represents Arc Flash Detection status.

Table G.9 Arc-Flash Detection Logical Node Class Definition (Sheet 1 of 2)

PAFD Class				
Data Object Name	Common Data Class	Explanation	T[a]	M/O/C/E[b]
LNName		Shall be inherited from Logical-Node Class (see IEC 61850-7-2).		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M

Table G.9 Arc-Flash Detection Logical Node Class Definition (Sheet 2 of 2)

PAFD Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
Data Objects				
Status Information				
Str	ACD	Start		E
Op	ACT	Operate	T	E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table G.10 defines the data class Demand Metering Statistics. This class is a collection of demand currents.

Table G.10 Demand Metering Statistics Logical Node Class Definition

MDST Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		Shall be inherited from Logical-Node Class (see IEC 61850-7-2).		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Measured values				
DmdA	WYE	Demand Currents		E
PkDmdA	WYE	Peak Demand Currents		E
DmdWh[c]	MV	Real energy demand (default demand direction: energy flow from busbar away)		E
PosVArh[c]	MV	Reactive energy demand (default demand direction: energy flow from busbar away)		E
NegVArh[c]	MV	Reactive energy supply (default supply direction: energy flow towards busbar)		E
VAh[c]	MV	Apparent energy, 3-phase		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.
[c] These data objects are only available when using firmware version R105 or higher.

Table G.11 defines the data class Motor Measurement Data. This class is a collection of motor measurement data.

Table G.11 Motor Measurement Data Logical Node Class Definition (Sheet 1 of 2)

MTHR Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		Shall be inherited from Logical-Node Class (see IEC 61850-7-2).		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Measured values				
StrTcu	MV	Stator % Thermal Capacity Used		E
RtrTcu	MV	Rotor % Thermal Capacity Used		E

Table G.11 Motor Measurement Data Logical Node Class Definition (Sheet 2 of 2)

MTHR Class				
Data Objects				
Measured values				
Mload	MV	Motor Load, pu of FLA		E
ThrmTp	MV	Thermal Trip in, seconds		E
Trst	MV	Time to reset, minutes		E
StrtAv	MV	Starts available		E
Mrt	MV	Motor Running Time, hours		E
Mstp[c]	MV	Motor Stopped Time, hours		E
NumBkrop[d]	MV	Number of Breaker Operations		E
NumConop[d]	MV	Number of Contactor Operations		E
NumEmrst[d]	MV	Number of Emergency Starts		E
NumRstrt[d]	MV	Number of Restarts		E
NumStrt[d]	MV	Number of Starts		E
NumTrips[c]	MV	Number of Total Trips		E
NumAlrms[c]	MV	Number of Total Alarms		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.
[c] These data objects are only available using firmware version R107 or higher.
[d] These data objects are only available using firmware version R105 or higher.

Table G.12 Compatible Logical Nodes With Extensions

Logical Node	IEC 61850	Description or Comments
Generic Process I/O	GGIO	This LN is used for Remote analog data.

Table G.13 Generic Process I/O Logical Node Class Definition

GGIO Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2.		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Measured values				
AnIn	MV	Analog input		O
Ra	MV	Remote analog		E
Controls				
SPCSO	SPC	Single point controllable status output		O
Status Information				
Ind	SPS	General indication (binary input)		O

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Logical Nodes

The following tables, *Table G.14* through *Table G.18*, show the Logical Nodes (LN) supported in the SEL-849 and the associated Relay Word bits or measured quantities.

Table G.14 shows the LN associated with protection elements defined as Logical Device PRO.

Table G.14 Logical Device: PRO (Protection) (Sheet 1 of 4)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = CO			
MCCSWI1	Pos.Oper.ctlVal	COMMSTR:COMMSTP[a]	Motor Start/Stop command (0 stops, 1 starts)
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PART_NUM	Part Number
Functional Constraint = ST			
A49PTTR1	Op.general	49A	Thermal (Overload) alarm.
A55POPF1	Op.general	55A	Power Factor Alarm.
A55POPF1	Str.general	55A	Power Factor Alarm.
A55POPF1	Str.dirGeneral	unknown	Direction undefined.
ABSLOPMRI1	Op.general	ABSLO	Motor lockout condition driven by minimum motor-stopped time (Anti Backspin) function.
BFR1RBRF1	OpEx.general	BFT	Breaker Failure Trip.
BFR1RBRF1	Str.general	BFI	Breaker Failure Initiated.
BK1XCBR1	BlkCls.stVal	0	Breaker/Contactor close blocking not configured by default
BK1XCBR1	BlkOpn.stVal	0	Breaker/Contactor open blocking not configured by default
BK1XCBR1	CBOpCap.stVal	None	Breaker/Contactor physical operation capabilities not known to relay
BK1XCBR1	Loc.stVal	0	Breaker/Contactor local control status not configured by default
BK1XCBR1	OpCnt.stVal	0	Breaker operation counts not available.
BK1XCBR1	Pos.stVal	52A?1:2[b]	Breaker/Contactor Status.
D1TPTOF1	Op.general	81D1T	Definite-Time Over and Underfrequency Element Level 1 Trip.
D1TPTOF1	Str.general	81D1T	Definite-Time Over and Underfrequency Element Level 1 Trip.
D1TPTOF1	Str.dirGeneral	unknown	Direction undefined.
D2TPTOF2	Op.general	81D2T	Definite-Time Over and Underfrequency Element Level 2 Trip.
D2TPTOF2	Str.general	81D2T	Definite-Time Over and Underfrequency Element Level 2 Trip.
D2TPTOF2	Str.dirGeneral	unknown	Direction undefined.
FLTRDRE1	OpCntRs.stVal	NUMEVE[c]	Number of Fault Events
FLTRDRE1	RcdMade.stVal	FLREP[c]	Fault Event Reports Present
FLTRDRE1	FltNum.stVal	FLRNUM[c]	Unique Fault Event ID Number
G1TPIOC5	Op.general	50G1T	Definite-Time Residual Overcurrent Level 1 Trip.
G1TPIOC5	Str.general	50G1	Definite-Time Residual Overcurrent Level 1 Pickup.
G1TPIOC5	Str.dirGeneral	unknown	Direction undefined.

Table G.14 Logical Device: PRO (Protection) (Sheet 2 of 4)

Logical Node	Attribute	Data Source	Comment
G1TPTOC4	Op.general	51G1T	Residual Time-Overcurrent Trip.
G1TPTOC4	Str.general	51G1	Residual Time-Overcurrent Pickup.
G1TPTOC4	Str.dirGeneral	unknown	Direction undefined.
G2TPIOC6	Op.general	50G2T	Definite-Time Residual Overcurrent Level 2 Trip.
G2TPIOC6	Str.general	50G2	Definite-Time Residual Overcurrent Level 2 Pickup.
G2TPIOC6	Str.dirGeneral	unknown	Direction undefined.
GAFPIOC11	Op.general	50GAF	Sample-Based Residual Overcurrent Element for Arc Flash Detection.
GAFPIOC11	Str.general	50GAF	Sample-Based Residual Overcurrent Element for Arc Flash Detection.
GAFPIOC11	Str.dirGeneral	unknown	Direction undefined.
JALRMPMSS1	Op.general	JAMALRM	Load-Jam Alarm.
JALRMPMSS1	Str.general	JAMALRM	Load-Jam Alarm.
JALRMPMSS1	Str.dirGeneral	unknown	Direction undefined.
JTRIPPMSS2	Op.general	JAMTRIP	Load-Jam Trip.
JTRIPPMSS2	Str.general	JAMTRIP	Load-Jam Trip.
JTRIPPMSS2	Str.dirGeneral	unknown	Direction undefined.
LALRMPTUC1	Op.general	LOSSALRM	Load-Loss Alarm.
LALRMPTUC1	Str.general	LOSSALRM	Load-Loss Alarm.
LALRMPTUC1	Str.dirGeneral	unknown	Direction undefined.
LJTRPMSS3	Op.general	LJ_TR	Loadjam Trip.
LJTRPMSS3	Str.general	LJ_TR	Loadjam Trip.
LJTRPMSS3	Str.dirGeneral	unknown	Direction undefined.
LOPPTUV3	Op.general	LOP	Loss of Potential.
LOPPTUV3	Str.general	LOP	Loss of Potential.
LOPPTUV3	Str.dirGeneral	unknown	Direction undefined.
LTRIPPTUC2	Op.general	LOSSTRIP	Load-Loss trip.
LTRIPPTUC2	Str.general	LOSSTRIP	Load-Loss trip.
LTRIPPTUC2	Str.dirGeneral	unknown	Direction undefined.
MCCSWI1	OpCls.general	COMMSTR	Start Command issued from communications ports.
MCCSWI1	OpOpn.general	COMMSTP	Stop or Open command issued from communications ports.
MCCSWI1	Pos.stVal	52A?1:2[b]	Breaker/Contactor Status.
N1TPIOC7	Op.general	50N1T	Definite-Time CBCT Overcurrent Level 1 Trip.
N1TPIOC7	Str.general	50N1	Definite-Time CBCT Overcurrent Level 1 Pickup.
N1TPIOC7	Str.dirGeneral	unknown	Direction undefined.
N1TPTOC6	Op.general	51N1T	Neutral Time-Overcurrent Trip.
N1TPTOC6	Str.general	51N1	Neutral Time-Overcurrent Pickup.
N1TPTOC6	Str.dirGeneral	unknown	Direction undefined.
N2TPIOC8	Op.general	50N2T	Definite-Time CBCT Overcurrent Level 2 Trip.
N2TPIOC8	Str.general	50N2	Definite-Time CBCT Overcurrent Level 2 Pickup.
N2TPIOC8	Str.dirGeneral	unknown	Direction undefined.
NOSLOPMRI2	Op.general	NOSLO	Motor lockout condition driven by starts per hour function.
P1TPIOC1	Op.general	50P1T	Definite-Time Phase Overcurrent Level 1 Trip.

Table G.14 Logical Device: PRO (Protection) (Sheet 3 of 4)

Logical Node	Attribute	Data Source	Comment
P1TPIOC1	Str.general	50P1	Definite-Time Phase Overcurrent Level 1 Pickup.
P1TPIOC1	Str.dirGeneral	unknown	Direction undefined.
P1TPTOC3	Op.general	51P1T	Phase Time-Overcurrent Trip.
P1TPTOC3	Str.general	51P1	Phase Time-Overcurrent Pickup.
P1TPTOC3	Str.dirGeneral	unknown	Direction undefined.
P1TPTOV1	Op.general	59PP1T	Overvoltage Level 1 Trip.
P1TPTOV1	Str.general	59PP1	Overvoltage Level 1 Pickup.
P1TPTOV1	Str.dirGeneral	unknown	Direction undefined.
P1TPTUV1	Op.general	27PP1T	Undervoltage Level 1 Trip.
P1TPTUV1	Str.general	27PP1	Undervoltage Level 1 Pickup.
P1TPTUV1	Str.dirGeneral	unknown	Direction undefined.
P2TPIOC2	Op.general	50P2T	Definite-Time Phase Overcurrent Level 2 Trip.
P2TPIOC2	Str.general	50P2	Definite-Time Phase Overcurrent Level 2 Pickup.
P2TPIOC2	Str.dirGeneral	unknown	Direction undefined.
P2TPTOV2	Op.general	59PP2T	Overvoltage Level 2 Trip.
P2TPTOV2	Str.general	59PP2	Overvoltage Level 2 Pickup.
P2TPTOV2	Str.dirGeneral	unknown	Direction undefined.
P2TPTUV2	Op.general	27PP2T	Undervoltage Level 2 Trip.
P2TPTUV2	Str.general	27PP2	Undervoltage Level 2 Pickup.
P2TPTUV2	Str.dirGeneral	unknown	Direction undefined.
PAFPIOC10	Op.general	50PAF	Sample-Based Phase Overcurrent Element for Arc Flash Detection.
PAFPIOC10	Str.general	50PAF	Sample-Based Phase Overcurrent Element for Arc Flash Detection.
PAFPIOC10	Str.dirGeneral	unknown	Direction undefined.
PTCTPTTR7	Op.general	PTCTRIP	Asserts when measured PTC loop resistance is greater than trip value.
PWR1PDOP1	Op.general	3PWR1T	3-Phase Power Element Level 1 Trip.
PWR1PDOP1	Str.general	3PWR1	3-Phase Power Element Level 1 Pickup.
PWR1PDOP1	Str.dirGeneral	unknown	Direction undefined.
PWR1PDUP1	Op.general	3PWR1T	3-Phase Power Element Level 1 Trip.
PWR1PDUP1	Str.general	3PWR1	3-Phase Power Element Level 1 Pickup.
PWR1PDUP1	Str.dirGeneral	unknown	Direction undefined.
PWR2PDOP1	Op.general	3PWR2T	3-Phase Power Element Level 2 Trip.
PWR2PDOP1	Str.general	3PWR2	3-Phase Power Element Level 2 Pickup.
PWR2PDOP1	Str.dirGeneral	unknown	Direction undefined.
PWR2PDUP1	Op.general	3PWR2T	3-Phase Power Element Level 2 Trip.
PWR2PDUP1	Str.general	3PWR2	3-Phase Power Element Level 2 Pickup.
PWR2PDUP1	Str.dirGeneral	unknown	Direction undefined.
Q1TPIOC9	Op.general	50Q1T	Definite-Time Negative-Sequence Overcurrent Level 1 Trip.
Q1TPIOC9	Str.general	50Q1	Definite-Time Negative-Sequence Overcurrent Pickup.
Q1TPIOC9	Str.dirGeneral	unknown	Direction undefined.
Q1TPTOC5	Op.general	51Q1T	Negative-Sequence Time-Overcurrent Trip.
Q1TPTOC5	Str.general	51Q1	Negative-Sequence Time-Overcurrent Pickup.

Table G.14 Logical Device: PRO (Protection) (Sheet 4 of 4)

Logical Node	Attribute	Data Source	Comment
Q1TPTOC5	Str.dirGeneral	unknown	Direction undefined.
R49PTTR4	Op.general	49T_RTR	Thermal (Overload) trip. Asserted on rotor overload condition.
RS59PTOV4	Op.general	59RS	Restart Overvoltage.
RS59PTOV4	Str.general	59RS	Restart Overvoltage.
RS59PTOV4	Str.dirGeneral	unknown	Direction undefined.
RSLOPMRI5	Op.general	RS_LO	Motor Restart Lockout condition.
S49PTTR3	Op.general	49T_STR	Thermal (Overload) trip. Asserted on stator overload condition.
SPDSALPZSU1	Op.general	SPDSAL	Speed Switch Alarm.
SPDSALPZSU1	Str.general	SPDSAL	Speed Switch Alarm.
SPDSALPZSU1	Str.dirGeneral	unknown	Direction undefined.
SPDSTRPZSU2	Op.general	SPDSTR	Speed Switch Trip.
SPDSTRPZSU2	Str.general	SPDSTR	Speed Switch Trip.
SPDSTRPZSU2	Str.dirGeneral	unknown	Direction undefined.
T47PTOV3	Op.general	47T	Phase Reversal Trip.
T47PTOV3	Str.general	47T	Phase Reversal Trip.
T47PTOV3	Str.dirGeneral	unknown	Direction undefined.
T49PTTR2	Op.general	49T	Thermal (Overload) trip. Asserted on stator or rotor overload conditions.
T55POPF2	Op.general	55T	Power Factor Trip.
T55POPF2	Str.general	55T	Power Factor Trip.
T55POPF2	Str.dirGeneral	unknown	Direction undefined.
TBSLOPMRI3	Op.general	TBSLO	Motor lockout condition driven by minimum time between starts function.
THRMLOPMRI4	Op.general	THERMLO	Motor lockout condition due to stator or rotor TCU being too high.
TOL1PAFD1	Op.general	TOL1	Arc-Flash light input element pickup
TOL1PAFD1	Str.general	TOL1	Arc-Flash light input element pickup
TOL1PAFD1	Str.dirGeneral	unknown	Direction undefined.
TRIPPTRC1	Tr.general	TRIP	Output of Trip Logic.
UB46APTOC1	Op.general	46UBA	Phase Current Unbalance Alarm.
UB46APTOC1	Str.general	46UBA	Phase Current Unbalance Alarm.
UB46APTOC1	Str.dirGeneral	unknown	Direction undefined.
UB46TPTOC2	Op.general	46UBT	Phase Current Unbalance Trip.
UB46TPTOC2	Str.general	46UBT	Phase Current Unbalance Trip.
UB46TPTOC2	Str.dirGeneral	unknown	Direction undefined.
UVRSLOPMRI5	Op.general	UV_RS_LO	Restart Lockout by Undervoltage.
UVTRPTUV4	Op.general	UV_TR	Undervoltage Trip.
UVTRPTUV4	Str.dirGeneral	unknown	Direction undefined.
UVTRPTUV4	Str.general	UV_TR	Undervoltage Trip.

[a] Writing a 0 to MCCSWI1.Pos.Oper.ctlVal will cause COMMSTP to assert, and writing any other value will cause COMMSTR to assert.
[b] If breaker/contactor is closed, value = 10(2). If breaker/contactor is open, value = 01(1).
[c] These attributes are only available when using firmware version R107 or higher and a compatible ICD file.

Table G.15 shows the LN associated with measuring elements defined as Logical Device MET.

Table G.15 Logical Device: MET (Metering) (Sheet 1 of 4)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PART_NUM	Part Number
Functional Constraint = MX[a]			
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	DmdWh.instMag.f[b]	MWH3P	Real energy, 3-phase OUT of Bus
METMDST1	NegVArh.instMag.f[b]	MVARH3PI	Reactive energy, 3-phase IN to Bus
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	PosVArh.instMag.f	MVARH3PO	Reactive energy, 3-phase OUT of Bus
METMDST1	VAh.instMag.f	MVAH3P	Apparent energy, 3-phase
METMHAI1	ThdA.phsA.instCVal.mag.f	IA_THD	THD, Phase Current IA
METMHAI1	ThdA.phsB.instCVal.mag.f	IB_THD	THD, Phase Current IB
METMHAI1	ThdA.phsC.instCVal.mag.f	IC_THD	THD, Phase Current IC
METMHAI1	ThdPhV.phsA.instCVal.mag.f	VA_THD	THD, Phase Current VA
METMHAI1	ThdPhV.phsB.instCVal.mag.f	VB_THD	THD, Phase Current VB
METMHAI1	ThdPhV.phsC.instCVal.mag.f	VC_THD	THD, Phase Current VC
METMHAI1	ThdPPV.phsAB.instCVal.mag.f	VAB_THD	THD, Phase Current VAB
METMHAI1	ThdPPV.phsBC.instCVal.mag.f	VBC_THD	THD, Phase Current VBC
METMHAI1	ThdPPV.phsCA.instCVal.mag.f	VCA_THD	THD, Phase Current VCA
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.mag.f	IN_MAG	Current, Core-Balance CT, magnitude
METMMXU1	Hz.instMag.f	FREQ	Frequency
METMMXU1	PhV.res.instCVal.mag.f	3V0	Voltage, 3V0 Zero-Sequence, magnitude
METMMXU1	PhV.res.instCVal.ang.f	3V0_ANG	Voltage, 3V0 Zero-Sequence, angle
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	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

Table G.15 Logical Device: MET (Metering) (Sheet 2 of 4)

Logical Node	Attribute	Data Source	Comment
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	Real power, 3-phase, magnitude
METMMXU1	TotW.instMag.f	P	Reactive power, 3-phase, magnitude
METMSQI1	MaxImbA.instMag.f	UBI	Current imbalance, %
METMSQI1	MaxImbV.instMag.f	UBV	Voltage imbalance, %
METMSQI1	SeqA.c2.instCVal.mag.f	3I2	Current, Negative-sequence current, magnitude
METMSQI1	SeqA.c2.instCVal.ang.f	3I2_ANG	Current, Negative-sequence current, angle
METMSQI1	SeqA.c1.instCVal.mag.f	I1	Current, Positive-sequence, magnitude
METMSQI1	SeqA.c1.instCVal.ang.f	I1_ANG	Current, Positive-sequence, angle
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.c3.instCVal.mag.f	3V0	Voltage, 3V0 Zero-Sequence, magnitude
METMSQI1	SeqV.c3.instCVal.ang.f	3V0_ANG	Voltage, 3V0 Zero-Sequence, angle
METMSQI1	SeqV.c2.instCVal.mag.f	3V2	Voltage, Negative-sequence, magnitude
METMSQI1	SeqV.c2.instCVal.ang.f	3V2_ANG	Voltage, Negative-sequence, angle
METMSQI1	SeqV.c1.instCVal.mag.f	V1	Voltage, Positive-sequence, magnitude
METMSQI1	SeqV.c1.instCVal.ang.f	V1_ANG	Voltage, Positive-sequence, angle
METMSTA1	AvAmps.instMag.f	IAVG	Current, Average current, magnitude
METMSTA1	AvVolts.instMag.f	VAVG	Voltage, Average voltage, magnitude
METMSTA1	MaxA.phsA.instCVal.mag.f[b]	IAMX	Current, A-phase, maximum magnitude
METMSTA1	MaxA.phsB.instCVal.mag.f[b]	IBMX	Current, B-phase, maximum magnitude
METMSTA1	MaxA.phsC.instCVal.mag.f[b]	ICMX	Current, C-phase, maximum magnitude
METMSTA1	MaxA.res.instCVal.mag.f[b]	IGMX	Current, calculated residual, maximum magnitude
METMSTA1	MaxA.neut.instCVal.mag.f[b]	INMX	Current, Core-Balance CT, maximum magnitude
METMSTA1	MaxHz.instMag.f[b]	FREQMX	Maximum frequency
METMSTA1	MaxP2PV.phsAB.instCVal.mag.f[b]	VABMX	Voltage, A-to-B-phase, maximum magnitude
METMSTA1	MaxP2PV.phsBC.instCVal.mag.f[b]	VBCMX	Voltage, B-to-C-phase, maximum magnitude
METMSTA1	MaxP2PV.phsCA.instCVal.mag.f[b]	VCAMX	Voltage, C-to-A-phase, maximum magnitude
METMSTA1	MaxPhV.phsA.instCVal.mag.f[b]	VAMX	Voltage, A-phase-to-neutral, maximum magnitude
METMSTA1	MaxPhV.phsB.instCVal.mag.f[b]	VBMX	Voltage, B-phase-to-neutral, maximum magnitude
METMSTA1	MaxPhV.phsC.instCVal.mag.f[b]	VCMX	Voltage, C-phase-to-neutral, maximum magnitude
METMSTA1	MaxVA.instMag.f[b]	KVA3PMX	Apparent power, 3-phase, maximum magnitude
METMSTA1	MaxVAr.instMag.f[b]	KVAR3PMX	Reactive power, 3-phase, maximum magnitude
METMSTA1	MaxW.instMag.f[b]	KW3PMX	Real power, 3-phase, maximum magnitude

Table G.15 Logical Device: MET (Metering) (Sheet 3 of 4)

Logical Node	Attribute	Data Source	Comment
METMSTA1	MinA.phsA.instCVal.mag.f[b]	IAMN	Current, A-phase, minimum magnitude
METMSTA1	MinA.phsB.instCVal.mag.f[b]	IBMN	Current, B-phase, minimum magnitude
METMSTA1	MinA.phsC.instCVal.mag.f[b]	ICMN	Current, C-phase, minimum magnitude
METMSTA1	MinA.res.instCVal.mag.f[b]	IGMN	Current, calculated residual, minimum magnitude
METMSTA1	MinA.neut.instCVal.mag.f[b]	INMN	Current, Core-Balance CT, minimum magnitude
METMSTA1	MinHz.instMag.f[b]	FREQMN	minimum frequency
METMSTA1	MinP2PV.phsAB.instCVal.mag.f[b]	VABMN	Voltage, A-to-B-phase, minimum magnitude
METMSTA1	MinP2PV.phsBC.instCVal.mag.f[b]	VBCMN	Voltage, B-to-C-phase, minimum magnitude
METMSTA1	MinP2PV.phsCA.instCVal.mag.f[b]	VCAMN	Voltage, C-to-A-phase, minimum magnitude
METMSTA1	MinPhV.phsA.instCVal.mag.f[b]	VAMN	Voltage, A-phase-to-neutral, minimum magnitude
METMSTA1	MinPhV.phsB.instCVal.mag.f[b]	VBMN	Voltage, B-phase-to-neutral, minimum magnitude
METMSTA1	MinPhV.phsC.instCVal.mag.f[b]	VCMN	Voltage, C-phase-to-neutral, minimum magnitude
METMSTA1	MinVA.instMag.f[b]	KVA3PMN	Apparent power, 3-phase, minimum magnitude
METMSTA1	MinVAr.instMag.f[b]	KVAR3PMN	Reactive power, 3-phase, minimum magnitude
METMSTA1	MinW.instMag.f[b]	KW3PMN	Real power, 3-phase, minimum magnitude
MOTORMMOT1	Mload.instMag.f	MLOAD	Motor Load
MOTORMMOT1	Mrt.instMag.f	MRT	Motor Running Time in hours
MOTORMMOT1	Mstp.instMag.f[c]	MSTP	Motor Stopped Time in hours
MOTORMMOT1	NumAlrms.instMag.f[c]	TOTAL_A	Number of Total Alarms
MOTORMMOT1	NumBkrop.instMag.f[b]	NUMBKROP	Number of Breaker Operations
MOTORMMOT1	NumConop.instMag.f[b]	NUMCONOP	Number of Contactor Operations
MOTORMMOT1	NumEmrst.instMag.f[b]	NUMEMRST	Number of Emergency Starts
MOTORMMOT1	NumRstrt.instMag.f[b]	NUMRSTRT	Number of Restarts
MOTORMMOT1	NumStrt.instMag.f[b]	NUMSTRT	Number of Starts
MOTORMMOT1	NumTrips.instMag.f[c]	TOTAL_T	Number of Total Trips
MOTORMMOT1	RtrTcu.instMag.f	TCURTR	Rotor % Thermal Capacity Used
MOTORMMOT1	StrtAv.instMag.f	STRTAV	Starts Available
MOTORMMOT1	StrTcu.instMag.f	TCUSTR	Stator % Thermal Capacity Used
MOTORMMOT1	ThrmTp.instMag.f	THRMTP	Thermal Trip In
MOTORMMOT1	Trst.instMag.f	TRST	Time to Reset
RMSMMXU2	A.phsA.instCVal.mag.f	IARMS	RMS Current, A-phase, magnitude
RMSMMXU2	A.phsB.instCVal.mag.f	IBRMS	RMS Current, B-phase, magnitude
RMSMMXU2	A.phsC.instCVal.mag.f	ICRMS	RMS Current, C-phase, magnitude
RMSMMXU2	A.res.instCVal.mag.f	IGRMS	RMS Current, Calculated-residual, magnitude
RMSMMXU2	A.neut.instCVal.mag.f	INRMS	RMS Current, Core-Balance CT, 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

Table G.15 Logical Device: MET (Metering) (Sheet 4 of 4)

Logical Node	Attribute	Data Source	Comment
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

[a] MX values contain instantaneous attributes (instMag and instVal), which are updated whenever the source updates and other attributes which are only updated when the source goes outside the data source's dead band (mag and cVal). Only the instantaneous values are shown in the table.

[b] These attributes are only available when using firmware version R105 or higher and a compatible ICD file.

[c] These attributes are only available when using firmware version R107 or higher and a compatible ICD file.

Table G.16 shows the LN associated with control elements defined as Logical Device CON.

Table G.16 Logical Device: CON (Remote Control)

Logical Node	Control	Status	Relay Word Bit	Comment
RBGGIO1	SPCSO01.Oper.ctlVal–SPCSO08.Oper.ctlVal	SPCSO01.stVal–SPCSO08.stVal	RB01–RB08	Remote Bits RB01–RB08

Table G.17 shows the LN associated with annunciation elements defined as Logical Device ANN.

Table G.17 Logical Device: ANN (Annunciation) (Sheet 1 of 3)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PART_NUM	
Functional Constraint = MX[a]			
MVGGIO13	AnIn01.instMag.f–AnIn08.instMag.f	MV01–MV08	Math Variables
RAGGIO15	Ra001.instMag.f–Ra032.instMag.f	RA001–RA032	Remote Analogs
SCGGIO14	AnIn01.instMag.f–AnIn08.instMag.f	SC01–SC08	SELogic Counters
Functional Constraint = ST			
ALMGGIO10	Ind01.stVal	HALARM	Indication of a diagnostic failure or warning that warrants an ALARM.
ALMGGIO10	Ind02.stVal	HALARML	Latches in for relay diagnostic failures.
ALMGGIO10	Ind03.stVal	HALARMP	Pulses for 5 seconds when a warning diagnostic condition occurs.
ALMGGIO10	Ind04.stVal	HALARMA	Pulses for five seconds every minute until reset when a hardware diagnostic warning occurs.
ALMGGIO10	Ind05.stVal–Ind08.stVal	0	Reserved for future use.
ALMGGIO10	Ind09.stVal	SALARM	Indication of software or user activity that warrants an ALARM.
ALMGGIO10	Ind10.stVal	ACCESS	Asserted while any user is logged in at Access Level 2 or higher.
ALMGGIO10	Ind11.stVal	PASNVAL	Pulses for 1 second when any user enters an invalid password.
ALMGGIO10	Ind12.stVal	ACCESSP	Pulses for 1 second when any user increases their access level to 2 or higher.
ALMGGIO10	Ind13.stVal	0	Reserved for future use.

Table G.17 Logical Device: ANN (Annunciation) (Sheet 2 of 3)

Logical Node	Attribute	Data Source	Comment
ALMGGIO10	Ind14.stVal	SETCHG	Pulses for 1 second whenever settings are changed.
ALMGGIO10	Ind15.stVal	CHGPASS	Pulses for 1 second whenever a password is changed.
ALMGGIO10	Ind16.stVal	BADPASS	Pulses for 1 second whenever a user enters three successive bad passwords.
ETHGGIO11	Ind01.stVal	P2ASEL	Asserted when Port 2A is active.
ETHGGIO11	Ind02.stVal	LINK2A	Asserted when a valid link is detected on Port 2A.
ETHGGIO11	Ind03.stVal	P2BSEL	Asserted when Port 2B is active.
ETHGGIO11	Ind04.stVal	LINK2B	Asserted when a valid link is detected on Port 2B.
ETHGGIO11	Ind05.stVal	LINK2	Asserted when a valid link is detected on Port 2.
ETHGGIO11	Ind06.stVal	LINKFAIL	Asserted when a valid link is not detected on the active port(s).
ETHGGIO11	Ind07.stVal	NETFAIL	NETFAIL SELOGIC equation.
ETHGGIO11	Ind08.stVal	0	Reserved for future use.
INGGIO1	Ind01.stVal–Ind06.stVal	IN01–IN06	Standard Contact Inputs.
INGGIO12	Ind01.stVal–Ind06.stVal	IN07–IN12[b]	Optional Contact Inputs.
LTGGIO5	Ind01.stVal–Ind08.stVal	LT01–LT08	Latch Bits.
MISCGGIO8	Ind01.stVal	SMTRIP	Asserts when Start Motor Timer times out.
MISCGGIO8	Ind02.stVal	LOADUP	Asserts when the selected load parameter exceeds an upper level setting.
MISCGGIO8	Ind03.stVal	LOADLOW	Asserts when the selected load parameter drops below a lower level setting.
MISCGGIO8	Ind04.stVal	PTCFLT	Indicates faulted/shorted thermistor.
MISCGGIO8	Ind05.stVal	50S	Motor starting overcurrent element.
MISCGGIO8	Ind06.stVal	PHDEM	Phase demand current pickup.
MISCGGIO8	Ind07.stVal	AFS1EL	Arc-Flash Sensor input excessive ambient light pickup.
MISCGGIO8	Ind08.stVal	AFS1DIAG	Arc-Flash Sensor input diagnostic failure.
MISCGGIO8	Ind09.stVal	FREQTRK	Asserts when relay is tracking frequency.
MISCGGIO8	Ind10.stVal	WARNING	Asserted when any element in the Warning List is asserted.
MISCGGIO8	Ind11.stVal	HMIDET	HMI Detected
MISCGGIO8	Ind12.stVal	TR	Trip SELOGIC control equation.
MISCGGIO8	Ind13.stVal	TRX	Extended Trip SELOGIC control equation.
MISCGGIO8	Ind14.stVal	TR1	Trip SELOGIC 2nd control equation.
MISCGGIO8	Ind15.stVal	49A_RTR	Thermal (Overload) alarm, Rotor.
MISCGGIO8	Ind16.stVal	49A_STR	Thermal (Overload) alarm, Stator.
MISCGGIO8	Ind17.stVal	EXT_TRIP	External Trip SELOGIC control Equation.
MISCGGIO8	Ind18.stVal	ULTRIP	Unlatch (auto reset) trip SELOGIC control equation.
MISCGGIO8	Ind19.stVal	FAULT	Fault Condition SELOGIC control equation.
MISCGGIO8	Ind20.stVal	BSTR_CL	Block Start/Close SELOGIC control equation.
MISCGGIO8	Ind21.stVal	MATHERR	Asserted on SELOGIC math computation errors.
MISCGGIO8	Ind22.stVal	TSOK	Time Synchronization OK.
MISCGGIO8	Ind23.stVal	DST	Asserted during Daylight-Saving Time.
MISCGGIO8	Ind24.stVal	HBL2T	Combined-phase second-harmonic block timed out.
MISCGGIO8	Ind25.stVal	HBL5T	Combined-phase fifth-harmonic block timed out.
MISCGGIO8	Ind26.stVal–Ind32.stVal	0	Reserved for future use.
MOTGGIO7	Ind01.stVal	RUNNING	Asserts when the motor is running.

Table G.17 Logical Device: ANN (Annunciation) (Sheet 3 of 3)

Logical Node	Attribute	Data Source	Comment
MOTGGIO7	Ind02.stVal	STARTING	Asserts when the motor is starting.
MOTGGIO7	Ind03.stVal	STOPPED	Asserts when the motor is stopped.
MOTGGIO7	Ind04.stVal	MOTOR	Motor application.
MOTGGIO7	Ind05.stVal	RESTART	Motor Restart.
MOTGGIO7	Ind06.stVal	RSACTIVE	Motor Restart Active.
MOTGGIO7	Ind07.stVal	UV_SHRT	Short Undervoltage.
MOTGGIO7	Ind08.stVal	UV_MED	Medium Undervoltage.
MOTGGIO7	Ind09.stVal	UV_LONG	Long Undervoltage.
MOTGGIO7	Ind10.stVal	REMOTE	Remote Control Mode Indication.
MOTGGIO7	Ind11.stVal	EMRSTR	Emergency Start SELOGIC control equation.
MOTGGIO7	Ind12.stVal	STAR	Asserts when the Star-Delta Starting function issues a command to switch motor configuration to Star.
MOTGGIO7	Ind13.stVal	DELTA	Asserts when the Star-Delta Starting function issues a command to switch motor configuration to Delta.
MOTGGIO7	Ind14.stVal	SPEED2	Speed2 SELOGIC control equation.
MOTGGIO7	Ind15.stVal	SPEEDSW	Speed Switch SELOGIC control equation.
MOTGGIO7	Ind16.stVal	VFDBYPAS	VFD Bypass SELOGIC equation.
MOTGGIO7	Ind17.stVal	SHRT_RS	Restart on Short Voltage Dip.
MOTGGIO7	Ind18.stVal	RSDT	Restart Delay Timed Out.
MOTGGIO7	Ind19.stVal	EMRSTP	Emergency Stop SELOGIC control equation.
MOTGGIO7	Ind20.stVal	COASTOP	Asserts when the motor is stopped after coasting.
MOTGGIO7	Ind21.stVal	52A_CR	Contactor Status SELOGIC control equation.
MOTGGIO7	Ind22.stVal	52A_CB	Breaker Status SELOGIC control equation.
MOTGGIO7	Ind23.stVal–Ind32.stVal	0	Reserved for future use.
OUTGGIO2	Ind01.stVal–Ind04.stVal	OUT01–OUT04	Contact Outputs.
SVGGIO3	Ind01.stVal–Ind08.stVal	SV01–SV08	SELOGIC Variables.
SVTGGIO4	Ind01.stVal–Ind08.stVal	SV01T–SV08T	SELOGIC Variable Timers.
TLEDGGIO6	Ind01.stVal	ENABLED	Enable LED
TLEDGGIO6	Ind02.stVal	TRIP_LED	Trip LED
TLEDGGIO6	Ind03.stVal–Ind10.stVal	TLED_01–TLED_08	Target LEDs.
VBGGIO9	Ind001.stVal–Ind032.stVal	VB001–VB032	Virtual Bits.

[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 dead band (mag and cVal). Only the instantaneous values are shown in the table.
[b] Active data only if optional contact inputs are present.

Table G.18 shows the LNs associated with the configuration element, defined as Logical Device CFG.

Table G.18 Logical Device: CFG (Configuration)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PART_NUM	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. Because the standard explicitly dictates which services and functions must be implemented to achieve conformance, only the optional services and functions are listed.

Table G.19 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	Y	

Table G.20 PICS for T-Profile Support

Profile		Client	Server	Value/Comment
T1	TCP/IP	N	Y	
T2	OSI	N	N	
T3	GOOSE/GSE	Y	Y	Only GOOSE, Not GSSE
T4	GSSE	N	N	
T5	Time Sync	N	Y	

Refer to *ACSI Conformance Statements* for information on the supported services.

MMS Conformance

The Manufacturing Messaging Specification (MMS) stack provides the basis for many IEC 61850 protocol services. *Table G.21* defines the service support requirement and restrictions of the MMS services in the SEL-800 series products supporting IEC 61850. Generally, only those services whose implementation is not mandatory are shown. Refer to the IEC 61850 standard, Part 8-1, for more information.

Table G.21 MMS Service Supported Conformance (Sheet 1 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
	Supported	Supported
status		Y
getNameList		Y
identify		Y
rename		
read		Y
write		Y
getVariableAccessAttributes		Y
defineNamedVariable		
defineScatteredAccess		
getScatteredAccessAttributes		
deleteVariableAccess		
defineNamedVariableList		
getNamedVariableListAttributes		Y
deleteNamedVariableList		

Table G.21 MMS Service Supported Conformance (Sheet 2 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
	Supported	Supported
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		
SreportEventConditionStatus		
alterEventConditionMonitoring		
triggerEvent		
defineEventAction		
deleteEventAction		
alterEventEnrollment		
reportEventEnrollmentStatus		
getEventEnrollmentAttributes		

Table G.21 MMS Service Supported Conformance (Sheet 3 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
	Supported	Supported
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 G.22 lists specific settings for the MMS parameter Conformance Building Block (CBB).

Table G.22 MMS Parameter CBB (Sheet 1 of 2)

MMS Parameter CBB	Client-CR Supported	Server-CR Supported
	Supported	Supported
STR1		Y
STR2		Y
VNAM		Y
VADR		
VALT		Y
TPY		

Table G.22 MMS Parameter CBB (Sheet 2 of 2)

MMS Parameter CBB	Client-CR Supported	Server-CR Supported
	Supported	Supported
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 G.23 AlternateAccessSelection Conformance Statement

AlternateAccessSelection	Client-CR Supported	Server-CR Supported
	Supported	Supported
accessSelection		Y
component		Y
index		
indexRange		
allElements		
alternateAccess		Y
selectAccess		Y
component		Y
index		
indexRange		
allElements		

Table G.24 VariableAccessSpecification Conformance Statement

VariableAccessSpecification	Client-CR	Server-CR
	Supported	Supported
listOfVariable		Y
variableSpecification		Y
alternateAccess		Y
variableListName		Y

Table G.25 VariableSpecification Conformance Statement

VariableSpecification	Client-CR Supported	Server-CR Supported
	Supported	Supported
name		Y
address		
variableDescription		
scatteredAccessDescription		
invalidated		

Table G.26 Read Conformance Statement

Read	Client-CR Supported	Server-CR Supported
	Supported	Supported
Request		
specificationWithResult		
variableAccessSpecification		
Response		
variableAccessSpecification		Y
listOfAccessResult		Y

Table G.27 GetVariableAccessAttributes Conformance Statement

GetVariableAccessAttributes	Client-CR Supported	Server-CR Supported
	Supported	Supported
Request		
name		
address		
Response		
mmsDeletable		Y
address		
typeSpecification		Y

Table G.28 DefineNamedVariableList Conformance Statement

DefineNamedVariableList	Client-CR Supported	Server-CR Supported
	Supported	Supported
Request		
variableListName		
listOfVariable		
variableSpecification		
alternateAccess		
Response		

Table G.29 GetNamedVariableListAttributes Conformance Statement

GetNamedVariableListAttributes	Client-CR Supported	Server-CR Supported
	Supported	Supported
Request		
ObjectName		
Response		
mmsDeletable		Y
listOfVariable		Y
variableSpecification		Y
alternateAccess		Y

Table G.30 DeleteNamedVariableList Conformance Statement

DeleteNamedVariableList	Client-CR Supported	Server-CR Supported
	Supported	Supported
Request		
Scope		
listOfVariableListName		
domainName		
Response		
numberMatched		
numberDeleted		
DeleteNamedVariableList-Error		

GOOSE Services Conformance Statement

Table G.31 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 G.32 ACSI Basic Conformance Statement

Services		Client/Subscriber	Server/Publisher	SEL-849 Support
Client-Server Roles				
B11	Server side (of Two-Party Application-Association)		c1[a]	YES
B12	Client side (of Two-Party Application-Association)	c1[a]		
SCMS Supported				
B21	SCSM: IEC 61850-8-1 used			YES
B22	SCSM: IEC 61850-9-1 used			
B23	SCSM: IEC 61850-9-2 used			
B24	SCSM: other			
Generic Substation Event Model (GSE)				
B31	Publisher side		O[b]	YES
B32	Subscriber side	O[b]		YES
Transmission of Sampled Value Model (SVC)				
B41	Published side		O[b]	
B42	Subscriber side	O[b]		

[a] c1 is mandatory if support for LOGICAL-DEVICE model has been declared.
[b] O = Optional.

Table G.33 ACSI Models Conformance Statement (Sheet 1 of 2)

Services		Client/Subscriber	Server/Publisher	SEL-849 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[b]	YES
M4	Dataset	c5[d]	c5[d]	YES
M5	Substitution	O[e]	O[e]	
M6	Setting group control	O[e]	O[e]	
Reporting				
M7	Buffered report control	O[e]	O[e]	YES
M7-1	sequence-number			YES
M7-2	report-time-stamp			YES
M7-3	reason-for-inclusion			YES
M7-4	data-set-name			YES
M7-5	data-reference			YES
M7-6	buffer-overflow			YES
M7-7	entryID			YES
M7-8	BufTm			YES
M7-9	IntgPd			YES
M7-10	G1			YES
M8	Unbuffered report control	O[e]	O[e]	YES
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		Y	YES
M-8-8	GI		Y	YES
Logging				
M9	Log control	O[e]	O[e]	
M9-1	IntgPd	O[e]	O[e]	
M10	Log	O[e]	O[e]	
M11	Control	M[f]	M[f]	YES
If GSE (B31/32) Is Supported				
M12	GOOSE	O[e]	O[e]	YES
M12-1	entryID			YES
M12-2	DataRefInc			YES
M13	GSSE	O[e]	O[e]	

Table G.33 ACSI Models Conformance Statement (Sheet 2 of 2)

Services		Client/Subscriber	Server/Publisher	SEL-849 Support
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]	YES
M17	File Transfer	O[e]	O[e]	

[a] c2 is "M" if support for the LOGICAL-NODE model has been declared.
[b] c3 is "M" if support for the DATA model has been declared.
[c] c4 is "M" if support for the DATA-SET, Substitution, Report, Log Control, or Time models have been declared.
[d] c5 is "M" if support for the Report, GSE, or SV models have been declared.
[e] O = Optional.
[f] M = Mandatory.

Table G.34 ACSI Services Conformance Statement (Sheet 1 of 3)

Services		AA: TP/MC	Client/Subscriber	Service/Publisher	SEL-849 Support
Server (Clause 6)					
S1	ServerDirectory	TP		M[a]	YES
Application Association (Clause 7)					
S2	Associate		M[a]	M[a]	YES
S3	Abort		M[a]	M[a]	YES
S4	Release		M[a]	M[a]	YES
Logical Device (Clause 8)					
S5	LogicalDeviceDirectory	TP	M[a]	M[a]	YES
Logical Node (Clause 9)					
S6	LogicalNodeDirectory	TP	M[a]	M[a]	YES
S7	GetAllDataValues	TP	O[b]	M[a]	YES
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		M[a]	M[a]	
Setting Group Control (Clause 13)					
S18	SelectActiveSG		O[b]	O[b]	
S19	SelectEditSG		O[b]	O[b]	
S20	SetSGValues	TP	O[b]	O[b]	
S21	ConfirmEditSGValues	TP	O[b]	O[b]	
S22	GetSGValues	TP	O[b]	O[b]	
S23	GetSGCBValues	TP	O[b]	O[b]	

Table G.34 ACSI Services Conformance Statement (Sheet 2 of 3)

Services		AA: TP/MC	Client/Subscriber	Service/Publisher	SEL-849 Support
Reporting					
Buffered Report Control Block (BRCB)					
S24	Report	TP	c6[c]	c6[c]	YES
S24-1	data-change (dchg)				YES
S24-2	qchg-change (qchg)				YES
S24-3	data-update (dupd)				
S25	GetBRCBValues	TP	c6[c]	c6[c]	YES
S26	SetBRCBValues	TP	c6[c]	c6[c]	YES
Unbuffered Report Control Block (URCB)					
S27	Report	TP	c6[c]	c6[c]	YES
S27-1	data-change (dchg)				YES
S27-2	qchg-change (qchg)				YES
S27-3	data-update (dupd)				
S28	GetURCBValues	TP	c6[c]	c6[c]	YES
S29	SetURCBValues	TP	c6[c]	c6[c]	YES
Logging					
Log Control Block					
S30	GetLCBValues	TP	M[a]	M[a]	
S31	SetLCBValues	TP		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	GetGOOSEElementNumber	TP	O[b]	c9[f]	
S38	GetGoCBValues	TP	O[b]	O[b]	YES
S39	SetGoCBValues	TP	O[b]	O[b]	
GSSE Control Block					
S40	SendGSSEMessage	MC	c8[e]	c8[e]	
S41	GetReference	TP	O[b]	c9[f]	
S42	GetGSSEElementNumber	TP	O[b]	c9[f]	
S43	GetGsCBValues	TP	O[b]	O[b]	
S44	SetGsCBValues	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]	

Table G.34 ACSI Services Conformance Statement (Sheet 3 of 3)

Services		AA: TP/MC	Client/Subscriber	Service/Publisher	SEL-849 Support
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	M[a]	O[b]	YES
S53	Cancel	TP	O[b]	M[a]	YES
S54	Operate	TP	M[a]	M[a]	YES
S55	Command-Termination	TP	M[a]	M[a]	YES
S56	TimeActivated-Operate	TP	O[b]	O[b]	
File Transfer (Clause 20)					
S57	GetFile	TP	O[b]	M[a]	
S58	SetFile	TP	O[b]	O[b]	
S59	DeleteFile	TP	O[b]	O[b]	
S60	GetFileAttributeValues	TP	O[b]	M[a]	
Time (Clause 5.5)					
T1	Time resolution of internal clock (nearest negative power of 2 in seconds)				20 (1μs)
T2	Time accuracy of internal clock				7 (10 ms) for SNTP
	T1				
	T2				
	T3				
	T4				
	T5				
T3	Supported TimeStamp resolution (nearest negative power of 2 in seconds)				7 (10 ms) for SNTP

[a] M = Mandatory.
[b] O = Optional.
[c] c6 must declare support for at least one (BRCB or URCB).
[d] c7 must declare support for at least one (QueryLogByTime or QueryLogAfter).
[e] c8 must declare support for at least one (SendGOOSEMessage or SendGSSEMessage).
[f] c9 must declare support if TP association is available.
[g] c10 must declare support for at least one (SendMSVMessage or SendUSVMessage).

Appendix H
Relay Word Bits

The protection and control element results are represented by Relay Word bits in the SEL-849 Motor Management 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 H.1 shows the Relay Word bits and their corresponding descriptions. Any Relay Word bit can be used in SELOGIC control equations and the Sequential Events Recorder (SER) trigger list settings (see *Section 9: Analyzing Events*).

Table H.1 Relay Word Bits[a] (Sheet 1 of 12)

Row	Bit	Name	Bit Description
HMI Target/Status Indication			
Row 0			
	7	ENABLED	Enable LED
	6	TRIP_LED	Trip LED
	5—0	*	Reserved for future use
Row 1			
	7	TLED_01	Target LED 1
	6	TLED_02	Target LED 2
	5	TLED_03	Target LED 3
	4	TLED_04	Target LED 4
	3	TLED_05	Target LED 5
	2	TLED_06	Target LED 6
	1	TLED_07	Target LED 7
	0	TLED_08	Target LED 8

Table H.1 Relay Word Bits[a] (Sheet 2 of 12)

Row	Bit	Name	Bit Description
Motor Elements			
Row 2			
	7	49T	Thermal trip—asserts when the relay issues a thermal element trip because of locked rotor or running overload conditions, i.e., 49T = 49T_RTR OR 49T_STR.
	6	49T_STR	Thermal (overload) trip, asserted on stator overload condition
	5	49T_RTR	Thermal (overload) trip, asserted on rotor overload condition
	4	THERMLO	Motor lockout condition due to stator or rotor TCU being too high
	3	NOSLO	Motor lockout condition driven by starts-per-hour function
	2	TBSLO	Motor lockout condition driven by minimum time between starts function
	1	ABSLO	Motor lockout condition driven by minimum motor-stopped time (anti-backspin) function
	0	50S	Motor starting overcurrent element (Pickup = 2.5 • Full-Load Current, Dropout = 2.4 • Full-Load Current)
Row 3			
	7	49A	Thermal (overload) alarm
	6	49A_STR	Thermal (overload) alarm, stator
	5	49A_RTR	Thermal (overload) alarm, rotor
	4	RUNNING	Asserts when the motor is running
	3	STARTING	Asserts when the motor is starting
	2	STOPPED	Asserts when the motor is stopped
	1	STAR	Asserts when the Star-Delta Starting function issues a command to switch motor configuration to Star
	0	DELTA	Asserts when the Star-Delta Starting function issues a command to switch motor configuration to Delta
Row 4			
	7	LOSSTRIP	Load-loss trip
	6	LOSSALRM	Load-loss alarm
	5	JAMTRIP	Load-jam trip
	4	JAMALRM	Load-jam alarm
	3	46UBA	Phase current unbalance alarm
	2	46UBT	Phase current unbalance trip
	1	47T	Phase reversal trip
	0	*	Reserved for future use
Row 5			
	7	55A	Power factor alarm
	6	55T	Power factor trip
	5—1	*	Reserved for future use
	0	MOTOR	Motor application

Table H.1 Relay Word Bits[a] (Sheet 3 of 12)

Row	Bit	Name	Bit Description
Row 6			
	7	SMTRIP	Asserts when Start Motor Timer times out
	6	SPDSTR	Speed Switch Trip
	5	SPDSAL	Speed Switch Alarm
	4	LOADUP	Asserts when the selected load parameter exceeds an upper level setting
	3	LOADLOW	Asserts when the selected load parameter drops below a lower level setting
	2	PTCTRIP	Asserts when measured PTC loop resistance is greater than trip value
	1	PTCFLT	Indicates faulted/shorted thermistor
	0	*	Reserved for future use
Trip and Stop Elements			
Row 7			
	7	TRIP	Output of trip logic
	6	STP_OPFP	Stop or Open command issued from HMI
	5	COMMSTP	Stop or Open command issued from communications port
	4	LOCSTOP	Local Stop or Open command
	3	REMSTOP	Remote Stop or Open command
	2	STOP	Stop or Open command
	1	TR1	Trip SELOGIC 2nd control equation
	0	TR	Trip SELOGIC control equation
Trip Breaker Status and Target Reset			
Row 8			
	7	EXT_TRIP	External trip SELOGIC control equation
	6	ULTRIP	Unlatch (autoreset) trip SELOGIC control equation
	5	TRX	Extended trip SELOGIC control equation
	4	FAULT	Fault condition SELOGIC control equation
	3	52A	Breaker/contactor status SELOGIC control equation
	2	BFI	Breaker failure initiate SELOGIC control equation
	1	BFT	Breaker failure trip
	0	TRGTR	Target reset
Definite-Time Overcurrent Elements			
Row 9			
	7	50P1	Definite-time phase overcurrent level 1 pickup
	6	50P2	Definite-time phase overcurrent level 2 pickup
	5	50N1	Definite-time CBCT overcurrent level 1 pickup
	4	50N2	Definite-time CBCT overcurrent level 2 pickup
	3	50G1	Definite-time residual overcurrent level 1 pickup
	2	50G2	Definite-time residual overcurrent level 2 pickup
	1	50Q1	Definite-time negative-sequence overcurrent pickup
	0	*	Reserved for future use

Table H.1 Relay Word Bits[a] (Sheet 4 of 12)

Row	Bit	Name	Bit Description
Row 10			
	7	50P1T	Definite-time phase overcurrent level 1 trip
	6	50P2T	Definite-time phase overcurrent level 2 trip
	5	50N1T	Definite-time CBCT overcurrent level 1 trip
	4	50N2T	Definite-time CBCT overcurrent level 2 trip
	3	50G1T	Definite-time residual overcurrent level 1 trip
	2	50G2T	Definite-time residual overcurrent level 2 trip
	1	50Q1T	Definite-time negative-sequence overcurrent level 1 trip
	0	ORED50T	Logical OR of all the definite-time overcurrent element trips
Inverse Time-Overcurrent Elements			
Row 11			
	7	51P1	Phase time-overcurrent pickup
	6	51G1	Residual time-overcurrent pickup
	5	51N1	Neutral time-overcurrent pickup
	4	51Q1	Negative-sequence time-overcurrent pickup
	3	51P1T	Phase time-overcurrent trip
	2	51G1T	Residual time-overcurrent trip
	1	51N1T	Neutral time-overcurrent trip
	0	51Q1T	Negative-sequence time-overcurrent trip
Miscellaneous Overcurrent Elements			
Row 12			
	7	51P1R	Phase time-overcurrent reset
	6	51G1R	Residual time-overcurrent reset
	5	51N1R	Neutral time-overcurrent reset
	4	51Q1R	Negative-sequence time-overcurrent reset
	3	*	Reserved for future use
	2	DI_C	Phase C distortion index
	1	DI_B	Phase B distortion index
	0	DI_A	Phase A distortion index
Start and Restart Logic Elements			
Row 13			
	7	EMRSTR	Emergency Start SELOGIC control equation
	6	COMMSTR	Start command issued from communications ports
	5	STR_CLFP	Start or Close command issued from HMI
	4	STR_CLO	Start or Close command
	3	LOCSTART	Local Start or Close command
	2	REMSTART	Remote Start or Close command
	1	RESTART	Motor restart
	0	RSACTIVE	Motor restart active

Table H.1 Relay Word Bits[a] (Sheet 5 of 12)

Row	Bit	Name	Bit Description
Row 14			
	7	RS_LO	Motor restart lockout condition
	6	UV_SHRT	Short undervoltage
	5	UV_MED	Medium undervoltage
	4	UV_LONG	Long undervoltage
	3	UV_RS_LO	Restart lockout by undervoltage
	2	UV_TR	Undervoltage trip
	1	LJ_TR	Load jam trip
	0	59RS	Restart overvoltage
PHDEM and AFD Elements			
Row 15			
	7	50PAF	Sample-based phase overcurrent element for arc-flash detection
	6	50GAF	Sample-based residual overcurrent element for arc-flash detection
	5	TOL1	Arc-flash light input element pickup
	4	AFS1EL	Arc-flash sensor input excessive ambient light pickup
	3	AFS1DIAG	Arc-flash sensor input diagnostic failure
	2	PHDEM	Phase demand current pickup
	1, 0	*	Reserved for future use
Under- and Overvoltage Elements			
Row 16			
	7	27PP1	Undervoltage level 1 pickup
	6	27PP1T	Undervoltage level 1 trip
	5	27PP2	Undervoltage level 2 pickup
	4	27PP2T	Undervoltage level 2 trip
	3	59PP1	Overvoltage level 1 pickup
	2	59PP1T	Overvoltage level 1 trip
	1	59PP2	Overvoltage level 2 pickup
	0	59PP2T	Overvoltage level 2 trip
Power Frequency and LOP Elements			
Row 17			
	7	3PWR1	3-phase power element level 1 pickup
	6	3PWR1T	3-phase power element level 1 trip
	5	3PWR2	3-phase power element level 2 pickup
	4	3PWR2T	3-phase power element level 2 trip
	3	81D1T	Definite-time over- and underfrequency element level 1 trip
	2	81D2T	Definite-time over- and underfrequency element level 2 trip
	1	LOP	Loss-of-potential
	0	FREQTRK	Asserts when relay is tracking frequency

Table H.1 Relay Word Bits[a] (Sheet 6 of 12)

Row	Bit	Name	Bit Description
Inputs and Outputs			
Row 18			
	7	IN08	Contact input IN08
	6	IN07	Contact input IN07
	5	IN06	Contact input IN06
	4	IN05	Contact input IN05
	3	IN04	Contact input IN04
	2	IN03	Contact input IN03
	1	IN02	Contact input IN02
	0	IN01	Contact input IN01
Row 19			
	7—4	*	Reserved for future use
	3	IN12	Contact input IN12
	2	IN11	Contact input IN11
	1	IN10	Contact input IN10
	0	IN09	Contact input IN09
Row 20			
	7—4	*	Reserved for future use
	3	OUT04	Control equation for contact output OUT04
	2	OUT03	Control equation for contact output OUT03
	1	OUT02	Control equation for contact output OUT02
	0	OUT01	Control equation for contact output OUT01
Control Elements			
Row 21			
	7	REMOTE	Remote control mode indication
	6	REMCONFP	Remote control selected from HMI
	5	STR_CLEQ	Local Start/Close SELOGIC control equation
	4	REMSTREQ	Remote Start SELOGIC control equation
	3	BSTR_CL	Block Start/Close SELOGIC control equation
	2	REMCONEQ	Remote control SELOGIC control equation
	1	SPEED2	Speed2 SELOGIC control equation
	0	SPEEDSW	Speed Switch SELOGIC control equation
Control and Status Elements Warning List			
Row 22			
	7	VFDBYPAS	VFD bypass SELOGIC equation
	6	SPD2FP	Speed2/Reverse selected at HMI
	5	WARNING	Asserted when any element in the Warning List is asserted
	4, 3	*	Reserved for future use
	2	TESTDB	Command TEST DB (asserts when analog and digital values reported via Modbus, IEC 61850, or Fast Meter protocol may be overridden)

Table H.1 Relay Word Bits[a] (Sheet 7 of 12)

Row	Bit	Name	Bit Description
	1	HMIDET1	HMI with display detected (SEL-3421)
	0	HMIDET	HMI detected (SEL-3421 or SEL-3422)
Event Triggers and Reset Equations			
Row 23			
	7	ER	Event report trigger SELOGIC control equation
	6	MSRTRG	Motor start report trigger SELOGIC control equation
	5	RSTTRGT	Reset targets SELOGIC control equation
	4	RSTDEM	Reset demand data SELOGIC control equation
	3	RSTENRGY	Reset energy data SELOGIC control equation
	2	RSTMXMN	Reset max/min data SELOGIC control equation
	1	RST_HAL	Reset for HALARMA
	0	RSTMOT	Reset motor statistics SELOGIC control equation
Torque Control Equations			
Row 24			
	7	50P1TC	Maximum level 1 phase IOC torque control SELOGIC control equation
	6	50P2TC	Maximum level 2 phase IOC torque control SELOGIC control equation
	5	50Q1TC	Negative-sequence IOC torque control SELOGIC control equation
	4	50G1TC	Level 1 residual IOC torque control SELOGIC control equation
	3	50G2TC	Level 2 residual IOC torque control SELOGIC control equation
	2	50N1TC	GF-CB level 1 IOC torque control SELOGIC control equation
	1	50N2TC	GF-CB level 2 IOC torque control SELOGIC control equation
	0	*	Reserved for future use
Row 25			
	7	51P1TC	Maximum phase TOC torque control SELOGIC control equation
	6	51Q1TC	Maximum negative-sequence TOC torque control SELOGIC control equation
	5	51G1TC	Residual TOC torque control SELOGIC control equation
	4	51N1TC	Neutral TOC torque control SELOGIC control equation
	3	27PP1TC	Undervoltage torque control SELOGIC control equation 1
	2	27PP2TC	Undervoltage torque control SELOGIC control equation 2
	1	59PP1TC	Overvoltage torque control SELOGIC control equation 1
	0	59PP2TC	Overvoltage torque control SELOGIC control equation 2
Row 26			
	7	81D1TC	Under-/overfrequency torque control SELOGIC control equation 1
	6	81D2TC	Under-/overfrequency torque control SELOGIC control equation 2
	5	HBL2TC	Second-harmonic block torque control SELOGIC control equation
	4	HBL5TC	Fifth-harmonic block torque control SELOGIC control equation
	3–0	*	Reserved for future use

Table H.1 Relay Word Bits[a] (Sheet 8 of 12)

Row	Bit	Name	Bit Description
SELOGIC Latches			
Row 27			
	7	LT01	Latch bit LT01 asserted
	6	LT02	Latch bit LT02 asserted
	5	LT03	Latch bit LT03 asserted
	4	LT04	Latch bit LT04 asserted
	3	LT05	Latch bit LT05 asserted
	2	LT06	Latch bit LT06 asserted
	1	LT07	Latch bit LT07 asserted
	0	LT08	Latch bit LT08 asserted
SELOGIC Variables			
Row 28			
	7	SV01	SELOGIC control equation variable timer input SV01 asserted
	6	SV02	SELOGIC control equation variable timer input SV02 asserted
	5	SV03	SELOGIC control equation variable timer input SV03 asserted
	4	SV04	SELOGIC control equation variable timer input SV04 asserted
	3	SV05	SELOGIC control equation variable timer input SV05 asserted
	2	SV06	SELOGIC control equation variable timer input SV06 asserted
	1	SV07	SELOGIC control equation variable timer input SV07 asserted
	0	SV08	SELOGIC control equation variable timer input SV08 asserted
Row 29			
	7	SV01T	SELOGIC control equation variable timer output SV01T asserted
	6	SV02T	SELOGIC control equation variable timer output SV02T asserted
	5	SV03T	SELOGIC control equation variable timer output SV03T asserted
	4	SV04T	SELOGIC control equation variable timer output SV04T asserted
	3	SV05T	SELOGIC control equation variable timer output SV05T asserted
	2	SV06T	SELOGIC control equation variable timer output SV06T asserted
	1	SV07T	SELOGIC control equation variable timer output SV07T asserted
	0	SV08T	SELOGIC control equation variable timer output SV08T asserted
SELOGIC Counters			
Row 30			
	7	SC01QU	SELOGIC counter SC01 asserted when counter = preset value
	6	SC02QU	SELOGIC counter SC02 asserted when counter = preset value
	5	SC03QU	SELOGIC counter SC03 asserted when counter = preset value
	4	SC04QU	SELOGIC counter SC04 asserted when counter = preset value
	3	SC05QU	SELOGIC counter SC05 asserted when counter = preset value
	2	SC06QU	SELOGIC counter SC06 asserted when counter = preset value
	1	SC07QU	SELOGIC counter SC07 asserted when counter = preset value
	0	SC08QU	SELOGIC counter SC08 asserted when counter = preset value

Table H.1 Relay Word Bits[a] (Sheet 9 of 12)

Row	Bit	Name	Bit Description
Row 31			
	7	SC01QD	SELOGIC counter SC01 asserted when counter = 0
	6	SC02QD	SELOGIC counter SC02 asserted when counter = 0
	5	SC03QD	SELOGIC counter SC03 asserted when counter = 0
	4	SC04QD	SELOGIC counter SC04 asserted when counter = 0
	3	SC05QD	SELOGIC counter SC05 asserted when counter = 0
	2	SC06QD	SELOGIC counter SC06 asserted when counter = 0
	1	SC07QD	SELOGIC counter SC07 asserted when counter = 0
	0	SC08QD	SELOGIC counter SC08 asserted when counter = 0
Remote and Virtual Bits			
Row 32			
	7	RB01	Remote bit RB01 asserted
	6	RB02	Remote bit RB02 asserted
	5	RB03	Remote bit RB03 asserted
	4	RB04	Remote bit RB04 asserted
	3	RB05	Remote bit RB05 asserted
	2	RB06	Remote bit RB06 asserted
	1	RB07	Remote bit RB07 asserted
	0	RB08	Remote bit RB08 asserted
Row 33			
	7	VB001	Virtual bit VB001 asserted
	6	VB002	Virtual bit VB002 asserted
	5	VB003	Virtual bit VB003 asserted
	4	VB004	Virtual bit VB004 asserted
	3	VB005	Virtual bit VB005 asserted
	2	VB006	Virtual bit VB006 asserted
	1	VB007	Virtual bit VB007 asserted
	0	VB008	Virtual bit VB008 asserted
Row 34			
	7	VB009	Virtual bit VB009 asserted
	6	VB010	Virtual bit VB010 asserted
	5	VB011	Virtual bit VB011 asserted
	4	VB012	Virtual bit VB012 asserted
	3	VB013	Virtual bit VB013 asserted
	2	VB014	Virtual bit VB014 asserted
	1	VB015	Virtual bit VB015 asserted
	0	VB016	Virtual bit VB016 asserted

Table H.1 Relay Word Bits[a] (Sheet 10 of 12)

Row	Bit	Name	Bit Description
Row 35			
	7	VB017	Virtual bit VB017 asserted
	6	VB018	Virtual bit VB018 asserted
	5	VB019	Virtual bit VB019 asserted
	4	VB020	Virtual bit VB020 asserted
	3	VB021	Virtual bit VB021 asserted
	2	VB022	Virtual bit VB022 asserted
	1	VB023	Virtual bit VB023 asserted
	0	VB024	Virtual bit VB024 asserted
Row 36			
	7	VB025	Virtual bit VB025 asserted
	6	VB026	Virtual bit VB026 asserted
	5	VB027	Virtual bit VB027 asserted
	4	VB028	Virtual bit VB028 asserted
	3	VB029	Virtual bit VB029 asserted
	2	VB030	Virtual bit VB030 asserted
	1	VB031	Virtual bit VB031 asserted
	0	VB032	Virtual bit VB032 asserted
Alarms and Warnings			
Row 37			
	7	HALARM	Indication of a diagnostic failure or warning that warrant an ALARM
	6	HALARML	Latches in for relay diagnostic failures
	5	HALARMP	Pulses for 5 seconds when a warning diagnostic condition occurs
	4	HALARMA	This bit pulses for five seconds every minute, once a diagnostic warning condition has occurred; it stops pulsing within one second of the rising edge of RST_HAL
	3–0	*	Reserved for future use
Row 38			
	7	SALARM	Indication of software or user activity that warrant an ALARM
	6	ACCESS	Asserted while any user is logged in at access level 1 or higher
	5	PASNVAL	Pulses for 1 second when any user enters an invalid password
	4	ACCESSP	Pulses for 1 second when any user increases their access level to 1 or higher
	3	*	Reserved for future use
	2	SETCHG	Pulses for 1 second whenever settings are changed
	1	CHGPASS	Pulses for 1 second whenever a password is changed
	0	BADPASS	Pulses for 1 second whenever a user enters three successive bad passwords

Table H.1 Relay Word Bits[a] (Sheet 11 of 12)

Row	Bit	Name	Bit Description
Ethernet Status			
Row 39			
	7	LINK2	Asserted when a valid link is detected on port 2
	6	LINK2A	Asserted when a valid link is detected on port 2A
	5	LINK2B	Asserted when a valid link is detected on port 2B
	4	LINKFAIL	Asserted when a valid link is not detected on the active port(s)
	3	P2ASEL	Asserted when port 2A is active
	2	P2BSEL	Asserted when port 2B is active
	1	NETFAIL	Network link failure
	0	*	Reserved for future use
Time Synchronization Status			
Row 40			
	7	TSOK	Time synchronization OK
	6	DST	Asserted during daylight-saving time
	5	DSTP	Asserts up to a minute before daylight-saving time change
	4	LPSEC	Leap second polarity—add if deasserted, delete if asserted
	3	LPSECP	Leap second pending—asserts up to a minute prior to leap second insertion
	2—0	*	Reserved for future use
Row 41			
	7	TSNTPB	Asserted when relay time is based on SNTP, using backup server
	6	TSNTPP	Asserted when relay time is based on SNTP, using primary server
	5	TUTCS	Offset hours sign from UTC time, subtract the UTC offset if TUTCS is asserted; otherwise, add
	4	TUTC1	Offset hours from UTC time, binary, add 1 if asserted
	3	TUTC2	Offset hours from UTC time, binary, add 2 if asserted
	2	TUTC4	Offset hours from UTC time, binary, add 4 if asserted
	1	TUTC8	Offset hours from UTC time, binary, add 8 if asserted
	0	TUTCH	Offset half-hour from UTC time, binary, add 0.5 if asserted
Target LED Equations			
Row 42			
	7	T01_LED	Target LED 01 SELOGIC control equation
	6	T02_LED	Target LED 02 SELOGIC control equation
	5	T03_LED	Target LED 03 SELOGIC control equation
	4	T04_LED	Target LED 04 SELOGIC control equation
	3	T05_LED	Target LED 05 SELOGIC control equation
	2	T06_LED	Target LED 06 SELOGIC control equation
	1	T07_LED	Target LED 07 SELOGIC control equation
	0	T08_LED	Target LED 08 SELOGIC control equation

Table H.1 Relay Word Bits[a] (Sheet 12 of 12)

Row	Bit	Name	Bit Description
Misc.			
Row 43			
	7	SHRT_RS	Restart on short voltage dip
	6	RSDT	Restart delay timed out
	5	HMI_STP	HMI STOP pushbutton
	4	EMRSTP	Emergency Stop SELOGIC control equation
	3	COASTOP	Asserts when the motor is stopped after coasting
	2	52A_CR	Contactor status SELOGIC control equation
	1	52A_CB	Breaker status SELOGIC control equation
	0	*	Reserved for future use
Row 44			
	7	HBL2T	Combined-phase second-harmonic block timed out
	6	HBL2AT	Phase A second-harmonic block timed out
	5	HBL2BT	Phase B second-harmonic block timed out
	4	HBL2CT	Phase C second-harmonic block timed out
	3	HBL5T	Combined-phase fifth-harmonic block timed out
	2	HBL5AT	Phase A fifth-harmonic block timed out
	1	HBL5BT	Phase B fifth-harmonic block timed out
	0	HBL5CT	Phase C fifth-harmonic block timed out
Row 45			
	7	PB01	Pushbutton Bit 1 asserted
	6	PB02	Pushbutton Bit 2 asserted
	5	PB03	Pushbutton Bit 3 asserted
	4	PB04	Pushbutton Bit 4 asserted
	3	PB05	Pushbutton Bit 5 asserted
	2	PB06	Pushbutton Bit 6 asserted
	1	PB07	Pushbutton Bit 7 asserted
	0	PB08	Pushbutton Bit 8 asserted
Spare			
Row 46–Row 51			
	7—0	*	Reserved for future use

[a] Relay Word bits have the same name as their SELOGIC settings counterpart.

When the relay part number does not show support for an option, such as voltage, physical input or output, single or dual Ethernet, or IEC 61850, the related Relay Word bits for those options will display as "*" (an asterisk).

Appendix I

Analog Quantities

The SEL-849 Motor Management Relay contains several analog quantities that can be used for more than one function. The part number of the relay determines the actual analog quantities available. Typically, analog quantities are 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 25 ms and may not be suitable for fast-response control and protection applications. *Table I.1* lists the analog quantities for the following specific functions.

- Communications ports (commands and reports)
- SEL-3421 Motor Relay HMI (commands and reports)
- SEL Fast Meter (see *Appendix C: SEL Communications Processors*)
- Display points (SEL-3421 Motor Relay HMI)
- SELOGIC control equations (see *Section 4: Protection and Logic Functions*)
- Load-profile recorder (see *Section 5: Metering and Monitoring*)
- DNP3 (see *Appendix D: DNP3 Communications*)
- EtherNet/IP (see *Appendix F: EtherNet/IP Communications*)
- Modbus (see *Appendix E: Modbus Communications*)
- IEC 61850 (see *Appendix G: IEC 61850 Communications*)

Table I.1 Analog Quantities (Sheet 1 of 8)

Name	Description	Unit	Comm Port	SEL-3421 HMI	Fast Meter	Display Points	SELOGIC	Load Profile	DNP3/ EtherNet/IP	Modbus	IEC 61850
Instantaneous (Fundamental) Metering											
IA_MAG	Current, A-phase, magnitude	A pri	x	x	x	x	x	x	x	x	x
IA_ANG	Current, A-phase, angle	degrees	x	x		x	x	x	x	x	x
IB_MAG	Current, B-phase, magnitude	A pri	x	x	x	x	x	x	x	x	x
IB_ANG	Current, B-phase, angle	degrees	x	x		x	x	x	x	x	x
IC_MAG	Current, C-phase, magnitude	A pri	x	x	x	x	x	x	x	x	x
IC_ANG	Current, C-phase, angle	degrees	x	x		x	x	x	x	x	x
IAVG	Current, average current, magnitude	A pri	x	x	x	x	x	x	x	x	x
UBI	Current imbalance	%	x	x	x	x	x	x	x	x	x
IG_MAG	Current, calculated-residual, magnitude	A pri	x	x	x	x	x	x	x	x	x

Table I.1 Analog Quantities (Sheet 2 of 8)

Name	Description	Unit	Comm Port	SEL-3421 HMI	Fast Meter	Display Points	SELOGIC	Load Profile	DNP3/ EtherNet/IP	Modbus	IEC 61850
IG_ANG	Current, calculated-residual, angle	degrees	x	x		x	x	x	x	x	x
IN_MAG	Core-Balance CT current, magnitude	A pri	x	x	x	x	x	x	x	x	x
I1	Positive-sequence current, magnitude	A pri				x	x	x	x	x	x
I1_ANG	Positive-sequence current, angle	degrees				x	x	x	x	x	x
3I2	Current, negative-sequence current, magnitude	A pri	x	x		x	x	x	x	x	x
3I2_ANG	Negative-sequence current, angle	degrees				x	x	x	x	x	x
VA_MAG	Voltage, A-phase-to-neutral, magnitude	V pri	x	x	x	x	x	x	x	x	x
VA_ANG	Voltage, A-phase-to-neutral, angle	degrees	x	x		x	x	x	x	x	x
VB_MAG	Voltage, B-phase-to-neutral, magnitude	V pri	x	x	x	x	x	x	x	x	x
VB_ANG	Voltage, B-phase-to-neutral, angle	degrees	x	x		x	x	x	x	x	x
VC_MAG	Voltage, C-phase-to-neutral, magnitude	V pri	x	x	x	x	x	x	x	x	x
VC_ANG	Voltage, C-phase-to-neutral, angle	degrees	x	x		x	x	x	x	x	x
VAB_MAG	Voltage, A-to-B-phase, magnitude	V pri	x	x	x	x	x	x	x	x	x
VAB_ANG	Voltage, A-to-B-phase, angle	degrees	x	x		x	x	x	x	x	x
VBC_MAG	Voltage, B-to-C-phase, magnitude	V pri	x	x	x	x	x	x	x	x	x
VBC_ANG	Voltage, B-to-C-phase, angle	degrees	x	x		x	x	x	x	x	x
VCA_MAG	Voltage, C-to-A-phase, magnitude	V pri	x	x	x	x	x	x	x	x	x
VCA_ANG	Voltage, C-to-A-phase, angle	degrees	x	x		x	x	x	x	x	x
VAVG	Average voltage, magnitude	V pri	x	x	x	x	x	x	x	x	x
UBV	Voltage imbalance	%	x	x	x	x	x	x	x	x	x
3V0	Voltage, 3V0 zero-sequence, magnitude	V pri	x	x	x	x	x	x	x	x	
3V0_ANG	Voltage, 3V0 zero-sequence, angle	degrees	x	x		x	x	x	x	x	
V1	Positive-sequence voltage, magnitude	V pri				x	x	x	x	x	x
V1_ANG	Positive-sequence voltage, angle	degrees				x	x	x	x	x	x
3V2	Voltage, Negative-sequence, magnitude	V pri	x	x		x	x	x	x	x	
3V2_ANG	Negative-sequence voltage, angle	degrees				x	x	x	x	x	x
S	Apparent power, 3-phase, magnitude	kVA pri	x	x	x	x	x	x	x	x	x
P	Real power, 3-phase, magnitude	kW pri	x	x	x	x	x	x	x	x	x
Q	Reactive power, 3-phase, magnitude	kVAR pri	x	x	x	x	x	x	x	x	x
PF	Power factor, 3-phase, magnitude		x	x	x	x	x	x	x	x	x
FREQ	Frequency	Hz	x	x	x	x	x	x	x	x	x
Motor Data											
MLOAD	Motor Load	pu of FLA	x	x	x	x	x	x	x	x	x
TCURTR	Rotor % Thermal Capacity Used	%	x	x	x	x	x	x	x	x	x
TCUSTR	Stator % Thermal Capacity Used	%	x	x	x	x	x	x	x	x	x
THRMTP	Thermal Trip In	sec	x	x		x	x	x	x	x	x
TRST	Time to Reset	sec	x	x		x	x	x	x	x	x
STRTAV	Starts Available		x	x		x	x	x	x	x	x

Table I.1 Analog Quantities (Sheet 3 of 8)

Name	Description	Unit	Comm Port	SEL-3421 HMI	Fast Meter	Display Points	SELogic	Load Profile	DNP3/ EtherNet/IP	Modbus	IEC 61850
MRT	Motor Running Time	hours	x	x		x	x	x	x	x	x
NUMSTRT	Number of Starts		x	x		x	x	x	x	x	x
NUMRSTRT	Number of Restarts		x	x		x	x	x	x	x	x
NUMEMRST	Emergency Starts		x	x		x	x	x	x	x	x
NUMCONOP	Number of Contactor Operations		x	x		x	x	x	x	x	x
NUMBKROP	Number of Breaker Operations		x	x		x	x	x	x	x	x
MLOADHR	Motor Load, High Resolution								x	x	
MOT_E_M	Elapsed Time-mm								x	x	
MOT_E_H	Elapsed Time-hh								x	x	
MOT_E_D	Elapsed Time-dd								x	x	
MOT_R_M	Running Time-mm								x	x	
MOT_R_H	Running Time-hh								x	x	
MOT_R_D	Running Time-dd								x	x	
MOT_S_M	Stopped Time-mm								x	x	
MOT_S_H	Stopped Time-hh								x	x	
MOT_S_D	Stopped Time-dd								x	x	
MOTRST_S	MOT RST Time-ss								x	x	
MOTRST_M	MOT RST Time-mm								x	x	
MOTRST_H	MOT RST Time-hh								x	x	
MOTRSD_D	MOT RST Date-dd								x	x	
MOTRSD_M	MOT RST Date-mm								x	x	
MOTRSD_Y	MOT RST Date-yy								x	x	
STRT_T_A	Start Time Average	sec							x	x	
MAXSTI_A	Max Start I Average	A							x	x	
MINSTV_A	Min Start V Average	V							x	x	
STRTTC_A	Start %TCU Average	%							x	x	
RUNTC_A	Running %TCU Average	%							x	x	
RUNI_A	Running CUR Average	A							x	x	
RUNKW_A	Running KW Average	kW							x	x	
RUKVRI_A	Running KVARIN Average	kVAR							x	x	
RUKVRO_A	Running KVAROUT Average	kVAR							x	x	
RUNKVA_A	Running KVA Average	kVA							x	x	
STRT_T_P	Start Time Peak	sec							x	x	
MAXSTI_P	Max Start I Peak	A							x	x	
MINSTV_P	Min Start V Peak	V							x	x	
STRTTC_P	Start %TCU Peak	%							x	x	
RUNTC_P	Running %TCU Peak	%							x	x	
RUNI_P	Running CUR Peak	A							x	x	
RUNKW_P	Running KW Peak	kW							x	x	

Table I.1 Analog Quantities (Sheet 4 of 8)

Name	Description	Unit	Comm Port	SEL-3421 HMI	Fast Meter	Display Points	SELOGIC	Load Profile	DNP3/ EtherNet/IP	Modbus	IEC 61850
RUKVRI_P	Running KVARIN Peak	kVAR							x	x	
RUKVRO_P	Running KVAROUT Peak	kVAR							x	x	
RUNKVA_P	Running KVA Peak	kVA							x	x	
THERM_A	Overload Alarm Counter								x	x	
LOCKR_A	Locked Rotor Alarm Counter								x	x	
LDLOSS_A	Undercurrent Alarm Counter								x	x	
LDJAM_A	Jam Alarm Counter								x	x	
UBI_A	Current Imbalance Alarm Counter								x	x	
SPDSW_A	Speed Switch Alarm Counter								x	x	
PF_A	Power Factor Alarm Counter								x	x	
TOTAL_A	Total Alarms Alarm Counter								x	x	x
THERM_T	Overload Trip Counter								x	x	
LOCKR_T	Locked Rotor Trip Counter								x	x	
LDLOSS_T	Undercurrent Trip Counter								x	x	
LDJAM_T	Jam Trip Counter								x	x	
UBI_T	Current Imbalance Trip Counter								x	x	
PHFLT_T	Overcurrent Trip Counter								x	x	
GRFLT_T	Ground Fault Trip Counter								x	x	
SPDSW_T	Speed Switch Trip Counter								x	x	
UNDV_T	Undervoltage Trip Counter								x	x	
OVRV_T	Overvoltage Trip Counter								x	x	
POWER_T	Power Trip Counter								x	x	
PF_T	Power Factor Trip Counter								x	x	
PHREV_T	Phase Reversal Trip Counter								x	x	
UNDFRQ_T	Underfrequency Trip Counter								x	x	
OVRFRQ_T	Overfrequency Trip Counter								x	x	
PTC_T	PTC Trip Counter								x	x	
STTIM_T	Start Timer Trip Counter								x	x	
COMM_T	Remote Stop Trip Counter								x	x	
LOC_T	Local Stop Trip Counter								x	x	
OTHTR_T	Other Trips Trip Counter								x	x	
TOTAL_T	Total Trips Trip Counter								x	x	x
RMS Metering											
IARMS	RMS Current, A-phase, magnitude	A pri	x	x		x	x	x	x	x	x
IBRMS	RMS Current, B-phase, magnitude	A pri	x	x		x	x	x	x	x	x
ICRMS	RMS Current, C-phase, magnitude	A pri	x	x		x	x	x	x	x	x
IGRMS	RMS Residual Current, magnitude	A pri	x	x		x	x	x	x	x	x
INRMS	RMS Ground Current, magnitude	A pri	x	x		x	x	x	x	x	x

Table I.1 Analog Quantities (Sheet 5 of 8)

Name	Description	Unit	Comm Port	SEL-3421 HMI	Fast Meter	Display Points	SELOGIC	Load Profile	DNP3/ EtherNet/IP	Modbus	IEC 61850
VARMS	RMS Voltage, A-phase, magnitude	V pri	x	x		x	x	x	x	x	x
VBRMS	RMS Voltage, B-phase, magnitude	V pri	x	x		x	x	x	x	x	x
VCRMS	RMS Voltage, C-phase, magnitude	V pri	x	x		x	x	x	x	x	x
VABRMS	RMS Voltage, AB-phase-to-phase, magnitude	V pri	x	x		x	x	x	x	x	x
VBCRMS	RMS Voltage, BC-phase-to-phase, magnitude	V pri	x	x		x	x	x	x	x	x
VCARMS	RMS Voltage, CA-phase-to-phase, magnitude	V pri	x	x		x	x	x	x	x	x
Harmonic Metering											
IA_THD	THD, Phase Current IA	%	x	x		x	x		x	x	x
IB_THD	THD, Phase Current IB	%	x	x		x	x		x	x	x
IC_THD	THD, Phase Current IC	%	x	x		x	x		x	x	x
VA_THD	THD, Phase Voltage VA	%	x	x		x	x		x	x	x
VB_THD	THD, Phase Voltage VB	%	x	x		x	x		x	x	x
VC_THD	THD, Phase Voltage VC	%	x	x		x	x		x	x	x
VAB_THD	THD, Phase-Phase Voltage VAB	%	x	x		x	x		x	x	x
VBC_THD	THD, Phase-Phase Voltage VBC	%	x	x		x	x		x	x	x
VCA_THD	THD, Phase-Phase Voltage VCA	%	x	x		x	x		x	x	x
Demand Metering											
IAD	Phase A Current Demand	A pri	x	x		x	x		x	x	x
IBD	Phase B Current Demand	A pri	x	x		x	x		x	x	x
ICD	Phase C Current Demand	A pri	x	x		x	x		x	x	x
Peak Demand Metering											
DMLRT_S	Demand Last Reset Time Seconds		x	x					x	x	x
DMLRT_M	Demand Last Reset Time Minutes		x	x					x	x	x
DMLRT_H	Demand Last Reset Time Hours		x	x					x	x	x
DMLRD_D	Demand Last Reset Date Day		x	x					x	x	x
DMLRD_M	Demand Last Reset Date Month		x	x					x	x	x
DMLRD_Y	Demand Last Reset Date Year		x	x					x	x	x
IAPD	Phase A Current Peak Demand	A pri	x	x	x	x	x	x	x	x	x
IBPD	Phase B Current Peak Demand	A pri	x	x	x	x	x	x	x	x	x
ICPD	Phase C Current Peak Demand	A pri	x	x	x	x	x	x	x	x	x
Energy Metering											
EM_LRT_S	Energy last reset time seconds		x	x					x	x	x
EM_LRT_M	Energy last reset time minutes		x	x					x	x	x
EM_LRT_H	Energy last reset time hours		x	x					x	x	x
EM_LRD_D	Energy last reset date day		x	x					x	x	x
EM_LRD_M	Energy last reset date month		x	x					x	x	x

Table I.1 Analog Quantities (Sheet 6 of 8)

Name	Description	Unit	Comm Port	SEL-3421 HMI	Fast Meter	Display Points	SELogic	Load Profile	DNP3/ EtherNet/IP	Modbus	IEC 61850
EM_LRD_Y	Energy last reset date year		x	x					x	x	x
MWH3P	Real energy, 3-phase OUT of bus	MWh pri	x	x		x	x	x	x	x	x
MVARH3PI	Reactive energy, 3-phase IN to bus	MVARh pri	x	x		x	x	x	x	x	x
MVARH3PO	Reactive energy, 3-phase OUT to bus	MVARh pri	x	x		x	x	x	x	x	x
MVAH3P	Apparent energy, 3-phase	MVAh pri	x	x		x	x	x	x	x	x
KWH3P	Real energy, 3-phase OUT of bus	KWh pri	x	x		x		x	x	x	x
KVARH3PI	Reactive energy, 3-phase IN to bus	KVARh pri	x	x		x		x	x	x	x
KVARH3PO	Reactive energy, 3-phase OUT of bus	KVARh pri	x	x		x		x	x	x	x
KVAH3P	Apparent energy, 3-phase	KVAh pri	x	x		x		x	x	x	x
Max/Min Metering											
MM_LRT_S	Max/Min last reset time seconds		x	x					x	x	x
MM_LRT_M	Max/Min last reset time minutes		x	x					x	x	x
MM_LRT_H	Max/Min last reset time hours		x	x					x	x	x
MM_LRD_D	Max/Min last reset date day		x	x					x	x	x
MM_LRD_M	Max/Min last reset date month		x	x					x	x	x
MM_LRD_Y	Max/Min last reset date year		x	x					x	x	x
IAMX	Current, A-phase, maximum magnitude	A pri	x	x		x	x	x	x	x	x
IBMX	Current, B-phase, maximum magnitude	A pri	x	x		x	x	x	x	x	x
ICMX	Current, C-phase, maximum magnitude	A pri	x	x		x	x	x	x	x	x
INMX	Current, neutral, maximum magnitude	A pri	x	x		x	x	x	x	x	x
IGMX	Current, residual, maximum magnitude	A pri	x	x		x	x	x	x	x	x
IAMN	Current, A-phase, minimum magnitude	A pri	x	x		x	x	x	x	x	x
IBMN	Current, B-phase, minimum magnitude	A pri	x	x		x	x	x	x	x	x
ICMN	Current, C-phase, minimum magnitude	A pri	x	x		x	x	x	x	x	x
INMN	Current, neutral, minimum magnitude	A pri	x	x		x	x	x	x	x	x
IGMN	Current, residual, minimum magnitude	A pri	x	x		x	x	x	x	x	x
VABMX	Voltage, A-to-B phase, maximum magnitude	V pri	x	x		x	x	x	x	x	x
VBCMX	Voltage, B-to-C phase, maximum magnitude	V pri	x	x		x	x	x	x	x	x
VCAMX	Voltage, C-to-A phase, maximum magnitude	V pri	x	x		x	x	x	x	x	x
VAMX	Voltage, A-phase-to-neutral, maximum magnitude	V pri	x	x		x	x	x	x	x	x
VBMX	Voltage, B-phase-to-neutral, maximum magnitude	V pri	x	x		x	x	x	x	x	x
VCMX	Voltage, C-phase-to-neutral, maximum magnitude	V pri	x	x		x	x	x	x	x	x

Table I.1 Analog Quantities (Sheet 7 of 8)

Name	Description	Unit	Comm Port	SEL-3421 HMI	Fast Meter	Display Points	SELOGIC	Load Profile	DNP3/ EtherNet/IP	Modbus	IEC 61850
VABMN	Voltage, A-to-B phase, minimum magnitude	V pri	x	x		x	x	x	x	x	x
VBCMN	Voltage, B-to-C phase, minimum magnitude	V pri	x	x		x	x	x	x	x	x
VCAMN	Voltage, C-to-A phase, minimum magnitude	V pri	x	x		x	x	x	x	x	x
VAMN	Voltage, A-phase-to-neutral, minimum magnitude	V pri	x	x		x	x	x	x	x	x
VBMN	Voltage, B-phase-to-neutral, minimum magnitude	V pri	x	x		x	x	x	x	x	x
VCMN	Voltage, C-phase-to-neutral, minimum magnitude	V pri	x	x		x	x	x	x	x	x
KVA3PMX	Apparent power, 3-phase, maximum magnitude	KVA pri	x	x		x	x	x	x	x	x
KW3PMX	Real power, 3-phase, maximum magnitude	kW pri	x	x		x	x	x	x	x	x
KVAR3PMX	Reactive power, 3-phase, maximum magnitude	kVAR pri	x	x		x	x	x	x	x	x
KVA3PMN	Apparent power, 3-phase, minimum magnitude	kVA pri	x	x		x	x	x	x	x	x
KW3PMN	Real power, 3-phase minimum magnitude	kW pri	x	x		x	x	x	x	x	x
KVAR3PMN	Reactive power, 3-phase, minimum magnitude	kVAR pri	x	x		x	x	x	x	x	x
FREQMX	Maximum frequency	Hz	x	x		x	x	x	x	x	x
FREQMN	Minimum frequency	Hz	x	x		x	x	x	x	x	x
Date/Time											
DATE	Present date		x	x		x				x	x
TIME	Present time		x			x				x	x
YEAR	Year number (0000–9999)						x			x	
DAYY	Day of Year number (1–366)						x				
WEEK	Week number (1–52)						x				
DAYW	Day of Week number (1–7)						x				
MINSM	Minutes since Midnight						x				
RID/TID											
RID	Relay Identifier		x	x		x				x	x
TID	Terminal Identifier		x	x		x				x	x
DEVCODE	Unique Device Code								x	x	x
Part Number/Serial Number											
PART_NUM	Part Number		x	x		x				x	x
SER_NUM	Serial Number		x	x		x				x	x
Math Variables											

Table I.1 Analog Quantities (Sheet 8 of 8)

Name	Description	Unit	Comm Port	SEL-3421 HMI	Fast Meter	Display Points	SELogic	Load Profile	DNP3/ EtherNet/IP	Modbus	IEC 61850
MV01 to MV08	Math Variable 01 to Math Variable 08		x	x		x	x	x	x	x	x
SELogic Counters											
SC01 to SC08	SELogic Counter 01 to SELogic Counter 08		x	x		x	x	x	x	x	x
Remote Analogs											
RA001 to RA032	Remote Analog 01 to Remote Analog 32		x	x	x	x	x	x	x	x	x

Appendix J
Cybersecurity Features

The SEL-849 provides a number of features to help meet cybersecurity design requirements.

Access Control

The SEL-849 has a number of mechanisms for managing electronic access. These include limiting access, providing user authentication, and monitoring electronic and physical access.

Physical Port Controls

The optional serial port and the Ethernet port can be individually disabled with the EPORT setting. By default, all of the ports are enabled. Disabling unused ports is good security practice.

IP Ports

When using Ethernet, there are a number of IP ports available within the SEL-849. Many of these IP port numbers are configurable. All IP ports can be disabled. *Table J.1* describes each of these.

Table J.1 IP Port Numbers

IP Port Default	Port Selection Setting	Network Protocol	Default Port State	Port Enable Setting	Purpose
21	--	TCP	Enabled	EFTPSERV	FTP protocol access for file transfer of settings and reports
23	TPORT	TCP	Enabled	ETELNET	Telnet access for general engineering terminal access
80	HTTPPORT	TCP	Enabled	EHTTP\EHTTPS	Web server access to various relay information
443	HTTPSPRT	TCP	Disabled	EHTTPS	Secure web server access to various relay information
102	--	TCP	Disabled	E61850	IEC 61850 MMS for SCADA functionality
123	SNTPPORT	UDP	Disabled	ESNTP	SNTP time synchronization
502	MODPORT1/ MODPORT2	TCP	Disabled	EMOD	Modbus for SCADA functionality
2222/ 44818	--	TCP/UDP	Disabled	EEIP	EtherNet/IP for SCADA functionality
20000	DNPNUM	TCP/UDP	Disabled	EDNP	DNP for SCADA functionality

Authentication and Authorization

The SEL-849 supports four levels of access, as described in the *Access Levels on page 7.20*. Refer to this section to learn how each level is accessed and how to change passwords. Changing the default passwords of each access level and using a unique password for each level are good security practices.

The MAXACC setting limits the level of access for each port. This permits you to operate under the principle of “least privilege,” restricting ports to the levels necessary for the functions performed on those ports.

The SEL-849 supports strong passwords with as many as 12 characters, using any printable character, allowing users to select complex passwords if they so choose. SEL recommends that passwords have a minimum of 8 characters and include at least one of each of the following: lowercase letter, uppercase letter, number, and special character.

Monitoring and Logging

The SEL-849 provides Relay Word bits that are useful for monitoring relay access.

- BADPASS—Pulses for approximately one second if a user enters three successive incorrect passwords in an SEL ASCII terminal session or web session.
- ACCESS—Asserted while any user is logged into Access Level 1 or higher.
- ACCESSP—Pulses for approximately one second whenever a user gains access to Access Level 2 or higher.
- PASNVAL—Pulses for approximately one second when an incorrect password is entered when attempting to Access Level 1 or higher, or when an incorrect password is entered when attempting to change passwords.
- LINK2, LINK2A, LINK2B—Asserted while the link is active on the Ethernet port(s). Loss of link can be an indication that an Ethernet cable has been disconnected.
- LNKFAIL—Asserted if link is lost on the active IP port (Ports 2, 2A, or 2B).

These bits can be mapped for SCADA monitoring via DNP3, IEC 61850, Modbus, EtherNet/IP, or SEL Fast Message. They also may be added to the SER for later analysis or assigned to output contacts for alarm purposes.

The SEL-849 SER is a useful tool for capturing a variety of relay events. In addition to capturing state changes of user selected Relay Word bits, it captures all power-ups and settings changes. See *Sequential Events Recorder (SER) on page 9.27* for more information about SER.

Physical Access Security

Physical security of cybersecurity assets is a common concern. SEL-849 relays can be installed within a control enclosure that provides physical security. Other times, relays are installed in breakers or enclosures within the switchyard. The SEL-849 provides tools to help manage physical security, especially when the unit is installed in the switch yard.

You can monitor physical ingress by wiring a door sensor to one of the SEL-849 contact inputs. This input can then be mapped for SCADA monitoring or added to the SER log so that you can monitor when physical access to the relay occurs. It is also possible to wire an electronic latch to an SEL-849 contact output. You could then map this output for SCADA control.

Configuration Management

Many users are concerned about managing the configuration of their relays. The SEL-849 provides mechanisms to help users manage relay configuration. All settings changes are logged to the SER log. Analysis of this log indicates if any unauthorized settings changes occurred.

The following Relay Word bits also indicate changes in relay configuration:

- SETCHG—Pulses for approximately one second when settings are changed or saved
- CHGPASS—Pulses for approximately one second when a password changes

Firmware Hash Verification

This device supports digitally signed firmware upgrades. SEL uses the SHA-256 secure hash algorithm to compress and digitally sign firmware upgrade files. The signature ensures that the file has been provided by SEL and that its contents have not been altered. When the file is uploaded to the relay, the signature is verified using a public key stored on the relay. If the relay cannot verify the signature, it rejects the file. See *Appendix B: Firmware Upgrade Instructions* for more information on firmware upgrades.

Malware Protection

The SEL-849 has inherent and continuous monitoring for malware. For a full description of this, see selinc.com/mitigating_malware/.

Vulnerability Notification Process

Security Vulnerabilities Process

SEL provides security disclosure alerts to customers, and SEL instruction manuals document all releases. SEL security vulnerability disclosures are described in *The SEL Process for Disclosing Security Vulnerabilities* at selinc.com.

Emailed Security Notification

You can sign up to receive email notifications when SEL releases security vulnerability notices and service bulletins at selinc.com/support/securitynotifications/.

Settings Erasure

It is often necessary to erase the settings from the relay when it is removed from service. You can completely erase all the configuration settings from the SEL-849 using this procedure.

Step 1. Go to Access Level C (see *Access Levels on page 7.20*).

Step 2. Execute the **R_S** command.

Step 3. Allow the relay to restart.

NOTE: Do not erase settings when sending the relay to the factory for service. SEL needs to see how the relay was configured to properly diagnose any problems.

Once this procedure is complete, all internal instances of user settings and passwords are erased. Do not do this when sending the relay to the factory for service. SEL needs to see how the relay was configured to properly diagnose any problems.

Glossary

A Abbreviation for amps or amperes; units of electrical current magnitude.

ACSELERATOR QuickSet SEL-5030 Software A Windows-based program that simplifies settings and provides analysis support.

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:

- 27 Undervoltage Element
- 37 Underpower Element
- 46 Phase Balance or Current Unbalance Element
- 47 Phase Sequence Element
- 49 Thermal Element
- 50 Instantaneous Overcurrent Element
- 51 Inverse Time-Overcurrent
- 52 AC Circuit Breaker
- 55 Power Factor Element
- 59 Overvoltage Element
- 66 Jogging Device (limits number of operations within a given time of each other)
- 81 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
- Q Negative-Sequence (3I2) Element
- N CBCT Ground Element

Antibackspin Protection Relay function that prevents the motor from being started for a short time after it is stopped. Used on pump motors to prevent a start attempt while fluid is running backward through the pump.

Antijogging Protection Relay functions that prevent the motor from being started too many times within an hour (also referred to as Starts Per Hour protection) or too soon following the last start (also referred to as Minimum Time Between Starts protection).

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.

Arc-Flash Hazard A dangerous condition associated with the release of energy caused by an electric arc.

Arc-Flash Protection (Relay)
An action performed by the relay to minimize the arc-flash hazard.

ASCII
Abbreviation for American Standard Code for Information Interchange. Defines a standard way to communicate text characters between two electronic devices. The SEL-849 Motor Management Relay uses ASCII text characters to communicate using the relay front- and rear-panel EIA-232 serial ports.

Assert
To activate; to fulfill the logic or electrical requirements needed to operate a device. To apply a short-circuit or closed contact to an SEL-849 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 mathematical sum of the relay code.

CID
Abbreviation for Checksum Identifier. The checksum of the specific firmware installed in the relay.

COMTRADE
Common format for Transient Data Exchange for power systems. COMTRADE is a file format for oscilloscope data standardized by IEEE (ANSI C37.111-1999).

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 Element
Protection element that 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 motor rated full-load amps or by the average magnitude, whichever is larger. Unbalance current causes heating in the rotor of the protected motor. The unbalance element can trip the motor in the presence of heavy unbalance to prevent rotor damage resulting from overheating. In the SEL-849, this element works together with the motor thermal element, which also provides unbalance current protection.

Deassert
To deactivate; to remove the logic or electrical requirements needed to operate a device. To remove a short-circuit or closed contact from an SEL-849 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."

Also used for motor winding configuration during Star-Delta starting.

Distributed Network Protocol (DNP) Manufacturer-developed, hardware-independent communications protocol.

Dropout Time The time measured from the removal of an input signal until the output signal deasserts. The time can be settable, as in the case of a logic variable timer, or can be a result of the characteristics of an element algorithm, as in the case of an overcurrent element dropout time.

EtherNet/IP An Ethernet-based protocol that provides ease of integration for industrial automation applications and provides access to metering data, protection elements, targets, and contact I/O.

Energy Meter Displays real, reactive, and apparent energy a motor is using.

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 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 communications 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-849 that includes the present values measured at the relay ac inputs. The word "Fundamental" is used to indicate that the values are Fundamental Frequency values and do not include harmonics.

hp Abbreviation for horsepower. 1 hp = 745.7 W.

HMI Human-Machine Interface.

IA, IB, IC A-, B-, and C-phase currents measured with a Rogowski sensor.

IEC International Electrotechnical Commission.

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 motor 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 (Core-Balance CT) for motor ground fault detection on resistance-grounded systems.

LCD Abbreviation for Liquid Crystal Display. Used as the HMI alphanumeric display.

LED Abbreviation for Light-Emitting Diode. Used as indicator lamps on the HMI and relay top panel.

Load-Jam Element A motor protection element that, when enabled, can trip the protected motor if the rotor stops turning due to a sudden increase in load torque or decrease in bus voltage. When the rotor stops, the motor phase current increases. The relay detects the stopped rotor using a settable overcurrent element and trips after a settable time-delay.

Load-Loss Element A motor protection element that, when enabled, can trip the protected motor if the motor shaft is suddenly decoupled from the mechanical load. The relay detects the sudden decrease in mechanical load through use of an undercurrent or underpower element.

Max/Min Meter Displays maximum and minimum operating quantities of the motor such as currents, voltages, power, and frequency.

Motor Thermal Element A motor protection element that measures motor current, calculates a representation of the energy dissipated in the motor, and compares the present energy estimate to trip thresholds defined by the relay settings. The output of the motor thermal element is represented as a % Thermal Capacity. When the % Thermal Capacity reaches 100, the relay trips to protect the motor. The Motor Thermal Element provides motor protection for the following conditions that cause motor overheating: locked rotor, overload operation, and current unbalance.

NEMA Abbreviation for National Electrical Manufacturers Association.

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 or stop output contact, the protected motor 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 Reversal Element A protection element that detects the phase rotation of the voltage or current signals applied to the protected motor, and trips if that phase rotation is the opposite of the desired phase rotation.

Phase Rotation The sequence of voltage or current phasors in a multi-phase electrical system. In an ABC phase rotation system, the B-phase voltage lags the A-phase voltage by 120 degrees, and the C-phase voltage lags B-phase voltage by 120 degrees. In an ACB phase rotation system, the C-phase voltage lags the A-phase voltage by 120 degrees, and the B-phase voltage lags the C-phase voltage by 120 degrees.

Pickup Time The time measured from the application of an input signal until the output signal asserts. The time can be settable, as in the case of a logic variable timer, or can be a result of the characteristics of an element algorithm, as in the case of an overcurrent element pickup time.

Pinout The definition or assignment of each electrical connection at an interface. Typically refers to a cable, connector, or jumper.

Power, P Real part of the complex power (S) expressed in units of Watts (W), kilovolt-watts (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).

PRP Parallel Redundancy Protocol provides seamless recovery from any single Ethernet network failure in a dual redundant Ethernet network, in accordance with IEC 62439-3.

PT Abbreviation for potential transformer. Also referred to as a voltage transformer or VT.

PTC Abbreviation for Positive Temperature Coefficient, a thermistor detector that makes use of the change of resistivity of semiconductor with change in temperature. The thermistor detectors are often embedded in the stator winding of the motor.

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.

Reactive Power Element A motor protection element that can trip the protected motor if the measured reactive power exceeds a settable threshold.

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.

RMS Abbreviation for root-mean-square. Refers to the effective value of the sinusoidal current and voltage measured by the relay, accounting for the fundamental frequency and higher order harmonics in the signal.

Rogowski Coil An air-core coil around a current carrying conductor that generates a voltage proportional to the rate of change of current. An integrator is used to derive current from the output of the Rogowski coil.

Rogowski Sensor Current measurement sensor that uses a Rogowski coil and an integrator.

ROM Abbreviation for Read-Only Memory. Nonvolatile memory where the relay firmware is stored.

Self-Test A function that verifies the correct operation of a critical device subsystem and indicates if an out-of-tolerance condition is detected. The SEL-849 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.

Speed Switch An electrical contact that closes to indicate that a motor speed exceeds a certain value.

Star Motor winding configuration during Star-Delta starting.

Terminal Emulation Software Personal computer (PC) software that can be used to send and receive ASCII text messages via the PC serial port.

Underfrequency Element A protection element that causes the relay to trip when the measured electrical system frequency is less than a settable frequency.

Underpower Element A protection element that causes the relay to trip when the measured electrical power consumed by a motor is less than a settable value.

VA, VB, VC Measured A-, B-, and C-phase-to-neutral voltages.

VAB, VBC, VCA Measured or calculated phase-to-phase voltages.

3V0 Residual voltage calculated from the sum of the three phase-to-neutral voltages, if connected.

VFD A Variable Frequency Drive (VFD) is used to control ac motor speed by adjusting the frequency.

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 relay driver version when creating or editing relay settings files.

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SEL-849 Command Summary

The table below lists the SEL-849 ASCII commands associated with particular activities. The commands are shown in uppercase letters, but they can also be entered using lowercase letters.

Serial Port Command	Command Description
Access Level 0 Commands	
ACC	Goes to Access Level 1.
EXI	Terminates a Telnet session.
ID	Relay identification code.
QUI	Goes to Access Level 0.
Access Level 1 Commands	
2AC	Goes to Access Level 2.
CEV ***n***	Shows compressed event report number *n*, at 1/4-cycle resolution. Attach R for compressed raw report, at 1/32-cycle resolution.
CMSR ***n***	Shows compressed motor start record data, where *n* is the record number.
COU ***n***	Shows 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***	Enters the date in DMY format.
DAT ***mm/dd/yyyy***	Enters the date in MDY format if DATE_F setting is MDY.
DAT ***yyyy/mm/dd***	Enters the date in YMD format if DATE_F setting is YMD.
ETH	Shows the Ethernet port status.
ETH C or **R**	Resets Ethernet statistics.
EVE ***n***	Shows event report *n* with 4 samples per cycle. If *n* is omitted, most recent report is displayed.
EVE ***n*****R**	Shows event report *n* with raw (unfiltered) 32 samples per cycle analog data and 4 samples per cycle digital data.
FIL DIR	Returns a list of files.
FIL READ ***filename***	Transfers settings file *filename* from the relay to the PC.
FIL SHOW ***filename***	Filename 1 displays contents of the file *filename*.
GOO ***k***	Displays transmit and receive GOOSE messaging information. Enter number *k* to scroll the GOOSE data *k* times on the screen.
HEL	Displays a short description of selected commands.
HIS ***n***	Shows summary of *n* latest event reports, where *n* = 1 is the most recent entry. If *n* is not specified, all event report summaries are displayed.
HIS C or **R**	Clears or resets history buffer.
LDP	Displays signal profile data.
LDP C	Clears signal profile data.
MAC	Displays the MAC address of the Ethernet port (**PORT 2**).
MET	Displays instantaneous fundamental metering data.
MET ***k***	Displays instantaneous fundamental metering data *k* times, where *k* is between 1 and 32767.

Serial Port Command	Command Description
MET D	Display demand and peak demand metering data.
MET D R	Resets demand and peak demand metering data.
MET E	Displays energy metering data.
MET E R	Resets energy metering data.
MET H	Displays current and voltage % THD (total harmonic distortion) metering data.
MET MM	Displays max/min metering data.
MET MM R	Resets max/min metering data.
MET RA	Displays remote analogs data.
MET RMS	Displays rms metering data.
MET MV	Displays SELOGIC math variable data.
MOT	Displays motor operating statistics report.
MOT R or **C**	Clears all motor statistics data except for the learned parameters.
MSR *n*	Displays motor start record data where *n* is the record number.
MST	Displays motor start trend data.
MST R or **C**	Resets motor start trend data.
PING *x.x.x.x t*	Determines if Ethernet port is functioning or configured properly. x.x.x.x is the IP address and *t* is the PING interval settable from 2 to 255 seconds. Default *t* is 1 second. Press Q to stop.
SER	Displays all Sequential Events Recorder (SER) data.
SER *d1*	Displays all **SER** records made on date *d1*.
SER *d1 d2*	Displays all **SER** records made from dates *d2* to *d1*, inclusive, starting with *d2*.
SER *n*	Displays the *n* most recent **SER** records starting with record *n*.
SER *n1 n2*	Displays **SER** records *n2* to *n1*, starting with *n2*.
SER C or **R**	Clears **SER** data.
SHO	Displays relay protection settings.
SHO DNP *m*	Displays the DNP data map settings for Map *m* (*m* = 1, 2, or 3).
SHO E *m*	Displays EtherNet/IP assembly map settings for Map *m* (*m* = 1, 2, or 3).
SHO H	Displays HMI settings.
SHO L	Displays general logic settings.
SHO M	Displays Modbus user map settings.
SHO P *n*	Displays port settings, where *n* specifies **PORT** (**1**, **2**, or **3**); *n* defaults to the active port if not listed.
SHO R	Displays report settings.
STA	Displays relay self-test status.
STA S	Displays SELOGIC usage status report.
SUM	Displays an event summary.
SUM R or **C**	Resets event summary buffer.
TAR	Displays default target row or the most recently viewed target row.
TAR *n*	Displays target row *n*.
TAR *n k*	Displays target row *n*. Repeat display of row *n* for repeat count *k*.
TAR *name*	Displays the target row with target name in the row.
TAR *name k*	Displays the target row with target name in the row. Repeat display of this row for repeat count *k*.

Serial Port Command	Command Description
TAR R	Resets any latched targets and the most recently viewed target row.
TIM	View time.
TIM *hh:mm:ss*	Sets time by entering **TIM** followed by hours, minutes, and seconds, as shown (24-hour clock).
TRI	Triggers an event report data capture.
Access Level 2 Commands	
ANA *p t*	Tests analog output channel where *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.
CAL	Enters Access Level C. The relay prompts for the entry of the Access Level C password. Access Level C is reserved for SEL use only.
CON RB*nn k*	Selects a remote bit to set, clear, or pulse where *nn* is a number from 01 to 08, representing RB01 through RB08. *k* is S, C, or P for Set, Clear, or Pulse.
CON O OUT*xx*	Tests OUT*xx* with one second pulse duration.
FIL WRITE *filename*	Transfers settings file *filename* from the PC to the relay.
L_D	Loads new firmware.
PAS 1	Changes Access Level 1 password to *xxxxxxxx*.
PAS 2	Changes Access Level 2 password to *xxxxxxxx*.
PUL OUT*xx t*	Pulse OUTxx for *t* (1 to 30, default is 1) seconds.
R_S	Restores the factory-default settings and passwords and reboots the system.
SET	Modifies relay protection settings.
SET *name*	For all **SET** commands, jumps ahead to a specific setting by entering the setting name, e.g., 50P1P.
SET DNP *m*	Modifies the DNP data map settings for Map *m* (*m* = 1, 2, or 3).
SET E *m*	Modifies the EtherNet/IP assembly map settings for Map *m* (*m* = 1, 2, or 3).
SET H	Modifies HMI settings.
SET L	Modifies SELOGIC variable and timer settings.
SET M	Modifies Modbus user map settings.
SET P *n*	Modifies port *n* settings (*n* = 1, 2, or 3; if not specified, the default is the active port).
SET R	Modifies report settings.
SET…TERSE	For all **SET** commands, **TERSE** disables the automatic **SHO** command after the settings entry.
STA R or **C**	Clears self-test status and restarts the relay.
STO	Stops motor.
STR	Starts motor.
TCUR	Resets the stator and rotor thermal capacity used to zero. Also resets THERMLO, TBSLO, NOSLO.
VEC D	Displays diagnostic vector report (useful to the factory in troubleshooting).
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