SEL-749M

Motor Protection Relay

Instruction Manual

20201111

SCHWEITZER ENGINEERING LABORATORIES

PM749M-01

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Preface

Manual Overview

The SEL-749M 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.

Introduction and Specifications. Describes the basic features and functions of the SEL-749M; lists the relay specifications.

Installation. Describes how to mount and wire the SEL-749M; illustrates wiring connections for various applications.

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

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.

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

Settings. Describes how to enter and record settings for basic motor protection, voltage-based protection, and RTD-based protection.

Communications. Describes how to connect the SEL-749M to a PC for communication; shows serial port pinouts; lists and defines serial port commands. Describes the optional communications card that provides DeviceNet protocol.

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

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

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

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

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

SEL Communications Processors. Provides examples of how to use the SEL-749M with the SEL-2032, SEL-2030, and SEL-2020 Communications Processors for total substation automation solutions.

Modbus RTU Communications Protocol. Describes the Modbus protocol support provided by the SEL-749M.

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

Motor Thermal Element. Contains a fundamental description of the SEL-749M thermal element. Describes interpretation of percent thermal capacity and thermal capacity used to start quantities.

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

SEL-749M Relay Command Summary. Briefly describes the serial port commands that are fully described in *Section 7: Communications*.

Safety Information

Dangers, Warnings, and Cautions

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

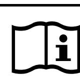
⚠DANGER
Indicates an imminently hazardous situation that, if not avoided, **will** result in death or serious injury.

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

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

Safety Symbols

The following symbols are often marked on SEL products.

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

Safety Marks

The following statements apply to this device.

General Safety Marks

⚠CAUTION There is danger of explosion if the battery is incorrectly replaced. Replace only with Rayovac no. BR2335 or equivalent recommended by manufacturer. See Owner's Manual for safety instructions. The battery used in this device may present a fire or chemical burn hazard if mistreated. Do not recharge, disassemble, heat above 100°C or incinerate. Dispose of used batteries according to the manufacturer's instructions. Keep battery out of reach of children.	⚠ATTENTION Une pile remplacée incorrectement pose des risques d'explosion. Remplacez seulement avec un Rayovac no BR2335 ou un produit équivalent recommandé par le fabricant. Voir le guide d'utilisateur pour les instructions de sécurité. La pile utilisée dans cet appareil peut présenter un risque d'incendie ou de brûlure chimique si vous en faites mauvais usage. Ne pas recharger, démonter, chauffer à plus de 100°C ou incinérer. Éliminez les vieilles piles suivant les instructions du fabricant. Gardez la pile hors de la portée des enfants.
⚠CAUTION To ensure proper safety and operation, the equipment ratings, installation instructions, and operating instructions must be checked before commissioning or maintenance of the equipment. The integrity of any protective conductor connection must be checked before carrying out any other actions. It is the responsibility of the user to ensure that the equipment is installed, operated, and used for its intended function in the manner specified in this manual. If misused, any safety protection provided by the equipment may be impaired.	⚠ATTENTION Pour assurer la sécurité et le bon fonctionnement, il faut vérifier les classements d'équipement ainsi que les instructions d'installation et d'opération avant la mise en service ou l'entretien de l'équipement. Il faut vérifier l'intégrité de toute connexion de conducteur de protection avant de réaliser d'autres actions. L'utilisateur est responsable d'assurer l'installation, l'opération et l'utilisation de l'équipement pour la fonction prévue et de la manière indiquée dans ce manuel. Une mauvaise utilisation pourrait diminuer toute protection de sécurité fournie par l'équipement.
Motor Overload: Class 10, 20, and 30.	Surcharge du Moteur: Classe 10, 20, et 30.
For use in Pollution Degree 3 environment.	Pour l'utilisation dans un environnement de Degré de Pollution 3.
Ambient air temperature shall not exceed 40°C (104°F).	La température de l'air ambiant ne doit pas dépasser 40°C (104°F).
For use on a flat surface of a Type 1 enclosure.	Destiné à l'utilisation sur une surface plane d'un boîtier de Type 1.
Terminal Ratings Wire Material Use 75°C (167°F) copper conductors only. Tightening Torque CT Terminal Blocks: 0.9–1.4 Nm (8–12 in-lb) Compression Plug: 0.5–1.0 Nm (4.4–8.8 in-lb) Compression Plug Mounting Ear Screw: 0.18–0.25 Nm (1.6–2.2 in-lb)	Spécifications des bornes Type de filage Utiliser seulement conducteurs en cuivre 75°C (167°F). Couple de serrage CT borniers : 0,9–1,4 Nm (8–12 livres-pouce) Fiche à compression : 0,5–1,0 Nm (4,4–8,8 livres-pouce) Vis à oreille de montage de la fiche à compression : 0,18–0,25 Nm (1,6–2,2 livres-pouce)

Hazardous Locations Safety Marks

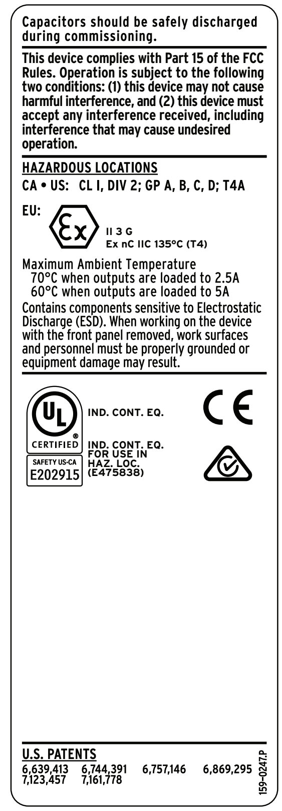
⚠WARNING – EXPLOSION HAZARD Open circuit before removing cover.	⚠AVERTISSEMENT – DANGER D'EXPLOSION Ouvrir le circuit avant de déposer le couvercle.
⚠WARNING – EXPLOSION HAZARD Substitution of components may impair suitability for Class I, Division 2.	⚠AVERTISSEMENT – DANGER D'EXPLOSION La substitution de composants peut détériorer la conformité à Classe I, Division 2.
Ambient air temperature shall not exceed 40°C (104°F).	La température de l'air ambiant ne doit pas dépasser 40°C (104°F).

Hazardous Locations Approvals

The SEL-749M is UL certified for hazardous locations to U.S. and Canadian standards. In North America, the relay is approved for Hazardous Locations Class I, Division 2, Groups A, B, C, and D, and temperature class T4A with the maximum surrounding air temperature of 40°C.

To comply with the requirements of the European ATEX standard for hazardous locations, the SEL-749M must be installed in an enclosure that meets the requirements of an Ex n enclosure rated IP54 or better. The enclosure should be certified to these requirements or be tested for compliance as part of the complete assembly.

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



Product Compliance Label for the SEL-749M

Other Safety Marks (Sheet 1 of 2)

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

Other Safety Marks (Sheet 2 of 2)

⚠WARNING During installation, maintenance, or testing of the optical ports, use only test equipment qualified for Class 1 laser products.	⚠AVERTISSEMENT Durant l'installation, la maintenance ou le test des ports optiques, utilisez exclusivement des équipements de test homologués comme produits de type laser de Classe 1.
⚠WARNING Before working on a CT circuit, first apply a short to the secondary winding of the CT.	⚠AVERTISSEMENT Avant de travailler sur un circuit TC, placez d'abord un court-circuit sur l'enroulement secondaire du TC.
⚠CAUTION Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.	⚠ATTENTION Les composants de cet équipement sont sensibles aux décharges électrostatiques (DES). Des dommages permanents non-décelables peuvent résulter de l'absence de précautions contre les DES. Raccordez-vous correctement à la terre, ainsi que la surface de travail et l'appareil avant d'en retirer un panneau. Si vous n'êtes pas équipés pour travailler avec ce type de composants, contacter SEL afin de retourner l'appareil pour un service en usine.
⚠CAUTION Use of controls or adjustments, or performance of procedures other than those specified herein, may result in hazardous radiation exposure.	⚠ATTENTION L'utilisation de commandes ou de réglages, ou l'application de tests de fonctionnement différents de ceux décrits ci-après peuvent entraîner l'exposition à des radiations dangereuses.
⚠CAUTION Class 1 Laser Product. Looking into optical connections, fiber ends, or bulkhead connections can result in hazardous radiation exposure.	⚠ATTENTION Produit Diode élecroluminescente de Classe 1. Regarder vers les connecteurs optiques, les extrémités des fibres ou les connecteurs de cloison peut entraîner une exposition à des rayonnements dangereux.

General Information

Typographic Conventions

There are two ways to communicate with the SEL-749M:

- ➤ Using a command line interface on a PC terminal emulation window
- ➤ Using the front-panel menus and pushbuttons

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

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

Trademarks

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

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

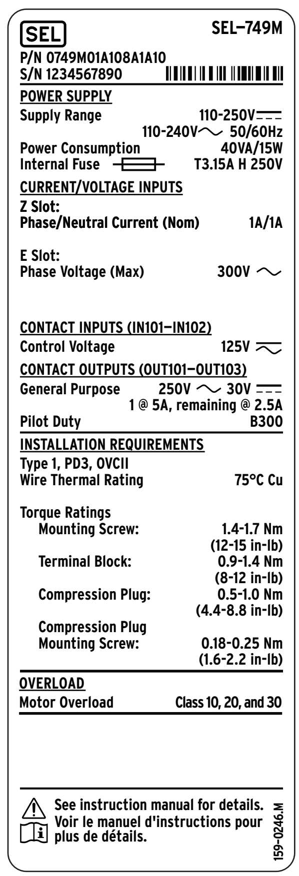
ACSELERATOR QuickSet®	SELOGIC®
ACSELERATOR Report Server®	SYNCHROWAVE®

Examples

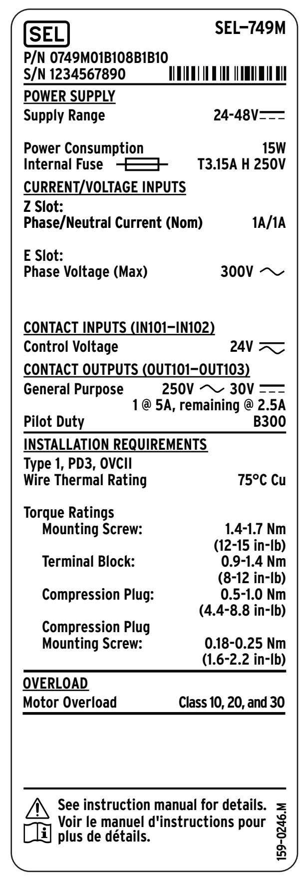
This instruction manual uses several example illustrations and instructions to explain how to effectively operate the SEL-749M. These examples are for demonstration purposes only; the firmware identification information or settings values included in these examples may not necessarily match those in the present version of your SEL-749M.

Product Labels

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



(High-Voltage Supply)



(Low-Voltage Supply)

Environmental Conditions and Voltage Information

The following table lists important environmental and voltage information.

Condition	Range/Description
Indoor/outdoor use	Indoor
Altitude[a]	As high as 2000 m
Temperature	
IEC Performance Rating (per IEC/EN 60068-2-1 and IEC/EN 60068-2-2)	–40 to +85°C
UL/CSA Safety Rating	–40° to +70°C
Relative humidity	5% to 95%
Main supply voltage fluctuations	As high as ±10% of nominal voltage
Overvoltage	Category II
Pollution	Degree 3
Atmospheric pressure	80 to 110 kPa

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

Wire Sizes and Insulation

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

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

Instructions for Cleaning and Decontamination

Use a mild soap or detergent solution and a damp cloth to carefully clean the SEL-749M 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-749M Motor Relay is designed to protect three-phase motors. The basic relay provides locked rotor, overload, unbalance, and short-circuit protection. Voltage-based and RTD-based protection are available as options. All relay models provide monitoring functions.

This manual contains the information necessary to install, set, test, operate, and maintain any SEL-749M. It is not necessary to 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 (50G)
- Ground Fault (50N)
- Motor Starting/Running
  - Protection Inhibit During Start
  - Start Motor Timer
  - Notching or Jogging Device (66)
  - TCU (Thermal Capacity Utilization) Start Inhibit
  - Anti-Backspin Timer
  - Emergency Start
  - Two-Speed Protection
  - Reduced Voltage Starting (19)
  - Stall–Speed Switch (14)
- Frequency (81)

Optional Protection Features

The SEL-749M has the following optional protection features:

- PTC Overtemperature (49) (positive temperature coefficient switching thermistor)
- Voltage-Based Protection
  - Undervoltage (27)
  - Overvoltage (59)
  - Underpower (37)
  - Reactive Overpower
  - Phase Reversal (47)
  - Power Factor (55)
- RTD-Based Protection

  As many as twelve (12) RTDs may be monitored when an external SEL-2600 series RTD module is used. There are separate Trip and Warn settings for each RTD.

Monitoring Features

The SEL-749M has the following monitoring features:

- Event Summaries that contain relay ID, date and time, trip cause, and current/voltage magnitudes. The last five trip causes are saved in nonvolatile memory.
- Event Reports including filtered and raw analog data.
- Sequential Events Record (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
  - Number of various Alarms and Trips
- Motor Start Reports, for as long as 60 seconds, for each of the last 5 starts.
- Motor Start Trend data for the past eighteen 30-day intervals.
- A complete suite of accurate metering functions.

Communications and Control

- EIA-232, front-panel port
- EIA-232, EIA-485, and fiber-optic (receive only) rear-panel ports
- IRIG-B connection
- Modbus RTU Slave and DeviceNet protocols
- SEL ASCII, Compressed ASCII, Fast Meter, Fast Operate, Fast SER, and Fast Message Protocols
- Programmable Boolean operators, logic functions, and timers

Models, Options, and Accessories

Models

Complete ordering information is not provided in this instruction manual. See the latest SEL-749M Model Option Table at selinc.com/products/configure/749M.

Base Model

The SEL-749M base model has the following features:

- Front panel with LCD display, eight target LEDs (six programmable), operator control interface, and EIA-232 serial port
- Processor and communications card (Slot B) with EIA-232 serial port, multimode (ST) fiber-optic serial port (receive only), and IRIG-B time code input or PTC (thermistor) input
- Power supply card with two digital inputs and three output contacts (Slot A)
- IA, IB, IC, and IN current inputs card
- ACSELERATOR QuickSet SEL-5030 Software
- User-configurable labels
- Protocols include Modbus RTU, SEL ASCII, SEL Compressed ASCII, SEL Fast Meter, SEL Fast Operate, SEL Fast SER, SEL Fast Message
- Three expansion card slots

Options

The SEL-749M has the following options:

- Voltage Option (Slot E): four-wire wye or open-delta connected VTs.
- Input/Output (I/O) Option (Slot D): one 4–20 mA analog (transducer) output, three additional control inputs, and four additional contact outputs.
- Input/Output (I/O) Option (Slot C): eight additional digital inputs.
- Communications Options (Protocol/Ports; Slot C):
  - Modbus RTU protocol and EIA-485/EIA-232 ports
  - DeviceNet (**Note:** This option has been discontinued and is no longer available as of September 25, 2017.)
- Choice of IRIG-B time-code input or PTC (thermistor) input on Terminals B01–B02. (IRIG-B input at Port 3 is unavailable with PTC option.)
- Choice of high voltage supply (110–240 Vac, 110–250 Vdc) or low voltage supply (24–48 Vdc).

Accessories

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

- The following devices are required to add RTD protection:
  - An external SEL-2600 series RTD module
  - A simplex 62.5/125 µm fiber-optic cable with ST connector for connecting the external RTD module to the SEL-749M
- An SEL-2505 Remote I/O Module with EIA-232 (DB9) serial port for connecting to EIA-232 Port 3 on the relay
- SEL-749M Configurable Labels (Part #9260012)
- Rack-Mounting Kits:
  - For one relay (Part #915900007)
  - For two relays (Part #915900008)
  - For one relay and a test switch (Part #915900009)
- Replacement Rear Connector Kits:
  - Without retaining screws (Part #915900010)
  - With retaining screws (Part #915900014)
- Rear Terminal Dust Protection Assembly rated to IP50 (Part #915900170)
- Relay Wire Termination Kits—See *Application Note AN2014-08: Wiring SEL-2400, SEL-2200, and SEL-700 Series Devices*
- For information on additional SEL-749M mounting accessories, including adapter plates, go to selinc.com/applications/mountingselector/

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 zero-sequence core balance current transformer
- With or without external RTD module
- Across the line starting
- Star-delta starting
- Two-speed motors

Getting Started

Understanding basic relay operation principles and methods will help you use the SEL-749M effectively. This section presents the fundamental knowledge you need to operate the SEL-749M, 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-749M with 110–240 Vac, 110–250 Vdc or 24–48 Vdc.

- ➤ Observe proper polarity, as indicated by the **+/H** (Terminal **A01**) and the **–/N** (Terminal **A02**) on the power connections.
- ➤ Connect the ground lead; see *Grounding (Earthing)* in *Section 2: Installation*.
- ➤ Once connected to power, the relay does an internal self-check and the **ENABLED** LED illuminates.

Establishing Communication

The SEL-749M has two EIA-232 serial communications ports. The following steps require PC terminal emulation software and an SEL-C234A Cable (or equivalent) to connect the SEL-749M to the PC. See *Section 6: Settings* for further information on serial communications connections and the required cable pinout.

Step 1. Use the serial communications cable to connect the PC and the SEL-749M.

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

Step 3. Start the PC terminal emulation program.

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

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

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

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

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

You will see a computer screen display as shown in *Figure 1.1*.

If you see jumbled characters, change the terminal emulation type in the PC terminal emulation program.

Table 1.1 SEL-749M 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	15
HDWR HANDSHAKING	RTSCTS	N

```
=>QUIT <Enter>
Motor 1                           Date: 12/10/2003    Time: 10:31:43.797
Station 1
```

Figure 1.1 Response Header

Checking Relay Status

Use the **STA** serial port command to view the SEL-749M operational status. Analog channel dc offset and monitored component status are listed in the status report depicted in *Figure 1.2*.

```
=>STA <Enter>

SEL-749M                          Date: 12/24/2009    Time: 13:20:35.316
MOTOR RELAY                       Time Source: internal

FID=SEL-749M-X504-V0-Z003003-D20091223       CID=C29E

Part Number 0749M01B600X0X1X

SELF TESTS

W=Warn    F=Fail

Current  IA       IB       IC       IN
Offset:  OK       OK       OK       OK

Voltage  VA       VB       VC
Offset:  OK       OK       OK

+0.9V    +1.2V    +1.5V    +1.8V    +2.5V    +3.3V
 0.90     1.20     1.50     1.81     2.51     3.33

+3.75V   +5V      -1.25V   -5V      BATT
 3.75     4.98    -1.24    -4.87     3.06

FPGA     GPSB     HMI
OK       OK       OK

RAM      ROM      CR_RAM   NON_VOL  CLOCK
OK       OK       OK       OK       OK

PTC      RTD      Current  Voltage  I/O_Crd
OK       OK       OK       OK       OK

Relay Enabled
=>
```

Figure 1.2 STA Command Response—No Communications Card or Communications Card/Modbus RTU Protocol

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

```
=>STA <Enter>

SEL-749M                          Date: 12/24/2009    Time: 13:21:00.665
MOTOR RELAY                       Time Source: internal

FID=SEL-749M-X504-V0-Z003003-D20091223       CID=C29E

Part Number 0749M01B603X0X1X

SELF TESTS

W=Warn    F=Fail
Current  IA       IB       IC       IN
Offset:  OK       OK       OK       OK
Voltage  VA       VB       VC
Offset:  OK       OK       OK

+0.9V    +1.2V    +1.5V    +1.8V    +2.5V    +3.3V
 0.90     1.20     1.50     1.81     2.51     3.33
+3.75V   +5V      -1.25V   -5V      BATT
 3.75     4.98    -1.25    -4.88     3.06

FPGA     GPSB     HMI
OK       OK       OK

RAM      ROM      CR_RAM   NON_VOL  CLOCK
OK       OK       OK       OK       OK

PTC      RTD      Current  Voltage  I/O_Crd  COM_Crd
OK       OK       OK       OK       OK       OK

MAC_ID   ASA               DN_Rate  DN_Status
3        1a0d c1e9h        AUTO     0000 0000

Relay Enabled
=>
```

Figure 1.3 STA Command Response—Communications Card/DeviceNet Protocol

If a communications card with Modbus RTU protocol is present, then the status report depicted in *Figure 1.2* applies.

Table 7.47 provides the definition of each status report designator and *Table 10.8* shows all the self-tests performed by the relay. The beginning of the status report printout (see *Figure 1.2*) contains the relay firmware identification (FID) string 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-749M. If the date stored in the relay is July 29, 2003 and the DATE_F setting is MDY, the relay will reply:

```
7/29/2003
```

If the DATE_F setting is YMD, the relay will reply: `2003/7/29`

If the DATE_F setting is DMY, the relay will reply: `29/7/2003`

Changing the Date

Type **DAT** followed by the correct date at the prompt to change the date stored in the relay. For example, to change the date to May 2, 2003 (DATE_F = MDY), enter the following at the action prompt:

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

You can separate the month, day, and year parameters with spaces, commas, slashes, colons, and semicolons.

TIM (Time Command)

Viewing the Time

Enter **TIM** at the prompt to view the time stored in the SEL-749M. 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 Listed to U.S. and Canadian safety standards (File E202915, NRGU, NRGU7)

UL Certified for Hazardous Locations to U.S. and Canadian standards (File E475838)

Hazardous Locations
EU ATEX: II 3 G
Ex ec nC IIC T3 Gc
DEMKO 18 ATEX 2081X

CE Mark

RCM Mark

General

AC Current Input

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

Measurement Category: II

Phase Currents

I_{NOM} = 5 A

Continuous Rating:	3 • I_{NOM} @ 85°C 4 • I_{NOM} @ 55°C
A/D Measurement Limit:	156 A peak (110 A rms symmetrical)
1-Second Thermal:	500 A
Burden (per phase):	<0.1 VA @ 5 A

I_{NOM} = 1 A

Continuous Rating:	3 • I_{NOM} @ 85°C 4 • I_{NOM} @ 55°C
A/D Measurement Limit:	31.2 A peak (22 A rms symmetrical)
1-Second Thermal:	100 A
Burden (per phase):	<0.01 VA @ 1 A

Neutral Currents

I_{NOM} = 5 A

Continuous Rating:	3 • I_{NOM} @ 85°C 4 • I_{NOM} @ 55°C
A/D Measurement Limit:	16.7 A peak (11.8 A rms symmetrical)
1-Second Thermal:	500 A
Burden (per phase):	<0.1 VA @ 5 A

I_{NOM} = 1 A

Continuous Rating:	3 • I_{NOM} @ 85°C 4 • I_{NOM} @ 55°C
A/D Measurement Limit:	3.3 A peak (2.4 A rms symmetrical)
1-Second Thermal:	100 A
Burden (per phase):	<0.01 VA @ 1 A

AC Voltage Inputs

[VNOM (L-L)/PT Ratio] Range:	100–250 V (if DELTA_Y = DELTA) 100–440 V (if DELTA_Y = WYE)
Rated Continuous: Voltage:	300 Vac
10-Second Thermal:	600 Vac

	Burden	Input Impedance (Per Phase)	Input Impedance (Phase-to-Phase)
Vphase	0.01 VA @ 120 Vac	5 MΩ	10 MΩ

Power Supply

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

High-Voltage Supply

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

Low-Voltage Supply

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

Fuse Ratings

Low-Voltage Power Supply Fuse

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

High-Voltage Power Supply Fuse

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

Output Contacts

General

OUT103 is a Form C trip output, all other outputs are Form A.

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

Standard Contacts

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

DC Output Ratings

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

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

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

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

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

AC Output Ratings

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

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

Utilization Category:	AC-15

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

Voltage Protection Across Open Contacts:	270 Vac, 40 J

Optoisolated Control Inputs

Pickup/Dropout Time:	3/4 cycle maximum

When Used With dc Control Signals

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

When Used With ac Control Signals

250 V:	ON for 170.6–312.5 Vac OFF below 160 Vac
220 V:	ON for 150.3–275 Vac OFF below 93.2 Vac
125 V:	ON for 85–156.2 Vac OFF below 53 Vac
110 V:	ON for 75.1–137.5 Vac OFF below 46.6 Vac
48 V:	ON for 32.8–60 Vac OFF below 20.3 Vac
24 V:	ON for 14–30 Vac OFF below 5 Vac
Current Draw at Nominal dc Voltage:	2 mA (at 220–250 V) 4 mA (at 48–125 V) 10 mA (at 24 V)
Rated Insulation Voltage:	300 Vac
Rated Impulse Withstand Voltage (U_{imp}):	4000 V

Analog Output (Optional)

Single Analog Current Output:	4–20 mA
Max Load:	300 Ω
Error:	<±1%, full scale, at 25°C
Select From:	FLA; % Thermal Capacity; Hottest Winding RTD; Hottest Bearing RTD; Avg. Phase Current; Max. Phase Current; Power; Power Factor

Frequency and Phase Rotation

System Frequency:	50, 60 Hz
Phase Rotation:	ABC, ACB
Frequency Tracking:	44–66 Hz

Time-Code Input

Format:	Demodulated IRIG-B
On (1) State:	$V_{ih} \geq 2.2$ V
Off (0) State:	$V_{il} \leq 0.8$ V

Input Impedance:	2 kΩ
Synchronization Accuracy Internal Clock:	±1 µs
All reports:	±5 ms
Unsynchronized Clock Drift:	2 minutes per year typical

Communications Ports

Standard EIA-232 (2 Ports)

Location:	Front panel Rear panel
Data Speed:	300–38400 bps
Protocols:	SEL ASCII, Modbus RTU

Optional Communications Card

Option 1:	Modbus RTU Protocol or ASCII Protocol over EIA-232 or EIA-485
Option 2:	DeviceNet Protocol

Operating Temperature

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

Note: Not applicable to UL applications.

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

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

Operating Environment

Typical conditions under which the relay is designed to operate:	Indoor Use
Insulation Class:	1
Pollution Degree:	3
Overvoltage Category:	II
Atmospheric Pressure:	80–110 kPa
Relative Humidity:	5%–95%, noncondensing
Maximum Altitude Without Derating (Consult the Factory for Higher Altitude Derating):	2000 m

Dimensions

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

Weight

2.0 kg (4.4 lb)

Relay Mounting Screws (#8-32) Tightening Torque

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

Terminal Connections

Terminal Block

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

Terminal Block Tightening Torque

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

Compression Plug Tightening Torque

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

Compression Plug Mounting Ear Screw

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

Product Standards

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

Type Tests

Environmental Tests

Enclosure Protection:	IEC 60529:2001 + CRDG:2003 IP65 enclosed in panel IP20 for terminals and the relay rear panel IP50 for terminals with optional dust protection assembly (Part #915900170). 10°C temperature derating applies.
Vibration Resistance:	IEC 60255-21-1:1998 IEC 60255-27:2013, Section 10.6.2.1 Endurance: Class 2 Response: Class 2
Shock Resistance:	IEC 60255-21-2:1998 IEC 60255-27:2013, Section 10.6.2.2 IEC 60255-27:2019, Section 10.6.2.3 Withstand: Class 1 Response: Class 2 Bump: Class 1
Seismic (Quake Response):	IEC 60255-21-3:1993 IEC 60255-27:2013, Section 10.6.2.4 Response: Class 2
Cold:	IEC 60068-2-1:2007 IEC 60255-27:2013, Section 10.6.1.2 IEC 60255-27:2013, Section 10.6.1.4 –40°C, 16 hours
Dry Heat:	IEC 60068-2-2:2007 IEC 60255-27:2013, Section 10.6.1.1 IEC 60255-27:2013, Section 10.6.1.3 +85°C, 16 hours
Damp Heat, Steady State:	IEC 60068-2-78:2001 IEC 60255-27:2013, Section 10.6.1.5 40°C, 93% relative humidity, 10 days

Damp Heat, Cyclic: IEC 60068-2-30:2001
IEC 60255-27:2013, Section 10.6.1.6
25–55°C, 6 cycles,
95% relative humidity

Change of Temperature: IEC 60068-2-14:2009
IEC 60255-1:2010, Section 6.12.3.5
–40° to +85°C, ramp rate 1°C/min,
5 cycles

Dielectric Strength and Impulse Tests

Dielectric (HIPOT): IEC 60255-27:2013; Section 10.6.4.3
IEEE C37.90-2005
2.5 kVac on current inputs, contact I/O
2.0 kVac on ac voltage inputs
1.0 kVac on PTC input and analog output
3.6 kVdc on power supply

Impulse: IEC 60255-27:2013, Section 10.6.4.2
IEEE C37.90:2005
0.5 J, 5.0 kV on power supply, contact I/O, ac current and voltage inputs
0.5 J, 530 V on PTC and analog output

RFI and Interference Tests

EMC Immunity

Electrostatic Discharge Immunity: IEC 61000-4-2:2008
IEC 60255-26:2013; Section 7.2.3
IEEE C37.90.3:2001
Severity Level 4
8 kV contact discharge
15 kV air discharge

Radiated RF Immunity: IEC 61000-4-3:2010
IEC 60255-26:2013; Section 7.2.4
10 V/m
IEEE C37.90.2-2004
20 V/m

Fast Transient, Burst Immunity[a]: IEC 61000-4-4:2011
IEC 60255-26:2013; Section 7.2.5
4 kV @ 5.0 kHz
2 kV @ 5.0 kHz for comm. ports

Surge Immunity[a]: IEC 61000-4-5:2005
IEC 60255-26:2013; Section 7.2.7
2 kV line-to-line
4 kV line-to-earth

Surge Withstand Capability Immunity[a]: IEC 60255-26:2013; Section 7.2.6
EN 61000-4-18:2010
2.5 kV common-mode
1 kV differential-mode
1 kV common-mode on comm. ports
IEEE C37.90.1–2002
2.5 kV oscillatory
4 kV fast transient

Conducted RF Immunity: IEC 61000-4-6:2008
IEC 60255-26:2013; Section 7.2.8
10 Vrms

Magnetic Field Immunity: IEC 61000-4-8:2009
IEC 60255-26:2013, Section 7.2.10
Severity Level: 1000 A/m for 3 seconds, 100 A/m for 1 minute; 50/60 Hz
IEC 61000-4-9:2001
Severity Level: 1000 A/m
IEC 61000-4-10:2001
Severity Level: 100 A/m
(100 kHz and 1 MHz)

Power Supply Immunity: IEC 61000-4-11:2004
IEC 61000-4-17:1999
IEC 61000-4-29:2000
IEC 60255-26:2013, Section 7.2.11
IEC 60255-26:2013, Section 7.2.12
IEC 60255-26:2013, Section 7.2.13

EMC Emissions

Conducted Emissions: IEC 60255-26:2013 Class A
FCC 47 CFR Part 15.107 Class A
ICES-003 Issue 6
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
ICES-003 Issue 6
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

Showering Arc NEMA ICSI-2000 Severity Level: 1.5 kV

Processing Specifications

AC Voltage and Current Inputs: 16 samples per power system cycle

Digital Filtering: One-cycle cosine after low-pass analog filtering. Net filtering (analog plus digital) rejects dc and all harmonics greater than the fundamental.

Protection and Control Processing: Processing interval is 4 times per power system cycle

Relay Elements

Thermal Overload (49)

Full-Load Current (FLA) Limits: 0.2–5000.0 A primary

Locked Rotor Current: (2.5–12.0) • FLA

Hot Locked Rotor Time: 1.0–600.0 seconds

Service Factor: 1.01–1.50

Accuracy: 5% ±25 ms at multiples of FLA > 2 (cold curve method)

Note: FLA is a setting (see the *Main Settings (SET Command)* of the *SEL-749M Settings Sheets* at the end of *Section 6* for setting ranges).

PTC Overtemperature (49)

Type of Control Unit: Mark A

Max. Number of Thermistors: 6 in a series connection

Max. Cold Resistance of PTC Sensor Chain: 1500 Ω

Trip Resistance: 3400 Ω ±150 Ω

Reset Resistance:	1500–1650 Ω
Short-Circuit Trip Resistance:	25 Ω ±10 Ω

Undercurrent (Load Loss) (37)

Setting Range:	Off, (0.10–1.00) • FLA
Accuracy:	±5% of setting ±0.02 • I_{NOM} A secondary
Maximum Pickup/Dropout Time:	1.5 cycles
Time Delay:	0.4–120.0 s, 1 s increment
Accuracy:	±0.5% of setting ±1/4 cycle

Current Unbalance and Phase Loss (46)

Setting Range:	Off, 5–80%
Accuracy:	±10% of setting ±0.02 • I_{NOM} A secondary
Maximum Pickup/Dropout Time:	1.5 cycles
Time Delay:	0.0–240.0 s, 1 s increment
Accuracy:	±0.5% of setting ±1/4 cycle

Overcurrent (Load Jam)

Setting Range:	Off, (1.00–6.00) • FLA
Accuracy:	±5% of setting ±0.02 • I_{NOM} A secondary
Maximum Pickup/Dropout Time:	1.5 cycles
Time Delay:	0.0–120.0 s, 1 s increment
Accuracy:	±0.5% of setting ±1/4 cycle

Short Circuit (50P)

Setting Range:	Off, (0.10–20.00) • FLA
Accuracy:	±5% of setting ±0.02 • I_{NOM} A secondary
Maximum Pickup/Dropout Time:	1.5 cycles
Time Delay:	0.0–5.0 s, 0.01 s increment
Accuracy:	±0.5% of setting ±1/4 cycle

Ground Fault (50G)

Setting Range:	Off, (0.10–1.00) • FLA
Accuracy:	±5% of setting ±0.02 • I_{NOM} A secondary
Maximum Pickup/Dropout Time:	1.5 cycles
Time Delay:	0.0–5.0 s, 1 s increment
Accuracy:	±0.5% of setting ±1/4 cycle

Ground Fault (50N)

Setting Range:	Off, 0.01–25.00 A primary
Accuracy:	±5% of setting ± 0.01 A secondary
Maximum Pickup/Dropout Time:	1.5 cycles
Time Delay:	0.0–5.0 s, 0.01 s increment
Accuracy:	±0.5% of setting ±1/4 cycle

Undervoltage (27)

Setting Range:	Off, (0.60–1.00) • VNOM
Accuracy:	±5% of setting ±2 V
Maximum Pickup/Dropout Time:	1.5 cycles
Time Delay:	0.0–120.0 s, 0.1 s increment
Accuracy:	±0.5% of setting ±1/4 cycle

Note: VNOM is a setting (see the *Main Settings (SET Command)* of the *SEL-749M Settings Sheets* at the end of *Section 6* for setting ranges).

Overvoltage (59)

Setting Range:	Off, (1.00–1.20) • VNOM
Accuracy:	±5% of setting ±2 V
Maximum Pickup/Dropout Time:	1.5 cycles
Time Delay:	0.0–120.0 s, 1 s increment
Accuracy:	±0.5% of setting ±1/4 cycle

Underpower (37)

Setting Range:	Off, 1–25000 kW primary
Accuracy:	±3% of setting ±5 W secondary
Maximum Pickup/Dropout Time:	10 cycles
Time Delay:	0.0–240.0 s, 1 s increment
Accuracy:	±0.5% of setting ±1/4 cycle

Reactive Power (VAR)

Setting Range:	Off, (1–25000) kVAR primary
Accuracy:	±5% of setting ±5 VAR secondary for PF between –0.9 to +0.9
Maximum Pickup/Dropout Time:	10 cycles
Time Delay:	0.0–240.0 s, 1 s increment
Accuracy:	±0.5% of setting ±1/4 cycle

Power Factor (55)

Setting Range:	Off, 0.05–0.99
Accuracy:	±5% of full scale for current ≥ 0.5 • FLA
Maximum Pickup/Dropout Time:	10 cycles
Time Delay:	0.0–240.0 s, 1 s increment
Accuracy:	±0.5% of setting ±1/4 cycle

Frequency (81)

Setting Range:	Off, 55.0–65.0 Hz for FNOM = 60 Off, 45.0–55.0 Hz for FNOM = 50
Accuracy:	±0.1 Hz
Maximum Pickup/Dropout Time:	5 cycles
Time Delay:	0.0–240.0 s, 1 s increment
Accuracy:	±0.5% of setting ±1/4 cycle

Note: FNOM is a setting (see the *Global Settings (SET G Command)* of the *SEL-749M Settings Sheets* at the end of *Section 6* for setting ranges).

RTD Protection (Optional Using an SEL-2600 Series Module)

As many as 12 RTD inputs (SEL-2600 series RTD module as far as 1000 m away, using fiber-optic cable)

Setting Range:	Off, 1–250°C
Accuracy:	±2°C
RTD Open-Circuit Detection:	>250°C
RTD Short-Circuit Detection:	<–50°C
RTD Types:	PT100, NI100, NI120, CU10
RTD Lead Resistance:	25 ohm max. per lead
Lead Length:	<10 m to meet IEC 60255-22-1 and IEC 60255-22-5, otherwise <25 ohm limit
Update Rate:	<3 s
Noise Immunity on RTD Inputs:	As much as 1.4 Vac (peak) at 50 Hz or greater frequency
RTD Trip/Alarm Time Delay:	Approx. 6 s

Metering

Accuracies are specified at 20°C, nominal frequency, ac phase currents within (0.2–20.0) • I_{NOM} A secondary, ac neutral currents within (0.2–2.0) • I_{NOM} A secondary, and ac voltages within 50–250 V secondary unless otherwise noted.

Motor Phase Currents:	±2% of reading, ±1.5% of I_{NOM}, ±2°
3-Phase Average Motor Current:	±2% of reading, ±2% of I_{NOM}
3-Phase Average Motor Load (%FLA):	±2% of reading, ±2% of I_{NOM}
Current Unbalance (%):	±2% of reading, ±2% of I_{NOM}
IG (Residual Current):	±3% of reading, ±2% of I_{NOM}, ±2°
IN (Neutral Current):	±2% of reading, ±1°
3I2 Negative-Sequence Current:	±3% of reading, ±2% of I_{NOM}
System Frequency:	±0.1 Hz of reading for frequencies within 44–66 Hz
Thermal Capacity:	±1% TCU Time to trip ±1 second
Line-to-Line Voltages:	±2% of reading, ±1° for voltages within 24–264 V
3-Phase Average Line-to-Line Voltage:	±2% of reading for voltages within 24–264 V
Line-to-Ground Voltages:	±2% of reading, ±1° for voltages within 24–264 V
3-Phase Average Line-to-Ground Voltages:	±2% of reading for voltages within 24–264 V
Voltage Unbalance (%):	±2% of reading for voltages within 24–264 V
3V2 Negative-Sequence Voltage:	±2% of reading for voltages within 24–264 V
Real 3-Phase Power (kW):	±5% of reading for 0.10 < pf < 1.00
Reactive 3-Phase Power (kVAR):	±5% of reading for 0.00 < pf < 0.90
Apparent 3-Phase Power (kVA):	±2% of reading
Power Factor:	±2% of reading
RTD Temperatures	±2°C

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

Section 2
Installation

Overview

⚠CAUTION
Class 1 Laser Product. Looking into optical connections, fiber ends, or bulkhead connections can result in hazardous radiation exposure.

The first steps in applying the SEL-749M 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-749M. Use these drawings as a starting point for planning your particular relay application.

There are also instructions for using the versatile front-panel custom label option. This allows you to use SELOGIC control equations and slide-in configurable front-panel labels to change the function and identification of target LEDs.

Relay Placement

Proper placement of the SEL-749M helps make certain that you receive years of trouble-free motor protection. Use the following guidelines for proper physical installation of the SEL-749M.

Physical Location

The SEL-749M is EN 61010-1 certified at Installation/Overvoltage Category II and Pollution Degree 3. This allows mounting of the relay in a sheltered indoor environment that does not exceed the temperature and humidity ratings for the relay. The SEL-749M 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 1.11*.) For EN 61010-1 certification, the SEL-749M rating is 2000 m (6562 ft) above mean sea level.

To comply with the requirements of the European ATEX standard for hazardous locations, the SEL-749M shall be installed in an ATEX-certified enclosure with a tool-removable door or cover that provides a degree of protection not less than IP54, in accordance with EN 60079-0. The enclosure shall be limited to the surrounding air temperature range of

–20°C ≤ Ta ≤ +50°C. The enclosure should be certified to these requirements or be tested for compliance as part of the complete assembly. The enclosure must be marked “WARNING—Do not open when an explosive atmosphere is present.” In North America, the relay is approved for Hazardous Locations Class I, Division 2, Groups A, B, C, and D, and temperature class T4A in the maximum surrounding air temperature of 40°C.

Relay Mounting

To flush mount the SEL-749M in a panel, cut a rectangular hole with the dimensions shown in *Figure 2.1*. Use the supplied front-panel gasket for protection against dust and water ingress into the panel (IP65). For extremely dusty environments use optional IP50 rated terminal dust protection assembly (SEL Part #915900170). 10°C temperature derating applies to the temperature specifications of the relay.

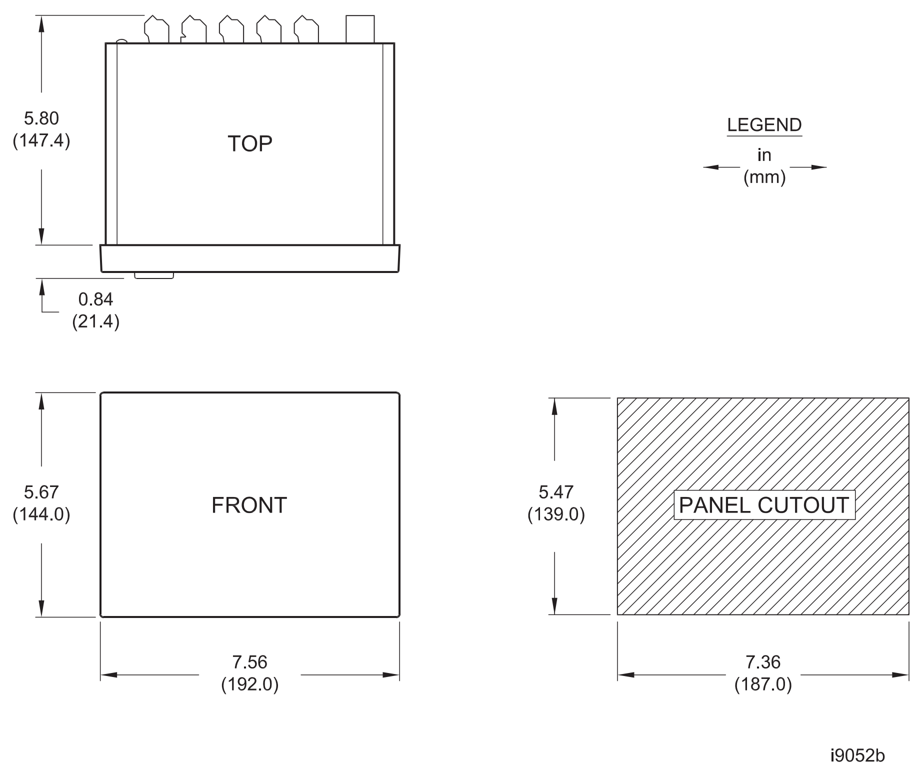


Figure 2.1 Relay Panel-Mount Dimensions

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

I/O Configuration

Your SEL-749M offers flexibility in tailoring I/O to your specific application. In total, the SEL-749M has six rear-panel slots, labeled as Slots **A**, **B**, **C**, **D**, **E**, and **Z**. Slots **A**, **B**, and **Z** are base unit slots, each associated with a specific function. Optional digital/analog I/O, communications, and voltage cards are available for the SEL-749M. *Table 2.1* shows the slot allocations for the cards.

Table 2.1 Slot Allocations for Different Cards

Rear-Panel Slot	Software Reference	Description
A	1 (e.g., OUT101)	Power supply and I/O (two inputs, and three outputs) card in the base unit
B	N/A	CPU/Communications card (IRIG-B/PTC, EIA-232, fiber-optic receive ports) in the base unit
C	3 (e.g., IN301)	Communications card or digital inputs (8 DI) card
D	4 (e.g., OUT401)	Input/output (digital or analog) card (3 DI/4 DO/1 AO)
E	N/A	Voltage card
Z	N/A	CT card in base unit

Choose the combination of cards most suited for your application from the following selection.

Power Supply and I/O (2 inputs, 3 outputs) Card. Supported in Slot **A**. See the model option table at selinc.com/products/configure/749M/ for the power supply and input voltage options.

Processor/Communications Card. Supported in Slot **B**. Select IRIG-B input or PTC input option.

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

Table 2.2 Communications Ports

Port	Location	Feature	Description
F	Front Panel	Standard	Nonisolated EIA-232 serial port
2	Rear Panel	Standard	Isolated multimode fiber-optic port with ST connector (receive only)
3	Rear Panel	Standard	Nonisolated EIA-232 serial port

Port F supports the following protocols:

- SELBOOT
- SEL ASCII and Compressed ASCII
- SEL Fast Meter
- SEL Settings File Transfer
- Modbus RTU Slave

Port 2 (RX only)

- Supports SEL-2600 series RTD modules

Port 3 supports the following protocols:

- Modbus RTU Slave
- SEL ASCII and Compressed ASCII
- SEL Fast Meter
- SEL Fast Operate
- SEL Fast SER
- SEL Fast Message Unsolicited Write
- SEL Settings File Transfer

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

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

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

Table 2.3 Communications Card Interfaces and Connectors

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

The communications card supports the following protocols:

- Modbus RTU Slave
- SEL ASCII and Compressed ASCII
- SEL Fast Meter
- SEL Fast Operate
- SEL Fast SER
- SEL Fast Message Unsolicited Write
- SEL Settings File Transfer

Voltage Card. Supported in Slot **E** only, order this card when you have three-phase (wye or delta) PTs. With a voltage card installed, the SEL-749M tracks the frequency (using positive-sequence voltage) and samples at 16 times a cycle, see *Processing Specifications on page 1.12* for more information.

Table 2.4 Voltage Card Terminal Designations

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

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

Current Card. Supported in Slot **Z** only, this card provides current inputs for three-phase CTs and one neutral CT. Secondary phase current ratings are either all 1 A or all 5 A; you cannot order a combination of 1 A and 5 A phase CTs on one card. However, the phase CTs and the neutral CT can be of different current rating. You can order one of two neutral CT ratings, 1 A or 5 A. With a current card installed, the SEL-749M tracks the frequency (using positive-sequence current if voltage is absent) and samples at 16 times a cycle—see *Processing Specifications on page 1.12* for more information.

Table 2.5 Current Card Terminal Designations

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

I/O Card (3 DI/4 DO/1 AO). Supported in Slot **D**, this card has three digital inputs, four digital outputs, and one analog output. *Table 2.6* shows the terminal allocation.

Table 2.6 I/O (3 DI/4 DO/1 AO) Card Terminal Designations

Terminal Number	Software Reference, Description
01, 02	OUT401, driven by OUT401 SELOGIC control equation
03, 04	OUT402, driven by OUT402 SELOGIC control equation
05, 06	OUT403, driven by OUT403 SELOGIC control equation
07, 08	OUT404, driven by OUT404 SELOGIC control equation
09, 10	AO401, Analog Output
11, 14	IN401, drives IN401 element
12, 14	IN402, drives IN402 element
13, 14	IN403, drives IN403 element

I/O Card (8 DI). Supported in Slot **C** only, this card has eight digital inputs. *Table 2.7* shows the terminal allocation.

NOTE: All digital input and digital output connections are polarity neutral.

Table 2.7 I/O (8 DI) Card Terminal Designations

Terminal Number	Description
01, 02	IN301, drives IN301 element
03, 04	IN302, drives IN302 element
05, 06	IN303, drives IN303 element
07, 08	IN304, drives IN304 element
09, 10	IN305, drives IN305 element
11, 12	IN306, drives IN306 element
13, 14	IN307, drives IN307 element
15, 16	IN308, drives IN308 element

Card Configuration Procedure

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

The SEL-749M offers flexibility in tailoring I/O for your specific application. The SEL-749M has six rear-panel slots, labeled as Slots **A**, **B**, **C**, **D**, **E**, and **Z**. Slots **A**, **B**, and **Z** are base unit slots, each associated with a specific function. Optional digital/analog I/O cards are available for the SEL-749M in Slots **C** and **D**. Optional communications cards and an 8 DI card are available only for

Slot **C**, a 3 DI/4 DO/1 AO card is available only for Slot **D**, a voltage card is available for Slot **E**, and 1 A/5 A CT combinations for current cards are available only on Slot **Z**. Because installations differ substantially, the SEL-749M offers a variety of card configurations that provide options for many diverse applications. Choose the combination of cards most suited for your application.

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

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

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

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

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

Step 3. Disconnect all the connection plugs.

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

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

Step 6. Insert the card in the correct slot.

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

Step 7. Before reattaching the rear cover, check for and remove any foreign material that may remain inside the SEL-749M case.

Step 8. Carefully reattach the rear cover.

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

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

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

```
STATUS FAIL
X Card Failure
```

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

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

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

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

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

The front panel displays the following:

```
STATUS
Relay Status
```

Step 14. Press the **ENT** button.

The front panel displays the following:

```
Serial Num
000000000000000000000000
```

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

The front panel displays the following:

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

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

The front panel displays the following:

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

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

The front panel displays the following:

```
Config Accepted
Enter to Reboot
```

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

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

After reconfiguration, the relay updates the part number, except for the following indicated digits. These digits remain unchanged, i.e., these digits retain the same character as before the reconfiguration. Also, a communications card installed in Slot C is reflected as an empty slot in the part number. The part number for the respective slots should be updated manually.

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

```
PART NUM = 0749M01A512X1A10
                  ↑↑ ↑ ↑ ↑ ↑
```

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

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

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

Slot B CPU Card Replacement

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

1. Ensure that the card has the latest firmware from the factory.
2. Review the firmware revision history for the changes that were made; note that new settings added, if any, might affect existing settings in the relay or its application.
3. Save all the settings and event reports before replacing the card.

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

Step 1. Turn off the power to the relay.

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

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

Step 4. Remove the rear panel.

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

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

Step 7. Apply new side stickers to the relay.

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

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

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

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

The CAL level default password is CLARKE.

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

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

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

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

Slot A Power Supply Card

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

Password, Breaker Control, and SELBOOT Jumper Selection

Figure 2.2 shows the major components of the Slot **B** card in the base unit. Notice the three sets of pins labeled A, B, and C.

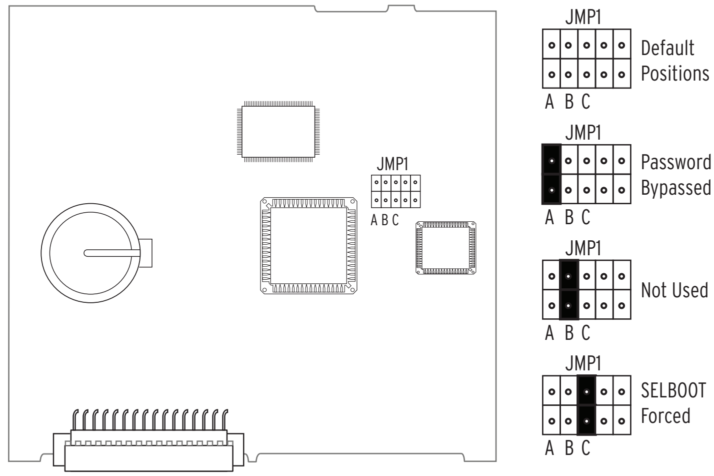


Figure 2.2 Pins for Password Jumper, Breaker Control Jumper, and SELBOOT Jumper

Pins labeled A bypass the password requirement and pins labeled C force the relay to the SEL operating system called SELBOOT (pins labeled B are not used). In the unlikely event that the SEL-749M experiences an internal failure, communication with the relay may be compromised. Forcing the relay to SELBOOT provides you with a way to download new firmware. To force the relay to SELBOOT, place the jumper in Position C, as shown in *Figure 2.2* (SELBOOT Forced). After the relay is forced to SELBOOT, you can only communicate with it via the front-panel port.

To gain access to Level 1 and Level 2 command levels without passwords, position the jumper in position A, as shown in *Figure 2.2* (Password Bypassed). Although you gain access to Level 2 without a password, the alarm contact still closes momentarily when accessing Level 2. See *Table 2.8* for the functions of the three sets of pins and their jumper default positions.

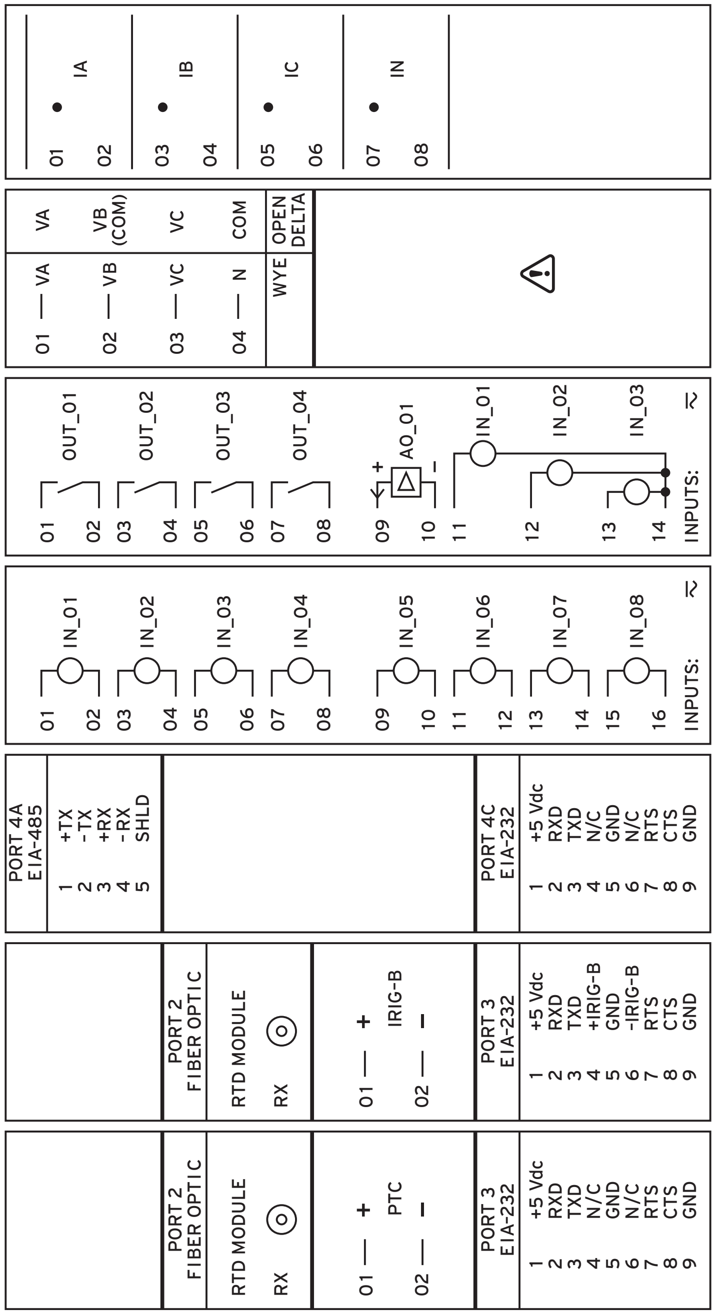
Table 2.8 Jumper Functions and Default Positions

Pins	Jumper Default Position	Description
A	Not bypassed (requires password)	Password bypass
B	Not used	Not used
C	Not bypassed (not forced SELBOOT)	Forced SELBOOT

Rear-Panel Connections

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

Figure 2.3 shows the rear-panel connections for selected card options.



Card 1: Current Card (4 ACI)

Card 2: Voltage Card (AVI)

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

Card 4: Eight Digital Inputs Card (8 DI)

Card 5: Communications Card (EIA-232/EIA-485)

Card 6: Main Board with IRIG-B and EIA-232 Rear Port

Card 7: Main Board with PTC and EIA-232 Rear Port

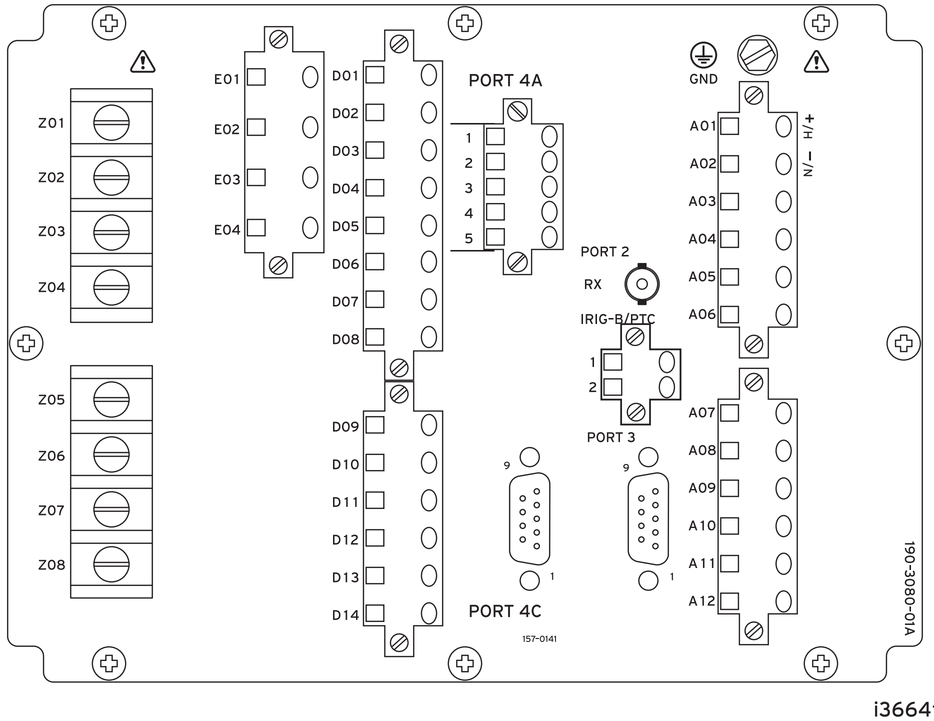
NOTE: All digital input and digital output connections are polarity neutral.

Figure 2.3 Rear-Panel Connections of Card Options

Rear-Panel and Top-Panel Diagrams

The physical layout of the connectors on the rear-panel and top-panel diagrams of three sample configurations of the SEL-749M are shown in *Figure 2.4*, *Figure 2.5*, and *Figure 2.6*.

(A) Rear-Panel Layout



(B) Top-Panel Input and Output Designations

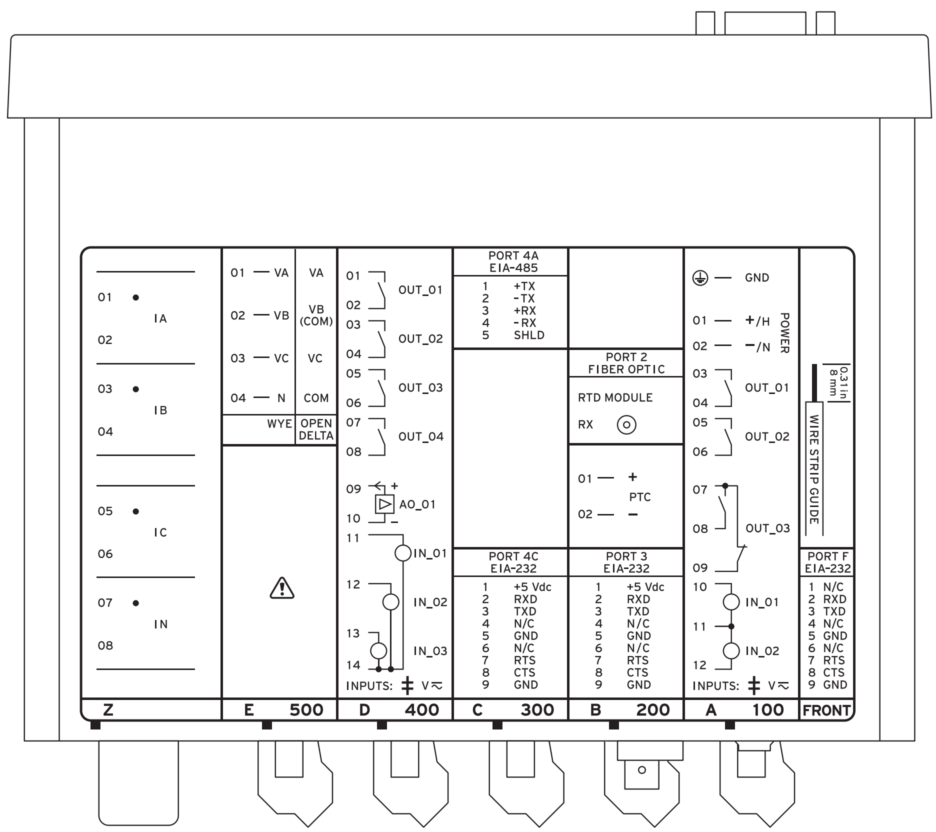
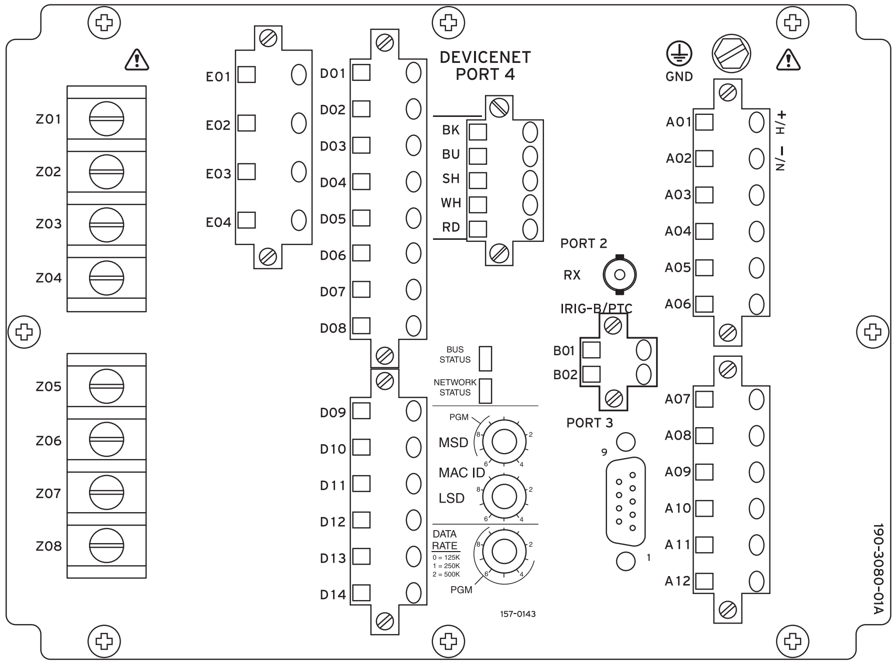


Figure 2.4 PTC Input, EIA-232/EIA-485 Communications Card, 3 DI/4 DO/1 AO Card, and Voltage Card Options

(A) Rear-Panel Layout



(B) Top-Panel Input and Output Designations

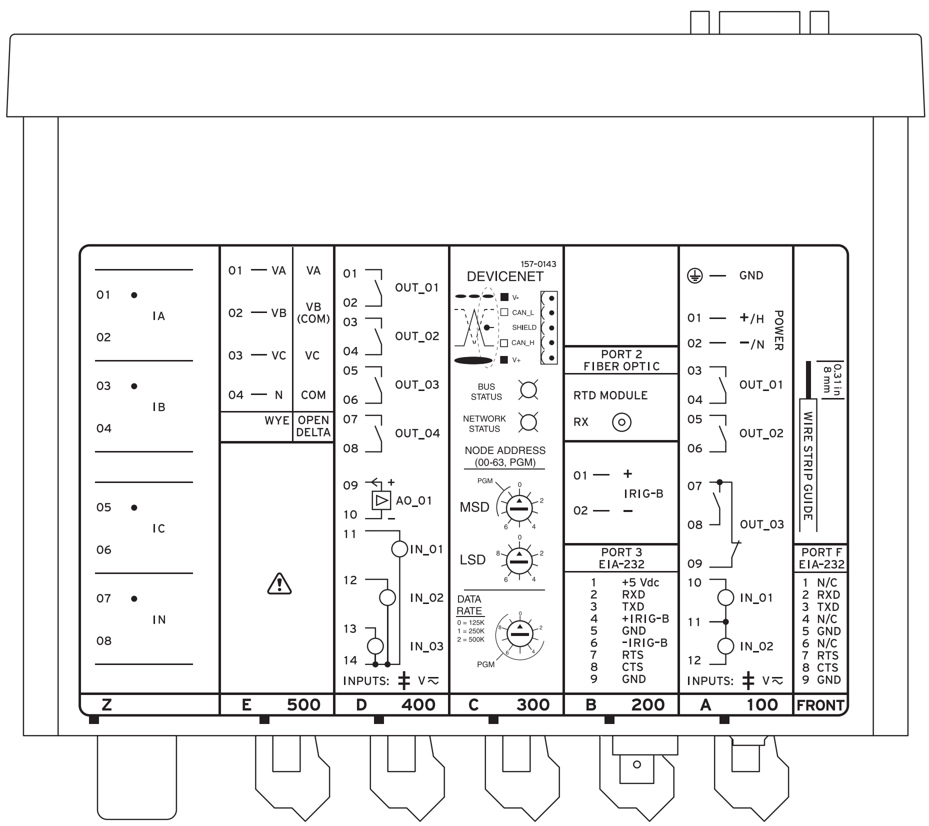
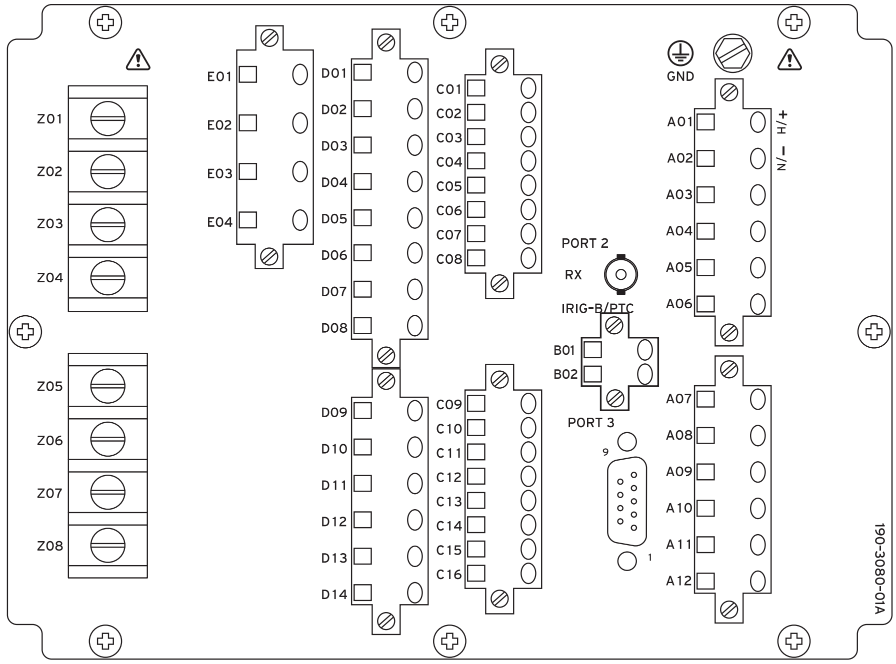
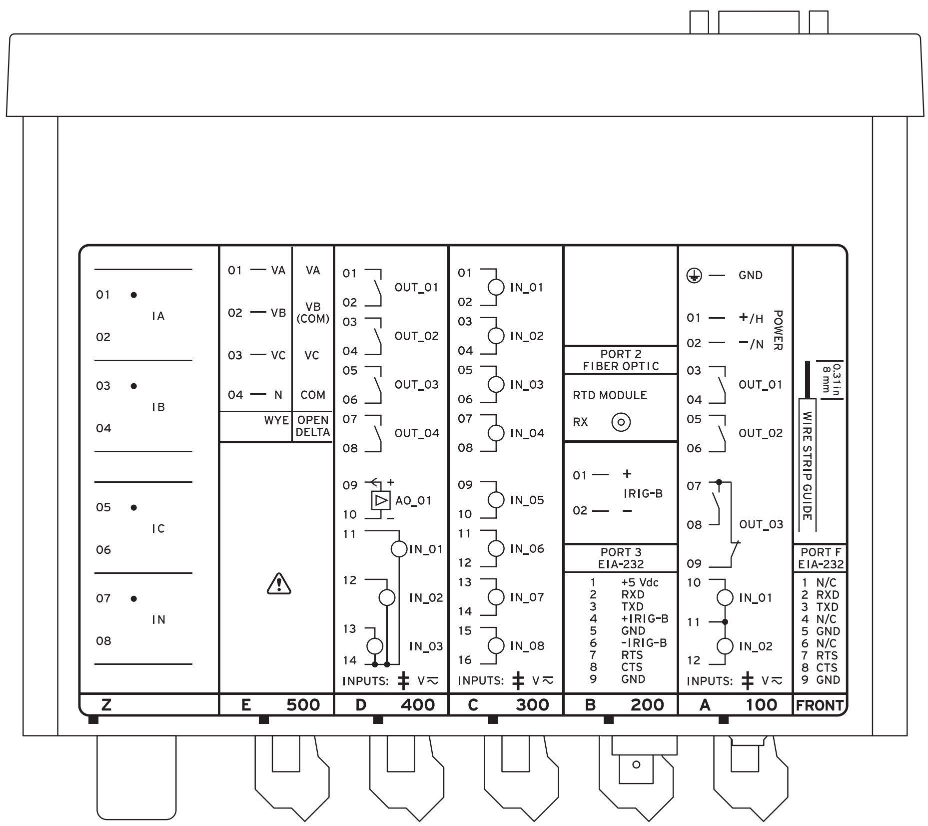


Figure 2.5 IRIG-B Input, DeviceNet Card, 3 DI /4 DO/1 AO Card, and Voltage Card Options

(A) Rear-Panel Layout



(B) Top-Panel Input and Output Designations



‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING   i4151a

Figure 2.6 IRIG-B Input, 8 DI Card, 3 DI/4 DO/1 AO Card, and Voltage Card Options

Power Connections

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

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

The **POWER** terminals on the rear panel (**A01(+/H)** and **A02(—/N)**) must connect to 110–240 Vac, 110–250 Vdc or 24–48 Vdc (see *Power Supply on page 1.9* 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-749M; this device should interrupt both the hot (**+/H**) and neutral (**–/N**) power leads. The maximum current rating for the power disconnect circuit breaker or optional overcurrent device (fuse) should be 20 A, 300 V.

Operational power is internally fused by a power supply fuse. See *Field Serviceability on page 2.22* for details. Be sure to use fuses that comply with IEC 60127-2.

Grounding (Earthing)

You must connect the ground terminal labeled **GND** on the rear panel to a rack frame or switchgear ground for proper safety and performance. Use 14 AWG (2.1 mm^2) to 18 AWG (0.8 mm^2) wire less than 2 m (6.6 ft) in length for the ground connection.

Serial Ports

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

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

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

IRIG-B Time-Code Input

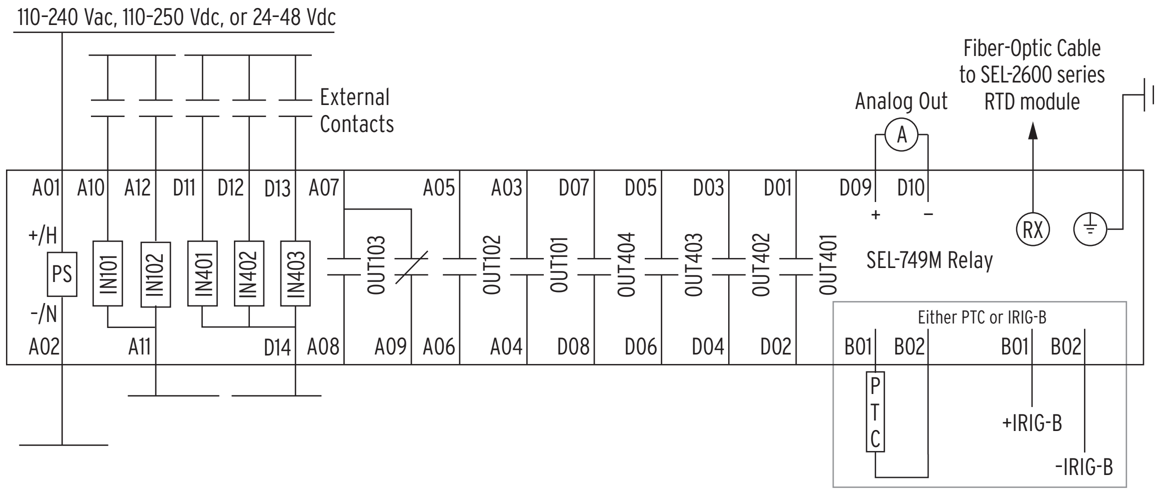
When ordered with optional IRIG-B input, the SEL-749M accepts a demodulated IRIG-B time signal to synchronize the internal clock with an external source. Two options for IRIG-B signal input are given, but only one should be used at a time. IRIG-B (**B01** and **B02**) inputs or an SEL communications processor via EIA-232 serial **Port 3** can be used. The available communications processors are the SEL-2032, SEL-2030, SEL-2020, and the SEL-2100 Logic Processor.

Fiber-Optic Port

The SEL-749M includes a multimode (receive only) with ST connector, fiber-optic port which is compatible with the SEL-2600 series RTD modules.

I/O Diagram

A more functional representation of the control (I/O) connections for a typical SEL-749M configuration with the 3 DI/4 DO/1 AO card option is shown in *Figure 2.7*. Additional I/O options include the 8 DI card for Slot **C**.



NOTE: All digital input and digital output connections are polarity neutral.

NOTE: The B01–B02 input located on the card in Slot B is either a PTC (thermistor) input or an IRIG-B Time-Code input depending on the SEL-749M model number. As many as six thermistors can be connected in series. Refer to Table 2.9 for PTC external cable length restrictions.

- Optoisolated inputs IN101 and IN102 are standard and are located on the card in Slot **A**.
- Optoisolated inputs IN401, IN402, IN403 are located on the optional 3 DI/4 DO/1 AO I/O Expansion card in Slot **D**.
- All optoisolated inputs are single-rated: 24, 48, 110, 125, 220, or 250 Vac/Vdc. IN101/102 may have a different rating than IN401/402/403.
- Output contacts OUT101, OUT102, and OUT103 are standard and are located on the card in Slot **A**.
- Output contacts OUT401, OUT402, OUT403, and OUT404 are located on the optional 3 DI/4 DO/1 AO I/O Expansion card in Slot **D**.
- The Analog (transducer) Output is located on the optional 3 DI/4 DO/1 AO I/O Expansion card in Slot **D**.
- The RX fiber-optic receiver port is standard and is located on the card in Slot B. A Simplex 62.5/125 µm fiber-optic cable is required to connect the SEL-749M with an SEL-2600 series RTD module. This fiber-optic cable should be 1000 meters or shorter.
- The chassis ground connector located on the rear panel just above card Slot A must always be connected to the local ground mat.

Figure 2.7 Control I/O Connections

Table 2.9 shows the maximum cable lengths for the PTC connections.

Table 2.9 PTC Cable Requirements

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

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 2.8*. 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.

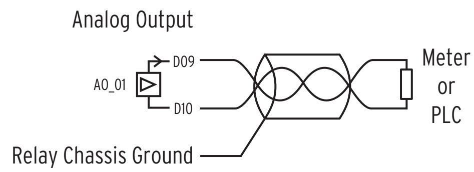


Figure 2.8 Analog Output Wiring Example

AC/DC Control Connection Diagrams

This section describes fail-safe versus nonfail-safe tripping, describes voltage connections, and provides the ac and dc wiring diagrams for the following applications:

- ➤ Across the line starting
- ➤ Star-delta starting
- ➤ Two-speed motor

Fail-Safe/Nonfail-Safe Tripping

Figure 2.9 shows the output OUT103 relay coil and Form C contact. When the relay coil is de-energized, the contact between A07 and A08 is open while the contact between A07 and A09 is closed.

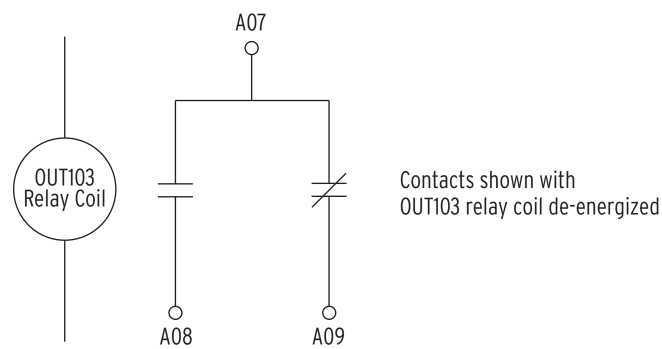


Figure 2.9 Output OUT103 Relay Output Contact Configuration

The SEL-749M 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-749M is powered and operational.
- ➤ When the SEL-749M generates a trip signal, the relay coil is de-energized.
- ➤ The relay coil is also de-energized if the SEL-749M power supply voltage is removed or if the SEL-749M fails (self-test status is FAIL).

Figure 2.10 shows fail-safe and nonfail-safe wiring methods to control breakers and contactors.

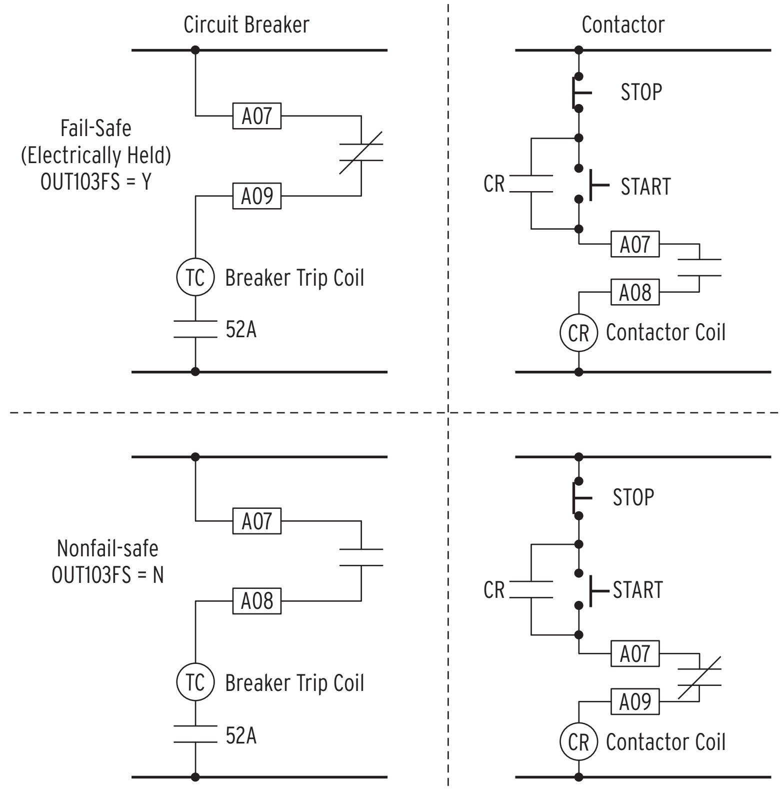


Figure 2.10 OUT103 Contact Fail-Safe and Nonfail-Safe Options

Figure 2.11 shows a typical contactor application using the factory-default settings for output OUT102 and output OUT103. Note that the application uses the START Relay Word bit in addition to the manual start pushbutton to start the motor. This allows internal relay logic to start the motor. *Figure 4.24* shows the logic the relay uses to initiate motor starts.

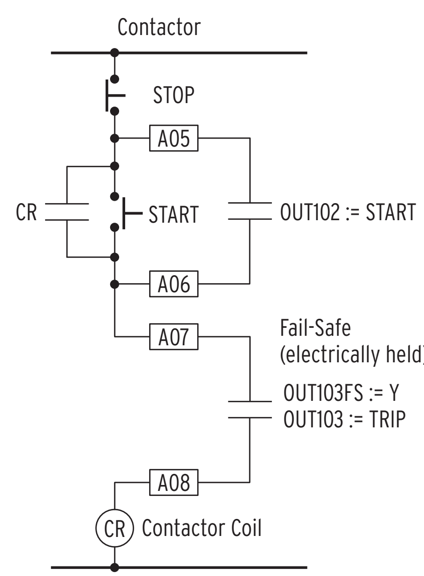


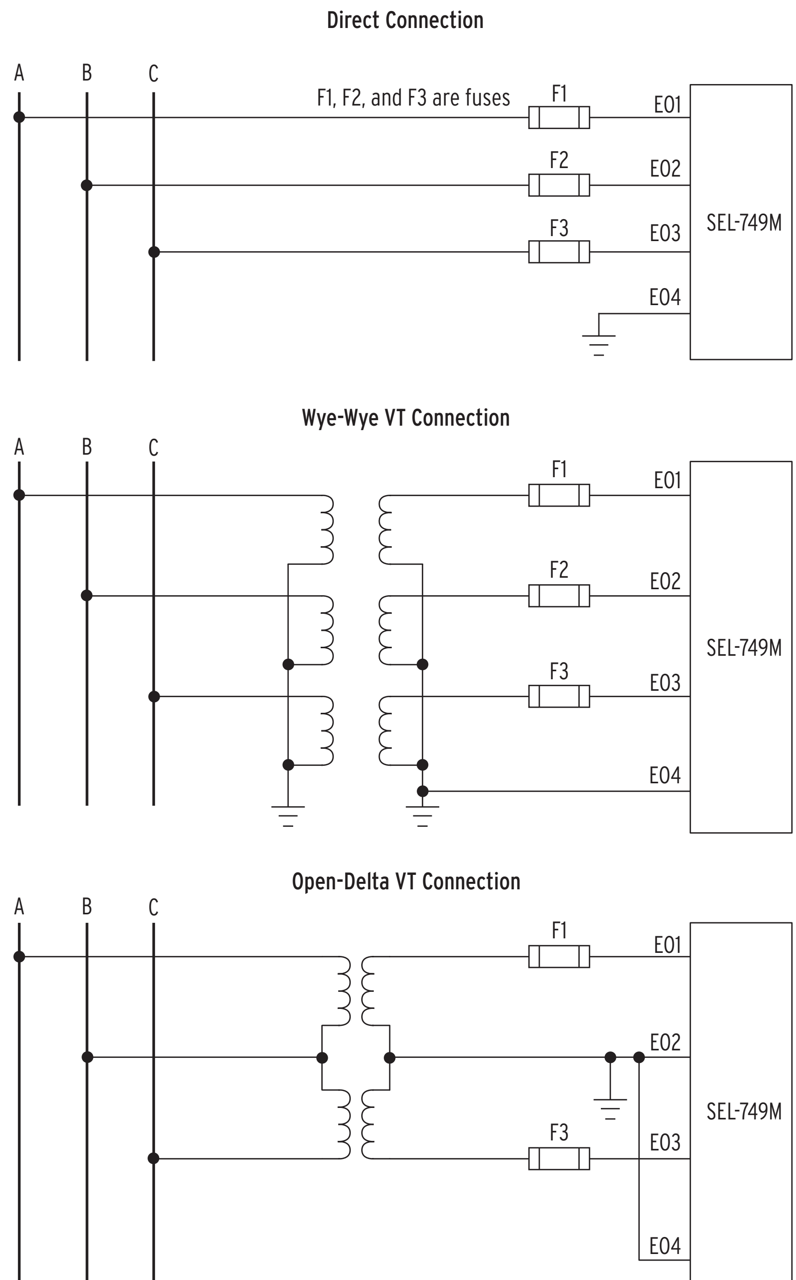
Figure 2.11 Contactor Application Using Factory-Default Settings

Voltage Connections

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

With the voltage inputs option, the three-phase voltages can be directly connected, wye-wye VT connected, or open-delta VT connected.

Figure 2.12 shows the three methods of connecting the three-phase voltages.

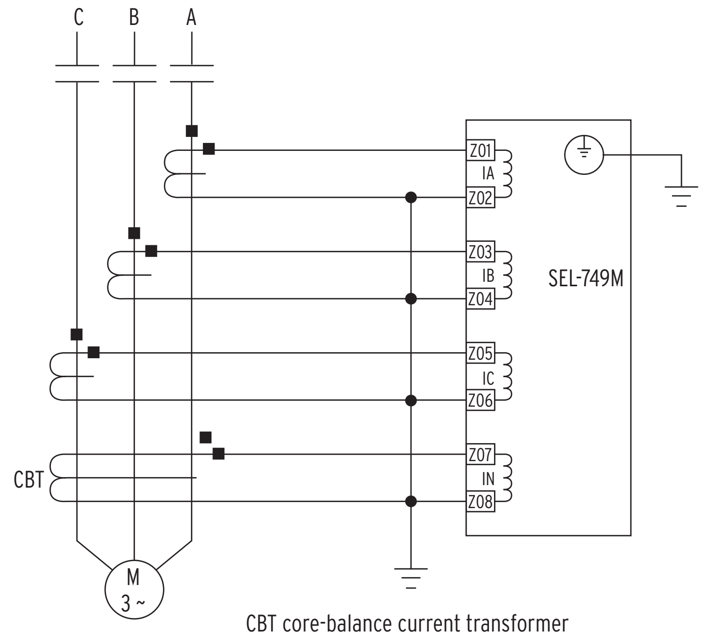


Note: The VT secondary circuit should be grounded in the relay cabinet.

Note: For open-delta VT connections, the figure shows grounding Phase B (E10). You can choose to ground Phase A or Phase C instead of Phase B, but the jumper between terminals E10 and E12 must remain as is.

Figure 2.12 Voltage Connections

Across the Line Starting



CBT core-balance current transformer

The current transformers and the SEL-749M chassis should be grounded in the relay cabinet.

Figure 2.13 AC Connections With Core-Balance CT

The implementation in *Figure 2.14* requires the following settings:

OUT103FS = **Y**
OUT103 = **TRIP**
OUT101 = **SALARM OR HALARM**

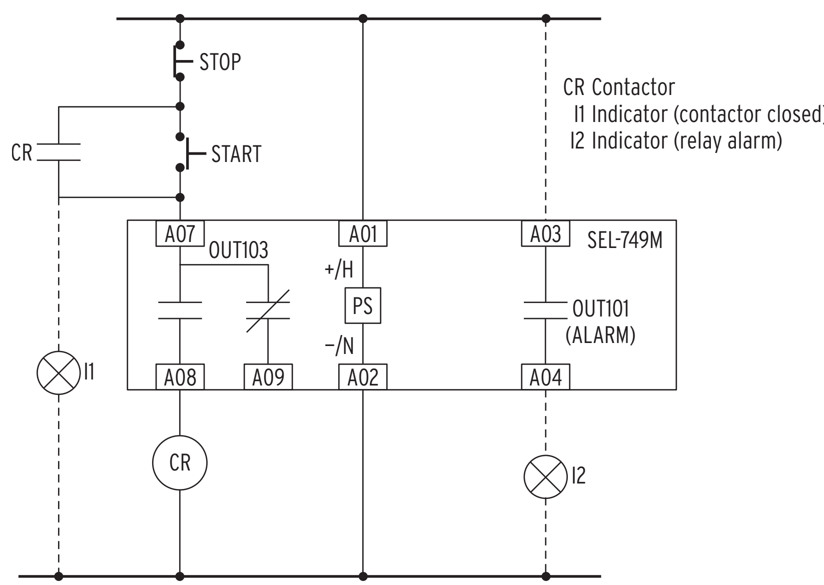


Figure 2.14 Control Connections for Failsafe Tripping

Star-Delta Starting

NOTE: A single winding motor rated for star-delta starting is required. The current transformers must be located as shown, outside the delta.

The implementation in *Figure 2.15* and *Figure 2.16* requires the following settings.

OUT103FS = **Y**
OUT103 = **TRIP**
OUT101 = **SALARM OR HALARM**
OUT401 = **DELTA**
OUT402 = **STAR**

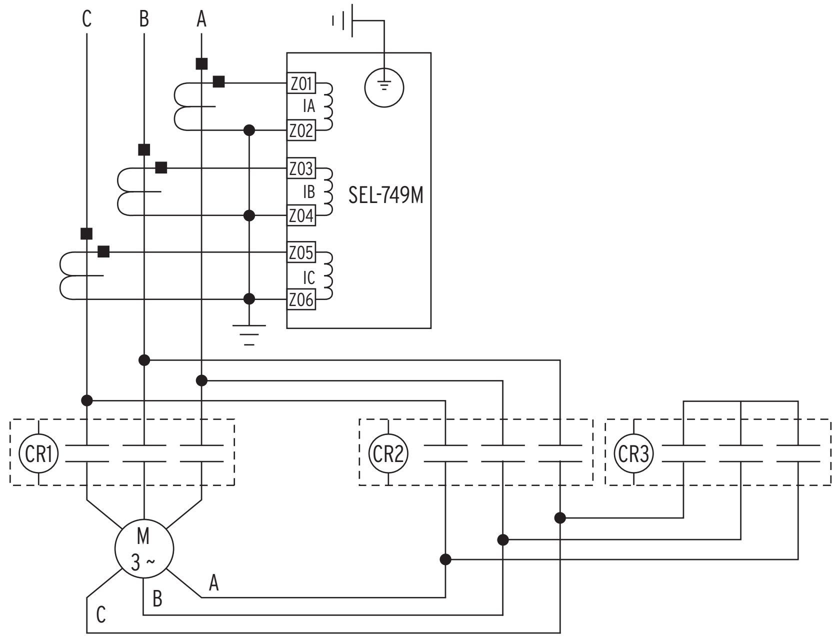


Figure 2.15 AC Connections for Star-Delta Starting

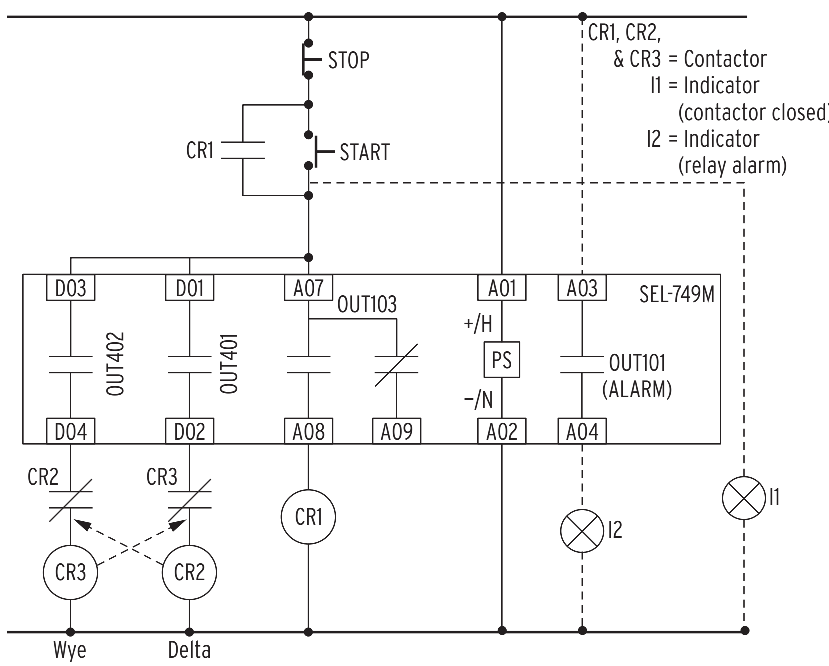


Figure 2.16 Control Connections for Star-Delta Starting

Two-Speed Motor

In *Figure 2.17*, contactors C1 and C2 are interlocked so that only one is energized to select either Speed1 or Speed2. The following setting is required.

SPEED2 := IN101

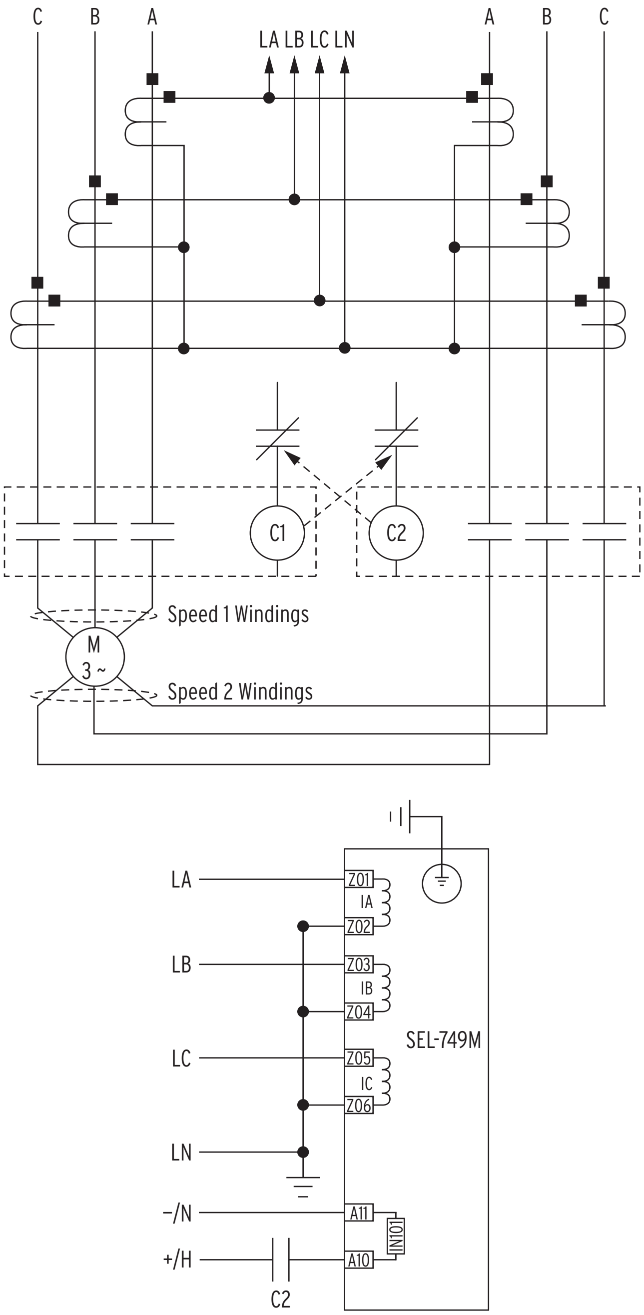


Figure 2.17 AC Connections for a Two-Speed Motor–Paralleled CTs

Field Serviceability

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

The SEL-749M firmware may be upgraded in the field; refer to *Appendix B: Firmware Upgrade Instructions* for firmware upgrade instructions. You may know when a self-test failure has occurred by configuring an output contact to create a diagnostic alarm as explained in *Section 4: Protection and Logic Functions*. By using the metering functions, you can know if the analog front-end (not monitored by relay self-test) is functional. Refer to *Section 10: Testing and Troubleshooting* for detailed testing and troubleshooting information.

The only two components that may be replaced in the field are the power supply fuse and the real-time clock battery. A lithium battery powers the clock (date and time) if the external power source is lost or removed. The battery is a 3 V lithium coin cell, Rayovac BR2335 or equivalent. At room temperature (25°C), the battery will operate nominally for 10 years at rated load. When the relay is powered from an external source, the battery experiences a low self-discharge rate. Thus, battery life may extend well beyond 10 years. The battery cannot be recharged.

Fuse Replacement

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

To replace the power supply fuse, perform the following steps:

Step 1. De-energize the relay.

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

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

Step 4. Locate the fuse on the board.

Step 5. Remove the fuse from the fuse holder.

Step 6. Replace the fuse with a time delay, 5 x 20 mm, 3.15 A, high-breaking capacity, 250 V fuse (T3.15 H 250 V).

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

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

Real-Time Clock Battery Replacement

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

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

Step 1. De-energize the relay.

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

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

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

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

Properly dispose of the old battery.

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

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

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

Step 9. Set the relay date and time.

Section 3

PC Software

Overview

This section describes how to get started with the SEL-749M and ACSELERATOR QuickSet SEL-5030 Software. SEL provides many PC software solutions (applications) to support the SEL-749M Motor Protection Relay and other SEL devices. *Table 3.1* lists SEL-749M software solutions.

Table 3.1 SEL Software Solutions

Part Number	Product Name	Description
SEL-5010	SEL-5010 Relay Assistant Software	Manages a connection directory and settings of multiple relays.
SEL-5030	ACSELERATOR QuickSet SEL-5030 Software	See *Table 3.2*
SEL-5040	ACSELERATOR Report Server SEL-5040 Software	Automatically retrieves, files, and summarizes reports
SEL-5601-2	SEL-5601-2 SYNCHROWAVE Event Software	Plots SEL ASCII format event report oscillography; performs custom calculations on analog, digital, and complex quantities.
SEL-5801	SEL-5801 Cable Selector	Selects the proper SEL cables for your application

QuickSet is a powerful setting, event analysis, and measurement tool that aids in setting, applying, and using the SEL-749M. *Table 3.2* shows the suite of QuickSet applications provided for the SEL-749M.

Table 3.2 ACSELERATOR QuickSet SEL-5030 Software

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

[a] Available only in licensed versions of QuickSet.

Setup

Follow the steps outlined in *Section 2: Installation* to prepare the SEL-749M for use. Perform the following steps to initiate communications:

Step 1. Connect the appropriate communications cable between the SEL-749M and the PC.

Step 2. Apply power to the SEL-749M.

Step 3. Start QuickSet.

Communications

QuickSet uses relay communications **Port 3**, **Port 4**, or **Port F** (front panel) to communicate with the SEL-749M. Perform the following steps to configure QuickSet to communicate effectively with the relay.

Step 1. Click **Communications** on the QuickSet main menu bar, as shown in *Figure 3.1*.

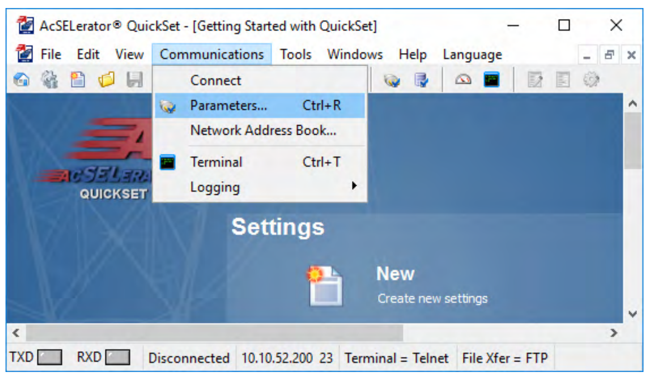


Figure 3.1 Communications Parameter Menu Selection

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

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

Step 4. Configure QuickSet to match the SEL-749M default settings by entering Access Level 1 and Access Level 2 passwords in the respective text boxes.

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

For the SEL-749M, always select FTP as the file transfer option.

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

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

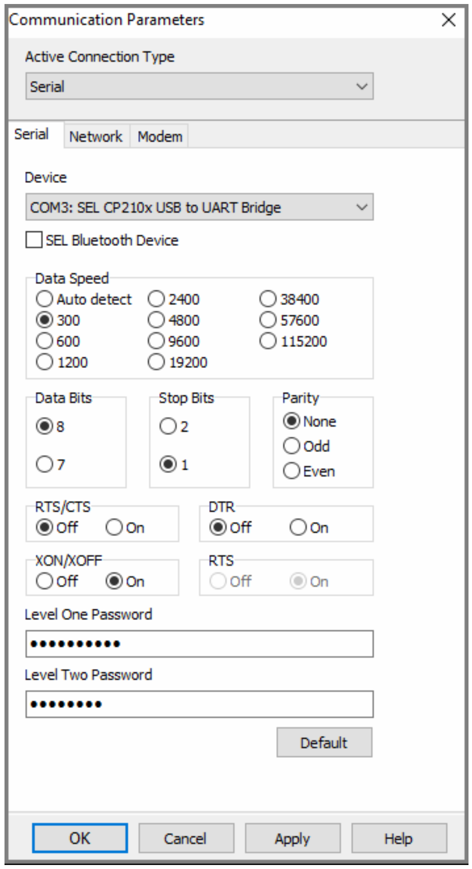


Figure 3.2 Serial Port Communication Parameters Dialog Box

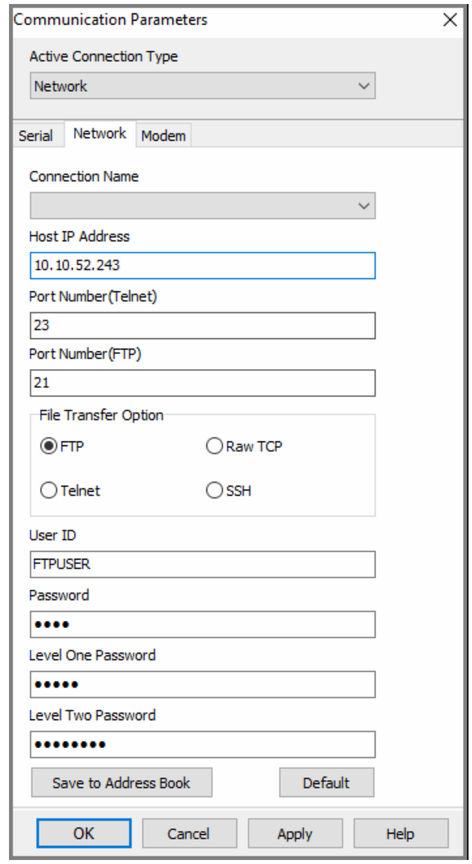


Figure 3.3 Network Communication Parameters Dialog Box

Terminal

Terminal Window

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

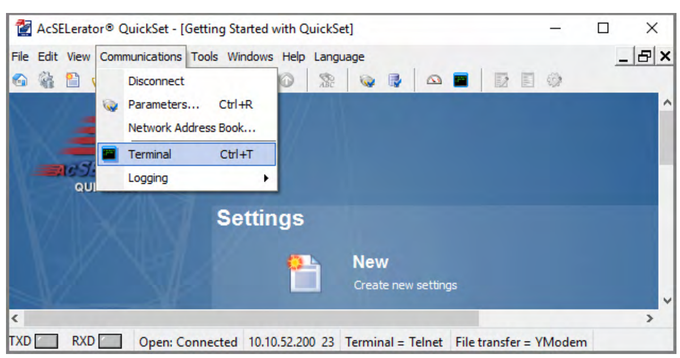


Figure 3.4 Communications Terminal Menu Selection

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

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

Terminal Logging

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

Drivers and Part Number

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

```
=>ID <Enter>
"FID=SEL-749M-X156-V0-Z003003-D20070223","0904"
"BFID=BOOTLDR-R101-V0-Z000000-D20030612","0942"
"CID=4BCA","0277"
"DEVID=SEL-749M","041B"
"DEVCODE=59","0315"
"PARTNO=0749M01B500X1X1X","0644"
"CONFIG=11111001","03E9"

=
```

Figure 3.5 Relay Response to the ID Command

Locate and record the Z number (Z003003) in the FID string. The first portion of the Z number (Z003…) determines the QuickSet relay settings driver version when you are creating or editing relay settings files. The use of the driver version is discussed in more detail in *Settings Editor on page 3.8*. Compare the part number (PARTNO=0749MXXXXXXXXXXXXX) with the Model Option Table (MOT) to ensure the correct relay configuration.

Settings Database Management and Driver

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

Database Manager

Click **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 in the **Database Description** text box.

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

Step 4. Highlight one of the relays listed in **Settings** and click the **Copy** 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

Copy creates an identical device or settings file that appears in both databases. Move removes the device or settings file from one database and places the device in another database. To copy/move settings between settings databases, perform the following steps:

Step 1. Click 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 **Settings Database B** option button to open a relay database.

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

a. Highlight a device or settings files in **Settings Database A,**

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

Step 4. Reverse this process to copy or move a device or settings file from **Settings Database B** to **Settings Database A**.

Create a New Database/Copy an Existing Database

To create a new database:

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

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

Step 3. Click **OK**.

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

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

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

Step 2. Click the **Settings Database 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 or settings files into the new database as in *Copy/Move Settings Between Databases on page 3.5*.

Settings

QuickSet offers the capability of creating settings for one or more SEL-749M relays. Store existing relay settings downloaded from SEL-749M relays with QuickSet. Create a library of relay settings, then modify and upload these settings from the settings library to an SEL-749M. QuickSet makes setting the relay easy and efficient. However, you do not have to use QuickSet to configure the SEL-749M; 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.

The QuickSet settings editor shows the relay settings in easy-to-understand categories. 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 option 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.

Settings Menu

QuickSet uses a database to store and manage SEL relay settings. Each unique relay has its own settings records. Use the **File** menu to **Open** an existing record, create and open a **New** record, or **Read** relay settings from a connected SEL-749M and then create and open a new record. Click **Tools > Settings > Convert** to convert and open an existing record in the settings editor.

Table 3.3 File/Tools Menus

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

To configure SEL-749M settings with the settings editor, click **File > New** on the main menu bar and select the SEL-749M and the latest driver version (00*X*) on the **Settings Editor Selection** screen, as shown in *Figure 3.6*. QuickSet creates the new settings file using the driver that you specify in the **Settings Editor Selection** screen. QuickSet uses the Z-number in the FID string to create a particular settings file.

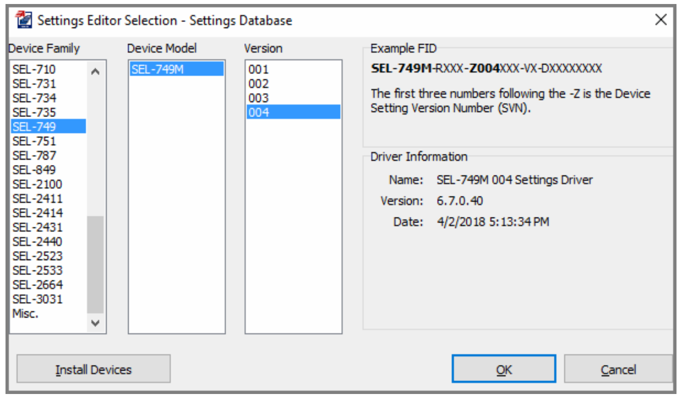


Figure 3.6 Driver Selection

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

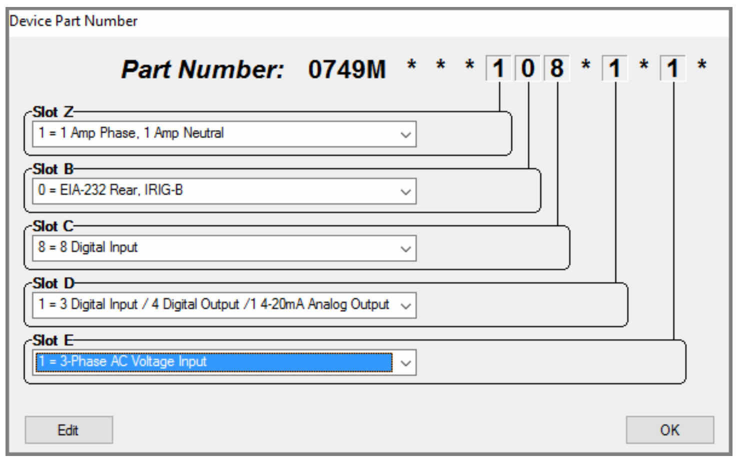


Figure 3.7 Update Part Number

Figure 3.8 shows the **Settings Editor** screen. Check the driver version number in the title bar of the Settings Editor screen. Compare the QuickSet settings driver number and the first portion of the Z-number in the FID string (click **Tools > HMI > Status**). These numbers must match. QuickSet uses this first portion of the Z-number to determine the correct settings editor to display.

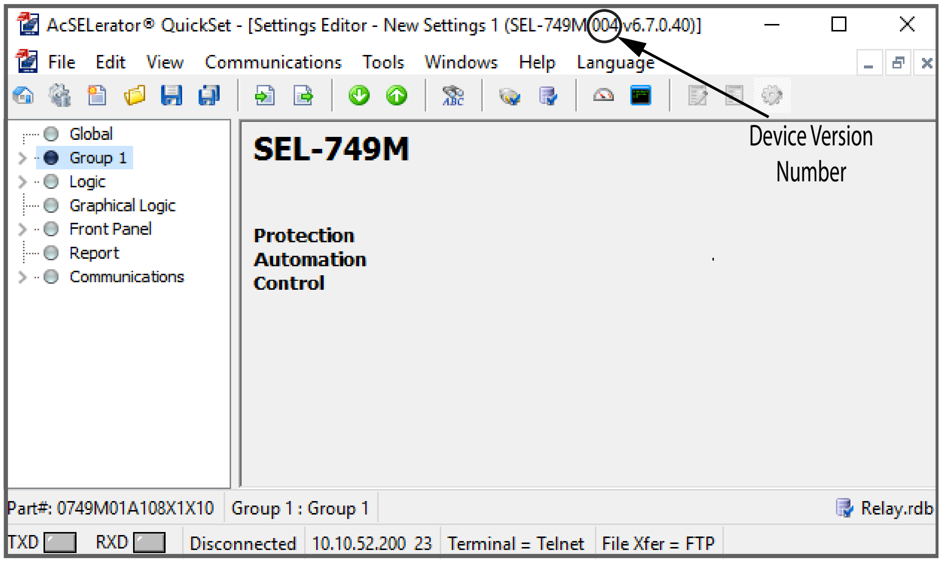


Figure 3.8 New Settings Editor Screen

File > Open

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

File > Read

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

Tools > Settings > Convert

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

Settings Editor

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

Enter Settings

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

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

Step 2. Press **<Tab>** to navigate through the settings, or click a setting text box.

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

Step 4. To restore the factory-default settings value, right-click on the setting text box and click **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 Expression Builder, a rules-based editor for programming SELOGIC control equations. Expression Builder organizes device elements, analog quantities, and SELOGIC control equation variables.

Access Expression Builder

Use the ellipsis button ... that follows the settings text boxes in the settings editor to create expressions, as shown in *Figure 3.9*.

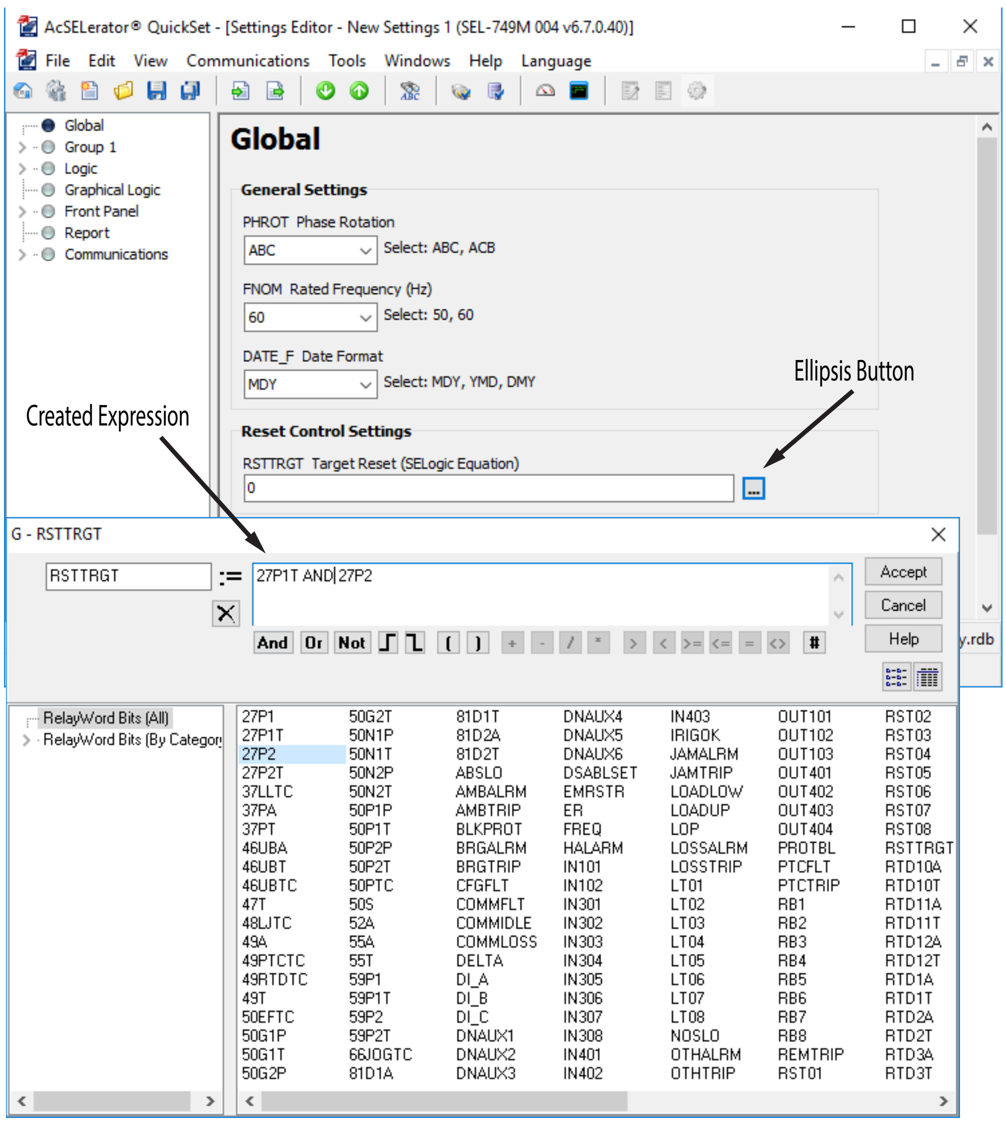


Figure 3.9 Expressions Created With Expression Builder

Using the Expression Builder

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

File > Save

Click the **Save** menu item from the **File** menu once settings are entered into QuickSet to ensure that the settings are not lost.

File > Send

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

Edit > Part Number

Use the **Part Number** menu item to change the part number.

Text Files

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

Event Analysis

QuickSet has integrated analysis tools that help you retrieve information about relay operations quickly and easily. Use the event information that the SEL-749M stores to evaluate the performance of a system (click **Tools > Events > Get Event Files**). *Figure 3.10* shows composite screens for retrieving events.

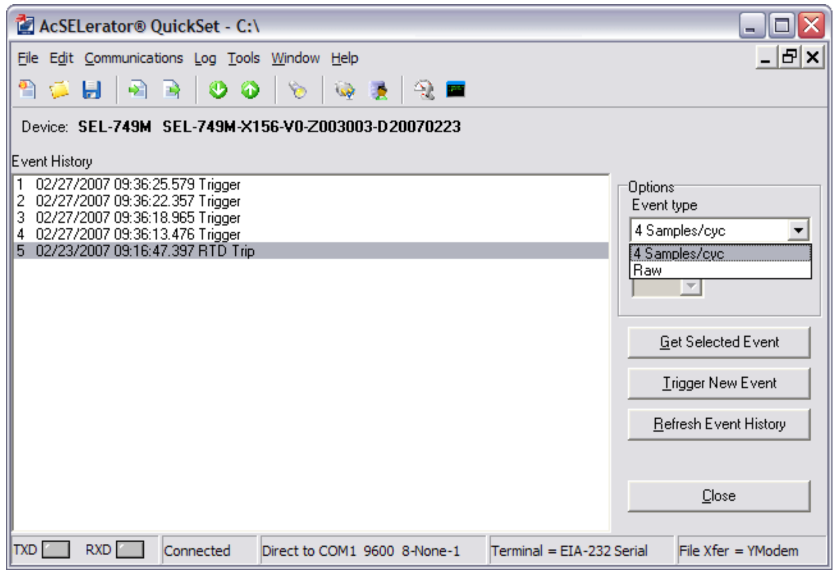


Figure 3.10 Composite Screens for Retrieving Events

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

View Event History

The SEL-749M is capable of capturing two types of events: 4 samples/cycle filtered data and 16 samples/cycle unfiltered (raw) data. Use the **Options** function in *Figure 3.10* to select the 16 samples/cycle unfiltered (raw) data event (the default is 4 samples/cycle filtered data). See *Section 9: Analyzing Events* for more information on recording events.

Get Event

Highlight the event you want to view (e.g., Event 1 in *Figure 3.10*), click the event type on the **Event Type** drop-down list (4 samples or 32 samples), and click **Get Selected Events**. When downloading is complete, QuickSet queries whether to save the file on your computer, as shown in *Figure 3.11*.

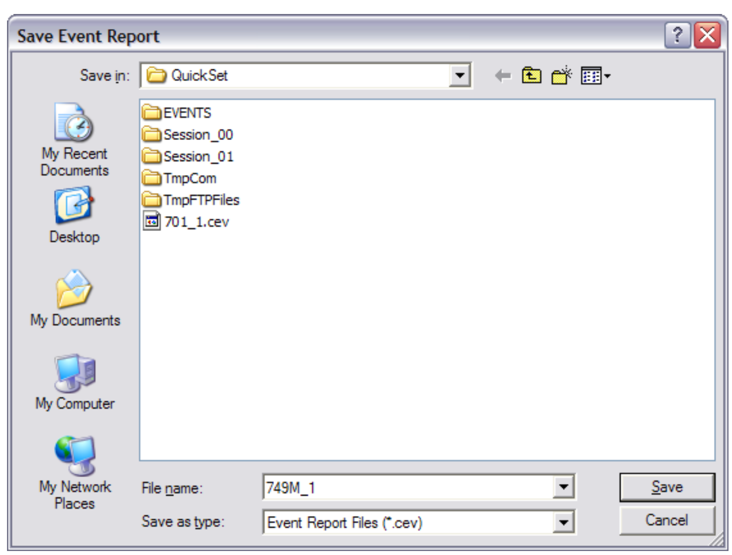


Figure 3.11 Saving the Retrieved Event

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

View Event Files

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

Meter and Control

Click **Tools > HMI > HMI** to display a screen similar to the one shown in *Figure 3.12*. The HMI tree view shows all the functions available from the HMI function. Unlike the self-configuration of the device, the HMI tree remains the same regardless of the type of cards installed.

Device Overview

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

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

The front-panel LEDs display the status of the eight front-panel LEDs. Use the front-panel settings to change the front-panel LED assignment. The **Fundamental**, **Thermal**, etc., screens display the corresponding values.

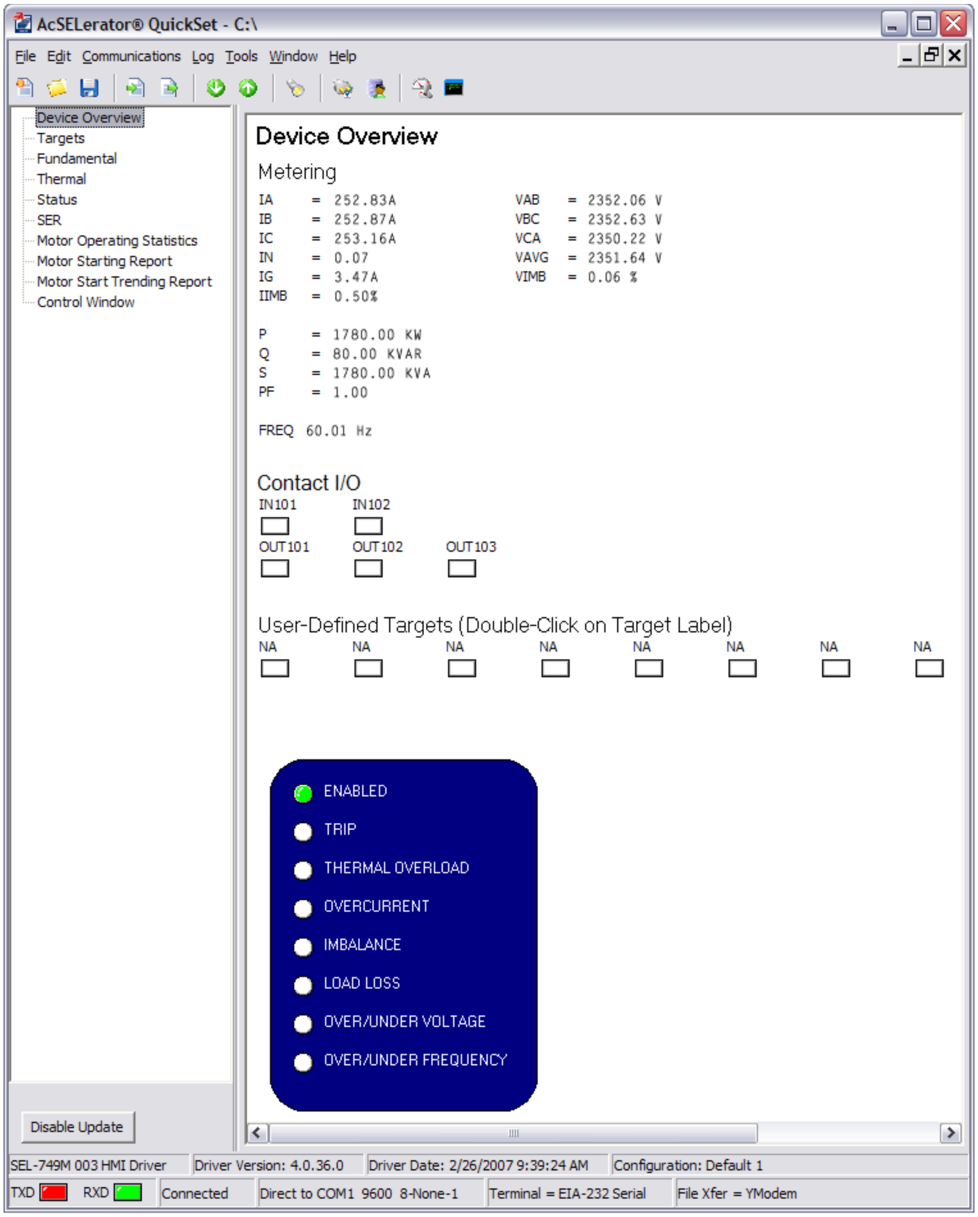


Figure 3.12 Device Overview Screen

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

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

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 3.13*.

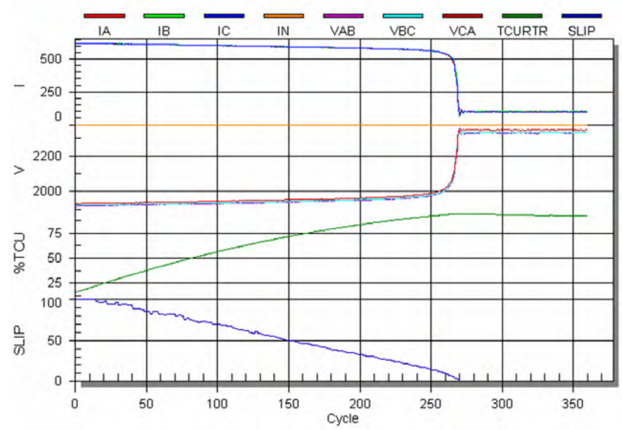


Figure 3.13 Graphical Display of Motor Start Report

Figure 3.14 shows the control screen. From here you can reset metering data; clear the event history, SER, MIRRORED BITS report; or trigger events. You can also reset the targets, synchronize with IRIG, and set the time and date. If supported, you can run arc-flash sensor diagnostic tests.

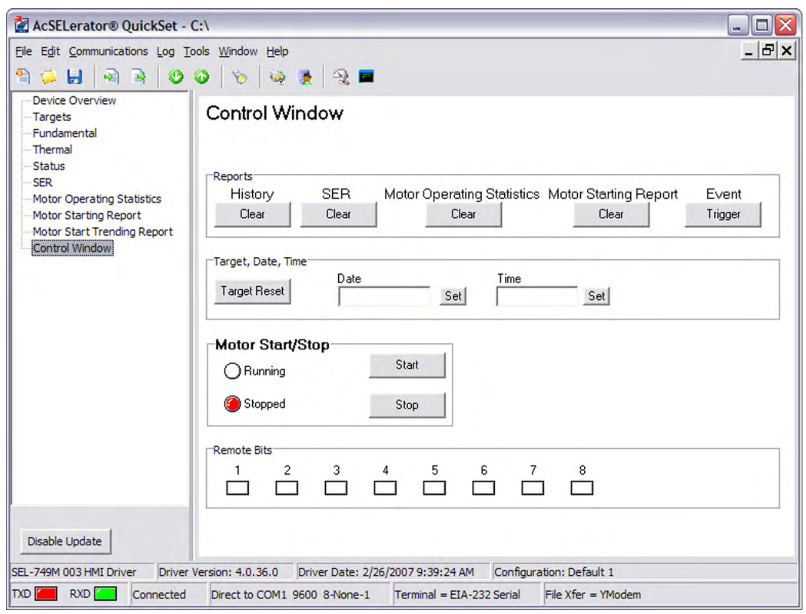


Figure 3.14 Control Screen

To control the Remote bits, click on the appropriate square, then select the operation from the box shown in *Figure 3.15*.

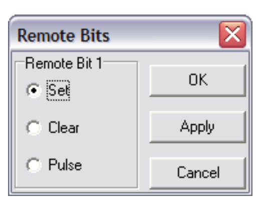


Figure 3.15 Remote Bit Operation Selection

QuickSet Help

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

Table 3.4 QuickSet Help Forms

Help Types	Description
General QuickSet	Select **Help** from the main menu bar
SEL-749M Settings	Select **Settings Help** from the **Help** menu bar while the settings editor is open.

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Section 4
Protection and Logic Functions

Overview

This section describes the SEL-749M Relay settings, including the motor protection elements and basic functions, control I/O logic, as well as the settings that control the communications ports and front-panel displays.

See *Section 6: Settings* for settings hide rules and settings interdependency checks. The settings are not case sensitive.

NOTE: Each SEL-749M is shipped with factory-default settings. Calculate the settings for your motor to ensure secure and dependable protection. Document and enter the settings (see Section 6: Settings).

This section includes the following subsections:

Application Data. Lists information that you will need to know about the protected motor before calculating the relay settings.

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

Basic Motor Protection. Lists settings for protection elements included in all models of the SEL-749M, including the thermal element, overcurrent elements, load-loss functions, and load-jam functions.

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

Voltage-Based Protection (Relays With Voltage Inputs). 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.

Frequency and Load Control Settings. Lists settings included in all models of the SEL-749M with enhanced and/or expanded performance when optional voltage inputs are used.

I/O Configuration. Lists inputs/output configuration settings including Analog Output, Trip Inhibit, Trip/Close logic and Motor Control logic.

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

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

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

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

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

Logic Functions. Explains the settings and operation of the logic functions of the SEL-749M.

When you calculate the protection element settings to protect your motor, proceed through the subsections listed earlier. Skip the RTD- and voltage-based protection subsections if they do not apply to your specific relay model or installation. See *Section 6: Settings* for the list of all settings (*SEL-749M Settings Sheets*) and various methods of accessing them.

NOTE: The DeviceNet port parameters can only be set at the rear of the relay on the DeviceNet card (see Figure E.1 and Figure E.2).

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

Application Data

It is faster and easier for you to calculate settings for the SEL-749M if you collect the following information before you begin (collect the information for each speed for a two-speed motor application):

- Specifications of the protected motor, including the following details:
  - Rated full load current
  - Service factor
  - Locked rotor current
  - Maximum locked rotor time with the motor at ambient and/or operating temperature
  - 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 may 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
- Current transformer primary and secondary ratings and connections
- System phase rotation and nominal frequency
- Voltage transformer ratios and connections, if used
- Type and location of resistance temperature detectors (RTDs), if used
- Expected fault current magnitudes for motor or cable ground and three-phase faults

Main Settings (SET Command)

Identifier Settings

All models of the SEL-749M have the identifier settings described in *Table 4.1*.

Table 4.1 Identifier Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
UNIT ID LINE 1	16 Characters	RID := SEL-749M
UNIT ID LINE 2	16 Characters	TID := MOTOR RELAY

The SEL-749M prints the Relay and Terminal Identifier strings at the top of responses to serial port commands to identify messages from individual relays.

Enter as many as 16 characters, including capital letters A–Z, numbers 0–9, periods (.), dashes (-), and spaces. Suggested identifiers include the location, process, circuit, size, or equipment number of the protected motor.

Current Transformer (CT) Configuration, Full Load Current Settings

Table 4.2 CT Configuration and Full Load Current Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PHASE CT RATIO	1–5000	CTR1 := 100
MOTOR FLA	0.2–5000 A	FLA1 := 250[a]
TWO SPEED ENABLE	Y, N	E2SPEED := N
CT RATIO–2nd	1–5000	CTR2 := 100
MOTOR FLA–2nd	0.2–5000 A	FLA2 := 250[a]
NEUTRAL CT RATIO	1–2000	CTRN := 100

[a] FLAn default settings are 50 A for secondary phase input current of 1 A.

NOTE: Motor FLA settings are in Primary Amperes.

NOTE: The SEL-749M normally uses settings CTR1 and FLA1. When setting E2SPEED is Y and SPEED2 control input is asserted, the relay uses CTR2 and FLA2 (see Table 4.32).

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

EXAMPLE 4.1 Phase CT Ratio Setting Calculation

Consider an application where the phase CT rating is 100:5 A.

Set CTR1 or CTR2 := 100/5 := 20

See *Equation 4.3* for sample calculations of Motor FLA.

Voltage Transformer (VT) Configuration Settings

Table 4.4 shows voltage settings for relay models with optional voltage inputs.

Table 4.3 Voltage Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PHASE PT RATIO	1.00–250.00	PTR := 35.00
LINE VOLTAGE	100–30000 V	VNOM := 4160
XFMR CONNECTION	Delta, Wye	DELTA_Y := DELTA

NOTE: The line voltage setting VNOM is line-line voltage in primary volts.

These settings configure the optional relay voltage inputs to correctly measure and scale the voltage signals. Set the phase PT ratio (PTR) setting equal to the VT ratio.

EXAMPLE 4.2 Phase VT Ratio Setting Calculations

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

Set PTR := 4200/120 := 35 and DELTA_Y := DELTA

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

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

VNOM/PTR Range Check

The relay performs a range check for the PTR and VNOM settings that depends upon the voltage-input delta or wye configuration. When setting DELTA_Y is DELTA, then the allowed range of the quotient VNOM/PTR is 100–250 V (l-l). When setting DELTA_Y is WYE, then the allowed range of VNOM/PTR is 100–440 V (l-l).

Note that the VNOM is always set in line-to-line voltage, irrespective of the DELTA or WYE configuration. The expanded range of VNOM/PTR for the WYE configuration is intended only for solidly grounded power systems. Do not use VNOM/PTR > 250 V if the system is either ungrounded or high impedance grounded. This is because a line-to-ground fault in such a system can raise line-to-ground voltage on an ungrounded phase by a factor of 1.732.

Basic Motor Protection

Thermal Overload Element

The SEL-749M motor thermal element provides integrated protection for all of the following motor operating conditions:

- Locked Rotor Starts
- Running Overload
- Unbalance 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-749M. The Thermal Method setting essentially offers the two options described below:

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. Alternatively, you can set the RTC1 or RTC 2 setting to a specific value to further optimize the overload protection.

Rating Thermal Method (SETMETH := Rating or Rating_1). When selected, the relay configures a thermal curve based on the motor Full Load Amps, Service Factor, Run State Time Constant, Locked Rotor Amps, Hot Locked Rotor Time, and Acceleration Factor (Locked Rotor Trip Time Dial) settings.

Curves Thermal Method (SETMETH := Curve). When selected, the relay offers 45 standard motor thermal limit curves that you can select by curve number.

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. When the % Thermal Capacity reaches 100 percent, the relay trips. You can see the present % Thermal

Capacity value by using the relay front-panel `Meter > Thermal` function or the serial port **METER T** command. See *Appendix F: Motor Thermal Element* for more detail on the thermal model.

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 999 as noted in *Section 5: Metering and Monitoring*.

Table 4.4 Overload (Thermal Model) Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
OVERLOAD ENABLE	Y, N	E49MOTOR := Y
THERMAL METHOD	Rating, Rating_1, Curve	SETMETH := RATING
OL RESET LEVEL	10–99 %TCU	49RSTP := 75
SERVICE FACTOR	1.01–1.50	SF := 1.15
THERM OL CURVE1	1–45	CURVE1 := 5
THERM OL CURVE2	1–45	CURVE2 := 7
MOTOR LRA	2.5–12.0 xFLA	LRA1 := 6.0
LOCKD ROTOR TIME	1.0–600.0 sec	LRTHOT1 := 10.0
ACCEL FACTOR	0.10–1.50	TD1 :=1.00
RUN STATE TIME K	Auto, 1–2000 min	RTC1 := AUTO
MOTOR LRA–2nd	2.5–12.0 xFLA2	LRA2 := 6.0
MOTOR LRT–2nd	1.0–600.0 sec	LRTHOT2 := 10.0
ACCEL FACT–2nd	0.10–1.50	TD2 :=1.00
RUN ST TC–2nd	Auto, 1–2000 min	RTC2 := AUTO

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.

Rating Thermal Method

NOTE: When SETMETH := Rating, the relay automatically raises the initial heat estimate at Starting (motor current > 2.5 per unit of FLA) to an operating level and ramps up the trip value to the starting element threshold. The ramping feature ensures that an overload condition during the start-to-run transition period of the model will result in trip time equal to or faster than hot overload-trip time. You may observe a sudden rise in % Thermal Capacity value when you start the motor. This is normal operation for the SEL-749M.

The SEL-749M thermal element always operates in one of two modes: STARTING (50S = 1) and RUNNING (50S = 0). In starting mode, the thermal element trips in locked rotor time at locked rotor current. Set SETMETH := Rating if you like the thermal element to trip in hot locked rotor time whether the rotor is at ambient or at normal operating temperature. This is a conservative approach suitable for most applications where motor acceleration time is significantly less than hot locked rotor time. Set SETMETH := Rating_1 if the acceleration time is close to hot locked rotor time. In running mode, the thermal element provides overload protection by limiting the motor heat energy estimate to a value represented by the overload settings.

The 50S overcurrent element uses the sum of positive- and negative-sequence magnitudes, 2.5 • FLA as a pickup threshold, and 2.4 • FLA as a dropout threshold.

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.

EXAMPLE 4.3 Thermal Element Setting

NOTE: The SEL-749M normally uses settings CTR1, FLA1, LRA1, LRTHOT1, TD1, and RTC1. When setting E2SPEED is Y and SPEED2 control input is asserted, the relay will instead use CTR2, FLA2, LRA2, LRTHOT2, TD2, and RTC2 (see Table 4.32).

A 4000 V, 600 HP motor is protected by the SEL-749M Thermal Overload Element. The motor data sheet includes the following information.

Rated Horsepower = 600 HP
Rated Voltage = 4000 V
Rated Full Load Current = 80 A
Rated Locked Rotor Amps = 480 A
Safe Stall Time at 100% Volts:
Cold = 18 secondsHot = 15 secondsService Factor = 1.2

Phase current transformers with 100:5 A rating are selected for the application. The SEL-749M settings for the application are calculated as follows:

Current Transformer Ratio: CTR1 := 100/5 := 20 (see Main Settings (SET Command))
Full Load Amps (FLA): FLA1 := 80 A primary (see Main Settings (SET Command))
Service Factor: SF := 1.2
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

NOTE: For IEC applications, set SF = 1.05 or higher, but no higher than 1.2.

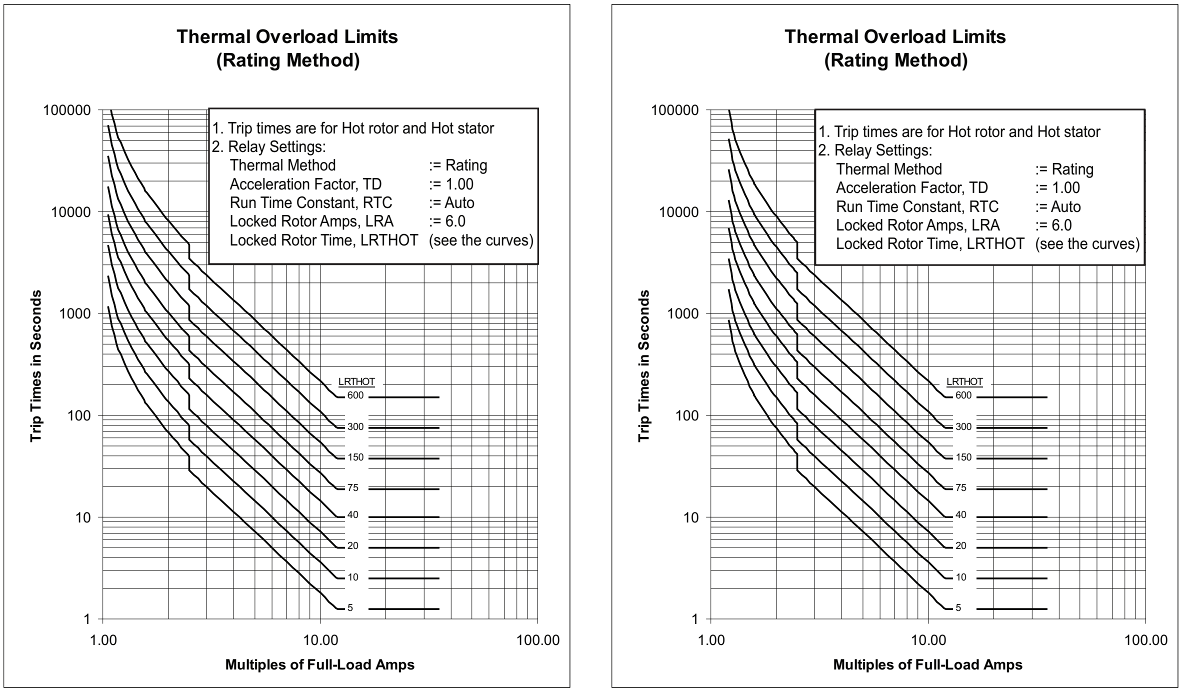
$$RTC = \frac{(TD + 0.2) \bullet LRTHOT}{60 \bullet ln\left[\frac{LRA^2 - (0.9 \bullet SF)^2}{LRA^2 - SF^2}\right]}$$

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

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

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.

If you know that the driven load will always 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 4.18*) to provide locked rotor protection. See *Figure 4.1* for thermal overload limits for selected settings. Refer to *Equation F.10* through *Equation F.19* in *Appendix F: Motor Thermal Element* for these and additional curves.



(A) Service Factor = 1.01 (B) Service Factor = 1.15

Figure 4.1 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 always 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.

Curve Thermal Method

The Curve method is similar to the Rating method except in the following ways:

- You select one of the 45 available standard motor overload/locked rotor curves, set the motor rated Full Load Amps and Service Factor. Based on the curve number, the relay determines and hides LRA, LRTHOT, TD, and RTC settings automatically.
- The relay does not raise the initial heat estimate at starting (motor current > 2.5 per unit of FLA); however, the relay does ramp up the trip value to the starting element threshold. The locked rotor trip time, for a motor at ambient temperature, will be 120 percent of the time for the same motor at operating temperature (similar to the Rating_1 method).

Figure 4.2 shows several of the available curves. Refer to *Equation F.10* through *Equation F.19* in *Appendix F: Motor Thermal Element* for these and additional curves.Be sure that the standard 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 curve thermal limit time at six times full load current. For a cold rotor, the curve 10 trip time at six times full load current is 25 seconds.

Table 4.5 shows the thermal limit time versus current for several curves. For a hot rotor, each increase in the curve number yields a 2.08 second increase in the hot rotor thermal limit time at six times full load current. Continue calculating the balance of thermal element settings with overload settings in *Table 4.6*.

EXAMPLE 4.5 Thermal Element Curve Method Setting

A 4160 V, 800 HP motor is to be protected through use of the SEL-749M 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

Each increase in generic curve number increases the hot rotor thermal limit time by 2.08 seconds at six times full load current. Therefore, we can select the maximum curve number by using the following equation.

$$\text{Curve} = \frac{\text{Safe Stall Time, Hot (seconds)} \bullet \left(\frac{\text{Locked Rotor Amps}}{FLA}\right)^2}{2.08 \text{ seconds} \bullet 36}$$

$$\text{Curve} = 15.12; \text{ select curve 15 or less}$$

Phase current transformers having 150:5 ratios are selected for the application. The SEL-749M settings for the application are as follows:

Current Transformer Ratio (CTR) = 150/5 = 30
Full Load Amps (FLA) = 101 A primary
Service Factor (SF) = 1.15
Curve Number (CURVE) = 14

See Example 4.3 for the equation to calculate the RTC, use

TD = 1
LRA = 6
LRTHOT = Curve# • 2.08
RTC = 81 minutes
COOLTIME = 3 • 81 + 1 = 244 minutes

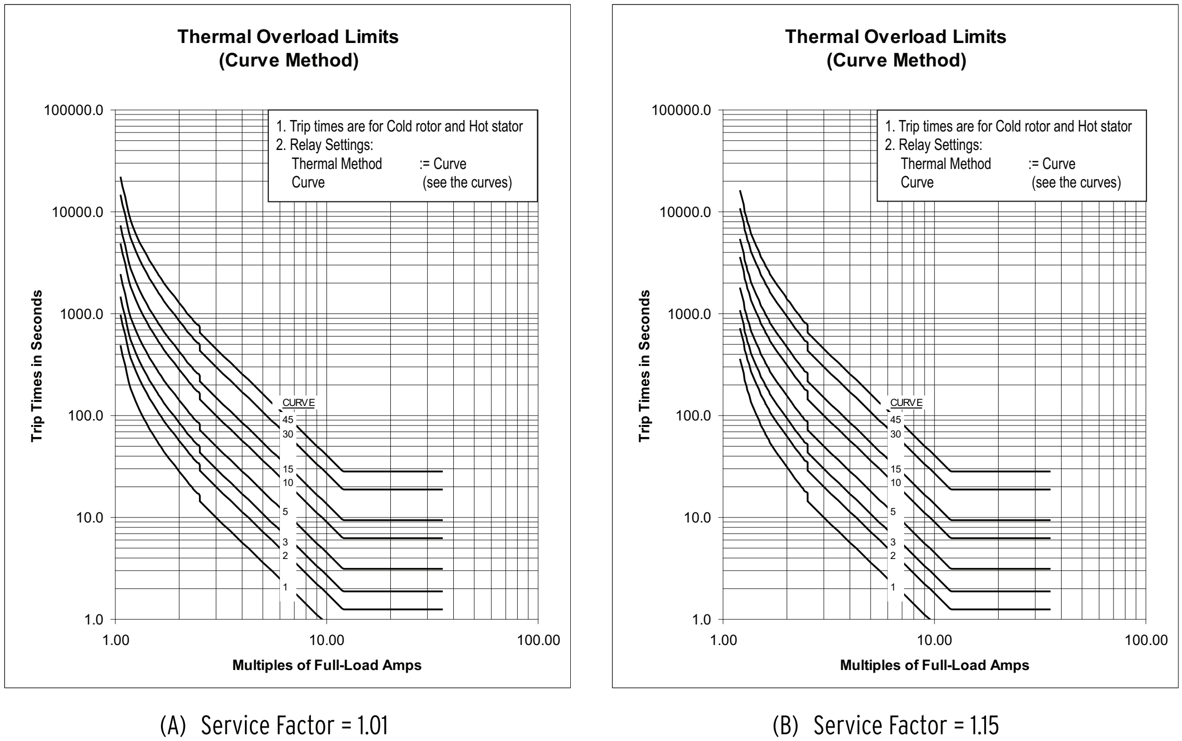


Figure 4.2 Thermal Overload Limits (Curve Method)

Table 4.5 Thermal Limit Tripping Times in Seconds vs. Multiples of Full-Load Amps (Service Factor = 1.01)[a]

Multiples of FLA	Curve 1	Curve 2	Curve 3	Curve 5	Curve 10	Curve 15	Curve 30	Curve 45	Remarks
1.10	318.3	636.5	954.8	1,591	3,183	4,774	9,548	14,321	Running Model Limits[b]
1.20	171.7	343.4	515.1	858.6	1,717	2,576	5,151	7,727	
1.30	115.0	229.9	344.9	574.9	1,150	1,725	3,449	5,174	
1.40	84.83	169.7	254.5	424.1	848.3	1,272	2,545	3,817	
1.50	66.21	132.4	198.6	331.1	662.1	993.2	1,986	2,979	
2.00	28.51	57.02	85.53	142.6	285.1	427.7	855.3	1,283	
2.45	17.27	34.53	51.80	86.33	172.7	259.0	518.0	777.0	
2.50	14.40	28.80	43.20	72.00	144	216	432	648.0	Starting Model Limits[c]
3.00	10.00	20.00	30.00	50.00	100	150	300	450.0	
4.00	5.63	11.25	16.88	28.13	56.25	84.38	169	253.1	
5.00	3.60	7.20	10.80	18.00	36.00	54.00	108	162.0	
6.00	2.50	5.00	7.50	12.50	25.00	37.50	75.00	112.5	
7.00	1.84	3.67	5.51	9.18	18.37	27.55	55.10	82.65	
8.00	1.41	2.81	4.22	7.03	14.06	21.09	42.19	63.28	
9.00	1.11	2.22	3.33	5.56	11.11	16.67	33.33	50.00	
10.0	0.90	1.80	2.70	4.50	9.00	13.50	27.00	40.50	
11.0	0.74	1.49	2.23	3.72	7.44	11.16	22.31	33.47	
12.0	0.63	1.25	1.88	3.13	6.25	9.38	18.75	28.13	
14.0	0.63	1.25	1.88	3.13	6.25	9.38	18.75	28.13	

[a] (Trip time for Curve n) = (Trip time for Curve 45)*n/45 at same multiple of FLA.
[b] Tripping times are for the stator initially at operating temperature (hot).
[c] Tripping times are for the rotor initially at ambient temperature (cold).

Additional Thermal Overload Settings

Table 4.6 Overload Settings (Alarm, Start Inhibit, Cooling, and RTD Bias)

Setting Prompt	Setting Range	Setting Name := Factory Default
OL WARN LEVEL	Off, 50–99 %TCU	TCAPU := 85
START INH. LEVEL	Off, 1–99 %TCU	TCSTART := OFF
STOP COOL TIME	1–6000 min	COOLTIME := 84
OL RTD BIASING	Y, N	ETHMBIAS := N

NOTE: The overload warning feature is enabled only during normal running mode after a successful motor start.

NOTE: The Overload Alarm function (Relay Word bit 49A) has 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.

When the motor thermal capacity used exceeds the overload warning level setting (TCAPU), the relay issues a warning (the Relay Word bit 49A asserts). 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 criteria to avoid nuisance overload warnings when running the motor at full load:

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

Equation 4.1

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 starting thermal capacity to allow a motor start without tripping. The available thermal capacity required to start is (100–TCSTART), where TCSTART is the start inhibit level setting. This feature can be disabled by setting TCSTART equal to OFF.

$$\text{TCSTART} \geq \text{Start\%TCU}$$

Equation 4.2

The function of setting 49RSTP is similar to that of TCSTART, except that 49RSTP asserts only after an overload trip. Setting 49RSTP determines the running thermal capacity above which the relay does not allow reset (automatic or manual) following an overload trip.

$$\text{49RSTP} \leq \frac{100}{\text{SF}^2}$$

Equation 4.3

A stopped motor can take longer to cool than a running motor because of reduced airflow or loss of forced coolant. Based on the setting names, the cooling time equation is shown in *Equation 4.4*:

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

Equation 4.4

NOTE: The relay will prompt you with the minimum allowable COOLTIME when you attempt to save a value lower than the minimum. This is useful when RTC is set to AUTO.

where:

RTC = RTC1 or RTC2 (whichever is higher)

Round up the result to the next integer.

The factory-default settings assume that the motor stopped cooling time is the same as the motor running cooling time.

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 3 and add one to calculate the motor stopped cooling time setting (COOLTIME). If a time is provided, use this time directly for COOLTIME.

NOTE: In addition to setting ETHMBIAS := Y, you must set one RTD location equal to ambient, at least one RTD location equal to winding, and set the winding trip level (see Table 4.20 for details).

You can bias the thermal model by ambient temperature when ETHMBIAS is set equal to Y. The overload RTD bias is calculated using the ambient temperature above 40°C and winding RTD trip temperature setting.

When the ambient RTD temperature is greater than 40°C, and the minimum stator winding trip threshold is greater than 40°C, then the stator RTD trip temperatures are lowered (if ERTDBIAS := Y) as follows:

$$K_{RTD} = T_{AMB} - 40 \qquad \text{Limit: } 0 \le K_{RTD} \le 45$$

$$T_{VRTDn} = TRTMP_n - K_{RTD} \qquad \text{Limit: } T_{VRTDn} \ge \text{MIN } (85, TRTMP_n)$$

where

T_{AMB} = measured ambient temperature

T_{VRTDn} = biased stator winding temperature trip threshold for the *n*th winding RTD

$TRTMP_n$ = the *n*th winding trip threshold setting

The relay calculates the RTD thermal capacity used (TCRTD) from the stator winding RTD closest to its corresponding trip threshold and the ambient temperature RTD. If ETHMBIAS := Y, then compare this value against the thermal model thermal capacity for the RTD bias alarm.

$$TC_{RTD} = 1 - \frac{T_{VRTDn} - T_{RTDn}}{T_{VRTDn} - T_{AMB}}$$

where

T_{RTDn} = the winding RTD temperature that is closest to its trip temperature

T_{VRTDn} = the corresponding biased stator winding trip temperature

T_{AMB} = measured ambient temperature

Additionally, the relay calculates the ambient bias factor K_{TH} and uses it in the thermal model to calculate start and run state trip values (TVS and TVR), as shown in the following equations.

$$\text{Trip Value} = K_{TH} \bullet \text{(Unbiased Thermal Model Trip Value)}$$

$$K_{TH} = \{1\} \quad T_{AMB} \le 40°C \text{ or } \min\{TRTMP_n\} \le 60°C$$

$$K_{TH} = \left\{1 - \frac{K_{RTD}}{min\{TRTMP_n\}}\right\} \quad T_{AMB} > 40°C \text{ and } \min\{TRTMP_n\} > 60°C$$

where

$0 \le K_{TH} \le 1$

$\min\{TRTMP_n\}$ = the stator RTD trip threshold temperature corresponding to the winding temperature T_{RTDn}

Overcurrent Elements

Table 4.7 Phase Overcurrent Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
PH OC TRIP LVL	Off, 0.10–20.00 xFLA	50P1P := 10.00
PH OC TRIP DLAY	0.00–5.00 sec	50P1D := 0.00

Table 4.7 Phase Overcurrent Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
PH OC WARN LVL	Off, 0.10–20.00 xFLA	50P2P := OFF
PH OC WARN DLAY	0.00–5.00 sec	50P2D := 0.50

If the SEL-749M 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 0.0 second time delay. Set the phase overcurrent warn level (50P2P) to a specified value with appropriate time delay.

NOTE: The cosine filter provides excellent performance in removing dc offset and harmonics. However, the bipolar peak detector has the best performance in situations of severe CT saturation when the cosine-filter magnitude estimation is significantly degraded. Combining the two methods provides an elegant solution for ensuring dependable short-circuit overcurrent element operation.

The phase overcurrent elements (50P1 and 50P2; see *Figure 4.3*) normally operate using the output of the cosine filter, but during CT saturation 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: Neutral OC trip level settings are in primary amperes.

Table 4.8 Neutral Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
NEUT OC TRIP LVL	Off, 0.01–25.00 A[a]	50N1P := OFF
NEU OC TRIP DLAY	0.00–5.00 sec	50N1D := 0.50
NEUT OC WARN LVL	Off, 0.01–25.00 A[a]	50N2P := OFF
NEU OC WARN DLAY	0.0–120.0 sec	50N2D := 10.0

[a] Setting range is in primary amps.

The relay offers two types of ground fault detecting overcurrent elements. The neutral 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 4.3*).

When a core balance CT is connected to the relay IN input, as in *Figure 2.13*, use the neutral overcurrent element to detect motor ground faults. Calculate the trip and warn level settings based on the available ground fault current and the core balance CT ratio.

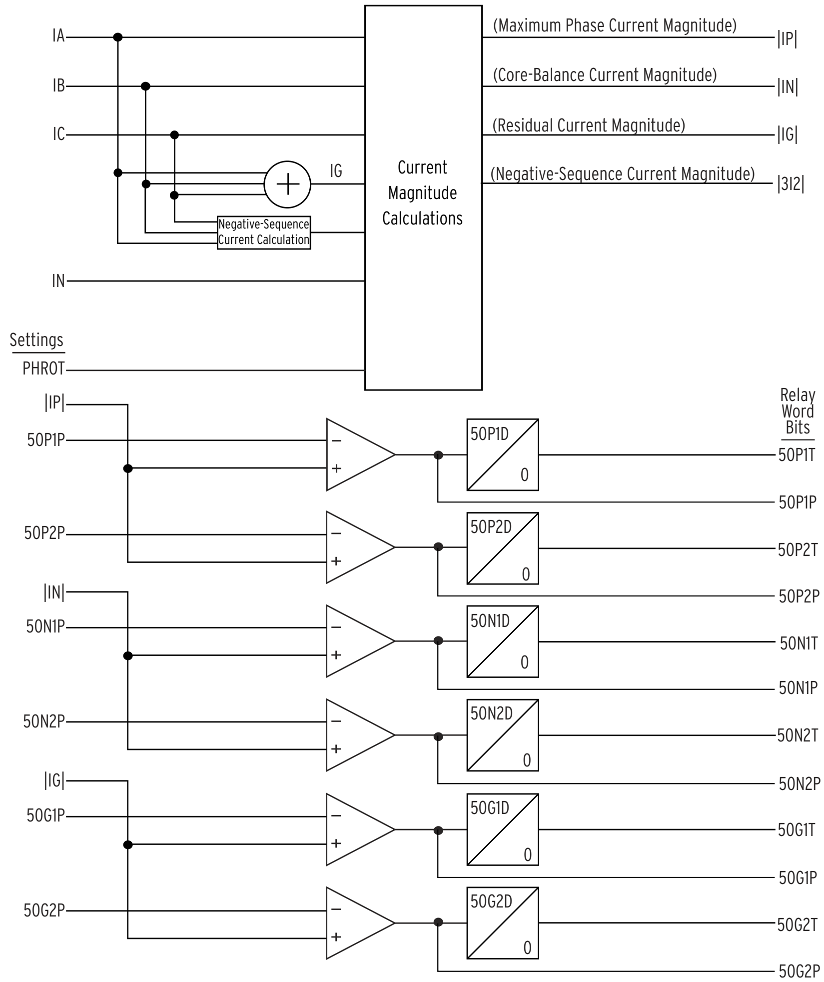


Figure 4.3 Overcurrent Element Logic

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 10:1 core balance CT. The CT secondary is connected to the SEL-749M **IN** current input, as shown in Figure 4.4. Setting the Neutral OC CT Ratio (CTRN, see Main Settings (SET Command) on page 4.3) equal to 10 and Neutral Trip Lvl (50N1P) equal to 5 A with 0.10 second time delay ensures that the element will quickly detect and trip for motor ground faults, but prevent misoperation resulting from unequal breaker or contactor pole closing times.

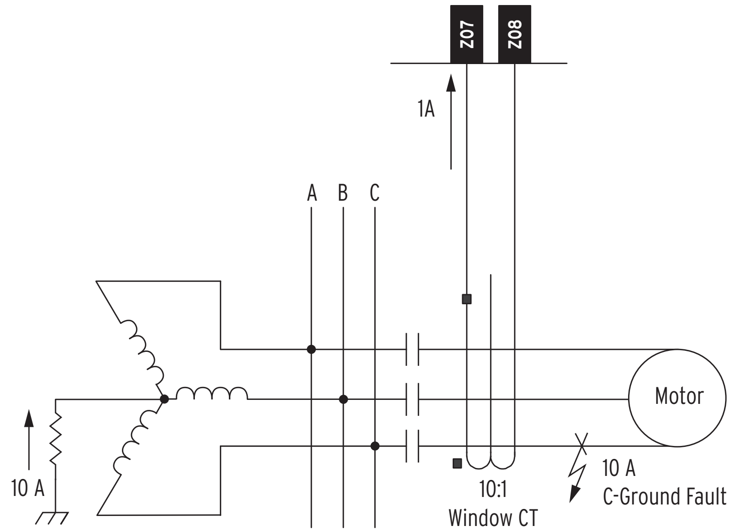


Figure 4.4 Ground Fault Protection Using Core-Balance CT

Table 4.9 Residual Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
RES OC TRIP LVL	Off, 0.10–1.00 xFLA	50G1P := OFF
RES OC TRIP DLAY	0.00–5.00 sec	50G1D := 0.50
RES OC WARN LVL	Off, 0.10–1.00 xFLA	50G2P := OFF
RES OC WARN DLAY	0.0–120.0 sec	50G2D := 10.0

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

When a core balance CT is not available, use the 50G residual overcurrent elements. 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 the warn level more sensitively, but with a longer time delay. The long time delay allows the sensitive warn element to ride through the false residual current that can result from phase CT saturation during motor starting.

Load Jam Elements

Table 4.10 Load Jam Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
JAM TRIP LEVEL	Off, 1.00–6.00 xFLA	LJTPU := OFF
JAM TRIP DELAY	0.0–120.0 sec	LJTDLY := 0.5
JAM WARN LEVEL	Off, 1.00–6.00 xFLA	LJAPU := OFF
JAM WARN DELAY	0.0–120.0 sec	LJADLY := 5.0

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 4.5*). 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 full load amps (FLA) setting.

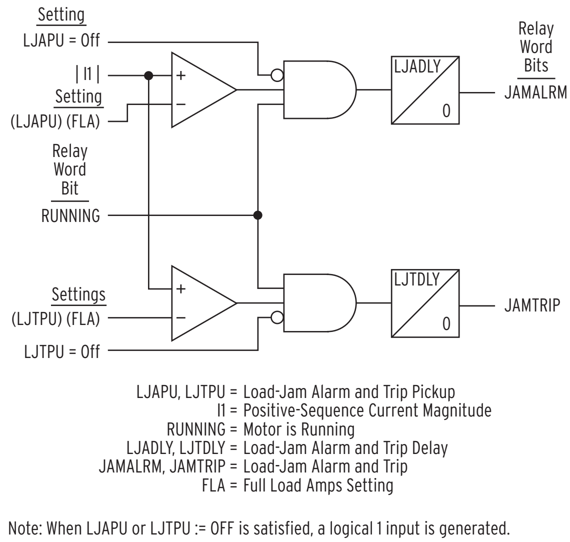


Figure 4.5 Load-Jam Element Logic

Undercurrent (Load Loss) Elements

Table 4.11 Undercurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
UC TRIP LEVEL	Off, 0.10–1.00 xFLA	LLTPU := OFF
UC TRIP DELAY	0.4–120.0 sec	LLTDLY := 5.0
UC WARN LEVEL	Off, 0.10–1.00 xFLA	LLAPU := OFF
UC WARN DELAY	0.4–120.0 sec	LLADLY := 10.0
UC START DELAY	0–1500 sec	LLSDLY := 0

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 *Figure 4.6*). 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.

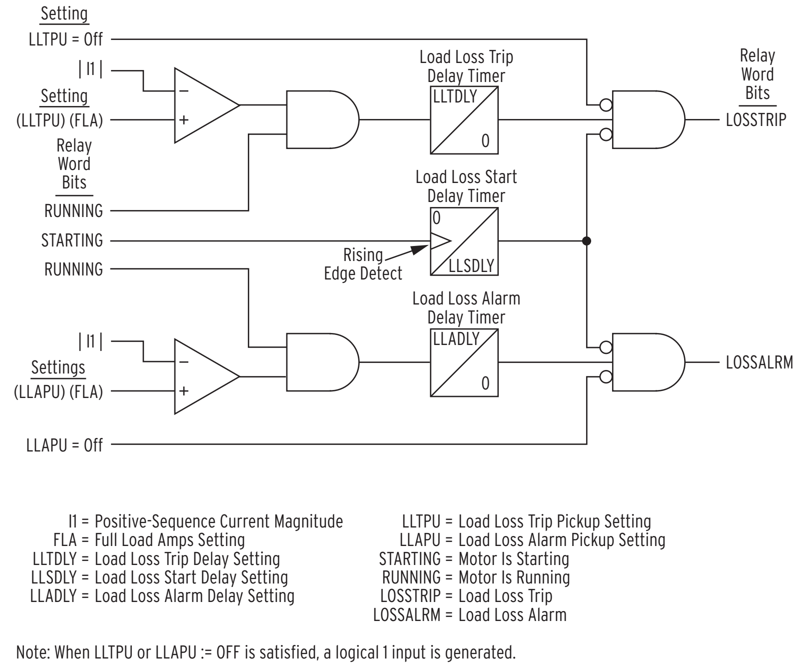


Figure 4.6 Undercurrent (Load-Loss) Logic

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 full load amps (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.

Current Unbalance Elements

Table 4.12 Current Unbalance Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
CI TRIP LEVEL	Off, 5–80%	46UBT := OFF
CI TRIP DELAY	0–240 sec	46UBTD := 5
CI WARN LEVEL	Off, 5–80%	46UBA := 10
CI WARN DELAY	0–240 sec	46UBAD := 10

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-749M motor thermal element models the heating effect of the negative-sequence current, you may want the additional unbalanced and single-phasing protection offered by a current unbalance element.

The SEL-749M 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:

$$\mathrm{UB\%} = 100 \bullet \frac{\mathrm{Im}}{\mathrm{Iav}} \qquad \textbf{Equation 4.5}$$

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

$$UB\% = 100 \cdot \frac{Im}{FLA}$$

Equation 4.6

where

UB% = Current unbalance percentage
Im = Maximum deviation of Iav from highest and lowest magnitudes of the phase currents
Iav = Magnitude of the average phase current
FLA = Motor-rated full load current

In either case, the function is disabled if the average phase current magnitude is less than 25 percent of the full load amps setting (see *Figure 4.7*).

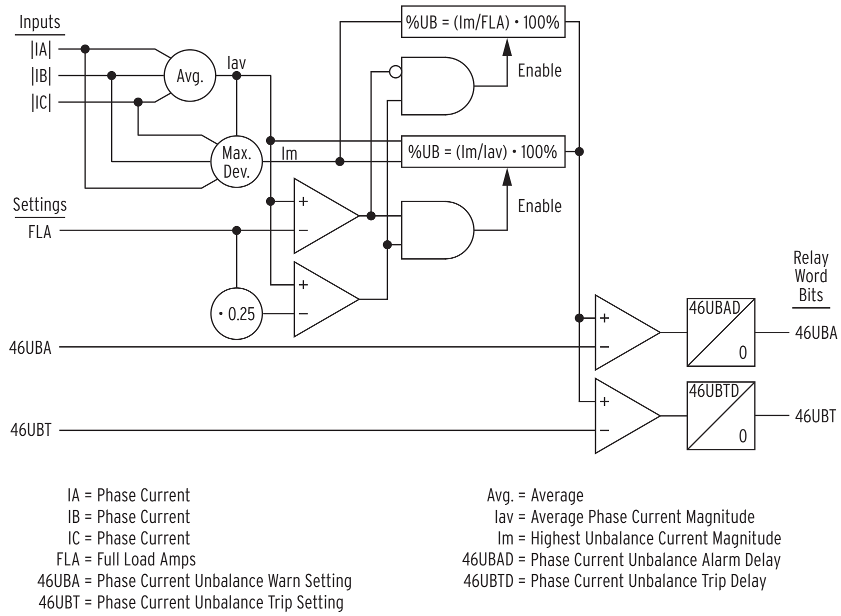


Figure 4.7 Current Unbalance Element Logic

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.

Protection Disable

NOTE: The protection can be seriously jeopardized when either of the inhibit time settings is used. For most applications, set both PROTBL_T and THERBL_T equal to OFF.

NOTE: The SEL-749M determines the motor state (Starting, Running, or Stopped) primarily based on the motor current (see Figure 4.23).

Table 4.13 Protection Disable Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PROT INHIBIT TIME	Off, 1–240 sec	PROTBL_T := OFF
OL INHIBIT TIME	Off, 1–240 sec	THERBL_T := OFF

You can disable trip and warning levels of preselected protection elements for a set time delay during motor starting. Set the protection inhibit time setting (PROTBL_T) for the time you want to disable undercurrent, phase overcurrent, current unbalance, ground fault, and undervoltage elements. Set the overload inhibit time setting (THERBL_T) for the time you want to disable the overload (thermal model) element. If you use the time delay settings, keep the delays as short as possible.

Start Monitoring

Table 4.14 Start Monitor Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
START MOTOR TIME	Off, 1–240 sec	START_T := OFF

NOTE: With Star-Delta (Wye-Delta) starting, the total starting time (Star and Delta) is monitored. If immediate tripping is necessary 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 4.8* shows the typical current during motor start and the START_T time setting.

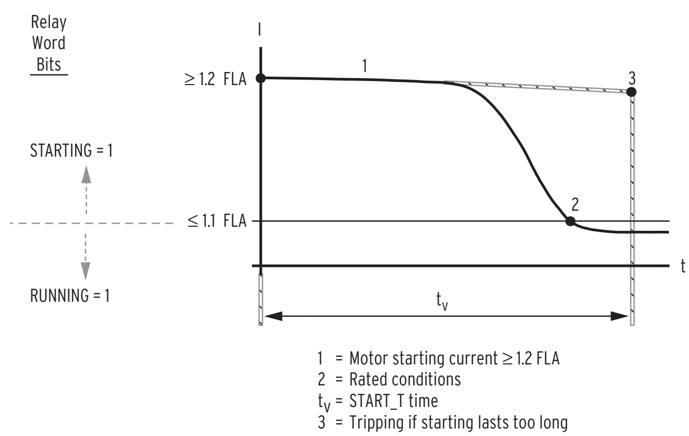


Figure 4.8 Monitoring Starting Time

Star-Delta (Wye-Delta) Starting

Table 4.15 Star-Delta Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
STAR-DELTA ENABL	Y, N	ESTAR_D := N
MAX STAR TIME	Off, 1–600 sec	STAR_MAX := OFF

NOTE: In addition to enabling the Star-Delta, you must assign Star and Delta to Auxiliary output relays (one each); see Figure 2.15 and Figure 2.16 for typical connection diagrams.

The SEL-749M 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 STAR_MAX setting (if used), regardless of magnitude of the starting current.

You can switch on or off, as necessary, 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 you must switch off the motor when the total start time (Star and Delta) exceeds a set time, you must also use start monitoring.

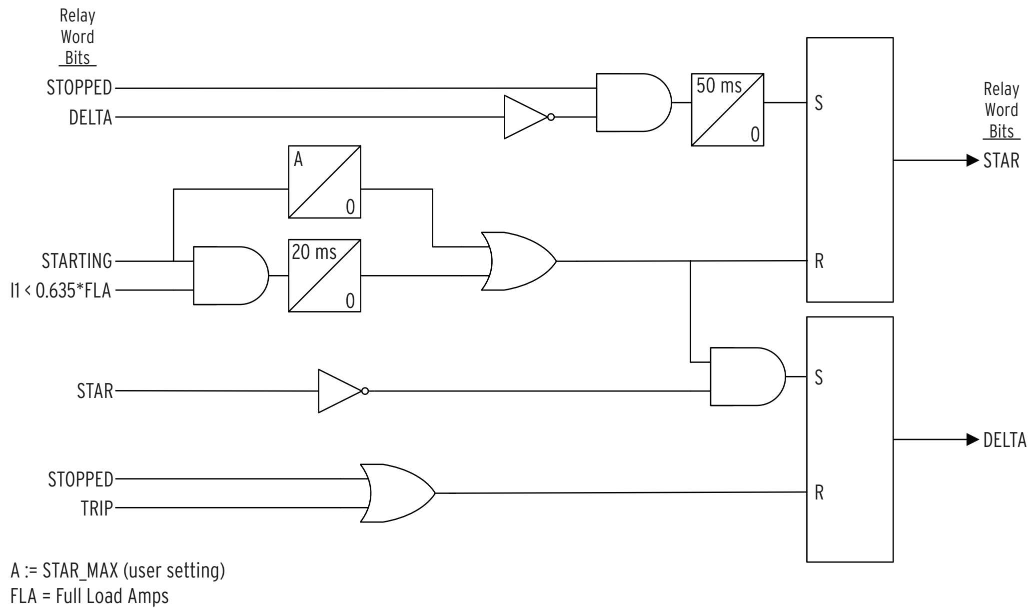


Figure 4.9 Star-Delta Starting

Start Inhibit Function

NOTE: See Figure 4.21 and Figure 4.24 for the logic diagrams.

Table 4.16 Start Inhibit Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
STARTS/HR.	Off, 1–15	MAXSTART := OFF
MIN. OFF TIME	Off, 1–150 min	TBSDLY := OFF
RESTART BLK TIME	Off, 1–60 min	ABSDLY := OFF

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.

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 RESTART BLK 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 the restart block period.

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

Table 4.17 Phase Reversal Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
PH REV. ENABLE	Y, N	E47T := Y

The SEL-749M 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 4.10*).

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.

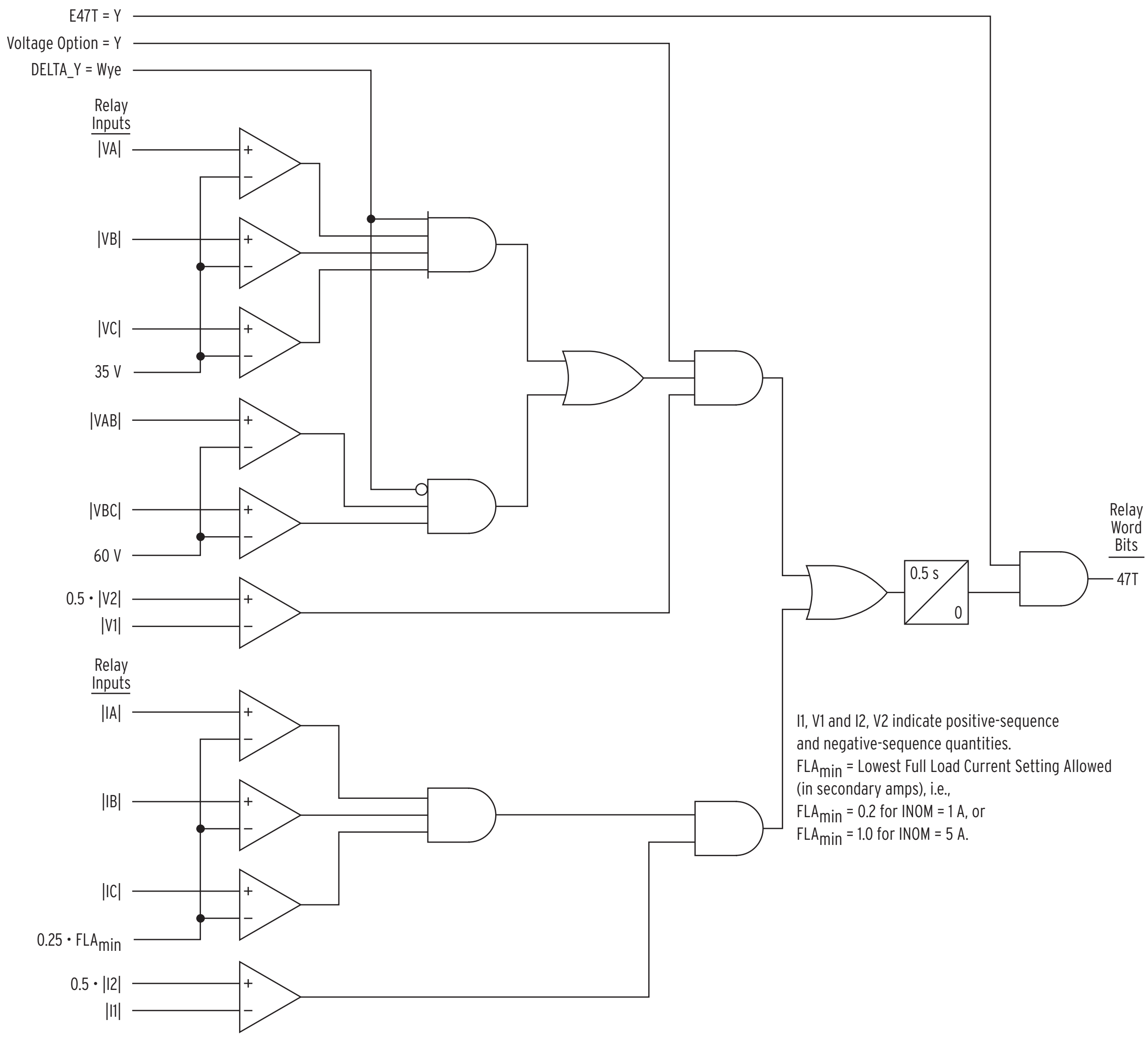


Figure 4.10 Phase Reversal Element Logic

Speed Switch (Stalling During Start) Function

Table 4.18 Speed Switch Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
SS TRIP DELAY	Off, 1–240 sec	SPDSDLYT := OFF
SS WARN DELAY	Off, 1–240 sec	SPDSDLYA := OFF

NOTE: In addition to setting the SS DELAY, you must connect the speed switch contact to an input assigned to the speed switch (see Table 4.32 and Figure 2.7, Figure 2.17 for connection diagrams).

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 SS 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 4.11* shows typical currents during motor start (normal and stall during start) and the SS TRIP DELAY time setting. *Figure 4.12* shows the speed switch logic.

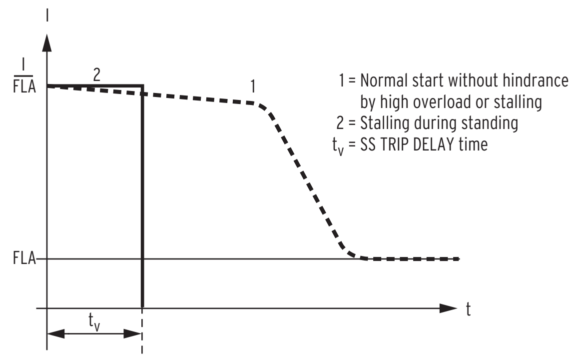


Figure 4.11 Stalling During Starting

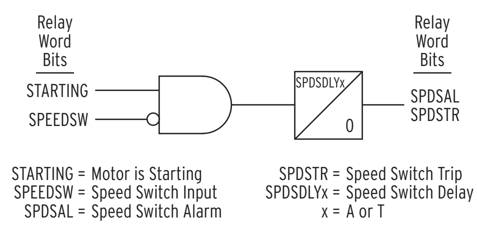


Figure 4.12 Speed Switch Logic

PTC/RTD-Based Protection

Thermistor (PTC) Input Function

Table 4.19 PTC Settings

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

NOTE: In addition to enabling the PTC function, you must also connect at least one thermistor to the relay (see Figure 2.7 for a connection diagram).

You can connect as many as six thermistors detectors (PTC) to the SEL-749M. 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 detectors and their leads are monitored for short circuits.

Figure 4.13 shows the characteristics of the PTC.

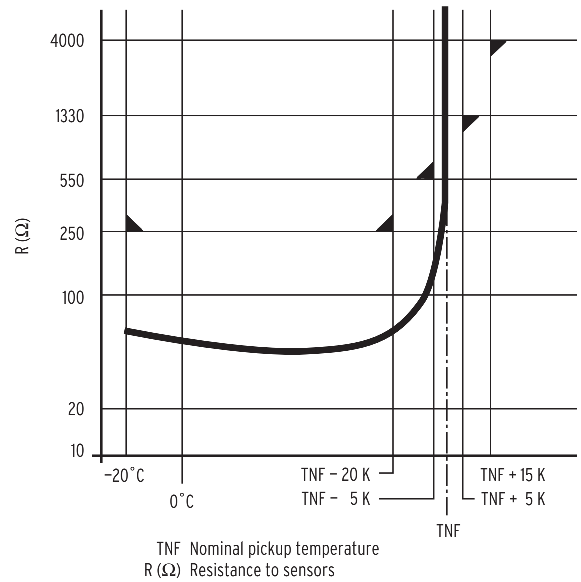


Figure 4.13 Characteristic of PTC Sensors as per IEC 34-11-2

RTD Input Function

When you connect an SEL-2600 series RTD module, the SEL-749M offers several protection and monitoring functions, settings for which are described in *Table 4.20*. See *Figure 2.5* for the location of the RTD module fiber-optic cable connector.

NOTE: The SEL-749M can monitor as many as 12 RTDs connected to an SEL-2600 series RTD module. Table 4.20 shows Location, Type, and Trip/Warn Level settings only for RTD1; settings for RTD2–RTD12 are similar.

NOTE: RTD curves in SEL products are based on the DIN/IEC 60751 standard.

Table 4.20 RTD Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
RTD ENABLE	Y, N	E49RTD := N
RTD1 LOCATION	Off, WDG, BRG, AMB, OTH	RTD1LOC := OFF
RTD1 TYPE	PT100, NI100, NI120, CU10	RTD1TY := PT100
RTD1 TRIP LEVEL	Off, 1–250°C	TRTMP1 := OFF
RTD1 WARN LEVEL	Off, 1–250°C	ALTMP1 := OFF
•	•	•
•	•	•
•	•	•
WIND TRIP VOTING	Y, N	EWDGV := N
BEAR TRIP VOTING	Y, N	EBRGV := N
TMP RTD BIASING?	Y, N	ERTDBIAS := N

When an SEL-2600 series RTD module is not connected to the relay, disable the RTD function by setting E49RTD equal to N.

RTD Location

The relay allows you to independently define the location of each monitored RTD by using the RTD location settings.

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

- ➤ If an RTD is not connected to an input or has failed in place and will not be replaced, set the RTD location for that input equal to OFF.
- ➤ For RTDs embedded in motor stator windings, set the RTD location equal to WDG.
- ➤ For inputs connected to RTDs measuring bearing race temperature, set the RTD location equal to BRG.
- ➤ For the input connected to an RTD measuring ambient motor cooling air temperature, set the RTD location equal to AMB. Only one ambient temperature RTD is allowed.
- ➤ For inputs connected to monitor temperatures of another apparatus, set the RTD location equal to OTH.

The relay allows you to independently define the type of each monitored RTD with the RTD type settings.

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

RTD Type

The four available RTD types are:

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

RTD Trip/Warning Levels

The SEL-749M provides temperature warnings and trips through use of the RTD temperature measurements and the warning and trip temperature settings in *Table 4.20*.

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

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

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

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

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

RTD Biasing

When you have connected an ambient temperature sensing RTD and set trip temperatures for one or more winding RTDs, the relay gives you the option to enable RTD trip temperature biasing by setting ERTDBIAS equal to Y. The thermal model can also be biased by setting ETHMBIAS equal to Y (see *Table 4.6*). When you enable either biasing, the relay does the following:

- Calculates RTD % Thermal Capacity and adds the value to the Thermal Meter values.
- Automatically reduces the winding RTD trip temperatures if ambient temperature rises above 40°C and ERTDBIAS is set equal to Y.
- Automatically reduces the thermal model element trip threshold if ambient temperature rises above 40°C and ETHMBIAS is set equal to Y.
- Provides an RTD bias alarm if the winding temperature exceeds 60°C rise over ambient and the RTD % Thermal Capacity exceeds the thermal element % Thermal Capacity by more than 10 percent.

The relay uses *Equation 4.7* to calculate RTD % Thermal Capacity.

$$\begin{matrix}\text{RTD\%}\\ \text{Thermal Capacity}\end{matrix} = \frac{\begin{pmatrix}\text{Winding RTD}\\ \text{Temperature}\end{pmatrix} - \begin{pmatrix}\text{Ambient}\\ \text{Temperature}\end{pmatrix}}{\begin{pmatrix}\text{Winding RTD Trip}\\ \text{Temperature}\end{pmatrix} - \begin{pmatrix}\text{Ambient}\\ \text{Temperature}\end{pmatrix}} \bullet 100\%$$

Equation 4.7

As ambient temperature rises, the ability of a motor to shed heat to the surroundings is reduced and internal temperatures rise.

When you enable RTD biasing, the SEL-749M automatically reduces the RTD trip temperatures for all winding RTDs when ambient temperature is above 40°C. The relay reduces the trip temperatures by 1°C for each degree rise in ambient temperature over 40°C.

Finally, when you enable thermal model biasing, the relay provides an RTD bias alarm when the RTD % Thermal Capacity exceeds the thermal element % Thermal Capacity by more than 10 percentage points while the winding temperature rise is higher than 60°C over ambient. This alarm can be a useful indicator that the motor has lost coolant flow or that the winding RTD trip temperature is conservatively low.

For all the RTD thermal capacity and bias calculations described previously, the relay uses the winding RTD with the measured temperature closest to the winding trip value.

Voltage-Based Protection

The following information applies to relay models with voltage inputs.

Undervoltage Function

Table 4.21 Undervoltage Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
UV TRIP LEVEL	Off, 0.60–1.00 xVnm	27P1P := 0.80
UV TRIP DELAY	0.0–120.0 sec	27P1D := 0.5
UV WARN LEVEL	Off, 0.60–1.00 xVnm	27P2P := OFF
UV WARN DELAY	0.0–120.0 sec	27P2D := 5.0

Overvoltage Function

Table 4.22 Overvoltage Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
OV TRIP LEVEL	Off, 1.00–1.20 xVnm	59P1P := 1.10
OV TRIP DELAY	0.0–120.0 sec	59P1D := 0.5
OV WARN LEVEL	Off, 1.00–1.20 xVnm	59P2P := OFF
OV WARN DELAY	0.0–120.0 sec	59P2D := 5.0

NOTE: The under- and overvoltage level settings are in per unit nominal voltage, Vnm. The relay automatically calculates Vnm, using the settings VNOM and Delta_Y as follows:
Vnm = VNOM if DELTA_Y := Delta;
Vnm = VNOM/1.732 if DELTA_Y := Wye.

When you connect the SEL-749M voltage inputs to phase-to-phase connected VTs, as in *Figure 2.12*, the relay provides two levels of phase-to-phase overvoltage and undervoltage elements.

When you connect the SEL-749M voltage inputs to phase-to-neutral connected VTs, as in *Figure 2.12*, the relay provides two levels of phase-to-neutral overvoltage and undervoltage elements.

Each of the elements has an associated time delay. You can use these elements as you choose for tripping and warning. *Figure 4.14* and *Figure 4.15* show the logic diagram for the undervoltage and overvoltage elements, respectively. To disable any of these elements, set the level settings equal to OFF.

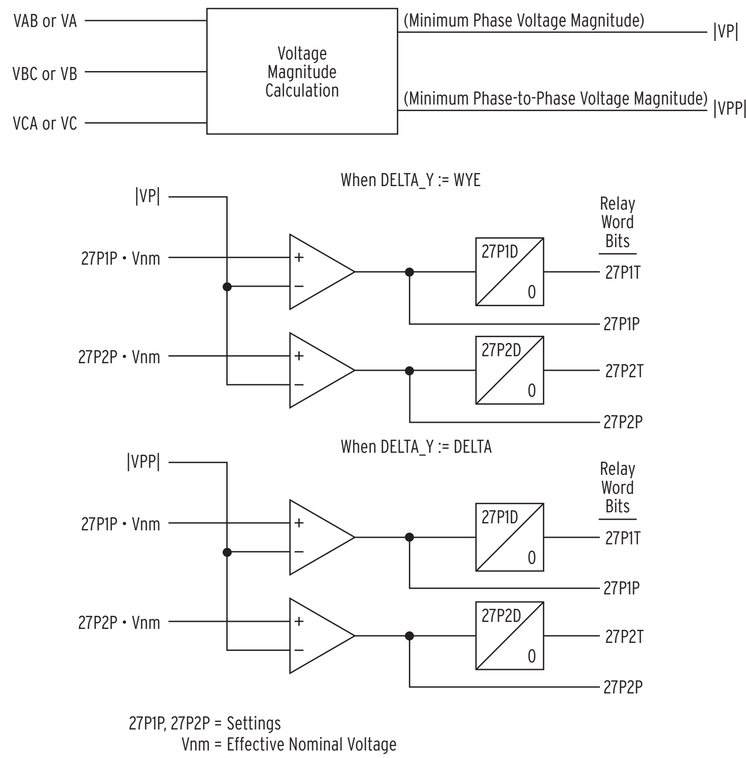


Figure 4.14 Undervoltage Element Logic

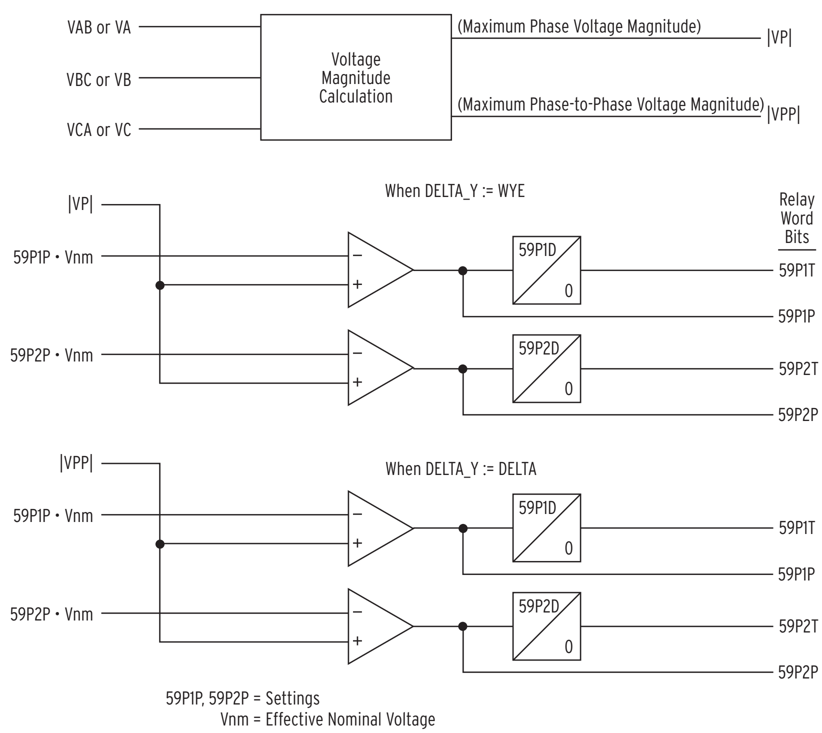


Figure 4.15 Overvoltage Element Logic

VAR Function

NOTE: VAR Trip and Warning Level settings are in primary KVAR.

Table 4.23 VAR Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
NEG VAR TRIP LEV	Off, 1–25000 kVAR	NVARTP := OFF
POS VAR TRIP LEV	Off, 1–25000 kVAR	PVARTP := OFF
VAR TRIP DLY	0–240 sec	VARTD := 1
NEG VAR WARN LEV	Off, 1–25000 kVAR	NVARAP := OFF
POS VAR WARN LEV	Off, 1–25000 kVAR	PVARAP := OFF
VAR WARN DLY	0–240 sec	VARAD := 1

If the positive or negative reactive power exceeds the appropriate level for longer than the time delay setting, the relay can issue a warning or trip signal. The reactive power elements are disabled when the motor is stopped or starting. *Figure 4.16* shows the logic diagram for the VAR elements. These elements can be used to detect synchronous motor out-of-step or loss-of-field conditions.

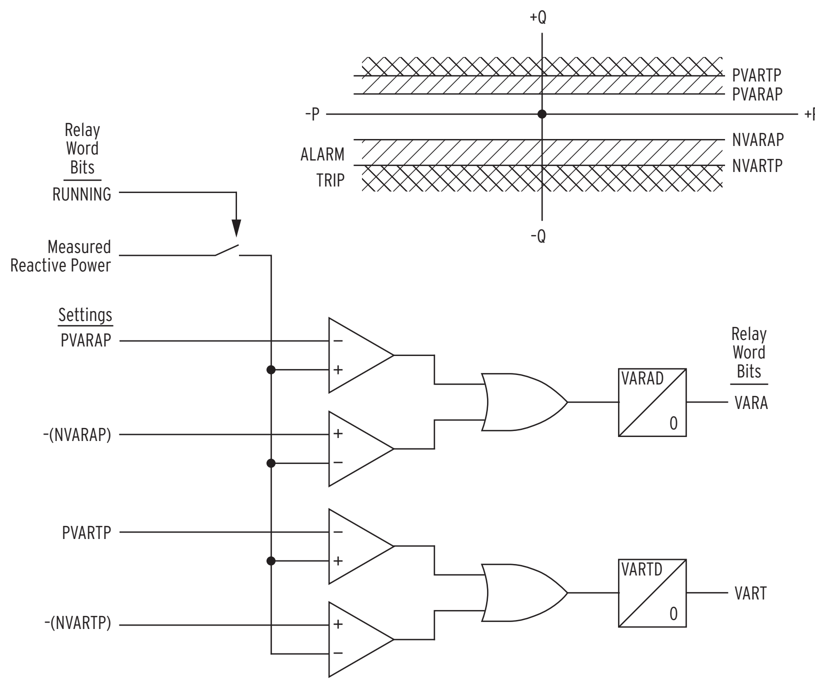


Figure 4.16 Reactive Power (VAR) Element Logic

Refer to *Figure 5.3* for the relay power measurement convention.

For relay application on an induction motor, disable the elements by setting both the negative VAR warn level (NVARAP) and negative VAR trip level (NVARTP) settings to OFF.

Underpower Function

NOTE: Underpower Trip and Warning Level settings are in primary kW.

Table 4.24 Underpower Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
UP TRIP LEVEL	Off, 1–25000 kW	37PTP := OFF
UP TRIP DELAY	0–240 sec	37PTD := 1
UP WARN LEVEL	Off, 1–25000 kW	37PAP := OFF
UP WARN DELAY	0–240 sec	37PAD := 1

If the real three-phase power falls below the warning or trip level for longer than the time delay setting, the relay can issue a warning or trip signal. The underpower elements are disabled when the motor is stopped or starting. *Figure 4.17* shows the logic diagram for the underpower elements. These elements operate in addition to the load loss function, and you can use them to detect motor load loss and other underpower conditions.

You can disable the elements by setting the underpower warning level (37PAP) and underpower trip level (37PTP) settings to OFF.

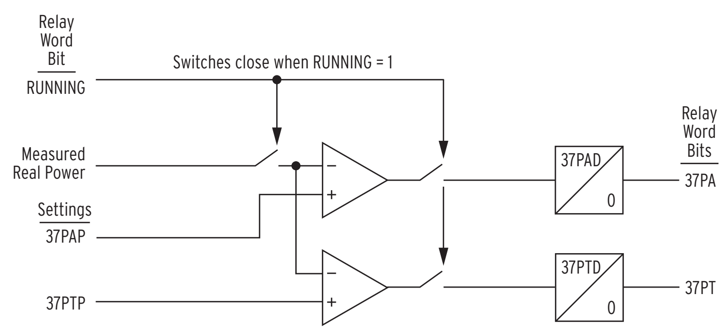


Figure 4.17 Underpower Element Logic

Power Factor Elements

Table 4.25 Power Factor Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PF LAG TRIP LEVL	Off, 0.05–0.99	55LGTP := OFF
PF LD TRIP LEVEL	Off, 0.05–0.99	55LDTP := OFF
PF TRIP DELAY	0–240 sec	55TD := 1
PF LAG WARN LEVL	Off, 0.05–0.99	55LGAP := OFF
PF LD WARN LEVEL	Off, 0.05–0.99	55LDAP := OFF
PF WARN DELAY	0–240 sec	55AD := 1

If the measured power factor falls below the leading or lagging level for longer than the time delay setting, the relay can issue a warning or trip signal. The power factor elements are disabled when the motor is stopped or starting. *Figure 4.18* 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 5.3* 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.

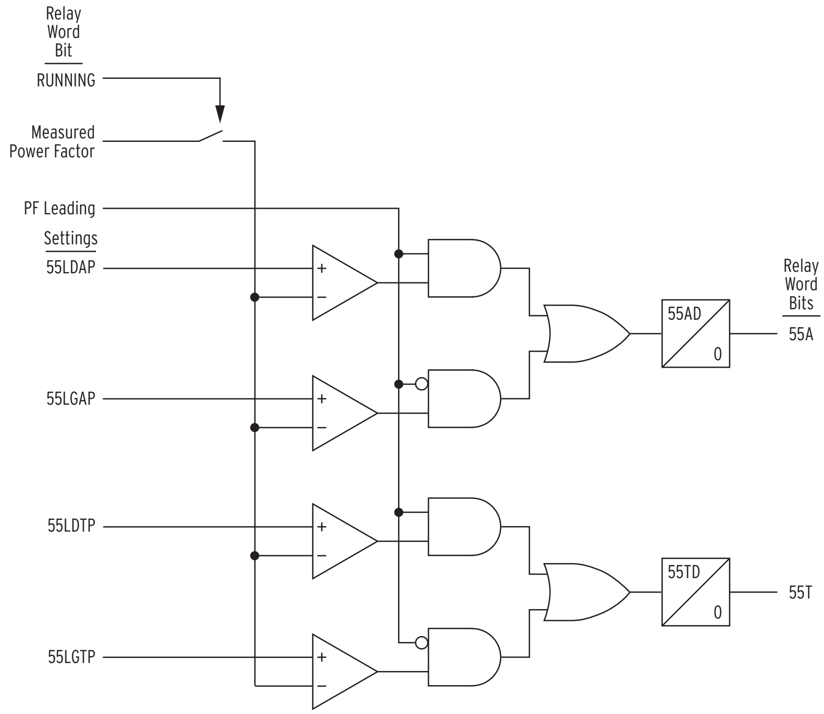


Figure 4.18 Power Factor Elements Logic

Loss-of-Potential (LOP) Protection

The SEL-749M sets Relay Word bit LOP (loss-of-potential) upon detecting a loss of relay ac voltage input such as that caused by blown potential fuses or by the operation of molded-case circuit breakers. Because accurate relaying potentials are necessary for certain protection elements (undervoltage 27 elements, for example), you can use the loss-of-potential function to supervise these protection elements.

The relay declares a loss-of-potential when there is more than a 25 percent drop in the measured positive-sequence voltage (V1) with no corresponding magnitude or angle change (greater than a pre-determined threshold) in positive-sequence (I1), negative-sequence (I2), or zero-sequence currents (I0).

If this condition persists for 60 cycles, then the relay latches the LOP Relay Word bit at logical 1. The relay resets LOP when the positive-sequence voltage (V1) returns to a level greater than 75 percent of nominal while negative-sequence voltage (V2) and zero-sequence voltage (V0) are both less than 5 V secondary (VNOM and PTR are relay settings).

Settings

The loss-of-potential function has no settings and is always active. You must incorporate the LOP function in a SELOGIC control equation in order to supervise relay protection elements (see *Example 4.7*).

LOP Impact on Other Protection Elements

Undervoltage and directional power elements require accurate relaying potentials for correct operation. It is critical that the relay detects a loss-of-potential condition and prevents operation of these elements. For example, when a technician drops a wrench on the phase-voltage input fuse holders, the relay LOP logic accurately determines that this loss of input voltages is a loss-of-potential condition and does not trip (if the LOP Relay Word bit supervises selected tripping elements, see *Example 4.7*). If you are using voltage-determined relay elements for tripping decisions, then blocking these elements is crucial when the voltage component is no longer valid.

EXAMPLE 4.7 Supervising Voltage-Element Tripping With Loss-of-Potential

Use the loss-of-potential function to supervise undervoltage tripping. If you use the undervoltage trip element 27P1, then change a portion of the SV01 equation to the following:

SV01 := .... OR (NOT LOP AND 27P1T) 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 37PT OR 55T OR VART)) 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 a loss-of-potential 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.

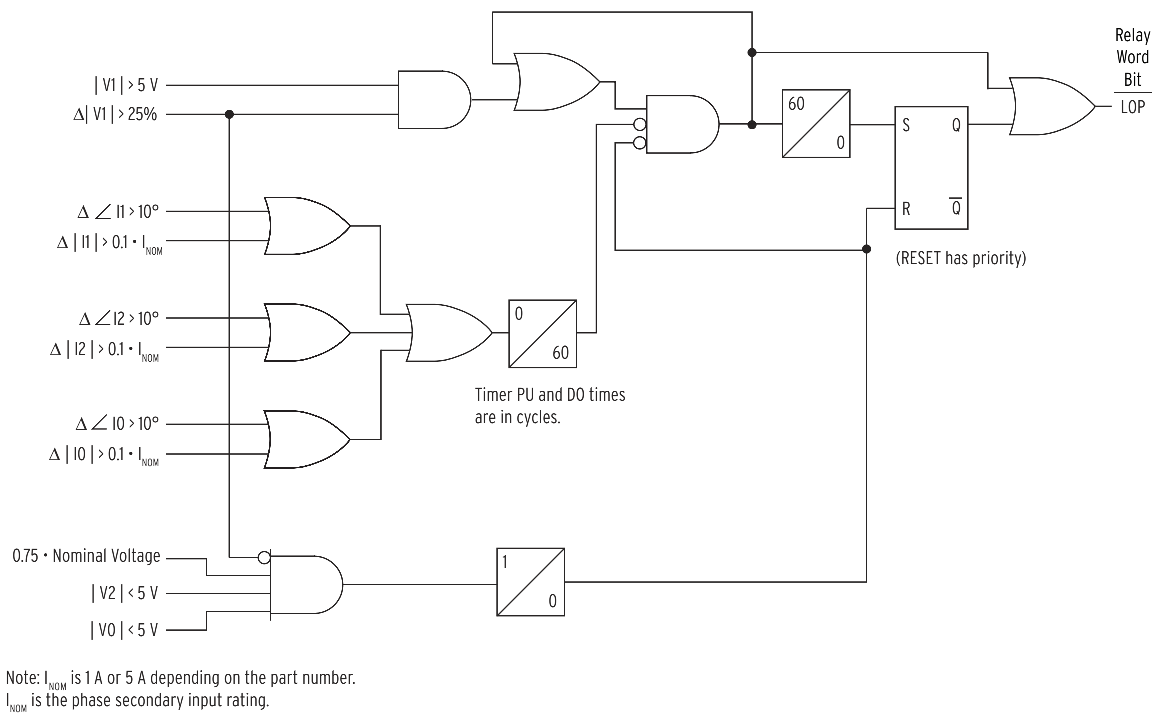


Figure 4.19 Loss-of-Potential (LOP) Logic

Frequency and Load Control Settings

Frequency Tracking

NOTE: The relay tracks and measures system frequency for these elements with the positive-sequence voltage, if the voltage input option is present and the applied positive-sequence voltage is greater than 0.75 volts for at least four cycles. Otherwise, the relay uses positive-sequence current as long as it is greater than 0.25 A (5 A nominal) or 0.05 A (1 A nominal).

The SEL-749M relay tracks frequency between 44–66 Hz. The tracking algorithm uses V1 (positive-sequence voltage) if available, and greater than 0.75 V. For models without voltage inputs or when the voltage is below 0.75 V the relay uses I1 (positive-sequence current).

The Relay Word bit FREQ is asserted when the relay is tracking frequency. The frequency is clamped at the maximum (66 Hz) or minimum (44 Hz) when it crosses the bounds. When there is no frequency measurement due to low voltage and current, the relay switches to nominal frequency.

Frequency Elements

NOTE: The setting range for Trip and Warn Levels shown in Table 4.26 are for FNOM := 60 Hz. The setting ranges will be "Off, 45.0–55.0 Hz" when FNOM := 50 Hz.

Table 4.26 Frequency Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
FREQ1 TRIP LEVEL	Off, 55.0–65.0 Hz	81D1TP := OFF
FREQ1 TRIP DELAY	0.0–240.0 sec	81D1TD := 1.0
FREQ1 WARN LEVEL	Off, 55.0–65.0 Hz	81D1AP := OFF
FREQ1 WARN DELAY	0.0–240.0 sec	81D1AD := 1.0
FREQ2 TRIP LEVEL	Off, 55.0–65.0 Hz	81D2TP := OFF
FREQ2 TRIP DELAY	0.0–240.0 sec	81D2TD := 1.0
FREQ2 WARN LEVEL	Off, 55.0–65.0 Hz	81D2AP := OFF
FREQ2 WARN DELAY	0.0–240.0 sec	81D2AD := 1.0

The SEL-749M provides two warning and two trip over- or underfrequency elements with independent level and time-delay settings. When an element level setting is less than the nominal frequency setting, the element operates as an underfrequency element. When the level setting is greater than the nominal frequency setting, the element operates as an overfrequency element. *Figure 4.20* shows the logic diagram for the frequency elements.

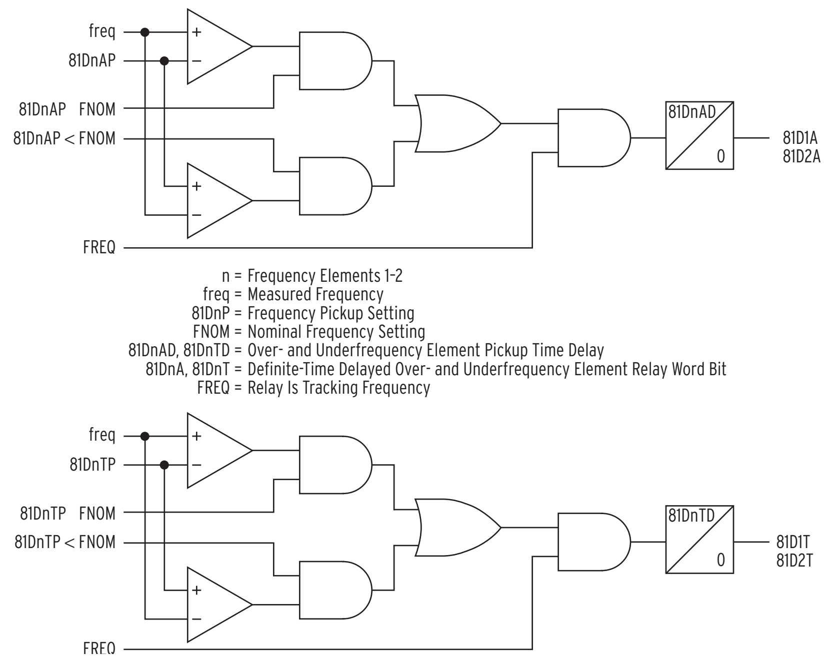


Figure 4.20 Over- and Underfrequency Element Logic

Load Control Function

NOTE: Prompt of the settings LOADUPP and LOADLOWP are dependent on the LOAD setting. All possible prompts are shown in Table 4.27. The relay will show only the appropriate prompts based on the LOAD setting.

Table 4.27 Load Control Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
LOAD CONTROL SEL	Off, Current, Power, TCU	LOAD := OFF
LD CTL CUR UPPER	Off, 0.20–2.00 xFLA	LOADUPP := OFF
LD CTL CUR LOWER	Off, 0.20–2.00 xFLA	LOADLOWP := OFF
LD CTL PWR UPPER	Off, 1–25000 kW	LOADUPP := OFF
LD CTL PWR LOWER	Off, 1–25000 kW	LOADLOWP := OFF
LD CTL TCU UPPER	Off, 1–99 %TCU	LOADUPP := OFF
LD CTL TCU LOWER	Off, 1–99 %TCU	LOADLOWP := OFF

NOTE: In addition to setting the load control levels, you must assign LOADUP and LOADLOW to auxiliary output relays (one each); see Table 4.37, and Figure 2.7 for connection diagrams.

The SEL-749M provides an ability to control external devices based on the parameter load control selection. You can select current, power, or thermal capacity utilized to operate auxiliary outputs. Load control is active only when the motor is in the running state. It is disabled when relay word bit 50S asserts (current exceeds 2.5 pu).

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 greater than the lower-level setting for one second.

You can use this feature to control the motor load within set limits.

I/O Configuration

Analog Output

Table 4.28 Analog Output Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
ANALOG OUT SEL	LOAD_I, AVG_I, MAX_I, %THERM, WDG_RTD, BRG_RTD, PWR_kW, PF	AOPARM := LOAD_I

The SEL-749M provides a 4–20 mA dc analog current output with a variety of output parameters. Use the analog output select setting (AOPARM) to select the necessary parameter from the list of available options. *Table 4.29* shows description and scaling of the output for different parameter selections.

Table 4.29 Scaling of Analog Output

ANALOG OUT SEL (AOPARM)	Description	Output Scaling (4 mA–20 mA) (Unit)
LOAD_I	Average Load Current	0.0–1.0 Per Unit of FLA
AVG_I	Average Load Current	0.2–2.0 Per Unit of FLA
MAX_I	Maximum of the Phase Currents	0.2–2.0 Per Unit of FLA
%THERM	Percentage Thermal Capacity	0–100 %TCU
WDG_RTD	Hottest Winding RTD Temperature	0–250 Degrees C
BRG_RTD	Hottest Bearing RTD Temperature	0–250 Degrees C
PWR_kW	Motor Power	0.0–1.0 per unit FLVA
PF	Motor Power Factor	0.8 Lag–0.8 Lead

Select LOAD_I to scale the analog output based on motor current if the output is not of interest during overload conditions. Select either AVG_I or MAX_I to scale the analog output based on motor current and if the output is required during overload conditions.

Both LOAD_I and AVG_I use an average magnitude of three phase currents to drive the analog output; MAX_I uses a maximum magnitude of the three phase currents.

If the relay includes the voltage input option, and you select PWR_kW parameter, the analog output full scale reference is per unit, full load apparent power, FLVA. *Equation 4.8* defines per unit FLVA:

$$FLVA = 1.732 \bullet (VNOM) \bullet FLAn \qquad \textbf{Equation 4.8}$$

where:

VNOM = Nominal voltage setting

FLA*n* = Full Load Current setting (n = 1 for Speed-1, or n = 2 for Speed-2)

The analog output sends real power in kW, which is always less than the full-scale analog output (in pu FLVA) because of the motor power factor.

If the relay includes the voltage input option, and you select the PF parameter, the analog output will be scaled using power factor. For power factors 0.8 lag, unity, and 0.8 lead, the analog outputs will be 4 mA, 12 mA, and 20 mA, respectively.

Trip Inhibit (Block) Function

Table 4.30 Trip Inhibit Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
BLOCK PROTECT	SELOGIC Variable	BLKPROT := 0
CURRENT IMBALANC	Y, N	BLK46 := N
JAM	Y, N	BLK48 := N
GROUND FAULT	Y, N	BLK50EF := N
SHORT CIRCUIT	Y, N	BLK50P := N
UNDERCURRENT	Y, N	BLK37 := N
START INHIBIT	Y, N	BLK66 := N
PTC	Y, N	BLK49PTC := N
RTD	Y, N	BLK49RTD := N

You can assign any control input to the SELOGIC control equation BLKPROT. One or more protective functions listed in *Table 4.30* can be inhibited when the BLKPROT control input asserts.

During certain operational phases, when the level (e.g., motor current) differs from normal values, selected functions are completely disabled as long as the control input is asserted. For operational phases such as those listed below, you could have no warning, no trip or reset, and tripping delays that begin to run only after the function is reenabled:

- During starting (earth fault and short-circuit protection)
- At no-load (protection against asymmetry and underload)
- During brief overload phases (high overload/jam)
- During commissioning and fault location (localizing the source of the trouble)

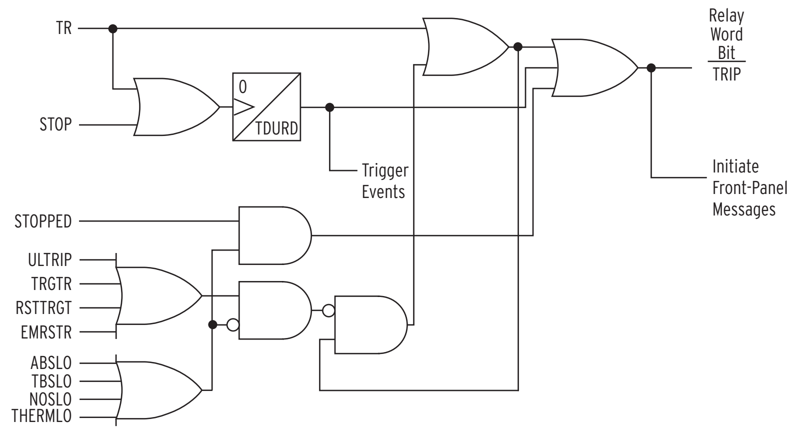
Trip/Close Logic

Table 4.31 Trip and Close Logic Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
MIN TRIP TIME	0.0–400.0 sec	TDURD := 0.5
TRIP EQUATION	SV	TR := 49T OR LOSSTRIP OR JAMTRIP OR 46UBT OR 50P1T OR 50G1T OR 59P1T OR 47T OR 55T OR SPDSTR OR 50N1T OR SMTRIP OR 81D1T OR 81D2T OR SV01T
REMOTE TRIP EQN	SV	REMTRIP := 0
UNLATCH TRIP EQN	SV	ULTRIP := 0
CONTACTOR STATUS	SV	52A := NOT IN101

NOTE: The factory-default assignment of the Relay Word bit TRIP is the output OUT103. See Table 4.37 for the output contacts settings.

The SEL-749M 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 motor contactor or breaker. *Figure 4.21* illustrates the tripping logic.



TRGTR = Target Reset Command, Front Panel or Serial Ports
RSTTRGT = Target Reset SELOGIC Control Equation
STOP = Motor Stop Command, Front Panel or Serial Ports
TR = Trip SELOGIC Control Equation
ULTRIP = Unlatch Trip SELOGIC Control Equation
EMRSTR = Emergency Start Command, Front Panel or Modbus/DeviceNet Command
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

Figure 4.21 Stop/Trip Logic

The trip logic settings, including the SELOGIC control equations, are described below.

TDURD MINIMUM TRIP TIME

This timer establishes the minimum time duration for which the TRIP Relay Word bit asserts. This is a rising edge initiated timer.

Trips initiated by the STOP Relay Word bit (asserted at the front-panel or by the STOP serial port command) are maintained for at least the duration of the minimum trip duration time (TDURD) setting.

TR TRIP CONDITIONS SELOGIC CONTROL EQUATION

The SEL-749M Trip Logic offers two ways to stop the protected motor:

- Conditions mapped to TR
- Front panel or serial port (including Modbus and DeviceNet) **STOP** command

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 OUT103 set to TRIP and fail-safe setting OUT103FS at Y. See *Section 2: Installation*, *Fail-Safe/Nonfail-Safe Tripping on page 2.16*.

NOTE: You can use an indirect mapping (e.g., SV01T) as in the factory-default setting. See Table 4.36 for the SV01 settings.

Set the TR SELOGIC control equation to include an OR-combination of all the enabled protection element Relay Word bits that you want to cause the relay to trip. Use the factory-default setting as a guideline.

REMTRIP REMOTE TRIP CONDITIONS SELOGIC CONTROL EQUATION

The REMTRIP SELOGIC control equation is intended to define a remote trip condition.

For example, the following settings will trip the breaker by input IN303 via REMTRIP.

REMTRIP := IN303

TR := ...OR REMTRIP

The HMI will display **Remote Trip** to indicate the trip by remote trip logic.

ULTRIP UNLATCH TRIP CONDITIONS SELOGIC CONTROL EQUATION

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.

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

- 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.
- One of the following occurs:
  - Unlatch Trip SELOGIC control equation setting ULTRIP asserts to logical 1.
  - Target Reset SELOGIC control equation setting RSTTRGT asserts to logical 1.
  - Target Reset Relay Word TRGTR asserts. The TRGTR is asserted when the front-panel **RESET** pushbutton is pressed or a target reset serial port command is executed (ASCII, Modbus, or DeviceNet).
  - An **EMERGENCY RESTART** command is executed or the EMRSTR SELOGIC control equation setting asserts to logical 1.

Lockout After Stop

The relay automatically locks out the motor by asserting the trip signal under any of the following conditions:

- **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 (TCU) 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.

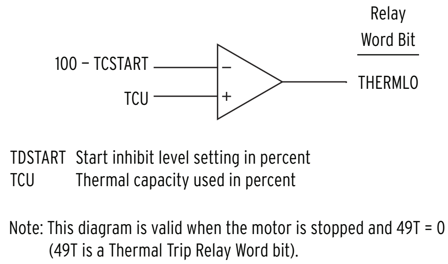


Figure 4.22 Thermal Element Lockout Logic

If any of the previous protection functions is not enabled by the relay settings, that function does not affect trip unlatch.

Also note that the relay automatically asserts the trip signal if the motor stops and a lockout condition is in effect. The trip signal is maintained until all the enabled motor lockout conditions are satisfied.

52A CONTACTOR/BREAKER STATUS CONDITIONS SELOGIC CONTROL EQUATION

NOTE: When the 52A is used with an appropriate control input, it enhances the motor state logic (see Figure 4.23). This is particularly important if the motor has low operational idling current (less than 10 percent FLA).

NOTE: Set 52A := 0 if you do not connect the contactor/breaker auxiliary contact to the relay input.

You can connect an auxiliary contact of the contactor or the breaker to the relay. The SELOGIC control equation 52A allows you to configure the relay for either 52b or 52a contact input (or other contact that indicates the motor is switched on). The factory-default setting assumes connection of the 52b contact to input IN101 (see *Figure 2.7* for the input/output connections).

If you do not connect the 52b contact to input IN101, you must change the factory-default logic equation 52A. For example, set 52A := IN101 if you connect the 52a contact to input IN101.

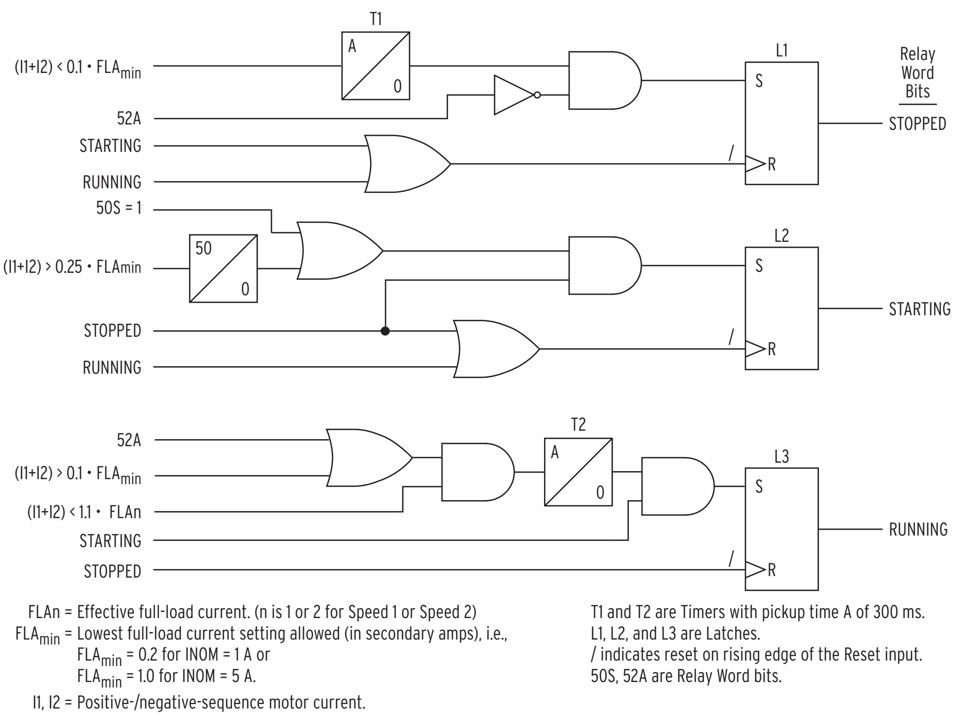


Figure 4.23 Motor State Logic

Motor Control

The Motor Control settings interface the SEL-749M for external start control and motor speed control. *Table 4.32* lists these SELOGIC control equation settings.

Table 4.32 Motor Control Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
START EQUATION	SV	STREQ := 0
EMERGENCY START	SV	EMRSTR := IN102 AND STOPPED
SPEED 2	SV	SPEED2 := 0
SPEED SWITCH	SV	SPEEDSW := 0

Start Controls

Figure 4.24 shows the logic the relay uses to initiate motor starts.

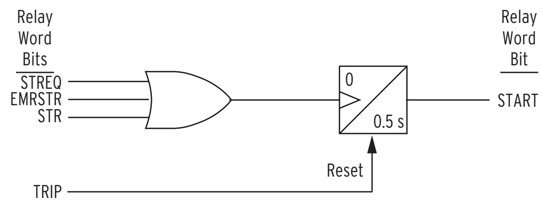


Figure 4.24 Start Logic

If the TRIP Relay Word bit is not asserted, the relay asserts the START Relay Word bit in response to any of the following conditions:

- Start motor signal received from SELOGIC control equation STREQ.
- Emergency restart signal received from SELOGIC control equation EMRSTR, front panel, or Modbus/DeviceNet command.
- Start motor signal is received from the front panel or serial ports.

The START Relay Word bit remains asserted for 0.5 seconds, unless the relay trips. If the relay trips before the 0.5 second timer expires, the relay resets the timer, clearing the START Relay Word bit.

In an emergency, it may be necessary to quickly start the motor even though a protection lockout condition exists and is holding the **TRIP** output asserted. The lockout might be a result of the thermal element or another protection function (see *Figure 4.21*). You can override all of the lockout conditions. Use the emergency restart function.

The relay asserts the emergency restart bit (EMRSTR) in response to any of the following conditions:

- The control input assigned to EMRSTR asserts.
- The relay receives an emergency restart control command from front panel or Modbus/DeviceNet command.

When the emergency restart bit asserts, the relay does the following:

- ➤ Resets the motor thermal element capacity used to 0 percent.
- ➤ Manipulates the starts-per-hour, minimum time between starts, and antibackspin functions to permit an immediate start.
- ➤ Deasserts the **TRIP** output if no fault detecting element is picked up.
- ➤ Initiates a motor start through the logic shown in *Figure 4.24*.

Speed Controls

You can assign any control input to the SELOGIC control equations SPEED2 and SPEEDSW. When SPEED2 control input is asserted **and** the two-speed enable setting E2SPEED is Y (see *Table 4.2*) the SEL-749M selects second values for the settings shown in *Table 4.33*. See *Table 4.2* and *Table 4.4* for full description of various settings. Use the SPEED2 input for two-speed motor applications. You can also use this input to change the settings 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. *Speed Switch (Stalling During Start) Function on page 4.21* for more detail

Table 4.33 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 (CTR1)	CT RATIO–2nd (CTR2)
Full Load Current	MOTOR FLA (FLA1)	MOTOR FLA–2nd (FLA2)
Locked Rotor Current	MOTOR LRC (LRA1)	MOTOR LRC–2nd (LRA2)
Hot Locked Rotor Time	LOCKED ROTOR TIME (LRTHOT1)	MOTOR LRT–2nd (LRTHOT2)
Acceleration Factor	ACCEL FACTOR (TD1)	ACCEL FACT–2nd (TD2)
Run State Time Constant	RUN STATE TIME K (RTC1)	RUN ST TC–2nd (RTC2)
Overload Curve Number	THERM OL CURVE1 (CURVE1)	THERM OL CURVE2 (CURVE2)

Logic Settings (SET L Command)

NOTE: SV in the Setting Range column of the settings tables indicates SELOGIC control equation.

Settings associated with latches, timers, and output contacts are listed below. *Logic Functions on page 4.47* explains the settings and operation of the logic input/output and the SELOGIC control equations of the SEL-749M.

SELOGIC Enables

Table 4.34 SELOGIC Enable Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
SELOGIC LATCHES	N, 1–8	ELAT := N
SV/TIMERS	N, 1–8	ESV := 1

The enable settings ELAT and ESV control the settings shown in *Table 4.35* and *Table 4.36*. This helps limit the number of settings that need to be made.

Latch Bits Equations

NOTE: The SEL-749M includes eight latches. Table 4.35 shows settings only for Latch 1; settings for Latch 2-Latch 8 are similar.

Table 4.35 Latch Bits Equations Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
SET01	SV	SET01 := NA
RST01	SV	RST01 := NA
•		
•		
•		

SV/Timers Set

NOTE: The SEL-749M includes eight SELOGIC variable/timers. Table 4.36 shows settings only for SV01 and SV02; settings for SV03–SV08 are similar to SV02.

Table 4.36 SELOGIC Variable/Timer Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
SV TIMER PICKUP	0.00–3000.00 sec	SV01PU := 0.00
SV TIMER DROPOUT	0.00–3000.00 sec	SV01DO := 0.00
SV INPUT EQ	SV	SV01 := WDGTRIP OR BRGTRIP OR OTHTRIP OR AMBTRIP OR REM-TRIP OR 37PT OR VART OR PTC-TRIP
SV TIMER PICKUP	0.00–3000.00 sec	SV02PU := 0.00
SV TIMER DROPOUT	0.00–3000.00 sec	SV02DO := 0.00
SV INPUT EQ	SV	SV02 := NA
•		
•		
•		

Output Contacts

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

Table 4.37 Control Output Equations and Contact Behavior Settings

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

The SEL-749M 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 you apply relay control power. The output falls to its de-energized position when you remove control power. Contact positions with de-energized output relays are indicated on the relay chassis and in *Figure 2.7*.

When TRIP output fail-safe is enabled 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, disable TRIP output fail-safe by selecting N.

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.

Global Settings (SET G Command)

General Settings

Table 4.38 General Global Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PHASE ROTATION	ABC, ACB	PHROT := ABC
RATED FREQ.	50, 60 Hz	FNOM := 60
DATE FORMAT	MDY, YMD, DMY	DATE_F := MDY

The phase rotation setting tells the relay your phase labeling standard. Set PHROT equal to ABC when B-phase current lags A-phase current by 120°. Set PHROT equal to ACB when B-phase current leads A-phase current by 120°.

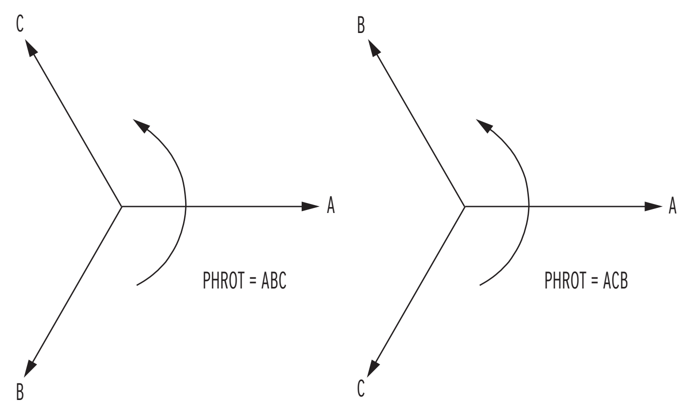


Figure 4.25 Phase Rotation Setting

Set the FNOM setting equal to your system nominal frequency. The DATE_F setting allows you to change the relay date presentation format to either North American standard (Month/Day/Year), engineering standard (Year/Month/Day), or European standard (Day/Month/Year).

Data Reset

Table 4.39 Target Reset Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
TARGET RESET EQ	SV	RSTTRGT := 0

The RSTTRGT setting resets the trip output and front-panel **TRIP** LED, provided there is no trip condition present (including start inhibit lockouts). See *Figure 4.21* for more details. You should assign a contact input (e.g., RSTTRGT := IN401) if you want remote target reset.

Access Control

Table 4.40 Setting Change Disable Setting

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

NOTE: DSABLSET does not disable the setting changes from the serial ports.

The DSABLSET setting defines conditions for disabling all front-panel setting changes. You can view the settings but cannot change relay settings when the Relay Word bit DSABLSET is asserted. You can assign a contact input (e.g., DSABLSET := IN402) if you want to disable setting changes from the front panel.

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

Port Settings (SET P Command)

The SEL-749M provides settings that allow you to configure the parameters for the communications ports. See *Section 7: Communications* for a detailed description. The front-panel Serial Port **F** and the rear Port **3** consist of EIA-232. The rear Port **4** consists of EIA-485 (Port **4A**) or EIA-232 (Port **4C**). See *Figure 2.4* for the rear-panel layout. *Table 4.41* through *Table 4.43* show the serial port settings.

Port F

Table 4.41 Front-Panel Serial Port F Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
PROTOCOL	SEL, MOD	PROTO := SEL
SPEED	300–38400 bps	SPEED := 9600
DATA BITS	7, 8 bits	BITS := 8
PARITY	O, E, N	PARITY := N
STOP BITS	1, 2 bits	STOP := 1
PORT TIME-OUT	0–30 min	T_OUT := 5
SEND AUTOMESSAGE	Y, N	AUTO := N

NOTE: The Modbus protocol is available on Port F, Port 3, and Port 4. These ports can support Modbus sessions concurrently.

Table 4.41 Front-Panel Serial Port F Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
HDWR HANDSHAKING	Y, N	RTSCTS := N
FAST OP MESSAGES	Y, N	FASTOP := N
MODBUS SLAVE ID	1–248	SLAVEID := 1

Port 3

Table 4.42 Rear-Panel Serial Port 3 Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PROTOCOL	SEL, MOD	PROTO := SEL
SPEED	300–38400 bps	SPEED := 9600
DATA BITS	7, 8 bits	BITS := 8
PARITY	O, E, N	PARITY := N
STOP BITS	1, 2 bits	STOP := 1
PORT TIMEOUT	0–30 min	T_OUT := 5
SEND AUTOMESSAGE	Y, N	AUTO := N
HDWR HANDSHAKING	Y, N	RTSCTS := N
FAST OP MESSAGES	Y, N	FASTOP := N
MODBUS SLAVE ID	1–248	SLAVEID := 1

Port 4

Table 4.43 Rear-Panel Serial Port 4 Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
COMM INTERFACE	232, 485	COMMINF := 485
PROTOCOL	SEL, MOD	PROTO := MOD
SPEED	300–38400 bps	SPEED := 19200
DATA BITS	7, 8 bits	BITS := 8
PARITY	O, E, N	PARITY := N
STOP BITS	1, 2 bits	STOP := 2
PORT TIMEOUT	0–30 min	T_OUT := 0
SEND AUTOMESSAGE	Y, N	AUTO := N
HDWR HANDSHAKING	Y, N	RTSCTS := N
FAST OP MESSAGES	Y, N	FASTOP := N
MODBUS SLAVE ID	1–248	SLAVEID := 248

Set the speed, data bits, parity, and stop bits settings to match the serial port configuration of the equipment that is communicating with the serial port.

After Port Timeout minutes of inactivity on a serial port at Access Level 2, the port automatically returns to Access Level 1. This security feature helps prevent unauthorized access to the relay settings if the relay is accidentally left in Access Level 2. If you do not want the port to time out, set Port Timeout equal to 0 minutes.

Set PROTO := SEL (standard SEL ASCII protocol) or MOD (Modbus RTU protocol) for Port F, Port 3, and Port 4 as necessary for your application. Note that the Modbus protocol is available at Port F, Port 3, and Port 4 and that all three ports can support concurrent Modbus sessions, if necessary. For detailed information, refer to *Appendix C: SEL Communications Processors* and *Appendix D: Modbus RTU Communications Protocol*.

Set the AUTO := Y to allow automatic messages at a serial port.

The relay EIA-232 serial ports support software (XON/XOFF) flow control. If you want to enable support for hardware (RTS/CTS) flow control, set the RTSCTS setting equal to Y.

Set FASTOP := Y to enable binary Fast Operate messages at the serial port. Set FASTOP := N to block binary Fast Operate messages. Refer to *Appendix C: SEL Communications Processors* for the description of the SEL-749M Fast Operate commands.

Use the Port 4 factory-default settings to establish communications when the DeviceNet card is in use. *Table 4.44* shows the additional settings, which you can set only at the rear on the DeviceNet card. Once the relay detects the DeviceNet card, all Port 4 settings are hidden. Refer to *Appendix E: DeviceNet* for details on DeviceNet.

Table 4.44 Rear-Panel DeviceNet Port Settings

Setting Name	Setting Range
MAC_ID	0–63
ASA	8 Hex characters assigned by factory
DN_Rate	125, 250, 500 kbps

Front-Panel Set (SET F Command)

General Settings

Table 4.45 General LCD Display Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
LCD TIMEOUT	Off, 1–30 min	FP_TO := 15
LCD CONTRAST	1–8	FP_CONT := 5

Use the front-panel LCD timeout setting (FP_TO) as a security measure. If the display is within an Access Level 2 function, such as the relay setting entry, the function is automatically terminated (without saving changes) after inactivity for this length of time. The front-panel display will return to the default display (see *Table 4.46* for the default rotating display settings).

If you prefer to disable the front-panel timeout function during relay testing, set the LCD timeout equal to OFF. Use the front-panel LCD contrast setting (FP_CONT) to adjust the contrast of the liquid crystal display.

Display Enable

NOTE: The rotating display is updated approximately every two (2) seconds.

Table 4.46 Display Enable Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
TIME & DATE	Y, N	FP_TD := N
GROUND CURRENT	Y, N	FP_GC := N
CURRENT IMBALANC	Y, N	FP_LA := N
FREQUENCY	Y, N	FP_MF := N
THERM CAP USED	Y, N	FP_TH := N

Table 4.46 Display Enable Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
VOLTAGE IMBALANC	Y, N	FP_VA := N
POWER	Y, N	FP_PE := N
RTD TEMPERATURE	Y, N	FP_RTD := N
CLOSE RESET LEDS	Y, N	RSTLED := Y

The relay default front-panel rotating display shows unit identifiers (see *Table 4.1*) and magnitudes of measured phase currents and, if included, phase-to-phase voltages.

The display enable settings give you the option to add quantities listed in *Table 4.46* to the default display. When you select Y for a quantity, it will be added to the rotating display.

Voltage unbalance and power displays require the voltage input option. When the relay is equipped with external RTD inputs and the display enable RTD temperature setting (FP_RTD) equals Y, the relay displays the temperatures of the hottest winding, bearing, and other RTDs, plus the ambient temperature.

Target LED Set

Table 4.47 Target LED Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
TRIP LATCH T_LED	Y, N	T01LEDL := Y
LED1 EQUATION	SV	T01_LED := 49T OR AMBTRIP OR BRGTRIP OR OTHTRIP OR WDGTRIP
TRIP LATCH T_LED	Y, N	T02LEDL := Y
LED2 EQUATION	SV	T02_LED := 50P1T OR 50N1T or 50G1T
TRIP LATCH T_LED	Y, N	T03LEDL := Y
LED3 EQUATION	SV	T03_LED := 46UBT OR 47T
TRIP LATCH T_LED	Y, N	T04LEDL := Y
LED4 EQUATION	SV	T04_LED := LOSSTRIP OR 37PT
TRIP LATCH T_LED	Y, N	T05LEDL := Y
LED5 EQUATION	SV	T05_LED := (NOT STOPPED AND 27P1T) OR 59P1T
TRIP LATCH T_LED	Y, N	T06LEDL := Y
LED6 EQUATION	SV	T06_LED := 81D1T OR 81D2T

The SEL-749M settings T01_LED through T06_LED control the six front-panel LEDs (see *Figure 8.1* and *Figure 8.7* for the programmable LED locations).

NOTE: If the LED TRIP 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.

The target LEDs can be either trip-type (corresponding setting T0*n*LEDL := Y) or status-type (setting T0*n*LEDL := N). With T*n*LEDL set to Y, the LEDs latch the LED start at TRIP assertion. To reset these latched LEDs, the trip condition should no longer exist and one of the following takes place:

- Pressing **TARGET RESET** on the front panel.
- Issuing the serial port command **TAR R**.
- The assertion of the SELOGIC control equation RSTTRGT.

With T*n*LEDL settings set to N, the LEDs do not latch and directly follow the state of the associated SELOGIC control equation setting.

Enter any of the Relay Word bits (or combination of the 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.

Report Settings (SET R Command)

The report settings use Relay Word bits for the SER and event report trigger as shown in *Table 4.48* and *Table 4.49*. See *Appendix G: Relay Word Bits* for detail. Refer to *Section 9: Analyzing Events* for additional information about SER and event reports.

SER Trigger Lists

Table 4.48 SER[a] Trigger Settings

Setting Prompt	Setting Name := Factory Default
SER1	SER1 := IN101 IN102 IN401 IN402 IN403 TRIP RTDIN OUT101 OUT102 OUT103 OUT401 OUT402 OUT403 OUT404 ABSLO TBSLO NOSLO THERMLO
SER2	SER2 := 49T LOSSTRIP JAMTRIP 46UBT 50P1T RTDT PTCTRIP 50G1T VART 37PT 27P1T 59P1T 47T 55T SPDSTR 50N1T SMTRIP 81D1T 81D2T OTHTRIP
SER3	SER3 := AMBTRIP PTCFLT RTDFLT COMMIDLE COMMLOSS REMTRIP RSTTRGT 49A LOSSALRM JAMALRM 46UBA RTDA 55A 50N2T 50G2T VARA 37PA 27P2T 59P2T
SER4	SER4 := SPDSAL 81D1A 81D2A OTHALRM AMBALRM SALARM WARNING LOADUP LOADLOW 50P2T STOPPED RUNNING STARTING STAR DELTA START SPEED2

[a] Use as many as 24 Relay Word elements separated by spaces or commas for each setting.

Event Report Set

Table 4.49 Event Report Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
EVENT TRIGGER	SV	ER := R_TRIG LOSSALRM OR R_TRIG 46UBA OR R_TRIG 49A OR R_TRIG 37PA OR R_TRIG 55A OR R_TRIG VARA
EVENT LENGTH	15, 64 cyc	LER := 15
PREFAULT LENGTH	1–59 cyc	PRE := 5

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

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

Start Report Setting

Table 4.50 Motor Start Report Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
MSR RESOLUTION	0.25, 0.5, 1, 2, 5 cyc	MSRR := 5

The setting MSRR defines resolution of the motor start report; refer to *Section 5: Metering and Monitoring* for additional information.

Logic Functions

This subsection explains the settings and operation of the logic input/output of the SEL-749M, including the following:

- Optoisolated Inputs
- Remote Control Switches
- Latch Control Switches
- SELOGIC Control Equation Variables/Timers
- Output Contacts

Introduction

Table 4.51 describes all of the logic input/output of the SEL-749M.

Table 4.51 SEL-749M Logic Inputs and Outputs

Description	Setting
Optoisolated inputs	IN101–IN102
Optoisolated inputs (Optional)	IN401–IN403
Optoisolated inputs (Optional)	IN301–IN308
Remote control switches	Remote bits RB1–RB8
Latch control switches	Latch bits LT01–LT08
SELOGIC control equations variables/timers	SV01/SV01T–SV08/SV08T
Output contacts	OUT101–OUT103
Output contacts (Optional)	OUT401–OUT404

Optoisolated Inputs

Figure 4.26 and *Figure 4.27* show the resultant Relay Word bits that follow corresponding optoisolated inputs for the different SEL-749M models. Inputs IN301–IN308 operate similarly and the resultant Relay Word bits are IN301–IN308.

The figures show examples of energized and de-energized optoisolated inputs and corresponding Relay Word bit states. To assert an input, apply rated control voltage to the appropriate terminal pair (see *Figure 2.5* and *Figure 2.7*).

Figure 4.26 is used for the following discussion/examples. The optoisolated inputs in *Figure 4.27* operate similarly.

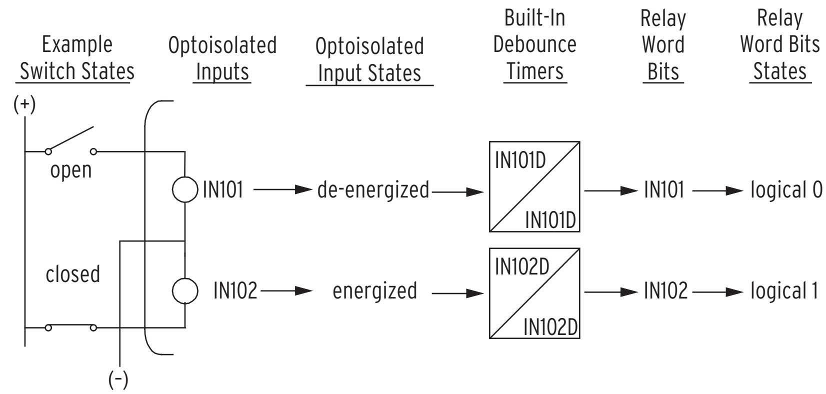


Figure 4.26 Example Operation of Optoisolated Inputs IN101–IN102

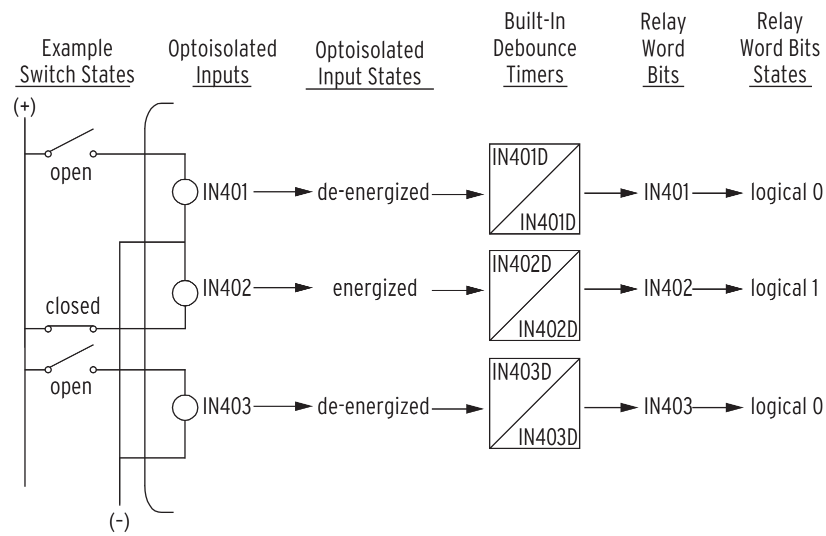


Figure 4.27 Example Operation of Optoisolated Inputs IN401–IN403

The control signal can be ac or dc. The input has a maximum pickup time of 3/4 cycle and a maximum dropout time of 3/4 cycle.

The relay processing interval is 1/4 cycle, so Relay Word bits IN101–IN102 are updated every 1/4 cycle.

If more than 3/4 cycle of debounce is necessary, run Relay Word bit IN*n* (*n* = 101–102) through a SELOGIC control equation variable timer and use the output of the timer for input functions (see *Figure 4.31*).

Input Functions

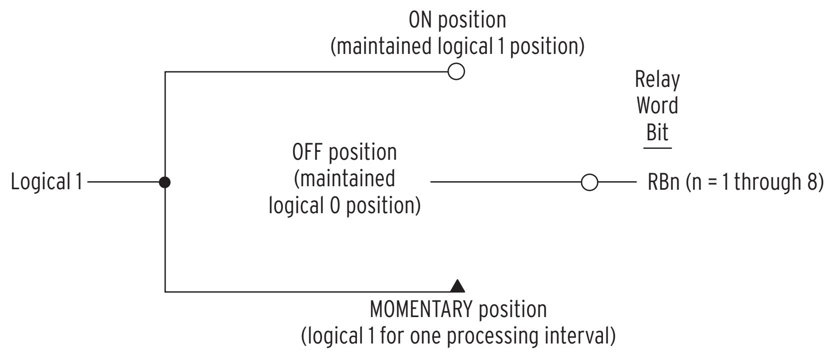
There are no optoisolated input settings such as IN101 := OUT101 or IN102 := ER1.

Optoisolated inputs **IN101** and **IN102** control Relay Word bits IN101 and IN102 that are used in SELOGIC control equations.

Remote Control Switches

Remote control switches are operated via the serial communications port only (see *CONTROL Command (Control Remote Bit) on page 7.14*).

The outputs of the remote control switches in *Figure 4.28* are Relay Word bits RB*n* (*n* = 1–8), called remote bits. Use these remote bits in SELOGIC control equations.



The switch representation in this figure is derived from the standard:

Graphic Symbols for Electrical and Electronics Diagrams
IEEE Standard 315-1975, CSA Z99-1975, ANSI Y32.2-1975
4.11 Combination Locking and Nonlocking Switch, Item 4.11.1

Figure 4.28 Remote Control Switches Drive Remote Bits RB1–RB8

Any given remote control switch can be put in one of the following three positions:

ON	(logical 1)
OFF	(logical 0)
MOMENTARY	(logical 1 for one processing interval–1/4 cycle)

Remote Bit States When Power Lost

The states of the remote bits (Relay Word bits RB1–RB8) are not retained if relay power is cycled. The remote control switches always come back in the OFF position (corresponding remote bit is deasserted to logical 0) when power is restored to the relay.

Remote Bit States When Settings Changed

The state of each remote bit (Relay Word bits RB1–RB8) is retained if relay settings are changed.

If a remote control switch is in the ON position (corresponding remote bit is asserted to logical 1) before a setting change, it comes back in the ON position (corresponding remote bit is still asserted to logical 1) after the change. If a remote control switch is in the OFF position (corresponding remote bit is deasserted to logical 0) before a settings change, it comes back in the OFF position (corresponding remote bit is still deasserted to logical 0) after the change.

Remote Control Switch MOMENTARY Position

This subsection describes how to operate remote bit RB3 as a momentary switch. You can make RB1–RB8 operate in the same way.

The **CON 3** command and **PRB 3** subcommand place Remote Control Switch 3 into the MOMENTARY position for one processing interval, regardless of the initial state of the switch. Remote Control Switch 3 is then placed in the OFF position.

If RB3 is initially at logical 0, pulsing it with the **CON 3** command and **PRB 3** subcommand will change RB3 to logical 1 for one processing interval and then return it to logical 0. In this situation, the R_TRIG RB3 (rising edge operator) will also assert for one processing interval, followed by the F_TRIG RB3 (falling edge operator) one processing interval later.

If RB3 is initially at logical 1 instead, pulsing it with the **CON 3** command and **PRB 3** subcommand will change RB3 to a logical 0. In this situation, the R_TRIG RB3 (rising edge operator) will not assert, but the F_TRIG RB3 (falling edge operator) will assert for one processing interval.

Latch Bits

Latch control switches (latch bits are the outputs of these switches) replace traditional latching relays. Traditional latching relays maintain output contact state. The SEL-749M latch control switches also retain state even when power to the relay is lost. If the latch control switch is set to a programmable output contact and power to the relay is lost, the state of the latch control switch is stored in nonvolatile memory, but the relay de-energizes the output contact. When power to the relay is restored, the programmable output contact will go back to the state of the latch control switch after relay initialization.

Traditional latching relay output contact states are changed by pulsing the latching relay inputs (see *Figure 4.29*). Pulse the set input to close (set) the latching relay output contact. Pulse the reset input to open (reset) the latching relay output contact. The external contacts wired to the latching relay inputs are often from remote control equipment (e.g., SCADA, RTU).

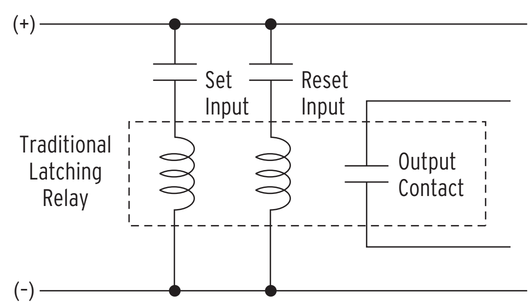


Figure 4.29 Traditional Latching Relay

Eight latch control switches in the SEL-749M provide latching relay functionality.

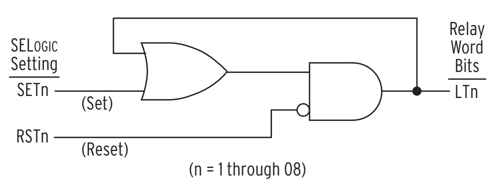


Figure 4.30 Latch Control Switches Drive Latch Bits LT01–LT08

The output of the latch control switch in *Figure 4.30* is a Relay Word bit LT*n* (*n* = 01–08), called a latch bit. The latch control switch logic in *Figure 4.30* repeats for each latch bit LT01–LT08. Use these latch bits in SELOGIC control equations.

These latch control switches each have the following SELOGIC control equation settings:

SET*n* (set latch bit LT*n* to logical 1)

RST*n* (reset latch bit LT*n* to logical 0)

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.

Latch Bits: Nonvolatile State

Power Loss

NOTE: If a latch bit is set to a programmable output contact, such as OUT103 := LT02, and power to the relay is lost, the relay retains the state of the latch bit in nonvolatile memory but de-energizes the output contact. When power to the relay is restored, the programmable output contact will go back to the state of the latch bit after relay initialization.

The states of the latch bits (LT01–LT08) are retained if power to the relay is lost and then restored. If a latch bit is asserted (e.g., LT02 := logical 1) when power is lost, it is asserted (LT02 := logical 1) when power is restored. If a latch bit is deasserted (e.g., LT03 := logical 0) when power is lost, it is deasserted (LT03 := logical 0) when power is restored.

Settings Change

If individual settings are changed the states of the latch bits (Relay Word bits LT01 through 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 through 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 an EEPROM self-test failure. **An average of 70 cumulative latch bit state changes per day can be made for a 25-year relay service life**.

NOTE: Use caution in setting SELOGIC control equations SETn and RSTn for any given latch bit LTn (n = 01–08), to avoid exceeding the EEPROM write limit.

Settings SET*n* and RST*n* cannot result in continuous cyclical operation of latch bit LT*n*. Use timers to qualify conditions set in settings SET*n* and RST*n*. If you use any optoisolated inputs in settings SET*n* and RST*n*, the inputs each have a separate debounce timer that can help in providing the necessary time qualification.

SELOGIC Control Equation Variables/ Timers

The SEL-749M has eight (8) SELOGIC control equation variables/timers. Each SELOGIC control equation variable/timer has a SELOGIC control equation setting input and variable/timer outputs as shown in *Figure 4.31*.

Timers SV01T through SV08T in *Figure 4.31* have a setting range of 0.00–3000.00 seconds in 1/4-cycle increments

These timer setting ranges apply to both pickup and dropout times (SV*n*PU and SV*n*DO, *n* = 1 through 8).

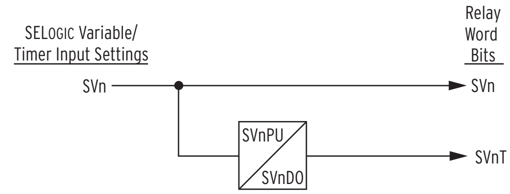


Figure 4.31 SELOGIC Control Equation Variables/Timers SV01/SV01T–SV8/SV8T

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. *Table 4.52* contains a summary of operators available in the SEL-749M.

Operator Precedence

When you combine several operators and operands within a single expression, the SEL-749M 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 relay evaluates the NOT operation of SV04 first and uses the result in subsequent evaluation of the expression. Operator precedence is shown in *Table 4.52*.

Table 4.52 Operator Precedence

Operator	Description
( )	Parenthesis
NOT	Boolean Complement
R_TRIG	Rising Edge Trigger
F_TRIG	Falling Edge Trigger
AND	Boolean AND
OR	Boolean OR

Timers Reset When Power Lost or Settings Changed

If the relay loses power or settings change, the SELOGIC control equation variables/timers reset. Relay Word bits SV*n* and SV*n*T (*n* = 1–8) reset to logical 0 after power restoration or a settings change.

Figure 4.32 shows an effective seal-in logic circuit, created by the use of Relay Word bit SV07 (SELOGIC control equation variable SV07) in SELOGIC control equation SV07:

SV07 = **(SV07 OR OUT101) AND (OUT102 OR OUT401)**

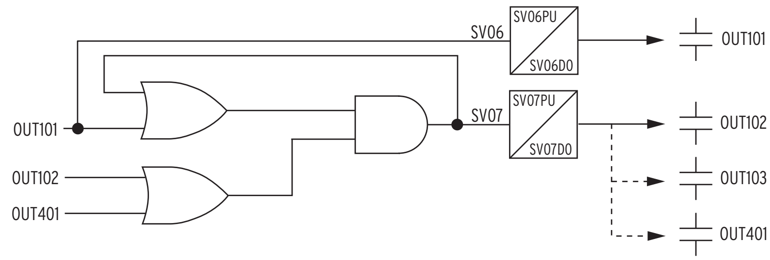


Figure 4.32 Example Use of SELOGIC Variables/Timers

Output Contacts

Figure 4.33 shows the example operation of output contact Relay Word bit OUT101 resulting from SELOGIC control equation operation.

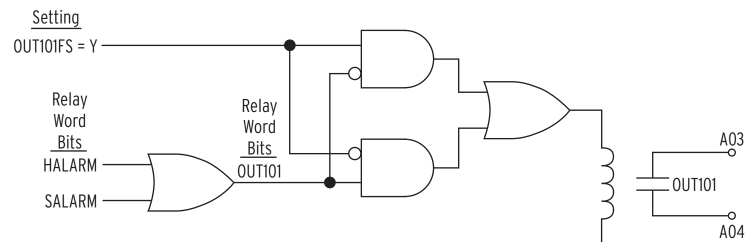


Figure 4.33 Factory-Default Contact Output OUT101 Operation

Factory Setting Example

In the factory SELOGIC control equation settings, three output contacts are used:

NOTE: See Table 4.37 for a complete list of the output settings.

OUT101FS := Y	**OUT102FS := N**	**OUT103FS := Y**
OUT101 := SALARM OR HALARM	**OUT102 := START**	**OUT103 := TRIP**

Operation of Output Contact

The assertion of SELogic control equation setting OUT*m* (*m* = 101–404) to logical 1 asserts the corresponding Relay Word bit OUT*m* (*m* = 101–404) to logical 1.

The assertion of Relay Word bit OUT*m* (*m* = 101–404) to logical 1 causes the output contact **OUTm** to change state. Depending on the contact type (a or b) and the fail-safe setting, the output contact closes or opens. An a contact output is open when the output coil is de-energized and closed when the output coil is energized. A b contact output is closed when the output contact coil is de-energized and open when the output contact coil is energized.

Output contact pickup/dropout time is 8 ms.

Configuring an Output as an Alarm Output Contact

Refer to *Figure 4.33* and *Self-Test on page 10.11*.

Use the SALARM and HALARM bits to develop the output **OUT101** as an alarm output contact. The alarm logic SALARM and/or HALARM keeps the output contact coil energized. Loss of relay power or assertion of the SALARM and/or HALARM de-energizes the coil and opens the output **OUT101** contact.

Relay Word bit SALARM and/or HALARM assert to logical 1 when the relay detects an alarm condition. In addition, when the relay enters Access Level 2, the SALARM Relay Word bit momentarily asserts to logical 1.

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Section 5

Metering and Monitoring

Overview

The SEL-749M Motor Protection Relay includes metering functions to display the present values of current, voltage (if included), and RTD measurements (with an external SEL-2600 series RTD module). The relay provides the following methods to read the present meter values:

- Front-panel rotating display
- Front-panel menu
- EIA-232 serial ports (using SEL ASCII text commands or ACSELERATOR QuickSet SEL-5030 Software)
- Modbus via Port **3** or Port **4**
- DeviceNet port
- Analog output

For monitoring and preventive maintenance purposes, the SEL-749M provides a motor operating statistics report, available using either the front panel, the serial port, or the optional DeviceNet port.

Also helpful in preventive maintenance tasks, the SEL-749M 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.

Metering

The SEL-749M meter data fall into the following categories:

- Fundamental metering
- Thermal metering
  - Thermal model metering
  - RTD metering (with an external SEL-2600 series RTD module)

Table 5.1 details each of the meter data types in the SEL-749M. *Section 8: Front-Panel Operations* and *Section 7: Communications* describes how to access the various types of meter data by using the relay front-panel and communications ports.

Fundamental Metering

Table 5.1 Measured Values

Relay Option	Meter Values
All Models	Line Currents IA, IB, IC and IN (Core-Balance Ground Fault Current) magnitudes (A) and phase angles (deg) IG (Residual Ground Fault Current) magnitude (A) and phase angle (deg) IM (Average Current Magnitude) Average Motor Load (xFLA) Negative-Sequence Current (3I2) Current Unbalance % System Frequency (Hz)
With Voltage Option	VAB, VBC, VCA or VAN, VBN, VCN, VG magnitudes (V) and phase angles (deg) Average Voltage (L-L or L-N) Negative-Sequence (3V2) Voltage Unbalance % Real Power (kW) Reactive Power (kVAR) Apparent Power (kVA) Power Factor System Frequency (Hz)

All angles are displayed between –180 and +180 degrees. The angles are referenced to VAB or VAN (for delta- or wye-connected PT, respectively) or IA. If the voltage channels are not supported, or if VAB < 13 V (for delta-connected PT) or VAN < 13 V (for wye-connected PT), the angles are referenced to IA current.

Thermal Metering

NOTE: The time to thermal trip calculation is only performed when the motor is running and the current in per unit satisfies SF < I < 2.5. When time to thermal trip is not calculated, it is displayed as 9999.

The thermal metering function reports the present values of the RTD input temperatures and several quantities related to the motor thermal protection function (*Table 5.2*).

Table 5.2 Thermal Meter Values

Relay Option	Thermal Values
All Models	Motor Load (xFLA) Thermal Capacity Used % Time to Trip (sec) Time to Reset (min) Starts Available
With External SEL-2600 Series RTD Module	All RTD Temperatures RTD % Thermal Capacity

The thermal meter function also reports the state of connected RTDs if any have failed. *Table 5.3* shows failure messages.

NOTE: If the overload protection is disabled by setting E49MOTOR := N, the relay will always report % Thermal Capacity = 0 and Calculated Time to Thermal Trip (sec) = 9999.

Table 5.3 RTD Input Status Messages

Message	Status
Open	RTD leads open
Short	RTD leads shorted
Comm Fail	Fiber-optic communications to SEL-2600 series RTD module have failed
Stat Fail	SEL-2600 series RTD module self-test status failure

Figure 5.1 shows an example of the **METER** command report, and *Figure 5.2* provides an example of the **METER_T** command report.

```
=>MET <Enter>

SEL-749M                          Date: 02/27/2007    Time: 14:38:35.344
MOTOR RELAY                       Time Source: internal
                            IA         IB         IC         IN         IG
Current Magnitude (A)      200.2      201.1      199.4       0.0        3.1
Current Angle (deg)        -32.0     -151.8       88.6      93.7     -147.8

Average Current Magnitude (A)        200.2
Motor Load (xFLA1)                     0.8

Negative-Seq. Current (3I2) (A)        1.2
Current Imbalance (%)                  0.6

                                VAN        VBN        VCN        VG
Voltage Magnitude L-N (V)       2377       2385       2388         39
Voltage Angle (deg)              0.0     -119.7      120.9     -143.6

Average Phase (V)               2383
Negative-Seq. Volt. (3V2) (V)   30.6
Voltage Imbalance (%)            0.1

Real Power (kW)           1212
Reactive Power (kVAR)      762
Apparent Power (kVA)      1432
Power Factor              0.85 LAG

Frequency (Hz)            60.0
=>
```

Figure 5.1 METER Command Report With Voltage Option

```
=>>MET T <Enter>
SEL-749M                          Date: 02/27/2007    Time: 17:04:56.974
MOTOR RELAY                       Time Source: internal
Max Winding RTD = 135 C
Max Bearing RTD = 123 C
Ambient RTD     =  35 C
Max Other RTD   =  23 C
 RTD 1 BRG = 122 C
 RTD 2 BRG = 123 C
 RTD 3 BRG = 120 C
 RTD 4 BRG = 119 C
 RTD 5 WDG = 133 C
 RTD 6 WDG = 132 C
 RTD 7 WDG = 134 C
 RTD 8 WDG = 135 C
 RTD 9 WDG = 135 C
RTD 10 WDG = 132 C
RTD 11 AMB =  35 C
RTD 12 OTH =  23 C
Motor Load (xFLA)                            0.7
Thermal Capacity Used (%)                     55.0
RTD % Thermal Capacity Used (%)                0.0
Thermal Trip In (sec)                       9999
Time to Reset (min)                            0
Starts Available                               3

=>>
```

Figure 5.2 METER T Command Report With RTDs

Power Measurement Conventions

The SEL-749M uses the IEEE convention for power measurement assuming motor action. The implications of this convention are depicted in *Figure 5.3*.

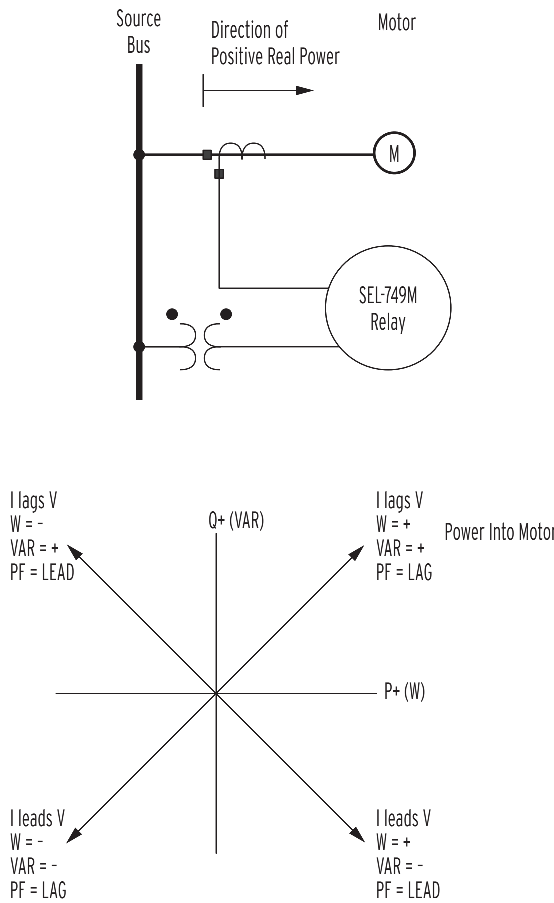

Figure 5.3 Complex Power Measurement Conventions—Motor Action

In the SEL-749M, reported positive real power is always into the motor.

Motor Operating Statistics

The SEL-749M retains useful machine operating statistics information for the protected motor.

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.

Use the serial port **MOTOR** command and the front-panel MONITOR menu to view motor operating statistics. The data also appear in the Modbus memory map and are available at the optional DeviceNet port. You can reset the data using either a communications port (e.g., serial port **MOTOR R** command) or the front-panel MONITOR menu. The Motor Start Reports are also reset when the motor statistics data are reset. Items included in the report are shown in the *Figure 5.4*.

NOTE: The relay records motor operating statistics every six hours to nonvolatile memory. If the power is removed from the relay, the relay will lose the information collected between the last save and the time of the power removal.

```
=>>MOT <Enter>

SEL-749M                          Date: 02/27/2007    Time: 11:30:03.024
MOTOR RELAY                       Time Source: internal

Operating History (elapsed time in ddd:hh:mm)     Since: 11/17/2003 17:21:54
Running Time          0:00:02
Stopped Time      >   0:02:18
Time Running            2.1%

Number Of Starts                      2
Number Of Emergency Starts            0

                      Average          Peak
Start Time (s)        9.1              9.3
Max Start I (A)       1079             1152
Min Start V (V)       4113             4111
Start % TCU           91.8             93.6
Running % TCU         90.9             93.8
Running Cur (A)       224.9            242.2
Running kW            1362             1467
Running kVARin        854.3            922.7
Running kVARin        854.3            922.7
Running kVA           1607             1732

                      Alarms      Trips
Overload                  0           0
Locked Rotor              0           0
Undercurrent              0           0
Jam                       0           0
Current Imbal             0           0
Overcurrent               0           0
Ground Fault              0           0
Speed Switch              0           0
Undervoltage              0           0
Overvoltage               0           0
Underpower                0           0
Power Factor              0           0
Reactive Power            0           0
Phase Reversal                        0
Underfrequency            0           0
Overfrequency             0           0
Start Timer                           0
Remote Trip                           0
Other Trips                           0
Total                     0           0

=>>
```

Figure 5.4 MOTOR Command Example

Motor Start Report

The SEL-749M 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. The Motor Start Reports are automatically reset when the motor statistics data are reset (see *Motor Operating Statistics*). 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 % Thermal Capacity Used (%TCU)
- ➤ Maximum start current
- ➤ Minimum start voltage, if voltage inputs card option 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 motor start time from the time the starting current is detected until the running state is declared (see *Figure 4.23*). The %TCU value is the 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 relay detects the starting current. The relay stores 720 sets of the data with the period determined by the setting MSRR (motor start report resolution). The following data are stored:

- ➤ Magnitude of A-, B-, and C-phase currents
- ➤ Magnitude of neutral current, IN
- ➤ % Thermal Capacity Used (%TCU)
- ➤ Magnitude of AB, BC, and CA phase-to-phase voltages, if included

The relay outputs start data in a comma-delimited text format for easy integration into computer spreadsheets for motor starting analysis. *Figure 5.5* shows data from an example Motor Start Report.

```
=>>MSR 3 <Enter>
SEL-749M                          Date: 02/27/2007    Time: 15:49:22.845
MOTOR RELAY                       Time Source: internal
FID=SEL-749M-R100-V0-Z001001-D20031210       CID=1988
Date of Motor Start                       11/07/2003
Time of Motor Start                     12:37:13.257
Number of Starts                                   3
Start Time (s)                                   6.8
Start %TCU                                        92
Max Start I (A)                                 1403
Min Start V (V)                                 4116
Cycle, IA (A), IB (A), IC (A), IN (A), VAB (V), VBC (V), VCA (V), %TCU
5.00,1401,1401,1399,0,4119,4122,4146,3
10.00,1399,1399,1399,0,4118,4124,4147,3
15.00,1398,1403,1398,0,4118,4123,4147,3
20.00,1399,1399,1396,0,4119,4122,4147,3
  .
  .
  .
1800.00,199,199,201,0,4117,4123,4146,90
1805.00,201,201,202,0,4119,4120,4148,90
1810.00,201,199,200,0,4118,4119,4140,90
1815.00,200,200,200,0,4117,4122,4149,90
1820.00,201,199,200,0,4118,4124,4148,90
  .
  .
  .
3595.00,199,201,199,0,4114,4121,4144,89
3600.00,200,200,198,0,4115,4124,4144,89
```

Figure 5.5 Motor Start Report Example

Motor Start Trending

For each motor start, the relay stores a motor start report and adds these data (described in *Summary Data on page 5.6*) 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 % Thermal Capacity Used
  - Maximum Start Current
  - Minimum Start Voltage, if Voltage Inputs card option installed

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.

View the motor start trending data using the serial port **MST** command.

Figure 5.6 shows data from an example Motor Start Trend Report.

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.

```
=>>MST <Enter>

SEL-749M                          Date: 02/27/2007    Time: 11:35:24.049
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     11/17/2003       2      9.1       92        1079      4113
   2        ---        ---     ---       ---         ---       ---
   3        ---        ---     ---       ---         ---       ---
   4        ---        ---     ---       ---         ---       ---
   5        ---        ---     ---       ---         ---       ---
   6        ---        ---     ---       ---         ---       ---
   7        ---        ---     ---       ---         ---       ---
   8        ---        ---     ---       ---         ---       ---
   9        ---        ---     ---       ---         ---       ---
  10        ---        ---     ---       ---         ---       ---
  11        ---        ---     ---       ---         ---       ---
  12        ---        ---     ---       ---         ---       ---
  13        ---        ---     ---       ---         ---       ---
  14        ---        ---     ---       ---         ---       ---
  15        ---        ---     ---       ---         ---       ---
  16        ---        ---     ---       ---         ---       ---
  17        ---        ---     ---       ---         ---       ---
  18        ---        ---     ---       ---         ---       ---

=>>
```

Figure 5.6 Motor Start Trending Report Example

Section 6
Settings

Overview

The SEL-749M Relay stores settings you enter in nonvolatile memory. Settings are divided into the following six setting classes:

1. Group
2. Logic
3. Global
4. Port *p* (where *p* = F, 3, or 4)
5. Front Panel
6. Report

Some setting classes have multiple instances. In the previous list, there are three port setting instances, one for each serial port.

Settings may be viewed or set in several ways, as shown in *Table 6.1*.

Table 6.1 Methods of Accessing Settings

	Serial Port Commands[a]	**Front Panel HMI Set/Show Menu**[b]	**ACSELERATOR QuickSet SEL-5030** (PC software)[c]
Display Settings	All settings (**SHO** command)	All settings	All settings
Change Settings	All settings (**SET** command)	All settings	All settings

[a] Refer to Section 7: Communications for detailed information on set-up and use of the serial communications port.
[b] Refer to Section 8: Front-Panel Operations for detailed information on the front-panel layout, menus and screens, and operator control pushbuttons.
[c] Refer to Section 3: PC Software for detailed information.

Setting entry error messages, together with corrective actions, are also presented in this section to assist correct settings entry.

The *SEL-749M Settings Sheets* at the end of this section list all SEL-749M settings, the setting definitions, and input ranges. Refer to *Section 4: Protection and Logic Functions* for detailed information on individual elements and settings.

View/Change Settings Using the Front Panel

You can use the pushbuttons on the front panel to view/change settings. *Section 8: Front-Panel Operations* presents the operating details of the front panel.

Enter the front-panel menu by pushing the **ESC** button. It will display the following message:

```
MAIN
Meter
```

Scroll down the menu by using the **Down Arrow** pushbutton until the display shows the following message:

```
Control
Set/Show
```

The cursor (underline) should be on the **SET/SHOW** command. Enter the **SET/SHOW** command by pushing the **Enter** pushbutton. The display shows the following message:

```
SET/SHOW
RELAY
```

Enter the underlined RELAY message with the **Enter** pushbutton, and the relay will present you with the RELAY settings as listed in the *SEL-749M Settings Sheets*. Use the **Up Arrow** and **Down Arrow** and the **Left Arrow** and **Right Arrow** pushbuttons to scroll through the relay settings and view/change them according to your needs by selecting and editing them. After viewing/changing the RELAY settings, press the **ESC** pushbutton until the following message appears:

```
Save Changes?
Yes   No
```

Select and enter the appropriate command by pushing the **Enter** pushbutton. Select Yes to save the settings changes and No to discard the changes.

NOTE: Each SEL-749M is shipped with default factory settings. Calculate the settings for your motor to ensure secure and dependable protection. Document the settings on the SEL-749M Settings Sheets at the end of this section before entering new settings in the relay.

Figure 6.1 shows a front-panel menu navigation example for the relay to enter the MOTOR FLA, FLA1 setting.

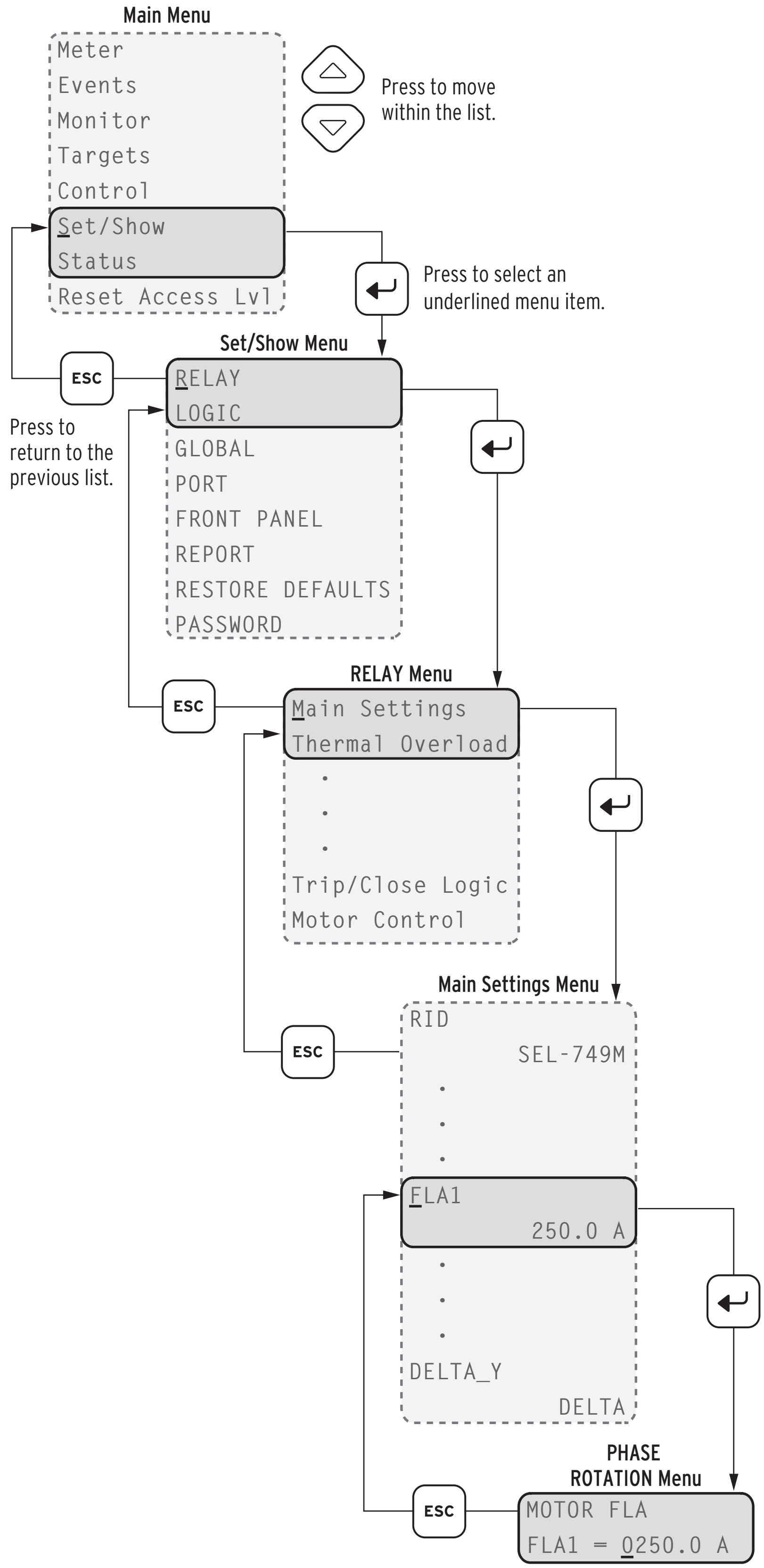

Figure 6.1 Front-Panel Setting Entry Example

View/Change Settings With Serial Port

Refer to *Section 7: Communications* for information on how to set up and access the relay serial port with a personal computer and how to use ASCII commands to communicate with the relay.

View Settings

Use the **SHOW** command to view relay settings. The **SHOW** command is available from Access Level 1 and Access Level 2.

Table 6.2 lists the **SHOW** command options.

Table 6.2 SHOW Command Options

Command	Description
SHOW	Show relay group settings.
SHO A	Show all relay settings: enabled, disabled/hidden.
SHO L	Show logic settings.
SHO G	Show global configuration settings.
SHO P *n*	Show serial port settings for Port *n* (*n* = F, 3, or 4).
SHO F	Show front-panel display and LED settings.
SHO R	Show Sequential Event Report (SER) and Event Report 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. To display all settings, including disabled/hidden settings, append an **A** to the **SHOW** command (e.g., **SHOW A**).

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.

Table 6.3 SET Command Options

Command	Settings Type	Description
SET	Relay	Protection elements, timers, etc.
SET L	Logic	General logic settings
SET G	Relay	Global configuration settings
SET P	Port	Serial port settings
SET F	Front Panel	Front-panel display and LED settings
SET R	Reports	SER and Event Report settings

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 5 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 G, L, F, R, or P to identify the class of settings.
m	is left blank or is F, 3, or 4 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 one of the error messages 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
50P*m*P • FLA*n*/CTR*n* must be greater than or equal to 0.50 Amp (for current rating 5 A) (*m* = 1 or 2, *n* = 1 or 2)	Phase Overcurrent and Main Settings	Modify the 50P*m*P (or FLA*n*/CTR*n*) to satisfy: 50P*m*P • (FLA*n*/CTR*n*) ≥ 0.5 for phase input current rating of 5 A.
50P*m*P • FLA*n*/CTR*n* must be greater than or equal to 0.10 Amp (for current rating 1 A) (*m* = 1 or 2, n = 1 or 2)	Phase Overcurrent and Main Settings	Modify the 50P*m*P (or FLA*n*/CTR*n*) to satisfy: 50P*m*P • (FLA*n*/CTR*n*) ≥ 0.1 for phase input current rating of 1 A.
50G*m*P is too low for FLA*n*, CTR*n* combination (m = 1 or 2, n = 1 or 2)	Residual Overcurrent and Main Settings	Modify the 50GmP (or FLAn/CTRn) to satisfy: 50G*m*P • (FLA*n*/CTR*n*) Š 0.5 for phase input current rating of 5 A. 50G*m*P • (FLA*n*/CTR*n*) Š 0.1 for phase input current rating of 1 A.
50N*n*P must be within (0.050 • CTRN) xx.xx and (10.0 • CTRN) yy.yy	Neutral Overcurrent	Modify the 50N*n*P (or CTRN) setting to satisfy the requirement shown in the error message.
50N*n*P must be within (0.010 • CTRN) xx.xx and (2.0 • CTRN) yy.yy (n = 1 or 2)	Neutral Overcurrent	Modify the 50N*n*P (or CTRN) setting to satisfy the requirement shown in the error message.
Choose PRE from 1-10 cycles	Event Report Settings	Modify the PRE setting to satisfy the requirement shown in the error message.
CTR*n*,FLA*n* Setting Combination Out of Range (*n* = 1 or 2)	Main Settings	Modify the CTR*n* or FLA*n* setting to satisfy: 1.0 ≤ (FLA*n*/CTR*n*) ≤ 8 for phase input current rating of 5 A. 0.2 ≤ (FLA*n*/CTR*n*) ≤ 1.6 for phase input current rating of 1 A
Minimum STOP COOL TIME: xxxx min	Thermal Overload	Modify the COOLTIME setting to satisfy the requirement shown in the error message.
Only one ambient RTD allowed (n = 1–12)	RTD	Modify the RTD location setting (RTD*n*LOC) to satisfy the requirement shown in the error message.
Output contacts cannot be set to NA.	Output Contact Logic Setting	Use 0, 1, or SELOGIC control equation for the logic setting.
PTR Setting Out of Range	Main Settings	Modify VNOM or PTR setting to satisfy: 100 ≤ (VNOM/PTR) ≤ 250 for DELTA_Y := DELTA 100 ≤ (VNOM/PTR) ≤ 440 for DELTA_Y := WYE

SEL-749M Settings Sheets

These settings sheets include the definition and input range for each setting in the relay. You can access the settings from the relay front panel and the serial ports. For factory-default settings see the ACSELERATOR QuickSet SEL-5030 Software.

- Some settings require an optional module (see *Section 4: Protection and Logic Functions* for details).
- Some of the settings ranges may be more restrictive than shown, because of settings interdependency checks performed when new settings are saved (see *Table 6.6*).
- The settings are not case sensitive.

Main Settings (SET Command)

UNIT ID LINE 1 (16 Characters)	**RID**	:= ____________________
UNIT ID LINE 2 (16 Characters)	**TID**	:= ____________________
PHASE CT RATIO (1–5000)	**CTR1**	:= ____________________
MOTOR FLA (0.2–5000 A)	**FLA1**	:= ____________________
TWO SPEED ENABLE (Y, N)	**E2SPEED**	:= ____________________
CT RATIO-2nd (1–5000) *(Hidden if E2SPEED := N)*	**CTR2**	:= ____________________
MOTOR FLA-2nd (0.2–5000 A) *(Hidden if E2SPEED := N)*	**FLA2**	:= ____________________
NEUTRAL CT RATIO (1–2000)	**CTRN**	:= ____________________
PHASE PT RATIO (1.00–250.00) *(Hidden if voltages not included)*	**PTR**	:= ____________________
LINE VOLTAGE (100–30000 V) *(Hidden if voltages not included)*	**VNOM**	:= ____________________
XFMR CONNECTION (Delta, Wye) *(Hidden if voltages not included)*	**DELTA_Y**	:= ____________________

Thermal Overload

OVERLOAD ENABLE (Y, N) *(All of the following overload settings are hidden if E49MOTOR := N)*	**E49MOTOR**	:= ____________________
THERMAL METHOD (Rating, Rating_1, Curve)	**SETMETH**	:= ____________________
OL RESET LEVEL (10–99 %TCU)	**49RSTP**	:= ____________________
SERVICE FACTOR (1.01–1.50)	**SF**	:= ____________________
MOTOR LRA (2.5–12.0 xFLA) *(Hidden if SETMETH := CURVE)*	**LRA1**	:= ____________________
LOCKD ROTOR TIME (1.0–600.0 sec) *(Hidden if SETMETH := CURVE)*	**LRTHOT1**	:= ____________________
ACCEL FACTOR (0.10–1.50) *(Hidden if SETMETH := CURVE)*	**TD1**	:= ____________________
RUN STATE TIME K (Auto, 1–2000 min) *(Hidden if SETMETH := CURVE)*	**RTC1**	:= ____________________

Date ____________
Group ____________

MOTOR LRA-2nd (2.5–12.0 xFLA) *(Hidden if E2SPEED := N or SETMETH := CURVE)*	**LRA2**	:=	____________
MOTOR LRT-2nd (1.0–600.0 sec) *(Hidden if E2SPEED := N or SETMETH := CURVE)*	**LRTHOT2**	:=	____________
ACCEL FACT-2nd (0.10–1.50) *(Hidden if E2SPEED := N or SETMETH := CURVE)*	**TD2**	:=	____________
RUN ST TC-2nd (Auto, 1–2000 min) *(Hidden if E2SPEED := N or SETMETH := CURVE)*	**RTC2**	:=	____________
THERM OL CURVE1 (1–45) *(Hidden if SETMETH := Rating or Rating_1)*	CURVE1	:=	____________
THERM OL CURVE2 (1–45) *(Hidden if E2SPEED := N or SETMETH := Rating or Rating_1)*	CURVE2	:=	____________
OL WARN LEVEL (OFF, 50–99 %TCU)	**TCAPU**	:=	____________
START INH. LEVEL (OFF, 1–99 %TCU)	**TCSTART**	:=	____________
STOP COOL TIME (1–6000 min)	**COOLTIME**	:=	____________
OL RTD BIASING? (Y, N) *(Hidden if E49RTD := N)*	**ETHMBIAS**	:=	____________

Phase Overcurrent

PH OC TRIP LVL (Off, 0.10–20.00 xFLA)	**50P1P**	:=	____________
PH OC TRIP DLAY (0.00–5.00 sec) *(Hidden if 50P1P := Off)*	**50P1D**	:=	____________
PH OC WARN LVL (Off, 0.10–20.00 xFLA)	**50P2P**	:=	____________
PH OC WARN DLAY (0.00–5.00 sec) *(Hidden if 50P2P := Off)*	**50P2D**	:=	____________

Neutral Overcurrent

NEUT OC TRIP LVL (Off, 0.01–25.00 A primary)	**50N1P**	:=	____________
NEUT OC TRIP DLAY (0.00–5.00 sec) *(Hidden if 50N1P := Off)*	**50N1D**	:=	____________
NEUT OC WARN LVL (Off, 0.01–25.00 A primary)	**50N2P**	:=	____________
NEUT OC WARN DLAY (0.0–120.0 sec) *(Hidden if 50N2P := Off)*	**50N2D**	:=	____________

Residual Overcurrent

RES OC TRIP LVL (Off, 0.10–1.00 xFLA)	**50G1P**	:=	____________
RES OC TRIP DLAY (0.00–5.00 sec) *(Hidden if 50G1P := Off)*	**50G1D**	:=	____________
RES OC WARN LVL (Off, 0.10–1.00 xFLA)	**50G2P**	:=	____________
RES OC WARN DLAY (0.0–120.0 sec) *(Hidden if 50G2P := Off)*	**50G2D**	:=	____________

Jam

JAM TRIP LEVEL (Off, 1.00–6.00 xFLA)	**LJTPU**	:=	____________
JAM TRIP DELAY (0.0–120.0 sec) *(Hidden if LJTPU := Off)*	**LJTDLY**	:=	____________

JAM WARN LEVEL (Off, 1.00–6.00 xFLA)	**LJAPU**	:=	____________
JAM WARN DELAY (0.0–120.0 sec) *(Hidden if LJAPU := Off)*	**LJADLY**	:=	____________

Undercurrent

UC TRIP LEVEL (Off, 0.10–1.00 xFLA)	**LLTPU**	:=	____________
UC TRIP DELAY (0.4–120.0 sec) *(Hidden if LLTPU := Off)*	**LLTDLY**	:=	____________
UC WARN LEVEL (Off, 0.10–1.00 xFLA)	**LLAPU**	:=	____________
UC WARN DELAY (0.4–120.0 sec) *(Hidden if LLAPU := Off)*	**LLADLY**	:=	____________
UC START DELAY (0–1500 sec) *(Hidden if both LLAPU and LLTPU := Off)*	**LLSDLY**	:=	____________

Current Unbalance

CI TRIP LEVEL (Off, 5–80 %)	**46UBT**	:=	____________
CI TRIP DELAY (0–240 sec) *(Hidden if 46UBT := Off)*	**46UBTD**	:=	____________
CI WARN LEVEL (Off, 5–80 %)	**46UBA**	:=	____________
CI WARN DELAY (0–240 sec) *(Hidden if 46UBA := Off)*	**46UBAD**	:=	____________

Protection Disable

PROT INHIBT TIME (Off, 1–240 sec)	**PROTBL_T**	:=	____________
OL INHIBIT TIME (Off, 1–240 sec)	**THERBL_T**	:=	____________

Start Monitoring

START MOTOR TIME (Off, 1–240 sec)	**START_T**	:=	____________

Star-Delta

STAR-DELTA ENABL (Y, N)	**ESTAR_D**	:=	____________
MAX STAR TIME (Off, 1–600 sec) *(Hidden if ESTAR_D := N)*	**STAR_MAX**	:=	____________

Start Inhibit

STARTS/HR. (Off, 1–15)	**MAXSTART**	:=	____________
MIN. OFF TIME (Off, 1–150 min)	**TBSDLY**	:=	____________
RESTART BLK TIME (Off, 1–60 min)	**ABSDLY**	:=	____________

Phase Reversal

PH REV. ENABLE (Y, N)	**E47T**	:=	____________

Speed Switch

SS TRIP DELAY (Off, 1–240 sec)	**SPDSDLYT**	:=	____________
SS WARN DELAY (Off, 1–240 sec)	**SPDSDLYA**	:=	____________

Date ____________
Group___________

PTC (Hidden if PTC option not included)

PTC ENABLE (Y, N)	**EPTC**	:=	____________

RTD

RTD ENABLE (Y, N) *(All of the following RTD settings are hidden if E49RTD := N)*	**E49RTD**	:=	____________
RTD1 LOCATION (Off, WDG, BRG, AMB, OTH)	**RTD1LOC**	:=	____________
RTD1 TYPE (PT100, NI100, NI120, CU10) *(Hidden if RTD1LOC := Off)*	**RTD1TY**	:=	____________
RTD1 TRIP LEVEL (Off, 1–250°C) *(Hidden if RTD1LOC := Off)*	**TRTMP1**	:=	____________
RTD1 WARN LEVEL (Off, 1–250°C) *(Hidden if RTD1LOC := Off)*	**ALTMP1**	:=	____________
RTD2 LOCATION (Off, WDG, BRG, AMB, OTH)	**RTD2LOC**	:=	____________
RTD2 TYPE (PT100, NI100, NI120, CU10) *(Hidden if RTD2LOC := Off)*	**RTD2TY**	:=	____________
RTD2 TRIP LEVEL (Off, 1–250°C) *(Hidden if RTD2LOC := Off)*	**TRTMP2**	:=	____________
RTD2 WARN LEVEL (Off, 1–250°C) *(Hidden if RTD2LOC := Off)*	**ALTMP2**	:=	____________
RTD3 LOCATION (Off, WDG, BRG, AMB, OTH)	**RTD3LOC**	:=	____________
RTD3 TYPE (PT100, NI100, NI120, CU10) *(Hidden if RTD3LOC := Off)*	**RTD3TY**	:=	____________
RTD3 TRIP LEVEL (Off, 1–250°C) *(Hidden if RTD3LOC := Off)*	**TRTMP3**	:=	____________
RTD3 WARN LEVEL (Off, 1–250°C) *(Hidden if RTD3LOC := Off)*	**ALTMP3**	:=	____________
RTD4 LOCATION (Off, WDG, BRG, AMB, OTH)	**RTD4LOC**	:=	____________
RTD4 TYPE (PT100, NI100, NI120, CU10) *(Hidden if RTD4LOC := Off)*	**RTD4TY**	:=	____________
RTD4 TRIP LEVEL (Off, 1–250°C) *(Hidden if RTD4LOC := Off)*	**TRTMP4**	:=	____________
RTD4 WARN LEVEL (Off, 1–250°C) *(Hidden if RTD4LOC := Off)*	**ALTMP4**	:=	____________
RTD5 LOCATION (Off, WDG, BRG, AMB, OTH)	**RTD5LOC**	:=	____________
RTD5 TYPE (PT100, NI100, NI120, CU10) *(Hidden if RTD5LOC := Off)*	**RTD5TY**	:=	____________
RTD5 TRIP LEVEL (Off, 1–250°C) *(Hidden if RTD5LOC := Off)*	**TRTMP5**	:=	____________
RTD5 WARN LEVEL (Off, 1–250°C) *(Hidden if RTD5LOC := Off)*	**ALTMP5**	:=	____________
RTD6 LOCATION (Off, WDG, BRG, AMB, OTH)	**RTD6LOC**	:=	____________

RTD6 TYPE (PT100, NI100, NI120, CU10) *(Hidden if RTD6LOC := Off)*	**RTD6TY**	:=	____________________
RTD6 TRIP LEVEL (Off, 1–250°C) *(Hidden if RTD6LOC := Off)*	**TRTMP6**	:=	____________________
RTD6 WARN LEVEL (Off, 1–250°C) *(Hidden if RTD6LOC := Off)*	**ALTMP6**	:=	
RTD7 LOCATION (Off, WDG, BRG, AMB, OTH)	**RTD7LOC**	:=	____________________
RTD7 TYPE (PT100, NI100, NI120, CU10) *(Hidden if RTD7LOC := Off)*	**RTD7TY**	:=	____________________
RTD7 TRIP LEVEL (Off, 1–250°C) *(Hidden if RTD7LOC := Off)*	**TRTMP7**	:=	____________________
RTD7 WARN LEVEL (Off, 1–250°C) *(Hidden if RTD7LOC := Off)*	**ALTMP7**	:=	____________________
RTD8 LOCATION (Off, WDG, BRG, AMB, OTH)	**RTD8LOC**	:=	____________________
RTD8 TYPE (PT100, NI100, NI120, CU10) *(Hidden if RTD8LOC := Off)*	**RTD8TY**	:=	____________________
RTD8 TRIP LEVEL (Off, 1–250°C) *(Hidden if RTD8LOC := Off)*	**TRTMP8**	:=	____________________
RTD8 WARN LEVEL (Off, 1–250°C) *(Hidden if RTD8LOC := Off)*	**ALTMP8**	:=	____________________
RTD9 LOCATION (Off, WDG, BRG, AMB, OTH)	**RTD9LOC**	:=	____________________
RTD9 TYPE (PT100, NI100, NI120, CU10) *(Hidden if RTD9LOC := Off)*	**RTD9TY**	:=	____________________
RTD9 TRIP LEVEL (Off, 1–250°C) *(Hidden if RTD9LOC := Off)*	**TRTMP9**	:=	____________________
RTD9 WARN LEVEL (Off, 1–250°C) *(Hidden if RTD9LOC := Off)*	**ALTMP9**	:=	____________________
RTD10 LOCATION (Off, WDG, BRG, AMB, OTH)	**RTD10LOC**	:=	____________________
RTD10 TYPE (PT100, NI100, NI120, CU10) *(Hidden if RTD10LOC := Off)*	**RTD10TY**	:=	____________________
RTD10 TRIP LEVEL (Off, 1–250°C) *(Hidden if RTD10LOC := Off)*	**TRTMP10**	:=	____________________
RTD10 WARN LEVEL (Off, 1–250°C) *(Hidden if RTD10LOC := Off)*	**ALTMP10**	:=	____________________
RTD11 LOCATION (Off, WDG, BRG, AMB, OTH)	**RTD11LOC**	:=	____________________
RTD11 TYPE (PT100, NI100, NI120, CU10)	**RTD11TY**	:=	____________________
RTD11 TRIP LEVEL (Off, 1–250°C) *(Hidden if RTD11LOC := Off)*	**TRTMP11**	:=	____________________
RTD11 WARN LEVEL (Off, 1–250°C) *(Hidden if RTD11LOC := Off)*	**ALTMP11**	:=	____________________
RTD12 LOCATION (Off, WDG, BRG, AMB, OTH) *(Hidden if RTD11LOC := Off)*	**RTD12LOC**	:=	____________________

RTD12 TYPE (PT100, NI100, NI120, CU10) *(Hidden if RTD12LOC := Off)*	**RTD12TY**	:=	____________
RTD12 TRIP LEVEL (Off, 1–250°C) *(Hidden if RTD12LOC := Off)*	**TRTMP12**	:=	____________
RTD12 WARN LEVEL (Off, 1–250°C) *(Hidden if RTD12LOC := Off)*	**ALTMP12**	:=	____________
WIND TRIP VOTING (Y, N) *(Hidden if less than 2 locations are WDG)*	**EWDGV**	:=	____________
BEAR TRIP VOTING (Y, N) *(Hidden if less than 2 locations are BRG)*	**EBRGV**	:=	____________
TMP RTD BIASING? (Y, N) *(Hidden if no RTDnLOC := AMB or if all winding RTD trip temperatures are Off)*	**ERTDBIAS**	:=	____________

Undervoltage (Hidden if voltages not included)

UV TRIP LEVEL (Off, 0.60–1.00 xVnm)	**27P1P**	:=	____________
UV TRIP DELAY (0.0–120.0 sec) *(Hidden if 27P1P := Off)*	**27P1D**	:=	____________
UV WARN LEVEL (Off, 0.60–1.00 xVnm)	**27P2P**	:=	____________
UV WARN DELAY (0.0–120.0 sec) *(Hidden if 27P2P := Off)*	**27P2D**	:=	____________

Overvoltage (Hidden if voltages not included)

OV TRIP LEVEL (Off, 1.00–1.20 xVnm)	**59P1P**	:=	____________
OV TRIP DELAY (0.0–120.0 sec) *(Hidden if 59P1P := Off)*	**59P1D**	:=	____________
OV WARN LEVEL (Off, 1.00–1.20 xVnm)	**59P2P**	:=	____________
OV WARN DELAY (0.0–120.0 sec) *(Hidden if 59P2P := Off)*	**59P2D**	:=	____________

VAR (Hidden if voltages not included)

NEG VAR TRIP LEV (Off, 1–25000 kVAR)	**NVARTP**	:=	____________
POS VAR TRIP LEV (Off, 1–25000 kVAR)	**PVARTP**	:=	____________
VAR TRIP DELAY (0–240 sec) *(Hidden if both NVARTP and PVARTP := Off)*	**VARTD**	:=	____________
NEG VAR WARN LEV (Off, 1–25000 kVAR)	**NVARAP**	:=	____________
POS VAR WARN LEV (Off, 1–25000 kVAR)	**PVARAP**	:=	____________
VAR WARN DELAY (0–240 sec) *(Hidden if both NVARAP and PVARAP := Off)*	**VARAD**	:=	____________

Underpower (Hidden if voltages not included)

UP TRIP LEVEL (Off, 1–25000 kW)	**37PTP**	:=	____________
UP TRIP DELAY (0–240 sec) *(Hidden if 37PTP := Off)*	**37PTD**	:=	____________
UP WARN LEVEL (Off, 1–25000 kW)	**37PAP**	:=	____________
UP WARN DELAY (0–240 sec) *(Hidden if 37PAP := Off)*	**37PAD**	:=	____________

Power Factor (Hidden if voltages not included)

PF LAG TRIP LEVEL (Off, 0.05–0.99)	**55LGTP**	:=	____________
PF LD TRIP LEVEL (Off, 0.05–0.99)	**55LDTP**	:=	____________
PF TRIP DELAY (0–240 sec) *(Hidden if both 55LGTP and 55LDTP := Off)*	**55TD**	:=	____________
PF LAG WARN LEVEL (Off, 0.05–0.99)	**55LGAP**	:=	____________
PF LD WARN LEVEL (Off, 0.05–0.99)	**55LDAP**	:=	____________
PF WARN DELAY (0–240 sec) *(Hidden if both 55LGAP and 55LDAP := Off)*	**55AD**	:=	____________

Frequency (Frequency setting ranges shown for FNOM := 60 Hz; ranges are Off, 45.0-55.0 Hz if FNOM := 50 Hz)

FREQ1 TRIP LEVEL (Off, 55.0–65.0 Hz)	**81D1TP**	:=	____________
FREQ1 TRIP DELAY (0.0–240.0 sec) *(Hidden if 81D1TP := Off)*	**81D1TD**	:=	____________
FREQ1 WARN LEVEL (Off, 55.0–65.0 Hz)	**81D1AP**	:=	____________
FREQ1 WARN DELAY (0.0–240.0 sec) *(Hidden if 81D1AP := Off)*	**81D1AD**	:=	____________
FREQ2 TRIP LEVEL (Off, 55.0–65.0 Hz)	**81D2TP**	:=	____________
FREQ2 TRIP DELAY (0.0–240.0 sec) *(Hidden if 81D2TP := Off)*	**81D2TD**	:=	____________
FREQ2 WARN LEVEL (Off, 55.0–65.0 Hz)	**81D2AP**	:=	____________
FREQ2 WARN DELAY (0.0–240.0 sec) *(Hidden if 81D2AP := Off)*	**81D2AD**	:=	____________

Load Control

LOAD CONTROL SEL (Off, Current, Power, TCU)	**LOAD**	:=	____________
If LOAD := Current:			
LD CTL CUR UPPER (Off, 0.2–2.00 xFLA)	**LOADUPP**	:=	____________
LD CTL CUR LOWER (Off, 0.2–2.00 xFLA)	**LOADLOWP**	:=	____________
If LOAD := Power:			
LD CTL PWR UPPER (Off, 1–25000 kW)	**LOADUPP**	:=	____________
LD CTL PWR LOWER (Off, 1–25000 kW)	**LOADLOWP**	:=	____________
If LOAD := TCU:			
LD CTL TCU UPPER (Off, 1–99 %TCU)	**LOADUPP**	:=	____________
LD CTL TCU LOWER (Off, 1–99 %TCU)	**LOADLOWP**	:=	____________

Analog Output

ANALOG OUT SEL (LOAD_I, AVG_I, MAX_I, %THERM, WDG_RTD, BRG_RTD, PWR_kW, PF)	**AOPARM**	:=	____________

Trip Inhibit

BLOCK PROTECTION (SV)
BLKPROT := ____________________

CURRENT IMBALANC (Y, N)	**BLK46**	:=	________
JAM (Y, N)	**BLK48**	:=	________
GROUND FAULT (Y, N)	**BLK50EF**	:=	________
SHORT CIRCUIT (Y, N)	**BLK50P**	:=	________
UNDERCURRENT (Y, N)	**BLK37**	:=	________
START INHIBIT (Y, N)	**BLK66**	:=	________
PTC (Y, N) *(Hidden if PTC option not included)*	**BLK49PTC**	:=	________
RTD (Y, N)	**BLK49RTD**	:=	________

Trip/Close Logic

MIN TRIP TIME (0.0–400.0 sec)	TDURD	:=	________

TRIP EQUATION (SV)
TR := ____________________

REMOTE TRIP EQN (SV)
REMTRIP := ____________________

UNLATCH TRIP EQN (SV)
ULTRIP := ____________________

CONTACTOR STATUS (SV)
52A := ____________________

Motor Control

START EQUATION (SV)
STREQ := ____________________

EMERGENCY START (SV)
EMRSTR := ____________________

SPEED 2 (SV)
SPEED2 := ____________________

SPEED SWITCH (SV)
SPEEDSW := ____________________

Logic Settings (SET L Command)

SELOGIC Enables

SELOGIC LATCHES (N, 1–8) **ELAT** := ____________________

SV/TIMERS (N, 1–8) **ESV** := ____________________

Latch Bits Equations

SET01 (SV) *(Hidden if ELAT := N)*

SET01 := ____________________

RST01 (SV) *(Hidden if ELAT := N)*

RST01 := ____________________

SET02 (SV) *(Hidden if ELAT := N or < 2)*

SET02 := ____________________

RST02 (SV) *(Hidden if ELAT := N or < 2)*

RST02 := ____________________

SET03 (SV) *(Hidden if ELAT := N or < 3)*

SET03 := ____________________

RST03 (SV) *(Hidden if ELAT := N or < 3)*

RST03 := ____________________

SET04 (SV) *(Hidden if ELAT := N or < 4)*

SET04 := ____________________

RST04 (SV) *(Hidden if ELAT := N or < 4)*

RST04 := ____________________

SET05 (SV) *(Hidden if ELAT := N or < 5)*

SET05 := ____________________

RST05 (SV) *(Hidden if ELAT := N or < 5)*

RST05 := ____________________

SET06 (SV) *(Hidden if ELAT := N or < 6)*

SET06 := ____________________

RST06 (SV) *(Hidden if ELAT := N or < 6)*

RST06 := ____________________

SET07 (SV) *(Hidden if ELAT := N or < 7)*

SET07 := ____________________

RST07 (SV) *(Hidden if ELAT := N or < 7)*

RST07 := ____________________

SET08 (SV) *(Hidden if ELAT := N or < 8)*

SET08 := ____________________

RST08 (SV) *(Hidden if ELAT := N or < 8)*

RST08 := ____________________

SV/Timers

SV TIMER PICKUP (0.00–3000.00 sec) *(Hidden if ESV := N)* **SV01PU** := ____________________

SV TIMER DROPOUT (0.00–3000.00 sec) *(Hidden if ESV := N)* **SV01DO** := ____________________

SV INPUT EQ (SV) *(Hidden if ESV := N)*

SV01 := ____

SV TIMER PICKUP (0.00–3000.00 sec) *(Hidden if ESV := N or < 2)* **SV02PU** := ____________________

SV TIMER DROPOUT (0.00–3000.00 sec) *(Hidden if ESV := N or < 2)* **SV02DO** := ____________________

SV INPUT EQ (SV) *(Hidden if ESV := N or < 2)*

SV02 := ____

SV TIMER PICKUP (0.00–3000.00 sec) *(Hidden if ESV := N or < 3)* **SV03PU** := ____________________

SV TIMER DROPOUT (0.00–3000.00 sec) *(Hidden if ESV := N or < 3)* **SV03DO** := ____________________

SV INPUT EQ (SV) *(Hidden if ESV := N or < 3)*

SV03 := ____

SV TIMER PICKUP (0.00–3000.00 sec) *(Hidden if ESV := N or < 4)* **SV04PU** := ____________________

SV TIMER DROPOUT (0.00–3000.00 sec) *(Hidden if ESV := N or < 4)* **SV04DO** := ____________________

SV INPUT EQ (SV) *(Hidden if ESV := N or < 4)*

SV04 := ____

SV TIMER PICKUP (0.00–3000.00 sec) *(Hidden if ESV := N or < 5)* **SV05PU** := ____________________

SV TIMER DROPOUT (0.00–3000.00 sec) *(Hidden if ESV := N or < 5)* **SV05DO** := ____________________

SV INPUT EQ (SV) *(Hidden if ESV := N or < 5)*

SV05 := ____

SV TIMER PICKUP (0.00–3000.00 sec) *(Hidden if ESV := N or < 6)* **SV06PU** := ____________________

SV TIMER DROPOUT (0.00–3000.00 sec) *(Hidden if ESV := N or < 6)* **SV06DO** := ____________________

SV INPUT EQ (SV) *(Hidden if ESV := N or < 6)*

SV06 := ____

SV TIMER PICKUP (0.00–3000.00 sec) *(Hidden if ESV := N or < 7)* **SV07PU** := ____________________

SV TIMER DROPOUT (0.00–3000.00 sec) *(Hidden if ESV := N or < 7)* **SV07DO** := ____________________

SV INPUT EQ (SV) *(Hidden if ESV := N or < 7)*

SV07 := ____

SV TIMER PICKUP (0.00–3000.00 sec) *(Hidden if ESV := N or < 8)* **SV08PU** := ____________

SV TIMER DROPOUT (0.00–3000.00 sec) *(Hidden if ESV := N or < 8)* **SV08DO** := ____________

SV INPUT EQ (SV) *(Hidden if ESV := N or < 8)F* **SV08** := ____________

Output Contacts

OUT101 FAIL-SAFE (Y, N) **OUT101FS** := ____________

OUT101 (SV)
OUT101 := ____________

OUT102 FAIL-SAFE (Y, N) **OUT102FS** := ____________

OUT102 (SV)
OUT102 := ____________

OUT103 FAIL-SAFE (Y, N) **OUT103FS** := ____________

OUT103 (SV)
OUT103 := ____________

OUT401 FAIL-SAFE (Y, N) *(Hidden if I/O expansion card is not included)* **OUT401FS** := ____________

OUT401 (SV) *(Hidden if I/O expansion card is not included)*
OUT401 := ____________

OUT402 FAIL-SAFE (Y, N) *(Hidden if I/O expansion card is not included)* **OUT402FS** := ____________

OUT402 (SV) *(Hidden if I/O expansion card is not included)*
OUT402 := ____________

OUT403 FAIL-SAFE (Y, N) *(Hidden if I/O expansion card is not included)* **OUT403FS** := ____________

OUT403 (SV) *(Hidden if I/O expansion card is not included)*
OUT403 := ____________

OUT404 FAIL-SAFE (Y, N) *(Hidden if I/O expansion card is not included)* **OUT404FS** := ____________

OUT404 (SV) *(Hidden if I/O expansion card is not included)*
OUT404 := ____________

Global Settings (SET G Command)

General

PHASE ROTATION (ABC, ACB)	**PHROT**	:= ____________________
RATED FREQ. (50, 60 Hz)	**FNOM**	:= ____________________
DATE FORMAT (MDY, YMD, DMY)	**DATE_F**	:= ____________________

Data Reset

TARGET RESET EQ (SV)
RSTTRGT := ____

Access Control

DISABLE SETTINGS (SV)
DSABLSET := ____

BLOCK MODBUS SET (NONE, R_S, ALL)
BLKMBSET :=____

SET P F, SET P 3, or SET P 4 Commands

NOTE: Modbus protocol is available on Port F, Port 3, and Port 4, and all ports can support Modbus sessions concurrently.

Port F

PROTOCOL (SEL, MOD)	**PROTO**	:= ____________________
SPEED (300–38400 bps)	**SPEED**	:= ____________________
DATA BITS (7, 8 bits) (*Hidden if PROTO := MOD*)	**BITS**	:= ____________________
PARITY (O, E, N)	**PARITY**	:= ____________________
STOP BITS (1, 2 bits) (*Hidden if PROTO := MOD*)	**STOP**	:= ____________________
PORT TIME-OUT (0–30 min) (*Hidden if PROTO := MOD*)	**T_OUT**	:= ____________________
SEND AUTOMESSAGE (Y, N) (*Hidden if PROTO := MOD*)	**AUTO**	:= ____________________
HDWR HANDSHAKING (Y, N) (*Hidden if PROTO := MOD*)	**RTSCTS**	:= ____________________
MODBUS SLAVE ID (1–248) (*Hidden if PROTO := SEL*)	**SLAVEID**	:= ____________________

Port 3

PROTOCOL (SEL, MOD)	**PROTO**	:= ____________________
SPEED (300–38400 bps)	**SPEED**	:= ____________________
DATA BITS (7, 8 bits) *(Hidden if PROTO := MOD)*	**BITS**	:= ____________________
PARITY (O, E, N)	**PARITY**	:= ____________________

STOP BITS (1, 2 bits) *(Hidden if PROTO := MOD)*	**STOP**	:= ____________________
PORT TIME-OUT (0–30 min) *(Hidden if PROTO := MOD)*	**T_OUT**	:= ____________________
SEND AUTOMESSAGE (Y, N) *(Hidden if PROTO := MOD)*	**AUTO**	:= ____________________
HDWR HANDSHAKING (Y, N) *(Hidden if PROTO := MOD)*	**RTSCTS**	:= ____________________
FAST OP MESSAGES (Y, N) *(Hidden if PROTO := MOD)*	**FASTOP**	:= ____________________
MODBUS SLAVE ID (1–248) *(Hidden if PROTO := SEL)*	**SLAVEID**	:= ____________________

Port 4 (Hidden if DeviceNet communications card is detected)

COMM INTERFACE (232, 485)	**COMMINF**	:= ____________________
PROTOCOL (SEL, MOD)	**PROTO**	:= ____________________
SPEED (300–38400 bps)	**SPEED**	:= ____________________
DATA BITS (7, 8 bits) *(Hidden if PROTO := MOD)*	**BITS**	:= ____________________
PARITY (O, E, N)	**PARITY**	:= ____________________
STOP BITS (1, 2 bits) *(Hidden if PROTO := MOD)*	**STOP**	:= ____________________
PORT TIME-OUT (0–30 min) *(Hidden if PROTO := MOD)*	**T_OUT**	:= ____________________
SEND AUTOMESSAGE (Y, N) *(Hidden if PROTO := MOD)*	**AUTO**	:= ____________________
HDWR HANDSHAKING (Y, N) *(Hidden if PROTO := MOD)*	**RTSCTS**	:= ____________________
FAST OP MESSAGES (Y, N) *(Hidden if PROTO := MOD)*	**FASTOP**	:= ____________________
MODBUS SLAVE ID (1–248) *(Hidden if PROTO :=* SEL*)*	**SLAVEID**	:= ____________________

NOTE: Port 4 has the following additional settings when DeviceNet card is in use. These settings can be viewed by using either the **STA** serial port command or the front-panel menu item `Status`. The settings can be changed only at the rear of the relay on the DeviceNet card.

MAC_ID (0–63)	**MAC_ID**	:= ____________________
ASA (8 hex characters assigned by factory)	**ASA**	:= ____________________
DN_Rate (125, 250, 500 kbps, Auto)	**DN_Rate**	:= ____________________

Front-Panel Settings (SET F Command)

General

LCD TIMEOUT (Off, 1–30 min)	**FP_TO**	:= ____________________
LCD CONTRAST (1–8)	**FP_CONT**	:= ____________________

Display Enable

TIME & DATE (Y, N)	**FP_TD**	:= ____________________
GROUND CURRENT (Y, N)	**FP_GC**	:= ____________________
CURRENT IMBALANC (Y, N)	**FP_LA**	:= ____________________
FREQUENCY (Y, N)	**FP_MF**	:= ____________________

THERM CAP USED (Y, N) **FP_TH** := ______________________

VOLTAGE IMBALANC (Y, N) **FP_VA** := ______________________
(Hidden if voltage card is not included)

POWER (Y, N) *(Hidden if voltage card is not included)* **FP_PE** := ______________________

RTD TEMPERATURE (Y, N) *(Hidden if E49RTD := N)* **FP_RTD** := ______________________

CLOSE RESET LEDS (Y, N) **RSTLED** := ______________________

Target LED

TRIP LATCH T_LED (Y, N) **T01LEDL** := ______________________

LED1 EQUATION (SV)
T01_LED := ____

TRIP LATCH T_LED (Y, N) **T02LEDL** := ______________________

LED2 EQUATION (SV)
T02_LED := ____

TRIP LATCH T_LED (Y, N) **T03LEDL** := ______________________

LED3 EQUATION (SV)
T03_LED := ____

TRIP LATCH T_LED (Y, N) **T04LEDL** := ______________________

LED4 EQUATION (SV)
T04_LED := ____

TRIP LATCH T_LED (Y, N) **T05LEDL** := ______________________

LED5 EQUATION (SV)
T05_LED := ____

TRIP LATCH T_LED (Y, N) **T06LEDL** := ______________________

LED6 EQUATION (SV)
T06_LED := ____

Report Settings (SET R Command)

SER Trigger Lists

SER*n* = As many as 24 Relay Word elements separated by spaces or commas. Use NA to disable setting.

SER1
SER1 := ____

SER2
SER2 := ____

SER3
SER3 := ____

SER4
SER4 := ____

Event Report

EVENT TRIGGER (SV)

ER := ____

EVENT LENGTH (15, 64 cyc) **LER** := ____________________

PREFAULT LENGTH (1–59 cyc) **PRE** := ____________________

Start Report

MSR RESOLUTION (0.25, 0.5, 1, 2, 5 cyc) **MSRR** := ____________________

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Section 7
Communications

Overview

A communications interface and protocol are required for communicating with the SEL-749M Relay.

A communications interface is the physical connection on a device. Serial ports that conform to the EIA-232 standard (often called RS-232) use DB-9 or DB-25 connectors as the physical interface.

Once you have established a physical connection, you must use a communications protocol to interact with the relay. A communications protocol is a language used to perform relay operations and collect data.

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 used with the EIA-232 serial port(s).

Communications Interfaces

The SEL-749M physical interfaces are shown in *Table 7.1*. Several optional SEL devices are available to provide alternative physical interfaces, including EIA-485 and fiber-optic cable.

NOTE: Modbus protocol is available on Port F, Port 3, and Port 4, and all ports can support Modbus sessions concurrently.

Table 7.1 SEL-749M Port Interfaces

Port	Serial Port Interface
PORT 1	Reserved
PORT 2	Rear fiber-optic port RTD MODULE RX This port receives the RTD measurement information from the optional external SEL-2600 RTD Module RTD module. Refer to the SEL-2600 RTD Module *Instruction Manual* for information on the fiber-optic interface.
PORT 3	EIA-232 (SEL or Modbus protocols)
PORT 4 (Optional)	**Option 1:** EIA-232 or EIA-485 (SEL or Modbus protocols) **Option 2:** DeviceNet Rear-panel DeviceNet port (available only with the optional DeviceNet protocol card). Refer to *Appendix E: DeviceNet* for information on the DeviceNet communications card.
PORT F	EIA-232 (SEL or Modbus protocols)

Serial Port

To connect a PC serial port to the relay front-panel serial port and enter relay commands, you will need the following:

- A personal computer equipped with one available EIA-232 serial port.
- A communications cable to connect the computer serial port to the relay serial ports.
- Terminal emulation software to control the computer serial port.
- An SEL-749M Relay.

Some of the SEL devices available for integration or communications system robustness are included in the following list:

- SEL Communications Processors (SEL-2032, SEL-2030, SEL-2020)
- SEL-2800 Fiber-Optic Transceiver
- SEL-2890 Ethernet Transceiver

A variety of terminal emulation programs on personal computers can communicate with the relay. For the best display, use VT-100 terminal emulation or the closest variation.

The default settings for all EIA-232 serial ports are listed below:

Baud Rate = 9600
Data Bits = 8
Parity = N
Stop Bits = 1

To change the port settings, use the **SET P** command (see *Section 6: Settings*) or the front-panel. *Section 8: Front-Panel Operations* provides details on making settings with the front panel.

IRIG-B

Two physical interfaces are provided for the demodulated IRIG-B time-code input. One physical interface is via terminals (B01 and B02) and the other is part of the serial Port 3 physical interface. Only one interface can be used at a time. When you use serial Port 3, connect to an SEL communications processor with Cable C273A (see the cable diagrams that follow in this section or SEL-5801 Cable Selector software.

+5 Vdc Power Supply

Port power can provide as much as 0.25 A total from all of the +5 Vdc pins. Some SEL communications devices require the +5 Vdc power supply.

Connect Your PC to the Relay

The front port of the SEL-749M is a standard female 9-pin connector with pin numbering shown in *Figure 7.1*. The pinout assignments for this port are shown in *Figure 7.6*. You can connect to a standard 9-pin computer port with SEL-C234A Cable; wiring for this cable is shown in *SEL-749M Cable Connections to Communications Devices on page 7.3*. SEL-C234A Cable and other cables are available from SEL. Use the SEL-5801 Cable Selector Software to select an appropriate cable for another application. This software is available for free download from the SEL website at selinc.com.

For best performance, SEL-C234A Cable should not be more than 15 m (49 ft) long. For long-distance communications and for electrical isolation of communications ports, use the SEL family of fiber-optic transceivers. Contact SEL for more details on these devices.

Port Connector and Communications Cables

Figure 7.1 shows the front-panel EIA-232 serial port (PORT F) DB-9 connector pinout for the SEL-749M.

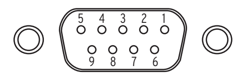

Figure 7.1 EIA-232 DB-9 Connector Pin Numbers

Table 7.2 shows the pin functions for the EIA-232 and EIA-485 serial ports.

Table 7.2 EIA-232/EIA-485 Serial Port Pin Functions

Pin[a]	Port 3 EIA-232	Port 4C EIA-232	Port 4A EIA-485[a]	Port F EIA-232
1	+5 Vdc	+5 Vdc	+TX	N/C
2	RXD	RXD, RX	–TX	RXD
3	TXD	TXD, TX	+RX	TXD
4	IRIG+	N/C	–RX	N/C
5	GND	GND	Shield	GND
6	IRIG–	N/C		N/C
7	RTS	RTS		RTS
8	CTS	CTS		CTS
9	GND	GND		GND

[a] For EIA-485, the pin numbers represent relay terminals C01 through C05.

The following cable diagrams show several types of EIA-232 serial communications cables that connect the SEL-749M to other devices. These and other cables are available from SEL. Contact the factory for more information.

SEL-749M Cable Connections to Communications Devices

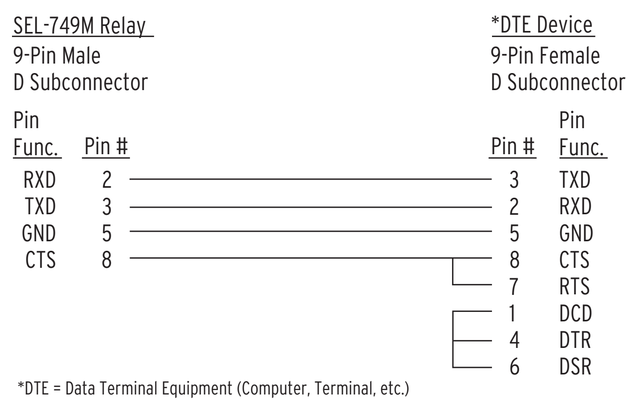

Figure 7.2 SEL-C234A Cable—SEL-749M to DTE Device

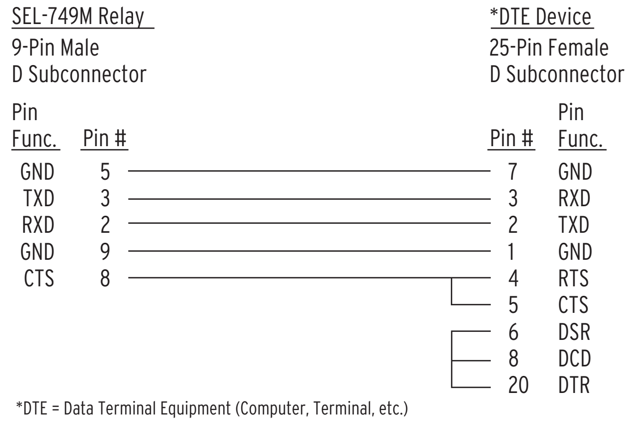

Figure 7.3 SEL-C227A Cable—SEL-749M to DTE Device

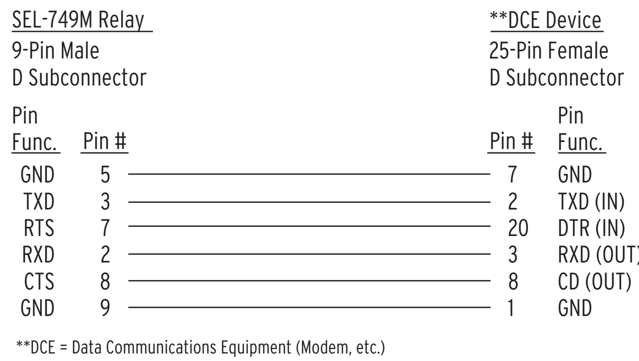

Figure 7.4 SEL-C222—SEL-749M to Modem

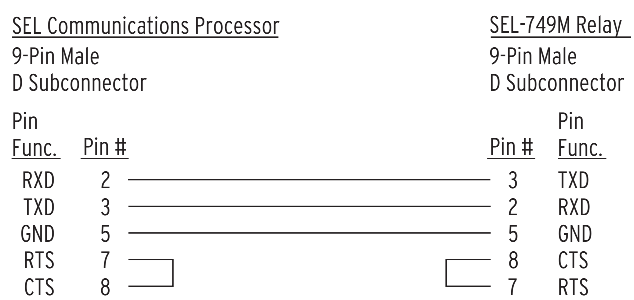

Figure 7.5 SEL-C272A Cable—SEL-749M to SEL Communications Processor (Without IRIG-B Signal)

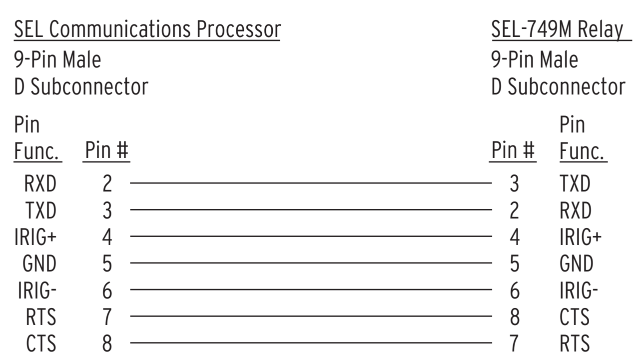

Figure 7.6 SEL-C273A—SEL-749M to SEL Communications Processor (With IRIG-B Signal)

EIA-485 Two-Wire Communications

Modbus RTU protocol is available on EIA-485 Port 4A (requires optional communications card). Connect the SEL-749M Relay EIA-485 port (Port 4A) to a two-wire Modbus network as shown in *Figure 7.7*.

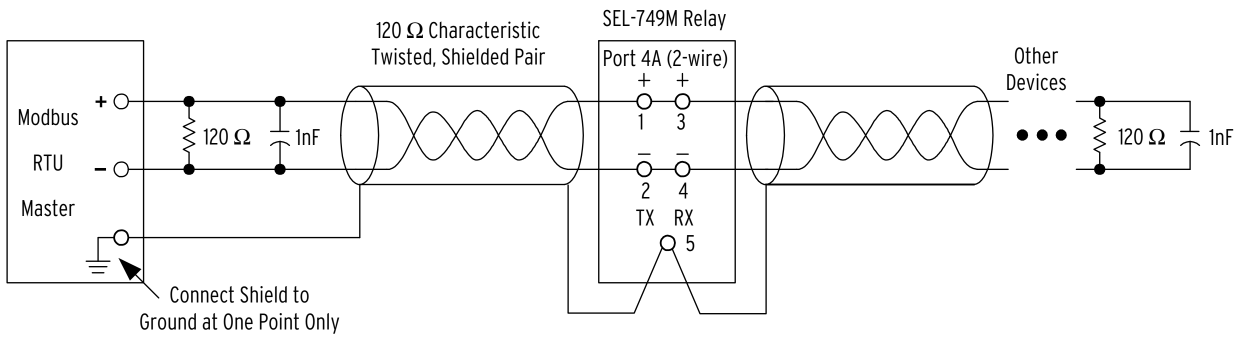

Figure 7.7 Port 4A EIA-485 Serial Port Connections

Communications Protocol

Hardware Flow Control

All EIA-232 serial ports support RTS/CTS hardware handshaking (hardware flow control).

To enable hardware handshaking, use the **SET P** command or front-panel `Set Port` submenu to set RTSCTS = Y. Disable hardware handshaking by setting RTSCTS := N.

If RTSCTS := N, the relay permanently asserts the RTS line.

If RTSCTS := Y, the relay deasserts RTS when it is unable to receive characters.

If RTSCTS := Y, the relay does not send characters until the CTS input is asserted.

Protocols

The SEL-749M supports the protocols and command sets shown in *Table 7.3*.

Table 7.3 PROTO Setting and Command Sets

PROTO Setting Value	Command Set	Description
SEL	SEL ASCII	Commands and responses
SEL	SEL Compressed ASCII	Commands and comma-delimited response
SEL	Fast Meter	Binary meter and digital element commands and response
SEL	Fast Operate	Binary operation command
MOD	Modbus RTU Slave	Binary operation command and responses

SEL Communications Protocols

SEL ASCII. This protocol is described in *SEL ASCII Protocol Details on page 7.6*.

SEL Compressed ASCII. This protocol provides compressed versions of some of the ASCII commands. The compressed commands are described in *SEL ASCII Protocol Details on page 7.6* and the protocol is described in *Appendix C: SEL Communications Processors*.

SEL Fast Meter. This protocol supports binary messages to transfer metering and digital element messages. Compressed ASCII commands that support Fast Meter are described in *SEL ASCII Protocol Details* and the protocol is described in *Appendix C: SEL Communications Processors*.

SEL Fast Operate. This protocol supports binary messages to transfer operation messages. The protocol is described in *Appendix C: SEL Communications Processors*.

Modbus RTU Protocol

The SEL-749M provides Modbus RTU support at Port F, Port 3, and Port 4 and can be used on these ports concurrently. Modbus is described in *Appendix D: Modbus RTU Communications Protocol*.

DeviceNet

The SEL-749M provides DeviceNet Support. DeviceNet is an optional protocol described in *Appendix E: DeviceNet*.

SEL ASCII Protocol Details

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-749M.

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. The automatic messages are described in *Table 7.4*.

Table 7.4 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-749M sends a status report each time it detects a self-test warning or failure condition. See *STATUS Command (Relay Self-Test Status) on page 7.25*.

Access Levels

Commands can be issued to the SEL-749M via the serial port to view metering values, change relay settings, etc. The available serial port commands are listed in the *SEL-749M Relay Command Summary* at the end of this manual. These commands can be accessed only from the corresponding access level, as shown in the *SEL-749M Relay Command Summary*. The access levels are:

- Access Level 0 (the lowest access level)
- Access Level 1
- Access Level 2 (the highest access level)
- Access Level C (restricted access level; should be used under direction of SEL only)

Access Level 0

Once serial port communication is established with the SEL-749M, 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-749M Relay Command Summary* at the end of this manual. Enter the **ACC** command at the Access Level 0 prompt:

```
=ACC <Enter>
```

The **ACC** command takes the SEL-749M to Access Level 1. See *Access Commands (ACCESS, 2ACCESS, and CAL) on page 7.10* for more detail.

Access Level 1

When the SEL-749M is in Access Level 1, the relay sends the following prompt:

```
=>
```

See the *SEL-749M Relay Command Summary* at the end of this manual for the commands available from Access Level 1. The relay can go to Access Level 2 from this level.

The **2AC** command places the relay in Access Level 2. See *Access Commands (ACCESS, 2ACCESS, and CAL)* for more detail. Enter the **2AC** command at the Access Level 1 prompt:

```
=>2AC <Enter>
```

Access Level 2

When the relay is in Access Level 2, the SEL-749M sends the prompt:

```
=>>
```

See the *SEL-749M Relay Command Summary* at the end of this manual for the commands available from Access Level 2.

Any of the Access Level 1 commands are also available in Access Level 2.

Access Level C

The **CAL** access level is intended for use by the SEL factory, and for use by SEL field service personnel to help diagnose troublesome installations. A list of commands available at the **CAL** level is available from SEL upon request. Do not enter the **CAL** access level except as directed by SEL.

The **CAL** command allows the relay to go to Access Level C. Enter the **CAL** command at the Access Level 2 prompt:

```
=>>CAL <Enter>
```

Command Summary

The *SEL-749M Relay Command Summary* at the end of this manual lists the serial port commands alphabetically. Much of the information available from the serial port commands is also available via the front-panel pushbuttons.

Access Level Functions

The serial port commands at the different access levels offer varying levels of control:

- ➤ The Access Level 0 commands provide the first layer of security. In addition, Access Level 0 supports several commands 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-749M 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 7.5 lists header item definitions:

Table 7.5 Command Response Header (Sheet 1 of 2)

Item	Definition
[RID Setting]:	This is the RID (Relay Identifier) setting. The relay is shipped with the default setting `RID = 749M`; see *Identifier Settings on page 4.3*.
[TID Setting]:	This is the TID (Terminal Identifier) setting. The relay is shipped with the default setting `TID = MOTOR RELAY`; see *Identifier Settings on page 4.3*.

Table 7.5 Command Response Header (Sheet 2 of 2)

Item	Definition
Date:	This is the date when the command response was given, except for relay response to the **EVE** command (Event), when it is the date the event occurred. You can modify the date display format (Month/Day/Year, Year/Month/Day, or Day/Month/Year) by changing the DATE_F relay setting.
Time:	This is the time when the command response was given, except for relay response to the **EVE** command, when it is the time the event occurred.
Time Source:	This is internal if no time-code input is attached and external if an input is attached.

Command Explanations

This section lists ASCII commands alphabetically. Commands, command options, and command variables to enter are shown in bold. Lowercase italic letters and words in a command represent command variables that are determined based on the application. For example, circuit breaker number ***n*** = 1 or 2, remote bit number ***nn*** = 1–8, and ***level***.

Command options appear with brief explanations about the command function. Refer to the references listed with the commands for more information on the control function corresponding to the command or examples of the control response to the command.

You can simplify the task of entering commands by shortening any ASCII command to the first three characters; for example, **ACCESS** becomes **ACC**. Always send a carriage return **<CR>** character or a carriage return character followed by a line feed character **<CR><LF>** to command the control to process the ASCII command. Usually, most terminals and terminal programs interpret the Enter key as a **<CR>**. For example, to send the **ACCESS** command, type **ACC <Enter>**.

Tables in this section show the access level(s) where the command or command option is active. Access levels in this device are Access Level 0, Access Level 1, and Access Level 2.

Access Commands (ACCESS, 2ACCESS, and CAL)

The **ACC**, **2AC**, and **CAL** commands provide entry to the multiple access levels. Different commands are available at the different access levels, as shown in the *SEL-749M Relay Command Summary* at the end of this manual. Commands **ACC** and **2AC** are explained together because they operate similarly. See *Access Levels on page 7.7* for placing the relay in an access level.

Table 7.6 Access Commands

Command	Description	Access Level
ACC	Moves from Access Level 0 to Access Level 1.	0
2AC	Moves from Access Level 1 to Access Level 2.	1
CAL	Moves from Access Level 2 to Access Level CAL.	2

Password Requirements

Passwords are required if they are not disabled. See *PASSWORD Command (View/Change Passwords) on page 7.20* 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 (View/Change Passwords) on page 7.20*. 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.sss
[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 SALARM Relay Word bit for one second and remains at Access Level 0 (= prompt).

Access Level Attempt (Password Not Required)

Assume the following conditions

➤ Access Level 1 password is disabled.

➤ Access Level is 0.

At the Access Level 0 prompt, enter the **ACC** command:

```
=ACC <Enter>
```

Because the password is disabled, the relay does not prompt you for a password and goes directly to Access Level 1. The relay responds with the following:

```
[RID Setting]                              Date: mm/dd/yyyy  Time: hh:mm:ss.sss
[TID Setting]                              Time Source: external
Level 1
=>
```

The => prompt indicates 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 or if access is denied.

ANALOG Command

Use the **ANALOG** ***p t*** command to test the relay analog current output.

Table 7.7 ANALOG Command

Command	Description	Access Level
ANA *p t*	Test the analog output port.	2

Table 7.8 ANALOG Command Format

Parameter	Description
p	Parameter ***p*** is a percentage of full scale between 0–100% (or either the letter “R” or “r” to indicate ramp mode).
t	Parameter ***t*** is time in 1.0–10.0 minutes in decimal minutes.

When you use the **ANALOG** command, the relay ends normal analog current output and sends a signal defined by the percentage value, p = 0–100% for t minutes (t = 1–10 minutes). For example, when the analog output signal type is 4–20 mA, the command **ANA 75 5.5** instructs the relay to output 16 mA (75% of full scale) for 5.5 minutes or until any character or space key is pressed to end the test.

You can also use the ANALOG command to generate a current signal that increases linearly. Replace the fixed percentage value with an **R** to ramp the signal from zero to full scale over time. For example, the command ANA R 10 instructs the relay to ramp the analog signal from zero to full scale, reaching full scale in 10 minutes. You can stop the test by pressing any keyboard character key or the space bar.

BNAMES Command

The **BNA** command produces ASCII names of all relay status bits reported in the Fast Meter Data Block (A5D1) message in Compressed ASCII format.

Table 7.9 BNAMES Command

Command	Description	Access Level
BNA	Display ASCII names of all relay status bits.	0

CASCII Command

The **CAS** command produces the Compressed ASCII configuration message. This configuration instructs an external computer on the method for extracting data from other Compressed ASCII commands.

Table 7.10 CASCII Command

Command	Description	Access Level
CAS	Return the Compressed ASCII configuration message.	0

Upon receiving the **CAS** command, the relay responds with the configurations of all Compressed ASCII commands: **CEV**, **CHI**, **CST**, and **CSU**. The configuration message for only the **CHI** command follows as an example:

```
= CAS"CAS",4,"yyyy"<CR>
"CHI",1,"yyyy"<CR>
"1H","FID","yyyy"<CR>
"1D","45S","yyyy"<CR>
"11H","REC_NUM","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","EVENT","CURR","TARG
    ETS","yyyy"<CR>
"30D","I","I","I","I","I","I","I","I","16S","F","8S","yyyy"<CR>
```

where:

yyyy is the 4-byte hex ASCII representation of the checksum
#H represents a header line to precede one or more data lines with # number of subsequent ASCII names
#D represents a data format line corresponding to maximum # number of subsequent data lines

Format fields are of the following types:

I Integer data
mS String of maximum m characters

CEVENT Command (Compressed Event Report)

The **CEV** command provides event report data in a Compressed ASCII response. These data are similar to those produced by the **EVENT** command. Use this command to retrieve data that can be displayed by PC software in oscillographic form. See *Section 9: Analyzing Events* for further details on event reports.

Table 7.11 CEVENT Command (Compressed Event Report)

Command	Description	Access Level
CEV *n*	Return the *n* event report with4 samples/cycle data of the first 15 cycles.	1
CEV *n* L	Return the *n* event report with 4 samples/cycle data of the entire event stored, 15 or 64 cycles.	1
CEV *n* R	Return the *n* event report with raw (unfiltered) 16 samples/cycle analog data and 4 samples/cycle digital data stored, 16 or 65 cycles.	1

Table 7.12 CEVENT Command Format

Parameter	Description
n	Parameter ***n*** specifies the event report number to be returned. Use the **HIS** command to determine the event report number of the event you want to display. If ***n*** is not specified, the relay will display event report 1 by default.

CHISTORY Command (Compressed History)

The relay generates the Compressed ASCII history in response to the **CHI** command.

Table 7.13 CHISTORY Command (Compressed History)

Command	Description	Access Level
CHI ***x***	Generates the Compressed ASCII history report.	0

Table 7.14 CHISTORY Command Format

Parameter	Description
x	Parameter ***x*** indicates the number of events the relay will display. The relay will show fewer than ***x*** events when ***x*** is greater than the number of stored events. In this case, the relay will display all of the stored events.

The **CHI** report format follows:

```
<STX>"FID","yyyy"<CR>
"FID=SEL-RlyType-Rrrr-VO-Zzzzzzz-Dddddddd","yyyy"<CR>
"REC_NUM","MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","EVENT",
"CURR","TARGETS","yyyy"<CR>
xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,xxxx,"xxxxxxxxxxxxxxxx",xxxx,"xxxxxxxx","yyyy"<C
    R>
<ETX>
(the last line is then repeated for each record)
```

If the history buffer is empty, the relay displays the following:

```
<STX>"No Data Available","0668"<CR><ETX>
```

CONTROL Command (Control Remote Bit)

The **CON** command is a two-step command for controlling remote bits, which are Relay Word bits RB1–RB8.

Table 7.15 CONTROL Command

Command	Description	Access Level
CON ***n***[a]	First step of a two-command sequence. The SEL-749M will prompt for the second step (subcommand), shown below.	2

[a] Parameter n is a number from 1 to 8 representing RB1–RB8.

Table 7.16 CONTROL Subcommands

Subcommand	Description
SRB ***n***	Set Remote Bit *n* (ON position)
CRB ***n***	Clear Remote Bit *n* (OFF position)
PRB ***n***	Pulse Remote Bit *n* for 1/4 cycle (MOMENTARY position)

Use the **CON** command to exercise remote bits.

```
>>CON 5 <Enter>
CONTROL RB5: PRB 5 <Enter>
=>>
```

You must enter the same remote bit number in both command steps. If the bit numbers do not match, the recloser control responds with the following:

```
Invalid Command
```

See *Logic Functions on page 4.47* for more information.

CSTATUS Command (Compressed Status)

The **CST** command generates a relay status report in Compressed ASCII format.

Table 7.17 CSTATUS Command (Compressed Status)

Command	Description	Access Level
CST	Return the relay status in Compressed ASCII.	1

CSUMMARY Command

The **CSU** command retrieves the event summary information from the last event report in Compressed ASCII format. See *Section 9: Analyzing Events*.

Table 7.18 CSUMMARY Command

Command	Description	Access Level
CSU	Return the most recent event summary (with label lines) in Compressed ASCII format.	1

DATE Command (View/Change Date)

Use the **DATE** command 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 IRIG. Enter the **DATE** command with a date to set the internal clock date.

Separate the month, day, and year parameters with spaces, commas, slashes, colons, and semicolons. Set the year in 4-digit form (for dates 2000–2099). Global setting DATE_F sets the date format.

DNAMES Command

The **DNA** command produces the ASCII names of all Relay Word bits reported in a Fast Meter message in Compressed ASCII format.

Table 7.20 DNAMES Command

Command	Description	Access Level
DNA	Display ASCII names of all Relay Word bits digital I/O.	0

EVENT Command (Event Reports)

Use the **EVE** command to view event reports. See *Section 9: Analyzing Events* for further details on retrieving and analyzing event reports.

See the *HISTORY Command on page 7.17* for details on clearing event reports.

Table 7.21 EVENT Command (Event Reports)

Command	Description	Access Level
EVE *n*	Return the *n* event report with 4-samples/ cycle data.	1
EVE *n* R	Return the *n* event report with raw (unfiltered) 16 samples/cycle analog data and 4 samples/cycle digital data.	1

Table 7.22 EVENT Command Format

Parameter	Description
n	Parameter ***n*** specifies the event report number to be returned. Use the **HIS** command to determine the event report number of the event you want to display. If ***n*** is not specified, the relay will display event report 1 by default.

FILE Command

The **FIL** command provides a safe and efficient means of transferring files between intelligent electronic devices (IEDs) and external support software (ESS). Use the **FIL** commands for sending settings to the SEL-749M and receiving settings from the relay.

Table 7.23 FILE Command

Command	Description	Access Level
FIL DIR	Return a list of files.	1
FIL READ *filename*	Transfer settings file *filename* from the relay to the PC.	1
FIL WRITE *filename*	Transfer settings file *filename* from the PC to the relay.	2
FIL SHOW *filename*	Filename 1 displays contents of the file *filename*.	1

HISTORY Command

Use the **HIS** command 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*	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	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 to extract device identification codes.

Table 7.25 IDENTIFICATION Command

Command	Description	Access Level
ID	Return a list of device identification codes.	0

IRI Command

IRI directs the relay to read the demodulated IRIG-B time code at the serial port or IRIG-B input.

Table 7.26 IRI Command

Command	Description	Access Level
IRI	Force synchronization of internal control clock to IRIG-B time-code input.	1

To force the relay to synchronize to IRIG-B, enter the following command:

```
=>IRI <Enter>
```

If the relay successfully synchronizes to IRIG, it sends the following header and access level prompt:

```
SEL-749M                                    Date: 12/10/2003 Time: 08:56:03.190
MOTOR RELAY                                 Time Source: external
=>
```

If no IRIG-B code is present at the serial port input or if the code cannot be read successfully, the relay responds:

```
IRIG-B DATA ERROR
=>
```

If an IRIG-B signal is present, the relay synchronizes its internal clock with IRIG-B. It is not necessary to issue the **IRI** command to synchronize the relay clock with IRIG-B. Use the **IRI** command to determine if the relay is properly reading the IRIG-B signal.

L_D Command (Load Firmware)

Use the **L_D** command to load firmware. See *Appendix A: Firmware and Manual Versions* for information on changes to the firmware and instruction manual. See *Appendix B: Firmware Upgrade Instructions* for further details on downloading firmware.

Table 7.27 L_D Command (Load Firmware)

Command	Description	Access Level
L_D	Loads new firmware.	2

Only download firmware to the front port.

METER Command

The **MET** commands provide access to the relay metering data. The relay divides the displayed information into two groups:

NOTE: All ASCII command responses in this section are examples only. Your specific relay will have differences based on model number, firmware revision number, and application.

- Instantaneous
- Thermal and RTD

METER k (Instantaneous Metering)

The **MET *k*** command displays instantaneous magnitudes (and angles, if applicable) of the measured and calculated analog quantities.

Table 7.28 METER k (Instantaneous Metering)

Command	Description	Access Level
MET *k*	View/reset relay measured quantities.	1

All angles are displayed between –180 and +180 degrees. For delta-connected PTs, angles are referenced to VAB or L1. For wye-connected PTs, angles are referenced to VAN or L1. If the voltage channels are not supported, or VAB < 13 V (for delta) or VAN < 13 V (for wye), angles are referenced to L1 current.

To view the instantaneous meter values once, use the **MET** command (see the example in *Figure 5.1*). To view the meter values *k* times, use the **MET *k*** command, where ***k*** is a number between 1 and 32767.

METER T (Thermal and RTD Metering)

NOTE: Maximum time to trip is 3600 seconds, values greater than 3600 are displayed as 9999.

The **MET T** command displays the temperatures of any connected RTDs. This command also shows the average motor current (xFLA), the present % Thermal Capacity used, and the RTD % Thermal Capacity (if ambient and winding temperatures are monitored and a winding RTD trip temperature is set). To view the thermal meter values *k* times, use the **MET T *k*** command as described in *METER k (Instantaneous Metering) on page 7.18*.

Table 7.29 METER T (Thermal and RTD Metering)

Command	Description	Access Level
MET T	Displays the instantaneous thermal data for the induction machine.	1

If the motor is in overload, this command response shows the calculated time to a thermal trip. If the motor is not in overload (such as in the example in *Figure 5.2*), the time shown is 9999 seconds. The relay also displays starts available and time to reset.

MOTOR Command

The **MOT** command 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.	2

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 2 clears the report.

MSR Command

Use the **MSR** (Motor Start Report) command to view motor start reports. The relay records a 720-data point report each time the motor starts. The general command format is listed in *Table 7.31*.

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
MSR F	Display the format of a motor start report.	1

See *Section 5: Metering and Monitoring* for information on the contents of motor start reports. Motor Start Report data are cleared when **MOT R** or **MOT C** command is executed.

MST Command

Use the **MST** (Motor Start Trend) command 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. The general command format is listed in *Table 7.32*.

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 the data stored in the motor start trend buffers.	2

PASSWORD Command (View/Change Passwords)

Use the **PAS** command to inspect or change existing passwords.

Table 7.33 PASSWORD Command

Command	Description	Access Level
PAS	Display the passwords for each access level (except Access Level 0, which has no password).	2, C
PAS ***level new-password***	Set a password *new-password* for Access Level *level*.	2, C
PAS ***level***	Display the password for the Access Level *level*.	2, C

Table 7.34 PAS Command Format

Parameter	Description
level	Parameter ***level*** represents the relay Access Levels 1, 2, and C.
new-password	New password.

The factory-default passwords are as shown in *Table 7.35*.

Table 7.35 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:

```
=>>PAS 1 #Ot3579!ijd7 <Enter>
Set
=>>
```

Similarly, use **PAS 2** to change Level 2 passwords and **PAS C** to change Level C passwords.

Table 7.36 Valid Password Characters

Alpha	A B C D E F G H I J K L M N O P Q R S T U V W X Y Z a b c d e f g h i j k l m n o p q r s t u v w x y z
Numeric	0 1 2 3 4 5 6 7 8 9
Special	! " # $ % & ' ( ) * + , - . / : ; < = > ? @ [\ ] ^ _ ` { | } ~

Passwords can contain as many as 12 characters. Upper- and lowercase letters are treated as different characters. Strong passwords consist of 12 characters, with at least one special character or digit and mixed case sensitivity, but do not form a name, date, acronym, or word. Passwords formed in this manner are less susceptible to password guessing and automated attacks. Examples of valid, distinct, and strong passwords are as follows:

#0t3579!ijd7

$A24.68&,mvj

(Ih2dcs)36dn

*4u-Iwg+?lf-

After entering new passwords, type **PAS <Enter>** to confirm that you entered the passwords correctly. Make sure that the passwords are what you intended, and record the new passwords.

If you want to disable password protection for a specific access level, set the password to DISABLE. For example, **PAS 1 DISABLE <Enter>** disables password protection for Level 1.

QUIT Command

Use the **QUIT** command to revert to Access Level 0.

Table 7.37 QUIT Command

Command	Description	Access Level
QUI	Go to Access Level 0.	0

Access Level 0 is the lowest access level; the SEL-749M performs no password check to descend to this level (or to remain at this level).

R_S Command (Restore Factory Defaults)

Use the **R_S** command 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 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 ***row1*** **SER** ***row1 row2*** **SER** ***date1*** **SER** ***date1 date2***	Use the **SER** command to display a chronological progression of all available SER rows (as many as 512 rows). Row 1 is the most recently triggered row and row 512 is the oldest. Use the **SER** command with parameters to display a chronological or reverse chronological subset of the SER rows.	1
SER C	Use this command to clear/reset the SER records.	1
SER R	Use this command to clear/reset the SER records.	1

Table 7.40 SER Command Format

Parameter	Description
row1	Append ***row1*** to return a chronological progression of the first ***row1*** rows. For example, use **SER 5** to return the first five rows.
row1 row2	Append ***row1*** and ***row2*** to return all rows between ***row1*** and ***row2***, beginning with ***row1*** and ending with ***row2***. Enter the smaller number first to display a numeric progression of rows through the report. Enter the larger number first to display a reverse numeric progression of rows. For example, use **SER 1 10** to return the first ten rows in numeric order or **SER 10 1** to return these same items in reverse numeric order.
date1	Append ***date1*** to return all rows with this date. For example, use **SER 1/1/2003** to return all records for January 1, 2003.
date1 date2	Append ***date1*** and ***date2*** to return all rows between ***date1*** and ***date2*** 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 the following:

```
No SER data
```

SET Command (Change Settings)

The **SET** command is for viewing or changing the relay settings (see *Table 6.1*).

Table 7.41 SET Command (Change Settings)

Command	Description	Access Level
SET *s* TERSE	Set the Group settings, beginning at the first setting.	2
SET L *s* TERSE	Set general logic settings.	2
SET G *s* TERSE	Set global settings.	2
SET P *n* *s* TERSE	Set serial port settings. *n* specifies the port (3, 4, or F); *n* defaults to the active port if not listed.	2
SET R *s* TERSE	Set report settings such as Sequential Events Recorder (SER) and Event Report (ER) settings.	2
SET F *s* TERSE	Set front-panel settings.	2

Table 7.42 SET Command Format

Parameter	Description
s	Append ***s***, the name of the specific setting you want to view and jumps to this setting. If ***s*** is not entered, the relay starts at the first setting.
TERSE	Append **TERSE** to skip the settings display after the last setting. Use this parameter to speed up the **SET** command. If you want to review the settings before saving, do not use the **TERSE** option.

When you issue the **SET** command, the relay presents a list of settings one at a time. Enter a new setting or press **<Enter>** to accept the existing setting. Editing keystrokes are shown in *Table 7.43*.

Table 7.43 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 five seconds while it saves the new settings. The SALARM Relay Word bit is set momentarily, and the **ENABLED** LED extinguishes while the relay is disabled.

SHOW Command (Show/View Settings)

When showing settings, the relay displays the settings label and the present value from nonvolatile memory for each setting class.

Table 7.44 SHOW Command (Show/View Settings)

Command	Description	Access Level
SHO ***s***	Show group settings.	1
SHO L ***s***	Show general logic settings.	1
SHO G ***s***	Show global settings.	1
SHO P ***n s***	Show serial port settings. *n* specifies the port (3, 4, or F); *n* defaults to the active port if not listed.	1
SHO R ***s***	Show report settings such as Sequential Events Recorder (SER) and Event Report (ER) settings.	1
SHO F ***s***	Show front-panel settings.	1

Table 7.45 SHOW Command Format

Parameter	Description
s	Append ***s***, the name of the specific setting you want to view and jumps to this setting. If ***s*** is not entered, the relay starts at the first setting.

```
=>SHO <Enter>
RID     := SEL-749M
TID     := MOTOR RELAY
CTR1    := 100      FLA1    := 250.0    E2SPEED := N        CTRN    := 100
PTR     := 35.00    VNOM    := 4160     DELTA_Y := DELTA
E49MOTOR:= Y        SETMETH := RATING   49RSTP  := 75       SF      := 1.15
LRA1    := 6.0      LRTHOT1 := 10.0     TD1     := 1.00     RTC1    := AUTO
TCAPU   := 85       TCSTART := OFF      COOLTIME:= 18

50P1P   := 10.00    50P2P   := OFF      50N1P   := OFF      50N2P   := OFF
50G1P   := OFF      50G2P   := OFF
LJTPU   := OFF      LJAPU   := OFF
LLTPU   := OFF      LLAPU   := OFF
46UBT   := OFF      46UBA   := 10       46UBAD  := 10       PROTBL_T:= OFF
THERBL_T:= OFF
START_T := OFF
ESTAR_D := N
MAXSTART:= OFF      TBSDLY  := OFF      ABSDLY  := OFF
E47T    := Y
SPDSDLYT:= OFF      SPDSDLYA:= OFF
EPTC    := N
E49RTD  := N
27P1P   := 0.80     27P1D   := 0.5      27P2P   := OFF
59P1P   := 1.10     59P1D   := 0.5      59P2P   := OFF
NVARTP  := OFF      PVARTP  := OFF      NVARAP  := OFF      PVARAP  := OFF
37PTP   := OFF      37PAP   := OFF
55LGTP  := OFF      55LDTP  := OFF      55LGAP  := OFF      55LDAP  := OFF
81D1TP  := OFF      81D1AP  := OFF
81D2TP  := OFF
81D2AP  := OFF
LOAD    := OFF
AOPARM  := LOAD_I
BLKPROT := 0
BLK46   := N        BLK48   := N        BLK50EF := N        BLK50P  := N
BLK37   := N        BLK66   := N        BLK49PTC:= N        BLK49RTD:= N
TDURD   := 0.5
TR      := 49T OR LOSSTRIP OR JAMTRIP OR 46UBT OR 50P1T OR 50G1T OR 59P1T OR 47T
 OR 55T OR SPDSTR OR 50N1T OR SMTRIP OR 81D1T OR 81D2T OR SV01T
REMTRIP := 0
ULTRIP  := 0
52A     := NOT IN101
STREQ   := 0
EMRSTR  := IN102 AND STOPPED
SPEED2  := 0
SPEEDSW := 0
=>
```

Figure 7.8 SHOW Command Example

SNS Command

The **SNS** command displays the SER settings in Compressed ASCII format.

Table 7.46 SNS Command

Command	Description	Access Level
SNS	The SNS command displays the SER settings in Compressed ASCII format.	0

The setting name values are gathered in groups of eight names to be displayed on each line of the report. The last line of the report may have fewer than eight names. Each line is formatted as a comma-separated list of quoted setting names, followed by a quoted hexadecimal representation of the checksum. The checksum is calculated from the first quote mark of the line to the last comma before the checksum. If there are no setting name values, (i.e., all SER settings are NA), no lines are generated for the report.

```
=>SNS <Enter>
"IN101","IN102","IN401","IN402","IN403","TRIP","RTDIN","OUT101","0DA4"
"OUT102","OUT103","OUT401","OUT402","OUT403","OUT404","ABSLO","TBSLO","0FC6"
"NOSLO","THERMLO","49T","LOSSTRIP","JAMTRIP","46UBT","50P1T","RTDT","104B"
"PTCTRIP","50G1T","VART","37PT","27P1T","59P1T","47T","55T","0D20"
"SPDSTR","50N1T","SMTRIP","81D1T","81D2T","OTHTRIP","AMBTRIP","PTCFLT","10E2"
"RTDFLT","COMMIDLE","COMMLOSS","REMTRIP","RSTTRGT","49A","LOSSALRM","JAMALRM","1383
    "
"46UBA","RTDA","55A","50N2T","50G2T","VARA","37PA","27P2T","0C67"
"59P2T","SPDSAL","81D1A","81D2A","OTHALRM","AMBALRM","SALARM","WARNING","10B3"
"LOADUP","LOADLOW","50P2T","STOPPED","RUNNING","STARTING","STAR","DELTA","11E2"
"START","SPEED2","0411"
=>
```

STATUS Command (Relay Self-Test Status)

The **STA** command displays the status report.

Table 7.47 STATUS Command (Relay Self-Test Status)

Command	Description	Access Level
STA *n*	Display the relay self-test information *n* times (*n* = 1–32767). Defaults to 1 if *n* is not specified.	1
STA S	Display the memory and execution utilization for the SELOGIC control equations.	1
STA C or **R**	Reboot the relay and clear self-test warning and failure status results.	2

Refer to *Section 10: Testing and Troubleshooting* for self-test thresholds and corrective actions, as well as hardware configuration conflict resolution.

Table 7.48 shows the status report definitions and message formats for each test. Refer to *Figure 1.2* and *Figure 1.3* for examples of **STATUS** command response.

Table 7.48 STATUS Command Report and Definitions (Sheet 1 of 2)

STATUS Report Designator	Definition	Message Format
FID	Firmware identifier string	Text/Data
CID	Firmware checksum identifier	xxxx
Current Offset (IA, IB, IC, IN)	DC offset in hardware circuits of current channels	OK/WARN

Table 7.48 STATUS Command Report and Definitions (Sheet 2 of 2)

STATUS Report Designator	Definition	Message Format
Voltage Offset (VA, VB, VC)	DC offset in hardware circuits of voltage channels	OK/WARN
x.x V	Power supply status	Voltage/FAIL
FPGA	FPGA programming unsuccessful, or FPGA failed	OK/FAIL
GPSB	General Purpose Serial Bus	OK/FAIL
HMI	Front-Panel FGPA programming unsuccessful, or Front-Panel FPGA failed	OK/WARN
RAM	Volatile memory integrity	OK/FAIL
ROM	Firmware integrity	OK/FAIL
CR_RAM	Integrity of settings in RAM and code that runs in RAM	OK/FAIL
Non_Vol	Integrity of data stored in nonvolatile memory	OK/FAIL
Clk_Bat	Clock battery integrity	OK/WARN
Clock	Clock functionality	OK/WARN
PTC	Integrity of PTC	OK/FAIL
RTD	Integrity of RTD module/communications	OK/FAIL
Current	Integrity of current board	OK/FAIL
Voltage	Integrity of voltage board	OK/FAIL
I/O_Crd	Integrity of I/O card	OK/FAIL
COM_Crd	Integrity of DeviceNet card and network	OK/FAIL
MAC_ID	DeviceNet card specific card identification	xxxxxx
ASA	Manufacturer identifier for DeviceNet	xxxx xxxxx
DN_Rate	DeviceNet card network communications data speed	___ kbps
DN_Status	DeviceNet connection and fault status	000b bbbb

Figure 7.9 shows the typical relay output for the **STATUS S** command, showing the available SELOGIC control equation capability.

NOTE: The **STA S** report gives the available SELOGIC capacity of the relay. Example Execution 90% means 90% of execution capacity is still available.

```
=>>STA S
SEL-749M                          Date: 10/23/2004    Time: 13:37:18.276
MOTOR RELAY                       Time Source: internal
FID=SEL-749M-R102-V0-Z002002-D20041022       CID=3BB9
Available Capacity for SELOGIC Control Equations
Execution                91%
Settings (Group)         68%
Settings (Logic)         87%
Settings (Global)        81%
Settings (Report)        99%
Settings (Front Panel)   67%
=>>
```

Figure 7.9 Typical Relay Output for STATUS S Command

STOP Command

The **STO** command causes the relay to trip, opening the motor contactor or circuit breaker and stopping the motor. For further details refer to *Figure 4.21*.

Table 7.49 STOP Command

Command	Description	Access Level
STO *n*	Initiates user operation of an output to stop the motor.	2

STR Command

The **STR** command uses internal relay logic to initiate a motor start. For further details refer to *Section 4: Protection and Logic Functions*.

Table 7.50 STR Command

Command	Description	Access Level
STR	Initiates user operation of an output to start and run the motor.	2

SUMMARY Command

The **SUM *n*** command displays a summary list, in reverse chronological order, of all the archived event summary reports (maximum of five events).

Table 7.51 SUMMARY Command

Command	Description	Access Level
SUM	Displays a summary list, in reverse chronological order, of all archived event reports.	1
SUM R	Use this command to clear the archive.	1

An example event summary report is in *Figure 7.10*. 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).

The ***n*** parameter with the **SUM *n*** command can have a value as much as 5 and defines the number of events requested. If ***n*** is not specified, then as many as five of the most recent reports are listed.

For additional information on events, refer to *Section 9: Analyzing Events*.

```
=>SUM <Enter>

SEL-749M                          Date: 10/14/2004    Time: 22:45:18.677
MOTOR RELAY                       Time Source: internal

Event #: 1                    Event: Overcurrent Trip
Event Date: 10/15/2004        Event Time: 22:24:00.101
Frequency (Hz): 60.0

                         IA         IB         IC         IN         IG
CURRENT MAG (A)         711.1     1049.2      591.2       0.04      10.63

                        VAB        VBC        VCA
VOLTAGE MAG L-L (V)     2806       2513       1338

                     Winding    Bearing    Ambient      Other
Hottest RTD(C):         123        110         45        160

Press RETURN to continue
```

Figure 7.10 SUMMARY Command Example

TARGET Command (Display Relay Word Bit Status)

The **TAR** command displays the status of front-panel target LEDs or Relay Word bit, whether these LEDs or Relay Word bits are asserted or deasserted.

NOTE: The **TARGET R** command cannot reset the latched targets if a TRIP condition is present.

Table 7.52 TARGET Command (Display Relay Word Bit Status)

Command	Description	Access Level
TAR *name* ROW **TAR *n k* ROW**	Use **TARGET** without parameters to display Relay Word Row 0 or last displayed target row. Adding **ROW** to the command displays the Relay Word Row number at the start of each line.	1
TAR R	Clears front-panel tripping targets.Unlatches the trip logic for testing purposes (see *Figure 8.1*). Shows Relay Word Row 0.	1

Table 7.53 TARGET Command Format

Parameter	Description
name	Display the Relay Word row with Relay Word bit ***name***.
n k	Show Relay Word row number ***n*** (0–65) and repeat ***k*** times (1–32767).
ROW	Adding **ROW** to the command displays the Relay Word row number at the start of each line.

The elements are represented as Relay Word bits and are listed in rows of eight, called Relay Word rows. The first four rows, representing the front-panel operation and target LEDs, correspond to *Table 7.54*. All Relay Word rows are described in *Table G.1* and *Table G.2*.

Relay Word bits are used in SELOGIC control equations. See *Appendix G: Relay Word Bits*. The **TAR** command does not remap the front-panel target LEDs, as is done in some previous SEL relays.

Table 7.54 Front-Panel LEDs and the TAR 0 Command

LEDs	7	6	5	4	3	2	1	0
TAR 0	ENABLED	TRIP	TLED_01	TLED_02	TLED_03	TLED_04	TLED_05	TLED_06

TIME Command (View/Change Time)

The **TIME** command returns information about the SEL-749M 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 7.55 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-749M responds, `Invalid Time`.

TRIGGER Command (Trigger Event Report)

Use the **TRI** command to trigger the SEL-749M to record data for high-resolution oscillography and event reports.

Table 7.56 TRIGGER Command (Trigger Event Report)

Command	Description	Access Level
TRI	Trigger event report data capture.	1

When you issue the **TRI** command, the SEL-749M responds, `Triggered`. If the event did not trigger within 1 second, the relay responds, `Did not trigger`. See *Section 9: Analyzing Events* for further details on event reports.

VEC Command (Show Diagnostic Command)

Issue the **VEC** command under the direction of SEL. The information contained in a vector report is formatted for SEL in-house use only. Your SEL application engineer or the factory may request a **VEC** command capture to help diagnose a relay or system problem.

Table 7.57 VEC Command

Command	Description	Access Level
VEC	Displays the exception vector report.	2

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Section 8
Front-Panel Operations

Overview

The SEL-749M Relay front panel makes motor data collection and control quick and efficient. Use the front panel to analyze operating information, view and change relay settings, and perform control functions. The SEL-749M features a straightforward menu-driven control structure presented on the front-panel liquid crystal display (LCD). Front-panel targets and other LED indicators give a quick look at SEL-749M operation status. The features that help you operate the relay from the front panel include the following:

- Reading metering
- Inspecting targets
- Accessing settings
- Controlling relay operations

Front-Panel Layout

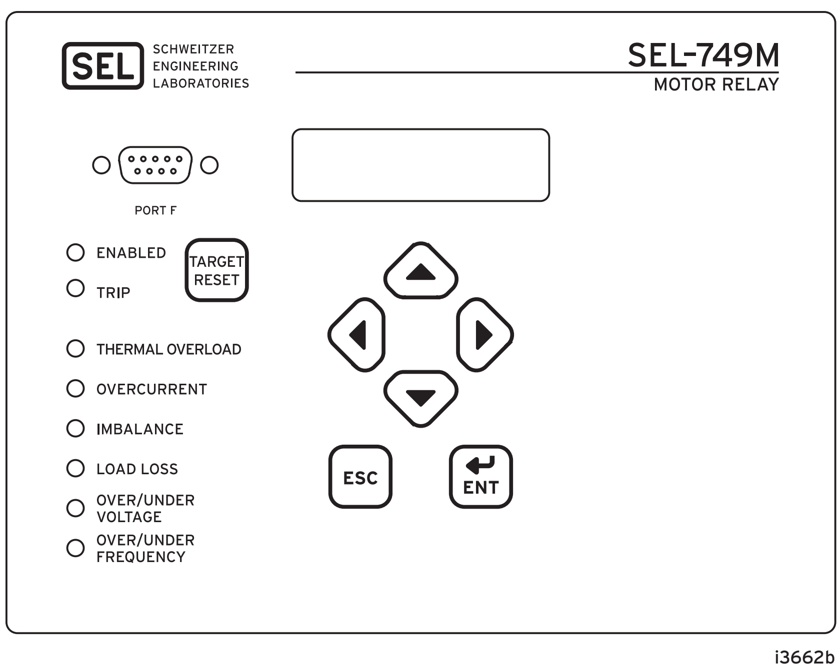


Figure 8.1 Front-Panel Pushbuttons—Overview

Figure 8.1 shows and identifies the following regions:

- EIA-232 Serial Port. See *Section 7: Communications* for details on the serial port.
- Human-Machine Interface (HMI)
- Operation and target LEDs

This versatile front panel supports the following features so you can customize it for your needs:

- Rotating display on the HMI
- Programmable target LEDs
- Slide-in configurable front-panel labels to change the identification of operation and target LEDs

Human-Machine Interface

Contrast

NOTE: See the Preface for an explanation of typographic conventions used to describe menus, the front-panel display, and the front-panel pushbuttons.

You can adjust the LCD screen contrast to suit your viewing angle and lighting conditions. To change screen contrast, press and hold the **ESC** pushbutton for two seconds. The SEL-749M displays a contrast adjustment box. Pressing the **Right Arrow** pushbutton increases the contrast. Pressing the **Left Arrow** pushbutton decreases the screen contrast. When you are finished adjusting the screen contrast, press the **ENT** pushbutton; this process is a short cut for changing the LCD contrast setting FP_CONT in the front-panel settings.

Front-Panel Automatic Messages

The relay displays automatic messages under the conditions described in *Table 8.1*.

Table 8.1 Front-Panel Automatic Messages

Condition	Front-Panel Message
Relay detecting any failure	Displays the type of latest failure (see *Section 10: Testing and Troubleshooting*).
Relay trip has occurred	Displays the type or cause of the trip. Refer to *Table 9.1* for the list of trip display messages.
Motor running overload	Displays the predicted time to thermal element trip in seconds.
Relay alarm condition has occurred	Displays the type of alarm. The **TRIP** LED is also flashing during an alarm condition.
When a start is requested during a lockout condition	Displays the type of lockout condition. Press the **ESC** pushbutton to gain more information on lockout type and lockout time remaining.
Control input set to disable protection	Displays `Protect Disabled By Control Input`.
During emergency start	Displays `Emergency Start`.

Front-Panel Security

Front-Panel Access Levels

The SEL-749M front panel typically operates at Access Level 1 and provides viewing of relay measurements and settings. Some activities, such as editing settings and controlling output contacts, are restricted to those operators who know the Access Level 2 passwords or can disable these passwords from the front panel.

Pressing the **Left Arrow** and **Right Arrow** pushbuttons for 10 seconds toggles the **PASSWORD DISABLE/ENABLE** if passwords are set. When you disable passwords, through use of the front-panel pushbuttons, the SALARM Relay Word bit asserts for one second. Use caution when including the SALARM Relay Word bit in the control logic.

In the figures that follow, restricted activities are indicated by the padlock symbol shown in *Figure 8.2*.

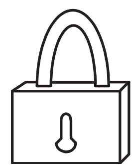


Figure 8.2 Access Level Security Padlock Symbol

Before you can perform a front-panel menu activity that is marked with the padlock symbol, you must enter the correct Access Level 2 passwords. After you have correctly entered the password, you can perform other Access Level 2 activities without reentering the password.

Access Level 2 Password Entry

When you try to perform an Access Level 2 activity, the relay determines whether you have entered the correct Access Level 2 password since the front-panel inactivity timer expired. If you have not, the relay displays the screen shown in *Figure 8.3* for you to enter the password.

```
Password=
Del Clr Accept
A B C D E F G H
I J K L M N O P
Q R S T U V W X
Y Z . . . . . .
a b c d e f g h
i j k l m n o p
q r s t u v w x
y z . . . . . .
0 1 2 3 4 5 6 7
8 9 . . . . . .
! " # $ % & ' (
) * + , - . / :
; < = > ? @ [ \
] ^ _ ` { | } ~
```

Figure 8.3 Password Entry Screen

See *PASSWORD Command (View/Change Passwords) on page 7.20* for the list of default passwords and for more information on changing passwords.

Front-Panel Timeout

To help prevent unauthorized access to password-protected functions, the SEL-749M provides a front-panel timeout, setting FP_TO. A timer is reset every time a front-panel pushbutton is pressed. Once the timeout period has expired, the access level is reset to Access Level 1. Manually reset the access level by selecting `Reset Access Lvl` from the `MAIN` menu.

Front-Panel Menus and Screens

Navigating the Menus

The SEL-749M front panel gives you access to most of the information that the relay measures and stores. You can also use front-panel controls to view or modify relay settings.

All of the front-panel functions are accessible through use of the six-button keypad and LCD display. Use the keypad (shown in *Figure 8.4*) to maneuver within the front-panel menu structure, described in detail throughout the remainder of this section. *Table 8.2* describes the function of each front-panel pushbutton.

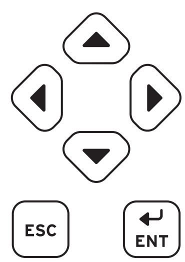
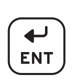


Figure 8.4 Front-Panel Pushbuttons

Table 8.2 Front-Panel Pushbutton Functions

Pushbutton		Function
	Up Arrow	Move up within a menu or data list. While editing a setting value, increase the value of the underlined digit.
	Down Arrow	Move down within a menu or data list. While editing a setting value, decrease the value of the underlined digit.
	Left Arrow	Move the cursor to the left.
	Right Arrow	Move the cursor to the right.
	ESC	Escape from the current menu or display. Displays additional information if lockout condition exists. Hold for 2 seconds to display contrast adjustment screen.
	ENT	Move from the rotating display to the **MAIN** menu. Select the menu item at the cursor. Select the displayed setting to edit that setting.

The SEL-749M automatically scrolls information that requires more space than provided by a 16-character LCD line. Use the **Left Arrow** and **Right Arrow** pushbuttons to suspend automatic scrolling and enable manual scrolling of this information.

SEL-749M Menu Structure

Figure 8.5 describes the menu hierarchy. Menus and displays are available for most SEL-749M functions. Several of these menus and displays are described in detail later in this section.

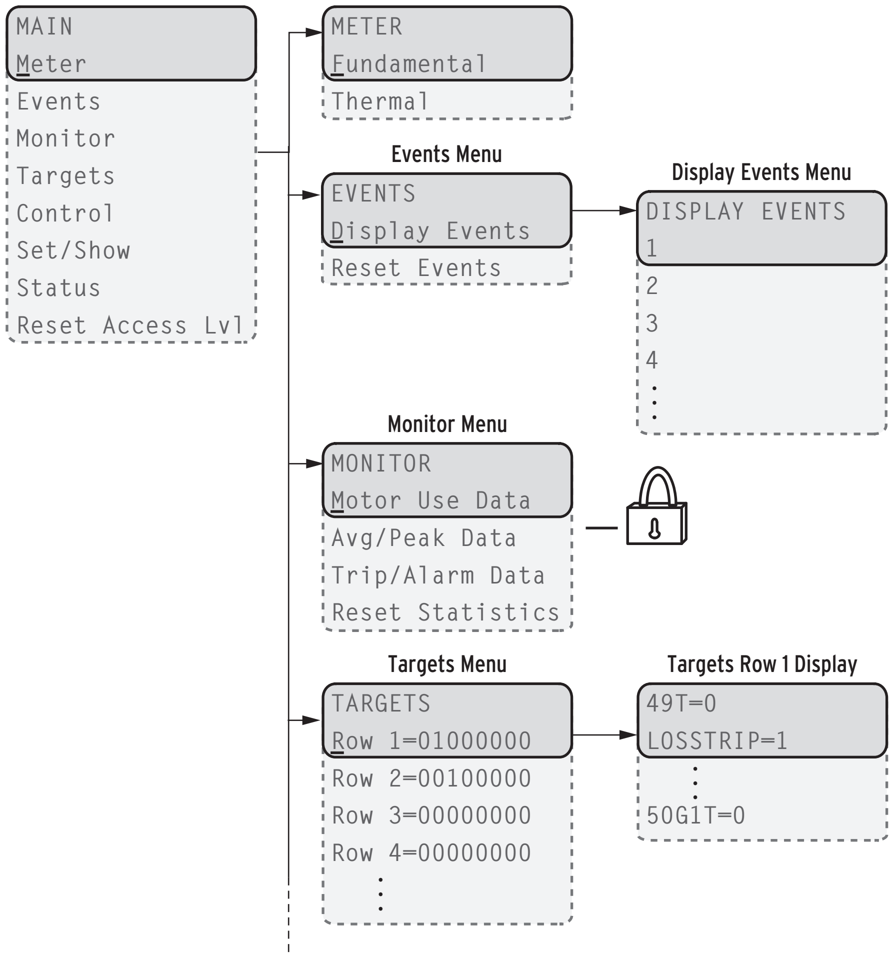


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Figure 8.5 Front-Panel Menu Structure (Continued)

Continued from previous page

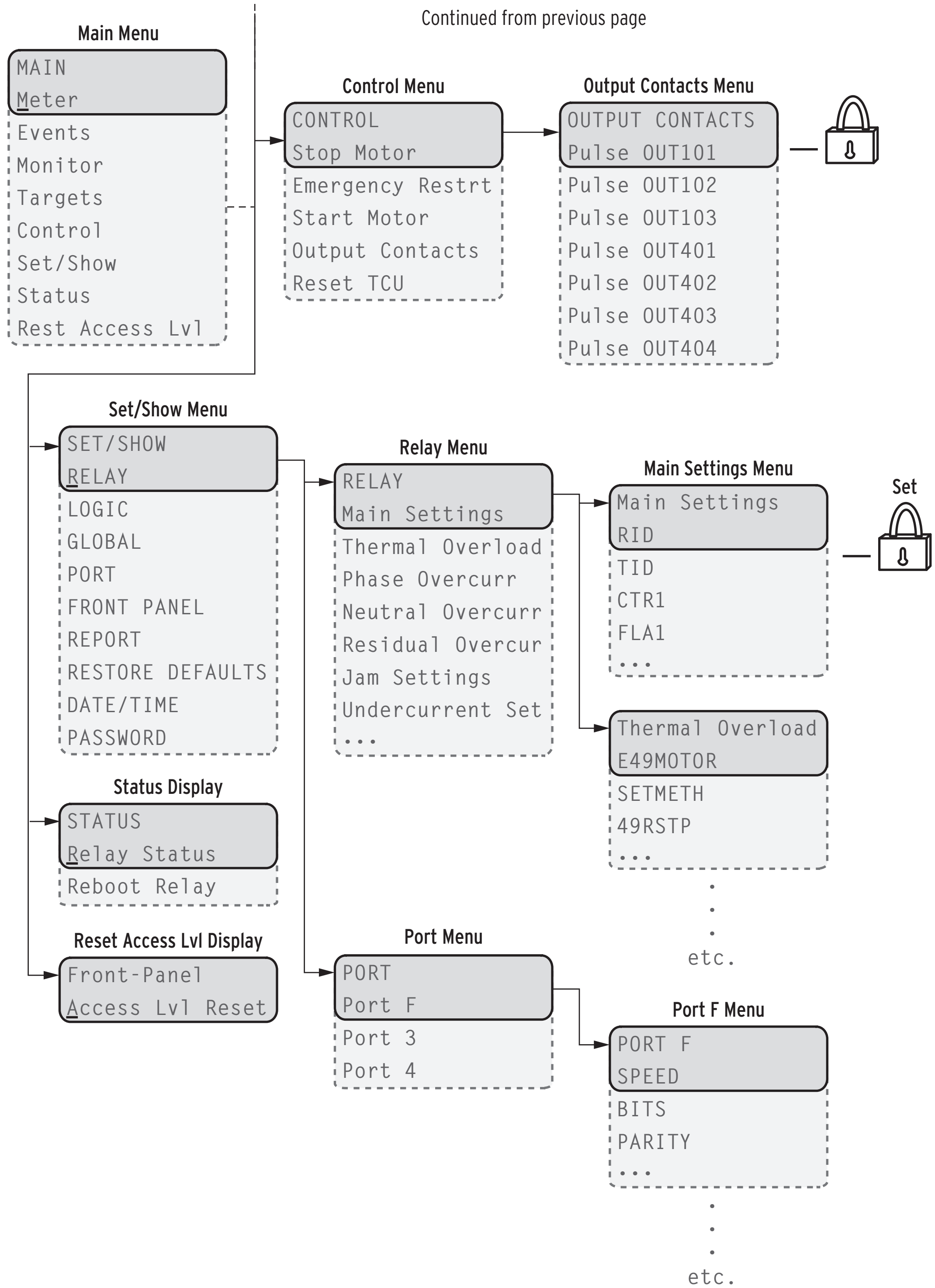

Figure 8.5 Front-Panel Menu Structure

Meter Menu

Select the `Meter` menu item on the `MAIN` menu to access the `Fundamental` and `Thermal` metering data. See *Metering on page 5.1* for a description of the data available.

Events Menu

Select the `Events` menu from the `MAIN` menu to access `Display Events` or `Reset Events`. Select `Display Events` to show events in order of occurrence, starting with the most recent.

Press the **ENT** pushbutton to display elements.	`EVENTS`
	`Display Events`
	`Reset Events`

Press the **ENT** pushbutton to reset events.	`EVENTS`
	`Display Events`
	`Reset Events`

Monitor Menu

Select the `Monitor` menu item on the `MAIN` menu to access the motor operating statistics that include `Motor Use Data`, `Avg/Peak Data`, `Trip/Alarm Data`, and `Reset Statistics`. See *Motor Operating Statistics on page 5.5* for a description of the data available.

Targets Menu

Select the `Targets` menu item on the `MAIN` menu to access the target rows (Relay Word bits). Use the following features to monitor the relay during operation and testing.

Navigate to the target row that contains the Relay Word bit you want to access. Monitor two consecutive rows that contain 16 Relay Word bits with this display.	`Row 11=01001100` `Row 12=11000100`
Display the Relay Word bit names and status of two consecutive bits by pressing **ENT** while the cursor is at the row you want to access. Use the **Up Arrow** or **Down Arrow** to navigate to any of the Relay Word bits in the selected row.	`50P1P=0` `50P2P=1`

Control Menu

The SEL-749M provides great flexibility in control through the `MAIN` < `Control` menu. Use the front-panel `CONTROL` menu for the following control actions:

`Stop Motor` Initiates STOP input to the Stop/Trip Logic (see *Figure 4.21*)

`Emergency Restrt` Asserts Relay Word EMRSTR to initiate an emergency start (see *Figure 4.24*)

`Start Motor` Asserts Relay Word STR to initiate a motor start (see *Figure 4.24*)

`Output Contacts` Use the `Output Contacts` menu item to test SEL-749M output contacts and associated circuits. You can pulse the selected Relay Word bit associated with the contact outputs from this menu (see *Figure 4.33* for a typical output logic).

Press the **ENT** pushbutton to pulse the output.	`OUTPUT CONTACTS` `Pulse OUT101`
The LCD displays a password screen if a password is required. Enter your Level 2 password.	`Password=_` `Del  Clr Accept`
Press the **Right Arrow** to select `Yes` and then press **ENT**.	`Pulse OUT101` `No Yes`

`Reset TCU`: Resets the thermal capacity used (see *Thermal Overload Element on page 4.4* for description).

Set/Show Menu

The SEL-749M settings are arranged in easy-to-understand categories. The settings structure simplifies relay setting. Access the settings class (relay, global, port, or front-panel) required by performing the following steps, which are similar to the entry of the appropriate **SET/SHOW** command:

Step 1. Select the `Set/Show` menu item on the `MAIN` menu to view or modify the settings (refer to *SEL-749M Menu Structure on page 8.5*).

Step 2. Select the settings class, date/time, or password settings from the `SET/SHOW` menu.

Each settings class includes headings that create subgroups of associated settings. These headings are displayed in the settings screen captures in *Section 6: Settings*. Select the heading that contains the setting of interest. An example of the `RELAY` heading is shown in *Figure 8.6*.

```
RELAY
Main Settings
RID
TID
CTR1
FLA1
...
```

Figure 8.6 RELAY Heading Example

Navigate to the setting of interest. View or edit the setting by pressing **ENT**. For text settings, use the four navigation pushbuttons to scroll through available alphanumeric and special character settings. For numeric settings, use the **Left Arrow** and **Right Arrow** pushbuttons to select the digit to change and the **Up Arrow** and **Down Arrow** pushbuttons to change the value. Press **ENT** to enter the new setting.

Setting changes can also be made using ACSELERATOR QuickSet SEL-5030 software or ASCII **SET** commands via a communications port.

Status Menu

The `Status` menu item of the `MAIN` menu allows you to access the `Relay Status` data and `Reboot Relay`. See *STATUS Command (Relay Self-Test Status) on page 7.25* for the **STATUS** command description.

Reset Access Lvl Menu

Select the `Reset Access Lvl` menu item on the `MAIN` menu to reset the front-panel access to level 1. The reset is confirmed by the display message `Access Lvl Reset`.

Operation and Target LEDs

Programmable LEDs

The SEL-749M provides quick confirmation of relay conditions via operation and target LEDs. *Figure 8.7* shows this region with factory-default text on the front-panel configurable labels.

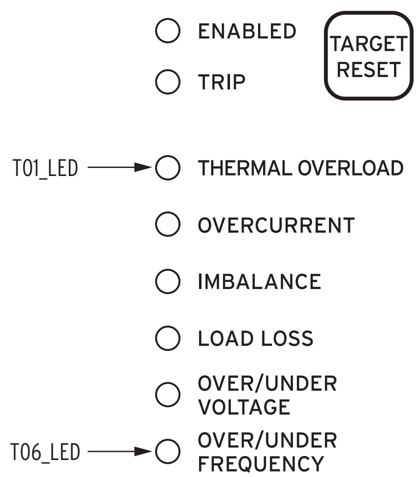

Figure 8.7 Factory-Default Front-Panel LEDs

You can reprogram all of these indicators except the **ENABLED** and **TRIP** LEDs to reflect operating conditions other than the factory-default programming described in this subsection.

Settings T0*n*_LED are SELOGIC control equations that, when asserted during a relay trip event, illuminate the corresponding LED. Parameter *n* is a number from 1 through 6 that indicates each LED. The user can set the target LEDs to latch by setting T0*n*LEDL to Y. Disable the latch by setting this setting to N. After setting the target LEDs, issue the **TAR R** command to reset the target LEDs. For a concise listing of the default programming on the front-panel LEDs, see *Table 4.47*.

The SEL-749M 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. Included on the SEL-749M Product Literature CD are Customer Label Templates to print labels for the slide-in label carrier.

The ENABLED LED indicates that the relay is powered correctly, is functional, and has no self-test failures. Trip events illuminate the TRIP LED. The prominent location of the TRIP LED in the top target area aids in recognizing trip events quickly.

The TRIP LED has an additional function that notifies you of warning conditions. When the TRIP LED is flashing, the warning conditions in *Table 8.3* are active when you set the corresponding relay element. For Relay Word bit definitions see *Appendix G*.

Table 8.3 Possible Warning Conditions (Flashing TRIP LED)

Warning Message	Relay Word Bit Logic Condition
Overload Warning	49A AND RUNNING
Locked Rotor Warning	49A AND STARTING
Undercurrent Warning	LOSSALRM
Jam Warning	JAMALRM
Current Imbal. Warning	46UBA
Ground Fault Warning	50N2T OR 50G2T
Overcurrent Warning	50P2T
Speed Switch Warning	SPDSAL
Undervoltage Warning	27P2T
Overvoltage Warning	59P2T
Underpower Warning	37PA
Power Factor Warning	55A
Reactive Power Warning	VARA
RTD Warning	WDGALRM OR BRGALRM OR AMBALRM OR OTHALRM
RTD Failure	RTDFLT
PTC Failure	PTCFLT
Comm. Loss Warning	COMMLOSS
Comm. Idle Warning	COMMIDLE
Comm. Fault Warning	COMMFLT

TARGET RESET Pushbutton

TARGET RESET

For a trip event, the SEL-749M latches the trip-involved target LEDs except for the ENABLED LED. Press the TARGET RESET pushbutton to reset the latched target LEDs. When a new trip event occurs and the previously latched trip targets have not been reset, the relay clears the latched targets and displays the new trip targets. Pressing and holding the TARGET RESET pushbutton illuminates all the LEDs. Upon release of the TARGET RESET pushbutton, two possible trip situations can exist: the conditions that caused the relay to trip have cleared, or the trip conditions remain present at the relay inputs. If the trip conditions have cleared, the latched target LEDs turn off. If the trip event conditions remain, the relay re-illuminates the corresponding target LEDs. The TARGET RESET pushbutton also removes the trip automatic message displayed on the LCD menu screens if the trip conditions have cleared.

Lamp Test

The TARGET RESET pushbutton also provides a front-panel lamp test. Pressing and holding TARGET RESET illuminates all the front-panel LEDs, and these LEDs remain illuminated for as long as TARGET RESET is pressed. The target LEDs return to a normal operational state after release of the TARGET RESET pushbutton.

Other Target Reset Options

Use the ASCII command **TAR R** to reset the target LEDs; see *TARGET Command (Display Relay Word Bit Status) on page 7.28* for more information. Programming specific conditions in the SELOGIC control equation RSTTRGT is another method for resetting target LEDs. Access RSTTRGT in the Global settings (Data Reset Control). See *Table 4.39* for further information.

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Section 9
Analyzing Events

Overview

The SEL-749M Relay provides several tools (listed below) to analyze the cause of relay operations. Use these tools to help diagnose the cause of the relay operation and more quickly restore the protected motor to service.

- Event Reporting
  - Event Summary Reports
  - Event History Reports
  - Event Reports
- Sequential Events Recorder Report

  Resolution: 1 ms

  Accuracy: ±1/4 cycle

All reports are stored in nonvolatile memory, ensuring that a loss of power to the SEL-749M will not result in lost data.

Event Reporting

Analyze events with the following event reporting functions:

- Event Summaries—Enable automatic messaging to allow the relay to send event summaries out a serial port when port setting AUTO := Y. A summary provides a quick overview of an event. The summaries may also be retrieved by using the **SUMMARY** command.
- Event History—The relay keeps an index of stored nonvolatile event reports. Use the **HISTORY** command to obtain this index. The index includes some of the event summary information so that the appropriate event report can be identified and retrieved.
- Event Reports—These detailed reports are stored in nonvolatile memory for later retrieval and detailed analysis.

Each time an event occurs a new summary, history record, and report are created. Event report information includes:

- Date and time of the event
- Individual sample analog inputs (currents and voltages)
- Digital states of selected Relay Word bits (listed in *Table G.1 on page G.1*)
- Event summary, including the front-panel target states at the time of tripping and fault type
- Group, logic, global, and report settings (that were in service when the event was recorded)

Compressed ASCII Event Reports, Event Summaries, and History

The SEL-749M 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** command to display Compressed ASCII event reports. See the *CEVENT Command (Compressed Event Report) on page 7.13* and *SEL Compressed ASCII Commands on page C.1* for further information.

Compressed ASCII Event Reports contain **all** of the Relay Word bits.

Sequential Events Recorder (SER)

The SER report captures detailed digital element state changes over a long time period. Settings allow as many as 96 Relay Word bits to be monitored, in addition to the automatically generated triggers for relay power-up, settings changes, and active setting group changes. State changes are time-tagged to the nearest millisecond.

SER report data are useful in commissioning tests and during operation for system monitoring and control.

SER information is stored when state changes occur.

Event Reporting

Length

NOTE: Changing the LER setting will clear all events in memory. Be sure to save critical event data prior to changing the LER setting.

The SEL-749M provides selectable event report length (LER) and prefault length (PRE). Event report length is either 15 or 64 cycles. Prefault length is 1–10 cycles for LER = 15 and 1–59 cycles for LER = 64. Prefault length is the first part of the total event report length and precedes the event report triggering point.

See the **SET R** command in *Table 7.41* and *Report Settings (SET R Command) on page SET.14* of the *SEL-749M Settings Sheets* for instructions on setting the LER and PRE settings.

Changing the PRE setting has no effect on the stored reports.

Triggering

The SEL-749M triggers (generates) an event report when any of the following occur:

- ➤ Relay Word bit TRIP asserts
- ➤ Programmable SELOGIC control equation setting ER asserts to logical 1 (in Report settings)
- ➤ **TRI** (Trigger Event Reports) serial port command executed

Relay Word Bit TRIP

Refer to *Figure 4.21*. If Relay Word bit TR asserts to logical 1, an event report is automatically generated. Thus, any Relay Word bit that causes a trip does **not** have to be entered in SELOGIC control equation setting ER.

Programmable SELOGIC Control Equation Setting ER

The programmable SELOGIC control equation event report trigger setting ER is set to trigger event reports for conditions other than trip conditions (see SET R in *Table 7.41*). When setting ER detects a logical 0 to logical 1 transition, it generates an event report (if the SEL-749M is not already generating a report that encompasses the new transition). The factory setting is shown in *Table 4.49*.

TRI (Trigger Event Report) Command

The sole function of the **TRI** serial port command is to generate event reports, primarily for testing purposes.

See *TRIGGER Command (Trigger Event Report) on page 7.29* for more information on the **TRI** (Trigger Event Report) command.

Event Summaries

For every triggered event, the relay generates and stores an event summary. The relay stores at least the most recent 77 (if event report length setting LER := 15) or 19 (if LER := 64) event summaries. When the relay stores a new event summary, it discards the oldest event and event summary if the event memory is full. Event summaries contain the following information:

NOTE: Clearing the HISTORY report with the **HIS C** command also clears all event data within the SEL-749M event memory.

- ➤ Relay and Terminal Identification (RID and TID)
- ➤ Event number, date, time, event type, and frequency (see *Table 9.1*)
- ➤ The primary magnitudes of line, neutral and residual currents
- ➤ The primary magnitudes of the line to neutral voltage (if DELTA_Y := WYE) or phase-to-phase voltages (if DELTA_Y := DELTA), optional Voltage Inputs card required
- ➤ Hottest RTD temperatures, SEL-2600 series RTD module required

The relay includes the event summary in the event report. The identifiers, date, and time information is at the top of the event report, and the remaining information follows at the end. See *Figure 9.3*.

NOTE: Figure 9.3 is on multiple pages.

The example event summary in *Figure 9.1* corresponds to the standard 15-cycle event report in *Figure 9.3*.

```
=>SUM <Enter>

SEL-749M                          Date: 12/10/2003    Time: 22:45:18.677
MOTOR RELAY                       Time Source: internal

Event #: 1                    Event: Overcurrent Trip
Event Date: 10/15/2004        Event Time: 22:24:00.101
Frequency (Hz) : 60.0


                         IA         IB         IC         IN        IG
CURRENT MAG (A)         711.1     1049.2      591.2        0.04     10.63

                         VAB        VBC        VCA
VOLTAGE MAG L-L (V)     2806       2513       1338

                     Winding    Bearing    Ambient      Other
Hottest RTD(C):          123        110         45        160

Press RETURN to continue
```

Figure 9.1 Example Event Summary

The relay sends event summaries to all serial ports with setting AUTO := Y each time an event triggers.

Event Type

The Event field displays the event type. Event types and the logic used to determine event types are shown in the order of priority in *Table 9.1*.

Table 9.1 Event Types

Event Type	Event Type Logic
Overload Trip	(49T AND RUNNING) AND TRIP
Lockd Rotor Trip	(49T AND STARTING) AND TRIP
Undercurr Trip	LOSSTRIP AND TRIP
Jam Trip	JAMTRIP AND TRIP
Curr Imbal Trip	46UBT AND TRIP
Overcurrent Trip	50P1T AND TRIP
Ground Flt Trip	(50N1T OR 50G1T) AND TRIP
Speed Sw Trip	SPDSTR AND TRIP
Overvolt Trip	59P1T AND TRIP
Underpower Trip	37PT AND TRIP
Pwr Factor Trip	55T AND TRIP
React Pwr Trip	VART AND TRIP
Phase Rev Trip	47T AND TRIP
Underfreq Trip	81*n*T AND TRIP, 81*n*TP < FNOM
Overfreq Trip	81*n*T AND TRIP, 81*n*TP > FNOM
RTD Trip	(WDGTRIP OR BRGTRIP OR AMBTRIP OR OTHTRIP) AND TRIP
PTC Trip	PTCTRIP AND TRIP
Start Trip Time	SMTRIP AND TRIP
Remote Trip	REMTRIP AND TRIP
Undervolt Trip	27P1T AND TRIP
RTD Fail Trip	RTDFLT AND TRIP
PTC Fail Trip	PTCFLT AND TRIP
CommIdleLossTrip	(COMMIDLE OR COMMLOSS) AND TRIP
Trigger	Serial Port TRI command
Stop Command	Serial Port or Front-Panel Stop Command
ERTrigger	ER Equation assertion
Trip	TRIP (trip from any cause not defined previously)
Trip*	Upon cycling power on the relay if the TRIP LED is latched and no active TRIP exists

Currents, Voltages, and RTD Temperatures

The relay determines the maximum phase current during an event. The instant the maximum phase current occurs is marked by an asterisk (*) in the event report (see *Figure 9.3*). This row of data corresponds to the analogs shown in the summary report for the event.

The Current Mag. (A) fields display the primary current magnitudes at the instant when the maximum phase current was measured. The currents displayed are listed below.

- Line Currents (IA, IB, IC)
- Neutral Current (IN)
- Residual Current (IG), calculated from IA, IB, IC

The Voltage Mag. (V) fields (optional voltage card required) display the primary voltage magnitudes at the instant when the maximum phase current was measured. The voltages displayed are listed below.

- DELTA_Y := WYE
  - Phase-to-Neutral Voltages (VAN, VBN, VCN)
  - Residual Voltage VG, calculated from VA, VB, VC
- DELTA_Y := DELTA
  - Phase-to-Phase Voltages (VAB, VBC, VCA)

The Hottest RTD (°C) fields display the hottest RTD reading in each RTD group. The hottest RTD temperatures in degrees centigrade (°C) are listed below.

- Winding
- Bearing
- Ambient
- Other

Event History

The event history report gives you a quick look at recent relay activity. The relay labels each new event in reverse chronological order with `1` as the most recent event. See *Figure 9.2* for a sample event history. Use this report to view the events that are presently stored in the SEL-749M.

The event history contains the following.

- Standard report header
  - Relay and terminal identification
  - Date and time of report
  - Time source (if IRIG-B model)
- Event number, date, time, event type (see *Table 9.1*)
- Maximum motor current
- Target LED status

```
=>>HIS <Enter>

SEL-749M                          Date: 12/10/2003    Time: 22:24:11.418
MOTOR RELAY                       Time Source: internal

#     DATE        TIME          EVENT            CURR       TARGETS

1   12/03/2003 22:24:00.101 Overcurrent Trip    1049.2      11010000
2   12/03/2003 22:15:20.714 Overload Trip       1493.0      11100000
3   12/03/2003 15:21:10.663 Trigger                4.7      11000000
4   12/03/2003 15:21:07.512 PTC Trip               7.8      11000000
5   12/03/2003 10:49:34.103 Trigger                6.4      11000000
6   12/03/2003 10:49:30.040 PTC Trip               7.7      11000000
7   12/02/2003 20:50:54.846 Lockd Rotor Trip       1.2      11100000
8   12/02/2003 20:44:58.448 Lockd Rotor Trip    1494.4      11100010
9   12/02/2003 16:38:04.829 Trigger                1.4      10000000
```

Event Number — Event Type — Maximum Current — User-Defined Target LEDs [See Table 7.54]

Figure 9.2 Sample Event History

Viewing the Event History

Access the history report from the communications ports, using the **HIS** command or the analysis menu within ACSELERATOR QuickSet SEL-5030 Software. View and download history reports from Access Level 1 and higher.

Use the **HIS** command from a terminal to obtain the event history. You can specify the number of the most recent events that the relay returns. See *HISTORY Command on page 7.17* for information on the **HIS** command.

Use the front-panel `MAIN > Events > Display Events` menu to display event history data on the SEL-749M front-panel display.

Use QuickSet to retrieve the relay event history. View the Relay Event History dialog box via the **Analysis > Get Event Files** menu.

Clearing

Use the **HIS C** command to clear or reset history data from Access Levels 1 and higher. Clear/reset history data at any communications port. This will clear all event summaries, history records, and reports.

Event Reports

The latest event reports are stored in nonvolatile memory. Each event report includes four sections:

⚠CAUTION
Changing the LER setting will clear all events in memory. Be sure to save critical event data prior to changing the LER setting.

- Analog values of current, voltage, and digital states of the various Relay Word bits
- Digital states of the protection and control elements, including overcurrent, and voltage elements, plus status of digital output and input states
- Event Summary
- Settings in service at the time of event retrieval, consisting of Group, Logic, Global, and Report settings classes

Use the **EVE** command to retrieve the reports. There are several options to customize the report format.

Filtered and Unfiltered Event Reports

The SEL-749M samples the power system measurands (ac voltage and ac current) 16 times per power system cycle. A digital filter extracts the fundamental frequency component of the measurands. The relay operates on the filtered values and reports these values in the standard, filtered event report.

To view the raw inputs to the relay, select the unfiltered event report using the **EVE R** command. Use the unfiltered event reports to observe power system conditions:

- Power system transients on current and voltage channels
- Decaying dc offset during fault conditions on current channels
- Power system harmonics (with appropriate analytical PC software tools)

Raw event reports display one extra cycle of data at the beginning of the report.

Event Report Column Definitions

NOTE: Figure 9.3 on page 9.11 is on multiple pages.

Refer to the example event report in *Figure 9.3* to view event report columns. This example event report displays rows of information each 1/4 cycle. Retrieve this report with the **EVE** command.

The columns contain ac current, ac voltage, input, output, and protection and control element information.

Use the serial port **SUM** command (see *SUMMARY Command on page 7.27*) to retrieve event summary reports.

Current and Voltage Columns. *Table 9.2* summarizes the event summary report current and voltage columns.

Table 9.2 Event Report Current and Voltage Columns

Column Heading	Description
IA	Current measured by channel IA (primary A)
IB	Current measured by channel IB (primary A)
IC	Current measured by channel IC (primary A)
IG	Residual current (IA + IB + IC, primary A)
IN	Current measured by channel IN (primary A)
VAN or VAB	Voltage measured by channel VAN or VAB (primary V)
VBN or VBC	Voltage measured by channel VBN or VBC (primary V)
VCN or VCA	Voltage measured by channel VCN or VCA calculated from VAB and VBC (primary V)

Table 9.3 Output, Input, Protection, and Control Element Event Report Columns

Column Heading	Column Symbols	Description
Motor	S R .	STARTING asserted RUNNING asserted STOPPED asserted
Load	J I L	JAMTRIP asserted LOSSALARM AND NOT LOSSTRIP LOSSTRIP
46	A T	46UBA AND NOT 46UBT 46UBT
47	T	47T
49	A T	49A AND NOT 49T 49T
O/C 50P	1 2 b	50P1T AND NOT 50P2T NOT 50P1T AND 50P2T 50P1T AND 50P2T
O/C 50G	1 2 b	50G1T AND NOT 50G2T NOT 50G1T AND 50G2T 50G1T AND 50G2T
O/C 50N	1 2 b	50N1T AND NOT 50N2T NOT 50N1T AND 50N2T 50N1T AND 50N2T
RTD Wdg (SEL-2600 series RTD module required)	w W	WDGALRM AND NOT WDGTRIP WDGTRIP
RTD Brg (SEL-2600 series RTD module required)	b B	BRGALRM AND NOT BRGTRIP BRGTRIP
RTD Oth (SEL-2600 series RTD module required)	o O	OTHALRM AND NOT OTHTRIP OTHTRIP
RTD Amb (SEL-2600 series RTD module required)	a A	AMBALRM AND NOT AMBTRIP AMBTRIP
RTD In	1	RTDIN
In 12	1 2 b	IN101 AND NOT IN102 NOT IN101 AND IN102 IN101 AND IN102
In 34 Aux I/O required	3 4 b	IN401 AND NOT IN402 NOT IN401 AND IN402 IN401 AND IN402
In 5	5	IN403
Out 12	1 2 b	OUT101 AND NOT OUT102 NOT OUT101 AND OUT102 OUT101 AND OUT102
Out 3	3	OUT103
Out 45	4 5 b	OUT401 AND NOT OUT402 NOT OUT401 AND OUT402 OUT401 AND OUT402
Out 67	6 7 b	OUT403 AND NOT OUT404 NOT OUT403 AND OUT404 OUT403 AND OUT404

Note that the ac values change from plus to minus (–) values in *Figure 9.3*, indicating the sinusoidal nature of the waveforms.

Other figures help in understanding the information available in the event report current columns:

Figure 9.4: shows how event report current column data relate to the actual sampled current waveform and rms current values.

Figure 9.5: shows how event report current column data can be converted to phasor rms current values.

Example 15-Cycle Event Report

The following example of a standard 15-cycle event report in *Figure 9.3* also corresponds to the example SER report in *Figure 9.6*. The circled numbers in *Figure 9.3* correspond to the SER row numbers in *Figure 9.6*. The row explanations appear in *Table 9.4*.

In *Figure 9.3*, an arrow (>) in the column following the `VCA` column would identify the "trigger" row. This is the row that corresponds to the Date and Time values at the top of the event report.

The asterisk (*) in the column following the `VCA` column identifies the row with the maximum phase current. The maximum phase current is calculated from the row identified with the asterisk and the row one quarter-cycle previous (see *Figure 9.4* and *Figure 9.5*). These currents are listed at the end of the event report in the event summary. If the trigger row (>) and the maximum phase current row (*) are the same row, the * symbol takes precedence, as is the case in *Figure 9.3*.

```
=>EVE <Enter>
Processing event report.

SEL-749M                                    Date: 12/10/2003    Time: 22:56:14.629
MOTOR RELAY                                 Time Source: internal

FID=SEL-749M-R100-V0-Z001001-D20031210         CID=6FBD
                                                                  M L    O/C RTD  R     O
                                                                  o o             T I   u
                                                                  t a444 555 WBOA D n   t
         Currents (A Pri)                Voltages (V Pri)        o d679 000 drtm I 135 1346
    IA      IB      IC      IN      IG    VAB    VBC    VCA    r      PGN gghb n 24  2 57
[1]
   74.0  -95.7   15.7    0.0   -6.0  4165      1  2608 R .... ... .... . ... ....
   64.7   33.7  -98.7    0.0   -0.3   658     -3 -3313 R .... ... .... . ... ....
  -74.3   93.7  -17.0    0.0    2.3 -4166     -1 -2608 R .... ... .... . ... ....
  -65.0  -35.0   96.3    0.0   -3.7  -657      0  3312 R .... ... .... . ... ....
[2]
   73.0  -94.0   15.7   -0.0   -5.3  4166     -1  2605 R .... ... .... . ... ....
   64.7   32.7  -97.7   -0.0   -0.3   653      1 -3314 R .... ... .... . ... ....
  -75.0   94.7  -17.0    0.0    2.7 -4166      0 -2604 R .... ... .... . ... ....
  -67.7  -35.0   96.3   -0.0   -6.3  -652     -2  3315 R .... ... .... . ... ....
[3]
   74.0  -95.0   15.7   -0.0   -5.3  4165     -1  2603 R .... ... .... . ... ....
   66.3   34.7  -98.7    0.0    2.3   649      0 -3317 R .... ... .... . ... ....
  -75.0   90.7  -17.0   -0.0   -1.3 -4165      0 -2604 R .... ... .... . ... ....
  -65.7  -33.0   97.3   -0.0   -1.3  -649     -1  3318 R .... ... .... . ... ....
[4]
   73.0  -92.0   16.7    0.0   -2.3  4164      0  2600 R .... ... .... . ... ....
   64.7   31.7  -97.7    0.0   -1.3   645      1 -3322 R .... ... .... . ... ....
  -74.3   91.7  -18.0   -0.0   -0.7 -4167     -2 -2599 R .... ... .... . ... ....
  -65.0  -34.0   98.3    0.0   -0.7  -642     -1  3323 R .... ... .... . ... ....
[5]
  216.3  -94.0   16.7   -0.0  139.0  4167      1  2596 R .... ... .... . ... ....
  415.0   32.7  -99.7   -0.0  348.0   639     -2 -3325 R .... ... .... . ... ....
 -746.3   92.7  -18.0    0.0 -671.7 -4168     -1 -2595 R .... ... .... . ... ....
 -873.0  -34.0   98.3   -0.0 -808.7  -640      0  3322*R .... 1.. .... . ... ....
[6]
 1131.3  -93.0   15.7    0.0 1054.0  4169      0  2592 R .... 1.. .... . ... .3..
  973.0   33.7  -99.7    0.0  907.0   637     -1 -3323 R .... 1.. .... . ... .3..
-1135.3   92.7  -18.0   -0.0-1060.7 -4171     -1 -2593 R .... 1.. .... . ... .3..
 -971.3  -34.0   99.3    0.0 -906.0  -633      1  3325 R .... 1.. .... . ... .3..
[7]
 1134.3  -94.0   15.0    0.0 1055.3  4170      0  2590 R .... 1.. .... . ... .3..
  970.0   31.7  -99.7   -0.0  902.0   630     -1 -3329 R .... 1.. .... . ... .3..
-1135.3   91.7  -17.0    0.0-1060.7 -4170      0 -2590 R .... 1.. .... . ... .3..
 -971.3  -34.0   98.3   -0.0 -907.0  -630      0  3329 R .... 1.. .... . ... .3..
[8]
 1135.0  -93.0   16.7    0.0 1058.7  4170     -1  2588 R .... 1.. .... . ... .3..
  970.0   32.7 -100.3   -0.0  902.3   627      0 -3331 R .... 1.. .... . ... .3..
-1137.3   93.7  -17.0   -0.0-1060.7 -4170     -1 -2585 R .... 1.. .... . ... .3..
 -970.3  -35.0   97.3    0.0 -908.0  -626     -1  3331 R .... 1.. .... . ... .3..
[9]
 1137.0  -95.0   15.7    0.0 1057.7  4169      0  2582 R .... 1.. .... . ... .3..
  969.3   33.7  -97.7    0.0  905.3   624     -1 -3332 R .... 1.. .... . ... .3..
-1137.3   92.7  -17.0   -0.0-1061.7 -4171      1 -2584 R .... 1.. .... . ... .3..
 -969.7  -33.0   97.3   -0.1 -905.3  -623      0  3333 R .... 1.. .... . ... .3..
[10]
 1135.0  -95.0   15.7    0.0 1055.7  4170     -1  2580 R .... 1.. .... . ... .3..
  968.3   32.7  -98.7    0.0  902.3   620     -1 -3334 R .... 1.. .... . ... .3..
-1136.3   91.7  -18.0   -0.0-1062.7 -4171     -2 -2579 R .... 1.. .... . ... .3..
 -968.7  -35.0   98.3    0.0 -905.3  -619      0  3335 R .... 1.. .... . ... .3..
[11]
 1136.0  -90.0   16.7    0.0 1062.7  4171      1  2577 R .... 1.. .... . ... .3..
  966.3   33.7  -99.7   -0.0  900.3   616     -3 -3338 R .... 1.. .... . ... .3..
-1136.3   89.0  -18.0    0.0-1065.3 -4171      0 -2577 R .... 1.. .... . ... .3..
 -967.7  -36.7   97.3   -0.0 -907.0  -615      0  3337 R .... 1.. .... . ... .3..
[12]
 1133.3  -91.0   16.7   -0.0 1059.0  4171     -2  2574 R .... 1.. .... . ... .3..
  966.3   33.7  -97.7    0.0  902.3   612      0 -3340 R .... 1.. .... . ... .3..
-1137.3   90.7  -17.0   -0.0-1063.7 -4173     -1 -2574 R .... 1.. .... . ... .3..
 -967.7  -34.0   97.3   -0.0 -904.3  -611      0  3341 R .... 1.. .... . ... .3..
[13]
 1139.0  -94.0   15.0    0.0 1060.0  4172      0  2570 R .... 1.. .... . 1.. .3..
  964.7   32.7  -97.7    0.0  899.7   610     -2 -3343 R .... 1.. .... . 1.. .3..
-1140.0   94.7  -15.0    0.0-1060.3 -4173      0 -2569 R .... 1.. .... . 1.. .3..
 -966.7  -35.0   96.3    0.0 -905.3  -609      1  3342 R .... 1.. .... . 1.. .3..
[14]
 1138.0  -95.7   15.0    0.0 1057.3  4174      0  2566 R .... 1.. .... . 1.. .3..
  967.3   34.7  -97.7   -0.0  904.3   603     -2 -3343 R .... 1.. .... . 1.. .3..
-1141.0   93.7  -17.0   -0.0-1064.3 -4173     -2 -2567 R .... 1.. .... . 1.. .3..
 -965.7  -36.7   96.3    0.0 -906.0  -604      1  3344 R .... 1.. .... . 1.. .3..
[15]
 1140.0  -94.0   15.7    0.0 1061.7  4173      0  2565 R .... 1.. .... . 1.. .3..
  962.7   35.3  -96.7    0.0  901.3   602     -1 -3346 R .... 1.. .... . 1.. .3..
-1141.0   92.7  -18.0   -0.0-1066.3 -4176     -1 -2564 R .... 1.. .... . 1.. .3..
 -962.0  -35.7   97.3   -0.0 -900.3  -599     -1  3346 R .... 1.. .... . 1.. .3..
```

Date and Time of event

firmware identifier

firmware checksum identifier

SEL-2600 series RTD module required

Optional Voltage Card Required

one cycle of data

①

②

see Figure 9.4 and Figure 9.5

SER example, see Figure 9.6

③

```
Event: Overcurrent Trip

                          IA         IB         IC         IN        IG
CURRENT MAG (A)         1148.5       98.7      100.0        0.04    1051.2

                         VAB        VBC        VCA
VOLTAGE MAG L-L (V)     4217       4215       4263

                     Winding    Bearing    Ambient      Other
Hottest RTD(C):           NA         NA         NA         NA

RID     := SEL-749M
TID     := MOTOR RELAY
CTR1    := 100     FLA1    := 250.0   E2SPEED := N       CTRN    := 100
PTR     := 35.00   VNOM    := 4160    DELTA_Y := DELTA

E49MOTOR:= Y       SETMETH := RATING  49RSTP  := 75      SF      := 1.15
LRA1    := 6.0     LRTHOT1 := 10.0    TD1     := 1.00    RTC1    := AUTO
TCAPU   := 85      TCSTART := OFF     COOLTIME:= 18      ETHMBIAS:= N
50P1P   := 4.00    50P1D   := 0.00    50P2P   := OFF     50N1P   := OFF
50N2P   := OFF     50G1P   := OFF     50G2P   := OFF
LJTPU   := OFF     LJAPU   := OFF

LLTPU   := OFF     LLAPU   := OFF

46UBT   := OFF     46UBA   := 10      46UBAD  := 10      PROTBL_T:= OFF
THERBL_T:= OFF
START_T := OFF

ESTAR_D := N

MAXSTART:= OFF     TBSDLY  := OFF     ABSDLY  := OFF

E47T    := Y
SPDSDLYT:= OFF     SPDSDLYA:= OFF
EPTC    := N
E49RTD  := Y       RTD1LOC := OFF     RTD2LOC := OFF     RTD3LOC := OFF
RTD4LOC := OFF     RTD5LOC := OFF     RTD6LOC := OFF     RTD7LOC := OFF
RTD8LOC := OFF     RTD9LOC := OFF     RTD10LOC:= OFF     RTD11LOC:= OFF
RTD12LOC:= OFF
27P1P   := 0.80    27P1D   := 0.5     27P2P   := OFF
59P1P   := 1.10    59P1D   := 0.5     59P2P   := OFF
NVARTP  := OFF     PVARTP  := OFF     NVARAP  := OFF     PVARAP  := OFF
37PTP   := OFF     37PAP   := OFF
55LGTP  := OFF     55LDTP  := OFF     55LGAP  := OFF     55LDAP  := OFF
81D1TP  := OFF     81D1AP  := OFF
81D2TP  := OFF
81D2AP  := OFF

LOAD    := OFF

AOPARM  := LOAD_I

BLKPROT := 0

BLK46   := N       BLK48   := N       BLK50EF := N       BLK50P  := N
BLK37   := N       BLK66   := N       BLK49PTC:= N       BLK49RTD:= N

TDURD   := 0.5
TR      := 49T OR LOSSTRIP OR JAMTRIP OR 46UBT OR 50P1T OR 50G1T OR 59P1T OR 47T
 OR 55T OR SPDSTR OR 50N1T OR SMTRIP OR 81D1T OR 81D2T OR SV01T
REMTRIP := 0
ULTRIP  := 0
52A     := NOT IN101

STREQ   := 0
EMRSTR  := IN102 AND STOPPED
SPEED2  := 0
SPEEDSW := 0

Report Settings

SER1    := IN101 IN102 NOSLO THERMLO
SER2    := 49T LOSSTRIP JAMTRIP 46UBT 50P1T RTDT PTCTRIP 50G1T VART 37PT 27P1T
59P1T 47T 55T SPDSTR 50N1T SMTRIP 81D1T 81D2T OTHTRIP
SER3    := AMBTRIP PTCFLT RTDFLT COMMIDLE COMMLOSS REMTRIP RSTTRGT 49A LOSSALRM
JAMALRM 46UBA RTDA 55A 50N2T 50G2T VARA 37PA 27P2T 59P2T
SER4    := SPDSAL 81D1A 81D2A OTHALRM AMBALRM SALARM WARNING LOADUP LOADLOW
50P2T STOPPED RUNNING STARTING STAR DELTA START SPEED2

ER      := R_TRIG 50P1T
LER     := 15      PRE     := 5      MSRR    := 5
```

Figure 9.3 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution

Figure 9.4 and *Figure 9.5* look in detail at one cycle of A-phase current (channel IA) identified in *Figure 9.3*. *Figure 9.4* shows how the event report ac current column data relate to the actual sampled waveform and rms values. *Figure 9.5* shows how the event report current column data can be converted to phasor rms values. Voltages are processed similarly.

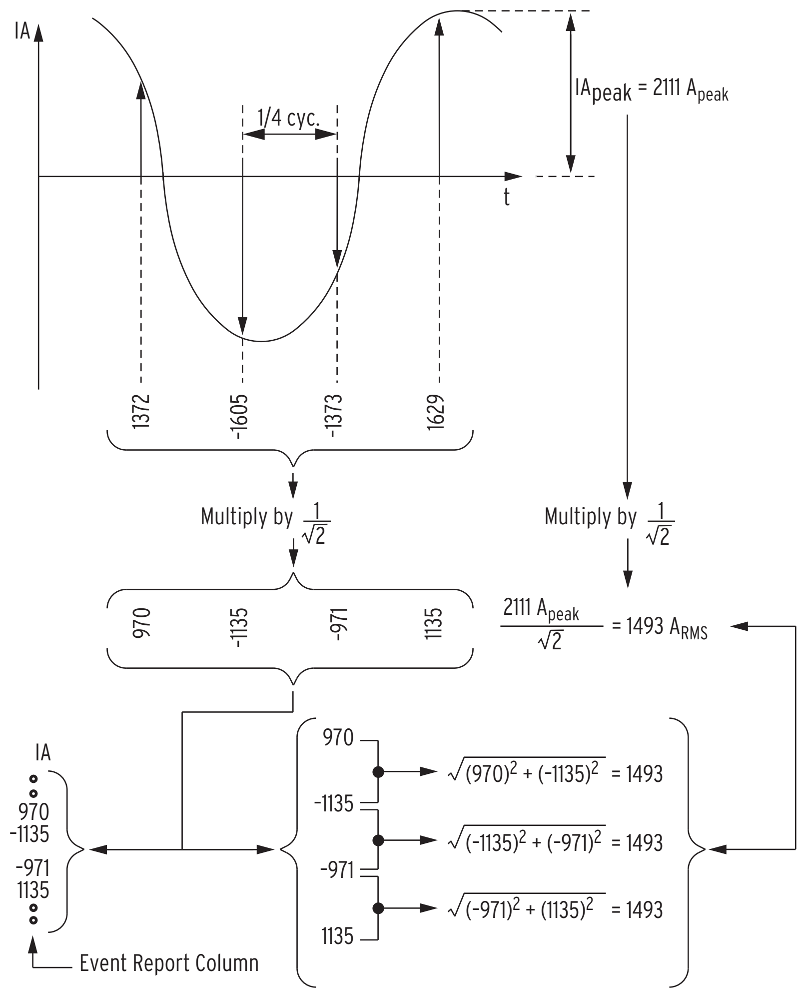
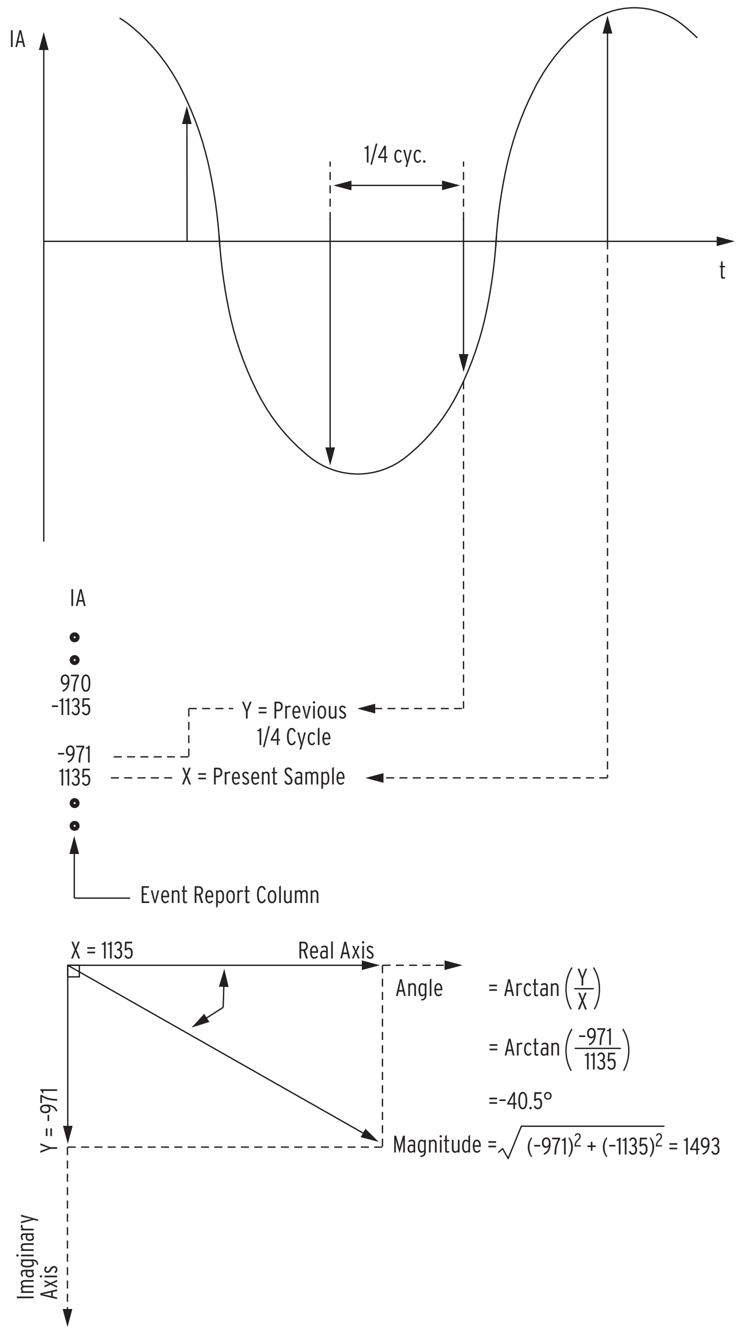


Figure 9.4 Derivation of Event Report Current Values and RMS Current Values From Sampled Current Waveform

In *Figure 9.4*, note that any two rows of current data from the event report in *Figure 9.3*, 1/4 cycle apart, can be used to calculate rms current values.



NOTE: The arctan function of many calculators and computing programs does not return the correct angle for the second and third quadrants (when X is negative). When in doubt, graph the X and Y quantities to confirm that the angle that your calculator reports is correct.

Figure 9.5 Derivation of Phasor RMS Current Values From Event Report Current Values

In *Figure 9.5*, note that two rows of current data from the event report in *Figure 9.3*, 1/4 cycle apart, can be used to calculate phasor rms current values. In *Figure 9.5*, at the present sample, the phasor rms current value is:

$$IA = 1493\ A\ \angle{-40.5^\circ} \qquad \textbf{Equation 9.1}$$

The present sample (IA = 1135 A) is a real rms current value that relates to the phasor rms current value:

$$1493\ A \bullet (\cos{-40.5^\circ}) = 1135\ A \qquad \textbf{Equation 9.2}$$

Sequential Events Recorder (SER) Report

The SER report captures relay element state changes over an extended period. The SER report data are useful in commissioning tests and root cause analysis studies. SER information is stored when state changes occur. The report records the most recent 512 state changes if a relay element is listed in the SER trigger equations.

SER Triggering

Settings SER1 through SER4 are used to select entries in the SER report. To capture relay element state changes in the SER report, the relay element name must be programmed into one of the four SER trigger equations. Each of the four programmable trigger equations allows entry of as many as 24 relay elements; the SER report can monitor a total of 96 relay elements.

The relay adds a message to the SER to indicate power up or settings change conditions:

```
Relay newly powered up or settings changed
```

Each entry in the SER includes the SER row number, date, time, element name, and element state.

Retrieving and Clearing SER Reports

See *SER Command (Sequential Events Recorder Report) on page 7.21* for details on the **SER** command.

Example SER Report

The example SER report in *Figure 9.6* includes records of events that occurred before the beginning of the event summary report in *Figure 9.3*.

```
=>SER 10 <Enter>
SEL-749M                          Date: 12/10/2003    Time: 23:56:14.749
MOTOR RELAY                       Time Source: internal
FID=SEL-749M-R100-V0-Z001001-D20031210       CID=6FBD
#     DATE        TIME           ELEMENT            STATE
10    12/10/2003  22:56:14.629   50P1T              Asserted
9     12/10/2003  22:56:14.632   OUT103             Asserted
8     12/10/2003  22:56:14.749   IN101              Asserted
7     12/10/2003  22:58:01.248   27P1T              Deasserted
6     12/10/2003  22:58:46.983   27P1T              Asserted
5     12/10/2003  22:59:25.471   Relay newly powered up or settings changed
4     12/10/2003  22:59:25.487   STOPPED            Asserted
3     12/10/2003  22:59:26.399   27P1T              Asserted
2     12/10/2003  22:59:27.428   RTDFLT             Asserted
1     12/10/2003  22:59:27.428   WARNING            Asserted
```

Figure 9.6 Example Sequential Events Recorder (SER) Event Report

Table 9.4 Example SER Event Report Explanation

Item # as shown in Figure 9.3	Explanation
①	A-phase current exceeds 50P1P setting; because 50P1D delay equals 0.0 seconds, the 50P1T Relay Word bit asserts immediately.
②	OUT103 asserts as a result of 50P1T asserting.
③	IN101 asserts to indicate the circuit breaker or contactor has opened; however, because the motor currents are not cleared, this event indicates a starter fault clearing failure.

Section 10
Testing and Troubleshooting

Overview

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

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-749M Relay. Because the SEL-749M 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 10.13* provides a guide to isolating and correcting the problem.

Testing Tools

Serial Port Commands

The following features assist you during relay testing.

The **METER** command shows the ac currents and voltages (magnitude and phase angle) presented to the relay in primary values. In addition, the command shows power system frequency. Compare these quantities against other devices of known accuracy. The **METER** command is available at the serial ports and front-panel display. See *Section 7: Communications* and *Section 8: Front-Panel Operations*.

The relay generates a 15- or 64-cycle event report in response to faults or disturbances. Each report contains current and voltage information, relay element states, and input/output contact information. If you question the relay response or your test method, use the event report for more information. The **EVENT** command is available at the serial ports. See *Section 9: Analyzing Events*.

The relay provides a Sequential Events Recorder (SER) event report that time-tags changes in relay element and input/output contact states. The SER provides a convenient means to verify the pickup/dropout of any element in the relay. The **SER** command is available at the serial ports. See *Section 9: Analyzing Events*.

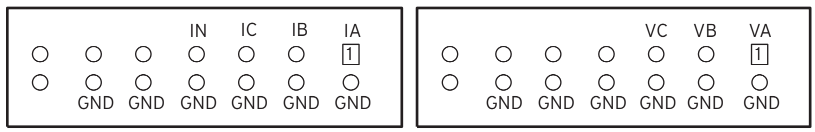
Use the **TARGET** command to view the state of relay control inputs, relay outputs, and relay elements individually during a test. The **TARGET** command is available at the serial ports and the front panel. See *Section 7: Communications* and *Section 8: Front-Panel Operations*.

Low-Level Test Interface

NOTE: The SEL-RTS Relay Test System consists of the SEL-AMS Adaptive Multichannel Source and SEL-5401 Test System Software.

The SEL-749M has a low-level test interface on the current and voltage input printed circuit boards. You can test the relay in either of two ways: conventionally, by applying ac signals to the relay inputs or by applying low magnitude ac voltage signals to the test interface on the printed circuit boards.

You can use the SEL-RTS Low-Level Relay Test System to provide the signals to test the relay. *Figure 10.1* shows the Test Interface connectors. *Table 10.1* shows the resultant signal scale factor information for the calibrated inputs. The SEL-5401 program uses these scale factors.



(A) Connector J2 on Current Input Board   (B) Connector J4 on Voltage Input Board

Figure 10.1 Low-Level Test Interface (J2 and J4)

Table 10.1 Resultant Scale Factors for Inputs

Channel Label	Circuit Board & Connector	SEL-5401 Channel No.	Nominal Input	Output	Scale Factor (A/V or V/V)
IA	CT Board / J2	1	1 A	28.78 mV	34.7
IB	CT Board / J2	2	1 A	28.78 mV	34.7
IC	CT Board / J2	3	1 A	28.78 mV	34.7
IN	CT Board / J2	4	1 A	274.7 mV	3.64
IA	CT Board / J2	1	5 A	28.78 mV	173.7
IB	CT Board / J2	2	5 A	28.78 mV	173.7
IC	CT Board / J2	3	5 A	28.78 mV	173.7
IN	CT Board / J2	4	5 A	274.7 mV	18.2
VA	Voltage / J4	7	250 V	698.1 mV	358.1
VB	Voltage / J4	8	250 V	698.1 mV	358.1
VC	Voltage / J4	9	250 V	698.1 mV	358.1

Access the low-level test interface connectors by using the following procedure.

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

Step 1. Loosen eight (8) mounting (and one ground) screws on the back and remove the back cover.

Step 2. Remove the CT board from Slot **Z**.

Step 3. Locate jumpers JMP1–JMP4 and change them from Pin 1–2 (Normal position) to Pin 2–3 (Low-Level Test position).

Step 4. Locate connector J2 and connect low-level signal connector (e.g., ribbon cable connector of SEL-RTS Test System).

Step 5. Insert the CT board back in its Slot **Z**.

Step 6. Remove the voltage board from Slot **E**.

Step 7. Locate connector J4 and connect low-level signal connector (e.g., ribbon cable connector of SEL-RTS Test System).

Step 8. Insert the voltage board back into Slot **E**.

NOTE: You can use the 14-pin connectors of the SEL-RTS ribbon cable C734 (preferred) or C750A. The connectors are not keyed; make sure Pin 1 is connected to the IA/VA channel on the CT and voltage board, respectively.

Refer to the *SEL-RTS Instruction Manual* for additional detail.

When simulating a delta PT connection with the low-level test interface referenced in *Figure 10.1*, apply the following signals:

Step 1. Apply low-level test signal VAB to Pin VA.

Step 2. Apply low-level test signal –VBC (equivalent to VCB) to Pin VC.

Step 3. Do not apply any signal to pin VB.

Commissioning Tests

SEL performs a complete functional check and calibration of each SEL-749M before it is shipped. This helps to ensure that you receive a relay that operates correctly and accurately.

Commissioning tests should verify that the relay is properly connected to the motor and all auxiliary equipment. Verify control signal inputs and outputs. Use an ac connection check to verify that the relay current and voltage inputs are of the proper magnitude and phase rotation.

Brief functional tests ensure that the relay settings are correct. It is not necessary to test every element, timer, and function in these tests.

The following procedure is a guideline to help you enter settings into the SEL-749M and to verify that it is properly connected. Modify the procedure as necessary to conform to your standard practices. Use this 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-749M, installed and connected according to your protection design
- PC with serial port, terminal emulation software, and serial communications cable
- *SEL-749M Settings Sheets* with settings appropriate to your application and protection design
- AC and dc elementary schematics and wiring diagrams for this relay installation
- Continuity tester
- 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-749M by opening the appropriate breaker(s) or removing fuses.

Step 2. Isolate the relay contact assigned to be the **TRIP** output.

Step 3. Verify correct ac and dc connections by performing point-to-point continuity checks on the associated circuits.

Step 4. Apply ac or dc control voltage to the relay.

After the relay is energized, the front-panel green **ENABLED** LED should illuminate.

Step 5. Use the appropriate serial cable (SEL-C234A Cable or equivalent) to connect a PC to the relay.

Step 6. Start the PC terminal emulation software and establish communication with the relay.

Refer to *Section 7: Communications* for more information on serial port communications.

Step 7. Set the correct relay time and date by using either the front-panel or serial port commands.

Step 8. Using the **SET**, **SET P**, **SET G**, and **SET L** serial port commands, enter the relay settings from the settings sheets for your application.

Step 9. If you are connecting an external SEL-2600 series RTD module, follow the substeps below; otherwise continue with the next step.

a. Connect the fiber-optic cable to the module fiber-optic output.

b. Plug the relay end of the fiber-optic cable into the relay fiber-optic input.

Step 10. Verify the relay ac connections.

Step 11. Connect the ac test source current or voltage to the appropriate relay terminals.

NOTE: Make sure the current transformer secondary windings are shorted before they are disconnected from the relay.

Disconnect the current transformer and voltage transformer (if present) secondaries from the relay prior to applying test source quantities.

If you set the relay to accept phase-to-ground voltages (DELTA_Y := Wye), set the current and/or voltage phase angles as shown in *Figure 10.2*.

If you set the relay to accept delta voltages (DELTA_Y := Delta), set the current and/or voltage phase angles as shown in *Figure 10.3*.

Step 12. Apply rated current (1 A or 5 A).

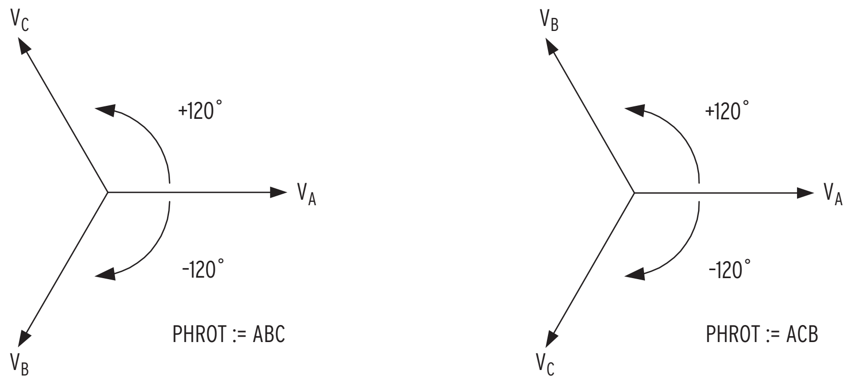
Step 13. If the relay is equipped with voltage inputs, apply rated voltage for your application.

Step 14. Use the front-panel METER VALUES > INSTANTANEOUS METER function or serial port **METER** command to verify that the relay is measuring the magnitude and phase angle of both voltage and current correctly, taking into account the relay PTR and CTR1 settings and the fact that the quantities are displayed in primary units.

Step 15. If you are using a core balance current transformer, apply a single-phase current (A-Phase) to the **IN** terminals. Do not apply voltage.

Step 16. Verify that the relay is measuring the magnitude and phase angle correctly.

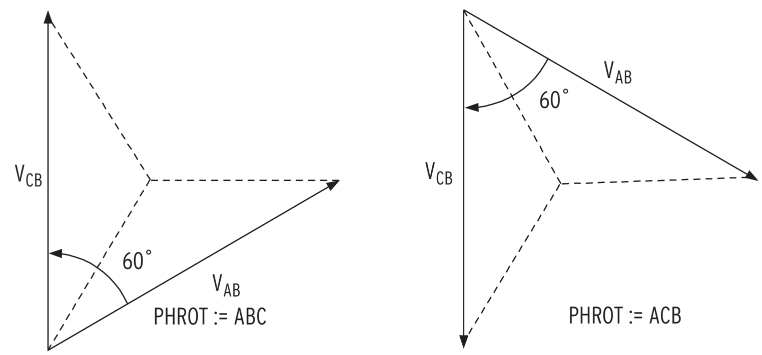
The expected magnitude is (applied phase current) • (CTRN). The expected phase angle is zero (0).



When setting PHROT := ABC, set angle V_a = angle I_a = 0°
set angle V_b = angle I_b = -120°
set angle V_c = angle I_c = 120°

When setting PHROT := ACB, set angle V_a = angle I_a = 0°
set angle V_b = angle I_b = 120°
set angle V_c = angle I_c = -120°

Figure 10.2 Three-Phase Wye AC Connections



When setting PHROT := ABC, set angle I_a = 0°
set angle I_b = -120°
set angle I_c = 120°
set angle V_{ab} = +30°
set angle V_{cb} = +90°

When setting PHROT := ACB, set angle I_a = 0°
set angle I_b = 120°
set angle I_c = -120°
set angle V_{ab} = -30°
set angle V_{cb} = -90°

Figure 10.3 Three-Phase Open-Delta AC Connections

Step 17. Verify control input connections. Using the front-panel `MAIN > TARGETS > ROW 9` function, check the control input status in the relay.

As you apply rated voltage to each input, the position in Row 9 corresponding to that input should change from zero (0) to one (1).

Step 18. Verify output contact operation:

a. For each output contact, set the input to Logic 1. This causes the output contact to close. For example, setting OUT101 := 1 causes the output **OUT101** contact to close.

b. Repeat the process for all contact outputs.

Make sure that each contact closure does what you want it to do in the annunciation, control, or trip circuit associated with that contact closure.

Step 19. Perform any necessary protection element tests. Perform only enough tests to prove that the relay operates as intended; exhaustive element performance testing is not necessary for commissioning.

Step 20. Connect the relay for tripping duty.

Step 21. Verify that any settings changed during the tests performed in *Step 18* and *Step 19* are changed back to the correct values for your application.

Step 22. Use the serial port commands in *Table 10.2* to clear the relay data buffers and prepare the relay for operation.

This prevents data generated during commissioning testing from being confused with operational data collected later.

Table 10.2 Serial Port Commands That Clear Relay Data Buffers

Serial Port Command	Task Performed
MOT R	Clears Motor Statistics buffers.
SUM R	Resets Event Report and Summary Command buffers.
SER R	Resets Sequential Events Record buffer.

Step 23. When it is safe to do so, start the motor.

Step 24. Verify the following ac quantities by using the front-panel METER or serial port **METER** command.

- ➢ Phase current magnitudes should be nearly equal.
- ➢ Phase current angles should be balanced, have proper phase rotation, and have the appropriate phase relationship to the phase voltages.

Step 25. If your relay is equipped with voltage inputs, check the following:

- ➢ Phase voltage magnitudes should be nearly equal.
- ➢ Phase voltage phase angles should be balanced and have proper phase rotation.

The SEL-749M is now ready for continuous service.

Functional Tests

Phase Current Measuring Accuracy

Step 1. Connect the current source to the relay, as shown in *Figure 10.4*.

Step 2. Using the front-panel or the serial port **SHOW** command, 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 10.2*.

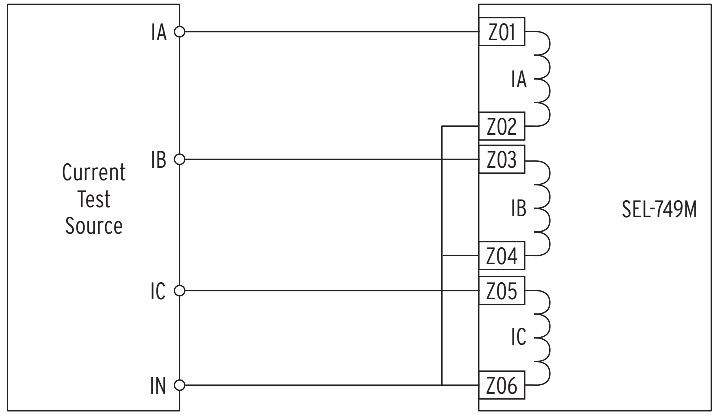


Figure 10.4 Current Source Connections

Step 4. Set each phase current magnitude equal to the values listed in Column 1 of *Table 10.3*.

Use the front-panel to view the phase current values. The relay should display the applied current magnitude times the CTR1 setting.

Table 10.3 Phase Current Measuring Accuracy

|I| Applied (A secondary)[a]	Expected Reading CTR1 x |I|	A-Phase Reading (A primary)	B-Phase Reading (A primary)	C-Phase Reading (A primary)
0.2 x I_{NOM}				
0.9 x I_{NOM}				
1.6 x I_{NOM}				

[a] I_{NOM} = rated secondary amps (1 or 5)

Current Unbalance Element Accuracy

Step 1. Connect the current source to the relay, as shown in *Figure 10.4*.

Step 2. Using the front-panel SET/SHOW function or the serial port **SHOW** command, 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 10.2*.

Step 4. Apply the appropriate magnitude for each phase current, as shown in Column 1 of *Table 10.4*.

Table 10.4 Current Unbalance Measuring Accuracy

|I| Applied (A secondary)	Expected Reading (%)	Actual Reading (%)
|IA| = 0.9 • FLA1/CTR1 |IB| = FLA1/CTR1 |IC| = FLA1/CTR1	**7%**	
|IA| = 0.75 • FLA1/CTR1 |IB| = FLA1/CTR1 |IC| = FLA1/CTR1	**17%**	
|IA| = FLA1/CTR1 |IB| = 1.2 • FLA1/CTR1 |IC| = 1.2 • FLA1/CTR1	**12%**	
|IA| = 0.9 • FLA1/CTR1 |IB| = 1.1 • FLA1/CTR1 |IC| = 1.1 • FLA1/CTR1	**13%**	

Power and Power Factor Measuring Accuracy

Wye-Connected Voltages

Perform the following steps to test wye-connected voltages:

Step 1. Connect the current source to the relay, as shown in *Figure 10.4*.

Step 2. Connect the voltage source to the relay, as shown in *Figure 10.5*. Make sure that DELTA_Y := Wye.

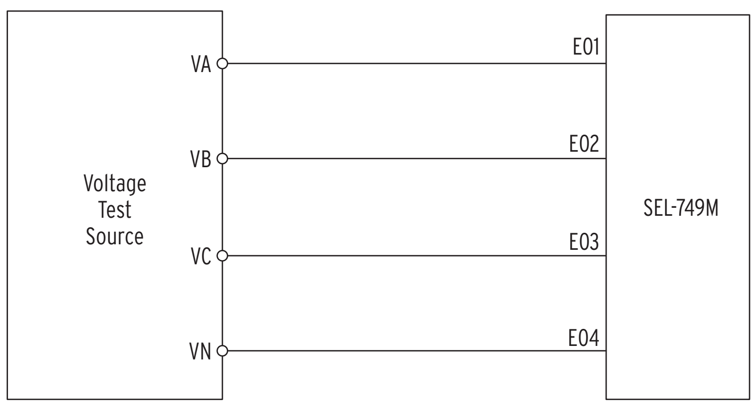


Figure 10.5 Wye Voltage Source Connections

Step 3. Using the front-panel SET/SHOW or the serial port **SHOW** command, record the CTR1, PTR, and PHROT setting values.

Step 4. Apply the current and voltage quantities shown in Column 1 of *Table 10.5*.

Values are given for PHROT := ABC and PHROT := ACB.

Step 5. Use the front-panel METER function or the serial port **MET** command to verify the results.

Table 10.5 Power Quantity Accuracy—Wye Voltages

Applied Currents and Voltages	Real Power (kW)	Reactive Power (kVAR)	Power Factor (pf)
PHROT := ABC Ia = 2.5 Ð-26 Ib = 2.5 Ð-146 Ic = 2.5 Ð+94	**Expected:** P = 0.4523 • CTR1 • PTR	**Expected:** Q = 0.2211 • CTR1 • PTR	**Expected:** pf = 0.90 lag
Va = 67 Ð0 Vb = 67 Ð-120 Vc = 67 Ð+120	**Measured:**	**Measured:**	**Measured:**
PHROT := ACB Ia = 2.5 Ð-26 Ib = 2.5 Ð+94 Ic = 2.5 Ð-146	**Expected:** P = 0.4523 • CTR1 • PTR	**Expected:** Q = 0.2211 • CTR1 • PTR	**Expected:** pf = 0.90 lag
Va = 67 Ð0 Vb = 67 Ð+120 Vc = 67 Ð-120	**Measured:**	**Measured:**	**Measured:**

Delta-Connected Voltages

Perform the following steps to test delta-connected voltages:

Step 1. Connect the current source to the relay, as shown in *Figure 10.4*.

Step 2. Connect the voltage source to the relay, as shown in *Figure 10.6*. Make sure that DELTA_Y := Delta.

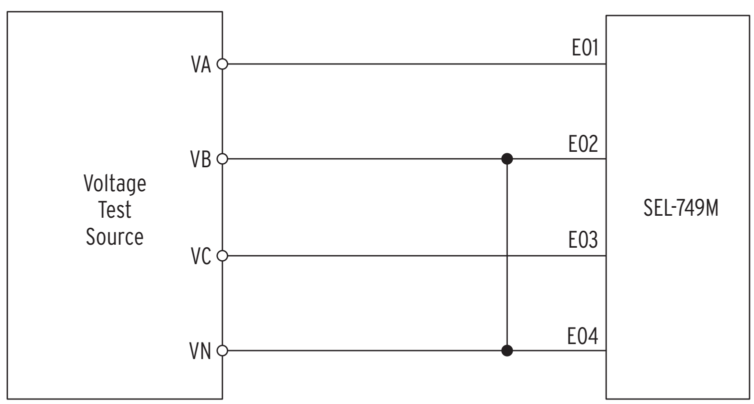


Figure 10.6 Delta Voltage Source Connections

Step 3. Using the front-panel `SET/SHOW` or the serial port **SHOW** command, record the CTR1, PTR, and PHROT setting values.

Step 4. Apply the current and voltage quantities shown in Column 1 of *Table 10.6*.

Values are given for PHROT := ABC and PHROT := ACB.

Step 5. Use the front-panel `METER` or the serial port **MET** command to verify the results.

Table 10.6 Power Quantity Accuracy—Delta Voltages

Applied Currents and Voltages	Real Power (kW)	Reactive Power (kVAR)	Power Factor (pf)
PHROT := ABC Ia = 2.5 ∠–26 Ib = 2.5 ∠–146 Ic = 2.5 ∠+94	**Expected:** P = 0.4677 • CTR1 • PTR	**Expected:** Q = 0.2286 • CTR1 • PTR	**Expected** pf = 0.90 lag
Vab = 120 ∠+30 Vbc = 120 ∠–90	**Measured:**	**Measured:**	**Measured:**
PHROT := ACB Ia = 2.5 Ð-26 Ib = 2.5 Ð+94 Ic = 2.5 Ð-146	**Expected:** P = 0.4677 • CTR1 • PTR	**Expected:** Q = 0.2286 • CTR1 • PTR	**Expected:** pf = 0.90 lag
Vab = 120 Ð-30 Vbc = 120 Ð+90	**Measured:**	**Measured:**	**Measured:**

Periodic Tests (Routine Maintenance)

Because the SEL-749M is equipped with extensive self-tests, the most effective maintenance task is to monitor the front-panel messages after a self-test failure. In addition, each relay event report generated by a fault should be reviewed. Such reviews frequently reveal problems with equipment external to the relay, such as instrument transformers and control wiring.

The SEL-749M does not require specific routine tests, but your operation standards may require some degree of periodic relay verification. If you need or want to perform periodic relay verification, the following checks are recommended.

Table 10.7 Periodic Relay Checks

Test	Description
Relay Status	Use the front-panel `STATUS` or serial port **STATUS** command to verify that the relay self-tests have not detected any WARN or FAIL conditions.
Meter	Verify that the relay is correctly measuring current and voltage (if included) by comparing the relay meter readings to separate external meters.
Control Input	Using the front-panel `MAIN > Targets > Row 13` function, check the control input status in the relay. As you apply rated voltage to each input, the position in Row 13 corresponding to that input should change from zero (0) to one (1).
Contact Output	For each output contact, set the input to Logic 1. This causes the output contact to close. For example, setting OUT101 := 1 causes the output **OUT101** contact to close. Repeat the process for all contact outputs. Make sure that each contact closure does what you want it to do in the annunciation, control, or trip circuit associated with that contact closure.

Self-Test

NOTE: Refer to Access Commands (ACCESS, 2ACCESS, and CAL) on page 7.10 for more information on when SALARM is pulsed for access level changes and unsuccessful password entry attempts.

The SEL-749M runs a variety of self-tests. Two Relay Word bits, HALARM and SALARM, signal self-test problems. SALARM is pulsed for software-programmed conditions; these include settings changes, access level changes, and unsuccessful password entry attempts. 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*.

Table 10.8 lists hardware self-tests. In the **Alarm Status** column, **Latched** indicates that HALARM is continuously asserted, **Not Latched** indicates that HALARM is pulsed for 5 seconds, and **NA** indicates that HALARM is not asserted.

All hardware self-test failures generate a front-panel message that is automatically sent to the serial port. All hardware self-test failures (**Latched** entry in **Alarm Status** column) disable the relay.

Table 10.8 Relay Self-Tests (Sheet 1 of 3)

Self-Test	Description	Limits	Protection Disabled on Failure	Alarm Status	Front-Panel Message on Failure	Corrective Action
Watchdog Timer	Periodic resetting (1/32 cycle)		Yes	De-energized	NA	
External RAM (power up)	Performs a read/write test on system RAM		Yes	Latched	Status Fail RAM Failure	
External RAM (run time)	Performs a read/write test on system RAM		Yes	Latched	Status Fail RAM Failure	Contact SEL.
Internal RAM (power up)	Performs a read/write test on CPU RAM		Yes	Latched	Status Fail RAM Failure	
Internal RAM (run time)	Performs a read/write test on CPU RAM		Yes	Latched	Status Fail RAM Failure	Contact SEL.
Critical RAM (settings)	Performs a checksum test on the active copy of settings	Checksum	Yes	Latched	Status Fail CR_RAM Failure	Contact SEL.
Critical RAM (run time)	Verify instruction matches FLASH image		Yes	Latched	Status Fail CR_RAM Failure	Contact SEL.
Code Flash (power up)	SELBOOT qualifies code with a checksum	Checksum	NA	NA	NA	
Code Flash (run time)	Checksum is computed on the entire code base	Checksum	Yes	Latched	Status Fail ROM Failure	
Data Flash (power up)	Checksum is computed on critical data	Checksum	Yes	Latched	Status Fail Non_Vol Failure	
Data Flash (run time)	Checksum is computed on critical data	Checksum	Yes	Latched	Status Fail Non_Vol Failure	
Front Panel (power up)	Fail if ID registers do not match expected or if FPGA programming is unsuccessful		No	Not Latched	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.

Table 10.8 Relay Self-Tests (Sheet 2 of 3)

Self-Test	Description	Limits	Protection Disabled on Failure	Alarm Status	Front-Panel Message on Failure	Corrective Action
I/O Board Failure	Check if ID register matches part number		Yes	Latched	Status Fail I/O Card Failure	
DeviceNet Board Failure	DeviceNet card does not respond in three consecutive 300 ms time out periods		NA	NA	COMMFLT Warning	
Exception Vector	CPU error		Yes	Latched	Vector nn Relay Disabled	Contact SEL.
CT Board A/D Offset Warn	Measure dc offset at each input channel	>50 mV	No	Not Latched	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
VT Board (power up)	Fail if ID register does not match part number		Yes	Latched	Status Fail Volt Card Fail	
VT Board A/D Offset Warn	Measure dc offset at each input channel	>50 mV	No	Not Latched	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
VT Board A/D Fail	Fail if any bits between 15 and 12 are set or if number of conversions not as expected		Yes	Latched	Status Fail Volt Card Fail	
+0.9 V Fail	Monitor +0.9 V power supply	0.855 to 0.945 V	Yes	Latched	Status Fail +0.9 V Failure	
+1.2 V Fail	Monitor +1.2 V power supply	1.152 to 1.248 V	Yes	Latched	Status Fail +1.2 V Failure	
+1.5 V Fail	Monitor +1.5 V power supply	1.35 to 1.65 V	Yes	Latched	Status Fail +1.5 V Failure	
+1.8 V Fail	Monitor +1.8 V power supply	1.71 to 1.89 V	Yes	Latched	Status Fail +1.8 V Failure	
+3.3 V Fail	Monitor +3.3 V power supply	3.07 to 3.53 V	Yes	Latched	Status Fail +3.3 V Failure	
+5 V Fail	Monitor +5 V power supply	4.65 to 5.35 V	Yes	Latched	Status Fail +5 V Failure	
+2.5 V Fail	Monitor +2.5 V power supply	2.32 to 2.68 V	Yes	Latched	Status Fail +2.5 V Failure	
+3.75 V Fail	Monitor +3.75 V power supply	3.48 to 4.02 V	Yes	Latched	Status Fail +3.75 V Failure	
–1.25 V Fail	Monitor –1.25 V power supply	–1.16 to –1.34 V	Yes	Latched	Status Fail -1.25 V Failure	
–5 V Fail	Monitor –5 V power supply	–4.65 to –5.35 V	Yes	Latched	Status Fail -5 V Failure	
Clock Battery Warn	Check battery voltage level		No	Not Latched	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.

Table 10.8 Relay Self-Tests (Sheet 3 of 3)

Self-Test	Description	Limits	Protection Disabled on Failure	Alarm Status	Front-Panel Message on Failure	Corrective Action
RTC Chip	Unable to communicate with clock or fails time keeping test		No	Not Latched	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
RTC Chip Internal RAM	Clock chip static RAM fails		No	Not Latched	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
Mainboard FPGA (power up)	Fail if mainboard Field Programmable Gate Array does not accept program		Yes	Latched	Status Fail FPGA Failure	
Mainboard FPGA (run time)	Fail on lack of data acquisition interrupts		Yes	Latched	Status Fail FPGA Failure	
PTC Short	Fail if short detected		NA	NA		
External RTD	Fail if the external RTD module reports that at least one enabled RTD input is open or shorted, if there is no comm, or if there is a power supply failure for the external RTD module		NA	NA	RTD Failure	STA C, to clear the warning in the status report. Contact SEL if failure returns.
Back-plane comms diagnostics	Fail if GPSB is busy on entry to processing interval		Yes	Latched	Status Fail GPSB Failure	

Troubleshooting

Refer to *Table 10.9* for troubleshooting instructions for particular situations.

Table 10.9 Troubleshooting (Sheet 1 of 2)

Problem	Possible Cause	Solution
The relay **ENABLED** front-panel LED is dark.	Input power is not present or a fuse is blown.	Verify that input power is present. Check fuse continuity.
	Self-test failure.	View the self-test failure message on the front-panel display.
The relay front-panel display does not show characters.	The relay front-panel has timed out.	Press the **ESC** pushbutton to activate the display.
	The relay is de-energized.	Verify input power and fuse continuity.
The relay does not accurately measure voltages or currents.	Wiring error.	Verify input wiring.
	Incorrect CTR1, CTRN, or PTR setting.	Verify instrument transformer ratios, connections, and associated settings.
	Voltage neutral terminal (N) is not properly grounded.	Verify wiring and connections.

Table 10.9 Troubleshooting (Sheet 2 of 2)

Problem	Possible Cause	Solution
The relay does not respond to commands from a device connected to the serial port.	Cable is not connected.	Verify the cable connections.
	Cable is not the correct type.	Verify the cable pinout.
	The relay or device is at an incorrect baud rate or has another parameter mismatch.	Verify Device software setup.
	The relay serial port has received an XOFF, halting communications.	Type **<Ctrl+Q>** to send the relay XON and restart communications.
The relay does not respond to faults.	The relay is improperly set.	Verify the relay settings.
	Improper test source settings.	Verify the test source settings.
	Current or voltage input wiring error.	Verify input wiring.
	Failed relay self-test.	Use the front-panel RELAY STATUS function to view self-test results.

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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Fax: +1.509.332.7990
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Email: info@selinc.com

Appendix A
Firmware 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 (see *STATUS Command (Relay Self-Test Status) on page 7.25 in Section 7: Communications* for more information on the **STA** command). The status report displays the firmware identification (FID) string.

The firmware version will be either a standard release or a point release. A standard release adds new functionality to the firmware beyond the specifications of the existing version. A point release is reserved for modifying firmware functionality to conform to the specifications of the existing version.

A standard release is identified by a change in the R-number of the device firmware identification (FID) string.

Existing firmware:

FID=SEL-749M-**R100**-V0-Z001001-D*xxxxxxxx*

Standard release firmware:

FID=SEL-749M-**R101**-V0-Z001001-D*xxxxxxxx*

A point release is identified by a change in the V-number of the device FID string.

Existing firmware:

FID=SEL-749M-R100-**V0**-Z001001-D*xxxxxxxx*

Point release firmware:

FID=SEL-749M-R100-**V1**-Z001001-D*xxxxxxxx*

The release date is after the D. For example, the following is firmware revision number 100, release date December 10, 2003.

FID=SEL-749M-R100-V0-Z001001-**D20031210**

Table A.1 and *Table A.2* list the firmware versions, a description of modifications, and the instruction manual date code that corresponds to firmware versions. The most recent firmware version is listed first.

Table A.1 200 Series Firmware Revision History (Sheet 1 of 2)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-749M-R207-V3-Z004005-D20201111	Includes all the functions of SEL-749M-R207-V2-Z004005-D20191011 with the following additions: ➤ Modified the real-time clock (RTC) diagnostics logic to show a warning only if the RTC diagnostics fail three consecutive times. The self-test diagnostics are run every six hours. ➤ Resolved an issue where the VBC voltage was reported incorrectly in the motor start report (MSR) for relays configured with wye-connected PTs. Only firmware versions R207-V1 and R207-V2 are affected by this issue.	20201111
SEL-749M-R207-V2-Z004005-D20191011	Includes all the functions of SEL-749M-R207-V1-Z004005-D20180720 with the following additions: ➤ Resolved an issue in which Modbus communications could cease on one of the serial ports when multiple serial ports were actively communicating via Modbus protocol. This issue requires the relay to be restarted to restore Modbus communications.	20191011
SEL-749M-R207-V1-Z004005-D20180720	Includes all the functions of SEL-749M-R207-V0-Z004005-D20150731 with the following additions: ➤ Resolved an issue in R207-V0 where the overlap of nonvolatile storage between latch bits and motor start records occasionally caused NON_VOL failure. ➤ Resolved an issue where the relay would vector when contrast setting (FP_CONT) is changed from the Set/Show menu via the front panel. ➤ Resolved an issue with RTD biasing where, for certain cases, it causes the relay to TRIP on 49T (Thermal model or winding RTD trip) under certain ambient RTD failure modes. ➤ Resolved an issue with NOSLO Relay Word bit asserting for a second when BLKPROT := STARTING and BLK66 := Y.	20180720
SEL-749M-R207-V0-Z004005-D20150731	➤ Revised the firmware to support HMI hardware revisions. Firmware R207 is supported by the previous hardware. Hardware shipped with R207 and later does not support firmware R206 and earlier. ➤ Improved the security of RTD ALARM and TRIP by adding an approximately six (6) second delay to qualify the event. ➤ Changed storage of the latch and local bits from clock battery backed memory to nonvolatile memory.	20150731
SEL-749M-R206-V1-Z004005-D20191011	Includes all the functions of SEL-749M-R206-V0-Z004005-D20120130 with the following additions: ➤ Resolved an issue in which Modbus communications could cease on one of the serial ports when multiple serial ports were actively communicating via Modbus protocol. This issue requires the relay to be restarted to restore Modbus communications.	20191011
SEL-749M-R206-V0-Z004005-D20120130	➤ Corrected the time to thermal trip reporting for instances when the current is equal to the approximate SF current. ➤ Extended the delay in programming `FPGA` at relay start-up.	20120130
SEL-749M-R205-V0-Z004005-D20111230	➤ Corrected an issue where in some cases the **ENABLED** LED did not turn off when the relay was disabled (the alarm contact worked correctly). ➤ Added Global Settings and Logic Settings to event report data.	20111230
SEL-749M-R204-V0-Z004005-D20110425	➤ Corrected an issue where the relay was displaying incorrect `Thermal Trip in (sec)` for currents less than SF (service factor). The display should show a fixed value of `9999 sec`. Protection was unaffected by the issue.	20110425
SEL-749M-R203-V0-Z004005-D20101130	➤ Corrected displayed Thermal Lockout “Time to Reset” issue.	20101130

Table A.1 200 Series Firmware Revision History (Sheet 2 of 2)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-749M-R202-V0-Z004005-D20100830	➤ Renamed the Relay Word bit TRIP in Row 0 of *Table G.1: SEL-749M Relay Word Bits* to TRIP_LED to eliminate confusion with the Relay Word bit TRIP in Row 10. ➤ Corrected a Vector 3 issue related to certain setting changes from the front-panel HMI.	20100830
SEL-749M-R201-V0-Z004004-D20100601	➤ Added Modbus protocol support to Port F (front port). Also added three concurrent Modbus sessions capability to Port F, Port 3, and Port 4. ➤ Added Rating_1 choice to the Thermal Method setting. Rating_1 method is exactly the same as Rating method except it does not raise the initial heat estimate at start like the Rating method. ➤ Added ACCESS Control setting BLOCK MODBUS SET (BLKMBSET) to be able to block settings changes from a remote Modbus or DeviceNet master.	20100601
SEL-749M-R200-V0-Z003003-D20100120	➤ Revised firmware for processor update. ➤ Extended event report storage capability to at least seventy-seven 15-cycle or nineteen 64-cycle event reports.	20100120
Previous firmware versions cannot be upgraded to R200 and above.		

Table A.2 100 Series Firmware Revision History (Sheet 1 of 2)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-749M-R112-V1-Z003004-D20150731	Includes all the functions of SEL-749M-R112-V0-Z003004-D20111230 with the following addition: ➤ Resolved an issue that causes SELOGIC timers to momentarily deassert after a temporary deassertion of the input. The issue occurs when the duration of the input deassertion is longer than the difference between the dropout time setting and the pickup time setting but less than the timer's drop out time setting. If the input deassertion time is longer than the dropout time setting then the timer operates correctly.	20150731
SEL-749M-R112-V0-Z003004-D20111230	➤ Corrected an issue where in some cases the **ENABLED** LED did not turn off when the relay was disabled (the alarm contact worked correctly). ➤ Added Global Settings and Logic Settings to event report data.	20111230
SEL-749M-R111-V0-Z003004-D20110425	➤ Corrected an issue where the relay was displaying incorrect `Thermal Trip in (sec)` for currents less than SF (service factor). The display should show a fixed value of `9999 sec`. Protection was unaffected by the issue.	20110425
SEL-749M-R110-V0-Z003004-D20101130	➤ Corrected displayed Thermal Lockout "Time to Reset" issue.	20101130
SEL-749M-R109-V0-Z003004-D20100830	➤ Renamed the Relay Word bit TRIP in Row 0 of *Table G.1:* SEL-749M *Relay Word Bits* to TRIP_LED to eliminate confusion with the Relay Word bit TRIP in Row 10.	20100830
SEL-749M-R108-V0-Z003003-D20091123	➤ Corrected the Curve Method RTC (auto) calculation for the minimum cooltime calculation and setting interdependency check error message.	20091123
SEL-749M-R107-V0-Z003003-D20091103	➤ Improved thermal capacity calculation accuracy. ➤ Improved analog channels phase angle accuracy.	20091103
SEL-749M-R106-V0-Z003003-D20071109	➤ Corrected thermal model operation for two-speed applications.	20071109

Table A.2 100 Series Firmware Revision History (Sheet 2 of 2)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code

SEL-749M-R105-V0-Z003003-D20070308	➤ Enhanced thermal element protection during phase reversal condition by adding negative-sequence current magnitude to 50S element and to motor state logic.
	➤ Added hysteresis to 49A (thermal alarm) logic to eliminate occasional nuisance alarm due to chatter.
	➤ Added hysteresis to 50S element such that pickup is at 2.5 pu and dropout is at 2.4 pu.
	➤ Added Fast Meter protocol to front port (Port F) to support ACSELERATOR QuickSet SEL-5030 Software.
	➤ Added 8 DI card (8 optoisolated inputs) support to SEL-749M Slot C. The inputs are IN301, IN302 . . . IN308.
	➤ Modbus protocol is now standard in base SEL-749M and is available at Port 3 or Port 4, but not on both ports.
	➤ The thermal model has been revised such that when RTC (Run State Time Constant) is set 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.
	➤ In the thermal model, redefined “Hot” motor criteria from 0.9 pu to 0.9 • SF pu load, where SF is the motor service factor, to better represent “Hot” motor condition. These criteria are used to calculate RTC when RTC = AUTO.
	➤ Added Registers 212C–2130 to Modbus Map for four additional Relay Word bit rows (for the 8 DI card option and spares).
	➤ Changed Modbus Register 2100, Bit 7, to “Starting” (from OUT103 Status). Bit 0 is already OUT103.
	➤ Changed Modbus Register 2101, Bit 0, to Enabled (from Starting).
	➤ Added more resolution to %TCU in the MET T report.
	➤ Settings-related changes:
	  ➤ Changed RTC equations when RTC = AUTO.
	  ➤ Changed default setting for COOLTIME to 84 minutes.
	➤ Added PROTOCOL and SLAVEID settings to Port 3 for Modbus or SEL protocol selection.
		20070308

SEL-749M-R104-V0-Z002002-D20060126	➤ Added SEL-5010 Relay Assistant Software compatibility. ➤ Changed default value of frequency parameter from 0 to 60 Hz for DeviceNet. ➤ Improved frequency tracking algorithm to make it robust. ➤ Corrected delay timer operation for LOADUP and LOADLOW elements. ➤ Corrected blocking of LOP function.	20060126
SEL-749M-R103-V0-Z002002-D20050623	➤ Corrected possible error condition when reading event reports.	20050623
SEL-749M-R102-V0-Z002002-D20041027	➤ Modified 50P and Undercurrent (Load Loss) element ranges. ➤ Added Loss-of-Potential function. ➤ Added Frequency in event reporting. ➤ Lengthened passwords to 12 characters. ➤ Added “Time to Reset” for lockout timer in Modbus map (register 011B) and Meter T report.	20041027
SEL-749M-R101-V0-Z001001-D20040216	➤ Corrected timing for Curve Method Starting element.	20040216
SEL-749M-R100-V0-Z001001-D20031210	➤ Initial version.	20031219

DeviceNet and Firmware Versions

The firmware on the DeviceNet interface has two versions, as listed in *Table A.3*. The version number of this firmware is only accessible via the DeviceNet interface.

Table A.3 DeviceNet Card Versions

DeviceNet Card Software Version	Revisions	Release Date
Major Rev: 1, Minor Rev: 5 (Rev 1.005)	Reads product code, DeviceNet card parameter descriptions, etc., from the relay.	20080407
Major Rev: 1, Minor Rev: 3 (Rev 1.003)	Resolves some Conformance Issues (Card defines product code = 100, fixed descriptions for DeviceNet card parameters, etc.)	20050922
Major Rev: 1, Minor Rev: 1 (Rev 1.001)	Base Version (Card defines product code = 100, fixed descriptions for DeviceNet card parameters, etc.)	20030612

The Electronic Data Sheet (EDS) file is not updated every time a firmware release is made. Only when there is a change in the Modbus or DeviceNet parameters is a new EDS file released. The EDS file and an ICON file for the SEL-749M, are zipped together on the SEL-749M Product Literature CD (SEL-*xxx*R*xxx*.EXE). The file can also be downloaded from the SEL website at selinc.com. *Table A.4* lists the compatibility among the EDS files and the various firmware versions of the relay.

Table A.4 EDS File Compatibility

EDS File	Firmware Revisions Supported	Release Dated
SEL-749M201.EDS	R201–R207 (with DeviceNet version 1.005)	20100601
SEL-749MR106.EDS	R106–R112, R200 (with DeviceNet version 1.003)	20071109
SEL-749MR105.EDS	R105 (with DeviceNet version 1.003)	20070308
SEL-749MR104.EDS	R104 (with DeviceNet version 1.003)	20060126
SEL-749MR103.EDS	R103 (with DeviceNet version 1.003)	20050623
SEL-749MR102.EDS	R102 (with DeviceNet version 1.001)	20041027
SEL-749MR101.EDS	R101 (with DeviceNet version 1.001)	20040216
SEL-749MR100.EDS	R100 (with DeviceNet version 1.001)	20031219

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 6)

Revision Date	Summary of Revisions
20201111	Appendix A ➤ Updated *Table A.1: 200 Series Firmware Revision History* for firmware version R207-V3.
20191011	Preface ➤ Updated *General Safety Marks*, *Other Safety Marks*, and *Trademarks*. Section 1 ➤ Updated *Specifications*. Section 2 ➤ Added a Class 1 Laser Product note to *Overview.* ➤ Updated *Physical Location*. ➤ Updated *Slot B CPU Card Replacement* procedure. ➤ Updated *Power Connections*, *Grounding (Earthing)*, and *Serial Ports*. Section 3 ➤ Updated *Table 3.1: SEL Software Solutions*. ➤ Updated *View Event Files*. Section 7 ➤ Updated *Table 7.27: L_D Command (Load Firmware)*. Section 9 ➤ Updated *Compressed ASCII Event Reports, Event Summaries, and History.* Appendix A ➤ Updated for firmware versions R207-V2 and R206-V1. Command Summary ➤ Updated for ACC and 2AC commands. ➤ Updated SER commands.
20180720	Section 3 ➤ Updated section to match software. Section 4 ➤ Updated *Additional Thermal Overload Settings* to describe the RTD biasing feature. ➤ Updated *Target LED Set* to describe the function of latched LEDs. Section 5 ➤ Updated *Motor Operating Statistics* and *Motor Start Report* to clarify when motor start reports are reset. Section 7 ➤ Updated *Table 7.30: MOTOR Command*. Section 9 ➤ Updated *Table 9.1: Event Types* to include Trip*. Section 10 ➤ Added note to *Self-Test*. ➤ Updated *Table 10.8: Relay Self-Tests* to clarify the description of the External RTD Self-Test. Appendix A ➤ Updated for firmware version R207-V1.

Table A.5 Instruction Manual Revision History (Sheet 2 of 6)

Revision Date	Summary of Revisions
20171006	Preface ➤ Added caution statement at beginning of *Safety Information.* ➤ Updated *Safety Marks* in *Safety Information.* ➤ Updated *Hazardous Locations Safety Marks* in *Safety Information.* ➤ Updated the table in *Wire Sizes and Insulation*. ➤ Updated *Accessories* under *Models, Options, and Accessories.* ➤ Updated the compliance label and the product labels. ➤ Added *Trademarks.* Section 1 ➤ Updated *Specifications*. Section 2 ➤ Updated *Relay Placement*. Section 4 ➤ Updated the definition for FLAmin in *Figure 4.10: Phase Reversal Element Logic* and *Figure 4.23: Motor State Logic*. Appendix G ➤ Updated the definition for Warning Relay Word bit.
20150731	Preface ➤ Updated the *General Safety Marks* and *Other Safety Marks* tables. ➤ Updated the table in the *Wire Sizes and Insulation* section. Section 1 ➤ Updated the *Mechanical Durability* specification. ➤ Updated the *AC Current Input* and *AC Voltage Inputs* sections of *Specifications*. ➤ Updated the *Power Supply* section of *Specifications*. ➤ Added *Relay Mounting Screws (#8-32) Tightening Torque* to *Specifications*. ➤ Updated *Terminal Connections* in *Specifications*. ➤ Updated *Protection and Control Processing* in *Specifications*. ➤ Updated *RTD Protection (Optional Using an SEL-2600 Series Module)* in *Specifications*. Section 2 ➤ Updated *Card Configuration Procedure*. ➤ Added *Password, Breaker Control, and SELBOOT Jumper Selection*. ➤ Updated *Rear-Panel and Top-Panel Diagrams*, *Figure 2.3 PTC Input, EIA-232/EIA-485 Communications Card, 3 DI/4 DO/1 AO Card, and Voltage Card Options*, *(A) Rear-Panel Layout*. ➤ Added *Analog Output Wiring*. ➤ Added notes for VT secondary circuit grounding and open-delta VT connections to *Figure 2.12: Voltage Connections*. ➤ Updated *Figure 2.13: AC Connections With Core-Balance CT.* Section 3 ➤ Updated *Table 3.1:* SEL *Software Solutions* and *Table 3.2: ACSELERATOR QuickSet* SEL-*5030 Software*. ➤ Updated *Settings Database Management and Drivers*. Section 4 ➤ Updated *Table 4.5: Load-Jam Element Logic* and *Table 4.6: Undercurrent (Load-Loss) Logic*. ➤ Added *Figure 4.9: Star-Delta Starting*. ➤ Added a note for the RTD ALARM and TRIP delay to *RTD Trip/Warning Levels*. ➤ Added a note for the rotating display to *Display Enable*. Section 5 ➤ Added a note for the time to thermal trip calculation to *Thermal Metering*.

Table A.5 Instruction Manual Revision History (Sheet 3 of 6)

Revision Date	Summary of Revisions
	Section 7 ➤ Added a note to *METER T (Thermal and RTD Metering)* for maximum time to trip. ➤ Added a note to *STATUS Command (Relay Self-Tests Status)* for execution capacity. ➤ Added *VEC Command (Show Diagnostic Information)*. Section 9 ➤ Updated *Event Reports*. Section 10 ➤ Updated *Table 10.8: Relay Self-Tests*. Appendix A ➤ Updated for firmware versions R112-V1 and R207. Appendix B ➤ Updated and added to *Appendix B: Firmware Upgrade Instructions*. Appendix F ➤ Updated *Rating Method Equations* and *Curve Method Equations*.
20150123	Preface ➤ Added *Safety Information* and *General Information*. ➤ Updated the compliance label in *Hazardous Locations Approvals* and the product labels in *General Information*. Section 1 ➤ Changed the *Certifications* section title to *Compliance* and relocated the section to the beginning of the *Specifications*.
20120130	Appendix A ➤ Updated for firmware version R206.
20111230	Appendix A ➤ Updated for firmware versions R112 and R205.
20110425	Section 1 ➤ Revised upper voltage levels of the *Control Inputs* specification. ➤ Added LCD related note to *Operating Temperature* specification. Section 4 ➤ Added note to RTD section regarding IEC specification. Appendix A ➤ Updated for firmware versions R111 and R204.
20101130	Section 1 ➤ Revised *Analog Output* accuracy specification to ±1%. Appendix A ➤ Updated for firmware versions R110 and R203.
20100830	Section 1 ➤ Updated UL and CSA certification statements. Section 8 ➤ Updated *Table8.3: Possible Warning Conditions (Flashing TRIP LED)* to show the actual WARNING messages. Section 10 ➤ Added Watchdog timer self-test to *Table10.8: Relay Self-Tests*. Appendix A ➤ Updated for firmware versions R109 and R202. Appendix G ➤ Revised Row 0 of *Table G.1:* SEL-749M *Relay Word Bits* from TRIP to TRIP_LED and added the TRIP_LED definition to *TableG.2: Relay Word Bit Definitions for the SEL-749M*.

Table A.5 Instruction Manual Revision History (Sheet 4 of 6)

Revision Date	Summary of Revisions
20100601	Section 2 ➤ Added note that digital inputs and outputs are polarity neutral. Section 4 ➤ Added Rating_1 as the third choice for Thermal method. This method does not bump up the heat estimate at start like the Rating method. This allows more thermal capacity to start. ➤ Added description of ACCESS CONTROL setting BLOCK MODBUS SET (BLKMBSET) to be able to block settings changes from remote Modbus or DeviceNet master. Section 6 ➤ Added RATING_1 to the Thermal Method setting SETMETH. ➤ Revised Port F settings to include Modbus protocol choice. ➤ Added BLOCK MODBUS SET setting to ACCESS CONTROL in GLOBAL settings. Section 7 ➤ Edited to reflect Modbus choice on Port F, Port 3, and Port 4. ➤ Added CAL level access commands to access the CAL level and change CAL level password. Appendix A ➤ Updated for firmware version R201. Command Summary ➤ Added CAL level access and password commands.
20100120	Section 1 ➤ Updated current metering accuracy under Metering in Specifications. ➤ Updated *Figure 1.2: STA Command Response—No Communications Card or Communications Card/Modbus RTU Protocol* and *Figure 1.3: STA Command Response—Communications Card/DeviceNet Protocol*. Section 4 ➤ Revised *Event Report Set* to update number of event reports that can be stored. ➤ Revised *Figure 4.34: Loss-of- Potential (LOP) Logic.* Section 10 ➤ Updated *Table 10.7: Periodic Relay Checks* to show additional voltage checks on updated processor card. Appendix A ➤ Updated for firmware version R200.
20091123	Appendix A ➤ Updated for firmware version R108.
20091103	Appendix A ➤ Updated for firmware version R107.
20080918	Section 1 ➤ Added AC Current Input Neutral specifications. Appendix K ➤ Added Thermal Element Trip-Time Equations.
20071109	Preface ➤ Revised Safety and General Information to include hazardous locations approvals. Section 1 ➤ Revised Specifications to include hazardous locations approvals. Section 2 ➤ Revised to include hazardous locations approvals. Appendix A ➤ Updated for firmware version R106.

Table A.5 Instruction Manual Revision History (Sheet 5 of 6)

Revision Date	Summary of Revisions
20070308	Section 1 ➤ Revised and updated for addition of 8 DI card option. Section 2 ➤ Revised and added I/O Configuration subsection, including 8 DI card option. Section 3 ➤ Revised for the newly added SEL-749M HMI feature in the ACSELERATOR QuickSet Software. Section 4 ➤ Revised Thermal Element, Port Settings (SET P Command), Logic Functions, and Optoisolated Inputs segments. Section 6 ➤ Added Port 3 PROTOCOL and Modbus SLAVEID settings. Appendix A ➤ Updated for firmware version R105. Appendix D ➤ Revised and updated Modbus Register Map Table. ➤ Added Registers 212C–2130 to Modbus Map for four additional Relay Word bit rows (for the 8 DI card option and spares). ➤ Changed Modbus Register 2100, Bit 7, to "Starting" (from OUT103 Status). Bit 0 is already OUT103. ➤ Changed Modbus Register 2101, Bit 0, to Enabled (from Starting). Appendix G ➤ Tables G1 and G2 revised for new Relay Word bits IN301. . .IN308.
20060126	Preface ➤ Added safety information. Section 1 ➤ Removed figure. ➤ Expanded on RTD specifications; improved specifications. Section 2 ➤ Added 2-wire communication information; added figure. Section 10 ➤ Elaborated on cable use. Appendix A ➤ Updated for firmware version R104. Appendix D ➤ Updated high range for MAC ID.
20050623	Appendix A ➤ Updated for firmware version R103.
20041027	Overview ➤ Updated patents. Section 1 ➤ Added further guidance on grounding. ➤ Improved Specifications (Output Contacts, 50P and Undercurrent [Load Loss] element-range modifications). Section 2 ➤ Added further guidance on grounding.

Table A.5 Instruction Manual Revision History (Sheet 6 of 6)

Revision Date	Summary of Revisions
	Section 4 ➤ Clarified VNOM/PTR settings range. ➤ Updated starting %TCU and TCSTART setting. ➤ Clarified cooling time setting calculations. ➤ Added Loss-of-Potential protection description. ➤ Modified 50P and Undercurrent (Load Loss) element ranges. Section 6 ➤ Modified 50P and Undercurrent (Load Loss) element ranges. Section 7 ➤ Described improved password protection. ➤ Added **STA S** command explanation. ➤ Added Frequency to Event Summary. Section 8 ➤ Added flashing TRIP LED explanation. Section 9 ➤ Added Frequency to Event Report. Appendix A ➤ Updated for firmware version R102. Appendix D ➤ Modified 50P and Undercurrent (Load Loss) element ranges.
20040216	Section 1 ➤ Updated product compliance from IP54 to IP65 on page 1.11. Appendix A ➤ Updated for firmware version R101.
20031219	➤ Initial version.

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Appendix B
Firmware Upgrade Instructions

Overview

These firmware upgrade instructions apply to all SEL-700 series industrial products except the SEL-701 Relay and SEL-734 Meter.

SEL occasionally offers firmware upgrades to improve the performance of your relay. Because the SEL-749M 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.

This instruction guides you through the process of upgrading firmware in the device. The firmware upgrade will be either a standard release or a point release. A standard release adds new functionality to the firmware beyond the specifications of the existing version. A point release is reserved for modifying firmware functionality to conform to the specifications of the existing version.

A standard release is identified by a change in the R-number of the device firmware identification (FID) string.

Existing firmware:

FID=SEL-749M-**R100**-V0-Z001001-D*xxxxxxxx*

Standard release firmware:

FID=SEL-749M-**R101**-V0-Z001001-D*xxxxxxxx*

A point release is identified by a change in the V-number of the device FID string.

Existing firmware:

FID=SEL-749M-R100-**V0**-Z001001-D*xxxxxxxx*

Point release firmware:

FID=SEL-749M-R100-**V1**-Z001001-D*xxxxxxxx*

Required Equipment

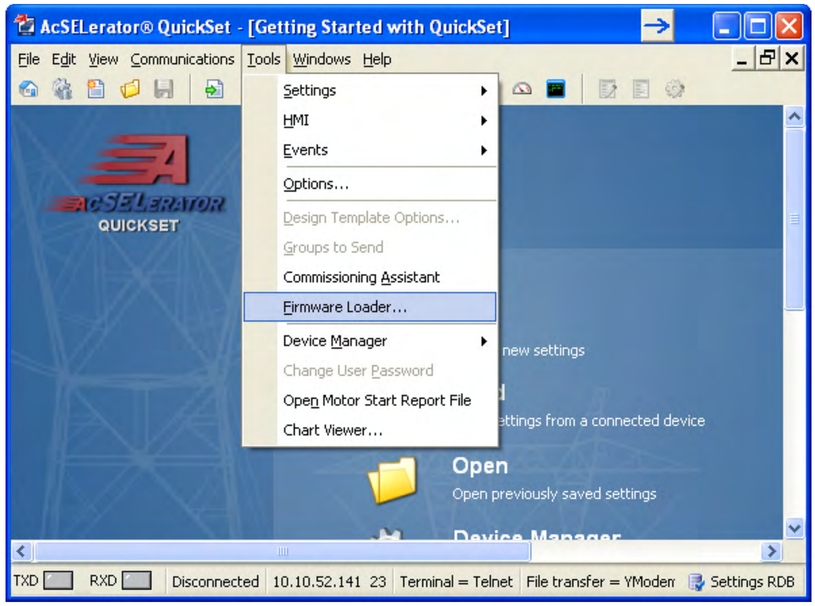
Gather the following equipment before starting this firmware upgrade:

- Personal computer (PC)
- Terminal emulation software that supports Xmodem/CRC or 1k Xmodem/CRC protocol
- Serial communications cable (SEL-C234A Cable or equivalent, or a null-modem cable)
- Disk containing the firmware upgrade file (e.g., r1017*xxxxxx*.s19 or r1017*xxxxxx*.z19)
- QuickSet Software

NOTE: Firmware releases are also available as zip files (.z19). Use the zip file for faster download.

Upgrade Firmware Using QuickSet

Select **Tools** > **Firmware Loader** from the QuickSet menu bar to launch a wizard that walks you through the steps to load firmware into your SEL device. Refer to *Section 3: PC Software* for setup and connection procedures for QuickSet.

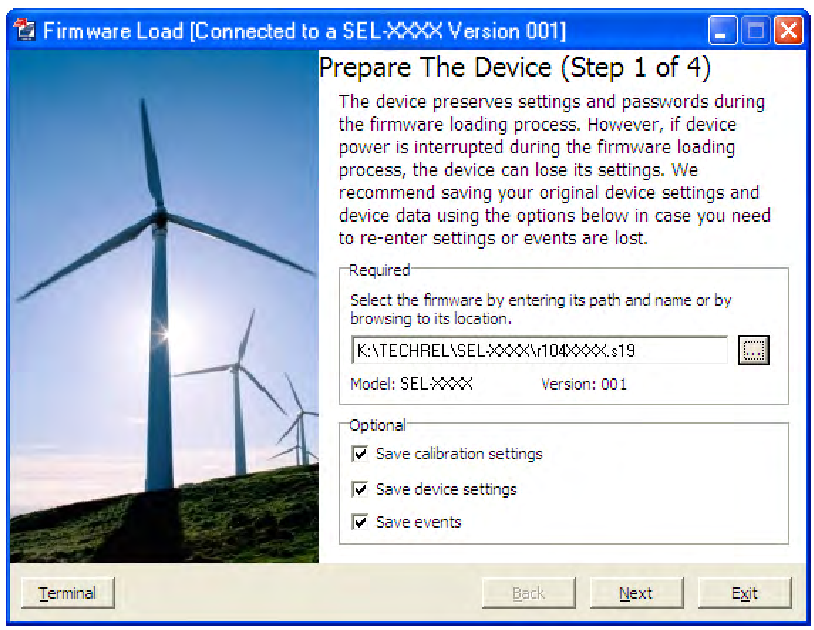


Firmware Loader does not start if:

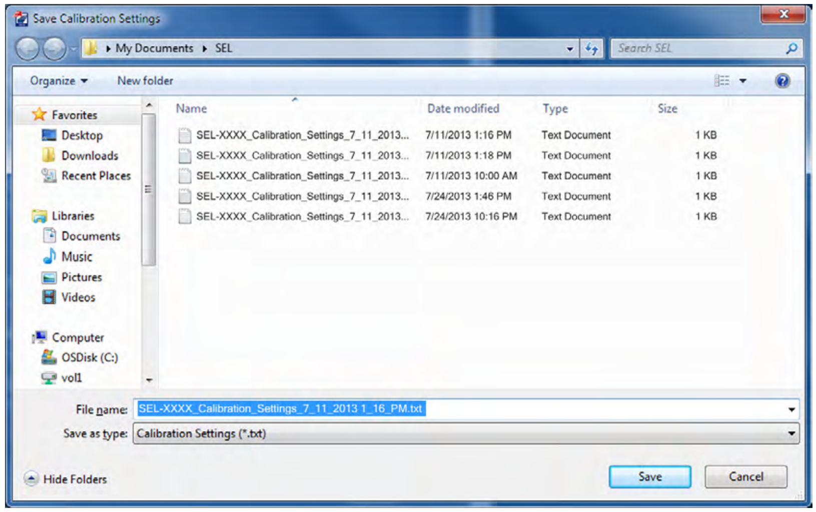
- ➤ The device is unsupported by QuickSet.
- ➤ The device is not connected to the computer with a communications cable.
- ➤ The device is disabled.

Step 1. Prepare the device.

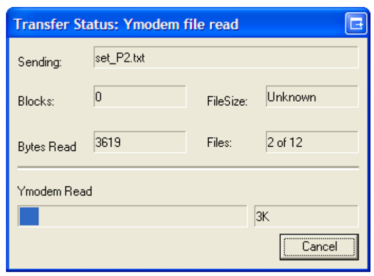
a. Select the firmware to be loaded using the browse control and select **Save calibration settings**, **Save device settings**, and **Save events**. Select **Next** to continue the wizard.

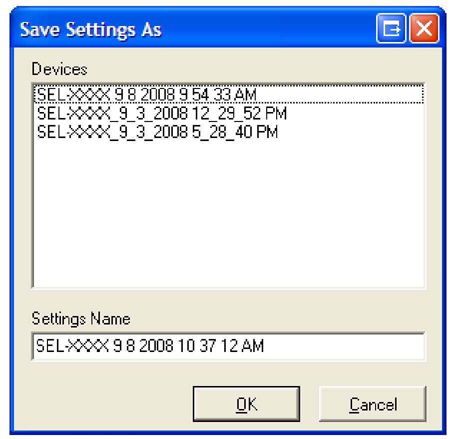


b. Select a file name to save the selected settings or accept the defaults as shown. Click **Save**.



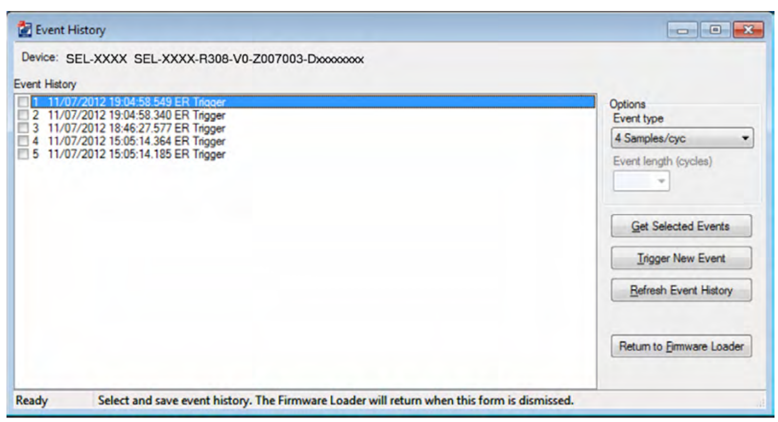
c. The **Transfer Status: Ymodem file read** window shows the transfer progress of the settings file. Clicking **Cancel** stops the transfer.
After the device settings are downloaded, select a file name and path to save the settings or accept the default, as shown.





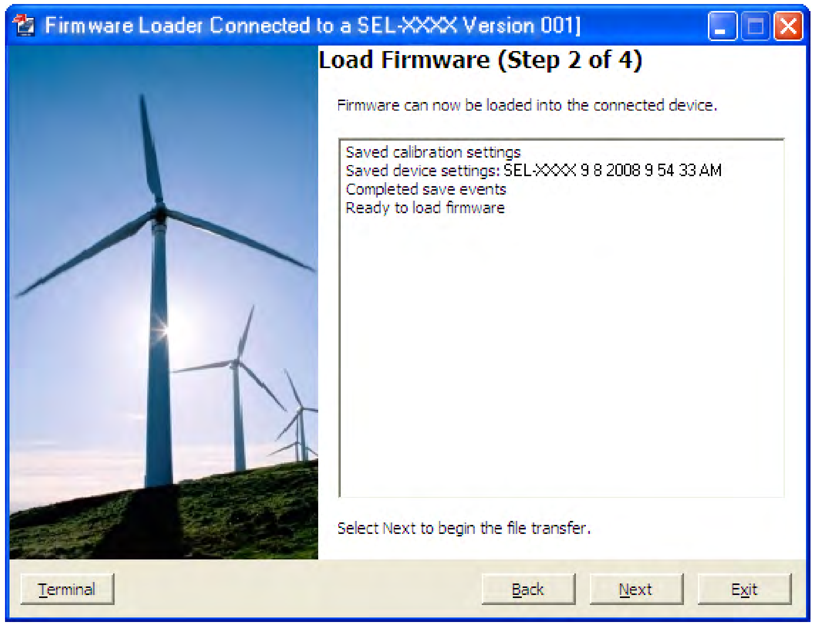
d. Click **Return to Firmware Loader** if this product does not have any event reports.

If there are any event reports to be saved, click the **Get Selected Event** button after selecting the events. After saving them, click the **Return to Firmware Loader** button.



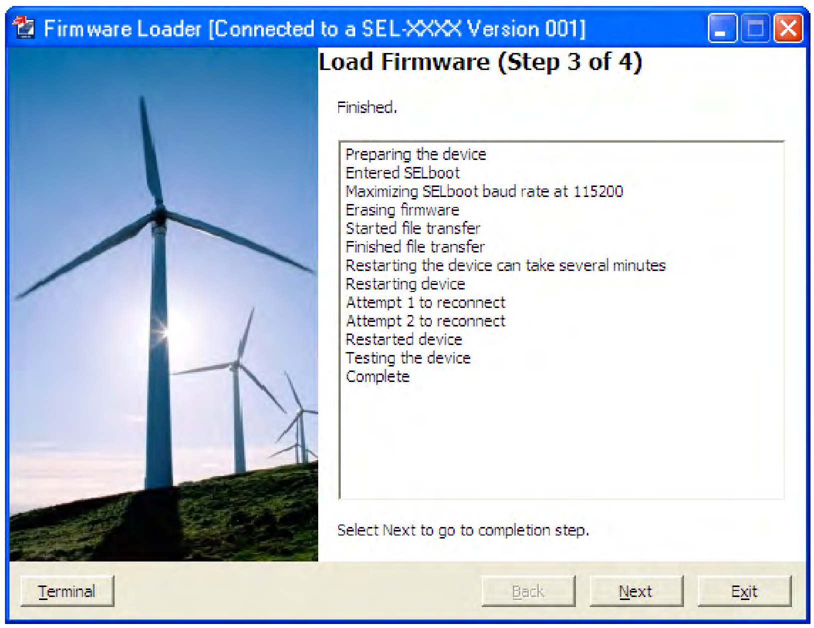
Step 2. Transfer Firmware.

Click **Next** to begin the firmware transfer.

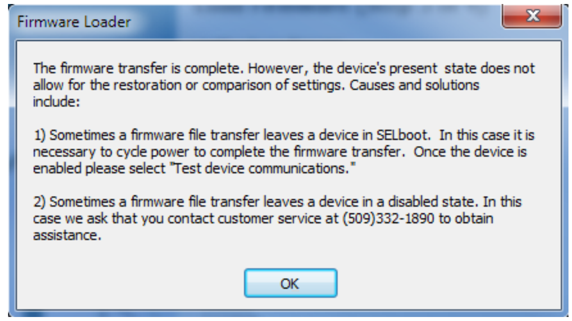


Step 3. Load Firmware.

During this step, the device is put into SELBOOT. The transfer speed is maximized and the firmware transfer begins.



NOTE: The following screen can appear if you have one of the two conditions mentioned.



If the relay is disabled as mentioned in condition number 2, check for the **ENABLED** LED on the front panel of the relay. If the **ENABLED** LED is not illuminated or the front panel displays `STATUS FAIL`, `EEPROM FAILURE`, or `Non_Vol Failure`, use the following procedure to restore the factory-default settings:

a. Click the **Terminal** button on the Firmware Load screen of QuickSet.

b. Set the communications software settings to 9600 baud, 8 data bits, and 1 stop bit.

c. Enter Access Level 2 by issuing the **2AC** command.

d. Issue the **R_S** command to restore the factory-default settings

e. Enter Access Level 2.

f. Issue the **STATUS** command.

If the STATUS report shows option card `FAIL` and `Relay Disabled` and the message:

```
Confirm Hardware Config
Accept & Reboot (Y/N)?
```

Enter **Y**.

This saves the relay calibration settings. The relay responds:

```
Config Accepted
```

The relay reboots and becomes enabled.

Step 4. Verify Device Settings.

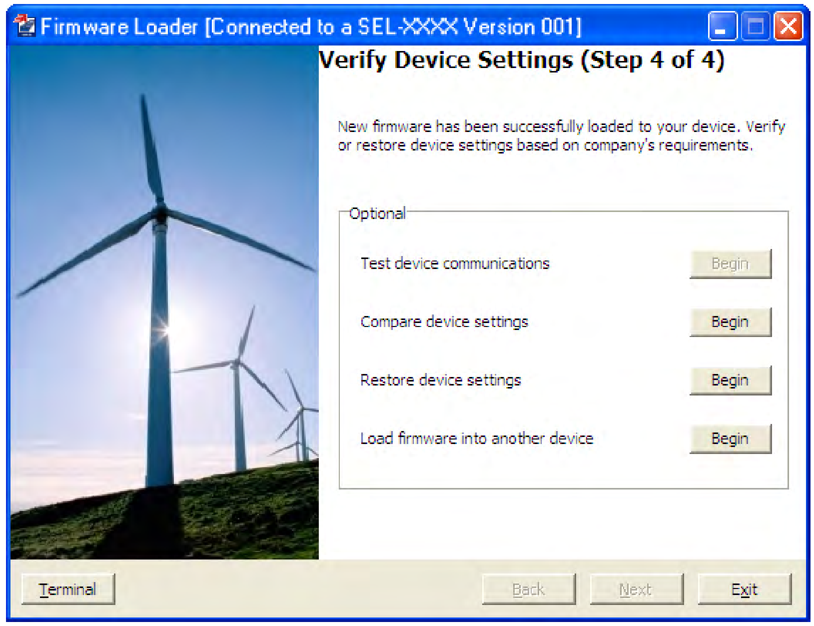
Four verification options are provided. When enabled, these options perform as follows.

Test Device Communications. If the device cannot be restarted, then turn power off and back on to restart it. Once the device is enabled, this option reconnects and re-initializes the device.

Compare Device Settings. This option verifies settings by reading them from the device and comparing them with settings saved to the database.

Restore Device Settings. This option restores settings by writing settings saved in the database to the device. Settings are converted automatically, if necessary.

Load Firmware Into Another Device. Returns the wizard to *Step 1*: *Prepare Device* to repeat the firmware-loading process with another device.



Upgrade Firmware Using a Terminal Emulator

The following instructions assume you have a working knowledge of your personal computer terminal emulation software. In particular, you must be able to modify your serial communications parameters (data 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 the front-panel serial port and enter Access Level 2.

Step 3. Save the present relay settings.

You can use the PC software (described in the instruction manual PC software section) to save and restore settings easily. Otherwise, use the following steps.

NOTE: To save the calibration settings, perform **SHO C** from the terminal by logging into the CAL level using the CAL level password. The factory-default password for the CAL level is CLARKE.

a. Issue the following commands at the ASCII prompt:

SHO, **SHO L**, **SHO G**, **SHO P**, **SHO F**, **SHO R**, **SHO C**, etc.

b. Record all the settings for possible reentry after the firmware upgrade.

c. We recommend that you save all stored data in the relay, including EVENTS, before the upgrade.

Step 4. Start upgrading of firmware.

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 sends the `!>` prompt.

Step 5. Change the data rate, if necessary.

NOTE: If you have difficulty at 115200 bps, choose a slower data transfer rate (e.g., 38400 bps or 57600 bps). Be sure to match the relay and PC data rates.

a. Type **BAU 115200 <Enter>**.

This changes the data rate of the communications port to 115200.

b. Change the data rate of the PC to 115200 to match the relay.

Step 6. Begin the transfer of new firmware to the relay by issuing the **REC** command.

Step 7. Type **Y** to erase the existing firmware or press **<Enter>** to abort.

Step 8. Press any key (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 protocol and send the file that contains the new firmware (e.g., r101*xxxxxx*.s19 or r101*xxxxxx*.z19).

The file transfer takes less than 5–15 minutes at 115200 baud, depending on the product. After the transfer is complete, the relay reboots and returns to Access Level 0.

Figure B.1 shows the entire process.

```
=>>L_D <Enter>

Disable relay to receive firmware (Y,N)? Y <Enter>
Are you sure (Y,N)? Y <Enter>
Relay Disabled

BFID=BOOTLDR-R501-V0-Z000000-D20140224
!>BAU 115200 <Enter>
!>REC <Enter>
This command uploads new firmware.
When new firmware is uploaded successfully, IED will erase old firmware,
load new firmware and reboot.

Are you sure you want to erase the existing firmware(Y,N)? Y <Enter>
Press any key to begin transfer and then start transfer at the terminal.<Enter>
Erasing firmware.
Erase successful.
Writing new firmware.
Upload completed successfully. Attempting a restart.
```

Figure B.1 Firmware File Transfer Process

Step 10. The relay illuminates the **ENABLED** front-panel LED if the relay settings were retained through the download.

If the **ENABLED** LED is illuminated, proceed to *Step 11*.

If the **ENABLED** LED is not illuminated or the front panel displays STATUS FAIL, EEPROM FAILURE, or Non_Vol Failure, use the following procedure to restore the factory-default settings:

a. Set the communications software settings to 9600 baud, 8 data bits, and 1 stop bit.

b. Enter Access Level 2 by issuing the **2AC** command.

c. Issue the **R_S** command to restore the factory-default settings.

The relay then reboots with the factory-default settings.

d. Enter Access Level 2.

e. Issue the **STATUS** command.

If the relay is enabled, go to *Step f*.

If the **STATUS** report shows option card FAIL and Relay Disabled and the message:

Confirm Hardware Config
Accept & Reboot (Y/N)?

Enter **Y**. This saves the relay calibration settings.

The relay responds:

Config Accepted

The relay reboots and becomes enabled.

f. Restore relay settings back to the settings saved in *Step 3*.

Step 11. Change the data rate of the PC to match that of the relay prior to *Step 5*, and enter Access Level 2.

Step 12. Issue the **STATUS** command; verify all relay self-test results are OK.

Step 13. Apply current and voltage signals to the relay.

Step 14. Issue the **METER** command; verify that the current and voltage signals are correct.

Step 15. Autoconfigure the SEL-2032, SEL-2030, or SEL-2020 port if you have a communications processor connected.

This step reestablishes automatic data collection between the SEL-2032, SEL-2030, or SEL-2020 Communications Processor and the SEL relay. Failure to perform this step can result in automatic data collection failure when cycling communications processor power.

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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Pullman, WA 99163-5603 U.S.A.
Tel: +1.509.338.3838
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Appendix C
SEL Communications Processors

SEL Communications Protocols

The SEL-749M Relay supports SEL protocols and command sets shown in *Table C.1*.

Table C.1 Supported Serial Command Sets

Command Set	Description
SEL ASCII	Use this protocol to send ASCII commands and receive ASCII responses that are human readable with an appropriate terminal emulation program.
SEL Compressed ASCII	Use this protocol to send ASCII commands and receive Compressed ASCII responses that are comma-delimited for use with spreadsheet and database programs or for use by intelligent electronic devices.
SEL Fast Meter	Use this protocol to send binary commands and receive binary meter and target responses.
SEL Fast Operate	Use this protocol to receive binary control commands.
SEL Fast SER	Use this protocol to receive binary Sequential Events Recorder unsolicited responses.

SEL ASCII Commands

We originally designed SEL ASCII commands for communication between the relay and a human operator via a keyboard and monitor or a printing terminal. A computer with a serial port can also use the SEL ASCII protocol to communicate with the relay, collect data, and issue commands.

SEL Compressed ASCII Commands

The relay supports a subset of SEL ASCII commands identified as Compressed ASCII commands. Each of these commands results in a comma-delimited message that includes a checksum field. Most spreadsheet and database programs can directly import comma-delimited files. Devices with embedded processors connected to the relay can execute software to parse and interpret comma-delimited messages without expending the customization and maintenance labor necessary to interpret nondelimited messages. The relay calculates a checksum for each line by numerically summing all of the bytes that precede the checksum field in the message. The program that uses the data can detect transmission errors in the message by summing the characters of the received message and comparing this sum to the received checksum.

Most commands are available only in SEL ASCII or Compressed ASCII format. Selected commands have versions in both standard SEL ASCII and Compressed ASCII formats. Compressed ASCII reports generally have fewer characters than conventional SEL ASCII reports because the compressed reports reduce blanks, tabs, and other white space between data fields to a single comma.

Table C.2 lists the Compressed ASCII commands and contents of the command responses.

Table C.2 Compressed ASCII Commands

Command	Response	Access Level
BNAME	ASCII names of Fast Meter status bits	0
CASCII	Configuration data of all Compressed ASCII commands available at access levels > 0	0
CEVENT	Event report	1
CHISTORY	List of events	1
CSTATUS	Relay status	1
CSUMMARY	Summary of an event report	1
DNAME	ASCII names of digital I/O reported in Fast Meter	0
ID	Relay identification	0
SNS	ASCII names for SER data reported in Fast Meter	0

Interleaved ASCII and Binary Messages

SEL relays have two separate data streams that share the same physical serial port. Human data communications with the relay consist of ASCII character commands and reports that you view through use of a terminal or terminal emulation package. The binary data streams can interrupt the ASCII data stream to obtain information; the ASCII data stream continues after the interruption. This mechanism uses a single communications channel for ASCII communication (transmission of an event report, for example) interleaved with short bursts of binary data to support fast acquisition of metering data. The device connected to the other end of the link requires software that uses the separate data streams to exploit this feature. However, you do not need a device to interleave data streams to use the binary or ASCII commands. Note that XON, XOFF, and CAN operations operate on only the ASCII data stream.

An example of using these interleaved data streams is when the SEL-749M 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-749M and use the ASCII data stream for commands and responses.

SEL Fast Meter, Fast Operate, and Fast SER

SEL Fast Meter is a binary message that you solicit with binary commands. Fast Operate is a binary message for control. The relay can also send unsolicited Fast SER messages. If the relay is connected to an SEL communications processor, these messages provide the mechanism that the communications processor uses for SCADA or DCS functions that occur simultaneously with ASCII interaction.

SEL Communications Processor

SEL offers SEL communications processors, powerful tools for system integration and automation. The SEL-2030 series and the SEL-2020 communications processors are similar, except that the SEL-2030 series has two slots for network protocol cards. These devices provide a single point of contact for integration networks with a star topology, as shown in *Figure C.1*.

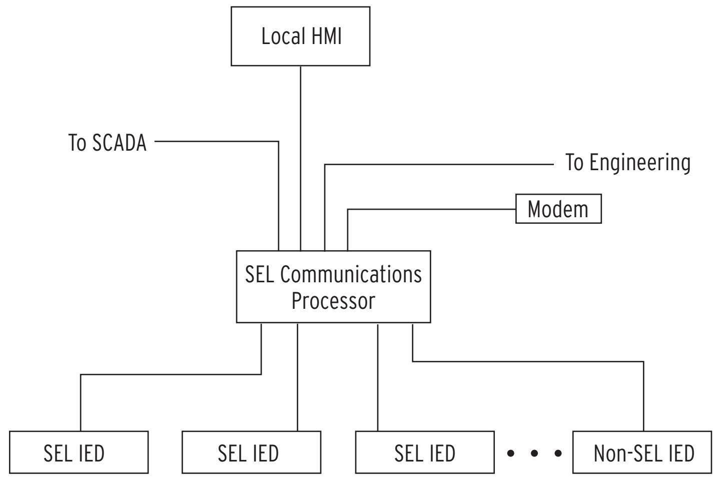

Figure C.1 SEL Communications Processor Star Integration Network

In the star topology network in *Figure C.1* the SEL communications processor offers the following substation integration functions:

- Collection of real-time data from SEL and non-SEL IEDs
- Calculation, concentration, and aggregation of real-time IED data into databases for SCADA, HMI, and other data consumers
- Access to the IEDs for engineering functions including configuration, report data retrieval, and control through local serial, remote dial-in, and Ethernet network connections
- Distribution of IRIG-B time synchronization signal to IEDs based on external IRIG-B input, internal clock, or protocol interface
- Simultaneous collection of SCADA data and engineering connection to SEL IEDs over a single cable
- Automated dial-out on alarms

The SEL communications processors have 16 serial ports plus a front port. This port configuration does not limit the size of a substation integration project, because you can create a multitiered solution as shown in *Figure C.2*. In this multitiered system, the lower-tier SEL communications processors forward data to the upper-tier SEL communications processor that serves as the central point of access to substation data and substation IEDs.

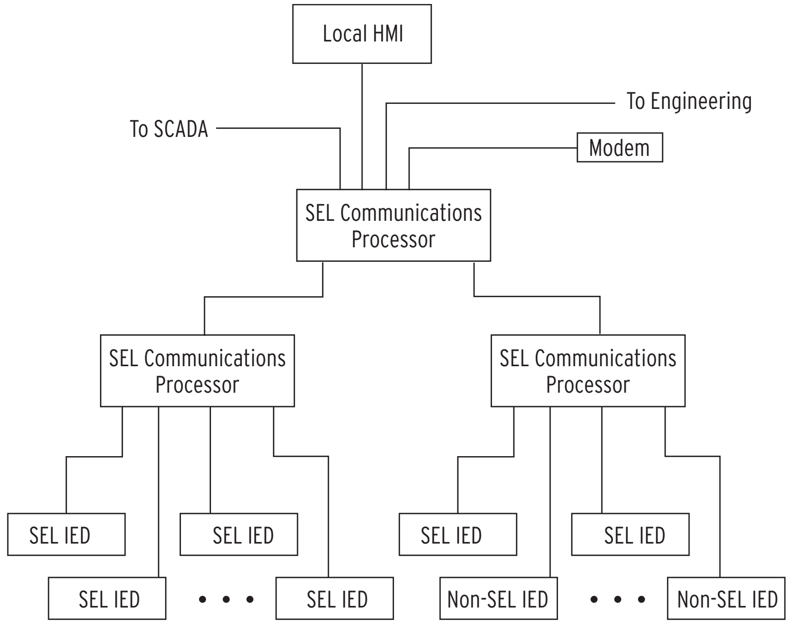

Figure C.2 Multitiered SEL Communications Processor Architecture

You can add additional communications processors to provide redundancy and eliminate possible single points of failure. SEL communications processors provide an integration solution with a reliability comparable to that of SEL relays. In terms of MTBF (mean time between failures), SEL communications processors are 100 to 1000 times more reliable than computer-based and industrial technology-based solutions.

Configuration of an SEL communications processor is different from other general-purpose integration platforms. You can configure SEL communications processors with a system of communication-specific keywords and data movement commands rather than programming in C or another general-purpose computer language. SEL communications processors offer the protocol interfaces listed in *Table C.3*.

Table C.3 SEL Communications Processors Protocol Interfaces

Protocol	Connect to
DNP3 Level 2 Slave	DNP3 masters
Modbus RTU Protocol	Modbus masters
SEL ASCII/Fast Message Slave	SEL protocol masters
SEL ASCII/Fast Message Master	SEL protocol slaves including other communications processors and SEL relays
ASCII and Binary auto messaging	SEL and non-SEL IED master and slave devices
Modbus Plus[a]	Modbus Plus peers with global data and Modbus Plus masters
FTP (File Transfer Protocol)[b]	FTP clients
Telnet[b]	Telnet servers and clients
UCA2 GOMSFE[b]	UCA2 protocol masters
UCA2 GOOSE[b]	UCA2 protocol and peers

[a] Requires SEL-2711 Modbus Plus protocol card.
[b] Requires SEL-2701 Ethernet Processor.

SEL Communications Processor and Relay Architecture

You can apply SEL communications processors and SEL relays in a limitless variety of applications that integrate, automate, and improve station operation. Most system integration architectures utilizing SEL communications processors involve either developing a star network or enhancing a multidrop network.

Developing Star Networks

The simplest architecture using both the SEL-749M and an SEL communications processors is shown in *Figure C.1*. In this architecture, the SEL communications processor collects data from the SEL-749M and other station IEDs. The SEL communications processor acts as a single point of access for local and remote data consumers (local HMI, SCADA, engineers). The communications processor also provides a single point of access for engineering operations including configuration and the collection of report-based information.

By configuring a data set optimized to each data consumer, you can significantly increase the utilization efficiency on each link. A system that uses an SEL communications processor to provide a protocol interface to an RTU will have a shorter lag time (data latency); communication overhead is much less for a single data exchange conversation to collect all substation data (from a communications processor) than for many conversations 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-749M relays and other serial IEDs. The SEL-749M data appear in models in a virtual device domain. The combination of the SEL-2701 with an SEL communications processor offers a significant cost savings because you can use existing IEDs or purchase less expensive IEDs. For full details on applying the SEL-2701 with an SEL communications processor, see the SEL-*2701 Ethernet Processor Instruction Manual*.

The engineering connection can use either an Ethernet network connection through the SEL-2701 or a serial port connection. This versatility will accommodate the channel that is available between the station and the engineering center. SEL software can use either a serial port connection or an Ethernet network connection from an engineering workstation to the relays in the field.

Enhancing Multidrop Networks

You can also use an SEL communications processor to enhance a multidrop architecture similar to the one shown in *Figure C.3*. In this example, the SEL communications processor enhances a system that uses the SEL-2701 with an Ethernet HMI multidrop network. In the example, there are two Ethernet networks, the SCADA LAN and the Engineering LAN. The SCADA LAN provides real-time data directly to the SCADA Control Center via a protocol gateway and to the HMI (Human Machine Interface).

In this example, the SEL communications processor provides the following enhancements when compared to a system that employs only the multidrop network:

- ➤ Ethernet access for IEDs with serial ports
- ➤ Backup engineering access through the dial-in modem
- ➤ IRIG-B time signal distribution to all station IEDs
- ➤ Integration of IEDs without Ethernet
- ➤ Single point of access for real-time data for SCADA, HMI, and other uses
- ➤ Significant cost savings by use of existing IEDs with serial ports

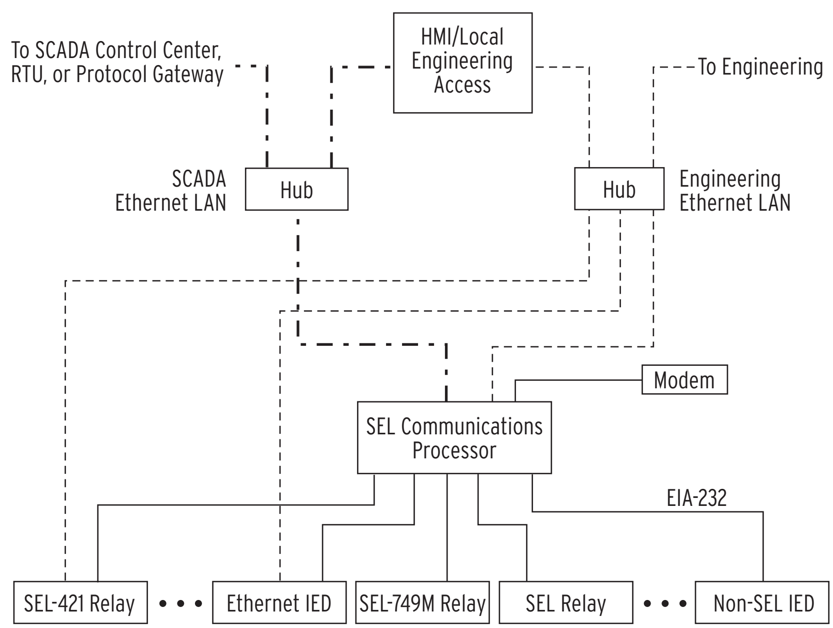

Figure C.3 Enhancing Multidrop Networks With SEL Communications Processors

SEL Communications Processor Example

This example demonstrates the data and control points available in the SEL communications processor when you connect an SEL-749M. The physical configuration used in this example is shown in *Figure C.4*.

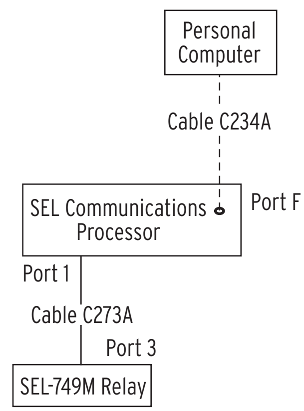

Figure C.4 Example of SEL Relay and SEL Communications Processor Configuration

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
TIMEOUT	30	Idle timeout that terminates transparent connections of 30 seconds

[a] Automatically collected by the SEL communications processor during autoconfiguration.

Data Collection

The SEL communications processor is configured to collect data from the SEL-749M, using the list in *Table C.5*.

Table C.5 SEL Communications Processor Data Collection Automessages

Message	Data Collected
20METER	Power system metering data
20TARGET	Selected Relay Word bit elements
20HISTORY	History Command (ASCII)
20STATUS	Status Command (ASCII)
20EVENTS	Standard 4 sample/cycle event report (data with settings)
20EVENT	Standard 4 sample/cycle event report (data only)

Table C.6 shows the automessage (Set A) settings for the SEL communications processor.

Table C.6 SEL Communications Processor Port 1 Automatic Messaging Settings

Setting Name	Setting	Description
AUTOBUF	Y	Save unsolicited messages
STARTUP	ACC\nOTTER\n	Automatically log-in at Access Level 1
SEND_OPER	Y	Send Fast Operate messages for remote bit and breaker bit control
REC_SER	N	Automatic sequential event recorder data collection disabled
NOCONN	NA	No SELOGIC control equation entered to selectively block connections to this port
MSG_CNT	2	Two automessages
ISSUE1	P00:00:01.0	Issue Message 1 every second
MESG1	20METER	Collect metering data
ISSUE2	P00:00:01.0	Issue Message 2 every second
MESG2	20TARGET	Collect Relay Word bit data
ARCH_EN	N	Archive memory disabled
USER	0	No USER region registers reserved

Table C.7 shows the map of regions in the SEL communications processor for data collected from the SEL-749M. 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–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 SEL Communications Processor METER Region Map

Item	Starting Address	Type
_YEAR	2000h	int
DAY_OF_YEAR	2001h	int
TIME(ms)	2002h	int[2]
MONTH	2004h	char
DATE	2005h	char
YEAR	2006h	char
HOUR	2007h	char
MIN	2008h	char
SECONDS	2009h	char
MSEC	200Ah	int
IA	200Bh	float
IB	200Dh	float
IC	200Fh	float
IAVG	2011h	float
IN	2013h	float
IR	2015h	float
IIMB	2017h	float
TCU(%)	2019h	float
FREQ	201Bh	float
VAB	201Dh	float
VBC	201Fh	float
VCA	2021h	float
*	2023h	float
VAVG	2025h	float
VIMB	2027h	float
P (MW)	2029h	float
Q (MVAR)	202Bh	float
S (MVA)	202Dh	float
PF	202Fh	float
WDG	2031h	float
BRG	2033h	float
AMB	2035h	float
OTH	2037h	float

Relay Word Bits Information

Table C.9 lists the Relay Word bit data available in the SEL communications processor TARGET region.

Table C.9 SEL Communications Processor TARGET Region Map

Address	Relay Word Bits (in Bits 7–0)							
	7	6	5	4	3	2	1	0
2804h	*	*	*	STSET	*	*	*	*
2805h	*	WARNING	*	*	*	*	*	*
2806h	See *Table G.1*, Row 0							
2807h	See *Table G.1*, Row 1							
2808h	See *Table G.1*, Row 2							
2809h	See *Table G.1*, Row 3							
280Ah	See *Table G.1*, Row 4							
280Bh	See *Table G.1*, Row 5							
280Ch	See *Table G.1*, Row 6							
280Dh	See *Table G.1*, Row 7							
280Eh	See *Table G.1*, Row 8							
280Fh	See *Table G.1*, Row 9							
2810h	See *Table G.1*, Row 10							
2811h	See *Table G.1*, Row 11							
• • •	• • •							
2827h	See *Table G.1*, Row 32							

Control Points

The SEL communications processor can automatically pass control messages, called Fast Operate messages, to the SEL-749M. You must enable Fast Operate messages by using the FASTOP setting in the SEL-749M port settings for the port connected to the SEL communications processor. You must also enable Fast Operate messages in the SEL communications processor by setting the automessage setting SEND_OPER equal to Y.

When you enable Fast Operate functions, the SEL communications processor automatically sends messages to the relay for changes in remote bits RB1–RB8 on the corresponding SEL communications processor port. In this example, if you set RB1 on Port 1 in the SEL communications processor, it automatically sets RB1 in the SEL-749M.

Breaker bit BR1 operates differently than remote bits. There are no breaker bits in the SEL-749M. For Circuit Breaker 1, when you set BR1, the SEL communications processor sends a message to the SEL-749M that asserts the motor stop bit STOP for one processing interval. If you clear BR1, the SEL communications processor sends a message to the SEL-749M that asserts the motor start bit STR for one processing interval. STOP will stop the motor and STR will start the motor. See *Figure 4.21* and *Figure 4.24* for the motor stop and start logic diagrams, respectively.

Appendix D
Modbus RTU Communications Protocol

Overview

This appendix describes Modbus RTU communications features supported by the SEL-749M Relay on communications Port F, Port 3, and Port 4.

Complete specifications for the Modbus protocol are available from the Modbus user's group website at www.modbus.org.

NOTE: Modbus protocol is available in Port F, Port 3, and Port 4, and all ports can support Modbus sessions concurrently.

Enable Modbus protocol with the serial port settings. When Modbus protocol is enabled, the relay switches the port to Modbus protocol and deactivates the ASCII protocol.

Modbus RTU is a binary protocol that permits communication between a single master device and multiple slave devices. The communication is half duplex; only one device transmits at a time. The master transmits a binary command that includes the address of the necessary slave device. All of the slave devices receive the message, but only the slave device with the matching address responds.

The SEL-749M Modbus communication allows a Modbus master device to do the following:

- ➤ Acquire metering, monitoring, and event data from the relay.
- ➤ Control SEL-749M output contacts.
- ➤ Read the SEL-749M self-test status and learn the present condition of all the relay protection elements.
- ➤ Read most of the relay settings and modify the relay settings.

Communications Protocol

Modbus Queries

Modbus RTU master devices initiate all exchanges by sending a query. The query consists of the fields shown in *Table D.1*.

Table D.1 Modbus Query Fields

Field	Number of Bytes
Slave Device Address	1 byte
Function Code	1 byte
Data Region	0–251 bytes
Cyclical Redundancy Check (CRC)	2 bytes

The SEL-749M SLAVEID setting defines the device address. Set this value to a unique number for each device on the Modbus network. For Modbus communication to operate properly, no two slave devices may have the same address.

The cyclical redundancy check detects errors in the received data. If the relay detects an error, it discards the packet.

Modbus Responses

The slave device sends a response message after it performs the action the query specifies. If the slave cannot execute the query command for any reason, it sends an error response. Otherwise, the slave device response is formatted similarly to the query and includes the slave address, function code, data (if applicable), and a cyclical redundancy check value.

Supported Modbus Function Codes

The SEL-749M supports the Modbus function codes shown in *Table D.2*.

Table D.2 SEL-749M Modbus Function Codes

Codes	Description
03h	Read Holding Registers
04h	Read Input Registers
06h	Preset Single Register
10h	Preset Multiple Registers
60h	Read Parameter Information
61h	Read Parameter Text
62h	Read Enumeration Text
7Dh	Encapsulate Modbus Packet With Control
7Eh	NOP (can only be used with the 7Dh function)

Modbus Exception Responses

The SEL-749M sends an exception code under the conditions described in *Table D.3*.

Table D.3 SEL-749M 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-749M is in the wrong state for the function a query specifies. This also stands for Service Failure for DeviceNet interface applications. The relay is unable to perform the action specified by a query (i.e., cannot write to a read-only register).

In the event that any of the errors listed in *Table D.3* occur, the relay assembles a response message that includes the exception code in the data field. The relay sets the most significant bit in the function code field to indicate to the master that the data field contains an error code, instead of the required data.

Cyclical Redundancy Check

The SEL-749M calculates a 2-byte CRC value through use of the device address, function code, and data region. It appends this value to the end of every Modbus response. When the master device receives the response, it recalculates the CRC. If the calculated CRC matches the CRC sent by the SEL-749M, 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.

03h Read Holding Register Command

Use function code 03h to read directly from the Modbus Register Map shown in *Table D.23*.

You can read a maximum of 125 registers at once with this function code. Most masters use 4X references with this function code. If you are accustomed to 4X references with this function code, for five-digit addressing, add 40001 to the standard database address.

Table D.4 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 D.5*.

Table D.5 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 D.23*.

You can read a maximum of 125 registers at once with this function code. Most masters use 4X references with this function code. If you are accustomed to 4X references with this function code, for five-digit addressing, add 40001 to the standard database address.

Table D.6 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 D.7*.

Table D.7 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

06h Preset Single Register Command

The SEL-749M uses this function to allow a Modbus master to write directly to a database register. Refer to the Modbus Register Map in *Table D.23* for a list of registers that can be written by using this function code. If you are accustomed to 4X references with this function code, for six-digit addressing, add 400001 to the standard database addresses.

In *Table D.8*, the command response is identical to the command required by the master.

Table D.8 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 D.9*.

Table D.9 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

10h Preset Multiple Registers Command

This function code works much like code 06h, except that it allows you to write multiple registers at once, as many as 100 per operation. If you are accustomed to 4X references with the function code, for six-digit addressing, simply add 400001 to the standard database addresses.

Table D.10 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 in *Table D.11*.

Table D.11 10h Preset Multiple Registers Query Error Messages

Error	Error Code Returned	Communications Counter Increments
Illegal register to set	Illegal Data Address (02h)	Invalid Address Illegal Write
Illegal number of registers to set	Illegal Data Value (03h)	Illegal Register Illegal Write
Incorrect number of bytes in query data region	Illegal Data Value (03h)	Bad Packet Format Illegal Write
Invalid register data value	Illegal Data Value (03h)	Illegal Write

60h Read Parameter Information Command

The SEL-749M uses this function to allow a Modbus master to read parameter information from the relay. One parameter (setting) is read in each query.

Table D.12 60h Read Parameter Information Command (Sheet 1 of 2)

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (60h)
2 bytes	Parameter Number
2 bytes	CRC-16

Table D.12 60h Read Parameter Information Command (Sheet 2 of 2)

Bytes	Field
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (60h)
2 bytes	Parameter Number
1 byte	Parameter Descriptor
1 byte	Parameter Conversion
2 bytes	Parameter Minimum Settable Value
2 bytes	Parameter Maximum Settable Value
2 bytes	Parameter Default Value
2 bytes	CRC-16

The Parameter Descriptor field is defined in *Table D.13*.

Table D.13 60h Read Parameter Descriptor Field Definition

Bit	Name	Description
0	RO: Read-only	1 when the setting is read-only
1	H: Hidden	1 when the setting is hidden
2	DBL: 32-bit	1 when the following setting is a fractional value of this setting
3	RA: RAM-only	1 when the setting is not saved in nonvolatile memory
4	RR: Read-only if running	1 when the setting is read-only if in running/operational state
5	P: Power Cycle or Reset	1 when the setting change requires a power cycle or reset
6	0	Reserved
7	Extend	Reserved to extend the descriptor table

The Parameter Conversion field is defined in *Table D.14*.

Table D.14 60h Read Parameter Conversion Field Definition

Conversion Value	Type	Multiplier	Divisor	Offset	Base
0	Boolean	1	1	0	1
1	Unsigned Integer	1	1	0	1
2	Unsigned Integer	1	10	0	1
3	Unsigned Integer	1	100	0	1
4	Unsigned Integer	1	1000	0	1
5	Hexidecimal	1	1	0	1
6	Integer	1	1	0	1
7	Integer	1	10	0	1
8	Integer	1	100	0	1
9	Integer	1	1000	0	1
10	Enumeration	1	1	0	1
11	Bit Enumeration	1	1	0	1

Use *Equation D.1* to calculate the actual (not scaled) value of the parameter (setting):

$$value = \frac{(ParameterValue + Offset) \bullet Multiplier \bullet Base}{Divisor} \quad \textbf{Equation D.1}$$

Use *Equation D.2* to calculate the scaled setting value:

$$value = \frac{value \bullet Divisor}{Multiplier \bullet Base} - Offset \quad \textbf{Equation D.2}$$

The relay response to errors in the query are shown in *Table D.15*.

Table D.15 Responses to 60h Read Parameter Information Query Errors

Error	Error Code Returned	Communications Counter Increments
Illegal parameter to read	Illegal Address (02h)	Invalid Address

61h Read Parameter Text Command

The SEL-749M uses this function to allow a Modbus master to read parameter text from the relay. One parameter text (setting name) is read in each query.

Table D.16 61h Read Parameter Text Command

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (61h)
2 bytes	Parameter Number
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (61h)
2 bytes	Parameter Number
16 bytes	Parameter Text (setting name)
4 bytes	Parameter Units (e.g., Amps)
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table D.17*.

Table D.17 61h Read Parameter Text Query Error Messages

Error	Error Code Returned	Communications Counter Increments
Illegal parameter to read	Illegal Address (02h)	Invalid Address

62h Read Enumeration Text Command

The SEL-749M uses this function to allow a Modbus master to read parameter enumeration or bit enumeration values (setting lists) from the relay. One parameter enumeration is read in each query.

Table D.18 62h Read Enumeration Text Command

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (62h)
2 bytes	Parameter Number
1 byte	Enumeration Index
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (62h)
2 bytes	Parameter Number
1 byte	Enumeration Index
16 bytes	Enumeration Text
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table D.19*.

Table D.19 61h Read Parameter Enumeration Text Query Error Messages

Error	Error Code Returned	Communications Counter Increments
Illegal parameter to read	Illegal Address (02h)	Invalid Address
Illegal enumeration in index	Illegal Data Value (03h)	Illegal Register

7Dh Encapsulated Packet With Control Command

The SEL-749M uses this function to allow a Modbus master to perform control operations and another Modbus function with one query. The Device Net card will transmit this command periodically to achieve high-speed I/O processing and establish a heartbeat between the DeviceNet card and the main board.

Table D.20 7Dh Encapsulated Packet With Control Command (Sheet 1 of 2)

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Control Command (same as write to 2000h)
1 byte	Embedded Modbus Function
n bytes	Optional Data to Support Modbus Function (0–250)
2 bytes	CRC-16

Table D.20 7Dh Encapsulated Packet With Control Command (Sheet 2 of 2)

Bytes	Field
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Status Information (Register 2100h or 2101h based on Bit 3 in Control Command Word)
1 byte	Embedded Modbus Function
n bytes	Optional data to support the Modbus function (0–250)
2 bytes	CRC-16

The format of the relay responses to errors in the query is shown in *Table D.21*.

Table D.21 7Dh Encapsulated Packet Query Errors

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Status Information (Register 2100h or 2101h based on Bit 3 in Control Command Word)
1 byte	Modbus Function with Error Flag
1 bytes	Function Error Code[a]
2 bytes	CRC-16

[a] If the embedded function code is invalid, then an illegal function code is returned here and the illegal function counter is incremented. This error code is returned by the embedded function for all valid embedded functions.

7Eh NOP Command

This function code has no operation. This allows a Modbus master to perform a control operation without any other Modbus command. This is only used inside of the 7Dh when no regular Modbus query is required.

Table D.22 7Eh NOP Command

Bytes	Field
An example of a 7D message response using 7E will have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Status Information
1 byte	Function Code (7Eh)
2 bytes	CRC-16

Reading Parameter Information and Value Using Modbus

Through use of Modbus commands, you can read the present value of a parameter as well as parameter name, units, low limit, high limit, scale, and even the enumeration string (if the parameter is an enumeration type). This means that you can use a general user interface to retrieve and display specific parameter details from the relay. Use the **60h**, **61h**, and **62h** commands to retrieve parameter information, and use the **03** command to retrieve values.

Modifying Relay Settings Using Modbus

The SEL-749M does not provide password protection. It is assumed that because the interface is a binary protocol with CRC-16 protection, the interface is being handled by an intelligent master system. Therefore, the master would provide password protection.

Any of the settings listed in the Modbus Register Map (*Table D.23*) can be changed. The high and low limits provided in the table might cover a wider range than what is acceptable by the particular model or configuration. The settings are not saved as and when they are received. The relay acknowledges the write operation, but it does not change the relay settings. The relay holds these settings until there are no further edits for a time specified by SETTINGS TIMEOUT register (4010h). After this timeout, the relay attempts to save the settings. If there are no errors, the settings are saved. If, however, a setting interdependency rule is violated, the settings are not saved. The relay will set the Config Fault bit in the TRIP STATUS HI register to indicate that the save settings operation has failed. The relay will also set ERROR REGISTER (4016h) flags to indicate the type of error.

Parameters such as date and time can be changed with the appropriate registers by using Modbus Function Code 06h or 10h.

The ability to change the settings via Modbus protocol can be blocked by the global setting BLKMBSET or the BLOCK MODBUS SET register.

Controlling Output Contacts Using Modbus

The SEL-749M includes registers for controlling some of the outputs. See the LOGIC COMMAND (2000h), the RESET COMMAND (2001h), and the registers in the Reset Settings region for the control features supported by the relay. Use Modbus function codes 06h or 10h to write appropriate flags. Remember that when writing to the Logic command register with output contacts, it is not a bit operation. All the bits in that register need to be written together to reflect the state you want for each of the outputs.

Reading History Data Using Modbus

Through use of the Modbus Register Map (*Table D.23*), you can download a complete history of the last five events via Modbus. The history contains the date and time stamp, type of event that triggered the report, currents, and voltages at the time of the event. Please refer to the Historical Data section in the map.

To use Modbus to download history data, write the event number (1–5) to the EVENT LOG SEL register at address 0176h. Then read the history of the specific event number you requested from the registers shown in the Historical Data section of the Modbus Register Map (*Table D.23*).

Modbus Register Map

Table D.23 Modbus Register Map[a] (Sheet 1 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range			Scale Factor	DeviceNet Parameter Number
			Low	High	Step		
0000	Reserved		0	1		1	
Global Settings							
0001 (RW)	PHASE ROTATION 0 = ABC 1 = ACB		0	1		1	101
0002 (RW)	RATED FREQ. 0 = 50 Hz 1 = 60 Hz	Hz	0	1		1	102
0003 (RW)	DATE FORMAT 0 = MDY 1 = YMD 2 = DMY		0	2		1	103
Main Settings							
0004 (RW)	PHASE CT RATIO		1	5000	1	1	104
0005 (RW)	MOTOR FLA	A	2	50000	0.1	0.1	105
0006 (RW)	TWO SPEED ENABLE 0 = N 1 = Y		0	1		1	106
0007 (RW)	CT RATIO–2nd		1	5000	1	1	107
0008 (RW)	MOTOR FLA–2nd	A	2	50000	0.1	0.1	108
0009 (RW)	NEUTRAL CT RATIO		1	2000	1	1	109
000A (RW)	PHASE PT RATIO		100	25000	0.01	0.01	110
000B (RW)	LINE VOLTAGE	V	100	30000	1	1	111
000C (RW)	XFMR CONNECTION 0 = DELTA 1 = WYE		0	1		1	112
Thermal Overload							
000D (RW)	OVERLOAD ENABLE 0 = N 1 = Y		0	1		1	113
000E (RW)	THERMAL METHOD 0 = RATING 1 = CURVE		0	1		1	114
000F (RW)	OL RESET LEVEL	%TCU	10	99	1	1	115
0010 (RW)	SERVICE FACTOR		101	150	0.01	0.01	116
0011 (RW)	MOTOR LRA	xFLA	25	120	0.1	0.1	117
0012 (RW)	LOCKD ROTOR TIME	s	10	6000	0.1	0.1	118
0013 (RW)	ACCEL FACTOR		10	150	0.01	0.01	119
0014 (RW)	RUN STATE TIME K 0 = AUTO	min	0	2000	1	1	120

Table D.23 Modbus Register Map[a] (Sheet 2 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range			Scale Factor	DeviceNet Parameter Number
			Low	High	Step		
0015 (RW)	MOTOR LRA–2nd	xFLA	25	120	0.1	0.1	121
0016 (RW)	MOTOR LRT–2nd	s	10	6000	0.1	0.1	122
0017 (RW)	ACCEL FACT–2nd		10	150	0.01	0.01	123
0018	RUN ST TC–2nd	min	0	2000	1	1	124
0019	THERM OL CURVE1		1	45	1	1	125
001A (RW)	THERM OL CURVE2		1	45	1	1	126
001B (RW)	OL WARN ENABLE 0 = N 1 = Y		0	1		1	127
001C (RW)	OL WARN LEVEL	%TCU	50	99	1	1	128
001D (RW)	START INH. LEVEL 0=Off	%TCU	0	99	1	1	129
001E (RW)	STOP COOL TIME	min	1	6000	1	1	130
001F (RW)	OL RTD BIASING? 0 = N 1 = Y		0	1		1	131
Phase Overcurrent							
0020 (RW)	PH OC TRIP ENABL 0 = N 1 = Y		0	1		1	132
0021 (RW)	PH OC TRIP LVL	xFLA	10	2000	0.01	0.01	133
0022 (RW)	PH OC TRIP DLAY	s	0	500	0.01	0.01	134
0023 (RW)	PH OC WARN ENABL 0 = N 1 = Y		0	1		1	135
0024 (RW)	PH OC WARN LVL	xFLA	10	2000	0.01	0.01	136
0025 (RW)	PH OC WARN DLAY	s	0	500	0.01	0.01	137
Neutral Overcurrent							
0026 (RW)	NEUT OC TRIP EN 0 = N 1 = Y		0	1		1	138
0027 (RW)	NEUT OC TRIP LVL	A	1	2500	0.01	0.01	139
0028 (RW)	NEU OC TRIP DLAY	s	0	500	0.01	0.01	140
0029 (RW)	NEUT OC WARN EN 0 = N 1 = Y		0	1		1	141
002A (RW)	NEUT OC WARN LVL	A	1	2500	0.01	0.01	142
002B (RW)	NEU OC WARN DLAY	s	0	1200	0.1	0.1	143
Residual Overcurrent							
002C (RW)	RES OC TRIP EN 0 = N 1 = Y		0	1		1	144
002D (RW)	RES OC TRIP LVL	xFLA	10	100	0.01	0.01	145

Table D.23 Modbus Register Map[a] (Sheet 3 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range			Scale Factor	DeviceNet Parameter Number
			Low	High	Step		
002E (RW)	RES OC TRIP DLAY	s	0	500	0.01	0.01	146
002F (RW)	RES OC WARN EN 0 = N 1 = Y		0	1		1	147
0030 (RW)	RES OC WARN LVLL	xFLA	10	100	0.01	0.01	148
0031 (RW)	RES OC WARN DLAY	s	0	1200	0.1	0.1	149
Jam Settings							
0032 (RW)	JAM TRIP ENABLE 0 = N 1 = Y		0	1		1	150
0033 (RW)	JAM TRIP LEVEL	xFLA	100	600	0.01	0.01	151
0034 (RW)	JAM TRIP DELAY	s	0	1200	0.1	0.1	152
0035 (RW)	JAM WARN ENABLE 0 = N 1 = Y		0	1		1	153
0036 (RW)	JAM WARN LEVEL	xFLA	100	600	0.01	0.01	154
0037 (RW)	JAM WARN DELAY	s	0	1200	0.1	0.1	155
Undercurrent Settings							
0038 (RW)	UC TRIP ENABLE 0 = N 1 = Y		0	1		1	156
0039 (RW)	UC TRIP LEVEL	xFLA	10	100	0.01	0.01	157
003A (RW)	UC TRIP DELAY	s	4	1200	0.1	0.1	158
003B (RW)	UC WARN ENABLE 0 = N 1 = Y		0	1		1	159
003C (RW)	UC WARN LEVEL	xFLA	10	100	0.01	0.01	160
003D (RW)	UC WARN DELAY	s	4	1200	0.1	0.1	161
003E (RW)	UC START DELAY	s	0	1500	1	1	162
Current Unbalance Settings							
003F (RW)	CI TRIP ENABLE 0 = N 1 = Y		0	1		1	163
0040 (RW)	CI TRIP LEVEL	%	5	80	1	1	164
0041 (RW)	CI TRIP DELAY	s	0	240	1	1	165
0042 (RW)	CI WARN ENABLE 0 = N 1 = Y		0	1		1	166
0043 (RW)	CI WARN LEVEL	%	5	80	1	1	167
0044 (RW)	CI WARN DELAY	s	0	240	1	1	168

Table D.23 Modbus Register Map[a] (Sheet 4 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range Low	Range High	Range Step	Scale Factor	DeviceNet Parameter Number
Protection Disable							
0045 (RW)	PROT INHIBT TIME 0 = Off	s	0	240	1	1	169
0046 (RW)	OL INHIBIT TIME 0 = Off	s	0	240	1	1	170
Start Monitoring							
0047 (RW)	START MOTOR TIME 0 =Off	s	0	240	1	1	171
Star Delta Settings							
0048 (RW)	STAR-DELTA ENABL 0 = N 1 = Y		0	1		1	172
0049 (RW)	MAX STAR TIME 0 =Off	s	0	600	1	1	173
Start Inhibit Settings							
004A (RW)	STARTS/HR 0=Off		0	15	1	1	174
004B (RW)	MIN. OFF TIME 0=Off	min	0	150	1	1	175
004C (RW)	RESTART BLK TIME	min	0	60	1	1	176
Phase Reversal Settings							
004D (RW)	PH REV. ENABLE 0 = N 1 = Y		0	1		1	177
Speed Switch Settings							
004E (RW)	SS TRIP DELAY 0=Off	s	0	240	1	1	178
004F (RW)	SS WARN DELAY 0=Off	s	0	240	1	1	179
PTC Settings							
0050 (RW)	PTC ENABLE 0 = N 1 = Y		0	1		1	180
RTD Settings							
0051 (RW)	RTD ENABLE 0 = N 1 = Y		0	1		1	181
0052 (RW)	RTD1 LOCATION 0 = OFF 1 = WDG 2 = BRG 3 = AMB 4 = OTH		0	4		1	182

Table D.23 Modbus Register Map[a] (Sheet 5 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range Low	Range High	Range Step	Scale Factor	DeviceNet Parameter Number
0053 (RW)	RTD1 TYPE 0 = PT100 1 = NI100 2 = NI120 3 = CU10		0	3		1	183
0054 (RW)	RTD1 TRIP LEVEL 0 = Off	°C	0	250	1	1	184
0055 (RW)	RTD1 WARN LEVEL 0 = Off	°C	0	250	1	1	185
0056 (RW)	RTD2 LOCATION 0 = OFF 1 = WDG 2 = BRG 3 = AMB 4 = OTH		0	4		1	186
0057 (RW)	RTD2 TYPE 0 = PT100 1 = NI100 2 = NI120 3 = CU10		0	3		1	187
0058 (RW)	RTD2 TRIP LEVEL 0 = Off	°C	0	250	1	1	188
0059 (RW)	RTD2 WARN LEVEL 0 = Off	°C	0	250	1	1	189
005A (RW)	RTD3 LOCATION 0 = OFF 1 = WDG 2 = BRG 3 = AMB 4 = OTH		0	4		1	190
005B (RW)	RTD3 TYPE 0 = PT100 1 = NI100 2 = NI120 3 = CU10		0	3		1	191
005C (RW)	RTD3 TRIP LEVEL 0 = Off	°C	0	250	1	1	192
005D (RW)	RTD3 WARN LEVEL 0 = Off	°C	0	250	1	1	193
005E (RW)	RTD4 LOCATION 0 = OFF 1 = WDG 2 = BRG 3 = AMB 4 = OTH		0	4		1	194

Table D.23 Modbus Register Map[a] (Sheet 6 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range Low	Range High	Range Step	Scale Factor	DeviceNet Parameter Number
005F (RW)	RTD4 TYPE 0 = PT100 1 = NI100 2 = NI120 3 = CU10		0	3		1	195
0060 (RW)	RTD4 TRIP LEVEL 0 = Off	°C	0	250	1	1	196
0061 (RW)	RTD4 WARN LEVEL 0 = Off	°C	0	250	1	1	197
0062 (RW)	RTD5 LOCATION 0 = OFF 1 = WDG 2 = BRG 3 = AMB 4 = OTH		0	4		1	198
0063 (RW)	RTD5 TYPE 0 = PT100 1 = NI100 2 = NI120 3 = CU10		0	3		1	199
0064 (RW)	RTD5 TRIP LEVEL 0 = Off	°C	0	250	1	1	200
0065 (RW)	RTD5 WARN LEVEL 0 = Off	°C	0	250	1	1	201
0066 (RW)	RTD6 LOCATION 0 = OFF 1 = WDG 2 = BRG 3 = AMB 4 = OTH		0	4		1	202
0067 (RW)	RTD6 TYPE 0 = PT100 1 = NI100 2 = NI120 3 = CU10		0	3		1	203
0068 (RW)	RTD6 TRIP LEVEL 0 = Off	°C	0	250	1	1	204
0069 (RW)	RTD6 WARN LEVEL 0 = Off	°C	0	250	1	1	205
006A (RW)	RTD7 LOCATION 0 = OFF 1 = WDG 2 = BRG 3 = AMB 4 = OTH		0	4		1	206

Table D.23 Modbus Register Map[a] (Sheet 7 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range			Scale Factor	DeviceNet Parameter Number
			Low	High	Step		
006B (RW)	RTD7 TYPE 0 = PT100 1 = NI100 2 = NI120 3 = CU10		0	3		1	207
006C (RW)	RTD7 TRIP LEVEL 0 = Off	°C	0	250	1	1	208
006D (RW)	RTD7 WARN LEVEL 0 = Off	°C	0	250	1	1	209
006E (RW)	RTD8 LOCATION 0 = OFF 1 = WDG 2 = BRG 3 = AMB 4 = OTH		0	4		1	210
006F (RW)	RTD8 TYPE 0 = PT100 1 = NI100 2 = NI120 3 = CU10		0	3		1	211
0070 (RW)	RTD8 TRIP LEVEL 0 = Off	°C	0	250	1	1	212
0071 (RW)	RTD8 WARN LEVEL 0 = Off	°C	0	250	1	1	213
0072 (RW)	RTD9 LOCATION 0 = OFF 1 = WDG 2 = BRG 3 = AMB 4 = OTH		0	4		1	214
0073 (RW)	RTD9 TYPE 0 = PT100 1 = NI100 2 = NI120 3 = CU10		0	3		1	215
0074 (RW)	RTD9 TRIP LEVEL 0 = Off	°C	0	250	1	1	216
0075 (RW)	RTD9 WARN LEVEL 0 = Off	°C	0	250	1	1	217
0076 (RW)	RTD10 LOCATION 0 = OFF 1 = WDG 2 = BRG 3 = AMB 4 = OTH		0	4		1	218

Table D.23 Modbus Register Map[a] (Sheet 8 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range			Scale Factor	DeviceNet Parameter Number
			Low	High	Step		
0077	RTD10 TYPE 0 = PT100 1 = NI100 2 = NI120 3 = CU10		0	3		1	219
0078 (RW)	RTD10 TRIP LEVEL 0 = Off	°C	0	250	1	1	220
0079 (RW)	RTD10 WARN LEVEL 0 = Off	°C	0	250	1	1	221
007A (RW)	RTD11 LOCATION 0 = OFF 1 = WDG 2 = BRG 3 = AMB 4 = OTH		0	4		1	222
007B (RW)	RTD11 TYPE 0 = PT100 1 = NI100 2 = NI120 3 = CU10		0	3		1	223
007C (RW)	RTD11 TRIP LEVEL 0 = Off	°C	0	250	1	1	224
007D (RW)	RTD11 WARN LEVEL 0 = Off	°C	0	250	1	1	225
007E (RW)	RTD12 LOCATION 0 = OFF 1 = WDG 2 = BRG 3 = AMB 4 = OTH		0	4		1	226
007F (RW)	RTD12 TYPE 0 = PT100 1 = NI100 2 = NI120 3 = CU10		0	3		1	227
0080 (RW)	RTD12 TRIP LEVEL 0 = Off	°C	0	250	1	1	228
0081 (RW)	RTD12 WARN LEVEL 0 = Off	°C	0	250	1	1	229
0082 (RW)	WIND TRIP VOTING 0 = N 1 = Y		0	1		1	230
0083 (RW)	BEAR TRIP VOTING 0 = N 1 = Y		0	1		1	231
0084 (RW)	TMP RTD BIASING? 0 = N 1 = Y		0	1		1	232

Table D.23 Modbus Register Map[a] (Sheet 9 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range Low	Range High	Range Step	Scale Factor	DeviceNet Parameter Number
Undervoltage Settings							
0085 (RW)	UV TRIP ENABLE 0 = N 1 = Y		0	1		1	233
0086 (RW)	UV TRIP LEVEL	xVnm	60	100	0.01	0.01	234
0087 (RW)	UV TRIP DELAY	s	0	1200	0.1	0.1	235
0088 (RW)	UV WARN ENABLE 0 = N 1 = Y		0	1		1	236
0089 (RW)	UV WARN LEVEL	xVnm	60	100	0.01	0.01	237
008A (RW)	UV WARN DELAY	s	0	1200	0.1	0.1	238
Overvoltage Settings							
008B (RW)	OV TRIP ENABLE 0 = N 1 = Y		0	1		1	239
008C (RW)	OV TRIP LEVEL	xVnm	100	120	0.01	0.01	240
008D (RW)	OV TRIP DELAY	s	0	1200	0.1	0.1	241
008E (RW)	OV WARN ENABLE 0 = N 1 = Y		0	1		1	242
008F (RW)	OV WARN LEVEL	xVnm	100	120	0.01	0.01	243
0090 (RW)	OV WARN DELAY	s	0	1200	0.1	0.1	244
VAR Settings							
0091 (RW)	NEG VAR TRIP EN 0 = N 1 = Y		0	1		1	245
0092 (RW)	NEG VAR TRIP LEV	kVAR	1	25000	1	1	246
0093 (RW)	POS VAR TRIP EN 0 = N 1 = Y		0	1		1	247
0094 (RW)	POS VAR TRIP LEV	kVAR	1	25000	1	1	248
0095 (RW)	VAR TRIP DELAY	s	0	240	1	1	249
0096 (RW)	NEG VAR WARN EN 0 = N 1 = Y		0	1		1	250
0097 (RW)	NEG VAR WARN LEV	kVAR	1	25000		1	251
0098 (RW)	POS VAR WARN EN 0 = N 1 = Y		0	1		1	252
0099 (RW)	POS VAR WARN LEV	kVAR	1	25000	1	1	253
009A (RW)	VAR WARN DELAY	s	0	240	1	1	254

Table D.23 Modbus Register Map[a] (Sheet 10 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range Low	Range High	Range Step	Scale Factor	DeviceNet Parameter Number
Underpower Settings							
009B (RW)	UP TRIP ENABLE 0 = N 1 = Y		0	1		1	255
009C (RW)	UP TRIP LEVEL	kW	1	25000	1	1	256
009D (RW)	UP TRIP DELAY	s	0	240	1	1	257
009E (RW)	UP WARN ENABLE 0 = N 1 = Y		0	1		1	258
009F (RW)	UP WARN LEVEL	kW	1	25000	1	1	259
00A0 (RW)	UP WARN DELAY	s	0	240	1	1	260
Power Factor Settings							
00A1 (RW)	PF LAG TRIP ENABL 0 = N 1 = Y		0	1		1	261
00A2 (RW)	PF LAG TRIP LEVL		5	99	0.01	0.01	262
00A3 (RW)	PF LD TRIP ENABL 0 = N 1 = Y		0	1		1	263
00A4 (RW)	PF LD TRIP LEVEL		5	99	0.01	0.01	264
00A5 (RW)	PF TRIP DELAY	s	0	240	1	1	265
00A6 (RW)	PF LAG WARN ENABL 0 = N 1 = Y		0	1		1	266
00A7 (RW)	PF LAG WARN LEVL		5	99	0.01	0.01	267
00A8 (RW)	PF LD WARN ENABL 0 = N 1 = Y		0	1		1	268
00A9 (RW)	PF LD WARN LEVEL		5	99	0.01	0.01	269
00AA (RW)	PF WARN DELAY	s	0	240	1	1	270
Frequency Settings							
00AB (RW)	FREQ1 TRIP ENABL 0 = N 1 = Y		0	1		1	271
00AC (RW)	FREQ1 TRIP LEVEL	Hz	450	650	0.1	0.1	272
00AD (RW)	FREQ1 TRIP DELAY	s	0	2400	0.1	0.1	273
00AE (RW)	FREQ1 WARN ENABL 0 = N 1 = Y		0	1		1	274
00AF (RW)	FREQ1 WARN LEVEL	Hz	450	650	0.1	0.1	275
00B0 (RW)	FREQ1 WARN DELAY	s	0	2400	0.1	0.1	276
00B1 (RW)	FREQ2 TRIP ENABL 0 = N 1 = Y		0	1		1	277

Table D.23 Modbus Register Map[a] (Sheet 11 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range Low	Range High	Range Step	Scale Factor	DeviceNet Parameter Number
00B2 (RW)	FREQ2 TRIP LEVEL	Hz	450	650	0.1	0.1	278
00B3 (RW)	FREQ2 TRIP DELAY	s	0	2400	0.1	0.1	279
00B4 (RW)	FREQ2 WARN ENABL 0 = N 1 = Y		0	1		1	280
00B5 (RW)	FREQ2 WARN LEVEL	Hz	450	650	0.1	0.1	281
00B6 (RW)	FREQ2 WARN DELAY	s	0	2400	0.1	0.1	282
Load Control Settings							
00B7 (RW)	LOAD CONTROL SEL 0 = OFF 1 = CURRENT 2 = POWER 3 = TCU		0	3		1	283
00B8 (RW)	LD CTL UPP ENABL 0 = N 1 = Y		0	1		1	284
00B9 (RW)	LD CTL CUR UPPER	xFLA	20	200	0.01	0.01	285
00BA (RW)	LD CTL PWR UPPER	kW	1	25000	1	1	286
00BB (RW)	LD CTL TCU UPPER	%TCU	1	99	1	1	287
00BC (RW)	LD CTL LOW ENABL 0 = N 1 = Y		0	1		1	288
00BD (RW)	LD CTL CUR LOWER	xFLA	20	200	0.01	0.01	289
00BE (RW)	LD CTL PWR LOWER	kW	1	25000	1	1	290
00BF (RW)	LD CTL TCU LOWER	%TCU	1	99	1	1	291
Analog Output							
00C0 (RW)	ANALOG OUT SEL 0 = LOAD_I 1 = %THERM 2 = WDG_RTD 3 = BRG_RTD 4 = PF 5 = PWR_kW 6 = AVG_I 7 = MAX_I		0	7		1	292

Table D.23 Modbus Register Map[a] (Sheet 12 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range Low	Range High	Range Step	Scale Factor	DeviceNet Parameter Number
Trip Inhibit							
00C1 (RW)	TRIP INHIBIT Bit 0 = CURR IMBALANC Bit 1= JAM Bit 2 = GROUND FAULT Bit 3 = SHORT CIRCUIT Bit 4 = UNDERCURRENT Bit 5 = START INHIBIT Bit 6 = PTC Bit 7 = RTD 0 = N 1 = Y		0	255		1	293
Trip/Close Logic							
00C2 (RW)	MIN TRIP TIME	s	0	4000	0.1	0.1	294
SELogic Enables							
00C3 (RW)	SELogic LATCHES		0	8		1	295
00C4 (RW)	SV/TIMERS		0	8		1	296
Output Contacts							
00C5 (RW)	OUT101 FAIL-SAFE 0 = N 1 = Y		0	1		1	297
00C6 (RW)	OUT102 FAIL-SAFE 0 = N 1 = Y		0	1		1	298
00C7 (RW)	OUT103 FAIL-SAFE 0 = N 1 = Y		0	1		1	299
00C8 (RW)	OUT401 FAIL-SAFE 0 = N 1 = Y		0	1		1	300
00C9 (RW)	OUT402 FAIL-SAFE 0 = N 1 = Y		0	1		1	301
00CA (RW)	OUT403 FAIL-SAFE 0 = N 1 = Y		0	1		1	302
00CB (RW)	OUT404 FAIL-SAFE 0 = N 1 = Y		0	1		1	303
Event Report Settings							
00CC (RW)	EVENT LENGTH 0 = 15 1 = 64	cyc	0	1		1	304
00CD (RW)	PREFAULT LENGTH	cyc	1	59	1	1	305
00CE (RW)	MSR RESOLUTION	cyc	1	4		1	306

Table D.23 Modbus Register Map[a] (Sheet 13 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range Low	Range High	Range Step	Scale Factor	DeviceNet Parameter Number
Front-Panel Settings							
00CF (RW)	LCD TIMEOUT 0 = Off	min	0	30	1	1	307
00D0 (RW)	LCD CONTRAST		1	8	1	1	308
00D1 (RW)	DISPLAY ENABLE Bit 0 = TIME & DATE Bit 1 = GROUND CURRENT Bit 2 = CURRENT IMBALANC Bit 3 = FREQUENCY Bit 4 = THERM CAP USED Bit 5 = VOLTAGE IMBALANC Bit 6 = POWER Bit 7 = RTD TEMPERATURE 0 = N 1 = Y		0	255		1	309
Reset Settings							
00D2 (RW)	RESET TRIP 0 = Ready 1 = Reset		0	1		1	310
00D3 (RW)	SET TO DEFAULTS 0 = Ready 1 = Reset		0	1		1	311
00D4 (RW)	RESET STAT DATA 0 = Ready 1 = Reset		0	1		1	312
00D5 (RW)	RESET HIS DATA 0 = Ready 1 = Reset		0	1		1	313
00D6 (RW)	RESET COMM CNTR 0 = Ready 1 = Reset		0	1		1	314
00D7 (RW)	RESET MOT DATA 0 = Ready 1 = Reset		0	1		1	315
00D8–00DC (R)	Reserved		0	1		1	316–320
Date/Time Settings							
00DD (RW)	SET SEC		0	5999	0.01	0.01	321
00DE (RW)	SET MIN		0	59		1	322
00DF (RW)	SET HOUR		0	23		1	323
00E0 (RW)	SET DAY		1	31		1	324
00E1 (RW)	SET MONTH		1	12		1	325
00E2 (RW)	SET YEAR		2000	9999		1	326

Table D.23 Modbus Register Map[a] (Sheet 14 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range			Scale Factor	DeviceNet Parameter Number
			Low	High	Step		
Current Data							
00E3 (R)	IA CURRENT	A	0	65535		1	327
00E4 (R)	IA ANGLE	deg	–1800	1800		0.1	328
00E5 (R)	IB CURRENT	A	0	65535		1	329
00E6 (R)	IB ANGLE	deg	–1800	1800		0.1	330
00E7 (R)	IC CURRENT	A	0	65535		1	331
00E8 (R)	IC ANGLE	deg	–1800	1800		0.1	332
00E9 (R)	IN CURRENT	A	0	65535		1	333
00EA (R)	IN ANGLE	deg	–1800	1800		0.1	334
00EB (R)	IG CURRENT	A	0	65535		1	335
00EC (R)	IG ANGLE	deg	–1800	1800		0.1	336
00ED (R)	AVERAGE CURRENT	A	0	65535		1	337
00EE (R)	MOTOR LOAD	xFLA	0	120		0.1	338
00EF (R)	NEG-SEQ CURR 3I2	A	0	65535		1	339
00F0 (R)	CURRENT IMBAL	%	0	1000		0.1	340
Voltage Data							
00F1 (R)	VAB	V	0	65535		1	341
00F2 (R)	VAB ANGLE	deg	–1800	1800		0.1	342
00F3 (R)	VBC	V	0	65535		1	343
00F4 (R)	VBC ANGLE	deg	–1800	1800		0.1	344
00F5 (R)	VCA	V	0	65535		1	345
00F6 (R)	VCA ANGLE	deg	–1800	1800		0.1	346
00F7 (R)	AVERAGE LINE	V	0	65535		1	347
00F8 (R)	VAN	V	0	65535		1	348
00F9 (R)	VAN ANGLE	deg	–1800	1800		0.1	349
00FA (R)	VBN	V	0	65535		1	350
00FB (R)	VBN ANGLE	deg	–1800	1800		0.1	351
00FC (R)	VCN	V	0	65535		1	352
00FD (R)	VCN ANGLE	deg	–1800	1800		0.1	353
00FE (R)	VG	V	0	65535		1	354
00FF (R)	VG ANGLE	deg	–1800	1800		0.1	355
0100 (R)	AVERAGE PHASE	V	0	65535		1	356
0101 (R)	VOLTAGE IMBAL	%	0	1000		0.1	357
0102 (R)	NEG-SEQ VOLT 3V2	V	0	65535		1	358

Table D.23 Modbus Register Map[a] (Sheet 15 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range Low	Range High	Range Step	Scale Factor	DeviceNet Parameter Number
Power Data							
0103 (R)	REAL POWER	kW	–32768	32767		1	359
0104 (R)	REACTIVE POWER	kVAR	–32768	32767		1	360
0105 (R)	APPARENT POWER	kVA	–32768	32767		1	361
0106 (R)	POWER FACTOR		–100	100		0.01	362
0107 (R)	FREQUENCY	Hz	0	660		0.1	363
RTD Data							
0108 (R)	MAX WINDING RTD 7FFFh = Open 8000h = Short 7FFCh = Comm Fail 7FF8h = Stat Fail 7FFEh = Fail 7FF0h = NA	°C	–32768	32767		1	364
0109 (R)	MAX BEARING RTD	°C	–32768	32767		1	365
010A (R)	MAX AMBIENT RTD	°C	–32768	32767		1	366
010B (R)	MAX OTHER RTD	°C	–32768	32767		1	367
010C (R)	RTD 1	°C	–32768	32767		1	368
010D (R)	RTD 2	°C	–32768	32767		1	369
010E (R)	RTD 3	°C	–32768	32767		1	370
010F (R)	RTD 4	°C	–32768	32767		1	371
0110 (R)	RTD 5	°C	–32768	32767		1	372
0111 (R)	RTD 6	°C	–32768	32767		1	373
0112 (R)	RTD 7	°C	–32768	32767		1	374
0113 (R)	RTD 8	°C	–32768	32767		1	375
0114 (R)	RTD 9	°C	–32768	32767		1	376
0115 (R)	RTD 10	°C	–32768	32767		1	377
0116 (R)	RTD 11	°C	–32768	32767		1	378
0117 (R)	RTD 12	°C	–32768	32767		1	379
0118 (R)	RTD % TCU	%	0	100		1	380
Overload Status							
0119 (R)	THERM CAP USED	%	0	9990		0.1	381
011A (R)	TIME TO TRIP	s	0	9999		1	382
011B (R)	TIME TO RESET	s	0	9999		1	383
011C (R)	STARTS AVAILABLE		0	255		1	384
011D (R)	Reserved		0	0		1	385
Motor Statistics							
011E (R)	ELAPSED TIME–dd		0	59		1	386
011F (R)	ELAPSED TIME–hh		0	23		1	387
0120 (R)	ELAPSED TIME–mm		0	65535		1	388
0121 (R)	RUNNING TIME–dd		0	59		1	389

Table D.23 Modbus Register Map[a] (Sheet 16 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range Low	Range High	Range Step	Scale Factor	DeviceNet Parameter Number
0122 (R)	RUNNING TIME–hh		0	23		1	390
0123 (R)	RUNNING TIME–mm		0	65535		1	391
0124 (R)	STOPPED TIME–dd		0	59		1	392
0125 (R)	STOPPED TIME–hh		0	23		1	393
0126 (R)	STOPPED TIME–mm		0	65535		1	394
0127 (R)	% TIME RUNNING	%	0	1000		0.1	395
0128 (R)	STARTS COUNT		0	65535		1	396
0129 (R)	EMER START COUNT		0	65535		1	397
012A (R)	LAST RST TIME–ss		0	5999		0.01	398
012B (R)	LAST RST TIME–mm		0	59		1	399
012C (R)	LAST RST TIME–hh		0	23		1	400
012D (R)	LAST RST DATE–dd		1	31		1	401
012E (R)	LAST RST DATE–mm		1	12		1	402
012F (R)	LAST RST DATE–yr		2000	9999		1	403
Average Statistics							
0130 (R)	START TIME (S)	sec	0	9999		0.1	404
0131 (R)	MAX START I (A)	A	0	65535		1	405
0132 (R)	MIN START V (V)	V	0	65535		1	406
0133 (R)	START %TCU	%	0	9990		0.1	407
0134 (R)	RUNNING %TCU	%	0	9990		0.1	408
0135 (R)	RTD %TCU	%	0	100		1	409
0136 (R)	RUNNING CUR (A)	A	0	65535		0.1	410
0137 (R)	RUNNING KW	kW	0	65535		0.1	411
0138 (R)	RUNNING KVARIN	kVAR	0	65535		0.1	412
0139 (R)	RUNNING KVAROUT	kVAR	0	65535		0.1	413
013A (R)	RUNNING KVA	kVA	0	65535		0.1	414
013B (R)	MAX WDG TRD (C)	°C	–32768	32767		1	415
013C (R)	MAX BRG TRD (C)	°C	–32768	32767		1	416
013D (R)	AMBIENT RTD (C)	°C	–32768	32767		1	417
013E (R)	MAX OTH RTD (C)	°C	–32768	32767		1	418
Peak Statistics							
013F (R)	START TIME (S)	sec	0	9999		0.1	419
0140 (R)	MAX START I (A)	A	0	65535		1	420
0141 (R)	MIN START V (V)	V	0	65535		1	421
0142 (R)	START %TCU	%	0	9990		0.1	422
0143 (R)	RUNNING %TCU	%	0	9990		0.1	423
0144 (R)	RTD %TCU	%	0	100		1	424
0145 (R)	RUNNING CUR (A)	A	0	65535		0.1	425
0146 (R)	RUNNING KW	kW	0	65535		0.1	426
0147 (R)	RUNNING KVARIN	kVAR	0	65535		0.1	427
0148 (R)	RUNNING KVAROUT	kVAR	0	65535		0.1	428

Table D.23 Modbus Register Map[a] (Sheet 17 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range Low	Range High	Range Step	Scale Factor	DeviceNet Parameter Number
0149 (R)	RUNNING KVA	kVA	0	65535		0.1	429
014A (R)	MAX WDG TRD (C)	°C	–32768	32767		1	430
014B (R)	MAX BRG TRD (C)	°C	–32768	32767		1	431
014C (R)	AMBIENT RTD (C)	°C	–32768	32767		1	432
014D (R)	MAX OTH RTD (C)	°C	–32768	32767		1	433
Alarm Counters							
014E (R)	OVERLOAD		0	65535		1	434
014F (R)	LOCKED ROTOR		0	65535		1	435
0150 (R)	UNDERCURRENT		0	65535		1	436
0151 (R)	JAM		0	65535		1	437
0152 (R)	CURRENT IMBAL		0	65535		1	438
0153 (R)	OVERCURRENT		0	65535		1	439
0154 (R)	GROUND FAULT		0	65535		1	440
0155 (R)	SPEED SWITCH		0	65535		1	441
0156 (R)	UNDERVOLTAGE		0	65535		1	442
0157 (R)	OVERVOLTAGE		0	65535		1	443
0158 (R)	UNDERPOWER		0	65535		1	444
0159 (R)	POWER FACTOR		0	65535		1	445
015A (R)	REACTIVE POWER		0	65535		1	446
015B (R)	UNDERFREQUENCY		0	65535		1	447
015C (R)	OVERFREQUENCY		0	65535		1	448
015D (R)	RTD		0	65535		1	449
015E (R)	TOTAL ALARMS		0	65535		1	450
Trip Counters							
015F (R)	OVERLOAD		0	65535		1	451
0160 (R)	LOCKED ROTOR		0	65535		1	452
0161 (R)	UNDERCURRENT		0	65535		1	453
0162 (R)	JAM		0	65535		1	454
0163 (R)	CURRENT IMBAL		0	65535		1	455
0164 (R)	OVERCURRENT		0	65535		1	456
0165 (R)	GROUND FAULT		0	65535		1	457
0166 (R)	SPEED SWITCH		0	65535		1	458
0167 (R)	UNDERVOLTAGE		0	65535		1	459
0168 (R)	OVERVOLTAGE		0	65535		1	460
0169 (R)	UNDERPOWER		0	65535		1	461
016A (R)	POWER FACTOR		0	65535		1	462
016B (R)	REACTIVE POWER		0	65535		1	463
016C (R)	PHASE REVERSAL		0	65535		1	464
016D (R)	UNDERFREQUENCY		0	65535		1	465
016E (R)	OVERFREQUENCY		0	65535		1	466
016F (R)	RTD		0	65535		1	467
0170 (R)	PTC		0	65535		1	468
0171 (R)	STARTTIMER		0	65535		1	469

Table D.23 Modbus Register Map[a] (Sheet 18 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range Low	Range High	Range Step	Scale Factor	DeviceNet Parameter Number
0172 (R)	REMOTE TRIP		0	65535		1	470
0173 (R)	OTHER TRIPS		0	65535		1	471
0174 (R)	TOTAL TRIPS		0	65535		1	472
Historical Data							
0175 (R)	NO. EVENT LOGS		0	5		1	473
0176 (R)	EVENT LOG SEL.		1	5		1	474
0177 (R)	EVENT TIME ss		0	5999		0.01	475
0178 (R)	EVENT TIME mm		0	59		1	476
0179 (R)	EVENT TIME hh		0	23		1	477
017A (R)	EVENT DAY dd		0	31		1	478
017B (R)	EVENT DAY mm		0	12		1	479
017C (R)	EVENT DAY yy		0	9999		1	480
017D (R)	EVENT TYPE 0 = NO TRIP 1 = OVERLOAD TRIP 2= LOCKD ROTOR TRIP 3 = UNDERCURR TRIP 4 = JAM TRIP 5 = CURR IMBAL TRIP 6 = OVERCURRENT TRIP 7 = GROUND FLT TRIP 8 = SPEED SW TRIP 9 = UNDERVOLT TRIP 10 = OVERVOLT TRIP 11 = UNDERPOWER TRIP 12 = PWR FACTOR TRIP 13 = REACT PWR TRIP 14 = PHASE REV TRIP 15 = UNDERFREQ TRIP 16 = OVERFREQ TRIP 17 = RTD TRIP 18 = PTC TRIP 19 = START TIME TRIP 20 = RESERVED 21 = RTD FAIL TRIP 22 = PTC FAIL TRIP 23 = RESERVED 24 = TRIGGER 25 = COMMIDLELOSS TRIP 26 = REMOTE TRIP 27 = RESERVED 28 = RESERVED 29 = STOP COMMAND 30 = ER TRIGGER 31 = TRIP		0	31		1	481
017E (R)	EVENT IA	A	0	65535		1	482
017F (R)	EVENT IB	A	0	65535		1	483
0180 (R)	EVENT IC	A	0	65535		1	484

Table D.23 Modbus Register Map[a] (Sheet 19 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range			Scale Factor	DeviceNet Parameter Number
			Low	High	Step		
0181 (R)	EVENT IN	A	0	65535		1	485
0182 (R)	EVENT IG	A	0	65535		1	486
0183 (R)	EVENT VAB/VAN	V	0	65535		1	487
0184 (R)	EVENT VBC/VBN	V	0	65535		1	488
0185 (R)	EVENT VCA/VCN	V	0	65535		1	489
0186 (R)	EVENT VG	V	0	65535		1	490
0187 (R)	EVENT DELTA/WYE 0 = DELTA 1 = WYE		0	1		1	491
0188 (R)	EVENT FREQ	Hz	4400	6600		0.1	492
0189–018E (R)	Reserved		0	0		1	493–498
Trip/Warn Data							
018F (R)	TRIP STATUS LO Bit 0 = Overload Bit 1 = Undercurrent Bit 2 = Jam Bit 3 = Curr. Imbalance Bit 4 = Overcurrent Bit 5 = RTD–Wind Bear Bit 6 = PTC Bit 7 = Ground Curr Bit 8 = VAR Bit 9 = Underpower Bit 10 = Undervoltage Bit 11 = Overvoltage Bit 12 = Phase Reversal Bit 13 = Power Factor Bit 14 = Speed Switch Bit 15 = Neutral Curr		0	65535		1	499
0190 (R)	TRIP STATUS HI Bit 0 = Start Time Bit 1 = Frequency 1 Bit 2 = Frequency 2 Bit 3 = RTD–Other Bit 4 = RTD–Ambient Bit 5 = PTC Error Bit 6 = RTD Error Bit 7 = Reserved Bit 8 = Comm Idle Bit 9 = Comm Loss Bit 10 = Remote Trip Bit 11 = Comm Fault Bit 12 = Config Fault Bit 13 = Reserved Bit 14 = Reserved Bit 15 = Reserved		0	65535		1	500

Table D.23 Modbus Register Map[a] (Sheet 20 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range Low	Range High	Range Step	Scale Factor	DeviceNet Parameter Number
0191 (R)	WARN STATUS LO Bit 0 = Overload Bit 1 = Undercurrent Bit 2 = Jam Bit 3 = Curr. Imbalance Bit 4 = RTD–Wind Bear Bit 5 = Power Factor Bit 6 = Neutral Curr Bit 7 = Ground Curr Bit 8 = VAR Bit 9 = Underpower Bit 10 = Undervoltage Bit 11 = Overvoltage Bit 12 = Speed Switch Bit 13 = Frequency 1 Bit 14 = Frequency 2 Bit 15 = RTD–Other		0	65535		1	501
0192 (R)	WARN STATUS HI Bit 0 = RTD–Ambient Bit 1 = SALARM Bit 2 = Warning Bit 3–6 = Reserved Bit 7 = Overcurrent Bit 8–15 = Reserved		0	65535		1	502
Communications Counters							
0193 (R)	NUM MSG RCVD		0	65535		1	503
0194 (R)	NUM OTHER MSG		0	65535		1	504
0195 (R)	INVALID ADDR		0	65535		1	505
0196 (R)	BAD CRC		0	65535		1	506
0197 (R)	UART ERROR		0	65535		1	507
0198 (R)	ILLEGAL FUNCTION		0	65535		1	508
0199 (R)	ILLEGAL REGISTER		0	65535		1	509
019A (R)	ILLEGAL WRITE		0	65535		1	510
019B (R)	BAD PKT FORMAT		0	65535		1	511
019C (R)	BAD PKT LENGTH		0	65535		1	512
019D–01C1 (R)	Reserved		0	0		1	513–549
Extra Settings—Access Control							
01C2 (RW)	BLOCK MODBUS SET 0 = NONE 1 = R_S 2 = ALL		0	2		0	550

Table D.23 Modbus Register Map[a] (Sheet 21 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range			Scale Factor	DeviceNet Parameter Number
			Low	High	Step		
Control I/O Commands							
2000 (W)	LOGIC COMMAND Bit 0 = Motor Start Bit 1 = Motor Stop Bit 2 = Emergency Restart Bit 3 = Return Status 0/1 Bit 4 = DN Aux 1 Cmd Bit 5 = DN Aux 2 Cmd Bit 6 = DN Aux 3 Cmd Bit 7 = DN Aux 4 Cmd Bit 8 = DN Aux 5 Cmd Bit 9 = DN Aux 6 Cmd Bit 10 = DN Aux 7 Cmd Bit 11 = DN Aux 8 Cmd Bit 12 = DN Aux 9 Cmd Bit 13 = DN Aux 10 Cmd Bit 14 = DN Aux 11 Cmd Bit 15 = DN Aux 12 Cmd		0	65535			
2001 (W)	RESET COMMAND Bit 0 = Trip Reset Bit 1 = Set to Defaults Bit 2 = Reset Stat Data Bit 3 = Reset Hist Data Bit 4 = Reset Comm Cntr Bit 5 = Reset MOT Data Bit 6 = Reserved Bit 7 = Reserved		0	255			
Relay Elements							
2100 (R)	FAST STATUS 0 Bit 0 = Faulted (OUT 103) Bit 1 = Warning Bit 2 = IN101 Status Bit 3 = IN102 Status Bit 4 = IN401 Status Bit 5 = IN402 Status Bit 6 = IN403 Status Bit 7 = Starting Bit 8 = OUT101 Status Bit 9 = OUT102 Status Bit 10 = OUT401 Status Bit 11 = OUT402 Status Bit 12 = OUT403 Status Bit 13 = OUT404 Status Bit 14 = Running Bit 15 = Stopped		0	65535			

Table D.23 Modbus Register Map[a] (Sheet 22 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range Low	Range High	Range Step	Scale Factor	DeviceNet Parameter Number
2101 (R)	FAST STATUS 1 Bit 0 = Enabled Bit 1 = Reserved Bit 2 = Reserved Bit 3 = Reserved Bit 4 = Reserved Bit 5 = Reserved Bit 6 = Reserved Bit 7 = Reserved Bit 8 = IN301 Status Bit 9 = IN302 Status Bit 10 = IN303 Status Bit 11 = IN304 Status Bit 12 = IN305 Status Bit 13 = IN306 Status Bit 14 = IN307 Status Bit 15 = IN308 Status		0	65535			
2102 (R)	TRIP STATUS LO		0	65535		1	
2103 (R)	TRIP STATUS HI		0	65535		1	
2104 (R)	WARN STATUS LO		0	65535		1	
2105 (R)	WARN STATUS HI		0	65535		1	
2106 (R)	AVERAGE CURRENT	A	0	65535		1	
2107 (R)	IA CURRENT	A	0	65535		1	
2108 (R)	IB CURRENT	A	0	65535		1	
2109 (R)	IC CURRENT	A	0	65535		1	
210A (R)	THERM CAP USED	%	0	9990		0.1	
210B (R)	CURRENT IMBAL	%	0	1000		0.1	
210C (R)	MAX WINDING RTD	°C	–32768	32767		1	
210D (R)	IN CURRENT	A	0	65535		1	
210E (R)	IG CURRENT	A	0	65535		1	
210F (R)	LATCHED TAR ROW 0		0	255		1	
2110 (R)	ROW 1		0	255		1	
2111 (R)	ROW 2		0	255		1	
2112 (R)	ROW 3		0	255		1	
2113 (R)	ROW 4		0	255		1	
2114 (R)	ROW 5		0	255		1	
2115 (R)	ROW 6		0	255		1	
2116 (R)	ROW 7		0	255		1	
2117 (R)	ROW 8		0	255		1	
2118 (R)	ROW 9		0	255		1	
2119 (R)	ROW 10		0	255		1	
211A (R)	ROW 11		0	255		1	
211B (R)	ROW 12		0	255		1	

Table D.23 Modbus Register Map[a] (Sheet 23 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range Low	Range High	Range Step	Scale Factor	DeviceNet Parameter Number
211C (R)	ROW 13		0	255		1	
211D (R)	ROW 14		0	255		1	
211E (R)	ROW 15		0	255		1	
211F (R)	ROW 16		0	255		1	
2120 (R)	ROW 17		0	255		1	
2121 (R)	ROW 18		0	255		1	
2122 (R)	ROW 19		0	255		1	
2123 (R)	ROW 20		0	255		1	
2124 (R)	ROW 21		0	255		1	
2125 (R)	ROW 22		0	255		1	
2126 (R)	ROW 23		0	255		1	
2127 (R)	ROW 24		0	255		1	
2128 (R)	ROW 25		0	255		1	
2129 (R)	ROW 26		0	255		1	
212A (R)	ROW 27		0	255		1	
212B (R)	ROW 28		0	255		1	
212C (R)	ROW 29		0	255		1	
212D (R)	ROW 30		0	255		1	
212E (R)	ROW 31		0	255		1	
212F (R)	ROW 32		0	255		1	
2130 (R)	Reserved		0	0			
PAR Group Indices							
3000 (R)	Reserved		0	0			
3001 (R)	GLOBAL SETTINGS		1	3		1	
3002 (R)	MAIN SETTINGS		4	12		1	
3003 (R)	THERMAL OVERLOAD		13	31		1	
3004 (R)	PHASE OVERCURR		32	37		1	
3005 (R)	NEUTRAL OVERCURR		38	43		1	
3006 (R)	RESIDUAL OVERCUR		44	49		1	
3007 (R)	JAM SETTINGS		50	55		1	
3008 (R)	UNDERCURRENT SET		56	62		1	
3009 (R)	CURRENT IMB SET		63	68		1	
300A (R)	PROT. DISABLE		69	70		1	
300B (R)	START MONITORING		71	71		1	
300C (R)	STAR DELTA SET		72	73		1	
300D (R)	START INHIBIT SET		74	76		1	
300E (R)	PHASE REV SET		77	77		1	
300F (R)	SPEED SW SET		78	79		1	
3010 (R)	PTC SETTINGS		80	80		1	

Table D.23 Modbus Register Map[a] (Sheet 24 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range Low	Range High	Range Step	Scale Factor	DeviceNet Parameter Number
3011 (R)	RTD SETTINGS		81	132		1	
3012 (R)	UNDERVOLTAGE SET		133	138		1	
3013 (R)	OVERVOLTAGE SET		139	144		1	
3014 (R)	VAR SETTINGS		145	154		1	
3015 (R)	UNDERPOWER SET		155	160		1	
3016 (R)	POWER FACTOR SET		161	170		1	
3017 (R)	FREQ SETTINGS		171	182		1	
3018 (R)	LOAD CONTROL SET		183	191		1	
3019 (R)	ANALOG OUTPUT		192	192		1	
301A (R)	TRIP INHIBIT		193	193		1	
301B (R)	TRIP/CLOSE LOGIC		194	194		1	
301C (R)	SELOGIC ENABLES		195	196		1	
301D (R)	OUTPUT CONTACTS		197	203		1	
301E (R)	EVENT REPORT SET		204	206		1	
301F (R)	FRONT PANEL SET		207	209		1	
3020 (R)	RESET SETTINGS		210	220		1	
3021 (R)	DATE/TIME SET		221	226		1	
3022 (R)	CURRENT DATA		227	240		1	
3023 (R)	VOLTAGE DATA		241	258		1	
3024 (R)	POWER DATA		259	263		1	
3025 (R)	RTD DATA		264	280		1	
3026 (R)	OVERLOAD STATUS		281	285		1	
3027 (R)	MOTOR STATISTICS		286	303		1	
3028 (R)	AVG STATISTICS		304	318		1	
3029 (R)	PEAK STATISTICS		319	333		1	
302A (R)	ALARM COUNTERS		334	350		1	
302B (R)	TRIP COUNTERS		351	372		1	
302C (R)	HISTORICAL DATA		373	398		1	
302D (R)	TRIP/WARN DATA		399	402		1	
302E (R)	COMMN COUNTERS		403	449		1	
302F (R)	EXTRA SETTINGS		450	450		1	
Product Information							
4000 (R)	VENDOR CODE 865 = SEL		0	65535			
4001	not used						
4002 (RW)	ASA NUMBER LOW		0	65535			
4003 (RW)	ASA NUMBER HIGH		0	65535			
4004 (R)	FIRMWARE REVISION		1	32639			
4005 (R)	NUM OF PAR		1	500			
4006 (R)	NUM OF PAR GROUP		1	50			

Table D.23 Modbus Register Map[a] (Sheet 25 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range			Scale Factor	DeviceNet Parameter Number
			Low	High	Step		
4007 (RW)	MAC ID		1	99			
4008 (RW)	DN BAUD RATE 0 = 125 kbps 1 = 250 kbps 2 = 500 kbps 3 = AUTO		0	3			
4009 (RW)	DN STATUS Bit 0 = Explicit Cnxn Bit 1 = I/O Cnxn Bit 2 = Explicit Fault Bit 3 = I/O Fault Bit 4 = I/O Idle Bit 5–15 = Reserved		0	31			
400A	not used						
400B (R)	CONFIG PAR CKSUM		0	65535			
400C (R)	LANGUAGE CODE 0 = English 1 = French 2 = Spanish (Mexican) 3 = Italian 4 = German 5 = Japanese 6 = Portuguese 7 = Mandarin Chinese 8 = Russian 9 = Dutch						
400D (R)	FIRMWARE BUILD NUM		16400	16400			
400E	not used						
400F (R)	Product Support Bits Bit 0 = 2nd IO Card installed Bits 1–15 = Reserved		0	1			
4010 (RW)	SETTINGS TIMEOUT	ms	500	65535			
4011–4013	Reserved						
4014 (R)	CONFIGURED BIT Bit 0 = Unit Configured Bits 1–15 = Reserved		0	1			
4015 (R)	Reserved		0	0			

Table D.23 Modbus Register Map[a] (Sheet 26 of 26)

Address[b] (Hex)	Name/Enums[c]	Units	Range			Scale Factor	DeviceNet Parameter Number
			Low	High	Step		
4016 (R)	ERROR REGISTER Bit 0 = Settings Read Error Bit 1 = Settings Write Error Bit 2 = Settings Update Error Bit 3 = Settings Resource Error Bit 4 = Settings Locked Bit 5 = Group Settings Error Bit 6 = Global Settings Error Bit 7 = Logic Settings Error Bit 8 = Report Settings Error Bit 9 = Front Panel Settings Error Bit 10 = Memory Not Available Bit 11 = Settings Prep Error Bit 12 = Settings Changes Disabled Bit 13 = Memory Diag Error Bit 14–15 = Reserved		0	65535			
4017–401F (R)	Reserved		0	0			

[a] All addresses in this table refer to the register addresses in the Modbus packet.
[b] Registers labeled (RW) are read-write registers. Registers labeled (W) are write-only registers. Registers labeled (R) are read-only registers.
[c] Reserved addresses return 0.

Appendix E
DeviceNet

Overview

This appendix describes DeviceNet communications features supported by the SEL-749M Relay.

DeviceNet is a low-level communications network that provides direct connectivity among industrial devices, resulting in improved communication and device-level diagnostics that are otherwise either unavailable or inaccessible through expensive hardwired I/O interfaces. Industrial devices for which DeviceNet provides this direct connectivity include limit switches, photoelectric sensors, valve manifolds, motor starters, process sensors, bar code readers, variable frequency drives, panel displays, and operator interfaces. See the DeviceNet Communications Card User's Guide for information on the installation and use of the DeviceNet card.

DeviceNet Card

NOTE: The DeviceNet option has been discontinued and is no longer available to order after September 25, 2017.

The DeviceNet Communications Card is an optional accessory that enables connection of the SEL-749M to the DeviceNet automation network. The card occupies the communication expansion slot in the relay.

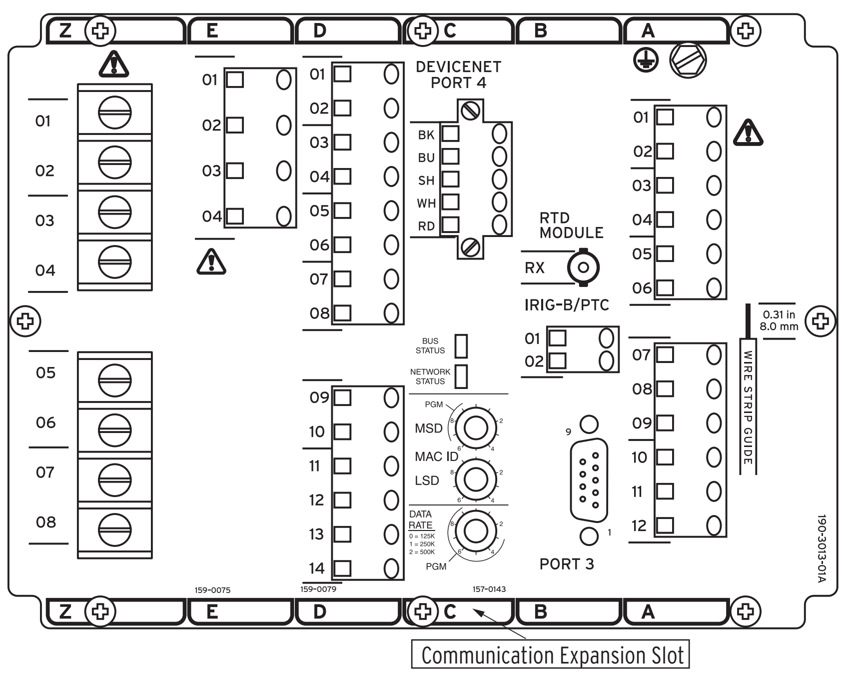

Figure E.1 SEL-749M Motor Relay Back Panel View With DeviceNet

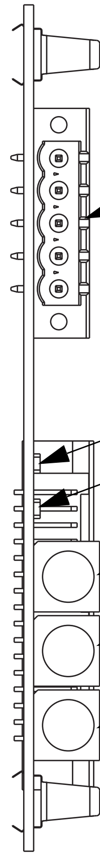

Figure E.2 DeviceNet Card Component Overview

Features

The DeviceNet Communications Card features the following:

- The card receives the required power from the DeviceNet network.
- Rotary switches let you set the node address and network data rate prior to mounting in the SEL-749M and applying power. Alternatively, you can set the switches to positions that allow for configuration of these settings over the DeviceNet network, using a network configuration tool such as RSNetWorx for DeviceNet.
- Status indicators report the status of the device bus and network communications. They are visible from the back panel of the SEL-749M as installed.

You can do the following with the DeviceNet interface:

- Retrieve metering data such as the following:
  - Currents
  - Voltages
  - Power
- Retrieve motor statistics data

- Retrieve and modify relay settings
- Read and set time
- Monitor device status, trip/warning status, and I/O status
- Perform high-speed control
- Reset trip, target, and accumulated data, and retrieve events history

The DeviceNet interface can be configured through the use of address and data transmission rate switches. Indicators on the card at the back of the relay show network status and network activity.

Electronic Data Sheet

Electronic Data Sheet (EDS) is a specially formatted file that includes configurable parameters for the device and public interfaces to those parameters. The EDS file contains information such as number of parameters; groupings; parameter name; minimum, maximum, and default values; units; data format; and scaling. This information makes possible user-friendly configuration tools (e.g., RSNetWorx for DeviceNet or DeviceNet Configurator from OMRON) for device parameter monitoring, modification, or both. The interface to the device can also be easily updated without revision of the configuration software tool itself.

All the registers defined in the Modbus Register Map (*Table D.23*) are available as parameters in a DeviceNet configuration. Parameter names, data ranges, and scaling; enumeration values and strings; parameter groups and product information are the same as specified in the Modbus Register Map defined in *Table D.23*. The parameter numbers are offset by a count of 100 from the register numbers.

The EDS file for the SEL-749M, SEL-749M`Rxxx.EDS`, is located on the SEL-749M Product Literature CD, or you can download the file from the SEL website at selinc.com.

Complete specifications for the DeviceNet protocol are available on the Open DeviceNet Vendor's Association (ODVA) website www.odva.org. ODVA is an independent supplier organization that manages DeviceNet specification and supports the worldwide growth of DeviceNet.

Appendix F
Motor Thermal Element

Overview

The SEL-749M Relay uses a patented protection algorithm to provide effective motor thermal protection. The relay offers two convenient methods to set the thermal element. They are:

- Motor ratings method
- Thermal limit curve method

These setting methods are described in detail in *Section 4: Protection and Logic Functions*. The two methods accommodate differences in protected motors and in the amount and type of motor information available. They also offer the majority of relay users at least one familiar setting method.

While the implementation details of each setting method vary, the fundamental thermal element is the same for both, so this generalized discussion applies to both methods equally. Regardless of the setting method used, the thermal element provides motor protection for the following potentially damaging conditions:

- Locked Rotor Starts
- Running Overload
- Operation Under Unbalanced Currents
- Too Frequent or Prolonged Starting

To provide integrated protection for all these conditions, the thermal element:

- Continuously maintains a numeric estimate analogous to the heat energy in the motor.
- Adjusts the heat estimate based on the measured positive-sequence and negative-sequence current flowing in the motor.
- Weights the heating effect of negative-sequence current as five times the heating effect of positive-sequence current when the motor is running.
- Weights the heating effects of positive- and negative-sequence current equally when the motor is starting.
- Models the heat lost to the surroundings when the motor is running.
- Compares the present heat estimate to an adaptive starting trip threshold or a running trip threshold, depending on the state of the motor.
- Provides a trip output if the present heat estimate exceeds the present trip threshold.

- Provides an alarm output if the present heat estimate exceeds the present alarm threshold (user-settable as a percentage of the trip threshold).
- Adjusts the present trip threshold based on RTD ambient temperature measurement when enabled.

Purpose of Motor Thermal Protection

A typical induction motor draws six times the full load current for which it is rated when starting. This high stator current induces a comparably high current in the rotor. The rotor resistance at zero speed typically is three times the rotor resistance when the motor is at rated speed. Thus, the I^2r heating in the rotor is approximately 62 • 3 or 108 times the I^2r heating when the motor runs normally. Consequently, the motor must tolerate an extreme temperature for a limited time in order to start. Manufacturers communicate the motor tolerance through the maximum locked rotor time and locked rotor amps specifications for each motor. In a similar manner, the motor manufacturer communicates the ability of the motor to operate under continuous heavy load through the service factor specification.

The purpose of motor thermal protection is to allow the motor to start and run within the manufacturer’s published guidelines but trip if the motor heat energy exceeds those ratings because of overloads, negative-sequence current, or locked rotor starting.

Figure F.1 shows a typical motor thermal limit characteristic plotted with the motor starting current. Some motor protection applications use an inverse-time phase overcurrent element to provide locked rotor and overload protection along with a separate negative-sequence overcurrent relay to prevent overheating resulting from current unbalance. Unfortunately, neither of these elements accounts for the motor thermal history or track temperature excursions. The SEL-749M thermal element, with its integrated design, offers distinct advantages over the use of discrete elements.

The SEL-749M thermal element always operates in one of two modes: starting or running. In starting mode, the thermal element provides locked rotor protection, allowing the motor to absorb the high energy of the I2t threshold represented by the rated locked rotor current and time. In running mode, the thermal element provides overload and unbalance protection by limiting the motor heat energy estimate to a value represented by the service factor and two other motor parameters.

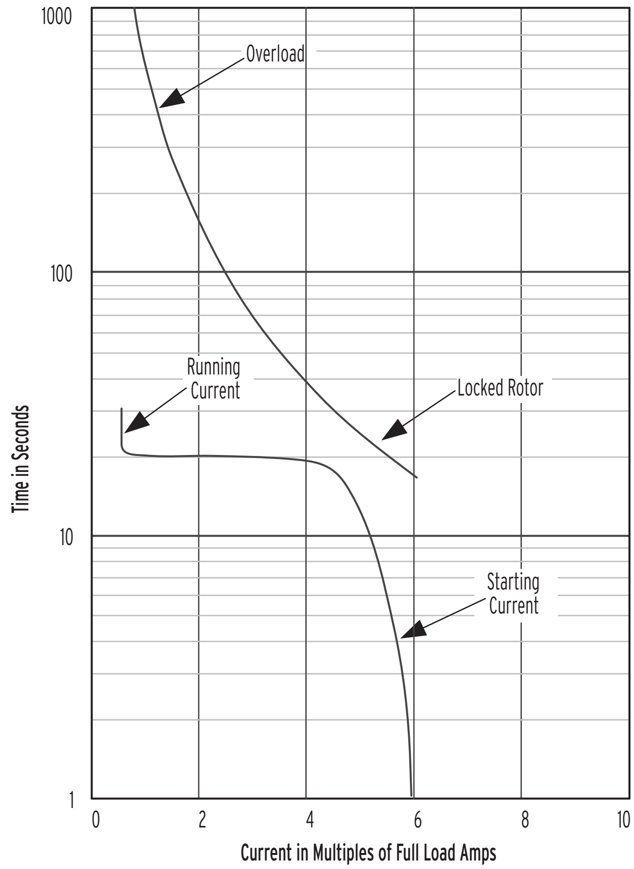

Figure F.1 Motor Thermal Limit Characteristic Plotted With Motor Starting Current

The Basic Thermal Element

Figure F.2 shows a simple electrical analog for a thermal system. The thermal element includes:

➤ A heat source, modeled as a current source.

➤ A thermal capacitance, modeled as a capacitor.

➤ A thermal impedance to ambient, modeled as a resistor.

➤ A comparator to compare the present heat estimate, U, to the thermal trip value.

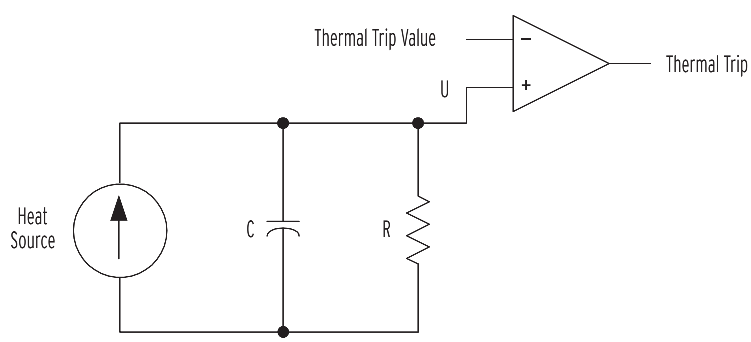

Figure F.2 Electrical Analog of a Thermal System

To define a thermal element for an induction motor, the characteristics of each component in *Figure F.2* must be defined, starting with the heat source. In an induction motor, heat principally is caused by I^2r losses. To consider the effects of negative-sequence current (I_2) on the motor, the heat source is called out separately in *Equation F.1*.

$$\text{Heat Source} = I_1^{\ 2} \bullet K_1 + I_2^{\ 2} \bullet K_2 \qquad \textbf{Equation F.1}$$

where:

I_1 = Positive-sequence current
I_2 = Negative-sequence current

Heating factors K1 and K2 are defined by the positive-sequence rotor resistance and negative-sequence rotor resistance, respectively.

Figure F.3 shows a plot of a typical induction motor current, torque, and rotor resistance versus slip. When motor slip is 1 per unit, rotor speed is zero. As the motor approaches rated speed, slip decreases to near zero.

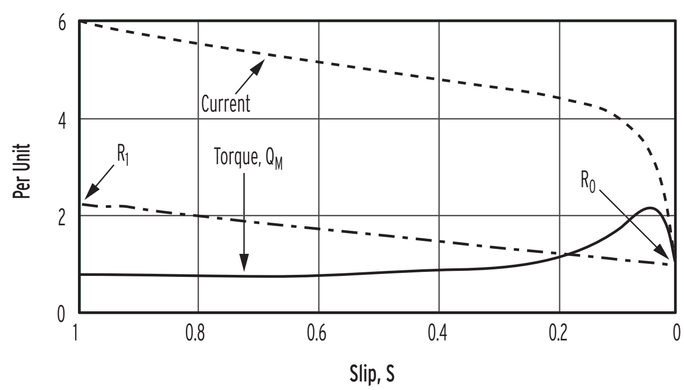

Figure F.3 Typical Induction Motor Current, Torque, and Rotor Resistance versus Slip

Use *Equation F.2* to calculate the positive-sequence rotor resistance plotted in *Figure F.3*.

$$R_r = \left(\frac{Q_M}{I^2}\right) \bullet S \qquad \textbf{Equation F.2}$$

where:

S = Motor slip
Q_m = Motor torque at slip S
I = Motor positive-sequence current at slip S

The positive-sequence rotor resistance is represented as a linear function of slip S by *Equation F.3*.

$$R_{r+} = (R_1 - R_0) \bullet S + R_0 \qquad \textbf{Equation F.3}$$

where:

R_1 = Positive-sequence rotor resistance at slip S = 1
R_0 = Positive-sequence rotor resistance at slip S = 0

To properly account for the heating effects of the negative-sequence current, calculate the negative-sequence rotor resistance. The rotor has slip with respect to the stator negative-sequence current. To determine the value of the negative-sequence slip as a function of positive-sequence slip, S, observe that negative-sequence stator currents cause counter-rotating magnetic poles on the inside face of the stator. When rotor speed is zero, the counter-rotating poles induce fundamental frequency currents in the rotor: negative-sequence slip equals positive-sequence slip, S. When the rotor is spinning at near synchronous speed, the counter-rotating magnetic poles induce approximately double-frequency currents in the rotor: negative-sequence slip equals twice the fundamental frequency.

Based on these observations, negative-sequence slip equals (2–S). Substituting this value for S in *Equation F.3*, calculate negative-sequence rotor resistance, Rr–.

$$R_{r-} = (R_1 - R_0) \bullet (2 - S) + R_0$$

Equation F.4

where:

R_1 = Positive-sequence rotor resistance at slip S = 1
R_0 = Positive-sequence rotor resistance at slip S = 0

To obtain factors expressing the relative heating effect of positive- and negative-sequence current, divide *Equation F.3* and *Equation F.4* by R0. For the locked rotor case (slip, S = 1).

$$\left.\frac{R_{r+}}{R_0}\right|_{S=1} = \left.\frac{R_{r-}}{R_0}\right|_{S=1} = \frac{R_1}{R_0} = 3$$

Equation F.5

When the motor is running (S » 0), the positive-sequence heating factor, K1, is solved as shown in *Equation F.6*.

$$K_1 = \left.\frac{R_{r+}}{R_0}\right|_{S=0} = \frac{R_0}{R_0} = 1$$

Equation F.6

The negative-sequence heating factor, K2, at S » 0 is solved as shown in *Equation F.7*.

$$K_2 = \left(\left.\frac{R_{r-}}{R_0}\right|_{S=0} = 2 \bullet \left(\frac{R_1}{R_0}\right) - 1 = 5\right)$$

Equation F.7

To summarize, based on the assumption that the locked-rotor resistance is three times the running rotor resistance:

NOTE: Starting and running states for the thermal element described here are not the same as STARTING and RUNNING bits described in Figure 4.23.

- ➤ The heating factor of positive-sequence current, K1, when the motor is running is 1 per unit.
- ➤ The heating factor of negative-sequence current, K2, when the motor is running is 5 per unit.
- ➤ Both K1 and K2 are 3 per unit when the rotor is locked.

The differences in the positive- and negative-sequence heating factors immediately suggest that the thermal element should have two models representing motor starting and running. The SEL-749M Relay thermal element automatically selects the appropriate model to use based on the measured sum of the positive-sequence current and the negative-sequence current. When the summed current is greater than 2.5 times the motor rated full load current setting, the relay uses the starting model. When the summed current drops below 2.4 times the rated full load current, the relay uses the running model.

Motor Starting Protection

Figure F.4 shows the thermal element used when the motor is starting. Locked rotor heating occurs over just a few seconds, so the model assumes that no heat is lost to the surroundings and the resistor is removed from the thermal circuit. The thermal trip value is defined by the motor rated locked rotor current, I_L, squared, times the rated hot motor locked rotor time, To. The thermal capacitance is selected to match the heat source heating factor, 3. By setting the capacitance equal to 3, when the motor positive-sequence current, I_1, equals locked rotor current, I_L, the heat estimate, U, reaches the trip value in exactly locked rotor time, To. This is true for the motor initially at or below the normal operating temperature and during use of the rating method. If you use a less conservative curve method, the locked rotor trip time will adapt to the actual initial temperature (heat estimate at the beginning of the motor start). For example, the locked rotor trip time will be 120 percent of To for the motor at an ambient temperature.

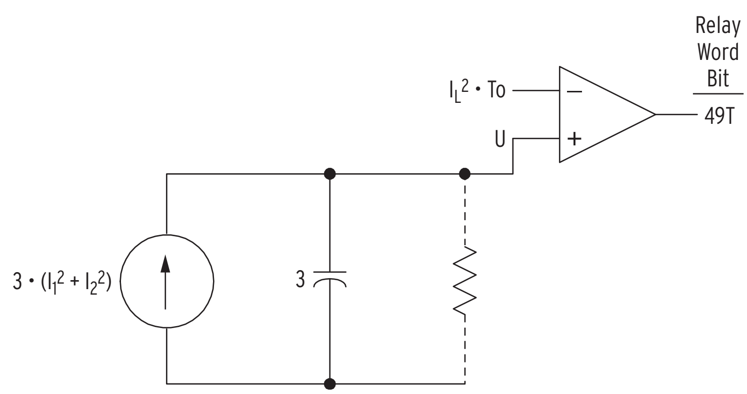

Figure F.4 Motor Starting Thermal Element

NOTE: The trip value shown in the Figure F.4 is the limiting value. Actually, the trip value ramps up during the starting mode and will not reach the limit for a successful motor start.

When a successful motor start occurs and positive-sequence current drops below 2.4 times full load current, the relay switches from the starting thermal element to the running thermal element. The present heat estimate, U, and the present trip value are transferred directly to the running element, representing the heat build-up that occurred during motor starting.

Motor Running Protection

When the motor is running, it returns heat energy to the surroundings through radiation, conduction, convection, and, in some cases, forced cooling. The motor running thermal element provides a path for that energy return through the resistor, R, as shown in *Figure F.5*.

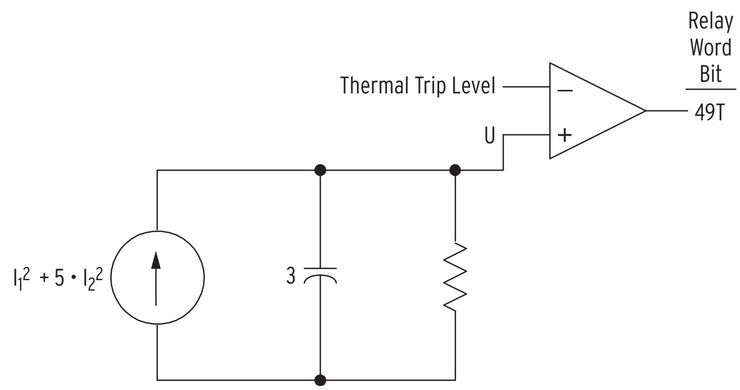

Figure F.5 Motor Running Thermal Element With Resistance and Trip Level Undefined

To determine the value of that resistor, recall that the motor will reach an energy level representing the motor rated operating temperature when 1 per unit of positive-sequence current flows in the motor for a long time. Because the positive-sequence heat factor, K1, is 1 in the running model, and 1 per unit of I1 squared equals 1, the value of resistor R equals the energy level representing the motor rated operating temperature.

To determine the normal operating energy, recall that many motor data sheets publish two locked rotor trip times: one longer time (referred to as Ta) when the motor is started from ambient temperature and one shorter time (To) when the motor is started from operating temperature.

Figure F.6 shows a graphical representation of the problem and corresponding solution. The motor normal operating energy is the difference between the ambient and operating temperature locked rotor times, multiplied by locked rotor current squared. For those motors without published separate locked rotor times, assume that the locked rotor trip energy is approximately six times the operating energy in the relation.

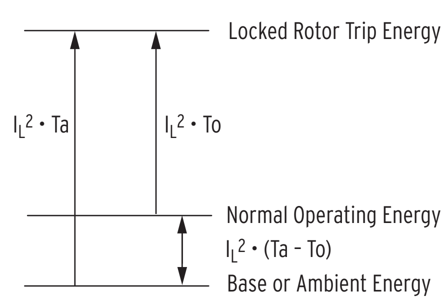

Figure F.6 Calculating the Normal Operating Energy by Using Locked Rotor Trip Times

$$\frac{I_L^2 \bullet Ta}{I_L^2 \bullet (Ta - To)} = 6$$
$$\therefore \frac{Ta}{To} = 1.2$$
$$\therefore (Ta - To) = 0.2 \bullet To$$

Equation F.8

The motor ratings allow the motor to be run continuously at the motor service factor. The service factor, SF, is accounted for in the running thermal element trip threshold. *Figure F.7* shows the final running thermal element.

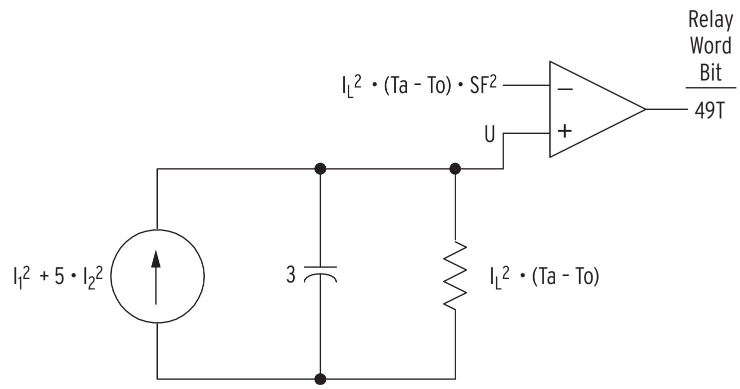

Figure F.7 Motor Running Thermal Element

NOTE: The Motor Starting Trip Threshold calculated in Example F.1 is the limiting value. The actual threshold ramps up during the starting mode and will not reach the limit for a successful motor start.

Example F.1 illustrates the difference between the trip thresholds of the starting and running thermal elements. When the relay switches from the starting to the running thermal element, it maintains the present heat estimate, U, which begins to decrease because of the drop in current squared and because of the insertion of the resistor into the model. The decay of U is exponential as a result of the interaction between the model thermal capacitance and resistance. Rather than instantly switching from the high starting trip threshold to the low running trip threshold, the relay allows the trip threshold to decay exponentially, using the same time constant as the thermal element RC circuit from the initial starting value to the final running value.

EXAMPLE F.1 Starting and Running Trip Level Calculations

Given a motor with the following characteristics, calculate the starting and running thermal model trip thresholds.

Service Factor, SF = 1.15
Locked Rotor Current, IL= 6 per unit of full load amps
Locked Rotor Time From Operating Temperature, To = 12 seconds
Locked Rotor Time From Ambient Temperature, Ta = 14.4 seconds
Motor Starting Trip Threshold
= IL2 • To
= 36 • 12
= 432
Motor Running Trip Threshold
= IL2 • (Ta – To) • SF^2
= 36 • 2.4 • 1.323
= 114.3

Interpreting Percent Thermal Capacity Values

Several of the SEL-749M reporting functions include a % Thermal Capacity value. At all times, the relay uses *Equation F.9* to calculate the percent thermal capacity.

$$\%\text{ Thermal Capacity} = \frac{\begin{pmatrix}\text{Present Heat}\\ \text{Estimate, U}\end{pmatrix}}{\begin{pmatrix}\text{Present Thermal}\\ \text{Trip Value}\end{pmatrix}} \cdot 100\%$$

Equation F.9

By this definition, when the % Thermal Capacity reaches 100%, the heat estimate equals the trip value and the thermal element trips.

As *Example F.1* shows, the thermal trip values for the running and starting elements are very different. For this reason, it is not generally meaningful to compare the % Thermal Capacity during a start to the % Thermal Capacity during running conditions. However, it is quite useful to compare the % Thermal Capacities of several starts using the relay Motor Start Reports and Motor Start Trend data. Using these data, you may notice an increasing trend in the Starting % Thermal Capacity, the final % Thermal Capacity value when the thermal model switches from starting to running. This may indicate gradually increasing load torque, which could eventually result in an unwanted locked rotor trip and subsequent downtime.

A normal motor start is expected to use a significant percentage of the available starting thermal capacity. After a motor start, it is generally necessary for the motor to cool for a time before another start is permitted. The cooling can usually take place while the motor is stopped or running.

The SEL-749M helps to ensure that a motor start is not attempted while the motor is still too hot to be started safely. The TCSTART setting allows you to define a fixed value of thermal capacity used above which the relay asserts the Thermal Lockout until the motor is cool. See *Equation 4.3*, *Equation 4.4*, and the associated description for setting criteria.

Thermal Element Trip-Time Equations

Figure 4.1 and *Figure 4.2* in *Section 4: Protection and Logic Functions* show trip time curves for selected settings of the thermal element. Following are equations for calculating the trip times or curves for any settings.

As stated earlier, the motor model consists of distinct starting and running thermal elements (see *Figure F.4* and *Figure F.7*). Equations for each element appear in the following text. 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

I_0 = Preload motor current in per unit of full load current
0.9 • SF for stator initially at normal operating temperature (hot stator) OR
O for cold stator and testing thermal element

T_p = Thermal element trip time in seconds

SETMETH = Thermal element method setting

SF = Service factor setting

RTC = Run state time constant (setting in minutes, see *Table 4.4* and *Example 4.3*)

T_O = Locked rotor time hot (setting LRTHOT in seconds)

I_L = Locked rotor current (setting LRA)

R = Thermal resistance = $0.2 \bullet I_L^2 \bullet T_0$

U_0 = Initial energy in per unit of R

TD = Acceleration factor setting

CURVE = Curve number setting (when SETMETH = Curve)

General Equations

Equation F.10 applies to the starting element when 12 ≥ I ≥ 2.5.

$$T_p = \frac{[(TD + 0.2) \bullet T_O \bullet I_L^2] - U_O}{I^2}$$

Equation F.10

Equation F.11 applies to the running element when 2.5 > I > SF.

$$T_p = 60 \bullet RTC \bullet \ln\left[\frac{I^2 - I_0^2}{I^2 - SF^2}\right]$$

Equation F.11

Rating Method Equations

Equation F.12 applies to the starting element when 12 ≥ I ≥ 2.5 and SETMETH = Rating. To obtain the trip time (hot or cold rotor), substitute $U_0 = R$ in *Equation F.10*. (Also, use *Equation F.10* when SETMETH := Rating_1 with $U_0 = R$ or $U_0 = 0$ for the hot and cold rotor, respectively.)

$$T_p = \frac{TD \bullet T_O \bullet I_L^2}{I^2}$$

Equation F.12

Equation F.13 and *Equation F.14* apply to the running element when 2.5 > I > SF and SETMETH = Rating or Rating_1.

To obtain the trip time (hot stator), substitute $I_0 = (0.9 \bullet SF)$ and RTC in *Equation F.11*.

RTC = Auto

$$T_p = \left[\frac{T_O \bullet (TD + 0.2)}{\ln\left[\frac{I_L^2 - (0.9 \bullet SF)^2}{I_L^2 - SF^2}\right]}\right] \bullet \ln\left[\frac{I^2 - (0.9 \bullet SF)^2}{I^2 - SF^2}\right]$$

Equation F.13

RTC ≠ Auto

$$T_p = 60 \bullet RTC \bullet \ln\left[\frac{I^2 - (0.9 \bullet SF)^2}{I^2 - SF^2}\right]$$

Equation F.14

To obtain the trip time for cold stator, substitute $I_0 = 0$ and RTC in *Equation F.11*.

RTC = Auto

$$T_p = \left[\frac{T_O \bullet (TD + 0.2)}{\ln\left[\frac{I_L^2 - (0.9 \bullet SF)^2}{I_L^2 - SF^2}\right]}\right] \bullet \ln\left[\frac{I^2}{I^2 - SF^2}\right]$$

Equation F.15

RTC ≠ Auto

$$T_p = 60 \bullet RTC \bullet \ln\left[\frac{I^2}{I^2 - SF^2}\right]$$

Equation F.16

Curve Method Equations

Equation F.17 and *Equation F.18* apply to the starting element when $12 \geq I \geq 2.5$ and SETMETH = Curve. To obtain the trip time (cold rotor), substitute $U_0 = 0$, $TD = 1.0$, $T_O = (2.08 \bullet \text{CURVE})$, and $I_L = 6.0$ in *Equation F.10*

$$T_p = \frac{90 \bullet \text{CURVE}}{I^2}$$

Equation F.17

To obtain the trip time (hot rotor), substitute $U_0 = R$, $TD = 1.0$, $T_O = (2.08 \bullet \text{CURVE})$, and $I_L = 6.0$ in *Equation F.10*

$$T_p = \frac{75 \bullet \text{CURVE}}{I^2}$$

Equation F.18

Equation F.19 applies to the running element when $2.5 > I > SF$ and SETMETH = Curve.

To obtain the trip time (hot stator), substitute $I_0 = (0.9 \bullet SF)$, and RTC in *Equation F.11*.

$$T_p = \left[\frac{2.5 \bullet CURVE}{\ln\left[\frac{36 - (0.9 \bullet SF)^2}{36 - SF^2}\right]}\right] \bullet \ln\left[\frac{I^2 - (0.9 \bullet SF)^2}{I^2 - SF^2}\right]$$

Equation F.19

To obtain the trip time for cold stator, substitute $I_0 = 0$ and RTC in *Equation F.11*.

$$T_p = \left[\frac{2.5 \bullet CURVE}{\ln\left[\frac{36 - (0.9 \bullet SF)^2}{36 - SF^2}\right]}\right] \bullet \ln\left[\frac{I^2}{I^2 - SF^2}\right]$$

Equation F.20

Appendix G
Relay Word Bits

Overview

The protection and control element results are represented by Relay Word bits in the SEL-749M 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 G.1 and *Table G.2* show a list of Relay Word bits and corresponding descriptions. The Relay Word bit row numbers correspond to the row numbers used in the **TAR** command (see *TARGET Command (Display Relay Word Bit Status) on page 7.28*).

Any Relay Word bit (except Row 0) can be used in SELOGIC control equations (see *Section 4: Protection and Logic Functions*) and the Sequential Events Recorder (SER) trigger list settings (see *Section 9: Analyzing Events*).

Table G.1 SEL-749M Relay Word Bits (Sheet 1 of 2)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
TAR 0	ENABLE	TRIP_LED	TLED_01	TLED_02	TLED_03	TLED_04	TLED_05	TLED_06
1	49T	LOSSTRIP	JAMTRIP	46UBT	50P1T	RTDT	PTCTRIP	50G1T
2	VART	37PT	27P1T	59P1T	47T	55T	SPDSTR	50N1T
3	SMTRIP	81D1T	81D2T	OTHTRIP	AMBTRIP	PTCFLT	RTDFLT	*
4	COMMIDLE	COMMLOSS	REMTRIP	COMMFLT	CFGFLT	*	*	*
5	49A	LOSSALRM	JAMALRM	46UBA	RTDA	55A	50N2T	50G2T
6	VARA	37PA	27P2T	59P2T	SPDSAL	81D1A	81D2A	OTHALRM
7	AMBALRM	SALARM	WARNING	LOADUP	LOADLOW	*	50S	50P2T
8	STOPPED	RUNNING	STARTING	STAR	DELTA	START	IRIGOK	*
9	IN101	IN102	IN401	IN402	IN403	*	RTDIN	*
10	TRIP	OUT101	OUT102	OUT103	OUT401	OUT402	OUT403	OUT404
11	50P1P	50P2P	50N1P	50N2P	50G1P	50G2P	27P1	59P1
12	WDGALRM	WDGTRIP	BRGALRM	BRGTRIP	THERMLO	NOSLO	TBSLO	ABSLO
13	PROTBL	THERBL	TRGTR	SPEEDSW	RTDBIAS	52A	SPEED2	HALARM
14	RTD1A	RTD1T	RTD2A	RTD2T	RTD3A	RTD3T	RTD4A	RTD4T
15	RTD5A	RTD5T	RTD6A	RTD6T	RTD7A	RTD7T	RTD8A	RTD8T

Table G.1 SEL-749M Relay Word Bits (Sheet 2 of 2)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
16	RTD9A	RTD9T	RTD10A	RTD10T	RTD11A	RTD11T	RTD12A	RTD12T
17	RB1	RB2	RB3	RB4	RB5	RB6	RB7	RB8
18	SV01	SV02	SV03	SV04	SV05	SV06	SV07	SV08
19	SV01T	SV02T	SV03T	SV04T	SV05T	SV06T	SV07T	SV08T
20	STR	STOP	EMRSTR	ER	ULTRIP	TR	FREQ	STREQ
21	SET01	SET02	SET03	SET04	SET05	SET06	SET07	SET08
22	RST01	RST02	RST03	RST04	RST05	RST06	RST07	RST08
23	LT01	LT02	LT03	LT04	LT05	LT06	LT07	LT08
24	46UBTC	48LJTC	50EFTC	50PTC	37LLTC	66JOGTC	49PTCTC	49RTDTC
25	*	*	DSABLSET	RSTTRGT	BLKPROT	LOP	27P2	59P2
26	DNAUX1	DNAUX2	DNAUX3	DNAUX4	DNAUX5	DNAUX6	*	*
27	*	*	*	*	*	DI_C	DI_B	DI_A
28	*	*	T01_LED	T02_LED	T03_LED	T04_LED	T05_LED	T06_LED
29	IN301	IN302	IN303	IN304	IN305	IN306	IN307	IN308
30	*	*	*	*	*	*	*	*
31	*	*	*	*	*	*	*	*
32	*	*	*	*	*	*	*	*

Definitions

Table G.2 Relay Word Bit Definitions for the SEL-749M (Sheet 1 of 7)

Bit	Definition	Row
*	Reserved for future use	28
27P1	Phase Undervoltage Level 1 Trip Pickup (see *Figure 4.14*)	11
27P1T	Phase Undervoltage Trip Definite time delayed (see *Figure 4.14*)	2
27P2	Phase Undervoltage Level 2 Alarm Pickup (see *Figure 4.14*)	25
27P2T	Phase Undervoltage Alarm/Warning Definite time delayed (see *Figure 4.14*)	6
37LLTC	37LL torque control. Bit controlled by Protection Disable (*Table 4.13*) and/or Trip Inhibit (*Table 4.30*) settings. (For internal use only.)	24
37PA	Underpower Alarm. Assert when the relay issues an underpower element alarm/warning (see *Figure 4.17*).	6
37PT	Underpower Trip. Assert when the relay issues an underpower element trip (see *Figure 4.17*).	2
46UBA	Phase Current Unbalance Alarm. Assert when the relay issues an alarm/warning in response to a current unbalance condition, as defined by that function and corresponding settings (see *Figure 4.7*).	5
46UBT	Phase Current Unbalance Trip. Assert when the relay issues a trip in response to a current unbalance condition, as defined by that function and corresponding settings (see *Figure 4.7*).	1
46UBTC	Phase current unbalance trip torque control. Bit controlled by Protection Disable (*Table 4.13*) and/or Trip Inhibit (*Table 4.30*) settings. (For internal use only.)	24
47T	Phase Reversal Trip. Asserts when the relay detects a phase reversal condition (see *Figure 4.10*).	2
48LJTC	Load jam torque control. Bit controlled by Protection Disable (*Table 4.13*) and/or Trip Inhibit (*Table 4.30*) settings. (For internal use only.)	24

Table G.2 Relay Word Bit Definitions for the SEL-749M (Sheet 2 of 7)

Bit	Definition	Row
49A	Thermal (Overload) Alarm. Assert when the relay issues a thermal element alarm/warning because of locked rotor starting or running overload conditions.	5
49PTCTC	49PTC torque control. Bit controlled by Protection Disable (*Table 4.13*) and/or Trip Inhibit (*Table 4.30*) settings. (For internal use only.)	24
49RTDTC	49RTD torque control. Bit controlled by Protection Disable (*Table 4.13*) and/or Trip Inhibit (*Table 4.30*) settings. (For internal use only.)	24
49T	Thermal (Overload) Trip. Assert when the relay issues a thermal element trip because of locked rotor starting or running overload conditions.	1
50EFTC	50EF torque control. Bit controlled by Protection Disable (*Table 4.13*) and/or Trip Inhibit (*Table 4.30*) settings. (For internal use only.)	24
50G1P	Definite-Time Residual Overcurrent Trip Pickup (see *Figure 4.3*)	11
50G1T	Definite-Time Residual Overcurrent (Trip Level, see *Figure 4.3*)	1
50G2P	Definite-Time Residual Overcurrent Alarm Pickup (see *Figure 4.3*)	11
50G2T	Definite-Time Residual Overcurrent (Warning Level, see *Figure 4.3*)	5
50N1P	Definite-Time Neutral Overcurrent Trip Pickup (see *Figure 4.3*)	11
50N1T	Definite-Time Neutral (Core Balance) Overcurrent (Trip Level, see *Figure 4.3*)	2
50N2P	Definite-Time Neutral Overcurrent Alarm Pickup (see *Figure 4.3*)	11
50N2T	Definite-Time Neutral (Core Balance) Overcurrent (Warning Level, see *Figure 4.3*)	5
50P1P	Definite-Time Phase Overcurrent Trip Pickup (see *Figure 4.3*)	11
50P1T	Definite-Time Phase Overcurrent (Short-Circuit Trip Level, see *Figure 4.3*)	1
50P2P	Definite-Time Phase Overcurrent Alarm Pickup (see *Figure 4.3*)	11
50P2T	Definite-Time Phase Overcurrent (Short-Circuit Warning Level, see *Figure 4.14*)	7
50PTC	50P torque control. Bit controlled by Protection Disable (*Table 4.13*) and/or Trip Inhibit (*Table 4.30*) settings. (For internal use only.)	24
50S	Motor starting overcurrent element (Pickup = 2.5 • Full Load Current)	7
52A	Asserts when the SELOGIC control equation 52A result is logical 1. Use to indicate that the motor contactor or circuit breaker is closed.	13
55A	Power Factor Alarm. Assert when the relay issues a power factor element alarm/warning (see *Figure 4.18*).	5
55T	Power Factor Trip. Assert when the relay issues a power factor element alarm or trip (see *Figure 4.18*).	2
59P1	Phase Overvoltage Level 1 Trip Pickup (see *Figure 4.15*)	11
59P1T	Phase Overvoltage Trip Definite time delayed (see *Figure 4.15*)	2
59P2	Phase Overvoltage Level 1 Alarm Pickup (see *Figure 4.15*)	25
59P2T	Phase Overvoltage Alarm/Warning Definite time delayed (see *Figure 4.15*)	6
66JOGTC	66JOG torque control. Bit controlled by Protection Disable (*Table 4.13*) and/or Trip Inhibit (*Table 4.30*) settings. (For internal use only.)	24
81D1A	Definite-Time Over- and Underfrequency Element (Warning Level 1). Assert when the frequency has been either above or below the element set point for a definite time (see *Figure 4.20*).	6
81D1T	Definite-Time Over- and Underfrequency Element (Trip Level 1). Assert when the frequency has been either above or below the element set point for a definite time (see *Figure 4.20*).	3
81D2A	Definite-Time Over- and Underfrequency Element (Warning Level 2). Assert when the frequency has been either above or below the element set point for a definite time (see *Figure 4.20*).	6
81D2T	Definite-Time Over- and Underfrequency Element (Trip Level 2). Assert when the frequency has been either above or below the element set point for a definite time (see *Figure 4.20*).	3
ABSLO	Motor Lockout Conditions. Antibackspin timer	12

Table G.2 Relay Word Bit Definitions for the SEL-749M (Sheet 3 of 7)

Bit	Definition	Row
AMBALRM	Ambient Temperature Alarm. Asserts if the healthy ambient RTD temperature exceeds the alarm/warning set point for that temperature.	7
AMBTRIP	Ambient Temperature Trip. Asserts when the healthy ambient RTD temperature exceeds its trip set point.	3
BLKPROT	Asserts when the SELOGIC control equation BLKPROT result is logical 1(see *Table 4.30*).	25
BRGALRM BRGTRIP	Bearing Temperature Alarm and Trip. BRGALRM asserts when any healthy bearing RTD temperature exceeds the corresponding alarm set point. BRGTRIP asserts when one or two (when EBRGV = Y) healthy bearing RTD temperatures exceed corresponding trip set points.	12
CFGFLT	Asserts on failed settings interdependency check during Modbus setting change	4
COMMFLT	Time-out of internal communication between CPU board and DeviceNet board	4
COMMIDLE	DeviceNet Card in programming mode	4
COMMLOSS	DeviceNet Card communication failure	4
DELTA	Asserts when the Star-Delta Starting function issues a command to switch motor configuration to Delta (see *Table 4.15*)	8
DI_A	Distortion index phase A (For internal use only; see *Overcurrent Elements on page 4.11*.)	27
DI_B	Distortion index phase B (For internal use only; see *Overcurrent Elements on page 4.11*.)	27
DI_C	Distortion index phase C (For internal use only; see *Overcurrent Elements on page 4.11*.)	27
DNAUX1	DeviceNet/Modbus AUX1 assert bit	26
DNAUX2	DeviceNet/Modbus AUX2 assert bit	26
DNAUX3	DeviceNet/Modbus AUX3 assert bit	26
DNAUX4	DeviceNet/Modbus AUX4 assert bit	26
DNAUX5	DeviceNet/Modbus AUX5 assert bit	26
DNAUX6	DeviceNet/Modbus AUX6 assert bit	26
DSABLSET	Settings changes not allowed from the front-panel interface–when asserted.	25
EMRSTR	Emergency restart asserts when input assigned to EMRSTR asserts or when front-panel Emergency Restart or Modbus/DeviceNet EMRSTR command is received	20
ER	Event report trigger SELOGIC control equation (see *Table 4.49*)	20
FREQ	Asserts when relay is tracking frequency	20
HALARM	Hardware alarm (see *Self-Test on page 10.11*)	13
IN101	Contact input (Slot A)	9
IN102	Contact input (Slot A)	9
IN301	Contact input (IN301–IN308 available with 8DI card in Slot C)	29
IN302	Contact input (IN301–IN308 available with 8DI card in Slot C)	29
IN303	Contact input (IN301–IN308 available with 8DI card in Slot C)	29
IN304	Contact input (IN301–IN308 available with 8DI card in Slot C)	29
IN305	Contact input (IN301–IN308 available with 8DI card in Slot C)	29
IN306	Contact input (IN301–IN308 available with 8DI card in Slot C)	29
IN307	Contact input (IN301–IN308 available with 8DI card in Slot C)	29
IN308	Contact input (IN301–IN308 available with 8DI card in Slot C)	29
IN401	Contact input (IN401–IN403 available with 3 DI/4 DO/1 AO card in Slot D)	9
IN402	Contact input (IN401–IN403 available with 3 DI/4 DO/1 AO card in Slot D)	9
IN403	Contact input (IN401–IN403 available with 3 DI/4 DO/1 AO card in Slot D)	9
IRIGOK	IRIG-B input OK	8
JAMALRM	Load-Jam Alarm/Warning (see *Figure 4.5*)	5

Table G.2 Relay Word Bit Definitions for the SEL-749M (Sheet 4 of 7)

Bit	Definition	Row
JAMTRIP	Load-Jam Trip (see *Figure 4.5*)	1
LOADLOW	Asserts when the selected load parameter drops below a lower level setting (see *Table 4.27*)	7
LOADUP	Asserts when the selected load parameter exceeds an upper level setting (see *Table 4.27*)	7
LOP	Loss-of-Potential logic asserted	25
LOSSALRM	Load-Loss Alarm/Warning. Assert when the relay detects a load-loss as defined by that function and corresponding settings (see *Figure 4.17*).	5
LOSSTRIP	Load-Loss Trip. Assert when the relay detects a load-loss as defined by that function and corresponding settings (see *Figure 4.6*).	1
LT01	Latch Bit 01 asserted (see *Figure 4.29*)	23
LT02	Latch Bit 02 asserted (see *Figure 4.29*)	23
LT03	Latch Bit 03 asserted (see *Figure 4.29*)	23
LT04	Latch Bit 04 asserted (see *Figure 4.29*)	23
LT05	Latch Bit 05 asserted (see *Figure 4.29*)	23
LT06	Latch Bit 06 asserted (see *Figure 4.29*)	23
LT07	Latch Bit 07 asserted (see *Figure 4.29*)	23
LT08	Latch Bit 08 asserted (see *Figure 4.29*)	23
NOSLO	Motor Lockout Conditions. Starts per hour function (NOSLO)	12
OTHALRM	Other Temperature Alarm. Asserts when any healthy Other RTD temperature exceeds the alarm/warning set point for that temperature.	6
OTHTRIP	Other Temperature Trip. Asserts when one (or more) healthy Other RTD temperature exceeds the trip set points.	3
OUT101	Control equation for contact outputs (Slot A)	10
OUT102	Control equation for contact outputs (Slot A)	10
OUT103	Control equation for contact outputs (Slot A)	10
OUT401	Control equation for contact outputs (**OUT401–OUT404** available with 3 DI/4 DO/1 AO card in Slot D)	10
OUT402	Control equation for contact outputs (**OUT401–OUT404** available with 3 DI/4 DO/1 AO card in Slot D)	10
OUT403	Control equation for contact outputs (**OUT401–OUT404** available with 3 DI/4 DO/1 AO card in Slot D)	10
OUT404	Control equation for contact outputs (**OUT401–OUT404** available with 3 DI/4 DO/1 AO card in Slot D)	10
PROTBL	Asserts for a specified time when protected motor starts. Indicates inhibit of some protection (see *Table 4.13*).	13
PTCFLT	Indicates faulted/shorted thermistor	3
PTCTRIP	Asserts when measured PTC loop resistance is greater than trip value	1
RB1	Remote Bit 1 asserted (see *Figure 4.28*)	17
RB2	Remote Bit 2 asserted (see *Figure 4.28*)	17
RB3	Remote Bit 3 asserted (see *Figure 4.28*)	17
RB4	Remote Bit 4 asserted (see *Figure 4.28*)	17
RB5	Remote Bit 5 asserted (see *Figure 4.28*)	17
RB6	Remote Bit 6 asserted (see *Figure 4.28*)	17
RB7	Remote Bit 7 asserted (see *Figure 4.28*)	17
RB8	Remote Bit 8 asserted (see *Figure 4.28*)	17
REMTRIP	Remote trip control input asserted (see *Table 4.31*)	4
RST01	Reset Latch Bit 01 (see *Table 4.35*)	22
RST02	Reset Latch Bit 02 (see *Table 4.35*)	22

Table G.2 Relay Word Bit Definitions for the SEL-749M (Sheet 5 of 7)

Bit	Definition	Row
RST03	Reset Latch Bit 03 (see *Table 4.35*)	22
RST04	Reset Latch Bit 04 (see *Table 4.35*)	22
RST05	Reset Latch Bit 05 (see *Table 4.35*)	22
RST06	Reset Latch Bit 06 (see *Table 4.35*)	22
RST07	Reset Latch Bit 07 (see *Table 4.35*)	22
RST08	Reset Latch Bit 08 (see *Table 4.35*)	22
RSTTRGT	Asserts when the SELOGIC control equation RSTTRGT result is logical 1. Used to reset trip logic and target LEDs (see *Table 4.36*).	25
RTD10A	RTD10 Alarm	16
RTD10T	RTD10 Trip	16
RTD11A	RTD11 Alarm	16
RTD11T	RTD11 Trip	16
RTD12A	RTD12 Alarm	16
RTD12T	RTD12 Trip	16
RTD1A	RTD1 Alarm	14
RTD1T	RTD1 Trip	14
RTD2A	RTD2 Alarm	14
RTD2T	RTD2 Trip	14
RTD3A	RTD3 Alarm	14
RTD3T	RTD3 Trip	14
RTD4A	RTD4 Alarm	14
RTD4T	RTD4 Trip	14
RTD5A	RTD5 Alarm	15
RTD5T	RTD5 Trip	15
RTD6A	RTD6 Alarm	15
RTD6T	RTD6 Trip	15
RTD7A	RTD7 Alarm	15
RTD7T	RTD7 Trip	15
RTD8A	RTD8 Alarm	15
RTD8T	RTD8 Trip	15
RTD9A	RTD9 Alarm	16
RTD9T	RTD9 Trip	16
RTDA	Winding/Bearing RTD Overtemperature Alarm/Warning	5
RTDBIAS	RTD Bias Alarm. When enabled, asserts when the motor winding temperature rise is greater than 60°C over ambient and the RTD % Thermal Capacity is more than ten percentage points higher than the motor thermal element % Thermal Capacity. Typically indicates a loss of motor cooling efficiency.	13
RTDFLT	Asserts when the relay detects an open or short-circuit condition on any enabled RTD input, or communication with the external RTD module has been interrupted.	3
RTDIN	Indicates status of contact connected to SEL-2600 series RTD module	9
RTDT	Winding and Bearing RTD Overtemperature Trip	1
RUNNING	Asserts when the motor is running (see *Figure 4.23*)	8
SALARM	Pulses for the following conditions: Setting Changes, Access Level Changes, and three unsuccessful password entry attempts	7

Table G.2 Relay Word Bit Definitions for the SEL-749M (Sheet 6 of 7)

Bit	Definition	Row
SET01	Set Latch Bit 01 (see *Table 4.35*)	21
SET02	Set Latch Bit 02 (see *Table 4.35*)	21
SET03	Set Latch Bit 03 (see *Table 4.35*)	21
SET04	Set Latch Bit 04 (see *Table 4.35*)	21
SET05	Set Latch Bit 05 (see *Table 4.35*)	21
SET06	Set Latch Bit 06 (see *Table 4.35*)	21
SET07	Set Latch Bit 07 (see *Table 4.35*)	21
SET08	Set Latch Bit 08 (see *Table 4.35*)	21
SMTRIP	Asserts when Start Motor Timer times out	3
SPDSAL	Speed Switch Alarm. Asserts when the relay does not detect a speed switch contact closure within a settable warning period from the beginning of a motor start (see *Figure 4.12*).	6
SPDSTR	Speed Switch Trip. Asserts when the relay does not detect a speed switch contact closure within a settable trip period from the beginning of a motor start (see *Figure 4.12*).	2
SPEED2	Asserts when the SELOGIC control equation SPEED2 result is logical 1 (see *Table 4.32*)	13
SPEEDSW	Speed Switch Input. Asserts when the SELOGIC control equation SPEEDSW result is logical 1 (see *Table 4.32*).	13
STAR	Asserts when the Star-Delta Starting function issues a command to switch motor configuration to Star (see *Table 4.15*)	8
START	Output of the motor start logic (see *Figure 4.24*)	8
STARTING	Asserts when the protected motor is starting (see *Figure 4.23*)	8
STOP	Stop motor—asserts when serial port command STOP or Front Panel or Modbus/DeviceNet Stop command is issued	20
STOPPED	Asserts when the motor is stopped (see *Figure 4.23*)	8
STR	Start motor—asserts when serial port command STR (START) or Front Panel or Modbus/DeviceNet Start command is issued	20
STREQ	Start motor SELOGIC control equation (see *Table 4.32*)	20
SV01	SELOGIC control equation variable timer input SV01 (see *Figure 4.31*)	18
SV01T	SELOGIC control equation variable timer output SV01T (see *Figure 4.31*)	19
SV02	SELOGIC control equation variable timer input SV02 (see *Figure 4.31*)	18
SV02T	SELOGIC control equation variable timer output SV02T (see *Figure 4.31*)	19
SV03	SELOGIC control equation variable timer input SV03 (see *Figure 4.31*)	18
SV03T	SELOGIC control equation variable timer output SV03T (see *Figure 4.31*)	19
SV04	SELOGIC control equation variable timer input SV04 (see *Figure 4.31*)	18
SV04T	SELOGIC control equation variable timer output SV04T (see *Figure 4.31*)	19
SV05	SELOGIC control equation variable timer input SV05 (see *Figure 4.31*)	18
SV05T	SELOGIC control equation variable timer output SV05T (see *Figure 4.31*)	19
SV06	SELOGIC control equation variable timer input SV06 (see *Figure 4.31*)	18
SV06T	SELOGIC control equation variable timer output SV06T (see *Figure 4.31*)	19
SV07	SELOGIC control equation variable timer input SV07 (see *Figure 4.31*)	18
SV07T	SELOGIC control equation variable timer output SV07T (see *Figure 4.31*)	19
SV08	SELOGIC control equation variable timer input SV08 (see *Figure 4.31*)	18
SV08T	SELOGIC control equation variable timer output SV08T (see *Figure 4.31*)	19
T01_LED	Asserts when the SELOGIC control equation T01_LED result is logical 1(see *Table 4.47*).	28

Table G.2 Relay Word Bit Definitions for the SEL-749M (Sheet 7 of 7)

Bit	Definition	Row
T02_LED	Asserts when the SELOGIC control equation T02_LED result is logical 1(see *Table 4.47*).	28
T03_LED	Asserts when the SELOGIC control equation T03_LED result is logical 1(see *Table 4.47*).	28
T04_LED	Asserts when the SELOGIC control equation T04_LED result is logical 1(see *Table 4.47*).	28
T05_LED	Asserts when the SELOGIC control equation T05_LED result is logical 1(see *Table 4.47*).	28
T06_LED	Asserts when the SELOGIC control equation T06_LED result is logical 1(see *Table 4.47*).	28
TBSLO	Motor Lockout Conditions. Minimum time between starts lockout.	12
THERBL	Asserts for a specified time when protected motor starts. Indicates inhibit of thermal protection (see *Table 4.13*).	13
THERMLO	Motor Lockout Conditions. Lockout asserted by the thermal element (THERMLO).	12
TLED_01	Front-Panel T01_LED.	0
TLED_02	Front-Panel T02_LED.	0
TLED_03	Front-Panel T03_LED.	0
TLED_04	Front-Panel T04_LED.	0
TLED_05	Front-Panel T05_LED.	0
TLED_06	Front-Panel T06_LED.	0
TR	Trip SELOGIC control equation (see *Table 4.31*)	20
TRGTR	Target Reset. Asserts for one quarter-cycle when you execute a front-panel, serial port target reset command, or Modbus target reset.	13
TRIP	Output of Trip Logic (see *Figure 4.21*)	10
TRIP_LED	Front-Panel TRIP LED status.	0
ULTRIP	Unlatch (auto reset) trip from SELOGIC control equation (see *Table 4.31*)	20
VARA	Reactive Power Alarm. Assert when the relay issues a reactive power element alarm/warning (see *Figure 4.16*).	6
VART	Reactive Power Trip. Assert when the relay issues a reactive power element trip (see *Figure 4.16*).	2
WARNING	Warning bit asserts for possible warning conditions as shown in *Table 8.3*. These conditions also trigger a flashing TRIP LED.	7
WDGALRM WDGTRIP	Winding Temperature Alarm and Trip. WDGALRM asserts when any healthy winding RTD temperature exceeds the corresponding alarm set point. WDGTRIP asserts when one or two (when EWDGV = Y) healthy winding RTD temperatures exceed corresponding trip set points.	12

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.

Ambient Temperature Temperature of the motor cooling air at the cooling air inlet. Measured by an RTD whose location setting is AMB.

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 Overcurrent Element
- 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
- N Neutral/Ground Element
- Q Negative-Sequence (3I2) 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.

ASCII Abbreviation for American Standard Code for Information Interchange. Defines a standard way to communicate text characters between two electronic devices. The SEL-749M 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 necessary to operate a device. To apply a short-circuit or closed contact to an SEL-749M 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.

Contiguous Items in sequence; the second immediately following the first.

CR_RAM Abbreviation for Critical RAM. Refers to the area of relay Random Access Memory (RAM) where the relay stores mission critical data.

CRC-16 Abbreviation for Cyclical Redundancy Check-16. A mathematical algorithm applied to a block of digital information to produce a unique, identifying number. Used to ensure that the information was received without data corruption.

CT Abbreviation for current transformer.

Current Unbalance 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-749M, 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 necessary to operate a device. To remove a short-circuit or closed contact from an SEL-749M 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.

Dropout Time The time measured from the removal of an input signal until the output signal deasserts. You may be able to set the time, as in the case of a logic variable timer, or the time can be a result of the characteristics of an element algorithm, as in the case of an overcurrent element dropout time.

EEPROM Abbreviation for Electrically Erasable Programmable Read-Only Memory. Nonvolatile memory where relay settings, event reports, SER records, and other nonvolatile data are stored.

Event History A quick look at recent relay activity that includes a standard report header; event number, date, time, and type; maximum fault phase current; and targets.

Event Report A text-based collection of data stored by the relay in response to a triggering condition, such as a fault or command. The data show relay measurements before and after the trigger, in addition to the states of protection elements, relay inputs, and relay outputs each processing interval. After an electrical system fault, use event reports to analyze relay and system performance.

Event Summary A shortened version of stored event reports. An event summary includes items such as event date and time, event type, fault voltages, currents, etc. The relay sends an event report summary (if auto messaging is enabled) to the relay serial port a few seconds after an event.

Fail-Safe Refers to an output contact that is energized during normal relay operation and de-energized when relay power is removed or if the relay fails.

Fast Meter, Fast Operate Binary serial port commands that the relay recognizes at the relay front-and rear-panel EIA-232 serial ports. These commands and the responses from the relay make relay data collection by a communications processor faster and more efficient than transfer of the same data through use of formatted ASCII text commands and responses.

FID Relay firmware identification string. Lists the relay model, firmware version and date code, and other information that uniquely identifies the firmware installed in a particular relay.

Firmware The nonvolatile program stored in the relay that defines relay operation.

Flash A type of nonvolatile relay memory used for storing large blocks of nonvolatile data, such as load profile records.

Fundamental Frequency The component of the measured electrical signal for which frequency is equal to the normal electrical system frequency, usually 50 or 60 Hz. Generally used to differentiate between the normal system frequency and any harmonic frequencies present.

Fundamental Meter Type of meter data presented by the SEL-749M 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.

IA, IB, IC Measured A-, B-, and C-phase currents.

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 for motor ground fault detection on resistance-grounded systems.

LCD Abbreviation for Liquid Crystal Display. Used as the relay front-panel alphanumeric display.

LED Abbreviation for Light-Emitting Diode. Used as indicator lamps on the relay front panel.

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.

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.

Neutral Overcurrent Element A protection element that causes the relay to trip when the neutral current magnitude (measured by the IN input) exceeds a user-settable value. Used to detect and trip in response to motor or cable ground faults.

Nominal Frequency Normal electrical system frequency, usually 50 or 60 Hz.

Nonfail-Safe Refers to an output contact that is not energized during normal relay operation. When referred to a trip 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°, and the C-phase voltage lags B-phase voltage by 120°. In an ACB phase rotation system, the C-phase voltage lags the A-phase voltage by 120°, and the B-phase voltage lags the C-phase voltage by 120°.

Pickup Time The time measured from the application of an input signal until the output signal asserts. You may be able to set the time, as in the case of a logic variable timer, or the time 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 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.

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.

Residual Current The sum of the measured phase currents. In normal, balanced operation, this current is very small or zero. When a motor ground fault occurs, this current can be large.

RMS Abbreviation for Root-Mean-Square. Refers to the effective value of the sinusoidal current and voltage measured by the relay, accounting for the fundamental frequency and higher order harmonics in the signal.

ROM Abbreviation for Read-Only Memory. Nonvolatile memory where the relay firmware is stored.

RTD Abbreviation for resistance temperature detector. An RTD is made of a metal having a precisely known resistance and temperature coefficient of resistance. The SEL-749M and the SEL-2600 RTD Modulemodules can measure the resistance of the RTD, and thus, determine the temperature at the RTD location—typically embedded in the motor windings or attached to the races of bearings.

Self-Test A function that verifies the correct operation of a critical device subsystem and indicates if the relay has detected an out-of-tolerance condition. The SEL-749M 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 512 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 you can use to send and receive ASCII text messages via the PC serial port.

Underfrequency Element A protection element that causes the relay to trip when the measured electrical system frequency is less than a settable frequency.

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.

VG Residual voltage calculated from the sum of the three phase-to-neutral voltages, if connected.

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-749M Relay Command Summary

The table below lists the front serial port ASCII commands associated with particular activities. The commands are shown in uppercase letters, but they can also be entered with lowercase letters.

Serial Port Command	Command Description
Access Level 0 Commands	
ACC	Go to Access Level 1. If the main board access jumper is not in place, the relay prompts for the entry of the Access Level 1 password.
BNA	Display ASCII names of all the Relay Word bits returned in the Fast Meter Data Block.
CAS	Return the Compressed ASCII configuration message.
DNA	Display ASCII names of Relay Word bits reported in Fast Meter.
ID	Relay identification code.
QUI	Go to Access Level 0.
SNS	Display SER settings in Compressed ASCII format.
Access Level 1 Commands	
2AC	Go to Access Level 2. If the main board access jumper is not in place, the relay prompts for the entry of the Access Level 2 password.
CEV *n*	Display compressed event report, 15 cycles (*n* is the event report).
CEV *n* L	Display compressed event report, 16 or 64 cycles.
CEV *n* R	Display compressed event report with raw (unfiltered) data, 16 or 65 cycles.
CHI	Display compressed history report.
CST	Display compressed status report.
CSU	Display compressed event summary.
DAT	View the date.
DAT *dd/mm/yyyy*	Enter date in DMY format if DATE_F setting is DMY.
DAT *mm/dd/yyyy*	Enter date in MDY format if DATE_F setting is MDY.
DAT *yyyy/mm/dd*	Enter date in YMD format if DATE_F setting is YMD.
EVE *n*	Show event report *n* with 4 samples per cycle. If *n* is omitted, most recent report is displayed.
EVE *n* R	Show event report *n* with raw (unfiltered) 16 samples per cycle analog data and 4 samples per cycle digital data.
FIL DIR	Return a list of files.
FIL READ *filename*	Transfer settings file *filename* from the relay to the PC.
FIL SHOW *filename*	Filename 1 displays contents of the file *filename*.
HIS *n*	Show summary of *n* latest event reports, where *n* = 1 is the most recent entry. If *n* is not specified, all event report summaries are displayed.
HIS C or **R**	Clear or reset history buffer.
IRIG	Force synchronization of internal control clock to IRIG-B time-code input.
MET	Display instantaneous metering data.
MET *k*	Display instantaneous metering data *k* times, where *k* is between 1 and 32767.
MET T	Display thermal and RTD metering data.
MOT	Display motor operating statistics report.
MSR *n*	Display motor start report where *n* is the event number.

Serial Port Command	Command Description
MSR F	Display the format of a motor start report.
MST	Display motor start trend data.
SER	Display the entire Sequential Events Recorder (SER) report.
SER *date1*	Display all the rows in the SER report recorded on the specified date (see **DATE** command for date format).
SER *date1 date2*	Display all the rows in the SER report recorded between dates *date1* and *date2*, inclusive.
SER *row1*	Display the latest *row1* rows in the SER report (*row1* = 1–2014, where 1 is the most recent entry).
SER *row1 row2*	Display rows *row1–row2* in the SER report.
SER C or **R**	Reset SER data.
SHO	Show relay settings.
SHO F	Show front-panel settings.
SHO G	Show global settings.
SHO P *n*	Show serial port settings, where *n* specifies the port (3, 4, or F); *n* defaults to the active port if not listed.
SHO R	Show report (event and SER) settings.
SHO L	Show general logic settings.
STA	Display relay self-test status.
STA S	Display SELOGIC usage status report.
SUM	View event summary reports.
SUM R or **C**	Reset event summary buffer.
TAR	Display Relay Word Row 0 (front-panel target LEDs).
TAR *n k*	Display Relay Word Row *n* (*n* = 0 to 10). Repeat *k* times.
TAR *name k*	Display Relay Word Row containing Relay Word *name*. Repeat *k* times.
TAR R	Reset front-panel trip/target LEDs.
TAR … ROW	Adding ROW to the command displays the Relay Word Row number at the start of each line
TIM	View time.
TIM *hh:mm:ss*	Set time by entering **TIM** followed by hours, minutes, and seconds, as shown (24-hour clock).
TRI	Trigger an event report data capture.
Access Level 2 Commands	
ANA *p t*	Test analog output port where *p* is a percentage of full scale between 0–100% and *t* is time in 1.0-10.0 minutes.
CAL	Enter Access Level C. If the main board access jumper is not in place, the relay prompts for the entry of the Access Level C password. Access Level C is reserved for SEL use only.
CON *n*	Set, clear, or pulse an internal remote bit (*n* is the remote bit number from 1–8).
FIL WRITE *filename*	Transfer settings file *filename* from the PC to the relay.
L_D	Load new firmware.
MOT R or **C**	Reset motor operating statistics.
MST R	Reset motor start trend data.
PAS	Show existing Access Level 1 and Level 2 passwords.
PAS 1 *xxxxxxxx*	Change Access Level 1 password to *xxxxxxxx*.
PAS 2 *xxxxxxxx*	Change Access Level 2 password to *xxxxxxxx*.
R_S	Restore factory settings and passwords.
SET	Enter/change relay settings.
SET F	Enter/change front-panel settings.

Serial Port Command	Command Description
SET G	Enter/change global settings.
SET L	Enter/change SELOGIC variable and timer settings.
SET ***name***	For all **SET** commands, jump ahead to a specific setting by entering the setting name, e.g., **50P1P**.
SET P ***n***	Enter/change serial Port *n* settings (*n* = 3, 4, or F; if not specified, the default is the active port).
SET R	Enter/change report (event and SER) settings.
SET … TERSE	For all **SET** commands, **TERSE** disables the automatic **SHO** command after settings entry.
STA R or **C**	Clear self-test status and restart relay.
STO	Stop motor.
STR	Start motor.
VEC	Displays the exception vector report.
Access Level C Commands	
PAS C	Change Access Level C password.

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SEL-749M Relay Command Summary

The table below lists the front serial port ASCII commands associated with particular activities. The commands are shown in uppercase letters, but they can also be entered with lowercase letters.

Serial Port Command	Command Description
Access Level 0 Commands	
ACC	Go to Access Level 1. If the main board access jumper is not in place, the relay prompts for the entry of the Access Level 1 password.
BNA	Display ASCII names of all the Relay Word bits returned in the Fast Meter Data Block.
CAS	Return the Compressed ASCII configuration message.
DNA	Display ASCII names of Relay Word bits reported in Fast Meter.
ID	Relay identification code.
QUI	Go to Access Level 0.
SNS	Display SER settings in Compressed ASCII format.
Access Level 1 Commands	
2AC	Go to Access Level 2. If the main board access jumper is not in place, the relay prompts for the entry of the Access Level 2 password.
CEV *n*	Display compressed event report, 15 cycles (*n* is the event report).
CEV *n* L	Display compressed event report, 16 or 64 cycles.
CEV *n* R	Display compressed event report with raw (unfiltered) data, 16 or 65 cycles.
CHI	Display compressed history report.
CST	Display compressed status report.
CSU	Display compressed event summary.
DAT	View the date.
DAT *dd/mm/yyyy*	Enter date in DMY format if DATE_F setting is DMY.
DAT *mm/dd/yyyy*	Enter date in MDY format if DATE_F setting is MDY.
DAT *yyyy/mm/dd*	Enter date in YMD format if DATE_F setting is YMD.
EVE *n*	Show event report *n* with 4 samples per cycle. If *n* is omitted, most recent report is displayed.
EVE *n* R	Show event report *n* with raw (unfiltered) 16 samples per cycle analog data and 4 samples per cycle digital data.
FIL DIR	Return a list of files.
FIL READ *filename*	Transfer settings file *filename* from the relay to the PC.
FIL SHOW *filename*	Filename 1 displays contents of the file *filename*.
HIS *n*	Show summary of *n* latest event reports, where *n* = 1 is the most recent entry. If *n* is not specified, all event report summaries are displayed.
HIS C or **R**	Clear or reset history buffer.
IRIG	Force synchronization of internal control clock to IRIG-B time-code input.
MET	Display instantaneous metering data.
MET *k*	Display instantaneous metering data *k* times, where *k* is between 1 and 32767.
MET T	Display thermal and RTD metering data.
MOT	Display motor operating statistics report.
MSR *n*	Display motor start report where *n* is the event number.

Serial Port Command	Command Description
MSR F	Display the format of a motor start report.
MST	Display motor start trend data.
SER	Display the entire Sequential Events Recorder (SER) report.
SER ***date1***	Display all the rows in the SER report recorded on the specified date (see **DATE** command for date format).
SER ***date1 date2***	Display all the rows in the SER report recorded between dates *date1* and *date2*, inclusive.
SER ***row1***	Display the latest *row1* rows in the SER report (*row1* = 1–2014, where 1 is the most recent entry).
SER ***row1 row2***	Display rows *row1*–*row2* in the SER report.
SER C or **R**	Reset SER data.
SHO	Show relay settings.
SHO F	Show front-panel settings.
SHO G	Show global settings.
SHO P ***n***	Show serial port settings, where *n* specifies the port (3, 4, or F); *n* defaults to the active port if not listed.
SHO R	Show report (event and SER) settings.
SHO L	Show general logic settings.
STA	Display relay self-test status.
STA S	Display SELOGIC usage status report.
SUM	View event summary reports.
SUM R or **C**	Reset event summary buffer.
TAR	Display Relay Word Row 0 (front-panel target LEDs).
TAR ***n k***	Display Relay Word Row *n* (*n* = 0 to 10). Repeat *k* times.
TAR ***name k***	Display Relay Word Row containing Relay Word *name*. Repeat *k* times.
TAR R	Reset front-panel trip/target LEDs.
TAR … ROW	Adding ROW to the command displays the Relay Word Row number at the start of each line
TIM	View time.
TIM ***hh:mm:ss***	Set time by entering **TIM** followed by hours, minutes, and seconds, as shown (24-hour clock).
TRI	Trigger an event report data capture.
Access Level 2 Commands	
ANA ***p t***	Test analog output port where *p* is a percentage of full scale between 0–100% and *t* is time in 1.0-10.0 minutes.
CAL	Enter Access Level C. If the main board access jumper is not in place, the relay prompts for the entry of the Access Level C password. Access Level C is reserved for SEL use only.
CON ***n***	Set, clear, or pulse an internal remote bit (*n* is the remote bit number from 1–8).
FIL WRITE ***filename***	Transfer settings file *filename* from the PC to the relay.
L_D	Load new firmware.
MOT R or **C**	Reset motor operating statistics.
MST R	Reset motor start trend data.
PAS	Show existing Access Level 1 and Level 2 passwords.
PAS 1 ***xxxxxxxx***	Change Access Level 1 password to *xxxxxxxx*.
PAS 2 ***xxxxxxxx***	Change Access Level 2 password to *xxxxxxxx*.
R_S	Restore factory settings and passwords.
SET	Enter/change relay settings.
SET F	Enter/change front-panel settings.

Serial Port Command	Command Description
SET G	Enter/change global settings.
SET L	Enter/change SELOGIC variable and timer settings.
SET ***name***	For all **SET** commands, jump ahead to a specific setting by entering the setting name, e.g., **50P1P**.
SET P ***n***	Enter/change serial Port *n* settings (*n* = 3, 4, or F; if not specified, the default is the active port).
SET R	Enter/change report (event and SER) settings.
SET … TERSE	For all **SET** commands, **TERSE** disables the automatic **SHO** command after settings entry.
STA R or **C**	Clear self-test status and restart relay.
STO	Stop motor.
STR	Start motor.
VEC	Displays the exception vector report.
Access Level C Commands	
PAS C	Change Access Level C password.

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